Detroit Diesel Engines

In-Line 71 Service Manual



6SE177 (Rev. 7/84)

Service Manual

Detroit Diesel Engines

IN-LINE 71

Detroit Diesel Allison
13400 Outer Drive, West
Detroit, Michigan 48239-4001

NOTE:
Additional copies of this service manual may be purchased from Detroit Diesel Allison Distributors. See your yellow pages—under Engines, Diesel.

Printed in U.S.A.

© 1984 General Motors Corporation

FOREWORD

This manual contains instructions on the overhaul, maintenance and operation of the basic Series 71 In-Line Detroit Diesel Engines.

Full benefit of the long life and dependability built into these engines can be realized through proper operation and maintenance. Of equal importance is the use of proper procedures during engine overhaul.

Personnel responsible for engine operation and maintenance should study the sections of the manual pertaining to their particular duties. Similarly, before beginning a repair or overhaul job, the serviceman should read the manual carefully to familiarize himself with the parts or sub-assemblies of the engine with which he will be concerned.

The information, specifications and illustrations in this publication are based on the information in effect at the time of approval for printing. This publication is revised and reprinted periodically. It is recommended that users contact an authorized *Detroit Diesel Allison Service Outlet* for information on the latest revisions. The right is reserved to make changes at any time without obligation.

IMPORTANT SAFETY NOTICE

Proper service and repair is important to the safe, reliable operation of all motor vehicles. The service procedures recommended by Detroit Diesel Allison and described in this service manual are effective methods for performing service operations. Some of these service operations require the use of tools specially designed for the purpose. The special tools should be used when and as recommended.

It is important to note that some warnings against the use of specific service methods that can damage the vehicle or render it unsafe are stated in this service manual. It is also important to understand these warnings are not exhaustive. Detroit Diesel Allison could not possibly know, evaluate and advise the service trade of all conceivable ways in which service might be done or of the possible hazardous consequences of each way. Consequently, Detroit Diesel Allison has not undertaken any such broad evaluation. Accordingly, anyone who uses a service procedure or tool which is not recommended by Detroit Diesel Allison must first satisfy himself thoroughly that neither his safety nor vehicle safety will be jeopardized by the service method he selects.

TABLE OF CONTENTS

SUBJECT	SECTION
GENERAL INFORMATION	
ENGINE (less major assemblies)	1
FUEL SYSTEM AND GOVERNORS	2
AIR INTAKE SYSTEM	3
LUBRICATION SYSTEM	4
COOLING SYSTEM	5
EXHAUST SYSTEM	6
ELECTRICAL EQUIPMENT, INSTRUMENTS AND PROTECTIVE SYSTEMS	7
POWER TAKE-OFF	8
TRANSMISSIONS	9
SPECIAL EQUIPMENT	12
OPERATION	13
TUNE-UP	14
PREVENTIVE MAINTENANCE, TROUBLESHOOTING AND STORAGE	15

©1983 General Motors Corporation

October, 1983

SCOPE AND USE OF THE MANUAL

This manual covers the basic Series 71 In-line diesel engines built by the Detroit Diesel Allison Division of General Motors Corporation. Multiple engine units are available in various combinations such as side-by-side twins, tandem twins and quads. Complete instructions on operation, adjustment (tune-up), preventive maintenance and lubrication, and repair (including complete overhaul) are covered. The manual was written primarily for persons servicing and overhauling the engine and, in addition, contains all of the instructions essential to the operators and users. Basic maintenance and overhaul procedures are common to all Series 71 In-line engines, and therefore, apply to all engine models.

The manual is divided into numbered sections. The first section covers the engine (less major assemblies). The following sections cover a complete system such as the fuel system, lubrication system or air system. Each section is divided into subsections which contain complete maintenance and operating instructions for a specific subassembly on the engine. For example, Section 1, which covers the basic engine, contains subsection 1.1 pertaining to the cylinder block, subsection 1.2 covering the cylinder head, etc. The subjects and sections are listed in the Table of Contents on the preceding page. Pages are numbered consecutively, starting with a new Page 1 at the beginning of each subsection. The illustrations are also numbered consecutively, beginning with a new Fig. 1 at the start of each subsection.

Information regarding a general subject, such as the lubrication system, can best be located by using the Table of Contents. Opposite each subject in the Table of Contents is a section number which registers with a tab printed on the first page of each section throughout the manual. Information on a specific subassembly or accessory can then be found by consulting the list of contents on the first page of the section. For example, the cylinder liner is part of the basic engine, therefore, it will be found in Section 1. Looking down the list of contents on the first page of Section 1, the cylinder liner is found to be in subsection 1.6.3. An Alphabetical Index at the back of the manual has been provided as an additional aid for locating information.

SERVICE PARTS AVAILABILITY

Genuine Detroit Diesel Allison service parts are available from authorized Detroit Diesel Allison distributors and service dealers throughout the world. A complete list of all distributors and dealers is available in the World Wide Parts and Service Directory, 6SE280. This publication can be ordered from any authorized distributor.

CLEARANCES AND TORQUE SPECIFICATIONS

Clearances of new parts and wear limits on used parts are listed in tabular form at the end of each section throughout the manual. It should be specifically noted that the "New Parts" clearances apply only when all new parts are used at the point where the various specifications apply. This also applies to references within the text of the manual. The column entitled "Limits" lists the amount of wear or increase in clearance which can be tolerated in used engine parts and still assures satisfactory performance. It should be emphasized that the figures given as "Limits" must be qualified by the judgment of personnel responsible for installing new parts. These wear limits are, in general, listed only for the parts more frequently replaced in engine overhaul work. For additional information, refer to the paragraph entitled *Inspection* under *General Procedures* in this section.

Bolt, nut and stud torque specifications are also listed in tabular form at the end of each section.

© 1983 General Motors Corp.

PRINCIPLES OF OPERATION

The diesel engine is an internal combustion power unit, in which the heat of fuel is converted into work in the cylinder of the engine.

In the diesel engine, air alone is compressed in the cylinder; then, after the air has been compressed, a charge of fuel is sprayed into the cylinder and ignition is accomplished by the heat of compression.

The Two-Cycle Principle

In the two-cycle engine, intake and exhaust take place during part of the compression and power strokes respectively (Fig. 1). In contrast, a four-cycle engine requires four piston strokes to complete an operating cycle; thus, during one half of its operation, the four-cycle engine functions merely as an air pump.

A blower is provided to force air into the cylinders for expelling the exhaust gases and to supply the cylinders with fresh air for combustion. The cylinder wall contains a row of ports which are above the piston when it is at the bottom of its stroke. These ports admit the air from the blower into the cylinder as soon as the rim of the piston uncovers the ports (Fig. 1) - (scavenging).

The unidirectional flow of air toward the exhaust valves produces a scavenging effect, leaving the cylinders full of clean air when the piston again covers the inlet ports.

As the piston continues on the upward stroke, the exhaust valves close and the charge of fresh air is subjected to compression (Fig. 1) - (compression).

Shortly before the piston reaches its highest position, the required amount of fuel is sprayed into the combustion chamber by the unit fuel injector (Fig. 1) - (power). The intense heat generated during the high compression of the air ignites the fine fuel spray immediately. The combustion continues until the fuel injected has been burned.

The resulting pressure forces the piston downward on its power stroke. The exhaust valves are again opened when the piston is about half way down, allowing the burned gases to escape into the exhaust manifold (Fig. 1) - (exhaust). Shortly thereafter, the downward moving piston uncovers the inlet ports and the cylinder is again swept with clean scavenging air. This entire combustion cycle is completed in each cylinder for each revolution of the crankshaft, or, in other words, in two strokes; hence, it is a "two-stroke cycle".

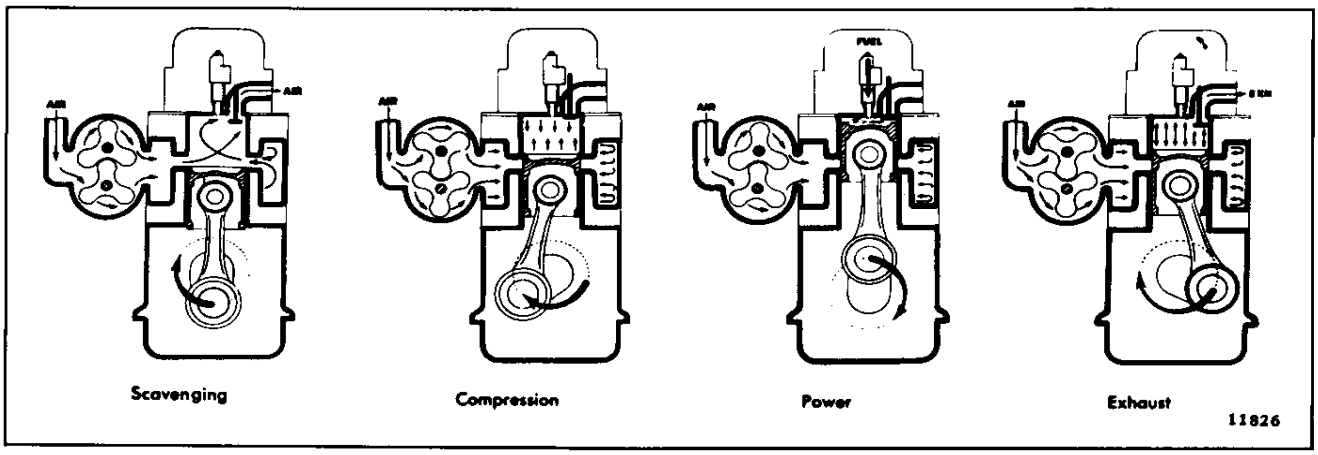


Fig. 1 - The Two-Stroke Cycle

© 1983 General Motors Corp.

GENERAL DESCRIPTION

The two-cycle diesel engines covered in this manual are produced in 3, 4 and 6 cylinder models having the same bore and stroke and many of the major working parts such as injectors, pistons, connecting rods, cylinder liners and other parts that are interchangeable.

The blower, water pump, governor and fuel pump form a group of standard accessories which can be located on either side of the engine, regardless of the direction of rotation. Further flexibility in meeting installation requirements can be had by placing the exhaust manifold and the water outlet manifold on either side of the engine (Fig. 2). This flexibility in the arrangement of parts is obtained by having both the cylinder block and the cylinder head symmetrical at both ends and with respect to each other.

The meaning of each digit in the model numbering system is shown in Fig. 2. The letter L or R indicates left or right-hand engine rotation as viewed from the front of the engine. The letter A, B, C or D designates the blower and exhaust manifold location as viewed from the rear of the engine.

Each engine is equipped with an oil cooler, lubricating oil filter, fuel oil strainer, fuel oil filter, air cleaner or silencer, governor, heat exchanger and raw water pump or fan and radiator and starting motor.

Full pressure lubrication is supplied to all main, connecting rod and camshaft bearings, and to other moving parts within the engine. A gear-type pump draws oil from the oil pan through an intake screen, through the oil filter and then to the oil cooler. From the oil cooler, the oil enters a longitudinal oil gallery in the cylinder block where the supply divides; a portion entering the bypass filter, if used, and then draining back into the oil pan, part going to the cam and balance shaft end bearings and cylinder head, with the remainder going to the main bearings and connecting rod bearings via the drilled crankshaft.

Coolant is circulated through the engine by a centrifugal-type water pump. Heat is removed from the coolant, which circulates in a closed system, by the heat exchanger or radiator. Control of the engine temperature is accomplished by a thermostat which regulates the flow of the coolant within the cooling system.

Fuel is drawn from the supply tank through the fuel strainer by a gear-type fuel pump. It is then forced through a filter and into the fuel inlet manifold in the cylinder head and to the injectors. Excess fuel is returned to the supply tank through the fuel outlet manifold and connecting lines. Since the fuel is constantly circulating through the injectors, it serves to cool the injectors and also carries off any air in the fuel system.

Air for scavenging and combustion is supplied by a blower which pumps air into the engine cylinders via the air box and cylinder liner ports. All air entering the blower first passes through an air cleaner or silencer.

Engine starting is provided by either a hydraulic or electric starting system. The electric starting motor is energized by a storage battery. A battery-charging generator, with a suitable voltage regulator, or an alternator serves to keep the battery charged.

Engine speed is regulated by a mechanical or hydraulic type engine governor, depending upon the engine application.

GENERAL SPECIFICATIONS

	3-71	4-71	6-71
Type	2 Cycle	2 Cycle	2 Cycle
Number of Cylinders	3	4	6
Bore (inches)	4.25	4.25	4.25
Bore (mm)	108	108	108
Stroke (inches)	5	5	5
Stroke (mm)	127	127	127
Compression Ratio (Nominal) (Std. & Turbo.)	17 to 1	17 to 1	17 to 1
Compression Ratio (Nominal) ("N" Engines)	18.7 to 1	18.7 to 1	18.7 to 1
Total Displacement - cubic inches	213	284	426
Total Displacement - litres	3.49	4.66	6.99
Firing Order - R.H. Rotation	1-3-2	1-3-4-2	1-5-3-6-2-4
Firing Order - L.H. Rotation	1-2-3	1-2-4-3	1-4-2-6-3-5
Number of Main Bearings	4	5	7

© 1983 General Motors Corp.

1 0 6 5 - 7 0 0 1

SERIES 71 IN-LINE ENGINE	NUMBER OF CYLINDERS	APPLICATION DESIGNATION (see below)	BASIC ENGINE *ARRANGEMENT* AND DRIVE SHAFT ROTATION (see below)	*DESIGN* VARIATION (see below)	*SPECIFIC* MODEL NUMBER

APPLICATION DESIGNATIONS:

1062-7001	MARINE
1063-7001	INDUSTRIAL F-F
1064-7001	POWER-BASE
1065-7001	GENERATOR
1067-7001	VEHICLE F-F
1068-7001	VEHICLE F-F

DESIGN VARIATIONS:

1062-7001	4 VALVE HEAD ("N" ENGINE)
1062-7101	2 VALVE HEAD ENGINE
1062-7201	4 VALVE HEAD ("E" ENGINE)
1062-7301	TURBOCHARGED ENGINE
1062-7501	CUSTOMER SPEC. ENGINE
1067-7701	CONSTANT HORSEPOWER

BASIC ENGINE ARRANGEMENTS:

Rotation: L (left) and R (right) designates rotation viewed from the front of the engine. Type A-B-C-D designates the accessory arrangements.

DRIVE SHAFT ROTATIONS:

11220001 LEFT-HAND
11229001 *RIGHT-HAND*

Shaft rotation on multiple units is determined from the rear of the unit.

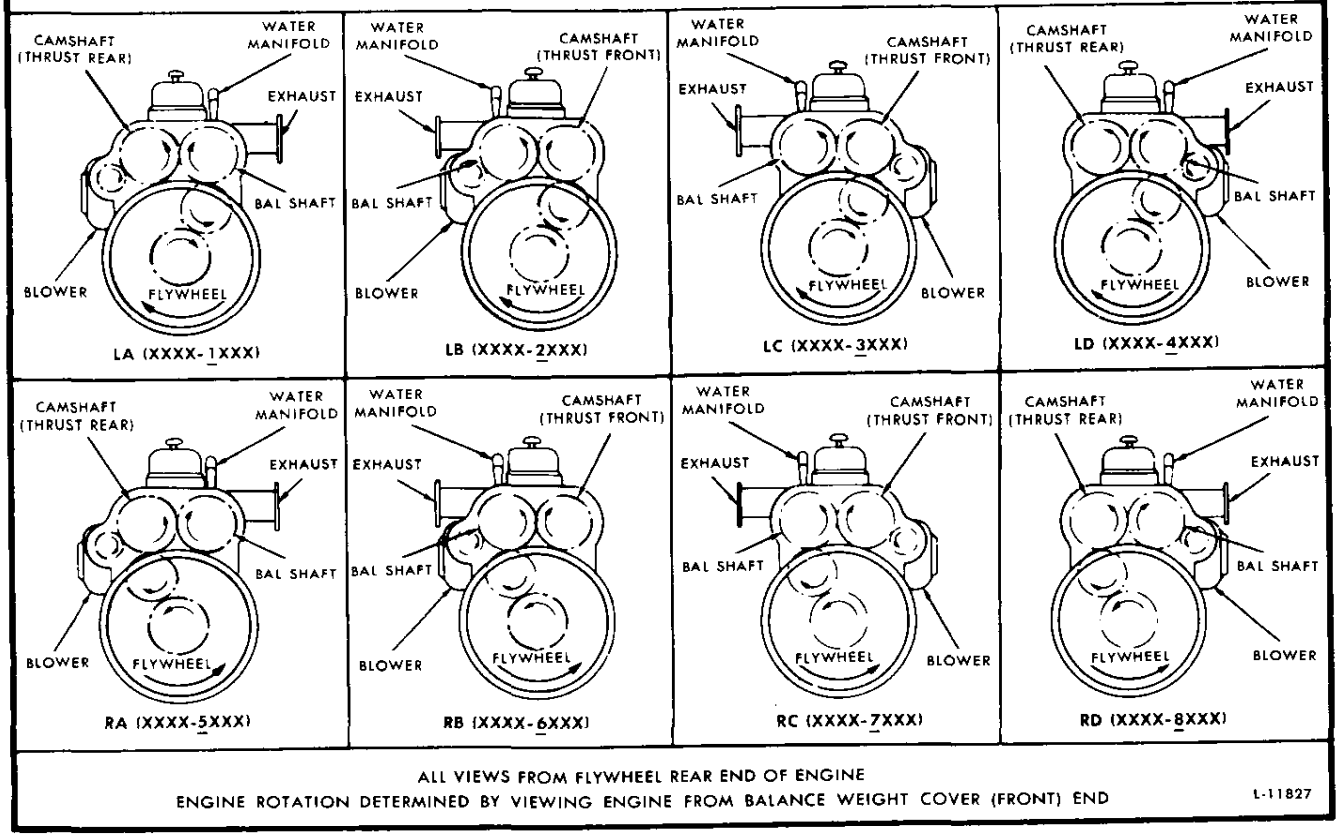


Fig. 2 - Model Description (Current Engines), Rotation and Accessory Arrangements

© 1978 General Motors Corp.

ENGINE MODELS

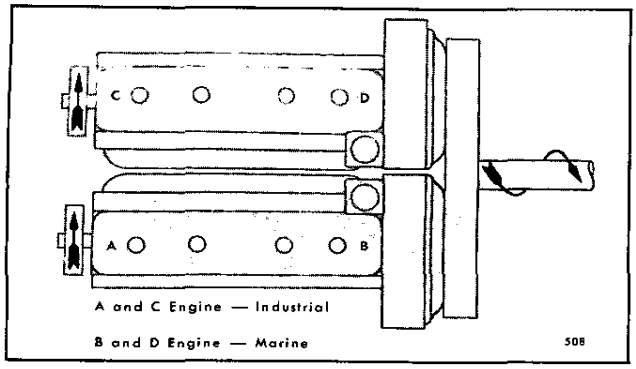


Fig. 3 - Typical Twin Engine Unit

Flexibility in the location of the basic engine accessories (such as the blower, governor, water outlet manifold and exhaust manifold) and a wide range of power take-offs and reduction gears makes it possible to provide a suitable unit to fulfill any requirement.

In addition to single engine models, the Series 71 twin and quad multiple engine units are designed to deliver increased power to a single drive shaft.

Each engine making up a multiple engine unit may be in use or cut out as desired through their individual control levers. Thus, flexibility in power output is possible by varying from idling speed on one engine to full throttle on all engines as the load demands.

A and C engines are used in the twin and quad industrial units and B and D engines are used in twin and quad marine units. Left-hand (LH) rotation is obtained at the power drive shaft with the arrangement shown in Figs. 3 and 4. Right-hand (RH) rotation at the power drive shaft is attained by reversing engine rotation with the same arrangement as shown in Figs. 3 and 4.

The tandem twin marine model, shown in Fig. 5, uses an RA and an LC engine. The accessories and throttle controls are mounted on the inboard side and the exhaust manifold is mounted on the outboard side. On starboard units, the drive shaft turns clockwise and on port units the drive shaft turns counterclockwise.

The marine inclined engine is available in two models (RB and LD), each with its own reduction gear and propeller shaft.

The accessories, throttle controls and exhaust manifold are mounted on the inboard side of both models. The propeller shaft on starboard units turns in a clockwise direction and on the port units it turns counterclockwise.

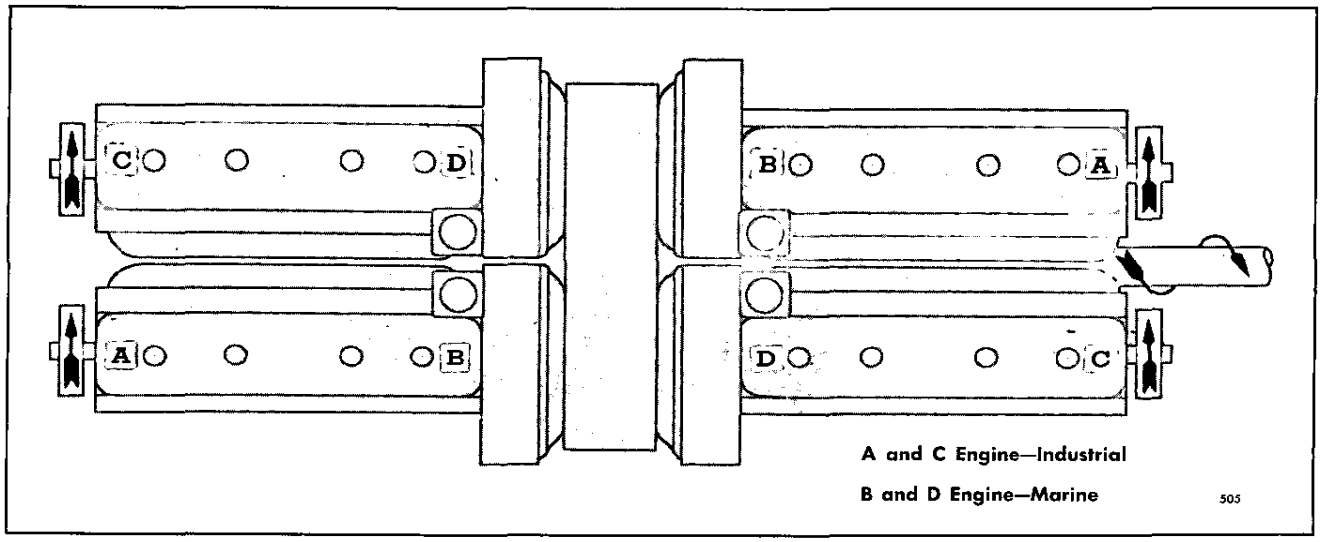


Fig. 4 - Typical Quad Engine Unit

© 1978 General Motors Corp.

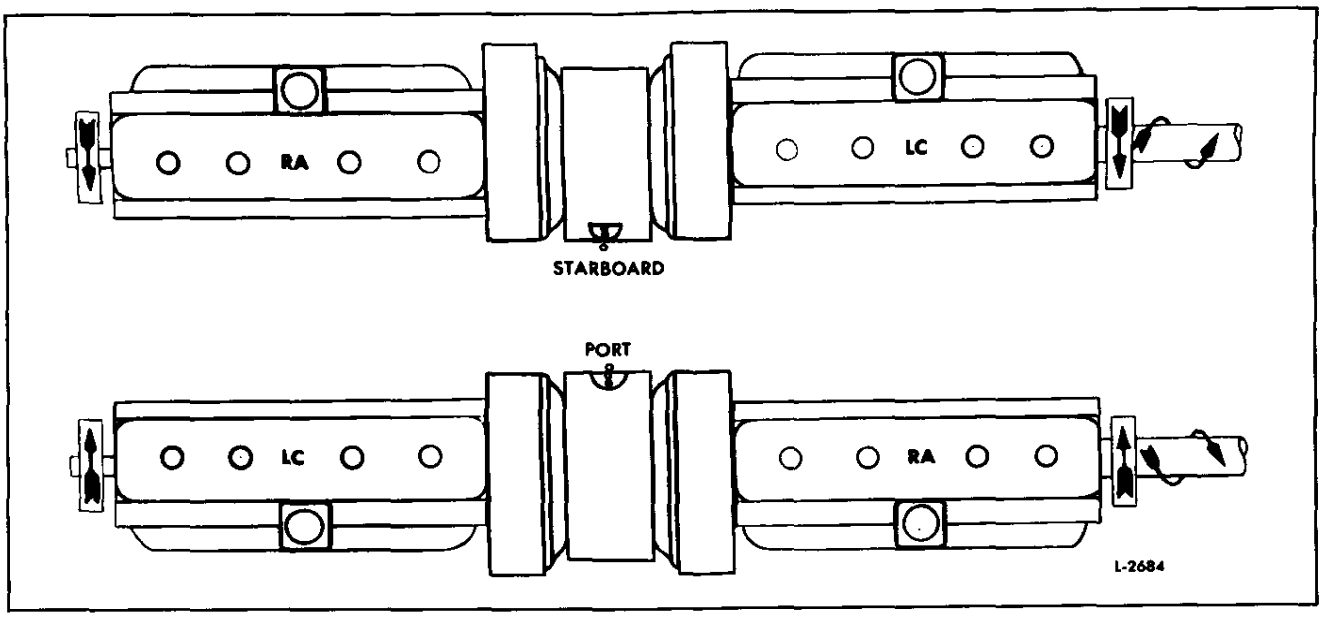


Fig. 5 - Typical Tandem Engine Unit

ENGINE MODEL, SERIAL NUMBER AND OPTION PLATE

Engine Model and Serial Numbers

On all current Series 71 engines, the engine serial number and the engine model number are stamped on the cylinder block (Figs. 6 and 7). The engine serial number and model number are also stamped on the option plate (when used) attached to the valve rocker cover.

On very early engines, the serial and model numbers were stamped on a name plate attached to the flywheel housing.

Effective with August, 1948 engines, the engine serial number is prefixed by numerals indicating the number of cylinders and the letter "A" which designates a Series 71 engine.

Current Series 71 engines are identified by an eight digit model number (Fig. 2). The engine model number 1065-7001 illustrated is interpreted as follows: Series 71 In-line engine (1), six-cylinder (06), generator set (5), right-hand rotation with "C" accessory arrangement (7), four-valve head "N" engine (0) and specific model variation No. 1 (01).

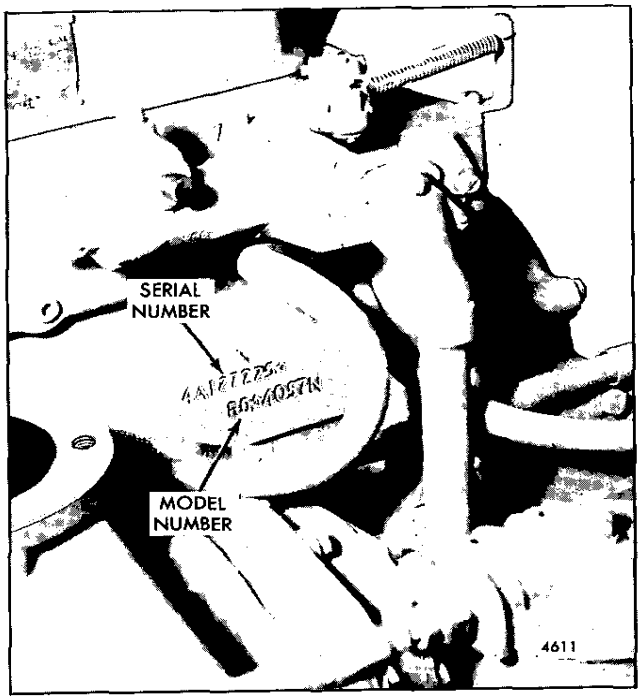


Fig. 6 - Typical Serial and Model Number - Stamped on Cylinder Block (Former Engines)

© 1983 General Motors Corp.

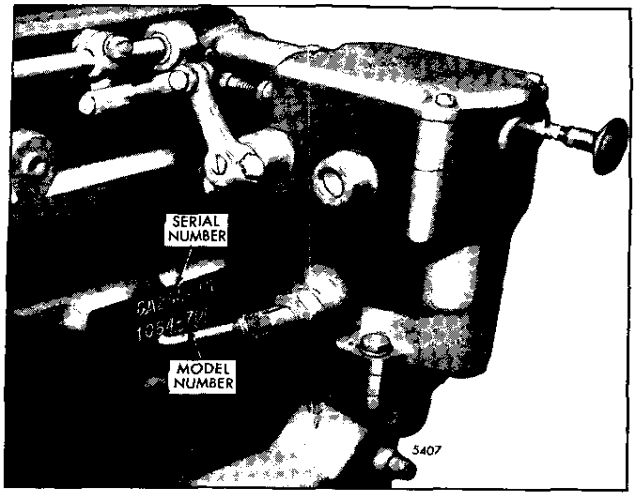


Fig. 7 - Typical Serial and Model Number - Stamped on Cylinder Block (Current Engines)

Option Plate

An option plate, attached to the valve rocker cover (only one valve rocker cover of a multiple engine unit), carries the engine serial number and model number and, in addition, lists any optional equipment used on the engine (Fig. 8).

On-highway vehicle engines also carry an exhaust emission certification label next to the option plate. It is separate from the option plate and is mounted permanently in the option plate retainer. The current

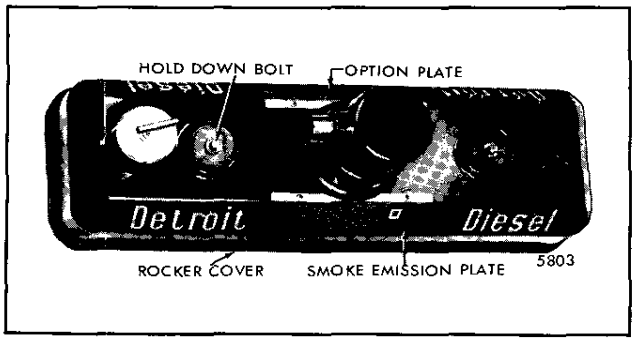


Fig. 8 - Option Plate

label includes information relating to an engine family for the maximum fuel injector size and maximum speed. *Due to Federal regulations, the exhaust emission plate should not be removed from the rocker cover.* Refer to Section 14 for further information regarding emission regulations.

With any order for parts, the engine model number and serial number must be given. In addition, if a type number is shown on the option plate covering the equipment required, this number should also be included on the parts order.

All groups of parts used on a unit are standard for the engine model unless otherwise listed on the option plate.

Power take-off assemblies, torque converters, marine gears, etc. may also carry name plates. The information on these name plates is also useful when ordering replacement parts for these assemblies.

© 1983 General Motors Corp.

GENERAL PROCEDURES

In many cases, a serviceman is justified in replacing parts with new material rather than attempting repair. However, there are times where a slight amount of reworking or reconditioning may save a customer considerable added expense. Crankshafts, cylinder liners and other parts are in this category. For example, if a cylinder liner is only slightly worn and within usable limits, a honing operation to remove the glaze may make it suitable for reuse, thereby saving the expense of a new part. Exchange assemblies such as injectors, fuel pumps, water pumps and blowers are also desirable service items.

Various factors such as the type of operation of the engine, hours in service and next overhaul period must be considered when determining whether new parts are installed or used parts are reconditioned to provide trouble-free operation.

For convenience and logical order in disassembly and assembly, the various subassemblies and other related parts mounted on the cylinder block will be treated as separate items in the various sections of the manual.

DISASSEMBLY

Before any major disassembly, the engine must be drained of lubricating oil, water and fuel. On engines cooled by a heat exchanger, the fresh water system and raw water system must both be drained. Lubricating oil should also be drained from any transmission attached to the engine.

To perform a major overhaul or other extensive repairs, the complete engine assembly, after removal from the engine base and drive mechanism, should be mounted on an engine overhaul stand; then, the various subassemblies should be removed from the engine. When only a few items need replacement, it is not always necessary to mount the engine on an overhaul stand.

Parts removed from an individual engine should be kept together so they will be available for inspection and assembly. Those items having machined faces, which might be easily damaged by steel or concrete, should be stored on suitable wooden racks or blocks, or a parts dolly.

CLEANING

Before removing any of the subassemblies from the engine (but after removal of the electrical equipment), the exterior of the engine should be thoroughly cleaned. Then, after each subassembly is removed and disassembled, the individual parts should be cleaned. Thorough cleaning of each part is absolutely necessary before it can be satisfactorily inspected. Various items of equipment needed for general cleaning are listed below.

The cleaning procedure used for all ordinary cast iron parts is outlined under *Clean Cylinder Block* in Section 1.1; any special cleaning procedures will be mentioned in the text wherever required.

Steam Cleaning

A steam cleaner is a necessary item in a large shop and is most useful for removing heavy accumulations of grease and dirt from the exterior of the engine and its subassemblies.

Solvent Tank Cleaning

A tank of sufficient size to accomodate the largest part that will require cleaning (usually the cylinder block) should be provided and provisions made for heating the cleaning solution to 180° -200° F (82° -90° C).

Fill the tank with a commercial heavy-duty solvent which is heated to the above temperature. Lower large parts directly into the tank with a hoist. Place small parts in a wire mesh basket and lower them into the tank. Immerse the parts long enough to loosen all of the grease and dirt.

Rinsing Bath

Provide another tank of similar size containing hot water for rinsing the parts.

Drying

Parts may be dried with compressed air. The heat from the hot tanks will quite frequently complete the drying of the parts without the use of compressed air.

© 1983 General Motors Corp.

Rust Preventive

If parts are not to be used immediately after cleaning, dip them in a suitable rust preventive compound. The rust preventive compound should be removed before installing the parts in an engine.

INSPECTION

The purpose of parts inspection is to determine which parts can be used and which must be replaced. Although the engine overhaul specifications given throughout the text will aid in determining which parts should be replaced, considerable judgment must be exercised by the inspector.

The guiding factors in determining the usability of worn parts, which are otherwise in good condition, is the clearance between the mating parts and the rate of wear on each of the parts. If it is determined that the rate of wear will maintain the clearances within the specified maximum allowable until the next overhaul period, the reinstallation of used parts may be justified. Rate of wear of a part is determined by dividing the amount the part has worn by the hours it has operated.

Many service replacement parts are available in various undersize and/or oversize as well as standard sizes. Also, service kits for reconditioning certain parts and service sets which include all of the parts necessary to complete a particular repair job are available.

A complete discussion of the proper methods of precision measuring and inspection are outside the scope of this manual. However, every shop should be equipped with standard gages, such as dial bore gages, dial indicators and inside and outside micrometers.

In addition to measuring the used parts after cleaning, the parts should be carefully inspected for cracks, scoring, chipping and other defects.

ASSEMBLY

Following cleaning and inspection, the engine should be assembled using new parts as determined by the inspection.

Use of the proper equipment and tools makes the job progress faster and produces better results. Likewise, a suitable working space with proper lighting must be provided. The time and money invested in providing the proper tools, equipment and space will be repaid many times.

Keep the working space, the equipment, tools and engine assemblies and parts clean at all times. The area where assembly operations take place should, if possible, be located away from the disassembly and cleaning operation. Also, any machining operations should be removed as far as possible from the assembly area.

Particular attention should be paid to storing of parts and subassemblies, after removal and cleaning and prior to assembly, in such a place or manner as to keep them clean. If there is any doubt as to the cleanliness of such parts, they should be recleaned.

When assembling an engine or any part thereof, refer to the table of torque specifications at the end of each section for proper bolt, nut and stud torques.

To ensure a clean engine at time of rebuild, it is important that any plug, fitting or fastener (including studs) that intersects with a through hole and comes in contact with oil, fuel or coolant must have a sealer applied to the threads.

A number of universal sealers are commercially available. It is recommended that Loctite J 26558-92 *pipe sealer with teflon,* or equivalent, be used.

> **NOTE:** Certain plugs, fittings and fasteners available from the Parts Depot already have a sealer applied to the threads. This pre-coating will not be affected when the pipe sealer with teflon is also applied.

The sealer information above must not be confused with International Compound No. 2, which is a lubricant applied before tightening certain bolts. Use International Compound No. 2 only where specifically stated in the manual.

© 1983 General Motors Corp.

WORK SAFELY

A serviceman can be severely injured if caught in the pulleys, belts or fan of an engine that is accidentally started. To avoid such a misfortune, take these precautions before starting to work on an engine:

1. Disconnect the battery from the starting system by removing one or both of the battery cables. With the electrical circuit disrupted, accidental contact with the starter button will not produce an engine start.

2. Make sure the mechanism provided at the governor for stopping the engine is in the stop position. This will mean the governor is in the no-fuel position. The possibility of the engine firing by accidentally turning the fan or, in the case of vehicle application, by being bumped by another vehicle is minimized.

Some Safety Precautions To Observe When Working On The Engine

1. Consider the hazards of the job and wear protective gear such as safety glasses, safety shoes, hard hat, etc. to provide adequate protection.

2. When lifting an engine, make sure the lifting device is fastened securely. Be sure the item to be lifted does not exceed the capacity of the lifting device.

3. Always use caution when using power tools.

4. When using compressed air to clean a component, such as flushing a radiator or cleaning an air cleaner element, use a safe amount of air. Recommendations regarding the use of air are indicated throughout the manual. Too much air can rupture or in some other way damage a component and create a hazardous situation that can lead to personal injury.

5. Avoid the use of carbon tetrachloride as a cleaning agent because of the harmful vapors that it releases. Use perchlorethylene or trichlorethylene. However, while less toxic than other chlorinated solvents, use these cleaning agents with caution. Be sure the work area is adequately ventilated and use protective gloves, goggles or face shield and an apron.

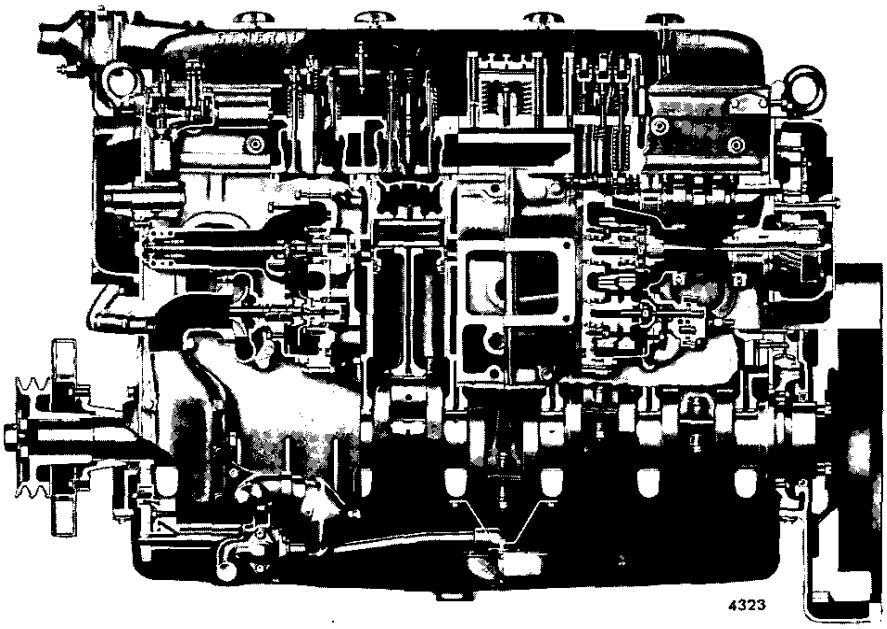
Exercise caution against burns when using oxalic acid to clean the cooling passages of the engine.

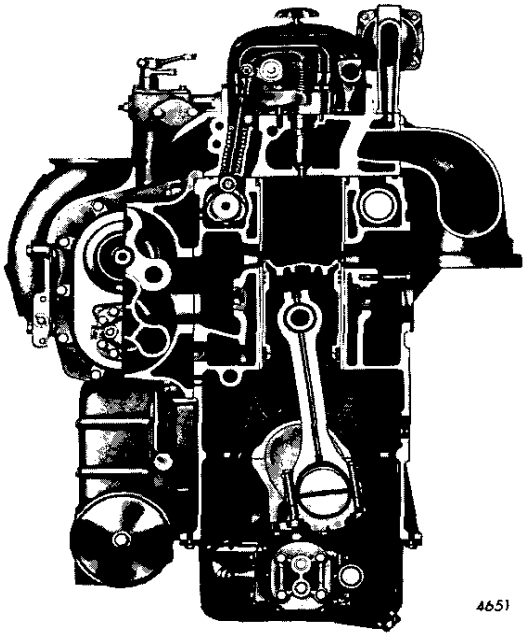
6. Use caution when welding on or near the fuel tank. Possible explosion could result if heat build-up inside the tank is sufficient.

7. Avoid excessive injection of ether into the engine during start attempts. Follow the instructions on the container or by the manufacturer of the starting aid

8. When working on an engine that is running, accidental contact with the hot exhaust manifold can cause severe burns. Remain alert to the location of the rotating fan, pulleys and belts. Avoid making contact across the two terminals of a battery which can result in severe arcing.

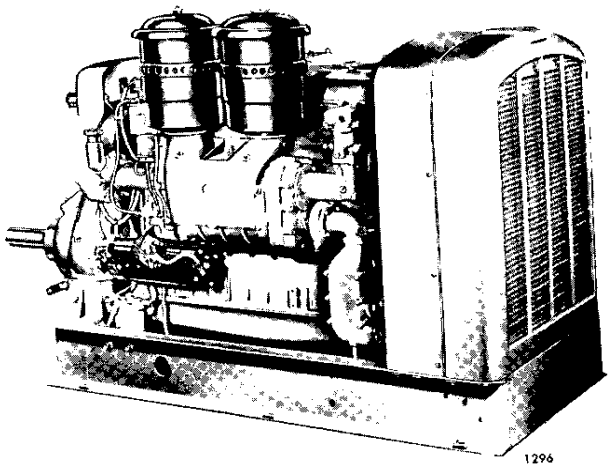
© 1983 General Motors Corp.



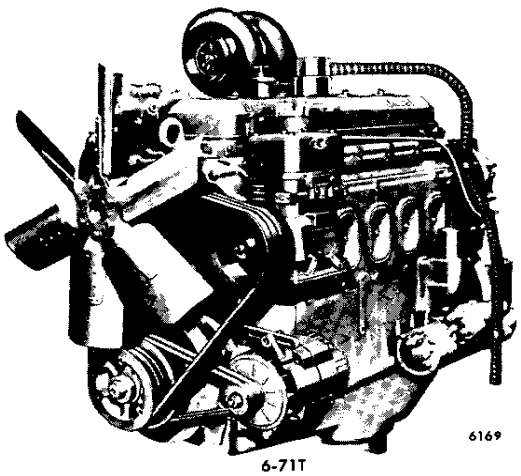


Cross-Sections of Typical Series 71 Engine

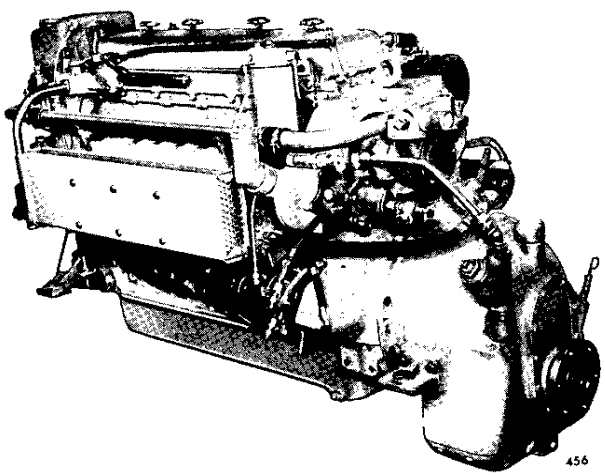
© 1983 General Motors Corp.



Typical Industrial Power Take-Off Unit

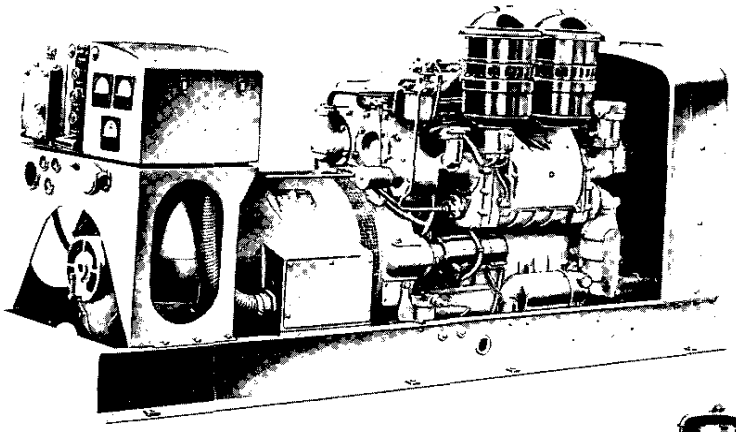


Typical Vehicle Engine



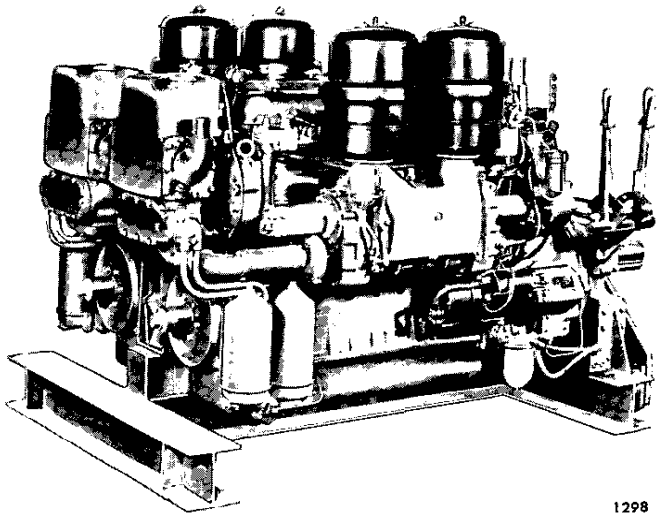
Typical Marine Propulsion Unit

© 1980 General Motors Corp.



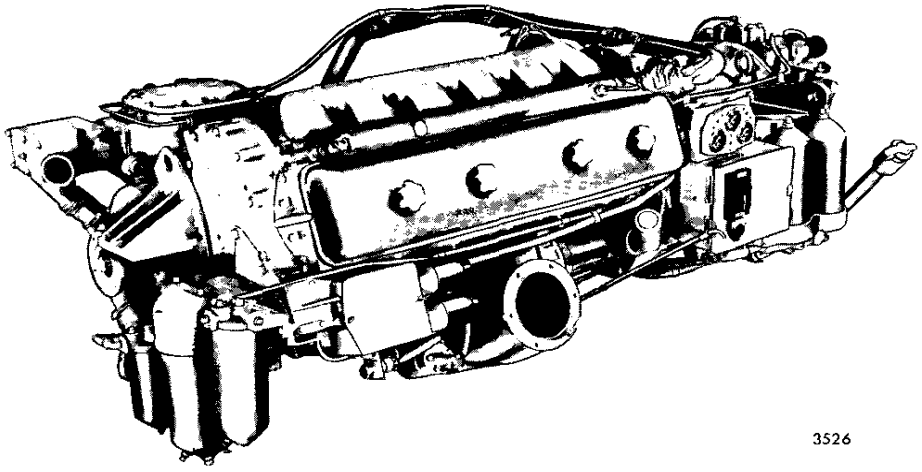
1297

Typical Power Generator Unit



1298

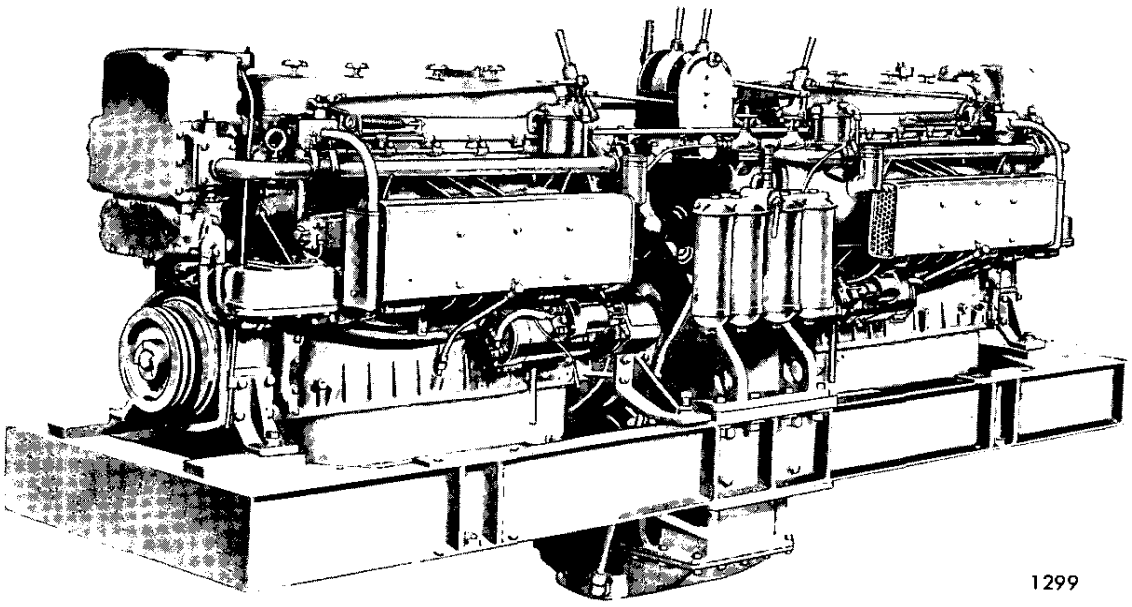
Typical Industrial Twin Engine Unit



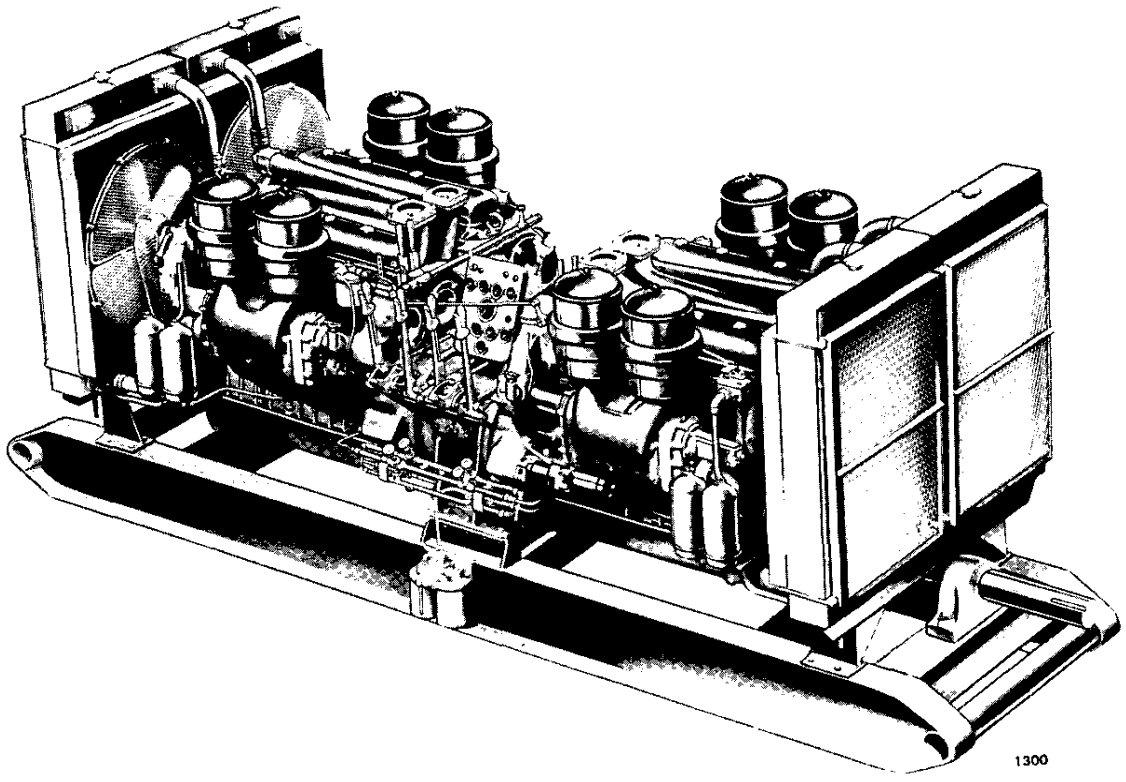
3526

Typical Diesel Railcar Engine

© 1980 General Motors Corp.



Typical Marine Tandem Twin Unit



Typical Industrial Quad Unit

© 1978 General Motors Corp

SECTION 1

ENGINE (less major assemblies)

CONTENTS

Cylinder Block	1.1
Cylinder Block End Plates	1.1.1
Air Box Drains	1.1.2
Cylinder Head	1.2
Valve and Injector Operating Mechanism	1.2.1
Exhaust Valves	1.2.2
Engine Lifter Brackets	1.2.3
Valve Rocker Cover	1.2.4
Crankshaft	1.3
Crankshaft Oil Seals	1.3.2
Crankshaft Cap	1.3.3
Crankshaft Main Bearings	1.3.4
Crankshaft Front Cover	1.3.5
Crankshaft Vibration Damper	1.3.6
Crankshaft Pulley	1.3.7
Flywheel	1.4
Clutch Pilot Bearing	1.4.1
Engine Drive Shaft Flexible Coupling	1.4.2
Flywheel Housing	1.5
Piston and Piston Rings	1.6
Connecting Rod	1.6.1
Connecting Rod Bearings	1.6.2
Cylinder Liner	1.6.3
Engine Balance and Balance Weights	1.7
Gear Train and Engine Timing	1.7.1
Camshaft, Balance Shaft and Bearings	1.7.2
Camshaft and Balance Shaft Gears	1.7.3
Idler Gear and Bearing Assembly	1.7.4
Crankshaft Timing Gear	1.7.5
Blower Drive Gear and Support Assembly	1.7.6
Accessory Drives	1.7.7
Balance Weight Cover	1.7.8
Shop Notes - Trouble Shooting - Specifications - Service Tools	1.0

© 1975 General Motors Corp.

CYLINDER BLOCK

The cylinder block serves as the main structural part of the engine (Figs. 1 and 2). The cylinder block may be made of either cast iron or aluminum, depending upon the application of the engine. Transverse members, cast integrally, provide rigidity and strength and ensure alignment of the block bores and bearings under load. Cylinder blocks for the three, four and six-cylinder engines are identical in design and dimensions except for length. The two ends of the block are similar, so the flywheel housing and gear train can be assembled to either end.

The block is bored to receive replaceable cylinder liners. Water jackets, which extend the full length of the bores, are divided into upper and lower sections which are connected by hollow struts (Fig. 2). Coolant from the pump enters at the bottom of each water jacket and leaves at the top of the block through holes which register with corresponding openings in the cylinder head.

To minimize electrolytic action between the aluminum cylinder block and the cast iron cylinder head and water pump, stainless steel inserts are pressed into the water outlet holes in the top surface and into the water pump inlet holes in the block. In addition, a cast iron water manifold is used in place of the former aluminum manifold. However, an aluminum heat exchanger inlet elbow and a revised aluminum heat exchanger inlet elbow spacer are used with the cast iron manifold.

An air box surrounding the water jackets conducts the air from the blower to the air inlet ports in the cylinder liners (Fig. 2). Air box openings on the side of the block opposite to the blower provide access to the air box and permit inspection of the pistons and compression rings through the air inlet ports in the cylinder walls (Fig. 3). The six-cylinder block has two additional air box openings on the blower side.

The camshaft and balance shaft bores are located on opposite sides near the top of the block.

The upper halves of the main bearing supports are cast integral with the block. The main bearing bores are line-bored with the bearing caps in place to ensure longitudinal alignment. Drilled passages in the block carry the lubricating oil to all moving parts of the engine, eliminating the need for external piping.

The perimeter of the top surface of the cylinder block is grooved, outside of the cam pockets, to accommodate a block-to-head oil seal ring. The top surface of the block is also counterbored at each water or oil passage to accommodate individual seal rings (Fig. 4).

Each cylinder liner is retained in the block by a flange at its upper end. The liner flange rests on a cast iron insert located in the counterbore in the block bore. An individual compression gasket is used at each cylinder.

When the cylinder head is installed, the gaskets and seal rings compress sufficiently to form a tight metal-to-metal contact between the head and block.

New service replacement cylinder block assemblies include the main bearing caps and bolts, dowels and the necessary plugs.

Since the cylinder block is the main structural part of the engine, the various subassemblies must be removed from the cylinder block when an engine is overhauled.

The hydraulically operated overhaul stand (J 6837-C) provides a convenient support when stripping a cylinder block (Fig. 5). The engine is mounted in an upright position. It may then be tipped on its side, rotated in either direction 90° or 180° where it is locked in place and then, if desired, tipped back with either end or the oil pan side up.

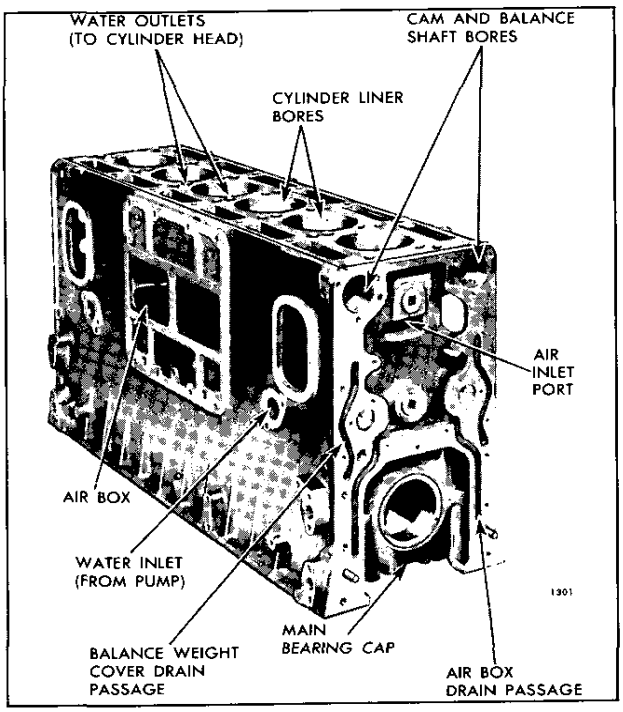


Fig. 1 - Typical Cylinder Block

© 1982 General Motors Corp.

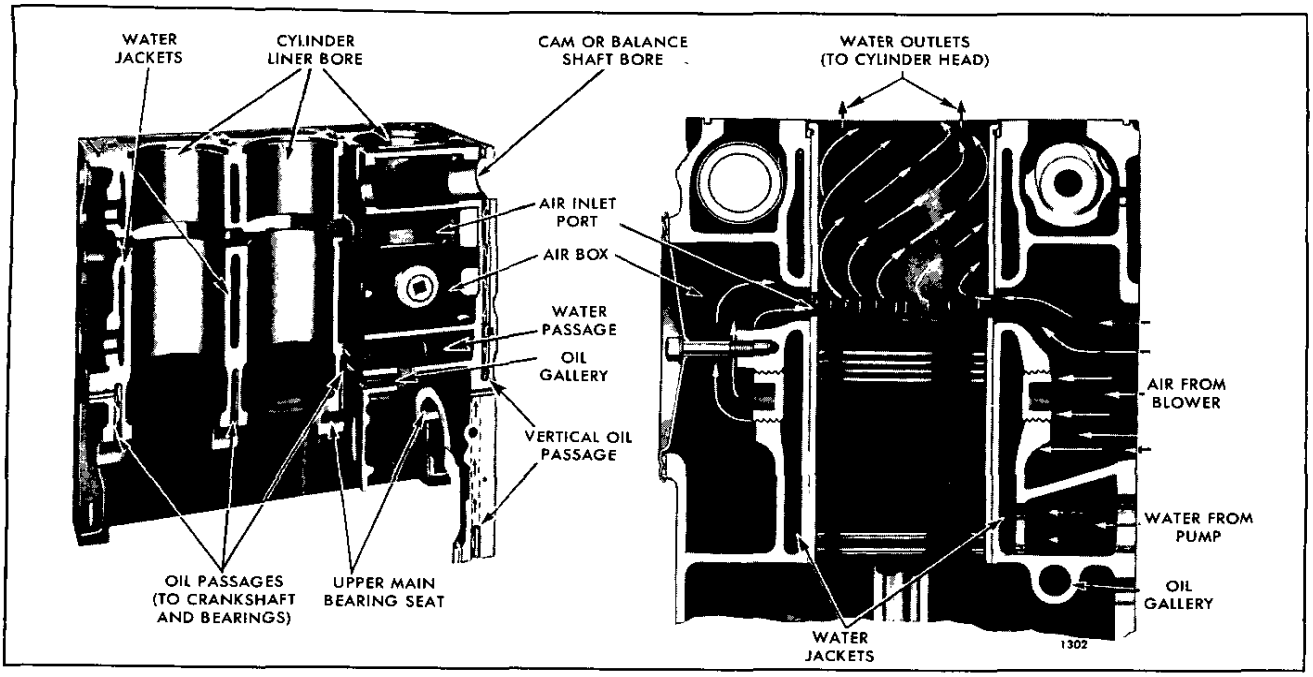


Fig. 2 - Cutaway View of Cylinder Block Showing Air and Water Passages

Remove and Disassemble Engine

Before mounting an engine on an overhaul stand, it must be removed from its base and disconnected from the transmission or other driven mechanism. Details of this procedure will vary from one application to another. However, the following steps will be necessary.

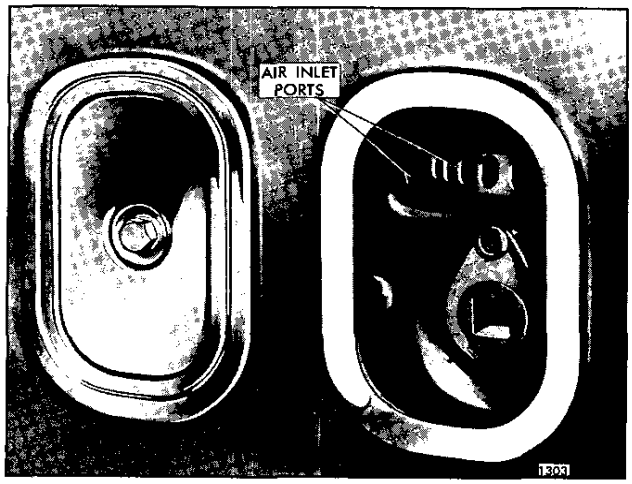


Fig. 3 - Air Box Covers and Air Inlet Ports

1. Drain the cooling system.

2. Drain the lubricating oil.

3. Disconnect the fuel lines.

4. Remove the air silencer or air cleaner and mounting bracket.

5. Remove the turbocharger, if used.

6. Disconnect the exhaust piping and remove the exhaust manifold.

7. Disconnect the throttle controls.

8. Disconnect and remove the starting motor, battery-charging generator and other electrical equipment.

9. Remove the air compressor, if used.

10. Remove the radiator and fan guard or the heat exchanger and other related cooling system parts.

11. Remove the air box covers.

12. Disconnect any other lubricating oil lines, fuel lines or electrical connections.

13. Separate the engine from the transmission or other driven mechanism.

© 1982 General Motors Corp.

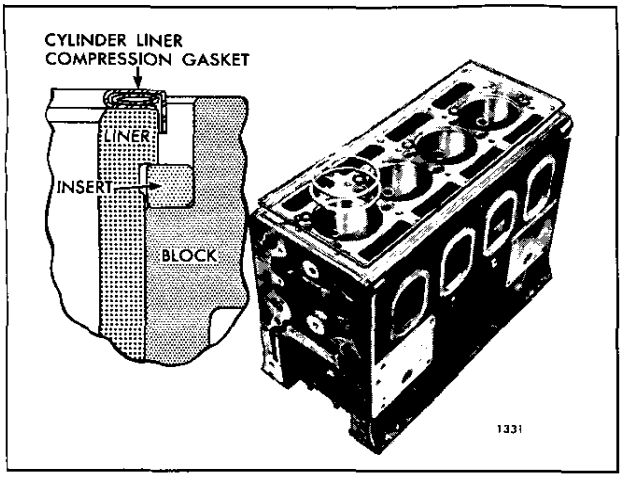


Fig. 4 - Sealing Arrangement of Cylinder Block

14. Remove the engine mounting bolts.

15. Use a spreader bar with a suitable sling and adequate chain hoist to lift the engine from its base (Fig. 6). To prevent bending of the engine lifter brackets the lifting device should be adjusted so the lifting hooks are vertical. To ensure proper weight distribution, all engine lifter brackets should be used to lift the engine.

NOTE: Do not lift an engine by the webs in the air inlet opening of the cylinder block.

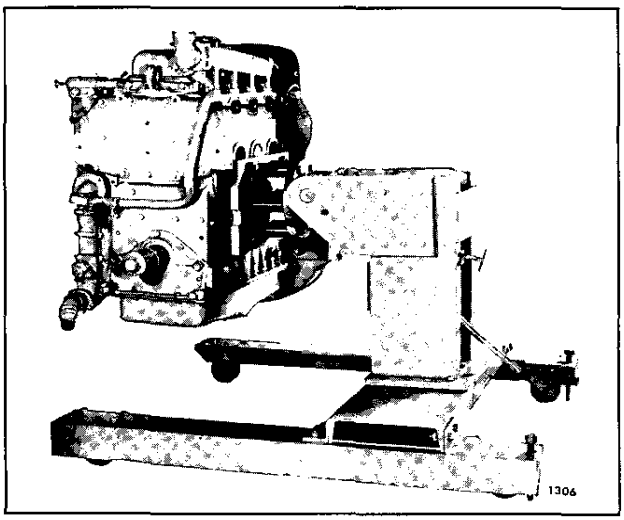


Fig. 5 - Engine Mounted on Overhaul Stand (J 6837-C) and Adaptor J 8196

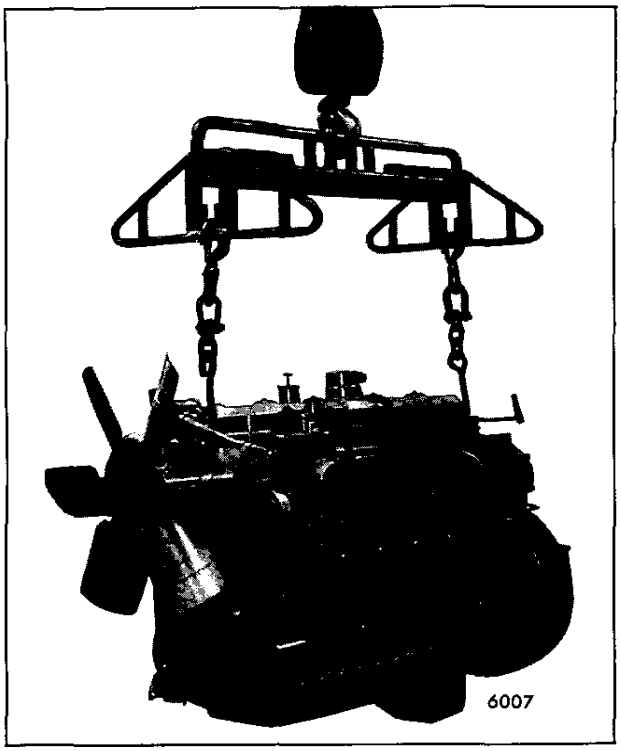


Fig. 6 - Lifting Engine with Spreader and Sling

16. Locate the center lug of the overhaul stand adaptor plate (J 8196) in the proper air box opening on the side of the block opposite the blower. The center lug is located in the center air box opening of three cylinder engines, in the number two opening of four cylinder engines and in the number four opening of six cylinder engines.

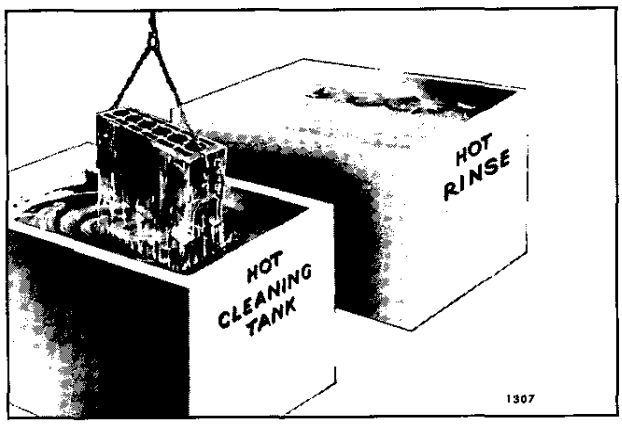


Fig. 7 - Cleaning Cylinder Block

© 1984 General Motors Corp.

The adaptor plate, used with the hydraulic engine overhaul stand, must be attached to the mounting plate on the overhaul stand with six spacers and bolts (Fig. 5). Long spacers and bolts are used with the three and four cylinder engines and short spacers and bolts are used with the six cylinder engines. The spacers provide the necessary clearance for the front balance weight cover and the flywheel housing when the engine is tipped on its side and rotated.

17. Loosen the lock nuts on the two holding lugs on the adaptor plate and lower the engine while guiding the lugs into the air box openings.

18. Turn the holding lugs crosswise in the air box openings and tighten the lock nuts, drawing the engine tight against the adaptor plate.

19. To be sure the engine does not shift on or break away from the overhaul stand, insert a 7/16"-14 x 2" bolt, with a plain washer under the head of the bolt, through the hole in the adaptor plate and into the pad on the cylinder block.

> **CAUTION:** Be sure the engine is securely mounted to the overhaul stand before releasing the lifting sling. Severe injery to personnel and destruction of engine parts will result if the engine breaks away from the overhaul stand.

20. With the engine mounted on the overhaul stand, remove all of the remaining subassemblies and parts from the cylinder block.

The procedure for removing each subassembly from the cylinder block, together with disassembly, inspection, repair and reassembly of each, will be found in the various sections of this manual.

After stripping, the cylinder block must be thoroughly cleaned and inspected.

Clean Cylinder Block

Scrape all gasket material from the cylinder block. Then remove all oil gallery plugs and core hole plugs (except cup plugs) to allow the cleaning solution to contact the inside of the oil and water passages. This permits more efficient cleaning and eliminates the possibility of the cleaning solution attacking the aluminum core hole plug gaskets.

If a core hole plug is difficult to remove, hold a 3/4" drift against the plug and give it a few sharp with a one-pound hammer. With a 1/2" flexible handle and a short extension placed in the countersunk hole in the plug, turn the plug slightly in the direction of tightening. Then turn it in the opposite direction and back the plug out.

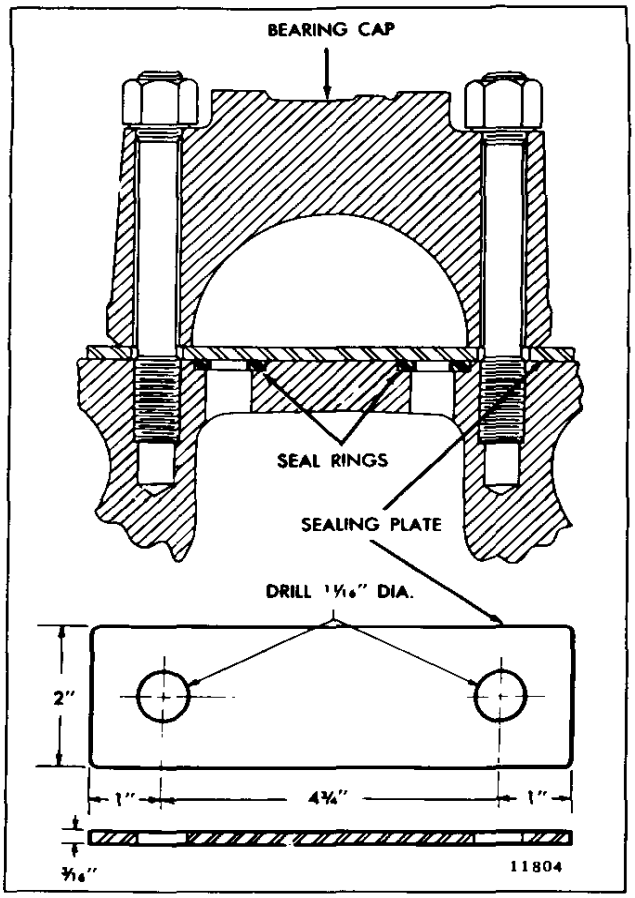


Fig. 8 - Sealing Plate Details for Pressure Testing Cylinder Block

Clean the cylinder block as follows:

CAST IRON CYLINDER BLOCK

1. Remove the grease by agitating the cylinder block in a hot bath of commercial heavy-duty alkaline solution (Fig. 7).

2. Wash the block in hot water or steam clean it to remove the alkaline solution.

3. If the water jackets are heavily scaled, proceed as follows:

a. Agitate the block in a bath of ihibited phosphoric acid.

b. Allow the block to remain in the acid bath until the bubbling action stops (approximately 30 minutes).

© 1984 General Motors Corp.

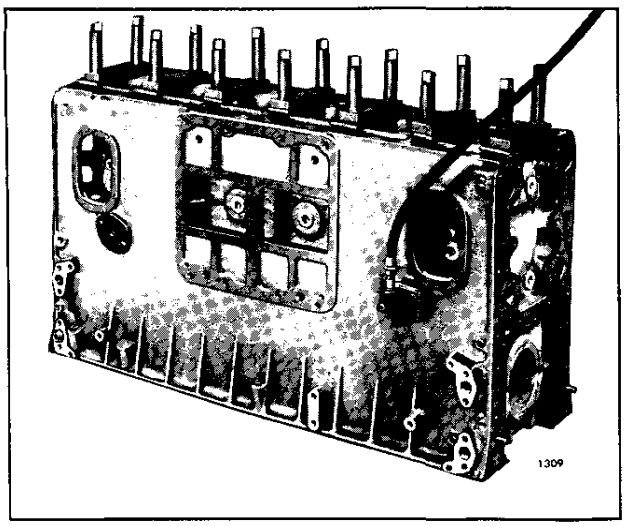


Fig. 9 - Cylinder Block Prepared for Pressure Test

c. Lift the block, drain it and reimmerse it in the same acid solution for 10 minutes.

d. Repeat Step "c" until all scale is removed.

e. Rinse the block in clear hot water to remove the acid solution.

f. Neutralize the acid that may cling to the casting by immersing the block in an alkaline bath.

g. Wash the block in clean water or steam clean it.

4. Dry the cylinder block with compressed air.

5. Make certain that all water passages, oil galleries and air box drain holes have been thoroughly cleaned.

NOTE: The above cleaning procedure may be used on all ordinary cast iron and steel parts of the engine. Mention will be made of special cleaning procedures whenever necessary.

ALUMINUM CYLINDER BLOCK

1. Make a solution of one part of emulsion type soap and five parts of water. Hook-up the container of solution to a steam line and steam clean the cylinder block.

2. Rinse the block in clear water and dry it with compressed air.

3. If further cleaning is necessary, proceed as follows:

a. Brush a commercial chlorinated solvent, suitable for aluminum, on the block and allow the solvent to remain on the block for several hours.

b. Steam clean the block with a soap solution as in Step 1.

c. Rinse the block with clear water and dry it with compressed air.

NOTE: If corrosion of the water hole counterbores has occurred on an early aluminum block, stainless steel inserts may be installed as outlined in Section 1.0 to minimize further electrolytic action between the block and cast iron subassemblies.

After the cylinder block has been thoroughly cleaned and dried, reinstall the core hole plugs. Coat the threads of the plugs with sealant. Install the core hole plugs in the sides of the block from 2" to 1-1/4" below the machined surface of the block. They must be water tight. The core hole plugs in the ends of the block are flanged to provide a positive stop against the counterbore of the hole, thus preventing the plugs from entering the water jacket and restricting the flow of water. Soft aluminum gaskets are used with the plugs. Coat the threads of the end plugs with sealant and, using new gaskets, reinstall the plugs and tighten them to 150-180 lb-ft (204-244 Nm) torque.

NOTE: Excessive torque applied to the core hole plugs may result in cracks in the water jacket.

Pressure Test Cylinder Block

Extremely tight fitting cylinder liners, severe scoring of the liners and overheating of the engine may result in cracks in the cylinder bores. Overheating of the engine may also result in cracks between the water jackets and the oil passages.

The cylinder block may be pressure tested for cracks or leaks by either one of two methods. In either method, it will be necessary to make plates to seal the water openings in the top of the block (Fig. 8). Main bearing caps may be used to secure the plates to the block with the cylinder head bolts or studs and nuts. Cylinder head seal rings may be used as gaskets between the plates and the block. It will also be necessary to use water hole cover plates and gaskets to cover the water pump inlet openings in the block. Drill and tap one cover plate to provide a connection for an air line (Fig. 9).

With the cylinder block prepared in the above manner, the core hole plugs installed and the plugs removed from the oil passages, test the block as follows:

© 1982 General Motors Corp.

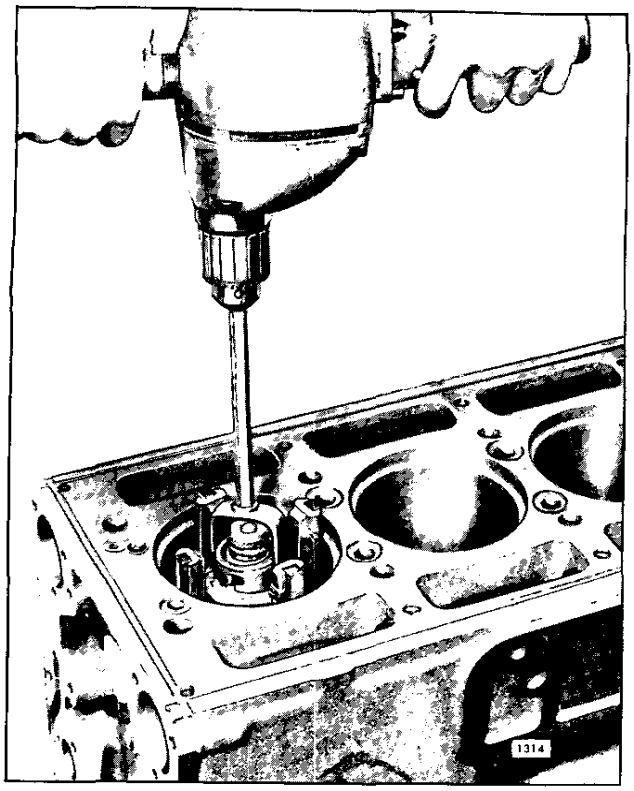


Fig. 10 - Honing Bore of Cylinder Block with Tool J 5902-01

METHOD "A"

This method may be used when a large enough water tank is available and the cylinder block is completely stripped of all parts.

1. Immerse the block for twenty minutes in a tank of water heated to 180-200 °F (82-93 °C).

2. Apply 40 psi (276 kPa) air pressure to the water jacket and observe the water in the tank for bubbles which indicate the presence of cracks or leaks in the block. A cracked cylinder block must be replaced by a new block.

3. After the pressure test is completed, remove the block from the water tank. Then remove the plates and gaskets and dry the block with compressed air.

METHOD "B"

This method may be used when a large water tank is unavailable, or when it is desired to check the block for cracks without removing the engine from the equipment which it powers. However, it is necessary to remove the cylinder head, blower, oil cooler, air box covers and oil pan.

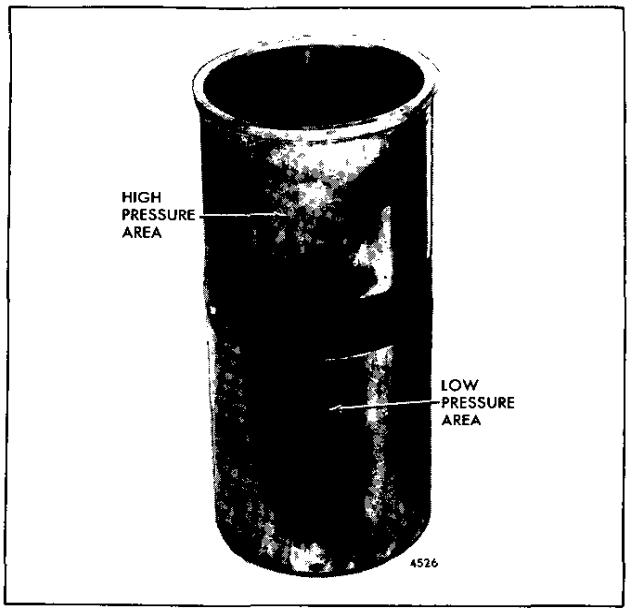


Fig. 11 - High Pressure Areas on Cylinder Liner

1. Attach sealing plates and gaskets as in Method "A". However, before attaching the last sealing plate, fill the water jacket with a mixture of water and one gallon of permanent type antifreeze. The antifreeze will penetrate small small cracks and its color will aid in detecting their presence.

NOTE: Do not use a methoxy propanol base antifreeze as it is detrimental to the water seals.

2. Install the remaining sealing plate and tighten it securely.

3. Apply 40 psi (276 kPa) air pressure to the water jacket and maintain this pressure for at least two hours to give the water and antifreeze mixture ample time to work its way through any cracks which may exist.

4. At the end of the test period, examine the cylinder bores, air box, oil passages, crankcase and exterior of the block for presence of the water and antifreeze mixture which will indicate the presence of cracks. A cracked cylinder block must be replaced by a new block.

5. After the test is completed, remove the plates, drain the water jacket and blow out all of the passages in the block with compressed air.

© 1982 General Motors Corp.

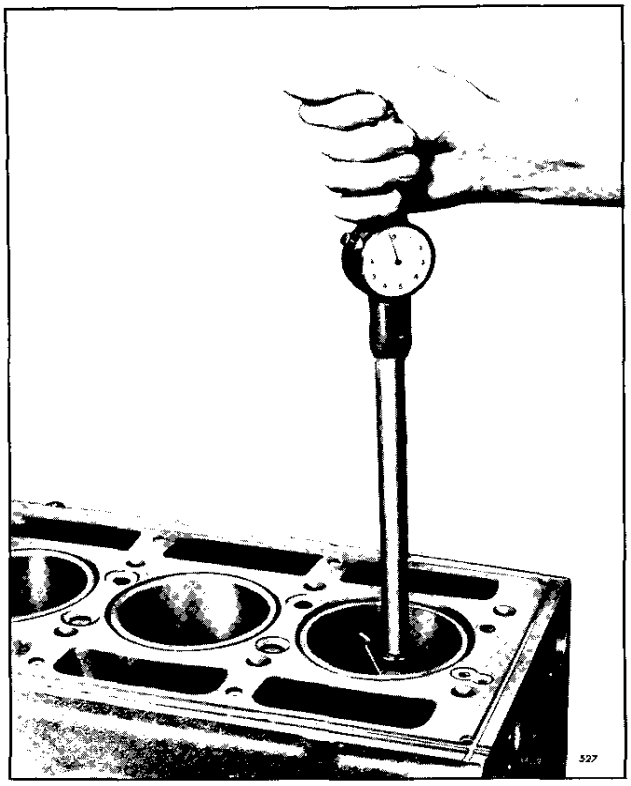


Fig. 12 - Checking Bore of Cylinder Block with Tool J 5347-01

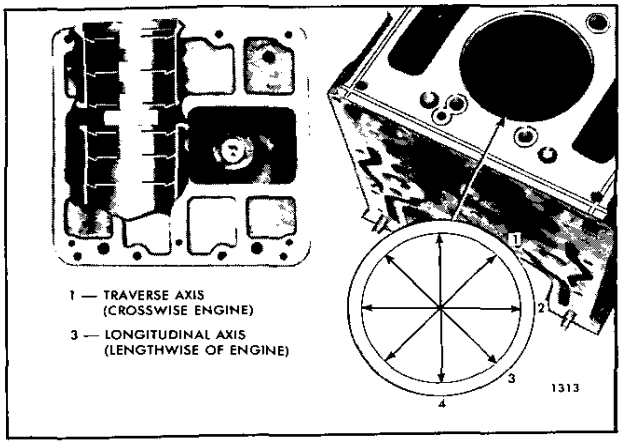


Fig. 13 - Cylinder Bore Measurement Diagram

Inspect Cylinder Block

After cleaning and pressure testing, inspect the cylinder block.

Since most of the engine cooling is accomplished by heat transfer through the cylinder liners to the water jacket, a good liner-to-block contact must exist when the engine is operating. Whenever the cylinder liners are removed from an engine, the block bores must be inspected.

NOTE: Before attempting to check the block bores, hone them throughout their entire length until about 75% of the area above the ports has been "cleaned-up".

1. Hone the block bores as follows:

a. Use a hone (J 5902-01) in which the cutting radius of the stones can be set in a fixed position to remove irregularities in the bore rather than following the irregularities as with a spring-loaded hone. Clean the stones frequently with a wire brush to prevent stone loading. Follow the *hone manufacturer's instructions* regarding the use of oil or kerosene on the stones. Do not use such cutting agents with a dry hone. In a cast iron cylinder block, use 120 grit stones J 5902-14. Use 320 grit stones J 5902-15 in an aluminum block.

b. *Insert the hone in the bore* (Fig. 10) and adjust the stones snugly to the narrowest section. When correctly adjusted, the hone will not shake in the bore, but will drag freely up and down when the hone is not running.

c. Start the hone and "feel out" the bore for high spots which will cause an increased drag on the stones. Move the hone up and down the bore with short overlapping strokes about 1" long. Concentrate on the high spots in the first cut. As these are removed, the drag on the hone will become lighter and smoother. Do not hone as long at the air inlet

	Trans.	45°	Long.	45°
	1	2	3	4
A				
B				
C				
Port Belt	X	X	X	X
D				
E				
F				

Fig. 14 - Block Bore Measurement Record Form

© 1982 General Motors Corp.

port area as in the rest of the bore because this area, as a rule, cuts away more rapidly. Feed lightly to avoid an excessive increase in the bore diameter. Some stones cut rapidly even under low tension.

d. When the bore is fairly clean, remove the hone, inspect the stones and measure the bore. Determine which spots must be honed most. Moving the hone from the top to the bottom of the bore will not correct an out-of-round condition. To remain in one spot too long will cause the bore to become irregular. Where and how much to hone can be judged by feel. A heavy cut in a distorted bore produces a steady drag on the hone and makes it difficult to feel the high spots. Therefore, use a light cut with frequent stone adjustments.

e. Wash the cylinder block thoroughly after the honing operation is completed.

2. The cylinder liner is alternately expanding and contracting, during engine operation, due to temperature variations. This may result in irregularities in the block bores (out-of-round and taper), the effects of which will be seen as high pressure areas on the outside diameter of the cylinder liner (Fig. 11). A slight increase in block bore size is normal with high mileage or long periods of engine operation.

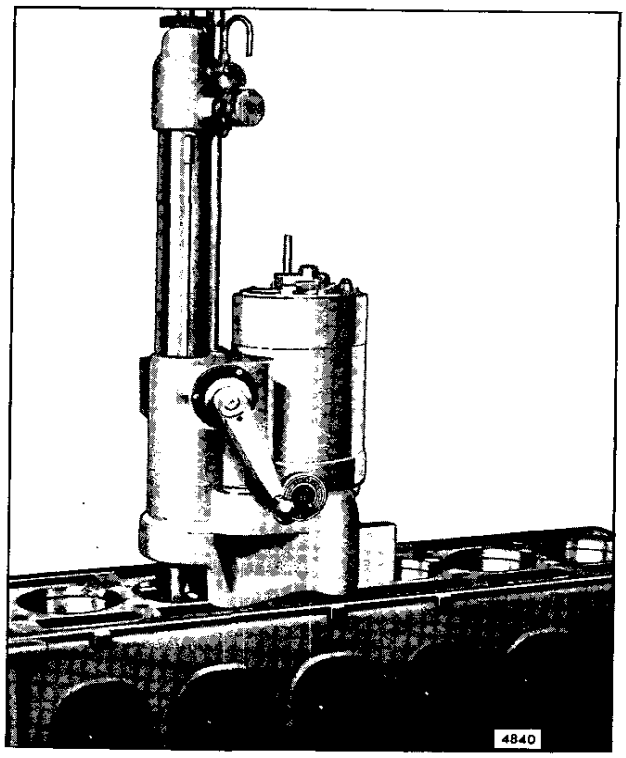


Fig. 15 - Boring Cylinder Block with Portable Boring Bar

a. Visually check the contact area as revealed by the honed surface. There must not be any low spots which are larger in area than a half dollar.

b. Measure the entire bore of each cylinder with cylinder bore gage J 5347-01 which has a dial indicator calibrated in .0001" increments (Fig. 12). The standard block bore is 4.6260" to 4.6275" (cast iron block) or 4.6250" to 4.6260" (aluminum block). Place the bore gage in the master ring gage J 8386-01 which has an I.D. of 4.6270" and set the dial to zero. Take measurements on the cleaned-up surface only at positions A, B, C, D, E and F in the bore on axes 45° apart (Fig. 13). Read the measurements from the zero mark on the gage. The readings may be recorded on a form similar to the one illustrated in Fig. 14.

NOTE: Dial bore gage setting master tool J 23059-01 may be used in place of the master ring gage.

3. The liner-to-block clearance with new parts is zero to .0015" (cast iron block) or .001" loose to .001" press fit (aluminum block). With used parts, the maximum clearance is .0025" (cast iron block) or .0015" (aluminum block). After measuring the block bores, measure the outside diameter of the cylinder liners (Section 1.6.3). Then determine the block-to-liner clearances (refer to Section 1.0 for the specified clearances) and whether it will be necessary to bore the block for oversize cylinder liners.

4. If necessary, bore the cylinder block as follows:

a. Each bore in a used block must not be out-of-round or tapered more than .002". If the average block bore is over 4.6285" (cast iron block) or 4.6275" (aluminum block), the block should be bored oversize (refer to Tables 1 and 2).

b. A typical commercially available portable boring bar is illustrated in Fig. 15. Instructions on correct use of the boring bar are provided by the manufacturer.

c. After boring the block for an oversize cylinder liner, check the bore finish to be sure it is smooth (120 RMS). Heat transfer from the cylinder liner to the block will be adversely affected if the block bore isn't smooth.

d. Wash the block thoroughly after the boring operation.

© 1982 General Motors Corp.

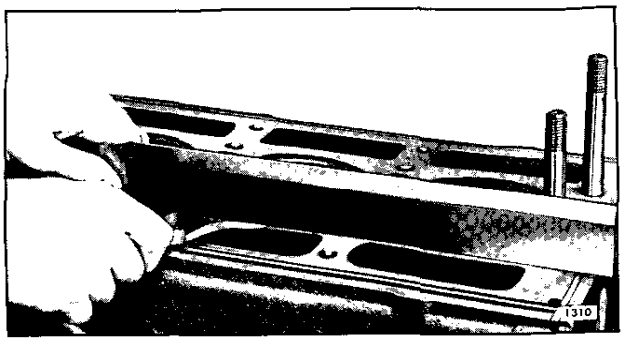


Fig. 16 - Checking Top Face of Cylinder Block

e. When an oversize liner is used, stamp the size of the liner on the top deck of the block adjacent to the liner counterbore. An oversize liner insert must be installed whenever an oversize liner is used (Section 1.6.3).

5. Check the top of the block for flatness with an accurate straight edge and a feeler gage (Fig. 16).

a. The top surface of the block must not vary more than .003" transversely and not over .006", .007" or .009" longitudinally on the 3, 4 and 6 cylinder blocks respectively. It will be difficult to prevent water, oil and compression leaks if the top surface of the block exceeds these tolerances.

b. If it is necessary to machine the top surface of the block to correct for the above conditions, do not remove more than .008" of metal. Stamp the amount of stock removed on the face of the block. The distance from the centerline of the crankshaft to the top of the block must not be less than 16.176" (Fig. 17).

For Average Block Bore I.D. Size	Use Liner O.D. Size	For Liner-to-Block Clearance
	CAST IRON BLOCK	
4.6260" / 4.6275"	Standard	.000" to .0025"
4.6270" / 4.6285"	.001" Oversize	.000" to .0025"
	ALUMINUM BLOCK	
4.6250" / 4.6265"	Standard	.0010" to .0015"
4.6260" / 4.6275"	.001" Oversize	.0010" to .0015"

TABLE 1

Block Boring Dimensions	Liner O.D. Size	Max. Block Bore I.D. on Used Block
	CAST IRON BLOCK	
4.6310" / 4.6320"	.005" Oversize	4.6325"
4.6360" / 4.6370"	.010" Oversize	4.6375"
4.6460" / 4.6470"	.020" Oversize	4.6475"
4.6560" / 4.6570"	.030" Oversize	4.6575"
	ALUMINUM BLOCK	
4.6300" / 4.6310"	.005" Oversize	4.6315"
4.6350" / 4.6360"	.010" Oversize	4.6365"
4.6450" / 4.6460"	.020" Oversize	4.6465"
4.6550" / 4.6560"	.030" Oversize	4.6565"

TABLE 2

c. If stock is removed from the top surface of the block, check the depth of the seal ring grooves and counterbores. The cylinder head seal strip grooves must be .092"-.107" deep. The large water hole counterbores (between the cylinders) must be .109"-.120" deep and the combination water and oil hole counterbores and small water hole counterbores must be .087"-.098" deep. If necessary, deepen the grooves or counterbores to the specified limits to retain the proper "crush" on the seal rings. It is not necessary to deepen the counterbores for the cylinder liners since .004" and .008" undersize thickness inserts are available for adjusting the liner position as outlined in Section 1.6.3 under *Fitting Cylinder Liner in Block Bore.*

6. Make sure the cylinder liner counterbores in the block are clean and free of dirt. Then check the depth (Fig. 18). The depth must be .4770" to .4795" (cast iron block) or .5470" to .5495" (aluminum block) and must not vary more than .0015" throughout the entire circumference. The counterbored surfaces must be smooth and square with the cylinder bore within .001" total indicator reading. There must not be over .001" difference between any two adjacent cylinder counterbores when measured along the cylinder longitudinal centerline of the cylinder block.

7. Check the main bearing bores as follows:

a. Check the bore diameters with the main bearing caps in their original positions. Apply a small

© 1982 General Motors Corp.

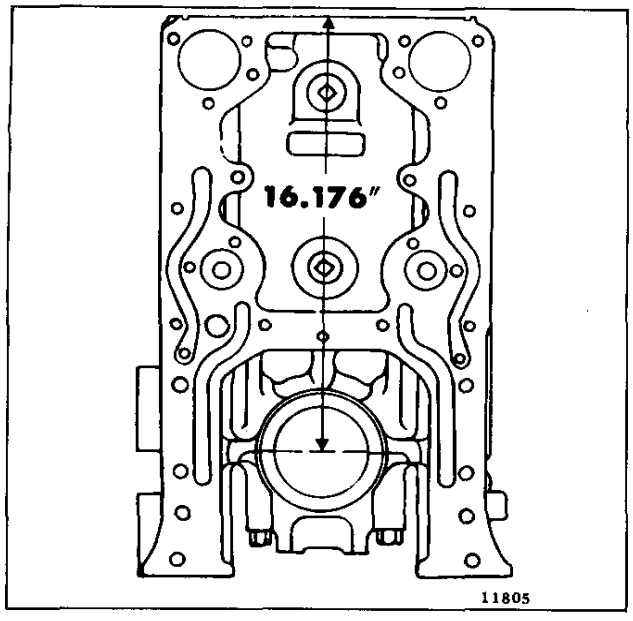


Fig. 17 - Minimum Distance from Center Line of Crankshaft to Top of Cylinder Block

quantity of International Compound No. 2, or equivalent, to the threads on the bolts or studs and nuts and to the bolt head (or nut) contact area. Main bearing cap bolts are especially designed for this purpose and must not be replaced by ordinary bolts. Then install and tighten the bolts to 165-175 lb-ft (224-238 Nm) torque or stud nuts to 140-155 lb-ft (190-211 Nm) torque (110-120 lb-ft (150-163 Nm) torque, aluminum cylinder block). The specified bore diameter is 3.812" to 3.813". If the bores do not fall within these limits, the cylinder block must be rejected.

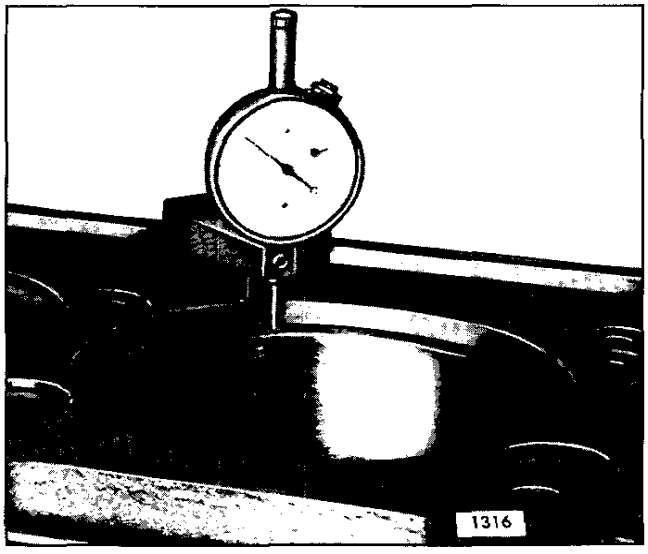


Fig. 18 - Checking Depth of Counterbore for Cylinder Liner with Tool J 22273-01

NOTE: Bearing caps are numbered to correspond with their respective positions in the cylinder block. It is imperative that the bearing caps are reinstalled in their original positions to maintain the main bearing bore alignment. The number of the front main bearing cap is stamped on the face of the oil pan mounting flange of the cylinder block, adjacent to its permanent location in the engine as established at the time of manufacture. The No. 1 main bearing cap is always located at the end opposite the flywheel end of the cylinder block (Fig. 19), regardless of engine rotation or accessory arrangement. As originally manufactured, the main bearing caps are installed with the numbered side facing the blower side of the engine. Machining of the cylinder block and main bearing caps is such that the mating parts are "offset" to prevent installation of the bearing caps 180° from their correct position. However, if an engine has been converted for a new application and the cylinder and bearing numbering sequence has been reversed, the bearing caps must be reinstalled in the original positions regardless if the block and bearing caps have or have not been renumbered.

b. Finished and unfinished main bearing caps are available for replacing broken or damaged caps. When fitting a *finished* replacement bearing cap, it may be necessary to try several caps before one will be found to provide the correct bore diameter and bore alignment. If a replacement bearing cap

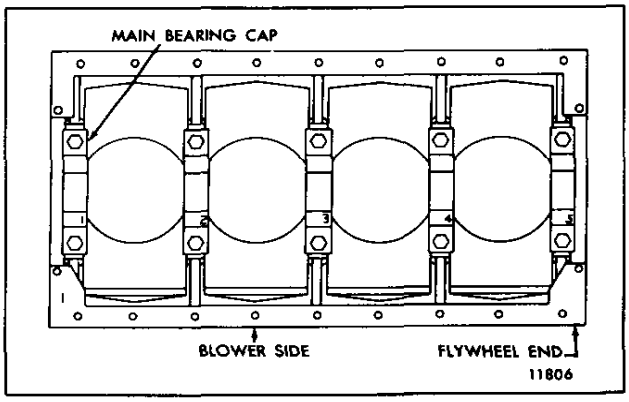


Fig. 19 - Cylinder Block Markings

© 1982 General Motors Corp.

is installed, be sure to stamp the correct bearing position number on the cap.

NOTE: Use the unfinished bearing caps for the front and intermediate bearing positions. The finished bearing caps, machined for the crankshaft thrust washers, are to be used in the rear bearing position.

c. Main bearing bores are line-bored with the bearing caps in place and thus are in longitudinal alignment. Bearing bores may be considered properly aligned with one another if the crankshaft can be rotated freely by hand after new bearing shells have been installed and lubricated and the bearing caps have been secured in place and the bolts tightened as specified in Section 1.3.4. If a main bearing bore is more than .001 " out of alignment, the block must be line-bored or scrapped. Misalignment may be caused by a broken crankshaft, excessive heat or other damage.

d. If the main bearing bores are not in alignment when a replacement bearing cap is used, the block must be line-bored. Install the bearing caps in their original positions and tighten the bolts to 165-175 lb-ft (224-238 Nm) torque (or tighten the nuts, if used, to 140-155 lb-ft (190-211 Nm) torque on a cast iron block or 110-120 lb-ft (150-163 Nm) torque on an aluminum block). Line-bore the block, but do not remove more than .001 " stock. After boring, all bores must be within the specified limits of 3.812 " to 3.813 ".

8. Refer to the *Cylinder Block Plugging Charts* at the end of this manual and install the necessary plugs and dowels.

9. Replace loose or damaged dowel pins. The dowels at the ends of the cylinder block must extend .625 " from the face of the block.

The dowels used to retain the crankshaft thrust washers on the rear main bearing cap must extend .110 " to .120 " from the surface of the bearing cap.

NOTE: A stepped dowel pin is available to replace loose pins in the rear main bearing cap. Before installing the stepped pins, rebore the dowel holes in the bearing cap with a No. 11 (.1910 ") or No. 12 (.1890 ") drill. After pressing the pins into the bearing cap, remove all burrs from the base of the dowel pins to ensure proper seating of the thrust washers.

10. Replace main bearing cap studs, if used, which are damaged or broken. Install new studs to a height of 4 " ± 1/32 " above the upper bearing seat at a torque of 35-75 lb-ft or 47-102 Nm (cast iron block) or 55 lb-ft or 75 Nm minimum (aluminum block).

11. If used, replace damaged or broken cylinder head studs. Install and drive a new stud to a height of 4 3/8 " ± 1/32 " at a minimum torque of 75 lb-ft or 102 Nm (cast iron block).

The two end studs on the blower side of the aluminum cylinder block must extend 4 3/8 " ± 1/32 " and all other studs must extend 4 9/16 " ± 1/32 " from the top surface of the block. Special self-tapping studs are used in place of the standard studs in some aluminum blocks. The special studs have a machined slot through the last few threads, which may be seen after the studs are removed. If it should be necessary to replace one of these studs, it is recommended that replacement be made by using a standard stud and a helical thread insert.

12. Examine the tapped bolt holes for the cylinder head or main bearing cap bolts and, if the threads are damaged, "clean-up" the threads or install a helical thread insert. The tapped holes may be tapped with a 5/8 "-11 UNC3B tap. All cylinder head bolt or stud holes must have the threads extending 1.84 " below the block surface.

NOTE: The current service replacement cast iron cylinder blocks use a special cylinder head bolt in all positions.

13. Check the drive pins (which plug the vertical oil galleries) in the corners of the block to be sure they are flush with or below the top surface of the block.

14. Check the remaining cylinder block surfaces and threaded holes. Check all of the mating surfaces, or mounting pads, for flatness, nicks and burrs. The flatness of the blower mounting pad must not vary more than .004 ". Clean-up damaged threads in tapped holes with a tap or install helical thread inserts, if necessary.

15. After inspection, if the cylinder block is not to be used immediately, spray the machined surfaces with engine oil. If the block is to be stored for an extended period of time, spray or dip it in a polar type rust preventive such as Valvoline Oil Company's "Tectyl 502-C", or equivalent. Castings free of grease or oil will rust when exposed to the atmosphere.

Assemble and Install Engine

After the cylinder block has been cleaned and inspected, assemble the engine as follows:

NOTE: Before a reconditioned or new service replacement cylinder block is used, steam clean

© 1979 General Motors Corp.

it to remove the rust preventive and blow out the oil galleries with compressed air.

1. Mount the cylinder block on the overhaul stand.

2. If a new service replacement block is used, stamp the engine serial number and model number on the pad located in the upper right-hand corner on the blower side of the block. Also stamp the position numbers on the main bearing caps (Fig. 19) and the position of the No. 1 bearing on the oil pan mounting flange of the block.

3. Install all of the required cylinder block plugs and drain cocks. Use a good grade of non-hardening sealant on the threads of the plugs and drain cocks. Install the plugs flush with or below the surface of the block.

4. *Clean* and inspect all engine parts and sub-assemblies and, using new parts as required, install them on the cylinder block by reversing the sequence of disassembly. The procedures for inspecting and installing the various parts and sub-assemblies are outlined in the following sections of this manual.

5. Use a chain hoist and suitable sling to transfer the engine to a dynamometer test stand.

6. Complete the engine build-up by installing all remaining accessories, fuel lines, electrical connections, controls etc.

7. Operate the engine on a dynamometer, following the RUN-IN procedure outlined in Section 13.2.1.

8. Reinstall the engine in the equipment which it powers.

© 1979 General Motors Corp.

EARLY DESIGN CYLINDER BLOCKS

Prior to engines 3A-8330, 4A-19529, 6A-16283, 8A-133, 12A-1345 and 24A-140, the cylinder blocks were smooth (ungrooved) on their top surfaces. A conventional type one-piece cylinder head gasket was used. The gasket contained the compression gaskets and small water and oil seal grommets within the one assembly. A separate four-piece oil seal gasket was used to seal around the outer edge of the block and cylinder head (Fig. 20).

The above cylinder blocks were known as the "low" blocks and are approximately 1/16" lower than the current "high" blocks as measured from the top surface of the block to the centerline of the crankshaft. The difference in height between the current and former blocks is a result of the change in the sealing arrangement between the cylinder head and block. Due to this difference in height, shorter camshaft intermediate bearing lock screws are used with the "low" block (Fig. 21).

Cylinder liners are installed in the "low" cylinder block with the top of the liner flange .002" to .006" *above* the top of the block. Shims are available to permit adjustment of the liner to these specifications. Liners are installed with the top of the liner flange *below* the top surfaces of the "high" block (Section 1.6.3). Cylinder liner inserts are used for adjusting the liners in the "high" block.

Cup plugs are used in place of drive pins to plug the vertical oil gallery openings at the four corners of the cyllnder block. Also, 5-3/4" long cylinder head studs are used with the "low" block whereas the studs in the holes in the "high" block are 6-3/8" long. The cylinder head stud holes in the "high" block have been drilled and tapped 5/8" deeper than the studs holes in the early design blocks to permit the use of the longer studs. The new stud holes are counterbored 1/2" deep rather than countersunk. This minimizes extrusion of the block around the studs when the cylinder head nuts are tightened to their specified torque.

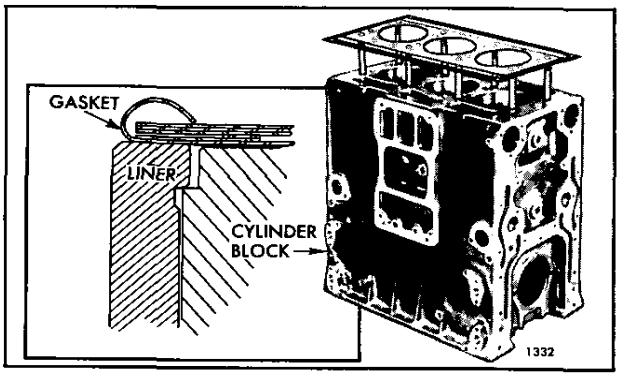


Fig. 20 - Sealing Arrangement for Low Cylinder Block

Clean-out holes are provided for the air box just below the hand hole covers on the side opposite the blower. The 1/4" pipe plugs may be removed from these tapped holes when necessary for draining cleaning solvents from the air box. These clean-out holes have been discontinued on current cylinder blocks since redesign of the air box drain passages makes them unnecessary.

Clean-out wires (sriggle pins) were used in the connecting passages between the air box and grooves in the ends of the cylinder blocks on engines 371-1986, 471-3116 and 671-3679 to 3A-3710, 4A-4133 and 6A-5647. These clean-out wires must be removed whenever the end plates are removed from the block and saved for reassembly purposes.

The current "high" cylinder block and its sealing arrangement replaces the former "low" block and its sealing arrangement for service.

Inspection of Low Cylinder Block

Cleaning and pressure testing procedures are the same as outlined for the current cylinder block. However, the gaskets used with the sealing plates in connection with the pressure test must be made from suitable sheet gasket material when testing the "low" block (Fig. 22).

After cleaning and pressure testing, inspect the block as follows:

1. Check cylinder block faces for flatness, using an accurate straight edge as shown in Fig. 16.

a. Remove the cylinder head studs and smooth down any raised areas at the stud holes, burrs or nicks. If extruded areas around the stud holes are not dressed down, they may prevent the cylinder head from properly mating with its gaskets and the cylinder block.

b. Check for brinelling at points where the cylinder head gasket grommets contact the block. These depressions could result in water and oil leaks. Resurface the block, if necessary, as indicated in Step "d".

c. Check the cup plugs used to plug the vertical oil

© 1982 General Motors Corp.

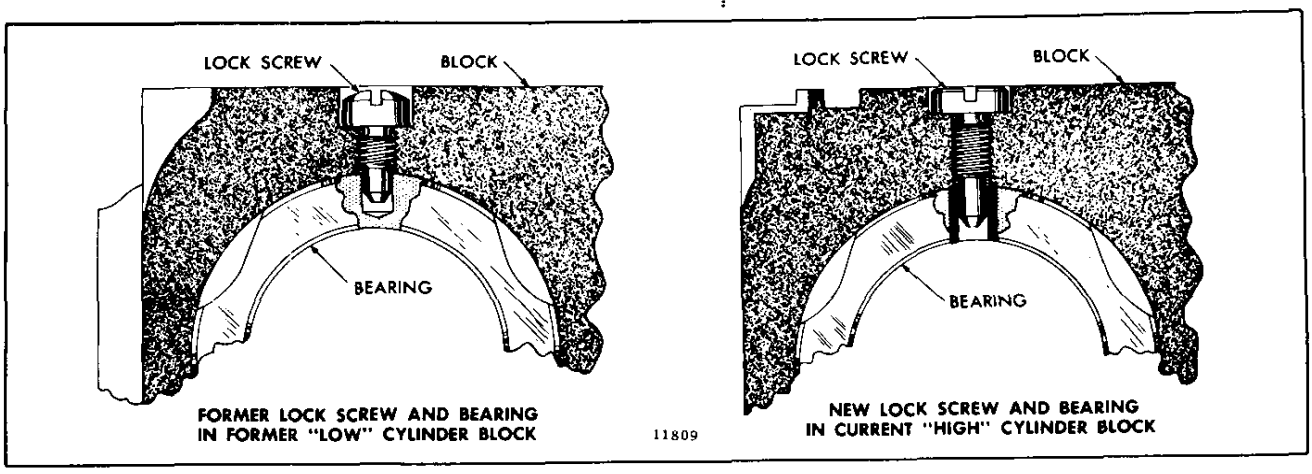


Fig. 21 - Camshaft Intermediate Bearing Lock Screws

galleries at the four corners of the block. In case the plugs are loose, a recommended procedure for repair is to drive the plug deeper in the hole and install a second plug on top after coating the plug with a sealant. Install the plug flush to 1/16" below the top surface of the block.

d. The top face of the block must not vary over .003" transversely and not over .006", .007" or .009" longitudinally in 3-71, 4-71 and 6-71 engines respectively. It will be difficult to maintain water oil, oil and compression sealing in an engine if the top surface of the block exceeds these tolerances.

If it is necessary to machine the top surface of the block to correct for the above conditions, do not remove more than .008" of metal. Stamp the amount of stock removed on the face of the block. The distance from the centerline of the crankshaft to the top of the block must not be less than 16.112", as shown in Fig. 23.

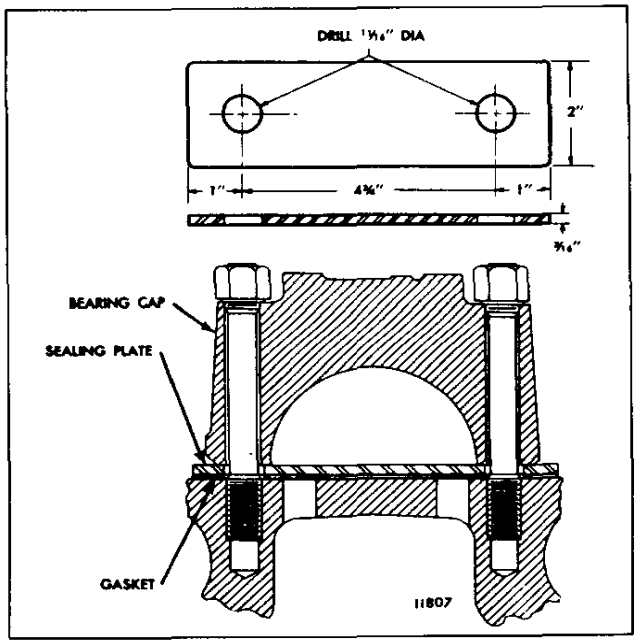


Fig. 22 - Sealing Plate Details for Pressure Testing Low Cylinder Block

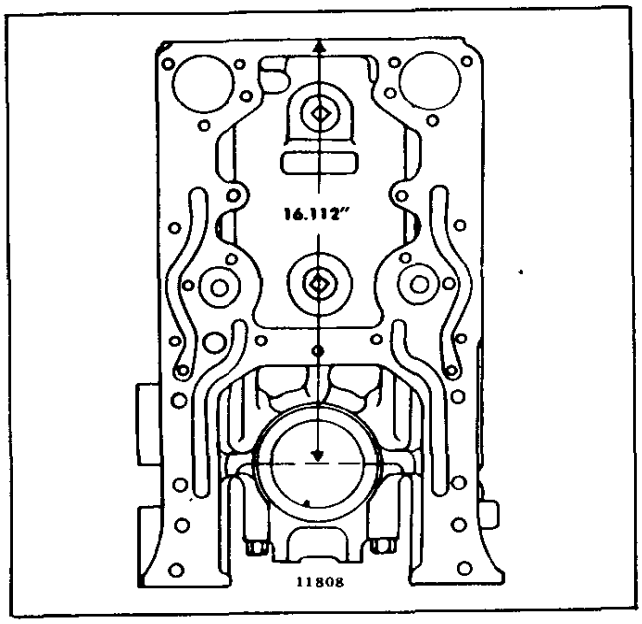
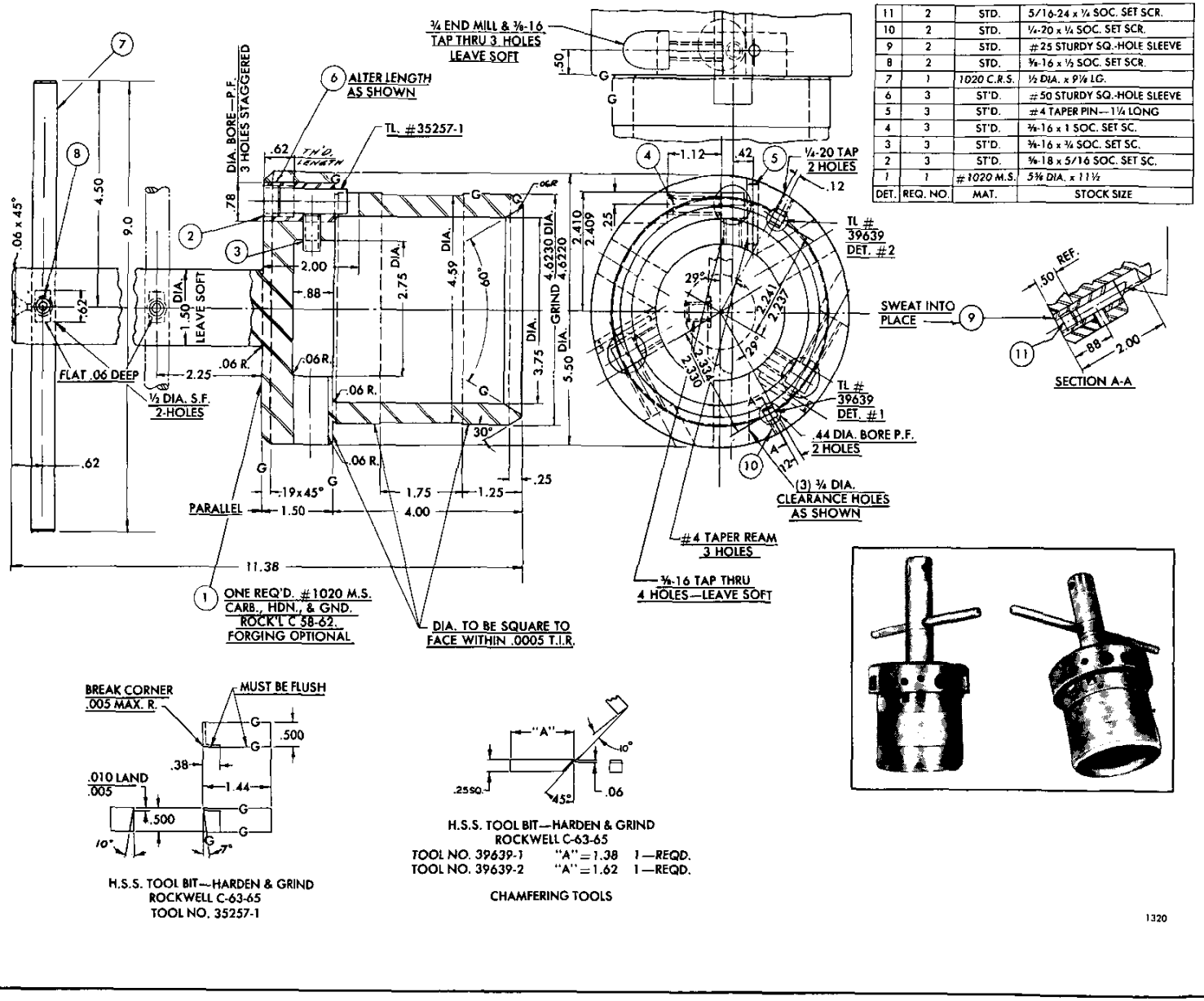


Fig. 23 - Minimum Distance from Centerline of Crankshaft to Top of Low Cylinder Block

© 1982 General Motors Corp.



DET.	REQ. NO.	MAT.	STOCK SIZE
11	2	STD.	5/16-24 x ¼ SOC. SET SCR.
10	2	STD.	¼-20 x ¼ SOC. SET SCR.
9	2	STD.	#25 STURDY SQ.-HOLE SLEEVE
8	2	STD.	⅜-16 x ½ SOC. SET SCR.
7	1	1020 C.R.S.	½ DIA. x 9⅛ LG.
6	3	ST'D.	#50 STURDY SQ.-HOLE SLEEVE
5	3	ST'D.	#4 TAPER PIN—1¼ LONG
4	3	ST'D.	⅜-16 x 1 SOC. SET SC.
3	3	ST'D.	⅜-16 x ¾ SOC. SET SC.
2	3	ST'D.	⅜-18 x 5/16 SOC. SET SC.
1	1	#1020 M.S.	5⅜ DIA. x 11½

Fig. 24 - Cylinder Liner Counterbore Tool Details

© 1982 General Motors Corp.

When the top of the block is resurfaced, the cylinder liner counterbores must also be remachined so that they are from .246" to .248" deep. In the event the counterbores are machined too deep cylinder liner shims are available to raise the liner to the correct position.

e. The blower mounting pad must not vary over .004" over its surface.

2. Replace broken or damaged cylinder head studs. Broken studs may be removed by drilling a hole in the center of the stud and backing the stud out by means of an "easy-out" tool. Also, examine the threaded holes in the block and, if damaged, "clean-up" the threads with the proper tap. Install helical thread inserts, if necessary.

Install and tighten the cylinder head studs to a torque of 35 to 75 lb-ft (47-102 Nm), then measure their extension above the cylinder block. After tightening, the studs must extend 4-7/16" ±1/32" above the top deck of the cylinder block.

NOTE: Special bolts have been used in place of cylinder head studs on some Series 71 engines (refer to Section 1.2).

3. Inspect the cylinder block bores as outlined in *Inspection* of the current cylinder block.

4. Hone the block bores as outlined in *Inspection* for current cylinder blocks.

NOTE: Prior to engines 371-1474, 471-2187 and 671-2455, engines used press fit cylinder liners. When servicing these early units, bore ALL block bores to produce .0005" to .0025" liner-to-block clearance. DO NOT use both slip fit and press fit liners in any one block.

5. Check the main bearing bores as outlined in *Inspection* for the current cylinder block.

6. Check the cylinder liner counterbores for squareness, proper depth and diameter. Counterbores must be from 5.0460" to 5.0485" in diameter. Counterbored surfaces must be square with the cylinder bore within .001" total indicator reading and must not vary in depth more than .001" around the entire circumference (Fig. 18).

Refer to Section 1.0 *Shop Notes* for reworking early cylinder blocks for 71E or 71T engines.

When an oversize liner is used, stamp the size of the liner on the top deck of the block adjacent to the cylinder liner counterbore.

Inserts are not used under the liner flange in "low" cylinder blocks. Therefore, check the counterbores for damaged surfaces due to brinelling, which may result in poor contact between the liner flange and the block. The counterbore must be .246" to .248" in depth.

A counterbore tool, made as shown in Fig. 24, may be used by hand to "clean-up" the liner counterbores in a "low" block which has had the top surface reground, or in cases where the surface of the counterbore has been damaged. Use of the tool must not alter the specified cylinder liner height of .002" to .006" above the top of the top of the block. Shims are available for adjusting the liners to the above specified height.

7. Check the remaining cylinder block surfaces and threaded holes as outlined under *Inspection* of the current block.

8. Install cylinder block plugs as outlined under *Inspection* for the current block.

NOTE: Excessive torque applied to the core hole plugs may result in cracks in the water jacket.

The cylinder block having been cleaned, pressure tested and inspected is now ready for rebuilding.

© 1982 General Motors Corp.

CYLINDER BLOCK END PLATES

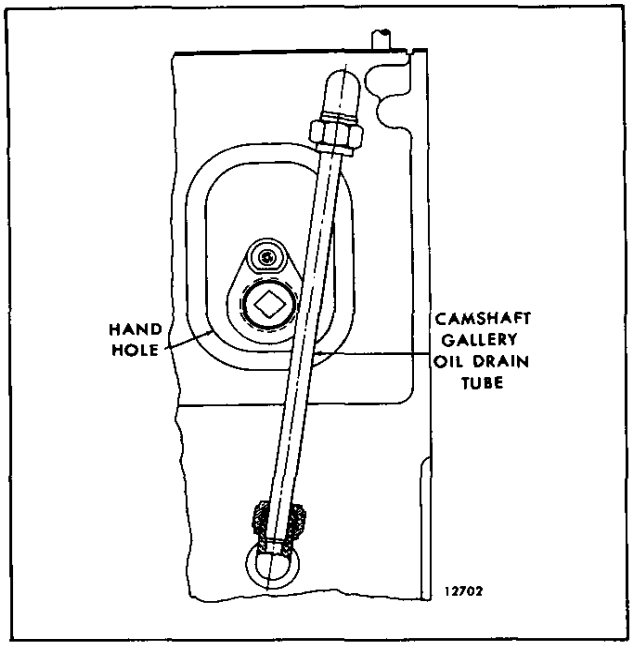


Fig. 1 – Former Method of Draining Camshaft Gallery in Inclined Marine Engine

A flat steel plate, one bolted to each end of the cylinder block, provides a support for the flywheel housing at the rear and the balance weight cover and crankshaft cover at the front of the engine. Since the blower drive gear assembly is supported on the rear end plate, this plate has a different contour than the one used at the front. Gaskets are used between the block and each end plate.

Inspection

When an end plate is removed, it is essential that all of the old gasket material be removed from both surfaces of the plate and the cylinder block. Clean the end plate as outlined under *Clean Cylinder Block* in Section 1.1.

Inspect both surfaces of each end plate for nicks, dents, scratches or score marks and check the end plates for warpage. Also check the tapped holes in the end plates at this time. If nicks or scratches on the sealing surfaces of the end plates are too deep to be cleaned up, replace the end plates.

The camshaft gallery oil drain hole has been relocated in the aluminum cylinder block used in the inclined marine propulsion units. Former units incorporated an external tube located on the side of the block to drain the oil as illustrated in Fig. 1. Effective with engines 4A–52814 and 6A–48855, the cylinder block was revised by drilling passages at each end of the camshaft gallery to provide a means of draining the oil (Fig. 2). Although only one drain hole is used, the block is drilled at each end to permit its use in either a "B" or "D" type engine. The drain hole in the block registers with holes in the current rear end plate (Fig. 3) and gasket. During engine operation, excess lubricating oil in the camshaft gallery flows through the drain holes in the block and end plate and returns to the oil pan. The drain hole at the front is blocked-off by the front end plate.

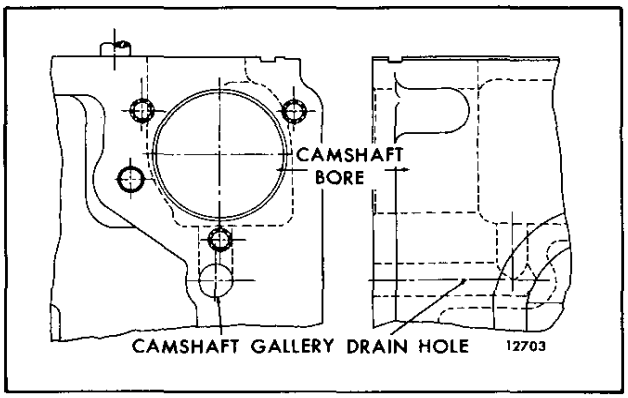


Fig. 2 – Current Method of Draining Camshaft Gallery in Inclined Marine Engine

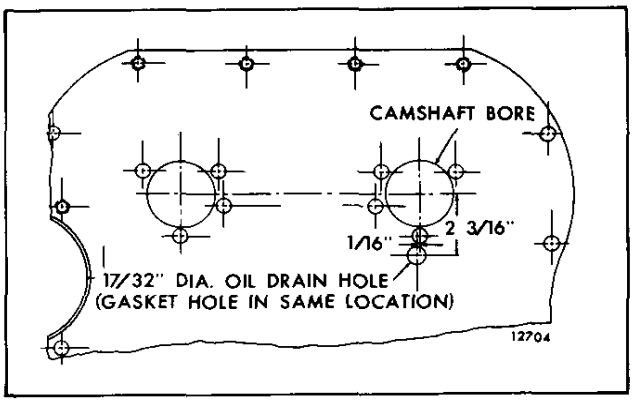


Fig. 3 – Current Rear End Plate for Inclined Marine Engine

© 1977 General Motors Corp.

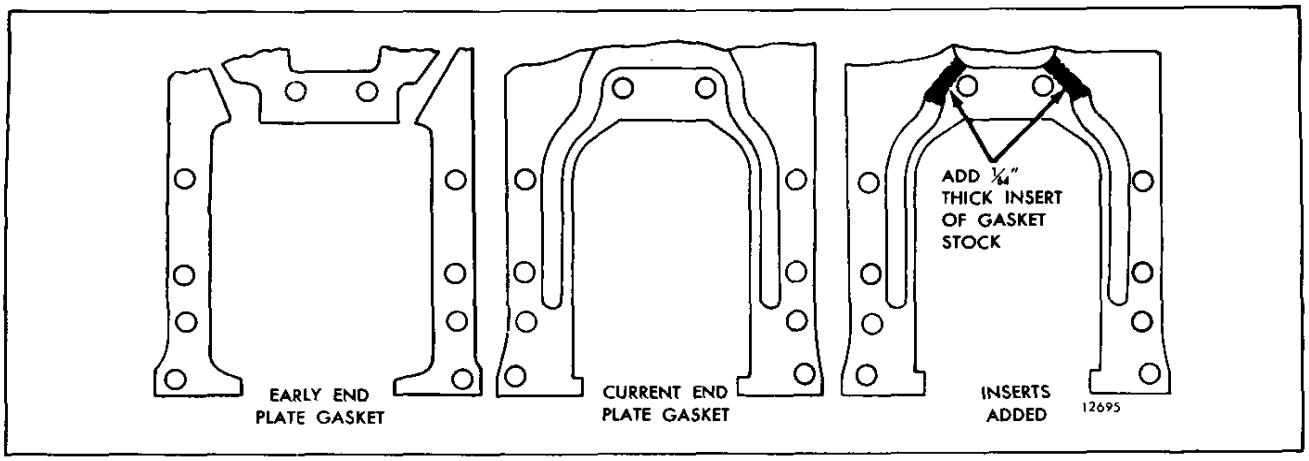


Fig. 4 – Reworking End Plate Gasket for use on Early Design Cylinder Block

CAUTION: The former rear end plate and gasket must NOT be used with a current inclined engine aluminum cylinder block, otherwise the drain hole will be blocked-off. However, the current rear end plate and gasket may be used with the former cylinder block.

Install End Plates

With all of the necessary plugs properly installed, the end plate-to-cylinder block dowels in place and the air box clean-out wires installed (on early design blocks only), attach the cylinder block front and rear end plates as outlined below.

NOTE: Air box drain clean-out wires cannot be used on engines prior to 371-450, 471-618 and 671-692 and are not required after engines 3A-3710, 4A-4133 and 6A-5647.

1. Affix a new gasket to each end of the cylinder block, using a non-hardening gasket cement. Also apply an even coating of gasket cement to the outer surface of each gasket (the surface next to the end plate).

NOTE: Very early cylinder blocks (engines prior to 371-450, 471-618 and 671-692) did not incorporate air box drain grooves in the ends of the block. Therefore, current end plate gaskets must be reworked when used on these units. Inserts of 1/64" thick gasket material must be

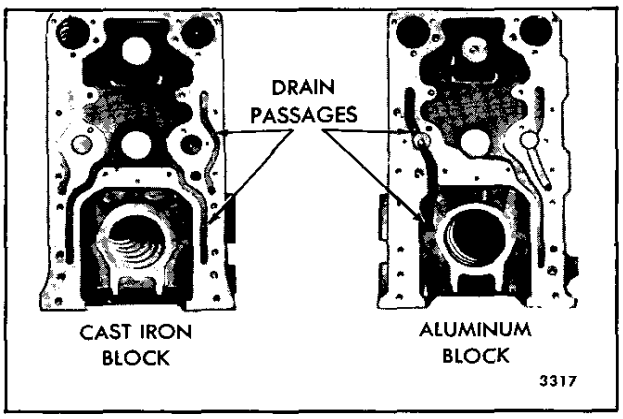


Fig. 5 – Comparison of Drain Passages in Aluminum and Cast Iron Cylinder Blocks

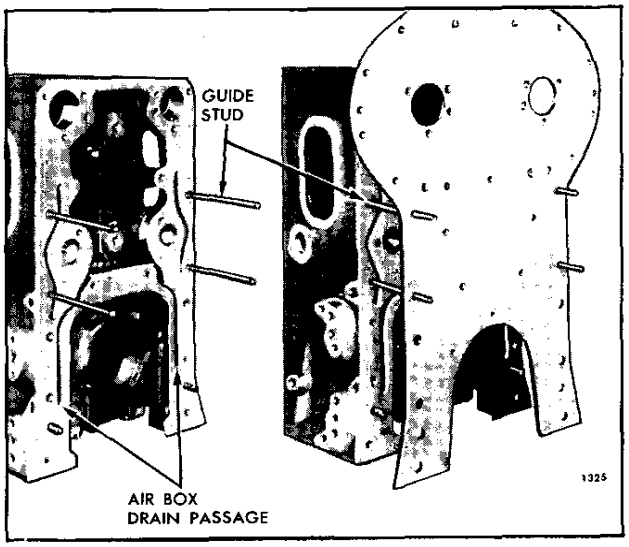


Fig. 6 – Installing Front End Plate

© 1977 General Motors Corp.

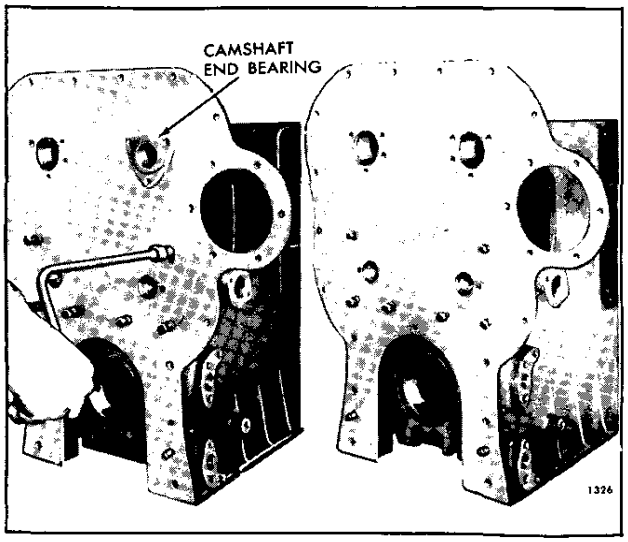


Fig. 7 - Installing Rear End Plate

cemented to the cylinder block in the positions shown in Fig. 4 after the end plate gasket is attached to the block. Otherwise, excessive crankcase pressure would result due to leakage of air from the air box into the crankcase.

CAUTION: The end plate gasket used with a cast iron cylinder block cannot be used with an aluminum block since the contour of the oil drain passages of the two blocks is not alike (Fig. 5).

2. Use guide studs J 1927-01 as shown in Fig. 6 to set the front end plate next to the cylinder block and install the bolts and lock washers. Do not tighten the bolts at this time. Wipe the excess gasket cement from the bores in the end plate and the cylinder block.

3. Insert a camshaft end bearing through the SMALL bearing bore in the end plate and into the bore of the block to accurately align the end plate as shown in Fig. 7.

4. With the bearing in place, tighten the 3/8" -16 end plate retaining bolts to 30-35 lb-ft (41-47 Nm) torque (cast iron block) or 25-30 lb-ft (34-41 Nm) torque (aluminum block). Tighten the 1/2" -13 bolts to 71-75 lb-ft (96-102 Nm) torque. Remove the camshaft bearing which served as a pilot while attaching the end plate.

5. Use the guide studs J 1927-01 and the camshaft end bearing to install the rear end plate in the same manner as outlined above.

© 1977 General Motors Corp.

AIR BOX DRAINS

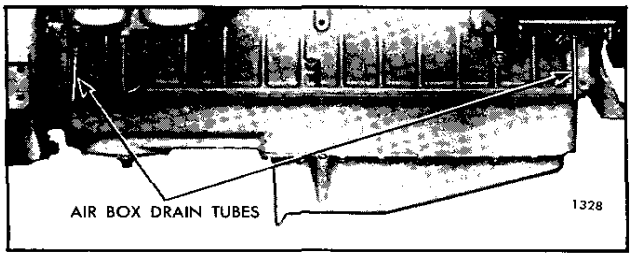


Fig. 1 - Air Box Drain Tubes

During normal engine operation, water vapor from the air charge, as well as a slight amount of fuel and lubricating oil fumes, condenses and settles on the bottom of the air box. This condensation is removed by the air box pressure through cored passages located at the front and rear of the cylinder block with drain outlets in the side of the block (Fig. 1).

Some engines are equipped with a drain tank to collect and retain the sediment from the air box (Fig. 2).

Air box drains must be kept open at all times, otherwise water and oil that may accumulate will be drawn into the cylinders.

A new air box drain tube and check valve have been added to the In-line 6-71 T and TT (Fuel Squeezer) vehicle engines. This is effective with engine serial number 6A-382107 (closed design - Fig. 3) and 6A-405930 (open design - Fig. 4).

To accommodate the closed design air box drain tube and check valve, the cylinder block was revised to include two additional tapped and drilled holes. The closed design air box drain tube is routed to the crankcase, at the rear face of the cylinder block on the side opposite the blower. The open design air box drain is mounted at either of the rear corners of the block (Fig. 4). With this design the drainage is routed to the atmosphere.

The air box check valve allows drainage only at low air box pressure.

The air box check valve cutaway, shown in Figs. 3 and 4, shows the valve operating at engine idle speed. As the engine rpm and air box pressure increase, the valve moves forward and seats, blocking airflow. The engine utilizes this additional air.

A limited number of 6-71T and TT engines were built with the check valves installed in the air box floor. This design is now obsolete. See Section 1.0 for conversion to the new external, open air box drain system.

Inspection

A periodic check for air flow from the air box drain tubes should be made (refer to Section 15.1). If a drain tank is used, service it periodically as outlined in Section 15.1.

Inspect the check valve for proper operation as follows:

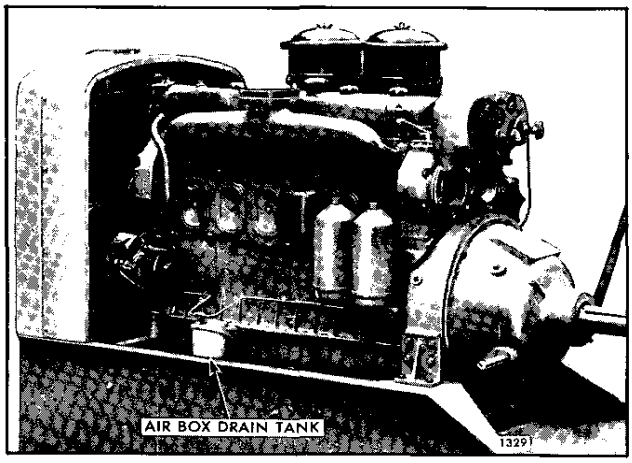


Fig. 2 - Air Box Drain Tank Installation

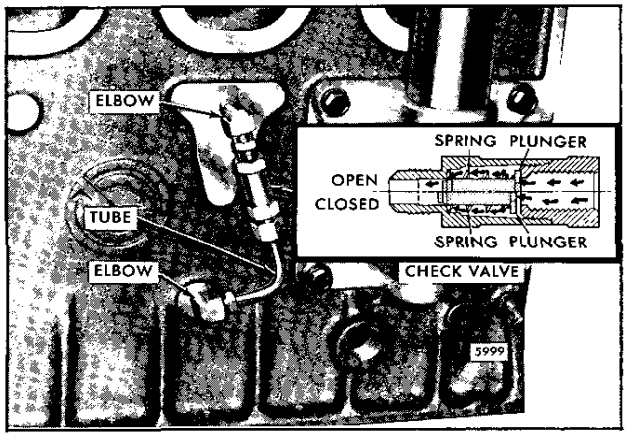


Fig. 3 - Closed Design Air Box Drain Tube (6-71T and 6-71TT)

© 1982 General Motors Corp.

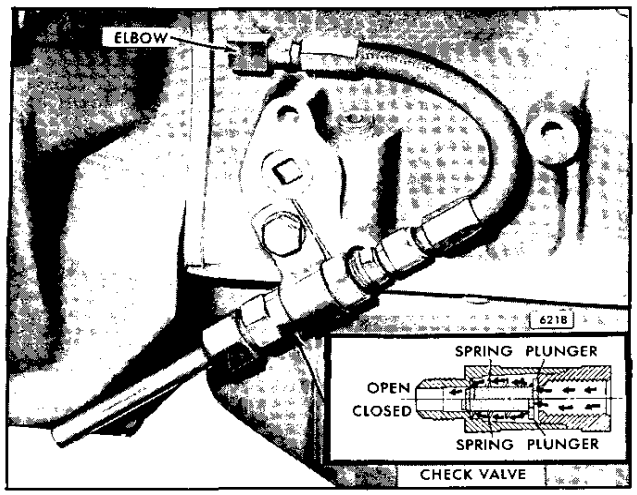


Fig. 4 - Open Design Air Box Drain Tube (6-71T and 6-71TT)

1. Disconnect the drain tube between the check valve and the air box drain tube nut at the air box cover (closed design).

2. Run the engine and note the air flow through the valve at idle speed.

3. Increase the engine speed.

4. If the check valve is operating properly, there will be no airflow at engine speeds above idle.

To check the air box pressures on an engine with the new drain tubes, use air box covers with a tapped hole for a fitting or one of the corner plugs.

1. Remove the plug in the cover or the plug at one of the four corners of the cylinder block.

2. Install a fitting and short drain tube.

3. Attach a manometer to the end of the drain tube and check the air box pressure as stated in Section 13.2.

© 1982 General Motors Corp.

CYLINDER HEAD

The cylinder head (Figs. 1, 2 and 3) is a one-piece casting securely held to the top of the cylinder block by special bolts.

The exhaust valves, fuel injectors and the valve and injector operating mechanism are located in the cylinder head.

Depending upon the engine application, either two or four exhaust valves are provided for each cylinder.

Exhaust valve seat inserts, pressed into the cylinder head, permit accurate seating of valves under varying conditions of temperature and materially prolong the life of the cylinder head.

To ensure efficient cooling, each fuel injector is inserted into a thin-walled tube (Fig. 4) which passes through the water space in the cylinder head. The lower end of the injector tube is pressed into the cylinder head and flared over; the upper end is flanged and sealed with a neoprene seal. The sealed

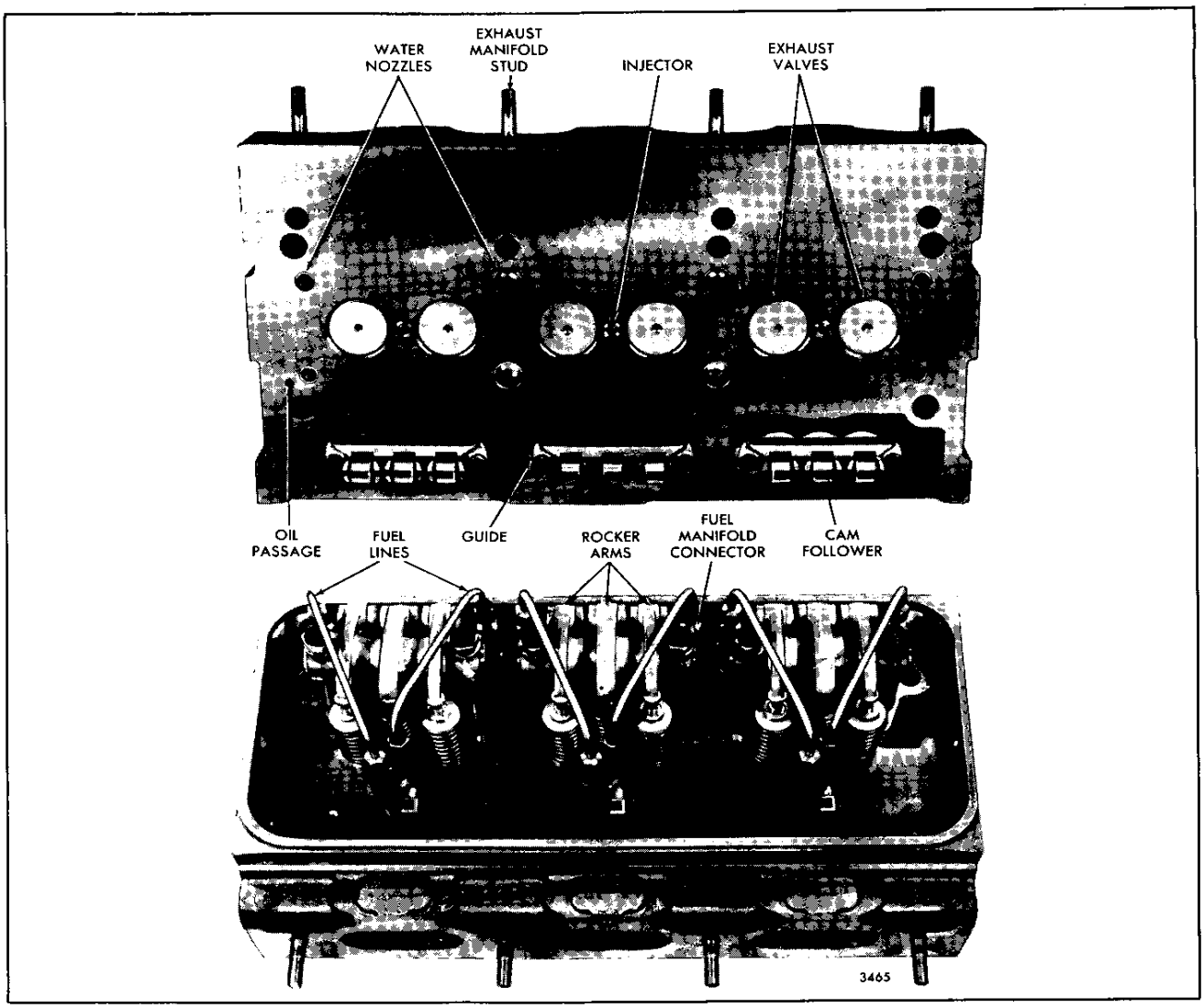


Fig. 1 - Typical Cylinder Head Assembly (Two-Valve)

© 1979 General Motors Corp.

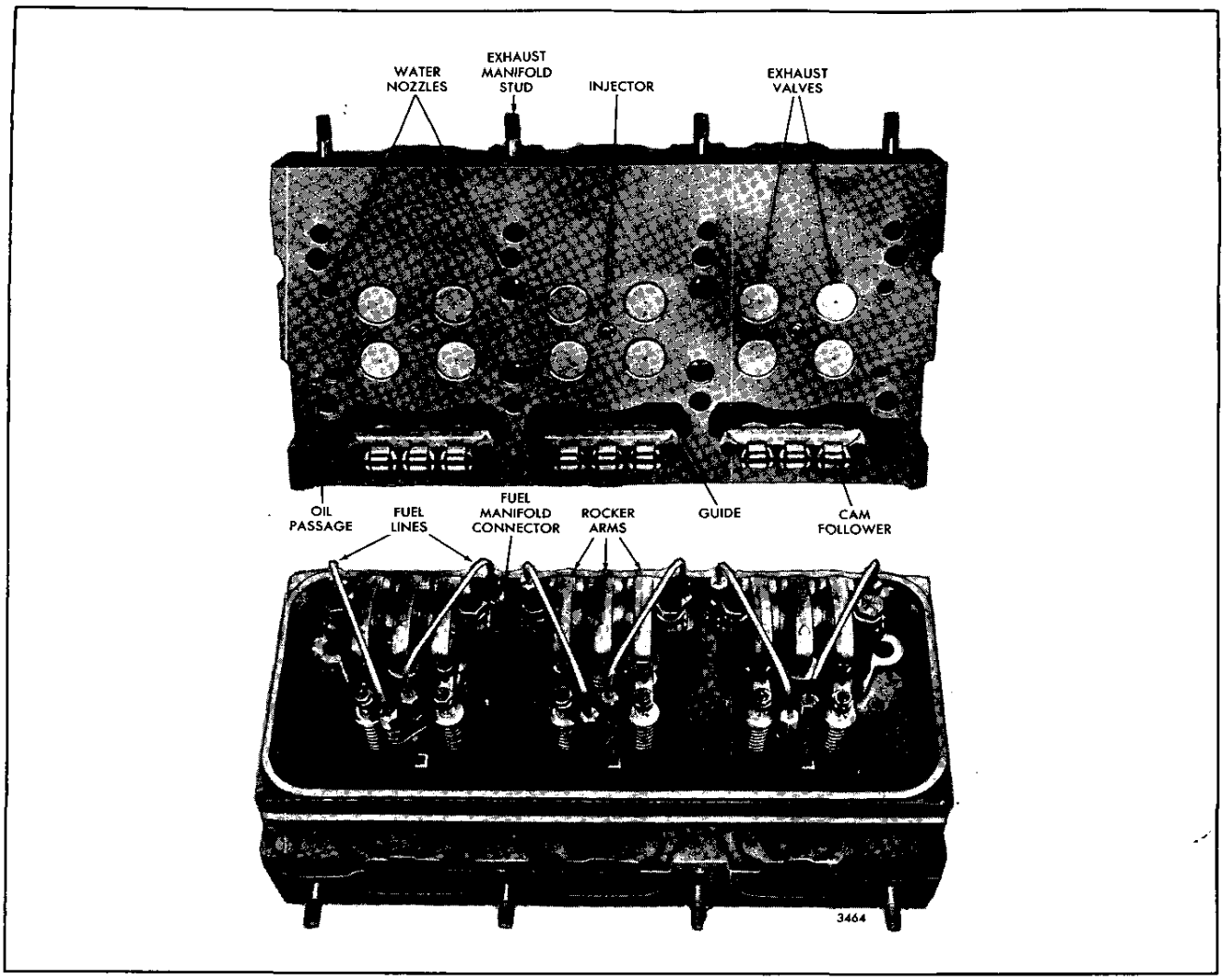


Fig. 2 - Typical Cylinder Head Assembly (Four-Valve)

upper end and flared lower end of the injector tube prevent water and compression leaks.

No water space is provided around the injectors in aluminum cylinder heads or very early cast iron four-valve cylinder heads. Therefore, no injector tubes are required in these heads.

The exhaust passages from the exhaust valves of each cylinder lead through a single port to the exhaust manifold. The exhaust passages and the injector tubes are surrounded by engine coolant.

In addition, cooling of the above areas is further ensured by the use of water nozzles (Figs. 5 and 6) pressed into the water inlet ports in the cylinder head. The nozzles direct the comparatively cool engine coolant at high velocity toward the sections of the cylinder head which are subjected to the greatest heat.

The fuel inlet and outlet manifolds are cast as an integral part of the current cylinder heads. Tapped holes are provided for connection of the fuel lines at various points along each manifold. On aluminum cylinder heads and former cast iron cylinder heads, separate fuel manifolds are attached to the side of the head (refer to Section 2.4).

The water manifold is also cast as an integral part of the cylinder head.

To seal compression between the cylinder head and the cylinder liner, separate laminated metal gaskets are provided at each cylinder. Water and oil passages between the cylinder head and cylinder block are

© 1979 General Motors Corp.

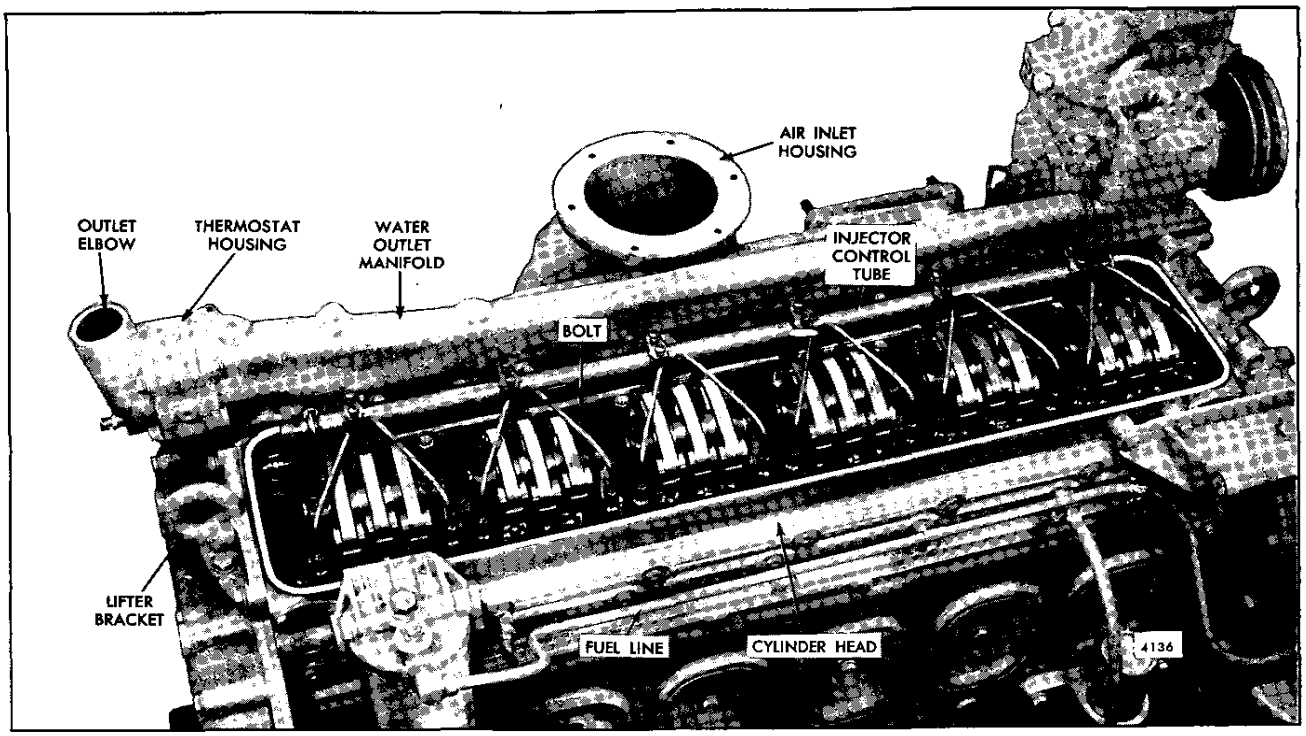


Fig. 3 - Typical Mounting of Cylinder Head

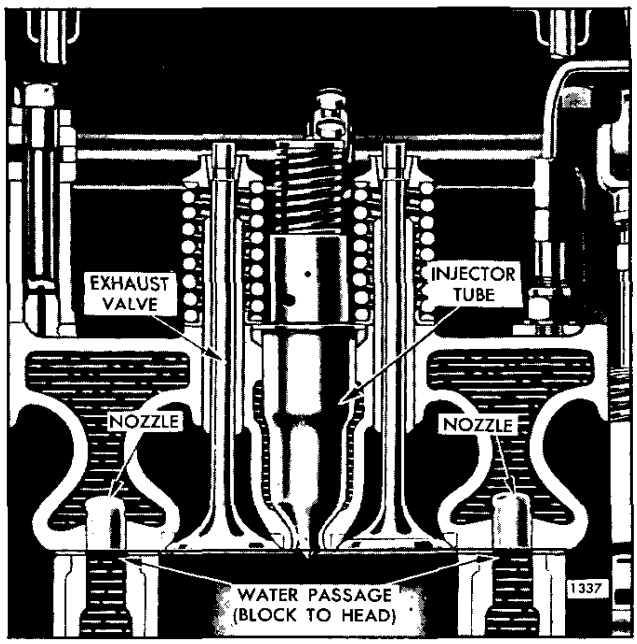


Fig. 4 - Coolant Passages Around Exhaust Valves and Fuel Injectors

sealed with synthetic rubber seal rings which fit into counterbored holes in the block. A synthetic rubber seal fits into a milled groove near the perimeter of the block. When the cylinder head is drawn down, a positive leakproof metal-to-metal contact is assured between the head and the block.

To make the cylinder heads more tolerant of abnormal coolant temperature, relief areas have been cast in the current four valve cylinder heads. These stress relief areas, which are shaped like a "dog bone" are cast in the fire deck of the cylinder head between the cylinders (Fig. 7). For visual identification of the current cylinder head on an engine, two bosses (at a later date a raised boss the shape of a "dog bone") are cast on the fuel manifold side of the three cylinder heads and a raised boss the shape of a "dog bone" is cast on the exhaust manifold side of the four and six cylinder heads (Fig. 8). The current service cylinder heads which include the stress relief areas in the fire deck also include the non-magnetic turbo exhaust valve inserts identified by the letter "T" stamped on the face of the cylinder head.

NOTE: Production non-turbocharged cylinder heads include cast steel exhaust valve seat inserts which have magnetic qualities. An easy method for determining the type of exhaust valve seat insert in a cylinder head is with a

© 1979 General Motors Corp.

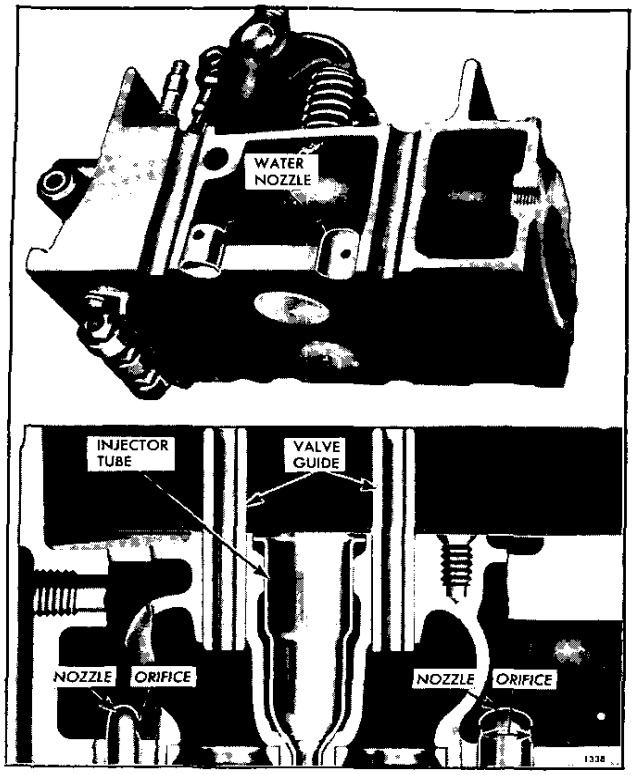


Fig. 5 - Water Nozzles in Two-Valve Cylinder Head

magnet. The magnet will be attracted to the non-turbo insert (will stick). The magnet will not be attracted to the turbo insert, it will jump tó the cylinder head.

Cylinder Head Maintenance

The engine operating temperature should be maintained between 160-185 °F (71-85 °C) and the cooling system should be inspected daily and kept full at all times. The cylinder head fire deck will overheat and crack in a short time if the coolant does not cover the fire deck surface. When necessary, add coolant *slowly* to a hot engine to avoid rapid cooling which can result *in distortion and cracking of the cylinder head (and* cylinder block).

Abnormal operating conditions or neglect of certain maintenance items may cause cracks to develop in the cylinder head. If this type of failure occurs, a careful inspection should be made to find the cause and avoid a recurrence of the failure.

Unsuitable water in the cooling system may result in lime and scale formation and prevent proper cooling. The cylinder head should be inspected around the

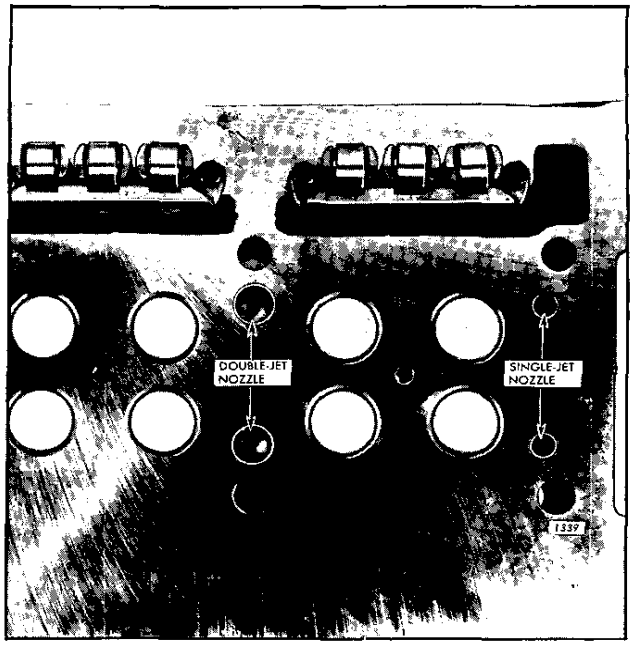


Fig. 6 - Water Nozzles in Four-Valve Cylinder Head

exhaust valve water jackets. This can be done by removing an injector tube. Where inspection discloses *such deposits, use a reliable non-corrosive scale* remover to remove the deposits from the cooling system of the engine, since a similar condition will exist in the cylinder block and other components of the engine. Refer to Section 13.3 for engine coolant recommendations.

Loose or improperly seated injector tubes may result in compression leaks into the cooling system and also result in loss of engine coolant. The tubes must be tight to be properly seated. Refer to Section 2.1.4.

Overtightened injector clamp bolts may also cause

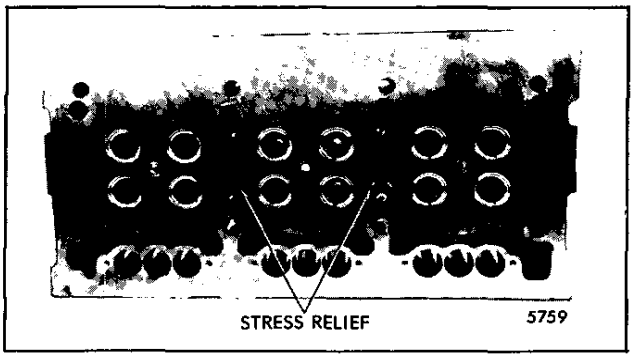


Fig. 7 - Current Four Valve Cylinder Head

© 1979 General Motors Corp.

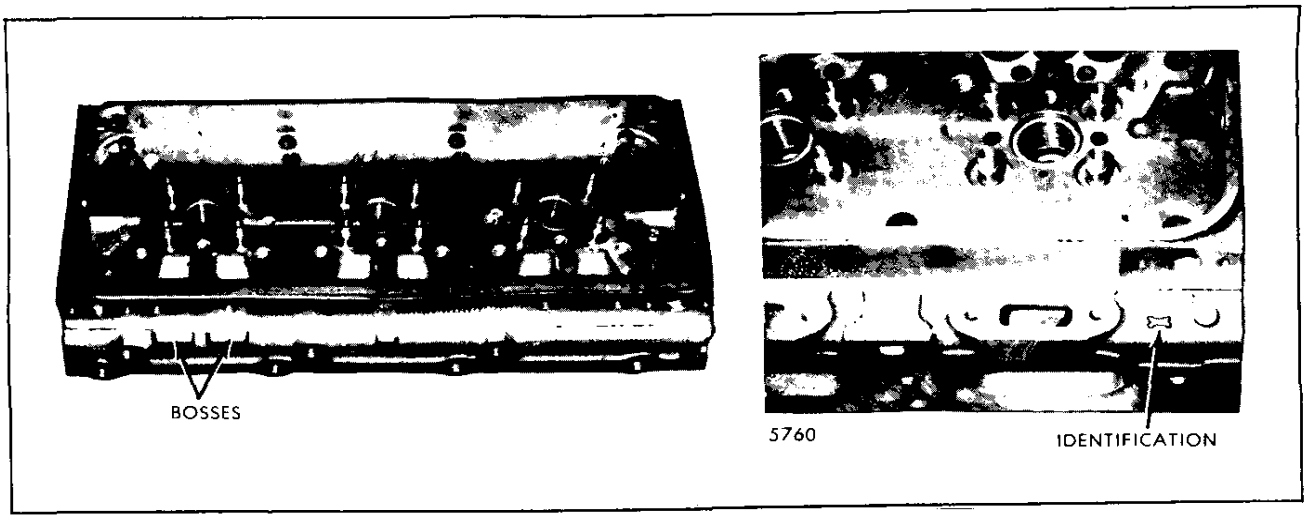


Fig. 8 - Current Four-Valve Cylinder Head Identification

head cracks. Always use a torque wrench to tighten the bolts to the specified torque.

Other conditions which may eventually result in cylinder head cracks are:

1. Excess fuel in the cylinders caused by leaking injectors.

2. Slipping fan belts can cause overheating by reducing air flow through the radiator.

3. Accumulation of dirt on the radiator core which will reduce the flow of air and slow the transfer of heat from the coolant to the air.

4. Inoperative radiator cap which will result in loss of coolant.

Remove Cylinder Head

Certain service operations on the engine require removal of the cylinder head:

1. Remove and install pistons.

2. Remove and install cylinder liners.

3. Remove and install exhaust valves.

4. Remove and install exhaust valve guides.

5. Recondition exhaust valves and valve seat inserts.

6. Replace fuel injector tubes.

7. Install new cylinder head gaskets and seals.

8. Remove and install camshaft.

Due to the various optional and accessory equipment used, only the general steps for removal of the cylinder head are covered. If the engine is equipped with accessories that affect cylinder head removal, note the position of each before disconnecting or removing them to ensure correct reinstallation. Then refer to Fig. 3 and remove the cylinder head as follows:

1. Drain the cooling system.

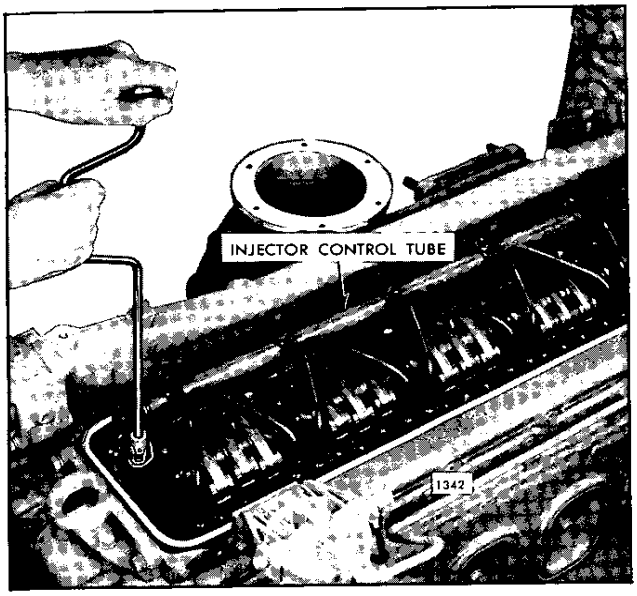


Fig. 9 - Removing or Installi
Tube

© 1981 General Motors Corp.

2. Disconnect the exhaust piping at the exhaust manifold. On turbocharged engines, remove the connections from the exhaust manifold to the turbocharger. Remove the turbocharger, if necessary.

3. Remove the air cleaners, or air silencer, and the air inlet housing.

4. Remove the exhaust manifold.

5. Disconnect the fuel lines at the cylinder head and remove the fuel filter (Fig. 3).

6. Remove the thermostat housing assembly.

7. Remove the water manifold.

8. Clean and remove the valve rocker cover and the governor cover.

9. Disconnect the fuel rod from the injector control tube lever and the governor. Remove the fuel rod.

10. Remove the injector control tube and brackets as an assembly (Fig. 9).

11. If the cylinder head is to be disassembled for reconditioning of the exhaust valves and valve seat inserts or for a complete overhaul, remove the fuel pipes and injectors at this time. Refer to Section 2.1 or 2.1.1 for removal of the injectors.

12. Loosen (three or four turns) the two bolts directly below each lifter bracket which attach the balance weight cover and flywheel housing to the front and rear end plates. Otherwise, the threaded ends of the bolts may interfere with removal of the cylinder head.

13. Remove the two bolts which secure the front lifter bracket to the balance weight cover and the two bolts attaching the rear lifter bracket to the flywheel

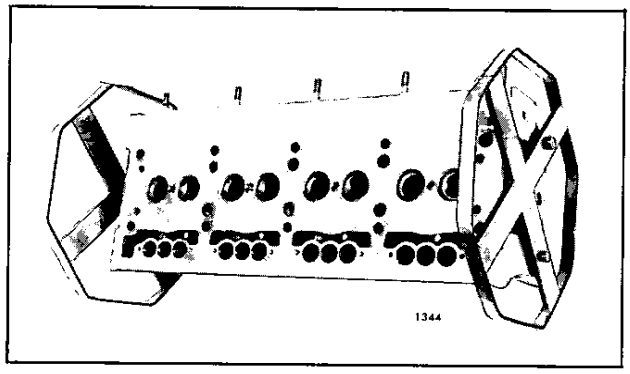


Fig. 10 - Cylinder Head Mounted on Holding Plates (J 3087-01)

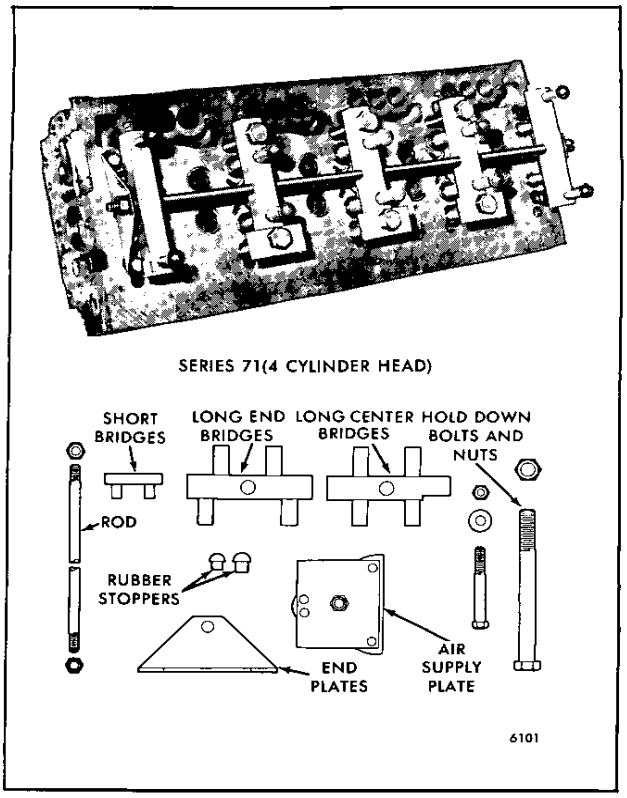


Fig. 11 - Cylinder Head Prepared for Pressure Test using Tool J 28454

housing. On heat exchanger units, remove the bolts securing the vent casting to the balance weight cover and the heat exchanger tank. Remove the vent casting and gasket.

14. Check the torque on the cylinder head bolts and stud nuts (if used), before removing the head. Then remove the bolts and nuts and, using lifting hooks and a chain hoist, lift the cylinder head from the cylinder block. Checking the torque before removing the head bolts and examining the condition of the compression gaskets and seals after the head is removed may reveal the causes of any cylinder head problems.

NOTE: When placing the cylinder head assembly on a bench, protect the cam followers and injector spray tips, if the injectors were not removed, by resting the valve side of the head on 2" thick wood blocks.

15. Place the cylinder head on its side and remove the engine lifter brackets and gaskets. Then attach the cylinder head holding plates J 3087-01 to raise the head above the work bench (Fig. 10).

© 1981 General Motors Corp.

16. Remove and discard the cylinder head compression gaskets, oil seals and water seals.

17. After the cylinder head has been removed, drain the lubricating oil from the engine. Draining the oil at this time will remove any coolant that may have worked its way to the oil pan when the head was removed.

Disassemble Cylinder Head

If complete disassembly of the cylinder head is necessary, refer to Sections 1.2.1 and 1.2.2 for removal of the exhaust valve and injector operating mechanism.

Clean Cylinder Head

After the cylinder head has been disassembled and all of the plugs (except cup plugs) have been removed, thoroughly steam clean the head. If the water passages are heavily coated with scale, remove the injector tubes and water nozzles. Then clean the cylinder head in the same manner as outlined for cleaning the cylinder block (Section 1.1).

Clean all of the cylinder head components with fuel oil and dry them with compressed air.

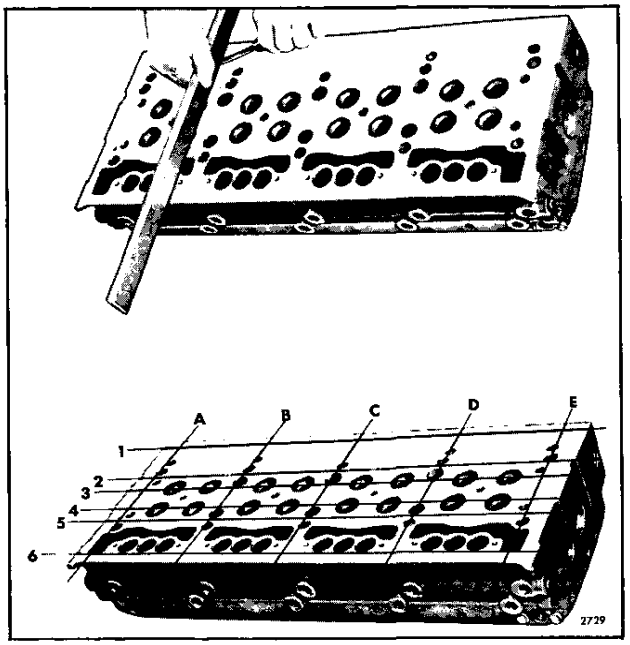


Fig. 12 - Checking Bottom Face of Cylinder Head

Inspect Cylinder Head

1. Before a cylinder head can be reused, it must be inspected for cracks. Any one or a combination of the following methods can be used for checking a cylinder head for cracks:

NOTE: If any method reveals cracks, the cylinder head should be considered unacceptable for reuse.

Magnetic Particle Method: The cylinder head is magnetized and then covered with a fine magnetic powder or solution. Flaws, such as cracks, form a small local magnet which cause the magnetic particles in the powder or solution to gather there, effectively marking the crack. The cylinder head must be demagnetized after the test.

Fluorescent Magnetic Particle Method: This method is similar to the magnetic particle method, but is more sensitive since it uses fluorescent magnetic particles which glow under a "Black Light". Very fine cracks, especially on discolored or dark surfaces, that may be missed using the Magnetic Particle Method will be disclosed under the "Black Light".

Fluorescent Penetrant Method: A highly fluorescent liquid penetrant is applied to the area in question. Then the excess penetrant is wiped off the surface and the part is dried. A developing powder is then applied which helps to draw the penetrant out of the flaws by capillary action. Inspection to find the crack is carried out using a "Black Light".

Non-Fluorescent Penetrant Method: The test area being inspected is sprayed with "Spotcheck" or Dye Check. Allow one to thirty minutes to dry. Remove the excess surface penetrant with clean cloths premoisened with cleaner/remover. DO NOT flush surface with cleaner/remover because this will impair sensitivity. Repeat this procedure with additional wipings until residual surface penetrant has been removed. Shake developer thoroughly until agaitator rattles. Invert spray can and spray short bursts to clear valve. Then spray this developer film evenly over the test area being inspected. Allow developer film to dry completely before inspecting. Recommended developing time is 5 to 15 minutes.

The above four methods provide basic instructions. Specific details should be obtained from the supplier of the equipment or material.

If cracks are visible in the head, *Do Not* use the Pressure Test Method.

Pressure Test Method - Cylinder Head Disassembled:

NOTE: When overhauling a cylinder head, use *Cylinder Head Disassembled* pressure test method. When a cylinder head is removed to assist in other repairs, the cylinder head can be

© 1983 General Motors Corp.

pressure tested using the method described in *Cylinder Head Assembled and Removed from Engine.*

A. To seal off the water holes in the cylinder head, assemble tool set J 28454 as follows (Fig. 11):

1. Install the rubber stoppers on the bridges.

   a. Large stoppers are installed on the long center bridge feet opposite the notch and on the long end bridge feet closest together.

   b. Small stoppers are installed opposite the large stoppers on center bridge and end bridge feet and on all short bridges.

2. Install the necessary parts, loosely, on the cylinder head.

3. Tighten the hold down bolts until the stoppers start to distort. A 5 lb-ft (7 Nm) torque is usually sufficient.

NOTE: Do not overtighten the hold down bolts. The rubber stopper could distort enough to seal both the inner and outer diameter of the water nozzles. If the outer diameter is sealed, a leak from the outer diameter would not be detected.

4. Install the air supply plate.

NOTE: Do not hook onto the pressure checking tool, or any part of it, to move the cylinder head from one location to another. If this is done it could result in permanent damage to the tool.

B. Install scrap or dummy injectors to ensure proper seating of the injector tubes. Dummy injectors may be made from old injector nuts and bodies -- the injector spray tips are not necessary. Tighten the injector clamp bolts to 20-25 lb-ft (27-34 Nm) torque.

C. Apply 40 psi (276 kPa) air pressure to the water jacket. Then immerse the cylinder head in a tank of water, previously heated to 180°-200°F (82°-93°C), for about twenty minutes to thoroughly heat the head. Observe the water in the tank for bubbles which indicate a leak or crack. Check for leaks at the top and bottom of the injector tubes, oil gallery, exhaust ports, fuel manifolds and the top and bottom of the cylinder head.

D. Relieve the air pressure and remove the cylinder head from the water tank. Then remove the plates, gaskets and injectors and dry the head with compressed air.

Pressure Test Method - Cylinder Head Assembled and Removed from Engine:

A. To seal off water holes in the cylinder head, assemble tool set J 28454 as follows:

1. Install the rubber stoppers on the bridges.

   a. Large stoppers are installed on the long center bridge feet opposite the notch and on the long end bridge feet closest together.

   b. Small stoppers are installed opposite the large stoppers.

2. Install necessary parts, loosely, on the cylinder head.

3. Tighten the hold down bolts until the stoppers start to distort. A 5 lb-ft (7 Nm) torque is usually sufficient.

NOTE: Do not overtighten the hold down bolts. The rubber stopper could distort enough to seal both the inner and outer diameter of the water nozzles. If the outer diameter is sealed, a leak from the outer diameter would not be detected.

4. Install the air supply plate to water jacket opening.

B. Apply 40 psi (276 kPa) air pressure to the air supply plate connection. Check for leaks, using Leak Tek solution or equivalent, at the tops and bottoms of the injector tubes, oil gallery, exhaust ports and fuel manifolds.

C. Relieve the air pressure slowly. Then remove all plates and gaskets.

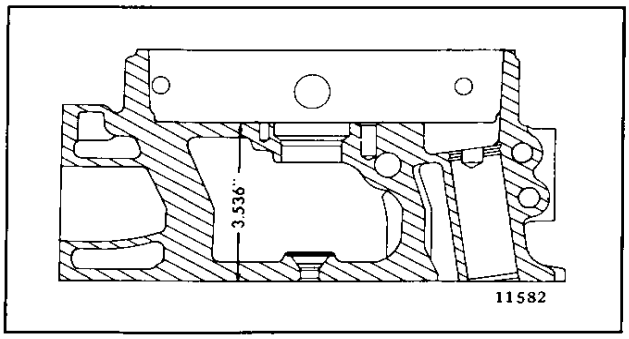


Fig. 13 - Minimum Distance Between Top and Bottom Faces of Cylinder Head

© 1983 General Motors Corp.

2. Check the bottom (fire deck) of the cylinder head for flatness:

a. Use a heavy, accurate straight-edge and feeler gages, tool J 3172, to check for transverse warpage at each end and between all cylinders. Also, check for longitudinal warpage in six places (Fig. 12). Refer to Table 1 for maximum allowable warpage.

Engine	Maximum Longitudinal Warpage	Maximum Transverse Warpage
3-71	.0055"	.004"
4-71	.008"	.004"
6-71	.010"	.004"

TABLE 1

b. Use the measurements obtained and the limits given in Table 1 as a guide to determine the advisability of reinstalling the head on the engine or of refacing it. The number of times a cylinder head may be refaced will depend upon the amount of stock previously removed.

c. If the head is to be refaced, remove the injector tubes prior to machining. Do not remove more metal from the fire deck of any cylinder head below the minimum distance of 3.536" (Fig. 13).

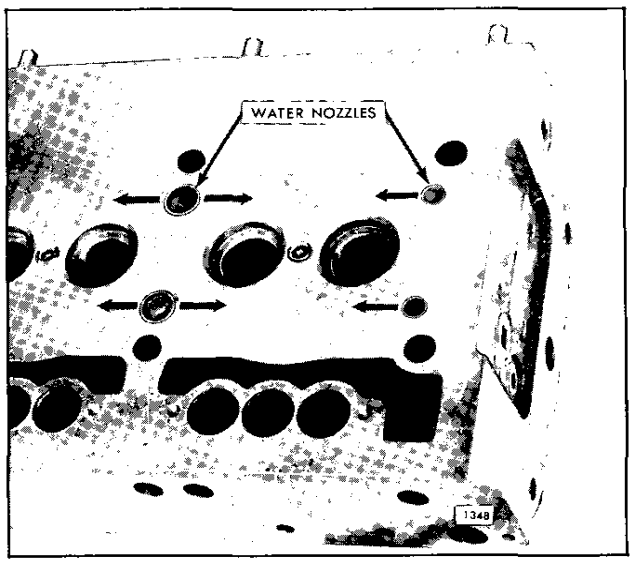


Fig. 14 - Correct Installation of Water Nozzles in Two-Valve Cylinder Head

NOTE: When a cylinder head has been refaced, critical dimensions such as the protrusion of valve seat inserts, exhaust valves, injector tubes and injector spray tips must be checked and corrected. The push rods must also be adjusted to prevent the exhaust valves from striking the pistons after the cylinder head is reinstalled in the engine.

3. Install new injector tubes (Section 2.1.4) if the old tubes leaked or the cylinder head was refaced.

4. Inspect the exhaust valve seat inserts and valve guides (refer to Section 1.2.2).

5. Inspect the cam follower bores in the cylinder head for scoring or wear. Light score marks may be cleaned up with crocus cloth wet with fuel oil. Measure the bore diameters with a telescope gage and micrometer and record the readings. Measure the diameter of the cam followers with a micrometer. Record and compare the readings of the followers and bores to determine the cam followers-to-bore clearances. The clearance must not exceed .006" with used parts (refer to Section 1.0 for Specifications). If the bores are excessively scored or worn, replace the cylinder head.

6. Check the water hole nozzles to be sure they are not loose. If necessary, replace the nozzles as follows:

NOTE: Early engines did not incorporate water nozzles in the cylinder head. It is recommended that nozzles be installed when an early engine is in for a regular overhaul or for reconditioning of the cylinder head.

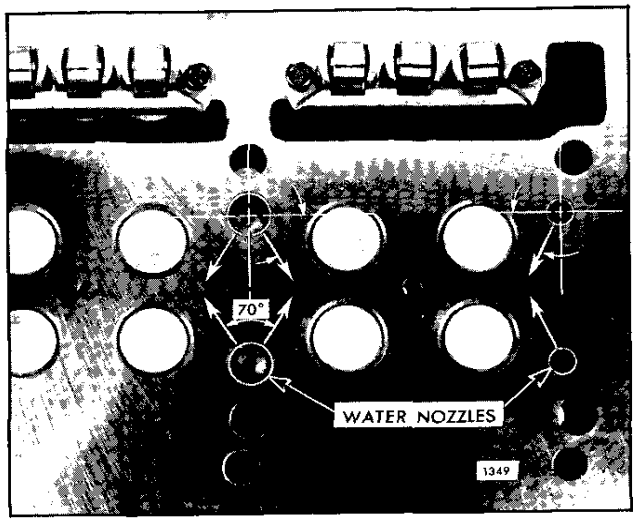


Fig. 15 - Correct Installation of Water Nozzles in Four-Valve Cylinder Head

© 1983 General Motors Corp.

a. Remove the old nozzles.

b. Make sure the water inlet ports in the cylinder head are clean and free of scale. The water holes at each end of the head may be cleaned up with a 1/2" drill and the intermediate holes may be cleaned up with a 13/16" drill. Break the edges of the holes slightly.

c. Press the nozzles in place with the nozzle openings parallel to the longitudinal center line of the *two-valve* cylinder head (Fig. 14). Install the 1/2" diameter nozzles at the ends of the cylinder head with their openings toward the center of the engine. For the positioning of the nozzles in a *four-valve* cylinder head, refer to Fig. 15. Press the nozzles flush to .0312" recessed below the surface of the cylinder head.

d. Check to make sure the nozzles fit tight. If necessary, use a wood plug or other suitable tool to expand the nozzles, or tin the outside diameter with solder to provide a tight fit. If solder is used, make sure the orifices in the nozzles are not closed with solder.

7. Replace broken or damaged studs. Apply sealant to the threads of new studs and drive them to 10-25 lb-ft (14-34 Nm) torque (water manifold cover studs) or to 25-40 lb-ft (34-54 Nm) torque (exhaust manifold studs).

8. Pilot sleeves have been added to the head mounting bolt holes at each end of the four-valve cylinder heads (on the camshaft side on current heads or exhaust side of former heads). Make sure the sleeves are flush or recessed below the fire deck of the cylinder head. Replace damaged sleeves. Pilot sleeves can be installed on early cylinder heads by reaming the end bolt holes (camshaft side of head) to .687"/.688" diameter by .750" deep and pressing the sleeves flush or slightly recessed below the fire deck. The sleeves, which act as a hollow dowel to provide a closer fit between the mounting bolts and the cylinder head, help to guide the head in place without disturbing the seals and gaskets.

9. Inspect all other components removed from the cylinder head.

If a service replacement cylinder head is to be installed, it must be thoroughly cleaned of all rust preventive compound, particularly inside the integral fuel manifolds, before installing the plugs. A simple method of removing the rust preventive compound is to immerse the head in a mineral spirits based solvent or fuel oil, then scrub the head and go through all of the openings with a soft bristle brush. A suitable brush for cleaning the various passages in the head can be made by attaching a 1/8" diameter brass rod to brush J 8152. After cleaning, dry the cylinder head with compressed air.

A service replacement cylinder head includes the exhaust valve guides, valve seat inserts, water nozzles, injector tubes, pilot sleeves, bridge guides, valve spring seats and the necessary plugs. In addition, studs, cover plates, gaskets, lock washers and nuts are provided to seal the water outlet openings that are not required on certain engines. A length of flexible fuel hose and fittings are also included where required.

Injector clamp bolts or studs are not included and it is necessary to use new parts or transfer the old parts to the new head. Injector clamp bolts are interchangeable with the former studs and nuts; the special washer is used with either the bolt or stud.

NOTE: When replacing a former cylinder head equipped with separate fuel manifolds by a current head, a reversal of fuel flow through the injectors may occur. Replace the injector fuel filters to prevent foreign matter in the old filters from entering the injectors.

The current cast iron service heads which are applicable to engines with an aluminum cylinder block use the same copper water nozzles as used in other cylinder heads. When installing a new head on an aluminum block which does not incorporate the steel water hole inserts (Section 1.0), it is recommended that a water filter be installed on the engine. The water filter tends to retard, but does not stop, electrolytic action.

Assemble Cylinder Head

After cleaning and inspection, assemble the cylinder head as follows:

1. Coat the threads of the plugs with Loctite Pipe Sealant with Teflon, then install the necessary plugs and tighten them to the specified torque (Section 1.0). Drive headless plugs flush to .0625" below the surface of the cylinder head. The 3/8" socket head oil gallery plug, at each end of the head, must not protrude more than .0625", and a .2187" diameter rod placed in the vertical oil feed hole must pass the inner face of the plug. Refer to the *Cylinder Head Plugging Charts* shown as fold-outs at the end of this manual.

2. After the following parts are cleaned, inspected and replaced, if necessary, reinstall them in the old cylinder head or transfer them to the new head.

a. Exhaust valves, valve seat inserts and springs (Section 1.2.2).

b. Cam followers, guides, push rods, springs,

© 1983 General Motors Corp.

retainers, rocker arms, shafts, brackets and other related parts (Section 1.2.1).

c. Place new washers on the fuel connectors. Then install the connectors and tighten them to 40-45 lb-ft (54-61 Nm) torque.

NOTE: If separate fuel manifolds are used (early cylinder head), install the manifolds and fuel connectors (refer to Section 2.4). If a new cylinder head is used, discard the manifolds and old fuel connectors.

d. The fuel injectors, fuel pipes, injector control tube assembly and water manifold, if used, can be installed at this time or after the cylinder head is installed on the engine.

e. Attach the engine lifter brackets temporarily to the cylinder head, without gaskets, to permit lifting the head into position. The lifter brackets must not be permanently attached until the cylinder head attaching bolts have been installed and tightened to the specified torque.

Pre-Installation Inspection

Make the following inspections just prior to installing the cylinder head whether the head was removed to service only the head or to facilitate other repairs to the engine.

1. Check the cylinder liner flange heights with relationship to the cylinder block (Section 1.6.3).

2. Make sure the piston crowns are clean and free of foreign material.

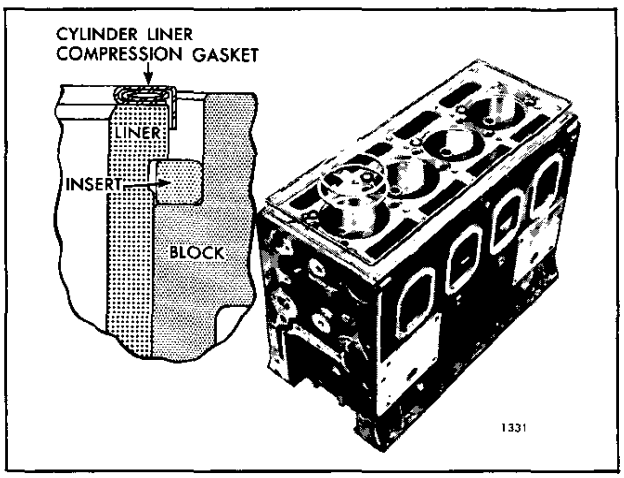


Fig. 16 - Cylinder Head Seals and Gaskets

3. Make sure that each push rod is threaded into its clevis until the end of the push rod projects through the clevis. This is important since serious engine damage will be prevented when the crankshaft is rotated during engine tune-up.

4. Check the cylinder block and cylinder head gasket surfaces, counterbores and seal grooves to be sure they are clean and free of foreign material. Also check to ensure that there are no burrs or sharp edges in the counterbores.

5. Inspect the cylinder head bolt holes in the block for accumulation of water, oil or any foreign material. Clean the bolt holes thoroughly and check for damaged threads.

6. Check for extruded areas around the stud holes in the top of the cylinder block, if studs are used. Also check the studs for damaged threads.

7. Check the four corner plugs or drive pins, used to plug the vertical oil galleries, to ensure that they are flush with or below the top surface of the cylinder block.

Install Cylinder Head

1. Refer to Fig. 16 and install the water and oil seal rings and compression gaskets as follows:

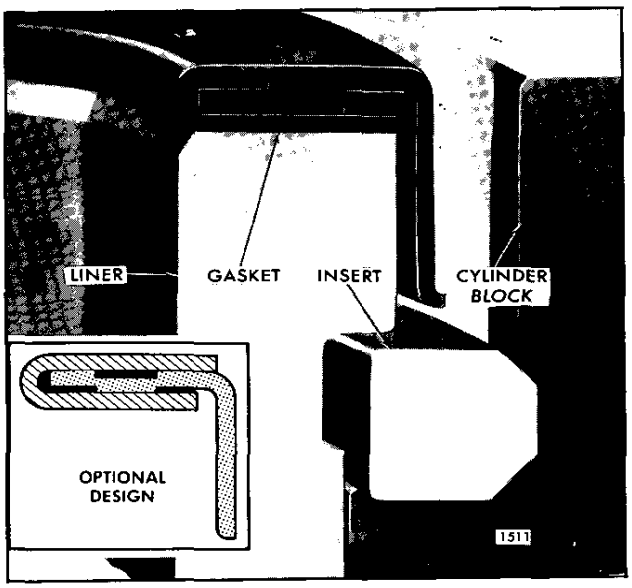


Fig. 17 - Compression Gasket Mounting in Cylinder Block

© 1983 General Motors Corp.

NOTE: Never install used compression gaskets or seals.

a. Place a new compression gasket on top of each cylinder liner. A new cylinder liner compression gasket with improved sealing capabilities is now being used (Fig. 17). The new gasket can be identified by GM-MC-H, GM-VG-H or GM-FP-H. The compression gasket is also color coded black, orange or white. The service gasket kits will only include a single color (black or orange). Only one color compression gaskets (seal) can be used under a single cylinder head to provide proper clamping.

NOTE: The new cylinder liner compression gasket is not interchangeable on an engine under the same cylinder head with the former compression gasket. Mixing of the former gasket with the new gasket could result in uneven loading.

b. Place new seal rings in the counterbores of the water and oil holes in the cylinder block. Silicone-composition water hole seals can be damaged if they move out of position in the cylinder block counterbore during engine rebuild. In turn, damaged seals can allow engine coolant to contaminate lube oil and cause serious engine damage. To prevent this, a spray adhesive may be used to hold seals in place if the following precautions are taken:

1. Attach a mask or template to the cylinder block fire deck to minimize overspray.

2. Using a high-tack, spray tube adhesive suitable for synthetic rubber seals (*3M Company Super-Tack Gasket Adhesive #8082,* or equivalent), spray a *light,* uniform coating of adhesive into the seal counterbores. Keep the adhesive off of adjacent block surfaces and wipe off any that gets on the fire deck or liner bores.

3. Allow the adhesive to dry to a high-tack consistency (stickiness) before installing the seal. This permits the evaporation of the liquid propellant used with the adhesive. Do not apply adhesive directly to the seal. The adhesive will coat the inner diameter of the seal and the spray propellant may cause the seal to swell temporarily.

c. Install a new oil seal in the groove at the perimeter of the cylinder block. The seal must lay flat in the groove and must not be twisted or stretched when installed. Installing the seal strip in the groove with the colored stripe facing away from the cylinder bores can improve its sealing capabilities.

NOTE: 3M Company Super-Tack Gasket adhesive #8082 or equivalent may also be used to hold the peripheral head-to-block oil seals in place during engine rebuild.

2. To install the cylinder head on the engine without disturbing the gaskets and seals, install guide studs J 9665 in two corner bolt holes in the cylinder block.

NOTE: Current four-valve cylinder heads have piloting sleeves installed in the corner bolt holes on the camshaft side of the head (former heads had the piloting sleeves on the exhaust side). A new pilot sleeve is available for the three and four cylinder heads. It has a larger outside diameter. The inside diameter remains the same standard size. The sleeves provide more accurate alignment of the cylinder head with the block bores. *Do not install the guide studs in the bolt holes which line-up with piloting sleeves in the head.* The guide studs are not required on early engines which include cylinder head studs in the block.

3. Insert the hooks of a chain, attached to a hoist, in the vent holes of the cylinder head, or the lifter brackets, and lift the head into position above the cylinder block.

4. Make a final visual check of the compression gaskets and seals to ensure that they are in place before the cylinder head is lowered. *This is a very important check.* Gaskets and seals which are not seated properly will cause leaks and "blow-by" and result in poor engine performance and damage to the engine.

5. Wipe the bottom of the cylinder head clean. Then lower the head until it is about 1/2" from the surface of the cylinder block.

6. Apply a small amount of International Compound No. 2, or equivalent, to the threads and underside of the head of all cylinder head attaching bolts (to stud threads and head contact surface of stud nuts, if used). Then install a bolt through each piloting sleeve (four-valve head) at the corners of the head and thread them finger tight into the cylinder block. Continue to tighten these bolts (finger tight) as the head is lowered into position on the cylinder block. Either one of two types of stud nuts are used. Both faces of one nut are square with the threads. The other type nut has a shoulder on one face. The shoulder side must contact the cylinder head.

NOTE: Cylinder head bolts are especially designed for this purpose and must not be replaced by ordinary bolts.

7. After the head is in place, remove the guide studs

© 1983 General Motors Corp.

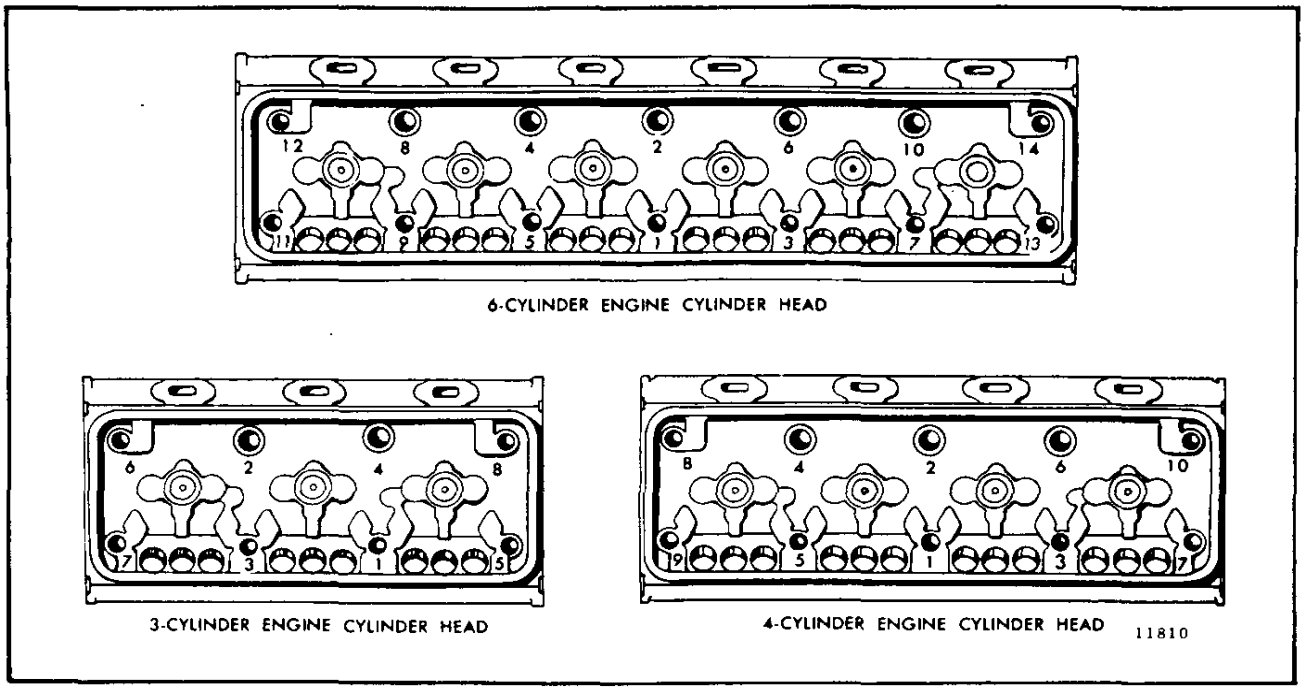


Fig. 18 - Cylinder Head Bolt Tightening Sequence

and chain hoist and install the remaining bolts, running all bolts down snug tight with a speed handle (15-20 lb-ft or 20-27 Nm torque). However, *before* tightening the bolts (or nuts), loosen the lifter bracket-to-cylinder head attaching bolts, otherwise the head may be prevented from seating properly on the cylinder block. A similar condition could exist if the exhaust manifold is attached to the cylinder head. Clearance must be assured between the exhaust manifold and the bosses on the cylinder block. On some engine models, these bosses serve as a rest for the exhaust manifold after the cylinder head has been installed on the cylinder block.

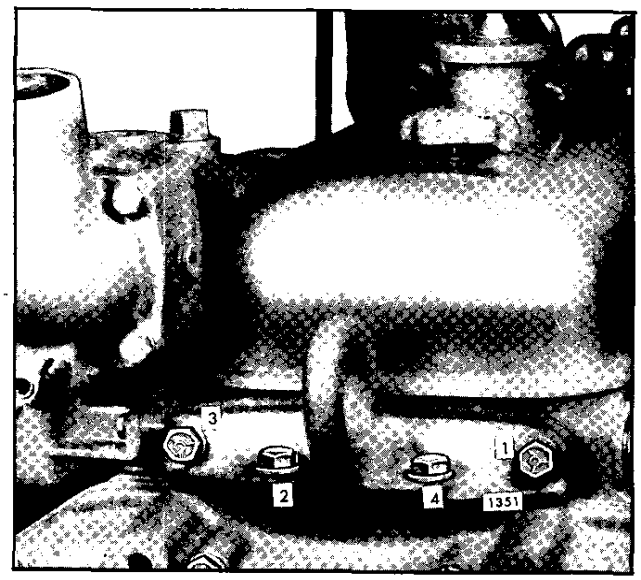


Fig. 19 - Lifter Bracket Bolt Tightening Sequence

8. Tighten the bolts (or nuts) to 170-180 lb-ft (231-244 Nm) torque in 50 lb-ft (68 Nm) increments with a torque wrench, in the sequence shown in Fig. 18. Repeat the tightening sequence at least once, because the first bolts tightened in the sequence tend to lose significant clamp load during tightening of the remaining bolts. Apply a steady pressure for two or three seconds at the prescribed torque to allow the bolts to turn while the gaskets yield to their final designed thickness. *Begin on the cam follower side of the head* to take up tension in the push rod springs. Tighten the bolts to the high side of the torque specification, but do not exceed the limit or the bolts may stretch beyond their elastic limits. Attempting to tighten the bolts in one step may result in trouble and consequent loss of time in diagnosis and correction of difficulties, such as compression leaks, when the engine is put into operation.

NOTE: Tightening the cylinder head bolts will not correct a leaking compression gasket or

© 1983 General Motors Corp.

seal. The head must be removed and the damaged gasket or seal replaced.

9. Tighten the two flywheel housing attaching bolts directly below the rear lifter bracket. Install a new gasket and secure the rear engine lifter bracket to the cylinder head and the flywheel housing. Tighten the bolts to 55-60 lb-ft (75-81 Nm) torque when threaded into cast iron or 35-40 lb-ft (47-54 Nm) torque when threaded into aluminum (Fig. 19).

10. Affix a new gasket to the front lifter bracket (or vent casting) and attach the bracket to the cylinder head and the balance weight cover. Tighten the bolts in the same sequence and to the same torque as on the rear lifter bracket bolts.

11. If the fuel injectors were not previously installed, refer to Section 2.1 or 2.1.1 and install them at this time.

12. On a four-valve cylinder head, adjust the exhaust valve bridges as outlined in Section 1.2.2.

13. Tighten the rocker arm bracket bolts to the specified torque (Section 1.0).

14. Align the fuel pipes and connect them to the injectors and the fuel connectors. Use socket J 8932-01 to tighten the connections to 12-15 lb-ft (16-20 Nm) torque.

NOTE: Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared ends of the fuel pipes and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings (refer to *Pressurize Fuel System - Check for Leaks* in Section 2.0).

15. Set the injector control tube assembly in place on the cylinder head and install the attaching bolts finger tight. When positioning the control tube, be sure the ball end of each injector rack control lever engages the slot in the corresponding injector control rack. With one end of the control tube return spring hooked around an injector rack control lever and the other end hooked around a control tube bracket, tighten the bracket bolts to 10-12 lb-ft (14-16 Nm) torque.

16. After tightening the bolts, revolve the injector control tube to be sure the return spring pulls the injector racks out (no-fuel position) after they have been moved all the way in (full-fuel position). Since the injector control tube is mounted in self-aligning bearings, tapping the tube lightly will remove any bind that may exist. The injector racks *must* return to the no-fuel position freely by aid of the return spring only. *Do not bend the spring.* If necessary, replace the spring.

17. When equipped with a hydraulic governor, start the fuel rod through the opening in the throttle rod bracket and the cylinder head. Press in the fuel rod knob and at the same time lower the subcap down on the governor housing so that the fuel rod enters the slot in the terminal lever and the fuel rod collar rests against the front finished surface of the terminal lever. Secure the subcap to the governor with bolts. Install bolts through the subcap the the throttle control bracket to secure the subcap to the cylinder head. Tighten the bolts.

18. When equipped with a mechanical governor, attach the fuel rod to the differential lever in the governor housing. Secure the governor to the cylinder head with bolts and lock washers.

19. Connect the governor fuel rod to the injector control tube lever.

20. Install the fuel filter and connect the fuel lines.

21. Install the exhaust manifold.

22. If used, install the water manifold.

23. Install the temperature gage thermocouple in the adaptor at the rear end of the water manifold.

24. Install the thermostat and secure the thermostat housing to the water manifold or heat exchanger with four bolts and lock washers.

25. Position the seal and clamp between the water manifold and the thermostat housing on a heat exchanger unit and tighten the seal clamp. Slide the hose into position on a radiator unit and secure it with two clamps.

26. Install any other equipment or parts that were previously removed.

27. Refer to Section 13.1 under *Preparation for Starting Engine First Time* and fill the cooling system and lubrication system.

28. Before starting the engine, perform an engine tune-up as outlined in Section 14.

© 1983 General Motors Corp.

VALVE AND INJECTOR OPERATING MECHANISM

Three rocker arms are provided for each cylinder (Fig. 1); the two outer arms operate the exhaust valves and the center arm operates the fuel injector.

Each set of three rocker arms pivots on a shaft supported by two brackets. A single bolt secures each bracket to the top of the cylinder head. Removal of the two bracket bolts permits the rocker arm assembly for one cylinder to be raised, providing easy access to the fuel injector and the exhaust valve springs.

The rocker arms are operated by the camshaft through cam followers and short push rods extending through the cylinder head.

Each cam follower operates in a bore in the cylinder head. A guide for each set of three cam followers is attached to the bottom of the cylinder head to retain the cam followers in place and to align the cam follower rollers with the camshaft lobes.

A coil spring, inside of each cam follower, maintains a pre-determined load on the cam follower to ensure contact of the cam roller on the camshaft lobe at all times.

Lubrication

The valve and injector operating mechanism is lubricated by oil from a longitudinal oil passage on the camshaft side of the cylinder head, which connects with the main oil gallery in the cylinder block. Oil from this passage flows through drilled passages in the rocker shaft bracket bolts to the passages in the rocker arm shaft to lubricate the rocker arms (Fig. 2).

Overflow oil from the rocker arms lubricates the exhaust valves, valve bridges and cam followers. The oil then drains from the top deck of the cylinder head through oil holes in the cam followers, into the camshaft pockets in the cylinder block and back to the oil pan.

The cam follower rollers are lubricated with oil from the cam followers, oil picked up by the camshaft lobes and by oil emitted under pressure from milled slots in the camshaft intermediate bearings.

Lubrication of the rocker arms and shafts on aluminum cylinder heads is provided by a vertical oil passage at one end of the cylinder head that aligns with the oil gallery in the cylinder block. Lubricating oil from this vertical passage enters the rocker arm shaft bracket through an elongated hole in the end of a spacer between the cylinder head and the rocker shaft bracket and fills the cavity surrounding the bracket hold-down bolt. The oil flows to the passages in the rocker arm shaft and then to the cavity surrounding the hold-down bolt in the opposite rocker shaft bracket. From this bracket, which is assembled on top of one end of a slotted intermediate spacer, oil passes along a slot in the spacer to the adjacent bracket mounted on the other end of the spacer. The intermediate spacers thus serve to channel lubricating oil from one valve and injector rocker arm unit to the adjacent unit.

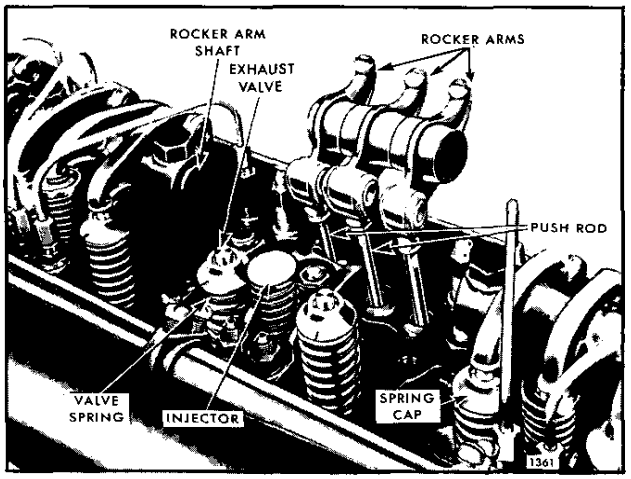


Fig. 1 - Valve and Injector Operating Mechanism (Two-Valve Head)

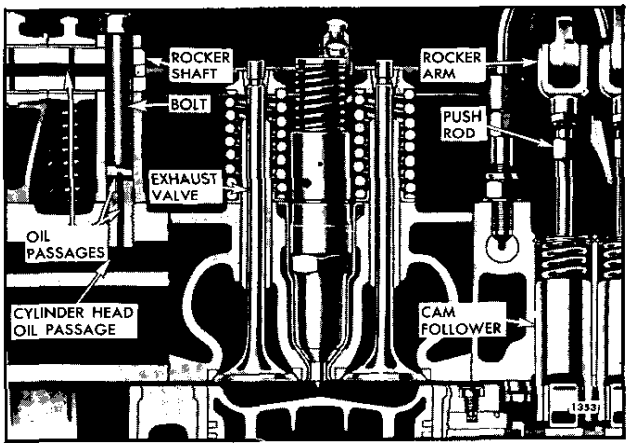


Fig. 2 - Lubrication of Valve Operating Mechanism

© 1982 General Motors Corp.

Service

Some service operations may be performed on the valve and injector operating mechanism without removing the cylinder head:

1. Adjust valve clearance.

2. Replace a valve spring.

3. Replace or adjust an exhaust valve bridge or replace a valve bridge guide (four-valve head).

4. Replace a rocker arm.

5. Replace a rocker arm shaft or bracket.

6. Replace a fuel injector.

It is also possible to replace a push rod, push rod spring, the spring seats or a cam follower without removing the cylinder head. However, these parts are more easily changed from the lower side when the cylinder head is off the engine. Both methods are covered in this section.

To replace the exhaust valves, valve guides and valve seat inserts, the cylinder head must be removed (refer to Section 1.2.2).

Remove Rocker Arms and Shaft

1. Clean and remove the valve rocker cover.

2. Remove the fuel pipes from the injector and the fuel connectors.

> **NOTE:** Immediately after removing the fuel pipes, cover the injector fuel inlet and outlet openings with shipping caps to prevent dirt or foreign material from entering.

3. Turn the crankshaft, or crank the engine with the starting motor, to bring the injector and valve rocker arms in line horizontally.

> **NOTE:** Do not bar the crankshaft in a left-hand direction of rotation with a wrench or barring tool on the crankshaft bolt, because the bolt may be loosened.

4. Remove the two bolts which secure the rocker arm shaft brackets to the cylinder head. Remove the brackets and shaft.

> **NOTE:** When removing the rocker arm shaft, fold the three rocker arms back just far enough so the shaft can be removed. *Do not force the rocker arms all the way back with the shaft in place as this may impose a load that could bend the push rods.*

5. Loosen the locknuts at the upper ends of the push rods, next to the clevises, and unscrew the rocker arms from the push rods.

> **NOTE:** If the rocker arms and shafts from two or more cylinders are to be removed, tag them so they may be reinstalled in their original positions.

Inspection

Wash the rocker arms, shaft, brackets and bolts with clean fuel oil. Use a small wire to clean out the drilled oil passages in the rocker arms and rocker shaft bolts. Dry the parts with compressed air.

Inspect the rocker arm shaft and rocker arm bushings for wear. A maximum shaft to bushing clearance of .004" is allowable with used parts (refer to Section 1.0). Service replacement bushings must be reamed to size after installation.

The current injector rocker arm used on coach engines does not use a bushing at the push rod clevis. The bore area is "lubrited" to provide improved lubrication in this area.

Inspect the rocker arms for galling or wear on the pallets (valve or injector contact surfaces). If worn, the

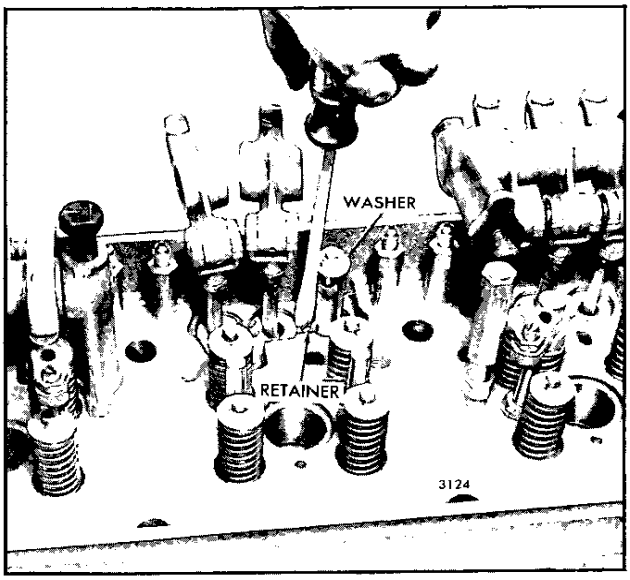


Fig. 3 - Removing Push Rod from Upper Side of Cylinder Head using Tool J 3092-01

© 1982 General Motors Corp.

surface may be refaced up to a maximum of .010". However, proceed with caution when surface grinding to avoid overheating the rocker arm. Maintain the radius and finish as close to the original surface as possible. Also inspect the valve bridges (four-valve head) for wear.

Remove Cam Follower and Push Rod (Cylinder Head on Engine)

When removing the cam followers and associated parts, tag them so they may be reinstalled in their original location.

To remove a push rod, spring, spring seats and cam follower from the top of the cylinder head, proceed as follows:

1. Remove the rocker arm shaft and brackets as outlined under *Remove Rocker Arms and Shaft.*

2. Loosen the locknut and unscrew the rocker arm from the push rod to be removed. Remove the locknut.

3. Install remover J 3092-01, a flat washer and the locknut on the push rod, with the lower end of the tool resting on the upper spring seat.

4. Thread the nut down to compress the spring.

5. Remove the spring seat retainer from the groove in the cylinder head (Fig. 3).

6. Unscrew the locknut to release the spring. Then remove the nut, flat washer and tool from the push rod.

7. Pull the push rod, spring, spring seats and cam follower out of the cylinder head.

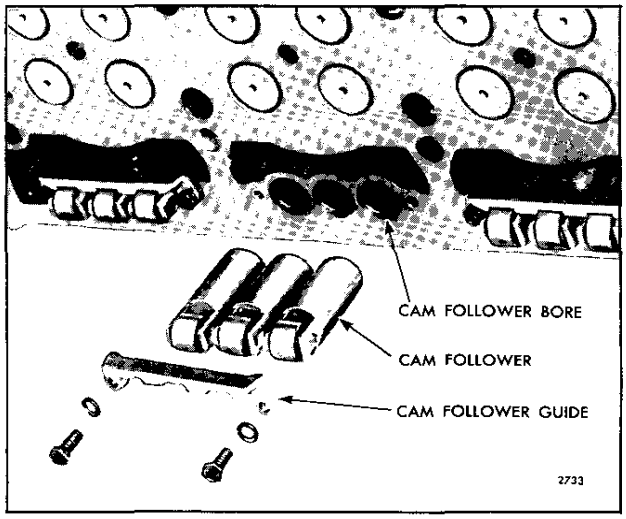


Fig. 4 - Cam Followers and Guide

Remove Cam Follower and Push Rod (Cylinder Head Removed)

When removing the cam followers and associated parts, tag them so they may be reinstalled in their original location.

1. Rest the cylinder head on its side and remove the cam follower guide (Fig. 4).

2. Pull the cam follower out of the cylinder head.

3. Remove the fuel pipes from the injector and the fuel connectors.

> **NOTE:** Immediately after removing the fuel pipes, cover the injector fuel inlet and outlet openings with shipping caps to prevent dirt or foreign material from entering.

4. Loosen the push rod locknut and unscrew the push rod from the rocker arm clevis.

5. Pull the push rod and spring assembly from the bottom of the cylinder head.

6. Remove the push rod locknut, spring and spring seats from the push rod.

If the cylinder head is to be replaced, remove the spring retainers and install them in the new head.

Inspection

Proper inspection and service of the cam follower is very necessary to obtain continued efficient engine performance. When any appreciable change in injector timing or exhaust valve clearance occurs during engine operation, remove the cam followers and their related parts and inspect them for excessive wear. This change in injector timing or valve clearance can usually be detected by excessive noise at idle speed.

Wash the cam followers with lubricating oil or Cindol 1705 and wipe dry. *Do not use fuel oil.* Fuel oil working its way in between the cam roller bushing and pin may cause scoring on initial start-up of the engine since fuel oil does not provide adequate lubrication. The push rods, springs and spring seats may be washed with clean fuel oil and dried with compressed air.

© 1982 General Motors Corp.

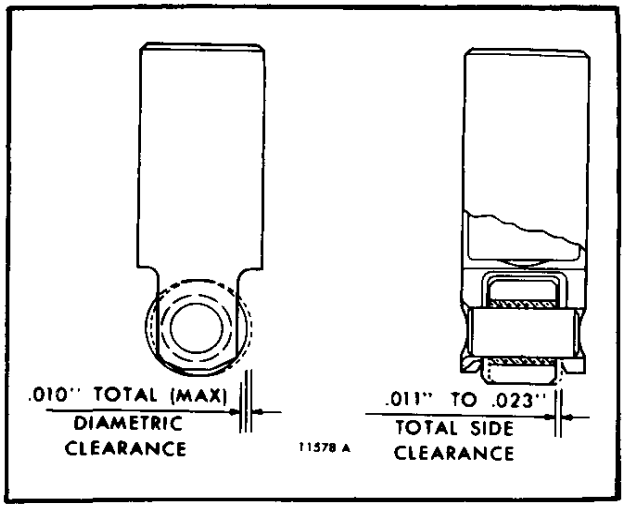


Fig. 5 - Cam Roller Clearances

Examine the cam follower rollers for scoring, pitting or flat spots. The rollers must turn freely on their pins. Measure the total diametric clearance and side clearance. Install a new roller and pin if the clearances exceed those specified in Fig. 5. Cam followers stamped with the letter "S" on the pin, roller and follower body are equipped with an oversize pin and roller. The same clearances apply to either a standard or oversize cam follower assembly.

Examine the camshaft lobes for scoring, pitting or flat spots. Replace the camshaft if necessary.

Measure the cam follower bores in the cylinder head with a telescope gage and micrometer and record the readings. Measure the diameter of the cam followers with a micrometer. Record the readings and compare the readings of the followers and bores to determine the cam follower-to-bore clearances (refer to Section 1.0 for specifications).

If the push rod breaks or is damaged, the rocker arm should be suspect. Any wear or excessive movement in the rocker arm or clevis can put a side load on the push rod, resulting in fracture or damage. Before replacing the push rod, inspect the rocker arm for signs of wear or cracking. If wear or excessive movement of the rocker arm or clevis is noted, replace the rocker arm.

Inspect the push rods and spring seats for wear. The current push rods have milled wrench flats and a bright "turned" finish and the lower spring seats are serrated along the push rod contact surfaces (Fig. 6).

NOTE: When replacing a push rod or lower spring seat, *do not* use a plain spring seat (Fig. 6) with a current type push rod. Any other combination of spring seat and push rod may be used.

Examine the cam follower springs for wear or damage and check the spring load. Replace a spring when a load of less than 172 lbs. will compress it to a length of 2.125". Use spring tester J 22738-02 to check the spring load (Fig. 7).

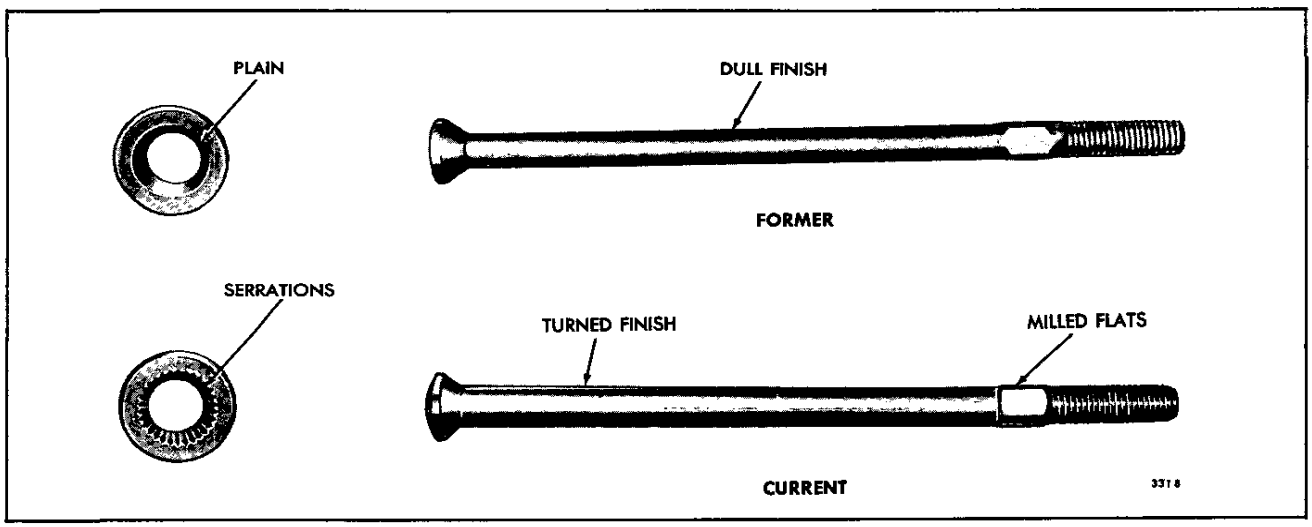


Fig. 6 - Comparison of Push Rods and Lower Spring Seats

© 1982 General Motors Corp.

Replace Cam Roller and Pin

To replace a cam roller and pin, proceed as follows:

NOTE: Do not attempt to bore out the legs of a standard cam follower for an oversize pin.

DISASSEMBLE CAM FOLLOWER

1. Pull the adjustable sliding support out against its stop (Fig. 8).

2. Place the cam follower with follower pin resting on the spring-loaded guide pin in the fixture. Push the follower down until the lower leg engages the slot in the support plate. This supports the roller which in turn supports the upper follower leg. Then, push the follower in until contact is made with the roller stop screw. This should put the roller pin in alignment with the pressing ram.

3. Lower the handle to put pressure on the roller pin.

4. Push the adjustable sliding support in until resistance is felt. This causes the lower follower leg to be supported.

5. Press the pin from the cam follower.

ASSEMBLE CAM FOLLOWER

NOTE: Before installing the new roller and pin, remove the preservative by washing the parts with clean lubricating oil or Cindol 1705 and wipe dry. *Do not use fuel oil.* After washing the parts, lubricate the roller and pin with Cindol 1705.

1. To install a new pin, pull the adjustable sliding support out and position the cam follower in the fixture (roller in place) as in Step 2 above.

NOTE: When assembling the cam follower with flats on the outside of the legs, push adaptor J 33421-3 onto the pressing ram to the limit depth of the press to the correct dimension. When pressing the pin into the follower with rounded legs, depth of the press is determined by the operator. Adapter J 33421-3 has a spring-loaded plunger in the set screw and does not normally require any adjustment

2. Align the pin over the follower leg, lower handle and place pressure on the pin.

3. To support the lower follower leg, push the adjustable sliding support in until resistance is felt.

4. Press the pin into place.

5. Remove the cam follower from the fixture and check the side clearance (Fig. 5). The clearance must be .011″ to .023″.

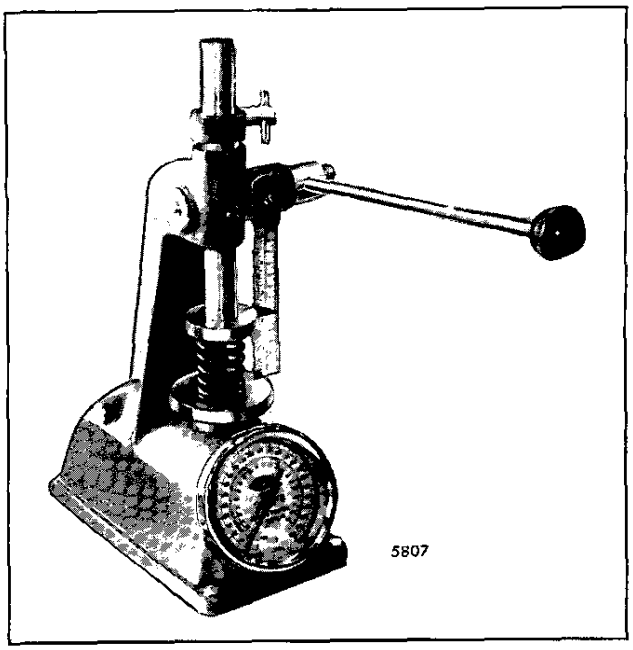


Fig. 7 - Testing Cam Follower Spring using Tool J 22738-02

Install Cam Follower and Push Rod

If new cam follower assemblies are to be installed, remove the preservative by washing with Cindol 1705 and wipe dry. *Do not use fuel oil.*

Before cam followers are installed, immerse them in clean Cindol 1705 (heated to 100-125° F or 38-52° C) for at least one hour to ensure initial lubrication of the cam roller pins and bushings. Rotate the cam rollers during the soaking period to purge any air from the bushing-roller area. The heated Cindol oil results in better penetration as it is less viscous than engine oil and flows more easily between the cam roller bushing and pin. After the cam followers are removed from the heated Cindol 1705, the cooling action of any air trapped in the bushing and pin area will tend to pull the lubricant into the cavity.

NOTE: Heat the Cindol 1705 in a small pail with a screen insert. The screen will prevent the cam followers from touching the bottom of the pail and avoid the possibility of contamination.

Install used cam followers and push rods in their original locations. Refer to Fig. 9 and proceed as follows:

CYLINDER HEAD ON ENGINE:

1. Note the oil hole in the bottom of the cam follower. With the oil hole directed away from the exhaust valves

© 1984 General Motors Corp.

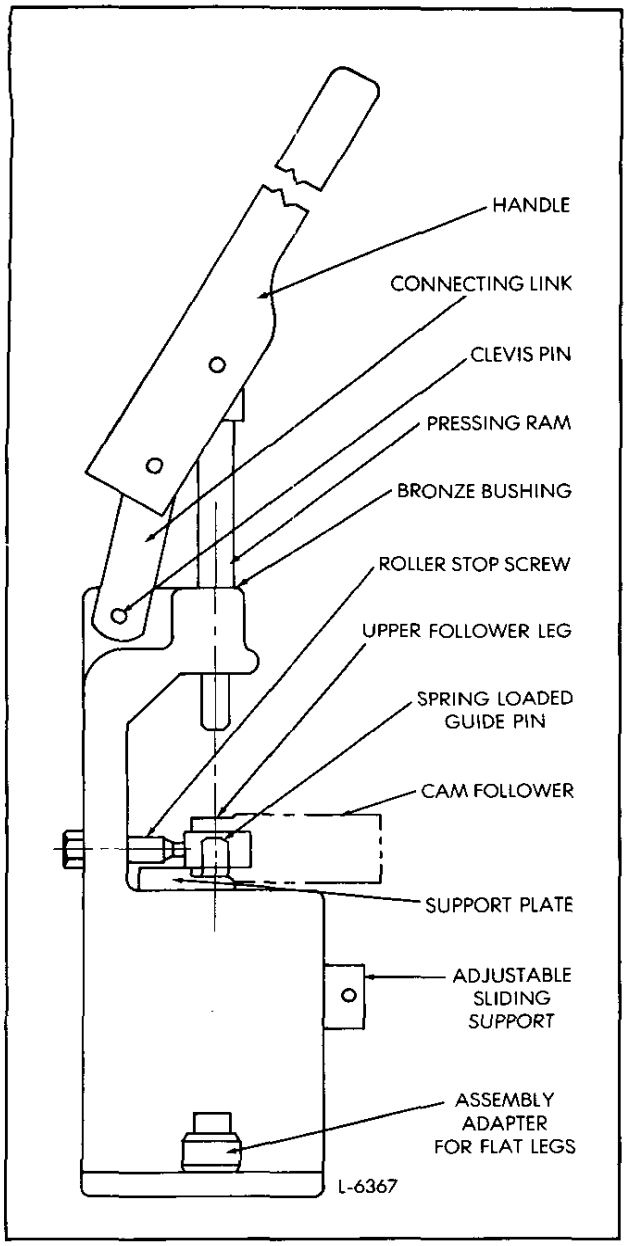


Fig. 8 - Removing or Installing Cam Follower Roller using Tool J 33421

(Fig. 10), slide the cam follower in position in the cylinder head.

2. Assemble the *serrated* lower spring seat (Fig. 6), spring and upper spring seat on the push rod.

3. Place a flat washer over the upper spring seat and start the locknut on the push rod. Place tool J 3092-01 on the push rod between the washer and the upper spring seat and place the push rod assembly in the cam follower. Then, thread the locknut on the push rod until the spring is compressed sufficiently to permit the spring retainer to be installed. Install the retainer with the tangs facing the notch in the cylinder head.

4. Remove the nut, flat washer and tool. Then reinstall the locknut and thread it as far as possible on the push rod.

CYLINDER HEAD REMOVED FROM ENGINE:

Refer to Fig. 9 and install the cam follower and push rod as follows:

1. Assemble the *serrated* lower spring seat (Fig. 6), spring, upper spring seat and locknut on the push rod.

2. With the spring retainer in place in the cylinder head, slide the push rod assembly in position from the bottom of the head.

3. Note the oil hole in the bottom of the cam follower. With the oil hole directed away from the exhaust valves

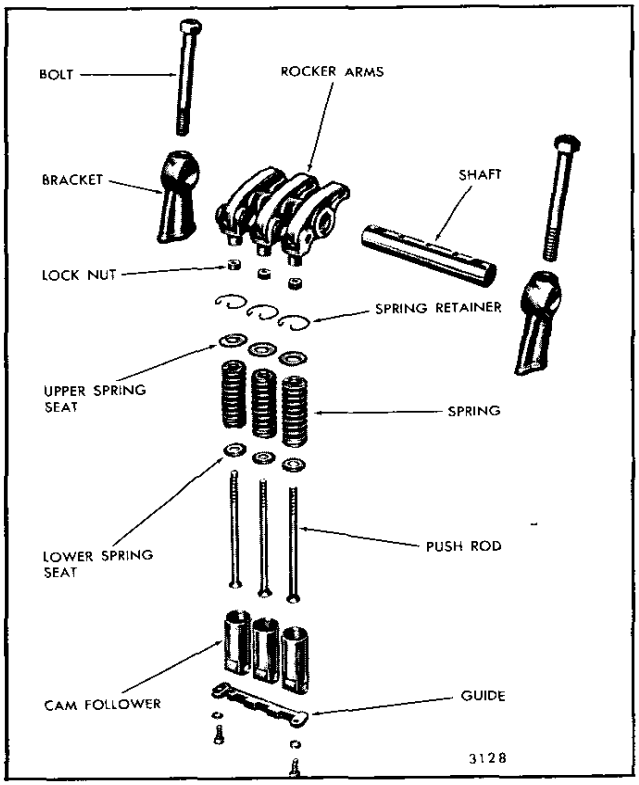


Fig. 9 - Valve and Injector Operating Mechanism and Relative Location of Parts

© 1984 General Motors Corp.

(Fig. 10), slide the cam follower in position from the bottom of the head.

4. Attach the follower guide to the cylinder head to hold the group of three cam followers in place. Tighten the guide bolts to 12-15 lb-ft (16-20 Nm) torque (cast iron head) or 7-9 lb-ft (10-12 Nm) torque (aluminum head). Check to be sure there is at least .005" clearance between the cam follower legs and the cam follower guide (Fig. 11). If there is insufficient clearance, loosen the guide bolts slightly and tap each corner of the guide with a brass rod (Fig. 12). Then, retighten the bolts to the specified torque.

NOTE: It is important to use the correct bolts as prescribed in the parts books. The hardened bolt is necessary to obtain the proper torque and to withstand the stress imposed on it during engine operation.

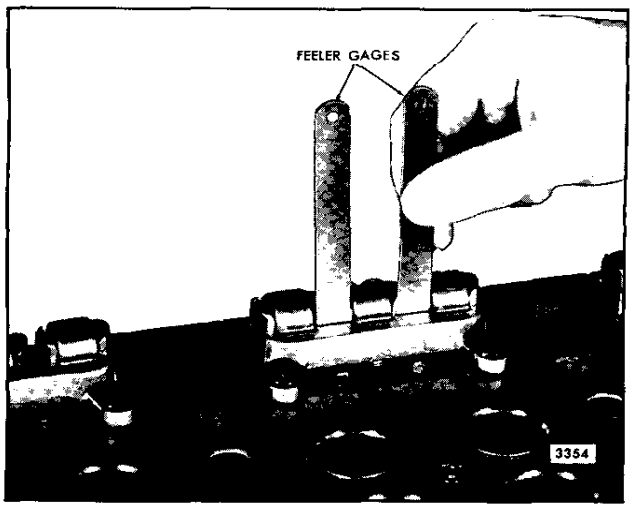


Fig. 11 - Checking Cam Follower to Guide Clearance

Install Rocker Arms and Shaft

The injector rocker arm (center arm of the group) is slightly different from the exhaust valve rocker arms; the boss for the shaft on the left and right-hand valve rocker arms is longer on one side. The extended boss of each valve rocker arm must face toward the injector rocker arm.

New injector rocker arm assemblies have an increased cross-sectional area between the pivot axis and pallet and the pivot axis and clevis. The former and current rocker arm assemblies are interchangeable and can be mixed in an engine. Only the new assemblies will be serviced.

NOTE: If the rocker arm is damaged or breaks, the push rod should *always* be changed when the new rocker arm is installed. A damaged rocker arm can cause side loading and weakening of the push rod. If reused, a side-loaded push rod can break.

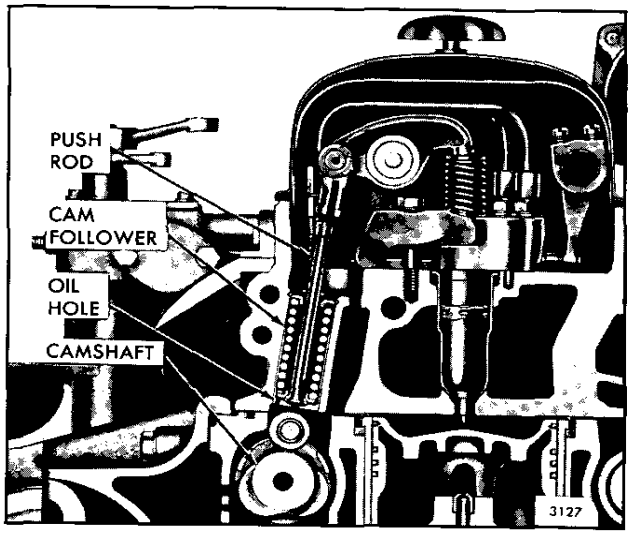


Fig. 10 - Installation of Cam Followers

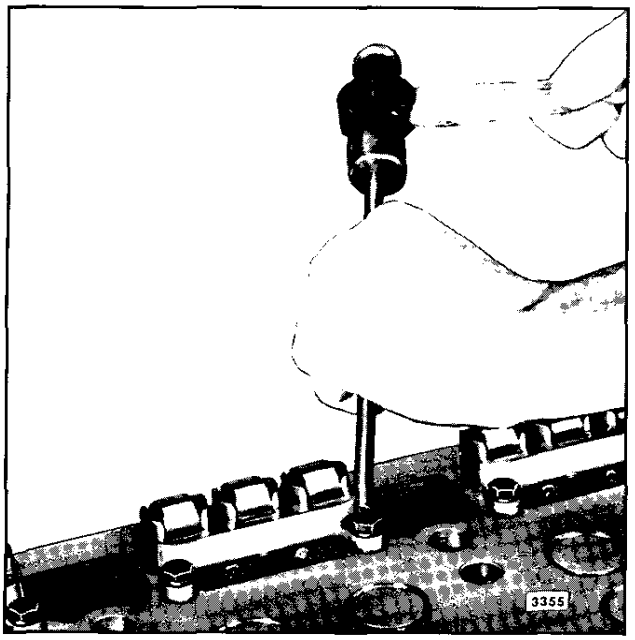


Fig. 12 - Adjusting Cam Follower Guide

© 1984 General Motors Corp.

1. Thread each rocker arm on its push rod until the end of the push rod is flush with or above the inner side of the clevis yoke. This will provide sufficient initial clearance between the exhaust valve and the piston when the crankshaft is turned during the valve clearance adjustment procedure.

2. If removed, install the cylinder head on the engine (refer to Section 1.2).

3. Lubricate the valve bridge guides (four-valve cylinder head) with sulphurized oil (E.P. type) and position the valve bridges in place on the guides. Refer to *Exhaust Valve Bridge Adjustment* in Section 1.2.2 and adjust the valve bridges.

4. If removed, install the fuel injectors.

5. Apply clean engine oil to the rocker arm shaft and slide the shaft through the rocker arms. Then place a bracket over each end of the shaft, with the finished face of the bracket next to the rocker arm.

6. Insert the rocker arm bracket bolts through the brackets and the shaft. Tighten the bolts to the specified torque (refer to Section 1.0).

7. Align the fuel pipes and connect them to the injectors and fuel connectors. Tighten the fuel pipe nuts to 12-15 lb-ft (16-20 Nm) torque using socket J 8932-01.

NOTE: Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared ends of the fuel pipes and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

8. Fill the cooling system.

9. Adjust the exhaust valve clearance (Section 14.1) and time the injectors (Section 14.2).

10. If necessary, perform an engine tune-up.

© 1984 General Motors Corp.

EXHAUST VALVES

Two or four exhaust valves are provided for each cylinder, depending upon the engine model (Figs. 1 and 2). The valve heads are heat treated and ground to the proper seat angle and diameter. The valve stems are ground to size and hardened at the end which contacts the rocker arm (two-valve head) or the exhaust valve bridge (four-valve head).

The exhaust valve stems are contained within exhaust valve guides which are pressed into the cylinder head (Fig. 3). Certain engines are equipped with exhaust valve guide oil seals.

Exhaust valve seat inserts (Fig. 3), pressed into the cylinder head, permit accurate seating of the exhaust valves under varying conditions of temperature and materially prolong the life of the cylinder head. The exhaust valves are ground to a 30° seating angle while the exhaust valve seat inserts are ground to a 31° seating angle.

The exhaust valve springs are held in place by the valve spring caps and tapered two-piece valve locks.

Excess oil from the rocker arms lubricates the exhaust valve stems. The valves are cooled by the flow of air from the blower past the valves each time the air inlet ports are uncovered.

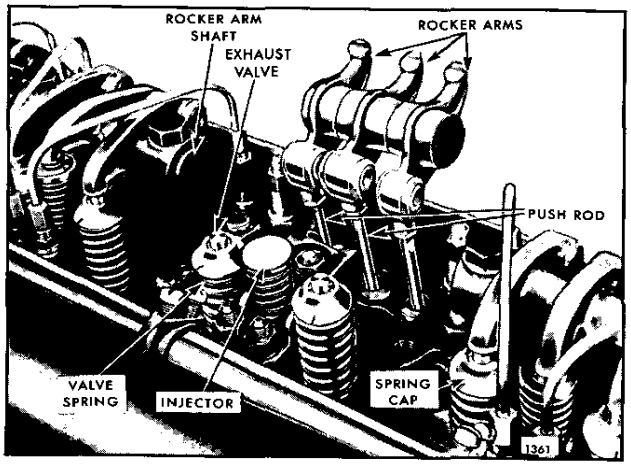


Fig. 1 - Location of Exhaust Valves (Two-Valve Cylinder Head)

Exhaust Valve Maintenance

Efficient combustion in the engine requires that the exhaust valves be maintained in good operating condition. Valve seats must be true and unpitted to assure leakproof seating, valve stems must work freely and smoothly within the valve guides and the correct valve clearance (Section 14.1) must be maintained.

Proper maintenance and operation of the engine is important to long valve life. Normal engine operating temperatures should be maintained (see Section 13.2). Low operating temperatures *usually due to extended periods of idling or light engine loads) result in incomplete combustion, formation of excessive carbon deposits and fuel lacquers on valves and related parts, and a greater tendency for lubricating oil to sludge.*

Unsuitable fuels may also cause formation of deposits on the valves, especially when operating at low temperatures.

When carbon deposits, due to partially burned fuel, build up around the valve stems and extend to that portion of the stem which operates in the valve guide, sticking valves will result. Thus, the valves cannot seat properly and pitted and burned valves and valve seats and loss of compression will result.

Lubricating oil and oil filters should be changed periodically to avoid the accumulation of sludge.

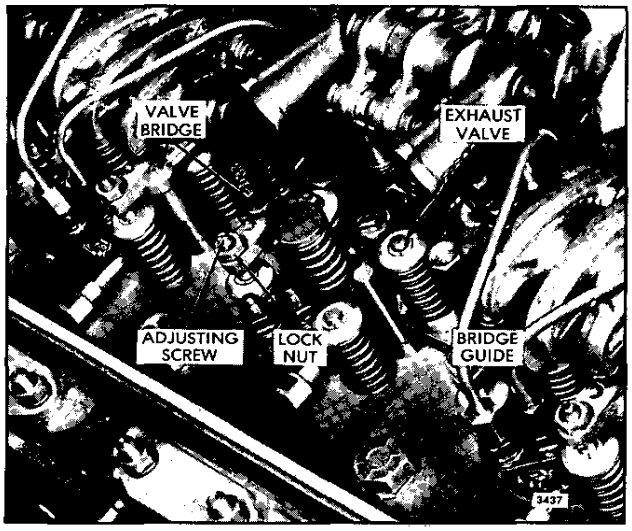


Fig. 2 - Location of Exhaust Valves (Four-Valve Cylinder Head)

© 1983 General Motors Corp.

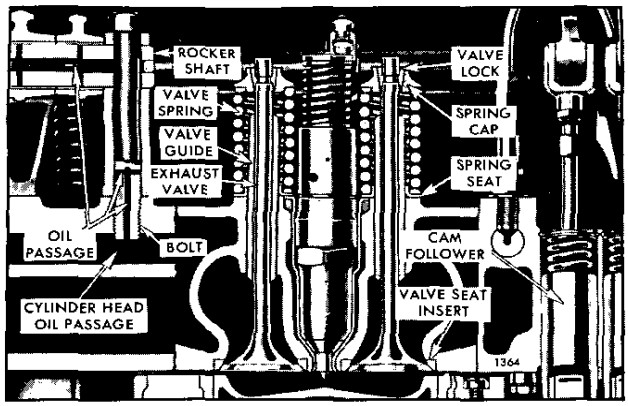


Fig. 3 - Assembly of Exhaust Valves and Guides

Valve sticking may also result from valve stems which have been scored due to foreign matter in the lubricating oil, leakage of antifreeze (glycol) into the lubricating oil which forms a soft sticky carbon and gums the valve stems, and bent or worn valve guides. Sticking valves may eventually be struck by the piston and become bent or broken.

It is highly important that injector timing and valve clearance be accurately adjusted and checked periodically. Improperly timed injectors or tightly adjusted valves will have adverse effects upon combustion.

Remove Exhaust Valve Spring (Cylinder Head Installed)

An exhaust valve spring may be removed, without removing the cylinder head from the engine, as follows:

1. Clean and remove the valve rocker cover.

2. Crank the engine over to bring the valve and injector rocker arms in line horizontally.

NOTE: When using a wrench on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation because the bolt may loosen.

3. Disconnect and remove the fuel pipes from the injector and the fuel connectors.

NOTE: Immediately after removing the fuel pipes, cover each injector opening with a shipping cap to prevent dirt or other foreign matter from entering the injector.

4. Remove the two bolts holding the rocker arm shaft brackets to the cylinder head. Then, remove the brackets and shaft.

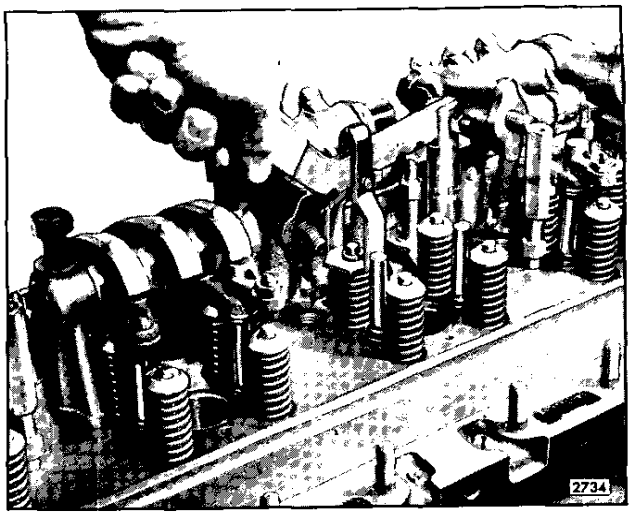


Fig. 4 - Removing Exhaust Valve Spring (Four-Valve Head Shown) using Tool J 7455

5. Remove the exhaust valve bridge (four-valve cylinder head only) and bridge spring (if used).

6. Remove the cylinder block air box cover so that piston travel may be observed, then turn the crankshaft until the piston is at the top of its stroke.

7. Thread the valve spring compressor adaptor J 7455-7 into one of the rocker arm bracket bolt holes in the

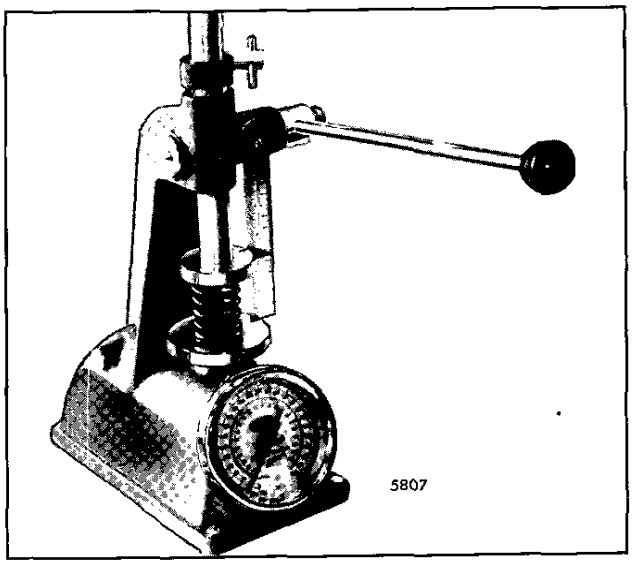


Fig. 5 - Testing Exhaust Valve Spring using Tool J 22738-02

© 1983 General Motors Corp.

cylinder head (Fig. 4). Then compress the valve spring and remove the two-piece tapered valve lock.

8. Release the tool and remove the valve spring cap, valve spring and spring seat.

Remove Exhaust Valves and Valve Springs (Cylinder Head Removed)

With the cylinder head removed from the engine, remove the exhaust valves and springs as follows:

1. Support the cylinder head on 2″ thick wood blocks to keep the cam followers clear of the bench.

2. Remove the fuel pipes from the injectors and the fuel connectors.

> **NOTE:** Immediately after removing the fuel pipes, cover each injector opening with a shipping cap to prevent dirt or other foreign matter from entering the injector.

3. Remove the two bolts holding the rocker arm shaft brackets to the cylinder head. Then, remove the brackets and the shaft.

4. Remove the fuel injectors.

5. Remove the exhaust valve bridges (four-valve cylinder head) and bridge springs.

6. Place a block of wood under the cylinder head to support the exhaust valves. Remove the exhaust valve springs as outlined in Steps 7 and 8 above.

7. Turn the cylinder head over, using care to keep the valves from falling out of the head. If the valves are to be reused, number each valve to facilitate reinstallation in the same location. Then, withdraw the valves from the cylinder head.

8. Remove the cam followers and push rod assemblies as outlined in Section 1.2.1 under *Remove Cam Follower and Push Rod Assembly (Cylinder Head Removed from Engine).*

Inspection

Clean the springs with fuel oil, dry them with compressed air and inspect them. Replace a pitted or fractured spring.

Use spring tester J 22738-02 to check the spring load (Fig. 5). Replace a two-valve cylinder head exhaust valve spring when a load of less than 25 pounds will compress it to 2.20″ (installed length). The exhaust

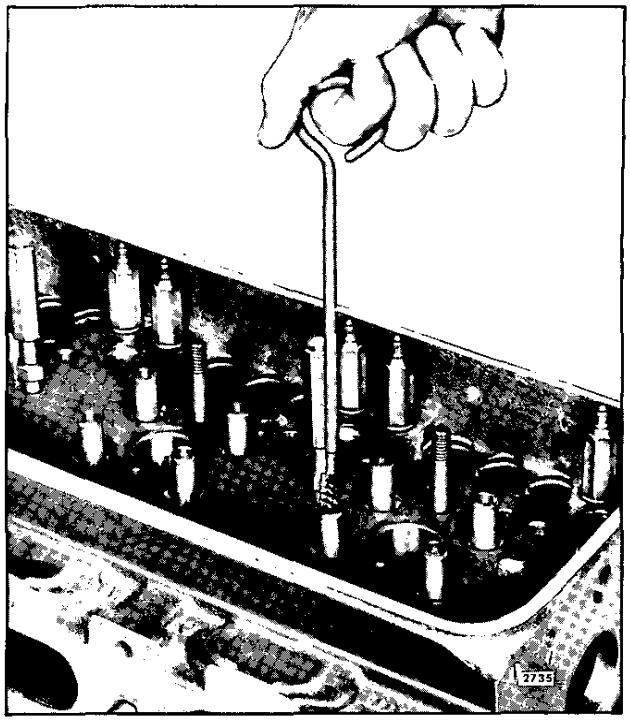


Fig. 6 - Cleaning Valve Guide

valve spring used on the current four-valve cylinder head has an outside diameter of approximately .953″. Replace this spring when a load of less than 25 pounds will compress it to 1.80″ (installed length). On former four-valve cylinder heads, a lighter exhaust valve spring (.859″ O.D.) was used for each valve and also for the valve bridge. Replace this spring when a load of less than 79 pounds will compress it to a length of 1.416″. When replacement of either the exhaust valve spring or valve bridge spring is required, it will be necessary to use the current larger exhaust valve springs, spring seats and caps *as the valve bridge spring is no longer required.*

> **NOTE:** When an exhaust valve spring is replaced on a four-valve head, both springs under a valve bridge should be replaced at the same time to ensure balanced valve operation.

Inspect the valve spring seats and caps for wear. If worn, replace with new parts.

Examine the contact surfaces of the exhaust valve bridge guides, bridges and adjusting screws for wear or galling. Replace excessively worn parts.

Carbon on the face of a valve could indicate blow-by due to a faulty seat. Black carbon deposits extending from the valve seats to the valve guides may result from

© 1983 General Motors Corp.

cold operation due to light loads or the use of too heavy a grade of fuel. Rusty brown valve heads with carbon deposits forming narrow collars near the valve guides is evidence of high operating temperatures. High operating temperatures are normally due to overloads, inadequate cooling or improper timing which results in carbonization of the lubricating oil.

Clean the carbon from the valve stems and wash the valves with fuel oil. The valve stems must be free from scratches or scuff marks and the valve faces must be free from ridges, cracks or pitting. If necessary, reface the valves or install new valves. If the valve heads are warped, replace the valves.

If there is evidence of engine oil running down the exhaust valve stem into the exhaust chamber, creating a high oil consumption condition because of excessive idling and resultant low engine exhaust back pressure, replace the valve guide oil seals or, if not previously used, install valve guide oil seals.

Clean the inside diameter of the valve guides with brush J 5437 (Fig. 6). This brush will remove all gum or carbon deposits from the valve guides, including the spiral grooves.

Inspect the valve guides for fractures, chipping, scoring or excessive wear. Measure the valve guide inside diameter with a pin gage or inside micrometer and record the readings. After inspecting and cleaning the exhaust valves, measure the outside diameter of the valve stems with a micrometer and record the readings. Compare the readings to obtain the valve-to-guide clearance. If the clearance exceeds .006" (two-valve head) or .005" (four-valve head), replace the valve guides.

Replace Exhaust Valve Guide

Remove an exhaust valve guide as follows:

1. Remove and discard the valve guide oil seal, if used.

2. Support the cylinder head, bottom side up, on 3" thick wood blocks.

3. Drive the valve guide out of the cylinder head with valve guide remover J 267 (two-valve head) or J 6569 (four-valve head) - (Fig. 7).

Place the cylinder head right side up on the bed of an arbor press and install the valve guide (Fig. 8) as follows:

1. Insert the internally threaded end of the valve guide in the proper valve guide installing tool (refer to Table 1). Be sure to use the correct tool to avoid damage to the valve guide, and to locate the valve guide to the proper dimension.



Fig. 7 - Removing Exhaust Valve Guide

When replacing the valve guides in a four-valve cylinder head, the current guide which is machined for use with a valve guide seal should be used in place of the 45° chamfered valve guide (Fig. 8). The current guide will facilitate field installation of valve guide seals when it is felt their use will be beneficial.

When replacing the valve guides in a two-valve cylinder head, use J 9530 with the current thin exhaust valve

VALVE GUIDE INSTALLER

Tool No.	Cylinder Head	Valve Guide	Distance of Guide Above Top of Head
J 9530 J 21520	2-Valve 4-Valve	Machined	1.530" .690"

TABLE 1

© 1983 General Motors Corp.

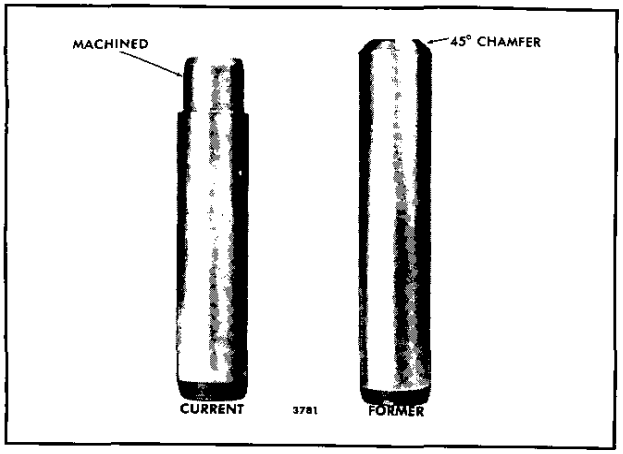


Fig. 8 - Former and Current Valve Guides

insert (.2505"-.2465") or when a valve guide oil seal is used.

2. Position the valve guide squarely in the bore in the cylinder head and press the installing tool gently to start the guide in place (Fig. 9). Then, press the guide in until the tool contacts the cylinder head.

> **NOTE:** Do not use the valve guides as a means of turning the cylinder head over or in handling the cylinder head.

Service replacement valve guides are completely finish reamed during manufacture and, therefore, do not require reaming after installation.

A service replacement valve guide which is .016" oversize on the outside diameter is also provided for service (two-valve cylinder head only).

3. Install a new valve guide oil seal, if used (refer to Item 5 under *Install Exhaust Valves and Springs*).

Inspect Exhaust Valve Bridge and Guide (Four-Valve Cylinder Head)

Inspect the valve bridge guide, valve bridge and adjusting screw for wear. Replace excessively worn parts.

The former threaded exhaust valve bridge guides have been replaced by press-fit bridge guides in the four-valve cylinder heads (Fig. 10). To conform with this change, current cylinder heads incorporate reamed bridge guide holes in place of the 7/16"-14 tapped

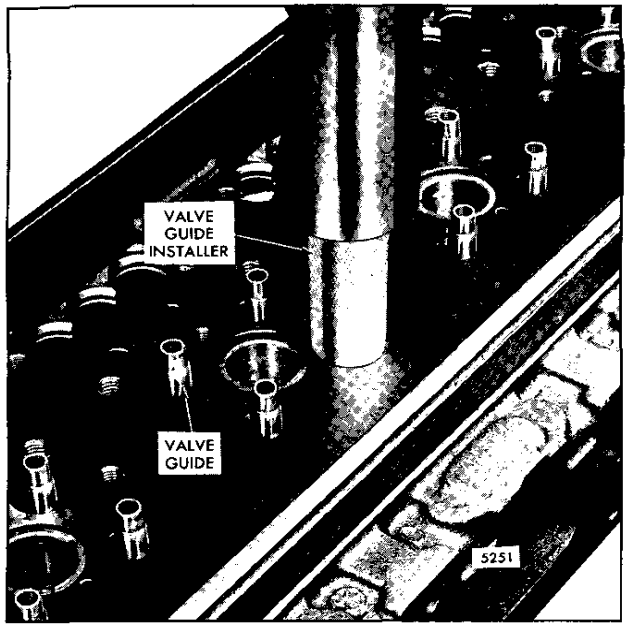


Fig. 9 - Installing Valve Guide

holes. The former threaded bridge guide had an integral spring seat to accommodate the valve bridge spring. To permit the use of spring-loaded valve bridges on a replacement cylinder head which incorporates the press-fit guides, separate valve bridge spring seats were used.

The current press-fit valve bridge guide is hardened steel while the valve bridge is relatively soft steel. The former threaded valve bridge guide was of soft steel and was used with a hardened steel valve bridge. The soft valve bridge may be identified by the letter "S" forged on one side of the bridge.

Avoid a combination of a soft steel guide and soft steel bridge, otherwise premature wear of the bridge and guide will occur. For service requirements, a threaded valve bridge guide of hardened steel is available and is identified by a 3/16" or 1/4" drill spot in the top end.

Two designs of the valve bridge are used. One has a drilled oil hole and the other has a forged oil hole in the side. The two bridges are interchangeable and can be mixed in an engine.

In addition, a new valve bridge adjusting screw with a redesigned valve contact surface replaces the former adjusting screw. The new screw may be identified by the machined (undercut) surface at the lower end of the screw. Only the new adjusting screw is available for service. Replace the former adjusting screws at the time of an engine overhaul.

© 1983 General Motors Corp.

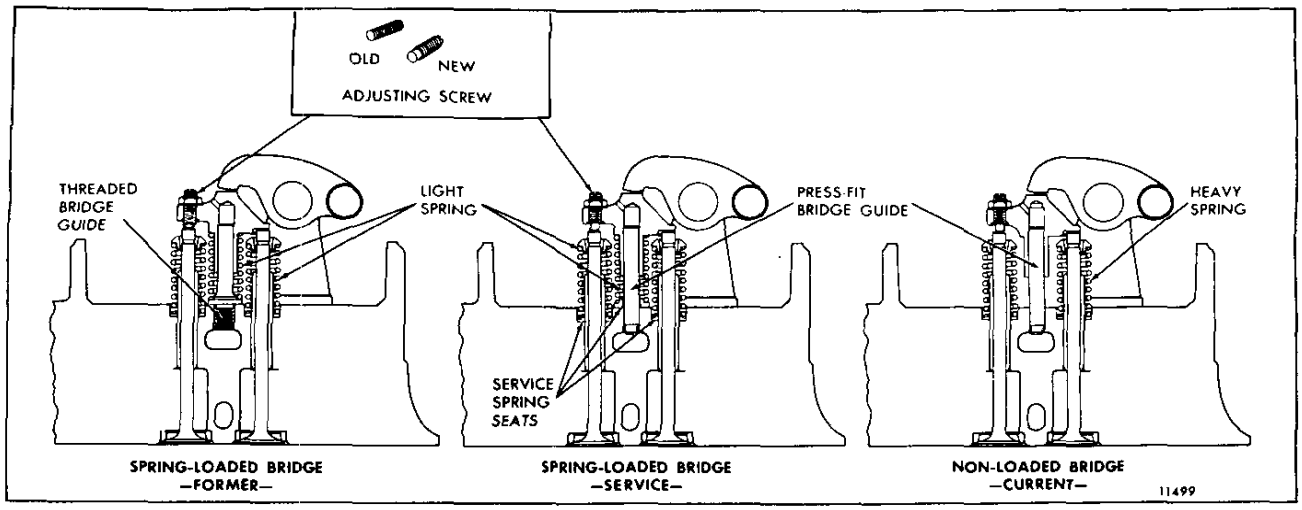


Fig. 10 - Exhaust Valve Bridge and Guide (Four-Valve Cylinder Head)

Remove Exhaust Valve Bridge Guide

Remove the valve bridge guide from a four-valve cylinder head as follows:

1. Remove the former threaded guide, identified by the hexagon section at the lower end, with socket J 6846.

2. Remove the press-fit guide (Fig. 11) with tool set J 7091-01 as follows:

a. File or grind two diametrically opposite notches 1/16" deep in the side of the guide, approximately 1-1/4" to 1-1/2" from the upper end.

b. Place spacer J 7091-3 over the guide. Then, slide the guide remover J 7091-5 over the guide and align the set screws with the notches in the guide. Tighten the set screws to hold the tool securely.

c. Place spacer J 7091-4 over the guide remover. Thread the nut on the guide remover and turn it clockwise to withdraw the guide from the cylinder head.

To remove a broken valve bridge guide, drill a hole approximately 1/2" deep in the end of the guide with a No. 3 (.2130") drill. Then, tap the guide with a 1/4"-28 bottoming tap. Thread remover J 7453 into the guide and attach slide hammer J 2619-01 to the remover tool. One or two sharp blows with the puller weight will remove the broken guide (Fig. 12).

Install Exhaust Valve Bridge Guide

Install the former threaded valve bridge guide with thin-wall socket J 6846. Lubricate the threads and nylon insert before installing the guide. Tighten the guide to 46-50 lb-ft (62-68 Nm) torque.

Install the current press-fit bridge guide as follows:

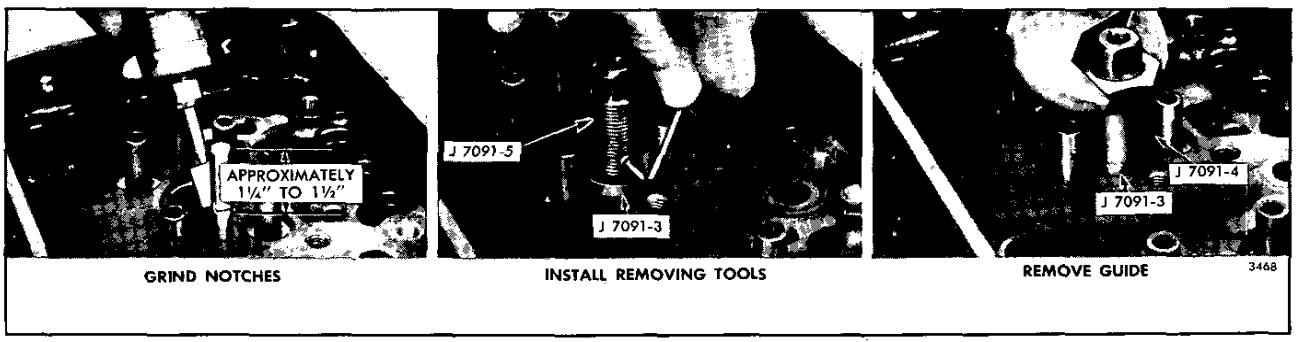


Fig. 11 - Removing Press-Fit Exhaust Valve Bridge Guide

© 1983 General Motors Corp.

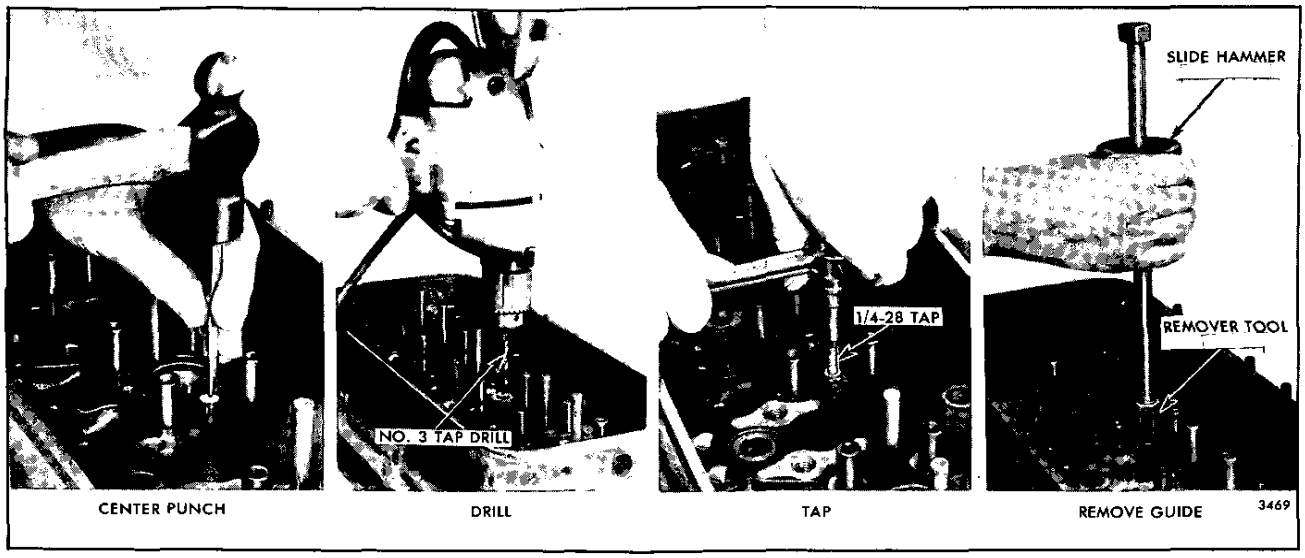


Fig. 12 - Removing Broken Exhaust Valve Bridge Guide using Tool J 7453 and Slide Hammer J 2619-01

Apply a sealant such as Permatex #1, 3M-EC971 or equivalent to the valve bridge guide.

1. Start the guide (undercut end first) into the cylinder head.

2. Place the installer J 7482 over the guide and drive it into place. The installer will properly position the guide to the correct height in the cylinder head (2.040").

Inspect Exhaust Valve Seat Insert

A new exhaust valve insert is pre-ground and only needs to be checked for concentricity after installation.

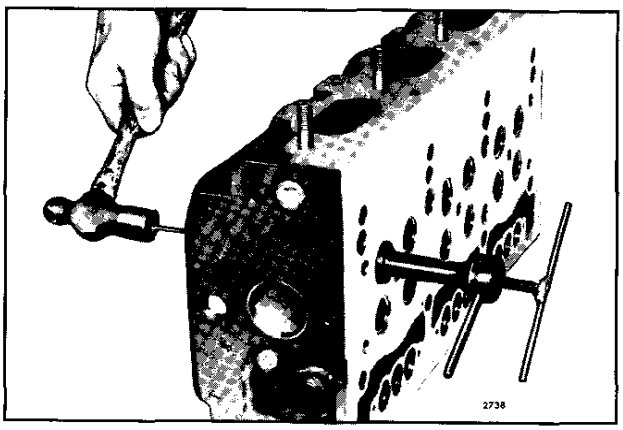


Fig. 13 - Removing Valve Seat Insert

Do not grind a new insert unless the runout exceeds .002".

Inspect the valve seat inserts for excessive wear, pitting, cracking or an improper seat angle. *The proper angle for the seating face of the valve is 30° and the angle for the insert is 31 °.*

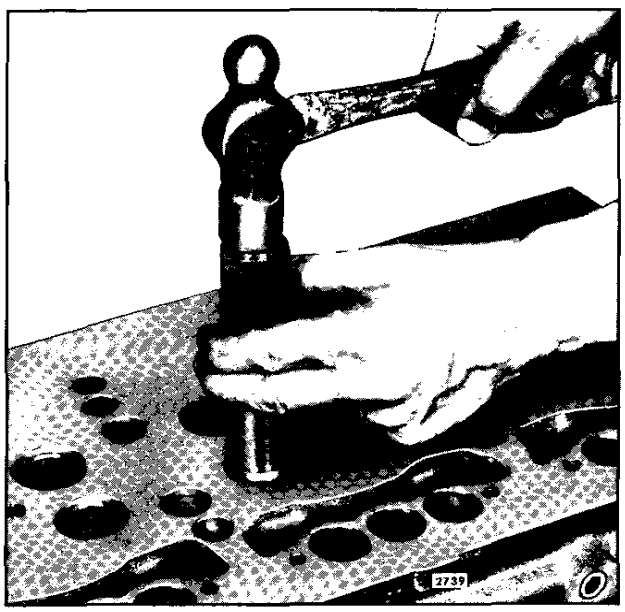


Fig. 14 - Installing Valve Seat Insert

© 1982 General Motors Corp.

Remove Exhaust Valve Seat Insert

The valve seat inserts are pressed into the cylinder head and must be removed as outlined in the following procedure to avoid damage to the cylinder head:

1. Place the cylinder head on its side as shown in Fig. 13.

2. Place the collet of tool J 4824-03 (two-valve head) or J 6567-02 (four-valve head) inside of the valve seat insert so that that bottom of the collet is flush with the bottom of the insert.

3. Hold the collet handle and turn the T handle to expand the collet cone until the insert is held securely by the tool.

4. Insert the drive bar of the tool through the valve guide.

5. Tap the drive bar once or twice to move the insert about 1/16" away from its seat in the cylinder head.

6. Turn the T handle to loosen the collet cone and move the tool into the insert slightly so the narrow flange at the bottom of the collet is below the valve seat insert.

7. Tighten the collet cone and continue to drive the insert out of the cylinder head.

> **NOTE:** In place of the above procedure, a *new* cam operated insert remover J 23479-15 and collet J 23479-9 (two-valve head) or J 23479-10 (four-valve head) can be used to remove the exhaust valve seat insert from the cylinder head.

Install Exhaust Valve Seat Insert

1. Clean the valve seat insert counterbores in the cylinder head with trichloroethylene or other suitable solvent. Also, wash the valve seat inserts with the same solvent. Dry the counterbores and the inserts with compressed air.

2. Inspect the counterbores in the cylinder head for cleanliness, concentricity, flatness and cracks. The counterbores in a two-valve cylinder head have a diameter of 1.626" to 1.627" and a depth of .3705" to .3845". The counterbores in a four-valve cylinder head have a diameter of 1.260" to 1.261" and a depth of .338" to .352". The counterbores must be concentric with the valve guides within .003" total indicator reading. Valve seat inserts which are .010" oversize on the outside diameter are available, if required.

3. Immerse the cylinder head for at least thirty minutes in water heated to 180-200° F (82-93° C).

4. Rest the cylinder head, bottom side up, on a bench and place an insert in the counterbore valve seat side up. Install the insert in the cylinder head while the head is still hot and the insert is at room temperature, otherwise installation will be difficult and the parts may be damaged.

5. Drive the insert in place with installer J 1736 (two-valve head) or J 6568 (four-valve head) as shown in Fig. 14 until it seats solidly in the cylinder head.

6. Check the valve seat inserts for concentricity in relation to the valve guides as outlined below.

Recondition Exhaust Valve and Valve Seat

An exhaust valve which is to be reused may be refaced, if necessary (Fig. 15). To provide sufficient valve strength and spring tension, the edge of the valve at the valve head must not be less than .031" in thickness and must still be within the specifications shown in Fig. 18 after refacing.

> **NOTE:** The seating area of the exhaust valve used on certain turbocharged engines is aluminized, which gives the valve seat a dull finish. *Do not remove the aluminum coating on a new valve.* However, a used valve may be refaced if necessary.

Before either a new or used valve is installed, examine the valve seat insert in the cylinder head for proper valve seating. *The proper angle for the seating face of the valve is 30° and for the valve seat insert it is 31°.*

When a new valve seat insert is installed or an old insert is reconditioned, the work must be done with a grinding wheel (Fig. 16).

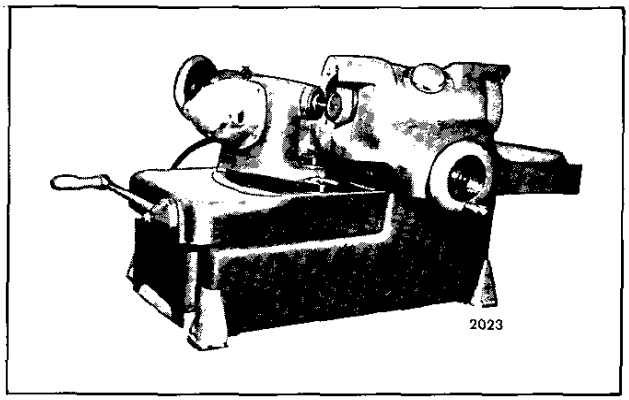


Fig. 15 - Refacing Exhaust Valve

© 1982 General Motors Corp.

The eccentric grinding method for reconditioning valve seat inserts is recommended. This method produces a finer, more accurate finish since only one point of the grinding wheel is in contact with the valve seat at any time. A micrometer feed permits feeding the grinding wheel into the work .001 " at a time.

Eccentric valve seat grinder set J 7040, which includes the grinder, dress stand and pilot, and dial gage, is used to grind the inserts. An adaptor set which includes the grinding wheels and pilot is used with the grinder.

Adaptor set J 6390-02, used for the four-valve head, consists of the following:

1. Pilot, tool J 7659-1.

2. Grinding wheel (15 °), tool J 6390-2.

3. Grinding wheel (31 °), tool J 6390-3.

4. Grinding wheel (60 °), tool J 6390-4.

Adaptor set J 8165-8, used for the two-valve cylinder head, consists of the following:

1. Pilot, tool J 8165-3.

2. Grinding wheel (15 °), tool J 8165-4.

3. Grinding wheel (31 °), tool J 8165-5.

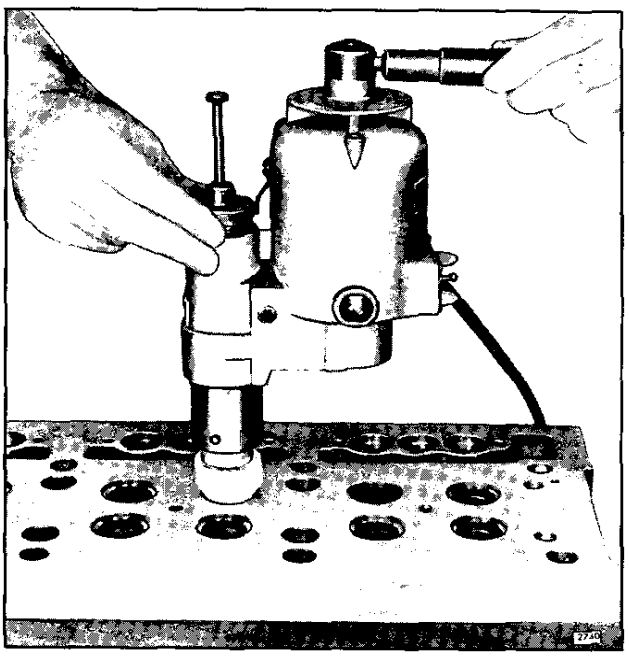


Fig. 16 - Reconditioning Valve Seat Insert

4. Grinding wheel (60 °), tool J 8165-7.

Grind the inserts as follows:

1. First apply the 31 ° grinding wheel on the valve seat insert.

2. Use the 60 ° grinding wheel to open the throat of the insert.

3. Grind the top surface of the insert with the 15 ° wheel to narrow the width of the seat to the dimensions shown in Fig. 18. The 31 ° face of the insert may be adjusted relative to the center of the valve face with the 15 ° and 60 ° grinding wheels.

NOTE: Do not permit the grinding wheel to contact the cylinder head when grinding the insert. When an insert has been ground to the extent that the grinding wheel will contact the cylinder head, install a new insert.

The maximum amount the exhaust valve should protrude beyond the cylinder head (when the valve is closed) and still maintain the proper piston-to-valve clearance is shown in Fig. 18. Grinding will reduce the thickness of the valve seat insert and cause the valve to recede into the cylinder head. If, after several grinding operations, the valve recedes beyond the specified limits, replace the valve seat insert.

NOTE: Engines with 18.7:1 compression ratios must incorporate valve seat inserts that are no more than .251 " thick to ensure adequate clearance between the pistons and the exhaust valves.

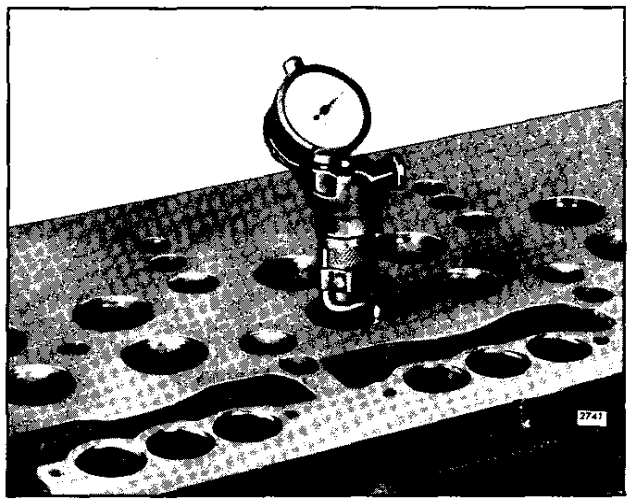


Fig. 17 - Determining Concentricity of Valve Seat Insert with Dial Indicator

© 1984 General Motors Corp.

When occasion requires, the grinding wheel may be dressed to maintain the desired seat angle with the dressing tool provided with the grinder set (Fig. 19).

4. After grinding has been completed, clean the valve seat insert thoroughly with fuel oil and dry it with compressed air. Set the dial indicator J 8165-2 in position as shown in Fig. 17 and rotate it to determine the concentricity of each valve seat insert relative to the valve guide. If the runout exceeds .002 ", check for a bent valve guide before regrinding the insert.

After the valve seat insert has been ground, determine the position of the contact area between the valve and the valve seat insert as follows:

1. Apply a light coat of Prussian blue, or a similar paste, to the valve seat insert.

2. Lower the stem of the valve in the valve guide and "bounce" the valve on the seat. *Do not rotate the valve.* This procedure will show the area of contact on the valve face. The most desirable area of contact is at the center of the valve face.

> **NOTE:** *The use of valve lapping compounds is* not recommended.

After the valve seat inserts have been ground and checked, clean the cylinder head before installing the valves.

Install Exhaust Valves and Springs

On four-valve cylinder heads that incorporate a spring-loaded valve bridge, a spring with 9/3/4 coils coils and an outside diameter of .859 " is used with each exhaust valve and valve bridge. On cylinder heads that do not incorporate the spring-loaded valve bridge, a heavier spring with 8-3/4 coils and an outside diameter of approximately .953 " is used on the exhaust valves only. Valve spring caps and seats of a corresponding diameter must be used with the valve springs. Since the current service cylinder heads are counterbored for use of the larger diameter spring, a service valve spring seat with a larger diameter and a raised center section is provided when the smaller spring is used.

Install the exhaust valves as follows:

1. Clean the valve guides.

2. Lubricate the valve stems with sulphurized oil (E.P. type) and slide the valves all the way into the guides.

> **NOTE:** If reconditioned valves are used, install them in the same relative location from which they were removed.

3. Hold the valves in place temporarily with a strip of masking tape. Then turn the cylinder head right side up on the work bench. Place a board under the head to support the valves and to provide clearance between the cam followers and the bench.

4. Install the valve spring seats.

5. Install the valve guide oil seals, *if used, on the valve* guides as follows:

a. Place a plastic seal installation cap of the proper size on the end of the valve stem. If the cap extends more than 1/6" below the groove on the valve stem, remove the cap and cut off the excess length.

b. Lubricate the installation cap with clean engine oil and start the seal carefully over the valve stem. Push the seal down slowly until it rests on top of the valve guide.

c. Remove the installation cap.

6. Install the valve springs and valve spring caps.

> **NOTE:** The current four-valve cylinder head valve spring caps have a ridge for identification

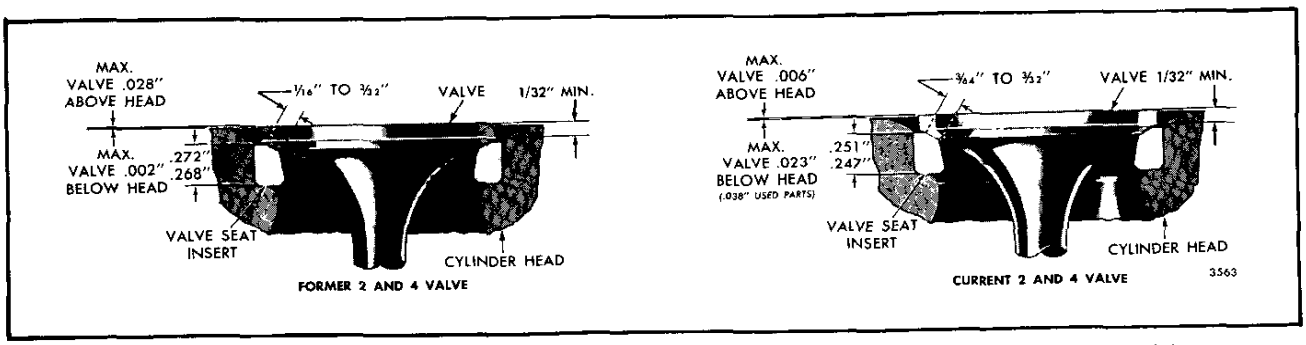


Fig. 18 - Relationship Between New Exhaust Valve, Insert and Cylinder Head (Both Exhaust Valve Seat Inserts Shown)

© 1984 General Motors Corp.

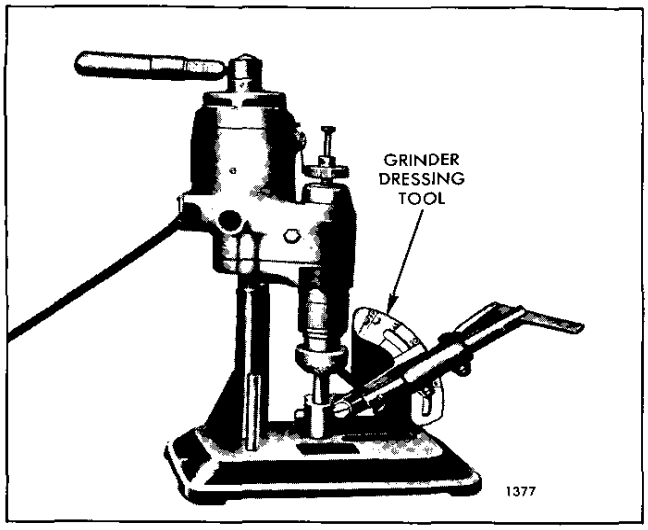


Fig. 19 - Grinding Wheel Dressing Tool of Set J 8165-1

7. Thread the valve spring compressor J 7455 into one of the rocker shaft bolt holes in the cylinder head (Fig. 4).

8. Apply pressure to the free end of the tool to compress the valve spring and install the two-piece tapered valve lock. Exercise care to avoid scoring the valve stem with the valve cap when compressing the spring.

NOTE: If valve guide oil seals are used, compress the valve spring only enough to permit installation of the valve locks. Compressing the spring too far may result in damage to the oil seal.

9. Release the tool and install the valve locks on the remaining exhaust valves in the same manner.

10. Check the position of the exhaust valves (Fig. 18). Support the cylinder head at each end with wood blocks and remove the masking tape so that the exhaust valves are free. Then give the end of the valve stem a sharp tap with a plastic hammer to seat the valve locks. This will aid in the proper seating of the valve locks and reduce the chances of failure.

11. With the exhaust valves installed in the cylinder head, use spring checking gage J 25076-01 and note the gage reading the moment the exhaust valve starts to open (Fig. 21). The minimum allowable pressure required to start to open the exhaust valve must not be less than 15 pounds for a two-valve cylinder head or 20 pounds for a four-valve cylinder head (two-spring design).

12. Install the injectors, rocker arms, shafts, brackets and any other parts previously removed from the cylinder head.

13. Install the cylinder head. Refer to *Pre-Installation Inspection* and *Install Cylinder Head* in Section 1.2. If the engine is equipped with a four-valve cylinder head, adjust the exhaust valve bridges as outlined below.

Exhaust Valve Bridge Adjustment

On an engine equipped with a four-valve cylinder head, the exhaust valve bridge assembly is adjusted and the adjustment screw is locked securely after the cylinder head is installed on the engine. Until wear occurs, or the cylinder head is reconditioned, no further adjustment is required on the valve bridge. A complete valve bridge adjustment is performed as follows:

1. Place the valve bridge in a vise or bridge holding fixture J 21772 and loosen the lock nut on the bridge adjusting screw.

NOTE: Loosening or tightening the lock nut with the bridge in place may result in a bent bridge guide or bent rear valve stem.

2. Install the valve bridge on the valve bridge guide, without the spring (if a spring-loaded bridge is used).

3. While firmly pressing straight down on the pallet surface of the valve bridge, turn the adjusting screw clockwise until it just touches the valve stem. Then turn the screw an additional 1/8 to 1/4 turn clockwise and tighten the locknut finger tight (Fig. 22).

4. Remove the valve bridge and place it in a vise. Hold the adjustment screw from turning with a screwdriver and tighten the locknut on the adjustment screw to 20-25 lb-ft (27-34 Nm) torque.

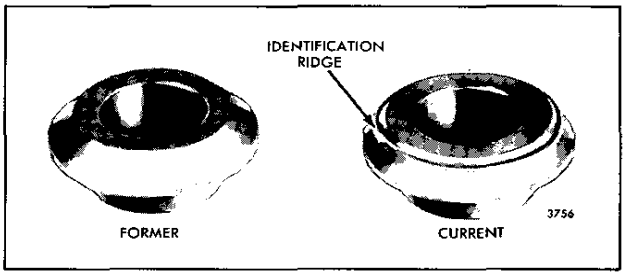


Fig. 20 - Former and Current Exhaust Valve Spring Caps (Four-Valve Heads)

© 1982 General Motors Corp.

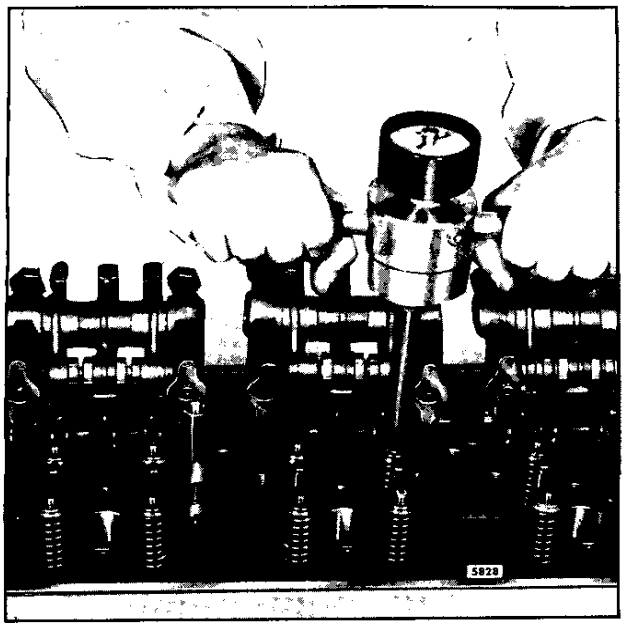


Fig. 21 - Checking Pressure Required to Open the Exhaust Valve in Cylinder Head with Tool J 25076-01

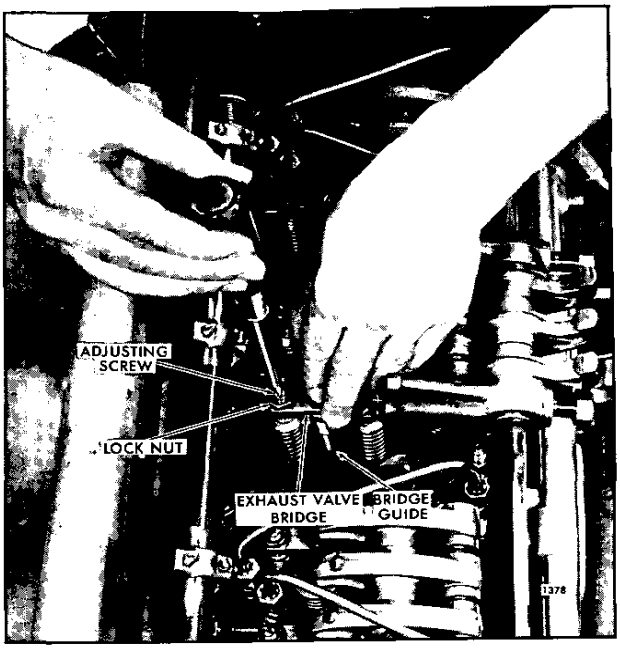


Fig. 22 - Valve Bridge Adjustment (Four-Valve Cylinder Head)

5. Lubricate the valve bridge guide and the valve bridge with engine oil.

6. Reinstall the valve bridge in its *original* position, without the spring (if a spring-loaded bridge is used).

7. Place a .0015" feeler gage (J 23185) under each end of the valve bridge or use a narrow strip cut from .0015" feeler stock to fit in the bridge locating groove over the inner exhaust valve. While pressing down on the pallet surface of the valve bridge, both feeler gages must be tight. If both of the feeler gages are not tight, readjust the adjusting screw as outlined in Steps 3 and 4.

8. Remove the valve bridge and reinstall it in its *original* position with the spring in place (if a spring-loaded bridge is used).

9. Adjust the remaining valve bridges in the same manner.

10. Swing the rocker arm assembly into position, making sure the valve bridges are properly positioned on the rear valve stems. This precaution is necessary to prevent valve damage due to mislocated valve bridges. Tighten the rocker arm shaft bracket bolts to the torque specified in Section 1.0.

After the cylinder head is installed and the valve bridges adjusted (four-valve head), proceed as follows:

1. Refer to Section 2.1 or 2.1.1 under *Install Injector* and install the fuel pipes.

2. Fill the cooling system.

> ***NOTE:*** *Remove the vent plug from the* thermostat housing or open the vent valve when filling the cooling system.

3. Adjust the exhaust valve clearance and time the injectors (Sections 14.1 and 14.2).

4. Start the engine and check for leaks in the fuel, cooling and lubrication systems.

5. Perform a complete engine tune-up as outlined in Section 14.

© 1982 General Motors Corp.

ENGINE LIFTER BRACKETS

The engine lifter brackets not only provide a means of lifting the engine assembly, the cylinder head or the flywheel housing, but also serve as a vent for the crankcase vapors.

On certain engines, such as marine units, eyebolts, installed in the front balance weight cover pads, serve as engine lifters; a vent casting is used in place of the rear engine lifter bracket (Fig. 1). The vent casting is provided with drilled bosses to which the heat exchanger tank is attached.

The rear engine lifter bracket may also be provided with drilled bosses to permit the use of a throttle control crosshaft Lifter brackets require no servicing other than removal during other service operations.

Install Engine Lifter Bracket

1. Remove all traces of the old gasket material.

2. Affix a new gasket to the front lifter bracket (or vent casting).

3. Attach the lifter bracket and gasket to the cylinder head with two bolts and to the front balance weight cover with two bolts.

NOTE: The lifter brackets must not be permanently attached until all of the cylinder head stud nuts or retaining bolts have been tightened to their specified torque.

4. Install the bolts finger tight, draw them down snug and then tighten to the specified torque. Draw the bolts down in the proper sequence (Fig. 2) for each of these steps to draw the mating parts together evenly, thus providing a good seal. Tighten the bolts to 55-60 lb-ft (75-81 Nm) torque when threaded into cast iron or 35-40 lb-ft (47-54 Nm) torque when threaded into aluminum.

5. Install the rear lifter bracket to the cylinder head and flywheel housing in a similar manner.

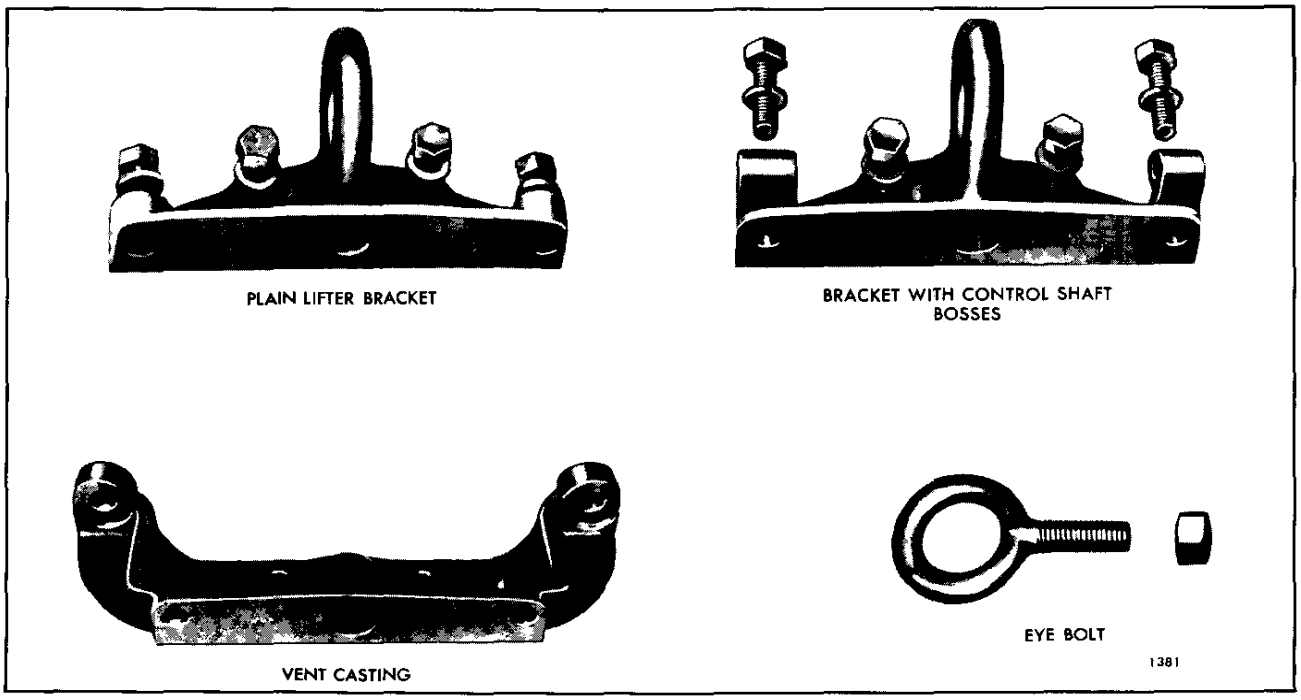


Fig. 1 - Various Types of Engine Lifter Brackets

© 1978 General Motors Corp.

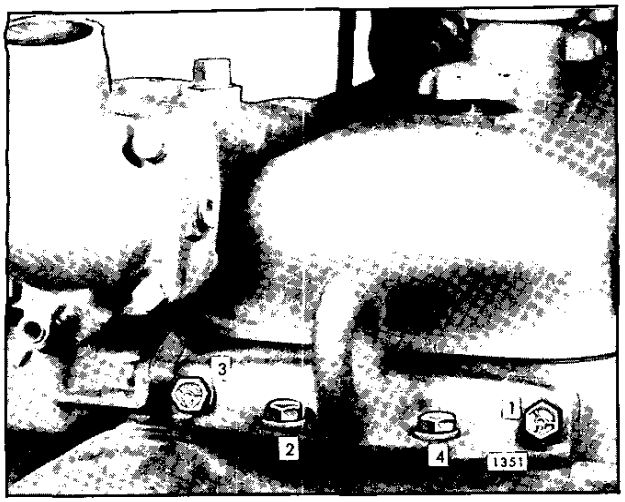


Fig. 2 - Typical Installation of Lifter Bracket and Bolt Tightening Sequence

© 1978 General Motors Corp.

VALVE ROCKER COVER

The valve rocker cover assembly (Fig. 1) completely encloses the valve and injector rocker arm compartment at the top of the cylinder head. The top of the cylinder head is sealed against oil leakage by a gasket located in the groove of the lower rail of the current die cast rocker cover or in the flange edge of the former stamped metal rocker cover.

An option plate is inserted in a retainer attached to the cover on each single engine unit and to one of the covers on a multiple engine unit.

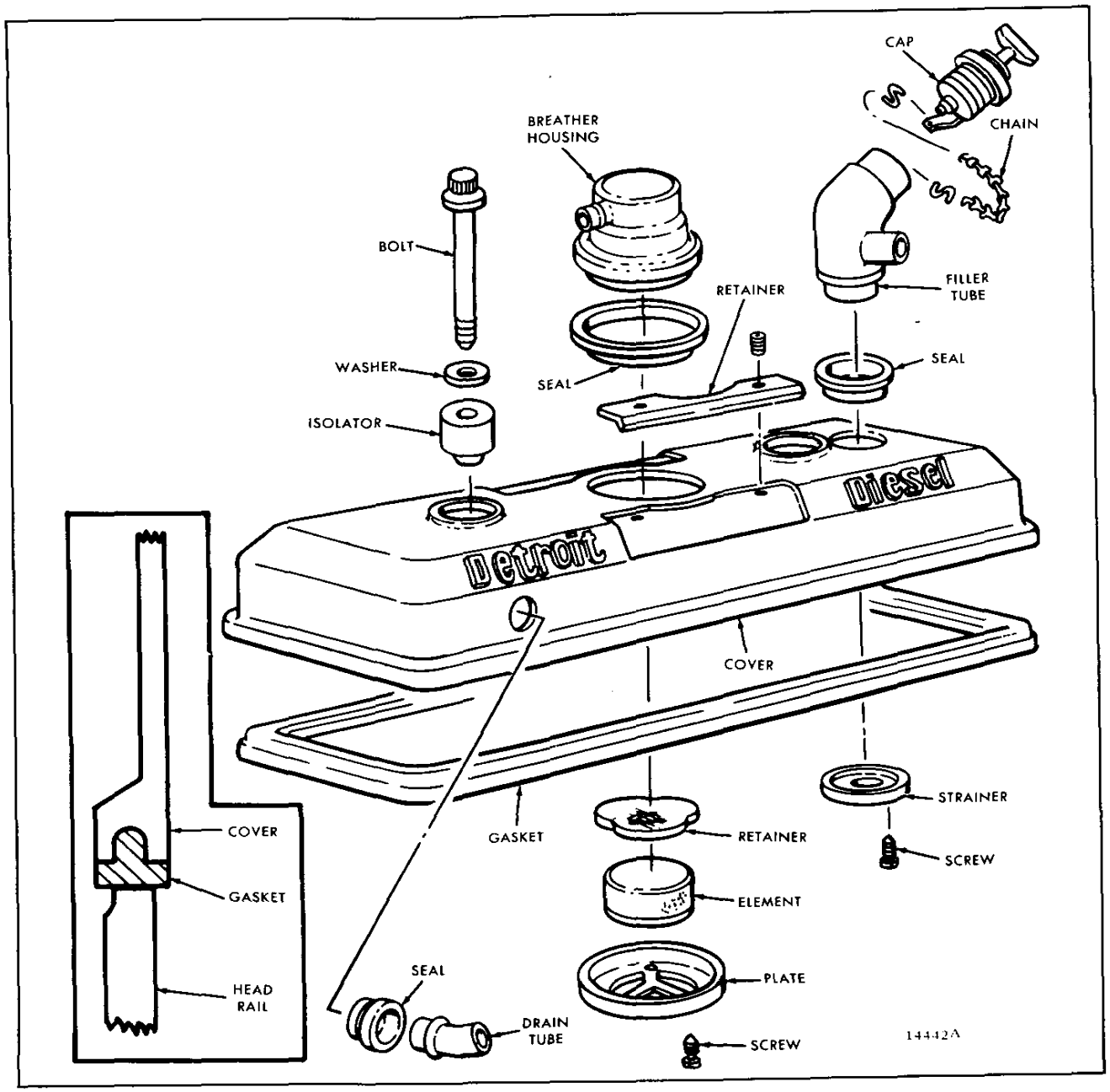


Fig. 1 - Typical Valve Rocker Cover Assembly (Current)

© 1979 General Motors Corp.

The current die cast rocker cover (Fig. 1) is held in place by 3/8 "-16 twelve-point head shoulder bolts with a steel washer and silicone isolator. The bolts have a shoulder which bottoms out against the cylinder head or throttle delay bracket. The isolaters and gasket use low compression-set materials which provide long sealing life and minimize engine noise levels. Tighten the bolts to 15-20 lb-ft (20-27 Nm) torque. The former stamped metal rocker cover is held in place with hold-down knobs (Fig. 2).

NOTE: The shorter rocker cover bolt, which threads into the throttle delay bracket, can crack the bracket if overtightened.

IMPORTANT: The rocker cover bolt is especially designed for this purpose and must not be replaced by an ordinary bolt.

The valve rocker cover assembly on certain engines may include a breather assembly or an oil filler, depending upon the engine application.

The former stamped metal rocker covers and the current die cast rocker covers are interchangeable. Only the current covers will be serviced. The former rocker cover gaskets, hold-down knobs and studs, and components of the former ventilating system and oil filler will be available for service on early engines.

When replacing a former stamped rocker cover with the new die cast aluminum rocker cover, remove the studs (adaptor) from the cylinder head. The new bolts are installed directly into the tapped holes in the cylinder head. A short (2.90 " long) bolt is used when the engine is equipped with a throttle delay or fuel modulator mechanism.

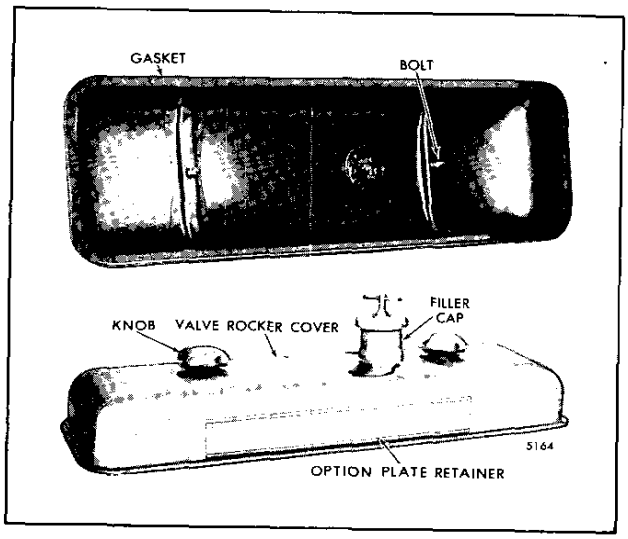


Fig. 2 - Valve Rocker Cover Assembly (Former)

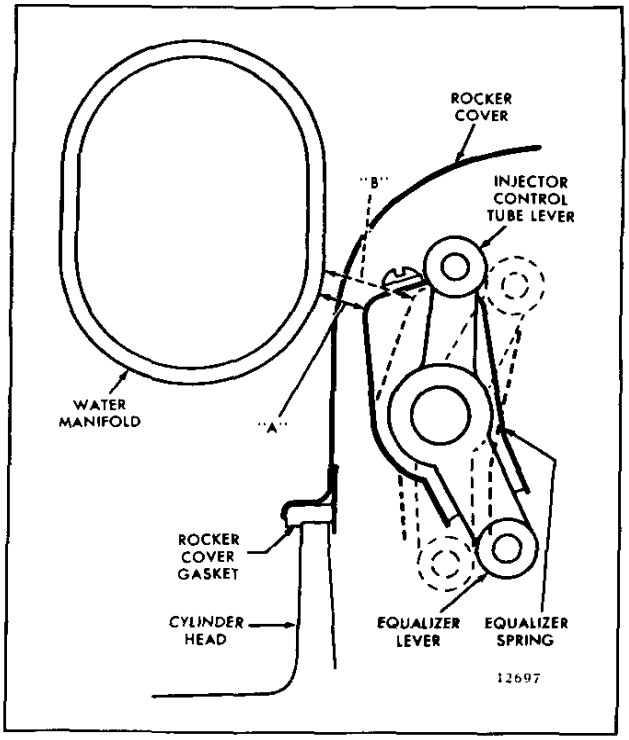


Fig. 3 - Installation of Valve Rocker Cover on Multiple Engine Unit

The current rocker cover gaskets and the current hold-down bolts can only be used with the current die cast rocker cover. Do not use the former gasket and hold-down knobs with the die cast cover.

Remove and Install Valve Rocker Cover

Clean the valve rocker cover before removing it from the engine to avoid dust or dirt from entering the valve mechanism. Then loosen the bolts (current engines) or the knobs (former engines) and lift the cover straight up from the cylinder head. Use a new gasket when reinstalling the cover.

Before a die cast rocker cover is installed on a cylinder head, it is important that the silicone gasket be properly installed in its groove in the rocker cover.

1. Clean and blow out the groove in the rocker cover with compressed air. Oil in the rocker cover groove or on the silicone gasket will make it difficult to install.

2. Press the stem side of the new T shaped gasket down into the groove at the four corners of the cover first. Then press the remainder of the gasket into place in the groove (see Fig. 1). Be sure the stem of the entire gasket bottoms in the groove.

© 1979 General Motors Corp.

NOTE: When the gasket is completely installed in the groove it should not fall out.

3. Before installing the rocker cover lubricate the cylinder head rail and the flat surface of the gasket with a thin film of engine oil. This will keep the gasket from sticking to the cylinder head rail.

Exercise special care when installing or removing the valve rocker cover on the "A" engine of multiple engine units which incorporate a governor equalizer cross link. Synchronization of the multiple engine unit can be upset by forcing the cover through the close opening between the water manifold and the injector equalizer spring at the front of the injector rack control tube, thus distorting the spring.

To preserve the adjustments, once the unit is synchronized, hold the governor stop lever in the *off* position during removal or installation of the valve rocker cover. This will place the injector control equalizer lever, the injector control tube lever and the equalizer spring in the position indicated by the dotted lines in Fig. 3. Thus the opening between the water manifold and the equalizer spring is increased sufficiently to facilitate easy removal or installation of the cover without disturbing the spring.

© 1979 General Motors Corp.

CRANKSHAFT

The crankshaft is a one-piece steel forging, heat-treated to ensure strength and durability (Figs. 1 and 2). All main and connecting rod bearing journal surfaces are induction hardened.

Complete static and dynamic balance of the crankshaft has been achieved by counterweights incorporated in the crankshaft.

The crankshaft end play is controlled by thrust washers located at the rear main bearing cap of the engine. Full pressure lubrication to all connecting rod and main bearings is provided by drilled passages within the crankshaft and cylinder block.

Two dowels and six tapped holes are provided in the rear end of the former crankshaft for locating and attaching the flywheel (Fig. 2). One hole is unequally spaced so that the flywheel can be attached in only one position.

To standardize, the current crankshaft will no longer incorporate the two dowels in the flywheel end of the crankshaft. The former and current crankshafts are interchangeable.

CAUTION: Extreme caution should be used when removing a flywheel by either leaving one or two bolts in the flywheel, or installing two suitable guide pins to support the flywheel until a lifting tool or some other suitable safe lifting device is attached to the flywheel.

Each main bearing journal is 3-1/2" in diameter and each connecting rod journal is 2-3/4" in diameter.

To provide improved clamping of the oil pump drive gear on the crankshaft (press fit instead of slip fit), a new crankshaft with a larger diameter at the drive gear area is now being used in the 6-71 engines. This is effective with engines built approximately December, 1978.

NOTE: The installation of the press fit drive gear in no way reduces the need for the proper front stack-up installation procedure.

The former and current crankshaft assemblies are interchangeable in an engine. Only the current crankshaft assembly will be serviced.

Remove Crankshaft

When removal of the crankshaft becomes necessary, first remove the transmission, then proceed as follows:

1. Clean the exterior of the engine.

2. Drain the cooling system.

3. Drain the engine crankcase.

4. Remove all engine to base attaching bolts. Then, with a chain hoist and sling attached to the lifter brackets or eye bolts at each end of the engine, remove the engine from its base.

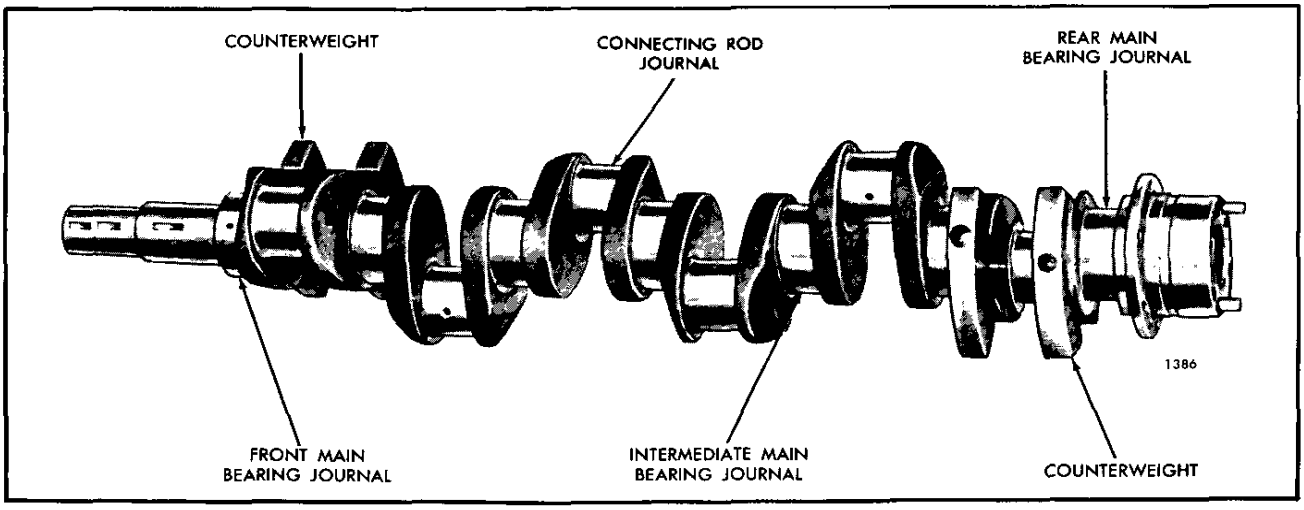


Fig. 1 - Typical Six Cylinder Crankshaft (Former)

© 1983 General Motors Corp.

5. Remove all of the accessories and assemblies with their attaching parts as necessary to permit the engine to be mounted on an overhaul stand.

6. Mount th engine on an overhaul stand and fasten it securely to the mounting plate.

CAUTION: Be absolutely sure the engine is securely attached to the stand before releasing the lifting sling. Severe injury to personnel and destruction of engine parts will result if the engine breaks away from the stand.

7. Remove the oil pan.

8. Remove the lubricating oil pump.

9. Remove the flywheel and flywheel housing.

10. Remove the crankshaft cap or pulley.

11. Remove the vibration damper, if used.

12. Remove the front engine support.

13. Remove the crankshaft front cover.

14. Remove the vibration damper inner cone or oil seal spacer.

15. Remove the cylinder head.

16. Remove the connecting rod bearing caps.

17. Remove the main bearing caps.

18. Remove the thrust washers from each side of the rear main bearing.

19. Remove the pistons, connecting rods and liners.

20. Remove the crankshaft, including the timing gear and oil pump drive gear (Fig. 2).

21. Refer to Section 1.7.5 for removal of the crankshaft timing gear and Section 4.1 for the procedure covering removal of the oil pump drive gear.

Inspection

After the crankshaft has been removed, clean and inspect it thoroughly before reinstalling it in the engine.

Remove the plugs and clean out the oil passages thoroughly with a stiff wire brush. Clean the crankshaft with fuel oil and dry it with compressed air. Then reinstall the plugs and torque to 10-12 lb-ft (14-16 Nm).

Inspect the keyways for evidence of cracks or wear. Replace the crankshaft, if necessary.

If the crankshaft shows evidence of excessive overheating, replace the crankshaft since the heat treatment has probably been destroyed.

Used crankshafts will sometimes show a certain amount of ridging caused by the groove in the upper

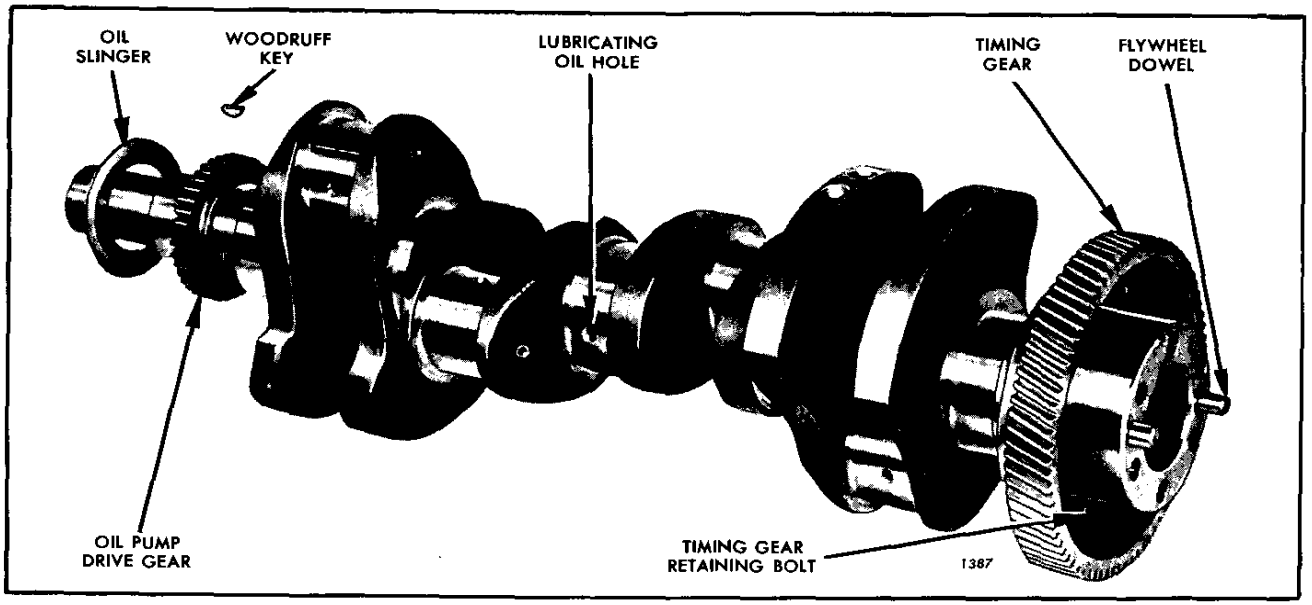


Fig. 2 - Former Crankshaft, Timing Gear and Oil Pump Drive Gear Assemby - Four Cylinder Engine

© 1983 General Motors Corp.

main bearing shell or lower connecting rod bearing shell (Fig. 3). Ridges exceeding .0002" must be removed. If the ridges are not removed, localized high unit pressures on new bearing shells will result during engine operation.

The ridges may be removed by working crocus cloth, wet with fuel oil, around the circumference of the crankshaft journal. If the ridges are greater than .0005", first use 120 grit emery cloth to clean up the ridge, 240 grit emery cloth for finishing and wet crocus cloth for polishing. Use of a piece of rawhide or other suitable rope wrapped around the emery cloth or crocus cloth and drawn back and forth will minimize the possibility of an out-of-round condition developing (keep the strands of rawhide apart to avoid bind). If rawhide or rope is not used, the crankshaft should be rotated at intervals. If the ridges are greater than .001", the crankshaft may have to be reground.

Carefully inspect the rear end of the crankshaft in the area of the oil seal contact surface for evidence of a rough or grooved condition. Any imperfections of the oil seal contact surface will result in oil leakage at this point.

Slight ridges on the crankshaft oil seal contact surface may be cleaned up with emery cloth and crocus cloth in the same manner as detailed for the crankshaft journals. If the crankshaft cannot be cleaned up satisfactorily, the oil seal may be repositioned in the flywheel housing as outlined in Section 1.3.2.

Check the crankshaft thrust surfaces for excessive wear or grooving. If only slightly worn, the surfaces may be dressed with a stone. Otherwise it will be necessary to regrind the thrust surfaces.

Check the oil pump drive gear and the crankshaft timing gear for worn or chipped teeth. Replace the gears, if necessary.

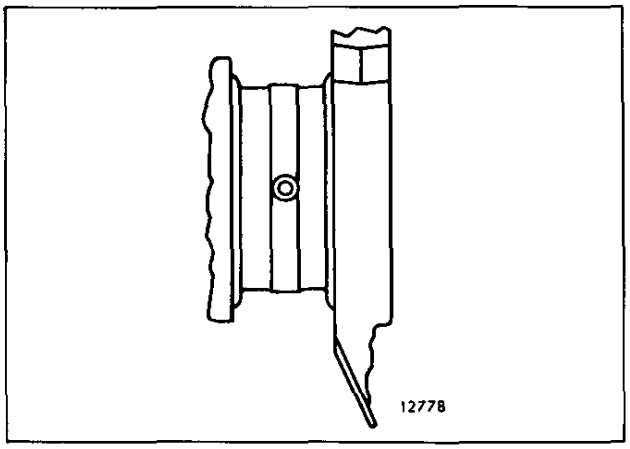


Fig. 3 - Typical Ridging of Crankshaft

Check the crankshaft dowel extension. Current dowels extend 1/2" from the crankshaft while former dowels extend 5/8". When coverting to or rebuilding engines for Torqmatic coverter applications, check to make sure the dowels DO NOT extend more than 1/2", otherwise interference with the Torqmatic converter flywheel will result.

Inspect the crankshaft for cracks as outlined under *Inspection for Cracks.*

Crankshaft Measurements

Support the crankshaft on its front and rear journals on V-blocks, in a lathe or the inverted engine block with only the front and rear upper bearing shells in place. Check the alignment at the adjacent intermediate main journals with a dial indicator.

When the high spots of runout on the adjacent journals is in opposite directions, the sum must not exceed .003" total indicator reading. When the high spots of runout on the adjacent journals of the four and six cylinder crankshaft is in the same direction, the difference must not exceed .003" total indicator reading. When the high spots of runout on the adjacent journals of the three cylinder crankshaft are at right angles to each other, the sum must not exceed .004" total indicator reading, or .002" on each journal. If the runout limit is greater than given in Table 1, crankshaft must be replaced.

CRANKSHAFT RUNOUT

Engine	Journals	Max. Runout (Total indicator reading)
371	At No. 2 and No. 3	.002"
471	At No. 2 and No. 4	.002"
	At No. 3	.004"
671	At No. 2 and No. 6	.002"
	At No. 3 and No. 5	.004"
	At No. 4	.006"

Measure all of the main and connecting rod bearing journals (Fig. 6). Measure the journals at several places on the circumference so that taper, out-of-round and bearing clearances can be determined. If the crankshaft is worn so that the maximum journal-to-bearing shell clearance (with new shells) exceeds .0044", the crankshaft must be reground. Measurements of the crankshaft should be accurate to the

© 1982 General Motors Corp.

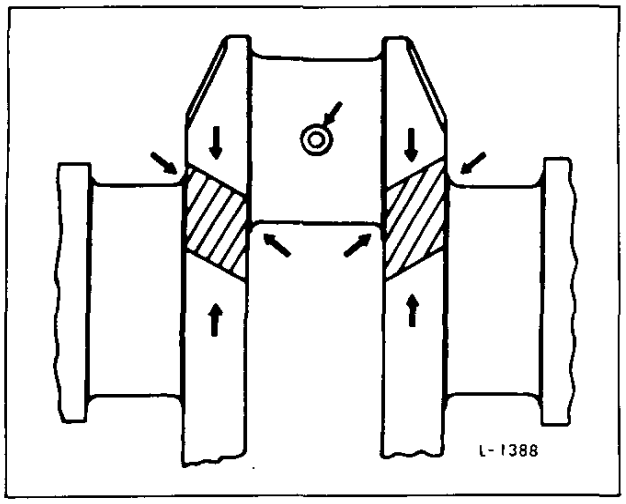


Fig. 4 - Critical Crankshaft Loading Zones

nearest .0002". Also, if the journal taper of a used crankshaft exceeds .0015" or the out-of-round is greater than .001",the crankshaft must be reground.

Also measure the crankshaft thrust surfaces (Fig. 8).

Inspection for Cracks

Carefully check the crankshaft for cracks which start at an oil hole and follow the journal surface at an angle of 45° to the axis. Any crankshaft with such cracks must be rejected. Several methods of determining the presence of minute cracks not visible to the eye are outlined below.

Magnetic Particle Method: The part is magnetized and then covered with a fine magnetic powder or solution. Flaws, such as cracks, form a small local magnet which causes the magnetic particles in the powder or solution to gather there, effectively marking the crack. The crankshaft must be de-magnetized after the test.

Fluorescent Magnetic Particle Method: This method is similar to the magnetic particle method, but is more sensitive since it employes magnetic particles which are fluorescent and glow under "black light". Very fine cracks that may be missed under the first method, especially on discolored or dark surfaces, will be disclosed under the "black light".

Flourescent Penetrant Method: This is a method which may be used on both *non-magnetic* and *magnetic* materials. A highly fluorescent liquid penetrant is applied to the part. Then the excess penetrant is removed from the surface and the part is dried. A developing powder is then applied which helps to draw the penetrant out of the flaws by capillary action. Inspection is carried out under "black light".

A majority of indications revealed by the above inspection methods are normal and harmless and only in a small percentage of cases is reliability of the part impaired when indications are found. Since inspection reveals the harmless indications with the same intensity as the harmful ones, detection of the indications is but a first step in the procedure. **Interpretation** of the indications is the most important step.

All Detroit Diesel crankshafts are magnetic particle inspected after manufacture to ensure against any shafts with harmful indications getting into the original equipment or factory parts stock.

Crankshaft failures are rare and when one cracks or breaks completely, it is very important to make a thorough inspection for contributory factors. Unless abnormal conditions are discovered and corrected, there will be a repetition of the failure.

There are two types of loads imposed on a crankshaft in service -- a *bending* force and a *twisting* force. The design of the shaft is such that these forces produce practically no stress over most of the surface. Certain small areas, designated as critical areas, sustain most of the load (Fig. 4).

Bending fatigue failures result from bending of the crankshaft which takes place once per revolution.

The crankshaft is supported between each of the cylinders by a main bearing and the load imposed by the gas pressure on top of the piston is divided between the adjacent bearings. An abnormal bending

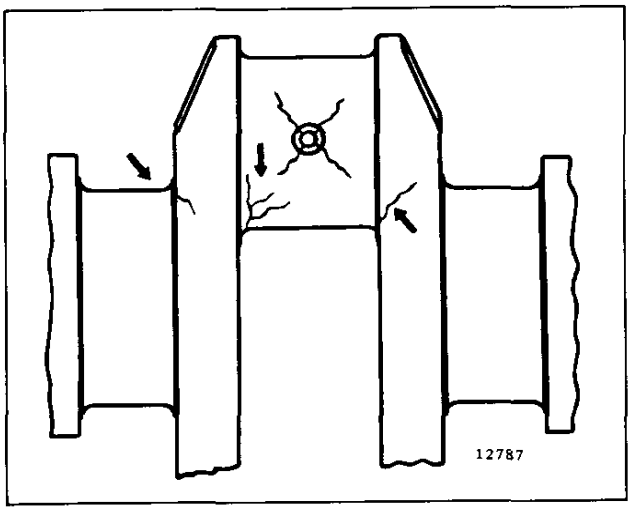


Fig. 5 - Crankshaft Fatigue Cracks

© 1982 General Motors Corp.

installed, *ALL* new main and connecting rod (upper and lower) bearing shells and new thrust washers must also be installed.

3. Apply clean engine oil 360° around all crankshaft journals and install the crankshaft in place so that the timing marks on the crankshaft timing gear and the idler gear match. Refer to Section 1.7.1 for the correct method of timing the gear train.

4. Install the upper halves of the crankshaft thrust washers on each side of the rear main bearing support and the doweled lower halves on each side of the rear main bearing cap. *The grooved side of the thrust washers must face toward the crankshaft thrust surfaces.*

NOTE: If the crankshaft thrust surfaces were reground, it may be necessary to install oversize thrust washers on one or both sides of the rear main journal. Refer to Fig. 9 and Table 3.

Nominal Size	Thrust Washer Thickness	
	Min.	Max.
Standard	.1190"	.1220"
.005" Oversize	.1240"	.1270"
.010" Oversize	.1290"	.1320"

TABLE 3

5. Install the lower bearing shells (no oil grooves) in the bearing caps. If the old bearing shells are to be used again, install them in the same bearing caps from which they were removed.

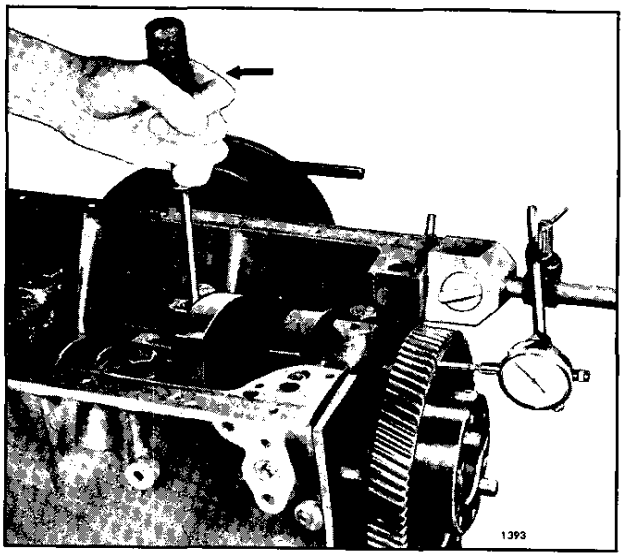


Fig. 10 - Checking Crankshaft End Play

6. Install the bearing caps and lower bearing shells as outlined under *Install Main Bearing Shells* in Section 1.3.4.

NOTE: If the bearings have been installed properly, the crankshaft will turn freely with all of the main bearing cap bolts drawn to the specified torque.

7. Check the crankshaft end play by moving the crankshaft toward the gage with a small (less than 12") pry bar (Fig. 10). Keep a constant pressure on the pry bar and set the dial indicator to zero. Then remove and insert the pry bar on the other side of the bearing cap. Force the crankshaft in the opposite direction and note the amount of end play on the dial. The end play should be .004" to .011" with new parts or a maximum of .018" with used parts. Insufficient end play can be the result of a misaligned rear main bearing or a burr or dirt on the inner face of one or more of the thrust washers.

8. Install the cylinder liner, piston and connecting rod assemblies (Section 1.6.3).

9. Install the cylinder head (section 1.2).

10. Install the flywheel housing (Section 1.5), then install the flywheel (Section 1.4).

11. Install the crankshaft front cover and gasket.

NOTE: Install the oil seal spacer or inner cone *after* the crankshaft front cover is in place to avoid damage to the oil seal lip.

12. Install the engine front support.

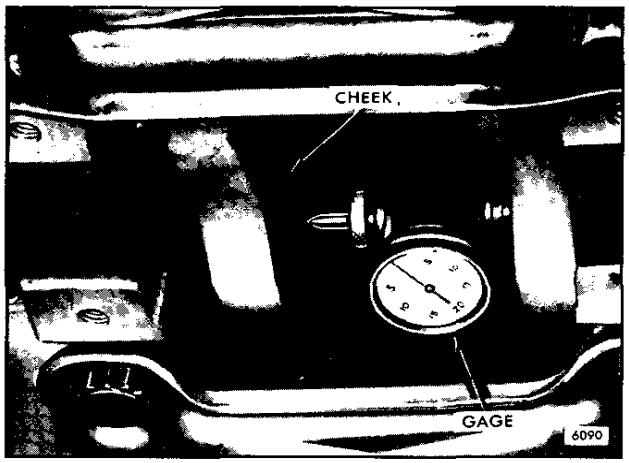


Fig. 11 - Crankshaft Distortion Measuring Gage Mounted on Crankshaft

© 1983 General Motors Corp.

13. Install the vibration damper inner cone or oil seal spacer.

14. Install the vibration damper assembly, if used.

15. Install the crankshaft cap or pulley (Section 1.3.7).

16. Install the lubricating oil pump assembly (Section 4.1).

17. Check the crankshaft for **distortion** at the rear connecting rod journal counterweights *before* and *after* installing the power take-off reduction gear assembly, transmission or power generator. An improperly installed power take-off reduction gear assembly, transmission or power generator can distort the crankshaft and cause a crankshaft failure.

Check the crankshaft distortion as follows:

a. Rotate the crankshaft clockwise until the crankshaft counterweights at the rear connecting rod journal are in the six o'clock position.

b. Center punch a hole in the inside face of each counterweight cheek, one quarter of an inch from the lower end of each counterweight, to support the gage.

c. Install a gage (Starrett Co. No. 696 dial gage, or equivalent) in the center punch holes in the cheek of each counterweight as shown in Fig. 11.

d. Set the dial indicator at zero, then rotate the crankshaft approximately 90° in both directions. Do not allow the gage to contact the connecting rod caps or bolts. Note and record the dial indicator readings at the 3, 6 and 9 o'clock crankshaft counterweight positions. The maximum allowable variation is .0045" total indicator reading.

NOTE: Remove the tool that was used to rotate the crankshaft when taking the dial indicator readings.

e. If the reading on the gage exceeds .0045", check the reduction gear, transmission or power generator for improper installation and realign as necessary.

18. Affix a new gasket to the oil pan flange and install the oil pan.

19. Use a chain hoist and sling attached to the lifting bracket or eye bolts at each end of the engine and remove the engine from the overhaul stand.

20. Install all of the accessories that were removed.

21. After the engine has been completely reassembled, refer to the *Lubrication Specifications* in Section 13.3 and refill the crankcase to the proper level on the dipstick.

22. Close all of the drains and fill the cooling system.

23. After replacing the main or connecting rod bearings or installing a new or reground crankshaft, operate the engine as outlined in the *run-in* schedule (Section 13.2.1).

© 1983 General Motors Corp.

stress in the crankshaft, particularly in the crank fillet, may be a result of misalignment of the main bearing bores, improperly fitted bearings, bearing failures, a loose or broken bearing cap, or unbalanced pulleys. Also, drive belts which are too tight may impose a bending load upon the crankshaft.

Failure resulting from bending start at the pin fillet and progress throughout the crank cheek, sometimes extending into the journal fillet. If main bearings are replaced due to one or more badly damaged bearings, a careful inspection must be made to determine if any cracks have started in the crankshaft. These cracks are most likely to occur on either side of the damaged bearing.

Torsional fatigue failures result from torsional vibration which takes place at high frequency.

A combination of abnormal speed and load conditions may cause the twisting forces to set up a vibration, referred to as torsional vibration, which imposes high stresses at the locations shown in Fig. 4.

Torsional stresses may produce a fracture in either the connecting rod journal or the crank cheek. Connecting rod journal failures are usually at the fillet at 45° to the axis of the shaft.

A loose, damaged or defective vibration damper, a loose flywheel or the introduction of improper or additional pulleys or couplings are usual causes of this type of failure. Also, overspeeding of the engine or resetting the governor at a different speed than intended for the engine application may be contributory factors.

As previously mentioned, most of the indications found during inspection of the crankshaft are harmless. The two types of indications to look for are circumferential fillet cracks at the critical areas and 45° cracks (45° with the axis of the shaft) starting from either the critical fillet locations or the connecting rod journal holes as shown in Fig. 5. Replace the crankshaft when cracks of this nature are found.

Bearing Sizes	Conn. Rod Journal Dia. "A"	Main Bearing Journal Dia. "B"
Standard	2.750"	3.500"
.002" Undersize	2.750"	3.500"
.010" Undersize	2.740"	3.490"
.020" Undersize	2.730"	3.480"
.030" Undersize	2.720"	3.470"

TABLE 2

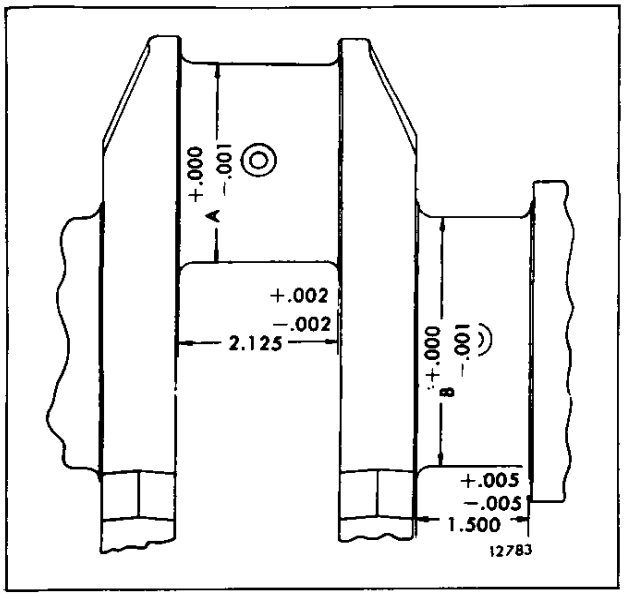


Fig. 6 - Dimensions of Crankshaft Journals

Crankshaft Grinding

In addition to the standard size main and connecting rod bearings, .002", .010", .020" and .030" undersize bearings are available.

NOTE: The .002" undersize bearings are used only to compensate for slight wear on crankshafts on which regrinding is unnecessary.

If the crankshaft is to be reground, proceed as follows:

NOTE: Connecting rod and/or main bearing journals which exhibit discoloration due to excessive overheating from bearing failure are not acceptable for rework.

1. Compare the crankshaft journal measurements taken during inspection with the dimensions in Table 2 and Fig. 6 and determine the size to which the journals are to be reground.

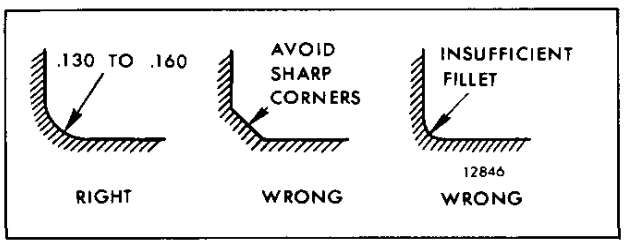


Fig. 7 - Crankshaft Journal Fillets

© 1982 General Motors Corp.

2. If one or more main connecting rod journals require grinding, then grind all of the main journals or all of the connecting rod journals to the same required size.

3. All journal fillets must have a .130" to .160" radius between the crank cheek and the journal and must not have any sharp grind marks (Fig. 7). The fillet must blend smoothly into the journal and the crank cheek and must be free of scratches. The radius may be checked with a fillet gage.

4. Care must be taken to avoid localized heating which often produces grinding cracks. Cool the crankshaft while grinding, using coolant generously. Do not crowd the grinding wheel into the work.

5. Polish the ground surfaces to an 8-12 R.M.S. finish. The reground journals will be subject to excessive wear unless polished smooth.

6. If the thrust surfaces of the crankshaft (Fig. 9) are worn or grooved excessively, they must be reground and polished. Care must be taken to leave a .130" to .160" radius between each thrust surface and the bearing journal.

7. Stone the edge of all oil holes in the journal surfaces smooth to provide a radius of approximately 3/32".

8. After grinding has been completed, inspect the crankshaft by the magnetic particle method to determine whether cracks have originated due to the grinding operation.

9. Demagnetize the crankshaft.

10. Remove the plugs and clean the crankshaft and oil

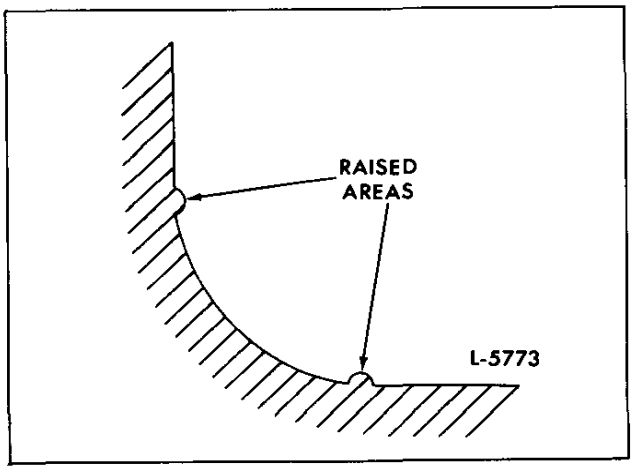


Fig. 8 - New or Morco Remanufactured Crankshaft

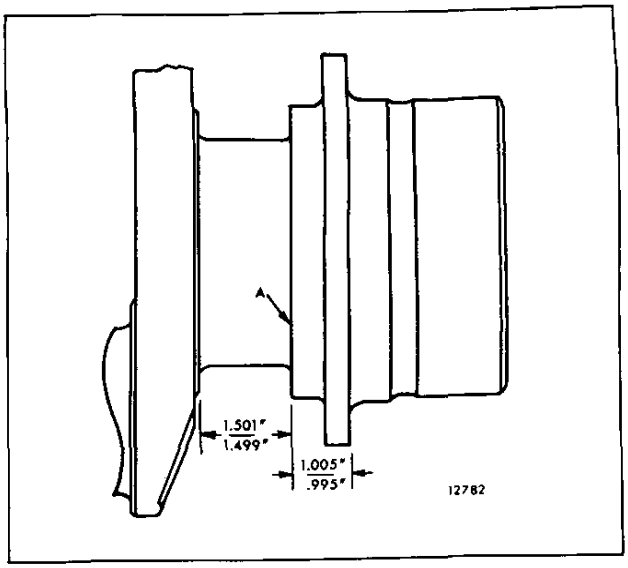


Fig. 9 - Standard Dimensions at Crankshaft Thrust Surfaces

passages thoroughly with fuel oil. Dry the shaft with compressed air and reinstall the plugs.

For additional information refer to DDA Manual 6SE453.

Install Crankshaft

If a new crankshaft is to be installed, steam clean it to remove the rust preventive, blow out the oil passages with compressed air and install the plugs.

> **NOTE:** A new or remanufactured "Morco" crankshaft receives a rolling process in the fillet area for added strength. Oftentimes this leaves a slightly raised area at each end of the fillet (Fig. 8). This is an acceptable shaft and must not be confused with outside reground shafts that are left with a notch rather than a required blend as outlined under *Crankshaft Grinding.*

Then install the crankshaft as follows:

1. Assemble the crankshaft timing gear (Section 1.7.5) and the oil pump drive gear (Section 4.1) on the crankshaft.

2. Refer to Section 1.3.4 for main bearing details and install the upper *grooved* main bearing shells in the block. If the old bearing shells are to be used again, install them in the same locations from which they were removed.

NOTE: When a new or reground crankshaft is

© 1982 General Motors Corp.

CRANKSHAFT OIL SEALS

An oil seal is used at each end of the crankshaft to retain the lubricating oil in the crankcase. The sealing lips of the oil seals are held firmly, but not tight, against the crankshaft sealing surfaces by a coil spring.

The front oil seal is pressed into the crankshaft front cover, and the lip of the seal bears against a removable spacer or vibration damper inner cone on the end of the crankshaft, next to the lubricating oil pump drive gear (Figs. 1 and 2).

A single-lip oil seal is used at the rear end of the crankshaft of most industrial engines (Fig. 3). A double-lip oil seal is used in engines where there is oil on both sides of the oil seal, as in the hydraulic marine gear; the lips of the seal face in opposite directions as shown in Fig. 4. The rear oil seal is pressed into the flywheel housing (Fig. 5).

Engines prior to 371-5767, 471-7411 and 671-31859 were equipped with an oil slinger attached to the rear face of the crankshaft timing gear. However, as the gear itself acts as an oil slinger and throws the surplus oil back into a cavity adjacent to the gear (the oil in the cavity flows back into the oil pan), the oil slinger is not required and may be discarded during an overhaul.

Oil leaks indicate worn or damaged oil seals. Oil seals may become worn or damaged due to improper installation, excessive main bearing clearances, excessive flywheel housing bore runout or grooved sealing surfaces on the crankshaft or oil seal spacers. To prevent a repetition of any oil seal leaks, these conditions must be checked and corrected.

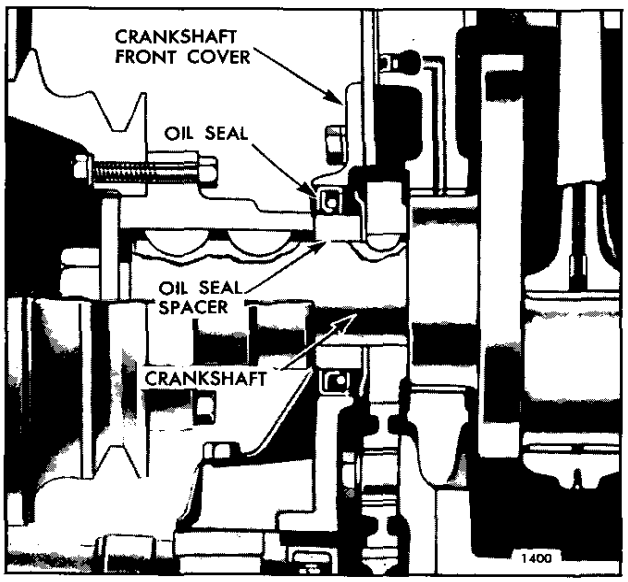


Fig. 1 - Crankshaft Front Oil Seal

Remove Crankshaft Oil Seals

Remove the crankshaft front cover (Section 1.3.5) and the flywheel housing (Section 1.5) and remove the oil seals as follows:

1. Support the forward face of the front cover or the rear face of the flywheel housing on wood blocks.

2. Drive the oil seal out and clean the seal bore in the front cover or flywheel housing. Discard the oil seal.

When necessary, an oil seal may be removed without removing the front cover or flywheel housing (except a front cover that is used with trunnion mounts - this cover must be removed). This may be done by drilling diametrically opposite holes in the seal casing and threading metal screws, backed by flat washers, into the casing. Remove the seal by prying against the washers with pry bars.

Inspection

Inspect the rear end of the crankshaft for wear caused by the rubbing action of the oil seal, dirt build-up or fretting by the action of the flywheel. The crankshaft

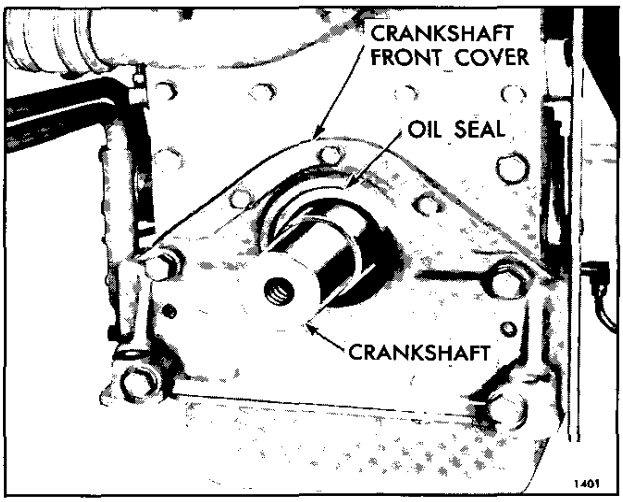


Fig. 2 - Crankshaft Front Oil Seal Mounting

© 1978 General Motors Corp.

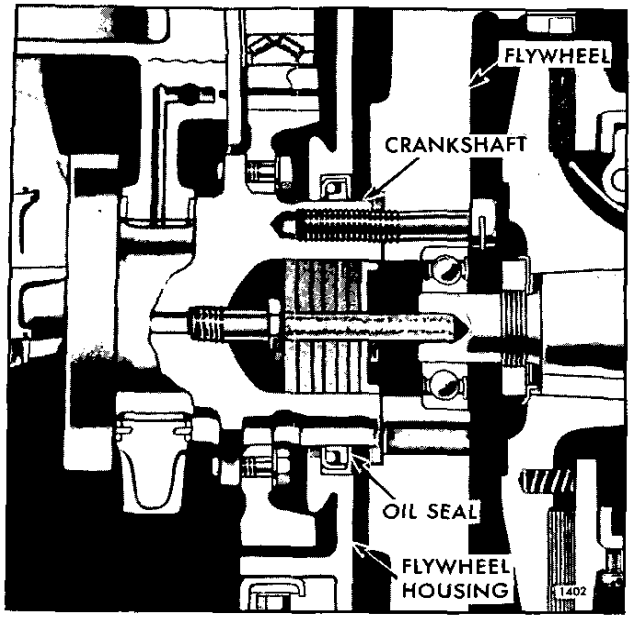


Fig. 3 - Crankshaft Rear Oil Seal - Single Lip

surface must be clean and smooth to prevent damaging the seal lip when a new oil seal is installed. Slight ridges may be removed from the crankshaft as outlined under *Inspection* in Section 1.3.

The maximum runout of the oil seal bore in the flywheel housing is .008 ". The bore may be checked with a dial indicator mounted on the end of the crankshaft in a manner similar to the procedure for checking the flywheel housing concentricity as outlined in Section 1.5. This check must be made with the flywheel housing in place on the engine and the oil seal removed.

If the crankshaft rear oil seal surface is grooved excessively, an oil seal spacer (Fig. 6) may be installed between the counterbore in the flywheel housing and the oil seal. The spacer changes the relative position of the seal and establishes a new contact surface. However, the spacer cannot be used with a double-lip type seal since the grooves worn in the crankshaft are too close together to permit repositioning of the seal.

When the oil seal spacer can no longer be used, an oil seal sleeve (Fig. 6) may be installed on the crankshaft to provide a replaceable wear surface at the point of contact with the rear oil seal. The oil seal sleeve may be used with either the single-lip or double-lip type oil seal, and can also be used in conjunction with the seal spacer. However, an oversize oil seal must be used with the sleeve.

Install an oil seal sleeve as follows:

1. Stone the high spots from the oil seal contact surface of the crankshaft.

2. Coat the area of the shaft where the sleeve will be positioned with shellac or an equivalent sealant.

3. Drive the sleeve squarely on the shaft with oil seal sleeve installer J 4194.

4. Wipe off any excess sealant.

5. Coat the outside diameter of the sleeve with engine oil.

To remove a worn sleeve, peen the outside diameter until the sleeve stretches sufficiently so it can be slipped off the end of the crankshaft.

Prior to the use of the crankshaft rear oil seal, early engines incorporated an oil deflector which was pressed into the crankshaft bore of the flywheel housing. However, all replacement flywheel housings are counterbored for the installation of an oil seal.

Oil Seals

Current oil seals are made of an oil resistant synthetic rubber which is pre-lubricated with a special lubricant. *Do not remove this lubricant.* Keep the sealing lip clean and free from scratches. *In addition, a plastic coating* which acts as a sealant has been applied to the outer surface of the casing. Do not remove this coating.

The rear oil seal may have either an open or closed back. Both types are serviced.

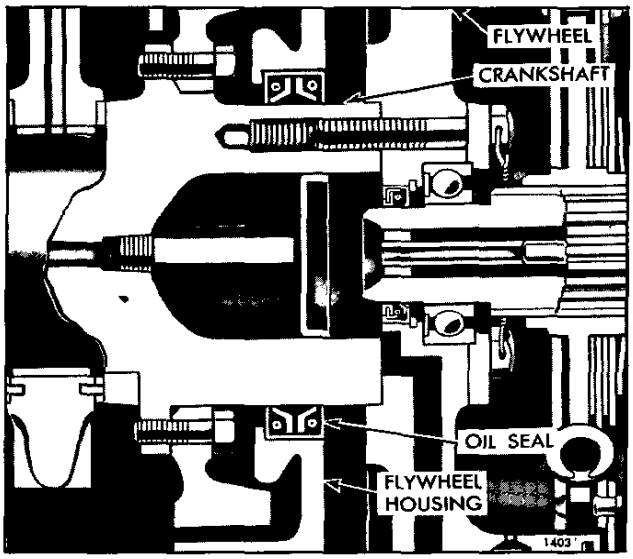


Fig. 4 - Crankshaft Rear Oil Seal - Double Lip

© 1978 General Motors Corp.

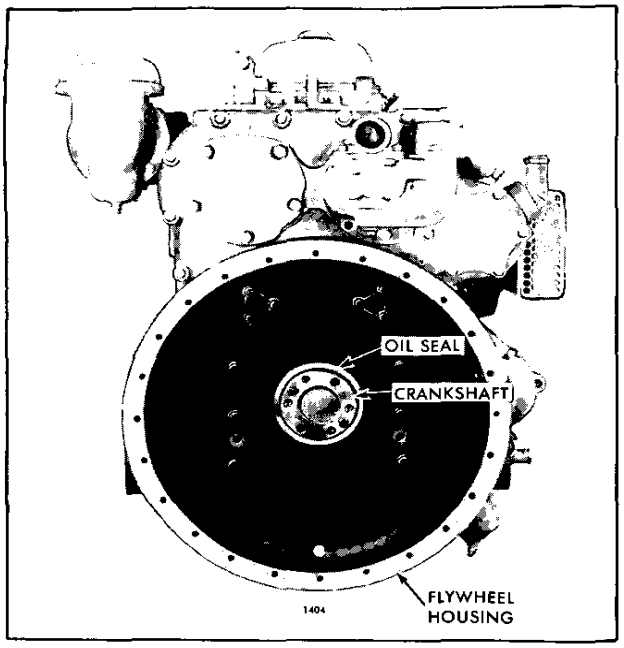


Fig. 5 - Crankshaft Rear Oil Seal Mounting

Install Crankshaft Front Oil Seal

1. If the oil seal is not pre-coated, apply a non-hardening sealant to the periphery of the metal casing.

2. Coat the lip of the new oil seal lightly with grease or vegetable shortening. Then position the seal in the front cover with the lip of the seal pointed toward the inner face of the cover.

NOTE: The vibration damper inner cone or oil seal spacer must be removed before installing the oil seal.

3. Drive the seal into the front cover with installer J 9783, which seats the oil seal in the bore. The installer prevents damage to the seal by exerting force only on the outer edge of the seal casing.

4. Remove any excess sealant from the cover and seal.

5. Install the crankshaft front cover as outlined in Section 1.3.5.

6. Install the vibration damper inner cone or oil seal spacer after the front cover and seal assembly is in place.

Install Crankshaft Rear Oil Seal

1. Support the inner face of the flywheel housing on a flat surface.

2. Install the rear oil seal spacer, if used. Install the spacer against the shoulder in the flywheel housing oil seal bore.

3. If the new seal is not pre-coated, apply a non-hardening sealant to the periphery of the metal casing. Then position the seal with the lip pointed toward the inner face (or shoulder in the counterbore) of the housing.

4. Coat the lip of the oil seal lightly with engine oil (single-lip seal) or vegetable shortening (double-lip seal). Do not scratch or nick the sealing edge of the oil seal.

5. Drive the seal into the housing with installer J 9727 and handle J 3154-1 (Fig. 7) until it is seated against the seal spacer (if used) or on the shoulder in the housing bore. The installer prevents damage to the seal by exerting force only on the outer edge of the seal casing.

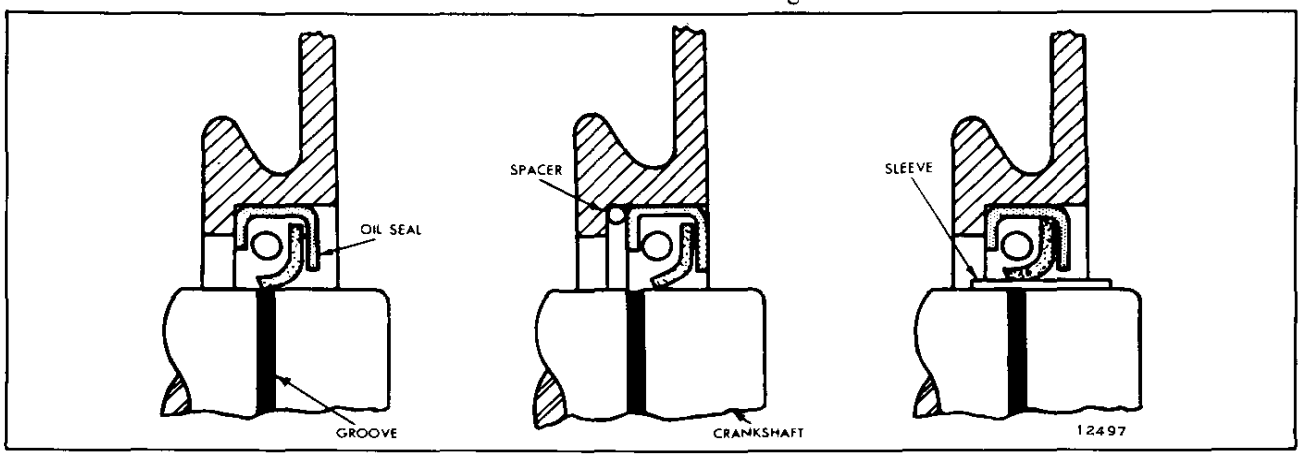


Fig. 6 - Use of Rear Oil Seal Spacer or Sleeve on Grooved Crankshaft

© 1978 General Motors Corp.

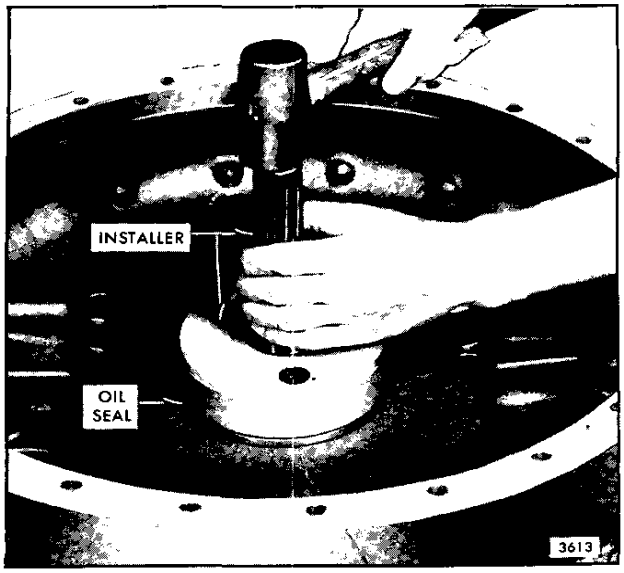


Fig. 7 - Installing Oil Seal in Flywheel Housing

If it is necessary to install the oil seal with the flywheel housing on the engine, place oil seal expander J 22425 (standard size seal) or expander J 4195-01 with handle J 8092 (oversize seal) against the end of the crankshaft. Then, with the lip of the seal pointed toward the engine, slide the seal over the tool and on the crankshaft. Remove the seal expander and drive the seal in place with installer J 9727 and handle J 3154-1.

6. Remove any excess sealant from the flywheel housing and the seal.

7. Install the flywheel housing as outlined in Section 1.5.

NOTE: If the oil seal is of the type which incorporates a brass retainer in the inner diameter of the seal, be sure the retainer is in place on the seal before installing the flywheel housing on the engine. If the retainer is left out, oil leakage will result.

© 1978 General Motors Corp.

CRANKSHAFT CAP

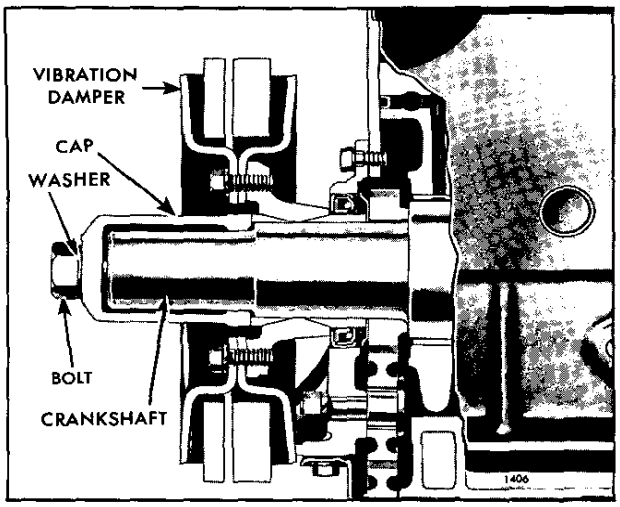


Fig. 1 - Crankshaft Cap Mounting

A one-piece crankshaft cap (Fig. 1) is installed on the front end of the crankshaft on engines which are not equipped with a crankshaft pulley. The crankshaft cap serves to securely fasten the vibration damper assembly to the crankshaft or, when no vibration damper is used, the cap secures the oil seal spacer. The cap is attached to the crankshaft by a special bolt and washer.

Prior to engines 371-90 (and 371-74-77-78-148-149), 471-174 (except 471-177) and 671-129 (and 671-125-126), a special washer and crankshaft end sleeve were used. The crankshaft end bolt thread was changed from 3/4 "-16 to 1 "-14 effective with the above engine units.

Engines incorporating a crankshaft pulley use a bolt and a special flat washer to retain the pulley in place. The bolt has a 7/32 " center drill in the head for use of a hand tachometer when checking engine speed.

The new crankshaft bolts are now lubrite coated to prevent possible damage (galling) to the bolt threads and to increasethe clamp load to the front end stack up (crankshaft pulley, vibration damper, etc). Also the new washer (retainer) is now case hardened.

The new bolts and washer can be identified by their black color. The former bolts and washer are a steel (gray) color.

Tighten the crankshaft cap retaining bolt as follows:

1. Tighten the bolt to 180 lb-ft (244 Nm) torque.

2. Strike the end of the bolt a sharp blow with a 2 to 3 lb. lead hammer.

3. Tighten the bolt to 300 lb-ft (407 Nm) torque and strike it again.

4. Tighten the bolt to 290-310 lb-ft (393-421 Nm) torque.

NOTE: Do not strike the bolt after final torque has been applied.

The hex head of the crankshaft bolt may be used to bar or turn the crankshaft. However, the barring operation should **ALWAYS** be performed in a clockwise direction. *It is very important to make certain that the bolt has not been loosened during the barring operation.* Otherwise serious engine damage may result if the vibration damper or pulley is not securely fastened to the crankshaft.

© 1978 General Motors Corp.

CRANKSHAFT MAIN BEARINGS

The crankshaft main bearing shells are precision made and are replaceable without machining (Fig. 1). They consist of an upper bearing shell seated in each cylinder block main bearing support and a lower bearing shell seated in each main bearing cap. The upper and lower bearing shells are located in the respective block and bearing cap by a tang at the parting line at one end of each bearing shell. The tangs on the lower bearing shells are off-center and the tangs on the upper bearing shells are centered to aid correct installation.

Various types of bearings have been used. Currently, multiple layer copper-lead coplated or aluminum triplated bearings are in use. These bearings have an inner surface, called the matrix, of copper-lead or aluminum. A thin deposit of babbitt is then plated onto the matrix. This babbitt overlay has excellent resistance to friction, corrosion and scoring tendencies which, combined with the material of the matrix, provides improved load carrying characteristics. These bearings are identified by the satin silver sheen of the babbitt when new and a dull gray after being in service. The former copper-lead bearings had a copper color when new and turned very dark during engine operation.

An oil hole in the groove of each upper bearing shell, midway between the parting lines, registers with a vertical oil passage in the cylinder block. Lubricating oil, under pressure, passes from the cylinder block oil gallery by way of the bearing shells to the drilled passages in the crankshaft, then to the connecting rods and connecting rod bearings.

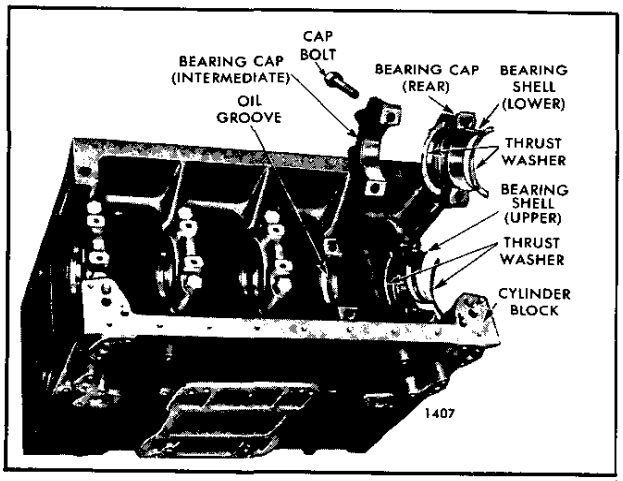


Fig. 1 - Main Bearing Shells, Bearing Caps and Crankshaft Thrust Washers

The lower main bearing shells have no oil grooves; therefore, the upper and lower bearing shells must not be interchanged.

Thrust washers (Fig. 1), on each side of the rear main bearing, absorb the crankshaft thrust. The lower halves of the two-piece washers are doweled to the bearing cap; the upper halves are not doweled.

All of the main bearing load is carried on the lower bearings; therefore, wear will occur on the lower bearing shells first. The condition of the lower bearing shells may be observed by removing the main bearing caps.

If main bearing trouble is suspected, remove the oil pan, then remove the main bearing caps, one at a time, as outlined below and examine the bearing shells.

Remove Main Bearing Shells (Crankshaft in Place)

The bearing caps are numbered 1, 2, 3, etc., indicating their respective positions and, when removed, must always be reinstalled in their original position.

All crankshaft main bearing journals, except the rear journal, are drilled for an oil passage. Therefore, the procedure for removing the upper bearing shells with the crankshaft in place is somewhat different on the drilled journals than on the rear journal.

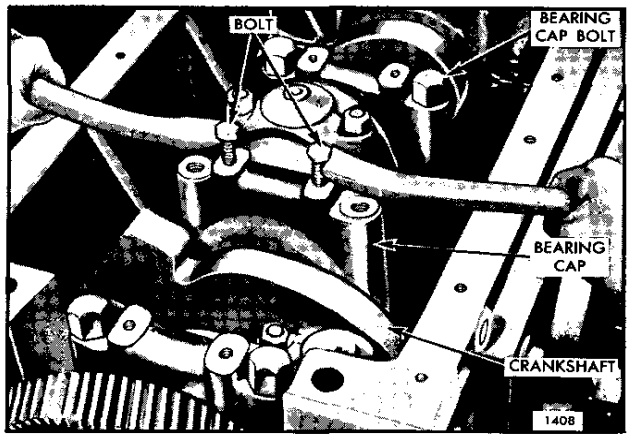


Fig. 2 - Removing Main Bearing Cap

© 1982 General Motors Corp.

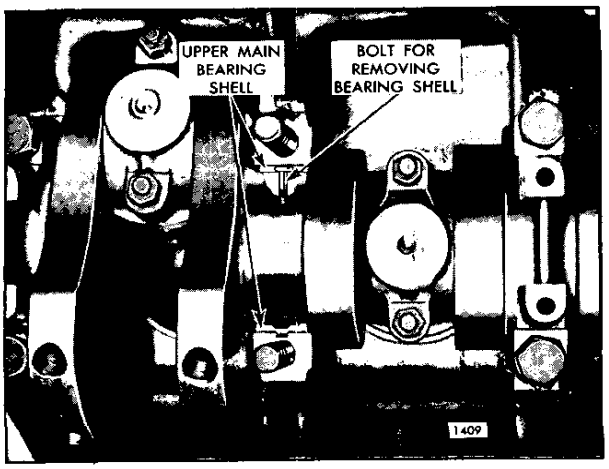


Fig. 3 - Removing Upper Main Bearing Shell (Except Rear Main)

Remove the main bearing shells as follows:

1. Drain and remove the oil pan to expose the main bearing caps.

2. Remove the oil pump and the oil inlet and outlet pipe assemblies.

NOTE: If shims are used between the oil pump and the main bearing caps, save the shims so that they may be reinstalled in exactly the same location.

3. Remove one main bearing cap at a time (Fig. 2) and inspect the bearing shells as outlined under *Inspection*. Reinstall each bearing shell and bearing cap before removing another bearing cap:

a. To remove all except the rear main bearing shell, insert a 1/4" x 1" bolt with a 1/2" diameter and 1/16" thick head (made from a standard bolt) into the crankshaft journal oil hole. Then revolve the shaft to the right (clockwise) and roll the bearing shell out of position as shown in Fig. 3. The head of the bolt must not extend beyond the outside diameter of the bearing shell.

b. Remove the rear main bearing upper shell by tapping on the edge of the bearing with a small curved rod, revolving the crankshaft at the same time to roll the bearing shell out as shown in Fig. 4.

c. The lower halves of the crankshaft thrust washers will be removed along with the rear main bearing cap. The upper halves of the washers can be removed for inspection by pushing on the ends of the washers with a small rod, forcing them around and out of the main bearing support.

Inspection

Bearing failures may result from deterioration (acid formation) or contamination of the oil or loss of oil. An analysis of the lubricating oil may be required to determine if corrosive acid and sulphur are present which cause acid etching, flaking and pitting. Bearing seizure may be due to low oil or no oil.

Check the oil filter elements and replace them, if necessary. Also, check the oil bypass valve to make sure it is operating freely.

After removal, clean the bearings and inspect them for scoring, pitting, flaking, etching, loss of babbitt or signs of overheating (Fig. 5). The lower bearing shells, which carry the load, will normally show signs of distress before the upper bearing shells. However, babbitt plated bearings may develop minute cracks or small isolated cavities on the bearing surface during engine operation. These are characteristics of and are not detrimental to this type of bearing. They should not be replaced for these minor surface imperfections since function of the bearings is in no way impaired and they will give many additional hours of trouble-free operation.

Inspect the backs of the bearing shells for bright spots which indicate they have been moving in the bearing

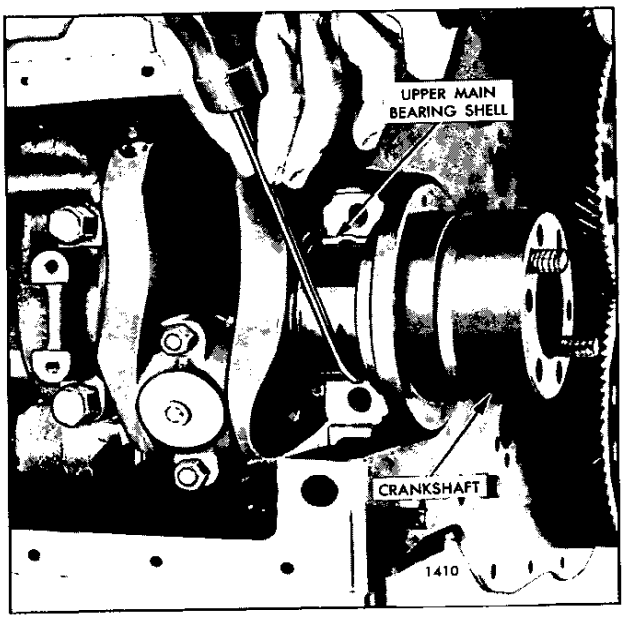


Fig. 4 - Removing Upper Rear Main Bearing Shell

© 1982 General Motors Corp.

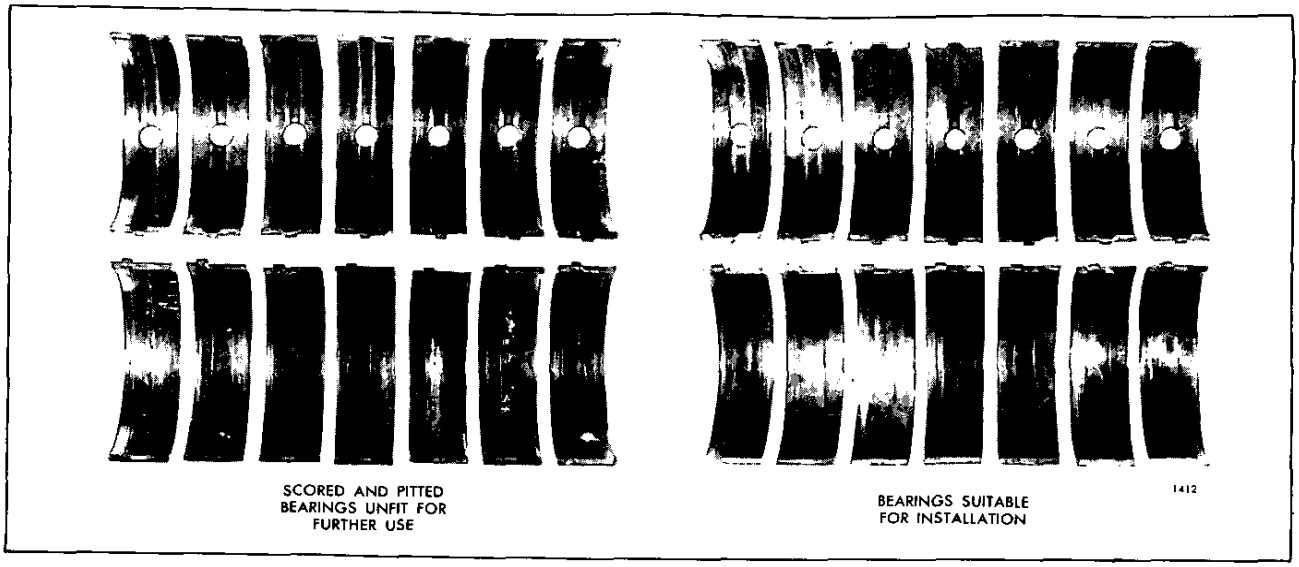


Fig. 5 - Comparison of Main Bearing Shells

caps or bearing supports. If such spots are present, discard the bearing shells.

Measure the thickness of the bearing shells at point "C", 90° from the parting line, as shown in Figs. 6 and 7. Tool J 4757, placed between the bearing shell and a micrometer, will give an accurate measurement. The bearing shell thickness will be the total thickness of the steel ball in the tool and the bearing shell, less the diameter of the ball. This is the only practical method for measuring the bearing thickness, unless a special micrometer is available for this purpose. The minimum thickness of a worn standard main bearing shell is .1530" and, if any of the bearing shells are thinner than this dimension, replace all of the bearing shells. A new standard bearing shell has a thickness of .1548" to .1553". Refer to Table 1.

Bearing Size	Bearing Thickness	Minimum Worn Thickness
Standard	.1548"/.1533"	.1530"
.002" Undersize	.1558"/.1563"	.1540"
.010" Undersize	.1598"/.1603"	.1580"
.020" Undersize	.1648"/.1653"	.1630"
.030" Undersize	.1698"/.1703"	.1680"

TABLE 1

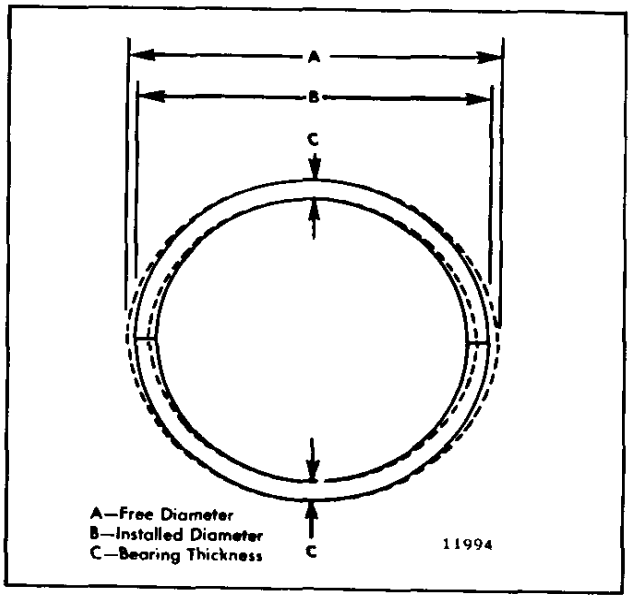


Fig. 6 - Main Bearing Measurements

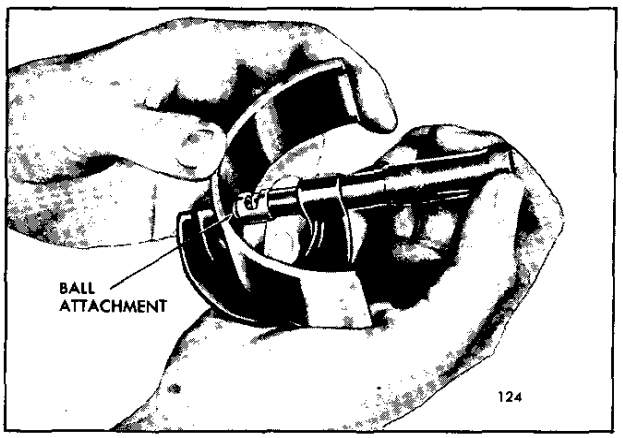


Fig. 7 - Measuring Thickness of Bearing Shell

© 1982 General Motors Corp.

In addition to the thickness measurement, check the clearance between the main bearings and the crankshaft journals. This clearance may be determined with the crankshaft in place by means of a soft plastic measuring strip which is squeezed between the journal and the bearing (refer to *Shop Notes* in Section 1.0). With the crankshaft removed, measure the outside diameter of the crankshaft main bearing journals and the inside diameter of the main bearing shells when installed in place with the proper torque on the bearing cap bolts. When installed, the bearing shells are .001" larger in diameter at the parting line than 90° from the parting line.

The bearing shells do not form a true circle when not installed. When installed, the bearing shells have a squeeze fit in the main bearing bore and must be tight when the bearing cap is drawn down. This *crush* assures a tight, uniform contact between the bearing shell and bearing seat. Bearing shells that do not have sufficient crush will not have uniform contact, as shown by shiny spots on the back, and must be replaced. If the clearance between any crankshaft journal and its bearing shells exceeds .0060", all of the bearing shells must be discarded and replaced. This clearance is .0014" to .0044" with new parts.

Before installing new replacement bearings, it is very important to thoroughly inspect the crankshaft journals. Very often, after prolonged engine operation, a ridge is formed on the crankshaft journals in line with the journal oil holes. If this ridge is not removed before the new bearings are installed, then, during engine operation, localized high unit pressures in the center area of the bearing shell will cause pitting of the bearing surface. Also, damaged bearings may cause bending fatigue and resultant cracks in the crankshaft. Refer to Section 1.3 under *Crankshaft Inspection* for removal of ridges and inspection of the crankshaft.

Do not replace one main bearing shell alone. If one bearing shell requires replacement, install all new upper and lower bearing shells. Also, if a new or reground crankshaft is to be used, install all new bearing shells.

Bearing shells are available in .002", .010", .020" and .030" undersize for service with reground crankshafts. To determine the size bearings required, refer to *Crankshaft Grinding* in Section 1.3. Bearings which are .002" undersize are available to compensate for slight journal wear where it is unnecessary to regrind the crankshaft.

NOTE: Bearing shells are NOT reworkable from one undersize to another under any circumstances.

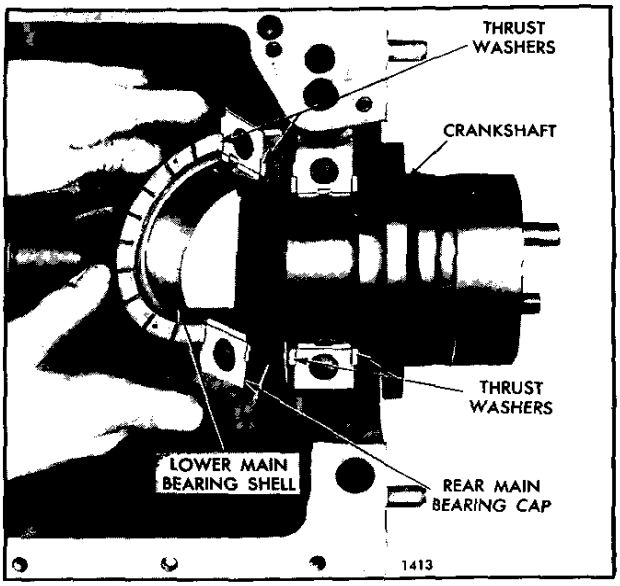


Fig. 8 - Crankshaft Thrust Washers in Place

Inspect the crankshaft thrust washers. If the washers are scored or worn excessively or the crankshaft end play is excessive, they must be replaced. Improper clutch adjustment can contribute to excessive wear on the thrust washers. Inspect the crankshaft thrust surfaces. Refer to *Install Crankshaft* in Section 1.3. If, after dressing or regrinding the thrust surfaces, new standard size thrust washers do not hold the crankshaft end play within the specified limits, it may be necessary to install oversize thrust washers on one or both sides of the rear main bearing. A new standard size thrust washer is .1190" to .1220" thick. Thrust washers are available in .005" and .010" oversize.

Install Main Bearing Shells (Crankshaft in Place)

Make sure all of the parts are clean. Then apply clean engine oil 360° around each crankshaft journal and install the upper main bearing shells by reversing the sequence of operations given for removal.

The upper and lower main bearing shells are not alike; the upper bearing shell is grooved and drilled for lubrication -- the lower bearing shell is not. Be sure to install the grooved and drilled bearing shells in the cylinder block and the plain bearing shells in the bearing caps, otherwise the oil flow to the bearings and to the upper end of the connecting rods will be blocked off. Used bearing shells must be reinstalled on the same journal from which they were removed.

1. When installing an upper main bearing shell with the crankshaft in place, start the plain end of the bearing shell around the crankshaft journal so that,

© 1982 General Motors Corp.

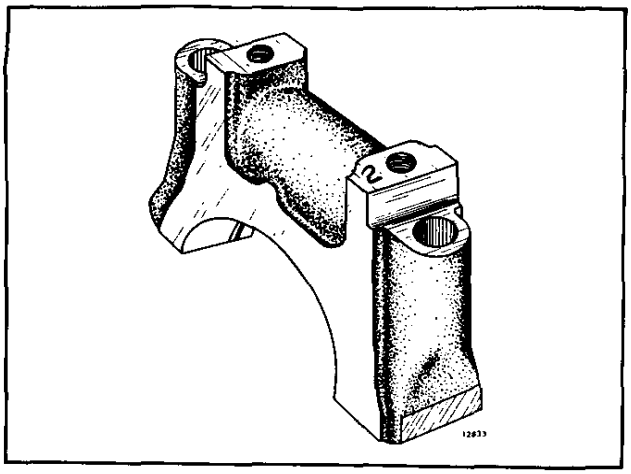


Fig. 9 - Main Bearing Cap Marking

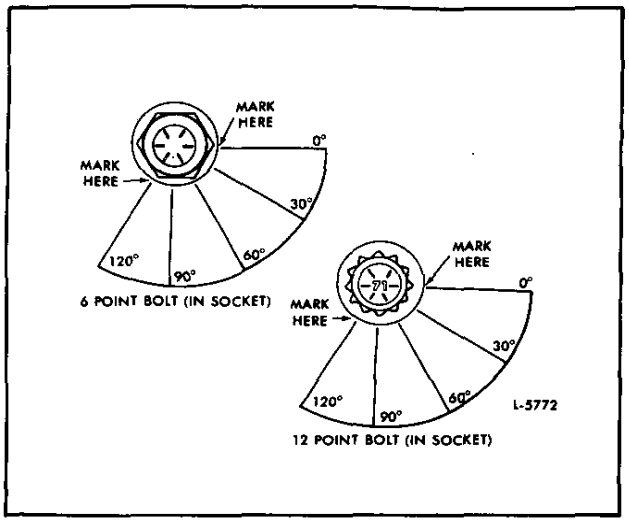


Fig. 10 - Main Bearing Cap Bolt Turn Torque Method

when the bearing is in place, the tang will fit into the groove in the bearing support.

2. Install the lower main bearing shell so that the tang on the bearing fits into the groove in the bearing cap.

3. Assemble the crankshaft thrust washers (Fig. 8) before installing the rear main bearing cap. Clean both halves of each thrust washer carefully and remove any burrs from the washer seats -- the slightest burr or particle of dirt may decrease the clearance between the washers and the crankshaft beyond the specified limit. Slide the upper halves of the thrust washers into place. Then assemble the lower halves over the dowel pins in the bearing cap.

NOTE: The main bearing caps are bored in position and stamped 1, 2, 3, etc. (Fig. 9). They must be installed in their original positions with the marked side of each cap toward the blower side of the cylinder block.

4. With the lower main bearing shells installed in the bearing caps, apply a small quantity of International Compound No. 2, or equivalent, to the bolt or stud and nut threads and the bolt head (or nut) contact area. Install the bearing caps and draw the bolts (or nuts) up snug. Then rap the caps sharply with a soft hammer to seat them properly and tighten all bolts to 45-55 lb-ft (61-75 Nm) torque. Turn all bolts (except the rear main bearing bolts) an additional 110 °-130 ° of bolt head rotation starting with the center bearing cap bolts and working alternately towards both ends of the block.

NOTE: An accurate way to determine bolt head rotation is to paint or permanently scribe the sockets used with two marks 120 ° apart (Fig. 10). After torquing bolts to 45-55 lb-ft (61-75 Nm) put a pencil line opposite the first mark on the socket. Then rotate the bolt until the next socket mark lines up with the pencil line.

Strike both ends of the crankshaft two or three sharp blows with a soft hammer to insure proper positioning of the rear main bearing cap in the block saddle. Turn the rear main bearing cap bolts an addition 110 °-130 ° of bolt head rotation. If studs and nuts are used, tighten all nuts (except the rear main bearing nuts) to 155-185 lb-ft (211-251 Nm) torque (cast iron block) or 120-140 lb-ft (163-190 Nm) torque (aluminum block) starting with the center bearing cap nuts and working alternately towards both ends of the block. Tighten the rear main bearing nuts to 40-50 lb-ft (54-68 Nm) torque. Strike both ends of the crankshaft two or three sharp blows with a soft hammer to insure proper positioning of the rear main bearing cap in the block saddle. Re-torque all bearing nuts to 155-185 lb-ft (211-251 Nm) (cast iron block) or 120-140 lb-ft (163-190 Nm) (aluminum block).

NOTE: If the bearings have been installed properly, the crankshaft will turn freely with all of the main bearing cap bolts or nuts drawn to the specified torque.

5. Check the crankshaft end play as outlined under *Install Crankshaft* in Section 1.3.

6. Install the lubricating oil pump and the oil inlet and outlet pipe assemblies.

NOTE: If shims were used between the pump and the bearing caps, install them in their original positions. Then check the oil pump gear clearance (Section 4.1).

© 1977 General Motors Corp.

7. Install the oil pan, using a new gasket.

8. Fill the crankcase to the proper level on the dipstick with *heavy-duty* lubricating oil of the recommended grade and viscosity (refer to *Lubricating Oil Specifications* in Section 13.3).

9. After installing new bearing shells, operate the engine on a run-in schedule as outlined in Section 13.2.1.

© 1977 General Motors Corp.

CRANKSHAFT FRONT COVER

The crankshaft front cover is mounted against the cylinder block end plate at the lower front end of the engine (Fig. 1). On marine engines, it serves as a housing for the vibration damper. The engine is supported at the front end by engine supports attached to the front cover.

It will be necessary to remove the crankshaft front cover to remove and install the crankshaft or when the engine is overhauled.

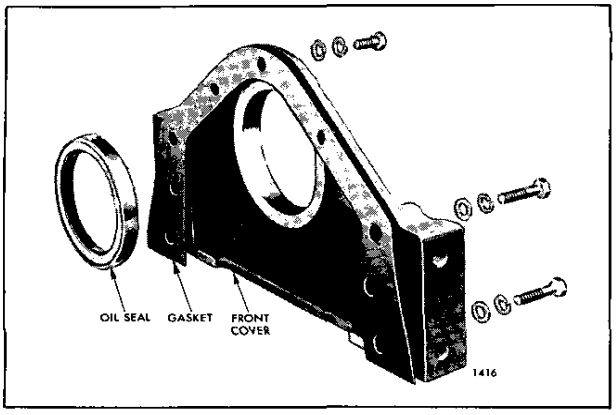


Fig. 2 - Crankshaft Front Cover Details and Relative Location of Parts

Remove Crankshaft Front Cover

1. Drain the oil and remove the oil pan.

2. Remove the vibration damper (Section 1.3.6), crankshaft pulley (Section 1.3.7) and any other accessories that may be mounted on the front of the crankshaft.

3. Remove the vibration damper inner cone or oil seal spacer.

4. Remove the cover attaching bolts and washers (Fig. 1).

5. Strike the rear face of the ears on the cover with a soft hammer to free the cover from the dowels. Pull the cover straight off the end of the crankshaft.

6. Remove the cover gasket.

7. Remove and inspect the oil slinger.

8. Replace the oil seal (Section 1.3.2).

Install Crankshaft Front Cover

1. Install the oil slinger in place next to the oil pump drive gear, with the dished outer diameter of the slinger facing away from the gear.

2. Shellac a new gasket to the bolting flange of the crankshaft front cover.

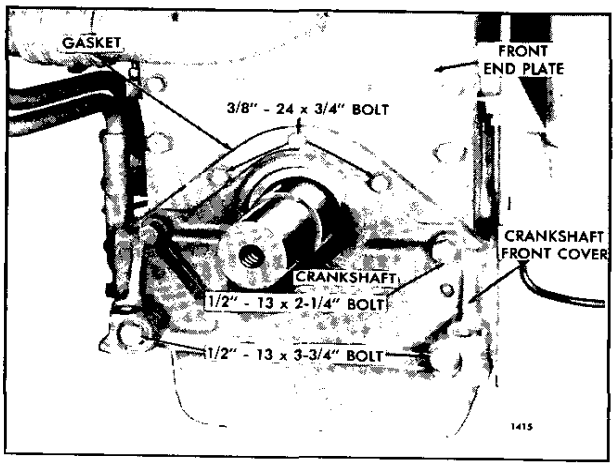


Fig. 1 - Crankshaft Front Cover Mounting (Vibration Damper Removed)

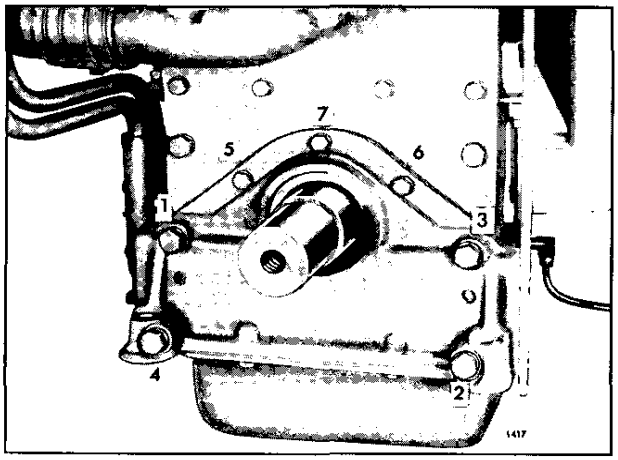


Fig. 3 – Crankshaft Front Cover Bolt Tightening Sequence

© 1977 General Motors Corp.

3. Coat the lip of the oil seal lightly with cup grease.

4. Attach the cover to the cylinder block front end plate with bolts and lock washers. Use plain washers in addition to lock washers on aluminum covers.

5. Tighten the cover attaching bolts by following the tightening sequence indicated in Fig. 3. Follow this sequence as the bolts are drawn up and then tightened to their proper torque to effect a good seal between the mating parts. Tighten the 3/8" -24 bolts to 25-30 lb-ft (34-41 Nm) and the 1/2" -13 bolts to 80-90 lb-ft (108-122 Nm) torque.

6. Apply a light coating of engine oil to the vibration damper inner cone or the oil seal spacer and slide it into place on the crankshaft.

7. Install the oil pan, using a new gasket.

8. Refer to *Lubricating Oil Specifications* in Section 13.3 and refill the crankcase with oil to the proper level on the dipstick.

© 1977 General Motors Corp.

CRANKSHAFT VIBRATION DAMPER

Some four and six cylinder engines require a vibration damper to reduce the crankshaft stresses to a safe value. The three cylinder engines do not require a vibration damper. Three different types of vibration dampers are available and their particular use depends on the number of cylinders, the governed speed and other characteristics of each engine. The three types of vibration dampers are described below.

The *double (rubber) damper* (Figs. 1 and 4) is made up of a light damper, a heavy damper, a hub, an inner cone and an outer cone. The light and heavy dampers in the assembly are in turn made up of rubber blocks bonded to an inertia mass in the form of a metal ring on one side and a stamped metal disc on the opposite side.

The two metal parts are, therefore, entirely separated and free to move freely within certain prescribed limits by virtue of the rubber blocks. The light and heavy dampers are bolted and doweled together and to the driving hub. The hub in turn is secured in place at the front end of the crankshaft between an inner and outer cone (Fig. 1). The two cones provide an adequate rigid mounting when the crankshaft cap, or a pulley, is drawn up tight against the outer cone by the bolt in the end of the crankshaft.

The new bolts are now lubrite coated to prevent possible damage (galling) to the bolt threads and to increase the clamp load to the front end stack up (crankshaft pulley, vibration damper, etc). Also, the new washer (retainer) is now case hardened.

The new bolts and washer can be identified by their black color. The former bolts and washer are a steel (gray) color.

The *single (rubber) damper* is similar to the double damper described above except that only the light damper is used with the hub and cones.

These vibration dampers are rigidly constructed and should give no trouble if given proper care; nevertheless, since rubber is used in the assembly, certain precautions are necessary. Fuel oil and lubricating oil, as well as excessive heat, are destructive to rubber. The assembly, therefore, should be protected against these destructive agents. Furthermore, for the damper to function properly and safeguard the crankshaft, it should be securely fastened to the shaft by the cones and the crankshaft cap or pulley which also act as a cone retainer.

The *viscous (fluid) type damper* is employed where the equipment which the engine powers requires frequent speed and load changes. The viscous damper provides faster response to load and speed changes and high temperatures have a less adverse effect than on the rubber type damper.

The viscous damper assembly consists of a sealed outer shell, an internal flywheel and a quanity of highly viscous fluid (Figs. 2 and 6). The small clearance between the flywheel and the outer shell is filled with the fluid which causes the flywheel to be driven upon acceleration and permits it to "freewheel" upon deceleration. The new 12" nylon coated flywheel style vibration dampers are now being used on the 6-71 engines. Only the current nylon coated dampers will be serviced.

During operation, the outer shell, which is firmly attached to the crankshaft, turns at the same speed as the crankshaft, its motion being transferred to the flywheel through the fluid within the shell. Inasmuch as "fluid-drive" is more or less inefficient with frequent speed changes, considerable slippage of the flywheel will take place as the power impulses are transmitted through the crankshaft. In this type of operation, the slippage is desirable since the acceleration and deceleration of the flywheel in the damper lessens the amplitude of the vibrations, thereby reducing their effects to a point where they are not harmful to the engine.

On certain marine engines, the vibration damper is the same as described above, except that it includes bushings that are designed to project slightly beyond the front and rear vertical face of the internal flywheel. These bushings serve to center the flywheel within the damper. Any axial contact with the inner face of the damper shell is taken by the vertical face of the bushing instead of the face of the flywheel. Any radial contact is taken by the bearing surface of the bushing.

The vibration damper must be removed whenever the crankshaft, crankshaft front cover or crankshaft front oil seal is removed or replaced.

Remove Vibration Damper From Crankshaft

1. Remove the crankshaft pulley or cap retaining bolt and washer.

2. Remove the crankshaft pulley or cap.

3. On rubber-type vibration dampers, remove two damper-to-hub bolts and lock washers diametrically opposite to each other (Fig. 3). Two puller holes are provided in the bolt circle of the viscous damper.

© 1984 General Motors Corp.

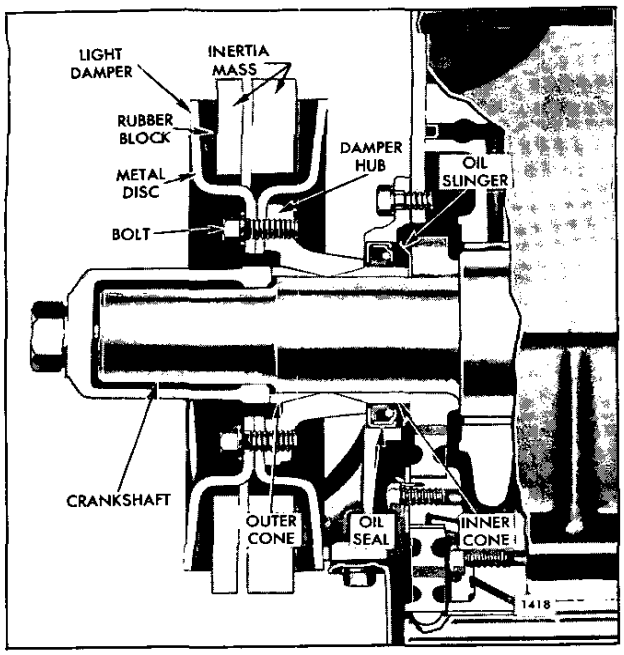


Fig. 1 - Crankshaft Cap and Double Vibration Damper Assembly and Mounting

4. Reinstall the pulley crankshaft bolt and install a puller to loosen the outer cone wedge between the crankshaft and the damper hub (Figs. 2 and 3). After loosening the cone, it may be "fished" from the inner diameter of the damper hub with two thin shank screwdrivers.

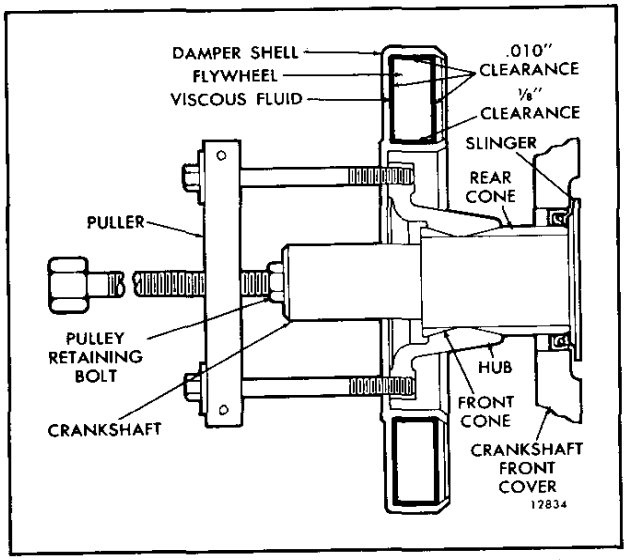


Fig. 2 - Removing Vibration Damper Assembly (Viscous Type)

NOTE: Pounding with a hammer or prying with other tools *must not* be resorted to in removing the viscous type damper from the crankshaft, since the outer shell may be dented and cause the flywheel to turn at the same speed as the outer shell, thus rendering the damper ineffective. *The damper cannot be repaired.*

5. Slide the vibration damper or dampers and damper hub as an assembly off the end of the crankshaft by hand.

6. Slide the inner cone from the crankshaft.

Inspect Vibration Damper

After removal, clean the vibration damper in fuel oil and dry it with compressed air.

NOTE: Do not allow fuel oil to remain on a rubber type vibration damper too long, but dry it immediately after cleaning, otherwise, damage due to the action of the fuel oil on the rubber may result.

Inspect the rubber type damper to see that the rubber is firmly bonded to the metal parts at each side. If the damper has been exposed to fuel oil, lubricating oil or excessive heat, the rubber may have become loosened from the metal. In this event, the damper must be discarded and replaced with a new one. Also, check to see that the metal discs are not bent.

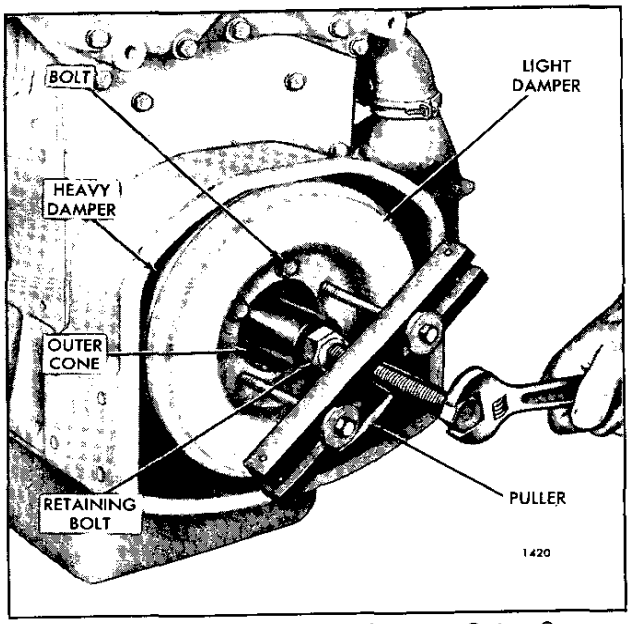


Fig. 3 - Loosening Vibration Damper Outer Cone using Tool J 24420-A

© 1984 General Motors Corp.

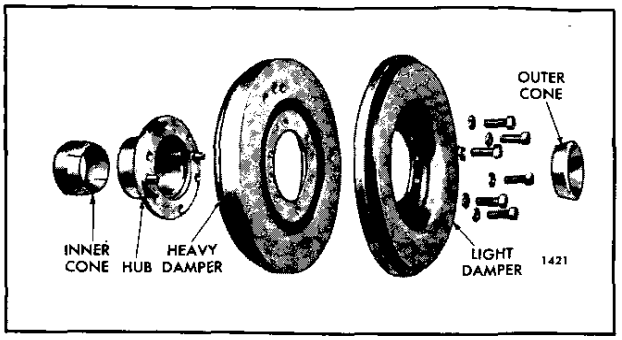


Fig. 4 - Double Vibration Damper (Rubber-Type) Details and Relative Location of Parts

Examine the viscous type damper for dents, nicks, fluid leakage or bulges in the outer casing of the damper. Any indications of the above are sufficient cause for replacing the damper. Due to the close clearances between the internal flywheel and outer casing, dents may render the damper ineffective. Bulges or splits indicate the fluid has ignited and expansion of the resultant gases has bulged or forced the casing open at its crimped edges.

Since the viscous type damper is a precision built closely fitted and sealed device, it is not possible to repair it.

Regardless of condition, the viscous type damper should be replaced at time of normal periodic major engine overhaul.

The former damper used on 6-71, 6-71T, 6-71TA, 6-71TT and 6-71TTA engines *must* be replaced with the new damper and scuff plate assembly at the time of normal engine overhaul or when physical damage or fluid leakage are evident.

NOTE: Do not install the new damper on any other Detroit Diesel engine models. Engines not designed to use this damper may experience serious crankshaft damage.

If damage to the vibration damper is extensive, inspect the crankshaft as outlined in Section 1.3. A loose or defective vibration damper, after extended operation, may result in a cracked crankshaft.

Inspect the damper spacer cones, hub, sleeve and the end of the crankshaft for galling or burrs. Slight scratches or burrs may be removed with emery cloth. If seriously damaged, the parts should be replaced and the end of the crankshaft refinished. Check the outside diameter of the inner cone for wear at the crankshaft front oil seal contact surface. If worn, replace the oil seal and cone (Section 1.3.2).

A loose engine mount could damage the vibration damper by allowing the engine to move slightly during operation. Therefore, it is good practice to periodically inspect the engine mounts to be sure they are not loose, cracked or deteriorated.

Effective July, 1974 new light and heavy rubber vibration dampers, indentified by the 36 ribs incorporated in the outer casting, are being used. The former dampers are cast smooth. The former light and current light dampers are not separately interchangeable on double damper applications. Therefore, a former heavy damper cannot be used with a new light damper. A new light and a new heavy vibration damper must be used together.

NOTE: The new light damper when used with a 7 1/2" diameter single groove pulley will result in interference between the pulley and the light damper. Rework the vibration damper hub as follows:

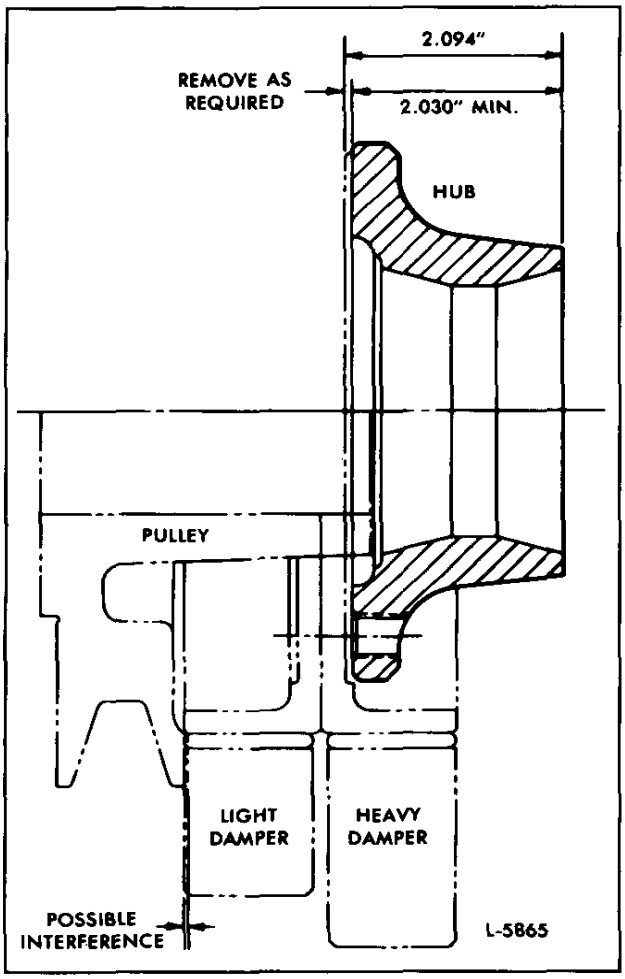


Fig. 5 - Reworking Vibration Damper Hub

© 1984 General Motors Corp.

1. Remove the dowels.

2. Machine .065″ from the damper end of the hub (Fig. 5).

3. Install new dowels and assemble the hub to the *vibration dampers.*

Install Vibration Damper on Crankshaft

Refer to the illustrations for relative location of the parts and assemble as follows:

1. Coat the lip of the oil seal in the front cover (trunnion) lightly with cup grease or vegetable shortening and lubricate the sleeve and spacer if used, with engine oil.

2. Slide the sleeve, if used, over the large diameter of the crankshaft and against the oil slinger, being sure the slinger is tight against the oil pump drive gear; then slide the spacer against the sleeve.

3. With the Woodruff keys (if used) in place, slide the inner cone, with the tapered end pointing to the front of the crankshaft, next to the oil slinger or against the spacer, if used.

NOTE: When the vibration damper and crankshaft pulley are bolted together and mounted on the front end of the crankshaft (Fig. 6), extra precaution should be taken to be certain that the inner cone does not prematurely clamp to the crankshaft.

4. If the light and heavy dampers were removed from the hub, assemble the two dampers over the dowels and against the hub with the flat faces of the dampers facing each other (Fig. 1). Secure the dampers to the hub with bolts and lock washers.

5. Slide the damper and hub as an assembly -- long end of the hub *facing the crankshaft cover* -- into position.

NOTE: Do not hit a viscous type damper with a hammer to position it on the crankshaft.

6. Install the crankshaft pulley and vibration damper assembly with the damper assembly side of the pulley facing the crankshaft front cover.

7. Slide the outer cone over the crankshaft and into the hub of the vibration damper (or the crankshaft pulley).

8. Install the crankshaft cap (or crankshaft pulley).

9. Thread the crankshaft cap (or pulley) retaining bolt with washer, if used, into the crankshaft and tighten it as follows:

a. Tighten to 180 lb-ft (244 Nm) torque.

b. Strike the end of the bolt a sharp blow with a 2 to 3 lb. lead hammer.

c. Tighten to 300 lb-ft (407 Nm) torque and strike the bolt again.

d. Tighten to 290-310 lb-ft (393-421 Nm) torque.

NOTE: Do not strike the bolt after final torque has been applied.

The hex head of the crankshaft bolt may be used to bar, or turn, the crankshaft. However, the barring operation should **ALWAYS** be performed in a clockwise direction. *It is very important to make certain that the bolt has not been loosened during the barring operation.* Otherwise, serious engine damage may result if the vibration damper or pulley is not securely fastened to the crankshaft.

NOTE: The damper assembly must be securely fastened to the crankshaft. When the bolt is drawn up to the specified torque, the cones will hold the damper rigidly in place.

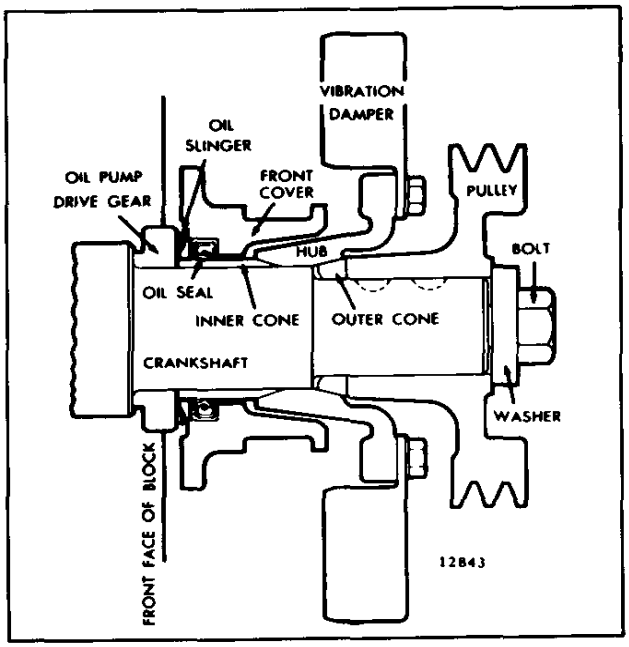


Fig. 6 - Vibration Damper and Crankshaft Pulley Assembly Mounting

© 1984 General Motors Corp.

CRANKSHAFT PULLEY

The engine application determines the type of crankshaft pulley to be used. One type of pulley used incorporates a rubber insulator between the pulley and the pulley hub, for vibration dampening. A static clip is used between the pulley and the hub on some engines for releasing electrical charges.

The crankshaft pulley is retained on the crankshaft with keys, cones or a combination of both and secured with a special washer and bolt.

The new crankshaft bolts are now lubrite coated to prevent possible damage (galling) to the bolt threads and to increase the clamp load to the front end stack up (crankshaft pulley, vibration damper, etc). Also the new washer (retainer) is now case hardened.

The new bolts and washer can be identified by their black color. The former bolts and washer are a steel (gray) color.

NOTE: The load carrying capability of the front crankshaft pulleys will vary depending upon the pulley used.

Inspection

The condition of a rubber mounted crankshaft pulley cannot be determined by the appearance of the rubber. The only reliable method of checking for failure of the rubber bushing is to hold the crankshaft stationary and apply pressure to the pulley. If the pulley cannot be rotated, the bushing is in satisfactory condition. An unsatisfactory rubber bushing should be replaced.

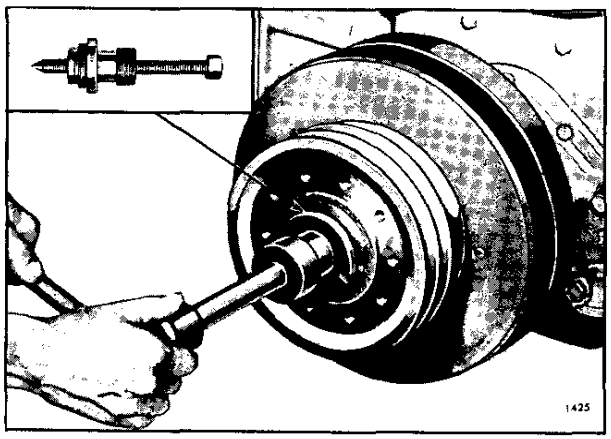


Fig. 1 - Removing Rubber Mounted Pulley from Crankshaft using Tool J 5356

Remove Crankshaft Pulley

The difference in the design of pulleys dictates the use of various puller tools as outlined below:

1. Remove the bolt and washer; also remove the static clip, if used, on the rubber mounted type crankshaft pulley.

2. If a rubber mounted pulley with an internal thread is being removed, use puller J 5356 as illustrated in Fig. 1. Clean the threads of the tool and pulley. Screw the 2 1/2"-16 thread into the pulley hub as far as possible with the center screw backed off. Then force the pulley off the crankshaft by turning the center screw in.

3. If a rigid type pulley without any tapped holes is being removed, use a two-jaw puller (J 4643).

4. If tapped holes are provided in the pulley hub, install the pulley bolt in the end of the crankshaft and use puller J 24420-A (Fig. 2).

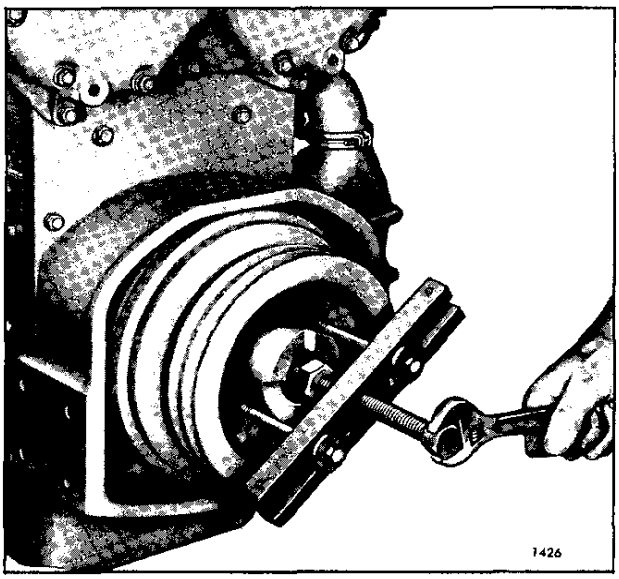


Fig. 2 - Removing Pulley with Tapped Holes from Crankshaft using Tool J 24420-A

© 1983 General Motors Corp.

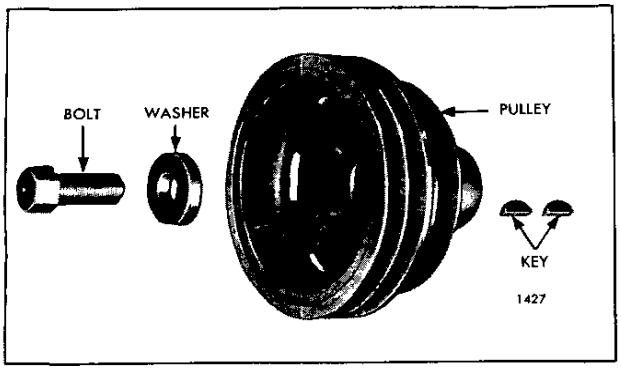


Fig. 3 - Crankshaft Pulley Details

Install Crankshaft Pulley

Install the keys and/or cones in the front end of the crankshaft as they were removed (Fig. 3).

2. Slide the pulley over the end of the crankshaft.

3. Place the washer on the bolt (also the static clip used with the rubber mounted type pulleys) and thread the bolt into the end of the crankshaft, drawing the pulley tight against the oil seal spacer. If the engine is equipped with a vibration damper, the pulley must be drawn tight against the outer cone.

4. Tighten the crankshaft pulley retaining bolt as follows:

a. Tighten the bolt to 180 lb-ft (244 Nm) torque.

b. Strike the end of the bolt a sharp blow with a 2 or 3 lb. lead hammer.

c. Tighten the bolt to 300 lb-ft (407 Nm) torque and strike the bolt again.

d. Tighten the bolt to 290-310 lb-ft (393-421 Nm) torque. Do not strike the bolt after final torque has been applied.

The hex head of the crankshaft bolt may be used to bar, or turn, the crankshaft. However, the barring operation should **ALWAYS** be performed in a clockwise direction. *It is very important to make certain that the bolt has not been loosened during the barring operation.* Otherwise, serious engine damage may result if the vibration damper or pulley is not securely fastened to the crankshaft.

© 1983 General Motors Corp.

FLYWHEEL

The flywheel is attached to the rear end of the crankshaft with six self-locking bolts (Fig. 1). Two dowels in the end of the crankshaft aid flywheel alignment and provide support when the flywheel bolts are removed. A scuff plate is used between the flywheel and the bolt heads to prevent the bolt heads from scoring the flywheel surface.

NOTE: Some early engines did not incorporate crankshaft dowels.

A steel ring gear, which meshes with the starting motor pinion, is shrunk onto the rim of the flywheel.

On current engines, a split tube type retainer (Fig. 2) is driven in the end of the crankshaft to prevent the pilot bearing from entering the crankshaft cavity. Former engines used a washer type retainer.

The flywheel is machined to provide true alignment with the clutch or a power take-off driving ring, and the center bore provides for installation of a clutch pilot bearing. The clutch or power take-off driving ring is bolted to the flywheel.

On some flywheel installations, a drive flange is attached to the rear face of the flywheel. The drive flange incorporates internal splines to receive a splined drive shaft.

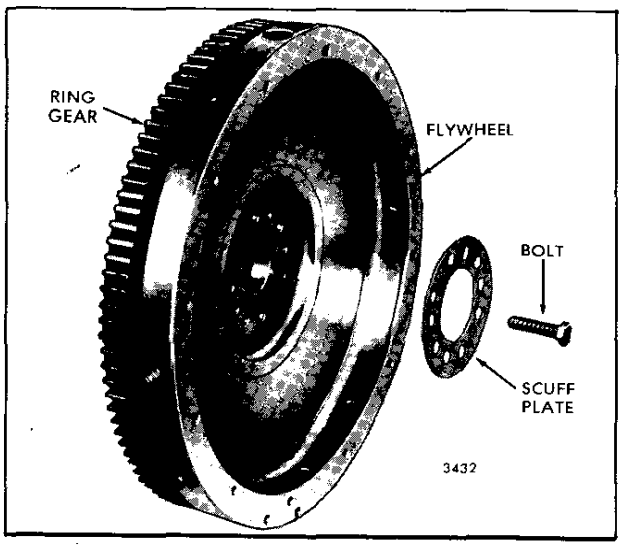


Fig. 1 - Typical Flywheel Assembly

On other applications, a clutch wear plate is bolted to the flywheel or four drive pins are installed in the inner diameter of the flywheel rim.

An oil seal ring, which provides an oil tight connection between the crankshaft and the flywheel, is fitted into a groove on flywheels used with hydraulic couplings, clutches or Torqmatic converters.

The flywheel must be removed for service operations such as replacing the starter ring gear, crankshaft or flywheel housing. On torque converter units, the flywheel is part of the torque converter assembly and is covered in the applicable converter service manual. The flywheel is also part of the Torqmatic marine gear assemblies and is covered in the *Marine Gear, Reduction Gear and Transmission Service Manual, form 6SE355.*

Remove Flywheel (Transmission Removed)

1. Remove the six flywheel attaching bolts and scuff plate. If the crankshaft is not provided with dowels, install one flywheel bolt after removing the scuff plate to hold the flywheel in place until the lifting tool is attached.

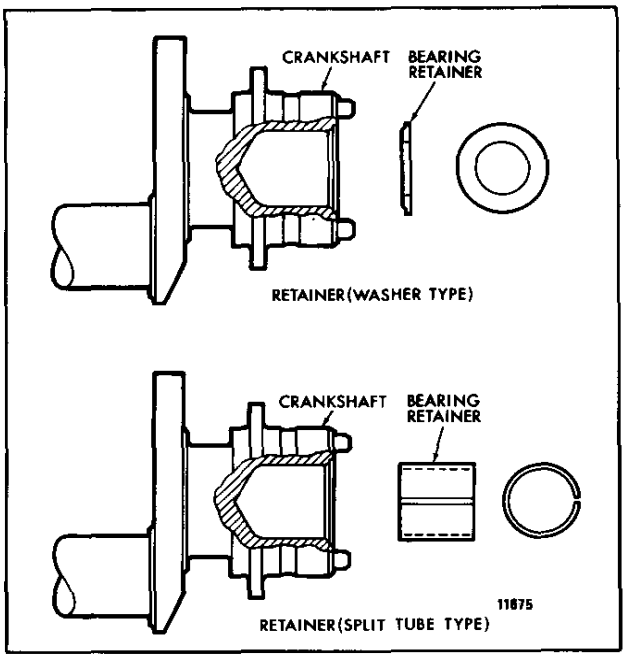


Fig. 2 - Pilot Bearing Retainers

© 1983 General Motors Corp.

NOTE: If the flywheel is equipped with a splined drive flange, it must be removed first.

2. Attach flywheel lifting tool J 6361-01 to the flywheel with two 7/16″-14 bolts of suitable length or use tool J 25026. Remove the remaining flywheel attaching bolt.

3. Attach a chain hoist to the lifting tool to support the flywheel (Fig. 3).

4. Move the upper end of the lifting tool in and out to loosen the flywheel, then withdraw the flywheel from the crankshaft and the flywheel housing.

5. Remove the clutch pilot bearing, if used, as outlined in Section 1.4.1.

6. Remove the washer type pilot bearing retainer, if used. It is not necessary to remove the split tube type retainer.

7. Remove the oil seal ring, if used.

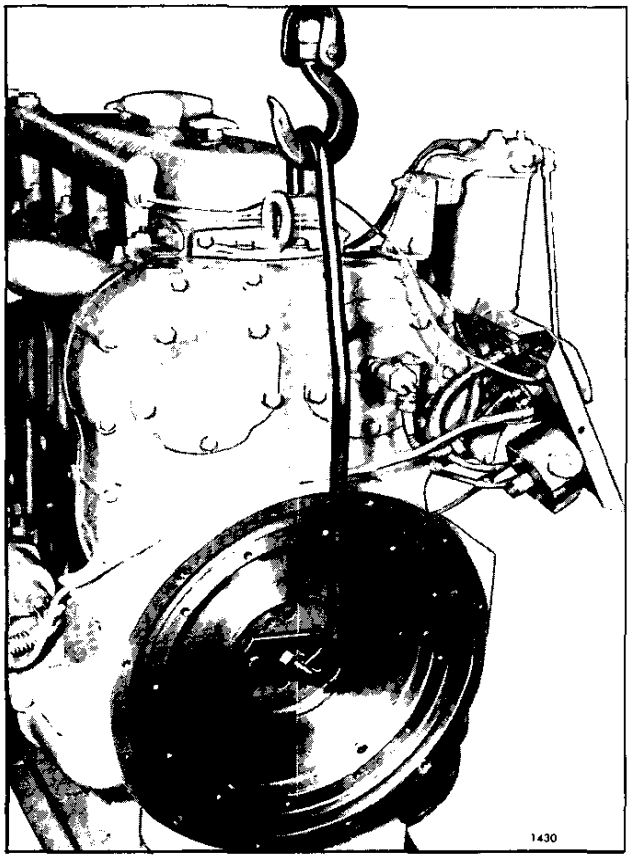


Fig. 3 - Removing Flywheel using Tool J 6361-01

Inspection

Check the clutch contact face of the flywheel for scoring, overheating or cracks. If scored, the flywheel may be refaced. However, *do not* remove more than .020″ of metal from the flywheel. Maintain all of the radii when refacing the flywheel.

Replace the ring gear if the gear teeth are excessively worn or damaged. Check the butt end of the crankshaft and flywheel contact surface. If necessary, lightly stone the crankshaft end and the flywheel contact surface to remove any fretting or brinnelling.

On crankshafts with dowels, be sure and check the dowel extension. Dowels must not extend more than 1/2″ from the crankshaft.

Make sure that the crankshaft and flywheel contact surfaces and the bolt threads in the crankshaft end are clean and dry, to insure proper metal-to-metal contact and maximum friction, before attaching the flywheel.

New bolts should be used to mount or remount the flywheel. However, if the original bolts are determined to be serviceable and are to be reused, clean them thoroughly before starting the assembly procedure.

Remove Ring Gear

Note whether the ring gear teeth are chamfered. The replacement gear must be installed so that the chamfer on the teeth faces the same direction with relationship to the flywheel as on the gear that is to be removed. Then, remove the ring gear as follows:

1. Support the flywheel, crankshaft side down, on a solid flat surface or hardwood block which is slightly smaller than the inside diameter of the ring gear.

2. Drive the ring gear off the flywheel with a suitable drift and hammer. Work around the circumference of the gear to avoid binding the gear on the flywheel.

Install Ring Gear

1. Support the flywheel, ring gear side up, on a solid flat surface.

2. Rest the ring gear on a flat **metal surface** and heat the gear uniformly with an acetylene torch, keeping the torch moving around the gear to avoid hot spots. Do not, under any circumstances, heat the gear over 400° F (204° C); excessive heat may destroy the original heat treatment.

NOTE: Heat indicating "crayons", which are placed on the ring gear and melt at a

© 1983 General Motors Corp.

predetermined temperature, may be obtained from most tool vendors. Use of these "crayons" will ensure against overheating the gear.

3. Use a pair of tongs to place the gear on the flywheel with the chamfer, if any, facing the same direction as on the gear just removed.

4. Tap the gear in place against the shoulder on the flywheel. If the gear cannot be tapped into place readily so that it is seated all the way around, remove it and apply additional heat, noting the above caution.

Install Flywheel

1. Install a new oil seal ring (if used).

2. Attach the flywheel lifting tool and, using a chain hoist, position the flywheel in the flywheel housing (use guide studs). Align the flywheel bolt holes with the crankshaft bolt holes.

3. Install the clutch pilot bearing (if used).

4. Install the washer type pilot bearing retainer, if used. To install a split tube type retainer, drive the retainer in flush with the end of the crankshaft with a soft hammer.

NOTE: Do not mar the bearing contact surface of the retainer.

5. Install two bolts through the scuff plate (or drive flange) 180° from each other. Snug the bolts to hold the flywheel and scuff plate (or drive flange) to the crankshaft. Remove the guide studs.

6. Remove the flywheel lifting tool.

7. Apply International Compound No. 2, or equivalent, to the threads and to the bolt head contact area (underside) of the remaining bolts. The bolt threads must be completely filled with International Compound No. 2 and any excess wiped off.

NOTE: International Compound No. 2 must never be used between two surfaces where maximum friction is desired as between the crankshaft and the flywheel.

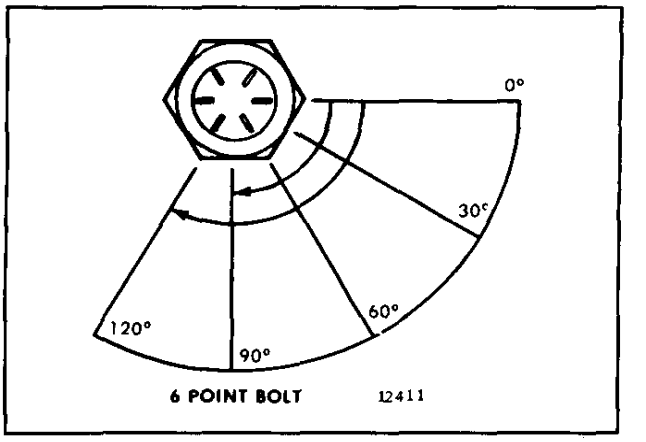


Fig. 4 - Torque-Turn Limits

8. Install the remaining bolts and run them in snug.

9. Remove the two bolts used temporarily to retain the flywheel, apply International Compound No. 2 as described above, then reinstall them.

10. Use an accurately calibrated torque wrench and tighten the bolts to 50 lb-ft (68 Nm) torque.

11. Turn the bolts an additional 90° -120° to obtain the required clamping (Fig. 4).

NOTE: Since the *torque-turn method* provides more consistent clamping than the former method of flywheel installation, bolt torque values should be ignored.

When a clutch pilot bearing is installed, index the flywheel bolts so that the corners of the bolt heads do not overlap the pilot bearing bore in the flywheel. Thus, one of the flats of each bolt head will be in line with the bearing bore. Always rotate bolts in the *increased* clamp direction to prevent underclamping.

12. Mount a dial indicator on the flywheel housing and check the runout of the flywheel at the clutch contact face. The maximum allowable runout is .001" total indicator reading per inch of radius (or .001mm per millimeter of radius). The radius is measured from the center of the flywheel to the outer edge of the clutch contact face of the flywheel.

© 1983 General Motors Corp.

CLUTCH PILOT BEARING

The clutch pilot bearing is pressed into the bore of the flywheel assembly and serves as a support for the inner end of the clutch drive shaft.

The clutch pilot bearing is held in place by a scuff plate, or bearing retainer, secured in place by the flywheel attaching bolts.

In certain applications, the clutch pilot bearing is mounted in a carrier (Fig. 1) which is attached to a boss on the flywheel by six bolts and lock washers. The bearing is pressed into the carrier bore until it contacts a retaining snap ring approximately midway in the bore.

The clutch pilot bearing used in the flywheel on power take-off installations is covered in Section 8.1.

The clutch pilot bearing used in the flywheel on marine installations is covered in the *Series 71 and 92 Marine Gears, Engine Reduction Gears and Transmissions Manual, 6SE355.*

Lubrication

A single-shielded ball type clutch pilot bearing should be packed with an all purpose grease such as Shell Alvania No. 2, or equivalent, if not previously packed by the manufacturer. A double-sealed ball type clutch pilot bearing is prepacked with grease and requires no further lubrication. The clutch pilot bearing was lubricated by an oil wick located in a threaded hole in the cavity at the rear end of the crankshaft on early engines.

On engines equipped with a power take-off assembly using a straight-roller type pilot bearing or unshielded ball bearing, the cavity in the end of the crankshaft is packed with Shell Alvania No. 2 grease, or equivalent.

Remove Clutch Pilot Bearing (Transmission Removed)

To remove a *roller type* pilot bearing, refer to *Remove Clutch Pilot Bearing* in Section 8.1. With the flywheel attached to the engine, remove the *ball type* clutch pilot bearing as follows:

1. Remove the six bolts (and lock wires, if used) attaching the flywheel to the crankshaft. Remove the bearing retainer and re-install two of the bolts to hold the flywheel in place.

NOTE: Install two 9/16 "-18 studs in place of two of the flywheel bolts, on engines without dowels in the end of the crankshaft, to prevent the flywheel from dropping off the end of the crankshaft.

2. With the clutch pilot bearing remover adaptor J 23907-2 attached to slide hammer J 23907-1, insert the fingers of the adaptor through the pilot bearing and tighten the thumb screw to expand the fingers against the inner race of the bearing.

3. Tap the slide hammer against the shoulder on the shaft and pull the bearing out of the flywheel.

With the flywheel removed from the engine, the clutch pilot bearing may be removed as follows:

1. Place the flywheel on wood supports to provide clearance for the bearing.

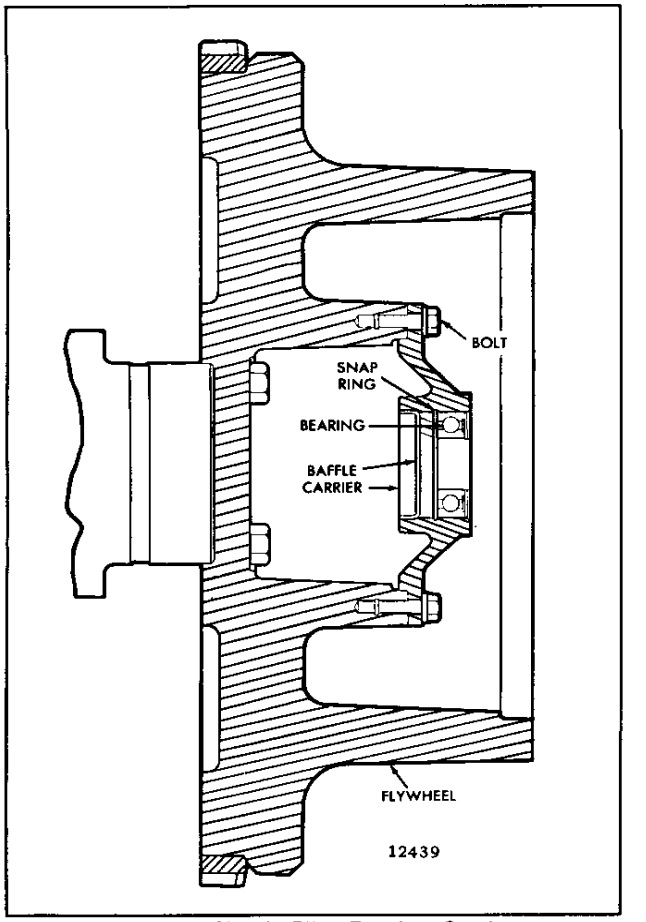


Fig. 1 - Clutch Pilot Bearing Carrier Installation

© 1978 General Motors Corp.

2. Use bearing remover J 23907-2, as outlined above, or tool J 3154-04 with suitable adaptor plates, to tap the bearing from the flywheel.

Inspection

Wipe the prepacked double-sealed bearing clean on the outside and inspect it. *Shielded bearings must not be washed;* dirt may be washed in and the cleaning fluid could not be entirely removed from the bearing. Clean the other types of bearing thoroughly with clean fuel oil and dry them with compressed air.

Check the bearing for free rolling by holding the inner race and revolving the outer race *slowly* by hand. Rough spots in the bearing are sufficient cause for rejecting it.

Install Clutch Pilot Bearing.

Install a *roller type* pilot bearing as outlined under *Install Clutch Pilot Bearing* in Section 8.1. Install a *ball type* bearing as follows:

1. Lubricate the outside diameter of the bearing with clean engine oil.

2. Start the bearing in the bore of the flywheel, with the numbered side of the bearing facing away from the engine, and drive the bearing in place with bearing installer J 3154-04 and suitable adaptor plates.

3. If a straight-roller type bearing or an unshielded ball bearing is used, pack the crankshaft cavity with Shell Alvania No. 2 grease, or equivalent, flush with the rear face of the crankshaft. *Make sure there are no air pockets in the grease.*

4. Install the flywheel on the crankshaft (refer to Section 1.4).

© 1978 General Motors Corp.

ENGINE DRIVE SHAFT FLEXIBLE COUPLING

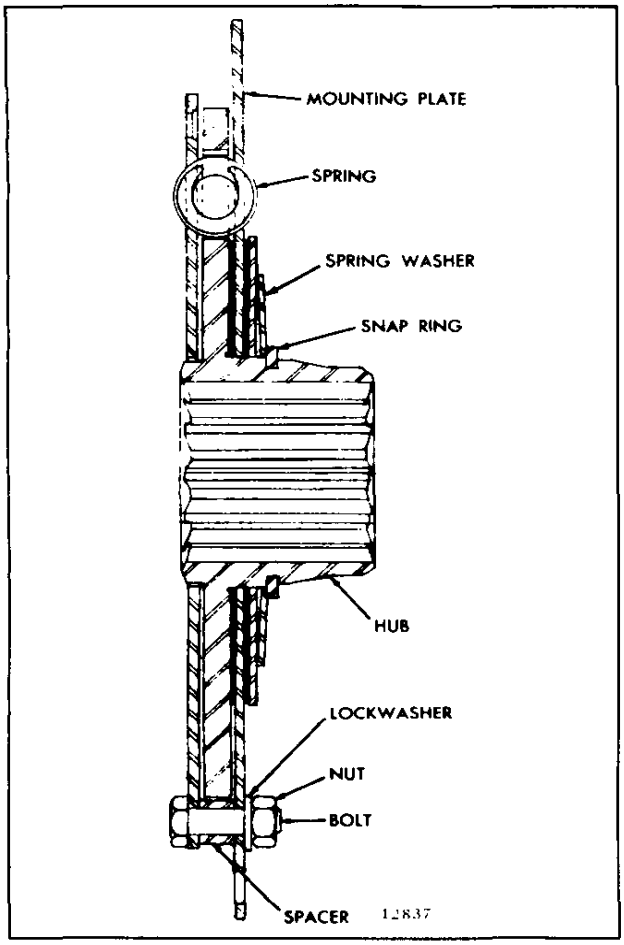


Fig. 1 - Engine Drive Shaft Flexible Coupling

The engine drive shaft flexible coupling (Fig. 1) is of the spring-loaded type having a splined hub to match with the splines on the transmission drive line shaft used on certain applications. The coupling, bolted to the engine flywheel, serves as a drive and also dampens out torque fluctuations between the engine and the transmission.

Remove Coupling (Transmission Removed)

Remove the eight 3/8 "-16 x 7/8 " bolts which attach the coupling to the flywheel and remove the coupling.

Inspect Coupling

Wash the coupling in clean fuel oil and dry it with compressed air. Check for broken or worn springs. Springs may be replaced by removing the six bolts, lock washers, nuts and spacers holding the two plates together and removing the smaller plate. After replacing the springs, bolt the plates together and tighten the nuts to 25-30 lb-ft (34-41 Nm) torque.

Examine the hub splines for wear and check the flatness of the mounting plate (the plate which bolts to the flywheel). Since the plates, spacers and hubs are manufactured in matched sets, worn hubs or plates cannot be replaced individually, but must be replaced by a complete fexible coupling assembly.

Install Coupling

Align the bolt holes in the coupling with the tapped holes in the flywheel. Since one bolt hole is offset, the coupling can be attached in only one position. Install the eight 3/8 "-16 x 7/8 " bolts and tighten them securely.

© 1978 General Motors Corp.

FLYWHEEL HOUSING

The flywheel housing (Fig. 1) is a one-piece casting, mounted against the rear cylinder block end plate, which provides a cover for the gear train and the flywheel. It also serves as a support for the starting motor and the transmission.

The crankshaft rear oil seal, which is pressed into the housing, may be removed or installed without removing the housing (Section 1.3.2).

Former design spring-loaded flywheel "dump valves", used on marine units, could be inspected and serviced through an inspection opening in the pad on top of the "bell" of the flywheel housing. Current production marine flywheel housings do not incorporate the inspection hole since the present ball-type design valves cannot be inspected or serviced through the flywheel housing. However, if necessary, the inspection of the former valves can be made at the starter mounting hole in the flywheel housing.

The size of the tapped holes in the SAE No. 1 flywheel housings, used for transmission attaching bolts, has been increased from 3/8"-16 to 7/16"-14 to conform with a revision in SAE flywheel housing standards. The retaining bolt holes in power transfer element housings have likewise been revised from 13/32" to 15/32" diameter to accommodate the larger retaining bolts. Current transmission housings, incorporating the 15/32" diameter holes, can be used with flywheel housings having 3/8"-16 tapped holes. However, former transmission housings must have the bolt holes enlarged to 15/32" for use with revised flywheel housings with the 7/16"-14 tapped holes.

Remove Flywheel Housing

1. Mount the engine on an overhaul stand as outlined in Section 1.1.

2. Remove the starting motor, oil pan, flywheel and any accessories attached to the flywheel housing.

3. Remove the two bolts securing the engine lifter bracket to the cylinder head. This will leave the lifter bracket attached to the flywheel housing for convenience in handling.

4. Remove the twelve attaching bolts inside of the flywheel housing bell which attach the housing to the idler gear hub, spacer and cylinder block. Remove the twelve remaining bolts around the upper portion of the housing and the two bolts which go through the rear end plate from the front and thread into the housing (Fig. 1).

NOTE: When removing the flywheel housing bolts, note the location of the various bolts and washers so they may be reinstalled in their proper location.

5. To guide the flywheel housing until it clears the end of the crankshaft, thread four pilot studs J 1927-01 into the cylinder block (Fig. 2).

6. With the flywheel housing supported by a chain hoist attached to the lifter bracket, strike the front face of the housing alternately on each side with a soft hammer to work it off the dowels and away from the cylinder block rear end plate.

Inspection

Clean the flywheel housing and inspect it for cracks or any other damage.

NOTE: The flywheel housing on some engine models had a 9.603" radius from the center of the crankshaft bore to the center of the starter hole. These engines used a 103 tooth flywheel ring gear. These flywheel housings have been replaced by new housings with a 9.520" crankshaft bore to starter hole radius. A 102 tooth flywheel ring gear must be used with the new housings. The old ring gear is retained for

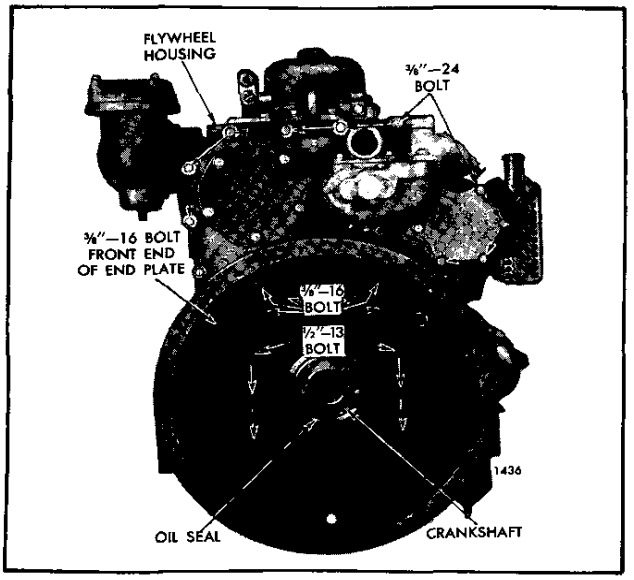


Fig. 1 - Typical Flywheel Housing Mounting

© 1983 General Motors Corp.

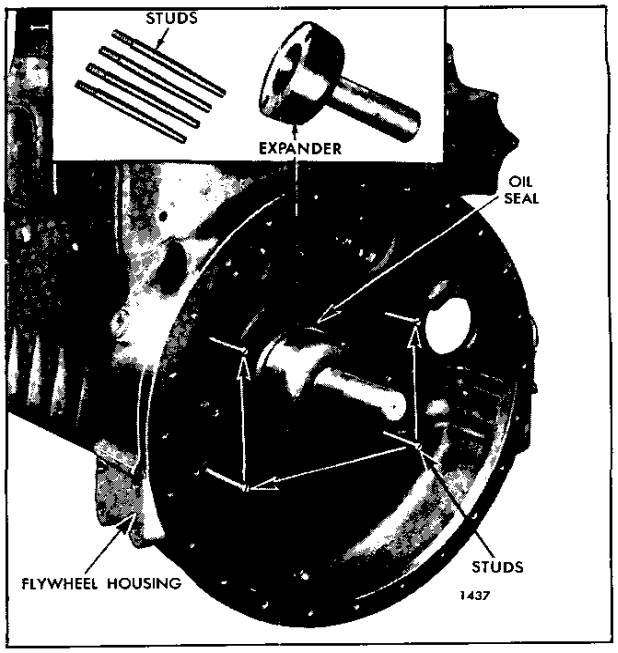


Fig. 2 - Removing or Installing Flywheel Housing

service for those engines still using the old housing.

It is very important that all old gasket material be thoroughly removed from the flywheel housing and the end plate, otherwise, runout of the pilot and the face of the housing may be affected when the housing is installed on the engine.

The steel oil deflector used in the flywheel housing on certain former engines is no longer required and is not available for service. It may be discarded at time of flywheel housing removal.

Remove and discard the crankshaft rear oil seal. Install a new oil seal as outlined in Section 1.3.2.

Install Flywheel Housing

1. Lubricate the gear train teeth with clean engine oil.

2. Affix a new housing-to-end plate gasket to the flywheel housing. Also, if a former design idler gear hub (used with the early design flanged idler gear bearing) or an idler gear hole spacer is used, attach the gaskets to the hub or the spacer or both, as required. No gasket is used with the current design hub or spacer (see Section 1.7.4).

NOTE: On certain flywheel housings, the idler gear hole spacer is cast integrally in the housing, opposite the idler gear (Fig. 3). As a result of this integral cast design, a shim must be installed between the flywheel housing and the cylinder block end plate. Use grease to hold the shim on the spacer during installation of the flywheel housing.

3. Coat the lip of the oil seal lightly with engine oil (single-lip seal) or vegetable shortening (double-lip seal). Do not scratch or nick the sealing edge of the oil seal.

4. Thread four pilot studs J 1927-01 into the cylinder block to guide the housing in place (Fig. 2). Use oil seal expander J 22425 (standard size seal) or expander J 4195-01 and handle J 8092 (oversize seal) on the end of the crankshaft to pilot the oil seal on the crankshaft.

5. With the housing suitably supported, position it over the crankshaft and up against the cylinder block rear end plate and gasket. Remove the oil seal expander.

6. Refer to Fig. 1 and install the six 3/8"-16 bolts with flat washers in the tapped holes of the idler gear hub and idler gear hole spacer, finger tight. Remove the pilot studs.

NOTE: If the idler gear hole spacer is integrally cast into the housing, be sure the shim is in place.

A self-locking type bolt and steel washer are currently being used to attach the flywheel housing to the idler

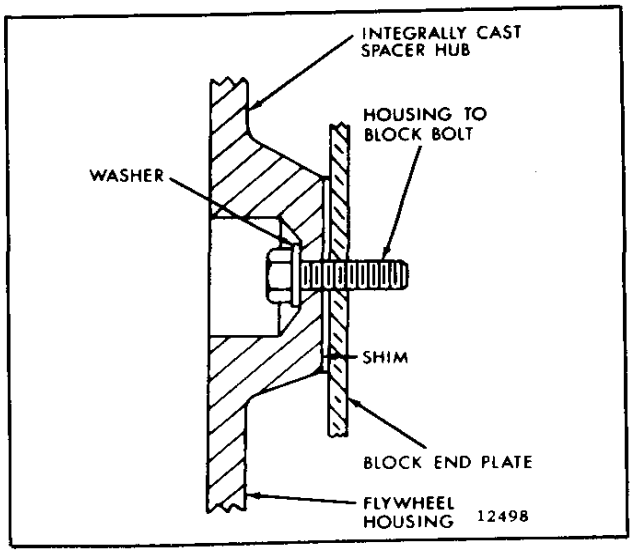


Fig. 3 - Idler Gear Hole Spacer Shim

© 1983 General Motors Corp.

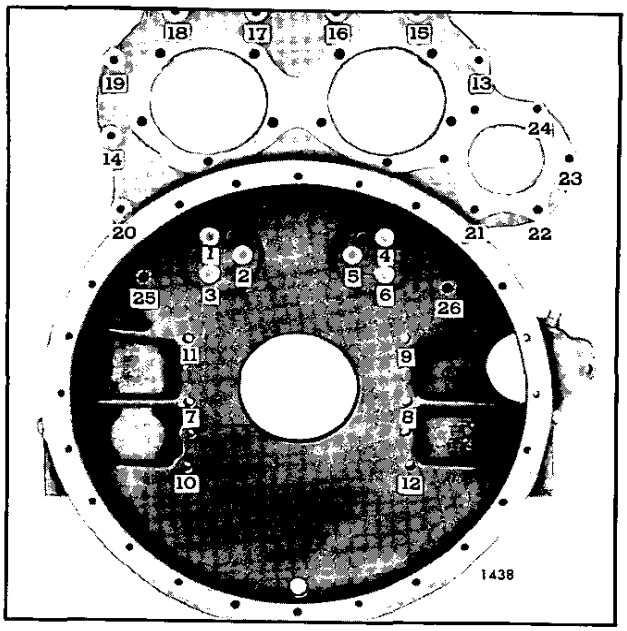


Fig. 4 - Flywheel Housing Bolt Tightening Sequence (Operation 1)

gear hub and hole spacer. With this type bolt, the additional operation of securing the bolts with a lock wire is eliminated, inasmuch as the head of the bolt is so designed that it will lock itself to the attaching member when the specified torque is applied.

NOTE: The self-locking bolts must be used in sets of three. Former drilled head bolts, if used, MUST be locked in place with safety wire.

7. Install the six 1/2"-13 housing to block bolts with lock washers, finger tight.

8. Install the remaining flywheel housing attaching bolts and washers, finger tight.

9. Refer to Fig. 4 for the bolt tightening sequence. Start at number 1 on a right-hand rotation engine or at number 4 on a left-hand rotation engine and, using the proper sequence, bring all bolts to within 10-15 lb-ft (14-20 Nm) of their specified torque, drawing the mating parts together evenly.

NOTE: When tightening the idler gear hub bolts, turn the crankshaft to prevent any bind or brinelling of the idler gear bearing. The crankshaft must be rotated for the flywheel housing bell bolt tightening also.

10. Refer to Fig. 5 for the final bolt tightening sequence and, starting at number 1, tighten all of the bolts to the specified torque. Tighten the 3/8"-16 idler gear hub and hole spacer self-locking bolts to 40-45 lb-ft (54-61 Nm) torque. Tighten all other 3/8"-16 and 3/8"-24 bolts to 25-30 lb-ft (34-41 Nm) torque, and the 1/2"-13 bolts to 90-100 lb-ft (122-136 Nm) torque (cast iron housing) or 71-75 lb-ft (96-102 Nm) torque (aluminum housing). Be sure to rotate the crankshaft when tightening the idler gear hub bolts and flywheel housing bell bolts.

If drilled head idler gear hub and spacer bolts are used, tighten them to 25-40 lb-ft (34-54 Nm) torque. Line-up the lock wire holes in the bolt heads and install the lock wire, locking each group of three bolts together. The wide range in the torque specification permits alignment of the bolt heads.

11. Install the flywheel (Section 1.4).

12. Check the flywheel housing concentricity and bolting flange face runout with tool set J 9737-C as follows:

a. Refer to Fig. 6 and thread the base post J 9737-3 tightly into one of the tapped holes in the flywheel. Then assemble the dial indicators on the base post.

b. Position the dial indicators straight and square with the flywheel housing bell face and inside

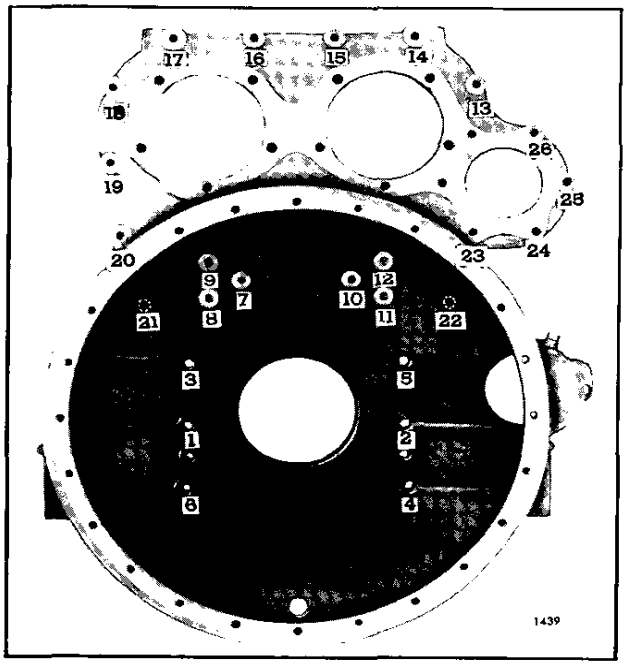


Fig. 5 - Flywheel Housing Bolt Tightening Sequence (Operation 2)

© 1983 General Motors Corp.

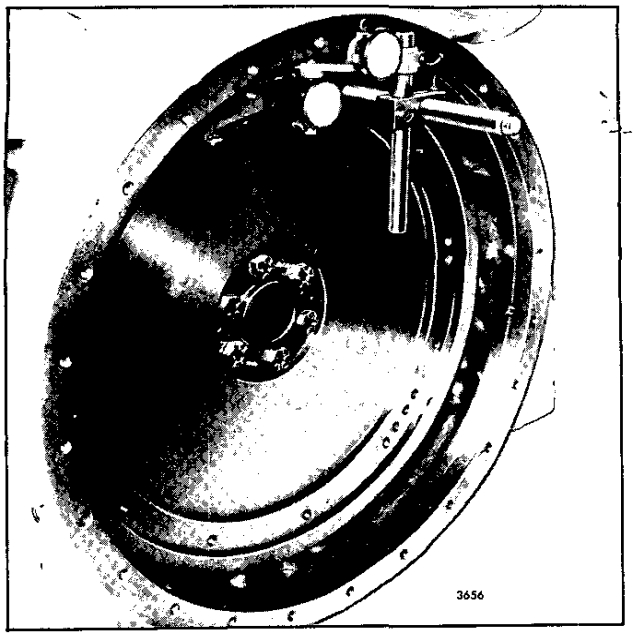


Fig. 6 - Checking Flywheel Housing Concentricity using Tool J 9737-C

bore of the bell. Make sure each indicator has adequate travel in each direction.

NOTE: If the flywheel extends beyond the housing bell, the bore and face must be checked separately. Use the special adaptor in the tool set to check the housing bore.

c. Pry the crankshaft toward one end of the block to ensure the end play is in one direction only.

d. *Adjust each dial indicator to read zero at the twelve o'clock position.* Rotate the crankshaft one full revolution, recording readings at 90° intervals (4 readings each for the bore and the bolting flange face). On "bossed" flywheel housings position the dial indicators at a location where clearance or obstruction is not a problem.

NOTE: The hex head of the front crankshaft bolt may be used to turn the crankshaft. However, the barring operation should ALWAYS be performed in a clockwise direction. It is very important to make certain that the bolt has not been loosened. Serious engine damage may result if the vibration damper or pulley is not securely fastened to the crankshaft.

On scalloped flywheel housings, position the dial indicators at the 4:30 position and rotate the crankshaft 270°.

e. Stop and remove the wrench or cranking bar before recording each reading to ensure accuracy. Record the readings and interpret as follows:

BORE and FACE RUNOUT

Check valve at six o'clock (6:00) position. This valve cannot exceed ±.013".

Check valves at three o'clock (3:00) and nine o'clock (9:00) positions.

1. Both readings "+" or "–". The difference must not exceed .013".

3:00	9:00	EXAMPLES	
		Good	Bad
+	+	+ .002" + .014" Difference = .012"	+ .002" + .016" Difference = .014"
–	–	– .002" – .014" Difference = – .012"	– .002" – .016" Difference = – .014"

2. Both readings different, "+/–" or "–/+". The total of dimensions must not exceed .013".

3:00	9:00	EXAMPLES	
		Good	Bad
+	–	+ .002" – .010" Total = .012"	+ .002" – .012" Total = .014"
–	+	– .002" + .010" Total = .012"	– .002" + .012" Total = .014"

BORE DIAMETER

Verification of bore diameter is required when 3:00 and 9:00 o'clock readings are both "+" or both "–". The total of dimensions must not exceed .030".

3:00	9:00	EXAMPLES	
		Good	Bad
+	+	+ .014" + .015" Total = .029"	+ .014" + .017" Total = .031"
–	–	– .014" – .015" Total = .029"	– .014" – .017" Total = .031"

f. If the bore or face runout exceeds the maximum limits, remove the flywheel housing and check for dirt or foreign material, such as old gasket material, between the end plate and flywheel

© 1983 General Motors Corp.

housing or between the end plate and the cylinder block. If the bore diameter still exceeds limits, replace the flywheel housing. Also, make certain the idler gear hub and the idler gear hole spacer gaskets, if required, are used correctly. No gaskets are required with the hub and spacer on current units with the roller type idler gear bearing. Conversely, gaskets *are* required with the former design hub and spacer on units equipped with the flange type idler gear bearing. However, if a roller bearing has replaced a flange type idler gear bearing, but the early design spacer (dummy hub) remains the same, *one* gasket is required with the spacer.

g. Reinstall the flywheel housing and the flywheel and tighten the attaching bolts in the proper sequence and to the specified torque. Then, recheck the bore and face runout and the bore diameter. If necessary, replace the flywheel housing.

13. Remove the bolts holding the lifter bracket to the flywheel housing. Affix a new gasket to the bracket, then alternately tighten the bracket-to-flywheel housing and bracket-to-cylinder head bolts, thus drawing the bracket into the corner formed by the cylinder head and housing (Section 1.2.3).

14. Install the oil pan (Section 4.7).

15. Remove the engine from the overhaul stand and complete assembly of the engine.

NOTE: The starting motor pad bolt holes have been relocated on certain SAE No. 1 and SAE No. 2 flywheel housings. If a current housing is installed on an early engine, the solenoid on a Sprag clutch type starting motor may have to be repositioned. Refer to Section 7.3 for the indexing procedure. It will be necessary to replace a Dyer drive type starting motor with a Sprag clutch type motor.

Installing Flywheel Housing Small Hole Covers

An RTV (room temperature vulcanizing) sealant is now being used in place of the gasket to seal flywheel housing small hole cover ("star cover"). Replace the covers as follows:

1. Clean the old gasket material and/or loose sealant from the housing and cover. It is not necessary to remove all the old sealant.

2. Apply a one-eighth inch (.125") diameter continuous, unbroken bead of sealant to the perimeter of the cover just inside the bolt holes. To provide an effective seal, this should be done not more than 10 minutes before the cover is to be secured to the flywheel housing.

NOTE: To make sure the sealant is properly applied, verify that the sealant is in the correct location by using a sample gasket as a template prior to installing the bead.

3. Attach the cover to the flywheel housing with the proper bolts and torque the bolts to 30-35 lb-ft (41-47 Nm).

© 1983 General Motors Corp.

PISTON AND PISTON RINGS

TRUNK-TYPE PISTON

The trunk-type malleable iron piston is plated with a protective coating of tin which permits close fitting, reduces scuffing and prolongs piston life (Fig. 1). The top of the piston forms the combustion chamber bowl and is designed to compress the air into close proximity to the fuel spray.

Each piston is internally braced with fin-shaped ribs and circular struts, scientifically designed to draw heat rapidly from the piston crown and transfer it to the lubricating oil spray to ensure better control of piston ring temperature.

The fire ring groove in the current piston is no longer induction hardened and the chrome on the wear surface on the bottom side of the piston fire ring has been eliminated. The new pistons can be identified by the part number stamped on the top of the piston.

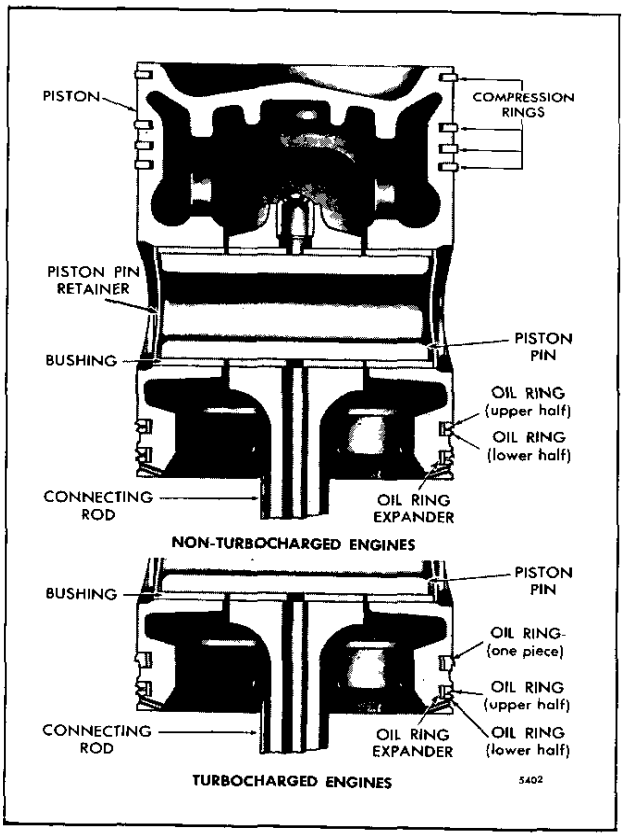


Fig. 1 - Typical Piston Assembly

The piston is cooled by a spray of lubricating oil directed at the underside of the piston head from a nozzle in the top of the connecting rod, by fresh air from the blower to the top of the piston and indirectly by the water jacket around the cylinder.

Each piston is balanced to close limits by machining a balancing rib, provided on the inside at the bottom of the piston skirt.

Two bushings, with helical grooved oil passages, are pressed into the piston to provide a bearing for the hardened, floating piston pin. After the piston pin has been installed, the hole in the piston at each end of the pin is sealed with a steel retainer. Thus lubricating oil returning from the sprayed underside of the piston head and working through the grooves in the piston pin bushings is prevented from reaching the cylinder walls.

The current turbocharged engines use a piston pin with a highly polished external surface finish and an oil hole to provide oil under pressure to the piston pin bushings. A groove on each side of the oil hole is for stress distribution (refer to Section 1.6.1).

Each piston is fitted with compression rings and oil control rings (Figs. 1 and 2). Equally spaced drilled holes just below each oil control ring groove permit excess oil, scraped from the cylinder walls, to return to the crankcase.

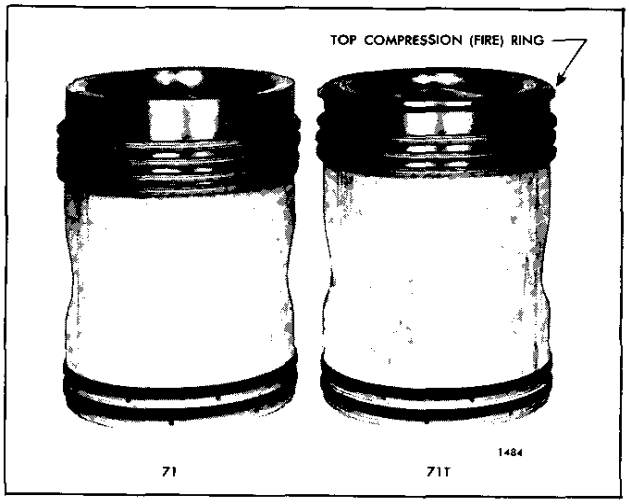


Fig. 2 - Comparison of Piston Ring Arrangements

© 1982 General Motors Corp.



Fig. 3 - Removing or Installing Piston Rings using Tool J 8128

A higher tension oil control ring expander is now being used in the upper and lower piston grooves on *naturally aspirated engines*. The current oil control ring expander is identified by a light blue paint strip or no paint strip. A white paint strip identifies the oil control ring expander on city coach engines. This is effective with engine serial numbers 3A-89500, 4A-228800 and 6A-369373.

The *no chrome* fire rings can be identified by their black or copper oxide color, top and bottom. The prestressed fire ring has a small indentation on the top side of the ring near the gap.

Inspect Piston Rings

When an engine is hard to start, runs rough or lacks power, worn or sticking compression rings may be the cause. Replacing the rings will aid in restoring engine operation to normal.

The compression rings may be inspected through the ports in the cylinder liners after the air box covers have been removed. If the rings are free and are not worn to the extent that the plating or grooves are gone, compression should be within operating specifications. Refer to Section 15.2 for the procedure for checking compression pressure.

Remove Piston and Connecting Rod

1. Drain the cooling system.

2. Drain the oil and remove the oil pan.

3. Remove the oil pump and inlet and outlet pipes, if necessary (Section 4.1).

4. Remove the cylinder head (Section 1.2).

5. Remove the carbon deposits from the upper inner surface of the cylinder liner.

6. Remove the bearing cap and the lower bearing shell from the connecting rod. Then push the piston and rod assembly out through the top of the cylinder block. The piston cannot be removed from the bottom of the cylinder block.

7. Reassemble the bearing cap and lower bearing shell to the connecting rod.

Disassemble Piston and Connecting Rod

Note the condition of the piston and rings. Then remove the rings and connecting rod from the piston as follows:

1. Secure the connecting rod in a vise equipped with soft jaws and remove the piston rings with tool J 8128 as shown in Fig. 3.

2. Punch a hole through the center of one of the piston pin retainers with a narrow chisel or punch and pry the retainer from the piston, being careful not to damage the piston or bushings.

3. Withdraw the piston pin from the piston, then remove the connecting rod.

4. Drive the remaining piston pin retainer out from the inside with a brass rod or other suitable tool.

Cleaning

Clean the piston components with fuel oil and dry them with compressed air. If fuel oil does not remove the carbon deposits, use a chemical solvent (Fig. 4) that will not harm the piston pin bushings or the tin-plate on the piston.

The upper part of the piston, including the compression ring lands and grooves, is not tin-plated and may be wire-brushed to remove any hard carbon. However, use care to avoid damage to the tin-plating on the piston skirt. Clean the ring grooves with a

© 1982 General Motors Corp.

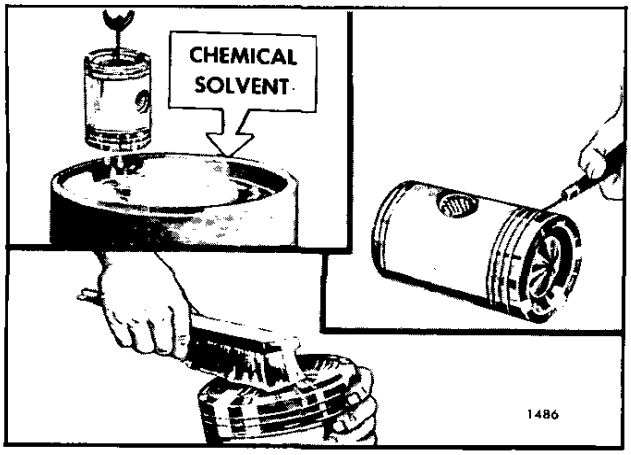


Fig. 4 - Cleaning Piston

suitable tool or a piece of an old compression ring that has been ground to a bevel edge.

Clean the inside surfaces of the piston and the oil drain holes in the piston skirt. Exercise care to avoid enlarging the holes while cleaning them.

Inspection

If the tin-plate on the piston and the original grooves in the piston rings are intact, it is an indication of very little wear.

Excessively worn or scored pistons, rings or cylinder liners may be an indication of abnormal maintenance or operating conditions which should be corrected to avoid recurrence of the failure. The use of the correct types and proper maintenance of the lubricating oil filters and air cleaners will reduce to a minimum the amount of abrasive dust and foreign material introduced into the cylinders and will reduce the rate of wear.

Long periods of operation at idle speed and the use of improper lubricating oil or fuel must be avoided, otherwise a heavy formation of carbon may result and cause the rings to stick.

Keep the lubricating oil and engine coolant at the proper levels to prevent overheating of the engine.

Examine the piston for score marks, cracks, damaged ring groove lands or indications of overheating. A piston with light score marks which can be cleaned up may be reused (Fig. 5). Any piston that has been severely scored or overheated must be replaced. Indications of overheating or burned spots on the piston may be the result of an obstruction in the connecting rod oil passage. Replace the piston if cracks are found across the internal struts.

Check the cylinder liner and block bore for excessive out-of-round, taper or high spots which could cause failure of the piston (refer to Section 1.0 for Specifications).

Inspection of the connecting rod and piston pin are covered in Section 1.6.1.

Other factors that may contribute to piston failure include oil leakage into the air box, oil pull-over from the air cleaner, dribbling injectors, combustion blow-by and low oil pressure (dilution of the lubricating oil).

Inspect and measure the piston pin bushings. The piston pin-to-bushing clearance with new parts is .0025" to .0034". A maximum clearance of .010" is allowable with worn parts. The piston pin bushings in the connecting rod are covered in Section 1.6.1.

When replacing worn parts (pistons, rings, etc.), refer to the parts catalog or microfiche to select the current parts for the particular engine being serviced.

Remove Bushings From Piston

Remove the piston pin bushings with tool set J 1513-02 as follows:

> **NOTE:** Do not remove the bushings from the pistons used in turbocharged engines because they are not serviced separately.

1. Place the piston in the holding fixture J 1513-1 so that the bushing bores are in alignment with the hole in the fixture base.

2. Drive each bushing from the piston with bushing remover J 1513-3 and handle J 1513-2 (Fig. 6).

Install Bushings in Piston

1. Place the spacer J 1513-4 in the hole in the fixture J 1513-1.

2. Place the piston on the fixture so that the spacer protrudes into the bushing bore.

3. Insert the installer J 1513-6 in a bushing, then position the bushing and installer over the lower bushing bore.

> **NOTE:** Locate the joint in the bushing toward the bottom of the piston (Fig. 7).

© 1983 General Motors Corp.

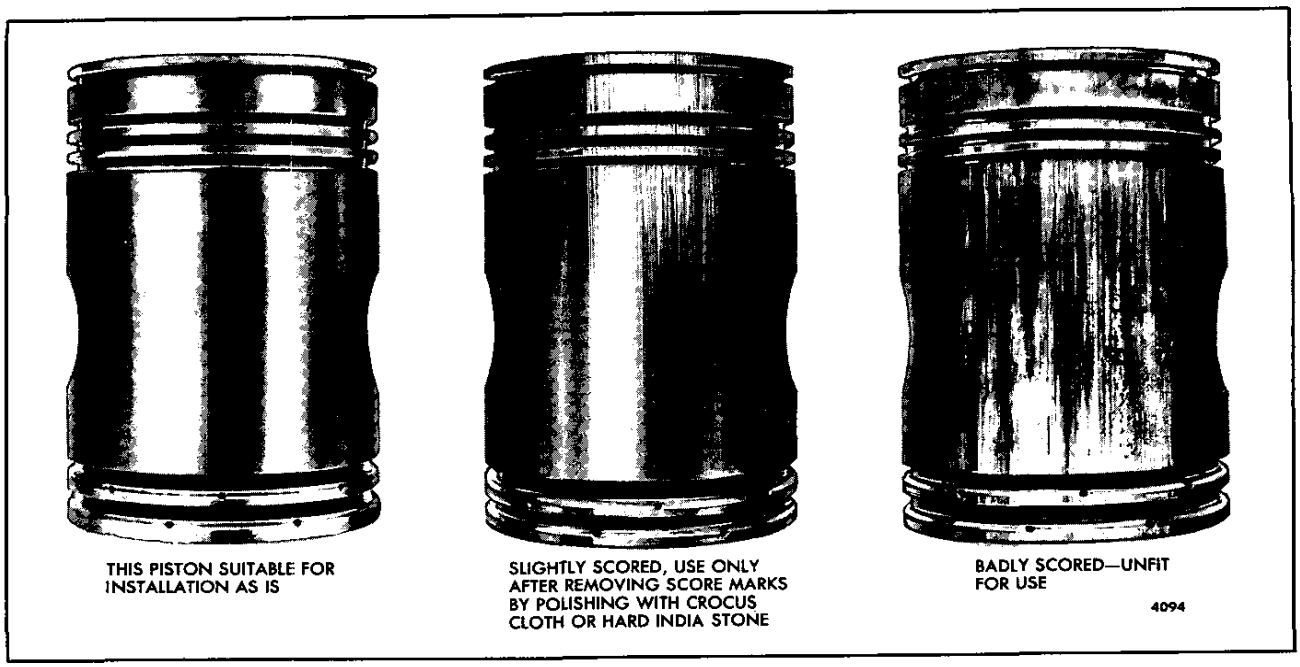


Fig. 5 - Comparison of Used Pistons

4. Insert the handle J 1513-2 in the bushing installer and drive the bushing in until it bottoms on the spacer.

5. Install the second bushing in the same manner.

6. The bushings must withstand an end load of 1800 pounds without moving after installation.

7. Ream the bushings to size, using tool set J 3071-01, as follows:

a. Clamp the reaming fixture J 5273 in a vise (Fig. 8). Then insert the guide bushing J 3071-7 in the fixture and secure it with the set screw.

b. Place the piston in the fixture and insert the pilot end of the reamer J 3071-6 through the clamping bar, bushings and into the guide bushing.

c. With the piston, fixture and reamer in alignment, tighten the wing nuts securely.

d. Ream the bushings (Fig. 8). Turn the reamer in a clockwise direction only, when reaming or withdrawing the reamer. For best results, use only moderate pressure on the reamer.

e. Withdraw the reamer and remove the piston from the fixture. Blow out the chips and measure the inside diameter of the bushings. The diameter must be 1.5025" to 1.5030".

Fitting Piston

Measure the piston skirt diameter lengthwise and crosswise of the piston pin bore. Measurements should be taken at room temperature (70°F or 21°C). The taper and out-of-round must not exceed .0005". Refer to Section 1.0 for piston diameter specifications.

The piston-to-liner clearance, with new parts, will vary with the particular piston and cylinder liner (refer to Section 1.0). A maximum clearance of .012" is allowable with use parts.

With the cylinder liner installed in the cylinder block, hold the piston upside down in the liner and check the clearance in four places 90° apart (Fig. 9).

Use feeler gage set J 5438-01 to check the clearance. The spring scale, attached to the proper feeler gage, is used to measure the force in pounds required to withdraw the feeler gage.

Select a feeler gage with a thickness that will require a pull of six pounds to remove. The clearance will be .001" greater than the thickness of the feeler gage used, i.e., a .004" feeler gage will indicate a clearance of .005" when it is withdrawn with a pull of six pounds. The feeler gage must be perfectly flat and free of nicks and bends.

If any bind occurs between the piston and the liner, examine the piston and liner for burrs. Remove burrs

© 1983 General Motors Corp.

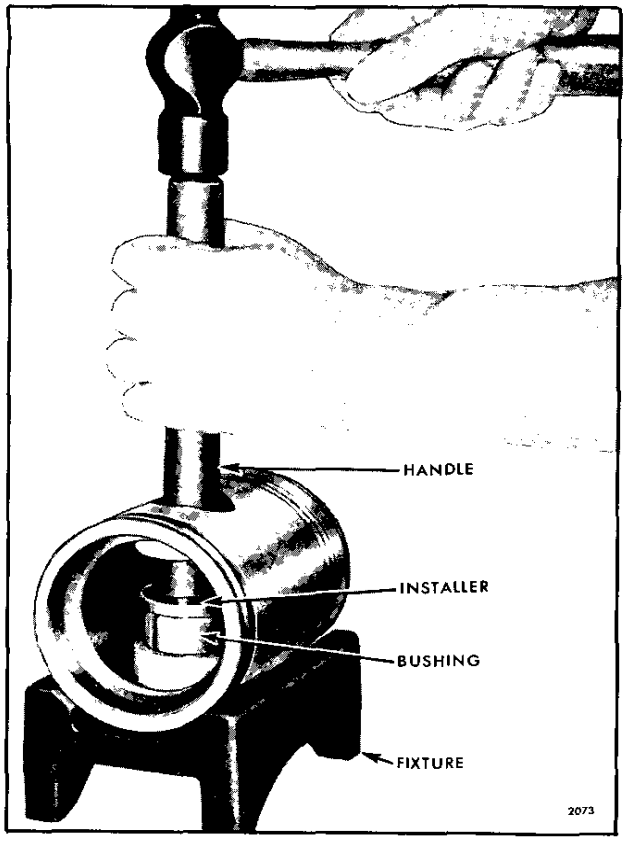


Fig. 6 - Removing or Installing Piston Pin Bushings in Piston

with a fine hone (a flat one is preferable) and recheck the clearance.

Fitting Piston Rings

The current fire rings can be identified by the black oxide or copper color on the top and bottom. The prestressed fire ring is further identified by a small indentation on the top side of the ring near the gap.

A prestressed compression ring, also identified by the indentation mark, is also used in the ring groove immediately below the fire ring.

A two-piece oil control ring is used in both oil ring grooves in the pistons for non-turbocharged (naturally aspirated) engines. A one-piece oil control ring is used in the upper ring groove and a two-piece ring in the lower ring groove in the pistons for turbocharged engines.

All new piston rings must be installed whenever a piston is removed, regardless of whether a new or used

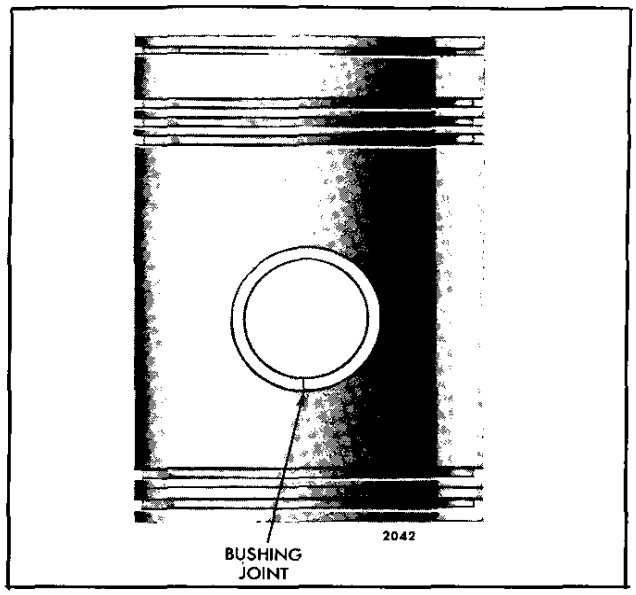


Fig. 7 - Location of Joint in Piston Pin Bushings for Piston

piston or cylinder liner is installed. Refer to the parts catalog or microfiche to select the current piston rings for a particular engine.

Insert one ring at a time inside of the cylinder liner and far enough down to be within the normal area of ring travel. Use a piston to push the ring down to be sure it is parallel with the top of the liner. Then

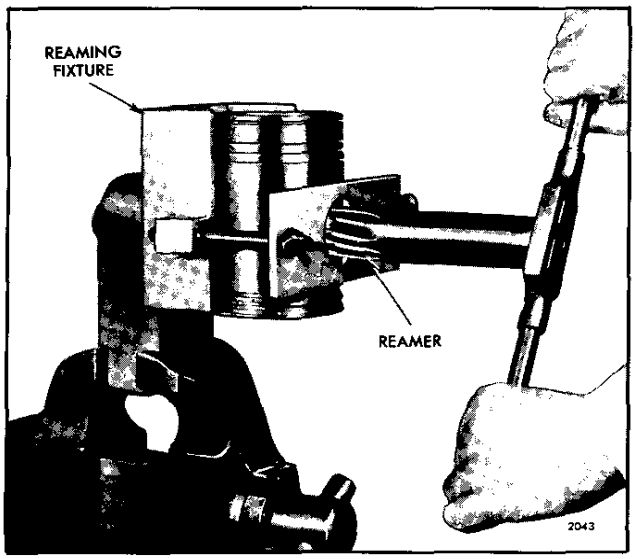


Fig. 8 - Reaming Bushings in Piston

© 1982 General Motors Corp.

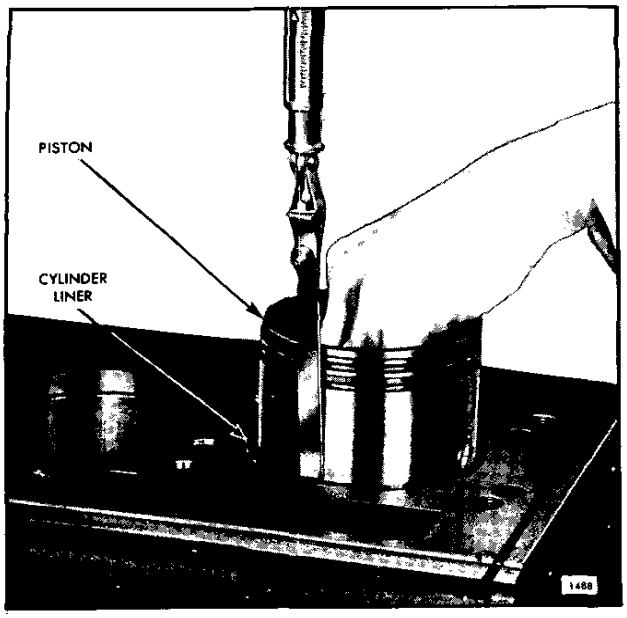


Fig. 9 - Measuring Piston-to-Liner Clearance using Tool J 5438-01

measure the ring gap with a feeler gage as shown in Fig. 10. Refer to Section 1.0 for ring gap specifications.

If the gap on a compression ring is insufficient, it may be increased by filing or stoning the ends of the ring. File or stone both ends of the ring so the cutting action is from the outer surface to the inner surface. This will prevent any chipping or peeling of the chrome plate on the ring. The ends of the ring must

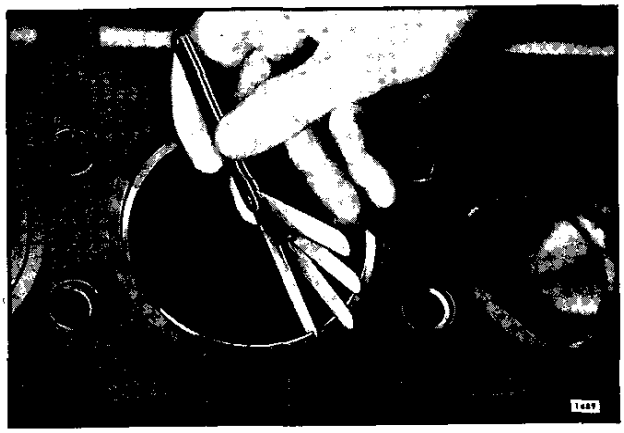


Fig. 10 - Measuring Piston Ring Gap

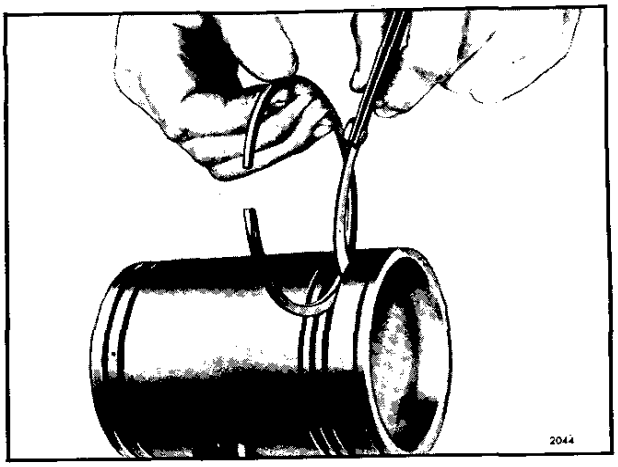


Fig. 11 - Measuring Piston Ring Side Clearance

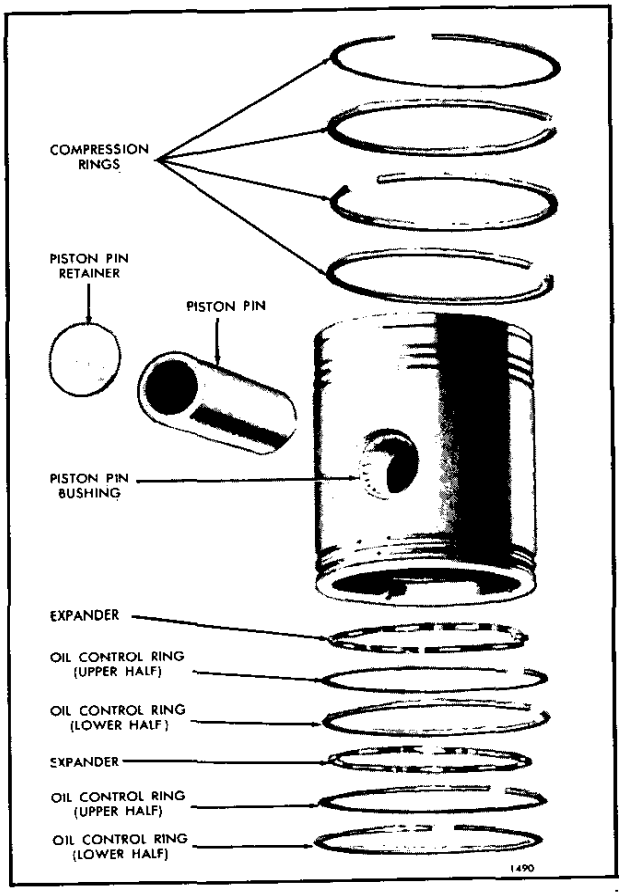


Fig. 12 - Typical Piston, Piston Rings, Pin and Relative Location of Parts

© 1982 General Motors Corp.

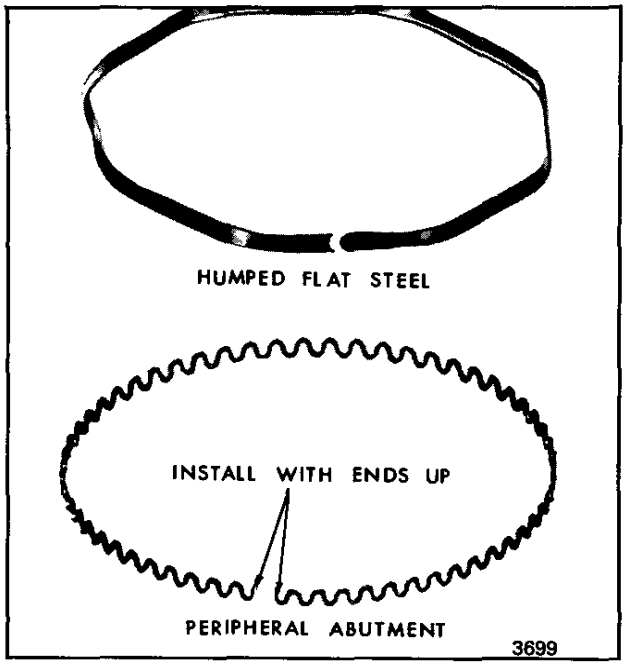


Fig. 13 - Oil Control Ring Expanders

remain square and the chamfer on the outer edge must be approximately .015".

Check the ring side clearance as shown in Fig. 11. Ring side clearances are specified in Section 1.0.

Install Piston Rings

Before installing the piston rings, assemble the piston and rod as outlined under *Assemble Connecting Rod to Piston* in Section 1.6.1. Then refer to Figs. 1 and 12 and install the piston rings.

NOTE: Lubricate the piston rings and piston with engine oil before installing the rings.

COMPRESSION RINGS

1. Starting with the bottom ring, install the compression rings with tool J 8128 as shown in Fig. 3. To avoid breaking or overstressing the rings, do not spread them any more than necessary to slip them over the piston. When installing the fire ring (top groove) and the top compression ring (second groove), be sure the oval marks are toward the top of the piston.

NOTE: Do not use fire rings with chrome in the new non-hardened fire ring groove. The new *no chrome* fire ring should not be used with the former hardened fire ring groove.

2. Stagger the ring gaps around the piston.

OIL CONTROL RINGS

The upper and lower oil control rings used on pistons for *non-turbocharged* engines consist of two halves (upper and lower). The upper oil control ring used on pistons for *turbocharged* engines is a one-piece ring while the lower ring is a two-piece ring (upper and lower halves). Peripheral abutment type oil ring expanders (Fig. 13) are used on 71N and 71T engines. Install the oil control rings as follows:

1. Install the ring expanders in the oil control ring grooves in the piston. When installing the oil control rings, use care to prevent overlapping the ends of the ring expanders. An overlapped expander will cause the oil ring to protrude beyond allowable limits and will result in breakage when the piston is inserted in the ring compressor during installation in the cylinder liner. Do not cut or grind the ends of the expanders to prevent overlapping. Cutting or grinding the ends will decrease the expanding force on the oil control rings and result in high lubricating oil consumption.

NOTE: When peripheral abutment type ring expanders (Fig. 13) are used, install them with the legs of the free ends toward the top of the piston. With the free ends pointing up, a noticeable resistance will be encountered during installation of the piston if the ends of the expander are overlapped and corrective action can be taken before ring breakage occurs.

2. To install the one-piece ring (turbocharged engines), position it over the upper ring groove, using tool J 8128, with the gap 180° from the gap in the expander and the scraper edge facing down. Press the ring against the gap side of the expander to prevent the ends of the expander from overlapping, then align the ring with the groove and release the tension on the tool, permitting the ring to slip in position.

Install the upper and lower halves of the lower oil control ring by hand. Install the upper half with the gap 180° from the gap in the expander. Then install the lower half with the gap 45° from the gap in the upper half of the ring. Make sure the scraper edges are facing down (toward the bottom of the piston).

NOTE: The scraper edges of all oil control rings must face downward (toward the bottom of the piston) for proper oil control.

3. Install the upper and lower halves of both oil control rings (non-turbocharged engines) as outlined above.

NOTE: The face of the top half of the upper oil control ring used on 71N engines is chrome-plated.

© 1982 General Motors Corp.

CROSS-HEAD TYPE PISTON

The cross-head piston (Figs. 14 and 15) is a two-piece piston consisting of a crown and skirt. A fluoroelastomer oil seal ring (former ring was metal) is used between the crown and skirt which are held together by the piston pin. Ring grooves are machined in the piston crown for a fire ring and two compression rings. The crown is also machined to accept a 150° slipper type bushing (bearing). The piston skirt incorporates two oil control ring grooves, piston pin holes and piston pin retainer counterbores. Equally spaced drain holes are located in the oil ring groove area to permit excess oil, scraped from the cylinder walls, to return to the crankcase. A lubricating oil tube and floating nut are contained inside of the piston pin. Two bolts and spacers are used to attach the connecting rod to the floating nut in the piston pin.

Detroit Diesel engines are designed to operate on diesel fuels containing less than 0.5% sulfur. Plasma-faced fire rings (Fig. 16) may be used in areas where approved fuel is not commercially available or economically feasible to obtain. It should be recognized that even with the use of the high sulfur fuel modification and maintenance procedures (see Section 15.1), engine life may still not equal that with our recommended fuels.

NOTE: Recommended engine modifications do not apply to U.S. certified automotive engines.

Internal parts of the piston are lubricated and cooled by the engine lubricating oil. Oil is pressure-fed up the drilled passage in the connecting rod, through the oil tube in the piston pin, then through the center hole in the bushing to the underside of the piston crown. A portion of the oil flows along the grooves in the bushing to lubricate the piston pin.

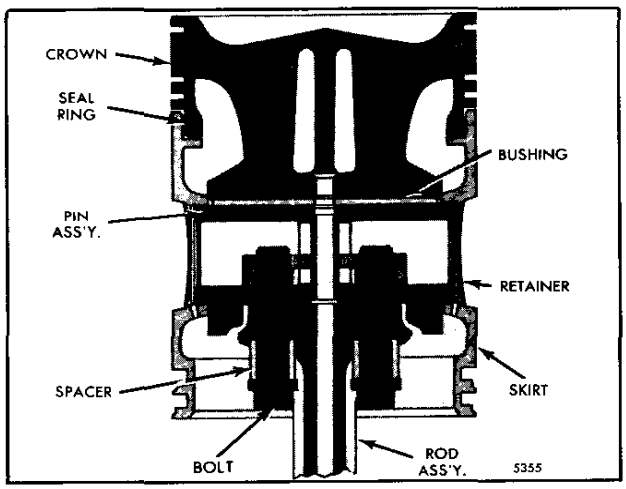


Fig. 14 - Cross-Head Piston and Connecting Rod Assembly

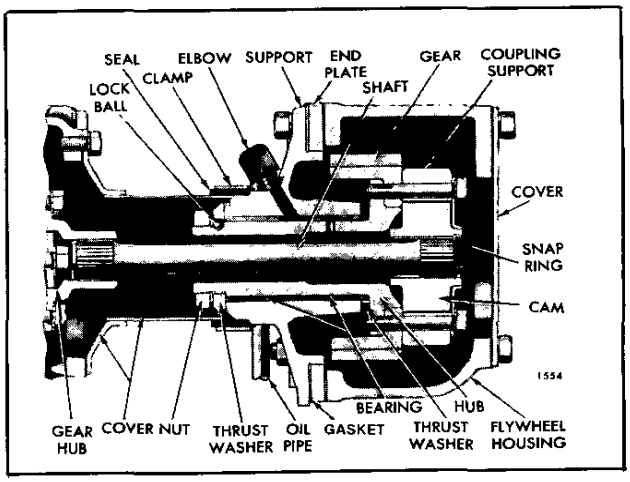


Fig. 15 - Cross-Head Piston and Connecting Rod Components

During engine operation, gas loads pushing down on the piston crown are taken directly by the piston pin and bushing. The piston skirt, being separate, is free from vertical load distortion; thermal distortion is also reduced as the piston crown expands. As the connecting rod swings to one side during downward travel of the piston, the major portion of the side load is taken by the piston skirt.

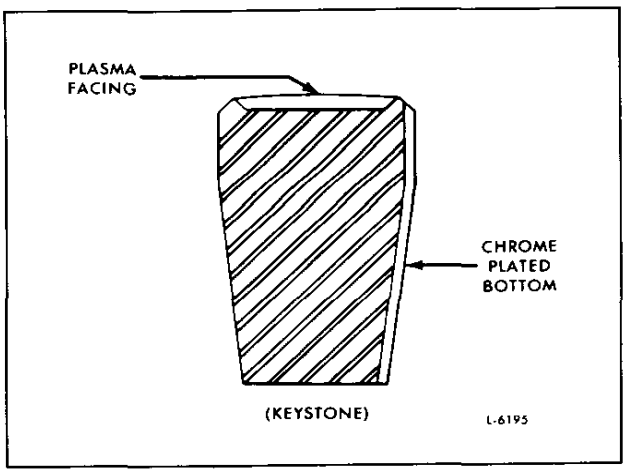


Fig. 16 - Plasma-Faced Fire Ring

© 1982 General Motors Corp.

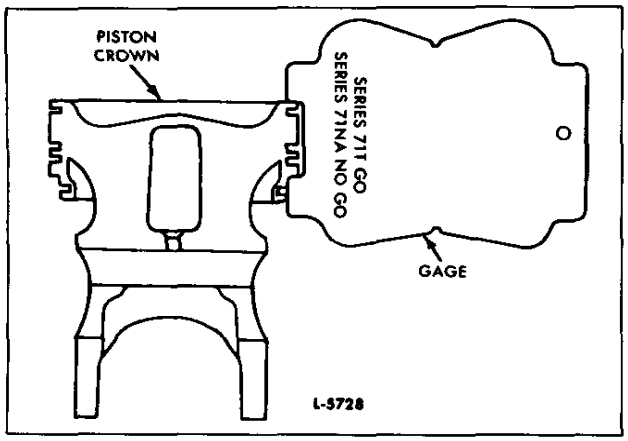


Fig. 17 - Piston Identification using Gage J 25397

The non-turbocharged (naturally aspirated) engines use an 18.7:1 compression ratio piston and the turbocharged engines use a 17:1 compression ratio piston. To aid identification of a piston, refer to Fig. 17. Fit the end of the gage between the top of the piston crown and the machined step below the third compression ring groove. A "GO" check identifies a piston used in a turbocharged engine. A space of approximately .030" ("NO-GO") identifies a piston used in a naturally aspirated engine.

NOTE: Cross-head pistons and trunk-type pistons must not be used together in an engine. The difference in weight of the pistons will affect engine balance.

Inspect Piston Rings

When an engine is hard to start, runs rough or lacks power, worn or sticking compression rings may be the cause. Replacing the rings will aid in restoring engine operation to normal.

The compression rings may be inspected through the ports in the cylinder liners after the air box covers have been removed. If the rings are free and are not worn to the extent that the plating or grooves are gone, compression should be within operating specifications. Refer to Section 15.2 for the procedure for checking compression pressure.

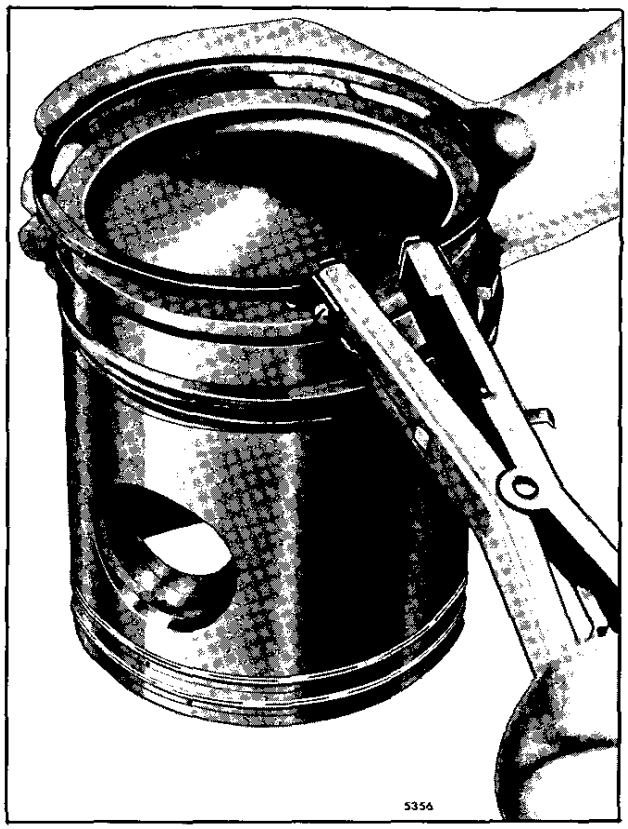


Fig. 18 - Removing or Installing Piston Rings using Tool J 8128

Remove Piston and Connecting Rod

1. Drain the cooling system.

2. Drain the oil and remove the oil pan.

3. Remove the oil pump and inlet and outlet pipes, if necessary (Section 4.1).

4. Remove the cylinder head (Section 1.2).

5. Remove the carbon deposits from the upper inner surface of the cylinder liner.

6. Remove the bearing cap and the lower bearing shell from the connecting rod. Then push the piston and rod assembly out through the top of the cylinder block. The piston cannot be removed from the bottom of the cylinder block.

7. Reassemble the bearing cap and lower bearing shell to the connecting rod.

© 1982 General Motors Corp.

Disassemble Piston and Connecting Rod

Piston assembly components should be match-marked during disassembly to ensure that they are reassembled in the same position. Note the condition of the piston and rings. Then remove the rings and disassemble the piston as follows:

1. Secure the connecting rod in a vise equipped with soft jaws and remove the piston rings with tool J 8128 as shown in Fig. 18.

2. Punch a hole through the center of one of the piston pin retainers with a narrow chisel or punch and pry the retainer from the piston, being careful not to damage the piston or bushing. Remove the opposite retainer in the same manner.

3. Loosen the two bolts which secure the connecting rod to the piston pin. Then remove the rod and piston assembly from the vise and place the assembly on the bench. Remove the two bolts and spacers and remove the connecting rod.

4. Withdraw the piston pin.

5. Separate the piston skirt from the piston crown. J 33048 will aid in disassembling the dome from the skirt of Series 71 crosshead piston assemblies using fluoroelastomer seal rings. After the piston pin is removed from the connecting rod and piston, the piston assembly should be grasped by the skirt and the pin area of the dome brought down onto the neoprene head of the tool with sufficient force to separate the dome from the skirt. A neoprene-padded base will absorb the impact of any dropped piston skirt.

> **CAUTION:** To reduce the risk of personal injury when disassembling the piston dome from the skirt, keep fingers out of the piston pin hole and wear steel-toed shoes.

6. Remove the seal ring from the piston crown.

7. Remove the piston pin bushing (bearing).

Cleaning

Clean the piston components with fuel oil and dry them with compressed air. If fuel oil does not remove the carbon deposits, use an approved chemical solvent that will not harm the tin-plate on the piston skirt. Do not use chemical solvent on the slipper bushing.

The piston crown, including the compression ring grooves, is not tin-plated and may be wire-brushed to remove any hard carbon. *Do not wire-brush the piston skirt.* Clean the ring grooves with a suitable tool or a piece of an old compression ring that has been ground to a bevel edge.

Clean the inside surfaces of the piston crown and skirt and the oil drain holes in the lower half of the piston skirt. Exercise care to avoid enlarging the holes while cleaning them.

Glass beading can be used to clean a piston crown. Mico Bead Glass Shot MS-M (.0029"-.0058") is recommended. Allowable air pressure is 80-100 psi (552-689 kPa). After cleaning, do not leave glass beads in the piston crown.

> **NOTE:** Do not attempt to clean the piston skirt by glass beading, as it will remove the tin-plating.

Use crocus cloth wet with fuel oil to remove any trace of fretting and/or corrosion on the connecting rod saddle-to-piston pin contact surface. Do not use crocus cloth on the bushing side of the pin. Polishing or refinishing the piston pin on the bushing side is not recommended.

Inspection

If the tin-plate on the piston skirt and the original grooves in the piston rings are intact (no visible wear step on the lower groove land), it is an indication of very little wear.

Excessively worn or scored piston skirts, rings or cylinder liners may be an indication of abnormal maintenance or operating conditions which should be corrected to avoid recurrence of the failure. The use of the correct types and proper maintenance of the lubricating oil filters and air cleaners will reduce to a minimum the amount of abrasive dust and foreign material introduced into the cylinders and will reduce the rate of wear.

Long periods of operation at idle speed and the use of improper lubricating oil or fuel must be avoided, otherwise a heavy formation of carbon may result and cause the rings to stick.

Keep the lubricating oil and engine coolant at the proper levels to prevent overheating of the engine.

Examine the piston skirt and crown for score marks, cracks, damaged ring groove lands or indications of overheating. Any piston that has been severely scored or overheated must be replaced. Indications of overheating or burned spots may be the result of an obstruction in the connecting rod oil passage.

Check the tapered fire ring groove width in the current piston crown with tool J 24599 as shown in Fig. 19.

© 1982 General Motors Corp.

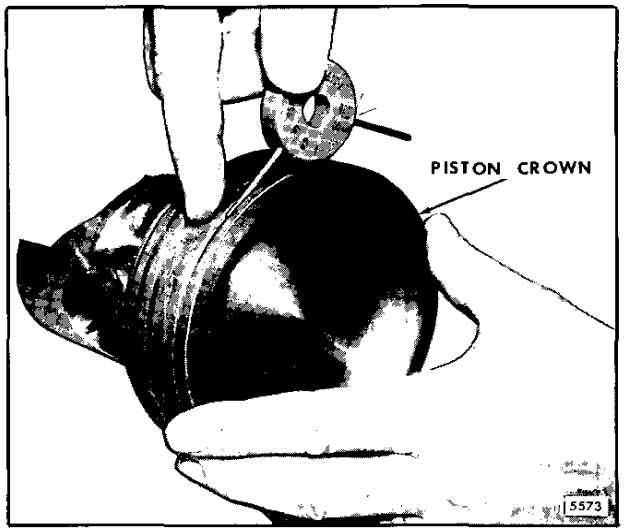


Fig. 19 - Checking Fire Ring Groove in Piston Crown using Tool J 24599

Slide the "NO-GO" wire (.106" diameter) of the tool completely around the fire ring groove. Should the wire be below flush at any one area, the piston crown must be replaced. The "GO" wire (.100" diameter)

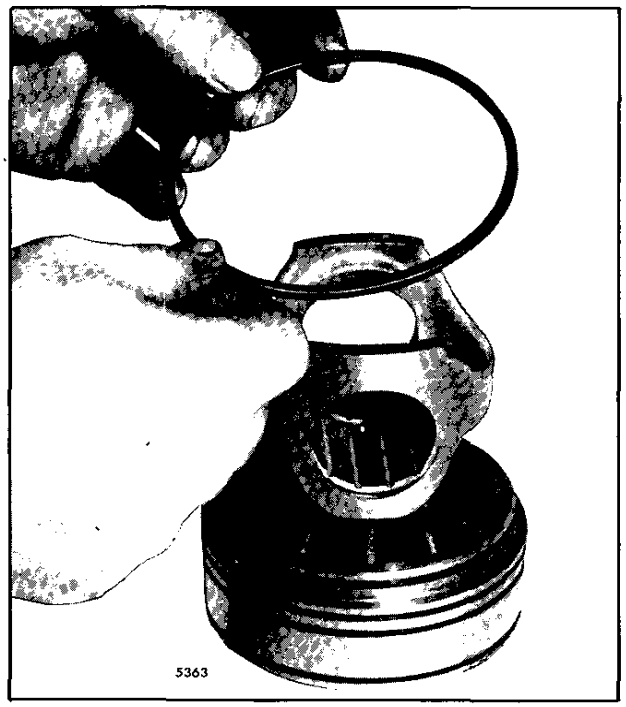


Fig. 20 - Installing Metal Seal Ring (Former)

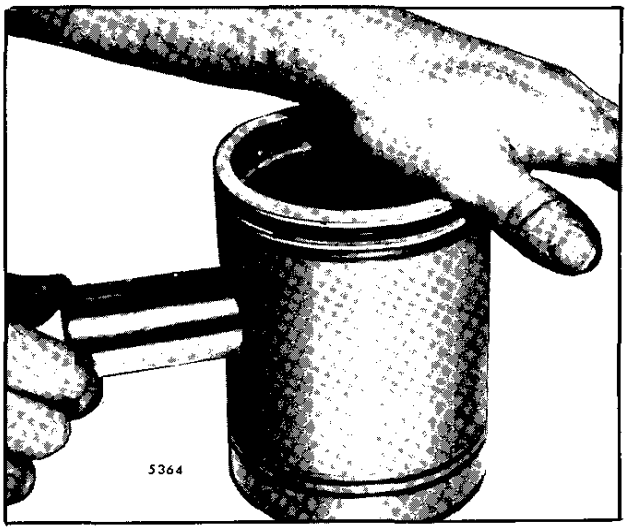


Fig. 21 - Installing Piston Pin

should be flush or protrude slightly from the fire ring groove.

Check the cylinder liner and block bore for excessive out-of-round, taper or high spots which could cause failure of the piston (refer to Section 1.0 for specifications).

Inspection of the connecting rod, piston pin and piston pin bushing are covered in Section 1.6.1.

Other factors that may contribute to piston failure include oil leakage into the air box, oil pull-over from the air cleaner, dribbling injectors, combustion blow-by and low oil pressure (dilution of the lubricating oil).

Assemble Piston and Connecting Rod

1. Refer to Section 1.0 for Specifications on reusing piston assembly components.

2. Install the bearing (bushing) in the piston crown. It should slide into the piston crown without force. With new parts, there is .0005" to .0105" clearance between the edge of the bushing and the groove in the piston crown.

NOTE: The bearing must be installed before assembling the piston skirt and crown.

3. Lubricate the seal ring with engine oil (Fig. 20). *Install the metal seal ring with the chamfer or counterbore directed toward the bottom of the piston.*

NOTE: The metal seal rings are made of cast

© 1982 General Motors Corp.

iron and are identified by the tin-plating on the outside diameter, a black oxide finish, or a dull cast iron color. These rings along with the fluoroelastomer seal ring can be mixed in an engine. The early steel ring, identified by a very shiny appearance, *must not* be used for service.

4. Compress the former seal ring with ring compressor J 23453 and push the skirt into position on the piston crown. The fluoroelastomer ring can be compressed by hand before the skirt is pushed into position on the piston crown. *Excessive stretching should be avoided.*

NOTE: Before completely assembling the piston, check to make sure the seal ring does not stick in the ring groove. It is imperative for satisfactory engine operation that the seal ring is free in the piston crown groove. Check the full 360° circumference of the groove to be sure there are no tight spots. When the piston crown, seal ring and piston skirt are assembled, the skirt should spin freely on the crown (crown top down on the bench). If the seal ring sticks, remove high spots or nicks in the groove with a flat file. If this does not relieve sticking, replace the piston crown.

5. Lubricate the piston pin with clean engine oil and install it as shown in Fig. 21.

NOTE: Line up the piston pin opening in the piston skirt with the bearing (bushing) opening in the piston crown to prevent damage to the pin or bushing.

6. Install the spacers on the two 7/16"-20 × 2" connecting rod to piston pin attaching bolts.

7. Apply a small amount of International Compound No. 2, or equivalent, to the bolt threads and bolt head contact surfaces.

8. Install and tighten the bolts finger tight. Then clamp the connecting rod in a vise and tighten the bolts to

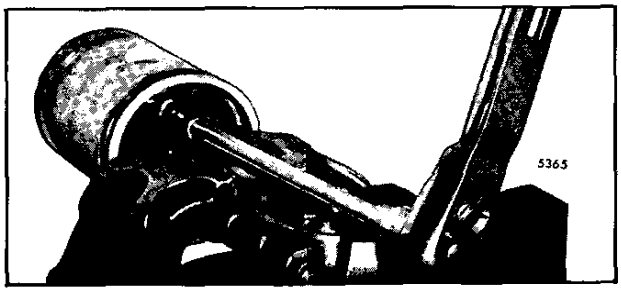


Fig. 22 - Tightening Connecting Rod to Piston Pin Bolts

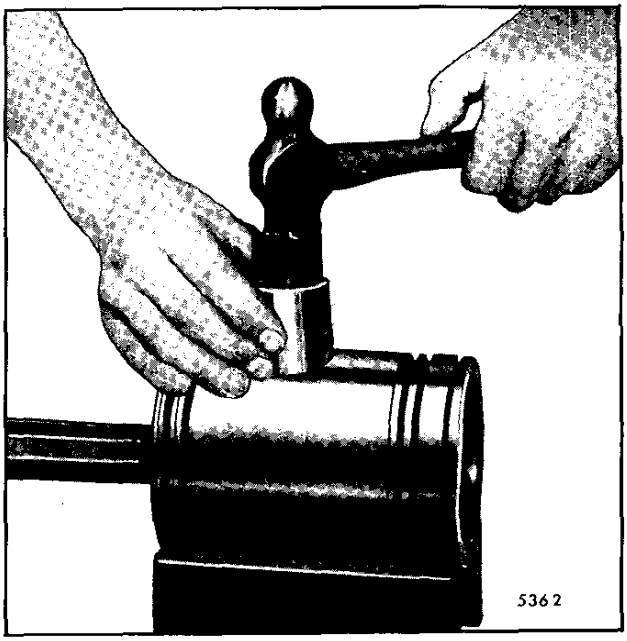


Fig. 23 - Installing Piston Pin Retainer using Tool J 23762

55-60 lb-ft (75-81 Nm) torque (Fig. 22). Do not exceed this torque.

9. Place a new piston pin retainer in position. Then place the crowned end of installer J 23762 against the retainer and strike the tool just hard enough to deflect the retainer and seat it evenly in the piston (Fig. 23).

10. Install the second piston pin retainer in the same manner.

NOTE: Due to the size of the counterbore in the

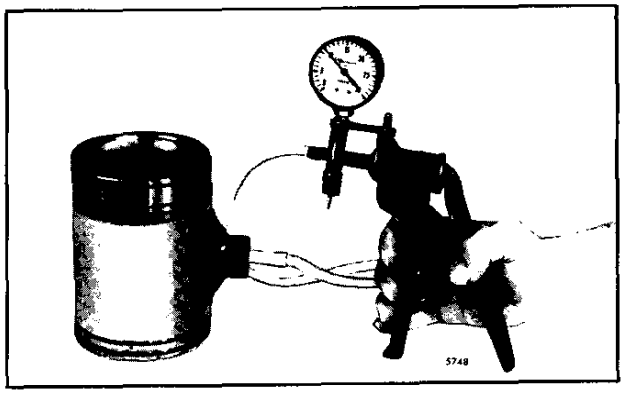


Fig. 24 - Checking Piston Pin Retainer for Proper Sealing using Tool J 23987-01

© 1982 General Motors Corp.

piston skirt, be careful when installing the piston pin retainers and inspect them to be sure they are not buckled and that they are fully seated in the counterbore. The width of the land should be even around the retainer.

11. One important function of the piston pin retainer is to prevent the oil, which cools the underside of the piston and lubricates the piston pin bushing, from reaching the cylinder walls. Check each retainer for proper sealing with leak detector J 23987-01 (Fig. 24). Place the suction cup over the retainer and hand operate the lever to pull a vacuum of ten inches on the gage. A drop in the gage reading indicates air leakage at the retainer.

Fitting Piston

Measure the piston skirt diameter lengthwise and crosswise of the piston pin bore. Measurements should be taken at room temperature (70°F or 21°C). Refer to Section 1.0 for Specifications.

The piston-to-liner clearance, with new parts, will vary with the particular piston and cylinder liner (refer to Section 1.0). A maximum clearance of .012" is allowable with used parts.

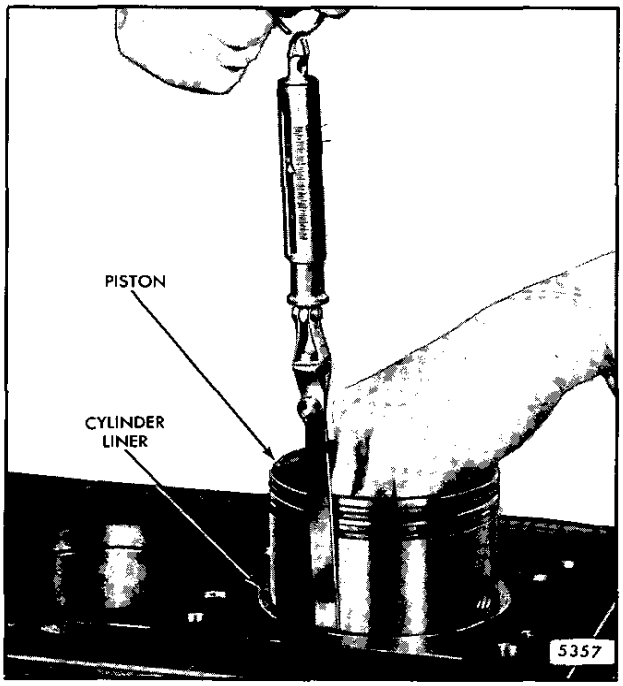


Fig. 25 - Measuring Piston-to-Liner Clearance using Tool J 5438-01

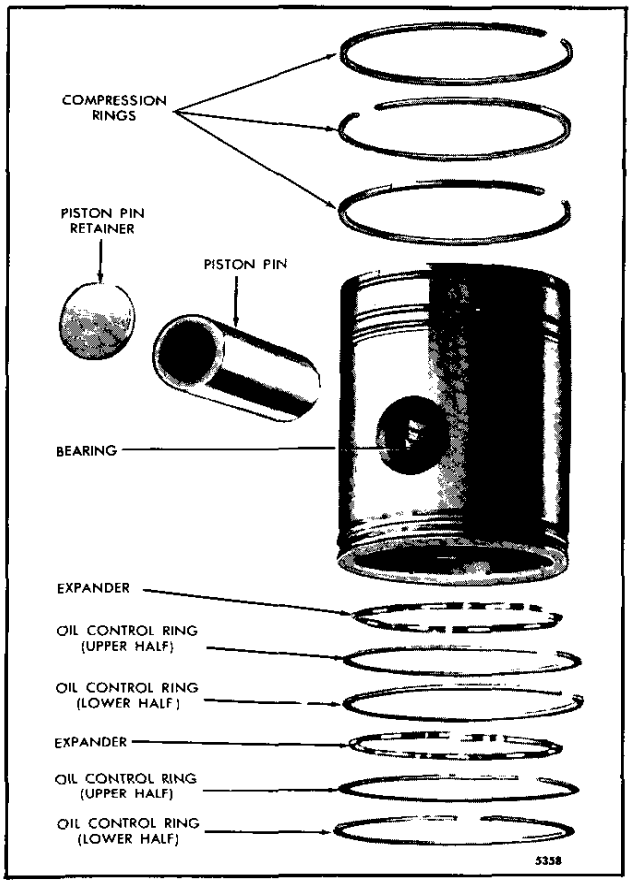


Fig. 26 - Piston Ring Location (Non-Turbocharged Engine)

With the cylinder liner installed in the cylinder block, hold the piston skirt upside down in the liner and check the clearance in four places 90° apart (Fig. 25).

Use feeler gage set J 5438-01 to check the clearance. The spring scale, attached to the proper feeler gage, is used to measure the force in pounds required to withdraw the feeler gage.

Select a feeler gage with a thickness that will require a pull of six pounds to remove. The clearance will be .001" greater than the thickness of the feeler gage used, i.e., a .004" feeler gage will indicate a clearance of .005" when it is withdrawn with a pull of six pounds. The feeler gage must be perfectly flat and free of nicks and bends.

If any bind occurs between the piston and the liner, examine the piston and liner for burrs. Remove burrs with a fine hone (a flat one is preferable) and recheck the clearance.

© 1982 General Motors Corp.

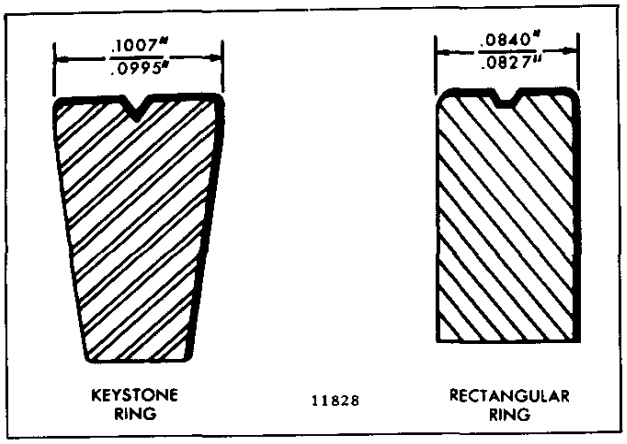


Fig. 27 - Comparison of Fire Rings

Fitting Piston Rings

Each piston is fitted with a fire ring, two compression rings and two oil control rings (Fig. 26).

The top (fire) ring and the upper compression ring (second groove) are pre-stressed. Both are identified by a small indentation mark on the top side.

> **NOTE:** The current piston crowns (18.7:1 and 17:1 compression ratio) have a tapered fire ring groove. To conform with this change, a tapered fire ring (Fig. 27) must be used. The former piston crown (17:1 compression ratio) had a rectangular fire ring groove. Only pistons with the tapered fire ring groove are available for service.

A two-piece oil control ring is used in both oil ring grooves in the pistons for all current engines with N75 or below injectors. A one-piece oil control ring in the upper ring groove and a two-piece ring in the lower ring groove are used in the pistons for *turbocharged* engines with injectors *above* N75.

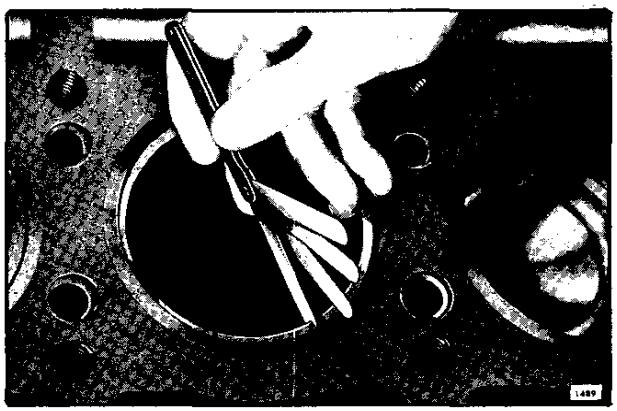


Fig. 28 - Measuring Piston Ring Gap

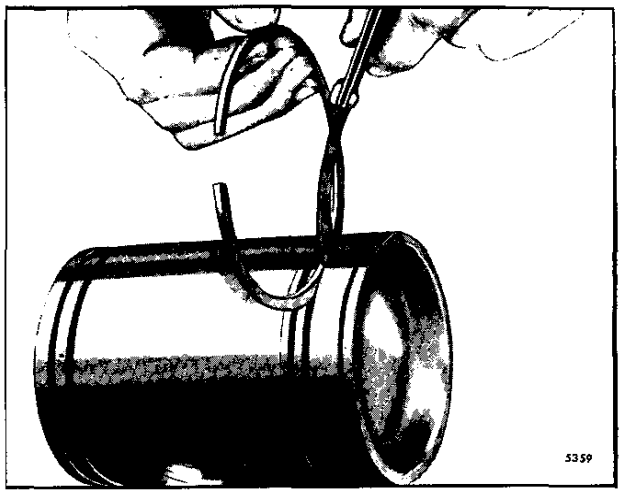


Fig. 29 - Measuring Piston Ring Side Clearance

All new piston rings must be installed whenever a piston is removed, regardless of whether a new or used piston or cylinder liner is installed. Refer to the parts catalog or microfiche to select the current piston rings for a particular engine.

Insert one ring at a time inside of the cylinder liner and far enough down to be within the normal area of ring travel. Use a piston skirt to push the ring down to *be sure it is parallel* with the top of the liner. Then measure the ring gap with a feeler gage as shown in Fig. 28. Refer to Section 1.0 for ring gap specifications.

If the gap on a compression ring is insufficient, it may be increased by filing or stoning the ends of the ring. File or stone both ends of the ring so the cutting action is from the outer surface to the inner surface. *This will prevent* any chipping or peeling of the chrome plate on the ring. The ends of the ring must remain square and the chamfer on the outer edge must be approximately .015".

Check the ring side clearance as shown in Fig. 29. Ring side clearances are specified in Section 1.0.

Install Piston Rings

> **NOTE:** Lubricate the piston rings and piston with engine oil before installing the rings.

© 1982 General Motors Corp.

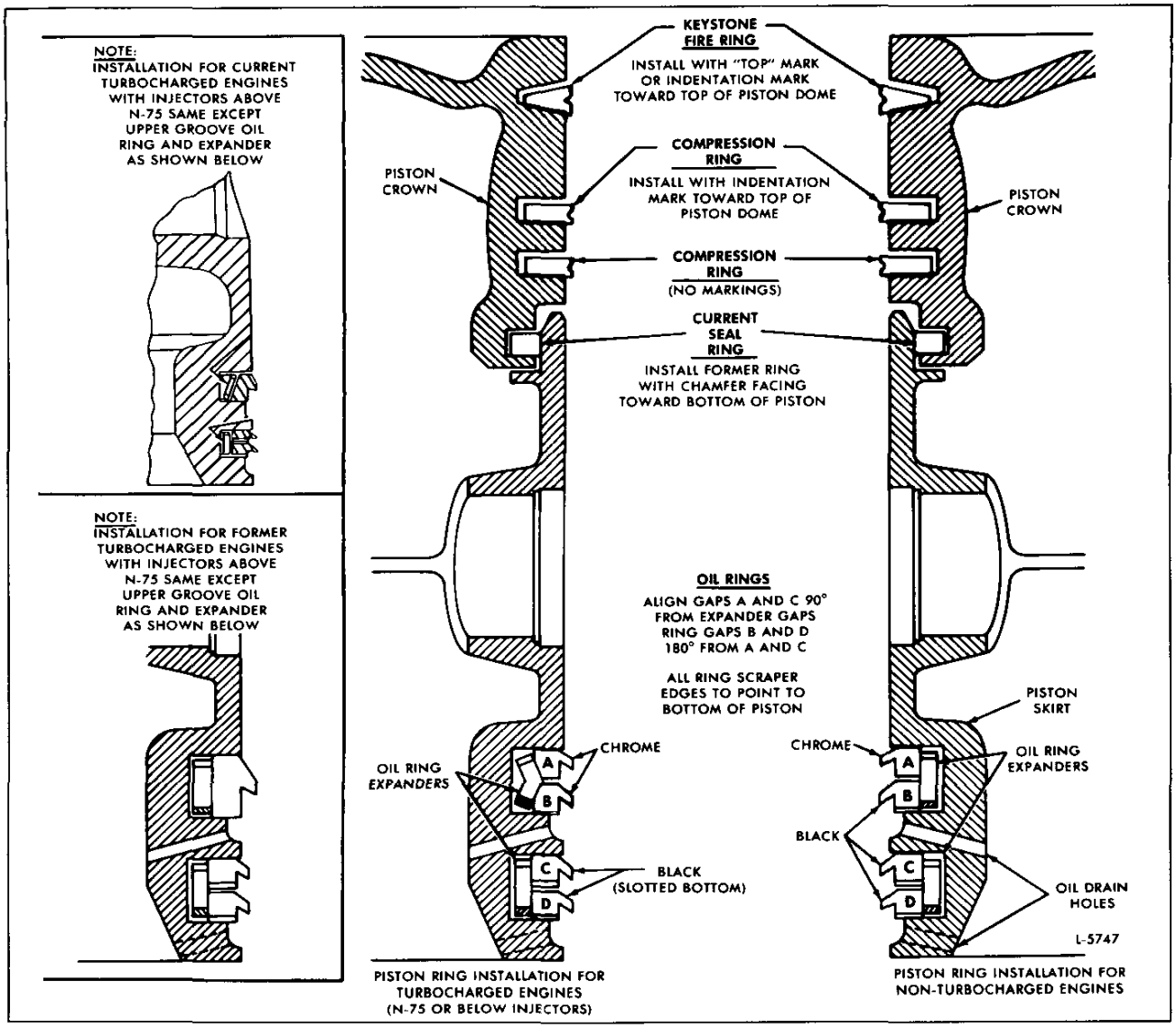


Fig. 30 - Piston Ring Installation Instructions

COMPRESSION RINGS

1. Starting with the bottom ring, install the compression rings with tool J 8128 as shown in Fig. 18. To avoid breaking or overstressing the rings, do not spread them any more than necessary to slip them over the piston. Refer to Fig. 30 for ring identification and location.

2. Stagger and ring gaps around the piston.

OIL CONTROL RINGS

Refer to Fig. 30 for the type and location and install the oil control rings as follows:

1. Install the ring expanders in the oil control ring grooves in the piston skirt. When installing the oil control rings, use care to prevent overlapping the ends of ring expanders. An overlapped expander will cause the oil ring to protrude beyond allowable limits and

© 1982 General Motors Corp.

will result in breakage when the piston is inserted in the ring compressor during installation in the cylinder liner. Do not cut or grind the ends of the expanders to prevent overlapping. Cutting or grinding the ends will decrease the expanding force on the oil control rings and result in high lubricating oil consumption.

NOTE: When peripheral abutment type ring expanders (Fig. 13) are used, install them with the legs of the free ends toward the top of the piston. With the free ends pointing up, a noticeable resistance will be encountered during installation of the piston if the ends of the expander are overlapped and corrective action can be taken before ring breakage occurs.

2. Install the oil control rings by hand. Start with the upper half of the top oil ring and align the gaps as indicated in Fig. 30.

NOTE: The scraper edges of all oil control rings must face downward (toward the bottom of the piston) for proper oil control.

Install the piston and connecting rod assembly in the engine as outlined in Section 1.6.3.

© 1982 General Motors Corp.

CONNECTING ROD

Trunk-Type Piston

Each connecting rod (Figs. 1 and 2) is forged to an "I" section with a closed hub at the upper end and a bearing cap at the lower end. The connecting rod is drilled to provide lubrication to the piston pin at the upper end and is equipped with a nozzle to spray cooling oil to the underside of the piston head. An orifice is pressed into a counterbore at the lower end of the oil passage to meter the flow of oil.

A helically-grooved bushing is pressed into each side of the connecting rod at the upper end. The cavity between the inner ends of these bushings registers with the drilled oil passage in the connecting rod and forms a duct around the piston pin. Oil entering this cavity lubricates the piston pin bushings, and is then forced out the spray nozzle to cool the piston. The piston pin floats in the bushings of both the piston and the connecting rod.

A service connecting rod includes the bearing cap, bolts, nuts, spray nozzle, orifice and the piston pin bushings pressed in place and bored to size.

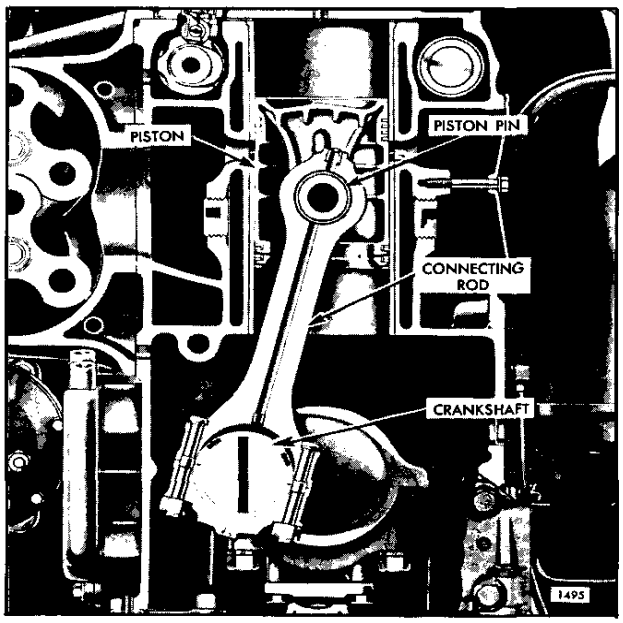


Fig. 1 - Connecting Rod Mounting

The replaceable connecting rod bearing shells are covered in Section 1.6.2.

Disassemble Connecting Rod from Piston

With the rod and piston assembly removed from the engine, disassemble the piston and connecting rod as outlined in Section 1.6.

Inspection

Clean the connecting rod and piston pin with a suitable solvent and dry them with compressed air. Blow compressed air through the drilled oil passage in the connecting rod to be sure the orifice, oil passage and spray holes are not clogged.

Visually check the connecting rod for twist or bending. Check for cracks (Fig. 3) by the magnetic particle method outlined in Section 1.3 under *Crankshaft Inspection.*

Remove any nicks or burrs from the connecting rod bolt holes with reamer J 28460 (Fig. 4). The reamer includes a 60° angle to clean-up the chamfer at the bolt hole to ensure proper seating of the underside of the bolt head.

If a new service connecting rod is required, stamp the cylinder number on the connecting rod and cap (refer to Section 1.6.3).

NOTE: Clean the rust preventive from a service replacement connecting rod and blow compressed air through the drilled oil passage to be sure the orifice, oil passage and spray holes are not clogged. Also, make sure the split line (cap to rod) is thoroughly cleaned to avoid trapped

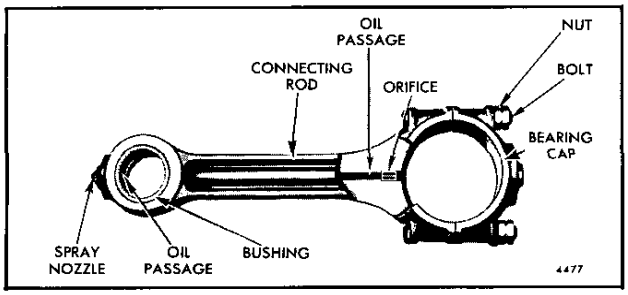


Fig. 2 - Connecting Rod Assembly

© 1984 General Motors Corp.

contaminants from adversely affecting bearing shell "crush".

Check the connecting rod bushings for indications of scoring, overheating or other damage. Bushings that have overheated may become loose and creep together, thus blocking off the supply of lubricating oil to the piston pin, bushings and spray nozzle.

Inspect the piston pin for signs of fretting. When reusing a piston pin, the highly polished and lapped surface of the pin must not in any way be refinished. Polishing or refinishing the piston pin is not recommended as it could result in very rapid bushing wear.

Since it is subjected to downward loading only, free movement of the piston pin is desired to secure perfect alignment and uniform wear. Therefore, the piston pin is assembled with a full floating fit in the connecting rod and piston bushings, with relatively large clearances. Worn piston pin clearances up to .010" are satisfactory.

NOTE: Current turbocharged engines use a piston pin which incorporates an oil hole (Fig. 5) to provide oil under pressure to the piston pin bushings. A similar piston pin is available as a service item for non-turbocharged engines.

Remove Bushings

If it is necessary to replace the connecting rod bushings, remove them as follows:

NOTE: Do not remove the bushings from the connecting rods used in turbocharged engines because they are not serviced separately.

1. Clamp the upper end of the connecting rod in holder J 7632 (Fig. 6) so that the bore in the bushings is aligned with the hole in the base of the holder.

2. Place the bushing remover J 1513-3 in the connecting rod bushing, insert handle J 1513-2 in the remover and drive the bushings from the rod.

Replace Spray Nozzle and Orifice

The connecting rod bushings must be removed before the spray nozzle or orifice can be replaced. Replace the spray nozzle as follows:

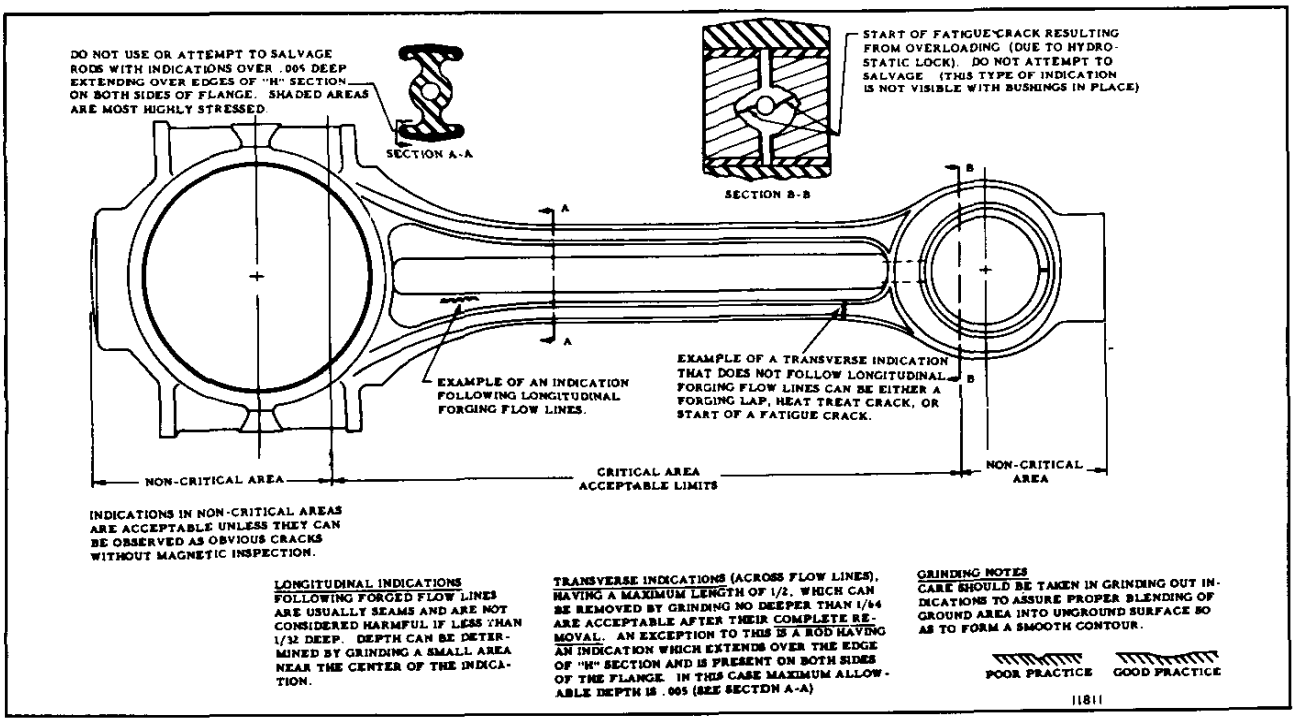


Fig. 3 - Magnetic Particle Inspection Limits for Connecting Rod

© 1984 General Motors Corp.

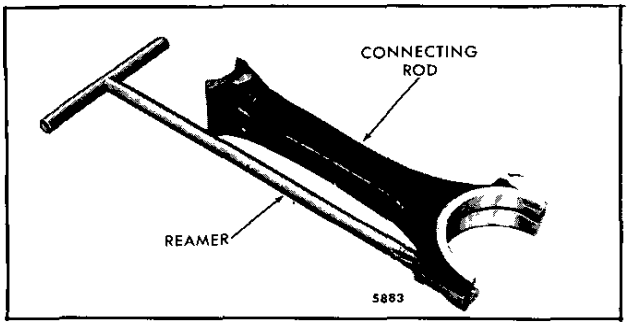


Fig. 4 - Connecting Rod Bolt Hole Reamer (J 28460)

1. Remove the connecting rod bushings (refer to NOTE above).

2. Insert spray nozzle remover J 8995 through the upper end of the connecting rod and insert the pin, in the curved side of the tool, in the opening in the bottom of the spray nozzle.

3. Support the connecting rod and tool in an arbor press (Fig. 7).

4. Place a short sleeve directly over the spray nozzle. Then, press the nozzle out of the connecting rod.

5. Remove the tool.

The steel bushing-type orifice in the lower end of the drilled passage can be replaced, if necessary, at this time. On vehicle engines effective with engines 3A-43400, 4A-86466 and 6A-95195 and prior to 3A-57339, 4A-112372 and 6A-121773, the connecting rod assemblies included a spring pin type orifice.

With the spray nozzle removed, insert a rod in the oil passage and drive the orifice from the lower end of the connecting rod. Install the current steel bushing-type orifice .3125" in from the lower surface of the rod. When installing a service spring pin type orifice, drive it in .200" from the lower surface of the rod.

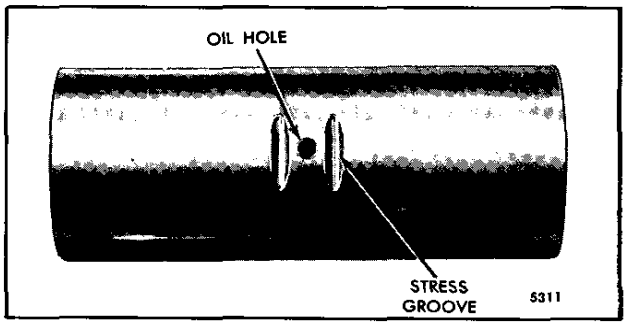


Fig. 5 - Piston Pin with Oil Hole

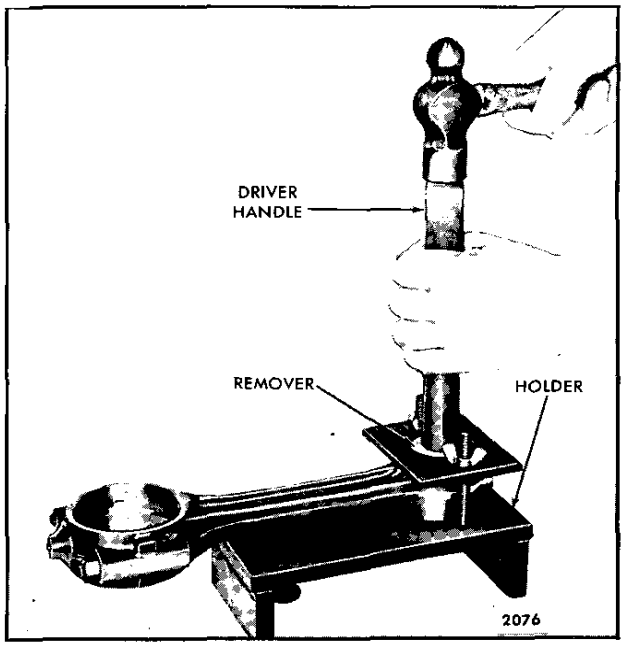


Fig. 6 - Removing or Installing Bushings with Holder J 7632

Install a new spray nozzle in the connecting rod as follows:

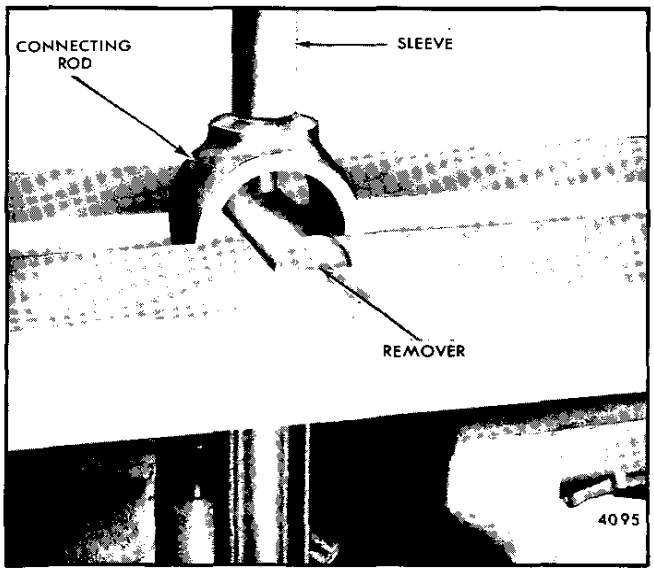


Fig. 7 - Removing Spray Nozzle

© 1984 General Motors Corp.

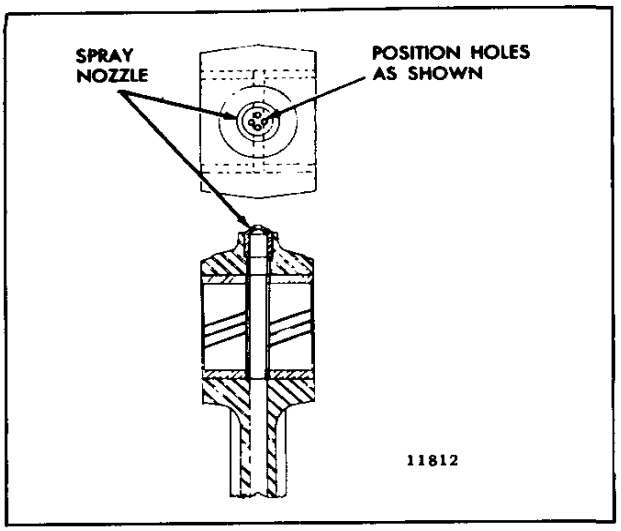


Fig. 8 - Position of Spray Nozzle Holes

1. Start the new spray nozzle, with the holes positioned as shown in Fig. 8, straight into the counterbore in the connecting rod.

2. Support the connecting rod in the arbor press, place a short 3/8″ I.D. sleeve on top of the nozzle and press the nozzle into the connecting rod until it bottoms in the counterbore.

3. Install new bushings in the connecting rod.

Install Bushings

A .812″ long bushing is serviced for the connecting rod assembly used in all non-turbocharged engines. The .760″ long vapor-blasted bushing used in turbocharged engines is not serviced separately.

Install connecting rod bushings as follows:

1. Clamp the upper end of the connecting rod assembly in holder J 7632 so that the bore for the bushings aligns with the hole in the base of the tool (Fig. 6).

2. Start a new bushing straight into the bore of the connecting rod, with the bushing joint at the top of the rod (Fig. 9).

3. Insert installer J 1513-6 in the bushing, then insert handle J 1513-2 in the installer and drive the bushing in until the flange of the installer bottoms on the connecting rod.

4. Turn the connecting rod over in the holder and install the second bushing in the same manner.

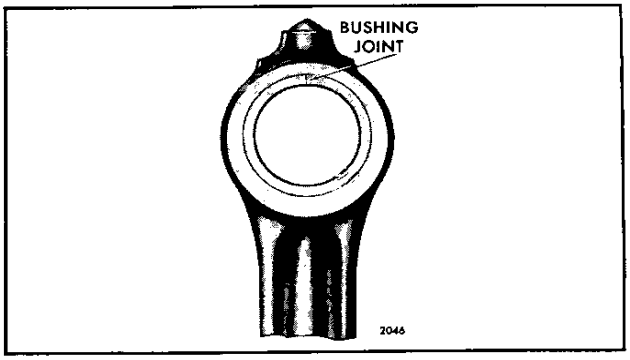


Fig. 9 - Location of Bushing Joint

5. The bushings must withstand an end load of 2000 pounds without moving after installation.

6. Ream the bushings to size, using tool set J 1686-03, as follows:

a. Clamp reaming fixture J 1686-9 in a bench vise.

b. Place the crankshaft end of the connecting rod on the arbor of the fixture (Fig. 10) and tighten the connecting rod cap nuts to 60-70 lb-ft (81-95 Nm) torque.

c. Slide the front guide bushing J 1686-11 (with the pin end facing out) in the fixture.

d. Align the upper end of the connecting rod with the hole in the reaming fixture.

e. Install the rear guide bushing J 1686-5 on reamer J 1686-20, then slide the reamer and bushing into the fixture.

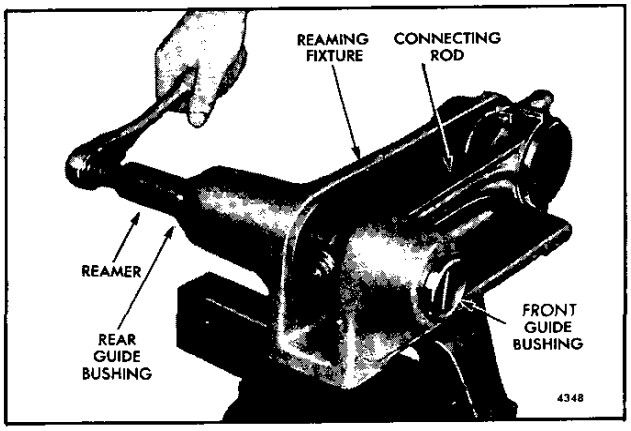


Fig. 10 - Reaming Bushings

© 1984 General Motors Corp.

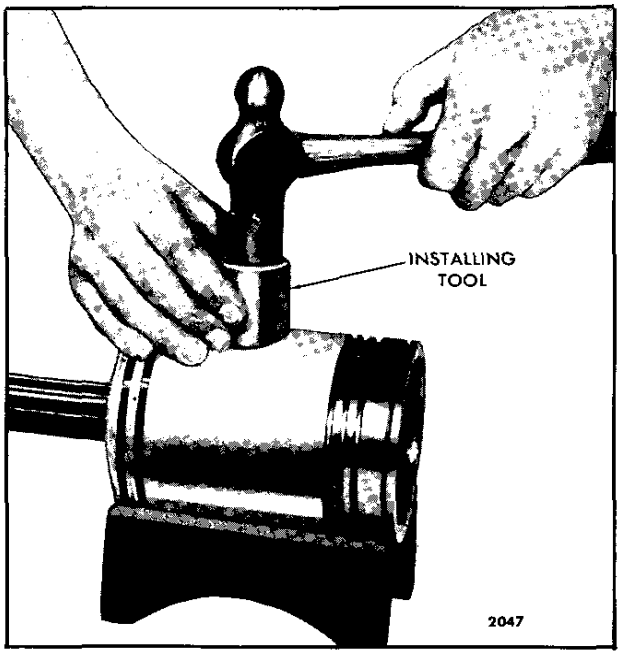


Fig. 11 - Installing Piston Pin Retainer with Tool J 1513-1

f. Turn the reamer in a clockwise direction only, when reaming or withdrawing the reamer. For best results, use only moderate pressure on the reamer.

g. Remove the reamer and the connecting rod from the fixture, blow out the chips and measure the inside diameter of the bushings. The inside diameter of the bushings must be 1.5025″ to 1.5030″. This will provide a piston-pin-to-bushing clearance of .0025″ to .0034″ with a new piston pin. A new piston pin has a diameter of 1.4996″ to 1.5000″.

Assemble Connecting Rod to Piston

Apply clean engine oil to the piston pin and bushings. Refer to Fig. 2 and assemble the connecting rod to the piston as follows:

1. Place the piston in the holding fixture (Fig. 11).

2. Place a new piston pin retainer in position. Then place the crowned end of installer J 24107-01 against the retainer and strike the tool just hard enough to deflect the retainer and seat it evenly in the piston.

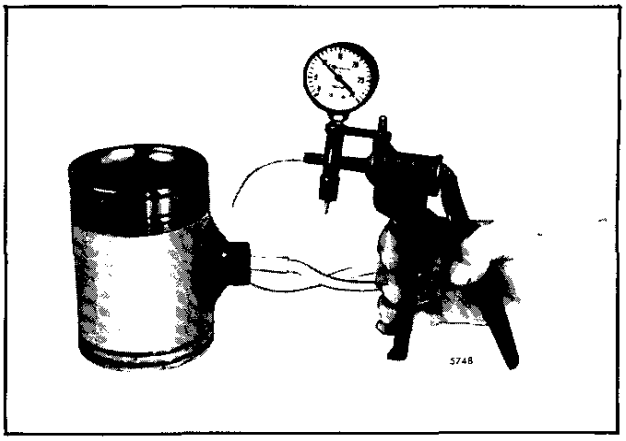


Fig. 12 - Checking Piston Pin Retainer for Proper Sealing with Tool J 23987

NOTE: Do not drive the retainer in too far or the piston bushing may be moved inward and result in reduced piston pin end clearance.

3. Place the upper end of the connecting rod between the piston pin bosses and in line with the piston pin holes. Then slide the piston pin in place. If the piston pin-to-bushing clearances are within the specified limits, the pin will slip into place without use of force.

4. Install the second piston pin retainer as outlined in Steps 1 and 2.

5. After the piston pin retainers have been installed, check for piston pin end clearance by *cocking* the connecting rod and shifting the pin in its bushings.

6. One important function of the piston pin retainer is to prevent the oil, which cools the underside of the piston and lubricates the piston pin bushings, from reaching the cylinder walls. Check each retainer for proper sealing with leak detector J 23987 (Fig. 12). Place the suction cup over the retainer and hand operate the lever to pull a vacuum of ten inches on the gage. A drop in the gage reading indicates air leakage at the retainer.

7. Install the piston rings on the piston as outlined in Section 1.6.

8. Install the piston and connecting rod assembly in the engine as outlined in Section 1.6.3.

© 1984 General Motors Corp.

CONNECTING ROD

Cross-Head Type Piston

The connecting rod (Fig. 13) is forged to an "I" section with an open or saddle type contour at the upper end and a bearing cap at the lower end. The bearing cap and connecting rod are forged in one piece and bored prior to separation.

The upper end of the connecting rod is machined to match the contour of the piston pin. The piston pin is secured to the connecting rod with two self-locking bolts and spacers. The bearing cap is secured to the connecting rod by two specially machined bolts and nuts.

Lubricating oil is forced through a drilled oil passage in the connecting rod to the piston pin and bushing.

A service connecting rod includes the bearing cap and the attaching bolts and nuts.

The replaceable connecting rod bearing shells are covered in Section 1.6.2.

Disassemble Connecting Rod from Piston

With the rod and piston assembly removed from the engine, disassemble the piston and connecting rod as outlined in Section 1.6.

Inspection

Clean the connecting rod and piston pin with a suitable solvent and dry them with compressed air. Blow compressed air through the oil passage in the connecting rod to be sure it is clear of obstructions. Use crocus cloth, wet with fuel oil, to remove any trace of fretting and/or corrosion on the connecting rod saddle and piston pin contact surface with the rod before reassembly.

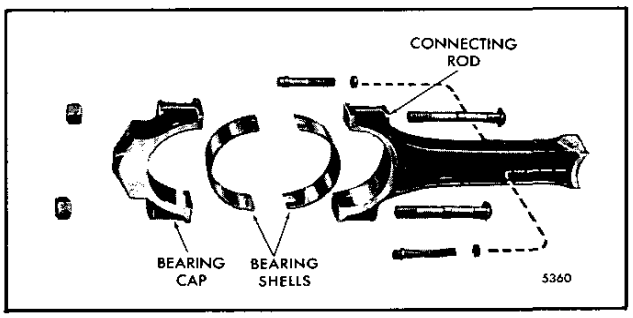


Fig. 13 - Connecting Rod Details

NOTE: Never use crocus cloth on the bearing side of the pin.

Connecting rods being removed from an original build engine can be reused as is, after considering the following:

1. Check for visual damage (bent).
2. A previous bearing(s) or related failure.
3. Is the connecting rod blue at the top or bottom end?
4. Fretting at split line between the connecting rod and cap.
5. Excessive pound-in of the bolt head or nut.

If the connecting rod has been subjected to any of the above, it should be scrapped.

In qualifying a used connecting rod from a source other than an original build engine, the following checks should be made in addition to the above.

1. Check for cracks (Fig. 14) by the magnetic particle method outlined in Section 1.3 under *Crankshaft Inspection.*

2. Determine the average bore diameter of the rod, using a dial bore gage and master ring as follows (Fig. 15):

a. Install the connecting rod cap on the connecting rod and tighten the bolt nuts to 60-70 lb-ft (81-95 Nm) torque.

NOTE: Do not over torque the connecting rod bolt nuts. Over torque may permanently distort the connecting rod cap.

b. Measure diameter A and B (Fig. 15).

c. Obtain the average of A and B to obtain size at split line.

$$\frac{A + B}{2} = X \text{ which is the average of } A + B$$

d. Measure C. The difference in the results of the measurements X and C gives the average bore out-of-round and can be .005" maximum.

© 1984 General Motors Corp.

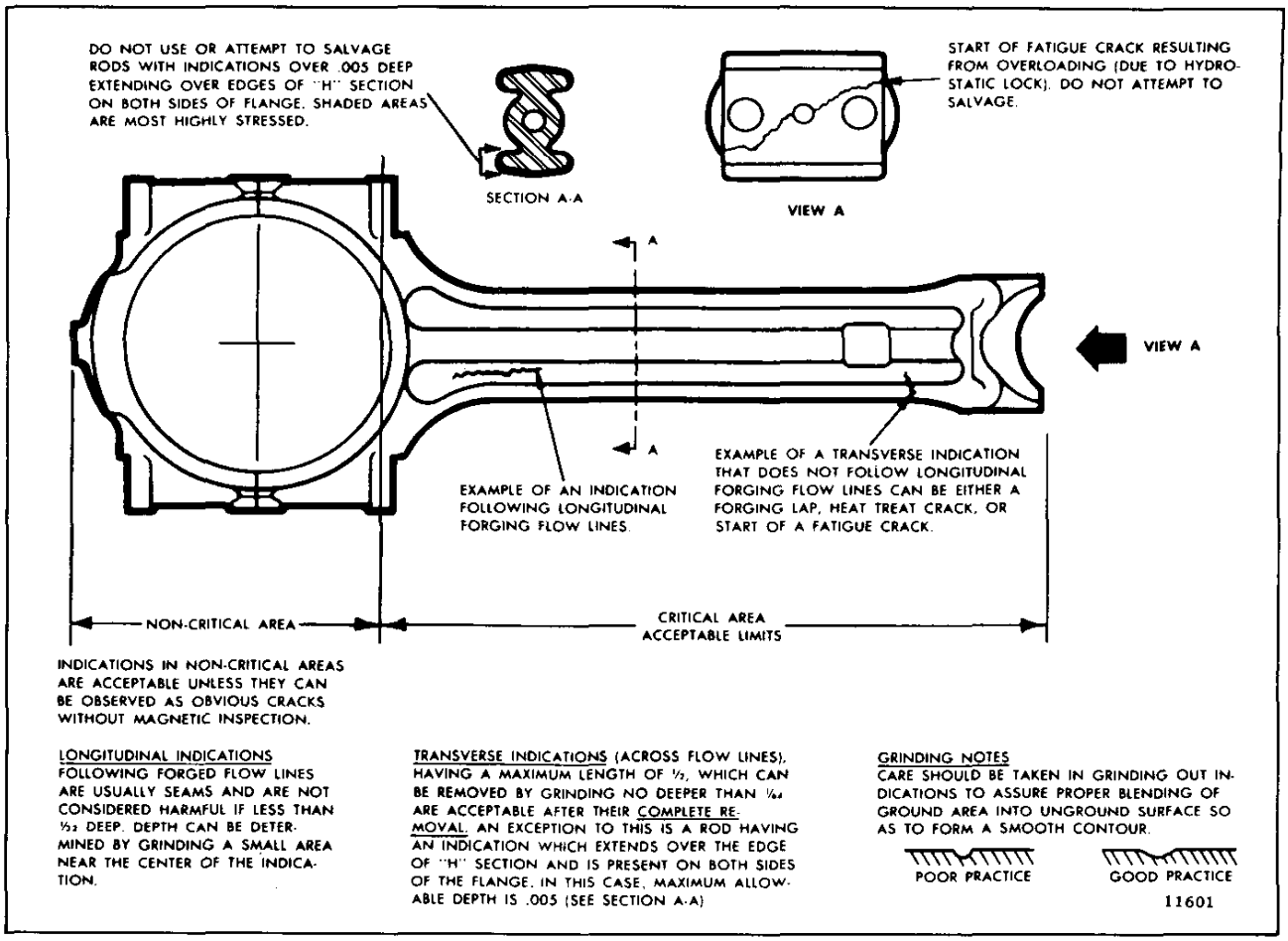


Fig. 14 - Magnetic Particle Inspection Limits for Connecting Rod

e. Add C with X and average to obtain average bore size.

$$\frac{C + X}{2} = \text{Average diameter of bore which must be within 3.2495" to 3.2515"}$$

NOTE: If the crosshead connecting rod bore is not to specifications, the rod must be scrapped and cannot be machined.

3. Determine taper as follows (Fig. 13):

a. Substract D1 from D2 to find the difference.

b. The difference can be .0005" maximum.

4. Determine length by finding the distance between E1 and E2 (Fig. 15).

Specifications: 10.121" to 10.126".

NOTE: The length of the rod can be measured on connecting rod measurement fixtures marketed by B. K. Sweeney, Tobin Arp or equivalent.

Remove any nicks or burrs from the connecting rod bolt holes with reamer J 28460 (Fig. 4). The reamer includes a 60° angle to clean-up the chamfer at the bolt hole to ensure proper seating of the underside of the bolt head.

If a new service connecting rod is required, stamp the cylinder number on the connecting rod and cap (refer to Section 1.6.3).

NOTE: Clean the rust preventive from a service replacement connecting rod and blow compressed air through the drilled oil passage to be sure it is clear of obstructions. Also make sure the split line (cap to rod) is thoroughly cleaned to avoid trapped contaminants from adversely affecting bearing shell "crush".

Inspect the bearing (bushing) for indications of

© 1982 General Motors Corp.

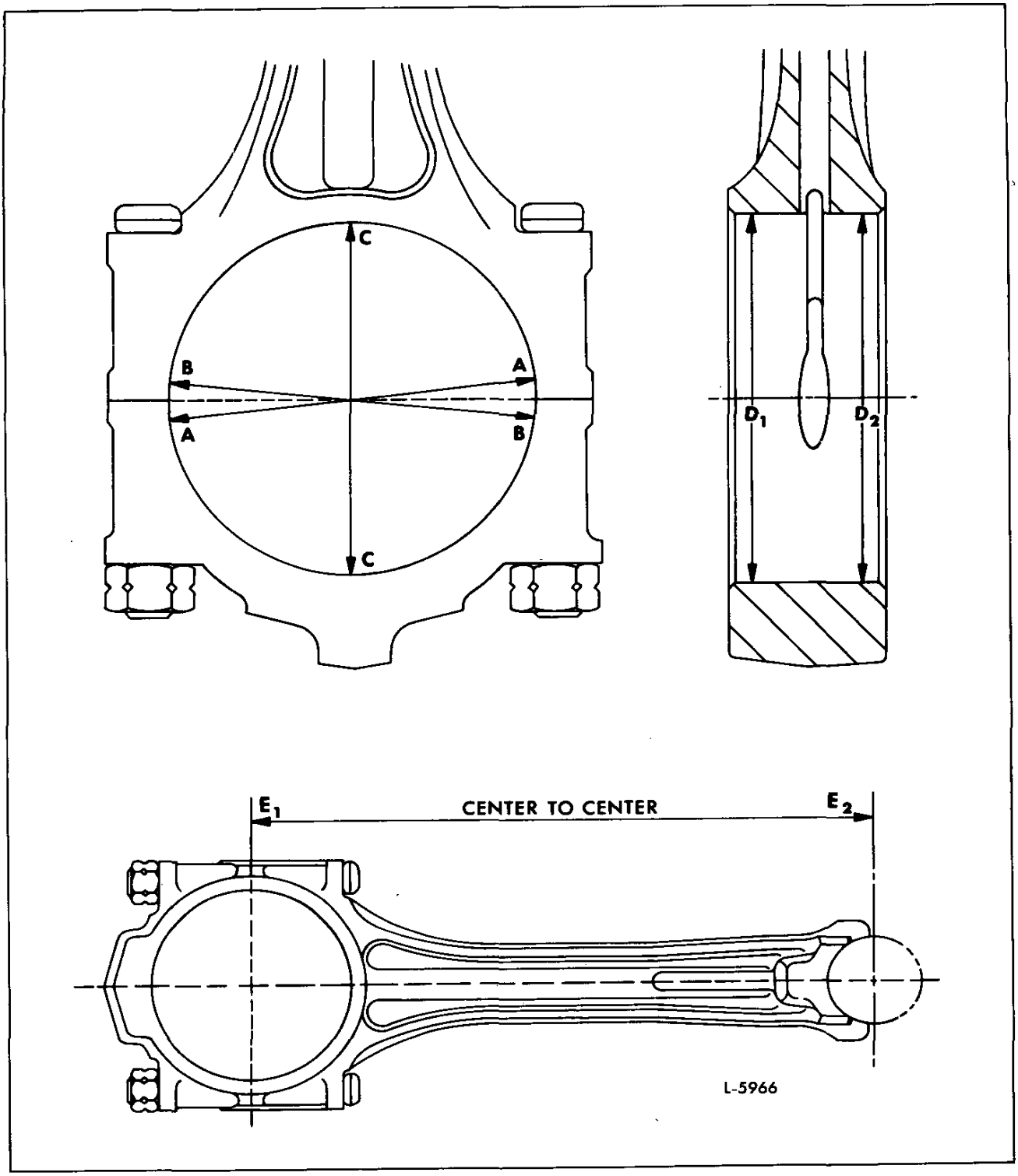


Fig. 15 - Dimensional Inspection of Cross-Head Piston Connecting Rods

© 1982 General Motors Corp.

scoring, overheating or other damage. Measure the thickness of the bushing along the center. Replace the bushing if it is damaged or worn to a thickness of .086 " or less. A new bushing is .087 " to .088 " thick.

Inspect the piston pin for signs of fretting. When re-using a piston pin, the highly polished and lapped surface of the pin must not in any way be refinished. Polishing or refinishing the piston pin is not recommended as it could result in very rapid bushing wear. A new piston pin has a diameter of 1.4996 " to 1.5000 ". Replace the piston pin if it is worn to a diameter of 1.4980 " or less.

Assemble Connecting Rod to Piston

Refer to *Assemble Piston* in Section 1.6 for assembly of the connecting rod to the piston.

© 1978 General Motors Corp.

CONNECTING ROD BEARINGS

The connecting rod bearing shells (Fig. 1) are precision made and are replaceable without shim adjustments. They consist of an upper bearing shell seated in the connecting rod and a lower bearing shell seated in the connecting rod cap. The upper and lower bearing shells are located in the connecting rod by a tang at the parting line at one end of each bearing shell.

Various types of bearings have been used. Currently, multiple layer copper-lead coplated or aluminum triplated bearings are in use. These bearings have an inner surface, called the matrix, of copper-lead or aluminum. A thin deposit of babbitt is then plated onto the matrix. This babbitt overlay has excellent resistance to friction, corrosion and scoring tendencies which, combined with the material of the matrix, provides improved load carrying characteristics. These bearings are identified by the satin silver sheen of the babbitt when new and a dull gray after being in service. The former copper-lead bearings had a copper color when new and turned very dark during engine operation.

The upper and lower connecting rod bearing shells are different and are not interchangeable. The upper bearing shell is grooved midway between the bearing edges, part way up from each parting line, with an oil hole through the shell at the termination of each groove. The lower bearing shell has a continuous oil groove, extending from one parting line to the other, in line with that of the upper bearing shell. These grooves maintain a continuous registry with the oil hole in the crankshaft connecting rod journal, thereby providing a constant supply of lubricating oil to the connecting rod bearings, piston pin bushings and spray nozzle through the oil passage in the connecting rod.

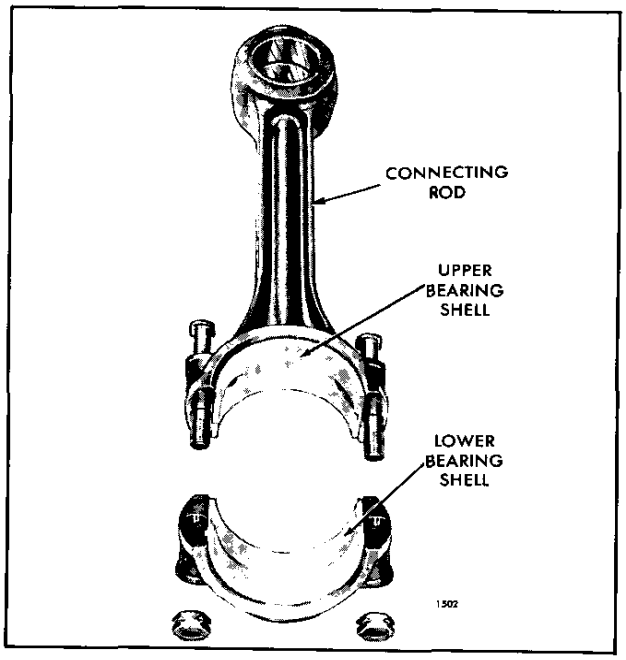


Fig. 1 - Connecting Rod and Bearing Shells

Remove Bearing Shells

The connecting rod bearing caps are numbered 1, 2, 3, etc., with matching numbers stamped on the connecting rods. When removed, each bearing cap and the bearing shells must always be reinstalled on the original connecting rod.

Remove the connecting rod bearings as follows:

1. Drain the oil and remove the oil pan.

2. Remove the lubricating oil pump and the pump inlet and outlet pipes.

> **NOTE:** If shims are used between the oil pump body and the main bearing caps, save the shims so they may be reinstalled when installing the oil pump.

3. Remove one connecting rod bearing cap. Push the piston and rod assembly up into the cylinder liner far enough to permit removal of the upper bearing shell. Do not pound on the edge of the bearing shell with a sharp tool.

4. Inspect the upper and lower bearing shells as outlined under *Inspection*.

5. Install the bearing shells and bearing cap before another connecting rod bearing cap is removed.

Inspection

Bearing failures may result from deterioration (acid formation) or contamination of the oil or loss of oil. An analysis of the lubricating oil may be required to determine if corrosive acid and sulphur are present which cause acid etching, flaking and pitting. Bearing seizure may be due to low oil or no oil.

After removal, clean the bearings and inspect them for

© 1982 General Motors Corp.

scoring, pitting, flaking, chipping, cracking, loss of babbitt or signs of overheating. If any of these defects are present, the bearings must be discarded. However, babbitt plated bearings may develop minute cracks or small isolated cavities on the bearing surface during engine operation. These are characteristics of and are NOT detrimental to this type of bearing. The bearings should not be replaced for these minor surface imperfections. The upper bearing shells, which carry the load, will normally show signs of distress before the lower bearing shells do.

Inspect the backs of the bearing shells for bright spots which indicate they have been shifting in their supports. If such spots are present, discard the bearing shells. Also inspect the connecting rod bearing bore for burrs, foreign particles, etc.

Measure the thickness of the bearing shells, using a micrometer and ball attachment J 4757, as described under *Inspection* in Section 1.3.4. The minimum thickness of a worn standard connecting rod bearing shell should not be less than .1530" and, if either bearing shell is thinner than this dimension, replace both bearing shells. A new standard bearing shell has a thickness of .1548" to .1553". Refer to Table 1.

Bearing Size	*New Bearing Thickness	Minimum Worn Thickness
Standard	.1548"/.1553"	.1530"
.002" Undersize	.1558"/.1563"	.1540"
.010" Undersize	.1598"/.1603"	.1580"
.020" Undersize	.1648"/.1653"	.1630"
.030" Undersize	.1698"/.1703"	.1680"

*Thickness 90° from parting line of bearing.

TABLE 1

In addition to the thickness measurement, check the clearance between the connecting rod bearing shells and the crankshaft journal. This clearance may be checked by means of a soft plastic measuring strip which is squeezed between the journal and the bearing (refer to *Shop Notes* in Section 1.0). The maximum connecting rod bearing-to-journal clearance with used parts is .006".

Before installing the bearings, inspect the crankshaft journals (refer to *Inspection* in Section 1.3).

Do not replace one connecting rod bearing shell alone. If one bearing shell requires replacement, install both new upper and lower bearing shells. Also, if a new or reground crankshaft is to be used, install all new bearing shells.

Bearing shells are available in .002", .010", .020" and .030" undersize for service with reground crankshafts. To determine the size bearings required, refer to *Crankshaft Grinding* in Section 1.3. Bearings which are .002" undersize are available to compensate for slight journal wear where it is unnecessary to regrind the crankshaft.

NOTE: Bearing shells are NOT reworkable from one undersize to another under any circumstances.

Install Connecting Rod Bearing Shells

With the crankshaft and the piston and connecting rod assembly in place, install the connecting rod bearings as follows:

1. Rotate the crankshaft until the connecting rod journal is at the bottom of its travel, then wipe the journal clean and lubricate it with clean engine oil.

2. Install the upper bearing shell -- the one with the short groove and oil hole at each parting line -- in the connecting rod. Be sure the tang on the bearing shell fits in the groove in the connecting rod.

3. Pull the piston and rod assembly down until the upper rod bearing seats firmly on the crankshaft journal.

4. Note the numbers stamped on the connecting rod and the bearing cap and install the lower bearing shell -- the one with the continuous oil groove -- in the bearing cap, with the tang on the bearing shell in the groove in the bearing cap.

5. Install the bearing and cap and tighten the connecting rod bolt nuts to 60-70 lb-ft (81-95 Nm) torque (lubrite nut) or 65-75 lb-ft (88-102 Nm) torque (castellated nut).

NOTE: Be sure the connecting rod bolt has not turned in the connecting rod before torque is applied to the nut.

6. Install the lubricating oil pump and the oil inlet and outlet pipes.

NOTE: If shims were used between the oil pump body and the main bearing caps, install the shims in exactly the same location from which they were removed.

7. Install the oil pan, using a new gasket.

8. Refer to the *Lubrication Specifications* in Section 13.3 and fill the crankcase to the proper level on the dipstick.

If new bearings were installed, operate the engine on the *run-in* schedule as outlined in Section 13.2.1.

© 1982 General Motors Corp.

CYLINDER LINER

The replaceable type cylinder liner is accurately machined and heat treated to provide a long wearing scuff-resistant surface (Fig. 1). The flange at the top fits into a counterbore in the cylinder block and rests on a replaceable cast iron insert which permits accurate alignment of the cylinder liner.

A long-oval port cylinder liner (Fig. 2) is used with pistons equipped with three compression rings and a fire ring (top ring groove). A short-oval port liner replaces the former liner with "figure 8" air inlet ports and is used with pistons not equipped with a fire ring. The short-oval port and "figure 8" liner can be used together in an engine.

NOTE: Do not use the short-oval port liners in an engine requiring long-oval port liners.

When rebuilding a TA or TTA engine, always make sure that the correct cylinder liner is installed. The TA/TTA liner has a .95" port height, while the standard liner has a 1.05" port height. If the standard liner is installed in place of the TA liner, a small loss in power and an increase in smoke will result. This will also, put the TA and the TTA engines in direct violation of EPA (Environmental Protection Agency) standards.

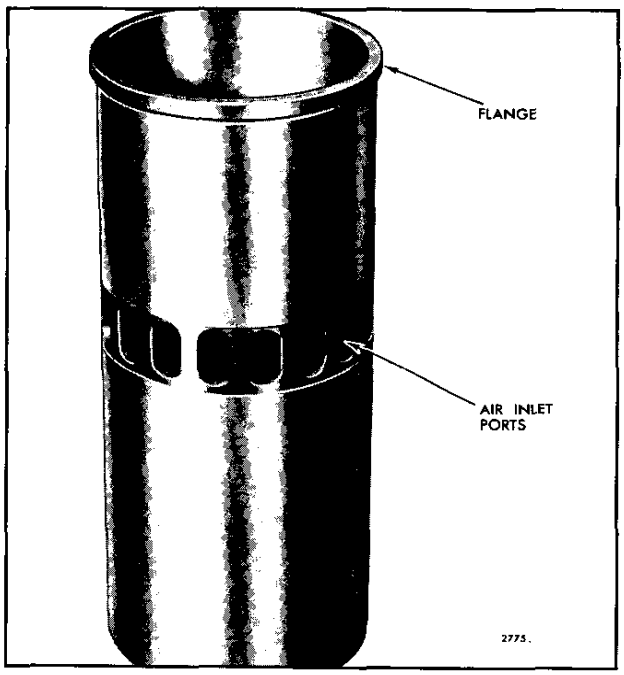


Fig. 1 - Typical Cylinder Liner

The .95" port height liner can be identified as follows:

1. The part number is stamped on the outside diameter of the liner.

2. The liner flange has an identification groove machined around the outside diameter surface.

The liner is cooled by means of a water jacket in the cylinder block and by the scavenging air introduced into the cylinder through the air inlet ports around the liner (Figs. 1 and 2). The air inlet ports are machined at an angle to create a uniform swirling motion to the air as it enters the cylinder. This motion persists throughout the compression stroke and facilitates scavenging and combustion.

The wear on a liner and piston is directly related to the amount of abrasive dust and dirt introduced into the engine combustion chamber through the air intake. This dust, combined with lubricating oil on the cylinder wall, forms a lapping compound and will result in rapid wear. Therefore, to avoid pulling contaminated air into the cylinder, the air cleaners must be serviced regularly according to the surroundings in which the engine is operating.

Remove Cylinder Liner (Cast Iron Cylinder Block)

It is very important that the proper method is followed when removing a cylinder liner. *Do not* attempt to push the liner out by inserting a bar in the liner ports and rotating the crankshaft, otherwise the piston may be damaged or the upper ring groove may collapse.

Remove a cylinder liner from a cast iron block as follows:

1. Remove the piston and connecting rod assembly as outlined in Section 1.6.

2. Remove the cylinder liner with tool J 1918-02 as follows:

a. Slip the lower puller clamp up on the puller rod and off the tapered seat. Cock the clamp so it will slide down through the liner. The clamp will drop back on the tapered seat after it clears the bottom of the liner. Then slide the upper puller clamp down against the top edge of the liner.

b. With the tool in place, strike the upset head on the

© 1983 General Motors Corp.

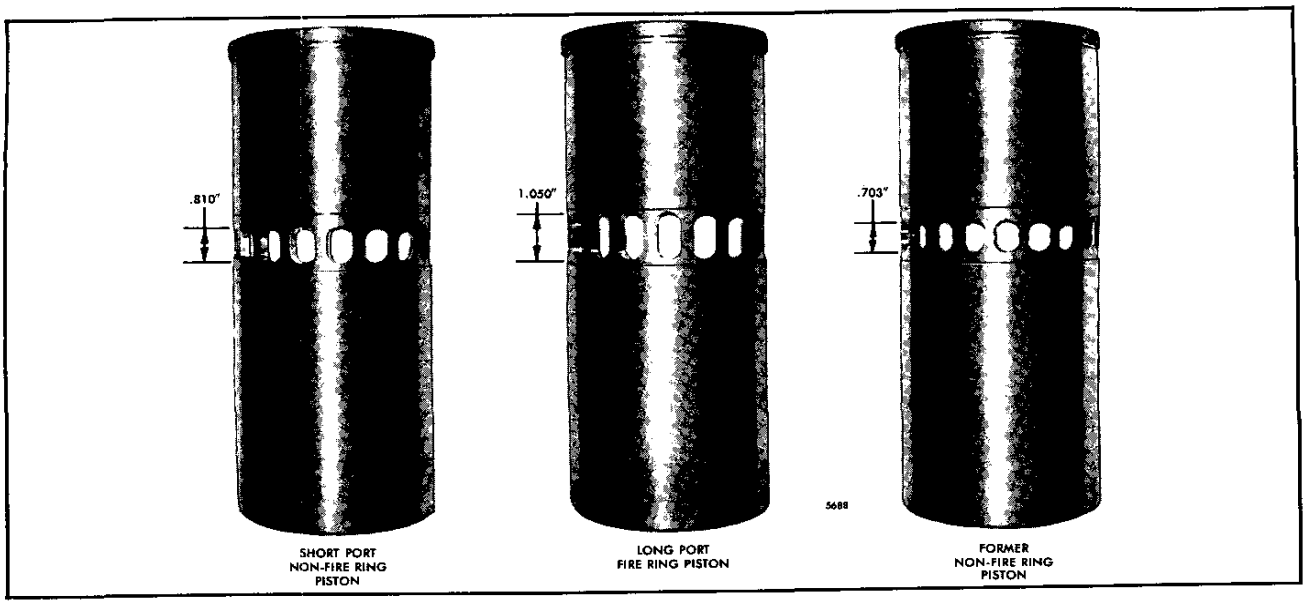


Fig. 2 - Comparison of Cylinder Liners

upper end of the puller rod a sharp blow with the puller weight, thus releasing the liner (Fig. 3).

c. Remove the tool from the liner. Then, remove the liner from the block.

d. Remove the liner insert and shims (if used) from the counterbore in the block.

e. Tag the liner, insert and shims.

If tool J 1918-02 is unavailable, tap the liner out with a hardwood block and hammer.

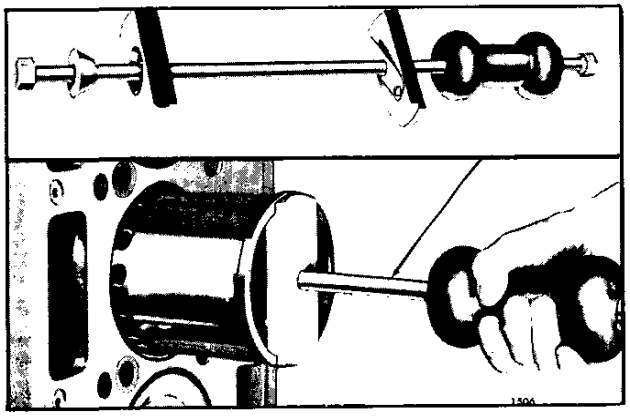


Fig. 3 - Removing Cylinder Liner with Tool J 1918-02

Remove Cylinder Liner (Aluminum Cylinder Block)

Due to the close liner-to-block clearance, the following procedure is recommended for removing a cylinder liner from an aluminum block.

1. Remove the piston and connecting rod assembly as outlined in Section 1.6.

2. Remove the water pump and the water hole cover from the cylinder block.

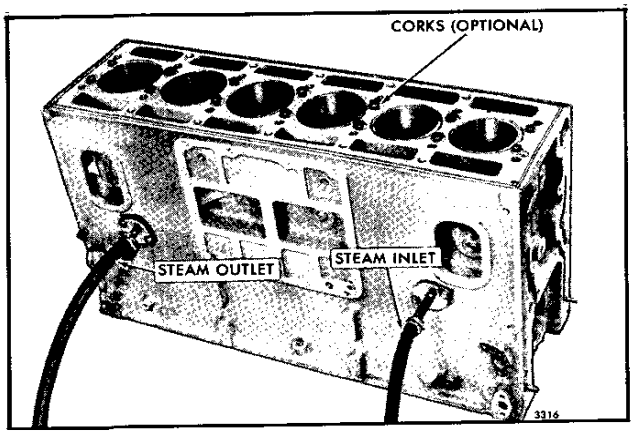


Fig. 4 - Method of Attaching Steam Lines to Aluminum Cylinder Block

© 1983 General Motors Corp.

3. Install a water hole cover (with a 3/8" NPTF tapped hole) over each cylinder block water hole.

4. Then, using suitable connectors or short 3/8" pipes, attach a steam line to one cover and a drain line to the other cover (Fig. 4).

CAUTION: Escaping steam can cause serious burns. As an added precaution, use corks to plug the water holes on top of the cylinder block.

5. Install tool J 1918-02 in the liner to be removed as outlined in the procedure for removing a liner from a cast iron cylinder block.

6. Introduce steam into the cylinder block water passages with sufficient pressure to assure complete circulation. Turn off the steam intermittently to avoid a build-up of pressure or loss of steam.

7. After approximately five minutes, turn off the steam and operate the slide hammer. If the liner cannot be removed, apply additional steam until the cylinder block is heated sufficiently to permit removal of the liner.

NOTE: Be sure to turn off the steam *before* attempting to remove the liner.

8. Remove the liner insert.

9. Tag the liner and the insert.

The above method may be used to remove the liners without removing the engine. However, if the cylinder block has been completely stripped down, it may be immersed in a tank of hot water (180°F or 82°C) for approximately twenty minutes to expand the bores sufficiently to reduce the effort required to remove the liners.

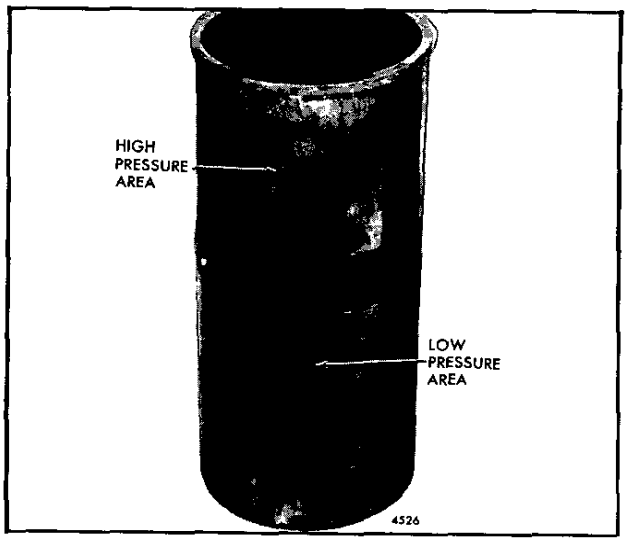


Fig. 5 - High and Low Pressure Contact Areas on Cylinder Liner

Inspect Used Cylinder Liner

When the cylinder liner is removed from the cylinder block, it must be thoroughly cleaned and then checked for:

Cracks
Scoring
Poor contact on outer surface
Flange irregularities
Inside diameter
Outside diameter
Out-of-round
Taper

A cracked or excessively scored liner must be discarded. A slightly scored liner may be cleaned-up and reused.

Excessive liner-to-block clearance or block bore distortion will reduce heat transfer from the liner to the block and to the engine coolant. Poor contact between the liner and the block bore may be indicated by stains or low pressure areas on the outer surface of the liner (Fig. 5).

Examine the outside diameter of the liner for fretting. Fretting is the result of a slight movement of the liner in the block bore during engine operation, which causes material from the block to adhere to the liner. These metal particles may be removed from the surface of the liner with a coarse, flat stone.

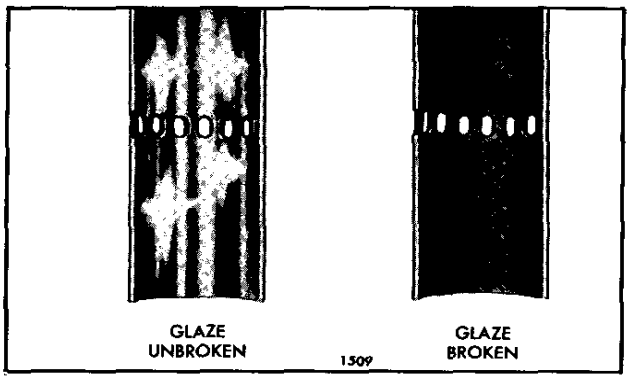


Fig. 6 - Glazed Surface of Cylinder Liner

© 1983 General Motors Corp.

The liner flange must be smooth and flat on both the *top and bottom surfaces.* Check for cracks at the flange. The liner insert must also be smooth and flat on the top and bottom surfaces. Replace the insert if there is evidence of brinelling.

A used cylinder liner must be honed for the following reasons:

> **NOTE:** Do not modify the surface finish in a *new* service liner. Since the liner is properly finished at the factory, any change will adversely affect seating of the piston rings.

1. Break the glaze (Fig. 6) due to the rubbing action of the piston rings which results after long periods of operation. Unless this glaze is removed, the time required to seat new piston rings will be lengthened.

2. Remove the ridge (Fig. 7) formed at the top by the piston ring travel. Otherwise, interference with the e travel of the new compression rings may result in ring breakage.

Therefore, even though the taper and out-of-round are within the specified limits, the glaze and ridge must be removed by working a hone up and down the full length of the liner a few times.

Place the liner in a fixture (a scrap cylinder block makes an excellent honing fixture). However, if it is necessary to hone a liner in the cylinder block that is to be used in building up the engine, the engine must be dismantled and then, after honing, the cylinder block and other parts must be thoroughly cleaned to ensure that all abrasive material is removed.

The hone J 5902-01, equipped with 120 grit stones J 5902-14, should be worked up and down the full

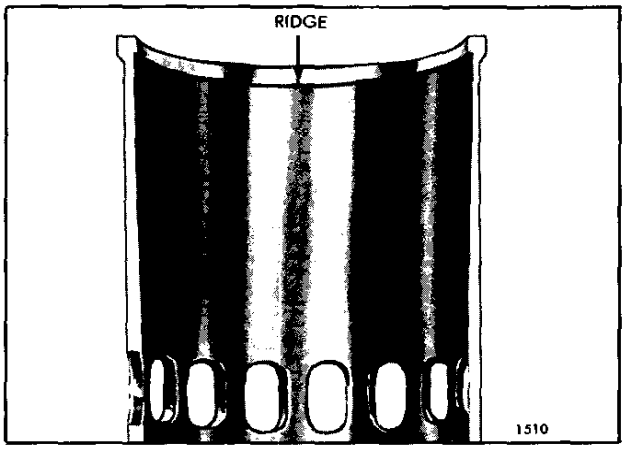


Fig. 7 - Cylinder Liner Ridge Due to Wear

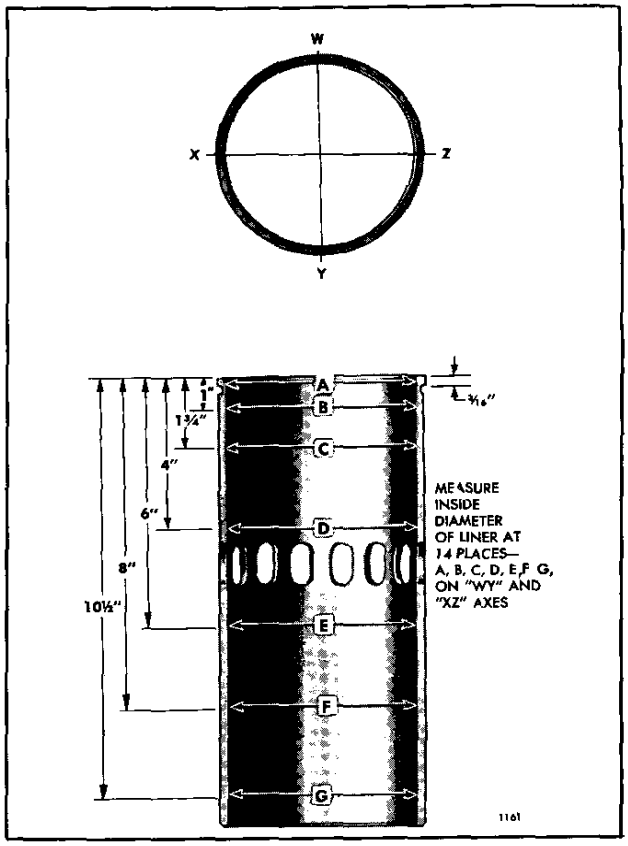


Fig. 8 - Cylinder Liner Measurement Diagram

length of the liner a few times in a criss-cross pattern that produces hone marks on a 45° axis.

After the liner has been honed, remove it from the fixture and clean it thoroughly. Then, dry it with compressed air and check the entire surface for burrs.

After honing, the liner must conform to the same limits on taper and out-of-round as a new liner and the piston-to-liner clearance must be within the specified limits (Section 1.0).

Liner Measurements

Measure the block bore and the outside diameter of the liner. If the liner-to-block clearance (with used parts) exceeds .0025" (cast iron block) or .001" press fit to .001" loose (aluminum block), it will be necessary to bore the block for an oversize liner as outlined in Section 1.1.

Install the liner in the proper bore of the cylinder block. Measure the inside diameter of the liner at the various points shown in Fig. 8. Use cylinder bore gage J 5347-01, which has a dial indicator calibrated in .0001" increments. Set the cylinder bore gage on zero

© 1983 General Motors Corp.

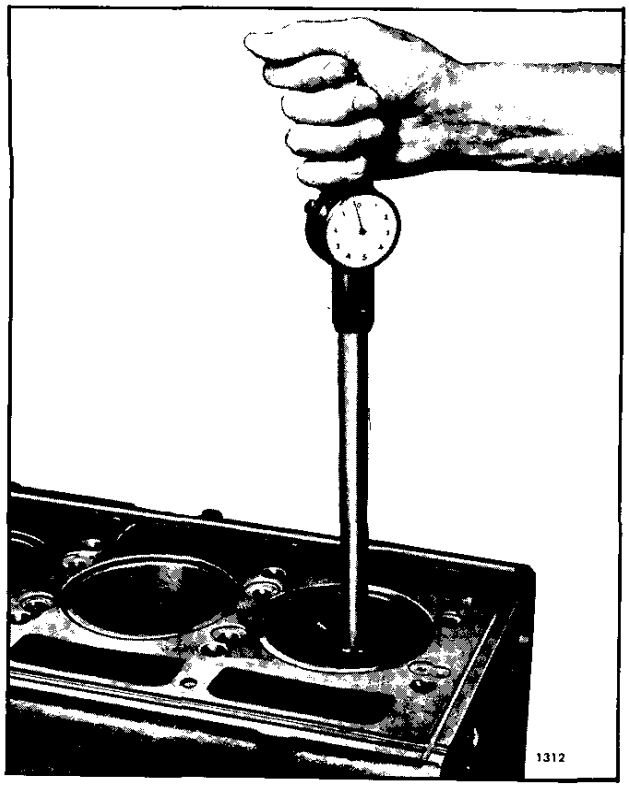


Fig. 9 - Checking Bore of Cylinder Line Using Tool J 5347-01

in master ring gage J 5580-1. Also check the liner for taper and out-of-round. It is not necessary to measure the inside diameter or taper of a *new* liner.

NOTE: Dial bore gage master setting fixture J 23059-01 may be used in place of the master ring gage.

The piston-liner clearance must be within the specified limits (Section 1.0). Also, the taper must not exceed .002 " and the out-of-round must not exceed .0025 " on a *used* liner. If the out-of-round exceeds .0025 ", rotate the liner 90 ° in the block bore and recheck.

New service liners, standard and oversize, have an *inside* diameter of 4.2489 " to 4.2511 ".

Cylinder liners are available in .001 ", .005 ", .010 ", .020 " and .030 " oversize on the *outside* diameter. When an oversize liner is installed, stamp the amount of oversize on top of the cylinder bore adjacent to the liner counterbore.

Selection of New Cylinder Liner

The cylinder bores in a *new* cylinder block are classified as #1, #2 or #3 (Table 1) designating the specific size range for each bore and the appropriate cylinder liner that may be fitted to each bore. The classification number is stamped on the fire deck of the cylinder block adjacent to each cylinder bore.

A *new* standard size cylinder liner is also classified as #1, #2 or #3 as illustrated in Fig. 10 and Table 1.

Although the block bores and liners should be measured to determine the liner-to-block clearance, the selection of a liner is narrowed down to only those in the appropriate classifications or possibly a .001 " oversize liner.

Before installing a liner in a *used* cylinder block, always lightly hone the block bore (refer to Section 1.1).

After honing the block bore, check the bore measurements to determine if a standard liner (classification #1, #2 or #3) or possibly a .001 " oversize liner can be used (refer to Tables 1 and 2). A push fit between the liner and the block is desirable. If an adequate push fit cannot be obtained, it may be necessary to bore the block to receive an oversize liner.

When it becomes necessary to install an oversize liner, the same care in selective tolerance fitting must be adhered to. However, it may be more difficult to select an oversize liner since the size range is not broken down into classifications.

In deciding whether boring is necessary or not, keep in mind that each bore in a *used* block must not be out-of-round or tapered more than .002 ". If the average block bore is over 4.6285 " (cast iron block) or 4.6275 " (aluminum block), the cylinder block should be bored oversize.

To determine what size to bore the cylinder block for an oversize liner, each service liner used must be measured on the outside diameter for size in three places (under the flange, between the flange and the ports, and above the ports). The cylinder bore size will be determined by the average liner measurement taken at the three positions.

EXAMPLE:

Service liner O.D. measures 4.6280 ".

O.D. size = 4.6280 "
plus clearance = .0005 "
bore size = 4.6285 "

Then, 4.6285 " + .001 " boring tolerance will allow a

© 1982 General Motors Corp.

NEW CYLINDER LINER TO NEW CYLINDER BLOCK BORE FITS				
Classification Number Stamped Adjacent to Each Cyl. Bore	Cylinder Bore Classification Diameter (I.D.)	Standard Cylinder Liner Diameters and Liner-to-Block Clearances When Properly Matched		
		Liner (O.D.) Classification	Liner (O.D.) Diameter	Liner/Block Clearance
CAST IRON BLOCK				
#0	4.6256"/4.6259"	#1	4.6250"/4.6255"	.0001"/.0009"
#1	4.6260"/4.6265"	#1 #2	4.6250"/4.6255" 4.6256"/4.6260"	.0005"/.0015" .0000"/.0009"
#2	4.6266"/4.6270"	#2 #3	4.6256"/4.6260" 4.6261"/4.6265"	.0006"/.0014" .0001"/.0009"
#3	4.6271"/4.6275"	#3	4.6261"/4.6265"	.0006"/.0014"
METRIC				
#0	117.490/117.498 mm	#1	117.475/117.488 mm	.002/.023 mm
#1	117.500/117.513 mm	#1 #2	117.475/117.488 mm 117.490/117.500 mm	.012/.038 mm .000/.023 mm
#2	117.516/117.526 mm	#2 #3	117.490/117.500 mm 117.503/117.513 mm	.016/.036 mm .003/.023 mm
#3	117.528/117.539 mm	#3	117.503/117.513 mm	.015/.036 mm
ALUMINUM BLOCK				
#1	4.6250"/4.6255"	#1 #2	4.6250"/4.6255" 4.6256"/4.6260"	.0005" press to .0005" clear .0001" to .0010" press fit
#2	4.6256"/4.6260"	#2 #3	4.6256"/4.6260" 4.6261"/4.6265"	.0004" press to .0004" clear .0001" to .0009" press fit
#3	4.6261"/4.6265"	#3	4.6261"/4.6265"	.0004" press to .0004" clear
METRIC				
#1	117.475/117.488 mm	#1 #2	117.475/117.488 mm 117.490/117.500 mm	.013 mm press to .013 mm clear .002 mm to .025 mm press fit
#2	117.490/117.500 mm	#2 #3	117.490/117.500 mm 117.503/117.513 mm	.005 mm press to .010 mm clear .003 mm to .018 mm press fit
#3	117.503/117.513 mm	#3	117.503/117.513 mm	.010 mm press to .010 mm clear

TABLE 1

© 1982 General Motors Corp.

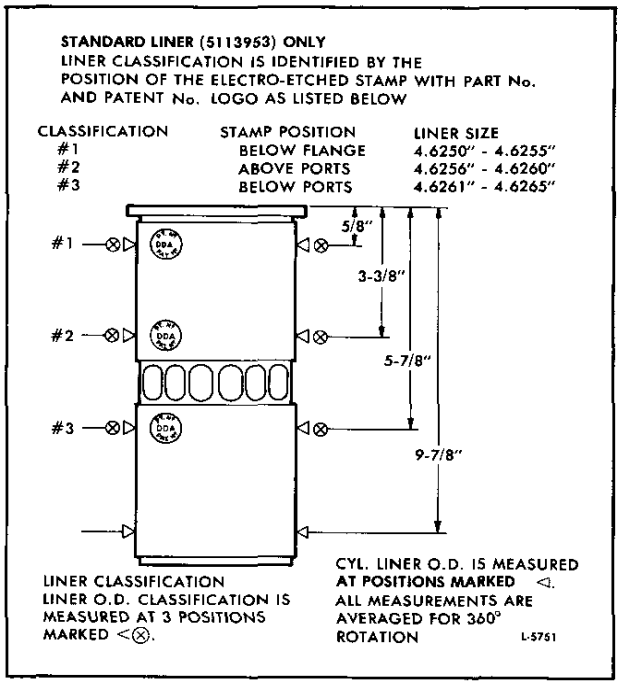


Fig. 10 - Cylinder Liner Classification

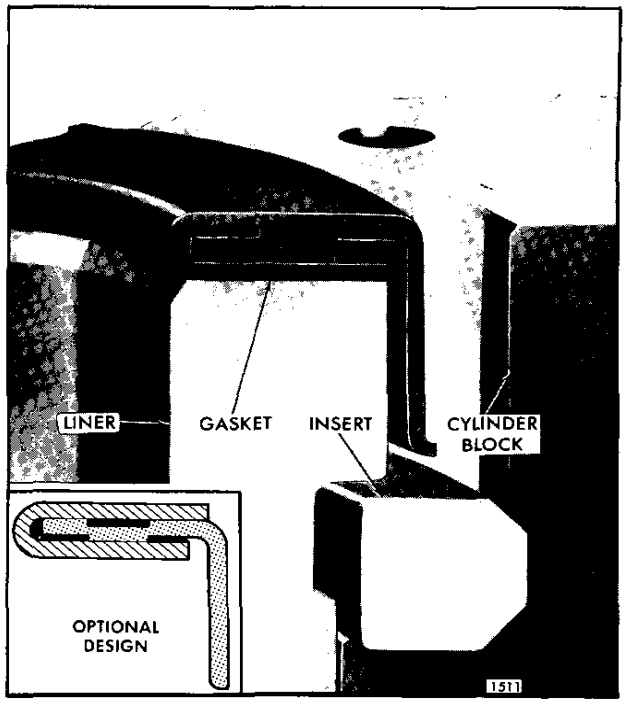


Fig. 11 - Cylinder Liner Mounting in Block

bore size of 4.6285 " to 4.6295 " (cast iron block) and a possible liner-to-block clearance of .0005 " to .0015 ". The clearance tolerance is the dimensional difference between the liner O.D. and the block bore I.D.

OVERSIZE SERVICE CYLINDER LINERS			
Service Liner Oversize	Liner Outside Diameter		Liner/Block Clearance Req'd After Boring Block
	inches	mm	
.001" (.0254 mm)	4.6280 4.6265	117.551 117.513	.0005"/.0015" (.013/.038 mm)
.005"	4.6315 4.6300	117.640 117.602	.0005"/.0015" (.013/.038 mm)
.010"	4.6365 4.6350	117.767 117.729	.0005"/.0015" (.013/.038 mm)
.020"	4.6465 4.6450	118.021 117.983	.0005"/.0015" (.013/.038 mm)
.030"	4.6565 4.6550	118.275 118.237	.0005"/.0015" (.013/.038 mm)

TABLE 2

Fitting Cylinder Liner in Block Bore

1. Wipe the inside and outside of the liner clean and make sure the block bore and counterbore are clean.

2. Place a standard size cylinder liner insert (.1795 "-.1800 " thick) in the block counterbore (Fig. 11).

NOTE: The current liner inserts used with an aluminum block are pressed in. Formerly, the inserts were a slip fit. Heat an aluminum block to 160-185 °F (71-85 °C), before installing an insert or cylinder liner, by submerging it in a tank of hot water for approximately twenty minutes.

3. Push the cylinder liner into the cylinder block until the liner flange rests on the insert. Do not use excessive force to install the liner. The liner should slide smoothly in place with hand pressure. If a new liner cannot be pushed in place, *light* honing of the block bore may be necessary to obtain the desired fit for best heat transfer.

4. Install a cylinder liner hold-down clamp as illustrated in Fig. 12.

© 1980 General Motors Corp.

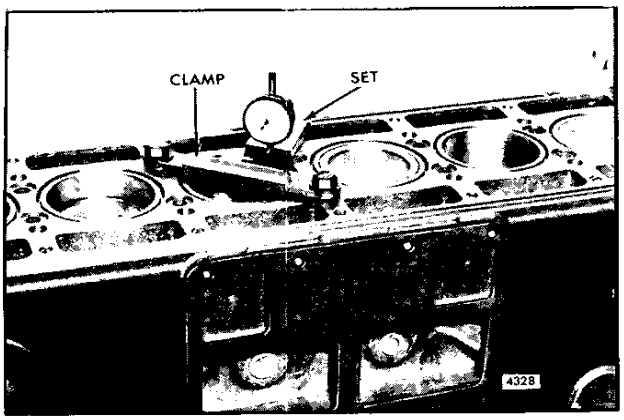


Fig. 12 - Checking Distance of Liner Flange Below Top Face of Block

5. Measure the distance from the top of the liner to the top of the block with a dial indicator (Fig. 12). The liner flange must be .045 " to .050 " below the surface of the block. However, even though all of the liners are within these specifications, there must not be over .002 " difference in depth between any two adjacent liners when measured along the cylinder longitudinal center line.

NOTE: A .002 " thick shim is available for adjusting the liner height. The shim must be installed *underneath* the liner insert. Do not cut the shim for installation. Liner inserts which are .0015 " thicker or thinner than standard are also available for service. In addition, the .004 " and .008 " thinner inserts , which are provided for use with resurfaced cylinder blocks, can also be used to adjust the liner height.

6. Matchmark the liner and the cylinder block with a felt pen so the liner may be reinstalled in the same position in the same block bore. The matchmarks should be toward the blower side of the engine.

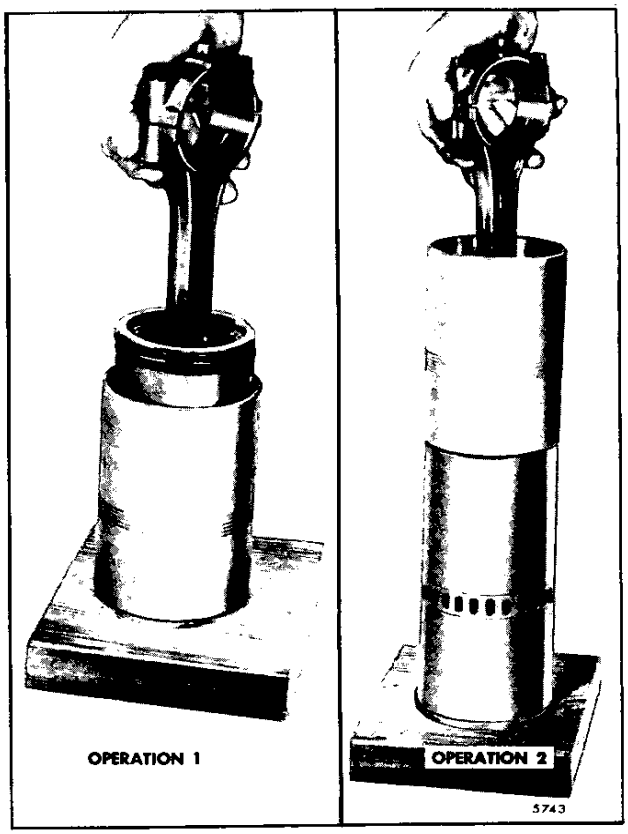


Fig. 13 - Installing Piston and Connecting Rod Assembly in Ring Compressor and Cylinder Liner

7. Remove the hold-down clamp and the cylinder liner.

NOTE: Do not remove the liner insert.

© 1980 General Motors Corp.

Install Piston and Connecting Rod Assembly

1. With the piston assembled to the connecting rod and the piston rings in place as outlined in Sections 1.6 and 1.6.1, apply clean engine oil to the piston, rings and the inside surface of the piston ring compressor J 3272-03.

NOTE: Inspect the ring compressor for nicks or burrs, especially at the non-tapered inside diameter end. Nicks or burrs on the inside diameter of the compressor will result in damage to the piston rings.

2. Place the piston ring compressor on a wood block, with the tapered end of the ring compressor facing up.

3. Position (stagger) the piston ring gaps properly on the piston. Make sure the ends of the oil control ring expanders are not overlapped.

4. Start the top of the piston straight into the ring compressor. Then push the piston down until it contacts the wood block ("Operation 1" of Fig. 13).

5. Note the position of the matchmark and place the liner, with the flange end down, on the wood block.

6. Place the ring compressor and the piston and connecting rod assembly on the liner so the numbers on the rod and cap are aligned with the matchmark on the liner ("Operation 2" of Fig. 13).

NOTE: The numbers on the side of the connecting rod and cap (Fig. 14) identify the rod with the cap and indicate the particular cylinder in which they are used. If a new service connecting rod is to be installed, the same identification numbers must be stamped in the same location as on the connecting rod that was replaced.

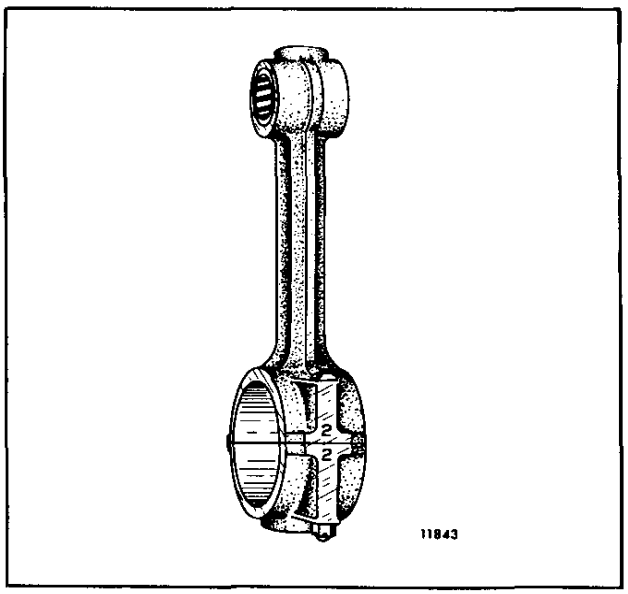


Fig. 14 - Typical Connecting Rod Markings

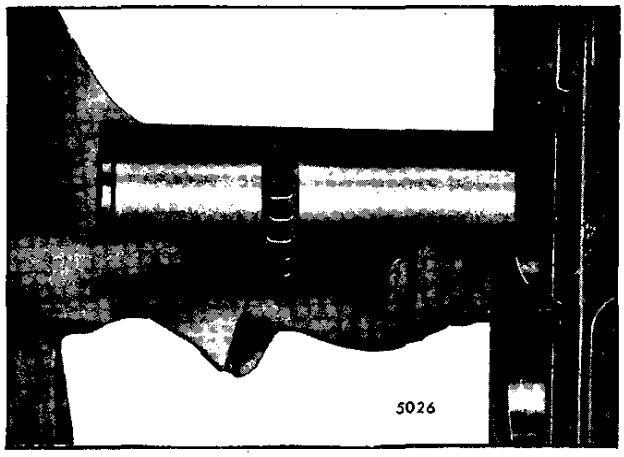


Fig. 15 - Installing Piston, Rod and Liner Assembly in Cylinder Block

7. Push the piston and connecting rod assembly down into the liner until the piston is free of the ring compressor.

NOTE: Do not force the piston into the liner. The peripheral abutment type expanders apply considerably more force on the oil ring than the standard expander. Therefore, extra care must be taken during the loading operation to prevent ring breakage.

8. Remove the connecting rod cap and the ring compressor. Then push the piston down until the compression rings pass the cylinder liner ports.

Install Cylinder Liner, Piston and Connecting Rod Assembly

After the piston and connecting rod assembly have been installed in the cylinder liner, install the entire assembly in the engine as follows:

1. If any of the pistons and liners are already in the engine, use hold-down clamps to retain the liners in place when the crankshaft is rotated.

2. Rotate the crankshaft until the connecting rod journal of the particular cylinder being worked on is at the bottom of its travel. Wipe the journal clean and lubricate it with clean engine oil.

© 1982 General Motors Corp.

3. Install the upper bearing shell, the one with a short oil groove at each parting line, in the connecting rod. Lubricate the bearing shell with clean engine oil.

4. Position the piston, rod and liner assembly in line with the block bore (Fig. 15) so the identification number on the rod is facing the blower side of the engine and the matchmarks on the liner and the block are in alignment. Guide the end of the connecting rod through the block bore carefully to avoid damaging or dislodging the bearing shell. Then slide the piston, rod and liner assembly straight into the block bore until the liner flange rests against the insert in the counterbore in the block.

5. Push or pull the piston and connecting rod into the liner until the upper bearing shell is firmly seated on the crankshaft journal.

6. Place the lower bearing shell, the one with the continuous oil groove from one parting line to the other, in the connecting rod cap, with the tang on the bearing shell in the notch in the connecting rod bearing cap. Lubricate the bearing shell with clean engine oil.

7. Install the bearing cap and the bearing shell on the connecting rod with the identification numbers on the cap and the rod adjacent to each other. Be sure the connecting rod bolt has not turned in the connecting rod before torque is applied to the nut. Tighten the connecting rod bolt nuts to 60-70 lb-ft (81-95 Nm) torque (lubrite nut) or 65-75 lb-ft (88-102 Nm) torque (castellated nut).

NOTE: The current connecting rod bolt is .200 " longer than the former bolt. After the oil pump piping is installed, bar the engine over for a clearance check. In the event interference occurs, loosen the pipe or item involved and retighten it while holding it away from the point of interference.

8. Check the connecting rod side clearance. The clearance must be .006 " to .012 ".

9. Install the remaining liner, piston and rod assemblies in the same manner. Use hold-down clamps to hold each liner in place.

10. After all of the liners and pistons have been installed, remove the hold-down clamps.

11. Install new compression gaskets and water and oil seals as outlined in Section 1.2. Then install the cylinder head and any other parts which were removed from the engine.

12. After the engine has been completely reassembled, refer to the *Lubrication Specifications* in Section 13.3 and refill the crankcase to the proper level on the dipstick.

13. Close all of the drains and fill the cooling system.

14. If new parts such as pistons, rings, cylinder liners or bearings were installed, operate the engine on the *run-in* schedule given in Section 13.2.1.

© 1982 General Motors Corp.

ENGINE BALANCE AND BALANCE WEIGHTS

Both rotating and reciprocating forces are completely balanced in the engines. The eccentric rotating masses of the crankshaft and connecting rods are balanced by counterweights on the crankshaft cheeks.

The reciprocating masses (the piston and upper end of the rod) produce an unbalanced couple by virtue of an arrangement on the crankshaft in which reciprocating masses, though equal, are not opposite. This unbalanced couple, which tends to rock the engine from end to end, is balanced by an arrangement of rotating counterweights, mounted at the front and rear ends of the camshaft and balance shaft, which produce a couple equal and opposite in magnitude. Consequently the engine will operate smoothly and in balance throughout its entire speed range.

Each set of weights (weights on one shaft comprise a set) rotates in an opposite direction with respect to the other. When the two weights at either end of the engine are in a vertical plane, their centrifugal forces are in the same direction and oppose the unbalanced couple; when they are in a horizontal plane, the centrifugal forces of these balance weights are opposite and are therefore cancelled. The front balance weights are eccentric in a direction opposite to the rear balance weights. Therefore, rotation will result in the desired couple effective only in a vertical plane.

The balance weights consist of two eccentric weights at each end of the engine. On three cylinder engines (through serial number 3A-48439), the weights at the rear are integral with the gears. On three cylinder engines effective with 3A-48440 and four cylinder and six cylinder engines, additional weights are attached to the gears.

The front balance weights are keyed to the front end of the camshaft and the balance shaft (Fig. 1).

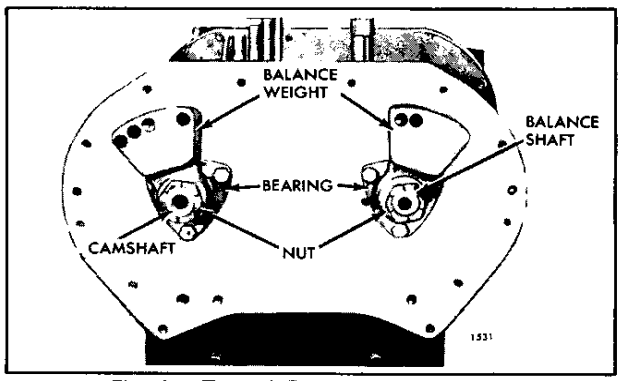


Fig. 1 - Typical Front Balance Weight Mounting

Current balance weights are of one-piece construction. Formerly, spring-loaded balance weights (Fig. 2) were used. The balance weight bushing oscillates on the hardened surface of the hub during engine operation. Torque variations are transmitted from the hub to the weight through the spacer and spring leaves.

Remove Front Balance Weights

1. Remove the balance weight cover.

2. Place a block of wood between the balance weights to prevent rotation (Fig. 3).

3. Loosen the balance weight retaining nuts on the camshaft and balance shaft with a 1-1/2 " socket wrench and remove the nuts and internal tooth lock washers.

4. Force the balance weight off the end of each shaft with two heavy screw drivers or pry bars between the heads of the bearing retaining bolts and the balance weight (Fig. 4).

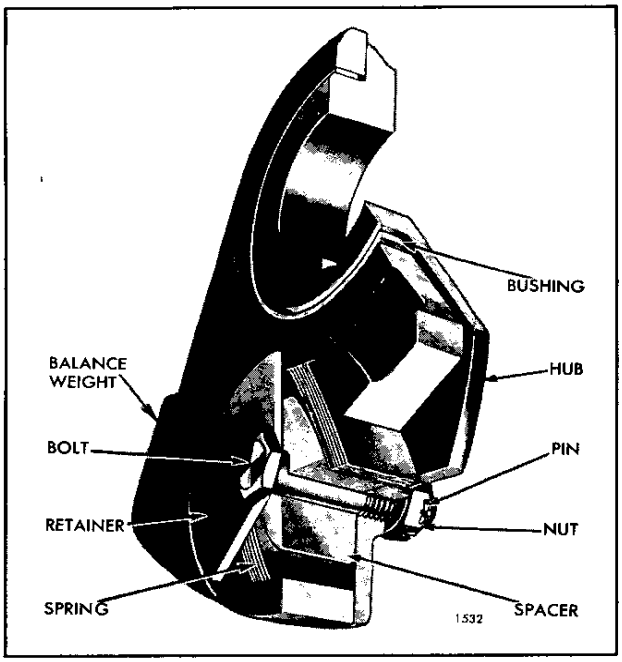


Fig. 2 - Spring-Loaded Type Front Balance Weight

© 1978 General Motors Corp.

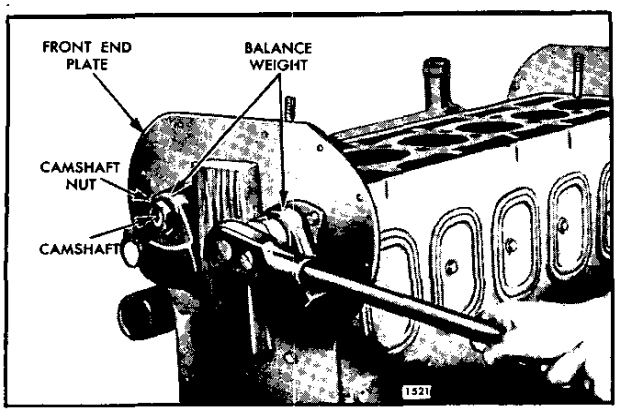


Fig. 3 - Loosening Nut on Camshaft or Balance Shaft.

Disassemble Spring-Loaded Balance Weight

1. Remove the cotter pin from the nut (Fig. 5).

2. Remove the bolt and the retainer.

3. Separate the balance weight from the hub.

4. Push the springs and spacer from the balance weight.

Inspection

Clean all of the parts thoroughly with fuel oil and dry them with compressed air.

If the thrust surface (side facing the camshaft or balance shaft thrust washers) of the balance weight hub is damaged or the bushing is worn, it will be necessary to install a pair of new balance weights.

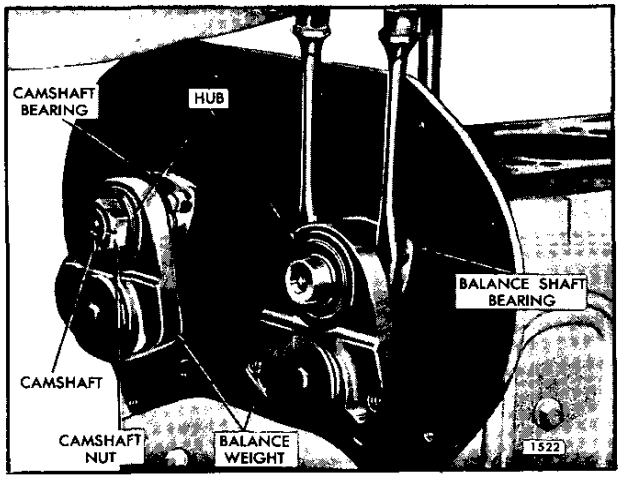


Fig. 4 - Removing Balance Weight Assemblies

The clearance between a balance weight bushing and the balance weight hub is from .0005 " to .0035 " with new parts and .006 " with used parts. The clearance between the weight and the hub should be from .010 " to .023 ".

The spring-loaded balance weights or components are no longer serviced. If any part of either weight assembly (camshaft or balance shaft) requires replacement, replace *both* weights with the current solid balance weights.

Assemble Spring-Loaded Balance Weight

1. Select the springs (17 per pack) to make four packs, each .251 " ±.008 " thick. Each spring is .015 " to .016 " thick. Measure the pack thickness while the springs are tightly clamped together in a vise or arbor press.

> **NOTE:** Wash each spring in the packs thoroughly and dry it with compressed air before taking the above measurements.

2. Lay the weight, machined face down, flat on a clean work bench.

3. Dip the spring pack in lubricating oil to completely coat all of the springs.

4. Arrange one spring pack on either side of the balance weight spring cavity.

5. Place the spring spacer on the blade of a screw driver and install the spacer, tapered end first, between the spring packs as shown in Fig. 6.

6. Insert the journal of the hub in the bushing of the balance weight. The weight should swing freely on the hub. Burnish the bushing if the clearance is not within the specified .0005 " to .0035 ".

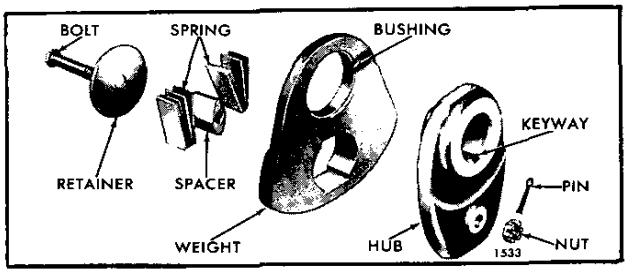


Fig. 5 - Details of Spring-Loaded Type Balance Weight and Hub Assy.

© 1978 General Motors Corp.

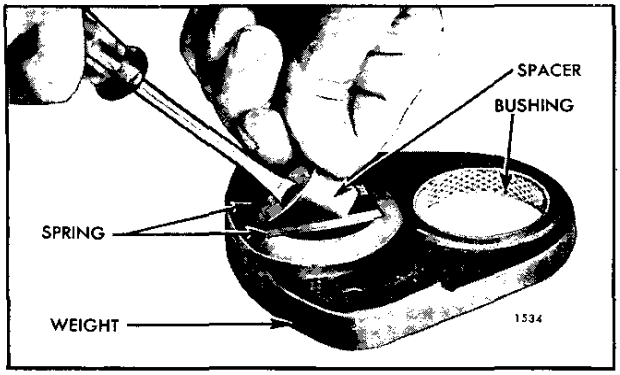


Fig. 6 - Installing Spring Spacer Between Spring Packs

7. Place the retainer against the spring spacer, insert the bolt through the retainer, spacer and hub and secure the bolt with a castellated nut. Tighten the nut to 25-30 lb-ft (34-41 Nm) torque and lock the nut with a cotter pin.

8. Check the clearance between the weight and the hub as shown in Fig. 7. The specified clearance is .010 " to .023 ". Adjust the clearance by loosening or tightening the castellated nut.

Install Front Balance Weights

1. If thrust washers are used ("B" and "C" engines), apply heavy cup grease to the steel faces of the washers and install the washers up against the camshaft and balance shaft and bearings.

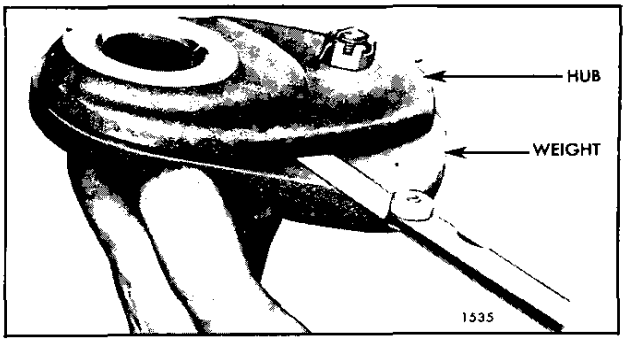


Fig. 7 - Measuring Clearance Between Balance Weight and Hub

2. Install Woodruff keys in the keyways at the front end of the camshaft and the balance shaft.

3. Align the keyway in the balance weight hub with the key in the shaft and slide the balance weight on the camshaft.

4. Install the balance weight on the balance shaft in the same manner.

5. Slip an internal tooth lock washer over the end of each shaft. Start the nuts on both shafts.

6. Place a block of wood between the balance weights as shown in Fig. 3 and tighten the retaining nuts to 300-325 lb-ft (407-441 Nm) torque.

7. Install the balance weight cover, using a new gasket.

© 1978 General Motors Corp.

GEAR TRAIN AND ENGINE TIMING

GEAR TRAIN

A completely enclosed train of five helical gears is located at the rear end of the engine (Figs. 1 and 2). A gear bolted to the crankshaft flange drives the camshaft and balance shaft gears, as well as the blower drive gear, through an idler gear mounted between the crankshaft and balance shaft gears on the RB, TC, LA and LD engines and between the crankshaft and camshaft gears on the RA, RD, LB and LC engines.

The camshaft gear and balance shaft gear mesh with each other and run at the same speed as the crankshaft gear. Since these two gears must be in time with each other, and the two as a unit in time with the crankshaft gear, the letter "O" is placed on one tooth of one of the gears with a corresponding mark at the root of the mating teeth of the other gear.

The camshaft and balance shaft gears are keyed to their respective shafts and held securely against the shoulder on the shaft by a nut. Viewing the engine from the flywheel or gear train end, the right-hand gear, whether on the balance shaft as shown on RA, RD, LA and LD engines or the camshaft as shown on RB, RC, LB and LC engines, has left-hand helical teeth (Figs. 1 and 2).

The idler gear rotates on a double-row, tapered roller bearing mounted on a stationary hollow hub. This hub is accurately located on the cylinder block end plate at the right-hand side of the LA, LB, LC and LD engines and at the left-hand side of the RA, RB, RC and RD engines as viewed from the gear train end.

A blower drive gear is located on the blower side to transmit power to the blower, governor, fuel pump and water pump.

Since the camshaft must be in time with the crankshaft, identification marks are located on two teeth of the idler gear with corresponding match marks stamped on the crankshaft gear and the camshaft gear (Figs. 1 and 2).

However, the timing is advanced on certain engines by aligning the "A" on the crankshaft gear with "L" or "R" (depending upon engine rotation) on the idler gear.

Before removing or replacing any of the gears, it is advisable to line up and make a sketch indicating the position of the timing marks. To do this, rotate the crankshaft until the timing marks are aligned on the camshaft gears. Then, check whether the "A", "L", or "R" timing mark on the crankshaft gear is aligned with the "L" or "R" on the idler gear and record this information for reassembly purposes. Refer to Table 1 as a guide.

CAMSHAFT TIMING	
Standard Timing	Advanced Timing
All two-valve models. All four-valve Models with 55E, S55, HV55, 60E, S60, DF6, HE6, 6E8, 6S8, HV6, N55, N60, N65 (white tag) injectors All electric power generator and turbocharged models.	All four-valve models with N65 (brown tag), S70, HV7, S80, HV8, S90, HV9, N70, N80 injectors. Except electric power generator and turbocharged models.

TABLE 1

Originally, cast iron gears with teeth cut to a 41° helical angle were used on the engines.

Effective with engines 371-3858, 471-5786 and 671-10193, a new gear train with a 19° helix angle replaced the 41° helix gears. The number of teeth was also increased on the new gears (Table 2). Therefore, the gear train must be replaced only in complete sets. Only the 19° helix gears are available for service.

Gear	Number of Teeth	
	41°	19°
Crankshaft	62	78
Idler	54	68
Cam or Balance Shaft	62	78
Blower Drive	32	40

TABLE 2

Balance weights, one fastened to the inner face of each gear (camshaft and balance shaft) are important in maintaining perfect engine balance. These are in addition to the weights cast integral with the gears.

Gear train noise is usually an indication of excessive gear lash, scoring, pitting or excessive bearing wear. Therefore, when noise develops in a gear train, the flywheel housing should be removed and the gear train and its bearings inspected. A rattling noise usually

© 1984 General Motors Corp.

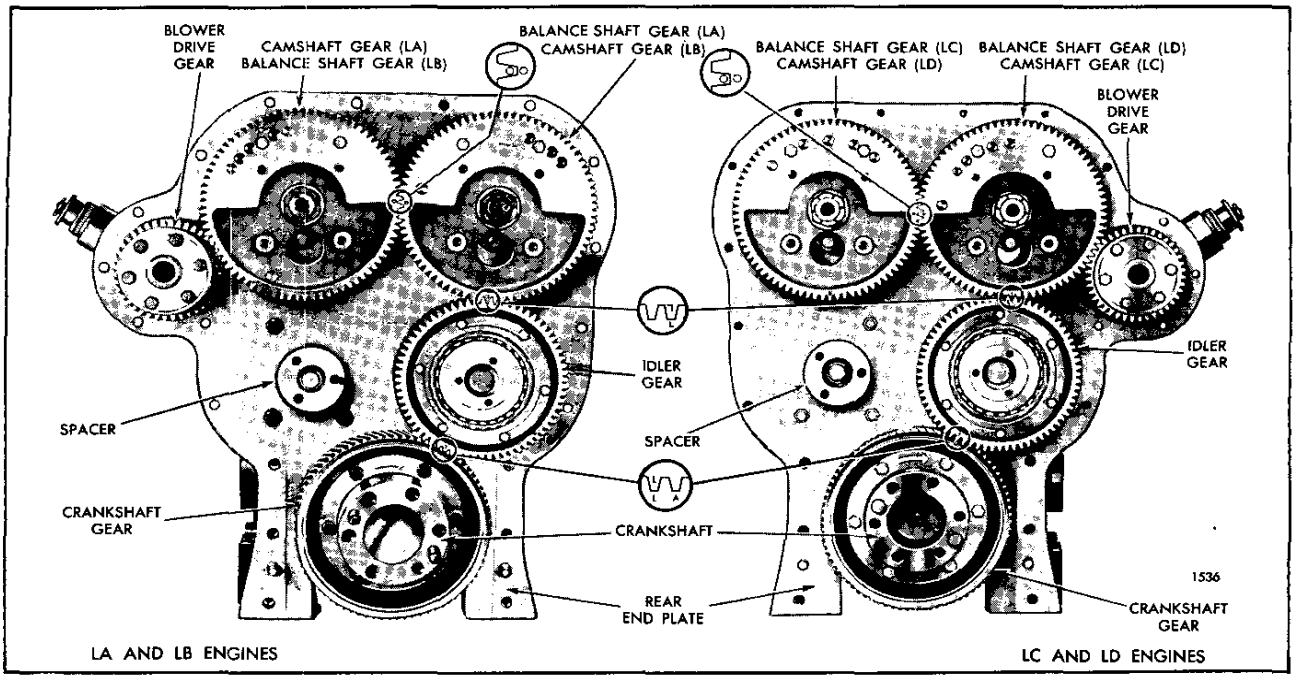


Fig. 1 - Gear Train and Timing Marks - Left-Hand Rotation Engines (Standard Timing Shown)

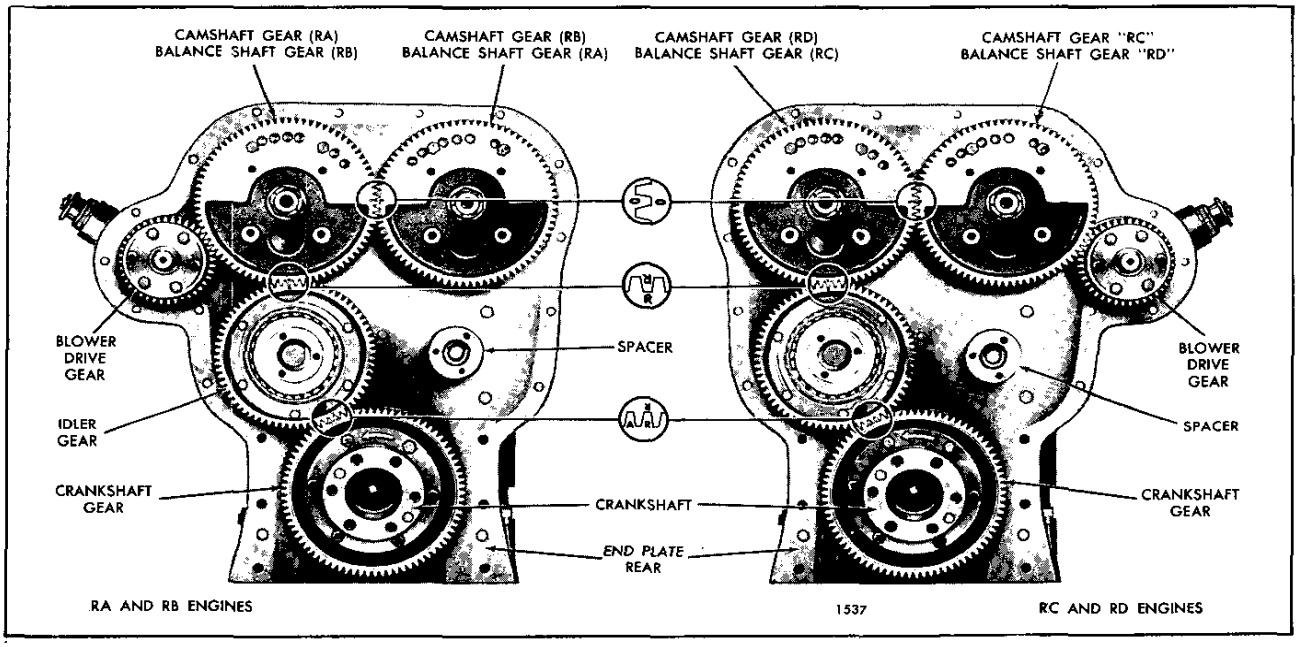


Fig. 2 - Gear Train and Timing Marks - Right-Hand Rotation Engines (Standard Timing Shown)

© 1984 General Motors Corp.

indicates excessive gear lash whereas a whining noise is a result of too little gear lash.

Excessive wear and scoring may result from abrasive substances or foreign material in the oil, introduced in the engine by such means as removal of the valve rocker cover without first cleaning away the dirt.

The backlash of the original 41° helix gear trains was .003″ to .005″. This was revised to .004″ to .006″ effective with engines 371-3917, 471-5785 and 671-10621 after the 19° helix cast iron gears came into use.

The backlash between the various mating gears in the current 19° helix steel gear train is from .003″ to .008″ with new parts and .010″ with used parts.

Since the camshaft and balance shaft gears each have the same number of teeth as the crankshaft gear, they will turn at crankshaft speed. However, as the blower drive gear has only about half as many teeth as the camshaft or balance shaft gear, it turns at approximately twice the speed of the crankshaft.

Lubrication

The gear train is lubricated by overflow oil from the camshaft and balance shaft pockets spilling into the gear train compartment. A certain amount of oil also spills into the gear train compartment from the camshaft and balance shaft end bearings and the idler gear bearing. The blower drive gear bearing is lubricated through an external pipe leading from the main cylinder block oil gallery to the gear hub bearing support. The idler gear bearing is pressure lubricated by oil passages in the idler gear hub which connect to the oil gallery in the cylinder block.

ENGINE TIMING

The correct relationship between the crankshaft and camshaft must be maintained to properly control fuel injection, the opening and closing of the exhaust valves and engine balance.

The crankshaft timing gear can be mounted in only one position since one attaching bolt hole is offset. The camshaft gear can also be mounted in only one position due to the location of the keyway relative to the cams. Therefore, when the engine is properly timed, the timing marks on the various gears will match (Figs. 1 and 2).

An engine which is *out of time* may result in pre-ignition, uneven running and a loss of power.

When an engine is suspected of being out of time due to an improperly assembled gear train, a quick check can be made without having to remove the flywheel and flywheel housing by following the procedure outlined below.

Check Engine Timing

Access to the vibration damper or crankshaft pulley, to mark the top-dead-center position of the selected piston, and to the front end of the crankshaft or flywheel for turning the crankshaft is necessary when performing the timing check. Then, proceed as follows:

1. Clean and remove the valve rocker cover.

2. Select any cylinder for the timing check -- it is suggested that a cylinder adjacent to one of the valve rocker cover bolt or stud holes be chosen since the stud or bolt may be used to mount a dial indicator.

3. Remove the injector as outlined in Section 2.1 or 2.1.1.

4. Carefully, slide a rod, approximately 12″ long, through the injector tube until the end of the rod rests on top of the piston.

© 1984 General Motors Corp.

5. Place the throttle in the *no-fuel* position. Then, turn the crankshaft slowly in the direction of engine rotation. Stop when the rod reaches the end of its upward travel. Remove the rod and turn the crankshaft, opposite the direction of rotation, between 1/16 and 1/8 of a turn.

6. Select a dial indicator with .001" graduations and with a spindle movement of at least one inch. Provide an extension for the indicator spindle. The extension must be long enough to contact the piston just before it reaches the end of its upward stroke. Also, select suitable mounting attachments for the indicator so that it can be mounted over the injector tube in the cylinder head.

7. Mount the indicator over the injector tube. The indicator mounting may be threaded into the rocker cover stud or the tapped hole in the cylinder head. Make sure that the indicator spindle is free in the injector tube and is free to travel at least one inch.

8. Attach a suitable pointer to the crankshaft front cover or engine front end plate as illustrated in Fig. 3. The pointer should extend over the vibration damper (or crankshaft pulley).

9. Turn the crankshaft slowly in the direction of engine rotation until the indicator hand stops moving. Continue turning the crankshaft until the indicator hand starts to move again.

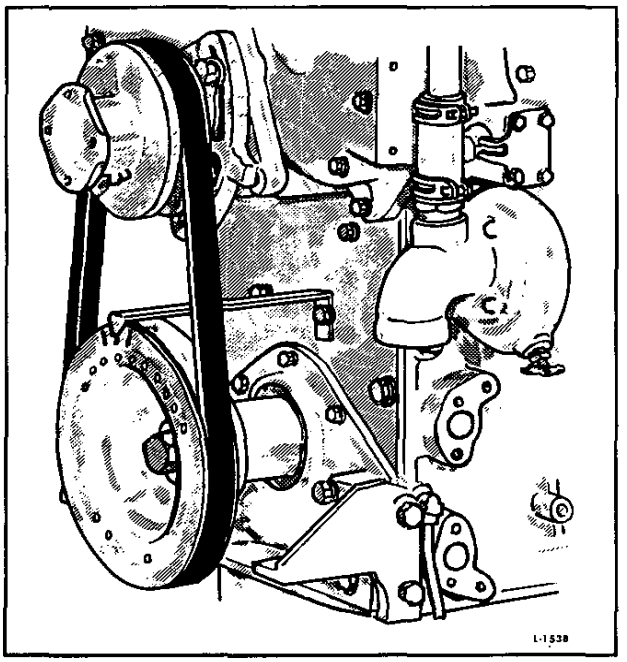


Fig. 3 - Pointer Installation for Marking Top-Dead-Center

10. Reset the dial indicator to zero. Turn the crankshaft until the indicator reading is .010".

11. Scribe a line on the vibration damper (or crankshaft pulley) in line with the end of the pointer.

12. Slowly turn the crankshaft opposite the direction of engine rotation until the indicator hand stops moving. Continue turning the crankshaft until the indicator hand starts to move again.

13. Set the dial to zero. Then, turn the crankshaft until the indicator reading is .010".

14. Scribe a second line on the vibration damper (or crankshaft pulley) in line with the end of the pointer.

15. Scribe a third line halfway between the first two lines. This is top-dead-center. The three scribed lines are shown on the crankshaft pulley (Fig. 3). Remove the indicator and rod from the engine.

NOTE: If the crankshaft pulley retaining bolt has loosened, tighten it to the specified torque (Section 1.3.7).

16. Install the injector as outlined in Section 2.1 or 2.1.1. Then, refer to Section 14 and adjust the valve clearance and time the injector.

17. Turn the crankshaft, in the direction of engine rotation, until the exhaust valves in the cylinder selected are completely open. Reinstall the dial indicator so the

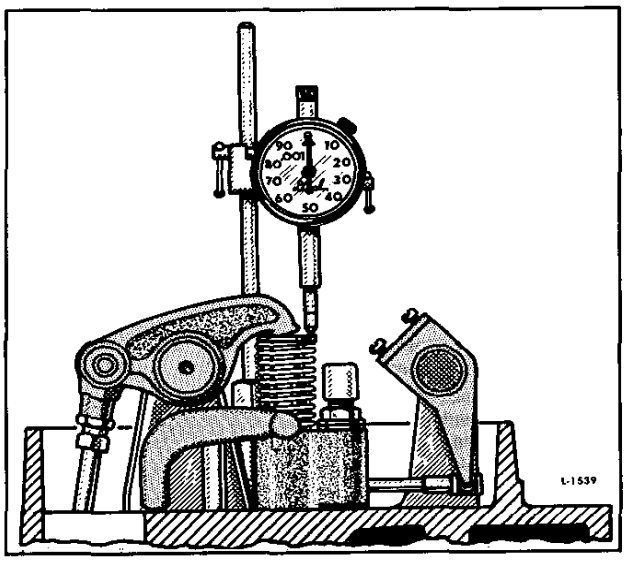


Fig. 4 - Checking Engine Timing By Measuring Injector Depression

© 1984 General Motors Corp.

ENGINES	*Indicator Reading		
	CORRECT*	RET'D 1-TOOTH	ADV. 1-TOOTH
(1) 3-71N, 4-71N & 6-71N	.228"	.198"	.248"
(2) 3-71N, 4-71N & 6-71N 6-71T & TT AUTO (Pre-1979) 4-71T & 6-71T INDUSTRIAL - GEN SET	.230"	.197"	.262"
(1) 3-71N, 4-71N & 6-71N (Adv. Cam. Timing)	.248"	.228"	.265"
(2) 3-71N, 4-71N & 6-71N (Adv. Cam. Timing)	.262"	.230"	.289" †
6-71T & TT AUTO (1979 & later) 6-71TA & TTA AUTO (1983½ Federal)	.189"	.157"	.222"
6-71TA-TTA AUTO (1980 & later - California)	.144"	.111"	.177"

* Readings nominal — allowable tolerance ± .005".
† 3-71N - Via idler gear, 4-71N & 6-71N - Integrally advanced (gear train std. timed).
(1) High velocity type injector cam (see Section 1.7.2).
(2) Low velocity type injector cam (see Section 1.7.2).

TABLE 3

indicator spindle rests on top of the injector follower (Fig. 4). Then, set the indicator on zero. Next turn the crankshaft slowly in the direction of engine rotation until the center mark on the pulley is in line with the pointer.

18. Note the indicator reading and compare it with the dimensions listed in Table 3.

19. After completing the timing check, remove the dial indicator. Also, remove the pointer from the crankshaft front cover.

20. Install the valve rocker cover.

© 1984 General Motors Corp.

CAMSHAFT, BALANCE SHAFT AND BEARINGS

The camshaft and the balance shaft are located just below the top of the cylinder block (Fig. 1) and each may be located on either side of the engine as required by engine rotation and accessory arrangement. The camshaft actuates the exhaust valve and injector operating mechanism.

The accurately ground cams ensure efficient, quiet cam follower roller action. They are also heat treated to provide a hard wear surface.

Both ends of the cam and balance shaft are supported by bearing assemblies, each consisting of a flanged housing and two bushings. In addition, intermediate two-piece bearings support the camshaft at uniform intervals throughout its length. The intermediate bearings are secured to the camshaft by lock rings, thereby permitting them to be inserted into the cylinder block with the shaft. Each intermediate bearing is secured in place, after the camshaft is installed, with a lock screw threaded into a counterbored hole in the top of the cylinder block.

The current engines are equipped with a low velocity, low lift injector cam lobe and a long closing ramp exhaust cam lobe design camshaft. Former engines were equipped with a high lift injector cam lobe camshaft. The two camshafts are interchangeable and only the current camshaft, which can be identified by the numeral "7" stamped on one end, is serviced.

On both the camshaft and the balance shaft, the gear thrust load is absorbed by two thrust washers, one on each end of the rear end shaft bearings of the "A" and "D" basic engines and at the front end of the "B" and "C" engines. The thrust washers bear against thrust shoulders on the shafts.

A helical drive gear with a counterweight is secured to each shaft with a Woodruff key (Fig. 2), nut, nut retainer, retainer bolts and lock washers. The drive gears are attached to the rear end of the shafts on all engines.

To help maintain engine balance, a balance weight is installed on the front end of each shaft.

Advanced Timed Camshafts

Effective with four and six cylinder engines built approximately June, 1976 which require advanced timing in conjunction with N65 mm or larger fuel injectors are equipped with the current camshaft which also has the required advance timing incorporated into the camshaft.

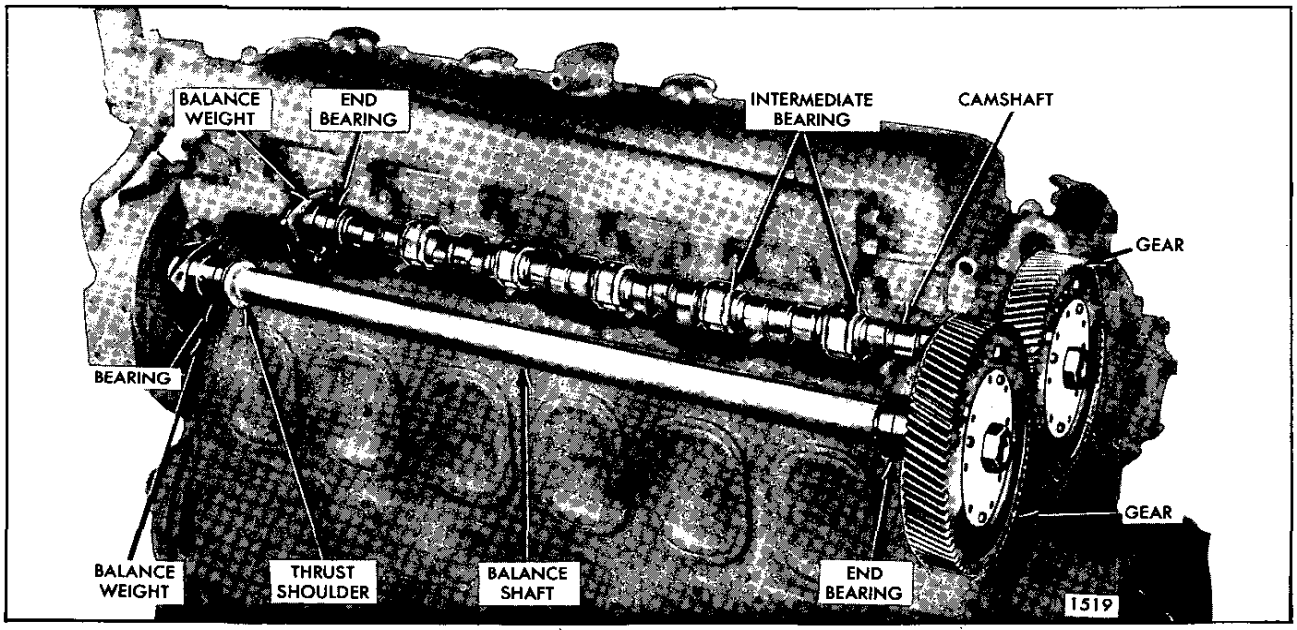


Fig. 1 - Camshaft and Balance Shaft Assemblies

© 1984 General Motors Corp.

The option data plate is marked to indicate whether an engine was built with the former standard camshaft with advanced gear timing or the current camshaft which has the required advance timing incorporated into the camshaft.

The required advanced timing built into the new (current) camshafts eliminate the need for installing the crankshaft gear one tooth advanced to the "A" position. This was accomplished by relocating the keyways at each end of the camshaft. Continue to use the standard (straight) Woodruff key (Fig. 2) with the new camshaft.

NOTE: When using the new camshaft make certain the gear train is NOT in the "A" position.

Service

Only the new camshafts (which have the required advanced timing incorporated into the the camshaft and includes both the standard and offset Woodruff keys) are serviced. Use the new camshafts and straight key combination to service an advanced timed engine. Use the new camshafts and the offset key to service a standard timed engine.

NOTE: The offset key is identified with an S (standard) and an arrow stamped on the face of the key (Fig. 2). With the keyways up, always install the offset keys with the arrow pointing inboard toward the center of the engine.

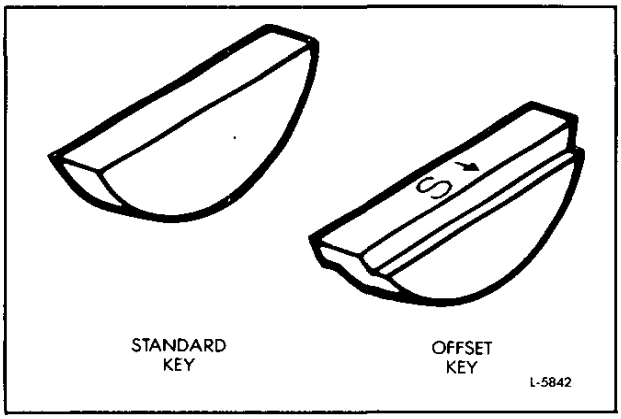


Fig. 2 - Woodruff Keys for Current Camshafts

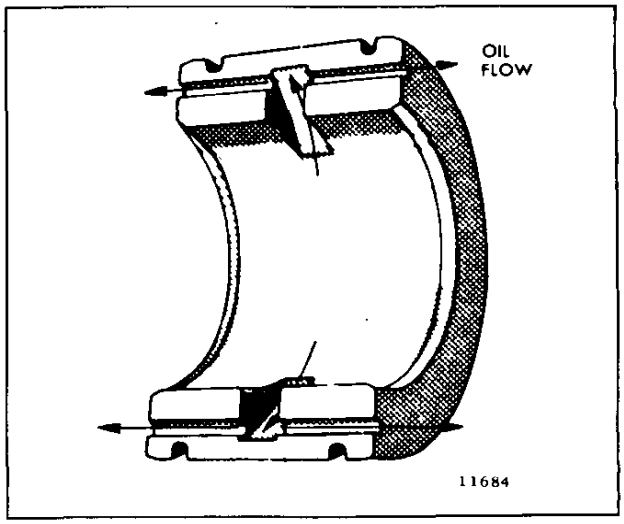


Fig. 3 - Camshaft Intermediate Bearing (Lower Half)

Lubrication

Lubricating oil is supplied under pressure to the bearings from the main oil gallery through a horizontal transverse passage at each end of the cylinder block, then up the connecting vertical passages in each corner of the block to the camshaft and balance shaft end bearings. The camshaft intermediate bearings are lubricated by the oil from the end bearings passing through the drilled passage in the shaft.

The lower halves of the camshaft intermediate bearings are grooved along the horizontal surface that mates with the upper halves of the bearings (Fig. 3). Oil from the passage in the camshaft is forced through the milled slots in the bearing and then out the grooves to furnish additional oil to the cam follower rollers. This permits

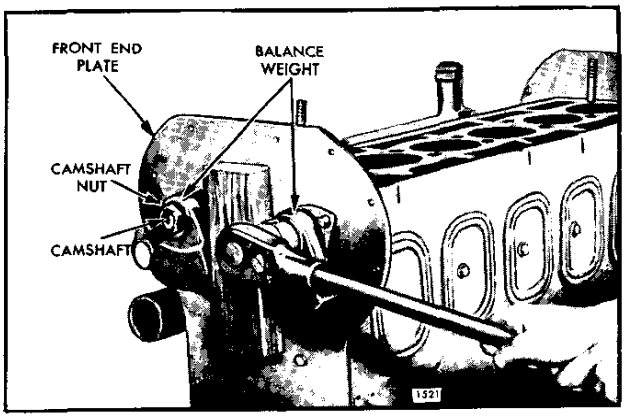


Fig. 4 - Loosening Nut on Camshaft or Balance Shaft

© 1984 General Motors Corp.

the cam pocket to be filled rapidly to the operating oil level immediately after starting the engine.

Remove Camshaft or Balance Shaft

Whenever an engine is being completely reconditioned or the camshaft, gears, bearings or thrust washers need replacing, remove the shafts from the engine as follows:

1. Drain the engine cooling system.

2. Remove all of the accessories and assemblies necessary to facilitate mounting the engine on an overhaul stand (Section 1.1).

3. Mount the engine on the overhaul stand. *Be sure the engine is securely mounted on the overhaul stand before releasing the lifting sling.*

4. Remove the cylinder head (refer to Section 1.2).

5. Remove the flywheel and flywheel housing (refer to Sections 1.4 and 1.5).

6. Remove the front balance weight cover and place a wood block between the balance weights (Fig. 4) or wedge a clean rag between the camshaft and balance shaft drive gears at the rear of the engine.

7. Remove the gear nut retaining plates.

8. Remove the gear retaining nuts on the gear end of the camshaft and the balance shaft. Remove the nut and lock washer from the balance weight end of each shaft.

9. Remove the front balance weights.

10. Remove the thrust washers between the bearings and the balance weight hubs on "B" and "C" engines.

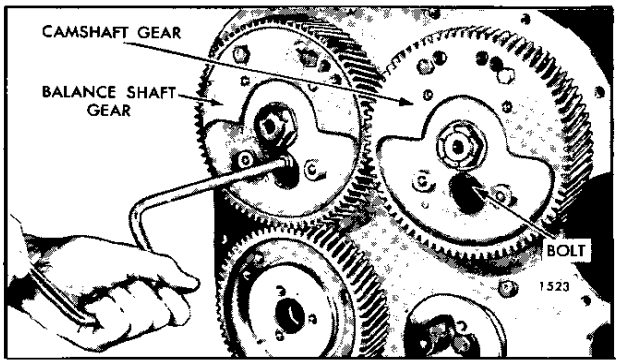


Fig. 5 - Removing or Installing Shaft Bearing Retainer Bolts

11. Remove the lock screws that secure the camshaft intermediate bearings.

12. Rotate the gears as required to reveal the end bearing retaining bolts. Remove the bolts (Fig. 5).

13. Withdraw the camshaft bearing and gear assembly and the balance shaft and gear from the rear end of the cylinder block.

If the thrust washers, located between the bearings and thrust shoulders at the front end of the shafts of the "B" and "C" engines, are not removed with the shafts, they should be pulled out when removing the bearings.

14. The cam and balance shaft front end bearings (and thrust washers on "B" and "C" engines) may be removed after taking out the bolts that hold the bearings to the end plate and cylinder block. If necessary, use a pry bar under the bearing flange.

Remove Camshaft (Flywheel Housing and Transmission in Place)

The camshaft may be removed and replaced without removing the flywheel housing and disconnecting the transmission if there is space enough to slide the shaft out through the front of the engine.

1. Drain the engine cooling system.

2. Remove the parts, accessories and assemblies that are necessary to facilitate the removal of the flywheel

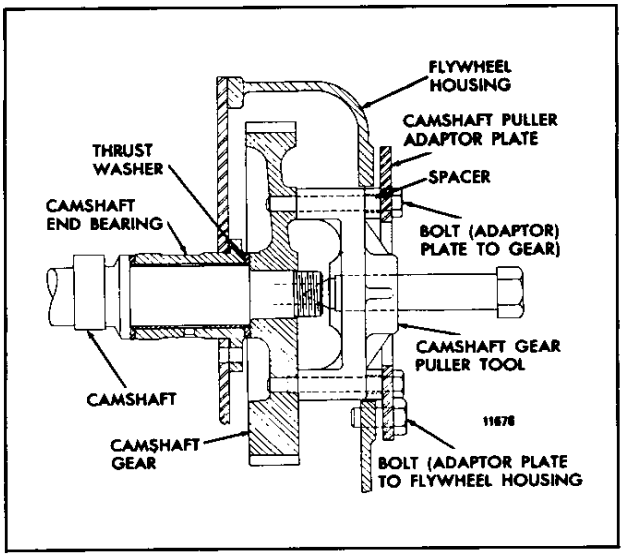


Fig. 6 - Removing Camshaft With Camshaft Gear Puller J 1902-01 and Adaptor Plate Set J 6202

© 1984 General Motors Corp.

housing hole cover over the camshaft and the front balance weight cover.

3. Remove the cylinder head.

4. Remove the front balance weight cover and place a wood block between the balance weights (Fig. 4).

5. Remove the gear nut retainer after removing the bolts. Remove the tachometer drive adaptor, if used.

6. Loosen and remove the nut at each end of the camshaft.

7. Remove the front balance weights.

8. Remove the thrust washer between the bearing and the balance weight hub ("B" and "C" engines only).

9. Remove the lock screws that secure the camshaft intermediate bearings.

10. Remove the three bolts that secure the camshaft bearing to the front end plate.

11. Install the camshaft gear puller J 1902-01, four spacers J 6202-2 and camshaft gear puller adaptor plate J 6202-1 on the camshaft gear (Figs. 6 and 7).

12. Turn the center screw of the puller clockwise to disengage the camshaft from the camshaft gear.

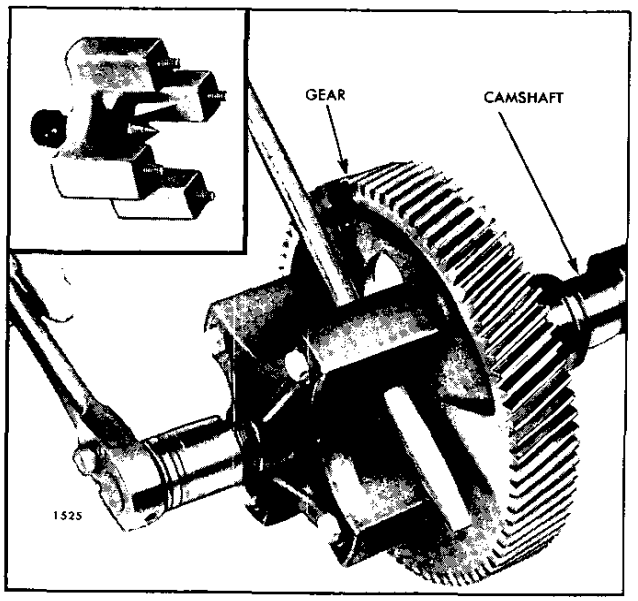


Fig. 7 - Removing Gear (Camshaft or Balance Shaft Gear Puller J 1902-01)

NOTE: Do not remove the puller or the adaptor plate until the camshaft is reinstalled. The adaptor plate, secured to both the flywheel housing and the camshaft gear, will hold the gear (also the thrust washer on "A" and "D" engines) securely in place and in alignment which will aid in the reinstallation of the camshaft.

13. Remove the front bearing from the camshaft and pull out the inner thrust washer ("B" or "C" engines). Then, pull the camshaft and intermediate bearings from the cylinder block.

Disassemble Camshaft and Balance Shaft

1. Remove the gear from the shaft (refer to Section 1.7.3).

2. Slide the rear bearing (and the thrust washer on the "A" and "D" engines) off of the shaft.

3. Remove the lock rings from the camshaft intermediate bearings and free the two halves of each bearing.

4. To facilitate the removal of any foreign material lodged behind the plugs, remove the end plugs from each camshaft as follows:

a. Clamp the camshaft in a vise equipped with soft jaws, being careful not to damage the cam lobes or machined surfaces of the shaft.

b. Make an indentation in the center of the camshaft end plug with a 31/64" drill (carboloy tip).

c. Punch a hole as deeply as possible with a center punch, to aid in breaking through the hardened surface of the plug.

d. Then, drill a hole straight through the center of the plug with a 1/4" drill (carboloy tip).

e. Use the 1/4" drilled hole as a guide and redrill the plug with a 5/16" drill (carboloy tip).

f. Tap the drilled hole with a 3/8"-16 tap.

g. Thread the 3/8"-16 adaptor J 6471-2 into the plug. Then attach the slide hammer J 2619-5 to the adaptor. Remove the plug by striking the weight against the handle.

h. Insert a .375" diameter steel rod into the camshaft oil gallery and drive the remaining plug out.

© 1984 General Motors Corp.

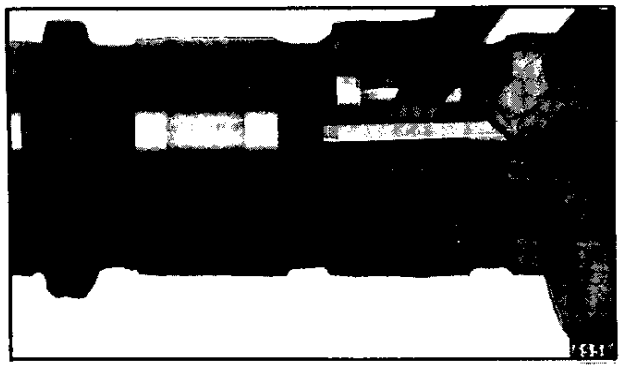


Fig. 8 - Checking Cam Lobe Wear

NOTE: If a steel rod is not available, remove the remaining plug as outlined in steps "a" through "g".

Inspection

Soak the camshaft in clean fuel oil. Then, run a wire brush through the oil gallery to remove any foreign material or sludge. Clean the exterior of the camshaft and blow out the gallery and the oil holes with compressed air. Clean the gears, camshaft bearings and related parts with fuel oil and dry them with compressed air.

Inspect the cams and journals for wear or scoring. If the cams are scored, inspect the cam followers as outlined in Section 1.2.1. Also, inspect the camshaft keyways and threads for damage.

If there is a doubt as to the acceptability of the camshaft for further service determine the extent of cam lobe wear as follows:

NOTE: The camshaft can be in or out of the engine during this inspection.

1. With a tapered leaf set of feeler gages (.0015"-.0100") and a piece of square hard material 1/8" x 3/8" x 1" measure the flat on the injector rise side of the cam lobes (Fig. 8).

2. If the flats measure less than .003" in depth and there are no other defects the camshaft is satisfactory for service.

3. A slightly worn lobe still within acceptable limits, may be stoned and smoothed over with a fine crocus cloth.

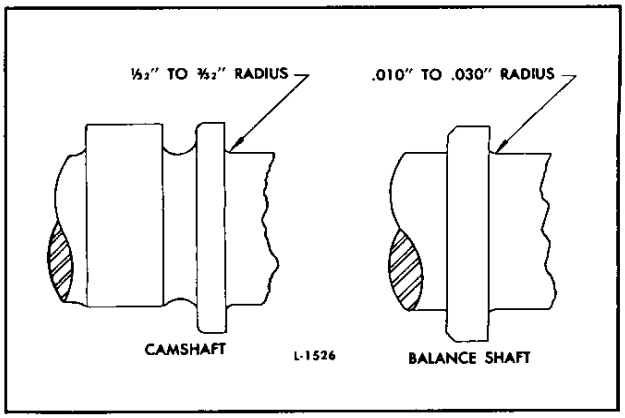


Fig. 9 - Camshaft and Balance Shaft Journal Fillets

Check the runout at the center bearing with the camshaft mounted on the end bearing surfaces. Runout should not exceed .002".

Examine both faces of each camshaft rear end bearing and thrust washer. Also, examine the surfaces of each camshaft and camshaft gear which contact the thrust washers. Replace excessively worn or scored parts. Camshaft or camshaft gear thrust surfaces that are not scratched too severely may be smoothed down with an oil stone.

NOTE: If a new camshaft is to be installed, steam clean it to remove the rust preventive and blow out the oil passages with compressed air.

New standard size-thrust washers are .119" to .122" thick. The clearance between the thrust washer and the thrust shoulder of the camshaft is .003" to .015" with new parts, or a maximum of .018" with used parts. Excessive clearance may be reduced by using thrust washers which are .005" or .010" oversize.

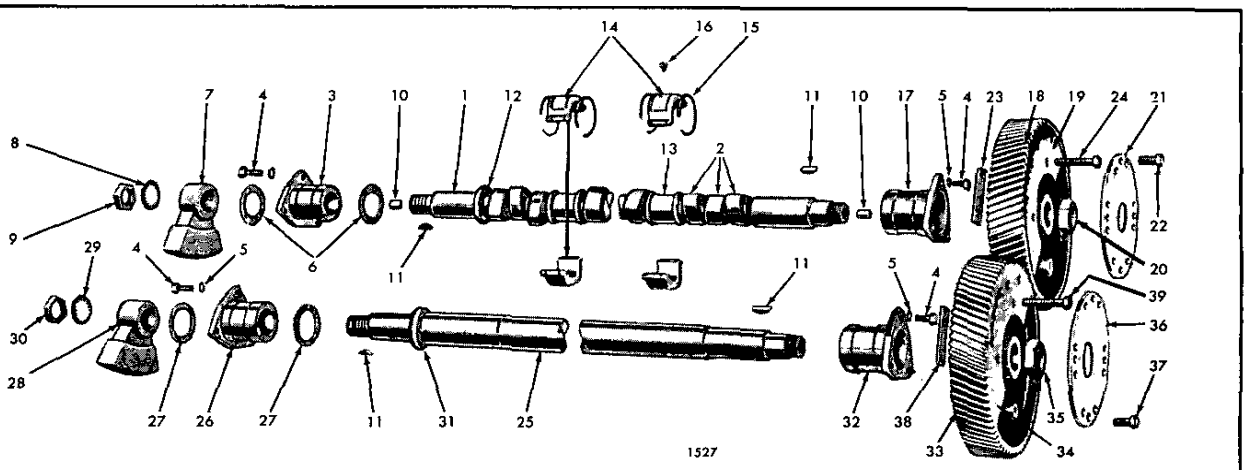
When the thrust surfaces of a camshaft or balance shaft are ground undersize, special care must be taken as follows:

1. Leave a .031" to .094" radius between the bearing surface of the thrust collar shoulder and the bearing surface of the camshaft (Fig. 9).

2. Leave a .010" to .030" radius between the bearing surface of the thrust collar shoulder and the bearing surface of the balance shaft (Fig. 9).

Use a fillet radius gage to measure the specified radii.

© 1984 General Motors Corp.



1. Camshaft
2. Cam
3. Bearing--Camshaft Front
4. Bolt--Bearing Retainer
5. Lock Washer
6. Washer--Camshaft Thrust
7. Balance Weight Assy.--Camshaft Front
8. Lock Washer
9. Nut--Camshaft Front
10. Plug--Camshaft
11. Key
12. Thrust Shoulder--Camshaft
13. Journal--Camshaft Intermediate
14. Bearing--Camshaft Intermediate
15. Lock Ring--Intermediate Bearing
16. Set Screw--Intermediate Bearing
17. Bearing--Camshaft Rear
18. Gear--Camshaft L.H. Helix
19. Weight--Camshaft Integral Balance
20. Nut--Camshaft Rear
21. Retainer--Camshaft Gear Nut
22. Bolt--Gear Nut Retainer
23. Balance Weight--Camshaft Rear
24. Bolt--Weight Retaining
25. Balance Shaft
26. Bearing--Balance Shaft Front
27. Washer--Balance Shaft Thrust
28. Balance Weight Assy.--Balance Shaft Front
29. Lock Washer--Balance Shaft Nut
30. Nut--Balance Shaft Front
31. Thrust Shoulder--Balance Shaft
32. Bearing--Balance Shaft Rear
33. Gear--Balance Shaft R.H. Helix
34. Weight--Balance Shaft Integral Balance
35. Nut--Balance Shaft Rear
36. Retainer--Balance Shaft Gear Nut
37. Bolt--Gear Nut Retainer
38. Balance Weight--Balance Shaft Rear
39. Bolt--Weight Retaining

Fig. 10 - Typical Camshaft and Balance Shaft Details and Relative Location of Parts

NOTE: Thrust washers were not used prior to engines 371-4702, 471-6608 and 671-16791. The thrust end bearings were babbitt or tin-plated on the end surfaces to take up the thrust. However, these bearings have been replaced by and are interchangeable with the current thrust washer and bearing arrangement.

Examine the faces of the shaft end bearings and any other surface which comes into contact with the thrust washers. Parts that are badly marred must be replaced; parts with slight scratches may be cleaned up with an oil stone.

NOTE: If a new camshaft is to be installed, steam clean it to remove the rust preventive and blow out the oil passages with compressed air.

Inspect the bushings in the shaft end bearings. Replace the bushings or end bearing assemblies if they are worn excessively or the bushings have turned within the bearing. New bushings must be finished bored to a 20 rms finish after installation and tested for the correct press fit. The correct press fit is indicated if the bushing does not move when a 2000 pound end load is applied. This test is of special importance with engines that operate at high (2300 rpm) speeds. The inside diameter of the bushings must be square with the rear face of the bearing within .0015" total indicator reading and concentric with the outside diameter of the bearing retainer within .002" total indicator reading. The bushings must project from .045" to .055" from each end of the bearing (Fig. 11).

The clearance between the camshaft and balance shaft end journals and the end bearing bushings is .0025" to .004" with new parts or a maximum of .006" with used parts. End bearings are available in .010" or .020" undersize for use with shafts that are worn or have been reground and the clearances exceed the specified limits.

© 1984 General Motors Corp.

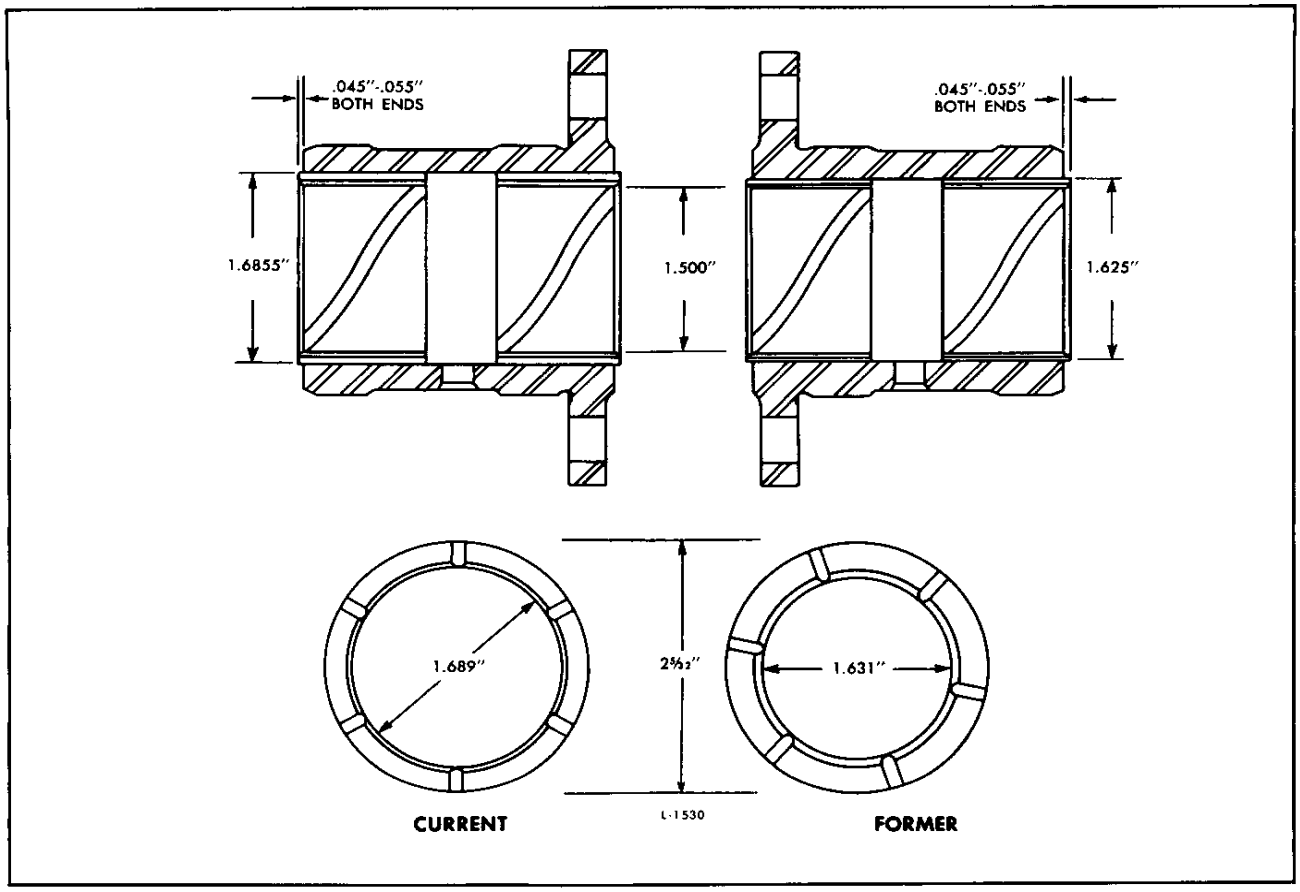


Fig. 11 - Comparison of End Bearings and Thrust Washers

Replace excessively scored or worn camshaft intermediate bearings. The clearance between the camshaft journals and the intermediate bearings is .0025" to .005" with new parts or a maximum of .009" with worn parts. Camshaft intermediate bearings are available in .010" and .020" undersize for use with worn or reground shafts in which the clearances exceed the specified limits. Examine the intermediate bearing lock screws and the tapped holes in the block. Damaged holes in the cylinder block may be plugged, redrilled and tapped. Discard lock screws with damaged threads.

Assemble Camshaft and Balance Shaft

Refer to Fig. 10 and assemble the camshaft and balance shaft as follows:

1. Install new end plugs in the camshaft. Press the plugs in to a depth of 1.940" to 2.060" (Fig. 12).

2. Apply grease to the steel face of each end thrust washer. Then, place a thrust washer against each end of the camshaft and balance shaft rear bearings ("A" and "D" engines). Be sure the steel faces of the thrust washers are next to the bearing.

> **NOTE:** Effective with engines 3A-27384, 4A-59280, 6A-57745 and 8A-1446, the camshaft and balance shaft end bearings incorporated bushings with a larger outside diameter and greater wall thickness. To accommodate the larger bushing, the former bearings may be rebored to an inside diameter of 1.685"-1.686". The thrust washer used with this bearing must have a larger inside diameter (Fig. 11).

3. Lubricate the rear camshaft and balance shaft bearing journals and slide the rear end bearings on each shaft, with the bolting flange of the bearing toward the outer (gear) end of the shaft.

4. Install the gears on the shafts.

© 1984 General Motors Corp.

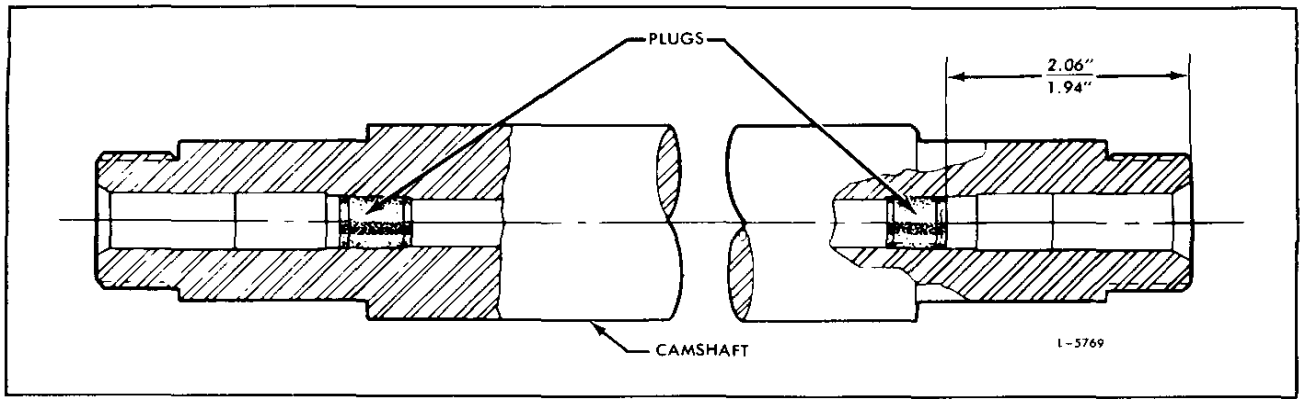


Fig. 12 - Camshaft Plug Installation

5. Lubricate the camshaft intermediate bearing journals. Then, place the two halves of each intermediate bearing on a camshaft journal and lock the halves together with two lock rings. Assemble each lock ring with the gap over the upper bearing and the ends an equal distance above the split line of the bearing.

NOTE: Two intermediate bearing lock rings are used. The current ring can be identified by the wider gap. The wide gap ring MUST be used with the grooved type lower half bearings and can also be used with the former intermediate bearings.

Install Camshaft and Balance Shaft

1. Insert the front end of the camshaft into the opening on the blower side of the LA, LC, RA, and RC engines and on the opposite side of the LB, LD, RB and RD engines. Push the camshaft into the cylinder block until the camshaft gear teeth almost engage the teeth of the mating gear. Use care when installing the camshaft to avoid damaging the cam lobes.

NOTE: The right-hand gear (viewing the engine from the flywheel end), whether it is attached to the camshaft or the balance shaft, has left-hand helical teeth.

2. Align the timing marks on the mating gears (see Section 1.7.1) and slide the camshaft gear in place.

3. Secure the camshaft rear end bearing to the cylinder block with the three bolts and lock washers. Rotate the camshaft gear, as required, to install the bolts through the hole in the gear web (Fig. 5). Tighten the bolts to 35-40 lb-ft (47-54 Nm) torque.

4. Insert the balance shaft in the bore in the cylinder block and push it in until the teeth of the balance shaft gear almost engage the camshaft gear teeth.

5. Align the timing marks on the mating gears (see Section 1.7.1) and slide the balance shaft gear into place.

6. Secure the balance shaft rear end bearing. Use the same procedure as outlined for the camshaft rear end bearing (Step 3).

7. Apply grease to the steel face of each thrust washer. Then, place a thrust washer against the inner end of the camshaft and balance shaft front end bearing ("B" and "C" engines). The steel face of the thrust washer must be against the bearing.

8. Install the camshaft and balance shaft front end bearings with the bolts and lock washers. Tighten the bolts to 35-40 lb-ft (47-54 Nm) torque.

NOTE: Install the front bearings with care to avoid dislodging the thrust washers. Do not hammer the bearings into the cylinder block.

9. Apply grease to the steel face of each thrust washer and place them so that the steel faces are against the outer end of the camshaft and balance shaft front bearings on "B" and "C" engines.

10. Turn the camshaft intermediate bearings until the holes in the bearings are in alignment with the tapped holes in the top of the cylinder block. Install the lock screws and tighten them to 15-20 lb-ft (20-27 Nm) torque. The current "high" cylinder blocks incorporate longer lock screws that were used formerly on the "low" blocks (Fig. 13).

© 1984 General Motors Corp.

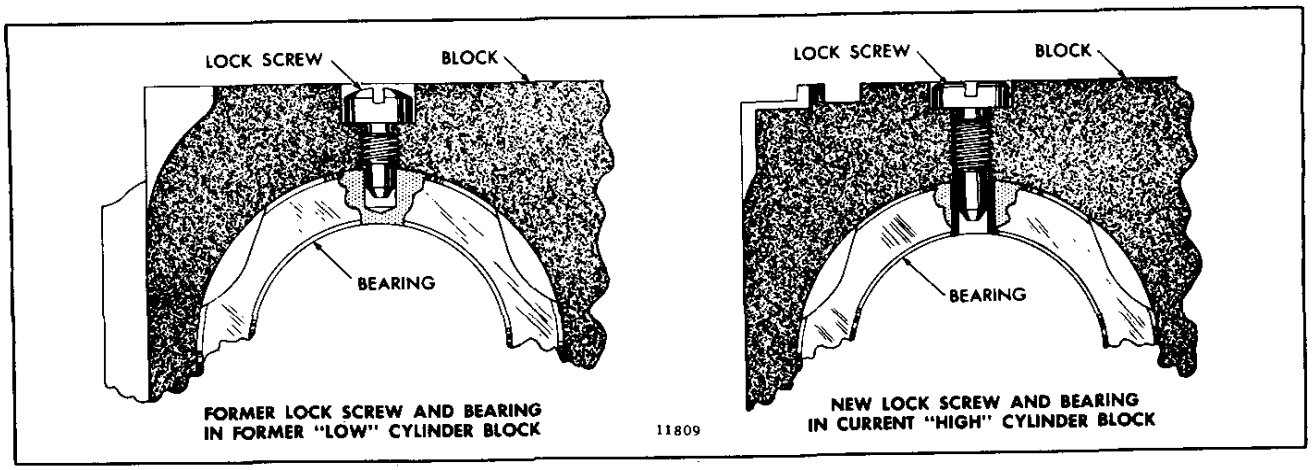


Fig. 13 - Camshaft Intermediate Bearing Lock Screws

NOTE: When the intermediate bearings are locked into position with the lock screw, the bearing must have slight movement in the block bore.

11. Install the front balance weights on the shafts.

12. Place an internal tooth lock washer on the end of each shaft and start the nuts on both shafts.

13. Use a wood block between the balance weights or wedge a clean cloth between the camshaft and balance shaft gears to prevent their turning (Fig. 4). Tighten the nuts to 300-325 lb-ft (407-441 Nm) torque.

14. Install the camshaft and balance shaft gear nut retainers with bolts and lock washers. Tighten the bolts to 35-39 lb-ft (47-53 Nm) torque.

15. Check the clearance between the thrust washer and the thrust shoulder of both the camshaft and balance shaft. The specified clearance is .003″ to .015″ with new parts or a maximum of .018″ with used parts.

16. Check the backlash between the mating gears. The specifed backlash between new gears is .003″ to .008″ or a maximum of .010″ between worn gears.

17. Install the flywheel housing and other parts or assemblies that were removed from the engine as outlined in their respective section of this manual.

18. Refill the cooling system.

Install Camshaft (Flywheel Housing and Transmission in Place)

1. On the "A" and "D" engines, apply grease to the steel face of the thrust washer and install it with the steel face against the bearing.

2. Install a Woodruff key in the drive gear end of the camshaft and insert this end into position from the front end of the engine. Push the shaft in until it slides into the rear end bearing. Use care in the installation of the camshaft to prevent damage to the cam lobes.

NOTE: Install the woodruff keys in the current advanced timed camshafts as outlined in the service note under *Advanced Timed Camshaft.*

3. Align the key in the shaft with the keyway in the camshaft drive gear and start the shaft into the gear. Tap the shaft into the gear with a soft (plastic or rawhide) hammer.

NOTE: On the "A" and "D" engines, make sure the thrust washer is in the correct position to prevent pushing the bushing into the bearing or damaging the bushing.

4. Remove the camshaft gear puller, spacers and adaptor plate. Finger tighten the gear retaining nut on the shaft.

5. Install the front end bearing (and thrust washers on "B" and "C" engines) with the bolts and lock washers. Tighten the bolts to 35-40 lb-ft (47-54 Nm) torque.

NOTE: Apply grease to the steel faces of the thrust washers and insure that the steel faces are towards the bearing.

© 1984 General Motors Corp.

6. Install the balance weight on the front end of the camshaft.

7. Start the balance weight retaining nut and lock washer on the camshaft (Fig. 8). Place a wood block between the balance weights (Fig. 4). Tighten the gear retaining nut and the balance weight nut to 300-325 lb-ft (407-441 Nm) torque.

8. Align the holes in the camshaft intermediate bearings with the tapped holes in the top of the cylinder block (Fig. 13). Install and tighten the lock screws to 15-20 lb-ft (20-27 Nm) torque.

9. Reinstall the parts, accessories and assemblies that were removed from the engine as outlined in their respective sections in this manual.

10. Refill the cooling system.

© 1984 General Motors Corp.

CAMSHAFT AND BALANCE SHAFT GEARS

The camshaft and balance shaft gears, located at the flywheel end of the engine, mesh with each other and run at the same speed as the crankshaft (Fig. 1). Either one of the gears may be driven from the crankshaft timing gear, through an idler gear, depending upon engine rotation. Viewing the engine from the flywheel or gear train end, the right-hand gear, whether on the balance shaft (LA, LD, RA, RD engines) or camshaft (LB, LC, RB RC engines), has left-hand helical teeth and the left-hand gear has right-hand helical teeth. The idler gear mates with the left-hand gear on right-hand rotation engines and with the right-hand gear on left-hand rotation engines.

Since the camshaft and balance shaft gears must be in time with each other, the letter "O" is stamped on one tooth of one of the gears with a corresponding mark at the root of the mating tooth of the other gear. Also, since these two gears as a unit must be in time with the crankshaft, identification marks (letter "R" or "L" for right-hand or left-hand rotation engines, respectively) are located on either the camshaft gear or balance shaft gear and the mating idler gear (refer to Section 1.7.1).

The camshaft and balance shaft gears are keyed to their respective shafts and held securely against the shoulder on the shaft by a nut. A gear nut retainer, with a double hexagon hole in the center, fits over the nut and prevents loosening of the nut. The retainer is attached to the gear by bolts threaded into tapped holes in the gear. These tapped holes are also utilized in mounting an accessory drive on the camshaft or balance shaft gear.

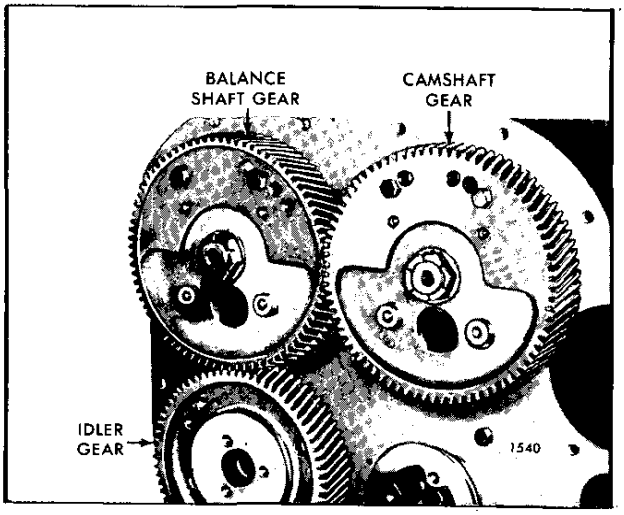


Fig. 1 - Camshaft and Balance Shaft Gears

The same two gears are used as camshaft and balance shaft gears on three, four and six cylinder engines. A small balance weight is attached to the inner face of each gear. A different size weight is used on three, four and six cylinder engines. The three cylinder engine weight is secured to the gear with two 3/8"-24 x 1-1/8" bolts, the four cylinder engine weight is secured with two 3/8"-24 x 1-3/8" bolts and the six cylinder engine weight is secured with two 3/8"-24 x 1-1/4" bolts. These weights are important in maintaining perfect engine balance.

NOTE: The current one-piece design balance weight used on the gears of six cylinder engines is interchangeable with the two-piece weight used on former 19° helix cast iron gears. However, the current and former design balance weights for four cylinder engine gears are not interchangeable.

Remove Camshaft and Balance Shaft Gears

1. Remove the camshaft and balance shaft from the engine as outlined in Section 1.7.2.

2. Support the camshaft suitably in the soft jaws of a bench vise, *being careful not to damage the cams.*

3. Remove the nut retaining the gear on the camshaft.

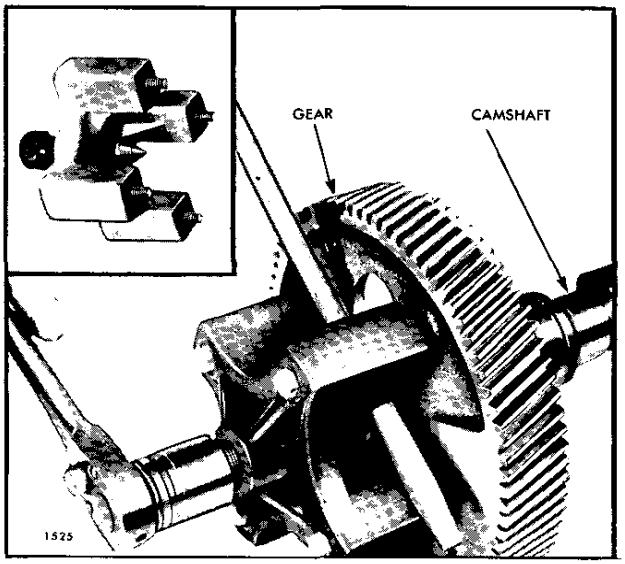


Fig. 2 - Removing Gear (Camshaft or Balance Shaft) with Tool J 1902-01

© 1984 General Motors Corp.

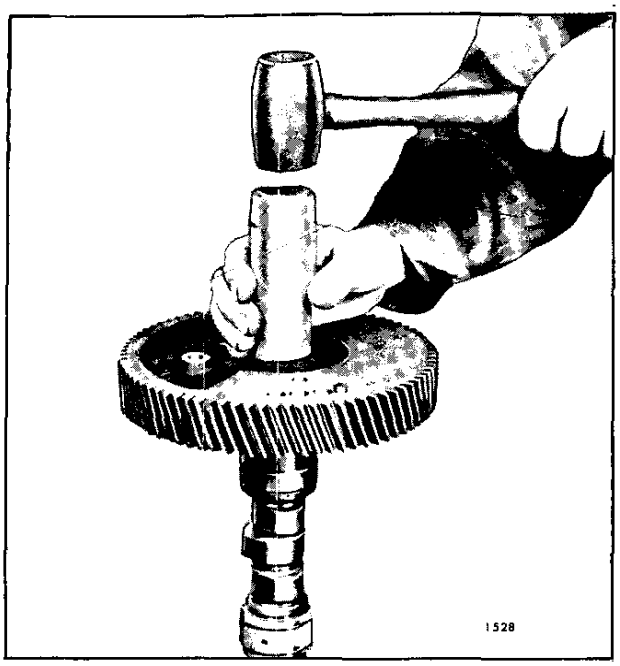


Fig. 3 - Replacing Gear (Camshaft Shown) using Tool J 1903

4. Back out the puller screw of tool J 1902-01 and attach the puller to the outer face of the gear with four bolts (Fig. 2).

5. Turn the puller screw down against the end of the shaft to remove the gear.

6. Remove the gear from the balance shaft in a similar manner.

7. If necessary, remove the two weight retaining bolts and remove the balance weights from each gear.

8. If necessary, remove the keys from the camshaft and balance shaft.

Inspection

Clean the gears with fuel oil and dry them with compressed air. Then, examine the gear teeth for evidence of scoring, pitting and wear. If severly damaged or worn, install a new gear. Also, check the other gears in the gear train.

Install Camshaft and Balance Shaft Gears

1. Install the balance weights, if removed, on the gears.

2. Lubricate the shaft journals and place the camshaft and balance shaft end bearings in place, with the bolting flanges facing toward the gear ends of the shafts. If the engine being serviced is an "A" or "D" engine, install the thrust washers between the end bearings and the thrust shoulders of the shafts, and between the end bearings and the gears.

NOTE: Be sure the steel faces of the thrust washers are next to the bearings.

3. Install the Woodruff keys for the gears in both shafts.

4. Note that the teeth on one gear form a right-hand helix and on the other a left-hand helix. When viewing the engine from the flywheel end, the gear with right-hand helical teeth is located on the left-side and the gear with left-hand helical teeth is located on the right-side of the engine. With this in mind, rest on the non-gear end of the camshaft on a wood block and start the gear on the other end of the shaft by hand so the keyway aligns with the key and with the flat finished face of the gear away from the bearing.

5. Use gear installer J 1903 to drive the gears on the camshaft and balance shaft (Fig. 3).

6. Start the gear retaining nuts on their respective shafts by hand. Tighten the nuts after the shafts have been installed in the cylinder block.

7. Install the camshaft and balance shaft in the engine as outlined in Section 1.7.2.

8. With the shafts and the front balance weights installed, wedge a clean cloth between the camshaft and balance shaft gears and tighten the gear retaining nuts to 300-325 lb-ft (407-441 Nm) torque.

9. Secure the nuts with retainers, retainer bolts and lock washers.

10. Check the backlash between the mating gears. The backlash should be .003″-.008″ with new parts or .010″ maximum with used parts.

© 1984 General Motors Corp.

IDLER GEAR AND BEARING ASSEMBLY

Figure 1 illustrates the mounting of the roller bearing type idler gear. The early flanged type idler gear and the former single spacer type idler gear are no longer serviced. When replacing any part of the gear assembly a complete current roller bearing type idler gear assembly must be used.

The idler gear is mounted on a double row, tapered roller bearing which, in turn, is supported on a stationary hub. This hub is secured directly to the cylinder block by a bolt which passes through the hub and rear end plate. A hollow dowel serves a two-fold purpose; first, as a locating dowel it positions the hub and prevents it from rotating and, second, conducts oil under pressure from an oil gallery in the cylinder block through a passage in the gear hub to the roller bearing.

The current idler gear bearing consists of two cups, two cones and an outer and inner spacer ring. The former idler gear bearing consists of a cup, two cones and a spacer ring.

The inner and outer cones of the idler gear bearing are pressed onto the gear hub and, therefore, do not rotate. Spacer rings or a spacer, separate the cones. No spacer was used on early design bearings. The bearing cup(s) has a light press fit in the idler gear and is held against a flanged lip inside the idler gear on one side and by a bearing retainer secured with six bolts and three bolt locks on the other side.

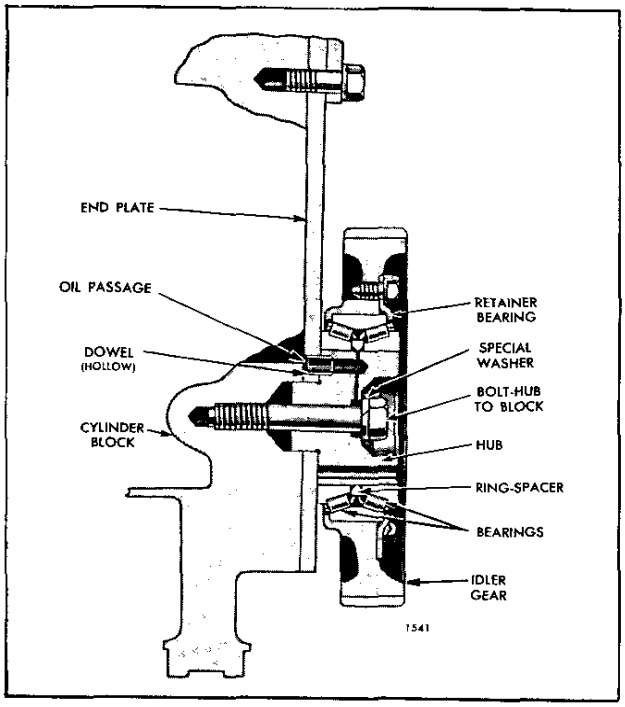


Fig. 1 - Idler Gear Mounting (Former Bearing)

A right-hand helix gear is provided for left-hand rotation engines, and a left-hand helix gear is provided for right-hand rotation engines (Figs. 1 and 2 in Section 1.7.1).

An idler gear hole spacer (dummy hub) is used on the side opposite the idler gear. NO gasket is used between the idler gear hub or dummy hub and the flywheel housing. The flywheel housing bears against the inner races of the idler gear bearing and also against the dummy hub. Three self-locking bolts and steel washers are used to attach the flywheel housing at the idler gear and dummy hub locations. The washers seat in 7/8" spot faces at the flywheel housing attaching bolt holes, thus preventing oil leakage at these locations.

To minimize oil leakage into the flywheel housing, a new idler gear spacer (dummy hub) is now being used in those engines not equipped with an integral idler gear spacer type flywheel housing (Fig. 2).

The former and new spacers are interchangeable. Only the new spacer will be serviced. The new flanged hex head bolts with a self locking sealing patch should be used with the new spacer. They can be used with the former spacer or at the idler gear position, however, do not use a flat washer under the new flanged head bolts.

SERVICE NOTE: The service idler gear assemblies will not include the new "seal patch" bolts. The flat washer has been deleted. Also, at the time of rebuild the new bolts should be used to minimize oil leakage into the flywheel housing.

Remove Idler Gear, Hub and Bearing Assembly and Idler Gear Hole Spacer (Flywheel Housing Previously Removed)

1. Remove the idler gear hub to cylinder block bolt and washer (Fig. 1) and withdraw the assembly from the cylinder block rear end plate.

NOTE: Before removing the idler gear check the idler gear, hub and bearing assembly for any perceptible wobble or shake when pressure is applied; by firmly grasping the rim of the gear

© 1979 General Motors Corp.

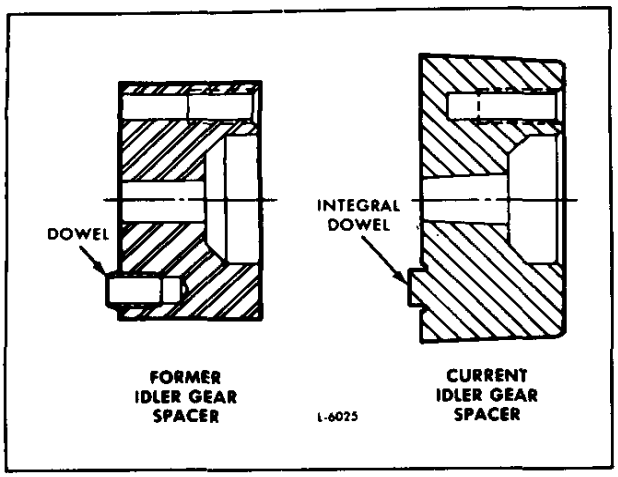


Fig. 2 - Idler Gear Spacer

with both hands and rocking in relation to the bearing. The bearing must be replaced if the gear wobbles or shakes. If the gear assembly is satisfactory, it is only necessary to check the pre-load before reinstallation.

2. Remove the idler gear hole spacer (Fig. 1 in Section 1.7.1) in the same manner if the engine is being completely reconditioned.

Disassemble Idler Gear, Hub and Bearing Assembly

While removing or installing an idler gear bearing, the bearing MUST be rotated to avoid the possibility of damaging the bearing by brinelling the bearing cones. Brinelling refers to the marking of the cones by applying a heavy load through the rollers of a non-rotating bearing in such a way that the rollers leave impressions on the contact surfaces of the cones. These impressions may not be easily discerned during normal inspection. For example, a bearing may be brinelled if a load were applied to the inner cone of the bearing assembly in order to force the outer cone into the idler gear bore, thus transmitting the force through the bearing rollers. A brinelled bearing may have a very short life.

Refer to Fig. 4 for the location and identification of parts and disassemble the bearing as follows:

1. Remove the six bolts and three bolt locks which secure the bearing retainer to the idler gear, and remove the bearing retainer.

NOTE: The component parts of the idler gear bearing are matched; therefore, matchmark the parts during disassembly to ensure reassembly of the parts in their original positions.

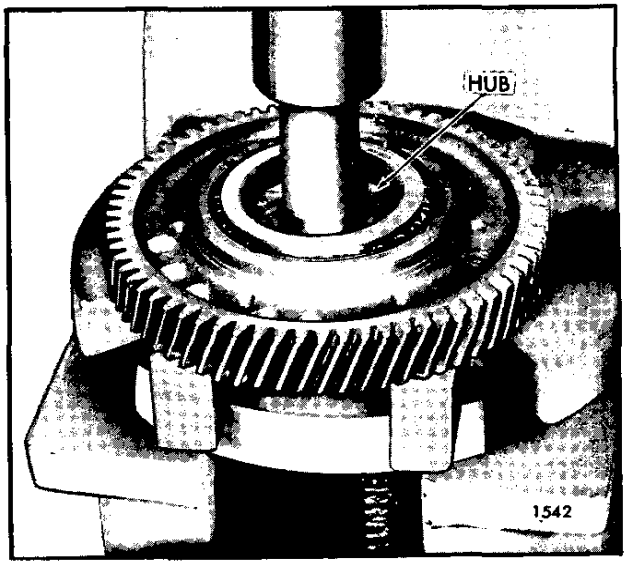


Fig. 3 - Pressing Hub Out of Bearing

2. Clean the idler gear and bearing assembly with fuel oil and dry it with compressed air.

3. Place the idler gear and bearing assembly in an arbor press with the bearing cone or inner race supported on steel blocks as shown in Fig. 3. While rotating the gear assembly, press the hub out of the bearing. Remove the gear assembly from the arbor press and remove the bearing cones and spacers.

4. Tap the bearing cups and spacer rings (current gear) or bearing cup and spacer (former gear) from the idler gear by using a brass drift alternately at four notches provided around the shoulder of the gear.

5. Early design idler gear and bearing assemblies did not incorporate the notches in the gear, or a spacer between the bearing cones. The bearing cones and rollers were held together by a snap ring (Fig. 5).

Disassemble the early type bearing as follows:

a. After pressing out the idler gear hub as outlined above, place the gear assembly on a clean work surface with the rear face of the gear toward the work surface.

b. Position the inner races until the notches in the bearing cones are approximately 180 ° from the gap of the snap ring.

c. Press against the snap ring and gently rock the

© 1979 General Motors Corp.

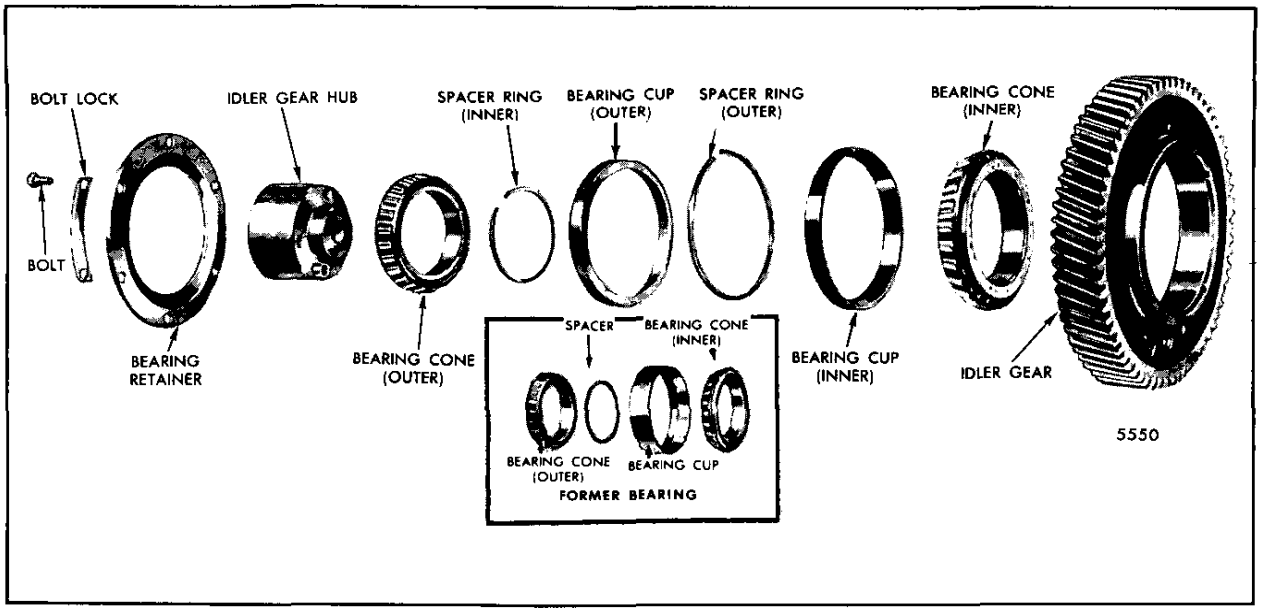


Fig. 4 - Idler Gear Details and Relative Locating Parts (Current Bearing)

gear to release the snap ring from the grooves in the bearing cones. The tang of a small file, or a similar tool, may be used for this operation. Ordinarily, the snap ring will remain with one of the two bearing cones.

NOTE: Exercise care to prevent the rollers escaping their cage and scattering. If this should occur, the bearing SHOULD NOT be reassembled and reused since the rollers were selectively mated to the bearing races when originally manufactured. A new bearing assembly must be used.

d. Lift the gear, bearing outer race, top inner race and its rollers away from the bottom inner race and the rollers.

e. Hold the top inner race and the rollers against the outer race, turn the gear over, and place it on work surface. Then lift the gear away from the inner race and the rollers.

f. Make a hardwood ram as shown in Fig. 6. Then

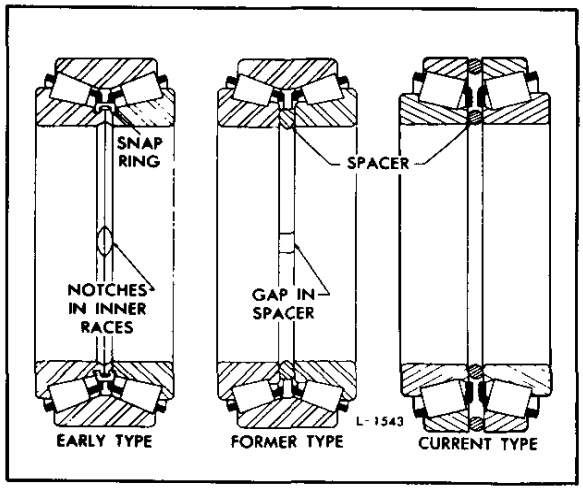


Fig. 5 - Comparison of Current, Former and Early Design Idler Gear Bearings

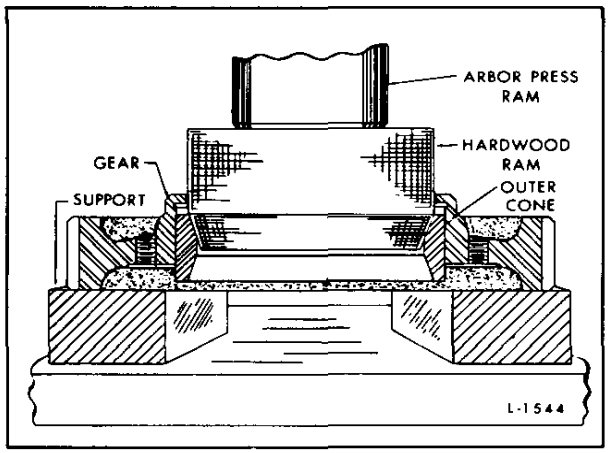


Fig. 6 - Hardwood Ram for Pressing Outer Bearing Race from Gear

© 1979 General Motors Corp.

position the idler gear in the arbor press and with the gear suitably supported, press the outer race from the gear.

g. Four equally spaced notches, approximately 3/16 " radius, may be filed or ground on the shoulder of the gear as shown in Fig. 7. Use care to avoid damage to the bore in the gear, break all sharp edges, and clean all chips and dirt from the gear.

Inspection

Wash the idler gear, hub, and bearing components thoroughly in clean fuel oil and dry with compressed air.

Check the idler gear hub and spacer. The three flywheel housing mounting bolt holes were not drilled through on early design hubs and spacers. Consequently, these hubs must be inspected to assure that no chips or foreign material is deposited in the holes so as to cause interference with the flywheel housing attaching bolts.

Inspect the bearings carefully for wear, pitting, scoring or flat spots on the rollers or cones. Replace the bearing if it is defective.

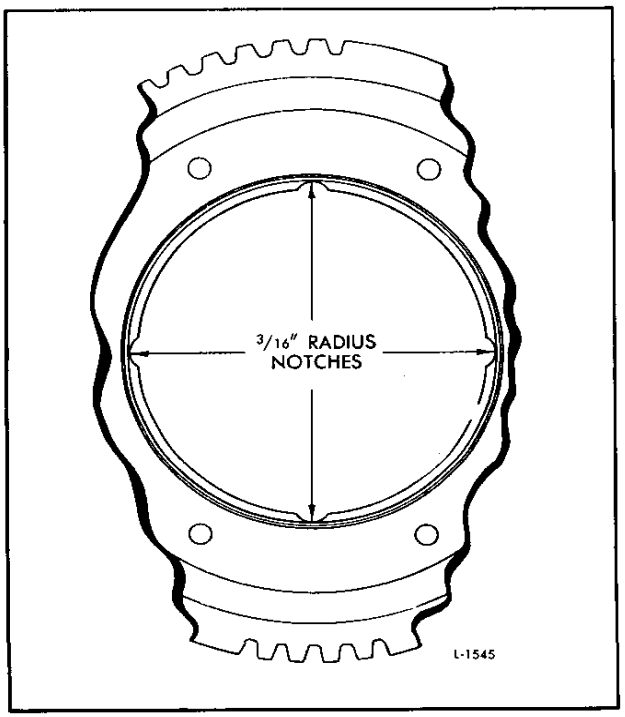


Fig. 7 - Location of Notches in Idler Gear

Examine the gear teeth for evidence of scoring, pitting and wear. If severly damaged or worn, replace the gear. Also, inspect the other gears in the gear train.

Assemble Idler Gear, Hub and Bearing

CURRENT BEARING

Refer to Fig. 8 and assemble the bearing components in their *original positions* (refer to identification marks made during disassembly) as outlined below:

NOTE: The current idler gear bearing is a matched assembly. *Do not* mix components.

1. Support the idler gear, shoulder down, on the bed of an arbor press. Start one of the bearing cups, numbered side up, squarely into the bore of the gear. Then press the bearing cup against the shoulder of the gear. Use a flat steel plate (pre-load test plate) between the ram of the press and the bearing cup.

2. Lay the outer spacer ring on the face of the bearing cup.

3. Start the other bearing cup, numbered side down, squarely into the bore of the gear. Then press the cup tight against the spacer ring. Use a flat steel plate (pre-load test plate) between the ram of the press and the bearing cup.

4. Press the inner bearing cone (numbered side up) on the idler gear hub, flush with the inner hub mounting face. Use the pre-load test plate (with the large center hole) between the ram of the press and the bearing.

5. Install the inner spacer ring on the idler gear hub so that the oil hole in the hub is 180 ° from the gap in the inner spacer ring.

6. Position the gear with both cups over the hub and the inner bearing cone.

7. Press the outer idler gear bearing cone over the hub while rotating the gear to seat the rollers properly between the cones. The bearing cones must be supported so as not to load the bearing rollers during this operation (Fig. 9).

8. Before installing the gear and bearing assembly, check the pre-load.

FORMER BEARING

Assemble the bearing components in their original positions (refer to the identification marks made during disassembly) as outlined below.

1. Support the idler gear, shoulder side down, on an

© 1979 General Motors Corp.

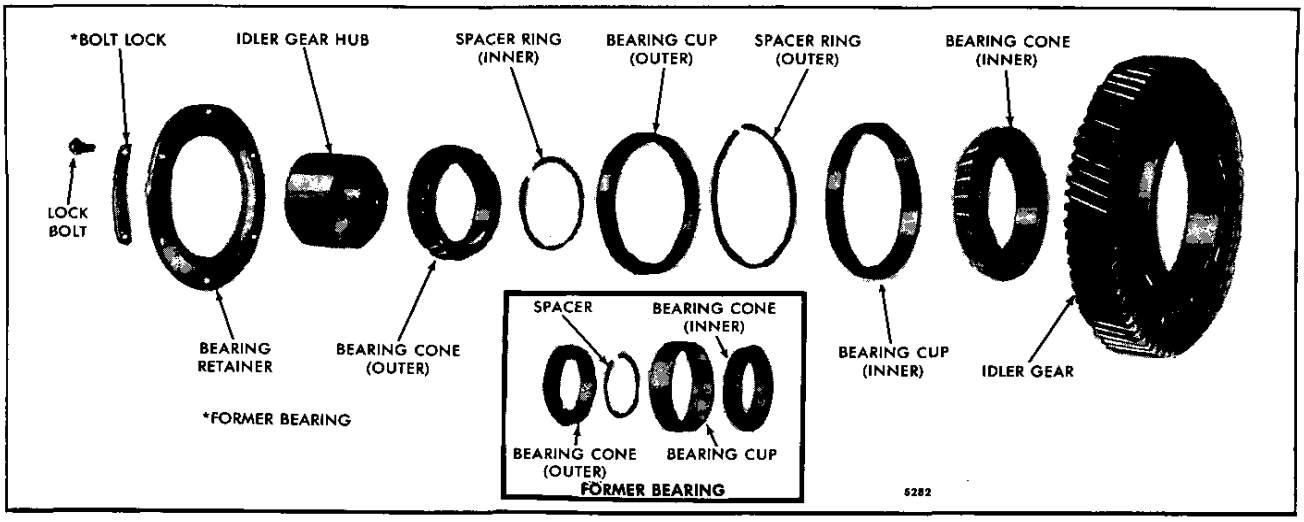


Fig. 8 - Idler Gear Details and Relative Location of Parts

arbor press and start the outer bearing cone squarely into the bore of the gear. Then, press the bearing cone tight against the shoulder of the gear, using a steel plate between the ram of the press and the bearing cone.

2. Support one bearing cone, numbered side down, on the arbor press and lower the idler gear and bearing cup assembly down over the bearing cone.

3. Place the spacer ring on the face of the bearing cone.

4. Place the second bearing cone, numbered side up, in the idler gear and bearing cup assembly and against the spacer ring.

5. Then position the idler gear hub over the bearing cones so that the oil hole in the hub is 180° from the gap in the spacer ring.

6. Press the hub into the idler gear bearing cones, while rotating the gear (to seat the rollers properly between the cones), until the face of the hub which will be adjacent to the cylinder block end plate is flush with the corresponding face of the bearing cone. The bearing cones should be supported so as not to load the bearing rollers during this operation (Fig. 9).

7. Prior to installing an securing the bearing retainer, check the pre-load of the bearing assembly as outlined below.

EARLY BEARING

Assemble the early design bearing in which the bearing cones are held together by a snap ring, as follows:

1. Place first bearing cone on work bench and place idler gear shoulder face up, over cone.

2. Lift both idler gear and bearing cone together, *being careful that the rollers do not escape their retainer,* and invert the gear and cone and place them over the second cone.

3. Press the upper bearing cone down by hand, then rock it to engage the snap ring in the grooves of the cones. *Do not lift the gear and bearing assembly from the work bench until the snap ring is engaged.*

4. Position notches of bearing cones so they are together.

5. Then, position the idler gear hub over the bearing cones so the oil hole in the hub is 180° from the notches in the cones.

6. Press the hub into the idler gear bearing cones,

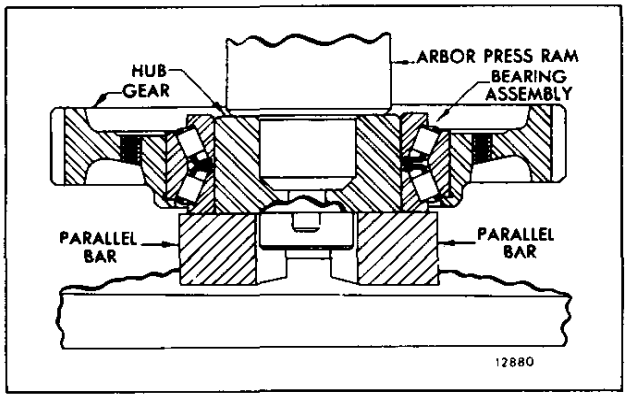


Fig. 9 - Pressing Hub into Bearing

© 1983 General Motors Corp.

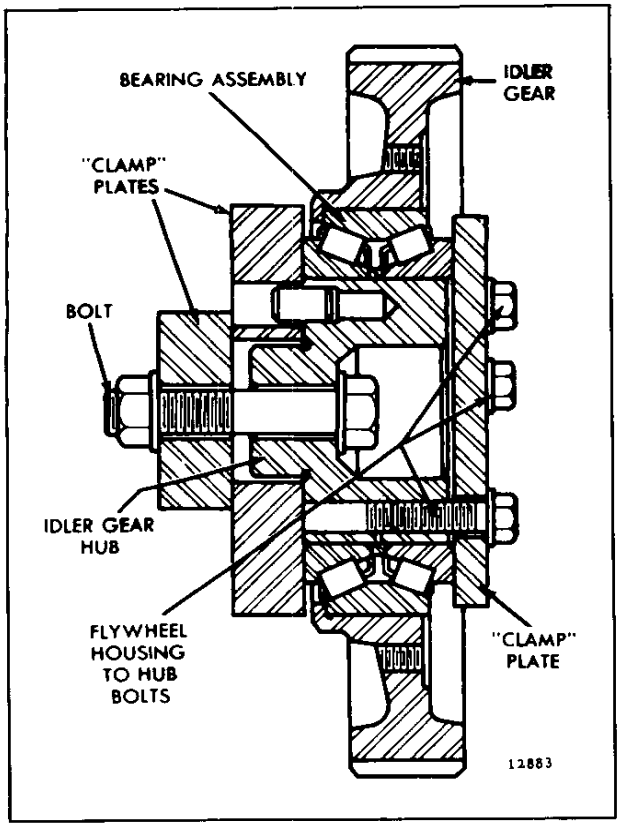


Fig.10 - Fixture for Testing Bearing Pre-Load

while rotaing the gear (to seat rollers properly between cones) until the face of the hub which will be adjacent to the cylinder block end plate is flush with the corresponding face of the bearing cone. The bearing cones should be supported so as not to load the bearing rollers during this operation (Fig. 9).

7. Prior to installing and securing the bearing retainer, check the preload of the bearing assembly as outlined below.

Check Pre-Load of Bearing

The rollers of the bearing are loaded between the bearing cup and bearing cones in accordance with design requirements to provide a rigid idler gear and bearing assembly. As the bearing cones are moved toward each other in a tapered roller bearing assembly, the rollers will be more tightly held between the cones and cup. In the idler gear bearings, a slight pre-load is applied by means of a selected spacer ring between the bearing cones, to provide rigidity of the gear and bearing assembly when it is mounted on its hub. This method of pre-loading is measured, in terms of *pounds-pull*, by the effort required at the outer diameter of the gear to turn the bearing cup in relation to the bearing cones.

Any time an idler gear assembly has been removed from an engine for servicing or inspection, while performing engine overhaul or other repairs, the pre-load should be measured as part of the operation.

The idler gear bearing must be clean and lubricated with light engine oil prior to the pre-load test. Idler gear assemblies which include new bearings should be *worked in* by grasping the gear firmly by hand and rotating the gear back and forth several times.

After the idler gear, hub, and bearing are assembled together, the bearing should be checked to ascertain that the gear may be rotated on its bearing without exceeding the maximum torque specifications, nor be so loose as to permit the gear to be moved in relation to the hub by tilting, wobbling or shaking the gear.

If the mating crankshaft and camshaft or balance shaft gears (depending upon engine rotation) are not already mounted on the engine, the torque required to rotate the idler gear may be checked by mounting the idler gear in position on the engine, using a steel plate 4" square (pre-load test plate) against the hub and cone as outlined below.

1. Mount the idler gear assembly on the engine.

2. Install the center bolt and washer through the gear hub and into the cylinder block (effective with 3A-48440, 4A-96718 and 6A-101590 a 1/2"-13 x 2 1/2" bolt replaced the 1/2"-13 x 2" bolt). Tighten the bolt to 80-90 lb-ft (108-122 Nm) torque.

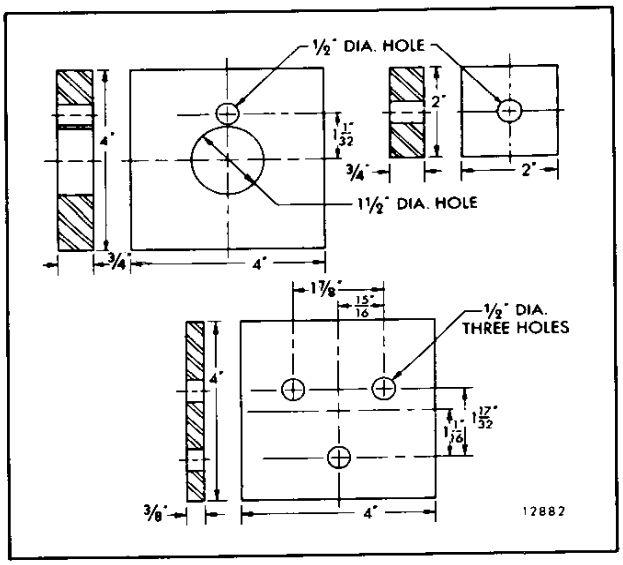


Fig. 11 - Plates for Bearing Test Fixture

© 1983 General Motors Corp.

3. Place steel plate (lower plate shown in Fig. 11) against hub and bearing. Insert three 3/8"-16 bolts through the plate and thread them into the hub. Tighten the bolts to 24-40 lb-ft (34-54 Nm) torque.

4. Tie one end of a piece of lintless 1/8" cord around a 1/8" round piece of wood (or soft metal stock). Place the wood between the teeth of gear, then wrap the cord around the periphery of the gear several times. Attach the other end of the cord to spring scale, J 8129 (Fig. 12). Maintain a straight, steady pull on the cord and scale, 90° to the axis of the hub, and note the pull, in pounds and ounces, required to start the gear rotating. Make several checks to obtain an average reading. If the pull is within 1/2 lb. minimum to 4 lbs. maximum and does not fluctuate more than 2 lbs. 11 ounces, the idler gear and bearing assembly are satisfactory for use.

NOTE: The specified pull is 1 1/2 to 15 lbs. for the early design bearing assembly which incorporates the snap ring.

If the crankshaft and camshaft gears are mounted on the engine, a suitable fixture, which may be held in a vise, can be made as shown in Fig. 10. Three plates (shown in Fig. 11) a 1/2"-13 x 2 3/4" bolt and a plain washer are used with a 1/2"-13 nut and plain washer for mounting. One of the plates is used to take the place of the flywheel housing, and the other two plates, the cylinder block. *Engine-mounted* conditions are simulated by tightening the nut to 80-90 lb-ft (108-122 Nm) torque and tightening the three plate-to-hub attaching bolts to 25-40 lb-ft (34-54 Nm) torque.

Check the pre-load as follows:

1. Attach the plates (two upper plate - Fig. 11) to the idler gear with 1/2"-13 bolt, washers and nuts (Fig. 10). Tighten the bolt to 80-90 lb-ft (108-122 Nm) torque.

2. Attach the third plate to the idler gear hub with three 3/8"-16 bolts. Tighten the bolts to 25-40 lb-ft (34-54 Nm) torque.

3. Clamp the idler gear assembly and fixture in vise (Fig. 12).

4. Attach the cord to the idler gear and spring scale and check the pre-load as outlined in step 4 of the previous method.

If the scale reading is within the specified 1/2 to 4 lbs., but fluctuates more than the permissible 2 lbs. 11 ounces, the idler gear and bearing assembly must NOT be installed on the engine. Fluctuations in scale reading may be caused by the cones or races not being concentric to each other, damaged cones or races or rollers, or dirt or foreign material within the bearings.

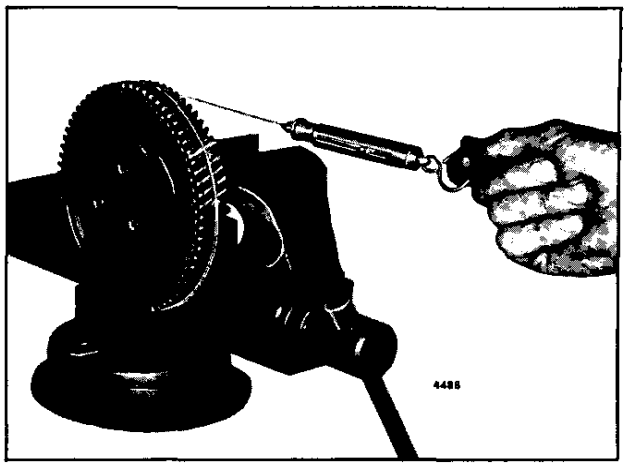


Fig. 12 - Checking Pre-Load of Idler Gear Bearing

In these cases, the bearing should be inspected for the cause of fluctuation in the scale readings and corrected or a new bearing installed.

A scale reading which exceeds the specified maximum indicates binding of the bearing rollers, or rollers improperly installed. When the scale reading is less than the specified minimum, the bearing is more likely worn and should be replaced.

After the pre-load test is completed, remove the steel plates and install the bearing retainer as follows:

Attach the bearing retainer to the idler gear with six new lock bolts. Because the lock bolts are coated with a locking compound, always use new lock bolts when assembling the idler gear. Tighten the bolts to 24-29 lb-ft (33-39 NM) torque.

NOTE: Do not use standard bolts and do not use the former bolt locks.

Idler gear assemblies which have a total length of 1.514" to 1.519" are to be used ONLY on engines equipped with a cast iron flywheel housing. Idler gear assemblies with a total length of 1.509" to 1.514" are used on engines with an aluminum flywheel housing and may also be used with cast iron housings.

Install Idler Gear, Hub and Bearing Assembly

1. Position the crankshaft gear and either the balance shaft or camshaft gear (depending upon engine rotation) so that the timing marks will align with those on the idler gear (refer to Figs. 1 and 2 in Section 1.7.1).

© 1983 General Motors Corp.

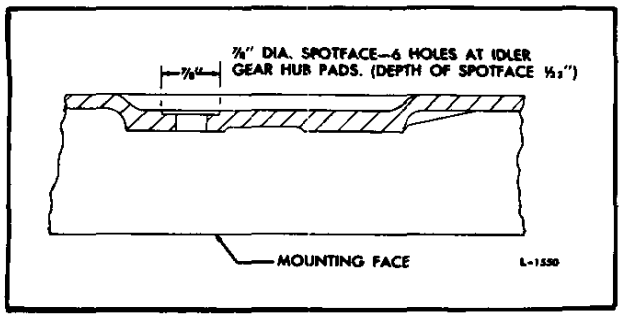


Fig. 13 - Details for Reworking Flywheel Housing (Early Engines)

2. With these marks in alignment, start the idler gear into mesh with the crankshaft gear and either the camshaft or balance shaft gear, and simultaneously rotate the gear hub so that the hollow dowel at the inner face of the hub registers with the oil hole in the end plate.

3. Roll the idler gear into position, align the hollow dowel with the hole in the end plate, and gently tap the hub until it seals against the end plate. Thus, the hollow dowel in the hub will conduct oil through the end plate and into the hub where it flows through a drilled passage to the roller bearing.

4. After making sure that the hub is tight against the end plate, secure the idler gear assembly with a 1/2"-13 bolt and special washer. Tighten the bolt to 80-90 lb-ft (108-122 Nm) torque (cast iron cylinder block) or 50-55 lb-ft (68-75 Nm) torque (aluminum cylinder block).

5. If previously removed, install the idler gear hole spacer (dummy hub). Secure the spacer to the cylinder block end plate and cylinder block with a 1/2"-13 bolt and special washer. Tighten the bolt to 80-90 lb-ft (108-122 Nm) torque (cast iron cylinder block) or 50-55 lb-ft (68-75 Nm) torque (aluminum cylinder block).

NOTE: Current engines use a new idler gear hub and idler gear hole spacer (dummy hub) which requires 1/2"-13 x 2-1/2" retaining bolts, replacing the 1/2"-13 x 2" bolts formerly used.

6. Lubricate the idler gear and bearing liberally with clean engine oil.

7. Check the backlash between the mating gears. The backlash must be .002" to .008" between new gears and must not exceed .010" between used gears.

8. No gasket is used between the roller bearing type idler gear assembly and the flywheel housing. However, if an OLD design idler gear spacer is used (on early engines), a small flywheel housing gasket must be used between the spacer and the flywheel housing.

NOTE: Make sure the oil passage in the cylinder block is plugged at the dummy hub location.

If the roller bearing type idler gear assembly has been installed place of a copper-lead flange type bearing on an early engine, it will be necessary to rework the flywheel housing at the idler gear hub pads to provide the 7/8" spot faces at the bolt holes (Fig. 13).

Install the flywheel housing as outlined in Section 1.5.

© 1983 General Motors Corp.

CRANKSHAFT TIMING GEAR

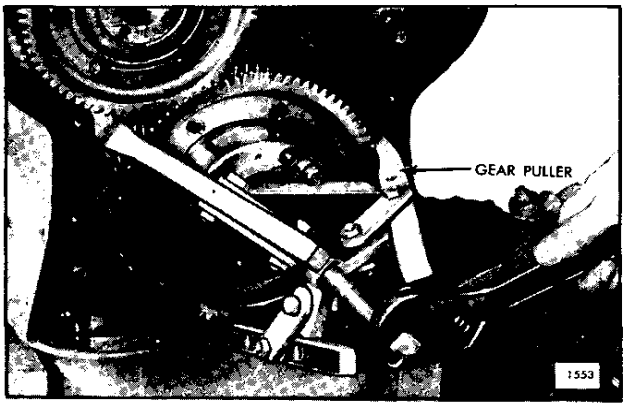


Fig. 1 – Removing Crankshaft Timing Gear

The crankshaft timing gear is bolted to the flange at the rear end of the crankshaft and drives the camshaft gear (LB, LC, RA and RD engines) or balance shaft gear (LA, LD, RB and RC engines) through an idler gear.

Since the camshaft must be in time with the crankshaft, timing marks are located on two teeth of the idler gear with corresponding timing marks stamped on the crankshaft gear and camshaft and balance shaft gears (refer to Section 1.7.1).

Remove Crankshaft Timing Gear (Flywheel Housing Removed)

The crankshaft gear is a press fit on the crankshaft. Remove the gear as follows:

1. Remove the crankshaft rear oil seal sleeve, if used. To remove the sleeve, peen the outside diameter of the sleeve until it stretches sufficiently so it can be slipped off of the crankshaft.

2. Before removing the crankshaft gear, align the timing marks of the gear train and note their location so the gear can be reinstalled in its original position.

3. Remove the six bolts and lock washers securing the gear to the crankshaft.

4. Provide a base for the puller screw by placing a steel plate across the cavity in the end of the crankshaft. Then remove the gear with a suitable puller as shown in Fig. 1.

Inspection

Clean the gear with fuel oil and dry it with compressed air. Examine the gear teeth for evidence of scoring, pitting or wear. If severely damaged or worn, install a new gear. Also check the other gears in the gear train.

Install Crankshaft Timing Gear

1. Position the gear on the rear end of the crankshaft with the flat finished hub of the gear facing toward the cylinder block and with all six bolt holes in the gear aligned with the tapped holes in the crankshaft. One bolt hole is offset so the gear can be attached in only one position.

2. Align the proper timing mark ("L" or "R") on the crankshaft gear tooth with the corresponding mark on the idler gear (refer to Section 1.7.1).

> **NOTE:** When advanced timing is required, align the timing mark "A" with the timing mark on the idler gear.

3. Start the six 3/8"–24 bolts with lock washers through the gear and into the crankshaft. Then draw the gear tight against the shoulder on the crankshaft. Tighten the bolts to 35–39 lb–ft (47–53 Nm) torque.

4. Check the backlash with the mating gear. The backlash should be .003" to .008" with new gears or .010" maximum with used gears.

5. Install a new crankshaft rear oil seal sleeve, if required, as outlined in Section 1.3.2.

© 1977 General Motors Corp.

BLOWER DRIVE GEAR AND SUPPORT ASSEMBLY

The blower drive gear is mounted on the blower drive gear support and in addition to driving the blower, drives the governor, water pump and fuel pump. The drive is cushioned by a spring-loaded flexible coupling which insures a uniform rotation of the blower rotors (Figs. 1 and 5).

The left-hand helix blower drive gear is driven by the camshaft gear on LA and RA engines and the balance shaft gear on LB and RB engines. The right-hand helix blower drive gear is driven by the camshaft gear on LC and RC engines, and the balance shaft gear on LD and RD engines (see Section 1.7.2).

> **NOTE:** The 39 tooth and the 40 tooth blower drive gears are interchangeable, however, the governor will have to be adjusted to compensate for the approximately 2.5% change in the governor drive speed.

The ratio of blower speed to engine speed on a 71T (turbocharged) engine is 1.55:1 and 1.69:1 on the 71E or 71N (economy) engines. This reduction in the ratio is possible through an additional set of blower rotor gears (see Section 3.4).

A new blower drive support assembly has replaced the former assembly (Fig. 2). The new and former blower drive assemblies are different in that the flanged bearing, which also served as a thrust surface, has been replaced by a new bearing. The inner bearing of the new assembly protrudes slightly from the inner face of the support to facilitate installation of and to serve as a pilot for the thrust washer.

Remove and Install Blower Drive Shaft

If the blower drive shaft is not broken, it may be removed as follows:

1. Remove the six bolts that secure the flywheel housing small hole cover (Fig. 1).

2. Refer to Fig. 4 and remove the snap ring and pull the blower drive shaft out of the drive assembly.

> **NOTE:** Some shafts have a tapped hole in the end which can be used as an aid in removing the shaft.

If the blower drive shaft is broken and it is not possible to remove all of the pieces, it will be necessary to remove the blower (see Section 3.4).

A broken drive shaft indicates an unusual loading which may have been caused by a bearing failure or other malfunction. Inspect the blower drive, blower rotors and the housing before replacing the drive shaft. See the blower inspection procedure in Section 3.4.

Reverse Steps 1 and 2 for the installation of the blower drive shaft.

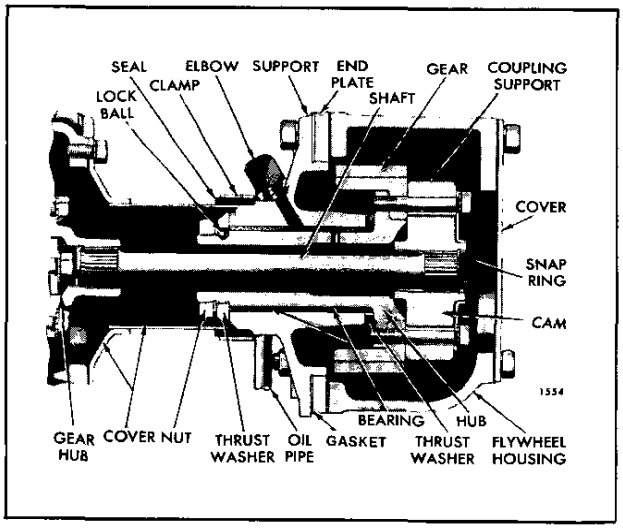


Fig. 1 - Typical Blower Drive Gear and Support Assembly

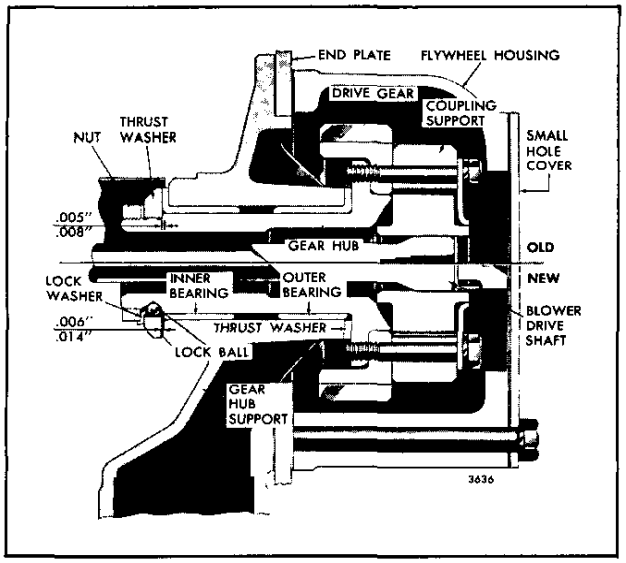


Fig. 2 - Blower Drive Support Assembly

© 1983 General Motors Corp.

Remove Blower Drive Gear and Support Assembly (Flywheel Housing Removed)

Removal of the flywheel housing is not necessary when removing the blower drive gear, however, an inspection of the gear train is advisable when any one of the gears requires service. The procedures for the removal of the flywheel and flywheel housing are found in Sections 1.4 and 1.5.

Before removing the blower drive gear, the blower drive shaft must be removed as previously outlined.

1. Remove the blower (Section 3.4).

2. Remove the blower drive oil line (Fig. 3).

3. Straighten the ears on the lock washer and loosen the drive gear hub nut (Fig. 5).

4. Remove the blower drive support attaching bolts.

5. Loosen the blower drive support by tapping it lightly and withdraw the support from the cylinder block rear end plate. Take care to prevent damage to the blower drive gear teeth. Discard the gasket.

Disassemble Blower Drive Gear and Support Assembly

1. Secure the blower drive gear and support assembly in a vise with soft jaws.

2. Take out the drive coupling bolts and remove the retainer and coupling support (Fig. 5).

3. Remove the drive gear hub nut, lock washer, lock ball and thrust washer and withdraw the blower drive gear hub.

4. On current engines, remove the thrust washer from the blower drive gear hub (Fig. 2).

5. Press the gear hub out of the blower drive gear.

Inspection

Clean the parts with fuel oil and dry them with compressed air. Ensure that the oil grooves, oil holes, and cavities are free of dirt.

Replace the thrust washers if they are worn or scored.

If the bearings are worn or scored excessively the drive gear hub support or bearings will have to be replaced. These bushing type bearings are diamond bored to an inside diameter of 1.6260" to 1.6265", after installation in the hub.

The clearance between the bearings and the hub is .0010" to .0025" with new parts and a maximum of .0050" with used parts.

The current bearing on the gear end protrudes .045" to .055" above the surface of the face to facilitate the installation of the blower drive thrust washer (Fig. 5). The other bearing is installed with the end flush to .030" below the surface of the face of the support. Each of the former bearings were flanged. Replacement bearings must withstand a 2000 lb end lo,ad without moving, also the bearing bores must be square with the inner and outer faces of the support within .001" total indicator reading.

Replace the blower drive shaft if the serrations are worn or damaged.

Inspect the blower drive coupling support, cam, spring seats and spring packs. Replace worn or damaged parts.

The current blower drive couplings effective with Engine Serial Numbers 3A-38417, 4A-77750 and 6A-84358, incorporate spring seats which prevent pressure and wear from the spring packs on the coupling, thereby, prolonging the life of the coupling. Shorter springs are required for use with the spring seats. When a spring replacement is necessary, the new springs and spring seats, available in a kit, must be installed.

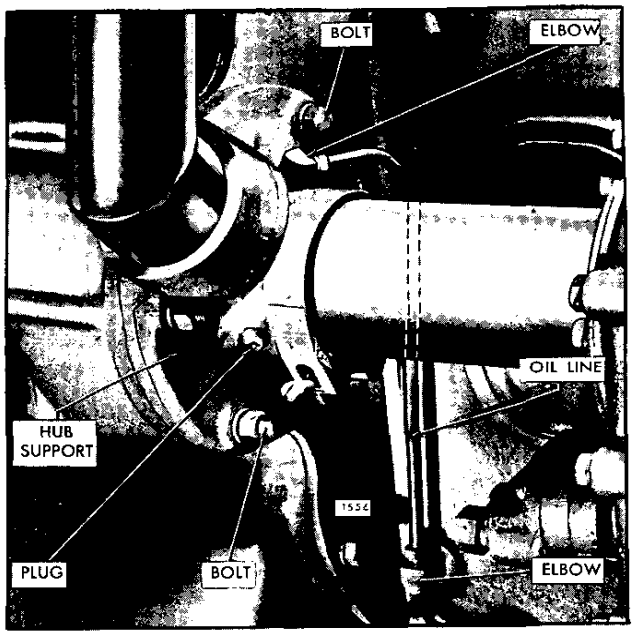


Fig. 3 - Blower Drive Gear and Support Assembly Mounting

© 1983 General Motors Corp.

Examine the blower drive gear. If the teeth are excessively worn, scored or pitted, the gear must be replaced.

Assemble Blower Drive Gear and Support Assembly

The relative location of the parts is shown in Fig. 5.

1. Secure the blower drive gear support in a vise with soft jaws.

2. Press the drive gear hub into the drive gear.

3. Lubricate the drive gear hub, bearings in the support, thrust surfaces and blower drive thrust washer with engine oil.

4. On current engines, place the thrust washer on the protruding bearing in the gear side of the support and insert the blower drive gear hub and gear assembly.

5. Locate the lock ball in its place on the drive gear hub and slide the hub thrust washer into position over the lock ball. The thrust washer must be installed with the tapered face toward the threads on the hub.

6. Install a new lock washer and finger tighten the nut on the hub. Install two bolts into the threaded holes in the drive gear hub. Place a suitable holding bar across the bolts to keep the hub from rotating and tighten the hub nut to 50-60 lb-ft (68-81 Nm) torgue. Bend the ears of the lock washer against the nut to lock the nut in place. Remove the two bolts.

7. Assemble the blower drive coupling.

a. Place the drive coupling support on wood blocks (Fig. 6).

b. Install the spring end seats and place the spring seats in each corner of the drive coupling support.

c. Apply engine oil to the drive coupling springs (there are 21 leaves in each spring pack) and insert them in the coupling support.

d. Place the blower drive cam on the installer J 1471, insert the round end of the tool between the spring packs and press the cam into position (Fig. 6).

8. Place the coupling support against the drive gear with the blower drive shaft ring groove in the cam facing away from the drive gear. Then, place the drive coupling retainer against the coupling support with the flared edge away from the support. Revolve the coupling assembly on the hub flange until the cam lobes are in line with the oil grooves in the gear hub to ensure proper lubrication (Fig. 7).

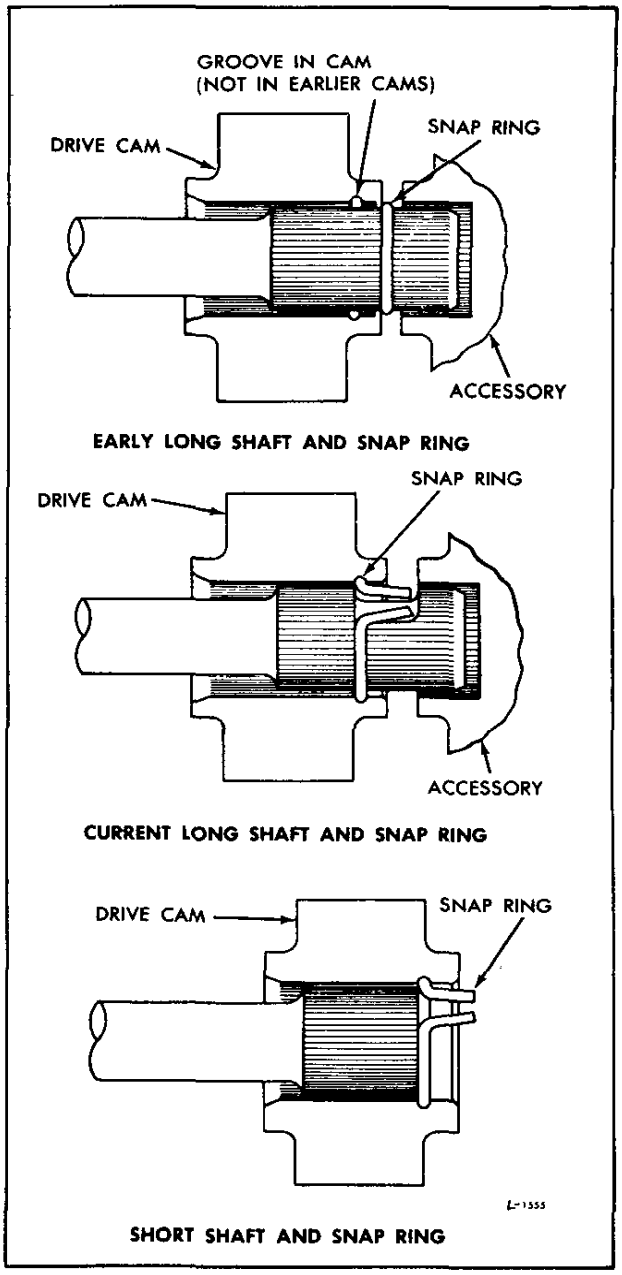


Fig. 4 - Blower Drive Shaft Mounting

9. Install the drive coupling bolts.

Install Blower Drive Gear and Support Assembly

1. Check the clearance (Fig. 2) between the drive support and gear hub thrust washer on current engines

© 1983 General Motors Corp.

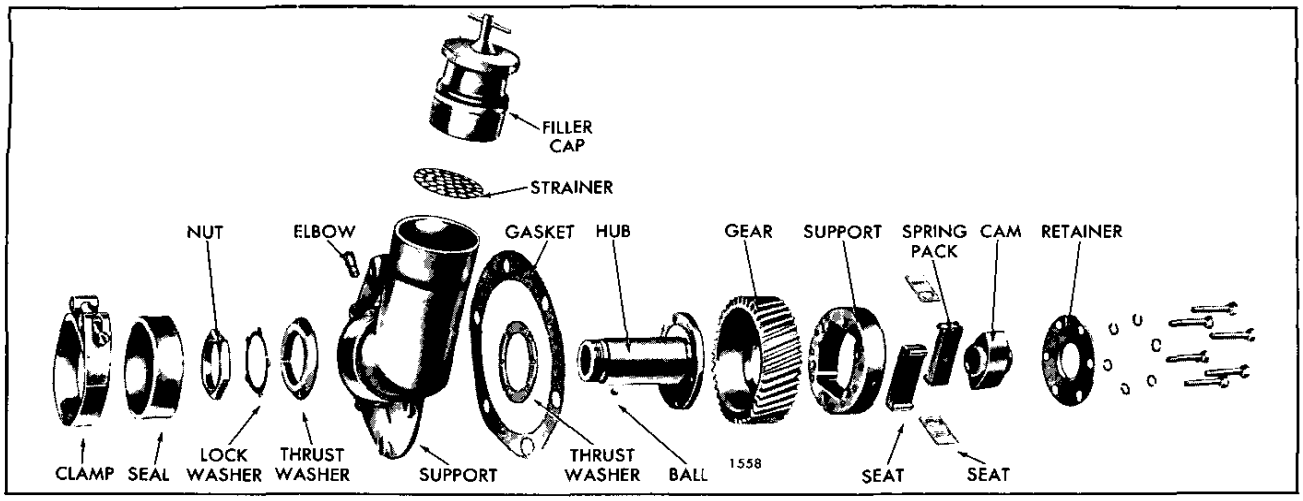


Fig. 5 - Typical Blower Drive Gear Details and Relative Location of Parts

or between the drive support bearing flange and the gear hub thrust washer on former engines, before installing the blower drive gear support assembly. The clearance on the current engines must be .006" to .014" and on the former engines with the flanged bearing .005" to .008".

2. Place a new gasket on the mounting face of the hub support (Fig. 5).

3. Attach the blower drive gear and support assembly to the cylinder block rear end plate with the two 3/8"-24 x 7/8 bolts.

4. Connect the oil line (Fig. 3).

5. Install the blower as outlined in Section 3.4 and secure the seal and clamp (Fig. 5).

6. Insert the blower drive shaft into the blower rotor gear hub. The end without the groove for the ring must be inserted first.

7. Lock the drive shaft in place by installing the ring in the groove provided in the coupling cam.

8. Reinstall the flywheel and flywheel housing as described in Sections 1.4 and 1.5 and install the remaining bolts that secure the blower drive gear and support assembly.

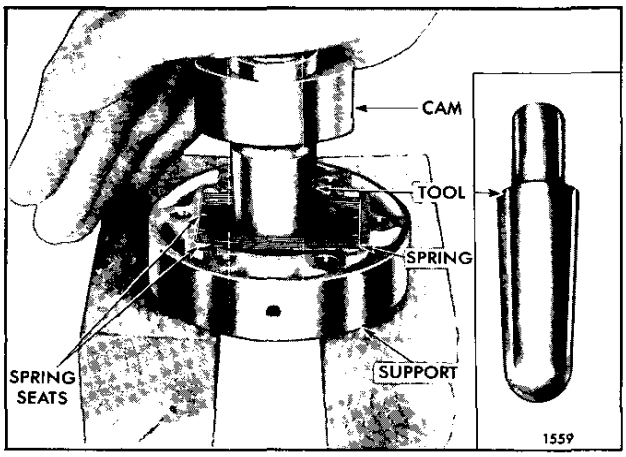


Fig. 6 - Inserting Blower Drive Cam

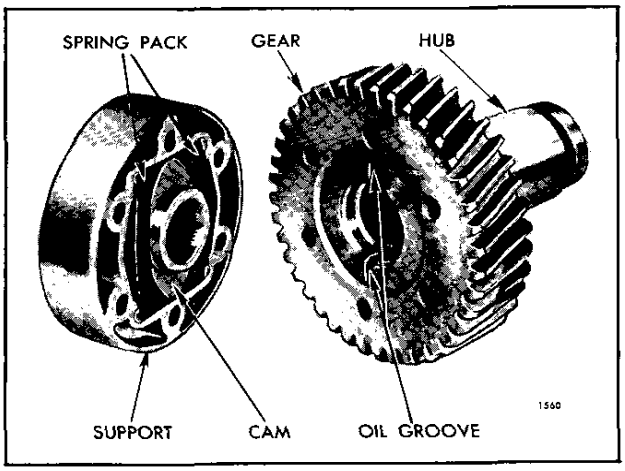


Fig. 7 - Relation of Blower Drive Cam to Oil Grooves in Gear Hub

© 1983 General Motors Corp.

ACCESSORY DRIVES

Accessory drives have been provided at the rear of the engines to accommodate both gear-driven and belt-driven accessories.

For the possible accessory drive location and rotation of the drive at a particular position, refer to Fig. 1.

The drive for direct gear-driven accessories, such as a raw water pump, is made up of a spacer (when used), accessory drive plate and drive coupling (Fig. 2).

The drive plate and spacer (when used) are bolted to the camshaft or balance shaft gear. The accessory is bolted to the flywheel housing and driven by a drive coupling which is splined to both the accessory shaft and accessory drive plate.

Belt-driven accessories, such as battery-charging generators or air compressors, are driven off the camshaft or balance shaft gears by a drive hub and pulley (Fig. 3) or a spacer (when used), accessory drive plate, drive shaft, accessory drive retainer assembly and pulley (Fig. 4).

In the first arrangement (Fig. 3), the drive hub is bolted to the camshaft or balance shaft gear. The oil seal retainer is bolted to the flywheel housing and the pulley is keyed to the drive hub shaft which extends through the oil seal retainer.

In the second arrangement (Fig. 4), the spacer (when used) and accessory drive plate are bolted to one of the balance gears. The accessory drive shaft is splined to the drive plate at one end and supported by a bearing in the accessory drive retainer at the other end. The accessory drive retainer, which also incorporates an oil seal, is bolted to the flywheel housing. The pulley is keyed to the drive shaft which extends through the drive retainer assembly.

On some coach engines, a step-up gear is attached to the camshaft gear with six allen head bolts and lock washers to drive the battery-charging alternator (Fig. 5). The alternator mounting adaptor is attached to the flywheel housing. Two set screws are used to adjust and hold a clearance (maximum .002 " runout) between the outer flange of the step-up gear and the alternator adaptor.

Position	Drive Ratio
1	1.1
2	1.1
*4 (blower)	1.95:1 or 2:1
*5 (blower)	1.95:1 or 2:1

*Depends upon engine application

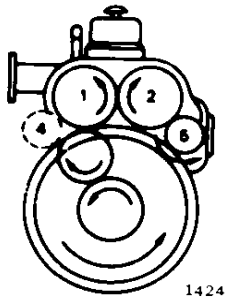


Fig. 1 - Accessory Drive Locations

The drive for the direct engine-driven hydrostarter charging pump (driven off the camshaft or balance shaft gear) is covered in *Hydrostarter System,* Section 12.6.1.

The drive for the hydraulic marine gear oil pump (driven off of an extended blower drive shaft) is outlined in *Torqmatic Marine Gear Components,* Section 9.1.2 of the *Series 71 Engine Transmissions, Reverse and Reduction Gears Manual,* Form 6SE355.

Remove Accessory Drive

Remove the gear-driven type accessory drive (Fig. 2) as follows:

1. Remove any external piping or connections to the accessory.

2. Remove the five bolts and lock washers attaching the accessory to the flywheel housing. Pull the accessory straight out from the flywheel housing.

3. Remove the drive coupling.

4. Place a clean, lintless cloth in the flywheel housing opening, underneath the accessory drive plate, to prevent bolts from accidently falling into the gear train. Remove the lock wires, if used. Then remove the four bolts (and lock washers, if used) attaching the accessory drive plate and spacer (when used) to the balance gear and remove the plate and spacer.

Remove the drive assembly for the belt-driven type accessory (Figs. 3 and 4) as follows:

1. Remove any external piping or connections to the accessory.

2. Loosen the accessory and slide it toward the drive pulley. Then remove the drive belt and the accessory.

3. Remove the bolt and washer (Fig. 3), or nut (Fig. 4), retaining the pulley on the drive shaft.

4. Use a suitable gear puller to remove the pulley from the drive shaft. Remove the Woodruff key.

© 1978 General Motors Corp.

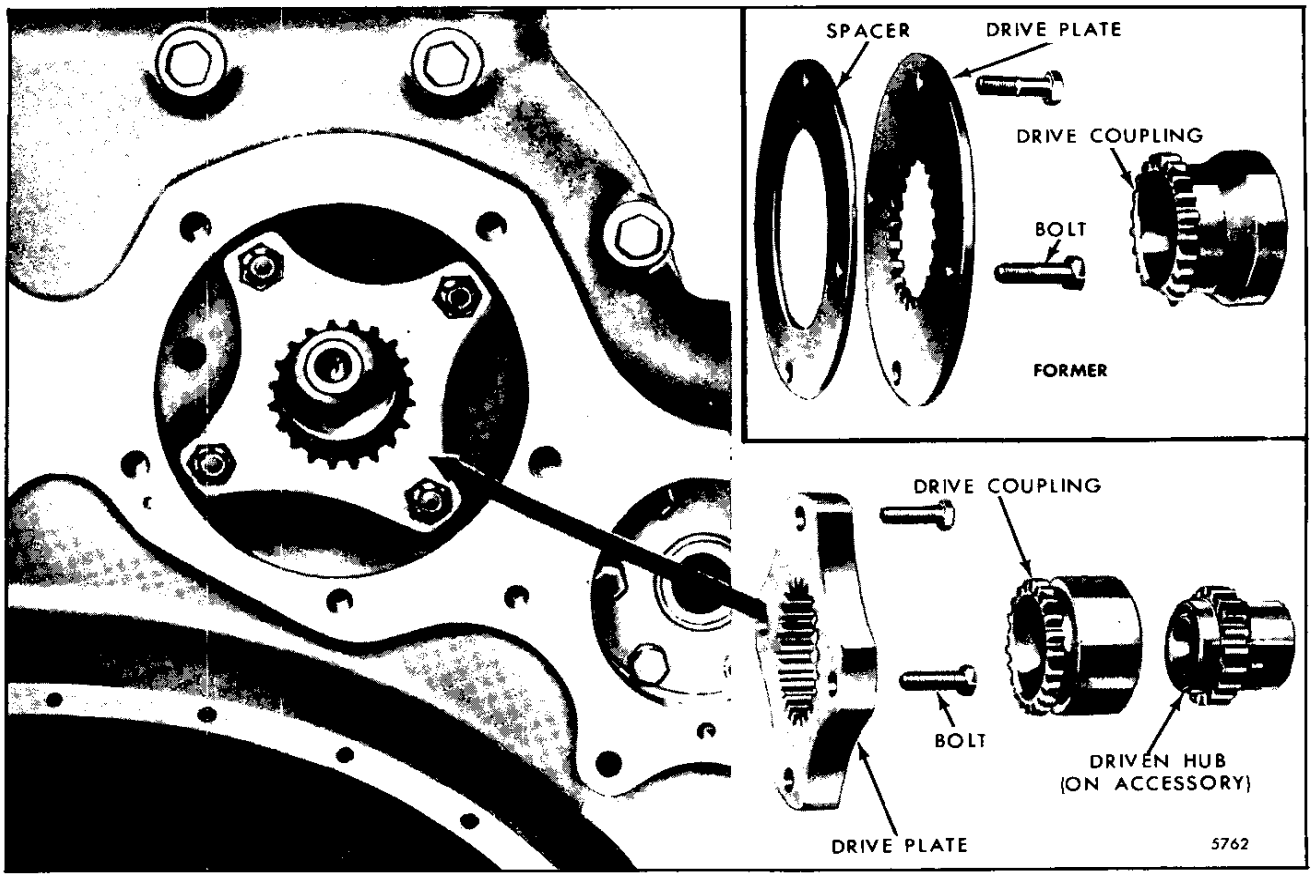


Fig. 2 - Typical Components of Accessory Drive for Direct-Driven Accessories

5. Remove the five bolts and lock washers which attach the drive retainer assembly to the flywheel housing. Remove the retainer assembly.

6. Remove the accessory drive shaft, drive plate and spacer (when used) (Fig. 4), or drive hub (Fig. 3), in a manner similar to that outlined in Steps 3 and 4 under removal of the direct gear-driven type accessory drive.

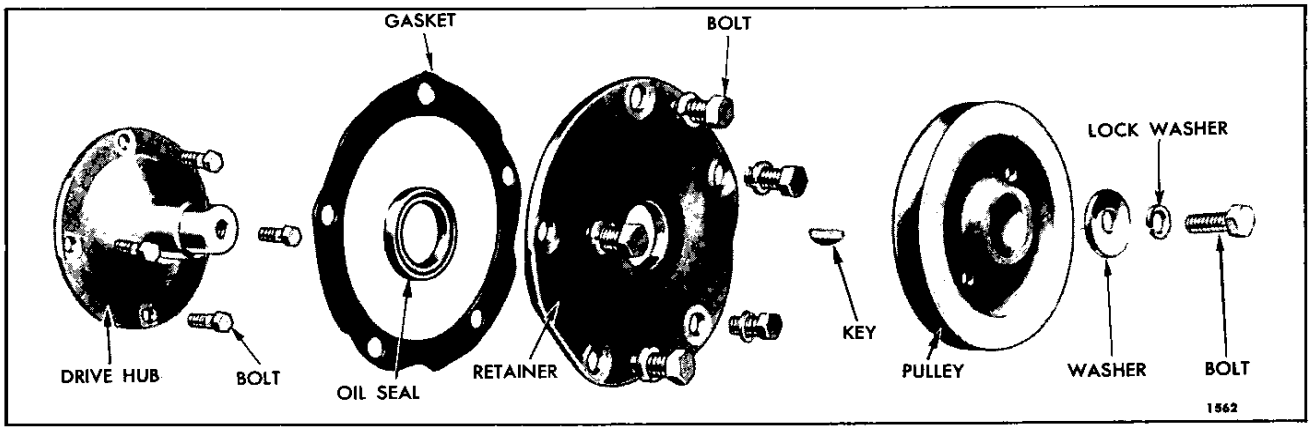


Fig. 3 - Components of Accessory Drive for Belt-Driven Accessory (Drive Hub Type)

© 1978 General Motors Corp.

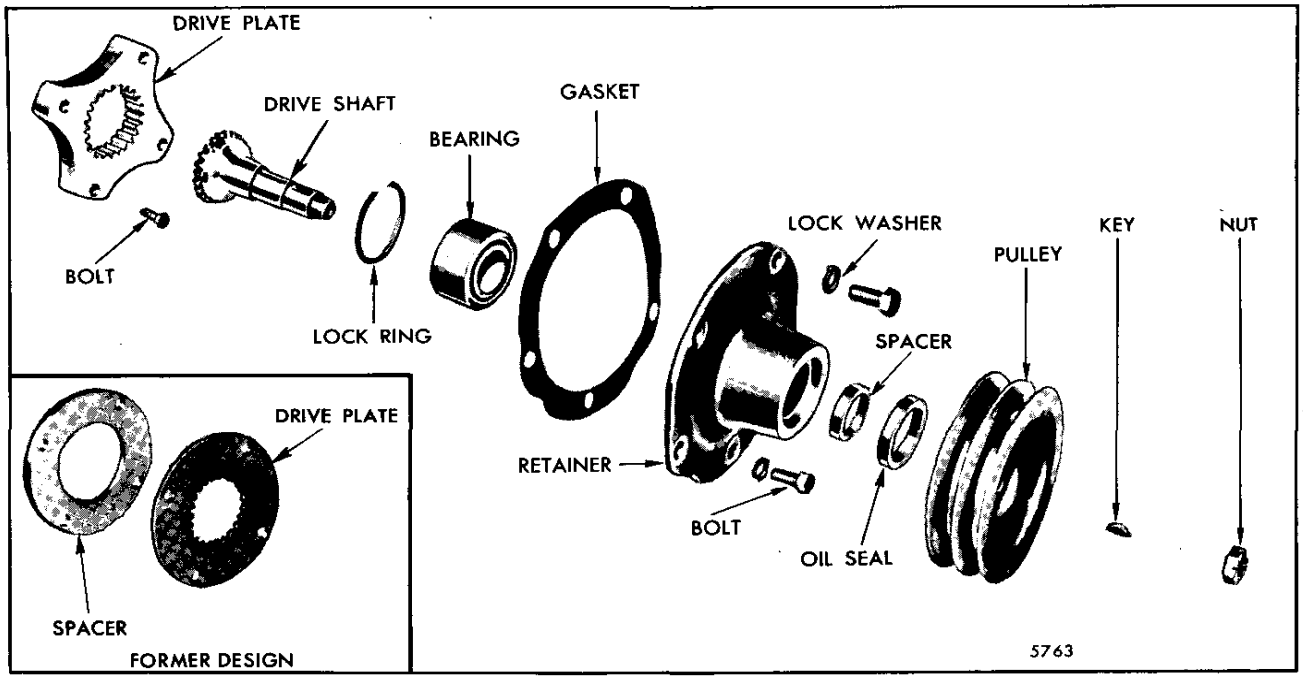


Fig. 4 - Components of Accessory Drive for Belt-Driven Accessory (Drive Plate Type)

7. Remove the snap ring and ball bearing from the accessory drive shaft retainer assembly shown in Fig. 4.

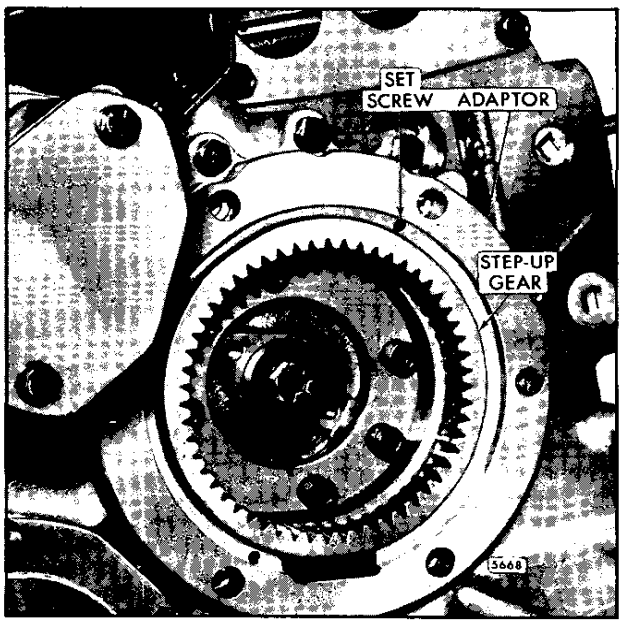


Fig. 5 - Step-Up Gear Drive Mounting

Inspection

Clean the accessory drive parts with clean fuel oil (except shielded bearings) and dry them with compressed air. Examine the gear teeth of the drive shaft, drive coupling or drive plate for wear. If worn excessively, replace with new parts.

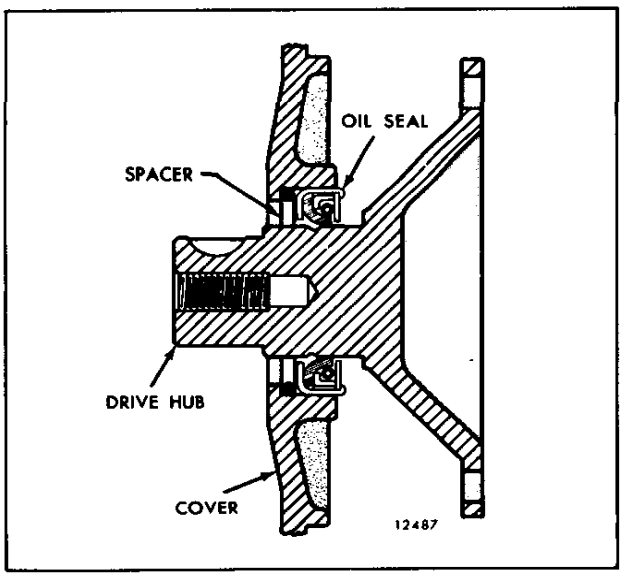


Fig. 6 - Location of Oil Seal Spacer

© 1978 General Motors Corp.

Inspect the ball bearing used to support the accessory drive shaft (Fig. 4). *Shielded bearings must not be washed;* dirt may be washed in and the cleaning fluid could not be entirely removed from the bearing. Wipe the outside of the bearing clean, then hold the inner race and revolve the outer race slowly by hand. If the bearing is worn or does not roll freely, replace it.

Inspect the accessory drive hub (Fig. 3) for grooving at the area of contact with the lip of the oil seal. If the hub is grooved to a point where the effectiveness of the oil seal is lost, a ring-type oil seal spacer is available which serves to re-position the seal and provide a new sealing surface (Fig. 5).

Install Accessory Drive

1. Remove the old gasket material from the flywheel housing. Use care so that no gasket material falls into the gear train compartment.

2. Insert a clean, lintless cloth in the flywheel housing opening to prevent bolts from accidentally falling in the gear train. Align the bolt holes in the accessory drive plate and spacer (when used), or accessory drive hub, with the tapped holes in the balance gear. Then secure the plate and spacer (when used), or drive hub, with four bolts (and lock washers or lock wire, if used).

> **NOTE:** Effective with units 3A-045, 4A-007, 6A-021, 8A-003, 12A-007 and 24A-001, the tapped holes in the balance gears were changed from 5/16 "-24 to 3/8 "-24 threads with a corresponding change in the size of the accessory drive attaching bolts. Also, the accessory drive plate used with 5/16 "-24 bolts incorporated four spacers as shown in Fig. 7; the current disc type spacer is separate from the accessory drive plate. The four spacers from the old drive plate may be removed and replaced by the disc type spacer for use with the current balance gears with the 3/8 "-24 tapped holes.

3. If an accessory drive plate is used, refer to Figs. 2, 4 and 7. Then align the bolt holes in the accessory drive plate (and spacer, if used) with the tapped holes in the camshaft gear. Secure the drive plate (and spacer) with the four special shoulder bolts (and lock washers, if used). Tighten the bolts to 45-50 lb-ft (61-68 Nm) torque.

4. If a gear-driven accessory is used, install the drive coupling (Fig. 2) and proceed as follows:

a. Affix a new gasket to the mounting flange on the accessory.

b. Place the accessory in position against the flywheel housing; rotate it, if necessary, to align the teeth of the driven hub with those in the drive coupling. Then secure the accessory to the flywheel housing with bolts and lock washers.

5. If a belt-driven accessory is used, refer to Figs. 3 or 4 and proceed as follows:

a. Place the accessory drive retainer on a bench, with the mounting flange side up. Lubricate the outside diameter of the bearing with oil. Then press or tap it (with the protruding face of the inner race facing toward the retainer) straight in until it contacts the shoulder in the retainer. Then install the lock ring.

b. Turn the retainer over and coat the bore with sealant. Then press a new oil seal into the bore of the retainer with the lip of the seal facing the bearing. Wipe any excess sealant from the retainer.

c. Turn the retainer over again, bearing side up, lubricate the drive shaft and press it in the bearing until the shoulder on the shaft contacts the bearing.

d. Affix a new gasket to the mounting flange on the retainer. Then position the retainer and shaft assembly against the flywheel housing. Rotate the shaft slightly, if necessary, to permit the teeth of the shaft to mesh with the teeth in the accessory drive plate. Secure the retainer to the flywheel housing with five bolts and lock washers. Tighten the bolts to 30-35 lb-ft (41-47 Nm) torque.

e. Install the key in the shaft. Then start the pulley on the shaft and tap it in place. Install the 3/4 "-16 retaining nut. Tighten the nut to 120-140 lb-ft (163-190 Nm) torque.

f. Slip the drive belts over the pulleys. Then position the accessory to provide the proper tension on the belts and secure it in place.

> **NOTE:** When installing or adjusting an accessory drive belt(s), be sure the bolt at the accessory adjusting pivot point is properly tightened, as well as the bolt in the adjusting slot (refer to Section 15.1).

6. If an accessory drive hub is used, refer to Fig. 3 and proceed as follows:

a. Align the bolt holes in the drive hub with the tapped holes in the balance gear. Then secure the drive hub to the gear with four shoulder bolts. Tighten the bolts to 45-50 lb-ft (61-68 Nm) torque.

b. Use a dial indicator to check the runout of the

© 1978 General Motors Corp.

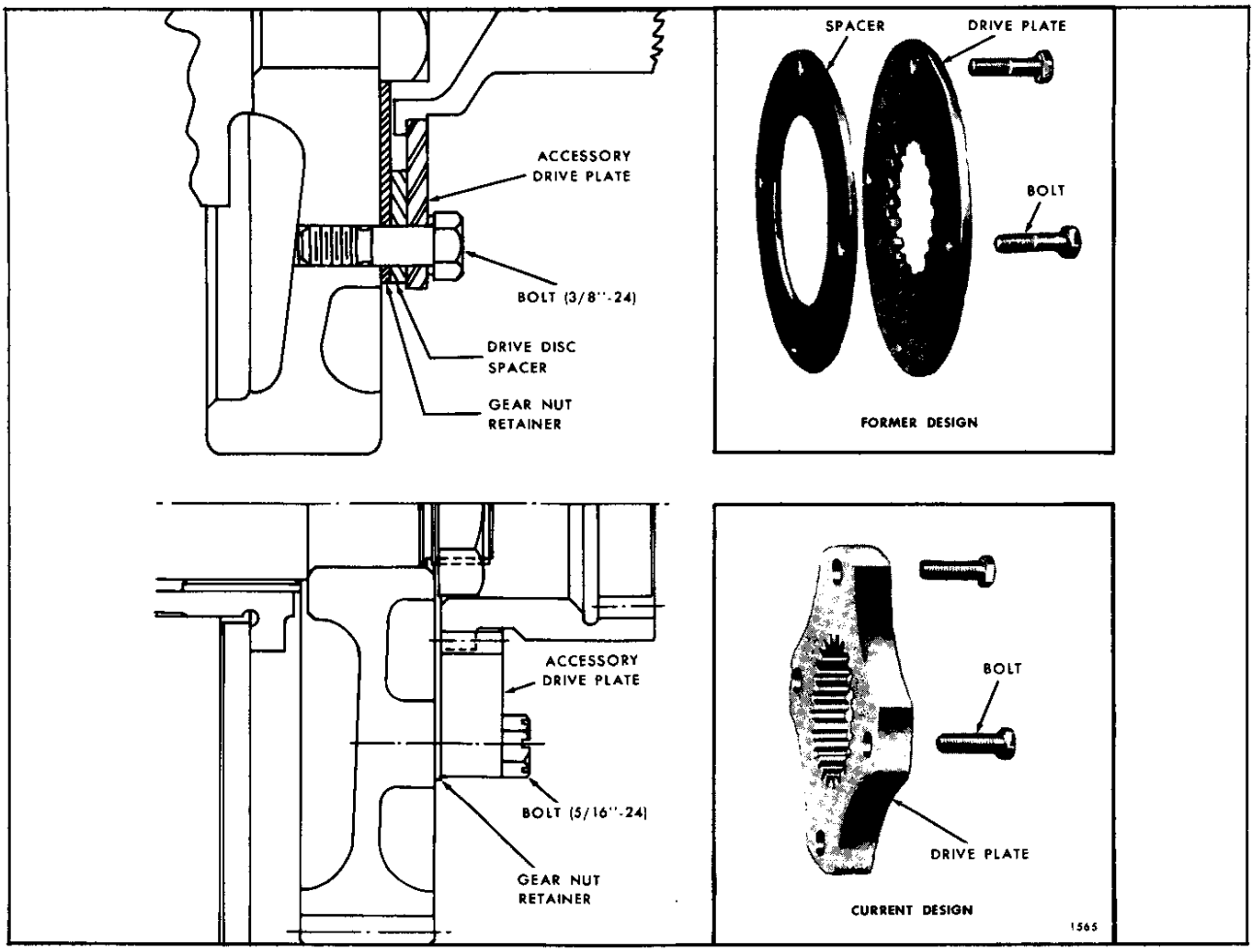


Fig. 7 - Comparison of Current and Former Design Accessory Drive Plates and Spacers

drive hub shaft. The runout must be within .010 " total indicator reading.

c. Coat the retainer bore with sealant and press a new oil seal in place. The lip of the seal must face the engine when the retainer is installed.

d. Affix a new gasket to the mounting flange of the retainer. Then place the retainer against the flywheel housing and install the five attaching bolts and lock washers. Before tightening the bolts, insert tool J 21166 over the shaft and into the retainer bore to align the oil seal with the shaft. Tighten the retainer bolts to 30-35 lb-ft (41-47 Nm) torque and remove the oil seal aligning tool.

e. Install the key in the drive hub. Then start the pulley on the drive hub and tap it in place. Install the plain washer, lock washer and bolt. Tighten the bolt to 35 lb-ft (47 Nm) torque.

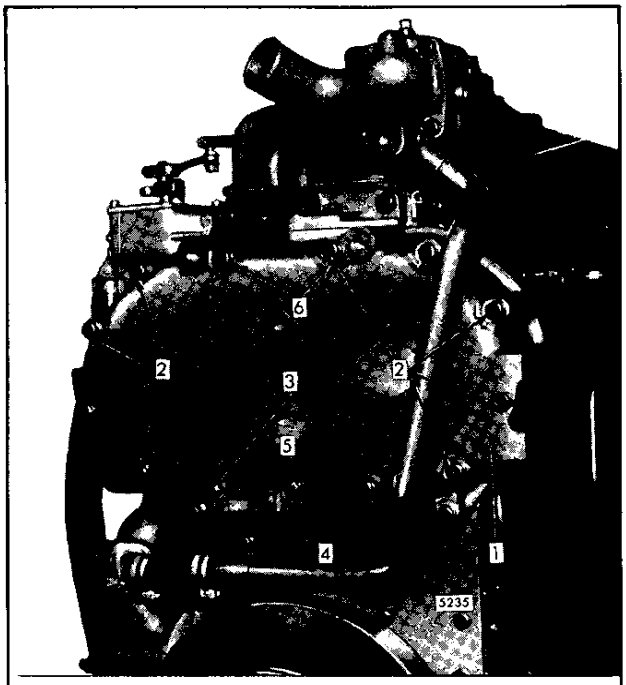
f. Slip the drive belt over the pulleys. Then position the accessory to provide the proper tension on the belt and secure it in place.

NOTE: When installing or adjusting the accessory drive belt, be sure the bolt at the accessory adjusting pivot point is properly tightened, as well as the bolt in the adjusting slot (refer to Section 15.1).

7. If the flywheel housing small hole covers were removed, install them as outlined in Section 1.5.

© 1982 General Motors Corp.

BALANCE WEIGHT COVER



1. Cover--Balance Weight
2. Bolt--3/8-24 x 3 (to end plate)
3. Bolt--3/8-16 x 3-1/2 (to cylinder block)
4. Bolt--3/8-16 x 1-7/8 (to cylinder block)
5. Bolt--3/8-24 x 1-1/2 (to end plate)
6. Washer--Plain

Fig. 1 – Balance Weight Cover Mounting

The front balance weight cover (Fig. 1) encloses the front engine balance weights and also serves as a support for various equipment such as the cooling fan support bracket or heat exchanger.

The balance weight cover requires no servicing. However, when an engine is being completely reconditioned or the camshaft, balance shaft or front balance weights need replacing, the balance weight cover must be removed.

Remove Cover

1. Drain the cooling system.

2. Loosen the hose connections between the radiator (or heat exchanger) and the engine.

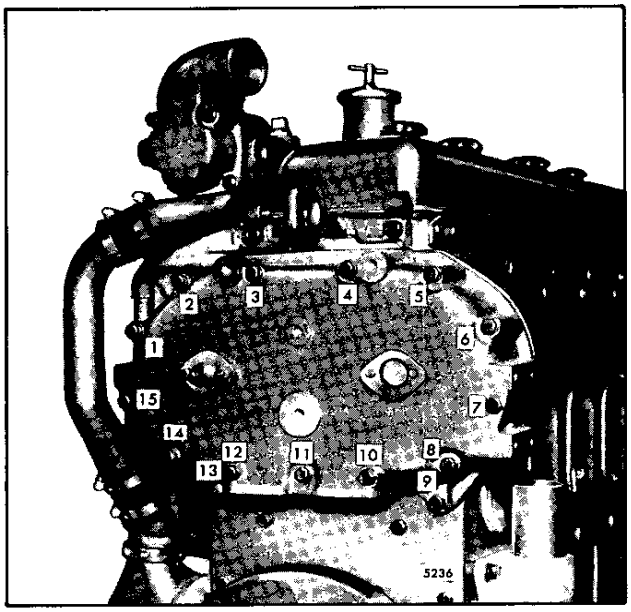


Fig. 2 – Balance Weight Cover Bolt Tightening Sequence

3. Remove the radiator (or heat exchanger).

4. Remove the fan, fan hub and adjusting bracket.

5. Remove the fifteen bolts, lock washers and plain washers (Fig. 1) which secure the balance weight cover to the cylinder block and the front end plate. Remove the cover and gasket.

6. Remove all traces of the old gasket material from the cover and the end plate.

Install Cover

1. Affix a new gasket to the balance weight cover.

2. Install the cover in place and install the fifteen attaching bolts, lock washers and plain washers finger tight.

3. Refer to Fig. 2 and tighten the bolts to 25–30 lb–ft (34–41 Nm) torque.

4. Install the various sub-assemblies that were previously removed.

© 1977 General Motors Corp.

SHOP NOTES - TROUBLE SHOOTING

SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

PISTON AND CYLINDER LINER USAGE (Trunk Type)

1. "N" pistons are .030" longer than the "E" pistons and approximately .155" longer than the special "E" piston. In addition, the fire ring turbocharged piston is .125" longer than the non-firing ring turbocharged piston. These dimension differences dictate that pistons *cannot be mixed in an engine.* To do so would result in misfiring and a rough idle condition which could ultimately result in cylinder liner scuffing.

2. The "E" and "turbo" figure 8 cylinder liner has .900" long ports compared to 1.055" long ports in the oval port liner and .703" long ports in the standard two valve figure 8 port liner. These port dimension differences *prohibit mixing of cylinder liners in an engine* which would result in a timing differential and compression ratio changes.

3. Only the oval port cylinder liners can be used with 18.7:1 compression ratio pistons. In addition, only oval port cylinder liners can be used with fire ring turbocharged pistons. The standard figure 8 port cylinder liner should be used only with the non-fire ring two valve piston.

4. Crown valve injectors can be used with the 18.7:1 pistons. *Crown valve and needle valve injectors must not be mixed in an engine.*

5. When converting to "N" pistons (see Item 1), it is important that the exhaust valve protrusion be measured carefully to assure that when fully closed the exhaust valves do not protrude more than .006" above the cylinder head fire deck. Only the "thin" exhaust valve inserts (for two valve or four valve heads) which are .247"/.251" thick can be used with the "N" piston.

ALUMINUM CYLINDER BLOCK

The aluminum cylinder block, used on certain engines, has been revised by enlarging the camshaft intermediate bearing lock screw holes. This change requires 3/8"-24 x .620" lock screws in place of the 1/4"-28 x .715" lock screws formerly used. The upper halves of the camshaft intermediate bearings have also been revised by enlarging the lock screw hole.

When replacing the aluminum block on engines prior to serial numbers 4A-79662 and 6A-76745, new camshaft intermediate bearing sets and new lock screws must also be used with the new block.

REUSING CROSSHEAD PISTON ASSEMBLY COMPONENTS

Components of the piston assemblies can, in certain instances, be reused. Undamaged piston pins, crowns and bushings that meet dimensional limits for used parts can be reused if installed within the same piston assembly from which they were removed.

The crown, pin and bushing of a crosshead piston assembly should be considered as matched. If a crown is replaced, the piston pin and bushing must also be replaced. The reason for this is that the bushing takes the shape of the saddle area of the piston dome during engine operation. Installing a used bushing in a new crown can result in uneven piston pin loading and possible piston pin damage. If a bushing needs replacement, a new pin must also be used. Conversely, if a new pin is required, the bushing must also be replaced. Before reusing any crosshead piston assembly components, see wear limits in this Section.

© 1982 General Motors Corp.

INSTALLATION OF STAINLESS STEEL INSERTS IN ALUMINUM BLOCK

To minimize electrolytic action between the aluminum cylinder block and the cast iron cylinder head and fresh water pump, stainless steel inserts have been added to the water inlet and outlet holes in the current cylinder blocks.

Inserts are available and may be added to early aluminum cylinder blocks by following the instructions for machining and installation as shown in Fig. 1.

The outer diameter of the inserts must be coated with a sealant such as Perfect Seal No. 3, or equivalent, at installation.

To further minimize electrolytic action, a cast iron water manifold replaces the aluminum manifold. However, the aluminum heat exchanger inlet elbow and a revised aluminum inlet elbow spacer are used with the cast iron manifold.

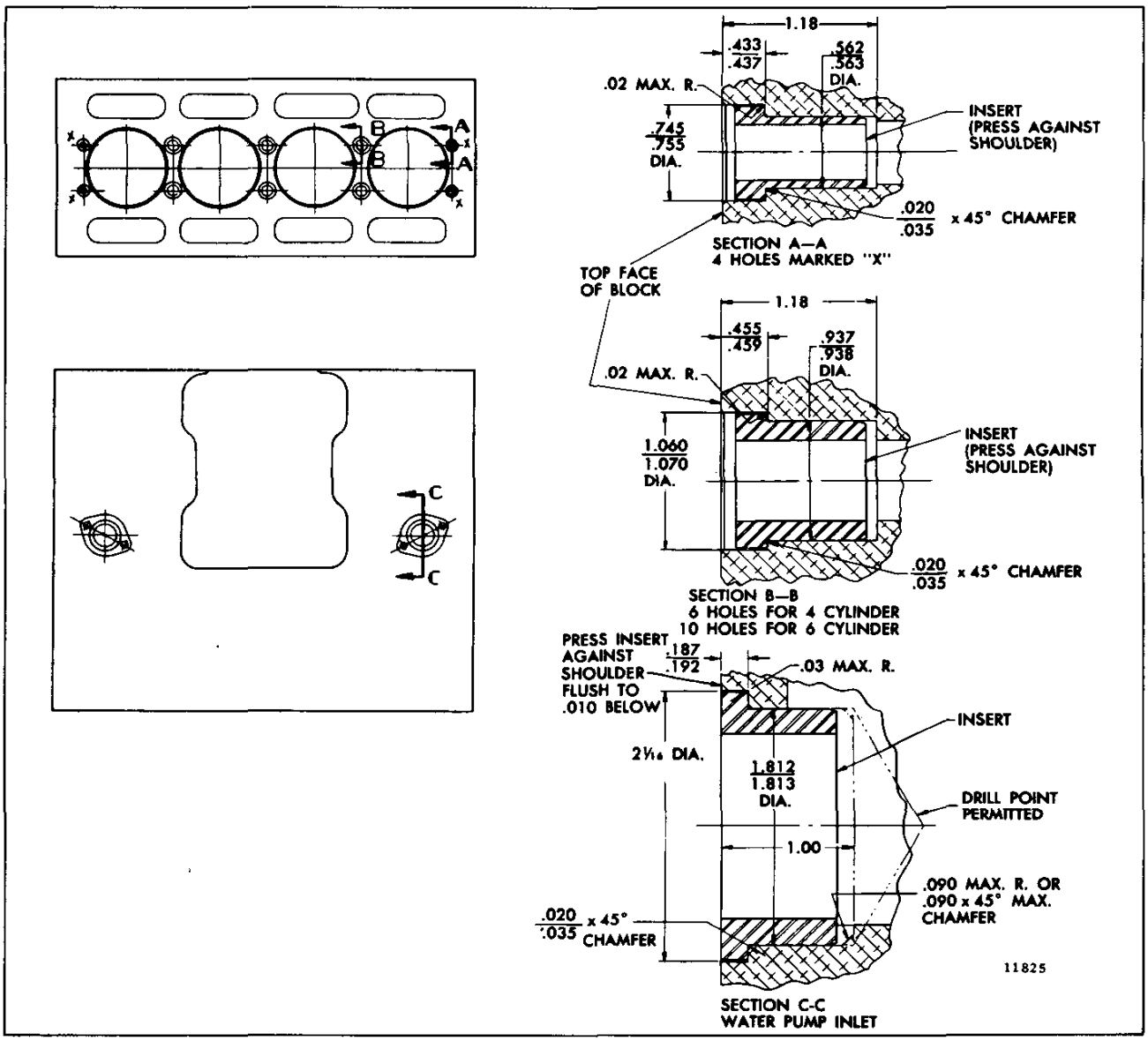


Fig. 1 - Installation of Water Hole Inserts in Aluminum Cylinder Block

© 1982 General Motors Corp.

The current cast iron cylinder head applicable to an engine with an aluminum block incorporates copper plated water nozzles, and the protective coating formerly applied to the internal surfaces has been discontinued. When a current cylinder head is to be installed on an early aluminum block, it is recommended that the water hole inserts be added to the block or a water filter be added to the unit. The filter will not stop electrolytic action, but will tend to retard it slightly.

CHECKING BEARING CLEARANCES

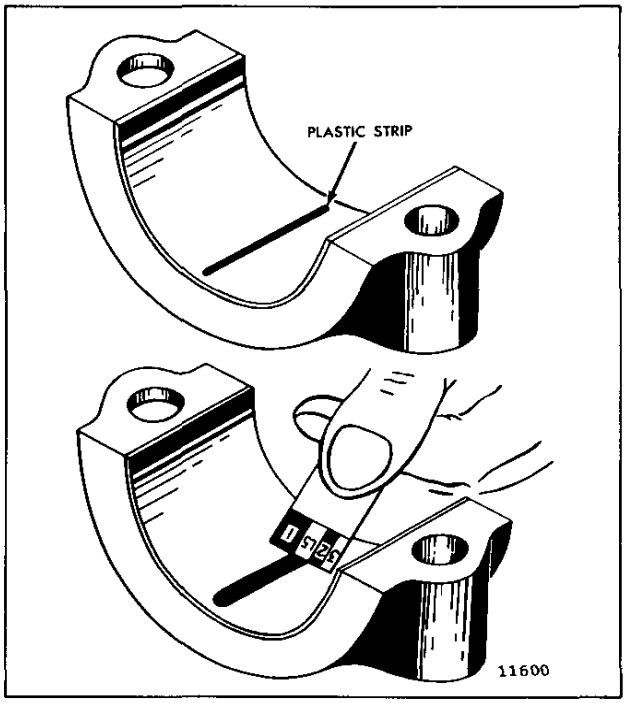


Fig. 2 - Using Plastic Strip to Measure Bearing-to-Crankshaft Clearance

A strip of soft plastic squeezed between the crankshaft journal and the connecting rod bearing or main bearing may be used to measure the bearing clearances.

The strip is a specially molded plastic "wire" manufactured commercially and is available in three sizes and colors. Type PG-1 (green) has a clearance range of .001" to .003", type PR-1 (red) has a range of .002" to .006" and type PB-1 (blue) has a range of .004" to .009".

The plastic strip may be used for checking the bearing clearances as follows:

1. Remove the bearing cap and wipe the oil from the bearing shell and the crankshaft journal.

> **NOTE:** When checking the main bearing clearances with the engine in a position where the main bearing caps are supporting the weight of the crankshaft and the flywheel, an erroneous reading, due to the weight of the crankshaft and flywheel, can be eliminated by supporting the weight of the crankshaft with a jack under the counterweight adjoining the bearing being checked.

2. Place a piece of the plastic strip the full width of the bearing shell, about 1/4" off center (Fig. 2).

3. Rotate the crankshaft about 30° from bottom dead center and reinstall the bearing cap. Tighten the bolts to the specified torque.

4. Remove the bearing cap. The flattened plastic strip will be found adhering to either the bearing shell or the crankshaft.

5. Compare the width of the flattened plastic strip at its widest point with the graduations on the envelope (Fig. 2). The number within the graduation on the envelope indicates the bearing clearance in thousandths of an inch. Taper may be indicated when one end of the flattened plastic strip is wider than the other. Measure each end of the plastic; the difference between the readings is the approximate amount of taper.

© 1982 General Motors Corp.

AIR BOX DRAIN TUBE CONVERTION

AIR BOX FLOOR CHECK VALVE

If replacement of the air box floor check valve becomes necessary, engines should be converted to the external, open air box drain system. Use this procedure:

1. Remove the two check valves from the floor of the air box at the No. 2 and No. 5 cylinder positions.

2. Apply 3M No. 971 Scotch-Grip Industrial Sealer, or equivalent, to the threads of two 3/4"-14 pipe plugs and install in the bottom drain openings.

3. Remove one of the plugs from either of the air box drain openings located at opposite ends of the block.

4. Install the components shown in Fig. 4 in Section 1.1.2.

REWORKING EARLY CYLINDER BLOCK FOR 71E or 71T ENGINES

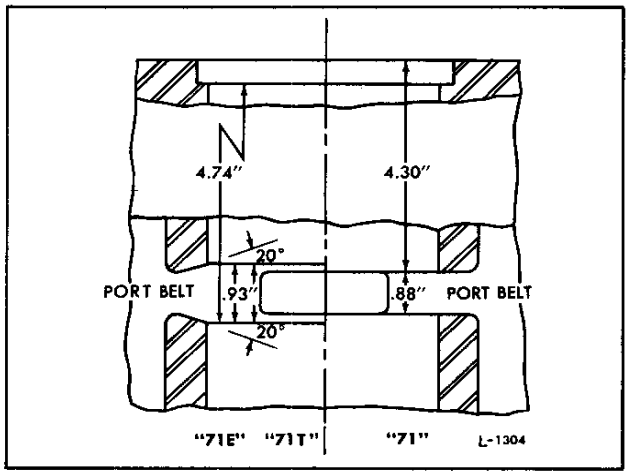


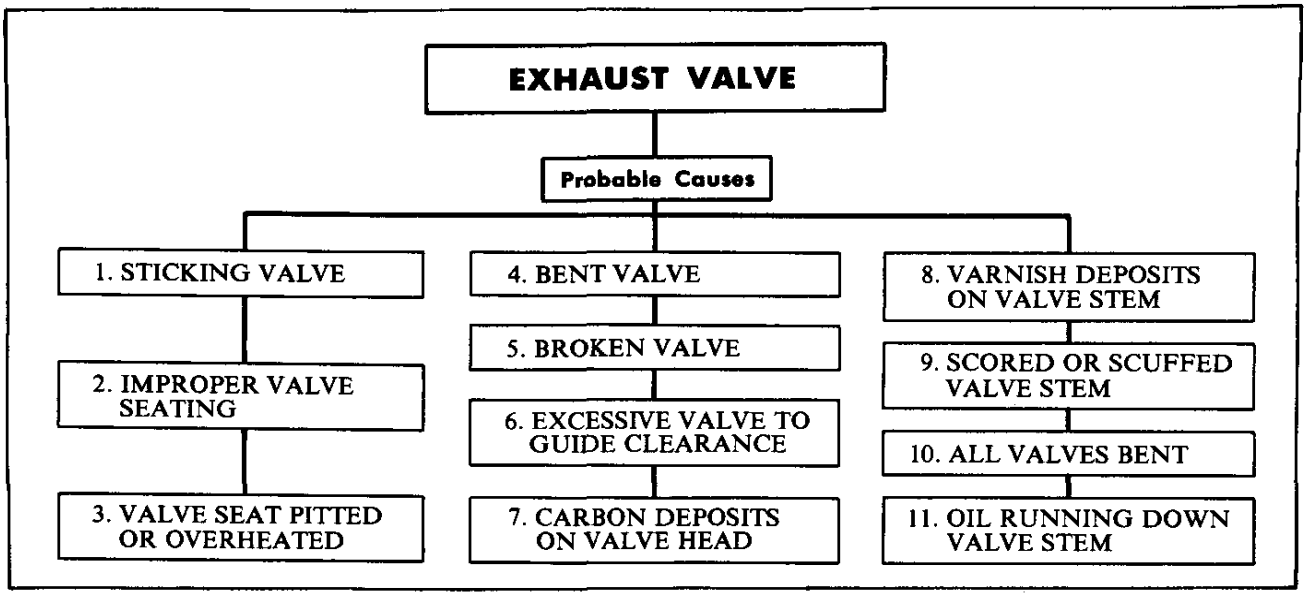
Fig. 3 - Cylinder Block Air Inlet Port Machining

The current service replacement cylinder blocks are applicable to all Series 71 engine models, including the 71E or 71T engines. The distance from the top surface of the current blocks to the top of the air inlet port opening is 3-63/64". This dimention was 4-19/64" on earlier service cylinder blocks. The larger port opening is required on 71E and 71T engines due to the increased port height of the cylinder liners used in these engine models. The port height of a service replacement block may be checked by inserting a 71E or 71T cylinder liner into the block bore and inspecting the liner ports through the hand hole in the side of the block.

The air inlet ports may be enlarged on an early block by grinding a small amount of metal from the port area as indicated in Fig. 3. This requires careful workmanship to avoid exceeding the dimensions shown. A 71E or 71T cylinder liner may be used as a gage to check the grinding operation.

© 1982 General Motors Corp.

TROUBLE SHOOTING



SUGGESTED REMEDY

1. Check for carbon deposits, a bent valve guide, defective spring or antifreeze (glycol) in the lubricating oil. Replace a bent guide. Clean-up and reface the valve. Replace the valve if necessary.

2. Check for excessive valve-to-guide clearance, bent valve guide or carbon deposits. Replace a bent or worn guide. Clean the carbon from the valve. Reface or replace the valve, if necessary.

3. Check the operating conditions of the engine for overload, inadequate cooling or improper timing. Reface the valve and insert. Replace the valve if it is warped or too badly pitted. Use a harder-face valve if the operating conditions warrant.

4. Check for contact between the valve head and the piston as a result of incorrect valve clearance, an improperly positioned exhaust valve bridge (four valve head) or a defective spring. Check the valve guide, insert, cylinder head and piston for damage. Replace damaged parts.

5. Check for excessive valve-to-guide clearance, a defective valve spring or etching of the valve stem at the weld. Improper valve clearance is also a cause of this type of failure. Check the guide, insert, cylinder head and piston for damage. Replace damaged parts.

6. Replace a worn valve guide. Check and replace the valve, if necessary.

7. Black carbon deposits extending from the valve seats to the guides indicates cold operation due to light loads or to the use of too heavy a fuel. Rusty brown valve heads with carbon deposits forming narrow collars near the guides indicate hot operation due to overloads, inadequate cooling or improper timing which results in carbonization of the lubricating oil. Clean-up the valves, guides and inserts. Reface the valves and inserts or replace them if they are warped, pitted or scored.

8. Check for a worn valve guide or excessive exhaust back pressure. Replace a worn guide. Check the valve seat for improper seating. Reface the valve and insert or, if necessary, replace.

9. Check for a bent valve stem or guide, metal chips or dirt, or for lack of lubrication. Clean up the valve stem with crocus cloth wet with fuel oil or replace the valve. Replace the guide. When installing a valve, use care in depressing the spring so that the spring cap DOES NOT scrape the valve stem.

10. Check for a gear train failure or for improper gear train timing.

11. Check the operation of the engine for excessive idling and resultant low engine exhaust back pressure. Install valve guide oil seals.

© 1982 General Motors Corp.

SPECIFICATIONS

Specifications, clearances and wear limits are listed below. It should be specifically noted that the clearances apply only when all new parts are used at the point where the various specifications apply. This also applies to references within the text of the manual. The column entitled "Limits" in this chart lists the amount of wear or increase in clearance which can be tolerated in used engine parts and still ensure satisfactory performance. It should be emphasized that the figures given as "Limits" must be qualified by the judgement of personnel responsible for installing new parts. These wear limits are, in general, listed only for the parts more frequently replaced in engine overhaul work. For additional information, refer to the text.

TABLE OF SPECIFICATIONS, NEW CLEARANCES AND WEAR LIMITS

These limits also apply to oversize and undersize parts

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Cylinder Block			
Block bore:			
Diameter (cast iron block)	4.6256"	4.6270"	
Diameter (aluminum block)	4.6250"	4.6265"	
Out-of-round		.0010"	.0020"
Taper		.0010"	.0020"
Cylinder liner counterbore:			
Diameter	5.0460"	5.0485"	
Depth (cast iron high block)	.4770"	.4795"	
Depth (aluminum high block)	.5470"	.5495"	
Main bearing bore:			
Inside diameter (vertical axis)	3.8120"	3.8130"	
Top surface of block:			
Centerline main bearing bore to block top	16.1840"	16.1890"	16.176" min.
Flatness--transverse (3, 4 and 6 cyl.)			.0030"
Flatness--longitudinal (3 cyl.)			.0060"
Flatness--longitudinal (4 cyl.)			.0070"
Flatness--longitudinal (6 cyl.)			.0090"
Depth of counterbores (top surface):			
Cylinder head seal strip groove	.0920"	.1070"	
Large water holes (between cylinders)	.1090"	.1200"	
Small water holes (at ends)	.0870"	.0980"	
Combination water and oil holes	.0870"	.0980"	
Cylinder Liner			
Outside diameter	4.6250"	4.6265"	
Inside diameter	4.2489"	4.2511"	
Clearance--liner-to-block:			
Cast iron block (high)	.0000"	.0020"	.0025"
Aluminum block	.001" loose	.001" press.	.0015" loose
Out-of-round--inside diameter		.0020"	.0025"
Taper--inside diameter		.0010"	.0020"
Depth of flange BELOW block	.0450"	.0500"	.0500"
Variation in depth between adjacent liners		.0020"	.0020"
Insert thickness	.1795"	.1800"	

© 1982 General Motors Corp.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Trunk Type Pistons and Rings			
71 Engines			
Piston:			
Height (centerline of bushing to top)	3.5130"	3.5180"	
Diameter (above compression rings)	4.2190"	4.2220"	
Diameter (at skirt)	4.2433"	4.2455"	
Clearance--piston skirt-to-liner (long port)	.0040"	.0078"	.0120"
Clearance--piston skirt-to-liner (short port)	.0040"	.0083"	.0120"
Out-of-round		.0005"	
Taper		.0005"	
Compression rings:			
Gap	.0180"	.0430"	.0600"
Clearance--ring-to-groove:			
No. 1 (top)	.0095"	.0130"	.0220"
No. 2	.0075"	.0110"	.0150"
No. 3 and 4	.0055"	.0090"	.0130"
Oil control rings:			
Gap	.0080"	.0230"	.0430"
Clearance--ring-to-groove	.0015"	.0055"	.0080"
71E Engines			
Piston:			
Height (centerline of bushing to top):			
Two valve head engine	3.3880"	3.3930"	
Four valve head engine	3.5130"	3.5180"	
Diameter (above compression rings):			
Two valve head engine	4.2217"	4.2247"	
Four valve head engine (60 cmm inj.)	4.2230"	4.2260"	
Four valve head engine (70 cmm inj.)	4.2190"	4.2220"	
Diameter (at skirt):			
Two valve head engine	4.2433"	4.2455"	
Four valve head engine (60 cmm inj.)	4.2433"	4.2455"	
Four valve head engine (70 cmm inj.)	4.2418"	4.2440"	
Clearance--piston skirt-to-liner:			
Two valve head engine	.0040"	.0078"	.0120"
Four valve head engine (60 cmm inj.)	.0040"	.0078"	.0120"
Four valve head engine (70 cmm inj.)	.0055"	.0093"	.0120"
Out-of-round		.0005"	
Taper		.0005"	
Compression rings:			
Gap (top-fire ring)	.0230"	.0380"	.0600"
Gap (No. 2, 3 and 4)	.0180"	.0430"	.0600"
Clearance--ring-to-groove:			
No. 1 (top, fire ring)	.0040"	.0070"	.0100"
No. 2	.0095"	.0130"	.0220"
No. 3	.0075"	.0110"	.0150"
No. 4	.0055"	.0090"	.0130"
Oil control rings:			
Gap	.0080"	.0230"	.0430"
Clearance--ring-to-groove	.0015"	.0055"	.0080"

© 1982 General Motors Corp.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
71M Engines			
Piston:			
Height (centerline of bushing to top)	3.5130"	3.5180"	
Diameter (above compression rings)	4.2230"	4.2260"	
Diameter (at skirt)	4.2418"	4.2440"	
Clearance--piston skirt-to-liner	.0055"	.0093"	.0120"
Out-of-round		.0005"	
Taper		.0005"	
Compression rings:			
Gap (top-fire ring)	.0230"	.0380"	.0600"
Gap (No. 2, 3 and 4)	.0180"	.0430"	.0600"
Clearance--ring-to-groove:			
No. 1 (top-fire ring)	.0040"	.0070"	.0100"
No. 2	.0095"	.0130"	.0220"
No. 3	.0075"	.0110"	.0150"
No. 4	.0055"	.0090"	.0130"
Oil control rings:			
Gap	.0080"	.0230"	.0430"
Clearance--ring-to-groove	.0015"	.0055"	.0080"
71N Engines			
Piston:			
Height (centerline of bushing to top)	3.5430"	3.5480"	
Diameter (above compression rings)	4.2225"	4.2255"	
Diameter (at skirt)	4.2428"	4.2450"	
Clearance--piston skirt-to-liner	.0045"	.0083"	.0120"
Out-of-round		.0005"	
Taper		.0005"	
Compression rings:			
Gap (top-fire ring)	.0230"	.0380"	.0600"
Gap (No. 2, 3 and 4)	.0180"	.0430"	.0600"
Clearance--ring-to-groove:			
No. 1 (top-fire ring)	.0040"	.0060"	.0100"
No. 2	.0100"	.0130"	.0220"
No. 3 and 4	.0040"	.0070"	.0130"
Oil control rings:			
Gap	.0080"	.0230"	.0430"
Clearance	.0015"	.0055"	.0080"
71T Engines			
Piston:			
Height (centerline of bushing to top)	3.3880"	3.3930"	
Diameter (above compression rings)	4.2197"	4.2227"	
Diameter (at skirt)	4.2413"	4.2435"	
Clearance--piston skirt-to-liner	.0060"	.0098"	.0120"
Out-of-round		.0005"	
Taper		.0005"	
Compression rings:			
Gap	.0180"	.0430"	.0600"
Clearance--ring-to-groove:			
No. 1	.0095"	.0130"	.0220"
No. 2	.0075"	.0110"	.0150"
No. 3 and 4	.0055"	.0090"	.0130"
Crankcase seal ring:			
Gap	.0050"	.0400"	.0400"
Clearance	.0100"	.0150"	.0170"

© 1982 General Motors Corp.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Oil control rings:			
Gap (two rings in lower groove)	.0050"	.0140"	.0340"
Gap (one ring in upper groove)	.0050"	.0140"	.0340"
Clearance (two rings in lower groove)	.0015"	.0055"	.0080"
Clearance (one ring in upper groove)	.0010"	.0035"	.0060"
Piston Pins (Trunk Pistons)			
Length	3.6050"	3.6200"	
Diameter	1.4996"	1.5000"	1.4980"
Clearance--pin to piston bushing	.0025"	.0034"	.0100"
Clearance--pin to conn. rod bushing	.0025"	.0034"	.0100"
Clearance--end (pin-to-retainer--retainer with lock ring)	.0160"	.0640"	.0640"
Piston bushing--inside diameter	1.5025"	1.5030"	1.5050"
Connecting Rod			
Inside diameter (upper bushing)	1.5025"	1.5030"	1.5080"
Normal side clearance	.0060"	.0120"	
Cross-Head Pistons and Rings 71N and 71T Engines			
Piston crown:			
Saddle-to-crown distance:			
N piston (18.7:1 compr. ratio)	2.7030"	2.7100"	
T piston (17:1 compr. ratio)	2.6730"	2.6800"	
Diameter:			
At top	4.2226"	4.2256"	
Below both compression rings	4.2391"	4.2421"	
Above and below seal ring groove	3.8850"	3.8950"	
Above and below bearing saddle	3.2360"	3.2370"	
Compression rings:			
Gap (top-fire ring)	.0230"	.0380"	.0600"
Gap (No. 2 and 3)	.0180"	.0430"	.0600"
Clearance--ring-to-groove:			
*Top (Keystone fire ring)	.0010"	.0050"	.0070"
No. 2 (rectangular section)	.0100"	.0130"	.0220"
No. 3 (rectangular section)	.0040"	.0070"	.0130"
Seal ring:			
Gap (in skirt counterbore)	.0020"	.0210"	.0270"
Clearance	.0005"	.0030"	.0040"
Piston skirt:			
†Diameter	4.2428"	4.2450"	
Clearance--skirt-to-liner	.0045"	.0083"	.0120"
Seal ring bore	3.9200"	3.9240"	3.9260"
Piston pin bore	1.5000"	1.5030"	1.5040"
Oil control rings:			
Gap (two rings in lower groove)(71N&T engines)	.0080"	.0230"	.0430"
Gap (two rings in upper groove)(71N engine)	.0080"	.0230"	.0430"
Gap (one ring in upper groove) (71T engine)	.0050"	.0140"	.0340"
Gap (two rings in upper groove) (71T engine)	.0080"	.0230"	.0430"
Clearance (lower groove)	.0015"	.0055"	.0080"
Clearance (upper groove)	.0010"	.0035"	.0060"

*Measured with Keystone fire ring flush with outside diameter of piston crown.
†Diameter above and below the piston pin may be 4.2414".

© 1983 General Motors Corp.

ENGINE PARTS (Stand Size, New)	MINIMUM	MAXIMUM	LIMITS
Piston Pins (Cross-Head Piston)			
Length	3.6150"	3.6250"	
Diameter	1.4996"	1.5000"	1.4980"
Slipper bearing (bushing):			
Thickness at center	.0870"	.0880"	.0860"
Clearance (edge of bushing to groove in piston)	.0005"	.0105"	.0120"
Crankshaft			
Journal diameter--main bearing	3.4990"	3.5000"	
Journal diameter--conn. rod bearing	2.7490"	2.7500"	
Journal out-of-round		.00025"	.0010"
Journal taper		.0005"	.0015"
§Runout on journals--total indicator reading:			
3 cylinder (mounted on No. 1 and No. 4 journals):			
At No. 2 and No. 3 journals		.0020"	
4 cylinder (mounted on No. 1 and No. 5 journals):			
At No. 2 and No. 4 journals		.0020"	
At No. 3 journal		.0040"	
6 cylinder (mounted on No. 1 and No. 7 journals):			
At No. 2 and No. 6 journals		.0020"	
At No. 3 and No. 5 journals		.0040"	
At No. 4 journal		.0060"	
Thrust washer thickness	.1190"	.1220"	
End play (end thrust clearance)	.0040"	.0140"	.0180"
Connecting Rod Bearings			
Inside diameter (vertical axis)	2.7514"	2.7534"	
Bearing-to-journal clearance	.0014"	.0044"	.0060"
Bearing thickness 90° from parting line	.1548"	.1553"	.153" min.
Main Bearings			
Inside diameter (vertical axis)	3.5014"	3.5034"	
Bearing-to-journal clearance	.0014"	.0044"	.0060"
Bearing thickness 90° from parting line	.1548"	.1553"	.153" min.
Camshaft			
Diameter (at bearing journals):			
Front and rear	1.4970"	1.4975"	
Center and intermediate	1.4980"	1.4985"	
Runout at center bearing mounted end bearings		.0020"	
Shaft diameter at gear	1.1875"	1.1880"	
End thrust	.0030"	.0150"	.0180"
Thrust washer thickness	.1190"	.1220"	
Balance Shaft			
Shaft diameter at bearings	1.4970"	1.4975"	
Shaft diameter at gear	1.1875"	1.1880"	
Length--thrust bearing end journal	2.8740"	2.8760"	
End thrust	.0030"	.0150"	.0180"
Thrust washer thickness	.1190"	.1220"	

§Runout tolerance given for guidance when regrinding crankshaft. When the runout on adjacent journals is in the opposite direction, the sum must not exceed .003" total indicator reading. When the runout on adjacent journals is in the same direction, the difference must not exceed .003" total indicator reading. When high spots of the runout on adjacent journals are at right angles to each other, the sum must not exceed .004" total indicator reading or .002" on each journal.

© 1983 General Motors Corp.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Camshaft and Balance Shaft Bearings			
Inside diameter:			
Front and rear	1.5000"	1.5010"	
Center and intermediate	1.5010"	1.5030"	
Clearance--bearing-to-shaft:			
Front and rear	.0025"	.0040"	.0060"
Center and intermediate	.0025"	.0050"	.0090"
Outside diameter:			
Front and rear	2.1875"	2.1880"	
Center and intermediate	2.1840"	2.1860"	
Diameter of cylinder block bore	2.1875"	2.1885"	
Clearance--bearings-to-block:			
Front and rear	.001" press.	.0005" loose	
Intermediate (extruded)	.0015"	.0065"	
Intermediate (die cast)	.0015"	.0105"	
Camshaft and Balance Shaft Gears			
Inside diameter	1.1865"	1.1875"	
Clearance--gear-to-shaft	.0015" press.	.0000"	
Backlash	.0030"	.0080"	.0100"
Idler Gear			
Backlash	.0030"	.0080"	.0100"
Pre-load--Variation on pull 2 lbs. 11 oz.	1/2 lb.	4 lbs.	
Crankshaft Timing Gear			
Inside diameter	4.7490"	4.7500"	
Clearance--gear-to-shaft	.001" press.	.001" loose	
Backlash	.0030"	.0080"	.0100"
Blower Drive Gear			
Backlash	.0030"	.0080"	.0100"
Gear-to-hub fit	.0005" press.	.001" loose	
Support-to-end plate	.0005" press.	.0025" loose	
Inside diameter (support bushing)	1.6260"	1.6265"	
Hub diameter (at bearing)	1.6240"	1.6250"	
Hub-to-support bushing clearance	.0010"	.0025"	.0050"
Hub-to-cam clearance	.0020"	.0070"	
End thrust (current bearing)	.0060"	.0140"	
End thrust (former flanged bearing)	.0050"	.0080"	.0100"
Cylinder Head			
Flatness--transverse (3, 4 and 6 cyl.)			.0040"
Flatness--longitudinal (3 cyl.)			.0055"
Flatness--longitudinal (4 cyl.)			.0080"
Flatness--longitudinal (6 cyl.)			.0100"
Distance between top deck and fire deck	3.5560"	3.5680"	3.5360"
Water nozzles	.0312" Recess	Flush	
Cam follower bores	1.0620"	1.0630"	1.0650"
Exhaust Valve Seat Inserts			
Seat width--45° (2-valve)	.0781"	.1094"	.1094"
Seat width--31° (2-valve)	.0625"	.0937"	.0937"
Seat width--31° (4-valve)	.0468"	.0937"	.0937"
Valve seat runout		.0020"	.0020"

© 1982 General Motors Corp.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Exhaust Valves			
Stem diameter (2-valve)	.3417"	.3425"	.3405"
Stem diameter (4-valve)	.3100"	.3105"	.3090"
Valve head-to-cylinder head:			
45° (2-valve)	.005" recess	.017" protr.	
30° (former 2-valve and 4-valve)	.002" recess.	.028" protr.	
30° (current 2-valve and 4-valve)	.023" recess.	.006" protr.	.038" recess.
Valve Guides			
Height above cylinder head:			
2-valve	1.5938"	1.5938"	
4-Valve (chamfered guide)	.8800"	.8800"	
4-valve (machined guide)	.6900"	.6900"	
Diameter--inside (2-valve)	.3445"	.3455"	.3465"
Diameter--inside (4-valve)	.3125"	.3135"	.3140"
Clearance--valve-to-guide (2-valve)	.0020"	.0038"	.0060"
Clearance--valve-to-guide (4 valve)	.0020"	.0035"	.0050"
Valve Bridge Guides			
Height above cylinder head (4-valve)	2.0400"	2.0400"	
Rocker Arms and Shafts			
Diameter--rocker shaft	.8735"	.8740"	
Diameter--inside (rocker arm bushing)	.8750"	.8760"	
Clearance--shaft-to-bushing	.0010"	.0025"	.0040"
Cam Followers			
Diameter	1.0600"	1.0610"	
Clearance--follower-to-head	.0010"	.0030"	.0060"
Rollers and pins:			
Clearance--pin-to-bushing	.0013"	.0021"	.010" Horiz.
Side clearance--roller to follower	.0110"	.0230"	.0230"

© 1982 General Motors Corp.

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb-ft)	Nm	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	Nm
1/4 -20	5- 7	7- 9	1/4 -20	7-9	10-12
1/4 -28	6- 8	8-11	1/4 -28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8 -16	23-26	31-35	3/8 -16	30-35	41-47
3/8 -24	26-29	35-40	3/8 -24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2 -13	53-56	72-76	1/2 -13	71-75	96-102
1/2 -20	62-70	84-95	1/2 -20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8 -11	103-110	140-149	5/8 -11	137-147	186-200
5/8 -18	126-134	171-181	5/8 -18	168-178	228-242
3/4 -10	180-188	244-254	3/4 -10	240-250	325-339
3/4 -16	218-225	295-305	3/4 -16	290-300	393-407
7/8 - 9	308-315	417-427	7/8 - 9	410-420	556-569
7/8 -14	356-364	483-494	7/8 -14	475-485	644-657
1 - 8	435-443	590-600	1 - 8	580-590	786-800
1 -14	514-521	697-705	1 -14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74,000 60,000
 Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
 Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
 Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
 Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
 Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

12252

BOLT IDENTIFICATION CHART

© 1982 General Motors Corp.

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	C.I. ENGINE TORQUE (lb-ft)	C.I. ENGINE TORQUE (Nm)	ALUM. ENGINE TORQUE (lb-ft)	ALUM. ENGINE TORQUE (Nm)
Cam follower guide bolt	1/4 -20	12-15	16-20	7-9	10-12
Injector control shaft bracket bolt	1/4 -20	10-12	14-16	--	--
Oil pan bolts	5/16-18	10-20	14-27	10-20	14-27
Blower drive coupling to gear hub bolt	5/16-24	20-25	27-34	20-25	27-34
Exhaust valve bridge adjusting screw lock nut	5/16-24	20-25	27-34	--	--
Idler gear bearing retainer bolts	5/16-24	24-29	33-39	24-29	33-39
Air box cover bolt	3/8 -16	10-15	14-20	10-15	14-20
Balance weight cover bolts	3/8 -16	25-30	34-41	25-30	34-41
Cam and balance shaft end bearing bolts	3/8 -16	35-40	47-54	--	--
Crankshaft front cover bolts	3/8 -16	--	--	25-30	34-41
End plate bolts	3/8 -16	--	--	25-30	34-41
Engine drive shaft flexible coupling	3/8 -16	25-30	34-41	--	--
Flywheel housing bolts	3/8 -16	--	--	25-30	34-41
*Idler gear hub and spacer bolts	3/8 -16	40-45	54-61	--	--
§Idler gear hub and spacer bolts	3/8 -16	25-40	34-54	--	--
Injector clamp bolts	3/8 -16	20-25	27-34	--	--
Accessory drive to gear bolt (steel disc)	3/8 -24	45-50	61-68	45-50	61-68
Balance weight cover bolts	3/8 -24	25-30	34-41	25-30	34-41
Balance weight to hub bolt	3/8 -24	25-30	34-41	25-30	34-41
Balance weight to timing gear bolt	3/8 -24	25-30	34-41	25-30	34-41
Blower drive gear hub bearing support bolts and nuts	3/8 -24	25-30	34-41	25-30	34-41
Camshaft intermediate bearing lock screw	3/8 -24	15-20	20-27	15-20	20-27
Crankshaft front cover bolts	3/8 -24	25-30	34-41	--	--
Exhaust manifold outlet flange nuts (brass)	3/8 -24	20-25	27-34	20-25	27-34
Flywheel housing bolts	3/8 -24	25-30	34-41	25-30	34-41
Fuel pipe nuts	3/8 -24	12-15	16-20	12-15	16-20
Injector clamp nut	3/8 -24	20-25	27-34	20-25	27-34
Water manifold nuts	3/8 -24	25-30	34-41	20-25	27-34
Air compressor adjusting support pivot bolt (300M)	7/16-14	72-77	98-104	--	--
Generator drive bearing retaining bolt	7/16-14	30-35	41-47	--	--
Generator drive oil seal retaining bolt	7/16-14	30-35	41-47	--	--
Lifter bracket bolt	7/16-14	55-60	75-81	35-40	47-54
Tachometer drive cover bolt	7/16-14	30-35	41-47	--	--
Connecting rod nut (castellated)	7/16-20	65-75	88-102	65-75	88-102
Connecting rod nut (lubrite)	7/16-20	60-70	81-95	60-70	81-95
**Cross-head piston pin to conn. rod bolt	7/16-20	55-60	75-81	--	--
Exhaust manifold nuts	7/16-20	30-35	41-47	25-30	34-41
Fuel manifold connectors (steel washer)	7/16-20	40-45	54-61	40-45	54-61
#Fuel manifold connectors (nylon insert)	7/16-20	30-35	41-47	30-35	41-47
Fuel manifold connector nuts	7/16-20	30-35	41-47	30-35	41-47

© 1982 General Motors Corp.

APPLICATION	THREAD SIZE	C.I. ENGINE TORQUE (lb-ft)	C.I. ENGINE TORQUE (Nm)	ALUM. ENGINE TORQUE (lb-ft)	ALUM. ENGINE TORQUE (Nm)
Crankshaft front cover bolts	1/2 -13	80-90	108-122	--	--
Flywheel housing bolts	1/2 -13	90-100	122-136	71-75	96-102
Generator drive bearing retaining bolt	1/2 -13	30-35	41-47	--	--
Generator drive oil seal retaining bolt	1/2 -13	30-35	41-47	--	--
Idler gear and dummy hub bolt	1/2 -13	80-90	108-122	50-55	68-75
@Rocker shaft bolts	1/2 -13	90-100	122-136	--	--
Tachometer drive cover bolt	1/2 -13	30-35	41-47	--	--
Blower rotor gear retaining nut	1/2 -20	55-65	75-88	--	--
**Cylinder head bolts	5/8 -11	175-185	238-251	--	--
**Main bearing bolts (assembly) (see Sect. 1.3.4)	5/8 -11				
**Main bearing bolts (boring)	5/8 -11	165-175	224-238	165-175	224-238
**Cylinder head nuts	5/8 -18	175-185	238-251	140-160	190-217
**Main bearing nuts (assembly)	5/8 -18	155-185	211-251	120-140	163-190
**Main bearing nuts (boring)	5/8 -18	140-155	190-211	110-120	150-163
**Flywheel bolts (see Sect. 1.4)	9/16-18				
Accessory drive pulley nut	3/4 -16	120-140	163-190	--	--
Crankshaft end bolt	1 -14	290-310	393-421	290-310	393-421
Camshaft and balance shaft nut	1 1/8 -18	300-325	407-441	300-325	407-441
Blower drive gear hub nut	1 1/2 -16	50-60	68-81	50-60	68-81

†These specifications apply where bolts or studs are threaded into aluminum.
*Self-locking only.
§Wired head only.
@75-85 lb-ft (102-115 Nm) torque on the two bolts attaching load limit or power control screw bracket (if used) to the rocker arm shaft bracket.
**Lubricate at assembly with International Compound No. 2, or equivalent (refer to Parts Catalog or Microfiche, Section 12.8000A).

STANDARD PIPE PLUG TORQUE SPECIFICATIONS

Use sealing compound on plugs without gaskets or teflon.

NPTF SIZE THREAD	TORQUE (lb-ft)	TORQUE (Nm)	NPTF SIZE THREAD	TORQUE (lb-ft)	TORQUE (Nm)
1/8	10-12	14-16	1	75-85	102-115
1/4	14-16	19-22	1-1/16	85-95	115-129
3/8	18-22	24-30	1-1/4	95-105	129-143
1/2	23-27	31-37	1-1/2	110-130	150-177
3/4	33-37	45-50			

© 1982 General Motors Corp.

SPECIAL PLUG TORQUE SPECIFICATIONS

APPLICATION	*PLUG	ASSEMBLY
Oil gallery plug	3/8" Dryseal PTF thread	†Assemble with max. 0.0625" protrusion from surface
Cylinder head (side)	3/8-16"	Assemble flush to 0.0625" protrusion from surface
Cylinder head (top)	1/2" PTF-SAE short	Flush to 1.1250" recessed
Cylinder head (end)	3/4" Dryseal PTF-SAE short	Flush to 0.1250' recessed
Water hole plug	1" NPTF thread	Assemble 2.000" to 2.250" below machined surface
Core hole plug	1 3/4"-16	150-180 lb-ft (204-244 Nm) torque
Oil drain plug (Nylon washer)	18mm	25-35 lb-ft (34-37 Nm) torque

*Apply sealing compound to plugs used without gaskets or teflon.
†After installation, a 1.2187" diameter rod inserted in oil line must pass inner face of plug.

STUD TORQUE SPECIFICATIONS

APPLICATION	TORQUE (lb-ft)	TORQUE (Nm)	HEIGHT (± .0312")
Cylinder head stud	75 min.	102 min.	4.3750"
Cylinder head stud (two end studs on blower side of aluminum block)	--	--	4.3750"
Cylinder head stud (all other positions of aluminum block)	--	--	4.5625"
Main bearing stud (cast iron block)	35-70	47-95	4.0000"
Main bearing stud (aluminum block)	55 min.	75 min.	4.0000"
Exhaust manifold stud	25-40	34-54	--
Injector clamp stud	10-25	14-34	--
Water manifold stud	10-25	14-34	--

SPRING SPECIFICATIONS

SPRING	REPLACE WHEN LOAD IS LESS THAN:
Cam follower (11 coils - .177" wire)	172 lbs.@2.1250"
Cam follower (11 1/2 coils - .162" wire)	133 lbs.@2.1094"
Exhaust valve (two-valve cylinder head)	25 lbs.@2.2000"
§Exhaust valve and bridge guide (9 3/4 coils - .135" wire) (former)	79 lbs@1.4160"
§Exhaust valve (8 3/4 coils - .148" wire) (current)	25 lbs.@1.8000"

§Four-valve cylinder head.

© 1982 General Motors Corp.

SERVICE TOOLS

TOOL NAME	TOOL NO.
Cylinder Block	
Cylinder Checking Gage and Master Ring Set	J 9353
Cylinder Hone Set (2 1/2" to 5 3/4")	J 5902-01
Dial Bore Gage Master Setting Fixture	J 23059-01
Dial Indicator Set	J 22273-01
Diesel Engine Parts Dolly	J 6387
Engine Overhaul Stand	J 6837-C
Engine Overhaul Stand Adaptor Plate	J 8196
Special Plug Remover	J 21996-01
Cylinder Head	
Cam Follower Service Fixture	J 5840-01
Cylinder Head Holding Plate Set	J 3087-01
Cylinder Head Pressure Checking Tool	J 28454
Feeler Gage Set (.0015" to .015")	J 3172
Feeler Stock (.0015")	J 23185
Guide Studs	J 9665
Push Rod Remover (set of 3)	J 3092-01
Slide Hammer	J 2619-01
Socket (Fuel Line Nut)	J 8932-01
Spring Tester	J 22738-02
Valve Bridge Holding Fixture	J 21772
Valve Bridge Guide Remover (Broken)	J 7453
Valve Bridge Guide Remover Set (Press Fit)	J 7091-01
Valve Bridge Guide Installer (Press Fit)	J 7482
Valve Bridge Guide Remover and Installer (Threaded - 4 Valve Head)	J 6846
Valve Guide Cleaner	J 5437
Valve Guide Installer (2-Valve Head)	J 4144
Valve Guide Installer (45° 2-Valve Head)	J 9530
Valve Guide Installer (45° 4-Valve Head)	J 9729
Valve Guide Installer (Machined 4-Valve Head)	J 21520
Valve Guide Remover (2-Valve Head)	J 267
Valve Guide Remover (4-Valve Head)	J 6569
Valve Seat Dial Gage	J 8165-2
Valve Seat Grinder	J 8165-1
Valve Seat Grinder Adaptor Set (2-Valve Head)	J 8165-8
Valve Seat Grinder Adaptor Set (4-Valve Head)	J 6390-02
Valve Seat Insert Installer (2-Valve Head)	J 1736
Valve Seat Insert Installer (4-Valve Head)	J 6568
Valve Seat Insert Remover (31° 2-Valve Head)	J 4824-03
Valve Seat Insert Remover (45° 4-Valve Head)	J 3091-02
Valve Seat Insert Remover (4-Valve Head)	J 6567-02
Valve Spring Checking Gage	J 25076-B
Valve Spring Compressor	J 7455
Crankshaft	
Crankshaft Front Oil Seal Installer	J 9783
Crankshaft Oil Seal Expander	J 22425
Crankshaft Pulley and Rubber Mounted Balancer Puller	J 5356
Crankshaft Rear Oil Seal Installer	J 9727
Crankshaft Rear Oil Seal Expander *(Oversize Seal)*	J 4195-01

© 1982 General Motors Corp.

TOOL NAME	TOOL NO.
Crankshaft Rear Oil Seal Service Sleeve Installer	J 4194-01
Dial Indicator Set	J 5959-01
Driver Handle	J 3154-1
Driver Handle	J 8092
Micrometer Ball Attachment	J 4757
Universal Bar Type Puller	J 24420
Flywheel	
Flywheel Lifting Fixture	J 25026
Flywheel Lifting Tool	J 6361-01
Oil Seal Removing and Replacing Tool Set	J 3154-04
Slide Hammer Set	J 5901-01
Flywheel Housing	
Crankshaft Oil Seal Expander	J 22425
Crankshaft Oil Seal Expander (O.S. Seal)	J 4195-01
Driver Handle	J 8092
Flywheel Housing Aligning Studs (Set of 4)	J 1927-01
Flywheel Housing Concentricity Gage Set	J 9737-C
Piston, Connecting Rod and Cylinder Liner	
Connecting Rod Bolt Hole Reamer	J 28460
Connecting Rod Bushing Reamer Set	J 1686-D
Connecting Rod Holding Fixture	J 7632
Connecting Rod Spray Nozzle Remover	J 8995
Crosshead Piston Dome Disassembly Tool	J 33048
Cylinder Checking Gage and Master Ring Set	J 9353
Cylinder Hone Set (2 1/2" to 5 3/4" range)	J 5902-01
Cylinder Liner Hold-Down Clamp	J 21793-B
Cylinder Liner Remover Set	J 1918-02
Dial Bore Gage Setting Fixture	J 23059-01
Dial Indicator Set	J 22273-01
Feeler Gage Set	J 3172
Fire Ring Groove Gage (cross-head piston)	J 24599
Micrometer Ball Attachment	J 4757
Piston and Connecting Rod Bushing Installer and Remover Set	J 1513-02
Piston Bushing Reamer Set	J 3071-01
Piston Bushing Reaming Fixture	J 5273
Piston Crown Identification Gage (cross-head)	J 25397
Piston Pin Alignment Tool	J 24285
Piston Pin Retainer Installer (Trunk-type piston)	J 24107-01
Piston Pin Retainer Installer (Cross-head piston)	J 23762
Piston Pin Retainer Leak Detector	J 23987-01
Piston Ring Compressor	J 3272-03
Piston Ring Remover and Installer	J 8128
Piston to Liner Feeler Gage Set	J 5438-01
Seal Ring Compressor (cross-head piston)	J 23453
Camshaft	
Accessory Drive Hub Oil Seal Aligning Tool	J 21166
Blower Drive Cam Installer	J 1471
Camshaft Gear Puller	J 1902-01
Camshaft Gear Puller Adaptor Plate Set	J 6202-01
Camshaft and Oil Pump Gear Replacer	J 1903
Dial Indicator and Attachment Set	J 5959-01
Slide Hammer Set	J 6471-02
Spring Scale	J 8129

© 1982 General Motors Corp.

SECTION 2

FUEL SYSTEM AND GOVERNORS

CONTENTS

Fuel System	2
Fuel Injector (Crown Valve)	2.1
Fuel Injector (Needle Valve)	2.1.1
Fuel Injector Tube	2.1.4
Fuel Pump	2.2
Fuel Strainer and Fuel Filter	2.3
Fuel Manifold	2.4
Fuel Cooler	2.5.1
Mechanical Governors	2.7
Limiting Speed Mechanical Governor	2.7.1
Limiting Speed Mechanical Governor (Fuel Modulating)	2.7.1.1
Limiting Speed Mechanical Governor (Dual High-Speed Range)	2.7.1.2
Limiting Speed Mechanical Governor (Variable Low-Speed)	2.7.1.3
Limiting Speed Mechanical Governor (Fast Idle Cylinder)	2.7.1.4
Limiting Speed Mechanical Governor (Variable High-Speed)	2.7.1.5
Variable Speed Mechanical Governor	2.7.2
Constant Speed Mechanical Governor	2.7.3
Mechanical Output Shaft Governor	2.7.4
Hydraulic Governors	2.8
SG Hydraulic Governor	2.8.1
PSG Hydraulic Governor	2.8.2
Hydraulic Governor Drive	2.8.3
Hydraulic Governor Synchronizing Motor	2.8.4
Fuel Injector Control Tube	2.9
Throttle Controls (Diesel Railcar Engine)	2.9.2
Shop Notes - Trouble Shooting - Specifications - Service Tools	2.0

FUEL SYSTEM

The fuel system (Fig. 1) includes the fuel injectors, fuel pipes (inlet and outlet), fuel manifolds (integral with the cylinder head), fuel pump, fuel strainer, fuel filter and fuel lines.

Fuel is drawn from the supply tank through the fuel strainer and enters the fuel pump at the inlet side. Leaving the pump under pressure, the fuel is forced through the fuel filter and into the inlet fuel manifold, then through fuel pipes into the inlet side of each fuel injector.

The fuel manifolds are identified by the words "IN" (top passage) and "OUT" (bottom passage) which are cast in several places in the side of the cylinder head. This aids installation of the fuel lines.

Surplus fuel returns from the outlet side of the injectors to the fuel return manifold and then back to the supply tank.

All engines are equipped with a restrictive fitting in the fuel outlet manifold to maintain the fuel system pressure. Refer to Section 13.2 for the size fitting required.

A check valve may be installed in the supply line

© 1978 General Motors Corp.

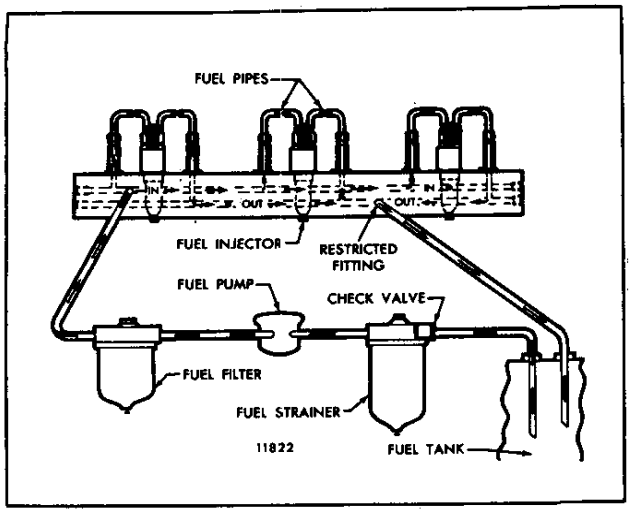


Fig. 1 - Schematic Diagram of Typical Fuel System

between the fuel tank and the fuel strainer to prevent fuel from draining back when the engine is shut down.

© 1978 General Motors Corp.

FUEL INJECTOR (Crown Valve)

The fuel injector (Fig. 1) is a lightweight compact unit which enables quick, easy starting directly on diesel fuel and permits the use of a simple open type combustion chamber. The simplicity of design and operation provides for simplified controls and easy adjustment. No high pressure fuel lines or complicated air-fuel mixing or vaporizing devices are required.

The fuel injector performs four functions:

1. Creates the high fuel pressure required for efficient injection.

2. Meters and injects the exact amount of fuel required to handle the load.

3. Atomizes the fuel for mixing with the air in the combustion chamber.

4. Permits continuous fuel flow.

Combustion required for satisfactory engine operation is obtained by injecting, under pressure, a small quantity of accurately metered and finely atomized fuel oil into the cylinder.

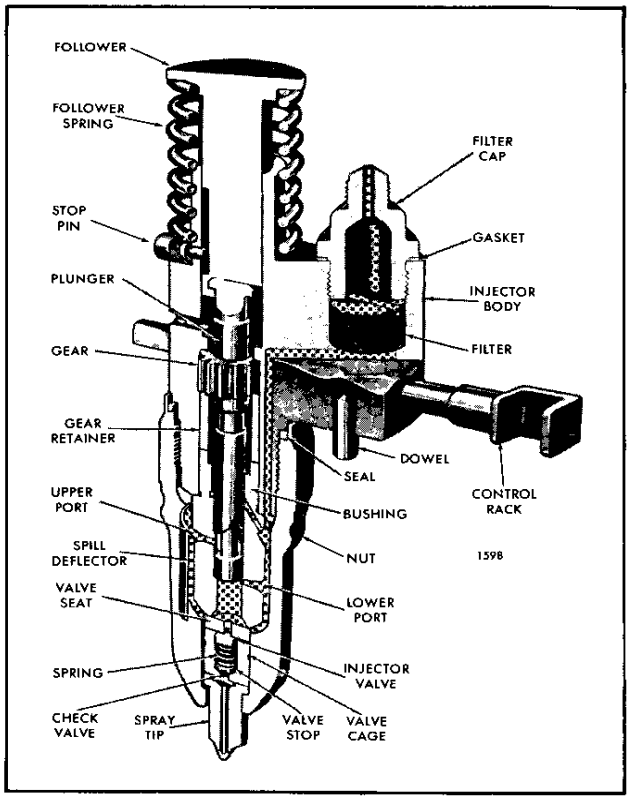


Fig. 1 - Fuel Injector Assembly

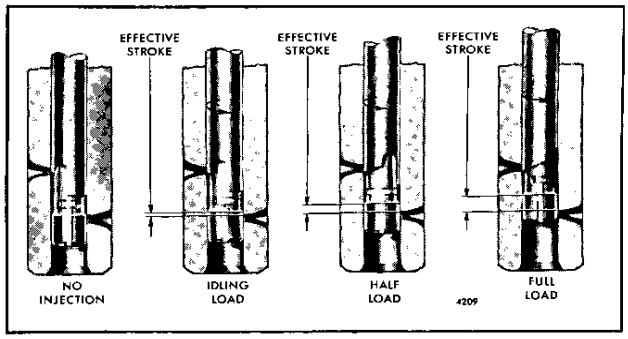


Fig. 2 - Fuel Metering from No-Load to Full-Load

Metering of the fuel is accomplished by an upper and lower helix machined in the lower end of the injector plunger. Figure 2 illustrates the fuel metering from no-load to full-load by rotation of the plunger in the bushing.

Figure 3 illustrates the phases of injector operation by the vertical travel of the injector plunger.

The continuous fuel flow through the injector serves, in addition to preventing air pockets in the fuel system, as a coolant for those injector parts subjected to high combustion temperatures.

To vary the power output of the engine, injectors having different fuel output capacities are used. The fuel output of the various injectors is governed by the helix angle of the plunger and the type of spray tip used. Refer to Fig. 4 for the identification of the injectors and their respective plungers and spray tips.

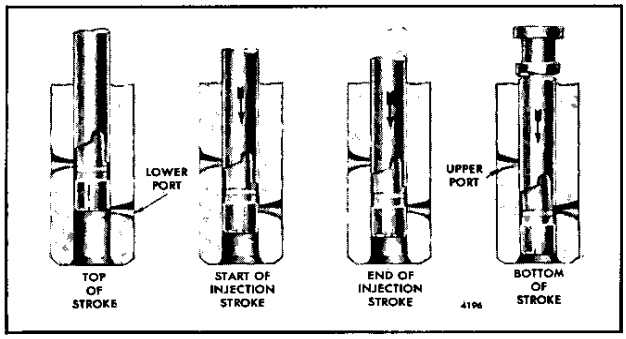


Fig. 3 - Phases of Injector Operation Through Vertical Travel of Plunger

© 1977 General Motors Corp.

INJECTOR	SPRAY TIP †	PLUNGER
HV55	6—.006—155—H	55
5S8	8—.005—165	55
6E8	8—.005—115—6H	6H
6S8	8—.005—165	6H
55E	8—.0055—165	55
S55	8—.0055—165	55
HV6	6—.006—155—H	6H
S60	8—.0055—165	6H
60	6—.006—155—0	6
HE6	8—.0055—165	6H
60E	8—.0055—165	6E
S65	8—.0055—165	65
70	7—.006—155—0	7X
HV7	7—.006—165—H	7H
S70	7—.006—165—H	7H
80	7—.006—155—0	8
HV8	7—.006—165—H	8H
S80	7—.006—165—H	8H
90	7—.006—155—0	9
HV9	7—.006—165—H	9H
S90	7—.006—165—H	9X

† First numeral indicates number of spray holes, followed by size of holes and angle formed by spray from holes. Letter "H" (or no letter) indicates current "high valve" injector; letter "O" indicates former "valve in spray tip" design injector.

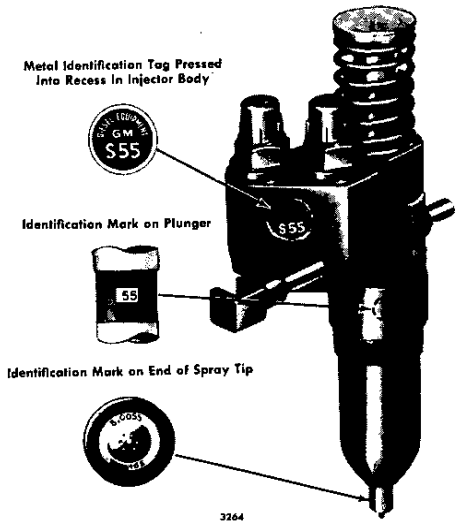


Fig. 4 - Injector Identification Chart

Since the helix angle on the plunger determines the output and operating characteristics of a particular type of injector, it is imperative that the correct injectors are used for each engine application. If injectors of different types are mixed, erratic operation will result and may cause serious damage to the engine or to the equipment which it powers.

Each fuel injector has a circular disc pressed into a recess at the front side of the injector body for identification purposes (Fig. 4). The identification tag indicates the nominal output of the injector in cubic millimeters.

Each injector control rack (Fig. 1) is actuated by a lever on the injector control tube which, in turn, is connected to the governor by means of a fuel rod. These levers can be adjusted independently on the control tube, thus permitting a uniform setting of all of the injector racks.

The injectors used in engines with a four valve cylinder head require an offset injector body due to the restricted area around the exhaust valve mechanism. A narrower injector clamp is required with the offset injector body and may be used with the standard injectors. Certain offset body injectors, designated as the "S" type, incorporate a clamp seat which is positioned lower on the injector body and require a different clamp (Fig. 5).

The fuel injector combines in a single unit all of the parts necessary to provide complete and independent fuel injection at each cylinder.

Operation

Fuel, under pressure, enters the injector at the inlet side through a filter cap and filter (Fig. 1). From the filter, the fuel passes through a drilled passage into the supply chamber, that area between the plunger bushing and the spill deflector, in addition to that area under the injector plunger within the bushing. The plunger operates up and down in the bushing, the bore of which is open to the fuel supply in the annular

© 1977 General Motors Corp.

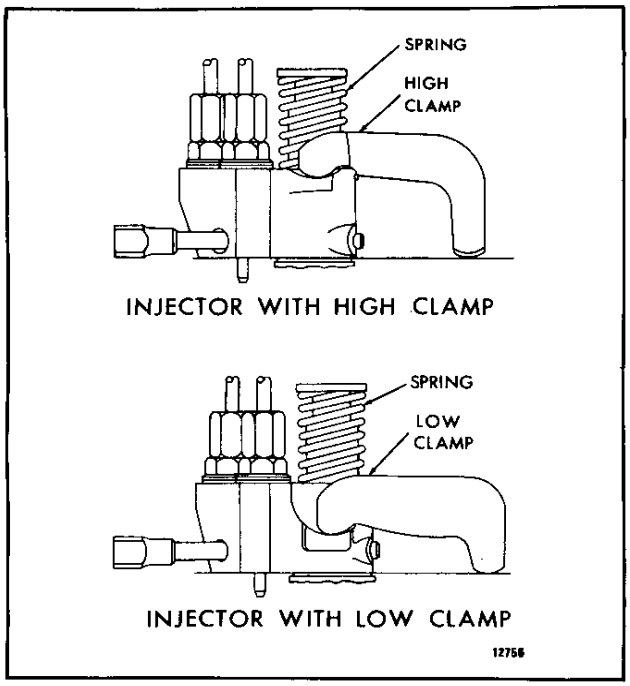


Fig. 5 - Comparison of High Clamp and Low Clamp Injectors

chamber by two funnel-shaped ports in the plunger bushing.

The motion of the injector rocker arm is transmitted to the plunger by the follower which bears against the follower spring (Fig. 6). In addition to the reciprocating motion, the plunger can be rotated, during operation, around its axis by the gear which meshes with the control rack. For metering the fuel, an upper helix and a lower helix are machined in the lower part of the plunger. The relation of the helices to the two ports changes with the rotation of the plunger.

As the plunger moves downward, under pressure of the injector rocker arm, a portion of that fuel trapped under the plunger is displaced into the supply chamber through the lower port until the port is closed off by the lower end of the plunger. A portion of the fuel trapped below the plunger is then forced up through a central passage in the plunger into the fuel metering recess and into the supply chamber through the upper port until that port is closed off by the upper helix of the plunger. With the upper and lower ports both closed off, the remaining fuel under the plunger is subjected to increased pressure by the continued downward movement of the plunger.

When sufficient pressure is built up, the injector valve is lifted off of its seat and the fuel is forced through small orifices in the spray tip and atomized into the combustion chamber.

A check valve, mounted in the spray tip, prevents air leakage from the combustion chamber into the fuel injector if the valve is accidentally held open by a small particle of dirt. The injector plunger is then returned to its original position by the injector follower spring. Figure 3 shows the various phases of injector operation by the vertical travel of the injector plunger.

On the return upward movement of the plunger, the high pressure cylinder within the bushing is again filled with fuel oil through the ports. The constant circulation of fresh cool fuel through the injector

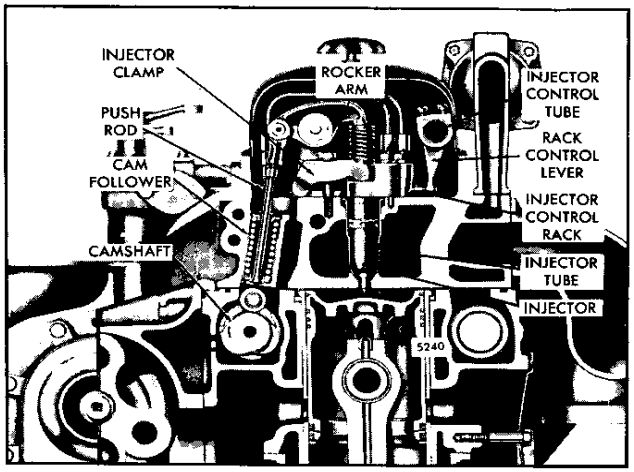


Fig. 6 - Fuel Injector Mounting

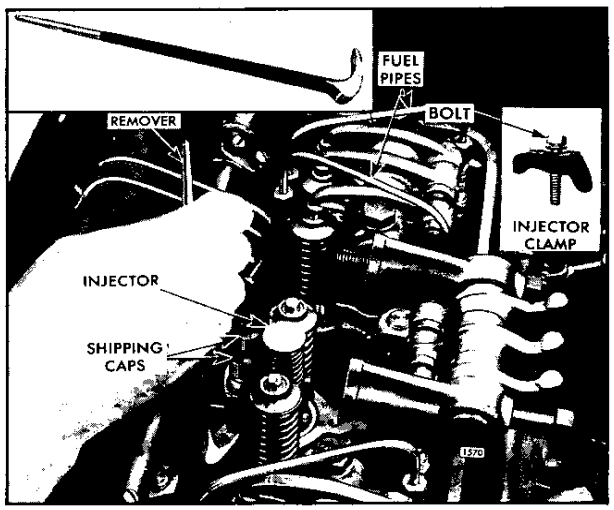


Fig. 7 - Removing Injector from Cylinder Head

© 1977 General Motors Corp.

renews the fuel supply in the chamber, helps cool the injector and also effectively removes all traces of air which might otherwise accumulate in the system and interfere with accurate metering of the fuel.

The fuel injector outlet opening, through which the excess fuel oil returns to the fuel return manifold and then back to the fuel tank, is directly adjacent to the inlet opening.

Changing the position of the helices, by rotating the plunger, retards or advances the closing of the ports and the beginning and ending of the injection period. At the same time, it increases or decreases the amount of fuel injected into the cylinder. Figure 2 shows the various plunger positions from no-load to full-load. With the control rack pulled out all the way (no injection), the upper port is not closed by the helix until after the lower port is uncovered. Consequently, with the rack in this position, all of the fuel is forced back into the supply chamber and no injection of fuel takes place. With the control rack pushed all the way in (full injection), the upper port is closed shortly after the lower port has been covered, thus producing a maximum effective stroke and maximum injection. From this no injection position to full injection position (full rack movement), the contour of the upper helix advances the closing of the ports and the beginning of injection.

General Instructions for Injector Care and Overhaul

The fuel injector is one of the most important and precisely built parts of the engine. The injection of the correct amount of fuel into the combustion chamber at exactly the right time depends upon this unit. Because the injector operates against the high compression pressure in the combustion chamber, efficient operation demands that the injector assembly is maintained in first-class condition at all times. Proper maintenance of the fuel system and the use of the recommended type fuel filters and clean water-free fuel are the keys to trouble-free operation of the injectors.

Due to the close tolerances of various injector parts, extreme cleanliness and strict adherence to service instructions is required.

Perform all injector repairs in a clean, well lighted room with a dust free atmosphere. An ideal injector room is slightly pressurized by means of an electric fan which draws air into the room through a filter. This pressure prevents particles of dirt and dust from entering the room through the door and windows. A suitable air outlet will remove solvent fumes along with the outgoing air. Also provide a source for 110 volt alternating current electric power.

Provide the injector repair room with a supply of *filtered, moisture-proof compressed* air for drying the injector parts after they have been cleaned. Use wash pans of rust-proof material and deep enough to permit all of the injector parts to be completely covered by the cleaning agent, usually clean fuel oil, when submerged in wire baskets of 16 mesh wire screen. Use baskets which will support the parts so as to avoid contact with the dirt which settles at the bottom of the pans.

Rags should never be used for cleaning injector parts since lint or other particles will clog parts of the injector when it is assembled. A lint-free cleaning tissue is a good, inexpensive material for wiping injector parts.

When servicing an injector, follow the general instructions outlined below:

1. Whenever the fuel pipes are removed from an injector, cover the filter caps with shipping caps to keep dirt out of the injector. Also protect the fuel

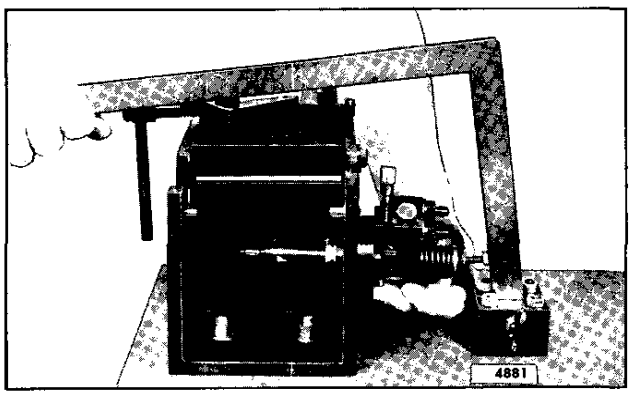


Fig. 8 - Checking Rack and Plunger For Free Movement

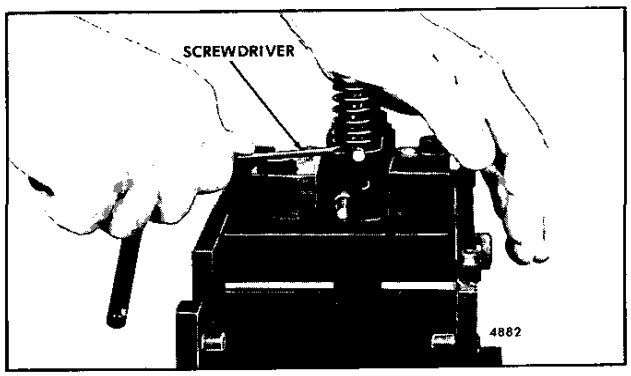


Fig. 9 - Removing Injector Follower Stop Pin

© 1977 General Motors Corp.

pipes and fuel connectors from the entry of dirt or other foreign material.

2. After an injector has been operated in an engine, do not remove the filter caps or filters while the injector is in the engine. Replace the filters only at the time of complete disassembly and assembly of an injector.

3. Whenever an injector has been removed and reinstalled or replaced in an engine, make the following adjustments as outlined in Section 14:

a. Time the injector.

b. Position the injector control rack.

4. Whenever an engine is to be out of service for an extended period, purge the fuel system, then fill it with a good grade of rust preventive (refer to Section 15.3).

5. When a reconditioned injector is to be placed in stock, fill it with injector test oil J 26400. *Do not use fuel oil.* Install shipping caps on both filter caps immediately after filling. Store the injector in an upright position to prevent test oil leakage.

NOTE: Make sure that new filters have been installed in a reconditioned injector which is to be placed in stock. This precaution will prevent dirt particles from entering the injector due to a possible reversal of fuel flow when installing the injector in an engine other than the original unit.

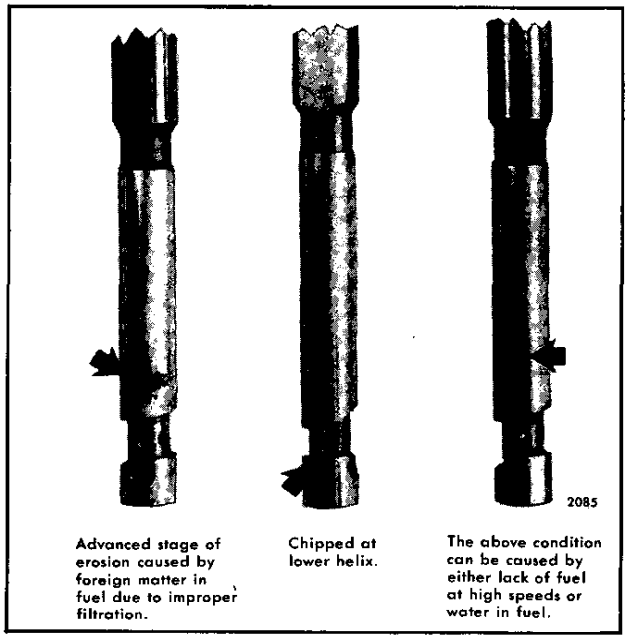


Fig. 10 - Unusable Injector Plungers

Remove Injector

1. Clean and remove the valve rocker cover.

2. Remove the fuel pipes from both the injector and the fuel connectors (Fig. 6).

NOTE: Immediately after removal of the fuel pipes from an injector, cover the filter caps with shipping caps to prevent dirt from entering the injector. Also protect the fuel pipes and fuel connectors from entry of dirt or foreign material.

3. Crank the engine to bring the outer ends of the push rods of the injector and valve rocker arms in line horizontally.

4. Remove the two rocker shaft bracket bolts and swing the rocker arms away from the injector and valves (Fig. 7).

5. Remove the injector clamp bolt, special washer and clamp.

6. Loosen the inner and outer adjusting screws on the injector rack control lever and slide the lever away from the injector.

7. Lift the injector from its seat in the cylinder head (Fig. 7).

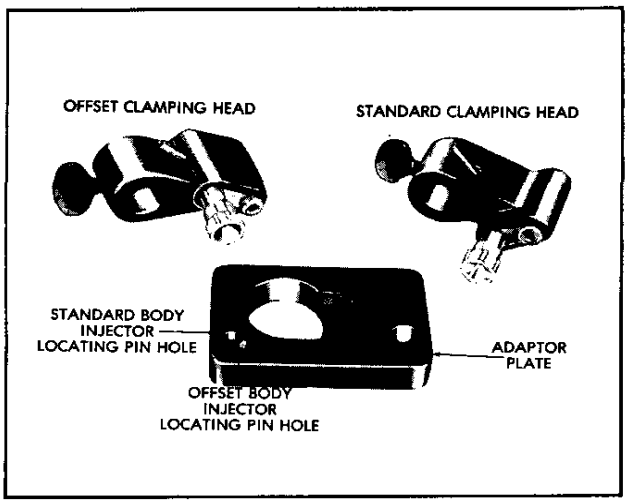


Fig. 11 - Injector Tester J 23010 Clamping Heads

© 1979 General Motors Corp.

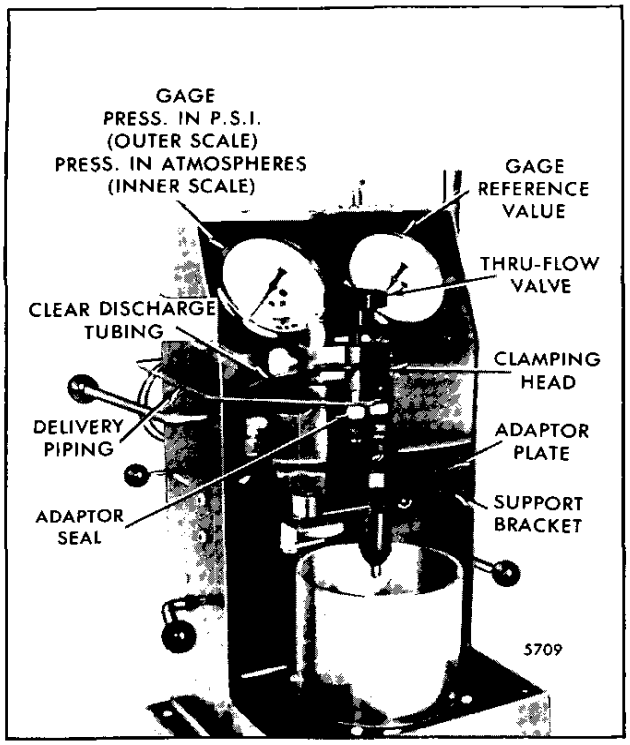


Fig. 12 - Injector Installed in Tester J 23010 with Clamping Head

8. Cover the injector hole in the cylinder head to keep foreign material out.

9. Clean the exterior of the injector with clean fuel oil and dry it with compressed air.

TEST INJECTOR

CAUTION: The fuel spray from an injector can penetrate the skin. Fuel oil which enters the blood stream can cause a serious infection. Therefore, follow instructions and use the proper equipment to test an injector.

If inspection does not reveal any external damage, then perform a series of tests to determine the condition of the injector to avoid unnecessary overhauling. Tests must be performed using injector test oil J 26400.

An injector that passes all of the tests outlined below may be considered to be satisfactory for service without disassembly, except for the visual check of the plunger.

However, an injector that fails to pass one or more of the tests is unsatisfactory. Perform all of the tests before disassembling an injector to correct any one condition.

Identify each injector and record the pressure drop and fuel output as indicated by the following tests:

Injector Control Rack and Plunger Movement Tests

Place the injector in the injector fixture and rack freeness tester J 22396. Refer to Fig. 8 and place the handle on top of the injector follower.

If necessary, adjust the contact screw in the handle to ensure the contact screw is at the center of the follower when the follower spring is compressed.

With the injector control rack held in the no-fuel position, push the handle down and depress the follower to the bottom of its stroke. Then very slowly release the pressure on the handle while moving the control rack up and down as shown in Fig. 8 until the follower reaches the top of its travel. If the rack does not fall freely, loosen the injector nut, turn the tip, then retighten the nut. Loosen and retighten the nut a couple of times if necessary. Generally this will free

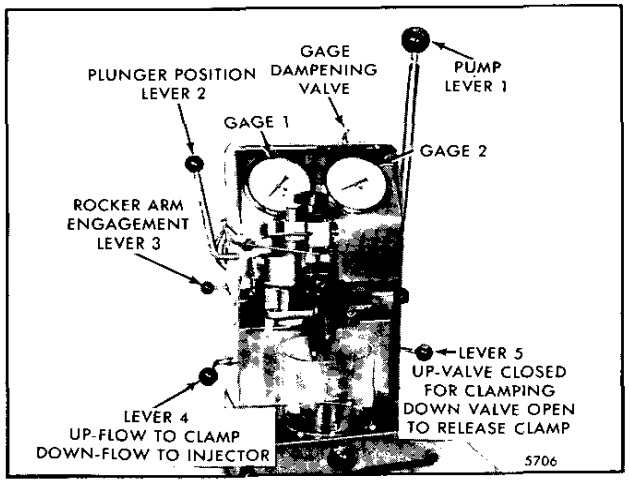


Fig. 13 - Injector in Position for Testing with Tester J 23010

© 1979 General Motors Corp.

the rack. Then, if the rack isn't free, change the injector nut. In some cases it may be necessary to disassemble the injector to eliminate the cause of the misaligned parts.

Visual Inspection of Plunger

An injector which passes all of the previous tests should have the plunger checked visually, under a magnifying glass, for excessive wear or a possible chip on the bottom helix. There is a small area on the bottom helix and lower portion of the upper helix, if chipped, that will not be indicated in any of the tests.

Remove the plunger from the injector as follows:

1. Support the injector, right side up, in holding fixture J 22396.

2. Compress the follower spring. Then raise the spring above the stop pin with a screw driver and withdraw the pin (Fig. 9). Allow the spring to rise gradually.

3. Remove the injector from the holding fixture. Turn the injector upside down, to prevent the entry of dirt, and catch the spring and plunger as they drop out.

4. Inspect the plunger. If the plunger is chipped (Fig. 10), replace the plunger and bushing assembly.

5. Reinstall the plunger, follower and spring.

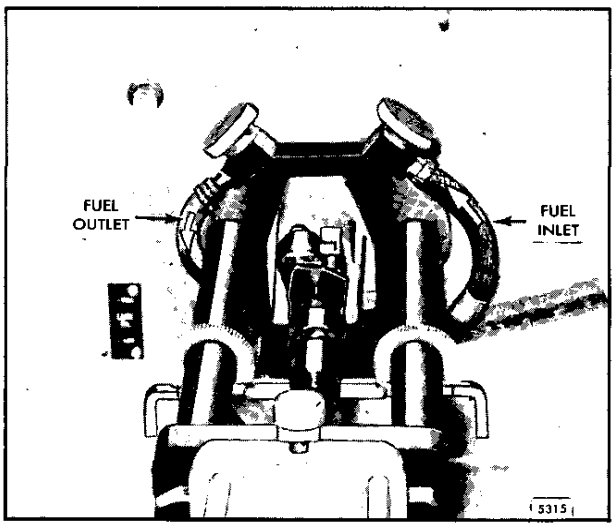


Fig. 14 - Position of Calibrator Fuel Flow Pipes

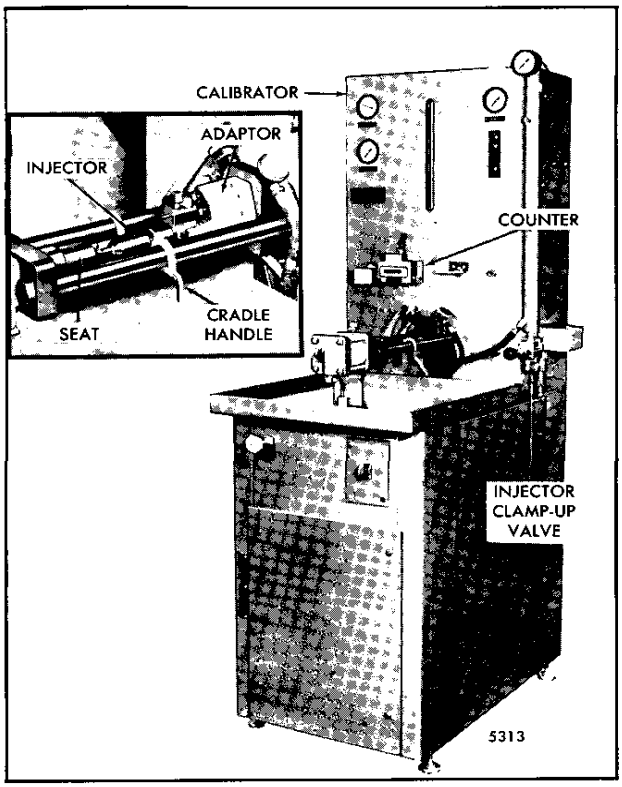


Fig. 15 - Injector in Calibrator J 22410

Installing Fuel Injector in Tester J 23010

1. Select the proper clamping head (Fig. 11). Position it on the clamping post and tighten the thumb screw into the lower detent position (Fig. 12).

2. Connect the test oil delivery piping into the clamping head.

3. Connect the test oil clear discharge tubing onto the pipe on the clamping head.

4. Locate the adaptor plate on top of the support bracket by positioning the 3/8 " diameter hole at the far right of the adaptor plate onto the 3/8 " diameter dowel pin. This allows the adaptor plate to swing out for mounting the injector.

5. Mount the injector through the large hole and insert the injector pin in the proper locating pin hole (Fig. 11).

6. Swing the mounted injector and adaptor plate inward until they contact the stop pin at the rear of the support bracket.

© 1982 General Motors Corp.

Clamping the Fuel Injector

1. Refer to Fig. 13 and position the tester levers as follows:

Lever 2 up and to the rear

Lever 3 in the rear detent position

Lever 4 up (horizontal)

Lever 5 up (horizontal)

2. Align the clamping head nylon seals over the injector filter caps (Fig. 12).

3. Back off the Thru-Flow valve about half-way to allow the self-aligning nylon seals to seat properly during the clamping operation.

4. Hold the clamping head in position over the filter caps and, with the left hand, operate pump lever 1 evenly to move the clamping head *down* to seal the filter caps. The Thru-Flow valve should still turn freely. If it does not, turn the valve counterclockwise until it rotates freely and reapply clamping pressure.

NOTE: Excessive force on lever 1 during clamping can damage the seals in the valves operated by levers 4 and 5.

Purging Air from the System

Move lever 4 down and operate pump lever 1 to produce a test oil flow through the injector. When air bubbles no longer pass through the clear discharge tubing, the system is free of air and is now ready for testing.

Injector Valve Opening and Spray Pattern Test

This test determines spray pattern uniformity and the relative pressure at which the injector valve opens and fuel injection begins.

1. Clamp the injector properly and purge the air from the system.

2. Close the Thru-Flow valve to allow pressure to build in gage 1 (do not overtighten or the nylon seal will be damaged).

3. With the fuel rack in the full-fuel position, operate pump lever 1 rapidly until the valve opening pressure of 450 to 850 psi (3 100 to 5 857 kPa) is reached and the spray pattern occurs. Note if all spray tip holes are open by the pattern of the spray produced.

Injector High Pressure Test

This test checks for leaks at the filter cap gaskets, body plugs and nut seal ring.

1. Clamp the injector properly and purge the air from the system.

2. Close the Thru-Flow valve, but do not overtighten.

NOTE: Be sure lever 4 is in the *down* position before operating pump lever 1.

3. Move lever 2 to the forward, horizontal position.

4. Operate pump lever 1 to build up to 1600-2000 psi (11 024-13 780 kPa) on gage 1 and check for leakage at the filter cap gaskets, body plugs and nut seal ring.

Injector Pressure Holding Test

This test determines if the body-to bushing mating surfaces in the injector are sealing properly and indicates proper plunger-to-bushing fit.

1. Clamp the injector properly and purge the air from the system.

2. Close The Thru-Flow valve, but do not overtighten.

3. Move lever 2 to the rear, horizontal position.

4. Operate pump lever 1 until gage 1 reads approximately 500 psi (3 445 kPa).

5. Move lever 4 to the *up* position.

6. Time the pressure drop between 450 to 250 psi (3 100 to 1 723 kPa). If the pressure drop occurs in less than 15 seconds (fixture J 23010) or 40 seconds (fixture J 9787), leakage is excessive.

Refer to the *Trouble Shooting Charts* in Section 2.0 if the fuel injector does not pass any of the preceding tests.

If the fuel injector passes all of the above tests, proceed with the *Fuel Output Test.*

Unclamping the Injector

1. Open the Thru-Flow valve to release pressure in the system.

2. Move lever 5 *down* to release the clamping pressure.

© 1982 General Motors Corp.

3. Swing out the adaptor plate and remove the injector after nylon seals in the clamping head are free and clear of the injector filter caps.

4. Carefully return lever 5 to the *up* (horizontal) position.

Fuel Output Test

Perform the injector fuel output test in calibrator J 22410.

When injectors are removed from an engine for fuel output testing and, if satisfactory, reinstalled without disassembly, extreme care should be taken to avoid reversing the fuel flow. When the fuel flow is reversed, dirt trapped by the filter is back-flushed into the injector components.

Before removing an injector from the engine, note the direction of the fuel flow. To avoid reversing the fuel flow when checking injector fuel output, use the appropriate adaptor. The position of the braided fuel inlet tube and the plastic fuel outlet tube on the calibrator (Fig. 14) depends on the adaptor being used and the direction of fuel flow through the injector.

Calibrator J 22410

To check the fuel output, operate the injector in calibrator J 22410 (Fig. 15) as follows:

> **NOTE:** Place the cam shift index wheel and fuel flow lever in their respective positions. Turn on the test fuel oil heater switch and preheat the test oil to 95-105 °F (35-40 °C).

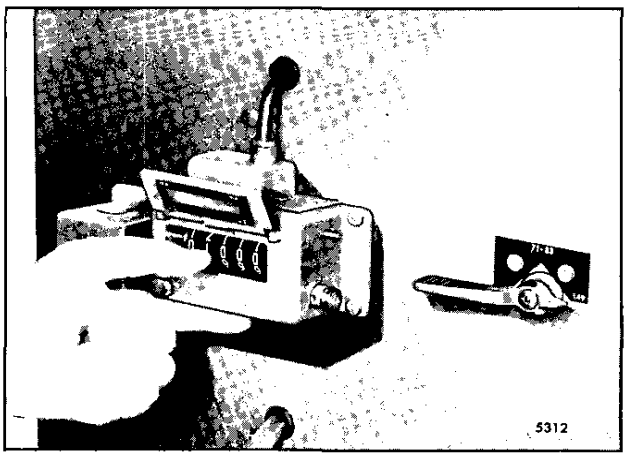


Fig. 16 - Setting Calibrator Stroke Counter

Injector	Calibrator J 22410	
	Min.	Max.
HV55	52	56
5S8	50	54
6E8	53	57
6S8	53	57
55E	55	59
S55	55	59
HV6	59	63
S60	59	63
60	60	64
HE6	60	64
60E	60	64
S65	64	68
70	71	75
HV7	71	75
S70	71	75
80	78	82
HV8	80	84
S80	80	84
90	87	92
HV9	87	92
S90	87	92

Fig. 17 - Fuel Output Check Chart

1. *Place the proper injector adaptor between the tie* rods and engage it with the fuel block locating pin. Then slide the adaptor forward and up against the fuel block face.

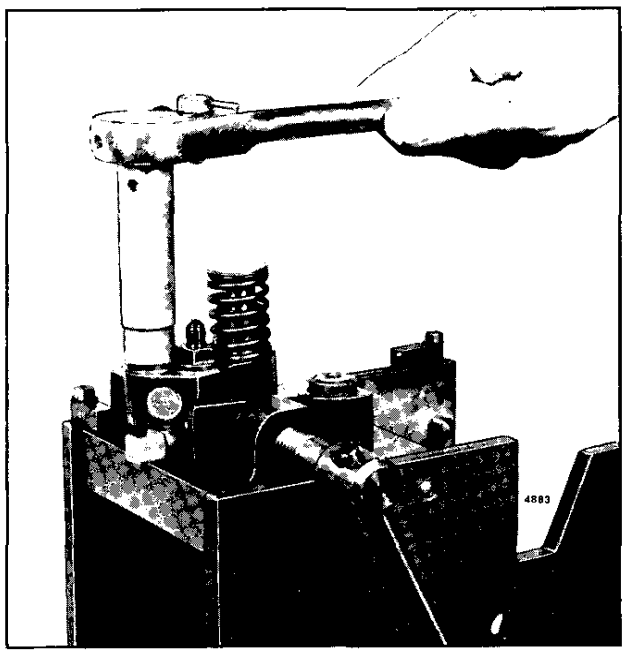


Fig. 18 - Removing or Installing Filter Cap

© 1979 General Motors Corp.

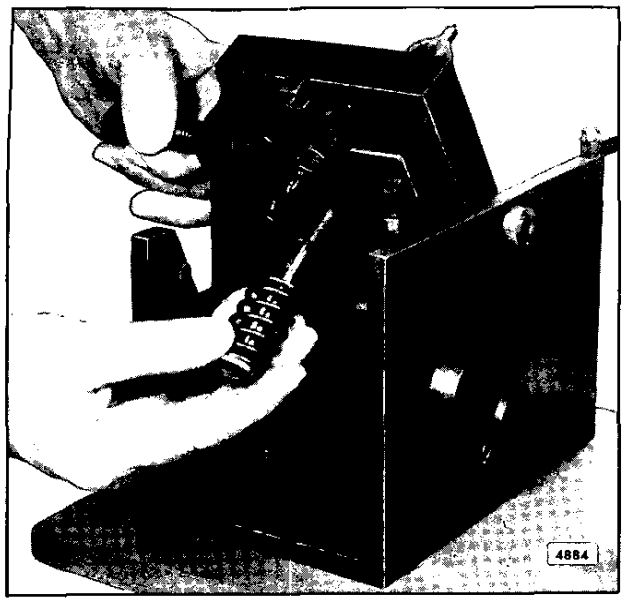


Fig. 19 - Removing or Installing Plunger Follower, Plunger and Spring

2. Place the injector seat J 22410-226 into the permanent seat (cradle handle in vertical position). Clamp the injector into position by operating the air valve.

NOTE: Make sure the counter (Fig. 16) on the calibrator is preset at 1000 strokes. If for any reason this setting has been altered, reset the counter to 1000 strokes by twisting the cover release button to the left and hold the reset lever in the full up position while setting the numbered wheels. Close the cover. Refer to the calibrator instruction booklet for further information.

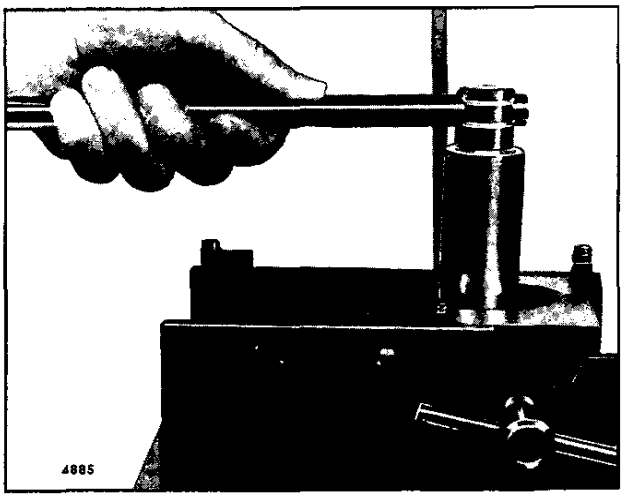


Fig. 20 - Removing Injector Nut

3. Pull the injector rack out to the no-fuel position.

4. Turn on the main power control circuit switch. Then start the calibrator by turning on the motor starter switch.

NOTE: The low oil pressure warning buzzer will sound briefly until the lubricating oil reaches the proper pressure.

5. After the calibrator has started, set the injector rack into the full-fuel position. Allow the injector to operate for approximately 30 seconds to purge the air that may be in the system.

6. After the air is purged, press the fuel flow start button (red). This will start the flow of fuel into the vial. The fuel flow to the vial will automatically stop after 1000 strokes.

7. Shut the calibrator off (the calibrator will stop in less time at full-fuel).

8. Observe the vial reading and refer to Fig. 17 to determine whether the injector fuel output falls within the specified limits. If the quantity of fuel in the vial

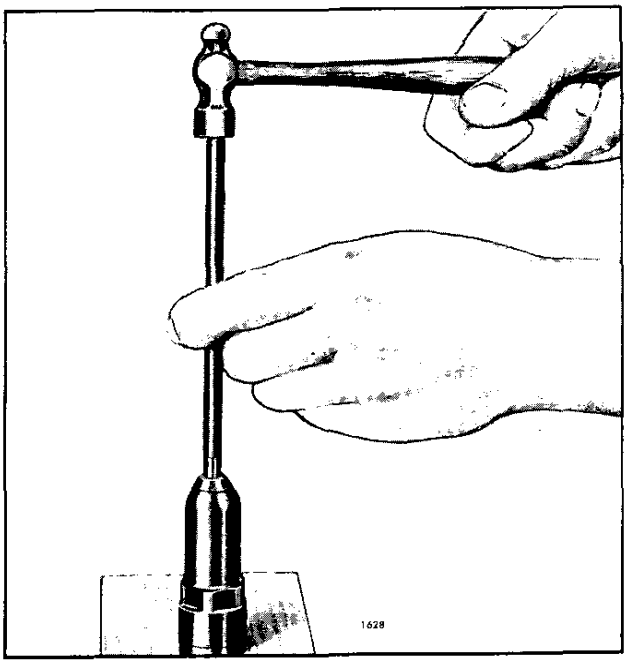


Fig. 21 - Removing Spray Tip from Injector Nut

© 1979 General Motors Corp.

does not fall within the specified limits, refer to *Trouble Shooting Chart* 3 and *Shop Notes* in section 2.0 for the cause and remedy.

NOTE: Refer to Section 2.0 for different factors that may affect the injector calibrator output reading.

The calibrator may be used to check and select a set of injectors which will inject the same amount of fuel in each cylinder at a given throttle setting, thus resulting in a smooth running, well balanced engine.

An injector which passes all of the above tests may be put back into service. However, an injector which fails to pass one or more of the tests must be rebuilt and checked on the calibrator.

Any injector which is disassembled and rebuilt must be tested again before being placed in service.

Disassemble Injector

If required, disassemble an injector as follows:

1. Support the injector upright in injector holding fixture J 22396 (Fig. 18) and remove the filter caps, springs (early design filter cap), filters and gaskets.

NOTE: Whenever a fuel injector is disassembled, discard the filters and gaskets and replace with new filters and gaskets.

2. Compress the follower spring as shown in Fig. 9. Then raise the spring above the stop pin with a screw driver and withdraw the pin. Allow the spring to rise gradually.

3. Refer to Fig. 19 and remove the plunger follower, plunger and spring as an assembly.

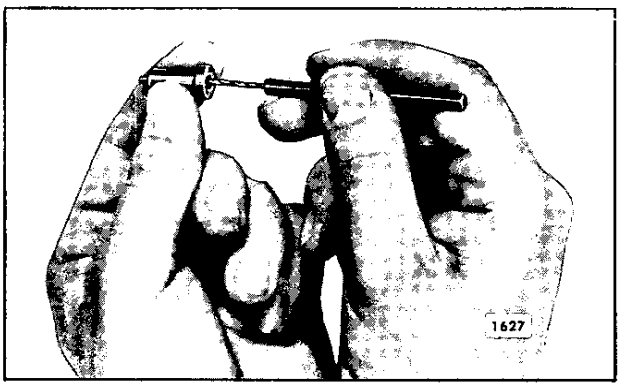


Fig. 22 - Cleaning Injector Spray Tip

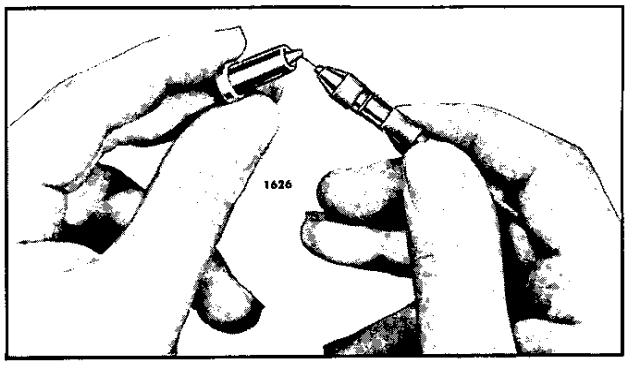


Fig. 23 - Cleaning Spray Tip Orifices

4. Invert the fixture and, using socket J 4983-01, loosen the nut on the injector body (Fig. 20).

5. Lift the injector nut straight up, being careful not to dislodge the spray tip and valve parts. Remove the spray tip and valve parts from the bushing and place them in a clean receptacle until ready for assembly.

When an injector has been in use for some time, the spray tip, even though clean on the outside, may not be pushed readily from the nut with the fingers. In this event, support the nut on a wood block and drive the tip down through the nut, using tool J 1291-02 as shown in Fig. 21.

6. Refer to Fig. 31 and remove the spill deflector and the seal ring from the injector nut.

7. Remove the plunger bushing, gear retainer and gear from the injector body.

8. Withdraw the injector control rack from the injector body.

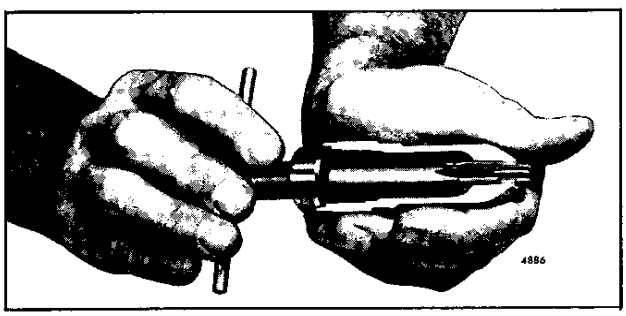


Fig. 24 - Cleaning Injector Nut Spray Tip Seat

© 1982 General Motors Corp.

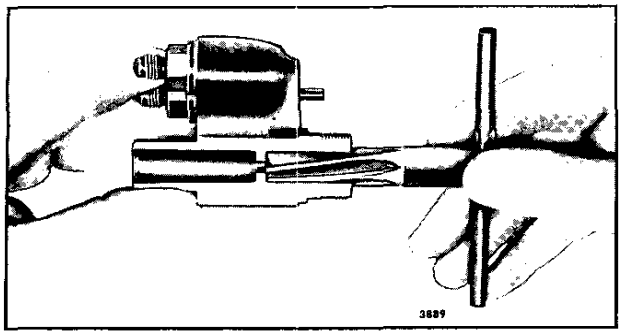


Fig. 25 - Cleaning Injector Body Ring

Clean Injector Parts

Since most injector difficulties are the result of dirt particles, it is essential that a clean area be provided on which to place the injector parts after cleaning and inspection.

Wash all of the parts with clean fuel oil or a suitable cleaning solvent and dry them with clean, filtered compressed air. *Do not use waste or rags for cleaning purposes.* Clean out all of the passages, drilled holes and slots in all of the injector parts.

Carbon on the inside of the spray tip may be loosened for easy removal by soaking for approximately 15 minutes in a suitable solution prior to the external cleaning and buffing operation.

Clean the spray tip with tool J 1243 (Fig. 22). Turn the reamer in a clockwise direction to remove the carbon deposits. Wash the spray tip in fuel oil and dry it with compressed air. Clean the spray tip orifices with pin vise J 4298-1, using the proper size spray tip cleaning wire (Fig. 23). Use wire J 21459 to clean .005 " diameter holes, wire J 21460 to clean .0055 " diameter holes and J-21461 wire to clean .006 " diameter holes.

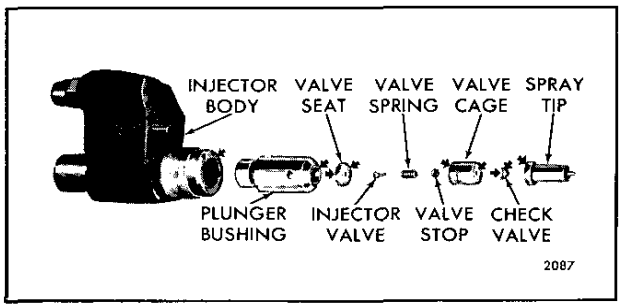


Fig. 26 - Sealing Surfaces Which May Require Lapping

Before using the wire, hone the end until it is smooth and free of burrs and taper the end a distance of 1/16 " with stone J 8170. Allow the wire to extend 1/8 " from tool J 4298-1.

The exterior surface of an injector spray tip may be cleaned by using a brass wire buffing wheel, tool J 7944. To obtain a good polishing effect and longer brush life, the buffing wheel should be installed on a motor that turns the wheel at approximately 3000 rpm. A convenient method of holding the spray tip while cleaning and polishing is to place the tip over the drill end of spray tip cleaner tool J 1243 and hold the body of the tip against the buffing wheel. In this way, the spray tip is rotated while being buffed.

NOTE: Do not buff excessively. *Do not use a steel wire buffing wheel or the spray tip holes may be distorted.*

When the body of the spray tip is clean, lightly buff the tip end in the same manner. This cleans the spray tip orifice area and will not plug the orifices.

Wash the spray tip in clean fuel oil and dry it with compressed air.

Clean and brush all of the passages in the injector body, using fuel hole cleaning brush J 8152 and rack hole cleaning brush J 8150. Blow out the passages and dry them with compressed air.

Carefully insert reamer J 4986-01 in the injector nut as shown in Fig. 24. Turn the reamer in a clockwise direction to remove the carbon deposits. Use care in reaming to prevent the removal of metal or setting up burrs on the spray tip seat. The purpose of the tool is to remove carbon build-up only, and is NOT meant to refinish the end area of the nut by removing metal Wash the injector nut in clean fuel oil and dry it with

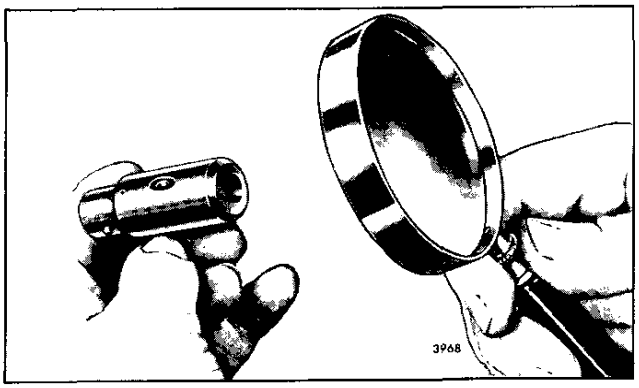


Fig. 27 - Examining Sealing Surface with a Magnifying Glass

© 1982 General Motors Corp.

compressed air. Carbon deposits on the spray tip seating surface of the injector nut will result in poor sealing and consequent fuel leakage around the spray tip.

Carefully insert reamer J 21089 in the injector body (Fig. 25). Turn it in a clockwise direction a few turns, then remove the reamer and check the face of the ring for reamer contact over the entire face of the ring. If necessary, repeat the reaming procedure until the reamer does make contact with the entire face of the ring. Clean up the opposite side of the ring in the same manner.

Carefully insert a .375 " diameter straight fluted reamer inside the ring bore in the injector body. Turn the reamer in a clockwise direction and remove any burrs inside the ring bore. Then wash the injector body in clean fuel oil and dry it with compressed air.

When handling the injector plunger, do not touch the finished plunger surfaces with your fingers. Wash the plunger and bushing with clean fuel oil and dry them with compressed air. Be sure the high pressure bleed hole in the side of the bushing is not plugged. If this hole is plugged, fuel leakage will occur at the upper end of the bushing where it will drain out of the injector body vent and rack holes, during engine operation, causing a serious oil dilution problem. *Keep the plunger and bushing together as they are mated parts.*

After washing, submerge the parts in a clean receptacle containing clean fuel oil. *Keep the parts of each injector assembly together.*

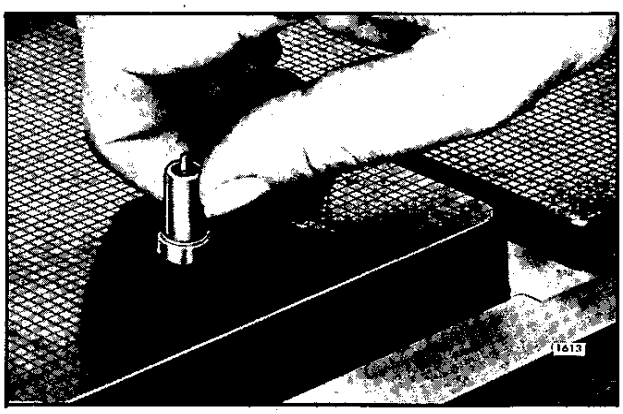


Fig. 28 - Lapping Spray Tip on Lapping Blocks J 22090

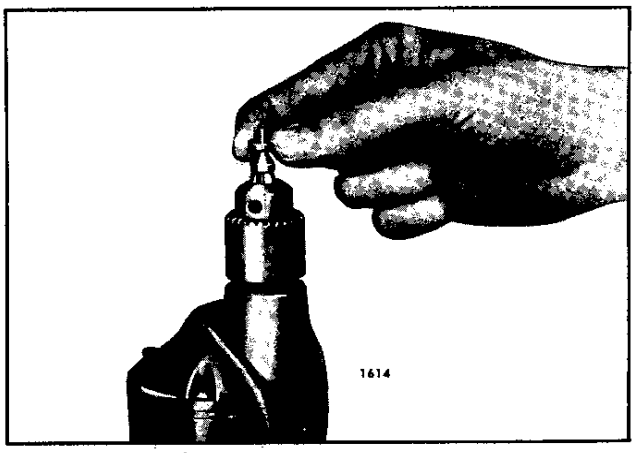


Fig. 29 - Lapping Edge of Hole in Valve Seat

Inspect Injector Parts

Inspect the teeth on the control rack and the control rack gear for excessive wear or damage. Also check for excessive wear in the bore of the gear and inspect the gear retainer. Replace damaged or worn parts.

Inspect the injector follower and pin for wear. Refer to Section 2.0.

Inspect both ends of the spill deflector for sharp edges or burrs which could create burrs on the injector body or injector nut and cause particles of metal to be introduced into the spray tip and valve parts. Remove burrs with a 500 grit stone.

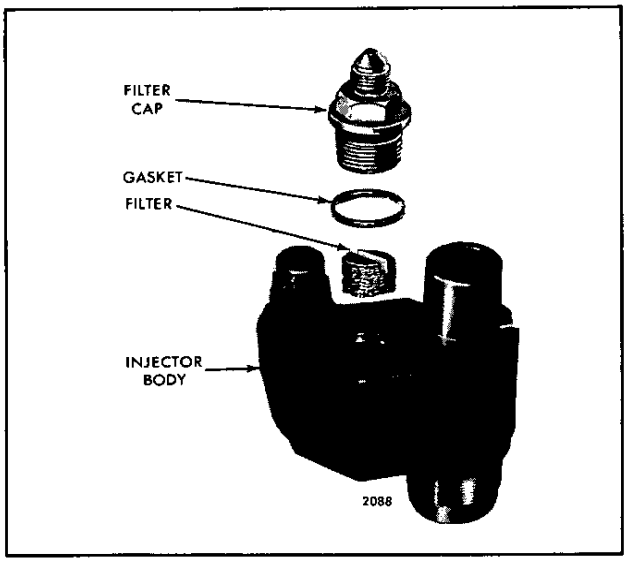


Fig. 30 - Details of Injector Filters and Caps and Their Relative Location

© 1982 General Motors Corp.

Inspect the follower spring for visual defects. Then check the spring with tester J 22738-02.

The current injector follower spring (.142 " diameter wire) has a free length of approximately 1.504 " and should be replaced when a load of less than 70 lbs. will compress it to 1.028 ". Formerly, a spring (.120 " diameter wire) with a free length of approximately 1.668 " was employed and it should be replaced when a load of less than 48 lbs. will compress it to 1.028 ".

It is recommended that at the time of overhaul, all injectors in an engine be converted to the current spring (.142 " diameter wire) which will provide improved cam roller to shaft follow. However, in the event that one or two injectors are changed, the remaining injectors need not be reworked to incorporate the current spring.

Check the seal ring area on the injector body for burrs or scratches. Also check the surface which contacts the injector bushing for scratches, scuff marks or other damage. If necessary, lap this surface. A faulty sealing surface at this point will result in high fuel consumption and contamination of the lubricating oil. Replace any loose injector body plugs or a loose dowel pin. Install the proper number tag on a service replacement injector body.

Inspect the injector plunger and bushing for scoring, erosion, chipping or wear. Check for sharp edges on that portion of the plunger which rides in the gear. Remove any sharp edges with a 500 grit stone. Wash the plunger after stoning it. Check the port holes in the inner diameter of the bushing for cracks or chipping. Slip the plunger into the bushing and check for free movement. *Replace the plunger and bushing as an assembly if any of the above damage is noted, since they are mated parts.* Use new mated factory parts to assure the best performance from the injector.

Injector plungers cannot be reworked to change the output. Grinding will destroy the hardened case at the helix and result in chipping and seizure or scoring of the plunger.

Part Name	Minimum Thickness
Tip, Spray (Shoulder)	.121"
Valve, Injector	.073"
Cage, Valve	.490"
Seat, Valve	.124"
Valve, Check	.027"

MINIMUM THICKNESS (Used Parts)

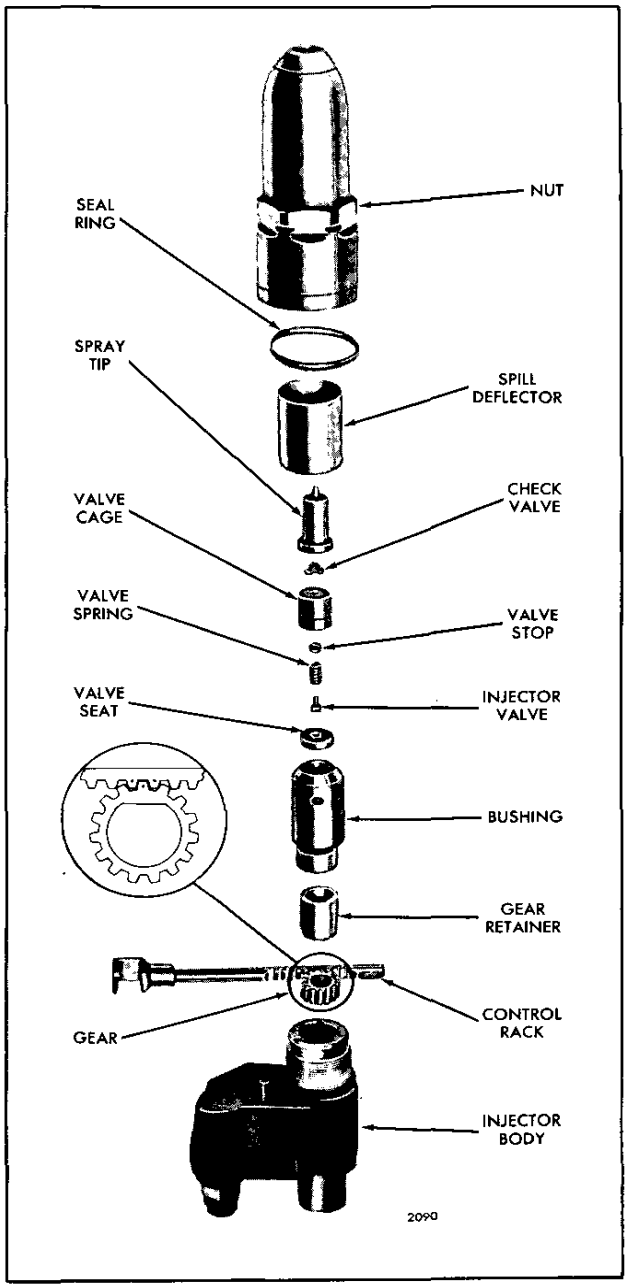


Fig. 31 - Injector Rack, Gear, Spray Tip and Valve Assembly Details and Relative Location of Parts

Examine the spray tip seating surface of the injector nut for nicks, burrs or brinelling. Reseat the surface or replace the nut if it is severely damaged.

The injector valve spring plays an important part in establishing the valve opening pressure of the injector assembly. Replace a worn or broken spring.

© 1982 General Motors Corp.

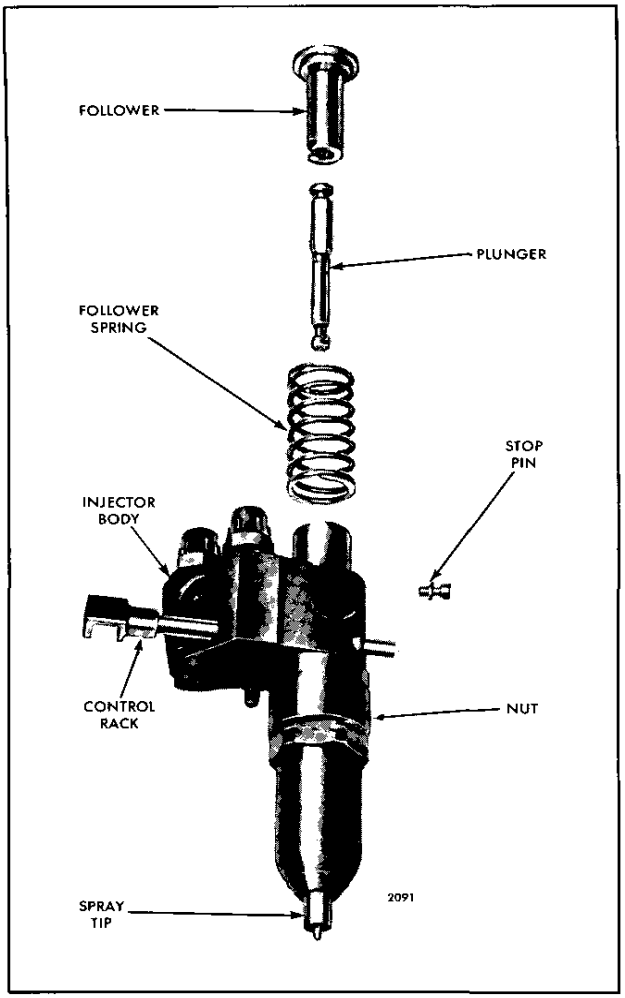


Fig. 32 - Injector Plunger, Follower and Relative Location of Parts

Inspect the sealing surfaces of the spray tip and valve parts indicated in Fig. 26. Examine the sealing surfaces with a magnifying glass as shown in Fig. 27 for even the slightest imperfections will prevent the injector from operating properly. Check for burrs, nicks, erosion, cracks, chipping and excessive wear. Also check for enlarged orifices in the spray tip. Replace damaged or excessively worn parts. Check the minimum thickness of the lapped parts as noted in the chart.

Before reinstalling used valve parts in an injector, lap all of the sealing surfaces indicated in Fig. 26, except the injector valve (crown valve). It is also good practice to lightly lap new valve parts, except the injector valve (crown valve), which may become burred or nicked during handling.

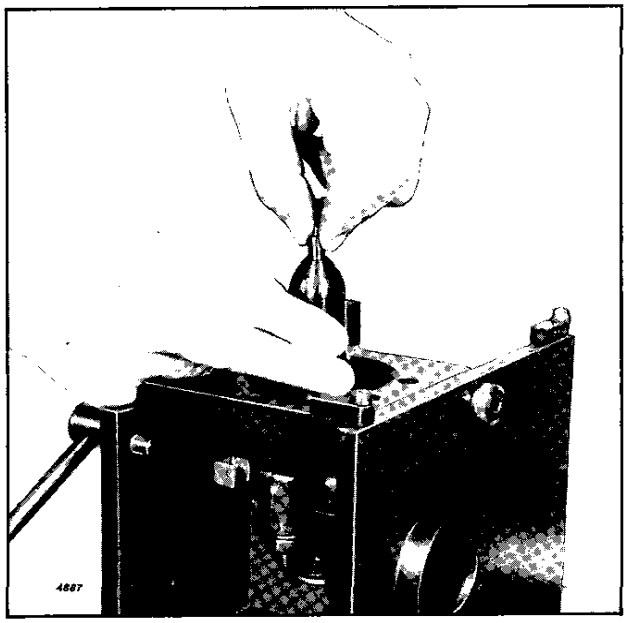


Fig. 33 - Tightening Injector Nut by Hand

Lapping Injector Parts

Lap the sealing surfaces indicated in Fig. 26 and the chart as follows:

1. Clean the lapping blocks (J 22090) with compressed air. Do not use a cloth or any other material for this purpose.

2. Spread a good quality 600 grit dry lapping powder on one of the lapping blocks.

3. Place the part to be lapped flat on the block as shown in Fig. 28 and, using a figure eight motion, move it back and forth across the block. Do not press on the part, but use just enough pressure to keep the

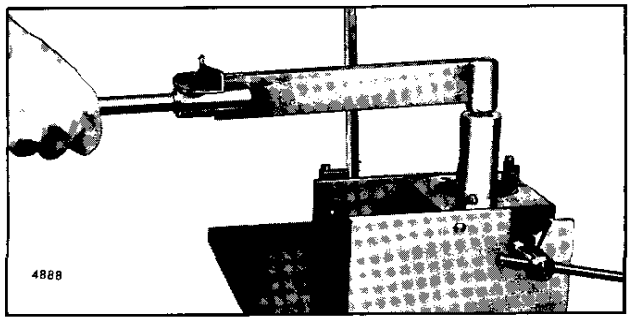


Fig. 34 - Tightening Injector Nut with Torque Wrench

© 1979 General Motors Corp.

part flat on the block. It is important that the part be kept flat on the block at all times.

4. After each four or five passes, clean the lapping powder from the part by drawing it across a clean piece of tissue placed on a flat surface and inspect the part. *Do not lap excessively* (refer to the chart on minimum thickness).

5. When the part is flat, wash it in cleaning solvent and dry it with compressed air.

6. Place the dry part on the second block. After applying lapping powder, move the part lightly across the block in a figure eight motion several times to give it a smooth finish. *Do not lap excessively.* Again wash the part in cleaning solvent and dry it with compressed air.

7. Place the dry part on the third block. Do not use lapping powder on this block. Keep the part flat and move it across the block several times, using the figure eight motion. Lapping the dry part in this manner gives it the "mirror" finish required for perfect sealing.

8. Examine the edge of the hole in the crown valve seat under a magnifying glass. If the edge of the hole shows small irregularities, lap the hole with tool J 7174. Since only the edge of this hole contacts the valve, it must be a true circle and present an unbroken surface.

Mount tool J 7174 in a drill motor (Fig. 29) and place a small amount of lapping powder and oil mixture on the tool. Place the valve seat over the pilot of the tool and start the drill motor. Touch the valve seat lightly against the rotating lapping tool to produce a uniform seat at the hole. After lapping the edge of the hole in this manner, flat lap the face of the seat lightly. Then clean and examine the width of the chamfer produced at the edge of the hole. The specified width is .002 " to .005 ". A width in excess of these limits, due to excessive lapping, will lower the valve opening pressure of the injector.

9. Wash all of the lapped parts in clean fuel oil and dry them with compressed air.

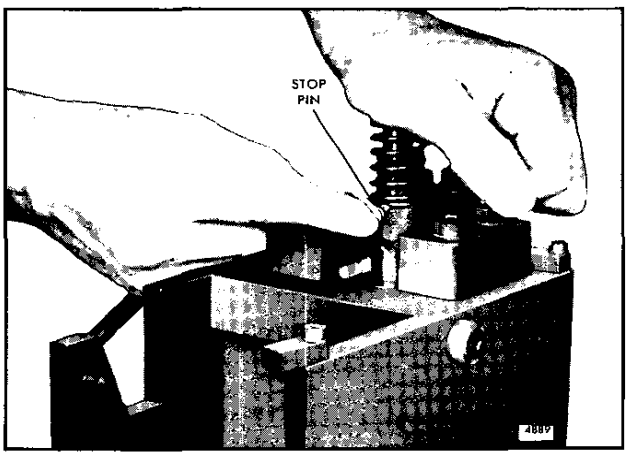


Fig. 35 - Installing Injector Follower Stop Pin

ASSEMBLE INJECTOR

Use an extremely clean bench to work on and to place the parts when assembling an injector. Also be sure all of the injector parts, both new and used, are clean.

Study Figs. 30 through 32 for the proper relative position of the injector parts, then proceed as follows:

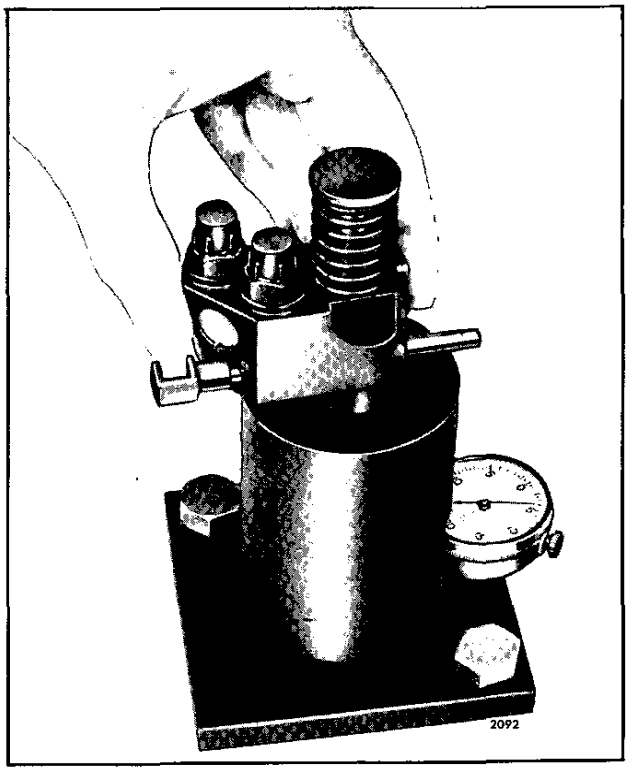


Fig. 36 - Checking Injector Spray Tip Concentricity

© 1979 General Motors Corp

Assemble Injector Filters

1. While holding the injector body right side up, place a new filter, slot in the filter up or toward the filter cap, in each of the fuel cavities in the top of the injector body (Fig. 30).

2. Place a spring on top of each filter (if an early design filter cap is used) and a new gasket on each filter cap. Lubricate the threads and install the filter caps. Use a 9/16 " deep socket wrench as shown in Fig. 18 to tighten the filter caps to 65-75 lb-ft (88-102 Nm) torque.

3. Purge the filters after installation by directing compressed air or fuel through the filter caps.

4. Install clean shipping caps on the filter caps to prevent dirt from entering the injector.

Assemble Rack and Gears

Refer to Fig. 31 and note the drill spot marks on the control rack and gear. Then proceed as follows:

1. Hold the injector body, bottom end up, and slide the rack through the hole in the body. Look into the bore and move the rack until you can see the drill marks. Hold the rack in this position.

2. Place the gear in the injector body so that the marked tooth is engaged between the two marked teeth on the rack.

3. Place the gear retainer on top of the gear. Next align the locating pin in the bushing with the slot in the injector body, then slide the end of the bushing into place.

Assemble Injector Valve and Related Parts

After having lapped and cleaned the injector valve and its related parts, refer to Figs. 1 and 32 and assemble them as follows:

1. Support the injector body, bottom end up, in the injector holding fixture J 22396.

2. Place a new seal ring on the shoulder of the body. Then slide the spill deflector over the barrel of the bushing.

> **NOTE:** Wet the seal ring with test oil and install the ring all the way down past the threads and onto the shoulder of the injector body. This will prevent the seal from catching in the threads and becoming shredded.

3. Place the valve seat on the end of the bushing. Then insert the stem of the valve in one end of the valve spring and the valve stop in the other end. Lower the valve cage over this assembly so that the valve stop seats in the cage. Place the valve cage assembly on the valve seat.

4. Locate the check valve centrally on the cage and place the spray tip over the check valve and against the valve cage.

5. Lubricate the threads in the injector nut and carefully thread the nut on the injector body by hand. Rotate the spray tip between your thumb and first finger while threading the nut on the injector body (Fig. 33). Tighten the nut as tight as possible by hand. At this point there should be sufficient force on the spray tip to make it impossible to turn with your fingers.

6. Use socket J 4983-01 and a torque wrench to tighten the injector nut to 55-65 lb-ft (75-88 Nm) torque (Fig. 34).

> **NOTE:** Do not exceed the specified torque. Otherwise, the nut may be stretched and result in improper sealing of the lapped surfaces in a subsequent injector overhaul.

Assemble Plunger and Follower

1. Refer to Fig. 32 and slide the head of the plunger into the follower.

2. Invert the injector in the assembly fixture (filter cap end up) and push the rack all the way in. Then place the follower spring on the injector body.

3. Refer to Fig. 35 and place the stop pin on the injector body so that the follower spring rests on the narrow flange of the stop pin. Then align the slot in the follower with the stop pin hole in the injector body. Next align the flat side of the plunger with the slot in the follower. Then insert the free end of the plunger in the injector body. Press down on the follower and at the same time press the stop pin into position. When in place, the spring will hold the stop pin in position.

Spray Tip Concentricity

To assure correct alignment, check the concentricity of the spray tip as follows:

1. Place the injector in the concentricity gage J29584 as shown in Fig. 36 and adjust the dial indicator to zero.

© 1982 General Motors Corp.

2. Rotate the injector 360 ° and note the total runout as indicated on the dial.

3. If the total runout exceeds .008 ", remove the injector from the gage. Then loosen the injector nut, center the spray tip and tighten the nut to 55-65 lb-ft (75-88 Nm) torque. Recheck the spray tip concentricity. If, after several attempts, the spray tip cannot be positioned satisfactorily, replace the injector nut.

Test Reconditioned Injector

Before placing a reconditioned injector in service, perform all of the tests (except the visual inspection of the plunger) previously outlined under *Test Injector.*

The injector is satisfactory if it passes these tests. Failure to pass any one of the tests indicates that defective or dirty parts have been assembled. In this case, disassemble, clean, inspect, assemble and test the injector again.

Install Injector

Before installing an injector in an engine, remove the carbon deposits from the beveled seat of the injector tube in the cylinder head. This will assure correct alignment of the injector and prevent any undue stresses from being exerted against the spray tip.

Use injector tube bevel reamer J 5286-9, Section 2.1.4, to clean the carbon from the injector tube. Exercise care to remove ONLY the carbon so that the proper clearance between the injector body and the cylinder head is maintained. Pack the flutes of the reamer with grease to retain the carbon removed from the tube.

Be sure the fuel injector is filled with fuel oil. If necessary, add clean fuel oil at the inlet filter cap until it runs out of the outlet filter cap.

Install the injector in the engine as follows:

1. Refer to Fig. 6 and insert the injector into the injector tube with the dowel in the injector body registering with the locating hole in the cylinder head.

2. Slide the rack control lever over so that it registers with the injector rack.

3. Install the injector clamp, special washer (with curved side toward injector clamp) and bolt. Tighten the bolt to 20-25 lb-ft (27-34 Nm) torque. Make sure that the clamp does not interfere with the injector follower spring or the exhaust valve springs.

> **NOTE:** Check the injector control rack for free movement. Excess torque can cause the control rack to stick or bind.

4. Move the rocker arm assembly into position and secure the rocker arm brackets to the cylinder head by tightening the bolts to the torque specified in Section 2.0.

> **NOTE:** On four valve cylinder heads, there is a possibility of damaging the exhaust valves if the exhaust valve bridges are not resting on the ends of the exhaust valves when tightening the rocker shaft bracket bolts. Therefore, note the position of the exhaust valve bridges before, during and after tightening the rocker shaft bolts.

5. Remove the shipping caps. Then install the fuel pipes and connect them to the injector and the fuel connectors. Use socket J 8932-01 to tighten the connections to 12-15 lb-ft (16-20 Nm) torque. Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared end of the fuel line and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings (refer to *Pressurize Fuel System-Check for Leaks* in Section 2.0).

> **NOTE:** An indication of fuel leakage at the fittings of the fuel injector supply lines and connector nut seals could be either low lubricating oil pressure (dilution) or fuel odor coming from the crankcase breathers or an open oil filler cap. When any of the above are detected, remove the valve rocker cover. A close inspection of the rocker cover, cylinder head, fuel lines and connectors will usually show if there is a fuel leakage problem. Under normal conditions, there should be a coating of lubricating oil throughout the cylinder head area and puddles of oil where the fuel pipes contact the connectors and where the fuel connectors contact the cylinder head. If these areas do not have the normal coating of lubricating oil, it is likely that fuel oil is leaking and washing off the lubricating oil. Remove and replace the leaking fuel pipes and/or connectors. Reinstall the rocker cover. Then drain the lubricating oil and change the oil filter elements. Refer to Section 13.3 and refill the crankcase to the proper level with the recommended grade of oil.

6. Perform a complete engine tune-up as outlined in Section 14. However, if only one injector has been removed and replaced and the other injectors and the governor adjustment have not been disturbed, it will only be necessary to adjust the valve clearance and time the injector for the one cylinder, and to position the injector rack control levers.

© 1982 General Motors Corp.

FUEL INJECTOR (Needle Valve)

The fuel injector (Figs. 1 and 2) is a lightweight compact unit which enables quick, easy starting directly on diesel fuel and permits the use of a simple open type combustion chamber. The simplicity of design and operation provides for simplified controls and easy adjustment. No high pressure fuel lines or complicated air-fuel mixing or vaporizing devices are required.

The fuel injector performs four functions:

1. Creates the high fuel pressure required for efficient injection.

2. Meters and injects the exact amount of fuel required to handle the load.

3. Atomizes the fuel for mixing with the air in the combustion chamber.

4. Permits continuous fuel flow.

Combustion required for satisfactory engine operation is obtained by injecting, under pressure, a small quantity of accurately metered and finely atomized fuel oil into the cylinder.

Metering of the fuel is accomplished by an upper and lower helix machined in the lower end of the injector plunger. Figure 3 illustrates the fuel metering from no-load to full-load by rotation of the plunger in the bushing.

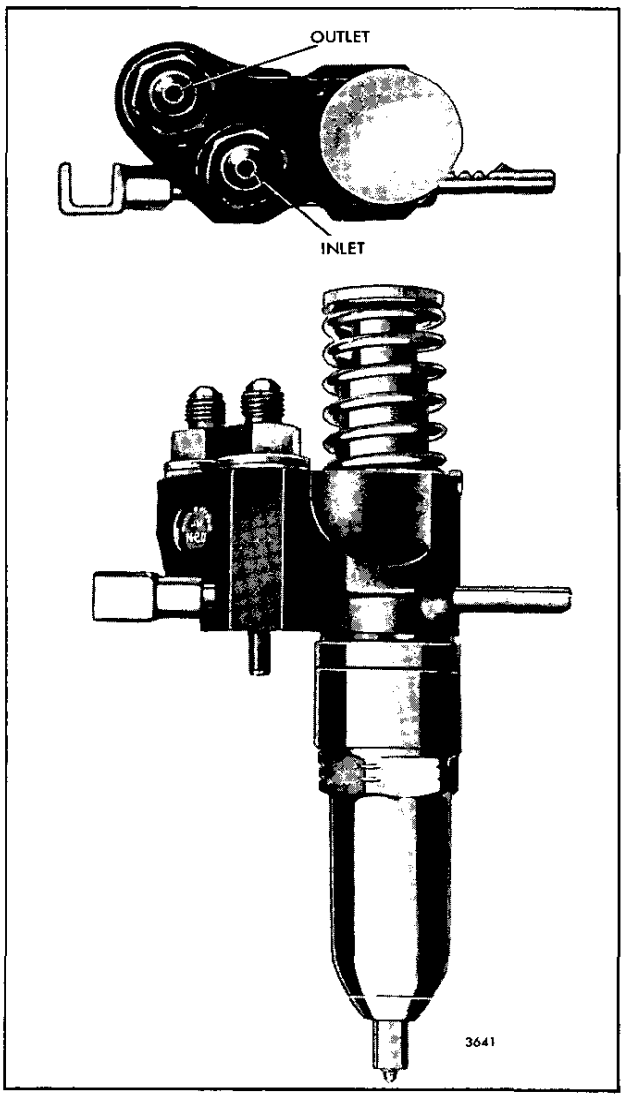


Fig. 1 - Fuel Injector Assembly

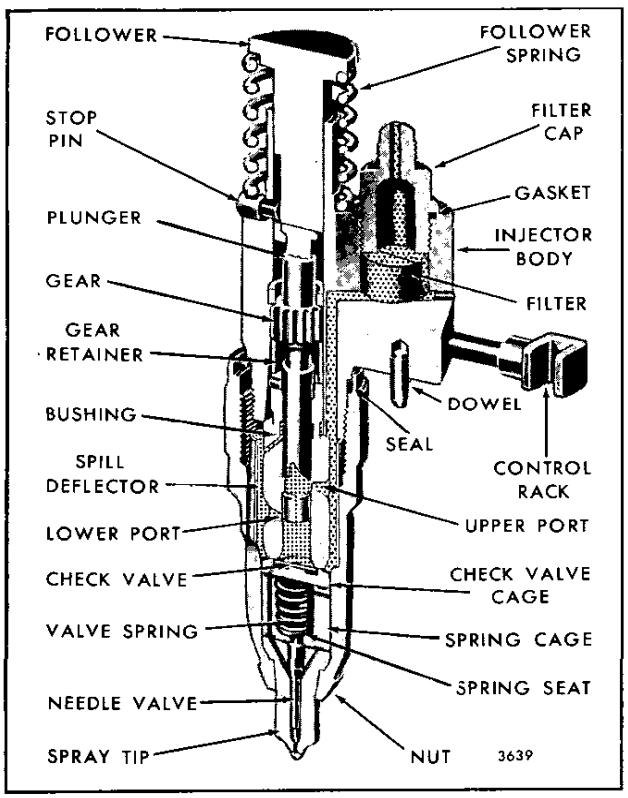


Fig. 2 - Cutaway View of Fuel Injector

© 1979 General Motors Corp.

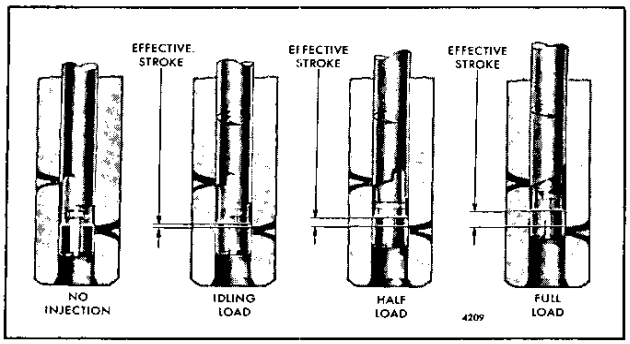


Fig. 3 - Fuel Metering from No-Load to Full-Load

Figure 4 illustrates the phases of injector operation by the vertical travel of the injector plunger.

The continuous fuel flow through the injector serves, in addition to preventing air pockets in the fuel system, as a coolant for those injector parts subjected to high combustion temperatures.

To vary the power output of the engine, injectors having different fuel output capacities are used. The fuel output of the various injectors is governed by the helix angle of the plunger and the type of spray tip used. Refer to Fig. 5 for the identification of the injectors and their respective plungers and spray tips.

Since the helix angle on the plunger determines the output and operating characteristics of a particular type of injector, it is imperative that the correct injectors are used for each engine application. If injectors of different types are mixed, erratic operation will result and may cause serious damage to the engine or to the equipment which it powers.

NOTE: Do not intermix the needle valve injectors with other types of injectors in an engine.

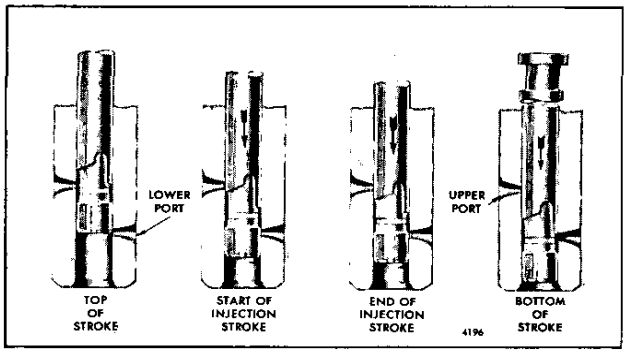


Fig. 4 - Phases of Injector Operation Through Vertical Travel of Plunger

Each fuel injector has a circular disc pressed into a recess at the front side of the injector body for identification purposes (Fig. 5). The identification tag indicates the nominal output of the injector in cubic millimeters.

Each injector control rack (Fig. 2) is actuated by a lever on the injector control tube which, in turn, is connected to the governor by means of a fuel rod. These levers can be adjusted independently on the control tube, thus permitting a uniform setting of all injector racks.

The fuel injector combines in a single unit all of the parts necessary to provide complete and independent fuel injection at each cylinder.

Operation

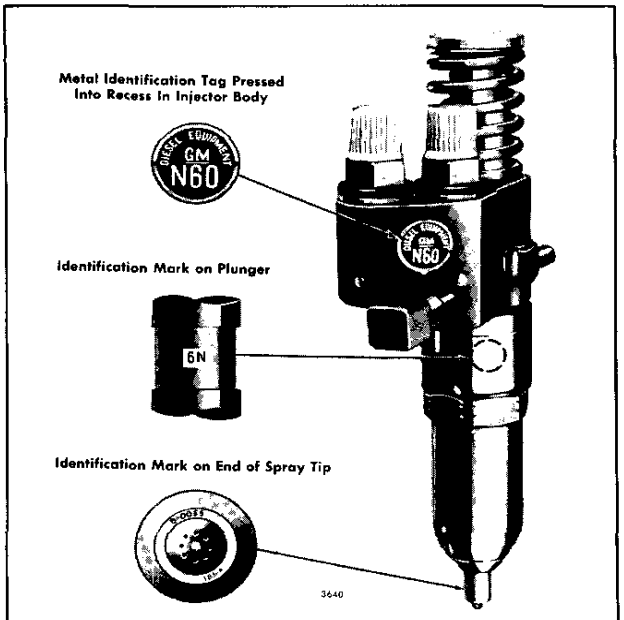
Fuel, under pressure, enters the injector at the inlet side through a filter cap and filter (Fig. 2). From the filter, the fuel passes through a drilled passage into the supply chamber, that area between the plunger bushing and the spill deflector, in addition to that area under the injector plunger within the bushing. The plunger operates up and down in the bushing, the bore of which is open to the fuel supply in the annular chamber by two funnel-shaped ports in the plunger bushing.

The motion of the injector rocker arm is transmitted to the plunger by the follower which bears against the follower spring (Fig. 6). In addition to the reciprocating motion, the plunger can be rotated, during operation, around its axis by the gear which meshes with the control rack. For metering the fuel, an upper helix and a lower helix are machined in the lower part of the plunger. The relation of the helices to the two ports changes with the rotation of the plunger.

As the plunger moves downward, under pressure of the injector rocker arm, a portion of that fuel trapped under the plunger is displaced into the supply chamber through the lower port until the port is closed off by the lower end of the plunger. A portion of the fuel trapped below the plunger is then forced up through a central passage in the plunger into the fuel metering recess and into the supply chamber through the upper port until that port is closed off by the upper helix of the plunger. With the upper and lower ports both closed off, the remaining fuel under the plunger is subjected to increased pressure by the continued downward movement of the plunger.

When sufficient pressure is built up, it opens the flat, non-return check valve. The fuel in the check valve

© 1979 General Motors Corp.



INJECTOR	SPRAY TIP*	PLUNGER
71N5	8 — 0055 — 165A	5N
N55	8 — 0055 — 165A	55N
N60	8 — 0055 — 165A	6N
N65 (white tag)	8 — 0055 — 165A	75N
N65 (brown tag)	8 — 006 — 165A	N65
HN65	7 — 006 — 165A	7N
N70	7 — 006 — 165	7N
N75	7 — 006 — 165	75N
N80	7 — 0065 — 165A	8N
N90	7 — 0065 — 165A	9N
M95	7 — 0065 — 165A	95M
71C5	8 — 0055 — 165A	5C
C55	8 — 0055 — 165A	55C
C60	8 — 0055 — 165A	6C
C65	7 — 006 — 165A	65C
C70	7 — 006 — 165	7C
7C70	9 — 0058 — 165A	7N
7C75	9 — 0058 — 165A	75N
B55	8 — 006 — 162	45C
B60	8 — 006 — 162	5C
B65	8 — 006 — 165A	65B
71B5	8 — 006 — 162	4C
B55E	8 — 006 — 162	B55E
7B5E	8 — 006 — 162	7B5E
7A50	9 — 0055 — 165A	A5
7A55	9 — 0055 — 165A	A55
7A60	9 — 0055 — 165A	A6
7A65	9 — 0058 — 165A	65A
7A70	9 — 0058 — 165A	A7
7A75	9 — 0058 — 165A	75A
7E50	8 — 0055 — 165A	5E
7E55	8 — 0055 — 165A	55E
7E60	8 — 0055 — 165A	6E
7E65	8 — 006 — 165A	65E
7E75	9 — 0055 — 165A	N8
7G65	9 — 0058 — 165A	7G65
7G70	9 — 0058 — 165A	7G70
7G75	9 — 0058 — 165A	7G75

*First numeral indicates number of spray holes, followed by size of holes and angle formed by spray from holes.

Fig. 5 - Injector Identification Chart

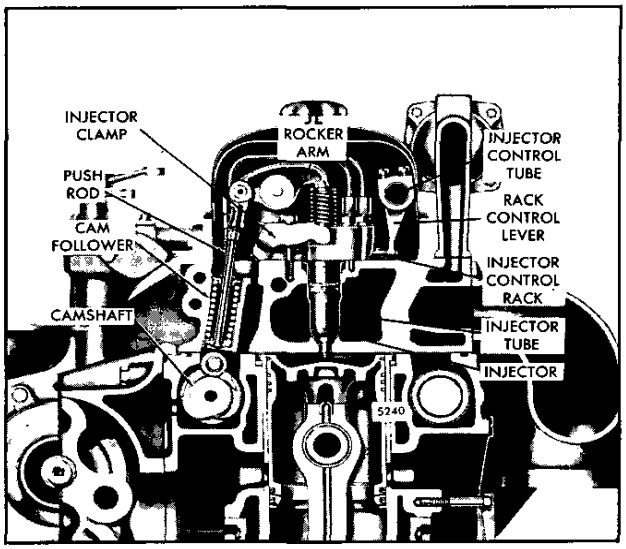


Fig. 6 - Fuel Injector Mounting

cage, spring cage, tip passages and tip fuel cavity is compressed until the pressure force acting upward on the needle valve is sufficient to open the valve against the downward force of the valve spring. As soon as the needle valve lifts off of its seat, the fuel is forced through the small orifices in the spray tip and atomized into the combustion chamber.

When the lower land of the plunger uncovers the lower port in the bushing, the fuel pressure below the plunger is relieved and the valve spring closes the needle valve, ending injection.

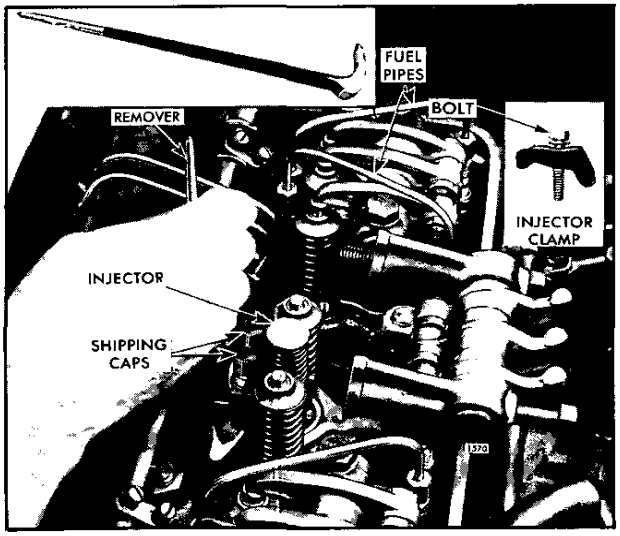


Fig. 7 - Removing Injector from Cylinder Head

© 1982 General Motors Corp.

A pressure relief passage has been provided in the spring cage to permit bleed-off of fuel leaking past the needle pilot in the tip assembly.

A check valve, directly below the bushing, prevents leakage from the combustion chamber into the fuel injector in case the valve is accidentally held open by a small particle of dirt. The injector plunger is then returned to its original position by the injector follower spring. Figure 4 shows the various phases of injector operation by the vertical travel of the injector plunger.

On the return upward movement of the plunger, the high pressure cylinder within the bushing is again filled with fuel oil through the ports. The constant circulation of fresh cool fuel through the injector renews the fuel supply in the chamber, helps cool the injector and also effectively removes all traces of air which might otherwise accumulate in the system and interfere with accurate metering of the fuel.

The fuel injector outlet opening, through which the excess fuel oil returns to the fuel return manifold and then back to the fuel tank, is directly adjacent to the inlet opening.

Changing the position of the helices, by rotating the plunger, retards or advances the closing of the ports and the beginning and ending of the injection period. At the same time, it increases or decreases the amount of fuel injected into the cylinder. Figure 3 shows the various plunger positions from no-load to full-load. With the control rack pulled out all the way (no injection), the upper port is not closed by the helix until after the lower port is uncovered. Consequently, with the rack in this position, all of the fuel is forced back into the supply chamber and no injection of fuel takes place. With the control rack pushed all the way in (full injection), the upper port is closed shortly after the lower port has been covered, thus producing a maximum effective stroke and maximum injection. From this no injection position to full injection position (full rack movement), the contour of the upper helix advances the closing of the ports and the beginning of injection.

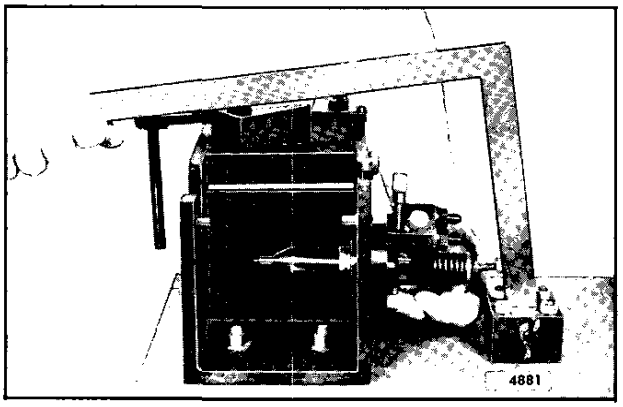


Fig. 8 - Checking Rack and Plunger for Free Movement with J 22396

General Instructions for Injector Care and Overhaul

The fuel injector is one of the most important and precisely built parts of the engine. The injection of the correct amount of fuel into the combustion chamber at exactly the right time depends upon this unit. Because the injector operates against high compression pressure in the combustion chamber, efficient operation demands that the injector assembly is maintained in first-class condition at all times. Proper maintenance of the fuel system and the use of the recommended type fuel filters and clean water-free fuel are the keys to trouble-free operation of the injectors.

Due to the close tolerances of various injector parts, extreme cleanliness and strict adherence to service instructions is required.

Perform all injector repairs in a clean, well lighted room with a dust free atmosphere. An ideal injector room is slightly pressurized by means of an electric fan which draws air into the room through a filter. This pressure prevents particles of dirt and dust from entering the room through the doors and windows. A suitable air outlet will remove solvent fumes along with the outgoing air. Also provide a source for 110 volt alternating current electric power.

Provide the injector repair room with a supply of filtered, moisture-proof compressed air for drying the injector parts after they have been cleaned. Use wash pans of rust-proof material and deep enough to permit

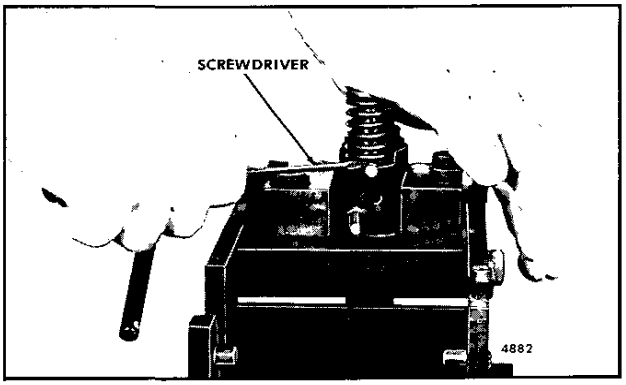


Fig. 9 - Removing Injector Follower Stop Pin

© 1982 General Motors Corp.

all of the injector parts to be completely covered by the cleaning agent, usually clean fuel oil, when submerged in wire baskets of 16 mesh wire screen. Use baskets which will support the parts so as to avoid contact with the dirt which settles at the bottom of the pans.

Rags should never be used for cleaning injector parts since lint or other particles will clog parts of the injector when it is assembled. A lint-free cleaning tissue is a good, inexpensive material for wiping injector parts.

When servicing an injector, follow the general instructions outlined below:

1. Whenever the fuel pipes are removed from an injector, cover the filter caps with shipping caps to keep dirt out of the injectors. Also protect the fuel pipes and fuel connectors from the entry of dirt or other foreign material.

2. After an injector has been operated in an engine, do not remove the filter caps or filters while the injector is in the engine. Replace the filters only at the time of complete disassembly and assembly of an injector.

NOTE: In the offset injector, a filter is used in the inlet side only. No filter is required on the outlet side (Fig. 34).

3. Whenever an injector has been removed and reinstalled or replaced in an engine, make the following adjustments as outlined in Section 14:

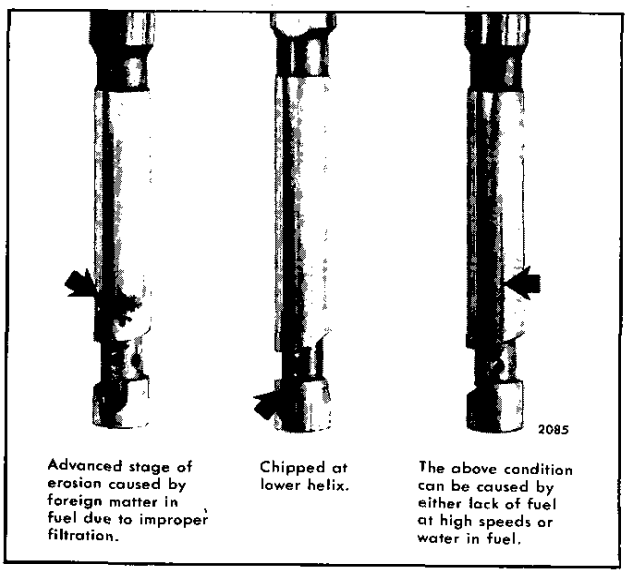


Fig. 10 - Unusable Injector Plungers

a. Time the injector.

b. Position the injector control rack.

4. Whenever an engine is to be out of service for an extended period, purge the fuel system, then fill it with a good grade of rust preventive (refer to Section 15.3).

5. When a reconditioned injector is to be placed in stock, fill it with injector test oil J 26400. *Do not use fuel oil.* Install shipping caps on both filter caps immediately after filling. Store the injector in an upright position to prevent test oil leakage.

NOTE: Make sure that new filters have been installed in a reconditioned injector which is to be placed in stock. This precaution will prevent dirt particles from entering the injector due to a possible reversal of fuel flow when installing the injector in an engine other than the original unit.

Remove Injector

1. Clean and remove the valve rocker cover.

2. Remove the fuel pipes from both the injector and the fuel connectors (Fig. 6).

NOTE: Immediately after removal of the fuel pipes from an injector, cover the filter caps with shipping caps to prevent dirt from entering the injector. Also protect the fuel pipes and fuel connectors from entry of dirt or foreign material.

3. Crank the engine to bring the outer ends of the push rods of the injector and valve rocker arms in line horizontally.

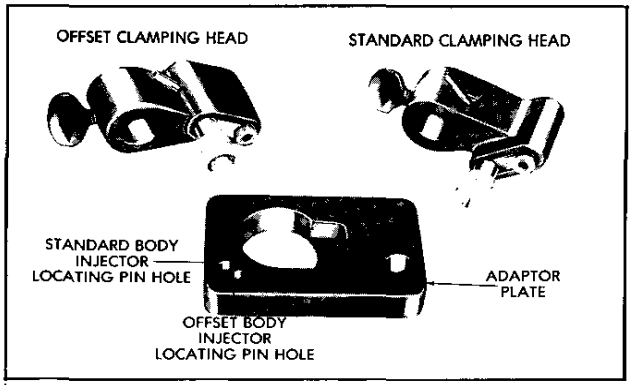


Fig. 11 - Injector Tester J 23010 Clamping Heads

© 1979 General Motors Corp.

4. Remove the two rocker shaft bracket bolts and swing the rocker arms away from the injector and valves (Fig. 7).

5. Remove the injector clamp bolt, special washer and clamp.

6. Loosen the inner and outer adjusting screws (certain engines have only one adjusting screw and lock nut) on the injector rack control lever and slide the lever away from the injector.

7. Lift the injector from its seat in the cylinder head.

8. Cover the injector hole in the cylinder head to keep foreign material out.

9. Clean the exterior of the injector with clean fuel oil and dry it with compressed air.

TEST INJECTOR

CAUTION: The fuel spray from an injector can penetrate the skin. Fuel oil which enters the blood stream can cause a serious infection. Therefore, follow instructions and use the proper equipment to test an injector.

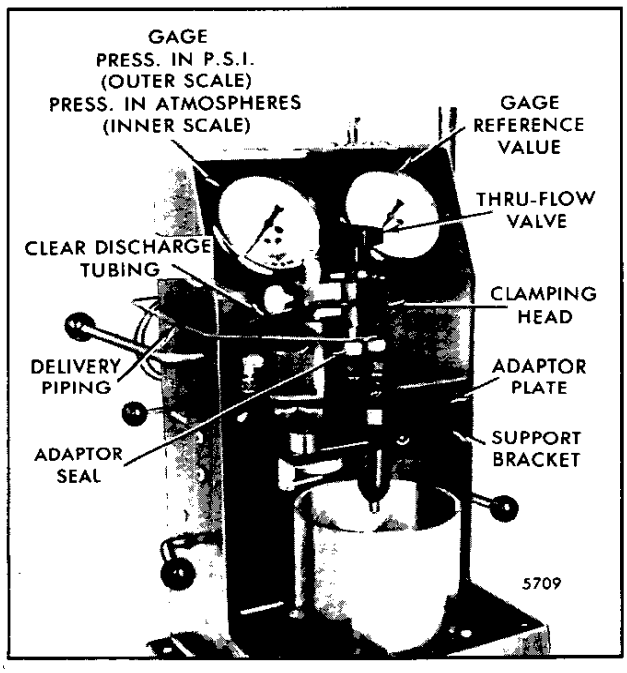


Fig. 12 - Injector Installed in Tester J 23010 with clamping Head

If inspection does not reveal any external damage, then perform a series of tests to determine the condition of the injector to avoid unnecessary overhauling. Tests must be performed using injector test oil J 26400.

An injector that passes all of the tests outlined below may be considered to be satisfactory for service without disassembly, except for the visual check of the plunger.

However, an injector that fails to pass one or more of the tests is unsatisfactory. Perform all of the tests before disassembling an injector to correct any one condition.

Identify each injector and record the pressure drop and fuel output as indicated by the following tests:

Injector Control Rack and Plunger Movement Test

Place the injector in the injector fixture and rack freeness tester J 22396. Refer to Fig. 8 and place the handle on top of the injector follower.

If necessary, adjust the contact screw in the handle to ensure the contact screw is at the center of the follower when the follower spring is compressed.

With the injector control rack held in the no-fuel position, push the handle down and depress the follower to the bottom of its stroke. Then very slowly release the pressure on the handle while moving the control rack up and down as shown in Fig. 8 until the

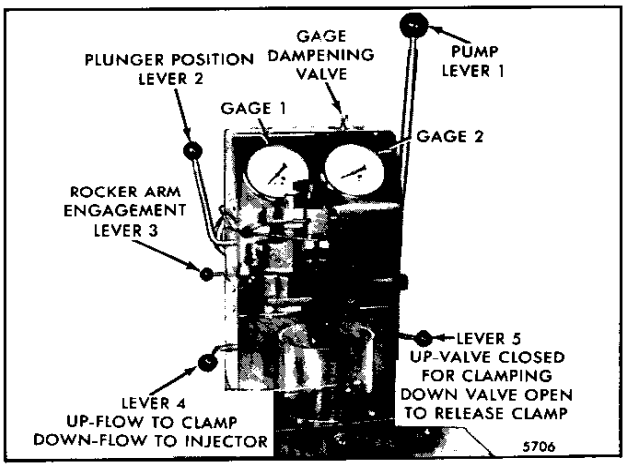


Fig. 13 - Injector in Position for Testing with Tester J 23010

© 1979 General Motors Corp.

follower reaches the top of its travel. If the rack does not fall freely, loosen the injector nut, turn the tip, then retighten the nut. Loosen and retighten the nut a couple of times if necessary. Generally this will free the rack. Then, if the rack isn't free, change the injector nut. In some cases it may be necessary to disassemble the injector to eliminate the cause of the misaligned parts.

Visual Inspection of Plunger

An injector which passes all of the previous tests should have the plunger checked visually, under a magnifying glass, for excessive wear or a possible chip on the bottom helix. There is a small area on the bottom helix and lower portion of the upper helix, if chipped, that will not be indicated in any of the tests.

Remove the plunger from the injector as follows:

1. Support the injector, right side up, in holding fixture J 22396.

2. Compress the follower spring. Then raise the spring above the stop pin with a screw driver and withdraw the pin (Fig. 9). Allow the spring to rise gradually.

3. Remove the injector from the holding fixture. Turn the injector upside down, to prevent the entry of dirt, and catch the spring and plunger as they drop out.

4. Inspect the plunger. If the plunger is chipped (Fig. 10), replace the plunger and bushing assembly.

5. Reinstall the plunger, follower and spring.

Installing Fuel Injector in Tester J 23010

1. Select the proper clamping head (Fig. 11). Position it on the clamping post and tighten the thumb screw into the lower detent position (Fig. 12).

2. Connect the test oil delivery piping into the clamping head.

3. Connect the test oil clear discharge tubing onto the pipe on the clamping head.

4. Locate the adaptor plate on top of the support bracket by positioning the 3/8 " diameter hole at the far right of the adaptor plate onto the 3/8 " diameter dowel pin. This allows the adaptor plate to swing out for mounting the fuel injector.

5. Mount the injector through the large hole and insert the injector pin in the proper locating pin hole (Fig. 11).

6. Swing the mounted injector and adaptor plate inward until they contact the stop pin at the rear of the support bracket.

Clamping the Fuel Injector

1. Refer to Fig. 13 and position the injector tester levers as follows:

Lever 2 up and to the rear

Lever 3 in the rear detent

Lever 4 up (horizontal)

Lever 5 up (horizontal)

2. Align the clamping head nylon seals over the injector filter caps (Fig. 12).

3. Back off the Thru-Flow valve about half-way to allow the self-aligning nylon seals to seat properly during the clamping operation.

4. Hold the clamping head in position over the filter caps and, with the left hand, operate pump lever 1 evenly to move the clamping head *down* to seal the filter caps. The Thru-Flow valve should still turn freely. If it does not, turn the valve counterclockwise until it rotates freely and reapply clamping pressure.

> **NOTE:** Excessive force on lever 1 during clamping can damage the seals in the valves operated by levers 4 and 5.

Purging Air from the System

Move lever 4 down and operate pump lever 1 to produce a test oil flow through the injector. When air bubbles no longer pass through the clear discharge tubing, the system is free of air and is now ready for testing.

Injector Valve Opening and Spray Pattern Test

This test determines spray pattern uniformity and the relative pressure at which the injector valve opens and fuel injection begins.

1. Clamp the injector properly and purge the air from the system.

2. Move lever 4 *down*.

© 1982 General Motors Corp.

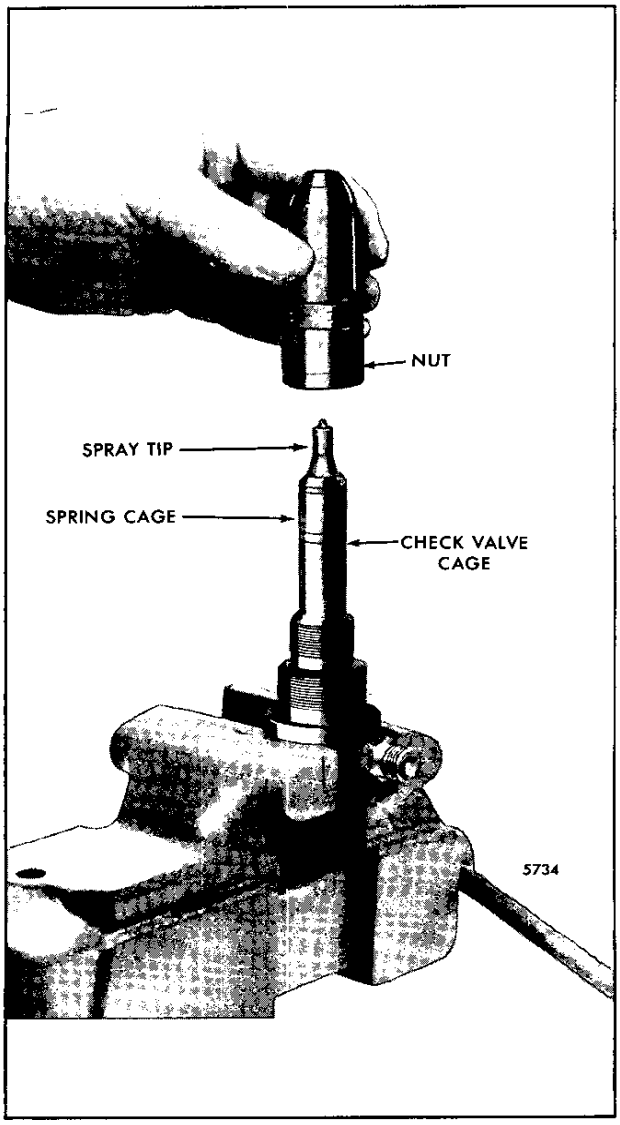


Fig. 14 - Assembling Injector Valve Parts on Tip Tester Adaptor J 23010-129

3. Position the injector rack in the full-fuel position.

4. Place pump lever 1 in the vertical position.

5. Move lever 3 to the forward detent position.

6. The injector follower should be depressed rapidly (40 to 80 strokes per minute) to simulate operation in the engine. Observe the spray pattern to see that all spray orifices are open and dispersing the test oil evenly. The beginning and ending of injection should be sharp and the test oil should be finely atomized with no drops of test oil forming on the end of the tip.

The highest pressure reference number shown on gage 2 will be reached just before injection ends. Use the following reference values to determine the relative acceptability of the injector. Reference values for Series 71 injectors, except the N-90, 7B5E, B55E and B65 are from 127 minimum to 146 maximum. Reference values for the N-90, 7B5E, B55E and B65 are from 138 minimum to 162 maximum.

NOTE: The reference value obtained when pop testing the needle valve injectors is to be used as a trouble shooting and diagnosis aid. This allows comparative testing of injectors without disassembly. Exact valve opening pressure values can only be determined by the *Needle Valve Tip Test* using tester J 23010 and tip test adaptor J 23010-129 or auxiliary tester J 22640.

Injector High Pressure Test

This test checks for leaks at the filter cap gaskets, body plugs and nut seal ring.

1. Clamp the injector properly and purge the air from the system.

2. Close the Thru-Flow valve, but do not overtighten.

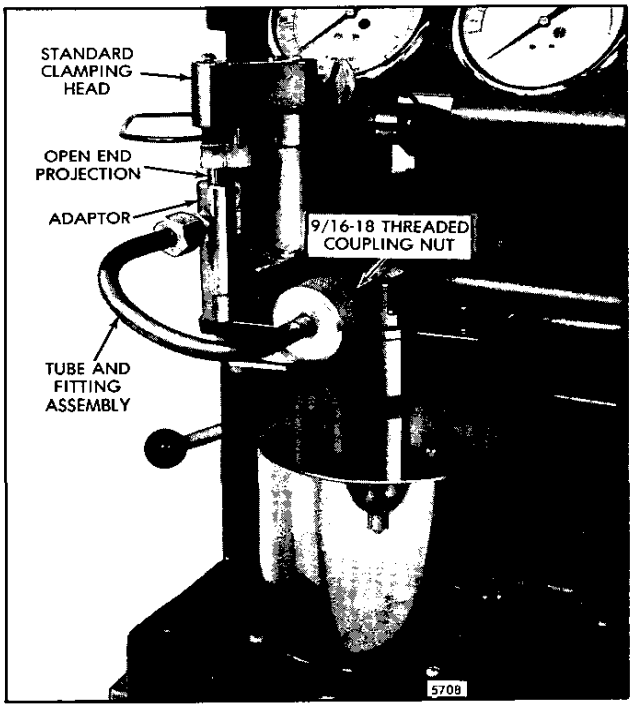


Fig. 15 - Adaptor and Tube Assembly on Injector Tester J 23010

© 1982 General Motors Corp

NOTE: Make sure lever 4 is in the *down* position before operating pump lever 1.

3. Operate pump lever 1 to build up to 1600 to 2000 psi (11 024-13 780 kPa) on gage 1. Check for leakage at the injector filter cap gaskets, body plugs and injector nut seal ring.

Injector Pressure Holding Test

This test determines if the body-to-bushing mating surfaces in the injector are sealing properly and indicates proper plunger-to-bushing fit.

1. Clamp the injector properly and purge the air from the system.

2. Close the Thru-Flow valve, but do not overtighten.

3. Move lever 2 to the rear, horizontal position.

4. Operate pump lever 1 until gage 1 reads approximately 700 psi (4 823 kPa).

5. Move lever 4 to the *up* position.

6. Time the pressure drop between 450 to 250 psi (3 100 to 1 723 kPa). If the pressure drop occurs in less than 15 seconds (fixture J 23010) or 40 seconds (fixture J 9787), leakage is excessive.

Refer to the *Trouble Shooting Charts* in Section 2.0 if the fuel injector does not pass any of the preceding tests.

If the fuel injector passes all of the above tests, proceed with the *Fuel Output Test*.

Unclamping the Injector

1. Open the Thru-Flow valve to release pressure in the system.

2. Move lever 5 *down* to release the clamping pressure.

3. Swing out the adaptor plate and remove the injector after the nylon seals in the clamping head are free and clear of the injector filter caps.

4. Carefully return lever 5 to the *up* (horizontal) position.

Needle Valve Tip Test (Using J 23010 Tester and Tip-Test Adaptor)

Assemble injector parts on tip test adaptor as follows:

1. Clamp the flat sides of the tip test adaptor J 23010-129 firmly in a vise and assemble the cleaned injector parts including the check valve cage, spring, spring seat, spring cage and spray tip assembly.

2. Carefully pilot the injector nut over the spray tip and valve parts and thread it onto the adaptor (Fig. 14).

3. Tighten the injector nut.

4. Mount the adaptor and assembled injector parts in the support bracket (adaptor plate not needed). Refer to Fig. 15.

5. Install the offset clamping head on the clamping post (on J 23010 testers without serial numbers, use the upper detent position and on J 23010 testers numbered 1051 and higher, use the lower detent position).

6. Select the (larger) 9/16 "-18 threaded coupling nut J 23010-20 and thread it on tubing J 23010-75.

Install the tubing and fitting to adaptor J 23010-167.

7. Connect the tubing to tip test adaptor J 23010-129 by threading the coupling nut on the tip test adaptor.

Installing Adaptor and Tube Assembly on Tester J 23010

1. Position the adaptor and tubing assembly with the solid projecting end located in the hole on the left side of the support bracket.

2. Swing the clamping head over the adaptor and clamp it with the oil supply outlet aligned over the open projecting end of the adaptor (Fig. 15).

NOTE: Use the fuel injector clamping procedure to clamp adaptor J 23010-167 in the injector tester.

Spray Tip Test

1. Move lever 4 *down* and operate the pump lever 1 rapidly with smooth even strokes (40 strokes per minute) simulating the action of the tip functioning in the engine (Fig. 13).

2. Note the pressure at which the needle valve opens on gage 1. The valve should open between 2200 and

© 1982 General Motors Corp.

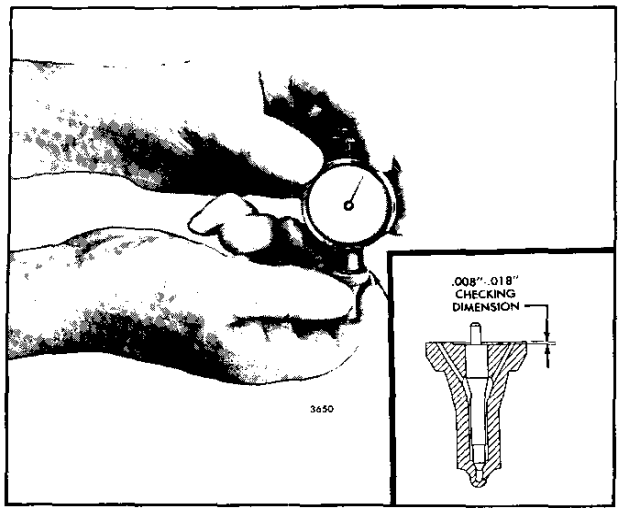


Fig. 16 - Checking Needle Valve Lift

3300 psi (15 158 and 22 737 kPa). The opening and closing action should be sharp and produce a normal, finely atomized spray pattern.

If the valve opening pressure is below 2200 psi (15 158 kPa) and/or atomization is poor, the cause is usually a weak valve spring or a poor needle valve seat.

If the valve opening pressure is within 2200-3300 psi (15 158-22 737 kPa), proceed to check for spray tip leakage as follows:

a. Actuate pump lever 1 several times and hold the pressure at 1500 psi (10 335 kPa) for 15 seconds.

b. Inspect the spray tip for leakage. There should be no fuel droplets, although a slight wetting at the spray tip is permissable.

Needle Valve Lift Test

To measure the needle valve lift, use tool J 9462-02 (Fig. 16) as follows:

1. Zero the indicator by placing the bottom surface of the plunger assembly on a flat surface and zero the indicator dial.

2. Place the spray tip and needle valve assembly tight against the bottom of the gage with the quill of the needle valve in the hole in the plunger.

3. While holding the spray tip and needle valve assembly tight against the gage, read the needle valve lift on the indicator. The lift should be .008 " to .018 ". If it exceeds .018 ", the tip assembly must be replaced. If it is less than .008 ", inspect for foreign material between the needle valve and the tip seat.

4. If the needle valve lift is within limits, install a new needle valve spring and recheck the valve opening pressure and valve action. Low valve opening pressure or poor atomization with a new spring and seat indicates the spray tip and needle valve assembly should be replaced.

5. Reassemble the injector as outlined under *Assemble Injector* and check the injector output with calibrator J 22410.

Needle Valve Tip Test (Using Auxiliary Tester J 22640)

1. Connect the pipe from auxiliary tester J 22640 to the rear of the J 23010 tester at the connection located near the bottom of the tester (Fig.17).

2. Assemble cleaned injector parts, including the check valve cage, spring, spring seat, spring cage and spray tip assembly, on the auxiliary tester J 22640 (Fig. 18).

3. Carefully pilot the injector nut over the spray tip and valve parts and thread it on the auxiliary tester.

4. Tighten the injector nut.

5. Open the valve on the auxiliary tester and place lever 4 in the *up* (horizontal) position.

6. Install the shield on the auxiliary tester and operate pump lever 1 until the needle valve has opened several times to purge the air from the system.

7. Operate pump lever 1 rapidly with smooth even strokes (40 strokes per minute) simulating the action of the tip functioning in the engine. Note the pressure at which the test oil delivery occurs. Test oil delivery should occur between 2200 and 3300 psi (15 158 and 22 737 kPa). The beginning and ending of delivery should be sharp and the test oil should be a finely atomized spray.

If the valve opening pressure is below 2200 psi (15 158 kPa) and/or atomization is poor, the cause is usually a weak valve spring or poor needle valve seat.

If the valve opening pressure is within 2200-3300 psi (15 158-22 737 kPa), proceed to check for spray tip leakage as follows:

a. Actuate the pump lever several times and hold the pressure at 1500 psi (10 335 kPa) for 15 seconds.

b. Inspect the spray tip for leakage. There should be

© 1982 General Motors Corp.

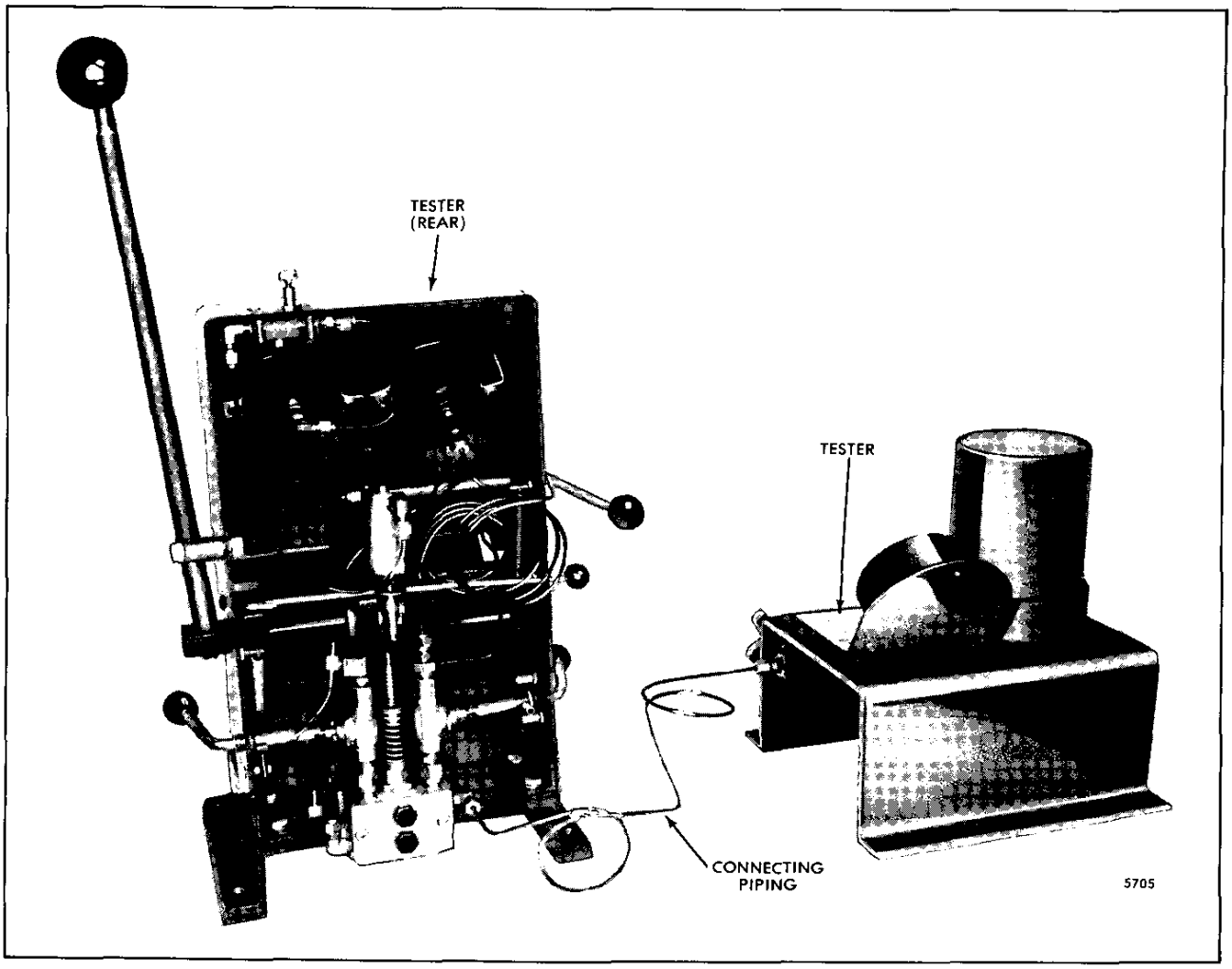


Fig. 17 - Injector Needle Valve Tester J 23010 with Auxiliary Tester J 22640

no fuel droplets although a slight wetting at the spray tip is permissable.

Perform the needle valve lift test.

Fuel Output Test

Perform the injector fuel output test in calibrator J 22410.

When injectors are removed from an engine for fuel output testing and, if satisfactory, reinstalled without disassembly, extreme care should be taken to avoid reversing the fuel flow. When the fuel flow is reversed, dirt trapped by the filter is back-flushed into the injector components.

Before removing an injector from the engine, note the direction of the fuel flow. To avoid reversing the fuel flow when checking injector fuel output, use the appropriate adaptor. The position of the braided fuel inlet tube and the plastic fuel outlet tube on the calibrator (Fig. 20) depends on the adaptor being used and the direction of fuel flow through the injector.

Calibrator J 22410

To check the fuel output, operate the injector in calibrator J 22410 (Fig. 21) as follows:

NOTE: Place the cam shift index wheel and fuel flow lever in their respective positions. Turn on the test fuel oil heater switch and preheat the test oil to 95-105 °F (35-40 °C).

1. Place the proper injector adaptor between the tie

© 1979 General Motors Corp.

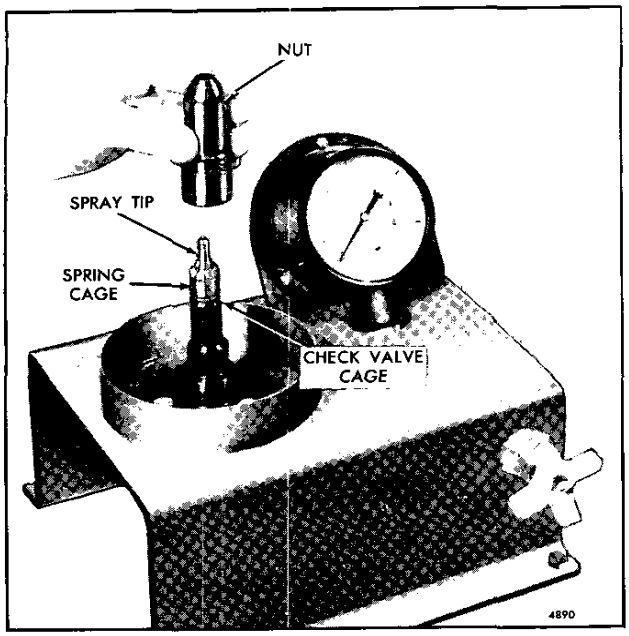


Fig. 18 - Installing Injector Valve Parts on Auxiliary Tester J 22640

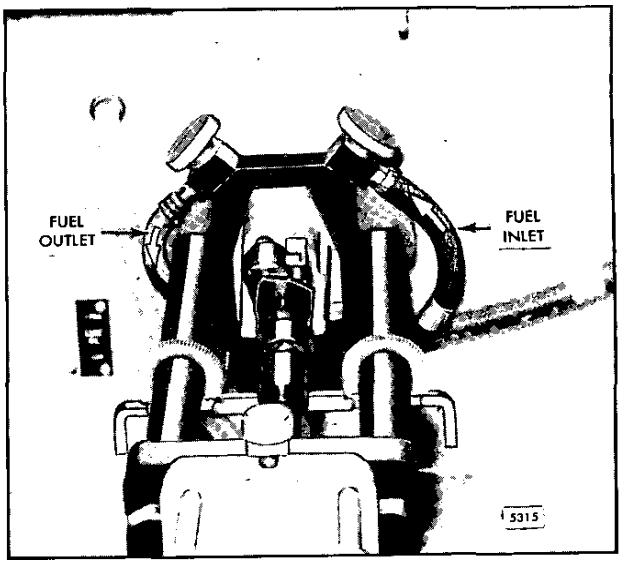


Fig. 20 - Position of Calibrator Fuel Flow Pipes

rods and engage it with the fuel block locating pin. Then slide the adaptor forward and up against the fuel block face.

INJECTOR	CALIBRATOR J 22410 Min.-Max.		INJECTOR	CALIBRATOR J 22410 Min.-Max.	
71N5	50	55	7A50	53	58
N55	53	58	7A55	56	61
N60	57	62	7A60	60	65
N65 (white tag)	64	69	7A65	66	71
N65 (brown tag)	64	69	7A70	72	77
NH65	70	72	7A75	75	80
N70	71	76			
N75	75	80	7E50	50	55
N80	81	86	7E55	53	58
N90	87	93	7E60	57	62
			7E65	63	68
M95	97	103	7E75	75	80
71C5	50	55	7G65	67	72
C55	53	58	7G70	72	77
C60	57	62	7G75	77	82
C65	64	69			
C70	71	76			
7C70	71	76			
7C75	75	80			
B55	53	58			
B60	57	62			
B65	64	69			
71B5	50	55			
B55E	53	58			
7B5E	50	55			

Fig. 19 - Fuel Output Chart

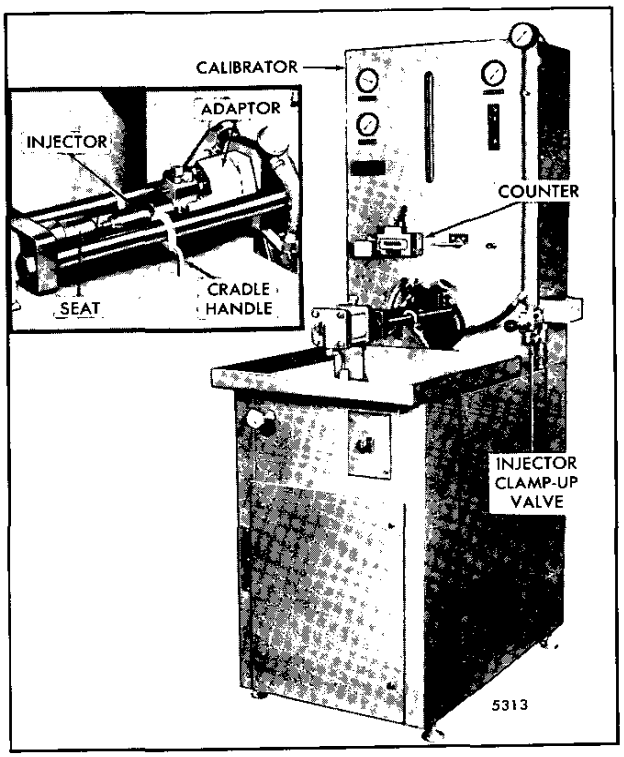


Fig. 21 - Injector in Calibrator J 22410

© 1979 General Motors Corp.

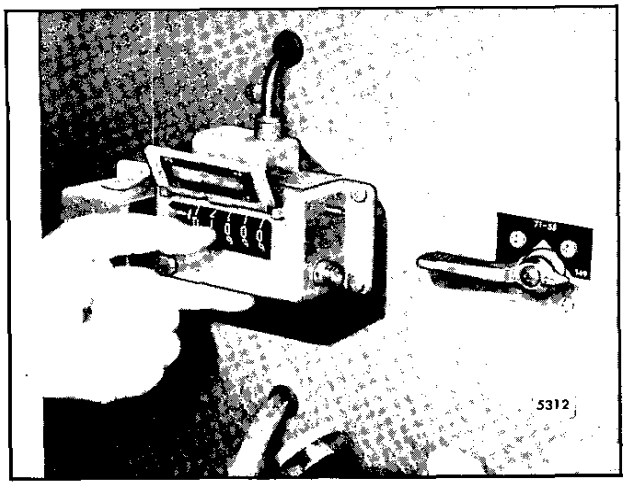


Fig. 22 - Setting Calibrator Stroke Counter

2. Place the injector seat J 22410-226 into the permanent seat (cradle handle in vertical position). Clamp the injector into position by operating the air valve.

NOTE: Make sure the counter (Fig. 22) on the calibrator is preset at 1000 strokes. If for any reason this setting has been altered, reset the counter to 1000 strokes by twisting the cover release button to the left and hold the reset lever in the full up position while setting the numbered wheels. Close the cover. Refer to the calibrator instruction booklet for further information.

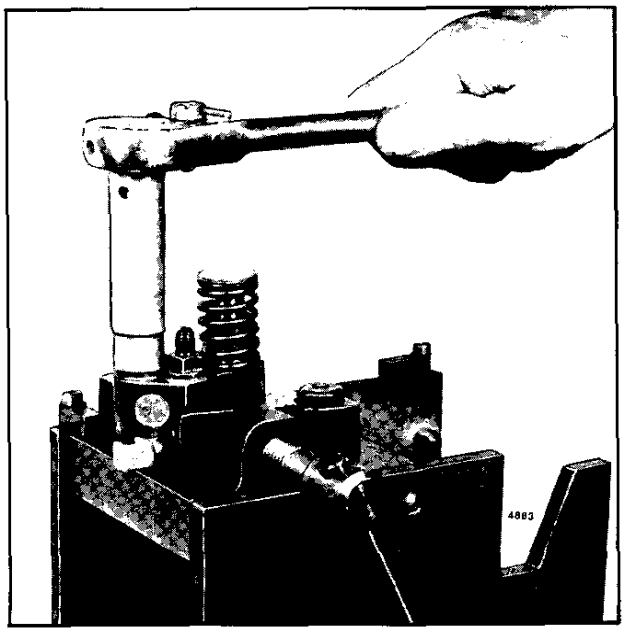


Fig. 23 - Removing or Installing Filter Cap

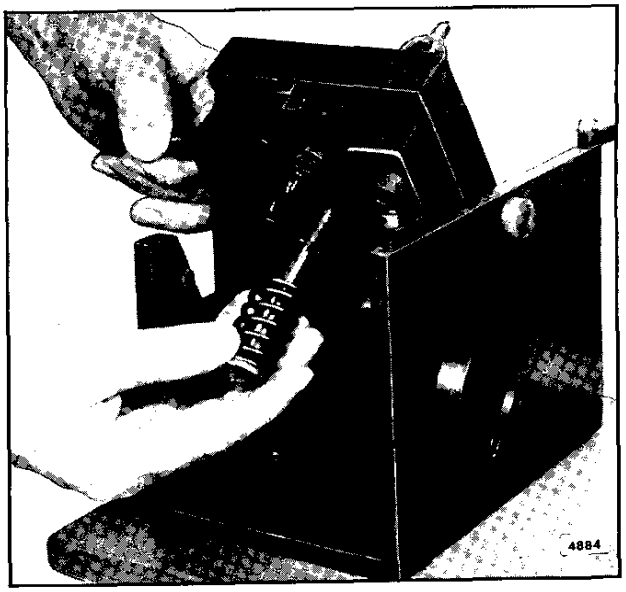


Fig. 24 - Removing or Installing Plunger Follower, Plunger and Spring

3. Pull the injector rack out to the no-fuel position.

4. Turn on the main power control circuit switch. Then start the calibrator by turning on the motor starter switch.

NOTE: The low oil pressure warning buzzer will

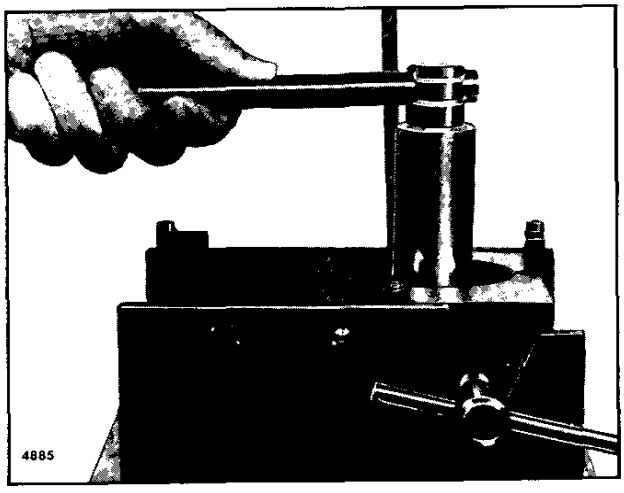


Fig. 25 - Removing Injector Nut

© 1979 General Motors Corp.

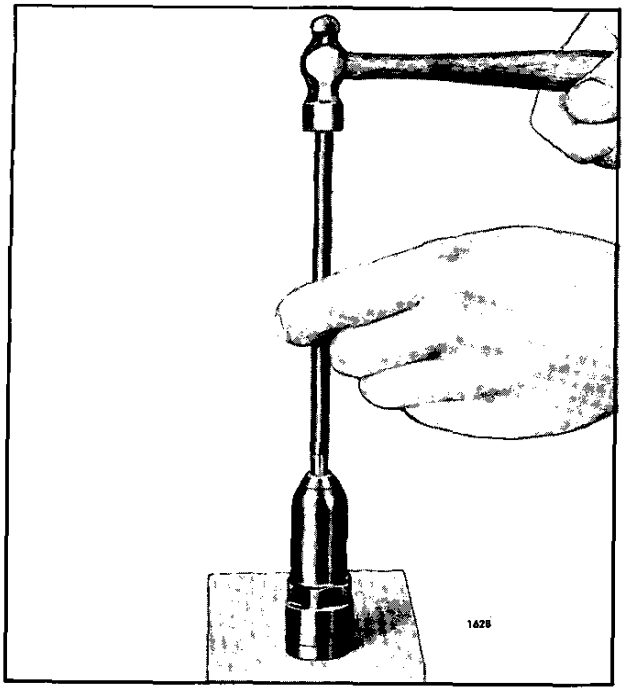


Fig. 26 - Removing Spray Tip from Injector Nut

sound briefly until the lubricating oil reaches the proper pressure.

5. After the calibrator has started, set the injector rack into the full-fuel position. Allow the injector to operate for approximately 30 seconds to purge the air that may be in the system.

6. After the air is purged, press the fuel flow start button (red). This will start the flow of fuel into the vial. The fuel flow to the vial will automatically stop after 1000 strokes.

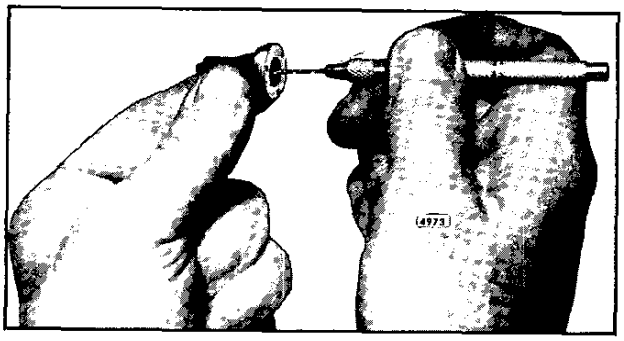


Fig. 27 - Cleaning Injector Spray Tip

7. Shut the calibrator off (the calibrator will stop in less time at full-fuel).

8. Observe the vial reading and refer to Fig. 19 to determine whether the injector fuel output falls within the specified limits. If the quantity of fuel in the vial does not fall within the specified limits, refer to *Trouble Shooting Chart* 6 and *Shop Notes* in section 2.0 for the cause and remedy.

NOTE: Refer to Section 2.0 for different factors that may affect the injector calibrator output reading.

The calibrator may be used to check and select a set of injectors which will inject the same amount of fuel in each cylinder at a given throttle setting, thus resulting in a smooth running, well balanced engine.

An injector which passes all of the above tests may be put back into service. However, an injector which fails to pass one or more of the tests must be rebuilt and checked on the calibrator.

Any injector which is disassembled and rebuilt must be tested again before being placed in service.

Disassemble Injector

If required, disassemble an injector as follows:

1. Support the injector upright in injector holding fixture J 22396 (Fig. 23) and remove the filter caps, gaskets and filters.

NOTE: Whenever a fuel injector is disassembled, discard the filters and gaskets and replace with new filters and gaskets. *In the offset injector, a filter is used in the inlet side only. No filter is required in the outlet side (Fig. 34).*

2. Compress the follower spring as shown in Fig. 11.

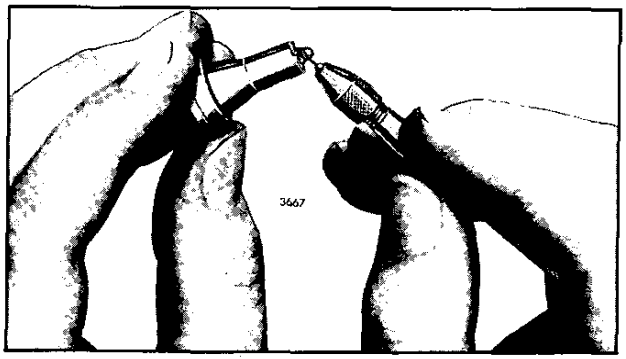


Fig. 28 - Cleaning Spray Tip Orifices

© 1979 General Motors Corp.

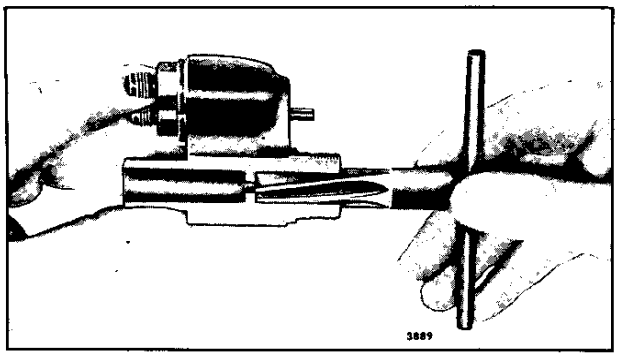


Fig. 29 - Cleaning Injector Body Ring with Tool J 21089

Then raise the spring above the stop pin with a screw driver and withdraw the pin. Allow the spring to rise gradually.

3. Refer to Fig. 24 and remove the plunger follower, plunger and spring as an assembly.

4. Invert the fixture and, using socket J 4983-01, loosen the nut on the injector body (Fig. 25).

5. Lift the injector nut straight up, being careful not to dislodge the spray tip and valve parts. Remove the spray tip and valve parts from the bushing and place them in a clean receptacle until ready for assembly.

When an injector has been in use for some time, the spray tip, even though clean on the outside, may not be pushed readily from the nut with the fingers. In this event, support the nut on a wood block and drive the tip down through the nut, using tool J 1291-02 as shown in Fig. 26.

6. Refer to Fig. 36 and remove the spill deflector. Then lift the bushing straight out of the injector body.

7. Remove the injector body from the holding fixture. Turn the body upside down and catch the gear retainer and gear in your hand as they fall out of the body.

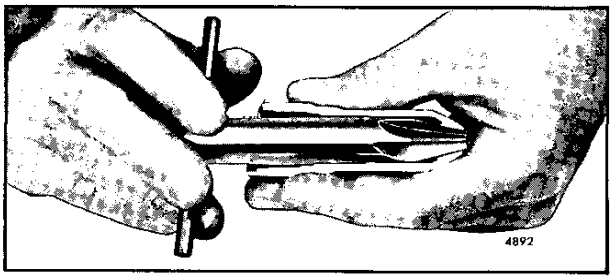


Fig. 30 - Cleaning Injector Nut Spray Tip Seat with Tool J 9418-5

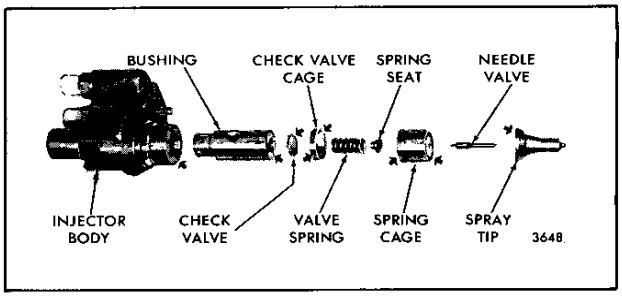


Fig. 31 - Sealing Surfaces which may Require Lapping

8. Withdraw the injector control rack from the injector body. Also remove the seal ring from the body.

Clean Injector Parts

Since most injector difficulties are the result of dirt particles, it is essential that a clean area be provided on which to place the injector parts after cleaning and inspection.

Wash all of the parts with clean fuel oil or a suitable cleaning solvent and dry them with clean, filtered compressed air. *Do not use waste or rags for cleaning purposes.* Clean out all of the passages, drilled holes and slots in all of the injector parts.

Carbon on the inside of the spray tip may be loosened for easy removal by soaking for approximately 15 minutes in a suitable solution prior to the external cleaning and buffing operation.

Clean the spray tip with tool J 9464-01 (Fig. 27).

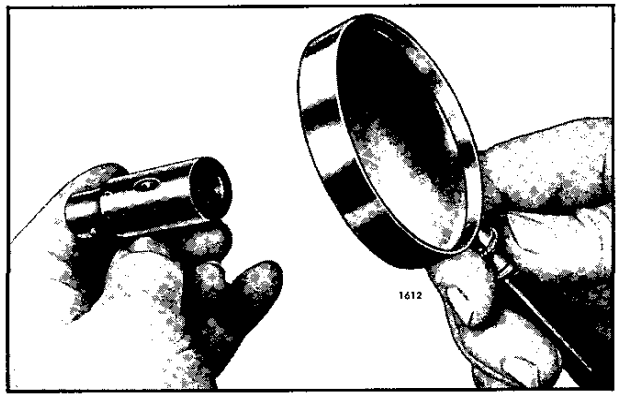


Fig. 32 - Examining Sealing Surface with a Magnifying Glass

© 1982 General Motors Corp.

NOTE: Care must be exercised when inserting the carbon remover J 9464-01 in the spray tip to avoid contacting the needle valve seat in the tip.

Wash the tip in fuel oil and dry it with compressed air. Clean the spray tip orifices with pin vise J 4298-1 and the proper size spray tip cleaning wire. Use wire J 21460 to clean .0055 " diameter holes and wire J 21461 to clean .006 " diameter holes (Fig. 28).

Before using the wire, hone the end until it is smooth and free of burrs and taper the end a distance of 1/16 " with stone J 8170. Allow the wire to extend 1/8 " from tool J 4298-1.

The exterior surface of an injector spray tip may be cleaned by using a brass wire buffing wheel, tool J 7944. To obtain a good polishing effect and longer brush life, the buffing wheel should be installed on a motor that turns the wheel at approximately 3000 rpm. A convenient method of holding the spray tip while cleaning and polishing is to place the tip over the drill end of the spray tip cleaner tool J 1243 and hold the body of the tip against the buffing wheel. In this way, the spray tip is rotated while being buffed.

NOTE: Do not buff excessively. *Do not use a steel wire buffing wheel or the spray tip holes may be distorted.*

When the body of the spray tip is clean, lightly buff the tip end in the same manner. This cleans the spray tip orifice area and will not plug the orifices.

Wash the spray tip in clean fuel oil and dry it with compressed air.

Clean and brush all of the passages in the injector body, using fuel hole cleaning brush J 8152 and rack hole cleaning brush J 8150. Blow out the passages and dry them with compressed air.

Carefully insert reamer J 21089 in the injector body (Fig. 29). Turn it in a clockwise direction a few turns, then remove the reamer and check the face of the ring for reamer contact over the entire face of the ring. If necessary, repeat the reaming procedure until the reamer does make contact with the entire face of the ring. Clean up the opposite side of the ring in the same manner.

Carefully insert a .375 " diameter straight fluted reamer inside the ring bore in the injector body. Turn the reamer in a clockwise direction and remove any burrs inside the ring bore. Then wash the injector body in clean fuel oil and dry it with compressed air.

Remove the carbon deposits from the lower inside diameter taper of the injector nut with carbon remover J 9418-5 (Fig. 30). Use care to minimize removing metal or setting up burrs on the spray tip seat. Remove only enough metal to produce a clean uniform seat to prevent leakage between the tip and the nut. Carefully insert carbon remover J 9418-1 in the injector nut. Turn it clockwise to remove the carbon deposits on the flat spray tip seat.

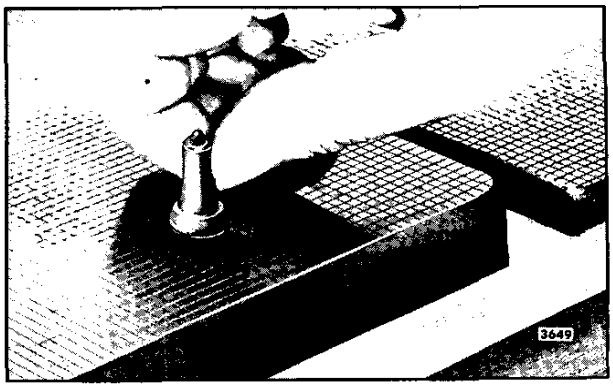


Fig. 33 - Lapping Spray Tip on Lapping Blocks J 22090

Wash the injector nut in clean fuel oil and dry it with compressed air. Carbon deposits on the spray tip seating surfaces of the injector nut will result in poor sealing and consequent fuel leakage around the spray tip.

When handling the injector plunger, do not touch the finished plunger surfaces with your fingers. Wash the plunger and bushing with clean fuel oil and dry them with compressed air. Be sure the high pressure bleed hole in the side of the bushing is not plugged. If this hole is plugged, fuel leakage will occur at the upper end of the bushing where it will drain out of the injector body vent and rack holes, during engine

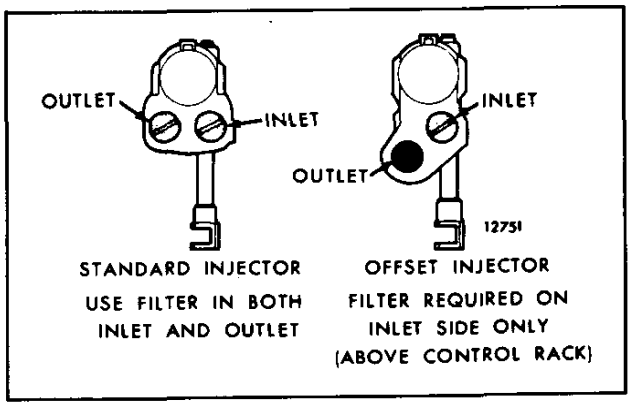


Fig. 34 - Location of Filter in Injector Body

© 1982 General Motors Corp.

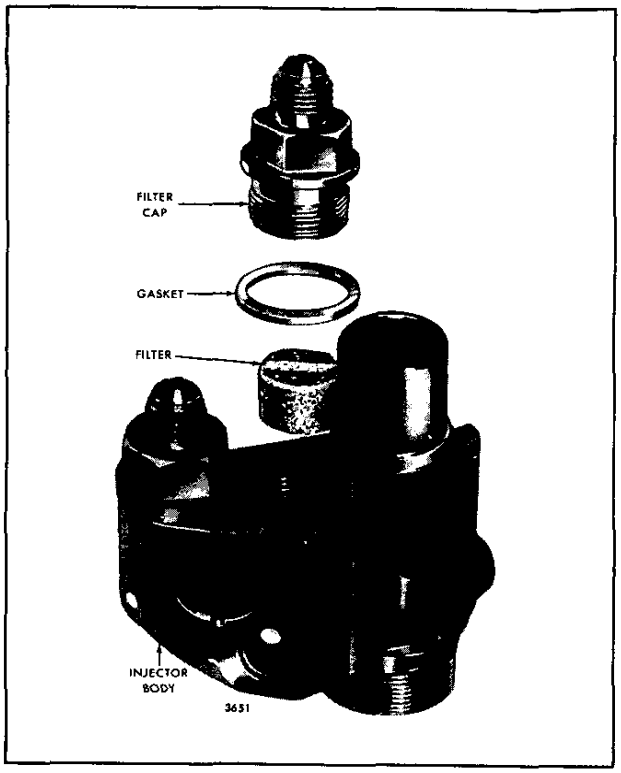


Fig. 35 - Details of Injector Filters and Caps and Their Relative Location

operation, causing a serious oil dilution problem. *Keep the plunger and bushing together as they are mated parts.*

After washing, submerge the parts in a clean receptable containing clean fuel oil. *Keep the parts of each injector assembly together.*

Inspect Injector Parts

Inspect the teeth on the control rack and the control rack gear for excessive wear or damage. Also check for excessive wear in the bore of the gear and inspect the gear retainer. Replace damaged or worn parts.

Inspect the injector follower and pin for wear. Refer to Section 2.0.

Inspect both ends of the spill deflector for sharp edges or burrs which could create burrs on the injector body or injector nut and cause particles of metal to be introduced into the spray tip and valve parts. Remove burrs with a 500 grit stone.

Inspect the follower spring for visual defects. Then check the spring with spring tester J 22738-02.

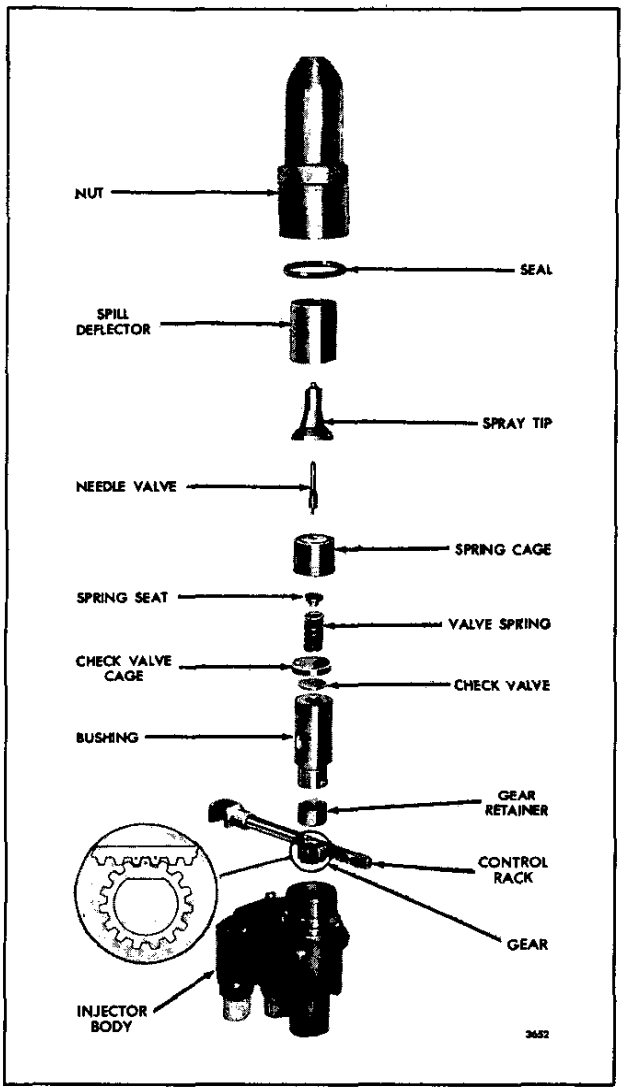


Fig. 36 - Injector Rack, Gear, Spray Tip and Valve Assembly Details and Relative Location of Parts

The current injector follower spring (.142 " diameter wire) has a free length of approximately 1.504 " and should be replaced when a load of less than 70 lbs. will compress it to 1.028 ".

It is recommended that at the time of overhaul, all injectors in an engine be converted to the current spring (.142 " diameter wire) which will provide improved cam roller to shaft follow. However, in the event that one or two injectors are changed, the remaining injectors need not be reworked to incorporate the current spring.

Check the seal ring area on the injector body for burrs

© 1982 General Motors Corp.

or scratches. Also check the surface which contacts the injector bushing for scratches, scuff marks or other damage. If necessary, lap this surface. A faulty sealing surface at this point will result in high fuel consumption and contamination of the lubricating oil. Replace any loose injector body plugs or a loose dowel pin. Install the proper number tag on a service replacement injector body.

Inspect the injector plunger and bushing for scoring, erosion, chipping or wear. Check for sharp edges on that portion of the plunger which rides in the gear. Remove any sharp edges with a 500 grit stone. Wash the plunger *after stoning it.* Check the port holes in the inner diameter of the bushing for cracks or chipping. Slip the plunger into the bushing and check for free movement. *Replace the plunger and bushing as an assembly if any of the above damage is noted, since they are mated parts.* Use new mated factory parts to assure the best performance from the injector.

Injector plungers cannot be reworked to change the output. Grinding will destroy the hardened case at the helix and result in chipping and seizure or scoring of the plunger.

Examine the spray tip seating surface of the injector nut and spray tip for nicks, burrs, erosion or brinelling. Reseat the surface or replace the nut or tip if it is severely damaged.

The injector valve spring plays an important part in establishing the valve opening pressure of the injector assembly. Replace a worn or broken spring.

Inspect the sealing surfaces of the injector parts indicated by arrows in Fig. 31. Examine the sealing surfaces with a magnifying glass as shown in Fig. 32 for even the slightest imperfections will prevent the injector from operating properly. Check for burrs, nicks, erosion, cracks, chipping and excessive wear. Also check for enlarged orifices in the spray tip. Replace damaged or excessively worn parts. Check the minimum thickness of the lapped parts as noted in the chart.

Examine the seating area of the needle valve for wear or damage. Also examine the needle quill and its contact point with the valve spring seat. Replace damaged or excessively worn parts.

Examine the needle valve seat area in the spray tip for foreign material. The smallest particle of such material can prevent the needle valve from seating properly. Polish the seat area with polishing stick J 22964. Coat only the tapered end of the stick with polishing compound J 23038 and insert it directly into the center of the spray tip until it bottoms. Rotate the

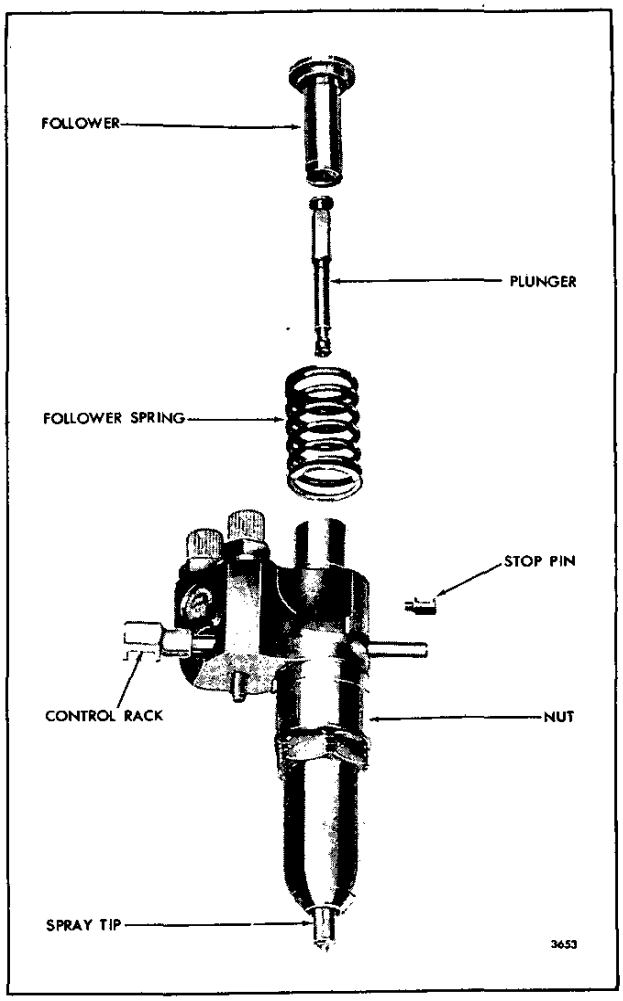


Fig. 37 - Injector Plunger, Follower and Relative Location of Parts

stick 6 to 12 times, applying a light pressure with the thumb and forefinger.

NOTE: Be sure that no compound is accidentally placed on the lapped surfaces located higher up in the spray tip. The slightest lapping action on these surfaces can alter the near-perfect fit *between the needle valve and tip.*

Before reinstalling used injector parts, lap all of the sealing surfaces indicated by the arrows in Fig. 31. It is also good practice to lightly lap the sealing surfaces of new injector parts which may become burred or nicked during handling.

NOTE: The sealing surface of current spray tips is precision lapped by a new process which leaves the surface with a dull satin-like finish; the lapped surface on former spray tips was

© 1982 General Motors Corp.

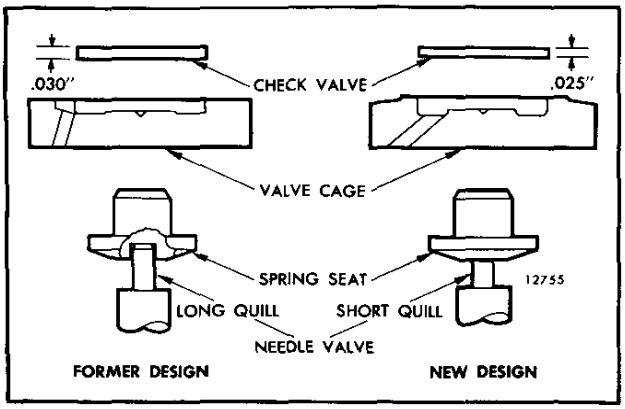


Fig. 38 - Comparison of Former and New Design Injector Parts

bright and shinny (Fig. 39). It is not recommended to lap the surface of the *new* current spray tip.

Lapping Injector Parts

Lap the sealing surfaces indicated in Fig. 31 and Table 1 as follows:

Part Name	Minimum Thickness
Spray Tip (shoulder)	.199"
Check Valve Cage	.163" – .165"
Check Valve	.022"
Valve Spring Cage	.602"

TABLE 1 – Minimum Thickness (Used Parts)

1. Clean the lapping blocks (J 22090) with compressed air. Do not use a cloth or any other material for this purpose.

2. Spread a good quality 600 grit dry lapping powder on one of the lapping blocks.

3. Place the part to be lapped flat on the block as shown in Fig. 33 and, using a figure eight motion, move it back and forth across the block. Do not press on the part, but use just enough pressure to keep the part flat on the block. It is important that the part be kept flat on the block at all times.

4. After each four or five passes, clean the lapping powder from the part by drawing it across a clean piece of tissue placed on a flat surface and inspect the part. *Do not lap excessively* (refer to Table 1).

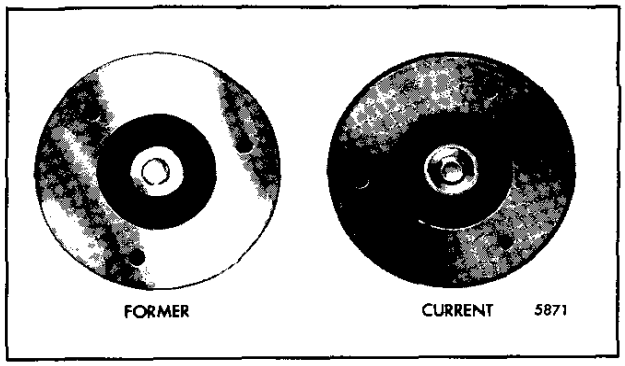


Fig. 39 - Spray Tip Sealing Surface Identification

5. When the part is flat, wash it in cleaning solvent and dry it with compressed air.

6. Place the dry part on the second block. After applying lapping powder, move the part lightly across the block in a figure eight motion several times to give it a smooth finish. *Do not lap excessively.* Again wash the part in cleaning solvent and dry it with compressed air.

7. Place the dry part on the third block. Do not use lapping powder on this block. Keep the part flat and

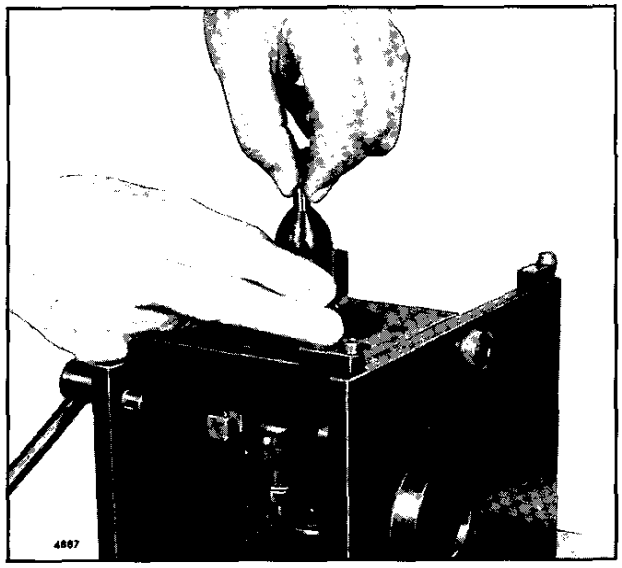


Fig. 40 - Tightening Injector Nut by Hand

© 1982 General Motors Corp.

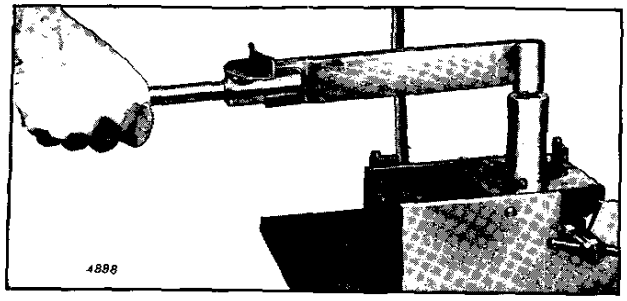


Fig. 41 - Tightening Injector Nut With Torque Wrench

move it across the block several times, using the figure eight motion. Lapping the dry part in this manner gives it the "mirror" finish required for perfect sealing.

8. Wash all of the lapped parts in clean fuel oil and dry them with compressed air.

ASSEMBLE INJECTOR

Use an extremely clean bench to work on and to place the parts when assembling an injector. Also be sure all of the injector parts, both new and used, are clean.

Study Figs. 34 through 37 for the proper relative position of the injector parts, then proceed as follows:

Assemble Injector Filters

Always use new filters and gaskets when reassembling an injector.

1. Insert a new filter, dimple end down, slotted end up, in each of the fuel cavities in the top of the injector body (Fig. 35).

> **NOTE:** Install a new filter in the inlet side (located over the injector rack) in a fuel injector with an offset body. No filter is required in the outlet side of the offset body injector (Fig. 34).

2. Place a new gasket on each filter cap. Lubricate the threads and install the filter caps. Tighten the filter caps to 65-75 lb-ft (88-102 Nm) torque with a 9/16" deep socket (Fig. 23).

3. Purge the filters after installation by directing compressed air or fuel through the filter caps.

4. Install clean shipping caps on the filter caps to prevent dirt from entering the injector.

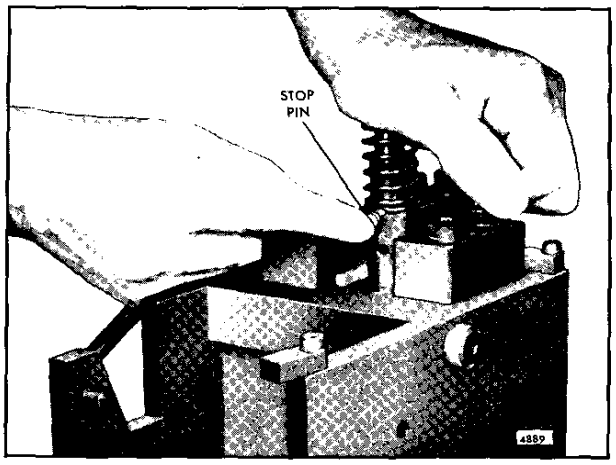


Fig. 42 - Installing Injector Follower Stop Pin

Assemble Rack and Gears

Refer to Fig. 36 and note the drill spot marks on the control rack and gear. Then proceed as follows:

1. Hold the injector body, bottom end up, and slide the rack through the hole in the body. Look into the body bore and move the rack until you can see the drill marks. Hold the rack in this position.

2. Place the gear in the injector body so that the marked tooth is engaged between the two marked teeth on the rack (Fig. 36).

3. Place the gear retainer on top of the gear.

4. Align the locating pin in the bushing with the slot in the injector body, then slide the end of the bushing into place.

Assemble Spray Tip, Spring Cage and Check Valve Assemblies

Refer to Fig. 36 and assemble the parts as follows:

1. Support the injector body, bottom end up, in injector holding fixture J 22396.

2. Place a new seal ring on the shoulder of the body.

> **NOTE:** Wet the seal ring with test oil and install the ring all the way down past the threads and onto the shoulder of the injector body. This will prevent the seal from catching in the threads and becoming shredded.

A new injector nut seal ring protector (J 29197) is now available to install the seal ring. Use the following

© 1982 General Motors Corp.

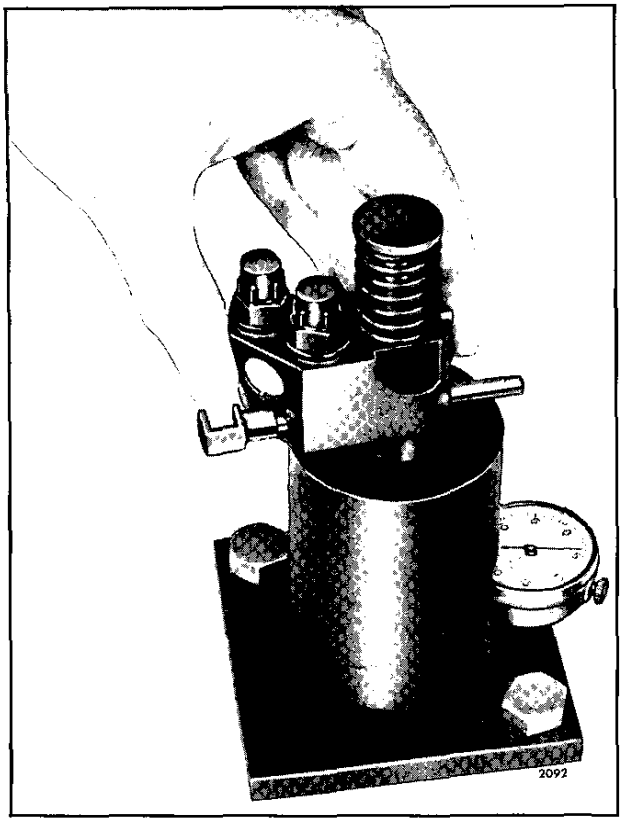


Fig. 43 - Checking Injector Spray Tip Concentricity using Tool J 29584

procedure when installing the seal ring with the new protector:

a. PLace the new seal ring and protector in a container with a small amount of injector test oil.

NOTE: Lubrication of the seal ring and protector is important to assure proper installation of the seal ring.

b. Support the injector body, bottom end up, in injector holding fixture J 22396.

c. Place the lubricated protector over the threads of the injector body. Place the new seal over the nose of the protector and down onto the shoulder of the injector body. Do not allow the seal to roll or twist.

d. Remove the protector.

3. Install the spill deflector over the barrel of the bushing.

4. Place the check valve (without the .010" hole) centrally on the top of the bushing. Then place the check valve cage over the check valve and against the bushing.

NOTE: The former and new check valve and check valve cage are not separately interchangeable in a former injector (Fig. 38).

5. Insert the spring seat in the valve spring, then insert the assembly into the spring cage, spring seat first.

NOTE: Install a new spring seat (Fig. 38) in a former injector if a new design spray tip assembly is used.

6. Place the spring cage, spring seat and valve spring assembly (valve spring down) on top of the check valve cage.

NOTE: When installing a new spray tip assembly in a former injector, a new valve spring seat must also be installed. The current needle valve has a shorter quill.

7. Insert the needle valve, tapered end down, inside of the spray tip (Fig. 2). Then place the spray tip and needle valve on top of the spring cage with the quill end of the needle valve in the hole in the spring cage.

8. Lubricate the threads in the injector nut and carefully thread the nut on the injector body by hand. Rotate the spray tip between your thumb and first finger while threading the nut on the injector body (Fig. 40). Tighten the nut as tight as possible by hand. At this point there should be sufficient force on the spray tip to make it impossible to turn with your fingers.

9. Use socket J 4983-01 and a torque wrench to tighten the injector nut to 75-85 lb-ft (102-115 Nm) torque (Fig. 41).

10. After assembling a fuel injector, always check the area between the nut and the body. If the seal is still visible after the nut is assembled, try another nut which may allow assembly on the body without extruding the seal and forcing it out of the body-nut crevice.

NOTE: Do not exceed the specified torque. Otherwise, the nut may be stretched and result in improper sealing of the lapped surfaces in a subsequent injector overhaul.

© 1981 General Motors Corp.

Assemble Plunger and Follower

1. Refer to Fig. 37 and slide the head of the plunger into the follower.

2. Invert the injector in the assembly fixture (filter cap end up) and push the rack all the way in. Then place the follower spring on the injector body.

3. Refer to Fig. 42 and place the stop pin on the injector body so that the follower spring rests on the narrow flange of the stop pin. Then align the slot in the follower with the stop pin hole in the injector body. Next align the flat side of the plunger with the slot in the follower. Then insert the free end of the plunger in the injector body. Press down on the follower and at the same time press the stop pin into position. When in place, the spring will hold the stop pin in position.

Check Spray Tip Concentricity

To assure correct alignment, check the concentricity of the spray tip as follows:

1. Place the injector in the concentricity gage J 29584 as shown in Fig. 43 and adjust the dial indicator to zero.

2. Rotate the injector 360° and note the total runout as indicated on the dial.

3. If the total runout exceeds .008", remove the injector from the gage. Loosen the injector nut, center the spray tip and tighten the nut to 75-85 lb-ft (102-115 Nm) torque. Recheck the spray tip concentricity. If, after several attempts, the spray tip cannot be positioned satisfactorily, replace the injector nut.

Test Reconditioned Injector

Before placing a reconditioned injector in service, perform all of the tests (except the visual inspection of the plunger) previously outlined under *Test Injector.*

The injector is satisfactory if it passes these tests. Failure to pass any one of the tests indicates that defective or dirty parts have been assembled. In this case, disassemble, clean, inspect, reassemble and test the injector again.

Install Injector

Before installing an injector in an engine, remove the carbon deposits from the beveled seat of the injector tube in the cylinder head. This will assure correct alignment of the injector and prevent any undue stresses from being exerted against the spray tip.

Use injector tube bevel reamer J 5286-9, Section 2.1.4, to clean the carbon from the injector tube. Exercise care to remove ONLY the carbon so that the proper clearance between the injector body and the cylinder head is maintained. Pack the flutes of the reamer with grease to retain the carbon removed from the tube.

Be sure the fuel injector is filled with fuel oil. If necessary, add clean fuel oil at the inlet filter cap until it runs out of the outlet filter cap.

Install the injector in the engine as follows:

1. Refer to Fig. 6 and insert the injector into the injector tube with the dowel pin in the injector body registering with the locating hole in the cylinder head.

2. Slide the injector rack control lever over so that it registers with the injector rack.

3. Install the injector clamp, special washer (with curved side toward injector clamp) and bolt. Tighten the bolt to 20-25 lb-ft (27-34 Nm) torque. Make sure that the clamp does not interfere with the injector follower spring or the exhaust valve springs.

> **NOTE:** Check the injector control rack for free movement. Excess torque can cause the control rack to stick or bind.

4. Move the rocker arm assembly into position and secure the rocker arm brackets to the cylinder head by tightening the bolts to the torque specified in Section 2.0.

> **NOTE:** On four valve cylinder heads, there is a possibility of damaging the exhaust valves if the exhaust valve bridge is not resting on the ends of the exhaust valves when tightening the rocker shaft bracket bolts. Therefore, note the position of the exhaust valve bridge before, during and after tightening the rocker shaft bolts.

5. Remove the shipping caps. Then install the fuel pipes and connect them to the injector and the fuel connectors. Use socket J 8932-01 to tighten the connections to 12-15 lb-ft (16-20 Nm) torque. Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening will twist or fracture the flared end of the fuel line and result in leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings (refer to *Pressurize Fuel System - Check for Leaks* in Section 2.0).

> **NOTE:** An indication of fuel leakage at the fittings of the fuel injector supply lines and

© 1981 General Motors Corp.

connector nut seals could be either low lubricating oil pressure (dilution) or fuel odor coming from the crankcase breathers or an open oil filler cap. When any of the above are detected, remove the valve rocker cover. A close inspection of the rocker cover, cylinder head, fuel lines and connectors will usually show if there is a fuel leakage problem. Under normal conditions, there should be a coating of lubricating oil throughout the cylinder head area and puddles of oil where the fuel pipes contact the connectors and where the fuel connectors contact the cylinder head. If these areas do not have the normal coating of lubricating oil, it is likely that fuel oil is leaking and washing off the lubricating oil. Remove and replace the leaking fuel pipes and/or connectors. Reinstall the rocker cover. Then drain the lubricating oil and change the oil filter elements. Refer to Section 13.3 and refill the crankcase to the proper level with the recommended grade of oil.

6. Perform a complete engine tune-up as outlined in Section 14. However, if only one injector has been removed and replaced and the other injectors and the governor adjustment have not been disturbed, it will only be necessary to adjust the valve clearance and time the injector for the one cylinder, and to position the injector rack control lever.

© 1981 General Motors Corp.

FUEL INJECTOR TUBE

The bore in the cylinder head for the fuel injector is directly through the cylinder head water jacket (Fig. 1). To prevent coolant from contacting the injector and still maintain maximum cooling of the injector, a tube is pressed into the injector bore. This tube is sealed at the top with a neoprene ring and upset into a flare on the lower side of the cylinder head to create water-tight and gas-tight joints at the top and bottom.

NOTE: Aluminum cylinder heads and early design cast iron four valve cylinder heads do not incorporate injector tubes. The injectors seat directly into machined openings in the head.

Ethylene glycol base antifreeze is recommended for use in all Detroit Diesel engines. Methyl alcohol base antifreeze is not recommended because of its effect on the fluoroelastomer seal rings in the cylinder head.

Repair Leaking Injector Tube

To enable the repair of a leaking fuel injector hole tube at the seal ring, without removing the cylinder head from the cylinder block, a new injector hole tube swaging tool J 28611-A is now available.

Before removing the fuel injector, pressurize the cooling system at the radiator to verify the injector tube seal ring leak. Then with the fuel injector removed, insert the swaging tool into the fuel injector hole tube. The tool is tapered and flanged to prevent damage to the cylinder head or injector tube. Hit the top of the tool moderately with a one pound hammer two or three blows seating the tool. This will cause the top edge of the injector hole tube to expand, thus increasing the crush on the injector tube seal ring and seal the leak. Install the fuel injector and again pressurize the cooling system to verify the leak has been stopped.

This tool was designed mainly for use on engines built between July, 1973 and August, 1977 with fuel injector hole tube seal rings that may be pressure senstive and, if so, could take a heat set. The result being a coolant leak at the seal ring. The use of the swaging tool, as stated above, will restore tension to the seal ring.

Remove Injector Tube

When removal of an injector tube is required, use injector tube service tool set J 22525 as follows:

1. Remove, disassemble and clean the cylinder head as outlined in Section 1.2.

2. Place the injector tube installer J 5286-4A in the injector tube. Insert the pilot J 5286-5 through the small opening of the injector tube and thread the pilot into the tapped hole in the end of the installer (Fig. 1).

3. Tap on the end of the pilot to loosen the injector tube. Then, lift the injector tube, installer and pilot from the cylinder head.

Install Injector Tube

Thoroughly clean the injector tube hole in the cylinder head to remove dirt, burrs or foreign material that may prevent the tube from seating at the lower end or sealing at the upper end. Then, install the tube as follows:

1. Lubricate the new injector tube seal ring with engine oil and place it in the counterbore in the cylinder head.

NOTE: **DO NOT** lubricate the outside of the injector tube or inside the cylinder head injector tube bore to facilitate installation of the tube. Lubricant will cause the tube to turn during reaming or rolling operations possibly damaging the injector tube or reamers.

2. Place the installer J 5286-4A in the injector tube. Then, insert the pilot J 5286-5 through the small opening of the injector tube and thread it into the tapped end of the installer (Fig. 2).

3. Slip the injector tube into the injector bore and drive it in place (Fig. 2). Sealing is accomplished between the head counterbore (inside diameter) and outside

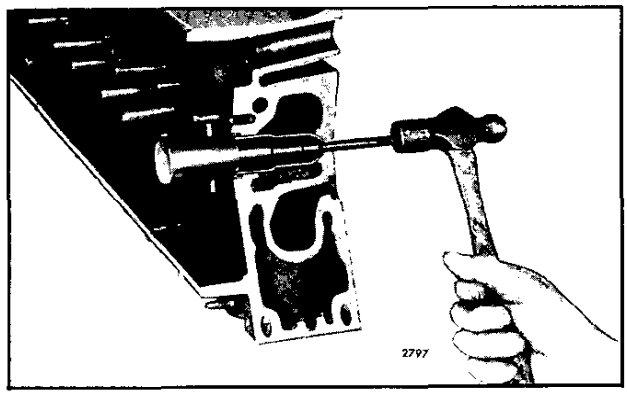


Fig. 1 - Removing Injector Tube with Tools J 5286-4A and J 5286-5

© 1983 General Motors Corp.

diameter of the injector tube. The tube flange is merely used to retain the seal ring.

4. With the injector tube properly positioned in the cylinder head, upset (flare) the lower end of the injector tube as follows:

a. Turn the cylinder head bottom side up, remove the pilot J 5286-5 and thread the upsetting die J 5286-6 into the tapped end of the installer J 5286-4A (Fig. 3).

b. Then, using a socket and torque wrench, apply approximately 30 lb-ft (41 Nm) torque on the upsetting die.

c. Remove the installing tools and ream the injector tube as outlined below.

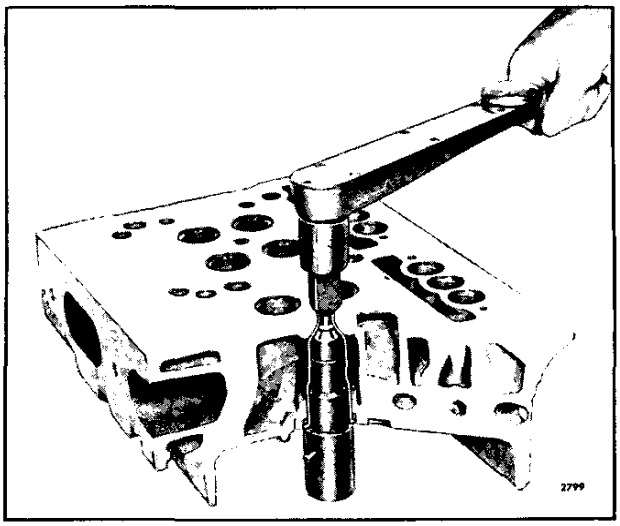


Fig. 3 - Upsetting Injector Tube with Tools J 5286-4A and J 5286-6

Ream Injector Tube

After an injector tube has been installed in a cylinder head, it must be finished in three operations:

First, *hand reamed,* (Fig. 4) to receive the injector body nut and spray tip.

Second, *spot-faced* to remove excess stock at the lower end of the injector tube.

Third, *hand reamed,* (Fig. 5) to provide a good seating surface for the bevel or the lower end of the injector nut. Reaming must be done carefully and without undue force or speed so as to avoid cutting through the thin wall of the injector tube.

NOTE: The reamer should be turned in a *clockwise direction* only, both when inserting and when withdrawing the reamer, because movement in the opposite direction will dull the cutting edges of the flutes.

1. Ream the injector tube for the injector nut and spray tip. With the cylinder head right side up and the

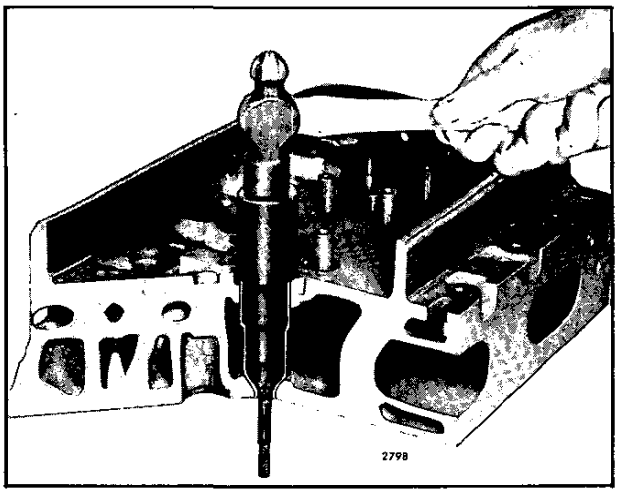


Fig. 2 - Installing Injector Tube with Tools J 5286-4A and J 5286-5

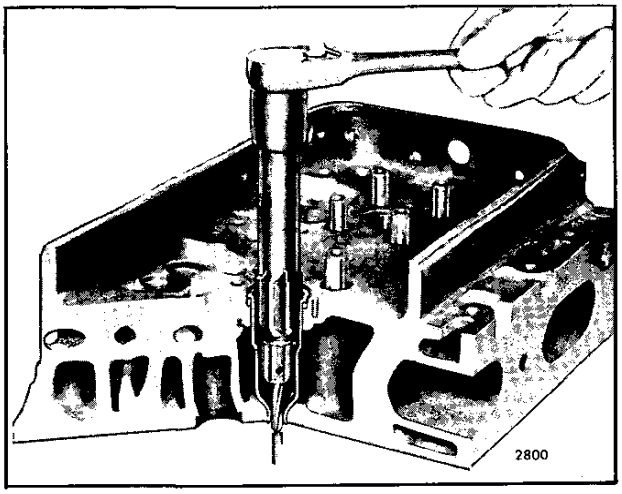


Fig. 4 - Reaming Injector Tube for Injector Body Nut and Spray Tip with Tool J 22525-1

© 1983 General Motors Corp.

injector tube free from dirt, proceed with the first reaming operation as follows:

a. Place a few drops of light cutting oil on the reamer flutes, then carefully position the reamer J 22525-1 in the injector tube.

b. Turn the reamer in a clockwise direction (withdrawing the reamer frequently for removal of chips) until the lower shoulder of the reamer contacts the injector tube (Fig. 4). Clean out all of the chips.

2. Remove excess stock:

a. With the cylinder head bottom side up, insert the pilot of cutting tool J 5286-8 into the small hole of the injector tube.

b. Place a few drops of cutting oil on the tool. Then, using a socket and a speed handle, remove the excess stock so that the lower end of the injector tube is from flush to .005" below the finished surface of the cylinder head.

3. Ream the bevel seat in the injector tube:

The tapered lower end of the injector tube must provide a smooth and true seat for the lower end of the injector nut to effectively seal the cylinder pressures and properly position the injector tip in the combustion chamber. Therefore, to determine the amount of stock that must be reamed from the bevel seat of the tube, refer to Fig. 6.

Install gage J 25521 in the injector tube. Zero the sled gage dial indicator J 22273 to the fire deck. Gage J 25521 should be flush to ±.014" with the fire deck of the cylinder head (Fig. 7).

NOTE: Any fire deck resurfacing work must be done prior to final injector tube seat gaging. Refer to Section 1.2 for resurfacing instructions.

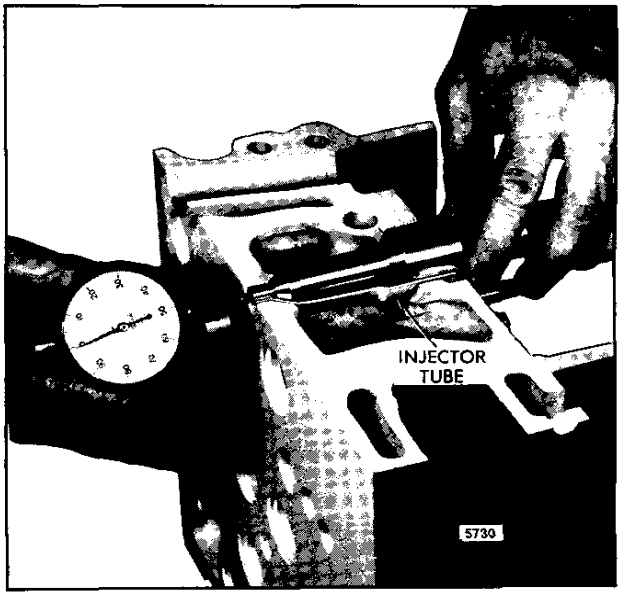


Fig. 6 - Measuring Relationship of Bevel Seat of Injector Tube to Fire Deck of Cylinder Head with Tool J 25521 and Gage J 22273

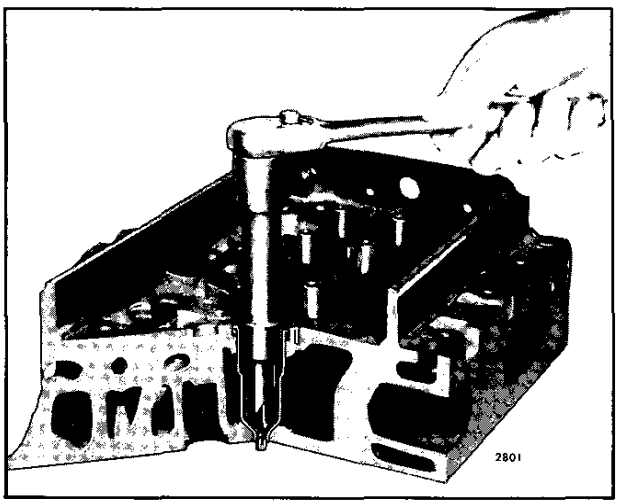


Fig. 5 - Reaming Injector Tube for Injector Nut with Tool J 5286-9

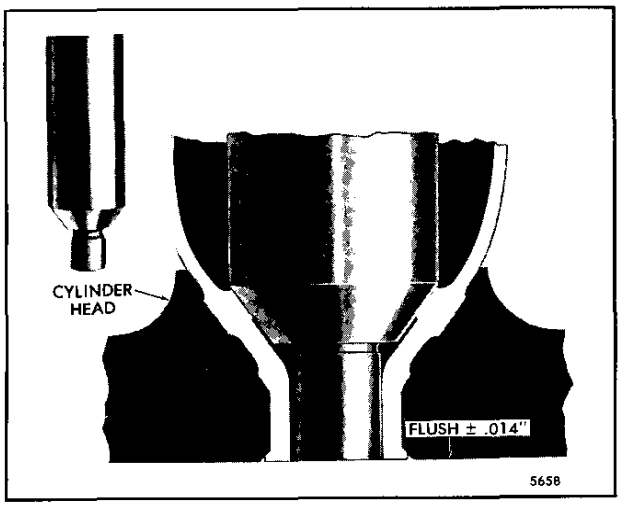


Fig. 7 - Measuring Relationship of Gage to Fire Deck of Cylinder Head with Tool J 25521

© 1982 General Motors Corp.

With the first reaming operation completed and the injector tube spot-faced, wash the interior of the injector tube with clean solvent and dry it with compressed air. Then perform the second reaming operation as follows:

a. Place a few drops of cutting oil on the bevel seat of the tube. Carefully lower the reamer J 5286-9 into the injector tube until it contacts the bevel seat.

b. Make a trial cut by turning the reamer steadily without applying any downward force on the reamer. Remove the reamer, blow out the chips and look at the bevel seat to see what portion of the seat has been cut.

c. Proceed carefully with the reaming operation, withdrawing the reamer occasionally to observe the reaming progress.

d. Remove the chips from the injector tube and, using gage J 25521, continue the reaming operation until the shoulder of the spray tip is flush to ±.014" with the fire deck of the cylinder head as shown in Fig. 7. Then wash the interior of the injector tube with clean solvent and dry it with compressed air.

© 1982 General Motors Corp.

FUEL PUMP

The positive displacement gear-type fuel pump (Fig. 1) transfers fuel from the supply tank to the fuel injectors. The pump circulates an excess supply of fuel through the injectors which purges the air from the system and cools the injectors. The unused portion of fuel returns to the fuel tank by means of a fuel return manifold and fuel return line.

The fuel pump is attached to the rear end plate cover of the blower assembly with three nylon patch bolts which prevents the oil in the blower cover from seeping out around the bolt threads. The pump is driven off the end of the blower lower rotor by means of a drive coupling fork attached to the end of the pump drive shaft and mating with a drive disc attached to the blower rotor (Fig. 2).

On certain applications, the fuel pump is attached to a special flywheel housing large hole cover. It is driven off of the balance shaft gear by means of a drive coupling fork attached to the end of the pump drive shaft and mating with a drive adaptor bolted to the balance shaft gear.

Fuel pumps are furnished in left-hand or right-hand rotation, according to the engine model, and are stamped "LH IN" or "RH IN". The left-hand pumps are used on LA-LB-RA-RB engines while the right-hand pumps are used on LC-LD-RC-RD engines. These pumps are not interchangeable, nor can a pump made for one rotation be rebuilt for the other rotation since the relief valve can be installed in only one position in the pump body.

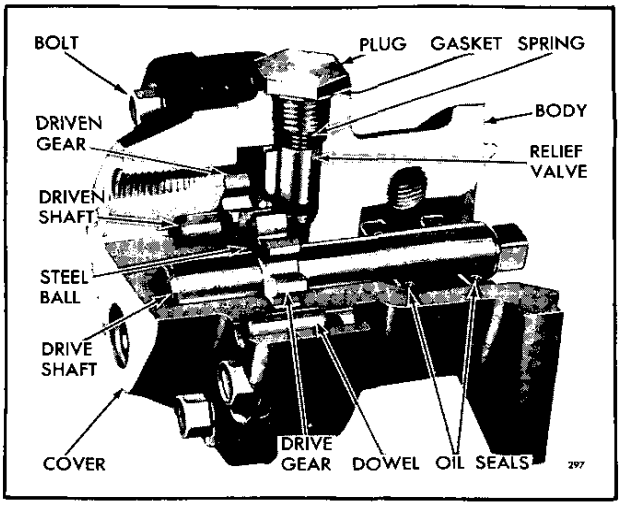


Fig. 1 - Typical Fuel Pump Assembly

Certain engine applications use a high-capacity fuel pump with 3/8" wide gears to increase fuel flow and reduce fuel spill temperature. The high-capacity fuel pump and the standard fuel pump with 1/4" wide gears may not be completely interchangeable; therefore, when replacing a standard pump with a high-capacity pump, the appropriate fuel lines and connections must be used.

The fuel pump cover and body are positioned by two dowels. The dowels aid in maintaining gear shaft alignment. The mating surfaces of the pump body and cover are perfectly flat ground surfaces. No gasket is used between the cover and body since the pump clearances are set up on the basis of metal-to-metal contact. A very thin coat of sealant provides a seal against any minute irregularities in the mating surfaces. Cavities in the pump cover accommodate the ends of the drive and driven shafts.

The fuel pump body is recessed to provide running space for the pump gears (Fig. 3). Recesses are also provided at the inlet and outlet positions of the gears. The small hole "A" permits the fuel oil in the inlet side of the pump to lubricate the relief valve at its outer end and to eliminate the possibility of a hydrostatic lock which would render the relief valve inoperative. Pressurized fuel contacts the relief valve through hole "B" and provides for relief of excess discharge pressures. Fuel reenters the inlet side of the pump through hole "C" when the discharge pressure is great enough to move the relief valve back from its seat. Part of the relief valve may be seen through hole "C". The cavity "D" provides escape for the fuel oil which is squeezed out of the gear teeth as they mesh together on the discharge side of the pump. Otherwise, fuel trapped at the root of the teeth would tend to force the gears apart, resulting in undue wear on the gears, shafts, body and cover.

Two oil seals are pressed into the bore in the flanged side of the pump body to retain the fuel oil in the pump and the lubricating oil in the blower timing gear compartment (Fig. 4). A small hole "E" (Fig. 3) serves as a vent passageway in the body, between the inner oil seal and the suction side of the pump, which prevents building up any fuel oil pressure around the shaft ahead of the inner seal.

A higher temperature material lip type seal is now being used in the fuel pumps. The new fuel pump seal is made of a polyacrylate material, whereas the former seal is made of nitrile. The new fuel pumps (with the polyacrylate seals) will have the seals installed with the lips of the seals facing in the opposite direction of each other (Fig. 4). The former fuel pumps have the

© 1983 General Motors Corp.

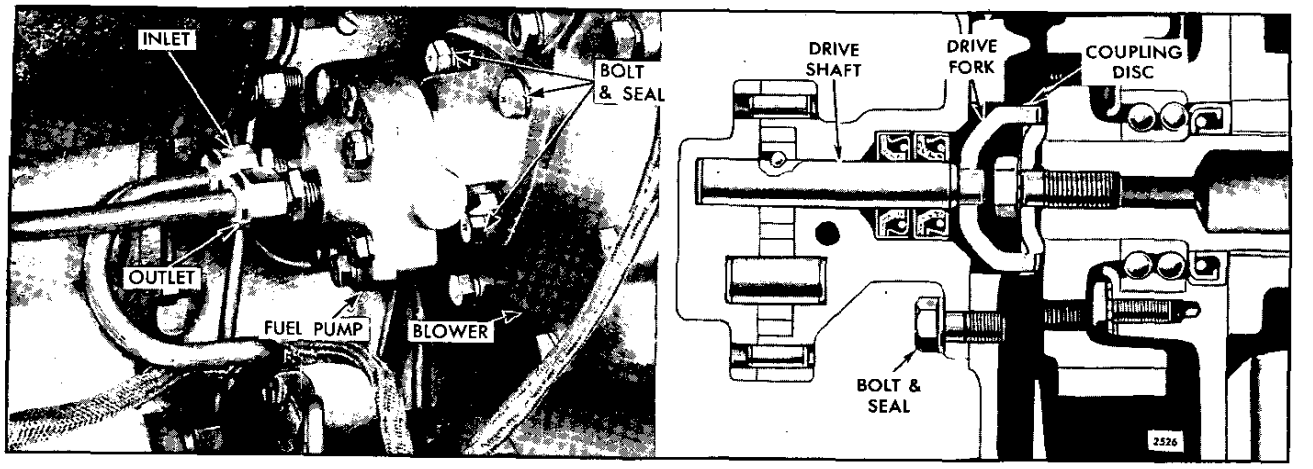


Fig. 2 - Typical Fuel Pump Mounting and Drive

nitrile seals installed with both seal lips facing the mounting flange end of the pump. Both the polyacrylate and nitrile seals are interchangeable in a fuel pump. Only the polyacrylate seals and fuel pumps with polyacrylate seals will be serviced.

Some fuel oil seepage by the fuel pump seals can be expected, both with a running engine and immediately after an engine has been shut down. This is especially true with a new fuel pump and/or new pump seals, as the seals have not yet conformed to the pump drive shaft. Fuel pump seals will always allow some seepage.

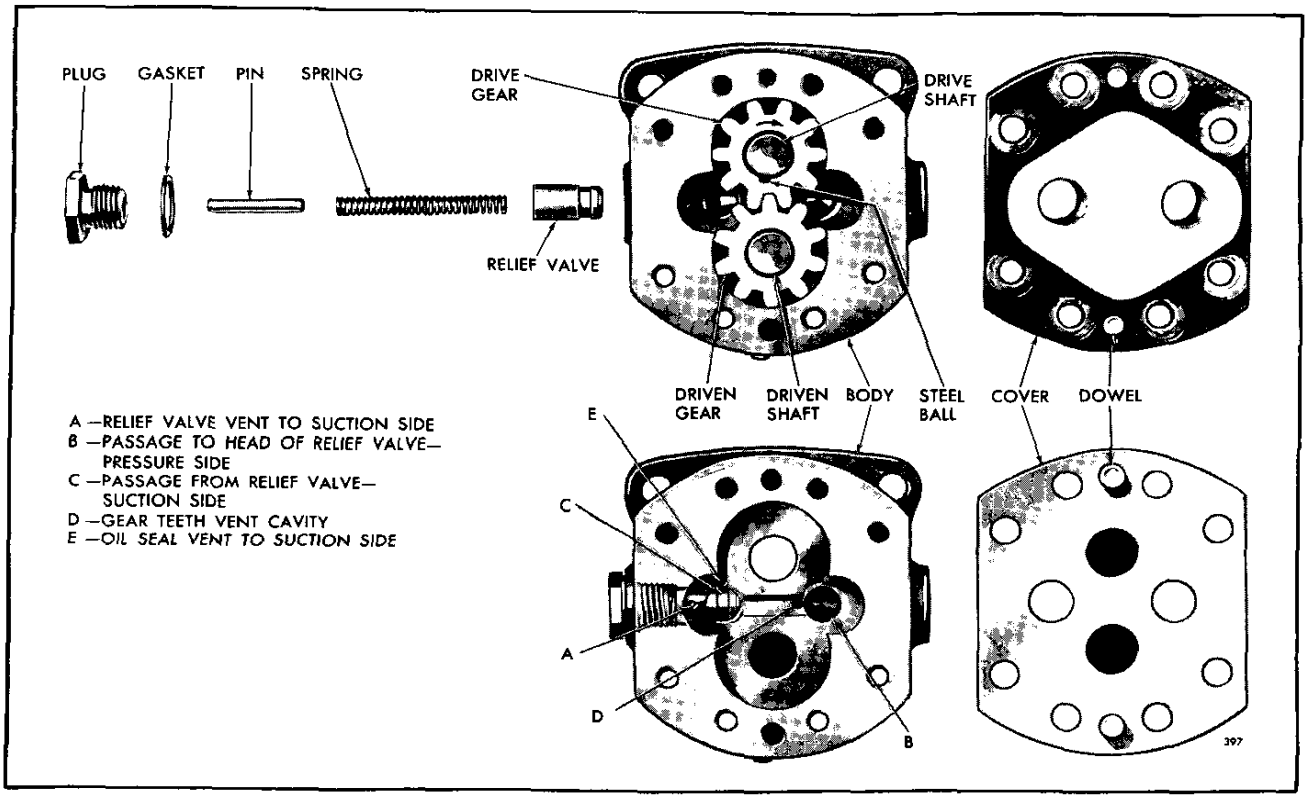


Fig. 3 - Fuel Pump Valving and Rotation (Right-Hand Pump)

© 1983 General Motors Corp.

Tapped holes in the pump body are provided to prevent fuel oil from being retained between the seals. Excessive fuel retention between the seals could provide enough pressure to cause engine oil dilution by fuel, therefore, drainage of the excess fuel oil is mandatory. However, if leakage exceeds one drop per minute, replace the seals.

The drive and driven gears are a line-to-line to .001" press fit on their shafts. The drive gear is provided with a gear retaining ball to locate the gear on the shaft (Fig. 2).

A spring-loaded relief valve incorporated in the pump body normally remains in the closed position, operating only when pressure on the outlet side (to the fuel filter) reaches approximately 65 psi (448 kPa).

Operation

In operation, fuel enters the pump on the suction side and fills the space between the gear teeth which are exposed at that instant. The gear teeth then carry the fuel oil to the discharge side of the pump and, as the gear teeth mesh in the center of the pump, the fuel is forced out into the outlet cavity. Since this is a continuous cycle and fuel is continually being forced into the outlet cavity, the fuel flows from the outlet cavity into the fuel lines and through the engine fuel system under pressure.

The pressure relief valve relieves the discharge pressure by bypassing the fuel from the outlet side of the pump to the inlet side when the discharge pressure reaches approximately 65 to 75 psi (448 to 517 kPa).

The fuel pump should maintain the fuel pressure at the fuel inlet manifold (see Section 13.2).

Remove Fuel Pump

1. Disconnect the fuel lines from the inlet and outlet openings of the fuel pump.

2. Disconnect the drain tube, if used, from the fuel pump.

3. Remove the three pump attaching bolts, using wrench J 4242, and withdraw the pump from the blower.

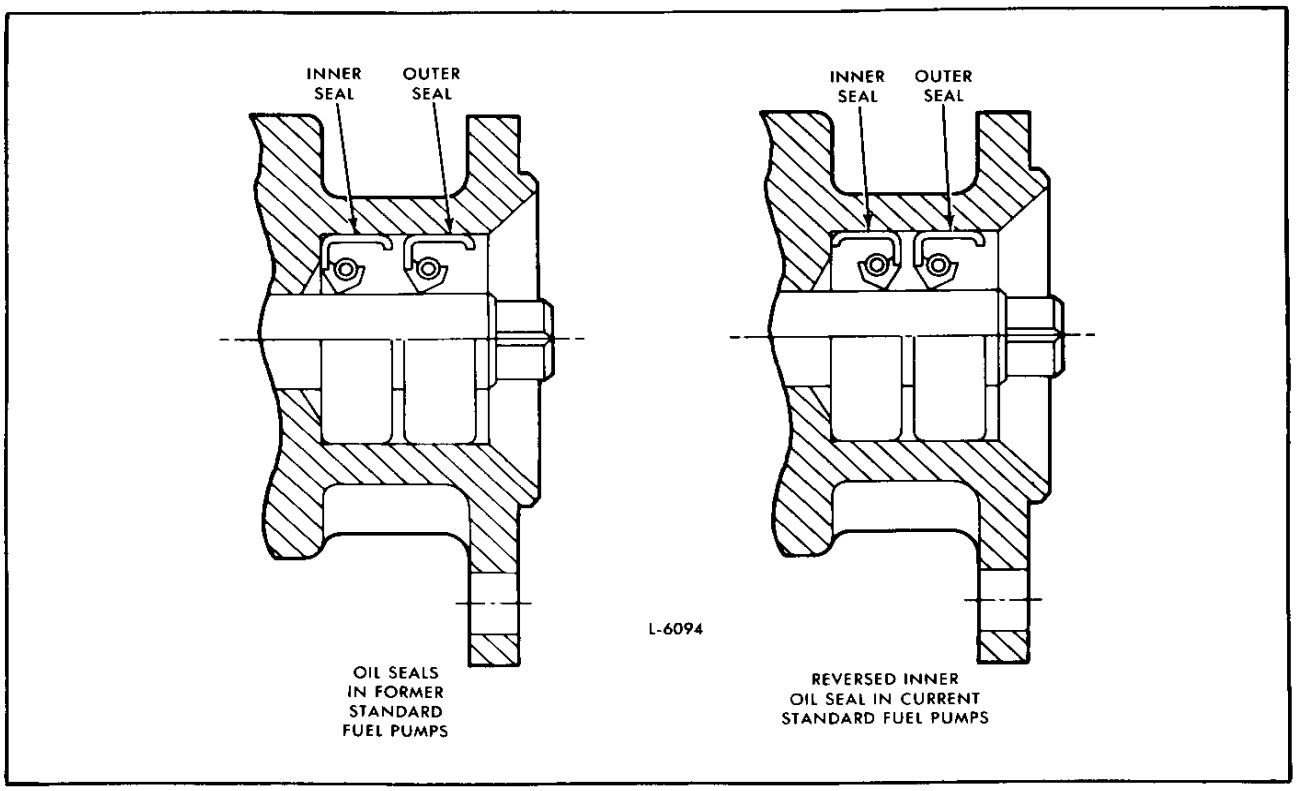


Fig. 4 - Fuel Pump Oil Seal Arrangements

© 1983 General Motors Corp.

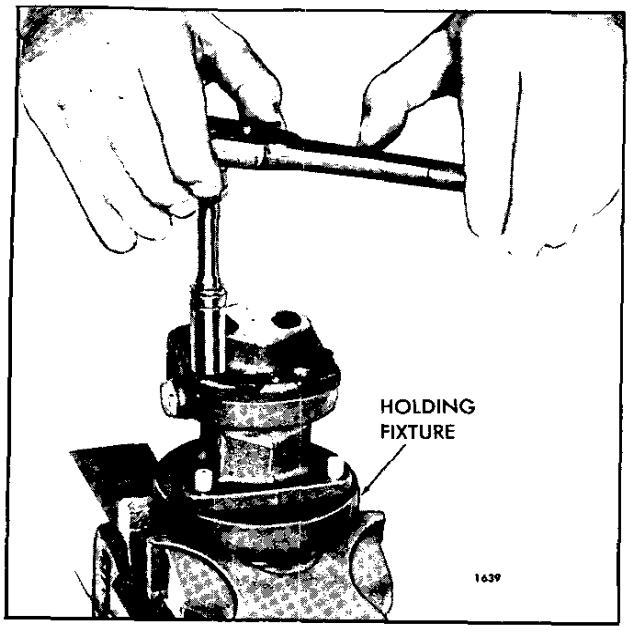


Fig. 5 - Removing Pump Cover

4. Check the drive coupling fork and, if broken or worn, replace it with a new coupling.

Disassemble Fuel Pump

With the fuel pump removed from the engine and mounted in holding fixture J 1508-10 (Fig. 5), refer to Figs. 1 and 7 and disassemble the pump as follows:

1. Remove the eight cover bolts and withdraw the pump cover from the pump body. Use care not to damage the finished faces of the pump body and cover.

2. Withdraw the drive shaft, drive gear and gear retaining ball as an assembly from the pump body.

3. Press the drive shaft just far enough to remove the steel locking ball. Then invert the shaft and gear assembly and press the shaft from the gear. *Do not misplace the steel ball.* Do not press the squared end of the shaft through the gear as slight score marks will damage the oil seal contact surface.

4. Remove the driven shaft and gear as an assembly from the pump body. *Do not remove the gear from the shaft.* The driven gear and shaft are serviced only as an assembly.

5. Remove the relief valve plug and copper gasket.

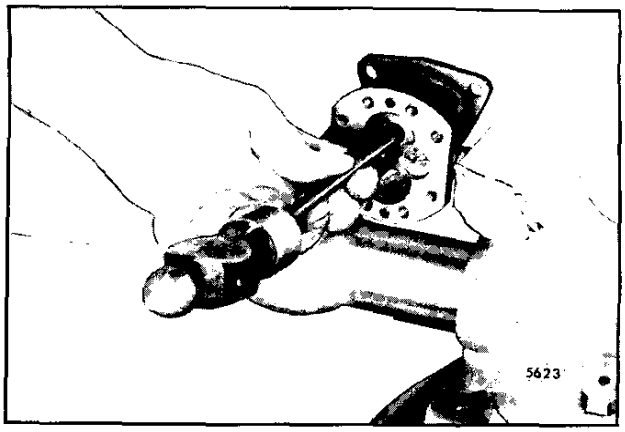


Fig. 6 - Removing Oil Seals with Tool J 1508-13

6. Remove the valve spring, pin and relief valve from the valve cavity in the pump body.

7. If the oil seals need replacing, remove them with oil seal remover J 1508-13 (Fig. 6). Clamp the pump body in a bench vise and tap the end of the tool with a hammer to remove the outer and inner seals.

> **NOTE:** Observe the position of the oil seal lips before removing the old seals to permit installation of the new seals in the same position.

Inspection

Clean all of the parts in clean fuel oil and dry them with compressed air.

Oil seals, once removed from the pump body, must be discarded and replaced with new seals.

Check the pump gear teeth for scoring, chipping or wear. Check the ball slot in the drive gear for wear. If necessary, replace the gear.

Inspect the drive and driven shafts for scoring or wear. Replace the shafts, if necessary. The driven shaft is serviced as a gear and shaft assembly only.

The mating faces of the pump body and cover must be flat and smooth and fit tightly together. Any scratches or slight damage may result in pressure leaks. Also, check for wear at areas contacted by the gears and shafts. Replace the pump cover or body, if necessary.

The relief valve must be free from score marks and burrs and fit its seat in the pump body. If the valve is

© 1983 General Motors Corp.

scored and cannot be cleaned up with fine emery cloth or crocus cloth, it must be replaced.

Current standard fuel pumps (with 1/4" wide gears) incorporate a 1/8" shorter pump body with three drain holes, a 1/8" shorter drive shaft and a cover with a 3/8" inlet opening. When replacing a former pump, a 3/8" x 1/4" reducing bushing is required for the inlet opening and the unused drain holes must be plugged.

Assemble Fuel Pump

Refer to Figs. 1, 3 and 7 and assemble the pump as follows:

1. Lubricate the lips of the oil seals with a light coat of vegetable shortening, then install the oil seals in the pump body as follows:

a. Place the inner oil seal on the pilot of the installer handle J 1508-8 so that the lip of the seal will face in the same direction as the original seal which was removed.

NOTE: When replacing the former nitrile fuel pump seals with the current polyacrylate seals, install them in a reversed order (Fig. 4).

b. With the pump body supported on wood blocks, insert the pilot of the installer handle in the pump body so the seal starts straight into the pump flange (Fig. 8). Then drive the seal in until it bottoms.

c. Place the shorter end of the adaptor J 1508-9 over the pilot and against the shoulder of the installer handle. Place the outer oil seal on the pilot of the installer handle with the lip of the seal facing the adaptor. Then, insert the pilot of the installer handle into the pump body and drive the seal in until the shoulder of the adaptor contacts the pump body (Fig. 9). Thus the oil seals will be positioned so that the space between them will correspond with the drain holes located in the bottom of the pump body.

2. Clamp the pump body in a bench vise (equipped with soft jaws) with the valve cavity up. Lubricate the outside diameter of the valve and place it in the cavity with the hollow end up. Insert the spring inside of the valve and the pin inside of the spring. With a new gasket in place next to the head of the valve plug,

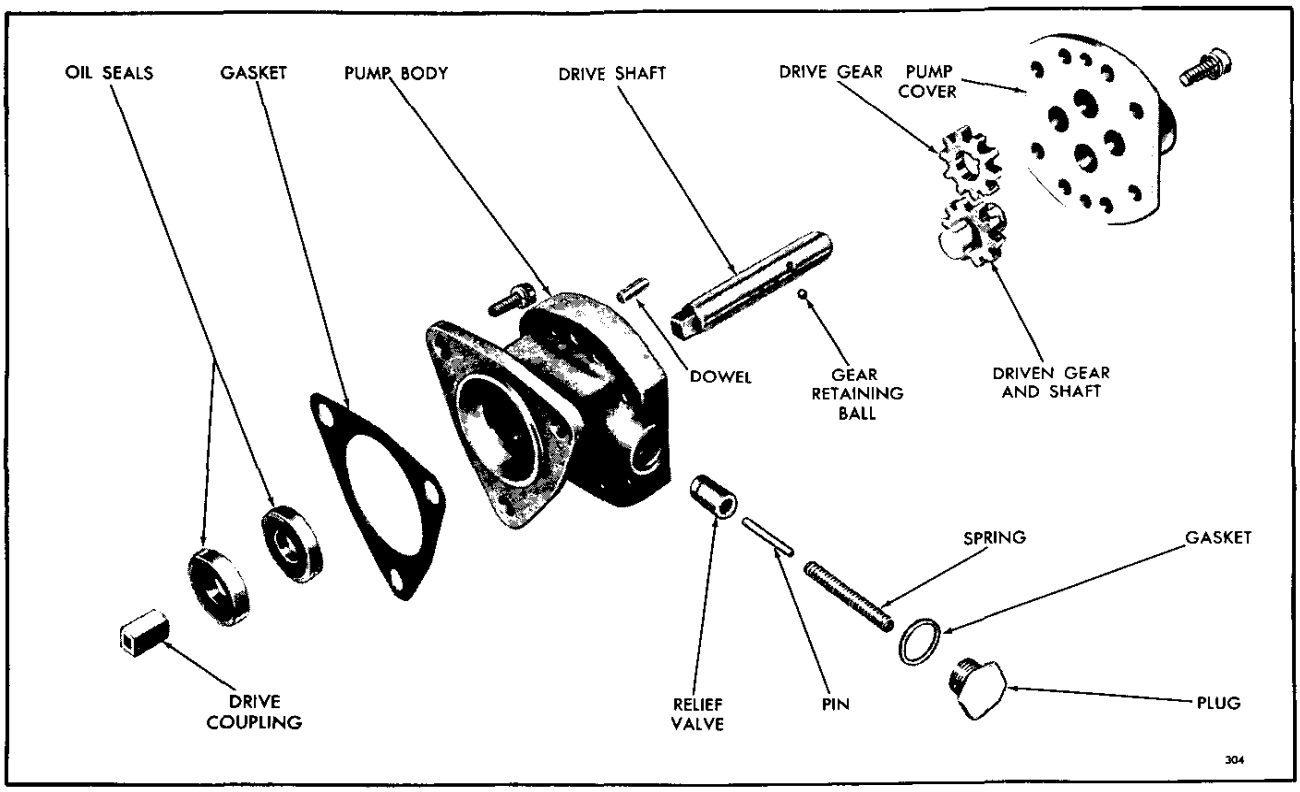


Fig. 7 - Fuel Pump Details and Relative Location of Parts

© 1983 General Motors Corp.

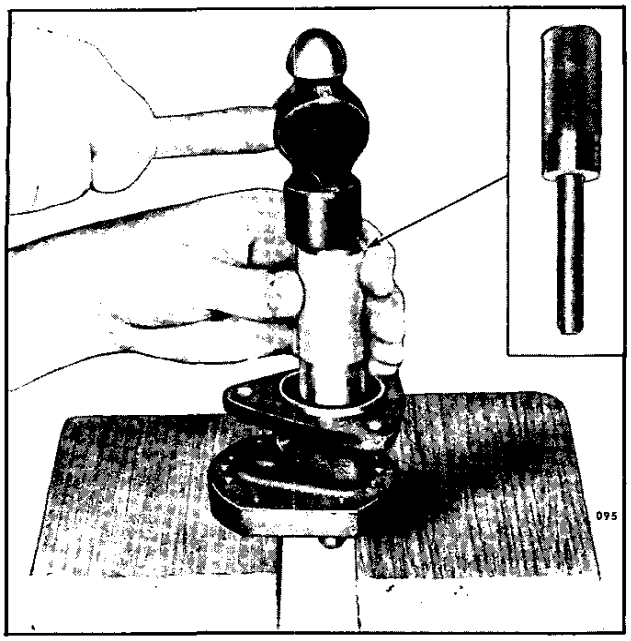


Fig. 8 - Installing Inner Oil Seal using Tool J 1508-8

place the plug over the spring and thread it into the pump body. Tighten the 1/2"-20 plug to 18-22 lb-ft (24-30 Nm) torque.

3. Install the fuel pump drive gear over the end of the drive shaft which is not squared (so the slot in the gear will face the plain end of the shaft). This operation is very important, otherwise fine score marks caused by pressing the gear into position from the square end of the shaft may cause rapid wear of the oil seals. Press the gear beyond the gear retaining ball detent. Then place the ball in the detent and press the gear back until the end of the slot contacts the ball.

4. Lubricate the pump shaft and insert the square end of the shaft into the opening at the gear side of the pump body and through the oil seals (Fig. 10).

5. Place the driven shaft and gear assembly in the pump body.

NOTE: The driven gear must be centered on the shaft to give proper end clearance. Also, the chamfered end of the gear teeth of the production gear must face the pump body. If a service replacement gear with a slot is used, the slot must face toward the pump cover.

6. Lubricate the gears and shafts with clean engine oil.

7. Apply a thin coat of quality sealant on the face of the pump cover outside of the gear pocket area. Then place the cover against the pump body with the two dowel pins in the cover entering the holes in the pump body. The cover can be installed in only one position over the two shafts.

NOTE: The coating of sealant must be extremely thin since the pump clearances have been set up on the basis of metal-to-metal contact. Too much sealant could increase the clearances and affect the efficiency of the pump. Use care that sealant is not squeezed into the gear compartment, otherwise damage to the gears and shafts may result.

8. Secure the cover in place with eight bolts and lock washers, tightening the bolts alternately and evenly.

9. After assembly, rotate the pump shaft by hand to make certain that the parts rotate freely. If the shaft does not rotate freely, attempt to free it by tapping a corner of the pump.

10. Install 1/8" pipe plugs in the upper unused drain holes.

11. If the pump is not to be installed immediately, place plastic shipping plugs in the inlet and outlet openings to prevent dirt or other foreign material from entering the pump.

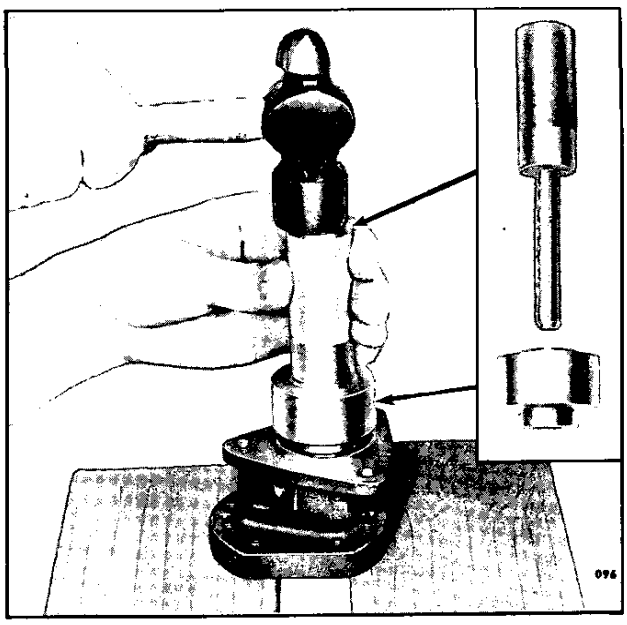


Fig. 9 - Installing Outer Oil Seal using Tools J 1508-8 and J 1508-9

© 1983 General Motors Corp.

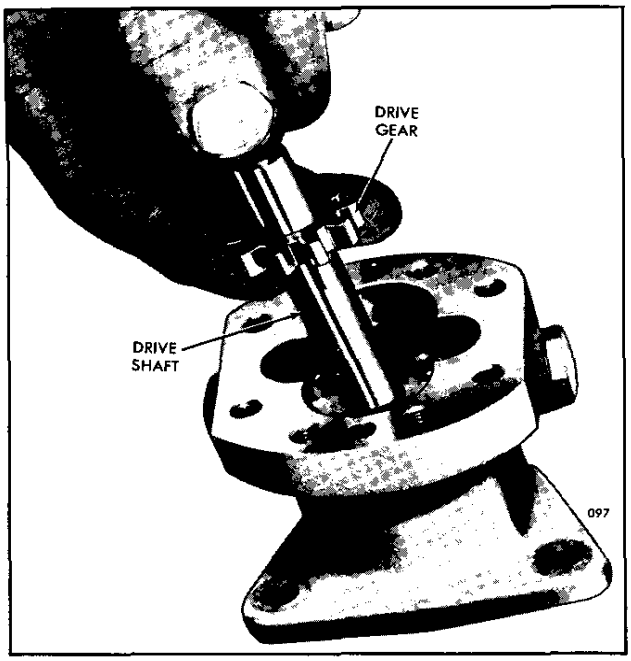


Fig. 10 - Installing Drive Shaft and Gear Assembly

Install Fuel Pump

The left-hand pump is used on "A" and "B" engines and the right-hand pump is used on "C" and "D" engines. The pumps are not interchangeable and cannot be rebuilt to operate in an opposite direction. The pump must always be installed with the inlet opening in the pump cover (marked "LH IN" or "RH IN") on the side toward the cylinder block. Note in Fig. 2 that the fuel pump is bolted to the blower. The pump is driven by a drive disc at the rear of the blower lower rotor. Install the pump as follows:

1. Affix a new gasket to the pump body mounting flange. Then place the drive coupling fork on the square end of the drive shaft.

2. Place the fuel pump against the blower, being certain that the drive coupling fork registers with the slots in the drive disc on the blower rotor shaft.

3. Secure the pump to the blower with three nylon patch bolts.

> **NOTE:** To provide improved sealing against leakage, nylon patch bolts are used in place of the former bolt and seal assemblies.

4. If removed, install the fuel inlet and outlet fittings in the pump cover.

5. Connect the inlet and outlet fuel lines to the fuel pump.

6. Connect the fuel pump drain tube, if used, to the pump body.

7. If the fuel pump is replaced or rebuilt, prime the fuel system before starting the engine using tool J 5956. This will prevent the possibility of pump seizure upon initial starting.

© 1983 General Motors Corp.

FUEL STRAINER AND FUEL FILTER

(Bolt-On Type)

A fuel strainer (primary) and fuel filter (secondary), Figs. 1 and 2, are used to remove impurities from the fuel. The fuel strainer is located between the fuel tank and the fuel pump. The replaceable density-type element is capable of filtering out particles of 30 microns (a micron is approximately .00004"). The fuel filter is installed between the fuel pump and the fuel inlet manifold. The replaceable paper-type element (Fig. 3) can remove particles as small as 10 microns.

NOTE: A fuel tank of galvanized steel should never be used for fuel storage, as the fuel oil reacts chemically with the zinc coating to form powdery flakes which quickly clog the fuel filter and cause damage to the fuel pump and the fuel injectors.

The fuel strainer and fuel filter are essentially the same in construction and operation, and they will be treated as one in this section.

The filter and strainer, illustrated in Figs. 4 and 5, consist basically of a shell, a cover, and a replaceable filtering element. The assembly is made oil tight by a shell gasket, a cover nut or bolt, and a cover nut or bolt gasket.

The central stud is a permanent part of the shell and, when the unit is assembled, extends up through the

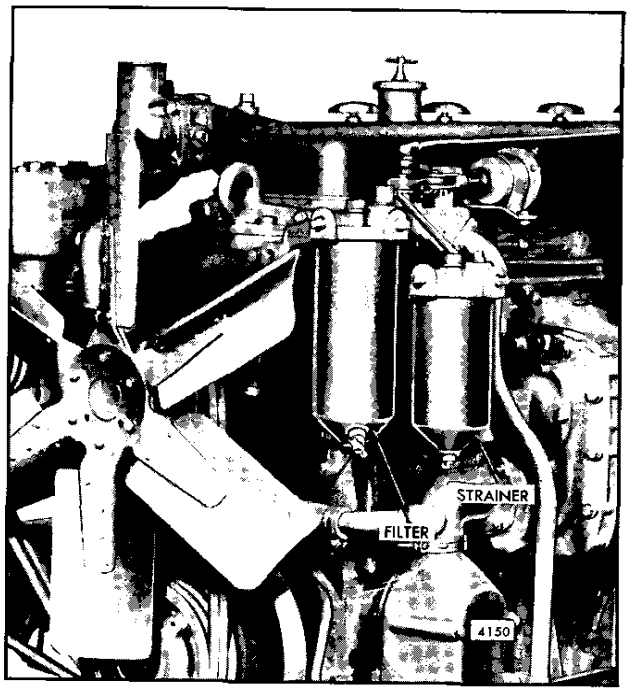


Fig. 1 - Typical Mounting of Fuel Filter and Fuel Strainer

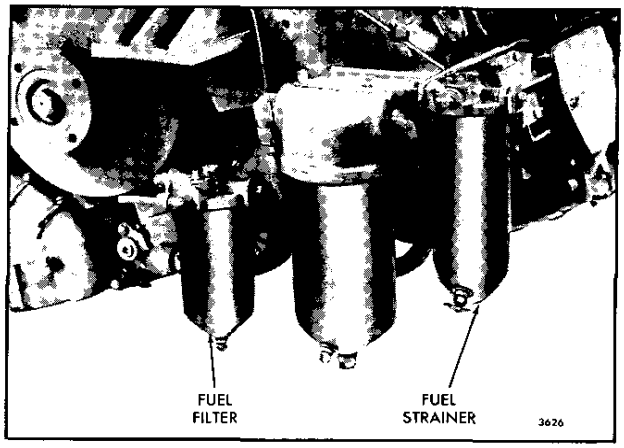


Fig. 2 - Fuel Filter and Fuel Strainer Mounting on Railcar Engine

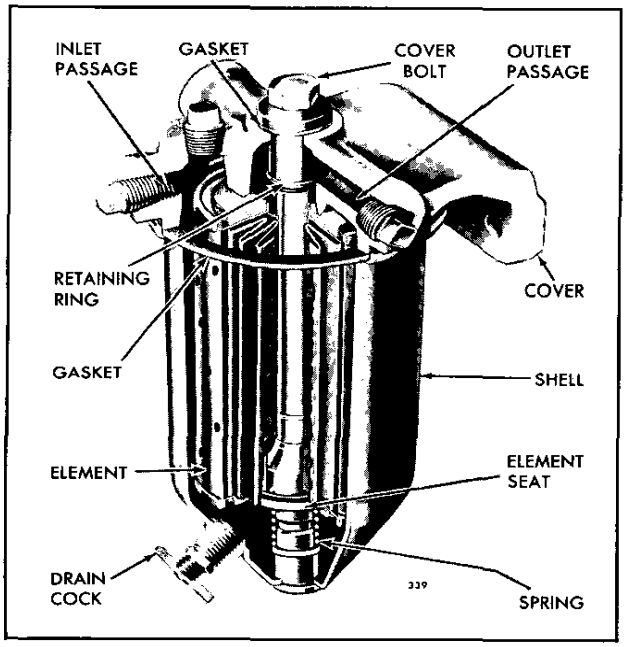


Fig. 3 - Fuel Filter Assembly

© 1980 General Motors Corp.

cover where the nut or bolt holds the assembly together.

A filter element sets over the central stud inside the shell and is centered in the shell by the stud.

The former and current cover assemblies are visibly different by a cast letter "P" (primary) that has been added to the top of the strainer cover and the letter "S" (secondary) that has been added to the top of the filter cover.

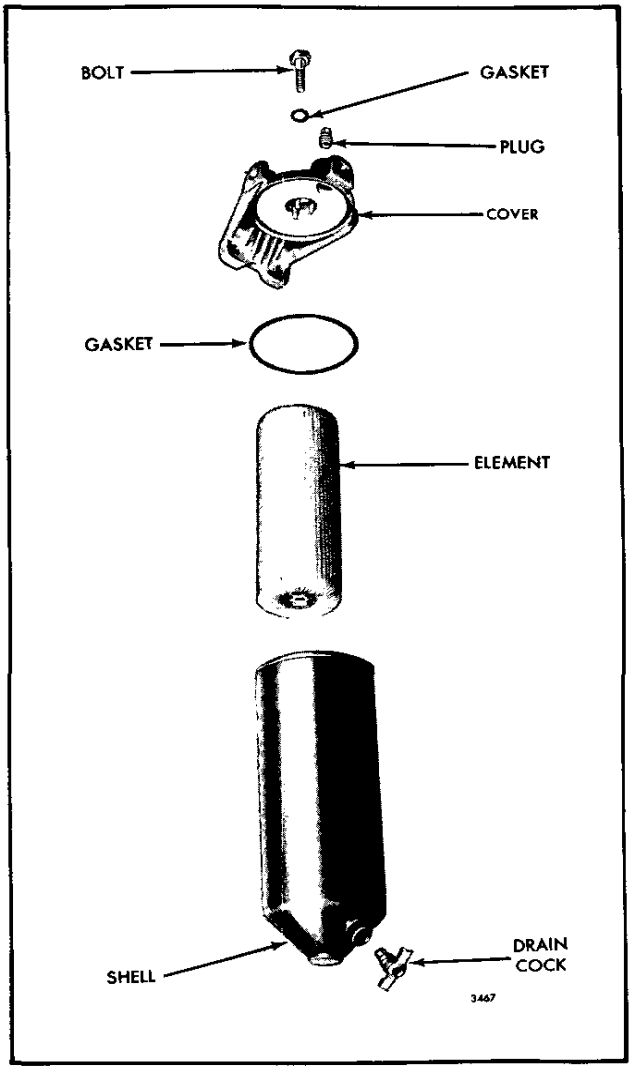


Fig. 4 - Fuel Strainer Details and Relative Location of Parts

Operation

Since the fuel strainer is between the fuel supply tank and the fuel pump, it functions under suction. The fuel filter, placed between the fuel pump and the fuel inlet manifold in the cylinder head, operates under pressure. Fuel enters through the inlet passage in the cover and into the shell surrounding the filter element. Pressure or suction created by the pump causes the fuel to flow through the filter element where dirt particles are removed. Clean fuel flows to the interior of the filter element, up through the central passage in the cover and into the outlet passage, then to the fuel inlet manifold in the cylinder head.

If engine operation is erratic, indicating shortage of fuel or flow obstructions, refer to *Trouble Shooting* in Section 15.2 for corrective measures.

Replace Fuel Strainer or Filter Element

The procedure for replacing an element is the same for the fuel strainer or fuel filter. Refer to Figs. 4 and 5 and replace the element as follows:

> **NOTE:** Only filter elements designed for fuel oil filtration should be used to filter the fuel.

1. With the engine stopped, place a container under the strainer or filter and open the drain cock. Loosen the cover nut or bolt just enough to allow the fuel oil to drain out freely. Then close the drain cock.

> **NOTE:** The wiring harness, starting motor or other electrical equipment must be shielded during the filter change, since fuel oil can permanently damage the electrical insulation.

2. While supporting the shell, unscrew the cover nut or bolt and remove the shell and element. Also remove and discard the cover nut retaining ring, if used.

3. Remove and discard the filter element and shell gasket, the cover nut or bolt gasket, and, if used, the cover bolt snap ring.

> **NOTE:** Current strainers and filters do not incorporate the cover bolt snap ring. This was eliminated to facilitate replacement of the bolt gasket with each element replacement.

4. Wash the shell thoroughly with clean fuel oil and dry it with compressed air.

5. Examine the element seat and the retaining ring to make sure they have not slipped out of place. Check the spring by pressing on the element seat. When released, the seat must return against the retaining ring.

© 1980 General Motors Corp.

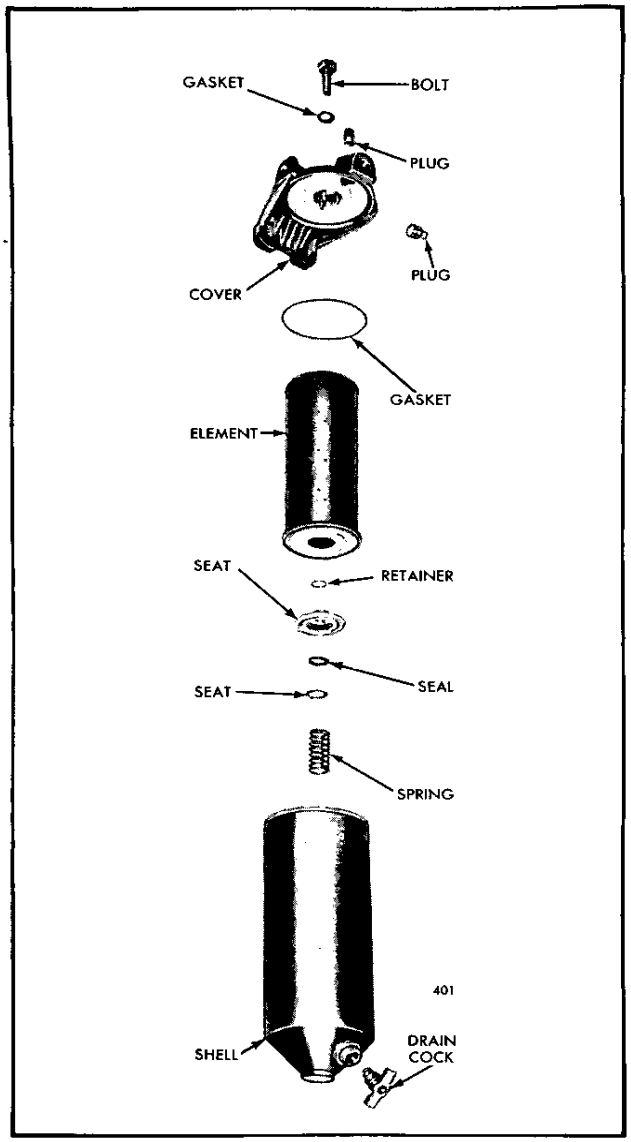


Fig. 5 - Fuel Filter Details and Relative Location of Parts

NOTE: The element seat, spring, washer and seal can not be removed from the strainer shell. If necessary, the shell assembly must be replaced. However, the components of the filter shell are serviced. Examine the filter retainer seal for cracks or hardening. If necessary, replace the seal.

The current strainer and filter elements include the element, the cover gasket and cover bolt gasket. The strainer element also includes both the former and current bolt gaskets.

6. Place a new element over the center stud and push it down against the element seat. Make sure the drain cock is closed, then fill the shell about two-thirds full with clean fuel oil.

NOTE: Thoroughly soak the density-type *strainer* element in clean fuel oil before installing it. This will expel any air entrapped in the element and is conducive to a faster initial start.

7. Place a new shell gasket in the recess of the shell; also place a new gasket on the cover nut or bolt.

8. Place the shell and element in position under the cover. Then thread the cover bolt (or nut) in the center stud.

9. With the shell and the gasket properly positioned, tighten the cover bolt or nut just enough to prevent fuel leakage.

10. Remove the pipe plug at the top of the cover and complete filling of the shell with fuel. Fuel system primer J 5956 may be used to prime the entire fuel system.

11. Start the engine and check the fuel system for leaks.

FUEL STRAINER AND FUEL FILTER
(Spin-On Type)

A spin-on type fuel strainer and fuel filter (Fig. 6) is used on certain engines. The spin-on filter cartridge consists of a shell, element and gasket combined into a unitized replacement assembly (Fig. 7). No separate springs or seats are required to support the filters.

The filter covers incorporate a threaded sleeve to accept the spin-on filter cartridges. The word "Primary" is cast on the fuel strainer cover and the word "Secondary" is cast on the fuel filter cover for identification.

No drain cocks are provided on the spin-on filters. Where water is a problem, it is recommended that a

© 1980 General Motors Corp.

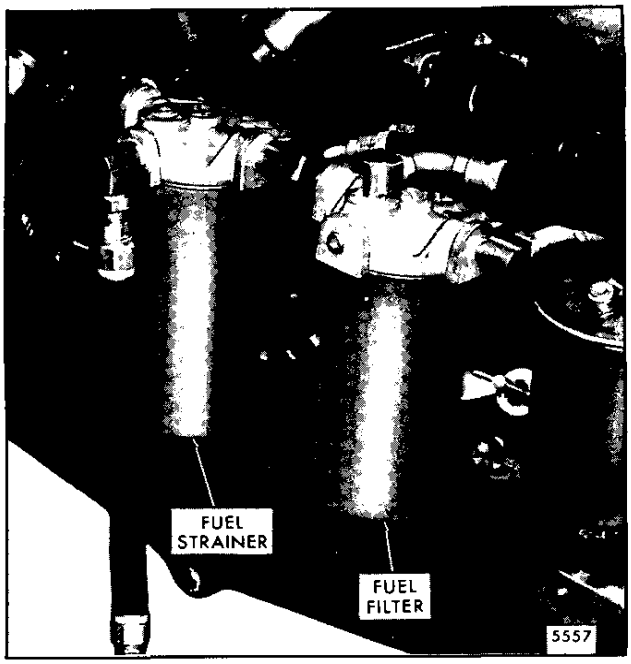


Fig. 6 - Typical Spin-On Filter Mounting

water separator be installed. Otherwise, residue may be drained by removing and inverting the filter. Refill the filter with clean fuel oil before reinstalling it.

Filter Replacement

A 1" diameter twelve-point nut on the bottom of the filter is provided to facilitate removal and installation.

Replace the filter as follows:

1. Unscrew the filter (or strainer) and discard it.

2. Fill a new filter replacement cartridge about two-thirds full with clean fuel oil. Coat the seal gasket lightly with clean fuel oil.

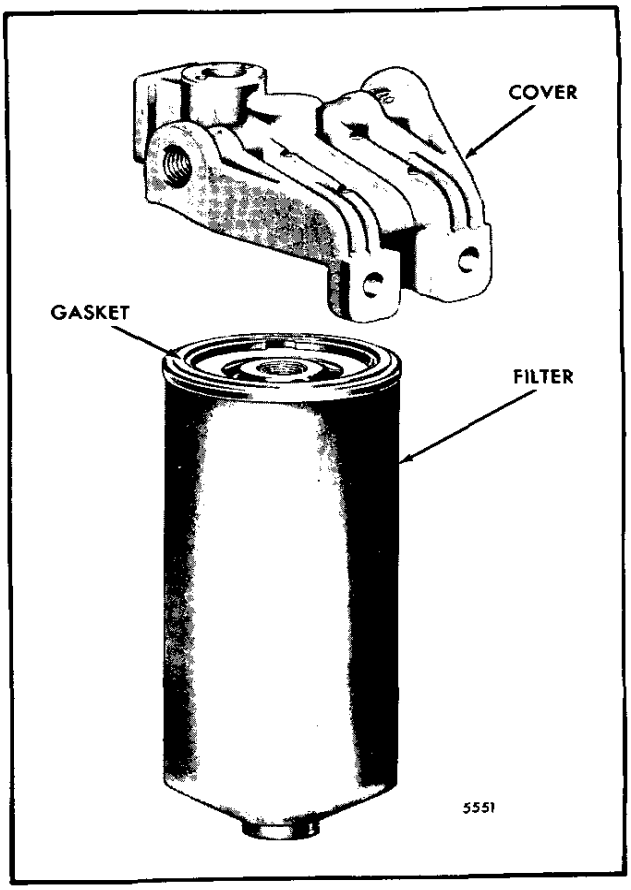


Fig. 7 - Spin-On Filter Details

3. Install the new filter assembly and tighten it to one-half of a turn beyond gasket contact.

4. Start the engine and check for leaks.

© 1980 General Motors Corp.

FUEL MANIFOLD

The fuel injectors are supplied with fuel oil through pipes connected to the fuel inlet manifold. Excess fuel oil is returned to the fuel tank from the fuel injectors through pipes connected to the fuel outlet manifold.

The fuel inlet and outlet manifolds are an integral part of the current cylinder heads (Fig. 1). Since there are inlet and outlet passages provided opposite each injector position in the side of the head as well as at each end, greater flexibility is permitted in the installation of the fuel lines to the fuel manifolds. The fuel passages are identified by the words "IN" (top manifold) and "OUT" (bottom manifold) cast in several places in the side of the cylinder head.

The fuel manifold connectors are assemblied to the integral fuel manifold cylinder head, using special steel sealing washers, and tightened to 40-45 lb-ft (54-61 Nm) torque.

The former external fuel manifolds were attached to the side of the cylinder head and locked in position by fuel connectors which set in tapered seats in the fuel manifold tee connectors (Fig. 2).

The fuel manifold connectors used with the former external fuel manifolds were assembled to the cylinder head with a copper sealing washer and a lock nut which incorporated a threaded fibre insert (Fig. 3). Later, an unthreaded fibre insert was used and the nut was installed with the fibre end down. Threads were cut into the insert when the nut was assembled to the connector and provided a more effective seal against leakage of lubricating oil to the outside of the cylinder head. In a later change, the staking operation, which secured the insert in place, was omitted from the nut. This provided a smooth sealing surface on the nut and the copper washer was eliminated. However, a one-piece connector which incorporated a nylon insert replaced the former connector and nut. When the connector is installed, the nylon insert effects a complete seal between the threads of the connector and the cylinder head.

A special fitting with a restricted opening is used in the fuel outlet manifold to maintain the proper pressure within the fuel system. Refer to Section 13.2 for the size of restriction used.

Service

When replacing a former cylinder head equipped with external fuel manifolds by a current cylinder head, discard the old fuel manifolds and connectors.

A service cylinder head includes the new shorter fuel connectors and the steel sealing washers. The current and former fuel connectors are not interchangeable. A length of flexible hose and two hose fittings are also provided. Since the fuel inlet can be located at any one of the inlet passages in the side of the head, the flexible hose can be cut to the required length for connecting the fuel filter to the fuel inlet manifold.

The direction of flow of the fuel will, in most cases, be reversed when replacing a cylinder head with the external fuel manifolds by one with the integral manifolds. Therefore, replace the filters before the injectors are reinstalled in the replacement head. Otherwise, damage to the injectors will result due to foreign particles in the filter entering the injector.

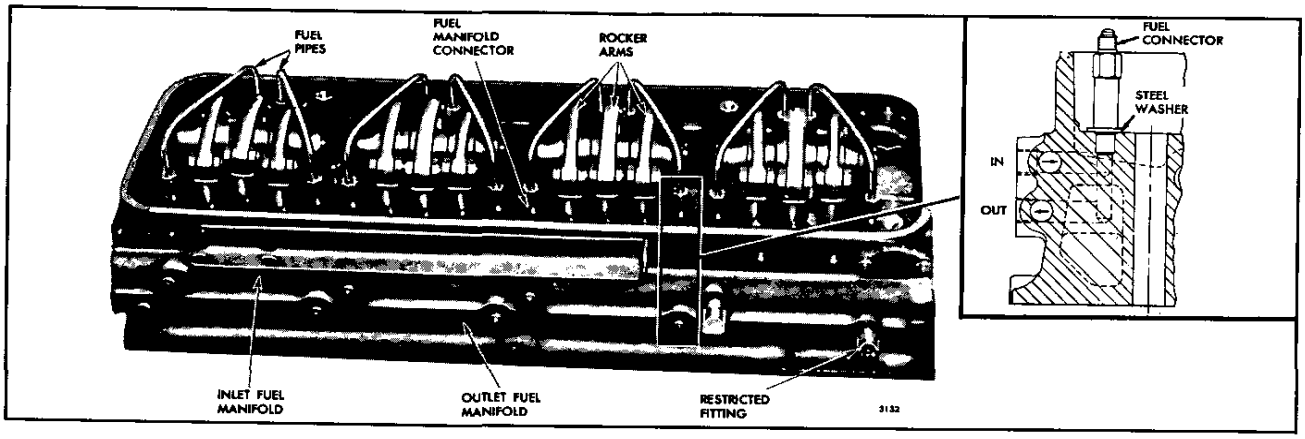


Fig. 1 - Cylinder Head with Integral Fuel Manifolds

© 1978 General Motors Corp.

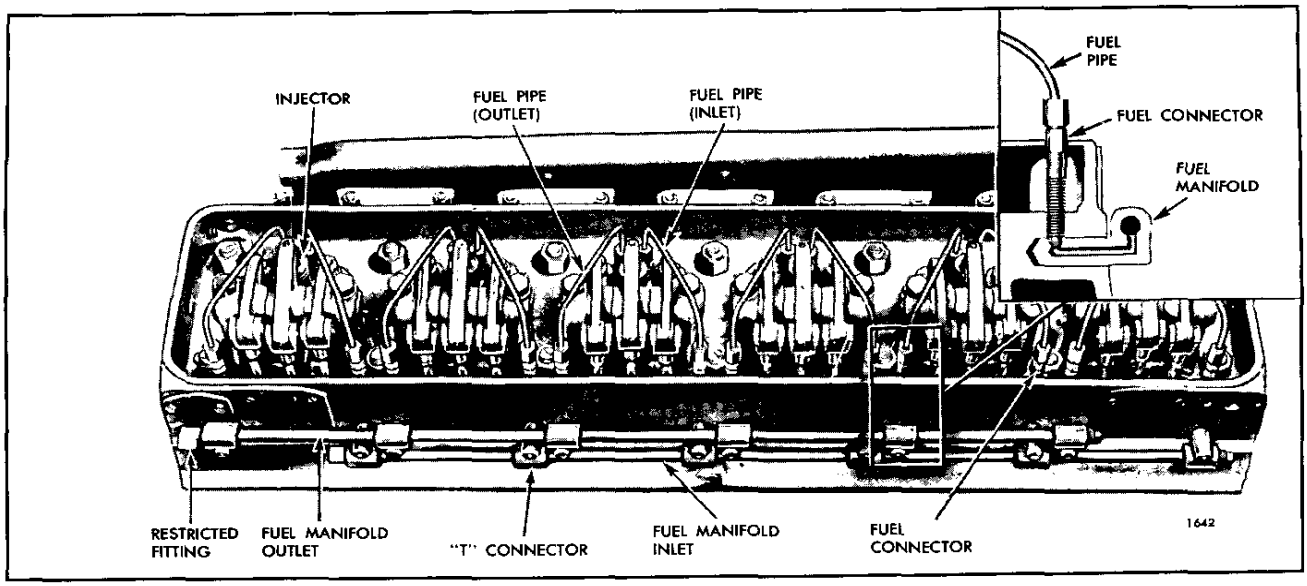


Fig. 2 - Former Cylinder Head with External Fuel Manifolds

Remove External-Type Fuel Manifolds

Remove the fuel manifolds as follows:

1. Clean and remove the valve rocker cover.

2. Refer to Fig. 2 and disconnect the fuel oil pipes from the injectors and the fuel connectors.

3. Disconnect the fuel lines from the fittings at the ends of the manifolds.

4. Remove the fuel connectors from the cylinder head.

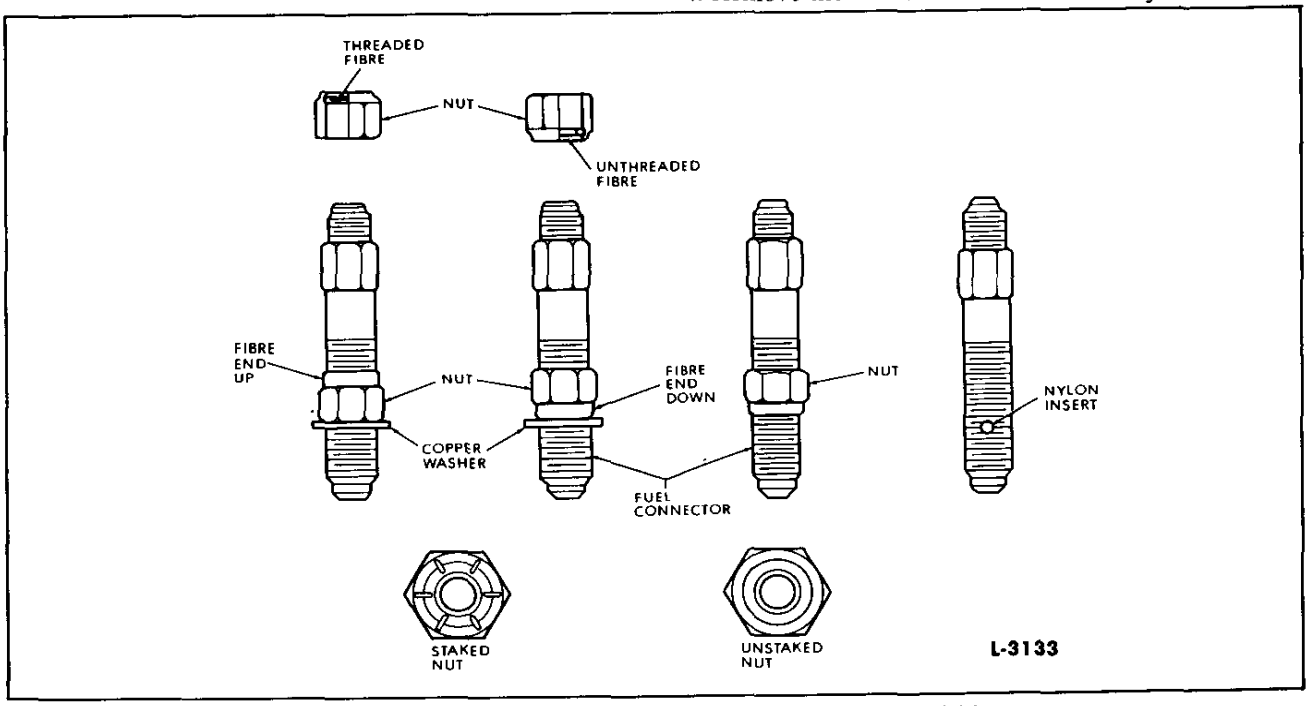


Fig. 3 - Fuel Connectors Used with External Fuel Manifolds

© 1978 General Motors Corp.

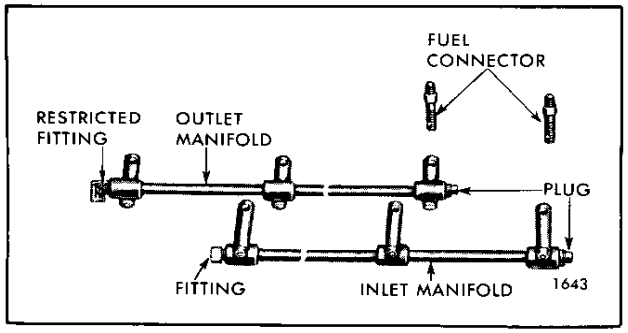


Fig. 4 - External Type Fuel Manifold Details and Relative Location of Parts

5. Withdraw the fuel manifolds carefully.

Inspection

Since the former external fuel manifolds are positioned and locked in place by the fuel connectors, be sure the tapered seats in the manifold tee connectors and the tapered ends of the fuel connectors are clean and free of score marks. If scored surfaces cannot be cleaned up, replace the parts.

Install Former External-Type Fuel Manifolds

Refer to Figs. 2 and 4 and note that the tee connectors on the manifolds are on the top side of the lower manifold and on the bottom side of the upper manifold. The upper and lower manifolds are not interchangeable. Install the manifolds as follows:

1. Clean out the cylinder head openings for the fuel connectors and fuel manifold fittings.

2. Guide the tee connectors of the manifolds into the openings in the side of the cylinder head so that the tapered seats are in approximate alignment with the fuel connector openings in the top of the cylinder head.

3. Lubricate the threads of the fuel connectors equipped with a nylon insert. Start the connectors into the tapped holes (inset in Fig. 2). Then centralize the tee connectors with the fuel connectors by alternately turning the connectors while moving the manifold in and out slightly. Centering the tee connectors is important and necessary to ensure leakproof joints. If a lock nut is used with the connector, install the nut with the fibre end down. If the nut is staked, a new copper sealing washer must also be used.

4. Tighten all of the fuel connectors (and lock nuts, if used) uniformly to 30-35 lb-ft (41-47 Nm) torque.

5. Install the special restricted fitting at the end of the fuel outlet manifold. The fitting is identified by a letter "R" stamped on its surface. If the fitting is replaced for any reason, be sure the replacement part has the same size orifice as the one removed. It is very important that the correct size fitting be installed to maintain the proper fuel pressure and an adequate flow of fuel within the system.

6. Attach the fuel oil pipes to the fuel connectors and the fuel injectors. Be sure the flared ends of the fuel pipes are properly seated before tightening the connections. Use socket J 8932-01 and a torque wrench to tighten the connections to 12-15 lb-ft (16-20 Nm) torque.

> **NOTE:** Do not bend the fuel pipes and do not exceed the specified torque. Excessive tightening can twist or fracture the flared ends of the fuel pipes and result in fuel leaks. Lubricating oil diluted by fuel oil can cause serious damage to the engine bearings.

7. Connect the fuel lines to the fuel manifolds.

8. Start the engine and check all of the fuel connections for leaks. Lubricating oil diluted with fuel oil can cause serious damage to the engine bearings.

> **NOTE:** Any leakage between the fuel connectors and the tapered seats of the manifold tee connectors would be observed at the side of the cylinder head.

9. Install the valve rocker cover, using a new gasket.

© 1978 General Motors Corp.

FUEL COOLER

A fuel cooler may be mounted in the raw water system, between the heat exchanger and the raw water pump, so that the fuel leaving the engine is cooled before it returns to the fuel tank.

Fuel continually cycling through an engine causes the fuel in the tank to become heated after extended operation. Excessive fuel temperatures can affect engine operation. An increase in the fuel inlet temperature above 90 °F (32.2 °C) will result in a brake horsepower loss of approximately 2% per 20 °F (—6.67 °C) increment fuel temperature increase.

Remove Fuel Cooler

1. Disconnect the flexible hoses at the fuel cooler.

2. Loosen the hose clamps and slide the hoses back on the raw water pump tubes.

Clean Fuel Cooler

Clean the oil side of the cooler core first, then immerse it in the following solution: Add 1/2 pound (227 grams) of oxalic acid to each 2-1/2 gallons (1.893 litres) of a solution composed of 1/3 muriatic acid and 2/3 water. The cleaning action is evident by the bubbling and foaming.

Watch the process carefully and, when bubbling stops (this usually takes from 30 to 60 seconds), remove the core from the cleaning solution and thoroughly flush it with clean, hot water. After cleaning, dip the core in light oil.

Pressure Test Fuel Cooler

CAUTION: When making this pressure test be sure that personnel are adequately protected against any stream of pressurized water from a leak or rupture of the cooler core.

After the fuel cooler has been cleaned, check it for leaks by plugging one of the fuel openings with a 1/4 " pipe plug and attaching an air hose to the other opening. Apply approximately 100 psi (689 kPa) air pressure and submerge the cooler in a container of heated water (180 °F or 82 °C). A leak will be indicated by air bubbles in the water. If leaks are indicated, replace the cooler.

Install Fuel Cooler

Reverse the procedure for removing the fuel cooler.

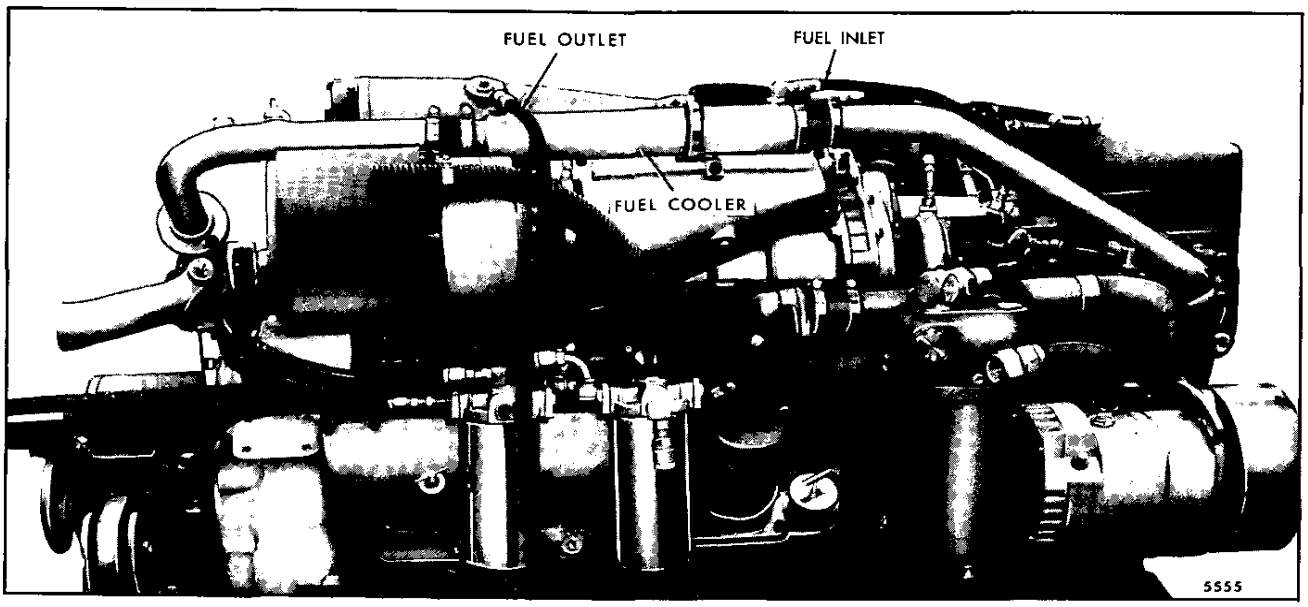


Fig. 1 - Fuel Cooler Mounting

© 1978 General Motors Corp.

MECHANICAL GOVERNORS

Horsepower requirements on an engine may vary due to fluctuating loads; therefore, some method must be provided to control the amount of fuel required to hold the engine speed reasonably constant during load fluctuations. To accomplish this control, a governor is introduced in the linkage between the throttle control and the fuel injectors. The governor is mounted on the front end of the blower and is driven by the upper blower rotor. The following types of mechanical governors are used:

1. Limiting Speed Mechanical Governor.

2. Variable Speed Mechanical Governor.

3. Constant Speed Mechanical Governor.

Engines requiring a minimum and maximum speed control, together with manually controlled intermediate speeds, are equipped with a limiting speed mechanical governor.

Engines subjected to varying load conditions that require an automatic fuel compensation to maintain a near constant engine speed, which may be changed manually by the operator, are equipped with a variable speed mechanical governor.

Constant speed mechanical governors are used on engines which require a constant speed of predetermined value. There is no intermediate or manually controlled range between high and low engine speeds. The only requirement is to control the idle speed and maintain a constant operating speed.

Each type of governor has an identification plate located on the control housing, containing the governor assembly number, type, idle speed range and drive ratio. The maximum engine speed, not shown on the identification plate, is stamped on the option plate attached to the valve rocker cover.

Check Governor Operation

Governor difficulties are usually indicated by speed variations of the engine; however, it does not necessarily mean that all such speed fluctuations are caused by the governor. Therefore, when improper speed variations are present, check the engine as follows:

1. Make sure the speed changes are not the result of excessive load fluctuations.

2. Check the engine to be sure that all of the cylinders are firing properly (refer to Section 15.2). If any cylinder is not firing properly, remove the injector, test it and, if necessary, recondition it as outlined in Section 2.1 or 2.1.1.

3. Check for bind that may exist in the governor operating mechanism or in the linkage between the governor and the injector control tube.

With the fuel rod connected to the injector control tube lever, the mechanism should be free from bind throughout the entire travel of the injector racks. If friction exists in the mechanism, it may be located and corrected as follows:

1. If an injector rack sticks or moves too hard, it may be due to the injector hold-down clamp being too tight or improperly positioned. To correct this condition, loosen the injector clamp, reposition it and tighten the clamp bolt to 20-25 lb-ft (27-34 Nm) torque.

2. An injector which is not functioning properly may have a defective plunger and bushing or a bent injector rack. Recondition a faulty injector as outlined in Section 2.1 or 2.1.1.

3. An injector rack may bind as the result of an improperly positioned rack control lever. Loosen the rack control lever adjusting screws. If this relieves the bind, relocate the lever on the control tube and position the rack as outlined in Section 14.

4. The injector control tube may bind in its support brackets, thus preventing free movement of the injector racks to their no-fuel position due to tension of the return spring. This condition may be corrected by loosening and realigning the control tube supporting brackets. If the control tube support brackets were loosened, realigned and tightened, the injector racks must be repositioned as outlined in Section 14.

5. A bent injector control tube return spring may cause friction in the operation of the injector control tube. If the spring has been bent or otherwise distorted, install a new spring.

6. Check for bind at the pin which connects the fuel rod to the injector control tube lever; replace the pin, if necessary.

If, after making these checks, the governor fails to control the engine properly, remove and recondition the governor.

© 1978 General Motors Corp.

LIMITING SPEED MECHANICAL GOVERNOR

The limiting speed mechanical governor, illustrated in Fig. 1, may be either a single weight or a double weight type governor and it performs the following functions:

1. Controls the engine idling speed.

2. Limits the maximum operating speed of the engine.

The governor is mounted on the front end of the blower and is driven by the upper blower rotor, (Fig. 2). The governor consists of three subassemblies:

1. Control Housing Cover.

2. Control Housing.

3. Weights and Housing.

The governor provides full fuel for starting when the speed control lever is in the idle position. Immediately after starting, the governor moves the injector racks to that position required for idling.

Governors dated March, 1975 or later in turbocharged engines include a starting aid screw threaded into the governor housing. Only the governor housing with the external starting aid screw is serviced. If the starting aid screw is not required back it out as far as possible to make it ineffective.

A tamper-resistant single weight limitng speed governor is provided for highway vehicle engines (refer to Section 2.0).

Operation (Single Weight Governor)

The centrifugal force of the revolving governor weights is converted into linear motion which is transmitted through the riser and operating shaft to the operating shaft lever. One end of lever operates against the high and low speed springs through the spring cap, while the other end provides a moving fulcrum on which the differential lever pivots.

When the centrifugal force of the revolving governor weights balances out the tension on the high or low speed spring (depending on the speed range), the governor stabilizes the engine speed for a given setting of the governor control lever.

In the low speed range, the centrifugal force transmitted operates against the low speed spring. As the engine speed is increased, the centrifugal force compresses the low speed spring until the spring cap is tight against the high speed plunger. This removes the low speed spring from operation and the governor is then in the intermediate speed range. In this range, the centrifugal force is operating against the high speed spring and thus the engine speed is manually controlled.

As the engine speed is increased to a point where the centrifugal force overcomes the pre-load of the high speed spring, the governor will move the injector racks out to that position required for maximum no-load speed.

A fuel rod, connected to the differential lever and injector control tube lever, provides a means for the governor to change the fuel settings of the injector control racks.

The engine idle speed is determined by the centrifugal force required to balance out tension on the low speed spring.

Adjustment of the engine idle speed is accomplished by changing the tension of the low speed spring by means of the idle adjusting screw. Refer to Section 14.3 for the idle speed adjustment.

The maximum no-load speed is determined by the centrifugal force required to balance out the tension on the high speed spring.

Adjustment of the maximum no-load speed is accomplished by the high speed spring retainer. Movement of the high speed spring retainer nut will increase or decrease the tension on the high speed spring. Refer to Section 14.3 for the maximum no-load speed adjustment.

Operation (Double Weight Governor)

The centrifugal force of the revolving governor weights is converted into linear motion which is transmitted through the riser and operating shaft to the operating shaft lever. One end of lever operates against the high and low speed springs through the spring cap, while the other end provides a moving fulcrum on which the differential lever pivots.

When the centrifugal force of the revolving governor weights balances out the tension on the high or low speed spring (depending on the speed range), the governor stabilizes the engine speed for a given setting of the governor control lever.

In the low speed range, the centrifigal force of the low speed weights operates against the low speed spring. As the engine speed increases, the centrifugal force of the low speed weights compresses the low speed spring until the weights are against their stops, thus limiting

© 1983 General Motors Corp.

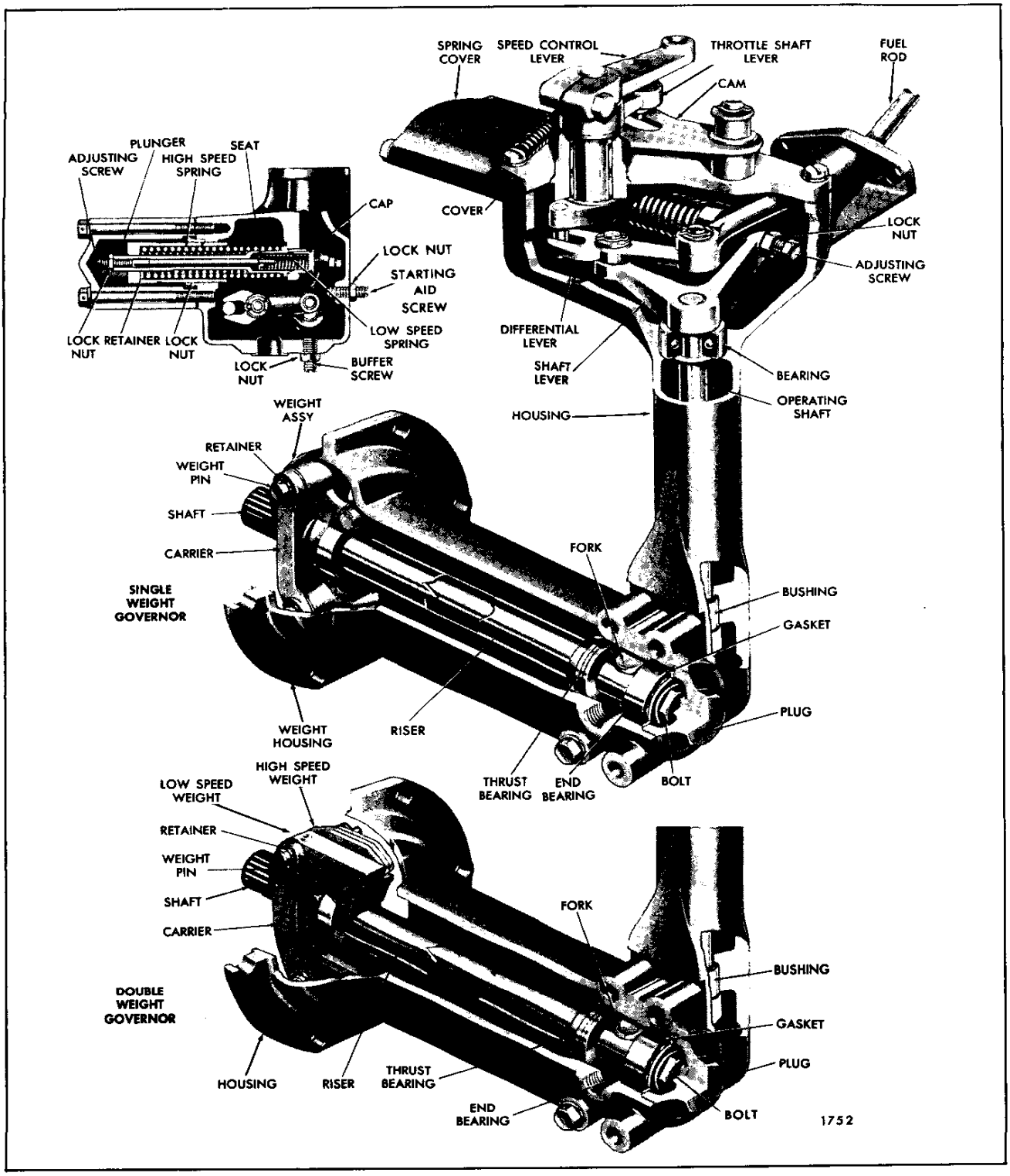


Fig. 1 - Limiting Speed Mechanical Governor

© 1983 General Motors Corp.

their travel, at which time the low speed spring is fully compressed and the low speed cap is against the high speed plunger.

Throughout the intermediate speed range the operator has complete control of the engine because both the low speed spring and the low speed weights are against their stops, and the high speed weights are not exerting enough force to overcome the high speed spring.

As the speed continues to increase, the centrifugal force of the high speed weights increases until this force can overcome the high speed spring and the governor again takes control of the engine, limiting the maximum engine speed.

A fuel rod, connected to the differential lever and injector control tube lever, provides a means for the governor to change the fuel settings of the injector control racks.

The engine idle speed is determined by the centrifugal force of the low speed weights required to balance out tension on the low speed spring.

Adjustment of the engine idle speed is accomplished by changing the tension on the low speed spring by means of the idle adjusting set screw. Refer to Section 14.3 for the idle speed adjustment.

The maximum no-load speed is determined by the centrifugal force of the high speed weights required to balance out the tension on the high speed spring.

Adjustment of the maximum no-load speed is accomplished by the high speed spring retainer. Movement of the high speed spring retainer nut will increase or decrease the tension on the high speed spring. Refer to Section 14.3 for the maximum no-load speed adjustment.

Lubrication

Surplus oil returning from the cylinder head provides lubrication for the parts in the governor control housing, the riser thrust bearings, and the weight shaft end bearing. Oil, picked up from a reservoir in the blower front end plate by a slinger attached to the lower rotor shaft, provides lubrication for the governor weights and weight carrier.

Pressure lubrication has been provided for the weight housing bearings on the current engines. The oil tube is attached between the oil gallery in the cylinder block and the governor weight housing.

Remove Governor From Engine

Governor operation should be checked as outlined in Section 2.7 before the governor is removed from the engine. If, after performing these checks, the governor fails to control the engine properly, it should be removed and reconditioned.

1. Disconnect the linkage attached to the governor control levers (Fig. 2).

2. Remove the breather tube.

3. Remove four screws and lock washers and lift the governor cover (Fig. 3) and gasket from the governor housing.

4. Refer to Figs. 1 and 2 and disconnect the fuel rod from the differential lever and the injector control tube lever.

5. Disconnect the oil tube at the governor weight housing, or cover and remove the cover, if used.

6. Remove two governor-to-cylinder head bolts.

7. Remove the control housing from the cylinder head and weight housing.

8. Use tool J 4242, to remove the six governor weight housing-to-blower bolts, then withdraw the housing from the blower.

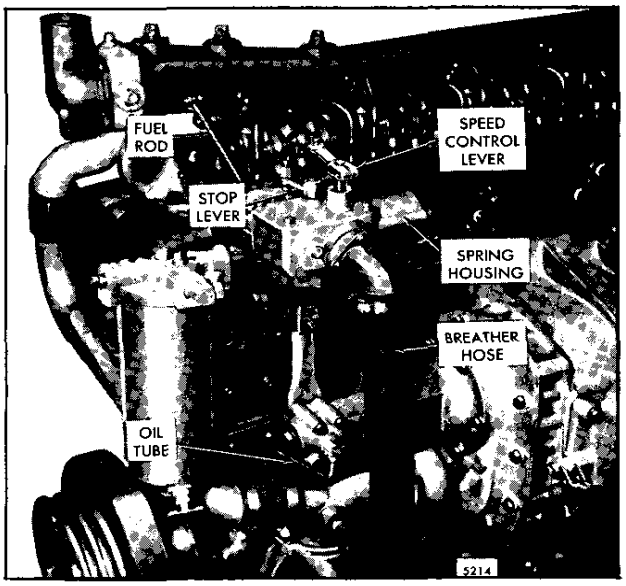


Fig. 2 - Typical Limiting Speed Governor Mounting

© 1982 General Motors Corp.

Disassemble Governor

1. Disassemble the governor cover:

a. Remove the plug from the throttle shaft (Fig. 3).

b. Loosen the speed control lever bolt, and lift the speed control lever from the throttle shaft.

c. Remove the tapered pin from the shutdown lever. Lift the lever and the seal ring retainer from the throttle shaft. Withdraw the throttle shaft from the cover.

d. Remove the cam retainer and plain washer from the cam pin. Lift the cam, and the stop lever, if used, off the pin.

e. Remove the seal ring from the governor cover.

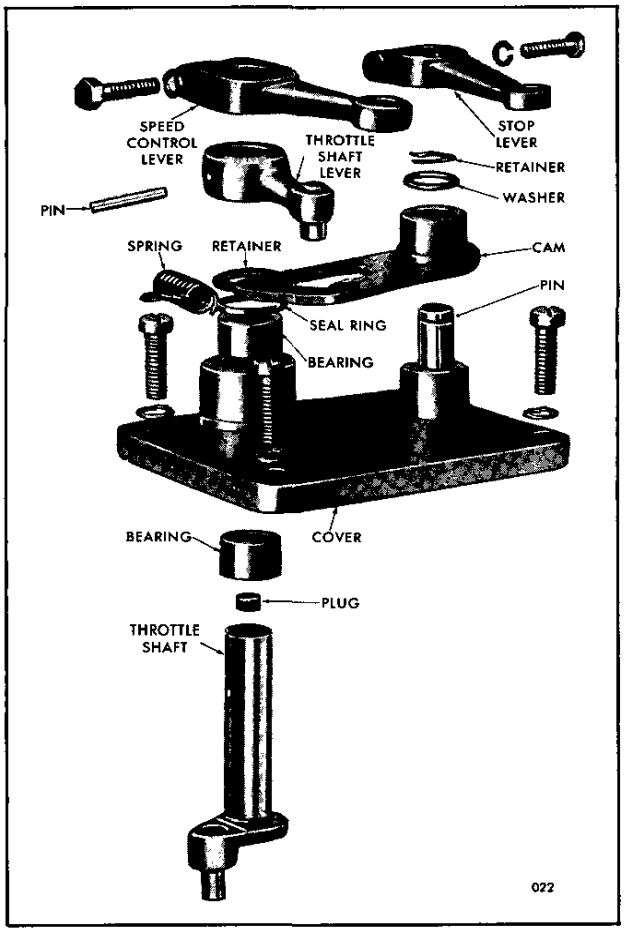


Fig. 3 - Governor Cover Details and Relative Location of Parts

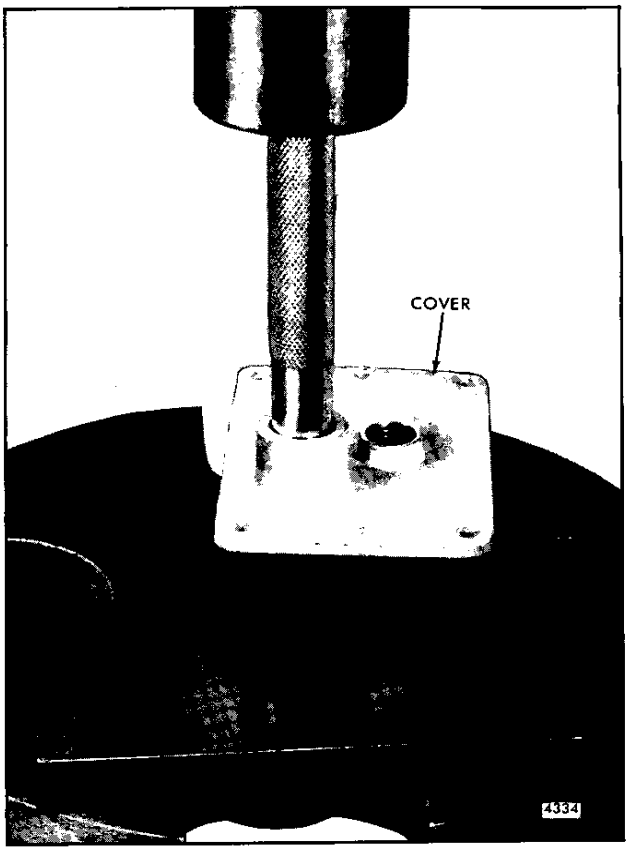


Fig. 4 - Removing Needle Bearings from Governor Cover using Tool J 21967-01

f. Wash the cover assembly (containing needle bearings) thoroughly in clean fuel oil and inspect the needle bearings for wear or damage. If the bearings are satisfactory for further use, removal is unnecessary.

g. If needle bearing removal is necessary, place the inner face of the cover over the opening in the bed of the press. Place remover J 21967-01 on top of the bearing and press both bearings out of the cover (Fig. 4).

2. Disassemble the governor control housing (single and double weight governors):

a. Place the control housing in a soft jawed vise.

b. Remove two bolts (53) (Fig. 5) and withdraw the high speed spring retainer cover (51).

c. Loosen the lock nut (49) with tool J 5345-5. Remove the high speed spring retainer (50), idle adjusting set screw (55), high speed spring (48),

© 1982 General Motors Corp.

spring plunger (44), low speed spring (46), spring seat (45), and spring cap (47) as an assembly.

d. Remove the spring retainer (25) and washer, then lift the differential lever (23) from the pin of the operating shaft lever (27).

e. Remove the expansion plug (41) out of the lower end of the control housing.

f. Remove the bearing retaining screw (32), flat washer (33), and lock washer.

g. Loosen the operating fork set screw, if used.

h. Support the control housing as shown in Fig. 6. Press the operating shaft (26) from the operating fork (73) using a brass rod. Withdraw the operating shaft, operating lever (27), and bearing (30) as an assembly from the control housing.

i. Support the operating shaft and lever on bed of press as shown in Fig. 7. Press the shaft from the operating lever and bearing with a brass rod.

j. Remove the starting aid screw from governors dated March, 1975 or later, if necessary.

3. Disassemble governor weight housing:

a. Place the weight housing (59) in a soft jawed vise. Remove the plug (83) and gasket (82).

b. Straighten the tang of the lock washer and remove the bearing retaining bolt (71).

c. Thread a 5/16"-24 x 3" bolt into the tapped end of the weight shaft (66). Support the weight housing (59) on the bed of the press as shown in Fig. 8 and press the shaft from the bearing.

d. Slide the riser thrust bearing (60) and governor riser (67) from the shaft (66).

This bearing is specially designed to absorb thrust loads; therefore, looseness between the mating parts does not indicate excessive wear.

e. Remove the bearing (70) from the weight housing.

NOTE: The weight shaft end bearing should be discarded on removal as it becomes brinnelled during the disassembly process.

f. Mark the weights (76 or 92 and 93) and carrier (75) with a center punch for identification, also note position of the thin washers (78) between the weights so that the parts can be replaced in their original position.

g. If removal of the weights from the carrier is necessary on the current double weight governors, refer to Fig. 9 and remove the retainers from the weight pin. Press the pin from the low speed weights. The high speed weight is not a press fit. On former governors remove the set screw from the low speed weights with a 3/32" allen wrench. Then remove the weight pin and weight from the carrier.

Remove the second pair of weights in the carrier in the same manner as described above.

NOTE: If necessary the needle bearing in the high speed weights may be removed at this time.

h. If required, the weight carrier (75) may be pressed from the governor weight shaft and a new carrier installed.

Inspection

Clean all the parts with fuel oil, and dry them with compressed air.

Revolve the ball bearings slowly by hand. Replace bearings which indicate rough or tight spots. Also replace bearings which are corroded or pitted.

Examine the riser thrust bearings for excessive wear, flat spots, or corrosion. If any of these conditions exist, install a new riser and bearing assembly.

Inspect the weight carriers, weights and retaining pins for wear.

Inspect the bushings in current weights and replace if worn excessively. In former weights inspect the needle bearings for wear and replace if necessary.

Inspect the operating shaft and bushing for excessive wear. If excessive wear is noted, a new bushing and shaft must be installed.

Assemble Governor Cover

1. If the needle bearings were removed from the governor cover, place the governor cover on the bed of an arbor press with inner face of the cover down. Start the upper bearing straight into the bearing bore of the cover with the number on the bearing up. Insert the bearing installer J 21068 in the bearing and press the bearing in until the shoulder on the tool contacts the cover (Fig. 10).

2. Turn the cover over and start the second bearing, number side up, in the bearing bore. Press the bearing in flush with the cover with tool J 21068.

© 1983 General Motors Corp.

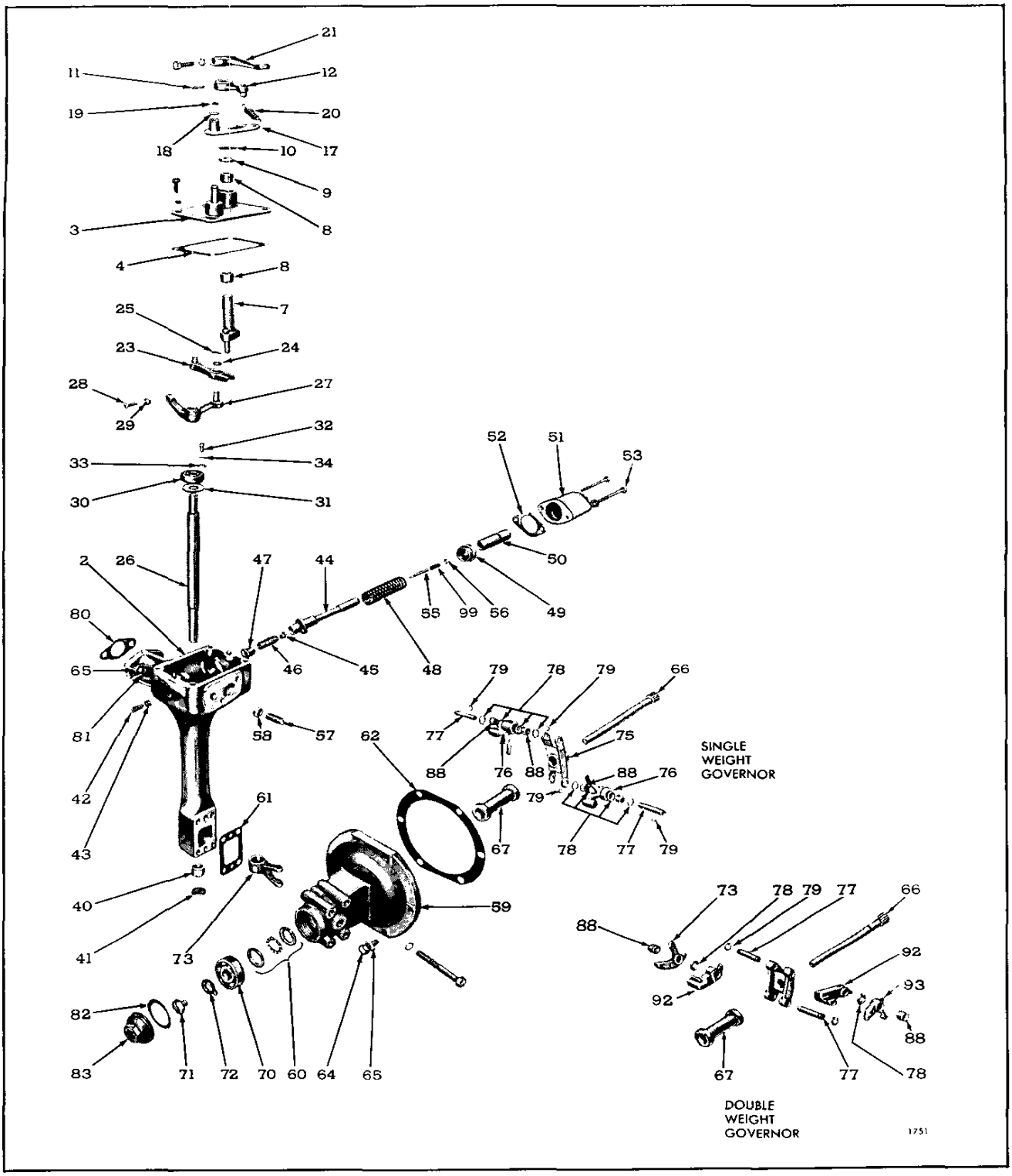


Fig. 5 - Limiting Speed Governor Details and Relative Location of Parts

© 1983 General Motors Corp.

2. Housing--Governor Control
3. Cover--Governor
4. Gasket
7. Shaft--Throttle
8. Bearing--Throttle Shaft
9. Ring--Seal
10. Retainer--Seal Ring
11. Pin--Tapered
12. Lever--Throttle Shaft
17. Cam
18. Washer--Plain
19. Retainer--Spring
20. Spring--Cam Control
21. Lever--Speed Control
23. Lever--Differential
24. Washer--Lever Pin
25. Retainer--Spring
26. Shaft--Operating
27. Lever--Operating Shaft
28. Screw--Gap Adjusting
29. Lock Nut
30. Bearing--Operating Shaft
31. Washer--Bearing
32. Screw
33. Washer--Flat
34. Lock Washer
40. Bushing--Operating Shaft
41. Plug--Expansion
42. Screw--Starting Aid
43. Lock Nut
44. Plunger--High Speed Spring
45. Seat--Low Speed Spring
46. Spring--Low Speed
47. Cap--Low Speed Spring
48. Spring--High Speed
49. Lock Nut--Retainer
50. Retainer--High Speed Spring
51. Cover--High Speed Spring Retainer
52. Gasket
55. Pin--Idle Speed Adjusting
56. Lock Nut
57. Screw--Buffer
58. Lock Nut
59. Housing--Weight
60. Bearing--Riser Thrust
61. Gasket--Weight Housing Cover
62. Gasket--Governor to Blower
66. Shaft Assy.--Weight
67. Riser--Governor
70. Bearing--Shaft End
71. Bolt--Retaining
72. Lock Washer
73. Fork--Operating Shaft
75. Carrier--Weight
76. Weight Assy.--Single Weight Governor
77. Pin--Weight
78. Washer--Flat
79. Retainer
80. Gasket--Governor to Cylinder Head
81. Bolt
82. Gasket
83. Plug--Weight Housing
88. Bearing--Governor Weight
92. Weight--Low Speed
93. Weight--High Speed
99. Screw--Set

Fig. 5 - Limiting Speed Governor Details and Relative Location of Parts

NOTE: Do not use impact tools to install needle bearings.

3. Apply lubricant to the retaining pin and place the cam (Fig. 3) over the pin with the boss of the cam up. Install the stop lever, if used.

4. Place the washer over the pin and secure it with the spring retainer.

5. Install the plug in the throttle shaft.

6. Pack the needle bearings with grease. Then, slide the throttle shaft assembly through the bearings.

7. Insert the seal ring over the shaft and into the counterbore against the upper bearing. Place the retainer over the shaft and against the seal ring.

8. Start the throttle shaft lever over the throttle shaft with the holes in lever and shaft for tapered pin in alignment.

9. Support the lower end of the throttle shaft on the bed of the arbor press, then place a sleeve on the throttle lever and under the ram of the press. Align the slot in the cam with the pin in the throttle lever, then press the lever down on the shaft until the hole in the lever is in line with the hole in the shaft.

10. Insert the tapered pin in the hole of the lever, then support the lever and cover assembly on a steel block and drive the pin into place.

11. Position the speed control lever on the throttle shaft and tighten the retaining bolt.

12. Attach one end of the spring in small hole of cam.

Assemble Governor Control Housing

1. Place the washer (31) over the short finished end of the operating shaft (26). Start the bearing (30) over the end of the shaft. Support the opposite end of the shaft on the bed of a press. Press the bearing on the shaft tight against the washer with a sleeve which has the same diameter as the bearing inner race.

2. With the pivot pin in the operating lever (27) up, start the lever over the end of the shaft with the flat on the shaft registering with the flat surface in the lever. Press the lever on the shaft tight against the bearing (30).

3. Lubricate the bearing and operating shaft bushing (40) in the housing with clean engine oil. Insert the lever and operating shaft assembly in the control housing.

4. Position the operating fork over the lower end of the operating shaft (Fig. 6) so the finished side of the fork finger will rest against the thrust bearing when assembled as shown in Fig. 1.

5. Support the operating shaft and control housing in an arbor press with the upper end of the operating shaft resting on a steel block. Align the flat in the operating fork with the flat on the operating shaft,

© 1980 General Motors Corp.

then place a sleeve over the end of the shaft and rest it on the fork. Bring the ram of the press down on the sleeve and press the fork straight down and tight against the shoulder on the shaft.

6. Tighten the fork set screw, if used.

7. Apply a good quality sealant around the periphery of the expansion plug (41) (Fig. 5) and press the plug into the lower end of the control housing.

8. Place a lock washer and flat washer over the retaining screw (32). Thread the screw in the control housing to secure the operating shaft bearing (30).

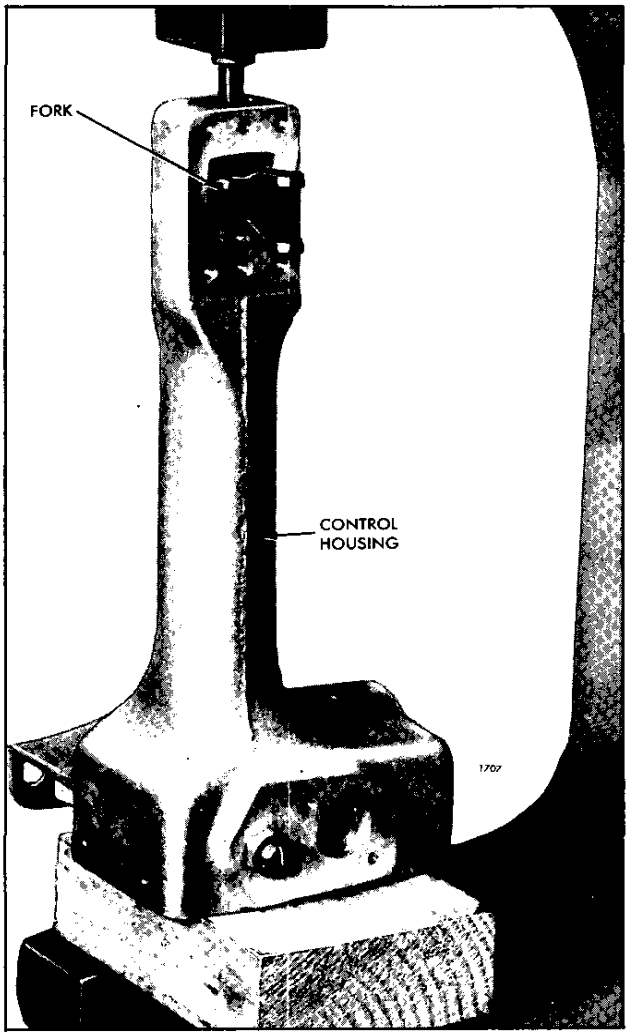


Fig. 6 - Removing Operating Fork from Operating Shaft

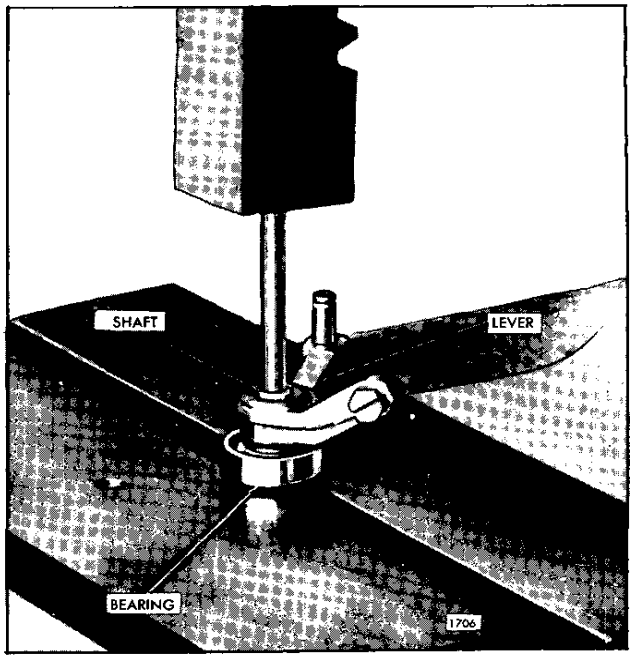


Fig. 7 - Removing Operating Shaft from Operating Lever

9. Place the differential lever (23) over the pivot pin of the operating lever. Install a plain washer and spring retainer (25).

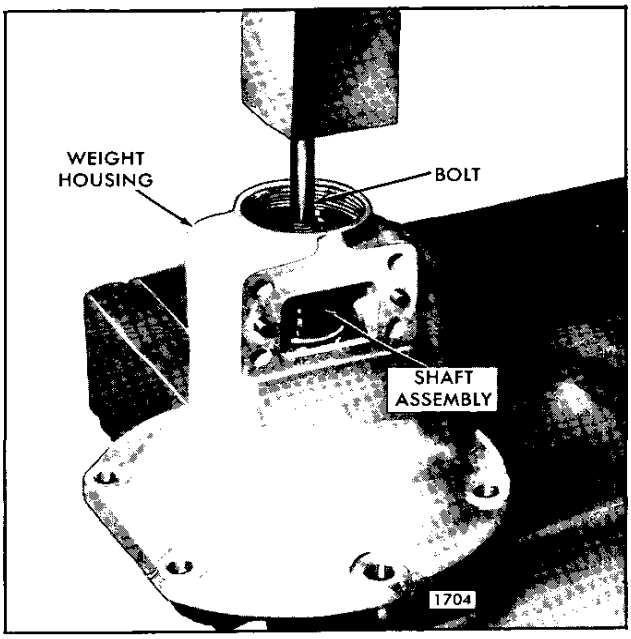


Fig. 8 - Removing Governor Weight and Shaft Assembly

© 1980 General Motors Corp.

Assemble Governor Springs, Plungers, and Adjusting Screws

1. Thread the lock nut (58), Fig. 5 on the buffer screw (57) and thread the buffer screw into the control housing.

2. Thread the lock nut (Fig. 1) on the high speed spring retainer approximately 1 1/2 ". Place the high speed spring over the high speed spring plunger with the close wound coils inside of the spring retainer.

3. Insert the plunger and spring assembly in the high speed spring retainer. Thread the set screw approximately 1.00 " into the tapped end of the plunger. Thread the lock nut over the set screw.

4. Insert the low speed spring in the low speed spring cap and the small end of the spring seat in the opposite end of the low speed spring.

5. Insert the low speed spring seat and low speed spring and cap assembly in the high speed spring plunger with the spring seat against the shoulder of the set screw.

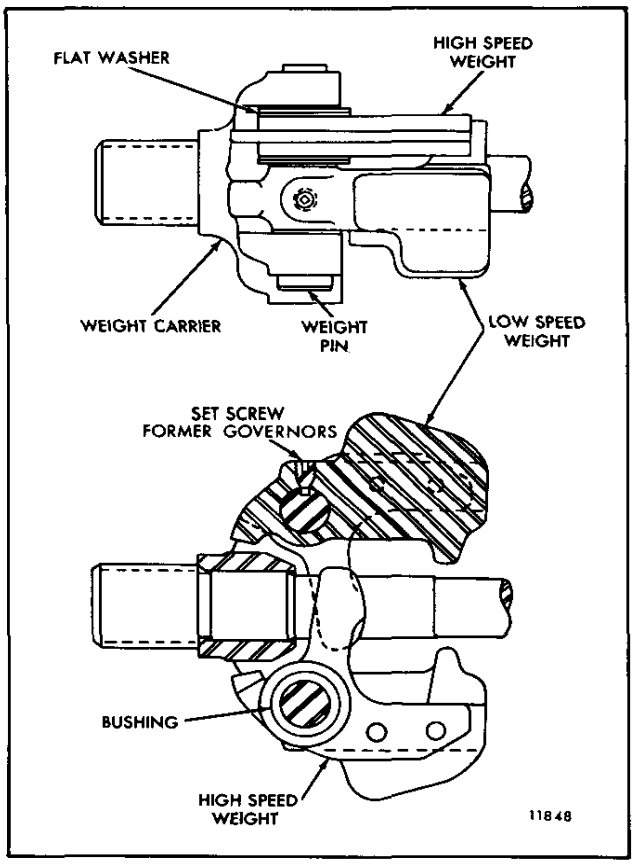


Fig. 9 - Cross Section of Governor Weight for Current Double Weight Governor

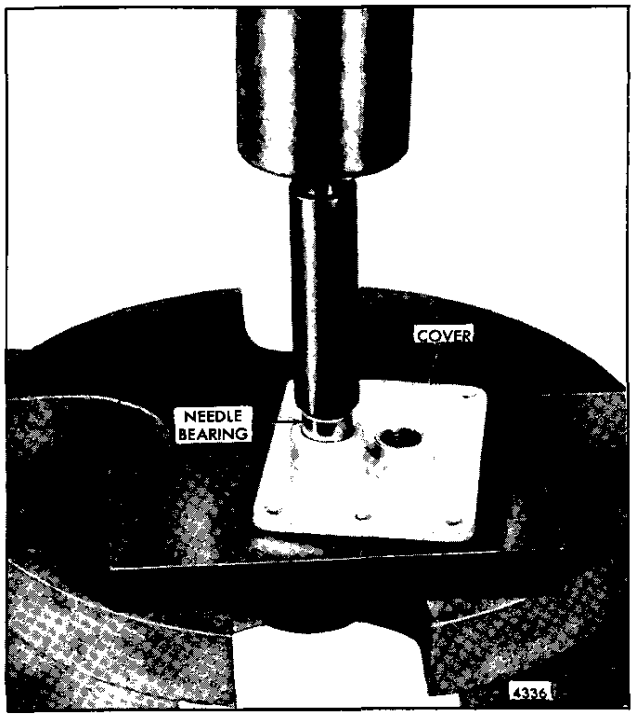


Fig. 10 - Installing Needle Bearings on Governor Covers using Tool J 21068

6. Start the governor high speed spring assembly into the opening of the control housing and thread the high speed spring retainer in the housing approximately 1.00 ".

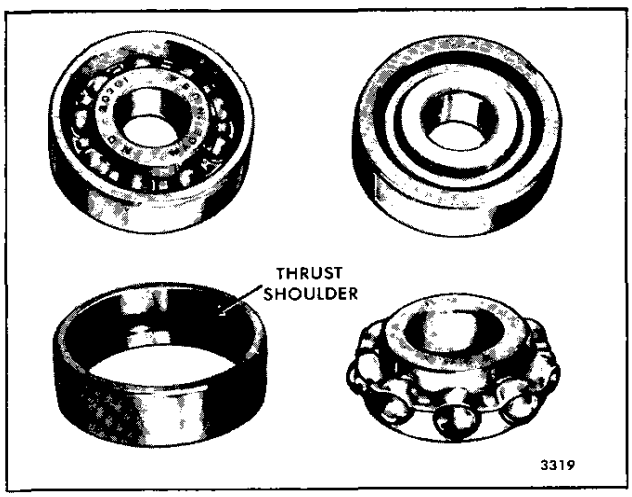


Fig. 11 - Former Governor Weight Shaft Bearing

© 1982 General Motors Corp.

7. Installation of the high speed spring retainer cover is not required until after the governor has been installed on the engine and the tune-up procedures outlined in Section 14 have been completed.

Assemble Governor Weight Housing

1. Assemble the weights

Single Weight Governor--

a. Install the retainer (79), Fig. 5, in the groove of the weight pin (77). Place a flat washer over the pin and against the lock ring.

b. Start the pin through the opening in the weight carrier. Place a second washer over the pin and against the projecting arm of the weight carrier.

c. Position the governor weight between the projecting arms of the weight carrier. Push the pin through the governor weight.

d. Place the third flat washer over the pin and against the weight.

e. Then, push the pin completely through the weight carrier and place the fourth flat washer over the pin and against the projecting arm of the weight carrier. Install a second lock ring in the groove of the weight carrier pin.

f. Install the second governor weight in a similar manner.

g. If removed install the starting aid screw.

Double Weight Governor--

a. With current governors refer to Fig. 9 and install a retainer on either end of the weight pin. Note the match marks placed on the weight carrier and weights at the time of disassembly. Then slide the weight pin through the carrier, flat washer and the high speed weight and its bushing.

b. Place the low speed weight in position. Then press the weight pin through the low speed weight and carrier until the retainer bottoms against the carrier. Maintain a clearance of .004"-.012" with the weight pressed in position.

NOTE: To maintain this clearance insert a .004"-.012" shim between the low speed weight and carrier while pressing the pin into position.

c. Remove the shim and install the second weight pin retainer.

d. Install the second pair of weights in the carrier in the same manner as described above.

Former Double Weight Governor--

a. With former governors refer to Fig. 5 and start pin (77) through the opening in the weight carrier (75).

b. Place the low speed weight (92) on the pin and slide the pin through.

c. Place two flat washers (78) on the pin next to the low speed weights.

d. Install the high speed weights (93) on their shafts after installing the needle bearing or bushings.

e. Place the high speed weight on the pin and slide the pin through the weight.

f. Place two more flat washers on the pin between the high speed weights and the carrier. Slide the pin through the washers and into the carrier.

g. Align the indentation in the pin with the set screw hole in the low speed weights. Apply a sealant such as Loctite grade C or CV or equivalent on the threads of each set screw. Insert the set screws and tighten them to 20 **lb-in** (2.26 Nm) minimum. Be sure to stake each set screw in two places after tightening the screws.

NOTE: Before applying the sealant to a new set screw immerse the set screw in Loctite Primer T or equivalent.

2. Assemble weight shaft and carrier assembly.

a. Slide the riser over the weight shaft and against the finished surfaces of the governor weights as shown in Fig. 1.

b. Assemble the riser thrust bearing (60) on the weight shaft (66) with the bearing race with the smallest inside diameter against the thrust riser. Incorrect installation of the bearing will result in erratic operation of the governor.

c. Insert the weight carrier and shaft assembly in the weight housing.

d. Support the splined end of the shaft on the bed of an arbor press. Start the shaft end bearing in the housing and over the end of the shaft with the numbered side of the bearing facing away from the shaft. Press the new bearing in place using a 1 3/8" diameter metal bar flat on the ends which bear against both the inner and outer races of the bearing.

© 1982 General Motors Corp.

NOTE: The former bearing had thrust capacity in one direction only. Be sure to install the former bearing so that the thrust shoulder (Fig. 11) is toward the governor weights. Otherwise, the force exerted by the weights will pull the inner race and ball assembly away from the outer race and result in damage to the bearing and erratic governor operation.

e. Place the washer (72) (Fig. 5) over the bearing retaining bolt (71). Thread the bolt into the tapped end of the shaft and tighten it. Bend the tang on the washer against the head of the bolt.

f. Place a gasket (82) in the housing and against the bearing. Apply a Loctite sealant, grade HV or equivalent, to the full 360° circumference of the plug and thread the plug into the tapped end of the governor weight housing. Tighten the plug to 45 lb-ft (61 Nm) torque with either flat or point of head on a horizontal line.

Install Governor

1. Affix a new gasket (62) (Fig. 5) to the governor weight housing. Refer to Fig. 2 and start the splined end of the weight shaft in the upper blower rotor and position the housing against the blower end plate.

2. Place a new copper gasket on each weight housing-to-blower bolt and thread the bolts into the blower end plate, finger tight only.

3. Place a new gasket (61) over the dowels and against the side of the weight housing facing the engine.

- **NOTE:** Check the dowel pins for excessive protrusion. The specified protrusion is 3/32".

4. Move the thrust bearing assembly and riser toward the weight end of the shaft.

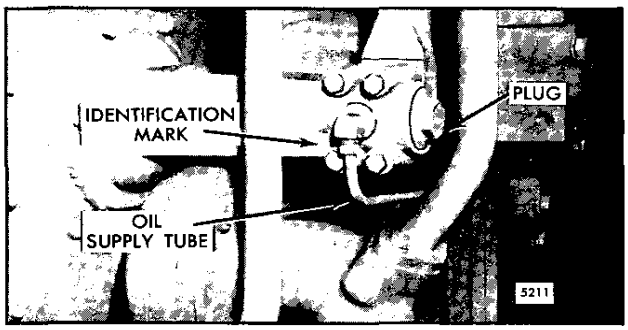


Fig. 12 - Governor Weight Housing (Current 4 and 6 Cylinder Engines)

5. Position the lower end of the control housing over the dowel pins in the weight housing. The finished surface of the operating fork must be placed against the outer side of the thrust bearing as shown in Fig. 1.

NOTE: For ease in assembling the governor control housing (4 or 6 cylinder engine) to the interim weight housing (no identification mark, Fig. 12) install a special bolt (3/8"-24 x 3/4" or 7/8") from which the outer 1/2" of thread down to a diameter of 5/16" to 1/4" has been removed, as a tool in the 1/8" NPTF oil hole to prevent the thrust bearing from moving too far forward in the weight housing. Current weight housing has two ribs cast on the inner surface of the housing to prevent any part of the riser thrust bearing from sliding forward to where the operating fork could be inserted on the wrong side of one or more parts of the bearing.

6. Affix a new gasket (80) to the governor control housing, then attach the governor control housing to the cylinder head with two bolts (Fig. 2). Tighten the bolts.

7. Tighten the governor-to-blower bolts with wrench J 4242.

8. Affix a new gasket to the weight housing cover (former governors only) and place the cover in position. Install the four weight housing-to-control housing bolts with lockwashers and tighten the bolts.

9. Connect the oil tube to the restricted fitting on the weight housing or cover (if used).

10. Refer to Figs. 1 and 2 and position the fuel rod over the differential lever pin. Place a flat washer over the pin and secure it with the retainer.

11. Attach the fuel rod to the injector control tube lever with a pin and cotter pin.

12. Place a new gasket (4) (Fig. 5) on the governor control housing and mount the governor cover on the housing with the pin on the throttle shaft registering with the machined slot in the differential lever as shown in Fig. 1.

13. Install the four cover screws with lock washers. Connect one end of the cam spring to one of the cover screws as shown in Fig. 2.

14. Connect throttle linkage.

15. Attach the breather tube to the governor housing.

16. Perform the engine tune-up as outlined in Section 14.3.

© 1983 General Motors Corp.

LIMITING SPEED MECHANICAL FUEL MODULATING GOVERNOR

The limiting speed mechanical fuel modulating governor is a double weight type and performs the following functions:

1. Controls the engine idle speed.

2. Limits the maximum operating speed of the engine.

3. Regulates the fuel input at part throttle.

The governor is mounted on the front end of the blower and is driven by the upper blower rotor.

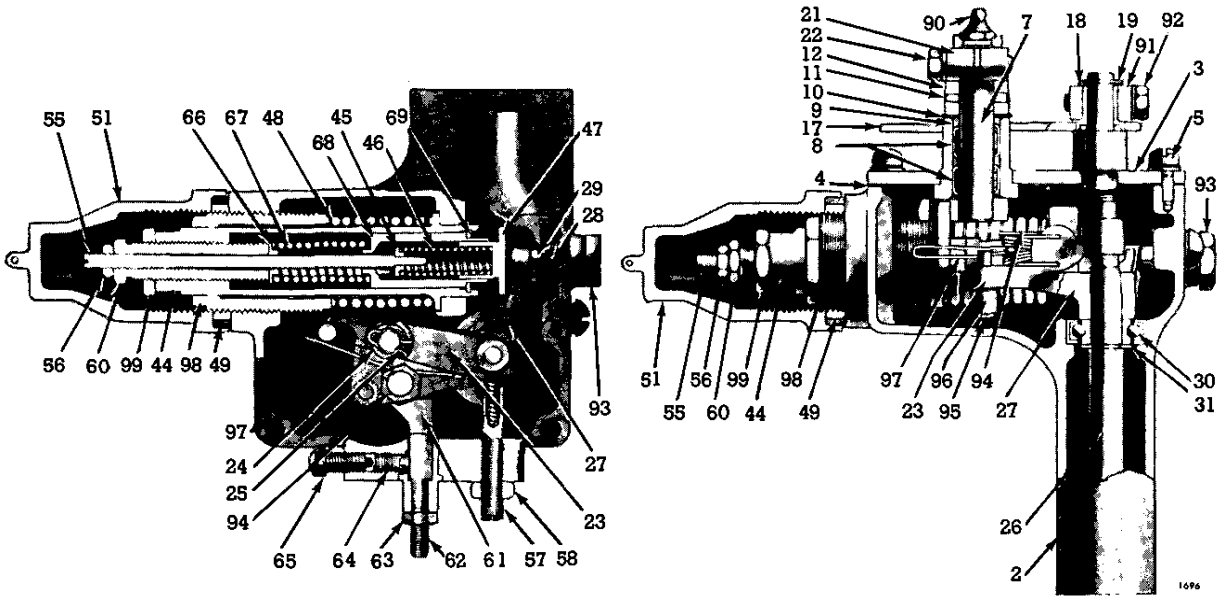
The governor consists of three subassemblies:

1. Control Housing Cover.

2. Control Housing.

3. Weights and Housing.

The governor provides full fuel for starting when the speed control lever is in the idle position. Immediately



2. Housing--Control
3. Cover--Governor
4. Gasket--Cover
5. Screw
7. Shaft--Throttle
8. Roller Bearings
9. Seal
10. Seal Washer
11. Pin--Taper
12. Lever--Throttle
17. Cam--Control
18. Washer
19. Spring Retainer
21. Lever--Speed Control
22. Bolt
23. Lever--Differential
24. Washer--Lever Pin
25. Spring Retainer
26. Shaft--Operating
27. Lever--Operating Shaft
28. Screw--Low Speed Gap Adjusting
29. Lock Nut
30. Bearing--Operating Shaft
31. Washer--Bearing
44. Plunger--High Speed Spring
45. Seat--Low Speed Spring
46. Spring--Low Speed
47. Cap--Low Speed Spring
48. Spring--High Speed
49. Lock Nut--High Speed
51. Cover--Adjustment
55. Screw--Idle Speed Adjusting
56. Locknut--Idle Speed Screw
57. Screw--Buffer
58. Lock Nut--Buffer Screw
60. Screw--Modulating Speed Adjusting
61. Cam--Modulating
62. Screw--Cam Adjusting
63. Lock Nut
64. Lock Screw--Cam
65. Plugging Screw
66. Seat--Modulating Spring
67. Spring--Modulating
68. Plunger--Modulating Spring
69. Retainer Ring
90. Lubrication Fitting
91. Lever--Stop
92. Bolt
93. Plug--Control Housing
94. Screw--Torsion Spring
95. Pin--Roller
96. Roller
97. Spring--Torsion
98. Screw--High Speed Adjusting
99. Lock Nut--Modulating Screw

Fig. 1 - Fuel Modulator Governor

© 1977 General Motors Corp.

after the engine starts, the governor moves the injector racks to that position required for idling.

Operation

The fuel modulating governor (Fig. 1) has been developed to improve combustion and fuel economy during low-speed full-throttle operation. The fuel modulator incorporated with the mechanical limiting speed governor automatically controls the fuel input to assure complete combustion, thus providing maximum fuel economy, clean exhaust, and longer engine life. This control is assured regardless of the throttle setting maintained by the operator.

The governor includes a low speed spring (46), a high speed spring (48), a set of low speed weights, and a set of high speed weights, similar to those included in the limiting speed mechanical governor.

In addition, the governor incorporating the fuel modulator includes a fuel modulator spring (67), which provides governor control for the purpose of gradually reducing the fuel input in the fuel modulating range. Over this speed, the forces of the low speed and modulator springs react against the force of the high speed weights.

As the engine speed decreases below top modulator range, the gradual reduction in high speed weight force permits the force of the low speed spring (46) and modulating spring (67) to open the fuel modulator gap in the governor by moving the low speed spring cap (47) back away from the high speed spring plunger (44). The movement of the low speed spring cap moves the operating lever (27) -- the operating lever moves the differential lever (23) -- toward the engine, causing the differential lever to rotate around the pin which connects it to the operating lever. The rotation of the differential lever is restricted by the engagement of the roller (96), on the bottom of the lever, with the fuel modulator cam (61). The cam causes the differential lever to rotate in a direction which pulls the governor link back into the governor and thus pulls the injector racks out from the full fuel position.

During this time, the differential lever torsion spring (97) opposes the above rotation with a light tension and maintains the roller (96) in its proper position against the fuel modulator cam (61). It is this differential lever torsion spring which allows the fuel modulator to operate regardless of the throttle position maintained by the operator.

The fuel modulator spring tension is set so that the injector racks start to leave the "full in" position as the engine speed is reduced. The engine speed at which this occurs is controlled by the rate and tension of the modulating spring used. Fuel modulating action begins at approximately 200 rpm below the fuel modulating gap closing speed with 80 cu. mm. injectors, and approximately 300 rpm below fuel modulating gap closing speed with 70 cu. mm. injectors. Delay in modulating action with 70 cu. mm. injectors is due to the helix design on the injector plunger, which does not reduce the fuel input until after .075 " rack movement.

RPM		Modulator Spring	High Speed Spring	Injector
Max.	Min.			
2300	1975	175# (G)	55# (Y)	70
2300	2075	225# (W)	55# (Y)	70
2300	2075	225# (W)	55# (Y)	80
2300	1865	150# (B)	55# (Y)	70

*RPM given is full load; to obtain no-load (floor setting) speed, add 125 RPM.

When engine is equipped with a rubber damper full load speed must not exceed 2000 RPM. When full load speed in excess of 2000 RPM is desired, engine must be equipped with a fluid (viscous) damper.

Color stripe -- (W) white, (G) green, (B) brown and (Y) yellow.

TABLE 1

Table 1 specifies proper fuel modulating and high speed spring combination to be used at the desired full load engine rpm.

Remove Governor From Engine

Governor operation should be checked as outlined in Section 2.7 before the governor is removed from the engine. If after performing these checks, the governor fails to control the engine properly, it should be removed and reconditioned.

1. Disconnect the linkage attached to the governor levers.

2. Remove the breather tube from the governor.

3. Remove four cover screws and lock washers and lift the governor cover (3) and gasket (4) from the governor control housing (2).

4. Disconnect the fuel rod from the differential lever (23) and the injector control tube lever.

5. Disconnect the oil tube at the governor weight housing, or cover. Remove cover, if used.

© 1977 General Motors Corp.

6. Remove two governor-to-cylinder head bolts.

7. Remove the control housing from the cylinder head and weight housing.

8. Remove six governor weight housing-to-blower bolts using wrench J 4242 and withdraw the housing from the blower.

Disassemble Governor Cover

1. Remove the plug from the throttle shaft (Fig. 2).

2. Loosen the clamping bolt and remove the speed control lever from the throttle shaft.

3. Loosen the clamping bolt and remove the stop lever, if used.

4. Remove the tapered pin from the throttle shaft lever. Lift the lever and the seal ring retainer from the throttle shaft. Withdraw the shaft from the cover.

5. Remove the cam from the control shaft.

6. Remove the seal ring from the governor cover.

7. Wash the cover assembly (with needle bearings) thoroughly in clean fuel oil and inspect the bearings for wear or damage.

8. If needle bearing removal is necessary, place the inner face of the cover over the opening in the bed of the arbor press (Fig. 3). Place the bearing remover J 21967-01 on top of the bearing and press both bearings out of the cover.

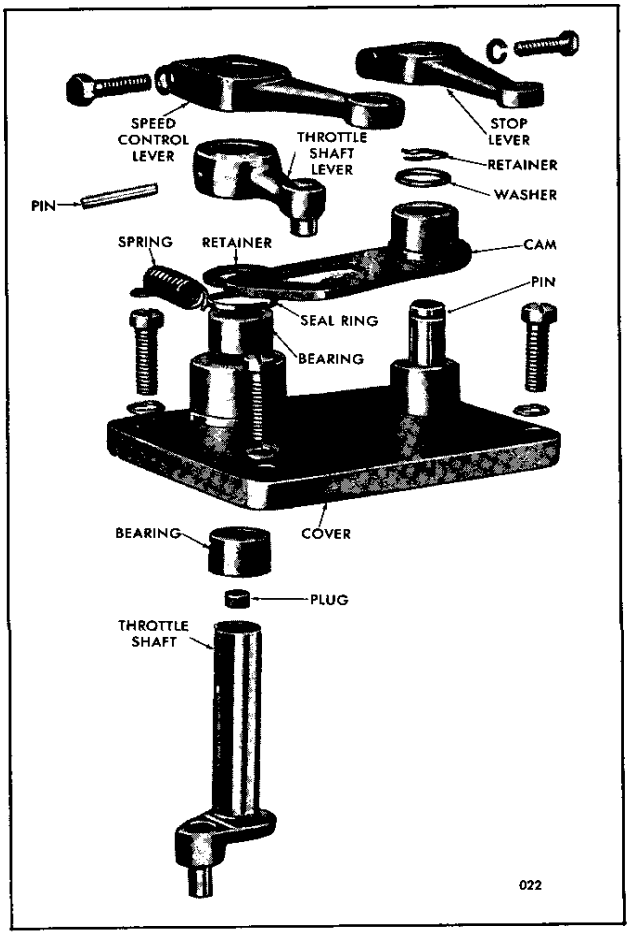


Fig. 2 - Governor Cover Details and Relative Location of Parts

Disassemble Governor Control Housing

1. Remove the adjustment cover (51) Fig. 1. Loosen the high speed adjusting screw lock nut (49) using a spanner wrench. Use an end wrench to thread the high speed adjusting screw (98) out of the control housing. When the adjusting screw is free of the housing, the entire assembly of springs and plungers can be removed and placed on a bench for further disassembly.

2. Remove the low speed spring cap (47), low speed spring (46), and low speed spring seat (45).

3. Loosen the idle speed adjusting screw lock nut (56), also the modulating speed spring adjusting screw locknut (99).

4. Remove the idle speed adjusting screw (55), also the modualting spring adjusting screw (60).

5. Remove the modulating spring plunger retainer ring (69) from the high speed spring plunger witn sharp-nosed pliers.

6. Remove the modulating spring plunger (68), modulating spring (67) and modulating spring seat (66) from inside the high speed spring plunger.

7. Remove the spring retainer (25) and the washer. Lift the differential lever (23) from the pin on the operating shaft lever (27).

8. Remove the special screw (94) retaining the torsion spring (97) to the differential lever, then remove the spring from the screw.

© 1982 General Motors Corp.

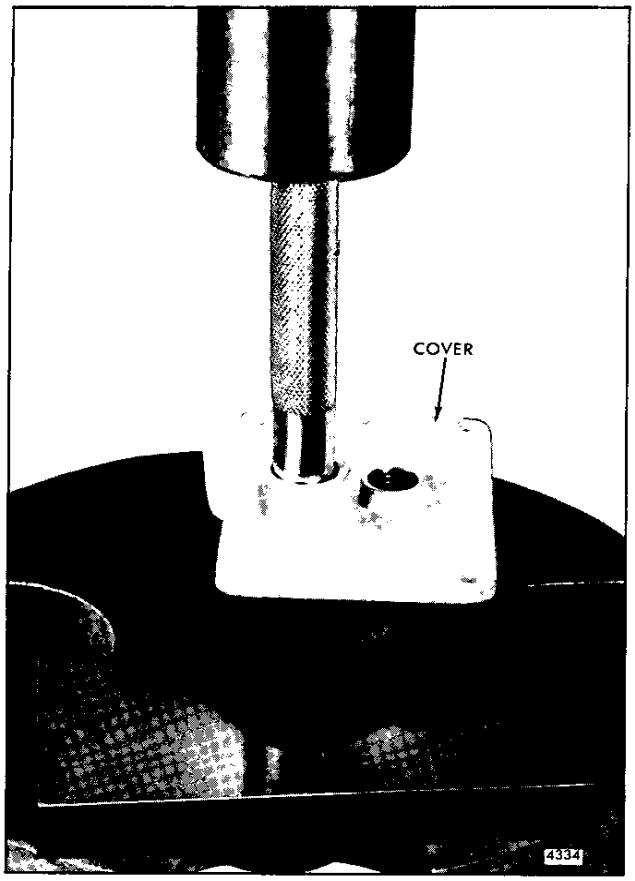


Fig. 3 - Removing Needle Bearings from Governor Cover using Tool J 21967-01

9. Remove the expansion plug out of the lower end of the control housing.

10. Remove the lock screw, lock washer and plain washer holding the upper bearing (30) in the control housing.

11. Loosen the operating fork set screw, if used.

12. Support the control housing as shown in Fig. 6 in Section 2.7.1. Press the operating shaft from the operating fork with a brass rod. Withdraw the operating shaft, operating lever, and bearing as an assembly from the control housing.

13. Support the operating shaft and lever on the bed of the press as shown in Fig. 7 Section 2.7.1. Press the shaft from the operating lever and bearing with a brass rod.

Disassemble Governor Weight Housing

1. Place the weight housing (Fig. 4) in a soft jawed vise. Remove the plug and gasket.

2. Straighten the tang on the lock washer and remove the bearing retaining bolt.

3. Thread a 5/16"-24 x 3" bolt into the tapped end of the weight shaft. Support the weight housing on bed of press as shown in Fig. 8 in Section 2.7.1. Press the shaft from the bearing.

4. Slide the riser thrust bearing and governor riser from the shaft.

This bearing is specially designed to absorb thrust loads; therefore, looseness between the mating parts does not indicate excessive wear.

5. Remove the bearing from the weight housing.

> **NOTE:** The weight shaft end bearing should be discarded on removal as it becomes brinnelled during the disassembly process.

6. Mark the weights and carrier with a center punch for identification, also note the position of the thin washers between the weights so that the parts can be replaced in their original position.

7. If removal of the weight from the carrier is necessary on the current double weight governors, refer to Fig. 8 and remove the retainers from the weight pin. Press the pin from the low speed weights. The high speed weight is not a press fit. On former governors remove the set screw from the low speed weights with a 3/32" allen wrench. Them remove the weight pin and weight from the carrier.

Remove the second pair of weights in the carrier in the same manner as described above.

> **NOTE:** If necessary the needle bearings in the high speed weights may be removed at this time.

8. If required, the weight carrier (Fig. 4) may be pressed from the governor weight shaft and a new carrier installed.

Inspection

Clean all of the parts with fuel oil and dry them with compressed air.

Revolve the ball bearings slowly by hand. Replace the bearings which indicate rough or tight spots. Also replace bearings which are corroded or pitted.

© 1982 General Motors Corp.

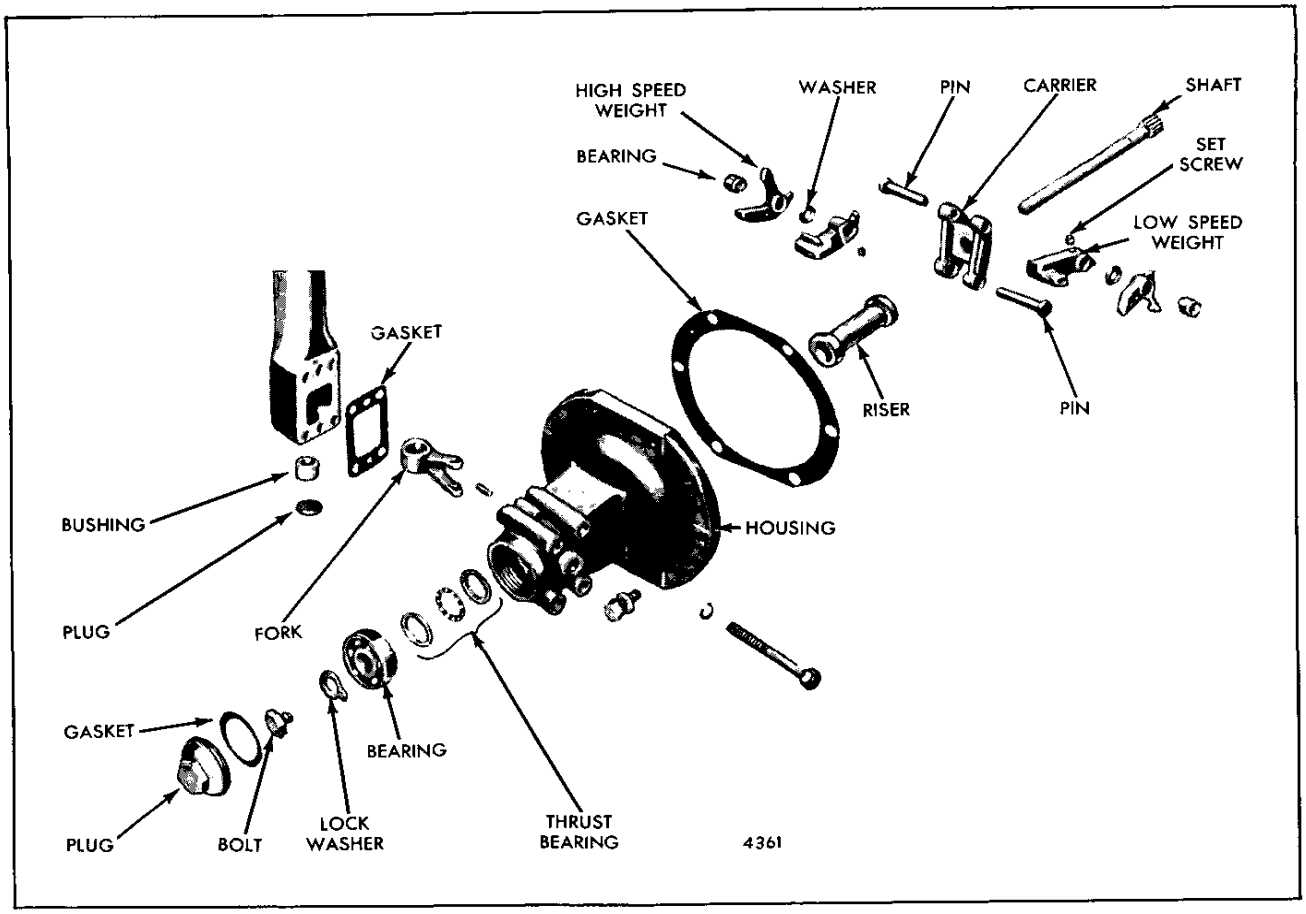


Fig. 4 - Fuel Modulating Governor Weight Housing Details and Relative Location of Parts

Examine the riser thrust bearings for excessive wear, flat spots, or corrosion. If any of these conditions exist, install a new riser and bearing assembly.

Inspect the weight carriers, weights and retaining pins for wear.

Inspect the bushings in current weights and replace them if they are worn excessively. In former weights inspect the needle bearings for wear and replace if necessary.

Inspect the operating shaft and bushing for excessive wear. If excessive wear is noted, a new bushing and shaft must be installed.

Assemble Governor Cover

1. If the needle bearings were removed from the governor cover, place the governor cover on the bed of an arbor press with the inner face of the cover down. Start the upper bearing straight into the bearing bore of the cover with the number on the bearing up. Insert bearing installer J 21068 in the bearing and press the bearing in until the shoulder on the tool contacts the cover (Fig. 5).

2. Turn the cover over and start the second bearing, number side up, in the bearing bore. Press the bearing in flush with the cover with tool J 21068.

NOTE: Do not use impact tools to install needle bearings.

3. Apply lubricant to the cam pin and referring to Figs. 1 and 2 place the cam (17) over the pin with the boss of the cam up. Install the stop lever.

4. Place washer (18) over the pin and secure it with the spring retainer (19).

5. Install the plug in the throttle shaft.

6. Pack the needle bearings with grease. Then, slide the throttle shaft through the bearings.

© 1982 General Motors Corp.

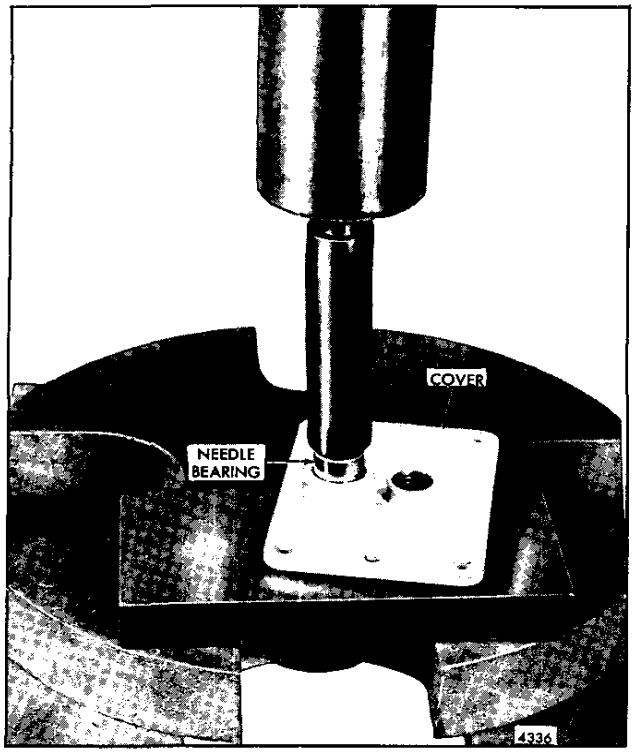


Fig. 5 - Installing Needle Bearings in Governor Cover using Tool J 21068

7. Insert the seal ring (9) over the shaft and into the counterbore against the upper bearing (8). Place the retainer (10) over the shaft and against the seal ring.

8. Start the throttle control lever (12) over the throttle shaft (7) with the holes in the lever and shaft for tapered pin (11) in alignment.

9. Support the lower end of the throttle shaft on the bed of an arbor press, then place a sleeve on the throttle lever and under the ram of the press. Align the slot in the cam (17) with the pin in the throttle lever, then press the lever down on the shaft until the hole in the lever is in line with the hole in the shaft.

10. Insert the tapered pin in the hole in the lever, then support the lever and cover assembly on a steel block and drive the pin into place.

11. Position the speed control lever (21) on the throttle shaft and tighten the retaining bolt (22).

Assemble Governor Control Housing

1. Place the washer (31), Fig. 1 over the short finished end of the operating shaft (26). Start the bearing (30) over the end of the shaft. Support the opposite end of the shaft on the bed of the press. Press the bearing on the shaft tight against the washer with a sleeve which has the same diameter as the bearing inner race.

2. With the pivot pin in the operating lever (27) up, start the lever over the end of the shaft with the flat on shaft registering with the flat surface in the lever. Press the lever on the shaft tight against the bearing (30).

3. Lubricate the bearing and the operating shaft bushing in the housing with clean engine oil. Insert the lever and the operating shaft assembly in the control housing.

4. Position the operating fork over the lower end of the operating shaft (Fig. 4) so the finished side of the fork finger will rest against the thrust bearing when assembled as shown in Fig. 1 in Section 2.7.1.

5. Support the operating shaft and control housing in an arbor press with the upper end of the operating shaft resting on the steel block. Align the flat in the operating fork with the flat on the operating shaft, then place a sleeve over the end of the shaft and rest it on the fork. Bring the ram of the press down on the sleeve and press the fork straight down and tight against the shoulder on the shaft.

6. Tighten the fork set screw, if used.

7. Apply a good quality sealant around the periphery of the expansion plug and press the plug into the lower end of the control housing.

8. Place a lock washer and flat washer over the retaining screw. Thread the screw in the control housing to secure the operating shaft bearing (30).

9. Install the torsion spring (97) to the differential lever (23) with special screw (94). Tighten the screw securely.

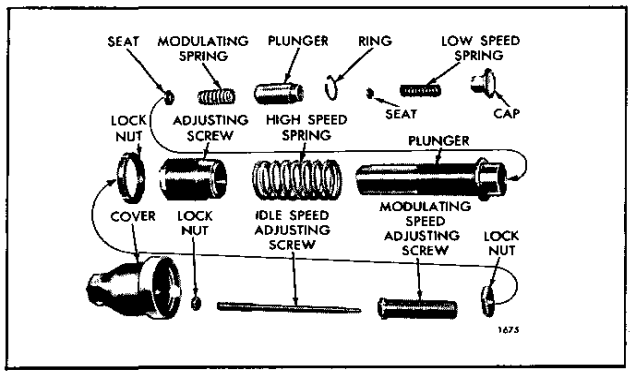


Fig. 6 - Governor Springs, Plungers and Adjusting Screws (Fuel Modulating Governor)

© 1982 General Motors Corp.

10. Refer to Fig. 1 and place the differential lever (23) over the pivot pin of the operating lever. Install a plain washer and spring retainer (25).

Assemble Governor Springs, Plungers, and Adjusting Screws

1. Thread the idle speed adjusting screw into the modulating spring adjusting screw, then thread these two pieces into the high speed spring plunger (Fig. 6).

2. Install the modulating spring seat, the modulating spring, and the modulating spring plunger into the high speed spring plunger. The spring seat shoulder must be toward the spring.

3. With the modulating spring seat, spring, and plunger installed in the high speed spring plunger, install the retainer ring in the groove near the end of the high speed spring plunger. Be sure the ring is fully seated in the groove.

4. Install the low speed spring seat, low speed spring, and low speed spring cap into the high speed spring plunger. The spring seat shoulder must be toward the spring.

5. Slide the high speed spring and high speed adjusting screw over the high speed spring plunger.

6. Hold the assembly while positioning it in the control housing, with the high speed spring plunger against the support in the housing. Thread the high speed spring adjusting screw into the housing sufficiently to retain the assembly.

7. Thread the high speed adjusting screw into the housing until the end of the screw is approximately .750" from the spanner lock nut. Thread the modulating spring adjusting screw in until the end of the screw is approximately 1.500" from the spanner lock nut.

Assemble Governor Weight Housing

1. With the current governor refer to Fig. 8 and install a retainer on either end of the weight pin. Note the match marks placed on the weight carrier and weights at the time of disassembly. Then slide the weight pin through the carrier, flat washer and the high speed weight and its bushing.

Place the low speed weight in position. Then press the weight pin through the low speed weight and carrier until the retainer bottoms against the carrier. Maintain a clearance of .004"-.012" with the weight pressed in position.

NOTE: To maintain this clearance insert a .004"-.012" shim between the low speed weight and carrier while pressing the pin into position.

Remove the shim and install the second weight pin retainer.

Install the second pair of weights in the carrier in the same manner as described above.

2. With the former governor start the weight pin through the opening in the weight carrier (Fig. 4).

Place the low speed weight on the pin and slide the pin through.

Place two flat washers on the pin next to the low speed weights.

Install the high speed weights on their shafts after installing the needle bearings or bushings.

Place the high speed weight on the pin and slide the pin through the weight.

Place two more flat washers on the pin between the high speed weights and the carrier. Slide the pin through the washers and into the carrier.

Align the indentation in the pin with the set screw hole in the low speed weights. Apply a sealant such as Loctite grade C or CV or equivalent on the threads of each set screw. Insert the set screws and tighten them to 20 lb-in (2.26 Nm) minimum. Be sure to stake each set screw in two places after tightening the screws.

NOTE: Before applying the sealant to a new set screw, immerse the set screw in Loctite Primer T or equivalent.

3. Slide the riser over the shaft and against the finished surfaces on the governor weights as shown in Fig. 4.

4. Assemble the riser thrust bearing on the weight shaft with the bearing race with the smallest inside diameter against the thrust riser. Incorrect installation of the bearing will result in erratic operation of the governor.

5. Insert the weight carrier and shaft assembly in the weight housing.

6. Support the splined end of the shaft on the bed of an arbor press. Start the shaft end bearing in the housing and over the end of the shaft with the numbered side of the bearing facing away from the shaft. Press the new bearing in place using a 1 3/8" diameter metal bar flat on the ends which will bear against both the inner and outer races of the bearing.

© 1982 General Motors Corp.

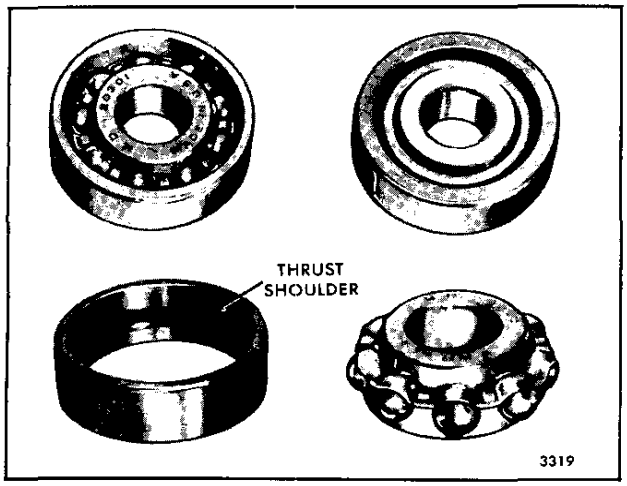


Fig. 7 - Former Governor Weight Shaft Bearing

NOTE: The former bearing has thrust capacity in one direction only. Be sure to install the bearing so that the thrust shoulder (Fig. 7) is toward the governor weights. Otherwise, the force exerted by the weights will pull the inner race and ball assembly away from the outer race and result in damage to the bearing and erratic governor operation.

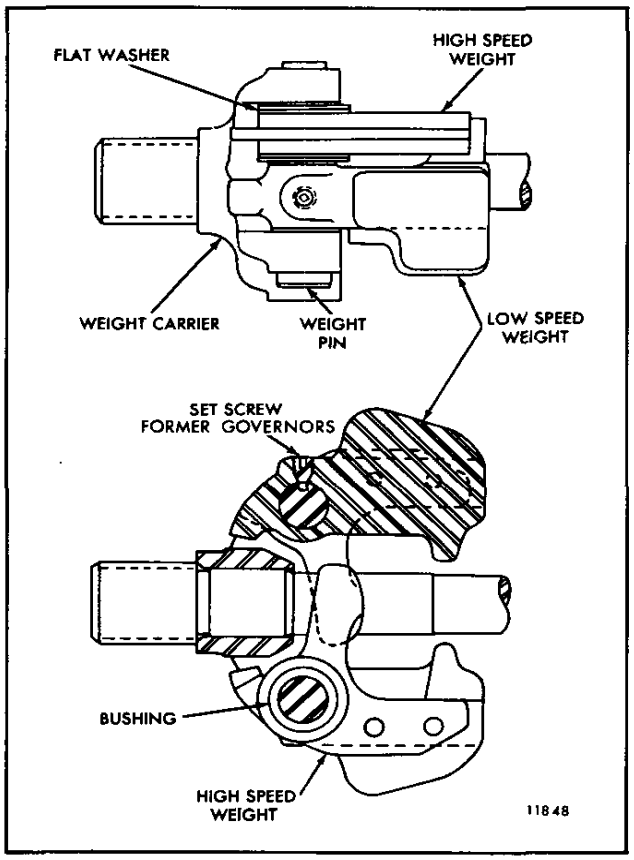


Fig. 8 - Cross Section of Governor Weight for Current Double Weight Governor

7. Place the washer (Fig. 4) over the bearing retaining bolt. Thread the bolt into the tapped end of the shaft and tighten it. Bend the tang on the washer against the head of the bolt.

8. Place a gasket in the housing and against the bearing. Apply a Loctite sealant, grade HV or equivalent, to the full 360° circumference of the plug and thread the plug into the tapped end of the governor weight housing. Tighten the plug to 45 lb-ft (61 Nm) torque with either flat or point of head on a horizontal line.

Install Governor

1. Affix a new gasket (Fig. 4) to the governor weight housing. Start the splined end of the weight shaft in the upper blower rotor and position the housing against the blower end plate.

2. Place a new copper gasket on each weight housing-to-blower bolt and thread the bolts into the blower end plate, finger tight only.

3. Place a new gasket (Fig. 4) over the dowels and against the side of the weight housing facing the engine.

4. Move the thrust bearing assembly and riser toward the weight end of the shaft.

5. Position the lower end of the control housing over the dowel pins in the weight housing. The finished surface of the operating fork must be placed against

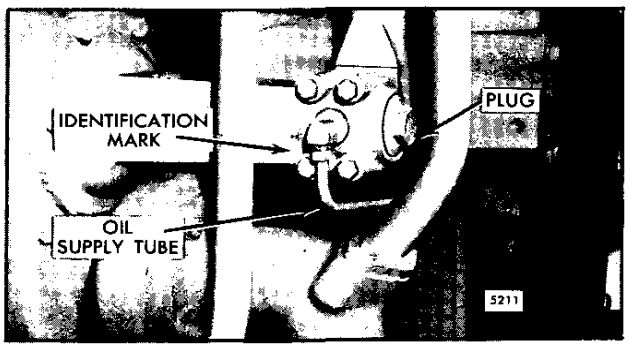


Fig. 9 - Governor Weight Housing (Current 4 and 6 Cylinder Engines)

© 1982 General Motors Corp.

the outer side of the thrust bearing as shown in Fig. 1 in Section 2.7.1.

> **NOTE:** For ease in assembling the governor control housing (4 or 6 cylinder engine) to the interim weight housing (no identification mark, Fig. 9), install a special bolt (3/8"-24 x 3/4" or 7/8"), from which the outer 1/2" of thread down to a diameter of 5/16" to 1/4" has been removed, as a tool in the 1/8" NPTF oil hole to prevent the thrust bearing from moving too far forward in the weight housing. Current weight housing has two ribs cast on the inner surface of the housing to prevent any part of the risen thrust bearing from sliding forward to where the operating fork could be inserted on the wrong side of one or more parts of the bearing.

6. Affix a new gasket to the governor control housing, then attach the governor control housing to the cylinder head with two bolts. Tighten the bolts.

7. Tighten the governor-to-blower bolts with wrench J 4242.

8. Affix a new gasket to the weight housing cover (former governors only) and place the cover in position. Install the four weight housing-to-control housing bolts and lock washers and tighten the bolts.

9. Connect the oil tube to the restricted fitting on the weight housing, or cover (if used).

10. Refer to Fig. 1 in Section 2.7.1 and position the fuel rod over the differential lever pin. Place a flat washer over the pin and secure it with the retainer.

11. Attach the fuel rod to the injector control tube lever with a pin and cotter pin.

12. Place a new gasket (Fig. 1) on the governor control housing and mount the governor cover on the housing with the pin on the throttle shaft registering with the machined slot in the differential lever.

13. Install the four cover screws with lock washers. One end of the cam spring is anchored to one of the cover screws (Fig. 2).

14. Connect the throttle linkage.

15. Attach the breather tube to the governor housing.

16. Perform the engine tune-up as outlined in Section 14.5.

© 1982 General Motors Corp.

LIMITING SPEED MECHANICAL GOVERNOR

(DUAL HIGH SPEED RANGE)

The limiting speed mechanical double weight dual high-speed range governor is similar to the limiting speed governor shown in Fig. 1 in Section 2.7.1 except the spring and piston assemblies illustrated in Figs. 1 and 2.

The dual range governor is used on highway vehicle engines that require a high maximum speed part of the time and a low maximum speed the remainder of the time.

Due to the governors dual speed feature, it permits a high engine speed in the lower gear ratios for maximum vehicle acceleration while providing a conservative vehicle speed in the high gears. The valve for controlling the high and low speed ranges of the governor is usually connected to the transmission. Shifting the transmission from a lower gear to a high gear will automatically shift the governor from its high maximum speed range to the low maximum speed range. This two speed operation is accomplished by the use of air pressure behind a piston (Figs. 1 and 2) to increase the tension on the governor high speed spring. The removal of air pressure from behind the piston permits the governor high speed spring to force the piston against the low maximum speed adjusting screw that retains enough tension in the governor high speed spring to operate the engine at the desired lower speed.

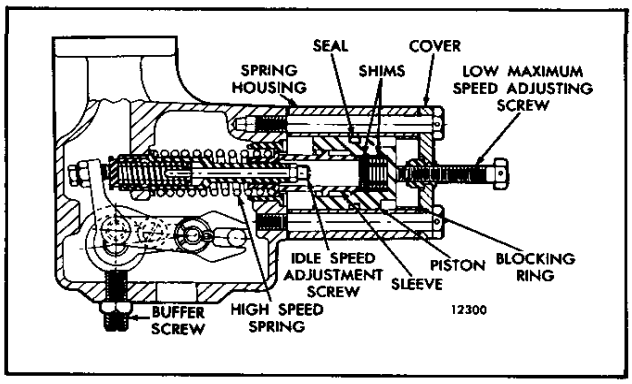


Fig. 1 - Spring and Piston Assembly of Current Dual Range Governor

Lubrication

Surplus oil returning from the cylinder head provides lubrication for the parts in the governor control housing, the riser thrust bearings and the weight shaft end bearing. Oil picked up from a reservoir in the blower front end plate by a slinger attached to the lower rotor shaft, provides lubrication for the governor weights and weight carrier.

Pressure lubrication has been provided for the weight housing bearings on current engines. The oil tube is attached between the oil gallery in the cylinder block and the weight housing.

Remove Governor From Engine

Governor operation should be checked as outlined in Section 2.7 before the governor is removed from the engine. If, after performing these checks, the governor fails to control the engine properly, it should be removed and reconditioned.

1. Disconnect the linkage attached to the governor levers.

2. Remove the breather tube.

3. Remove four screws and lock washers and lift the

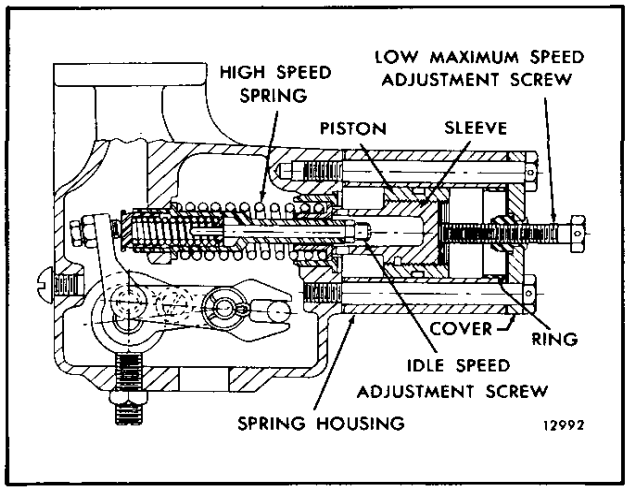


Fig. 2 - Spring and Piston Assembly of Former Dual Range Governor

© 1982 General Motors Corp.

governor cover and gasket from the control housing. Discard the gasket.

4. Disconnect the fuel rod from the differential lever and the injector control tube lever.

5. Disconnect the oil tube at the governor weight housing, or cover and remove the cover, if used.

6. Remove both governor-to-cylinder head bolts.

7. Remove the governor control housing from the cylinder head and governor weight housing.

8. Remove six weight housing-to-blower bolts, using wrench J 4242, and withdraw the housing from the blower.

Disassemble Governor Cover

1. Loosen the lever bolts and remove the speed control lever and stop lever from their respective shafts.

2. Remove the plug from the throttle shaft.

3. Remove the seal retaining ring and spacers from the stop lever shaft and withdraw the shaft from the cover.

4. Remove the seal ring from the governor cover.

5. Remove the spacer (if used), the retaining ring and washers from the throttle shaft and withdraw the shaft from the cover.

6. Wash the cover assembly thoroughly in clean fuel oil and inspect the needle bearings for wear or damage. If bearing removal is necessary, place the inner face of the cover over the opening in the bed of the press. Place remover tool J 21967-01 on top of bearing (Fig. 4) and press both bearings out of the cover.

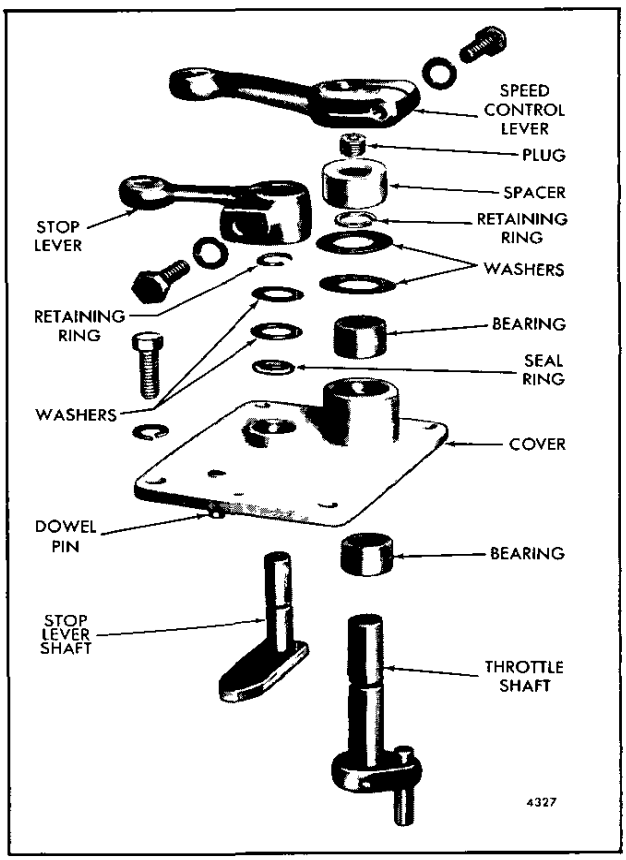


Fig. 3 - Exploded View of Governor Cover

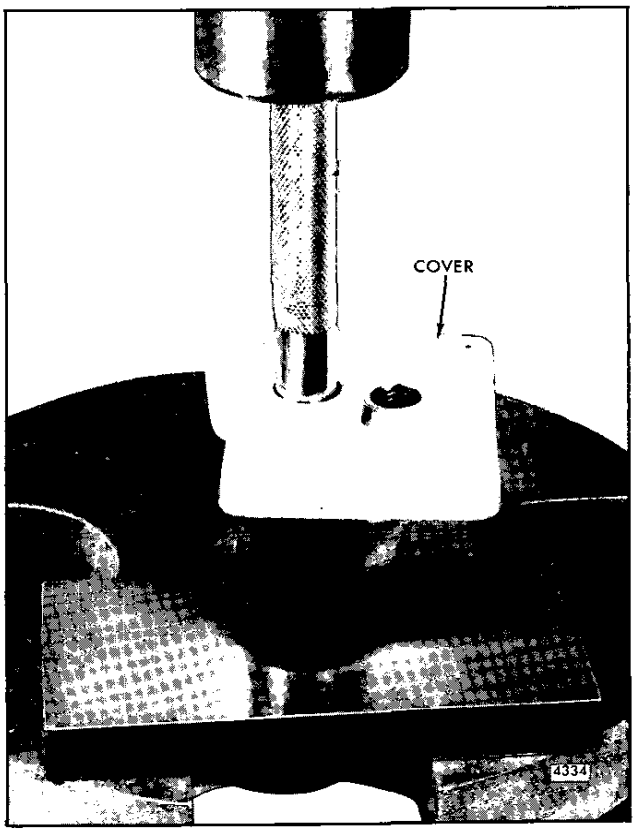


Fig. 4 - Removing Needle Bearing from Governor Cover using Tool J 21967-01

© 1982 General Motors Corp.

Disassemble Governor Control Housing

1. Remove the two bolts securing the spring housing cover and withdraw the cover, piston, sleeve and low maximum speed adjustment screw as an assembly (Figs. 1 and 2).

> **NOTE:** Current governors have a blocking ring in the spring housing to prevent removal of the seal from the rear end (cover end) of the spring housing, thus preventing seal ring damage.

2. Remove the spring retainer and washer, then lift the differential lever from the pin of the operating shaft lever (Fig. 5).

3. Remove the expansion plug from the lower end of the control housing.

4. Remove the bearing retaining screw, washer and lock washer.

5. Loosen the operating fork set screw, if used.

6. Support the control housing as shown in Fig. 6 in Section 2.7.1. Press the operating shaft from the operating fork with a brass rod. Withdraw the shaft, lever and bearing as an assembly from the control housing.

7. Support the operating shaft and lever on the bed of the press (see Fig. 7 in Section 2.7.1). Press the shaft from the operating lever and bearing with a brass rod.

Disassemble Governor Weight Housing

1. Place the weight housing in a soft jawed vise. Remove the plug and gasket.

2. Straighten the tang on the lock washer and remove the bearing retaining bolt.

3. Thread a 5/16"-24 x 3" bolt into the tapped end of the weight shaft. Support the weight housing on the bed of the press as shown in Fig. 8 in Section 2.7.1. Press the shaft from the bearing.

4. Slide the riser thrust bearing and governor riser from the shaft.

> **NOTE:** This bearing is specially designed to absorb thrust loads; therefore, looseness between the mating parts does not indicate excessive wear.

5. Remove the bearing from the weight housing.

> **NOTE:** The weight shaft end bearing should be discarded on removal as it becomes brinnelled during the disassembly process.

6. Mark the weights and carrier with a center punch for identification, also note the position of the thin washer between the weights so that the parts can be replaced in their original position.

7. If removal of the weights from the carrier is necessary on the current double weight governor, refer to Fig. 6 and remove the retainer from the weight pin. Press the pin from the low speed weights. The high speed weight is not a press fit. On former governors remove the set screws from the low speed weights with a 3/32" allen wrench. Then remove the weight pin and weight from the carrier.

Remove the second pair of weights in the carrier in the same manner as described above.

> **NOTE:** If necessary the needle bearing assembly in the high speed weights may be removed at this time.

8. If required, the weight carrier may be pressed from the governor weight shaft and a new carrier installed.

Inspection

Clean all of the parts with fuel oil, and dry them with compressed air.

Revolve the ball bearings slowly by hand. Replace the bearings which indicate rough or tight spots. Also replace the bearings which are corroded or pitted.

Examine the riser thrust bearings for excessive wear, flat spots, or corrosion. If any of these conditions exist, install a new riser and bearing assembly.

Inspect the weight carriers, weights and retaining pins for wear.

Inspect the bushings in the current weights and replace them if they are worn excessively. In the former weights inspect the needle bearings for wear and replace them if necessary.

Inspect the operating shaft and bushing for excessive wear. If excessive wear is noted, install a new bushing and shaft.

Assemble Governor Cover

1. If the needle bearings were removed from the governor cover, place the governor cover on the bed of an arbor press with the inner face of the cover down. Start the upper bearing straight into the bearing bore

© 1982 General Motors Corp.

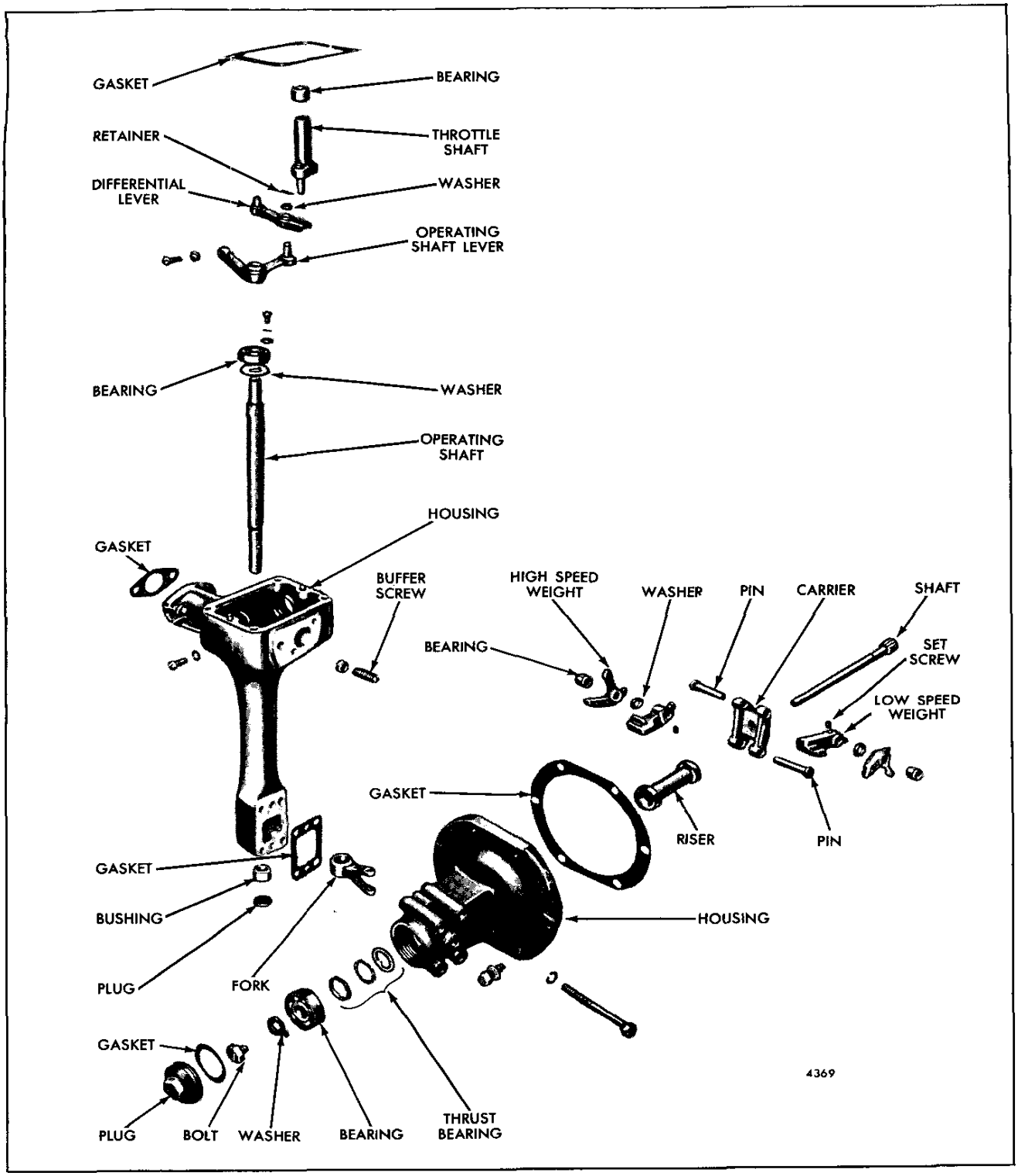


Fig. 5 - Exploded View of Governor Control and Weight Housings

© 1982 General Motors Corp.

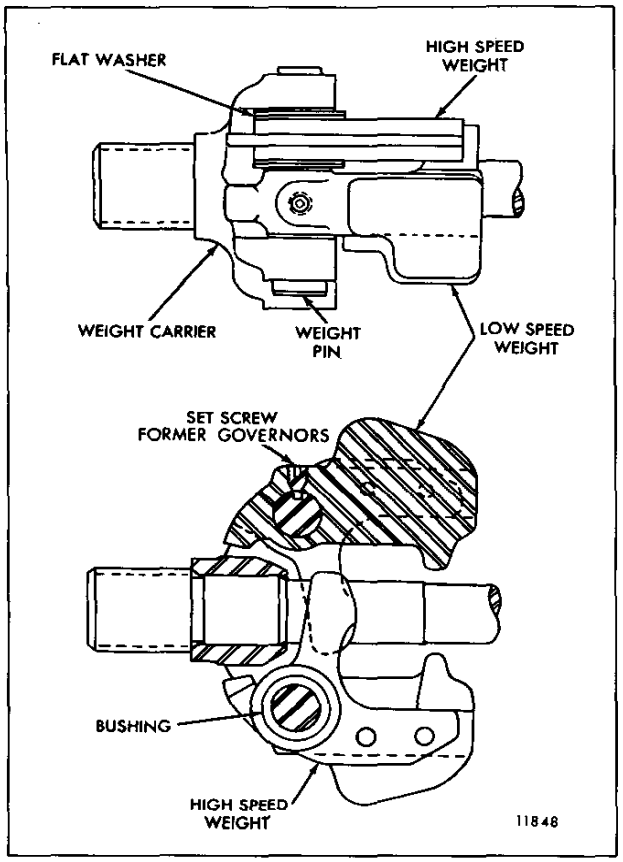


Fig. 6 - Cross Section of Governor Weight for Current Double Weight Governor

of the cover with the number on the bearing up. Insert bearing installer J 21068 in the bearing and press the bearing in until the shoulder on the tool contacts the cover (Fig. 7).

2. Turn the cover over and start the second bearing, number side up, in the bearing bore. Press the bearing in flush with the cover with tool J 21068.

NOTE: Do not use impact tools to install needle bearings.

3. Install the plug in the throttle shaft.

4. Pack the needle bearings with grease. Then, slide the throttle shaft assembly through the bearings.

5. Install two retaining washers and retaining ring on the throttle shaft.

6. Install the spacer on the shaft (slip fit) against the retainer washers and over the snap ring.

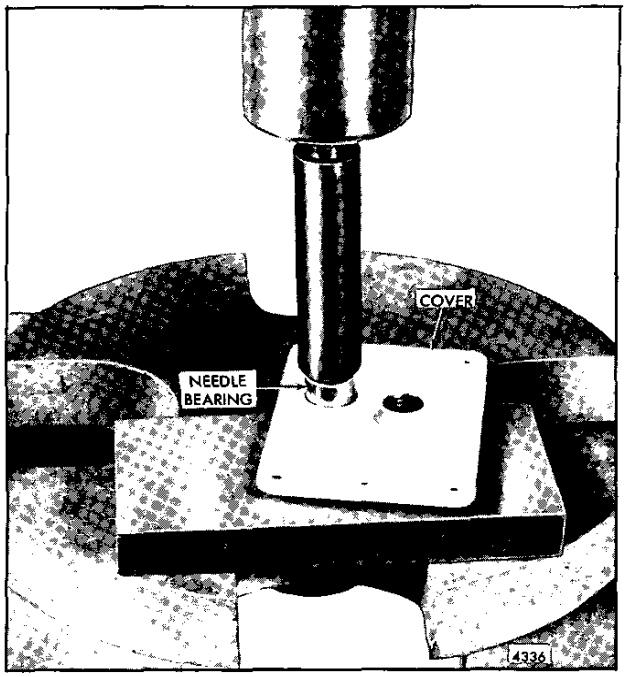


Fig. 7 - Installing Needle Bearings in Governor Cover using Tool J 21068

NOTE: Prior to September 1970 a spacer was not used. When assembling a governor cover on an engine built prior to September 1970 include a .440" thick spacer.

7. Lubricate the stop lever shaft with engine oil and slide the shaft through the cover.

8. Install a new seal ring over the shaft and in the cover, then install two seal retaining washers and a retaining ring.

9. Install the stop lever and speed control lever and tighten the clamping bolts.

Assemble Governor Control Housing

1. Place the washer over the short finished end of the operating shaft (Fig. 5). Start the bearing over the end of the shaft. Support the opposite end of the shaft on the bed of a press. Press the bearing on the shaft tight against the washer with a sleeve which has the same diameter as the bearing inner race.

2. With the pivot pin in the operating lever up, start the lever over the end of the shaft with the flat on the shaft registering with the flat surface in the lever. Press the lever on the shaft tight against the bearing.

© 1982 General Motors Corp.

3. Lubricate the bearing and operating shaft bushing in the housing with clean engine oil. Insert the lever and operating shaft assembly in the control housing.

4. Position the operating fork over the lower end of the operating shaft (Fig. 5) so the finished side of the fork finger will rest against the thrust bearing when assembled as shown in Fig. 1 of 2.7.1.

5. Support the operating shaft and control housing in an arbor press with the upper end of the operating shaft resting on a steel block. Align the flat in the operating fork with the flat on the operating shaft, then place a sleeve over the end of the shaft and rest it on the fork. Bring the ram of the press down on the sleeve and press the fork straight down and tight against the shoulder on the shaft.

6. Tighten the fork set screw, if used.

7. Apply a good quality sealant around the periphery of the expansion plug (Fig. 5) and press the plug into the lower end of the control housing.

8. Place a lock washer and flat washer over the retaining screw. Thread the screw in the control housing to secure the operating shaft bearing.

9. Place the differential lever over the pivot pin of the operating lever (Fig. 5). Install a plain washer and spring retainer.

Assemble Governor Springs, Plungers and Adjusting Screws

1. Thread the lock nut on the buffer screw and thread the buffer screw into the governor control housing.

2. Thread the idle speed adjusting screw into the high speed spring plunger, then thread the lock nut on the end of the adjusting screw.

3. Slip the high speed spring, spring guide, and governor spring retainer over the end of the plunger.

4. Insert the low speed spring seat, low speed spring, and spring cap in the other end of the plunger.

5. Slip the low speed spring end of the assembly through the control housing. Then, thread the high speed spring retainer into the control housing, using tool J 1652-01.

6. Apply Perfect Seal No. 3 sealant, or equivalent, on the threads of the piston sleeve, then thread the sleeve into the piston until the sleeve extends approximately .781" from the piston.

7. Install a seal ring in the groove of the piston.

8. Position the blocking ring in the spring housing so the opening in the ring is in line with the threaded hole. If the spring housing did not incorporate a blocking ring, the installation of a blocking ring is recommended. This ring will prevent the piston and seal ring from sliding out the cover end of the spring housing, and possible damage to the seal ring by the sharp edges of the threaded hole.

9. Lubricate the inside surface of the spring housing with an all purpose grease and insert the piston and sleeve assembly inside the spring housing at the end opposite to the pipe plug boss.

10. Use a new gasket at each end of the spring housing and attach the cover to the end of the housing (end with the boss for the pipe plug) and install the spring housing on the control housing.

11. Install the low maximum speed adjustment screw and lock nut in the spring housing cover.

Assemble Governor Weight Housing (Double Weight)

1. With the current governor refer to Fig. 6 and install a retainer on either end of the weight pin. Note the match marks placed on the weight carrier and weights at the time of disassembly. Then slide the weight pin through the carrier, flat washer and the high speed weight and its bushing.

Place the low speed weight in position. Then press the weight pin through the low speed weight and carrier until the retainer bottoms against the carrier. Maintain a clearance of .004"-.012" with the weight pressed in position.

> **NOTE:** To maintain this clearance insert a .004"-.012" shim between the low speed weight and carrier while pressing the pin into position.

Remove the shim and install the second weight pin retainer.

Install the second pair of weights in the carrier in the same manner as described above.

2. With the former governor start the weight pin through the opening in the weight carrier (Fig. 5).

Place the low speed weight on the pin and slide the pin through.

Place two flat washers on the pin next to the low speed weights.

Install the high speed weights on their shafts after installing the needle bearings.

© 1982 General Motors Corp.

Place the high speed weight on the pin and slide the pin through the weight.

Place two more flat washers on the pin between the high speed weights and the carrier. Slide the pin through the washers and into the carrier.

Align the indentation in the pin with the set screw hole in the low speed weights. Apply a sealant such as Loctite grade C or CV or equivalent on the threads of each set screw. Insert the set screws and tighten them to 20 *lb-in* (2.26 Nm) minimum. Be sure to stake each set screw in two places after tightening the screws.

NOTE: Before applying the sealant apply a Loctite primer to the set screws.

3. Slide the riser over the shaft and against the finished surfaces of the governor weights as shown in Fig. 1 in Section 2.7.1.

4. Assemble the riser thrust bearing on the weight shaft with the bearing race having the smaller inside diameter against the thrust riser. Incorrect installation of the bearing will result in erratic operation of the governor.

5. Insert the weight carrier and shaft assembly in the weight housing.

6. Support the splined end of the shaft on the bed of an arbor press. Start the shaft end bearing in the housing and over the end of the shaft with the numbered side of the bearing facing away from the shaft. Press the new bearing in place using a 1 3/8" diameter metal bar flat on the ends which will bear against both the inner and outer races of the bearing.

NOTE: The former bearing had thrust capacity in one direction only. Be sure to install the former bearing so that the thrust shoulder (see Fig. 11 in Section 2.7.1) is toward the governor weights. Otherwise, the force exerted by the weights will pull the inner race and ball assembly away from the outer race and result in damage to the bearing and erratic governor operation.

7. Place the washer, (Fig. 5) over the bearing retaining bolt. Thread the bolt into the tapped end of the shaft and tighten it. Bend the tang on the washer against the head of the bolt.

8. Place a gasket in the housing and against the bearing. Apply a Loctite sealant, grade HV or equivalent, to the full 360° circumference of the plug and thread the plug into the tapped end of the governor weight housing. Tighten the plug to 45 lb-ft (61 Nm) torque with either flat or point of head on a horizontal line.

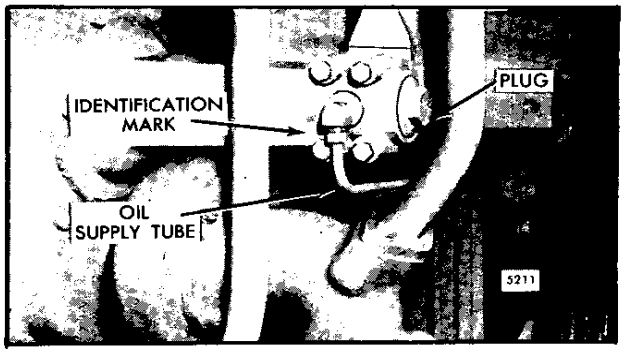


Fig. 8 - Governor Weight Housing (current 4 and 6 Cylinder Engines)

Install Governor

1. Affix a new gasket (Fig. 5) to the governor weight housing. Start the splined end of the weight shaft in the upper blower rotor and position the housing against the blower end plate.

2. Place a new copper gasket on each weight housing-to-blower bolt and thread the bolts into the blower end plate, finger tight only.

3. Place a new gasket (Fig. 5) over the dowels and against the side of the weight housing facing the engine.

4. Move the thrust bearing assembly and riser toward the weight end of the shaft.

5. Position the lower end of the control housing over the dowel pins in the weight housing. The finished surface of the operating fork must be placed against the outer side of the thrust bearing as shown in Fig. 1 in Section 2.7.1.

NOTE: For ease in assembling the governor control housing (4 or 6 cylinder engine) to the interim weight housing (no identification mark, Fig. 8), install a special bolt (3/8"-24 x 3/4" or 7/8"), from which the outer 1/2" of thread down to a diameter of 5/16" to 1/4" has been removed, as a tool in the 1/8" NPTF oil hole to prevent the thrust bearing from moving too far forward in the weight housing. Current weight housing has two ribs cast on the inner surface of the housing to prevent any part of the riser thrust bearing from sliding forward to where the operating fork could be inserted on the wrong side of one or more parts of the bearing.

6. Affix a new gasket (Fig. 5) to the governor control housing then, attach the governor control housing to the cylinder head with two bolts. Tighten the bolts.

© 1982 General Motors Corp.

7. Tighten the governor-to-blower bolts with wrench J 4242.

8. Install the four weight housing to control housing bolts with lock washers. On former engines affix a new gasket to the weight housing cover, then place the cover in position and install the four weight housing to control housing bolts with lock washers. Tighten the bolts.

9. Connect the oil tube to the restricted fitting on the weight housing, or cover if used.

10. Refer to Fig. 1 in Section 2.7.1 and position the fuel rod over the differential lever pin. Place a flat washer over the pin and secure it with the retainer.

11. Attach the fuel rod to the injector control tube lever with a pin and cotter pin.

12. Place a new gasket (Fig. 5) on the governor control housing and mount the governor cover on the housing with the pin on the throttle shaft registering with the machined slot in the differential lever.

13. Install the four cover screws with lock washers.

14. Connect the throttle linkage.

15. Attach the breather tube to the governor housing.

16. Tune-up the engine as outlined in Section 14.3.2.

© 1982 General Motors Corp.

LIMITING SPEED MECHANICAL GOVERNOR

(Variable Low-Speed)

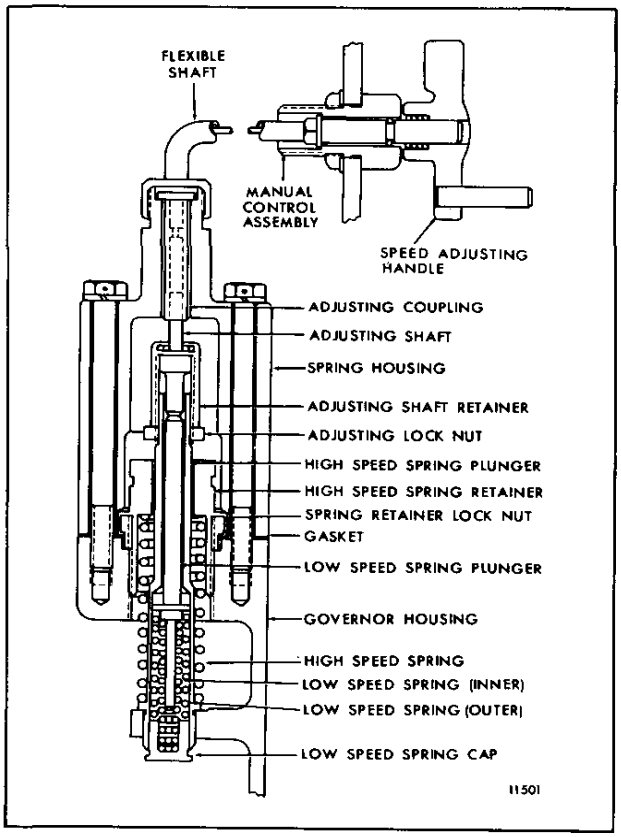


Fig. 1 - Cable Operated Governor Spring Housing and Components

The variable low-speed limiting speed mechanical governor is used on 6-71 highway vehcile engines where the same engine powers both the vehicle and the auxiliary equipment for unloading bulk products (such as cement, grain and liquids) and a high idle speed range is desired during auxiliary operation.

The current governor is a single-weight type and provides an idle speed range of 500 to 1800 rpm. The former governor was a double-weight type and provided an idle speed range of 450 to 1300 rpm.

The governor is mounted on the front end of the blower and is driven by the upper blower rotor.

Governor identification is provided by a name plate attached to the governor housing. The letters V.L.S.L.S. stamped on the name plate denote a variable low-speed limiting speed mechanical governor.

Operation

During highway operation, the governor functions as a limiting speed governor, controlling the engine idling speed and limiting the maximum operating speed. At the unloading area, the throttle is left in the idle speed position and the speed adjusting handle, on the cable operated governor (Fig. 1), is turned to the speed required within the above range to operate the auxiliary equipment. For the air operated governor (Fig. 3), the engine speed is changed to the speed required by increasing or decreasing the air supply pressure to the governor. The governor then function as a variable speed governor, maintaining a constant speed when the load is constantly changing, during the unloading operation. Before resuming highway operations, the speed adjusting handle on the cable operated governor must be turned back to the stop, then turned ahead about one-quarter of a turn. The air operated governor's air supply pressure must be vented before resuming highway operations.

Lubrication

The governor is lubricated in the same manner as the limiting speed mechanical governor (Section 2.7.1).

Check Governor Operation

Governor difficulties should be checked out in the same manner as outlined in Section 2.7. If, after making the checks, the governor fails to control the engine or auxiliary equipment properly, it should be removed and reconditioned.

© 1978 General Motors Corp.

CABLE OPERATED GOVERNOR

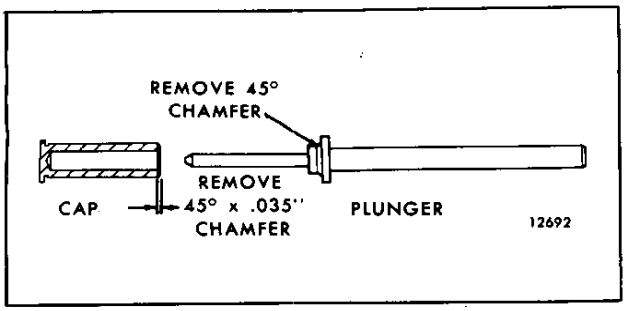


Fig. 2 - Rework Former Plunger and Cap

Remove Governor

1. Disconnect the manual control flexible shaft from the governor spring housing.

2. Remove the governor following the same procedures outlined in Section 2.7.1.

Disassemble Governor

The variable low-speed limiting speed governor is similar to the limiting speed governor with the exception of the spring housing and its components. Therefore, disassemble the governor as outlined in Section 2.7.1, then disassemble the spring housing and its components (Fig. 1) as follows:

1. Clamp the flange of the governor housing in a vise equipped with soft jaws.

2. Remove the two bolts and lock washers securing the spring housing to the governor housing and withdraw the spring housing and gasket.

3. Remove the adjusting coupling from the adjusting shaft.

4. Hold the adjusting lock nut with a wrench and back off the retainer and adjusting shaft.

5. Unscrew the adjusting shaft from the retainer.

6. Unscrew the idle speed adjusting lock nut from the end of the high-speed spring plunger.

7. Unscrew the high-speed spring retainer lock nut and remove the high-speed spring retainer, plunger and spring along with the low-speed spring plunger, inner and outer springs and low-speed spring cap as an assembly from the governor housing.

8. Remove the high-speed spring retainer and spacer assembly and spring from the high-speed spring plunger. Remove the low-speed spring cap from the opposite end of the high-speed spring plunger and remove the low-speed spring plunger along with the inner and outer low-speed springs.

> **NOTE:** The high-speed spring retainer on early engines did not include a spacer. If the shaft sticks in the retainer, replace it with the current retainer and spacer assembly.

Inspect Governor Parts

Wash all of the parts in clean fuel oil and dry them with compressed air, then inspect them as outlined in Section 2.7.1.

Assemble Governor

> **NOTE:** During assembly, lubricate all spring housing components and needle bearing assemblies with MIL. G3278A, Aero Shell 7A grease, or equivalent (special grease for high and low temperature operations).

Assemble the governor as outlined in Section 2.7.1, then assemble the spring housing and components (Fig. 1).

To assure a 500 rpm idle speed for certain on highway vehicle engines, the spring seat chamfer has been removed from the low-speed spring plunger and cap. The internal chamfer has been removed from both ends of the coil of the outer low-speed spring. A high idle condition could be the result if an unchamfered spring did not seat properly due to the chamfer on the former plunger and cap. To correct this condition, install a current (modified) plunger and cap, or remove the 45 ° chamfer from the spring seat area of the plunger and also the 45 ° x .035 " chamfer on the cap (shaded area, Fig. 2).

> **NOTE:** A chamfered spring should not be used with an unchamfered plunger and cap, because a severe wear condition will result.

1. Thread the spring retainer lock nut on the high-speed spring retainer approximately 1-1/2 ".

2. Place the high-speed spring on the high-speed spring plunger.

3. Insert the high-speed spring and plunger assembly in the high-speed spring retainer.

4. Insert the low-speed spring plunger into the high-speed spring plunger.

5. Place the inner and outer springs in the lower end

© 1978 General Motors Corp.

of the high-speed spring plunger, over the low-speed spring plunger.

6. Install the low-speed spring cap over the end of the inner low-speed spring and into the end of the high-speed spring plunger and install the assembly in the governor housing.

NOTE: Place the spring housing gasket in position before installing the assembly.

7. Thread the idle speed adjusting lock nut on the threaded end of the high-speed spring plunger approximately 1/2 ".

8. Screw the adjusting shaft into the adjusting shaft retainer all the way in as shown in Fig. 1.

9. Install the adjusting retainer and shaft onto the high-speed spring plunger. Turn down the adjusting retainer against the idle speed adjusting lock nut.

10. Install the adjusting coupling and spring housing after the governor adjustments (Section 14.3.3) have been performed.

Install Governor

Install the governor as outlined in Section 2.7.1, then connect the manual control flexible shaft to the governor spring housing (Fig. 1).

Adjust the governor as outlined in Section 14.3.3.

AIR OPERATED GOVERNOR

Remove Governor From Engine

1. Disconnect the air controls from the governor spring housing.

2. Remove the governor following the same procedures outlined in Section 2.7.1.

Disassemble Governor

The air operated variable low-speed limiting speed governor is similar to the limiting speed governor with the exception of the spring housing and its components. Therefore, disassemble the governor as outlined in Section 2.7.1, then disassemble the spring housing and its components (Fig. 3) as follows:

1. Clamp the flange of the governor housing in a vise equipped with soft jaws.

2. Remove the two bolts and lock washers securing the spring housing to the governor housing and withdraw the spring housing and gasket. Discard the gasket.

3. Loosen the 5/16 "-24 idle speed jam nut and remove the idle speed adjusting screw, seal ring and nut as an assembly. Discard the seal ring.

4. Hold the 1/2 "-20 jam nut on the high-speed spring plunger with a wrench and unscrew the air cylinder cap, retainer ring, pin, piston, air cylinder and seal ring as an assembly from the end of the high-speed spring plunger.

a. Disengage the retainer ring from the air cylinder and remove the air cap and piston from the air cylinder.

b. Remove the seal ring from the piston. Discard the seal ring.

5. Unscrew the high-speed spring retainer lock nut and remove the high-speed spring retainer, plunger and spring along with the low-speed spring plunger, inner and outer springs and low-speed spring cap as an assembly from the governor housing.

6. Remove the high-speed spring retainer and spacer assembly and spring from the high-speed spring plunger. Remove the low-speed spring cap from the opposite end of the high-speed spring plunger and remove the low-speed spring plunger along with the inner and outer low-speed springs.

Inspect Governor Parts

Wash all of the parts in clean fuel oil and dry them with compressed air, then inspect them as outlined in Section 2.7.1.

Assemble Governor

NOTE: During assembly, lubricate all spring housing components with MIL. G3278A, Aero Shell 7A grease, or equivalent (special grease for high and low temperature operations).

Assemble the governor as outlined in Section 2.7.1, then assemble the spring housing and components as follows (Fig. 3):

1. Thread the spring retainer lock nut on the high-speed spring retainer approximately 1-1/2 ".

© 1978 General Motors Corp.

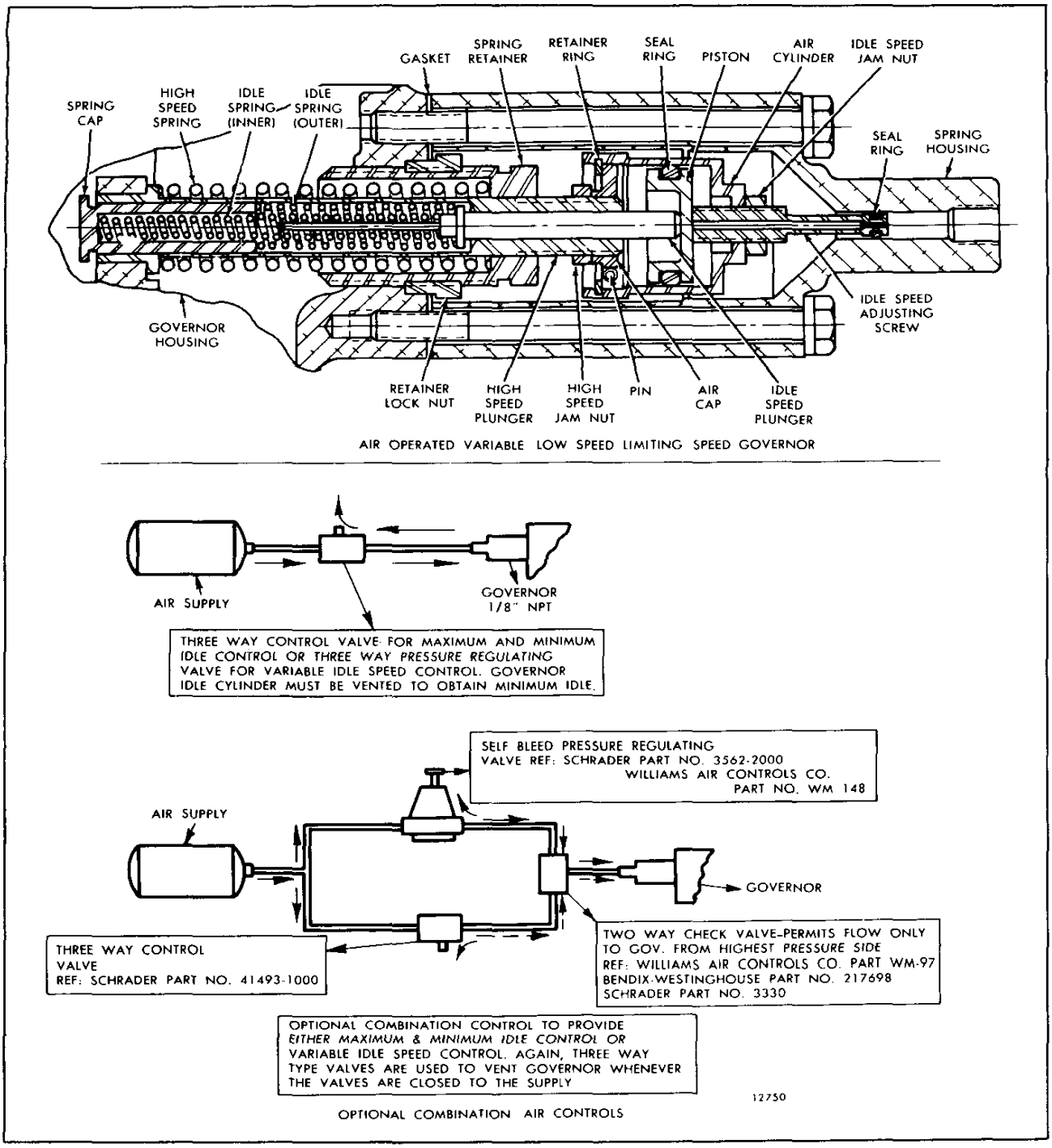


Fig. 3 - Air Operated Variable Low Speed Limiting Speed Governor and Air Controls

2. Place the high-speed spring on the high-speed spring plunger.

3. Insert the high-speed spring and plunger assembly in the high-speed spring retainer.

© 1978 General Motors Corp.

4. Insert the low-speed spring plunger into the high-speed spring plunger.

5. Place the inner and outer springs in the lower end of the high-speed spring plunger, over the low-speed spring plunger.

6. Install the low-speed spring cap over the end of the inner low-speed spring and into the end of the high-speed spring plunger and install the assembly in the governor housing.

NOTE: Place the new spring housing gasket in position before installing the assembly.

7. If removed, thread the 1/2 "-20 high-speed spring jam nut on the threaded end of the plunger approximately 1/2 ".

8. Place a new seal ring on the piston and assemble the piston and air cap in the air cylinder. Secure them in the air cylinder with the retainer ring.

9. Screw the air cylinder assembly on the high-speed spring plunger and against the high-speed spring plunger and jam nut.

10. Place a new seal ring on the idle speed adjusting screw and install the adjusting screw and jam nut in the air cylinder.

11. Install the spring housing after the governor adjustments (Section 14.3.3) have been performed.

NOTE: Be sure and lubricate the bore of the spring housing with grease as stated in the above note.

Intall Governor

Install the governor as outlined in Section 2.7.1, then connect the air controls to the governor spring housing (Fig. 3).

Adjust the governor as outlined in Section 14.3.3.

© 1978 General Motors Corp.

LIMITING SPEED MECHANICAL GOVERNOR

(FAST IDLE CYLINDER)

The double-weight limiting speed governor equipped with a fast idle air cylinder is used on vehicle engines where the engine powers both the vehicle and auxiliary equipment.

The fast idle system consists of a fast idle air cylinder installed in place of the buffer screw and a throttle locking air cylinder mounted on a bracket fastened to the governor cover (Fig. 1). An engine shutdown air cylinder, if used, is also mounted on the governor cover.

For operation and adjustment of the fast idle air cylinder, refer to Section 14.3.4.

Lubrication

The governor is lubricated in the same manner as the limiting speed governor (Section 2.7.1).

Check Governor Operation

Governor difficulties should be checked in the manner outlined in Section 2.7. If, after making the checks, the governor fails to control the engine or auxiliary equipment properly, it should be removed and reconditioned.

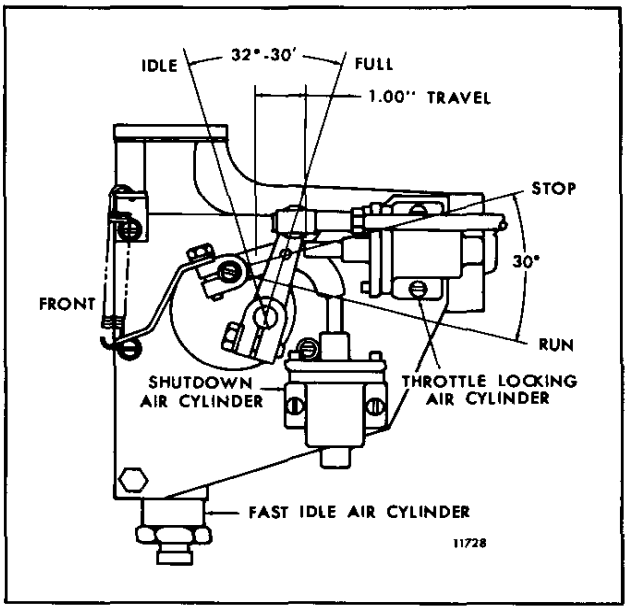


Fig. 1 - Governor with Fast Idle Cylinder

Remove Governor

1. Release any air in the system and disconnect the air hoses from the air cylinders.

2. Remove the governor by following the procedure outlined in Section 2.7.1.

Disassemble Governor

1. Disassemble the governor as outlined in Section 2.7.1.

2. Refer to Fig. 2 and disassemble the fast idle cylinder as follows:

a. Pull the plunger out of the buffer spring and cylinder.

b. Clamp the air cylinder in a vise equipped with soft jaws.

c. Apply pressure on the end of the air inlet plug and remove the plug retaining ring from the groove in the air cylinder.

d. Pull the air inlet plug and seal ring assembly from the air cylinder. Remove the seal ring from the groove in the plug.

e. Insert a 3/32" diameter steel rod in the plunger opening in the air cylinder and push the piston, seal ring, dual idle spring and spring follower out

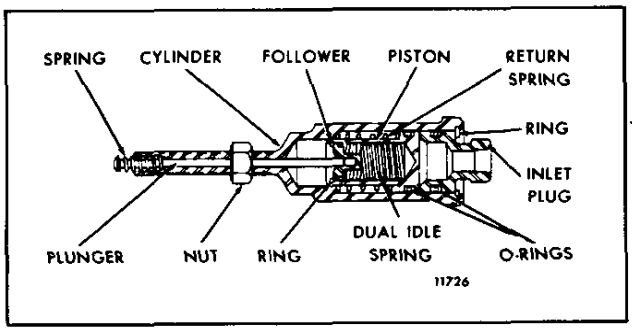


Fig. 2 - Fast Idle Air Cylinder

© 1976 General Motors Corp.

of the air cylinder as an assembly. Then remove the air cylinder spring from the cylinder.

f. Remove the seal ring from the groove in the piston. Apply pressure on the spring follower and remove the follower retaining ring from the groove in the piston. Remove the follower and spring.

Inspection

Wash all of the governor components in clean fuel oil and dry them with compressed air. Then inspect them as outlined in Section 2.7.1.

Examine the fast idle air cylinder components for wear or any defects. Replace worn or damaged parts.

Assemble Governor

1. Assemble the governor as outlined in Section 2.7.1.

2. Assemble the fast idle cylinder as follows:

a. Refer to Fig. 2 and insert the dual idle spring inside of the fast idle air cylinder. Place the spring follower, with the small diameter end down, inside of the spring. Apply pressure on the spring follower and compress the spring enough to expose the retaining groove. Then install the retaining ring in the groove.

b. Install a new seal ring in the groove in the piston. Then install the air cylinder spring over the small diameter end of the piston.

c. Lubricate the seal ring on the piston with engine oil. Then insert the piston and spring assembly, with the small diameter end of the piston first, straight into the air cylinder spring seats on the shoulder in the cylinder.

d. Install a new seal ring in the groove of the air cylinder air inlet plug.

e. Lubricate the seal ring with engine oil. Then insert the air inlet plug straight into the air cylinder and against the piston.

f. Clamp the air cylinder in a vise equipped with soft jaws. Apply pressure on the end of the air inlet plug and compress the spring enough to expose the retaining ring groove. Then install the retaining ring.

g. If removed, thread the lock nut on the air cylinder. Then insert the plunger through the buffer spring and into the air cylinder.

3. Install the fast idle air cylinder assembly in the governor housing buffer screw hole.

Install Governor

1. Install the governor on the engine as outlined in Section 2.7.1.

2. Install the throttle locking and engine shutdown air cylinders.

3. Connect the air hoses to the air cylinders.

4. Adjust the governor as outlined in Section 14.3.4.

© 1976 General Motors Corp.

LIMITING SPEED MECHANICAL GOVERNOR

(Variable High Speed)

The air operated variable high speed limiting speed mechanical governor is provided for highway vehicle applications where the same engine powers both the vehicle and auxiliary equipment, for unloading bulk products (such as cement, grain or liquids) and where a variable speed range is desired during auxiliary constant speed operation.

Operation

The idle speed range for these governors is the same as for the standard limiting speed governors. The normal no-load speed range is the same as for the standard limiting speed governor. A variable high speed limiting governor will control engine RPM from any normal no-load speed down to near idle speed. Also, in addition to the high speed control kit, a regulated air supply and an air cylinder to move the throttle to the wide open throttle position is required.

Install Control Housing

Without disturbing the engine tune-up, install a high speed control housing assembly on a standard limiting speed governor having a long spring pack, as follows (Fig. 1):

1. Loosen the two bolts and copper washers and remove the spring retainer housing.

2. Remove the idle speed adjustment screw and replace it with the longer high speed control idle speed screw and reset the idle speed RPM to the desired setting.

NOTE: If the governor has the former one piece idle speed screw, replace it with the current idle speed pin and long screw.

The engine tune-up procedure for the high speed control governor is the same as stated in Section 14.3 except the idle speed adjustment is made, using the longer idle speed screw.

3. Assemble the high speed control housing as follows:

   a. Install the small ring in the spring housing and the large seal ring on the piston.

   b. Lubricate the piston and inside of the housing with engine oil. Install the piston in the housing bottoming the piston on its stop.

4. Slide the housing and piston assembly over the spring retainer and idle speed screw.

5. Install the idle screw self-locking nut and make the following adjustments:

   a. Place a .010" feeler gage between the VHS housing gasket and the main governor housing.

   b. Adjust the elastic stop nut, while holding the idle screw stationary, until a slight drag is felt on the shim (Fig. 2). This adjustment is made easily with Tool J 28598-A.

   c. Remove the shim.

6. Install the gasket and either flat or tamper-resistant

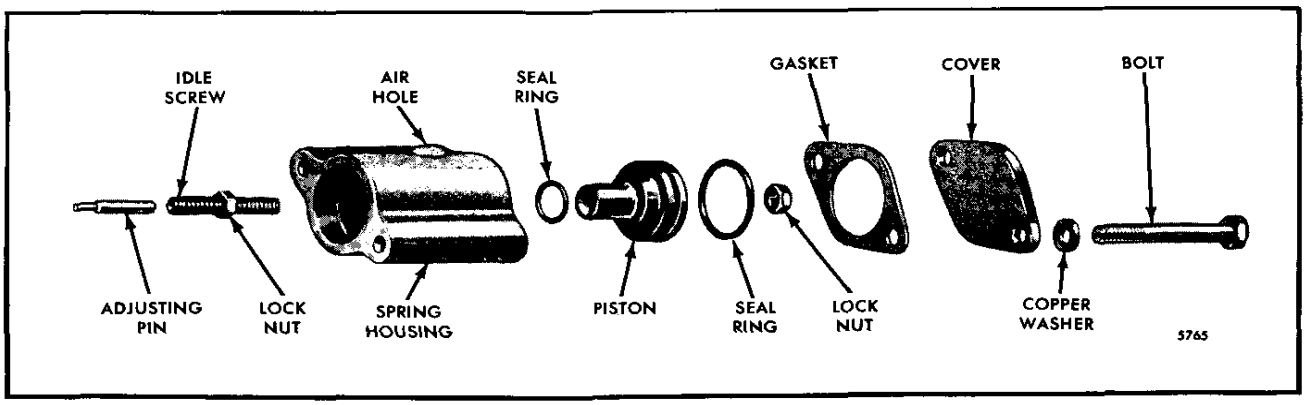


Fig. 1 - Air Operated Variable High Speed Limiting Speed Mechanical Governor Components

© 1981 General Motors Corp.

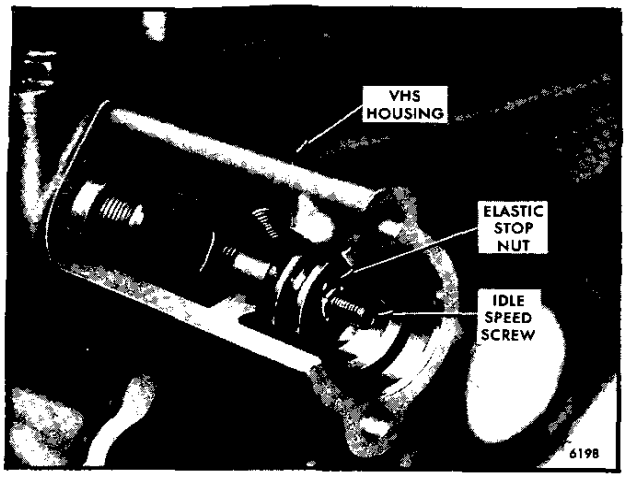


Fig. 2 - Adjust Elastic Stop Nut using Tool J 28598-A

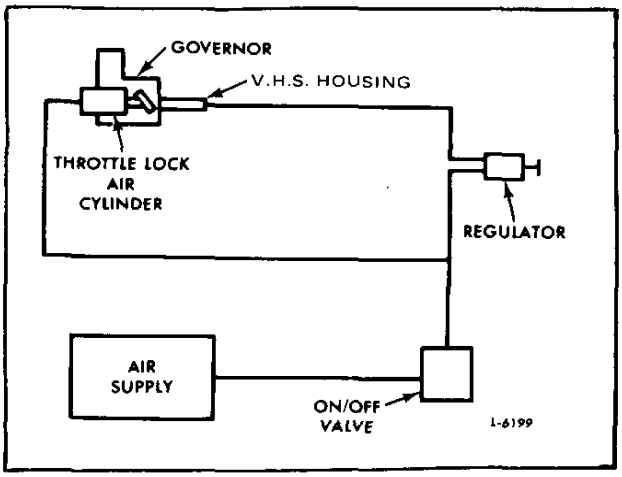


Fig. 3 - Schematic Drawing of Limiting Speed Mechanical Governor (Variable High Speed)

cover with two copper washers and two 5/16" bolts. Tighten bolts.

Install the air cylinder (throttle lock) on the governor cover so that it does not interfere with the throttle linkage when no air pressure is applied and moves the speed control lever to the wide open throttle position when full air pressure is applied (Fig. 3).

Supply air should only be taken from the accessory air supply. At no time should supply air be taken from the service brake system. However all air supply components should be plumbed and mounted in compliance with the recommendations for the air brake system. Both air cylinders must be vented to insure rapid disengagement.

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman must determine that the injector racks move to the no fuel postion when the governor stop lever is placed in the stop position. Engine over-speed will result if the injector racks cannot be pc sitioned at no fuel with the governor stop lever.

CAUTION: An over-speeding engine can result in engine damage which could cause personal injury.

© 1981 General Motors Corp.

VARIABLE SPEED MECHANICAL GOVERNOR

The variable speed mechanical governor performs three functions (Fig. 1):

1. Controls the engine idle speed.

2. Limits the maximum no-load speed.

3. Holds the engine at any constant speed, between idle and maximum, as desired by the operator.

The single weight governor is mounted on the front of the blower and is driven by the upper blower rotor (Fig. 2).

The governor consists of four subassemblies:

1. Control Housing Cover.

2. Control Housing.

3. Weight and Housing.

4. Variable Speed Spring Housing and Shaft.

Operation

Two manual controls are provided on the variable speed governor: a stop lever for starting and stopping, and a speed control lever (Fig. 1). For starting, the stop lever is moved to the *run* position, which holds the injector control racks near the full-fuel position. Upon starting, the governor moves the injector racks toward the idle speed position. The engine speed is then controlled manually by moving the speed control lever.

The centrifugal force of the revolving governor weights is converted into linear motion, which is transmitted through the riser and operating shaft to the operating shaft lever. One end of the operating lever bears against the variable speed spring plunger, while the other end provides a changing fulcrum on which the differential lever pivots.

The centrifugal force of the governor weights is opposed by the variable speed spring. Load changes or movement of the speed control lever momentarily creates an unbalanced force between the revolving governor weights and tension on the variable speed spring. When the forces reach a balanced condition again, the engine speed will be stabilized for the new speed setting or new load.

A fuel rod connected to the differential lever and injector control tube lever, provides a means for the governor to change the fuel settings of the injector control racks.

The engine idle speed is determined by the centrifugal force required to balance out the tension on the variable speed spring in the low speed range.

Adjustment of the engine idle speed is accomplished by changing the tension on the variable speed spring by means of the idle speed adjusting screw. Refer to Section 14.4 for idle speed adjustment.

Adjustment of the maximum no-load speed is accomplished by varying the tension on the variable speed spring by the installation or removal of stops and shims, as required. Refer to Section 14.4 for maximum no-load speed adjustment.

Lubrication

Surplus oil returning from the cylinder head provides lubrication for the parts in the governor control housing, the riser thrust bearings, and the weight shaft end bearing. Oil, picked up from a reservoir in the blower front end plate, by a slinger attached to the lower rotor shaft, provides lubrication for the governor weights and weight carrier.

Pressure lubrication has been provided for the weight housing bearings on current engines. The oil tube is attached between the oil gallery in the cylinder block and the governor weight housing.

Remove Governor

Governor operation should be checked as outlined in Section 2.7 before the governor is removed from the engine. If, after performing these checks, the governor fails to control the engine properly, it should be removed and reconditioned.

1. Refer to Fig. 2 and disconnect the throttle control rod and booster spring from the speed control lever.

2. On former engines, disconnect the retracting spring from the stop lever.

3. Remove the breather tube.

4. Remove the four cover screws and lift the governor cover, with the stop lever and retraction spring (current engine), and cover gasket from the governor housing.

5. Refer to Figs. 1 and 2 and disconnect the fuel rod

© 1982 General Motors Corp.

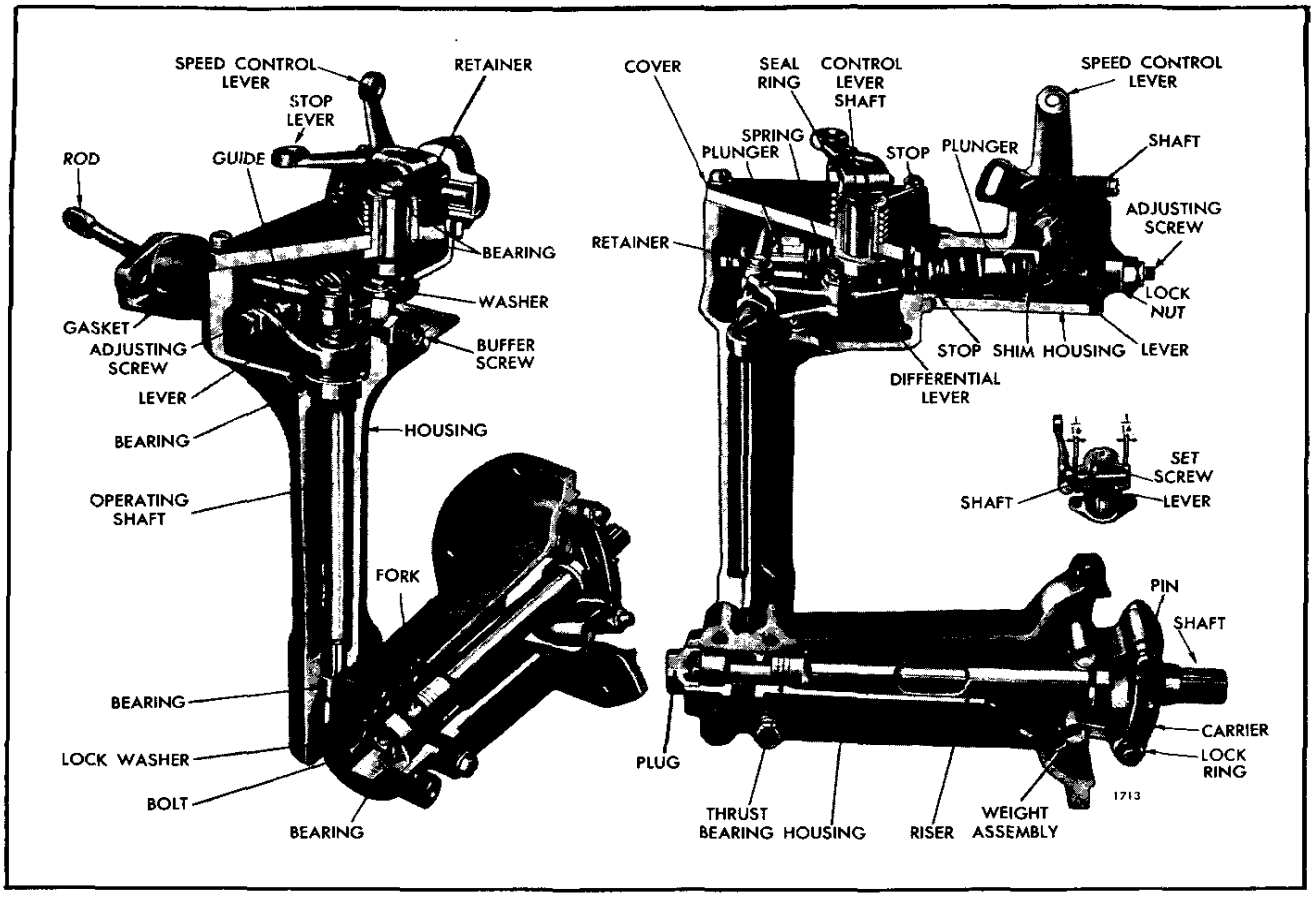


Fig. 1 - Variable Speed Mechanical Governor

from the differential lever and injector control tube lever.

6. Disconnect the oil tube at the governor weight housing, or cover, if used.

7. Remove the two governor-to-cylinder head bolts.

8. Remove the control housing from the cylinder head and weight housing.

9. Use wrench J 4242 and remove the six governor weight housing-to-blower bolts, then withdraw the housing from the blower.

Disassemble Governor

With the cover removed from the control housing, disassemble the governor as follows:

1. Disassemble the governor cover (Fig. 3).

a. Loosen the clamping bolt and remove the stop lever from the shaft. Remove the lever torsion retraction spring (current engine).

b. Remove the control shaft lock ring and seal retainer. Withdraw the control shaft from the cover.

c. Remove the seal ring from the governor cover.

d. Wash the cover assembly (on former engines the cover assembly contained two needle bearings, however on current engines, the cover assembly contains a bushing which is not serviced. When replacment is necessary use needle bearings) thoroughly in clean fuel oil and inspect the needle bearings or bushing for wear or damage.

e. If needle bearing or bushing removal is necessary, place the inner face of the cover over the opening in the bed of an arbor (Fig. 4). Place remover J 21967-01 on top of the bearing or bushing and

© 1982 General Motors Corp.

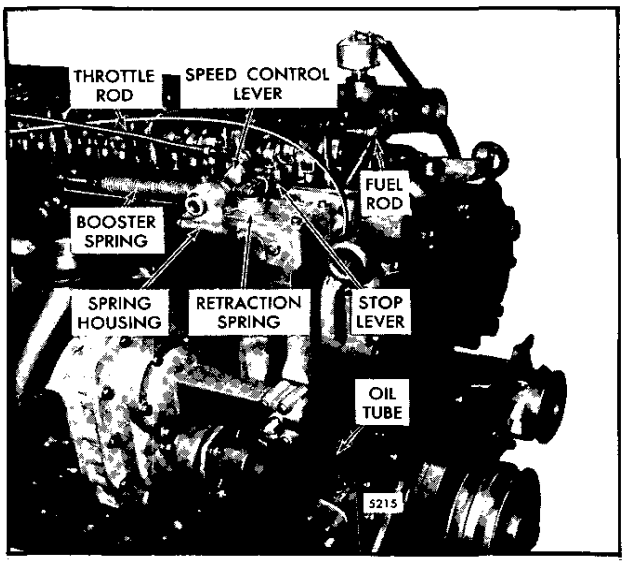


Fig. 2 - Variable Speed Governor Mounting

under the ram of the press, then press both bearings or bushing out of the cover.

2. Disassemble the governor control housing.

a. Place the control housing in the soft jaws of a vise (Fig. 5).

b. Remove two bolts and lock washers and withdraw the variable speed spring housing, spring plunger, and spring as an assembly. Withdraw the spring plunger from the plunger guide.

c. Remove the spring retainer and washer. Lift the differential lever off the pin of the operating shaft lever.

d. Refer to Fig. 6 and remove the variable speed spring plunger guide. Remove the bearing retaining screw, flat washer and lock washer.

e. Remove the expansion plug out of the lower end of the control housing.

f. Loosen the operating fork set screw, if used.

g. Support the control housing bottom side up on the bed of the press. Use a brass rod and press the operating shaft from the operating fork (Fig. 7). Withdraw the operating shaft, operating lever and bearing as an assembly from the control housing (Fig. 5).

h. Support the operating shaft and lever on the bed of the press as shown in Fig. 8. Use a brass rod

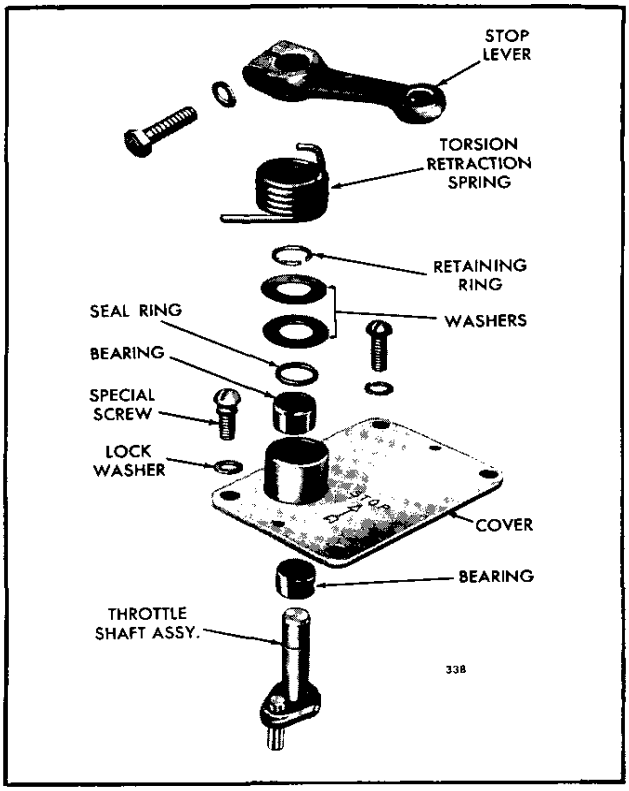


Fig. 3 - Governor Cover Details and Relative Location of Parts

and press the shaft from the operating lever and bearing.

3. Disassemble the governor weight housing.

a. Place the weight housing in the soft jaws of a vise (Fig. 9). Remove the end plug and gasket.

b. Straighten the tang of the lock washer and remove the bearing retaining bolt.

c. Thread a 5/16"-24 x 3" bolt into the tapped end of the weight shaft. Support the weight housing on the bed of the press as shown in Fig.10, then press the shaft from the bearing.

d. Slide the riser thrust bearing and governor riser from the shaft.

This bearing is specially designed to absorb thrust load; therefore, looseness between the mating parts does not indicate excessive wear.

e. Remove the bearing from the weight housing.

NOTE: The weight shaft end bearing should be

© 1982 General Motors Corp.

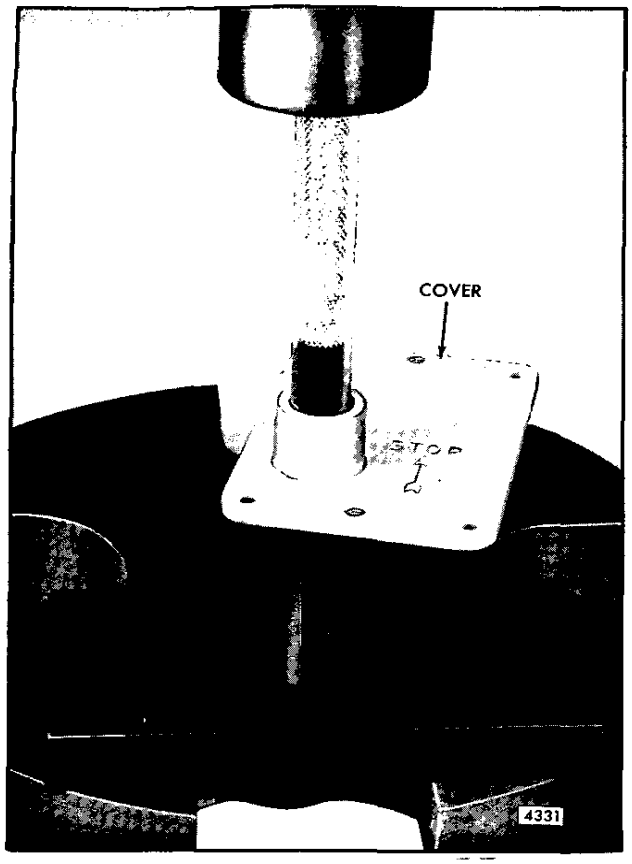


Fig. 4 - Removing Bearings from Cover using Tool J 21967-01

discarded on removal as it becomes brinnelled during the disassembly process.

f. Use tool J 4880 and remove one lock ring from each weight pin. Withdraw the pins, flat washers and governor weights.

g. If required, the weight carrier may be pressed from the governor weight shaft and a new carrier installed (Fig. 9).

4. Disassemble the governor variable speed spring housing.

a. Refer to Fig. 1 and withdraw the variable speed spring, stops, spring plunger and shims from the spring housing.

b. Loosen the bolt and withdraw the speed control lever from the speed control lever shaft (Fig. 1). Remove the Woodruff key from the shaft (Fig. 14).

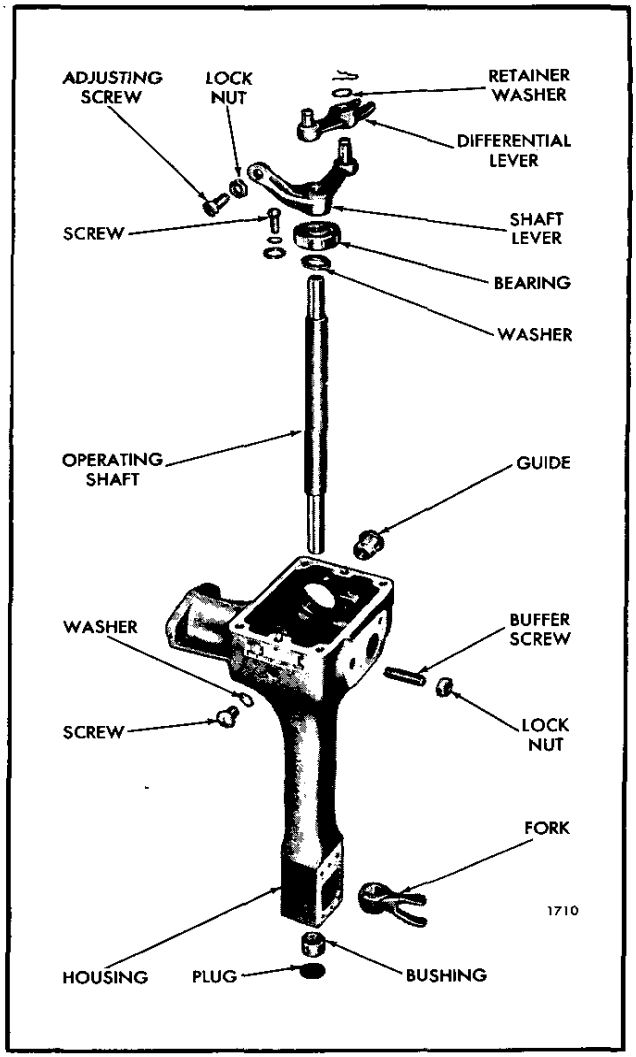


Fig. 5 - Governor Control Housing Details and Relative Location of Parts

c. Remove the plain washer and seal from the shaft.

d. On the former spring housing, remove the pipe plug in the top of the spring housing. On the current spring housing, remove one screw and lock washer and remove the spring housing cover and gasket. Then remove the set screw from the spring lever.

e. Support the spring housing on the bed of the press *with the shaft up.* Use a brass rod and press the shaft, plug and bearing from the housing. Remove the bearing from the shaft and the spring lever from the housing.

© 1982 General Motors Corp.

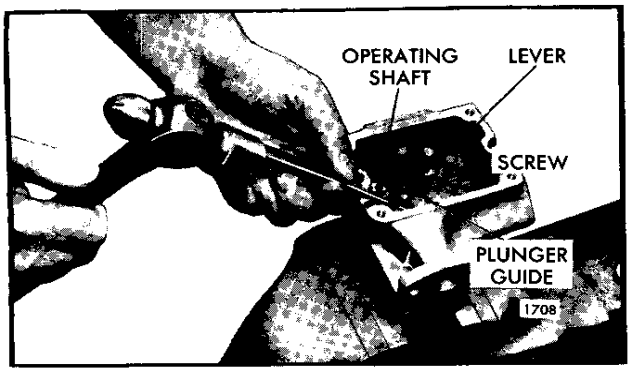


Fig. 6 - Removing Variable Speed Spring Plunger Guide

f. If required, the second bearing may be pressed from the housing.

Inspection

Clean all of the parts with fuel oil and dry them with compressed air.

Inspect all of the governor components and replace worn or damaged parts.

Revolve the operating shaft bearing and the governor weight shaft bearing slowly by hand; replace the bearings if rough or tight spots are detected.

Inspect the operating shaft and shaft bushing for excessive wear. If excessive wear is noted, a new bushing and shaft must be installed.

Examine the riser thrust bearing for excessive wear, flat spots or corrosion. If any of these conditions exist, a new thrust bearing assembly must be installed.

Inspect the needle bearing or bushing and the control lever shaft for excessive wear or flat spots. If one or both conditions exists, new bearings and control shaft must be installed.

The bushing contained in the current cover assemblies is not serviced. When replacement is necessary, use needle bearings.

Inspect the spring lever shaft and bearings for excessive wear or flat spots at the bearing surface. If one or both conditions exist, a new shaft and bearings must be installed.

When installing, a new bearing in the spring housing lever assembly, note that the roller type bearing rides on a hardened bearing pin and is a press fit in the spring lever. Also, when installing the current roller type bearing, the pressed-in pin must be below the surface of the lever and staked in three places on both sides. With the former roller type bearing, the pressed-in pin is to have equal protrusion on both sides of the lever. The early ball type bearing (with two washers) rides on a soft bearing pin and must be swagged at both ends to retain the bearing in the spring lever.

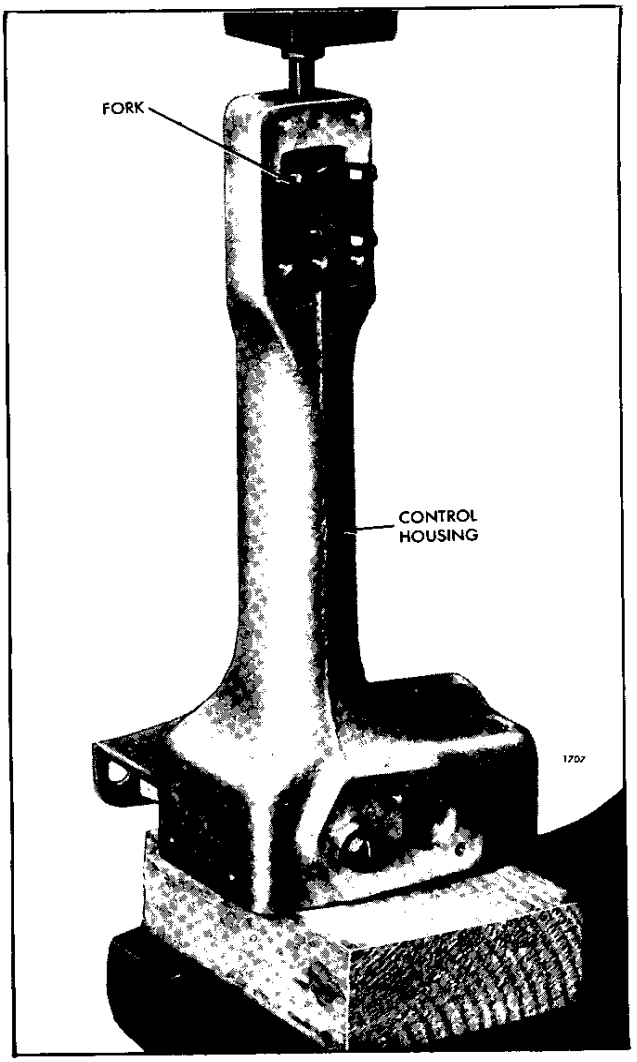


Fig. 7 - Removing Operating Shaft from Operating Fork

Examine the weight carrier pins and bearings for excessive wear and flat spots. If either of these conditions exist, new parts must be installed.

Check the finished surface of the governor weights for flat spots. If flat spots are noted, new weights should be installed.

© 1982 General Motors Corp.

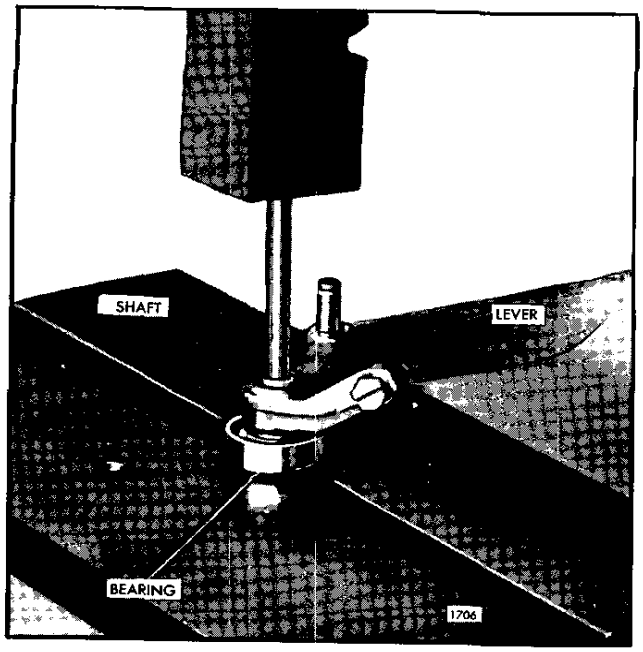


Fig. 8 - Removing Operating Shaft from Operating Lever

Assemble Governor Cover

1. If new needle bearings are to be installed in the governor cover, place the governor cover on the bed of an arbor press with the inner face of the cover down. Start a new needle bearing straight into the bearing bore of the cover with number on the bearing up. Then insert bearing installer J 21068 in the bearing and press the bearing in until the shoulder on the tool contacts the cover (Fig. 11).

2. Reverse the governor cover on the bed of the press (inner face of cover up). Start the second bearing straight into the bore of the cover with the bearing number up. Press the bearing in flush with the cover with tool J 21068.

NOTE: Do not use impact tools to install needle bearings.

3. Pack the needle bearings with grease. If the cover contained a bushing which was not removed, lubricate it with clean engine oil. Insert the throttle shaft through the bearing or bushing.

4. Insert a seal ring over the throttle shaft and into the counterbore against the upper bearing. Place the retainer over the shaft and against the seal ring.

5. Locate the lock ring in the groove of the throttle shaft.

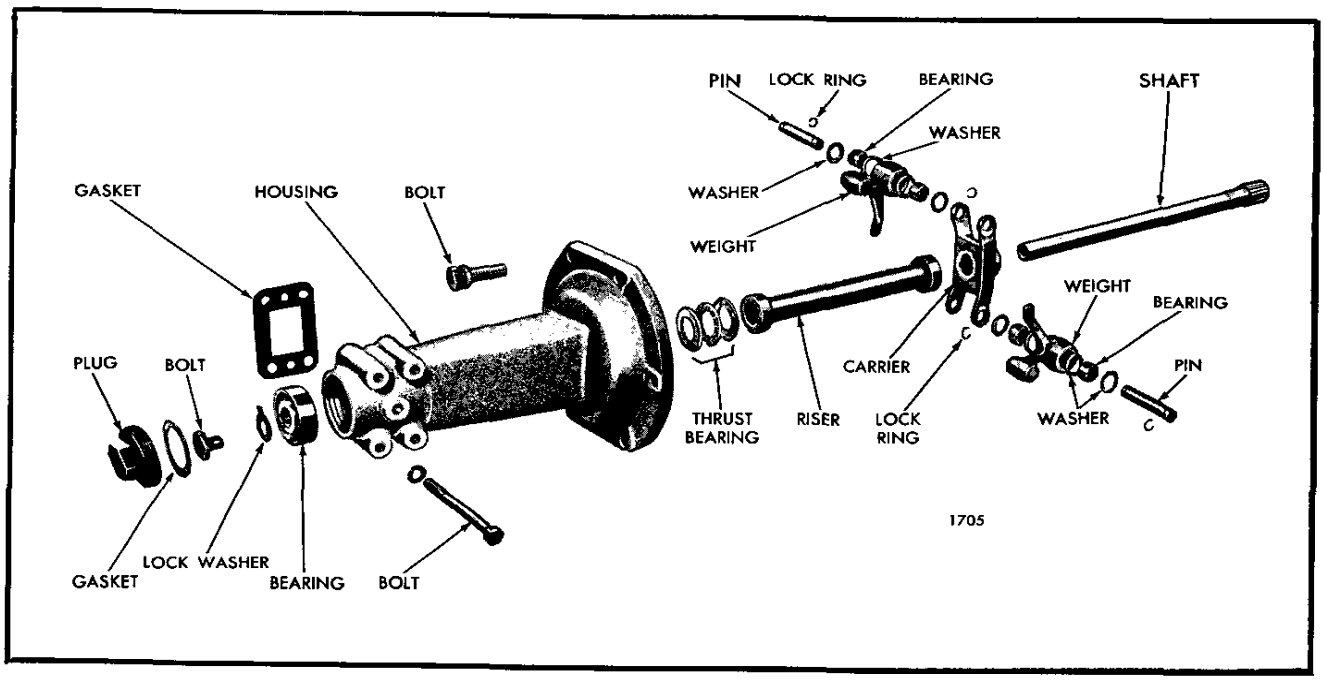


Fig. 9 - Governor Weight Housing Details and Relative Location of Parts

© 1982 General Motors Corp.

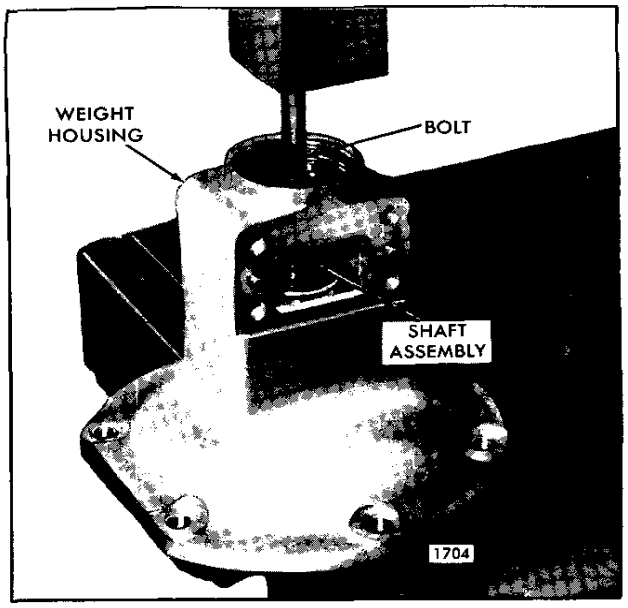


Fig. 10 - Removing Governor Weight and Shaft Assembly

6. Place the torsion retraction spring over the cover hub with the hooked end up (Fig. 2). Then place the stop lever on the shaft and tighten the clamping bolt . On former units, the retracting spring is installed after the governor is assembled (see *Install Governor).*

Assemble Governor Control Housing

1. Place the bearing washer over the short, finished end of the operating shaft (Fig. 5). Start the bearing over the end of the shaft. Support the opposite end of the shaft on the bed of the press. Using a sleeve having the same diameter as the bearing inner race, press the bearing on the shaft tight against the washer.

2. With the pivot pin in the operating lever up, start the lever over the end of the shaft with the flat on the shaft registering with the flat surface in the lever. Press the lever on the shaft tight against the bearing.

3. Lubricate the bearing and operating shaft bushing in the housing with clean engine oil. Insert the lever and operating shaft assembly in the control housing.

4. Position the operating fork over the lower end of the operating shaft so the finished side of the fork fingers will rest against the thrust bearing as shown in Fig. 1.

5. Support the operating shaft and control housing on the bed of an arbor press with the upper end of the shaft resting on a steel block. Align the flat in the operating fork with the flat on the shaft, then place the sleeve over the end of the shaft and rest it on the fork. Press the fork straight down tight against the shoulder on the shaft.

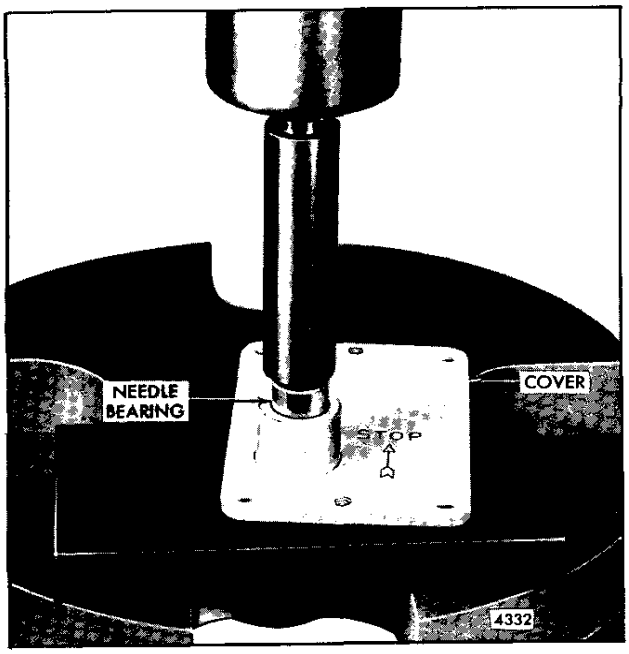


Fig. 11 - Installing Needle Bearing in Governor Cover using Tool J 21068

6. Tighten the fork set screw (if used).

7. Place the differential lever over the pivot pin of the operating lever. Install the plain washer and spring retainer.

8. Place the lock washer and the flat washer over the bearing retaining screw. Refer to Fig. 1 and thread the screw in the control housing tight to secure the bearing.

9. Refer to Fig. 6 and insert the variable speed spring plunger guide in the control housing.

10. Apply a good quality sealant around the outer periphery of the expansion plug and tap the plug into the lower end of the control housing.

Assemble Governor Weight Housing

1. Install the lock ring in the groove of the weight pin (Fig. 9). Place the flat washer over the pin and against the lock ring.

© 1982 General Motors Corp.

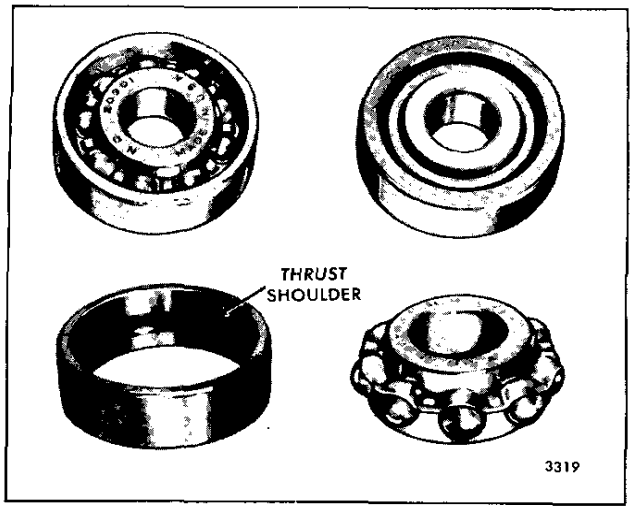


Fig. 12 - Former Governor Weight Shaft Bearing

2. Start the pin through the opening in the weight carrier. Place the second washer over the pin and against the projecting arm of the weight carrier.

3. Position the governor weight between the projecting arms of the weight carrier. Push the pin through the governor weight. Place the third flat washer over the pin and against the weight.

4. Then push the pin completely through the weight carrier and place the fourth flat washer over the pin and against the projecting arm of the weight carrier. Install the second lock ring in the groove of the weight carrier pin.

5. Install the second governor weight as outlined in Steps 1 through 4.

6. Slide the riser over the shaft and against the finished surfaces of the governor weights as shown in Fig. 1.

7. Assemble the riser thrust bearing on the weight shaft with the bearing race having the smaller inside diameter against the thrust riser. Incorrect installation of the bearing will result in erratic operation of the governor.

8. Insert the weight carrier and shaft assembly in the weight housing.

9. Support the splined end of the shaft on the bed of an arbor press. Start the shaft end bearing in the housing and over the end of the shaft with the numbered side of the bearing facing away from the shaft. Press the new bearing in place using a 1 3/8"

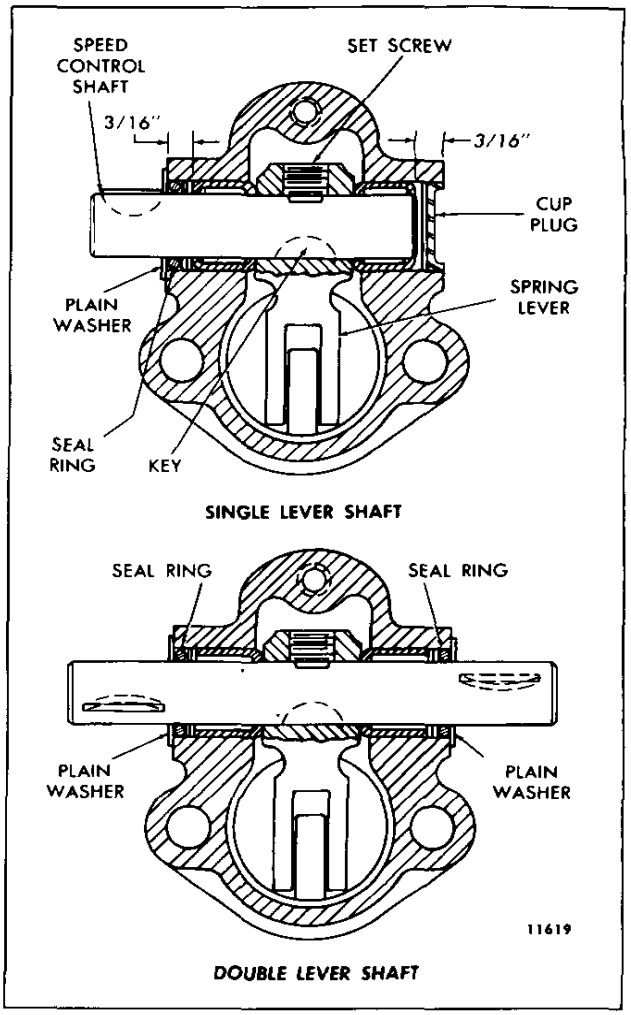


Fig. 13 - Cross Section of Governor Variable Speed Spring Housings (Current)

diameter metal bar flat on the ends which will bear against both the inner and outer races of the bearing.

NOTE: The former bearing had thrust capacity in one direction only. Be sure to install the former bearing so the thrust shoulder is toward the governor weights. Otherwise, the force exerted by the weights will pull the inner race and ball assembly away from the outer race and result in damage to the bearing and erratic governor operation.

10. Place a washer over the bearing retaining bolt (Fig. 9). Thread the bolt into the tapped end of the shaft and tighten it. Bend the tang of the washer against the head of the bolt.

© 1982 General Motors Corp.

11. Place a gasket in the housing and against the bearing. Apply a Loctite sealant, grade HV, or equivalent, to the full 360° circumference of the end plug and thread the plug into the tapped end of the governor weight housing. Tighten the plug to 45 lb-ft (61 Nm) torque with either the flat or the point of the head on a horizontal line.

Assemble Variable Speed Spring Housing

1. Refer to Figs. 13 and 14. Lubricate the speed control lever shaft needle bearings with Shell Alvania No. 2 grease, or equivalent. Then start one of the bearings, numbered end up, straight in the bearing bore in the right-hand side of the spring housing.

2. Install the needle bearing pilot rod J 9196-2 in the installer body J 9196-1 and secure it in place with the retaining screw.

3. Place the pilot rod end of the bearing installer assembly in the bearing. Support the spring housing, bearing and installer on a short sleeve on the bed of an arbor press as shown in Fig. 15, then press the bearing in the housing until the shoulder on the installer contacts the housing.

NOTE: When the shoulder on the installer body contacts the housing, the bearing will be properly positioned in the housing.

4. If removed, install the spring lever Woodruff key in the center keyway in the speed control lever shaft.

5. Place the spring lever assembly between the bearing bores inside the spring housing with the arm (roller end) of the lever facing out.

6. Insert the correct end of the single or double lever type, speed control lever shaft through the bearing bore in the side of the spring housing, opposite the bearing previously installed (Fig. 13). Align the key in the shaft with the keyway in the spring lever, and push the shaft through the lever and in the bearing until the flat on the top of the shaft is centered under the set screw hole in the lever.

7. Thread the set screw into the spring lever, making sure the point of the screw is seated in the flat on the shaft.

8. Place the second speed control lever shaft needle bearing, numbered end up, over the protruding end of the shaft and start it straight in the bore of the housing.

9. Remove the bearing pilot rod J 9196-2 from the installer body J 9196-1 and place the installer body over the end of the shaft and against the bearing. Support the spring housing, bearings and installer on a short sleeve on the bed of an arbor press as shown in Fig. 15, then press the bearing in the housing until the shoulder on the installer contacts the housing.

10. If a single lever shaft was installed in the spring housing, apply a thin coat of sealing compound to the outside diameter of the cup plug. Start the cup plug straight in the bearing bore in the housing, then

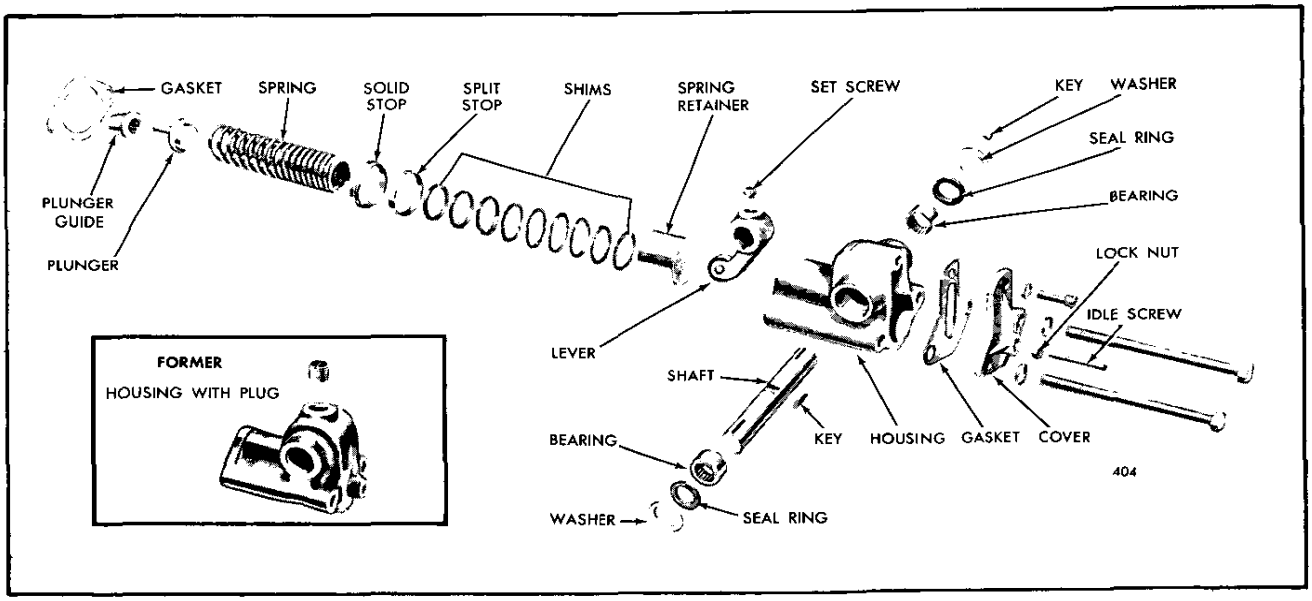


Fig. 14 - Variable Speed Spring Housing and Shaft Details and Relative Location of Parts

© 1982 General Motors Corp.

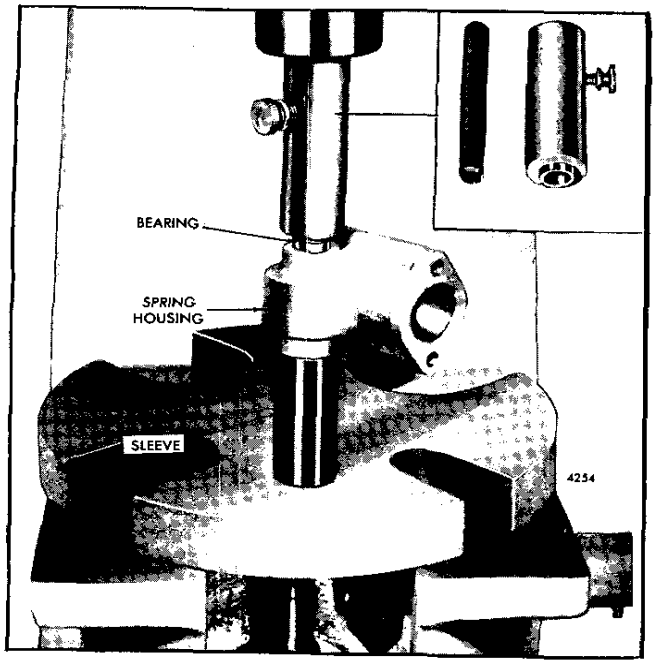


Fig. 15 - Installing Speed Control Shaft Bearings in Spring Housing using Tool J 9196

support the spring housing, bearings and shaft assembly on a sleeve on the bed of an arbor press, and press the cup plug in flush with the outside face of the housing (Fig. 13).

11. Clamp the spring housing assembly in a bench vise equipped with soft jaws. Then tighten the spring lever retaining set screw to 5-7 lb-ft (7-10 Nm) torque.

12. Stake the edge of the spring lever set screw hole with a small center punch and hammer to retain the set screw in the lever. Then, install the plug in the former spring housing.

13. On a single lever shaft, place a seal ring over the end of the shaft and push it into the bearing bore and against the bearing. Place the plain washer over the shaft and against the housing, then install the Woodruff key in the keyway in the shaft.

14. On a double lever shaft, place a seal ring over each end of the shaft and push them into the bearing bores and against the bearings. Place a plain washer over each end of the shaft and against the housing, then install a Woodruff key in the keyway at each end of the shaft.

15. Place the speed control lever(s) on the shaft in its original position. Align the keyway in the lever with the key in the shaft and push the lever in against the plain washer and secure it in place with the retaining bolt and lock washer.

16. If removed, thread the lock nut on the idle speed adjusting screw. Then, thread the idle speed adjusting screw into the spring housing cover approximately 1.00".

Assemble Variable Speed Spring Housing to the Control Housing

1. Refer to Fig. 14 and insert the small end of the spring plunger in the plunger guide. Insert the solid stop in the governor control housing.

2. Place the spring retainer in the spring housing, with the closed end of the retainer against the spring lever. If shims were used, place them inside of the spring retainer. Insert the split stop in the spring housing and against the spring retainer.

> **NOTE:** Be sure to use shims with an .344" inside diameter. Either spring retainer may be used with shims which have a .750" I.D. However, do not use the .344" I.D. shims with a spring retainer which has only one air bleed hole.

3. Insert the variable speed spring in the spring plunger with the tightly wound end of the spring against the shims.

4. Insert the bolts through the spring housing. Place a new gasket over the bolts and against the housing.

5. Place the spring housing in position against the control housing with the spring plunger engaged in the end of the variable speed spring. Thread the bolts in the control housing and tighten them securely.

Install Governor

1. Affix a new governor-to-blower gasket to the governor weight housing. Refer to Fig. 2 and start the splined end of the weight shaft into the upper blower rotor and position the housing against the blower end plate.

2. Place a new copper gasket on each weight housing-to-blower bolt and thread the bolts into the blower end plate, finger tight only.

3. Place a new gasket over the dowels and against the side of the weight housing facing the engine (Fig. 9).

4. Move the thrust bearing assembly and riser toward the weight end of the shaft.

5. Refer to Fig. 2 and position the lower end of the

© 1982 General Motors Corp.

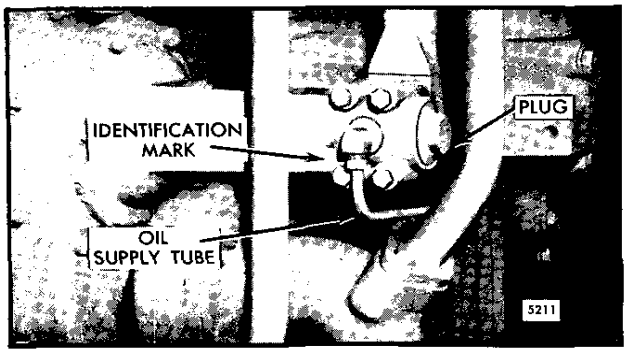


Fig. 16 - Governor Weight Housing (Current 4 and 6 Cylinder Engines)

control housing over the dowel pins of the weight housing. The finished surface of the operating fork must be placed against the outer side of the thrust bearing.

NOTE: For ease in assembling the governor control housing (4 or 6 cylinder engine) to the interim weight housing (no identification mark, Fig. 16), install a special bolt (3/8"-24 x 3/4" or 7/8"), from which the outer 1/2" of thread down to a diameter of 5/16" to 1/4" has been removed, as a tool in the 1/8" NPTF oil hole to prevent the thrust bearing from moving too far forward in the weight housing. Current weight housing has two ribs cast on the inner surface of the housing to prevent any part of the riser thrust bearing from sliding forward to where the operating fork could be inserted on the wrong side of one or more parts of the bearing.

6. Use a new gasket and attach the governor control housing to the cylinder head with two bolts (Fig. 2). Tighten the bolts.

7. Tighten the governor-to-blower bolts with tool J 4242.

8. Affix a new gasket to the weight housing cover (former governors only) and place the cover in position. Install the four weight housing-to-control housing bolts with lock washers and tighten the bolts.

9. Connect the oil tube to the restricted fitting on the weight housing, or cover if used.

10. Refer to Fig. 1 and position the fuel rod over the differential lever pin. Place a flat washer over the pin and secure it with a retainer.

11. Attach the fuel rod to the injector control tube lever with a pin and cotter pin.

12. Place a new gasket on the governor control housing and mount the governor cover on the housing with the pin on the lever shaft registering with the machined slot in the differential lever as shown in Fig. 1.

13. Secure the cover to the governor housing with three regular screws, one special screw and lock washers.

14. Hook the torsion retraction spring to the special cover screw and the stop lever (Fig. 2).

15. On former engines the governor cover is installed with four regular cover screws and lock washers. The former retracting spring is hooked between the stop lever and the retracting spring clip mounted on the end of the variable speed spring housing.

16. Perform an engine tune-up as outlined in Section 14.4.

© 1982 General Motors Corp.

CONSTANT SPEED MECHANICAL GOVERNOR

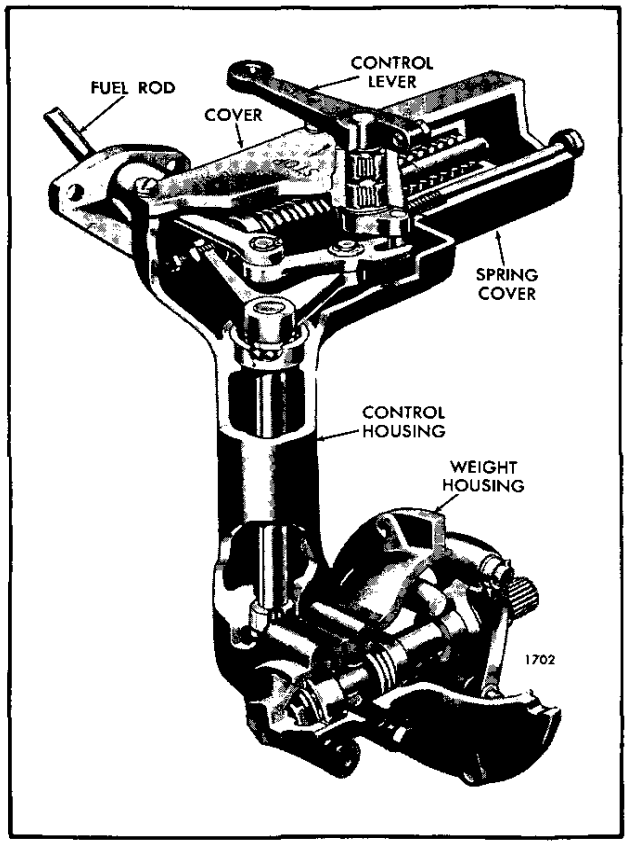


Fig. 1 - Constant Speed Governor

The horsepower requirements of an engine vary continually due to fluctuating loads. Therefore, some means must be provided to control the amount of fuel required to hold the engine speed reasonably constant during such fluctuations. To accomplish this control, a mechanical governor of the constant speed type has been provided.

The constant speed mechanical governor (Fig. 1) has a speed range of 1200-2000 rpm at full load. Upon starting, the engine will automatically attain approximately 50 rpm more than the pre-determined speed.

As load is applied, the engine speed drops until it reaches the desired speed at full load. This speed can be adjusted by moving the high speed spring retainer. Other style governors can be adjusted by the use of shims behind the governor spring.

The governor is mounted at the front end of the blower and is driven by the upper blower rotor.

A spring on top of the governor holds the governor control lever in the *run* position. A cable from the instrument panel, when pulled, overcomes the spring and draws the injector racks to the no-fuel position (through the governor), thus stopping the engine.

The centrifugal force of the revolving flyweights is converted into linear motion which is transmitted through the riser and the operating shaft to the operating shaft lever, one end of which is the spring seat while the other end provides a changing fulcrum on which the differential lever pivots. A fuel rod, connected to the differential lever and injector control tube lever, provides a means for the governor to change the fuel settings of the injector control racks.

The centrifugal force of the governor weights is opposed by the governor spring. Load changes create an unbalanced force between the revolving governor weights and the tension of the spring. When the two forces are equal, the engine speed stabilizes. Whenever the centrifugal force of the revolving weights overcomes the tension of the spring, the injector racks will be moved toward the no-fuel position. Also, whenever the centrifugal force of the weights allows the spring to expand, the injector racks will move toward the full-fuel position.

When governor difficulties are encountered which would necessitate the removal, disassembly, cleaning and inspection, assembly and installation of the constant speed mechanical governor, refer to Section 2.7.1 for the proper procedure.

When engine tune-up is necessary, refer to Section 14.6.

© 1982 General Motors Corp.

MECHANICAL OUTPUT SHAFT GOVERNOR

The Pierce mechanical output shaft governor is used on certain engines, equipped with a torque converter, to regulate the speed of the output shaft. The front mounted output shaft governor is mounted at the front of the engine and is driven by a flexible shaft from the torque converter output shaft and is connected, through linkage, to the engine governor (Fig. 1). The rear mounted output shaft governor is mounted on the torque converter and is driven through a drive adaptor by the output shaft and is connected, through linkage, to the engine governor (Fig. 2). The mechanical limiting speed governor on the engine regulates the maximum and idle speeds of the engine while the output shaft governor has control of the engine speed in the intermediate speed range, between maximum and idle engine speed.

The flyweights on the output shaft governor are driven through the operating spider and shaft assembly by the governor drive adaptor (Fig. 3). A shoulder on the flyweights bears against the riser that transmits the motion of the flyweights, through the riser thrust bearing, to the operating fork. The operating fork is attached to the rocker shaft that rides in the rocker shaft ball bearings. Pinned to the rocker shaft is the spring lever and the rocker shaft lever (Fig. 4). Connected to the spring lever is the speed adjusting spring that is, in turn, connected through the eyebolt to the speed adjusting spring lever. The speed adjusting spring lever is mounted on the speed adjusting shaft and is controlled by the engine operator when establishing and desired engine speed. Two screws (minimum and maximum output shaft speed adjusting screws) limit the travel of the speed adjusting shaft and thus the minimum and maximum output shaft speed settings.

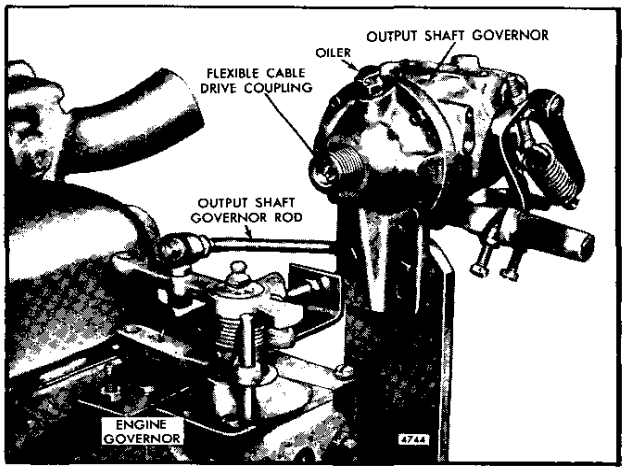


Fig. 1 - Front Mounted Output Shaft Governor

The linkage that operates the engine governor throttle is connected to the rocker shaft lever. The movement of the rocker shaft lever increases or decreases the speed of the engine.

Lubrication

The output shaft governor is lubricated by engine oil that is contained within the governor housing. The movement of the governor weights throws the oil to all parts in the governor requiring lubrication.

With the output shaft stopped, fill the governor sump through the hinged cap oiler until the oil begins to drip

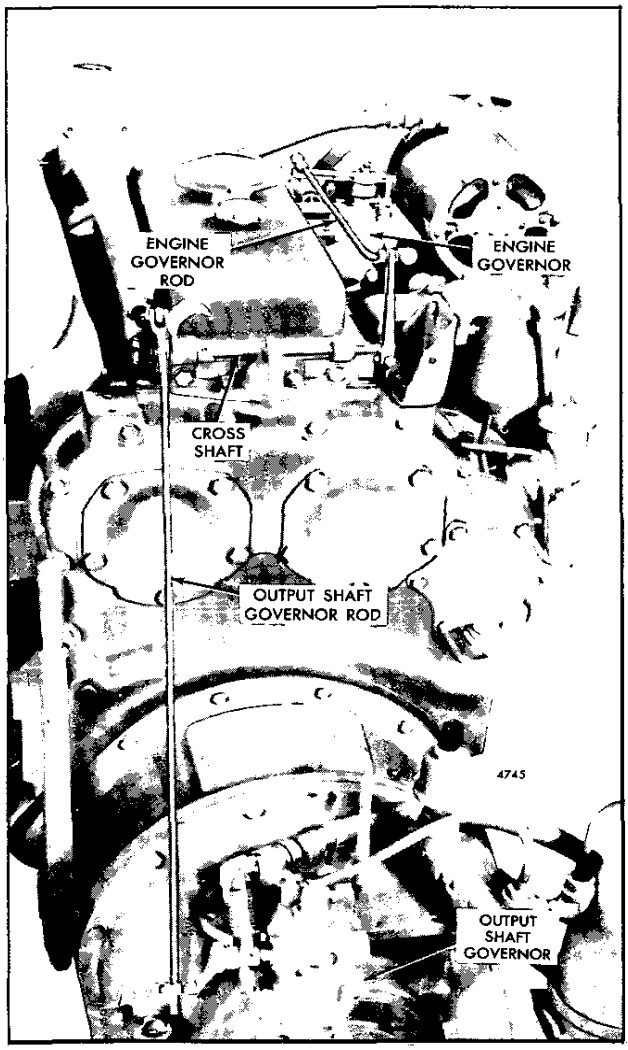


Fig. 2 - Rear Mounted Output Shaft Governor

© 1984 General Motors Corp.

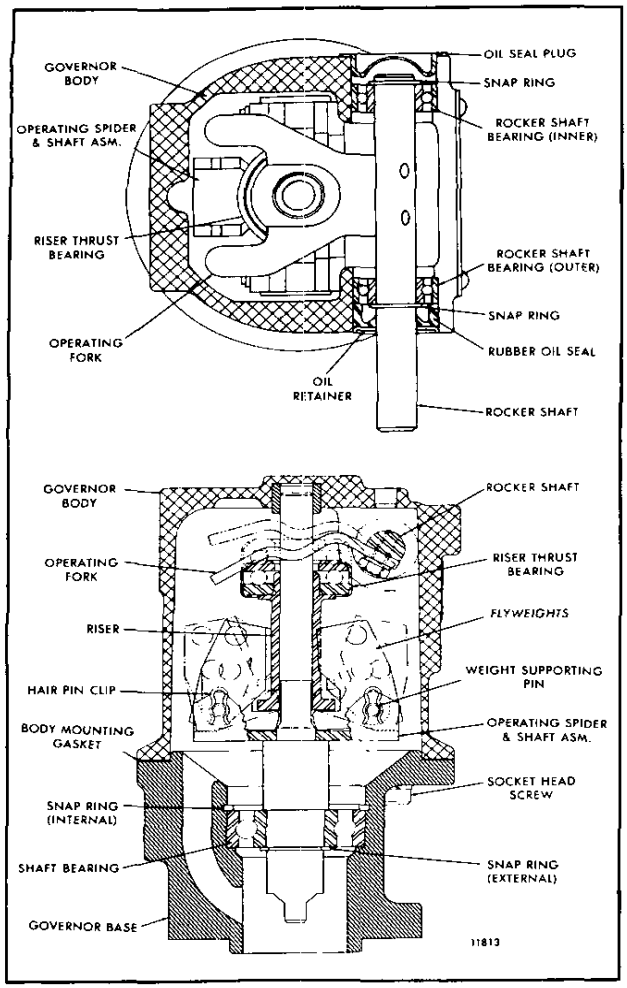


Fig. 3 - Cross-Section of Governor

out of the oil level hole (Fig. 1). When the sump is full, the oil will drip from the oil level hole. The plug should be installed and tightened sufficiently to prevent oil leakage.

NOTE: Care should be taken to remove all dirt or foreign material from the governor openings before filling or checking the oil level.

The bearing surfaces of the speed adjusting shaft should be lubricated by a hand oiler with engine oil. Rod end ball joints are sealed assemblies and do not require lubrication. The throttle control lever and the levers surrounding its shaft should be lubricated with all purpose grease through the grease fitting.

Disassembly

After removing the governor and before removing any parts from the governor, wash the entire unit with clean fuel oil and dry it with compressed air. Then, inspect for worn or damaged parts that can be repaired or replaced without complete disassembly. The output shaft governor may be disassembled by referring to Figs. 3 and 4 and proceeding as follows:

1. Remove the two socket head screws and lock washers that secure the speed adjusting shaft bracket to the governor body. Unhook the speed adjusting spring from the speed adjusting spring lever and the spring lever while removing the bracket.

2. Remove the speed adjusting shaft bracket retaining snap ring from the speed adjusting shaft using snap ring pliers J 4880. Remove the washer and slide the bracket from the shaft.

3. If desired, note the position of the speed adjusting spring lever on the speed adjusting shaft and, using a small punch, drive out the 5/32″ roll pin that retains the lever to the speed adjusting shaft. After removing the roll pin, it will then be necessary to tap the end of the shaft with a soft hammer to facilitate the removal of the lever. The minimum and maximum speed adjusting screws may be removed from the speed adjusting spring lever, if desired.

4. Remove the four socket head screws and lock washers that secure the governor base to the body. Remove the body to base gasket. Remove the riser and thrust bearing from the governor operating spider and shaft assembly.

5. Remove the two bolts and lock washers that secure the operating fork to the rocker shaft.

6. Drive lightly against the lower edge of the oil seal plug with a small punch to force the upper edge of the plug outward. Then, place a screwdriver behind the plug and force it out of the governor body.

7. Remove the bearing retaining snap ring from the rocker shaft.

8. Tap the end of the rocker shaft gently and withdraw the shaft from the governor body. If the governor body is placed in a vise, care must be taken not to overtighten the vise as this could distort the aluminum body.

9. Remove the rocker shaft inner and outer bearings. The outer bearing may have to be tapped slightly to free it from the governor body.

10. Remove the snap ring, rubber oil seal and oil seal retainer from the governor rocker shaft.

11. Use a small punch and drive out the 5/32″ roll pins that secure the spring lever and rocker shaft lever to the

© 1984 General Motors Corp.

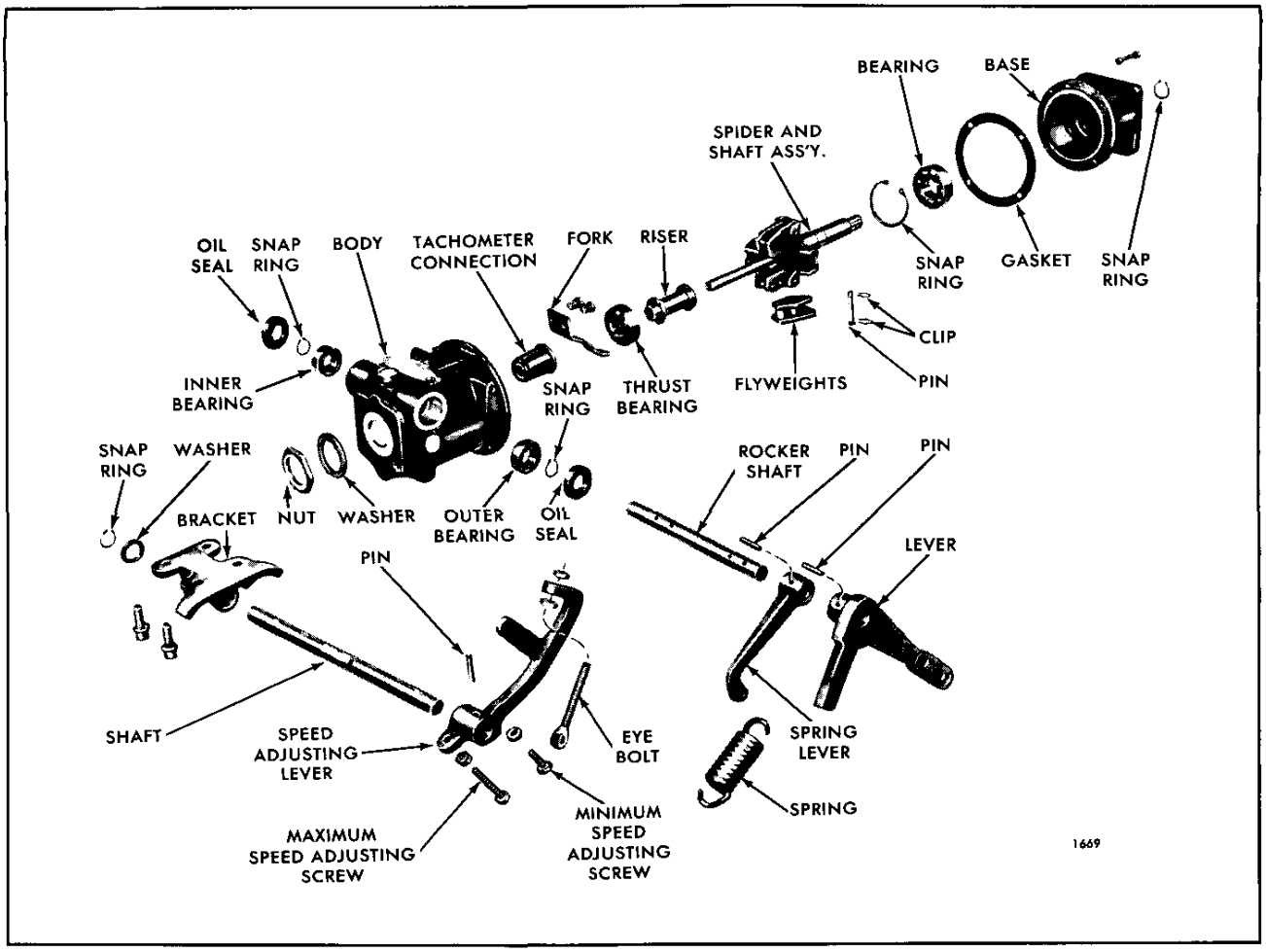


Fig. 4 - Output Shaft Governor Details and Relative Location of Parts

rocker shaft after noting the relationship of the levers on the shaft. Then, tap the end of the rocker shaft with a soft hammer to facilitate the removal of the levers from the shaft.

12. Secure the governor base in an inverted position in a vise and remove the lower bearing retaining snap ring using tool J 4880.

13. Tap the splined end of the operating spider and shaft assembly lightly to loosen the shaft from the bearing. Remove the operating spider and shaft assembly.

14. Invert the governor base in the vise and remove the internal snap ring retaining the upper bearing.

15. Gently press the bearing out of the counterbore in the governor base.

16. Remove the eight hair pin clips that secure the weights on their supporting pins. Then, using a 5/32" punch, gently tap out the four flyweight supporting pins.

17., Carefully support the lower side of the riser thrust bearing in an arbor press. Then, using a 7/16" rod, gently press the riser from the inner race of the bearing. Use extreme care to prevent damage to the bearing shoulder of the riser.

18. Remove the nut and washer from the tachometer connection and remove the connection from the inside governor body.

Inspection

After the governor assembly has been disassembled, thoroughly clean each piece in fuel oil and dry with compressed air.

Inspect the rocker shaft bearings for excessive wear. Replace them, if necessary.

© 1984 General Motors Corp.

Inspect the operating shaft bearing for excessive wear.

Inspect the rubber oil seal on the governor rocker shast. The slightest wear on this part can cause oil leakage. It is recommended that when overhauling a governor, a new oil seal be installed.

Inspect the tachometer connection for wear to either the bushing or oil seal. If either part appears worn or damaged excessively, replace the entire connecting assembly.

Inspect all of the retaining snap rings to determine if they have been damaged at the time of disassembly. Replace them, if necessary.

Inspect the riser bearing surface of the flyweights for excessive wear or a flat spot. If either condition exists, new weights must be installed. The flyweights must work freely on their supporting pins for satisfactory governor operation.

Inspect the governor operating fork for excessive wear or distortion. If either condition exists, install a new fork.

Inspect the governor body for distortion or damage to the bearing seating surfaces and replace it, if necessary.

Assembly

After all of the parts have been cleaned and inspected, refer to Figs. 3 and 4 and assemble the governor as follows:

1. Place the governor base on a bench, bottom side down, and press the bearing into the base with the stamped side of the bearing inner race facing downward.

2. Install the upper bearing retainer internal snap ring into the base.

3. Replace the flyweights by positioning the operating shaft and spider assembly in a vertical position and install the supporting pins from left to right through the spider and weights. Retain the supporting pins with the hair pin clips at each end.

4. Lubricate the governor spider and operating shaft assembly lightly at the bearing end and, using an arbor press, force the shaft gently until it seats on the inner race of the bearing.

5. Install the lower bearing retainer snap ring.

6. Insert the tachometer connector into the governor body and retain it securely with the washer and nut.

7. Slide the spring lever and the rocker shaft lever on the rocker shaft, if removed, and pin the levers to the shaft with new 5/32″ roll pins.

8. Place the oil seal retainer, lip out, and the oil seal, lip in, on the governor rocker shaft. Install the outer bearing retainer snap ring on the governor rocker shaft, taking precaution against damaging the bearing surface.

9. Place the outer rocker shaft bearing on the rocker shaft with the stamped side of the bearing facing (outward) the snap ring.

10. Place the governor body on a bench, with the name plate up and the body to base gasket surface facing the serviceman, then insert the rocker shaft into the governor body from the left side until the bearing seats in the bore of the body.

11. Press the rubber oil seal into the governor body. Gently tap around the circumference of the oil seal retainer until it is firmly in place.

12. Place the inner rocker shaft bearing in place on the shaft and gently press it into the governor body with its stamped side outward.

13. Install the inner bearing retainer snap ring on the rocker shaft and install a new oil seal plug, pressing it firmly into the governor body.

14. Place the governor operating fork in the governor body on the flat section of the rocker shaft and securely tighten the retaining bolts.

15. Slide the speed adjusting spring lever, if removed, on the speed adjusting shaft and pin it securely, using a new 5/32″ roll pin. Install the minimum and maximum speed adjusting screws, if removed.

16. Slide the speed adjusting shaft through the speed adjusting shaft bracket and install the washer and snap ring.

17. Support the riser in a vertical position on an arbor press and place the thrust riser bearing in position on the riser, with the protruding race of the bearing facing upward. Then, carefully press the bearing down until it is seated on the shoulder of the riser.

18. Install the riser on the operating spider and shaft assembly (Fig. 3).

19. Install a new body to base gasket and assemble the governor base to the body, using four socket head screws, with the oil drain hole boss in the governor base on the lever side of the governor.

20. Place the governor on a bench with the name plate downward. Hook the speed adjusting spring to the adjusting spring speed lever and rocker shaft spring lever.

21. Install the two socket head screws in the two lower holes of the speed adjusting shaft bracket and fasten them securely to the governor body.

22. Install the governor.

© 1984 General Motors Corp.

HYDRAULIC GOVERNORS

Horsepower requirements on an engine may vary due to fluctuating loads. Therefore, some method must be provided to control the amount of fuel required to hold the engine speed reasonably constant during load fluctuations. To accomplish this control, a governor is introduced in the linkage betweeen the throttle control and the fuel injectors.

Engines, subjected to varying load conditions that require an automatic fuel compensation to maintain more nearly constant engine speed with a minimum speed droop, are equipped with a hydraulic governor.

In the hydraulic governor, the fuel is decreased by the action of the governor throttle control terminal lever retracting spring and increased by the opposing action of the power piston. A pilot valve controls the admission of oil flow to the power piston and the movement of the pilot valve in turn is controlled by the governor flyweights. The centrifugal force of these flyweights is opposed by the speeder spring compression which may be varied and yet accurately set and held at any speed between idle and maximum speed. The speed droop, which is the difference between no-load speed and full-load speed, is adjustable to within a very small percentage at maximum speed.

Check Governor Operation

Governor difficulties are usually indicated by speed variations of the engine. However, it does not necessarily mean that all such speed fluctuations are caused by the governor. Therefore, when improper speed variations appear, check the unit as follows:

1. Make sure the speed changes are not the result of excessive load fluctuations.

2. Check the engine to be sure that all of the cylinders are firing properly (refer to Section 15.2). If any cylinder is not firing properly, remove and test the injector and, if necessary, replace or recondition it.

3. Check for bind that may exist in the governor operating mechanism or in the linkage between the governor and the injector control tube. With the fuel rod connected to the injector control tube lever, the mechanism must be free from bind throughout the entire travel of the injector racks. If friction exists in the mechanism, locate and correct it as follows:

a. If an injector rack sticks or moves too hard, check the injector hold-down clamp. If it is too tight or improperly positioned, loosen the clamp bolt, reposition the clamp and re-tighten the bolt to 20-25 lb-ft (27-34 Nm) torque.

b. An internal dirt accumulation, a defective plunger and bushing or a bent injector control rack can result in bind. To correct this condition, remove the injector, then recondition and test it.

c. An improperly positioned control rack lever will result in a binding injector rack. To relieve the bind, loosen the control rack lever adjusting screws. Then relocate the lever on the control tube and position it as outlined in Section 14.

d. If the injector control tube binds in its support brackets, it will prevent free movement of the injector control racks to their no-fuel position. Loosen and re-align the control tube supporting brackets, then tighten the bolts to correct this condition. Reposition the injector racks after re-aligning the support brackets.

e. Replace an injector control tube return spring which has been bent or otherwise distorted. When the injector control tube and the injector racks are free from bind, the control tube will return to the no-fuel position by action of the return spring.

NOTE: Never stretch or tamper with an injector control tube return spring to change its tension. Use a new spring.

f. Check for bind in the pin which connects the fuel rod to the injector control tube lever. If necessary, remove the pin and polish it with fine emery cloth.

4. If neither load, engine irregularities or bind are found to be the cause of the speed variations, the trouble is probably in the governor or governor drive. Check as follows:

a. If the speed changes noted are in rapid oscillation (governor hunting), adjust the speed droop of the governor as outlined in Section 14. This applies only if the governor is overhauled or where the speed droop has been changed from the original factory setting.

b. Worn blower rotor bearings or rubbing of the rotors on the housing will cause the load on the blower drive coupling (between the gear train and the blower) to vary erratically. This variation in load will be transmitted as a speed change to the governor. The governor will act to compensate for the change by moving the fuel rod. If this condition exists, inspect the blower.

© 1980 General Motors Corp.

c. If the speed variations are small in magnitude, check the governor drive. Excessive or insufficient clearance between the bevel drive gears can cause this condition.

d. If the speed variations are large and erratic and unaffected (except, perhaps, in magnitude) by changes in the speed droop adjustment, or if the governor fails to control the speed at all, replace or overhaul the governor.

If, after making these checks, the governor fails to control the engine properly, remove and recondition the governor.

To be certain whether the governor or engine is at fault, install a new governor (with the same part number) and check the performance of the engine.

© 1980 General Motors Corp.

SG HYDRAULIC GOVERNOR

The governors are a hydraulic type with a speed droop stabilization mechanism (Fig. 1 and 2). Hydraulic action is transmitted by oil admitted under pressure from the engine lubricating system to an auxiliary oil pump in the governor. The auxiliary pump then develops the oil pressure necessary to actuate the governor mechanism.

To stabilize the governor, a speed droop adjustment is incorporated in the governor mechanism. The speed droop is regulated by a droop adjusting bracket attached to the top (current governor) or side (former governor) of the terminal lever. Move the droop adjusting bracket IN to decrease the governor droop and move it in the opposite direction to increase the governor droop.

The governor operates in such a manner that the amount of fuel supplied to the injectors is increased by the hydraulically operated power piston and decreased by action of the fuel rod spring (Figs. 1 and 2).

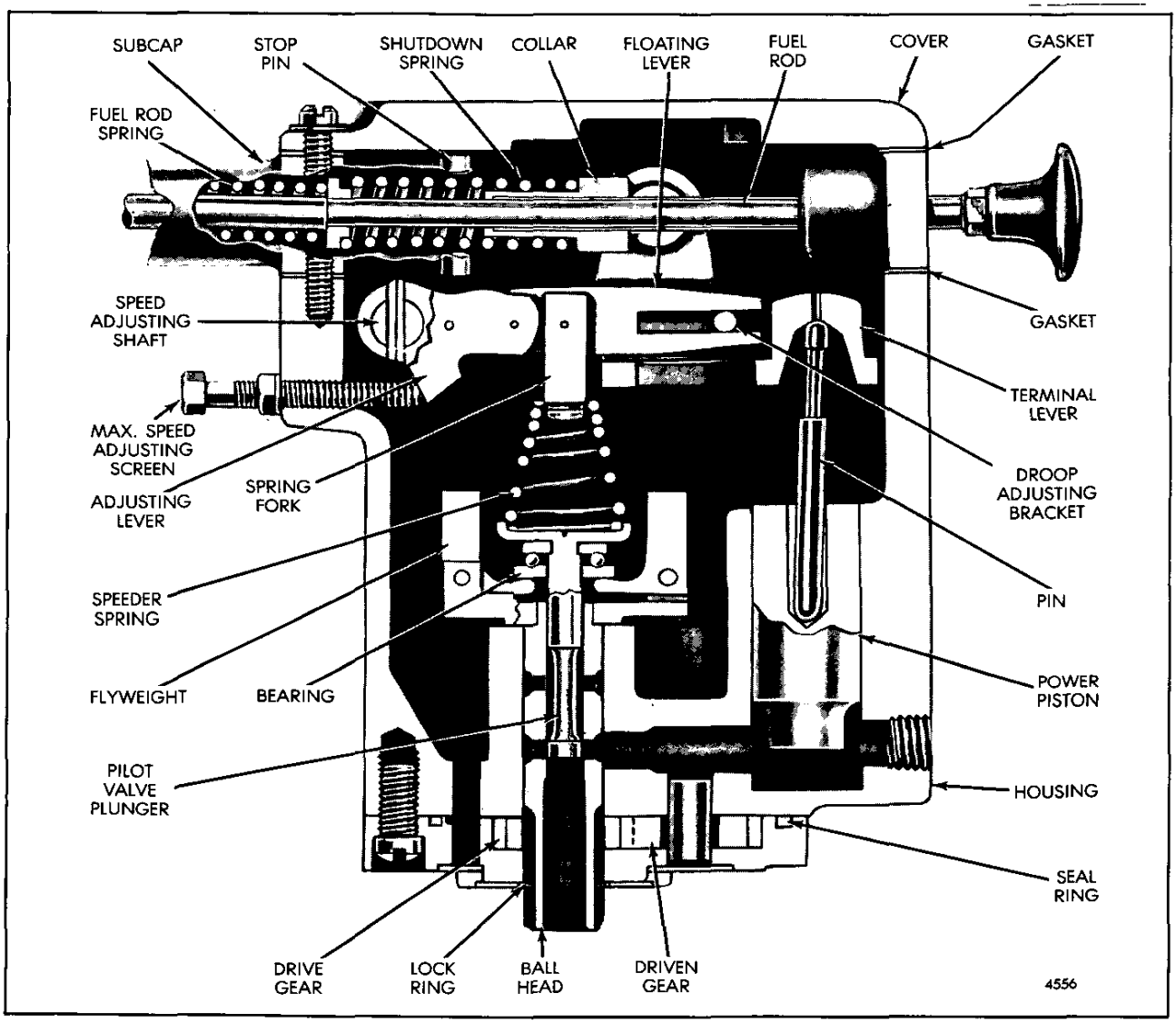


Fig. 1 - Hydraulic Governor Assembly (Current)

© 1984 General Motors Corp.

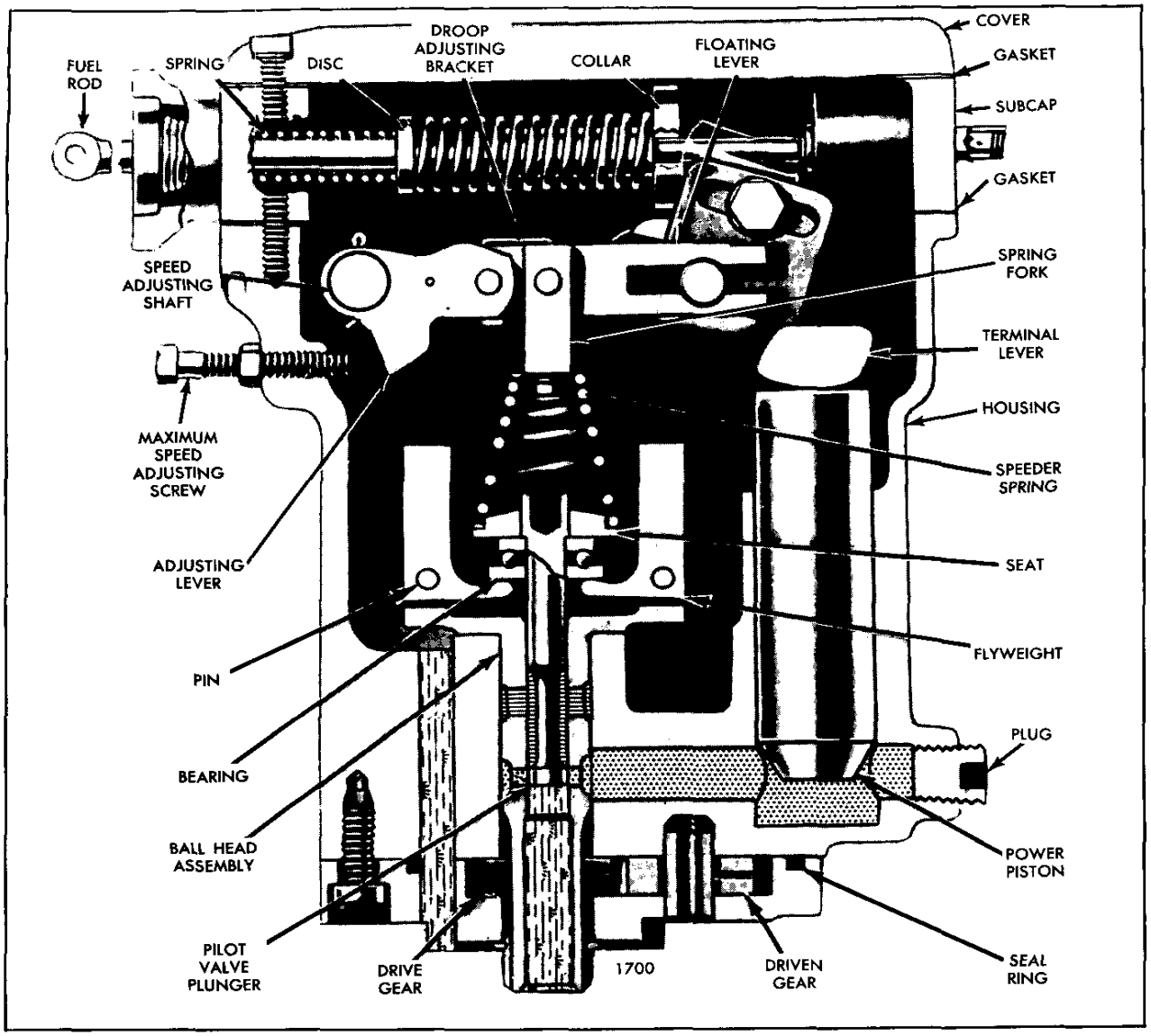


Fig. 2 - Hydraulic Governor Assembly (Former)

The governor is connected to the fuel injectors by a fuel rod attached to a lever on the injector control tube (Figs. 3 and 4).

The governor is driven by the upper blower rotor through an integral horizontal drive shaft and bevel gear and an integral vertical driven shaft and bevel gear, both mounted on ball bearings and retained in the drive housing (see Section 2.8.3).

When starting a cold engine, considerable time is required to develop sufficient oil pressure to operate the governor and thus move the injector control racks to the full-fuel position so the engine can start. Since this delay is not desired, the starting time can be shortened by pressing in on the fuel rod knob. The inward movement of this knob takes the control of the injector fuel racks away from the governor.

The engine can be stopped, regardless of the governor, by pulling out on the fuel rod knob.

In addition to its function of regulating the engine speed under varying load conditions, the hydraulic governor acts as an automatic shutdown device in the event of lubricating oil pressure failure. Should the engine fail to supply oil to the governor, the

© 1984 General Motors Corp.

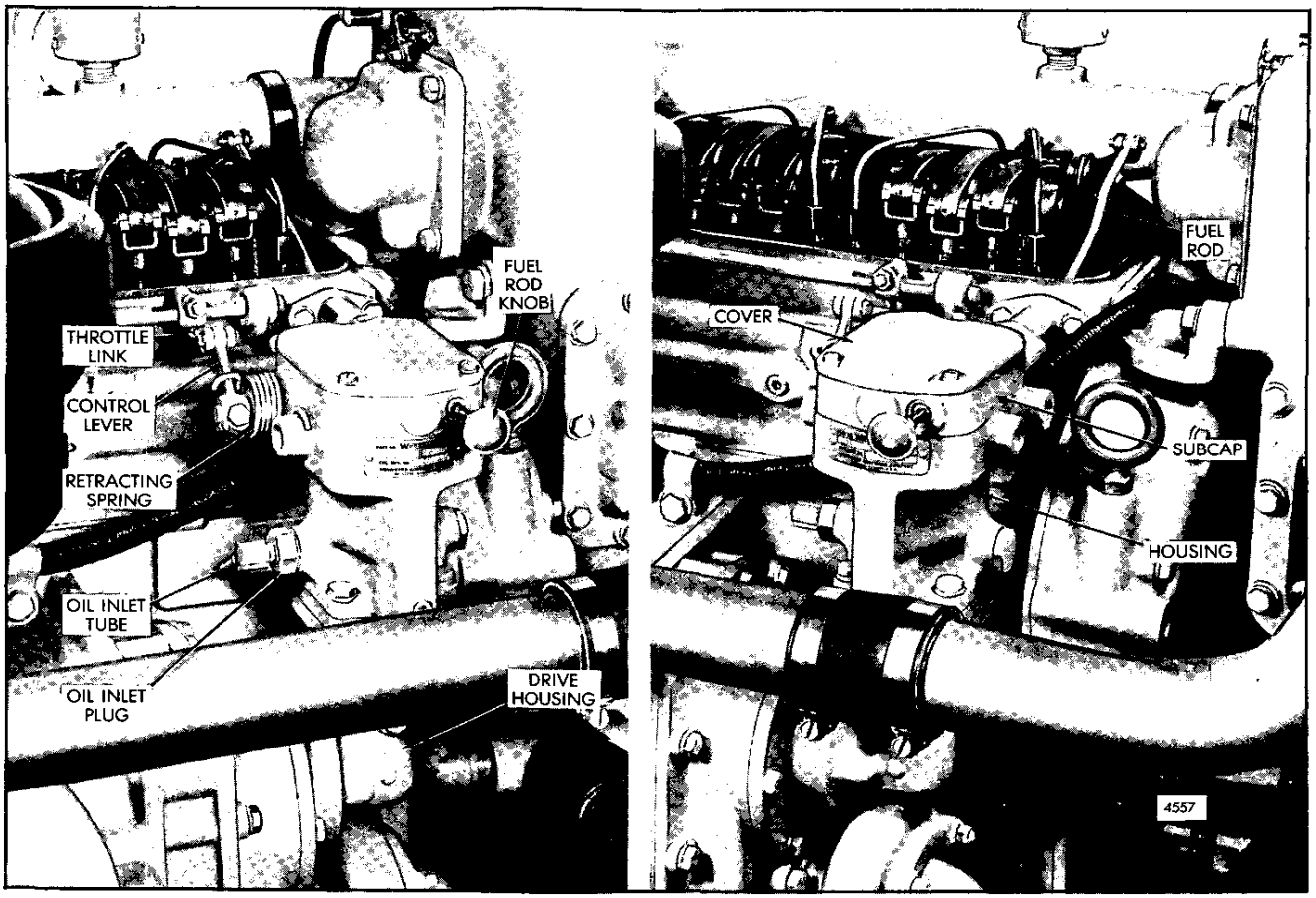


Fig. 3 - Hydraulic Governor Mounting (Current)

Operation

With the engine operating, oil from the engine lubricating system is admitted to the space around the pump gear. The gears raise the oil pressure to a value determined by the relief valve plunger which opposes the relief valve plunger. The oil pressure is maintained in the annular space between the under cut portion of the pilot valve plunger and the bore in the ball head (Fig. 5). For any given throttle setting, the speeder spring has a definite compression force which is opposed by the centrifugal force of the revolving flyweights. When the two forces are equal the land on the pilot valve plunger covers the lower opening in the ball head, thus producing a constant speed condition (Fig. 5).

When the load on an engine is increased, the engine speed will drop momentarily and the governor weights servo-position will drop, letting the fuel rod to return to the no-fuel position. will be forced inward by the speeder spring permitting the pilot valve plunger to uncover the lower port in the ball head. With this port uncovered, oil, under pressure of the governor pump, will be admitted to the cavity at the lower end of the power piston and force the piston and the floating lever upward (Fig. 6). The upward motion of the piston is transmitted through the terminal lever and the fuel rod to the injector control tube, causing the fuel setting of the engine to be increased.

As the power piston and floating lever rise, the compression load on the speeder spring is reduced, allowing the flyweights to again move out to their normal vertical position.

With the governor weights in a vertical position, the land on the pilot valve plunger will again cover the ports in the ball head, thus trapping the regulating oil under the power piston. With the power piston held in its new position by the trapped regulating oil, the engine will carry the increased load at a slightly reduced speed.

© 1984 General Motors Corp.

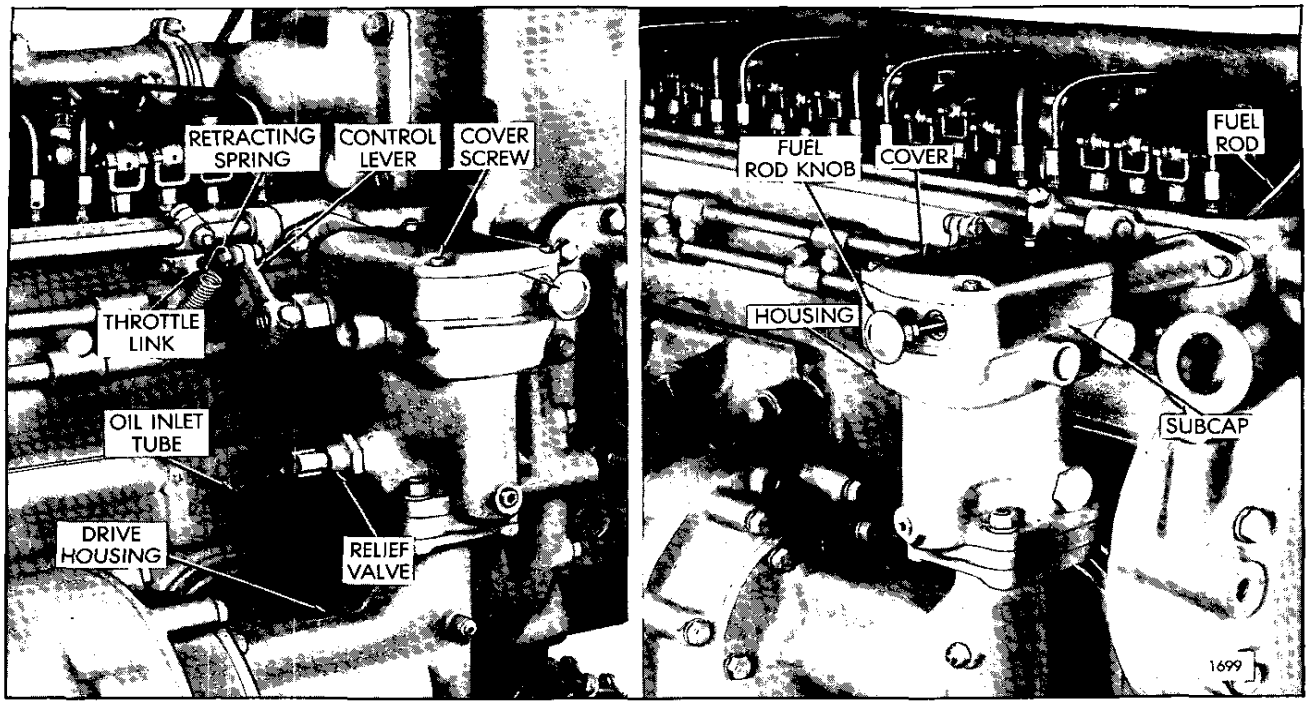


Fig. 4 - Hydraulic Governor Mounting (Former)

Fig. 7 illustrates the governor reaction as the load on the engine is decreased and the engine speed increases.

Lubrication

Oil seeping past the power piston and the pilot valve plunger is vaporized by the revolving governor

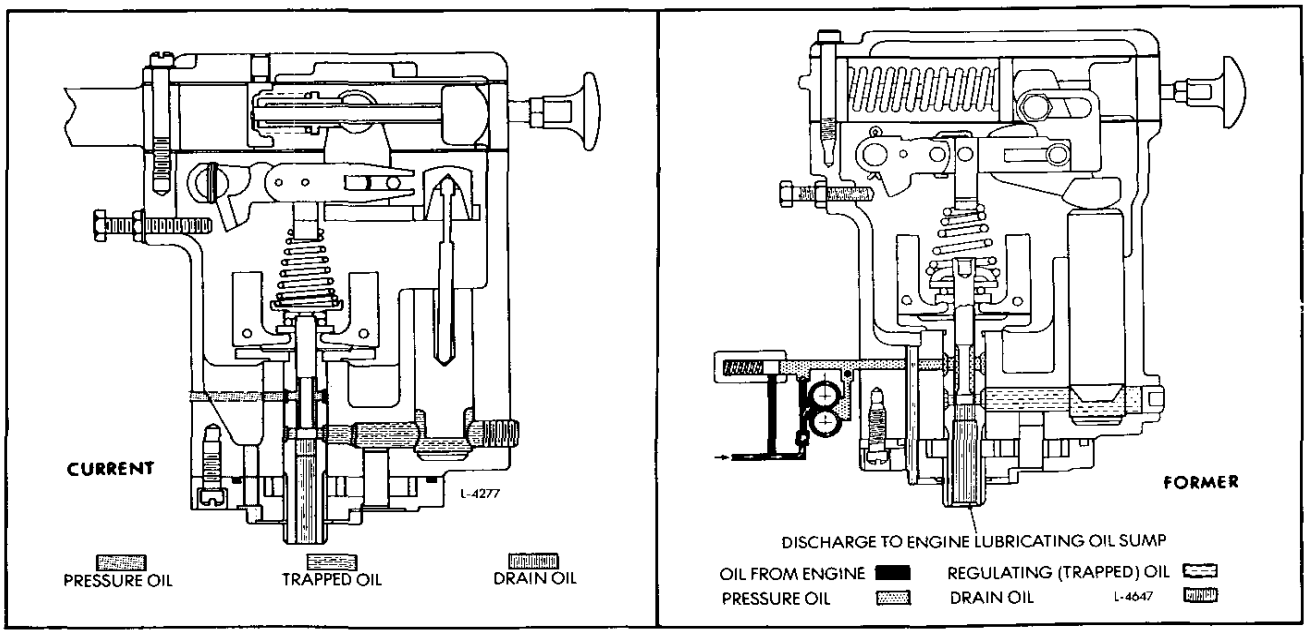


Fig. 5 - Stable Position of Governor Mechanism When Load on Engine is Constant

© 1984 General Motors Corp.

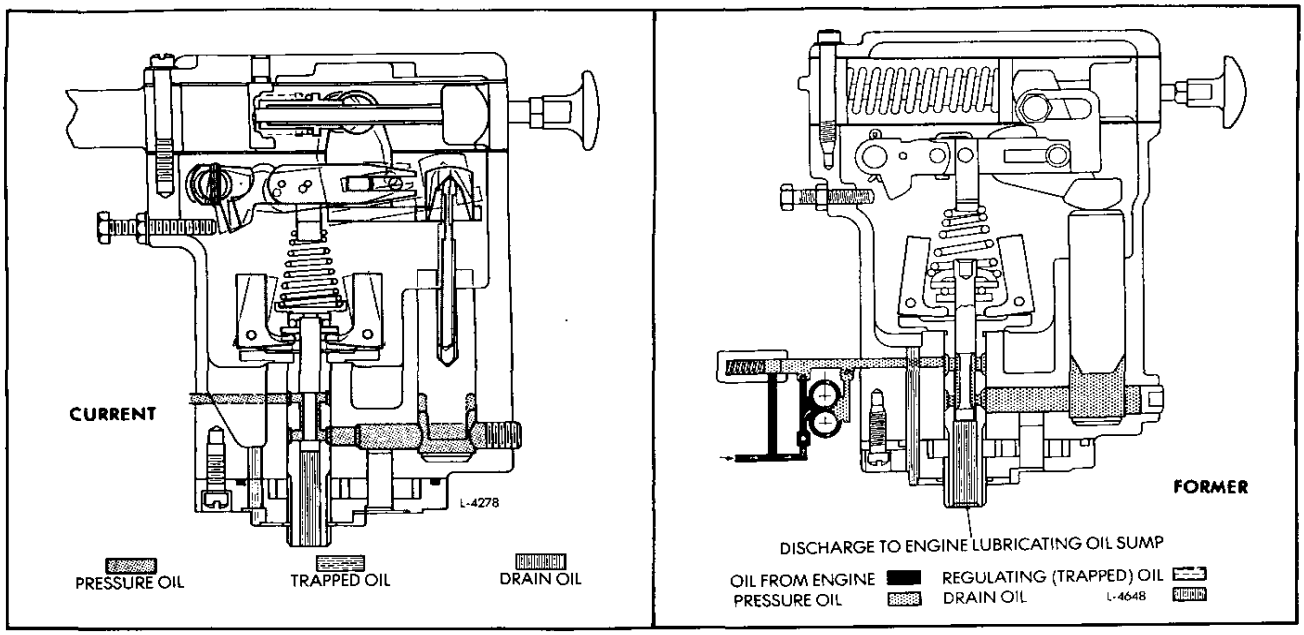


Fig. 6 - Position of Governor Mechanism as Load Increases and Engine Speed Tends to Decrease

flyweights, thus providing lubrication for the moving parts in the governor housing. The governor pump, pilot valve plunger and power piston are all exposed to pressurized oil. Oil that collects on the floor of the governor housing passes through a drilled passage into the governor drive housing, providing lubrication for the governor drive and driven shaft beveled gears and their bearings.

The surplus oil returns to the engine crankcase through connecting drilled passages in the blowe end plate and the cylinder block.

Remove Governor

1. Remove the valve rocker cover.

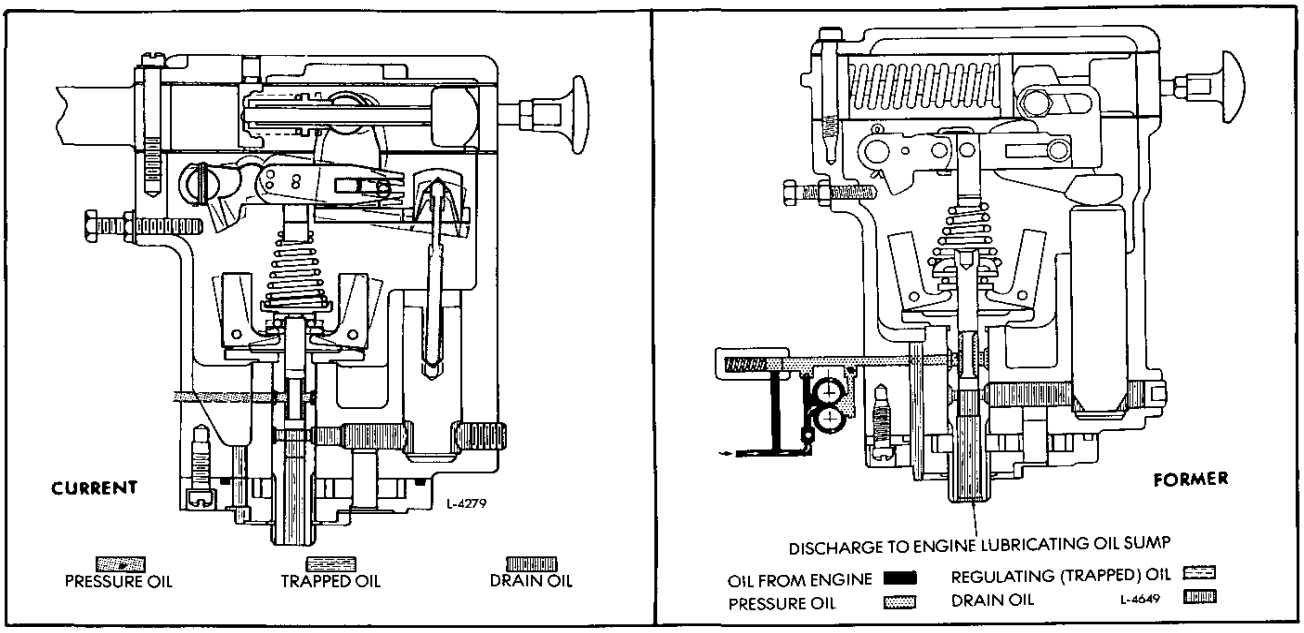


Fig. 7 - Position of Governor Mechanism as Load Decreases and Engine Speed Tends to Increase

© 1984 General Motors Corp.

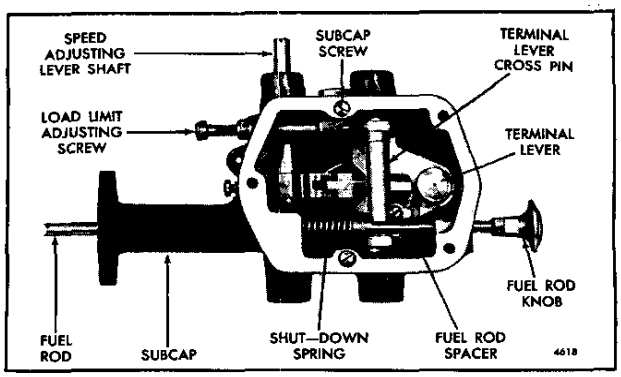


Fig. 8 - Top View of Current Governor with Cover Removed

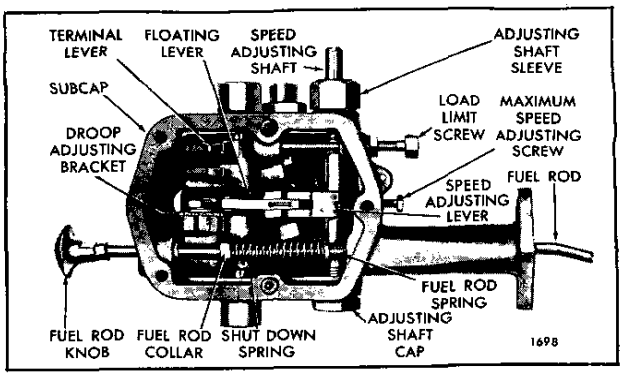


Fig. 9 - Top View of Former Governor with Cover Removed

2. Refer to Figs. 3 and 4 and disconnect the fuel rod from the injector control tube lever.

3. Remove the end of the current retracting spring from the control lever. Then, remove the cotter pin and pin securing the control link to the control lever.

Remove the end of the former retracting spring from the pin securing the throttle link to the control lever. Then, remove the pin.

4. Disconnect the oil inlet tube assembly from the governor oil inlet plug (current governor) or from the relief valve assembly (former governor).

5. On a governor equipped with a synchronizing motor, tag and disconnect the wires from the motor.

6. Remove the three cover screws, then lift the governor cover and gasket from the governor housing. Remove the two subcap-to-cylinder head bolts. Remove the two subcap retaining screws (Figs. 8 and 9).

7. Lift up on the subcap assembly until a definite snap indicates that the fuel rod and collar have been freed from the terminal lever cross pin. Remove the subcap assembly, pulling the fuel rod out of the hole in the cylinder head and throttle control rod mounting bracket.

8. Remove the four bolts or nuts and lock washers, then lift the governor away from the drive housing. Remove the gasket.

1. Housing--Governor
2. Cover--Governor
6. Subcap
7. Bushing--Subcap
8. Rod--Fuel
9. Gasket--Fuel Rod
10. Locknut--Fuel Rod Knob
11. Seal--Fuel Rod Oil
12. Spacer--Fuel Rod
13. Disc--Fuel Rod
14. Spring--Shutdown
15. Spring--Fuel Rod
16. Collar--Fuel Rod
17. Knob--Fuel Rod
18. Screw--Load Limit
19. Nut--Load Limit Screw
21. Plug--Dummy Hole
22. Gasket--Plug
24. Shaft--Speed Adjusting
26. Copper Washer--Load Limit Screw
28. Plug--Subcap
29. Pin--Speed Adjusting Lever Roll
31. Lever--Floating
32. Fork--Spring
35. Pin--Spring Fork Wire
36. Bracket--Droop Adjusting
37. Screw--Bracket
40. Lever--Speed Adjusting
41. Pin--Cotter
42. Shaft--Terminal Lever
44. Plug--Housing Cap
45. Piston--Power
46. Screw--Maximum Speed Adjusting
47. Nut--Adjusting Screw
48. Spring--Speeder
49. Ball Head Assy.
50. Plunger--Pilot Valve
51. Bearing--Plunger
52. Lock Ring
53. Plug--Oil Inlet
54. Gasket--Plug
55. Sleeve--Relief Valve Plunger
56. Spring--Sleeve Retaining
58. Plunger--Relief Valve
59. Base--Governor
60. Screw--Base to Housing
61. Ring--Housing to Base Seal
62. Gear--Oil Pump Drive
63. Gear--Oil Pump Driven
64. Lever--Terminal
65. Pin--Terminal Lever to Piston
66. Pin--Terminal Lever Cross
67. Spring--Retracting (Syn. Motors Only)

Fig. 10 - Hydraulic Governor Details and Relative Location of Parts (Current)

© 1984 General Motors Corp.

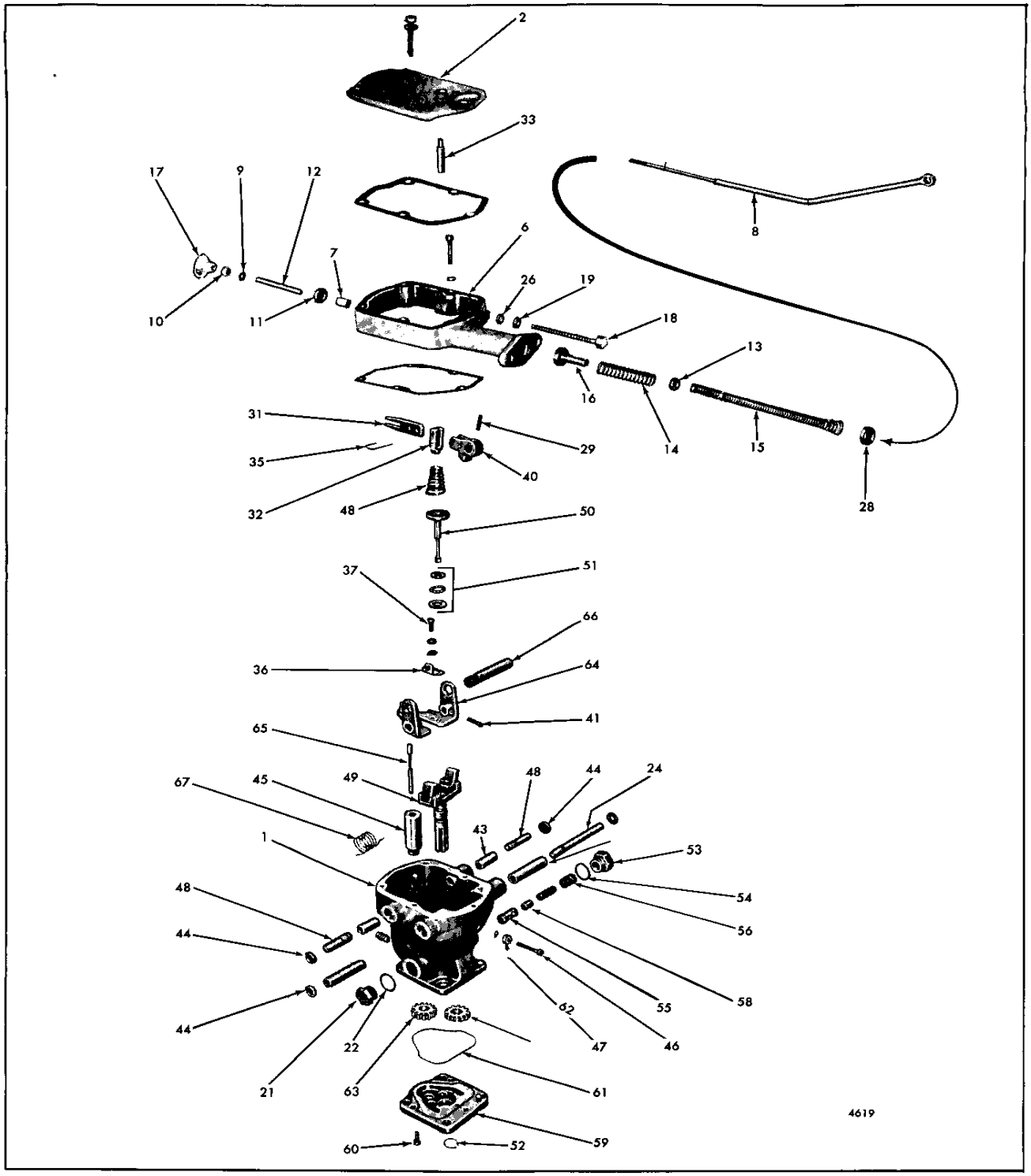


Fig. 10 - Hydraulic Governor Details and Relative Location of Parts (Current)

© 1984 General Motors Corp.

1. Housing--Governor
2. Cover--Governor
6. Subcap
7. Bushing--Subcap
8. Rod--Fuel
12. Spacer--Fuel Rod
13. Disc--Fuel Rod
14. Spring--Shutdown
15. Spring--Fuel Rod
16. Collar--Fuel Rod
17. Knob--Fuel Rod
18. Screw--Load Limit
19. Nut--Load Limit Screw
21. Plug--Dummy Hole
22. Gasket--Plug and Sleeve
24. Shaft--Speed Adjusting
26. Copper Washer--Load Limit Screw
31. Lever--Floating
32. Fork--Spring
35. Pin--Spring Fork Wire
36. Bracket--Droop Adjusting
37. Bolt--Bracket
40. Lever--Speed Adjusting
41. Pin--Cotter
42. Shaft--Terminal Lever
44. Plug--Sleeve
45. Piston--Power
46. Screw--Maximum Speed Adjusting
47. Nut--Adjusting Screw
48. Spring--Speeder
49. Ball Head Assy.
50. Plunger--Pilot Valve
51. Bearing--Plunger
52. Lock Ring
58. Valve Assy.--Relief
59. Base--Governor
60. Screw--Fil. Head
61. Ring--Housing to Base Seal
62. Gear--Oil Pump Drive
63. Gear--Oil Pump Driven
64. Lever--Terminal
68. Gasket--Relief Valve
69. Sleeve--Speed Adjusting Shaft
70. Gasket--Sleeve
71. Cap--Speed Adjusting Shaft
72. Pin--Spring Fork
73. Washer--Copper
74. Nut--Stop Pin
75. Sleeve--Shaft

Fig. 12 - Hydraulic Governor Details and Relative Location of Parts (Former)

Disassemble Governor

Before removing any parts from the governor, wash the unit thoroughly in clean fuel oil, dry it with compressed air and inspect it for worn or damaged parts that may be repaired or replaced without completely disassembling the governor.

Governor disassembly need be carried out only as far as necessary to correct the difficulties which interfere with proper governor operation.

Refer to Figs. 1, 10 and 11 (current governor) or Figs. 2 and 12 (former governor) for the location of the various parts.

Disassemble the governor subcap as follows:

1. Loosen the fuel rod knob locknut (10) and remove the knob (17) and nut from the fuel rod (8).

2. Slide the fuel rod gasket (9) off of the fuel rod and pull the spacer (12) out of the subcap and off of the fuel rod.

3. Pull the fuel rod out of the subcap and remove the fuel rod collar (6), shutdown spring (14), fuel rod disc (13) and the fuel rod spring (15) from the subcap.

4. Loosen the load limit adjusting screw locknut (19) and remove the load limit screw (18), nut and copper washer (26) from the subcap.

5. If necessary, remove the fuel rod oil seal (11) and the subcap plug (28) from the subcap.

6. Examine the fuel rod bushing in the subcap. If the bushing is worn or damaged, press it out of the subcap with an arbor press.

Current Governor

1. Remove the terminal lever cross pin (66) from the arms of the terminal lever (64).

2. Refer to Fig. 3 and remove the nut, lock washer and bolt securing the governor control lever to the speed adjusting shaft; then, remove the lever and the retracting spring from the shaft.

3. If necessary, remove the oil inlet elbow from the governor housing oil inlet plug.

4. Clamp the governor housing and base assembly in a bench vise equipped with soft jaws (Fig. 13).

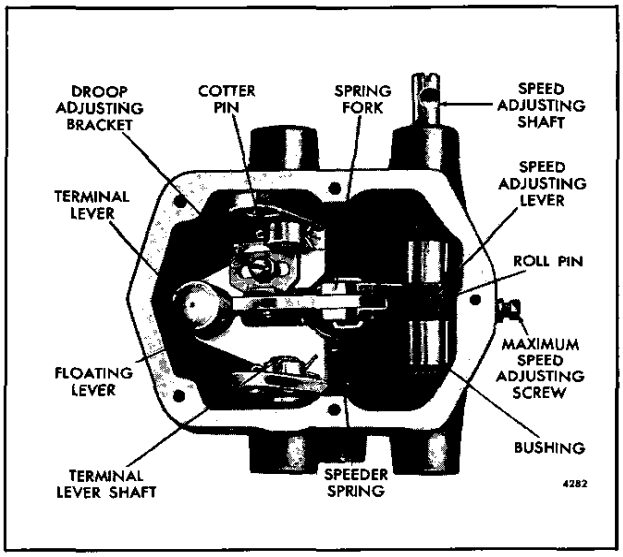


Fig. 11 - Top View of Governor With Subcap Removed

© 1984 General Motors Corp.

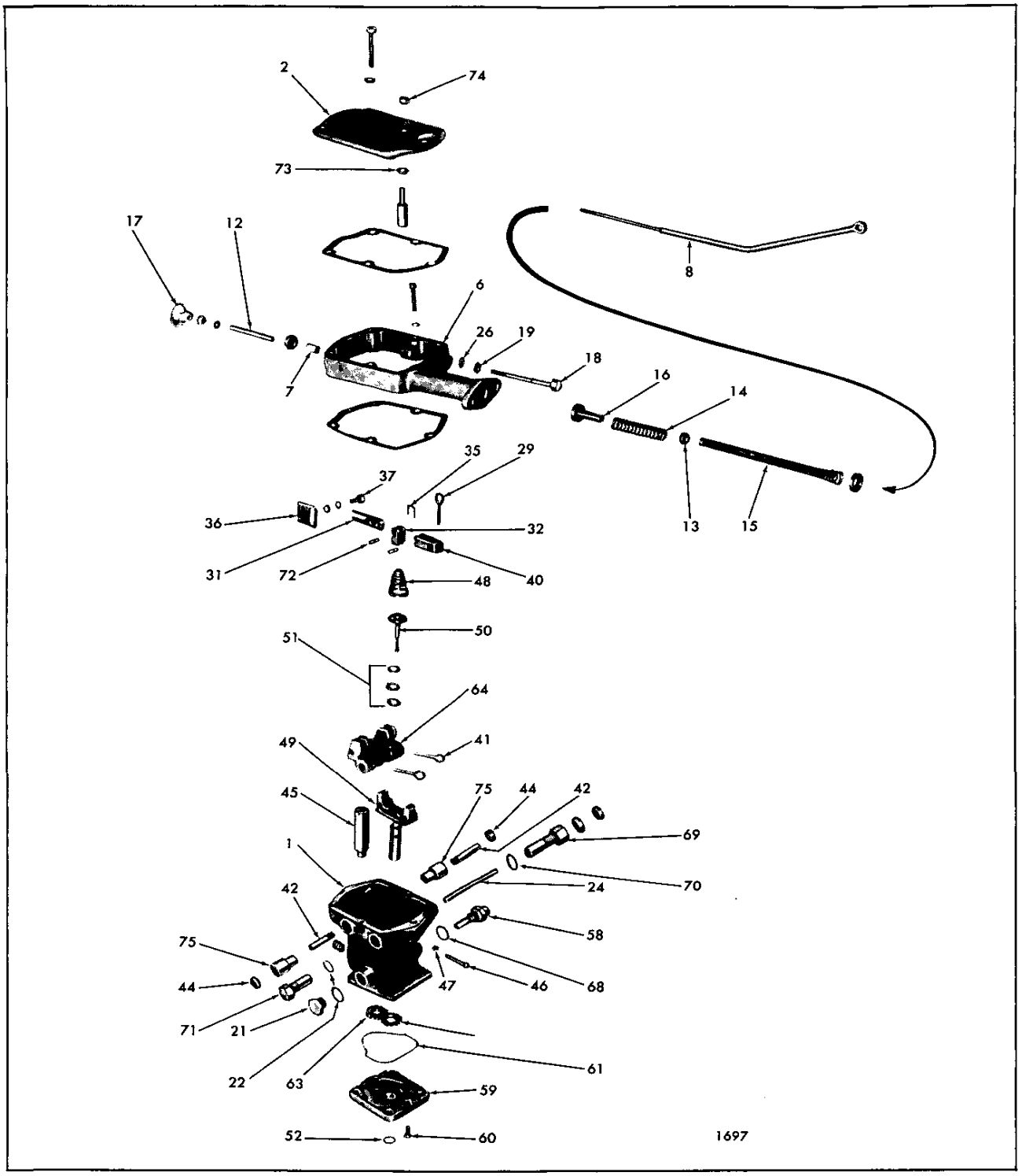


Fig. 12 - Hydraulic Governor Details and Relative Location of Parts (Former)

© 1984 General Motors Corp.

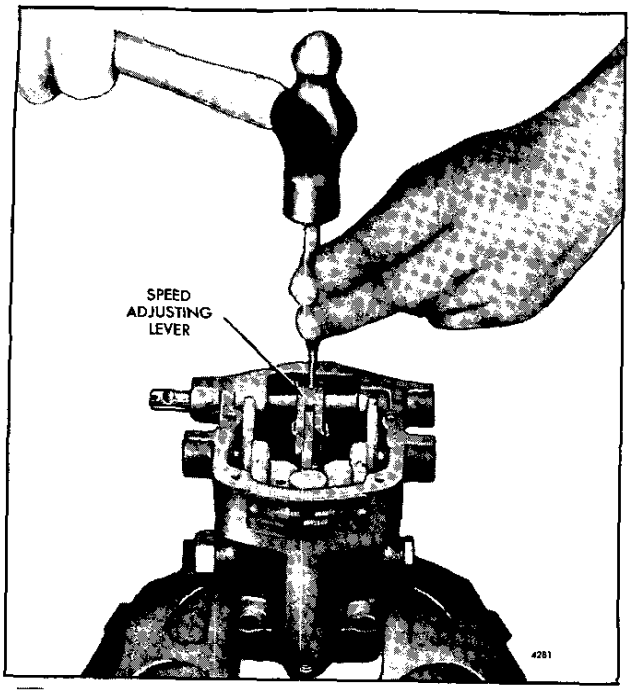


Fig. 13 - Removing Speed Adjusting Lever Roll Pin

5. On a governor equipped with a synchronizing motor, remove the end of the speed adjusting lever retracting spring from the hole in the side of the speed adjusting lever (40), using a pair of small nose pliers.

6. Loosen the maximum speed adjusting screw locknut (47) and remove the adjusting screw (46) from the governor housing.

NOTE: If the maximum speed adjusting screw (46) is not removed, the speed adjusting lever spring pin will hit the screw when it is being removed from the adjusting lever.

7. Remove the speed adjusting lever roll (spring) pin (29) from the speed adjusting lever and the lever shaft with a small punch and hammer (Fig. 13).

8. Note and record the position of the groove in the outside diameter of the speed adjusting lever shaft to ensure the groove will be installed in the same position at the time of assembly. Then, pull the shaft out of the speed adjusting lever and governor housing.

9. Remove the speed droop adjusting bracket screw, lock washer and plain washer from the terminal lever; then, remove the droop adjusting bracket (36) from the speed adjusting floating lever (31) and the terminal lever (64).

10. Lift the speed adjusting lever, floating lever, spring fork, speeder spring and pilot valve plunger as an assembly from the governor housing (Fig. 14).

11. Remove the pilot valve plunger thrust bearing (51) and the roll spring pin (29) from the governor housing.

12. On a governor equipped with a synchronizing motor, slide the speed adjusting lever retracting spring off of the speed adjusting shaft bushing and remove it from the housing.

13. If necessary, the speed adjusting lever (40), floating lever (31), spring fork (32), speeder spring (48) and pilot valve plunger and spring seat assembly may be disassembled as follows:

a. Straighten the bent end of the wire pin (35) securing the speed adjusting lever and spring fork to the speed adjusting floating lever.

b. Pull the pin out of the speed adjusting lever, floating lever and spring fork with a pair of pliers.

c. Insert a small screwdriver between the spring and fork and pry the speeder spring from the spring fork.

d. Work a small screwdriver around and under the speeder spring and remove the spring from the pilot valve plunger and spring seat assembly.

14. Remove the two cotter pins securing the terminal lever to the terminal lever shafts.

15. Place a 1/4″ brass rod, approximately 5″ long, against the inner end of the terminal lever shaft; then, drive the governor housing cup plug out of the boss at the side of the housing (Fig. 15).

NOTE: Use care when removing the cup plugs; do not damage the serrations inside the terminal lever with the brass rod.

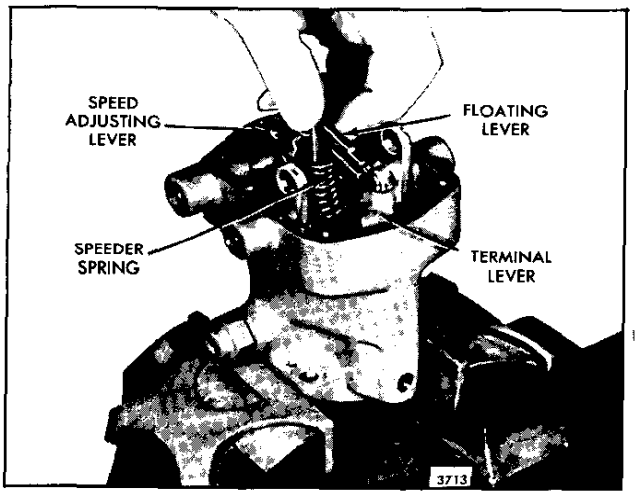


Fig. 14 - Removing Speed Adjusting Lever, Floating Lever, Spring Fork, Speeder Spring and Pilot Valve Plunger Assembly

© 1984 General Motors Corp.

16. Remove the remaining governor housing cup plug from the boss in the opposite side of the housing in the same manner as outlined in Step 15.

17. Push the terminal lever shafts out of the terminal lever and housing with the brass rod. Then, lift the terminal lever out of the housing.

18. Remove the terminal lever-to-power piston pin (65) from the piston.

20. Remove the governor housing from the bench vise. Turn the governor upside down and remove the power piston from the housing.

NOTE: It may be necessary to tap the face of the governor housing lightly against a wood block to jar the piston out of the housing.

20. Place the housing, bottom side up, on a bench.

21. Remove the lock ring (52) from the groove in the shaft of the ball head (49) with a pair of snap ring pliers; then, remove the ball head and flyweight assembly from the housing.

22. Remove the three screws (60) securing the governor base (59) to the governor housing (1).

23. Tap the edge of the governor base lightly with a plastic hammer to loosen it; then, remove the base and seal ring from the governor housing and dowel pins.

24. Remove the oil pump drive and driven gears (62) and (63) from the governor base or housing.

25. Clamp the bottom (square portion) of the governor housing between the soft jaws of a bench vise.

26. Remove the oil inlet plug (53), gasket (54), relief valve plunger sleeve retaining spring (56) and relief valve plunger spring (55) from the governor housing (1).

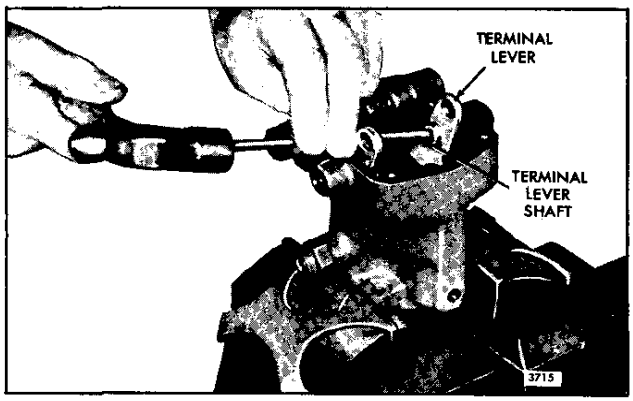


Fig. 15 - Removing Cup Plug from Governor Housing

27. Remove the dummy hole plug (21) and gasket (22) from the opposite side of the governor housing. Then, insert a small brass rod through the dummy hole opening and push the relief valve plunger (58) and the relief valve plunger sleeve (55) out of the governor housing. Catch the plunger and sleeve by hand when removing them.

NOTE: The relief valve plunger incorporates a No. 8-32 thread to facilitate the removal of the plunger from the housing, if required, without removing and disassembling the governor.

28. If necessary, remove the speed adjusting lever shaft hole plug in the governor housing by inserting a 1/4" brass rod through the shaft opening and tap the cup plug out of the housing with a hammer.

29. If necessary, remove the speed adjusting shaft oil seal from the governor housing.

Former Governor

1. Refer to Fig. 4 and remove the nut, lock washer and bolt securing the governor control lever to the speed adjusting shaft; then, remove the lever from the shaft.

2. Clamp the governor housing and base assembly in a bench vise equipped with soft jaws.

3. Loosen the maximum speed adjusting screw locknut (47) and remove the adjusting screw (46) and nut from the governor housing.

4. Remove the speed droop adjusting bracket bolt (37), lock washer and plain washer from the terminal lever; then, remove the droop adjusting bracket (36) from the speed adjusting floating lever (31) and terminal lever.

5. Remove the two cotter pins (41) securing the terminal lever (64) to the terminal lever shafts (42).

6. Drive on the lower edge of the terminal lever shaft sleeve cup plug with a small punch and hammer to force the upper edge out of the sleeve (Fig. 16). Then, pull the plug out of the sleeve with a pair of pliers.

7. Place a small rod, slightly curved on one end, against the inner end of the terminal lever shaft and push the shaft out of the terminal lever and shaft sleeve (Fig. 17).

8. Place a 1/4" rod, approximately 6" long, through the terminal shaft sleeve, terminal lever and against the end of the second terminal lever shaft. Then, drive the cup plug out of the terminal lever shaft sleeve in the opposite side of the governor housing with a hammer.

© 1984 General Motors Corp.

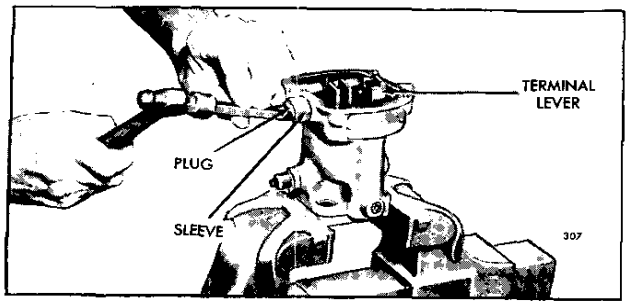


Fig. 16 - Removing Terminal Lever Shaft Sleeve Plug

9. Push the terminal lever shaft out of the terminal lever and sleeve. Then, remove the rod and terminal lever from the housing.

10. Remove the speed adjusting shaft sleeve (69) and gasket from the governor housing. Then, remove the speed adjusting shaft cap (71) and gasket from the opposite side of the housing.

11. Remove the speed adjusting shaft, floating lever, spring fork, speeder spring, speed adjusting lever, pilot valve plunger and plunger bearing from the governor housing (Fig. 18).

12. If necessary, the speed adjusting shaft (24), speed adjusting lever (40), floating lever (31), spring fork (32), speeder spring (48) and pilot valve plunger and spring seat assembly may be disassembled as follows:

a. Remove the cotter pin securing the speed adjusting lever to the speed adjusting shaft and pull the shaft out of the lever.

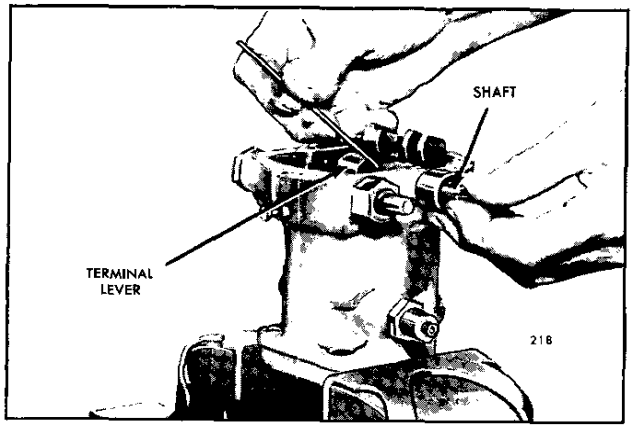


Fig. 17 - Removing Terminal Lever Shaft

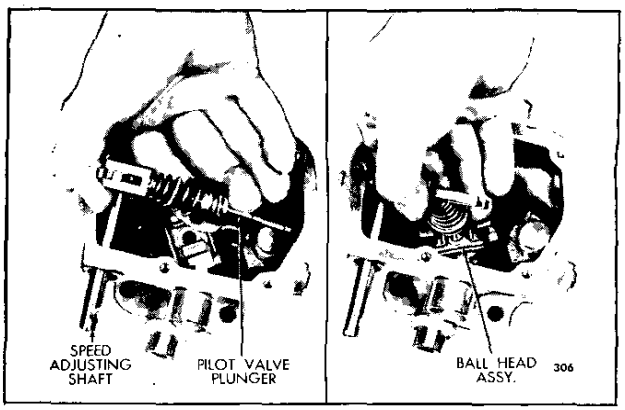


Fig. 18 - Removing or Installing Speed Adjusting Shaft, Lever, Floating Lever, Spring Fork, Speeder Spring and Pilot Valve Plunger

b. Straighten the bent end of the wire pin (35) securing the speed adjusting lever and spring fork to the speed adjusting floating lever.

c. Pull the wire pin out of the speed adjusting lever and floating lever with a pair of pliers. Then, remove the two spring fork pins from the spring fork, floating lever and speed adjusting lever.

d. Insert a small screwdriver between the spring and fork and pry the speeder spring from the spring fork.

e. Work a small screwdriver around and under the speeder spring and remove the spring from the pilot valve plunger and spring seat assembly.

13. Remove the relief valve assembly (58) and gasket from the side of the governor housing. Then, remove the dummy hole plug (22) and gasket from the opposite side of the housing.

14. Remove the governor housing from the bench vise. Turn the governor upside down and remove the power piston from the housing.

NOTE: It may be necessary to tap the face of the governor housing lightly on a wood block to jar the piston out of the housing.

15. Place the governor housing bottom side up on a bench.

16. Remove the lock ring (52) from the groove in the shaft of the ball head (49) with a pair of snap ring pliers; then, remove the ball head and flyweight assembly from the housing.

17. Remove the three screws (60) securing the governor base (59) to the governor housing.

© 1984 General Motors Corp.

18. Tap the edge of the governor base lightly with a plastic hammer to loosen it; then, remove the base and seal ring from the governor housing and dowel pins.

19. Remove the oil pump drive and driven gears (62) and (63) from the governor base or housing.

20. Inspect the terminal lever shaft sleeve bushings for wear or scoring and, if necessary, remove the sleeve and bushing assemblies from the governor housing as follows:

a. Clamp the bottom (square portion) of the governor housing between the soft jaws of a bench vise.

b. Insert a 5/16″ bolt, approximately 5″ long, through one of the terminal lever shaft sleeves, then thread a 5/16″ nut, approximately 1/4″ from the end, on the bolt inside of the housing.

c. Place the threaded end of the bolt inside the sleeve in the opposite side of the housing. Then, drive the sleeve and bushing assembly out of the governor housing with a hammer.

d. Reverse the bolt in the governor housing and remove the remaining terminal lever shaft sleeve and bushing assembly.

21. If necessary, remove the pipe plug in the forward face of the governor housing.

Inspection

Wash all of the governor parts in clean fuel oil and dry them with compressed air.

Examine the pilot valve plunger and its bore in the ball head for scoring and burrs. If slightly scored, the area may be cleaned up with a fine india stone. Care must be used to prevent stoning flat areas and rounding off the edges of the plunger.

Examine the oil pump gears and the driven gear bushing for excessive wear and damage.

Examine the power piston and its cylinder (bore) in the governor housing for scoring and burrs. If slightly scored, the areas may be cleaned up with a fine india stone. Care must be used to prevent stoning flat areas and rounding off the edges of the piston.

Examine the ends of the power piston-to-terminal lever pin for wear and scoring. If slightly scored, clean the ends up with a fine india stone. Also, check the pin seats in the terminal lever and power piston for wear and scoring.

Examine the ends of the terminal lever cross pin and the holes in the terminal lever for wear and scoring.

Examine the outside diameter of the ball head and its bore in the governor housing for scoring and burrs. If slightly scored, the areas may be cleaned up with a fine india stone. Care must be used to prevent flat areas and rounding off the edges of the ball head. The current pilot valve plunger has two oil holes to provide additional lubrication to the pilot valve thrust bearings.

NOTE: The pilot valve plunger, power piston and ball head assembly must operate freely in their respective bores.

Examine the pilot valve thrust bearing for excessive wear and flat spots.

Inspect the finished radius (thrust bearing contact surfaces) of the flyweights for excessive wear or flat spots. The flyweights must operate freely on their support pins for satisfactory governor operation.

Inspect the terminal lever and speed adjusting lever shaft bushings in the governor housing. If scored or worn excessively, replace the bushings.

Examine the face of the fuel rod collar where it contacts the terminal lever cross pin for scoring and wear.

Examine the speed adjusting floating lever, spring fork, speed adjusting lever and spring fork pins for scoring and wear.

Examine the relief valve plunger and the inside diameter of the plunger sleeve for wear, scratches and sludge in the grooves and holes in the plunger and sleeve. The plunger in the former governors did not incorporate four relief holes and the sleeve and washer were separate pieces. Do not mix the former and current plunger and sleeve in a governor.

Inspect the bushings in the terminal lever and speed adjusting shaft sleeve in a former governor.

Check the speed adjusting lever retracting spring for fractured coils.

Examine the shutdown and fuel rod springs for fractured coils.

Inspect the fuel rod bushing and oil seal for excessive wear.

Replace all of the governor parts that are excessively worn or damaged.

© 1984 General Motors Corp.

Assemble Governor (Current)

Refer to Figs. 1 and 10 and assemble the governor as follows:

1. If removed, install new speed adjusting lever and terminal shaft bushings in the governor housing to the specified dimensions shown in Fig. 19.

2. Lubricate the two oil pump gears (62) and (63) and place them in their respective positions in the governor base (59) - (Fig. 10).

3. Place a new seal ring (61) in the groove of the governor base, with the wide side of the seal down in the groove.

4. Set the governor housing (1) on the base with the dowels in the base registering with the holes in the housing and the driven gear stud in the housing registering with the hole in the driven gear. Press the housing down against the base seal ring.

5. Lubricate the outside diameter of the ball head with engine oil; then, insert the end of the ball head and flyweight assembly straight into and through the bore of the governor housing, drive gear and base.

NOTE: It is important when installing the drilled driven gear stud that it be installed with the mark on the stud pointing towards the relief valve side of the governor. Also, that the shaft of the arrow is parallel to a line through the center of the governor and the relief valve.

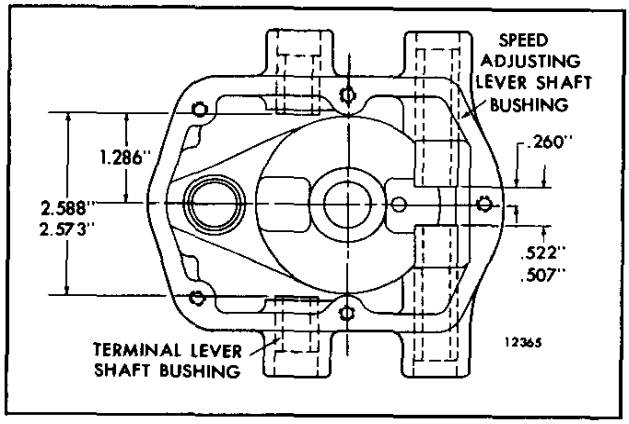


Fig. 19 - Location of Speed Adjusting Lever and Terminal Lever Shaft Bushing in Governor Housing

6. Insert three screws (60) through the governor base and thread them into the governor housing. Turn the ball head assembly while tightening the screws to make sure the ball head assembly revolves freely.

If a bind exists, loosen the screws, tap the sides of the base lightly with a plastic hammer and tighten the screws again. Revolve the ball head assembly again and check for bind. Repeat, if necessary, until all parts rotate freely.

NOTE: To install a current design governor base (59) on a former design housing (1) or a former design base on a current design housing, No. 3 taper dowel pins must be used. Refer to Fig. 20 for fabrication of tools necessary to properly align the base and the housing and proceed as follows:

a. Position the dummy gear over the idler gear stud.

b. Position the base against the governor housing and align them with the tapered arbor.

c. Enlarge the dowel pin holes to .200"-.212" diameter and taper ream to allow for a No. 3 tapered pin. Always drill from the base to the housing and be sure the tapered pin is flush with the bottom of the governor mounting flange.

7. Install the ball head lock ring (52) in the groove of the ball head shaft with a pair of snap ring pliers.

8. Refer to Fig. 21 and install the relief valve plunger, plunger sleeve, plunger retaining spring, sleeve retaining spring, oil inlet plug and dummy plug in the governor housing as follows:

a. Lubricate the outside diameter of the relief valve plunger and plunger sleeve with engine oil. Then, insert the relief valve plunger inside of the plunger sleeve.

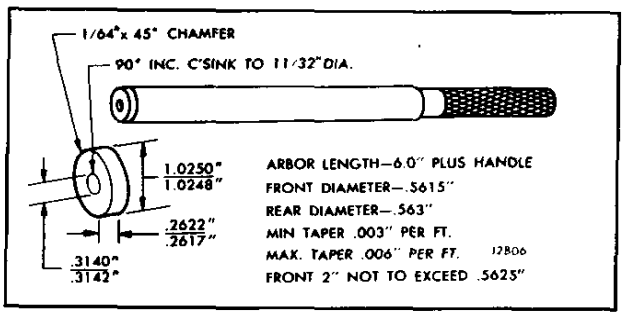


Fig. 20 - Fabrication of Governor Housing-to-Base Alignment Tool

© 1984 General Motors Corp.

b. Determine the type of governor being assembled, right-hand or left-hand, then insert the relief valve plunger and sleeve assembly straight into the proper opening in the side of the governor housing, with the tapped hole in the relief valve plunger facing out, and push it in against the shoulder in the housing.

c. Place the relief valve plunger spring and the plunger sleeve retaining spring in the housing and against the plunger and sleeve.

d. Place a gasket on the oil inlet plug, then place the plug over the ends of the springs and thread it into the governor housing.

e. Place a gasket on the dummy hole plug and thread it into the opening in the opposite side of the governor housing.

f. Clamp the bottom (square portion) of the governor housing between the soft jaws of a bench vise. Then, tighten the oil inlet plug and dummy hole plug securely.

9. Lubricate the power piston (45) with engine oil, then insert the piston, small end down, straight into the piston bore in the governor housing and push it in until it bottoms.

10. Install the terminal lever (64), terminal lever shafts (42), cotter pins (41) and cup plugs (44) in the governor housing as follows:

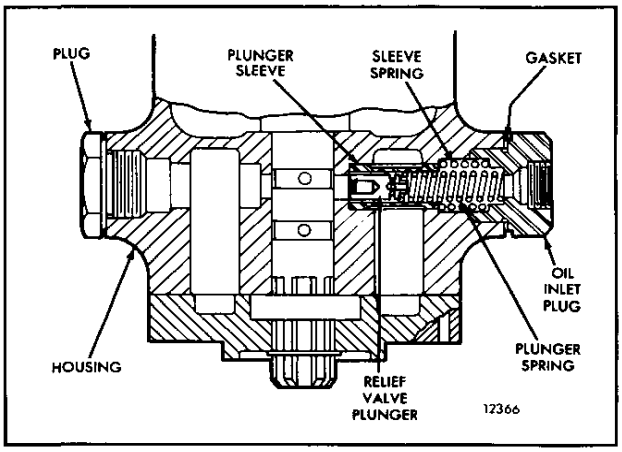


Fig. 21 - Location of Oil Relief Valve Plunger, Plunger Sleeve, Springs, Oil Inlet Plug and Dummy Plug in Governor Housing (R.H. Governor Shown)

a. Clamp the governor housing and base assembly in a bench vise equipped with soft jaws.

b. Lubricate one of the terminal lever shafts (42) with engine oil. Place the terminal lever in between the ends of the two bushings inside of the governor housing; then insert the serrated end of the shaft into the bushing in the housing with the cotter pin holes in the shaft and terminal lever in alignment (Fig. 22). Push the shaft into the lever until the two holes are in alignment.

c. Install a cotter pin through the terminal lever and shaft and bend the ends over against the side of the terminal lever.

d. Install the second terminal lever shaft in the housing and terminal lever at the opposite side of the governor housing in the same manner as outlined in Steps b and c.

e. Apply a thin coat of sealing compound to the outside diameter of a new governor housing cup plug (44). Start the plug, open end out, straight into one of the shaft openings, then press the plug in flush with the outside face of the housing boss.

f. Install the second new governor housing cup plug in the boss at the opposite side of the housing in the same manner as described in Step e.

11. Lubricate the terminal lever-to-power piston pin (65) with engine oil. Raise the edge of the terminal lever and insert the pin in the hole in the power piston, then lower the terminal lever down on the pin.

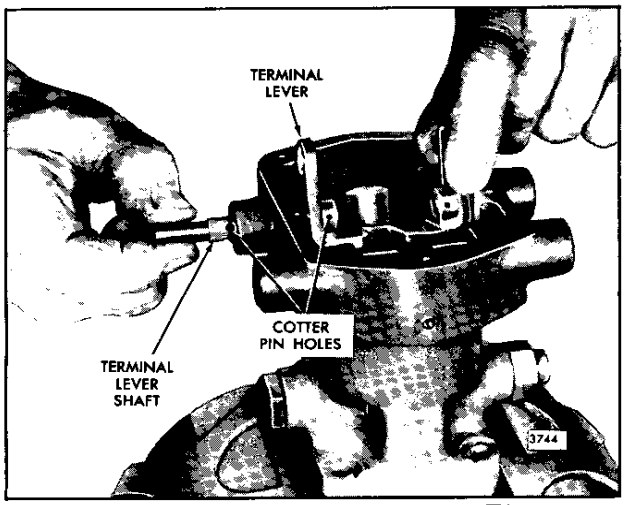


Fig. 22 - Installing Terminal Lever Shaft in Governor Housing and Terminal Lever

© 1984 General Motors Corp.

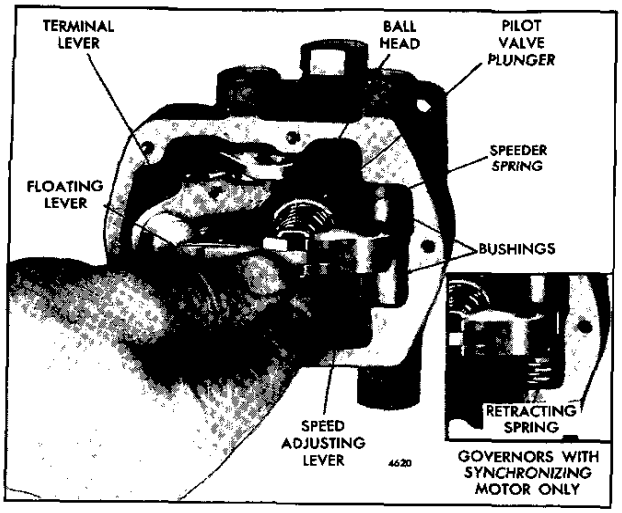


Fig. 23 - Installing Speed Adjusting Lever, Floating Lever, Speeder Spring and Pilot Valve Plunger Assembly

15. Lubricate the pilot valve plunger thrust bearing (51) with engine oil and place it over the end of the pilot valve plunger with the smallest, outside diameter, bearing race next to the spring seat (Fig. 1).

16. Lubricate the pilot valve plunger with engine oil. Then, hold the thrust bearing against the spring seat and insert the assembly in the governor housing with the speed adjusting lever facing the two bushings inside the housing (Fig. 23). Start the pilot valve plunger straight into the bore of the ball head and push the assembly in until the speed adjusting lever is in position between the two bushings and the thrust bearing is resting on the lip of the flyweights (Fig. 1).

17. Install the speed adjusting lever shaft (24), roll (spring) pin (29) and cup plug (44) in the governor housing as follows:

a. Clamp the governor housing and base assembly in a bench vise equipped with soft jaws.

b. Lubricate the speed adjusting lever shaft with engine oil. Rotate the shaft so the machined slot in the outside diameter of the shaft is in the same position it was in at the time of removal. Then, insert the shaft in the shaft bushing in the housing, from the oil inlet plug side, with the roll pin hole in the shaft and lever in alignment (Fig. 24).

c. While holding the speed adjusting lever, push the shaft through the bushing, lever and into the second shaft bushing until the pin holes are in alignment.

12. If disassembled, the speed adjusting lever (40), floating lever (31), spring fork (32), speeder spring (41) and the pilot valve plunger (50) may be assembled as follows:

a. Place the non-slotted end of the speed adjusting floating lever (31) in the slot on the speed adjusting lever (40) so the pin holes are in alignment (Fig. 1).

b. Insert the long end of the speed adjusting lever-to-floating lever wire pin through the pin hole in the speed adjusting lever and floating lever (Fig. 8).

c. Place the speed adjusting floating lever (31) in the slot of the spring fork (32) with the pin holes in alignment, then, insert the short end of the wire pin (35) through the hole in the spring fork and the floating lever.

d. Push the wire pin in against the speed adjusting lever and spring fork and bend the protruding end of the pin over toward the slotted end of the floating lever.

e. Press the lower end of the spring fork (32) into the small end of the speeder spring (41); then, insert the opposite end of the spring in the spring seat of the pilot valve plunger (50).

13. Remove the governor housing from the bench vise and place it on its side, oil inlet plug side up, on a work bench with the top of the housing facing out.

14. On a governor equipped with a synchronizing motor, place the speed adjusting lever retracting spring over the speed adjusting lever shaft bushing in the governor housing, with the hooked end of the spring over the slot between the two shaft bushings (see inset in Fig. 23).

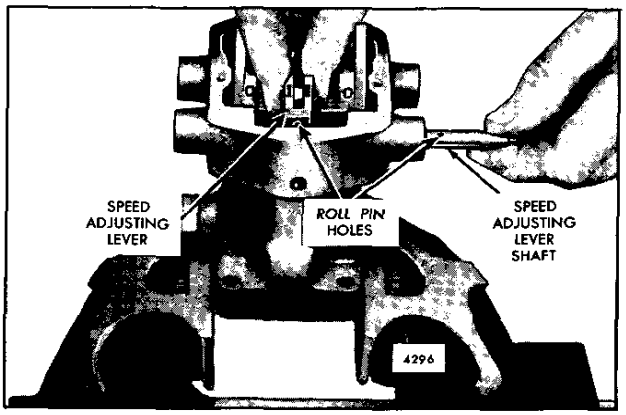


Fig. 24 - Installing Speed Adjusting Lever Shaft in Governor Housing and Adjusting Lever

© 1984 General Motors Corp.

NOTE: On a governor equipped with a synchronizing motor, be sure the hooked end of the speed adjusting lever retracting spring is on top of the speed adjusting lever before installing the shaft (see inset in Fig. 23).

d. Start the speed adjusting lever roll (spring) pin (29) straight into the pin hole in the lever; then, tap the pin through the lever and shaft until it is flush with the top of the lever.

e. On a governor equipped with a synchronizing motor, rotate the speed adjusting lever retracting spring clockwise around the shaft bushing and insert the hooked end of the spring in the small hole in the side of the speed adjusting lever with a pair of small nose pliers.

f. If removed, apply a thin coat of sealing compound to the outside diameter of the speed adjusting lever shaft cup plug (44). Start the plug, open end out, straight into the boss in the opposite side of the governor housing, then press the plug in flush with the edge of the boss.

g. If removed, apply a thin coat of sealing compound to the outside diameter of the speed adjusting shaft oil seal. Place the oil seal, lip of seal facing in, over the end of the speed adjusting shaft and start it in the bore in the housing, then press the seal in flush with the edge of the boss.

18. Place the flat side of the speed droop adjusting bracket (36) against the top (bolting) surface of the terminal lever, with the pin in the bracket in the slot of the speed adjusting floating lever (31). Secure the bracket to the terminal lever with a flat washer, lock washer and screw (37).

19. If removed, thread the locknut (47) on the maximum speed adjusting screw (46). Place the copper washer on the adjusting screw, then thread the screw approximately half way in the governor housing (Fig. 1).

20. Install the terminal lever cross pin through the pin holes of the terminal lever, with the fuel rod slot in the pin facing up (Fig. 8).

Assemble Governor (Former)

Refer to Figs. 2 and 12 and assemble the governor as follows:

1. If removed, install the terminal lever shaft sleeve and bushing assemblies in the governor housing as follows:

a. Place a support plate, the proper length, between the inside faces of the housing adjacent to each terminal lever shaft sleeve opening.

b. Support the governor housing on its side on the bed of an arbor press so it is level.

c. Start the small end of the terminal lever shaft sleeve straight in the opening in the housing, then press the sleeve in the housing until the shoulder on the sleeve contacts the housing.

d. Reverse the governor housing on the bed of the arbor press and install the remaining terminal lever shaft sleeve. Then, remove the support plate.

2. If removed, install the pipe plug in the governor housing.

3. Lubricate the two oil pump gears (62) and (63) with engine oil, and place them in their respective positions in the governor base (59).

4. Place a new seal ring (61) in the groove in the governor base, with the wide side of the seal down in the groove.

5. Set the governor housing (1) on the base with the dowels in the base registering with the holes in the housing and the idler gear stud in the housing registering with the hole in the idler gear. Press the housing down against the seal ring in the base.

NOTE: It is important when installing the driven gear stud that it be installed with the arrow on the stud pointing towards the relief valve side of the governor. Also, that the shaft of the arrow is parallel to a line through the center of the governor and the relief valve.

6. Lubricate the outside diameter of the ball head and flyweight assembly with engine oil; then, insert the end of the ball head straight into and through the bore of the governor housing, drive gear and base.

7. Insert the three screws (60) through the governor base and thread them into the governor housing. Turn the ball head assembly while tightening the three screws to make sure the ball head assembly revolves freely.

If a bind exists, loosen the screws, tap the sides of the base lightly with a plastic hammer, and tighten the screws again. Revolve the ball head assembly again and check for bind. Repeat, if necessary, until all parts rotate freely.

NOTE: To install a current design governor base (59) on a former design housing (1) or a former design base on a current design housing, No. 3 tapered dowel pins must be used. Refer to

© 1984 General Motors Corp.

Fig. 20 for fabrication of tools necessary to properly align the base and the housing and proceed as follows:

a. Position the dummy gear over the idler gear stud.

b. Position the base against the governor housing and align them with the tapered arbor.

c. Enlarge the dowel pin holes to .200"-.212" diameter and taper ream to allow for a No. 3 tapered pin. Always drill from the base to the housing and be sure the tapered pin is flush with the bottom of the governor mounting flange.

8. Install the ball head lock ring (52) in the groove in the ball head shaft with a pair of snap ring pliers.

9. Determine the type of governor being assembled, right-hand or left-hand, then place a new gasket (68) on the relief valve assembly (58) and thread it into the proper opening in the side of the governor housing.

10. Place a new gasket (22) on the dummy hole plug (21) and thread it into the opening in the housing opposite the relief valve assembly.

11. Clamp the bottom (square portion) of the governor housing between the soft jaws of a bench vise. Then, tighten the relief valve assembly and dummy hole plug securely.

12. Lubricate the power piston (45) with engine oil; then insert the piston, small end down, straight into the piston bore in the governor housing and push it in until it bottoms.

13. If disassembled, refer to Figs. 2 and 12 and assemble the speed adjusting lever (40), floating lever (31), spring fork (32), speeder spring (48), pilot valve plunger (50) and speed adjusting shaft (24) as follows:

a. Place the non-slotted end of the speed adjusting floating lever (31) in the slot of the speed adjusting lever (40) so the pin holes are in alignment.

b. Insert the pin (72) through the pin holes in the levers, with the small pin hole in the pin and floating lever in alignment, then insert the long end of the wire pin (35) through the floating lever and pin.

c. Place the speed adjusting floating lever in the slot of the spring fork (32) so the pin holes are in alignment.

d. Insert the second pin (72) through the pin holes in the spring fork and floating lever, with the small pin hole in the pin and floating lever in alignment, then insert the short end of the wire pin through the floating lever and pin. Push the wire pin in against the floating lever and bend the long end of the wire pin over against the floating lever.

e. Insert the serrated end of the speed adjusting shaft (24) into the speed adjusting lever with the cotter pin hole in the shaft and lever in alignment and the machined slot in the non-splined end of the shaft in the same position it was in at the time of removal. Align the pin holes in the shaft and lever and install the cotter pin. Bend the ends of the cotter pin over.

f. Press the lower end of the spring fork (32) into the small end of the speeder spring (48); then insert the large end of the spring in the spring seat of the pilot valve plunger (50).

14. Lubricate the pilot valve plunger thrust bearing (51) with engine oil and place it over the end of the pilot valve plunger with the smallest, outside diameter, bearing race next to the spring seat.

15. Hold the bearing against the bottom of the spring seat (Fig. 18) and start the end of the speed adjusting shaft through the proper opening, relief valve assembly side, in the governor housing. Then, start the end of the pilot valve plunger straight in the opening in the ball head assembly and push it in until the bearing race rests on the flyweights.

NOTE: Do not damage the plunger by applying undue pressure.

On a governor equipped with a synchronizing motor, place the speed adjusting lever retracting spring over the speed adjusting lever shaft and place the hooked end of the spring over the top of the speed adjusting lever before installing the assembly in the governor housing.

16. If removed, apply a thin coat of sealing compound to the outside diameter of the new speed adjusting shaft oil seals, then press the oil seals in the speed adjusting shaft sleeve with the lip of the inner seal facing down and the lip of the outer seal facing up.

17. Place a gasket (70) on the speed adjusting shaft sleeve (69). Lubricate the speed adjusting shaft with engine oil, then start the small end of the sleeve over the end of the shaft and thread it into the governor housing. Tighten the sleeve securely.

18. Place a gasket (22) on the speed adjusting shaft cap (71) and thread the cap into the opposite side of the governor housing, and over the end of the speed adjusting shaft. Tighten the cap securely.

19. On a governor equipped with a synchronizing motor, rotate the speed adjusting lever retracting spring clockwise around the shaft sleeve and insert the hooked end of the spring in the small hole in the side of the speed adjusting lever with a pair of small nose pliers.

© 1984 General Motors Corp.

20. Install the terminal lever (64), terminal lever shafts (42), cotter pins (41) and cup plugs (44) in the governor housing as follows:

a. Place the flat side of the droop adjusting bracket (36) against the inside face of the terminal lever boss (Fig. 2) and secure it to the terminal lever with a flat washer, lock washer and bolt.

b. Place the terminal lever between the ends of the terminal lever shaft sleeves in the governor housing with the convex bearing surface resting on the power piston and the droop adjusting bracket pin in the slot of the floating lever (31) - (Fig. 2).

c. Lubricate one of the terminal lever shafts with engine oil. Insert the serrated end of the shaft into the bushing in the sleeve with the cotter pin holes in the shaft and terminal lever in alignment (Fig. 25). Push the shaft into the lever until the two holes are in alignment.

d. Install a cotter pin through the terminal lever and shaft and bend the ends over against the side of the terminal lever.

e. Install the second terminal lever shaft in the sleeve and terminal lever at the opposite side of the governor housing in the same manner as outlined in Steps c and d.

f. Apply a thin coat of sealing compound to the outside diameter of a new terminal lever shaft sleeve cup plug (44). Start the plug, open end out, straight into one of the shaft sleeves; then, press the plug in flush with the end of the sleeve.

g. Install the second new terminal lever shaft sleeve cup plug in the sleeve at the opposite side of the housing in the same manner as outlined in Step f.

21. If removed, thread the locknut (47) on the maximum speed adjusting screw (46). Place the copper washer on the adjusting screw, then thread the screw approximately half way in the governor housing (Fig. 2).

Assemble Governor Subcap

1. If removed, press a new fuel rod bushing (7) in the subcap, flush with the bottom of the counterbore. Then, press a new fuel rod oil seal, with the lip of the seal facing out, straight in and against the bottom of the counterbore in the subcap.

2. If removed, apply a thin coat of sealing compound to the outside diameter of a new governor subcap cup plug. Start the plug, open end out, straight into the plug opening; then, press the plug in against the shoulder in the bore of the subcap.

3. Insert the threaded end of the fuel rod (8) through the hole in the cup plug in the projecting end of the subcap.

4. Place the large end of the fuel rod spring (15) over the threaded end of the fuel rod and push it in against the cup plug in the subcap.

5. Place the fuel rod disc (13), large outside diameter end first, over the threaded end of the fuel rod and against the fuel rod spring.

6. Place the shutdown spring (14) over the end of the fuel rod and over the end of the fuel rod disc (13).

7. Place the fuel rod collar (16), small outside diameter end first, over the end of the fuel rod and inside the shutdown spring.

8. Push the fuel rod through the bushing in the subcap, then slide the fuel rod spacer (12) over the end of the fuel rod and through the bushing in the subcap.

9. Push the fuel rod through the spacer until the threads on the end of the fuel rod are through the spacer. Then, install the gasket, locknut and fuel rod knob on the end of the fuel rod.

10. If removed, thread a locknut (19) on the load limit screw (18). Place the copper washer (26) over the end of the load limit screw, then thread the screw into the subcap until the end protrudes approximately 1/8" through the second boss inside the subcap (Fig. 8).

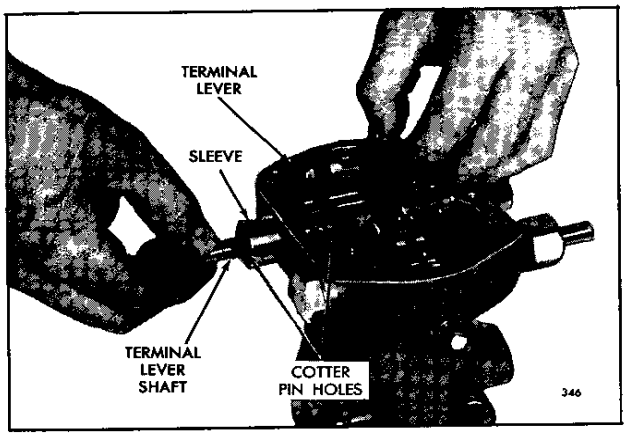


Fig. 25 - Installing Terminal Lever Shaft in Governor Housing and Terminal Lever

© 1984 General Motors Corp.

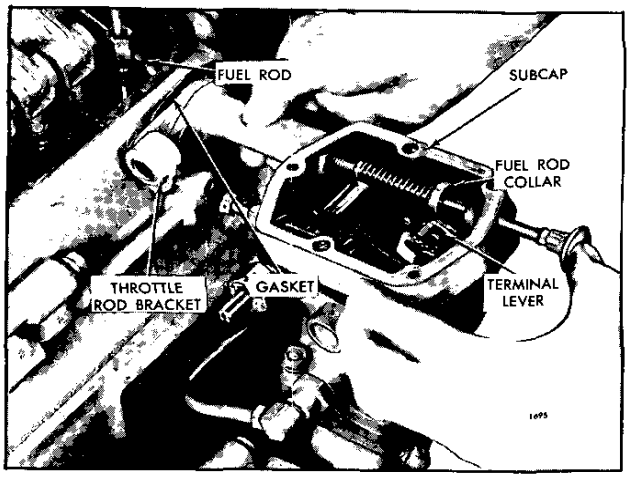


Fig. 26 - Installing Governor Subcap

Install Governor

Refer to Figs. 3 and 4 and proceed as follows:

1. Loosen the six governor drive housing-to-blower cover bolts.

2. Affix a new gasket to the top of the governor drive housing.

3. Position the governor over the drive housing with the maximum speed adjusting screw facing the cylinder head. Turn the ball head assembly slightly to align the splines of the ball head shaft with the splines in the driven shaft sleeve; then, enter the shaft straight in the sleeve and rest the governor housing on the gasket.

4. Install the four governor to to drive housing bolts and lock washers. Tighten the bolts to 13-17 lb-ft (18-23 Nm) torque.

5. Affix a new subcap to governor housing gasket to the top face of the housing.

6. Affix a new gasket to both sides of the throttle control rod mounting bracket, then place the bracket over the end of the throttle control rod.

7. Start the fuel rod through the opening in the throttle control rod mounting bracket and the cylinder head.

Push in on the fuel rod knob (current governor) and at the same time lower the subcap down on the governor housing so that the fuel rod enters the slot in the terminal lever cross pin and the fuel rod collar rests in the front side of the collar adjacent to the side of the terminal lever (Fig. 8).

Push in on the fuel rod knob (former governor) and at the same time lower the subcap down on the governor housing so that the fuel rod enters the slot in the terminal lever and the fuel rod collar rests against the front finished surface of the terminal lever (Fig. 26).

8. Install the two subcap to governor housing screws and lock washers. Tighten the screws securely.

9. Insert the two bolts and lock washers through the subcap bolting flange and throttle control rod mounting bracket and thread them into the cylinder head. Tighten the bolts to 7-9 lb-ft (10-12 Nm) torque. Then, tighten the governor drive housing to blower cover bolts to 13-17 lb-ft (18-23 Nm) torque.

10. If removed, install the oil supply tube elbow in the governor oil inlet plug (current governor) or the relief valve assembly (former governor). Then, attach the oil inlet tube assembly to the elbow.

11. Refer to Fig. 3 (current governor) and place the control lever retracting spring over the end of the speed adjusting shaft with the hooked end of the spring facing out.

12. Place the control lever over the end of the speed adjusting shaft and install the bolt, lock washer and nut. Tighten the nut to 7-9 lb-ft (10-12 Nm) torque.

13. Place the throttle link over the end of the control lever and install the link pin and cotter pin, if used.

14. On current governors, place the straight end of the retracting spring on top of the boss at the side of the housing. Then, hook the opposite end of the spring over the control lever (Fig. 3).

On former governors, hook the end of the speed adjusting shaft retracting spring in the hole in the link pin.

15. Connect the fuel rod to the injector rack control tube lever with a pin and a cotter pin.

16. Pour approximately one pint of engine lubricating oil in the top of the governor to provide initial governor lubrication.

17. Affix a new gasket to the top of the governor subcap. Place the governor cover on top of the gasket and install the three screws and lock washers. Tighten the screws securely.

18. On a governor equipped with a synchronizing motor, connect the wires to the motor.

19. Position the injector control racks and make the final governor adjustments as outlined under *Engine Tune-Up Procedures* in Section 14.

© 1984 General Motors Corp.

PSG HYDRAULIC GOVERNOR

The PSG hydraulic governor is the isochronous hydraulic type with speed droop stabilization (Fig. 1). Hydraulic action is transmitted by oil which is admitted under pressure from the engine lubricating system to an auxiliary oil pump in the governor. The pump then develops the oil pressure necessary to actuate the governor mechanism.

The isochronous feature of this governor is its ability, at zero droop, to hold the engine at a constant speed regardless of the load, providing the load is within the rated capacity of the power generator.

The mechnical connection of the governor to the fuel injectors is by means of a fuel rod attached to a lever on the injector control tube.

The governor operates in such a manner that fuel supplied to the injectors is decreased by action of a fuel rod spring and increased by the opposing action of the hydraulic operated power piston. Admission of oil under the power piston is controlled by the vertical movement of the pilot valve plunger. This plunger is in turn, controlled by the flyweights. The flyweight ball head is mounted on the pilot valve bushing.

Rotation of the governor is accomplished by the upper blower rotor through an integral horizontal drive shaft and bevel gear and an integral vertical driven shaft and bevel gear both mounted on ball bearings and retained in a drive housing.

In starting a cold engine, considerable time is required for the lubricating oil pressure to become sufficient to operate the governor and thus move the injector control racks to the full-fuel position so the engine can start. Since this delay in starting is considered objectionable, the starting time can be shortened by pressing in on the knob which is threaded on the fuel rod and projects from the side of the governor subcap. The inward movement of this knob takes the control of the injector fuel racks away from the governor.

The engine can be stopped in a similar manner, regardless of the governor, by pulling out on the fuel rod knob.

In addition to its function of holding the engine speed constant under varying load conditions, the hydraulic governor acts as an automatic shutdown device in the event of lubricating oil pressure failure. Should the engine fail to supply oil to the governor, the power piston will drop, thus allowing the fuel rod to return to the no-fuel position.

Operation

With the engine operating, oil from the engine lubricating system is admitted to the space around the drive and driven oil pump gears. The gears raise the oil pressure to a value determined by the spring in the relief valve (14) opposing the relief valve plunder. The oil, now under pressure, is maintained in the annular space between the undercut portion of the pilot valve plunger (12) and the bore in the pilot valve bushing (21) (Fig. 2).

For any given throttle setting, the speeder spring (10) has a definite compression value which is opposed by the centrifugal force of the flyweights (13). When these two forces are equal, the control land (20) on the pilot valve plunger (12) covers the lower ports in the pilot valve bushing (21).

Under these conditions equal oil pressures are maintained on both sides of the buffer piston (16) and tension on the two buffer springs (15 and 17) is equal. Also, the oil pressure is equal on both sides of the receiving compensating land (19) of the pilot valve plunger, due to oil passing through the compensating needle valve (18). Thus, the hydraulic system is in balance and engine speed remains constant.

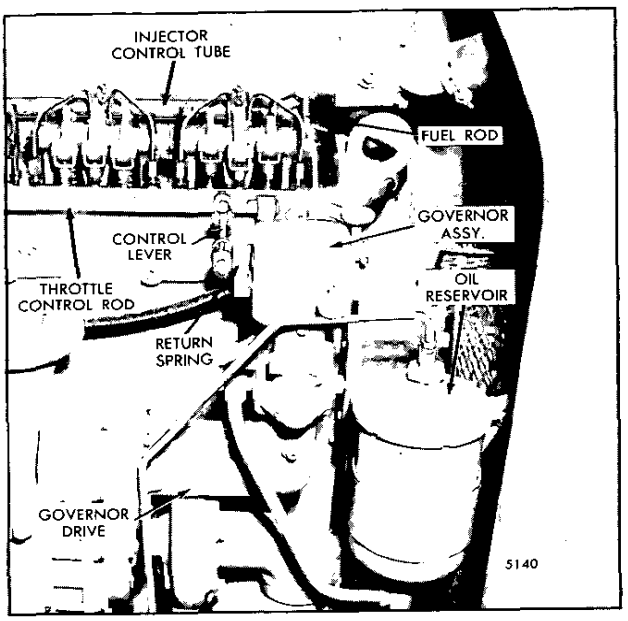
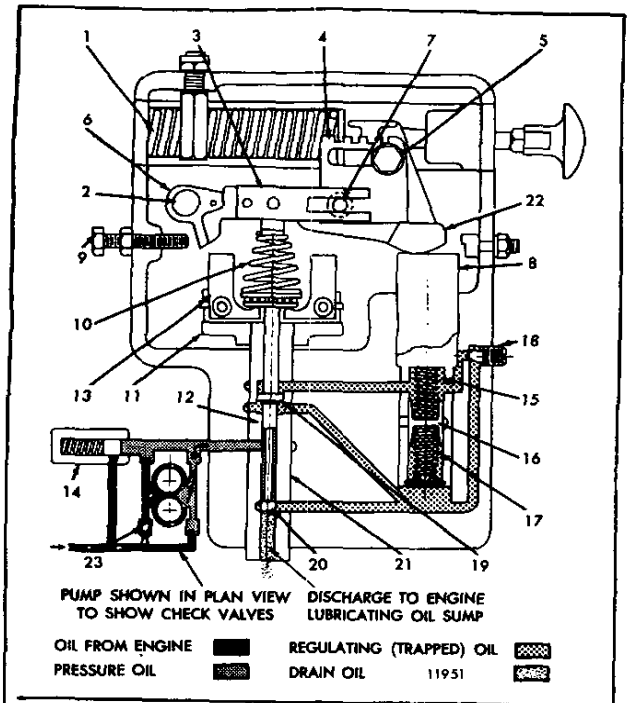


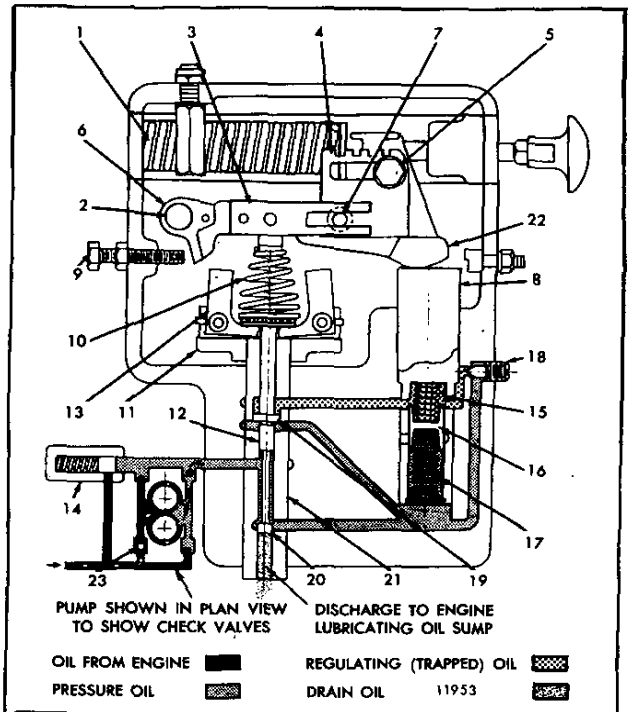
Fig. 1 - Typical PSG Hydraulic Governor Mounting

© 1983 General Motors Corp.



1. Spring--Fuel Rod
2. Shaft--Speed Adjusting
3. Lever--Speed Adjusting Floating
4. Bracket--Droop Adjusting
5. Bolt
6. Lever--Speed Adjusting
7. Shaft--Terminal Lever
8. Piston--Power
9. Screw--Maximum Speed Adjusting
10. Spring--Speeder
11. Ball Head Assy.
12. Plunger--Pilot Valve
13. Flyweight
14. Valve Assy.--Relief
15. Spring--Buffer (Upper)
16. Piston--Buffer
17. Spring--Buffer (Lower)
18. Valve--Compensating Needle
19. Land--Receiving Compensation
20. Land--Pilot Valve Control
21. Bushing--Pilot Valve
22. Lever--Terminal
23. Valve--Check

Fig. 2 - Stable Position of Governor when Load on Engine is Constant



1. Spring--Fuel Rod
2. Shaft--Speed Adjusting
3. Lever--Speed Adjusting Floating
4. Bracket--Droop Adjusting
5. Bolt
6. Lever--Speed Adjusting
7. Shaft--Terminal Lever
8. Piston--Power
9. Screw--Maximum Speed Adjusting
10. Spring--Speeder
11. Ball Head Assy.
12. Plunger--Pilot Valve
13. Flyweight
14. Valve Assy.--Relief
15. Spring--Buffer (Upper)
16. Piston--Buffer
17. Spring--Buffer (Lower)
18. Valve--Compensating Needle
19. Land--Receiving Compensating
20. Land--Pilot Valve Control
21. Bushing--Pilot Valve
22. Lever--Terminal
23. Valve--Check

Fig. 3 - Position of Governor Mechanism as Load Increases and Engine Speed Tends to Decrease

Now refer to Fig. 3 and assume that a load increase is applied to the engine. The engine speed will momentarily drop and the governor flyweights (13) will be forced inward, thus lowering the pilot valve plunger (12). Oil under pressure will be admitted under the power piston (8) causing it to rise. This upward motion of the power piston will be transmitted through the terminal lever (22) and the fuel rod to the injector control tube, causing the fuel setting of the engine to be increased.

Oil, forcing the power piston (8) upward also forces the buffer piston (16) upward because the oil pressure on the two sides of the buffer piston are unequal.

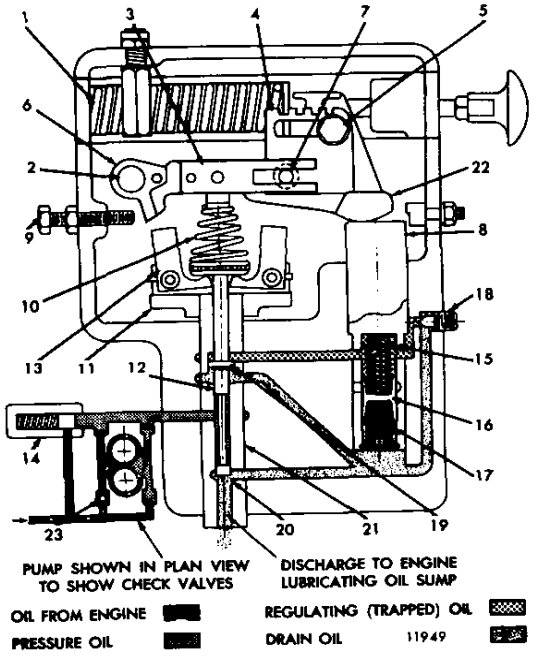
This upward motion of the piston compresses the buffer spring (15) and relieves the pressure on the lower buffer spring (17).

The oil cavities above and below the buffer piston (16) (Fig. 3) are common to the receiving compensating land (19) on the pilot valve plunger (12). Since the high pressure is below the compensating land, the pilot valve plunger is forced upward, recentering the flyweights and causing the control land (20) of the pilot valve to close off the regulating port; thus the upward movement of the power piston stops when it has moved far enough to make the necessary fuel correction.

© 1983 General Motors Corp.

Oil passing through the compensating needle valve (18) equalizes the pressures above and below the buffer piston, thus allowing the piston to return to its center position which in turn equalizes the pressure above and below the receiving compensating land (19). The pilot valve plunger then moves to its central position and the engine speed returns to its original setting because there is no longer any excessive outward force on the flyweights.

Fig. 4 illustrates the governor reaction as the load on the engine is decreased and engine speed returns to normal. With a load decrease the engine speed will momentarily increase and the flyweights will move outward thus raising the pilot valve plunger.



1. Spring--Fuel Rod
2. Shaft--Speed Adjusting
3. Lever--Speed Adjusting Floating
4. Bracket--Droop Adjusting
5. Bolt
6. Lever--Speed Adjusting
7. Shaft--Terminal Lever
8. Piston--Power
9. Screw--Maximum Speed Adjusting
10. Spring--Speeder
11. Ball Head Assy.
12. Plunger--Pilot Valve
13. Flyweight
14. Valve Assy.--Relief
15. Spring--Buffer (Upper)
16. Piston--Buffer
17. Spring--Buffer (Lower)
18. Valve--Compensating Needle
19. Land--Receiving Compensating
20. Land--Pilot Valve Control
21. Bushing--Pilot Valve
122. Lever--Terminal
123. Valve--Check

Fig. 4 - Position of Governor Mechanism as Load Decreases and Engine Speed Tends to Increase

This allows oil below the buffer piston (and below the receiving compensating land) to flow to the drain passage, thus reducing the pressure on the lower side of the buffer piston and on the lower side of the receiving compensating land. This allows a downward movement of the power piston which is transmitted through the terminal lever to the fuel rod, resulting in a fuel correction to the injectors.

The compensating mechanism described produces stable operation by permitting the governor to move instantaneously in response to a load change and make the necessary fuel adjustment to maintain the initial engine speed.

The speed changes previously described were the result of load changes. Similar governor movements occur through movement of the governor control lever. Movement of the control lever (through the vernier control and connecting linkage) changes the tension on the speeder spring (10) thus causing the pilot valve plunger (12) to raise or lower.

Lubrication

Oil passes up through a drilled passage in the pilot valve plunger and is directed at the thrust bearing from where it is vaporized by rotation of the flyweights, resulting in sufficient lubrication of the upper moving parts. Governor pump gears, pilot valve plunger, power piston and buffer piston are all exposed to pressurized oil. Oil which collects on the floor of the governor passes through a drilled passage into the governor drive housing, thus lubricating the governor drive shaft, drive shaft bearing, driven shaft and driven shaft bearing.

Surplus oil returns to the engine crankcase through connecting drilled passages in the blower end plate and cylinder block.

Remove Governor from Engine (Fig. 1)

1. Remove the cotter pin and withdraw the clevis pin that holds the fuel rod to the injector control tube lever.

2. Disconnect the oil pressure line at the governor relief valve.

3. Remove the clevis pin and separate the throttle control link from the control lever.

4. Remove the two subcap-to-cylinder head attaching bolts.

5. Remove the three governor cover bolts and separate the cover and cover gasket from the subcap.

© 1983 General Motors Corp.

6. Remove the two bolts holding the governor subcap to the governor housing.

7. Lift up on the subcap assembly until a definite snap indicates that the fuel rod has been freed from the terminal lever. Remove the subcap assembly, pulling the fuel rod out of the hole in the cylinder head. Remove the two gaskets.

8. Remove the four bolts (or nuts) and lock washers that secure the governor housing to the governor drive housing and then lift the governor away from the drive housing. Remove the gasket.

Install Governor on Engine

With the subcap removed from the governor housing, install the governor as follows:

1. Loosen the six governor drive-to-blower attaching bolts with tool J 4242.

2. Place a new gasket on the governor drive housing. Hold the governor so that the relief valve points toward the blower and position the governor over the drive housing. Turn the ball head assembly slightly to align the splines on the pilot valve bushing with the splines in the driven shaft sleeve. Then, set the governor down on the drive housing.

3. Secure the governor to the drive housing with four bolts and lock washers. Tighten the bolts uniformly. On earlier units, the governor was attached to the drive housing by four studs, lock washers and nuts.

4. Affix a new gasket to the top bolting flange of the governor housing.

5. Affix a new gasket on the subcap adaptor and between the cylinder head and the throttle control shaft bracket. Start the fuel rod through the hole in the control shaft bracket and cylinder head and lower the subcap assembly down on the governor housing. At the same time, press in on the fuel knob to allow the fuel rod to enter the slotted position of the terminal lever and the fuel rod collar to rest against the front working face of the terminal lever.

6. Secure the subcap to the governor housing with two bolts.

7. Install two bolts through the subcap adaptor, throttle control shaft bracket and into the cylinder head. Tighten the bolts securely.

8. Pour approximately one pint (1/2 liter) of lubricating oil in the governor housing for initial governor lubrication.

9. Connect the oil line to the relief valve.

10. Place a new gasket on top of the subcap and install the cover. Insert three bolts through the governor cover and subcap and into the governor housing. Tighten the bolts securely.

11. Refer to Fig. 1 and connect any governor control linkage previously removed.

12. Tighten the six governor drive-to-blower attaching bolts with tool J 4242.

© 1983 General Motors Corp.

HYDRAULIC GOVERNOR DRIVE

The governor drive assembly consists of an integral horizontal drive shaft and bevel gear and an integral vertical driven shaft and bevel gear, both mounted on ball bearings and contained in a governor drive housing (Fig. 1).

A second bearing is used on the horizontal drive shaft on six cylinder engines to provide additional support.

Drive to the horizontal shaft is through serrations on the shaft engaging with serrations in the upper blower rotor shaft. The governor proper is driven through splines on the lower end of the ball head registering with splines in the upper end of the driven shaft sleeve.

The bearing on the horizontal shaft is retained by two bolts, flat washers, and lock washers and on the vertical shaft by two set screws, flat washers, and lock washers. The drive housing flange at the drive shaft is gasketed and bolted to the blower front end cover, while the governor is gasketed and bolted to the drive housing at the driven shaft opening.

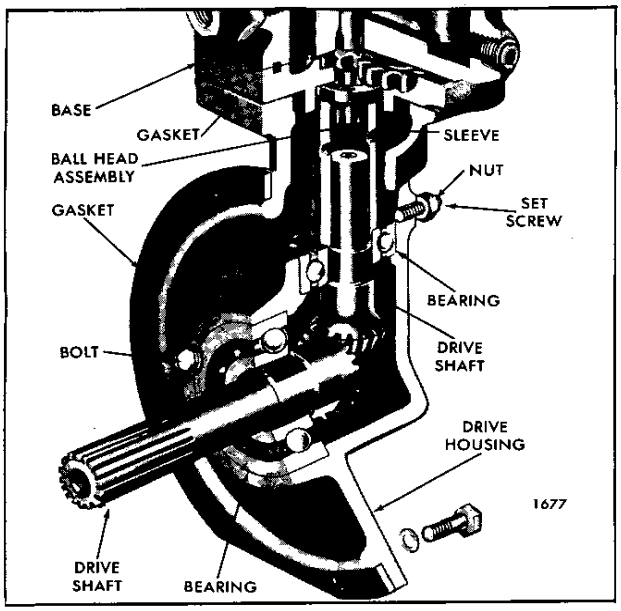


Fig. 1 - Governor Drive Assembly

Lubrication

Gears and bearings of the governor drive assembly are lubricated by surplus oil from the governor which spills over the moving parts and then returns to the engine crankcase through connnecting drilled passages in the blower front end plate and cylinder block.

If the governor fails to control the engine speed properly, the fault may lie in the governor drive. To function properly, the clearance between the bevel gears of the drive and driven shafts should not be less than .001″ or exceed .003″.

Remove Governor Drive

1. Remove the governor.

2. Remove the six drive housing to blower bolts and plain washers and withdraw the housing assembly from the blower.

Disassemble Governor Drive

1. Refer to Figs. 1 and 2 and remove the two bearing retaining bolts and two set screws.

2. Withdraw the horizontal drive shaft and bearing as an assembly from the drive housing.

The horizontal drive shaft in hydraulic governors used on six cylinder engines is supported in two bearings separated by a spacer; therefore, remove the shaft, bearings, and spacer as an assembly.

3. Withdraw the driven shaft, bearing and sleeve as an assembly from the drive housing.

4. If inspection of the drive and driven shaft bearings, as outlined below, indicate they should be replaced, rest

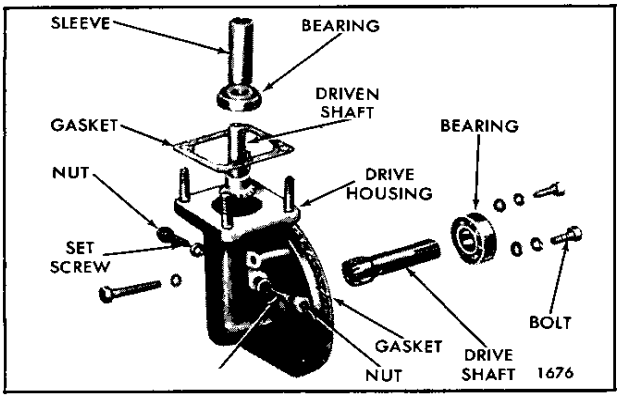


Fig. 2 - Governor Drive Details and Relative Location of Parts

© 1984 General Motors Corp.

the bearing on the bed of an arbor press and press the shaft from the bearing, using a brass bar between the ram of the press and the shaft.

Inspection

After the governor drive has been disassembled, wash all parts in clean fuel oil and dry them with compressed air.

Examine the gear teeth of the drive and driven shafts for chipping or scoring and, if either of these conditions exist, replace the shafts.

Revolve the bearings by hand to check for excessive wear, bind, or rough spots. If any of these conditions exist, install new bearings.

Slight end play is not objectionable in single row annular ball bearings, since they are built with that characteristic.

If inspection reveals the bearings are in good condition, lubricate them with clean engine oil prior to using.

Assemble Governor Drive

1. With the drive bearing properly supported on the bed of an arbor press, press the drive shaft into the bearing and against the shoulder on the shaft.

2. Start the driven bearing on the driven shaft followed by the sleeve, then with the sleeve properly supported on the bed of an arbor press, and using a brass bar between ram and gear, press the shaft into the bearing and sleeve.

3. Lower the driven shaft assembly into the governor drive housing from the top with the bearing resting on the shoulder in the housing.

4. Start a nut and flat washer on each retaining screw and thread the screws into the governor housing until they bottom on the outer race of the bearing (Fig. 1).

5. Install the horizontal drive shaft assembly in the governor housing with the drive bearing resting in the counterbore provided and with the teeth of the horizontal drive gear in mesh with the teeth on the vertical driven gear.

6. Place a lock washer and flat washer over each bearing retaining bolt and thread the bolts into the governor housing to secure the bearing.

Install Governor Drive

1. Affix a new gasket to the bolting flange of the governor drive housing, then start the serrations of the horizontal drive shaft into mesh with the serrations of the upper blower rotor shaft.

2. Set the drive housing in position against the blower end cover and attach it to the cover with six holes and plain washers. Do not tighten the bolts until the governor has been attached securely to the drive housing and the cylinder head.

3. Install the governor assembly.

© 1984 General Motors Corp.

HYDRAULIC GOVERNOR SYNCHRONIZING MOTOR

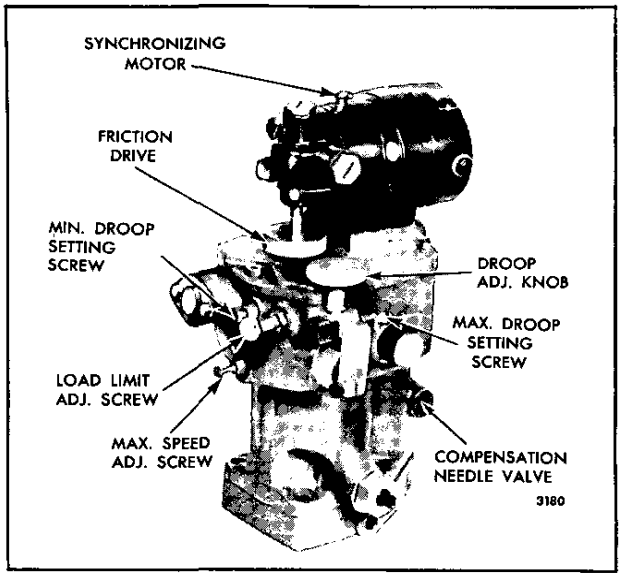


Fig. 1 - Typical Synchronizing Motor Mounting

Some hydraulic governors are equipped with a reversible electric synchronizing motor mounted on the governor cover (Fig. 1). This motor, used in place of a vernier control knob, permits close adjustment of the engine speed from a remote control point. This feature is especially valuable when synchronizing two generators from a central control panel.

The motor is connected to the source of electrical supply through a two-way switch (Fig. 2).

The friction drive components are assembled to the drive shaft of the current type synchronizing motor and extend down through the governor cover (Fig. 1). The speed adjusting screw of the friction drive is threaded into the governor cover and bears directly on the speed adjusting lever (Fig. 3).

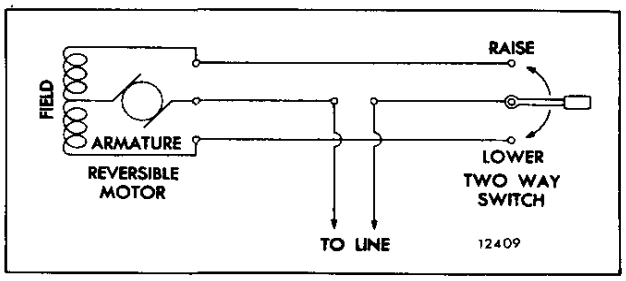


Fig. 2 - Synchronizing Motor Wiring Diagram

The former type synchronizing motor was assembled off-center on the governor cover with the motor drive shaft extending down to a point near the governor speed adjusting shaft (Fig. 4). The friction drive components were assembled to the governor speed adjusting shaft and the driving worm pinion was assembled to the end of the motor drive shaft (Figs. 5 and 6). The speed adjusting shaft was splined to conform with the internally splined speed adjusting lever of the governors using the former type synchronizing motor.

Operation

The synchronizing motor is used to change the engine speed when the unit is running alone, or to adjust the load when the unit is operating in parallel with other units.

When the two-way control switch on the control panel is closed, the motor shaft turns the governor speed adjusting shaft by means of the reduction gear and friction drive. The direction of rotation (clockwise or counterclockwise) is dependent upon the position of the switch. When the desired engine speed is indicated

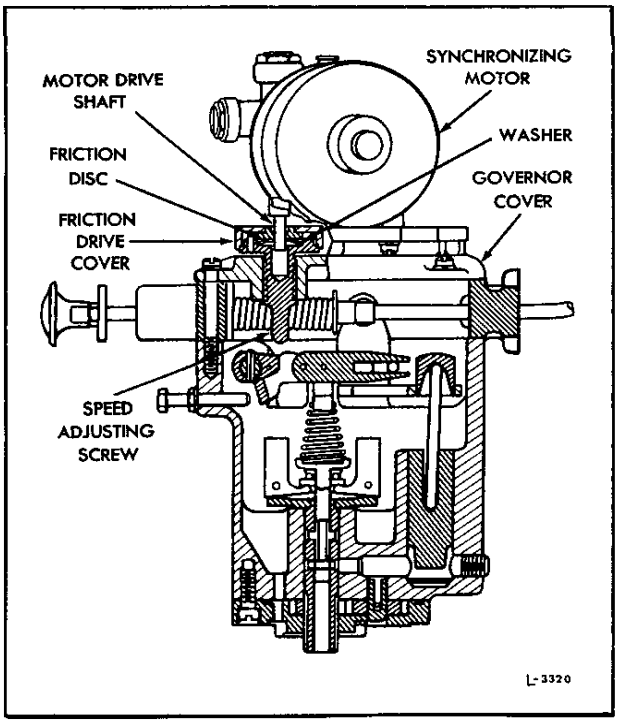


Fig. 3 - Friction Drive Assembly

© 1983 General Motors Corp.

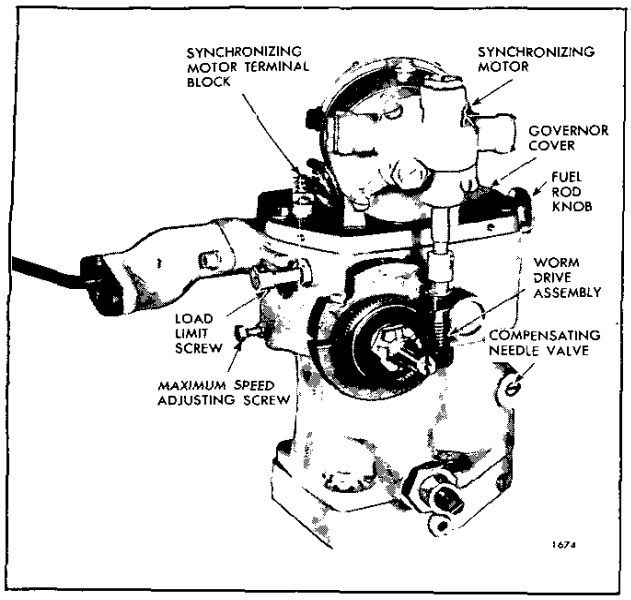


Fig. 4 - Former Synchronizing Motor Assembly

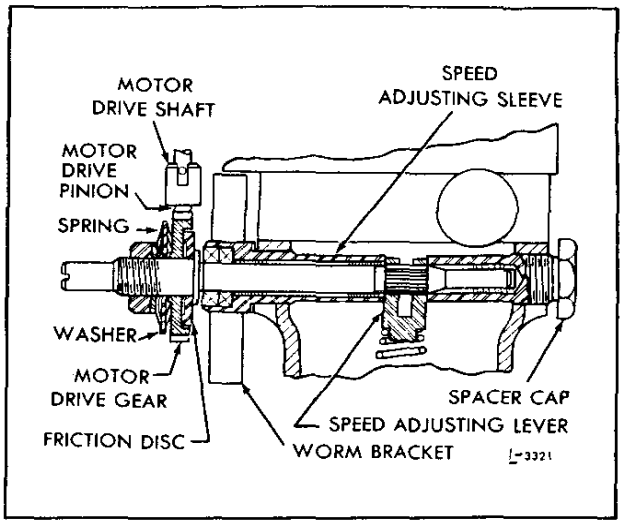


Fig. 5 - Former Friction Drive Assembly

on a tachometer or frequency meter on the control panel, the switch is returned to the OFF position by the operator.

If the switch is held in the LOWER speed position too long, the synchronizing motor will continue to lower the engine speed until it ultimately shuts the engine down. If the switch is held too long in the RAISE speed position, the motor will turn the governor speed adjusting shaft until it strikes the maximum speed adjusting screw, after which the friction drive will slip and the motor will continue to run at a slightly reduced speed without further effect.

Service

The synchronizing motor is constructed to render long satisfactory service. However, if the motor is damaged or fails to operate, replace the entire motor as an assembly.

The spring washer of the friction drive or slip-clutch must be strong enough to permit the motor to carry the speed adjusting lever up against the maximum speed adjusting screw without slipping, yet it must be loose enough to slip after the lever contacts the screw.

The early "Signal" synchronizing motors are no longer available and have been replaced by "Bodine" motors. To replace a "Signal" motor by a "Bodine" motor on units with the external worm gear drive, a new mounting plate is required. Service kits that include the motor, mounting plate and attaching parts are available.

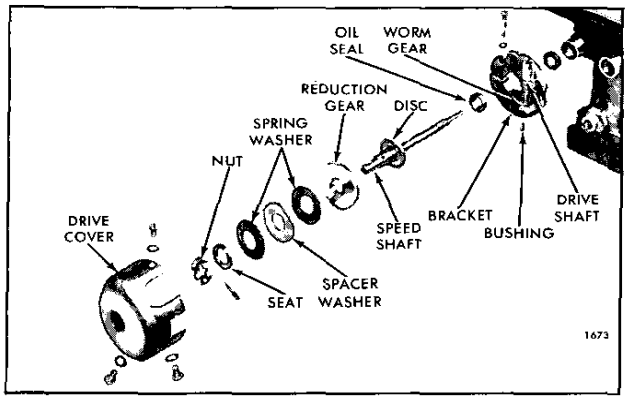


Fig. 6 - Former Speed Adjusting Shaft and Friction Clutch Details and Relative Location of Parts

© 1983 General Motors Corp.

FUEL INJECTOR CONTROL TUBE

The fuel injector control tube assembly is mounted on the cylinder head and consists of a control tube, injector rack control levers, a return spring and injector control tube lever mounted in two bracket and bearing assemblies attached to the cylinder head (Fig. 2).

The injector rack control levers connect with the fuel injector control racks and are held in position on the control tube with two adjusting screws. The return spring enables the rack levers to return to the no-fuel position. The injector control tube lever is pinned to the end of the control tube and connects with the fuel rod which connects with the engine governor. Refer to Section 14 for positioning of the injector rack control levers.

Certain engines use a spring-loaded injector control tube assembly (Fig. 1), similar to the above except it has a yield spring at each injector rack control lever and only one screw and locknut to keep each injector rack properly positioned. This enables an engine to be brought to a lesser fuel position if there is an inoperative fuel injector, whereas with the non-spring loaded two screw injector control tube this could not be done. The above also permits the use of an air inlet housing with no emergency air shutoff valve as is required in some applications.

> **NOTE:** Do not replace the spring-loaded fuel injector control tube and lever assembly with the two screw design control tube assembly without including an air inlet housing that incorporates an emergency air shutoff valve. However, when the spring-loaded fuel injector control tube and lever assembly is installed on an engine and the emergency shutdown mechanism is removed from the air inlet housing, the shaft holes at each end of the housing must be plugged. Ream the shaft holes to .6290" and install a 5/8" cup plug at each end of the housing.

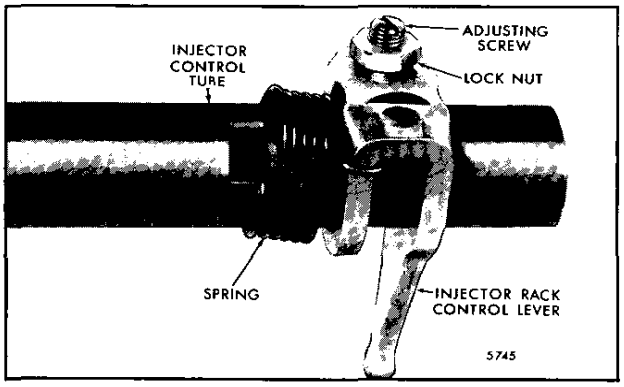


Fig. 1 - Injector Control Tube and Rack Lever (Spring-Loaded)

Engine shut down (normal or emergency) is accomplished on the spring-loaded fuel injector control tube (one screw design) by pulling the governor shutdown lever to the no-fuel position. With the two screw design injector control tube and lever assembly, emergency engine shutdown is accomplished by tripping the air shutoff valve in the air inlet housing. Normal shut down is accomplished by pulling the governor shutdown lever to the no-fuel position. Adjustment of the single screw and locknut on each injector rack control lever can be performed the same as for the two screw design rack control lever as outlined in Section 14.

Remove Injector Control Tube

1. Remove the cotter pin and clevis pin connecting the fuel rod to the injector tube control lever.

2. Remove the two attaching bolts and lock washers at each bracket. Disengage the rack levers from the injector control racks and lift the control tube assembly from the cylinder head.

Disassemble Injector Control Tube

The injector control tube, one mounting bracket, a spacer and injector control tube lever are available as a service assembly. When any part of this assembly needs replacing, it is recommended the complete service assembly be replaced. Therefore, the disassembly and assembly procedure for these items is not included in the following:

1. Remove the bracket from the injector control tube.

2. Loosen the adjusting screws or adjusting screw and locknut at each injector rack control lever.

3. With the spring-loaded injector control tube, disconnect the yield springs at each rack lever, then roll the yield springs out of the slots and notch of the control tube.

4. Disconnect the return spring from the bracket and front or rear rack lever.

5. Then, remove the yield springs and/or return spring and rack levers from the control tube.

© 1984 General Motors Corp.

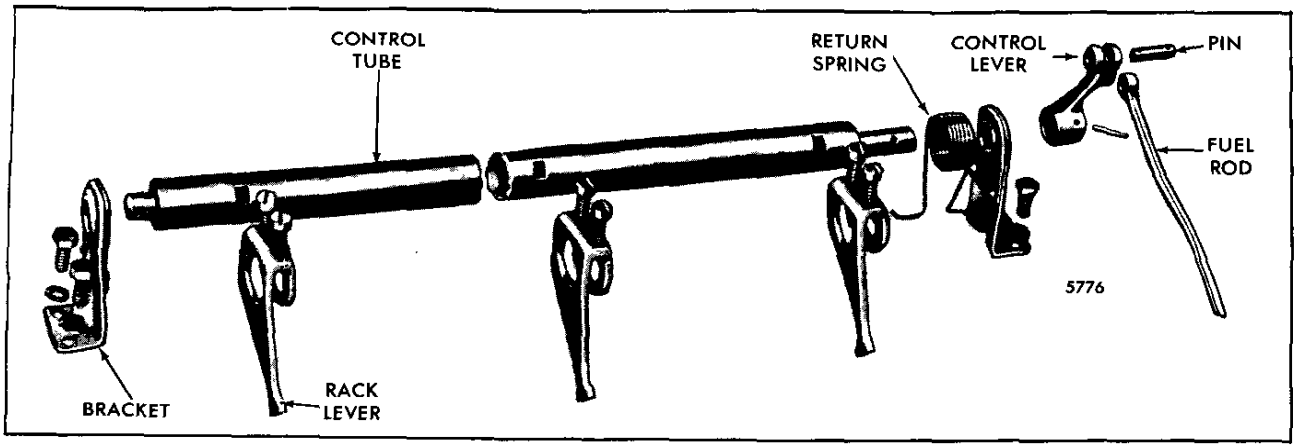


Fig. 2 - Injector Control Tube Assembly (Non-Spring Loaded)

Inspection

Wash all of the injector control tube parts in clean fuel oil and dry them with compressed air.

Examine the control tube, control lever, control tube rack control levers and brackets for excessive wear, cracks or damage and replace them, if necessary. The bearing in the bracket is not serviced separately. Examine the yield springs and/or return spring and replace them if worn or fractured.

Assemble Injector Control Tube

With all of the parts cleaned and inspected and the necessary new parts on hand, refer to Fig. 1 or 2 and assemble as follows:

Two Screw design injector control tube.

Install the rack control levers on the control tube, with the levers facing the front bracket position. Turn the adjusting screws into the slots in the control tube far enough to position the levers.

One Screw and Locknut design injector control tube.

Install the rack control levers with the levers facing the front bracket position and the R. H. helix yeild springs. Then, install the odd (L. H. helix) yield spring and rack control lever with the lever facing the front bracket position.

Attach the curled end of the yield springs to the rack control levers and roll the springs into the notch (odd yield spring) and the slots (R. H. helix yield springs) in the control tube. Then, turn the adjusting screws and locknuts into the notch and slots far enough to position the levers on the control tube.

2. On both designs, install the control tube return spring and front bracket on the control tube. Attach the curled end of the return spring to the rack control lever and the extended end of the spring behind the front bracket.

Indexing a New Replacement Control Lever to the Injector Control Tube

Use the following procedure to properly index and install a replacement control lever onto the injector control tube:

1. Remove the injector control tube from the engine. Then, loosen the adjusting screw for the rack lever closest to the control lever and slide the return spring and rack lever back 3 to 4 inches.

2. Fabricate an indexing bracket from a 5″ long piece of 1/2″ wide, 1/8″ thick bar stock (Fig. 3). Secure the indexing bracket to the control tube with a hose clamp (Fig. 4).

3. Insert a 1/4″ x 1-3/4″ L. bolt through the end of the control lever. Rotate the bracket and clamp until the bracket is resting against the bolt. Tighten the clamp to hold the bracket securely against the bolt. Make sure the indexing bracket cannot be moved.

4. Remove the pin from the control lever and press the old lever off the control tube (Fig. 5).

5. Reinsert the 1/4″ x 1-3/4″ L. bolt through the end of a new lever and press the lever onto the control tube with the bolt resting against the indexing bracket

© 1984 General Motors Corp.

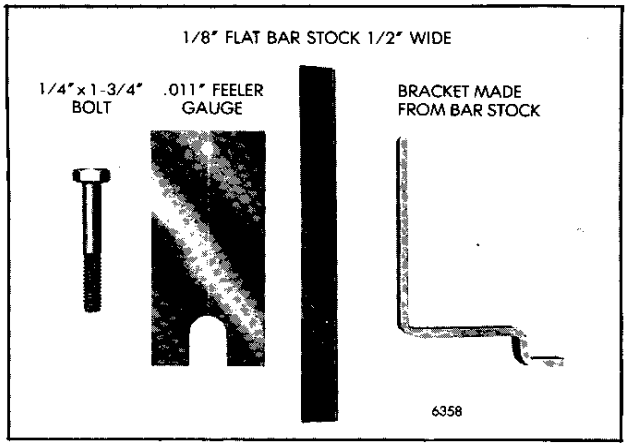


Fig. 3 - Fabricate Indexing Bracket

(Fig. 6). Place a .011" feeler gage under the lever to get proper clearance between the lever and the spacer on the control tube. Before pressing on the lever, make sure the opposite end of the control tube is supported.

6. Position the control tube on the table of a drill press and drill a 1/8" hole through the control lever approximately 45° from the location of the former hole. (Use the replaced lever for reference). After drilling, install a new pin.

7. Clean the control tube thoroughly and install on the engine. Adjust the injector racks as outlined in Section 14.3.

Install Injector Control Tube

1. Engage the injector rack control levers with the injector control racks and place the brackets over the mounting holes on the cylinder head.

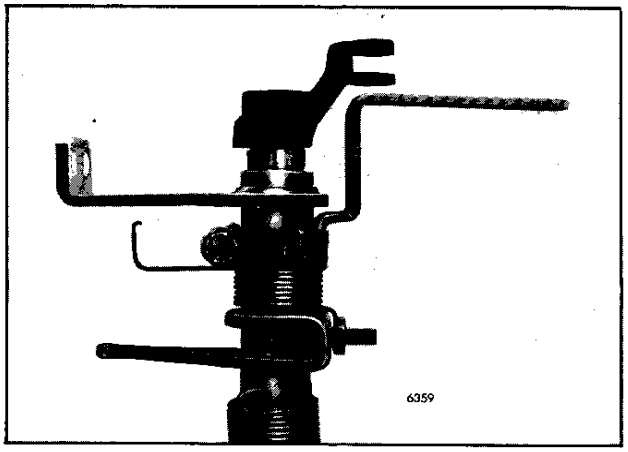


Fig. 4 - Secure Indexing Bracket to Control Tube

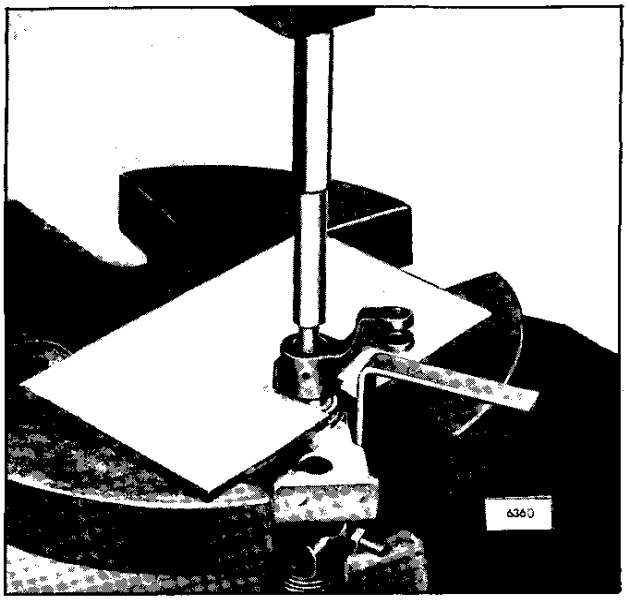


Fig. 5 - Press Old Lever off Control Tube

2. Install the two 1/4"-20 x 5/8" bolts and lock washers at each bracket to attach the injector control tube assembly to the cylinder head. Tighten the bolts to 10-12 lb-ft (14-16 Nm) torque.

3. Check the control tube to be sure it is free in the brackets. Tap the control tube lightly to align the bearings in the bracket, if necessary.

4. Connect the fuel rod to the injector tube control lever with a clevis pin and a new cotter pin.

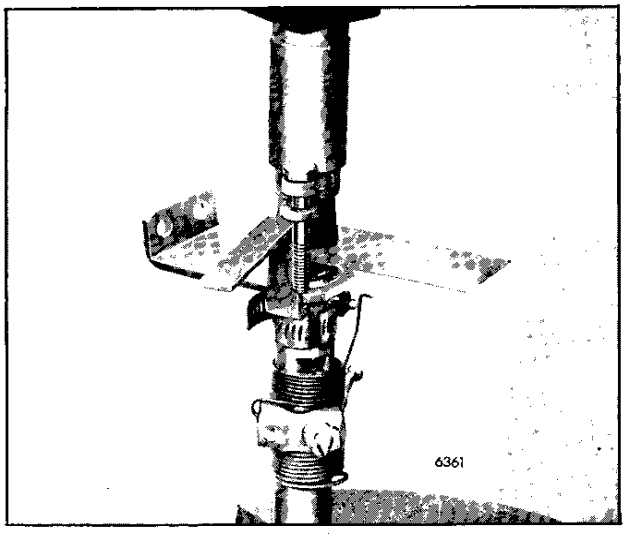


Fig. 6 - Installing New Lever

© 1984 General Motors Corp.

5. Refer to Section 14 and position the injector rack control levers. Be sure the injector rack control levers can be placed in a no-fuel position before restarting the engine.

CAUTION: Loss of shutdown control could result in a runaway engine which could cause personal injury.

© 1984 General Motors Corp.

THROTTLE CONTROLS (Diesel Railcar Engine)

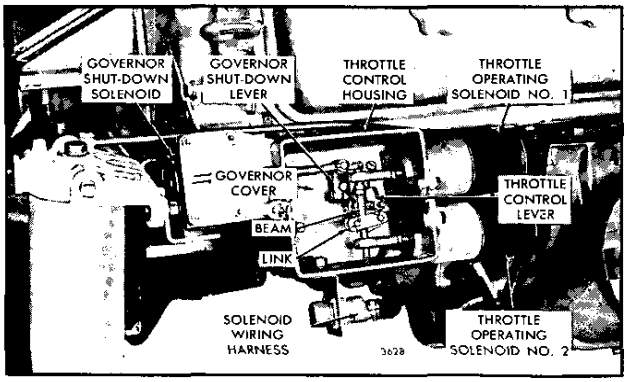


Fig. 1 - Throttle Control Linkage Arrangement

The electrically-operated throttle control linkage and governor shutdown lever are contained in a housing attached to the cover on the railcar engine governor.

The throttle control lever is attached to the governor throttle shaft and is operated by two solenoids through a beam and link arrangement (Fig. 1).

The governor shutdown lever is attached to a cam, located beneath the governor cover, which operates against the differential lever link pin to move the injector control racks to the no-fuel position. The shutdown lever is also operated by a solenoid.

Remove Throttle Control Housing and Governor Cover

The throttle control housing, solenoids and governor cover must be removed whenever the governor or cylinder head are removed for service, or when an engine tune-up is performed.

1. Separate the solenoid wiring harness at the disconnect plug attached to the throttle control housing.

2. Disconnect the electrical leads from the throttle operating and governor shutdown solenoids. Make sure the wires are identified so they may be reconnected in their original positions.

3. Remove the thumb screw, wing nut and washers from the throttle control housing cover. Then remove the cover and gasket.

4. Remove the spring retainer and washer which secure the governor shutdown control rod end to the shutdown lever.

5. Disconnect the control rod end from the governor shutdown lever and remove the control rod end from the solenoid plunger. Then remove the four bolts, lock washers and nuts which secure the governor shutdown solenoid to the throttle control housing. Withdraw the solenoid from the housing.

6. Remove the four screws which secure the throttle control housing and governor cover to the governor control housing. Then remove the throttle housing, governor cover and throttle operating solenoids as an assembly. Remove the governor cover gasket.

Install Throttle Control Housing and Governor Cover

1. Place a new gasket on the governor control housing.

2. Place the throttle control housing, throttle operating solenoids and governor cover as an assembly on the governor control housing, with the pin in the throttle shaft lever registering with the slot in the differential lever and the dowel pins in the governor entering the holes in the governor cover. Then secure the housing and cover to the governor with four screws.

3. Insert the solenoid plunger through the opening in the throttle control housing and thread the control rod end approximately four turns on the end of the plunger. Then install the four bolts, lock washers and nuts which secure the solenoid to the throttle control housing. Do not tighten the bolts.

4. Place the end of the control rod end over the pin in the governor shutdown lever. Then tighten the solenoid attaching bolts and nuts. Install the washer and spring retainer on the control lever pin to secure the control rod end.

5. Attach the electrical leads to the governor shutdown and throttle operating solenoids.

6. Adjust the throttle controls as outlined in Section 14.3.5.

7. Attach a new gasket to the throttle control housing cover. Then place the cover and gasket on the housing and secure it in place with the thumb screw, wing nut and washers.

© 1978 General Motors Corp.

SHOP NOTES - TROUBLE SHOOTING - SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

INJECTOR CALIBRATOR READINGS

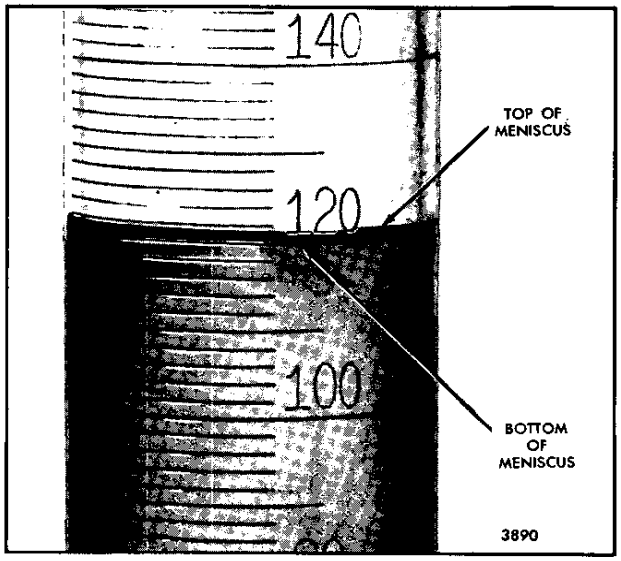


Fig. 1 - Checking Fuel Output

Several factors affect the injector calibrator output readings. The four major items are:

1. **Operator Errors:** If the column of liquid in the vial is read at the top of the meniscus instead of at the bottom, a variation of 1 or 2 points will result. Refer to Fig. 1.

2. **Air In Lines:** This can be caused by starting a test before the air is purged from the injector and lines, or from an air leak on the vacuum side of the pump.

3. **Counter Improperly Set:** The counter should be set to divert the injector output at 1,000 strokes.

This should not be confused with counter overrun that will vary from 2 to 6 digits, depending upon internal friction. The fuel diversion is accomplished electrically and will occur at 1,000 strokes (if properly set) although the counter may overrun several digits.

4. **Test Oil:** A special test oil is supplied with the calibrator and should always be used. If regular diesel fuel oil (or any other liquid) is used, variations are usually noted because of the effect of the oil on the solenoid valve and other parts.

The fuel oil introduced into the test oil when the fuel injector is placed in the calibrator for a calibration check contaminates the test oil. Therefore, it is important that the test oil and test oil filter be changed every six months, or sooner if required.

In addition, other malfunctions such as a slipping drive belt, low level of test oil, a clogged filter, a defective pump or leaking line connections could cause bad readings. A frequent check should be made for any of these tell-tale conditions.

CHECKING INJECTOR TESTER J 9787 or J 23010

The injector tester (J 9787 or J 23010) should be checked monthly to be sure that it is operating properly. The following check can be made very quickly using test block J 9787-49.

Fill the supply tank in the injector tester with clean injector test oil J 26400. Open the valve in the fuel supply line. Place the test block on the injector locating plate and secure the block in place with the fuel inlet connector clamp. Operate the pump handle until all of the air is out of the test block, then clamp the fuel outlet connector onto the test block. Break the connection at the gage and operate the pump handle until all of the air bubbles in the fuel system disappear. Tighten the connection at the gage. Operate the pump handle to pressurize the tester fuel system to 2400-2500 psi. (16 536-17 225 kPa). Close the valve on the fuel supply line. After a slight initial drop, the pressure should remain steady. This indicates that the injector tester is operating properly. Open the fuel valve and remove the test block.

If there is a leak in the tester fuel system, it will be indicated by a drop in pressure. The leak must be

© 1979 General Motors Corp.

located, corrected and the tester rechecked before checking an injector.

Occasionally dirt will get into the pump check valve in the tester, resulting in internal pump valve leakage and the inability to build up pressure in the tester fuel system. Pump valve leakage must be corrected before an injector can be properly tested.

When the above occurs, loosen the fuel inlet connector clamp and operate the tester pump handle in an attempt to purge the dirt from the pump check valve. A few quick strokes of the pump handle will usually correct a dirt condition. Otherwise, the pump check valve must be removed, lapped and cleaned or replaced (J 9787). The pump check valve must be replaced on tester J 23010.

If an injector tester supply or gage line is damaged or broken, install a new replacement line (available from the tester manufacturer). Do not shorten the old lines or the volume of test oil will be altered sufficiently to give an inaccurate valve holding pressure test.

If it is suspected that the lines have been altered, i.e. by shortening or replacing with a longer line, check the accuracy of the tester with a master injector on which the pressure holding time is known. If the pressure holding time does not agree with that recorded for the master injector, replace the lines.

REFINISH LAPPING BLOCKS

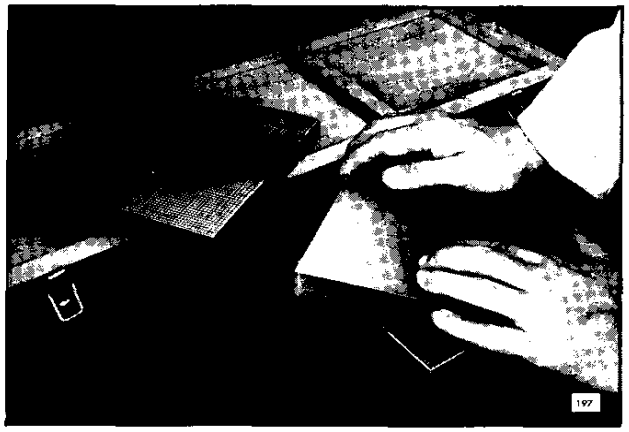


Fig. 2 - Refinishing Lapping Blocks

As the continued use of the lapping blocks will cause worn or low spots to develop in their lapping surfaces, they should be refinished from time to time.

It is good practice, where considerable lapping work is done, to devote some time each day to refinishing the blocks. The quality of the finished work depends to a great degree on the condition of the lapping surfaces of the blocks.

To refinish the blocks, spread some 600 grit lapping powder of good quality on one of the blocks. Place another block on top of this one and work the blocks together as shown in Fig. 2. Alternate the blocks from time to time. For example, assuming the blocks are numbered 1, 2 and 3, work 1 and 2 together, then 1 and 3, and finish by working 2 and 3 together. Continue this procedure until all of the blocks are perfectly flat and free of imperfections.

Imperfections are evident when the blocks are clean and held under a strong light. The blocks are satisfactory when the entire surface is a solid dark grey. Bright or exceptionally dark spots indicate defects and additional lapping is required.

After the surfaces have been finished, remove the powder by rinsing the lapping blocks in trichloroethylene and scrubbing with a bristle brush.

When not in use, protect the lapping blocks against damage and dust by storing them in a close fitting wooden container.

MASTER INJECTOR CALIBRATING KIT

Use Master Injector Calibrating Kit J 26298 to determine the accuracy of the injector calibrator.

With the test fluid temperature at 100 °F ±1 ° (38 °C ±1 °) and each injector warm after several test cycles, run the three injectors contained in the kit. Several readings should be taken with each injector to check for accuracy and repeatability. If the output readings are within 2% of the values assigned to the calibrated masters, the calibrator can be considered accurate.

Injector testing can be carried out now without any adjustment of figures. However, when testing new injectors for output, any difference between the calibrator and the masters should be used to compute new injector calibration. If more than a 2% variation from the masters is noted, consult the calibrator manufacturer for possible causes.

The calibrated masters should only be used to qualify injector output calibration test equipment.

© 1979 General Motors Corp.

INJECTOR TIMING

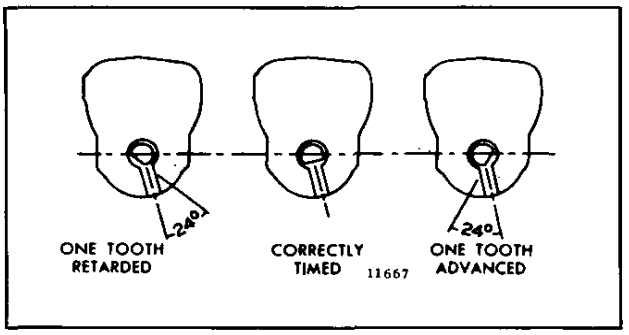


Fig. 3 - Injector Rack-to-Gear Timing

If it is suspected that a fuel injector is "out of time", the injector rack-to-gear timing may be checked without disassembling the injector.

A hole located in the injector body, on the side opposite the identification tag, may be used to visually determine whether or not the injector rack and gear are correctly timed. When the rack is all the way in (full-fuel position), the flat side of the plunger will be visible in the hole, indicating that the injector is "in time". If the flat side of the plunger does not come into full view (Fig. 3) and appears in the "advanced" or "retarded" position, disassemble the injector and correct the rack-to-gear timing.

INJECTOR SPRAY TIPS

Due to a slight variation in the size of the small orifices in the end of each spray tip, the fuel output of an injector may be varied by replacing the spray tip.

Flow gage J 25600 may be used to select a spray tip that will increase or decrease fuel injector output for a particular injector after it has been rebuilt and tested on the calibrator.

EFFECT OF PRE-IGNITION ON FUEL INJECTOR

Pre-ignition is due to ignition of fuel or lubricating oil in the combustion chamber before the normal injection period. The piston compresses the burning mixture to excessive temperatures and pressures and may eventually cause burning of the injector spray tip and lead to failure of the injectors in other cylinders.

When pre-ignition occurs, remove all of the injectors and check for burned spray tips or enlarged spray tip orifices.

Before replacing the injectors, check the engine for the cause of pre-ignition to avoid recurrence of the problem. Check for oil pull-over from the oil bath air cleaner, damaged blower housing gasket, defective blower oil seals, high crankcase pressure, plugged air box drains, ineffective oil control rings or dilution of the lubricating oil.

INJECTOR PLUNGERS

The fuel output and the operating characteristics of an injector are, to a great extent, determined by the type of plunger used. Three types of plungers are illustrated in Fig. 4. The beginning of the injection period is controlled by the upper helix angle. The lower helix angle retards or advances the end of the injection period. Therefore, it is imperative that the correct plunger is installed whenever an injector is overhauled.

If injectors with different type plungers (and spray tips) are mixed in an engine, erratic operation will result and may cause serious damage to the engine or to the equipment which it powers.

Injector plungers cannot be reworked to change the output or operating characteristics. Grinding will destroy the hardened case and result in chipping at the helices and seizure or scoring of the plunger.

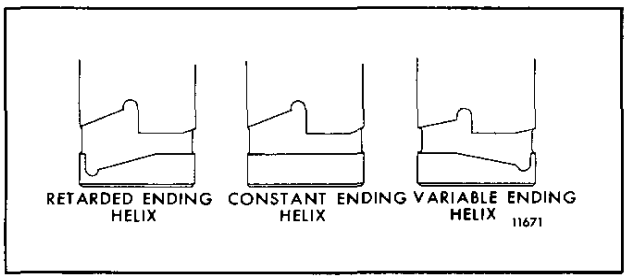


Fig. 4 - Types of Injector Plungers

© 1981 General Motors Corp.

REFINISHING INJECTOR FOLLOWER FACE

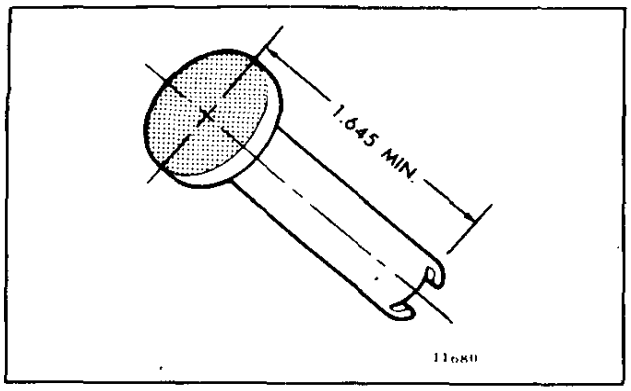


Fig. 5 - Injector Follower

When refinishing the face of an injector follower, it is extremely important that the distance between the follower face and the plunger slot is not less than 1.645" minimum as shown in Fig. 5. If this distance is less than specified, the height of the injector follower in relation to the injector body will be altered and proper injector timing cannot be realized.

FUEL LINES

Flexible fuel lines are used to facilitate connection of lines leading to and from the fuel tank, and to minimize the effects of any vibration in the installation.

Be sure a restricted fitting of the proper size is used to connect the fuel return line to the fuel return manifold. Do not use restricted fittings anywhere else in the fuel system.

When installing fuel lines, it is recommended that connections be tightened only sufficiently to prevent leakage of fuel; thus flared ends of the fuel lines will not become twisted or fractured because of excessive tightening. After all fuel lines are installed, run the engine long enough to determine whether or not all connections are sufficiently tight. If any leaks occur, tighten the connections only enough to stop the leak. Also check the filter cover bolts for tightness.

LOCATING AIR LEAKS IN FUEL LINES

Air drawn into the fuel system may result in uneven running of the engine, stalling when idling, or a loss of power. Poor engine operation is particularly noticeable at the lower engine speeds. An opening in the fuel suction lines may be too small for fuel to pass through but may allow appreciable quantities of air to enter.

Check for loose or faulty connections. Also check for improper fuel line connections such as a fuel pump suction line connected to the short fuel return line in the fuel tank which would cause the pump to draw air.

Presence of an air leak may be detected by observing the fuel filter contents after the filter is bled and the engine is operated for 15 to 20 minutes at a fairly high speed. No leak is indicated if the filter shell is full when loosened from its cover. If the filter shell is only partly full, an air leak is indicated.

© 1981 General Motors Corp.

PRESSURIZE FUEL SYSTEM - CHECK FOR LEAKS

Always check the fuel system for leaks after injector or fuel pipe replacement and any time the fuel connections under the rocker cover are suspected of leaking. Failure to correct a serious fuel leak in this area can lead to dilution of the lube oil and bearing and/or cylinder kit damage.

Prime and Purge

Prime and/or purge the engine fuel system before starting the fuel leak check. *Prime* the system by blocking or disconnecting the line from the fuel pump, then apply fuel under pressure (60-80 psi or 413-552 kPa) to the inlet of the sceondary filter. If the system is to be *purged* of air as well, allow the fuel to flow freely from the fuel return line until a solid stream without air bubbles is observed.

Check for Leaks

Use one of the following methods to check for leaks.

Method 1. Use when the engine has been operating 20-30 minutes.

After operating the engine, shut it off and remove the rocker covers. Inspect the lube oil puddles that normally form where the fuel connectors join the cylinder head and where the fuel pipes join the fuel pipe nuts.

If there is any leakage at these connections, the lube oil puddles will be smaller or thinner than the puddles on the connectors that are not leaking. Disassemble, inspect and correct or replace the suspect part (connector washer, connector, injector or jumper line). Test and reinspect.

Method 2. Use when the engine is not operating such as during or after repairs.

Remove the rocker covers. Pour lube oil over all fuel pipes and connectors which would normally be splashed with oil during engine operation. This will cause oil puddles to form at the joining surfaces as mentioned in Method 1.

Block off the fuel return line and disconnect the fuel pump supply line at the secondary filter. Install a pressure gage in the filter adaptor, then apply 60-80 psi (413-552 kPa) fuel to the outlet side of the secondary filter with the inlets plugged. Severe leaks will show up immediately. Minor leaks caused by nicks or burrs on sealing surfaces will take longer to appear. After maintaining 40-80 psi (276-552 kPa) for 20 to 30 minutes, a careful puddle inspection should reveal any suspect connectors. Inspect and repair or replace connectors as necessary. Test and reinspect (see note).

Method 3. Use while the engine is operating at 400-600 rpm.

Apply an outside fuel source capable of 60-80 psi (413-552 kPa) to the outlet side of the secondary filter. Pour lube oil over jumper lines and connectors so that oil puddles form where lines and connectors meet. Install a valve and a pressure gage in the fuel return line. With the engine idling, close the valve enough to raise the engine fuel pressure to 70 psi (483 kPa). After 10 to 20 minutes inspect the oil puddles to see if any have become smaller or run off completely. The undiluted oil will hang the same as when the oil was poured on. Repair and retest.

> **NOTE:** With the engine at rest, as in Method 2 all injectors will leak to some extent when pressurized. The leakage occurs because there is no place else for the pressurized fuel to go. When the low and high pressure cavities in the injector are subjected to the high test pressure, fuel is forced past the plunger into the rack and gear cavity. Result: Droplets of fuel form at the rack and drip off.
>
> Slightly worn plungers may leak more under these conditions. This leakage will not occur while the engine is running because of the dynamic and pressure conditions that exists.
>
> If injectors are suspected of leaking and contributing to dilution of the lube oil, they should not be tested by pressurizing the fuel system as in Method 2. Injectors should be removed from the engine and tested for pressure-holding capability (see Fuel Injector Section).

Points to Remember

Lube oil puddle inspection is the key to pressure testing the fuel system for internal leaks. This test can be performed any time the rocker covers are removed, after the fuel pipes and connectors have been splashed with oil and there is normal fuel pressure in the system. The weak or missing puddles show where the leaks are.

All leakage or spillage of fuel during leak detection testing further dilutes the lube oil, so the final step in maintenance of this type should include lube oil and lube oil filter changes.

© 1981 General Motors Corp.

HYDRAULIC GOVERNOR RETRACTING SPRING

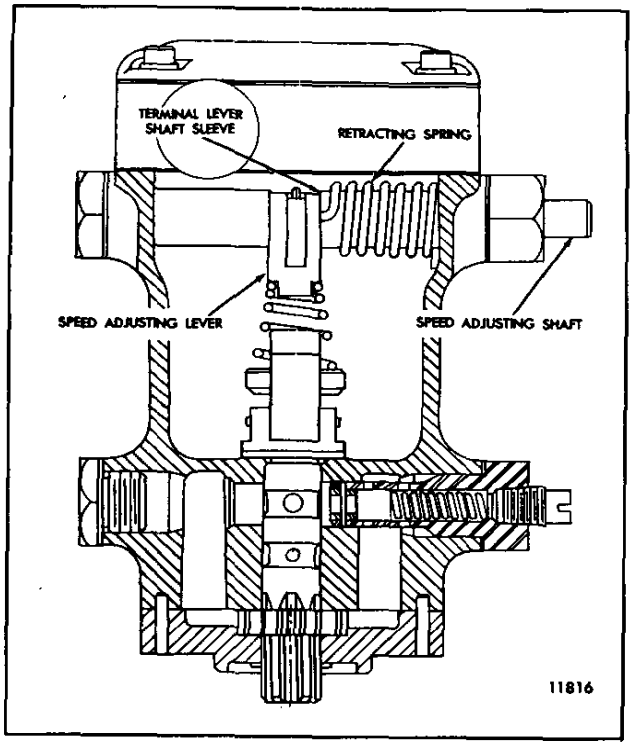


Fig. 6 - Hydraulic Governor Retracting Spring Installation

The retracting spring (Fig. 6) was installed for standardization in hydraulic governors used on the Series 71 engines. The retracting spring hooked in the side of the speed adjusting lever and was incorporated to permit the governor on some applications to reach and hold low speeds by exerting force upward on the speed adjusting lever and, at the same time, remove tension from the governor speeder spring. The

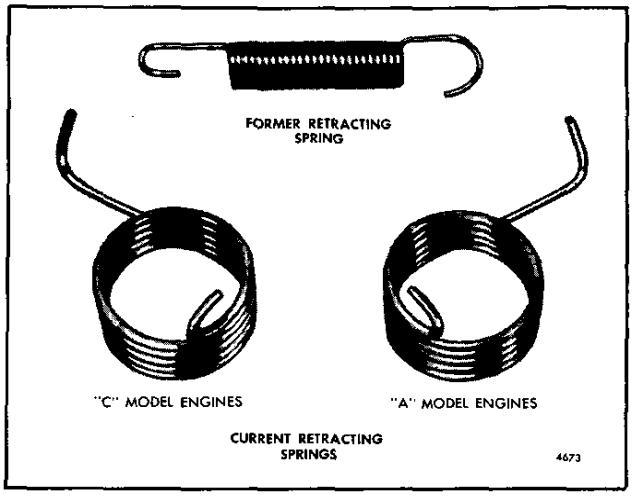


Fig. 7 - Hydraulic Governor Control Lever Retracting Springs

retracting spring is required in comparatively few applications, and has been removed from all of the hydraulic governor assemblies, except the governor assemblies equipped with synchronizing motors.

Figure 7 illustrates the former and current hydraulic governor control lever retracting springs used on hydraulic governors. The extension type retracting spring has been replaced by two new torsion type retracting springs, one for "A" model engines and one for "C" model engines.

The former retracting spring was attached to the lower external fuel manifold and the control lever. However, since the engines now incorporate integral fuel manifolds, the current retracting springs are installed over the governor speed adjusting shaft sleeve.

© 1981 General Motors Corp.

LOW-SPEED STOP SCREW AND GOVERNOR COVER

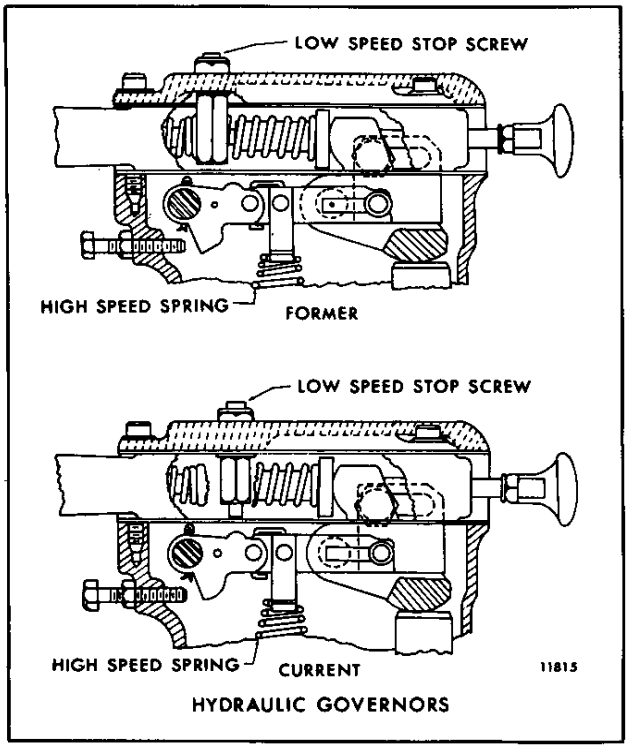


Fig. 8 – Hydraulic Governor Low-Speed Stop Screw

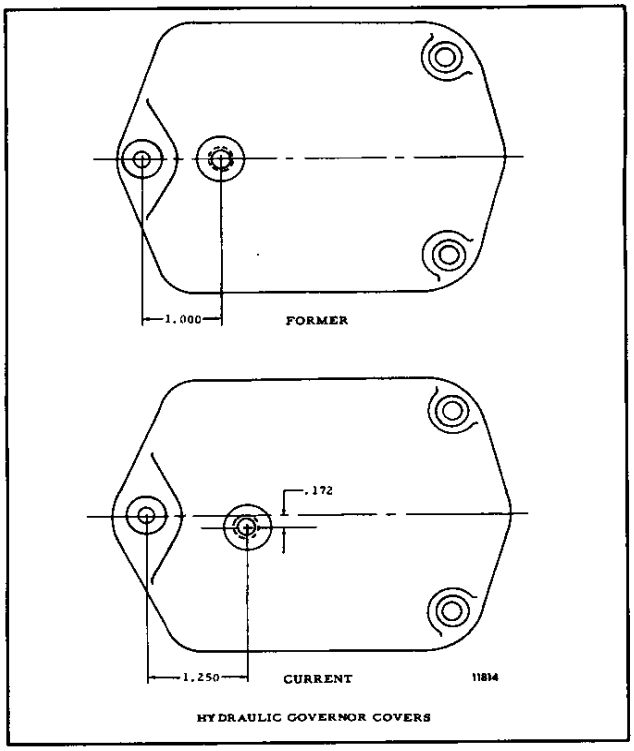


Fig. 9 – Hydraulic Governor Covers

More accurate alignment of the low-speed stop screw and the speed adjusting shaft lever has been accomplished by relocation of the low-speed stop screw in the cover of all hydraulic governors (Figs. 8 and 9) except the SGT dual hydraulic governor.

This improved alignment more effectively limits the travel of the speed adjusting shaft lever, thus preventing the lever from traveling beyond the stop position, and also eliminates the possibility of unseating the speeder spring from the spring seat. Also, to provide a more positive seating shoulder for the low-speed stop screw, the governor cover has been revised to provide a flat seating surface (Fig. 8). The low-speed stop screw has been reduced in size at its lower end so as to contact the speed adjusting lever with greater accuracy.

The current and former design stop screws and covers are not interchangeable.

© 1981 General Motors Corp.

TAMPER-RESISTANT GOVERNOR FOR HIGHWAY VEHICLE ENGINES

A tamper-resistant single weight limiting speed "TT" governor is provided for highway vehicle engines.

This governor incorporates a special high-speed spring housing and a break-off head governor cover screw, designed to make unauthorized governor adjustments difficult.

The governor spring housing has one inch of additional metal resembling two bosses cast on the bolt head of the housing (Fig. 10). These bosses are counterbored to accept the two bolts which hold the spring housing on the governor housing and to allow for the installation of plugs over the bolt heads. The plugs are secured in the counterbores by tapered pins which, when driven in place, cannot be removed when the governor is mounted on the blower. In order to remove the pins to get to the spring housing retainer bolts, the complete governor must be removed from the blower and cylinder head. In addition the head of the break-off head screw must be drilled out to permit removal of the governor cover.

The governor is not normally tamper-resistant as furnished on the engine by the factory. The spring housing retainer bolts are removable and the break-off head governor cover screw has not been broken off. This is to permit governor adjustments that maybe necessary before the engine is placed in service.

To make the governor tamper-resistant install two plugs and two tapered pins and break off the head of the cover break-off head screw by overtightening.

Refer to Fig. 10 and install the tamper-resistant plugs and pins in the counterbores of the spring housing as follows:

a. Install the inboard plug with the drilled passage in the vertical position and the larger opening up.

b. Install the outboard plug with the drilled passage horizontal and the larger opening away from the engine.

c. Drive the tapered pins, small end first, into the drilled passages in the top and side of the spring housing until the pins are below flush and firmly in place.

d. Turn the governor cover brake-off head screw by tightening the screw until the head separates.

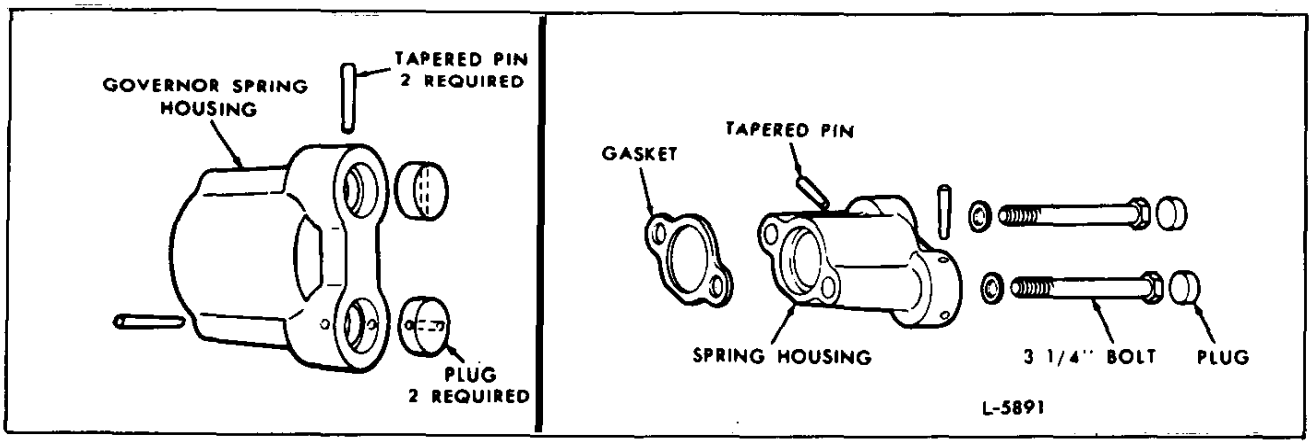


Fig. 10 - Tamper-Resistant Governor Components

© 1981 General Motors Corp.

TROUBLE SHOOTING

FUEL PUMP

The fuel pump is so constructed as to be inherently trouble free. By using clean, water-free fuel and maintaining the fuel filters in good condition, the fuel pump will provide long satisfactory service and require very little maintenance.

However, if the fuel pump fails to function satisfactorily, first check the fuel level in the fuel tank, then make sure the fuel supply valve is open. Also check for external fuel leaks at the fuel line connections and filter gaskets. Make certain that all fuel lines are connected in their proper order.

Next, check for a broken pump drive shaft or drive coupling. Insert the end of a wire through the pump flange drain hole, then crank the engine momentarily and note whether the wire vibrates. Vibration will be felt if the pump shaft rotates.

All fuel pump failures result in no fuel or insufficient fuel being delivered to the fuel injectors and may be indicated by uneven running of the engine, excessive vibration, stalling at idling speeds or a loss of power.

The most common reason for failure of a fuel pump to function properly is a sticking relief valve. The relief valve, due to its close fit in the valve bore, may become stuck in a fully open or partially open position due to a small amount of grit or foreign material lodged between the valve and its bore or seat. This permits the fuel to circulate within the pump rather than being forced through the fuel system.

Therefore, if the fuel pump is not functioning properly, remove the relief valve plug, spring and pin and check the movement of the valve within the valve bore. If the valve sticks, recondition it by using fine emery cloth to remove any scuff marks. Otherwise, replace the valve. Clean the valve bore and the valve components. Then lubricate the valve and check it for free movement throughout the entire length of its travel. Reinstall the valve.

After the relief valve has been checked, start the engine and check the fuel flow at some point between the restricted fitting in the fuel return manifold at the cylinder head and the fuel tank.

CHECKING FUEL FLOW

1. Disconnect the fuel return hose from the fitting at the fuel tank and hold the open end in a convenient receptacle (Fig. 11).

2. Start and run the engine at 1200 rpm and measure the fuel flow. Refer to Section 13.2 for the specified quantity per minute.

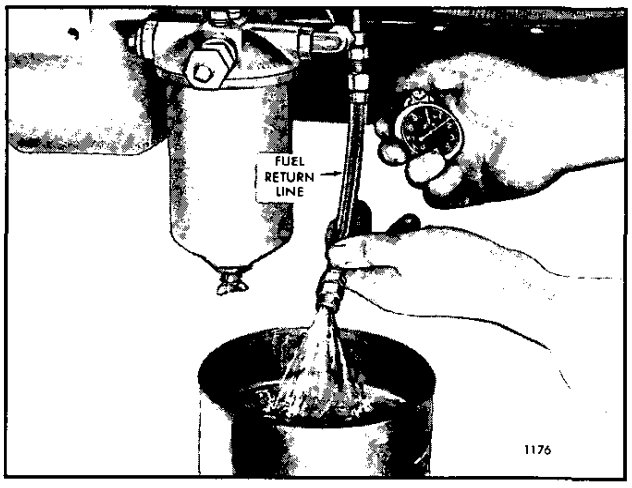


Fig. 11 - Measuring Fuel Flow

3. Immerse the end of the fuel hose in the fuel in the container. Air bubbles rising to the surface of the fuel will indicate air being drawn into the fuel system on the suction side of the pump. If air is present, tighten all fuel line connections between the fuel tank and the fuel pump.

4. If the fuel flow is insufficient for satisfactory engine performance, then:

a. Replace the element in the fuel strainer. Then start the engine and run it at 1200 rpm to check the fuel flow. If the flow is still unsatisfactory, perform Step "b" below:

b. Replace the element in the fuel filter. If the flow is still unsatisfactory, do as instructed in Step "c".

c. Substitute another fuel pump that is known to be in good condition and again check the fuel flow. When changing a fuel pump, clean all of the fuel lines with compressed air and be sure all fuel line connections are tight. Check the fuel lines for restrictions due to bends or other damage.

© 1981 General Motors Corp.

If the engine still does not perform satisfactorily, one or more fuel injectors may be at fault and may be checked as follows:

1. Run the engine at idle speed and cut out each injector in turn by holding the injector follower down with a screw driver. If a cylinder has been misfiring, there will be no noticeable difference in the sound and operation of the engine when that particular injector has been cut out.

2. Stop the engine and remove the fuel pipe between the fuel return manifold and the injector.

3. Hold a finger over the injector fuel outlet and crank the engine with the starter. A gush of fuel while turning the engine indicates an ample fuel supply; otherwise, the injector filters are clogged and the injector must be removed for service.

DIESEL RAILCAR ENGINE THROTTLE AND CLUTCH OPERATING SOLENOIDS

The throttle and clutch operating solenoids used on the diesel railcar engine consists of a plunger, a plunger spring, a pull-in coil, a hold-in coil, a set of contact points and a condenser. The major operating components shown in Fig. 12 are enclosed in the case.

Operation

When the solenoid is energized, current passes through both the pull-in and hold-in coils causing the coils to set up the magnetic force that moves the plunger. The plunger nearing the end of its stroke opens the contact points, de-energizing the pull-in coil.

The hold-in coil retains the plunger in the energized position until the solenoid is de-energized. When the solenoid is de-energized, the plunger spring forces the plunger back to the de-energized position and the contact points are allowed to close. A condenser is connected across the contact points to decrease arcing.

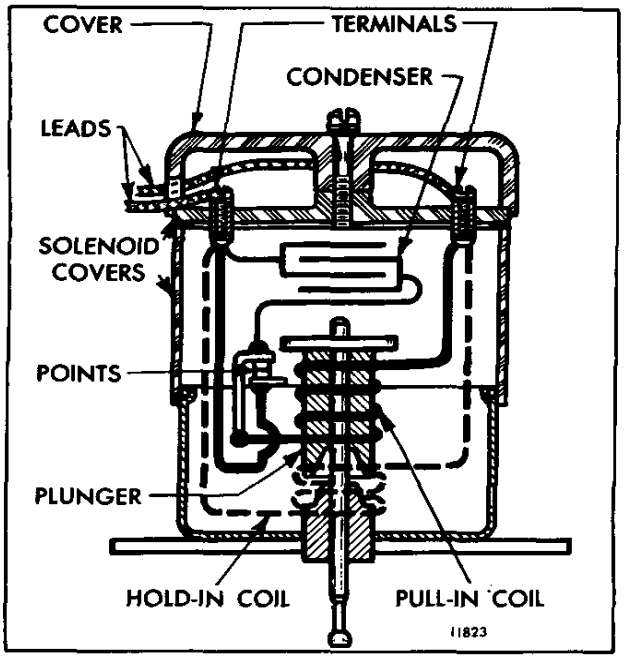


Fig. 12 - Engine Throttle and Clutch Operating Solenoid Assembly

Operating Solenoid Check

When trouble occurs involving the operation of a throttle or clutch operating solenoid, the following checks to ascertain the condition of the solenoid should be performed.

Preliminary Check

Before removing the operating solenoid from the unit, check the voltage to the solenoid as follows:

1. Remove the solenoid cover, then attach a voltmeter to the two terminals.

2. Operate the solenoid, by using the controller in the cab, and note the voltage. Low voltage will result from high resistance in the cables, corroded connections, low battery voltage, or loose connections in the electrical system.

> **NOTE:** Any loose connections in the electrical system such as faulty line plugs, switches, loose terminals, etc., or foreign material in the forward or reverse transmission control valves will cause the solenoids to flutter.

3. If a low voltage condition exists, it should be corrected before performing any further checks on the solenoid.

4. If it is determined that low voltage is not the cause of the faulty operation, remove the solenoid and perform the following checks.

© 1981 General Motors Corp.

Resistance Check

1. Remove the solenoid cover, if not previously removed.

2. Measure the coil resistance across the two terminals with an ohmmeter while the solenoid is at a temperature of 80°F or 27°C. A reading of 19.0 to 23.5 ohms is normal. This resistance reading measures the total resistance of the pull-in and hold-in coils in parallel.

If resistance is higher, check for broken wire leads, an "open" in coils or oxidized, dirty or open contact points. If the contact points are suspected, make a contact point and condenser check.

3. With the ohmmeter still connected to the two solenoid terminals, pull the solenoid plunger (rod) out to its full length of stroke and retain. Measure the coil resistance across the two terminals while the solenoid is at a temperature of 80°F or 27°C. A reading of 405 to 490 ohms indicates a good hold-in coil.

NOTE: At normal room temperature, a slightly lower reading will be experienced due to reduction in the internal resistance of the solenoid coil resulting from the lower temperature. The coil resistance related to the coil temperature is shown in Table 1.

Solenoid Temperature		Resistance in Ohms
°F	°C	64 Volt
80	26.7	405-490
70	21.1	397-480
60	15.6	387-468
50	10.0	378-456
40	4.4	368-448
30	- 1.1	360-439
20	- 6.7	353-425
10	-12.2	344-418
0	-17.8	336-408

TABLE 1

If resistance is not within the above limits, check for broken leads, grounded leads or faulty contact points.

If resistance values are within normal limits, connect the solenoid terminals to a normal battery source. The solenoids should operate without fluttering. Operate the solenoids several times for positive operation.

If the solenoid does not operate, check the pull-in coil for grounded or broken (wire) leads and the contact points for oxidation or faulty adjustment. Refer to *Contact Points and Condenser Check.*

If operation of the solenoid appears normal, apply a normal battery voltage across the two solenoid terminals and, with the aid of a rheostat connected in series with the solenoid, reduce the voltage slowly until the solenoid drops out (de-energized position). The drop out should not be greater than 50 volts.

Contact Points and Condenser Check

1. Remove the bakelite cover plate by removing the nuts (covered with black cement) adjacent to the solenoid terminals.

2. Remove lead (wire) connections from the back side of cover plate, then remove the cover from the condenser and contact points.

3. Inspect and adjust the contact points as follows:

a. If the contact points are oxidized or dirty, clean them by pulling a clean piece of rough canvas through the closed points.

b. If the contact points are pitted, they may be cleaned up with a point file. Never use sandpaper or emery cloth to clean the contact points.

NOTE: Dirty contact points are caused by a burned-out coil or by faulty gaskets under the cover and cover plate.

c. The contact point opening is .022" with the solenoid plunger fully extended. If contact point adjustment is necessary, bend the secondary contact support to get the correct point opening.

d. Check the contact point pressure which should be 10-20 ounces. This may be estimated by feel or measured by the use of a spring scale. The point contact pressure may be increased by enlarging the radius at the bend with the aid of a small pair of pliers.

4. Check the condenser as follows:

a. Check the condenser capacity. A reading of .18 to .23 microfarads indicates a proper capacity.

b. Visually examine the solenoid capacitors for brittle or broken insulation.

c. A short test is the only test recommended by the manufacturer. The short test can be made with a test voltage of up to 500 volts A.C., applied between the condenser case and the lead terminal. During this test, the contacts should be separated with a piece of insulation and the condenser lead terminal should be disconnected from the

© 1981 General Motors Corp.

solenoid circuit. The condenser mounting need not be disturbed.

d. The condenser must withstand a test flash of 750 volts D.C. Replace a solenoid that does not meet or cannot be readjusted to meet the aforementioned check.

5. Install the cover over the top of the condenser and contact points.

6. Affix a new gasket to the back face of the cover plate, then attach the lead (wire) connections to the back side of the cover plate.

7. Place the cover plate over the studs and up against the solenoid cover and install the nuts.

8. Connect the two wires to the solenoid terminals and install the cover.

Air-Operated Variable High Speed Governors

The most common condition is that the minimum rpm is too high. This is especially true on kit installations to an unknown governor. The most frequent causes are these:

1. **Lack of enough air pressure to completely overcome the high speed spring preload.**

In-line 71 engines with single weight systems may require 90 psi (621 kPa) or more and double weight systems need 70 psi (483 kPa) or more. This air pressure is required at the governor after the regulator. The regulator must have an operating range of 0-120 psi (0-827 kPa).

2. **An interaction between the idle circuit and the high speed circuit.**

Many DDA governors were designed to idle as low as 350 rpm. If these older design governors are being modified, a low minimum control with the VHS cannot be obtained, especially if a high normal idle is used. Series 71 engines produced prior to 1975 commonly use governors with heavy idle weight systems which are not compatible with full-range VHS control. In-line 71 engines require disassembly to determine the weight type. All engines supplied by DDA with the VHS feature installed as original equipment have a compatible governor which will allow control from no-load to within 100 rpm of idle.

The following chart shows the minimum control speed of the heavy weight governors with various idle speeds and idle springs.

NOTE: Minimum certified idle values should not be violated.

Single weight governors capable of accepting the VHS are also capable of reducing the minimum rpm to within 100 rpm of idle.

3. **Idle screw protrudes beyond VHS position, or elastic stop nut is not tight.**

a. Determine if the idle screw or piston hits the VHS cover.

b. If idle screw hits the VHS cover, raise the idle until the screw is flush with the end of the piston. In certain cases the idle screw may have to be shortened to meet the criteria of being flush and acquire the desired idle speed.

c. If the piston hits first, the elastic stop nut is not properly adjusted. Readjust, making sure that the piston is bottomed, then proceed to adjust the elastic stop nut (see Section 2.7.1.5).

4. **Engine overshoot.**

This usually relates to the non-synchronized engagement of the throttle lock and the regulated air supply to the VHS housing. A variable orifice (needle valve type) in one of the air supply lines will provide capability for synchronization as follows:

In cases of *overshoot*, the variable orifice is installed in the supply line to the throttle lock.

In case of *undershoot*, the variable orifice is installed in the regulated air pressure line to the VHS housing.

5. **Lowered idle or no-load.**

GOVERNORS W/TYPICAL HEAVY WEIGHT IDLE CIRCUIT

NORMAL IDLE OF	500	550	600	650	750
Minimum Control w/Blue Stripe Idle Spring	500	550	850	1100	1200
w/Green or Yellow Stripe Idle Spring	650	850	1100	1300	NA

© 1981 General Motors Corp.

Usually caused by air from the air supply leaking into or being trapped in the VHS housing. Any pressure in the VHS housing will lower both the no-load and idle. Recheck the air plumbing.

6. **Lack of normal power.**

The elastic stop nut is screwed in too tight, pulling the high speed plunger off its seat. This will cause low power but no change in the no-load rpm. Readjust the elastic stop-nut.

7. **No-load increased.**

Interference of the piston and idle screw. Check to be sure that the screw is free as it protrudes through the piston.

© 1981 General Motors Corp.

TROUBLE SHOOTING CHARTS (Crown Valve Injectors)

Chart 1

LOW OR HIGH VALVE OPENING PRESSURE

LOW VALVE OPENING PRESSURE

Probable Cause

1. WORN OR ERODED VALVE SEAT
2. VALVE SEAT CHIPPED AT POINT OF CONTACT
3. CRACKED VALVE SEAT
4. WORN VALVE OR VALVE STOP
5. WORN OR BROKEN VALVE SPRING
6. DIRT OR FOREIGN MATERIAL IN INJECTOR
7. WORN VALVE STOP SEAT IN CAGE

HIGH VALVE OPENING PRESSURE

Probable Cause

8. CARBON OR FOREIGN MATERIAL IN SPRAY TIP
9. CARBON IN SPRAY TIP ORIFICES

SUGGESTED REMEDY

1. A worn or eroded valve seat may be lapped, but not excessively as this would reduce thickness of the part causing a deviation from the valve stack-up dimension.

2. If the valve seat is chipped at the point of contact with the valve, lap the surface of the seat and the I.D. of the hole. Mount tool J 7174 in a drill motor and place the valve seat on the pilot of the tool, using a small amount of lapping compound on the lapping surface. Start the drill motor and apply enough pressure to bring the seat to the point of lap. Check the point of lap contact after a few seconds. If the edge of the hole appears sharp and clear, no further lapping is required. Excessive lapping at this point will increase the size of the hole and lower the injector valve opening pressure.

3. Replace the valve seat.

4. Replace the valve or valve stop.

5. Replace the spring. Check the valve cage and valve stop for wear; replace them if necessary.

6. Disassemble and clean the injector.

7. Replace the valve cage.

8. Carbon in the tip should be removed with tip reamer J 1243 which is especially designed and ground for this purpose.

9. Check the size of the spray tip orifices. Then, using tool J 4298-1 with the proper size wire, clean the orifices.

© 1981 General Motors Corp.

TROUBLE SHOOTING CHARTS (Crown Valve Injectors)

Chart 2

INSUFFICIENT INJECTOR HOLDING TIME

Probable Cause

1. POOR BUSHING TO BODY FIT
2. INJECTOR NUT NOT TIGHTENED TO SPECIFIED TORQUE
3. CRACKED VALVE PARTS
4. VALVE SEAT CHIPPED AT POINT OF CONTACT
5. WORN OR ERODED VALVE SEAT
6. WORN OR BROKEN VALVE SPRING
7. WORN VALVE
8. DEFECTIVE SEAL RING
9. BODY PLUG LEAKS
10. FILTER GASKET LEAKS
11. POOR SEALING SURFACES ON FUEL FITTINGS
12. DIRT OR FOREIGN MATERIAL IN INJECTOR

SUGGESTED REMEDY

1. Lap the injector body.

2. Tighten the nut to 55 to 65 lb-ft (75-88 Nm) torque. Do not exceed the specified torque.

3. Replace the valve parts.

4. If the valve seat is chipped at the point of contact with the valve, lap the surface of the seat and the I.D. of the hole. Mount tool J 7174 in a drill motor and place the valve seat on the pilot of the tool, using a small amount of lapping compound on the lapping surface. Start the drill motor and apply enough pressure to bring the seat to the point of lap. Check the point of lap contact after a few seconds. If the edge of the hole appears sharp and clear, no further lapping is required. Excessive lapping at this point will increase the size of the hole and lower the injector valve opening pressure.

5. A worn or eroded valve seat may be lapped, but not excessively as this would reduce the thickness of the part causing a deviation from the valve stack-up dimension.

6. Replace the spring. Check the valve cage and valve stop for wear; replace them if necessary.

7. Replace the valve.

8. Replace the seal ring.

9. Install new body plugs.

10. Replace the filter gaskets and tighten the filter caps to 65 to 75 lb-ft (88-102 Nm) torque.

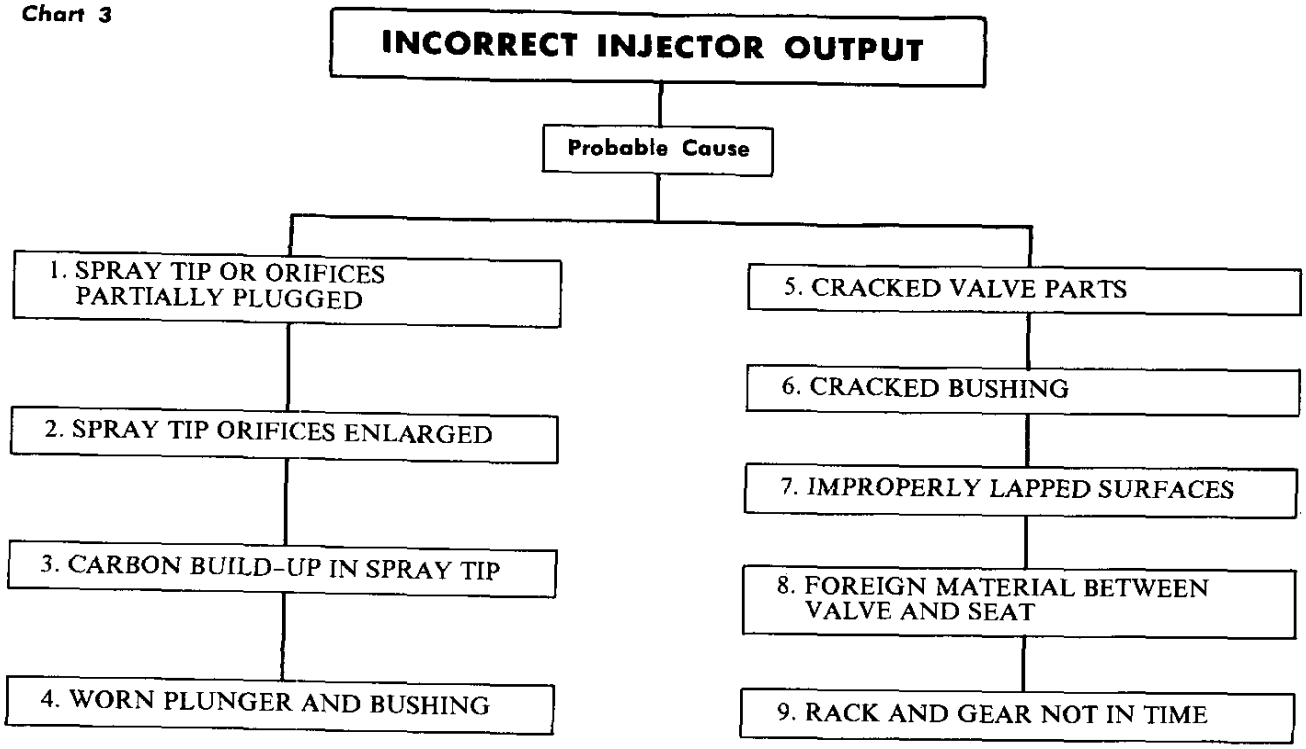
11. Clean up the sealing surfaces or replace the filter caps, if necessary.

12. Disassemble the injector and clean all of the parts.

© 1979 General Motors Corp.

TROUBLE SHOOTING CHARTS (Crown Valve Injectors)

Chart 3



SUGGESTED REMEDY

1. Clean the orifices with tool J 4298-1, using the proper size wire.

2. Replace the spray tip.

3. Clean the injector tip with tool J 1243.

4. After the possibility of an incorrect or faulty tip has been eliminated and the injector output still does not fall within its specific limits, replace the plunger and bushing with a new assembly.

NOTE: The fuel output of an injector varies with the use of different spray tips of the same size due to manufacturing tolerances in drilling the tips. If the fuel output does not fall within the specified limits of the *Fuel Output Check Chart,* try changing the spray tip. However, use only a tip specified for the injector being tested.

5. Replace the cracked parts.

6. Replace the plunger and bushing assembly.

7. Lap the sealing surfaces.

8. Disassemble the injector and clean all of the parts.

9. Assemble the gear with the drill spot mark on the tooth engaged between the two marked teeth of the rack.

© 1979 General Motors Corp.

TROUBLE SHOOTING CHARTS (Needle Valve Injectors)

Chart 4

LOW OR HIGH VALVE OPENING PRESSURE

LOW VALVE OPENING PRESSURE

Probable Cause

1. WORN OR ERODED NEEDLE VALVE OR VALVE SEAT IN SPRAY TIP
2. WORN OR DAMAGED NEEDLE VALVE QUILL
3. WORN OR DAMAGED NEEDLE VALVE SPRING SEAT
4. WORN OR BROKEN VALVE SPRING
5. DIRT OR FOREIGN MATERIAL IN INJECTOR

HIGH VALVE OPENING PRESSURE

Probable Cause

6. CARBON OR FOREIGN MATERIAL IN SPRAY TIP
7. CARBON IN SPRAY TIP ORIFICES

SUGGESTED REMEDY

1. Replace the needle valve and spray tip assembly.
2. Replace the needle valve and spray tip assembly.
3. Replace the spring seat.
4. Replace the valve spring.
5. Disassemble the injector and clean all of the parts.
6. Remove the carbon in the spray tip with tip reamer J 9464-01 which is especially designed and ground for this purpose.
7. Check the size of the spray tip orifices. Then, using tool J 4298-1 with the proper size wire, clean the orifices.

© 1979 General Motors Corp.

TROUBLE SHOOTING CHARTS (Needle Valve Injectors)

Chart 5

INSUFFICIENT INJECTOR HOLDING TIME

Probable Cause

1. POOR BUSHING TO BODY FIT
2. INJECTOR NUT NOT TIGHTENED TO SPECIFIED TORQUE
3. EXCESSIVE PLUNGER TO BUSHING CLEARANCE
4. CRACKED SPRAY TIP
5. WORN OR ERODED NEEDLE VALVE
6. WORN OR ERODED NEEDLE VALVE SEAT IN SPRAY TIP
7. WORN OR BROKEN NEEDLE VALVE QUILL
8. WORN OR BROKEN VALVE SPRING
9. WORN OR DAMAGED VALVE SPRING SEAT
10. DEFECTIVE SEAL RINGS
11. BODY PLUG LEAKS
12. FILTER GASKETS LEAK
13. POOR SEALING SURFACES ON FUEL FITTINGS
14. DIRT OR FOREIGN MATERIAL IN INJECTOR

SUGGESTED REMEDY

1. Lap the injector body.

2. Tighten the injector nut to 75–85 lb–ft (102–115 Nm) torque. Do not exceed the specified torque.

3. Replace the plunger and bushing.

4, 5, 6 and 7. Replace the needle valve and spray tip assembly.

8. Replace the valve spring.

9. Replace the valve spring seat.

10. Replace the seal rings.

11. Install new body plugs.

12. Replace the filter cap gaskets and tighten the filter caps to 65–75 lb–ft (88–102 Nm) torque.

13. Clean up the sealing surfaces or replace the filter caps, if necessary. Replace the filter if a cap is replaced.

14. Disassemble the injector and clean all of the parts.

© 1979 General Motors Corp.

TROUBLE SHOOTING CHARTS (Needle Valve Injectors)

Chart 6

INCORRECT INJECTOR OUTPUT

Probable Cause

1. SPRAY TIP OR ORIFICES PARTIALLY PLUGGED
2. SPRAY TIP ORIFICES ENLARGED
3. CARBON BUILD-UP IN SPRAY TIP
4. WORN PLUNGER AND BUSHING
5. WORN OR DAMAGED NEEDLE VALVE QUILL
6. WORN OR DAMAGED NEEDLE VALVE SPRING SEAT
7. WORN OR BROKEN VALVE SPRING
8. CRACKED CHECK VALVE CAGE, SPRING CAGE OR SPRAY TIP
9. CRACKED BUSHING
10. IMPROPERLY LAPPED SURFACES
11. FOREIGN MATERIAL BETWEEN VALVE AND SEAT
12. RACK AND GEAR NOT IN TIME
13. SPRAY TIP – PLUNGER AND BUSHING COMBINATION PROVIDES INCORRECT OUTPUT

SUGGESTED REMEDY

1. Clean the spray tip as outlined under *Clean Injector Parts*.

2. Replace the needle valve and spray tip assembly.

3. Clean the spray tip with tool J 1243.

4. After the possibility of an incorrect or faulty spray tip has been eliminated and the injector output still does not fall within its specific limits, replace the plunger and bushing with a new assembly.

NOTE: The fuel output of an injector varies with the use of different spray tips of the same size due to manufacturing tolerances in drilling the tips. If the fuel output does not fall within the specified limits of the *Fuel Output Check Chart*, try changing the spray tip. However, use only a tip specified for the injector being tested.

5. Replace the needle valve and spray tip assembly.

6. Replace the spring seat.

7. Replace the valve spring.

8. Replace the cracked parts.

9. Replace the plunger and bushing assembly.

10. Lap the sealing surfaces.

11. Disassemble the injector and clean all of the parts.

12. Assemble the gear with the drill spot mark on the tooth engaged between the two marked teeth on the rack.

13. Replace the spray tip and the plunger and bushing assembly to provide the correct output.

© 1979 General Motors Corp.

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb-ft)	Nm	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	Nm
1/4 -20	5- 7	7- 9	1/4 -20	7-9	10-12
1/4 -28	6- 8	8-11	1/4 -28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8 -16	23-26	31-35	3/8 -16	30-35	41-47
3/8 -24	26-29	35-40	3/8 -24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2 -13	53-56	72-76	1/2 -13	71-75	96-102
1/2 -20	62-70	84-95	1/2 -20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8 -11	103-110	140-149	5/8 -11	137-147	186-200
5/8 -18	126-134	171-181	5/8 -18	168-178	228-242
3/4 -10	180-188	244-254	3/4 -10	240-250	325-339
3/4 -16	218-225	295-305	3/4 -16	290-300	393-407
7/8 - 9	308-315	417-427	7/8 - 9	410-420	556-569
7/8 -14	356-364	483-494	7/8 -14	475-485	644-657
1 - 8	435-443	590-600	1 - 8	580-590	786-800
1 -14	514-521	697-705	1 -14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head		GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None		GM 255-M	1	No. 6 thru 1 1/2	60,000
None		GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74,000 60,000
	Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
	Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
	Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
	Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
	Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

12252

BOLT IDENTIFICATION CHART

© 1979 General Motors Corp.

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	C.I. ENGINE TORQUE (lb-ft)	C.I. ENGINE TORQUE (Nm)	ALUM. ENGINE TORQUE (lb-ft)	ALUM. ENGINE TORQUE (Nm)
Limiting speed low weight set screw	10-32	20 in-lb	2.26	--	--
Variable speed spring lever set screw	5/16-24	5-7	7-10	--	--
Injector clamp bolt	3/8 -16	20-25	27-34	20-25	27-34
Injector clamp stud	3/8 -16	10-25	14-34	10-25	14-34
Fuel pipe nut	3/8 -24	12-15	16-20	12-15	16-20
Injector clamp nut	3/8 -24	20-25	27-34	20-25	27-34
Fuel manifold connector nut	7/16-20	30-35	41-47	30-35	41-47
*Fuel manifold connector (nylon insert)	7/16-20	30-35	41-47	30-35	41-47
*Fuel manifold connector (steel washer)	7/16-20	40-45	54-61	--	--
†Rocker arm bracket bolt	1/2 -13	90-100	122-136	--	--
Injector filter cap	5/8 -24	65-75	88-102	65-75	88-102
Injector nut (crown valve)	15/16-24	55-65	75-88	55-65	75-88
Injector nut (needle valve)	15/16-24	75-85	102-115	75-85	102-115

*Lubricate before assembly.
†75-85 lb-ft (102-115 Nm) torque on the two bolts attaching load limit or power control screw bracket (if used) to the rocker arm shaft brackets.

© 1981 General Motors Corp.

SERVICE TOOLS

TOOL NAME	TOOL NO.
INJECTOR	
Auxiliary injector tester ("N" injectors)	J 22640
Fuel pipe socket	J 8932-01
Fuel system primer	J 5956
Injector body reamer	J 21089
Injector body thread reconditioning set	J 22690
Injector calibrator	J 22410
Injector nut seal ring installer	J 29197
Injector service set (includes *tools)	J 1241-07
Injector service set ("N" injectors - includes §tools)	J 23435-02
*Deburring tool	J 7174
§*Fuel hole brush	J 8152
§*Injector nut socket wrench	J 4983-01
§*Injector nut and seat carbon remover set	J 9418
§*Injector spray tip driver	J 1291-02
*Injector tip cleaner	J 1243-01
§*Pin vise	J 4298-1
§*Rack hole brush	J 8150
§*Spray tip carbon remover	J 24838
*Spray tip seat remover	J 4986-01
*Spray tip wire (.005")	J 21459-01
§*Spray tip wire (.0055")	J 21460-01
§*Spray tip wire (.006")	J 21461-01
§*Wire sharpening stone	J 8170
†Injector test oil	J 26400
Injector tester	J 9787
Injector tester	J 23010
Injector tester modification package (J 23010 only)	J 23010-194
Injector tip concentricity gage	J 29584
Injector vise and rack freeness tester	J 22396
Injector vise jaws (offset body)	J 8912
Injector vise jaws (standard body)	J 1261
Lapping Block set	J 22090
Polishing compound ("N" injectors)	J 23038
Polishing stick set ("N" injectors)	J 22964
Spray tip flow gage	J 25600
Spray tip gage ("N" injectors)	J 9462-02
Spring tester	J 22738-02
Wire brush (brass)	J 7944
INJECTOR TUBE	
Cylinder head holding plates	J 3087-01
Injector protrusion gage	J 25521
Injector tube service tool set	J 22525
Injector tube service tool set (for power equipment)	J 22515
Injector tube swaging tool	J 28611-A

†Available in 5, 15, 30 and 55 gallons.

© 1981 General Motors Corp.

TOOL NAME	TOOL NO.
FUEL PUMP	
Fuel pump tool set	J 1508-03
Fuel pump wrench	J 4242
Fuel system primer	J 5956
MECHANICAL GOVERNOR	
Adjustable spanner wrench	J 5345-5
Elastic stop nut adjustment tool	J 28598-A
Governor cover bearing installer	J 21068
Governor cover bearing remover/installer	J 21967-01
High-speed spring retainer nut wrench	J 1652-01
Variable speed spring housing bearing installer set	J 9196
HYDRAULIC GOVERNOR	
Governor speeder spring wrench (PSG governor)	J 4873-01
Needle bearing installer (SGX governor)	J 21068
Snap ring pliers (external type) (PSG governor)	J 4880
Snap ring pliers (internal type) (PSG governor)	J 5403

© 1981 General Motors Corp.

SECTION 3

AIR INTAKE SYSTEM

CONTENTS

Air Intake System	3
Air Cleaner	3.1
Air Silencer	3.2
Air Shutdown Housing	3.3
Blower	3.4
Turbocharger (Airesearch)	3.5
Turbocharger (Elliott)	*
Turbocharger Intercooler	3.5.2
Turbocharger Aftercooler	3.5.3
Shop Notes - Trouble Shooting - Specifications - Service Tools	3.0

*For service and overhaul procedures for the Elliott turbocharger assemblies, refer to Elliott Company, Jeannette, Pennsylvania 15644.

AIR INTAKE SYSTEM

In the scavenging process employed in the 71 In-Line engines, a charge of air is forced into the cylinders by the blower and thoroughly sweeps out all of the burned gases through the exhaust valve ports. This air also helps to cool the internal engine parts, particularly the exhaust valves. At the beginning of the compression stroke, therefore, each cylinder is filled with fresh, clean air which provides for efficient combustion.

The air, entering the blower from the air cleaner or air silencer, is picked up by the blower rotor lobes and carried to the discharge side of the blower as indicated by the arrows in Fig. 1. The continuous discharge of fresh air from the blower creates an air pressure of approximately 7 psi (48 kPa) in the air chamber of the cylinder block at maximum engine speed. This air sweeps through the intake ports, which start to open as the piston approaches the end of its downward travel and close after the compression stroke begins.

The angle of the ports in the cylinder liners creates a uniform swirling motion to the intake air as it enters the cylinders. This motion persists throughout the compression stroke and facilitates scavenging and combustion.

Turbopowering of the 4-71 and 6-71 engines is accomplished by introducing a turbocharger in series with the blower of the air system as illustrated in Fig. 2. The expanding exhaust gases turn a single-stage turbine wheel which drives an impeller thus supplying air under pressure to the blower. Even though the blower speed is reduced considerably

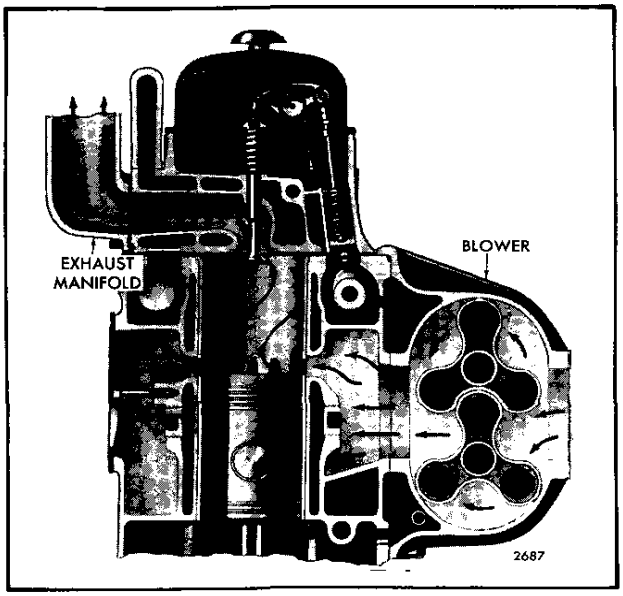


Fig. 1 - Air Flow Through Blower and Engine

© 1980 General Motors Corp.

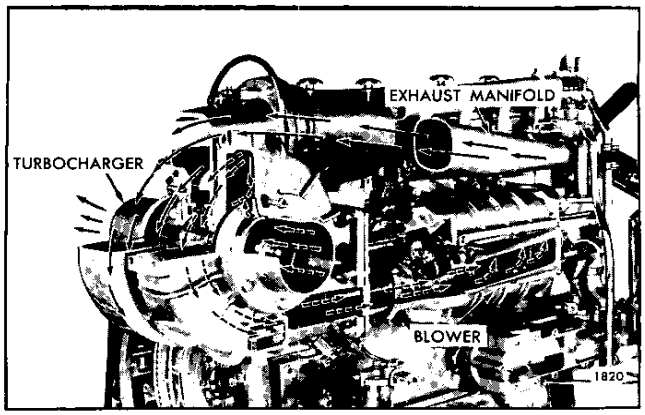


Fig. 2 - Air Flow Through Turbocharger and Blower

through an additional pair of gears in the blower gear train, the air box pressure is nearly doubled by the increased flow of air and the result is freer breathing, quieter operation and more complete combustion and scavenging.

© 1980 General Motors Corp.

AIR CLEANER

The air cleaners used on 71 engines are designed to remove foreign matter from the air, pass the required volume of air for proper combustion and scavenging, and maintain their efficiency for a reasonable period of time before requiring service.

The importance of keeping dust and grit-ladden air out of an engine cannot be over-emphasized since clean air is so essential to satisfactory engine operation and long engine life. The air cleaner must be able to remove fine materials such as dust and blown sand as well as coarse materials such as chaff, sawdust, or lint from the air. It must also have a reservoir capacity large enough to retain the material separated from the air to permit operation for a reasonable period before cleaning and servicing are required.

Dust and dirt entering an engine will cause rapid wear of piston rings, cylinder liners, pistons and the exhaust valve mechanism with a resultant loss of power and high lubricating oil consumption. Also, dust and dirt which is allowed to build-up in the air cleaner passages will eventually restrict the air supply to the engine and result in heavy carbon deposits on pistons and valves due to incomplete combustion.

Air Cleaner Mounting

Air cleaner mountings vary in accordance with the air cleaner installation and the engine units on which they are employed. The light duty oil wetted type, oil bath type and the dry type air cleaners are mounted on the air inlet housing. Heavy duty air cleaners are remotely mounted from the air inlet housing and are connected to it by air tight ducts.

Current design heavy duty air cleaners may be mounted in parallel to the same air inlet elbow for additional air cleaner capacity. Some earlier installations introduced an additional cleaner into the system between the main cleaner and the blower inlet. The heaviest cleaning job was imposed upon the main cleaner, whereas the additional cleaner, called the after cleaner, filters out any dirt particles that may have passed through the main cleaner.

Air Cleaner Maintenance

Although the air cleaner is highly efficient, this efficiency depends upon proper maintenance and periodic servicing.

Damaged gaskets, loose hose connections or leaks in the duct work, which permit dust-laden air to completely bypass the cleaner and enter the engine directly, will lower the efficiency of the air cleaner. If the air cleaner is not serviced periodically, the engine will not receive a sufficient amount of clean air.

No set rule for servicing an air cleaner can be given since it depends upon the type of air cleaner, the condition of the air supply, and the type of application. An air cleaner operating in severe dust will require more frequent service than an air cleaner operating in comparatively clean air. The most satisfactory service period should be determined by frequently inspecting the air cleaner under normal operating conditions, then setting the service period to best suit the requirements of the particular engine application.

The following maintenance procedure will assure efficient air cleaner operation.

1. Keep the air cleaner tight on the air intake pipe to the engine.

2. Keep the air cleaner properly assembled so the joints are strictly oil and air tight.

3. Repair any damage to the air cleaner or related parts immediately.

4. Inspect and clean or replace the air cleaner element as operating conditions warrant. In the dry type cleaner, it is possible to clean and reuse the element several times as long as the paper is not ruptured in the process. In an oil bath type cleaner keep the oil at the level indicated on the air cleaner sump. Overfilling may result in oil being drawn through the element and into the engine, thus carrying dirt into the cylinders and also resulting in excessive engine speed.

5. After servicing the air cleaner, remove the air inlet housing and clean accumulated dirt deposits from the blower screen and the inlet housing. Keep all air intake passages and the air box clean.

6. Where a rubber hose is employed, cement it in place. Use a new hose and hose clamps, if necessary, to obtain an air tight connection.

7. Carefully inspect the entire air system periodically. Enough dust-laden air will pass through an almost invisible crack or opening to eventually cause damage to an engine.

© 1981 General Motors Corp.

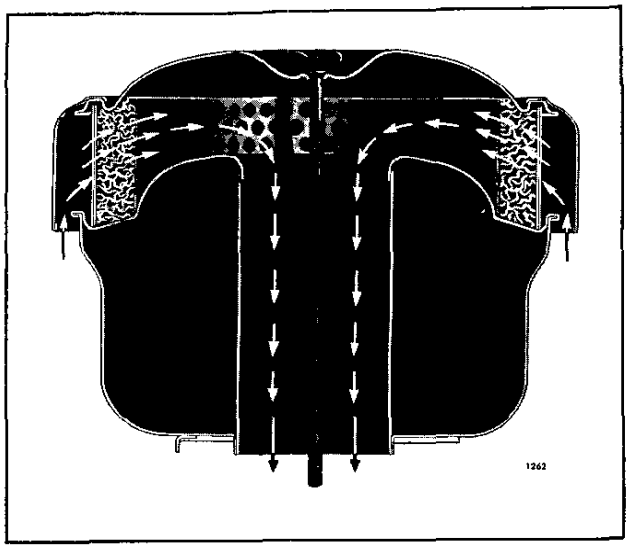


Fig. 1 - Oil Wetted Type Air Cleaner Assembly

Light Duty Oil Wetted Type Air Cleaner

The oil wetted type air cleaner consists essentially of a metal screen element saturated with oil and supported inside a cylindrical housing (Fig. 1). Air drawn into the cleaner passes through the element where dust and other foreign matter is removed, then it travels down the central tube in the cleaner to the blower inlet. This lower portion serves as a chamber to reduce air intake noise.

Light Duty Oil Bath Type Air Cleaner

The light duty oil bath type air cleaners consist essentially of a wire screen element supported inside a sylindrical housing which contains an oil bath directly below the element (Figs. 2 and 3). Air drawn through the cleaner passes over the top of the oil bath. The air stream direction reverses when the air impinges on the oil in the sump and is then directed upwards by baffles. During this change in the direction of air flow, much of the foreign matter is trapped by the oil and is carried to the sump where it settles out. The air passes upward through the metal-wool elements where more dust and the entrained oil are removed. A second change of air direction, at the top of the cleaner directs the air downward through the center tube and into the blower inlet housing.

Service (Light-Duty)

To service the light duty air cleaner, loosen the wing bolt and remove the cleaner from the air inlet housing. The cleaner may then be separated into two sections. The upper section contains the metal-wool elements and the lower section is made up of the oil sump, removable baffle and the center tube.

The upper shell and metal-wool elements may be cleaned by soaking the entire section in kerosene or fuel oil. This will loosen the oil and dust in the elements and facilitate flushing out the dirt. The oil should be emptied from the sump, the baffle removed, and the sump and baffle cleaned in kerosene or fuel oil to remove all sediment. A lintless cloth should be pushed through the center tube of the cleaner before the baffle is installed and the sump refilled to the oil level mark with clean engine oil. NEVER use cotton waste to wipe the center tube. Use the same viscosity and grade of oil that is used in the engine crankcase. All gaskets and sealing surfaces should be checked and cleaned to ensure air-tight seals.

After the filter element has been thoroughly drained of the flushing fluid, the cleaner should be assembled. However, before installing the cleaner on the engine, the air inlet housing and blower inlet screen should be checked for the presence of dirt accumulations. If the service period has been too long, or dust-laden air has been leaking past the seals, the inlet housing and screen will be dirty. This will serve as a good check on the maintenance of the air cleaner installation. When installing the cleaner (and its seal) on the inlet housing, be sure that the cleaner seats properly, then

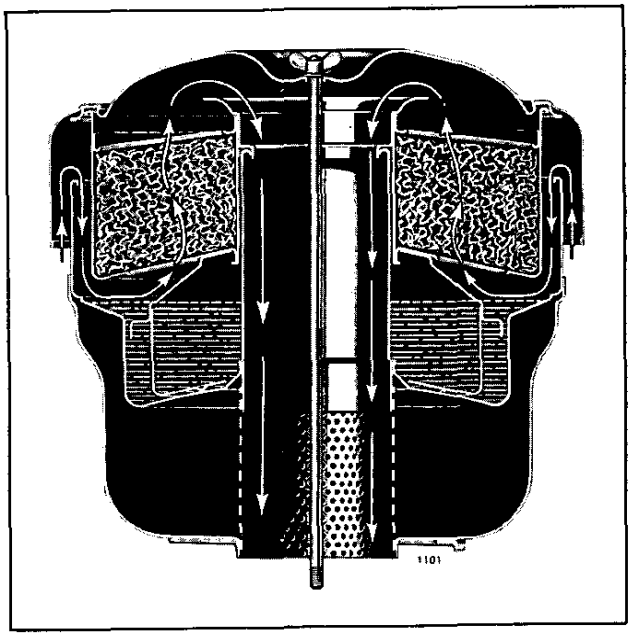


Fig. 2 - Light Duty Oil Bath Air Cleaner and Silencer Assembly

© 1981 General Motors Corp.

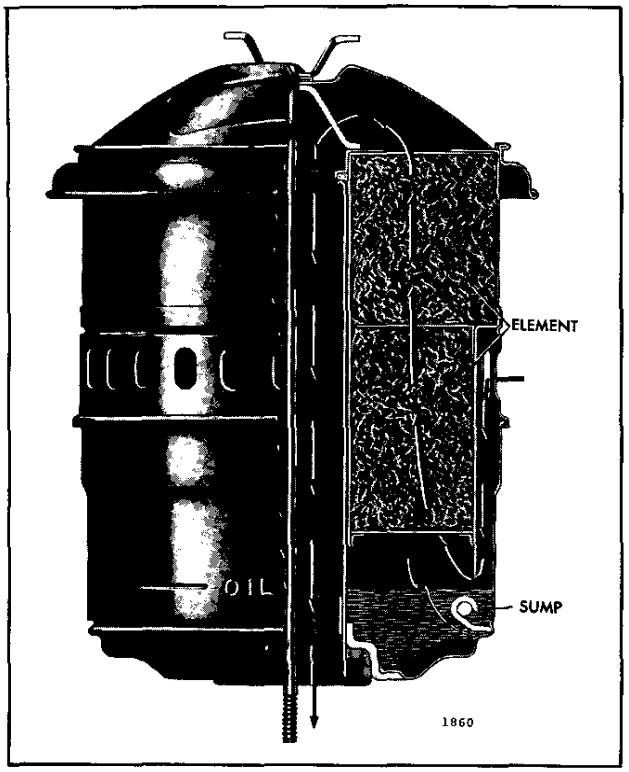


Fig. 3 - Light Duty Oil Bath Air Cleaner and Silencer Assembly

tighten the wing bolt securely until the cleaner is rigidly mounted.

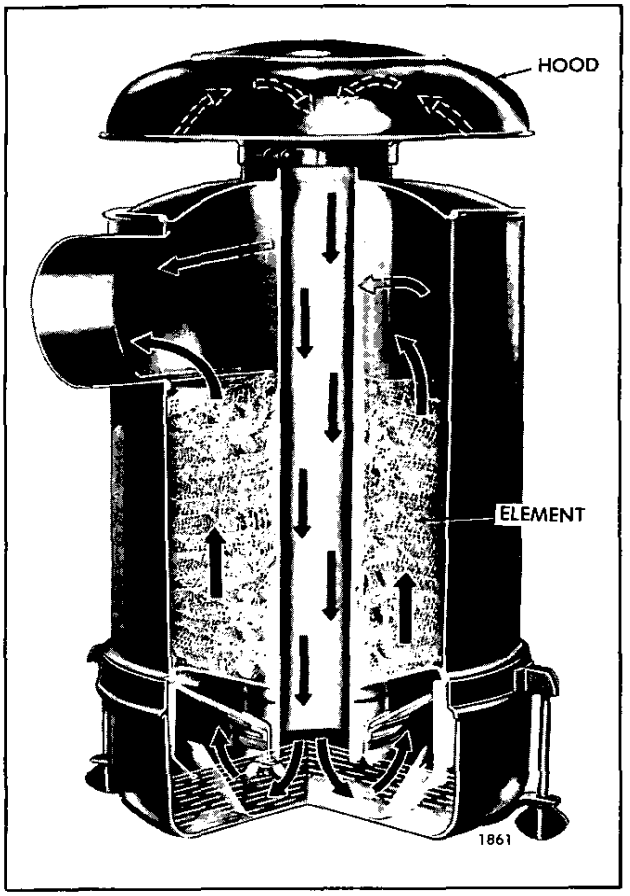


Fig. 4 - Heavy Duty Oil Bath Air Cleaner and Silencer Assembly

Heavy Duty Type Air Cleaner

In all heavy duty air cleaners air is drawn through the air inlet hood, which acts as a cleaner and down through the center tube (Fig. 4). At the bottom of the tube, the direction of air flow is reversed and oil is picked up from the oil reservoir cup. The oil laden air is carried up into the separator screen where the oil which contains the dirt particles is separated from the air by collecting on the separator screen.

A low pressure area is created toward the center of the air cleaner as the air passes a cylindrical opening formed by the outer perimeter of the central tube and the inner diameter of the separator screen (Fig. 5). This low pressure is caused by the difference in air current velocity across the opening. The low pressure area, plus the effect of gravity and the inverted cone shape of the separator screen, causes the oil and dirt mixture to drain to the center of the cleaner cup. This oil is again picked up by the incoming air causing a

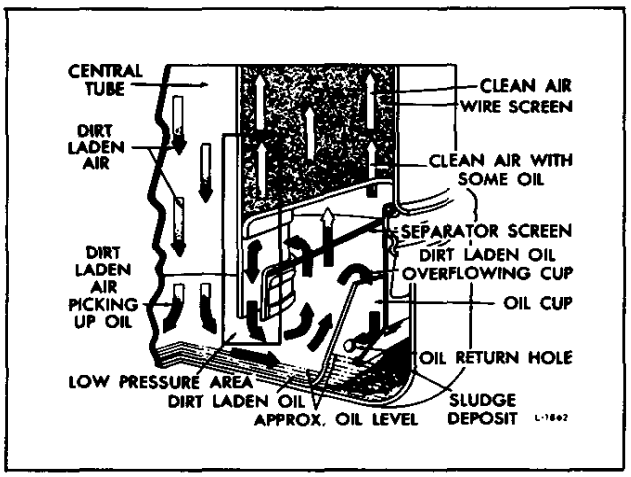


Fig. 5 - Air Flow Through Heavy Duty Oil Bath Air Cleaner

© 1981 General Motors Corp.

looping cycle of the oil, however, as the oil is carried toward another cycle, some of the oil will overflow the edge of the cup carrying the dirt with it. The dirt will be deposited in the outer area surrounding the cup. Oil will then flow back into the cup through a small hole located in the side of the cup. Above the separator screen, the cleaner is filled with a wire screen element which will remove any oil which passes through the separator screen. This oil will also drain to the center and back into the pan. The clean air then leaves the cleaner through a tube at the side and enters the blower through the air inlet housing.

An air inlet hood or pre-screener must be used with the heavy duty air cleaners, depending upon operating conditions. This equipment normally requires cleaning more frequently than the main air cleaner. The usual installation employs an air inlet hood which serves only to prevent rain, rags, paper, leaves, etc., from entering the air cleaner. The smaller cleaners employ a spherical-shaped hood. Air enters the hood through a heavy screen which forms the lower portion of the hood, and the air is reversed in the hood and pulled downward into the air cleaner. The hood is mounted on the air cleaner inlet tube and is held in place by the fit of the hood in the inlet tube.

The larger cleaners use a dome-shaped hood. A heavy screen inside the dome guards against large pieces of foreign material entering the cleaner. The hood is mounted on the air inlet tube of the cleaner and is secured to it by a screw-clamp. As previously mentioned, the hoods serve only to prevent rain and large pieces of foreign material from entering the cleaner. The openings in the hoods should be kept clear to prevent excessive restriction to air flow.

A pre-screener should be used on the inlet tube of the air cleaner instead of the inlet hood for those operations in which the air cleaner elements load up with lint or chaff. The purpose of the pre-screener is to remove as much of the lint or chaff as possible before the air enters the cleaner.

Service (Heavy-Duty)

The air inlet hoods used on heavy-duty air cleaners are not intended to do any cleaning. However, some dirt will collect on the heavy screens and in the hood itself. Therefore, it will be necessary to remove the hood occasionally for cleaning by brushing or with compressed air.

Some applications may be equipped with a pre-screener. The pre-screener catches the lint and chaff on the screen surrounding the shell. This screen can be removed by unhooking the retaining springs, and cleaned by brushing or with compressed air. The shell can be cleaned, if necessary, by wiping it with a lintless cloth. The pre-screener may then be assembled and installed on the cleaner inlet tube.

Although the pre-screener will remove most of the lint and chaff from the air, some may still find its way into the main cleaner. Therefore, it is essential that the fixed element of the main cleaner be checked, each time the cleaner is serviced, to prevent excessive lint deposits.

When the oil sump is removed on some heavy-duty air cleaners, a tray type screen attached to the tube will be visible. It may be removed by loosening the wing nuts and rotating the tray so that it unlocks from the tube. On other heavy duty models, the tray rests on the lip of the inner oil cup of the sump and is not retained by wing nuts.

The efficiency of the tray type oil bath air cleaner can be greatly reduced unless the fibrous material caught in the tray is removed. It is extremely important that the tray be cleaned regularly and properly.

If a tray is plugged with lint or dirt, wash the tray in a solvent or similar washing solution and blow out with high velocity compressed air or steam (Fig. 6). An even pattern of light should be visible through the screens when a clean tray is held up to the light (Fig. 6). It may be necessary, as a last resort, to burn off the lint. Extreme care must be taken not to melt the galvanized coating in the tray screens. Some trays have equally spaced holes in the retaining baffle. Check to make sure that they are clean and open.

It is advisable to have a spare tray on hand to replace the tray that required cleaning. Having an extra tray available makes for better servicing and the plugged tray can be cleaned thoroughly at leisure.

Check for dirt accumulation in air cleaner center tube. Remove dirt by passing a lintless cloth through the center tube. Some tubes have a restricted portion at the lower end and care must be exercised not to damage this end.

Check oil sump for any dirt accumulation in both the inner and outer cups and clean if necessary.

At some regular period of engine service, remove the entire air cleaner from the engine and clean the fixed element. This can be done by passing a large quantity of clean solvent through the air outlet and down into the fixed element. When clean, allow element to dry thoroughly before installing cleaner.

When all of the components have been cleaned, the cleaner is ready for assembly. The removable screen should be installed and the oil sump should be filled with clean engine oil to the indicated level and

© 1981 General Motors Corp.

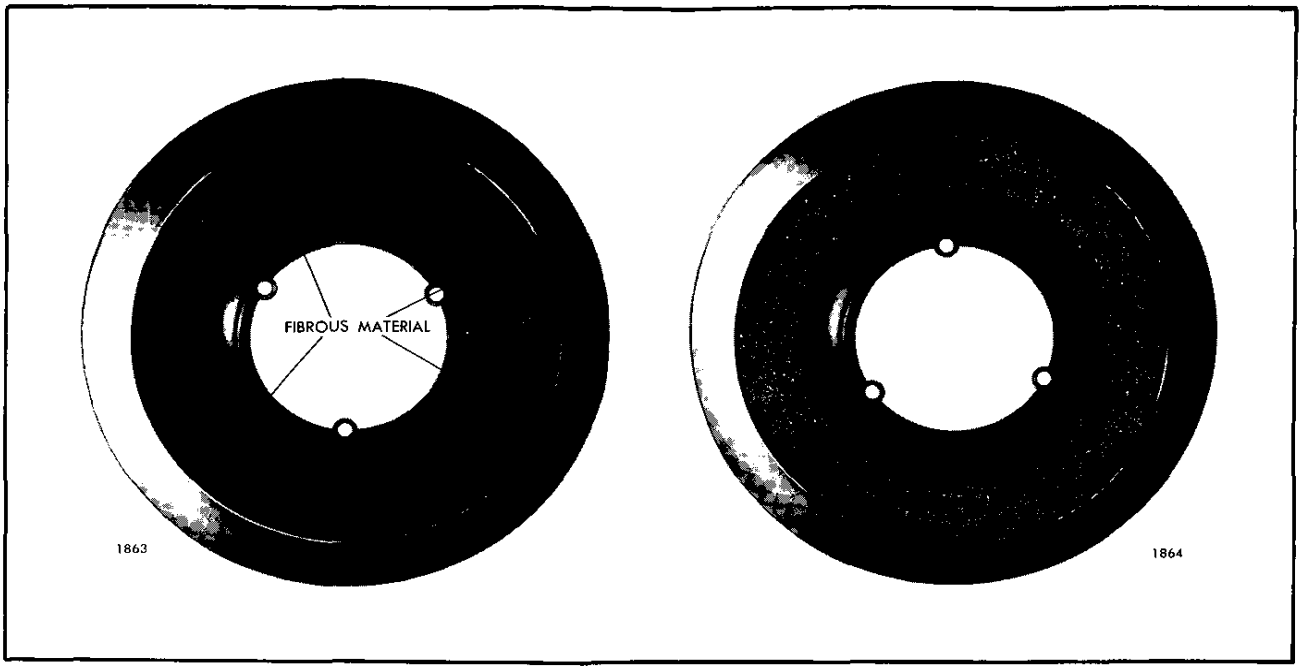


Fig. 6 - Comparison of Air Cleaner Trays

installed on the cleaner. Care should be exercised that all gaskets and joints are tight. All connections from the cleaner to the engine should be checked for air leaks to prevent any air bypassing the air cleaners.

If it is found that unfiltered air is being admitted into the engine through the duct work of an air cleaner installation, the following procedure may be used for finding air leaks in an air duct system. The air cleaning system does not have to be dismantled, thus effecting a saving in time.

To make this check, it is necessary that suitable plugs be provided to block the air cleaner system inlet and outlet. The air cleaner inlet plug should contain a suitable air connection and shutoff valve to maintain two pounds pressure in the air duct system. The outlet plug need only be of sufficient size to form a completely air-tight seal at the outlet end of the system. Then check the system as follows:

1. Remove the air inlet hood or pre-screener.

2. Insert the plug (with the fitting for the air hose) in the air cleaner inlet to form an air-tight seal.

3. Insert the other plug in the outlet end of the system to form an air-tight seal.

4. Attach an air hose to the plug in the air cleaner inlet and regulate pressure not to exceed 2 psi (14 kPa).

5. Brush a soapsuds solution on all air duct connections. Any opening which would allow dust to enter the engine can then be detected by the escaping air causing bubbles in the soapsuds solution. All leaks thus discovered should be remedied until the system checks "air-tight".

6. Remove plugs and install air inlet hood or pre-screener.

A rotational type of service program may be followed on heavy duty air cleaner installations that employ a main and after cleaner, in accordance with the following procedure, since the heaviest cleaning job is imposed upon the main cleaner.

1. Remove and clean the sump and removable screen of the main cleaner.

2. Check all joints and tubes of the main cleaner and ensure that they are air-tight.

3. Install the cleaned removable screen on the main cleaner.

4. Remove the sump of the after cleaner and install it on the main cleaner.

5. Remove and clean the removable screen of the after cleaner.

© 1981 General Motors Corp.

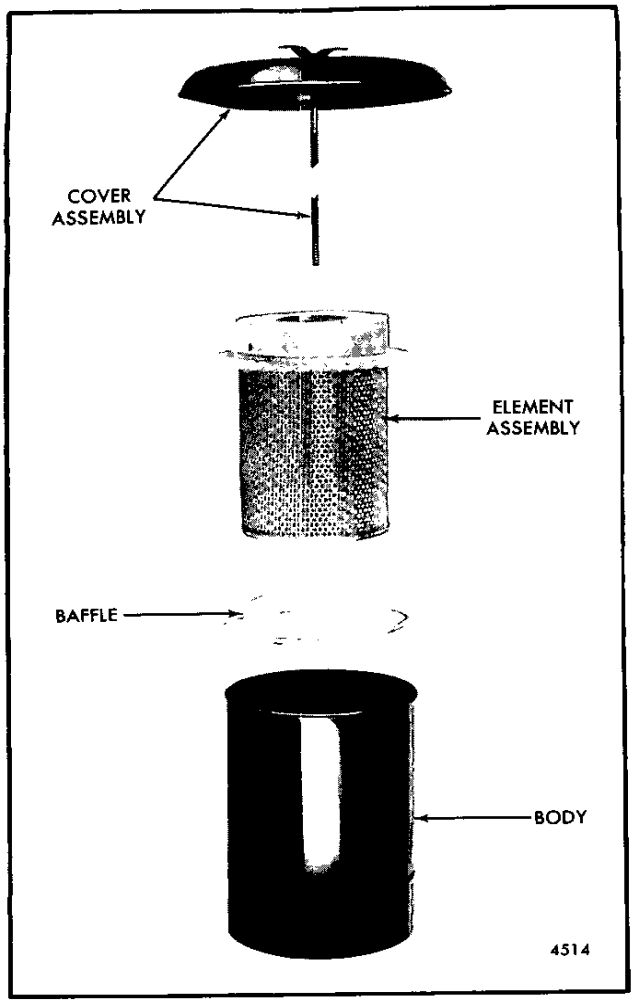


Fig. 7 - Dry Type Air Cleaner

6. Check all joints and tubes of the after cleaner and ensure that they are air-tight.

7. Install the remaining screen and sump on the after cleaner.

The design and function of the heavy duty air cleaners is such that the fixed elements tend to be self-cleaning. However, it may be necessary, occasionally, to remove the entire cleaner from its mountings and clean these elements. If the fixed elements require too frequent cleaning, it is advisable to relocate the air intake to provide a cleaner air supply.

Proper selection of air cleaners and good air cleaner maintenance go "hand in hand" in providing long engine life and trouble-free operations.

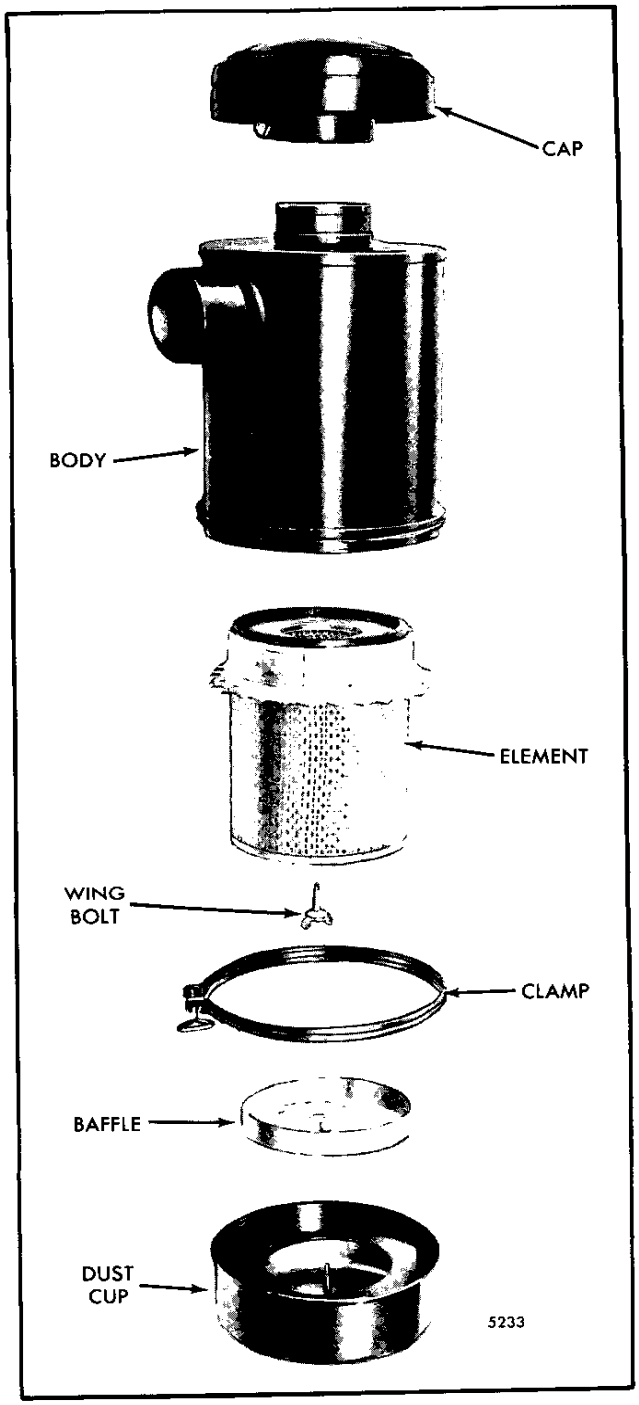


Fig. 8 - Dry Type Air Cleaner (Heavy Duty)

© 1981 General Motors Corp.

Dry Type Air Cleaner

The Donaldson dry type air cleaners shown in Figs. 7, 8 and 9 are designed to provide highly efficient air filtration under all operating conditions. The cleaners have a replaceable impregnated paper filter element that can be cleaned.

The fins on the element give high speed rotation to the intake air, which separates a large portion of the dust from the air by centrifugal action. The plastic fins, the element and the gasket make up a single replaceable element assembly.

The dust is swept through a space in the side of the baffle and collects in the lower portion of the body or dust cup. The dust remaining in the precleaned air is removed by the element.

The dry type cleaner *cannot be used* where the atmosphere contains oil vapors, or fumes from the breather can be picked up by the air cleaner.

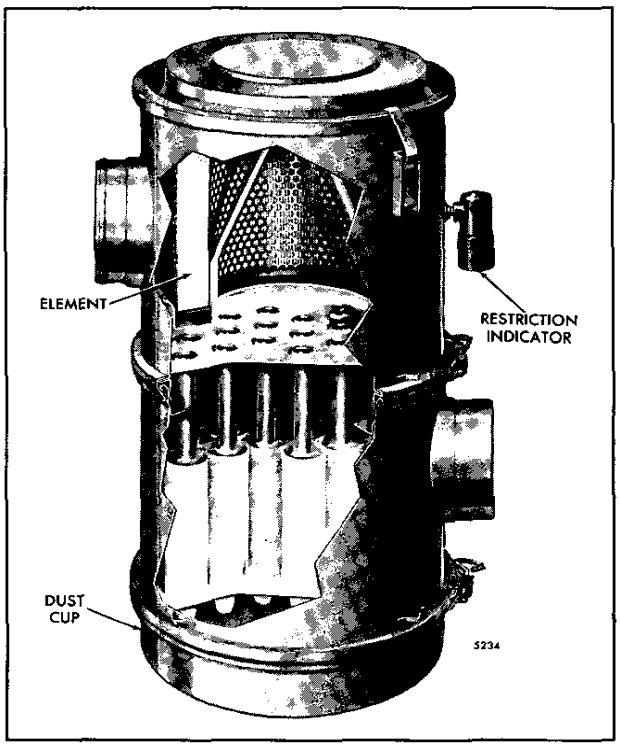


Fig. 9 - Dry Type Air Cleaner (Extra Heavy Duty)

Service (Dry Type)

The air cleaner should be serviced as operating conditions warrant. See Section 15.1 for element change intervals.

Under no engine operating conditions should the maximum allowable air intake restriction shown in Section 13.2 of the service manual be exceeded. Check restriction with a water manometer using the procedure outlined under "final RUN-IN" in Section 13.2.1. In addition, inlet restriction should be adjusted for high altitude conditions (see TABLE 1). A clogged air cleaner element will cause excessive intake restriction, reduce air supply to the engine, poor performance and higher valve and cylinder temperatures.

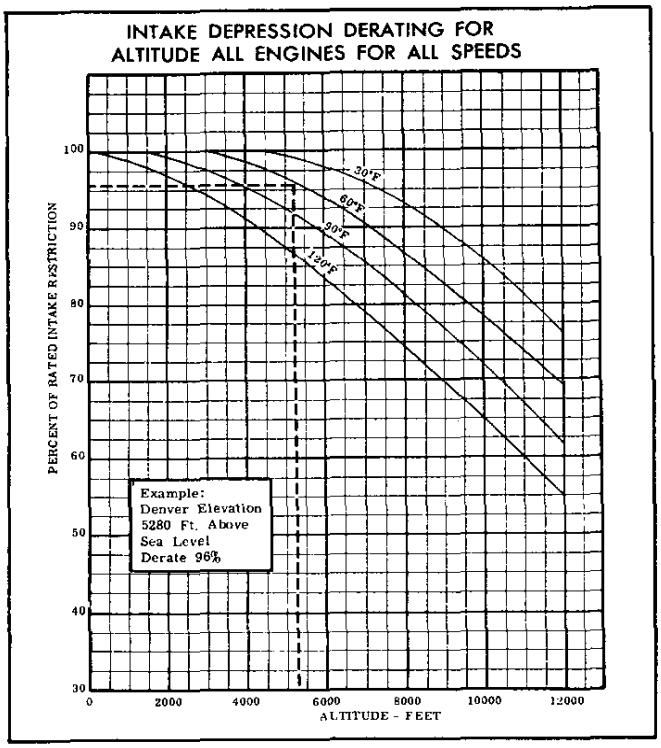


TABLE 1

Disassemble the cleaner as shown in Fig. 7 as follows:

1. Loosen the cover bolt and remove the cover and bolt as an assembly.

2. Remove the element assembly and baffle from the cleaner body.

3. Remove the dust and clean the cleaner body thoroughly.

© 1981 General Motors Corp.

Disassemble the cleaner in Fig. 8 as follows:

1. Loosen the dust cup clamp and remove the dust cup.

2. Loosen the wing bolt in the dust cup and remove the baffle from the dust cup.

3. Remove the wing bolt from the cleaner body and remove the element assembly.

4. Remove the dust and thoroughly clean the cleaner body, dust cup and baffle.

The paper pleated element assembly can be cleaned as follows:

NOTE: The pre-cleaning fins are not removable.

1. The element can be dry cleaned by directing clean air up and down the pleats on the clean air side of the element.

NOTE: Air pressure at the nozzle of the air hose must not exceed 100 psi (689 kPa). Maintain a reasonable distance between the nozzle and the element.

2. To wash the element, use the Donaldson Filter Cleaner or a non-sudsing equivalent. Proportions are 2 ounces of cleaner to 1 gallon of water. For best mixing results, use a small amount of cool tap water then add it to warm (100°F or 38°C) water to give the proper proportion. Soak the element for 15 minutes, then rinse it thoroughly with clean water from a hose (maximum pressure 40 psi or 135 kPa). Air dry the element completely before reusing (a fan or air draft may be used, but *do not heat* the element to hasten drying).

The filter manufacturer has no control over the field cleaning method or procedure. Therefore, it is the responsibility of the person or shop cleaning the element to assure the reliability of the filter after cleaning. It is also the responsibility of the installer to assure proper sealing of the gaskets.

Donaldson advises that elements used in on-highway applications should not be washed or reused. The reason for this is that on-highway trucks operate in an environment contaminated by a mixture of fine dust and exhaust carbon. To better enable dry type air cleaners to handle this type of contaminant, most on-highway truck air cleaners contain special chemically treated elements. Washing can remove the chemical treatment and shorten element life. Consequently, on-highway air cleaner elements should not be washed and reused.

Most Donaldson primary elements used in off-highway applications do not receive the same chemical treatment. These can be cleaned and reused according to the manufacturer's recommendations. Secondary (safety) elements should not be cleaned or reused.

3. Inspect the cleaned element with a light bulb after each cleaning. Thin spots, pin holes, or the slightest rupture will admit sufficient air borne dirt to render the element unfit for further use and cause rapid failure of the piston rings. Replace the element assembly if necessary.

4. Inspect the gasket on the end of the element. If the gasket is damaged or missing, replace the element.

Reassemble the air cleaner in reverse order of disassembly. Replace the air cleaner body gasket, if necessary.

NOTE: Do not use oil in the bottom of the cleaner body.

The element assembly should be replaced after six (6) cleanings, or annually.

Element Life

The recommended product life (shelf life plus service life) of Donaldson dry type air cleaner elements is three years. Consequently, Donaldson elements should be put into service no later than two years from the date of manufacture. Farr air cleaner elements should be put into service within one year from the date of manufacture.

© 1981 General Motors Corp.

AIR SILENCER

BLOWER

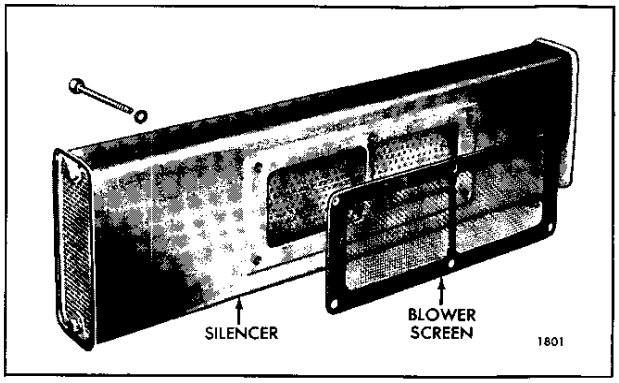


Fig. 1 - Blower Air Inlet Silencer Assembly

The air silencer is attached to the air intake side of the blower rotor housing (Fig. 1). A perforated sheet metal partition divides the silencer into two sections. The inner portion forms an air duct the entire length of the silencer. Air enters this duct from both ends and flows toward the outlet opening at the center and then into the blower. The outer portion is filled with sound abosorbent, flame-proof, felted cotton waste.

A blower screen is used between the air silencer and the blower housing to prevent foreign objects from entering the blower.

Remove and Install Air Silencer

The air silencer requires no service. However, it must be removed to clean or to replace the blower screen or to service the blower. Remove the silencer as follows:

1. Remove the bolt that retains the breather pipe to the air silencer.

2. While supporting the silencer, remove the six attaching bolts and washers. Then remove the silencer and blower screen from the blower.

3. Clean or replace the blower screen.

4. Place the washers over the six silencer attaching bolts. Then slide the bolts through the bolt holes in the silencer.

5. Place the blower screen and gasket assembly over the projecting bolts, with the screen side of the assembly toward the blower, and position the silencer against the blower housing. Then tighten the bolts.

TURBOCHARGER

The air silencer used on the air inlet side of the turbocharger consists of an inner and outer cover (Fig. 2). A fiber glass insulation pad and a perforated sheet metal screen located against the inner wall of each cover absorb the sound of the incoming air. Three through bolts, which hold the covers, insulation pads and screens together, are used to attach the silencer assembly to the compressor of the turbocharger assembly.

Air is drawn into a passage formed between the inner and outer covers of the silencer and flows into the turbocharger compressor via the outlet opening in the inner cover. A perforated steel screen that surrounds the silencer prevents any large objects from entering the silencer.

Effective with engine 6A-69103, the inner cover was revised to incorporate longer bolt bosses, thus eliminating the spacers formerly used (Fig. 2). The inner insulation and inner screen were revised to provide clearance around the bolt bosses. The perimetrical screen formerly retained by bolts was also replaced by a new screen that is retained by a spring.

Service

Very little service, other than an occasional cleaning of the silencer, is required. However, the silencer must be removed when service operations are performed on the turbocharger. Remove the silencer as follows:

1. Loosen the three attaching bolts and withdraw the silencer assembly.

2. Unhook the spring that holds the ends of the perimetrical screen together (two bolts and lock

© 1983 General Motors Corp.

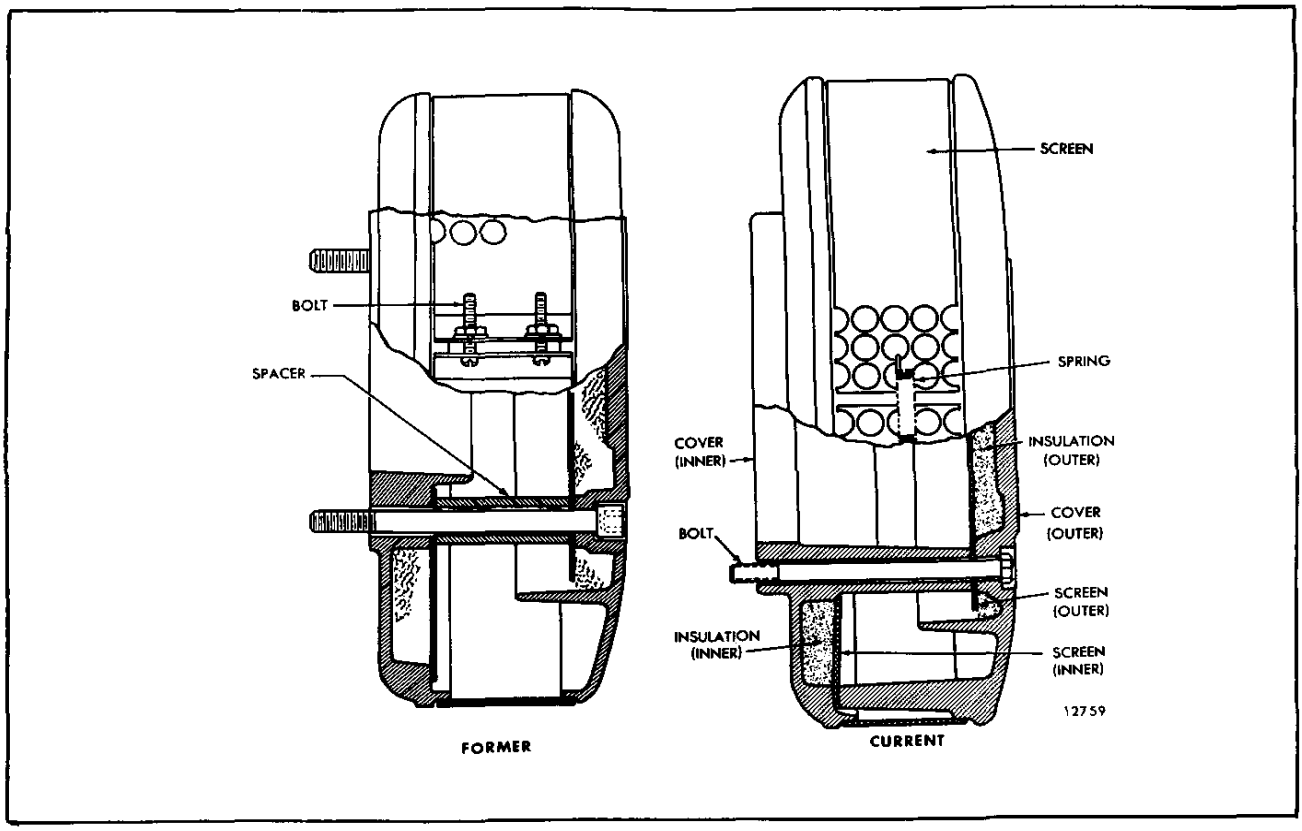


Fig. 2 - Turbocharger Air Inlet Silencer

washers are used in place of the spring on earlier silencers).

3. Withdraw the three bolts from the silencer, thus disassembling the entire silencer.

4. Clean and inspect the silencer components. If the covers on the earlier type silencer need replacing, the entire silencer must be replaced.

5. Refer to Fig. 2 and reassemble the silencer.

6. Install the silencer on the compressor side of the turbocharger.

NOTE: Tighten the bolts evenly and only enough to secure the silencer to the turbocharger. Excessive torque may disrupt alignment of the turbocharger.

© 1983 General Motors Corp.

AIR SHUTDOWN HOUSING

The air shutdown housing, mounted on the side of the blower, serves as a mounting for the air cleaner or for air cleaner ducting. The air shutdown housing contains an air shutdown valve(s) that shuts off the air supply and stops the engine whenever abnormal operating conditions require an emergency shut down (Section 7.4.1).

Remove Air Shutdown Housing

1. Remove the air cleaner or air cleaner ducts.

2. Disconnect the Bowden wire or cable assembly from the air shutoff cam pin handle (shutdown control nut, early engines).

3. Remove the bolts and washers that retain the housing to the blower and remove the housing from the blower. Remove the air shutdown housing gasket from the blower.

Disassemble Air Shutdown Housing

If necessary, the air shutoff valve assembly may be disassembled after the air shutdown housing has been removed from the blower.

Refer to Figs. 1, 2 and 3 and disassemble the air shutoff valve assembly as follows:

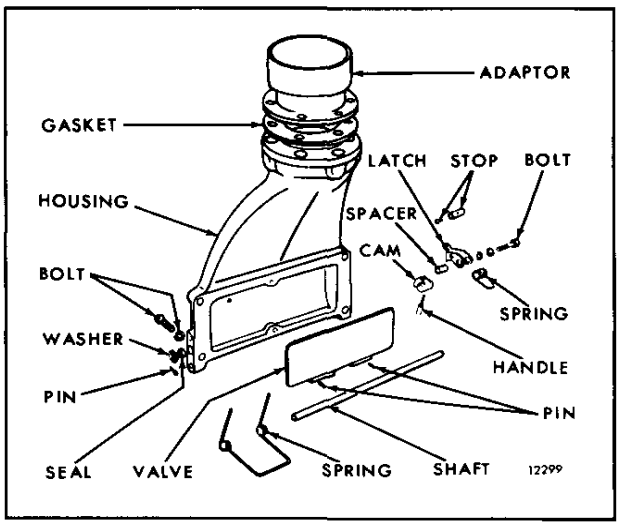


Fig. 1 - Typical Current Cam and Latch Type Air Shutdown Housing Details and Relative Location of Parts

1. Use a small punch to remove the pin from the air shutoff valve shaft. Remove the washer from the shaft. Remove and discard the seal ring from the housing.

2. Remove the pins that secure the air shutoff valve(s) to the shaft.

CURRENT CAM AND LATCH TYPE

1. Note the position of the air shutoff valve spring and the valve. Then, withdraw the shaft from the housing to release the valve(s) and spring in the housing. Remove and discard the seal ring from the housing.

2. Remove the bolt, lock washer and plain washer from the housing and remove the latch, latch spring and spacer.

EARLY BALL AND DETENT LEVER TYPE

1. Note the position of the shutdown lever and valve(s) on the shaft. Then, withdraw the shaft and detent lever assembly from the housing.

NOTE: Be careful not to lose the steel ball and spring when separating the lever from the lock plate. If necessary, remove the pin from the lever and shaft to remove the lever from the shaft.

2. Remove the lock plate from the housing. Then, remove and discard the seal ring from the housing.

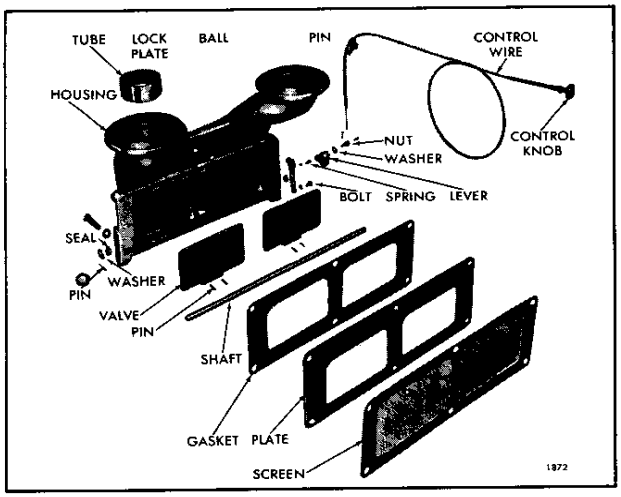


Fig. 2 - Typical Early Ball and Lever Type Air Shutdown Housing Details and Relative Location of Parts

© 1984 General Motors Corp.

Inspection

Clean all of the parts thoroughly, including the blower screen, with fuel oil and dry them with compressed air. Inspect the parts for wear or damage. The face of the air shutoff valve(s) must be perfectly flat to assure a tight seal when it is in the shutdown position.

Accumulation of dirt behind the steel ball in the detent lever (early engines) may prevent the lever from moving when an attempt is made to close the valves. Make sure the ball detent is clean.

Assemble Air Shutdown Assembly

CURRENT CAM AND LATCH TYPE

The holes for the cam pin handle and the retaining pins must be drilled at the time a new service shaft or air shutoff valve(s) are assembled (see *Shop Notes* in Section 3.0 for procedure). Refer to Figs. 1, 2 and 3 and proceed as follows:

1. Place the valve(s) and spring in position in the housing and slip the shaft in place. The shaft must extend .760″ from the side of the housing where the shutdown latch is assembled. Then, install the pins which retain the valve(s) to the shaft.

2. Lubricate with engine oil and install a new seal ring at each end of the shaft.

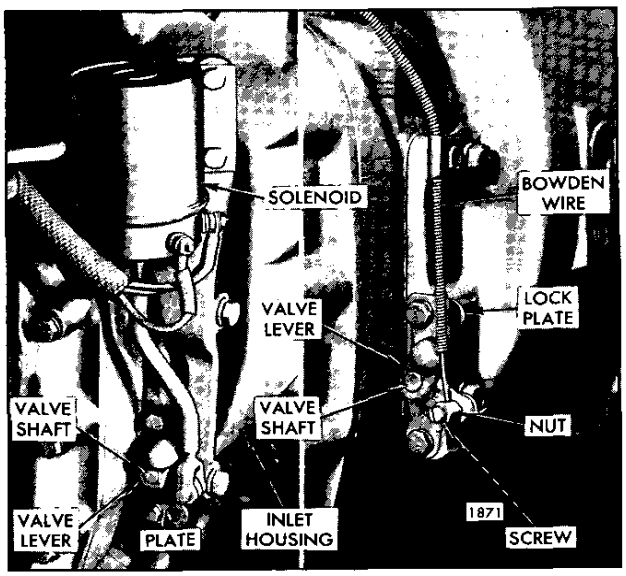


Fig. 3 - Position of Lock Plate on Manual and Automatic Shutdown (Early Engines)

3. Install the cam and cam pin handle on the shaft.

4. Install a washer and retaining pin at the other end of the shaft.

5. Assemble the spacer and spring on the latch. Then, slip the attaching bolt through the lock washer, plain washer, latch and spacer. Attach the latch assembly to the housing and tighten the bolt.

6. After assembly, check for .015″ to .040″ shaft end play.

EARLY BALL AND DETENT LEVER TYPE

The holes for the shutdown detent lever and the valve(s) retaining pins must be drilled at the time a new service shaft or shutdown valve(s) are assembled (see *Shop Notes* in Section 3.0 for procedure). Refer to Figs. 2 and 3 and proceed as follows:

1. Place the valve(s) in position in the housing and slip the shaft in place. Drill and pin the valve(s) to the shaft (see Section 3.0).

2. Lubricate with engine oil and install new seal rings at each end of the shaft.

3. Install the lock plate over the shaft and against the housing with a bolt and washer, in the same position as removed. Tighten the bolt.

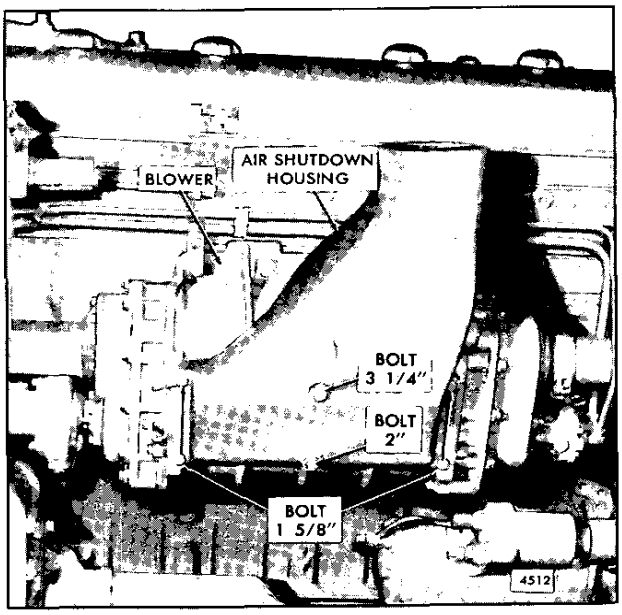


Fig. 4 - Air Shutdown Housing Mounting and Bolt Location

© 1984 General Motors Corp.

NOTE: The lock plate is stamped manual and automatic.

4. Install the spring and ball in the detent in the lever and assemble the lever on the shaft. Pin the lever to the shaft. Then, move the valve(s) into the open or closed position, depending on the type of shutdown. This will cause the ball to seat in the top hole of the lock plate.

5. Install the washer and retaining pin at the other end of the shaft.

6. After assembly, check for .008″ to .015″ shaft end play and make sure the valve assembly works freely.

Install Air Shutdown Housing

Before attaching the shutdown assembly to the blower, place a steel straight-edge lengthwise on the finished face of the housing bolting flange and close the valves against the straight-edge. The finished pads at each end of both valves must be flush against the straight-edge when it is moved from the top to the bottom of the inlet housing flange. Now turn the straight-edge crosswise on the housing flange and draw it from end-to-end. Both the upper and lower finished pads of the valves must be flush against the straight-edge throughout the length of the valves.

1. Place the blower screen and gasket assembly in position with the screen side of the assembly toward the blower.

NOTE: The current blower screen gasket consists of wire mesh secured between two sheets of gasket material. The former screen was imbedded in one sheet of gasket material and was installed with the screen side toward the blower.

2. Refer to Fig. 4 and mount the air shutdown housing together with the striker plate gasket and striker plate (if used) on the blower with bolts and lock washers and tighten the bolts to 16-20 lb-ft (22-27 Nm) torque.

NOTE: The 3/8″-16 x 3-1/4″ bolt and the 3/8″-16 x 2″ bolt must be installed as shown in Fig. 4. The four 1-5/8″ bolts are installed in the four corner bosses of the housing.

3. Connect the Bowden wire or cable assembly to the air shutoff cam handle pin (shutoff control nut on early engines).

4. Start and run the engine at idle speed and no load. Trip the air shutdown. If the engine does not stop, check it for air leakage between the valve(s) and the striker plate. If necessary, reposition the valve(s).

5. Install the air cleaner or air cleaner ducts.

© 1984 General Motors Corp.

BLOWER

The blower, designed especially for efficient diesel operation, supplies the fresh air needed for combustion and scavenging. Its operation is similar to that of a gear-type oil pump. Two hollow three-lobe rotors revolve with very close clearances in the housing bolted to the cylinder block. To provide continuous and uniform displacement of air, the rotor lobes are made with a helical (spiral) form, (Figs. 1 and 2).

Two timing gears, located on the drive end of the rotor shafts, space the rotor lobes with a close tolerance; therefore, as the lobes of the upper and lower rotors do not touch at any time, no lubrication is required.

Oil seals located in the blower end plates prevent air leakage and also keep the oil used for lubricating the timing gears and rotor shaft bearings from entering the rotor compartment.

Lip type oil seals are installed in the blower end plates of naturally aspirated engine blowers. Metal ring-type oil seals are incorporated in the blower used on turbocharged engine and the large bearing (P) blower (see inset, Fig. 2). Each ring-type oil seal consists of a carrier pressed into the rotor shaft, a collar pressed into the end plate and a seal ring contained in a groove in the carrier. The outside diamter of the seal ring rides against the collar to prevent leakage of air or oil.

Each rotor is supported in the doweled end plates of the blower housing by a roller bearing at the front end and a double row pre-loaded radial and thrust ball bearing at the gear end.

The blower upper rotor is driven by the blower drive shaft which is coupled to the upper rotor timing gear by means of a flexible drive hub (20 - Figs. 1 or 2).

A flexible coupling, formed by an elliptical cam driven by two bundles of leaf springs which ride on four semi-cylindrical supports and spring seats is attached to the blower drive gear (42 - Fig. 1), and prevents the transfer of torque fluctuations to the blower.

The former 71E and 71N engines used a 1.69:1 ratio blower and the former 71T engines used a 1.55:1 ratio blower. Early engines employ a 2.00:1 ratio standard blower.

Currently a standard and a small diameter rotor blower are used on In-line 71 engines. The small diameter rotor blower with a 2.00:1 blower-to-engine speed ratio is employed in the 71E and 71N engines and a 1.95:1 blower-to-engine speed ratio is employed in the 71T engines. When higher pressures are required such as for bulk unloading, a large bearing 2.00:1 ratio (P) blower with metal ring type oil seals is used. The ratio between the blower speed and the engine speed, and the number of teeth in the blower drive gears and reduction gears is given in Table 1.

Engine Type	Blower Type	Ratio Blower-to-Engine Speed	No. Teeth (Blower Drive Gear)	No. Teeth (Reduction Gear)
CURRENT 71E, 71N, 71T AND 71P ENGINES				
71,	Standard	2.00:1	39	No Reduction Gears
71E, 71N	Small dia. Rotor	2.00:1	39	No Reduction Gears
71T	Small dia. Rotor	1.95:1	40	No Reduction Gears
71T 71TTA	Small dia. Rotor +	1.65:1	40	No Reduction Gears
71P 71M	Large Bearing*	2.00:1	39	No Reduction Gears
FORMER 71, 71E, 71N and 71T ENGINES				
71E, 71N	Standard	1.69:1	39	33 (Drive) 39 (Driven)
71T	Standard	1.55:1	39	45 (Drive) 58 (Driven)

* 1.95:1 ratio - 2 valve head engines.
\+ 1979 vehicle engines.

TABLE 1

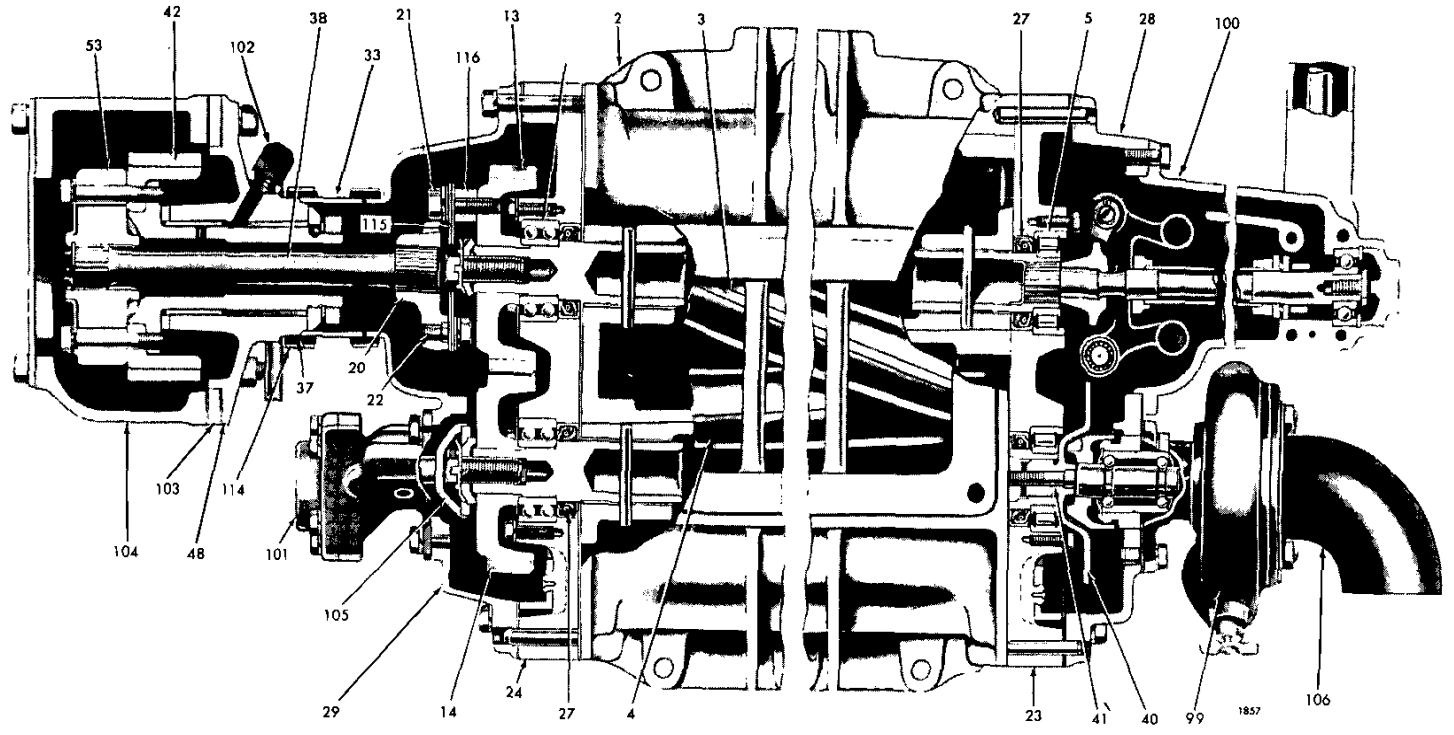
Reduced blower speed on the former 71E, 71N and 71T reduction blowers is accomplished by the use of an additional pair of gears mounted on the rotor shafts. The upper drive gear (140) is mounted on a double row ball bearing and is driven by the blower drive shaft by means of a flexible drive hub attached to the gear (Fig. 2). The drive gear mates with a lower driven gear (142) that is splined to the lower blower rotor shaft.

Since the lower rotor (timing) gear (14) is also splined to the lower rotor shaft, it drives the upper rotor (timing) gear (13).

The blower rotors are timed by the two rotor (timing) gears (13) and (14) at the rear end of the rotor shafts. This timing must be correct, otherwise the required clearance between the rotor lobes will not be maintained.

Normal gear wear causes a decrease in the rotor-to-rotor clearance between the leading edge of the upper rotor lobes and the trailing edge of the lower rotor lobes of the standard blower and the small diameter rotor blower. In the former 71E, 71N and 71T reduction blowers, the lower rotor is the leading rotor and the upper rotor is the trailing rotor; therefore,

© 1982 General Motors Corp.



2. Housing--Blower
3. Rotor--Blower--Upper R.H. Helix
4. Rotor--Blower--Lower L.H. Helix
5. Bearing (Roller--Front
9. Bearing (Ball)--Rear--Double Row Thrust
13. Gear--Rotor--Upper R.H. Helix
14. Gear--Rotor--Lower L.H. Helix
20. Hub--Rotor Drive Gear
21. Bolt--Plate to Gear
22. Bolt--Plate to Hub
23. End Plate--Front
24. End Plate--Rear
27. Oil Seal--End Plate
28. Cover--End Plate--Front
29. Cover--End Plate--Rear
33. Cover--Blower Drive Shaft
37. Seal--Drive Shaft Cover
38. Shaft--Blower Drive
40. Coupling Assy.--Water Pump Drive
41. Bolt--Allen Head--Coupling
42. Gear--Blower Drive
48. Support--Blower Drive Gear Hub
53. Coupling Assy.--Blower Drive
99. Pump--Fresh Water
100. Governor
101. Pump--Fuel
102. Elbow (90°)--Oil Line to Blower Drive
103. End Plate--Cylinder Block--Rear
104. Housing--Flywheel
105. Fork--Fuel Pump Drive
106. Cover--Water Pump Inlet
114. Clamp--Drive Cover Seal
115. Plate--Blower Rotor Drive Hub
116. Spacer--Plate to Gear

Fig. 1 - Blower and Drive Assembly and Accessories Including Mechanical Governor Attached to Standard Blower or Small Diameter Rotor Blower (71 Engines)

© 1982 General Motors Corp.

gear wear will cause a decrease in the rotor-to-rotor clearances between the leading edge of the lower rotor lobes and the trailing edge of the upper rotor lobes. Clearance between the opposite sides of the rotor lobes is increased correspondingly.

While the rotor lobe clearance may be adjusted by the use of shims behind the gears, gear backlash cannot be corrected. When gears have worn to the point where the backlash exceeds .004", replace the gears.

Lubrication

Oil drains from the valve operating mechanism on the cylinder head into the camshaft pocket (A and C engines) or balance shaft pocket (B and D engines) in the cylinder block. Then, when it reaches a certain level, the oil flows from the pocket into cavities at the upper corners of the blower and through passages in the blower and end plates to lubricate the bearings, governor and water pump drives at the front end, and bearings and gears at the rear end of the blower. A slinger attached to the front end of the lower rotor shaft throws oil onto the front roller bearings and governor weights. A dam in the blower end plates maintains oil at a level adequate to submerge the lower portion of the slinger and the driven gear.

Surplus oil overflows the dams in the end plates and returns through two drilled holes in the cylinder block to the engine crankcase.

On the former blower, the oil dam was located in the blower end plate cover.

Inspection of Blower

The blower may be inspected for any of the following conditions without being removed from the engine. However, the air silencer or air shutdown housing must be removed.

> **CAUTION:** When inspecting a blower on an engine with the engine running, keep fingers and clothing away from the moving parts of the blower and run the engine at low speeds only.

Dirt or chips drawn through the blower will make deep scratches in the rotors and housing and throw up burrs around such abrasions. If burrs cause interference between the rotors or between the rotors and the housing, remove the blower from the engine and dress the parts down to eliminate the interference, or replace the rotors if they are too badly scored.

Leaky oil seals are usually manifested by the presence of oil on the blower end plates and rotors or the inside surfaces of the housing. This condition may be checked by running the engine at low speed and directing a light into the rotor compartment at the end plates and the oil seals. A thin film of oil radiating away from the seals is indicative of an oil leak.

A worn blower drive, resulting in a rattling noise inside the blower, may be detected by grasping the top rotor firmly and attempting to rotate it. Rotors may move from 3/8" to 5.8", measured at the lobe crown, with a springing action. When released, the rotors should move back at least 1/4". If the rotors cannot be moved as directed above, or if the rotors move too freely, inspect the flexible blower drive coupling and replace it if necessary.

If the drive coupling is worn, the blower drive gear assembly may be removed from the cylinder block end plate after the blower has been removed from the engine and the drive gear hub bearing support to cylinder block end plate bolts are removed (refer to Section 1.7.6).

Loose rotor shafts or damaged bearings will cause rubbing and scoring between the crowns of the rotor lobes and the mating rotor roots, between the rotors and the end plates, or between the rotors and the housing. Generally, a combination of these conditions exists. A loose shaft usually causes rubbing between the rotors and the end plates. Worn or damaged bearings will cause rubbing between the mating rotor lobes at some point or perhaps allow the rotor assemblies to rub the blower housing. This condition will usually show up at the end where the bearings have failed.

Excessive backlash between the blower timing gears usually results in the rotor lobes rubbing throughout their entire length.

To correct any of the above conditions, remove the blower from the engine and either repair or replace it.

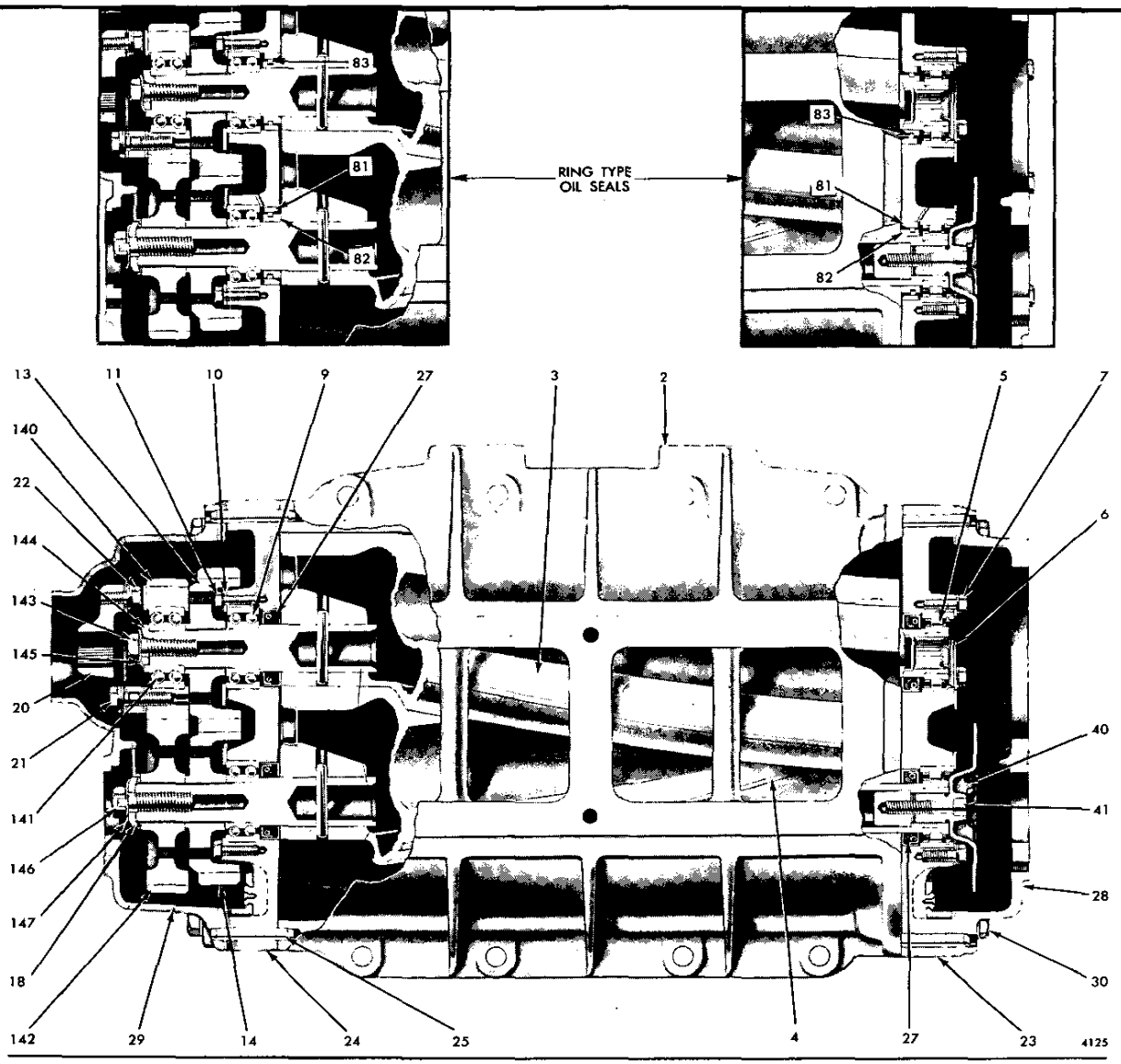
Inspect the blower inlet screen periodically as noted in Section 15.1 for an accumulation of dirt which, after prolonged operation, may affect the air flow. Servicing of the screen consists of thoroughly washing it in fuel oil and cleaning with a stiff brush until the screen is free of all the dirt deposits.

Remove Blower

In most cases, removal of the blower, together with the governor drive, fresh water pump, fuel oil pump, and the blower drive shaft cover, will be found most advantageous. For removal of this assembly, refer to Figs. 3 and 4 and proceed as follows:

1. Drain the cooling system.

© 1982 General Motors Corp.



2. Housing--Blower
3. Rotor--Upper R.H. Helix
4. Rotor--Lower L.H. Helix
5. Bearing (Roller)--Front
6. *Retainer--Bearing--Front*
7. Bolt--Bearing Retainer--Front
9. Bearing (Ball)--Rear--Double Row Thrust
10. *Retainer--Bearing--Rear*
11. Bolt--Bearing Retainer--Rear
13. Gear--Rotor--Upper R.H. Helix (Timing)
14. Gear--Rotor--Lower L.H. Helix (Timing)
18. *Disc--Fuel Pump Coupling*
20. Hub--Rotor Drive
21. Bolt--Plate to Gear
22. Bolt--Plate to Hub
23. *End Plate--Front*
24. End Plate--Rear
25. Pin (Dowel)--Housing to End Plate
27. Oil Seal--End Plate
28. Cover--End Plate--Front
29. Cover--End Plate--Rear
30. Bolt--End Plate Cover
40. Coupling Assy.--Water Pump Drive
41. Bolt--Allen Head--Coupling
81. Collar--Blower End Plate
82. Carrier--Seal Ring
83. *Ring--Seal (Piston Type)*
140. Gear--Drive--R.H. Helix (Reduction)
141. Bearing (Ball)--Drive Gear
142. Gear--Driven--L.H. Helix (Reduction)
143. Bolt--Drive Gear Retaining
144. Retainer--Drive Gear Bearing
145. Lock Washer--Bolt to Drive Gear
146. Bolt--Driven Gear *Retaining*
147. Lock Washer--Bolt to Driven Gear

Fig. 2 - Former Reduction Blower Assembly (71E, 71N and 71T)

© 1982 General Motors Corp.

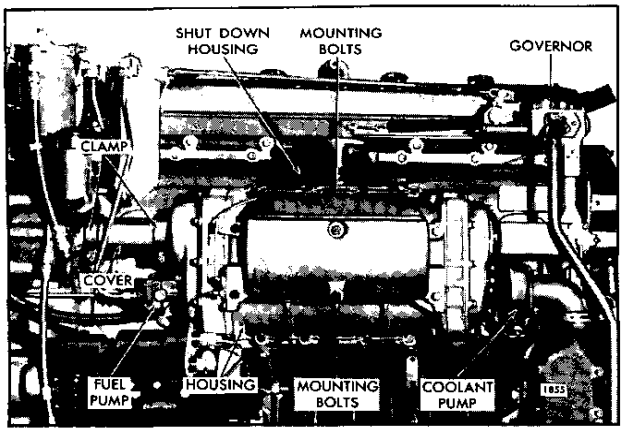


Fig. 3 - Typical Blower Mounting (71 Engine)

2. Remove the governor control housing assembly as outlined under *Remove Governor* in Section 2.7.1 for a limiting speed governor, and Section 2.7.2 for a variable speed governor. If the engine is equipped with a hydraulic governor, refer to *Remove Governor* in Section 2.8.1 or 2.8.2.

3. Disconnect the fuel lines at the fuel pump.

4. Loosen the water pump connections at the pump cover (inlet) and the cylinder block.

5. If the engine is equipped with a turbocharger, loosen the hose clamps and slide the hose and clamps back on the air inlet housing (Fig. 4).

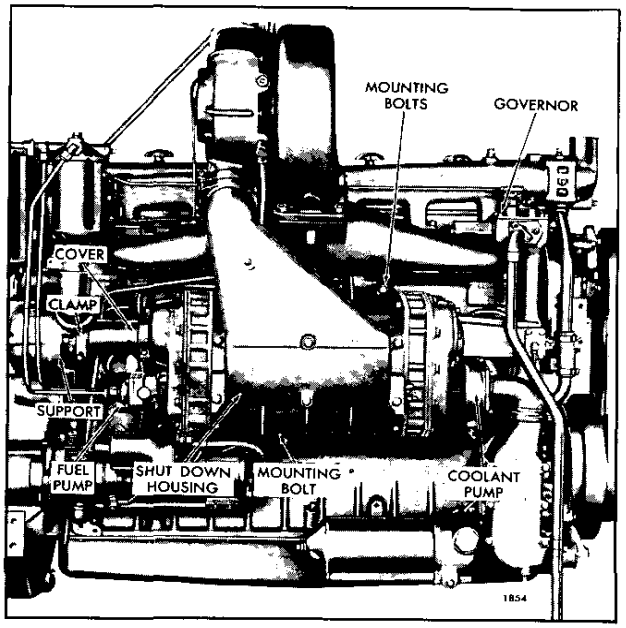


Fig. 4 - Typical Blower Mounting (71T Engine)

6. If the engine is equipped with an automatic shutdown solenoid, tag and remove the wires from the solenoid. Then, remove the solenoid.

7. If the engine is equipped with a manually operated shutdown, disconnect the control wire from the air shutdown valve shaft lever, then remove the bolt securing the control wire clip to the air shutdown housing.

8. Remove the air cleaner (non-turbocharged engines), then remove the air inlet housing, gasket, striker plate and air inlet screen and gasket from the blower.

9. Remove the blower drive shaft as outlined in Section 1.7.6.

10. Loosen the blower drive shaft cover seal clamp (114 - Fig. 1) at the blower drive gear hub support.

11. Remove the bolts and plain washers securing the blower to the cylinder block. Slide the blower slightly forward, withdraw the blower drive shaft cover from the seal, then lift the blower away from the cylinder block.

Remove Accessories from Blower

1. Remove the three bolts and seal washer assembly securing the fuel pump to the blower rear end plate cover, then remove the fuel pump, gasket and drive coupling fork.

2. On the current blower, loosen the seal clamp securing the blower drive shaft cover to the blower end

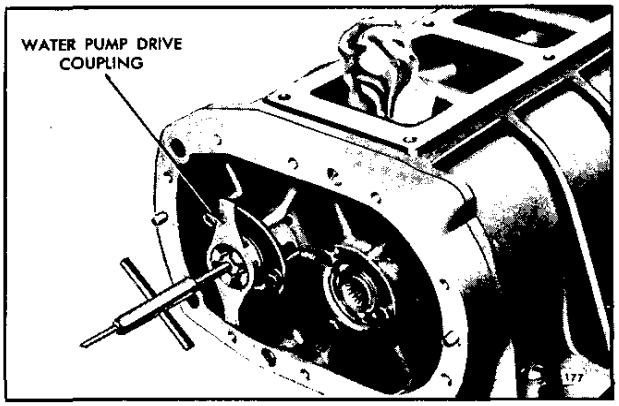


Fig. 5 - Removing Water Pump Drive Coupling Bolt from Blower Rotor Shaft

© 1982 General Motors Corp.

plate cover, then remove cover, seal and clamp from the end plate cover.

On the former blower remove the six bolts and seal washer assembly securing the blower drive shaft cover to the blower end plate cover, then remove the cover and gasket.

3. Remove the three bolts and seal washer assembly securing the fresh water pump to the blower front end plate cover, then remove the water pump and gasket. If necessary, tap the pump with a plastic hammer to loosen it.

4. Remove the six bolts and seal washer assembly securing the governor weight housing or drive housing (hydraulic governor) to the blower front end plate cover, then remove the weight housing or drive housing and gasket.

Disassemble Blower

Refer to Figs. 1, 2, 11 and 12 and disassemble the blower as follows:

1. Remove the ten bolts and lock washers securing the end plate covers (28) and (29) to the blower front and rear end plates. Tap the ends of the end plate covers with a plastic hammer to loosen the covers from the gaskets and dowel pins in the end plates. Then, remove the covers and gaskets from the end plates.

2. Place a clean folded cloth between the rotors to prevent the rotors from turning. Then, remove the bolt securing the water pump drive coupling to the blower rotor shaft as shown in Fig. 5.

3. Thread adaptor J 6471-4 (1/2"-20 threads) or adaptor J 6471-10 (9/16"-18) into the water pump drive coupling, then attach slide hammer and shaft J 6471-1 to the adaptor and pull the drive coupling from the blower rotor shaft.

4. Refer to Figs. 11 and 12 and remove the bolts (21), lock washers and plain washers securing the blower rotor drive hub (20) and drive hub plates (115) to the blower rotor timing gear (13) or drive gear (140). Remove the drive hub plates and spacers (116) (and bearing retainer (117) on former 71E, 71N and 71T blowers) from the gear. If necessary, remove the three bolts (22), lock washers and plain washers securing the drive plates to the drive hub.

5. Remove the reduction drive gears (if used), and the blower rotor timing gears as follows:

a. Remove bolt, lock washer and retainer securing the timing gear, or the reduction drive gear (is used) to the right-hand helix rotor shaft. Then remove the bolt, lockwasher and fuel pump coupling disc (18) securing the other timing gear, or the reduction driven gear (is used), to the left-hand helix rotor shaft. If used, slide the right-hand helix reduction drive gear with bearing off the upper rotor shaft. Remove the reduction driven gear from the lower rotor.

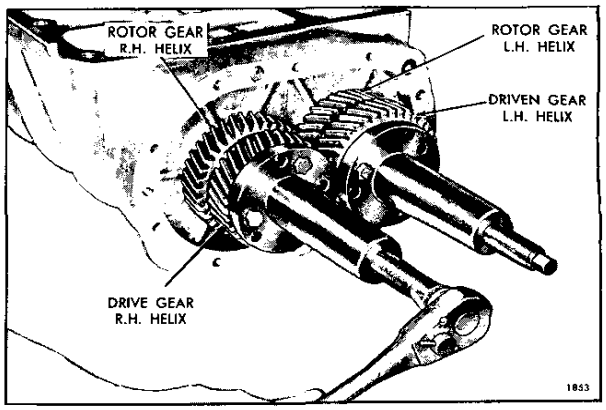


Fig. 6 - Removing Blower Rotor Gears from Blower Rotor Shafts with Tool Set J 6270-F

b. Back out the center screw of both pullers J 6270-31 and secure the pullers to the timing gears with 5/16"-24 x 1-1/2" bolts.

NOTE: Both gears must be pulled from the rotor shafts at the same time.

c. With the shop towels between the blower rotors and housing to prevent them from turning, turn the puller screws uniformly clockwise and pull the gears from the rotor shafts (Fig. 6).

d. Remove the shims from the rotor shafts or the inner face of the gears and note the number and thickness of the shims used with each gear.

6. Remove the bolts and lock washers securing the rotor shaft bearing retainers (6) to both the front and rear end plates. Remove the retainers.

7. Remove the blower rear end plate and bearing assembly from the blower housing and rotors with the two pullers J 6270-31 as follows:

a. Remove the two fillister head screws (26) securing the rear end plate (24) to the blower housing, and loosen the two fillister head screws securing the front end plate (23) to the housing approximately three turns.

b. Back out the center screws of the pullers far enough to permit the flange of each puller to lay flat on the face of the end plate.

© 1982 General Motors Corp.

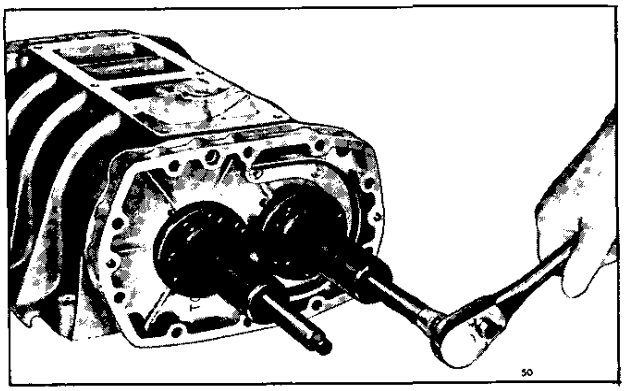


Fig. 7 - Removing Blower End Plate using Tool Set J 6270-F

c. Align the hole in each puller flange with the tapped holes in the end plate and secure the pullers to the end plate with six 1/4"-20 x 1-1/4" bolts.

NOTE: Be sure that the 1/4"-20 bolts are threaded all the way into the tapped holes in the end plate to provide maximum anchorage for the pullers and to eliminate possible damage to the end plate.

d. Turn the two pullers screws uniformly clockwise and withdraw the end plate and bearings from the blower housing and rotors as shown in Fig. 7.

8. Remove the blower front end plate in the same manner as described in Step 7 above.

9. Withdraw the blower rotors from the housing.

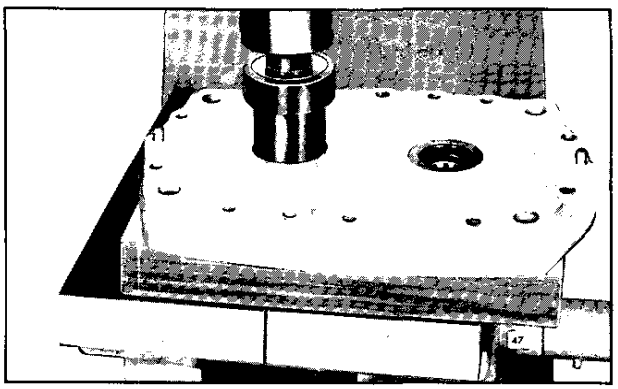


Fig. 8 - Removing Oil Seal (or Seal Ring Collar) and Bearing from End Plate with Tool J 6270-3

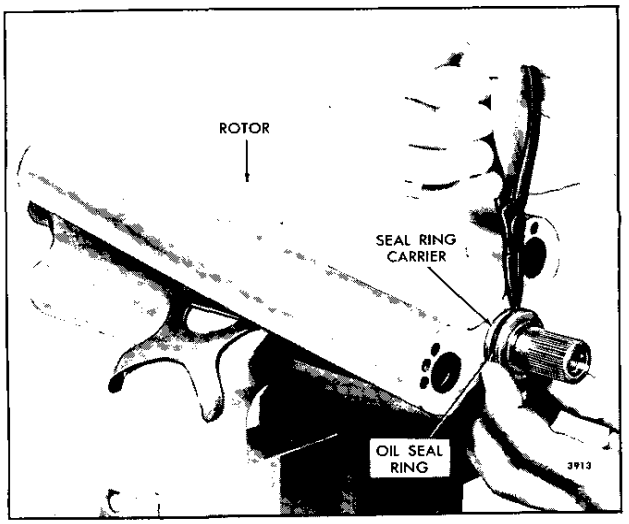


Fig. 9 - Removing Oil Seal Ring from Carrier

10. Remove the bearings and the lip type oil seals from the blower end plates as follows:

a. When performing a major overhaul, discard the oil seals, otherwise inspect the oil seals. If the seals are scored, or hard, new seals must be installed. If necessary, remove the seals from the end plates at the same time the individual bearings are removed.

b. Support the outer face of the end plate on wood blocks on the bed of an arbor press.

c. Place the long end of the oil seal remover and installer J 6270-3 down through the oil seal and into the bearing, with the opposite end of the remover under the ram of the press (Fig. 8). Then, press the bearing and oil seal out of the end plate. Discard the oil seal.

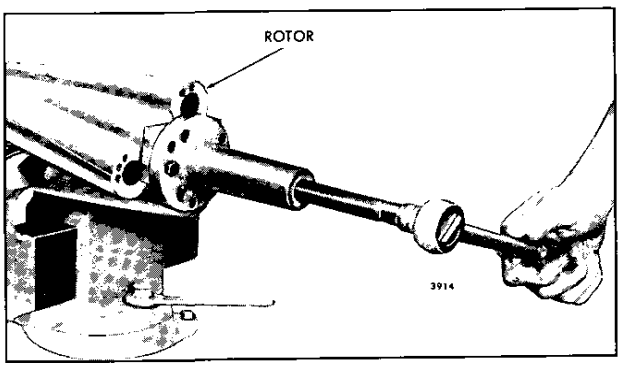


Fig. 10 - Removing Oil Seal Ring Carrier from Blower Rotor Shaft with Tool Set J 6270-F

© 1982 General Motors Corp.

d. Remove the remaining bearings and oil seals from the end plates in the same manner.

11. Remove the bearings and *ring type* oil seals, carriers, and collars from the blower rotor shafts and end plates as follows:

a. Clamp one lobe of the rotor in a bench vise equipped with soft jaws (Fig. 9). Tighten the vise just enough to hold the rotor stationary.

b. If used, remove .005" shim (spacer) on the 71P blower.

c. Remove the oil seal ring from the seal ring carrier on each blower rotor shaft with a pair of snap ring pliers J 4880 as shown in Fig. 9.

NOTE: To avoid breakage or distortion, do not spread or twist the ring any more than necessary to remove it.

d. Refer to Fig. 10 and place the seal ring carrier remover adaptor J 6270-2 over the carrier. Make sure the adaptor is seated in the groove of the carrier.

e. Back out the center screw of puller J 6270-31 far enough to permit the puller flange to lay flat against the adaptor J 6270-2.

f. Place the puller over the end of the rotor shaft and against the adaptor on the oil seal ring carrier. Align the holes in the puller flange with the tapped holes in the adaptor, then secure the puller to the adaptor with two bolts.

g. Turn the puller screw clockwise and pull the oil seal ring carrier from the rotor shaft (Fig. 10).

h. Remove the remaining oil seal ring carriers from the rotor shafts in the same manner.

i. Refer to Fig. 8 and support the outer face of the blower end plate on wood blocks on the bed of an arbor press.

j. Place the long end of the oil seal remover and installer J 6270-3 down through the oil seal ring collar and into the bearing, with the opposite end of the remover under the ram of the press (Fig. 8). Then, press the bearing and oil seal ring collar out of the end plate.

k. Remove the remaining bearings and oil seal ring collars from the end plates in the same manner.

Inspection

Wash all of the blower parts in clean fuel oil and dry them with compressed air.

Examine the bearings for any indications of corrosion or pitting. Lubricate each bearing with light engine oil. Then, while holding the bearing inner race from turning, revolve the outer race slowly by hand and check for rough spots.

The double-row ball bearings are pre-loaded and have no end play. A new double-row bearing will seem to have considerable resistance to motion when revolved by hand.

Check the oil seal rings, carriers and collars for wear and scoring. If worn excessively, they must be replaced. The current oil seal rings are chrome flashed and the carriers are liquid nitrided. When replacement of an oil seal ring or carrier is necessary, both parts must be replaced together.

NOTE: When a blower with lip type oil seals is being reconditioned oversize oil seals and oil seal spacers are available in the blower kit to replace the standard oil seals where the blower rotor shafts are grooved.

Inspect the blower rotor lobes, especially the sealing ribs, for burrs and scoring. Rotors must be smooth for efficient operation of the blower. If the rotors are slightly scored or burred, they may be cleaned up with emery cloth.

Examine the rotor shaft serrations for wear, burrs or peening. Also, inspect the bearing and oil seal contact surfaces of the shafts for wear and scoring.

Inspect the inside surface of the blower housing for burrs and scoring. The inside surface must be smooth for efficient operation of the blower. If the inside surface of the housing is slightly scored or burred, it may be cleaned up with emery cloth.

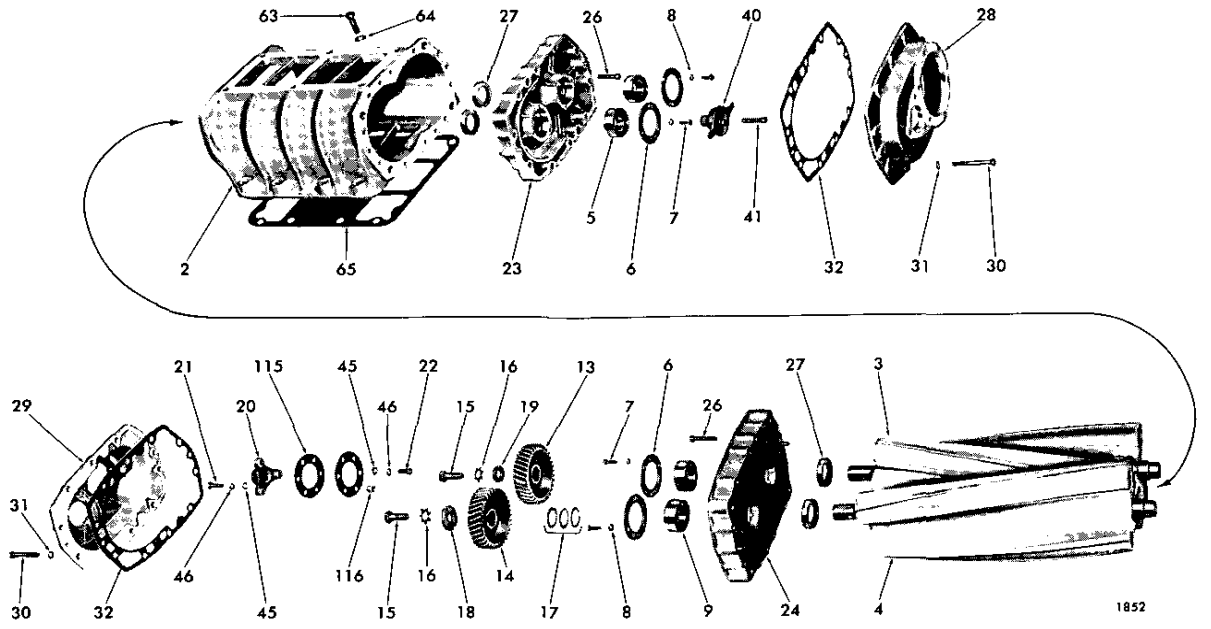
Check the finished ends of the blower housing, for flatness and burrs. The end plates must set flat against the blower housing.

The finished inside face of each end plate must be smooth and flat. If the finished face is slightly scored or burred, it may be cleaned up with emery cloth.

NOTE: Be careful not to remove metal at the joint face between the end plates and the housing. Air or oil leaks could develop after assembly.

Examine the serrations in the blower timing gears for wear and peening; also check the teeth for wear,

© 1982 General Motors Corp.



2. Housing--Blower
3. Rotor--Blower--Upper--R.H. Helix
4. Rotor--Blower--Lower--L.H. Helix
5. Bearing (Roller)--Front
6. Retainer--Bearing
7. Bolt--Bearing--Retainer
8. Lock Washer
9. Bearing (Ball)--Rear Double Row Thrust
13. Gear--Rotor--Upper--R.H. Helix
14. Gear--Rotor--Lower--L.H. Helix
15. Bolt--Rotor Gear
16. Lock Washer--Bolt to Rotor Gear
17. Shim--Gear to Bearing (For Timing Rotors)
18. Disc--Fuel Pump Coupling
19. Washer--Rotor Gear Retaining
20. Hub--Rotor Drive
21. Bolt--Plate to Gear
22. Bolt--Plate to Hub
23. End Plate--Front
24. End Plate--Rear
25. Pin (Dowel)--Housing to End Plate
26. Bolt--End Plate
27. Oil Seal--End Plate
28. Cover--End Plate--Front
29. Cover--End Plate Rear
30. Bolt--End Plate Cover
31. Lock Washer
32. Gasket--End Plate Cover
40. Coupling Assy.--Water Pump Drive
41. Bolt
45. Plain Washer
46. Lock Washer
63. Bolt--Blower Mounting
64. Plain Washer--Blower Mounting
115. Plate--Blower Rotor Drive Hub
116. Spacer--Place to Gear

Fig. 11 - Typical Details and Relative Location of Parts - Standard and Small Diameter Rotor Six Cylinder 71 Blowers

chipping or damage. If the gears are worn to the point where the backlash between the gear teeth exceeds .004", or damaged sufficiently to require replacement, both gears must be replaced as a set.

Check the blower drive shaft serrations for wear or peening. Replace the shaft if it is bent, cracked or has excessive spline wear.

Inspect the serrations inside the rotor drive hub for wear and peening.

Inspect the blower drive coupling springs (pack) and the cam for wear.

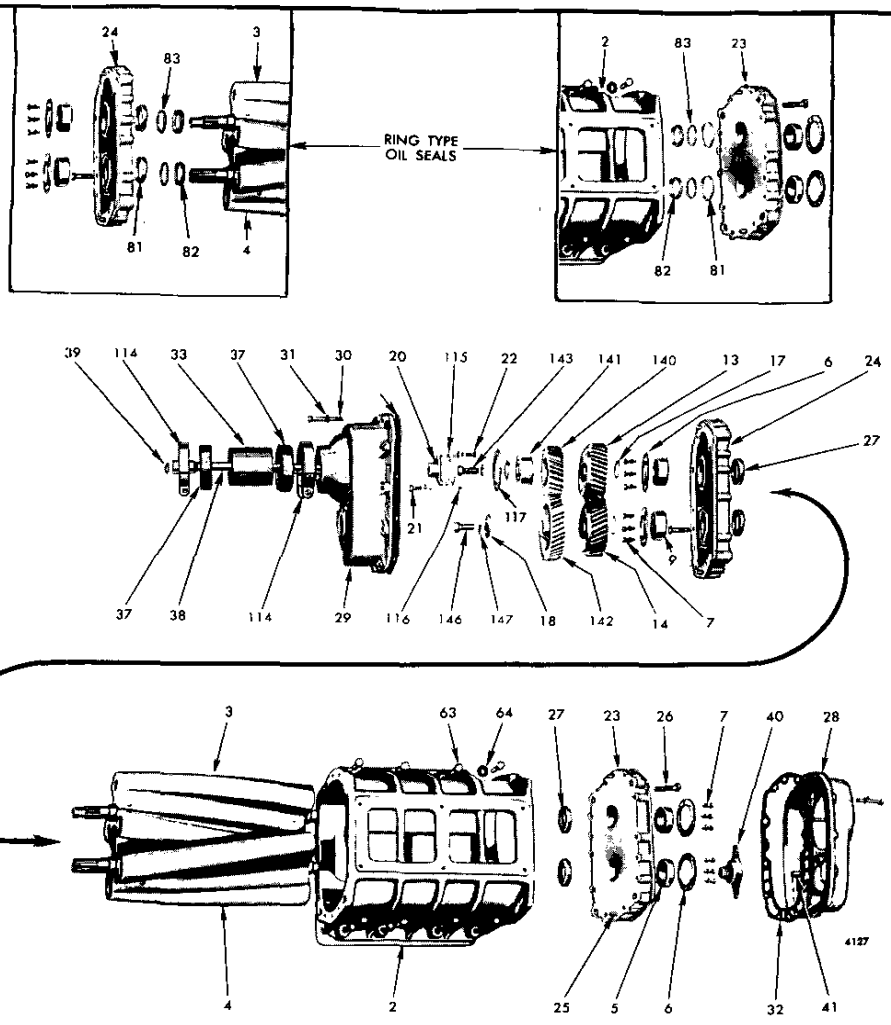
Replace all worn or excessively damaged blower parts.

Assemble Blower

Several precautions are given below to assure proper assembly of the rotors and gears for correct blower timing.

The lobes on the upper blower rotor and the teeth on its gear form a right-hand helix while the lobes and teeth of the lower rotor and gear form a left-hand helix. Therefore, a rotor with right-hand helix lobes must be used with a gear having right-hand helix teeth and vice versa (Fig. 13).

© 1982 General Motors Corp.



2. Housing--Blower
3. Rotor Assy.--Upper--R.H. Helix
4. Rotor Assy.--Lower--L.H. Helix
5. Bearing (Roller)--Front
6. *Retainer--Bearing*
7. Bolt--Bearing Retainer
9. Bearing (Ball)--Rear--Double Row Thrust
13. Gear--Rotor--Upper L.H Helix
14. Gear--Rotor--Lower L.H. Helix
17. Shim--Gear to Bearing (For Timing Rotors)
18. Disc--Fuel Pump Coupling
20. Hub--Rotor Drive
21. Bolt--Plate to Gear
22. Bolt--Plate to Hub
23. End Plate--Front
24. End Plate--Rear
25. Pin (Dowel)--Housing *to End Plate*
26. Bolt--End Plate
27. Oil Seal--End Plate
28. Cover--End Plate--Front
29. Cover--End Plate--Rear
30. Bolt--End Plate Cover
31. Lock Washer
32. Gasket--End Plate Cover
33. Cover--Blower Drive Shaft
34. Bolt--Drive Shaft Cover
35. Lock Washer
36. Gasket--Drive Shaft Cover
37. Seal--Blower Drive Cover
38. *Shaft--Blower Drive*
39. Snap Ring--Drive Shaft
40. Coupling Assy.--Water Pump Drive
41. Bolt--Allen Head
63. Bolt--Blower Mounting
64. Plain Washer
81. Collar--Blower End Plate
82. Carrier--Seal Ring
83. Ring--Seal (Piston Type)
114. Clamp--Blower Drive Cover Seal
115. Plate--Blower Rotor Drive Hub
116. Spacer--Plate to Gear
117. Retainer--Bearing
140. *Gear--Drive--R.H. Helix*
141. Bearing (Ball)--Drive Gear
142. Gear--Driven--L.H. Helix
143. Bolt--Drive Gear Retaining
146. Bolt--Driven Gear Retaining
147. Lock Washer

Fig. 12 - Typical Details and Relative Location of Parts - Six Cylinder Former Reduction Blowers

© 1982 General Motors Corp.

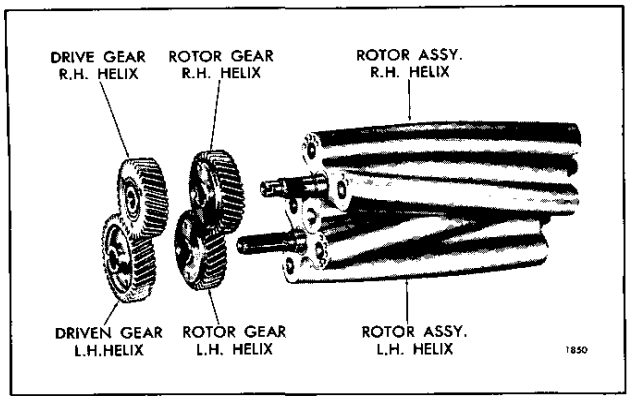


Fig. 13 - Upper and Lower Rotor and Gears (Former Reduction Blowers)

One serration is omitted on the drive end of each blower rotor shaft and a corresponding serration is omitted in each gear. Assemble the gears on the rotor shafts with the serrations in alignment.

With this precaution in mind, proceed with blower assembly, referring to Figs. 11 through 24 as directed in the text.

1. Install the lip type oil seals as follows (Fig. 15):

a. Support the blower end plate, finished surface facing up, on wood blocks on the bed of an arbor press (Fig. 14).

NOTE: If oversize oil seals are being used in the blower end plates, use installer J 6270-28 to install the oversize oil seal spacers on the rotor shafts.

b. Start the oil seal straight into the bore in the end plate with the sealing edge facing down (toward the bearing bore).

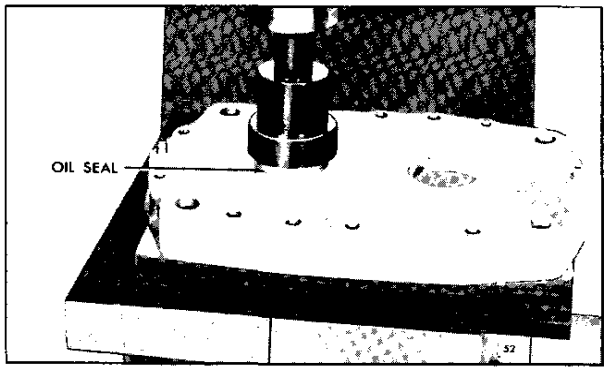


Fig. 14 - Installing Oil Seal (or Seal Ring Collar) in Blower End Plate using Tool J 6270-3

c. Place the short end of oil seal remover and installer J 6270-3 in the oil seal and press the oil seal into the end plate until the shoulder on the installer contacts the end plate (Fig. 14).

NOTE: A step under the shoulder of the installer will position the oil seal approximately .005" below the finished face of the end plate. This is within the .002" to .008" specified.

d. Install the remaining oil seals in the end plates in the same manner.

2. Install the *ring type* oil seal, carriers, and collars on the rotor shafts and in the end plates as follows:

a. Support one of the rotor assemblies on wood blocks on the bed of an arbor press as shown in Fig. 16.

b. Lubricate the inside diameter of the oil seal ring carrier with engine oil. Then start the carrier straight over the end of the rotor shaft with the chamfered inside diameter end facing the rotor.

c. Place the oil seal ring carrier installer J 6270-4 over the end of the rotor shaft and against the carrier with the end of the installer under the ram of the press. Then, press the carrier down tight against the rotor.

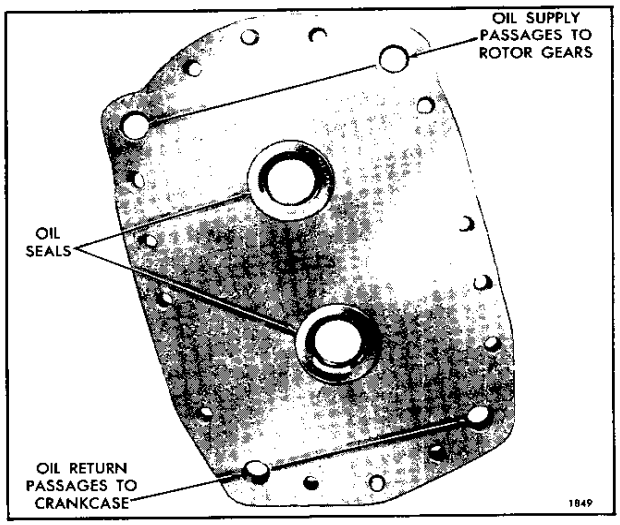


Fig. 15 - Blower End Plate and Lip Type Oil Seal Location

© 1982 General Motors Corp.

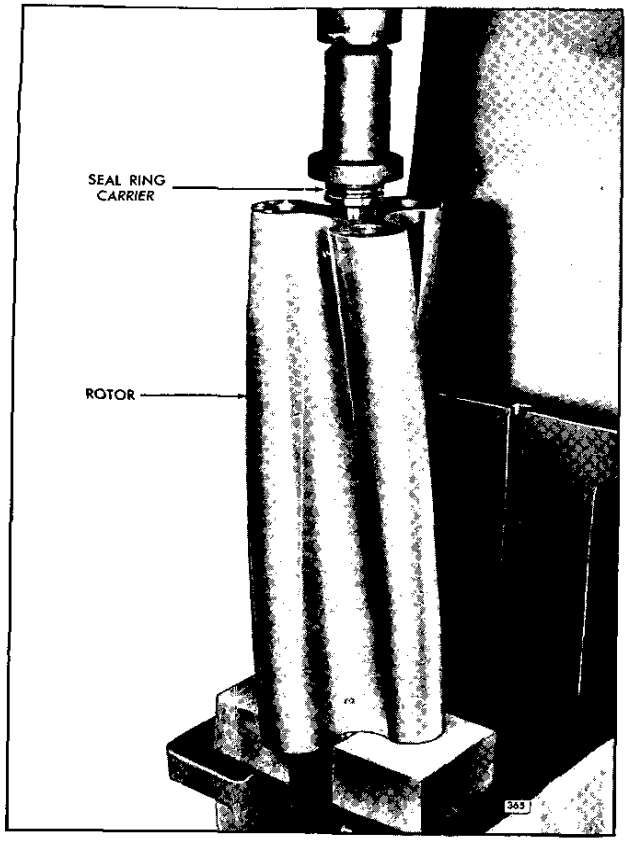


Fig. 16 - Installing Oil Seal Ring Carrier on Blower Rotor Shaft with Tool J 6270-4

d. Install the remaining oil seal ring carriers on the rotor shafts in the same manner.

e. Install an oil seal ring in the ring groove of each carrier with a pair of snap ring pliers J 4880 in the same manner as shown in Fig. 9.

NOTE: To avoid breaking the oil seal rings, do not spread them any more than necessary to place them over the end of the carrier. Do not twist the rings or possible distortion may result in loss of side contact area.

f. Support one of the blower end plates, inner face up, on wood blocks on the bed of an arbor press as shown in Fig. 14.

g. Lubricate the outside diameter of a seal ring collar with engine oil. Then start the chamfered outside diameter end of the collar straight into the bore in the end plate.

h. Place the oil seal ring collar installer J 6270-4 on top of the seal ring collar and press the collar into the end plate until the shoulder on the installer contacts the end plate (Fig. 14).

NOTE: A step under the shoulder of the installer will position the collar approximately .005" below the finished face of the end plate. This is within the .002" to .008" specified.

i. Install the remaining oil seal ring collars in the end plates in the same manner.

Assemble Rotors and End Plates (Lip Type Oil Seals)

No gaskets are used between the end plates and the housing; therefore, the mating surfaces must be perfectly flat and smooth.

For naturally aspirated engines apply a rubber base sealant as required to avoid leakage between the end plates and the blower housing.

For turbocharged engines apply a rubber base sealant between the entire joint face of the both ends of the blower housing to end plates interfaces, especially around the bolt holes and dowels.

NOTE: Be sure no sealant protrudes into the blower housing. Also, the sealant must not

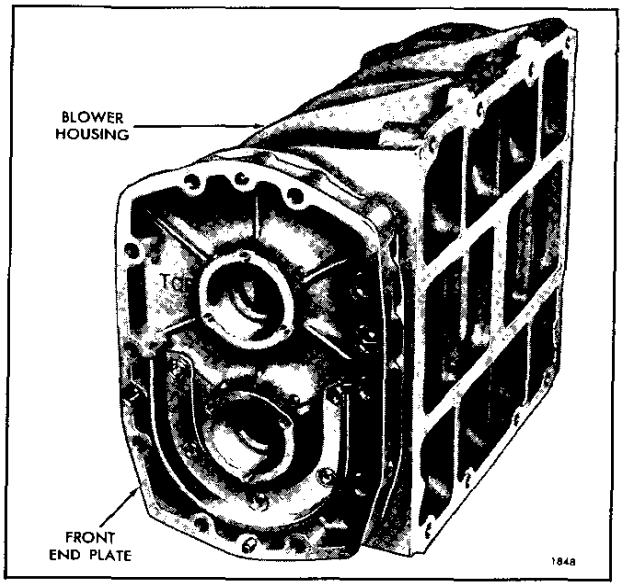


Fig. 17 - Position of Blower Front End Plate on Housing

© 1982 General Motors Corp.

prevent the end plates from laying against the housing.

1. Install the blower front end plate. Make sure the mark TOP on the outer ribbed side is at the top of the blower housing, identified by the flange which supports the housing on the top edge of the cylinder block (Fig. 17).

The front and rear end plates of the blower are interchangeable.

One end plate should be assembled to the front end of the blower housing first and the other plate should be assembled to the rear of the blower housing after the rotors are in place. Attach an end plate to the front of the blower housing as follows:

a. Check the dowel pins. The dowel pins must project .380" from the flat inner face, and .270" from the outer face of the front end plate to assure proper alignment of the end plate to the housing and the cover to the end plate.

b. Place the blower housing on a bench with the top of the housing up, and the front end of the housing facing the outside of the bench.

c. Position the end plate in front of the blower housing with the flat finished face of the end plate facing the housing and the end marked TOP facing the flanged side of the housing. Then, start the dowel pins straight into the dowel pin holes in the housing. Push or tap the end plate against the housing.

d. Insert the two fillister head screws through the end plate and thread them into the housing. Tighten the screws to 5-10 lb-ft (7-14 Nm) torque. Do not use lock washers on these screws.

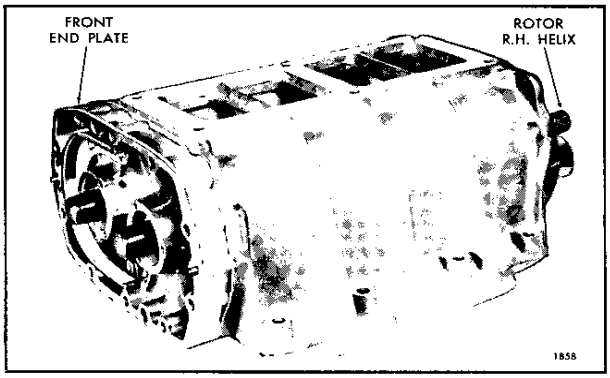


Fig. 18 - Assembling Blower Rotors into Housing and Front End Plate (Lip Type Oil Seals) using Tool J 6270-5

2. Assemble the blower rotors in the blower housing and front end plate as follows:

The rotors must be assembled in the blower housing with the omitted serrations in the rotor shafts aligned as shown in Fig. 28.

NOTE: The housing used in E, T and P Blower assemblies are stamped for identification with the letter "E", "T" or "P" near the top of the housing. The "N" engines are also stamped "E".

a. Place an oil seal pilot J 6270-5 on the short (non-splined) end of each rotor shaft. Then, place the rotors in mesh with the omitted serrations in the shafts in alignment as shown in Fig. 28.

NOTE: When oversize oil seals are used in the blower end plate, use oil seal spacer installers J 6270-28 for the oil seal pilots in place of J 6270-5.

b. Insert the blower rotors with oil seal pilots straight into the blower housing with the right-hand helix rotor at the top, flange, side of the housing. Then, push the rotor shafts and oil seal pilots on through the oil seal in the front end plate as shown in Fig. 18.

c. Remove the oil seal pilots from the rotor shafts.

3. Attach the blower rear end plate to the blower housing as follows:

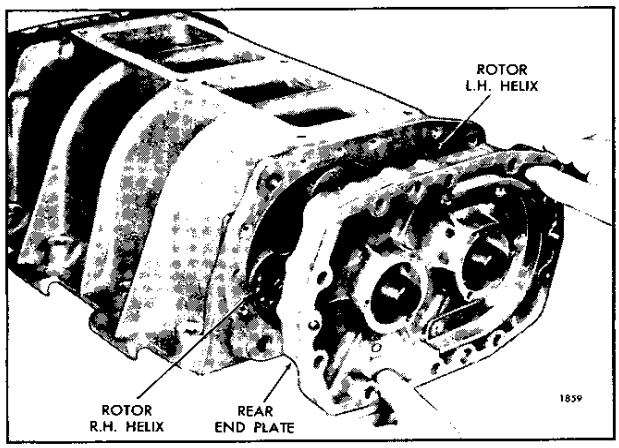


Fig. 19 - Installing Blower Rear End Plate (Lip Type Oil Seals) using Tool J 6270-5

© 1982 General Motors Corp.

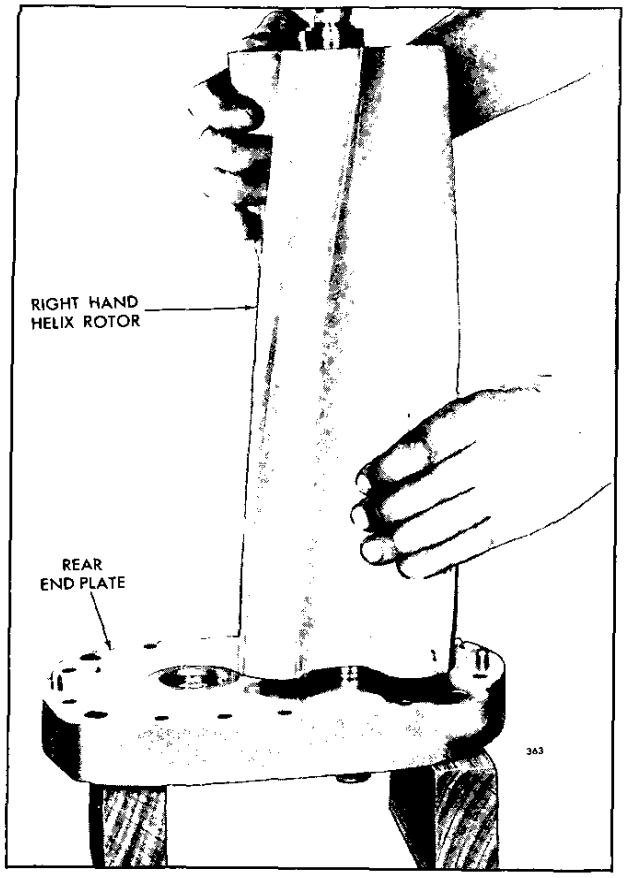


Fig. 20 - Installing Blower Rotor in Rear End Plate (Ring Type Oil Seals)

a. Reverse the blower housing on the bench (rear end of housing facing the outside of the bench).

b. Place an oil seal pilot J 6270-5 on the serrated end of each rotor shaft.

NOTE: When oversize oil seals are used in the blower end plate, use oil seal spacer installers J 6270-28 for the oil seal pilots in place of J 6270-5.

c. Check the dowel pins. The dowel pins must project .380" from the flat inner face, and .270" from the outer face of the rear end plate to assure proper alignment of the end plate to the housing and the cover to the end plate.

d. Place the rear end plate in position in front of the oil seal pilots with the flat finished face of the end plate facing the blower housing and the mark TOP on the end plate at the top flange side of the housing.

e. Place the rear end plate over the oil seal pilots (Fig. 19) and start the dowel pins straight into the dowel pin holes in the housing. Push or tap the end plate against the housing.

f. Insert the two fillister head screws through the end plate and thread them into the housing. Tighten the screws to 5-10 lb-ft (7-14 Nm) torque. Do not use lock washers on these screws.

g. Remove the oil seal pilots from the rotor shafts.

Assemble Rotors and End Plates (Ring Type Oil Seals)

No gaskets are used between the end plates and the housing. Therefore, the mating surfaces must be perfectly flat and smooth.

For naturally aspirated engines apply a rubber base sealant as required to avoid leakage between the end plates and the blower housing.

For turbocharged engines apply a rubber base sealant between the entire joint face of both ends of the blower housing to end plates interfaces, especially around the bolt holes and dowels.

NOTE: Be sure no sealant protrudes into the blower housing. Also, the sealant must not prevent the end plates from laying against the housing.

1. The front and rear blower end plates are interchangeable. Install the blower rotors in the blower rear end plates as outlined below:

a. Check the dowel pins. The dowel pins must project .380" from the flat inner face, and .270" from the outer face of the rear end plate to assure proper alignment of the end plate to the housing and the cover to the end plate.

b. Support the rear end plate on two wood blocks, approximately 4" high, with the inner face of the end plate facing up and the TOP side of the plate facing the serviceman's right (Fig. 20).

c. Lubricate the oil seal ring in the carrier on the rear (splined) end of the right-hand helix rotor shaft with engine oil.

d. Hold the right-hand helix rotor in a vertical position (gear end up), and position the seal ring in the carrier so the ring protrudes from its groove the same amount on each side and the gap is facing away from the serviceman.

© 1982 General Motors Corp.

e. With the omitted serration in the splines of the shaft facing toward the top side of the end plate, start the end of the rotor shaft straight into the right-hand shaft opening in the end plate so that the gap portion of the seal ring is started into the ring collar (Fig. 20). Continue to lower the rotor and very carefully apply pressure to the seal ring approximately 180° from the gap while gently working the seal ring into the collar until the rotor contacts the end plate.

f. Perform Steps "c" and "d" above on the left-hand helix rotor.

g. Position the rotors so the lobes are in mesh and the omitted serration in splines of both shafts face toward the top of the end plate. Then, start the splined end of the shaft straight into the left-hand shaft opening in the end plate. Continue to lower the rotor in place as outlined in Step "e".

2. Determine the rotation of the blower being assembled, then install the blower housing over the rotors as follows:

a. Position the blower housing above the rotors with its mounting flange facing toward the right-hand helix rotor. Lower the housing over the rotors until it contacts the dowel pins in the end plate.

b. Align the dowel pin holes in the blower housing with the dowel pins in the end plate. Push the housing tight against the end plate. If necessary, tap the housing lightly with a plastic hammer.

c. Insert the two fillister head screws through the end plate and thread them into the housing. Tighten the screws to 5-10 lb-ft (7-14 Nm) torque. Do not use lock washers on these screws.

3. Install the blower front end plate on the rotors and housing as outlined below:

a. Check the dowel pins. The dowel pins must project .380" from the flat inner face, and .270" from the outer face of the front end plate to assure proper alignment of the end plate to the housing and the cover to the end plate.

b. Lubricate the oil seal rings in the carriers on the rotor shaft with engine oil.

c. Position the oil seal rings in the carrier so the ring protrudes from its groove the same amount on each side.

d. Position the front end plate over the top of the rotor shafts with the inner face of the end plate facing the rotors and the mark "TOP" on the end plate at the flange side of the housing as shown in Fig. 21.

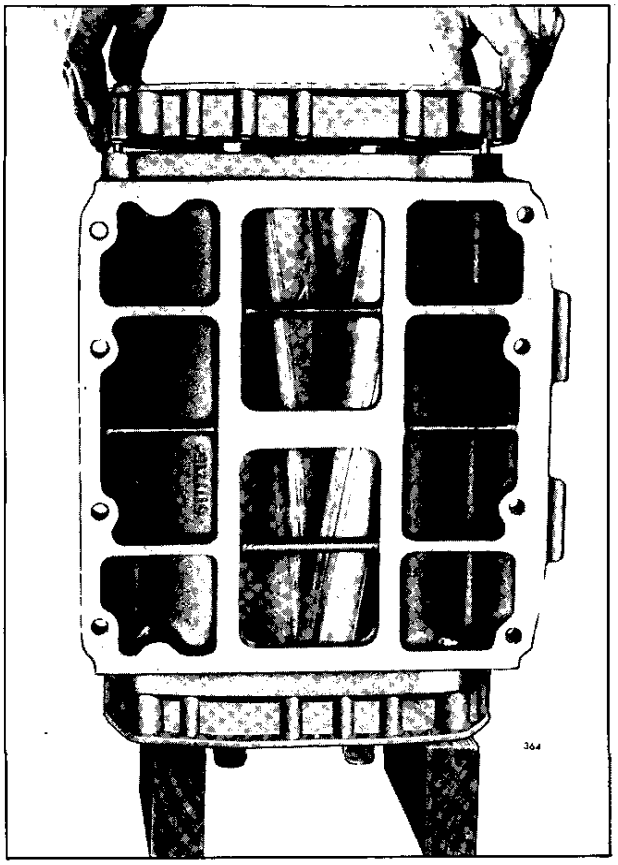


Fig. 21 - Installing Front End Plate on Blower Rotors and Housing (Ring Type Oil Seals)

e. Lower the end plate straight over the rotor shafts until the dowel pins in the end plate contact the blower housing (Fig. 21). Then carefully work the dowel pins into the dowel pin holes in the housing and the oil seal rings into the collars. Push the end plate tight against the housing. If necessary, tap the end plate lightly with a plastic hammer.

f. Insert the two fillister head screws through the front end plate and thread them into the housing. Tighten the screws to 5-10 lb-ft (7-14 Nm) torque. Do not use lock washers on these screws.

Install Blower Rotor Shaft Bearings and Gears

1. With the blower housing, rotors and end plates still supported in a vertical position on the two wood blocks, install the roller bearings on the rotor shafts and in the front end plate as follows:

© 1982 General Motors Corp.

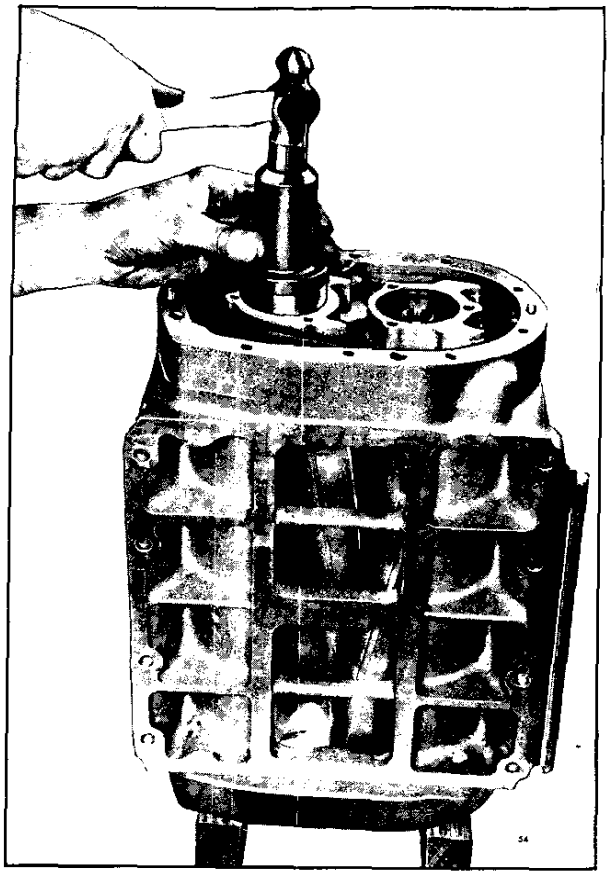


Fig. 22 - Installing Roller Bearing on Rotor Shaft and in Front End Plate using Tool J 6270-4

a. Lubricate one of the roller bearings with engine oil. Start the bearing, numbered end up, straight on one of the rotor shafts.

b. Place installer J 6270-4 on top of the bearing and tap the bearing on the shaft and into the front end plate as shown in Fig. 22.

c. Install the second roller bearing on the remaining rotor shaft in the same manner.

d. Place the bearing retainers on top of the bearings and the end plate; then, install the retainer bolts and lock washers. Tigthen the bolts to 7-9 lb-ft (9-12 Nm) torque.

2. Start the end of the water pump drive coupling straight into the left-hand helix rotor shaft. Then, place a clean folded cloth between the blower rotors to prevent them from turning. Install the drive coupling retaining bolt and draw the coupling and slinger tight against the end of the shaft, then tighten the bolt to 18 lb-ft (24 Nm) torque.

3. Refer to Fig. 11 or 12 and affix a new gasket (32) to the blower front end plate cover (28).

NOTE: The former blower end plate cover is not interchangeable with the current blower end plate cover.

4. Position the end plate cover over the end plate dowel pins, with the large hole in the cover toward the top of the end plate, then push the cover against the end plate. Install the ten bolts and lock washers. Tighten the bolts to 13-17 lb-ft (18-23 Nm) torque.

5. Install the ball bearings on the rotor shafts and in the rear end plate as follows:

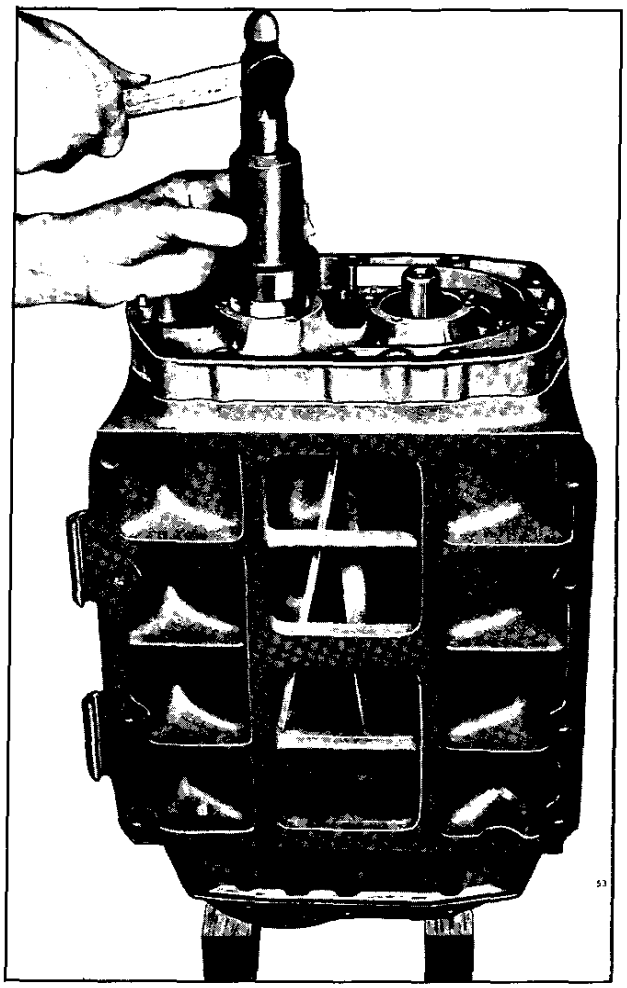


Fig. 23 - Installing Ball Bearing on Rotor Shaft and in Rear End Plate using Tool J 6270-7

© 1982 General Motors Corp.

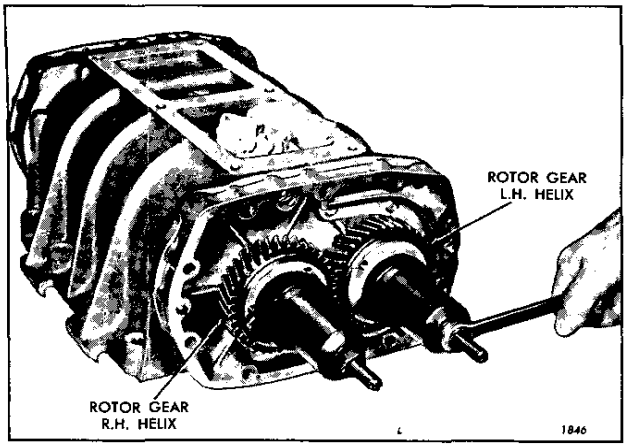


Fig. 24 - Installing Rotor Gears on Rotor Shafts for Preliminary Check of Clearances using Tool J 6270-6, 7 and 8

a. Reverse the position of the blower housing on the two wood blocks (Fig. 23).

b. On a blower with ring type oil seals, insert the two fillister head screws through the rear end plate and thread them into the housing. Tighten the screws to 5-10 lb-ft (7-14 Nm) torque. Do not use lock washers on these screws.

c. Lubricate one of the ball bearings with engine oil. Start the bearing numbered end up, straight on one of the rotor shafts.

d. Place installer J 6270-7 on top of the bearing and tap the bearing straight on the shaft and into the rear end plate as shown in Fig. 23.

e. Install the second ball bearing on the remaining rotor shaft in the same manner.

f. Place the bearing retainers on top of the bearings and the end plate; then, install the retainer bolts and lock washers. Tighten the bolts to 7-9 lb-ft (9-12 Nm) torque.

6. Make a preliminary check of the rotor-to-end plate and rotor-to-housing clearances at this time with a feeler gage as shown in Fig. 29. Refer to Figs. 26 and 27 for minimum blower clearances.

7. Install the blower rotor timing gears on a standard blower or a smaller diameter rotor blower as follows:

One serration is omitted on the drive end of each blower rotor shaft and a corresponding serration is omitted in each gear. Assemble the gears on the rotor shafts with the serrations in alignment.

A center punch mark placed in the end of each rotor shaft at the omitted serrations will assist in aligning the gears on the shafts.

a. Place the blower housing and rotor assembly on the bench with the air inlet side of the housing facing up and the rear end (serrated end of rotor shafts) of the blower facing the outside of the bench.

b. Rotate the rotors to bring the omitted serrations on the shafts in alignment and facing the top of the blower housing (Fig. 28).

c. Install the same number and thickness of shims on the rotor shafts that were removed at the time of disassembly.

NOTE: When rebuilding a blower with new rotors or new gears, first install the gears on the rotor shafts without the shims, then check the clearances between the rotors to determine the location and thickness of shims to be used; refer to Fig. 28.

d. Lubricate the serrations of the rotor shafts with engine oil.

e. Place the teeth of the rotor gears in mesh so that the omitted serrations inside the gears are in alignment and facing the same direction as the serrations on the shafts.

f. Start both rotor gears straight on the rotor shafts with the right-hand helix gear on the right-hand helix rotor and the left-hand helix gear on the left-hand helix rotor, and the omitted serrations in the gears in line with the omitted serrations on the rotor shafts.

g. Thread an installer screw J 6270-8 in the end of each rotor shaft until it bottoms. Place gear installer J 6270-7 over the installer screw and against the right-hand helix gear and gear installer J 6270-6 over the installer screw and against the left-hand helix gear. Then, thread a nut on each installer screw (Fig. 24).

h. Place a clean folded cloth between the lobes of the rotors, to prevent the rotors from turning. Then, turn the nuts on the installer screws clockwise as shown in Fig. 24 and draw the two gears into position at the same time, tight against the shims and bearing inner races.

i. Remove the rotor timing gear installers from the rotor shafts.

© 1982 General Motors Corp.

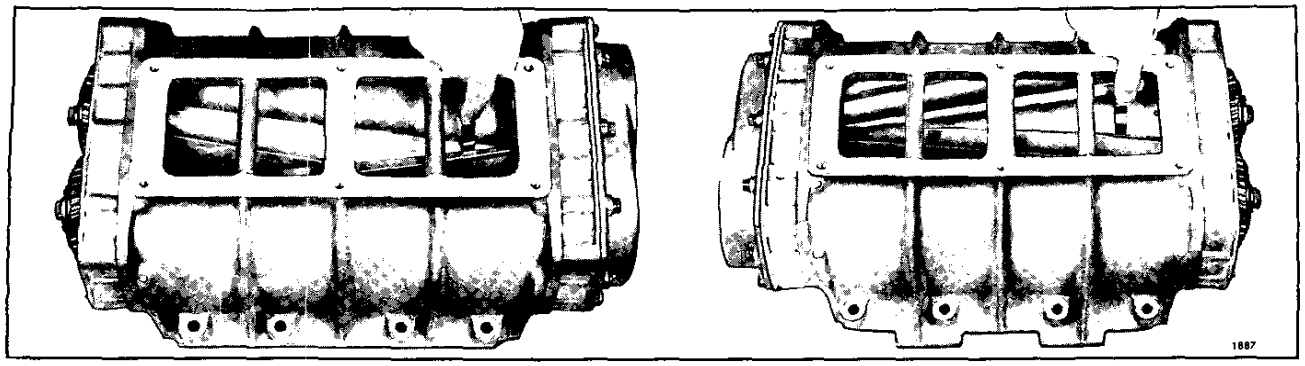
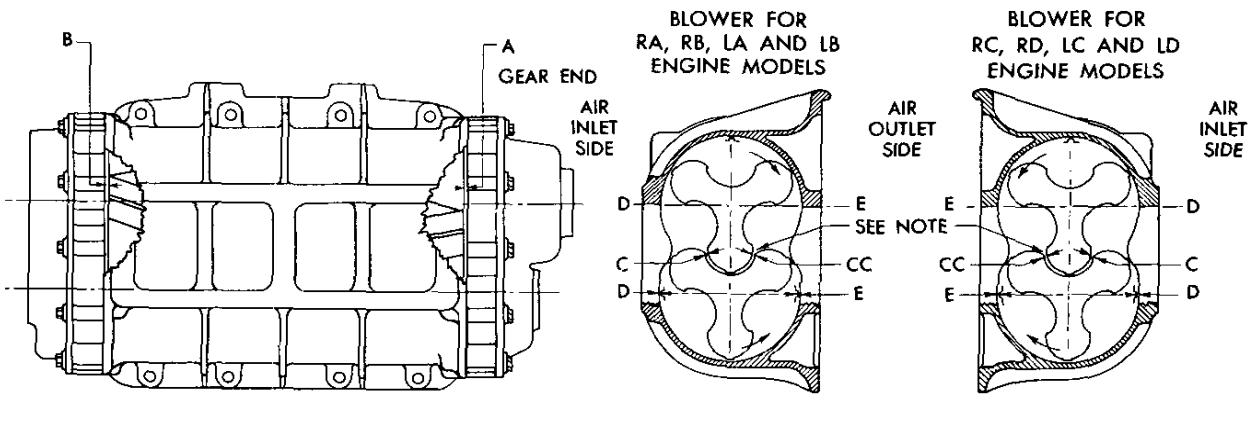


Fig. 25 - Measuring "CC" and "C" Clearances Between Blower Rotor Lobes

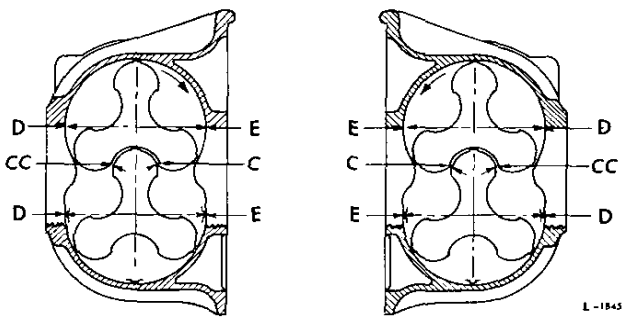
j. Place a lock washer (16) and the gear retaining washer (19) on one of the gear retaining bolts (Fig. 11 or 12). Thread the bolt into the right-hand helix rotor shaft, and guide the lugs on the retaining washer in the slots in the gear hub.



		A	B	C	CC	D	E
3-71	MIN.	.007	.007	.010	.004	.015	.004
	MAX.				.008		
4-71	MIN.	.007	.009	.010	.004	.015	.004
	MAX.				.008		
6-71	MIN.	.007	.014	.010	.004	.015	.004
	MAX.				.008		
6-71P	MIN.	.012	.019	.014	.002	.030	.004
	MAX.				.006		

TIME ROTORS TO DIMENSIONS ABOVE

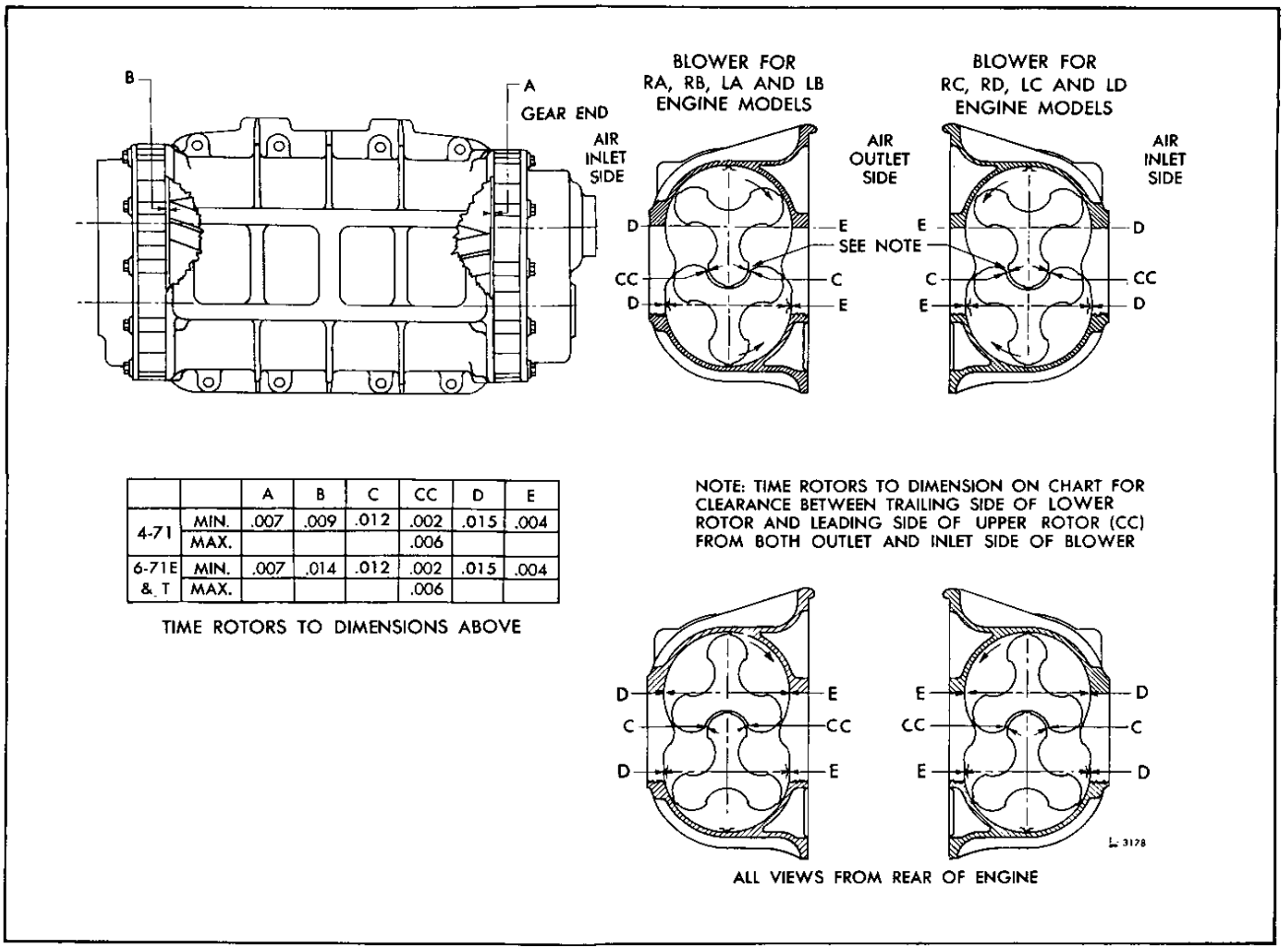
NOTE: TIME ROTORS TO DIMENSION ON CHART FOR CLEARANCE BETWEEN TRAILING SIDE OF UPPER ROTOR AND LEADING SIDE OF LOWER ROTOR (CC) FROM BOTH OUTLET AND INLET SIDE OF BLOWER



ALL VIEWS FROM REAR OF ENGINE

Fig. 26 - Chart of Minimum Clearances for Standard Blowers, Smaller Diameter Rotor Blowers and Large Bearing (P) Blowers

© 1982 General Motors Corp.



		A	B	C	CC	D	E
4-71	MIN.	.007	.009	.012	.002	.015	.004
	MAX.				.006		
6-71E & T	MIN.	.007	.014	.012	.002	.015	.004
	MAX.				.006		

TIME ROTORS TO DIMENSIONS ABOVE

Fig. 27 - Chart of Minimum Clearance for Former Reduction Blowers

Bend one of the tangs on the lock washer over into the slot of the retaining washer. Tighten the gear retaining bolt to 55-65 lb-ft (75-88 Nm) torque.

k. Place a lock washer (16) and the fuel pump drive coupling disc (18) on the remaining gear retaining bolt (Fig. 11 or 12). Thread the bolt into the left-hand helix rotor shaft and guide the lugs on the disc in the slots in the gear hub. Then bend one of the tangs on the lock washer over into the slot in the disc. Tighten the gear retaining bolt to 55-65 lb-ft (75-88 Nm) torque.

l. Bend one of the tangs of each lock washer over against the head of the gear retaining bolt. Remove the cloth from between the blower rotors.

8. Install the blower rotor timing gears on the former reduction blower as follows (Fig. 12):

One serration is omitted on the drive end of each blower rotor shaft and a corresponding serration is omitted in each gear. Assemble the gears on the rotor shafts with the serrations in alignment.

A center punch mark placed in the end of each rotor shaft at the omitted serrations will assist in aligning the gears on the shafts.

a. Place the blower housing and rotor assembly, air inlet side of housing facing up, on the bench with the rear end (serrated end of rotor shaft) of the blower facing the outside of the bench.

b. Rotoate the rotors to bring the omitted serrations on the shaft in alignment and facing the top of the blower housing (Fig. 28).

c. Install the same number and thickness of shims on

© 1982 General Motors Corp.

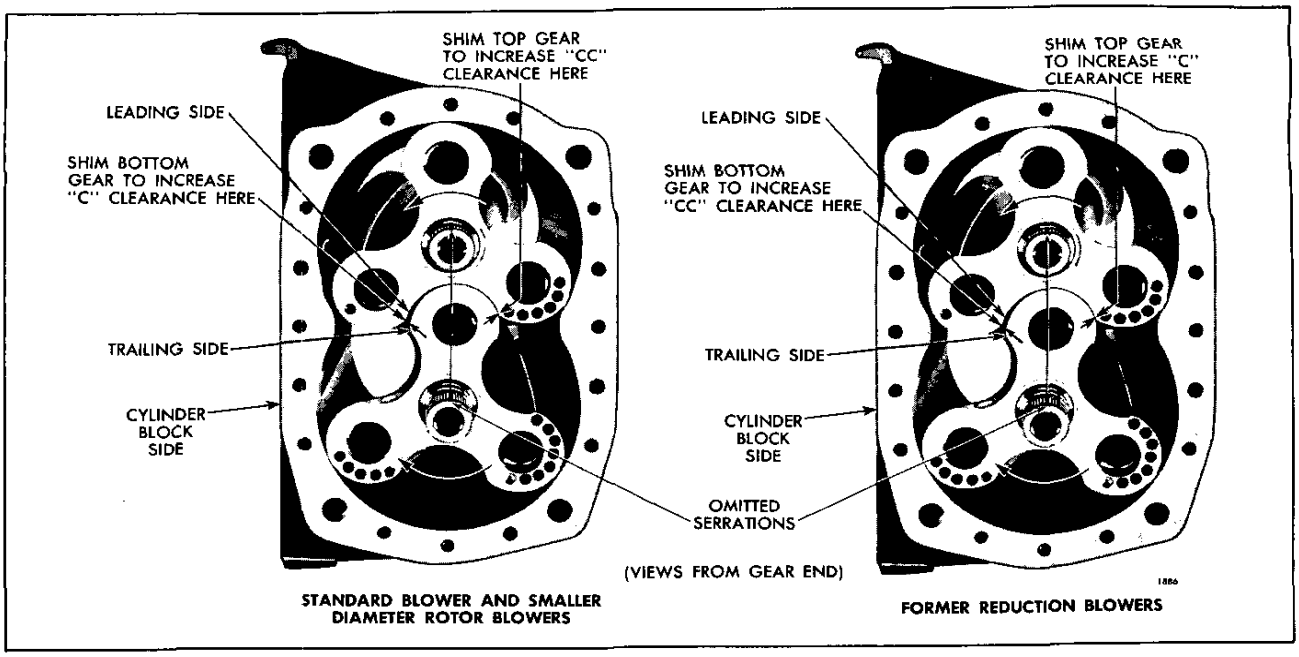


Fig. 28 - Diagram Showing Proper Location of Shims for Correct Rotor Lobe Clearances (C and D Engines Shown - A and B Engines Opposite)

the rotor shafts that were removed at the time of disassembly.

NOTE: When rebuilding a blower with new rotors or new gears, first install the gears on the rotor shafts without the shims, then check the clearances between the rotors to determine the location and thickness of shims to be used; refer to Fig. 28.

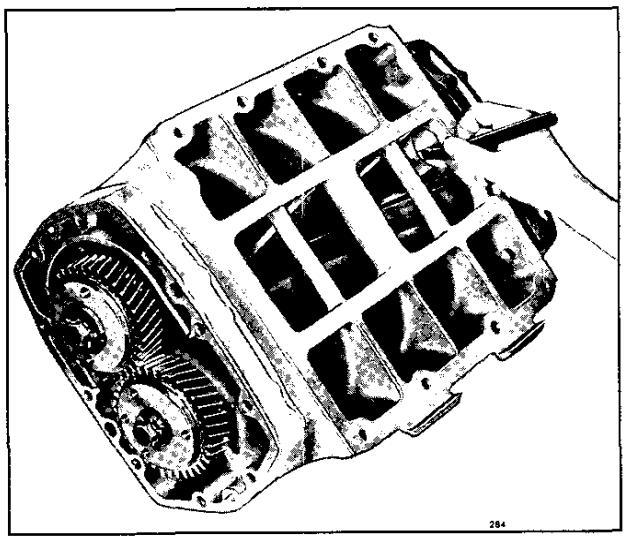


Fig. 29 - Measuring End Clearance Between Blower Rotors and End Plate

d. Lubricate the serrations on the rotor shafts with engine oil.

e. Start the left-hand helix gear on the shaft of the left-hand helix rotor with the omitted serrations in the gear and the shaft in alignment.

f. Thread an installer screw J 6270-8 in the end of the rotor shaft until it bottoms. Place the installer J 6270-7 over the screw and against the gear, and thread a nut on the installer screw.

g. Place a clean folded cloth between the lobes of the rotors, to prevent the rotors from turning. Then, turn the nut on the installer screw clockwise and force the gear on the shaft until the outer face of the gear is flush or slightly below the end of the shaft.

h. Start the right-hand helix gear on the shaft of the right-hand helix rotor with the gear teeth in mesh and the omitted serrations in the gear and the shaft in alignment.

i. Thread an installer screw J 6270-8 in the end of the rotor shaft until it bottoms. Place the installer J 6270-6 over the screw and against the gear, and

© 1982 General Motors Corp.

thread a nut on the installer screw. Then, turn the nuts on the installer screws uniformly clockwise and force the two gears into position at the same time, tight against the shims and bearings as shown in Fig. 24.

j. Remove the rotor timing gear installers from the rotor shafts.

k. Remove the cloth from between the blower rotors.

Timing Blower Rotors

After the blower rotors and timing gears are installed, the blower rotors must be timed.

The blower rotors, when properly positioned in the housing, run with a slight clearance between the lobes. This clearance may be varied by moving one of the helical gears in or out on the shaft relative to the other gear.

If the right-hand helix gear is moved out, the right-hand helix rotor will turn counterclockwise when viewed from the gear end. If the left-hand helix gear is moved out, the left-hand helix rotor will turn clockwise when viewed from the gear end. This positioning of the gear, to obtain the proper clearance between the rotor lobes, is known as blower timing.

Moving the gears "OUT" or "IN" on the rotor shafts is accomplished by adding or removing shims between the gears and the bearings.

The clearance between the rotor lobes should be checked with 1/2" wide feeler gages in the manner shown in Fig. 25. When measuring clearances of more than .005", laminated feeler gages that are made up of .002", .003" or .005" feeler stock are more practical and suitable than a single feeler gage. Clearances should be measured from both the inlet and outlet sides of the blower.

A specially designed feeler gage set J 1698-02 for the blower clearance operation is available. Time the rotors as follows:

1. 71 Blower -- Timing the rotors to have .002'' or .004'' to .006'' or .008'' clearance between the TRAILING edge of the UPPER rotor and LEADING edge of the LOWER rotor ("CC" clearance) measured from both the inlet and outlet sides as shown in Figs. 25 and 26. If possible, keep this clearance to the minimum dimension. Then check the clearance between the LEADING edge of the UPPER and the TRAILING edge of the LOWER rotors ("C" clearance) for the minimum clearance shown in Fig. 26. Rotor-to-rotor measurements should be taken 1'' from each end and at the center of the blower.

Former Reduction Blowers -- Time the rotors to have .002" to .006" clearance between the TRAILING edge of the LOWER rotor and the LEADING edge of the UPPER rotor ("CC" clearance) measured from both the inlet and outlet sides as shown in Figs. 25 and 27. If possible keep this clearance to the minimum (.002"). Then check the clearance between the LEADING edge of the LOWER and the TRAILING edge of the UPPER rotors ("C" clearance) for the minimum clearance shown in Fig. 27. Rotor-to-rotor measurements should be taken one inch from each end and at the center of the blower.

2. After determining the amount one rotor must be revolved to obtain the proper clearance, add shims back of the proper gear to produce the desired result. When more or less shims are required, both gears must be removed from the rotors. Placing a .003" shim in back of a rotor gear will revolve the rotor .001".

3. Install the required thickness of shims back of the proper gear and next to the bearing inner race and reinstall both gears. Recheck the clearances between the rotor lobes.

4. Determine the minimum clearances at points "A" and "B" shown in Figs. 26 and 27. Insert the feeler gages, as shown in Fig. 29, between the end plates and the ends of the rotors. This operation must be performed at the ends of each lobe, making twelve measurements in all. See Figs. 26 and 27 for the minimum clearances.

5. Check the clearance between each rotor lobe and the blower housing at both the inlet and outlet side -- twelve measurements in all. See Figs. 26 and 27 for the minimum clearances.

After the blower rotors are timed, complete the assembly of the blower as outlined below.

1. On the former reduction blowers (Fig. 12), install the rotor drive and driven gears on the rotor shafts as follows:

a. Place the blower housing and rotor assembly, air inlet side of housing facing up, on the bench with the timing gear end of the blower facing the outside of the bench.

b. Start the left-hand helix driven gear on the shaft of the left-hand helix rotor with the omitted serrations in the gear and the shaft in alignment. Then, tap the gear on the shaft and against the timing gear with a plastic hammer, or install the gear with the gear installers J 6270-6, 7 and 8.

c. If removed, install the drive gear bearing in the right-hand helix drive gear with the number on

© 1982 General Motors Corp.

the race of the bearing facing the outside face of the gear.

d. Lubricate the bearing in the drive gear with engine oil, then place the drive gear on the rotor shaft with the numbered side of the bearing facing out.

e. Place the lock washer and the bearing retainer (117) on the 7/16-20 x 1-1/4" drive gear retaining bolt (143). Thread the bolt into the right-hand helix rotor shaft and guide the lug on the rear face of the retainer in the slot in the end of the rotor shaft. Then bend one of the tangs on the lockwasher over into the slot in the retainer. Tighten the bolt to 55-65 lb-ft (75-88 Nm) torque.

f. Place the lock washer (147) and the fuel pump drive coupling disc (18) on the 1/2"-20 x 1-1/4" driven gear retaining bolt (146). Thread the bolt into the left-hand helix rotor shaft, and guide the lugs on the disc in the slots in the gear hub, then bend one of the tangs on the lock washer over into the slot in the disc. Tighten the bolt to 55-65 lb-ft (75-88 Nm) torque.

g. Bend one of the tangs of each lock washer over against the head of each gear retaining bolt.

2. Refer to Figs. 11 and 12 and attach the blower rotor drive hub (20) and drive hub plates (115) to the blower gears as follows:

a. If removed, attach the rotor drive hub plates (115) to the drive hub (20) with three bolts (22), lock washers and plain washers. Tighten the bolts to 25-30 lb-ft (34-41 Nm) torque.

b. Attach the rotor drive hub and drive plates to the right-hand helix rotor timing gear with three bolts (21), lock washers, plain washers and three spacers (116) on the standard blower and smaller diameter rotor blower, or drive gear (140) on the former reduction blowers, along with three spacers (116) and bearing retainer (117) between the plates and the face of the gear. Tighten the bolts to 25-30 lb-ft (34-41 Nm) torque.

c. Check the runout of the splines in the rotor drive hub with an indicator. The spline runout must not exceed .020" total indicator reading.

3. Affix a new gasket (32) to the blower rear end plate cover (29).

NOTE: The former blower end plate cover is *not* interchangeable with the current blower end plate cover.

4. Position the end plate cover over the end plate dowel pins, then push the cover against the end plate. Install the ten bolts and lock washers. Tighten the bolts to 13-17 lb-ft (18-23 Nm) torque.

Attach Accessories to Blower

Refer to Fig. 1 and attach the fuel pump, water pump, blower drive shaft cover and governor weight housing or drive housing (hydraulic governor) assembly to the blower as follows:

1. Attach the fuel pump to the blower as outlined under *Attach Fuel Pump to Blower* in Section 2.2.

2. Attach the water pump to the blower as outlined under *Install Fresh Water Pump* in Section 5.1. To convert the former water pump drive coupling to the current coupling, refer to Section 3.0.

3. Attach the governor weight housing ro drive housing assembly to the blower as outlined under *Install Governor* in Section 2.7.1 for the limiting speed governor, Section 2.7.2 for the variable speed governor and Section 2.8.3 for the hydraulic governor.

4. On the current blower, attach the blower drive shaft cover (33) to the blower rear end plate cover (29) with cover seal (37) and seal clamp (114) as shown in Fig. 1.

5. On a former blower (Fig. 12), affix a new gasket to the bolting flange of the blower drive shaft cover (33) and attach it to the blower rear end plate cover with six bolts and seal washer assemblies, finger tight only.

Attach Blower to Engine

Refer to Figs. 3, 4 or 12 and attach the blower assembly to the engine as follows:

Before attaching the blower assembly to the engine, check the inside of the blower for any foreign material and revolve the rotors by hand to be sure they turn freely.

1. Affix a new blower to block gasket to the cylinder block with Scotch Grip Rubber adhesive No. 1300, or equivalent, to prevent the gasket from shifting when placing the blower against the block.

2. Place a new drive shaft cover seal (37) and seal clamp (114) over the end of the drive shaft cover (33).

3. Place the water pump outlet packing flange, flat face toward pump body, and slide a new packing ring over the pump outlet. Then, place a new water pump cover seal and clamp on top of the oil cooler housing outlet opening.

© 1982 General Motors Corp.

4. Place the blower assembly into position against the cylinder block, being careful not to dislodge the blower gasket.

5. Install the eight blower to cylinder block bolts and plain washers, and tighten the bolts to 55-60 lb-ft (75-81 Nm) torque (cast iron block) or 35-40 lb-ft (47-54 Nm) torque (aluminum block).

6. Slide the blower drive shaft cover seal (37) into position againt the blower drive gear hub support and tighten the seal clamp.

7. On a former blower, tighten the bolts securing the blower drive shaft cover (33) to the blower rear end plate cover.

8. Install the blower drive shaft (38) by pushing the plain end, without squared hole, of the shaft through the blower drive coupling from the rear of the engine, then into the blower drive gear hub. If necessary, rotate the blower rotors slightly to align the splines of the drive shaft with those in the gear hub (20). Then, install the lock ring in the blower drive cam.

9. Install the flywheel housing small hole cover.

10. Connect the water pump outlet packing flange to the cylinder block. Also, tighten the seal clamp connecting the water pump cover to the oil cooler housing.

11. Place the blower air shutdown housing, together with the striker plate gasket, striker plate (if used) and screen and gasket assembly against the blower (with the screen side of gasket assembly toward the blower). Secure them in place with bolts and lock washers. Tighten the bolts to 16-20 lb-ft (22-27 Nm) torque.

12. If the engine is equipped with an automatic shutdown solenoid, install the solenoid and connect the wires to the solenoid.

13. If the engine is equipped with a manual shutdown assembly, connect the control wire to the air shutdown valve shaft lever and attach the control wire clip under the head of the air inlet housing attaching bolt.

14. Install the governor control housing assembly as outlined under *Install Governor* in Section 2.7.1 for the limiting speed governor, and Section 2.7.2 for the variable speed governor. If the engine is equipped with a hydraulic governor, refer to *Install Governor* in Section 2.8.1 or 2.8.2.

15. Install the air cleaners (non-turbocharged engines).

16. Connect the fuel lines to the fuel pump.

17. If the engine is equipped with a turbocharger, slide the hose into position on the air inlet housing and turbocharger (Fig. 4) and secure in place with the hose clamps.

18. Fill the cooling system with clean fresh water plus rust inhibitor (or sufficient quantity of an ethylene glycol base antifreeze) and check the system for leaks.

© 1982 General Motors Corp.

TURBOCHARGER (Airesearch)

The turbocharger (Figs. 1 and 2) is designed to increase the overall efficiency of the engine. Power to drive the turbocharger is extracted from the waste energy in the engine exhaust gas.

The turbocharger consists of a radial inward flow turbine wheel and shaft, a centrifugal compressor wheel, and a center housing which serves to support the rotating assembly, bearings, seals, a turbine housing and a compressor housing. The center housing has connections for oil inlet and oil outlet fittings.

The turbine wheel is located in the turbine housing and is mounted on one end of the turbine shaft. The compressor wheel is located in the compressor housing and is mounted on the opposite end of the turbine wheel shaft to form an integral rotating assembly.

The rotating assembly consists of a turbine wheel and shaft assembly, piston ring(s), thrust spacer (thrust collar, thrust bearing-T04D), compressor wheel and wheel retaining nut. The rotating assembly is supported on two pressure lubricated bearings which are retained in the center housing by snap rings. Internal oil passages are drilled in the center housing to provide lubrication to the turbine wheel shaft bearings, thrust washer, thrust collar and thrust spacer (thrust bearing, piston ring and thrust collar-T04D).

The turbine housing is a heat resistant alloy casting which encloses the turbine wheel and provides a flanged engine exhaust gas inlet and an axially-located turbocharger exhaust gas outlet. The other than TV61 and TV71 turbine housing is bolted to the turbine end of the center housing and the TV61 and TV71 turbine housing is secured to the turbine end of the center housing with a "V" band coupling, thus providing a compact and vibration free assembly.

The compressor housing, which encloses the compressor wheel, provides an ambient air inlet and a compressed air discharge outlet. The compressor housing (other than the T04D) is secured to the compressor end of the center housing backplate assembly with a "V" band coupling. The T04D is bolted to the backplate assembly and the backplate assembly is bolted to the compressor end of the center housing.

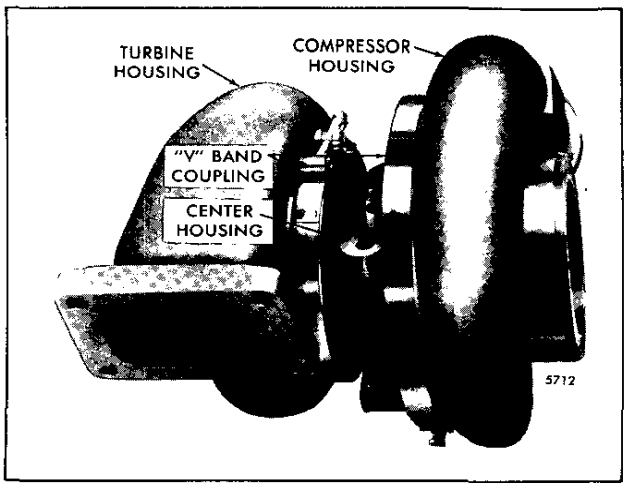


Fig. 1 - Typical Turbocharger Assembly

Operation

The turbocharger is mounted on the exhaust outlet flange of the engine exhaust manifold. After the engine is started, the exhaust gases flowing from the engine and through the turbine housing cause the turbine wheel and shaft to rotate (Fig. 3). The gases are discharged into the atmosphere after passing through the turbine housing.

The compressor wheel, which is mounted on the opposite end of the turbine wheel shaft, rotates with the turbine wheel. The compressor wheel draws in

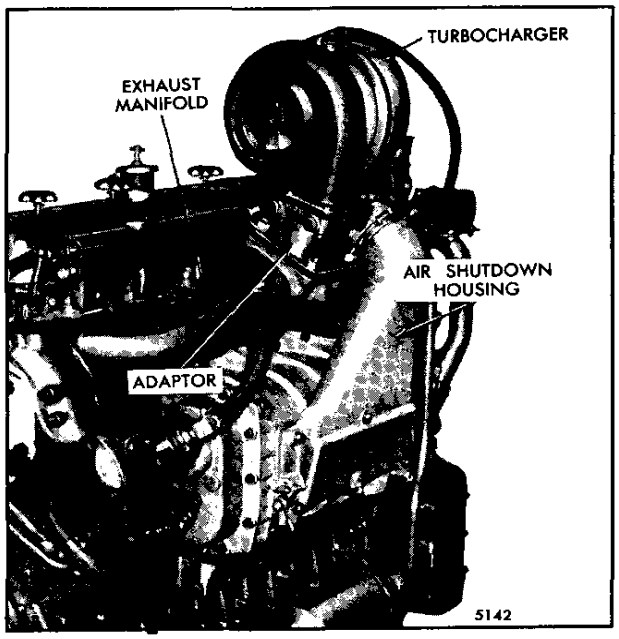


Fig. 2 - Typical Turbocharger Mounting

(C) 1982 General Motors Corp.

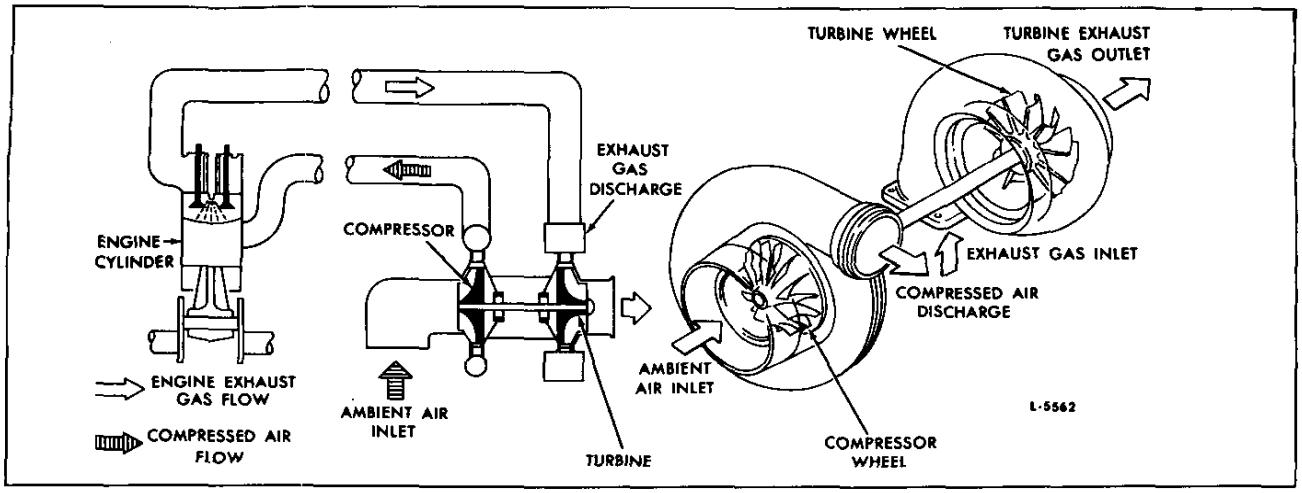


Fig. 3 - Schematic Air Flow Diagram

fresh air, compresses it and delivers high pressure air through the engine blower to the engine cylinders.

During operation, the turbocharger responds to the engine load demands by reacting to the flow of the engine exhaust gases. As the engine power output increases or decreases, the turbocharger responds to the engine's demand to deliver the required amount of air under all conditions.

Certain engines are quipped with an aftercooler to cool the air going into the engine, after it passes through both the turbocharger and the engine blower (refer to Section 3.5.3).

Certain marine engines are equipped with an intercooler to reduce the temperature of the discharge air from the turbocharger before it enters the engine blower (refer to Section 3.5.2).

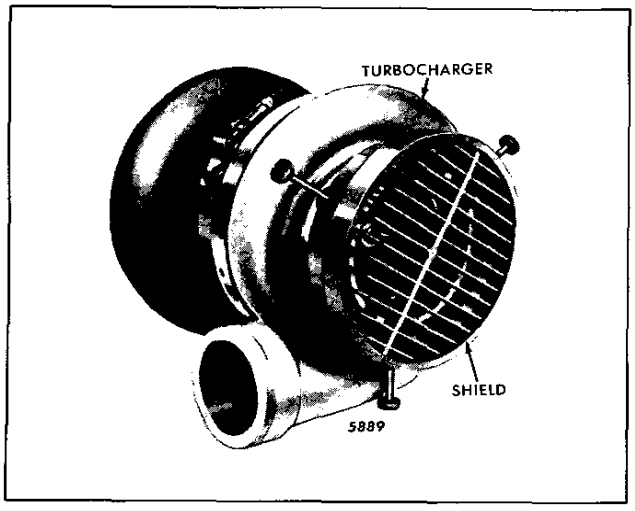


Fig. 4 - Inlet Shield (J 26554-A)

Lubrication

Lubricating oil for the turbocharger is supplied under pressure through an external oil line extending from the engine cylinder block to the top of the center housing. From the oil inlet in the center housing, the oil flows through the drilled oil passages in the housing to the shaft bearings (thrust collar, thrust bearing-T04D), thrust ring, thrust bearing and backplate or thrust plate (Fig. 5). The oil returns by gravity to the engine oil pan through an external oil line extending from the bottom of the turbocharger center housing to the cylinder block.

Before the initial engine start, when a new or overhauled turbocharger is installed, the turbocharger must be prelubricated as outlined under *Install Turbocharger*.

NOTE: Failure to perform the prelubrication procedure may result in premature bearing failure due to "oil lag" or lack of lubrication.

Periodic Inspection

NOTE: A turbocharger compressor inlet shield J 26554-A, (Fig. 4) is available for use anytime the engine is operated with the air inlet piping removed. The shield helps to prevent foreign objects from entering the turbocharger and prevents a serviceman from touching the

© 1982 General Motors Corp.

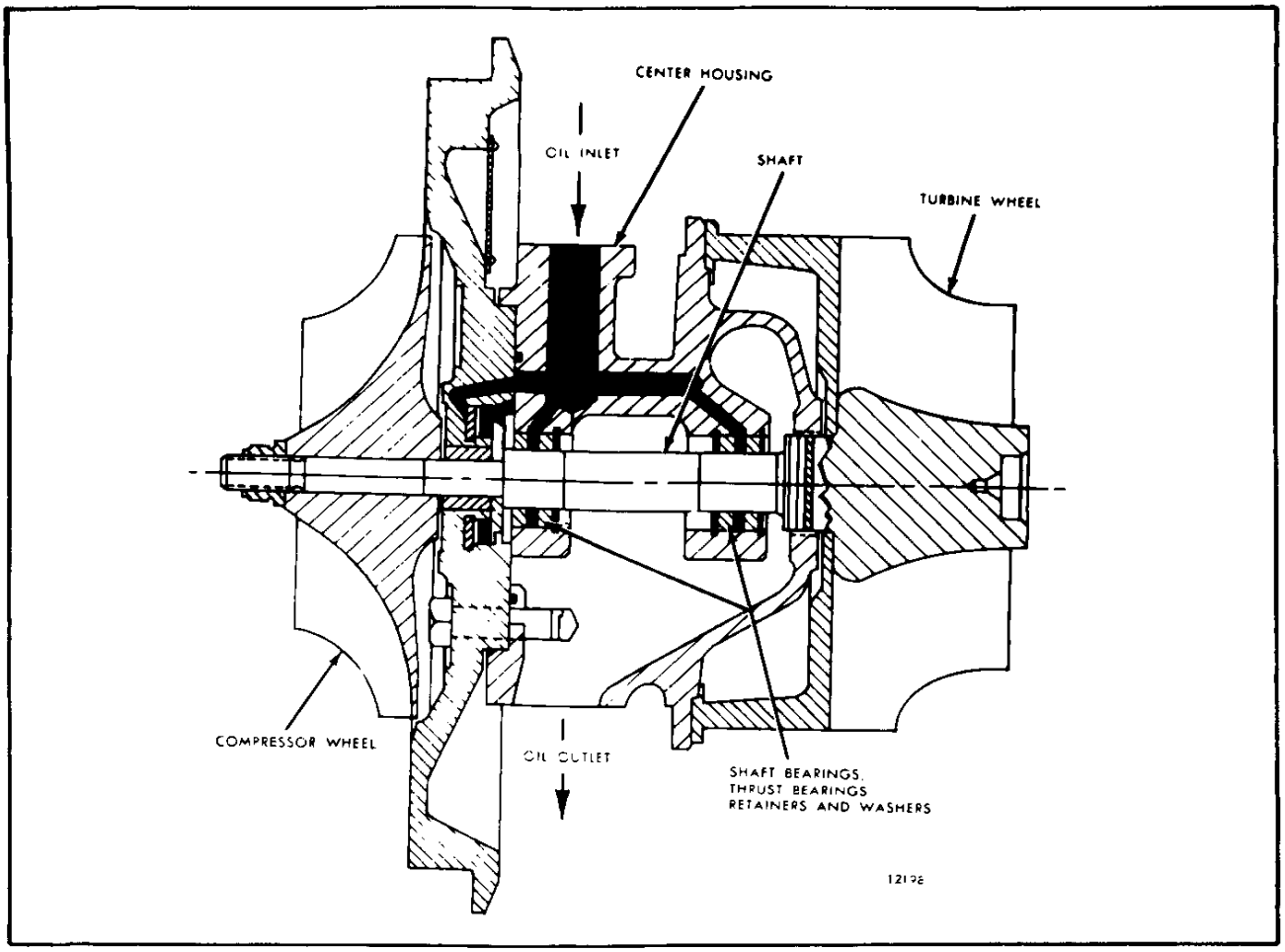


Fig. 5 - Turbocharger Oil Flow Diagram

moving impeller. The use of this shield *does not* preclude any other saftey practices contained in this manual.

Inadequate air filtering and excessive restrictions to air and exhaust flows will adversely affect turbocharger life and performance. Do not permit restriction levels to exceed the specified limits (refer to Section 13.2).

A periodic inspection of the turbocharger should be made along with an engine inspection.

Inspect the turbocharger mountings and check all of the air ducting and connections for leaks. Make the inspection with the engine running and with it shut down. Check for leaks at the manifold connection, the turbine inlet and exhaust manifold gasket.

NOTE: Do not operate the engine if leaks are found in the turbocharger ducting or if the air cleaner is not filtering efficiently. Dust leaking into the air ducting can damage the turbocharger and the engine.

Remove the inlet duct to the turbocharger compressor housing and check for carbon or dirt buildup on the impeller or in the housing. Excessive accumulations indicate either a leak in the ducting or a faulty air filtering system. Remove all such accumulations and determine and correct the cause. Refer to *Trouble Shooting Charts* (Fig. 6). Uneven deposits left on the compressor wheel can affect the balance and cause premature bearing failure.

NOTE: Do not attempt to remove carbon or dirt buildup on the compressor or turbine wheels without removing the turbocharger from the engine. The blades on the wheels must be thoroughly cleaned. If chunks of carbon are left on the blades, an unbalanced condition would exist and subsequent failure of the bearings would result if the turbocharger is operated.

© 1979 General Motors Corp.

TROUBLE SHOOTING CHARTS

CHART 1

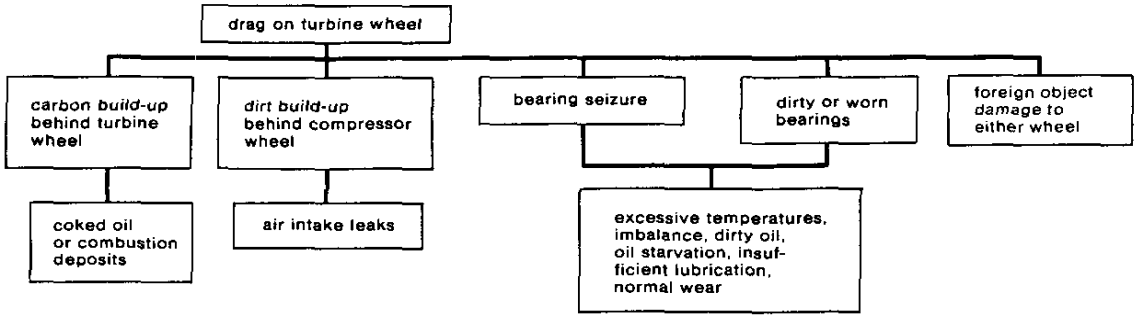


CHART 2

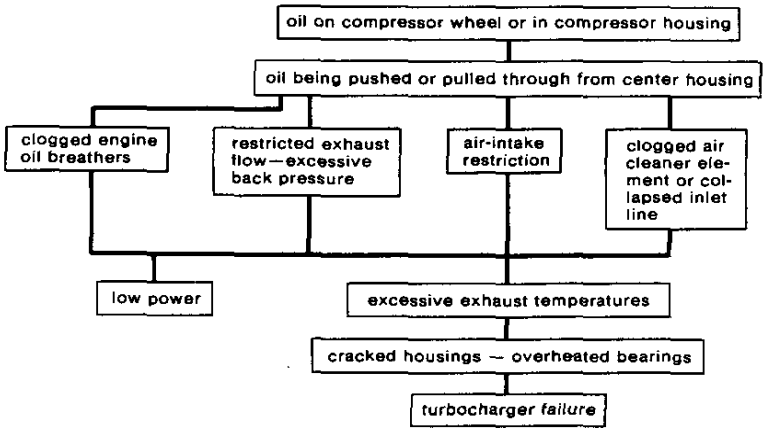


CHART 3

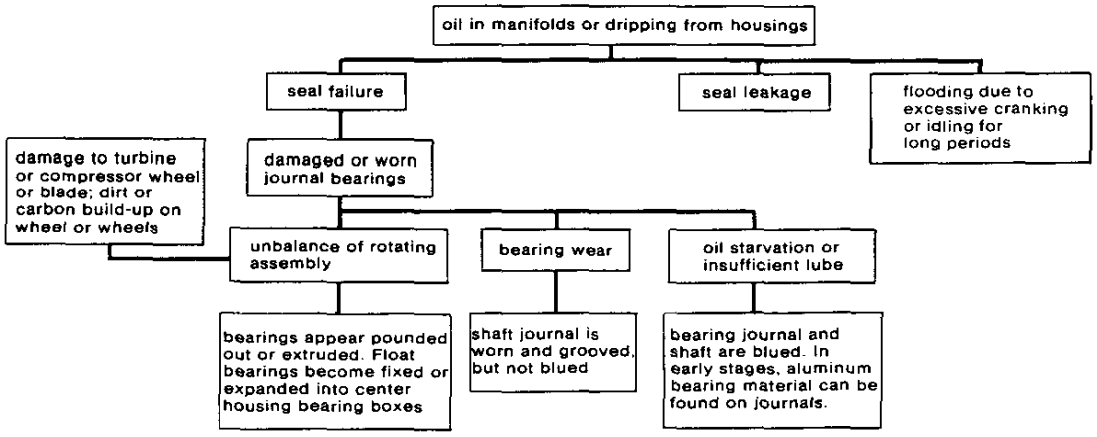


Fig. 6 - Inspection Checks for Turbocharger

© 1979 General Motors Corp.

However, it is not necessary to disassemble the turbocharger to remove dirt or dust build-up.

For proper operation, the turbocharger rotating assembly must turn free. Whenever the exhaust ducting is removed, spin the turbine wheel by hand. If it does not spin freely, refer to Chart 1 of Fig. 6. Inspect the compressor and turbine wheels for nicks or loss of material. Both wheels are precision balanced. A broken or bent blade can throw the rotating assembly out of balance and shorten the life of the turbocharger.

Inspect the oil inlet and oil return lines to make certain all of the connections are tight and that the lines are not dented or looped so that oil flow to and from the center housing is restricted. Looping the oil return lines disrupts gravity flow of the oil back to the engine.

NOTE: Be sure the oil inlet lines are filled with oil and that they are clear of the turbine housings.

Check for signs of oil leaking from the turbocharger housings.

Lubricant applied under pressure to the center housing while the shaft is not turning may allow oil to enter the turbine and compressor housings. However, after the turbocharger has been operated for a time under load conditions and with the inlet restriction at normal, oil in these sections should disappear. If the oil does not disappear, refer to Chart 2 of Fig. 6.

Oil pull-over from an oil bath type air cleaner can also cause oil to enter the compressor housing. Check for a dirty air cleaner element or for too low viscosity oil in the air cleaner. Also, too small an air cleaner could create excessive air flow velocity and result in oil pull-over.

Evidence of oil in the inlet or outlet ducts or dripping from either housing indicates a seal problem that will require overhaul of the turbocharger. Refer to Chart 3 of Fig. 6.

Tests show there are three conditions that contribute to oil seal leakage at the internal turbocharger oil seal.

1. A worn or defective oil seal, which must be replaced.

2. High air inlet restriction (above specified limits). This will cause oil to be pulled past the oil seal.

3. Long periods of operation where the engine is being motored (using the engine as a braking device when going down a long hill). This can also cause oil to pass by the oil seal.

To confirm oil leakage from one or more of these conditions, remove the compressor housing and inspect the backplate. If the surface is wet with oil, it indicates leakage.

If this test does not show leakage patterns, the oil seal assembly is good for normal operation. This simple test will allow some positive testing on each engine in all cases.

Turbocharger compressor end shaft oil seal effectiveness can be determined by the following procedure:

1. Determine that air inlet restriction is within the Detroit Diesel Allison maximum limit. Refer to Section 13.2.

2. Be certain that the turbocharger oil drain line is unrestricted.

3. Be certain that the turbocharger has not obviously been damaged and in need of major repair.

4. Remove the air intake ducting. Inspect inside of the ducting for evidence of oil. If oil is found in the intake system, determine the source before proceeding with the compressor seal test and also thoroughly remove oil from the intake. Some external sources of oil are oil bath air cleaners, air compressor line, or a leak near an oil source such as an engine breather, etc.

5. Remove the compressor housing from the turbocharger.

6. Thoroughly clean the internal surfaces of the compressor housing, impeller cavity behind the impeller, and the backplate annulus with suitable solvent spray and then dry completely with shop air.

7. Spray the backplate annulus with a light coating of "Spot-Check" developer type SKD-MF, or equivalent.

8. Install the compressor housing on the turbocharger and reconnect the inlet and outlet connections.

9. Warm-up the engine to normal operating temperature.

10. Operate the engine at no load at the governor limited high speed for approximately five minutes.

11. Return the engine to low idle, and then stop it.

12. Remove the intake duct and outlet hose, and then remove the compressor housing. Evidence of compressor end shaft seal oil leakage will be observed as oil streaks in the "Spot-Check" developer on the backplate annulus. This surface should be completely free of oil streaks after the test.

© 1984 General Motors Corp.

13. If leakage is detected, and oil is positively not entering through the intake duct, then the turbocharger may be removed from the engine and inspected for damaged components.

T18A40, TV61, TV71 and T04D Turbocharger

Remove Turbocharger

1. Disconnect the exhaust manifold adaptor attached to the turbine housing.

2. Disconnect the air inlet hose attached to the compressor housing.

3. Remove the oil inlet line from the top of the center housing.

4. Remove the oil outlet line from the bottom of the center housing.

5. Attach a chain hoist and a suitable lifting sling to the turbocharger assembly.

6. Remove the nuts and lockwashers securing the turbocharger assembly to the mounting bracket. Then, lift the turbocharger assembly away from the engine and place it on a bench.

7. Cover the end of each oil inlet and oil outlet line and the air inlet and exhaust outlet openings on the engine to prevent the entry of foreign material.

Disassemble Turbocharger (T18A40 - TV61 - TV71)

Clean the exterior of the turbocharger with a noncaustic cleaning solvent before disassembly and proceed as follows:

NOTE: Mark related positions of the compressor housing, center housing and turbine housing with a punch or scribe prior to disassembly to assure reassembly in the same relative position.

1. Refer to Fig. 7 or 8 and loosen the "V" band coupling (1) securing the compressor housing (2) to the backplate assembly (14) and remove the compressor housing and "V" band.

NOTE: Exercise care when removing the compressor housing and turbine housing to prevent damage to the compressor and turbine wheels.

2. With the T18A40 turbocharger, bend down the ends of the lockplates (4) and remove the eight bolts (3) securing the four lockplates and turbine housing clamps (5) to the center housing (27) and turbine housing (6). With the TV61 and TV71 turbocharger, loosen the "V" band coupling (28) securing the turbine housing (6) to the center housing (27). Remove the turbine housing from the center housing.

NOTE: Tap the housing with a soft hammer if force is needed for removal.

3. Position the turbine wheel (9) of the center housing assembly in a suitable holding fixture (Fig. 10). Remove the the wheel nut (7) from the shaft. If a holding fixture is not available, clamp a suitable socket or box end wrench in a vise and place the extended hub on the shaft in the socket or wrench. Hold the center housing upright and remove the wheel nut from the shaft.

NOTE: To prevent the possibility of bending the turbine wheel shaft, remove the compressor wheel nut from the shaft with a double universal socket and tee handle.

4. Press the compressor wheel (8) from the wheel shaft assembly (9).

5. Withdraw the wheel shaft assembly (9) from the center housing. The wheel shroud (10), which is not retained, will fall free when the wheel shaft is removed.

6. With the TV61 and TV71 turbocharger, remove and discard the turbine piston ring (11) from the wheel shaft.

7. Bend down the lock tabs and remove the four bolts (12) and lockplates (13) securing the backplate assembly (14) to the center housing (27) and remove the backplate assembly.

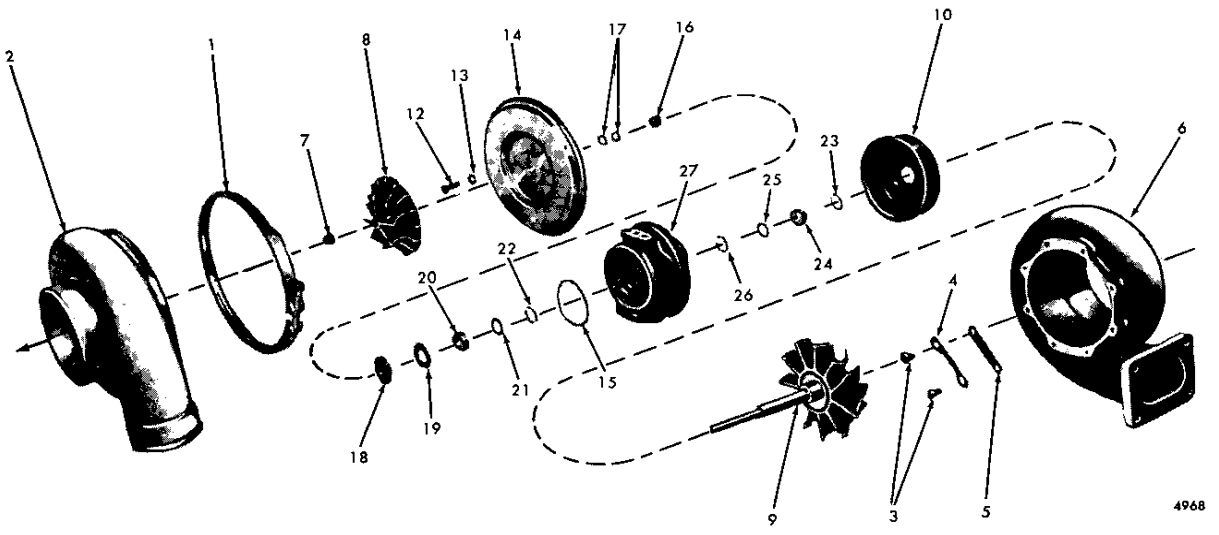
NOTE: Tap the backplate lightly to remove it from the center housing recess.

8. Remove and discard the seal ring (15) from the groove in the center housing.

9. Remove the thrust spacer (16) and piston ring(s) (17) from the backplate assembly. Discard the piston ring(s).

10. Remove the thrust collar (18), inboard thrust washer (19), bearing (20), bearing washer (21) and snap ring (22) from the center housing. Discard the thrust washer, bearing, washer and snap ring.

© 1984 General Motors Corp.



1. Coupling--"V" Band
2. Housing--Compressor
3. Bolt
4. Lockplate
5. Clamp--Turbine Housing
6. Housing--Turbine
7. Nut--Self-Locking
8. Wheel--Compressor
9. Shaft--Turbine Wheel Assembly
10. Shroud--Turbine Wheel
12. Screw
13. Lockplate
14. Backplate Assembly
15. Ring--Seal
16. Spacer--Thrust
17. Ring--Piston
18. Collar--Thrust
19. Washer--Inboard Thrust
20. Bearing
21. Washer--Bearing
22. Ring--Snap
23. Ring--Snap
24. Bearing
25. Washer--Bearing
26. Ring--Snap
27. Housing--Center

Fig. 7 - T18A40 Turbocharger Details and Relative Location of Parts

11. Remove the snap ring (23), bearing (24), bearing washers (25) and snap ring (26) from the opposite end of the center housing. Discard the snap rings, bearing and washers.

Disassemble Turbocharger (T04D)

Clean the exterior of the turbocharger with a noncaustic cleaning solvent before disassembling and proceed as follows:

NOTE: Mark related positions of the compressor *housing, center housing and turbine housing* with a punch or scribe prior to disassembly to assure reassembly in the same relative position.

1. Refer to Fig. 9 and bend the lock tabs of the lock plates down and remove the bolts which hold the lockplates and clamps securing the compressor housing and turbine housing.

NOTE: Exercise care when removing the compressor housing and turbine housing to prevent damage to the compressor and turbine wheels. Tap the housing with a soft hammer if force is needed for removal.

2. Position the turbine wheel of the center housing assembly in a suitable holding fixture (Fig. 10). Remove the wheel nut from the shaft.

NOTE: If a holding fixture is not available, clamp a suitable socket or box end wrench in a vise and place the extended hub on the shaft in the socket or wrench. Hold the center housing upright and remove the wheel nut from the shaft.

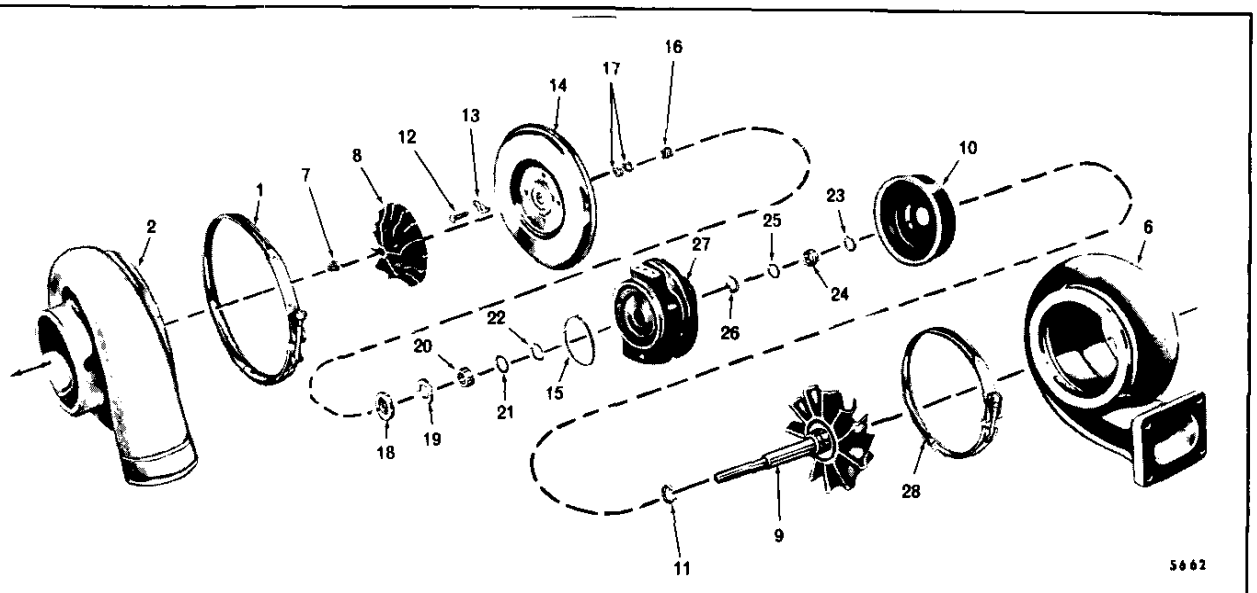
To prevent the possibility of bending the turbine wheel shaft, remove the compressor wheel nut from the shaft with a double universal socket and tee handle.

3. Lift the compressor wheel off of the turbine wheel shaft assembly.

4. Invert the center housing and turbine wheel assembly and remove the turbine wheel assembly (with piston ring) from the center housing. Remove the piston ring from the wheel assembly.

5. Bend the lock tabs down and remove the bolts and lockplates securing the backplate assembly to the center housing. Remove the back plate assembly.

© 1984 General Motors Corp.



1. Coupling--"V" Band
2. Housing--Compressor
6. Housing--Turbine
7. Nut--Self-Locking
8. Wheel--Compressor
9. Shaft--Turbine Wheel Assembly
10. Shroud--Turbine Wheel
11. Ring--Turbine Piston
12. Screw
13. Lockplate
14. Backplate Assembly
15. Ring--Seal
16. Spacer--Thrust
17. Ring--Piston
18. Collar--Thrust
19. Washer--Inboard Thrust
20. Bearing
21. Washer--Bearing
22. Ring--Snap
23. Ring--Snap
24. Bearing
25. Washer--Bearing
26. Ring--Snap
27. Housing--Center
28. Coupling--"V" Band

Fig. 8 - TV61 and TV71 Turbocharger Details and Relative Location of Parts

NOTE: Tap the backplate lightly to remove it from the center housing recess.

6. Do not disassemble the backplate assembly. Also, do not remove the pins from the center housing, unless it is necessary to replace the pins.

7. Remove and discard the seal ring from the groove in the center housing.

8. Remove the thrust bearing and piston ring from the backplate assembly. Discard the piston ring.

9. Remove the thrust collar, bearing and snap ring from the center housing. Discard the bearing and snap ring.

10. Remove the snap ring, bearing and snap ring from the opposite end of the center housing. Discard the snap rings and bearings.

Cleaning

Before cleaning, inspect the parts for signs of burning, rubbing or other damage which might not be evident after cleaning.

Soak all parts in a noncaustic cleaning solvent for about 25 minutes. After soaking, use a stiff bristle brush and remove all dirt particles. Dry all of the parts thoroughly.

CAUTION: Never use a caustic cleaning solution for cleaning as this will damage certain parts. Use the cleaning solution in an open or well ventilated area. Avoid breathing the fumes. Keep away from open flames. Do not use a wire brush or a steel blade scraper to clean the parts.

Make sure that both wheel blades are thoroughly clean. Deposits left on the blades will affect the balance of the rotating assembly.

© 1984 General Motors Corp.

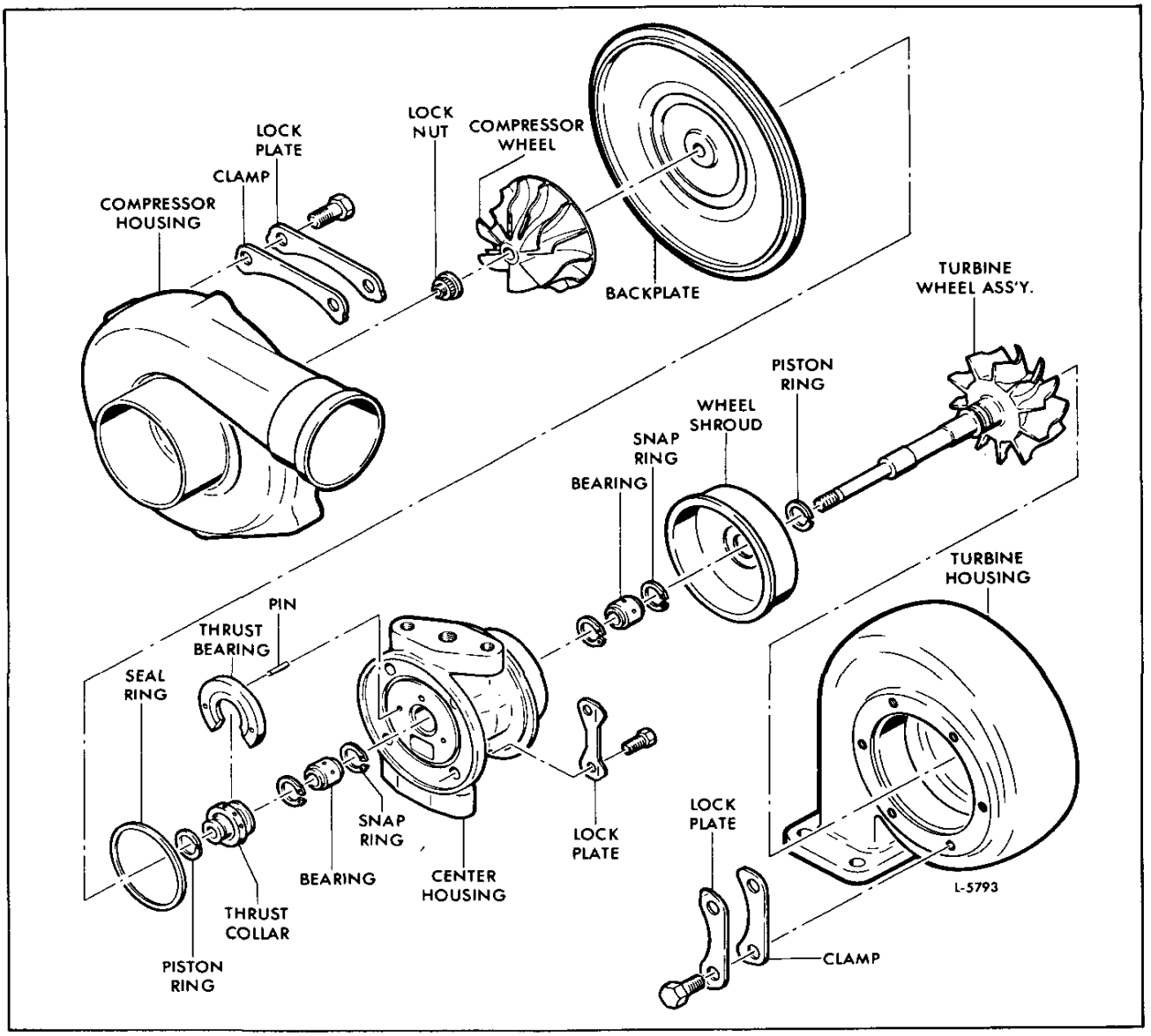


Fig. 9 - T04D Turbocharger Details and Relative Location of Parts

Clean all of the internal cavities and oil passages in the center housing thoroughly with dry compressed air.

Clean the oil passage in the center housing thrust plate with dry compressed air.

Remove the oil inlet and outlet lines from the engine and thoroughly clean the oil lines inside and out. An oil line that is dented or crimped enough to restrict the flow of oil must be replaced.

Inspection

Inspect all of the parts for signs of damage, corrosion or deterioration. Check for nicked, crossed or stripped threads.

Visually check the turbine wheel for signs of rubbing or wear. For shaft bearing journal dimensions and wear limits, refer to Section 3.0.

Inspect the shaft for signs of scoring, scratches or bearing seizure.

© 1979 General Motors Corp.

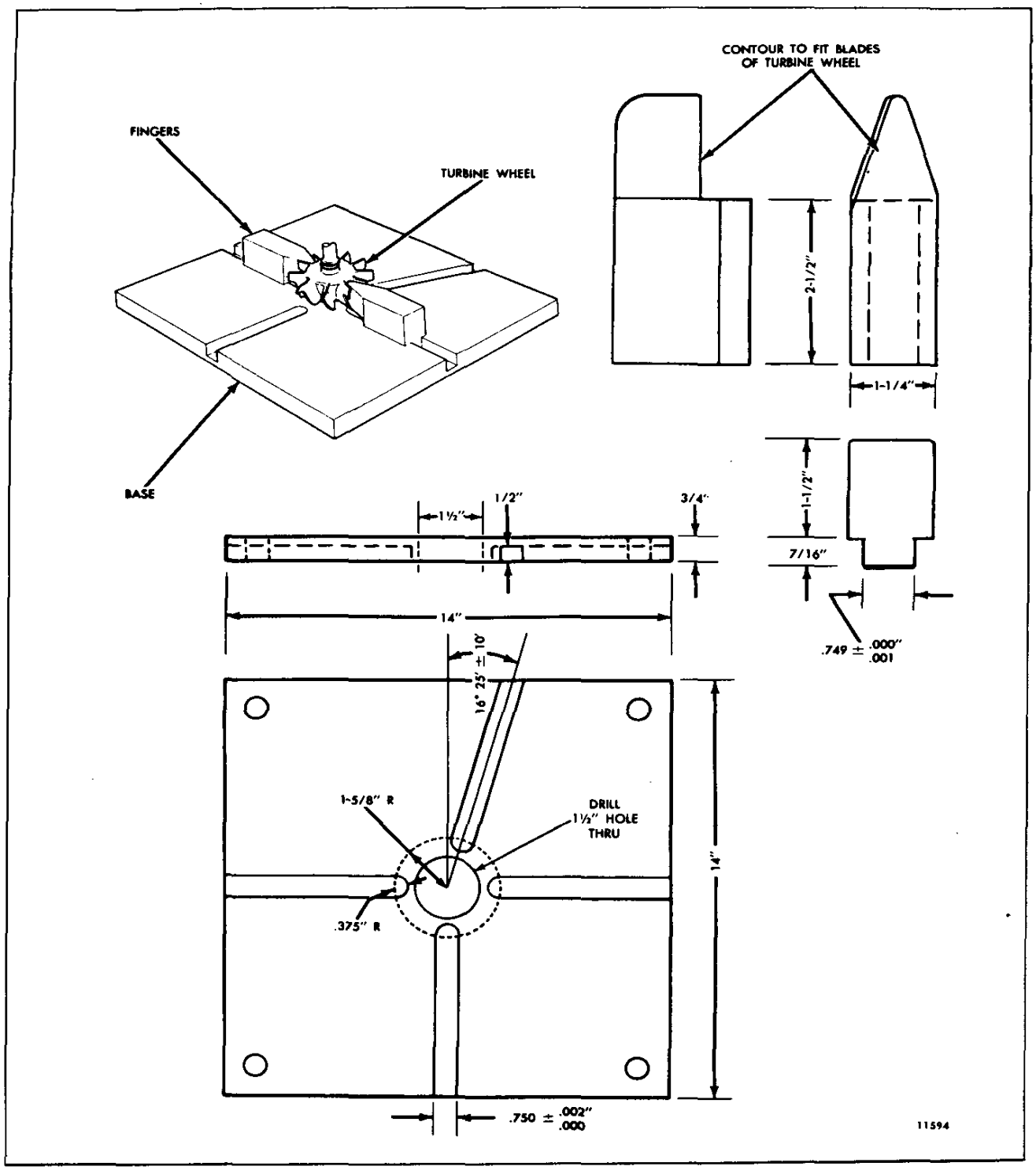


Fig. 10 - Turbocharger Holding Fixture

© 1979 General Motors Corp.

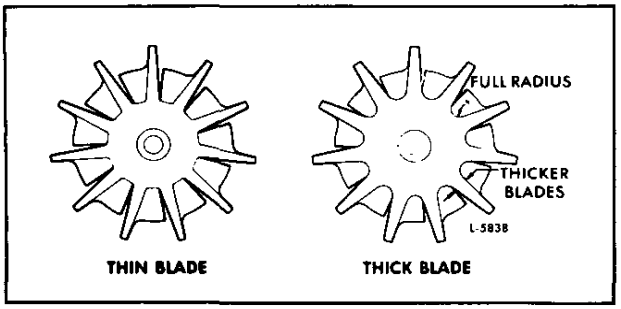


Fig. 11 - Comparison of Former and Current Turbine Wheels for T18A40 Turbocharger (Non-Vehicle Engines)

Check the compressor wheel for signs of rubbing or damage from foreign material. Check to see that the wheel bore is not galled. The wheel must be free of dirt and other foreign material.

Inspect the seal parts for signs of rubbing or scoring of the running faces.

Approximately November, 1976, the turbine wheel shaft assembly in the T18A40 turbocharger used in non-vehicle engines was revised in that the new turbine wheel has thicker blades and also full radius fillets between the blade roots to strengthen the blades (Fig. 11). The thinner blade turbine wheel shaft assembly will continue to be built into the T18A40 turbocharger used in the vehicle engines.

Inspect the backplate for wear or damaged bore (piston ring groove).

Inspect the housing for contact with the rotating parts. The oil and air passages must be clean and free of obstructions.

Minor surface damage may be burnished or polished. Use a Silicone Carbide abrasive cloth for aluminum parts or a crocus abrasive cloth for steel parts.

It is recommended that the piston ring(s), thrust washers, bearing, bearing washers and snap rings be replaced at time of disassembly.

Inspect the exhaust outlet elbow seal ring for signs of wear or breakage.

Assemble Turbocharger
(T18A40 - TV61 - TV71)

Check each part prior to installation to ensure cleanliness. As the parts are assembled, cover the openings to prevent entry of dirt or other foreign material.

Refer to Figs. 7 and 8 for parts orientation and proceed as follows:

1. Lubricate the new bearings (20 and 24) with clean engine oil.

2. Install a new snap ring (26), bearing washer (25), bearing (24) and snap ring (23) in the turbine end of the center housing (27).

3. Install a new snap ring (22), bearing washer (21) and bearing in the compressor end of the center housing.

NOTE: Install the current inboard thrust bearing (three oil grooves) with the smooth side against the center housing.

4. Install a new piston ring(s) (17) on the thrust spacer (16) and gently insert the spacer into the backplate assembly (14). With the T18A40 turbocharger, make sure the *current* small diameter thrust spacer (.672″-.673″) is used with the current thrust collar (Fig. 12). The former spacer was .677″-.678″ in diameter. The current thrust spacer (16) has two grooves. When replacing the former one groove spacer with the two groove spacer, be sure and include two piston rings.

NOTE: Do not force the piston rings into place.

5. Make sure the compressor bearing is in place, then position the new inboard thrust washer (19) flat against the center housing with the hole and cutout in the thrust washer in alignment with the pins in the center housing.

6. Install the thrust collar (18) snugly against the thrust washer. Lubricate the thrust collar and thrust washer with clean engine oil.

7. Install a new seal ring (15) in the groove at the compressor end of the center housing.

8. Align the oil feed holes in the center housing (27) and the backplate assembly (14) and attach the backplate to the center housing with four bolts (12) and new lockplates (13). Tighten the T18A40 bolts to 90-110 **lb-in** (10-12 Nm) torque or the TV61 and TV71 bolts to 80-100 **lb-in** (9-11 Nm) torque and bend the lockplate tangs up against the side of the bolt heads.

NOTE: If a new backplate with a warning plate is inadvertently installed, *the warning plate must be removed and the three drive screw holes plugged to prevent air leakage.*

9. On TV61 and TV71 turbochargers, install a new piston ring (11) on the turbine wheel shaft assembly.

© 1984 General Motors Corp.

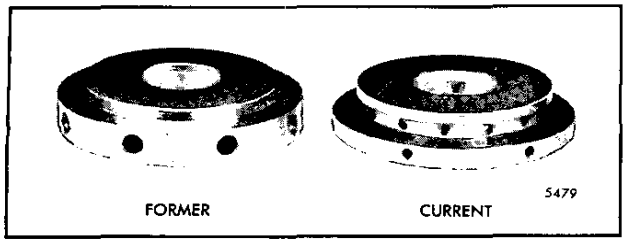


Fig. 12 - Former and Current Thrust Collar (T18A40 Turbocharger)

NOTE: Before installing the piston ring, fill the piston ring groove with Dow Corning High Vacuum Silicone grease, or equivalent.

10. Position the wheel shroud (10) against the center housing (27) and insert the wheel shaft assembly (9) through the wheel shroud and into the center housing.

NOTE: Be careful not to scuff or scratch the bearings when installing the shaft.

11. Place the turbine wheel shaft assembly, shroud, center housing and backplate upright in a suitable holding fixture (Fig. 10).

NOTE: If a holding fixture is not available, clamp a suitable socket or box wrench in a vise and place the extended hub on the shaft in the socket or wrench.

12. With the compressor wheel at room temperature, position it over the shaft.

13. Lightly lubricate the shaft threads and wheel face that will be under the nut with engine oil and install the retaining nut. Tighten the nut to 125-150 **lb-in** (14-17 Nm) torque to seat the compressor wheel against the thrust spacer.

14. Loosen the nut and inspect the nut face and front face of the compressor wheel to be sure they are smooth and clean.

15. Retighten the nut to 35-55 **lb-in** (4-6 Nm) torque.

16. Continue to tighten the retaining nut until the shaft increases in length .007″-.008″ (T18A40) or .009″-.010″ (TV61 and TV71). Tighten the nut in such a manner as not to impose bending loads on the shafts.

NOTE: If equipment is not available to measure the shaft stretch, tighten the wheel retaining nut to 35-55 **lb-in** (4-6 Nm) torque. Then, continue to tighten the nut through an angle of 100-110° turn for the T18A40 or 120-130° turn for the TV61 and TV71 (90° 1/4 turn).

17. Check the bearing axial end play:

a. Clamp the center housing assembly in a bench vise equipped with soft jaws (Fig. 13).

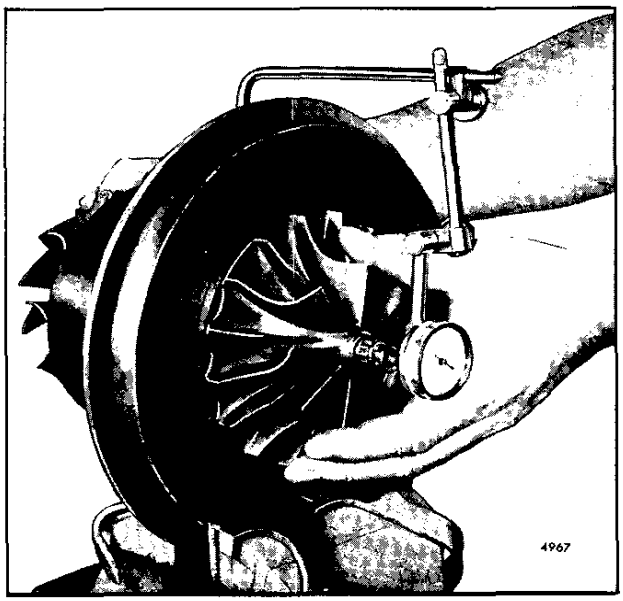


Fig. 13 - Checking Bearing Axial End Play

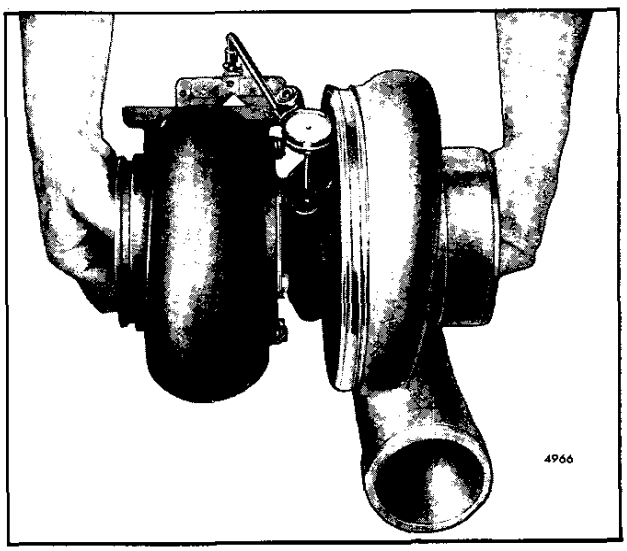


Fig. 14 - Checking Shaft Radial Movement

© 1984 General Motors Corp.

b. Fasten the dial indicator and magnetic base (J 7872-2) to the center housing so that the indicator tip rests on the end of the rotating shaft on the compressor side (Fig. 13).

c. Move the shaft axially back and forth by hand. The total indicator reading (thrust float) should be between .004 " and .009 " (T18A40) or .003 " and .010 " (TV61 and TV71). If the total dial indicator readings do not fall within the specified limits, repair or replace the rotating assembly.

18. Position the turbine housing (6) as marked at disassembly against the center housing (27) and secure it in place.

a. Secure the T18A40 turbine with four clamps (5), four new lockplates (4) and eight bolts (3). Tighten the bolts to 100-130 **lb-in** (11-15 Nm) torque.

b. Secure the TV61 and TV71 turbine housing with the "V" band coupling (28). Tighten the toggle nut as follows:

1. Lubricate the toggle bolt threads with a high temperature anti-seize compound, such as Jet Lube (Mil Spec A-907D), or equivalent.

2. Tighten the nut on the "V" band toggle bolt to approximately 160 **lb-in** (18 Nm) torque.

NOTE: Do not pull a misaligned turbine housing into alignment with the "V" band coupling. The parts must be aligned and seated first.

3. Loosen the "V" band coupling nut to approximately 50 **lb-in** (6 Nm) torque, then retorque the nut to 152-168 **lb-in** (17-19 Nm) torque.

19. Position the compressor housing (2) as marked at disassembly against the backplate (14) and secure it in place with the "V" band coupling (1). Lightly lubricate the threads of the toggle bolt with engine oil and tighten the nut to 110-130 **lb-in** (12-15 Nm) torque.

20. Check the shaft radial movement:

a. Position the magnetic base J 7872-2 with the swivel adaptor J 7872-3 on the flat surface of the turbine housing inlet flange (Fig. 14).

b. Fasten the dial indicator extension rod J 7872-1 to the dial indicator J 8001-3 and attach the dial indicator to the swivel adaptor.

c. Insert the extension rod J 7872-1 into the oil drain tube mounting pad opening so that the rod is against the wheel shaft and is perpendicular to the shaft.

NOTE: Make sure the extension rod does not make contact with the sides of the center housing, otherwise it will be impossible to obtain an accurate reading.

d. Grasp each end of the rotating assembly (Fig. 14) and, applying equal pressure at each end, move the rotating shaft first toward and then away from the dial indicator, creating a transverse movement in the shaft. The dial indicator displacement should be between .003" and .007". If the displacement does not fall within these limits, disassemble and repair or replace the rotating assembly.

21. If it is to be stored, lubricate the unit internally and install protective covers on all openings.

22. Stamp the letter "R" in the lower left-hand corner of the name plate to identify that the turbocharger has been reworked.

Assemble Turbocharger (T04D)

Check each part prior to installation to ensure cleanliness. As the parts are assembled, cover the openings to prevent entry of dirt or other foreign material.

Refer to Fig. 9 for parts orientation and proceed as follows:

1. Lubricate the new bearings with clean engine oil.

2. Install a new snap ring, bearing and snap ring in the turbine end of the center hosuing using snap ring pliers J 28507.

3. Install a new snap ring, bearing and snap ring in the compressor end of the center housing, using snap ring pliers J 28507.

4. Fill the piston ring groove in the turbine wheel shaft assembly with high vacuum silcone grease. Then, install the piston ring on the wheel assembly.

5. Position the wheel shroud on the wheel of the shaft assembly and insert the shaft assembly into the center housing as far as it will go.

NOTE: Be careful not to scuff or scratch the bearings when installing the shaft and do not force the piston ring into the center housing bore.

6. Place the turbine wheel shaft assembly, shroud and center housing upright in a suitable holding fixture (Fig. 10).

© 1984 General Motors Corp.

NOTE: If a holding fixture is not available, clamp a suitable socket or box wrench in a vise and place the extended hub on the shaft in the socket or wrench.

7. Lubricate the thrust collar and thrust bearing with clean engine oil and install the thrust collar on the shaft of the turbine wheel assembly. Then install the thrust bearing in the groove of the collar and slide the assembled parts down against the center housing so that the pins engage the holes in the thrust bearing.

8. Install a new piston ring on the thrust collar.

NOTE: To avoid breakage, do not force the piston ring into place.

9. Install a new seal ring in the groove at the compressor end of the center housing.

10. Install the backplate assembly over the shaft and carefully guide the piston ring on the shaft into the backplate bore, ring gap first.

11. Align the oil feed holes in the center housing and the backplate assembly and attach the backplate to the center housing with bolts and new lockplates. Tighten the bolts to 75-90 **lb-in** (8-10 Nm) torque and bend the lockplate tabs up against the side of the bolt heads.

NOTE: If a new backplate with a warning plate is inadvertently installed, *the warning plate must be removed and the three drive screw holes plugged to prevent air leakage.*

12. With the compressor wheel at room temperature, position it over the shaft.

13. Lightly lubricate the shaft threads and wheel face that will be under the nut with engine oil and install the locknut on the shaft. Tighten the nut to 18-20 **lb-in** (2 Nm) torque above the drag torque required to bottom the locknut.

NOTE: Bottoming of the locknut will be indicated by the sharp increase above the drag torque observed while running the nut down.

14. Retighten the locknut through an angle of 90° . This additional tightening will result in stretching the shaft .0055″ to .0065″ in length.

NOTE: Tighten the retaining nut in such a manner as not to impose a bending load on the shaft.

15. Check the bearing axial end play:

a. Clamp the center housing assembly in a bench vise equipped with soft jaws (Fig. 13).

b. Fasten the dial indicator and magnetic base J 7872-2 to the center housing so that the indicator tip rests on the end of the rotating shaft on the compressor side (Fig. 13).

c. Move the shaft axially back and forth by hand. The total indicator reading should be between .004″ and .009″. If the total dial indicator readings do not fall within the specified limits, repair or replace the rotating assembly.

16. Position the turbine housing as marked at disassembly against the center housing and secure it in place with clamps, new lockplates and bolts. Tighten the bolts to 100-130 **lb-in** (11-15 Nm) torque and bend the tabs of the lockplates up against the bolts.

17. Position the compressor housing as marked at disassembly against the center housing and secure it in place with clamps, new lockplates and bolts. Tighten the bolts to 100-130 **lb-in** (11-15 Nm) torque and bend the tabs of the lockplates up against the bolts.

18. Check the shaft radial movement:

a.-Position the magnetic base J 7872-2 with the swivel adaptor J 7872-3 on the flat surface of the turbine housing inlet flange (Fig. 14).

b. Fasten the dial indicator extension rod J-7872-1 to the dial indicator J 8001-3 and attach the dial indicator to the swivel adaptor.

c. Insert the extension rod J 7872-1 into the oil drain tube mounting pad opening so that the rod is against the wheel shaft and is perpendicular to the shaft.

NOTE: Make sure the extension rod does not make contact with the sides of the center housings, otherwise it will be impossible to obtain an accurate reading.

d. Grasp each end of the rotating assembly (Fig. 14) and, applying equal pressure at each end, move the rotating shaft first toward and then away from the dial indicator, creating a transverse movement in the shaft. The dial indicator displacement should be between .003″ and .007″. If the displacement does not fall within these limits, disassemble and repair or replace the rotating assembly.

19. If it is to be stored, lubricate the unit internally and install protective covers on all openings.

20. Stamp the letter "R" in the lower left-hand corner

© 1984 General Motors Corp.

of the name plate to identify that the turbocharger has been reworked.

Install Turbocharger

1. Attach a chain hoist and a suitable lifting sling to the turbocharger assembly.

2. Remove the covers from the air inlet and exhaust outlet openings on the engine that were placed over the openings when the turbocharger was removed. Install inlet shield J 26554-A in place (Fig. 4).

3. Place the turbocharger assembly into position on the mounting bracket. Use a new gasket between the exhaust manifold adaptor and the turbine housing flange.

NOTE: When attaching the exhaust flange or adaptor to the turbine housing, be sure the inner diameter of the flange or adaptor is the same as the turbine inner diameter. The turbine opening in a T04B turbocharger is 2.581" and the TV61 is 3.100.

4. Secure the turbocharger to the mounting bracket with bolts, lock washers and nuts. Tighten the nuts just enough to hold the turbocharger tight against the bracket.

NOTE: When self-locking nuts are used to secure the turbocharger to the mounting bracket, be sure there is full thread engagement (at least one full thread above the nut) of the self-locking nuts on the bolts.

5. Slide the blower air inlet tube hose over the compressor housing outlet opening and secure it in place with the hose clamps.

6. Tighten the turbocharger to exhaust manifold adaptor bolts securely. Then remove the chain hoist and lifting sling from the turbocharger.

7. Install the oil drain line between the opening in the bottom side of the center housing and the cylinder block.

8. Attach the oil inlet line to the cylinder block.

9. After installing a rebuilt or new turbocharger, it is very important that all moving parts of the turbocharger center housing be lubricated as follows:

a. Clean the area and disconnect the oil inlet (supply) line at the bearing (center) housing (Fig. 5).

b. Fill the bearing housing cavity with clean engine oil. Turn the rotating assembly by hand to coat all of the internal surfaces with oil.

c. Add additional clean engine oil to completely fill the bearing housing cavity and reinstall the oil line. Clean off any spilled oil.

d. Start and run the engine at idle until oil pressure and supply has reached all of the turbocharger moving parts. A good indicator that all of the moving parts are getting lubrication is when the oil pressure gage registers pressure (10 psig or 69 kPa at idle speed).

CAUTION: Do not hold the compressor wheel, for any reason, while the engine is running. This could result in personal injury.

The free floating bearings in the turbocharger center housing require positive lubrication. This is provided by the above procedure *before the turbocharger reaches its maximum operating speed* which is produced by high engine speeds. Starting any turbocharged engine and accelerating to any speed above idle before engine oil supply and pressure has reached the free floating bearings can cause severe damage to the shaft and bearings of the turbocharger.

10. Check all ducts and gaskets for leaks.

11. Operate the engine at rated output and listen for sounds of metallic contact from the turbocharger. If any such noise is apparent, stop the engine immediately and correct the cause.

NOTE: After the turbocharger has been operating long enough to permit the unit and the oil to warm up, the rotating assembly should coast freely to a stop after the engine is stopped. If the rotating assembly jerks to a sudden stop, the cause should be immediately determined and eliminated.

12. Remove inlet shield J 26554-A from turbocharger.

© 1982 General Motors Corp.

T18, T18A, TH08A TURBOCHARGERS

Remove Turbocharger

1. Disconnect the exhaust manifold adaptor attached to the turbine housing.

2. Disconnect the air inlet tube attached to the compressor housing.

3. Remove the oil inlet line from the top of the center housing.

4. Remove the oil outlet line from the bottom of the center housing.

5. Attach a chain hoist and a suitable lifting sling to the turbocharger assembly.

6. Remove the nuts and lock washers securing the turbocharger assembly to the mounting bracket. Then lift the turbocharger assembly away from the engine and place it on a bench.

7. Cover the end of each oil inlet and oil outlet line and the air inlet and exhaust outlet openings on the engine to prevent the entry of foreign material.

Disassemble Turbocharger

Refer to Figs. 15 and 23 for the location of the various parts and disassemble the turbocharger assembly as follows:

1. Thoroughly clean the exterior of the turbocharger with a noncaustic cleaning solvent.

2. Matchmark the compressor housing, center housing and the turbine housing with a punch or chisel (Fig. 16) so they may be installed in the same relative position.

3. Remove the twelve bolts, lock washers and clamps securing the T18 turbocharger compressor housing to the center housing. Then remove the compressor

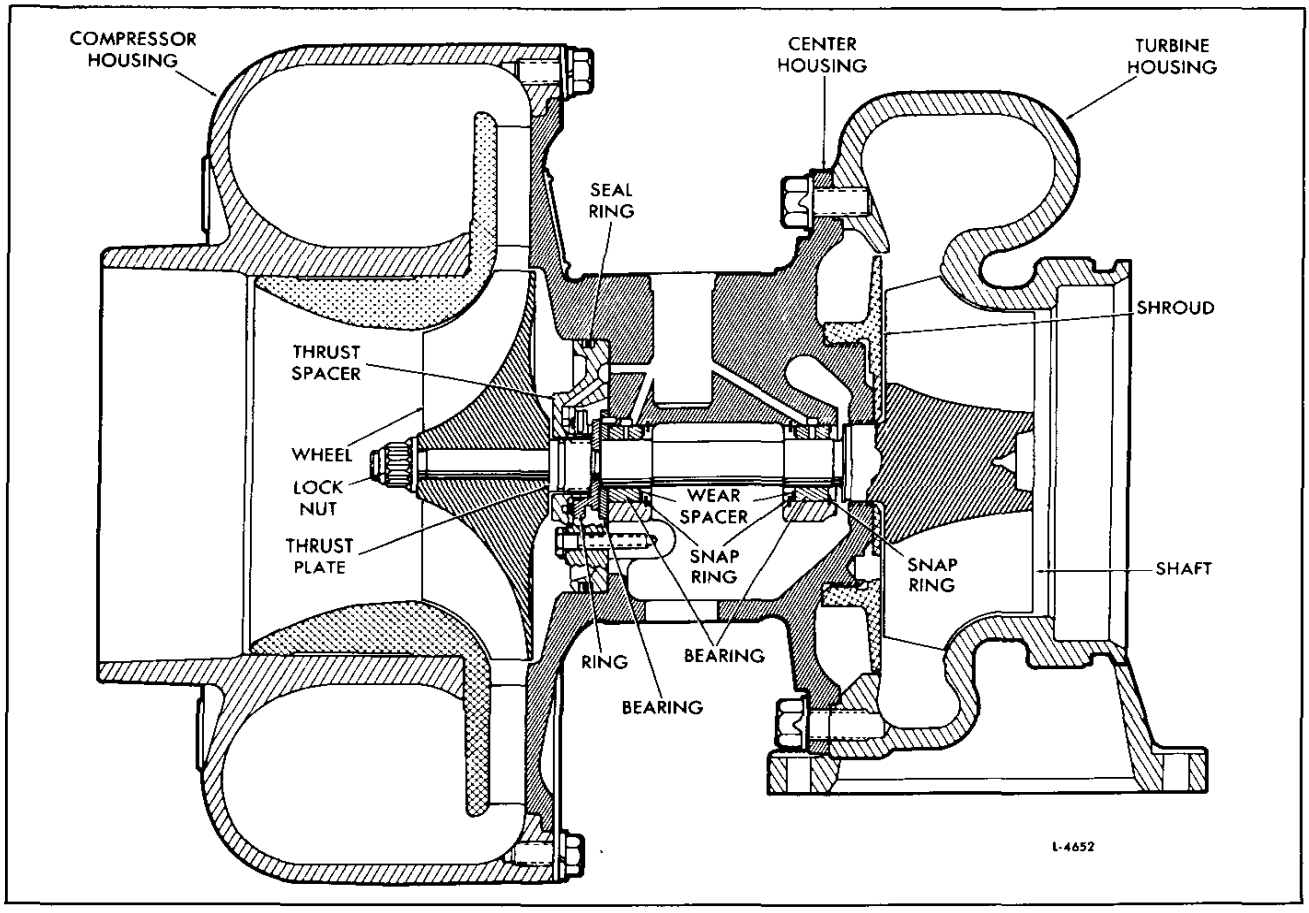


Fig. 15 - T18 Turbocharger Assembly

© 1982 General Motors Corp.

housing from the center housing. On the T18A or TH08A turbochargers, loosen the "V" band coupling securing the compressor housing to the backplate assembly and remove the compressor housing and "V" band. If necessary, tap the the compressor housing with a plastic hammer to loosen it.

4. Bend the ends of the turbine housing attaching bolt lockplates down. Then remove the six bolts (T18) or eight bolts (T18A or TH08A) securing the turbine housing to the center housing. If necessary, tap the turbine housing with a plastic hammer to loosen it.

5. Remove the compressor wheel from the shaft as follows:

NOTE: The hexagon countersunk hole in the end of the turbine wheel must be scraped clean before installing it in the holding fixture.

a. Clamp the turbine wheel holding fixture J 29086 in a bench vise. Then, place the center housing and rotating assembly in the holding fixture, turbine wheel down (Fig. 17), with the hexagon countersunk hole in the turbine wheel over the protruding hexagon head in the holding fixture. If required, use a suitable holding fixture (Fig. 26).

b. To prevent the possibility of bending the shaft, remove the lock nut from the shaft with a double universal socket and a tee handle (Fig. 17).

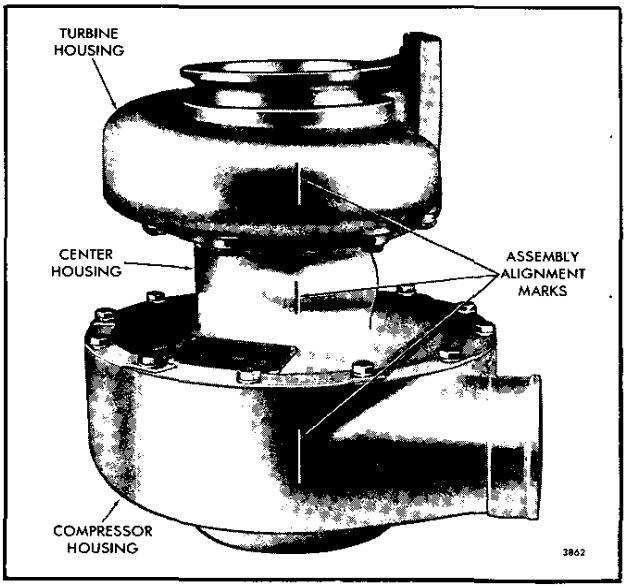


Fig. 16 - Assembly Alignment Marks on Housings

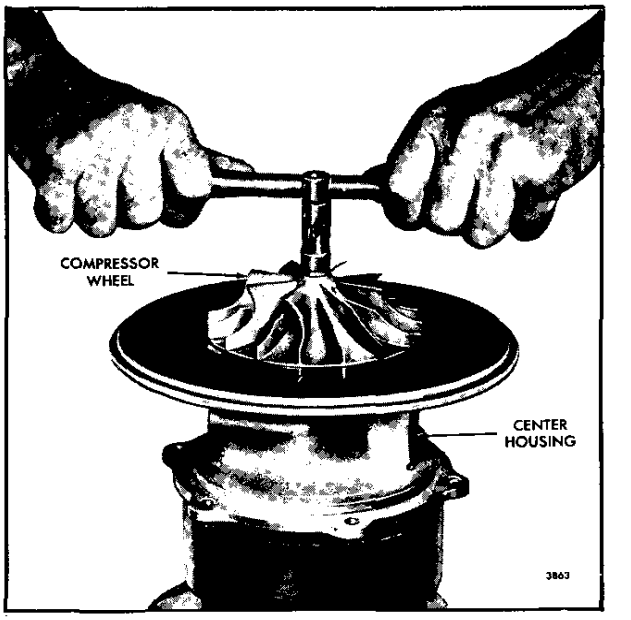


Fig. 17 - Removing Compressor Wheel Locknut

c. Place the center housing and rotating assembly in an oven, furnace or hot oil that has been preheated to 350-375 °F (177-190 °C) for no longer than ten minutes. If a hot oil bath is used, immerse only the compressor wheel in the oil.

NOTE: Be careful not to damage the wheel blades when placing the assembly in the oven

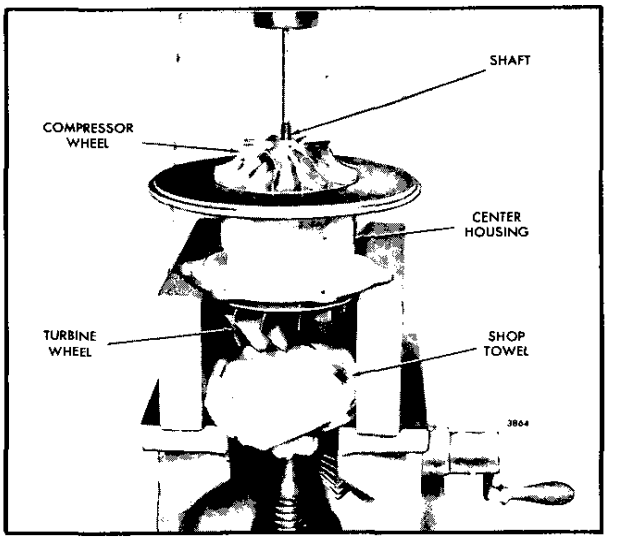


Fig. 18 - Removing Shaft from Compressor Wheel using Tool J 9496

© 1984 General Motors Corp.

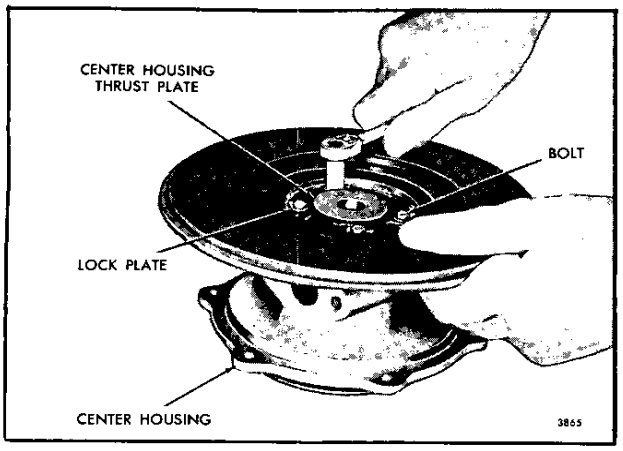


Fig. 19 - Removing Center Housing Thrust Plate Bolts

or furnace. Do not heat the compressor wheel above 375 °F (190 °C).

d. After heating the compressor wheel, remove the center housing and rotating assembly and support it on the bed of an arbor press with the compressor wheel end up (Fig. 18).

CAUTION: To avoid being burned, use a pair of heat resisting or asbestos gloves when handling the center housing and rotating assembly.

e. Place a clean shop towel on the bed of the press and under the turbine wheel to protect the blades. Then place the tapered end of the removing tool J 9496 in the center of the shaft and the opposite end under the ram of the press (Fig. 18). Press the shaft out of the compressor wheel.

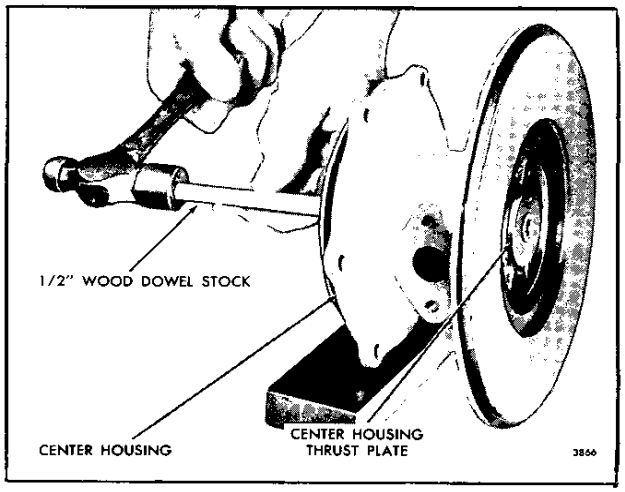


Fig. 20 - Removing Center Housing Thrust Plate

f. Remove the compressor wheel from the top of the center housing, then remove the center housing and shaft from the arbor press and place them on a bench. Pull the shaft assembly straight out of the center housing to prevent the threads on the end of the shaft from damaging the shaft bearings.

6. With the TH08A turbocharger, remove and discard the turbine piston ring from the wheel shaft.

7. Place the center housing, compressor housing end up, on the bench (Fig. 19).

8. Bend the end of the center housing thrust (back) plate attaching bolt lockplates down, then remove the four bolts and lockplates securing the backplate or thrust plate to the center housing.

9. Support the center housing on edge on the work bench (Fig. 20). Then insert a 1/2 " wood dowel approximately 8 " long through the shaft bearings and against the backplate or thrust plate. Tap the thrust plate or backplate out of the center housing with a hammer.

10. Remove the thrust spacer and seal ring from the backplate or thrust plate, then remove the seal ring from the outside diameter of the backplate or thrust plate.

11. Remove the thrust ring and the backplate or thrust plate bearing from the center housing.

12. Remove the shaft bearing from the compressor wheel end of the center housing by lifting it straight up out of the housing with one finger inserted in the bearing.

13. Remove the shaft bearing from the turbine end of the center housing as follows:

a. Place the center housing, turbine housing end up, on the bench (Fig. 21).

b. Remove the shaft bearing retaining ring from the center housing with a pair of snap ring pliers.

c. Lift the bearing straight up out of the housing.

d. If necessary, remove the two spacers (on current turbochargers) and the two remaining snap rings inside the center housing.

14. If there is an oil reservoir plug in the center housing, remove it in the following manner and discard it, as the plug is no longer required. The plug

© 1984 General Motors Corp.

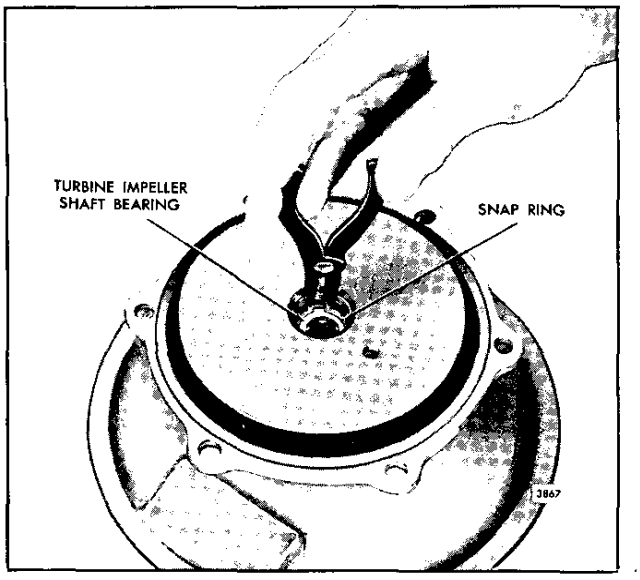


Fig. 21 - Removing Shaft Bearing Retaining Ring

should also be removed for thorough cleaning of the center housing.

a. Thread the inside diameter of the oil reservoir plug with a 1/2 "-13 tap approximately 1/2 " deep.

b. Attach a slide hammer and a 1/2 "-13 adaptor to the oil reservoir plug. Then pull the plug from the center housing by striking the sliding hammer against the end of its shaft.

15. The turbine wheel shroud which is attached to the turbine end of the center housing does not need to be removed. The plate is not readily removable after it has been subjected to prolonged exhaust heat.

Cleaning

Before cleaning, inspect the parts for signs of burning, rubbing or other damage which might not be evident after cleaning.

Soak all parts in a noncaustic cleaning solvent for about 25 minutes. Use a stiff bristle brush and remove all dirt particles. Dry all of the parts thoroughly.

CAUTION: Never use a caustic cleaning solution for cleaning as this will damage certain parts. Use the cleaning solution in an open or well ventilated area. Avoid breathing the fumes. Keep away from open flames. Do not use a wire brush or a steel blade scraper to clean the parts.

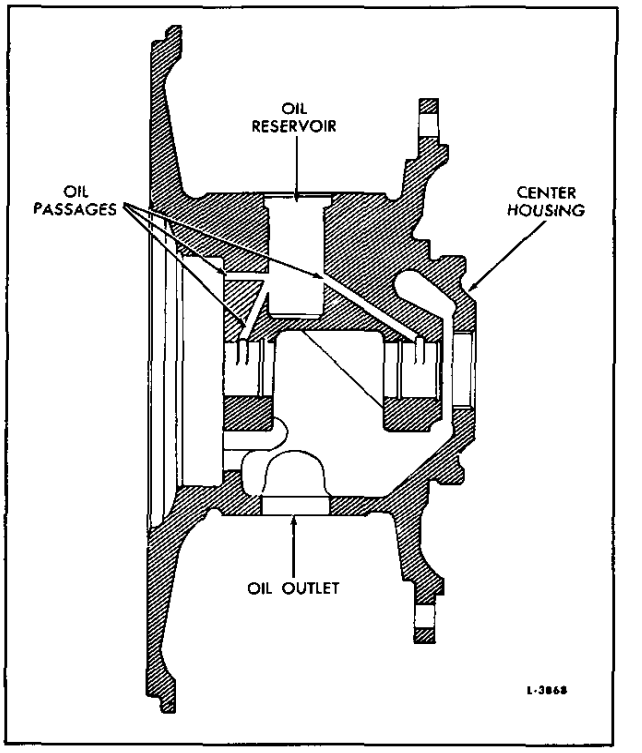


Fig. 22 - Location of Oil Passages in Center Housing

Make sure that both wheel blades are thoroughly clean. Deposits left on the blades will affect the balance of the rotating assembly.

Clean all of the internal cavities and oil passages in the center housing thoroughly with dry compressed air. Make sure all of the metal chips, from the tapping operation, are removed from the oil reservoir and oil passages in the center housing.

Clean the oil passage in the center housing backplate or thrust plate with dry compressed air.

Remove the oil inlet and outlet lines from the engine and thoroughly clean the oil lines inside and out. An oil line that is dented or crimped enough to restrict the flow of oil must be replaced.

Inspection

Inspect the turbocharger parts for signs of damage, corrosion or deterioration. If necessary, replace with new parts.

Examine the turbine wheel for signs of rubbing or wear. For shaft bearing journal dimensions and wear limits, refer to Section 3.0.

© 1979 General Motors Corp.

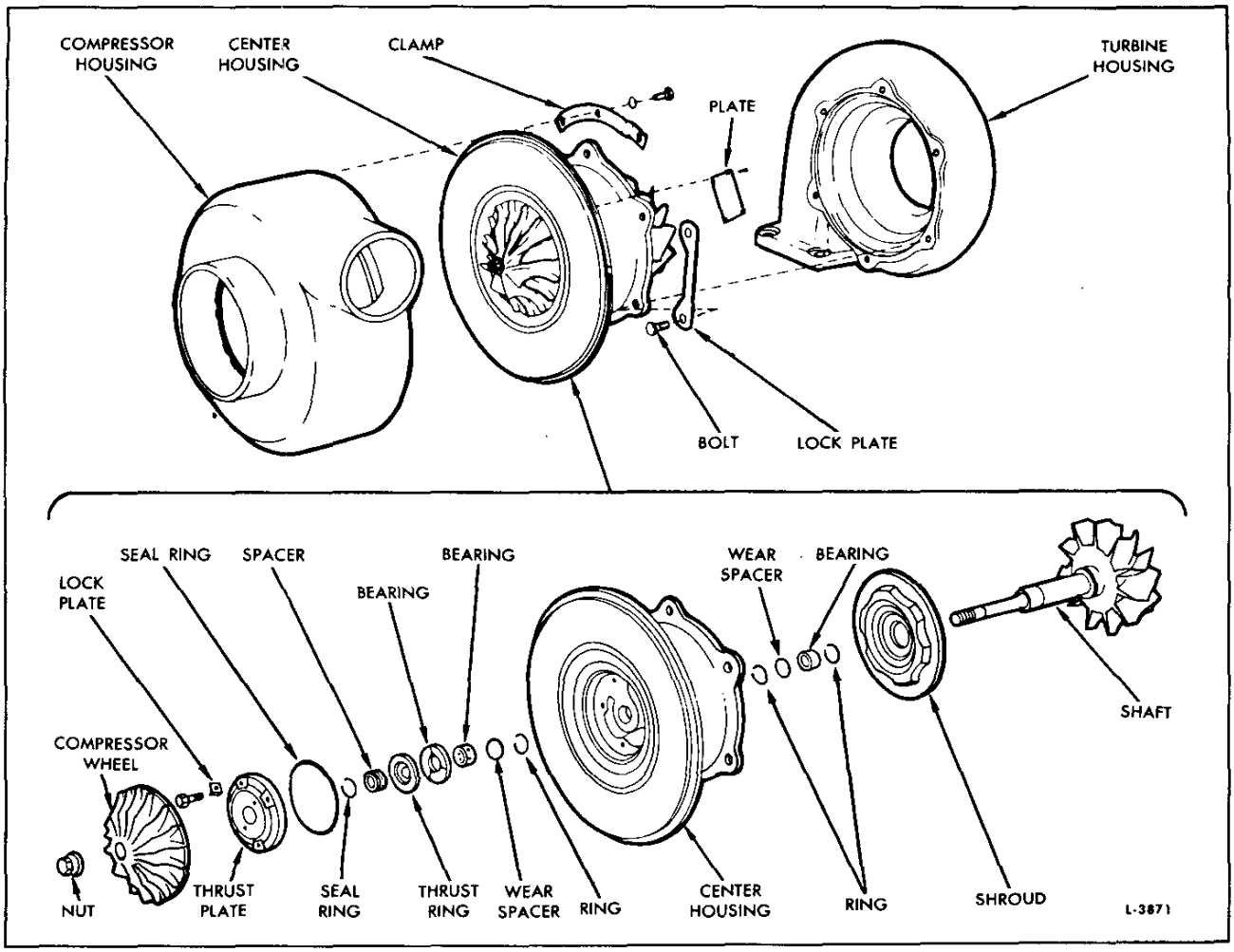


Fig. 23 - T18 Turbocharger Details and Relative Location of Parts

Examine the compressor wheel for signs of rubbing and bent blades. The wheel must be free of dirt and foreign material.

Check the compressor and turbine housings for signs of wheel contact.

Examine the thrust ring, shaft bearings and wear spacers, thrust spacer, seal ring and thrust plate bearing for signs of rubbing, scoring or wear. For shaft bearing dimensions and wear limits, refer to Section 3.0.

Assemble Turbocharger

NOTE: If foreign particles fall into the turbocharger during the assembly procedure, remove the particles immediately, even though extensive disassembly is required.

Refer to Figs. 15 and 23 for the location of the various parts and assemble the turbocharger as follows:

1. Install the shaft bearings in the center housing as follows:

   a. Place the center housing on the bench with the turbine end of the housing facing up.

   b. If removed, reinstall the inner shaft bearing retaining ring in the lower ring groove in the turbine wheel end bearing bore.

© 1979 General Motors Corp.

c. On current turbochargers, reinstall the wear spacer.

d. Lubricate the outside diameter of a shaft bearing with engine oil, then place the bearing straight into the bearing bore in the center housing as shown in Fig. 24 and push it down against the wear spacer. On former turbochargers, push it down against the bearing inner retaining ring.

e. Install the outer shaft bearing retaining ring in the ring groove in the center housing bearing bore.

f. Turn the center housing over on the bench so the compressor end of the housing is facing up.

g. If removed, reinstall the shaft bearing retaining ring in the ring groove in the compressor end of the center housing bearing bore.

h. On current turbochargers, reinstall the wear spacer.

2. Clamp the shaft holding fixture J 29086 in a bench vise. Place the shaft assembly in the holding fixture with the hexagon countersunk hole in the turbine wheel over the protruding hexagon head in the holding fixture as shown in Fig. 25. If required, use a suitable holding fixture (Fig. 26).

3. With the TH08A turbocharger, install a new piston ring on the turbine wheel shaft.

4. Lubricate the shaft bearing journals with engine oil, then place the center housing over the shaft with the turbine end of the housing facing down. Carefully lower the center housing straight down over the shaft until it seats on the hub of the turbine wheel (Fig. 27).

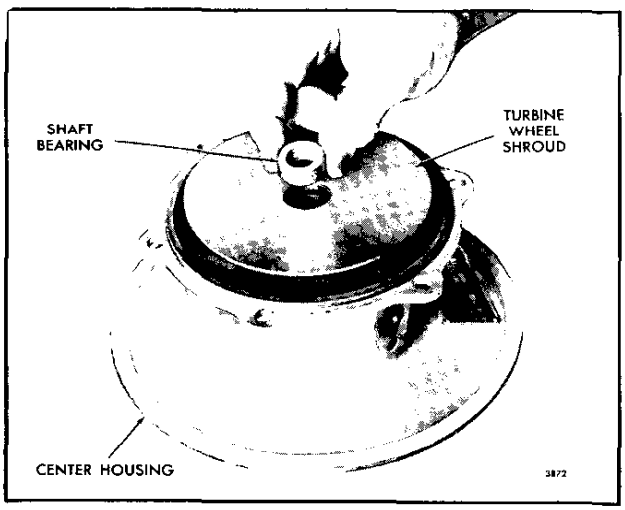


Fig. 24 - Installing Shaft Bearing in Center Housing (Turbine End)

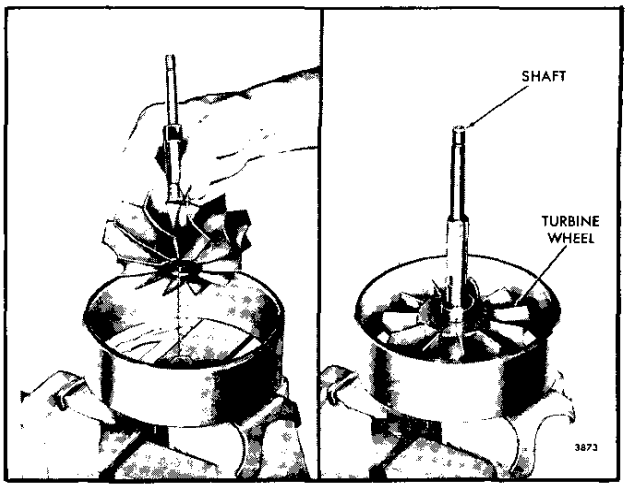


Fig. 25 - Installing Shaft Assembly in Holding Fixture (J 29086)

5. Lubricate the outside diameter of the second shaft bearing with engine oil, then place the bearing over the shaft and start it straight into the bearing bore as shown in Fig. 28. Push the bearing down in the bearing bore against the wear spacer. On former turbochargers, push the bearing down against the retaining ring.

6. Lubricate the backplate or thrust plate bearing with engine oil, then place it on the shaft with the three oil grooves in the face of the bearing facing up (Fig. 29). Align the hole and slot in the bearing with the dowel pins in the center housing, then place the bearing over the dowel pins and against the housing.

NOTE: Make sure the backplate or thrust plate bearing is seated flat against the face of the center housing.

7. Place the thrust collar over the end of the shaft, recess side facing up (Fig. 30), and against the backplate or thrust plate bearing.

8. Install a new seal ring in the groove in the thrust spacer.

9. Place the center housing backplate or thrust plate, less the thrust spacer and the rubber seal ring, over the shaft, with the bolt holes and the oil hole in the under side of the backplate or thrust plate in alignment with the oil and bolt holes in the center housing (Fig. 32).

10. Remove the backplate or thrust plate from the center housing. Then install the thrust spacer and seal

© 1982 General Motors Corp.

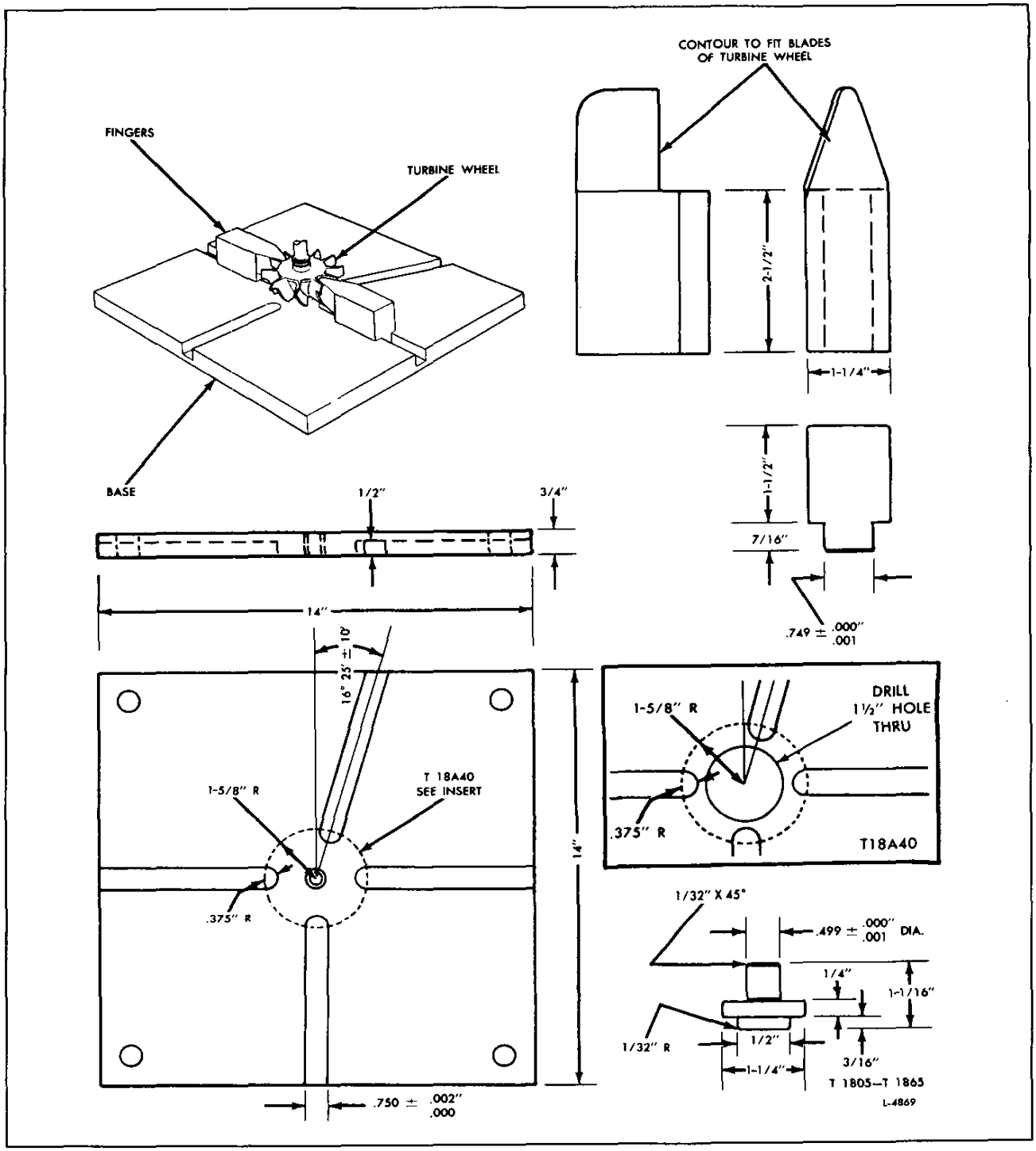


Fig. 26 - Turbocharger Holding Fixture

© 1982 General Motors Corp.

ring assembly in the backplate or thrust plate (Fig. 31).

11. Lubricate a new backplate or thrust plate seal ring (rubber) with engine oil, then place the seal ring in the seal ring groove in the outside diameter of the backplate or thrust plate.

12. Position the backplate or thrust plate, with the thrust spacer and seal ring, over the end of the shaft with the oil holes and bolt holes in the backplate or thrust plate and center housing in alignment (Fig. 32). Then, place the backplate or thrust plate on the shaft and lower it straight down against the center housing, being careful not to let the thrust spacer move up out of the backplate or thrust plate.

13. To align the backplate or thrust plate, insert two of the backplate or thrust plate attaching bolts into the bolt holes in the backplate or thrust plate and thread them into the center housing.

14. Carefully, push the backplate or thrust plate in the center housing until it contacts the thrust ring. Be sure the thrust spacer stays in the backplate or thrust plate.

NOTE: If the thrust spacer moves out of the backplate or thrust plate unseating the seal ring, repeat Steps 10 through 14 above.

15. Place a new lockplate on each backplate or thrust plate bolt and thread the bolts into the center housing. Tighten the 10-24 bolts to 30-40 **lb-in** (3-5 Nm) torque (T18 turbocharger) or to 90-110 **lb-in** (10-12 Nm) torque on the 5/16″-18 bolts on the T18A or TH08A turbocharger (Fig. 33). Then, bend one corner of each lockplate up against the flat side of each bolt head.

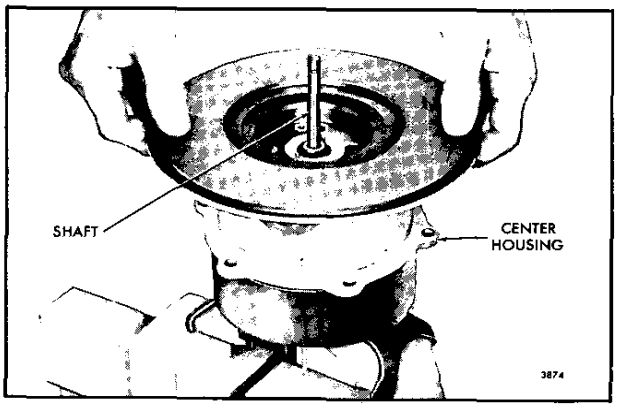


Fig. 27 - Installing Center Housing on Shaft using Tool J 29086

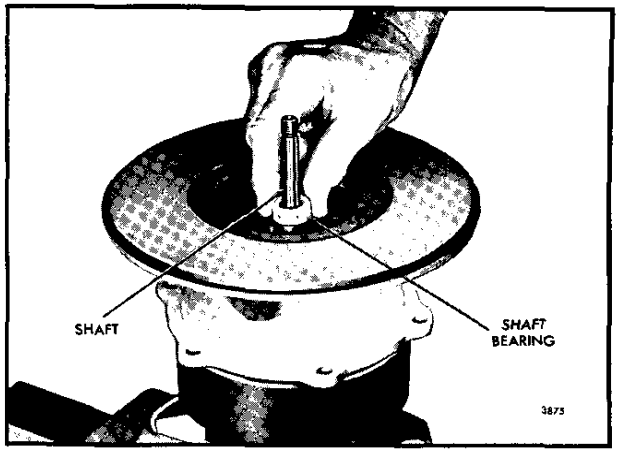


Fig. 28 - Installing Shaft Bearing in Center Housing (Compressor End)

16. Install the compressor wheel on the shaft as follows:

a. Place the compressor wheel in an oven, furnace or in hot oil that has been preheated to 350-375° F (177-190° C) for not longer than ten minutes.

CAUTION: To avoid being burned, use a pair of heat resisting or asbestos gloves when handling the compressor wheel.

b. After heating the compressor wheel, remove the wheel and start it straight on the shaft (Fig. 34). Push the wheel down against the thrust spacer.

NOTE: Place the compressor wheel on the shaft as soon as possible after removing it from the oven, furnace or hot oil.

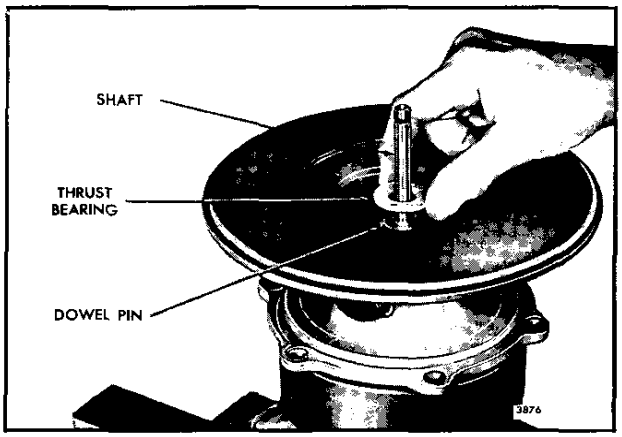


Fig. 29 - Installing Thrust Bearing in Center Housing

© 1984 General Motors Corp.

c. While the compressor wheel is still hot, install the locknut and tighten it to 110-130 **lb-in** (12-14 Nm) torque.

NOTE: To prevent the possibility of bending the shaft, use a double universal socket with the torque wrench.

d. After the compressor wheel has been allowed to cool to less than 150° F (66° C), remove the locknut from the shaft.

e. Inspect the flat surface of the locknut and the top face of the wheel hub for being smooth and clean.

f. Lubricate the threads and the flat surface of the wheel locknut lightly with engine oil, then install the locknut on the shaft and tighten it to 18-20 **lb-in** (2 Nm) torque. After tightening the locknut, turn it an additional 1/4 turn or 90° (T18 or T18A). Tighten the locknut through an angle of 120° on the TH08A turbocharger.

g. Place wrench J 21223-02 on the locknut and attach a sliding tee handle to the wrench (Fig. 35).

h. Place a magnetic base dial indicator on the center housing and position the stem of the indicator on the end of the shaft (Fig. 35).

i. Set the hand of the dial indicator at zero. Then, tighten the locknut until the shaft length increases .006″ to .007″ (T18 or T18A). The current shaft requires 285 **lb-in** (32 Nm) torque to increase or stretch the shaft length .006″ to .007″. The former "necked down" shaft requires only 260 **lb-in** (29 Nm) torque. Tighten the locknut until the shaft length increases .005″ to .006″ on the TH08A turbocharger.

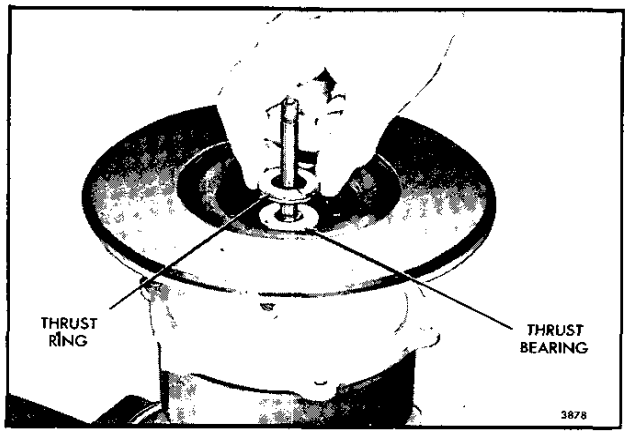


Fig. 30 - Installing Thrust Ring in Center Housing

NOTE: Do not use a box wrench or any other type wrench to tighten the locknut as the excessive side strain may bend the shaft. Use a sliding tee handle with wrench J 21223-02 and apply an even pressure on each end of the tee handle. This will eliminate the possibility of bending the shaft while tightening the locknut.

17. Check the shaft end play as follows:

a. Clamp the turbine housing and center housing and rotating assembly in a bench vise equipped with soft jaws (Fig. 36).

b. Attach a clamp or a magnetic base indicator on the center housing and position the stem of the dial indicator on the end of the shaft.

c. Push up on the rotating assembly by hand and note the indicator reading.

d. Push down on the rotating assembly by hand and note the indicator reading.

e. The end play is the difference between the two readings. The specified shaft end play is .004″ to .009″.

18. Check the shaft radial movement (bearing clearance) as follows:

a. Clamp the flange of the center housing in a bench vise equipped with soft jaws (Fig. 37), with the oil outlet opening in the center housing facing up.

b. Place the dial indicator adaptor J 21224 over the oil outlet opening in the center housing with the large flat end of the plunger against the center of the shaft and secure the tool in place with two 3/8″-16 bolts of suitable length.

c. Attach a clamp or a magnetic base type indicator to the dial indicator adaptor and position the stem of the dial indicator on the end of the plunger.

NOTE: For a true reading, the dial indicator stem must be on the same center line as the plunger of the dial indicator adaptor.

d. Raise the rotating assembly up by hand (Fig. 37) and note the indicator reading. Then, push the rotating assembly down by hand and note the indicator reading.

NOTE: Raise and lower both ends of the rotating assembly evenly when checking the radial movement.

© 1984 General Motors Corp.

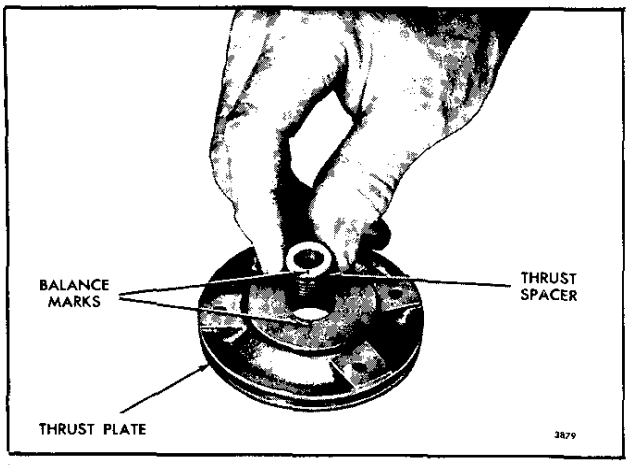


Fig. 31 - Installing Thrust Spacer in Center Housing Thrust Plate

e. The difference between the two readings is the total clearance between the shaft and the bearings. The specified clearance between the shaft and the bearings is .003" to .007". Repeat Steps d and e several times to be sure the readings are accurate.

NOTE: The shaft radial movement (bearing clearance) may be checked with the turbocharger assembly attached to the engine by mounting the dial indicator adaptor J 21224 and the dial indicator as shown in Fig. 38.

19. Place the compressor housing over the compressor wheel and against the center housing, with the marks previously placed on the housings in alignment.

20. Install the twelve bolts, lock washers and clamps that secure the T18 compressor housing to the center housing. Tighten the bolts to 100-110 **lb-in** (11-12 Nm) torque. On the T18A or TH08A turbochargers, position the compressor housing against the center housing and secure it in place with the "V" band coupling. Tighten the nut on the "V" band to 40-60 **lb-in** (5-7 Nm) torque.

21. Place the turbine housing over the turbine wheel and against the center housing, with the marks previously placed on the housings in alignment.

22. Lubricate the threads of the turbine housing retaining bolts with a high temperature anti-seize lubricant. Then install the three lockplates and six bolts securing the turbine housing to the center housing. Tighten the bolts to 100-110 **lb-in** (11-12 Nm) torque. Bend both ends of each lockplate up against the flat side of the bolt head.

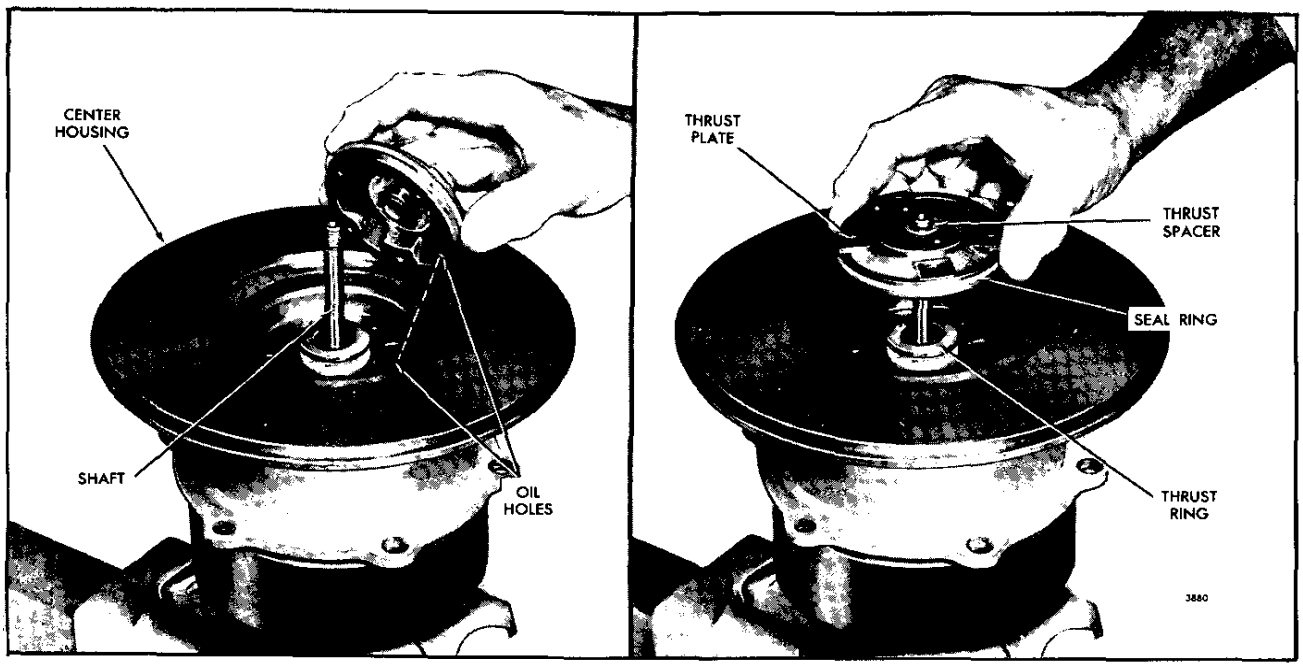


Fig. 32 - Installing Thrust Plate in Center Housing

© 1982 General Motors Corp.

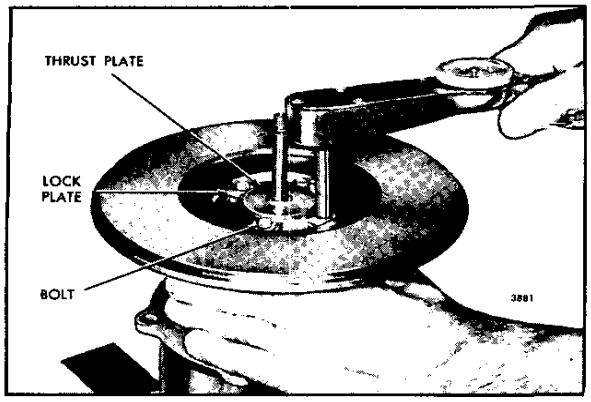


Fig. 33 - Tightening Thrust Plate Retaining Bolts

23. With the turbocharger assembled, spin the rotating assembly by hand. The rotating assembly must turn freely without any indications of dragging or binding.

24. Cover all of the openings in the turbocharger to prevent any foreign material from entering.

Install Turbocharger

1. Attach a chain hoist and a suitable lifting sling to the turbocharger assembly.

2. Remove the covers from the air inlet and exhaust outlet openings on the engine that were placed over the openings when the turbocharger was removed. Install inlet shield J 26554-A.

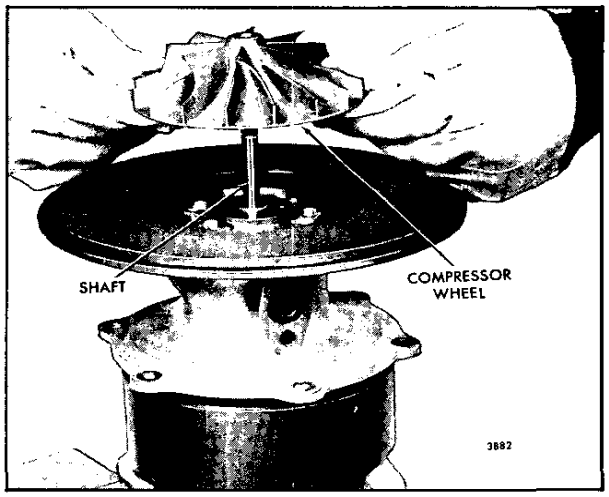


Fig. 34 - Installing Compressor Wheel on Shaft

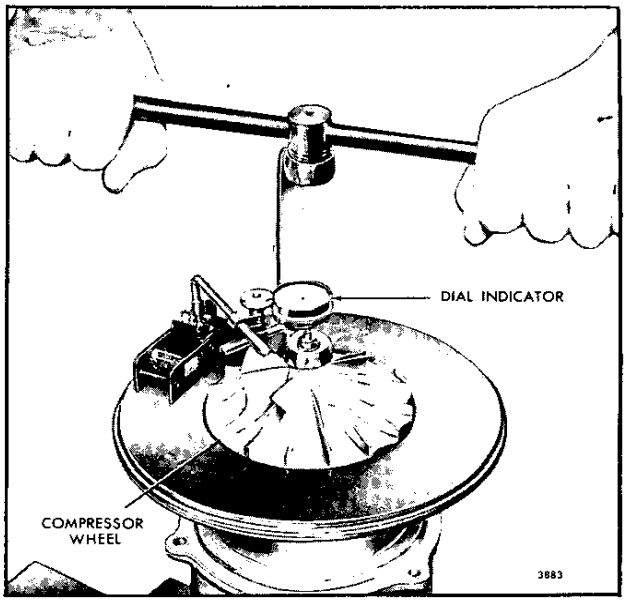


Fig. 35 - Tightening Compressor Wheel Lock Nut

3. Place the turbocharger assembly into position on the mounting bracket.

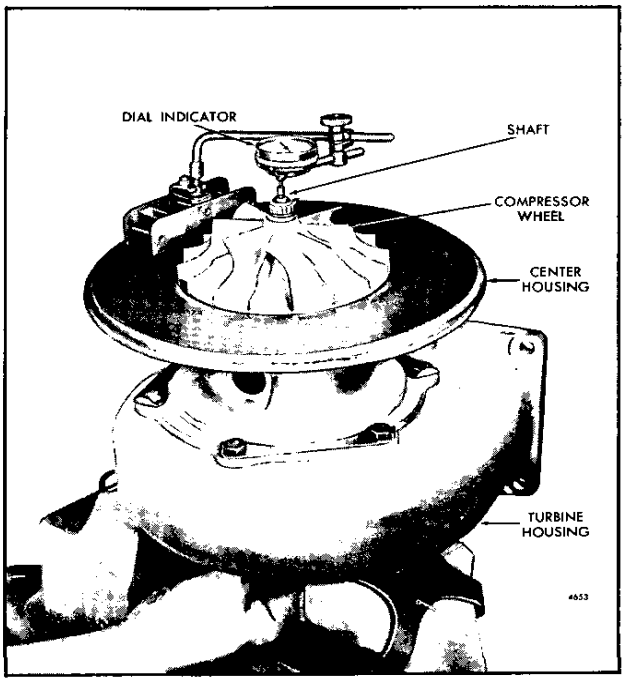


Fig. 36 - Checking Shaft End Play

© 1982 General Motors Corp.

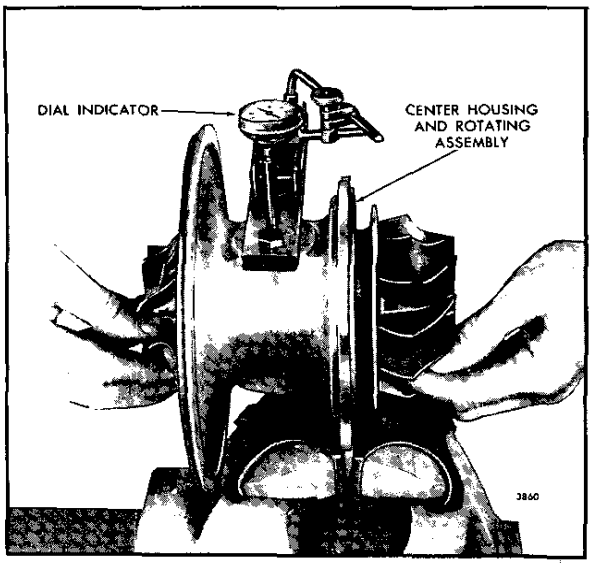


Fig. 37 - Checking Shaft Radial Movement

4. Secure the turbocharger to the mounting bracket with bolts, lock washers and nuts. Tighten the nuts just enough to hold the turbocharger tight against the bracket.

5. Slide the blower air inlet tube hose over the compressor housing outlet opening and secure it in place with the hose clamps.

6. Tighten the turbocharger to exhaust manifold adaptor bolts securely. Then remove the chain hoist and lifting sling from the turbocharger.

7. Install the oil drain line between the opening in the bottom side of the center housing and the cylinder block.

8. Attach the oil inlet line to the cylinder block.

9. After installing a rebuilt or new turbocharger, it is very important that all of the moving parts of the turbocharger center housing be lubricated as follows:

a. Clean the area and disconnect the oil inlet (supply) line at the bearing (center) housing (Fig. 5).

b. Fill the bearing housing cavity with clean engine oil. Turn the rotating assembly by hand to coat all of the internal surfaces with oil.

c. Add additional clean engine oil to completely fill the bearing housing cavity and reinstall the oil line. Clean off any spilled oil.

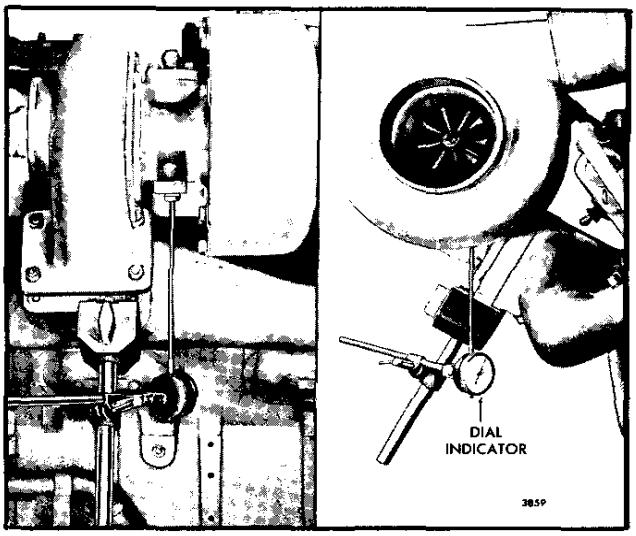


Fig. 38 - Indicator Mounting for Checking Shaft Radial Movement

d. Start and run the engine at idle until oil pressure and supply has reached all of the turbocharger moving parts. A good indicator that all moving parts are getting lubrication is when the oil pressure gage registers pressure (10 psig or 69 kPa at idle speed).

CAUTION: Do not hold the compressor wheel, for any reason, while the engine is running. This could result in personal injury.

The free floating bearings in the turbocharger center housing require positive lubrication. This is provided by the above procedure *before the turbocharger reaches its maximum operating speed* which is produced by high engine speeds. Starting any turbocharged engine and accelerating to any speed above idle before engine oil supply and pressure has reached the free floating bearings can cause severe damage to the shaft and bearings of the turbocharger.

10. Check all ducts and gaskets for leaks.

11. Operate the engine at rated output and listen for sounds of metallic contact from the turbocharger. If any such noise is apparent, stop the engine immediately and correct the cause.

12. Remove the inlet shield J 26554-A.

NOTE: After the turbocharger has been operating long enough to permit the unit and the oil to warm up, the rotating assembly should coast freely to a stop after the engine is stopped. If the rotating assembly jerks to a sudden stop, the cause should be immediately determined and eliminated.

© 1982 General Motors Corp.

TURBOCHARGER INTERCOOLER

An intercooler (Fig. 1) is placed between the air discharge side of the turbocharger and the air inlet side of the engine blower. The intercooler is used to reduce the temperature of the compressed air leaving the turbocharger before it reaches the blower. This permits a more dense charge of air to be delivered to the engine.

Cooling is accomplished by a raw water pump driven off the rear end of the engine supplying water to the intercooler. The water makes six passes through the core and is discharged from the connection diagonally opposite the inlet. The air from the turbocharger enters the finned side of the intercooler at the face opposite the water inlet and flows counterflow to the direction of water flow through the core.

Remove Intercooler

1. Drain the raw water system.

2. Disconnect the air and water inlet and outlet hose connections at the air shutdown housing, the turbocharger and the intercooler.

3. Remove the air inlet and outlet housings from the intercooler. Discard the gaskets.

4. Remove the intercooler from the support brackets.

NOTE: Be careful not to damage the core fins.

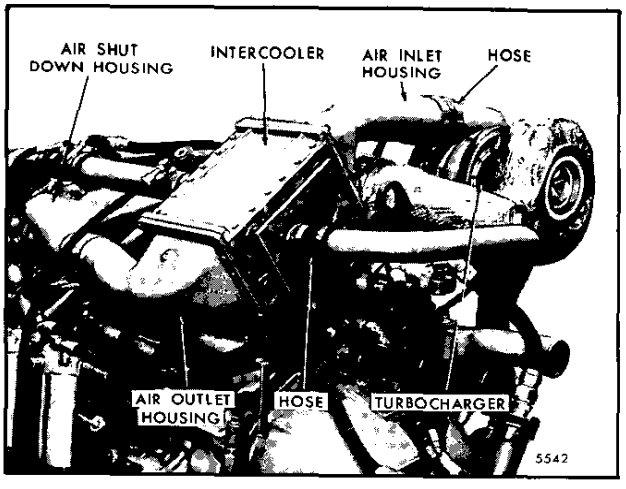


Fig. 1 - Turbocharger Intercooler Mounting

Clean Intercooler

1. Remove only the end covers of the intercoolers.

NOTE: Prior to removing the end covers, matchmark each cover in its original position.

2. Reinstall two bolts at each end of the intercooler in order to hold the side covers in position while cleaning the core side of the cooler.

3. The coolant side of the cooler should be cleaned first. If the coolant side of the cooler does not require cleaning disregard steps 1 and 2 and proceed to step 11 with cleaning the air side of the cooler.

4. After it is determined that the coolant side must be cleaned, block off both the inlet and outlet side of the core to prevent any of the blasting material from entering the air side of the cooler.

5. Glass bead both ends of the cooler and end covers in a suitable glass beading machine.

6. Rod out each tube in the core with either a suitable size brass rod, or using a 22 cal. rifle cleaning rod with wire brush.

7. Remove any blasting material with compressed air.

8. Reassemble the end covers using new gaskets; at this time only hand tighten the end cover bolts.

9. Place the complete assembly on a flat drill press table with slots, in order to allow the excess end cover gasket material to set in and allow the end covers to be square with the top and bottom of the core.

10. Tighten the end cover bolts to the standard bolt torque and trim excess gasket material from the top and bottom of the cooler.

11. Place the complete cooler assembly into a degreasing (mineral spirits) tank in order to remove any soot and greasy oil accumulations from the air side of the cooler. Blow dry with compressed air.

NOTE: Depending on how dirty the air side is, this step may require repeating until the accumulations are removed.

12. Pressure test the coolant side of the cooler to see if any of the tubes leak. Block off the inlet and outlet connections with fabricated plugs and apply regulated air pressure at 20 psi (138 kPa) at one of the drain openings in the end cover. Submerge the cooler in a tank of water and look for leaks.

© 1979 General Motors Corp.

Install Intercooler

1. Attach the intercooler to the support brackets with ten 5/16 " -18 x 1 " bolts and lock washers. Tighten the bolts.

2. Use new gaskets and attach the air inlet housing and air outlet housing to the intercooler with the sixteen 5/16" -18 x 1" and twenty 5/16" -18 x 1 1/4" bolts and lock washers. Tighten the bolts.

3. Connect the air and water inlet and outlet hoses at the shutdown housing, turbocharger and intercooler. Tighten the hose clamps.

4. Fill the raw water system. Start the engine and check for air or water leaks.

© 1979 General Motors Corp.

TURBOCHARGER AFTERCOOLER

The aftercooler is installed in the cylinder block air box at the blower opening (Fig. 1).

The cylinder block is machined at the blower opening and the outer surface of the water jacket to receive the aftercooler. Cup plugs are used at the core holes of the water jacket in place of threaded pipe plugs. A separate opening in the water jacket is provided for the aftercooler water inlet connection. The water outlet tubing is routed through the rear hand hole cover and then attaches to the cylinder head at the rear water manifold openings (Fig. 2).

Remove Aftercooler

1. Disconnect the turbocharger at the air inlet adaptor (refer Section 3.5).

2. Remove the air inlet adaptor from the blower.

3. Remove the blower from the cylinder block and any accessories attached to the blower (refer Section 3.4).

4. Disconnect the water outlet tube and elbow from the rear hand hole cover and unclamp it from the water return hose. Discard the 5/16" - 18 x 3/4" attaching bolts with nylon locking patch. Then remove the hand hole cover.

5. Remove the water outlet tube and adaptor at the aftercooler water outlet connection.

6. Remove and discard the 5/16" - 18 x 9/16" attaching bolts with nylon locking patch and remove the aftercooler from the cylinder block opening.

NOTE: Be careful not to damage the cooler fins when removing the aftercooler from the cylinder block.

7. Remove and discard the seal rings from the grooves in the water inlet and outlet connections of the aftercooler.

Clean Aftercooler

The length of time an aftercooler will function satisfactorily before cleaning will be governed largely by the kind of coolant and coolant additives used in the engine. Check all of the cooler fins and air and water passages for plugging at major overhaul. Clean the fins of dirt or any other foreign obstructions with a small brush. Do not apply more than 40 psi (276 kPa) air pressure to the water side of the cooler.

If an aftercooler core becomes clogged with oil, dirt or carbon during its service life on an engine, the procedure below may be used to clean it:

NOTE: This procedure is not effective on scale

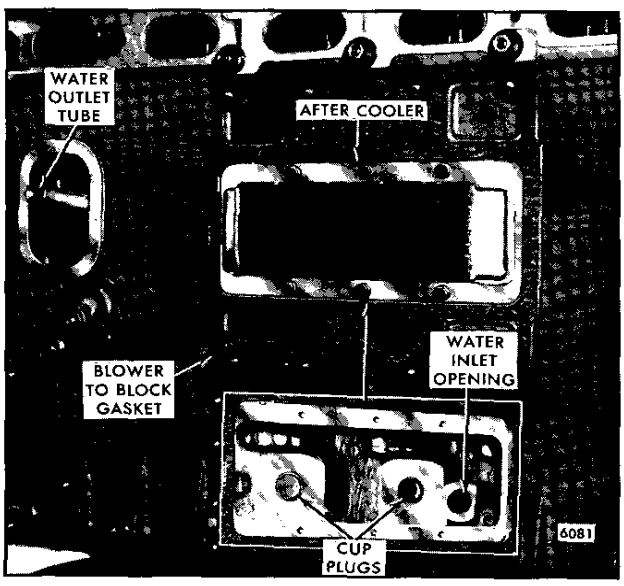


Fig. 1 - Aftercooler Mounting

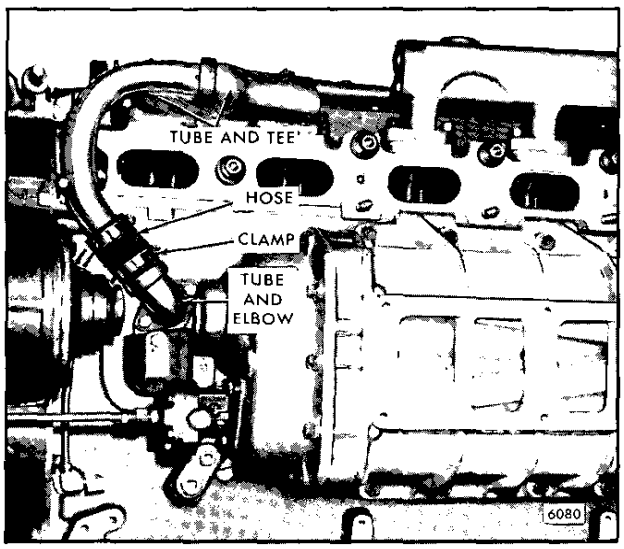


Fig. 2 - Aftercooler Attaching Parts

© 1982 General Motors Corp.

(mineral salts) plugging. If scale plugging has occurred, the air system should be thoroughly inspected and the cause of the scaling determined and eliminated.

1. Steam clean the outside of the core to remove any loose deposits or debris.

CAUTION: Some chemical agents (detergents, solvents, alkalis, etc.) may irritate the skin or be harmful to the eyes. Others must only be used with adequate ventilation. When working with potentially harmful chemical substances, read and heed the warnings on the product labels and follow prescribed safety precautions. When working with any potentially harmful substance - including live steam, hot water and compressed air - wear appropriate safety equipment (face shield, gloves, apron, etc.) if required, and use extreme care to avoid personal injury.

2. Immerse the core in a tank filled with a solution of clean parts dip such as "Soak-NS", or equivalent. Allow it to soak for approximately 12 hours. Leave the water connections open so that the cleaning solution can penetrate both water and air sides of the core.

3. Remove the core from the tank and rinse it thoroughly with a steam cleaner or high-pressure hot water.

4. Blow out the air and water sides of the core using compressed air. To ensure that debris is not forced farther into the fins, direct the stream of air opposite to the direction of normal coolant and air flow. Do not apply more than 40 psi (276 kPa).

5. Rinse the core with clean solvent (mineral spirits) to remove any residual oil or grease.

6. Remove the solvent from the core using a steam cleaner or high-pressure hot water rinse.

7. Using compressed air, blow dry the air and water sides of the core.

8. Visually inspect the cooler core tubes and fins to ensure that the cleaning process has completely removed all contamination. If necessary, repeat the cleaning procedure and reinspect.

Install Aftercooler

1. Install new seal rings in the two grooves on the aftercooler water inlet and outlet connections. Coat the seal rings lightly with engine oil or vegetable shortening. Do not scratch or nick the sealing edge of the seal rings.

2. Install the aftercooler in the cylinder block opening. The water inlet connection of the cooler seats in the water inlet opening in the cylinder block (Fig. 1). Install six new 5/16" - 18 x 9/16" attaching bolts with nylon locking patch. Tighten the bolts.

3. Install the water outlet tube and adaptor on the aftercooler outlet connection and through the rear hand hole cover opening.

4. Install the rear hand hole cover and gasket and tighten the cover bolt. Then with a new gasket (seal ring) connect the water outlet elbow and tube to the aftercooler outlet tube. Install two new 5/16" bolts with nylon lock patch that hold the elbow to the hand hole cover. Tighten the bolts.

5. Connect the elbow and tube to the water return hose. Tighten hose clamps.

6. Use a new blower to cylinder block gasket and install the blower and any accessories attached to the blower (refer to Section 3.4).

7. Attach the air inlet adaptor to the blower with the 7/16" - 14 x 1 1/2" attaching bolts and lock washers. Tighten the bolts to 46-50 lb-ft (62-68 Nm) torque.

8. Install the turbocharger (refer to Section 3.5).

© 1982 General Motors Corp.

SHOP NOTES - TROUBLESHOOTING

SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

INSTALLING WATER PUMP DRIVE AND ROTOR SHAFT KIT

The current design water pump intermediate drive coupling is designed to minimize wear, thereby increasing service life.

To convert the former drive coupling to the current coupling, a "Water Pump Drive and Rotor Shaft Kit" must be used.

> **NOTE:** Before the kit can be installed, refer to Section 3.4 and remove and disassemble the blower.

Remove Rotor Stub Shaft

Refer to Fig. 1 for identification and location of the parts.

1. Use a sharp screwdriver or similar tool to punch a hole in the center of the core plug, opposite the visible drilled hole in the rotor, and pry out the plug.

2. Drive the groove pin down through the shaft with a punch until it reaches the position shown by the dotted line.

3. Bend the groove pin with the punch until it is almost "L" shaped as shown by the solid line. This operation is necessary because the length of the pin is greater than the corresponding width of the rotor cavity.

4. Drive the groove pin in until it drops into the rotor cavity.

5. Remove the plug from the inside of the rotor shaft by driving it out of the shaft and into the rotor body.

6. Clamp the rotor firmly in a vise with soft wood blocks between the rotor and the vise jaws.

7. Insert the puller screw (J 4254-1) with the collets (J 4254-6) in the retracted position into the rotor shaft until the collets are beyond the shoulder on the internal surface of the shaft.

8. Push the collets on to the larger diameter of the puller screw as shown. Remove the collet expanding sleeve (J 4254-5).

9. Coat the threads of the puller screw with an extreme pressure lubricant.

10. Pull the puller screw outward by hand until the collets seat against the internal shoulder of the rotor shaft and maintain tension on the puller screw.

11. While holding the puller screw in this position, place the following tool components, in the order named, over the puller screw: puller sleeve (J 4254-2), puller sleeve cap (J 4254-3), thrust bearing, 1/2" plain washer and forcing nut (J 4254-4).

12. Tighten the forcing nut until it is finger tight.

13. Thread the forcing nut on the puller screw to remove the shaft from the rotor.

14. Remove the rotor from the vise and shake the rotor shaft plug and groove pin from the rotor cavity.

Install Service Rotor Front Stub Shaft

1. Coat the new blower rotor front shaft with lubriplate, or equivalent.

2. Use a suitable press arrangement, align the rotor shaft with its hole in the rotor and press the shaft into the rotor to the height of the spacer (J 4254-8).

3. Drill and ream a new .250" diameter, 2.500" deep pin hole in the rotor 120° from the existing pin hole.

4. Drive the new groove pin into the new hole. The end of the pin must be .0625" below the rotor surface.

5. Install a new core plug.

6. Stake the pin and the core plug after installation and remove all raised burrs.

After the modified lower blower rotor assembly has been used in the reassembly of the blower up to the point where the water pump intermediate drive coupling is to be installed, install the new water pump intermediate drive coupling in accordance with the following procedure.

© 1984 General Motors Corp.

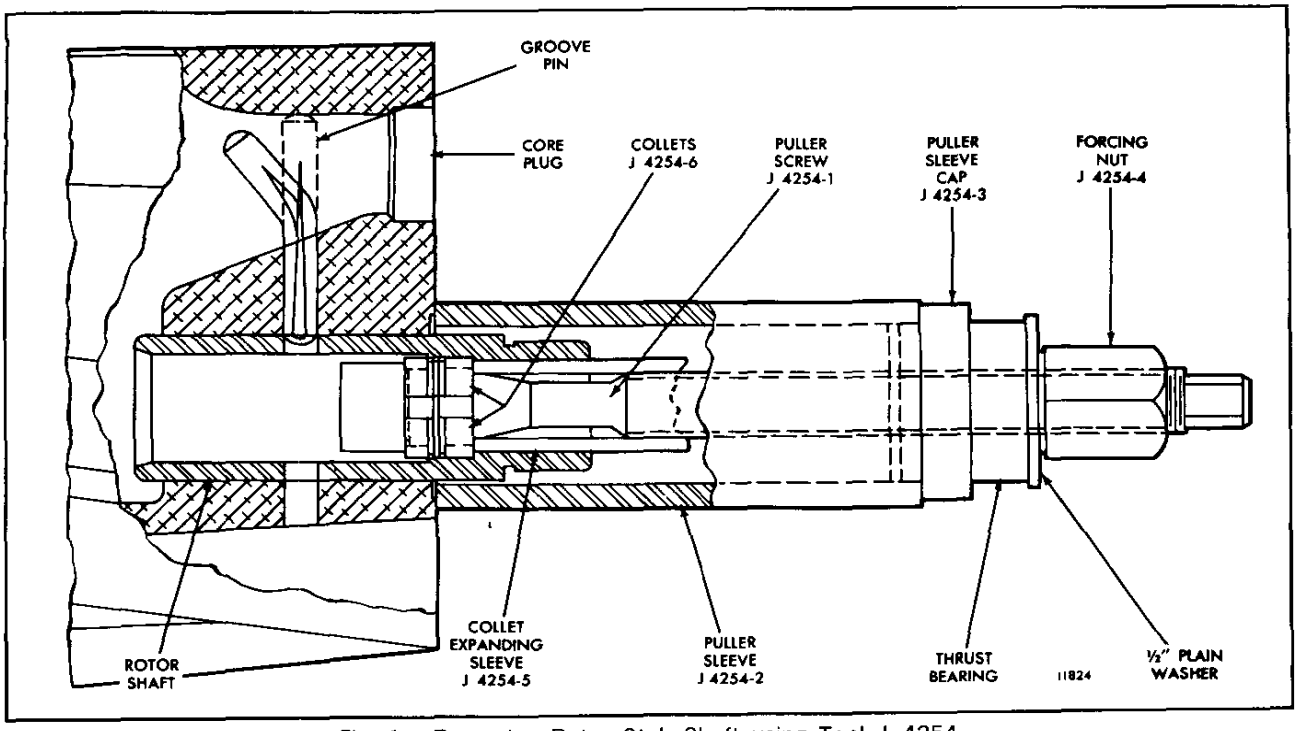


Fig. 1 - Removing Rotor Stub Shaft using Tool J 4254

Attach Water Pump Intermediate Drive Coupling to Blower Rotor

1. Install the splined end of the water pump intermediate drive coupling into the lower blower rotor front stub shaft.

2. Insert the 5/16" bolt through the water pump coupling and thread it into the rotor shaft and plug assembly.

3. Tighten the bolt to 15-19 lb-ft (20-26 Nm) torque.

DRILLING PROCEDURE FOR AIR SHUTDOWN REPLACEMENT SHAFT

Whenever a replacement air shutdown valve shaft is installed on a Series 149 engine, the shaft must be match-drilled to the cam and the flapper valve in order to ensure positive air shutdown operation. Failure to properly index the shaft can result in improper flapper valve operation and engine run-on at shutdown. Use the following procedure to drill the air shutdown valve shaft:

1. Install a 1/8" drill bit in the chuck of a drill press, then locate and align the bit through the existing hole in the shutdown cam (Fig. 2). Lock the cam in the holding fixture on the drill press, and withdraw the bit.

2. Insert the replacement shaft into the cam until the end of the shaft is recessed 1/8" from the end of the cam. Start the drill and bore a hole through the shaft (Fig. 2). Withdraw the drill bit, install the pin handle

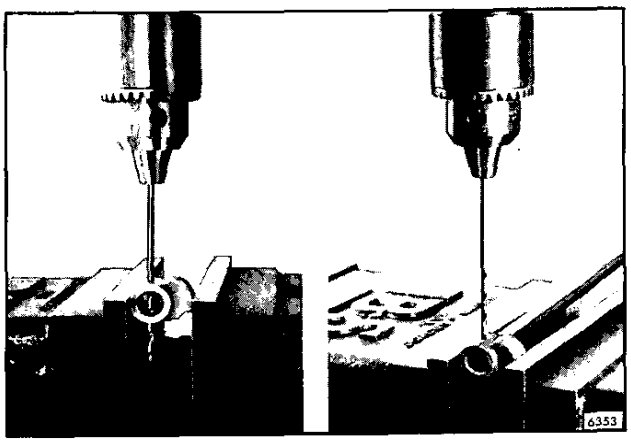


Fig. 2 - Aligning Drill Bit and Drilling Shaft

© 1984 General Motors Corp.

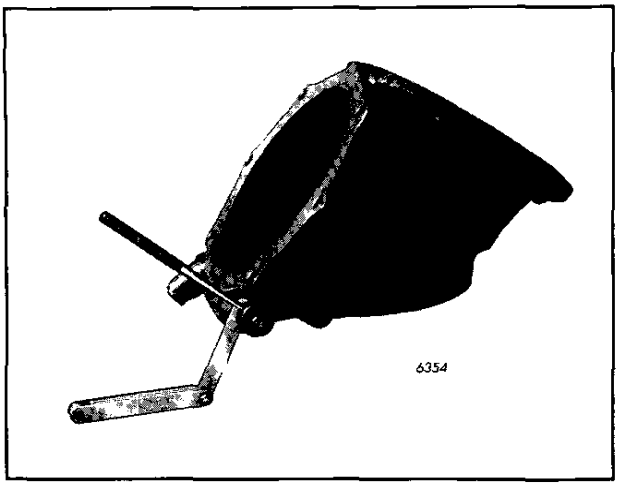


Fig. 3 - Center Punch Shaft thru Spacer Hole

through the hole and remove the shaft from the drill press.

3. Insert the shaft into the shutdown housing bore and install the spacer on the end of the shaft. Place a .015" feeler gage between the housing and spacer and mark the shaft with a center punch inserted into the existing hole in the spacer (Fig. 3).

4. Remove the shaft from the housing. Locate and align the 1/8" drill bit through the hole in the spacer and lock the spacer in the holding fixture on the drill press. Withdraw the drill bit.

5. Insert the shaft through the spacer, locate the center punched mark and drill a hole through the shaft. Remove the shaft and spacer from the drill press.

6. Assemble the shaft, seal rings spring, flapper valve and spacer in the housing (see Section 3.3). If using a *new valve, center punch for holes in approximately* the same position as on the old valve. If reusing the old valve, center punch for holes just inside the existing holes.

7. Align the notch on the cam with the latch and hold in this position with a piece of stiff wire (Fig. 4).

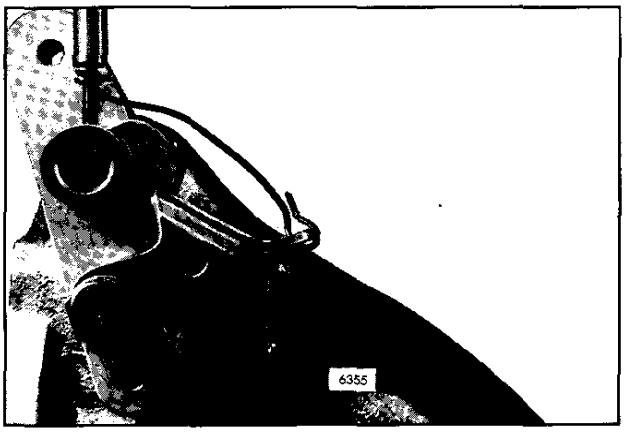


Fig. 4 - Cam and Latch Wired to Prevent Movement

8. Place the housing on the drill press. With the valve held in the wide open *run* position, align the 1/8" drill bit with the marks center punched on the valve in Step 6. Then, drill through the valve and shaft (Fig. 5). Install the retaining pins to hold the valve to the shaft.

9. Clean the air shutdown assembly thoroughly and check for proper operation before installing it on the engine.

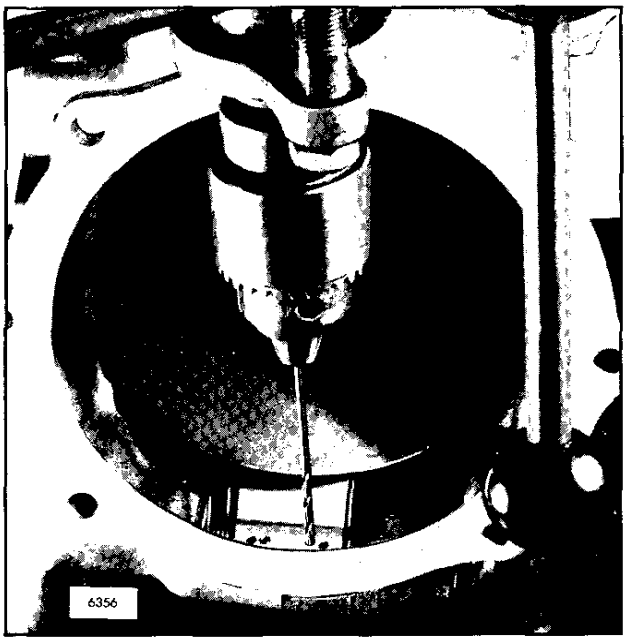


Fig. 5 - Drilling Valve-to-Shaft Holes

© 1984 General Motors Corp.

TROUBLESHOOTING

Turbocharger

CONDITION	PROBABLE CAUSE	SUGGESTED REMEDY
NOISY OPERATION OR VIBRATION	WHEEL SHAFT BEARINGS ARE NOT BEING LUBRICATED	Locate cause of loss of oil pressure and repair Remove, dis-assemble and inspect turbocharger for bearing damage.
	IMPROPER CLEARANCE BETWEEN TURBINE WHEEL AND HOUSING	Remove, disassemble, and inspect turbocharger.
	LEAK IN ENGINE AIR INTAKE OR EXHAUST MANIFOLD	Tighten all loose connections or replace exhaust manifold gaskets as necessary.
ENGINE WILL NOT DELIVER RATED POWER	CLOGGED AIR INTAKE SYSTEM	Check air cleaner and clean air intake ducts.
	FOREIGN MATERIAL LODGED IN COMPRESSOR OR TURBINE WHEELS	Remove, disassemble and clean turbocharger.
	EXCESSIVE DIRT BUILD-UP IN COMPRESSOR	Thoroughly clean compressor assembly. Clean air cleaner and check for leaks.
	LEAK IN ENGINE AIR INTAKE OR EXHAUST MANIFOLD	Tighten all loose connections or replace exhaust manifold gaskets as necessary.
	ROTATING ASSEMBLY BEARING SEIZURE	Remove and overhaul turbocharger.

© 1984 General Motors Corp.

Intercoolers

CONDITION	PROBABLE CAUSE	SUGGESTED REMEDY
BLACK SMOKE (AIR SIDE)	AIR INLET RESTRICTION	CLEAN SILENCER (SEE SECT. 3.2)
	INJECTORS — HIGH OUTPUT	SEE SECT. 2.0
	DIRTY FINS INTERCOOLER	CLEAN INTERCOOLER FINS
OVERHEATING (WATER SIDE)	THERMOSTATS	CHECK THERMOSTAT (SEE SECT. 5.2.1)
	RAW WATER PUMP	CHECK IMPELLER (SEE SECT. 5.6)
	HEAT EXCHANGER	CLEAN ELEMENT (SEE SECT. 5.5)
	INTERCOOLER (WATER SIDE)	CLEAN INTERCOOLER (SEE SECT. 3.5.2)
	SEA STRAINERS	CLEAN SEA STRAINER
	INDUSTRIAL FILTER	CLEAN FILTER

© 1984 General Motors Corp.

SPECIFICATIONS

Specifications, clearances and wear limits are listed below. It should be specifically noted that the clearances apply only when all new parts are used at the point where the various specifications apply. This also applies to references within the text of the manual. The column entitled "Limits" in this chart lists the amount of wear or increase in clearance which can be tolerated in used engine parts and still ensure satisfactory performance. It should be emphasized that the figures given as "Limits" must be qualified by the judgement of personnel responsible for installing new parts. These wear limits are, in general, listed only for the parts more frequently replaced in engine overhaul work. For additional information, refer to the text.

TABLE OF SPECIFICATIONS, NEW CLEARANCES AND WEAR LIMITS

These limits also apply to oversize and undersize parts.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
Blower			
Backlash (timing gears)	.0005"	.0025"	.0040"
Backlash (reduction gears)	.0020"	.0060"	.0080"
Oil seal or seal collar (below end plate surface)	.0020"	.0080"	
Dowel pin (projection beyond inside face of end plates)	.3800"		
T18 and T18A40 Turbochargers (Airesearch)			
End play--rotating shaft	.0040"	.0090"	
Radial movement--rotating shaft	.0030"	.0070"	
Turbine wheel shaft journal bearing:			
Inside diameter	.6268"	.6272"	
Outside diameter	.9780"	.9785"	
Journal diameter--turbine wheel shaft	.6247"	.6250"	.6242"
Bearing bore I.D.--center housing	.9830"	.9835"	.9845"
Back Plate Seal Bore:			
Inside diameter	.6875"	.6885"	.6895"
Thrust Collar:			
Thickness	.2990"	.3000"	.2970"
Bore - Inside diameter	.3754"	.3758"	.3778"
Thrust Spacer:			
Outside diameter	.6715"	.6725"	.6705"
Ring groove width	.0685"	.0695"	.0715"
Thrust Washer, Inboard:			
Thickness	.0900"	.0920"	
Compressor Wheel Bore:			
Inside diameter	.3736"	.3739"	.3749"

© 1984 General Motors Corp.

ENGINE PARTS (Standard Size, New)	MINIMUM	MAXIMUM	LIMITS
TV61 and TV71 Turbocharger (Airesearch)			
End play -- rotating shaft	.0030″	.0100″	
Radial movement -- rotating shaft	.0030″	.0070″	
Turbine wheel shaft journal bearings:			
Inside diameter	.6268″	.6272″	
Outside diameter	.9782″	.9787″	
Journal diameter -- turbine wheel shaft	.6250″	.6254″	
Bearing bore -- center housing:			
Inside diameter	.9827″	.9832″	.9842″
Back plate seal bore:			
Inside diameter	.6875″	.6885″	.6895″
Thrust collar:			
Thickness	.2990″	.3000″	.2970″
Bore - inside diameter	.3754″	.3758″	.3778″
Thrust Spacer:			
Outside diameter	.6715″	.6725″	.6705″
Ring groove width	.0685″	.0695″	.0715″
Thrust washer, inboard:			
Thickness	.0900″	.0920″	
Compressor wheel bore:			
Inside diameter (TV61)	.3121″	.3124″	.3134″
Inside diameter (TV71)	.3736″	.3739″	.3749″

© 1984 General Motors Corp.

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb-ft)	Nm	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	Nm
1/4 -20	5- 7	7- 9	1/4 -20	7-9	10-12
1/4 -28	6- 8	8-11	1/4 -28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8 -16	23-26	31-35	3/8 -16	30-35	41-47
3/8 -24	26-29	35-40	3/8 -24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2 -13	53-56	72-76	1/2 -13	71-75	96-102
1/2 -20	62-70	84-95	1/2 -20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8 -11	103-110	140-149	5/8 -11	137-147	186-200
5/8 -18	126-134	171-181	5/8 -18	168-178	228-242
3/4 -10	180-188	244-254	3/4 -10	240-250	325-339
3/4 -16	218-225	295-305	3/4 -16	290-300	393-407
7/8 - 9	308-315	417-427	7/8 - 9	410-420	556-569
7/8 -14	356-364	483-494	7/8 -14	475-485	644-657
1 - 8	435-443	590-600	1 - 8	580-590	786-800
1 -14	514-521	697-705	1 -14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head		GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None		GM 255-M	1	No. 6 thru 1 1/2	60,000
None		GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74,000 60,000
	Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
	Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
	Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
	Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
	Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

12252

BOLT IDENTIFICATION CHART

© 1984 General Motors Corp.

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	TORQUE lb-ft	TORQUE Nm
Blower drive hub-to-blower rotor gear bolt	5/16-24	25-30	34-41
Blower drive plate-to-drive hub bolt	5/16-24	25-30	34-41
Blower lower front bearing retaining bolt (Allen head)	5/16-24	18	24
Air inlet housing-to-blower housing bolt	3/8 -16	16-20	22-27
Blower housing-to-cylinder block bolt (Alum. block)	7/16-14	35-40	47-54
Blower housing-to-cylinder block bolt (C.I. block)	7/16-14	55-60	75-81
Blower rotor timing gear bolt	7/16-20	55-65	75-88
Blower rotor timing gear bolt	1/2 -20	55-65	75-88
Fuel pump drive disc bolt	1/2 -20	55-65	75-88

© 1984 General Motors Corp.

SERVICE TOOLS

TOOL NAME	TOOL NO.
Blower	
Blower clearance feeler set	J 1698-02
Blower rotor shaft remover and installer set	J 4254
Blower service tool set	J 6270-F
Slide hammer set	J 6471-02
Snap ring pliers (external type)	J 4880
Turbocharger (Airesearch)	
Compressor wheel nut wrench	J 21223-02
Compressor wheel remover	J 9496
Dial indicator adaptor	J 21224
Dial indicator set (magnetic base)	J 7872
Turbocharger inlet shield	J 26554-A
Turbocharger support fixture	J 29086
Turbocharger tool set	J 29149

© 1984 General Motors Corp.

SECTION 4

LUBRICATION SYSTEM

CONTENTS

Lubrication System	**4**
Lubricating Oil Pump	**4.1**
Lubricating Oil Pressure Regulator	**4.1.1**
Lubricating Oil Filters	**4.2**
Lubricating Oil Cooler	**4.4**
Oil Level Dipstick	**4.6**
Oil Pan	**4.7**
Ventilating System	**4.8**
Shop Notes - Specifications - Service Tools	**4.0**

LUBRICATION SYSTEM

Fig. 1 schematically illustrates the flow of oil through a typical In-line 71 lubricating system including the various components such as the oil pump, oil cooler, bypass and full-flow filters, the pressure regulator valve and bypass valve.

The lubricating oil is circulated by a gear-type pressure pump mounted on the No. 1 and No. 2 main bearing caps and gear driven from the crankshaft.

All the oil leaving the pump is forced through the full-flow oil filter to the cooler and then into the oil gallery in the cylinder block from where it is distributed to the various engine bearings. The drain from the cylinder head and other engine parts leads back to the oil pan.

A spring-loaded integral plunger-type relief valve, located in the oil pump body, bypasses excess oil from the discharge to the intake side of the pump when the pressure in the engine oil gallery exceeds approximately 105 psi (724 kPa).

If the oil cooler should become clogged, the oil will flow from the pump through a spring-loaded bypass valve directly into the oil gallery.

Clean engine oil is assured at all times by the use of a replaceable element type full-flow oil filter incorporated in the engine lubrication system. With this type filter, which is installed in the lubricating system between the pump and the cooler, all of the oil is filtered before entering the engine.

A bypass type filter with replaceable element is available as optional equipment. A portion of the oil is continually bypassed through the filter and the filtered oil is returned to the engine oil pan.

Stabilized oil pressure is maintained within the engine at all speeds, regardless of the oil temperature, by means of a regulator valve located between the pump outlet and the inlet to the cylinder block. When the oil pressure at the valve exceeds 50 psi (345 kPa), the regulator valve opens and remains open until the pressure is less than the opening pressure.

Oil Distribution

Oil from the cooler is conducted by a vertical passage to a longitudinal main oil gallery on the blower side of the cylinder block. As shown in Fig. 1, this gallery distributes the oil, under pressure, to the main bearings and to a horizontal, transverse passage at each end of the cylinder block. From each of these two horizontal passages, oil flows through two vertical bores (one at each end of the cylinder block) to the end bearings of the camshaft and balance shaft. In addition, oil is forced through an oil passage in the camshaft which lubricates the camshaft intermediate bearings. Oil for lubricating the connecting rod bearings, piston pins and for cooling the piston head is provided through the drilled crankshaft from the adjacent forward main bearings. The gear train is lubricated by the overflow of oil from the camshaft pocket through a communicating passage into the flywheel housing. Some oil spills into the flywheel

© 1982 General Motors Corp.

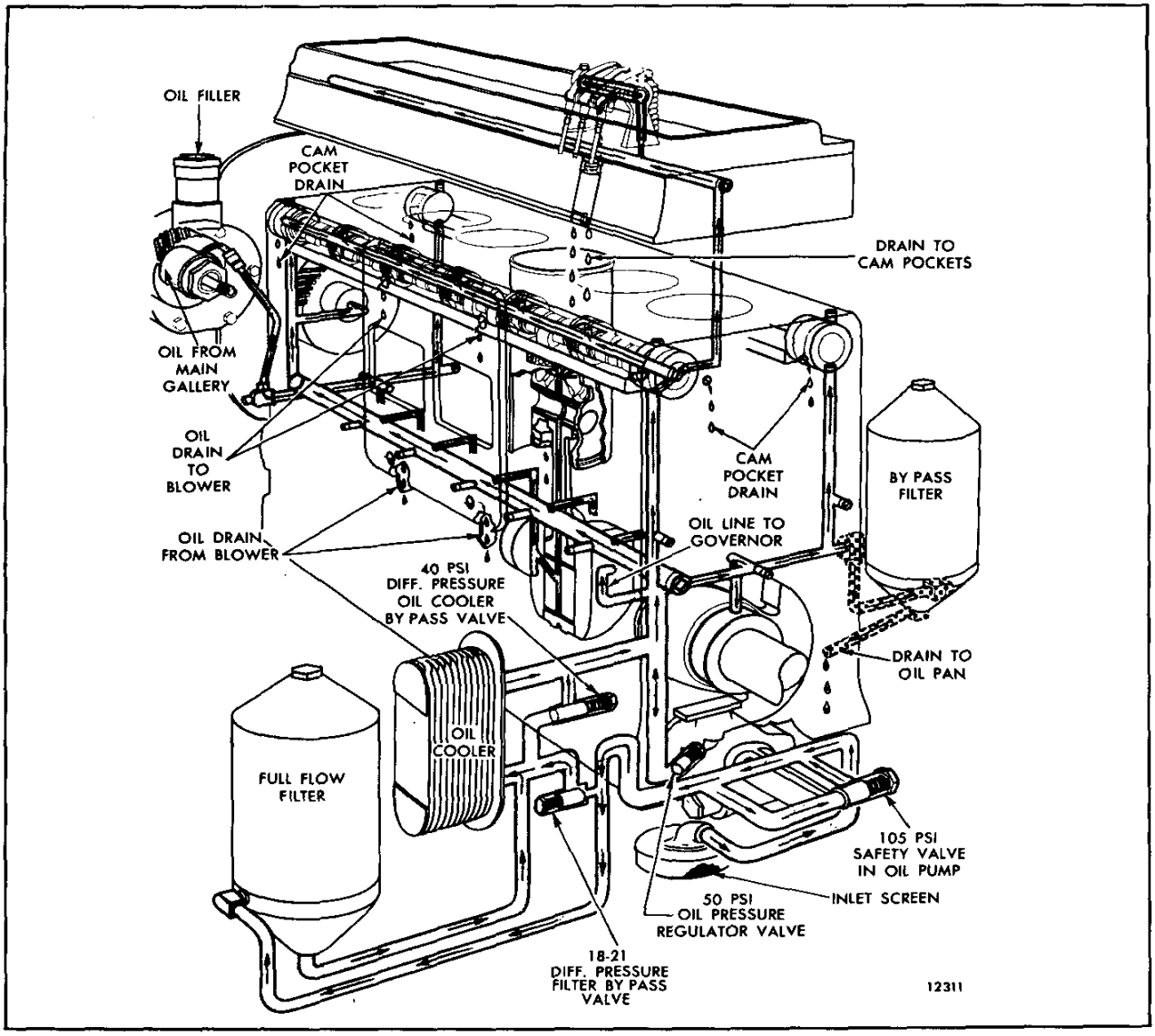


Fig. 1 - Schematic Diagram of Typical Lubrication System

housing from the bearings of the camshaft, balancer shaft and idler gear.

The blower drive gear bearing is lubricated through an external pipe from the rear horizontal oil passage of the cylinder block.

A longitudinal oil gallery on the camshaft side of the cylinder head is supplied with oil from one of the vertical bores located at each end of the cylinder block. Oil from this gallery enters the drilled rocker arm shafts through the rocker shaft brackets at the lower ends of the drilled bolts and lubricates the rocker arm bearings and push rod clevis bearings.

Excess oil from the rocker arms lubricates the ends of the valve push rods, injector push rods and the cam followers, and then drains to cam pockets in the top of cylinder block from which the cams are lubricated. When these pockets are filled, the oil overflows through two holes, one at each end of the blower housing, as shown in Figs. 1 and 2, and thus provides lubrication for the blower drive gears at the rear end and for the governor mechanism at the front end. A dam in the blower rear end plate cover maintains an

© 1982 General Motors Corp.

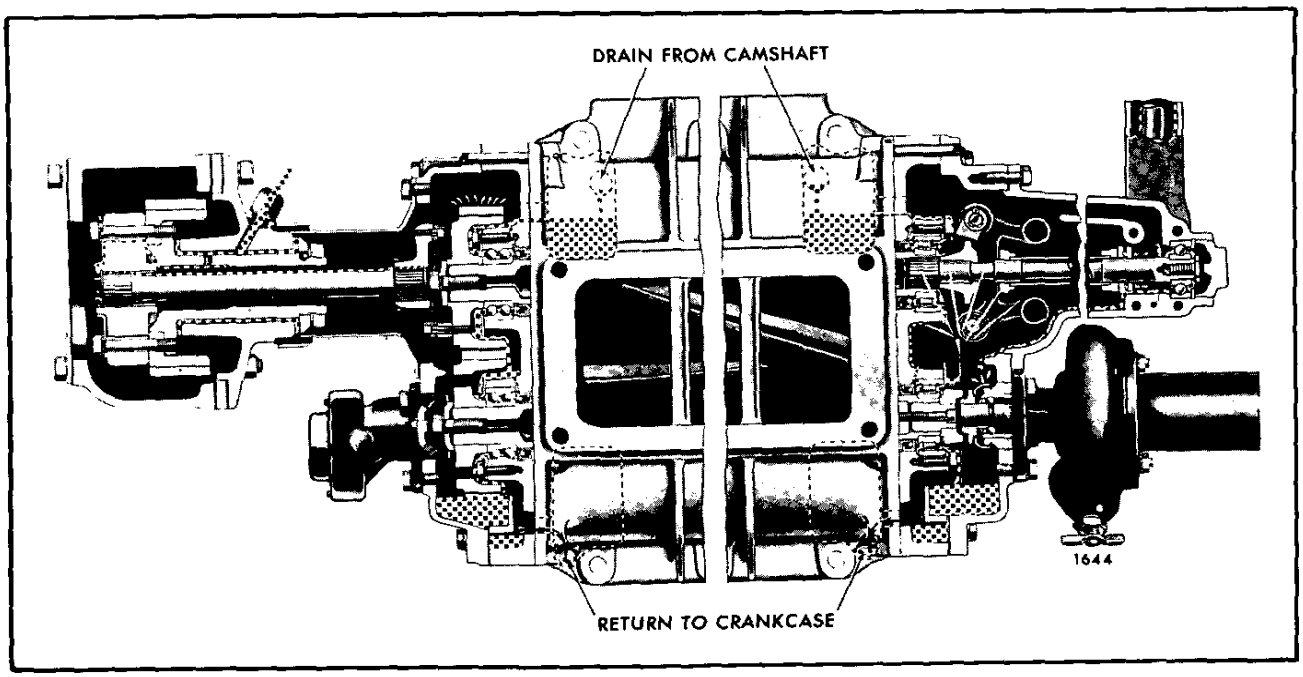


Fig. 2 - Blower Lubrication

oil level in which the teeth of the lower blower rotor timing gear run. A slinger at the forward end of lower rotor throws oil from the dam onto the governor weight assembly. Surplus oil overflows the dam in the two end plate covers and passes through drilled holes in the cylinder block to the oil pan.

Lubrication System Maintenance

Use the proper viscosity grade and type of *heavy duty* oil as outlined in the *Lubrication Specifications* in Section 13.3. Change the oil and replace the oil filter elements at the periods recommended by the oil supplier (based on his analysis of the drained engine oil) to ensure trouble-free lubrication and longer engine life.

The oil level should never be allowed to drop below the *low* mark on the dipstick. Overfilling the crankcase may contribute to abnormal oil consumption, high oil temperature, and also result in oil leaking past the crankshaft rear oil seal.

To obtain the true oil level, the engine should be stopped and sufficient time (approximately twenty minutes) allowed for the oil to drain back from the various parts of the engine. If more oil is required, add only enough to bring the level to the *full* mark on the dipstick.

Cleaning Lubrication System

Thorough flushing of the lubrication system is required at times. Should the engine lubrication system become contaminated by ethylene glycol antifreeze solution or other soluble material, refer to Section 5 for the recommended cleaning procedure.

Detection of Lube *Oil* Leaks

Detroit Diesel Allison uses red dye to detect lube oil system leaks during engine test. Customers receiving new engines may notice some residual dye remaining in their lube oil systems. This dye should be quickly dispersed after the first few hours of engine operation.

© 1982 General Motors Corp.

OIL PUMP

The gear type oil pump shown in Figs. 1 and 2 is mounted on the first and second main bearing caps and is gear driven from the front end of the crankshaft.

The oil pump helical gears rotate inside a housing (Fig. 1). The drive gear is keyed to the drive shaft which is supported inside the housing on two bushings with a drive-driven gear keyed to the outer end of the shaft. The driven gear is supported on the driven gear shaft which is pressed into the pump body.

An integral plunger-type relief valve bypasses excess oil to the inlet side of the pump when the pressure in the oil lines exceeds 105 psi (724 kPa).

An inlet pipe, attached to the inlet opening in the pump body, leads to the inlet screen which is mounted with brackets to a main bearing cap.

The inlet screen is located below the oil in the pan and serves to strain out any foreign material which might damage the pump.

The oil pump inlet screen should be removed and cleaned periodically in addition to the cleaning it receives each time the engine is reconditioned.

When required certain engines are equipped with a dual type pump which incorporates a scavenging pump. The scavenging pump consists of a spacer, two gears and a pump body (see inset, Fig. 3). Oil which normally flows to the front of the engine during inclined operation of the engine is transferred to the rear of the pan by the scavenging pump and is then

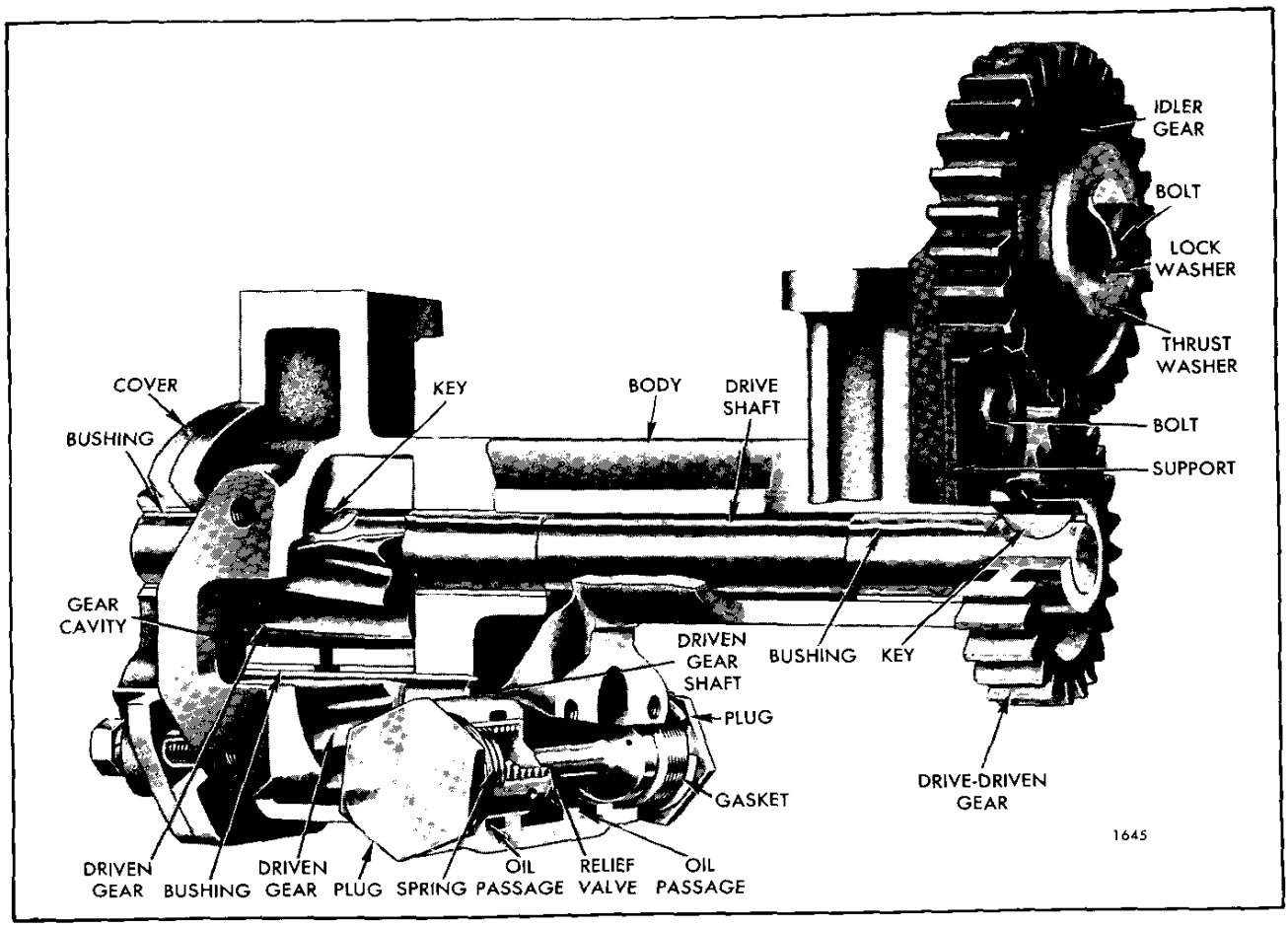


Fig. 1 - Oil Pump Assembly

© 1982 General Motors Corp.

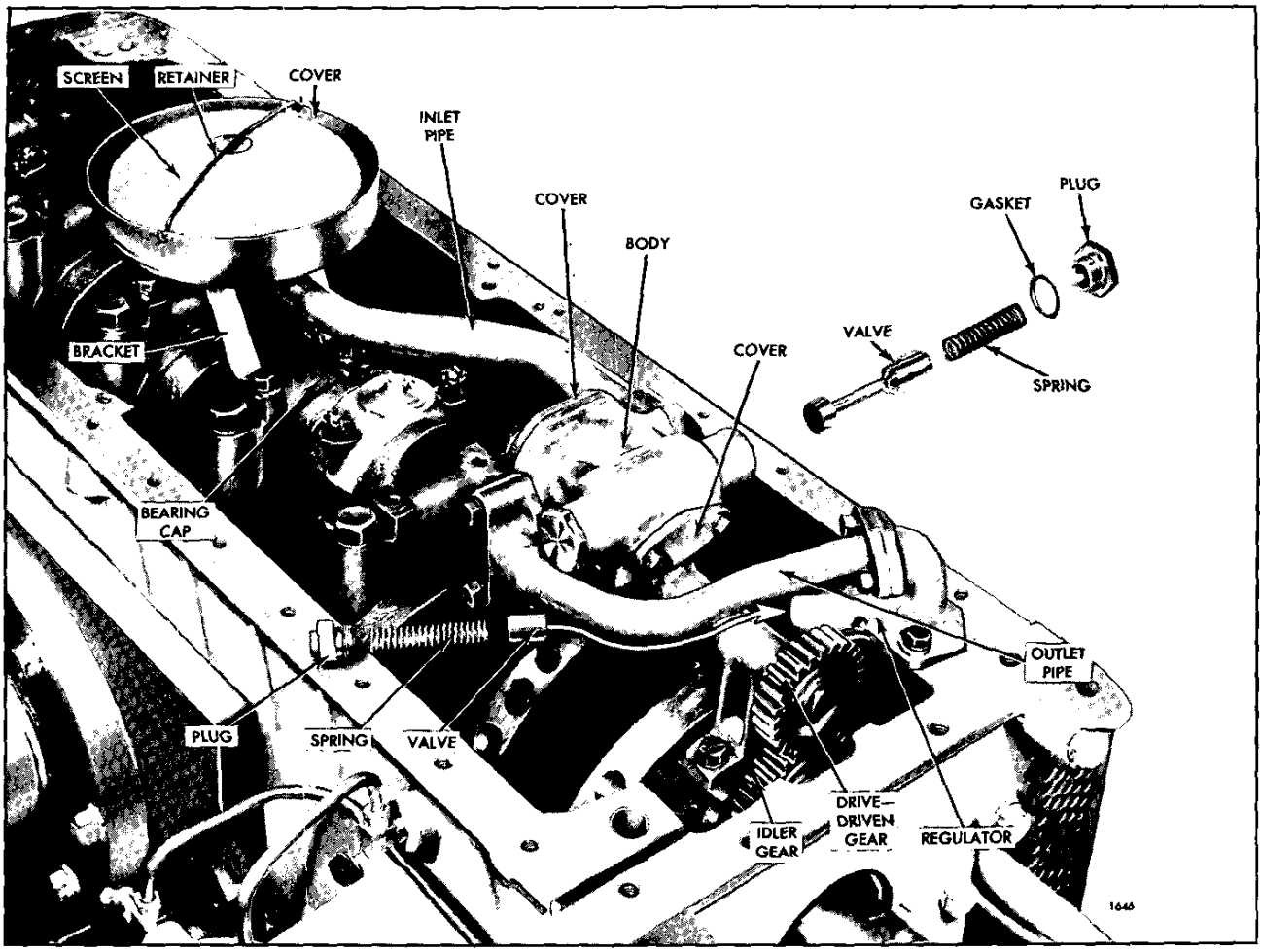


Fig. 2 - Typical Oil Pump Mounting

picked up by the oil pump for distribution throughout the engine.

An idler gear is mounted on a support bracket which is attached to the pump body (Fig. 1).

Pressure lubrication of the idler gear bushing is provided by means of a drilled passage in the pump body and a connecting passage in the idler gear support bracket.

Remove Oil Pump

1. Remove the drain plug from the oil pan and drain the oil.

2. Remove the oil pan bolts and remove the oil pan.

3. Remove the bolts and lock washers securing the oil pump, regulator body and oil outlet tube and oil inlet tube support (including scavenging pump tube supports if used) from the main bearing caps and cylinder block (Fig. 2).

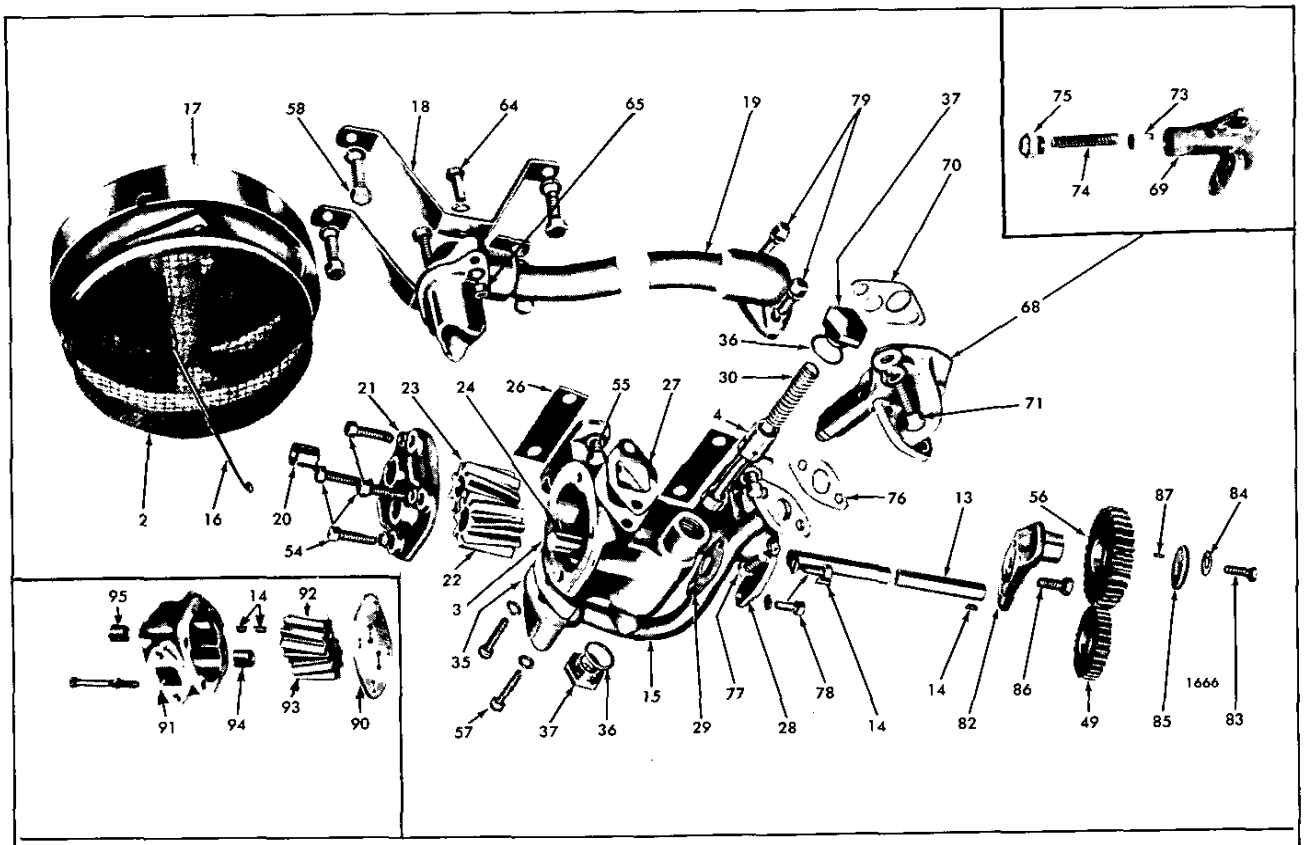
> **NOTE:** Remove and save the shims, if used between the oil pump mounting feet and the bearing caps.

Disassemble Oil Pump

Observe carefully the position of all parts including the oil inlet and outlet pipes during disassembly to facilitate reassembly of the pump.

1. Remove the scavenging pump inlet pipe together with the inlet screen, if so equipped, from the scavenging pump body.

© 1982 General Motors Corp.



2. Screen--Pump
3. Body--Oil Pump
4. Valve--Oil Pressure Relief
13. Shaft--Drive
14. Woodruff Key
15. Pipe--Pump Outlet
16. Retainer--Screen
17. Cover--Screen
18. Bracket--Screen
19. Pipe--Pump Inlet
20. Bushing--Drive Shaft (Short)
21. Cover--Pump
22. Gear--Driven
23. Gear--Drive 24. Shaft--Driven Gear
26. Shim
27. Gasket--Inlet Pipe to Pump
28. Cover--Pump Inlet Pad
29. Gasket--Pad Cover
30. Spring--Relief Valve
35. Gasket--Outlet Pipe to Pump
36. Gasket--Copper
37. Plug--Relief Valve
49. Gear--Drive-Driven
54. Bolt--Pump Cover
55. Bolt--Pump to Bearing Cap
56. Gear--Idler
57. Bolt--Outlet Pipe to Pump
58. Bolt--Screen Bracket to Bearing Cap
64. Bolt--Inlet Pipe and Cover to Bracket
65. Nut
68. Regulator Assy.--Oil Pressure
69. Regulator Body
70. Gasket--Regulator to Cylinder Block
71. Bolt--Regulator to Cylinder Block
73. Valve--Regulator
74. Spring--Regulator
75. Plug--Regulator
76. Gasket--Outlet Pipe to Pressure Regulator
77. Bolt--Outlet Pipe to Pressure Regulator
78. Bolt--Inlet Pad Cover
82. Support--Idler Gear
83. Bolt--Idler Gear to Support
84. Lock Washer--Idler Gear-to-Support Bolt
85. Washer--Idler Gear-to-Support Bolt
86. Bolt--Idler Gear Support-to-Pump
87. Locating Pin--Idler Gear Washer
90. Spacer--Pump Body
91. Body--Scavenging Pump
92. Gear--Scavenging Drive
93. Gear--Scavenging Driven
94. Bushing--Scavenging Driven Gear
95. Bushing--Scavenging Pump Body

Fig. 3 - Oil Pump Details and Relative Location of Parts

2. Remove the scavenging pump outlet pipe, if so equipped.

3. Remove the oil pump inlet pipe with the screen cover and mounting brackets.

4. Remove the oil pressure regulator and the oil pump outlet pipe as an assembly from the pump body.

5. Remove the four bolts and lock washers securing the scavenging pump body or the cover to the oil pump body.

6. Remove the scavenging pump drive and driven gears from the oil pump drive and driven shafts, if so equipped.

7. Remove the Woodruff keys from the drive shaft and slide the spacer off the end of the shafts, if Step 6 performed.

© 1982 General Motors Corp.

8. Remove the valve plugs (37) and copper gaskets (36) from each side of the pump body, and jar the relief valve parts from the body (Fig. 3).

9. Remove the pump driven gear (22) from the driven gear shaft (24).

10. Straighten the lip of the lock washer (84) and unscrew the bolt (83) thus freeing the idler gear (56).

11. Clamp the pump body, drive shaft and gear assembly in a bench vise. Pull the drive-driven gear from the outer end of the pump drive shaft as shown in Fig. 4.

12. Remove the Woodruff key (14) from the drive shaft and withdraw the shaft and driven gear (22) from the pump body.

13. Unscrew the bolt (86) and remove the idler gear support (82) from the pump body.

14. If the drive gear (23) is to be replaced, position the gear and shaft assembly on bed of arbor press with the long end of the shaft extending down through the slot in the bed plate and with the face of the gear resting on the plate as shown in Fig. 5. Place a short 1/2" round steel rod on the end of the shaft, and press the shaft from the gear.

Inspect Oil Pump Parts

Wash all parts in clean fuel oil and dry them with compressed air.

Examine the gear cavity in the pump body and the drive shaft bushings. If the driven gear bushings are worn, replace the bushings. Service replacement

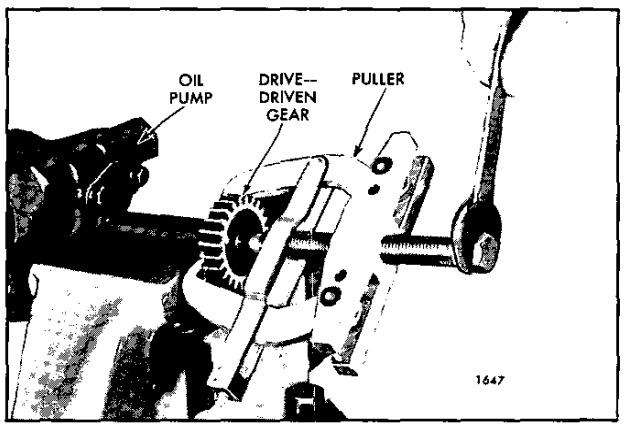


Fig. 4 - Removing Oil Pump Drive-Driven Gear from Shaft with Puller J 8174

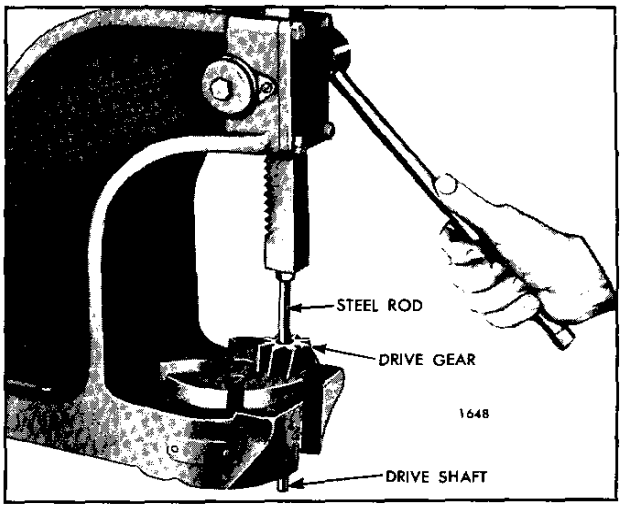


Fig. 5 - Removing Oil Pump Drive Gear from Shaft

bushings in the driven gears must be reamed after assembly. Bushings used with the .499" diameter driven gear shaft must be reamed to .500" ±.0005" and bushings used with the .623" diameter shaft must be reamed to .625 ±.0005".

Inspect the bushings in the pump body and cover or scavenging pump body. If the bushings are worn excessively, replace the pump and cover or scavenging pump body assemblies unless suitable boring equipment is available for finishing the new bushings. When installing new bushings, replace all of the bushings. The bushings must be located and positioned as shown in Fig. 6. Also, the gear bore and the bushing bore in both the pump body and cover or scavenging pump body must be concentric within .001". The shaft-to-pump body-bushing clearance with new parts is .0008" to .0025". The shaft-to-pump cover or scavenging pump body bushing clearance with new parts is .0010" to .0027".

In an efficient oil pump, the gears should have a free-running fit (not loose) in the pump housing. If the gear teeth are scored or worn, install new gears. The use of excessively worn gears will result in low engine oil pressure which in turn, may lead to serious damage throughout the engine.

Inspect the pressure relief valve and its seat in the pump body. If necessary, install new parts.

© 1982 General Motors Corp.

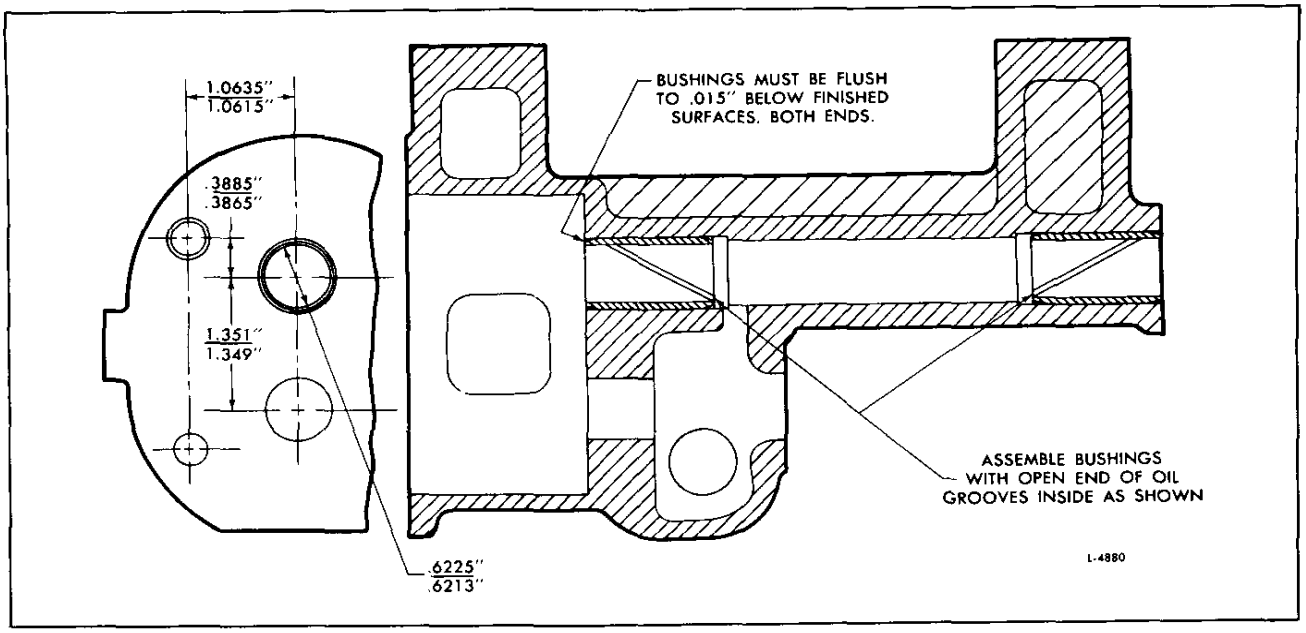


Fig. 6 - Diameter and Location of Bushing in Oil Pump

Assemble Oil Pump

Refer to Fig. 3, and assemble the oil pump as follows:

1. If the drive gear (23) was removed from the drive shaft (13), insert the Woodruff key (14) in the keyway and apply a light coat of engine oil on the shaft. Start the shaft squarely into the bore of the gear and, as shown in Fig. 5, press the shaft into the gear.

The gear must be 6-15/16" on 3 and 4 cylinder engines, or 6-15/32" on 6 cylinder engines, from the keyway end of the drive shaft (Fig. 7).

2. Press the dowel (88) into the pump body, if removed.

3. Place the idler gear support (82) in position against the forward end of the pump body (Fig. 3) and secure the support to the body with bolt (86). Tighten the bolt to 45-50 lb-ft (61-68 Nm) torgue.

4. Install the drive gear and shaft assembly in the pump body and slide the driven gear (22) onto the shaft (24).

5. If the engine is equipped with a scavenging pump, install the oil pump spacer (90) over the end of the drive and driven gear shafts flush against the oil pump body.

6. Insert two Woodruff keys in the keyway and slide the drive gear (gear with keyway) (92) against the spacer.

7. Slide the driven gear (93) on the driven shaft against the spacer.

8. Secure the pump cover (21) or scavenging pump body (91) to the oil pump body with four bolts (54) and lock washers.

9. Support the drive gear end of the drive shaft (13) on the bed of an arbor press and insert the Woodruff key (14) in the keyway of the shaft. Position the drive-driven gear (49) on the end of the drive shaft with the

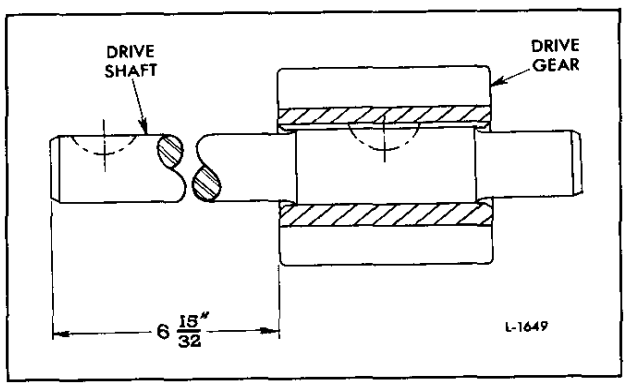


Fig. 7 - Oil Pump Drive Shaft and Gear Assembly—Six Cylinder Engine

© 1982 General Motors Corp.

extended hub side up away from the pump body. Insert a .004" to .006" feeler ribbon between the driven gear and the pump body and press the gear on the shaft until the clearance between the gear and the body is .004" to .006".

10. If the locating pin (87) was removed, install it in the idler gear support (82), then lubricate the bearing surface with engine oil and place the gear (56) in position on the support (82) with the flat side of gear facing the support.

11. Place the lock washer (84) on the bolt (83) and the special washer (85) next to the lock washer and start the bolt into the idler gear support. Then rotate the special washer and lock washer so that the slot in each washer engages the locating pin (87).

12. Tighten the idler gear bolt to 21-26 lb-ft (28-35 Nm) so the bolt head is over the end of the locating pin (87). Then bend the lock washer against one flat of the bolt head.

13. Screw the relief valve plug (37), with copper gasket (36), into place in the side of the pump body opposite the inlet opening. Then place the valve (4) and spring (30) in the bore at the inlet side of the pump body as shown in Fig. 2, and while compressing the spring, start the second relief valve plug (37), with gasket (36), into the body. Tighten the plugs to 25-35 lb-ft (34-47 Nm) torgue.

14. If the cover (28) and gasket (29) were removed from the pump body, reinstall and secure them with the two bolts (78) and lock washers.

The oil pump must turn freely after assembly. Any bind in the pump must be removed before it is installed on the engine.

Remove Oil Pump Driving Gear from Crankshaft

With the oil pan and lubricating oil pump removed, the oil pump driving gear may be removed from the crankshaft as follows:

1. Support the front end of the engine and remove the crankshaft front cover (Section 1.3.5).

2. Remove the oil slinger.

3. If required use puller J 3051 to pull the pump driving gear from the front end of the crankshaft as follows (Fig. 8):

a. Screw the crankshaft pulley or cap retaining bolt into the end of the crankshaft.

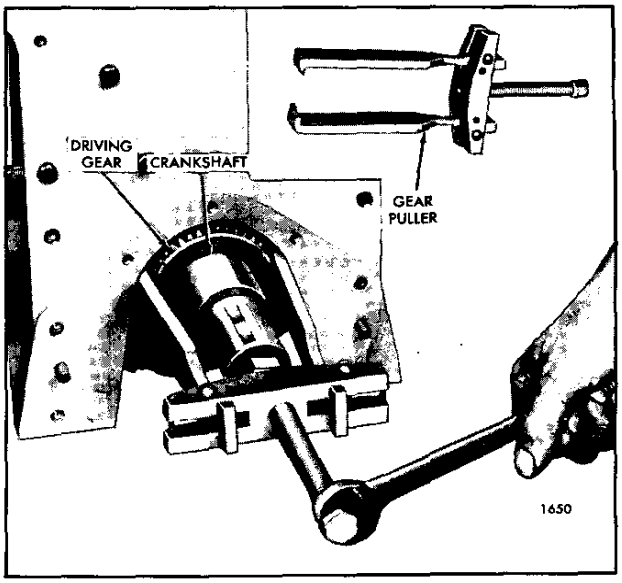


Fig. 8 - Removing Oil Pump Driving Gear from Crankshaft with Puller J 3051

b. Place the jaws of the puller behind the gear and locate the point of the puller screw in the center of the retaining bolt.

c. Turn the puller screw clockwise and draw the gear from the crankshaft.

4. Remove the Woodruff key from the crankshaft.

Install Oil Pump Driving Gear on Crankshaft

1. Install the Woodruff key in the crankshaft.

2. Position the driving gear so the chamfer on the gear hub is toward the main bearing cap and start the gear on the shaft and over the key.

3. Slide the gear on the crankshaft or use a sleeve if required, as illustrated in Fig. 9, and drive the gear tight against the shoulder on the crankshaft.

4. Install the oil slinger with the dished side away from the gear as illustrated in Fig. 1 in Section 1.3.6.

5. Install the crankshaft front cover as outlined in Section 1.3.5.

© 1982 General Motors Corp.

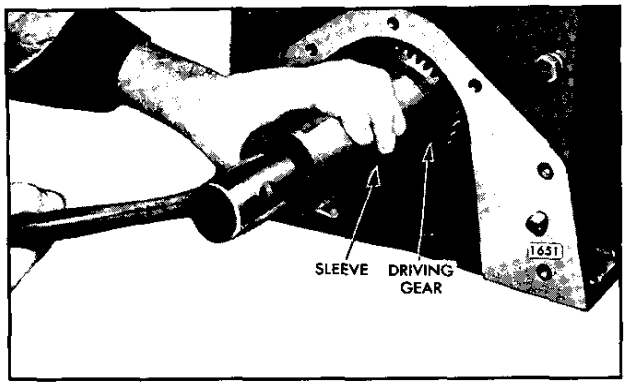


Fig. 9 - Installing Oil Pump Driving Gear on Crankshaft

Install Oil Pump

Refer to Fig. 2 and install the oil pump on the main bearing caps as follows:

1. Hold the pump assembly against the main bearing caps so the idler gear meshes with the driving gear on the crankshaft.

2. Insert the four bolts with lock washers through the mounting feet of the pump and into the bearing caps. Align the pump so that the teeth of crankshaft gear and the idler gear are parallel; then tighten the bolts to 35-39 lb-ft (47-53 Nm) cast iron cylinder block or 25-30 lb-ft (34-41 Nm) aluminum cylinder block and check clearance between the gear teeth with a feeler gage. Proper clearance between the crankshaft gear and idler gear is .005" minimum, .012" maximum (*Fig. 10*).

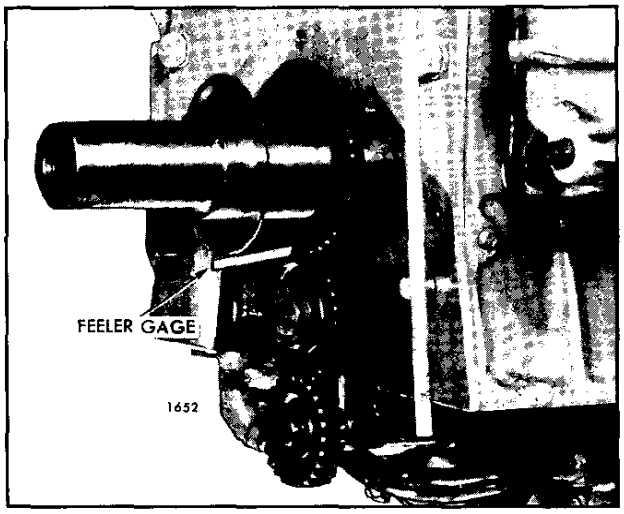


Fig. 10 - Measuring the Clearance Between the Teeth of the Oil Pump Driven Gears

NOTE: Always check the clearance between the crankshaft gear and the oil pump idler gear with the engine in the upright or *running* position.

If shims were used between the pump mounting feet and the bearing caps and new gears are *not* installed, the same shims (cleaned) or the same number of new (identical) shims should be installed and the number then adjusted to obtain the proper clearance between gear teeth. However, if new gears have been installed, a larger number of shims will be required under the mounting feet. In either event, the pump must be tightened on the bearing cap *before* the clearance between the gear teeth is measured.

NOTE: When adjusting for gear tooth clearance by installing or removing shims, the same number of shims must be changed under each foot so that the pump will always be level on the main bearing caps. The insertion or removal of one .005" shim will change the gear tooth clearance by .0035".

3. Place a new gasket between the outlet pipe and the pressure regulator and bolt the two parts together loosely. Use a new gasket and secure the outlet pipe to the oil pump body with the bolts not over 7/8" long. Attach the pressure regulator to the cylinder block using a new gasket.

When attaching the pump outlet and the pressure regulator, none of the bolts should be tightened until all the bolts have been started. After all bolts are started, the outlet pipe bolts should be tightened alternately, then the pressure regulator bolts should be tightened, and finally the pipe-to-regulator bolts should be secured. Current die cast regulators use bolts and self locking nuts. This procedure prevents twisting the outlet pipe.

4. Attach the pump screen brackets to the main bearing caps with lock washers and bolts. Do not tighten the bolts.

5. Affix a new gasket to the pump end of the inlet pipe, then attach the pipe to the oil pump.

6. Set the screen cover over the outer end of the oil inlet pipe and secure it to the pipe and brackets with bolts washer, lock washers and nuts. Tighten the bracket bolts to the bearing caps.

7. Place the screen in the cover and lock it in place with the retainer.

8. Affix a new gasket to the pump end of the

© 1982 General Motors Corp.

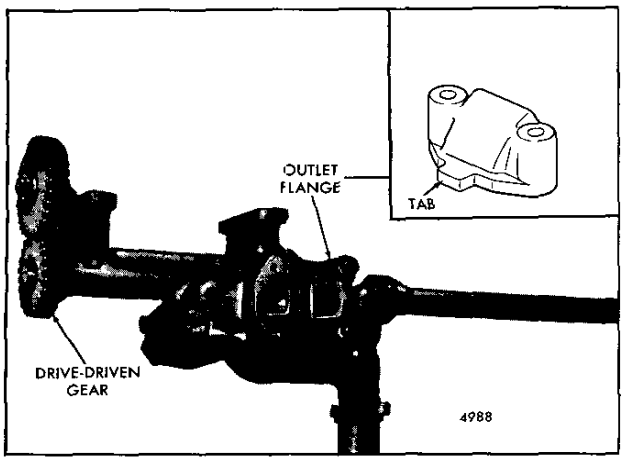


Fig. 11 - Oil Scavenging Outlet Flange Mounting

scavenging pump inlet pipe, if so equipped, and secure with bolts and lock washers.

On 3 and 4 cylinder engines equipped with the scavenging pump, the scavenging pump screen is part of the oil inlet tube; however, on 6 cylinder engines a separate screen is used. Install the scavenging pump screen, if used.

9. Affix a new gasket to the scavenging pump outlet pipe, then secure the pipe to the pump body with lock washers and bolts.

NOTE: When installing an outlet flange of the type illustrated in Fig. 11, be sure the opening in the flange is toward the front of the pump (toward the drive-driven gear).

10. Recheck all bolts for tightness to assure there will be no leaks in the oil pump and pipe mounting connections.

NOTE: On current engines a .20" longer connecting rod bolt is used which could interfere with the oil pump piping in the sump area. If there is interference, loosen the piping involved and retighten the bolts while holding the tubing away from the point of interference.

11. Place a new gasket on the oil pan and install the oil pan on the cylinder block. All the oil pan bolts should be started before any are tightened. Bolts should be tightened to 10-20 lb-ft (14-27 Nm) torque starting with the center bolts and working toward each end of the oil pan. Excessive tightening of the bolts will crush the oil pan gasket unnecessarily.

12. Fill the crankcase to the proper level with the oil recommended in the Lubrication Specifications in Section 13.3.

© 1982 General Motors Corp.

LUBRICATING OIL PRESSURE REGULATOR

Stabilized lubricating oil pressure is maintained within the engine at all speeds, regardless of the oil temperature, by an oil pressure regulator installed between the oil pump outlet pipe and the cylinder block.

The regulator assembly consists of a regulator body, a hollow piston-type valve, a spring and a plug to retain the valve and spring (Fig. 1). A new die cast lubricating oil pressure regulator assembly is now being using (Fig. 2).

The valve is held on its seat by the spring, which is compressed by the plug threaded into the valve opening in the regulator body. The entire assembly is bolted to the lower flange of the cylinder block and sealed against oil leaks by a gasket between the two members. When the oil pressure at the valve exceeds 50 psi (345 kPa), the valve is forced from its seat and oil from the engine oil gallery is by-passed to the oil pan.

Under normal conditions, the pressure regulator should require very little attention. If sludge accumulates in the lubrication system, the valve may not work freely, thereby remaining open or failing to open at the normal operating pressure.

Whenever the lubricating oil pump is removed for inspection, the regulator valve and spring should also be removed, thoroughly cleaned in fuel oil and inspected.

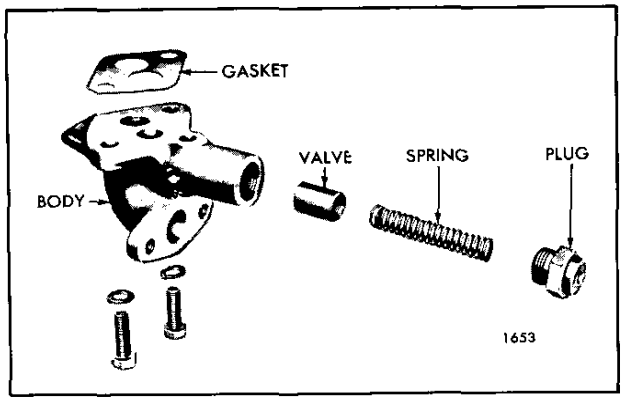


Fig. 1 - Lubricating Oil Pressure Regulator Details and Relative Location of Parts

Remove Oil Pressure Regulator

1. Remove the two oil pump outlet pipe to regulator attaching bolts and lock washers.

2. Remove the two regulator body-to-cylinder block bolts and lock washers.

3. Tap the lower end of the regulator body lightly to loosen the body from the gasket and cylinder block. Remove the gasket.

Disassemble Oil Pressure Regulator

1. Clamp the flange of the regulator body in a bench vise with soft jaws and remove the plug from the body.

2. Remove the spring and valve from the regulator body.

Inspection

Clean all of the regulator components in fuel oil and dry them with compressed air. Then inspect the parts for wear or damage.

The regulator valve must move freely in the valve body. If the valve or regulator body is scored and cannot be cleaned up with crocus cloth, they must be replaced.

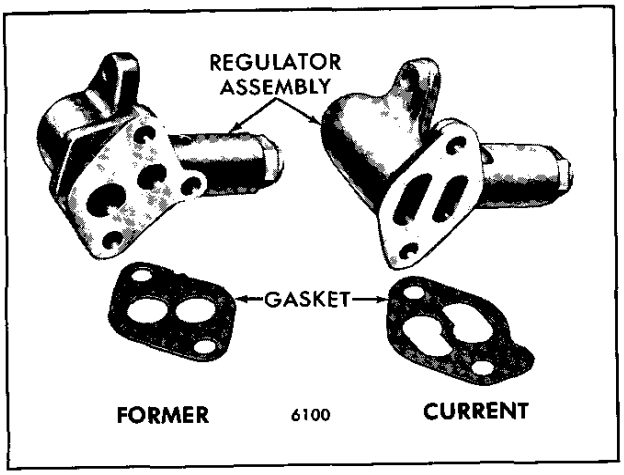


Fig. 2 - Lubricating Oil Pressure Regulator (Former and Current)

© 1979 General Motors Corp.

Replace a fractured or pitted spring.

Assemble Oil Pressure Regulator

Refer to Fig. 1 and assemble the regulator as follows:

1. Apply clean engine oil to the outer surface of the valve and slide it into the regulator body, closed end first.

2. Insert the spring in the valve and, while compressing the spring, start the plug into the regulator body. Tighten the plug.

Install Oil Pressure Regulator

1. Remove all traces of the old gasket from the regulator body, cylinder block and pump outlet pipe flange.

2. Affix a new gasket to the regulator body with the oil passage holes in the gasket in alignment with the oil passages in the body and secure the regulator to the cylinder block with two bolts.

> **NOTE:** When attaching a new regulator be sure the new gasket is installed so that the tab on the gasket faces the oil pump and crankshaft drive gears (lower front cover side).

3. Place a new gasket between the regulator and the pump outlet pipe and connect these parts together with two bolts.

© 1979 General Motors Corp.

LUBRICATING OIL FILTERS

In-line 71 engines are equipped with a full-flow type lubricating oil filter. A bypass type oil filter may be used in addition to the full-flow type filter when additional filtration is desired.

Full-Flow Oil Filter

The full-flow type lubricating oil filter is installed ahead of the oil cooler in the lubrication system. The filter may be remotely mounted or mounted on the engine as shown in Fig. 1.

The filter assembly consists of a replaceable element enclosed within a shell which is mounted on an adaptor or base. When the filter shell is in place, the element is restrained from movement by a coil spring.

All of the oil supplied to the engine by the oil pump passes through the filter before reaching the various moving parts of the engine. The oil is forced by pump pressure through a passage in the filter adaptor to the space surrounding the filter element. Impurities are filtered out as the oil is forced through the element to a central passage surrounding the center stud and out through another passage in the filter adaptor, and then, to the oil cooler.

A valve, which opens at approximately 18-21 psi (124-145 kPa), is located in the filter adaptor or base and will bypass the oil directly to the oil cooler should the filter become clogged.

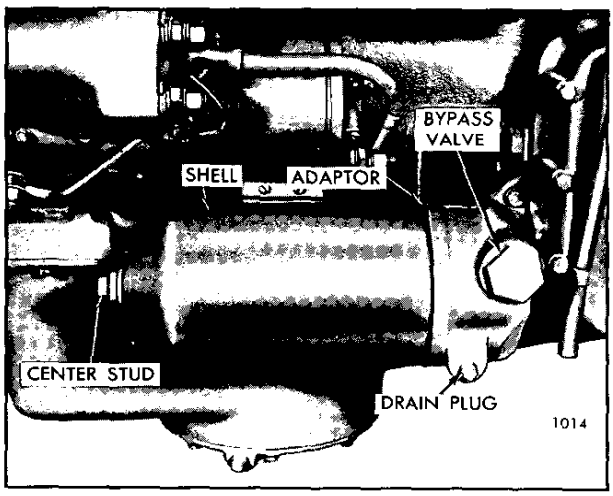


Fig. 1 - Typical Full-Flow Oil Filter Mounting (Canister)

Conversion adaptor kit (K-4) for spin-on, full-flow lube oil filters are now available as field replacement items for 6-71 engines.

NOTE: Spin-on filters should not replace filter assemblies on transmissions.

The spin-on lubricating oil filter (throwaway type) and mounting adaptor are now being installed on certain engines. The spin-on filter requires a new mounting adaptor which in some cases is part of the oil cooler cover.

Bypass Oil Filter

When additional filtration is desired, an oil filter of the bypass type (Fig. 2) may also be installed on the engine. However, *the size of the orifice on the discharge side of the filter must not exceed .062"* to control the

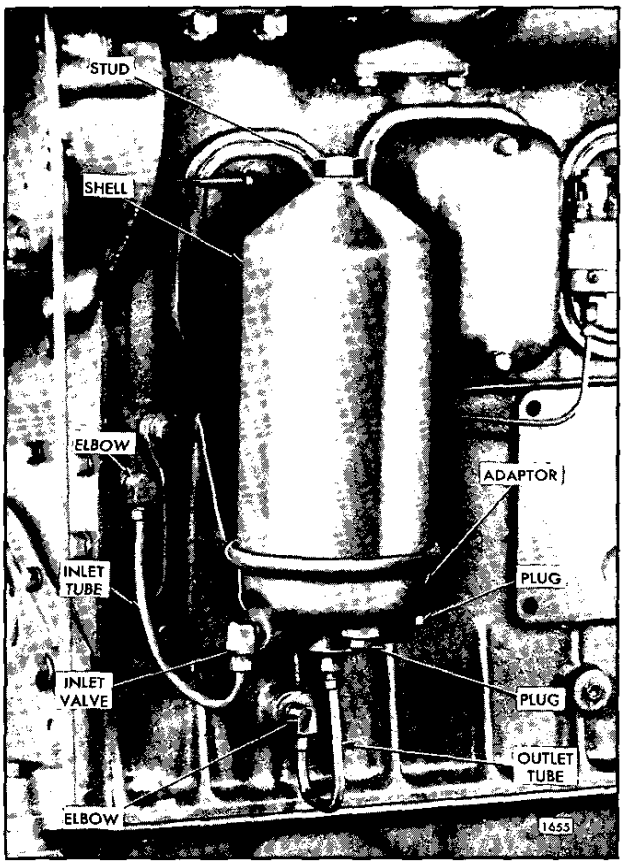


Fig. 2 - Typical Bypass Oil Filter Mounting (Canister)

© 1983 General Motors Corp.

oil flow rate and to provide sufficient oil pressure when the engine is running at idle speed.

When the engine is running, a portion of the lubricating oil is bled off the oil gallery and passed through the bypass filter. Eventually all of the oil passes through the filter, filtering out fine foreign particles that may be present.

The bypass filter assembly consists of a replaceable element contained in a shell mounted on a combination base and mounting bracket. When the shell is in place, the filter element is restrained from movement by a coil spring at the top. A hollow center stud serves as the outlet passage from the filter as well as securing the shell in place.

On certain applications, the bypass filter assembly consists of two replaceable elements, each contained in a separate steel shell with both mounted on a single adaptor (Fig. 4). The two filter elements operate in parallel since an oil passage in the filter adaptor connects with the annular space surrounding both elements.

Oil Filter Maintenance

With the use of detergent lubricating oils, the color of the lubricant has lost value as an indicator of oil cleanliness or proper filter action. Due to the ability of the detergent compounds to hold minute carbon particles in suspension, heavy duty oils will always appear dark colored on the oil level dipstick.

Heavy sludge deposits found on the filter elements at the time of an oil change must be taken as an indication that the detergency of the oil has been exhausted. When this occurs, the oil drain interval should be shortened. The removal of abrasive dust, metal particles and carbon must be ensured by replacement of the oil filter elements at the time the engine oil is changed.

Selection of a reliable oil supplier, strict observation of his oil change period recommendations and proper filter maintenance will ensure trouble-free lubrication and longer engine life.

Replace Oil Filter Element (Canister)

Replace the element in either the full-flow or bypass type oil filter assembly (Figs. 3 and 4) as follows:

1. Remove the drain plug from the filter shell or the filter adaptor or base and drain the oil.

2. Back out the center stud and withdraw the shell, element and stud as an assembly. Discard the element and the shell gasket.

3. Remove the center stud and gasket. Retain the gasket unless it is damaged and oil leaks occurred.

4. Remove the nut or snap ring on the full-flow filter center stud.

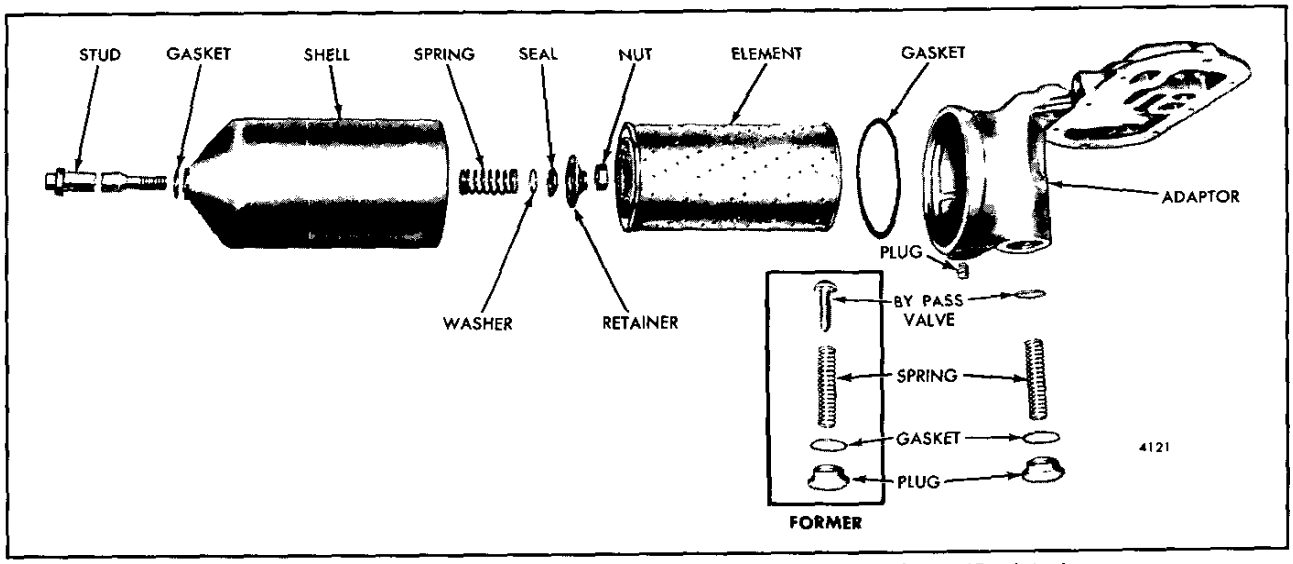


Fig. 3 - Full-Flow Oil Filter Details and Relative Location of Parts (Canister)

© 1983 General Motors Corp.

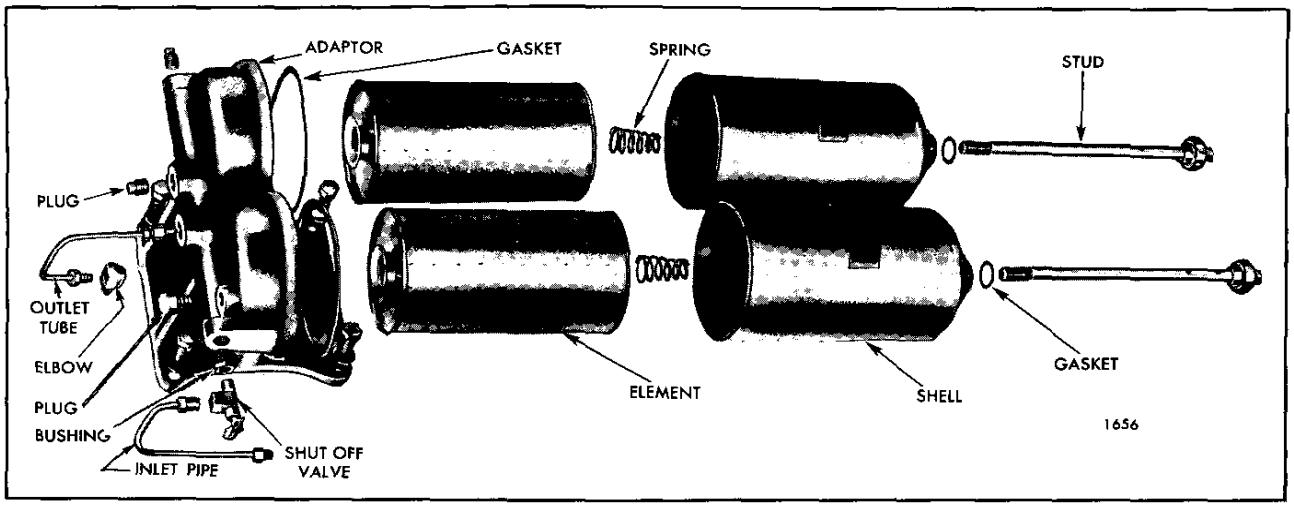


Fig. 4 - Bypass Type Oil Filter Details and Relative Location of Parts (Canister)

NOTE: The center stud on the current full-flow oil filter has been revised by removing the snap ring groove and increasing the 5/8"-18 thread length approximately 1/2". To conform with this change, a 5/8"-18 nut replaces the snap ring formerly used to retain the filter spring and seal.

5. Remove and discard the element retainer seal (Fig. 3). Install a new seal.

6. Clean the filter shell and the adaptor or base.

7. Install the center stud gasket and slide the stud (with the spring, washer, seal and retainer installed on the full-flow filter stud) through the filter shell.

8. Install a new shell gasket in the filter adaptor or base.

NOTE: Before installing the filter shell gasket, be sure all of the old gasket material is removed from the filter shell and the adaptor or base. Also, make sure the gasket surfaces of the shell and the adaptor or base have no nicks, burrs or other damage.

9. Position the new filter element carefully over the center stud and within the shell. Then, place the shell, element and stud assembly in position on the filter adaptor or base and tighten the stud to 50-60 lb-ft (68-81 Nm) torque.

10. Install the drain plug.

11. Start and run the engine for a short period and check for oil leaks. After any oil leaks have been corrected and the engine has been stopped long enough (approximately twenty minutes) for the oil from various parts of the engine to drain back to the crankcase, add sufficient oil to bring it to the proper level on the dipstick.

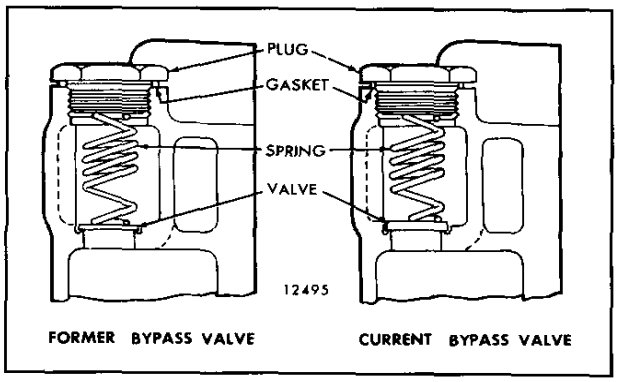


Fig. 5 - Bypass Valve

Replace Oil Filter (Spin-On)

1. Remove the oil filter using strap wrench tool J 29017 which must be used with a 1/2" drive socket wrench and extension.

2. Discard the used oil filter.

3. Clean the filter adaptor with a clean, lint-free cloth.

4. Lightly coat the oil filter gasket (seal) with clean engine oil.

© 1983 General Motors Corp.

5. Start the new filter on the adaptor and *tighten by hand* until the gasket touches the mounting adaptor head. Tighten an additional two-thirds turn.

NOTE: Mechanical tightening will distort or crack the filter adaptor.

6. Start and run the engine for a short period and check for oil leaks. After any oil leaks have been corrected and the engine has been stopped long enough for oil from the various parts of the engine to drain back to the crankcase (approximately twnety minutes), add sufficient oil to raise the oil level to the proper mark on the dipstick.

Remove and Install Bypass Valve

1. If necessary, remove the filter adaptor from the engine.

2. Remove the plug and gasket and withdraw the spring and bypass valve (Fig. 3).

3. Wash all of the parts in clean fuel oil and dry them with compressed air.

4. Inspect the parts for wear. If necessary, install new parts.

5. Reassemble and install the bypass valve. Use only the current bypass valve and spring for service (Fig. 5). The current thicker valve and stiffer spring increase the bypass pressure from 13-18 psi (90-124 kPa) to 18-21 psi (124-145 kPa) to permit more efficient filtration. Tighten the 1 1/4"-16 bypass valve plug to 95-105 lb-ft (129-143 Nm) torque.

NOTE: The current and early design (inset, Fig. 3) bypass valves are not interchangeable.

6. Use a new gasket and install the filter adaptor.

© 1983 General Motors Corp.

OIL COOLER

In order to perform its functions satisfactorily, the lubricating oil must be kept within the proper temperature limits. If the oil is too cold, it wil not flow freely. If the oil is too hot, it cannot support the bearing loads, it cannot carry away enough heat, and it may result in too great an oil flow. As a consequence, oil pressure may drop below acceptable limits and oil consumption may become excessive.

In performing its lubricating and cooling functions, the oil absorbs a considerable amount of heat and this heat must be dissipated by an oil cooler.

The engine oil cooler is located in the bottom section of the expansion tank on 6 cylinder engines equipped with a heat exchanger or keel cooling system (Fig. 1). On 3 and 4 cylinder engines, the lubricating oil cooler is mounted on the side of the cylinder block near the water pump.

On fan and radiator cooled engines, the lubricating oil cooler is usually located on the side of the engine just below the water pump (Fig. 3).

To assure engine lubrication if the oil cooler becomes clogged, a bypass valve located at the oil inlet to the cooler bypasses oil around the cooler directly to the oil gallery in the cylinder block.

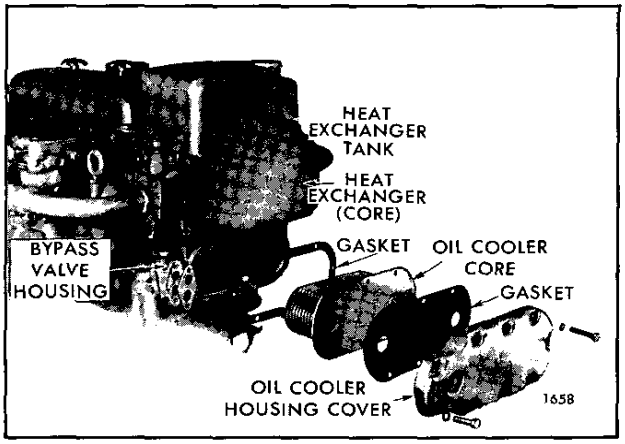


Fig. 2 - Lubricating Oil Cooler and Bypass Valve Details and Relative Location of Parts

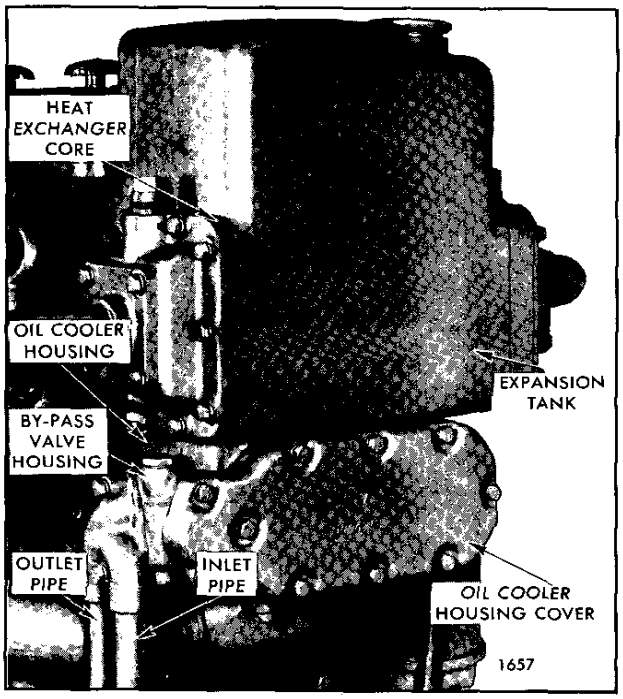


Fig. 1 - Typical Lubricating Oil Cooler Mounting-Heat Exchanger Cooled Engine

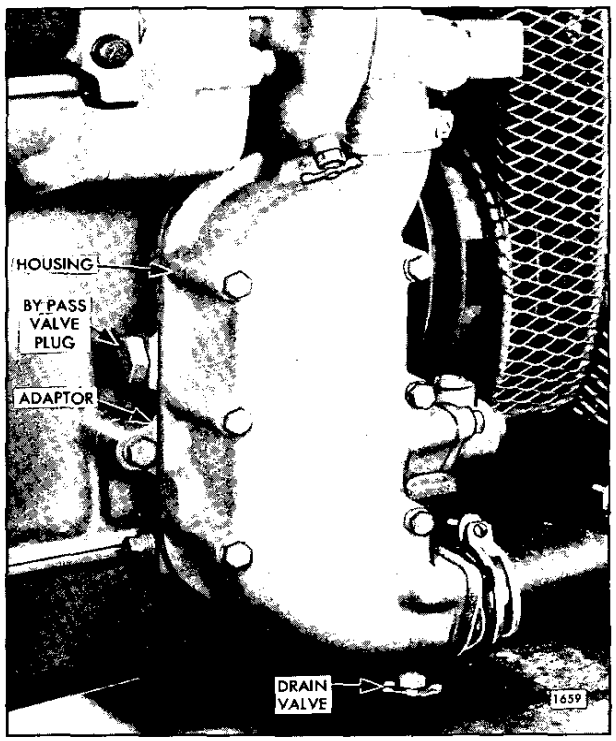


Fig. 3 - Typical Lubricating Oil Cooler Mounting-Radiator Cooled Engine

© 1982 General Motors Corp.

The core through which the oil passes while being cooled is sealed to prevent coolant from getting into the oil. Whenever an oil cooler is assembled, special care must be taken to have the proper gaskets in place and the retaining bolts tight.

In order to standardize, a new aluminum oil cooler cover has replaced two cast iron covers. The new oil cooler cover has two inlet holes (to filter) and two outlet holes (from filter). One each of these holes must be plugged when the new cover is used (Fig. 4). Different attaching bolts are required because of varying cover flange thicknesses. Only the new aluminum oil cooler will be serviced.

Remove Lubricating Oil Cooler Core (Heat Exchanger Cooled Engine)

The oil cooler core may be removed from the housing for cleaning and inspection without removing the oil cooler housing from the engine as follows:

1. Drain the cooling system.

2. Remove two bolts which hold the bypass valve housing to the oil cooler housing cover (Fig. 2).

3. Remove eight bolts and lock washers around the edge of the oil cooler housing cover.

4. Remove the cover and three gaskets - one between the cooler core and the housing, one between the core and the cover, and one between the cover and the bypass valve housing. When the cover is removed, the oil cooler core is free in the housing. Guard against the core falling from the housing when removing the cover.

5. Remove all traces of gasket material from the cylinder block and the oil cooler components.

6. If the openings are not marked *IN* and *OUT* on the oil cooler it is suggested that they be marked before reinstalling the oil cooler.

Clean Oil Cooler Core

1. **Clean Oil Side of Core** - Circulate a solution of trichloroethylene through the core passages with a force pump to remove carbon and sludge.

> **CAUTION:** This operation should be done in the open or in a well ventilated room when trichloroethylene or other toxic chemicals are used for cleaning.

Clean the core before the sludge hardens. If the oil passages are badly clogged, circulate an Oakite or alkaline solution through the core and flush thoroughly with clean hot water.

2. **Clean Water Side of Core** - After cleaning oil side of the core, immerse it in the following solution: add one-half (1/2) pound of oxalic acid to each two and one-half (2 1/2) gallons of solution composed of one-third (1/3) muriatic acid and two-thirds (2/3) water. The cleaning action is evidenced by bubbling and foaming. The process must be carefully watched and, when bubbling stops (this usually takes from 30 to 60 seconds), the core should be removed from the

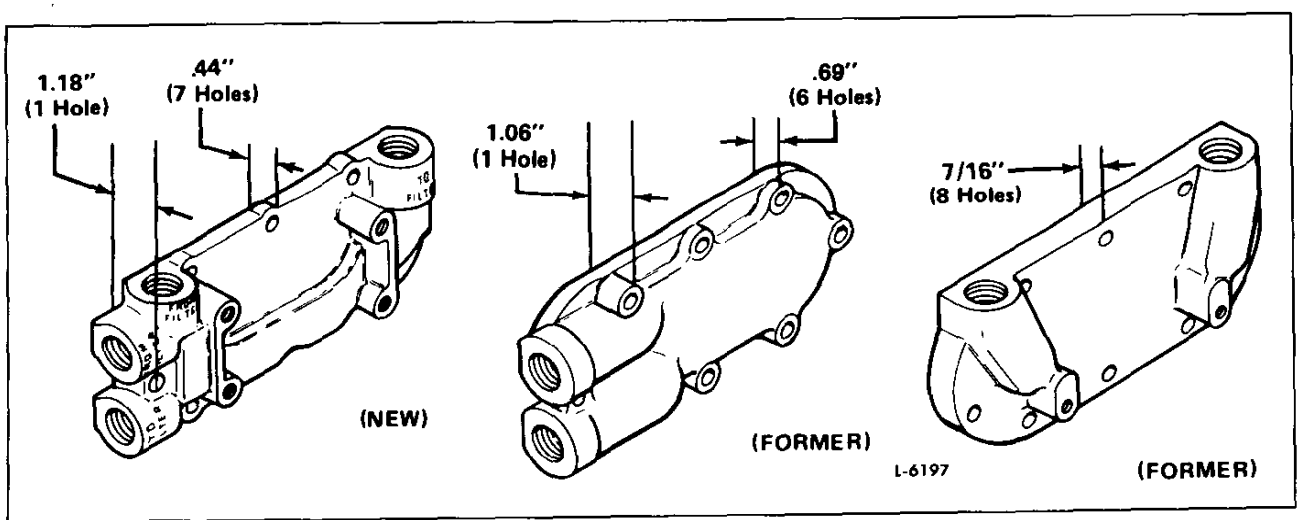


Fig. 4 - Oil Cooler Cover

© 1982 General Motors Corp.

cleaning solution and thoroughly flushed with clean hot water. After cleaning, dip the core in light oil.

NOTE: Do not attempt to clean an oil cooler core when an engine failure occurs in which metal particles from worn or broken parts are released into the lubricating oil. In this instance, replacement of the oil cooler core is strongly recommended.

Pressure Check Oil Cooler Core

1. Make a suitable plate and attach it to the flanged side of the oil cooler core. Use a gasket made from rubber to ensure a tight seal. Drill and tap the plate to permit an air hose fitting to be attached at the inlet side of the oil cooler core (Fig. 5).

2. Attach an air hose and apply 75-150 psi (517-1 034 kPa) air pressure. Then, submerge the oil cooler core and plate assembly in a tank of heated water (180 °F or 82 °C). Any leaks will be indicated by air bubbles in the water.

CAUTION: When making this pressure test be sure that personnel are adequately protected against any stream of pressurized water from a leak or rupture of a fitting, hose or the oil cooler core.

3. After the pressure check is completed, remove the plate and air hose and dry the oil cooler core with compressed air. Replace the oil cooler core if leaks were indicated.

NOTE: In cases where a leaking oil cooler core has caused contamination of the engine, the engine must be flushed immediately to prevent serious damage (refer to Section 5).

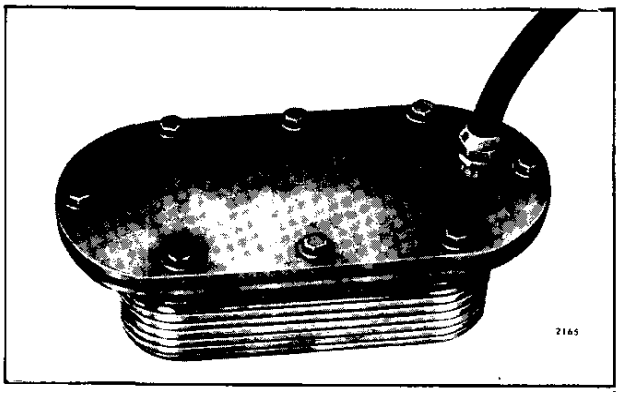


Fig. 5 - Oil Cooler Core Prepared for Pressure Check

Install Lubricating Oil Cooler Core (Heat Exchanger Cooled Engine)

The oil cooler core may be installed by reversing the sequence of operations given for removal as follows:

1. Affix new gaskets to the inner and outer faces of the core (Fig. 2). Insert the core into the housing.

NOTE: The inlet and outlet openings in the oil cooler core are marked "IN" and "OUT". Make sure the oil cooler core is reinstalled in its original position, otherwise the oil flow will be reversed and could result in foreign particles that may not have been removed to be loosened and circulated through the engine.

2. Affix a new cover-to-bypass valve housing gasket to the bypass valve housing.

3. Position the cover so that the two holes for the bolts in the cover align with the two holes in the bypass valve housing.

4. Install eight bolts and lock washers.

5. Install two bolts with lock washers through the cover and into the bypass valve housing.

6. Tighten the bolts.

7. Open the vent valve, fill the cooling system, and check for leaks. Close the vent valve.

Remove Lubricating Oil Cooler (Radiator Cooled Engine)

1. Drain the cooling system by opening the drain valve at the bottom of the oil cooler housing (Fig. 3).

2. Remove the bolts and lock washers that attach the water inlet connector to the oil cooler housing.

3. Loosen the clamp on the water pump inlet seal.

4. Remove the bolts attaching the oil cooler housing to the adaptor, and remove the housing and core as an assembly. Be careful when withdrawing the assembly not to drop or damage the oil cooler core.

5. Remove all traces of gasket material from the oil cooler components.

6. If the core openings are not marked *IN* and *OUT*, mark the openings.

7. If the adaptor is to be removed, remove the bolts that hold the adaptor to the cylinder block and remove the adaptor and gaskets.

(c) 1982 General Motors Corp.

8. Clean the oil cooler core as outlined under *Clean Oil Cooler Core.*

9. Pressure check the oil cooler core as outlined under *Pressure Check oil Cooler Core.*

Install Lubricating Oil Cooler (Radiator Cooled Engine)

Refer to Fig. 6 and install the lubricating oil cooler as follows:

1. If the oil cooler adaptor was removed from the cylinder block, remove the old gaskets from the bosses where the adaptor sets against the block. Affix new adaptor to cylinder block gaskets; then secure the adaptor to the cylinder block with bolts, lock washers and copper washer.

NOTE: The copper washer must be installed on the second bolt from the bottom of the oil cooler adaptor to prevent leakage of oil from the adaptor.

2. Affix new gaskets and to each side of the core and position the core inside the housing.

NOTE: The inlet and outlet openings in the oil cooler core are marked "IN" and "OUT". Make sure the oil cooler core is reinstalled in its original position, otherwise the oil flow will be reversed and could result in foreign particles that may not have been removed to be loosened and circulated through the engine.

3. Set the housing with the cooler core against the adaptor and secure with bolts and lock washers, at the same time locating the seal and clamp. Tighten the clamp (Fig. 3).

4. Affix a new gasket to the oil cooler water inlet connector and secure with bolts and lock washers.

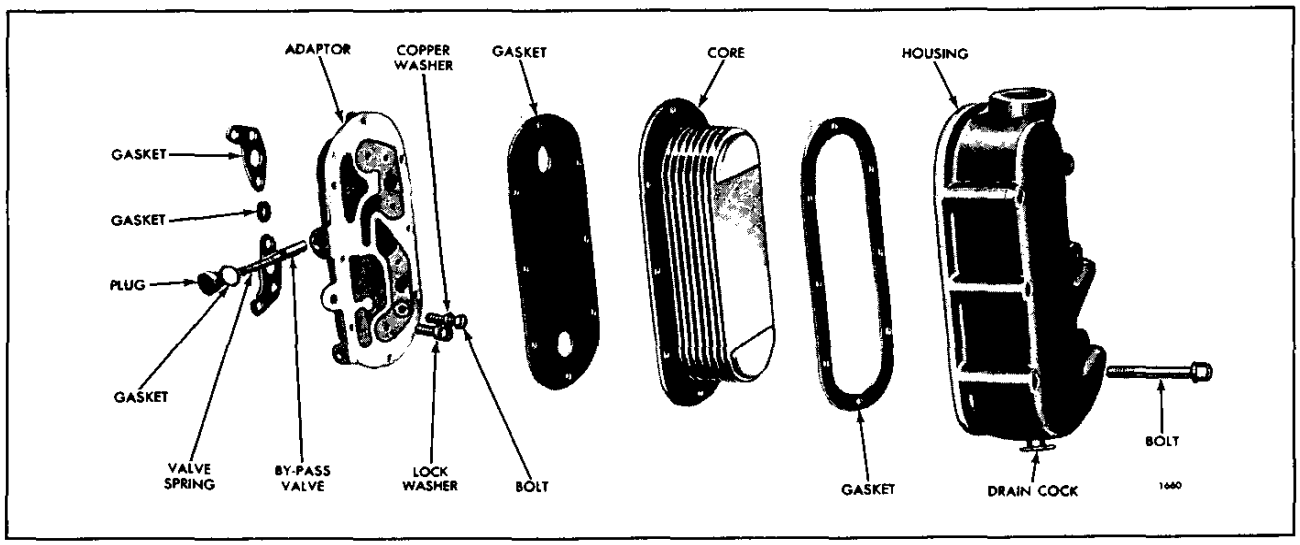


Fig. 6 - Lubricating Oil Cooler and Bypass Valve Details and Relative Location of Parts

© 1982 General Motors Corp.

LUBRICATING OIL COOLER BYPASS VALVE

To assure proper lubrication if the oil cooler core becomes clogged, a valve, located between the oil inlet and the core, bypasses the oil around the cooler directly to the oil gallery in the cylinder block.

On units where the oil cooler is mounted below the heat exchanger, the bypass valve is a self-contained unit consisting of a valve, spring, plug and gasket in a housing (Fig. 2).

When the oil cooler is mounted at the side of the engine, the bypass valve, spring, plug and gasket are housed in the oil cooler adaptor (Fig. 3).

The bypass valve should be removed, cleaned and reassembled whenever the cooler core is cleaned or replaced. However, if occasion requires, the bypass valve can be removed without removing the oil cooler.

Remove Bypass Valve

The bypass valve may be removed by removing the plug and lifting the gasket, valve and spring from the housing (Fig. 2) or adaptor (Fig. 3).

Remove Bypass Valve Housing (Oil Cooler Below Heat Exchanger)

1. Remove the bolts and lock washers which attach the oil inlet and outlet tube assembly to the bypass valve housing (Fig. 2).

2. Hold the valve housing and remove the bolts and lock washers which secure the bypass valve housing to the oil cooler cover (Fig. 2).

Inspection

Clean the bypass valve components with fuel oil and dry them with compressed air.

Inspect the valve parts for wear and replace the parts if necessary.

Install Bypass Valve

1. Apply clean engine oil to the outside surface of the bypass valve and place the valve in the housing or adaptor, closed end first.

2. Slide the valve spring into the valve and screw the plug, with the gasket, into the housing or adaptor.

Install Bypass Valve Housing (Oil Cooler Below Heat Exchanger)

1. Coat new gaskets with grease and affix to the bypass valve housing (Fig. 2).

2. Place the bypass valve housing in position and install the bolts and lock washers through the oil cooler cover and into the valve housing.

3. Attach the oil inlet and outlet tube assembly to the valve housing with bolts and lock washers.

© 1982 General Motors Corp.

OIL LEVEL DIPSTICK

A steel ribbon-type oil level dipstick is used to check the quantity of oil in the engine oil pan. The dipstick is located in an adaptor attached, by means of a guide, to an opening in the cylinder block or the oil pan. The current engines include a 3/4 " long rubber oil seal which prevents the escape of vapors carrying oil from the dipstick tube.

Maintain the oil level between the full and low marks on the dipstick and never allow it to drop below the low mark. No advantage is gained by having the oil level above the full mark. Overfilling will cause the oil to be churned by the crankshaft throws causing foaming or aereation of the oil. Operation below the low mark will expose the pump pick-up causing aereation and/or loss of pressure.

Check the oil level after the engine has been stopped for a minimum of twenty minutes to permit oil in the various parts of the engine to drain back into the oil pan.

Dipsticks are normally marked for use only when the equipment the engine powers is on a level surface. Improper oil levels can result if the oil level is checked with the equipment on a grade.

Fill the crankcase with oil as follows:

1. Fill the oil pan to the full mark on the dipstick.

2. Start and run the engine for approximately ten minutes.

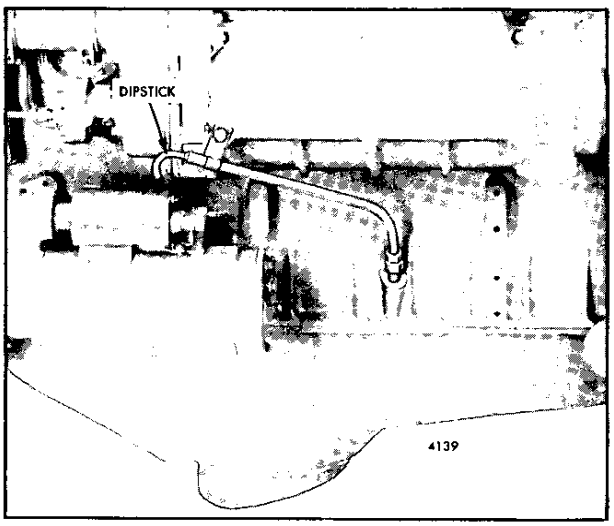


Fig. 1 - Typical Dipstick Mounting

3. Stop the engine and wait a minimum of twenty minutes. Then add the required amount of oil to reach the full mark on the dipstick.

Marine Engines

The oil level dipstick in all current marine engines, except the side-tilt models, is marked. The dipstick is now located at the point where the oil level remains relatively constant regardless of the angle of installation.

However, the dipstick furnished with earlier marine engines is marked after the engine is installed and the boat is afloat. The markings depend upon the installation angle, capacity of the oil pan, and the location of the dipstick.

A deep oil pan is used where the maximum installation is 20 °, and a shallow pan is used where the maximum installation angle is 10 °. The oil capacity varies with the type of oil pan as indicated in Table 1.

The installation angle of a marine engine will vary considerably when installed in different makes and types of boats. In a properly filled crankcase, the oil level must be below the crankshaft rear oil seal when the boat is at rest.

The dipstick used on an early unit may be marked, after the engine is installed in the boat, in accordance with the following procedure:

1. Remove the dipstick and wipe it clean.

2. Add the proper quantity of oil, as indicated in Table 1, to fill the oil pan to the *low* level.

*Engine	Dipstick Mark	Deep Pan			Shallow Pan		
		Install. Angle	Capacity qts.	Capacity litres	Install. Angle	Capacity qts.	Capacity litres
3-71	Full	0° -20°	12.7	12.0	0° -10°	16	15.1
	Low	0° -20°	9.7	9.2	0° -10°	14	13.2
4-71	Full	0° -20°	14.5	13.7	0° -10°	21	19.9
	Low	0° -20°	10.0	9.5	0° -10°	18	17.0
6-71	Full	0° -20°	21.6	20.4	0° -10°	31	29.3
	Low	0° -20°	13.5	12.8	0° -10°	26	24.6

*Engines built since 1959.

NOTE: Engine filters require an additional two quarts (1.9 litres).

TABLE 1

© 1979 General Motors Corp.

3. Insert the dipstick. Then remove the dipstick and center-punch it at the level shown to establish the *low* mark.

NOTE: Two center-punch marks, side-by-side, may be used to mark the dipstick. Do not use a chisel or file for marking, as this will weaken the steel ribbon of the dipstick.

4. Add 3 quarts (2.8 litres) of oil to 3-71 and 4-71 engines and 5 quarts (4.7 litres) of oil to the 6-71 engines.

5. Insert the dipstick. Then remove the dipstick and center-punch it at the level shown to establish the *full* mark.

6. Pour one quart (.9 litres) of oil over the valve and injector operating mechanism to provide initial lubrication.

7. Start and run the engine for approximately ten minutes to fill the oil filters, oil passages, etc. Then stop the engine. After the engine has been stopped for a minimum of twenty minutes to allow the oil to drain back to the oil pan, add oil as required to bring the oil level up to the *full* mark on the dipstick.

© 1979 General Motors Corp.

OIL PAN

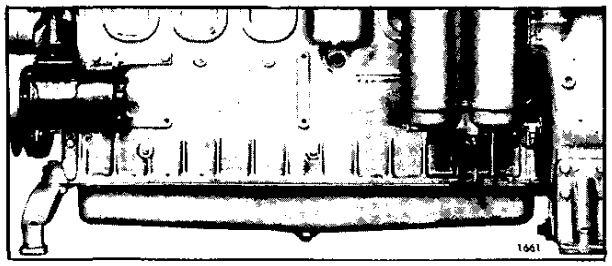


Fig. 1 - Typical Shallow-Type Oil Pan

A shallow type oil pan is used on engines where the longitudinal inclination ranges from 0° -10° (Fig. 1). On installations where the inclination angle is greater than 10° , engines are equipped with a deep sump oil pan (Fig. 2).

A sectional oil pan gasket is used on six-cylinder engines equipped with a cast iron oil pan. The gasket consists of two side sections and two end sections.

A one-piece gasket is used on six-cylinder engines equipped with a stamped metal oil pan and on all three and four cylinder engines.

Remove and Install Oil Pan

1. Remove the drain plug and drain the oil.

2. Remove the bolt and washer assemblies. Then, remove the oil pan and gasket.

> **NOTE:** The stamped metal oil pans used on some marine engines have a thin protective coating to shield the metal against the action of a salt water atmosphere. Therefore, do not rest, slide or rock the engine on its oil pan. If the surface of the oil pan is scratched, electrolysis will take place and damage to the oil pan will result. Also, exercise care when performing engine repairs, to avoid scratching the outer surfaces of the oil pan.

3. Clean all of the old gasket material from the cylinder block and the oil pan. Then, clean the oil pan with fuel oil and dry it with compressed air.

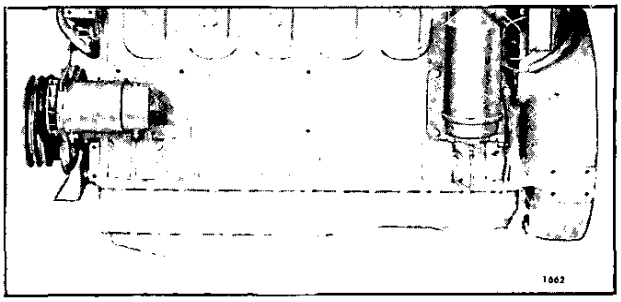


Fig. 2 - Typical Deep Sump-Type Oil Pan

4. Inspect a cast oil pan for porosity or cracks. Check a stamped oil pan for dents or breaks in the metal which may necessitate repair or replacement. Check for misaligned flanges or raised surfaces surrounding the bolt holes by placing the pan on a surface plate or other large flat surface.

5. When installing the oil pan, use a new gasket and, starting with the center bolt on each side and working alternately toward each end of the pan, tighten the bolts to 10-20 lb-ft (14-27 Nm) torque. *Do not overtighten the bolts.* Once the bolts are tightened to the specified torque, do not retighten them as it could be detrimental to the current type oil pan gasket. If a leak should develop at the oil pan, check if the lock washer is compressed. If not, the bolt may be tightened. However, if the lock washer is compressed and leaking occurs, remove the oil pan and determine the cause of the leakage.

> **NOTE:** Current oil pan bolts (stamped metal pans) are coated with a locking material. To reactivate the locking ability of the bolts, apply a drop or two of Loctite or equivalent, to the threads of the bolts at reassembly.

6. Install and tighten the drain plug to 25-35 lb-ft (34-47 Nm) (refer to Section 4.0).

7. Fill the oil pan with new oil (refer to Sections 4.6 and 13.3) to the full mark on the dipstick. Then, start and run the engine for a short period to check for oil leaks.

8. Stop the engine and, after approximately twenty minutes, check the oil level. Add oil, if necessary.

© 1984 General Motors Corp.

VENTILATING SYSTEM

Harmful vapors which may be formed within the engine are removed from the crankcase, gear train and valve compartments by a continuous pressurized ventilating system.

A slight pressure is maintained in the engine crankcase by the seepage of a small amount of air from the air box past the piston rings. This air sweeps up through the flywheel housing and is admitted to the valve compartment through cavities in the lifter brackets and vent castings.

Ventilating air in the valve compartment is drawn off via the governor control housing through the breather pipe (Figs. 1 and 3), through a breather attached to the valve rocker cover or through a breather attached to the side of the cylinder block (Fig. 2).

To index the breather assembly exhaust outlet on the current aluminum die cast valve rocker covers, no disassembly is required. Insert a 1-1/8" diameter pipe or wood dowel into the breather outlet, apply pressure and rotate the outlet to the desired location.

The crankcase breather on diesel railcar units is mounted on the top of the oil pan (Fig. 4). Minute particles of lubricating oil, carried along with the moving vapors, are trapped in an oil separator within the breather and eventually returned to the crankcase. The vapors are exhausted to the atmosphere through the breather pipe.

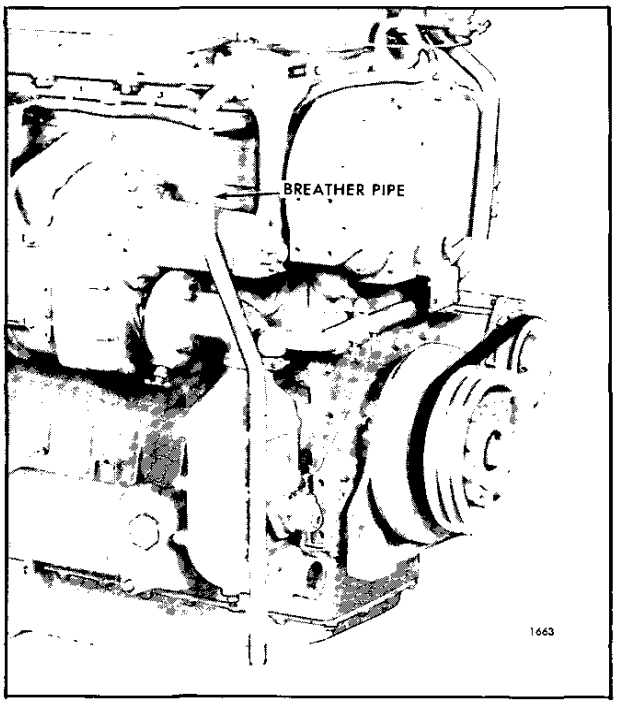


Fig. 1 - Breather Pipe Mounted on Governor

Service

Inspect and clean the breather tube or breather and baffle, if necessary, to eliminate the possibility of clogging. Remove the breather tube from the governor or the breather and baffle from the cylinder block. Wash with a suitable solvent and dry with compressed air.

The steel mesh pad should be removed and cleaned periodically (refer to Section 15.1).

To clean the breather assembly (Fig. 4):

1. Loosen the breather tube hose clamp adjacent to the breather cover and pull the hose off of the cover.

2. Remove the breather cover wing nut. Then lift the cover and clamp ring as an assembly from the breather.

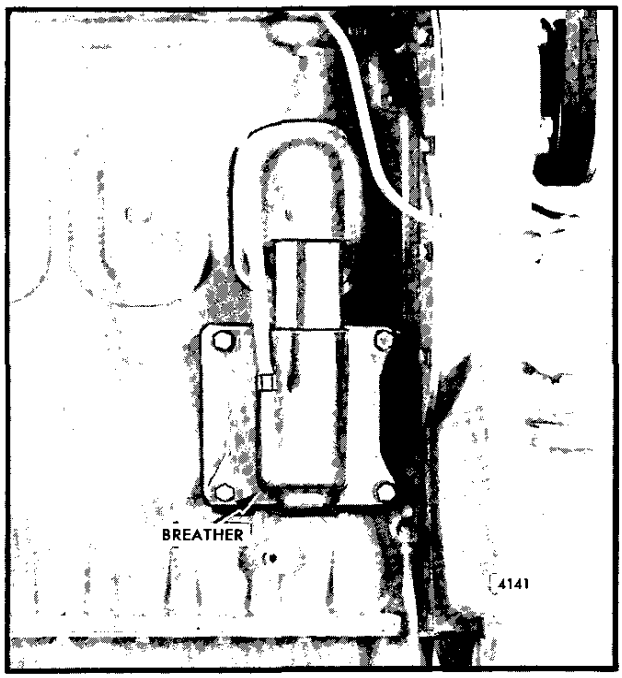


Fig. 2 - Breather Mounted on Cylinder Block

© 1980 General Motors Corp.

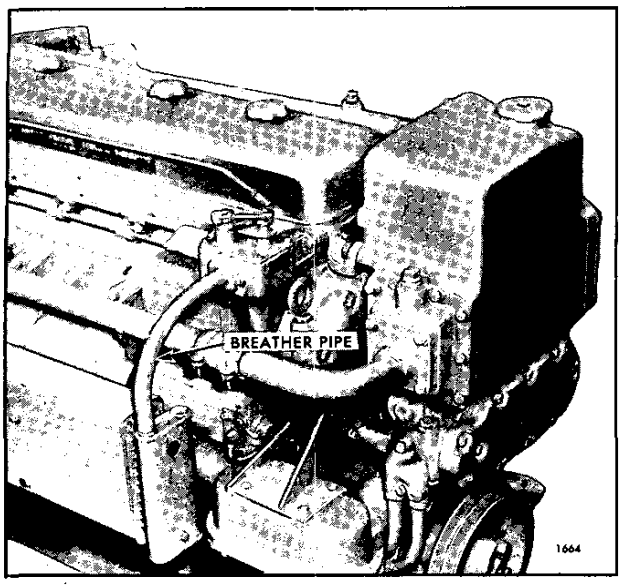


Fig. 3 - Typical Breather Pipe Mounting (Marine Engine)

3. Remove the four bolts, lock washers and flat washers securing the crankcase breather body to the engine oil pan. Then remove the body and breather as an assembly from the oil pan. Remove the body gasket.

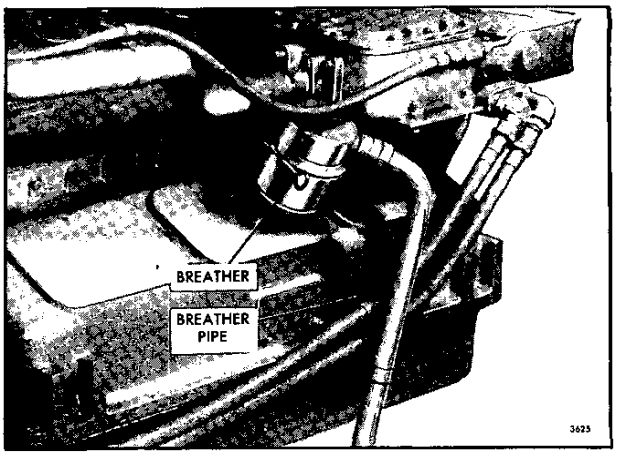


Fig. 4 - Crankcase Breather Oil Separator Mounting (Railcar Engine)

4. Remove the wing nut at the underside of the body. Then remove the breather and gasket from the body.

5. Wash the breather assembly and cover thoroughly in clean fuel oil and dry them with compressed air.

6. To reinstall the breather assembly, reverse the sequence used in removal, using new gaskets.

© 1980 General Motors Corp.

SHOP NOTES - SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

REVISING CRANKCASE BREATHER

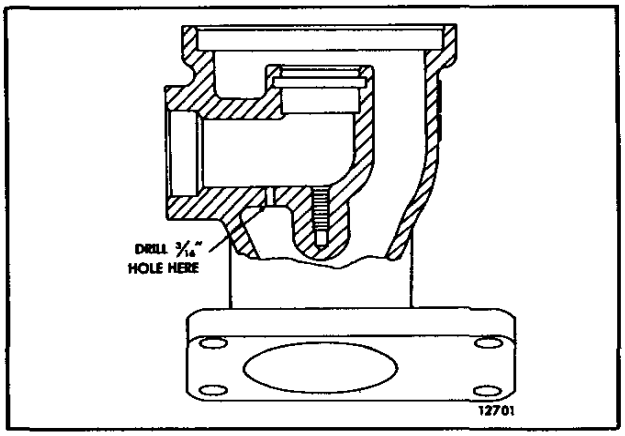


Fig. 1 - Revising Crankcase Breather

On occasion, oil accumulates in the crankcase breather body and pipe assembly used on the side-tilt marine propulsion engines and causes an increase in the crankcase pressure. This may be corrected in the following manner:

1. Remove the crankcase breather body.

2. Drill a 3/16" hole through the inner casting as illustrated in Fig. 1.

3. Remove all of the chips and clean the breather body.

4. Reinstall the breather body.

OIL COOLER AND FULL-FLOW OIL FILTER ADAPTOR REVISION

The method of sealing between the marine gear oil cooler-to-filter adaptor tubes and the full-flow oil filter adaptor was revised effective with engines 3A-30913, 4A-66536 and 6A-67924. Formerly, the seal rings were located in counterbores in the filter adaptor (Fig. 2-A). On current units, the counterbores have been eliminated from the adaptor, and chamfers were added to the tube flanges (Fig. 2-B).

When a new service filter adaptor is installed on former engines, new tube flanges must be used. The old flanges, which are brazed to the tubes, must be removed and the burrs cleaned from the tubes. Install the new flanges with the chamfered side facing *toward* the filter adaptor (Fig. 2-B). When a new tube assembly is used with the old adaptor, the flange must be installed with the chamfered side facing *away* from the adaptor (Fig. 2-C).

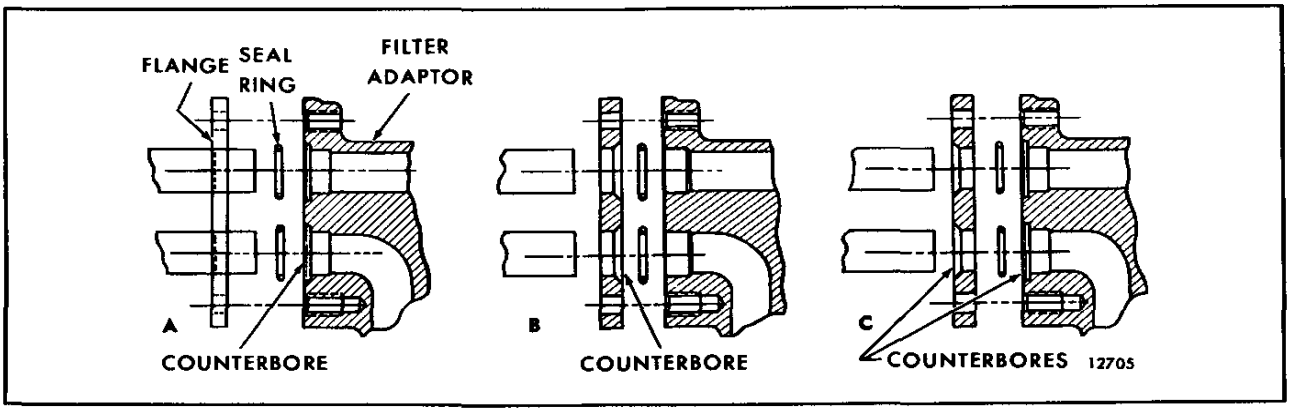


Fig. 2 - Methods of Sealing Marine Gear Oil Cooler-to-Filter Adaptor Tubes

© 1976 General Motors Corp.

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb-ft)	Nm	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	Nm
1/4 -20	5- 7	7- 9	1/4 -20	7-9	10-12
1/4 -28	6- 8	8-11	1/4 -28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8 -16	23-26	31-35	3/8 -16	30-35	41-47
3/8 -24	26-29	35-40	3/8 -24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2 -13	53-56	72-76	1/2 -13	71-75	96-102
1/2 -20	62-70	84-95	1/2 -20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8 -11	103-110	140-149	5/8 -11	137-147	186-200
5/8 -18	126-134	171-181	5/8 -18	168-178	228-242
3/4 -10	180-188	244-254	3/4 -10	240-250	325-339
3/4 -16	218-225	295-305	3/4 -16	290-300	393-407
7/8 - 9	308-315	417-427	7/8 - 9	410-420	556-569
7/8 -14	356-364	483-494	7/8 -14	475-485	644-657
1 - 8	435-443	590-600	1 - 8	580-590	786-800
1 -14	514-521	697-705	1 -14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74,000 60,000
Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

12252

BOLT IDENTIFICATION CHART

© 1976 General Motors Corp.

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	C.I. ENGINE TORQUE (lb-ft)	C.I. ENGINE TORQUE (Nm)	ALUM. ENGINE TORQUE (lb-ft)	ALUM. ENGINE TORQUE (Nm)
Oil pan bolts	5/16-18	10-20	14-27	10-20	14-27
Oil pump-to-bearing cap bolt	3/8 -24			25-30	34-41
Oil pump drive idler gear nut	1/2 -20	60-70	81-95	60-70	81-95
Oil pan drain plug (nylon washer)	18mm	25-35	34-47	15-25	20-34
Oil pump relief valve plug	7/8 -18	15-25	20-34		
By-pass valve plug	1 1/4-16	95-105	129-143		

STUD TORQUE SPECIFICATIONS

APPLICATION	TORQUE (lb-ft)	TORQUE (Nm)
Oil filter center stud	50-60	68-81

© 1983 General Motors Corp.

SERVICE TOOLS

TOOL NAME	TOOL NO.
Oil pump driving gear installer	J 22285
Spring tester	J 9666
Strap wrench (spin-on filter)	J 29917
Universal puller (range 4 " diam.)	J 24420-A
Universal puller (range 13 " diam.)	J 8190

© 1983 General Motors Corp.

SECTION 5

COOLING SYSTEM

CONTENTS

Cooling System	5
Water Pump	5.1
Water Manifold	5.2
Thermostat	5.2.1
Radiator	5.3
Pressure Control Cap	5.3.1
Engine Cooling Fan	5.4
Heat Exchanger	5.5
Raw Water Pump (Jabsco)	5.6
Raw Water Pump-Exhaust Cooling (Jabsco)	5.6.1
Raw Water Pump-Gear Type	5.6.2
Coolant Filter and Conditioner	5.7
Shop Notes - Specifications - Service Tools	5.0

COOLING SYSTEM

To effectively dissipate the heat generated by the engine, one of three different types of cooling systems is used on a Series 71 engine: radiator and fan, heat exchanger and raw water pump or keel cooling. A centrifugal type water pump attached to and driven by the blower, circulates the engine coolant in each system. A thermostat is utilized to maintain a normal engine operating temperature (refer to Section 13.2).

RADIATOR AND COOLING FAN

The engine coolant is circulated through the radiator (Fig. 1) where the heat is absorbed in the air stream developed by either a blower or suction fan which is belt driven from the crankshaft. The water pump draws the coolant through the oil cooler and discharges it into the lower part of the cylinder block. Openings in the water jacket around the cylinder bores connect with corresponding openings in the cylinder head through which the liquid rises to circulate around the valves and fuel injectors. Then the coolant passes through a water manifold, bolted to the cylinder head, past the thermostat and into the radiator.

Upon starting a cold engine or when the coolant is below operating temperature (thermostat closed) the coolant is by-passed from the water manifold directly to the pump, thus providing water circulation within the engine during the warm-up period.

© 1978 General Motors Corp.

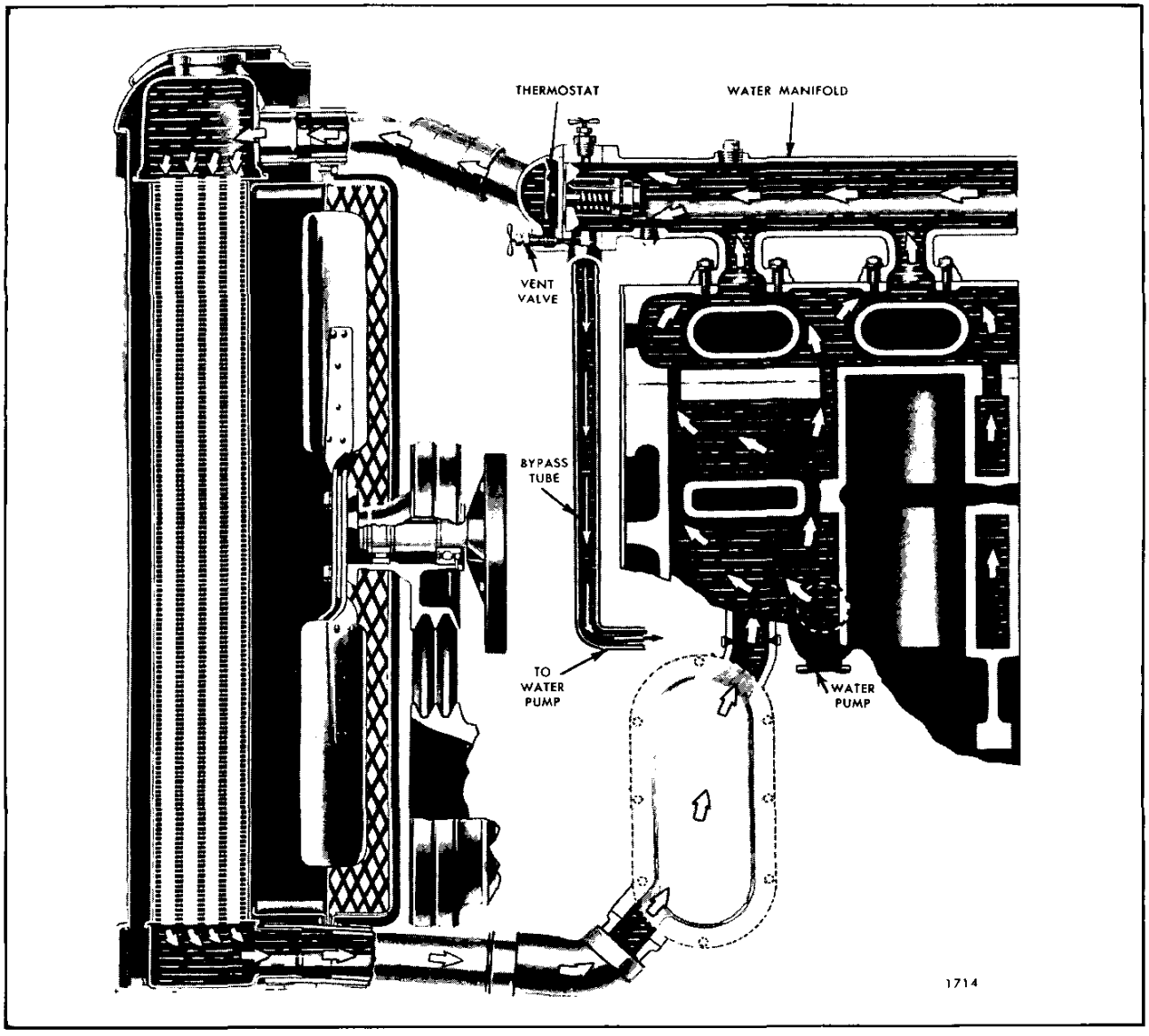


Fig. 1 - Typical Cooling System with Radiator and Fan

HEAT EXCHANGER COOLING SYSTEM

In the heat exhanger cooling system (Fig. 2), as applied to 3 and 4 cylinder units, the coolant is drawn by the circulating pump from the bottom of the expansion tank through the reverse gear oil cooler and engine oil cooler. On 6 cylinder single engine units, circulation is first through the engine oil cooler, then the reverse gear oil cooler, then through the engine. Openings in the water jacket around the cylinder bores connect with corresponding openings in the cylinder head through which the liquid rises to circulate around the valves and fuel injectors. Upon leaving the cylinder head, the coolant flows through the water manifold into the thermostat housing.

Upon leaving the thermostat housing, the coolant either flows down through the tubes of the heat exchanger element (core) and through the oil coolers from whence it returns to the water pump, or the coolant by-passes the heat exchanger and oil coolers

© 1978 General Motors Corp.

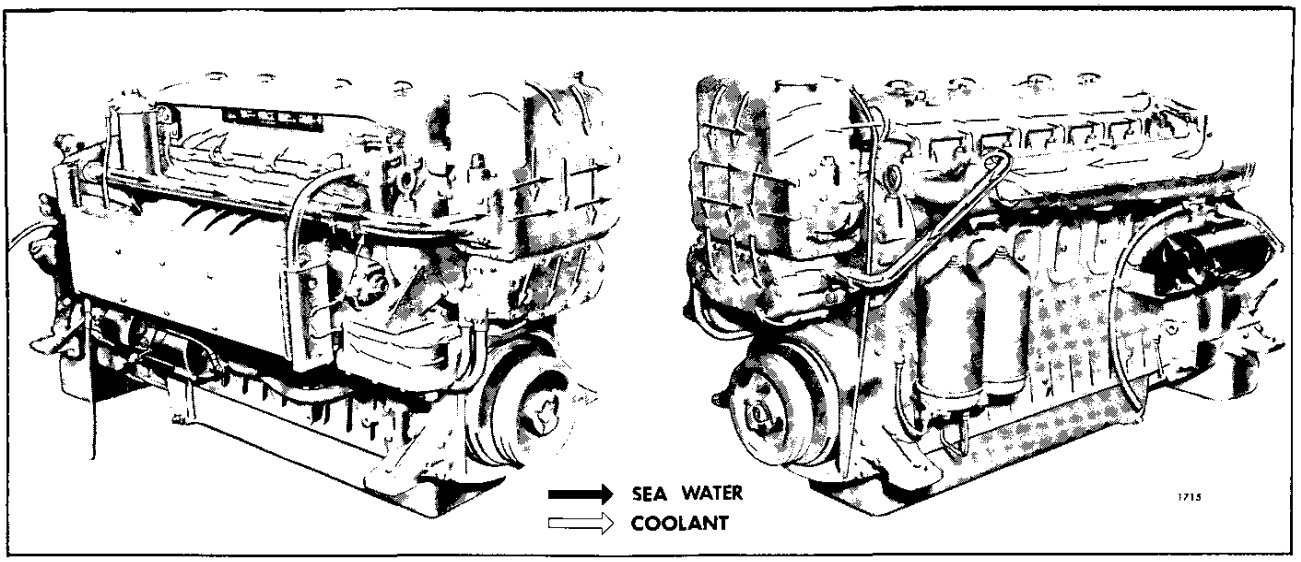


Fig. 2 - Typical Heat Exchanger Cooling System

and returns directly to the water pump, depending upon the coolant temperature.

As illustrated in Fig. 2, a portion of the engine coolant is always bypassed from the rear end of the water manifold into the rear end of the jacket surrounding the exhaust manifold. After circulating the length of the exhaust manifold, this coolant passes through a tube into the lower oil cooler section of the expansion tank.

KEEL COOLING SYSTEM

The keel cooling system (Fig. 3) is similar to the heat exchanger system, except heat transfer takes place in the keel cooler mounted on the hull, rather than in the heat exchanger mounted in the expansion tank.

In this sytem, the coolant is drawn by the circulating pump from the bottom of the expansion tank through the oil cooler, the cylinder block, cylinder head and into the water manifold. A portion of the coolant is bypassed from the aft end of the water manifold into the aft end of the jacket surrounding the exhaust manifold and then into the expansion tank.

When the thermostat is open, the major portion of the coolant in the water manifold passes through the thermostat housing and flows directly to the keel cooling coils. A cover plate installed in the expansion tank, keeps the water from flowing into the tank. When the thermostat is closed, that portion of the coolant entering the thermostat housing is bypassed directly to the engine water pump inlet where it remixes with the coolant from the exhaust manifold jacket. The coolant is then circulated through the cylinder block and cylinder head. With the thermostat closed, a quick warm up is assured since the circulating water does not pass through the keel cooling coils.

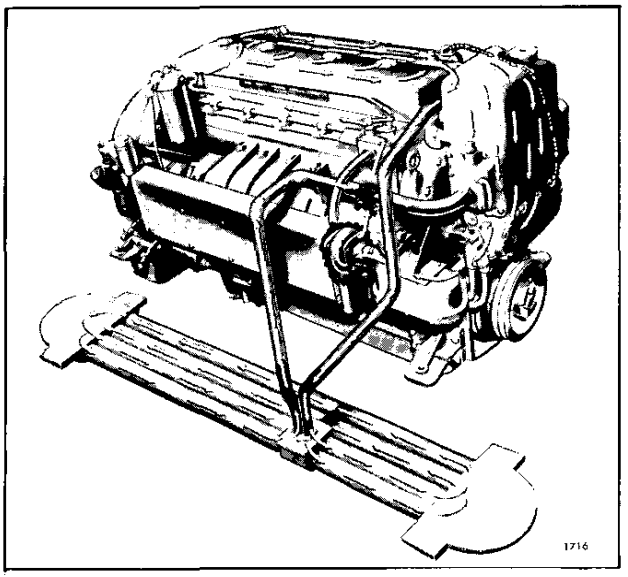


Fig. 3 - Typical Keel Cooling System

© 1983 General Motors Corp.

COOLING SYSTEM OF TURBOCHARGER UNITS

The cooling system has been altered to provide adequate cooling for both the turbocharger and the engine.

The turbocharger is cooled by the addition of a line leading from the water gallery within the cylinder block, near the rear of the blower, to the cooling water inlet, located near the bottom of the turbocharger. The coolant flows through a water jacket, within the turbocharger, which is adjacent to the turbine end, retarding the flow of heat at this point. The coolant discharges at the cooling water outlet, located near the top of the turbocharger and returns to the engine.

DIESEL RAILCAR ENGINE COOLING SYSTEM

Fig. 4 schematically illustrates the arrangements of the components of a typical diesel railcar engine cooling system.

In this system the engine coolant is circulated through a crossflow radiator where it gives up its heat to the air stream developed by the fan which is driven by an electric motor.

The water pump draws the cooling liquid from the radiator, through the engine oil cooler, then discharges it into cylinder block, through the cylinder block and into the cylinder head. Then the coolant passes through the water manifold, which is bolted to the cylinder head, through the transmission oil cooler, past the thermostats to the top of the radiator.

With the thermostats open, the coolant circulates through the radiator before returning to the water pump. With the thermostats closed, the coolant flows through the bypass tube to the engine oil cooler and water pump, thus assuring a quick warm-up of the unit.

The vent tubes attached to the top of the radiator, transmission oil cooler housing and engine water

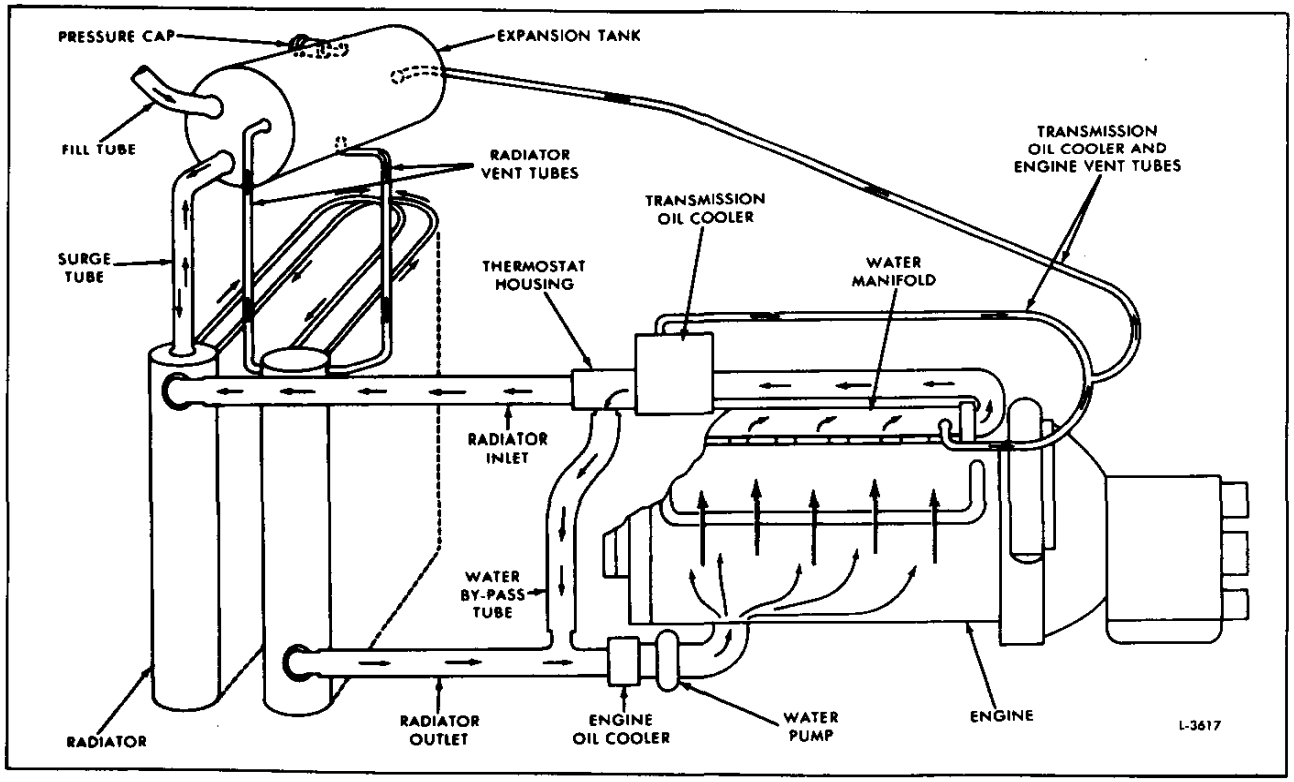


Fig. 4 - Schematic Engine Cooling System (Diesel Railcar Unit)

© 1983 General Motors Corp.

manifold are connected to the expansion tank (Fig. 4) to remove any air that may be trapped in the engine cooling system.

ENGINE COOLING SYSTEM MAINTENANCE

A properly maintained and clean cooling system will reduce engine wear and increase the satisfactory engine operating time between engine overhauls. This is accomplished by the elimination of hot spots within the engine. Thus, when operating within the proper engine temperature range and when not exceeding the recommended horsepower output of the unit, all engine parts will be within their operating temperature ranges and at their proper operating clearances.

Engine Coolant

The function of the engine coolant is to absorb the heat, developed as a result of the combustion process in the cylinders, from component parts such as exhaust valves, cylinder liners and pistons which are surrounded by water jackets. In addition, the heat absorbed by the oil is also removed by the engine coolant in the oil-to-water oil cooler. Refer to Section 13.3 for coolant recommendations.

Cooling System Capacity

The capacity of the basic engine cooling system (cylinder block, head, thermostat housings and oil cooler housing) is shown in the following chart.

COOLING SYSTEM CAPACITY
(Basic Engine)

Engine	Gallons	Litres
3-71	2.5	9.5
4-71	3.5	13.2
6-71, T, TT, TI*	5.5	20.8

*Raw water intercooled

To ascertain the complete amount of coolant in the cooling system, the additional capacity of the radiator, hoses and accessories such as a heater must be added to the capacity of the basic engine. The capacity of the radiator and related equipment should be obtained from the equipment supplier, or the capacity of a particular cooling system may be determined by filling the system with water, then draining and measuring the amount required.

Drain Cooling System

Drain the coolant by opening the drain cocks in the water outlet elbow, oil cooler housing, the fresh water pump, the radiator and, on certain engines the water hole cover located on the blower side toward the rear of the cylinder block. Components of the cooling system that do not have a drain cock, are drained through the oil cooler housing drain cock.

Remove the cooling system filler cap to permit the coolant to drain completely from the system.

To ensure that all of the coolant is drained completely from an engine, all cooling system drains should be opened. Should any water that may be trapped in the cylinder block or radiator freeze, it will expand and may cause damage. When freezing weather is expected, drain a unit not adequately protected by antifreeze. Leave all drain cocks open until refilling the cooling system.

Fill Cooling System

Before starting the engine, close all of the drain cocks and fill the cooling system with water. The use of clean, soft water will eliminate the need for descaling solutions to clean the cooling system. A hard, mineral-laden water should be made soft by using water softener chemicals before it is poured into the cooling system. These water softeners modify the minerals in the water and greatly reduce or eliminate the formation of scale.

Start the engine and, after normal operating temperature has been reached, allowing the coolant to expand to its maximum, check the coolant level. The coolant level should be within 2" of the top of the filler neck.

Should a daily loss of coolant be observed, and there are no apparent leaks, there is a possibility of gases leaking past the cylinder head water seal rings into the cooling system. The presence of air or gases in the cooling system may be detected by connecting a rubber tube from the overflow pipe to a water container. Bubbles in the water in the container during engine operation will indicate this leakage. Another method for observing trapped air in the cooling system is by inserting a transparent tube in the water outlet line.

© 1983 General Motors Corp.

Flush Cooling System

If a coolant filter is used and properly maintained, the cooling system need not be flushed. Otherwise, the cooling system should be flushed each spring and fall. The flushing operation cleans the system of antifreeze solution in the spring and removes the summer rust inhibitor in the fall, preparing the cooling system for a new solution. The flushing operation should be performed as follows:

1. Drain the previous season's solution from the unit.

2. Refill the cooling system with soft, clean water. If the engine is hot, fill slowly to prevent rapid cooling and distortion of the engine castings.

3. Start the engine and operate it for 15 minutes to thoroughly circulate the water.

4. Drain the cooling system completely.

5. Refill the system with the solution required for the coming season.

Cooling System Cleaners

If the engine overheats and the fan belt tension and water level are satisfactory, it will be necessary to clean and flush the entire cooling system. Scale formation should be removed by using a quality descaling solvent. Immediately after using the solvent, neutralize a system with a neutralizer. It is important that the directions printed on the container of the descaling solvent be thoroughly read and followed.

After the solvent and neutralizer have been used, completely drain the engine and radiator and flush it with clean water. Then fill the system with the proper cooling solution.

> **NOTE:** Whenever water is added to a hot engine, it must be done slowly to avoid rapid cooling which may cause distortion and possible cracking of engine castings.

Reverse Flushing

After the engine and radiator have been thoroughly cleaned, they should be reverse flushed. The water pump should be removed and the radiator and engine reverse flushed separately to prevent dirt and scale deposits clogging the radiator tubes or being forced through the pump. Reverse flushing is accomplished with hot water, under air pressure, being forced through the cooling system in a direction opposite to the normal flow of coolant, thus loosening and forcing the scale deposits out.

Reverse flush the radiator as follows:

1. Remove the radiator inlet and outlet hoses and replace the radiator cap.

2. Attach a hose at the top of the radiator to direct the water away from the engine.

3. Attach a hose to the bottom of the radiator and insert a flushing gun in the hose.

4. Connect the water hose of the gun to the water outlet and the air hose to the compressed air outlet.

5. Turn on the water and, when the radiator is full, turn on the air in short blasts.

> **NOTE:** Apply air gradually. Do not exert more than 30 psi (207 kPa) air pressure. Too great a pressure may rupture a radiator tube.

6. Continue flushing until only clean water is expelled from the radiator.

Reverse flush the cylinder block and cylinder head water passages as follows:

1. Remove the thermostat and the water pump.

2. Attach a hose to the water inlet of the cylinder block to drain the water away from the engine.

3. Attach a hose to the water outlet at the top of the engine and insert the flushing gun in the hose.

4. Block the bottom opening and fill the coolant passages with water; then unblock the bottom opening and blow the water from the engine with full air pressure from the flushing gun.

5. Again fill the engine cooling system with water and blow clean with full air pressure. Repeat this procedure until the flushing water runs clean.

If the scale deposits in the radiator cannot be removed by chemical cleaners or reverse flushing, it may be necessary to remove the upper tank and rod out the individual radiator tubes with flat steel rods. Circulate water through the radiator core from the bottom to the top during this operation.

Miscellaneous Cooling System Checks

In addition to the above cleaning procedures, the other components of the cooling system should be checked periodically to keep the engine operating at peak efficiency. The thermostat and the radiator pressure cap should be checked and replaced, if found defective.

© 1983 General Motors Corp.

When water connection seals and hoses are installed be sure the connecting parts are properly aligned and the seal or hose is in its proper position before tightening the clamps. All external leaks should be corrected as soon as detected. The fan belt must be adjusted to provide the proper tension and the fan shroud must be tight against the radiator core to prevent recirculation of air which may lower the cooling efficiency.

Contaminated Engine

When the cooling system or lubricating system becomes contaminated, it should be flushed thoroughly to remove the contaminants before the engine is seriously damaged. One possible cause of such contamination is a cracked oil cooler core. In such a case oil will be forced into the cooling system while the engine is operating, and coolant will leak into the lubricating system when the engine is stopped.

Coolant contamination of the lubricating system is especially harmful to engines when the cooling system is filled with an ethylene glycol base antifreeze solution. When mixed with the oil in the crankcase, this antifreeze forms a varnish which can cause the engine to seize of result in severe bearing wear.

Make certain that the cause the internal coolant leak has been corrected before flushing the contaminated system(s).

Contaminants may be flushed from the engine systems as follows:

COOLING SYSTEM

If the engine has had a failure resulting in the contamination of the cooling system with lubricating oil, the following flushing procedure is recommended:

1. Prepare a mixture of Calgon, or its equivalent, and water at the rate of two ounces (dry measure) to one gallon of water.

2. Remove the engine thermostat to permit the Calgon and water mixture to circulate through the engine and the radiator.

3. Fill the cooling system with the Calgon solution.

4. Run the engine for five minutes.

5. Drain the cooling system.

6. Repeat Steps 3 through 5.

7. Fill the cooling system with clean water.

8. Let the engine run five minutes.

9. Drain the cooling system completely.

10. Install the engine thermostat.

11. Close all of the drains and refill the engine with fresh coolant (see Section 13.3).

LUBRICATION SYSTEM

When the engine lubricating system has been contaminated by an ethylene glycol antifreeze solution or other soluble material, the following cleaning procedure, using Butyl Cellosolve, or its equivalent, is recommended.

> **CAUTION:** Use extreme care in the handling of these chemicals to prevent serious injury to the person or damage to finished surfaces. Wash off spilled fluid immediately with clean water.

If the engine is still in running condition, proceed as follows:

1. Drain all of the lubricating oil.

2. Remove and discard the oil filter element. Clean and dry the filter shell and install a new element.

3. Mix two parts of Butyl Cellosolve, or its equivalent, with one part SAE 10 engine oil. Fill the engine crankcase to the proper operating level with the mixture.

4. Start and run the engine at a fast idle (1,000 to 1,200 rpm) for 30 minutes to one hour. Check the oil pressure frequently.

5. After the specified time, stop the engine and immediately drain the crankcase and the filter. *Sufficient time must be allowed to drain all of the fluid.*

6. Refill the crankcase with SAE 10 engine oil after the drain plug is replaced, and run the engine at the same fast idle speed for ten or fifteen minutes. Then, stop the engine and drain the oil thoroughly.

7. Remove and discard the filter element, clean the filter shell and install a new element.

8. Install the drain plug and fill the crankcase to the proper level with the oil recommended for normal engine operation.

9. To test the effectiveness of the cleaning procedure, it is recommended that the engine be started and run at a fast idle (1,000 to 1,200 rpm) for approximately 30 minutes. Then, stop and immediately restart the

© 1983 General Motors Corp.

engine. There is a possibility that the engine is not entirely free of contaminant deposits if the starting speed is slow.

10. If the procedures for cleaning the lubricating oil system were not successful, it will be necessary to disassemble the engine and to clean the affected parts thoroughly.

Make certain that the cause of the internal coolant leak has been corrected before returning the engine to service.

MAXIMUM ENGINE COOLANT TEMPERATURE

The heat-dissipating capacity of the engine cooling systems and related components must be sufficient to prevent the coolant temperature from rising above 210°F (99°C). This temperature must not be exceeded under any engine operating condition, regardless of altitude, type of coolant used or cooling system condition. Exceeding this limit can result in malfunction or serious engine damage.

TEMPERATURE CONTROL COMPONENTS

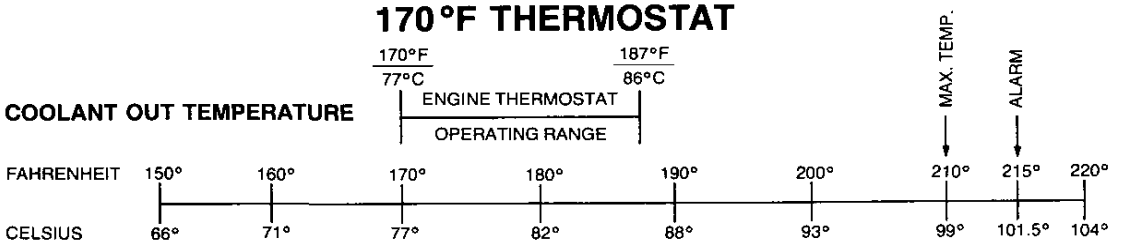
These engines are designed to operate with 170°F (77°C) or 180°F (82°C) thermostats which, combined with a radiator or heat exchanger, regulate coolant temperature within a range of 170°F-187°F (77°-86°C) or 180°-197°F (82°-92°C). Many engines also use radiator shutters, clutch fans or conbinations of both to help control coolant temperature. These "add on" cooling system components must operate in proper sequence to prevent coolant temperature instability and/or engine overheating.

A badly adjusted operating sequence can also have a detrimental effect on the life of the "add on" components as well.

The following charts give the recommended normal temperature settings for various coolant temperature control devices. These settings should not be exceeded, since this will unnecessarily increase the engine coolant and lubricating oil temperature, possibly resulting in serious engine damage.

© 1983 General Motors Corp.

170°F THERMOSTAT



SHUTTERS ONLY

OPTIONAL SHUTTERS		SHUTTERS	
CLOSE	OPEN	CLOSE	OPEN
160°F / 71°C	165°F / 74°C	178° - 183°F / 81° - 84°C	185° - 190°F / 85° - 88°C

CLUTCH FAN ONLY

MODULATING FAN		ON/OFF FAN	
START ON	FULL ON	OFF	ON
180°F / 82°C	192°F / 89°C	178° - 183°F / 81° - 84°C	185° - 190°F / 85° - 88°C

CLUTCH FAN AND SHUTTER COMBINATION

SHUTTERS		MODULATING FAN		ON/OFF FAN	
CLOSE	OPEN	START ON	FULL ON	OFF	ON
160°F / 71°C	165°F / 74°C	180°F / 82°C	192°F / 89°C	178° - 183°F / 81° - 84°C	185° - 190°F / 85° - 88°C

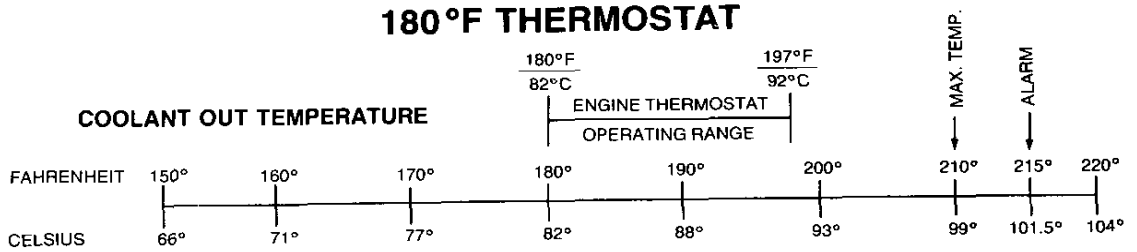
SHUTTER AND ON/OFF FAN CONTROL COMBINATION

SHUTTER CLOSED	FAN OFF	SHUTTER OPEN	FAN ON
178°F / 81°C	183°F / 84°C	185°F / 85°C	190°F / 88°C

CHART 1 - 170° Thermostat

© 1983 General Motors Corp.

180°F THERMOSTAT



SHUTTERS ONLY

OPTIONAL SHUTTERS		SHUTTERS	
CLOSE	OPEN	CLOSE	OPEN
170°F / 77°C	175°F / 79.5°C	188° - 193°F / 87° - 89.5°C	195° - 200°F / 90.5° - 93°C

CLUTCH FAN ONLY

MODULATING FAN		ON/OFF FAN	
START ON	FULL ON	OFF	ON
190°F / 88°C	202°F / 94.5°C	188° - 193°F / 87° - 89.5°C	195° - 200°F / 90.5° - 93°C

CLUTCH FAN AND SHUTTER COMBINATION

SHUTTERS		MODULATING FAN		ON/OFF FAN	
CLOSE	OPEN	START ON	FULL ON	OFF	ON
170°F / 77°C	175°F / 79.5°C	190°F / 88°C	202°F / 94.5°C	188° - 193°F / 87° - 89.5°C	195° - 200°F / 90.5° - 93°C

SHUTTER AND ON/OFF FAN CONTROL COMBINATION

SHUTTER CLOSED	FAN OFF	SHUTTER OPEN	FAN ON
188°F / 87°C	193°F / 89.5°C	195°F / 90.5°C	200°F / 93°C

CHART 2 - 180° Thermostat

© 1983 General Motors Corp.

WATER PUMP

The centrifugal-type water pump (Fig. 1 and 2) circulates the engine coolant through the cylinder block, cylinder head, heat exchanger or radiator, and the oil cooler. The drive end of the pump shaft is supported by a sealed double-row combination radial and thrust ball bearing. The pump shaft serves as the inner race of the bearing.

A spring-loaded seal assembly and a water slinger (former pumps), located between the seal and the bearing, prevent the coolant from passing along the shaft to the bearing. The carbon washer in the seal assembly bears against a steel insert that is pressed into the pump body. The insert may be replaced when worn.

A new seal has been released for the fresh water pumps, effective with engine serial numbers 3A-100049, 4A-266242 and 6A-433971. The new seal has a high grade carbon face, a stainless steel case and a shroud. The former seal had a phenolic face, a brass case and no shroud. Because of its design, the new seal provides improved resistance to leakage even after high engine hours or mileage. The former seal and the new seal are completely interchangeable and only the new seal will be available to service fresh water pumps.

The current water pump (Brummer type) differs from the former pump (Gits type) by use of a ceramic insert and spring loaded seal assembly. The spring-loaded water pump seal assembly bears against the insert. The ceramic insert prevents coolant from passing along the shaft, which does not include a slinger, to the sealed ball bearing.

The impeller is a press fit on one end of a stainless steel shaft. Former pump assemblies used a taper pin to hold the impeller on the shaft.

The pump is mounted at the front end of the blower (Fig. 3) and is driven by the lower blower rotor shaft. The drive coupling, pressed on the end of the pump shaft, has an integral oil thrower that shrouds the flange end of the pump body and deflects the oil away from the bearing.

Lubrication

The sealed type ball bearing is filled with lubricant at the time it is assembled to the pump shaft, and no further lubrication is required.

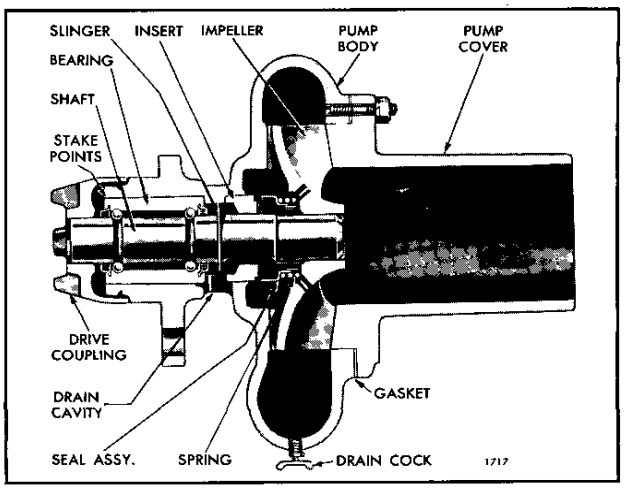


Fig. 1 - Water Pump Assembly (Former)

Remove Water Pump

Refer to Figs. 3 and 4 and remove the pump as follows:

1. Open the drain cock in the pump body and drain the cooling system.

2. Loosen the hose clamps and slide the water pump inlet hose back against the pump cover.

3. Remove the two bolts and lock washers that attach the pump outlet flange to the cylinder block. Remove

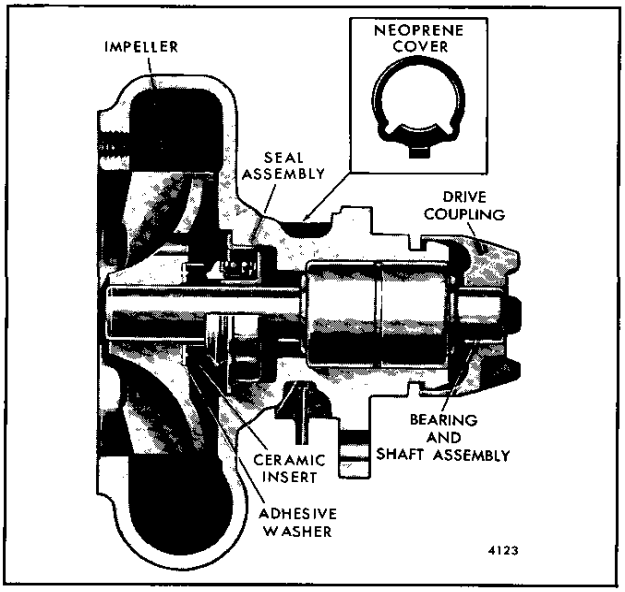


Fig. 2 - Water Pump With Ceramic Insert in Impeller (Current)

© 1983 General Motors Corp.

the flange and packing ring.

4. Remove the three bolt and seal assemblies that attach the pump to the blower assembly.

5. Withdraw the pump and remove the gasket.

Disassemble Water Pump

1. Remove the pump cover and gasket.

NOTE: Clean the corrosion from around the impeller and shaft before separating the shaft and bearing assembly from the impeller, seal and pump body.

2. Support the pump on its mounting flange in an arbor press (Fig. 5). Place a short steel rod on the end of the shaft and press the shaft and bearing assembly from the impeller, seal and pump body. If the impeller is pinned to the shaft, considerably more pressure will be required to shear the pin.

NOTE: Shaft bearing damage may occur on In-line 71 water pumps if an excessive thrust load is applied to the bearing assembly during pump disassembly for seal replacement. For this reason DDA recommends replacing the shaft and bearing assembly of the In-line 71 water pumps whenever the seal is replaced and/or at time of water pump overhaul.

3. Remove the impeller and seal assembly from the pump body. When removing the impeller, protect the ceramic insert from damage at all times. Always lay the

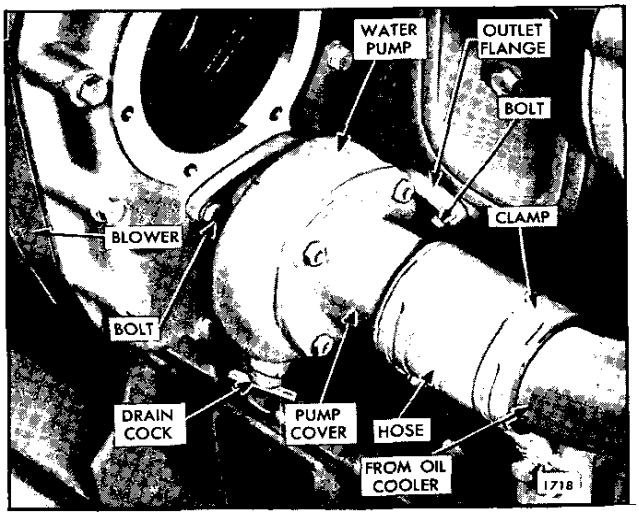


Fig. 3 - Water Pump Mounting

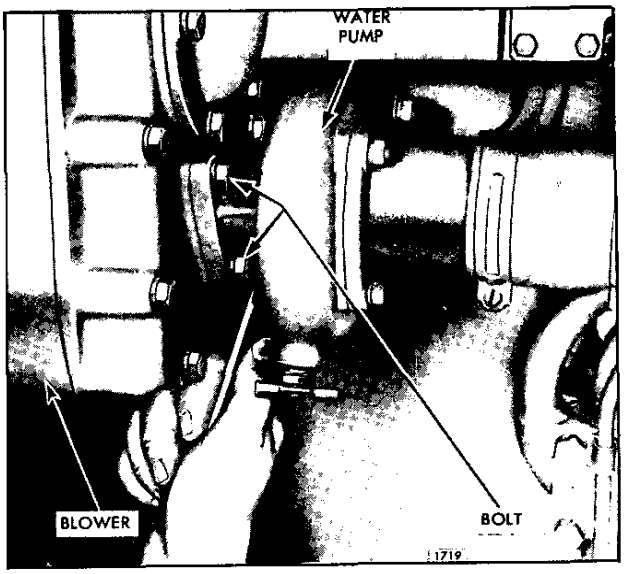


Fig. 4 - Loosening Inner Pump-to-Blower Attaching Bolt with Tool J 4242

impeller on the bench with the ceramic insert up to prevent damage to the insert.

NOTE: Always use a new ceramic insert and seal when overhauling the water pump.

4. If the steel insert is worn or scratched excessively, tap or press it out of the pump body.

5. Remove the water slinger from the shaft.

6. If the impeller was pinned to the shaft, remove the sheared taper pin from the shaft and impeller by tapping against the small end of the pin with a punch and hammer.

7. If necessary, remove the pump drive coupling from the shaft with tool J 1930 (Fig. 6).

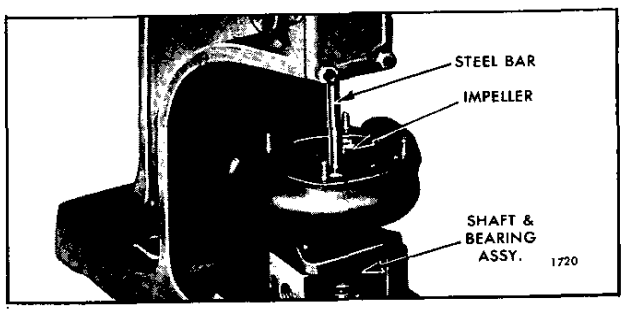


Fig. 5 - Pressing Pump Shaft from Impeller

© 1983 General Motors Corp.

Inspection

Clean all of the parts except the shaft and bearing assembly. The sealed type pump shaft bearing must not be immersed in a cleaning fluid since dirt may be washed in and the fluid cannot be entirely removed.

Revolve the pump shaft bearing slowly by hand. Replace the shaft and bearing assembly and the seal assembly.

Examine the former impeller and the seal components for wear and replace them, if necessary.

Inspect the ceramic insert for cracks, scratches and bond to the impeller. A new ceramic insert must be used if a new seal is installed. If the insert is damaged or a new seal is used, bond the ceramic insert to the impeller as follows:

> **NOTE:** Never attempt to reuse the ceramic insert when overhauling a water pump, regardless of its condition.

1. Bake the insert and impeller assembly at 500°F (260°C) for one hour. The insert can be removed easily while the adhesive is hot. After removing the insert, clean the insert area on the impeller with sandpaper, wire brush or a buffing wheel to remove the old adhesive, oxide, scale, etc.

2. Wet a clean cloth with a suitable solvent such as alcohol and thoroughly clean the impeller insert area and the grooved side of a new ceramic insert. Then wipe the parts with a clean, dry cloth.

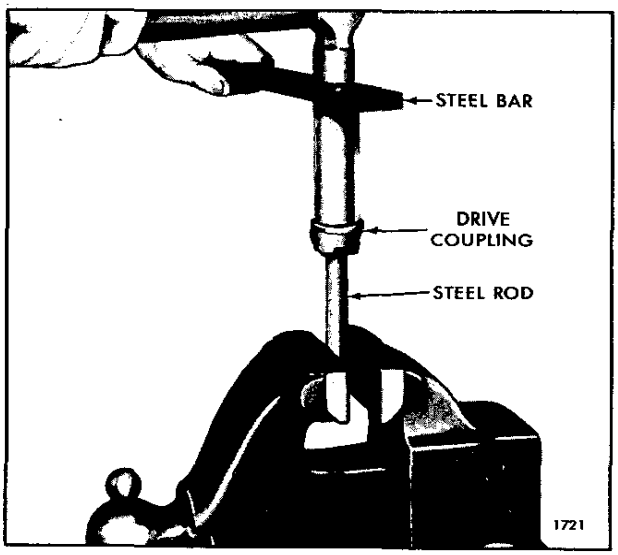


Fig. 6 - Removing Pump Drive Coupling from Shaft with Tool J 1930

3. Place the adhesive washer in the impeller bond area with the ceramic insert on top. The polished face of the ceramic insert should be visible to the assembler. Clamp the insert and impeller together with a 3/8" bolt and nut and two *smooth* .125" thick washers. Tighten the bolt to 10 lb-ft (14 Nm) torque.

> **NOTE:** Do not mar the polished surface of the ceramic insert.

4. Place the impeller assembly in a level position, with the ceramic insert up, in an oven preheated to 350°F (177°C) and bake it for one hour.

> **NOTE:** The face of the ceramic insert must be square with the axis of the tapered bore within .004". The pump shaft may be used as a mandrel for inspection.

5. Remove the impeller from the oven and, after it has cooled to room temperature, install it in the pump. Do not loosen the clamping bolt until the assembly cools. Make sure the mating surfaces of the water seal and the ceramic insert are free of dirt, metal particles and oil film.

Examine the studs in the pump body. If it is necessary to replace a stud, use a good grade of sealant on the threads and drive the stud in to 6-8 lb-ft (8-11 Nm) torque.

Assemble Water Pump

Refer to Figs. 1, 2 and 7 and assemble the pump as follows:

1. If a new insert is to be used in a former pump body, make sure the counterbore in the pump body is thoroughly clean before installing the new insert. Dirt in the counterbore can cause misalignment between the insert and the carbon washer and result in a leak at this point. Start the counterbored end of the insert into the pump body. Then press the insert in until it contacts the shoulder in the pump body. The insert has a .0015"-.0035" press fit in the pump body.

> **NOTE:** Do not mar the highly finished seal contact surface of the insert when pressing it into the pump body.

2. Install the slinger on the former pump shaft with the flange of the slinger approximately .1875" from the end of the outer race of the bearing.

3. Support the impeller end of the pump body on an arbor press and insert the coupling end of the shaft

© 1982 General Motors Corp.

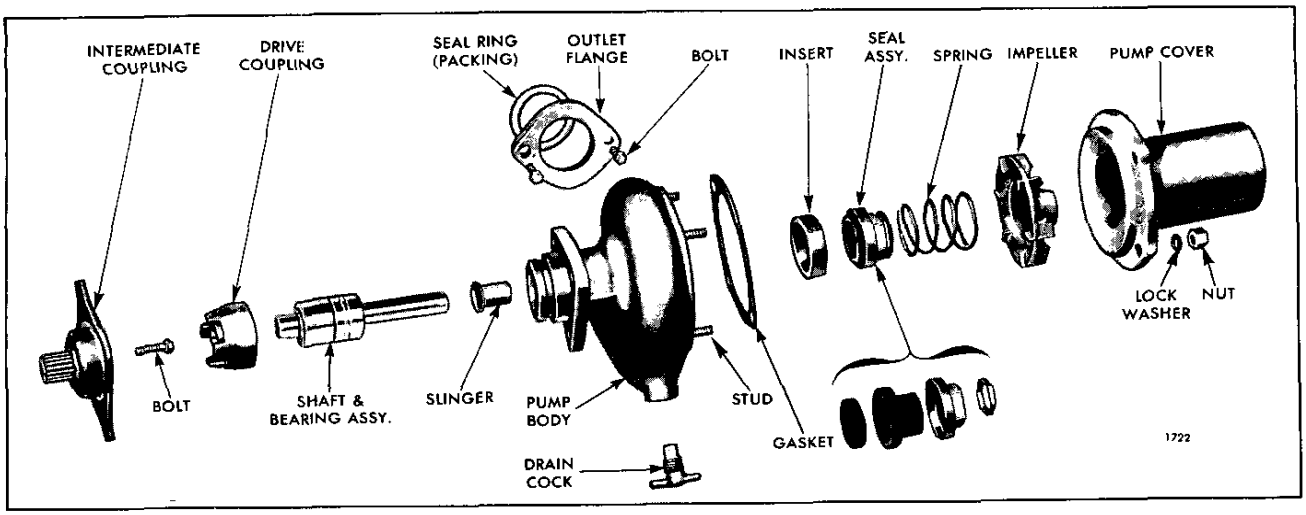


Fig. 7 - Water Pump Details and Relative Location of Parts

and bearing assembly. Then press against the outer race of the bearing until the bearing contacts the shoulder in the pump body (former pumps) or until the bearing is flush with the end of the pump body (current pumps).

NOTE: If the pump body requires modification to accommodate the current shaft and bearing assembly with an integral secondary seal, machine the pump body. Refer to Shop Notes in Section 5.0.

4. With the surface of the pump seal clean and free from dirt and metallic particles, apply a thin coat of liquid soap on the inside diameter of the rubber seal. Do not scratch or mar the surface of the carbon seal washer. To reduce possible coolant leakage, apply a light coat of non-hardening sealant on the outside diameter of a new water seal. Slide the former seal assembly on the pump shaft until the carbon seal washer is seated firmly against the pump body insert. Press the current seal assembly in place with a suitable sleeve until it seats firmly against the pump body. Then install the spring with the small end toward the seal.

5. On early pumps, place the impeller on the shaft with the pin hole in the shaft aligned midway between two adjacent blades of the impeller.

6. Support the bearing end of the shaft on the bed of an arbor press. Then press the impeller on the shaft (a force of 2500 lbs. minimum is required) using tool J 22437 (Fig. 8). Do not press against the outer race of the bearing. The distance between the end of the shaft and the face of the impeller hub is .031"-.033" (Fig. 9). On former engines, the end of the shaft must be flush with the face of the impeller hub with the bearing held against the shoulder in the pump body. On early engines which have the end of the shaft tapered, use impeller installer J 21971 (Fig. 8) to press the impeller on the shaft until the distance from the face of the pump body to the face of the impeller hub is .052"-.072", with the bearing held against the shoulder in the pump body.

7. If the impeller was previously pinned to the shaft and the old parts are reassembled, insert a .184" drill in the pin hole in the shaft and drill a new hole in the impeller hub. Install a new 3/16" x 7/8" groove pin. However, if a new impeller is installed on either a new

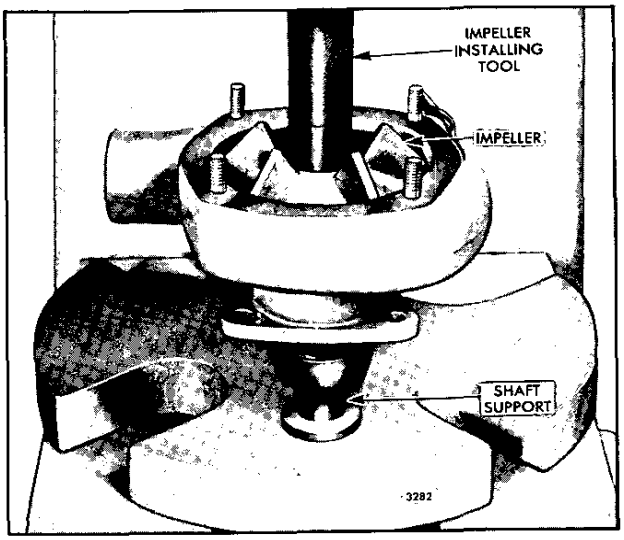


Fig. 8 - Installing Pump Impeller

© 1982 General Motors Corp.

or old shaft, it will not be necessary to pin it to the shaft since the impeller bore diameter has been decreased to permit a press fit.

8. Support the impeller end of the pump shaft on a suitable arbor press and press the drive coupling on the shaft until the coupling is flush with the end of the shaft. When installed, the drive coupling must hold 30 lb-ft (41 Nm) minimum torque.

9. Some pumps include a neoprene cover (Fig. 2) to allow coolant to drain, but still keep dust and dirt out of the pump body at the weep hole. The neoprene cover will stretch for removal or installation.

NOTE: Be sure the tip of the cover is located *below* the weep hole in the pump body.

10. Rotate the shaft by hand to be sure the rear face of the impeller blades does not rub the pump body.

11. Place a new pump cover gasket against the bolting flange of the pump body. Slide the pump cover over the studs and secure it to the pump body with four lock washers and nuts.

12. If previously removed, install the drain cock in the pump body.

Install Water Pump

Refer to Fig. 3 and install the water pump on the engine as follows:

1. To convert the former intermediate drive coupling to the current coupling, refer to Section 3.0.

2. Make sure the intermediate shaft coupling is secure. If it was previously removed, insert the splined end of the coupling into the mating splines in the blower rotor shaft. Then draw the coupling in place with the 5/16"-24 x 1-1/2" bolt. Tighten the bolt to 15-19 lb-ft (20-26 Nm) torque.

3. Place the pump outlet flange over the pump outlet with the flat side of the flange facing the pump body. Slip the packing ring over the pump outlet and next to the flange.

4. Use a new gasket at the bolting flange and place the pump against the blower end plate cover so that the lugs on the drive coupling mesh with the lugs on the intermediate shaft coupling. Secure the pump to the blower with the three bolts and seal washers.

5. Slide the pump outlet packing ring and packing flange against the cylinder block and secure the flange with two bolts and lock washers.

6. Slide the water pump inlet hose in place and secure it with the hose clamps.

7. Close the pump drain cock and fill the engine cooling system.

NOTE: When filling the cooling system of certain models, it is necessary to open the vent valve at the top of the thermostat housing.

HIGH CAPACITY WATER PUMP

The diesel railcar engine and certain other six-cylinder engines (effective with engine 6A-5987) are equipped with a water pump of greater capacity to provide increased circulation of the coolant. Six-cylinder turbocharged engines also require the high capacity pump to compensate for reduced pump speed; the ratio of blower speed (pump speed) to engine speed is 1.95:1 (former engines 1.55:1) for the turbocharged engines and 2.00:1 (former engines 1.69:1) for the non-turbocharged engines. However, the standard pump provides sufficient circulation of the coolant for the four-cylinder turbocharged engines.

The current pump assembly, effective with engine 6A-59447, incorporates a new seal assembly and impeller (Fig. 9). The shaft and bearing assembly and the seal assembly are the same as used in the current standard pump assembly.

Effective with engine 6A-118612, the water pump (Brummer type) incorporates an impeller with a ceramic insert.

Service

The high capacity pump (Fig. 9) is serviced in the same manner as the standard pump. However, on current engines, press the impeller on the shaft with impeller installer J 22437 until the distance between the end of the shaft and the face of the impeller hub is .031"-.033" (Fig. 9), with the bearing held against the shoulder in the pump body.

On former pumps which have the end of the shaft tapered, press the impeller on the shaft with impeller installer J 9303 until the distance between the end of

© 1982 General Motors Corp.

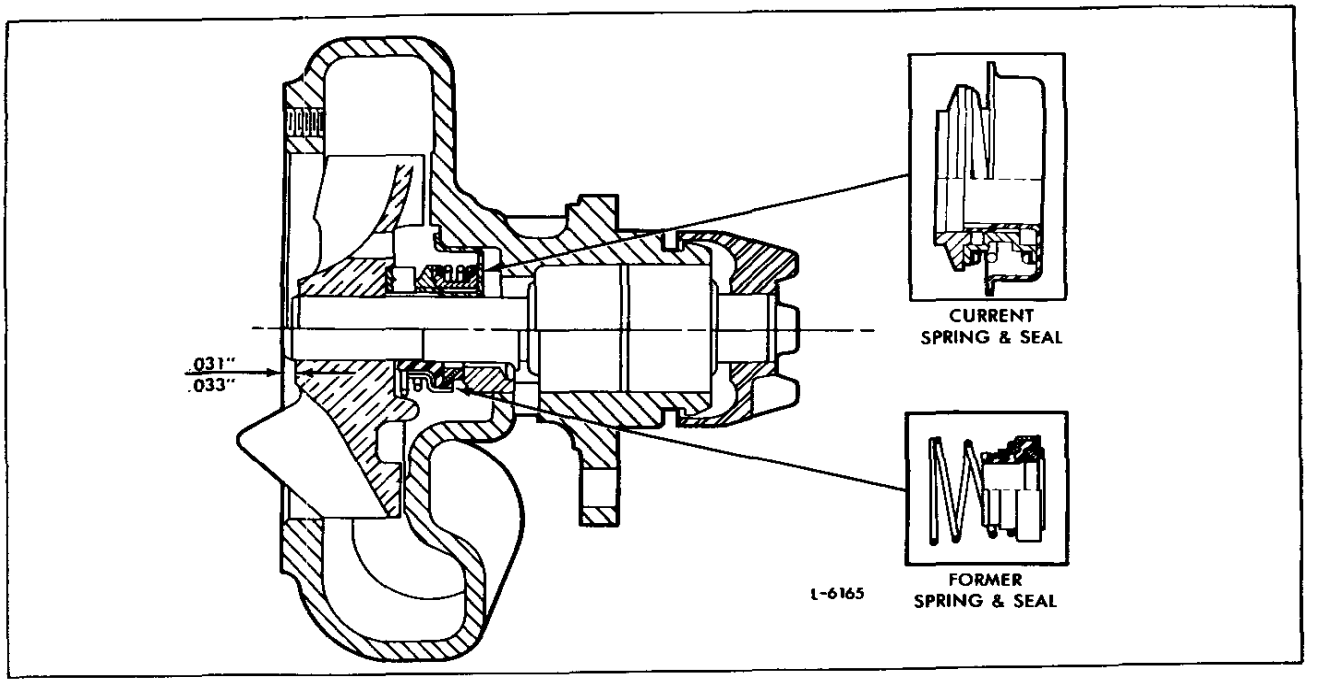


Fig. 9 - High Capacity Water Pump

the shaft and the face of the impeller hub is .099"-.101" with the bearing held against the shoulder in the pump body.

Effective with engine 6A-98234, two 1/4" holes were added to the water pump impeller (Fig. 10) to vent the seal chamber and eliminate the possibility of foreign material build-up between the impeller and the seal, which could result in leakage. Where pump seal difficulties are encountered on pumps with former impellers, it is recommended that vent holes be added as shown in Fig. 10.

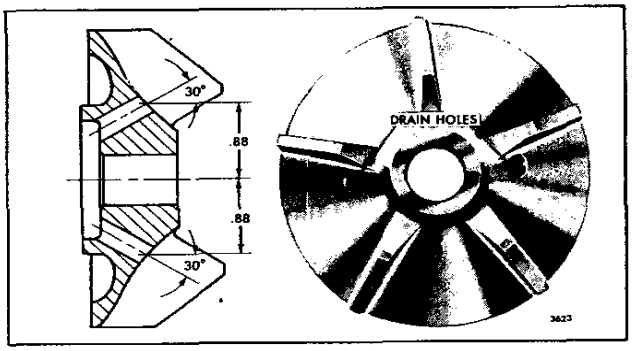


Fig. 10 - Reworking Diagram of Pump Impeller

NOTE: Remove any rough edges and burrs from the impeller after drilling the holes.

The old seal assembly is available for service. However, if the impeller requires replacement, the current seal assembly and impeller must be used together. The shaft with the milled flat must also be replaced if a current impeller and seal are installed.

NOTE: The current shaft and bearing assembly, seal assembly, seal spring, drive coupling and pump body insert are the same for both the standard and high capacity water pumps.

The high capacity water pump used in the low profile six-cylinder marine engine has two 1/4" tapped holes in the pump body. When the engine is to be installed so many degrees from horizontal, the lower tapped hole in the pump body must be plugged and the upper tapped hole must be open for installation of an air bleed line that connects to the water-cooled exhaust manifold.

© 1982 General Motors Corp.

WATER MANIFOLD

Cooling water, leaving the cylinder head through an opening over each exhaust port, enters the water manifold which is attached to the head with two nuts and lock washers at each of the six water openings, as shown in Fig. 1. A separate gasket is used at each attaching flange between the manifold and the cylinder head.

A gradually increasing area in the cast manifold from the rear end terminates in either a uniform circular section at the front where a seal and clamp connect the manifold to the thermostat housing, or a mounting flange to which the thermostat housing is attached by means of bolts and lock washers. On units employing a fresh water cooled exhaust manifold, a flexible tube at the aft end of the water manifold by-passes water to the exhaust manifold, as shown in Fig. 2. The water leaves the exhaust manifold through an external tube and flows to the engine oil cooler.

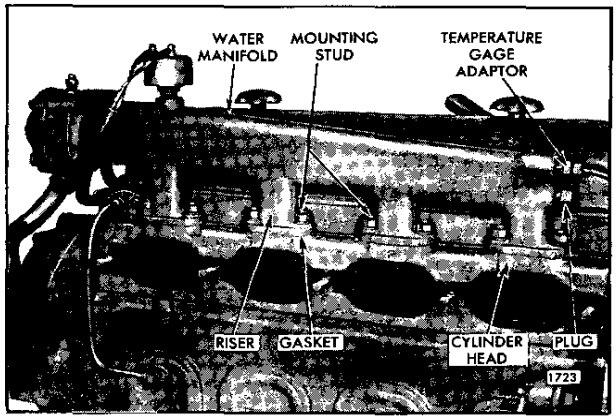


Fig. 1 - Typical Water Manifold Mounting Industrial Unit

Remove Water Manifold

The water manifold may be removed as follows:

1. Drain the cooling system to level necessary by opening the valve in the bottom of the fresh water pump and the valve in the thermostat housing.
2. On heat exchanger units, loosen the seal clamp. Slip the water manifold-to-thermostat housing seal over the neck of the thermostat housing.

   On radiator units, loosen the bolts which secure the outlet elbow and the thermostat housing to the water manifold.
3. Remove the cooling water temperature gage adaptor from the rear end of the water manifold.

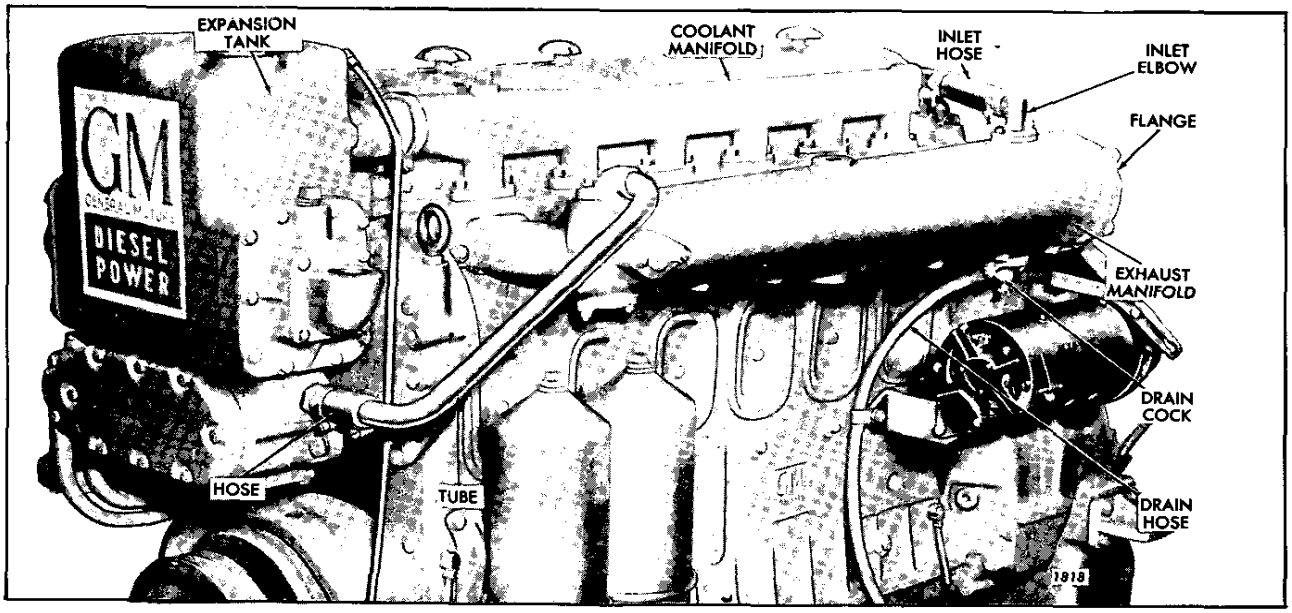


Fig. 2 - Typical Water Manifold Mounting (Heat Exchanger Unit)

© 1978 General Motors Corp.

4. Remove the water manifold stud nuts and lock washers and lift the manifold straight up off the studs. Remove the manifold to cylinder head gaskets.

Install Water Manifold

Effective approximately October, 1975 new four leg external water manifolds replaced the former six leg and four leg external water manifolds. The reduction of two legs from the former six leg manifold has no detrimental effect on engine cooling.

> **NOTE:** The number of water access holes are the same or more in the new four leg manifold, however, these access holes may be in a different location because the manifold is shorter.

When replacing a former six leg or a four leg external water manifold it will be necessary to include two plates, two gaskets, and four 3/8" - 16 x 1" bolts. Remove all old gaskets and install the manifold using new gaskets.

1. With new gaskets in place, lower the water manifold down over the studs and secure it to the cylinder head with two nuts and lock washer at each riser. Tighten the nuts to 25-30 lb-ft (34-41 Nm) torque.

2. Install the temperature gage adaptor in the end of the manifold.

3. On heat exchanger units, slide the seal onto the outlet end of the water manifold and secure the seal connection between the manifold and the thermostat housing with clamp.

   On radiator units, attach the thermostat housing and outlet elbow to the water manifold with bolts and lock washers.

4. Fill cooling system to proper level.

> **NOTE:** When filling cooling system on certain models, it is necessary to open the vent valve at the top of thermostat housing.

© 1978 General Motors Corp.

THERMOSTAT

The temperature of the engine coolant is automatically controlled by a thermostat located in a housing connected to the outlet end of the water manifold. A blocking type thermostat (Fig. 1) is used when a standard cooling system is employed; a semi-blocking type thermostat (Fig. 2) is used with a rapid warm-up cooling system.

On a diesel railcar unit, the thermostats are located in a housing attached to the forward end of the transmission oil cooler housing.

Operation

At coolant temperatures below approximately 160°to 170°F (71°to 77°C), the thermostat valves remain closed and block the flow of coolant to the radiator. During this period, all of the coolant in the standard system is circulated through the engine and is directed back to the suction side of the water pump via the bypass tube. In the rapid warm-up system, enough coolant to vent the system is bypassed to the radiator top tank or heat exchanger by means of a separate external deaeration line and then back to the water pump without going through the radiator or the heat exchanger cores. As the coolant temperature rises above 160°to 170°F (71°to 77°C) the thermostat valves start to open, restricting the bypass system, and permit a portion of the coolant to circulate through the radiator or the heat exchanger. When the coolant temperature reaches approximately 185°to 195°F (85°to 91°C) the thermostat valves are fully open, the bypass system is partially blocked off, and most of the coolant is directed through the radiator or the heat exchanger.

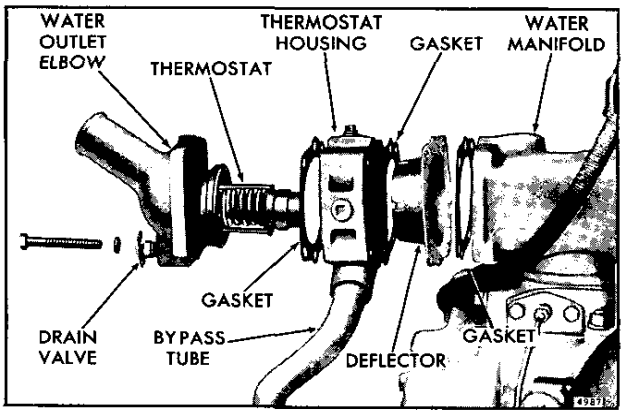


Fig. 1 - Typical Thermostat Housing Mounting (Radiator Cooling System)

The dual blocking type thermostats used on the railcar unit, provide a full flow bypass system which prevents the cool coolant in the radiator from entering the engine during the warm-up period and dropping the temperature below normal. After the engine reaches the correct operating temperature, the thermostats open and completely block off the water bypass tube permitting all of the coolant to circulate through the radiator, thus maintaining a more even engine temperature.

A properly operating thermostat is essential for efficient operation of the engine. If the engine operating temperature deviates from the normal range of 160°to 185°F (71°to 85°C) or 170°to 195°F (77°to 91°C), remove the thermostat and check it.

NOTE: There are areas where approved fuel (less than 0.5% sulfur) is not commercially available or economically feasible to obtain. It is important to keep the engine cooling system temperature of these engines on the high side of normal to prevent the condensation of sulfur trioxide gas, which combines with combustion water to form sulfuric acid. Therefore, install a 180°or 190°F (82°or 88°C) temperature thermostat and modify the cooling system to provide rapid warm-up in order to maintain coolant temperature at a minimum of 175°F (80°C).

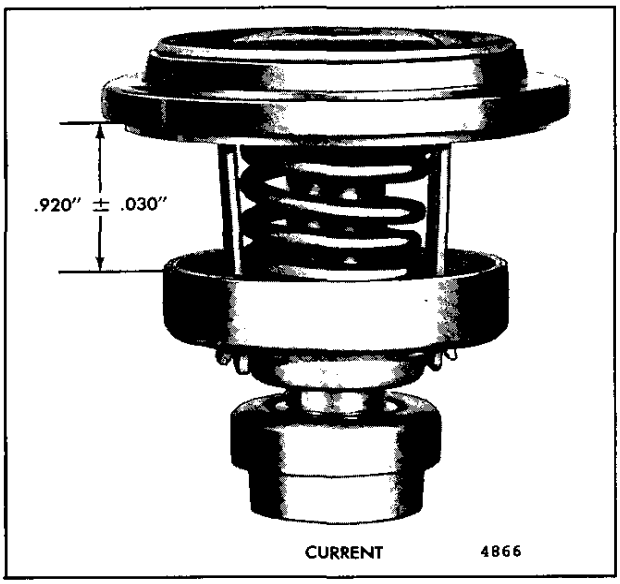


Fig. 2 - Semi-Blocking (Shielded) Type Thermostat

© 1981 General Motors Corp.

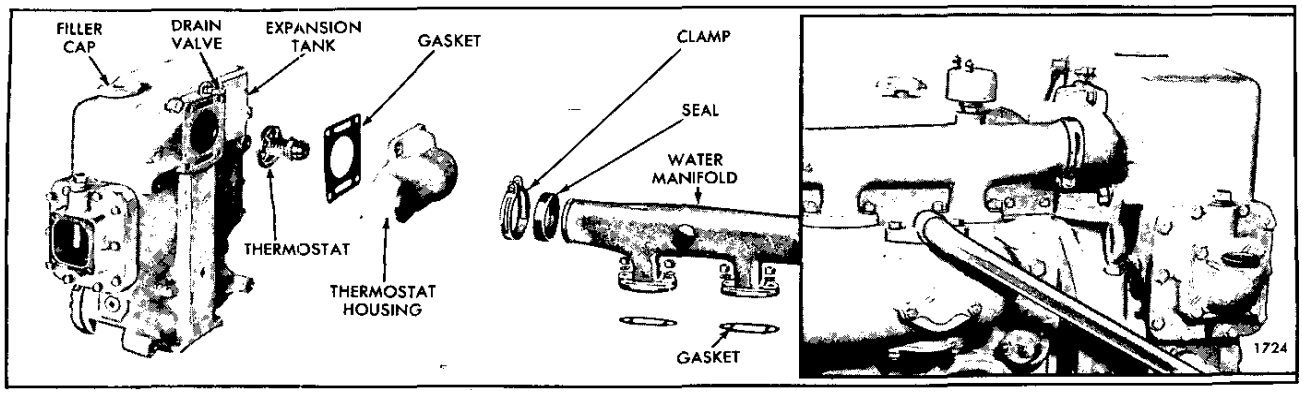


Fig. 3 - Typical Thermostat Housing Mounting and Details (Heat Exchanger Cooling System)

Remove Thermostat

1. Drain the cooling system to the necessary level by opening the drain valve.

2. On radiator units, remove the bolts which secure the outlet elbow and the thermostat housing (bypass tube) to the water manifold (Fig. 1).

On heat exchanger units, loosen the clamp and slide the seal onto the water manifold or thermostat housing (Fig. 3). Remove the four bolts and lock washers and separate the thermostat housing from the expansion tank.

On keel cooled units loosen the clamp and slide the seal onto the water manifold or thermostat housing (Fig. 4). Loosen the clamp and separate the water outlet hose from the water outlet housing. Remove the four bolts and lockwashers and separate the outlet housing from the thermostat housing. Remove the four bolts and lockwashers and separate the thermostat housing from the expansion tank.

On railcar units, loosen the water outlet and the water bypass tube hose clamps and remove the hoses from the thermostat housing outlet elbow. Then, remove the six bolts and lock washers securing the outlet elbow to the thermostat housing. Remove the outlet elbow, gasket and thermostats from the housing.

3. Remove the thermostat and the deflector (if used) and clean the seat for the thermostat in the housing (heat exchanger or keel cooled units) or outlet elbow (radiator units).

4. Remove and discard the seals pressed in the water outlet elbow (blocking-type thermostats).

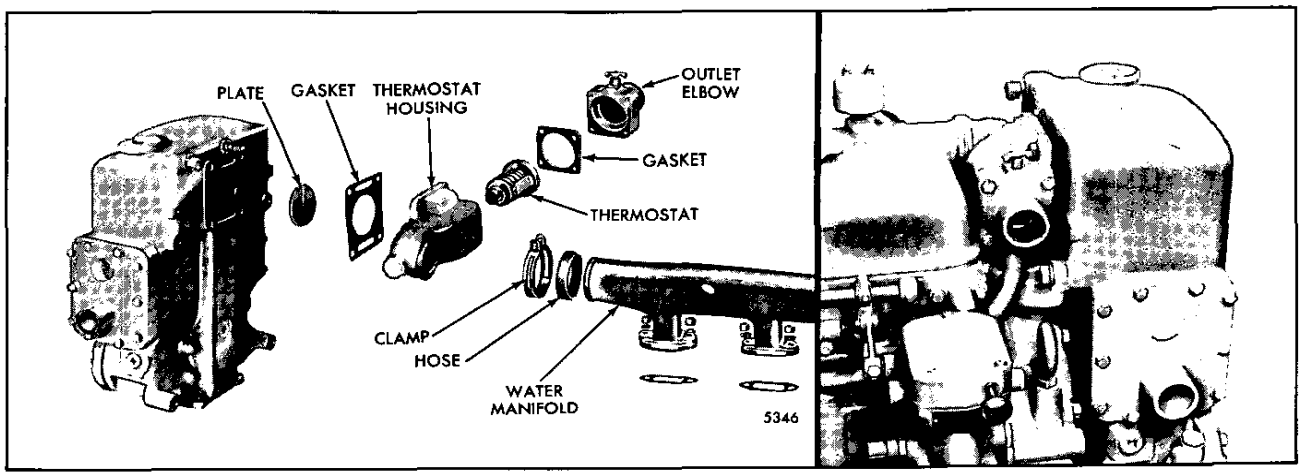


Fig. 4 - Typical Thermostat Housing Mounting and Details (Keel Cooling System)

© 1981 General Motors Corp.

Inspection

If the action of the thermostat has become impaired due to accumulated rust and corrosion from the engine coolant so that it remains closed, or only partially open, thereby restricting the flow of coolant, overheating of the engine will result. A thermostat which is stuck in the wide open position may not permit the engine to reach its normal operating temperature. The incomplete combustion of fuel due to cold operation will result in build-up of carbon deposits on the pistons, rings and valves.

Check the operation of a thermostat as follows:

1. Immerse the thermostat in a container of water (Fig. 6).

2. Place a thermometer in the container using care not to allow the thermometer to touch the bottom or sides of the container.

3. While slowly agitating the water to maintain an even temperature, apply heat to the container. As the water is heated, the thermostat should begin to open (the opening temperature is usually stamped on the thermostat). The thermostat should be fully open at approximately 185°- 195°F (85°-91° C). Allow at least 10 minutes for the thermostat to react.

Install Thermostat

1. Affix a new gasket to each side of the thermostat housing.

2. Set the deflector and new gasket (if used) and the thermostat in the housing. On radiator units, attach the outlet elbow and the thermostat housing to the water manifold. On keel cooled units attach the water outlet housing to the thermostat housing.

> **NOTE:** The openings in the side of the thermostat body (former service thermostat) must be fully open before the thermostat is installed. If the openings are partially closed in handling, they can be opened by grasping the body flange and turning the body.

On heat exchanger or keel cooled units, attach the thermostat housing to the expansion tank.

Using a new seal connect the thermostat housing to the water manifold.

> **NOTE:** On keel cooled units, be sure to install the 2.874" diameter cover plate (if removed) in the expansion tank before attaching the thermostat housing to the expansion tank (Fig. 4).

3. On railcar units, replace the thermostats (Fig. 5) as follows:

a. Install new thermostat seals in the water outlet elbow with installer J 8550 and handle J 7079-2.

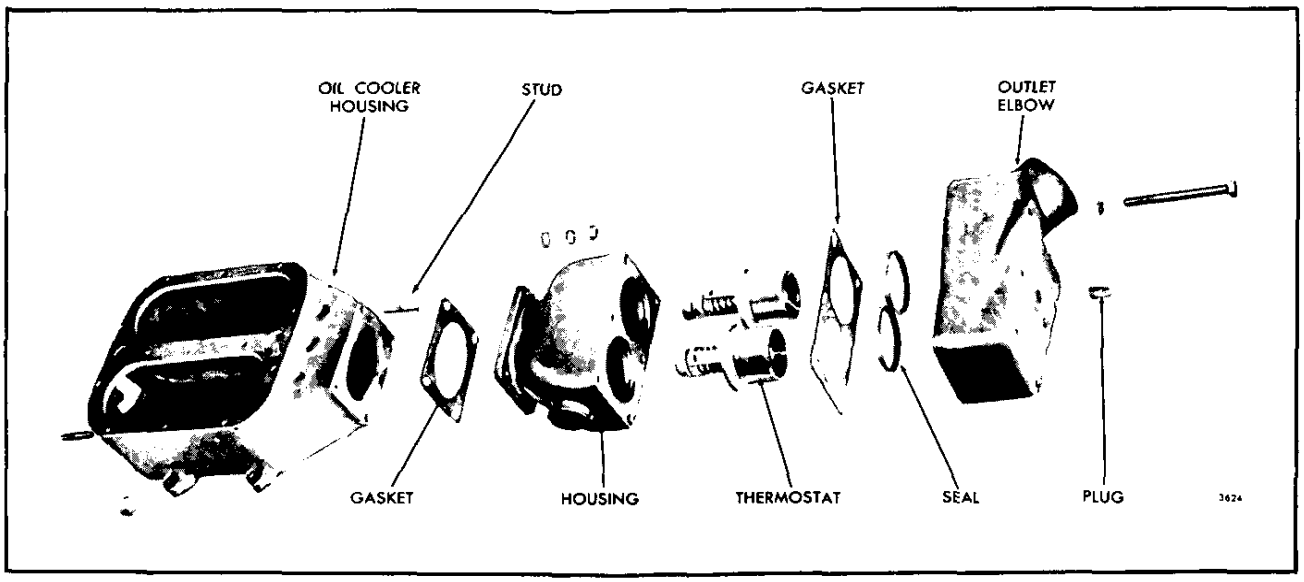


Fig. 5 - Thermostat Housing Details and Relative Location of Parts (Diesel Rail Car Unit)

© 1981 General Motors Corp.

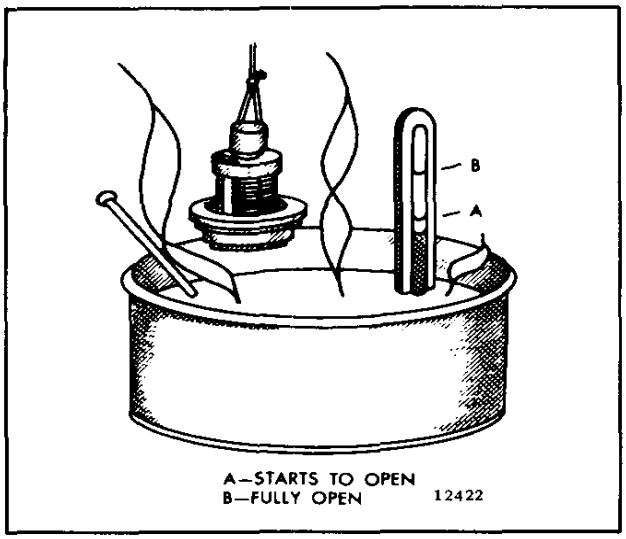


Fig. 6 - Method of Checking Thermostat Operation

Position the seals in the elbow so the lip of the seals face (down) away from the thermostats. The seal installing tool assures that the seals are positioned the correct distance from the finished face of the elbow and are parallel with the face of the elbow.

b. Place a thermostat in each opening in the thermostat housing.

c. Place a new gasket over the thermostats and against the housing.

d. Place the water outlet elbow with seals, over the thermostats and against the gasket. Install the six bolts and lock washers and tighten the bolts to 30-35 lb-ft (41-47 Nm) torque.

e. Connect the water outlet and bypass tube hoses to the water outlet elbow and tighten the clamps.

4. Connect any other piping which may have been disconnected.

5. Fill the cooling system and check for leaks.

© 1981 General Motors Corp.

RADIATOR

The temperature of the coolant circulating through the engine is lowered by the action of the radiator and the fan (Fig. 1). The radiator is mounted in front of the engine so that the fan will draw air through it, thereby lowering and maintaining the coolant temperature to the degree necessary for efficient engine operation.

To prolong the life of the radiator refer to Section 13.3 (Coolant Specifications) for the recommended type of coolant.

To increase the cooling efficiency of the radiator, a metal shroud is placed around the fan. The fan shroud must be fitted airtight against the radiator to prevent recirculation of the hot air drawn through the radiator. Hot air which is permitted to pass around the sides or bottom of the radiator and is again drawn through the radiator will cause overheating of the engine.

Another cause of overheating is slippage of the fan drive belts which is caused by incorrect belt tension, worn belts or worn fan belt pulley grooves, or the use of fan belts of unequal length when two or more belts are used. The belt tension and condition of the belts should be checked periodically as outlined in Section 15.1.

A radiator that has a dirty, obstructed core or is leaking, a leak in the cooling system, or an inoperative thermostat will also cause the engine to overheat. The radiator must be cleaned, the leaks eliminated, and defective thermostats replaced immediately to prevent serious damage from overheating.

The external cleanliness of the radiator should be checked if the engine overheats and no other causes are apparent.

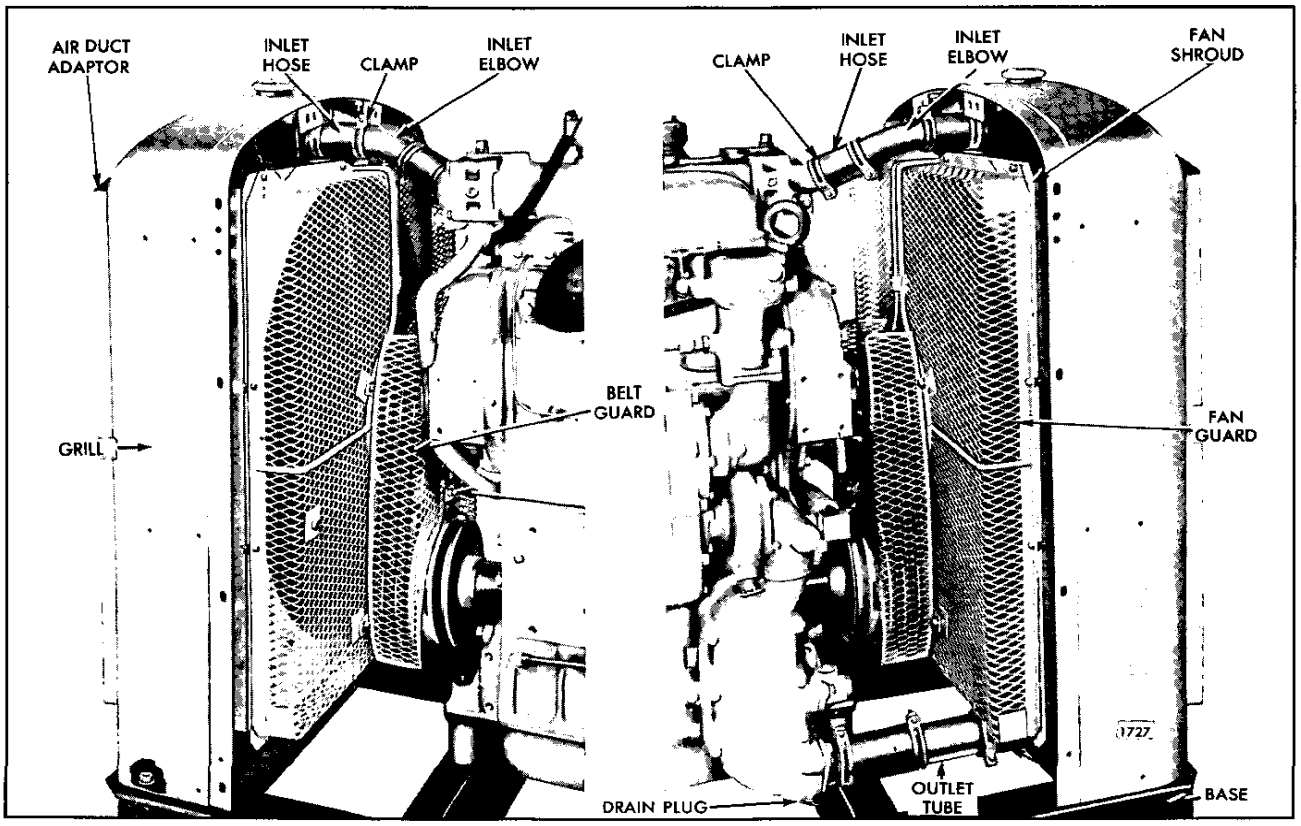


Fig. 1 - Typical Radiator Grill, Shroud and Fan Guard Mounting

© 1984 General Motors Corp.

Cleaning Radiator

The radiator should be cleaned whenever the foreign deposits are sufficient to hinder the flow of air or the transfer of heat to the air. In a hot, dusty area, periodic cleaning of the radiator will prevent a decrease in efficiency and add life to the engine.

The fan shroud and grill should be removed, if possible, to facilitate cleaning of the radiator core.

An air hose with a suitable nozzle if often sufficient to remove loose dust from the radiator core. Occasionally, however, oil may be present requiring the use of a solvent, such as mineral spirits, to loosen the dirt. The use of kerosene, or fuel oil is NOT recommended as a solvent. A spray gun is an effective means of applying the solvent to the radiator core. Use air to remove the remaining dirt. Repeat this process as many times as necessary, then rinse the radiator with clean water and dry it with air.

> **NOTE:** Provide adequate ventilation of the working area to avoid possible toxic effects of the cleaning spray.

Another method of cleaning the radiator is the use of steam or a steam cleaning device, if available. If the foreign deposits are hardened, it may be necessary to apply solvents.

The scale deposit inside the radiator is a result of using hard, high mineral content water in the cooling system. The effect of heat on the minerals in the water causes the formation of scale, or hard coating, on metal surfaces within the radiator, thereby reducing the transfer of heat. Some hard water, instead of forming scale, will produce a silt-like deposit which restricts the flow of water. This must be flushed out at least twice a year--more often if necessary (see Section 5).

A drain is provided at the bottom of the oil cooler housing (Fig. 1).

To remove the hardened scale, a direct chemical action is necessary. A flushing compound such as salammoniac, at the specified rate of 1/4 pound per each gallon of radiator capacity, should be added to the coolant water in the form of a dissolved solution while the engine is running. Operate the engine for at least 15 minutes, then drain and flush the system with clean water.

Other flusing compounds are commercially available and should be procured from a reliable source. Most compounds attack metals and should not remain in the engine for more than a few minutes. A neutralizer should be used in the cooling system immediately after a descaling solvent is used.

For extremely hard, stubborn coatings, such as lime scale, it may be necessary to use a stronger solution. The corrosive action of a stronger solution will affect the thin metals of the radiator, thereby reducing its operating life. A complete flushing and rinsing is mandatory and must be accomplished skillfully.

After the solvent and neutralizer have been used and the cooling system is flushed, completely drain the entire system again and fill it with clean, soft water plus a corrosion inhibitor or permanent type antifreeze (refer to Section 13.3). After filling the cooling system, inspect the radiator and engine for water leaks.

> **NOTE:** When draining or filling, the cooling system must be vented.

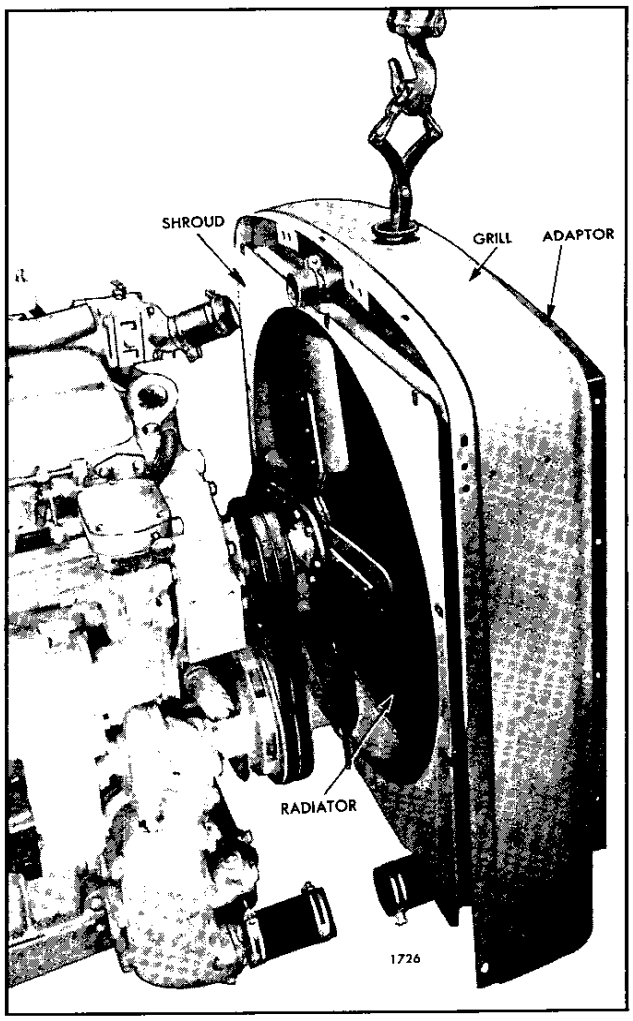


Fig. 2 - Removing Radiator, Shell and Shroud with Lifting Hook

© 1984 General Motors Corp.

After the radiator core has been thoroughly cleaned and dried, reinstall the fan shroud and grill, if removed.

Remove Radiator

Refer to Fig. 2 and remove radiator as follows:

1. Remove the radiator filler cap and open the drain cock to drain the cooling system. Also open the drain cock on the oil cooler and the engine block.

NOTE: When draining the cooling system on certain models, it is necessary to open the vent valve at the top of thermostat housing.

2. Remove the instrument panel and engine hood if engine is so equipped.

3. Remove bolts, nuts, plain washers, and lock washers which attach the fan belt guards to the rear of the fan guard and remove the guards.

4. Withdraw screws releasing fan guard from the fan shroud.

5. Loosen the hose clamps at the radiator inlet pipe elbow or hose and remove the elbow or hose.

6. Loosen the hose clamps at the radiator outlet pipe extension tube or hose and remove the tube or hose.

7. Use a chain hoist and a suitable lifting device (through the filler neck or otherwise) and draw the hoisting chain taut to steady the radiator.

8. Remove the bolts, nuts, plain washers, lock washer and bevel washer holding the radiator assembly to the base.

NOTE: Since the shroud is very close to the tips of the fan blades, to prevent damage to these parts great care must be exercised whenever the radiator is removed.

9. Lift the radiator assembly with a chain hoist and lifting hook as shown in Fig. 2, enough to clear the engine base; then move it away from the engine.

10. The fan shroud and radiator grille may be removed from the radiator by removing the attaching bolts, flat washers and lock washers.

Inspection

Clean all radiator parts thoroughly, removing dirt, scale and other deposits.

Examine the raditor for cracks or other damage. The radiator core fins should be straight and evenly spaced to permit the full flow of cooling air. The core tubes should be clean inside and outside and have no leaks.

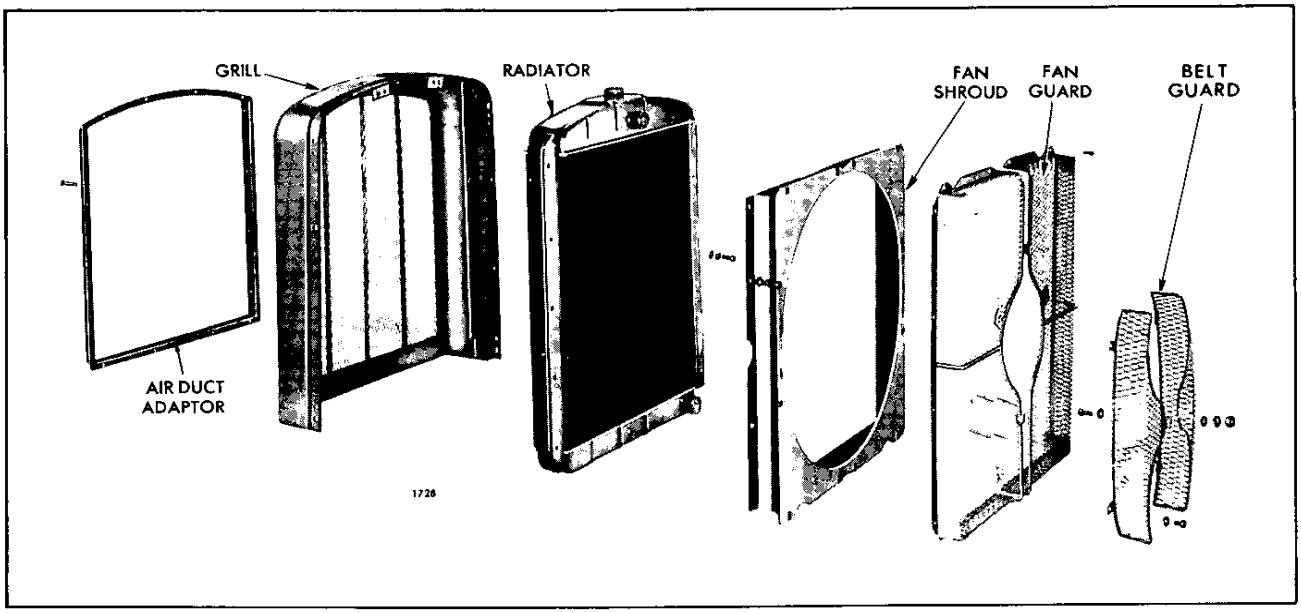


Fig. 3 - Radiator, Grill, Shroud and Fan Guard Details and Relative Location of Parts

© 1979 General Motors Corp.

If repainting the radiator core becomes necessary, it is recommended that a thin coat of dull black radiator paint or another high quality flat black plaint be used. Ordinary oil paints have an undesirable glossy finish and do not transmit heat as well.

Check all radiator hoses and clamps. Replace cracked and deteriorated hoses and damaged clamps.

Install Radiator

Assemble the radiator, grill and shroud (Fig. 3). Then mount the assembly on the engine base by reversing the procedure given for removal.

Check the clearance between the tips of the fan blades and radiator shroud after the radiator is in place. There must be sufficient clearance between these parts or damage to the fan and shroud will result when the engine is started. Use shims between the radiator and base, if necessary to obtain the proper clearance.

CROSS-FLOW DESIGN RADIATOR

Certain on-highway vehicle engines incorporate a cooling system radiator of a cross-flow design rather than the conventional down-flow design.

As the name implies, a cross-flow radiator has a core of horizontally positioned tubes and coolant flow moves across rather than down the radiator. Two reasons for using the cross-flow design radiator are:

1. The reduced height of the radiator permits a lower hood line design, thus providing better road visibility.

2. The area ahead of the engine crankshaft and below the radiator is open for mounting a power take-off unit, if desired.

The intent here is to describe briefly how the cross-flow radiator functions and to identify some of the components unique in the cross-flow system.

One such component is a Y-shaped device called an aspirator (Fig. 4) which is mounted externally on the filler cap side of the radiator and serves to rid the cooling system of air. The aspirator directs coolant under pressure through a venturi where entrapped air inside the radiator is picked up and moved to the supply chamber of the radiator where it is vented. The coolant line providing the drive flow originates at the engine thermostat housing. This hookup provides a flow of coolant to the aspirator regardless of whether the thermostat is open or closed. As the coolant flow passes through the aspirator, its action pulls coolant and any air that is present from the top of the radiator core outlet chamber into an internal "U" tube which vents near the filler cap inside the radiator supply chamber to complete the deaeration process. This "U" tube insures that the entire cooling circuit, other than the supply chamber, remains completely full when the engine is stopped. Also, it keeps the coolant from seeking a common level throughout the system and, thereby, eliminates an aerated system at the next engine start-up.

The cross-flow system (Fig. 5) for the In-line 6-71 engine does not require a by-pass restriction (required in 8V-71 and 6V-53 engines) because there is sufficient pressure in the system to provide adequate engine deaeration and aspirator performance.

Properly installed hose connections are required for adequate cross-flow radiator efficiency.

The cross-flow cooling system should always be drained at the radiator drain cock. This will insure that both the radiator and internal "U" tube is empty. If the "U" tube is not emptied, refilling the system will prove difficult.

Due to the design of the cross-flow radiator, air may be trapped inside of the radiator during the fill process resulting in a false coolant level reading. Therefore,

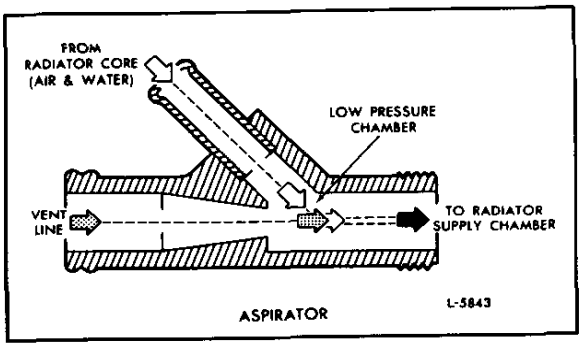


Fig. 4 - Aspirator for Cross-Flow Design Radiator

© 1979 General Motors Corp.

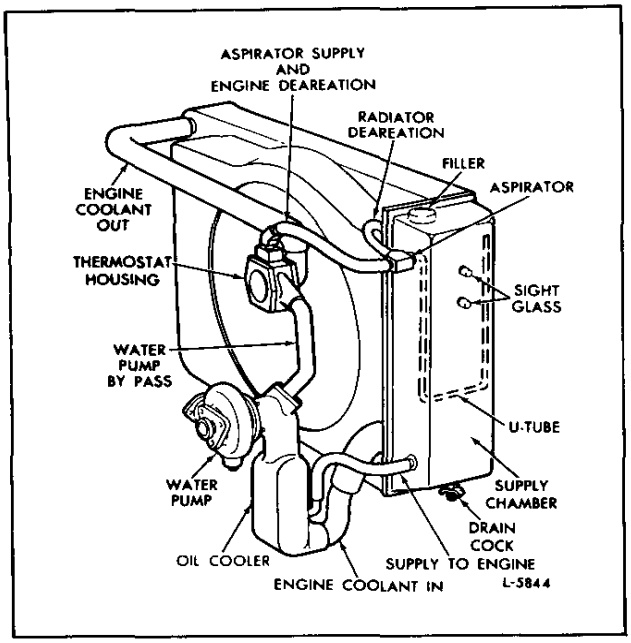


Fig. 5 - Cross-Flow Design Radiator

after filling the cooling system, the engine should be run for approximately 10 minutes at 1200-1400 rpm so that any entrapped air can be vented. Generally, additional coolant (approximately 3 to 4 quarts) will be required to bring the coolant to the proper level.

For efficient operation of the cross-flow radiator system, it is important that no leak exists between the radiator core and the supply tank. If an internal leak has developed between the radiator core and the supply tank it can cause the cooling system to become aerated at low RPM and following engine shut down. The radiator should be tested periodically for possible internal leaks. The procedure to determine if a leak is present is as follows:

1. Remove the radiator cap and run the engine for approximately 10 minutes at high idle to completely deaerate the cooling system. While the engine is running, add additional coolant to the supply chamber to bring the coolant level to the bottom of the filler neck.

2. Shut off the engine and drain 4 quarts of coolant from the radiator.

3. Start and run the engine at high idle for approximately 10 minutes and observe the coolant level.

4. Shut off the engine and again observe the coolant level. If the coolant rises substantially in the supply tank, an internal leak is present and immediate corrective action should be taken to repair the leak. If the coolant level remains constant or falls, the system is satisfactory.

5. After the test is completed, refill the cooling system to the proper coolant level.

If the leak situation is not corrected, the engine will be operating with an aerated coolant for abnormal periods of time which could lead to an engine failure.

© 1979 General Motors Corp.

COOLANT PRESSURE CONTROL CAP

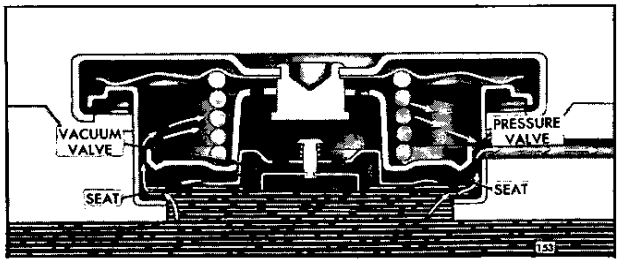


Fig. 1 - Pressure Control Cap (Pressure Valve Open)

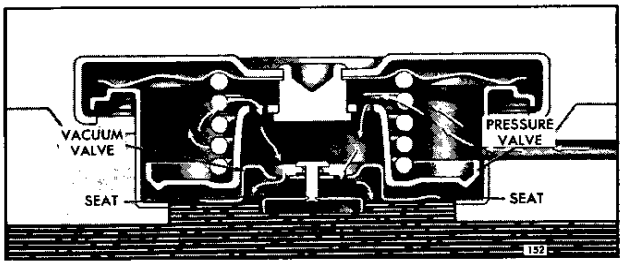


Fig. 2 - Pressure Control Cap (Vacuum Valve Open)

The radiator (or expansion tank) has a pressure control cap with a normally closed valve. The cap, with a number 7 stamped on its top, is designed to permit a pressure of approximately seven pounds in the system before the valve opens. The cap with a number 9 stamped on tis top, is designed to permit a pressure of approximately nine pounds (62 kPa) in the system before the valve opens. This pressure raises the boiling point of the cooling liquid and permits somewhat higher engine operating temperatures without loss of any coolant from boiling. To prevent the collapse of hoses and other parts which are not internally supported, a second valve in the cap opens under vacuum when the system cools.

CAUTION: Use extreme care when removing the coolant pressure control cap. Remove the cap *slowly* after the engine has cooled. The sudden release of pressure from a heated cooling system can result in loss of coolant and possible personal injury (scalding) from the hot liquid.

To ensure against possible damage to the cooling system from either excessive pressure or vacuum, check both valves periodically for proper opening and closing pressures. If the pressure valve does not open between 6.25 psi (43.1 kPa) and 7.5 psi (51.7 kPa) or the vacuum valve does not open at .625 psi (4.3 kPa) - (differential pressure), replace the pressure control cap.

It is recommended that all 71 on-highway vehicle engines use a minimum 9 psi (62 kPa) pressure control cap. If the pressure valve does not open between 8 psi (55 kPa) and 10 psi (69 kPa) or the vacuum valve does not open at .625 psi (4.3 kPa) - (differential pressure), replace the pressure control cap.

© 1982 General Motors Corp.

ENGINE COOLING FAN

The engine cooling fan is belt driven from the crankshaft pulley (Fig. 1).

The fan is bolted to a hub and pulley which is carried on two bearings. The bracket and shaft is mounted on the fan support which is in turn attached to the balance weight cover. The bracket is slotted to permit adjustment of the fan belt tension by moving the bracket and shaft on the attaching bolts (Fig. 2). Formerly, the bracket and shaft were separate pieces and the rear end of the shaft was supported in the bracket and retained by a snap ring. On compact front end engines the pulley hub turns on tapered roller bearings (Fig. 8).

Effective with engine serial number 4A-214597 and after engine serial number 6A-337000 a new shaft type pulley hub assembly is similar to the present pulley hub assembly except that it includes a front ball bearing and a rear roller bearing along with a hub cap (with relief valve), a dust cap and a grease fitting in the fan pulley hub (Fig. 9).

Lubrication

The bearings and the cavity between the bearings are packed with grease at the time the fan hub is assembled. Refer to Section 15.1 for the maintenance schedule.

Fan Belt Adjustment

Adjust the fan belt(s) periodically as outlined in Section 15.1.

Remove and Install Fan Blades

If enough clearance exists between the fan blades and the face of the radiator core, the fan blade and spacer may be removed by taking out the six mounting bolts, nuts and lock washers. If the blades cannot be removed in this manner, the fan, hub and bracket may be removed as an assembly. See the procedure for removing the fan, hub and bracket.

The fan blades maybe installed by reversing the procedure used for removal.

Remove Fan, Hub and Adjusting Bracket

The fan blades must rotate in a vertical plane parallel with and a sufficient distance from the radiator core. Bent fan blades reduce the efficiency of the cooling system, may throw the fan out of balance, and are apt to damange the radiator core. Before removing the fan, check the blades for alignment. Do not rotate the fan by pulling on the fan blades.

1. Remove the belt and fan guards.

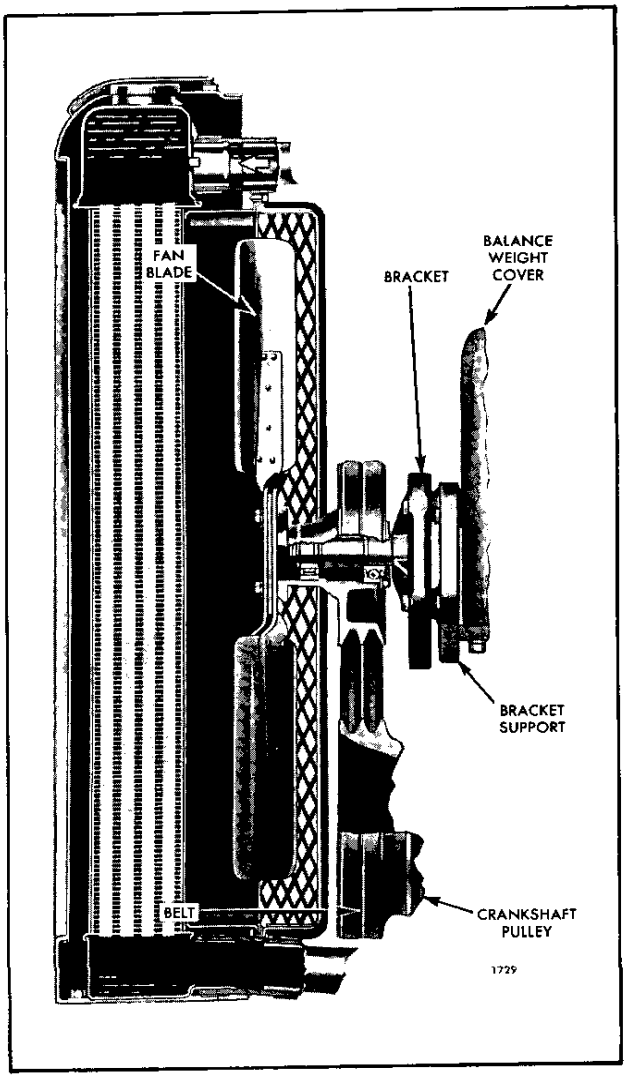


Fig. 1 - Typical Fan and Fan Hub Assembly

© 1978 General Motors Corp.

2. Remove the attaching bolts, lock washers and nuts, then remove the fan and spacer (if used).

NOTE: If insufficient clearance exists between the fan and radiator, remove the fan, hub and adjusting bracket as an assembly.

3. Remove the two adjusting bolts, lock washers and plain washers, then remove the drive belts.

4. Loosen the adjusting bracket pivot or adjusting bolts until the bracket is free. Remove the hub and bracket assembly from the engine.

Disassemble Fan, Hub and Bracket (Former)

Refer to Figs. 2 and 5 and disassemble the fan, hub and adjusting bracket as follows:

1. Remove the fan attaching bolts, nuts and lock washers and detach the fan and spacer (if used).

2. Remove the bracket retaining ring from the rear end of the shaft.

3. Place the hub and bracket assembly in an arbor press with the front face of the bracket supported on split plates so that the hub is clear of the bed of the press (Fig. 3).

Place a brass rod on the end of the shaft and press the shaft from the bracket. When the bracket is free, the bolt and lock washer may be removed from the bracket.

4. Place the hub in an arbor press with the shaft in line with the opening in the bed of the press (Fig. 4). Place a brass rod on the end of the shaft and press the shaft, front roller bearing and cap from the hub.

5. Slide the roller bearing from the shaft. If the inner race of the bearing is in good condition, it may be left on the shaft. If, however, removal of the inner race is necessary, first remove the retaining ring, then split the inner race and remove it from the shaft.

6. Remove the retaining ring from the hub and tap the rear ball bearing from the hub, using a brass rod against the rear of the bearing.

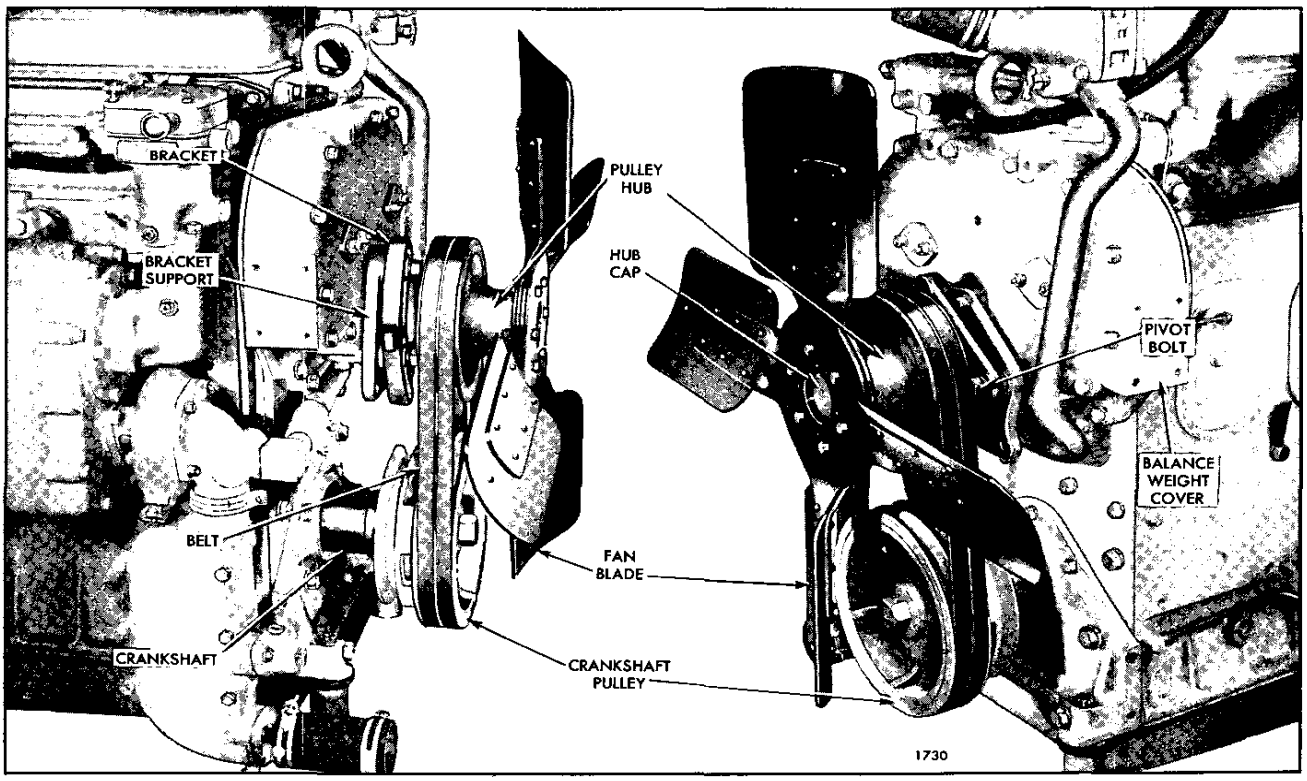


Fig. 2 - Fan Mounting

© 1978 General Motors Corp.

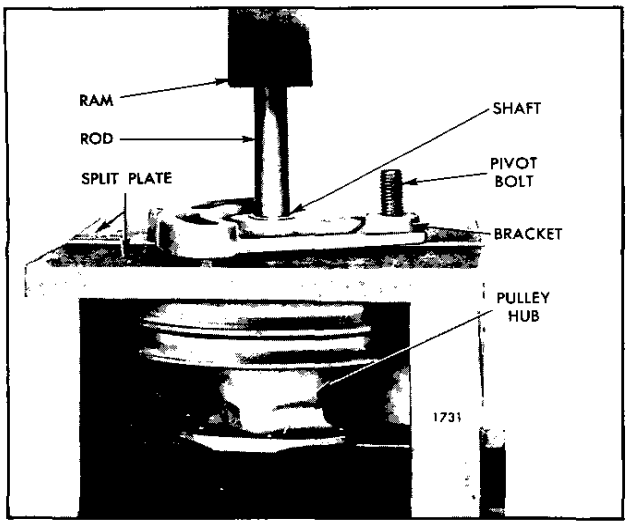


Fig. 3 - Removing Fan Shaft from Fan Adjusting Bracket

Disassemble Fan, Hub and Bracket (Current)

Refer to Figs. 2, 8 and 9 and disassemble the fan, hub and adjusting bracket as follows:

1. Remove the fan attaching bolts and lock washers and detach the fan and the spacer (if used).

2. Remove the fan hub cap (if a spacer and cap assembly were not used).

3. Remove the hub bolt and washer. Also remove the shims if the former hub assembly is used (Fig. 7).

4. Withdraw the hub and bearing assembly from the shaft. It may be necessary to tap the end of the shaft with a soft hammer to loosen the hub assembly.

5. Remove the bearings and oil seal as follows:

a. Remove the snap ring (if used) from the groove in the outer (front) of the hub.

b. Remove the current ball bearing by tapping alternately around the outer edge of the bearing with a small brass rod and hammer.

c. Remove the former roller bearing inner race from the outer (front) roller bearing.

d. Remove the shims and bearing spacer (if used).

e. Tap the outer race of the former roller bearing out of the pulley hub by tapping alternately around the rear face of the bearing outer race with a small brass rod and hammer.

f. Reverse the pulley hub and remove the dust cap (if used). Then drive the oil seal from the hub. Discard the oil seal.

g. Remove the inner (rear) roller in the same manner as outlined in Steps c and e.

h. Remove the grease retainer (if used) from the pulley hub.

Inspection

Clean the fan and related parts with fuel oil and dry them with compressed air. *Shielded bearings must not be washed;* dirt may be washed in and the cleaning fluid could not be entirely removed from the bearing. Examine the bearings for any indication of corrosion or pitting. Hold the inner race or cone and revolve the outer race or cup slowly by hand. If rough spots are found, replace the bearings.

Check the fan blades for cracks. Replace the fan if the

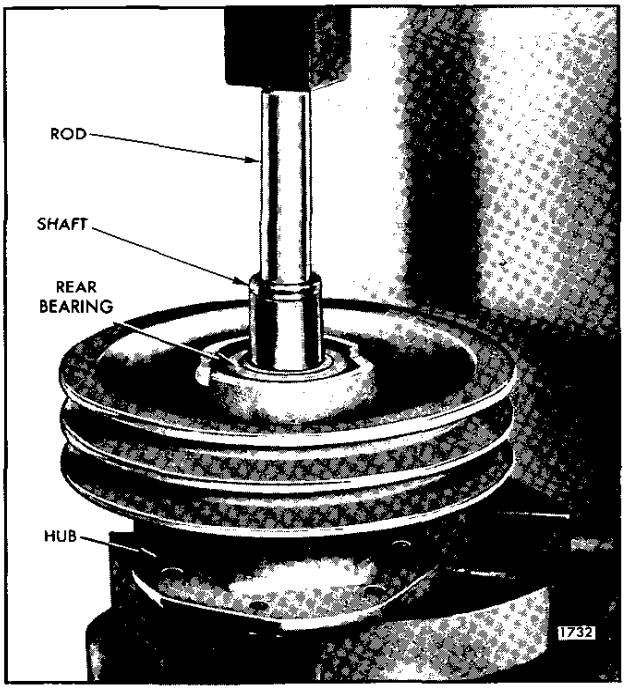


Fig. 4 - Removing Fan Shaft and Front Roller Bearing From Hub

© 1978 General Motors Corp.

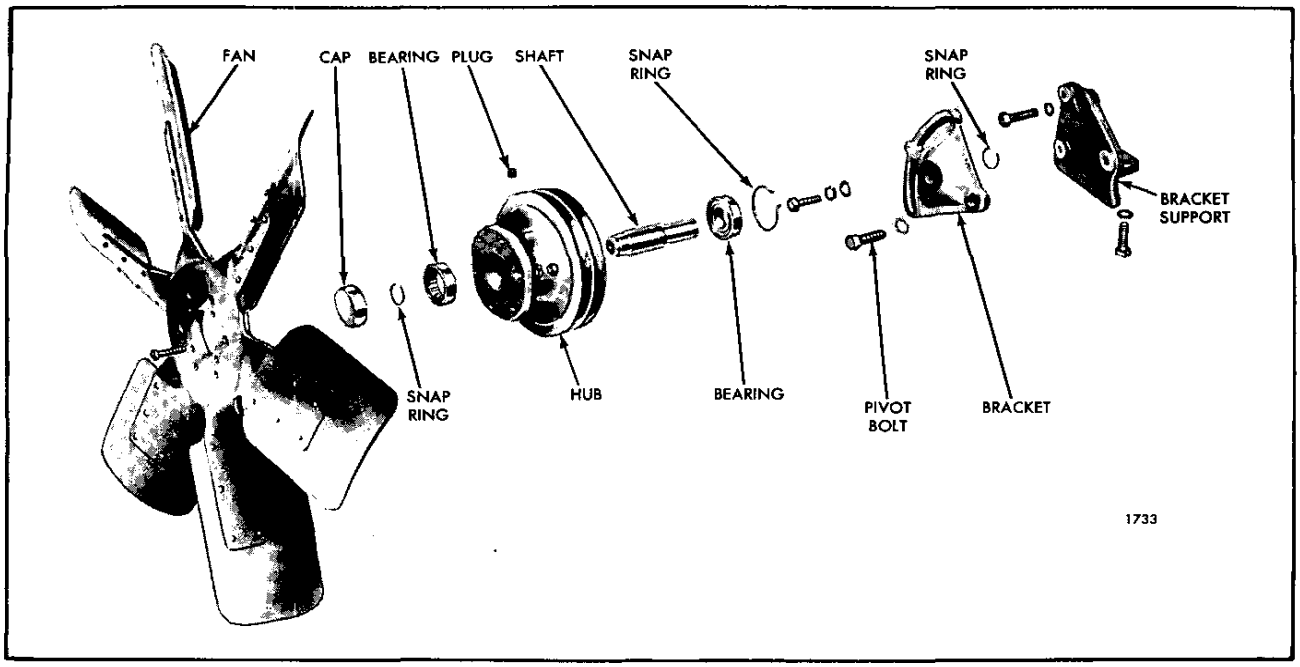


Fig. 5 - Fan Hub and Adjusting Bracket Details and Relative Location of Parts

blades are badly bent, since straightening may weaken the blades, particularly in the hub area.

Remove any rust or rough spots in the grooves of the fan pulley and crankshaft pulley. If the grooves are damaged or severely worn, replace the pulleys.

Check for cracks in the adjusting and support bracket castings.

New .560 " thick and .800 " thick fan hub spacers and a new fan hub cap replaces the former spacer and cap assemblies to provide spacers compatible with the six bolt hole mounting fan hub assemblies. The spacers (individually or in combination) also provide a means for setting the different clearances between the back of the fan blades and front groove of the crankshaft pulley.

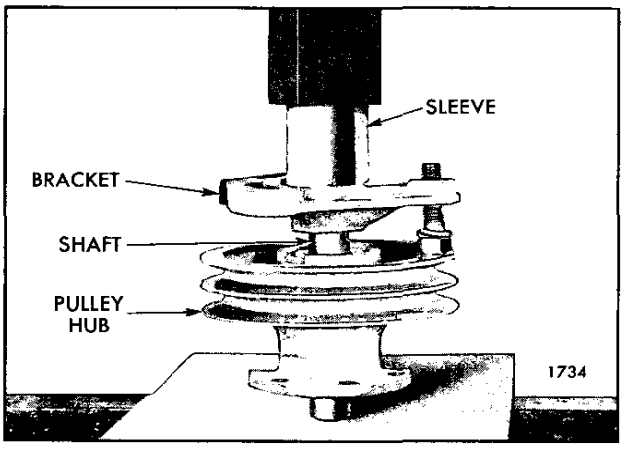


Fig. 6 - Installing Adjusting Bracket and Bolt on Fan Shaft

The spacers have a flange on one side that serves as a pilot for the fan as well as a spacer pilot for the second spacer when two or more spacers are used together.

> **EXAMPLE:** A former 1.800 " thick spacer and cap assembly have been replaced by two .560 " (was .500 ") thick spacers, one .800 " thick spacer (refer to Section 5.0) and the new fan hub cap.

When replacing the former fan hub spacer, be sure and include the new cap.

Fan hubs equipped with roller bearings may be modified by adding a grease fitting (refer to Section 5.0).

The current fan shaft rear bearing inner race should be inspected for any measurable wear. Replace the inner race if the outer diameter is less than 1.7299 ".

> **NOTE:** The inner and outer races are only serviced as a rear roller bearing assembly.

© 1978 General Motors Corp.

When installing the rear bearing inner race, press it on the shaft and position it 1.35 " to 1.37 " from the end of the shaft.

Assemble Hub and Bracket (Former)

Where grease is specified, use Texaco Premium RB grease or an equivalent Lithium base multi-purpose grease.

1. If the inner race of the roller bearing was removed, start a new bearing straight on the short journal end of the shaft. Then press the bearing inner race tight against the shoulder on the shaft.

2. Install the snap ring.

3. Insert the shaft and roller bearing into the flanged end of the pulley hub and pack the cavity with grease.

4. Start the ball bearing straight on the long journal end of the shaft. Place the hub in an arbor press with the forward end of the shaft resting on the plate and, using a sleeve over the rear end of the shaft, press the bearing tight against the shoulder on the shaft.

IMPORTANT: To prevent the possibility of the inner ball bearing race spinning on the shaft, apply a small quanity of Loctite No. RC601, or equivlant, to the full circumference of the bearing surface of the shaft. The bearing and shaft surfaces must be clean and dry. Make sure no Loctite gets into the bearing.

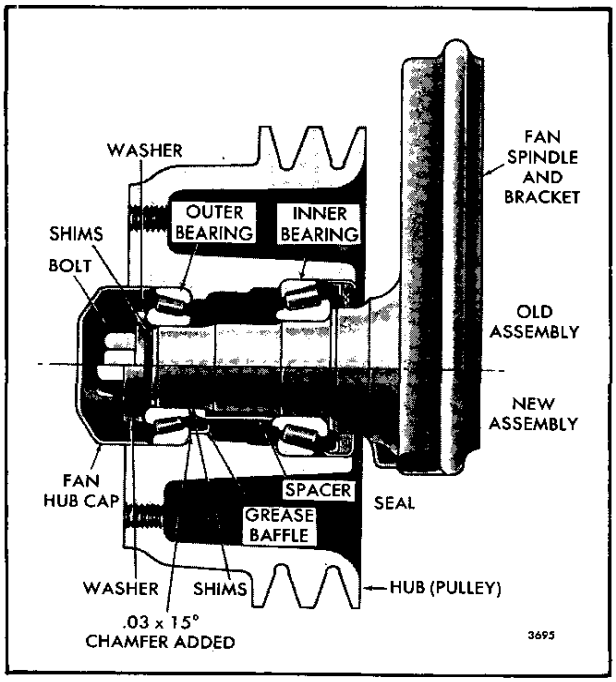


Fig. 7 - Shaft Type Fan Hub Assembly

5. Install the retaining ring in the hub.

6. Insert the bracket pivot bolt with lock washer through the 21/32 " hole in the bracket with the head of the bolt at the front side of the bracket (Fig. 6).

7. Support the forward end of the shaft on the plate of the arbor press. Start the bracket straight on the shaft and, using a sleeve, press the bracket into place as shown in Fig. 6.

8. Install the retaining ring on the end of the shaft.

9. Install the cap in the fan hub.

Assemble Fan, Hub and Bracket (Current)

Assemble the fan hub and bracket shown in Figs. 7, 8 and 9 as follows:

1. Apply Texaco Premium RB grease, or an equivalent Lithium base multi-purpose grease, to the rollers of both bearings before installing them in the pulley hub.

2. Install the inner (rear) roller bearing assembly (inner and outer race), with the protruding face of the inner race facing outward from the hub, (1.31 " from end of shaft), by tapping alternately around the face of the bearing outer race with a small brass rod and hammer.

3. Install a new oil seal with the rubber side flush with the outer edge of the hub.

NOTE: Certain engines use a rubber lip type oil seal.

4. Install the dust cap over the oil seal (if used).

5. Place the adjusting bracket assembly on wood blocks setting on the bed of an arbor press. Then press the pulley hub on the fan shaft and install the bearing spacer (if used).

6. Pack the cavity 20-30% full with grease as outlined in Step 1 and install the grease retainer (if used).

NOTE: The grease retainer is not required when a grease fitting is installed in the pulley hub (refer to Section 5.0).

7. Place the shims (if used) against the bearing spacer. Then install the outer (front) bearing assembly (current ball bearing or former roller bearing-inner and outer race), with the protuding face of the inner

© 1978 General Motors Corp.

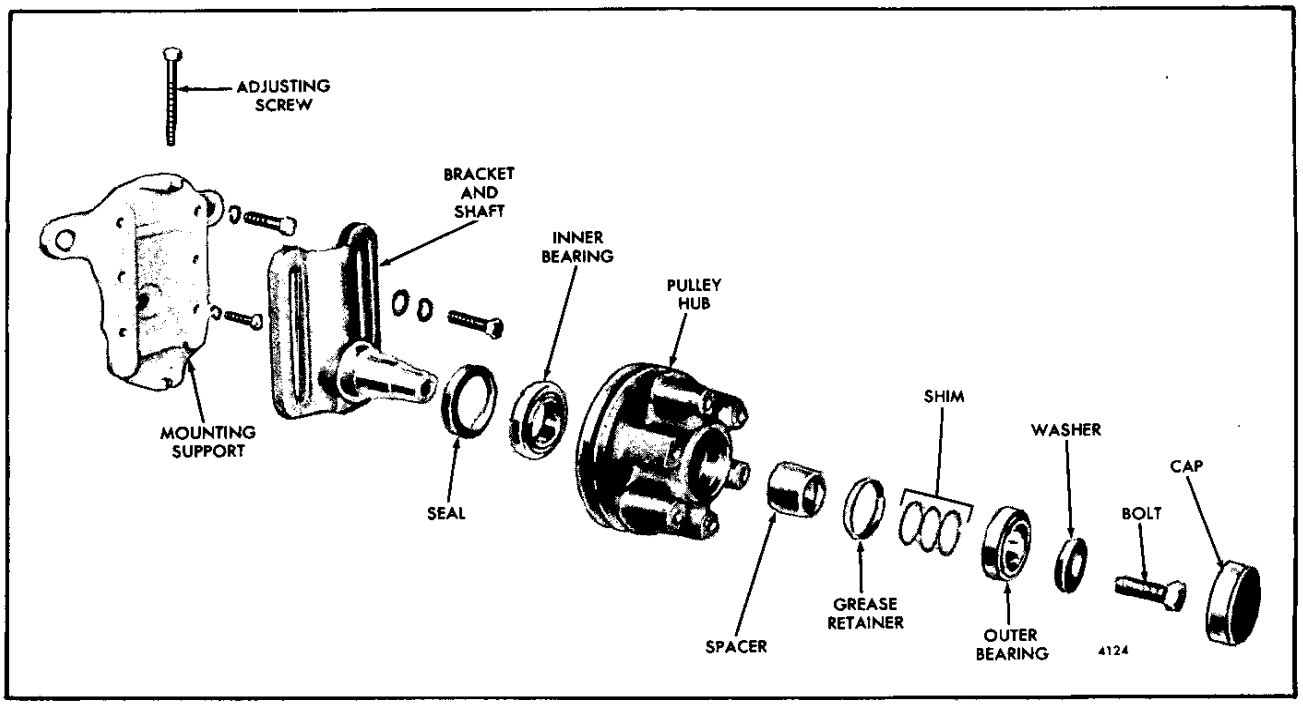


Fig. 8 - Shaft Type Fan Hub Assembly Details for Compact Front End Engine

race (former roller bearing) facing outward from the hub, as mentioned in Step 2.

8. Install snap ring (if used) in the groove of the pulley hub, to lock the outer (front) ball bearing onto the shaft.

9. Secure the hub with the washer and bolt. Tighten the 1/2 "-20 bolt to 83-93 lb-ft (113-126 Nm) torque while rotating the pulley.

10. Rotate the assembly and check the end play with the spindle (shaft) in a horizontal position. The end play must be within .001 " to .006 " on former hub assembly. If necessary, remove the bolt, washer and outer bearing and adjust the number and thickness of shims to obtain the required end play. Shims are available in .015 ", .020 " and .025 " thickness. Then reassemble the fan hub and check the end play.

11. Fill a new fan hub cap 75% minimum full of grease and install it in the end of the fan hub (pulley).

NOTE: The cap must not protude beyond the face of the hub.

12. Secure the fan blade and spacers to the pulley hub with six bolts, nuts and lock washers. Tighten the nuts to 15-19 lb-ft (20-26 Nm) torque.

Install Fan, Hub and Bracket (Former)

1. Place the fan belts on the pulley.

2. Position the bracket against the bracket support and thread the pivot or adjusting bolt into the support.

3. Thread the two adjusting bolts with lock washers and plain washers into the support. The bolts are tightened when making the fan belt adjustment.

4. Secure the fan to the pulley hub with bolts and lock washers.

5. Adjust the belt tension as outlined in Section 15.1.

Install Fan, Hub and Bracket (Current)

1. Attach the fan hub and adjusting bracket assembly to the support bracket on the engine with bolts, lock washers and plain washers. Do not tighten the bolts.

2. Install the drive belts and adjust the belt tension as outlined in Section 15.1. If used, install the adjusting bracket, bolt and plain washer (Fig. 7).

3. Install the fan (and fan spacer and cap, if used) on the hub and secure it with bolts and lock washers.

© 1978 General Motors Corp.

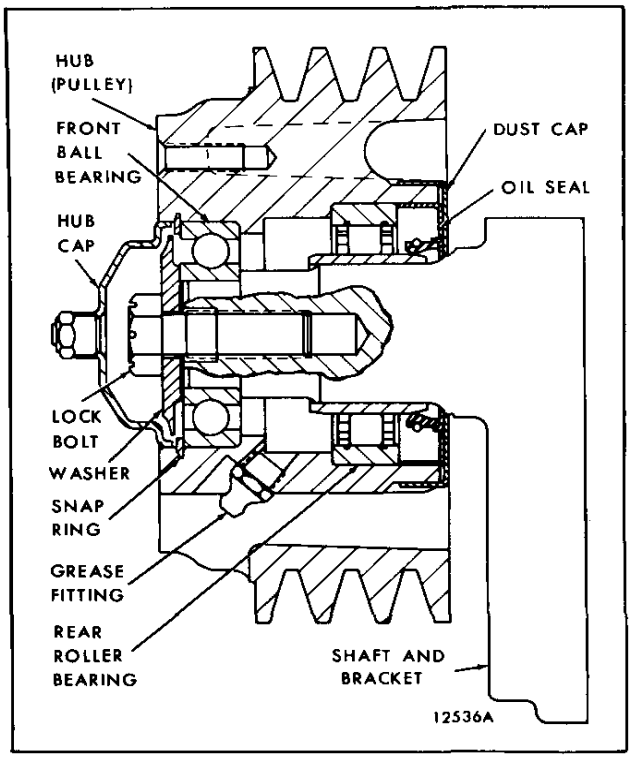


Fig. 9 - Shaft Type Fan Hub Assembly
(Current-Effective with October, 1976 Engines)

© 1978 General Motors Corp.

THERMO–MODULATED FAN

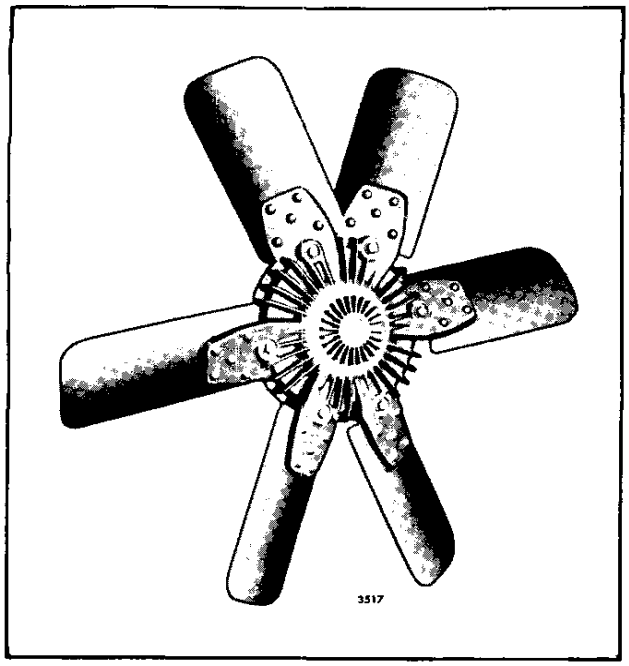


Fig. 10 - Thermo-Modulated Fan Assembly

A thermo-modulated suction fan assembly has been *provided on some engines (Fig. 10).*

This fan assembly is designed to regualte the fan speed and maintain an efficient engine coolant temperature regardless of the variations in the engine load or outside air temperature.

The entire fan drive assembly is a compact integral unit (Fig. 11) which requires no external piping or controls and operates on a simple principle. This principle consists of transmitting torque from the input shaft to the fan by the shearing of a silicon fluid film between the input and output plates in a sealed multiplate, fluid filled clutch housing.

The thermostatic control element, which is an integral part of the fan drive, reacts to changes in engine temperature and varies the fluid film thickness between the plates and thereby changes the fan speed. Proper selection of the control element setting is determined by the vehicle manufacturer to maintain optimum cooling and no further adjustment should be necessary.

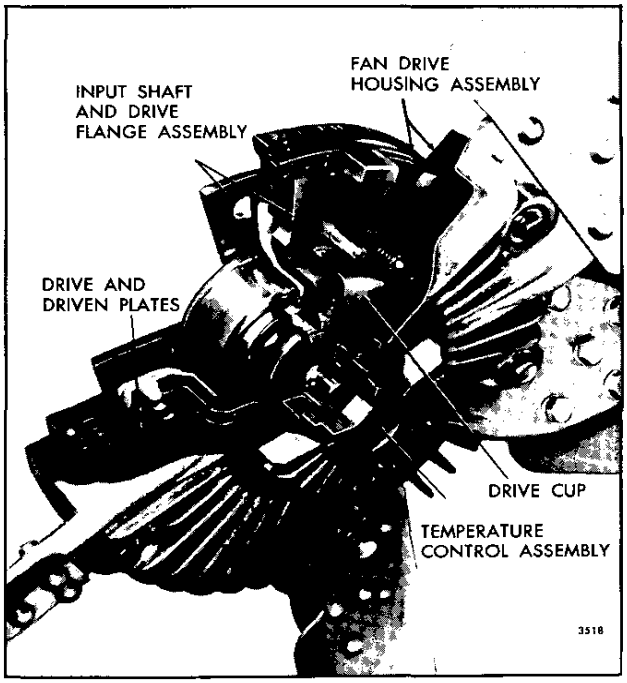


Fig. 11 - Thermo-Modulated Fan Drive Assembly

The thermo-modulated fan is mounted and driven by the engine in the same manner as the conventional fan.

Lubrication

The fan drive assembly is prelubricated by the manufacturer, however the drive fluid level and the roller bearing should be checked periodically (refer to Section 15.1).

Adjust Fan Belt

The adjustment of the fan belt tension is the same as on the conventional type fans.

Remove and Install Fan and Drive Assembly

The fan blades and fan drive may be taken off by removing the four shaft to pulley mounting bolts, and installed by reversing this procedure.

© 1978 General Motors Corp.

HEAT EXCHANGER

The heat exchanger core assembly consists of a series of vertical cells contained within a rectangular cage, with a header at one end and a circular water outlet at the opposite end (Fig. 1). The core is mounted inside of the expansion tank with the header (inlet end) bolted to the tank and the outlet end sealed inside of a retainer (Fig. 2). A gasket between the expansion tank and the flange of the core, another gasket between the flange of the core and the cover at the inlet side, and seals surrounding the circular outlet at the opposite end prevent the coolant from mixing with the raw cooling water on its horizontal course between the cells of the core.

In this system of engine cooling, the hot coolant flows from the water manifold to the expansion tank and down through the vertical cells of the heat exchanger core. The raw water, flowing horizontally between the cells of the heat exchanger core, lowers the temperature of the engine coolant as it passes through the cells. The engine coolant is then circulated through the cylinder block and head by the water pump.

Zinc electrodes, located in the heat exchanger inlet cover and the raw water pump inlet elbow, protect the heat exchanger core from electrolytic action.

The expansion tank provides a means of filling the engine cooling system, as well as space for expansion of the coolant as its temperature rises. An overflow pipe, attached near the top of the tank, provides a vent to the atmosphere.

> **IMPORTANT:** When installing a new filler neck in the expansion tank be sure to drill a 3/16" hole in the side of the new filler neck for the overflow pipe.

The length of time a heat exchanger will function satisfactorily before cleaning will be governed largely by the kind of coolant used in the engine, and the kind of raw water used. Soft water, plus a good grade of corrosion inhibitor or antifreeze, should be used as the engine coolant. The coolant level should be maintained near the top of the expansion tank.

If the heat exchanger fails to cool the engine properly, the core assembly should be examined for foreign deposits.

Clean Heat Exchanger Core

When foreign deposits accumulate in the heat exchanger to the extent that cooling efficiency is impaired, remove the heat exchanger core and clean it as follows:

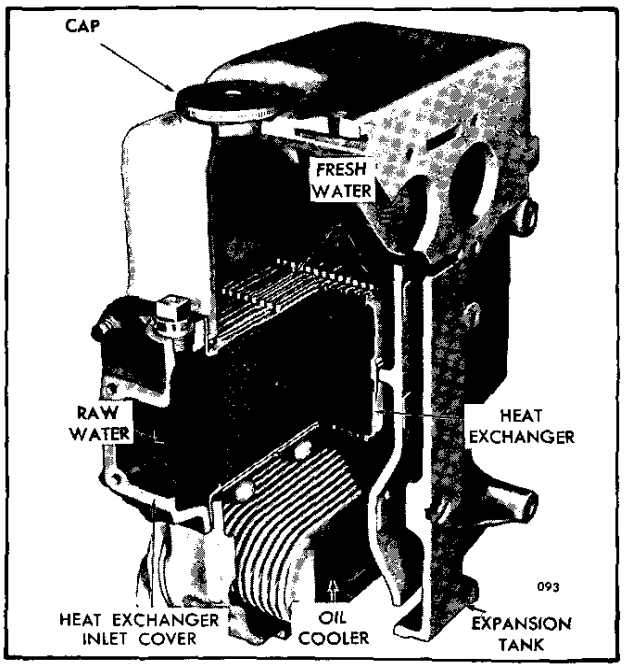


Fig. 1 - Heat Exchanger Assembly

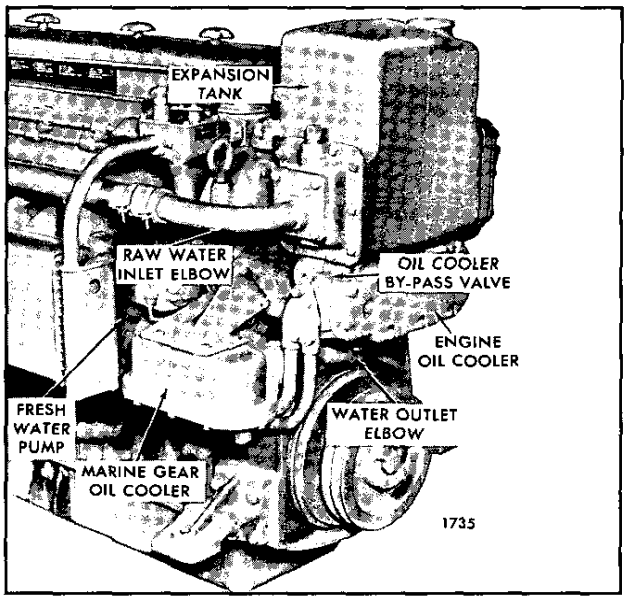


Fig. 2 - Expansion Tank, Heat Exchanger and Oil Cooler Mounting

© 1980 General Motors Corp.

Immerse the heat exchanger core in a scale solvent consisting of one-third (1/3) muriatic acid and two-thirds (2/3) water to which one-half (1/2) pounds of oxalic acid has been added to each two and one-half (2-1/2) gallons of solution. Remove the core when foaming and bubbling stops. This usually takes from thirty to sixty seconds. Flush the core thoroughly with clean hot water under pressure.

To prevent drying and hardening of accumulated foreign substances, the heat exchanger core must be cleaned as soon as possible after removing it from service.

Inspect Zinc Electrodes

Clean pitted electrodes with a wire brush. If replacement is required, remove the electrode from its holder. Thread a new electrode in the holder and install the assembly in the heat exchanger or raw water pump inlet elbow.

Remove Heat Exchanger Core

Remove the heat exchanger core for inspection or cleaning as follows:

1. Drain the engine coolant and the raw water system.

2. Remove the four bolts and lock washers that hold the raw water inlet tube to the heat exchanger. Then, withdraw the inlet tube and gasket.

3. Remove the ten bolts and lock washers that hold the heat exchanger inlet cover to the expansion tank.

4. Remove the four bolts and lock washers that hold the outlet tube to the cover. Then, remove the outlet tube and gasket.

5. Remove the ten bolts and lock washers that hold the outlet cover and seal retainer to the expansion tank.

6. Withdraw the outlet cover and seal retainer, together with the seals and seal gland, from the expansion tank. Remove the gasket.

7. Withdraw the heat exchanger core and gasket from the expansion tank.

Install Heat Exchanger Core

After the heat exchanger core has been cleaned and inspected, install it by reversing the sequence of operations given for removal, using new gaskets and seals.

> **NOTE:** To minimize electrolytic action of the raw water, brass pipe plugs are used in the raw water system components wherever pipe plugs are required. Replace any steel plugs that may be found on earlier units with brass plugs.

Refill the engine coolant and raw water systems and check for leaks.

© 1980 General Motors Corp.

RAW WATER PUMP (JABSCO)

Raw water for lowering the temperature of the engine coolant is circulated through the heat exchanger by a positive displacement pump (Figs. 1 and 2). The pump is attached to an adaptor which in turn is bolted to the flywheel housing and is driven through a coupling attached to the camshaft or balance shaft gear.

Note that the end cover is marked to show the outlet port for RH rotation and the outlet port for LH rotation. Follow these markings when installing the raw water pump to avoid any difficulty in direction of flow.

The drive from the camshaft or balance shaft is to the pump drive shaft which is carried on a double row ball bearing located in the flange end of the pump housing (Fig. 1). Oil seals at each end of the ball bearing prevent lubricating oil from entering the impeller compartment.

An impeller, splined to the end of the drive shaft, is lubricated by the water pumped and should not be run dry for longer than normally required for the pump to prime itself.

A wear plate in the impeller compartment prevents wear of the pump housing and can be reversed if wear on the plate becomes excessive. A slot machined in the outer periphery of the wear plate registers with a dowel in the pump housing, thus preventing it from rotating with the shaft.

A rotary type seal assembly seals against leakage along the shaft.

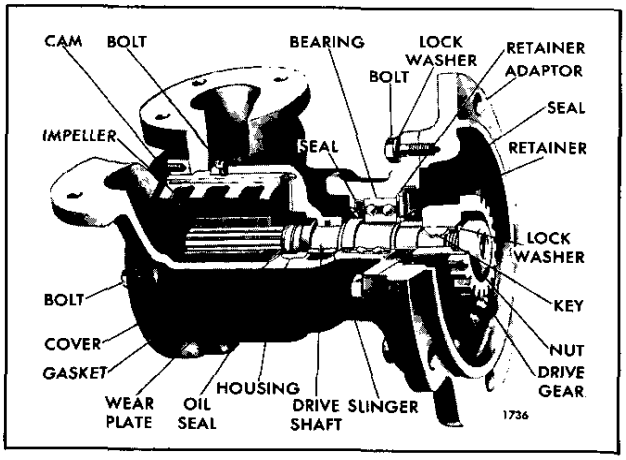


Fig. 1 - Raw Water Pump Assembly

The raw water pump used on the inclined marine propulsion units is similar except for the position of the adaptor. The adaptor is tilted 60° to the right for LH rotation engines and 60° to the left for RH rotation engines, the inlet and outlet ports of the pump remaining in the upright position. Also, the outboard bearing oil seal is of the spring-loaded lip type. The lip type seal is essential in the inclined engine unit pump due to the volume of lubricating oil encountered in an engine lying 70° on its side.

Operation

The pump can be operated in a clockwise or counterclockwise direction. Raw water is drawn into the pump through an inlet opening and discharged through the outlet opening, both openings being located at the top of the pump housing.

Lubrication

The shielded type double row ball bearing is filled with lubricant when assembled. No further lubrication is required.

Replace Pump Seal

Seal parts may be removed and replaced with new parts by removing the impeller, but without removing the pump from the engine.

NOTE: Use care not to scratch or burr the lapped surface of seal seat or the portion of the shaft which the seal contacts.

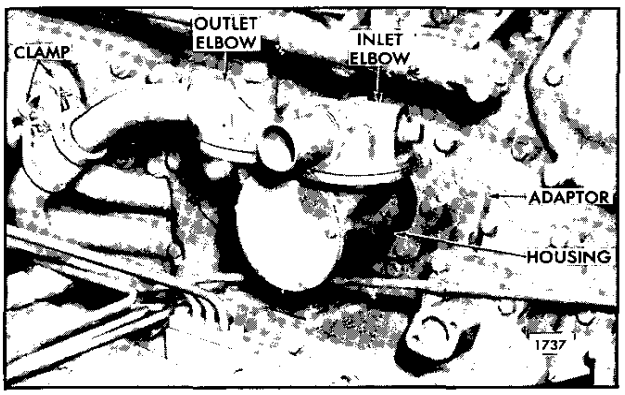


Fig. 2 - Raw Water Pump Mounting

© 1980 General Motors Corp.

1. Remove the cover screws and lift the cover and gasket from the housing (Fig. 3).

2. Grasp the impeller hub with water pump pliers and with draw it from the body.

3. Insert two wires, each with the hook at one end, between the housing and seal with the hook over edge of the carbon seal. Pull the seal assembly from the shaft.

4. The seal seat and gasket may be removed in the same manner.

5. Lubricate the seal gasket of the seal seat and gasket assembly and insert it in the seal bore of the body, with the polished surface facing outward. Care must be taken not to mar or scratch the seal seat face. Installing this assembly with a slight rotary motion will ensure seating the gasket firmly in the cavity.

6. Install the balance of the seal assembly with the polished carbon seal face against the seal seat. The seal assembly consists of the carbon seal and "O" ring which are contained within the metal ferrule. The metal ferrule has a neoprene washer cemented to its outside face against which the marcel spring washer is positioned.

NOTE: It is advisable to position the marcel spring washer so that the drive points are aligned with the indentation in the ferrule face.

7. Lubricate the impeller bore with a light coat of Marfax 2HD or equivalent. Start the impeller into the bore with a rotary motion in the intended direction of rotation until the splines engage, then push the impeller into the bore.

NOTE: Spline plugs are part of the impeller assembly on all current pumps to reduce the possibility of foreign material working into the splines and resulting in wear (Fig. 5).

8. Install the cover on the housing, using a new gasket.

Remove Raw Water Pump from Engine

1. Drain the raw water system.

2. Loosen the hose clamps at the outlet elbow and intermediate tube and slide the hose along the tube.

3. Loosen the hose clamps at the inlet elbow and inlet tube and slide the hose along the tube.

4. Remove the bolts and lock washers holding the inlet and outlet elbows to the pump and lift the elbows from the pump. Remove the gaskets.

5. Remove the adaptor to flywheel housing bolts and lock washers.

6. Loosen the pump from the flywheel housing by tapping on the edge of the adaptor with a soft hammer.

7. Withdraw the pump straight out from the flywheel housing, disengaging the drive gear from the coupling.

NOTE: Cover the pump opening in the flywheel housing with a clean cloth to prevent entrance of foreign matter.

Disassemble Pump

1. Refer to Fig. 3 and remove the impeller and seal assembly as previously outlined.

2. Mark the housing and adaptor for reference when reassembling, then remove the bolts and lock washers and separate the adaptor from the housing.

3. Clamp the drive gear in a soft-jawed vise and remove the retaining nut and lock washer from the shaft.

4. Take the gear from the vise and using a suitable puller, pull the gear from the shaft. Remove the Woodruff key from the shaft.

5. Slide the outer bearing seal from the housing.

NOTE: Certain pumps, marked with the letter "X" stamped on the pump body between the port flanges, have been assembled minus the outer bearing seal. When overhauling one of these pumps, the outer seal can continue to be omitted during reassembly.

6. Remove the bearing retainer from the groove in the housing.

7. Support the pump body in an arbor press with the mounting flange resting on the bed of the press and the splined end of the shaft under the ram of the press. Using a brass rod between the shaft and ram, press the shaft and ball bearing from the housing.

8. Remove the slinger from the shaft or housing.

9. Remove the inner bearing seal from the shaft or housing.

10. Remove the bearing retainer from the groove in the shaft and, using an arbor press and suitable sleeve against inner race of bearing, press the bearing off threaded end of the shaft.

© 1980 General Motors Corp.

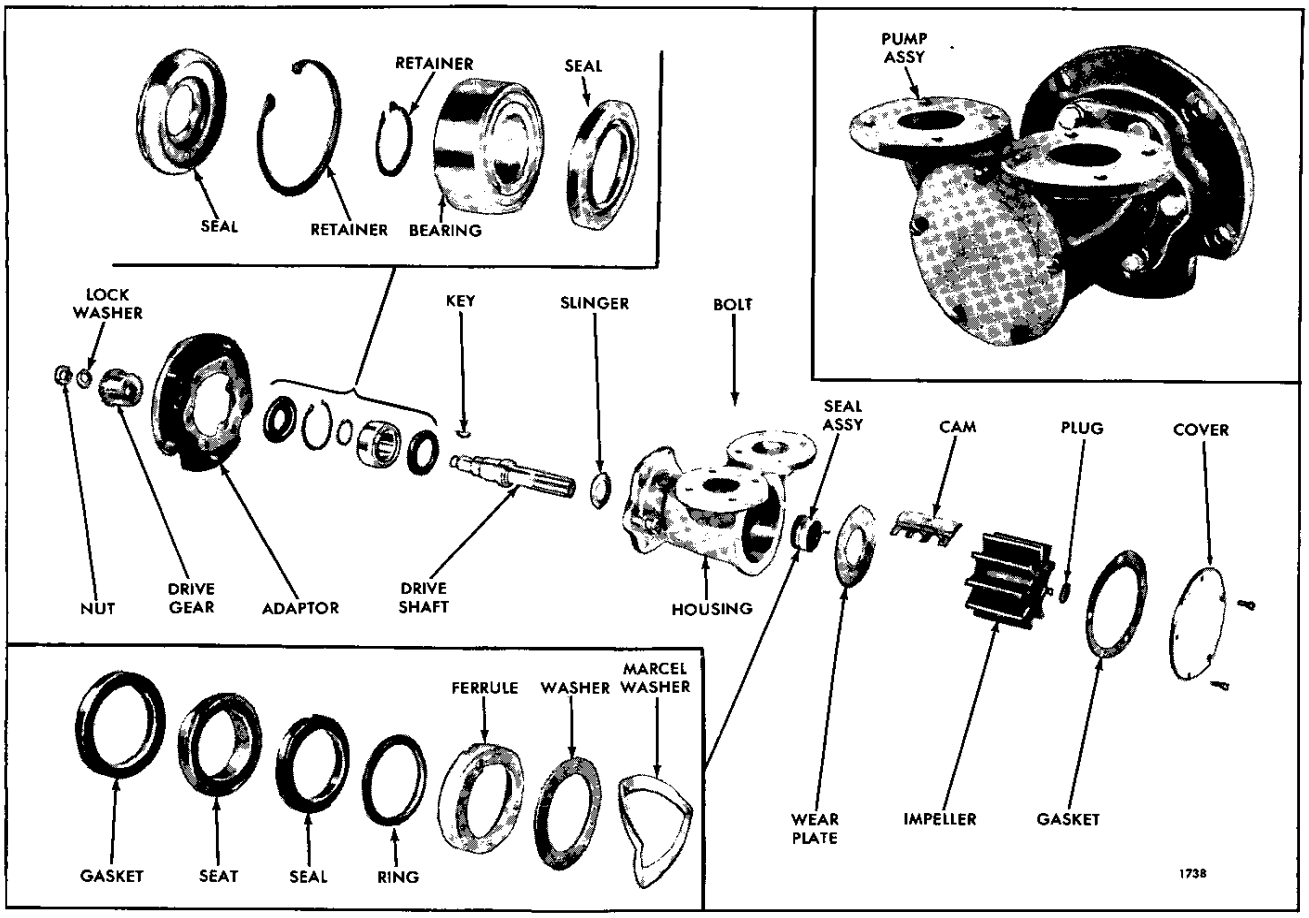


Fig. 3 - Raw Water Pump Details and Relative Location of Parts

11. Remove the cam bolt and lift the cam from the housing.

12. Lift the wear plate off the dowel.

Inspect Pump Parts

After disassembly, clean all parts thoroughly, except the bearing. Shielded bearings must not be washed, dirt may be washed in and the cleaning fluid could not be entirely removed from the bearing. Wipe the bearing clean on the outside and then inspect it. Hold the inner race and revolve the outer race slowly to detect possible wear or rough spots. Replace the bearing if it is worn or does not roll freely.

Examine the parts of the seal assembly, the ball bearing seals and discard any parts that have been cut, cracked or otherwise damaged.

Inspect the oil seal contact surfaces of the shaft for scratches or grooves. Smooth surface with crocus cloth wet with fuel oil, if scratched.

Inspect the impeller to make sure the bond between the neoprene and the insert is good. If the impeller blades have a permanent set, a new impeller should be used.

Remove burrs from wear plate. If wear on the plate is excessive, it may be reversed or replaced when the pump is assembled.

Assemble Pump

1. Refer to Figs. 1 and 3 and install the wear plate in the pump housing with the locating hole in the plate over the dowel in the housing.

2. Apply Permatex or equivalent to the screw threads

© 1980 General Motors Corp.

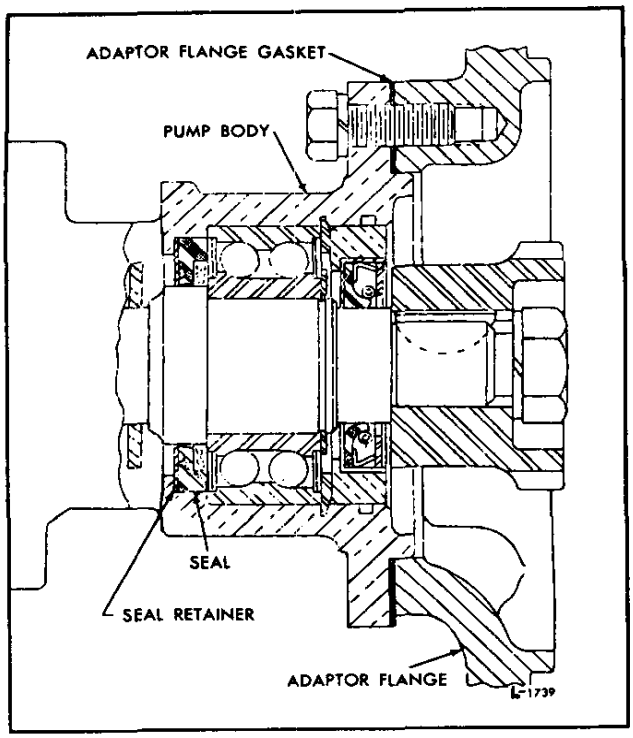


Fig. 4 - Installation of Adaptor Flange Gasket

and topside of the cam, then place the cam in the housing so the end of the cam is flush with end of the housing and install the cam bolt.

3. Support the splined end of the shaft on a wood block on the bed of the arbor press. Start the bearing straight on the shaft and, using a sleeve between the ram of press and inner race of bearing, press the bearing on the shaft tight against the shoulder on the shaft.

4. Install the bearing retainer in the groove on the shaft.

5. Lubricate the inner bearing seal with grease and press it into the body bearing seal bore, with the lip facing away from the bearing bore. All pump assemblies incorporate a spring loaded lip type seal, these seals are installed with the lip of the seal facing the pump impeller (Fig. 5).

6. Place the slinger in the opening in top of the pump housing.

7. Insert splined end of the shaft into flanged end of the housing and start the bearing straight into counterbore in the housing. Support the housing in an arbor press with threaded end of the shaft under ram of the press. Use a suitable sleeve between the ram and the outer race of bearing, press the bearing into counterbore in the housing.

8. Install the large bearing retainer in the groove in the housing.

9. Lubricate the lip of the seal and slide it over the threaded end of the shaft into counterbore in the housing with the lip facing toward the pump drive gear. All pump assemblies incorporate a spring loaded lip type oil seal, these seals are installed with the lip facing the pump drive gear (Fig. 5).

10. Install the Woodruff key in the shaft and start the drive gear straight on the shaft and over the key.

11. Place the pump housing in an arbor press with the splined end of the shaft supported on a wood block. Press the drive gear on the shaft tight against shoulder on the shaft.

12. Clamp the gear in a soft-jawed vise and install the lock washer and retaining nut. Tighten the nut to 25-30 ft-lb (34-71 Nm) torque. Do not exceed the specified torque, otherwise shaft fracture and consequent early pump failure may result. Remove the gear from the vise.

13. Position the adaptor on the housing by aligning the marks made when disassembling and install six lock washers and bolts.

> **NOTE:** Currently, a gasket is used between the pump adaptor flange and the pump body (Fig. 4). This gasket has been provided to eliminate any possibility of engine oil leakage between the adaptor and pump body. The gasket should be included during reassembly of any raw water pump.

14. Assemble the pump seal using new parts as required and install the impeller and seal assembly in the pump as outlined previously under "Renew Pump Seal".

Install Raw Water Pump on Engine

The pump may be installed by reversing the procedure used for removal.

Note that the end cover is marked to show the outlet port for RH rotation and the outlet port for LH rotation. Follow these markings when installing the raw water pump to avoid any difficulty regarding direction of flow. Also, when installing the inlet elbow or the outlet elbow, be sure to use two flat washers on the bolt being installed in the blind hole in the pump housing.

© 1980 General Motors Corp.

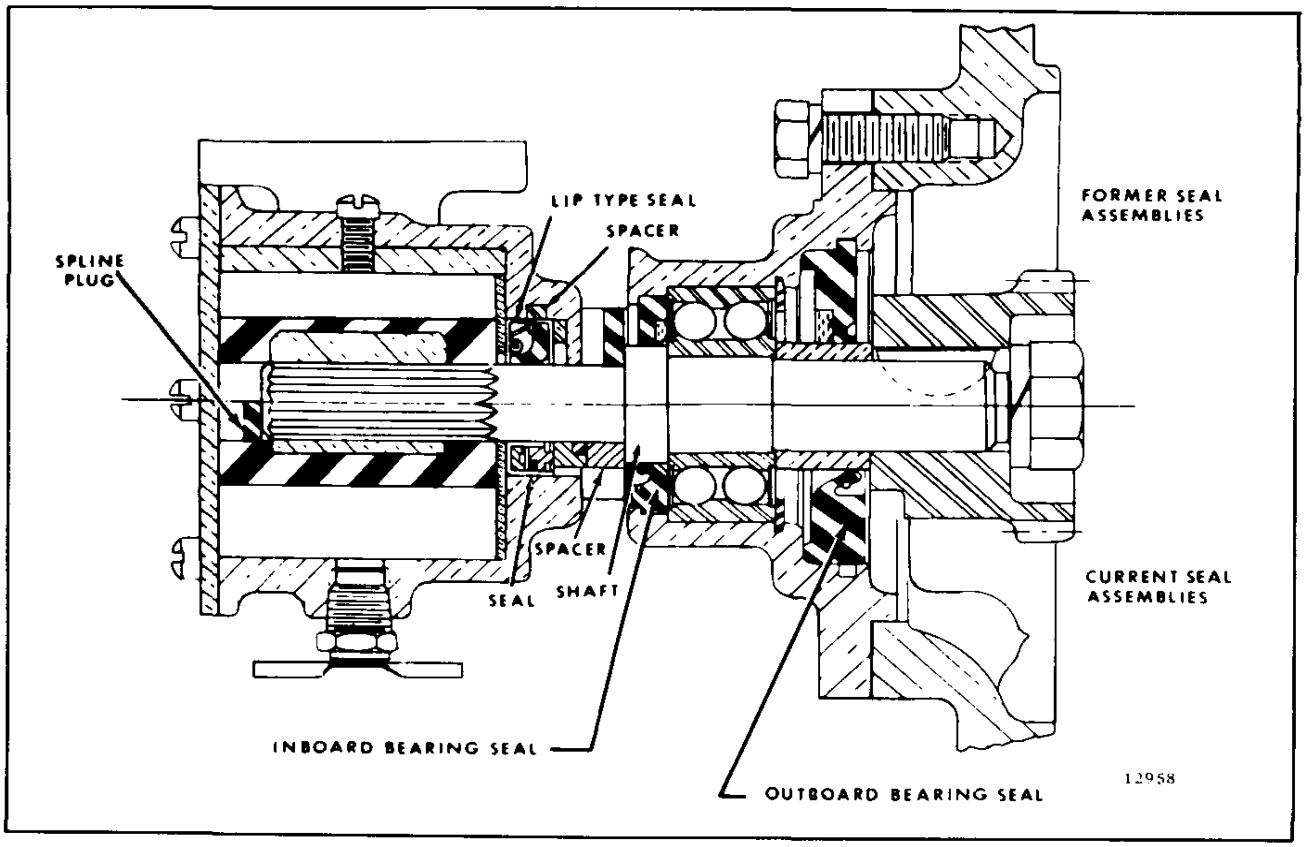


Fig. 5 - Location of Spline Plug and Comparison of Bearing Seals

In current engines, a plain camshaft and balance shaft gear nut and nut retainer are used and ensure positive engagement of the raw water pump drive gear with the drive coupling. However, earlier units used a self-locking type gear retainer nut and no gear nut retainer was required. As a result there is a possibility of non-engagement of the drive gear with the coupling when this type of pump is used. Therefore, when a Jabsco raw water pump is used, a camshaft or balance shaft gear nut retainer should also be installed.

© 1980 General Motors Corp.

COOLANT FILTER AND CONDITIONER

The engine cooling system filter and conditioner is a compact bypass type unit with a replaceable canister type element (Fig. 1), a spin-on type element (Fig. 2) or a clamp-on type element (Fig. 3).

A correctly installed and properly maintained coolant filter and conditioner provides a cleaner engine cooling system, greater heat dissipation, increased engine efficiency through improved heat conductivity and contributes to longer life of engine parts.

The filter provides mechanical filtration by means of a closely packed element through which the coolant passes. Any impurities such as sand and rust particles suspended in the cooling system will be removed by the straining action of the element. The removal of these impurities will contribute to longer water pump life and proper operation of the thermostat.

The filter also serves to condition the coolant by softening the water to minimize scale deposits, maintain an acid-free condition and act as a rust preventive.

Corrosion inhibitors are placed in the element and dissolve into the coolant, forming a protective rustproof film on all of the metal surfaces of the cooling system (refer to Section 13.3). The other components of the element perform the function of cleaning and preparing the cooling passages while the corrosion inhibitors protect them.

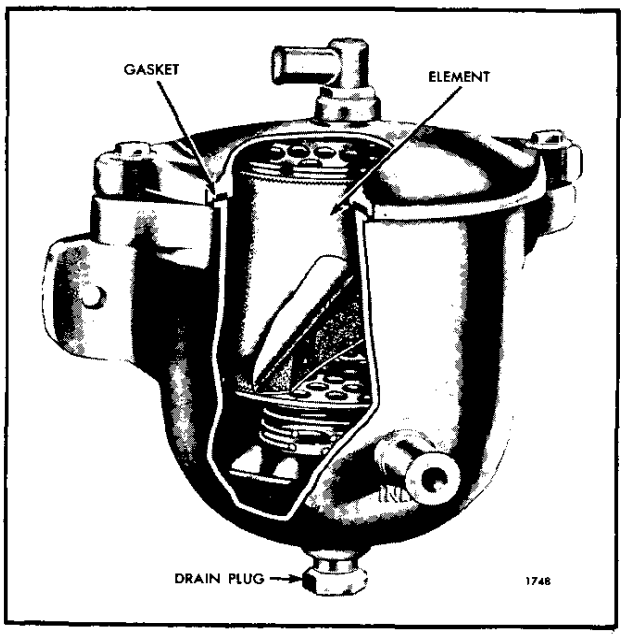


Fig. 1 - Coolant Filter and Conditioner (Canister Type)

Filter Installation

If a coolant filter and conditioner is to be installed on an engine which has been in service, drain and flush the cooling system prior to installation of the filter.

Filter Maintenance

Replace the chemically activated element, following the manufacturer's recommended change periods (refer to Section 15.1). The lower corrosion resistor plate (if used) must be buffed each time (discard the plate if excessive metal loss or pitting is evident) to ensure effective protection of the cooling system.

If the filter is installed on an engine which has previously been in service, it may be necessary to change the filter element two or three times at intervals of approximately 200 hours or 6,000 miles, or less, to clean up accumulations of scale and rust in the cooling system. It is advisable to drain and flush the system during these initial change intervals.

Make-up water up to approximately 40% of the total capacity of the cooling system may safely be added before a filter element change is required.

> **NOTE:** Sea water must never be used for make-up water in a marine engine, except under emergency conditions. If it is necessary to use sea water, the cooling system must be completely drained and flushed with fresh water upon reaching port. The filter element must be changed. Filters with resistor plates must be inspected for pitting. *Presence of salt in the coolant results in rapid pitting of the resistor plates.*

If it is necessary for any reason to drain the cooling system before an element change, the treated water should be saved and reused. If the treated water is discarded, a new filter element must be installed since the protective agents in the used filter will have been partially consumed in treating the discarded water.

> **NOTE:** A separate rust inhibitor should not be used in a cooling system protected by a coolant filter and conditioner.

© 1982 General Motors Corp.

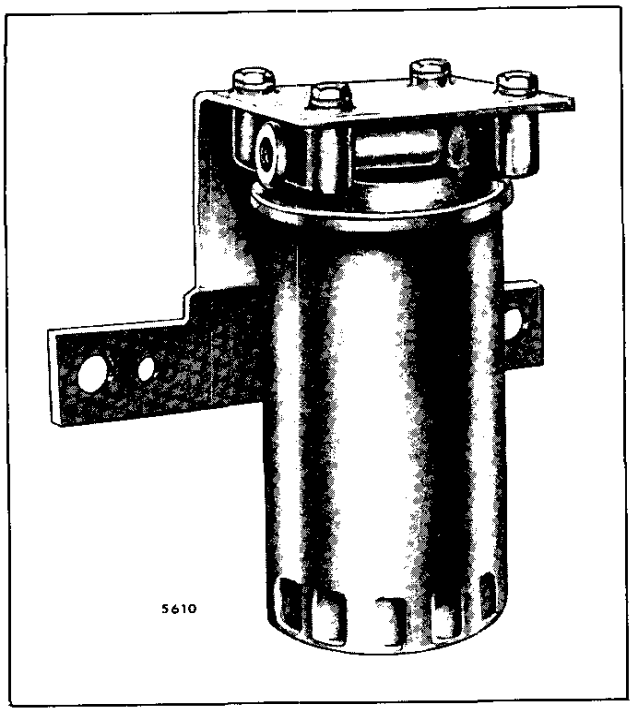


Fig. 2 - Coolant Filter and Conditioner (Spin-On Type)

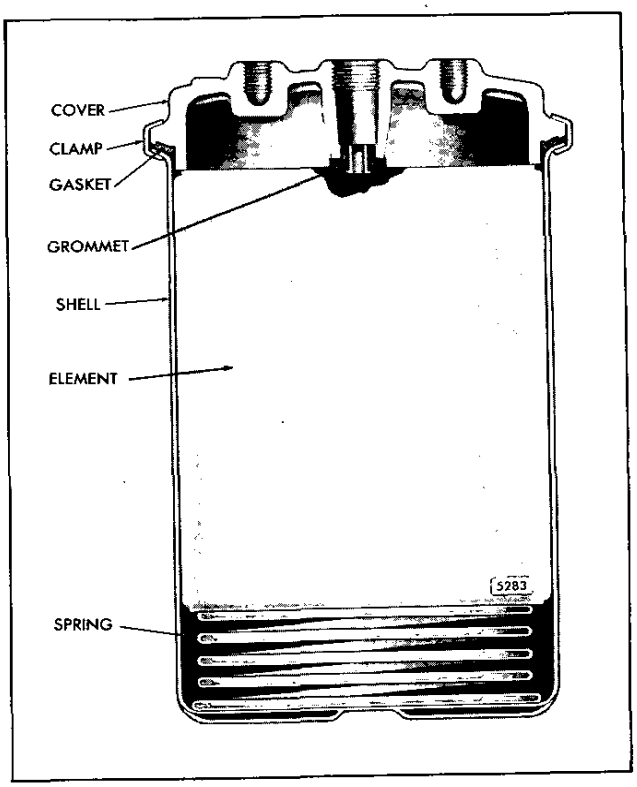


Fig. 3 - Coolant Filter and Conditioner (Clamp-On Type)

Service

The coolant filter may be grounded at the option of the user.

The current coolant filter includes a non-chromate type element. This element can be used in place of either of the former filter elements (antifreeze or plain water type) and thus provides year around cooling system protection. The current and the former filter elements are completely interchangeable in the former filter can (refer to Section 13.3).

Replace the element and service the filter and conditioner as follows:

1. Close the filter inlet and outlet shutoff valves. If shutoff valves are not provided, vise grip pliers can be used to clamp each hose closed during the filter change. Use caution to avoid damaging the hoses with the vise grip pliers.

2. Romove and replace the element.

Canister Type Element - Fig. 1:

a. Remove the drain plug in the bottom of the filter body and let drain.

b. Remove the filter cover-to-filter body bolts.

c. Remove and discard the element.

d. Remove and discard the corrosion resistor plates.

e. Remove the sludge and sediment and wash the filter body. Dry it thoroughly with compressed air.

f. Replace the drain plug in the bottom of the filter.

g. Insert the new element.

h. Use a new filter cover gasket and install the filter cover and tighten the bolts evenly.

Spin-On Type Element - Fig. 2:

a. Remove and discard the element.

b. Clean the gasket seal on the filter cover.

c. Remove the sludge and sediment and wash the filter body. Dry it thoroughly with compressed air.

d. Apply clean engine oil to the filter element gasket and install the new element. A 1/2 to 3/4 turn

© 1982 General Motors Corp.

after gasket contact assures a positive leakproof seal.

Clamp-On Type Element - Fig. 3:

a. Remove the retaining clamp.

b. Remove and discard the element.

c. Remove the sludge and sediment and wash the filter body. Dry it thoroughly with compressed air.

d. Insert the new element.

e. Secure the filter body in place with the clamp.

3. Open the inlet and outlet lines by opening the shutoff valves or removing the vise grip plier clamps.

4. Operate the engine and check for leaks. The top of the filter and the outlet line should feel warm to the touch with the rise in coolant temperature. If not, disconnect the filter outlet line at the end opposite the filter connection to bleed the air from the system and reconnect the line. Use caution to minimize coolant loss.

(c) 1982 General Motors Corp.

SHOP NOTES - SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

FAN HUB SPACER

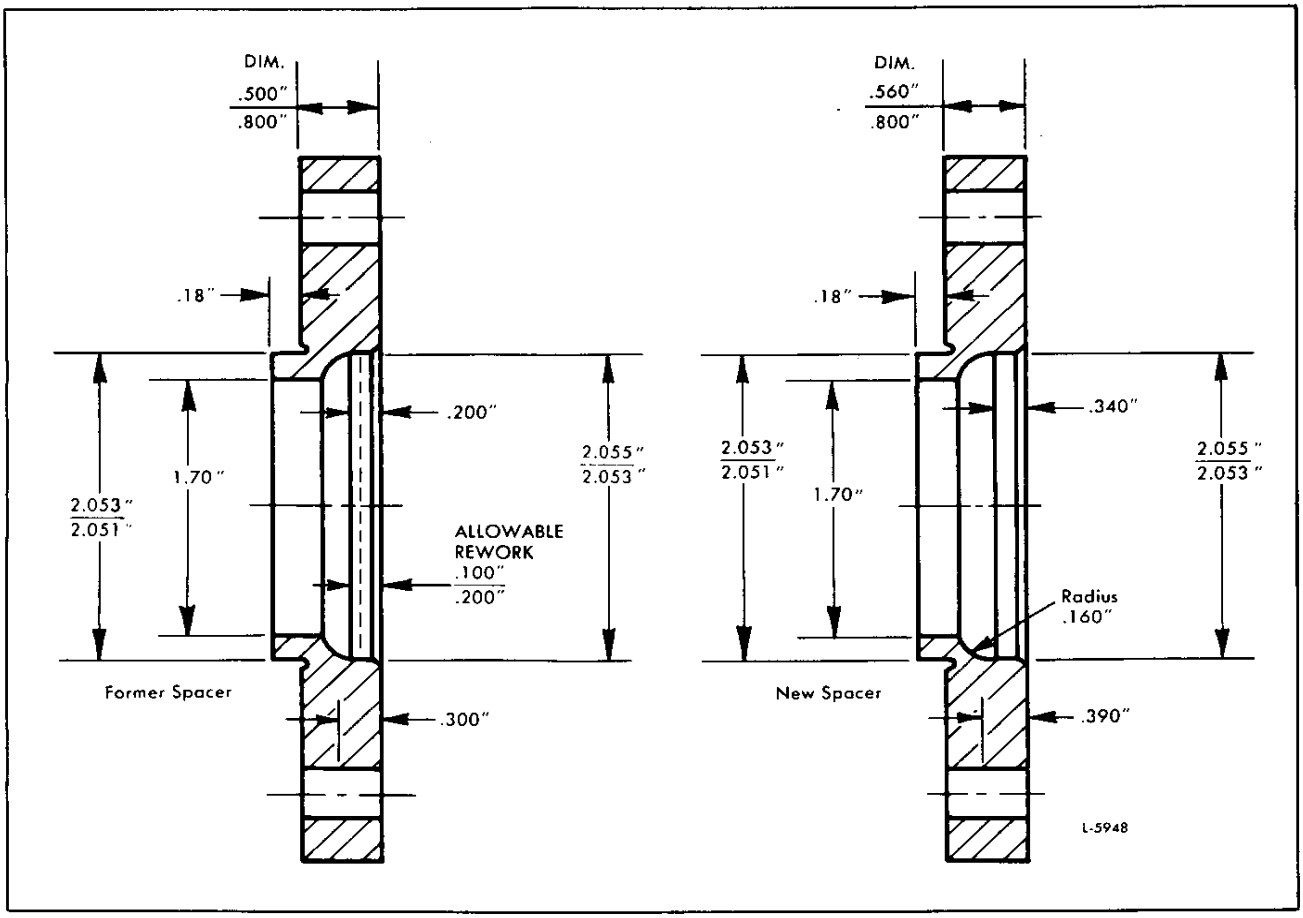


Fig. 1 - Former and New Spacers

The new fan hub spacers are similar to the former spacers except for the flange pilot radius and the width of the spacers (Fig. 1). The flange on the spacer serves as a pilot for the fan, as well as a pilot for the second spacer, when two or more spacers are used together.

The former and new spacers are interchangeable on a former fan pulley hub assembly and only the new spacers are serviced.

The former .800 " thick spacer must not be used with the current shaft type fan pulley hub assemblies, unless it is reworked (see Service Note).

Use of the former thick spacer will crush the fan hub cap causing the drive to bind.

SERVICE: The former .800 " thick spacer can be reworked into the new .800 " thick spacer by removing material at the radius (Fig. 1). A reworked spacer should be mated with the fan hub assembly. If a former thin spacer (.500 " thick) is used in conjunction with the reworked thick spacer, it should be postioned against the fan.

NOTE: The .500 " thick spacer cannot be reworked into the new .560 " thick spacer.

© 1983 General Motors Corp.

FAN HUB GREASE FITTING

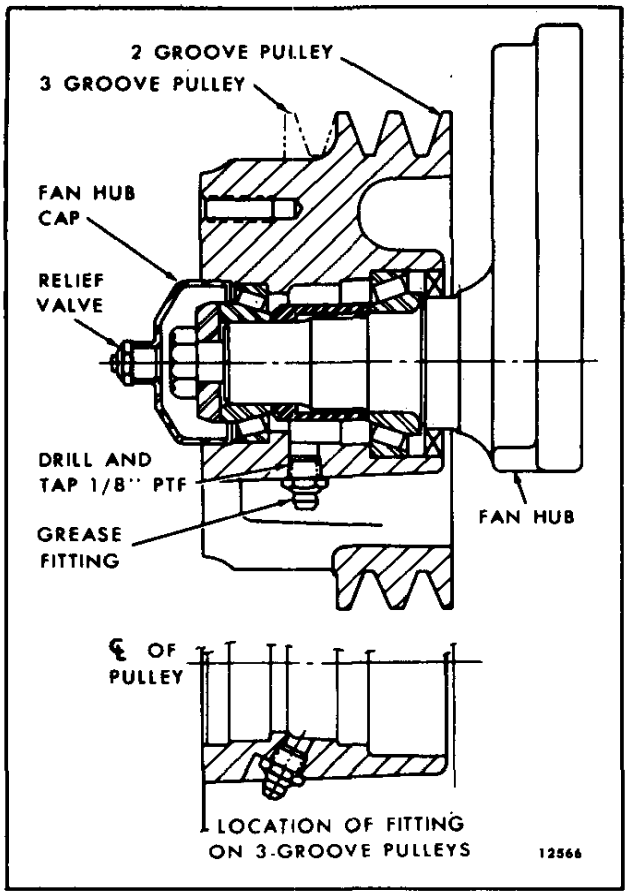


Fig. 2 - Location of Fan Hub Grease Fitting and Relief Valve

A grease fitting may be added to former fan hub assemblies used on vehicle engines to permit periodic lubrication of the bearings.

Re-work the fan hub as follows.

1. Refer to Section 5.4 and dis-assemble the fan hub assembly and clean the parts thoroughly.

2. Drill and tap the fan hub, at the location shown in Fig. 2, to accept a 1/8" PTF x 11/16" threaded lubricator fitting. Clean the hub to remove any metal chips.

3. Refer to Section 5.4 and re-assemble the fan hub. Discard the former grease retainer as it is not required when a grease fitting is used.

4. Install a *new* fan hub cap which is threaded for a relief valve (Fig. 2).

5. Install a grease fitting in the fan hub and a relief valve in the fan hub cap.

Refer to Section 15.1 for the maintenance schedule.

DRAINING JABSCO RAW WATER PUMP

Although all engine units are provided with drain cocks for the purpose of draining the cooling system, a small amount of coolant may remain in the impeller housing of a "Jabsco" pump.

Under normal circumstances, there would be no need in completely draining the impeller housing of a raw water pump, therefore, no drain plug has been incorporated at this location. However, certain models employ a raw water pump in conjunction with a fresh water cooling system.

In the event the engine is to be stored in below freezing temperatures, it is suggested that, in addition to draining the cooling system of the engine unit, the impeller housing of the "Jabsco" pump be completely drained. This may easily be accomplished by loosening the five fillister head screws which attach the end cover to the pump housing, at the impeller end of the pump, then pulling the end cover away from the pump body, while being careful to avoid damage to the gasket. The screws need only be loosened sufficiently to allow complete draining of the impeller housing, then retightened.

© 1983 General Motors Corp.

RAW WATER PUMP IMPELLERS

The Jabsco raw water pump is equipped with synthetic rubber impellers. Since the synthetic rubber begins to lose its elasticity at low temperatures, impellers made of natural rubber may be installed when it is necessary to pump raw water that has a temperature below 40°F (4.5°C). However, the standard impellers must be used when the pump operates in warmer water.

New service impellers of natural rubber are identified by a stripe of green paint.

WATER PUMP BODY MODIFICATION

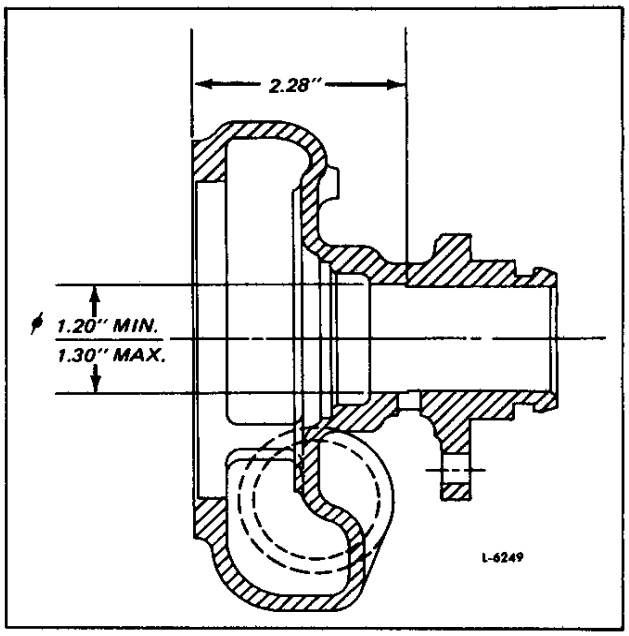


Fig. 3 - Pump Bearing Bore

The former water pump bodies can be reworked to accept a new shaft and bearing assembly. Use the following procedure.

1. Locate the center line of the pump bearing bore (Fig. 3).

2. Bore a hole 1.2" diameter minimum to 1.3" diameter maximum from the cover mounting face of the pump to a depth of 2.28" (±.010"). This will accommodate the secondary seal.

© 1982 General Motors Corp.

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb-ft)	Nm	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	Nm
1/4 -20	5- 7	7- 9	1/4 -20	7-9	10-12
1/4 -28	6- 8	8-11	1/4 -28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8 -16	23-26	31-35	3/8 -16	30-35	41-47
3/8 -24	26-29	35-40	3/8 -24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2 -13	53-56	72-76	1/2 -13	71-75	96-102
1/2 -20	62-70	84-95	1/2 -20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8 -11	103-110	140-149	5/8 -11	137-147	186-200
5/8 -18	126-134	171-181	5/8 -18	168-178	228-242
3/4 -10	180-188	244-254	3/4 -10	240-250	325-339
3/4 -16	218-225	295-305	3/4 -16	290-300	393-407
7/8 - 9	308-315	417-427	7/8 - 9	410-420	556-569
7/8 -14	356-364	483-494	7/8 -14	475-485	644-657
1 - 8	435-443	590-600	1 - 8	580-590	786-800
1 -14	514-521	697-705	1 -14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head		GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None		GM 255-M	1	No. 6 thru 1 1/2	60,000
None		GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74,000 60,000
	Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
	Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
	Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
	Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
	Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

12252

BOLT IDENTIFICATION CHART

© 1982 General Motors Corp.

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	C.I. ENGINE (lb-ft)	C.I. ENGINE (Nm)	ALUM. ENGINE (lb-ft)	ALUM. ENGINE (Nm)
Water pump coupling bolt (current)	5/16-24	18 min.	24 min.	18 min.	24 min.
Water manifold nut	3/8 -24	25-30	34-41	20-25	27-34
Water pump coupling bolt (former tapered shaft)	7/16-24	25-30	34-41	25-30	34-41
Raw water pump (Jabsco) drive gear retaining nut	5/8 -18	25-30	34-41	25-30	34-41

STUD TORQUE SPECIFICATIONS

APPLICATION	TORQUE (lb-ft)	TORQUE (Nm)
Water manifold stud	10-25	14-34

© 1982 General Motors Corp.

SERVICE TOOLS

TOOL NAME	TOOL NO.
Drive handle	J 7079-2
Thermostat seal replacer	J 8550
Water pump and fuel pump wrench	J 4242
Water pump drive coupling remover	J 1930
Water pump impeller installer (.031" -.033")	J 22437
Water pump impeller installer (.052" -.072)	J 21971
Water pump impeller installer (.099" -.101")	J 9303

© 1982 General Motors Corp.

SECTION 6

EXHAUST SYSTEM

CONTENTS

Exhaust System 6

Exhaust Manifold (Air-Cooled) 6.1
Exhaust Manifold (Water-Cooled) 6.1.1

EXHAUST SYSTEM

Fan and radiator cooled engines are equipped with an air-cooled exhaust manifold. A water-cooled exhaust manifold is provided for engines incorporating a heat exchanger or keel cooling system.

The outlet flange may be located at the end or at the mid-section of the exhaust manifold, depending upon the installation requirements. A flexible exhaust connection or a muffler may be attached to the outlet flange.

The exhaust manifold is attached to studs located between the exhaust ports and the outer side of the two end ports in the cylinder head. Special washers and nuts secure the manifold to the cylinder head.

© 1973 General Motors Corp.

EXHAUST MANIFOLD (Air-Cooled)

The air-cooled exhaust manifold (Fig. 1) is mounted on the cylinder head.

A new exhaust manifold hold-down crab is now being used. The new hold-down crab is made of a hardened steel and is heavier than the former hold-down crab. This will minimize wear and gouging of the manifold, crab and cylinder head mating surfaces, which results in a loss in the torque on the hold-down crab nut. The former and the new hold-down crabs are interchangeable on an engine, however, only the new crab will be serviced.

Also, a new special washer is now used at the center portions of the exhaust manifolds. This new washer will more accurately control the seating area for the 7/16" nut or bolt. Only the new special washer will be serviced.

Remove Exhaust Manifold

Remove the manifold as follows:

1. Disconnect the exhaust pipe or muffler from the exhaust manifold.

2. Remove the nuts and bevel washers that attach the exhaust manifold to the cylinder head. It is suggested that, as a safety measure, the nut be loosened but left on the center stud until all of the other nuts and washers have been removed.

3. Support the manifold and remove the nut and washer from the center stud.

4. Lift the manifold away from the cylinder head.

5. Remove the manifold gaskets.

Inspection

Remove the loose scale and carbon that may have accumulated on the internal walls of the exhaust manifold. It is especially important to clean the manifold used on a turbocharged unit to eliminate the possibility of loose scale entering and damaging the turbocharger.

Examine the exhaust manifold studs for damage. If necessary, replace the studs. New studs are driven in to 25-40 lb-ft (34-54 Nm) torque.

Install Exhaust Manifold

With all traces of the old gasket removed from the cylinder head and bolting flange of the exhaust manifold, it may be installed as follows:

1. Place a new gasket over the studs and up against the cylinder head. Metal-clad gaskets may look reusable, but once they've been used and taken a "set" they cannot be reused.

NOTE: When installing the metal-clad exhaust manifold gasket, be sure the crimped side of the gasket faces the cylinder head (Fig. 2).

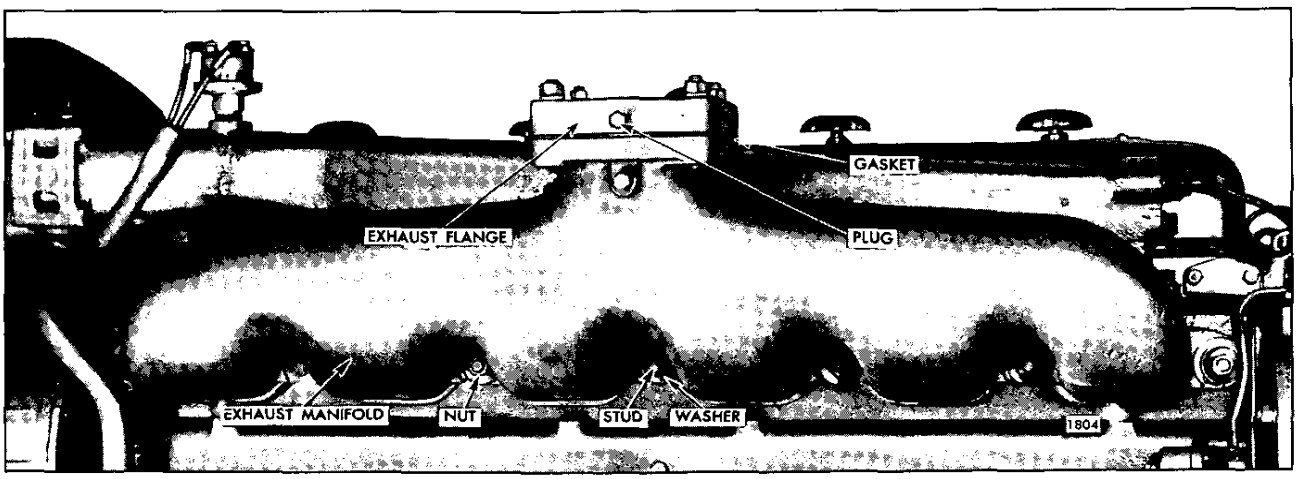


Fig. 1 - Typical Air-Cooled Exhaust Manifold Mounting

© 1982 General Motors Corp.

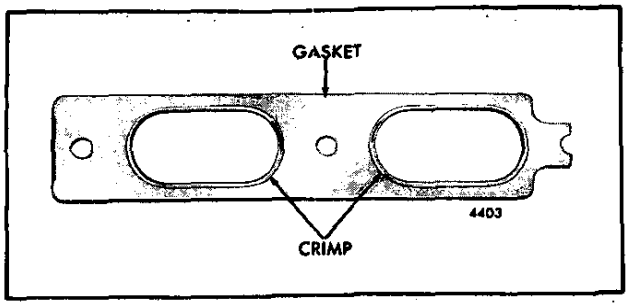


Fig. 2 - Metal Clad Exhaust Manifold Gasket

2. Position the exhaust manifold over the studs and up against the gasket.

3. Install the bevel washers on the studs.

NOTE: Install the bevel washers with the crowned sides toward the nuts.

4. Thread the nuts on the studs. Then, starting with the center nut and working alternately toward each end, tighten the manifold nuts to 30-35 lb-ft (41-47 Nm) torque (cast iron head) or 25-30 lb-ft (34-41 Nm) torque (aluminum head).

NOTE: If the cylinder head was removed from the engine, do not tighten the manifold nuts until AFTER the head is reinstalled. Otherwise, interference may be encountered between the manifold and cylinder block bosses which serve as a support for the manifold when the cylinder head is installed.

5. Connect the exhaust pipe or muffler to the manifold. Tighten the brass exhaust manifold outlet flange nuts to 20-25 lb-ft (27-34 Nm) torque.

NOTE: Do not allow exhaust piping to impose excessive loads on the turbocharger.

6. Inspect the exhaust outlet piping for dents, holes and potential sources of water infiltration such as loose clamps or deteriorated seals. Repair or replace, if necessary.

© 1982 General Motors Corp.

EXHAUST MANIFOLD (Water-Cooled)

The one-piece, water-cooled exhaust manifold is cast with an integral water jacket surrounding the exhaust chamber. The diameter of the exhaust chamber increases uniformly from one end to the other where it terminates in a flange to which an elbow and flexible exhaust connection is attached. A portion of the engine coolant is bypassed from the water manifold into the rear end of the jacket surrounding the exhaust manifold and is discharged from the forward end through a tube into the lower section of the expansion tank (Fig. 2). A drain cock, with an attached hose, is installed in the bottom of the manifold for draining the water jacket. A plug is provided in the bottom of the exhaust outlet elbow for draining moisture condensed from the exhaust gases.

Remove Exhaust Manifold

When an engine is being reconditioned, the exhaust manifold is removed along with the cylinder head. However, if only the manifold gaskets need replacing, the manifold can be removed from the cylinder head as follows:

1. Disconnect the exhaust pipe and elbow from the manifold.

2. Refer to Fig. 1 and loosen the two hose clamps and remove the water inlet hose.

3. Loosen the hose clamp on the water outlet hose. Then remove the two nuts and washers and separate the water outlet tube from the exhaust manifold.

4. Remove the exhaust manifold drain hose.

5. Remove the exhaust manifold retaining nuts and washers. To facilitate removal of the number two stud nut (between the two forward manifold legs), unscrew the nut to the end of the stud, remove all of the other manifold nuts and washers, then pull the manifold away from the cylinder head and remove the number two nut and washer.

6. Remove the manifold and gasket.

Inspection

Remove the loose scale and carbon that may have accumulated on the internal walls of the exhaust manifold. It is especially important to clean the manifold used on a turbocharged unit to eliminate the possibility of loose scale entering and damaging the turbocharger.

Examine the exhaust manifold studs for damage. If necessary, replace the studs. New studs are driven in to 25-40 lb-ft (34-54 Nm) torque.

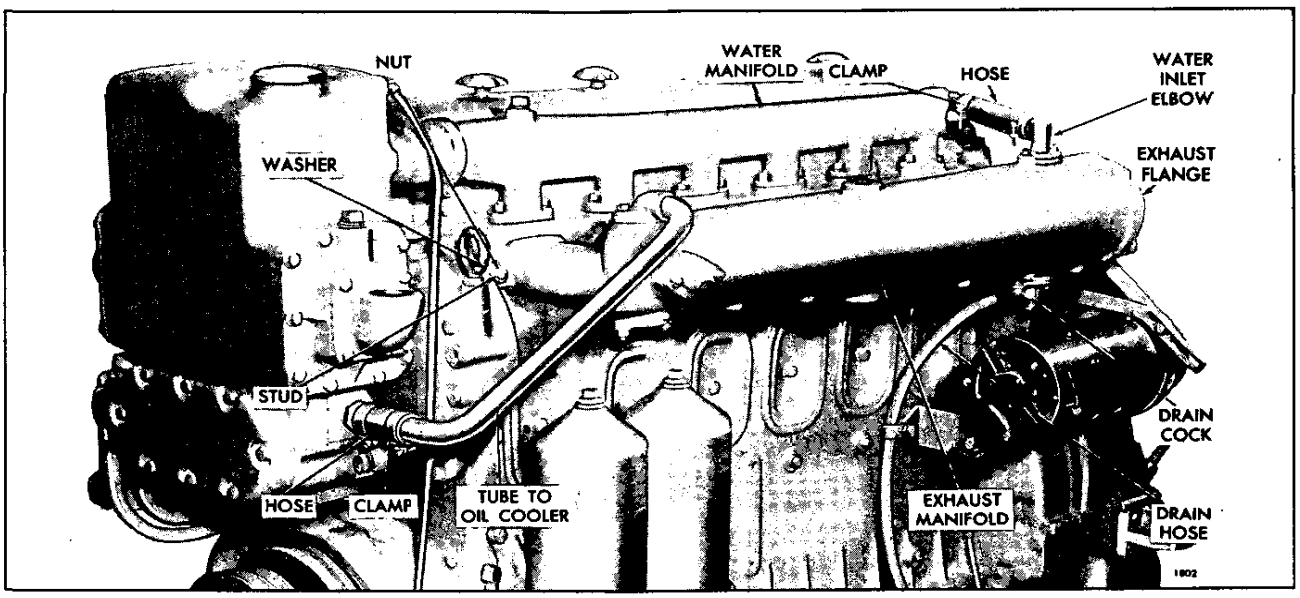


Fig. 1 - Typical Water-Cooled Exhaust Manifold Mounting

© 1982 General Motors Corp.

Install Exhaust Manifold

Install the exhaust manifold on the cylinder head as follows:

1. Place the manifold gasket over the studs and against the cylinder head.

2. Position the manifold on the studs so that about 1/2" of the stud threads extend beyond the mounting flanges of the manifold legs.

3. Place a bevel washer over the number two stud and thread the nut several turns on the stud.

NOTE: The bevel washers are installed so that the outer diameter will rest against the manifold and the crown of the washer will be next to the nut.

4. Slide the manifold up against the cylinder head and install the remaining washers and nuts. Then, starting with the center nut and working alternately toward each end, tighten the nuts to 30-35 lb-ft (41-47 Nm) torque (cast iron head) or 25-30 lb-ft (34-41 Nm) torque (aluminum head).

NOTE: If the cylinder head was removed from the engine, do not tighten the manifold nuts until AFTER the head is reinstalled. Otherwise, interference may be encountered between the manifold and cylinder block bosses which serve as a support for the manifold when the cylinder head is installed.

5. Connect the exhaust pipe and elbow to the manifold.

NOTE: Do not allow exhaust piping to impose excessive loads on the turbocharger.

6. Inspect the exhaust outlet piping for dents, holes and potential sources of water infiltration such as loose clamps or deteriorated seals. Repair or replace, if necessary.

7. Install the exhaust manifold drain hose.

8. Install the water inlet hose and tighten the hose clamps.

9. Use a new gasket and install the water outlet tube. Secure the tube to the manifold with two nuts and washers. Install the water outlet tube hose and secure it to the oil cooler water inlet with a hose clamp.

10. Fill the cooling system and check for leaks.

© 1982 General Motors Corp.

SECTION 7

ELECTRICAL EQUIPMENT, INSTRUMENTS AND PROTECTIVE SYSTEMS

CONTENTS

Electrical System	7
Battery-Charging Generator	7.1
Battery-Charging Generator Regulator	7.1.1
Storage Battery	7.2
Starting Motor	7.3
Solenoid Switch	7.3.1
Instruments and Tachometer Drive	7.4
Engine Protective Systems	7.4.1
Alarm System	7.4.2
Overspeed Governors	7.4.3
Diesel Railcar Control Cabinet and Shutdown System	7.4.4
Power Generator and Controls	7.5
Air Heater	7.8
Shop Notes - Trouble Shooting - Specifications - Service Tools	7.0

ELECTRICAL SYSTEM

A typical engine electrical system generally consists of a starting motor, a battery-charging generator (alternator), a transistor combination voltage regulator, current regulator and cutout relay to protect the electrical system, a storage battery and the necessary wiring.

Additional equipment such as an engine protective system may also be included.

Detailed information on maintenance and repair of the specific types of electrical equipment used can be found in the service manuals and bulletins issued by the equipment manufacturer. Information regarding equipment manufactured by the Delco-Remy Division of General Motors Corporation may be obtained from their electrical equipment operation and service manuals. The manuals may be obtained from AC-Delco service outlets, or from the Technical Literature Section, Delco-Remy Division of General Motors Corporation, Anderson, Indiana.

In most instances, repairs and overhaul work on electrical equipment should be referred to an authorized repair station of the manufacturer of the equipment. Replacement parts for electrical equipment should be ordered through the equipment manufacturer's outlets, since these parts are not normally stocked by Detroit Diesel Allison. For electrical equipment manufactured by Delco-Remy Division, repair service and parts are available through AC-Delco branches and repair stations.

© 1978 General Motors Corp.

BATTERY-CHARGING GENERATOR AND ALTERNATOR

The battery-charging circuit consists of a generator or alternator, regulator (Section 7.1.1), battery (Section 7.2) and the wiring. The battery-charging generator (Fig. 1) or alternator (Fig. 2) is introduced into the electrical system to provide a source of electrical current for maintaining the storage battery in a charged condition and to supply sufficient current to carry any other electrical load requirements up to the rated capacity of the generator or alternator.

HINGE-MOUNTED GENERATOR OR ALTERNATOR (Belt-driven)

Direct current generators are manufactured in a wide range of sizes and types, but the basic design of all generators is the same. The size and type of generator applied to a particular engine depends on many factors, including maximum electrical load, type of service, percentage of engine idling to running time, type of drive, drive ratio (engine speed to generator speed), generator mounting and environmental conditions.

The hinge-mounted alternating current self-rectifying alternator is belt driven. The alternator drive pulley is keyed to a shaft which is coupled to the blower drive gear.

An adequate alternator drive ratio is necessary for an engine equipped with extra electrical accessories and one that has to operate for extended periods at idle speeds. Diodes, built into the slip ring end frame, rectify the three phase A.C. voltage to provide D.C. voltage at the battery terminal of the alternator, thereby eliminating the need for an external rectifier. The alternator is also available in various sizes and types, depending upon the specific application.

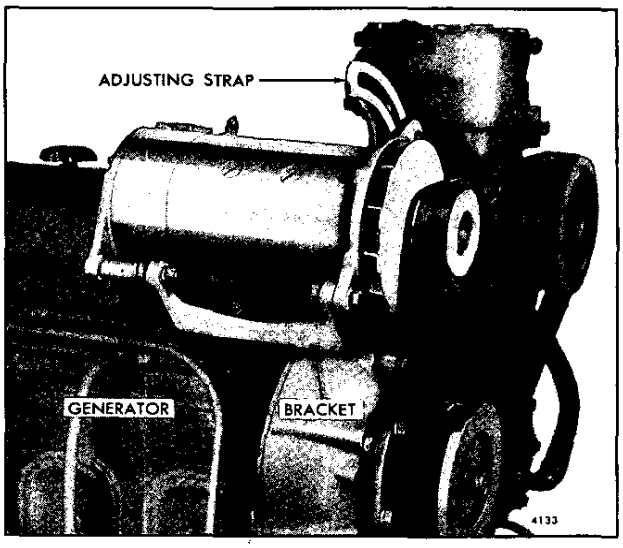


Fig. 1 - Typical Hinge-Mounted Generator

The 32 volt 50 ampere 25SI alternator used in marine applications has been replaced by the 30SI alternator rated at 60 amperes. When installing the 30SI alternator, a wire running from the alternator to the battery (insulated vs. negative ground) must be installed.

The SI series alternators have replaced the DN series alternator. With the new alternators, the need for a separately mounted voltage regulator is eliminated.

> **NOTE:** Effective with November, 1979 build engines, the 10SI alternators were converted to metric dimension, such as the attaching bolts, nuts and lockwashers. Also, hole sizes of some mounting parts will be changed to accommodate the new metric fasteners. The output terminal (BAT) thread will be changed from a 12-24 to a M6X1 thread.

The access hole permitting the external adjustment of

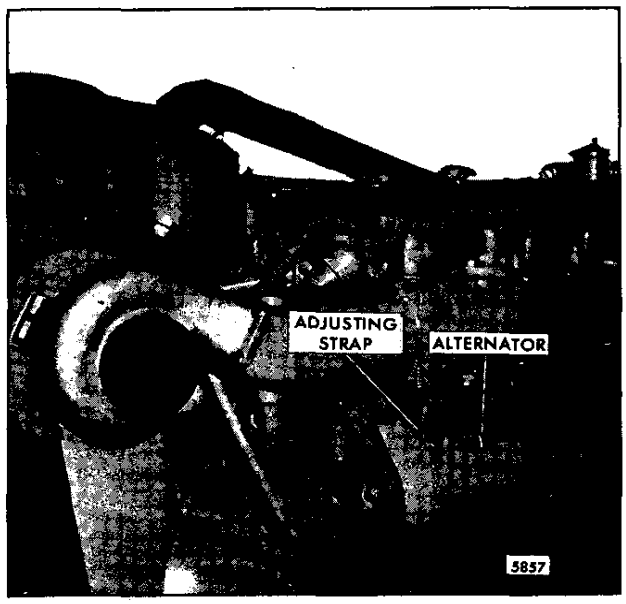


Fig. 2 - Typical Hinge-Mounted Alternator

© 1980 General Motors Corp.

the voltage regulator has been eliminated on current alternators. To adjust the voltage setting on the current alternators, remove the rectifier end plate. The voltage regulator adjustment is located on the voltage regulator circuit board. Refer to the pertinent Delco Service Bulletin for complete adjustment procedure.

The proper selection of a generator or alternator which will meet the needs of the battery-charging circuit on the particular engine is mandatory. This, together with adherence to the recommended maintenance procedures will reduce generator or alternator troubles to a minimum. Since most generators or alternators adhere to the same basic design, the maintenance, removal and installation procedures for all are similar.

Generator or Alternator Maintenance

1. Maintain the proper drive belt tension. Replace worn or frayed belts. Belts should be replaced as a set when there is more than one belt on the generator or alternator drive.

> **NOTE:** When installing or adjusting the drive belt, be sure the bolt at the pivot point is properly tightened, as well as the bolt in the adjusting slot.

2. Lubricate the generator bearings as outlined in the *Lubrication and Preventive Maintenance Chart* in Section 15.1.

3. Alternator bearings are permanently lubricated. There are no external oiler fittings.

Remove Generator or Alternator

1. Disconnect the cables at the battery supply. If the generator or alternator has a separately mounted regulator and field relay, disconnect all other leads from the generator or alternator and tag each one to ensure correct reinstallation.

2. Loosen the mounting bolts and the adjusting strap bolt. Then remove the drive belts.

3. While supporting the generator or alternator, remove the adjusting strap bolt and washers. Then remove the mounting bolts, washers and nuts. Remove the generator or alternator carefully and protect it from costly physical damage.

4. Remove the pulley assembly if the generator or alternator is to be replaced.

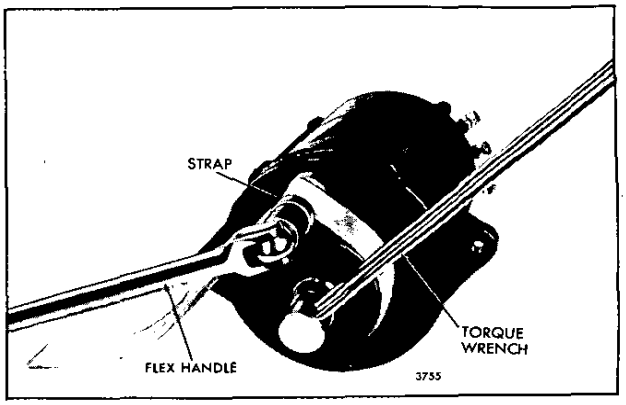


Fig. 3 - Tighten Generator or Alternator Pulley Retaining Nut

Generator or Alternator Service

Repairs and overhaul work on generators and alternators should be referred to an authorized repair station of the manufacturer of this equipment. Replacement parts for generators and alternators should be ordered through the equipment manufacturer's outlets. For generators and alternators manufactured by Delco-Remy Division, repair service and parts are available through AC Delco branches and repair stations.

Install Generator or Alternator

1. Install the drive pulley, if it was removed. Tighten the pulley retaining nut to 50-60 lb-ft (68-81 Nm) torque (Fig. 3).

> **NOTE:** If the pulley was not removed, check the retaining nut for proper torque.

2. Position the generator or alternator on the mounting brackets and start the bolts, with washers in place, through the bolt holes in the end frames. If nuts are used, insert the bolts through the bolt holes in the mounting bracket and end frame. Make sure that the washers and nuts are in their proper locations.

3. Align the threaded hole in the adjusting lug of the drive end frame with the slot in the adjusting strap. Start the bolt, with the washers, through the slot of the adjusting strap and into the threaded hole in the end frame.

4. Place the drive belts in the grooves of the pulleys.

5. Adjust the belt tension as outlined in Section 15.1. Tighten all of the bolts after the belt tightening is completed.

© 1980 General Motors Corp.

6. Attach the wires and cables. Be sure that each one is correctly installed in accordance with its previous location on the generator or alternator. Keep all connections clean and tight.

POLARIZING GENERATOR (Direct Current)

After each check or adjustment of the voltage regulator or generator, particularly after the leads have been disconnected and then reconnected, it is necessay to polarize the generator before starting the engine. This is to ensure correct polarity with respect to the battery.

NOTE: Never attempt to polarize an alternator.

Failure to polarize a generator will result in burned or stuck cutout relay contact points in the regulator, a rundown battery and damage to the generator.

The procedure for correctly polarizing a generator will vary with the type of electrical equipment installed and upon the generator regulator wiring circuit. If the generator field is grounded through the regulator, it is an "A" circuit; if it is internally grounded, it is a "B" circuit.

If Delco-Remy electrical equipment is installed, reference can be made to the Delco-Remy "Electrical Equipment Manual" and "Test Specifications" (refer to Section 7) to determine the type of circuit applicable to the regulator being used. Since it is possible to have either an "A" or "B" circuit regulator with any given generator, the polarizing procedures must be carefully adhered to. Use of the wrong polarizing procedure or neglecting to polarize will result in reversed generator polarity and serious damage to the electrical components.

After ascertaining the correct circuit used, polarize the generator as outlined below.

1. "A" Circuit:

   Connect a jumper lead momentarily between the "BAT" and "GEN" terminals of the regulator.

2. "B" Circuit:

   Remove the "F" lead from the regulator and momentarily connect it to the "BAT" terminal of the regulator.

A momentary surge of current to the generator correctly polarizes it with respect to the battery.

ALTERNATOR PRECAUTIONS

Precautions must be taken when working on or around alternators. The diodes and transistors in the alternator circuit are very sensitive and can be easily destroyed.

Avoid grounding or shorting the output wires or the field wires between the alternator and the regulator. Never run an alternator on an open circuit.

Grounding an alternator's output wire or terminals, which are always "hot" regardless of whether or not the engine is running or accidental reversing of the battery polarity will destroy the diodes. Grounding the field circuit will also result in the destruction of the diodes. Some voltage regulators provide protection against some of these circumstances. However, it is recommended that extreme caution be used.

Accidentally reversing the battery connections must be avoided.

Never disconnect the battery while an alternator is in operation. Disconnecting the battery will result in damage to the diodes due to the momentary high voltage and current generated by the rapid collapse of the magnetic field surrounding the field windings.

In marine applications which have two sets of batteries, switching from one set of batteries to the other while the engine is running will momentarily disconnect the batteries and result in damage to the alternator diodes.

If a booster battery is to be used, the batteries must be connected correctly (negative to negative and positive to positive).

Never use a fast charger with the battery connected or as a booster for battery output.

Never attempt to polarize the alternator.

The alternator diodes are also sensitive to heat and care must be exercised to prevent damage to them from soldering irons, etc.

If faulty operation of an alternator occurs on an engine equipped with an insulated starting motor, check to be sure that a ground strap is present and is correctly installed.

© 1980 General Motors Corp.

BATTERY-CHARGING GENERATOR OR ALTERNATOR REGULATOR

STANDARD REGULATOR - D. C. CHARGING CIRCUIT

To regulate the voltage and current output of the battery-charging generator and to maintain a fully charged storage battery, several protective devices are employed, depending on the type of electrical system. The most representative of these devices is the "three-unit" regulator (Fig. 1).

These regulators are identified as:

A "Circuit A" unit in which the generator field circuit is connected to ground within the regulator, and is used only with generators having an externally grounded field circuit.

A "Circuit B" unit in which the generator field circuit passes through the regulator and returns to ground inside the generator itself. This regulator must be used only with "Circuit B" generators in which the field is internally grounded.

The regulators are dust and moisture-proofed. On most applications, it is necessary to use shock mounts which insulate the regulator against vibration but necessitates the installation of a ground lead.

The three-unit regulator consists of a cutout relay, a voltage regulator and a current regulator mounted in a single assembly (Fig. 1). These three units are basic and generally apply to most regulators in a D.C. generator system.

CUTOUT RELAY

The cutout relay has two windings assembled on one core; a series winding of a few turns of heavy wire and a shunt winding of many turns of fine wire (Fig. 2). The relay core and windings are assembled into a frame. A flat steel armature is attached to the frame by a hinge so it is centered just above the center of the core. The armature has two or more contact points which are located just above a similar number of stationary contact points.

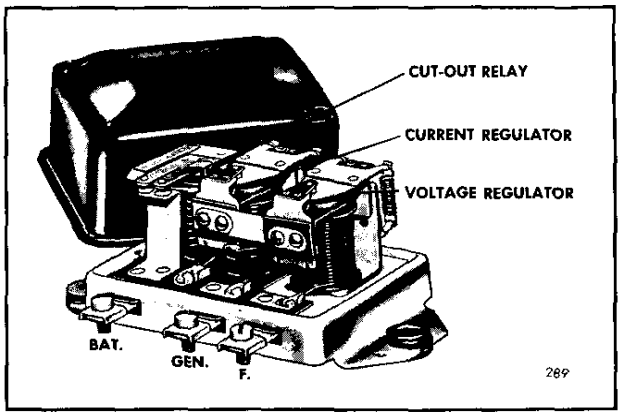


Fig. 1 - Typical Regulator Assembly

Operation

When the engine is not running, the armature contact points of the relay are held away from the stationary points by tension of a leaf spring.

As the engine starts and the generator speed increases, the current flowing through the shunt winding builds up until it reaches the value for which the relay has been set. At this point, sufficient magnetism overcomes the armature spring tension, the contact points close and the current flows to the battery. Then, the current which flows through the series winding is in the right direction to add to the magnetic force holding the armature down and the points closed.

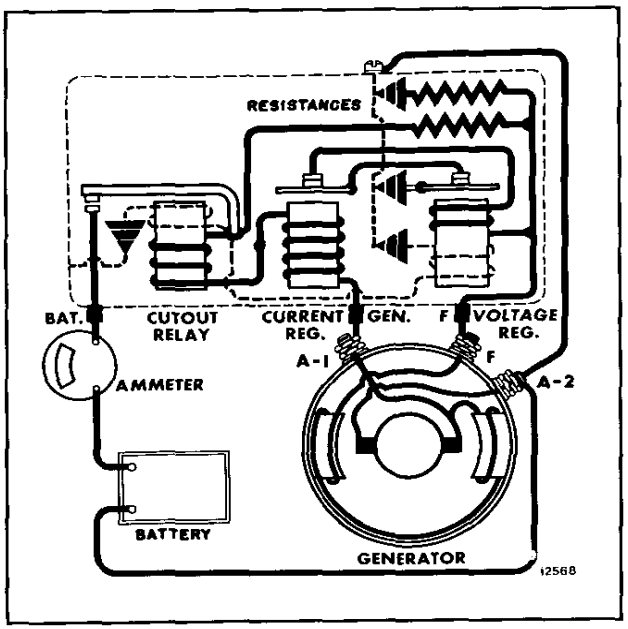


Fig. 2 - Wiring Circuit of Typical Three-Unit Regulator

© 1983 General Motors Corp.

When the engine is slowed down or stopped, current will begin to flow from the battery to the generator. This reverses the direction of current flow through the series winding, causing a reversal of the series winding magnetic field. The magnetic field of the shunt winding does not reverse. Therefore, the two windings now oppose each other magnetically and the resultant magnetic field is not strong enough to hold the armature down. The leaf spring pulls the armature away from the core and the points separate, opening the circuit between the generator and the battery.

NOTE: The regulator cutout relay contact points must never be closed by hand with the battery connected. This would cause a high current flow through the units and damage them.

VOLTAGE REGULATOR

The voltage regulator (Fig. 2) has two windings on a single core. One is a shunt winding consisting of many turns of fine wire which, in series with a resistor, is shunted across the generator at all times. The second winding is a field current winding which is connected between the generator field circuit and ground whenever the regulator contact points are closed. In addition to the core frame, armature and contact points, the unit has a spiral spring which holds the armature away from the core so the two contact points are touching when the voltage regulator is not operating.

Operation

When the generator voltage reaches the value for which the voltage regulator is adjusted, the combined magnetic field produced by the shunt winding and the field current winding overcomes the armature spring tension, pulls the armature down and separates the voltage regulator contact points. This introduces resistance into the generator field circuit so the generator field current and generator voltage are reduced. The lowering of the output of the generator causes the points to close again, thereby removing the resistance and increasing the generator output. The complete cycle of opening and closing the points and the alternate inserting and removing of the resistance in the generator field circuit is done rapidly, thus limiting the generator voltage to a predetermined maximum value. With the generator voltage limited, the generator supplies varying amounts of current to meet the requirements of varying states of battery charge and electrical loads.

CURRENT REGULATOR

The current regulator contains two windings assembled on one core: a series winding and a field current winding (Fig. 2). The series winding, consisting of a few turns of heavy wire, is connected into the charging circuit so that the full output of the generator passes through it. The field current winding is connected in series with the generator field circuit so that the field current flows through the field winding when the regulator contact points are closed.

The outward appearance of the current regulator is similar to that of the voltage regulator.

Operation

The magnetism produced by current flowing through the series winding overcomes the armature spring tension and the contact points open when the current reaches the value for which the current regulator is adjusted. This inserts a resistance into the generator field circuit, resulting in a drop in generator output. Immediately, the magnetic field of the series winding is weakened, the contact points close, the generator output starts to increase and the cycle is repeated. This action prevents the generator from exceeding its rated output.

Therefore, when the load demand is heavy, generator output will increase until it reaches the current value for which the current regulator is set; then the current regulator will begin to operate and pre-regulate the current output from the generator.

After any check or adjustment of the voltage regulator, it is necessary to polarize the generator before starting the engine to assure correct polarity with respect to the battery (refer to Section 7.1).

© 1983 General Motors Corp.

HEAVY DUTY REGULATOR - D.C. CHARGING CIRCUIT

The carbon pile regulator is a heavy duty unit designed for use with a high output D.C. generator (Fig. 3).

Compared with the vibrating-contact regulators, the carbon pile regulator functions on a different principle which should be clearly understood before adjustments of the regulator are attempted. In the carbon pile regulator, a stack or pile of small flat carbon discs is connected in series electrically with the generator field circuit. Control of the generator output is obtained by varying the pressure on the carbon stack which, in turn, varies its resistance without interrupting the field circuit.

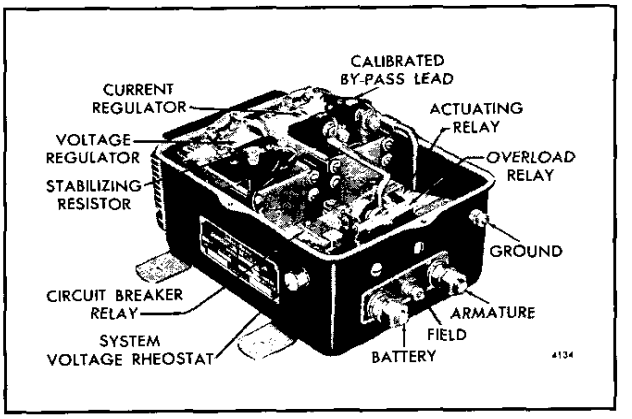


Fig. 3 - Carbon Pile Regulator Assembly

The regulator contains an actuating relay, a circuit breaker relay, a voltage regulator, a current regulator and an overload circuit breaker relay. In addition to these operating units, a system voltage rheostat is connected in series with the voltage regulator shunt winding.

In the carbon pile regulator, the units named in Fig. 3 perform the following functions. The actuating relay and circuit breaker relay operate together to close and open the charging circuit. The voltage regulator limits the generator voltage to a safe operating value. The current regulator limits the generator current output to its rated maximum. The system voltage rheostat provides an external means of adjusting the voltage regulator setting. The reverse current overload relay is a safety device which will cause the circuit breaker relay contact points to open on excessive reverse current.

BATTERY-CHARGING ALTERNATOR REGULATOR

A.C. CHARGING CIRCUIT

TRANSISTORIZED AND TRANSISTOR REGULATORS

In addition to the standard regulator, there are two other types of regulators used with the self- rectifying A.C. generators in the battery-charging circuit. One is a transistorized regulator which contains a vibrating voltage regulator unit and a field relay unit. The other is a transistor regulator which contains no moving parts and is used with a separately mounted field relay.

TRANSISTORIZED REGULATOR

The transistorized regulator (Fig. 4), for use on a negative ground circuit, contains a vibrating voltage regulator unit and a field relay unit. The regulator uses a single transistor and two diodes. The transistor works in conjunction with the conventional voltage unit having a vibrating contact point to limit the alternator voltage to a preset value. A field discharge diode reduces arcing at the voltage regulator contacts by dissipating the energy created in the alternator field windings when the contacts separate. A suppression diode prevents damage from transient voltages which may appear in the system.

Certain transistorized regulators are equipped with a choke coil to permit the installation of a capacitor between the regulator and the "BAT" terminal on installations experiencing radio interference. The capacitor suppresses the radio noise and the choke coil acts to prevent oxidation of the voltage regulator contacts. Regulators incorporating the choke coil are identified by a spot of green paint on the regulator base, next to the single mounting bolt hole.

NOTE: A capacitor must not be installed unless

© 1983 General Motors Corp.

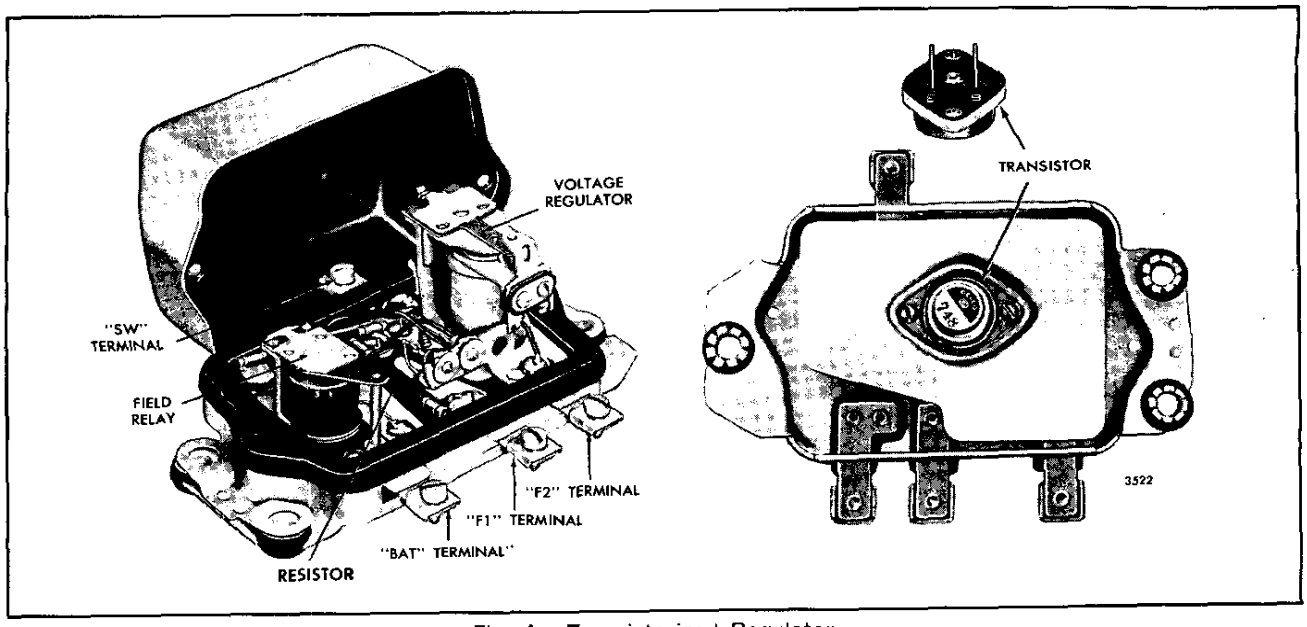


Fig. 4 - Transistorized Regulator

the transistorized regulator incorporates the choke coil.

Operation

When the engine starting switch is closed, the field relay winding is energized and causes the contacts to close. Current then flows from the battery through the relay contacts to the regulator "F2" terminal. From this point, the current flows through the alternator field winding and then through the transistor and voltage contact points to ground.

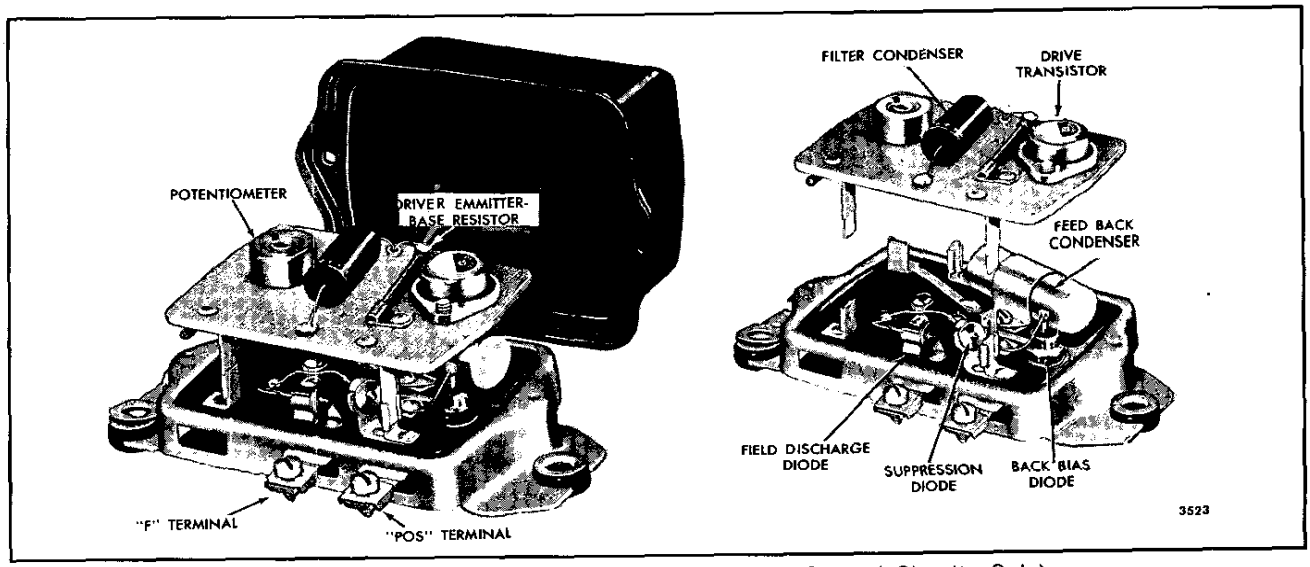


Fig. 5 - Former Transistor Regulator (Negative Ground Circuits Only)

© 1983 General Motors Corp.

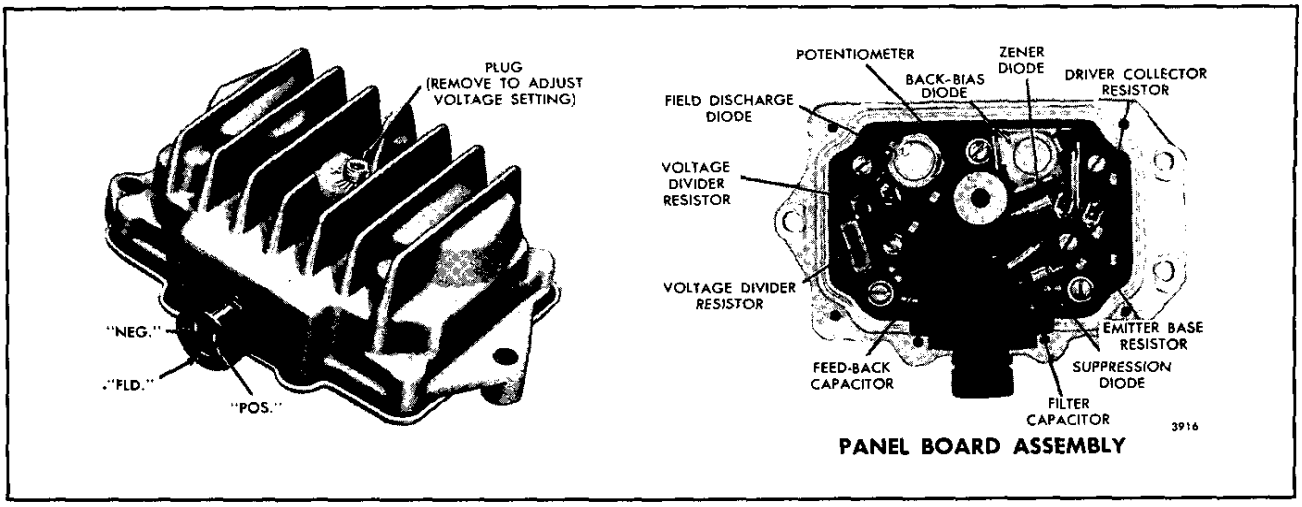


Fig. 6 - Transistor Regulator with Plug-In Connections

As the alternator speed increases, the increased voltage from the alternator "BAT" terminal is impressed through the field relay contacts across the regulator shunt winding. The magnetism created in the winding causes the voltage contacts to open, thus causing the transistor to shut off the field current. The alternator voltage then decreases and the voltage contacts reclose. This cycle repeats many times per second, thereby limiting the alternator voltage to the value for which the regulator is set.

The magnetism produced in an accelerator winding, when the voltage contacts are closed, aids the shunt winding in opening the contacts. When the contacts are open, the absence of the magnetism in the accelerator winding allows the spring to immediately reclose the contacts. This action speeds up the vibration of the contacts.

NOTE: Do not short across or ground any of the terminals on the regulator or the alternator and *do not* attempt to polarize the alternator.

TRANSISTOR REGULATOR

The transistor regulator is composed principally of transistors, diodes, capacitors and resistors to form a completely static electrical unit containing no moving parts.

The transistor is an electrical device which limits the alternator voltage to a preset value by controlling the alternator field current. The diodes, capacitors and resistors act together to aid the transistor in performing this function, which is the only function that the regulator performs in the charging circuit.

The voltage at which the alternator operates is determined by the regulator adjustment. Once adjusted, the alternator voltage remains almost constant, since the regulator is unaffected by length of service, changes in temperature or changes in alternator output and speed.

A separately mounted field relay connects the regulator "POS" terminal and the alternator field windings to the battery when the engine starting switch is closed.

The voltage regulator illustrated in Fig. 5 is designed for negative ground battery-charging circuits only. It has two exposed terminals. The voltage setting may be adjusted by relocating a screw in the base of the regulator.

The voltage regulator shown in Fig. 6 has shielded plug-in connections and requires a cable and plug assembly to connect the regulator into the battery-charging circuit. This type of regulator may be used in negative ground, positive ground and insulated charging circuits. The voltage setting may be adjusted by removing a plug in the cover and turning a slotted adjusting button inside the regulator.

Operation

When the engine starting switch is closed, the field relay winding is energized, which causes the relay contacts to close.

© 1983 General Motors Corp.

In the **negative ground circuit**, with the field relay contacts closed and the engine not running, alternator field current can be traced from the battery through the relay contacts to the regulator "POS" terminal. Current then continues through the back-bias diode (D-1) and power transistor (TR-1) to the regulator "FLD" terminal and then through the alternator field winding to ground, completing the circuit back to the battery.

When the alternator begins to operate, A.C. voltages are induced in the stator windings. These voltages are changed, or rectified, to a D.C. voltage which appears at the output, or "BAT", terminal on the alternator. The alternator then supplies current to charge the battery and operate various accessories.

As alternator speed increases, the voltage reaches the preset value and the components in the regulator cause transistor TR-1 to alternately "turn off" and "turn on" the alternator field voltage. The regulator thus operates to limit the alternator output voltage to the preset value.

In the **positive ground circuit**, when the switch is closed and the engine is not running, the field current can be traced from the battery positive ground to generator ground and then to the regulator "POS" terminal. The current continues through diode D-1 and transistor TR-1 to the regulator "FLD" terminal, and then through the field winding and field relay contacts back to the battery, thus completing the circuit. Except for this primary difference, this circuit operates in the same manner as that described for the negative ground circuit.

REGULATOR PRECAUTIONS

Never short or ground the regulator terminals; *Do Not attempt to polarize the circuit.*

Make sure all connections in the charging circuit are tight to minimize resistance.

Refer to *Alternator Precautions* in Section 7.1.

© 1983 General Motors Corp.

STORAGE BATTERY

The lead-acid storage battery is an electro-chemical device for converting chemical energy into electrical energy.

Function of Battery

The battery has three major functions:

1. It provides a source of current for starting the engine.

2. It acts as a stabilizer to the voltage in the electrical system.

3. It can, for a limited time, furnish current when the electrical demands exceed the output of the generator or alternator.

> **NOTE:** In the selection of a replacement battery, it is always good practice to select one of an "electrical size" at least equal to the battery originally engineered for the particular equipment by the manufacturer.

Install Battery

While the battery is built to satisfactorily withstand the conditions under which it will normally operate, excessive mechanical abuse leads to early failure.

Install the battery as follows:

1. Be sure the battery carrier is clean and that the battery rests level when installed.

2. Tighten the hold-down clamps evenly until snug. However, do not draw them down too tight or the battery case will become distorted or will crack.

3. Attach the cable clamps after making sure the cables and terminal clamps are clean and in good condition. To make the cable connections as corrosion resistant as possible, place a felt washer at the base of each terminal beneath the cable clamps. Coat the entire connection with a heavy general-purpose grease. Be sure the ground cable is clean and tight at the engine block or frame.

4. Check the polarity to be sure the battery is not reversed with respect to the generating system.

5. Connect the *grounded* terminal of the battery last to avoid short circuits which will damage the battery.

Servicing the Battery

A battery is a perishable item which requires periodic servicing. Only when the battery is properly cared for as described below can long and trouble-free service be expected.

1. Check the level of the electrolyte regularly. Add water if necessary, but do not overfill. Overfilling can cause poor performance or early failure.

2. Keep the top of the battery clean. When necessary, wash with a baking soda solution and rinse with fresh water. Do not allow the soda solution to enter the cells.

3. Inspect the cables, clamps and hold-down bracket regularly. Clean and reapply a coat of grease when needed. Replace corroded or damaged parts.

4. Use the standard battery test as the regular service test to check the condition of the battery.

5. Check the electrical system if the battery becomes discharged repeatedly.

Many electrical troubles caused by battery failures can be prevented by systematic battery service. In general,

Engine	Starting Motor Voltage	Qty.	12 Volt Batteries for 12 or 24 Volt Systems: S.A.E. Cold Cranking AMP @0°F. -17°C AMP Per Battery	Total S.A.E. Cold Cranking AMP @0°F.-17°C AMP Per Bank	Reference S.A.E. 20 AMP Hour Rate Per Bank	8 Volt Batteries for 24 or 32 Volt Systems (Marine) Qty.	S.A.E. Cold Cranking AMP@0°F -17°C AMP Per Battery	Total S.A.E. Cold Cranking AMP@0°F. -17°C AMP Per Battery	Connect Batteries
3, 4, 6-71	12V	1	900	Single Battery	205	—	—	—	Single
	24V	2	600	600	150	—	—	—	Series
	32V	—	—	—	—	4	600	600	Series
Note — Bank Refers to the Combined Connected Batteries									

BATTERY RECOMMENDATIONS

© 1983 General Motors Corp.

the care and maintenance recommendations for storage batteries are the same today as they have always been.

Battery Safety Precautions

When batteries are being charged, an explosive gas mixture forms beneath the cover of each cell. Part of this gas escapes through the holes in the vent plugs and may form an explosive atmosphere around the battery itself if ventilation is poor.

CAUTION: Explosive gas may remain in and around the battery for several hours after it has been charged. Sparks or flames can ignite this gas causing an explosion which could shatter the battery. Flying pieces of the battery structure and splash of electrolyte can cause personal injury.

© 1983 General Motors Corp.

STARTING MOTOR

The starting motor is mounted on the flywheel housing as illustrated in Fig. 1. When the starting circuit is closed, a small drive pinion on the armature shaft engages with the teeth on the engine flywheel ring gear to crank the engine. When the engine starts, it is necessary to disengage the drive pinion to prevent the armature from overspeeding and damaging the starting motor. To accomplish this, the starting motor is equipped with one of several types of drive mechanism: a heavy-duty sprag overrunning clutch, a Bendix drive or a Dyer drive.

NOTE: See Section 7.0 for the mounting of a Delco-Remy starter auxiliary magnetic switch.

Sprag Overrunning Clutch Type Starting Motor

A solenoid switch, mounted on the starting motor housing, operates the current sprag type overrunning clutch drive by linkage and a shift lever (Fig. 2). When the starting switch is engaged, the solenoid is energized and shifts the starting motor pinion into mesh with the flywheeel ring gear and closes the main contacts within the solenoid. Once engaged, the clutch will not disengage during intermittent engine firing. To protect the armature from excessive speed when the engine starts, the clutch "overruns", or turns faster than the armature, which permits the pinion to disengage itself from the flywheel ring gear.

The solenoid plunger and shift lever on this type of starting motor is totally enclosed to protect them from dirt, water and other foreign material.

An oil seal, between the shaft and the lever housing, and a linkage seal (Fig. 2) prevents the entry of transmission oil into the main frame of the starting motor and solenoid case, allowing the motor to be used on wet clutch applications.

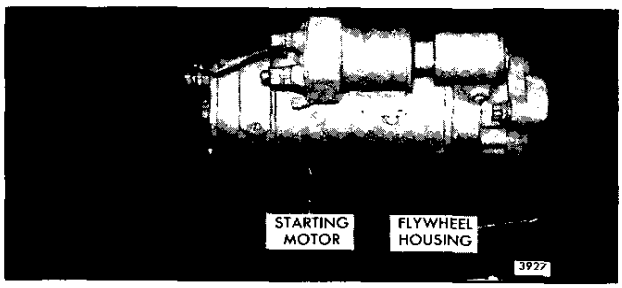


Fig. 1 - Sprag Overrunning Clutch Type Starting Motor Mounting (Current)

The nose housing on the sprag clutch type starting motor can be rotated to obtain a number of different solenoid positions with respect to the mounting flange. The nose housing, on starters equipped with the heavy-duty clutch, is attached to the lever housing by six bolts located around the outside of the housing (Fig. 2).

NOTE: When installing a current flywheel housing on an early engine, the starting motor nose housing may have to be indexed to reposition the solenoid.

When repositioning of the solenoid is required on a service replacement starting motor, proceed as follows:

1. Remove the six socket head screws (1 short and 5 long) and six neoprene plugs, if a twelve hole starter mounting flange is used.

2. Turn the nose housing to the required position.

NOTE: The solenoid must never be located below the centerline of the starter or dust, oil, moisture and foreign material can collect and cause solenoid failures.

3. Install the six socket head screws, with the short screw in the shallow hole nearest the solenoid and six neoprene plugs, if a twelve hole starter mounting flange is used.

4. Tighten the screws to 13-17 lb-ft (18-23 Nm) torque.

High-Output Starting Motor

A high-output 12 volt starting motor, with a sprag overrunning clutch type drive, is provided for certain vehicle applications which require the equivalent of 24 volts for starting the engine and 12 volts for lighting and operation of electrical accessories. The same total battery capacity recommended for use with a 24 volt starter (two 205 ampere-hour batteries) must be retained and connected in parallel for the high-output 12 volt starter.

Bendix Drive Type Starting Motor

The former Bendix drive type starting motor (Fig. 3) is energized through a magnetic solenoid switch, which is mounted separate from the starting motor.

When the magnetic switch circuit is closed by the engine starting switch, the armature begins to rotate.

© 1984 General Motors Corp.

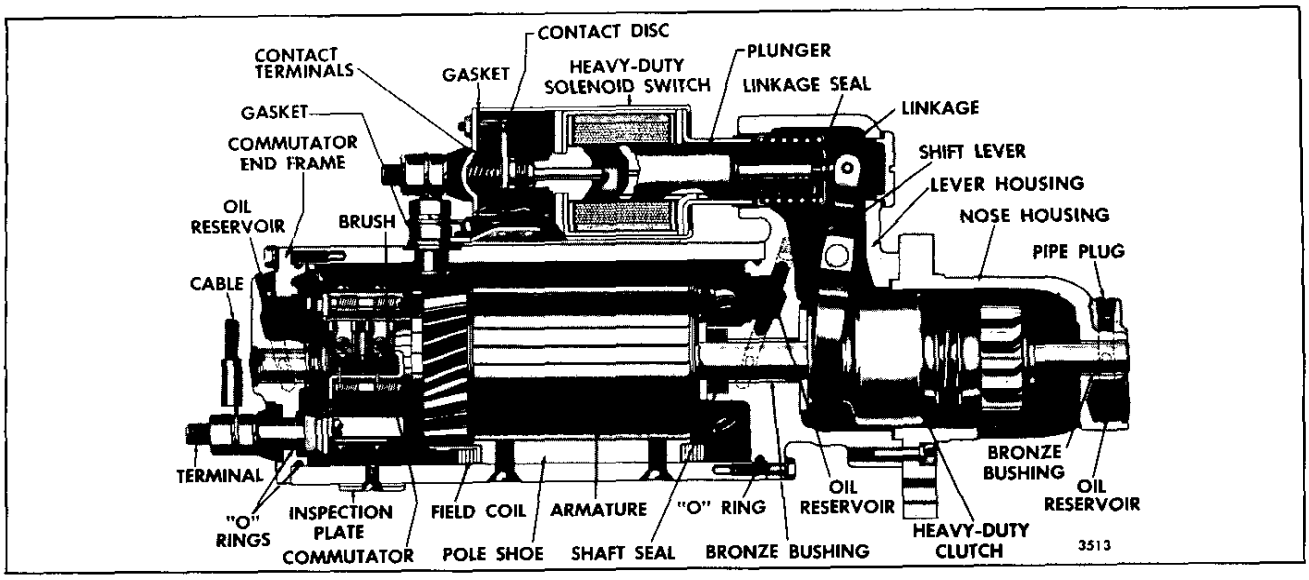


Fig. 2 - Cross-section of Starting Motor with Sprag Heavy-Duty Clutch Drive

The drive pinion (Fig. 4), being a loose fit on the drive sleeve located on the armature shaft, does not pick up speed as fast as the armature. Therefore, the drive pinion, having internally matched splines with respect to the splined drive sleeve, moves endwise on the shaft and into mesh with the flywheel. As the pinion hits the pinion stop, it begins to rotate the armature and cranks the engine. When the engine starts, the pinion backs out of mesh with the flywheel ring gear, protecting the armature from excessive speeds.

Dyer Drive Type Starting Motor

The former Dyer drive type starting motor (Fig. 5) is operated through a solenoid starting shift shift lever and switch mounted on the motor. The Dyer drive mechanism provides positive engagement of the starting motor pinion with the engine flywheel ring gear before the starting motor switch is closed and the armature begins to rotate.

When the engine starting switch is closed, the starter solenoid (Fig. 6) is energized and the solenoid plunger pulls the pinion into mesh with the flywheel ring gear. Continued movement of the plunger then closes the solenoid switch contacts and permits the starting motor to crank the engine. As soon as the engine starts, the pinion is automatically de-meshed by the reversal of torque so the armature will not be subjected to excessive speeds.

NOTE: When a current flywheel housing is installed on an early engine, it may be necessary to replace the Dyer drive starting motor with a sprag clutch type motor.

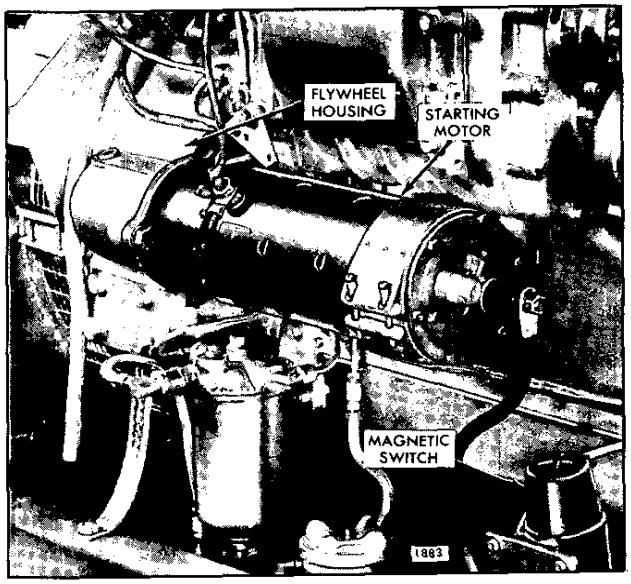


Fig. 3 - Bendix Drive Type Starting Motor Mounting (Former)

© 1984 General Motors Corp.

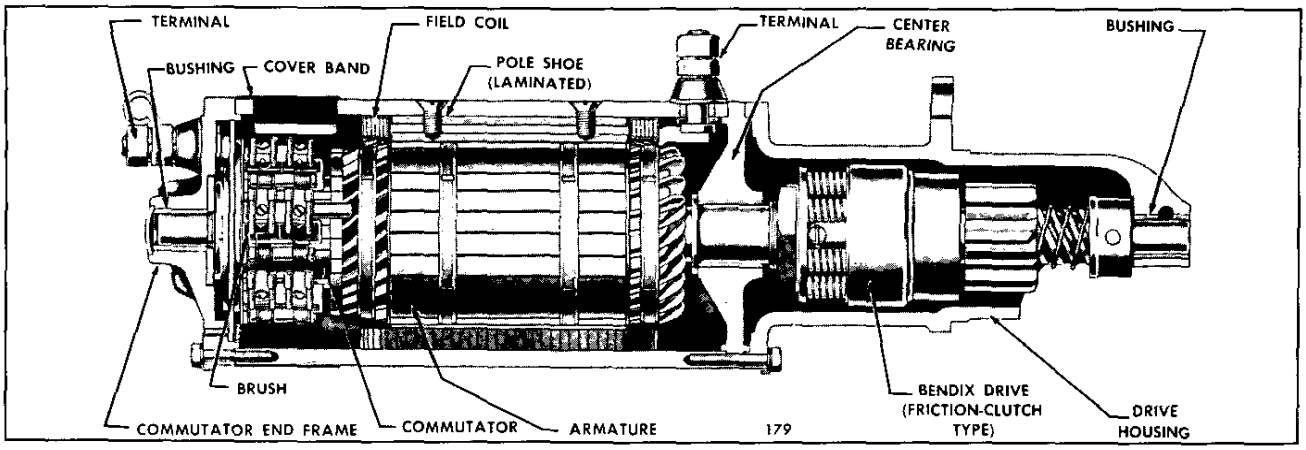


Fig. 4 - Cross-section of Starting Motor with Bendix Drive

Lubrication

Starting motors which are provided with lubrication fittings (hinge cap oilers, oil tubes sealed with pipe plugs, or grease cups) should be lubricated periodically (refer to Section 15.1).

Flywheel Ring Gears

The starting motor drive pinion and the engine flywheel ring gear must be matched to provide positive engagement and to avoid clashing of the gear teeth. Flywheel ring gear teeth have either no-chamfer, a Bendix chamfer or a Dyer chamfer (Fig. 7).

Flywheel ring gears with no chamfer are used with starting motors equipped with an overrunning clutch drive. Ring gears with a Bendix chamfer are used with starting motors equipped with either a Bendix drive or an overrunning clutch drive. Ring gears with the Dyer chamfer, used with Dyer drive type starting motors, may be reversed and used with the overrunning clutch drive type starting motors.

If the wrong type of ring gear is used, repeated starting attempts will be required for engagement of the drive pinion and burring of the gear teeth will result.

NOTE: The flywheel housing on some engine models had a 9.603" radius from the center of the crankshaft bore to the center of the starter hole. These engines used a 103 tooth flywheel ring gear. These flywheel housings have been replaced by new housings with a 9.520" crankshaft bore to starter hole radius. A 102 tooth flywheel ring gear must be used with the new housings. The old ring gear is retained for service for the engines still using the old housing.

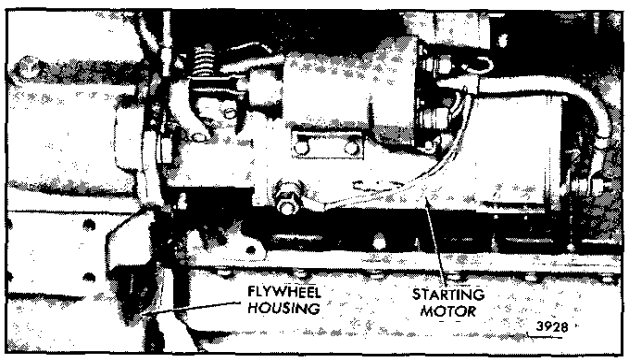


Fig. 5 - Dyer Drive Type Starting Motor Mounting (Former)

Remove Starting Motor

Failure of the starting motor to crank the engine at normal cranking speed may be due to a defective battery, worn battery cables, poor connections in the cranking circuit, defective engine starting switch, low temperature, condition of the engine or a defective starting motor.

If the engine, battery and cranking circuit are in good condition, remove the starting motor as follows:

1. Remove the ground strap or cable from the battery or the cable from the starting motor solenoid. Tape the end of the cable to prevent discharging the battery from a direct short.

© 1982 General Motors Corp.

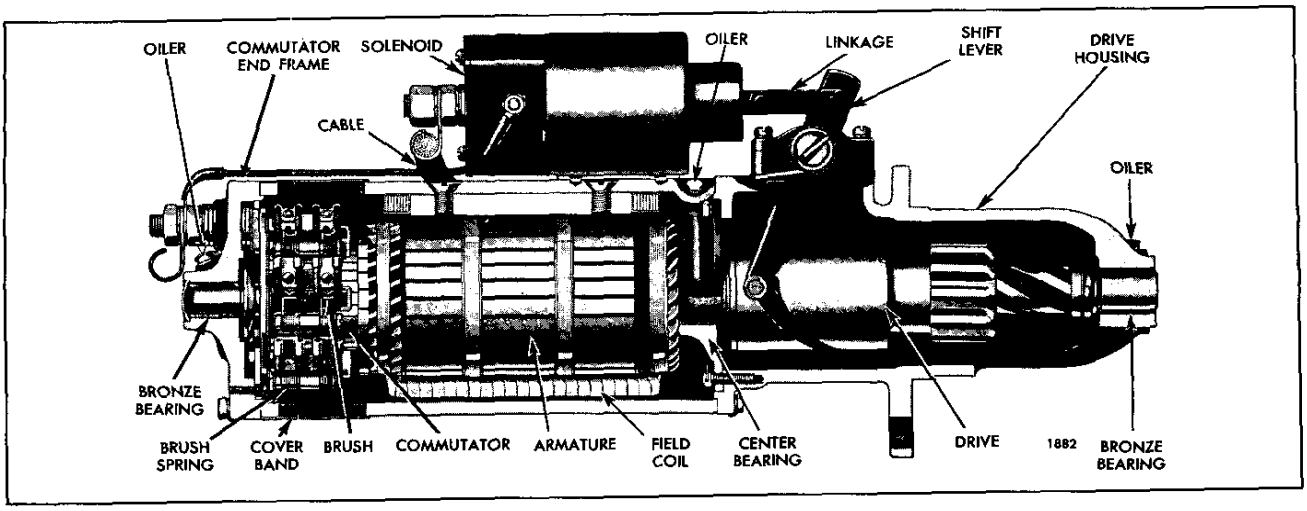


Fig. 6 - Cross-section of Starting Motor with Dyer Drive

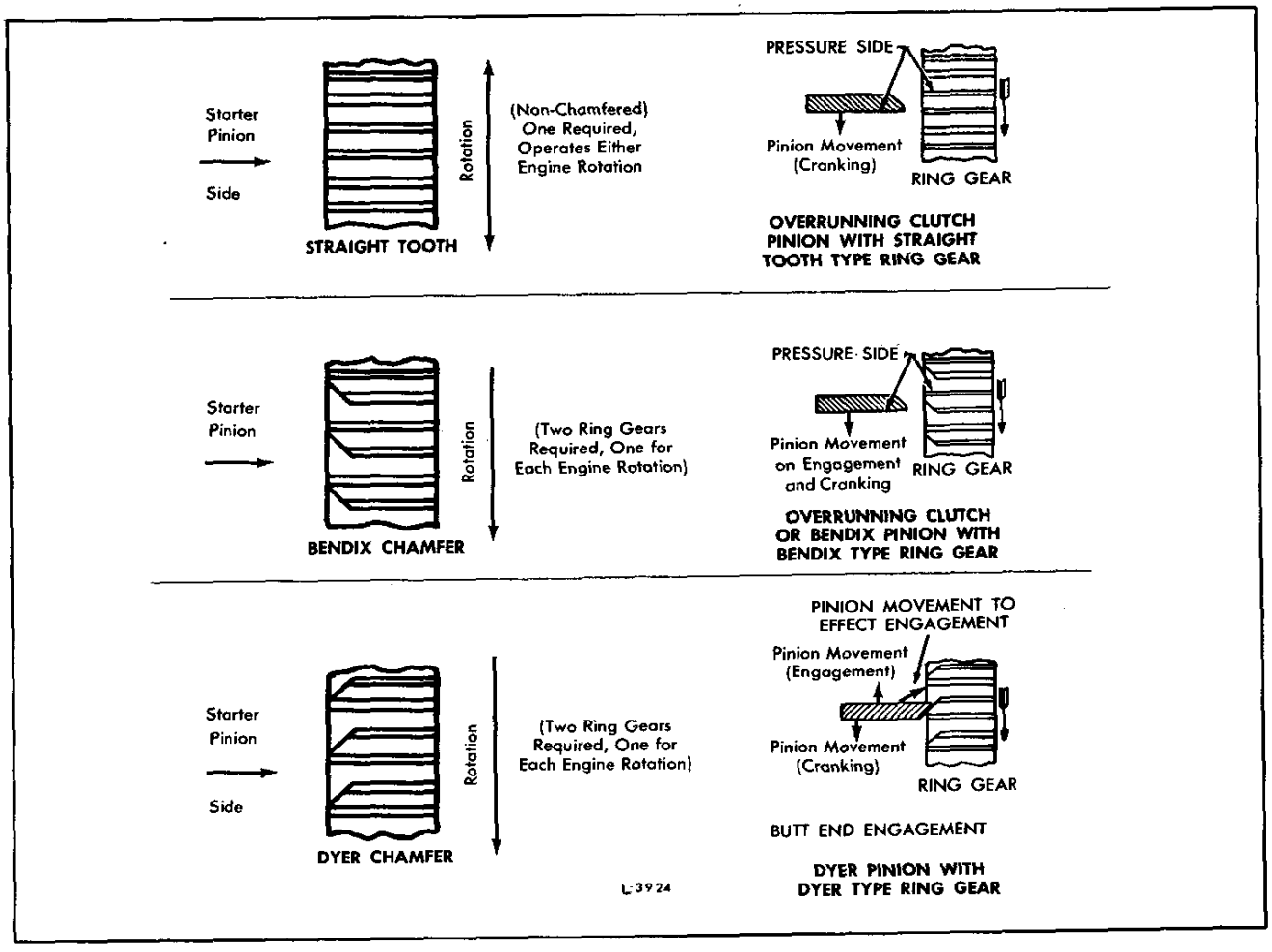


Fig. 7 - Types of Flywheel Ring Gears

© 1982 General Motors Corp.

2. Disconnect the starting motor cables and solenoid wiring.

> **NOTE:** Tag each lead to ensure correct connections when the starting motor is reinstalled.

3. Support the motor and remove the three bolts and lock washers which secure it to the flywheel housing. Then pull the motor forward to remove it from the flywheel housing.

Check the starting motor in accordance with the Delco-Remy "Cranking Circuit" maintenance handbook.

Install Starting Motor

To install the starting motor, reverse the procedure outlined for removal. Tighten the 5/8"-11 starter attaching bolts to 137-147 lb-ft (186-200 Nm) torque when a cast iron flywheel housing is used or to 95-105 lb-ft (129-143 Nm) torque when an aluminum flywheel housing is used.

Keep all of the electrical connections clean and tight. When installing wiring terminal leads to the starting motor and the solenoid switch, tighten the No. 10-32 connections to 16-30 **lb-in** (2-3 Nm) torque and the 1/2"-13 connections to 20-25 lb-ft (27-34 Nm) torque.

© 1982 General Motors Corp.

SOLENOID SWITCH

A solenoid switch is included in the starting system on Series 71 engines using a Bendix drive starter to provide a means of opening and closing the circuit between the starting motor and the battery during the cranking operation. The switch is mounted on a plate which in turn may be mounted on or near the starting motor (Fig. 1).

Specifications of a typical starting switch are as follows:

"Pull-In" Voltage potential of 15 volts, plus or minus one volt, is required to pull the plunger into operating position.

"Hold-In" Voltage potential of not less than 3.5 volts is required to hold the plunger in its operating position.

Resistance of Solenoid Winding is from 3.8 to 4.0 ohms.

Four terminals are provided on the switch, two of which are at the lower end for the connection of the battery and motor leads. Two smaller terminals, one on each side of the switch, are provided for the connection of the lead from the starting switch on the instrument panel and the lead from the fuse which is grounded to the engine base. Insulating bushings and washers are used to completely insulate the terminals from the switch body.

The starting motor-battery circuit is opened and closed inside the switch body by means of a contact disc (circular plate) which is attached to, but insulated from, a plunger which is free to move up or down within the body. When in the non-operating position, the contact disc is held away from the terminals by the tension of a spring, bearing against a cap attached to the upper end of the plunger.

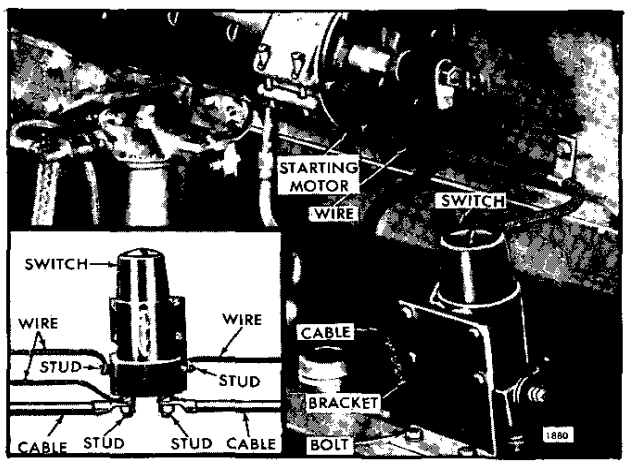


Fig. 1 - Typical Solenoid Switch Mounting and Wiring

Operation

When the instrument panel starting switch contacts are closed, a circuit is completed across the solenoid switch terminal studs and through the coil (Fig. 2). The resultant magnetic field created in the core of the coil overcomes the tension of the plunger return spring (Fig. 2) and the plunger is drawn downward into the magnetic field, carrying the contact disc with it. When the contact disc touches the battery cable terminal stud and the starting motor cable terminal stud the circuit between the motor and battery is completed and the cranking operation begins.

The cranking operation continues until the circuit is broken by releasing the starting switch on the instrument panel. When this happens, the circuit through the coil is broken and the magnetic field collapses. This allows the plunger return spring to pull the plunger out of the coil core and the contact disc away from the battery and starting motor (studs) contacts.

Starting Cautions

1. Press starting button firmly.

2. If the engine fails to start after first attempt, do not press starting button again until engine has stopped rotating.

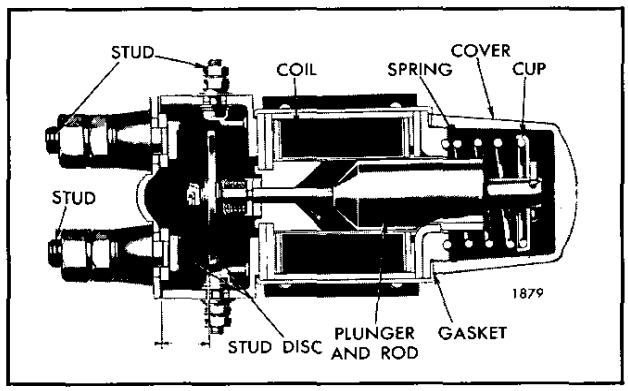


Fig. 2 - Typical Solenoid Switch Assembly

© 1983 General Motors Corp.

Serious damage may result to the motor if the above rules are not followed.

Periodically, inspect all terminals to make sure connections are clean and tight.

Remove Solenoid Switch

1. Disconnect the battery cable and starter switch wire from the battery cable terminal stud, also, disconnect the starting motor cable from the starting motor cable terminal stud.

2. Remove the wires from the switch terminal studs. Tag the wires for identification.

3. Remove the four nuts, lock washers, plain washers and bolts and remove the solenoid switch.

Install Solenoid Switch

The switch may be reinstalled on the engine as outlined below:

1. Attach the switch to the mounting plate with four bolts, plain washers, lock washers and nuts.

2. Connect the battery cable and starter switch wire to the battery cable terminal stud and connect the starting motor cable to starting motor cable terminal stud.

3. Connect the wires to the switch terminal studs. If the wires are not identified by tags, refer to the wiring diagram.

© 1983 General Motors Corp.

INSTRUMENTS AND TACHOMETER DRIVE

INSTRUMENTS

The instruments generally required in the operation of a diesel engine consist of an oil pressure gage, water temperature gage, an ammeter and a mechanical tachometer. Instruments with slotted cases are available for use with lighted dashes. Also, closely related and usually installed in the general vicinity of these instruments are certain controls consisting of an engine starting switch, an engine stop knob and an emergency stop knob (Figs. 1, 2 and 3).

All Torqmatic converters are equipped with an oil pressure gage and, in some instances, with an oil temperature gage. These instruments are mounted on a separate panel.

Instruments, throttle control and engine starting and stopping controls are mounted in various locations, depending upon the particular use of the engine.

Marine propulsion engines are provided with an instrument panel which usually includes an engine oil pressure gage, reverse gear oil pressure gage, water temperature gage, ammeter and a tachometer. The instrument panels are generally mounted some distance from the engine. Illuminated instrument panels are provided for marine applications which require night operations.

All illuminated instrument panels are wired for a 12 volt lighting circuit. Therefore, when marine propulsion units incorporate either a 24 or 32 volt electrical system, a 12 volt tap-off from the battery may be made, or resistors (Table 1) may be installed in the circuit to protect the instrument panel bulbs. As indicated in Fig. 4, one resistor is used in the lead for each instrument panel bulb.

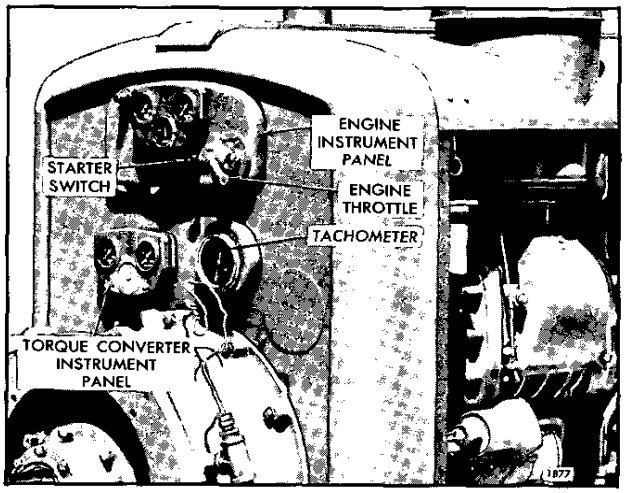


Fig. 1 - Typical Single Engine Unit Instrumentation

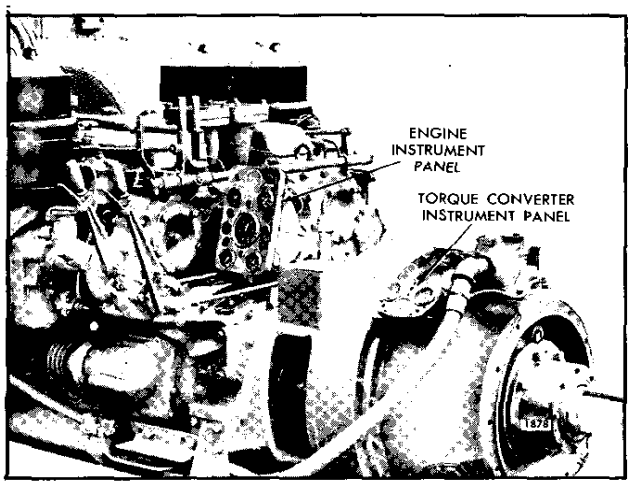


Fig. 2 - Typical Multiple Engine Unit Instrumentation

Resistor Specifications		
Volts	Ohms	Watts
24	50	10
32	100	10

TABLE 1 - Resistor Specifications

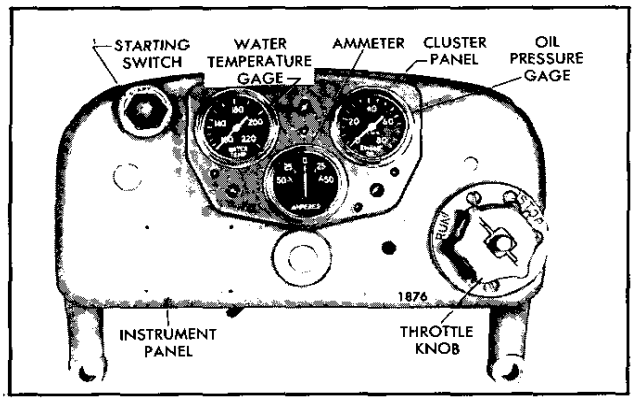


Fig. 3 - Typical Instrument Panel

© 1983 General Motors Corp.

Whenever performing service or preventive maintenance procedures on marine propulsion engine units which include a 24 or 32 volt electrical system, check the lighting circuit of the instrument panels to determine if either a 12 volt tap-off from the battery or resistors have been installed in the lighting circuit to protect the instrument panel bulbs.

Anti-Vibration Instrument Mountings

Anti-vibration mountings are used in many places to absorb engine vibration in the mounting of instruments, drop relays, tachometers, etc. When it may become necessary to service a part secured by rubber mounts, care should be exercised, during removal and installation of the part, so twist is not imposed into the rubber diaphram. At the time the part is removed from the engine for service, the mounts should be inspected for damage and replaced, if necessary.

The attaching screw, through the center of the mount, must be held from turning during final tightening of the nut. Support the screw and tighten the nut only. If this screw turns, it will pre-load the rubber diaphragm in torsion and considerably shorten the life of the mount.

Oil Pressure Gage

The oil pressure gage registers the pressure of the lubricating oil in the engine. As soon as the engine is started, the oil pressure gage should start to register. If the oil pressure gage does not register at least the minimum pressure listed in the *Operating Conditions* in Section 13.2, the engine should be stopped and the cause of the low oil pressure determined and corrected before the engine is started again.

Current oil pressure gages have male threads and require female fittings. When replacing a former gage with female threads, a new mounting clamp and connector must be used.

Water Temperature Gage

The engine coolant temperature is registered on the water temperature gage.

Incorrect coolant temperature readings will be registered if the gage assembly is incorrectly installed or the capillary tube is damaged.

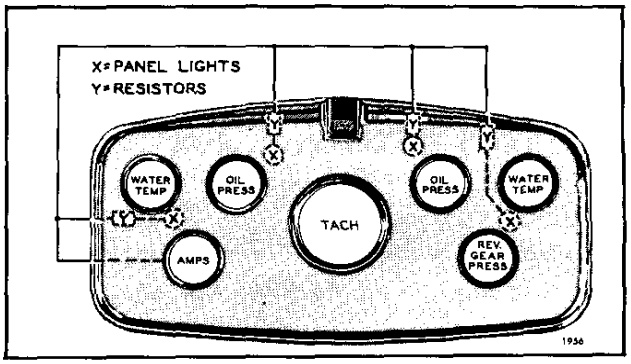


Fig. 4 - Installation of Resistors in Illuminated Instrument Panel

To prevent damage to the gage assembly from vibration, the capillary tube must be securely fastened to the engine the full length with suitable clips at intervals of ten inches or less. Sharp bends in the tube must be avoided, particularly at the gage or bulb connection areas. Where the tube must be bent around any object, the bend must not be less than one inch radius.

Any extra length can be taken up by coiling, the diameter of which should not be less than two inches. The coils must be located so that they may be securely fastened to prevent vibration.

Ammeter

The ammeter is wired into the electrical circuit to show the current flow to and from the battery. After starting the engine, the ammeter should register a high charge rate at rated engine speed. This is the rate of charge received by the battery to replenish the current used to start the engine. As the engine continues to operate, the ammeter should show a decline in the charge rate to the battery. The ammeter will not show zero charge rate since the regulator voltage is set higher than the battery voltage. The small current registered prevents rapid brush wear in the battery-charging generator. If

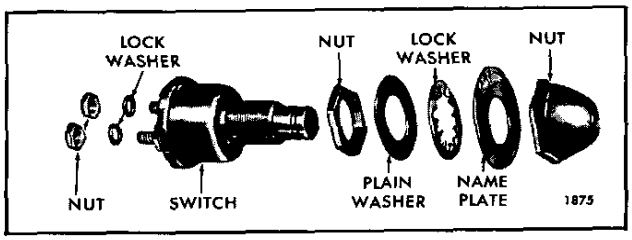


Fig. 5 - Typical Engine Starting Motor Switch

© 1983 General Motors Corp.

lights or other electrical equipment are connected into the circuit, then the ammeter will show discharge when these items are operating and the engine speed is reduced.

Tachometer

The tachometer, driven by the engine, registers the speed of the engine in revolutions per minute (rpm).

Throttle Control

The engine throttle is connected to the governor speed control shaft through linkage. Movement of the speed control shaft changes the speed setting of the governor and thus the engine speed.

Engine Starting Switch

To start the engine, a switch is used to energize the starting motor (Fig. 5). Starting switches may vary in design and their contacts must be rated sufficiently to carry the starter solenoid current.

NOTE: Tighten the starting switch mounting nut to 36-48 **lb-in** (4-5.5 Nm) torque.

Engine Stop Knob

A stop knob is used to stop the engine. When stopping an engine, the engine speed should be reduced to idle and the engine allowed to operate at idle for a few minutes to permit the coolant to reduce the temperature of the engine's moving parts. Then pull the stop knob and hold it until the engine stops. Pulling on the stop knob manually places the injector racks in the no-fuel position. Return the stop knob to its original position after the engine stops.

NOTE: When an emergency shut down is necessary on a current engine with the spring loaded fuel injector control tubes (one screw and locknut assembly), the stop knob should be pulled immediately and held until the engine stops.

Emergency Stop Knob

In an emergency, or if the engine continues to operate after pulling the stop knob, the emergency stop knob may be used to stop the engine. When the emergency stop knob is pulled, the air shutoff valve, located between the air intake and the blower, will trip and shut off the air supply to the engine. Lack of air to the engine will prevent further combustion of the fuel and stop the engine.

The emergency stop knob must be pushed back in after the engine is stopped and the air shutoff valve must be reset manually. The cause of the malfunction should be determined before the engine is started again.

TACHOMETER DRIVE

A tachometer drive shaft may be installed at any one of several locations on the engine.

At the front end of the engine, the tachometer drive shaft is pressed into the end of the camshaft or balance shaft and extends through an adaptor attached to the balance weight cover.

At the rear of the engine, the tachometer drive shaft may be installed in the end of either the camshaft, balance shaft or the blower drive shaft (Fig. 6). A tachometer drive shaft adaptor is attached to the flywheel housing cover or the blower rear end plate cover.

When required, a tachometer drive cable adaptor is used to change speed or to change direction of rotation, depending upon the location of the tachometer drive. A special key is used to connect the drive shaft to the tachometer drive cable adaptor.

The cable connection at the current tachometer head is a 5/8" threaded connection in place of the former 7/8" connection. To eliminate possible misalignment, the current tachometer angle drive has a short flexible cable and incorporates an integral oil seal. The output shaft key size has been increased from 5/32" to SAE 3/16". New flexible drive cables are also required with the current tachometers and angle drives.

Remove Tachometer Drive

If replacement is necessary, remove the tachometer drive shaft as follows:

1. Disconnect the tachometer drive cable from the tachometer drive cable adaptor.

2. If used, remove the tachometer drive cable adaptor

© 1983 General Motors Corp.

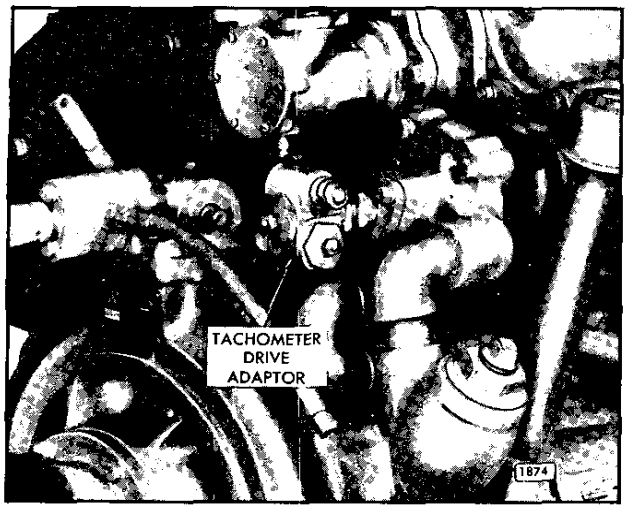


Fig. 6 - Typical Tachometer Drive Mounting

and key (key and seal assembly if the tachometer drive shaft is driven by the blower drive shaft).

3. Remove the tachometer drive shaft adaptor and gasket from the balance weight cover if the tachometer drive is located at the front of the engine. For a rear mounted tachometer drive, remove the flywheel housing cover and adaptor assembly and gasket. Examine the oil seal, if used, for wear or damage. Replace the oil seal (camshaft drive) or oil seal unit (blower drive shaft drive), if necessary.

4. If the tachometer drive shaft is driven by the blower drive shaft, remove the blower drive shaft.

5. If the tachometer drive shaft is pressed into the end of the camshaft or blower drive shaft, it cannot be be turned since the end is either square or knurled. Remove the drive shaft as follows:

a. If threads (5/16"-24 or 3/8"-24) are provided on the outer end of the tachometer drive shaft to accommodate a a removing tool, thread remover J 5901-3 on the shaft; then attach slide hammer J 2619-5 to the remover. A few sharp blows of the weight against the slide hammer rod will remove the tachometer drive shaft.

b. If threads are not provided on the outer end of the tachometer drive shaft, or if the end of the shaft is broken off, drill and tap the shaft. Then, thread a stud into the shaft and remove the shaft with the remover and slide hammer.

NOTE: Use adequate protective measures to prevent metal particles from falling into the gear train and oil pan.

Install Tachometer Drive

1. Start the tachometer drive shaft in the end of the camshaft or blower drive shaft. Then, using a suitable sleeve, tap or press against the shoulder on the tachometer drive shaft until the shoulder contacts the camshaft or blower drive shaft.

2. Install the blower drive shaft.

3. Install the tachometer drive cover and adaptor on the flywheel housing. Use a new gasket.

4. Align the tachometer drive cover and adaptor with the tachometer drive shaft as outlined in Section 7.0.

5. Install the oil seal and key assembly (blower drive shaft driven tachometer drive).

6. If used, install the tachometer drive cable adaptor and key. Lubricate the tachometer drive cable adaptor with grease through the fitting provided.

7. Attach the tachometer drive cable.

© 1983 General Motors Corp.

ENGINE PROTECTIVE SYSTEMS

MANUAL SHUTDOWN SYSTEM

A manually operated emergency engine shutdown device enables the engine operator to stop the engine in the event an abnormal condition should arise. If the engine continues to run after the engine throttle is placed in the NO FUEL position, or if combustible liquids or gases are accidentally introduced into the combustion chamber causing overspeeding of the engine, the shutdown device will prevent damage to the engine by cutting off the air supply and thus stopping the engine. The shutdown device consists of a flap valve mounted in the air inlet housing and a suitable operating mechanism.

Operation

The manually operated shutdown device is operated by a knob located on the instrument panel and connected to a latch on the valve shaft (current engines) or a detent lever (early engines) by a Bowden wire or cable assembly. Pulling the shutdown knob all the way out will stop the engine. Push the knob all the way in and manually reset the air shutdown device in the shutdown housing before the engine is started again.

Service

For disassembly and assembly of the emergency shutdown valve, refer to Section 3.3.

AUTOMATIC ELECTRICAL SHUTDOWN SYSTEM

The electrically operated automatic shutdown includes a fuel pressure switch, a lubricating oil pressure switch, a water temperature switch and a shutdown solenoid (Figs. 1 and 2).

An overspeed governor switch may be employed separately or in conjunction with the above electrical shutdown system (Fig. 4).

A hot wire relay or a solid state time delay switch may be introduced into the electrical shutdown system to prevent the fuel oil pressure switch from closing before the lubricating oil pressure switch opens, which would cause a shutdown of the engine.

When the engine is not running, the fuel oil pressure switch is open, the lubricating oil pressure switch is closed and the water temperature switch is open.

After starting the engine, the lubricating oil pressure switch contacts are open when the oil pressure is 10 psi (69 kPa) or higher (approximately 700 rpm), and the fuel oil pressure switch contacts are closed when the fuel oil pressure is 20 psi (138 kPa) or greater (approximately 800 rpm). The electrical circuit of this system is so arranged that the closing of the fuel pressure switch energizes the entire system, and at anytime thereafter, the closing of either the lubricating oil pressure switch or water temperature switch, will cause the shutdown to operate. When the engine starts, the fuel pressure increases so rapidly that the fuel pressure switch contacts close before the lubricating oil pressure reaches 10 psi (69 kPa). This condition would cause the engine to shutdown, except for the introduction of a hot wire relay or a solid state time delay switch into the circuit. This relay or time delay switch delays the energizing of the shutdown solenoid by 3 to 10 seconds, enabling the lubricating oil pressure to exceed 10 psi (69 kPa), thereby opening the lubricating oil pressure switch and preventing the energizing of the circuit. When the engine has reached normal operating speed, the fuel oil pressure switch is closed and the lubricating oil pressure switch is open.

When the lubricating oil pressure falls below 10 ±2 psi (69 ±14 kPa), the oil pressure switch closes and current flows to the hot wire relay or time delay switch which must be heated by the current to complete the circuit to the solenoid. The few seconds required to heat the hot wire relay or time delay switch provides sufficient delay to avoid engine shutdown when low oil pressure is caused by a passing condition such as an air bubble or by the temporary overlap in the operation of the lubricating oil pressure switch and fuel pressure during starting and stopping of the engine.

The high water temperature switch is connected in parallel with the lubricating oil pressure switch and normally remains open, closing only when the engine coolant temperature exceeds 200 ±5°F (93 ±3°C) thus energizing the shutdown solenoid.

The overspeed governor is driven by the blower drive shaft. If the engine speed exceeds the speed which has been established by the engine governor, the overspeed governor switch is actuated, causing the shutdown solenoid to close the shutdown valve.

© 1980 General Motors Corp.

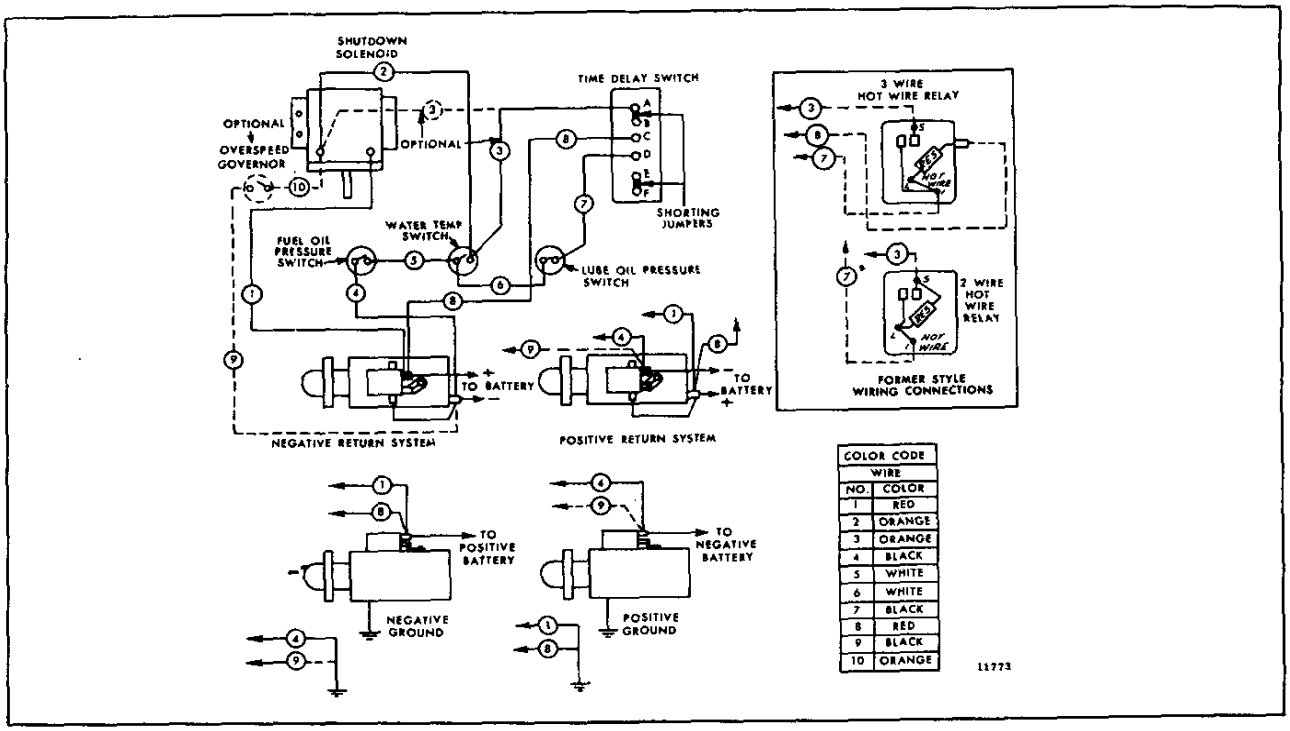


Fig. 1 - Automatic Shutdown Wiring Diagram

When the engine is shut down, as described above, the fuel oil pressure switch opens, thus breaking the circuit and eliminating the possibility of damage due to continued exposure to current.

Time Delay Switch

The current solid state time delay switch is designed as a direct replacement for the former hot wire relay.

It is a solid state time device which effectively withstands shock and vibrations. The switch is polarity conscious. If a reverse polarity is applied the switch will not work.

The switch has two circuits: a time circuit and an electronic circuit which consists of a silicone control rectifier. The rectifier has sufficient capacity to handle standard loads such as the emergency shutdown solenoid. Abnormal load situations such as a collapsing magnetic field in a coil can damage the rectifier rendering it inoperative. To protect the rectifier a discharge diode is connected across the terminals B and C of the solid state time delay switch. Check the time delay switch periodically to be sure it is operating properly (refer Section 7.0).

Fuel Oil Pressure Switch

From the above description, it can be seen that the fuel oil pressure switch is the controlling switch of the system, since this switch controls the flow of current to the other two switches. As previously stated, the fuel oil pressure switch is set to make contact when the fuel pressure reaches 20 psi (138 kPa), and the phrase "20-MAKE" is stamped on the switch cover.

As the fuel pressure increases upon starting, a diaphragm in the switch body is expanded and forces the plunger upwards. Since the bottom of the adjusting screw bears against this plunger, the adjusting screw and the lower breaker point are also forced upwards. When the fuel pressure reaches 20 psi (138 kPa), the breaker points close and the current flows to the terminals of the lubricating oil pressure switch and the water temperature switch.

When the engine is stopped, the fuel pressure decreases and the diaphragm in the switch body contracts. This action causes the plunger to lower and, when the fuel oil pressure decreases to 20 psi (138 kPa), permits the lower breaker point arm to lower, thus breaking the electrical circuit. The bracket to which the lower breaker point arm and the adjusting screw are attached is spring loaded which provides for

© 1980 General Motors Corp.

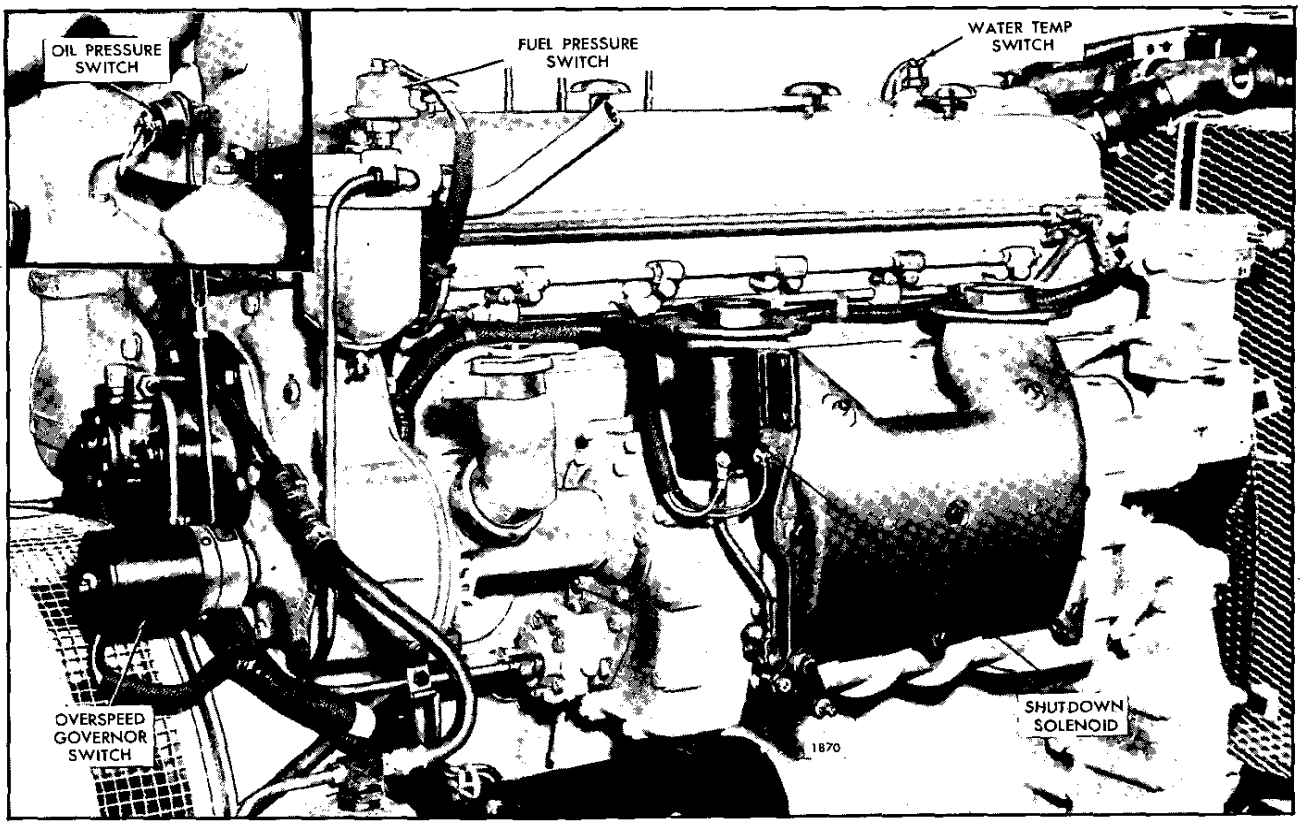


Fig. 2 - Typical Installation of Automatic Shutdown Device

positive breaking of the points when the fuel pressure decreases sufficiently.

Lubricating Oil Pressure Switch

The lubricating oil pressure switch is similar to the fuel oil pressure switch, except that the fuel oil pressure switch is of the "make" type while the lubricating oil pressure switch is of the "break" type. In other words, the lubricating oil pressure switch is calibrated to break contact when the lubricating oil pressure increases to 10 psi (69 kPa). The phrase "10-BREAK" is stamped on the switch cover.

As the lubricating oil pressure increases, when the engine starts, the diaphragm in the switch body expands and forces the plunger upwards. Since the bottom of the adjusting screw bears against the plunger and the adjusting screw is attached to the bracket which controls the upper breaker point arm, the arm is also forced upwards. When the lubricating oil pressure increases to 10 psi (69 kPa), the points separate. However, as previously described, current flows to the lubricating oil pressure switch only after the fuel oil pressure switch closes, at which time the points of the lubricating oil pressure switch are open. If the lubricating oil pressure decreases to 10 psi (69 kPa) during operation, the breaker point will close and either the alarm bell or the shutdown solenoid will be energized.

Water Temperature Switch

The terminals of the water temperature switch are connected into the shutdown system, and when the engine circulating water temperature reaches 205 ±5°F (96 ±3°C), the switch closes and completes the shutdown or alarm system.

As the water temperature increases, a plunger rises and contacts a wheel which is attached to the switch actuating lever. A further increase in water temperature forces the contact end of the actuating lever upwards. When the water temperature reaches 205 ±5°F (96 ±3°C), this lever forces the switch button upwards into the switch block thus closing the switch. Since this lever is spring loaded, the contact end of the

© 1980 General Motors Corp.

lever moves away from the switch button as the water temperature decreases.

If the engine has been stopped by any of the above mentioned switches, the shutdown valve must be reset in the open position before the engine can be started.

AUTOMATIC MECHANICAL SHUTDOWN SYSTEM

A mechanical type shutdown system is used on certain models to prevent damage to the engine in case of an emergency. This system makes use of an air valve in the air system. The air valve automatically closes if the engine overspeeds, overheats, or loses oil pressure.

Operation

By pulling the control knob from the instrument panel, a cam comes in contact with the starter button, energizing the starting motor (Fig. 3).

When the engine starts, the control knob is released after the oil pressure has built up and forced the latch into position to hold the air valve open (Fig. 4). If the engine overheats, the water temperature bellows will expand, releasing the air damper and allowing it to close (Fig. 5). If the engine loses oil pressure or overspeeds, the oil pressure bellows will contract, releasing the latch, and allows the air damper to close (Fig. 6).

Inspection

The operation of the components of the protective system should be checked periodically to determine that they function properly.

A partial check, is that the air valve will close every time the engine is shut down. If this does not occur, the bellows adjustment should be checked as stated under "Adjustment". This check is not a substitute for checking the operation of the components of the protective system.

Checking Shutdown System

To determine if the protective control unit is functioning properly, check the shutdown system periodically as follows:

1. Connect an oil pressure gage to the main oil gallery. Start the engine. With the control set in the operating position, manually reduce the engine speed by slowly pulling out the "stop" cable or by rotating the control lever on the top of the governor. Carefully observe the oil pressure at which shutdown occurs. This must be between 18 and 22 psi (124 and 152 kPa). If an adjustment is necessary, remove the control unit cover and loosen the lock nut on the oil pressure element adjusting sleeve. Turn the sleeve IN to raise the trip pressure and OUT to lower the trip pressure. Recheck and tighten the lock nut when the trip pressure is satisfactorily established. Remove the gage.

2. Operate the unit to check the overspeed governor. Then, with the rocker cover off, manually move the injector racks SLOWLY toward the full fuel position. This will cause the engine speed to increase. Use care and bring the speed up gradually. With a tachometer, and the aid of an assistant, note the speed at which the trip operates; this must be between 1400 and 1450 rpm. If an adjustment is needed, loosen the lock nut on the overspeed governor and turn the screw IN to increase the trip speed and OUT to lower the trip speed. Tighten the lock nut and recheck the adjustment. Replace the valve rocker cover on the engine.

3. Check the water temperature trip setting by blocking the air circulation through the radiator with a large sheet of cardboard or other suitable material. Install a mercury thermometer in the top of the radiator. Operate the unit with a moderate load and observe the water temperature on the thermometer. The trip must operate when the water temperature reaches 202 to 208 ° F (94 to 98 ° C).

If an adjustment is necessary, remove the control unit cover plate and loosen the small lock nut on the water temperature element (Fig. 7). Turn the adjusting nut UP to lower the trip temperature and DOWN to raise the trip temperature. Tighten the lock nut. To recheck the temperature setting, remove the radiator blocking material and operate the unit by manually holding the air valve in the open position in order to cool the unit down. Then, repeat the procedure to determine if the adjustment has provided the correct trip operating temperature.

> **NOTE:** Be sure to loosen the lock nut first (Fig. 7) before attempting to adjust the spring tension on the water temperature element. Otherwise, even a small amount of twisting force on the shaft will collapse the bellows and render the element inoperative.

4. When checking the protective system, the position of the starting control lever and the air valve must also be checked. The air valve must close freely and completely when released by the latch on the air valve shaft. The starting control rod must have about 1/8" travel before starting to rotate the air valve shaft.

© 1980 General Motors Corp.

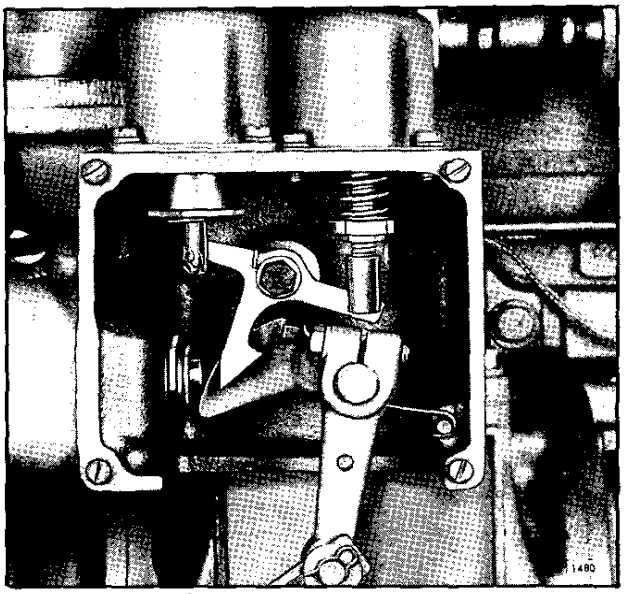


Fig. 3 - Cranking Position

The starting control rod has been pulled out, the air valve is open and the starter button is depressed.

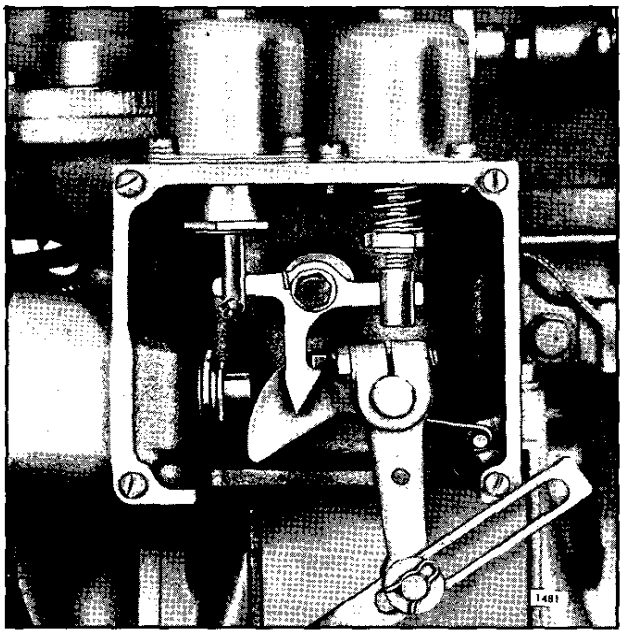


Fig. 4 - Normal Running Position

Oil pressure and water temperature normal. Latch is holding air valve open. Starting control rod is in released position.

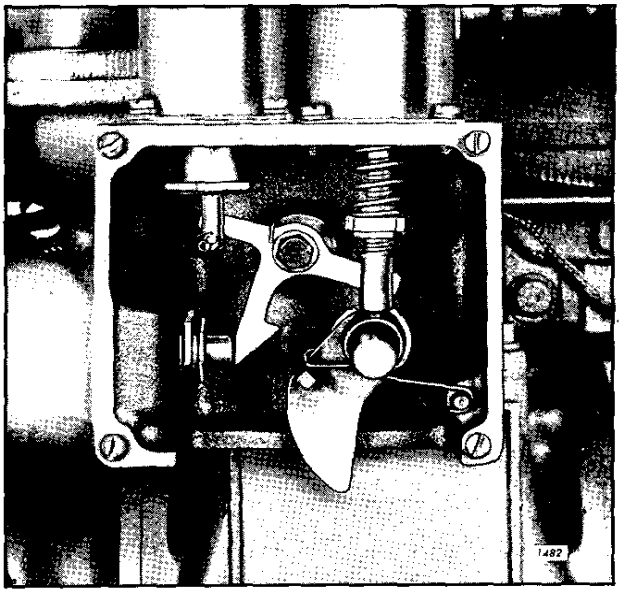


Fig. 5 - Shutdown High Water Temperature

Plunger has traveled downward causing latch to release air valve. Plunger will retract as unit cools. Starting control rod and lever have been removed to show relation of plunger to latch.

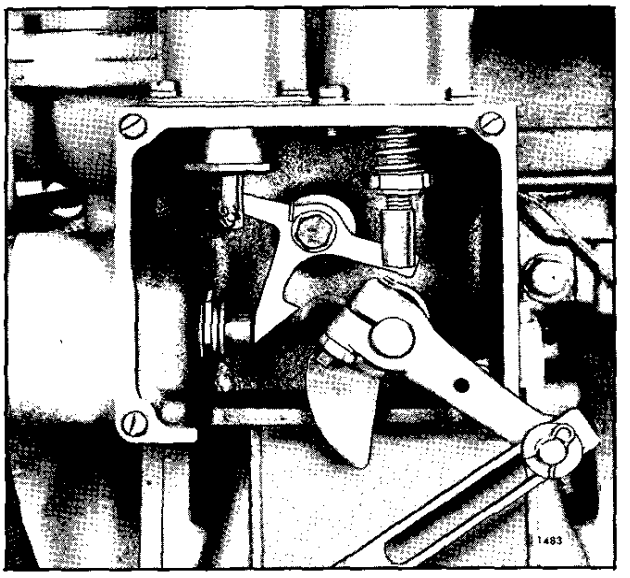


Fig. 6 - Shutdown Low Oil Pressure

Oil plunger has moved upward causing latch to release air valve. This release occurs whether engine is stopped manually or due to low oil pressure, overspeed or high water temperature.

© 1980 General Motors Corp.

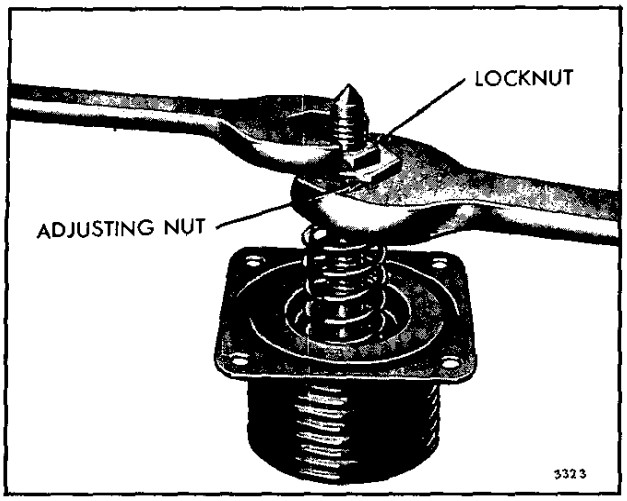


Fig. 7 - Loosening Lock Nut on Water Temperature Element

There must be a gap of approximately 1/32" between the cam and the starter button when the cam is in the latched position. All of the linkage must be free, all bolts and screws must be tight, and the unit must stop completely when the shutdown operates. The guide sleeve on the water temperature element plunger must fit over the latch by about 1/16" when the engine is stopped and is cold.

Water Temperature Thermo Bulb Installation

The water temperature shutdown device, which consists of a thermo bulb, tube and bellows, is a sealed unit that not only contains an operating fluid, but is also under vacuum. Therefore, the setting of the water temperature shutdown device may be altered considerably if damage results in leakage of air into the unit, or a change in the capacity of the thermo bulb. It is recommended that the water temperature device be replaced whenever it is found that the correct water temperature setting of the engine cannot be attained by adjustment of the unit.

The thermo bulb, which is mounted into a connector, extends into a copper pipe nipple that passes through the exhaust manifold outlet. The copper pipe nipple, an integral part of the exhaust manifold, has pipe threads at each end. Because the pipe nipple is made of copper, caution must be exercised when assembling the fittings to prevent damage. The torque given the fittings must be held to a minimum; therefore, a non-hardening sealant must be applied lightly to the threads of the pipe nipple before attaching the fittings.

An asbestos type gasket is used between the connector and the thermo bulb assembly, thus eliminating the need of a sealant at this point. Due to the use of the asbestos gasket, only a minimum amount of torque need be applied to the thermo bulb nut for sealing. When inserting the thermo bulb, the arrowhead on the thermo bulb positioning disc must point UPWARD.

AUTOMATIC MECHANICAL SHUTDOWN SYSTEM (TEMPERATURE-SENSING VALVE TYPE)

The automatic mechanical shutdown system is designed to stop the engine if there is a loss of oil pressure, loss of engine coolant, overheating of the engine coolant, or overspeeding of the engine. Engine oil pressure is utilized to activate the components of the system.

A coolant temperature-sensing valve and an adaptor and copper plug assembly are mounted on the exhaust manifold outlet. The power element of the temperature-sensing valve is placed against one end of the copper plug, and the other end of the plug extends into the exhaust manifold. Engine coolant is directed through the adaptor and passes over the power element of the valve. Engine oil, under pressure, is directed through a restricted fitting to the temperature-sensing valve and to an oil pressure actuated bellows located on the air shutdown housing.

The pressure of the oil entering the bellows overcomes the tension of the bellows spring and permits the latch to retain the air shutdown valve in the open position. If the oil pressure drops below a predetermined value, the spring in the bellows will release the latch and permit the air shutdown valve to close and thus stop the engine.

The overspeed governor (Fig. 8) used on certain applications, consists of a valve actuated by a set of spring-loaded weights. Engine oil is supplied to the valve through a connection in the oil line between the bellows and the temperature-sensing valve. An outlet in the governor valve is connected to the engine oil sump. Whenever the engine speed exceeds the overspeed governor setting, the valve (actuated by the governor weights) is moved from its seat and permits the oil to flow to the engine sump. This decreased the oil pressure to the bellows, thus actuating the shutdown mechanism and stopping the engine.

Some engines are equipped with a low oil pressure and overspeed valve assembly (Fig. 9). The valve assembly consists of a pair of springs, an oil piston, an oil dump valve, and an air piston. The springs establish a force

© 1980 General Motors Corp.

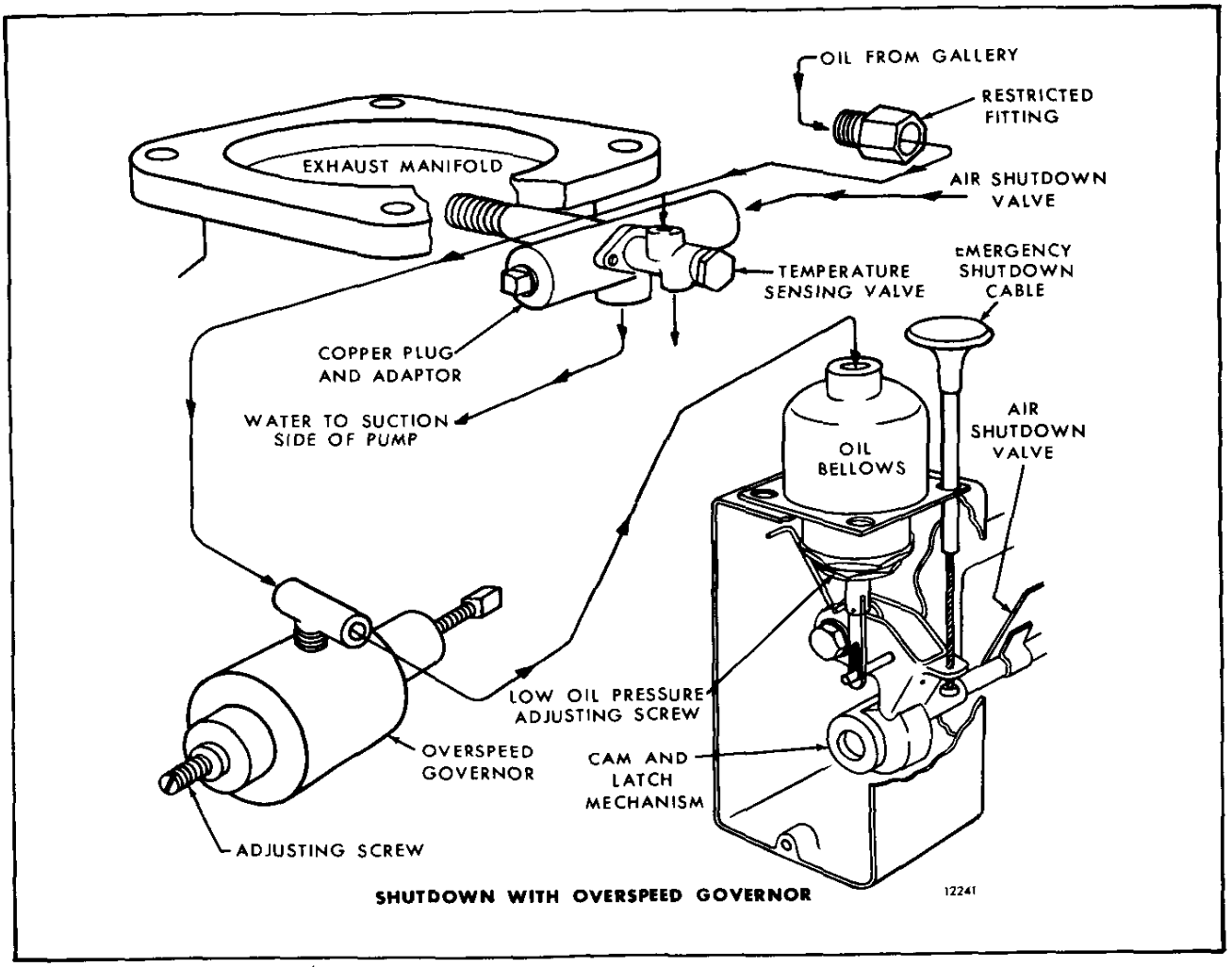


Fig. 8 - Schematic Drawing of Automatic Mechanical Shutdown System with Overspeed Governor

which is imposed on the dump valve and air piston. Air box pressure, which is dependent on engine speed, is used to maintain a balance between the secondary spring and the engine speed. If the oil pressure decreases to the balance point, the air box pressure will move the valve to the dump position, thus lowering the oil pressure to the bellows and actuating the shutdown mechanism. Overspeed control is obtained through a cam which controls the travel of the oil piston and establishes the maximum force that can be imposed on the valve and air piston. When air box pressure exceeds this force, the valve will open and permit the oil to flow to the engine crankcase. The resulting decrease in oil pressure will activate the shutdown mechanism.

A restricted fitting, which will permit a drop in oil pressure great enough to actuate the shutdown mechanism, is required in the oil line between the cyliner block oil gallery and the shutdown sensing devices.

Operation

To start an engine equipped with a mechanical shutdown system, first manually open the air shutdown valve and then press the engine starting switch. As soon as the engine starts, the starting switch may be released, but the air shutdown valve must be held in the open position until the engine oil pressure increases sufficiently to permit the bellow to retain the latch in the open position.

During operation, if the engine oil pressure drops below the setting of the pressure sensitive bellows, the spring within the bellows will release the latch and

© 1980 General Motors Corp.

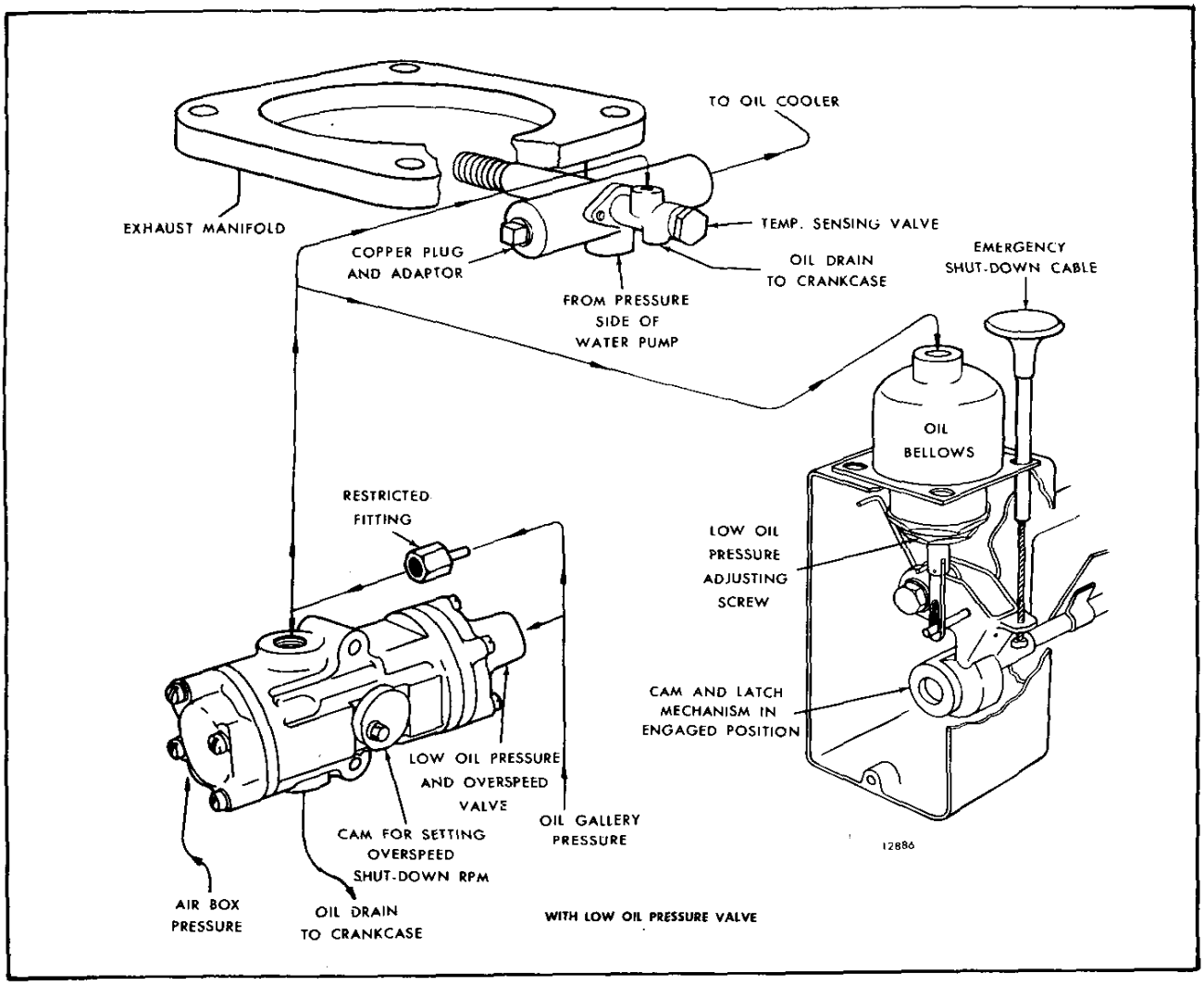


Fig. 9 - Schematic Drawing of Automatic Mechanical Shutdown System with Low Oil Pressure and Overspeed Valve

permit the air shutdown valve to close, thus stopping the engine.

If the engine coolant overheats, the temperature-sensing valve will open and permit the oil in the protective system to flow to the engine crankcase.

The resulting decrease in oil pressure will actuate the shutdown mechanism and stop the engine. Also if the engine loses its coolant, the copper plug will be heated up by the hot exhaust gases passing over it and cause the temperature- sensing valve to open and actuate the shutdown mechanism.

Whenever the engine speed exceeds the overspeed governor setting, the oil in the line flows to the sump, resulting in a decrease in oil pressure. The oil pressure bellows then releases the latch and permits the air shutdown valve to close.

If the overspeed valve assembly is used, a decrease in the oil pressure will reduce the spring tension in the valve and cause the air box pressure to open the dump valve and actuate the shutdown mechanism. If the engine speed increases, the air box pressure and oil pressure will also increase. However, since the travel of the oil piston is limited by the speed adjusting sleeve, the air box pressure will overcome the spring tension on the dump valve and actuate the shutdown mechanism.

When an engine is stopped by the action of the shutdown system, the engine cannot be started again

© 1980 General Motors Corp.

until the particular device which actuated the shutdown mechanism has returned to its normal position. The abnormal condition which caused the engine to stop must be corrected before attempting to start it again.

Inspection

The operation of the components of the protective system should be checked periodically to determine that they function properly.

A partial check, is that the air valve will close every time the engine is shut down. If this does not occur, the bellows adjustment should be checked as stated under "Adjustment". This check is not a substitute for checking the operation of the components of the protective system.

Adjustment

The only adjustments necessary in the mechanical shutdown system are the low oil pressure setting of the bellows and the overspeed setting of the overspeed governor or overspeed valve assembly. Replace the temperature-sensing valve when operation is unsatisfactory.

To adjust the low oil pressure setting of the bellows, start and run the engine until the normal operating temperature (160-185°F) (71-85°C) has been reached and the oil pressure has stabilized. Then, reduce the engine speed slowly until the bellows disengages the latch on the air shutdown valve and stops the engine. Note the oil pressure at which the shutdown occurred. The oil pressure at disengagement should be 5-10 psi (35-69 kPa) at 450-600 rpm; 10-15 psi (69-103 kPa) at 601-1400 rpm; or 15-20 psi (103-138 kPa) at 1401 and above rpm. If adjustment is necessary, loosen the lock nut on the bellows and turn the adjusting screw clockwise to increase the oil pressure setting or counterclockwise to decrease the setting. Hold the adjusting screw and tighten the lock nut when the proper setting has been obtained.

> **NOTE:** Set the bellows disengagement pressure as near as possible to the high end of the pressure range for the low engine speed specified for the engine. For an engine equipped with a dual speed governor, set the bellows disengagement at the lower setting of the engine governor.

Check the operation of the engine coolant temperature-sensing valve by placing a cover over the radiator while the engine is operating at part load and note the coolant outlet temperature at which the bellows disengages the air shutdown latch. The air shutdown valve should close and stop the engine within a temperature range of 200-210°F (93-99°C).

If the engine is not shutdown in this range, replace the temperature-sensing valve. If the engine is shutdown below 200°F (93°C), check the coolant flow through the plug and adaptor assembly and, if circulation is satisfactory, replace temperature-sensing valve.

> **NOTE:** If the temperature valve (sensing valve) or water temperature switch is removed examine the temperature shutdown valve plunger in the current type copper probe (Fig. 10). If it is not free in the probe and adaptor a new plunger, spring and adaptor should be installed. Deposits from the engine coolant building up between the plunger, spring and plug can cause the plunger to stick in the probe. On the former type probe, replace it with the current type plunger, spring and adaptor when the water holes become clogged with calcium deposits.

The temperature-sensing valve can be bench tested by attaching an air hose (40 psi or 276 kPa air supply) to the oil inlet side and installing a tube from the outlet side to a can of water. Then, immerse the power element of the valve in a container of water that is heated and agitated. Check the temperature of the water with a thermometer. Apply air to the valve. The

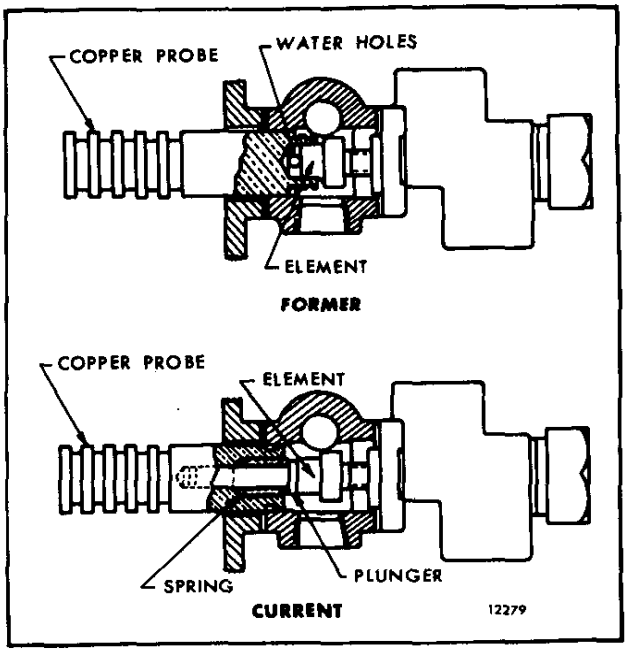


Fig. 10 - Comparison of New and Old Copper Probe

© 1982 General Motors Corp.

valve should be open, as indicated by the flow of air, at a water temperature of 195-206° F (91-97° C).

To adjust the overspeed governor, start and run the engine until normal operating temperature is reached. Then, increase the engine speed to the desired overspeed shutdown speed. At this speed, the bellows should disengage the air shutdown latch and stop the engine. If necessary, adjust the overspeed governor setting by loosening the lock nut on the adjusting screw at the rear of the governor and turn the screw clockwise to increase the shutdown speed or counterclockwise to decrease the shutdown speed. Then, tighten the lock nut, while holding the adjusting screw, when the proper setting is obtained.

On engines equipped with the overspeed valve assembly, loosen the cam retaining bolt and turn the knurled cam counterclockwise to increase the overspeed setting or clockwise to decrease the setting. Then, tighten the retaining bolt.

SHUTDOWN SYSTEM FOR DIRECT MOUNTED TURBOCHARGED ENGINES

With the use of a direct mounted turbocharger and the spring loaded fuel injector control racks, the air shutoff valve was eliminated from the air inlet housing. The spring loaded injector control racks enable the engine to come out of any advanced fuel position when an emergency situation arises.

When an engine is operating in an atmosphere subject to volatile fuel and is equipped with an air inlet housing without the air shutoff valve, a customer may request that the engine be equipped with an external or remote mounted emergency air shutdown assembly.

The remote mounted emergency air shutdown assembly that is equipped with the air shutoff valve can be installed upstream of the air inlet side of the turbocharger.

Care should be taken when installing the emergency air shutdown assembly between the turbocharger and the air cleaner. Because the engine shutdown system is activated, all of the piping between the shutdown system and the engine will be subjected to an abnormally high suction which may cause some of the piping components, i.e., rubber hoses and elbows to collapse. Therefore, it is recommended that all of these components be designed to withstand the maximum suction without a failure which would allow air to reach the engine air intake.

A 7 to 5 inch diameter reducing 90° rubber hose or a 7 to 5 inch diameter hump hose reducer can be used to adapt the shutdown to the turbocharger.

The rubber elbow can be obtained from the manufacturer; Griffin Rubber Mills in Portland, Oregon under their part number 51759.

The customer is also required to provide the mounting support brackets.

The emergency air shutdown assembly is manually operated. To be an automatic shutdown system, it will be necessary to install a solenoid.

© 1982 General Motors Corp.

ALARM SYSTEM

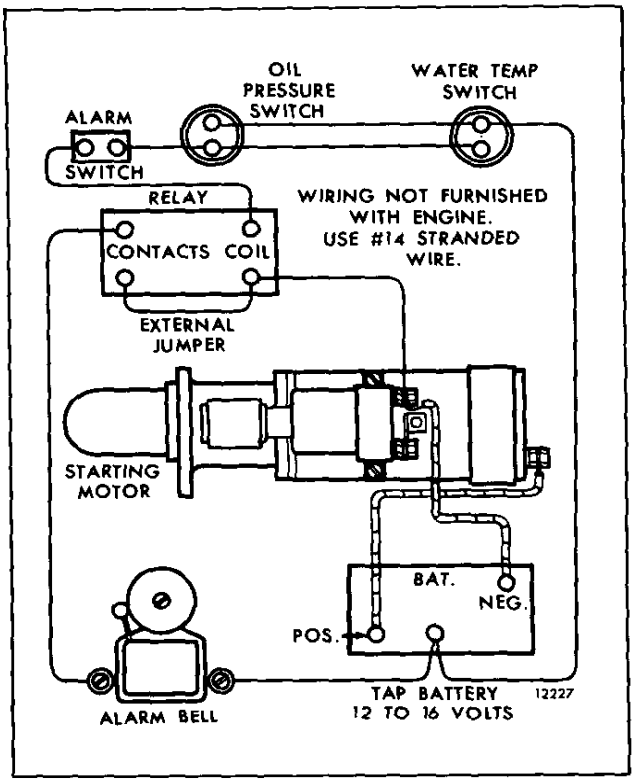


Fig. 1 - Alarm System Wiring Diagram

The alarm system is similar in many respects to the automatic shutdown system, but does not include the automatic shutdown feature incorporating the electrical solenoid or the flap valve in the air shutdown housing which is operated by the solenoid. A bell is substituted for the solenoid in the alarm system. The alarm may be substituted for the shutdown solenoid, or it may be added to the automatic shutdown system. In either case, the alarm notifies the operator of a dangerous condition in the engine.

The voltage used through the alarm bell, however, must not exceed 12 volts.

Note that the starting motor performs no essential function in the circuit.

An oil pressure switch, introduced into the engine oil gallery, is closed when the engine is not running, but opens after starting and remains open while the engine is running. This switch will close only in case of lowered oil pressure, thus causing the alarm to operate, or it will close if the engine is stopped by the operator. A water temperature switch, mounted in the water manifold, always remains open except in case of high water temperature when it closes and operates the alarm.

An automatic fuel oil switch closes after the engine is started and normal fuel oil pressure has been attained.

An optional overspeed switch is sometimes introduced into the system.

The water temperature switch and the oil pressure switch are similar to the same switches used in the automatic shutdown device.

Service of the alarm system is usually limited to replacement of the alarm bell.

© 1976 General Motors Corp.

OVERSPEED GOVERNORS

Certain engines are equipped with an electric overspeed governor or a hydraulic overspeed governor to prevent excessive engine speeds.

The governors are adjustable in the full-load engine speed range of 1200 to 2300 rpm.

The electric overspeed governors (Figs. 1,2,3,4 and 5) are mounted on the flywheel housing and are driven by the engine blower drive shaft, the cam shaft or balance shaft. The governors are connected electrically to a solenoid which actuates the shutdown mechanism on the air inlet housing or actuates a warning device.

The hydraulic overspeed governor (Fig. 6) is mounted in an adaptor which is mounted on the rear of the flywheel housing and is normally driven from the blower drive shaft. The shutdown mechanism on the air inlet housing is activated by an oil bellows (see Section 7.4.1).

ELECTRIC OVERSPEED GOVERNOR (Single Switch)

Series GWA and GYA Synchro-Start overspeed governors are calibrated by the manufacturer to open or close the switch contacts at the particular speed required. The switch contacts will reset automatically when the speed is reduced approximately 100 rpm below the trip speed.

The current overpseed single switch governor with the "Licon" switch (Fig. 1) is less sensitive to minor speed changes than the former "Micro" single switch governor (Fig. 2).

Service

Grease the governor shaft ball bearings every 10,000 hours (every 5,000 hours if the governor speed is above 2500 rpm) as follows:

1. Remove the adjusting screw and the adjusting stud; then, remove the governor cap.

2. Insert a sharp pointed instrument in the loop of the spring clip and pull the clip from the flexible shaft as far as possible. Then, remove the shaft assembly.

3. Remove the retaining ring from the groove in the housing.

4. Remove the weight and shaft assembly.

5. Inspect the oil seal and, if necessary, replace the seal as follows:

   a. Place the governor body in an arbor press with the mounting flange facing down and use a 9/16" diameter rod to press the oil seal out of the body.

   b. Press the new oil seal in place, 3/64" from the bottom of the bearing cacity.

6. Fill the grease reservoir between the bearings 3/4 full with Texaco "Unitemp" grease, or equivalent.

7. Reassemble the governor by reversing the procedure for disassembly and adjust the trip speed as outlined below.

Speed Adjustment

Loosen the cap adjusting lock screw and turn the cap until the desired trip speed is reached. Clockwise rotation of the cap lowers the trip speed, and counterclockwise rotation increases the trip speed. The total range of adjustment of the particular governor is indicated on the governor name plate. The governor should not be adjusted to trip below 100 rpm above the normal running speed of the engine. Make sure the governor cap locking screw is tightened after the adjustment has been completed.

NOTE: Under no circumstances should the governor switch be bypassed to prevent engine, shutdown in the event of overspeed, otherwise, serious damage to not only the engine, but also to the governor may be incurred since the governor is not designed to operate above its tripping speed.

© 1983 General Motors Corp.

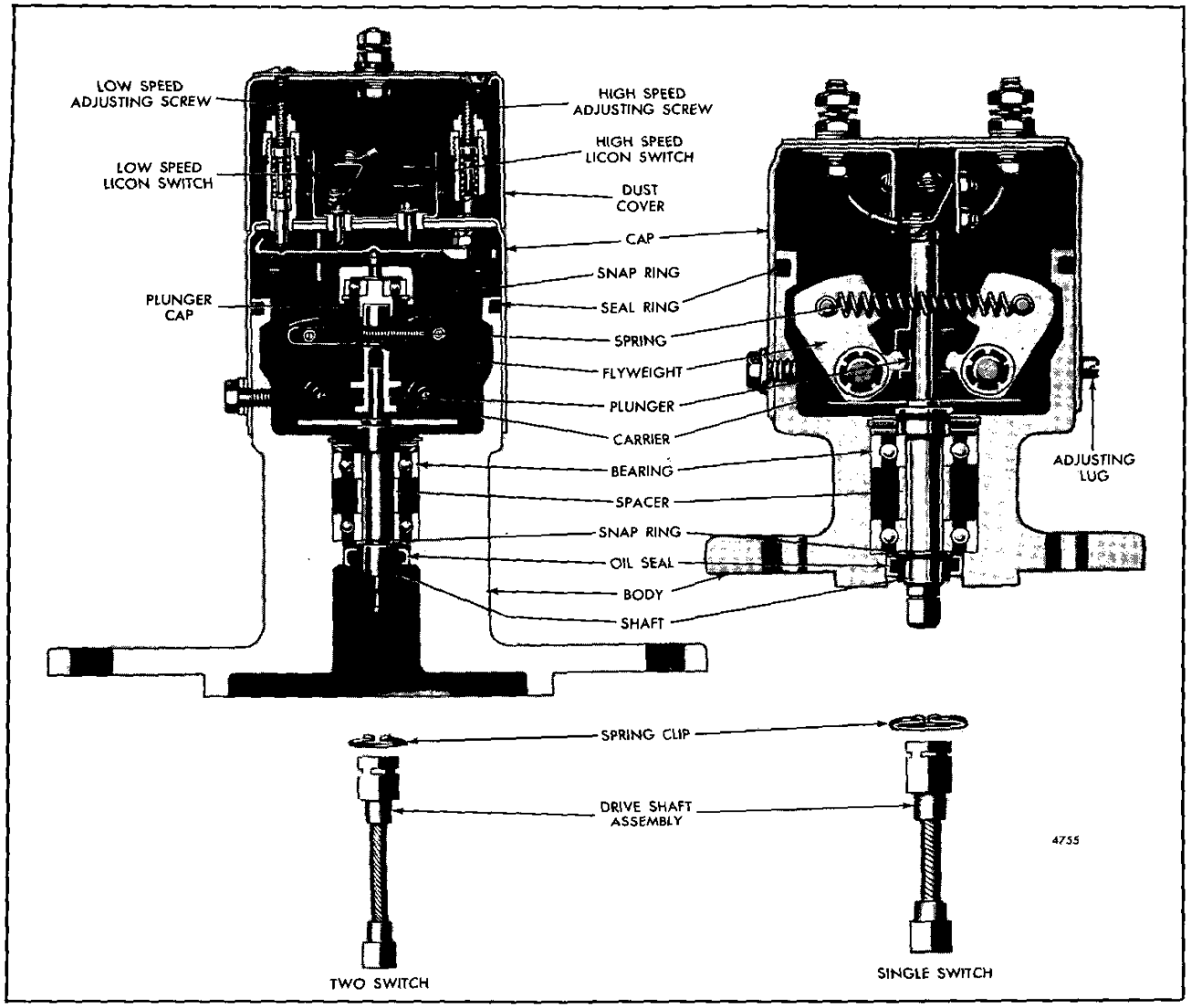


Fig. 1 - Electric Overspeed Governor (Licon Switch)

© 1983 General Motors Corp.

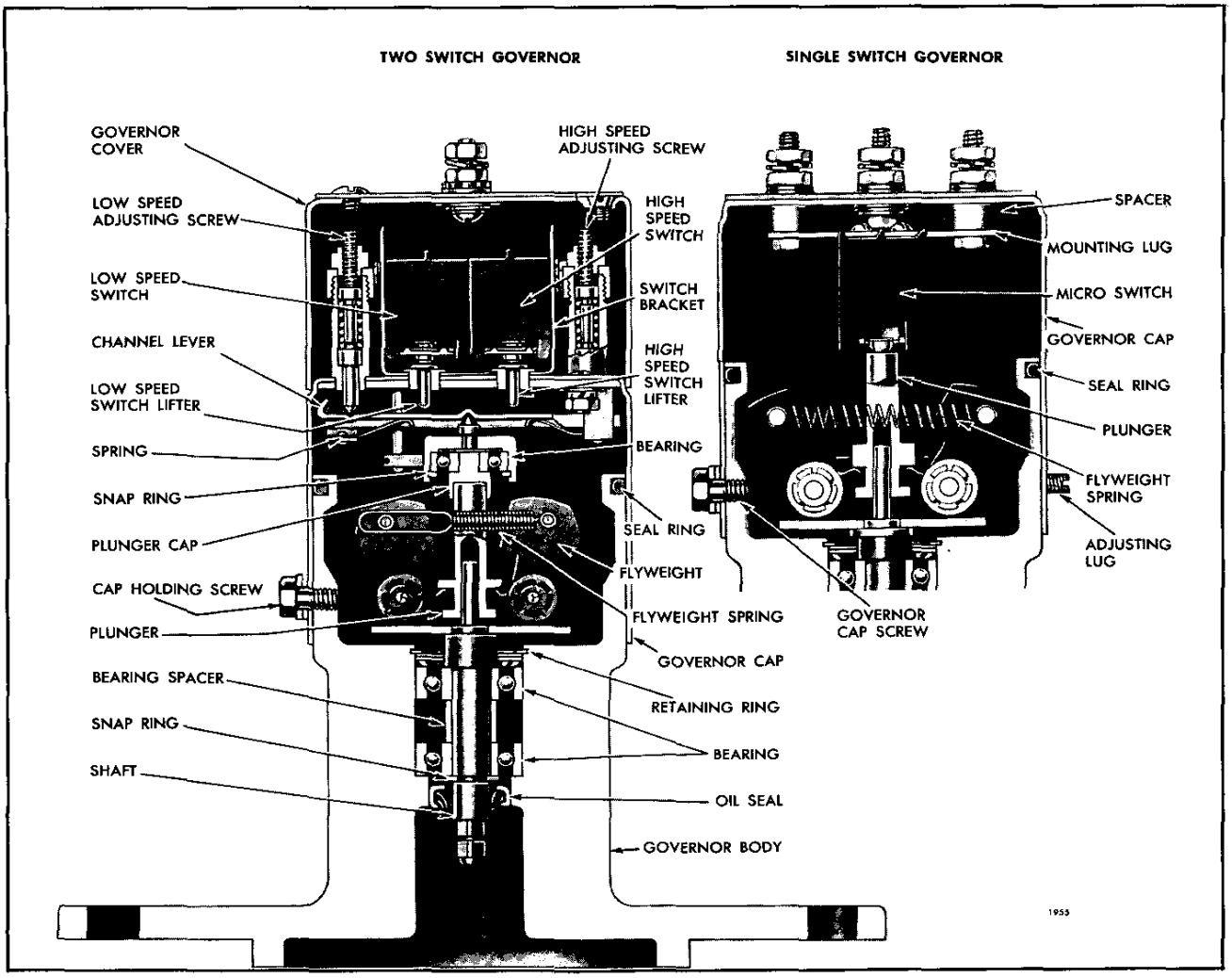


Fig. 2 - Electric Overspeed Governor (Micro Switch)

ELECTRIC OVERSPEED GOVERNOR (Two Switch)

Series GW-2 and GY-2 Synchro-Start overspeed governors contain two separate snap action switches wth single pole double throw contacts which operate at two different speeds. The governors are adjusted by the manufacturer to trip at the speeds required as indicated on the name plate. Unless otherwise specified, the name plate indicates trip points on increasing speed. Contacts will return to normal when speed is decreased approximatley 100 rpm below trip speed, except on the high speed switch of those models having a manual reset button. The letter "M" after any model number indicates the high speed switch must be reset manually.

The current overspeed two switch governor with the "Licon" switches (Fig. 1) is less sensitive to minor speed changes than the former "Micro" two switch governor (Fig. 2).

A series GW-2N syncro-start overspeed governor is used on the railcar engine (Fig. 3). It is the same as the other overspeed governors except that it has a six point connector and wire lead assembly attached to the governor cover, (see left-hand inset Fig. 2), for a quick disconnect. The service and speed adjustments of the GW-2N is the same as the GW-2 and GY-2 series governors.

© 1983 General Motors Corp.

Service

1. The snap action switches may be replaced as follows:

a. Mark the position of the dust cover.

b. Remove the hold down screws.

c. Observe the position of the switches. Usually they are positioned with 1/64" clearance between the switch button and the lifters. If the lifters are replaced, make certain that the long lifter is placed beneath the low speed switch and the short lifter is placed beneath the high speed switch.

d. Install the new switch and reassemble by reversing the above procedure.

NOTE: When replacing the dust cover on governors with manual reset, make certain that the switch wiring does not interfere with the reset mechanism.

e. Adjust the speed as outlined under "Speed Adjustment".

2. Remove the governor cap as follows:

a. Observe the marking on the cap and body.

b. Remove the three holding screws.

c. Remove the cap assembly being careful not to damage the seal ring.

d. Replace any internal parts as required.

e. Reassemble and return the cap to its original position. A light coat of grease will facilitate assembly of the seal ring to the body.

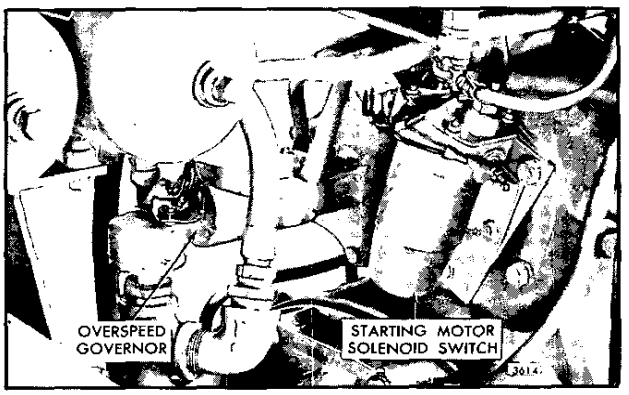


Fig. 3 - Overspeed Governor Mounting (Railcar)

NOTE: The position of the cap is very critical on governors in which the difference in trip points between the two switches is more than 1000 rpm and the trip point of the high speed switch is above 2100 rpm. These governors use elongated loop flyweight springs. If, after assembly, the No. 1 switch trips at a far higher point than normal, lower the cap position slightly. If the No. 2 switch trips at a very low speed, raise the cap position slightly. If difficulty arises, refer to Step 5 below.

f. Adjust the speed as outlined under "Speed Adjustment".

3. Replace the speed adjusting springs as follows:

a. Hold the speed adjusting stud with a 5/16" open end wrench and loosen the adjusting stud nut with a 3/8" open end wrench.

b. After the above nut is removed, the adjusting spring and related parts may be removed and replaced as necessary. Exercise care to prevent particles of dirt from accumulating on the parts.

4. Replace the flexible drive shaft as follows:

a. Insert a sharp pointed instrument in the loop of the spring clip, pull it from the shaft as far as possible and remove the shaft assembly.

b. Upon reassembly, first install the spring clip in the groove of the fitting on the end of the governor shaft.

c. Push the shaft assembly onto the square end of the governor shaft and the spring clip will snap in place.

NOTE: Check the position of the spring clip. If the clip has sprung out of position, use a small screwdriver to push it into place.

5. Adjusting governor cap (with dust cover in place):

a. Turn the low speed adjusting screw out for minimum speed adjustment. In this position, the top of the adjusting screw is approximately 1/8" from the top of the dust cover.

b. Turn the high speed adjusting screw in for almost maximum speed adjustment. In this position the top of the adjusting screw is approximately 5/16" from the top of the dust cover.

c. With partial tension on the cap holding screws, turn the governor cap to its maximum extended position.

© 1983 General Motors Corp.

d. Operate the governor at 200 rpm above the trip point of the low speed switch.

e. Rotate the cap slowly in a clockwise direction until the low speed switch trips, mark the cap position and stop the engine.

f. Turn the cap another 1/16" and lock the holding screws securely.

g. Complete the operation as outlined under "Speed Adjustment". Generally, the trip point of the low speed switch will have to be increased and the high speed switch decreased.

Grease the governor shaft ball bearings every 10,000 hours (every 5,000 hours if governor speed is above 2500 rpm) as follows:

1. Remove the governor cap.

2. Remove the flexible drive shaft.

3. Remove the retaining ring from the groove in the housing.

4. Remove the weight and shaft assembly.

5. Inspect the oil seal and, if necessary, replace it as follows:

a. Place the governor body in an arbor press with the mounting flange toward the bottom and use a 9/16" diameter rod to press out the oil seal.

b. Press a new oil seal in place 3/64" from the bottom of the bearing cavity.

6. Fill the grease reservoir between the bearings 3/4 full with Texaco "Unitemp" grease or equivalent.

7. Reassemble the governor by reversing the procedure for disassembly and adjust the trip speeds as outlined below.

Speed Adjustment

Both switches may be individually adjusted. Dust cover screw marked "1" covers the low speed adjuster; screw marked "2" covers the high speed adjuster. Proceed as follows:

1. Remove the appropriate dust cover screw.

2. Insert a 1/16" Allen wrench into the adjusting screw.

3. Turn the screw clockwise to increase the trip speed, or counterclockwise to decrease.

NOTE: If the adjusting screws are turned in too far, the switch will no longer operate. Do not attempt to use the slots in the cap for normal speed adjustments. This position is set and marked by the manufacturer for operating in the speed range required.

EARLY DESIGN ELECTRIC OVERSPEED GOVERNORS

Originally three governors were available for engines operating at 1200, 1600 or 1800 rpm full load, respectively. Later, one governor for all engines operating in the full-load speed range of 1200 to 2000 rpm was used (Fig. 4). These governors operate in a similar manner but include a slightly different switch arrangement.

The overspeed governor is activated by the square end of the governor weight shaft registering with a square opening in the blower drive shaft.

The governor shaft on which two flyweights are mounted is supported by a ball bearing and bushing both retained in a housing and secured in an adaptor by a set screw.

The finished radius on the flyweights bears against the thrust bearing located on the end of the governor drive shaft.

The micro-switch is connected electrically to the solenoid on the engine air inlet housing. On units equipped with automatic starting devices, another micro-switch (cut-out) is connected electrically to the starter solenoid.

Both switches are returned from contact points by the high speed spring.

Two screws and two locknuts secure each micro-switch to a bracket.

Operation

Motion transmitted by the centrifugal force of the revolving flyweights moves the switch guide toward the plunger. When contact is made, the electrical circuit to the shutdown solenoid closes, energizing the solenoid which operates the shutdown mechanism on the air inlet housing.

© 1983 General Motors Corp.

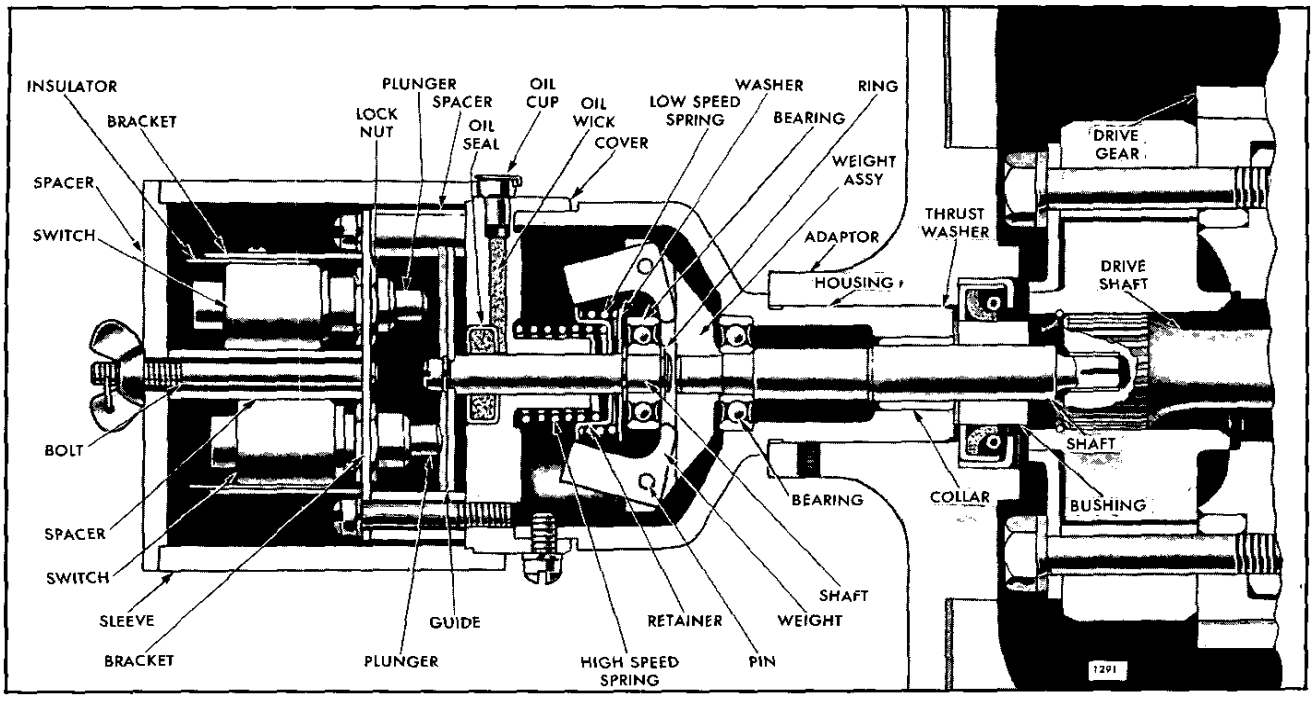


Fig. 4 - Overspeed Governor Assembly

Service

Since the overspeed governor bearings are of the prelubricated, sealed type, the governor requires very little maintenance. Maintenance consists of soaking the felt oil seal (Fig. 4) with a few drops of engine oil in the oil cup every 300 to 500 hours. The felts allow this oil to find its way onto the operating shaft and lubricate the shaft to body contact surfaces. This lubrication is sufficient, since the operating shaft does not rotate, but slides back and forth carrying the plate which actuates the switch.

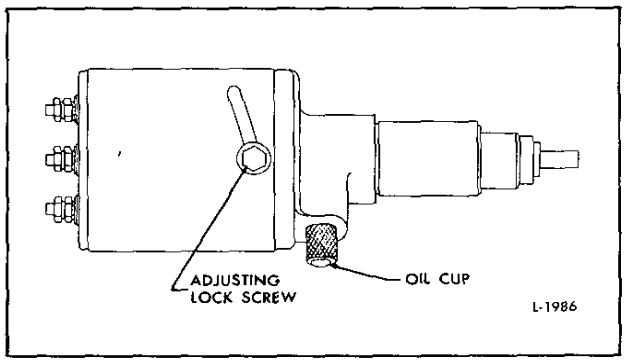


Fig. 5 - Model GSG Overspeed Governor

Adjustment

The overspeed governor should be set to operate the shutdown mechanism at approximately 10 to 15% over the maximum no-load speed as follows:

1. Cut the lock wire, remove the wing nut and then remove the spacer and sleeve.

2. Loosen the locknuts and the two screws.

3. Move the switch forward to lower the engine speed, or back to raise the engine speed.

4. Start the engine and test the setting by removing the engine governor cover and manually operating the governor fuel rod. Observe the speed at which the overspeed switch operates, shutting down the engine.

5. Tighten the locknuts and screws when the desired speed is attained.

6. Install the spacer and sleeve and secure with the wing nut and lock wire.

© 1983 General Motors Corp.

SYNCHRO-START MODEL GSG ELECTRIC OVERSPEED GOVERNOR

Description

Model GSG Synchro-Start overspeed governor is used on certain engine applications that operate in a speed range from 1800 to 2000 rpm at full load. This governor provides a simplified method of speed adjustment thus facilitating engine overspeed setting.

Operation

In operation, the engine drives a set of weights that are held together by a pair of governor springs. When the speed of the engine approaches the overspeed setting, centrifugal force of the weights overcomes the tension of the governor springs and the weights move outward, allowing the shoulder on the weights to move the plunger. As the speed continues to increase, the weights move further apart, moving the plunger closer to the micro-switch. This movement of the plunger continues until the governor trip setting is reached and the micro-switch trips, completing or breaking the electrical circuit.

Service

The governor should be lubricated every 100 hours with a few drops of engine oil in the oil cup.

Adjustment

The overspeed governor is adjusted by moving the micro-switch, which is attached to the cover of the governor, in relation to the plunger. This adjustment can be accomplished very readily by loosening the adjusting locking screw holding the governor cover (Fig. 5). Rotating the cover clockwise, when viewing the governor from the terminal end, will lower the overspeed setting, while rotating the cover counter-clockwise will increase the overspeed setting.

HYDRAULIC OVERSPEED GOVERNOR

The hydraulic overspeed governor which contains a set of spring loaded weights prevents excessive engine speeds.

Fig. 6 illustrates the old and new design hydraulic overspeed governors. The new governor differs from the old governor in the use of a new housing, cover and speed adjusting screw. The new housing is shorter and the new cover is longer than the old cover. The new adjusting screw differs from the former screw in the width of the seal ring groove which is wider on the new screw.

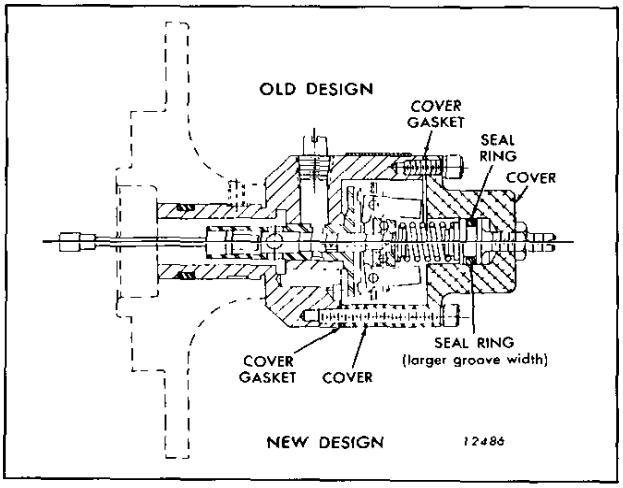


Fig. 6 - Hydraulic Overspeed Governor

The overspeed governor is mounted in an adaptor which is mounted on the rear of the flywheel housing. A seal ring in the adaptor end of the governor housing prevents oil seepage from the flywheel housing. The governor is driven by a flexible drive assembly from the blower drive shaft. Oil under pressure is supplied to the governor by a tube which is connected to the oil gallery in the cylinder block.

Operation

When the engine speed reaches the value for which the overspeed governor is set, the centrifugal force of the weights in the overspeed governor overcomes the spring tension and opens a pilot valve in the governor. The pilot valve dumps oil from the oil tube, lowering the pressure at the engine oil pressure switch, thus closing the switch and energizing the shutdown solenoid and closing the shutdown valve.

Lubrication

The overspeed governor is lubricated by oil from the engine crankcase.

Adjustment

The engine shutdown speed is determined by the position of the adjusting screw in the overspeed governor cover. To change the setting, loosen the locknut and turn the adjusting screw in to increase the speed, and out to decrease the speed. When the proper setting is obtained, tighten the adjusting screw locknut.

© 1983 General Motors Corp.

DIESEL RAILCAR CONTROL CABINET AND SHUTDOWN SYSTEM

A control cabinet assembly is mounted on each engine near the governor where it is accessible for starting and stopping the engine from the side of the car.

As illustrated in Fig. 1, the control cabinet proper houses the engine oil pressure switch, the start relay and switch, the automatic stop relay and the stop switch along with the necessary wiring harness. The engine start, stop and reset buttons are located on the control cabinet cover.

The engine water temperature switch is located on the water manifold and the transmission oil temperature switch is located at the side of the transmission. Both switches are connected electrically to the solenoid that closes a valve in the blower air inlet housing to shut off the air and stop the engine automatically when an abnormal operating condition exists, such as low oil pressure, high water temperature, high transmission oil temperature or if the engine overspeeds.

The engines can be started only from the engine control panel (Fig. 1) but can be stopped from either the engine control panel or at the regulator locker (refer to *Operating Instructions* in Section 13.1.4).

In Fig. 1, the cover on the control cabinet is shown open to expose the working parts of the engine control buttons and the various electrical components. The inset in Fig. 1 shows the engine start, stop and reset control buttons on the front face of the cover. The upper right-hand view shows the instrument panel assembly which include the engine oil pressure gage, the engine water temperature gage and the transmission (drive oil) pressure gage.

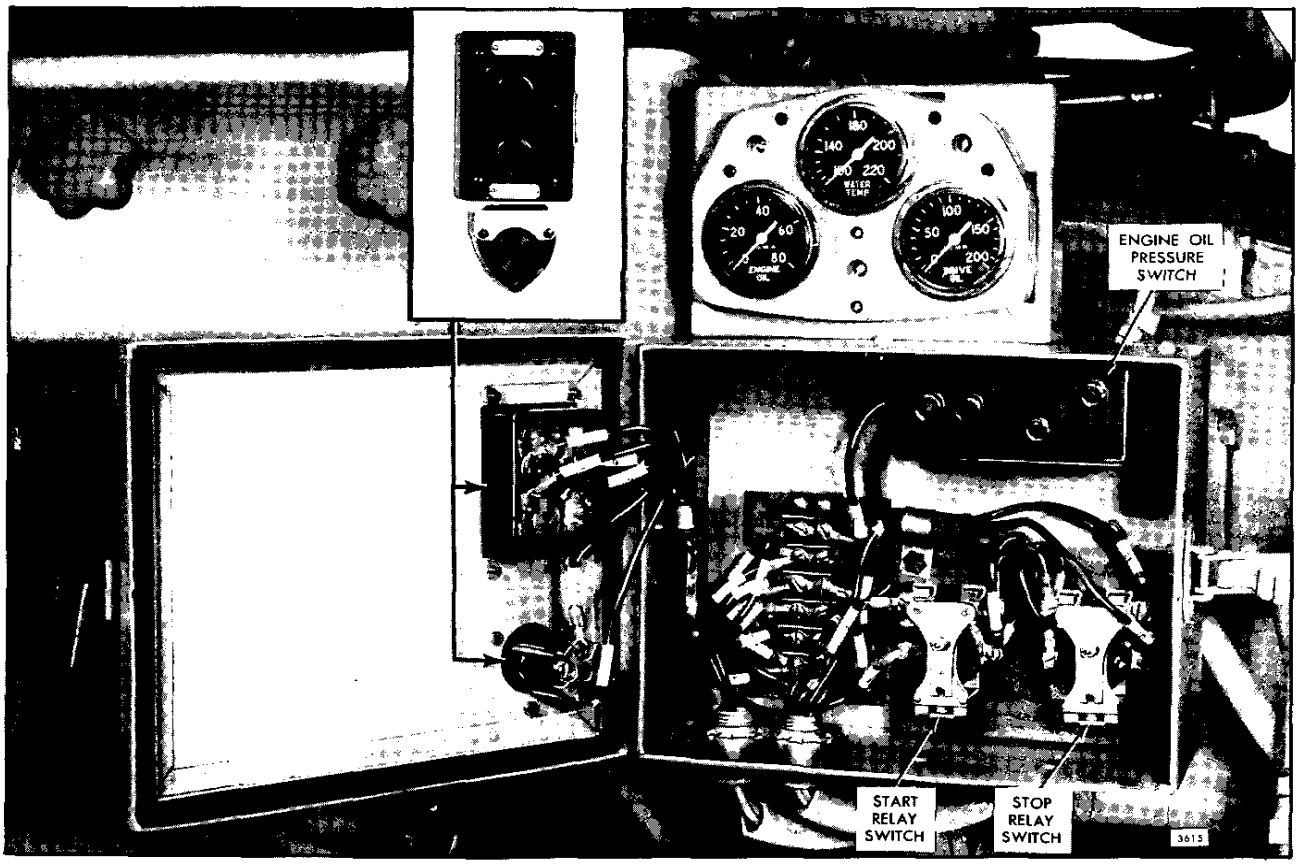


Fig. 1 - Control Cabinet Assembly

© 1984 General Motors Corp.

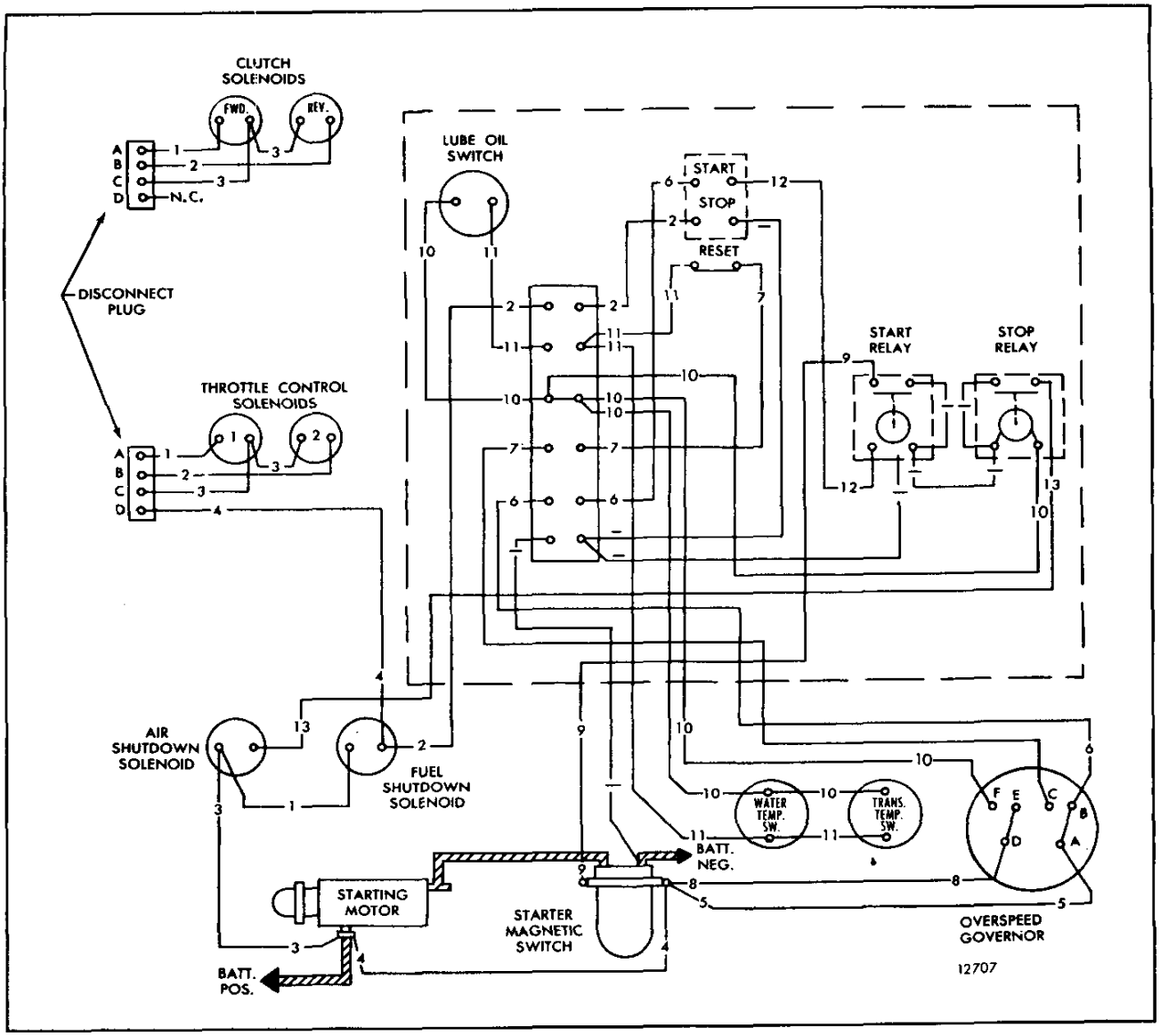


Fig. 2 - Engine and Transmission Wiring Diagram

Fig. 2 illustrates the engine and transmission wiring diagram. The wires, as numbered in this diagram, are the same wires as shown in the box.

A good practice, when making repairs on an electrical system, is to mark all the wires and terminals before disconnecting the wires to ensure that each wire will be replaced on its proper terminal.

Engine Shutdown System

The shutdown system on the diesel railcar is fully automatic. When the transmission oil temperature rises above a predetermined value, the engine coolant temperature rises above a predetermined value, the engine lubricating oil pressure drops below a predetermined value or the overspeed governor exceeds a predetermined value, the automatic air shutdown solenoid (Fig. 5) will operate to close the valve in the air inlet housing and stop the engine. After the engine has stopped, the air shutdown solenoid will automatically open the valve in the air inlet housing.

© 1984 General Motors Corp.

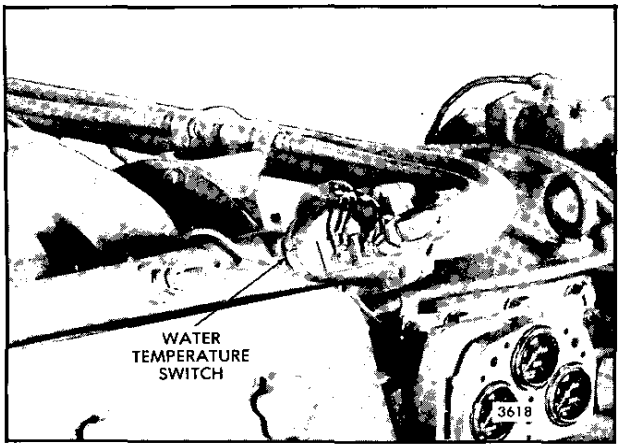


Fig. 3 - Engine High Water Temperature Switch Mounting

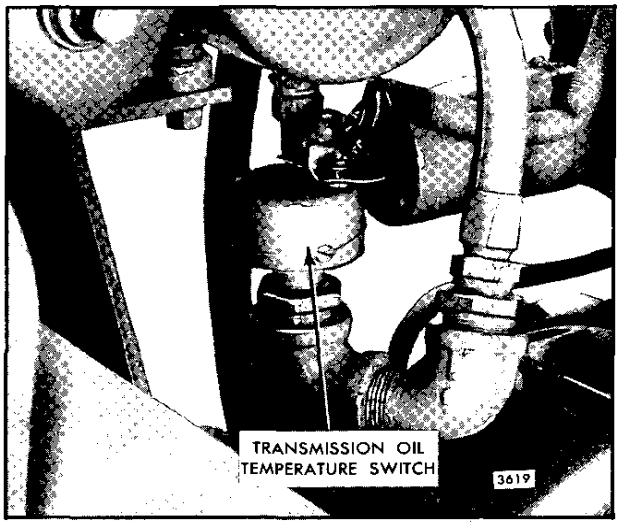


Fig. 4 - Transmission High Oil Temperature Switch Mounting

Engine Low Oil Pressure

An oil line is connected to the engine oil gallery and to the switch mounted inside the control cabinet (Fig. 1). The switch is connected electrically in series with the air shutdown relay and solenoid. When the engine oil pressure falls below the value 12 psi (83 kPa) at which the switch is set, the contact points in the switch close, energizing the air shutdown relay which, in turn, energizes the air shutdown solenoid to close the valve in the air inlet housing.

Engine High Water Temperature Switch

The engine high water temperature switch which is mounted at the rear end of the water manifold is connected electrically in series with the air shutdown relay and solenoid (Fig. 3). When the engine water temperature rises above a value (205° F or 96° C) at which the switch is set, the contact points in the switch close, energizing the air shutdown relay which, in turn, energizes the air shutdown solenoid to close the valve in the air inlet housing.

Transmission High Oil Temperature Switch

The transmission high oil temperature switch which is mounted in a "T" fitting at the side of the transmission is connected electrically in series with the air shutdown relay and solenoid (Fig. 4). When the transmission oil temperature rises above a value (265° F or 130° C) at which the switch is set, the contact points in the switch close, energizing the air shutdown relay which, in turn, energizes the air shutdown solenoid to close the valve in the air inlet housing.

When checking the transmission high oil temperature for accuracy or setting the high oil temperature switch, the switch should be removed from the transmission and the stem of the switch inserted in a pan of oil heated to 265-270° F (130-132° C). After checking for accuracy or setting the switch, the switch may be reinstalled in the transmission. If it is found the switch is faulty, replace it.

NOTE: If the transmission high oil temperature switch is being checked or adjusted with the switch still installed in the transmission, *do not* permit the transmission oil temperature to

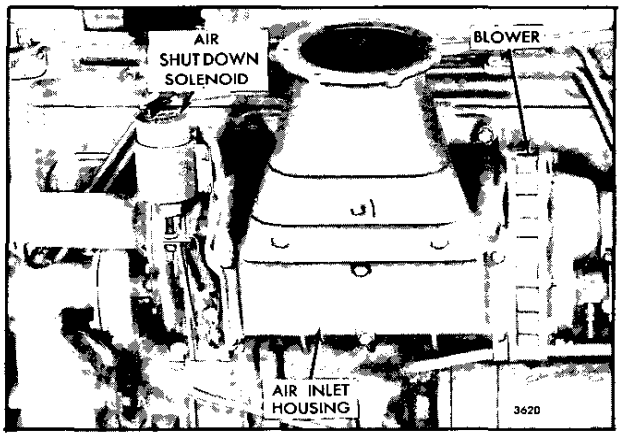


Fig. 5 - Air Shutdown Solenoid Mounting

© 1984 General Motors Corp.

exceed 265° F (130° C) or damage to the converter seals may occur.

When checking the temperature switches, the temperature of the oil or water should be increased very slowly in order to obtain a proper check.

Adjustments

The three switches are set at the factory and should need no further adjustment. If a switch is changed, however, adjustment may be necessary. For switch adjustment procedures, refer to Section 7.0. Refer to Section 7.4.3 for the overspeed governor adjustment.

© 1984 General Motors Corp.

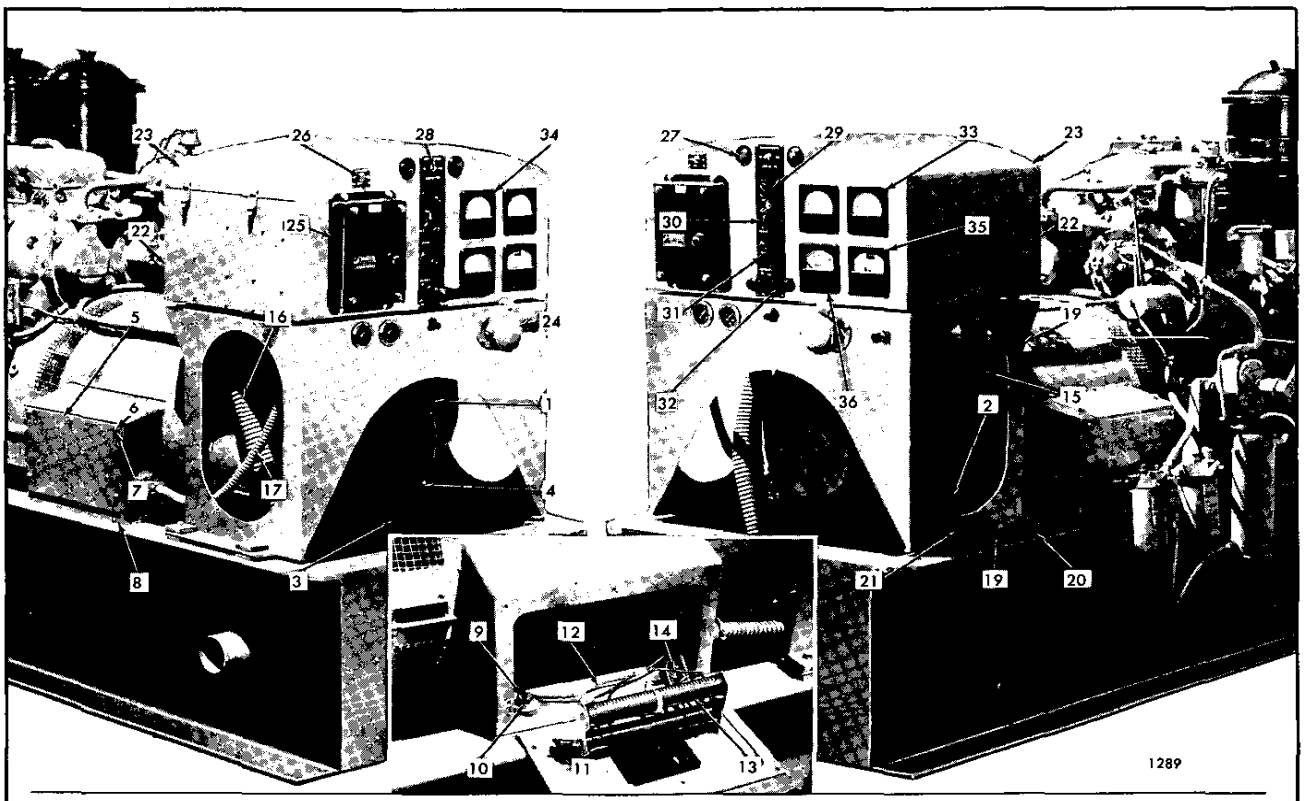
POWER GENERATOR AND CONTROLS

Detailed information on the maintenance and repair of power generators, control cabinets and component assemblies such as voltage regulators can be found in the service manuals and bulletins issued by the equipment manufacturers.

In many instances, repairs and overhaul work on electrical equipment may be referred to an authorized repair station of the manufacturer of the equipment.

Replacement parts for electrical equipment should be ordered through the equipment manufacturers outlets since these parts are not normally stocked by Detroit Diesel Allison.

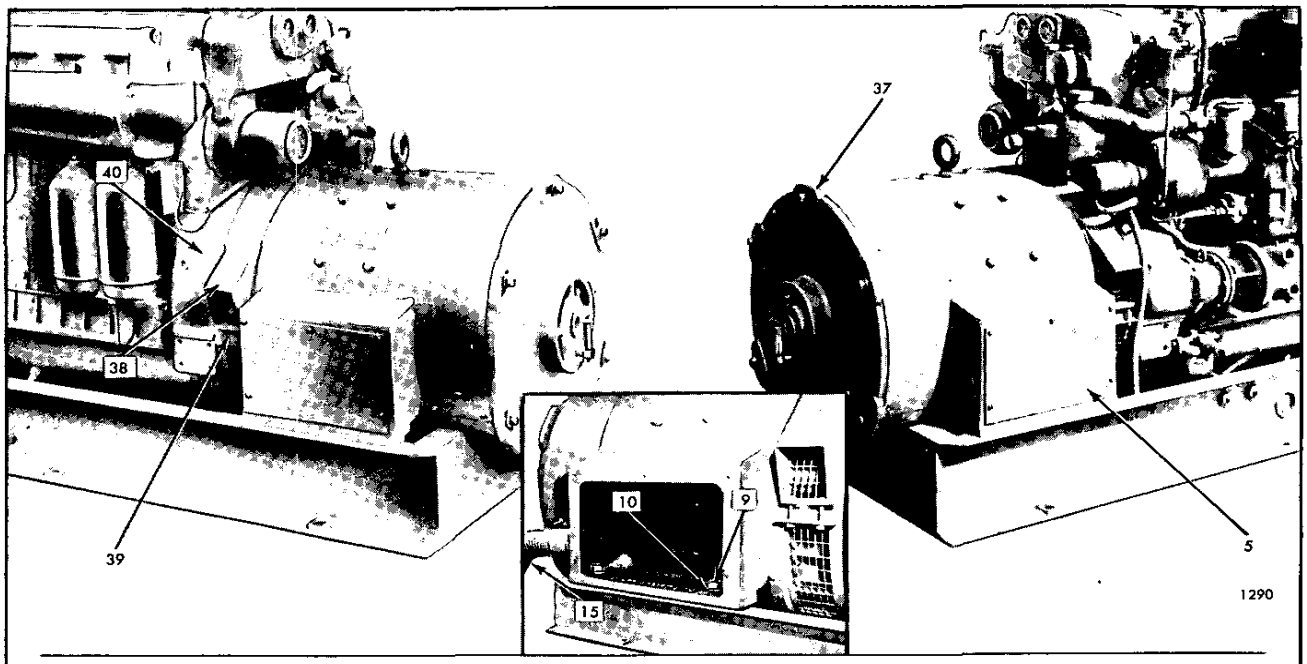
For service information regarding Delco Products equipment, direct all requests to the Service Department, Delco Products Division, General Motors Corporation, Dayton, Ohio 45401.



1. Cover--End Frame (Solid)
2. Cover--End Frame (Open)
3. Bolt--Cover Mounting
4. Lock Washer
5. Plate--Cover
6. Screw--Cover Plate
7. Lock Washer
8. Spacer
9. Bolt--Generator Mounting
10. Lock Washer
11. Resistor--Exciter Field Discharge
12. Wire--Exciter Field Lead
13. Resistor--Cross Current Compensating
14. Wire--Cross Current Compensating
15. Conduit--Power Lead
16. Conduit--Power Lead
17. Conduit--Exciter Lead
18. Base--Engine Mounting
19. Base--Control Cabinet Mounting
20. Spacer
21. Bolt
22. Cabinet--Control
23. Cover--Control Cabinet
24. Vernier Throttle Control
25. Regulator--Voltage
26. Switch--Voltage Regulator
27. Lamp--Synchronizing
28. Switch--Synchronizing Lamp
29. Switch--Field
30. Switch--Field Rheostat
31. Switch--Phase Selector
32. Switch--Circuit Breaker
33. Ammeter
34. Voltmeter
35. Frequency Meter
36. Kilowatt Meter

Fig. 1 - Typical Alternating Current Generator Mounting

© 1973 General Motors Corp.



5. Plate--Cover
9. Bolt--Generator Mounting
10. Lock Washer
15. Conduit--Power Lead
37. Frame--End
38. Cover--Generator Top (Fan End)
39. Cover--Generator Bottom (Fan End)
40. Housing--Flywheel

Fig. 2 - Typical Direct Current Generator Mounting

Remove Power Generator From Engine

If required, remove the power generator (Figs. 1 and 2) from the engine as follows:

1. If the generator bearing is lubricated by oil, remove the drain plug from the end frame or the bottom of the sight gage and drain the oil.

2. Remove the terminal box cover plate and remove all of the external power leads.

CAUTION: Tag each power lead before disconnecting to ensure correct connections when the generator is reinstalled.

3. If the unit is equipped with a control cabinet, disconnect all of the generator-to-control cabinet power leads at the cabinet. Also disconnect all engine instruments, throttle control linkage, electrical wiring harness or engine shutdown mechanism at the control cabinet.

CAUTION: Tag all electrical leads before disconnecting to ensure correct connections when the unit is reassembled.

4. Remove the control cabinet from the engine base.

5. Loosen the front engine-to-base mounting bolts. Also loosen the upper hose clamps at the radiator to prevent hose distortion when the flywheel end of the engine is raised.

6. Remove the generator foot-to-engine base mounting bolts and spacers (if used).

7. Attach a chain hoist to the generator eyebolt or lifting ears and raise the generator just enough to allow it to clear the engine base.

8. Place a suitable support under the flywheel housing to support the rear end of the engine before the generator is detached.

9. Remove the generator fan cover retaining bolts and remove the covers.

10. Remove the generator driving disc-to-engine flywheel mounting bolts.

11. With the chain hoist drawn taut, remove the generator frame flange-to-engine flywheel housing mounting bolts.

12. Apply pry bars at opposite sides of the generator to loosen it from the engine flywheel housing.

© 1973 General Motors Corp.

NOTE: The tenon on the generator frame flange pilots inside of the engine flywheel housing; therefore, the generator must be withdrawn straight back from the engine.

Install Power Generator on Engine

Before installing the generator, the front engine-to-base mounting bolts must be loose and the flywheel end of the engine must be raised and suitably supported.

1. Use a chain hoist to swing the generator in place square against the engine flywheel housing so the pilot of the generator frame enters the flywheel housing.

NOTE: The generator driving disc pilots inside of the engine flywheel with a close tolerance. The driving disc must set flat against the flywheel face when in place, otherwise the generator will be subjected to excessive vibration when placed in service.

2. Align the bolt holes in the generator driving disc with the mating holes in the engine flywheel. Then install the disc retaining bolts and tighten them.

3. Install the generator frame-to-engine flywheel housing bolts and tighten them.

4. Install the generator fan covers.

5. Install the generator foot-to-engine base mounting bolts and spacers (if used). Tighten the bolts.

6. Tighten the front engine-to-base mounting bolts.

7. Position the upper radiator hose and tighten the clamps.

8. Install the control cabinet.

9. Reconnect all power leads.

10. Install the generator terminal box cover plate.

11. Install the oil drain plug and fill the generator bearing oil reservoir, with the same grade of oil as specified for the engine, to the line on the sight gage. Do not overfill.

12. Reinstall and connect all other equipment which was removed during disassembly.

Balance Engine

If proper care is taken in attaching the generator to the engine, the unit should operate smoothly. However, if the unit runs rough (excessive vibration), it must be balanced as follows:

1. Loosen the generator driving disc-to-engine flywheel bolts approximately four turns.

2. Start the engine and run it at a speed not exceeding 600 rpm for approximately one minute. At this speed, the generator armature will tend to center itself with respect to the center line of the engine crankshaft.

3. Stop the engine and tighten the generator driving disc retaining bolts uniformly.

4. Normally, the above procedure will bring the unit into balance for smooth operation. However, if excessive vibration still exists, it may be corrected as follows:

a. Remove the generator driving disc retaining bolts and rotate the engine flywheel 180 °.

b. Install the driving disc bolts finger tight.

c. Repeat Steps 2 and 3 above.

© 1973 General Motors Corp.

AIR HEATER

The air heater is essentially a small pressure oil burner with electric ignition. It provides a means of pre-heating the in-going charge of air to the cylinders sufficiently to insure the engine will start in extremely low ambient temperatures, provided the lubricating oil in the engine is of the recommended viscosity.

The heater unit (Fig. 1), containing the nozzle, filter, ignition coil and ignition points, is mounted on the cylinder block, replacing one of the hand hole covers as illustrated in Figs. 1 and 2.

A hand operated pressure pump and a fuel supply valve are usually mounted on the instrument panel.

The pump draws fuel from the fuel strainer and delivers it under pressure to the burner unit where the charge is filtered before reaching the spray nozzle. The pump plunger, when not in use, is held in the IN position by a spring and ball mechanism and may be released merely by pulling the plunger out.

A pressure switch is located in the fuel line between the pump and the nozzle so that the pressure, created when actuating the pump plunger, will automatically close the contacts in the switch, completing the electrical circuit through the coil and causing a spark across the electrodes at the spray nozzle. Thus, when fuel is injected from the nozzle, the electric spark is present for ignition.

Operation

When starting an engine in cold weather, follow the *Air Heater Instructions* given on the plate attached to the instrument panel and repeated below for convenience of the operator.

Air Heater Instructions

1. Open the air heater valve.

2. With the engine throttle wide open, press the starting motor switch.

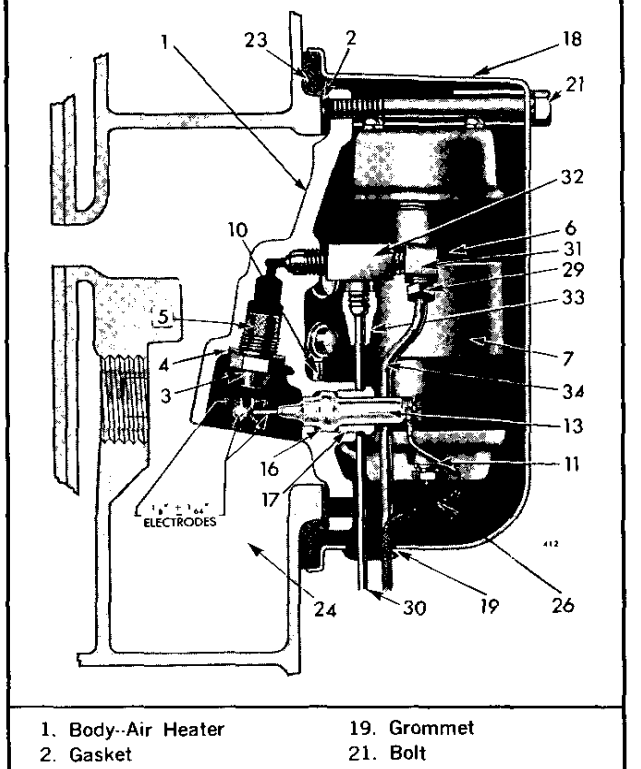
3. Operate the pump with smooth, even strokes, applying a firm pressure of 10 pounds or more on each pumping stroke.

4. With the engine running, regulate the throttle and push the plunger in all the way until the lock engages.

5. Close the air heater valve.

CAUTION: The air heater should be used for cold weather starting only.

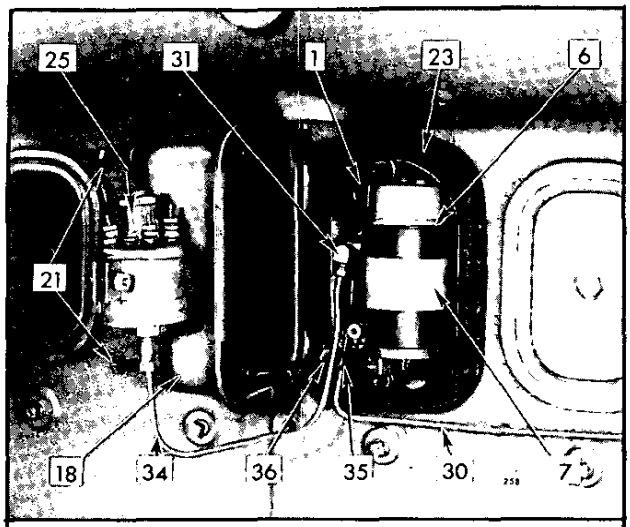
The engine usually starts firing during the first or second pumping stroke. At low temperatures, with heavy lubricating oil, the engine may fire for a time with the combined help of the starter and the heater before developing sufficient power to run unassisted. Under these conditions, it is advisable to pause briefly at the end of each pumping stroke to allow the engine time to absorb the heat generated. Also, at a temperature of 10 °F. or lower, it will be beneficial to



1. Body--Air Heater
2. Gasket
3. Nozzle--Spray
4. Washer--Spray Nozzle
5. Filter--Spray Nozzle
6. Coil--Air Heater
7. Bracket--Coil
10. Lead--Coil Ground
11. Lead--High Tension
13. Insulator
16. Gasket--Insulator
17. Nut--Insulator
18. Cover--Air Heater
19. Grommet
21. Bolt
23. Gasket--Cover
24. Air Box--Cylinder Block
26. Wire--Switch to Heater
29. Connector--Fuel Tube
30. Fuel Tube--Pump to Heater
31. Elbow
32. Two-Way Tee
33. Nut--Fuel Tube
34. Fuel Tube--Heater to Switch

Fig. 1 - Air Heater Assembly

© 1973 General Motors Corp.



1. Body--Air Heater
6. Coil--Air Heater
7. Bracket--Coil
18. Cover--Air Heater
21. Bolt
23. Gasket--Cover
25. Switch--Pressure
30. Fuel Tube--Pump to Heater
31. Elbow
34. Fuel Tube--Heater to Switch
35. Clip
36. Bolt--Clip

Fig. 2 - Air Heater Mounting

use the heater for a short time after the engine has started.

Dependable starting of a diesel engine by any means can be obtained only with adequate cranking speed. The lubricating oil used in cold weather must meet the specifications shown in Section 13.3.

If current is supplied from batteries, they must be kept in good condition. Air box drains must be open to prevent fuel from accumulating in the air box.

Check Air Heater Operation

If an engine fails to start after two or three heater pump stokes, it is advisable to stop cranking and check for possible causes of failure. Assuming that the engine is in running order and cranking speed is 80 rpm or over, the heater should be checked for failure of ignition or poor oil spray. Remove the heater from the cylinder block and reconnect it outside of the engine in such a position that the heater operation can be readily observed.

Remove Air Heater

Refer to Figs. 1, 2 and 4 and remove the air heater as follows:

1. Disconnect and tag wires (27), (28) and (26) from terminals 2, 4 and 3 respectively of the air heater pressure switch and loosen connector (29) at the pressure switch end of tube (34).

2. Remove the bolts (21) and lock washers and swing the air heater cover (18) and pressure switch (25) away from the cover gasket (felt) as shown in Fig. 2. Unscrew the pressure switch fuel tube connector (29) from the elbow (31) and disconnect the wire (26) from the coil (6). Slide the wire (26) from the grommet (19) and lift the air heater cover and pressure switch away from the engine.

3. Remove the bolt (36) and lock washer which secure the fuel tube clip (35) to the air heater body (1). Unscrew the fuel tube nut (33) freeing the tube (30) from the two-way tee (32).

4. Remove the felt gasket (23) from the heater body (1) and remove the bolt securing the air heater body to the cylinder block and lift the body away from the cylinder block.

Check Heater Unit

With the air heater removed from the cylinder block, two separate checks may be made to determine the reason for unsatisfactory operation of the heater: (1) to see if the coil is in good condition, as indicated by a continuous hot spark at the electrodes when the circuit is closed; (2) to see if the fuel being discharged at the spray nozzle is properly atomized.

CAUTION: These two checks must NOT be made at the same time.

To check the coil, refer to Fig. 4 and connect wire (28) direct from the battery to the No. 4 terminal of the pressure switch (25), coil wire (26) to the No. 3 terminal and wire (27) to the No. 2 terminal. Also connect coil wire (11) to electrode (13), if removed (Fig. 1).

Short across terminals No. 3 and No. 4 and across terminals No. 1 and No. 2 of the pressure switch (25), then if:

a. The coil interrupter does not vibrate when the switch is closed, check the coil points for dirt or carbon and the wiring for loose or broken connections. Points may be cleaned with fine sandpaper or a special point file and should be reset after cleaning to give .018 " gap with the

© 1973 General Motors Corp.

armature or vibrator arm held against the coil body.

b. The spark jumps across the porcelain of the electrode, check the gap and, if necessary, reset the wire electrode to approximately 1/8 ". If the gap is correct, then remove the porcelain electrode by removing the threaded gland and withdrawing the electrode assembly. Care should be taken that the small copper gasket (16) under the electrode is not dropped out and lost. The porcelain may be cleaned by washing it in fuel oil and scraping or sanding off any carbon accumulation.

To check the spray nozzle, disconnect wire (28) at terminal No. 4 of the pressure switch (25). Reconnect the fuel tubes (30) and (34) to the two-way tee (32) and elbow (31) respectively and tighten all connectors.

Then, with the air heater pump connected to the fuel supply, operate the pump and observe the spray pattern at the nozzle. If the spray nozzle is partially or completely plugged, indicated by failure of the nozzle to "fog" or "atomize" the fuel, or by excessive resistance to pump operation, it should be removed, cleaned and assembled as outlined below.

Remove Spray Nozzle from Heater Body (Air Heater Removed from Cylinder Block)

With the air heater removed from the cylinder block, refer to Figs. 1 and 3 and remove the spray nozzle and associated parts in the following manner:

1. Disconnect the high tension lead (11) from the electrode (13).

2. Disconnect the fuel tubes (30) and (34) from the two-way tee (32) and the elbow (31).

3. Unscrew the fuel tube elbow (31) and two-way tee (32) from the air heater body (1).

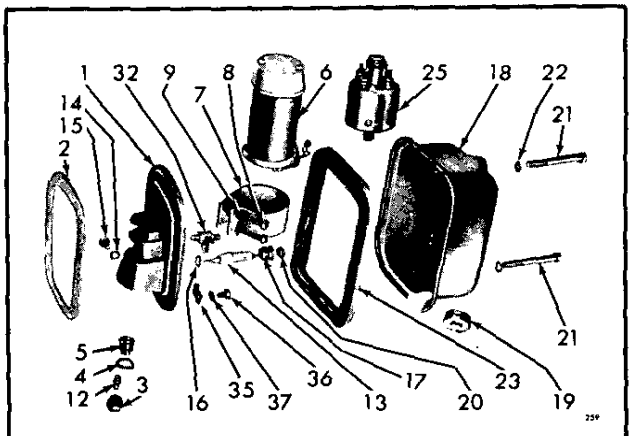
4. Remove the resistor from the coil, if so equipped.

5. Remove the two screws (8) and lock washers which secure the coil bracket (7) to the heater body and remove the bracket and coil (6) from the body.

6. Loosen the insulator nut (17) and remove the insulator (13) from the heater body carefully so as not to lose the small insulator gasket (16).

7. Remove the electrode (15) and lock washer from the heater body.

8. Remove the spray nozzle (3) from the heater body with a thin walled 5/8 " socket wrench. Unscrew the



1. Body--Air Heater	16. Gasket--Insulator
2. Gasket	17. Nut--Insulator
3. Nozzle--Spray	18. Cover--Air Heater
4. Washer--Spray Nozzle	19. Grommet
5. Filter--Spray Nozzle	20. Nut--Electrode
6. Coil--Air Heater	21. Bolt
7. Bracket--Coil	22. Lock Washer
8. Screw--Coil Bracket	23. Gasket--Cover
9. Lock Washer	25. Switch--Pressure
12. Swirl Pin--Spray Nozzle	32. Two-Way Tee
13. Insulator	35. Clip
14. Lock Washer	36. Bolt--Clip
15. Electrode	37. Lock Washer

Fig. 3 - Air Heater Details and Relative Location of Parts

filter (5) from the spray nozzle. Remove the spray nozzle washer (4) from the cavity in the heater body.

9. Remove the swirl pin (12) from the spray nozzle with a screw driver.

10. Wash all of the parts in clean fuel oil and dry them with compressed air.

NOTE: Do not use steel wire or a drill to clean the nozzle. The size and shape of the grooves and orifices are very important and any damage will render the nozzle useless.

Assemble Air Heater

Refer to Figs. 1 and 3 for the relative location of parts and assemble the heater unit as follows:

1. Thread the swirl pin (12) in the spray nozzle (3) and place the washer (4) over the threaded end and against the shoulder of the nozzle.

2. Thread the filter (5) in the spray nozzle. Then screw

© 1973 General Motors Corp.

the nozzle (3), with the swirl pin, filter and washer in place, into the heater body. Tighten the nozzle in place with a 5/8 " thin-walled socket wrench.

3. Install the electrode screw (15) with lock washer in the heater body.

4. Place the insulator gasket (16) on the lower shoulder of the electrode (13) and secure the electrode in place in the heater body with a nut (17), tightening the nut firmly but carefully so as not to crack the insulator.

5. Position the air heater coil (6) and bracket (7) in place on the heater body and secure them with two screws (8) and lock washers.

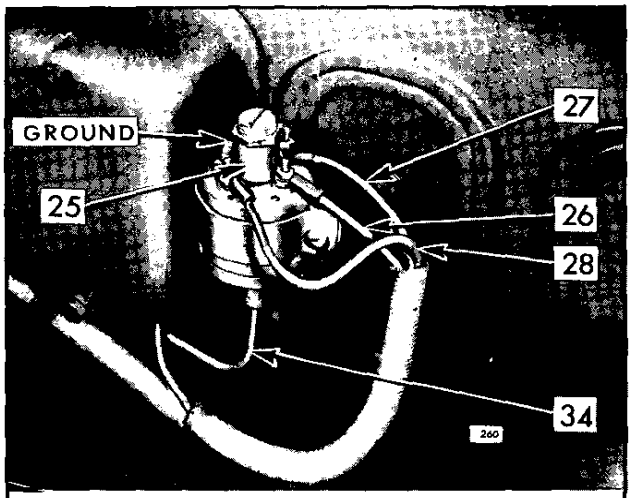
6. If used, connect the resistor to the ground at the coil.

NOTE: A 24 volt system requires a 3 ohm resistor and a 32 volt system requires a 5 ohm resistor.

7. Connect the high tension lead (11) to the electrode (13).

8. Install the two-way tee (32) and elbow (31) in place as shown in Fig. 1.

9. Set the electrode gap at 1/8 " (Fig. 1). Bend the electrode (15) ONLY when setting the gap.



25. Switch--Pressure
26. Wire--Switch to Heater
27. Wire--Starting Motor to Heater Switch
28. Wire--Starter Switch to Heater
34. Fuel Tube--Heater to Switch

Fig. 4 - Air Heater Pressure Switch Mounting

Install Air Heater

1. Place a new cork gasket (2) (dry) on the inner face of the heater body (1) so that it will be next to the cylinder block when the heater is assembled to the block (Fig. 1).

2. Attach the air heater to the cylinder block with a bolt and gasket and tighten the bolt firmly, but not too tight.

3. Place a felt gasket (23) around the outer edge of the heater body as shown in Fig. 2.

4. Connect the fuel tube (30) securely on the two-way tee (32).

5. Attach a fuel line clip (35) to the heater body with a bolt (36) and lock washer.

6. Connect the fuel tube (34) securely to the elbow (31) and in the proper position to meet the pressure switch inlet connector (Fig. 2).

7. Clamp the pressure switch, if removed, in position on the side of the heater cover (18), install the grommet (19), if removed, in the slot at the bottom of the cover, insert the wire (26) through the grommet and connect one end of the wire to the coil (6) and the other end to the No. 3 terminal of the pressure switch.

8. Attach the air heater cover and pressure switch assembly to the cylinder block with two bolts (21) and lock washers.

9. Connect the fuel tube (34) to the pressure switch (25).

10. Connect the wires (27) and (28) to terminals No. 2 and No. 4 respectively of the air heater pressure switch (25).

11. Check all of the electrical connections.

AIR HEATER PRESSURE SWITCH

An air heater pressure switch (Fig. 4) is introduced into the fuel line between the air heater pump and the spray nozzle. Pressure created when actuating the air heater pump not only atomizes the fuel from the spray nozzle into the air box but closes the contacts in the pressure switch, thus completing the electrical circuit through the coil and causing a spark across the electrodes at the spray nozzle and igniting the fuel.

A fuel tube (34) and elbow (31) connect the pressure switch to a two-way tee at the air heater body as shown in Fig. 2. Terminal 1 is grounded internally to the pressure switch case. Wires (27), (26) and (28),

© 1973 General Motors Corp.

attached to terminals No. 2, 3 and 4 respectively, tie the switch into the electrical system.

If it should become necessary to remove and replace a pressure switch, the operation may be performed as follows:

1. Tag and remove wires (27), (26) and (28) from terminals No. 2, 3 and 4 of the pressure switch.

2. Disconnect the fuel tube (34) from the pressure switch (25).

3. Loosen the clamp bolt and slide the pressure switch (25) from the clamp.

4. Install the pressure switch by reversing the above steps, making sure the wires are connected to the correct terminals of the pressure switch.

AIR HEATER PUMP

The air heater pump supplies fuel under pressure to the air heater. The principal parts of the pump are the body, the plunger and the fuel inlet and outlet valves.

The body is smooth-bored internally. One end is threaded externally for mounting purposes; the other end has two tapped openings. Special check valve assemblies are screwed into the tapped openings, one of which--the inlet opening--is at right angles to the body bore. The outlet opening is at the extreme end of the body in line with the bore.

Since the valve assemblies have the same outward appearance of standard fittings, each valve is stamped with an identifying mark on one of the flats of the hex. The inlet valve bears the mark "1/2" and the outlet valve is stamped "30".

The plunger has a short, externally threaded section at the operating knob end. Two seal rings are located in grooves at the opposite end. These seal rings, which are made of an oil resistant composition material, contact the inside of the body bore to make an air-tight seal between the plunger and the body.

Operation

The pump is manually operated by means of the knob (Fig. 5). When the knob is pulled outward (away from the panel), fuel is drawn into the body through the inlet valve, which is connected by tubing to the primary filter. On this stroke, a check valve in the outlet valve, which seats under suction, closes the outlet opening. On the forward stroke (toward the panel), the action is reversed: fuel is forced from the body through the outlet check valve which opens under pressure and the inlet opening is sealed by the inlet valve which seats under pressure.

Failure of the pressure pump can occur from two causes: (1) check valves and, (2) plunger seal rings.

1. The suction and discharge check valve assemblies are threaded into the pump body. An arrow indicating the direction of flow is stamped on each valve. The suction check valve (1/2 lb. valve) is marked "1/2" and the outlet valve is marked "30". The check valves are of the spring-loaded ball type and the parts cannot be disassembled without being damaged. The valves can be cleaned, if necessary, by forcing fuel oil through them with any suitable pump. Replace inoperative valves by new valves.

2. The seal rings are made from a special oil resistant composition and if they should break or become worn, they must be replaced. When any pump parts need replacing, the pump may be removed from the instrument or control panel, disassembled and reassembled as outlined below.

Remove Air Heater Pump

Remove the air heater pump from the instrument panel as follows:

1. Tag and disconnect the fuel tubes from the pump inlet and outlet valves.

2. Unscrew the plunger nut from the pump body and withdraw the pump plunger assembly from the pump body.

3. Loosen the pump body jam nut behind the instrument panel.

4. Remove the pump body assembly from the rear of the panel.

5. Remove the jam nut from the pump body.

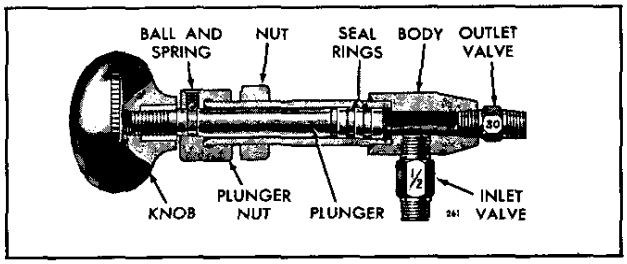


Fig. 5 - Air Heater Pump Assembly

© 1973 General Motors Corp.

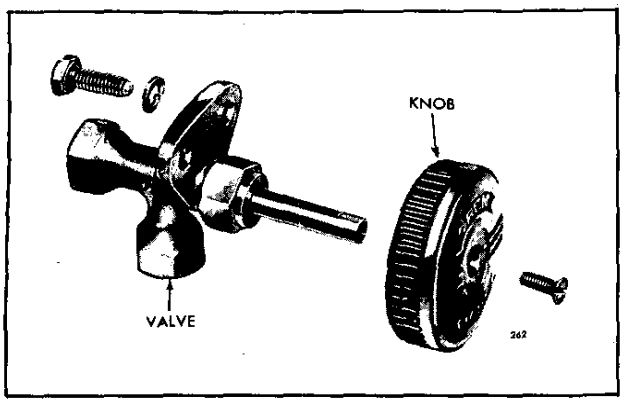


Fig. 6 - Air Heater Pump Valve Details and Relative Location of Parts

Inspection

After removing and thoroughly cleaning in fuel oil, examine the seal rings carefully for breaks, cracks or evidence of wear. If necessary, replace the seal rings.

Disassemble Pump

Note that when the air heater pump was removed from the instrument panel, the plunger assembly was removed from the pump body. Further disassembly of the pump may be carried out as follows:

1. Unscrew the knob from the plunger assembly.

2. Slide the plunger nut off the end of the plunger.

3. The steel balls and springs may be removed through the bore of the plunger nut by tapping the nut to dislodge them. The plugs need not be disturbed.

4. Clamp the pump body between the soft jaws of a bench vise and remove the inlet and outlet valves.

Assemble Pump

Refer to Fig. 5 for the relative location of parts and assemble the air heater pump as follows:

1. If the lock balls and springs were removed from the plunger nut, place the lock springs into the holes on the inside of the plunger nut with a pair of small-nose pliers. Then place the steel lock balls into the holes, on top of the springs.

2. Use a small screw driver or similar tool and depress the lock balls and slide the plunger nut--hex end first--over the external-threaded end of the plunger.

3. Screw the knob on the plunger.

4. Install the outlet valve in the pump body.

NOTE: This valve is marked "30" and the arrow, also stamped on the valve, should point away from the pump body when assembled.

5. Install the inlet valve in the side opening of the pump body with the arrow on the valve directed towards the pump body.

NOTE: This check valve is marked "1/2" and the arrow, also stamped on the valve, should point toward the pump body when assembled.

Install Air Heater Pump

The air heater pump may be installed on the instrument panel by reversing the sequence of operations for removal while referring to Fig. 5.

1. Screw the body jam nut on the outer end of the pump body.

2. Insert the threaded end of the pump body through the hole in the instrument panel, from the rear of the panel.

3. Install new seal rings on the plunger, lubricate the rings and slide the plunger assembly into the pump body, being careful not to damage the seal rings. Screw the plunger nut on the end of the pump body and tighten the nut.

4. Attach the fuel tubes to the inlet and outlet valves.

5. Check for leaks.

AIR HEATER PUMP VALVE

The air heater pump valve shown in Fig. 6 is provided for turning on and off the fuel oil when the air heater pump is used. A dial at the valve shows the OPEN and CLOSED positions. Before using the air heater, turn the valve to the OPEN position, and when the air heater pump is no longer required, turn the valve to the CLOSED position.

Remove Air Heater Pump Valve

1. Refer to Fig. 6 and remove the valve knob by backing out the screw and pulling the knob from the shaft.

2. Remove the two fuel tubes from the valve at the rear of the instrument panel.

© 1973 General Motors Corp.

3. Remove the bolts and lock washers and lift the pump valve out from the back of the panel.

Install Air Heater Pump Valve

1. Insert the valve shaft through the hole in the panel face, from rear side of the panel, with the mounting holes of the valve in alignment with the holes of the mounting bracket, which is welded to the rear face of the panel.

2. Secure the valve in place with two bolts and lock washers.

3. Reconnect the two fuel tubes to the valve at the rear of the instrument panel.

4. Install the valve knob and fasten it in place with the retaining screw.

© 1973 General Motors Corp.

SHOP NOTES - TROUBLE SHOOTING

SPECIFICATIONS - SERVICE TOOLS

SHOP NOTES

MOUNTING BATTERY-CHARGING GENERATOR REGULATORS

When a direct current battery-charging generator regulator is remotely mounted rather than mounted on the engine, it should be mounted on a vertical surface which is as free from vibration as possible. It is preferable that the terminals be pointed downward, although this is not absolutely necessary.

It is recommended that shock absorbing mountings be used. On marine installations, where the vessel is subject to shock from docking, the regulator should be mounted in the vertical position with the long axis of the regulator athwart ship.

By adhering to these recommendations, proper operation and long life of the regulator will be assured.

PARALLEL OPERATION OF BATTERY-CHARGING GENERATORS

When battery-charging generators are hooked up for parallel operation, with the generators charging a common battery, regulators designed for parallel operation must be used. Otherwise, the regulators are likely to burn out.

When parallel operation of generators is desired, contact the local United Delco Service outlet to determine the correct regulator to be used with the generators in the installation.

TESTING THE NORMALLY OPEN SHUTDOWN SYSTEM FOR THE PROPER OPERATION OF SWITCHES

Most industrial power units are equipped with an engine protective system (Fig. 1). This protective system is activated whenever low lubricating oil pressure, high coolant temperature, engine overspeed or any other abnormal condition develops that could damage the engine.

In a properly maintained installation, the protective system seldom has cause to function. Therefore, it is advisable to check the system periodically to be sure that it will function when needed. A check of the system can be made by servicing personnel using a reliable 0-100 psi (0-689 kPa) range pressure gage, a tachometer, a steel-jacketed thermometer, two jumper wires and a sheet of cardboard large enough to cover the radiator of the unit.

The following test procedure has been designed so that each component of the protective system can be checked individually. It is important that the engine be thoroughly warmed up before any component of the protective system is checked.

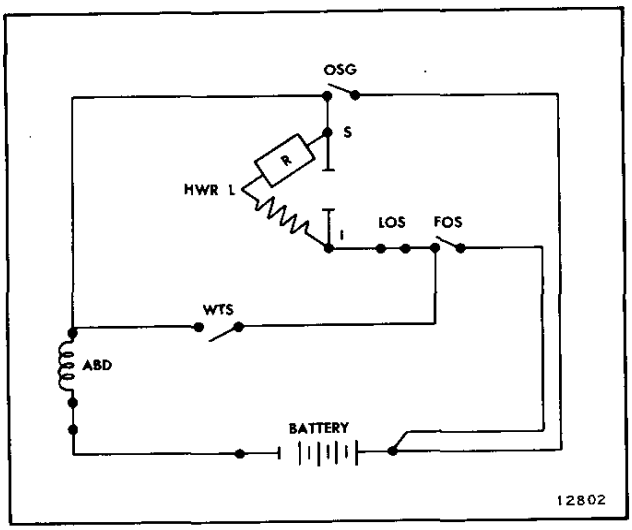


Fig. 1 - Schematic Shutdown System

© 1980 General Motors Corp.

Overspeed Governor

1. Remove the valve rocker cover.

2. Start the engine and move the speed control lever to the full-speed position.

3. While watching a tachometer, manually move the control tube slowly towards the increased fuel position until the air shut-off valve closes, stopping the engine.

NOTE: Do not exceed the engine no-load operating speed by more than 10%.

4. Note the speed at which the engine stops and adjust the overspeed governor, if necessary, as outlined in Section 7.4.3.

5. Replace the valve rocker cover.

Water Temperature Switch

1. Cover the radiator with a sheet of cardboard to prevent any circulation of air.

2. Remove the radiator cap, if the engine is operating near sea level, and insert a steel-jacketed thermometer.

NOTE: The boiling point of water lowers approximately 2°for each 1000 foot (304.8 m) rise in altitude. As an example, water boils at approximately 203°F (95°C) at 5000 feet (1524 m) and at 195°F (90.5°C) at 9000 feet (2743.2 m) altitude. It is necessary to retain the radiator pressure cap on engines which operate in excess of 1000 feet (304.8 m) altitude to prevent the boiling of coolant while performing this test. The engine temperature gage, if it is found to be accurate, may be used when performing this test.

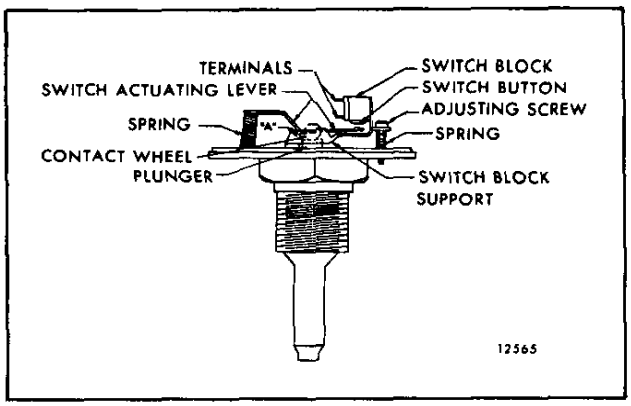


Fig. 2 - Water Temperature Switch (Former)

IMPORTANT: Do not exceed 210°F (99°C) when performing this test.

3. Start the engine and operate at rated speed and under enough load to raise the water temperature gradually until the air shut-off valve closes. The shutdown switch will usually be set at 205 °F (96°C) ±5°.

4. Note the temperature at which the air shut-off valve closed.

5. Remove the radiator cover and start the engine without load immediately after the engine stops. This will permit the engine to cool down to normal operating temperature.

6. The current water temperature switch cannot be adjusted. Adjust the setting of the former water temperature switch, if necessary, as follows:

a. Remove the two screws which hold the cover on the switch body and remove the cover.

b. Turn the adjusting screw clockwise to lower the temperature at which the switch closes and counterclockwise to increase the temperature at which the switch closes (Fig. 2).

c. Check the new setting by connecting two flashlight batteries and bulb in series across the terminals of the switch. While connected in this manner, insert the stem of the switch in a container of water and heat the water. Insert a thermometer, which reads up to 210°F (99°C) or higher, in the container and note the temperature of the water when the switch closes and the lamp lights. Further adjustment may be necessary until the switch closes at a temperature of 205°F (96°C) ±5°.

d. Care should be exercised when adjusting this switch since the switch block support may easily be bent, thus affecting the closing temperature setting.

Fuel Oil Pressure Switch

1. Insert a pressure gage on the discharge side of the secondary fuel filter.

2. Remove one of the leads from the lubricating oil pressure switch while this test is being performed to prevent the engine from being shut down by the low lubricating oil pressure switch.

3. Start the engine and operate at idle speed.

© 1980 General Motors Corp.

4. Slow the engine down by moving the speed control lever or the governor stop lever towards the no-fuel position until the fuel pressure is approximately 15 psi or 103 kPa (engine barely turning over).

5. Place a jumper wire across the water temperature switch.

6. Raise the engine speed slowly and watch the fuel oil pressure gage until the air shut-off valve closes.

7. Note the fuel pressure at which the air shut-off valve closed and adjust the fuel switch, if necessary, as follows:

a. With the aid of a small screw driver, remove the brass cap which is located in the center of the switch cover. Care should be exercised so as not to damage the brass cap or its gasket.

b. Loosen the 3/16" lock nut which locks the adjusting screw (Fig. 3). .

c. With the lock nut backed off, turn the adjusting screw clockwise to decrease the pressure at which the switch will make contact. Turn the adjusting screw counterclockwise to increase the pressure at which the switch will make contact.

8. Remove the jumper wire from the water temperature switch and reconnect the lubricating oil pressure switch.

Lubricating Oil Pressure Switch

1. Start the engine and operate at idle speed.

2. Place a jumper wire on the hot wire relay between the "1" and "S" terminals.

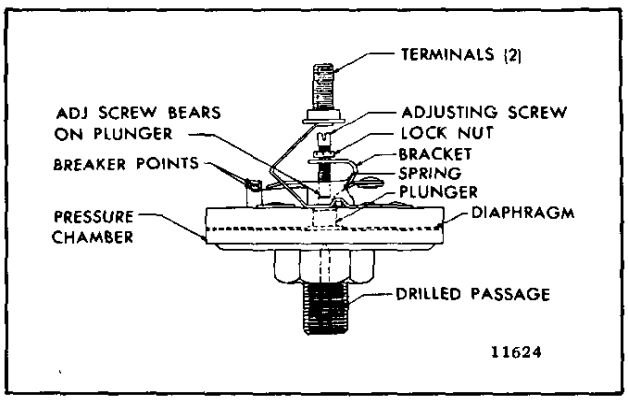


Fig. 3 - Fuel Oil Pressure Switch

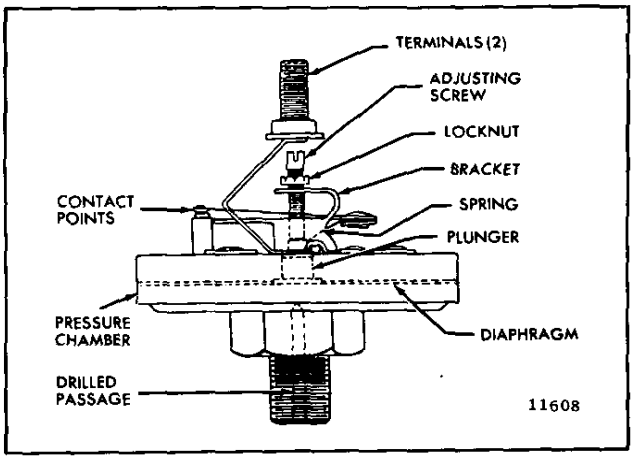


Fig. 4 - Lubricating Oil Pressure Switch

3. Place a jumper wire across the fuel oil pressure switch terminals.

4. Slow the engine down by moving the speed control lever or the governor stop lever towards the no-fuel position while watching the lubricating oil pressure gage.

5. Note the pressure at which the oil pressure switch stops the engine and adjust, if necessary, as follows:

a. As described above, remove the brass cap from the switch cover and loosen the lock nut.

b. Turn the adjusting screw clockwise to decrease the pressure at which the switch will break contact and counterclockwise to increase the pressure at which the switch will break contact (Fig. 4).

6. Remove the jumper wire from the hot wire relay.

Solid State Time Delay Switch

A bench test procedure for the solid state time delay switch is as follows:

1. Remove the time delay switch (Fig. 5) from the engine.

2. Install the jumper straps on terminals "A" to "B" and "E" to "F".

3. Install a positive battery lead to terminal "A".

4. Install a negative battery lead to one side of a 12 volt light.

5. Install a lead from the opposite side of the light to

© 1976 General Motors Corp.

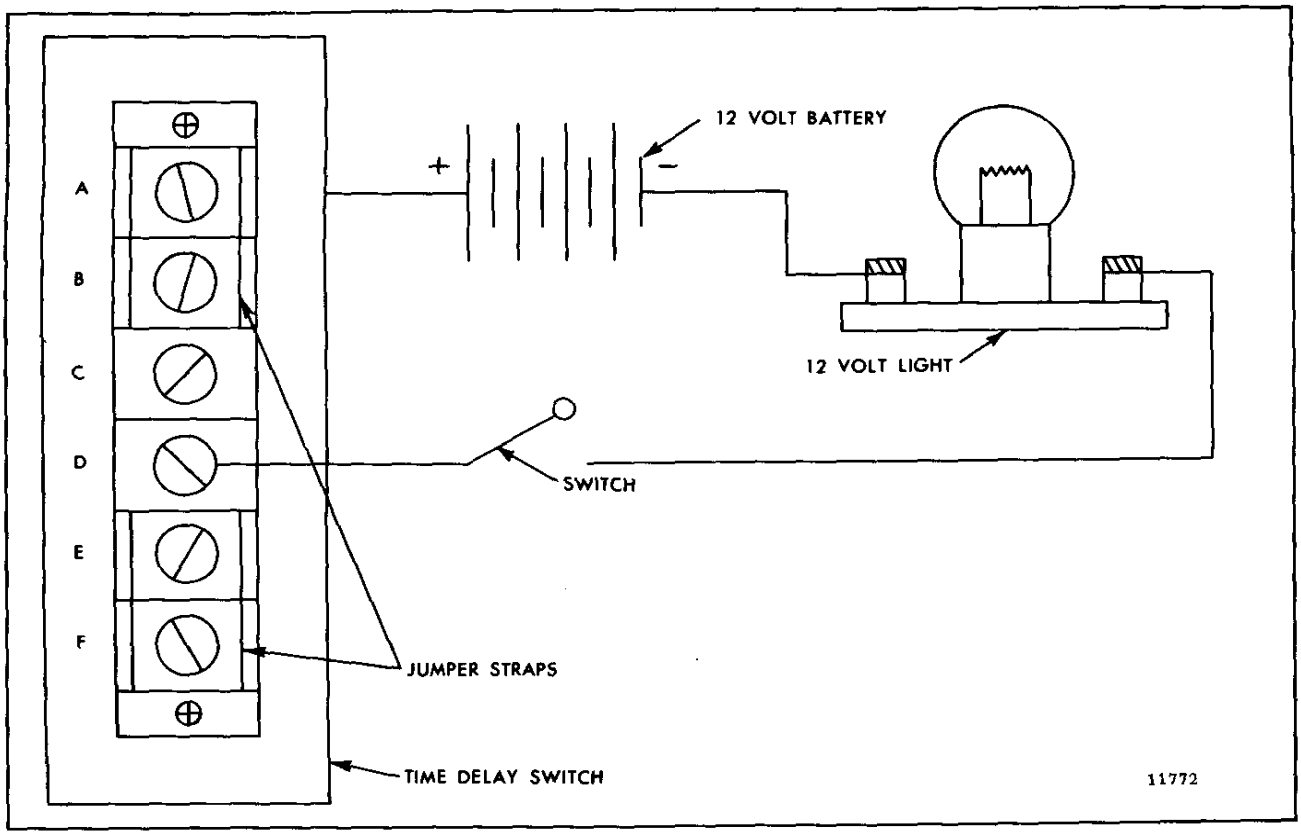


Fig. 5 - Time Delay Switch Testing Diagram

terminal "D". A switch may be used in this lead, if desired.

6. After the negative lead is connected to terminal "D" or the switch is closed, the lamp should light in 8 to 10 seconds. If not, the time delay switch must be replaced.

Hot Wire Relay

1. Start the engine and operate at idle speed.

2. Place the jumper wire across the terminals of the lubricating oil pressure switch while watching a second hand of a clock.

3. Not more than three to ten seconds for the hot wire relay or eight to ten seconds for the time delay switch should elapse between the time the jumper wire is placed across the terminals of the lubricating oil pressure switch and the air shut-off valve closes.

The above procedures completely test the normally open electrical engine protective system.

IMPORTANT: When the engine is operating at idle speed or above, the air shut-off valve will completely close off the air from the engine causing it to stop. However, when the engine is operating at the very low speeds that are necessary when performing the test on the fuel shutdown switch and the lubricating oil shutdown switch, the air shutdown solenoid will close the valve, but the engine may continue to run very slowly. This may be due to insufficient force exerted on the back of the valve by the low air flow needed to completely close the air shut-off valve.

NOTE: The 12 volt, 7-8 ampere (120 watt) generators do not generate sufficient current to operate the shutdown solenoid. Either replace the generator with one of greater capacity output or use a light duty battery.

Engine Water Temperature Switch (Railcar Engine)

The water temperature switch used on the railcar

© 1976 General Motors Corp.

engine is the same as the switch shown in Fig. 2. The switch adjustment procedure is outlined under *Water Temperature Switch* on Page 1.

Transmission Oil Temperature Switch (Railcar Engine)

The transmission oil temperature switch used on the railcar engine is the same as the switch shown in Fig. 2. The switch adjustment procedure is the same as the water temperature switch except the setting, which is 265-270 °F (130-132 °C).

Engine Low Oil Pressure Switch (Railcar Engine)

1. Start the engine and operate it at idle speed.

2. Remove the valve rocker cover.

3. Slow the engine down by moving the injector control tube toward the no-fuel position while watching the lubricating oil pressure gage.

4. Note the pressure at which the oil pressure switch stops the engine and adjust, if necessary, as follows:

   a. Remove the button plug from the opening in the top right-hand end of the control cabinet.

   b. Insert a screw driver through the opening and turn the adjusting screw clockwise to increase the pressure and counterclockwise to decrease the pressure at which the switch will open.

5. Repeat Steps 1 through 4 as often as necessary to correctly set the lubricating oil pressure switch.

6. With the switch properly set, replace the button plug and the valve rocker cover.

MOUNTING THE STARTER AUXILIARY MAGNETIC SWITCH

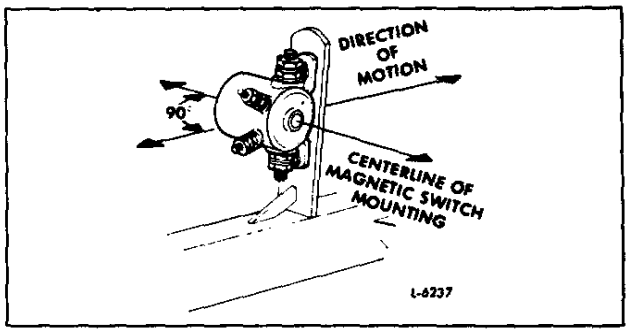


Fig. 6 - Starter Auxiliary Magnetic Switch Mounting

On certain railcar and highway units equipped with Detroit Diesel engines and Delco-Remy starter auxiliary magnetic switches, no-start conditions may result from damage to the starter auxiliary magnetic switch caused by vibration. The vibration may result from improper mounting of the auxiliary magnetic switch.

The following guidelines should be followed when mounting a Delco-Remy starter auxiliary magnetic switch (Fig. 6):

1. Do not mount the switch on the engine.

2. Position the mounting pads of the switch vertically (one above the other).

3. Mount the switch on a rigid bracket, base rail or fire wall.

4. Mount the switch on a surface perpendicular (90°) to the forward motion of the vehicle so that contact disc movement is not in line with gravity or vehicle movement.

© 1984 General Motors Corp.

RESISTOR REPLACES BATTERY IN ELECTRICAL SHUTDOWN SYSTEM

Whenever it is desirable to equip an engine with an electrical shutdown system of the normally-open circuit type that employs an air, inertia or hydraulic starting system, a resistor must be placed between the battery terminal and the positive ground terminal, as shown in Fig. 7, to prevent abnormal generator brush wear.

During operation of the generator, it is important that a current flow exist between the commutator bars and the brushes, which acts as a lubricant preventing excessive brush wear. When the unit is operated without the battery, excessive wear will occur to the brushes due to sliding friction resulting from loss of current flow. This can be eliminated by inserting a resistance to take the place of the battery to reestablish this current flow.

This resistance must be of sufficient size and capacity to withstand the current flow and to dissipate the heat generated.

Three electrical resistors (Table 1) are available, depending upon the system voltage.

System Voltage	Ohms	Watts
12	3	135
24	6	186
32	8	220

TABLE 1

It is suggested that the resistor be wired as shown in Fig. 7.

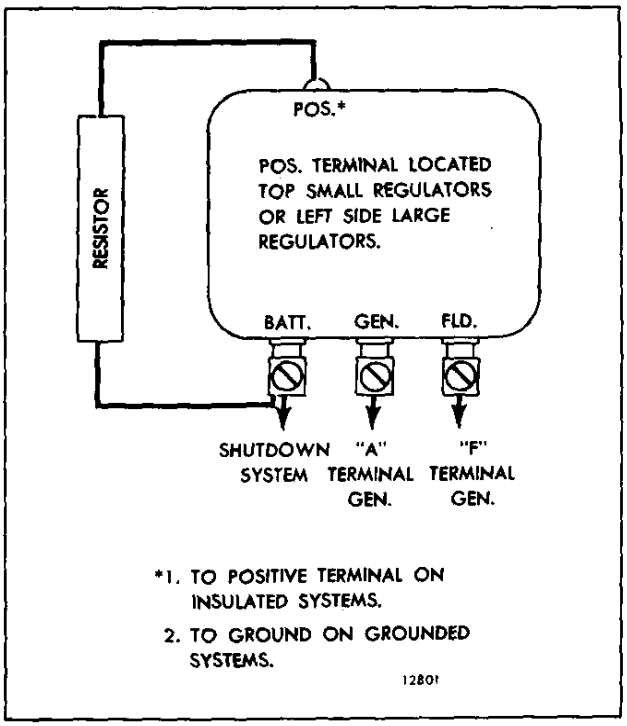


Fig. 7 - Resistor Connections

NOTE: Since the generator output drops when the engine speed is lowered, it will be necessary to retain a battery (light-duty type) for the operation of the shutdown system of units which may have occasion to operate at 1000 rpm or less. At this low engine speed, the generator output is not sufficient to operate the shutdown solenoid.

© 1984 General Motors Corp.

ALARM BELL FOR AUTOMATIC ELECTRICAL SHUTDOWN SYSTEM

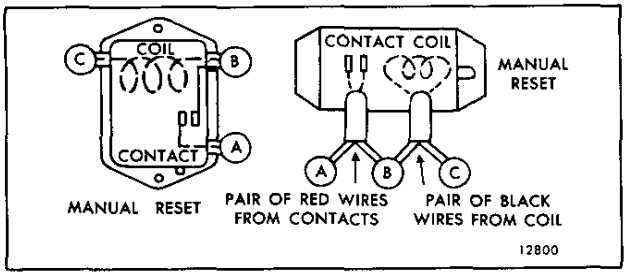


Fig. 8 - Two Types of Drop Relays for Use with Alarm Bell

On some engine installations, where the unit operates partly or wholly without an operator in attendance, it may be desirable to wire a 12 volt alarm bell into the automatic electrical shutdown system if it is of the "normally open circuit" type. The bell can be remotely mounted in an area where it can readily be heard should some unforeseen incident cause the engine to stop.

When wiring the alarm bell into the shutdown system so that the bell will ring continuously after the engine has stopped, until manually reset by the operating personnel, a drop relay (Fig. 8) is required.

The alarm bell may be wired into the shutdown system as shown in Figs. 9 and 10. It is important that the drop relay be correctly wired into the system so that when the engine shutdown solenoid is energized the operating coil in the drop relay will close the set of points and place the bell across the battery. Once the points are closed, the bell will continue to ring until the points are manually reset by the operator or service personnel.

If the engine is equipped with a 12 volt electrical system, the bell may be wired directly across the battery, but should the electrical system be 24 or 32 volts, then a 12 volt tap-off from the batteries will be required.

A 4 ohm resistor is installed to protect the drop relay operating coil whenever a 24 or 32 volt electrical shutdown system is employed on the engine.

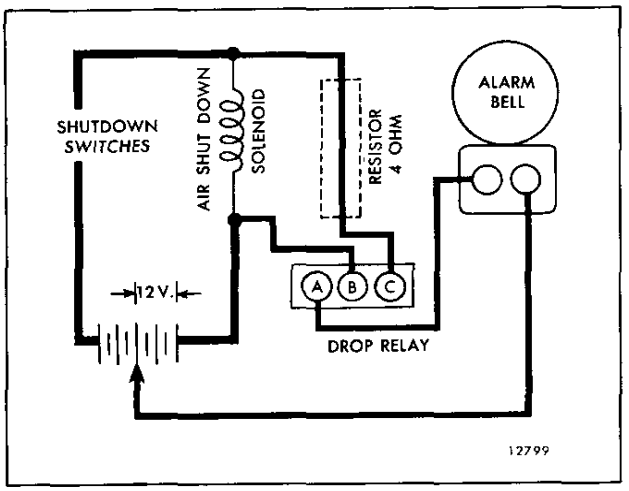


Fig. 9 - Single Engine Installation

Normally, a No. 14 wire will carry the bell current. Should the bell be mounted some distance from the engine, the bell wires should be suitably supported and well insulated to insure a permanent, trouble-free installation.

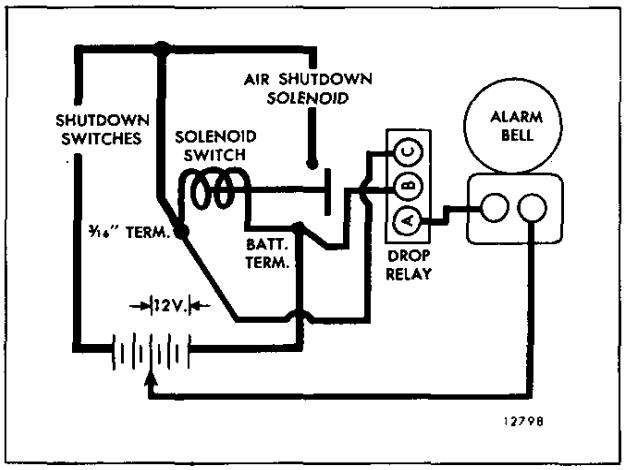


Fig. 10 - Twin and Quad Engine Installation

© 1982 General Motors Corp.

CHECK ENGINE STARTING SWITCH

If difficulty in starting motor engagement has been experienced in a vehicle which has been repowered by a diesel engine, check to see if the key-type starting switch on the instrument panel has been retained.

Key-type starting switches are usually not capable of carrying the current required for heavy-duty diesel engine starter solenoids. The excessive voltage drop in the solenoid circuit restricts the solenoid pull and results in failure of the starter to engage and crank. When tooth abutment occurs and the switch is turned off and on several times, breaking of the solenoid current causes burning or welding of the switch contacts.

Install a push button type starting switch which is capable of making, breaking and carrying the solenoid current without damage (refer to *Engine Starting Motor Switch* in Section 7.4). Otherwise, a heavy-duty magnetic switch should be used in the solenoid control circuit in addition to the key-type switch. The magnetic switch must be capable of making and breaking at least 90 amperes in a 12 volt system; the key switch would then carry no more than one ampere, which is sufficient to operate the magnetic swtich.

ALIGNMENT TOOLS FOR TACHOMETER DRIVE COVERS AND ADAPTORS

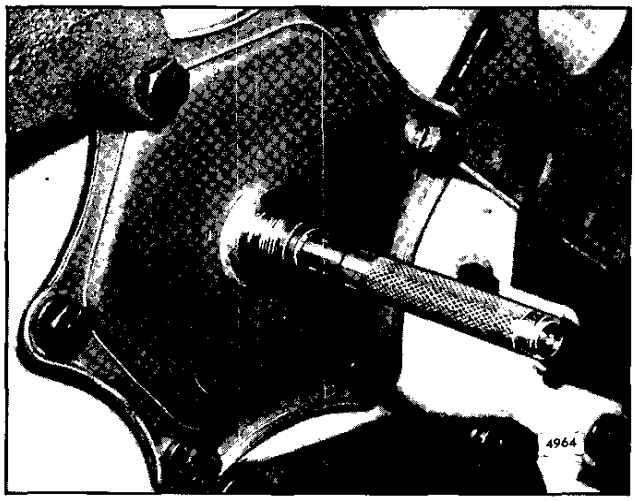


Fig. 11 - Checking Tachometer Drive Shaft Alignment

Whenever a tachometer drive cover assembly or a tachometer drive adaptor is installed on an engine, it is important that the cover assembly or adaptor be aligned properly with the tachometer drive shaft.

Misalignment of a tachometer drive shaft can impose a side load on a tachometer drive cable adaptor resulting in possible gear seizure and damage to other related components.

Use one of the three tools in set J 23068 to establish the proper alignment. Fig. 11 illustrates the use of the tools.

Because of the many different combinations of tachometer drive shafts, covers and adaptors available, it is not practical to itemize specific usages for each tool. When confronted with an alignment job, test fit each tool to determine which provides the best fit and proceed to make the alignment with that tool.

Correct alignment is established when there is no tachometer drive shaft bind on the inside diameter of the tool when one complete hand revolution of the engine is made.

© 1982 General Motors Corp.

TROUBLE SHOOTING

CHECKING D.C. ELECTRICAL STARTING SYSTEM

GROUNDED SYSTEM

The following quick checks can be made to determine whether or not units in the electrical system are operating properly. If not, the checks will indicate whether the generator or regulator is at fault, then proper corrective measures may be taken.

Case No. 1

A Fully Charged Battery and Low Charging Rate indicates normal voltage regulator operation.

To check the current regulator:

1. Use the starting motor for about 15 seconds with the engine throttle set in the no-fuel position.

2. With the engine running at a medium speed, note quickly the charging rate on the ammeter. This is the output value for which the current regulator is set.

3. Allow the engine to continue running and, as soon as the generator has restored the battery power consumed in cranking, the voltage regulator (if operating normally) will gradually decrease the output to a few amperes.

Case No. 2

A Fully Charged Battery and a High Charging Rate indicates that the voltage regulator is not reducing the generator output as it should. The charging rate to a fully charged hot battery may be greater than that obtained with a cool battery which has a fairly low specific gravity. If, considering the battery temperature and specific gravity, the charging rate is excessive, refer to Fig. 12 and proceed as follows to determine the cause:

1. Disconnect the field "F" terminal lead from the regulator. This opens the generator field circuit and the output should normally drop off. If it does not, the generator field circuit is grounded either internally or in the external wiring.

2. If the output drops to zero with the "F" terminal lead disconnected, the trouble has been isolated in the regulator.

3. Reconnect the "F" terminal lead, remove the regulator cover and depress the voltage regulator armature manually to open the points.

4. If the output now drops off, the voltage regulator unit has been failing to reduce the output as the battery came up to charge, and the necessity for voltage regulator adjustment is indicated.

5. If separating the voltage regulator contacts does not cause the output to drop off, inspect the field circuit within the regulator for shorts.

Give particular attention to the bushings and insulators under the contact point supports of the two regulator units, and make sure the insulators are correctly assembled.

Case No. 3

A Low Battery and a Low or No Charging Rate may be due to loose connections, frayed or damaged wires, low regulator setting, oxidized regulator contact points, or defects within the generator.

1. Check the circuit for loose connections and for frayed or damaged wires. High resistance resulting from these conditions will prevent a normal charge from reaching the battery. If the wiring is in good condition, then either the regulator or generator is at fault.

2. Temporarily ground the "F" terminal of the regulator and increase the generator speed to

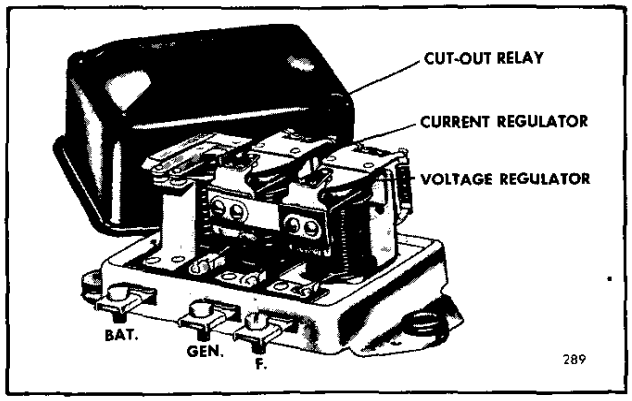


Fig. 12 - Current and Voltage Regulator Assembly

© 1982 General Motors Corp.

determine which unit needs attention. Use care to avoid excessive speed, since under these conditions the generator may produce a dangerously high output.

3. If the output does increase, the regulator needs attention. Check for dirty or oxidized contact points, or for a low voltage setting.

4. If the generator output remains at a few amperes with the "F" terminal grounded, the generator is at fault and should be checked further.

5. If the generator does not show any output at all (either with or without the "F" terminal grounded), very quickly disconnect the lead from the "GEN" terminal of the regulator and strike it against a convenient ground while the generator is operating at a medium speed. If there is no sparking at the lead, the trouble has now been definitely isolated in the generator. If no sparking occurs (although the generator output may build up), the cutout relay is not operating to permit the current to flow to the battery. This relay failure may be caused by burned points, failure of points to close, open shunt winding, ground high-voltage setting, or other reasons. Do not operate the generator with the "GEN" terminal lead disconnected for any length of time, since this is "open circuit" operation and the units will be damaged.

> **NOTE:** A burned resistance unit, regulator winding, or fused contacts can result from open circuit operation or extreme resistance in the charging circuit. When these conditions exist, check all wiring before reinstalling the regulator.

Do not run or test the generator on an open circuit. To do so will destroy the regulator or the generator.

If necessary, remove the batteries while the engine is operating and the generator is turning; the field terminal on the generator must be disconnected to safeguard the generator and the regulator against burning out.

INSULATED SYSTEM

The following quick checks can be made to determine whether or not the units in the electrical system are operating properly. If not, the checks will indicate whether the generator or the regulator is at fault; then proper corrective measures may be taken.

Case No. 1

A Fully Charged Battery and Low Charging Rate indicates normal voltage regulator operation.

To check the current regulator:

1. Use the starting motor for about 15 seconds with the engine throttle set in the no-fuel position.

2. With the engine running at a medium speed, note quickly the charging rate on the ammeter. This is the value for which the current regulator is set.

3. Allow the engine to continue running and, as soon as the generator has restored the battery power consumed in cranking, the voltage regulator (if operating normally) will gradually decrease the output to a few amperes.

Case No. 2

A Fully Charged Battery and a High Charging Rate indicates that the voltage regulator is not reducing the generator output as it should. A high charging rate to a fully charged battery will damage the battery and the accompanying high voltage is very injurious to all electrical equipment.

This operating condition may result from:

1. Improper voltage regulator setting.

2. Defective voltage regulator unit.

3. Short circuit between the charging circuit and field circuit, either in the generator, regulator or wiring.

4. High temperature which reduces the resistance of the battery to an electrical charge. Under this condition the battery will accept a high charging rate even though the voltage regulator setting is normal.

If the trouble is not attributable to high temperature, determine the cause by disconnecting the lead from the regulator field terminal while the generator is operating at medium speed. If the output remains high, the generator is at fault. If the output drops off, the regulator is at fault and it should be inspected for high setting or short circuits.

Case No. 3

A Low Battery and a Low or No Charging Rate may be due to loose connections, frayed or damaged wires, low regulator setting, oxidized regulator contact points, or defects within the generator. If the condition is not caused by loose connections or frayed or damaged wires, proceed as follows to locate the reason for the trouble.

To determine whether the generator or the regulator is at fault, bridge the regulator armature and field terminals momentarily with a jumper lead while the generator is operating at medium speed.

© 1982 General Motors Corp.

If the output does not increase, the generator is probably at fault.

If the generator output increases, the trouble is caused by:

1. A low voltage (or current) regulator setting.

2. Oxidized regulator contact points which increase the resistance in the generator field circuit; this results in a low regulator output.

3. Open generator field circuit (within the regulator) either at the connections or in the regulator windings.

© 1977 General Motors Corp.

SPECIFICATIONS

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb-ft)	Nm	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	Nm
1/4 -20	5- 7	7- 9	1/4 -20	7-9	10-12
1/4 -28	6- 8	8-11	1/4 -28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8 -16	23-26	31-35	3/8 -16	30-35	41-47
3/8 -24	26-29	35-40	3/8 -24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2 -13	53-56	72-76	1/2 -13	71-75	96-102
1/2 -20	62-70	84-95	1/2 -20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8 -11	103-110	140-149	5/8 -11	137-147	186-200
5/8 -18	126-134	171-181	5/8 -18	168-178	228-242
3/4 -10	180-188	244-254	3/4 -10	240-250	325-339
3/4 -16	218-225	295-305	3/4 -16	290-300	393-407
7/8 - 9	308-315	417-427	7/8 - 9	410-420	556-569
7/8 -14	356-364	483-494	7/8 -14	475-485	644-657
1 - 8	435-443	590-600	1 - 8	580-590	786-800
1 -14	514-521	697-705	1 -14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74,000 60,000
Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

12252

BOLT IDENTIFICATION CHART

© 1977 General Motors Corp.

EXCEPTIONS TO STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

APPLICATION	THREAD SIZE	TORQUE (lb-ft)	TORQUE (Nm)
Generator drive pulley nut		50-60	68-81
Starting motor connector	1/2 -13	20-25	27-34
Starting motor connector	No. 10-32	*	*
Starting motor switch mounting nut		§	§
Starting motor attaching bolt (Alum. F/W)	5/8 -11	95-105	129-143

* 16-30 **lb-in.** (2-3.5 Nm)
§36-48 **lb-in.** (4-5.5 Nm)

© 1982 General Motors Corp.

SERVICE TOOLS

TOOL NAME	TOOL NO.
Slide hammer	J 23907-1
Tachometer alignment tool set	J 23068
Tachometer drive shaft remover	J 5901-3

© 1982 General Motors Corp.

SECTION 8

POWER TAKE-OFF - TORQMATIC CONVERTER

For service and overhaul procedures covering the Power Take-Offs, refer to the *Power Take-Offs Manual, Form 6SE456.*

NOTE: Refer to 6SE456 for the Rockford Front Disconnect Mechanical Clutch adjustment used with the Allison 800-900 Series Torque Converter.

For service and overhaul procedures covering the Torqmatic Converter, refer to the service manuals listed below:

Allison 200-300 Series Torqmatic Converter Service Manual
Form SA 1099.

Allison 400-600 Series Torqmatic Converter Service Manual
Form SA 1046.

Allison 500 Series Torqmatic Converter Service Manual
Form SA 1058.

Allison 800-900 Series Torqmatic Converter Service Manual
Form SA 1054.

NOTE: Refer to SA 1054 for the Industrial Clutch Company Front Disconnect Mechanical Clutch adjustment.

© 1983 General Motors Corp.

SECTION 9

TRANSMISSIONS

For service and overhaul procedures, refer to the *Series 71 and 92 Engine Marine Gear, Reduction Gear and Transmission Service Manual, Form 6SE355.*

For service and overhaul procedures for the Paragon Marine Gear assembly, refer to:

Paragon Gear Works
610 Cushman St. - Drawer 430
Taunton, Mass. 02781

For service and overhaul procedures for the Twin Disc Marine Gears assembly, refer to:

Twin Disc, Inc.
1328 Racine Street
Racine, Wisc. 53403

© 1982 General Motors Corp.

SECTION 12

SPECIAL EQUIPMENT

CONTENTS

Bilge Pump 12.2

Air Compressor 12.4

Cold Weather Starting 12.6
Hydrostarter System 12.6.1

Trouble Shooting - Specifications - Service Tools 12.0

© 1975 General Motors Corp.

BILGE PUMP

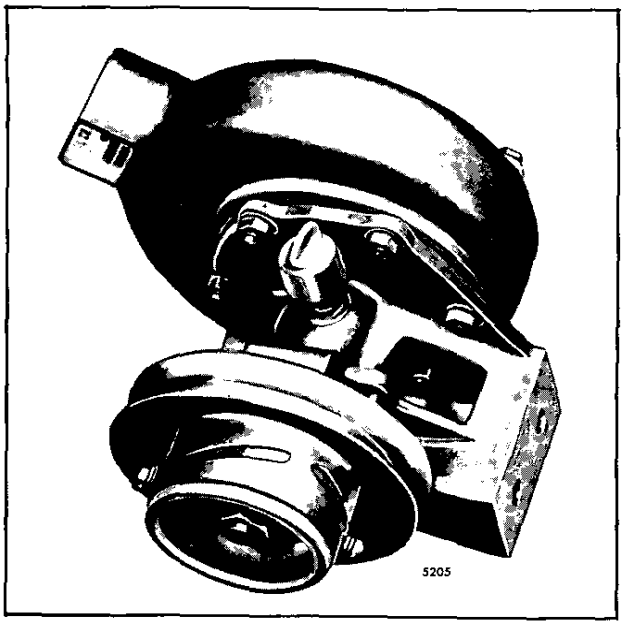


Fig. 1 - Bilge Pump

The bilge pump (Fig. 1) is mounted at the front of the engine and is driven by a V-belt from a pulley on the crankshaft.

The bilge pump runs continuously whenever the engine is operating and is kept in prime by a stream of overflow water from the engine, introduced on the intake side of the pump, through a priming pipe.

The drive shaft is supported on a bronze bushing at the impeller end and a ball bearing to take radial load at the pulley end.

Lubrication

A grease cup provides lubrication for the bronze bushing at the impeller end of the shaft. The cup should be given one-half turn daily, using water-proof grease of the same grade as used on the raw water pump. The ball bearing used at the pulley end of the shaft is grease packed and requires no attention.

A packing gland is provided to adjust the seal on the shaft. Do not tighten it more than necessary to stop leakage. When tightening, draw the nuts down evenly to avoid leaks and scoring of the pump shaft.

Service

Since the bilge pump runs continuously when the engine is operating, the drive belt should be checked at regular intervals. Tension on the belt should be sufficient to avoid slipping, but not great enough to impose an undue load on the pump bearings. Three-fourths inch slack midway between the two pulleys should provide satisfactory operation. Adjustment is accomplished by loosening the adjusting screws at the forward pulley hub and moving the hub in the slot to obtain suitable slack. In freezing weather, open the drain cock to empty the pump if the engine is to be standing idle for any length of time.

Remove and Install Pump

The bilge pump may be removed from the engine by removing the four bolts which attach the mounting bracket to the engine.

The pump is simple in construction and may be disassembled for inspection and re-assembled without special instructions. Since the pump priming pipe is permanently connected to the pump as installed on the engine, no special precautions are required for installation other than to make correct connections to the inlet and outlet sides.

CAUTION: All piping on the intake side of the bilge pump must be air tight. Use white lead or red lead on the pipe threads at all connections.

BILGE PUMP (MARINE QUAD UNIT)

A self-priming centrifugal bilge clutch and pump assembly is mounted on the base cross member at the forward end of each port and starboard marine quad unit (Fig. 2). The low position is easily accessible, permitting a direct drive belt arrangement with the pulley at the front end of the crankshaft, and reduces the suction head to a minimum.

A ball bearing, lubricated and sealed for life, supports the drive shaft at each end and absorbs the belt load. The idler pulley of the heavy duty clutch is mounted on an oversize sealed and lubricated ball bearing providing trouble free operation.

The bronze impeller, contained within a bronze

© 1973 General Motors Corp.

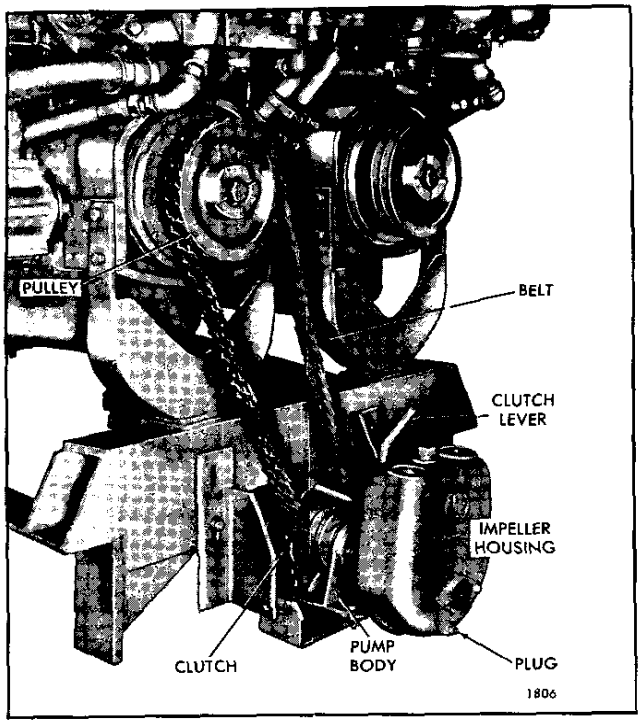


Fig. 2 - Bilge Pump Mounting (Quad)

housing, is pinned to the shaft which is sealed with semi-permanent metallic graphite packing.

A drain plug in the bottom of the impeller housing will permit draining of the housing in freezing weather. The clutch lever should be lubricated, through the fitting provided, every 100 hours of operation with a good grade of ball bearing grease.

Clutch Adjustment

Release the clutch, loosen the lock screw, turn the collar clockwise to tighten and reset the lock screw.

© 1973 General Motors Corp.

AIR COMPRESSOR

The air compressor (Fig. 1) may be mounted on a bracket attached to the cylinder block of the engine and belt-driven from the crankshaft pulley, or it may be flange-mounted to the flywheel housing and gear driven by means of an accessory drive attached to the camshaft or balance shaft gear.

A six bolt design air compressor mounting base, mounting bracket and gasket are used on current engines equipped with a belt-driven air compressor. Formerly, the air compressor was attached to the base and bracket with four bolts. When installing a new air compressor, it is recommended that the new mounting parts be used to eliminate the possibility of the bracket loosening and causing oil seepage at the gasket.

The air compressor runs continuously while the engine is running. While the compressor is running, actual compression of air is controlled by the compressor governor which acts in conjunction with the unloading mechanism in the compressor cylinder block. The governor starts and stops the compression of air by loading or unloading the compressor when the air pressure in the system reaches the desired minimum or maximum pressure.

During the down stroke of each piston, a partial vacuum is created above the piston which unseats the inlet valve and then allows air drawn from the air box in the engine cylinder block or through an intake strainer to enter the cylinder above the piston. As the piston starts the upward stroke, the air pressure on top of the inlet valves, plus the inlet valve return spring force, closes the inlet valve. The air above the piston is further compressed until the pressure lifts the discharge valve and the compressed air is discharged through the discharge line into the reservoir.

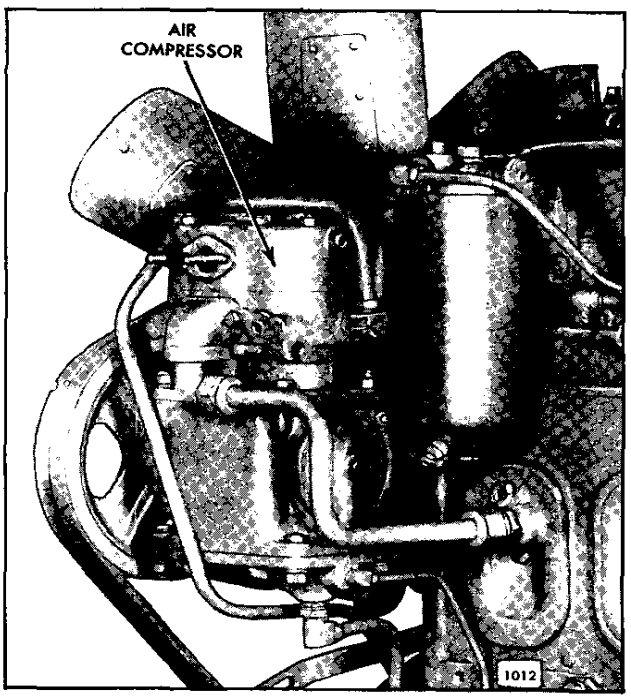


Fig. 1 - Air Compressor Mounting

As each piston starts its downstroke, the discharge valve above it returns to its seat, preventing the compressed air from returning to the cylinder and the same cycle is repeated.

When the air pressure in the reservoir reaches the maximum setting of the governor, compressed air from the reservoir passes through the governor into the cavity below the unloading pistons in the compressor cylinder block. The air pressure lifts the unloading pistons which in turn lifts the inlet valves off their seats.

With the inlet valves held off their seats, the air during each upstroke of the piston is merely passed back through the air inlet cavity and to the other cylinder where the piston is on the downstroke. When the air pressure in the reservoir drops to the minimum setting of the governor, the governor releases the air pressure beneath the unloading pistons. The unloading piston return spring then forces the piston down and the inlet valve springs return the inlet valves to their seats and compression is resumed.

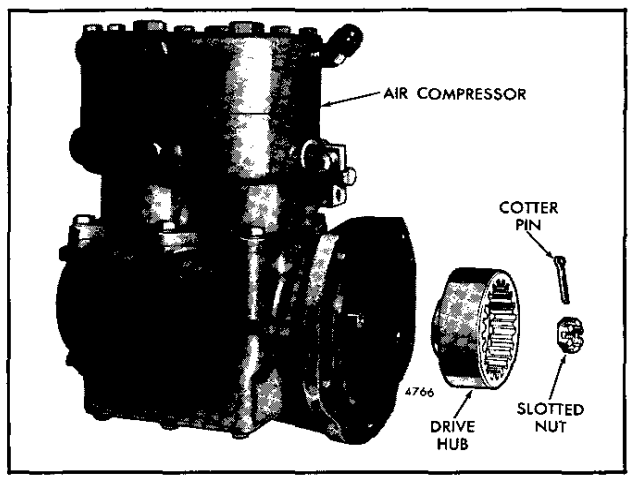


Fig. 2 - Typical Air Compressor with Drive Hub

© 1972 General Motors Corp.

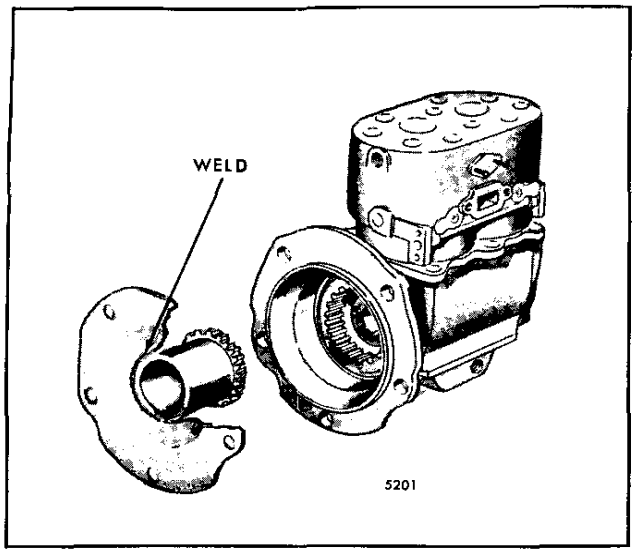


Fig. 3 - Fixture For Holding Drive While Installing or Removing Slotted Nut

Service Note

When installing a pulley or a drive hub on a flange mounted air compressor (Fig. 2), it is important the 3/4 "-10 drive shaft slotted nut be tightened to 100 lb-ft torque minimum before installing the 3/32 " x 1-1/4 " cotter pin.

The air compressor drive shaft will turn during the torquing operation unless some provision is made to hold it. One way this can be done is to weld a modified drive coupling to a support or base which in turn can be anchored to the mounting flange of the compressor. An old flywheel housing cover that matches the flange of the compressor makes an ideal base for the modified coupling. With the exterior splines of the coupling in mesh with the internal splines of the drive hub and the entire assembly secured to the compressor housing, the hub and shaft are kept from rotating when the torque is applied. That part of the base within the inner diameter of the coupling must be removed to permit placement of the wrench socket on the nut. Two bolts will secure the base to the compressor during the torquing operation (Fig. 3).

© 1972 General Motors Corp.

COLD WEATHER STARTING

When starting an internal combustion engine in cold weather, a large part of the energy of combustion is absorbed by the pistons, cylinder walls, coolant and in overcoming friction.

Under extremely low outside temperatures, the cold oil in the bearings and between the pistons and cylinder walls creates very high friction and the effort required to crank the engine is much greater than when the engine is warm.

In a diesel engine, the normal means of igniting the fuel sprayed into the combustion chamber is by the heat of the air compressed in the cylinder. This temperature is high enough under ordinary operating conditions, but at extremely low outside temperatures may not be sufficiently high enough to ignite the fuel injected.

To assist in starting an engine under low temperature conditions, several cold weather starting devices are available.

NOTE: Starting aids are not intended to correct deficiencies such as low battery, heavy oil, etc. They are for use when other conditions are normal but the air temperature is too low for the heat of compression to ignite the fuel-air mixture.

PRESSURIZED CYLINDER STARTING AID

Operation

Start the engine during cold weather, using the "Quick Start" starting aid system (Fig. 1) as follows:

1. Press the engine starter button.

2. Pull out the "Quick Start" knob for one or two seconds, then release it.

3. Repeat the procedure if the engine does not start on the first attempt.

CAUTION: Do not crank the engine more than 30 seconds at a time when using an electric starting motor. Always allow one minute intervals between cranking attempts to allow the starting motor to cool.

Service

Periodically perform the following service items to assure good performance:

1. Remove the fluid cylinder and lubricate the valve around the pusher pin under the gasket with a few drops of oil.

2. Lubricate the actuator cable.

3. Actuate the valve with the cable to distribute the oil on the cable and allow the oil to run down through the valve.

4. Remove any dirt from the orifice by removing the air inlet housing fitting, the orifice block and the screen. Then blow air through the orifice end only.

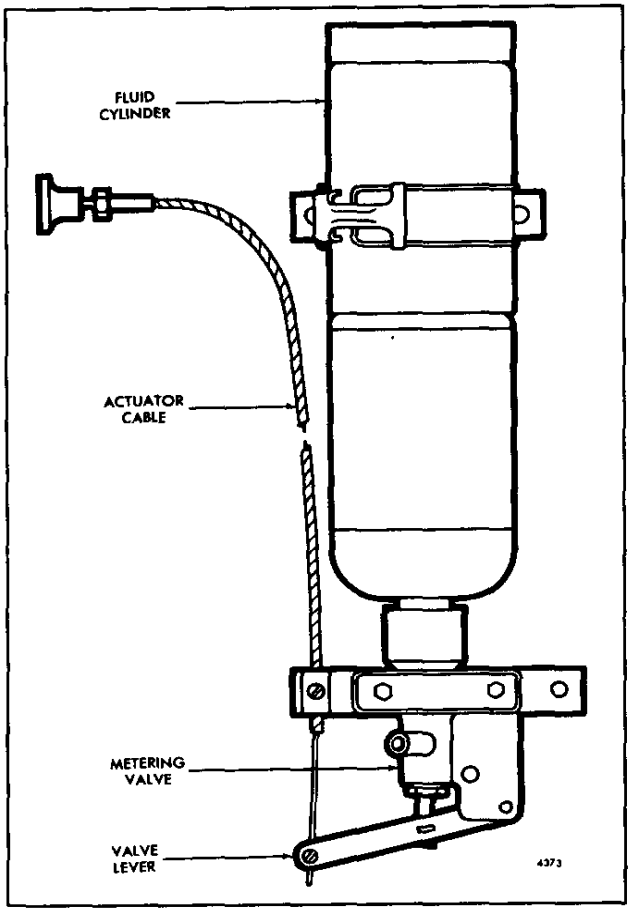


Fig 1 - "Quick Start" Assembly

© 1972 General Motors Corp.

5. Assemble and tighten the air inlet housing fitting to the actuator valve and tube.

6. Check for leakage of fluid (fogging) on the outside of the engine air inlet housing by actuating the starting aid while the engine is stopped. If fogging occurs, disassemble and retighten the air inlet housing fitting to the housing.

CAUTION: Do not actuate the starting aid more than once with the engine stopped. *Over-loading the engine air box with this high volatile fluid could result in a minor explosion.*

7. Check the fluid cylinder for hand tightness.

STARTING FLUID PRESSURE PRIMER

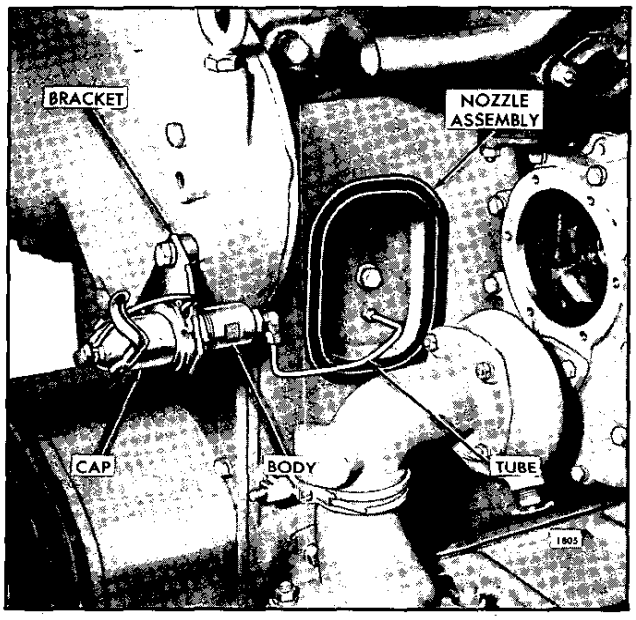


Fig. 2 - Pressure Primer Discharger Mounting

The starting fluid pressure primer is designed to inject a highly volatile fluid into the air intake system to assist ignition of the fuel at low ambient temperature. The fluid is contained in suitable pressure bulbs to facilitate handling.

Figure 2 shows the installation of the starting fluid pressure primer. It consists of a discharger body which is a cylindrical chamber fitted with a screw cap. Located inside the discharger body is a piercing pin. A tube from the discharger body leads to the atomizing nozzle in the air box cover on the side of the cylinder block.

Operation

1. Unscrew the cap of the pressure primer discharger, insert the steel pressure primer bulb (neck in down position) and screw the cap down.

2. After the starting motor has brought the engine up to cranking speed, discharge the pressure primer bulb by pushing (or pulling) up and over (180 degree swing) on the actuating lever of the discharger. The bulb requires approximately 15 seconds to discharge.

3. After the bulb in the discharger has had time to empty itself, throw the lever back to its original position, unscrew the discharger cap and insert another bulb in the discharger *only if it is to be used immediately to assist starting.*

4. Engines operating at extremely low temperatures may require the installation of two or more dischargers to keep them running on starting fluid until they are warmed up sufficiently to run on diesel fuel.

Precautions

The pressure primer bulbs are filled with a highly flammable Chevron starting fluid at approximately 250 pounds pressure to act as an expellent. The bulbs are a welded steel enclosure having a bursting pressure in excess of 6,000 psi, thus providing maximum safety in storage, handling and usage.

WARNING: Keep pressure primer bulbs away from heat. When a pressure primer discharger is being used for testing, inspecting or demonstrating purposes and is not installed on an engine, the contents of the pressure primer bulb should not be discharged in a confined area or near an open flame.

CAUTION: Pressure primer bulbs should only be inserted in the discharger at the time of and for starting.

© 1972 General Motors Corp.

FLUID STARTING AID

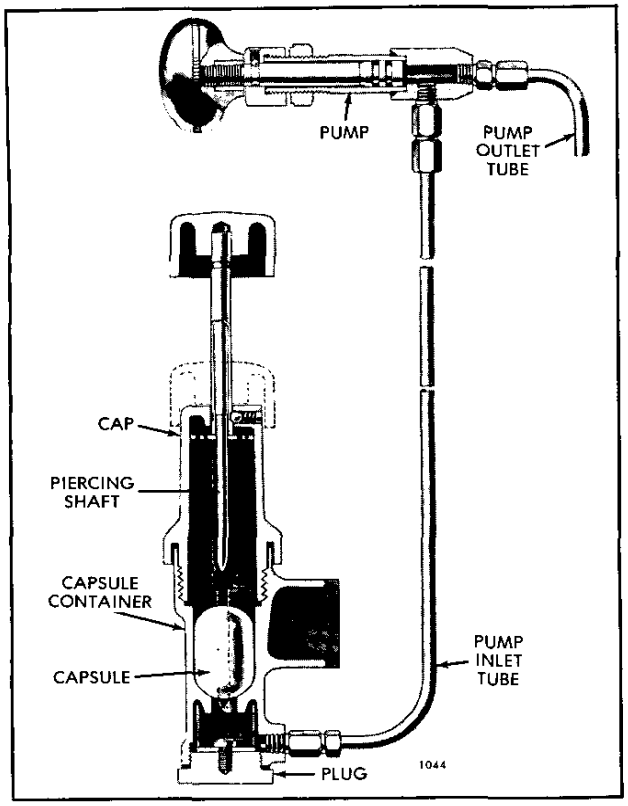


Fig. 3 - Fluid Starting Aid

The fluid starting aid is designed to inject a highly volatile fluid into the air intake system to assist ignition of the fuel at low ambient temperatures. It consists essentially of a pump and nozzle for injecting the fluid into the air intake and a suitable container for the fluid (Fig. 3). The fluid is contained in suitable capsules to facilitate handling.

This starting aid consists of a cylindrical capsule container fitted with a screw cap. Inside the container is a sliding plunger-like piercing shaft. From the capsule container, a tube leads from the container to a hand-operated pump and another tube leads from the pump to an atomizing nozzle threaded into a tapped hole in the air inlet housing.

Installation

The pump may be mounted on the instrument panel or in some other convenient location. The capsule container must be mounted in a vertical position away from such high heat areas as the exhaust manifold, muffler, etc. and should not be located under a hood or in a cab. The atomizing nozzle is screwed into a tapped hole in the air inlet housing. The tank-to-pump tube should be 3/16 " O.D. copper tubing and the pump-to-nozzle tube 1/8 " O.D.

Operation

1. Refer to Fig. 3 and remove the cap from the capsule container. Insert a fluid capsule in the container.

> **CAUTION:** Mount the capsule in an upright position within the container. Use care when handling, since the starting fluid is both toxic and inflammable.

2. Pull the piercing shaft all the way out and thread the cap tight on the container.

3. Push the piercing shaft down until it bottoms. This will break the capsule and fill the container with starting fluid vapor.

4. Move the engine throttle to the full-fuel position.

5. Engage the starter and simultaneously pull the pump plunger all the way out. Then push the plunger in *slowly*, forcing the starting fluid through the atomizing nozzle and into the air intake. *Continue to* push the pump plunger in until the engine starts. If the plunger is not all the way in when the engine starts, push it in *very slowly* until it locks in the *in* position.

6. Unscrew the cap and remove the used capsule. *Do not leave the empty capsule in the container.*

7. Reinstall the cap tightly on the container body.

> **NOTE:** When not in use, the piercing shaft should be all the way down.

Starting Aid Pump

The principal parts of the starting aid pump are the body, plunger and the spring-loaded ball type inlet and outlet check valves (Fig. 3). The pump body is threaded externally at one end for mounting purposes. One end of the plunger is threaded into the operating knob. Two seal rings of oil resistant material are located in grooves at the other end of the plunger. The inlet check valve, which opens on the suction stroke of the plunger and seats under pressure, is located in the side opening of the pump body. The outlet check valve, which seats under suction and opens under

© 1972 General Motors Corp.

pressure, is installed in the end opening of the pump body. The check valves are identified by the number "1/2" stamped on the inlet valve and the number "30" on the outlet valve. An arrow indicating the direction of flow is also stamped on each check valve.

Remove Pump

Remove the starting aid pump from the mounting panel as follows:

1. Disconnect the starting fluid inlet and outlet tubes from the pump.

2. Unscrew the plunger nut from the pump body and withdraw the plunger assembly.

3. Loosen the pump body jam nut behind the mounting panel.

4. Remove the pump body from the rear of the panel.

5. Remove the jam nut from the pump body.

Disassemble Pump

When the pump was removed from its mounting panel, the plunger assembly was removed from the pump body. If further disassembly is required, proceed as follows:

1. Unscrew the knob from the plunger assembly.

2. Slide the plunger nut from the plunger.

3. The plunger lock ball and spring may be removed by tapping the plunger nut to dislodge them. It is not necessary to remove the plug.

4. Remove the inlet and outlet check valves.

Inspection

Clean the parts with fuel oil and dry them with compressed air. Examine the seal rings for wear or cracks. Replace the seal rings if necessary. The check valves cannot be disassembled. However, they may be cleaned by forcing fuel oil through them with any suitable pump. Inoperative valves must be replaced.

If excessive resistance was encountered during operation of the pump, the nozzle in the air inlet housing may be plugged. Remove and clean the nozzle.

Assemble Pump

1. Install new seal rings on the plunger.

2. Install the lock spring in the plunger nut. Then place the steel ball on top of the spring.

3. Depress the lock ball and slide the plunger nut -- hex end first -- over the threaded end of the plunger.

4. Thread the knob on the plunger.

5. Install the outlet check valve (marked "30") in the end opening of the pump body. The arrow must point away from the pump body.

6. Install the inlet check valve (marked "1/2") in the side opening of the pump body. The arrow must point toward the pump body.

Install Pump

1. Thread the jam nut on the pump body.

2. Insert the thread end of the pump body through the mounting panel (from the rear of the panel).

3. Lubricate the seal rings and carefully slide the plunger assembly into the pump body. Thread the plunger nut on the end of the pump body and tighten it.

4. Install the starting fluid inlet and outlet tubes.

5. If removed, install the nozzle in the air inlet housing.

© 1972 General Motors Corp.

HYDROSTARTER SYSTEM

The Hydrostarter system illustrated in Figs. 1 and 2 is a complete hydraulic system for cranking internal combustion engines. The system is automatically recharged after each engine start, and can be manually recharged in an emergency. The starting potential does not deteriorate during long periods of inactivity and continuous exposure to hot or cold climates has no detrimental effect upon the Hydrostarter system. Also, the Hydrostarter torque for a given pressure remains substantially the same regardless of the ambient temperature.

The Hydrostarter system consists of a reservoir, an engine-driven charging pump, a manually operated pump, a piston type accumulator, a starting motor and connecting hoses and fittings.

Operation

Hydraulic fluid flows by gravity or slight vacuum from the reservoir to either the engine-driven pump inlet or hand pump inlet. The hand pump is used to supply the initial charge or to recharge the system after servicing or overhaul. Fluid discharging from either pump outlet at high pressure flows into the accumulator and is stored at 3250 psi (22 392 kPa) under the pressure of compressed nitrogen gas. When the starter is engaged with the engine flywheel ring gear and the control valve is opened, high pressure fluid is forced out of the accumulator, by the expanding nitrogen gas, and flows into the starting motor which rapidly accelerates the engine to a high cranking speed. The used fluid returns from the starter directly to the reservoir (Fig. 1).

The engine-driven Hydrostarter charging pump runs continuously during engine operation, recharging the accumulator with fluid. When the proper amount of fluid has been returned to the accumulator, a pressure-operated unloading valve in the engine-driven pump opens and returns the pump discharge directly to the reservoir.

System Components

RESERVOIR

The reservoir is a cylindrical steel tank with a fine mesh screen at the outlet. The filler cap contains a filter to prevent dust and dirt from entering the reservoir.

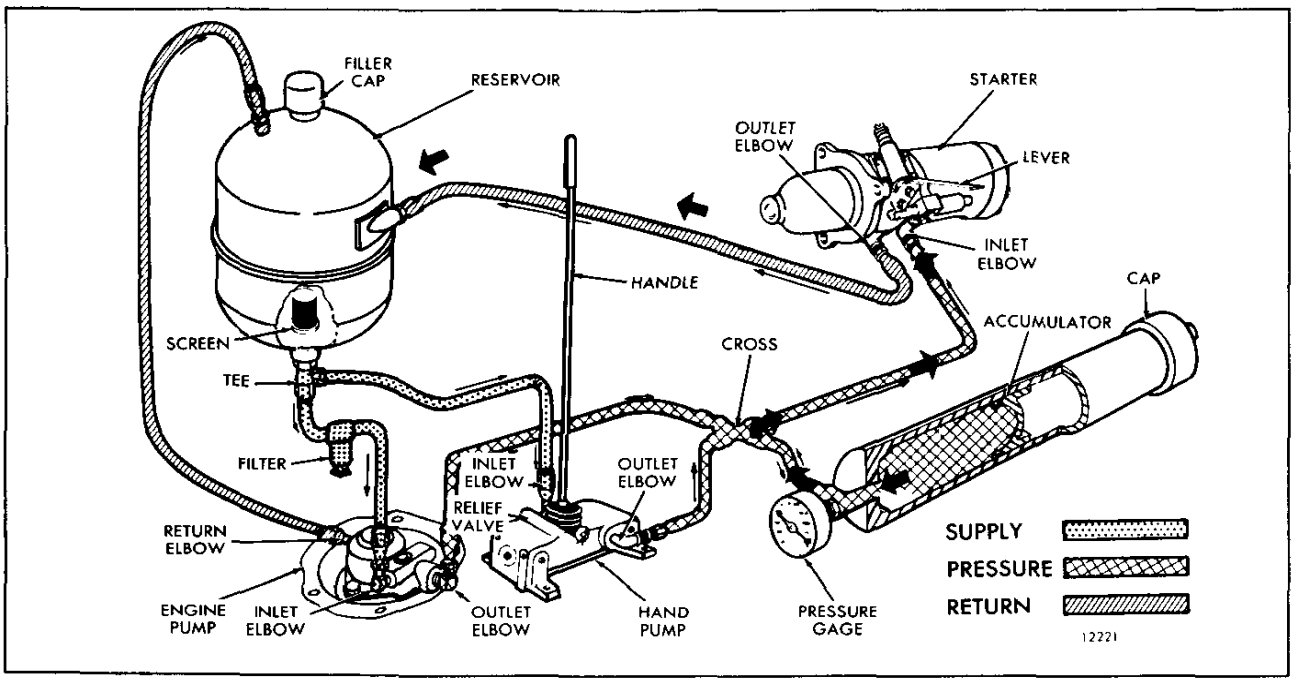


Fig. 1 - Schematic Diagram of Hydrostarter System Showing Oil Flows

© 1983 General Motors Corp.

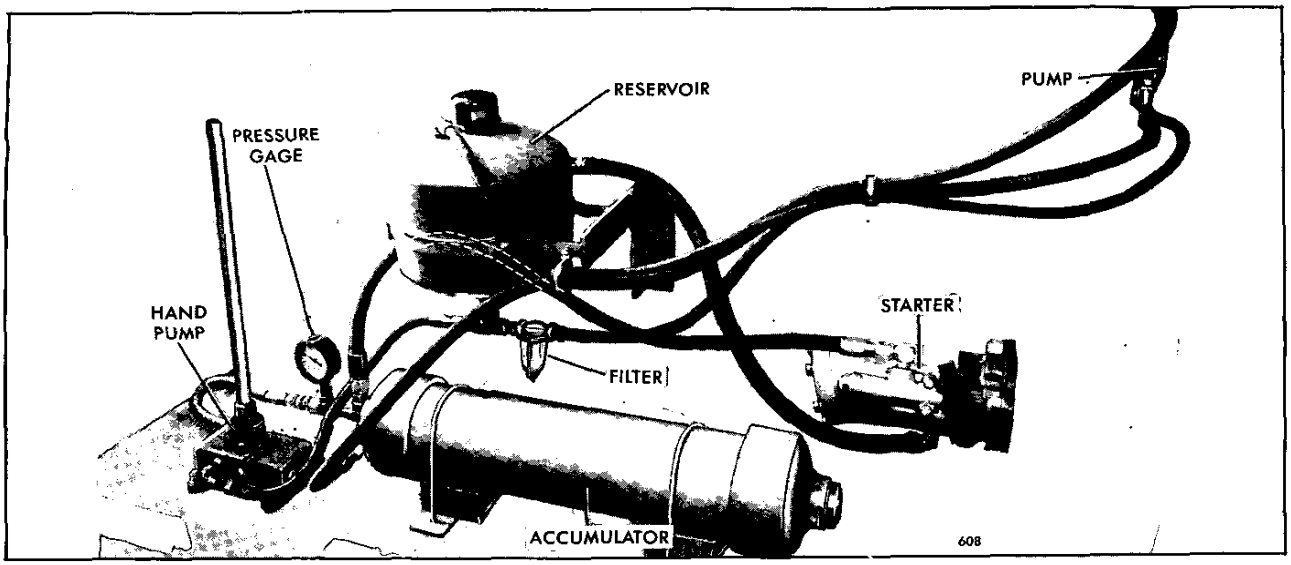


Fig. 2 - Typical Hydrostarter System Mounting

ENGINE-DRIVEN CHARGING PUMP

The engine-driven charging pump is a single piston, positive displacement type and should run at approximately engine speed. It contains ball check valves and an unloading valve operated by the accumulator pressure. Its operation is entirely automatic and will operate in either direction of rotation.

HAND PUMP

The hand pump is a single piston, double-acting, positive displacement type. Flow through the pump is controlled by ball check valves. A manually operated relief valve is provided in this pump so that the accumulator pressure may be relieved when servicing of any components is required.

ACCUMULATOR

The piston-type accumulator is precharged with nitrogen through a small valve. A seal ring between the piston and the shell prevents the loss of gas into the hydraulic system. The accumulator is supplied with the proper precharge.

STARTER

The starter mounts on the flywheel housing and has a pinion gear with an overrunning clutch for engaging the flywheel ring gear. Movement of the starter control lever engages the pinion and opens the control valve in the proper sequence. The motor is a multi-piston, swash plate type. Provision is made so that if pinion tooth abutment occurs, the motor rotates slowly until the pinion smaps into full engagement. When the control lever is released, the pinion is disengaged and the valve is closed by spring action.

Ordering Parts

When ordering replacement parts, always specify the information located by the arrows on each component (Fig. 3). Also, include the engine model and serial number to ensure obtaining the correct parts.

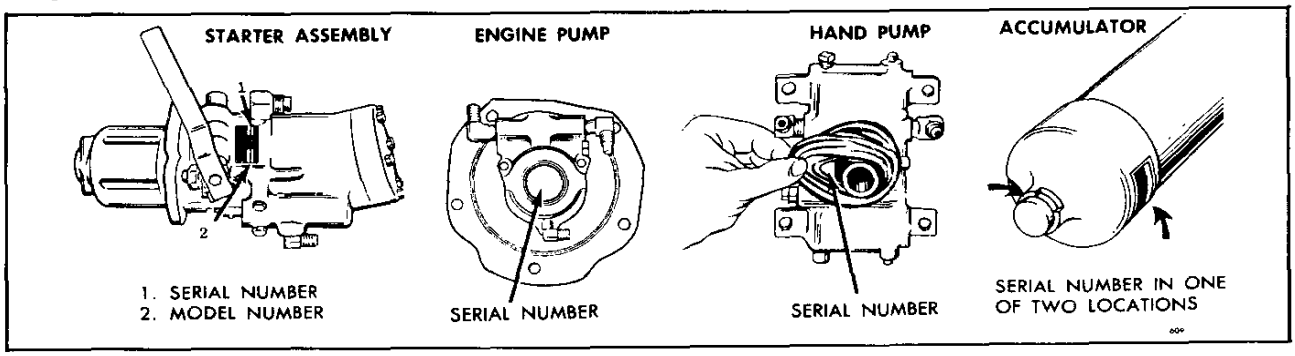


Fig. 3 - Hydrostarter Component Serial Number Locations

© 1983 General Motors Corp.

FILLING, PURGING AND STARTING

Fill Hydrostarter System

Remove the filler cap from the reservoir and add a sufficient quantity of recommended hydraulic fluid (a mixture of 75% diesel fuel and 25% SAE 10 or 30 lubricating oil) to fill the system.

The required amount of hydraulic fluid will vary depending upon the size of the reservoir, length of the hydraulic hoses and the size and number of accumulators. The reservoir is available in 10, 12, 16 and 23 quart (9, 11, 15 and 22 liters) capacities. In a 10 quart (9 liter) capacity reservoir, add approximately 8 quarts (7.6 liters) of hydraulic fluid; add approximately 10, 14 or 21 quarts (9, 13 or 20 liters) of hydraulic fluid to the 12, 16 and 23 quart (11, 15 and 22 liters) capacity reservoirs respectively.

> **NOTE:** When the accumulator is charged to 3000 psi (20 670 kPa) and all hoses are filled, there should be enough hydraulic fluid remaining in the reservoir to completely cover the screen in the bottom of the reservoir.

Purge Hydraulic Remote Control System, Hand Pump and Starter of Air

On units equipped with a hydraulic remote control starting system (Fig. 4) consisting of a foot pedal, master cylinder and connecting hose and fittings, purge that portion of the Hydrostarter system as follows:

Fill the master cylinder reservoir with diesel fuel oil. Loosen the hose swivel fitting at the back of the starter control valve body and actuate the master cylinder pedal to allow the air to escape from the hydraulic remote starting system. Replenish the fluid in the master cylinder reservoir as required during the purging operation. Then, tighten the hose swivel fitting.

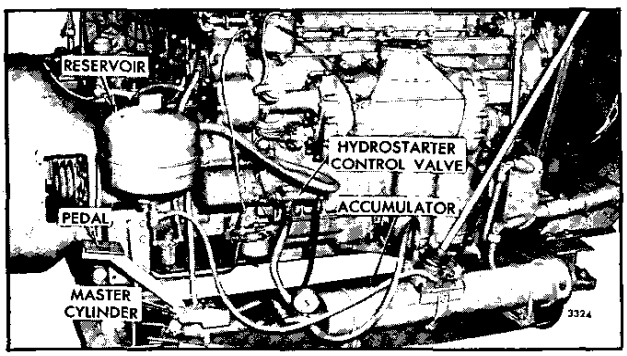


Fig. 4 - Remote Control for Hydrostarter

Remove the pressure hose (Fig. 1) on the side of the hand pump and pump a few strokes to prime the pump. Priming is complete when a full stream of oil is discharged at each end of the pumping stroke. Then, reconnect the pressure hose.

Move the starter control lever (Fig. 5) to engage the starter pinion with the flywheel ring gear and to open the control valve. While holding the lever in this position, operate the hand pump until the starter has turned several revolutions. Then, release the starter control lever.

Check Accumulator Precharge Pressure Prior to Initial Engine Start

The precharge pressure of the accumulator is the pressure of the nitrogen gas with which the accumulator is initially charged. This pressure should be checked before the system pressure is raised for the initial engine start. To check the precharge pressure, open the relief valve (Fig. 1) on the side of the hand pump, approximately 1/2 turn, allowing the pressure gage to return to zero. Close the relief valve and pump several strokes on the hand pump. The gage should show a rapid pressure rise from zero to the nitrogen precharge pressure, where it will remain without change for several additional strokes of the pump.

Initial Engine Start

Use the hand pump (Fig. 1) to raise the accumulator pressure until the gage reads as indicated in the following chart.

> **NOTE:** Use the priming pump (Fig. 27) to make sure the fuel filter, fuel lines and injectors are full of fuel before attempting to start the engine.

Ambient Temperature	Pressure Gage Reading
Above 40°F.	1500 psi
+40°F. to 0°F.	2500 psi
Below 0°F.	3300 psi

© 1983 General Motors Corp.

For ambient temperatures below 45°F (7°C), use a fluid starting aid.

> **NOTE:** Add starting fluid just prior to moving the Hydrostarter lever and during the cranking cycle as required. Do not wait to add the starting fluid after the engine is turning over because the accumulator charge may be used up before the engine starts. In this case, the accumulator charge must be replaced with the hand pump.

With the engine controls set for start (throttle at least half-open), push the control lever (Fig. 5) to simultaneously engage the starter pinion with the flywheel ring gear and to open the control valve. Close the valve quickly when the engine fires to conserve the oil pressure in the accumulator and to prevent excessive overrunning of the starter drive clutch assembly.

Three different basic types of flywheel ring gears are used -- no chamfer, Bendix chamfer and Dyer chamfer on the gear teeth. Some difficulty may be encountered in engaging the starter pinion with the Dyer chamfered ring gears. When this happens, it is necessary to disengage and re-engage until the starter pinion is cammed in the opposite direction enough to allow the teeth to mesh.

Purge Engine-Driven Pump of Air

With the engine running at 1500 rpm or above, loosen the hose connection at the discharge side of the engine-driven pump until a full stream of oil is discharged from the pump. Connect the hose to the pump and alternately loosen and tighten the swivel fitting on the discharge hose until the oil leaking out when the fitting is loose appears free of air bubbles. Tighten the fitting securely and observe the pressure gage. The pressure should rise rapidly to the accumulator precharge pressure of 1250 psi (8 612 kPa) at 70°F (21°C), then, increase slowly to 2900 to 3300 psi (19 991 to 22 737 kPa) in 6 to 10 minutes, depending upon the size of the particular accumulator.

If the accumulator pressure does not rise, make certain the relief valve (Fig. 1) is closed after the pressure is released and repeat the above purging procedure.

Engine-Driven Pump Bypass Check

The engine-driven pump should bypass oil to the reservoir when the pressure reaches 2900 to 3300 psi (19 991 to 22 737 kPa). Check to determine that the pump is bypassing by removing the reservoir filler cap and disconnecting the pump bypass hose at the reservoir and holding the hose over the open reservoir filler spout. An occasional spurt of oil may emit from the hose prior to bypassing. When the pump bypasses, a full and continuous stream of oil will flow from the hose. Reconnect the hose at the reservoir and install the filler cap.

HYDROSTARTER MOTOR

The Hydrostarter (starting) motor is mounted on the flywheel housing in the same manner as a conventional starting motor. This starting motor has an inherently high rate of acceleration; therefore, the engine is cranked faster than is possible with other starting systems. Right and left-hand starters are achieved by assembling the motor housing (Fig. 5) to the valve plate in one of two positions 180° apart and by changing the drive clutch assembly. The drive housing can be adjusted in 12 different positions to accommodate various flywheel housing configurations.

The control lever may be attached in any one of four positions where it is most accessible.

Positive starting motor engagement is assured because movement of the control lever mechanically pushes the starter pinion into engagement with the engine flywheel ring gear before the control valve is fully opened. When a tooth abutment is encountered, the valve permits a small flow of oil to turn the pinion slowly until it snaps into full engagement. Spring action disengages the pinion and closes the control valve when the lever is released. An overrunning clutch protects the starting motor at all times from being driven at high speeds by the engine before disengagement of the pinion.

Remove Hydrostarter Motor

1. Release the oil pressure in the hoses and the accumulator by opening the relief valve (Fig. 1) on the side of the hand pump.

> **CAUTION:** The oil pressure in the system must be released prior to servicing the Hydrostarter motor or other parts to prevent possible injury to personnel or equipment.

© 1983 General Motors Corp.

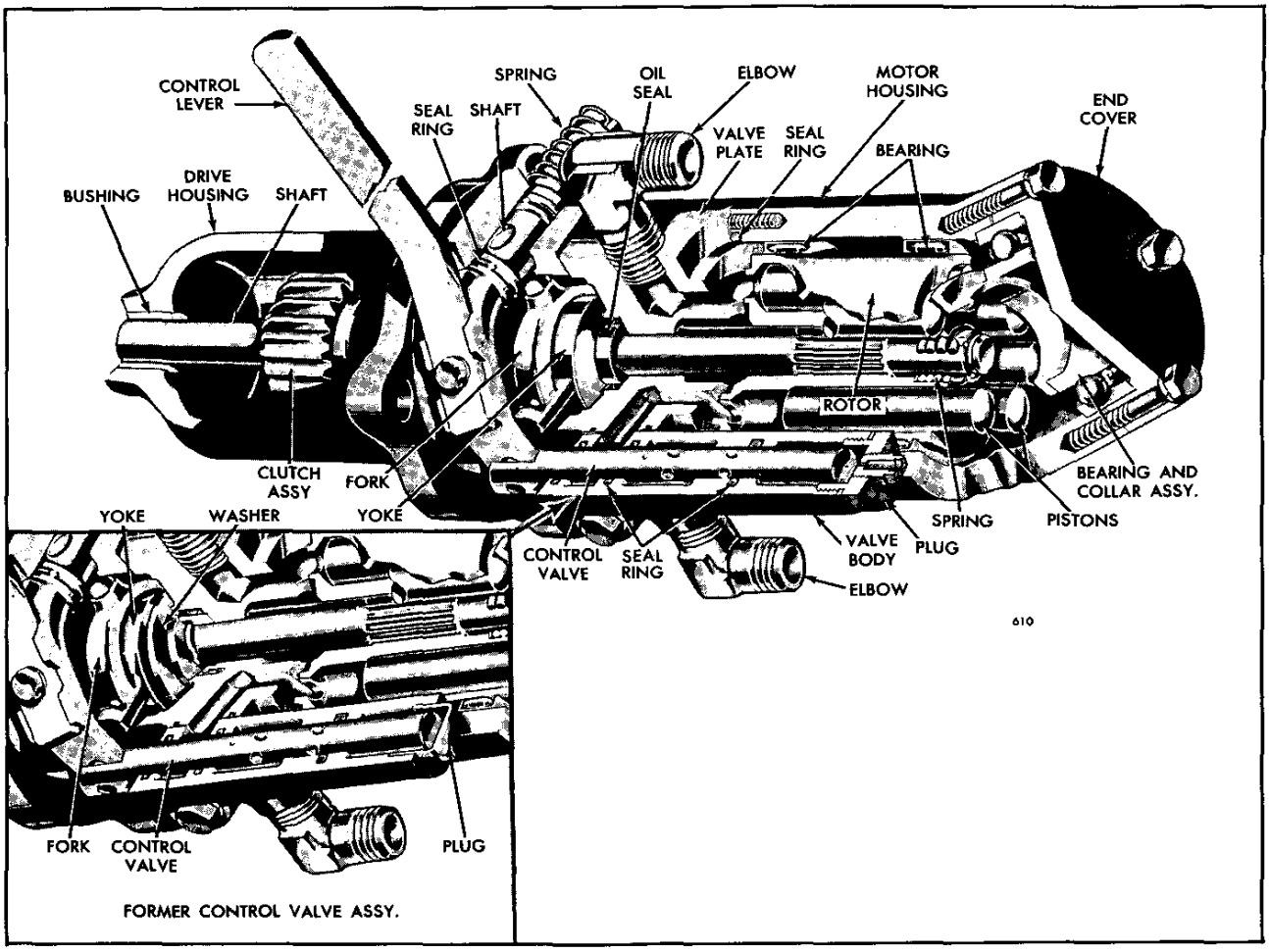


Fig. 5 - Cutaway View of Hydrostarter

2. Clean all of the exterior dirt from the Hydrostarter and the hydraulic hoses.

3. Disconnect the remote control hose or linkage, if used.

4. Disconnect the two hydraulic hoses from the starting motor. Cover the open ends of the hoses with masking tape to prevent the entry of dirt.

5. Remove the three bolts and lock washers and lift the starting motor away from the flywheel housing.

Disassemble Hydrostarter Motor

With the exterior of the Hydrostarter motor cleaned, scribe marks on the drive housing, clutch housing, valve plate and motor housing prior to disassembly to ensure their correct reassembly. Refer to Figs. 5 and 7 and proceed as follows:

1. Remove the two bolts and lock washers and lift the control valve assembly from the valve plate. Remove the body seal ring from the valve plate.

2. Withdraw the control valve from the valve body.

3. Remove the control valve plug only if the control valve body seals are to be replaced. If necessary, remove the seal rings from the valve body, being careful not to scratch or damage the valve body.

4. Remove the four bolts and lock washers and slide the drive housing off the shaft. Remove the plug and the oil wick from the drive housing.

5. Remove the four bolts and lock washers and separate the clutch housing and the clutch assembly

© 1983 General Motors Corp.

from the valve plate by sliding them off the shaft. Rotate the control shaft and disengage the overrunning clutch from the fork.

6. Lift the clutch yoke from the drive clutch assembly. Remove the fork from the control shaft.

7. Remove the torsion spring from the control shaft and pull the shaft from the clutch housing. Remove the seal rings from the control shaft. Remove the control lever only if broken or if its position on the control shaft is to be changed.

8. On a Series "20" Hydrostarter motor equipped with the former control valve assembly (inset in Fig. 5) remove the drive shaft oil seal washer from the starter shaft.

9. Withdraw the motor housing and needle bearing assembly together with the end cover and bearing as an assembly from the valve plate, being careful not to drop the pistons from the rotor.

10. Remove the pistons from the rotor.

11. Locate the shaft in an arbor press and, using spring compressor J 7187, press on the edge of the retainer to compress the spring (Fig. 6). Then, remove the snap ring.

12. Remove the retainer and compression spring from the starter shaft. Then, slide the rotor and the valve plate assembly off of the starter shaft.

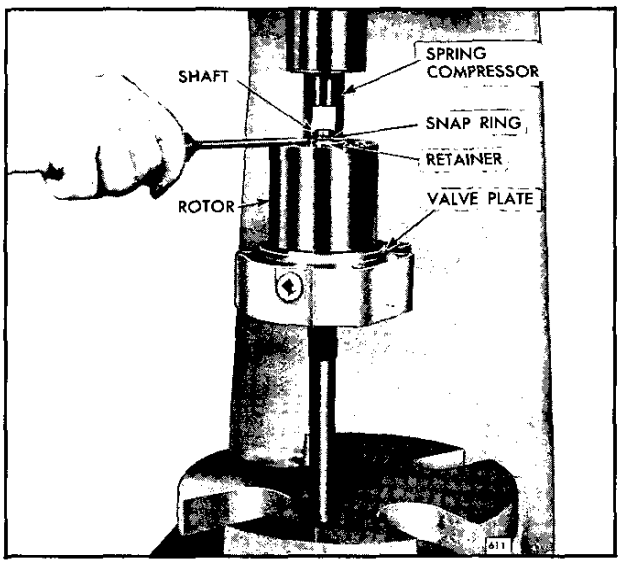


Fig. 6 - Removing Snap Ring from Starter Shaft

13. On a Series "20" motor, remove the starter shaft compression spring shim(s), if used, from the spring bore in the rotor.

On a Series "35" motor, remove the starter shaft compression spring special washer from the spring bore in the rotor.

14. Remove the starter shaft oil seal from the valve plate only if it is leaking.

15. Remove the seal ring from the motor housing.

16. Remove the bolts and lock washers and separate the end cover, bearing and gasket as an assembly from the motor housing.

17. Remove the bearing and collar assembly ("20" series motor) or the bearing assembly ("35" series motor) from the end cover.

Inspect Hydrostarter Motor Parts

Wash all of the parts in clean fuel oil and dry them with compressed air, with the exception of the drive clutch assembly.

Examine the teeth and internal splines of the drive clutch assembly for excessive wear and replace, if necessary.

If the overrunning clutch slips, preventing positive pinion engagement, replace it unless the slippage is due to extremely cold weather which would cause the grease to set up and prevent the clutch from operating. Then, wash it thoroughly in clean fuel oil to free the rollers in the clutch shell and lubricate with SAE 5W oil. Attach a tag to the starter, noting the lubricant used in the clutch assembly.

> **NOTE:** When replacing the drive clutch assembly, only the Delco Remy drive clutch assemblies are available for service and, if the unit did not incorporate a Delco Remy drive clutch before, it will be necessary to replace the drive housing also.

Check the rotor and pistons for scoring or other damage.

Replace the yoke if it is cracked or worn on the faces near slots.

Replace the clutch fork if the trunnions or machined shank of the fork is bent, or are worn out of alignment.

Replace the starter shaft oil seal if the lip is rough or hard.

© 1983 General Motors Corp.

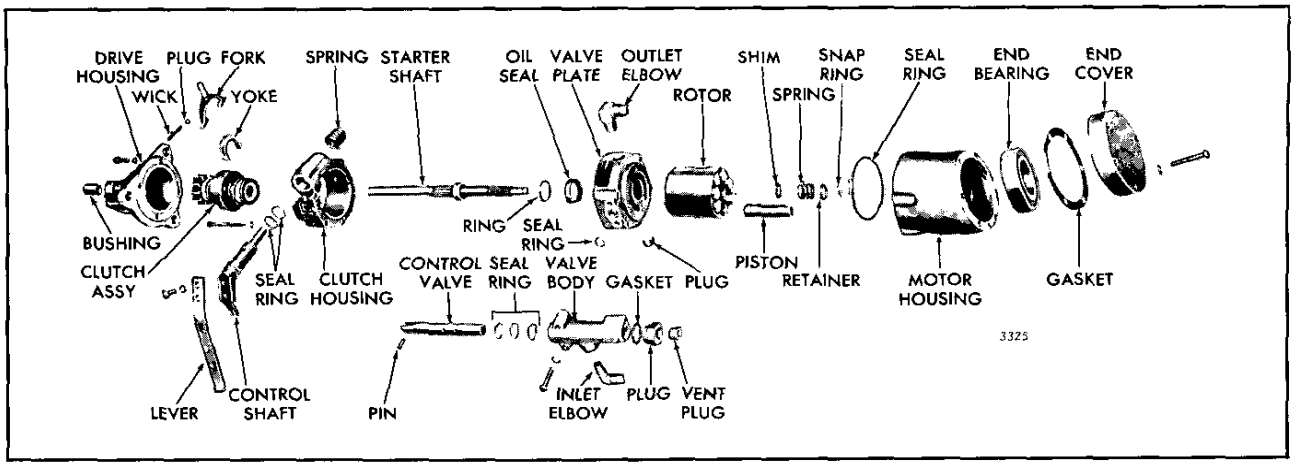


Fig. 7 - Hydrostarter Motor Details and Relative Location of Parts ("20" Series Motor Shown)

The rotor bearings (Fig. 5) should not require replacement; however, if they are worn excessively, a new motor housing and bearing assembly must be installed.

Apply light engine oil to the end bearing. Then, hold the inner race and revolve the outer race slowly by hand to check for rough spots.

Replace the control shaft torsion spring or compression spring if either is broken or damaged in any way.

A square section split ring was used with the compression spring retainer on early Hydrostarter motors. The current type retainer is used with a round section snap ring. The drive shaft was revised accordingly. When an early type shaft is replaced, a new spring retainer and snap ring are required.

The current Series "20" Hydrostarter motor incorporates a new design control valve assembly that may be identified by the threaded plug in the end of the valve housing. A tapped hole in the plug is provided for attachment of a flexible hose when a remote control is used, otherwise, a 1/8"-27 vent plug is installed. A cup plug was pressed in the former valve housing.

NOTE: The washer between the shaft seal and the clutch yoke (see inset in Fig. 5) is used ONLY in the early Series "20" Hydrostarter motors with the former type control valve. If the Hydrostarter motor is overhauled and a new control valve assembly is installed, remove the washer. However, if the control valve assembly is replaced and the motor is not disassembled, the washer may be left in the motor.

Assemble Hydrostarter Motor

Refer to Figs. 5 and 7 and assemble the Hydrostarter motor as follows:

NOTE: Do not reassemble a R.H. starter for L.H. rotation. The drive clutch for a R.H. starter will not drive at all if assembled on a L.H. starter. Similarly, the drive clutch for a L.H. starter will not drive if assembled on a R.H. starter. In both of these cases, the clutch will run free and will transmit no torque. The clutch will be forced to run at excessive speeds with a full accumulator and no driving load.

1. On a Series "20" motor, place the bearing and collar assembly in the end cover, thrust collar side up. On a Series "35" motor, place the bearing assembly, numbered end up, in the end cover. Then, attach the end cover to the motor housing with bolts and lock washers. Use a new gasket between the cover and the housing.

2. If the shaft oil seal was removed, install a new seal in the valve plate with the lip of the seal facing in (Fig. 8). The seal is properly positioned when the installer bottoms in the valve plate. Install the oil seal retaining ring in the ring groove in the valve plate.

On the former ("20" series motor) valve plate that does not incorporate the shaft oil seal retaining ring groove, stake the seal in place in at least six places.

3. Apply a thin coat of grease on the forward face of the starter shaft collar, then place the valve plate, seal side first, over the forward splined end of the starter shaft, followed by the rotor, shims (if used) on a "20" series motor, a special washer ("35" series motor), compression spring and the spring retainer.

© 1983 General Motors Corp.

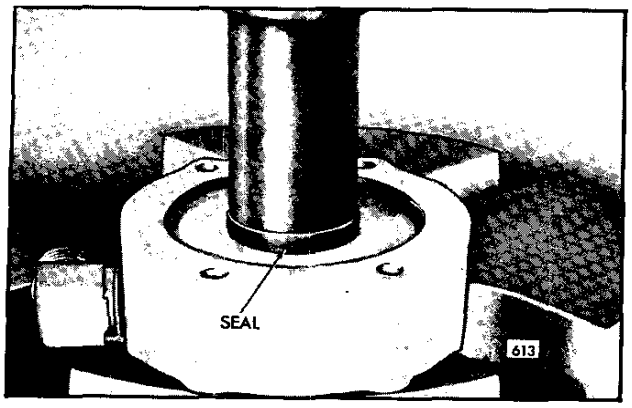


Fig. 8 - Installing Hydrostarter Shaft Seal in Valve Plate

4. With the assembly in an arbor press and using spring compressor J 7187 install the snap ring in the shaft ring groove (Fig. 6).

On the current Series "20" Hydrostarter motors, a .031" shim(s) is used on the starter shaft back of the compression spring (Fig. 9), to limit the starter shaft travel and prevent the collar on the shaft from moving past the lip of the oil seal and damaging the seal when the shaft returns to its normal position. When reassembling a Hydrostarter motor, the starter shaft should be checked (Fig. 10). If the starter shaft travel is more than .100", a .031" shim(s) must be placed back of the compression spring to limit the shaft travel.

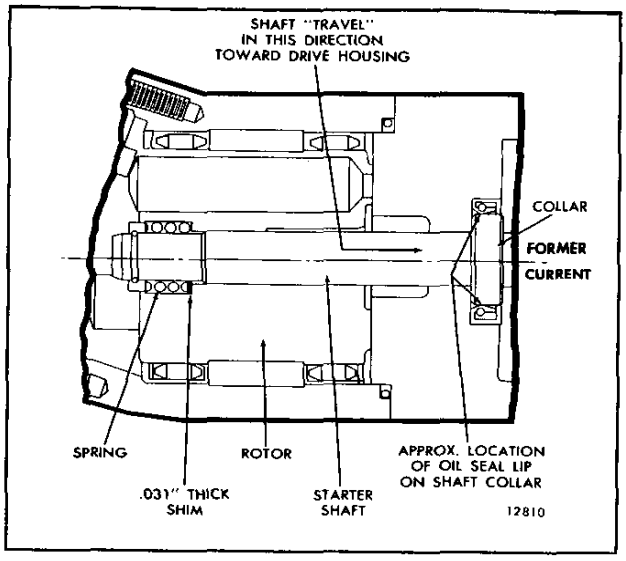


Fig. 9 - Location of Starter Shaft Compression Spring Shim (Series "20" Motor)

5. Insert the pistons, open end first, in the rotor.

6. Install the seal ring on the valve plate. Then, assemble the motor housing to the valve plate, noting the scribe marks previously made on the housing and the valve plate.

7. Lubricate and install new seal rings on the control shaft and guide the shaft into the clutch housing gently so as not to damage the seal rings.

8. Install the torsion spring on the end of the control shaft. Apply grease to the fingers of the clutch fork and insert the shank of the fork into the control shaft.

9. Apply grease to the slots of the yoke and to the spool of the drive clutch assembly. Then, set the yoke in the collar of the drive clutch assembly.

10. Grease the internal splines in the drive clutch assembly and the external splines on the starter shaft. Rotate the control shaft and insert the clutch fork trunnions into the slots on the yoke. Slide the oil seal washer, if used, onto the shaft. Then, slide the assembly, yoke end first, over the starter shaft and engage the clutch and the shaft splines.

NOTE: The starter shaft oil seal washer, mentioned in Step 10, is only used on Series "20" Hydrostarter motor assemblies using the former control valve assembly (inset in Fig. 5).

11. Align the scribe marks and the bolt holes of the motor housing, valve plate and clutch housing and install the attaching bolts and lock washers.

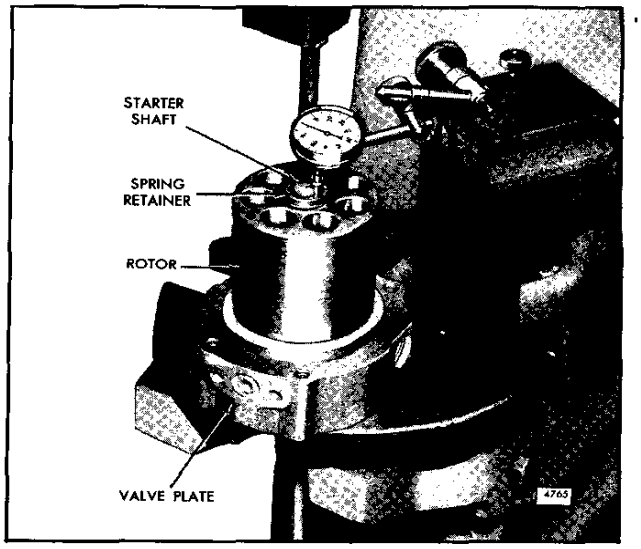


Fig. 10 - Checking Starter Shaft Travel (Series "20" Motor)

© 1983 General Motors Corp.

12. Dip the oil wick in engine oil and insert the wick in the drive housing and secure it with the pipe plug.

13. Align the scribe marks on the drive housing and the clutch housing, then secure the drive housing with bolts and lock washers.

14. If removed, install new seal rings in the seal ring grooves inside the control valve body, then, install the control valve body plug in the valve body and the vent plug in the body plug.

NOTE: On a former (Series "20" motor) control valve body (insert in Fig. 5) press the cup plug against the shoulder in the control valve body.

15. Lubricate the control valve with engine oil, then start the control valve, slotted end out, straight in the control valve body and push it through the three seal rings in the body.

16. Place a new seal ring in the counterbore of the valve plate, engage the roll pin in the slot of the control shaft and attach the control valve assembly to the valve plate with bolts and lock washers.

17. If removed, attach the control lever to the control shaft with bolts and lock washers.

Install Hydrostarter Motor

1. Attach the Hydrostarter motor securely to the flywheel housing with three bolts and lock washers.

2. Connect the two hydraulic hoses to the starter.

3. Connect the remote control hose or linkage, if used.

NOTE: Make sure the hoses and fittings are clean before any connections are made.

ENGINE-DRIVEN HYDROSTARTER CHARGING PUMPS

Depending upon the engine application, either a direct engine-driven charging pump or a belt-driven pump is included in the Hydrostarter system to maintain the proper operating pressure.

The charging pump runs continuously to maintain a

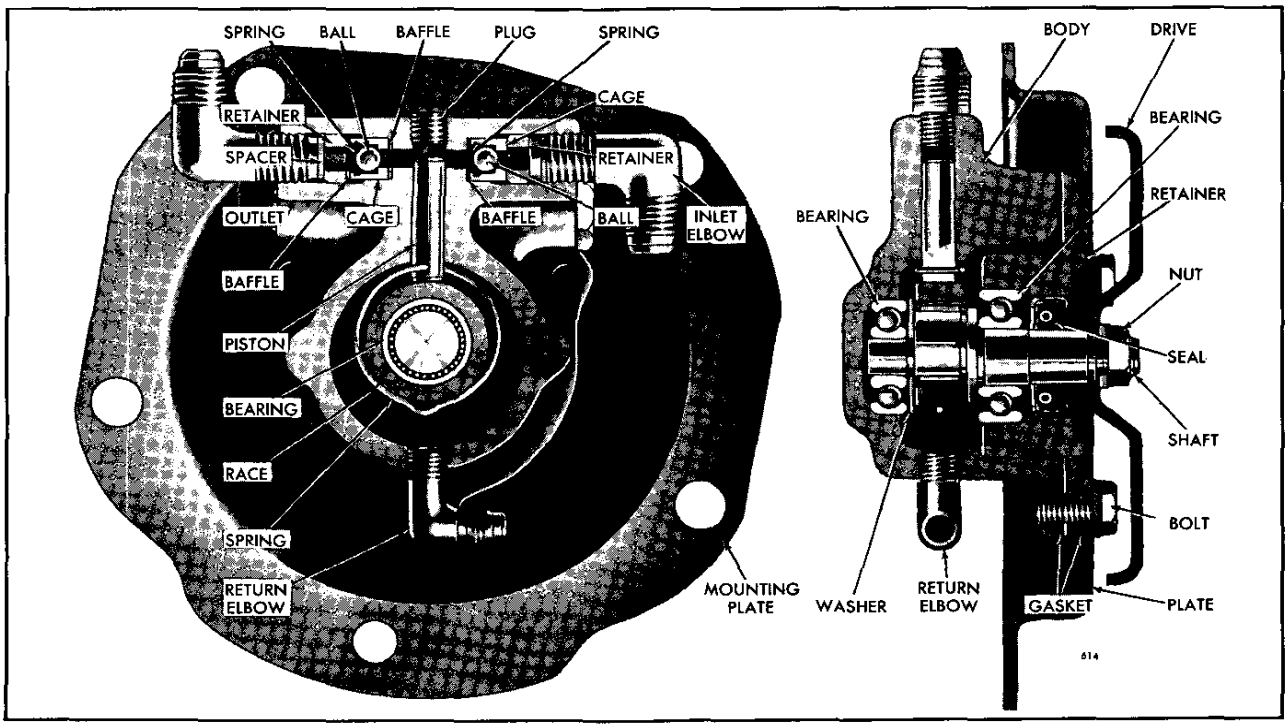


Fig. 11 - Direct Engine-Driven Hydrostarter Charging Pump

© 1983 General Motors Corp.

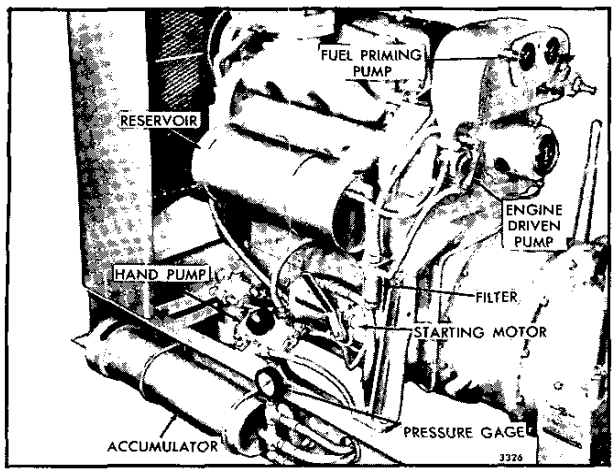


Fig. 12 - Direct Engine-Driven Charging Pump Mounting

pressure of approximately 2900 to 3300 psi (19 991 to 22 737 kPa) in the accumulator. However, the pump must not be driven at a constant speed exceeding 2500 rpm. An unloading valve, contained within the pump body, bypasses the pump discharge to the reservoir after the operating pressure is attained and, thereafter, permits the pump to operate at less load.

The pump, which will operate in either direction of rotation, will maintain the Hydrostarter system pressure, without appreciable loss, for long periods of time after the engine is shut down.

A sediment bowl is installed in the suction hose to provide the necessary finer degree of filtration required to protect the engine-driven pump mechanism. The sediment bowl encloses a stacked disc type element that may be cleaned and reused.

DIRECT ENGINE-DRIVEN CHARGING PUMP

The direct engine-driven charging pump is a single-piston positive displacement type (Fig. 12). The ball check valves and the unloading valve are automatically controlled by the accumulator pressure. The pump shaft is supported on ball bearings and a seal, pressed into the pump bearing retainer, prevents leakage. The pump is attached to the flywheel housing and is driven by a drive plate bolted to the camshaft or balance shaft gear (Fig. 13).

Remove Pump

If required, remove the pump as follows:

1. Release the oil pressure in the system by opening the relief valve (Fig. 1) on the side of the hand pump about 1/2 turn.

> **CAUTION:** The oil pressure in the system must be released prior to servicing the pump or other parts to prevent possible injury to personnel or equipment.

2. Clean all of the exterior dirt from the pump and the hydraulic hoses.

3. Disconnect the hydraulic hoses from the charging pump. Then, cover the open ends of the hoses to prevent the entry of dirt.

4. Remove the five bolts and lock washers securing the charging pump and mounting plate assembly to the flywheel housing (Fig. 13). Then, remove the pump and mounting plate assembly. Remove the mounting plate gasket.

Disassemble Pump

With the pump removed from the engine, refer to Figs. 11 and 14 and proceed as follows:

1. Remove the nut and lock washer and withdraw the pump drive from the shaft.

2. Scribe marks on the mounting plate and the pump body prior to disassembly to ensure their correct reassembly.

3. Remove the three bolts and lock washers and separate the mounting plate from the pump. Remove and discard the gasket. Withdraw the bearing retainer from the pump body. Remove and discard the second gasket.

4. Remove the shaft, bearings and fiber washer as an assembly from the pump body.

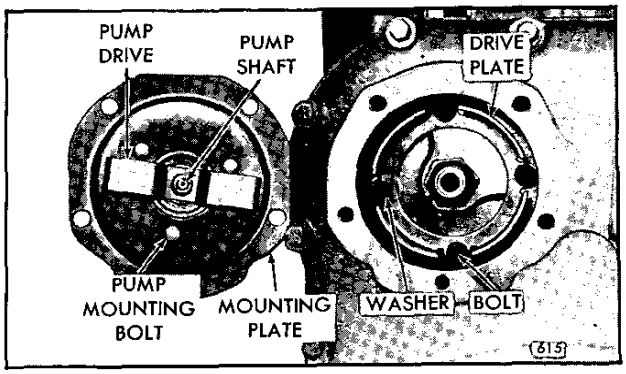


Fig. 13 - Pump Drive Plate Mounting

© 1983 General Motors Corp.

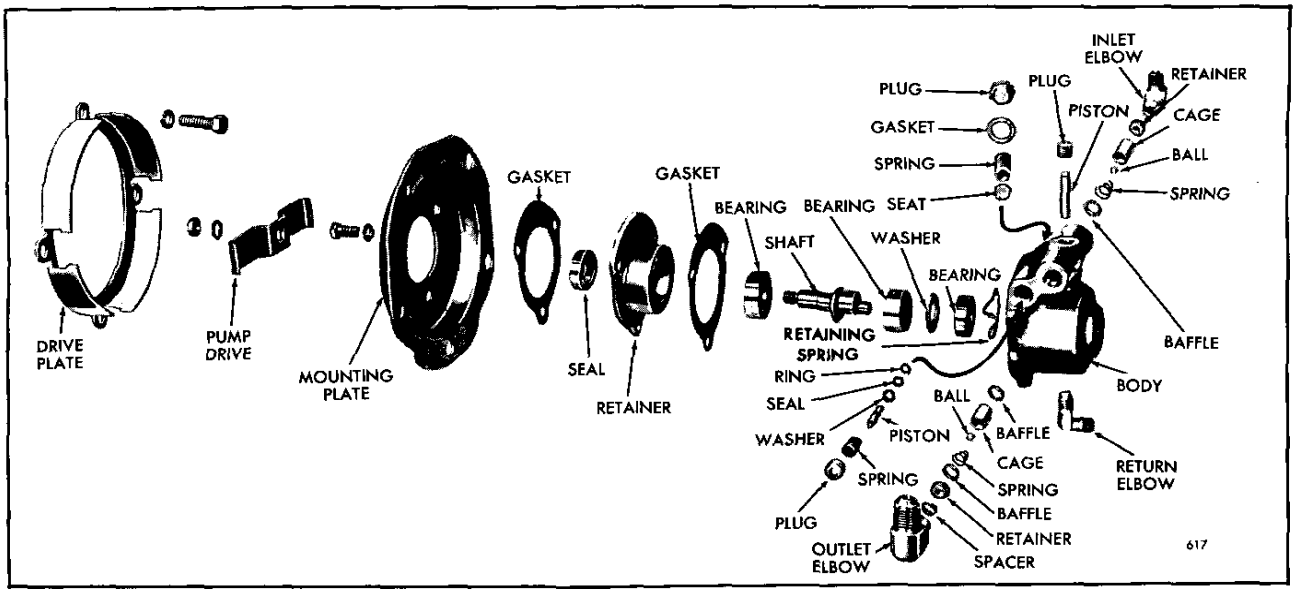


Fig. 14 - Direct Engine-Driven Charging Pump Details and Relative Location of Parts

5. If inspection reveals the bearings and fiber washer are worn excessively, remove them from the pump shaft for replacement by new parts.

6. Remove the pump piston and the retaining spring from the pump body.

7. Remove the pressure relief spring retaining plug, gasket, spring and spring seat.

8. Remove the compression spring retaining plug, compression spring, pressure relief piston, washer, seal ring and back-up ring.

9. Remove the pump outlet elbow, spacer, retainer and baffle.

The helical spring, ball and cage may then be removed as an assembly. Remove the baffle. DO NOT separate the helical spring and ball from the cage. If the check valve on either side of the pump is defective, replace the complete check valve assembly.

10. Remove the pump inlet elbow and the check valve retainer. Then, remove the cage, ball and spring as an assembly. Remove the baffle. DO NOT separate the spring and ball from the cage.

11. The pump-to-reservoir return elbow and plug may be removed, if necessary, to clean the pump body.

12. Remove the oil seal from the bearing retainer if the seal is worn or damaged.

Assemble Pump

After cleaning, inspecting and replacing the necessary parts, refer to Figs. 11 and 14 and proceed as follows:

1. Insert the spring seat and pressure relief spring in the pump body and lock them in place with a gasket and plug.

2. Slide a new back-up ring, new seal ring and washer onto the end of the pressure relief piston, opposite the flat end. DO NOT slide the seal across the groove in the piston.

3. Coat the back-up ring and seal ring liberally with hydraulic fluid. Then, insert the relief piston assembly into the pump body, the flat end of the piston first, using installer J 7192. Apply manual force to the installer in order to gradually work the back-up ring and seal ring into the counterbore around the pressure relief piston. Care must be taken to avoid cutting the seal ring as it is worked into place. Refer to Figs. 15 and 16.

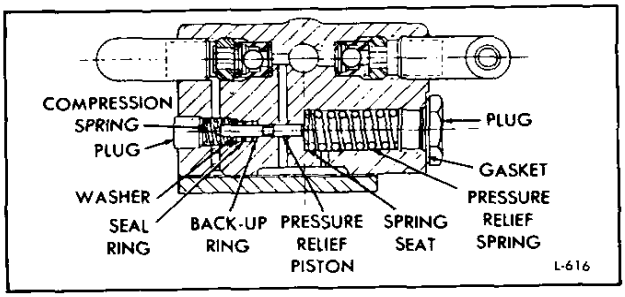


Fig. 15 - Engine-Driven Hydrostarter Charging Pump Pressure Relief Piston Assembly

© 1983 General Motors Corp.

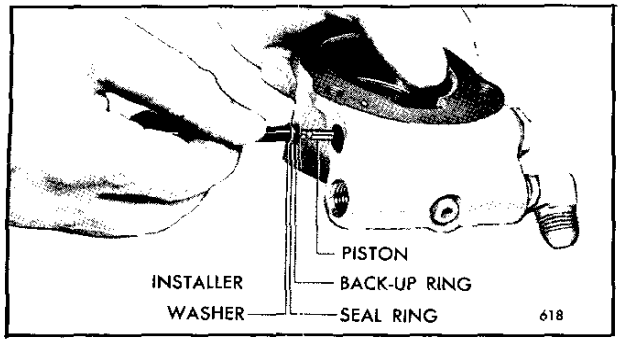


Fig. 16 - Installing Pressure Relief Piston, Back-Up Ring, Seal Ring and Washer in Pump Body with Installer J 7192

4. Remove the washer and inspect the work to make certain the seal ring is completely in the counterbored hole and that the pressure relief piston is down solidly against the spring seat.

5. Reassemble the washer over the pressure relief piston and insert the compression spring and secure it in place with the plug. Use sealant (Permatex No. 2, or equivalent) sparingly on the threads of the plug.

6. Insert the baffle, check valve assembly (with the spring end facing out) and the baffle into the pump body. Screw the check valve retainer into the body, against the baffle, and tighten it to 120-140 **lb-in** (13.5-16 Nm) torque.

7. Place the spacer in the body on top of the check valve retainer and install the pump outlet elbow, using sealant (Permatex No. 2, or equivalent) on the threads. DO NOT aply sealant on the last thread nearest the open end of the elbow.

8. Insert the baffle and check valve assembly (with the spring end of the assembly in first) into the pump body. Screw the check valve retainer into the pump body against the check valve cage and tighten it to 120-140 **lb-in** (13.5-16 Nm) torque. Install the pump inlet elbow, using sealant (Permatex No. 2, or equivalent) on all of the threads except the last one nearest the open end of the elbow.

9. If the pump-to-reservoir return elbow and plug were removed, apply sealant to all except the first thread on the elbow and plug and reinstall them.

10. Assemble the pump piston and retaining spring in the pump body.

11. Install the bearing and shaft assembly in the pump body. Work the retaining spring up on the bearing.

12. Affix a new gasket to the pump body and press the bearing retainer by hand into the pump body.

13. Install a new oil seal in the bearing retainer as follows:

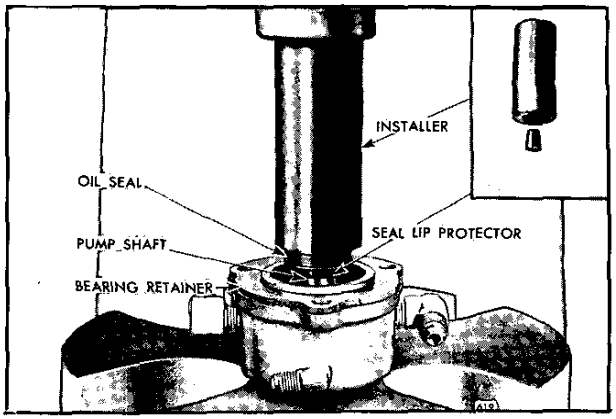


Fig. 17 - Installing Pump Shaft Oil Seal in Bearing Retainer

a. Apply a thin coat of sealing compound to the outside diameter of the oil seal casing.

b. Place the seal lip protector J 7191-3 over the shaft, lubricate the lip of the seal and slide the seal, lip side first, over the seal lip protector and down to the bearing retainer.

c. Place the seal installer J 7191-1 over the seal lip protector J 7191-3, covering the threaded end of the shaft. Then press the seal in flush with the retainer surface. Refer to Figs. 11 and 17.

14. Place a second gasket on the bearing retainer. Align the three bolt holes of the mounting plate, bearing retainer, pump body and both gaskets and secure the parts together with bolts and lock washers. Make sure the scribe marks previously made on the mounting plate and the pump body are aligned to ensure proper position of the pump when it is installed on the engine.

15. Secure the drive on the shaft with a nut and lock washer.

Install Pump

Refer to Figs. 12 and 13 and install the pump as follows:

1. Affix a new gasket to the flywheel housing using a non-hardening gasket cement on the flywheel housing side only.

2. Align the tangs on the pump drive with the slots in the drive plate. Attach the pump and mounting plate securely to the engine with bolts and lock washers:

> **CAUTION:** Do not force the pump into place. Use of force, or tightening the bolts when the mounting flange is not against the flywheel housing, will force the drive arm against the pump body and result in damage to the pump when the engine is started.

3. Connect the hydraulic hoses to the pump.

© 1983 General Motors Corp.

BELT-DRIVEN CHARGING PUMP

The belt-driven charging pump (Fig. 18) is similar in design and operation to the direct engine-driven pump, but has a longer shaft to accommodate a drive pulley.

Disassemble Pump

With the pump removed from the engine, refer to Figs. 18 and 20 and proceed as follows:

1. After removing the pulley retaining nut and lock washer, remove the pulley from the shaft, using a suitable puller.

2. Scribe marks on the bearing retainer and pump body prior to disassembly to ensure their correct reassembly.

3. Remove the three retaining bolts and lock washers. Separate the bearing retainer and pump shaft, including the shaft bearings, as an assembly from the pump body. Remove and discard the pump body gasket.

4. Press the pump shaft assembly from the bearing retainer using an arbor press or by tapping on the threaded end of the shaft with a plastic hammer.

5. If inspection reveals the pump shaft bearings and oil seal sleeve are worn excessively, remove them from the pump shaft for replacement by new parts.

6. Remove the needle bearing and outer race, fiber washer, retaining spring, piston and thrust ring from the pump body.

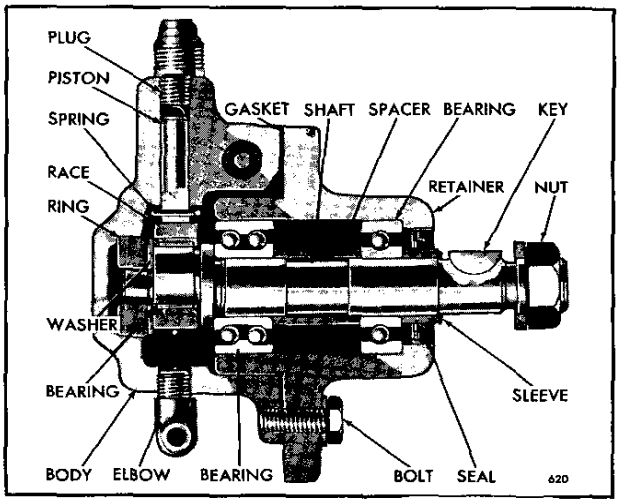


Fig. 18 - Belt-Driven Hydrostarter Charging Pump

7. Remove the oil seal from the bearing retainer if the seal is worn or damaged.

8. Remove the pressure relief spring retaining plug, gasket, spring and spring seat.

9. Remove the compression spring retaining plug, compression spring, pressure relief piston, washer, seal ring and back-up ring.

10. Remove the pump outlet elbow, spacer, retainer and baffle. The helical spring, ball and cage may then be removed as an assembly. Remove the baffle. DO NOT separate the helical spring and ball from the cage. If the check valve on either side of the pump is defective, replace the complete check valve assembly.

11. Remove the pump inlet elbow and the check valve retainer. Then, remove the cage, ball and spring as an assembly. Remove the baffle. DO NOT separate the spring and ball from the cage.

12. The pump-to-reservoir return elbow and plug may be removed, if necessary, to clean the pump body.

Assemble Pump

After cleaning, inspection and replacing the necessary parts, refer to Figs. 18 and 20 and proceed as follows:

1. Insert the spring seat and pressure relief spring in the pump body and lock them in place with a gasket and plug.

2. Slide a new back-up ring, new seal ring and washer onto the end of the pressure relief piston, opposite the flat end. DO NOT slide the seal across the groove in the piston.

3. Coat the back-up ring and seal ring liberally with hydraulic fluid. Then insert the relief piston assembly into the pump body, the flat end of the piston first, using installer J 7192. Apply manual force to the installer in order to gradually work the back-up ring

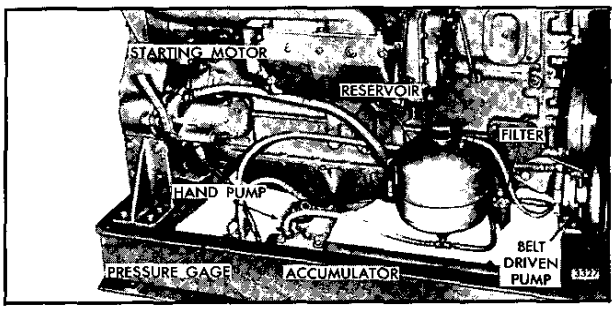


Fig. 19 - Belt-Driven Charging Pump Mounting

© 1983 General Motors Corp.

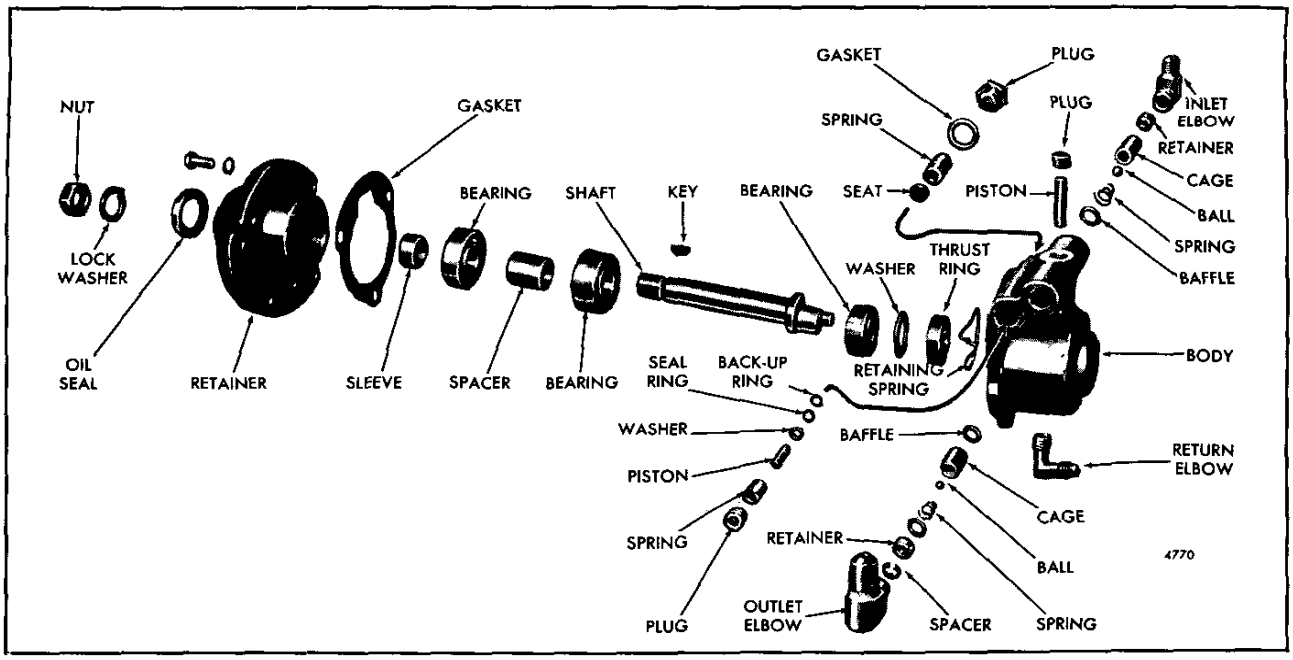


Fig. 20 - Belt-Driven Charging Pump Details and Relative Location of Parts

and seal ring into the counterbore around the pressure relief piston. Care must be taken to avoid cutting the seal ring as it is worked into place. Refer to Figs. 15 and 16.

4. Remove the washer and inspect the work to make certain the seal ring is completely in the counterbored hole and that the pressure relief piston is down solidly against the spring seat.

5. Reassemble the washer over the pressure relief piston and insert the compression spring and secure it in place with the plug. Use sealant (Permatex No. 2, or equivalent) sparingly on the threads of the plug.

6. Insert the baffle, check valve assembly (with the spring end facing out) and baffle into the pump body. Screw the check valve retainer into the body, against the baffle, and tighten it to 120-140 **lb-in** (13.5-16 Nm) torque.

7. Place the spacer in the pump body on top of the retainer and install the pump outlet elbow, using sealant (Permatex No. 2, or equivalent) on the threads. DO NOT apply sealant on the last thread nearest the open end of the elbow.

8. Insert the baffle and check valve assembly (with the spring end of the assembly in first) into the pump body. Screw the check valve retainer into the pump body against the check valve cage and tighten it to 120-140 **lb-in** (13.5-16 Nm) torque. Install the pump inlet elbow, using sealant (Permatex No. 2 or equivalent) on all of the threads except the last one nearest the open end of the elbow.

9. If the pump-to-reservoir return elbow and the plug were removed, apply sealant to all except the first thread on the elbow and plug and reinstall them.

10. Install the thrust ring in the counterbore of the pump body. Lay the fiber washer on the thrust ring.

11. Assemble the pump piston and the retaining spring in the pump body.

12. Install the needle bearing with its outer race in the retaining spring.

> **NOTE:** The current belt-driven pumps incorporate a 5/8" diameter shaft. Former pumps used an 11/16" diameter shaft. When an old pump assembly or shaft is replaced by a current pump or shaft, a new pulley with a 5/8" bore must also be provided. The diameter of the pulley must be such that the pump will not exceed a constant speed of 2500 rpm.

13. Slide the end of the pump shaft assembly through the needle bearing, and the fiber washer into the thrust ring.

14. Affix a new gasket to the pump body. Assemble the bearing retainer to the pump body. Align the scribe

© 1983 General Motors Corp.

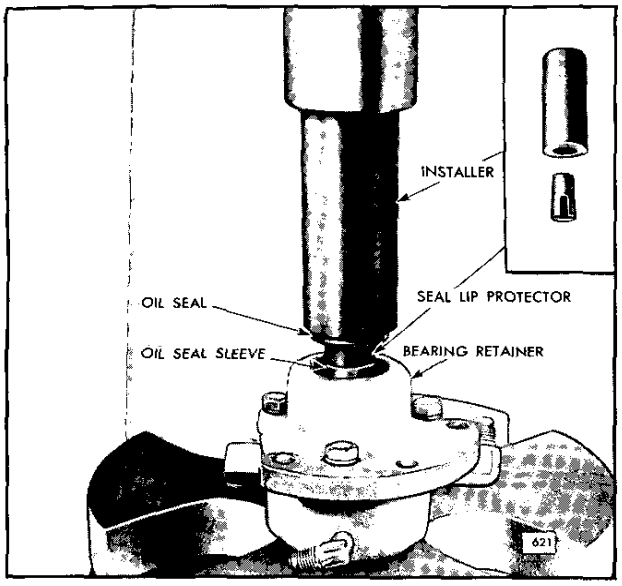


Fig. 21 - Installing Pump Shaft Oil Seal in Bearing Retainer

marks previously made on the retainer and pump body and install the retaining bolts and lock washers.

15. Install a new oil seal in the bearing retainer as follows:

a. Apply a thin coat of sealing compound to the outside diameter of the oil seal casing.

b. Place the oil seal lip protector J 7191-2 over the shaft, lubricate the lip of the seal and slide the seal, lip side first, over the oil seal lip protector and down to the bearing retainer.

c. Place the oil seal installer J 7191-1 over the seal lip protector J 7191-2, covering the threaded end of the shaft. Then, press the seal in flush with the outer face of the retainer. Refer to Figs. 18 and 21.

16. Install the pulley on the shaft.

17. Install the charging pump on the engine and connect the hydraulic hoses to the pump.

HAND PUMP

The hand pump is a single piston double-acting positive displacement type (Fig. 22). It is mounted in such a manner that the pumping action is never in a vertical direction and the handle clears all obstructions throughout its complete stroke. The handle may be removed and stored when the pump is not in use.

The hand pump is used to provide the initial hydraulic pressure for a new Hydrostarter installation or to build-up the pressure in the Hydrostarter system if it has been released for any reason.

Flow through the pump is controlled by ball check valves. A manually operated relief valve is provided in the hand pump to release the pressure when servicing of any of the components in the Hydrostarter system is required.

Remove Hand Pump

Remove the hand pump as follows:

1. Release the pressure in the Hydrostarter system by opening the relief valve (Fig. 22) on the side of the pump approximately 1/2 turn.

CAUTION: The oil pressure in the system must be released prior to servicing the hand pump or any other components of the system to prevent possible injury to personnel or equipment.

2. Clean all of the exterior dirt from the hand pump and the hydraulic hoses.

3. Disconnect the hydraulic hoses at the pump.

4. Remove the attaching bolts and lock washers and lift the pump from its mounting.

Disassemble Hand Pump

1. Withdraw the handle from the pump cam. Release the rubber boot from the pump body by removing the retaining ring.

2. Remove the two spring retainers and withdraw the pin.

3. Withdraw the cam and boot from the pump body.

4. Remove the four plugs, compression springs and check valve balls.

5. Remove the two plugs and metal gaskets and withdraw the piston, with the back-up rings and seal rings, from the pump body.

© 1983 General Motors Corp.

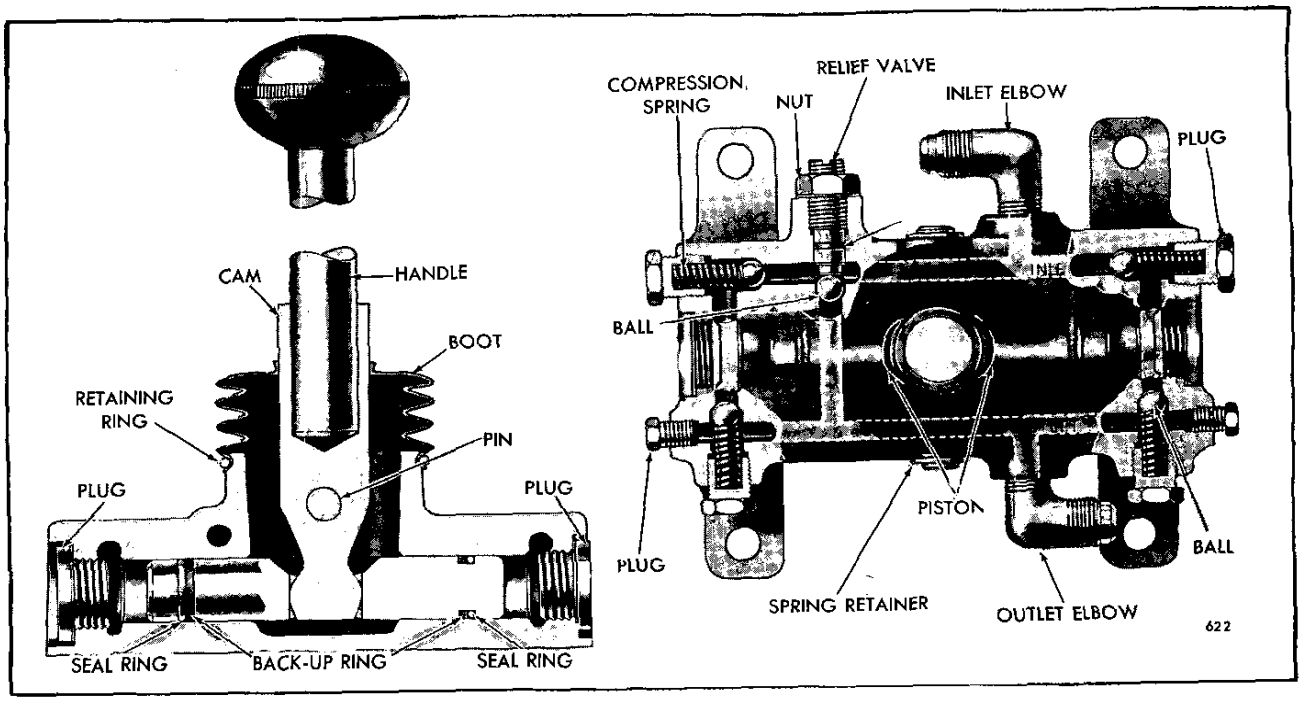


Fig. 22 - Cross Sections of Hydrostarter Hand Pump

6. Remove the relief valve and ball. The pump inlet and outlet elbows and remaining plugs may be removed, if necessary, in order to clean or inspect the pump body.

7. Remove the seal rings and the seal back-up rings from the piston.

Assemble Hand Pump

After an initial cleaning, inspect the pump parts. Stone the check valve ball seats in the pump body, if necessary. Then, thoroughly clean the pump parts and reseat the balls in the pump body, using a non-hardened steel rod. Assemble the pump as follows:

1. Thoroughly soak new back-up rings in warm oil prior to installation. Slide the back-up rings and new seal rings on the piston.

2. Insert the piston in the pump body, notched side up, and secure it in place with plugs and new metal gaskets.

3. Clean and install the four check valve balls and springs. Install the retaining plugs.

4. If the pump inlet and outlet elbows and plugs were removed, reinstall them in the pump body. Use Permatex No. 2, or equivalent, on all male threads except the thread nearest to the open end.

5. Assemble a new seal ring on the relief valve, then insert the ball in place and secure it with the relief valve and locknut.

6. Install the cam and insert the pin through the pump body and cam. Install the spring retainers on the pin. Install the rubber boot and secure it with a retaining ring.

7. Slide the handle into the cam.

Install Hand Pump

1. Secure the pump to its mounting with the attaching bolts and lock washers.

2. Refer to Fig. 1 and connect the two hydraulic hoses to the pump.

NOTE: Make sure the hoses and fittings are clean before any connections are made.

© 1983 General Motors Corp.

ACCUMULATOR

The accumulator is preloaded with nitrogen through a small valve and sealed at the time of manufacture. A seal ring is assembled in the groove of the piston, between two teflon (formerly leather) back-up rings, to prevent the nitrogen from entering the hydraulic system. The nitrogen is stored in the air valve end of the accumulator and the fluid is discharged at the opposite end.

Three different types of accumulators have been used with the Hydrostarter system (Fig. 23). The accumulator consists of a heavy duty shell assembly and piston designed to hold the nitrogen pressure for an extended period of time.

A rubber seal ring and a teflon (formerly leather) back-up ring are used at each cap to prevent the escape of fluid and nitrogen from the shell. Nitrogen is used because it is an inert gas that will not rust or corrode the piston or the accumulator. Also, it is inexpensive, non-toxic, non-explosive and readily available.

Oil enters the accumulator under pressure from either the engine-driven pump or the hand pump and forces the piston back, compressing the nitrogen gas and storing the energy to operate the system.

The accumulator is available in either 1-1/2 or 2-1/4 gallon (5.7 or 8.5 liters) capacity.

If a longer cranking period is desired, two or more accumulators may be connected in parallel, provided that a reservoir of sufficient capacity is used.

Service replacement accumulators are supplied with a precharge of nitrogen (1250 ±50 psi or 8 612 ±345 kPa).

Remove Accumulator

1. Release the oil pressure in the hoses and the accumulator by opening the relief valve on the side of the hand pump (Fig. 1).

> **CAUTION:** The oil pressure in the Hydrostarter system must be released prior to servicing the accumulator or other components to prevent possible injury to personnel or equipment.

2. Clean all of the exterior dirt from the accumulator and the hydraulic hoses.

3. Disconnect the hydraulic hose at the accumulator.

4. Remove the pressure gage and the fittings from the fluid end cap of the accumulator.

5. Remove the attaching U bolts and lift the accumulator from its mounting.

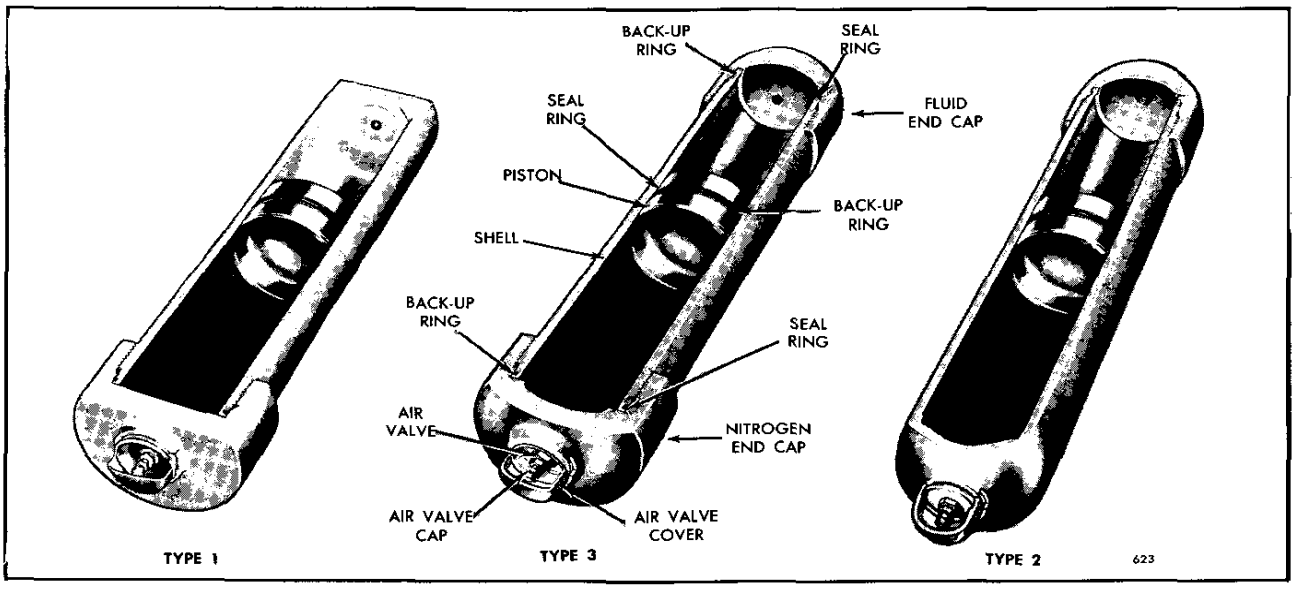


Fig. 23 - Cross Section of Typical Accumulators

© 1983 General Motors Corp.

Disassemble Accumulator

Normally, no maintenance of the accumulator is required other than painting to resist external corrosion. However, if there is a loss of the nitrogen precharge pressure due to a leaky air valve, indicated by bubbles in a soap solution applied around the valve, or due to leakage past the piston, indicated by bubbles and foaming in the reservoir, replace either the air valve or the piston seal rings as required. Seal rings between the end cap and the shell will rarely require replacement, unless the accumulator is disassembled.

1. If a defective air valve was the cause of leakage, remove the air valve cover (Fig. 23) from the accumulator cap and the air valve cap from the air valve. Loosen the 5/8" hex swivel nut on the air valve stem approximately 1-1/2 turns and then depress the valve core to release any remaining nitrogen pressure before removing the air valve. Remove the valve and replace it with a new part.

However, if damaged piston and cap seal rings are surmised, continue with the disassembly.

2. Remove the accumulator caps from the shell with a strap wrench, then push the piston out of the shell by hand.

On the former accumulator (TYPE 1 or 2), remove the cap from the shell with a strap wrench, then, insert a rod through the tapped hole in the fluid end or air valve end of the shell and push the piston out of the shell. Do not damage the threads in the accumulator with the rod.

3. Remove and discard the seal ring and the back-up rings from the piston.

4. Remove and discard the seal rings and the back-up rings from the shell.

Assemble Accumulator

After cleaning the shell, piston and cap thoroughly, assemble the accumulator as follows:

1. Install new teflon back-up rings (Fig. 23) and new seal rings ("O" rings) in the grooves of the shell, with the seal ring nearest the open end of the shell (Fig. 24).

NOTE: It is important that the teflon seal be installed in the ring groove of the shell so that the open ends do not catch on the threads of the steel cap when it is threaded into the end of the shell. Lubricate the seal ring and the sealing surface of the end cap with engine oil before installing the cap. Reverse positioning of the open ends of the back-up ring can cause contact between the ends and the cap itself. This can cause the back-up ring to buckle and result in an improper seal ring seal when the cap is threaded on the shell.

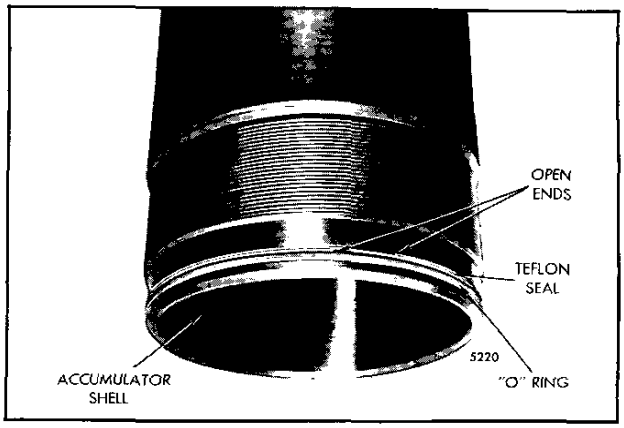


Fig. 24 - Proper Installation of Teflon Back-up Ring

2. On the current TYPE 3 accumulator, install the fluid end cap on the shell, being careful not to damage the seal ring.

3. Assemble a new seal ring between the two new teflon back-up rings in the piston ring groove. To insure correct positioning of the seal ring ("O" ring) and the two teflon back-up rings, it is recommended that a suitable ring compressor with a diameter capacity of 3-1/2" to 7" and a 3-1/2" high compression bank be used.

4. Install the ring compressor on the piston and rings and place the entire assembly on the open end of the shell (Fig. 25). Lubricate the inner surface of the ring compressor and the beginning inner region of the shell with engine oil to reduce friction between the piston and the shell.

5. Carefully drive the piston into the shell with a hammer and block of wood, tapping gently to slowly move the seal ring and back-up rings across the chamfered edge of the shell.

a. On TYPE 1 and 3 accumulators, slide the piston, crown side first, into the shell.

On a TYPE 2 accumulator, slide the piston, crown side facing out, into the shell.

b. On TYPE 1 and 3 accumulators, install the nitrogen end cap on the shell.

© 1983 General Motors Corp.

On a TYPE 2 accumulator, install the fluid end cap on the shell.

6. Install the fittings and pressure gage in the fluid end cap. Use sealant (Permatex No. 2, or equivalent) on all male threads except the thread nearest the open end.

Install Accumulator

1. Secure the accumulator to its mounting with the U bolts.

2. Connect the hydraulic hoses to the accumulator.

NOTE: Make sure the hoses and fittings are clean before any connections are made.

Charge Accumulator

Use the following procedure in precharging an accumulator with commercial nitrogen.

1. Attach the gage end of charging kit J 6714-C to the nitrogen tank (Fig. 26).

2. Remove the air valve cover from the accumulator cap and the cap from the air valve (Fig. 23).

3. Install the air valve stem extension on the air valve.

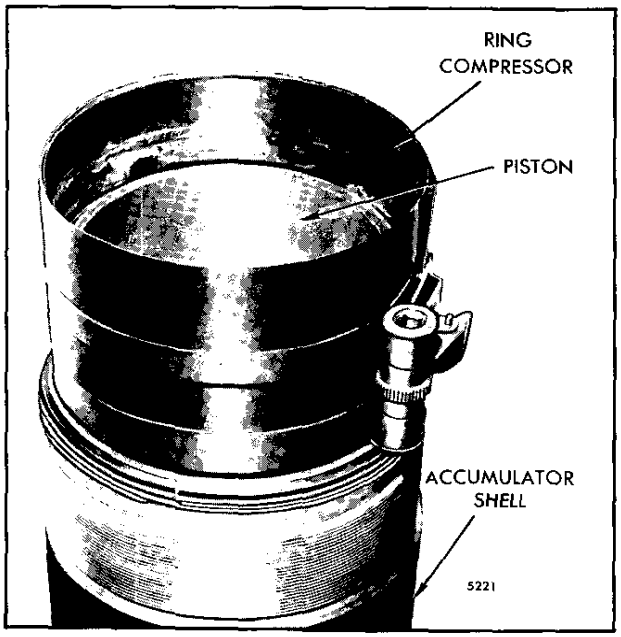


Fig. 25 - Installing Piston in Accumulator Shell

4. Completely back-off the shaft pin in the air check valve connector on the charging kit hose and install the connector on the air valve stem extension. Draw the swivel nut up tight.

5. Loosen the 5/8" hex locknut on the accumulator air valve stem by turning it counterclockwise. Do not turn the locknut more than one and one-half turns.

6. Turn the shaft pin in the air check valve connector clockwise until the valve core in the air valve is depressed.

7. Charge the accumulator by opening the valve on the nitrogen tank and allow a small flow of nitrogen to enter the accumulator until the charging kit gage registers 1300 psi (9 957 kPa). Close the nitrogen tank valve.

To check the precharge pressure during charging, simply shut off the valve to the nitrogen tank, allow a small increment of time for the pressure to stabilize and the pressure indicated on the gage is the accumulator precharge pressure.

8. Back-off the shaft pin in the air check valve and tighten the 5/8" hex locknut on the accumulator valve stem. This isolates the pressure in the charging kit hose.

9. Depress the bleed-off valve on the pressure gage to reduce the pressure in the hose to zero.

10. Repeat Steps 5 and 6 to check for a precharge pressure of 1250 psi (8 612 kPa).

11. Disconnect the accumulator charging kit from the accumulator and from the nitrogen tank.

12. Check for gas leakage by applying a soap solution to the accumulator valve stem.

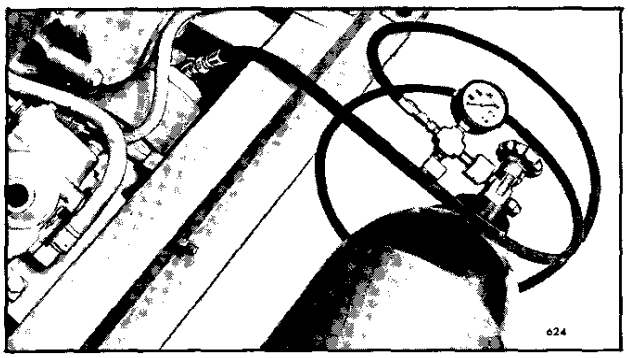


Fig. 26 - Charging Accumulator with Charging Kit J 6714-C

© 1983 General Motors Corp.

13. Replace the cap on the air valve and install the air valve cover on the accumulator cap.

14. Be sure the Caution Decal (This Vessel Precharged to 1250 psi with dry nitrogen) is on the accumulator.

RESERVOIR

The reservoir consists of a cylindrical steel tank of sufficient capacity to hold the entire oil supply for the Hydrostarter system. A filler cap and breather assembly, with a dry-type filter, is located at the top of the reservoir. A fine mesh screen at the reservoir outlet filters all of the fluid flowing to the suction side of the pump.

Reservoirs are available in two basic shapes to fit various installations. There are four sizes of reservoirs: 10, 12, 16 or 23 quart (9, 11, 15 or 22 liter) capacity. The size of the reservoir used depends upon the requirements of the particular Hydrostarter installation.

The supply hoses (Fig. 1) leading to the engine-driven pump and the hand pump are connected to the screen at the bottom of the reservoir. A return hose from the engine-driven pump connects to the top of the reservoir, while a drain hose from the Hydrostarter motor is connected to the fitting at the side of the reservoir.

The reservoir must be mounted (with the filler cap at the top) so that the outlet at the bottom of the tank is not more than 36" below nor 12" above the inlet of the engine-driven pump.

The reservoir requires very little attention other than periodically draining and flushing the old fluid out and cleaning the screen. After cleaning, fill the reservoir with new clean fluid. Make certain that the oil level is sufficient to completely cover the screen at the bottom of the reservoir. This check is made after the accumulator is charged and the engine-driven pump is bypassing oil to the reservoir.

FUEL SYSTEM PRIMING PUMP

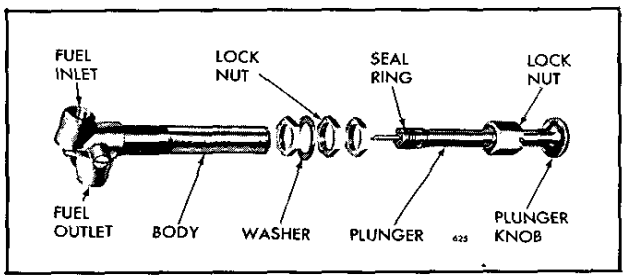


Fig. 27 - Fuel System Priming Pump and Relative Location of Parts

The small compact priming pump (Fig. 27) is used to permit the operator to prime the injectors. Before starting the engine, the operator must make sure ample fuel is present in the injectors, fuel lines, fuel filters and fuel manifolds.

The priming pump requires very little service other than an occasional cleaning of the ball check valves in the inlet and outlet passages of the pump or replacement of the seal rings. To clean the ball check valves, remove the plugs, springs and ball check valves. Clean the parts with fuel oil and reinstall them in the pump.

To replace the seal rings, loosen the locknut and withdraw the plunger. Discard the oil seal rings. Install new seal rings and insert the plunger carefully in the pump body. Tighten the locknut.

HYDRAULIC REMOTE CONTROL SYSTEM

The hydraulic remote control system consists of a master cylinder, a pedal, a lever arm, two springs and a flexible hose. It is an independent hydraulic system using diesel fuel oil as the hydraulic fluid to actuate the Hydrostarter control valve by means of the manually operated master cylinder.

The master cylinder (Figs. 28 and 29) is a single piston, positive displacement type of mechanism and is connected to the control valve on the Hydrostarter by a flexible hose. The fluid displaced by the piston is ported to the rear of the control valve.

Hydraulic pressure opens the control valve and engages the starter pinion with the engine flywheel ring gear in the proper sequence.

The master cylinder may be located at any desired

© 1983 General Motors Corp.

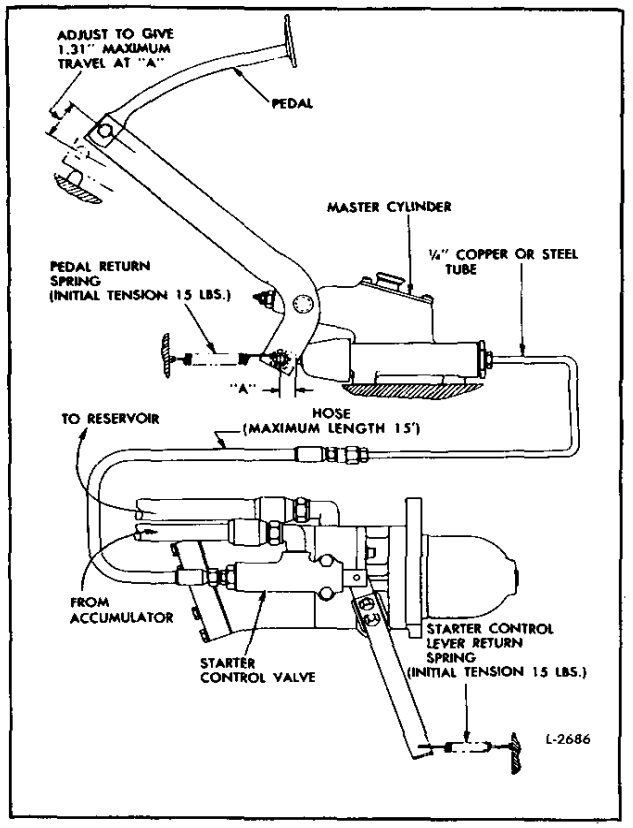


Fig. 28 - Hydraulic Remote Control System for Hydrostarter

location. However, for distances greater than 15 feet, 1/4" O.D. steel or copper tubing must be used between the flexible hose and the master cylinder. The flexible hose is always connected to the Hydrostarter control valve housing.

Current Hydrostarter motors are equipped with a control valve that incorporates a threaded valve housing plug with a 1/8"-27 tapped hole in the center for installation of the flexible hose. A 1/8"-27 vent plug is installed when the remote control system is not used. A cup plug was used in the valve housing on former Hydrostarter motors.

Springs are used to return the master cylinder piston and the Hydrostarter control lever to the off position. The springs have an initial tension of 15 lbs (Fig. 28).

The master cylinder lever arm must be adjusted to give the piston push rod a maximum travel of 1.31" (Fig. 28). The Hydrostarter control valve must be free to open to a minimum of 1-1/16".

The Hydrostarter remote control system may be purged of air as follows:

1. Fill the master cylinder with fuel oil.

2. Loosen the hose fitting at the Hydrostarter control valve.

3. Actuate the master cylinder pedal until all of the air is discharged from the system and a solid stream of fuel oil is being discharged with each stroke.

NOTE: Replenish the fluid in the master cylinder as required during the purging operation.

4. Tighten the hose fitting and check for leaks.

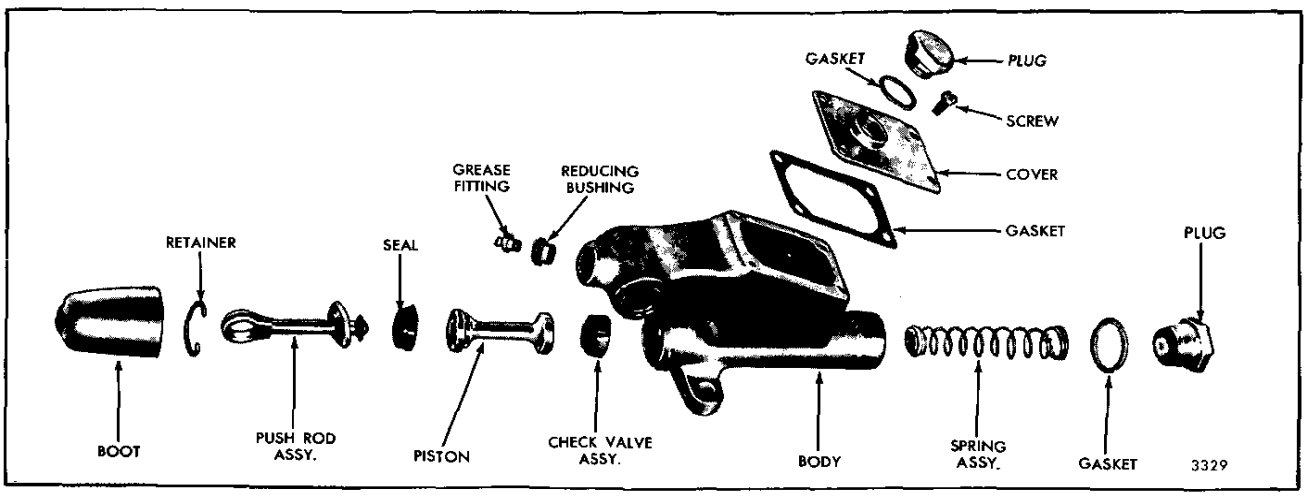


Fig. 29 - Hydraulic Starter Remote Control Master Cylinder Details and Relative Location of Parts

© 1983 General Motors Corp.

LUBRICATION AND PREVENTIVE MAINTENANCE

Inspect the system periodically for leaks. Primarily, examine the high pressure hoses, connections, fittings and the control valve on the starter. Make certain that the oil level in the reservoir is sufficient to completely cover the screen at the bottom of the tank. Make this check after the accumulator is charged and the engine-driven pump is bypassing oil to the reservoir.

Every 2000 hours, or as conditions warrant, drain the reservoir and remove the screen. Flush out the reservoir and clean the screen and filler cap. Then, reinstall the screen.

Remove the bowl and element from the filter in the engine-driven pump supply hose (Fig. 1). Wash the bowl and element in clean fuel oil and reassemble the filter.

Release the pressure and drain the remaining hydraulic fluid from the system by disconnecting the hoses from the Hydrostarter components. Then, reconnect all of the hydraulic hoses.

> **CAUTION:** The oil pressure in the system must be released prior to servicing the Hydrostarter motor or other components to prevent possible injury to personnel or equipment.

Make sure all hoses and fittings are clean before any connections are made.

Fill the Hydrostarter system with new clean fluid as recommended.

Lubrication

Remove the Hydrostarter from the engine every 2000 hours for lubrication. Before removing the Hydrostarter, release the pressure in the system by means of the relief valve in the hand pump. Then, remove the three bolts that retain the starting motor to the flywheel housing. Remove the starting motor without disconnecting the hydraulic hoses. This will prevent dirt and air from entering the hydraulic system.

Apply a good quality, lightweight grease on the drive clutch pinion to make sure the clutch will slide freely while compressing the spring. Also, apply grease to the fingers of the clutch fork and on the spool of the clutch yoke engaged by the fork. This lubrication period may be reduced or lengthened according to the severity of service.

Remove the pipe plug from the starting motor drive housing and saturate the shaft oil wick with engine oil. Then reinstall the plug.

After lubricating, install the starting motor on the flywheel housing and recharge the accumulator with the hand pump.

On units equipped with a hydraulic remote control system, lubricate the shaft in the master cylinder through the pressure grease fitting every 2000 hours.

Cold Weather Operation

Occasionally, when an engine is operated in regions of very low temperatures, the starter drive clutch assembly may slip when the starter is engaged. If the clutch slips, proceed as follows:

1. Release the oil pressure in the system by opening the relief valve in the hand pump.

> **CAUTION:** The oil pressure in the system must be released prior to servicing the Hydrostarter motor or other components to prevent possible injury to personnel or equipment.

2. Disconnect the hydraulic hoses from the starting motor.

3. Remove the three retaining bolts and lock washers and withdraw the starting motor from the flywheel housing.

4. Disassemble the starting motor.

5. Wash the Hydrostarter drive clutch assembly in clean fuel oil to remove the old lubricant.

6. When the clutch is free, apply SAE 5W lubricating oil.

7. Reassemble the starting motor and reinstall it on the engine. Then attach a tag to the starter noting the lubricant used in the clutch.

8. Recharge the accumulator with the hand pump.

Marine Application

In addition to the normal Hydrostarter lubrication and maintenance instructions, the following special precautions must be taken for marine installations or other

© 1983 General Motors Corp.

cases where equipment is subject to salt spray and air, or other corrosive atmospheres:

1. Clean all exposed surfaces and apply a coat of zinc-chromate primer, followed by a coat of suitable paint.

2. Apply a liberal coating of Lubriplate, type 130-AA, or equivalent, to the following surfaces.

a. The exposed end of the starter control valve and around the control shaft where it passes through the clutch housing (Fig. 5).

b. The exposed ends of the hand pump cam pin (Fig. 22).

3. Operate all of the moving parts and check the protective paint and lubrication every week.

Service

Before any work is performed, the oil pressure in the Hydrostarter system must be released to prevent possible injury to personnel or equipment.

Remove all of the exterior dirt before any portion of the hydraulic system is opened. Dust, dirt or other foreign material must never be allowed to enter the system.

© 1983 General Motors Corp.

TROUBLESHOOTING - SPECIFICATIONS - SERVICE TOOLS

TROUBLESHOOTING (Hydrostarter)

Chart 1

LOW OR NO ACCUMULATOR PRESSURE

ENGINE DRIVEN PUMP FAILS TO RAISE PRESSURE

Probable Causes

1. AIR IN SYSTEM
2. LOW FLUID LEVEL
3. SCREEN OR FILTER PLUGGED
4. CHECK VALVES NOT FUNCTIONING PROPERLY
5. DRIVE BELT SLIPPING (BELT-DRIVEN PUMP)
6. DRIVE ARM DEFECTIVE (DIRECT-DRIVEN PUMP)

SUGGESTED REMEDY

1. To purge the engine driven pump of air:

   a. Operate the engine at maximum no-load engine speed.

   b. Break the hose connection at the discharge side of the engine-driven pump until a full stream of oil is discharged from the pump.

   c. Connect the hose to the pump and alternately loosen and tighten the swivel fitting on the discharge hose until oil leaking out, when the fitting is loose, appears free of air bubbles.

   d. Tighten the fitting securely and observe the pressure gage. The pressure must rise rapidly to the accumulator precharge pressure (1250 psi or 8 619 kPa at 70° F or 21° C), then increase slowly to 2900 to 3300 psi (19 996 to 22 754 kPa) in six to ten minutes, depending upon the size of the particular accumulator. If the accumulator pressure does not rise, make certain that the hand pump relief valve is closed after the pressure is released and repeat the above purging procedure.

2. The fluid level in the reservoir must be sufficient to completely cover the screen at the bottom of the tank after the accumulator is charged and the engine-driven pump is bypassing a full stream of fluid to the reservoir.

3. Remove and clean the reservoir screen and flush out the reservoir tank. Also, clean the filter located in the supply hose between the reservoir and the engine-driven pump.

4. Open the relief valve on the side of the hand pump, while the engine is running, to permit the engine-driven pump to wash the check valves free from particles.

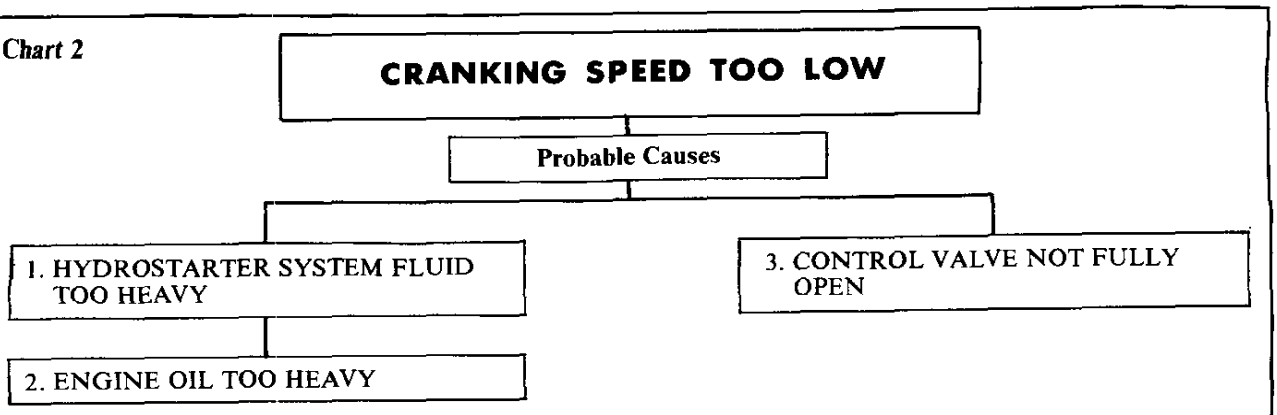
   If the accumulator can be charged with the hand pump but not with the engine-driven pump, then a check valve in the engine pump is defective. Replace the faulty check valve assembly.

5. Adjust or replace the drive belt, if necessary.

6. Replace the pump drive arm.

© 1983 General Motors Corp.

Chart 2



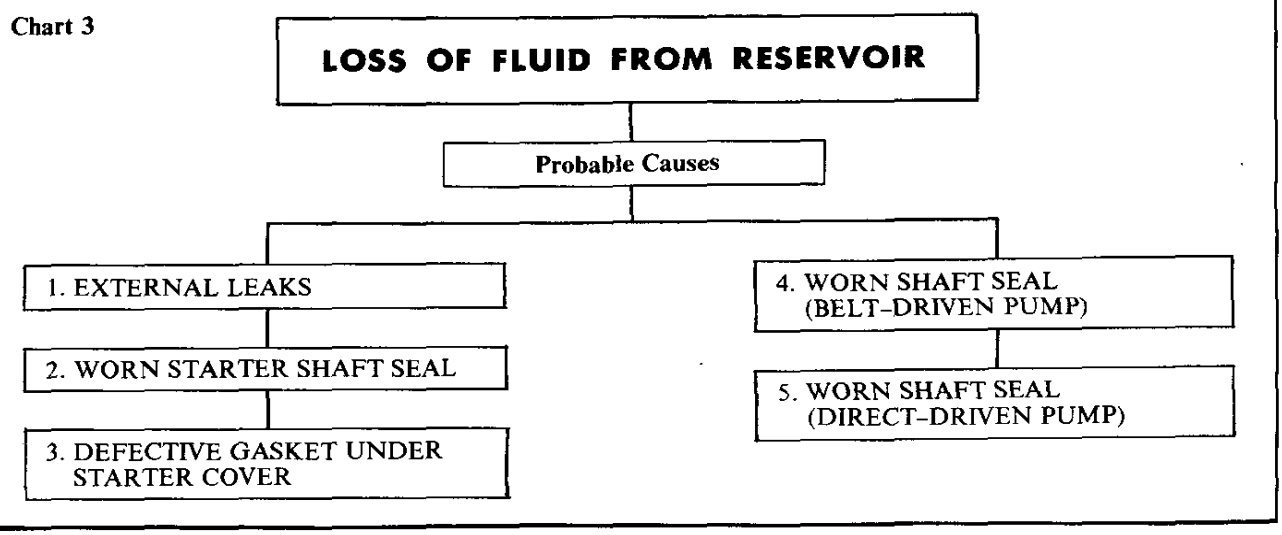
SUGGESTED REMEDY

1. Check the mixture of fluid in the system. Use fluid consisting of 75% diesel fuel and 25% SAE 10 or 30 lubricating oil.

2. Replace the oil with the proper viscosity grade. Refer to the *Lubrication Specifications* in Section 13.3.

3. Check the travel of the control valve located on the side of the starter. Minimum travel is 1-1/16″. Remove any obstruction that prevents sufficient control valve or control lever handle travel.

Chart 3



SUGGESTED REMEDY

1. With pressure in the system, check all hoses and fittings for leaks. Tighten or replace the fittings and any defective parts.

2. Remove the starter after releasing the system pressure and observe the inside of the clutch housing. If evidence of system fluid is found, replace the shaft seal.

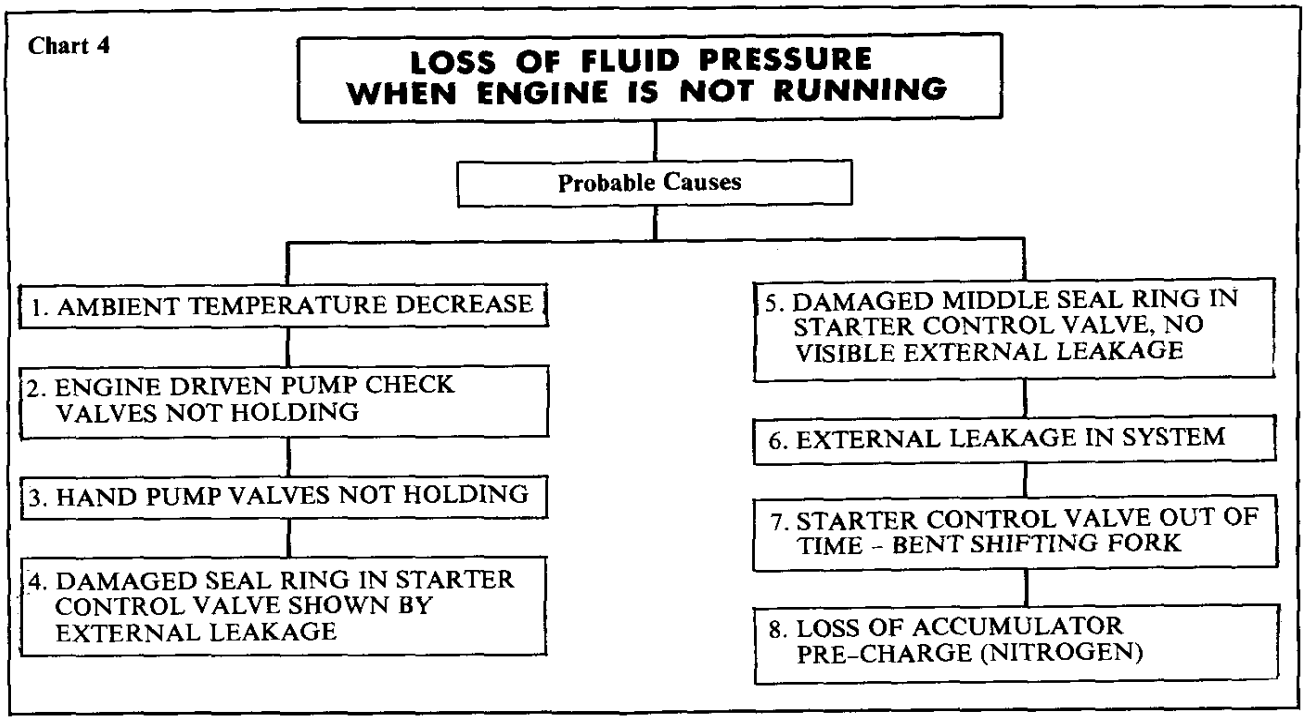
3. Operate the starter. During the cranking cycle, watch closely for fluid leaking around the cover or any of the retaining bolts.

4. While the pump is bypassing at full system pressure, examine the shaft for evidence of leaks. Replace the seal, if necessary.

5. After the pump has been bypassing at full system pressure, remove the pump from the flywheel housing and examine the back of the mounting plate near the seal for evidence of leaks. Replace the shaft seal, if necessary.

© 1983 General Motors Corp.

Chart 4



SUGGESTED REMEDY

1. A drop in temperature will decrease the nitrogen pressure. Adjust the pressure as needed for cranking requirements by use of the hand pump.

2. Disconnect the return hose and inlet hose from the engine-driven pump. Leakage from the inlet fitting means that both check valves are defective. Leakage at the return fitting means that only the outlet check valve is defective. Replace the defective check valve assembly(s).

3. Disconnect the inlet hose from the hand pump. Leakage from the inlet fitting means that either the relief valve alone or both the inlet and outlet check valves are defective. Stone and clean the ball seats in the pump body and replace the balls and springs, if necessary.

4. Remove the control valve from the starter and replace the seal ring.

5. Disconnect the return hose from the starter. Use the hand pump to raise the pressure, if necessary. If fluid leaks from the return fitting when the control valve is closed, the middle seal ring is damaged. Remove the control valve and replace the seal ring.

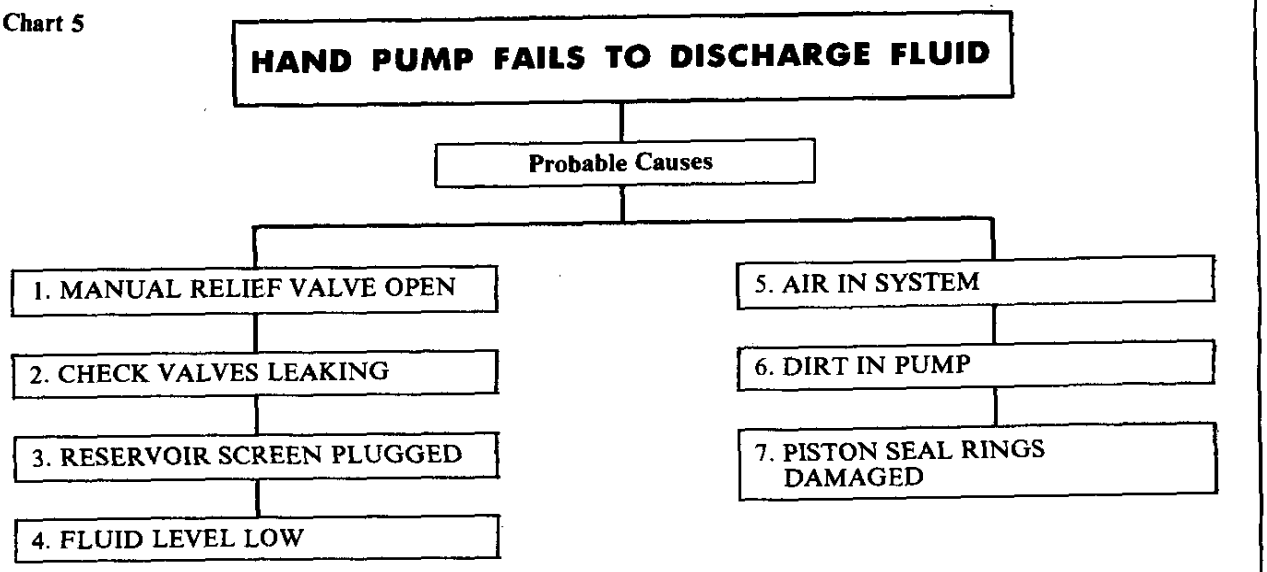
6. Examine all hoses and fitting for leaks. Tighten or replace the fittings and any defective parts.

7. With the control valve closed, check the length of the piston protruding beyond the valve body. The correct length is 7/8" ±1/32". If the length is incorrect, the shifting fork may be bent or the nylon yoke between the fork and the clutch collar may be damaged. Replace the faulty parts.

8. See Chart 7.

© 1983 General Motors Corp.

Chart 5



SUGGESTED REMEDY

1. Close the relief valve.

2. If caused by dirt, open the relief valve and operate the hand pump slowly for a few minutes to wash the particles out of the check valves. If this is unsuccessful, stone and clean the ball seats in the pump body and replace the balls and springs, if necessary.

3. Remove and clean the reservoir screen, flush the reservoir tank and reassemble.

4. See Chart 2., Item 2.

5. To purge the hand pump of air:

   a. Relieve any system pressure, then disconnect the outlet hose from the hand pump.

   b. Close the manual relief valve and operate the pump until fluid is discharged when stroking in both directions.

   c. Reconnect the outlet hose.

6. See Item 2.

7. Replace the seal rings.

© 1983 General Motors Corp.

Chart 6

STARTER TURNS BUT ENGINE DOES NOT

Probable Causes

1. PINION NOT ENGAGING FLYWHEEL RING GEAR
2. PINION CLUTCH SLIPPING (COLD WEATHER OR HEAVY LUBRICANT)
3. OVERRUNNING CLUTCH BURNED OUT
4. STARTER ASSEMBLED WRONG

SUGGESTED REMEDY

1. Check the shifting fork. If the fork is bent, replace it.

2. Wash out the heavy lubricating oil and replace it with SAE 5W or SAE 10 oil.

3. Replace the clutch. If a mechanical linkage is attached to the control lever, add sufficient spring force to assure that the clutch is withdrawn from engagement, and that the control valve is returned to the shutoff position. If no mechanical linkage is used, disengage the starter as soon as the engine starts. Prolonging the period during which the clutch overruns will reduce clutch life.

4. The starter may be assembled for L.H. rotation but with a R.H. overrunning clutch. Remove the starter and assemble it correctly.

Chart 7

LOSS OF ACCUMULATOR PRE-CHARGE (NITROGEN)

Probable Causes

1. DAMAGED SEAL RING ON PISTON
2. DEFECTIVE AIR VALVE
3. DAMAGED SEAL RING BETWEEN SHELL AND END CAP

SUGGESTED REMEDY

1. With some nitrogen precharge but no fluid pressure in the system, bubbles and foaming in the reservoir indicate that the nitrogen is leaking past the seal ring on the accumulator piston. Overhaul the accumulator.

2. Release the pressure in the system by opening the relief valve on the side of the hand pump. Then, loosen the hex locknut on the nitrogen valve approximately 3/4 turn to release the remaining percharge before attempting to remove the valve from the accumulator. Replace the air valve.

3. Apply light oil on the threaded end of the accumulator at the end of the cap. Bubbling of the oil indicates a leak past the end cap seal. Release the nitrogen precharge before removing the cap to replace the seals.

© 1983 General Motors Corp.

Chart 8

HIGH PRESSURE IN SYSTEM
3500 psi (24 133 kPa) or above

Probable Causes

1. DEFECTIVE GAGE
2. ENGINE DRIVEN PUMP UNLOADING VALVE NOT OPERATING PROPERLY

SUGGESTED REMEDY

1. Replace the gage.
2. Overhaul the pump.

Chart 9

FLUID EMERGES FROM RESERVOIR FILLER CAP WHEN STARTER IS USED

Probable Causes

1. FILTER ELEMENT IN FILLER CAP LOADED WITH DIRT
2. NITROGEN IN FLUID RETURNED TO RESERVOIR
3. EXCESS FLUID IN RESERVOIR

SUGGESTED REMEDY

1. Rinse the filler cap thoroughly in fuel oil and dry it with compressed air.

2. Overhaul the accumulator. See Chart 7, Item 1.

3. Check the fluid level after the accumulator is charged and the engine-driven pump is bypassing a full stream of oil to the reservoir. The fluid level must be sufficient to completely cover the screen in the bottom of the tank.

© 1983 General Motors Corp.

Chart 10

FLUID EMERGES AROUND RUBBER BOOT ON HAND PUMP

Probable Cause

1. DAMAGED PISTON SEAL RINGS

SUGGESTED REMEDY

1. Replace the seal rings and leather back-up rings on the pump piston.

Chart 11

FLUID EMERGES FROM ENDS OF STARTER CONTROL VALVE WHEN STARTER IS OPERATED

Probable Causes

1. DAMAGED FRONT CONTROL VALVE SEAL RING

2. BENT SHIFTING FORK CAUSING END OF CONTROL VALVE TO MOVE PAST THE REAR SEAL RING

SUGGESTED REMEDY

1. Operate the starter. If fluid emerges around the front end of the control valve, the seal ring is damaged.

2. See Chart 4, Item 7. Also, operate the starter. If fluid emerges from the cap on the rear of the control valve, the fork is bent and the seal ring may be damaged.

© 1983 General Motors Corp.

SPECIFICATIONS

Hydrostarter Motor

Type	Swash plate
Number of pistons	Seven
Displacement per revolution *20 Series*	2 cu. in. (32.8 cm^3)
Displacement per revolution *35 Series*	3.5 cu. in. (57.4 cm^3)
Maximum torque at 3000 psi *20 Series*	80 lb-ft (108 Nm)
Maximum torque at 3000 psi *35 Series*	140 lb-ft (190 Nm)
Drive	Overrunning clutch
Inlet port *20 and 35 Series*	No. 8 elbow (J1C 37° flare)
Return port *20 Series*	No. 10 elbow (SAE 45° flare)
Return port *35 Series*	No. 12 elbow (SAE 45° flare)

Engine-Driven Pump

Type	Positive displacement
Number of pistons	One
Displacement per revolution	0.0208 cu. in. (.400 cm^3)
Inlet port	No. 6 elbow (SAE 45° flare)
Outlet port	No. 6 elbow (J1C 37° flare)
By-pass port	No. 4 elbow (SAE 45° flare)
Maximum discharge pressure	3250 psi (22 409 kPa)
Maximum continuous speed	2500 rpm

Manual Pump

Type	Positive displacement
Number of pistons	One
Displacement per stroke	0.773 cu. in. (12.67 cm^3)
Inlet port	No. 6 elbow (SAE 45° flare)
Outlet port	No. 6 elbow (J1C 37° flare)

Accumulator

Type	Piston
Capacity	200 or 300 cu. in. (3278 or 4916 cm^3)
Precharge (nitrogen)	1250 psi (8 619 kPa)
Operating pressure	2900-3000 psi (19 996-20 685 kPa)
Port	3/8 NPTF

Reservoir

Capacity	10, 12, 16 or 23 qt. (9.5, 11.4, 15.1 or 21.8 liters)
Outlet port	1/4 NPT
Pump return port	1/8 NPT
Starter return port	1/2 NPT
Drain (plug) port	1/8 NPT

Remote Control Master Cylinder

Type	Positive displacement
Number of pistons	One
Displacement per stroke	1.2 cu. in. (19.7 cm^3)
Outlet port	7/16-24 inverted flare tap

Filter

Type	Sediment bowl-stacked disc
Degree of filtration	50 microns
Inlet port	1/8 NPTF
Outlet port	1/8 NPTF

© 1983 General Motors Corp.

STANDARD BOLT AND NUT TORQUE SPECIFICATIONS

THREAD SIZE	260M BOLTS TORQUE (lb-ft)	Nm	THREAD SIZE	280M OR BETTER TORQUE (lb-ft)	Nm
1/4 -20	5- 7	7- 9	1/4 -20	7-9	10-12
1/4 -28	6- 8	8-11	1/4 -28	8-10	11-14
5/16-18	10-13	14-18	5/16-18	13-17	18-23
5/16-24	11-14	15-19	5/16-24	15-19	20-26
3/8 -16	23-26	31-35	3/8 -16	30-35	41-47
3/8 -24	26-29	35-40	3/8 -24	35-39	47-53
7/16-14	35-38	47-51	7/16-14	46-50	62-68
7/16-20	43-46	58-62	7/16-20	57-61	77-83
1/2 -13	53-56	72-76	1/2 -13	71-75	96-102
1/2 -20	62-70	84-95	1/2 -20	83-93	113-126
9/16-12	68-75	92-102	9/16-12	90-100	122-136
9/16-18	80-88	109-119	9/16-18	107-117	146-159
5/8 -11	103-110	140-149	5/8 -11	137-147	186-200
5/8 -18	126-134	171-181	5/8 -18	168-178	228-242
3/4 -10	180-188	244-254	3/4 -10	240-250	325-339
3/4 -16	218-225	295-305	3/4 -16	290-300	393-407
7/8 - 9	308-315	417-427	7/8 - 9	410-420	556-569
7/8 -14	356-364	483-494	7/8 -14	475-485	644-657
1 - 8	435-443	590-600	1 - 8	580-590	786-800
1 -14	514-521	697-705	1 -14	685-695	928-942

Grade identification markings are normally stamped on the heads of the bolts. To aid identification of the various bolts used in Detroit Diesel engines, refer to the following chart.

Grade Identification Marking on Bolt Head	GM Number	SAE Grade Designation	Nominal Size Diameter (inch)	Tensile Strength Min. (psi)
None	GM 255-M	1	No. 6 thru 1 1/2	60,000
None	GM 260-M	2	No. 6 thru 3/4 over 3/4 to 1 1/2	74,000 60,000
Bolts and Screws	GM 280-M	5	No. 6 thru 1 over 1 to 1 1/2	120,000 105,000
Hex Head Sems Only	GM 275-M	5.1	No. 6 thru 3/8	120,000
Bolts and Screws	GM 290-M	7	1/4 thru 1 1/2	133,000
Bolts and Screws	GM 300-M	8	1/4 thru 1 1/2	150,000
Bolts and Screws	GM 455-M	None	No. 6 thru 1 1/2	55,000

12252

BOLT IDENTIFICATION CHART

© 1983 General Motors Corp.

SERVICE TOOLS

TOOL NAME	TOOL NO.
Accumulator charging kit	J 6714-C
Oil seal installer set	J 7191
Piston, back-up ring, seal ring and washer installer	J 7192
Spring compressor	J 7187

© 1983 General Motors Corp.

SECTION 13

OPERATING INSTRUCTIONS

CONTENTS

Engine Operating Instructions	13.1
Operating Instructions--A.C. Power Generator Set	13.1.1
Operating Instructions--D.C. Power Generator Set	13.1.2
Operating Instructions--Diesel Railcar Unit	13.1.4
Engine Operating Conditions	13.2
Engine Run-In Instructions	13.2.1
Fuels, Lubricants and Coolants	13.3

© 1972 General Motors Corp.

ENGINE OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

Before starting an engine for the first time, carefully read and follow the instructions in Sections 13 and 14 of this manual. Attempting to run the engine before studying these instructions may result in serious damage to the engine.

NOTE: When preparing to start a new or overhauled engine or an engine which has been in storage, perform all of the operations listed below. Before a routine start (at each shift), see *Daily Operations* in the *Lubrication and Preventive Maintenance Chart*, Section 15.1.

Cooling System

Install all of the drain cocks or plugs in the cooling system (drain cocks are removed for shipping).

Open the cooling system vents, if the engine is so equipped.

Loosen the water return line (if used) near the top of the turbocharger.

Remove the filler cap and fill the cooling system with a coolant specified under *Coolant Specifications* in Section 13.3. Keep the liquid level about two inches below the filler neck to allow for fluid expansion.

Close the vents, if used, after filling the cooling system.

Tighten the turbocharger water return line (if used).

On marine installations, prime the raw water cooling system and open any sea cocks in the raw water pump intake line. Prime the raw water pump by removing the pipe plug or electrode provided in the pump outlet elbow and pour water in the pump.

NOTE: Failure to prime the raw water pump may result in damage to the pump impeller.

Lubrication System

The lubricating oil film on the rotating parts and bearings of a new or overhauled engine, or one which has been in storage, may be insufficient for proper lubrication when the engine is started for the first time. Insufficient lubrication at start-up can cause serious damage to the engine components.

To ensure an immediate flow of oil to all bearing surfaces at initial engine start-up, DDA recommends that the engine lubrication system be charged with a commercially available pressure pre-lubricator. Use the following procedure:

1. Remove the pipe plug from the engine main oil gallery and attach the pre-lubricator hose.

2. Remove the valve rocker cover(s) and, using a positive displacement pump set at 25-35 psi (172-241 kPa), pump in the recommended grade of engine lubricating oil until it is observed flowing from the rocker arms.

3. If the engine is turbocharged, disconnect the oil supply lines at the turbo bearing (center) housings and fill the bearing housing cavities with approximately one pint of the recommended grade of clean engine oil. Turn the rotating assemblies by hand to coat all internal surfaces with oil and reinstall the turbo oil supply lines (refer to Section 3.5).

4. After 20 minutes, check the crankcase oil level. Add enough oil to bring the level to the "full" mark on the dipstick. *Do not overfill.*

5. Disconnect the pre-lubricator hose, plug the main oil gallery hole and replace all components previously removed.

6. Before initial engine start-up, DDA also recommends cranking the engine with the governor in the no-fuel position until oil pressure registers on the gage.

For engine lubricating oil recommendations, see *Lubrication Specifications* in Section 13.3 or contact a Detroit Diesel Allison distributor.

If a pressure prelubricator is not available, fill the crankcase to the proper level with *heavy-duty* lubricating oil as specified under *Lubrication Specifications* in Section 13.3. Then, prelubricate the upper engine parts by removing the valve rocker cover and pouring lubricating oil, of the same grade and viscosity as used in the crankcase, over the rocker arms.

Turbocharger

1. Clean the area and disconnect the oil inlet line at the bearing housing.

2. Fill the bearing housing cavity with clean engine oil. Turn the rotating assembly by hand to coat all of the internal surfaces with oil.

© 1983 General Motors Corp.

3. Add additional engine oil to completely fill the bearing housing cavity and reinstall the oil line. Clean off any spilled oil.

CAUTION: Do not hold the compressor wheel, for any reason, while the engine is running. This could result in personal injury.

4. Start and run the engine at idle until oil pressure and supply has reached all of the turbocharger moving parts. A good indicator that all of the moving parts are getting lubrication is when the oil pressure gage registers pressure (10 psig - 69 kPa at idle speed).

The free floating bearings in the turbocharger center housing require positive lubrication. This is provided by the above procedure *before the turbocharger reaches its maximum operating speed* which is produced by high engine speeds. Starting any turbocharged engine and accelerating to any speed above idle before engine oil supply and pressure has reached the free floating bearings can cause severe damage to the shaft and bearings of the turbocharger.

Air Cleaner

If the engine is equipped with oil bath air cleaners, fill the air cleaner oil cups to the proper level with clean engine oil. *Do not overfill.*

Transmission

Check the oil level and, if necessary, fill the transmission case, marine gear or torque converter supply tank to the proper level with the lubricant specified under *Lubrication and Preventive Maintenance* in Section 15.1.

Fuel System

Fill the fuel tank with the fuel specified under *Fuel Specifications* in Section 13.3.

If the unit is equipped with a fuel valve, it must be opened.

To ensure prompt starting, fill the fuel system between the pump and the fuel return manifold with fuel. If the engine has been out of service for a considerable length of time, prime the fuel system between the fuel pump and the fuel return manifold. The fuel system may be primed by removing the plug in the top of the fuel filter cover and slowly filling the filter with fuel.

In addition to the above, on an engine equipped with a hydrostarter, use a priming pump to make sure the fuel lines and the injectors are full of fuel before attempting to start the engine.

NOTE: The fuel system is filled with fuel before leaving the factory. If the fuel is still in the system when preparing to start the engine, priming should be unnecessary.

Lubrication Fittings

Fill all grease cups and lubricate at all fittings (except for fan hub pulley fitting -- refer to Section 15.1) with an all purpose grease. Apply lubricating oil to the throttle linkage and other moving parts and fill the hinged cap oilers with a hand oiler.

Drive Belts

Adjust all drive belts as recommended under *Lubrication and Preventive Maintenance* in Section 15.1.

Storage Battery

Check the battery. The top should be clean and dry, the terminals tight and protected with a coat of petroleum jelly and the electrolyte must be at the proper level.

NOTE: When necessary, check the battery with a hydrometer; the reading should be 1.265 or higher. However, hydrometer readings should always be corrected for the temperature of the electrolyte.

Generator Set

Where applicable, fill the generator end bearing housing with the same lubricating oil as used in the engine.

NOTE: The base of a generator set must be grounded.

A generator set should be connected and grounded in accordance with the applicable local electrical codes.

Clutch

Disengage the clutch, if the unit is so equipped.

STARTING

Before starting the engine for the first time, perform the operations listed under *Preparation For Starting Engine First Time.*

© 1983 General Motors Corp.

Before a routine start, see *Daily Operations* in the *Lubrication and Preventive Maintenance Chart*, Section 15.1.

If a manual or an automatic shutdown system is incorporated in the unit, the control must be set in the open position before starting the engine. The blower will be seriously damaged if operated with the air shutoff valve in the closed position.

Starting at air temperatures below 40° F (4° C) requires the use of a cold weather starting aid. See *Cold Weather Starting*, Section 12.6.

> **CAUTION:** Starting fluid used in capsules is highly inflammable, toxic and possesses anesthetic properties.

The instructions for the use of a cold weather fluid starting aid will vary dependent on the type being used. Reference should be made to these instructions before attempting a cold weather start.

Initial Engine Start (Electric)

Start an engine equipped with an electric starting motor as follows: Set the speed control lever at part throttle, then bring it back to the desired no-load speed. In addition, on mechanical governors, make sure the stop lever on the governor cover is in the *run* position; on hydraulic governors, make sure the stop knob is pushed all the way in. Then, press the starting motor switch firmly. If the engine fails to start within 30 seconds, release the starting switch and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

On twin or quad units, move the master throttle lever to the *idle* position and engage the starting motors one at a time.

> **NOTE:** To prevent serious damage to the starter, if the engine does not start, do not press the starting switch again while the starting motor is running.

Initial Engine Start (Hydrostarter)

Start an engine equipped with a hydrostarter as follows:

Use the priming pump to make sure the fuel filter, fuel lines and injectors are full of fuel before attempting to start the engine.

Raise the hydrostarter accumulator pressure with the hand pump until the gage reads as indicated in Table 1.

Ambient Temperature	Pressure Gage Reading	
	psi	kPa
Above 40° F (4.4° C)	1500	10 342
40 - 0° F (4.4 to -18° C)	2500	17 237
Below 0° F (-18° C)	3300	22 753

TABLE 1

Set the engine controls for starting with the throttle at least half open.

> **NOTE:** During cold weather, add starting fluid at the same time the hydrostarter motor lever is moved. Do not wait to add the fluid after the engine is turning over.

Push the hydrostarter control lever to simultaneously engage the starter pinion with the flywheel ring gear and to open the control valve. Close the valve as soon as the engine starts to conserve the accumulator pressure and to avoid excessive over-running of the starter drive clutch assembly.

RUNNING

Oil Pressure

Observe the oil pressure gage immediately after starting the engine. If there is no pressure indicated within 10 to 15 seconds, stop the engine and check the lubricating oil system. Refer to the *Trouble Shooting Charts* in Section 15.2.

Warm-Up

Run the engine at part throttle and no load for approximately five minutes, allowing it to warm-up before applying a load.

If the unit is operating in a closed room, start the room ventilating fan or open the windows, as weather conditions permit, so ample air is available for the engine.

Inspection

While the engine is running at operating temperature, check for coolant, fuel or lubricating oil leaks. Tighten the line connections, where necessary, to stop leaks.

© 1983 General Motors Corp.

Engine Temperature

See Section 13.2 for normal engine coolant temperatures.

Crankcase

If the engine crankcase was refilled, stop the engine after normal operating temperature has been reached, allow the oil to drain (approximately twenty minutes) back into the crankcase and check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick.

Use only the *heavy duty* lubricating oil specified under *Lubrication Specifications* in Section 13.3.

Clutch

Do not engage the clutch (with a sintered iron clutch plate) at engine speeds over 850 rpm. A clutch with an asbestos or vegetable fiber material clutch plate must not be engaged at speeds over 1000 rpm.

Cooling System

Remove the radiator or heat exchanger tank cap *slowly* after the engine has reached normal operating temperature and check the engine coolant level. The coolant level should be near the top of the opening. If necessary, add clean soft water or an ethylene glycol base antifreeze.

Transmission

Check the marine gear oil pressure. Refer to Section 13.2 for the specified oil pressure (Allison or Paragon gears) or Table 2 (Twin Disc gears).

Check and, if necessary, add sufficient oil to bring it to the proper level.

Turbocharger

Make a visual inspection of the turbocharger for leaks and excessive vibration. Stop the engine immediately if there is an unusual noise in the turbocharger.

Avoid Unnecessary Engine Idling

During long engine idling periods, the engine coolant temperature will fall below the normal operating range. The incomplete combustion of fuel in a cold engine will cause crankcase dilution, formation of lacquer or gummy deposits on the valves, pistons and rings and rapid accumulation of sludge in the engine.

NOTE: When prolonged engine idling is necessary, maintain at least 800 rpm.

STOPPING

Normal Stopping

1. Release the load and decrease the engine speed. Put all shift levers in the *neutral* position.

2. Allow the engine to run at half speed or slower with no load for four or five minutes, then move the stop lever to the *stop* position to stop the engine.

Emergency Stopping

To stop an engine (normal or emergency) equipped with the spring-loaded (one screw) design injector control tube, pull the governor stop lever to the stop position.

If an engine equipped with the non-spring loaded (two screw) design injector control tube does not stop after using the normal stopping procedure, pull the *Emergency Stop* knob all the way out. This control cuts off the air to the engine. Do not try to restart again until the cause for the malfunction has been found and corrected.

NOTE: The emergency shutdown system should never be used except in an emergency. Use of the emergency shutdown can cause oil to be sucked past the oil seals and into the blower housing.

The air shutoff valve, located on the blower air inlet housing, must be reset by hand and the *Emergency Stop* knob pushed in before the engine is ready to start again.

Fuel System

If the unit is equipped with a fuel valve, close it. Fill the fuel tank; a full tank minimizes condensation.

Exhaust System

Drain the condensation from the exhaust line or silencer.

Cooling System

Drain the cooling system if it is not protected with antifreeze and freezing temperatures are expected. Leave the drains open. Open the raw water drains of a heat exchanger cooling system.

© 1983 General Motors Corp.

Operating Oil Pressure at 180° F (82° C)*									
Marine Gear	Position	† Test rpm	Test Pressure psi	Test Pressure kPa	Marine Gear	Position	† Test rpm	Test Pressure psi	Test Pressure kPa
MG-506 (except 1.5:1 and 2:1 ratios)	Neutral and Engaged	600	280-315	1930-2170	MG-514 (less than 4:1 ratio) (shallow case)	Neutral	600	20-65	138-448
						Neutral	1800	45-92	310-634
	Neutral and Engaged	1800	300-320	2067-2205		Engaged	600	210-235	1447-1619
						Engaged	1800	228-237	1571-1633
	Cruising	Min.	270	1861		Cruising	Min.	215	1481
MG-506 (only 1.5:1 and 2:1 ratios)	Neutral and Engaged	600	330-365	2274-2515	MG-514 (4:1 and greater ratio) (deep case)	Neutral	600	35-65	241-448
						Neutral	1800	50-85	379-586
	Neutral and Engaged	1800	350-370	2412-2550		Engaged	600	187-215	1289-1481
						Engaged	1800	193-220	1330-1516
	Cruising	Min.	335	2308		Cruising	Min.	185	1275
MG-509	Neutral	600	35-70	241-483	MG-521	Neutral	600	45-85	310-586
	Neutral	1800	50-85	345-586		Neutral	1800	75-100	517-689
	Engaged	600	187-215	1289-1481		Engaged	600	180-215	1241-1481
	Engaged	1800	193-220	1330-1516		Engaged	1800	188-220	1296-1516
	Cruising	Min.	165	1137		Cruising	Min.	165	1137
MG-512	Neutral	600	45-70	310-483	MG-527	Neutral	600	45-85	310-586
	Neutral	1800	60-90	414-621		Neutral	1800	65-100	448-689
	Engaged	600	185-215	1275-1481		Engaged	600	180-215	1241-1481
	Engaged	1800	195-220	1344-1516		Engaged	1800	188-220	1296-1516
	Cruising	Min.	185	1275		Cruising	Min.	165	1137
MG-513	Neutral	600	70-110	483-758					
	Neutral	1800	90-130	621-896					
	Engaged	600	230-270	1585-1861					
	Engaged	1800	240-280	1654-1930					
	Cruising	Min.	234	1612					

* Sump or heat exchanger inlet 210° F (99° C) maximum. Normal operating range desired 140-180° F (60-82° C) minimum continuous duty.

† Sump or heat exchanger inlet 225° F (107° C) maximum intermittent permissable in pleasure craft.

TABLE 2 (Twin Disc Gears)

Crankcase

Check the oil level in the crankcase. Add oil, if necessary, to bring it to the proper level on the dipstick.

Transmission

Check and, if necessary, add sufficient oil to bring it to the proper level.

Inspection

Make a visual check for leaks in the fuel, lubricating and cooling systems.

Clean Engine

Clean and check the engine thoroughly to make certain it will be ready for the next run.

Refer to the *Lubrication and Preventive Maintenance Chart* in Section 15.1 and perform all of the daily maintenance operations. Also perform the operations required for the number of hours or miles the engine has been in operation.

Make the necessary adjustments and minor repairs to correct difficulties which may have occurred during the previous run.

© 1980 General Motors Corp.

OPERATING INSTRUCTIONS - A.C. POWER GENERATOR SET

These instructions cover the fundamental procedures for operating an alternating current power generator set. The operator should read these instructions before attempting to operate the unit.

Never operate a generator set for a short (15 minute) interval - the engine will not reach normal operating temperature in so short a period.

Avoid operating the set for extended periods at no load.

Ideally, operate the set for one hour with at least 40% load (generator rating).

When a test must be made with a line load of less than 40% of the generator rating, add a supplementary load.

Connect the supplementary load to the load terminals of the control cabinet circuit breaker so that the generator can be "loaded" whenever the breaker is closed.

Make certain that the supplementary load is such that it can be controlled to permit a reduction in the load should a normal load increase occur while the set is operating. Locate the supplementary load outside the engine room, if desirable, to provide adequate cooling.

Loading the generator set to 40% of the generator rating and operating it for one hour intervals will bring the engine and generator to normal operating temperatures and circulate the lubricants properly. Abnormal amounts of moisture, carbon and sludge are due primarily to low internal operating temperatures which are much less likely to occur when the set is tested properly.

PREPARATION FOR STARTING

Before attempting to start a new or overhauled engine or an engine which has been in storage, perform all of the operations listed under "Preparations for Starting Engine First Time" in Section 13.1. Before a routine start see "Daily Operations" in the "Lubrication and Preventive Maintenance Chart" in Section 15.1.

In addition to the "Engine Operating Instructions", the following instructions also apply when operating an alternating current power generator unit.

1. Before the first start, fill the generator main bearing oil reservoir to the proper level on the sight gage with the same grade of lubricating oil that is used in the engine crankcase. *Do not overfill.*

2. Check the interior of the generator for dust or moisture. Blow out dust with low pressure air (25 psi or 172 kPa maximum). If there is moisture on the interior of the generator or alternator, it must be dried before the unit is started. See appropriate Delco Products Maintenance Bulletin.

3. The air shutdown valve located in the air inlet housing must be in the open or reset position.

4. Refer to Fig. 1 and place the circuit breaker (162) in the *off* position.

5. Place the field switch (157) in the *off* position.

6. Place the synchronizing lamp switch (156) in the *off* position.

7. Place the voltage regulator switch (151) in the *off* or *manual* position.

8. Turn the field rheostat knob (159) clockwise to its lower limits.

9. Make sure the power generator set has been cleared of all tools or other objects which might interfere with its operation.

STARTING

If the unit is located in a closed space, start the ventilating fan or open the doors and windows, as weather permits, to supply ample air to the engine.

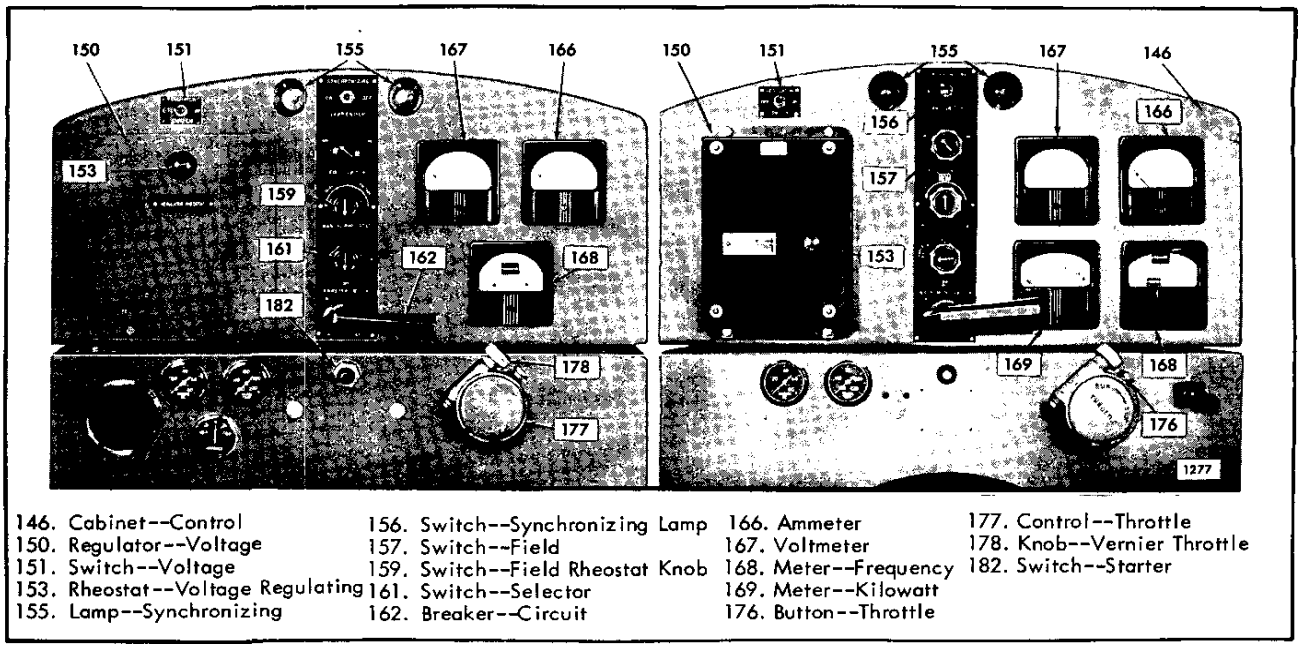
The engine will require the use of a cold weather starting aid if the ambient temperature is below 40°F (4°C). Refer to "Cold Weather Starting Aid" in Section 12.6.

Press the throttle button (176) and turn the throttle control (177) counterclockwise to a position midway between *run* and *stop* (Fig. 1). Then, press the starting motor switch (182) firmly.

If the engine fails to start within 30 seconds, release the starting switch and allow the starting motor to cool a few minutes before trying again. If the engine fails to start after four attempts, an inspection should be made to determine the cause.

NOTE: To prevent serious damage to the starter, if the engine does not start, do not press the starting switch again while the starter motor is rotating.

© 1983 General Motors Corp.



146. Cabinet--Control
150. Regulator--Voltage
151. Switch--Voltage
153. Rheostat--Voltage Regulating
155. Lamp--Synchronizing
156. Switch--Synchronizing Lamp
157. Switch--Field
159. Switch--Field Rheostat Knob
161. Switch--Selector
162. Breaker--Circuit
166. Ammeter
167. Voltmeter
168. Meter--Frequency
169. Meter--Kilowatt
176. Button--Throttle
177. Control--Throttle
178. Knob--Vernier Throttle
182. Switch--Starter

Fig. 1 - Typical Alternating Current Generator Control Cabinets

RUNNING

Oil Pressure

Observe the engine oil pressure gage immediately after starting the engine. If there is no oil pressure indicated within 10 to 15 seconds, stop the engine and check the engine lubricating system. The oil pressure should be at least 30 psi (207 kPa) at 1200 rpm.

Inspection

While the engine is running at rated speed and no load, check for water, fuel or lubricating oil leaks. Tighten line connections, where necessary, to stop leaks.

Engine Crankcase

If the engine crankcase was refilled, and the power supply from the unit is not immediately needed, stop the engine after it has been running approximately five minutes. Then, allow sufficient time for the oil to drain back to the crankcase and check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick.

Use only the Heavy Duty Lubricating Oils as specified under "Lubrication Specifications" in Section 13.3.

Cooling System

Remove the radiator or heat exchanger tank cap SLOWLY and check the engine coolant level. The coolant level should be near the top of the opening. If necessary, add clean soft water or an ethylene glycol base antifreeze.

PREPARING UNIT FOR LOAD

1. Bring the engine up to rated speed. Then, place the field switch (157) in the *on* position (Fig. 1).

2. Turn the voltage regulator switch (151) *on*.

3. Turn the instrument selector switch (161) to the desired position.

4. Turn the field rheostat (159) slowly in a counterclockwise direction to raise the voltage, while watching the voltmeter, until the desired voltage is reached. The voltage regulator will take control of the generator voltage as the field rheostat reaches the end of its travel.

5. If the power generator is equipped with a frequency meter, adjust the engine speed with the vernier throttle knob (178) until the desired frequency is indicated on the meter.

6. Adjust the voltage regulator rheostat (153) to obtain the desired voltage.

© 1983 General Motors Corp.

7. Make sure all power lines are clear of personnel, then, place the circuit breaker control (162) in the *on* position.

NOTE: Perform Step 7 only if the unit is not being paralleled with an existing power source. If the unit is being paralleled with a power source already on the line, read and follow the instructions under "Paralleling" before turning the the circuit breaker control to the *on* position.

PARALLELING

If the load conditions require an additional unit to be placed on the line, the following instructions will apply to power generator units of EQUAL CAPACITY, with one unit in operation on the line.

1. Prepare the unit to be paralleled as outlined under "Preparation for Starting", "Starting", "Running" and Items 1 through 6 under "Preparing Unit for Load".

2. Check the voltmeter (167) the voltage must be the same as the line voltage (Fig. 1). Adjust the voltage regulator rheostat control (153) if the voltages are not the same.

3. Place the synchronizing lamp switch (156), of the power unit to be paralleled, in the *on* position.

4. Turn the vernier throttle knob (178) until both units are operating at approximately the same frequency indicated by the slow change in the brilliancy of the synchronizing lamps.

5. When the synchronizing lamps glow and then go out at a very slow rate, time the dark interval. Then, in the middle of this interval turn the circuit breaker control to the *on* position. This places the incoming power unit on the line, with no load. The proper share of the existing load must now be placed on this unit.

6. The division of the kilowatt load between the alternating current generators operating in parallel depends on the power supplied by the engines to the generators as controlled by the engine governors and is practically independent of the generator excitation. Divide the kilowatt load between the units by turning the vernier throttle knob (178) counterclockwise on the incoming unit and clockwise on the unit that has been carrying the load (to keep the frequency of the units constant), until both kilowatt meters (169) indicate that each unit is carrying its proper percentage of the total K.W. load. Refer to Item 8 if the units are not equipped with kilowatt meters.

7. The division of the reactive KVA load depends on the generator excitation as controlled by the voltage regulator. Divide the reactive load between the units by turning the voltage regulator rheostat control on the incoming unit (generally counterclockwise to raise the voltage) until the ammeters read the same on both units and the sum of the readings is minimum.

NOTE: The units are equipped with a resistor and current transformer connected in a series with the voltage coil of the regulator (cross-current compensation) which equalizes most but not all of the reactive KVA load between the generators.

8. When the load is unity power factor (lighting and a few small motors only) follow the instructions in Item 6 above until both ammeters read the same.

The ammeter (166) of one 60 KW unit shows 75 amperes when paralleled with another identical 60 KW unit, one unit ammeter reads 50 amperes and the other reads 25 amperes. This improper division of the load may be corrected by turning the vernier knob (178) counterclockwise on unit having the low reading ammeter until both ammeters read the same.

9. When the load is 80% power factor lagging (motor and a few lights only), turn the vernier throttle knob (178) on the incoming unit until the ammeter on that unit reads approximately 40% of the total current load.

10. Rotate the voltage regulator rheostat control (153) on the incoming unit (generally counterclockwise to raise the voltage) until the ammeters read the same on both units.

NOTE: If a load was not added during paralleling, the total of the two ammeter readings should be the same as the reading before paralleling. Readjust the voltage regulator rheostat (153) on the incoming unit, if necessary.

11. To reset the load voltage, turn the voltage regulator rheostat controls slowly on each unit. It is necessary to turn the controls the same amount and in the same direction to keep the reactive current equally divided.

Power generator units with different capacities can also be paralleled by dividing the load proportionately to their capacity.

STOPPING

The procedure for stopping a power generator unit or taking a unit out of parallel is as follows:

© 1983 General Motors Corp.

1. Turn off all the load on the generator when stopping a single engine unit.

Shift the load from the generator when taking a unit out of parallel operation by turning the vernier throttle knob (178) until the ammeter (166) reads approximately zero (Fig. 1).

2. Place the circuit breaker control (162) in the *off* position.

3. Turn the voltage regulator switch (151) to the *off* position.

4. Place the field switch (157) in the *off* position.

5. Press the throttle button (176) and turn the throttle control (177) to *stop* to shutdown the engine.

NOTE: When performing a tune-up on a unit that will be operated in parallel with another unit, adjust the speed droop as specified in "Engine Tune-Up".

© 1983 General Motors Corp.

OPERATING INSTRUCTIONS - D.C. POWER GENERATOR SET

These instructions cover the fundamental procedures for operating an alternating current power generator set. The operator should read these instructions before attempting to operate the set.

Never operate a generator set for a short (15 minute) interval -- the engine will not reach normal operating temperature in so short a period.

Avoid operating the set for extended periods at no load.

Ideally, operate the set for one hour with at least 40% load (generator rating).

When a test must be made with a line load of less than 40% of the generator rating, add a supplementary load.

Connect the supplementary load to the load terminals of the control cabinet circuit breaker so that the generator can be "loaded" whenever the breaker is closed.

Make certain that the supplementary load is such that it can be controlled to permit a reduction in the load should a normal load increase occur while the set is operating. Locate the supplementary load outside the engine room, if desirable, to provide adequate cooling.

Loading the generator set to 40% of the generator rating and operating it for one-hour intervals will bring the engine and generator to normal operating temperatures and circulate the lubricants properly. Abnormal amounts of moisture, carbon and sludge are due primarily to low internal operating temperatures which are much less likely to occur when the set is tested properly.

PREPARATION FOR STARTING

Before starting an engine the first time, or one that has been inactive for a considerable period of time, the operator should read carefully and follow the instructions under "Preparation for Starting Engine First Time" in Section 13.1. Before a routine start see "Daily Operations" in Section 15.1.

For operating a direct current power generator set, include the following instructions.

1. Fill generator main bearing oil reservoir to level mark on sight gauge with lubricating oil of the same viscosity as that used in the engine crankcase.

2. Lubricate unit as outlined in the LUBRICATION and PREVENTIVE MAINTENANCE chart in Section 15.1.

3. See that the overspeed trip solenoid lever located at the air inlet housing has returned to the open or reset position.

4. Refer to Fig. 1 and place circuit breaker (162) in the *off* position.

5. Place field switch (157) in *off* position.

6. Place ground lamp switch (156) in *off* position.

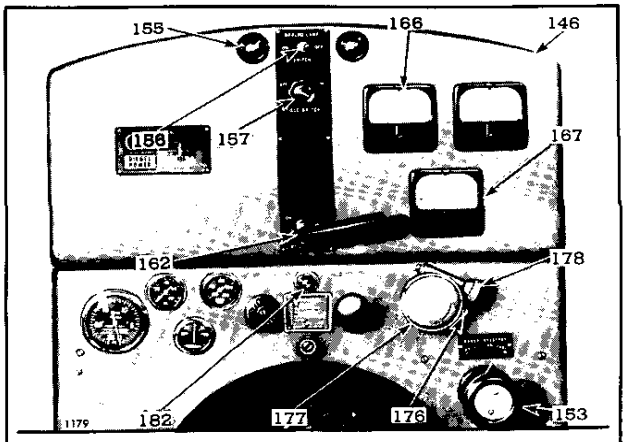
7. Turn field rheostat knob (153) counterclockwise (left) to its limit.

8. Clear power unit of loose tools or other obstructions that may hamper its operation.

STARTING

Refer to Fig. 1 and press throttle button (176) and turn throttle control (177) counterclockwise to a position midway between *run* and *stop*.

2. Press starting button firmly to start engine. Do not operate cranking motor more than 30 seconds at a time to avoid overheating motor.



146. Cabinet--Control
153. Rheostat--Voltage Adjusting
155. Lamp--Ground
156. Switch--Ground Lamp
157. Switch--Field
162. Breaker--Circuit
166. Ammeter
167. Voltmeter
176. Button--Throttle
177. Control--Throttle
178. Knob--Vernier
182. Button--Starter

Fig. 1 - Typical Control Cabinet

© 1983 General Motors Corp.

NOTE: If engine fails to start, DO NOT press button again until after cranking motor stops rotating. Serious damage to the cranking motor may result if the above rule is not followed.

If an engine fails to start after four periods of cranking, refer to TROUBLE SHOOTING CHART in Section 15.2.

Starting at air temperatures below 40°F (4°C) requires the use of a cold weather starting aid. See STARTING AIDS in section 12.6.

3. Immediately after starting, observe the oil pressure on gauge and, if no pressure is shown after 10-15 seconds, stop engine and check lubricating system.

Run engine at part throttle and no load for approximately 5 minutes to permit it to warm up before placing the load on the unit.

If circumstances prevent it, forego the warm-up period and apply load as soon as the oil pressure reaches normal.

4. If unit is operating in a closed room, start room ventilating fan or open windows as weather conditions permit to provide ample fresh air for the engine.

RUNNING

Check Unit

With engine running at normal operating temperature, check the unit carefully for water, fuel oil or lubricating oil leaks. Tighten line connections where necessary to stop leaks.

Engine Temperature

Under normal operating conditions, the engine coolant temperature should range between 160° and 185°F (71° and 85°C) with a corresponding oil temperature of 200° to 225°F (93° to 107°C).

Engine Crankcase

Upon starting an engine *the first time following a crankcase refill*, bring the engine up to its normal operating temperature. Then stop engine and allow sufficient time for the oil to drain back to the crankcase and check the oil level. Add oil, if necessary, to bring it to the proper level on the dipstick.

Cooling System

When the engine has reached its normal operating temperature, remove the radiator or heat exchanger tank cap slowly and check level of engine coolant. Add sufficient soft water or an ethylene glycol base antifreeze to bring coolant up to the proper level near the top of the tank.

PREPARING UNIT FOR LOAD

1. When engine is warm, refer to Fig. 1 and turn throttle control (177) counterclockwise to the *run* position.

2. Turn vernier throttle knob (178) and adjust engine speed approximately 50 rpm above the full-load rated speed.

3. If required, reset governor droop as outlined in Engine Tune-Up.

4. Place field switch (157) in the *on* position.

5. Check voltmeter and turn field rheostat (153) to raise or lower voltage to that desired.

NOTE: Step 5 may be performed only if unit is not being paralleled with an existing power source. If the unit is being paralleled with a power source already on the line, follow instructions under "Paralleling" before closing the circuit breaker.

6. Make sure all power lines are clear of personnel, then place the circuit breaker in the *on* position.

Check the electrical circuit occasionally for a ground by means of the ground lamps. With the unit operating, place switch (156) in the *on* position. If both lamps are dim and of equal brilliancy, the circuit is satisfactory. If one lamp remains dark and the other is bright, a ground exists on one of the power leads.

PARALLELING

If load conditions require that an additional unit be placed on the line, the following instructions will apply, *but only to those units equipped with equalizer connections and should not be attempted on other units.*

On "flat compound wound" two-wire direct current generators, it is necessary to connect the equalizer leads together for stable operation. The equalizer cables should have a current carrying capacity equal to or larger than the cables necessary to carry the

© 1983 General Motors Corp.

required load. On generators equipped with a three-wire system, a two-pole knife switch must be placed in the equalizer lines.

Do not use parallel operation if one unit is capable of carrying the required load, as both engine and generator operate more efficiently when operating alone at full load.

1. Place No. 1 unit in service as outlined under "Preparing Unit for Load".

2. Prepare unit to be paralleled as outlined in Items 1 through 5 under "Preparing Unit for Load".

3. Adjust speed of incoming unit to no load operating speed by the use of vernier throttle knob (178).

4. Adjust voltage of incoming unit to existing line voltage by the use of field rheostat (153).

5. Close equalizer switch, then close circuit breaker.

6. Adjust field rheostat (153) to equally divide the line load (Fig. 1).

STOPPING GENERATOR SET

When stopping a generator set or removing a unit from parallel operation, the following steps should be followed:

1. Shut off all load on the generator set when stopping a single engine unit.

Shift the load from the generator when removing the unit from parallel operation by turning field rheostat (153) toward minimum excitation position until the ammeter reads approximately zero.

2. Open circuit breaker.

3. Open equalizer switch.

4. Turn field rheostat to minimum excitation position.

5. Press throttle button (176) and turn the throttle control (177) to the no-fuel position. The engine will stop.

When performing an engine tune-up on a unit that will be operated in parallel with another unit, adjust the engine droop to that specified in the tune-up procedure.

© 1983 General Motors Corp.

OPERATING INSTRUCTIONS - DIESEL RAILCAR UNIT

Preparation for Starting Engine First Time

Before starting an engine the first time, the operator should carefully read and follow the instructions below. Attempting to run the engine before studying these instructions may result in serious damage to the unit.

> **NOTE:** When preparing to start a new unit or after a complete overhaul, perform all of the operations listed below. Before a routine start, see "Daily Operations" in Section 15.1.

Air Cleaner

Check the oil level in the air cleaner and add oil as required to bring the oil to the level mark. *Do not overfill.*

Cooling System

Install all drain cocks in the cooling system. Drain cocks are removed for shipping.

Check the level of the water in the expansion tank. When replenishing the water supply, use care so as not to overfill the tank.

It is not necessary to mix an antifreeze solution in the cooling water as long as steam is provided for yard parking when the engine is shut down. However, when using water alone in the cooling system, use a corrosion inhibitor (see Section 13.3).

Lubrication System

The lubricating oil film on certain upper parts of new engines, overhauled engines, or engines which have been in storage for a considerable length of time, may be inadequate for proper lubrication when the engine is first started. For this reason, it is recommended that the upper engine parts be pre-lubricated before starting the engine.

Remove the rocker cover and pour approximately two quarts (1.9 liters) of lubricating oil (of the same viscosity as that used in the engine crankcase) over the rocker arms and push rods.

Check the oil level in the crankcase by the means of the dipstick at the side of the control cabinet. Keep the oil level to the FULL mark on the dipstick.

Use only *heavy-duty* lubricating oils, as specified under "Lubrication Specifications" in Section 13.3.

Transmission

Fill the transmission to the FULL mark on the dipstick (located at the side of transmission oil filler tube) with Hydraulic Transmission Fluid, Type "C-2".

Fuel System

Fill the fuel tank with diesel engine fuel as specified under "Fuel Specifications" in Section 13.3.

Open fuel supply valves.

To ensure prompt starting, at least that portion of the fuel system between the pump and the fuel return manifold should be filled with fuel. The fuel oil filter (between the fuel pump and the injectors), on any engine that has been out of service a considerable length of time, should be primed. To prime the filter, remove the vent plug in the top of the filter cover, fill the filter with clean fuel oil, and reinstall the vent plug.

> **NOTE:** The fuel system of a new engine is filled with fuel before leaving the factory. If the fuel is still present in the system when preparing to start, priming should be unnecessary.

Storage Battery

See Operator's Manual.

Clear Power Unit

All tools or articles that might interfere with the engine operation should be stored in their proper places.

STARTING

Before starting the unit the first time, perform the operations listed under "Preparation for Starting Engine First Time". The following routine checks should be made each time the engine is started.

Make sure the remote transmission and throttle controls are at *off* position.

© 1983 General Motors Corp.

NOTE: The engine can be started only from the engine control panel.

Press the ARRANGUE (Portuguese for start) and the REAJUST (Portuguese for reset) buttons on the engine control panel. Hold both buttons in until the engine starts. Then, release the ARRANGUE button, and continue to hold the REAJUST button *in* until the engine oil pressure reaches an operating pressure of 15 psi (103 kPa) or above, then, release the button.

When the engine starts, if any unusual noises are detected, stop the engine immediately and investigate the noise.

NOTE: If the engine fails to start, DO NOT press the buttons again until after the starting motor has stopped rotating. Do not operate the starting motor more than 30 seconds at a time without pausing to allow it to cool for at least 2 minutes. Overheating, caused by excessive cranking will seriously damage the starting motor.

If the engine does not start after four periods of cranking, see "Troubleshooting Chart" in Section 15.2.

Oil Pressure

Immediately after starting, observe the oil pressure reading on the oil gage. If there is no oil pressure after 10 to 15 seconds, release the readjust button and stop the engine; then check the lubricating system. If the oil pressure rises, continue to hold the readjust button in until the oil pressure rises to approximately 15 psi (103 kPa), then, release the button.

Warm-Up Period

Run the engine at part throttle and no load for approximately five minutes to allow the engine to warm up.

RUNNING

Oil Pressure

Observe the engine (crankcase) and the drive oil (transmission) pressure gages. When the engine oil pressure drops below approximately 12 psi (83 kPa), the contact points in the switch close, energizing the air shutdown relay, which in turn, energizes the shutdown solenoid to close the valve in the air inlet housing.

The engine oil (crankcase) pressure should not fall below 30 psi (207 kPa) at 1200 rpm and the normal operating pressure should be higher.

The normal drive oil (transmission) pressure is between 115 and 125 psi (792 and 861 kPa).

Check Unit

With the engine running at operating temperature, check the unit carefully for any water, fuel oil, or lubricating oil leaks. Tighten the line connections where necessary to stop the leaks.

Engine Temperature

Under normal operating conditions, the coolant temperature should range between 160°and 185°F (71°and 85°C).

Crankcase Oil Level

After normal operating temperature has been reached, stop the engine for a sufficient length of time to allow the oil to drain back to the crankcase and then check the oil level. Replenish to the FULL mark on the dipstick.

NOTE: This is necessary only for the first start after a crankcase refill.

Use only *heavy-duty* lubricating oils as specified under "Lubrication Specifications" in Section 13.3.

Transmission

Check the oil level, with the engine stopped, on the gage (dipstick) located at the side of the transmission oil filler tube. Replenish to the FULL mark on the gage (dipstick) with Hydraulic Transmission Fluid, Type "C-2".

NOTE: The above check is necessary only for the first start after a transmission refill.

Cooling System

Check the level of the coolant in the expansion tank and add water as required.

NOTE: When the engine is running with a stalled countershaft, do not permit the oil temperature to exceed 265°F (129°C). It can be run continuously with the controller in the

© 1983 General Motors Corp.

No. 1 position. Whereas, with the controller in the No. 4 position the temperature will rise to approximately 250 °F (121 °C) in 30 seconds.

STOPPING

See that any remote throttle controller is in the *off* position.

To Stop Engine at the Control Panel:

1. Press the PARAR (Portuguese for stop) button at the engine control panel until the engine stops.

NOTE: Under certain specific operating conditions, the low lubricating oil automatic shutdown switch may take over and complete the stop. This may occur when the oil viscosity is low due to high oil temperature.

2. Stopping the engines at the engine control panel is recommended so that the power unit may be observed for leaks, or unusual conditions, and the oil pressure and water temperature may be checked.

To Stop the Engine in the Car:

1. Move the isolation switch in the regulator lock of the engine being shut down to *isolate*, then, to the *stop* position. Hold in the *stop* position until the engine stops. Then return the switch to *isolate*.

NOTE: *Emergency methods of shut down which* cut off the fuel supply can damage the injectors and should not be used except in an emergency.

Fuel System

Check the amount of fuel in the supply tank and replenish as required. A full fuel tank reduces condensation.

Cooling System

No anti-freeze solution is necessary in the cooling water. If the engine should stop, or is stopped by the operator en route, and there is danger of freezing, the cooling system should be drained.

For yard parking, antifreeze protection must be provided by a steam train-line.

Crankcase Oil Level

Add oil as required in the engine crankcase to bring it to its proper level.

Transmission

Check and replenish with the specified oil, as required, to bring it to the FULL mark on the gage (dipstick).

Air Cleaner

Check the oil level in the air cleaner and add oil as required to bring the oil to the level mark. *Do not overfill.*

Clean Engine

Clean and check the engine thoroughly to make certain it will be ready for the next run.

Refer to "LUBRICATION AND PREVENTIVE MAINTENANCE" chart in Section 15.1 and perform all daily maintenance operation. Also, perform all the operations required for the number of hours the unit has been in operation.

Make any routine adjustments and minor repairs needed to correct the difficulties which became apparent to the operator during the last run.

© 1983 General Motors Corp.

ENGINE OPERATING CONDITIONS

The engine operating charges are included as an aid for engine operation and trouble shooting. Any variations from the conditions as listed may indicate an abnormal situation in need of correction. Make sure that the readings represent true values, and that instruments are accurate, before attempting to make corrections to the engine.

3-71, 4-71 and 6-71 ENGINES (2-Valve Head)

	1200 rpm	1800 rpm	2100 rpm	2300 rpm
Lubrication Systems				
Lubricating oil pressure (psi):				
Normal	30-60	43-65	45-65	45-65
Minimum for safe operation	18	28	30	30
†Lubricating oil temperature (deg. F) - Normal	200-225	200-225	200-225	200-225
Air System				
Air box pressure (inches mercury) - min. full load:				
At zero exhaust back pressure:				
3-71 and 4-71 engines	2.0	7.3	10.0	12.0
6-71 engine	2.4	8.1	11.0	13.0
At max. exhaust back pressure:				
3-71 and 4-71 engines	3.5	10.6	14.1	16.4
6-71 engine	3.9	11.4	15.1	17.4
Air inlet restriction (inches water) - max. full load:				
Dirty air cleaner (oil bath or dry)	12.4	25.0	25.0	25.0
Clean air cleaner (with pre-cleaner) (oil bath or dry)	8.7	13.4	15.9	17.5
Clean air cleaner (less pre-cleaner) (dry)	5.2	9.1	11.5	12.5
Crankcase pressure (inches water) - max.:				
3-71 engine	1.2	1.8	2.1	2.1
4-71 engine	1.8	2.5	2.8	2.8
6-71 engine	2.0	2.8	3.1	3.1
Exhaust back pressure (inches mercury) - max.:				
Full load	1.8	4.0	@ 5.0	5.0
Fuel System				
Fuel pressure at inlet manifold (psi):				
Normal (.055″ and .080″ orifice)	30-65	45-70	45-70	45-70
Normal (.106″ orifice)	30-65	45-70	45-70	45-70
Fuel spill (gpm) - min. at no load:				
(.055″ orifice)	0.5	0.6	0.6	0.6
(.080″ and .106″ orifice)	0.8	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:				
Clean system	6.0	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0	12.0

© 1984 General Motors Corp.

3-71, 4-71 and 6-71 ENGINES (2-Valve Head) - Cont'd.

	1200 rpm	1800 rpm	2100 rpm	2300 rpm
Cooling System				
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185	160-185
Raw water pump:				
Inlet restriction (inches mercury) - max.:				
3-71 and 4-71 engines	4.8	# 5.0	# 5.0	5.0
6-71 engine	2.4	# 5.0	# 5.0	5.0
Outlet pressure (psi) - max.	4.8	#10.0	#10.0	10.0
Keel cooler pressure drop (psi) - max. thru sys.:				
3-71 and 4-71 engines	2.4	# 5.0	# 5.0	5.0
6-71 engine	2.9	# 6.0	# 6.0	6.0

Compression	
Compression pressure (psi at sea level):	
Average - new engine at 600 rpm	440
Minimum at 600 rpm	390

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.
@Marine engines only: 5.5 inches mercury at 2100 rpm.
#Maximum when this is full-load speed of engine.

© 1984 General Motors Corp.

71E ENGINE (2-Valve Head)

	1200 rpm	1800 rpm	2000 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	30-60	43-65	45-65
Minimum for safe operation	18	28	30
†Lubricating oil temperature (deg. F) - Normal	200-225	200-225	200-225
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure	2.0	5.1	6.5
At max. full load exhaust back pressure	3.5	8.4	10.6
Air inlet restriction (inches water) - max. full load:			
Dirty air cleaner (oil bath or dry)	12.4	25.0	25.0
Clean air cleaner (with pre-cleaner) (oil bath or dry)	8.7	13.4	15.0
Clean air cleaner (less pre-cleaner) (dry)	5.2	9.1	10.5
Crankcase pressure (inches water) - max.:			
4-71E engine	1.8	2.5	2.7
6-71E engine	2.0	2.8	3.0
Exhaust back pressure (inches mercury) - max.:			
Full load	1.8	4.0	5.0
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	30-65	45-70	45-70
Fuel spill (gpm) - min. at no load:			
(.055″ orifice)	0.5	0.6	0.6
(.080″ orifice)	0.8	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185
Raw water pump:			
Inlet restriction (inches mercury) - max.:			
4-71E engine	4.8	# 5.0	5.0
6-71E engine	2.4	# 5.0	5.0
Outlet pressure (psi) - max.	4.8	#10.0	10.0
Keel cooler pressure drop (psi) - max. thru sys.:			
4-71E engine	2.4	# 5.0	5.0
6-71E engine	2.9	# 6.0	6.0
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the block cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

Maximum when this is full-load speed of engine.

© 1984 General Motors Corp.

71E ENGINE (4-Valve Head)

	1200 rpm	1800 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	30-60	43-65	45-65
Minimum for safe operation	18	28	30
†Lubricating oil temperature (deg. F) - Normal	200-225	200-225	200-225
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure	1.7	4.3	6.0
At max. full load exhaust back pressure	3.2	7.6	10.1
Air inlet restriction (inches water) - max. full load:			
Dirty air cleaner (oil bath or dry)	12.4	25.0	25.0
Clean air cleaner (with pre-cleaner) (oil bath or dry)	8.7	13.4	15.9
Clean air cleaner (less pre-cleaner) (dry)	5.2	9.1	11.5
Crankcase pressure (inches water) - max.:			
4-71E engine	1.8	2.5	2.8
6-71E engine	2.0	2.8	3.1
Exhaust back pressure (inches mercury) - max.:			
Full load	1.5	3.3	# 4.0
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	30-65	45-70	45-70
Fuel spill (gpm) - min. at no load:			
(.055" orifice)	0.5	0.6	0.6
(.080" orifice)	0.8	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185
Raw water pump:			
Inlet restriction (inches mercury) - max.:			
4-71E engine	4.8	5.0	5.0
6-71E engine	2.4	5.0	5.0
Outlet pressure (psi) - max.	4.8	10.0	10.0
Keel cooler pressure drop (psi) - max. thru sys.:			
4-71E engine	2.4	5.0	5.0
6-71E engine	2.9	6.0	6.0
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

Marine engines only: 4.4 inches mercury at 2100 rpm.

© 1984 General Motors Corp.

71N ENGINE

	1200 rpm	1800 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	30-60	43-65	45-65
Minimum for safe operation	18	28	30
†Lubricating oil temperature (deg. F) - Normal	200-225	200-225	200-225
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
N injector	0.1	2.8	4.6
C injector	0.4	2.4	4.1
7E injector	0.4	2.4	4.0
At max. full load back pressure:			
N injector	1.2	5.3	7.6
C injector	1.5	4.9	7.1
7E injector	1.5	4.9	7.0
Air inlet restriction (inches water) - max. full load:			
Dirty air cleaner (oil bath or dry)	12.4	25.0	25.0
Clean air cleaner (with pre-cleaner) (oil bath or dry)	8.7	13.4	15.9
Clean air cleaner (less pre-cleaner) (dry)	5.2	9.1	11.5
Crankcase pressure (inches water) - max.:			
4-71N engine	1.8	2.5	2.8
6-71N engine	2.0	2.8	3.1
Exhaust back pressure (inches mercury) - max.:			
Full load	1.5	3.3	4.0
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal (.080" orifice)	30-65	45-70	45-70
Fuel spill (gpm) - min. at no load (.080" orifice)	0.8	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185
Engines built 1976 and later	170-195	170-195	170-195
Compression			
Compression pressure (psi at seal level):			
Average - new engine at 600 rpm	565		
Minimum at 600 rpm	515		

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cyliner block oil gallery, it will be approximately 10° lower than the oil pan temperature.

© 1984 General Motors Corp.

71M ENGINE

	1800 rpm	2100 rpm	2300 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	43-65	45-65	45-65
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) - Normal	200-225	200-225	200-225
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
4-71M and 6-71M engines	4.3	6.0	7.2
At max. full load exhaust back pressure:			
4-71M and 6-71M engines	6.8	9.4	11.3
Air inlet restriction (inches water) - max. full load:			
Dirty air cleaner (oil bath or dry)	25.0	25.0	25.0
Clean air cleaner (with pre-cleaner) (oil bath or dry)	13.4	15.9	17.5
Clean air cleaner (less pre-cleaner) (dry)	9.1	11.5	12.5
Crankcase pressue (inches water) - max.:			
4-71M engine	2.5	2.8	2.8
6-71M engine	2.8	3.1	3.1
Exhaust back pressure (inches mercury) - max.:			
Full load	3.3	4.5	5.5
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal (.080" orifice)	45-70	45-70	45-70
Fuel spill (gpm) - min. at no load (.080" orifice)	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185
Raw water pump:			
Inlet restriction (inches mercury) - max.:			
4-71M engine	# 5.0	# 5.0	5.0
6-71M engine	# 5.0	# 5.0	5.0
Outlet pressure (psi) - max.	#10.0	#10.0	10.0
Keel cooler pressure drop (psi) - max. thru sys.:			
4-71M engine	# 5.0	# 5.0	5.0
6-71M engine	# 6.0	# 6.0	6.0
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	440		
Minimum at 600 rpm	390		

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

#Maximum when this is full-load speed engine.

© 1984 General Motors Corp.

71T ENGINE (with M5, M10 or T1865 Turbocharger)

	1800 rpm	2100 rpm	2300 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	43-65	45-65	45-65
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) - Normal	200-235	200-235	200-235
Air System			
Air box pressure (inches mercury) - min. full load:			
At max. full load exhaust back pressure:			
70mm injector	17.1	23.0	@27.1
80mm injector	13.4	18.8	22.5
90mm injector	15.0	20.9	25.0
√ At minmum no-load speed:			
Air inlet restriction (inches water) - max. full load:			
Dirty air cleaner (oil bath or dry):			
4-71T (M5) and 6-71T (M10)	12.3	16.7	20.0
6-71T (M5) and 6-71T (T1865)	14.7	20.0	--
Clean air cleaner (oil bath):			
4-71T (M5) and 6-71T (M10)	9.8	13.3	16.0
6-71T (M5) and 6-71T (T1865)	11.8	16.0	--
Clean air cleaner (with pre-cleaner) (Dry):			
4-71T (M5) and 6-71T (M10)	7.5	10.0	12.0
6-71T (M5)	9.0	12.0	--
Clean air cleaner (less pre-cleaner) (Dry):			
4-71T (M5) and 6-71T (M10)	5.0	6.5	8.0
6-71T (M5)	6.0	8.0	--
Crankcase pressure (inches water) - max.:			
4-71T	0.5	0.6	0.6
6-71T	0.9	1.0	1.0
Exhaust back pressure (inches mercury) - max.:			
Full load:			
4-71T (M5) and 6-71T (M10)	1.5	2.1	2.5
6-71T (M5) and 6-71T (T1865)	1.8	2.5	--
■Turbocharger			
Compressor outlet pressure (inches mercury) - min.:			
Full load	11.1	14.7	17.1
Turbine inlet pressure (inches mercury) - min.:			
Full load	12.0	16.8	20.0
Fuel System			
Fuel pressure at inlet manifold (psi):			
Normal (.055" and .080" orifices)	§45-70	45-70	45-70
Normal (.106" orifice)	40-55	45-70	45-70
Fuel spill (gpm) - min. at no load:			
(.055" orifice)	0.6	0.6	0.6
(.080" orifice)	0.9	0.9	0.9
(.106" orifice)	1.2	1.2	1.2
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0

© 1984 General Motors Corp.

71T ENGINE (with M5, M10 or T1865 Turbocharger) - Cont'd.

	1800 rpm	2100 rpm	2300 rpm
Cooling System			
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185
Raw water pump:			
Inlet restriction (inches mercury) - max.:			
4-71T	# 5.0	# 5.0	5.0
6-71T	# 5.0	# 5.0	5.0
Outlet pressure (psi) - max.:			
4-71T	#10.0	#10.0	10.0
6-71T	#10.0	#10.0	10.0
Keel cooler pressure drop (psi) - max. thru sys.:			
4-71T	# 5.0	# 5.0	6.0
6-71T	# 5.0	# 5.0	6.0
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	450		
Minimum at 600 rpm	425		

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.
@4-71T engine with M5 turbocharger only.
√ Minimum at no-load speed - 10.0 at 2225 rpm or 12.0 at 2425 rpm.
■Operating conditions may vary these pressures by 10%. Factors affecting performance are air temperature, barometer pressure, high intake restriction and high back pressure. Turbocharger pressures listed above apply to performance at elevation below 8,000 ft.
§Normal fuel pressure with .055 orifice is 50-65 psi.
#Maximum when this is full-load speed of engine.

© 1984 General Motors Corp.

4-71T ENGINE (with THO8A Turbocharger)

(0.96 A/R* Turbine Housing)

INDUSTRIAL

	1800 rpm	2000 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	43-65	45-65	45-65
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) - Normal	200-235	200-235	200-235
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
N65 injector	14.0	19.2	22.0
N70 injector	17.0	22.2	25.0
N75 injector	18.0	23.2	26.0
At max. full load exh. back pressure (clean ports):			
N65 injector	12.5	17.0	19.8
N70 injector	15.5	20.0	22.8
N75 injector	16.5	21.0	23.8
Air inlet restriction (inches water) - max. full load:			
Dirty air cleaner (dry)	14.5	20.0	20.0
Clean air cleaner (dry)	8.1	12.0	12.0
Crankcase pressure (inches water) - max.	1.5	1.7	1.9
Exhaust back pressure (inches mercury) - max.:			
Full load	2.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70
Fuel spill (gpm) - min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

*Turbine housing designation (area over radius).
†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

© 1984 General Motors Corp.

4-71T ENGINE (with TV6141 Turbocharger)

(1.08 A/R* Turbine Housing)

INDUSTRIAL

	1800 rpm	2100 rpm	2300 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	43-65	45-65	45-65
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) - Normal	200-235	200-235	200-235
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
N65 injector	20.0	28.5	35.0
N70 injector	21.0	30.0	37.0
N75 injector	22.8	31.9	38.3
At max. full load exh. back pressure (clean ports):			
N65 injector	18.5	26.2	32.7
N70 injector	19.5	27.7	34.7
N75 injector	21.3	29.6	36.0
Air inlet restriction (inches water) - max.:			
Full-load speed:			
Dirty air cleaner (dry)	14.5	20.0	20.0
Clean air cleaner (dry)	8.7	12.0	12.0
No-load speed:			
Dirty air cleaner (dry)	8.7	12.0	12.0
Clean air cleaner (dry)	5.2	7.2	7.2
Crankcase pressure (inches water) - max.	0.5	0.9	1.2
Exhaust back pressure (inches mercury) - max.:			
Full load	2.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70
Fuel spill (gpm) - min. at no load (.080" orifice)	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

© 1984 General Motors Corp.

4-71T ENGINE (with TO4B Turbocharger)

(1.14 A/R* Turbine Housing)

INDUSTRIAL

	1800 rpm	2000 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	43-65	45-65	45-65
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) - Normal	200-235	200-235	200-235
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
N65, N70 and N75 injectors	24.2	32.9	38.9
At max. full load exh. back pressure (clean ports):			
N65, N70 and N75 injectors	22.7	30.7	36.7
Air inlet restriction (inches water) - max. full load:			
Dirty air cleaner (dry)	14.5	20.0	20.0
Clean air cleaner (dry)	8.7	12.0	12.0
Crankcase pressure (inches water) - max.	1.5	1.7	1.9
Exhaust back pressure (inches mercury) - max.:			
Full load	2.0	3.0	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70
Fuel spill (gpm) - min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

*Turbine housing designation (area over radius).

†The lubricating oil temperature is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

© 1984 General Motors Corp.

4-71T ENGINE (with TH08A Turbocharger)

(0.96 A/R* Turbine Housing)

GENERATOR SET

	1500 rpm	1800 rpm
Lubrication System		
Lubricating oil pressure (psi):		
Normal	37-63	43-65
Minimum for safe operation	23	28
†Lubricating oil temperature (deg. F) - Normal	200-235	200-235
Air System		
Air box pressure (inches mercury) - min. full load:		
At zero exhaust back pressure:		
N80 injector	13.9	20.0
N90 injector	15.9	22.0
M95 injector	17.9	24.0
At max. full load exh. back pressure (clean ports):		
N80 injector	12.9	18.5
N90 injector	14.9	20.5
M95 injector	16.9	22.5
Air inlet restriction (inches water) - max. full load:		
Dirty air cleaner (dry)	10.5	14.5
Clean air cleaner (dry)	6.2	8.7
Crankcase pressure (inches water) - max.	0.5	1.0
Exhaust back pressure (inches mercury) - max.:		
Full load	1.4	2.0
Fuel System		
Fuel pressure at inlet manifold (psi) - Normal	45-70	50-70
Fuel spill (gpm) - min. at no load (.080" orifice)	0.9	0.9
Pump suction at inlet (inches mercury) - max.:		
Clean system	6.0	6.0
Dirty system	12.0	12.0
Cooling System		
Coolant temperature (deg. F) - Normal	160-185	160-185
Compression		
Compression pressure (psi at sea level):		
Average - new engine at 600 rpm	475	
Minimum at 600 rpm	425	

*Turbine housing designation (area over radius).
†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

© 1984 General Motors Corp.

4-71T ENGINE (with TO4B Turbocharger)

(1.14 A/R* Turbine Housing)

GENERATOR SET

	1500 rpm	1800 rpm
Lubrication System		
Lubricating oil pressure (psi):		
Normal	37-63	43-65
Minimum for safe operation	23	28
†Lurbicating oil temperature (deg. F) - Normal	200-235	200-235
Air System		
Air box pressure (inches mercury) - min. full load:		
At zero exhaust back pressure:		
N80 injector	21.1	30.3
N90 injector	23.8	33.5
M95 injector	27.5	38.0
At max. full load exh. back pressure (clean ports):		
N80 injector	20.1	28.8
N90 injector	22.8	32.0
M95 injector	26.5	36.5
Air inlet restriction (inches water) - max. full load:		
Dirty air cleaner (dry)	10.5	14.5
Clean air cleaner (dry)	6.2	8.7
Crankcase pressure (inches water) - max.	0.5	1.0
Exhaust back pressure (inches mercury) - max.:		
Full load	1.4	2.0
Fuel System		
Fuel pressure at inlet manifold (psi) - Normal	45-70	50-70
Fuel spill (gpm) - min. at no load (.080" orifice)	0.9	0.9
Pump suction at inlet (inches mercury) - max.:		
Clean system	6.0	6.0
Dirty system	12.0	12.0
Cooling System		
Coolant temperature (deg. F) - Normal	160-185	160-185
Compression		
Compression pressure (psi at sea level):		
Average - new engine at 600 rpm	475	
Minimum at 600 rpm	425	

*Turbine housing designation (area over radius).
†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be aprroximately 10° lower than the oil pan temperature.

© 1984 General Motors Corp.

6-71T ENGINE (with T18A40 Turbocharger)

(1.00 A/R* Turbine Housing)

VEHICLE

	1800 rpm	2000 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	43-65	45-65	45-65
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) - Normal	200-235	200-235	200-235
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
N65 or C65 injector	23.2	28.5	31.5
N70 injector	24.0	29.3	32.3
N75 injector	24.7	30.0	33.0
At max. full load exhaust back pressure:			
N65 or C65 injector	21.7	26.6	29.6
N70 injector	22.5	27.4	30.4
N75 injector	23.2	28.1	31.1
Air inlet restriction (inches water) - max. full load:			
Dirty air cleaner (dry)	20.0	20.0	20.0
Clean air cleaner (dry)	12.0	12.0	12.0
Crankcase pressure (inches water) - max.	1.3	1.8	2.0
Exhaust back pressure (inches mercury) - max.:			
Full load	2.0	2.5	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70
Fuel spill (gpm) - min. at no load (.080″ orifice)	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185
Engines built 1976 and later	170-195	170-195	170-195
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

*Turbine housing designation (area over radius).
†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

© 1984 General Motors Corp.

6-71T ENGINE (with TV7101 Turbocharger)

(1.23 A/R* Turbine Housing)

VEHICLE

	1200 rpm	1800 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	43-65	45-65	45-65
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) - Normal	200-235	200-235	200-235
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
N65 injector	30.7	36.5	39.3
C70 injector	34.2	40.2	43.1
C75 injector	36.1	42.2	45.1
At max. full load exh. back pressure (clean ports):			
N65 injector	29.2	34.5	37.0
C70 injector	32.7	38.2	40.8
C75 injector	34.6	40.2	42.8
Air inlet restriction (clean ports) (inches water) - max.:			
Full-load speed:			
Dirty air cleaner (dry)	20.0	20.0	20.0
Clean air cleaner (dry)	12.0	12.0	12.0
Crankcase pressure (inches water) - max.	1.3	1.8	2.0
Exhaust back pressure (inches mercury) - max.:			
Full load	2.0	2.7	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70
Fuel spill (gpm) - min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	170-195	170-195	170-195
Compression			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

© 1984 General Motors Corp.

6-71TT ENGINE (with TV6141 Turbocharger)

(1.08 A/R* Turbine Housing)

VEHICLE

	1200 rpm	1800 rpm	1950 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32-70	50-70	50-70
Minimum for safe operation	25	30	30
†Lubricating oil temperature (deg. F) - Normal	200-250	200-250	200-250
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
7E75 injector	24.5	36.0	#37.8
At max. full load exh back pressure (clean ports):			
7E75 injector	23.9	34.5	#35.9
Air inlet restriction (clean ports) (inches water) - max.:			
Full-load speed:			
Dirty air cleaner (dry type)	9.0	20.0	20.0
Clean air cleaner (dry type)	6.0	12.0	12.0
Crankcase pressure (inches water) - max.	0.8	1.3	1.5
Exhaust back pressure (inches mercury) - max.:			
Full load	0.8	2.0	2.5
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70
Fuel spill (gpm) - min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	170-195	170-195	170-195
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

*Turbine housing designation (area over radius).
†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.
#230 BHP Values.

© 1984 General Motors Corp.

6-71TT ENGINE (with TV7101 Turbocharger)

(1.39 A/R* Turbine Housing)

VEHICLE

	1200 rpm	1800 rpm	1950 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32-70	50-70	50-70
Minimum for safe operation	25	30	30
†Lubricating oil temperature (deg. F) - Normal	200-250	200-250	200-250
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
N75 injector	14.7	#29.4	#34.4
At max. exhaust back pressure:			
N75 injector	14.0	#27.9	#32.6
Air inlet restriction (inches water) - max.:			
Full-load speed:			
Dirty air cleaner (dry)	--	#20.0	#20.0
Clean air cleaner (dry)	4.0	#12.0	#12.0
No-load speed:			
Dirty air cleaner (dry)	4.0	# 8.7	#10.3
Clean air cleaner (dry)	2.0	# 5.2	# 6.0
Crankcase pressure (inches water) - max.	0.8	1.3	1.5
Exhaust back pressure (inches mercury) - max.:			
Full load	0.9	2.0	2.5
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70
Fuel spill (gpm) - min. at no load (.080" orifice)	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	170-195	170-195	170-195
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

*Turbine housing designation (area over radius).
†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.
#230 BHP Values.

© 1984 General Motors Corp.

6-71TA and 6-71TTA ENGINE (with TV6141 Turbocharger)

(1.08 A/R* Turbine Housing) - 1983 Federal

VEHICLE

	1800 rpm	1950 rpm	■2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	43-65	45-65	45-65
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) - Normal	200-235	200-235	200-235
Air System			
Air box pressure (inches mercury) - min. full load:			
At 15" water - exhaust back pressure:			
6-71TA - 7C75 inj. - 1.458 timing	37.4	42.0	--
6-71TTA - 7E75 inj. - 1.460 timing	@32.6	@35.4	@38.7
At max. full load exh. back pressure (clean ports):			
6-71TA - 7C75 inj. - 1.458 timing	35.9	40.1	--
6-71TTA - 7E75 inj. - 1.460 timing	@31.1	@33.5	@36.4
Air inlet restriction (inches water) - max. full load:			
Dirty air cleaner - dry type	20.0	20.0	20.0
Clean air cleaner - dry type	12.0	12.0	12.0
Crankcase pressure (inches water) - max.	1.3	1.8	2.0
Exhaust back pressure (inches mercury) - max.:			
Full load	2.0	2.5	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70
Fuel spill (gpm) - minimum at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	170-195	170-195	170-195
Compression			
Compression pressure (psi at sea level):			
Average - new engine - at 600 rpm	565		
Minimum - at 600 rpm	515		

*Turbine housing designation (area over radius).
■TTA engines only.
†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.
@At 230 BHP.

© 1984 General Motors Corp.

6-71TA ENGINE (with TV6141 Turbocharger)

(1.39 A/R* Turbine Housing)

VEHICLE

	1800 rpm	2000 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	43-65	45-65	45-65
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) - Normal	200-235	200-235	200-235
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
7G65 injector	30.2	34.5	36.5
7G70 injector	32.3	36.5	38.5
7G75 injector	34.5	39.0	41.0
At max. exhaust back pressure (clean ports):			
7G65 injector	28.7	32.5	34.3
7G70 injector	30.8	34.5	36.3
7G75 injector	33.0	38.0	38.8
Air inlet restriction (clean ports) (inches water) - max.:			
Full-load speed:			
Dirty air cleaner (dry type)	20.0	20.0	20.0
Clean air cleaner (dry type)	12.0	12.0	12.0
Crankcase pressure (inches water) - max.	1.3	1.8	2.0
Exhaust back pressure (inches mercury) - max.:			
Full load	2.0	2.7	3.0
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70
Fuel spill (gpm) - min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	170-195	170-195	170-195
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

*Turbine housing designation (area over radius).
†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

© 1984 General Motors Corp.

6-71TTA ENGINE (with TV6141 Turbocharger)

(1.39 A/R* Turbine Housing)

VEHICLE

	1200 rpm	1800 rpm	1950 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32-70	50-70	50-70
Minimum for safe operation	25	30	30
†Lubricating oil temprature (deg. F) - Normal	200-250	200-250	200-250
Air System			
Airbox pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
7G75 injector	18.6	#31.5	#33.3
At max. exhaust back pressure (clean ports):			
7G75 injector	18.0	#30.0	#31.4
Air inlet restriction (clean ports) (inches water) - max.:			
Full-load speed:			
Dirty air cleaner (dry type)	9.0	20.0	20.0
Clean air cleaner (dry type)	6.0	12.0	12.0
Crankcase pressure (inches water) - max.	0.8	1.3	1.5
Exhaust back pressure (inches mercury) - max.:			
Full load	0.8	2.0	2.5
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70
Fuel spill (gpm) - min. at no load	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant Temperature (deg. F) - Normal	170-195	170-195	170-195
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

*Turbine housing designation (area over radius).
†The lubicating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.
#230 BHP Values.

© 1984 General Motors Corp.

6-71T ENGINE (with T18A40 Turbocharger)

(1.14 A/R* Turbine Housing)

INDUSTRIAL

	1800 rpm	2000 rpm	2100 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	43-65	45-65	45-65
Minimum for safe operation	28	30	30
†Lubricating oil temperature (deg. F) - Normal	200-235	200-235	200-235
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
N65 injector	17.7	23.0	26.0
N70 injector	18.5	23.8	26.8
N75 injector	19.2	24.5	27.5
N80 injector	25.0	30.2	33.0
N90 injector	31.5	36.7	39.5
M95 injector	34.0	39.0	41.5
At max. full load exhaust back pressure:			
N65 injector	16.2	21.2	24.2
N70 injector	17.0	22.0	25.0
N75 injector	17.7	22.7	25.7
N80 injector	23.5	28.4	31.2
N90 injector	30.0	34.9	37.7
M95 injector	32.5	37.2	39.7
Air inlet restriction (inches water) - max. full load:			
Dirty air cleaner (dry)	14.5	18.0	20.0
Clean air cleaner (dry)	8.7	10.8	12.0
Crankcase pressure (inches water) - max.	1.3	1.8	2.0
Exhaust back pressure (inches mercury) - max.:			
Full load	2.0	2.5	2.5
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70
Fuel spill (gpm) - min. at no load (.080" orifice)	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

*Turbine housing designation (area over radius).
†The lubricating oil temperature range is based on the temperature measurement in hte oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

© 1984 General Motors Corp.

6-71TT ENGINE (with TV7101 Turbocharger)

(1.39 A/R* Turbine Housing)

INDUSTRIAL

	1200 rpm	1800 rpm	1950 rpm
Lubrication System			
Lubricating oil pressure (psi):			
Normal	32-70	50-70	50-70
Minimum for safe operation	25	30	30
†Lubricating oil temperature (deg. F) - Normal	200-250	200-250	200-250
Air System			
Air box pressure (inches mercury) - min. full load:			
At zero exhaust back pressure:			
N75 injector	14.7	#29.4	#34.4
At max. full-load exhaust back pressure:			
N75 injector	14.0	#27.9	#32.6
Air inlet restriction (inches water) - max.:			
Full-load speed:			
Dirty air cleaner (dry)		#14.5	#17.0
Clean air cleaner (dry)	4.0	# 8.7	#10.5
No-load speed:			
Dirty air cleaner (dry)	4.0	# 8.7	#10.3
Clean air cleaner (dry)	2.0	# 5.2	# 6.0
Crankcase pressure (inches water) - max.	8.0	1.3	1.5
Exhaust back pressure (inches mercury) - max.:			
Full load	0.9	2.0	2.4
Fuel System			
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70
Fuel spill (gpm) - min. at no load (.080" orifice)	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:			
Clean system	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0
Cooling System			
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185
Compression			
Compression pressure (psi at sea level):			
Average - new engine at 600 rpm	475		
Minimum at 600 rpm	425		

*Turbine housing designation (area over radius).
†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.
#230 BHP Values.

© 1984 General Motors Corp.

6-71T ENGINE (with T18A40 Turbocharger)

(1.00 A/R* Turbine Housing)

GENERATOR SET

	1500 rpm	1800 rpm
Lubricating oil pressure (psi):		
Normal	37-63	43-65
Minimum for safe operation	23	28
†Lubricating oil temperature (deg. F) - Normal	200-235	200-235
Air System		
Air box pressure (inches mercury) - min. full load:		
At zero exhaust back pressure:		
N75 injector	18.0	24.7
N80 injector	18.9	25.0
N90 injector	24.4	31.5
M95 injector	25.0	34.0
At max. full-load exhaust back pressure:		
N75 injector	17.0	23.2
N80 injector	17.9	23.5
N90 injector	18.4	30.0
M95 injector	24.0	32.5
Air inlet restriction (inches water) - max.:		
Full-load speed:		
Dirty air cleaner (dry)	10.5	14.5
Clean air cleaner (dry)	6.2	8.7
No-load speed:		
Dirty air cleaner (dry)	6.2	8.7
Clean air cleaner (dry)	3.5	5.2
Crankcase pressure (inches water) - max.	0.7	1.3
Exhaust back pressure (inches mercury) - max.:		
Full-load	1.4	2.0
Fuel System		
Fuel pressure at inlet manifold (psi) - Normal	45-70	50-70
Fuel spill (gpm) - min. at no load (.080" orifice)	0.9	0.9
Pump suction at inlet (inches mercury) - max.:		
Clean system	6.0	6.0
Dirty system	12.0	12.0
Cooling System		
Coolant temperature (deg. F) - Normal	160-185	160-185
Compression		
Compression pressure (psi at sea level):		
Average - new engine at 600 rpm	475	
Minimum at 600 rpm	425	

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

© 1984 General Motors Corp.

6-71TI ENGINE (with T18A40 Turbocharger)

(1.32 A/R* Turbine Housing)

INTERCOOLED MARINE ENGINE

	1800 rpm	2000 rpm	2100 rpm	2300 rpm
Lubrication System				
Lubricating oil pressure (psi):				
Normal	43-65	45-65	45-65	45-65
Minimum for safe operation	28	30	30	30
†Lubricating oil temperature (deg. F) - Normal	200-235	200-235	200-235	200-235
Air System				
Air box pressure (inches mercury) - min. full load:				
At zero exhaust back pressure:				
N90 injector	20.4	25.9	28.6	34.0
At max. full load exh. back pressure (clean ports):				
N90 injector	18.9	24.1	26.8	32.2
Air inlet restriction (inches water) - max.:				
Full-load speed:				
Dirty air cleaner (dry)	14.5	18.0	20.0	20.0
Clean air cleaner (dry)	8.7	10.8	12.0	12.0
No-load speed:				
Dirty air cleaner (dry)	8.7	10.8	12.0	12.0
Clean air cleaner (dry)	5.2	6.6	7.3	7.3
Crankcase pressure (inches water) - max.	1.3	1.8	2.0	2.4
Exhaust back pressure (inches mercury) - max.:				
Full load	2.0	2.5	2.5	2.5
Fuel System				
Fuel pressure at inlet manifold (psi) - Normal	50-70	50-70	50-70	50-70
Fuel spill (gpm) - min. at no load (.080" orifice)	0.9	0.9	0.9	0.9
Pump suction at inlet (inches mercury) - max.:				
Clean system	6.0	6.0	6.0	6.0
Dirty system	12.0	12.0	12.0	12.0
Cooling System				
Coolant temperature (deg. F) - Normal	160-185	160-185	160-185	160-185
Compression				
Compression pressure (psi at sea level):				
Average - new engine at 600 rpm	475			
Minimum at 600 rpm	425			

*Turbine housing designation (area over radius).

†The lubricating oil temperature range is based on the temperature measurement in the oil pan at the oil pump inlet. When measuring the oil temperature at the cylinder block oil gallery, it will be approximately 10° lower than the oil pan temperature.

© 1984 General Motors Corp.

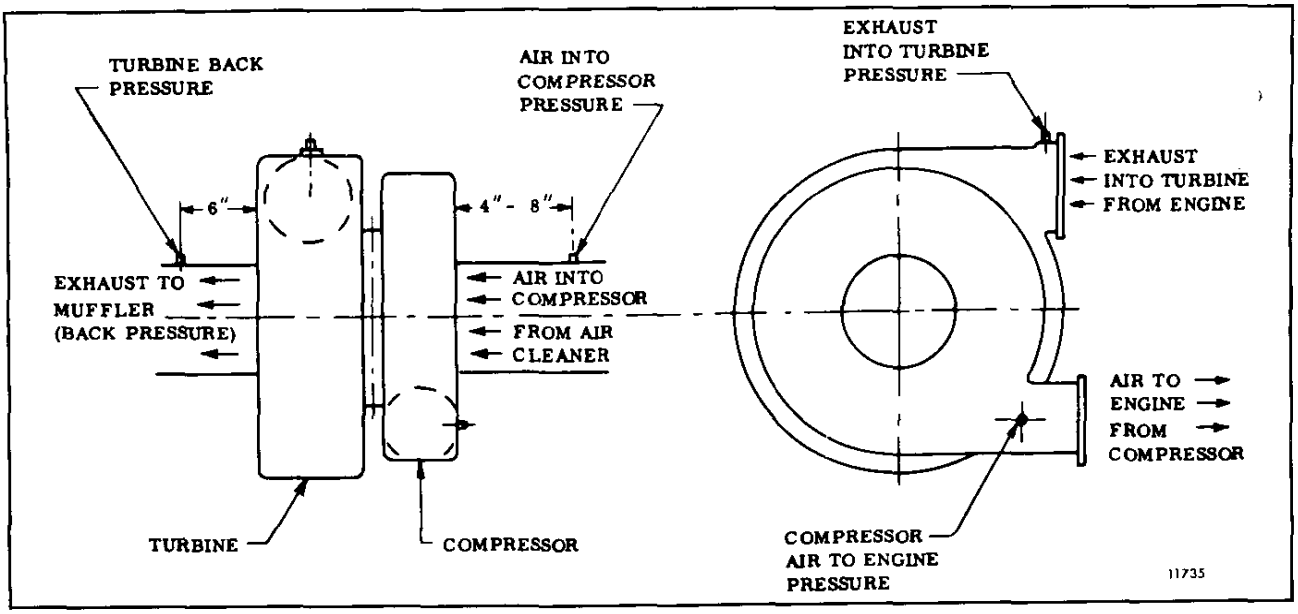


Fig. 1 - Points to Measure Intake and Exhaust Restriction

TRANSMISSION (Railcar)

	ALL SPEEDS
Torque converter charing pressure (psi):	
Series 400, 500 (minimum)--at stall	50
Series 600, 800, 900 (minimum)--at stall	60
Series 400, 500, 600, 800, 900 (maximum)--no load	120
Torque converter oil temperature--deg. F (maximum)	250
Railcar transmission converter charging pressure (psi):	
Minimum	115
Maximum	130
Railcar transmission converter oil temperature--deg. F (maximum)	265
Torqmatic marine gear oil pump pressure (psi):	
M and MH type (maximum)--single engine	125
M and MH type (minimum)--single engine	90
M type (maximum)--multiple engines	100
M type (minimum) multiple engines	60
MH type (maximum)--multiple engines	125
MH type (minimum)--multiple engines	90
Constant flow type (maximum) all engines	150
Constant flow type (minimum)--all engines	90
Torqmatic marine gear oil temperature:	
Deg. F (maximum)--reverse	225
Deg. F (average)--forward	200
Paragon marine gear oil pressure (psi):	
Minimum	90
Maximum	150
Paragon marine gear oil temperature maximum (deg. F)	250

© 1984 General Motors Corp.

ENGINE RUN-IN INSTRUCTIONS

Following a complete overhaul or any major repair job involving the installation of piston rings, pistons, cylinder liners or bearings, the engine should be "Run-In" on a dynamometer prior to release for service.

The dynamometer is a device for applying specific loads to an engine. It permits the serviceman to physically and visually inspect and check the engine while it is operating. It is an excellent method of detecting improper tune-up, misfiring injectors, low compression and other malfunctions, and may save an engine from damage at a later date.

The operating temperature within the engine affects the operating clearances between the various moving parts of the engine and determines to a degree how the parts will wear. Normal coolant temperature (see Section 13.2) should be maintained throughout the Run-In.

The rate of water circulation through the engine on a dynamometer should be sufficient to avoid having the engine outlet water temperature more than 10° F or 6° C higher than the water inlet temperature. Though a 10° F or 6° C rise across an engine is recommended, it has been found that a 15° F or 8° C temperature rise maximum can be permitted.

A thermostat is used in the engine to control the coolant flow. Therefore, be sure it is in place and fully operative or the engine will overheat during the Run-In. However, if the dynamometer has a water standpipe with a temperature control regulator, such as a Taylor valve or equivalent, the engine should be tested without the thermostat.

The *Basic Engine Run-In Schedule* is shown in Table 1. The horsepower shown is at SAE conditions: dry air density .0705 lb/cu. ft. (1.129 Kg/cu m, air temperature of 85° F (29.4° C) and 500 ft. elevation.

DYNAMOMETER TEST AND RUN-IN PROCEDURES

The Basic Engine

The great number of engine applications make any attempt to establish comparisons for each individual model impractical. For this reason, each model has a basic engine rating for comparison purposes.

A basic engine includes only those items actually required to run the engine. The addition of any engine driven accessories will result in a brake horsepower figure less than the values shown in the *Basic Engine Run-In Schedule.* The following items are included on the basic engine: blower, fuel pump, water pump and governor. The fan and battery-charging generator or alternator typify accessories not considered on the basic engine.

In situations where other than basic engine equipment is used during the test, proper record of this fact should be made on the *Engine Test Report.* The effects of this

BASIC ENGINE RUN-IN SCHEDULE

Speed (rpm)	Time (minutes)	Horsepower		
		3-71	4-71, 71E 71N	6-71, 71E 71N
1200	10	21	28	42
1800	30	67	90	135
*1800	30	82	110	164
*2100	30	85	118	180
*2300	30	92	128	196

*Run at only one of the speeds shown, whichever is at or nearest to the governed speed and reset governor after final run, if necessary.

FINAL ENGINE RUN-IN SCHEDULE (Trunk-Type Pistons)

Speed (rpm)	Time (minutes)	Horsepower	
		4-71T	6-71T
1200	10 (minimum)	0	0
2300	60	0	0
2100	30	57	86
2100	30	114	172
2100	30	+	+

+Within ± 5% of rated bhp.

FINAL ENGINE RUN-IN SCHEDULE (Cross-Head Pistons)

Speed (rpm)	Time (minutes)	Horsepower	
		4-71T	6-71T
1200	10 (minimum)	28	42
2100	30	116	174
2100	30	130	195
2100	30	+	+

+Within ± 5% of rated bhp.

TABLE 1

© 1984 General Motors Corp.

additional equipment on engine performance should then be considered when evaluating test results.

Dynamometer

The function of the dynamometer is to absorb and measure the engine output. Its basic components are a frame, engine mounts, the absorption unit, a heat exchanger, and a torque loading and measuring device.

The engine is connected through a universal coupling to the absorption unit. The load on the engine may be varied from zero to maximum by decreasing or increasing the resistance in the unit. The amount of power absorbed in a water brake type dynamometer, as an example, is governed by the volume of fluid within the working system. The fluid offers resistance to a rotating motion. By controlling the volume of water in the absorption unit, the load may be increased or decreased as required.

The power absorbed is generally measured in torque on a suitable scale. This value for a given engine speed will show the brake horsepower developed in the engine by the following formula:

$$BHP = (T \times RPM)/5250$$

Where:

BHP = brake horsepower
T = torque in lb-ft
RPM = revolutions per minute

Some dynamometers indicate direct brake horsepower readings. Therefore, the use of the formula is not required when using these units.

During the actual operation, all data taken should be recorded immediately on an *Engine Test Report* (see sample on page 3).

Instrumentation

Certain instrumentation is necessary so that data required to complete the *Engine Test Report* may be obtained. The following list contains both the minimum amount of instruments and the proper location of the fittings on the engine so that the readings represent a true evaluation of engine conditions.

a. Oil pressure gage installed in one of the engine main oil galleries.

b. Oil temperature gage installed in the oil pan, or thermometer installed in the dipstick hole in the oil pan.

c. Adaptor for connecting a pressure gage or mercury manometer to the engine air box.

d. Water temperature gage installed in the thermostat housing or water outlet manifold.

e. Adaptor for connecting a pressure gage or water manometer to the crankcase.

f. Adaptor for connecting a pressure gage or mercury manometer to the exhaust manifold at the flange.

g. Adaptor for connecting a vacuum gage or water manometer to the blower inlet.

h. Adaptor for connecting a fuel pressure gage to the fuel manifold inlet passage.

i. Adaptor for connecting a pressure gage or mercury manometer to the turbocharger.

In some cases, gages reading in pounds per square inch or kilopascals are used for determining pressures while standard characteristics are given in inches of mercury or inches of water. It is extremely important that the scale of such a gage be of low range and finely divided if accuracy is desired. This is especially true of a gage reading in psi or kPa, the reading of which is to be converted to inches of water. The following conversion factors may be helpful.

Inches of water = psi x 27.7″
Inches of mercury = psi x 2.04″
Inches or water = kPa x 4.02″
Inches of mercury = kPa x 0.30″

NOTE: Before starting the Run-In or starting the engine for any reason following an overhaul, it is of extreme importance to observe the instructions on *Preparation for Starting Engine First Time* in Section 13.1.

Run-In Procedure

The procedure outlined below will follow the order of the sample *Engine Test Report*.

A. PRE-STARTING

1. Fill the lubrication system as outlined under *Lubrication System – Preparation for Starting Engine First Time* in Section 13.1.

2. Prime the fuel system as outlined under *Fuel System – Preparation for Starting Engine First Time* in Section 13.1.

© 1984 General Motors Corp.

ENGINE TEST REPORT

Date _____ Unit Number _____

Repair Order Number _____ Model Number _____

A PRE-STARTING

1. PRIME LUBE OIL SYSTEM	2. PRIME FUEL SYSTEM	3. ADJUST VALVES	4. TIME INJ.	5. ADJ. GOV.	6. ADJUST INJ. RACKS

B BASIC ENGINE RUN-IN

TIME AT SPEED	TIME START	TIME STOP	RPM	BHP	WATER TEMP.	LUBE OIL PRESS.

C BASIC RUN-IN INSPECTION

1. Check oil at rocker arm mechanism	
2. Inspect for lube oil leaks	
3. Inspect for fuel oil leaks	
4. Inspect for water leaks	
5. Check and tighten all external bolts	
6.	

D INSPECTION AFTER BASIC RUN-IN

1. Adjust Valves (Hot)		4. Adjust Injector Racks	
2. Time Injectors		5.	
3. Adjust Governor Gap		6.	

E FINAL RUN-IN

TIME START	TIME STOP	TOP RPM NO LOAD	TOP RPM FULL LOAD	BHP	AIR BOX PRESSURE FULL LOAD	EXHAUST BACK PRESSURE F/L	CRANKCASE PRESSURE F/L

BLOWER INTAKE RES. - F/L	FUEL OIL PRESSURE RET. MAN. F/L	WATER TEMP. FULL LOAD	LUBE OIL TEMP. F/L	LUBE OIL PRESSURE FULL LOAD	LUBE OIL PRESSURE IDLE	IDLE SPEED

F INSPECTION AFTER FINAL RUN

1. Inspect Air Box, Pistons, Liners, Rings	6. Tighten Oil Pump Bolts
2. Inspect Blower	7. Inspect Oil Pump Drive
3. Check Generator Charging Plate	8. Replace Lube Filter Elements
4. Wash Oil Pan, Check Gasket	9. Tighten Flywheel Bolts
5. Clean Oil Pump Screen	10. Rust Proof Cooling System

REMARKS:

Final Run OK'd _____ Dynamometer Operator _____ Date _____

NOTE: *Operator must initial each check and sign this report.*

© 1984 General Motors Corp.

3. A preliminary valve clearance adjustment must be made before the engine is started. See *Valve Clearance Adjustment* in Section 14.1.

4. A preliminary injector timing check must be made before starting the engine. See *Fuel Injector Timing* in Section 14.2.

5. Preliminary governor adjustments must be made as outlined in Section 14.

6. Preliminary injector rack adjustment must be made (Section 14).

NOTE: Prior to starting a turbocharged engine, remove the oil supply line at the turbocharger and add clean engine oil to the oil inlet to ensure pre-lubrication of the turbocharger. Reconnect the oil line and idle the engine for at least one minute after starting and before increasing the speed.

B. BASIC ENGINE RUN-IN

The operator should be observant at all times, so that any malfunction which may develop will be detected. Since the engine has just been reconditioned, this Run-In will be a test of the workmanship of the serviceman who performed the overhaul. Minor difficulties should be detected and corrected so that a major problem will not develop.

After performing the preliminary steps, be sure all water valves, fuel valves, etc. are open. Also, inspect the exhaust system, air cleaner and air inlet piping to insure that it is properly connected to the engine. Always start the engine with minimum dynamometer resistance.

After the engine starts, if using a water brake type dynamometer, allow sufficient water, by means of the control loading valves, into the dynamometer absorption unit to show a reading of approximately 5 lb-ft (7 Nm) on the torque gage (or 10-15 HP on a horsepower gage). This is necessary, on some units, to lubricate the absorption unit seals and to protect them from damage.

Set the engine throttle at idle speed, check the lubricating oil pressure and check all connections to be sure there are no leaks.

Refer to the *Engine Test Report* sample which establishes the sequence of events for the test and Run-In, and to the *Basic Engine Run-In Schedule* which indicates the speed (rpm), length of time and the brake horsepower required for each phase of the test. Also, refer to the *Operating Conditions* in Section 13.2 which presents the engine operating characteristics. These characteristics will be a guide for tracing faulty operation or lack of power.

Any four or six cylinder engine to be run at speeds in excess of 1800 rpm must be equipped with a vibration damper.

Engine governors in most cases must be reset at the maximum full-load speed designated for the Run-In. If a governor is encountered which cannot be adjusted to this speed, a stock governor should be installed for the Run-In.

After checking the engine performance at idle speed and being certain the engine and dynamometer are operating properly, increase the engine speed to half speed and apply the load indicated on the *Basic Engine Run-In Sehedule.*

The engine should be run at this speed and load for 10 minutes to allow sufficient time for the coolant temperature to reach the normal operating range. Record length of time, speed, brake horsepower, coolant temperature and lubricating oil pressure on the *Engine Test Report.*

Run the engine at each speed and rating for the length of time indicated in the *Basic Engine Run-In Schedule.* This is the Basic Run-In. During this time, engine performance will improve as new parts begin to "seat in". Record all of the required data.

C. BASIC RUN-IN INSPECTION

While the engine is undergoing the Basic Run-In, check each item indicated in Section "C" of the *Engine Test Report.* Check for fuel oil or water leaks in the rocker arm compartment.

During the final portion of the Basic Run-In, the engine should be inspected for fuel oil, lubricating oil and water leaks.

Upon completion of the Basic Run-In and Inspection, remove the load from the dynamometer and reduce the engine speed gradually to idle and then stop the engine.

D. INSPECTION AFTER BASIC RUN-IN

The primary purpose of this inspection is to provide a fine engine tune-up. First, tighten the cylinder head and rocker arm shaft bolts to the proper torque. Next, complete the applicable tune-up procedure. Refer to Section 14.

© 1984 General Motors Corp.

FUEL OILS FOR DETROIT DIESEL ENGINES

GENERAL CONSIDERATIONS

The quality of fuel oil used for high-speed diesel engine operation is a very important factor in obtaining satisfactory engine performance, long engine life, and acceptable exhaust emission levels.

COMPLETELY DISTILLED FLUID

Fuel selected should be completely distilled material. That is, the fuel should show at least 98% by volume recovery when subjected to ASTM D-86 distillation. Fuels marketed to meet Federal Specification VV-F-800 (grades DF-1 and DF-2) and ASTM Designation D-975 (grades 1-D and 2-D) meet the completely distilled criteria. The differences in properties of VV-F-800 and ASTM D-975 fuels are shown in the following table.

FEDERAL SPECIFICATION & ASTM DIESEL FUEL PROPERTIES

Specification or Classification Grade	VV-F-800 DF-1	ASTM D-975 1-D	VV-F-800, DF-2 NORTH AMERICA	VV-F-800, DF-2 OTHER	ASTM D-975 2-D
Flash Point, min.	38°C 100°F	38°C 100°F	52°C 125°F	56°C 133°F	52°C 125°F
Carbon Residue (10% residuum), mass % max.	0.15	0.15	0.35	0.20	0.35
Water & Sediment, % by vol, max.	—	0.05	—	—	0.05
Ash, % by wt., max.	0.01	0.01	0.01	0.02	0.01
Distillation Temperature, 90% by vol. recovery, min.	—	—	—	—	282°C 540°F
max.	288°C 550°F	288°C 550°F	338°C 640°F	357°C 675°F	338°C 640°F
End Point max.	330°C 626°F	—	370°C 698°F	370°C 698°F	—
Viscosity					
Kinematic, cSt, min. @ 40°C	1.3	1.3	1.9	1.8@20°C	1.9
Saybolt, SUS, min. @ 100°F	—	—	—	—	32.6
Kinematic, cSt, max. @ 40°C	2.9	2.4	4.1	9.5@20°C	4.1
Saybolt, SUS, max. @ 100°F	—	34.4	—	—	40.1
Sulfur, mass % max.	0.50	0.50	0.50	0.70	0.50
Cetane No., min.	45	40.0	45	45	40.0

FUEL CLEANLINESS

Fuel oil should be clean and free of contamination. Storage tanks and stored fuel should be inspected regularly for dirt, water or water-emulsion sludge, and cleaned if contaminated. Storage instability of the fuel can lead to the formation of varnish or sludge in the tank. The presence of these contaminants from storage instability must be resolved with the fuel supplier.

FUEL SULFUR CONTENT

The *sulfur content* of the fuel should be as low as possible to avoid premature wear, excessive deposit formation, and minimize the sulfur dioxide exhausted into the atmosphere. Limited amounts can be tolerated, but the amount of sulfur in the fuel and engine operating conditions can influence corrosion and deposit formation tendencies.

The detrimental effect of burning high sulfur fuel is reflected in Detroit Diesel lube oil change interval recommendations. Detroit Diesel recommends that the Total Base Number (TBN-ASTM D-664) of the lube oil be monitored frequently and that the oil drain interval possibly be reduced. Consult the FUEL OIL SELECTION CHART.

FUEL OIL SELECTION CHART

Application	General Fuel Classification	Final Boiling Point	Cetane Number	Sulfur Content	Cloud Point
		(Max.)	(Min.)	(Max.)	
City Buses	No. 1-D	550°F 288°C	45	0.30	
	Winter No. 2-D*	675°F 357°C	45	0.50	SEE NOTES
	Summer No. 2-D*	357°C	40	0.50	
All Other Applications	Winter No. 2-D	675°F 357°C	45	0.50	
	Summer No. 2-D	675°F 357°C	40	0.50	SEE NOTES

*No. 2-D diesel fuel may be used in city coach engine models that have been certified to pass Federal and California emission standards.

Note 1: The cloud point should be 10°F (6°C) below the lowest expected fuel temperature to prevent clogging of the fuel filters by wax crystals.

Note 2: When prolonged idling periods or cold weather conditions below 32°F (0°C) are encountered, the use of lighter distillate fuels may be more practical. The same consideration must be made when operating at altitudes above 5,000 ft.

IGNITION QUALITY - CETANE NUMBER

There is a delay between the time the fuel is injected into the cylinder and the time that ignition occurs. The duration of this delay is expressed in terms of *cetane number* (rating). Rapidly ignited fuels have high cetane numbers (50 or above). Slowly ignited fuels have low cetane numbers (40 or below). The lower the ambient temperature, the greater the need for a high cetane fuel that will ignite rapidly.

Difficult starting may be experienced if the cetane number of the fuel is too low. Furthermore, engine knock and puffs of white smoke may be experienced during engine warmup especially in severe cold weather when operating with a low cetane fuel. If this condition is allowed to continue for any prolonged period, harmful fuel derived deposits will accumulate within the combustion chamber. Consult the FUEL OIL SELECTION CHART.

© 1983 General Motors Corp.

DISTILLATION END POINT

Fuel can be burned in an engine only after it has been vaporized. The temperature at which fuel is completely vaporized is described as the *distillation end point* (ASTM D-86). The distillation (boiling) range of diesel fuels should be low enough to permit complete vaporization at combustion chamber temperatures. The combustion chamber temperature depends on ambient temperature, engine speed, and load. Mediocre to poor vaporization is more apt to occur during severe cold weather and/or prolonged engine idling and/or light load operation. Therefore, engines will show better performance operating under the conditions described above when lower distillation end point fuels are used. Consult the FUEL OIL SELECTION CHART.

CLOUD POINT

The *cloud point* is that temperature at which wax crystals begin to form in diesel fuel. The selection of a suitable fuel for low temperature operability is the responsibility of the fuel supplier and the engine user. Consult the FUEL OIL SELECTION CHART.

DETROIT DIESEL FUEL OIL SPECIFICATIONS

Detroit Diesel Allison designs, develops and manufactures commercial diesel engines to operate on diesel fuels classified by the ASTM as Designation D-975 (grades 1-D and 2-D). These grades are very similar to grades DF-1 and DF-2 of Federal Specification VV-F-800.

Burner fuels (furnace oils or domestic heating fuels) generally require an open flame for satisfactory combustion. The ignition quality (cetane rating) of burner fuels (ASTM D-396) is poor when compared to diesel fuels (ASTM D-975).

In some regions, however, fuel suppliers may distribute one fluid that is marketed as either diesel fuel (ASTM D-975) or domestic heating fuel (ASTM D-396) sometimes identified as burner, furnace, or residual fuel. Under these circumstances, the fuel should be investigated to determine whether the properties conform with those indicated in the FUEL OIL SELECTION CHART.

The FUEL OIL SELECTION CHART also will serve as a guide in the selection of the proper fuel for various applications. The fuels used must be clean, completely distilled, stable, and non-corrosive. *Distillation Range, Cetane Number, Sulfur Content, and Cloud Point* are four of the most important properties of diesel fuels that must be controlled to insure satisfactory engine operation. Engine speed, load, and ambient temperature all influence the selection of diesel fuels with respect to distillation range and cetane number.

All diesel fuels contain a certain amount of sulfur. Too high a sulfur content results in excessive cylinder wear. For most satisfactory engine life, fuels containing less than 0.5% sulfur should be used.

During cold weather engine operation the *cloud point* (the temperature at which wax crystals begin to form in diesel fuel) should be 10°F (6°C) below the lowest expected fuel temperature in order to prevent clogging of the fuel filters by wax crystals.

A reputable fuel oil supplier is the only one who can assure you that the fuel you receive meets the *Distillation End Point, Cetane Number, Sulfur Content, and Cloud Point* property limits shown in the FUEL OIL SELECTION CHART. The responsibility for clean fuel that meets Detroit Diesel Allison specifications lies with the fuel supplier as well as the operator.

At temperatures below +32°F (0°C) particular attention must be given to cold weather starting aids for efficient engine starting and operation.

NUMEROUS FUELS BURNED IN DETROIT DIESEL ENGINES

Numerous fuels meeting the properties shown in the FUEL OIL SELECTION CHART may be used in Detroit Diesel engines. The table (next page) shows some of the alternate fuels (some with sulfur and/or cetane limits) that have been burned in Detroit Diesel engines. Among these are No. 1 and No. 2 diesel fuels, kerosene, aviation turbine (jet) fuels, and burner fuels.

PROPOSED ASTM D-975, GRADE 3-D

Detroit Diesel Allison does NOT recommend the use of proposed grade 3-D diesel fuel in any of its engines. This grade of fuel was proposed, but not accepted by, the ASTM.

The grade 3-D which was proposed is undesireable in that it possesses poor ignition quality (i.e., lower cetane), allows greater sulfur content (up to 0.70% by weight), allows the formation of more carbon deposits (Conradson carbon residue), and allows the blending of heavier, more viscous boiling point fractions that are difficult to burn. The latter tend to increase combustion chamber deposits. This type of fuel usually manifests poor cold

© 1983 General Motors Corp.

FUELS BURNED IN DETROIT DIESEL ENGINES

ASTM Designation	Federal Standard	Military Spec.	NATO Code	Grade	Description/Comments
D-975				1-D 2-D	Diesel Fuel
D-396				1, 2	Burner Fuel (Furnace Oil) ***Caution: If Used, The Max. Sulfur Content Allowed is 0.50 WT. % and the Minimum Cetane No. is 45. (See Fuel Oil Selection Chart).***
	VV-F-800		F-54	1, 2	DF-1 Winter Grade, DF-2 Regular Grade
	VV-F-800		F-56		DF-A (Arctic Grade). Limited Supply For Military.
		MIL-T-5624		JP-5	Kerosene
D-1655		MIL-T-83133	F-34	JP-8	Jet A-1, Kerosene Type Plus Special Anti-Icer
D-1655			F-35		Jet A, Kerosene
		MIL-F-16884	F-76	DFM	Diesel Fuel - Marine (DFM). ***Caution: If Used, The Max. Sulfur Content Allowed is 0.50 WT. %.***
		MIL-F-5161		JP-6	Referee Grade JP-5 Type Jet Fuel. Limited Quantities Supplied To Military Only.

weather properties (wax formation tendencies). In addition, the poor ignition quality adversely affects noise and emission levels.

A comparison of ASTM D-975 grade 2-D and the proposed grade 3-D fuel properties is shown in the following table.

USING DRAINED LUBE OIL IN DIESEL FUEL

Detroit Diesel Allison *does not recommend* the use of drained lubricating oil in diesel fuel. Furthermore, Detroit Diesel Allison will not be responsible for any detrimental effects which it determines resulted from this practice.

BURNING MIXTURES OF DIESOHOL AND GASOHOL AND/OR ADDING ALCOHOL AND/OR GASOLINE TO DIESEL FUEL

Very small amounts of isopropyl alcohol (isopropanol) may be used to preclude fuel line freeze-up in winter months. No more than ONE PINT of isopropyl alcohol should be added to 125 GALLONS of diesel fuel for adequate protection.

Commercially marketed DIESOHOL or GASOHOL or GASOLINE should never be added to diesel fuel. An explosive and fire hazard exists if these blends are mixed and/or burned.

COMPARISON OF ASTM D-975 GRADE 2-D AND PROPOSED GRADE 3-D PROPERTIES

Property	Grade	
	Recommended 2-D	Not Recommended 3-D
Cetane No., Min.	40.0	37.0
Sulfur, WT. %, Max.	0.50	0.70
Carbon Residue On 10% Residuum, %, Max.	0.35	0.40
Viscosity @ 40° Celsius, Centistokes	1.9 - 4.1	2.0 - 7.0
Distillation		
deg. Celsius (Fahrenheit)		
90% Recovery, Max.	338 (640)	360 (680)

STATEMENT OF POLICY ON FUEL AND LUBRICANT ADDITIVES

In answer to requests concerning the use of fuel and lubricating oil additives, the following excerpt has been taken from a policy statement of General Motors Corporation:

"It has been and continues to be General Motors policy to build motor vehicles that will operate satisfactorily on the commercial fuels and lubricants of good quality regularly provided by the petroleum industry through retail outlets. It is accordingly contrary to the policy of General Motors to recommend the regular and continued use of supplementary additives in fuels and lubricants."

Therefore, Detroit Diesel Allison does not recommend the use of any supplementary fuel or lubricant additives. These include all products marketed as fuel conditioners, smoke suppressants, masking agents, reodorants, tune-up compounds, top oils, break-in oils, graphitizers, and friction-reducing compounds.

NOTICE: The manufacturer's warranty applicable to Detroit Diesel engines provides in part that the provisions of such warranty shall not apply to any engine unit which has been subject to misuse, negligence or accident. Accordingly, malfunctions attributable to neglect or failure to follow the manufacturer's fuel or lubricating recommendations may not be within the coverage of the warranty.

© 1983 General Motors Corp.

LUBRICATING OILS FOR DETROIT DIESEL ENGINES

GENERAL CONSIDERATIONS

All diesel engines require heavy-duty lubricating oils. Basic requirements of such oils are lubricating quality, high heat resistance, and control of contaminants.

LUBRICATING QUALITY. The reduction of friction and wear by maintaining an oil film between moving parts is the primary requisite of a lubricant. Film thickness and its ability to prevent metal-to-metal contact of moving parts is related to oil viscosity. The optimums for Detroit Diesel engines are SAE 40 or 30 weight.

HIGH HEAT RESISTANCE. Temperature is the most important factor in determining the rate at which deterioration or oxidation of the lubricating oil will occur. The oil should have adequate thermal stability at elevated temperatures, thereby precluding formation of harmful carbonaceous and/or ash deposits.

CONTROL OF CONTAMINANTS. The piston and compression rings must ride on a film of oil to minimize wear and prevent cylinder seizure. At normal rates of consumption, oil reaches a temperature zone at the upper part of the piston where rapid oxidation and carbonization can occur. In addition, as oil circulates through the engine, it is continuously contaminated by soot, acids, and water originating from combustion. Until they are exhausted, detergent and dispersant additives aid in keeping sludge and varnish from depositing on engine parts. But such additives in excessive quantities can result in detrimental ash deposits. If abnormal amounts of insoluble deposits form, particularly on the piston in the compression ring area, early engine failure may result.

Oil that is carried up the cylinder liner wall is normally consumed during engine operation. The oil and additives leave carbonaceous and/or ash deposits when subjected to the elevated temperatures of the combustion chamber. The amount of deposits is influenced by the oil composition, additive content, engine temperature, and oil consumption rate.

OIL QUALITY is the responsibility of the oil supplier. (The term "oil supplier" is applicable to refiners, blenders, and rebranders of petroleum products). Oil quality can also be affected by handling cleanliness, contamination, dirt, water, etc.

There are hundreds of commercial crankcase oils marketed today. Obviously, engine manufacturers or users cannot completely evaluate the numerous commercial oils. The selection of a suitable lubricant in consultation with a reliable oil supplier, observance of his oil drain recommendations (based on used oil sample analysis and experience), and proper filter maintenance will provide the best assurance of satisfactory oil performance.

It should be noted that lube oil manufacturers may reformulate an oil while maintaining the same API classification, or may reformulate to a new API classification and continue the brand name designation. For example, SE oils being reformulated to SF letter code classification may perform differently after this reformulation. A close working relationship with the lube oil manufacturer should be maintained so that any reformulation can be reviewed and a decision made as to its effect on continued satisfactory performance.

COLD WEATHER OPERATION

Two important considerations relate to satisfactory operation under cold ambient temperature conditions. These are: (1) the ability to crank the engine fast enough to secure starting, and (2) providing adequate lubrication to internal wearing surfaces during starting and warm-up. Once started and warmed up, external ambient temperatures have little effect on internal engine temperatures. Both cold weather considerations can be adequately met through proper lube oil selection and the use of auxiliary heat prior to starting. Auxiliary heat can be used in the form of jacket water and oil pan heaters, hot air space heaters applied to engine compartments, or some combination of these.

Proper oil selection and oil heat can assure lubricant flow immediately upon starting. Improper oil selection and oil heat may result in starting with cold oil congealed in the oil pan, and little or no oil flow for lubricating internal parts once the engine has started.

Proper oil selection and jacket water heating can assure cranking capability by maintaining an oil film on cylinder walls and bearing surfaces in a condition which provides low friction, and hence, less cranking effort to achieve cranking speeds necessary for reliable starting. Improper oil selection and jacket water heating may result in congealed oil films on cylinder walls and bearing surfaces, which result in high friction loads and more cranking effort than is available, thus preventing sufficient cranking speeds to assure reliable starting.

© 1983 General Motors Corp.

LUBE OIL SPECIFICATIONS

API PERFORMANCE DESIGNATIONS, LUBE SUPPLIER, AND BRAND NAMES

Lubricants are blended to meet specific industry accepted tests developed by the American Society for Testing and Materials (ASTM). The service for which these products are intended is defined by the American Petroleum Institute (API). The lube supplier markets these products under a specific brand or trade name. The container identification indicates whether the contents meet or exceed specific API letter code designations (example: SF, CD).

RECOMMENDATION

Lubricating oils that meet the following performance levels, viscosity grades, sulfated ash limits and zinc requirements are recommended for Detroit Diesel engines. It is also recommended that the oil supplier provide to the user evidence of satisfactory performance of his products in Detroit Diesel engines.

LUBE OIL PERFORMANCE LEVELS

Lubricants are formulated to meet all the performance criteria defined in either commercial (API) and/or military specifications. Table L-1 shows the current commercial industry and military oil performance levels. The API letter designations are defined in SAE recommended practice J-183 published in the SAE Handbook.

Specific oil performance level recommendations for Detroit Diesel engines are indicated in Table L-1.

TABLE L-1
LUBE OIL PERFORMANCE LEVELS

API PERFORMANCE DESIGNATION		COMPARABLE MILITARY SPECIFICATION	RECOMMENDED FOR USE IN DDA ENGINES		COMMENTS & CURRENT API OR MILITARY QUALIFICATION STATUS
DIESEL ENGINES	GASOLINE ENGINES		2-CYCLE	4-CYCLE	
CB	—	MIL-L-2104A (Supplement 1)	YES	NO	Obsolete, still limited availability.
CC	—	MIL-L-2104B	YES	NO	Obsolete, still readily available.
CD	—	MIL-L-45199B (Series 3)	YES	NO	Still limited availability.
CC	SE	MIL-L-46152	YES	YES	Obsolete Diesel performance, intended for passenger cars burning gasoline.
CC	SF	NONE	YES	YES	Primarily for passenger cars burning gasoline.
CD	SC	MIL-L-2104C	YES	YES	Current spec. for heavy duty diesel powered military vehicles, acceptable for commercial diesel powered vehicles.
CD	SE		YES	YES	Diesel performance requirements are current. Gasoline fueled passenger cars performance requirements are obsolete.
CD	SF		YES	YES	Meet current diesel & gasoline performance requirements.
—	SF		NO	YES	Service station lubes.

VISCOSITY GRADES

Single grade SAE-40 and 30 lubricants are preferred and recommended for use in all Detroit Diesel 2-cycle engines. Table L-2 shows a viscosity grade selection chart as related to ambient temperatures. Note that 15W-40 multigrade oils are recommended as a third choice for Series 53, 71 and 92 engines only when ambient temperatures are below 32°F (0°C). Multigrade oils, including 15W-40, should never be used in Series 149 engines.

TABLE L-2
VISCOSITY — SAE GRADE SELECTION CHART

Ambient Temperature		ENGINE SERIES								
		149		92, 71, 53			8.2L			
		2-CYCLE		2-CYCLE			4-CYCLE			
		First	Second	First	Second	Third	First	Second	Third	Fourth
Deg. Fahr.	Deg. Celsius	**								
↑	↑	SAE 40	SAE 30	SAE 40	SAE 30	None	15W-40	10W-40	20W-40	30
50	10	SAE (40)	SAE 30 *	SAE (40)	SAE 30 *	None	* 15W-40	* 10W-40	* 20W-40	None
32	0	SAE (40)	SAE (30)	SAE (40)	SAE (30)	* 15W-40	(15W-40)	* 10W-40	(20W-40)	None
0	−18	SAE (40)	SAE (30)	SAE (40)	SAE (30)	(15W-40)	(15W-40)	(10W-40)	(20W-40)	None
−25	−32									

( ) Numbers in parentheses indicate that starting aids are required.

* Usually unaided starts can be accomplished.

** SAE 50 grade lube oil is recommended if the top tank coolant temperature is 195°F or above. (CAUTION: Do not use SAE-50 grade lube oil when or where cold ambient temperatures prevail.)

OTHER MULTIGRADE OILS

15W-40 oils are the only acceptable multigrade lubricants that should be considered in Series 53, 71 and 92 engines if prolonged cold ambient temperatures below 32°F (0°C) are expected. Detroit Diesel Allison does not recommend the use of any multigrade oils other than 15W-40 in these 2-cycle engines. Never use any kind of multigrade oils in Series 149 engines.

OIL CHANGES

CONDITION A: THE SULFUR CONTENT OF THE DIESEL FUEL IS LESS THAN 0.50% BY WEIGHT

Table L-3 shows the initial oil drain intervals recommended for all Detroit Diesel engines. Oil drain intervals may be increased or decreased depending upon the condition of the lubricant. Used lube oil analysis guidelines, indicating contamination limits, are shown elsewhere in Table L-4. DDA recommends that if the total base number (TBN by ASTM D-664) is reduced to 1.0 or if the TBN (ASTM-2896) is reduced to 2.0, the oil should be drained immediately.

© 1983 General Motors Corp.

CONDITION B: THE SULFUR CONTENT OF THE DIESEL FUEL IS GREATER THAN 0.50% BY WEIGHT

The detrimental effects of burning high sulfur fuel are known in industry. The use of high sulfur diesel fuel may be unavoidable in some locations.

The use of high TBN/ash oils (TBN greater than 10, ash up to 2.500% by weight) is recommended to counteract corrosion.

The trend manifested by extremely high TBN oils (TBN greater than 20/ash between 2.000 to 2.500% by weight) is to drop several TBN numbers and then level off. The condition of the used oil under these circumstances is that it has retained some alkaline reserve (neutralization power) but will become overloaded with suspended solids that tend to become insoluble, resulting in the formation of excessive engine deposits. Therefore, when using high TBN/ash oils, a rule of thumb for oil change intervals is to drain the oil when the TBN drops to one-half of the new oil TBN. *Since lubricant composition varies from brand to brand the time and rate of TBN reduction will vary.* These differences manifested by the various high TBN/ash oils will influence the drain interval.

TABLE L-3

RECOMMENDED LUBE OIL DRAIN AND FULL-FLOW FILTER CHANGE INTERVALS WHEN BURNING LOW SULFUR DIESEL FUELS (0.5% BY WT. OR LESS)*

SERVICE APPLICATION	ENGINE SERIES	ENGINE DESIGN	LUBE OIL DRAIN INTERVAL**	FILTER CHANGE INTERVAL
Hwy. Truck & Inter-City Buses	71 & 92 8.2L	2-Cycle 4-Cycle	20,000 Miles 6,000 Miles	20,000 Miles 6,000 Miles
City Transit Coaches & Pick-Up & Delivery Truck Service (Stop-and-Go) Short Distance	53, 71, 92 8.2L	2-Cycle 4-Cycle	12,000 Miles 6,000 Miles	12,000 Miles 6,000 Miles
Industrial & Marine	53, 71, 92 8.2L	2-Cycle 4-Cycle	150 Hours 150 Hours	150 Hours 150 Hours
Large Industrial & Marine	149 (NA) 149 (T)	2-Cycle 2-Cycle	500 Hrs. or One Yr. 300 Hrs. or One Yr.	500 Hrs. or One Yr. 300 Hrs. or One Yr.
Stationary (Stand-By) Engines	53, 71, 92 149 8.2L	2-Cycle 2-Cycle 4-Cycle	150 Hrs. or One Yr. 150 Hrs. or One Yr. 150 Hrs. or One Yr.	150 Hrs. or One Yr. 150 Hrs. or One Yr. 150 Hrs. or One Yr.
Generator Sets (Prime Power)	53, 71, 92	2-Cycle	500 Hrs. or One Mo.	500 Hrs. or One Mo.

* See sections indicating Detroit Diesel's recommendations when burning high sulfur content (0.5% by Wt. or more) diesel fuels.

** May be increased or decreased, depending on the results obtained from used lube oil analysis.

FULL-FLOW FILTER CHANGE PERIOD

Table L-3 shows the DDA recommended full-flow filter change period for the various service applications. The filter element should be changed at the same time the crankcase oil is drained. Filter life is affected by heat and vibration in addition to contaminant filtration. Filter change should not exceed 25,000 miles/500 hours maximum.

TABLE L-4

USED LUBE OIL ANALYSIS GUIDELINES

These values indicate the need for an immediate oil change, but do not necessarily indicate internal engine problems requiring engine teardown. Characteristics relating to lube oil dilution should trigger corrective action to identify and fix the source(s) of leaks, if these values are realized.

		ENGINE SERIES				
		2-CYCLE Series 149	2-CYCLE Series 92	2-CYCLE Series 71	2-CYCLE Series 53	4-CYCLE Series 8.2L
	ASTM Designation	WARNING LIMITS				
Pentane Insolubles, Wt. %	D-893	1.00	1.00	1.00	1.00	1.00
Carbon (Soot) Content Wt. % Max.	TGA †	0.80	0.80	0.80	0.80	2.00
Viscosity at 100°F, SUS	D-445 & D-2161					
% Max. Increase		40.0	40.0	40.0	40.0	40.0
% Max. Decrease		15.0	15.0	15.0	15.0	15.0
Total Base Number (TBN), Min.	D-664	1.00	1.00	1.00	1.00	1.00
Total Base Number (TBN), Min.	D-2896	2.00	2.00	2.00	2.00	2.00
Water Content (Dilution), Vol. %, Max.	D-95	0.30	0.30	0.30	0.30	0.30
Flash Point, °F. Max. Reduction	D-92	40.0	40.0	40.0	40.0	40.0
Fuel Dilution, Vol. %, Max.	—	1.00	2.50	2.50	2.50	2.50
Glycol Dilution, PPM., Max.	D-2982	1000.00	1000.00	1000.00	1000.00	1000.00
Iron Content, PPM., Max.	‡	35	150	150	150	250
Sodium Content, PPM Max. Allowed Over Lube Oil Baseline	‡	50	50	50	50	50
Boron Content, PPM., Max. Allowed Over Lube Oil Baseline	‡	20	20	20	20	20

† TGA = Thermogravimetric analysis used and recommended by Detroit Diesel. No ASTM procedure designation.

‡ Elemental analyses are conducted using either emission spectographic or atomic absorption instruments. Neither method has ASTM designation.

FREQUENCY OF LUBE OIL SAMPLES FOR ANALYSIS

The interval at which used lube oil samples may be obtained for analysis can be scheduled for the same period as when other preventative maintenance is conducted. For example, in highway truck applications, a sample may be obtained every 10,000 miles when engines are brought in for fuel and coolant filter replacement. (Reference instructions in Detroit Diesel Engine Service Manuals).

USED LUBE OIL ANALYSIS PROGRAM

A used lube oil analysis program is recommended for monitoring the condition of the crankcase oil in all engines.

© 1983 General Motors Corp.

Primarily, used lube oil analyses indicate the condition of the oil but not necessarily the condition of the engine. Never tear down an engine based solely on the analysis results obtained from a single used oil sample. However, the condition of the engine should be investigated using conventional mechanical and/or electronic diagnostic instruments. Frequently, visual inspections are all that is required to detect problem areas related to engine wear. It is also prudent to obtain another oil sample from the suspected distressed unit for analysis.

Abnormal concentrations of some contaminants such as diesel fuel, coolant, road salt, or airborne dirt cannot be tolerated for prolonged periods. Their presence will be reflected in accelerated engine wear, which can result in less than optimum engine life. The oil should be changed immediately if any contamination is present in concentrations exceeding the warning limits shown in Table L-4.

Experience in specific engine applications operating specific model engines is a prerequisite for proper interpretation of laboratory used lube oil sample analysis results. It is imperative to remember, in scrutinizing laboratory used lube oil sample results, that it is the change in value or deviation from baseline data obtained from the new oil (same brand or mixture of brands) that is significant. This is especially important to remember in investigations such as wear metal analysis, total base number and viscosity determinations.

SULFATED ASH LIMIT (ASTM D-874)

There is a performance trade-off when using either high or low ash oils. High ash oils (greater than 1.000% by weight) sometimes provide excessive exhaust valve and ring groove deposits but have shown superior anti-wear performance on compression rings and cylinder liners. Low ash oils, historically, have shown minimal engine deposit formation tendencies but premature wear has been experienced in some applications. As indicated in the oil changes section, low ash oils do not provide sufficient neutralization capability when high sulfur diesel fuels are used.

Therefore, DDA recommends that low ash (less than 1.000% by weight) oils continue to be used where satisfactory performance has been experienced. High ash oils (2.500% by weight max.) may be used under the following circumstances:

A. At locations where high sulfur diesel fuels (greater than 0.50% by weight) are continuously used.

B. At locations, regardless of the fuel sulfur content, where the oil supplier has submitted documented, conclusive evidence to the user that the lubricant provided satisfactory field test performance in Detroit Diesel engines.

ZINC CONTENT

The zinc content (zinc diorganodithiophosphate) of all low ash (less than 1.000% by weight) lube oils recommended for use in Detroit Diesel 2-cycle and 4-cycle engines shall be a minimum of 0.07% by weight. This requirement is waived where single grade SAE-40, intermediate viscosity index lubricants qualified for use in Electro-Motive Division (EMD) diesel engines are used in Detroit Diesel engines.

Some specific high ash oils (2.500% by weight maximum) do not contain zinc additives. These oils may be used under the following circumstances:

1. Where diesel fuels with greater than 0.50% by weight sulfur content are continuously used.

2. The oil supplier has submitted documented, conclusive evidence to the user that the lubricant has provided satisfactory field test performance in Detroit Diesel engines.

EVIDENCE OF SATISFACTORY PERFORMANCE

It is recommended that evidence of satisfactory lubricant performance in Detroit Diesel 2-cycle engines be obtained from the oil supplier prior to procurement. Controlled oil performance evaluations in field test engines are recommended. The type of field test used by the oil supplier depends on the series engine in which the candidate oil will be used and the service application. This information is summarized in Table L-5. The candidate test oil-operated engines should all operate for the mileage/hours indicated. Fuel and lube oil consumption should be monitored during the test period. Any serious mechanical problems experienced should be recorded. All of the oil test engines should be disassembled at the conclusion of the oil test period and inspected. The following oil performance parameters should be compared:

- Ring sticking tendencies and/or ring conditions
- Piston skirt scuffing and cylinder liner wear and scuffing
- Exhaust valve face and seat deposits
- Piston pin and connecting rod bushing wear (Note: Trunk pistons used in Series 53 engines)
- Overall valve train and bearing wear levels.

© 1983 General Motors Corp.

TABLE L-5

INDIVIDUAL USER SERVICE APPLICATION
LUBE FIELD TESTING

ENGINE SERIES	SERVICE APPLICATION	TEST DURATION	NO. ENGINES ON CANDIDATE TEST OIL	NO. SISTER ENGINES ON REFERENCE BASELINE SAE 40 or SAE 30
53	Pickup & Delivery Metro Area	50,000 Miles	5	5
71 & 92	Hwy. Truck 72,000 Lbs. GCW	200,000 Miles	5	5
149	Off Road Rear Dump 120 Ton	10,000 Hours	3*	3*

* Single Grade Only — No multigrades recommended for Series 149 engines.

MIL-L-46167 ARCTIC LUBE OILS FOR NORTH SLOPE AND OTHER EXTREME SUB-ZERO OPERATIONS

Lubricants meeting this specification are used in Alaska and other extreme sub-zero locations. Generally, they may be described as 5W-20 multigrade lubricants made up of synthetic base stock and manifesting low volatility characteristics. Although they have been used successfully in some severe cold regions, Detroit Diesel Allison does not consider their use as desirable as the use of SAE-40 or SAE-30 oils with auxiliary heating aids. For this reason, they should be considered only where engine cranking is a severe problem and auxiliary heating aids are not available on the engine.

SYNTHETIC OILS

Synthetic lubricants may be used in Detroit Diesel 2-cycle engines provided the ash limit, zinc requirements, and specified oil performance levels (for example, CD/SE or MIL-L-2104B, etc.) shown elsewhere in this specification are met. Viscosity grades SAE-40 or SAE-30 are recommended.

MISCELLANEOUS FUEL AND LUBRICANT INFORMATION

ENGINE OIL CLASSIFICATION SYSTEM

The American Petroleum Institute (API), the Society of Automotive Engineers (SAE), and the American Society for Testing and Materials (ASTM) jointly have developed the present commercial system for designating and identifying motor oil classifications. The table in this section shows a cross-reference of current commercial and military lube oil identification and specification systems.

CROSS-REFERENCE OF LUBE OIL CLASSIFICATION SYSTEM

API CODE LETTERS	COMPARABLE MILITARY OR COMMERCIAL INDUSTRY SPECIFICATION
CA	MIL-L-2104A
CB	Supplement 1
CC	MIL-L-2104B (See Note Below)
CD	MIL-L-45199B (Series 3)
‡	MIL-L-46152 (Supersedes MIL-L-2104B Military Only)
□	MIL-L-2104C (Supersedes MIL-L-45199B for Military Only)
SA	None
SB	None
SC	Auto Passenger Car 1964 MS Oils - Obsolete System
SD	Auto Passenger Car 1968 MS Oils - Obsolete System
SE	Auto Passenger Car 1972 MS Oils - Obsolete System
SF	Auto Passenger Car 1980 Production

‡ Oil performance meets or exceeds that of CC and SE oils.

□ Oil performance meets or exceeds that of CD and SC oils.

NOTE: MIL-L-2104B lubricants are obsolete for military service applications only.
MIL-L-2104B lubricants are currently marketed and readily available for commercial use.

Consult the following publications for complete descriptions:

1. Society of Automotive Engineers (SAE) Technical Report J-183a.
2. Federal Test Method Standard 791a.

PUBLICATION AVAILABLE SHOWING COMMERCIAL "BRAND" NAME LUBRICANTS

A list of "brand" name lubricants distributed by the majority of worldwide oil suppliers can be purchased from the Engine Manufacturers Association (EMA). The publication is titled *EMA Lubricating Oils Data Book for Heavy-Duty Automotive and Industrial Engines*. The publication shows the brand names, oil performance levels, viscosity grades, and sulfated ash contents of most "brands" marketed.

ENGINE MANUFACTURERS ASSOCIATION
111 EAST WACKER DRIVE
CHICAGO, ILLINOIS 60601

Upon request, the Detroit Diesel Allison Regional Office will counsel with customers in selecting a lubricating oil that will be suitable for their specific needs.

STATEMENT OF POLICY ON FUEL AND LUBRICANT ADDITIVES

See statement at the end of "FUEL OILS" section.

© 1983 General Motors Corp.

ENGINE COOLANT

The coolant provides a medium for heat transfer and controls the internal temperature of the engine during operation. In an engine having proper coolant flow, the heat of combustion is conveyed through the cylinder walls and the cylinder head into the coolant. Without adequate coolant, normal heat transfer cannot take place within the engine, and engine temperature rapidly rises. In general, water containing various materials in solution is used for this purpose.

The function of the coolant is basic to the design and to the successful operation of the engine. Therefore, coolant must be carefully selected and properly maintained.

COOLANT REQUIREMENTS

Coolant solutions must meet the following basic requirements:

1. Provide for adequate heat transfer.

2. Provide a corrosion-resistant environment within the cooling system.

3. Prevent formation of scale or sludge deposits in the cooling system.

4. Be compatible with the cooling system hose and seal materials.

5. Provide adequate freeze protection during cold weather operation.

The first four requirements are satisfied by combining a suitable water with reliable inhibitors. When freeze protection is required, a solution of suitable water and an antifreeze containing adequate inhibitors will provide a satisfactory coolant. Ethylene glycol-based antifreeze is recommended for use in Detroit Diesel engines.

	PARTS PER MILLION	GRAINS PER GALLON
Chlorides (Maximum)	40	2.5
Sulfates (Maximum)	100	5.8
Total Dissolved Solids (Maximum)	340	20
Total Hardness (Maximum)	170	10

TABLE 1

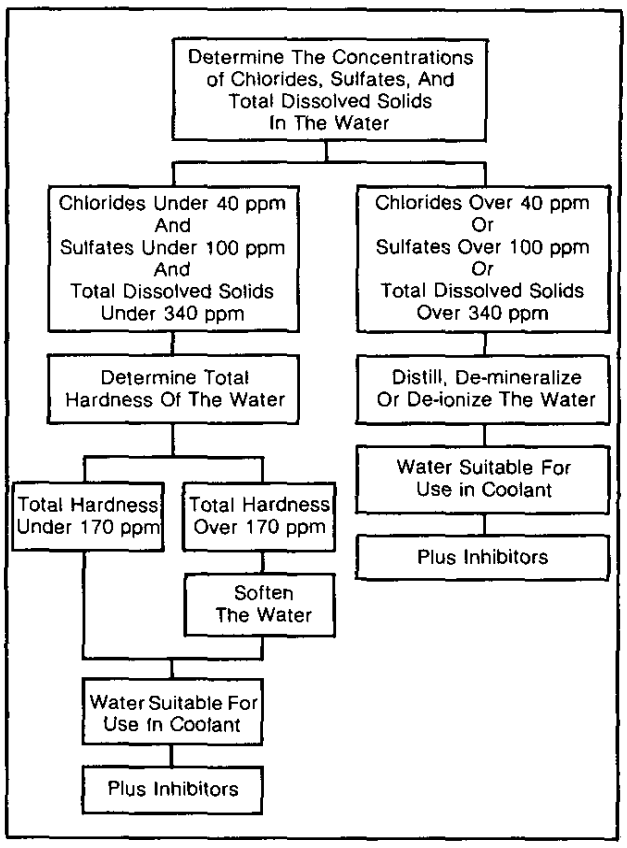


TABLE 2

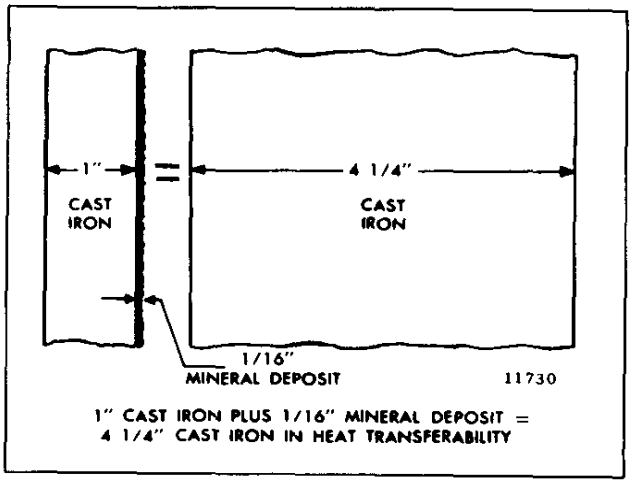


Fig. 1 - Heat Transfer Capacity

© 1983 General Motors Corp.

WATER

Any water, whether of drinking quality or not, will produce a corrosive environment in the cooling system, and the mineral content may permit scale deposits to form on internal cooling system surfaces. Therefore, water selected as a coolant must be properly treated with inhibitors to control corrosion and scale deposition.

To determine if a particular water is suitable for use as a coolant when properly inhibited, the following characteristics must be considered: the concentration of chlorides and sulfates, total hardness and dissolved solids.

Chlorides and/or sulfates tend to accelerate corrosion, while hardness (percentage of magnesium and calcium salts broadly classified as carbonates) causes deposits of scale. Total dissolved solids may cause scale deposits, sludge deposits, corrosion or a combination of these. Chlorides, sulfates, magnesium and calcium are among the materials which make up dissolved solids. Water, within the limits specified in Table 1 is satisfactory as an engine coolant when proper inhibitors are added. The procedure for evaluating water intended for use in a coolant solution is shown in Table 2.

CORROSION INHIBITORS VITAL

A corrosion inhibitor is a water-soluble chemical compound which protects the metallic surfaces of the cooling system against corrosive attack. Some of the more commonly used corrosion inhibitors are chromates, borates, nitrates, nitrites and soluble oil. (Soluble oil is not recommended as a corrosion inhibitor). Depletion of all types of inhibitors occurs through normal operation. Therefore, strength levels must be maintained by the addition of inhibitors at prescribed intervals.

The importance of a properly inhibited coolant cannot be overstressed. A coolant which has insufficient inhibitors, the wrong inhibitors, or-worse-no inhibitors at all invites the formation of rust and scale deposits within the cooling system. Rust, scale, and mineral deposits can wear out water pump seals and coat the walls of the cylinder block water jackets and the outside walls of the cylinder liners. As these deposits build up, they insulate the metal and reduce the rate of heat transfer. For example, a 1/16″ deposit of rust or scale on 1″ of cast iron is equivalent to 4-1/4″ of cast iron in heat transferability (Fig. 1).

An engine affected in this manner overheats gradually over a period of weeks or months. Liner scuffing, scoring, piston seizure and cylinder head cracking are the inevitable results. An improperly inhibited coolant can also become corrosive enough to "eat away" coolant passages and seal ring grooves and cause coolant leaks to develop. If sufficient coolant accumulates on top of a piston, a hydrostatic lock can occur while the engine is being started. This, in turn, can result in a bent connecting rod. Am improperly inhibited coolant can also contribute to *cavitation erosion.* Cavitation erosion is caused by the collapse of bubbles (vapor pockets) formed at the coolant side of an engine component. The collapse results from a pressure differential in the liquid caused by the vibration of the engine part. As bubbles collapse, they form pin points of very high pressure. Over a period of time, the rapid succession of millions of tiny bursting bubbles can wear away (erode) internal engine surfaces.

Components such as fresh water pump impellers and cylinder liners are especially susceptible to cavitation erosion. In extreme cases their surfaces can become so deeply pitted that they appear to be spongy, and holes can develop completely through them.

Chromates

Sodium chromate and potassium dichromate are two of the best and most commonly used *water* system corrosion inhibitors. Care should be exercised in handling these materials due to their toxic nature.

Chromate inhibitors should *not* be used in antifreeze solutions. Chromium hydroxide, commonly called "green slime", can result from the use of chromate inhibitors with antifreeze. This material deposits on the cooling system passages and reduces the heat transfer rate (Fig. 1) which results in engine overheating. Engines which have operated with a chromate-inhibited water must be chemically cleaned before the addition of antifreeze. A commercial heavy duty descaler should be used in accordance with the manufacturer's recommendation for this purpose.

Soluble Oil

Soluble oil has been used as a corrosion inhibitor for many years. It has, however, required very close attention relative to the concentration level due to adverse effects on heat transfer if the concentration exceeds 1% by volume. For example: 1.25% of soluble oil in the cooling system increases fire deck temperatures 6% and a 2.50% concentration raises fire deck temperature up to 15%. *Soluble oil is not recommended as a corrosion inhibitor.*

Non-Chromates

Non-chromate inhibitors (borates, nitrates, nitrites, etc.) provide corrosion protection in the cooling system with the basic advantage that they can be used with either water or a water-and-antifreeze solution.

© 1983 General Motors Corp.

INHIBITOR SYSTEMS

An inhibitor system is a combination of chemical compounds which provide corrosion protection, pH control and water-softening ability. Corrosion protection is discussed under the heading *Corrosion Inhibitors Vital.* The pH control is used to maintain an acid-free solution. The water-softening ability deters formation of mineral deposits. Inhibitor systems are available in various forms such as coolant filter elements, liquid and dry bulk inhibitor elements, liquid and dry bulk inhibitor additives and as an integral part of antifreeze.

Coolant Filter Elements

Replaceable elements are available with various chemical inhibitor systems. Compatibility of the element with other ingredients of the coolant solution cannot always be taken for granted.

Problems have developed from the use of the magnesium lower support plate used by some manufacturers in their coolant filters. The magnesium plate will be attacked by solutions which will not be detrimental to other metals in the cooling system. The dissolved magnesium will be deposited in the hottest zones of the engine where heat transfer is most critical. The use of an aluminum or zinc support plate in preference to magnesium is recommended to eliminate the potential of this type of deposit.

High chloride coolants will have a detrimental effect on the water-softening capabilities of systems using ion-exchange resins. Accumulations of calcium and magnesium ions removed from the coolant and held captive by the zeolite resin can be released into the coolant by a regenerative process caused by high chloride-content solutions.

Bulk Inhibitor Additives

Commercially packaged inhibitor systems are available which can be added directly to the engine coolant or to bulk storage tanks containing coolant solution. Both chromate and non-chromate systems are available and care should be taken regarding inhibitor compatibility with other coolant constituents.

Non-chromate inhibitor systems are recommended for use in Detroit Diesel engines. These systems can be used with either water or water-and-antifreeze solutions and provide corrosion protection, pH control and water softening. Some non-chromate inhibitor systems offer the additional advantage of a simple on-site test to determine protection level. Since they are added directly to the coolant, require no additional hardware or plumbing.

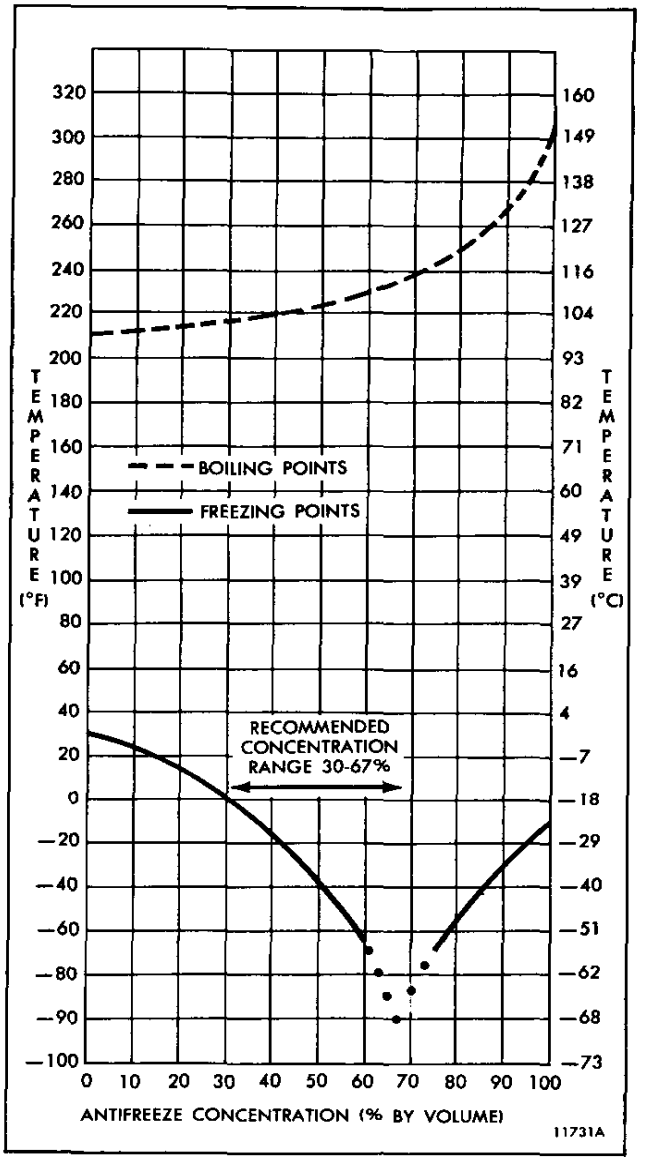


Fig. 2 - Coolant Freezing and Boiling Temperatures vs. Antifreeze Concentration (Sea Level)

All inhibitors become depleted through normal operation and additional inhibitor must be added to the coolant at prescribed intervals to maintain original strength levels. Always follow the supplier's recommendations on inhibitor usage and handling.

© 1983 General Motors Corp.

TEST STRIPS

Some chemical manufacturers have developed *test strips* for use with their antifreeze or coolant additives. These test strips are used to measure the freeze protection and/or inhibitor strength of ethylene glycol-based antifreeze. To avoid a false reading caused by variations in reserve alkalinity, Detroit Diesel Allison suggests using test strips that measure depletable inhibitor concentration directly. *Do not use one manufacturer's test strips to measure the chemical content of another's antifreeze and/or inhibitors.* Always follow the manufacturer's recommended test procedures.

ANTIFREEZE

When freeze protection is required, an antifreeze meeting GM Specification 1899M must be used. An inhibitor system is included in this type of antifreeze and no additional inhibitors are required on initial fill if a minimum antifreeze concentration of 30% by volume is used. Solutions of less than 30% concentration do not provide sufficient corrosion protection. Concentrations over 67% adversely affect freeze protection and heat transfer rates (Fig. 2).

Ethylene glycol base antifreeze is recommended for use in all Detroit Diesel engines. Methyl alcohol base anitfreeze is not recommended because of its effect on the non-metallic components of the cooling system and because of its low boiling point. Methoxy propanol base antifreeze is not recommended for use in Detroit Diesel engines due to the presence of fluoroelastomer seals in the cooling system.

Before installing ethylene glycol base antifreeze in a unit that has previously operated with methoxy propanol, the entire cooling system should be drained, flushed with clean water, and examined for rust, scale contaminants, etc. If deposits are present, the cooling system must be chemically cleaned with a commerical grade heavy-duty descaler.

The inhibitors in antifreeze should be replenished at approximately 500 hour intervals or by test with a non-chromate inhibitor system. Commercially available inhibitor systems may be used to reinhibit antifreeze solutions.

Sealer Additives

Antifreeze with sealer additives is not recommended for use in Detroit Diesel engines due to plugging possibilities throughout various areas of the cooling system, including cooling system bleed holes and water pump drain holes.

GENERAL RECOMMENDATIONS

All Detroit Diesel engines incorporate pressurized cooling systems which permit operation at temperatures higher than non-pressurized systems. It is essential that these systems be kept clean and leak-free, that filler caps and pressure relief mechanisms be correctly installed at all times and that coolant levels be properly maintained.

Always maintain engine coolant at the proper level. A low coolant level allows the water pump to mix air with the coolant. Air bubbles in the coolant can "insulate" the cylinder walls, preventing normal heat transfer. An abnormally low coolant level can cause the water pump to become (:air-bound," a condition in which it works feverishly but pumps nothing. Without proper heat transfer, silicone elastomer head-to-block water hole seals can deteriorate and cylinder components can expand so that pistons rapidly cut through the lubricant on the liner walls. Scuffing and piston seizure may follow.

> **CAUTION:** Use extreme care when removing a radiator pressure control cap from an engine. The sudden release of pressure from a heated cooling system can result in a loss of coolant and possible personal injury (scalding) from the hot liquid.

An engine may contain the correct amount of properly inhibited coolant, but still fail to adequately cool the engine. In cases where this occurs, other causes of low coolant flow, either engine or cooling system related, should be investigated.

1. Always use a properly inhibited coolant.
2. Do not use soluble oil.
3. Maintain the prescribed inhibitor strength.
4. Always follow the manufacturer's recommendations on inhibitor usage and handling.
5. If freeze protection is required, use a solution of water and antifreeze meeting GM Specification 1899M.
6. Reinhibit antifreeze with a recommended non-chromate inhibitor system.
7. Do not use a chromate inhibitor with antifreeze.
8. Do not use methoxy propanol base antifreeze in Detroit Diesel engines.
9. Do not mix ethylene glycol base antifreeze with methoxy propanol base antifreeze in the cooling system.
10. Do not use antifreeze containing sealer additives.
11. Do not use methyl alcohol base antifreeze.
12. Use extreme care when removing the radiator pressure control cap.

© 1983 General Motors Corp.

SECTION 14

ENGINE TUNE-UP

CONTENTS

Engine Tune-Up Procedures and Emission Regulations 14

Exhaust Valve Clearance Adjustment 14.1

Fuel Injector Timing 14.2

Limiting Speed Mechanical Governor and Injector Rack Control Adjustment:

- Single and Double-Weight 14.3
- Dual Range 14.3.2
- Variable Low-Speed 14.3.3
- Fast Idle Cylinder 14.3.4
- Governor Setting for "TT" Engines 14.3.5
- Diesel Railcar Engine 14.3.6

Variable Speed Mechanical Governor and Injector Rack Control Adjustment 14.4
Variable Speed Governor with Hydraulic Throttle Knockdown 14.4.1

Fuel Modulating Governor and Injector Rack Control Adjustment 14.5

Constant Speed Mechanical Governor and Injector Rack Control Adjustment 14.6

Hydraulic Woodward SG Governor and Injector Rack Control Adjustment 14.7

Hydraulic Woodward PSG Governor and Injector Rack Control Adjustment 14.8

Dual Hydraulic Woodward SGT Governor and Injector Rack Control Adjustment. 14.9

Mechanical Output Shaft Governor and Linkage Adjustment 14.10

Hydraulic Output Shaft Governor and Linkage Adjustment 14.11

Throttle Linkage Adjustment for Load Equalization - Twin and Quad Units 14.12

Hydraulic Woodward UG8 Governor and Throttle Linkage Adjustment 14.13

Supplementary Governing Device Adjustment:

- Engine Load Limit Device 14.14
- Power Control Device 14.14
- Throttle Delay Mechanism 14.14
- Fuel Modulator 14.14
- Fuel Shutoff Air Cylinder 14.14
- Governor Shutdown Solenoid 14.14
- Starting Aid Screw (See Section 14.3)

© 1983 General Motors Corp.

ENGINE TUNE-UP PROCEDURES

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating mechanism, governor, etc. should only be required periodically to compensate for normal wear on parts.

To comply with emissions regulations, injector timing, exhaust valve clearance, engine idle and no-load speeds, and throttle delay or fuel modulator settings must be checked and adjusted, if necessary, at 50,000 miles intervals (refer to Section 15.1). The type of governor used depends upon the engine application. Since each governor has different characteristics, the tune-up procedure varies accordingly. The following types of governors are used:

1. Limiting speed mechanical.
2. Variable speed mechanical.
3. Constant speed mechanical.
4. Hydraulic.

The mechanical governors are identified by a name plate attached to the governor housing. The letters D.W.-L.S. stamped on the name plate denote a double-weight limiting speed governor. A single-weight variable speed governor name plate is stamped S.W.-V.S.

Normally, when performing a tune-up on an engine in service, it is only necessary to check the various adjustments for a possible change in the settings. However, if the cylinder head, governor or injectors have been replaced or overhauled, then certain tune-up adjustments are required.

> **NOTE:** If a supplementary governing device, such as the throttle delay mechanism, is used, it must be disconnected prior to the tune-up. After the governor and injector rack adjustments are completed, the supplementary governing device must be reconnected and adjusted.

To tune-up an engine completely, perform all of the adjustments, except the valve bridge adjustment on a four-valve cylinder head, in the applicable tune-up sequence given below.

> **CAUTION:** To prevent the possibility of personal injury, use turbocharger inlet shield J 26554-A anytime the turbocharger inlet is exposed.

The tune-up procedures apply to the individual engines of multiple engine units as well as to the single engine units. However, the throttle linkage of multiple engine units must be adjusted after the individual engines have been tuned-up.

> **NOTE:** The exhaust valve bridges on a four-valve cylinder head are adjusted at the time the cylinder head is installed on the engine and, until wear occurs, no further adjustment is required. When wear is evident, perform a complete valve bridge adjustment as outlined in Section 1.2.2.

Use a new valve rocker cover gasket after the tune-up is completed.

Tune-Up Sequence for Mechanical Governor

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover, the serviceman must determine that the injector racks move to the no-fuel position when the governor stop lever is placed in the stop position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

> **CAUTION:** An overspeeding engine can result in engine damage which could cause personal injury.

1. Adjust the exhaust valve clearance, cold.
2. Time the fuel injectors.
3. Adjust the governor gap.
4. Position the injector rack control levers.
5. Adjust the maximum no-load speed.
6. Adjust the idle speed.
7. Adjust the buffer screw.
8. Adjust the throttle booster spring (variable speed governor only).
9. Adjust the supplementary governing device, if used.

> **NOTE:** The steps necessary to adjust an engine with a fuel modulating governor are covered in Section 14.5.

Tune-Up Sequence for Hydraulic Governor

1. Adjust the exhaust valve clearance.
2. Time the fuel injectors.
3. Adjust the fuel rod.
4. Position the injector rack control levers.
5. Adjust the load limit screw.
6. Compensation adjustment (PSG governors only).
7. Adjust the speed droop.
8. Adjust the maximum no-load speed.

© 1983 General Motors Corp.

EMISSION REGULATIONS FOR ON-HIGHWAY VEHICLE ENGINES

On-highway vehicle and coach engines built by Detroit Diesel Allison are certified to be in compliance with Federal and California Emission Regulations established for each model year beginning with 1970.

Engine certification is dependent on five physical characteristics:

1. Fuel injector type.
2. Maximum full-load engine speed.
3. Camshaft timing.
4. Fuel injector timing.
5. Throttle delay (orifice size).

The following Charts summarize all of the pertinent data concerning the specific engine configurations required for each model year.

When serviced, all on-highway vehicle and coach engines should comply with the specifications for the specific model year in which the engine was built.

Trucks in a fleet containing engines of various model years can be tuned to the latest model year, provided the engines have been updated to meet the specifications for that particular year.

1970 and 1971 CERTIFIED AUTOMOTIVE CONFIGURATIONS

Engines	3,4,6-71 (4 Valve)	3,4,6-71 (4 Valve)	3,4,6-71 (4 Valve)
Injectors	71N5 N55 N60	N65	N70
■ Maximum Full-load Speed	2100	2100	2300
Camshaft Timing	Std.	Adv.	Adv.
◆ Injector Timing	1.460"	1.484"	1.460"
Throttle Delay	No	No	No

◆ The adjusted height of the fuel injector follower in relation to the injection body.

■ No load engine speed will vary with injector size and governor type.

1972 CERTIFIED AUTOMOTIVE CONFIGURATIONS

Engines	3-71 4-71 6-71 (4 Valve)	3-71 4-71 6-71 (4 Valve)	3-71 4-71 6-71 (4 Valve)	6-71T	*6-71T
Injectors	71N5 N55 N60	N65	N70	N65	N70 N75
**Maximum Full Load Engine Speed	2300	2300	2300	2100	2100
Camshaft Timing	Std.	Adv.	Adv.	Std.	Std.
‡ Injector Timing	1.460"	1.484"	1.460"	1.484"	1.460"
Throttle Delay	No	No	No	.016" Orifice	.016" Orifice

*6-71T Fire Truck Application exempt from certification.

‡ The adjusted height of the fuel injector follower in relation to the injector body.

**No load engine speed will vary with injector size and governor type.

© 1983 General Motors Corp.

1973 CERTIFIED AUTOMOTIVE CONFIGURATIONS

Engines	3-71N 4-71N 6-71N (4 Valve) ▼	3-71N 4-71N 6-71N (4 Valve) ▼	3-71N 4-71N 6-71N (4 Valve) ▼	6-71T	6-71T	*6-71T	*6-71T
Injectors	71C5	C55 C60	C65 C70	C65	N70 N75	C65	N70 N75
**Maximum Full Load Engine Speed	2300	2300	2300	2100	2100	2300	2300
Camshaft Timing	Std.	Std.	Adv.	Std.	Std.	Std.	Std.
Injector Timing	1.484"	1.460"	1.484"	1.460"	1.484"	1.460"	1.484
Throttle Delay	No	No	No	● .016" Orifice	● .016" Orifice	● .016" Orifice	● .016" Orifice

● .078" diameter fill hole.
**No Load engine speed will vary with injector size and governor type.
▼ Includes certain Parlor and Suburban Coach Engines.
*Exempt Engine Rating for Fire Truck Application only (Code No. 351).
Use Minimum idle speed of 500 rpm on all engines, except coach engines where a minimum of 400 rpm is allowed.

1974 CERTIFIED AUTOMOTIVE CONFIGURATIONS

Engines	6-71N ■	6-71N ■	6-71N ■	6-71N ■	6-71N ■	6-71T	6-71T	6-71T
Injectors	71C5	C55	C60	C65	C70	C65	N70	N75
**Maximum Full-load Engine Speed	2300	2300	2300	2300	2300	2100	2100	2100
Camshaft Timing	Std.	Std.	Std.	Adv.	Adv.	Std.	Std.	Std.
Injector Timing	1.484"	1.460"	1.460"	1.484"	1.484"	1.460"	1.484"	1.484"
Throttle Delay	No	No	No	No	No	++.016" Orifice	++.016" Orifice	++.016" Orifice
Yield Link	No	No	No	No	No	Yes	Yes	Yes

++ .078" diameter fill hole.
** No load engine speed will vary with injector size and governor type.
■ Includes Certain Parlor and Suburban Coach Engine.

Use minimum idle speed of 500 rpm on all engines, except coach engines where a minimum of 400 rpm is allowed.

© 1983 General Motors Corp.

1975 CERTIFIED AUTOMOTIVE CONFIGURATIONS

FEDERAL								
ENGINE	*6-71N	*6-71N	*6-71N	*6-71N	*6-71N	6-71T	6-71T	6-71T
Injectors	71C5	C55	C60	C65	C70	C65	N70	N75
†Maximum Full-load Engine Speed	2300	2300	2300	2300	2300	2100	2100	2100
Camshaft Timing	Standard	Standard	Standard	Advanced	Advanced	Standard	Standard	Standard
Injector Timing	1.484"	1.460"	1.460"	1.484"	1.484"	1.460"	1.484"	1.484"
Throttle Delay	No	No	No	No	No	#.016" Orifice	#.016" Orifice	#.016" Orifice
Yield Link	No	No	No	No	No	Yes	Yes	Yes

FEDERAL AND CALIFORNIA				
ENGINE	6-71N	6-71N	6-71N	6-71N
Injectors	71B5	B55	B60	B65
†Maximum Full-load Engine Speed	2300	2300	2300	2300
Camshaft Timing	Standard	Standard	Standard	Advanced
Injector Timing	1.500"	1.500"	1.500"	1.484"
Throttle Delay	No	No	No	#Yes
Yield Link	No	No	No	Yes

† Not to exceed fuel injector size and maximum operating speed that has been established for the specific application of the engine.

* *Includes certain highway coach engines.*

.078" diameter fill hole.

Use minimum idle speed of 500 rpm on all engines, except coach engines where a minimum of 400 rpm is allowed.

© 1983 General Motors Corp.

1976 CERTIFIED AUTOMOTIVE CONFIGURATIONS

Engine	FEDERAL		CALIFORNIA
	6L-71N (c)	6L-71T	6L-71N
(a) Injectors	71C5 C55 C60 C65 C70	C65 N70 N75	71B5 B55 B60 B65
(b) Maximum Full-load Speed	2300	2100	2300
Camshaft Timing	Std. (71C5) Std. (C55) Std. (C60) Adv. (C65) Adv. (C70)	Std.	Std. (Adv.—B65)
Injector Timing	1.484" (71C5) 1.484" (C65) 1.484" (C70) 1.460" (C55) 1.460" (C60)	1.460" (C65) 1.484" (N70) 1.484" (N75)	1.500" 1.484" (B65)
Throttle Delay Yield Link	Not Req'd.	(g) Req'd.	Not Req'd. (Req'd. -B65) (g)
Turbocharger A/R		T18A40 1.00 4MF-782 4.70	

(a) Not to exceed injector size and maximum operating speed that has been established. No-load speed will vary with injector size and governor type.

(b) Use a minimum idle speed of 400 rpm on all coach engines with throttle delay and a minimum idle speed of 500 rpm on all other engines.

(c) Includes certain highway coach engines.

(g) Small fill hole (.078" Dia.), .016" discharge orifice.

© 1983 General Motors Corp.

1977 CERTIFIED AUTOMOTIVE CONFIGURATIONS

Engine	FEDERAL				CALIFORNIA
	6L-71N (c)	6L-71T			6L-71N
		T	T	TT	
(a) Injectors	71C5 C55 C60 C65 C70	C65 N70 N75	C65 N70 N75	N75	71B5 B55 B60
(a) Approved Minimum Constant Horsepower				220	
(a) Maximum Rated Speed	2300	2100	2100	2100	2300
(a) Minimum Rated Speed	2300 (71C5) 1950 (C55) 1900 (C60) 1950 (C65) 2100 (C70)	2100	1900	1900	2300 (71B5) 2100 (B55) 2100 (B60)
Gear Train Timing	Std.	Std.	Std.	Std.	Std.
Injector Timing	1.484" (71C5) 1.460" (C55) 1.460" (C60) 1.484" (C65) 1.484" (C70)	1.460" (C65) 1.484" (N70) 1.484" (N75)			1.500"
Throttle Delay (Yield Link) Setting	None	(f) Req'd .570"			None
Liner Port Height	1.05"	1.05"	1.05"	1.05"	1.05"
Compression Ratio	18.7:1	17:1	17:1	17:1	18.7:1
Blower Drive Ratio	2:1	1.95:1	1.95:1	1.95:1	2:1
Governor Type	Limiting Speed				
Thermostat	170-180° F (77-82° C) Nominal Opening Temperature				
Turbocharger A/R		T18A40 1.00 4MF-782 4.70	TV7101 1.39	TV7101 1.39	

(a) Not to exceed injector size and maximum operating speed that has been established. No-load speed will vary with injector size and governor type.

(c) Includes certain highway coach engines.

(f) Small fill hole (.078" Dia.), .016" discharge orifice.

Use minimum idle speed of 500 rpm on all engines, except coach engines where a minimum of 400 rpm is allowed.

© 1983 General Motors Corp.

1978 CERTIFIED AUTOMOTIVE CONFIGURATIONS

	FEDERAL					CALIFORNIA
ENGINE FAMILIES	(c) 6L-71N	6L-71T				6L-71NC
		T	OTM	TT	T	
INJECTORS (a)	71C5 C55 C60 C65 C70	C65 N70 N75	C65 N70 N75	N75	C65 N70 N75	71B5 B55 B60
APPROVED CONSTANT HORSEPOWER FOR TT & TTA ENGINES				220-230		
MAXIMUM FULL LOAD SPEED (b)	2300	2100	2100	2100	2100	2300
MINIMUM FULL LOAD SPEED	71C5-1800 C55-1800 C60-1800 C65-1900 C70-1900	1900	1900	1900	1900	1800
CAMSHAFT LOBE POSITION		STD.	STD.	STD.	STD.	STD.
INJECTOR TIMING			C65 - 1.460 N70 and N75 - 1.484			1.500
THROTTLE DELAY YIELD LINK	NOT REQ.	(f) REQ.	(f) REQ.	(f) REQ.	(f) REQ.	NOT REQ.
TURBOCHARGER A/R		*T18A40 1.00 *4MF-782 4.70 Sq. In.	TV7101 1.39	TV7101 1.39	*T18A40 1.50 *4MF-782 8.54 Sq. In.	

(a) See Engine Application Rating (Sales Tech Data Book I, Vol. 3) for specific application usage of injector size and full-load speed combination. No-load speed will vary with injector size and governor type.

(b) Use a minimum idle speed of 400 rpm on all coach engines with throttle delay and a minimum idle speed of 500 rpm on all other engines.

(c) Includes certain highway coach engines.

(f) Small fill hole (.078" dia.), .016" discharge orifice.

* These turbocharger options to be cancelled effective 9/1/78.

Use minimum idle speed of 500 rpm on all engines, except coach engines where a minimum of 400 rpm is allowed.

© 1983 General Motors Corp.

1979 CERTIFIED AUTOMOTIVE CONFIGURATIONS

	FEDERAL ENGINES			CALIFORNIA ENGINES
Families	**6L-71N*** **	**6L-71T**	**6L-71TT**	**6L-71NC**
Injectors	7E65, 7E60 7E55, 7E50	N65 7C70 7C75	7E75	71B5 B55 B60
Maximum Full Load Speed	2300	2100	2100	2300
Minimum Full Load Speed	1800 7E65-1900	1900	1800	1800
Minimum Idle Speed	500	500	500	500
Gear Train Timing	Std.%	Std.	Std.	Std.
Injector Timing	1.484 7E55-1.496	N65-1.490 7C70-1.470 7C75-1.460	1.466	71B5-1.500 1.508
Throttle Delay Setting	DNA	.570%%	.594%%	DNA
Liner Port Height	1.05	.95	.95	1.05
Liner Part Number	5113953	5102795	5102795	5113953
Turbocharger A/R	DNA	TV-7101 1.23 A/R	TV-6141 1.08 A/R	DNA
Turbocharger Part Number	DNA	5107617	5107616	DNA
Blower Drive Ratio	2:1	1.65:1	1.51:1	2:1
Blower Part Number	5138554-LH 5138553-RH 5142017-Hort.	5107609 5108031-RH	5107608	5138554-LH 5138553-RH 5142017-Hort.
Compression Ratio	18.7:1	17:1	17:1	18.7:1
Exhaust Valve *Material*	Inconel X *Type 751*	Nimonic 90 *Aluminized*	Nimonic 90 *Aluminized*	Inconel X *Type 751*
Exhaust Valve Part Number	5114288	5111336	5111336	5114288
Certification Label Number	14B7-268	14B7-263	14B7-263	14B7-269

% 7E65 — Built in advanced camshaft timing.
%% Small fill hole (.078 dia.) .016 diameter discharge orifice.
*** Includes certain highway coach engines.
DNA Does not apply.

TIMING GAGES

J-1853	For 1.460"
J-26888	For 1.466"
J-24236	For 1.470"
J-29065	For 1.480"
J-1242	For 1.484"
J-29066	For 1.490"
J-9595	For 1.496"
J-25454	For 1.500"
J-8909	For 1.508"
J-25502	For 1.520"

THROTTLE DELAY AND STARTING AID GAGES

J-24889	For .345"
J-28779	For .365"
J-24882	For .385"
J-28479	For .395"
J-9509-2	For .404"
J-23190	For .454"
J-29062	For .504"
J-25559	For .570"
J-26927	For .586" & .686"
J-25560	For .636"
J-29064	For .660"
J-29063	For .594"
J-26645	For .160"
J-26646	For .290"

PIN GAGE

J-25558	For .069" & .072"

© 1983 General Motors Corp.

1980 and 1981 CERTIFIED AUTOMOTIVE CONFIGURATIONS

	FEDERAL			CALIFORNIA	
ENGINE FAMILIES	(c) 6L-71N	6L-71T	6L-71TT	6L-71TAC	6L-71TTAC
Injectors (a)	7E50 7E55 7E60 7E65	N65 7C70 7C75	7E75	7G75	7G75
Maximum Full Load Speed (a)	2300	2100	2100	2100	2100
Minimum Full Load Speed	1800 7E65-1900	1800	1800	1800	1800
Minimum Idle Speed	500	500	500	700	700
Gear Train Timing	(d) Std.	Std.	Std.	Std.	Std.
Injector Timing	1.484 7E55-1.496	N65-1.490 7C70-1.470 7C75-1.460	1.466	1.470	1.470
Throttle Delay Setting	DNA	(f) .570	(f) .594	(f) .586	(f) .586
Turbocharger A/R	DNA	TV7101 1.23 A/R	TV6141 1.08 A/R	TV-6141 1.39	TV-6141 1.39

(a) Refer to Engine Application Rating (Sales Tech Data Book I, Vol. 3) for specific application usage of injector size and full load speed combination. No load speed will vary with injector size and governor.
(c) Includes certain highway coach engines.
(d) 7E65 Injector has built-in advance camshaft timing.
(f) Small fill hole (.078 dia.) .016 dia. dishcarge orifice.

THROTTLE DELAY AND STARTING AID GAGES

J 24889 For .345"
J 28779 For .365"
J 24882 For .385"
J 28479 For .395"
J 9509-2 For .404"
J 23190 For .454"
J 29062 For .504"
J 25559 For .570"
J 26927 For .586" & .686"
J 25560 For .636"
J 29064 For .660"
J 29063 For .594"
J 26645 For .160"
J 26646 For .290"

PIN GAGE

J 25558 For .069" & .072"

TIMING GAGES

J 1853 For 1.460"
J 26888 For 1.466"
J 24236 For 1.470"
J 29065 For 1.480"
J 1242 For 1.484"
J 29066 For 1.490"
J 9595 For 1.496"
J 25454 For 1.500"
J 8909 For 1.508"
J 25502 For 1.520"

1980 and 1981 CERTIFIED AUTOMOTIVE ENGINES

ENGINE	INJECTOR	RATED BHP	PEAK TORQUE (LB-FT.)
6L-71N	7E50 7E55 7E60 7E65	185 @ 2100 200 @ 2100 215 @ 2100 230 @ 2100	565 @ 1200 590 @ 1200 611 @ 1200 611 @ 1600
6L-71T	N65 7C70 7C75	245 @ 2100 260 @ 2100 275 @ 2100	736 @ 1200 781 @ 1200 801 @ 1400
6L-71TT	7E75	210 @ 1800 230 @ 1950 240 @ 2100	853 @ 1200 853 @ 1200 853 @ 1200
6L-71TAC (California)	7G75	270 @ 2100	783 @ 1200
6L-71TTAC (California)	7G75	230 @ 1950 240 @ 2100 *270 @ 2100	783 @ 1200 783 @ 1200 *783 @ 1200
ALL ENGINE HORSEPOWER RATINGS ARE BASED ON SAE CONDITIONS 85°F (29.4°C) — AIR INLET TEMPERATURE 29.00 IN. HG (98.19 kPa) — BAROMETER (DRY)			

*1980 ENGINES ONLY

© 1983 General Motors Corp.

1982 CERTIFIED AUTOMOTIVE CONFIGURATIONS

	FEDERAL			CALIFORNIA	
FAMILIES	**6L-71N** ***	**6L-71T**	**6L-71TT**	**6L-71TA**	**6L-71TTA**
INJECTORS	7E50, 71B5 7E55 B55 7E60 B60 7E65	N65 7C70 7C75	7E75	7G65 7G70 7G75	7G75
MAX. FULL LOAD SPEED	2300	2100	2100	2100	2100
MIN. FULL LOAD SPEED	1800 7E65-1900	1800	1800	1800	1800
MIN. IDLE SPEED	500	500	500	700	700
GEAR TR. TIMING	Std. %	Std.	Std.	Std.	Std.
INJECTOR TIMING	1.484 7E55-1.496 X	N65-1.490 7C70-1.470 7C75-1.460	1.466	1.470	1.470
THROTTLE DELAY SETTING	DNA	.570%%	.594%%	.586	.586
LINER PORT HGHT.	1.05	.95	.95	.95	.95
LINER PART NO.	5113953	5102795	5102795	5102795	5102795
TURBO-CHARGER A/R	DNA	TV7101 1.23 A/R	TV6141 1.08 A/R	TV-6141 1.39 A/R	TV-6141 1.39 A/R
TURBO-CHARGER P/N	DNA	5107617	5107616	8921391	8921391
BLOWER DR. RATIO	2:1	1.65:1	1.51:1	1.65:1	1.65:1
BLOWER PART NO.	5138554-LH 5138553-RH 5142017-HOR	5107609 5108031-RH 5142017-HOR	5107608	8921306 8921307 HOR	8921306 8921307 HOR
COMP. RATIO	18.7:1	17:1	17:1	17:1	17:1
EXHAUST VALVE P/N	5114288	5111336	5111336	5111336	5111336
CERT. LABEL NO.	14B7-329	14B7-330	14B7-330		

*** INCLUDES CERTAIN HIGHWAY COACH ENGINES
% 7E65 INJECTOR HAS BUILT IN ADVANCE TIMING
X B60, B55-1, 508 71B5-1.500
%% SMALL FILL HOLE (.078 DIA.) .016 DIA. DISCHARGE ORIFICE

Effective January 1, 1982, California allowed the use of Federal certified engines in *Public Transit Busses* and in *Authorized Emergency Vehicles* as defined in section 165 of the California Vehicle Code.

1982 CERTIFIED AUTOMOTIVE ENGINES

ENGINE	INJECTOR	RATED BHP	PEAK TORQUE (LB-FT)
6L-71N	7E50 7E55 7E60 7E65	185 @ 2100 200 @ 2100 215 @ 2100 230 @ 2100	565 @ 1200 590 @ 1200 611 @ 1200 611 @ 1600
6L-71T	N65 7C70 7C75	245 @ 2100 260 @ 2100 275 @ 2100	736 @ 1200 781 @ 1200 801 @ 1400
6L-71TT	7E75	210 @ 1800 230 @ 1950 240 @ 2100	853 @ 1200 853 @ 1200 853 @ 1200
6L-71TAC/ TTAC (California)	7G75	230 @ 1950 240 @ 2100 270 @ 2100	783 @ 1200 783 @ 1200 783 @ 1200

ALL ENGINE HORSEPOWER RATINGS ARE BASED ON SAE CONDITIONS

85°F (29.4°C) — AIR INLET TEMPERATURE
29.00 IN. HG (98.19 kPa) — BAROMETER (DRY)

© 1983 General Motors Corp.

1983 CERTIFIED AUTOMOTIVE CONFIGURATIONS

	FEDERAL					CALIFORNIA
ENGINE FAMILIES	(c) 6L-71N	6L-71T	6L-71TT	6L-71TA	6L-71TTA	6L-71TAC/TTAC
INJECTORS (a)	7E50 7E55 7E60 7E65	N65 7C70 7C75	7E75	7C75	7E75	7G75
MAXIMUM FULL LOAD SPEED (a)	2300	2100	2100	1950	2100	2100
MINIMUM FULL LOAD SPEED	1800 7E65-1900	1800	1800	1800	1800	1800
MINIMUM IDLE SPEED	500	500	500	500	500	700
GEAR TRAIN TIMING	(d) Std.	Std.	Std.	Std.	Std.	Std.
INJECTOR TIMING	1.484 7E55-1.496	N65-1.490 7C70-1.470 7C75-1.460	1.466	1.458	1.460	1.470
THROTTLE DELAY SETTING	DNA	(f) .570	(f) .594	(f) .550	(f) .570	(f) .586
MODULATOR SETTING	DNA	.365	.385	.404	.404	DNA
TURBOCHARGER A/R	DNA	TV7101 1.23 A/R	TV6141 1.08 A/R	TV6141 1.08 A/R	TV6141 1.08 A/R	TV6141 1.39 A/R
TURBOCHARGER PART NO.	DNA	5107617	5107616	5107616	5107616	8921391
BLOWER DRIVE RATIO	2.00:1	1.65:1	1.51:1	1.51:1	1.51:1	1.65:1
BLOWER PART NO.	5138554-LH 5138553-RH 5142017-HOR	5107609 5108031-RH 5142017-HOR	5107608	8924966	8924966	8921306 8921307 HOR.
COMPRESSION RATIO	18.7:1	17:1	17:1	18.7:1	18.7:1	17:1
EXHAUST VALVE PART NO.	5114288	5111336	5111336	5111336	5111336	5111336
LINER PART NO.	5113953	5102795	5102795	5102795	5102795	5102795
LINER PORT HEIGHT	1.05	.95	.95	.95	.95	.95

DNA Does not apply.

(a) Refer to Engine Application Rating (Sales Tech Data Book 1, Vol. 3) for specific application usage of injector size and full load speed combination. No load speed will vary with injector size and governor.

(c) Includes certain highway coach engines.

(d) 7E65 injector has built-in advance camshaft timing.

(f) Small fill hole (.078 dia.) .016 dia. discharge orifice.

Effective January 1, 1982, California allowed the use of Federal certified engines in *Public Transit Busses* and in *Authorized Emergency Vehicles* as defined in section 165 of the California Vehicle Code.

1983 CERTIFIED AUTOMOTIVE ENGINES

ENGINE	INJECTOR	RATED BHP	PEAK TORQUE (LB-FT.)
6L-71N	7E50	185 @ 2100	565 @ 1200
	7E55	200 @ 2100	590 @ 1200
	7E60	215 @ 2100	611 @ 1200
	7E65	230 @ 2100	611 @ 1600
6L-71T	N65	245 @ 2100	736 @ 1200
	7C70	260 @ 2100	781 @ 1200
	7C75	275 @ 2100	801 @ 1400
6L-71TT	7E75	180 @ 1800	853 @ 1200
		230 @ 1800	853 @ 1200
		230 @ 1950	853 @ 1200
		240 @ 2100	853 @ 1200
6L-71TA	7C75	260 @ 1800	810 @ 1200
		270 @ 1950	810 @ 1200
6L-71TTA	7E75	180 @ 1800	840 @ 1200
		230 @ 1800	840 @ 1200
		230 @ 1950	840 @ 1200
		240 @ 2100	840 @ 1200
6L-71TAC/ TTAC (California)	7G75	230 @ 1800	783 @ 1200
		230 @ 1950	783 @ 1200
		240 @ 2100	783 @ 1200
		270 @ 2100	783 @ 1200

ALL ENGINE HORSEPOWER RATINGS ARE BASED ON SAE CONDITIONS

85°F (29.4°C) — AIR INLET TEMPERATURE
29.00 IN. HG (98.19 kPa) — BAROMETER (DRY)

© 1983 General Motors Corp.

EXHAUST VALVE CLEARANCE ADJUSTMENT

The correct exhaust valve clearance at normal engine operating temperature is important for smooth, efficient operation of the engine.

Insufficient valve clearance can result in loss of compression, misfiring cylinders and, eventually, burned valve seats and valve seat inserts. Excessive valve clearance will result in noisy operation, increased valve face wear and valve lock damage.

Whenever the cylinder head is overhauled, the exhaust valves are reconditioned or replaced, or the valve operating mechanism is replaced or disturbed in any way, the valve clearance must be adjusted to the cold setting to allow for normal expansion of the engine parts during the engine warm-up period. This will ensure a valve setting that is close enough to the specified clearance to prevent damage to the valves when the engine is started.

ENGINES WITH TWO VALVE CYLINDER HEADS

All of the exhaust valves may be adjusted in firing order sequence during one full revolution of the crankshaft. Refer to the *General Specifications* at the front of the manual for the engine firing order.

Valve Clearance Adjustment (Cold Engine)

1. Remove the loose dirt from the valve rocker cover and remove the cover.

2. Place the governor speed control lever in the *idle* speed position. If a stop lever is provided, secure it in the *stop* position.

3. Rotate the crankshaft, manually or with the starting motor, until the injector follower is fully depressed on the particular cylinder to be adjusted.

> **NOTE:** If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation because the bolt may be loosened.

4. Loosen the exhaust valve rocker arm push rod locknut.

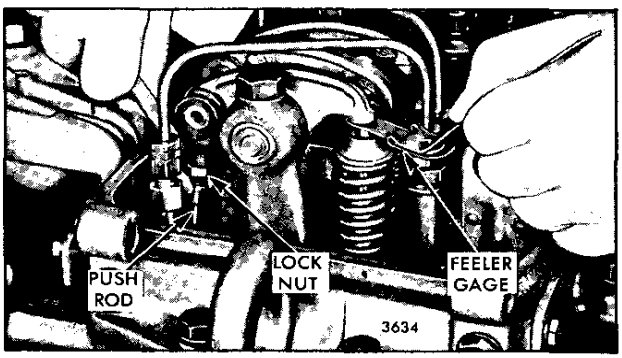


Fig. 1 - Adjusting Valve Clearance (Two Valve Head)

5. Place a .012″ feeler gage (J 9708-01) between the exhaust valve stem and the rocker arm (Fig. 1). Adjust the push rod to obtain a smooth pull on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16″ wrench and tighten the locknut with a 1/2″ wrench.

7. Recheck the clearance. At this time, if the adjustment is correct, the .011″ feeler gage will pass freely between the valve stem and the rocker arm, but the .013″ feeler gage will not pass through. Readjust the push rod, if necessary.

8. Check and adjust the remaining exhaust valves in the same manner as outlined above.

Valve Clearance Adjustment (Hot Engine)

> **NOTE:** It is *not* necessary to make a final hot engine exhaust valve clearance adjustment after a cold engine adjustment has been performed. However, if a hot engine adjustment is desired, use the following procedure.

Maintaining normal engine operating temperature is particularly important when making the final exhaust valve clearance adjustment. If the engine is allowed to cool before setting any of the valves, the clearance, when running at full load, may become insufficient.

> **NOTE:** Since these adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

1. With the engine at normal operating temperature (refer to Section 13.2), set the exhaust valve clearance with feeler gage J 9708-01. At this time, if the valve clearance is correct, the .008″ feeler gage will pass freely between the end of the valve stem and the rocker arm and the .010″ gage will not pass through. Readjust the push rod, if necessary.

© 1983 General Motors Corp.

2. After the exhaust valve clearance has been adjusted, check the fuel injector timing (Section 14.2).

Check Exhaust Valve Clearance Adjustment

1. With the engine at 100° F (38° C) or less, check the valve clearance.

2. If a .012" feeler gage (±.004") will pass between the valve stem and the rocker arm bridge, the valve clearance is satisfactory. If necessary, adjust the push rod.

ENGINES WITH FOUR VALVE CYLINDER HEADS

The exhaust valve bridges must be adjusted and the adjustment screws locked securely at the time the cylinder head is installed on the engine. The necessary adjustment procedure is outlined in Section 1.2.2.

The exhause valve bridge balance should be checked when a general valve adjustment is performed. After the bridges are balanced, adjust the valve clearance at the *push rod only.*

Do not disturb the exhaust valve bridge adjusting screw.

All of the exhaust valves may be adjusted in firing order sequence during one full revolution of the crankshaft. Refer to the *General Specifications* at the front of the manual for the engine firing order.

Valve Clearance Adjustment (Cold Engine)

1. Remove the loose dirt from the valve rocker cover and remove the cover.

2. Place the governor speed control lever in the *idle* speed position. If a stop lever is provided, secure it in the *stop* position.

3. Rotate the crankshaft, manually or with the starting motor, until the injector follower is fully depressed on the cylinder to be adjusted.

> **NOTE:** If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation because the bolt may be loosened.

4. Loosen the exhaust valve rocker arm push rod locknut.

5. Place a .016" feeler gage (J 9708-01) between the end of the exhaust valve stem and the valve bridge adjustment screw (spring-loaded bridge only) or between the valve bridge and the valve rocker arm pallet (unloaded bridge only) -- refer to Figs. 2 and 3. Adjust the push rod to obtain a smooth pull on the feeler gage.

6. Remove the feeler gage. Hold the push rod with a 5/16" wrench and tighten the locknut with a 1/2" wrench.

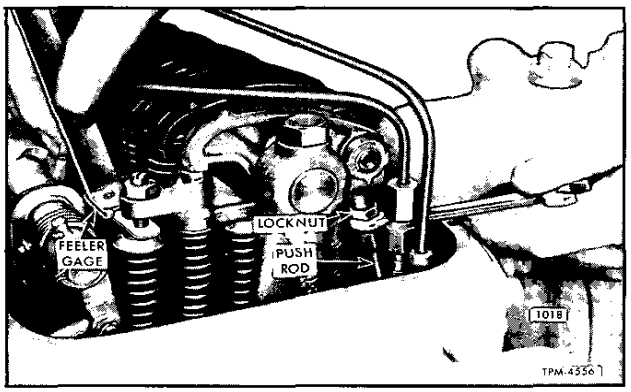


Fig. 2 - Adjusting Valve Clearance (Spring-Loaded Valve Bridge)

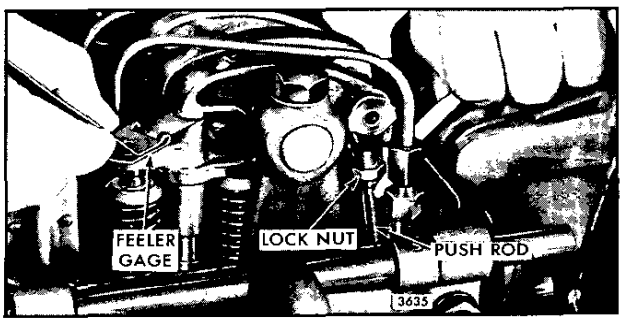


Fig. 3 - Adjusting Valve Clearance (Unloaded Valve Bridge)

© 1983 General Motors Corp.

7. Recheck the clearance. At this time, if the adjustment is correct, the .015″ gage will pass freely between the valve stem and the adjustment screw (spring-loaded bridge) or between the valve bridge and the rocker arm pallet (unloaded bridge), but the .017″ gage will not pass through. Readjust the push rod, if necessary.

8. Check and adjust the remaining exhaust valves in the same manner as above.

Valve Clearance Adjustment (Hot Engine)

NOTE: It is *not* necessary to make a final hot engine exhaust valve clearance adjustment after a cold engine adjustment has been performed. However, if a hot engine adjustment is desired, use the following procedure.

Maintaining normal engine operating temperature is particularly important when making the final exhaust valve clearance adjustment. If the engine is allowed to cool before setting any of the valves, the clearance, when running at full load, may become insufficient.

NOTE: Since these adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to maintain normal operating temperature.

1. With the engine at normal operating temperature (refer to Section 13.2), set the exhaust valve clearance with feeler gage J 9708-01. At this time, if the valve clearance is correct, the .013″ gage will pass freely between the valve stem and the valve bridge adjusting screw (spring-loaded bridge) or between the valve bridge and the rocker arm pallet (unloaded bridge), but the .015″ feeler gage will not pass through. Readjust the push rod, if necessary.

2. After the exhaust valve clearance has been adjusted, check the fuel injector timing (Section 14.2).

Check Exhaust Valve Clearance Adjustment

1. With the engine at 100° F (38° C) or less, check the valve clearance.

2. If a .016″ feeler gage (±.004″) will pass between the valve stem and the rocker arm bridge, the valve clearance is satisfactory. If necessary, adjust the push rod.

© 1983 General Motors Corp.

FUEL INJECTOR TIMING

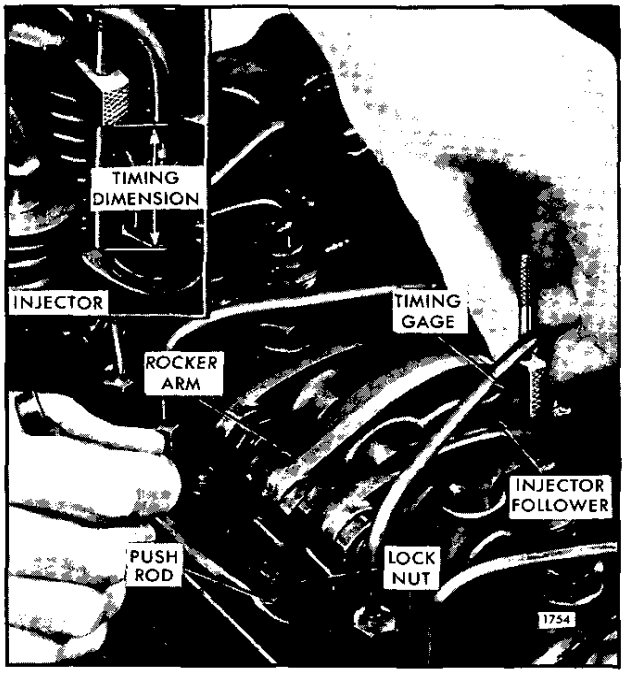


Fig. 1 - Timing Fuel Injector

Injector	Timing Dimension	Timing Gage
HV55	1.484"	J 1242
5S8	1.460"	J 1853
6E8	1.460"	J 1853
6S8	1.460"	J 1853
55E	1.460"	J 1853
S55	1.460"	J 1853
HV6	1.484"	J 1242
S60	1.460"	J 1853
60	1.484"	J 1242
HE6	1.460"	J 1853
60E	1.460"	J 1853
S65	1.460"	J 1853
70	1.460"	J 1853
HV7	1.460"	J 1853
S70	1.460"	J 1853
80	1.460"	J 1853
HV8	1.460"	J 1853
S80	1.460"	J 1853
90	1.460"	J 1853
HV9	1.460"	J 1853
S90	1.460"	J 1853

TABLE 1 - INJECTOR TIMING (Crown Valve)

To time an injector properly, the injector follower must be adjusted to a definite height in relation to the injector body.

All of the injectors can be timed in firing order sequence during one full revolution of the crankshaft. Refer to the *General Specifications* at the front of the manual for the engine firing order.

Time Fuel Injector

After the exhaust valve clearance has been adjusted (Section 14.1), time the fuel injectors as follows:

1. Place the governor speed control lever in the *idle* speed position. If a stop lever is provided, secure it in the *no-fuel* position.

2. Rotate the crankshaft, manually or with the starting motor, until the exhaust valves are fully depressed on the particular cylinder to be timed.

NOTE: If a wrench is used on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation because the bolt may be loosened.

3. Place the small end of the injector timing gage in the hole provided in the top of the injector body with the flat of the gage toward the injector follower (Fig. 1). Refer to Tables 1 and 2 for the correct timing gage (for vehicle engines, refer to Section 14).

4. Loosen the injector rocker arm push rod locknut.

5. Turn the push rod and adjust the injector rocker arm until the extended part of the gage will just pass over the top of the injector follower.

6. Hold the push rod and tighten the locknut. Check the adjustment and, if necessary, readjust the push rod.

7. Time the remaining injectors in the same manner as outlined above.

8. If no further engine tune-up is required, use a new gasket and install the valve rocker cover.

© 1983 General Motors Corp.

Injector	Timing Dimension	Timing Gage	Camshaft Timing
	Generator Set Applications		
All	1.460"	J 1853	Standard
	#All Other Applications		
71N5	*1.460"	J 1853	*Standard
N55	*1.460"	J 1853	*Standard
N60	*1.460"	J 1853	*Standard
N60 (turbo)	1.460"	J 1853	Standard
N65 (white tag)	1.460"	J 1853	Standard
N65 (turbo-brown tag)	1.484"	J 1242	Standard
N65 (non-turbo) (brown tag)	†1.484"	J 1242	†Advanced
HN65	1.460"	J 1853	Standard
N70 (turbo)	1.460"	J 1853	Standard
N70 (non-turbo)	1.460"	J 1853	Advanced
N75 (turbo)	1.460"	J 1853	Standard
N80 (turbo)	1.484"	J 1242	Standard
N80 (non-turbo)	†1.484"	J 1242	†Advanced
N90	1.460"	J 1853	Standard

For automotive applications, refer to Section 14.

* Use 1.484" timing gage (J 1242) when engine has advanced camshaft timing. Correct to standard camshaft timing and 1.460" injector timing at first opportunity to be consistent with current production build.

† Use 1.460" timing gage (J 1853) when engine has standard camshaft timing. Correct to advanced camshaft timing and 1.484" injector timing at first opportunity.

NOTE: Advanced camshaft timing is indicated by "ADV-GT ADV- CAM " stamped on lower right hand side of engine option plate.

TABLE 2 - INJECTOR TIMING (Needle Valve)

© 1983 General Motors Corp.

LIMITING SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

After adjusting the exhaust valves and timing the fuel injectors, adjust the limiting speed mechanical governor and the injector rack control levers.

NOTE: Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, reconnect and adjust the supplementary governing device as outlined in Section 14.14.

Back out the external starting aid screw.

NOTE: On "TT" engines back out the Belleville spring retainer nut until there is approximately .060" clearance between the washers and the retainer nut (Fig. 1).

Adjust Governor Gap (Fig. 2)
(Single-Weight Governor)

With the engine stopped and at normal operating temperature, adjust the governor gap as follows:

CAUTION: If the gap adjustment is to be made with the engine in the vehicle, it is suggested that the fan assembly be removed due to the closeness of the fan blades to the engine governor.

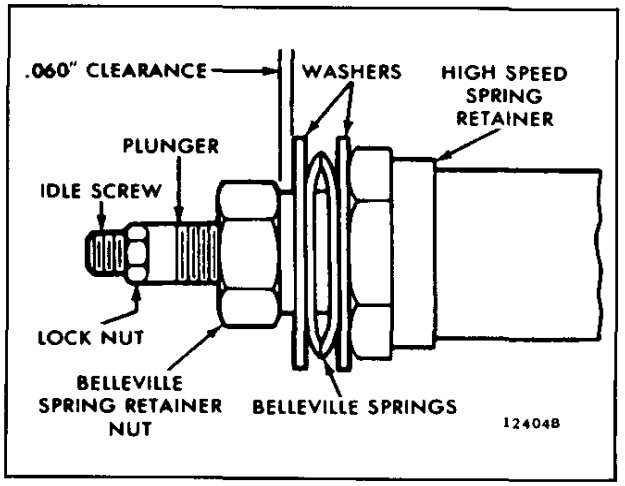


Fig. 1 - Belleville Washer Location

1. Remove the governor high-speed spring retainer cover.

2. Back out the buffer screw (Fig. 9) or fast idle cylinder until it extends approximately 5/8" from the locknut.

3. Start the engine and loosen the idle speed adjusting screw locknut. Then, adjust the idle screw to obtain the desired engine idle speed. Hold the screw and tighten the locknut to hold the adjustment. EPA certified minimum idle speeds are 500 rpm for trucks and highway coaches and 400 rpm for city coaches.

NOTE: Current limiting speed governors used in turbocharged engines include a starting aid screw threaded into a boss on the governor housing.

4. Stop the engine. Clean and remove the governor cover and lever assembly and the valve rocker cover. Discard the gaskets.

5. Remove the fuel rod from the differential lever and the injector control tube lever.

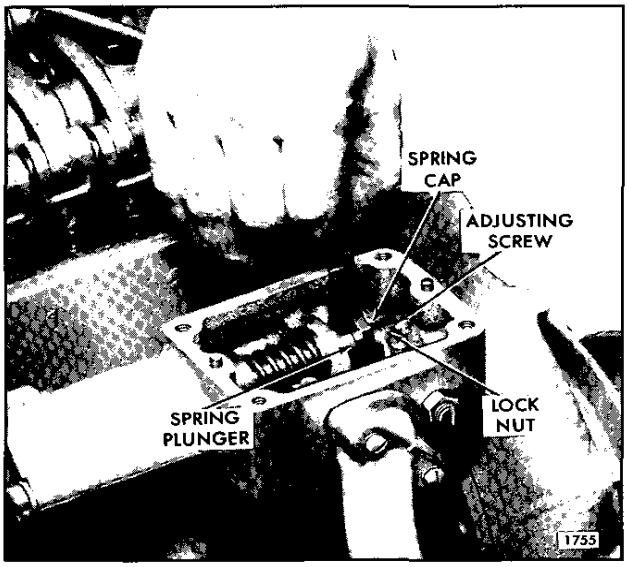


Fig. 2 - Adjusting Gap (Single-Weight Governor) using Tool J 5407

© 1983 General Motors Corp.

6. Check the gap between the low-speed spring cap and the high-speed spring plunger with gage J 5407 (.170") - (Fig. 2).

NOTE: Be sure the external starting aid screw (if used) is backed out far enough to make it ineffective when making this adjustment.

7. If required, loosen the locknut and turn the gap adjusting screw until a slight drag is felt on the gage.

8. Hold the adjusting screw and tighten the locknut.

9. Recheck the gap and readjust, if necessary.

10. Install the fuel rod between the governor and injector control tube lever.

11. Use a new gasket and install the governor cover and lever assembly.

Adjust Governor Gap (Fig. 3)
(Double-Weight Governor)

With the engine stopped and at normal operating temperature, adjust the governor gap as follows:

NOTE: If the governor gap adjustment is to be made with the engine in the vehicle, it is suggested that the fan assembly be removed due to the closeness of the fan blades to the engine governor.

1. Remove the governor high-speed spring retainer cover.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut (Fig. 9).

3. Start the engine and loosen the idle speed adjusting screw locknut and adjust the idle screw to obtain the desired engine idle speed (Fig. 9). Hold the screw and tighten the locknut to hold the adjustment. EPA certified minimum idle speeds are 500 rpm for trucks and highway coaches and 400 rpm for city coaches.

NOTE: Current limiting speed governors used in turbocharged engines include a starting aid screw threaded into a boss on the governor housing.

4. Stop the engine. Clean and remove the governor cover and lever assembly and the valve rocker cover. Discard the gaskets.

5. Remove the fuel rod from the differential lever and the injector control tube lever (Fig. 4).

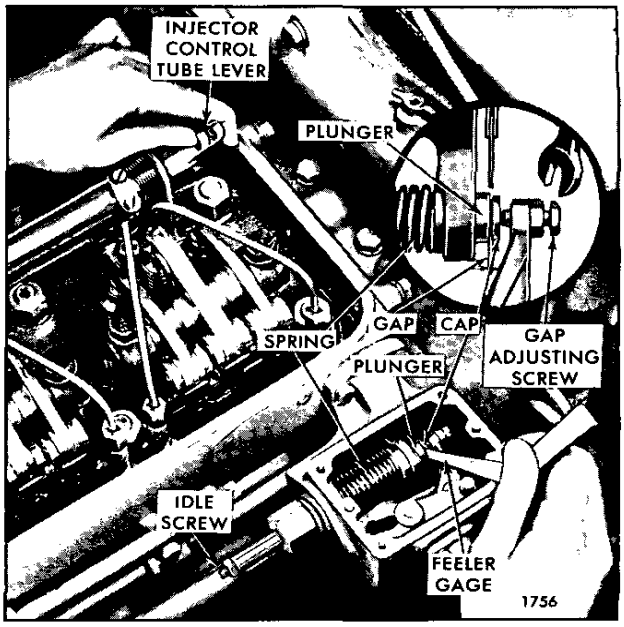


Fig. 3 - Adjusting Gap (Double-Weight Governor) using Tool J 3172

6. Start and run the engine between 1100 and 1300 rpm by manual operation of the differential lever.

NOTE: Do not overspeed the engine.

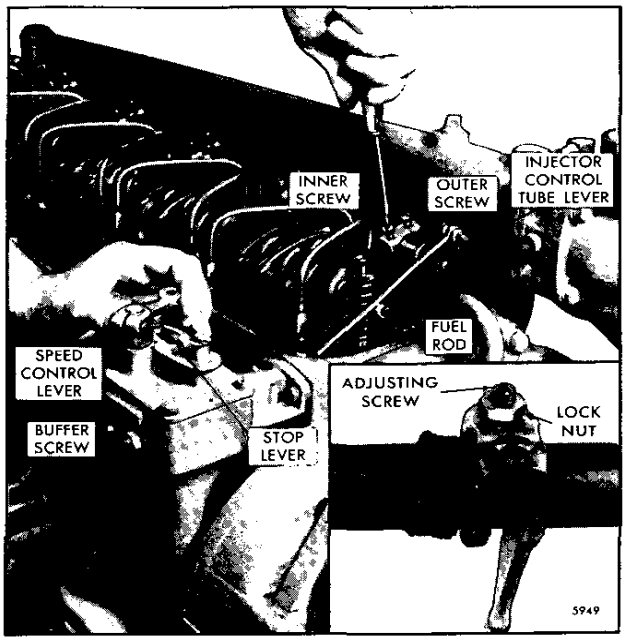


Fig. 4 - Positioning No. 1 Injector Rack Control Lever

© 1983 General Motors Corp.

7. Check the gap between the low-speed spring cap and the high-speed spring plunger with a feeler gage (Fig. 3). The gap should be .002"-.004". If the gap setting is incorrect, reset the gap adjusting screw.

8. On governors without the starting aid screw, hold the gap adjusting screw and tighten the locknut.

9. Recheck the gap with the engine operating between 1100 and 1300 rpm. Readjust if necessary.

10. Stop the engine and install the fuel rod between the differential lever and the control tube lever.

11. Use a new gasket and install the governor cover and lever assembly.

Position Injector Rack Control Levers

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the maximum speed position.

2. Governor low-speed gap closed.

3. High-speed spring plunger on the seat in the governor control housing.

4. Injector racks in the full-fuel position.

> **NOTE:** When positioning the injector racks on an early engine equipped with a fuel modulator, be sure no interference is encountered from the fuel modulator. Loosen the fuel modulator lever ("U" bolt) and move the modulator lever along the injector control tube to avoid contact with the modulator cam or the adjacent cylinder head stud nut.

Adjust the No. 1 injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers (Fig. 4).

1. Disconnect any linkage attached to the governor speed control lever.

2. Turn the idle speed adjusting screw until 1/2" of the threads (12-14 threads) project from the locknut when the nut is against the high-speed plunger (Fig. 3). This adjustment lowers the tension of the low-speed spring so it can be easily compressed. This permits closing the low-speed gap without bending the fuel rods or causing the *yield mechanism springs to yield or stretch.*

> **NOTE:** A false full fuel rack setting may result if the idle speed adjusting screw is not backed out as noted above.

Injector racks must be adjusted so that the effort to move the throttle from the *idle speed* position to the *maximum speed* position is uniform. A sudden increase in effort can result from:

a. Injector racks adjusted too tight, not allowing the speed control lever to reach the end of its travel.

b. Binding of the fuel rod.

c. Failure to back out the idle screw.

3. Back out the buffer screw approximately 5/8", if it has not already been done.

4. Loosen all of the inner and outer injector rack control lever adjusting screws or adjusting screws and locknuts. Be sure all of the control levers are free on the injector control tube.

> **NOTE:** On engines equipped with a yield link type fuel rod, attach a small "C" clamp at the shoulder of the rod to prevent the yield spring from compressing while adjusting the injector rack control levers.

5. Move the speed control lever to the maximum speed position (Fig. 4). Hold the lever in that position with light finger pressure and proceed as follows:

Two Screw Assembly -- Turn the inner adjusting screw on the No. 1 injector rack control lever down until a slight movement of the control tube is observed or a step-up in effort is noted. This will place the No. 1 injector rack in the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screw.

One Screw and Locknut Assembly -- Tighten the adjusting screw of the No. 1 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut.

> **NOTE:** Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

© 1983 General Motors Corp.

6. To be sure of the proper rack adjustment, hold the speed control lever in the maximum speed position and press down on the injector rack with a screwdriver or finger tip and note the "rotating" movement of the injector control rack when the speed control lever is in the maximum speed position (Fig. 5). Hold the speed control lever in the maximum speed position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward and when the pressure of the screwdriver is released, the control rack should "spring" back upward (Fig. 6).

If the rack does not return to its original position, it is too loose. To correct this condition with the *Two Screw Assembly,* back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly. To correct this condition with the *One Screw and Locknut Assembly,* loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if, when moving the speed control lever from the idle speed position to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover). This will result in a step-up in effort required to move the speed control lever to the end of its travel. To correct this condition with the *Two Screw Assembly,* back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly. To correct this condition with the *One Screw and Locknut Assembly,* loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

3. Hold the buffer screw and tighten the locknut.

7. To adjust the remaining injector rack control levers, remove the clevis pin from the fuel rod and the injector control tube lever. Hold the injector control racks in the full-fuel position by means of the lever on the end of the control tube and proceed as follows:

Two Screw Assembly:

a. Turn down the inner adjusting screw of the No. 2 injector until the injector rack has moved into the full-fuel position and the inner adjusting screw is bottomed on the injector control tube. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws.

NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Recheck the No. 1 injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while adjusting the No. 2 injector. If the rack of the No. 1 injector has become loose, back off slightly on the inner adjusting screw on the No. 2 injector rack control lever and tighten the outer adjusting screw.

One Screw and Locknut Assembly:

a. Tighten the adjusting screw of the No. 2 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

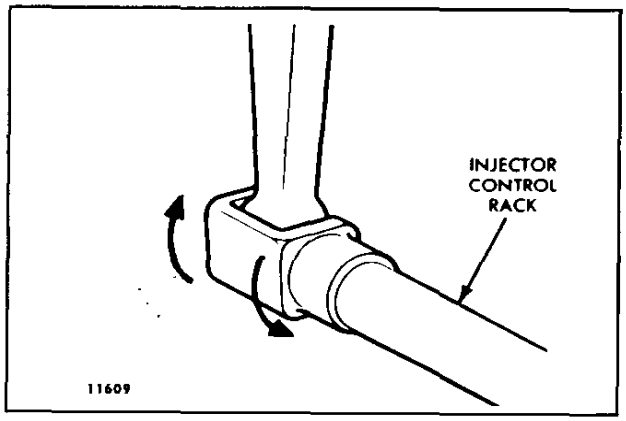


Fig. 5 - Checking Rotating Movement of Injector Control Rack

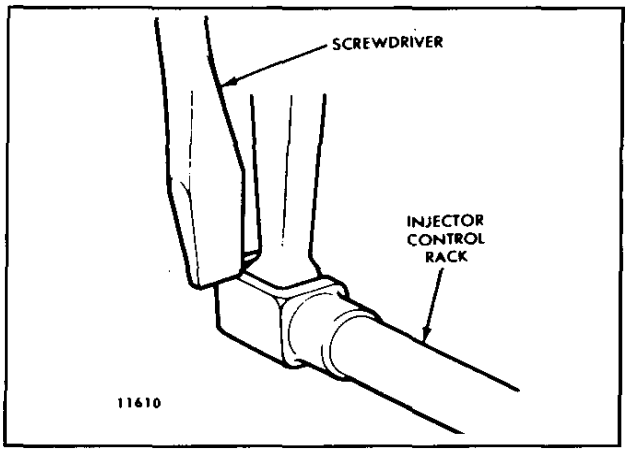
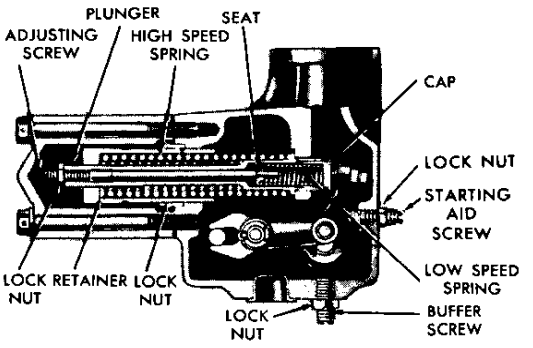
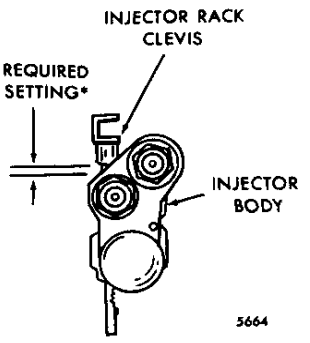


Fig. 6 - Checking Injector Control Rack "Spring"

© 1983 General Motors Corp.





INJECTOR	GAGE SETTING*	TOOL NUMBER
N60	.345"	J 24889
N65	.385"	J 24882
N70	.385"	J 24882
N75	.385"	J 24882
N80	.385"	J 24882
N90	.454"	J 23190
C65	.385"	J 24882
C70	.385"	J 24882
7C70	.385"	J 24882
7C75	.385"	J 24882
7E50	.345"	J 24889
7E55	.345"	J 24889
7E60	.345"	J 24889
7E65	.385"	J 24882
7E75	.385"	J 24882
71B5	.345"	J 24889
B55	.345"	J 24889
B60	.345"	J 24889
7G65	.385"	J 24882
7G70	.385"	J 24882
7G75	.385"	J 24882

Fig. 7 - Adjusting Starting Aid Screw (Current Turbocharged Engines)

NOTE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Verify the injector rack adjustment of the No. 1 as outlined in Step 6. If No. 1 does not "spring" back upward, turn the No. 2 adjusting screw counterclockwise slightly until the No. 1 injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 1 and No. 2 injectors. Turn clockwise or counterclockwise the No. 2 injector rack adjusting screw until both No. 1 and No. 2 injector racks are in the full-fuel position when the locknut is securely tightened.

When the settings are correct, the racks of both injectors must be snug on the ball end of their respective rack control levers.

8. Position the remaining injector rack control levers as outlined in Step 7.

9. Connect the fuel rod to the injector control tube lever.

10. Turn the idle speed adjusting screw until it projects 3/16" from the locknut to permit starting the engine.

NOTE: Remove the "C" clamp from the fuel rod on units equipped with a yield link.

11. On current *turbocharged* engines, adjust the external starting aid screw as follows:

a. With the engine *stopped,* place the governor stop lever in the *run* position and the speed control lever in the *idle speed* position.

b. Adjust the starting aid screw to obtain the required setting between the shoulder on the injector rack clevis and the injector body (Fig. 7). Select the proper gage and measure the setting at any convenient cylinder. When the starting aid screw is properly adjusted, the gage should have a small clearance of 1/64" in the space along the injector rack shaft between the rack clevis and the injector body.

c. After completing the adjustment, hold the starting aid screw and tighten the locknut.

d. Check the injector rack clevis-to-body clearance after performing the following:

1. Position the stop lever in the *run* position.

2. Move the speed control lever from the *idle speed position to the maximum speed* position.

3. Return the speed control lever to the *idle speed* position.

Movement of the speed control lever is to take-up the clearance in the governor linkage. The injector rack clevis-to-body clearance can be increased by turning the starting aid screw farther in against the operating shaft lever or reduced by backing it out.

NOTE: The starting aid screw will be ineffective if the speed control lever is advanced toward wide open throttle during start-up.

© 1983 General Motors Corp.

12. Use a new gasket and replace the valve rocker cover.

Adjust Maximum No-Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the option plate, set the maximum no-load speed as follows:

1. Loosen the locknut (Fig. 8) and back off the high-speed spring retainer approximately five turns.

2. With the engine at operating temperature and no-load on the engine, place the speed control lever in the full-fuel position. Turn the high-speed spring retainer IN until the engine is operating at the recommended no-load speed. The best method of determining the engine speed is with an accurate tachometer.

3. Hold the high-speed spring retainer and tighten the locknut.

Adjust Idle Speed

With the maximum no-load speed properly adjusted, adjust the idle speed as follows:

1. Remove the spring housing to uncover the idle speed adjusting screw.

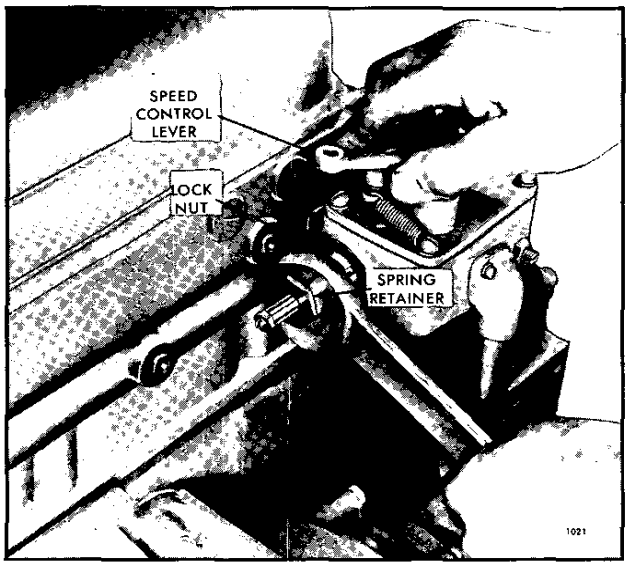


Fig. 8 - Adjusting Maximum No-Load Speed

2. With the engine at normal operating temperature and with the buffer screw (Fig. 9) backed out to avoid contact with the differential lever, turn the idle speed adjusting screw until the engine is operating at approximately 15 rpm below the recommended idle speed.

> **NOTE:** EPA certified minimum idle speeds are 500 rpm for trucks and highway coaches and 400 rpm for city coaches.

3. Hold the idle screw and tighten the locknut.

4. Install the high-speed spring retainer cover and tighten the two bolts.

5. For "TT" engines, refer to Section 14.3.5 for the adjustment of the Belleville spring.

Adjust Buffer Screw

With the idle speed properly set, adjust the buffer screw as follows:

1. With the engine running at normal operating temperature, turn the buffer screw (Fig. 9) in so it contacts the differential lever as lightly as possible and still eliminates engine roll.

> **NOTE:** Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2. Recheck the maximum no-load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.

3. Hold the buffer screw and tighten the locknut.

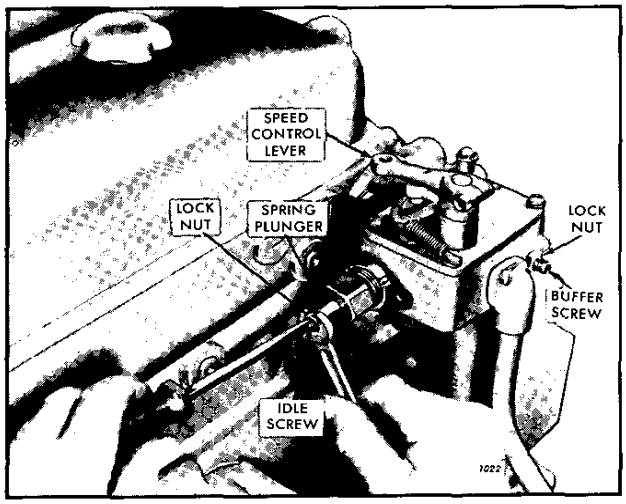


Fig. 9 - Adjusting Engine Idle Speed

© 1983 General Motors Corp.

LIMITING SPEED MECHANICAL GOVERNOR (DUAL RANGE) AND INJECTOR RACK CONTROL ADJUSTMENT

Adjust the limiting speed mechanical governor (dual range) and injector rack control levers after adjusting the exhaust valves and timing the fuel injectors.

NOTE: Loosen the lever and disconnect the air cylinder link (if used), before proceeding with the governor adjustment.

Adjust Governor Gap (Fig. 1)
(Double-Weight Governor)

1. With the engine stopped and at operating temperature, remove the two attaching bolts and withdraw the governor high-speed spring retainer cover.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut (Fig. 2).

3. Start the engine and loosen the idle speed adjusting screw locknut and adjust the idle screw to obtain the desired idle speed (Fig. 1). Hold the screw and tighten the locknut to retain the adjustment. The recommended idle speed is 450 rpm, but may vary with special engine applications.

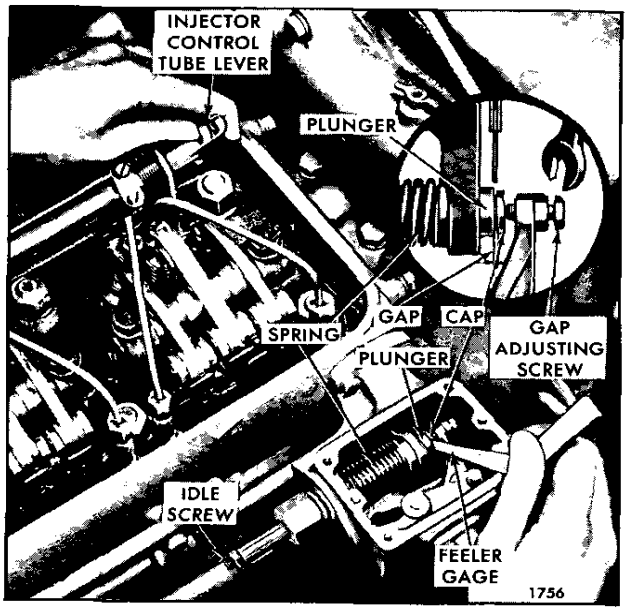


Fig. 1 - Adjusting Governor Gap using Tool J 3172

4. Stop the engine and remove the governor cover and lever assembly.

5. Remove the valve rocker cover.

6. Remove the fuel rod from the differential lever and the injector control tube lever.

7. Start and run the engine between 1100 and 1300 rpm by manual operation of the differential lever.

NOTE: Do not overspeed the engine.

8. Check the gap between the low-speed spring cap and the high-speed spring plunger with a feeler gage (Fig. 1). The gap should be .002"-.004". If the gap setting is incorrect reset the gap adjusting screw.

9. On governors without the starting aid screw, hold the gap adjusting screw and tighten the locknut.

10. Recheck the gap with the engine operating between 1100 and 1300 rpm. Readjust, if necessary.

11. Stop the engine and install the fuel rod between the differential lever and the control tube lever.

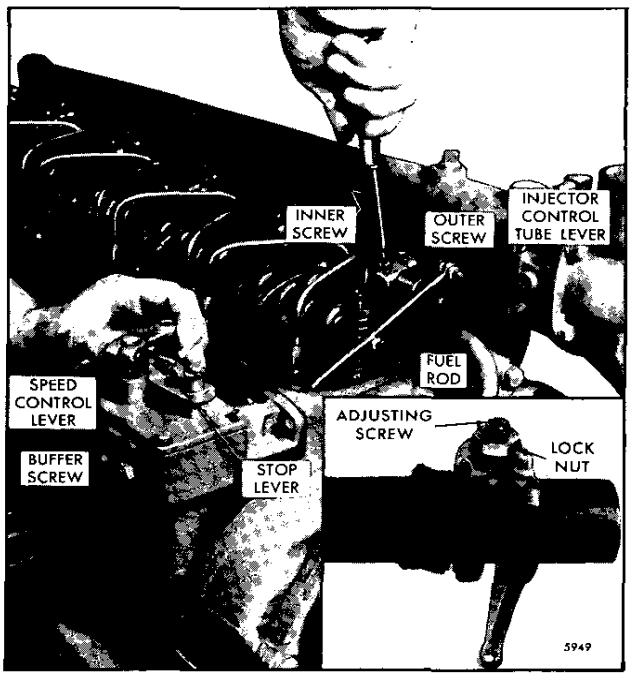


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

© 1983 General Motors Corp.

12. Install the governor cover and lever assembly.

Position Injector Rack Control Levers

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Properly positioned injector rack control levers will result in the following:

1. Speed control lever at the maximum speed position.

2. Governor low-speed gap closed.

3. High-speed spring plunger on the seat in the governor control housing.

4. Injector racks in the full-fuel position.

Adjust the No. 1 injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers (Fig. 2).

1. Disconnect any linkage attached to the governor speed control lever.

2. Loosen the idle speed adjusting screw locknut and back out the idle speed adjusting screw until 1/2″ of the threads project from the locknut when the nut is against the high-speed plunger.

3. Back out the buffer screw approximately 5/8″, if it has not already been done.

4. Loosen all of the inner and outer injector rack control lever adjusting screws or adjusting screws and locknuts. Be sure all the injector rack control levers are free on the injector control tube.

> **NOTE:** On engines equipped with a yield link type fuel rod, attach a small "C" clamp at the shoulder of the rod to prevent the yield spring from compressing while adjusting the injector rack control levers.

5. Move the governor speed control lever to the maximum speed position (Fig. 2). Hold the lever in that position with light finger pressure and proceed as follows:

Two Screw Assembly -- Turn the inner adjusting screw on the No. 1 injector rack control lever down until a slight movement of the control tube is observed or a step up in effort is noted. This will place the No. 1 injector rack in the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws.

One Screw and Locknut Assembly -- Tighten the adjusting screw of the No. 1 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut.

> **NOTE:** Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

6. To be sure the control lever is properly adjusted, hold the speed control lever in the maximum speed position and press down on the injector rack with a screwdriver or finger tip and note "rotating" movement of the injector control rack when the speed control lever is in the maximum speed position (Fig. 3). Hold the speed control lever in maximum speed position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward and when the pressure of the screwdriver is released, the control rack should "spring" back upward (Fig. 4).

If the rack does not return to its original position, it is too loose. To correct this condition with the *Two Screw Assembly*, back off the outer adjusting screw slightly

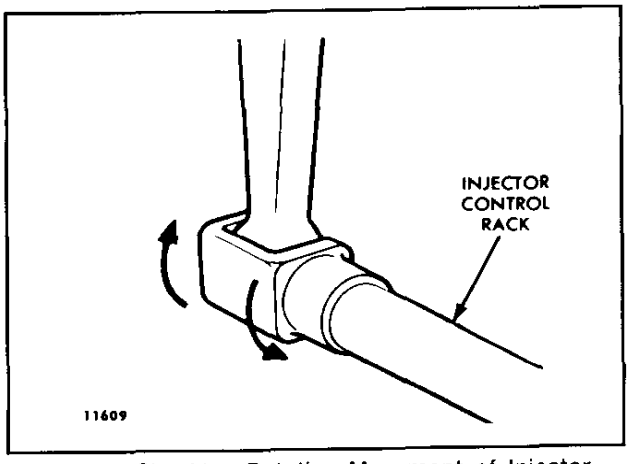


Fig. 3 - Checking Rotating Movement of Injector Control Rack

© 1983 General Motors Corp.

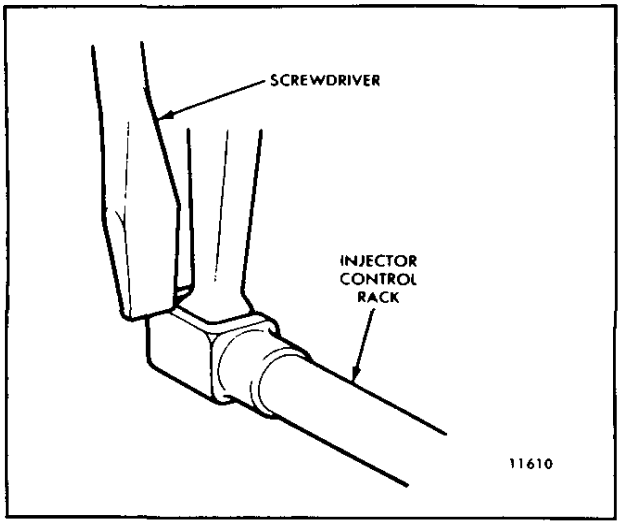


Fig. 4 - Checking Injector Control Rack "Spring"

and tighten the inner adjusting screw slightly. To correct this condition with the *One Screw and Locknut Assembly,* loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is to tight if, when moving the speed control lever from the idle speed to the maximum speed position, the injector rack becomes tight before the speed control lever reaches the end of its travel (as determined by the stop under the governor cover). This will result in a step-up in effort required to move the speed control lever to the end of its travel. To correct this condition with the *Two Screw Assembly,* back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly. To correct this condition with the *One Screw and Locknut Assembly,* loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

7. Disconnect the fuel rod from the injector control tube and manually hold the No. 1 injector in the maximum speed position.

Two Screw Assembly:

a. Turn down the inner adjusting screw of the No. 2 injector until the injector rack has moved into the full-fuel position and the inner adjusting screw is bottomed on the injector control tube. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws.

NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Recheck the No. 1 injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while adjusting the No. 2 injector rack. If the rack of the No. 1 injector has become loose, back off slightly on the inner adjusting screw on the No. 2 injector rack control lever and tighten the outer adjusting screw.

One Screw and Locknut Assembly:

a. Tighten the adjusting screw of the No. 2 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

NOTE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Verify the injector rack adjustment of No. 1 as outlined in Step 6. If No. 1 does not "spring" back upward, turn the No. 2 adjusting screw counterclockwise slightly until the No. 1 injector rack reutrns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 1 and No. 2 injectors. Turn clockwise or counterclockwise the No. 2 injector rack adjusting screw until both No. 1 and No. 2 injector racks are in the full-fuel position when the locknut is securely tightened.

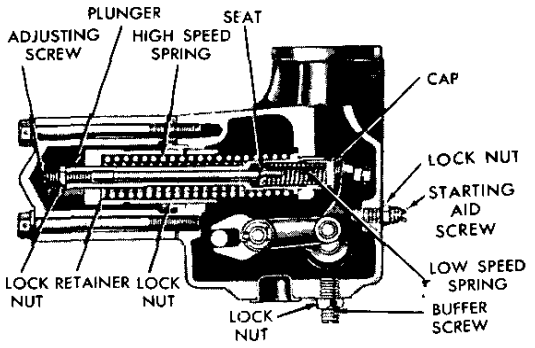
When the settings are correct, the racks of both injectors must be snug on the ball end of their respective rack control levers.

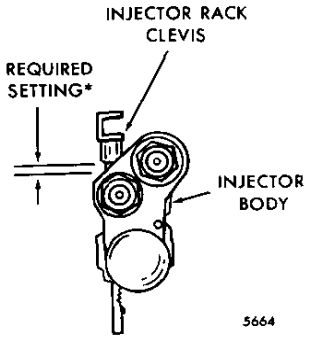
8. Position the remaining injector rack control levers as outlined in Step 7.

9. Connect the fuel rod to the injector control tube lever.

10. Turn the idle speed adjusting screw until it projects 3/16" from the locknut to permit starting the engine. Tighten the locknut.

© 1983 General Motors Corp.





INJECTOR	GAGE SETTING*	TOOL NUMBER
N60	.345"	J 24889
N65	.385"	J 24882
N70	.385"	J 24882
N75	.385"	J 24882
N80	.385"	J 24882
N90	.454"	J 23190
C65	.385"	J 24882
C70	.385"	J 24882
7C70	.385"	J 24882
7C75	.385"	J 24882
7E50	.345"	J 24889
7E55	.345"	J 24889
7E60	.345"	J 24889
7E65	.385"	J 24882
7E75	.385"	J 24882
71B5	.345"	J 24889
B55	.345"	J 24889
B60	.345"	J 24889
7G65	.385"	J 24882
7G70	.385"	J 24882
7G75	.385"	J 24882

Fig. 5 - Adjusting Starting Aid Screw (Current Turbocharged Engines)

NOTE: Remove the "C" clamp from the fuel rod on units having a yield link.

11. On current *turbocharged engines,* adjust the external starting aid screw as follows:

a. With the engine *stopped* place the governor stop lever in the *run* position and the speed control lever in the *idle speed* position.

b. Adjust the starting aid screw to obtain the required setting between the shoulder on the injector rack clevis and the injector body (Fig. 5). Select the proper gage and measure the setting at any convenient cylinder. When the starting aid screw is properly adjusted, the gage should have a small clearance of 1/64" in the space along the injector rack shaft between the rack clevis and the injector body.

c. After completing the adjustment, hold the starting aid screw and tighten the locknut.

d. Check the injector rack clevis-to-body clearance after performing the following:

1. Position the stop lever in the *run* position.

2. Move the speed control lever from the *idle speed* position to the *maximum speed* position.

3. Return the speed control lever to the *idle speed* position.

Movement of the speed control lever is to take-up the clearance in the governor linkage. The injector rack clevis-to-body clearance can be increased by turning the starting aid screw farther in against the operating shaft lever or reduced by backing it out.

NOTE: The starting aid screw will be ineffective if the speed control lever is advanced toward wide open throttle during start-up.

12. Use a new gasket and replace the valve rocker cover.

Adjust Maximum No-Load Engine Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the unit name plate, the maximum no-load speed may be set as follows:

Engines with Early Dual Range Limiting Speed Mechanical Governor.

After positioning the injector rack control levers and setting the idle speed, set the maximum engine speeds. Be sure the buffer screw projects 5/8" from the locknut to prevent its interference while adjusting the maximum no-load speeds.

NOTE: To prevent air leakage between the piston and sleeve assembly, coat the mating threads with sealant.

With the spring housing assembly mounted on the governor, the piston and sleeve assembly assembled as illustrated in Fig. 6, and the low maximum speed

© 1983 General Motors Corp.

adjusting screw extended from the spring housing approximately 3/4" beyond the locknut, proceed as follows:

NOTE: Do not apply air pressure to the governor until performing Step 1h.

1. Set the high maximum no-load speed.

a. Start the engine and place the speed control lever in the maximum speed position.

b. Loosen the locknut and turn the low maximum speed adjusting screw in until the desired no-load high maximum speed is obtained.

c. Stop the engine and remove the spring housing. Note the distance the sleeve extends beyond the spring housing.

NOTE: Do not permit the seal ring on the piston to slide past the air inlet port, since the seal ring will be damaged.

d. Remove the piston and sleeve from the bottom of the spring housing.

e. Turn the piston until the sleeve extends from the bottom of the piston the same distance the sleeve extends beyond the spring housing, Step c.

f. Check the adjustment by installing the piston and sleeve in the spring housing. The piston should be flush to 1/64" below the bottom of the spring housing when it is tight against the adjustment screw.

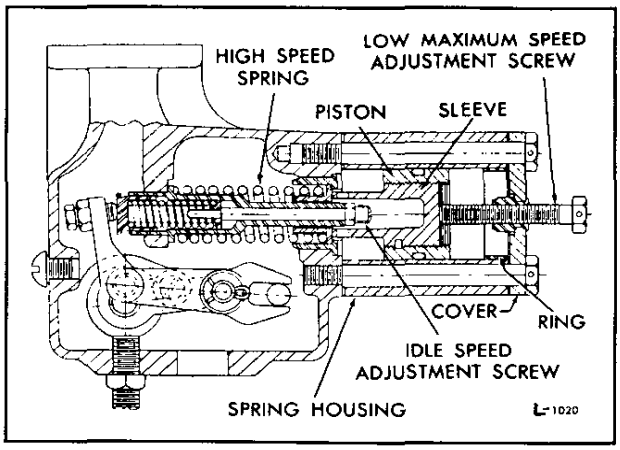


Fig. 6 - Former Dual Range Governor

NOTE: The cover, cover gasket and spring housing must be held as an assembly when checking the piston position.

g. Replace the piston and sleeve in the governor spring housing and assemble to the governor.

h. Start the engine and place the speed control lever in the maximum speed position and apply air pressure to the governor.

NOTE: To overcome the tension of the governor high-speed spring, 50 psi (345 kPa) air pressure will be required in the governor spring housing.

i. Back out the low maximum speed adjustment screw 1/4". If the piston is adjusted correctly, the engine will operate at the recommended high maximum no-load speed.

j. Remove the air pressure from the governor.

k. Make minor adjustment on the piston and sleeve, if necessary, to establish the exact speed desired.

2. Set the low maximum no-load engine speed.

a. Adjust the low maximum speed adjusting screw, with the engine speed control lever in the maximum speed position, until the desired low maximum speed is obtained. Turn the screw in to increase or out to decrease engine speed.

b. Tighten the locknut and recheck the engine speed.

3. Check both high maximum and low maximum engine speeds. Make any adjustment that is necessary as outlined in Steps 1 and 2.

Engines with Current Dual Range Limiting Speed Mechanical Governor.

After positioning the injector rack control levers, set the maximum engine speeds.

NOTE: Be sure the buffer screw projects 5/8" from the locknut to prevent interference while adjusting the maximum no-load speeds.

With the spring housing assembly mounted on the governor, the piston and sleeve assembled with four .100" shims and ten .010" shims as illustrated in Fig. 7, and the low maximum speed screw extending from the spring housing approximately 1-1/4", proceed as follows:

© 1983 General Motors Corp.

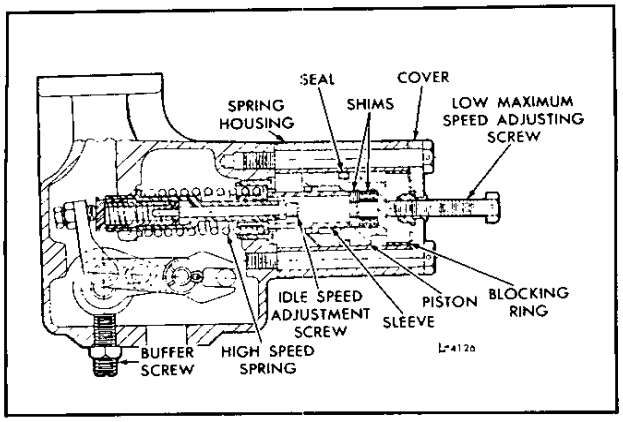


Fig. 7 - Current Dual Range Governor

NOTE: Do not apply air pressure to governor until performing Step 1f.

1. Set the high maximum no-load speed.

a. Start the engine and position the speed control lever in the maximum speed position.

b. Turn the low maximum speed adjustment screw in until the high maximum speed desired is obtained.

c. Stop the engine and remove the spring housing assembly.

NOTE: Do not permit the seal ring on the piston to slide past the air inlet port, since the seal ring will be damaged.

d. Note the distance the piston is within the spring housing when it is against the low maximum speed screw, and then remove the sleeve from the piston.

NOTE: When checking this distance, the piston should be held tight against the adjustment screw of the cover that is held in position, with its gasket, against the end of the spring housing.

e. Remove a quantity of shims, from the shims within the piston, equal to the distance noted in Step d.

f. Start the engine and position the engine speed control lever in the maximum speed position and apply air pressure to the governor and note the engine speed.

g. Remove the air pressure from the governor and stop the engine, then install or remove shims as required to obtain the correct high maximum no-load speed. Removing shims will decrease the engine speed and adding shims will increase the engine speed.

NOTE: Each .010" shim removed or added will decrease or increase the engine speed approximately 10 rpm.

2. Set the low maximum no-load engine speed.

a. Adjust the low maximum speed adjusting screw, with the speed control lever held in the maximum speed position, until the desired low maximum is obtained. Turn the screw in to increase or out to decrease the engine speed.

b. Recheck the engine speed and readjust, if necessary.

3. Check both the high maximum and low maximum engine speeds. Make any adjustment that is necessary as outlined in Steps 1 and 2.

Adjust Idle Speed

With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

1. Refer to Fig. 6 and 7 and remove the spring housing to uncover the idle speed adjusting screw.

2. With the engine at normal operating temperature and with the buffer screw (Fig. 7) backed out to avoid contact with the differential lever, turn the idle speed adjusting screw until the engine is operating at approximately 15 rpm below the recommended idle speed.

The recommended idle speed is 450 rpm but may vary with engine applications.

3. Hold the idle screw and tighten the locknut.

4. Install the high speed spring retainer and retain with the two bolts.

Adjust Buffer Screw

With the idle speed set, the buffer screw may be adjusted as follows:

1. With the engine running at normal operating temperature, turn the buffer screw in so that it contacts the differential lever as lightly as possible and still eliminates the engine roll.

NOTE: Do not increase the engine idle speed more than 15 rpm with the buffer screw.

2. Hold the buffer screw and tighten the locknut.

3. Recheck the maximum no-load speed. If it has increased more than 25 rpm, back off the buffer screw until the increase is less than 25 rpm.

© 1983 General Motors Corp.

LIMITING SPEED MECHANICAL GOVERNOR ADJUSTMENT

(Variable Low-Speed)

The variable low-speed limiting speed mechanical governor is used on 6-71 highway vehicle engines where the same engine powers both the vehicle and the auxiliary equipment for unloading bulk products (such as cement, grain or liquids) and a high idle speed range is desired during auxiliary operation.

The current governor is a single-weight type and provides an idle speed range of 500 to 1800 rpm. The former governor was a double-weight type and provided an idle speed range of 450 to 1300 rpm.

During highway operation, the governor functions as a limiting speed governor, controlling the engine idling speed and limiting the maximum operating speed. At the unloading area, the throttle is left in the idle speed position and the speed adjusting handle, on the cable operated governor (Fig. 1), is turned to the speed required within the above range to operate the auxiliary equipment. For the air operated governor (Fig. 2), the engine speed is changed to the speed required by increasing or decreasing the air supply pressure to the governor. The governor then functions as a variable speed governor, maintaining a constant speed when the load is constantly changing, during the unloading operation. Before resuming highway operations, the speed adjusting handle on the cable operated governor must be turned back to the stop, then turned ahead about one-quarter of a turn. The air operated governor's air supply pressure must be vented before resuming highway operations.

Governor identification is provided by a name plate attached to the governor housing. The letters V.L.S.-L.S. stamped on the name plate denote a variable low-speed limiting speed mechanical governor.

After adjusting the exhaust valves and timing the injectors, adjust the governor and position the injector rack control levers.

Adjust Governor Gap (Single-Weight Type)

With the engine at operating temperature, adjust the governor gap as follows:

1. Stop the engine, remove the two bolts and withdraw the governor spring retainer cover. Discard the gasket.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut.

3. For *Cable Operated Governor* make a preliminary idle speed (normal highway idle speed) adjustment as follows (Fig. 1):

a. Back out the variable low-speed adjusting shaft until the shoulder on the shaft contacts the shaft retainer.

b. Start the engine. Then, hold the locknut and loosen the low-speed adjusting shaft retainer.

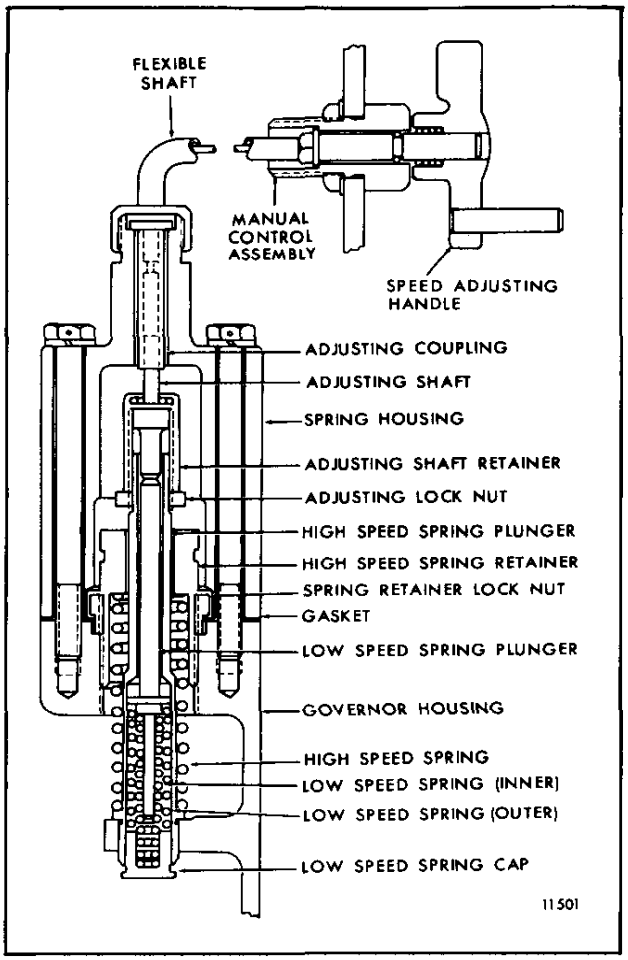


Fig. 1 - Cable Operated Governor Spring Housing and Components

© 1983 General Motors Corp.

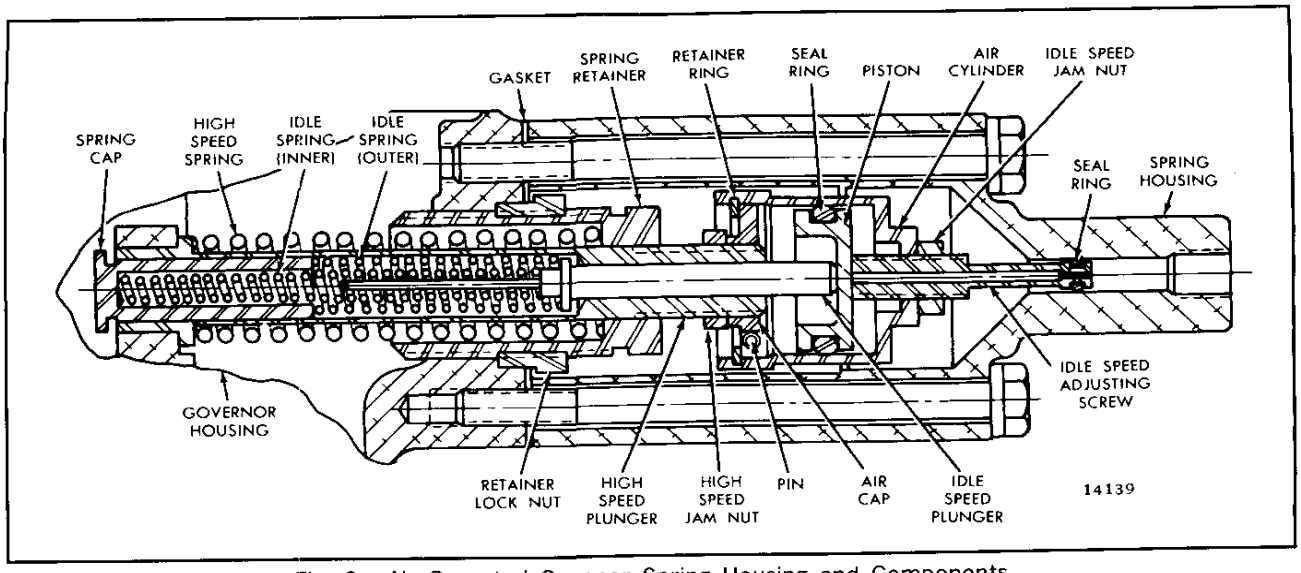


Fig. 2 - Air Operated Govenor Spring Housing and Components

c. Adjust the retainer and shaft assembly to obtain the desired idle speed (500 rpm minimum). Then, hold the retainer and tighten the locknut to retain the adjustment.

NOTE: It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8″).

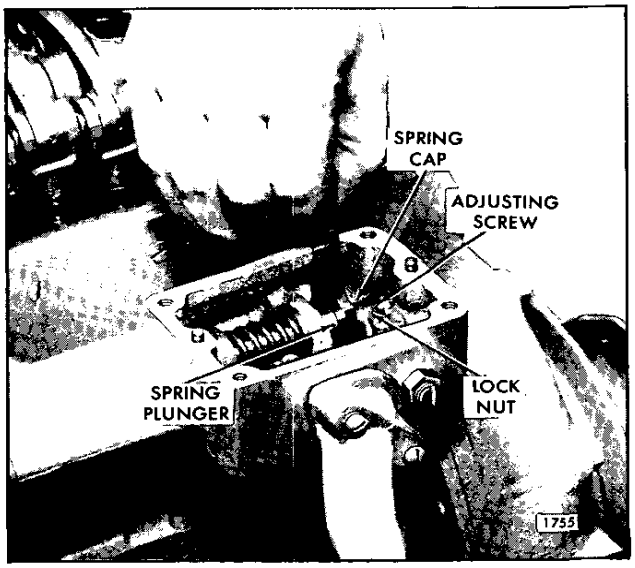


Fig. 3 - Adjusting Governor Gap (Single-Weight Governor)

d. Install the spring housing, using a new gasket. Tighten the attaching bolts.

4. For *Air Operated Governor* make a preliminary idle speed (normal highway idle speed) adjustment as follows (Fig. 2):

Adjust the maximum idle speed.

a. Loosen the idle speed and high idle speed jam (lock) nuts.

b. Turn the idle speed adjusting screw clockwise into the air cylinders, until the piston contacts the air cap. The air cylinder should be 2 or 3 threads from its position of maximum engagement with the high speed spring plunger, to prevent the piston from contacting the high speed plunger before it contacts the air cap.

NOTE: Do not force the idle speed adjusting screw.

c. Start the engine. With the speed control lever in the idle position, turn the air cylinder clockwise to raise the idle speed and counterclockwise to lower the idle speed.

d. Lock the air cylinder to the high speed plunger with the jam nut in the position which provides the desired maximum idle speed.

Adjust the minimum idle speed adjustment.

NOTE: Make this adjustment after the maximum idle speed adjustment is completed.

© 1983 General Motors Corp.

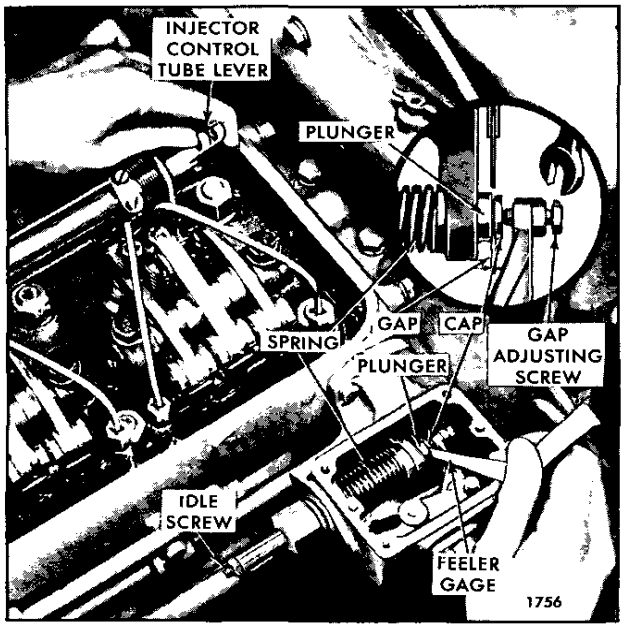


Fig. 4 - Adjusting Governor Gap (Double-Weight Governor)

a. Run the engine with the speed control lever in the idle speed position.

b. Turn the idle speed adjusting screw counterclockwise to lower the idle speed and clockwise to raise the idle speed.

c. Lock the idle speed adjusting screw with the jam nut, in the position which provides the desired minimum idle speed.

d. Stop the engine and lubricate the bore of the spring housing with engine lubrication oil.

e. Install the spring housing, using a new gasket. Tighten the attaching bolts.

5. Stop the engine and remove the governor cover and lever assembly.

6. Clean and remove the valve rocker cover.

7. Remove the fuel rod from the differential lever and the injector control tube lever.

8. Check the gap (.170") between the low-speed spring cap and the high-speed spring plunger with gage J 5407 (Fig. 3). A .170" stack-up of feeler gages can be used to check the gap if the gage is not available.

NOTE: Be sure the external starting aid screw is backed out far enough to make it ineffective when making this adjustment.

9. If required, loosen the locknut and turn the gap adjusting screw until a slight drag is felt on the gage.

10. Hold the adjusting screw and tighten the locknut.

11. Recheck the gap and readjust, if necessary.

12. Install the fuel rod between the governor and the injector control tube lever.

13. Affix a new gasket to the top of the governor housing. Place the governor cover assembly on the governor housing with the pin in the stop control shaft assembly in the slot of the diffrential lever and the dowel pins in the housing in the dowel pin holes in the cover.

Before starting an engine after an engine speed control adjustment or after removal of the engine governor cover and lever assembly, the serviceman must determine that the injector racks move to the no-fuel position when the governor stop lever is placed in the stop position. Engine overspeed will result if the injector racks cannot be positioned at no fuel with the governor stop lever.

CAUTION: An overspeeding engine can result in engine damage which could cause personal injury.

Adjust Governor Gap (Double-Weight Type) Cable Operated Governors Only

With the engine at operating temperature, adjust the governor gap as follows:

1. Stop the engine, remove the two bolts and withdraw the governor spring retainer cover.

2. Back out the buffer screw until it extends approximately 5/8" from the locknut.

3. Make a preliminary idle speed (normal highway idle speed) adjustment as follows:

a. Back out the variable low-speed adjusting shaft until the shoulder on the shaft contacts the shaft retainer (Fig. 1).

b. Start the engine. Then, hold the locknut and loosen the low-speed adjusting shaft retainer.

c. Adjust the retainer and shaft assembly to obtain the desired idle speed (450 rpm minimum). Then, hold the retainer and tighten the locknut to retain the adjustment.

NOTE: It may be necessary to use the buffer screw to eliminate engine roll. Back out the

© 1983 General Motors Corp.

buffer screw, after the idle speed is established, to the previous setting (5/8″).

d. Install the spring housing, using a new gasket. Tighten the attaching bolts.

4. Stop the engine. Clean and remove the governor cover and lever assembly and the valve rocker cover. Discard the gasket.

5. Start and run the engine between 1100 and 1300 rpm by manual operation of the differential lever.

NOTE: Do not overspeed the engine.

6. Check the gap between the low-speed spring cap and the high-speed spring plunger with a feeler gage (Fig. 4). The gap should be .002″-.004″. If the gap setting is incorrect, reset the gap adjusting screw.

7. On governors without the starting aid screw, hold the gap adjusting screw and tighten the locknut.

8. Recheck the gap with the engine operating between 1100 and 1300 rpm. Readjust, if necessary.

9. Reinstall the governor cover and lever assembly.

Position Injector Rack Control Levers

Position the injector rack control levers as outlined in Section 14.3.

Adjust Maximum No-Load Engine Speed

Adjust the maximum no-load engine speed as outlined for the limiting speed mechanical governor in Section 14.3.

Adjust Idle Speed

djust the normal highway idle speed as follows:

With the engine running at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, hold the locknut and loosen the variable low-speed adjusting shaft retainer. Adjust the retainer and shaft assembly to obtain a minimum of 500 rpm idle speed (current single-weight governor) or 450 rpm (former double-weight governor).

NOTE: It may be necessary to use the buffer screw to eliminate engine roll. Back out the buffer screw, after the idle speed is established, to the previous setting (5/8″).

Adjust Buffer Screw

Adjust the buffer screw as outlined in Section 14.3.

After the governor tune-up is completed, install the variable low-speed adjuster coupling and spring housing. Center the coupling before securing the spring housing to the governor. Install the flexible shaft and manual control assembly.

© 1983 General Motors Corp.

LIMITING SPEED MECHANICAL GOVERNOR ADJUSTMENT

(Fast Idle Cylinder)

The limiting speed governor equipped with a fast idle air cylinder is used on vehicle engines where the engine powers both the vehicle and auxiliary equipment.

The fast idle system consists of a fast idle air cylinder installed in place of the buffer screw and a throttle locking air cylinder mounted on a bracket fastened to the governor cover (Fig. 1). An engine shutdown air cylinder, if used, is also mounted on the governor cover.

The fast idle air cylinder and the throttle locking air cylinder are actuated at the same time by air from a common air line. The engine shutdown air cylinder is connected to a separate air line.

The air supply for the fast idle air cylinder is usually controlled by an air valve actuated by an electric solenoid. The fast idle system should be installed so that it will function only when the parking brake system is in operation to make it tamper-proof.

The vehicle accelerator-to-governor throttle linkage is connected to a yield link so the operator cannot overcome the force of the air cylinder holding the speed control lever in the idle position while the engine is operating at the single fixed high idle speed.

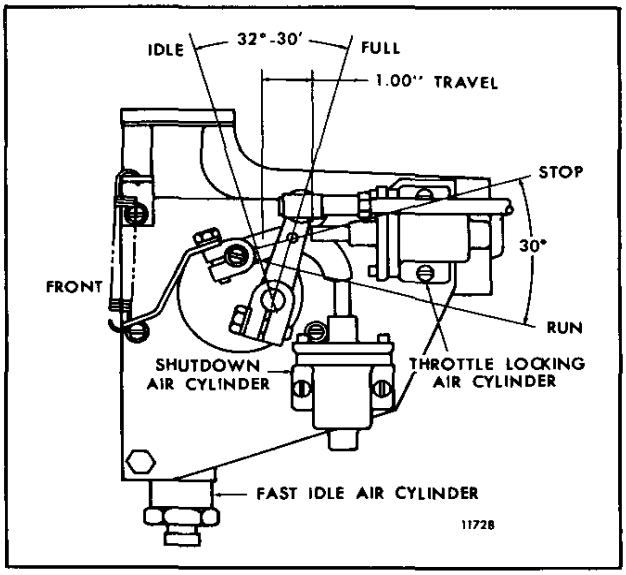


Fig. 1 - Governor with Fast Idle Cylinder

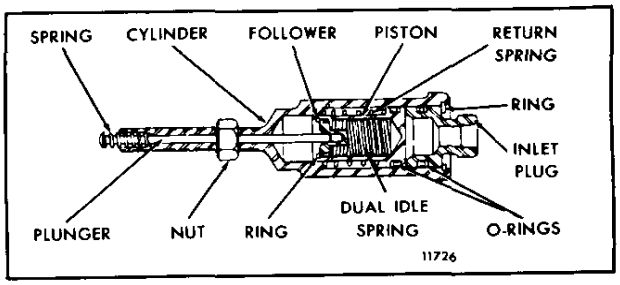


Fig. 2 - Fast Idle Air Cylinder

Operation

During highway operation, the governor functions as a limiting speed governor.

For operation of auxiliary equipment, the vehicle is stopped and the parking brake set. Then, with the engine running, the low speed switch is placed in the *on* position. When the fast idle air cylinder is actuated, the force of the dual idle spring (Fig. 2) is added to the force of the governor low-speed spring, thus increasing the engine idle speed.

The governor now functions as a constant speed governor at the high idle speed setting, maintaining a near constant engine speed regardless of the load within the capacity of the engine. The fast idle system provides a single fixed high idle speed that is not adjustable, except by disassembling the fast idle air cylinder and changing the dual idle spring. As with all

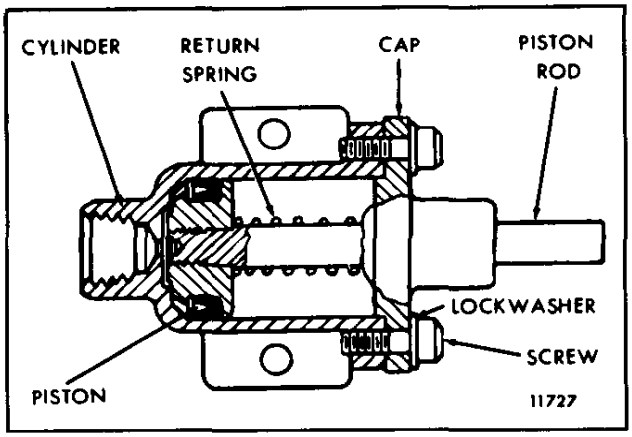


Fig. 3 - Throttle Locking Air Cylinder

© 1976 General Motors Corp.

mechanical governors, when load is applied, the engine speed will be determined by the governor droop.

Adjust Governor

Adjust the governor as outlined in Section 14.3. However, before adjusting the governor gap, back out the de-energized fast idle air cylinder until it will not interfere with the governor adjustments. After the normal idle speed setting is made, adjust the de-energized fast idle air cylinder as follows:

1. Turn in the fast idle cylinder assembly until an increase of idle speed is noted. The increase in idle speed should not exceed 15 rpm. Tighten the fast idle jam nut.

2. Lock the governor throttle in the idle position and apply full shop air pressure to the fast idle air cylinder. The engine idle speed must increase 250–550 rpm, depending upon the dual idle spring used.

The throttle locking air cylinder is adjusted on its mounting bracket so it will lock the throttle in the idle position when it is activated, but will not limit the throttle movement when not activated.

© 1976 General Motors Corp.

GOVERNOR SETTINGS FOR "TT" ENGINES

6-71TT ENGINE

The operating characteristics of a "TT" engine are - it's ability to maintain reasonably constant horsepower over a wide speed range and its 6% torque rise per one hundred rpm. These characteristics are achieved by the action of two Belleville springs (washers) in a limiting speed governor.

NOTE: The horsepower Table for the 6-71 "TT" engine indicate a flat horsepower performance curve. However, during dynamometer testing an engine may exhibit horsepower readings slightly above or below the flat curve. A 5% horsepower variation from the flat published curve is acceptable.

The spring force provided by the Belleville springs works with the governor weights to pull the injector racks out of fuel as the engine speed is increased (Fig. 1). Conversely, as the engine speed is reduced by increased load, the high-speed spring overcomes the force of the Belleville springs and moves the injector racks to an increased fuel position. The racks move progressively into more fuel to maintain the constant horsepower until the racks are in full fuel at a speed near 1500 rpm.

If the maximum speed of a 6-71TT engine equipped with single weight, limiting speed governor is reduced to 1950 rpm no load, 1800 rpm full load, the high-speed spring retainer may not provide sufficient thread engagement in the governor housing to make the adjustment. Consequently, the threads in the housing may be damaged when the locknut is tightened after the no-load speed is reached. To avoid this condition when adjusting engines to 1950 rpm no load, 1800 rpm full load, the high-speed spring with one green and one white stripe must be replaced with a spring with two pink stripes.

NOTE: Engines shipped from DDA with an 1800 rpm full-load speed specified on the sales order will not experience this condition.

Tune-up the 6-71"TT" engine the same as a standard engine tune-up as outlined in Section 14.3.

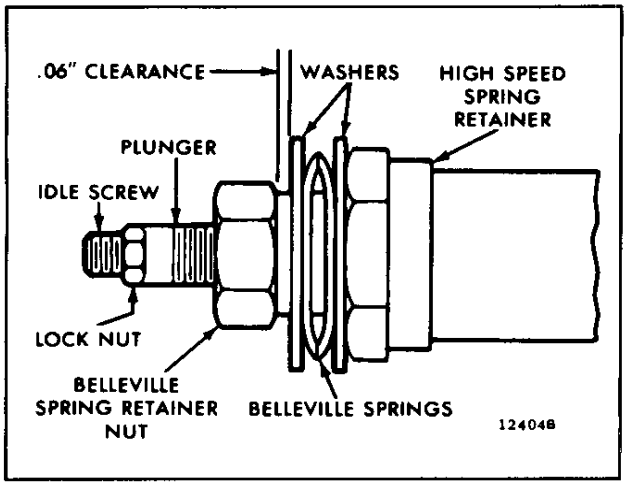


Fig. 1 - Belleville Washer Location

After completing the standard engine tune-up of setting injector timing, valve clearance, governor gap, injector racks and engine speeds, adjust the Belleville spring (washer) "TT" (tailor torqued) device.

NOTE: Use spanner wrench J 5345-5 to loosen or tighten the spring retainer locknut during the no-load speed adjustment. Always use the yield link in the governor when performing the engine tune-up.

Adjustment of the Belleville springs for the "TT" horsepower can be accomplished by two methods, depending on the equipment available at the service outlet. These methods are:

1. Idle Drop (Single Weight Governor)

2. Power Reduction Factor

For satisfactory results, both methods require an engine in good condition and properly tuned.

NOTE: Do not attempt Belleville spring adjustment until an engine tune-up has been correctly completed.

© 1983 General Motors Corp.

METHOD 1 - Idle Drop

The idle drop method is an effective, accurate means of setting "TT" horsepower.

The idle drop method requires a specific reduction in engine speed to position the Belleville springs and the governor low and high-speed springs. The positioning of these governor components results in obtaining the desired "TT" horsepower.

When performing an idle drop horsepower adjustment on a "TT" engine having a 102 or 118 tooth flywheel, an accurate tachometer is mandatory (Digital Tachometer J 26791 recommended). Each one (1) rpm error in setting the idle drop results in a two or three horsepower error.

The tachometer is installed in the flywheel housing drain plug hole and operates by counting the flywheel teeth, using a magnetic probe to pick-up impulses off the flywheel ring gear. The electronic module displays the engine speed digitally to one decimal place within one rpm accuracy. These capabilities make it ideal for setting horsepower on the "TT" engines using the idle drop method.

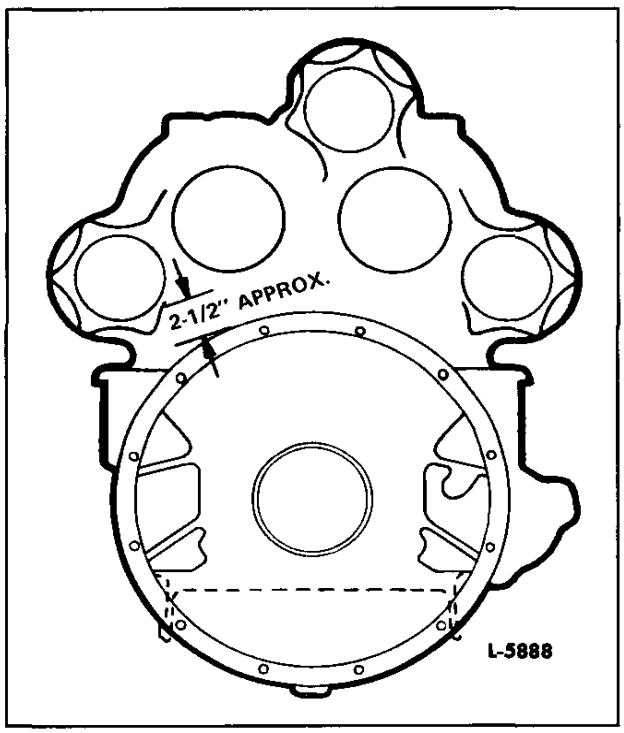


Fig. 2 - Identification of Engine Flywheel

To determine the number of teeth on the flywheel, when identification of the engine flywheel part number or type is not known, measure the distance from the camshaft flywheel housing cover lower bolt head and the outer circumference of the flywheel housing bell (Fig. 2). If this distance is approximately 1-1/4", it is a 118 tooth flywheel. For the 102 tooth flywheel, the distance will be approximately 2-1/2".

When the number of teeth on the flywheel is known, set the switch on the tachometer to the proper position. Proceed as follows:

1. Perform the standard engine tune-up. Set the no-load speed as required by the engine type, injector size and governor (refer to Table 1 for 1978 engines or Charts 1, 2 or 3 for 1979 engines).

2. Disconnect the accelerator linkage from the governor speed control lever if it has not already been done.

3. Run the engine until a stabilized engine coolant temperature is obtained.

4. Refer to Table 1 for 1978 engines and, using engine type, injector size and governor, select the initial and specified idle drop numbers for the rated "TT" horsepower and rated engine speed at which the engine is to operate.

IDLE DROP		
Rated H.P. @ Rated Speed	Initial Idle	Idle Drop Setting
230 @ 2100	1850	1795
230 @ 1950	1750	1730
230 @ 1900	1750	1732
220 @ 2100	1850	1785
220 @ 1950	1750	1720
220 @ 1900	1750	1722

Single Weight Governor 6-71TT with N-75 Injectors and Belleville Washer (Green Dye).

TABLE 1 (1978 Engines)

Refer to Charts 1, 2 and 3 for 1979 engines. Each idle drop Chart (1, 2 or 3) includes the following information:

Engine Series
Maximum Full Load RPMs
Governor Part Numbers
Belleville Washer Part Numbers

© 1983 General Motors Corp.

Injector Size
Initial Idle Drop Starting RPM

The above should be considered to insure the correct chart is being used. To maintain certification as required by law, the engine horsepower cannot be adjusted beyond the limits outlined on each Chart.

5. Set the initial idle speed (using the idle adjusting screw) to that determined in Step "4" above.

6. With the governor speed control lever in the idle position, turn the Belleville spring retainer nut (Fig. 1) clockwise on the plunger until the specified idle drop speed is achieved. Secure the retainer nut with the locking screw. When the specified idle speed is achieved, the engine is power controlled to the "TT" horsepower rating.

NOTE: Idle speeds must be exact and steady. If they are not, check for bind or rubbing in the fuel control system, governor, fuel rods, injector control tubes and injector control racks.

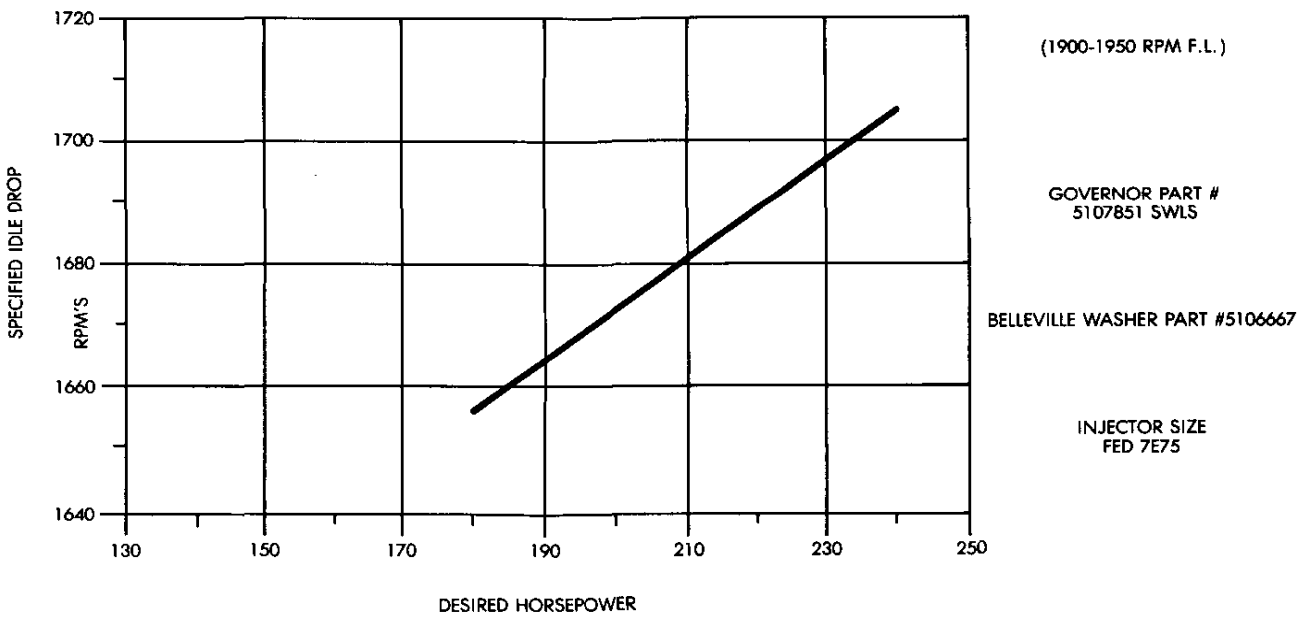
7. Lower the idle speed to the desired operating idle speed, using the idle adjusting screw.

8. Adjust the buffer screw and the starting aid screw.

6-71TT IDLE DROP SETTINGS FOR 1979 ENGINES

CHART 1 (1979 Engines)

INITIAL IDLE DROP STARTING RPM IS 1750. (SETTINGS FOR FEDERAL)



© 1983 General Motors Corp.

6-71TT IDLE DROP SETTINGS FOR 1979 ENGINES

CHART 2 (1979 Engines)

INITIAL IDLE DROP STARTING RPM IS 1850 (SETTINGS FOR FEDERAL)

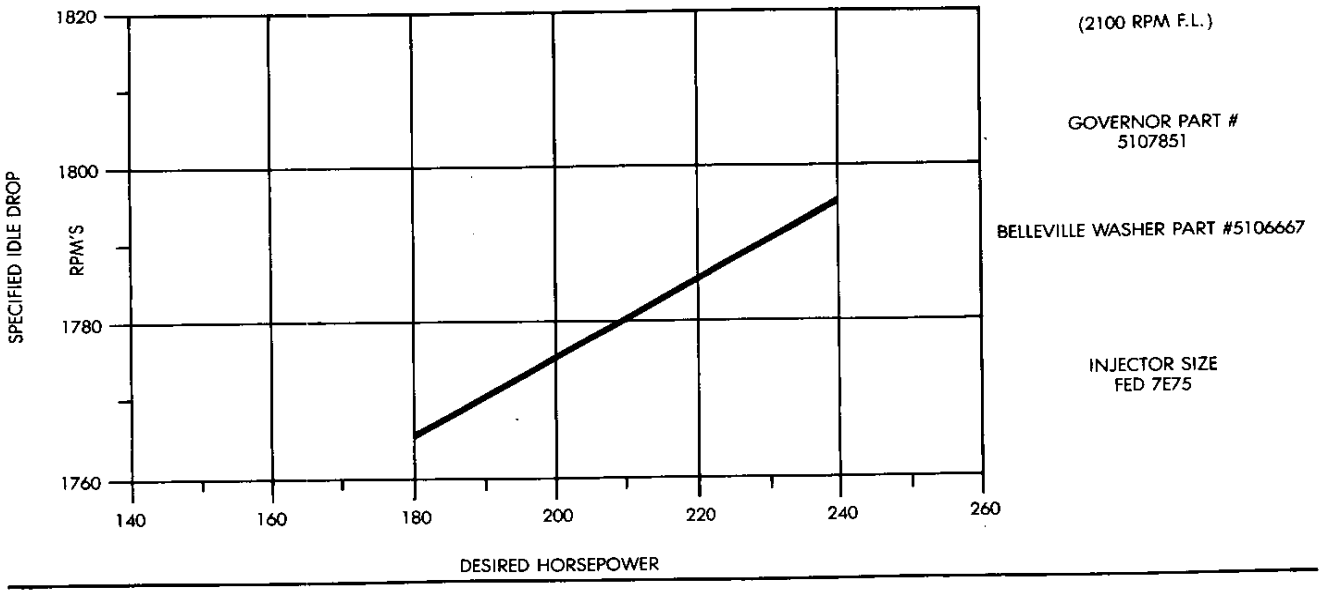
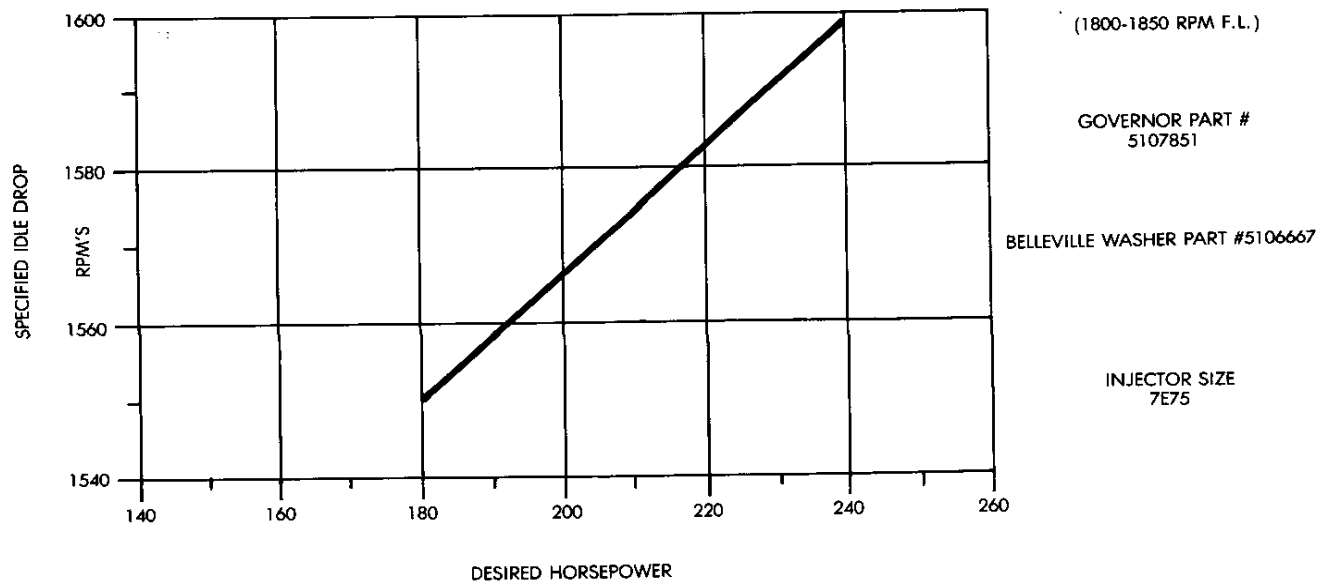


CHART 3 (1979 Engines)

INITIAL IDLE DROP STARTING RPM IS 1650 (SETTING FOR FEDERAL)



© 1983 General Motors Corp.

METHOD 2 - Power Reduction Factor

POWER REDUCTION FACTOR

ENGINE TYPE	MAXIMUM RATED B.H.P.	RATED "TT" HORSEPOWER	RATED ENGINE SPEED	NO-LOAD SPEED	POWER REDUCTION FACTOR
6-71TT – N-75 Injectors Federal Certified Throttle delay setting .5[70	272 @ 2100 RPM 2275 RPM Maximum No-Load	230	1900	2050	.91
		230	1950	2100	.89
		230	2100	2250	.86
		220	1900	2050	.85
		220	1950	2100	.86
		220	2100	2250	.83

TABLE 2 (1978 Engines)

This method consists of setting "TT" engine horsepower to a specific percentage below full throttle horsepower as observed on an engine, chassis or output shaft dynamometer.

This method will provide the desired horsepower, within a reasonable tolerance, even with normal variations of test conditions. Some of these variations would be:

Dynamometer Calibration
Driveline Efficiency
Fuel Grade and Temperature
Air Density
Tire Slippage

Proceed as follows:

1. Perform the standard engine tune up.

NOTE: The throttle delay piston must be removed and the Belleville spring retainer nut must be backed out until there is approximately .060" clearance between the washers and retainer nut prior to operating the engine on the dynamometer (Fig. 1).

2. Set the no-load speed as required (Table 2).

3. Run the engine until the engine coolant temperature is above 170° F (77° C).

4. Using an engine, chassis or output shaft dynamometer, measure and record full throttle horsepower at 100 rpm below rated engine speed with the Belleville springs loose (Fig. 1).

NOTE: Satisfactory power adjustment can be obtained only if the full throttle horsepower and adjusted horsepower (Step 4) are obtained with the engine cooling in the same mode, i.e., operating or not operating.

5. Select the power reduction factor in Table 2 (1978 Engines) or Table 3 (1979 Engines) for the desired rated horsepower and rated engine speed.

6. Multiply the horsepower recorded in Step 4 by the factor selected in Step 5. Record this value.

7. Adjust the Belleville spring retainer nut clockwise so that the observed horsepower is reduced to that recorded in Step 6 at 100 rpm below rated engine speed, with the governor speed control lever in the maximum speed position and the fan in the same mode as in Step 4. Verify that the engine is obtaining

POWER REDUCTION FACTOR

*Maximum Rated B.H.P.	Rated TT Horsepower	Power Reduction Factor
258 @ 1700 RPM Full Load	180	.70
	190	.73
	200	.77
	210	.81
	220	.85
	230	.89
	240	.93

*6-71TT Engines should only be full power checked @ 1700 RPM

TABLE 3 (1979 Engines)

© 1983 General Motors Corp.

adjusted "TT" horsepower, within 5%, at rated engine speed. If the adjusted "TT" horsepower cannot be obtained at rated engine speed, governor droop interference may be the cause. If necessary, to eliminate droop interference, readjust the engine no-load speed from 150 to 175 rpm above rated engine speed and repeat the power reduction factor method.

8. Check the idle speed and, if necessary, reset to the specified idle speed.

9. Adjust the buffer screw and starting aid screw.

FLEXISPEC ENGINE GOVERNOR ADJUSTMENTS FOR "TT" ENGINES

When it is desirable to adjust a 6-71 "TT" engine to obtain non "TT" maximum rated horsepower, proceed as follows:

1. Adjust the engine governor to obtain a no-load speed 175 rpm above the desired rated speed. Refer to Section 14.3 for the no-load engine speed adjustment.

NOTE: Do not exceed a full-load speed of 2100 rpm or a no-load speed of 2275 rpm.

2. Position the Belleville spring retainer to provide approximately .060" clearance between the Belleville washers and the retainer when the engine is not running (Fig. 1).

The exception to the above procedure would be a 6-71TT engine using a double weight limiting speed governor. The double weight "TT" governor's high speed spring may become "solid" not allowing the no-load speed to be adjusted properly. Therefore, in addition to backing off of the Belleville springs (washers), the governor's high-speed spring must be replaced. This replacement is to make sure that the no-load speed may be adjusted 175 rpm above the desired rated speed. High-speed spring part number 5153629 (two aluminum stripes) is the suggested replacement for the 6-71TT engine double weight limiting speed governor.

© 1983 General Motors Corp.

LIMITING SPEED MECHANICAL GOVERNOR, INJECTOR RACK CONTROL AND THROTTLE CONTROL ADJUSTMENT

Diesel Railcar Engine

The limiting speed governor controls the engine idle speed and maximum speed. Intermediate speeds are dependent on the throttle control lever position and the load on the engine.

The electrically-operated throttle control lever is attached to the governor throttle shaft and is operated by two solenoids (Fig. 1) which are electrically connected to the remote throttle controller. The throttle control lever is also connected, through the governor mechanism, to the injector control racks in such a manner as to move the racks to a predetermined position when the lever is moved between the idle and full-fuel positions.

The remote throttle controller has five positions--OFF, 1, 2, 3 and 4. Position 1 is the engine idle speed position and position 4 is maximum power.

When the throttle controller is moved to position 2, the No. 1 solenoid is energized and moves the throttle control operating beam away from the solenoids around point "A" as a fulcrum (Fig. 6). This moves the throttle lever away from the solenoids and allows more fuel to enter the cylinders.

When the throttle controller is moved to position 3, solenoid No. 1 is de-energized and solenoid No. 2 is energized, moving the beam away from the solenoids around point "B" as a fulcrum. Arm "X" is longer than arm "Y" (Fig. 6) and, since the plunger of solenoid No. 1 moved for position 2, then the throttle control lever moves farther in position 3 and admits additional fuel to the cylinders.

Both solenoids are energized when the throttle controller is moved to position 4; this places the throttle control lever in the maximum fuel position.

When both solenoids are de-energized, the throttle control lever moves to the IDLE position (not to the OFF position).

When the PARAR (Portuguese for stop) button on the control cabinet cover is pushed IN, the governor shut-down solenoid becomes energized and moves the shut-down lever which in turn moves the injector control rack to the OFF position. The stop button must be held in until the engine stops.

Before proceeding with the governor and throttle linkage adjustments, perform the following steps:

1. Set the railcar hand brake and the air brake.

2. Remove the generator fuse which is located in the regulator locker.

Preliminary Throttle Linkage Adjustment

A preliminary throttle linkage adjustment should be made to establish a starting point, if the governor or throttle linkage has been reconditioned or replaced, by adjusting the geometry of the linkage to a position where most of the adjustment will be established before proceeding with the final engine governor and throttle adjustments.

Refer to Fig. 6 and perform the preliminary throttle linkage adjustment as follows:

1. If the governor has been repaired or replaced, check the governor gap before the throttle control housing is installed.

2. Loosen the clamping bolt on the governor shutdown lever.

3. Loosen the throttle control lever clamping bolt. Then loosen the lock nut on both throttle control rod ends.

4. Loosen both lock nuts and thread the throttle control operating beam up so the plain end is just

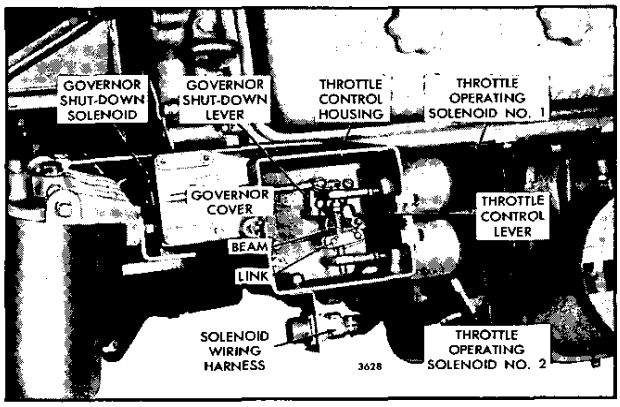


Fig. 1 - Throttle Control Linkage Arrangement

© 1978 General Motors Corp.

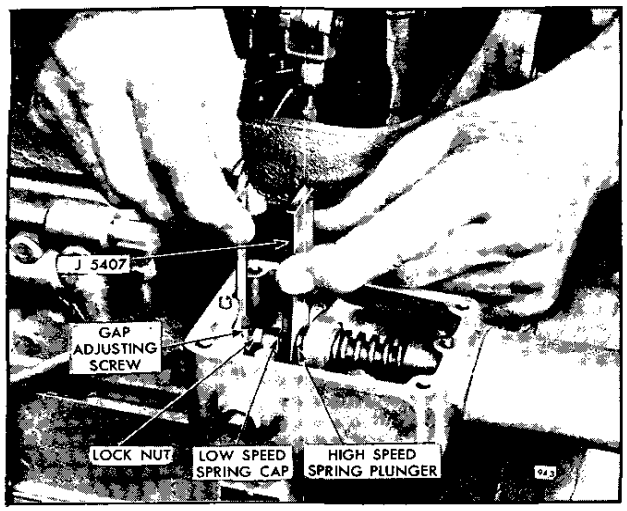


Fig. 2 - Adjusting Governor Gap

inside of the No. 2 throttle control rod end bearing. Tighten the lock nuts on the beam.

5. Adjust both throttle control rod ends so the threaded end of the beam is approximately 5 °-10 ° from the vertical (away from the solenoids). Tighten the control rod lock nuts.

6. Energize both solenoids. Then, with a wrench on the lubrication fitting, rotate the throttle control shaft to the full-fuel position and tighten the clamping bolt. De-energize the solenoids.

Adjust Governor Gap

If the governor has been reconditioned or replaced, adjust the gap as follows:

1. Start and warm-up the engine to the normal operating temperature. Then stop the engine and remove the governor high speed spring retainer cover.

2. Start the engine. Then loosen the idle speed adjusting screw lock nut (Fig. 2). Turn the idle speed adjusting screw to attain a speed of 840-850 rpm (at no-load). Then tighten the lock nut.

3. Stop the engine and remove the throttle control housing, solenoids and governor cover as an assembly (refer to Section 2.9.2).

4. Remove the valve rocker cover. Then remove the fuel rod from the governor differential lever and the injector control tube lever.

5. Check the gap between the low speed spring cap and the high speed spring plunger with gage J 5407 (.170 "). If necessary, loosen the lock nut and turn the gap adjusting screw until a slight drag is felt on the gage.

6. Hold the adjusting screw and tighten the lock nut. Then recheck the gap. If necessary, readjust the gap.

7. Install the fuel rod.

8. Install the throttle control housing, solenoids and governor cover (refer to Section 2.9.2).

Position Injector Rack Control Levers

Properly positioned injector rack control levers will result in the following:

1. Throttle control lever at the maximum speed position.

2. Governor low speed gap closed.

3. High speed spring plunger on the seat in the governor control housing.

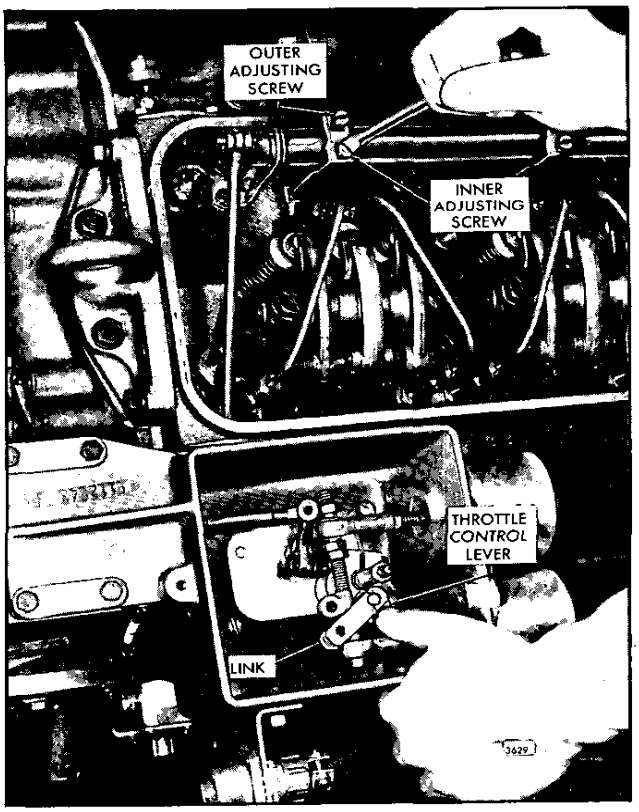


Fig. 3 - Positioning No. 1 Injector Rack Control Lever

© 1978 General Motors Corp.

4. Injector racks in the full-fuel position.

Adjust the No. 1 injector rack control lever first to establish a guide for adjustment of the remaining levers.

1. Disconnect the linkage attached to the throttle control lever. Then disconnect the control rod from the governor shut-down lever.

2. Loosen the lock nut and back out the idle speed adjusting screw until 1/2 " of the threads project from the lock nut when the nut is against the high speed plunger.

3. Loosen the lock nut and back out the buffer screw approximately 5/8 ".

4. Loosen all of the inner and outer injector rack control lever screws. All of the control levers must be free on the injector control tube.

5. Hold the throttle control lever in the full-fuel position and turn the inner adjusting screw down on the No. 1 injector rack control lever (Fig. 3) until a slight movement of the injector control tube lever is observed or a step-up in effort is noted. This will place the No. 1 injector rack in the full-fuel position. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

> **NOTE:** Step 5 will place the governor linkage and the injector control tube assembly in the same position they will attain when the engine is running at full load.

6. Hold the throttle control lever in the maximum speed position and check for a slight rotating movement of the injector control rack. If the rack is too loose, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly.

The setting is too tight if, when moving the throttle control lever from the idle to the maximum speed position, the injector rack becomes tight before the throttle control lever reaches the end of its travel (as determined by the stop under the governor cover). This will result in a step-up in effort required to move the throttle lever to the end of its travel. To correct this condition, back off the inner adjusting screw slightly and tighten the outer screw slightly.

7. Disconnect the fuel rod from the injector control tube lever and hold the No. 1 injector manually in the full-fuel position and turn down the inner adjusting screw of the No. 2 injector until the injector rack has moved into the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then alternately tighten both the inner and outer adjusting screws.

8. Recheck the No. 1 injector rack to be sure it has remained snug on the ball end of the injector rack control lever while adjusting the No. 2 injector. If the rack of the No. 1 injector has become loose, back off slightly on the inner adjusting screw on the No. 2 injector rack control lever and tighten the outer adjusting screw.

When the settings are correct, the racks of both injectors will be snug on the ball end of their respective rack control levers.

9. Position the remaining rack control levers as outlined in Steps 7 and 8.

10. Connect the fuel rod to the injector control tube lever.

11. Reset the idle speed adjusting screw until it projects 3/16 " from the lock nut to permit starting the engine.

Adjust Maximum No-Load Engine Speed

The governor is properly adjusted before the engine leaves the factory. However, if the governor has been reconditioned or replaced, to ensure the engine will not exceed the specified no-load speed, set the maximum no-load speed as follows:

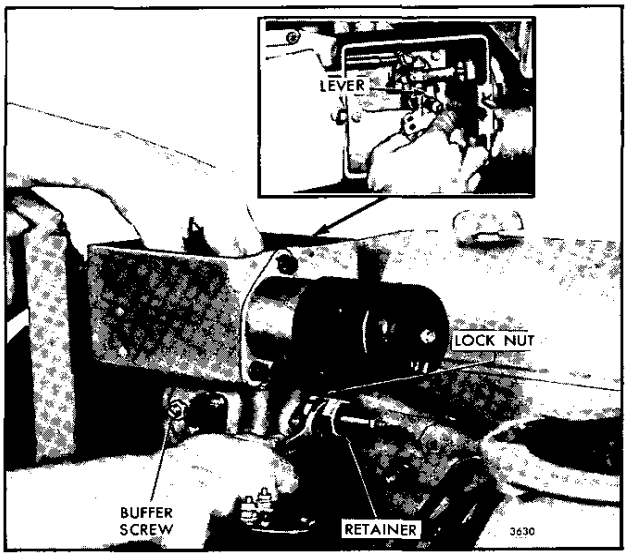


Fig. 4 - Adjusting Maximum No-Load Speed

© 1978 General Motors Corp.

1. Loosen the lock nut and back off the high speed spring retainer approximately five turns.

2. With the engine running at normal operating temperature and no load, place the throttle control lever in the maximum speed position. Then turn the high speed spring retainer (Fig. 4) until the engine is running at 2250-2280 rpm.

3. Hold the spring retainer and tighten the lock nut.

Adjust Idle Speed

With the maximum no-load speed properly set, adjust the idle speed as follows:

1. With the engine at normal operating temperature and with the buffer screw backed out to avoid contact with the differential lever, turn the idle speed adjusting screw (Fig. 5) until the engine is running at approximately 15 rpm below the specified idle speed.

2. Hold the idle screw and tighten the lock nut.

3. Install the high speed spring retainer cover.

Adjust Buffer Screw

With the idle speed set at approximately 15 rpm below the recommended idle speed, adjust the buffer screw as follows:

1. Run the engine at idle speed and turn the buffer screw in until the engine is running at 840-850 rpm idle speed. Do not raise the engine speed more than 15 rpm with the buffer screw.

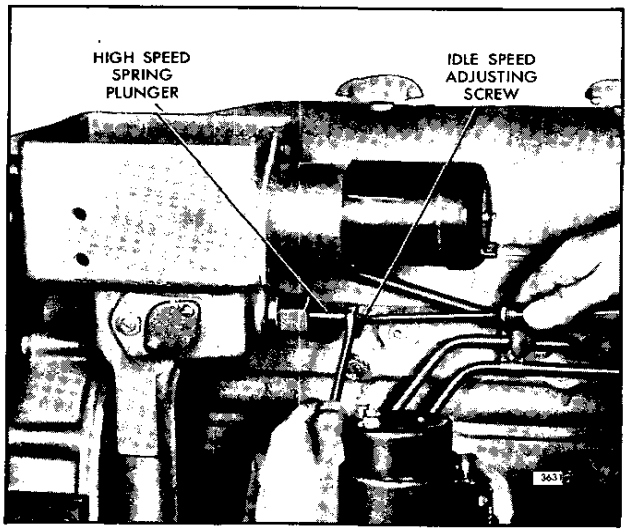


Fig. 5 - Adjusting Engine Idle Speed

2. Hold the buffer screw and tighten the lock nut.

3. Recheck the maximum no-load speed.

4. Stop the engine and connect the linkage to the throttle control lever.

Adjust Governor Shut-Down Solenoid

After the governor adjustments have been made, refer to Figs. 1 and 6 and adjust the governor shut-down lever as follows:

1. If the governor shut-down solenoid was previously removed, insert the solenoid plunger through the opening in the throttle control housing and thread the control rod end approximately four turns on the end of the plunger. Then install the four bolts, lock washers and nuts which secure the solenoid to the throttle control housing. Do not tighten the bolts.

2. Place the end of the control rod end over the pin in the governor shut-down lever. Then tighten the solenoid attaching bolts and nuts. Install the washer and spring retainer on the control lever pin to secure the control rod end.

3. Loosen the shut-down control lever clamping bolt and loosen the lever on the terminal shaft.

4. Place the injector racks in the no-fuel position and turn the shut-down control lever shaft counterclockwise until interference is encountered.

5. Move the injector racks to the full-fuel position by energizing the throttle control operating solenoids, then tighten the shut-down control lever clamping bolt.

6. With the injector racks still in the full-fuel position, loosen the lock nut and turn the shut-down solenoid plunger counterclockwise approximately one and one-half (1-1/2) turns. Then check for movement of the shut-down control lever by pushing it back towards the solenoid. The lever and plunger should have approximately 1/16 " travel. When the setting is correct, tighten the lock nut on the plunger.

7. De-energize the throttle operating control solenoids and start the engine to check the operation of the shut-down solenoid.

NOTE: When the shut-down solenoid is de-energized, the injector racks should be able to move to the full-fuel position. When the solenoid is energized, the injector racks should be in the no-fuel position.

© 1978 General Motors Corp

8. Install the valve rocker cover.

Adjust Throttle Controls

Check and adjust the throttle controls for the proper idle and maximum no-load speeds as follows:

1. Set the railcar hand brake and air brakes.

2. Remove the generator fuse from the regulator locker, if not previously removed.

3. Remove the plug from the receptacle on the transmission wiring harness.

4. Start and warm-up the engine until normal operating temperature has been reached.

5. Check the throttle controls as outlined under *Preliminary Throttle Linkage Adjustment.*

> **NOTE:** As a safety precaution while making the following tests, a second man, familiar with the car controls, should stay in the cab, or the wheels of the railcar should be securely blocked to prevent movement of the car if the brakes fail to hold.

6. Check the free engine speeds with the throttle linkage connected to the throttle control lever.

   a. Note the engine idle speed. If the speed is above 850 rpm, turn the throttle control operating solenoid plungers into the rod end bearings (refer to Fig. 6). If the speed is below 840 rpm, adjust the speed as outlined under *Adjust Idle Speed.*

   b. Move the throttle controller to Position No. 3 and check the maximum engine speed. If the speed is above or below the desired setting (2250-2280 rpm), readjust the speed as outlined under *Adjust Maximum No-Load Speed.*

7. Move the throttle controller to the NEUTRAL position and stop the engine.

8. Install the plug in the receptacle on the transmission wiring harness.

9. Start the engine and place the throttle controller in Position No. 4. The engine speed should be 1760 ± 75 rpm with the transmission stalled. If the engine speed falls short of the specified speed, recheck the maximum free engine speed. If the maximum free engine speed is correct, the engine may not be developing full power.

> **CAUTION:** Do not operate the engine with the controller in Position No. 4 longer than 30 seconds with the transmission stalled. The drive oil temperature should not exceed 265 °F. Any temperature in excess of this may be harmful to the torque converter of the transmission.

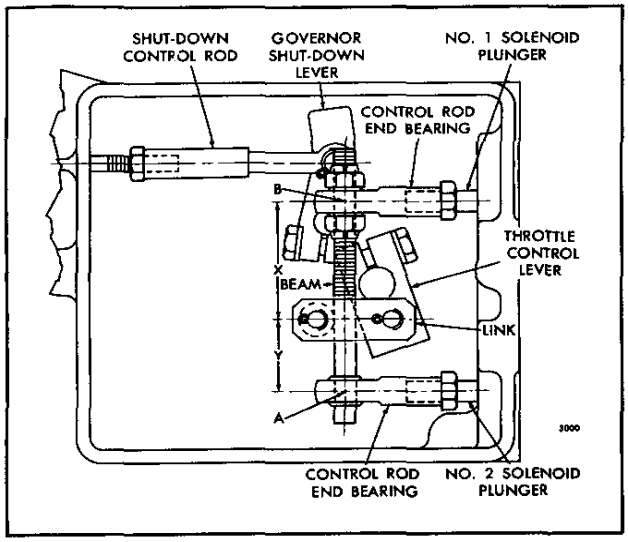


Fig. 6 - Throttle Control Linkage Adjustment Diagram

> **NOTE:** All engine speeds except no-load idle (840-850 rpm), idle stall (800 ± 5 rpm), and maximum stall (1760 ± 75 rpm) may be varied to suit the operating conditions. However, the maximum no-load engine speed must not exceed 2250-2280 rpm.

10. Do not install the generator fuse in the regulator locker until the engine intermediate speed adjustments are performed.

Adjust Engine Intermediate Speeds

The engine intermediate speeds may be adjusted so the engine or engines will be synchronized in their operation as follows:

1. With the hand and air brakes set, and the car wheels blocked or a second man in the cab, start and warm-up the engine until normal operating temperature has been reached.

2. Place the direction control handle (in the engineers cab) in the forward position. Then check and adjust the engine speeds with the transmission stalled as follows:

   a. Controller in Position No. 1: check the engine idle speed (800-810 rpm) with the transmission stalled.

© 1978 General Motors Corp.

b. Controller in Position No. 2: check the engine speed (1050 ± 10 rpm) with the transmission stalled.

c. Controller in Position No. 3: check the engine speed (1340 ± 50 rpm) with the transmission stalled.

d. Controller in Position No. 4: check the engine speed (1760 ± 75 rpm) with the transmission stalled.

CAUTION: *Do* not operate the engine in excess of 30 seconds in the higher throttle positions to prevent the drive oil temperature from exceeding 265 °F., otherwise the transmission high oil temperature switch will shut the engine down. Temperature in excess of 265 °F. may cause damage within the transmission.

NOTE: If the engine maximum speed is low or excessively high with the transmission stalled, refer to *Trouble Shooting--Transmission* in Section 9.9.0 of *Transmission Manual 6SE355* and *Trouble Shooting--Engine* in Section 15.2.

3. Place the throttle controller in Position No. 2 and adjust the engine speed, if necessary, by increasing or decreasing the angle of the beam about point "A" as a fulcrum (Fig. 6) until a speed of 1050 ± 10 rpm is obtained. To increase the speed, decrease the angle of the beam; to decrease the speed, increase the beam angle. Slight adjustments in the speed may be made by adjusting the beam upward to increase the speed or downward to decrease the speed.

CAUTION: Use care in adjusting the beam so it does not come out of the No. 2 control rod end bearing.

4. Place the throttle controller in Position No. 3 and check the engine speed (1340 ± 50 rpm).

NOTE: The engine speeds (with the transmission stalled) in Positions No. 2 and No. 3 may be varied from the settings given above, if desired, to suit the existing operating conditions. It should be noted, due to the construction of the throttle linkage, if the No. 3 speed is increased, the No. 2 speed will be decreased and, if the No. 2 speed is increased, the No. 3 speed will be decreased.

5. Repeat all of the above steps on the second engine. The speeds at the No. 2 controller position should be within 10 rpm on each of the two engines.

6. Install the generator fuse in the regulator locker.

© 1978 General Motors Corp.

VARIABLE SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and the injector rack control levers.

NOTE: Before proceeding with the governor and injector rack adjustments, disconnect any supplementary governing device. After the adjustments are completed, reconnect and adjust the supplementary governing device (see Section 14.14).

Adjust Governor Gap

1. With the engine running, set the idle screw at 550 rpm.

2. With the engine stopped and at normal operating temperature, disconnect any linkage attached to the governor levers.

3. Back out the buffer screw until it extends approximately 5/8″ from the locknut (Fig. 3).

4. Clean and remove the governor cover and valve rocker cover. Discard the gasket.

5. Place the speed control lever in the maximum speed position (Fig. 1).

6. Insert a .006″ feeler gage between the spring plunger and the plunger guide. If required, loosen the locknut and turn the adjusting screw in or out until a slight drag is noted on the feeler gage.

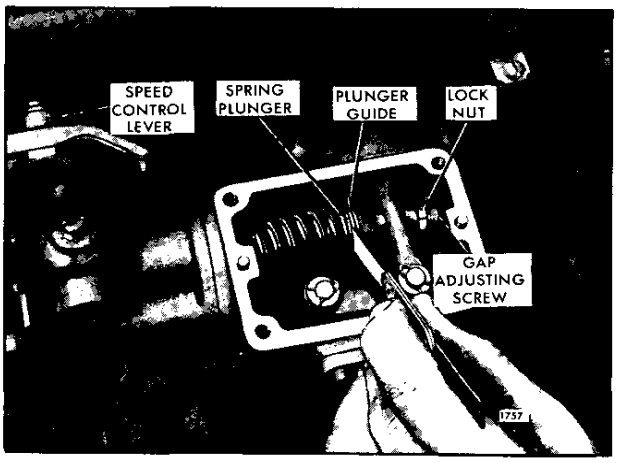


Fig. 1 - Adjusting Governor Cap

7. Hold the adjusting screw and tighten the locknut. Check the gap again and, if necessary, readjust.

8. Secure the governor cover to the governor housing with three regular screws, one special screw and lock washers. On former engines the governor cover is secured with four regular screws and lock washers.

9. Hook the torsion retracting spring on the special cover screw and the stop lever (Fig. 2). The former retracting spring is hooked between the stop lever and the retracting spring clip mounted on the end of the variable speed spring housing.

Position Injector Rack Control Levers

The position of the injector control rack levers must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

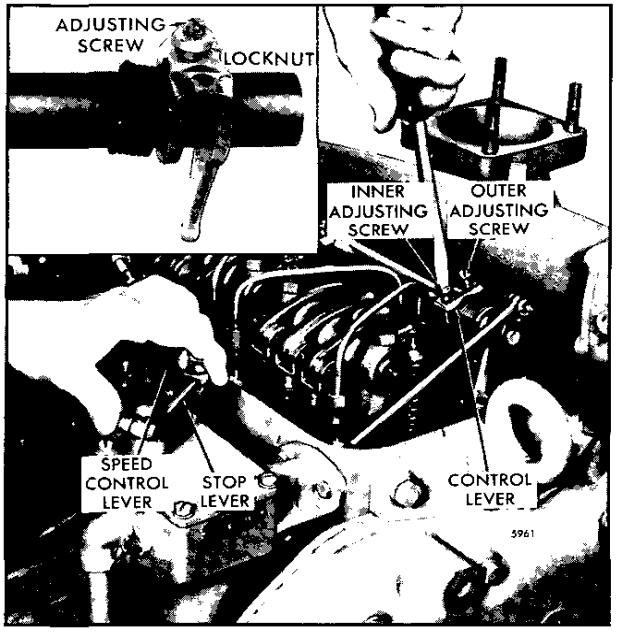


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

© 1983 General Motors Corp.

Properly positioned injector rack control levers with the engine at full load will result in the following:

1. Speed control lever at the maximum speed position.

2. Stop lever in the *run* position.

3. High-speed spring plunger on the seat in the governor control housing.

4. Injector fuel control racks in the full-fuel position.

> **NOTE:** The cross link equalizer spring must be removed from multiple engine units before performing the individual engine tune-up. See "Throttle Adjustment for Load Equalization on Twin or Quad Units With Variable Speed Mechanical Governors" for procedure on removing cross link equalizer spring.

Adjust the No. 1 injector rack control lever Fig. 2 first, to establish a guide for adjusting the remaining injector rack control levers.

1. Disconnect any linkage attached to the stop lever.

2. Loosen the locknut and back out the buffer screw approximately 5/8", if not done before (Fig. 3).

3. Loosen all the inner and outer injector rack control lever adjusting screws or adjusting screws and locknuts (Fig. 2). Be sure all the injector rack control levers are free on the injector control tubes.

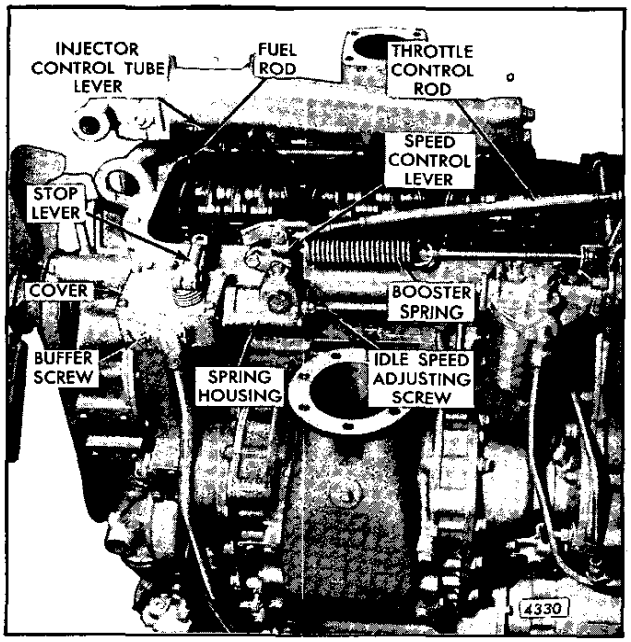


Fig. 3 - Buffer and Idle Speed Adjusting Screw

4. Move the speed control lever to the maximum speed position. Move the stop lever to the run position. Hold it in that position with light finger pressure and proceed as follows:

Two Screw Assembly -- Turn the inner adjusting screw of the No. 1 injector rack control lever down until a slight movement of the control tube is observed or a step-up in effort is noted. This will place the No. 1 injector rack in the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws.

One Screw and Locknut Assembly -- Tighten the adjusting screw of the No. 1 injector rack control lever until the injector rack clevis is observed to roll up or and increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut.

> **NOTE:** Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

The above step should result in placing the governor linkage and control tube assembly in the same position that they will attain while the engine is running at full load.

6. To be sure the control lever is properly adjusted, hold the speed control lever in the maximum speed position and press down on the injector rack with a screwdriver or finger tip and note "rotating" movement of the injector control rack when the speed control lever is in the maximum speed position (Fig. 4). Hold the speed control lever in the maximum speed position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward and when the pressure of the screwdriver is released, the control rack should "spring" back upward (Fig. 5).

If the rack does not return to its original position, it is too loose. To correct this condition with the *Two Screw Assembly*, back off the outer adjusting screw slightly and tighten the inner adjusting screw slightly. To correct this condition with the *One Screw and Locknut Assembly*, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

The setting is too tight if when moving the stop lever from the stop to the *run* position, the injector rack becomes tight before the stop lever reaches the end of

© 1983 General Motors Corp.

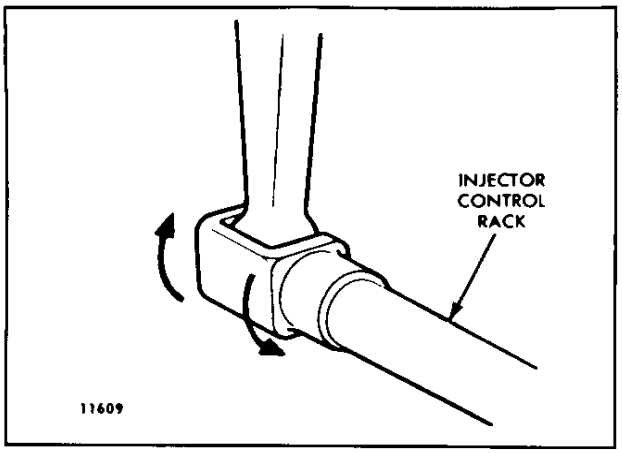


Fig. 4 - Checking Rotating Movement of Injector Control Rack

its travel as determined by the stop under the governor cover. This will result in a step-up in effort required to move the stop lever to the end of its travel. To correct this condition with the *Two Screw Assembly*, back off the inner adjusting screw slightly and tighten the outer adjusting screw slightly. To correct this condition with the *One Screw and Locknut Assembly*, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

7. Manually hold the No. 1 injector rack in the full-fuel position and proceed as follows:

Two Screw Assembly:

a. Turn down the inner adjusting screw of the No. 2 injector until the injector rack has moved into full-fuel position and the inner adjusting screw is bottomed on the injector control tube. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws until tight.

NOTE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Recheck the No. 1 injector rack to be sure that it has remained snug on the ball end of the injector rack control lever while positioning the No. 2 injector rack. If the rack of the No. 1 injector has become loose, back off slightly on the inner adjusting screw of the No. 2 injector control lever and tighten the outer adjusting screw.

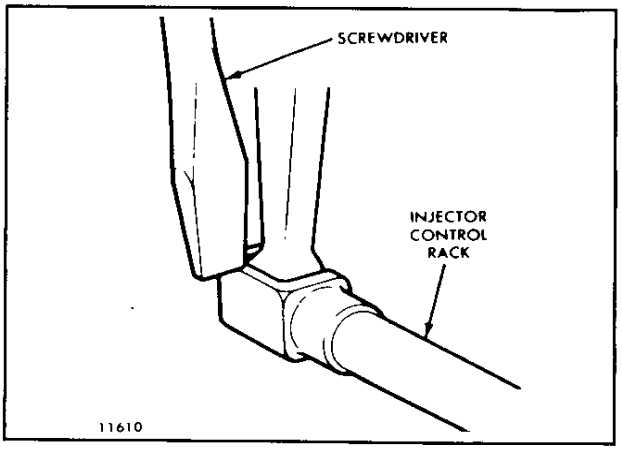


Fig. 5 - Checking Injector Control Rack "Spring"

One Screw and Locknut Assembly:

a. Tighten the adjusting screw of the No. 2 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

NOTE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Verify the injector rack adjustment of No. 1 as outlined in Step 6. If No. 1 does not "spring" back upward, turn the No. 2 adjusting screw counterclockwise slightly until the No. 1 injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 1 and No. 2 injectors. Turn clockwise or counterclockwise the No. 2 injector rack adjusting screw until both No. 1 and No. 2 injector racks are in the full-fuel position when the locknut is securely tightened.

8. Position the remaining injector rack control levers as outlined in Step 7.

9. Use a new gasket and replace the valve rocker cover.

Adjust Maximum No-Load Speed

The maximum no-load speed on engines equipped with variable speed governors must not be less than 125 rpm or more than 150 rpm above the recommended full-load speed.

© 1983 General Motors Corp.

With a hand tachometer, determine the maximum no-load speed of the engine then, make the following adjustments, if required:

1. Refer to Fig. 3 and disconnect the booster spring.

2. Remove the two bolts and withdraw the variable speed spring housing and the variable speed spring plunger from inside the spring housing.

3. Refer to Table 1 and Fig. 6 and determine the stop or shim required for the desired full load speed for engines with two valve cylinder heads.

TWO VALVE CYLINDER HEADS

Full Load Speed	Stops	Shims
1200 to 1425 rpm	2	Up to .325"
1426 to 1825 rpm	1	Up to .325"
1826 to 2100 rpm	0	Amount Required to get necessary speed.

TABLE 1

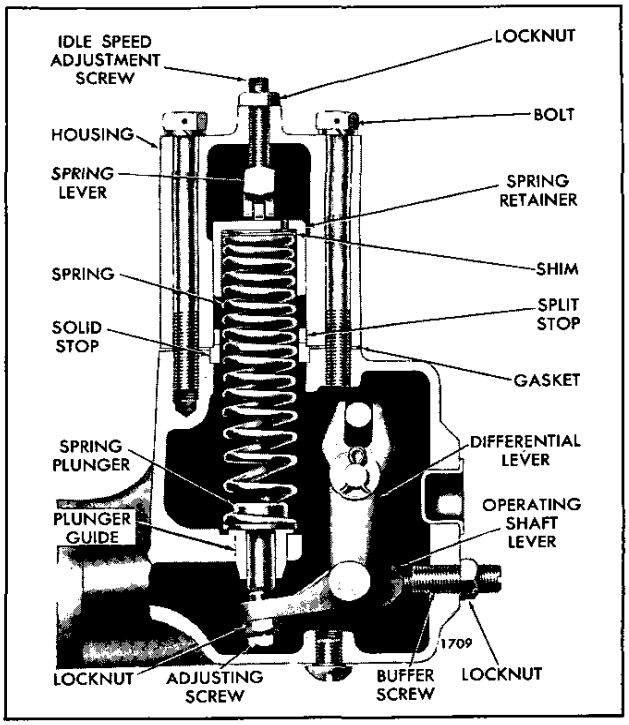


Fig. 6 - Location of Stops and Shims

A split stop can only be used with a solid stop (Fig. 6).

Refer to Table 2 and determine the stops or shims required for the desired full-load speeds for engines with four valve cylinder heads.

FOUR VALVE CYLINDER HEADS

Full Load Speed	Stops	Shims
1450 to 1650 rpm	2	Amount Required to get necessary speed.
1651 to 2150 rpm	1	
2151 to 2300 rpm	0	

TABLE 2

4. Install the variable speed spring housing and recheck the maximum no-load speed.

5. If required, add shims to obtain the necessary operating speed.

NOTE: If the maximum no-load speed is raised or lowered more than 50 rpm by the installation or removal of the governor shims, the governor gap should be rechecked.

If readjustment of the governor gap is required, the position of the injector racks must be rechecked.

Adjust Idle Speed

With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

1. Place the speed control lever in the idle position and the stop lever in the run position.

2. With the engine running at normal operating temperature, back out the buffer screw to avoid contact with the differential lever.

3. Loosen the locknut and turn the idle speed adjusting screw until the engine is operating at approximately 15 rpm below the recommended idle speed.

© 1983 General Motors Corp.

The recommended idle speed is 500-600 rpm but may vary with the engine application.

4. Hold the idle speed adjusting screw and tighten the locknut.

Adjust Buffer Screw

With the idle speed set at approximately 15 rpm below the recommended idle speed, the buffer screw may be set as follows:

1. Turn the buffer screw in until the engine is operating at the recommended idle speed. Do not raise the engine speed more than 15 rpm with the buffer screw.

2. Hold the buffer screw and tighten the locknut.

Adjust Booster Spring

With the engine idle speed set, adjust the booster spring as follows:

1. Move the speed control lever to the idle speed position.

2. Refer to Fig. 3 and loosen the booster spring retaining nut on the speed control lever. Loosen the locknuts on the eyebolt at the opposite end of the spring.

3. Move the spring retaining bolt in the slot of the speed control lever until the center of the bolt is on or slightly over center (toward the idle speed position) of an imaginary line through the bolt, lever shaft and eyebolt. Hold the bolt and tighten the locknut.

4. Start the engine and move the speed control lever to the maximum speed position and release it. The lever should return to the idle speed position. If it does not, reduce the booster spring tension. If it does, continue to increase the spring tension until the point is reached where it will not return to idle. Then, reduce the spring tension until the lever does return to idle and tighten the locknuts on the eyebolt. This setting will result in the minimum force required to operate the speed control lever.

© 1983 General Motors Corp.

VARIABLE SPEED GOVERNOR WITH HYDRAULIC THROTTLE KNOCKDOWN

A variable speed mechanical governor with a hydraulic throttle knockdown is used on certain engines to permit the shifting of hydraulic type transmissions without the application of full engine torque to the clutches at the time of their engagement. This reduction in engine torque is accomplished by the use of a knockdown assembly and valving that operates automatically when the shift lever is moved.

The variable speed governor assembly with hydraulic knockdown consists of a standard variable speed governor assembly, but having a revised spring housing (Fig. 1).

The speed adjusting shaft is mounted on roller bearings in the spring housing and has a variable speed spring lever keyed to it. One end of the speed adjusting shaft has a booster spring lever and at the other end a jaw is retained by a pin. A speed control lever is mounted on the speed adjusting shaft, riding on roller bearings, and connects to the shaft through a torsion spring. The variable speed spring lever bears against the variable speed spring plunger through a roller at its lower end. The upper end rides in the slot of the piston, bearing against the ends of the slot through a roller. The head of the piston rides in a cylinder and is sealed by a seal ring. The other end of the piston is retained in a plate and tube assembly. A spring presses against the plate and tube assembly retaining the piston in its forward position.

Operation

To start an engine equipped with this type of governor the governor control lever is placed in the run position and the engine is started. The engine will operate at idle speed until the speed control lever is moved to its maximum speed position.

As soon as the engine is started, oil pressure builds up in the transmission and is impressed on to the piston of the knockdown assembly. This oil pressure moves the piston to the end of its travel. Movement of the piston is stopped as the tube of the plate and tube assembly bottoms against the spring retainer. When the speed control lever is moved into the full-speed position the engine will accelerate to the maximum speed setting.

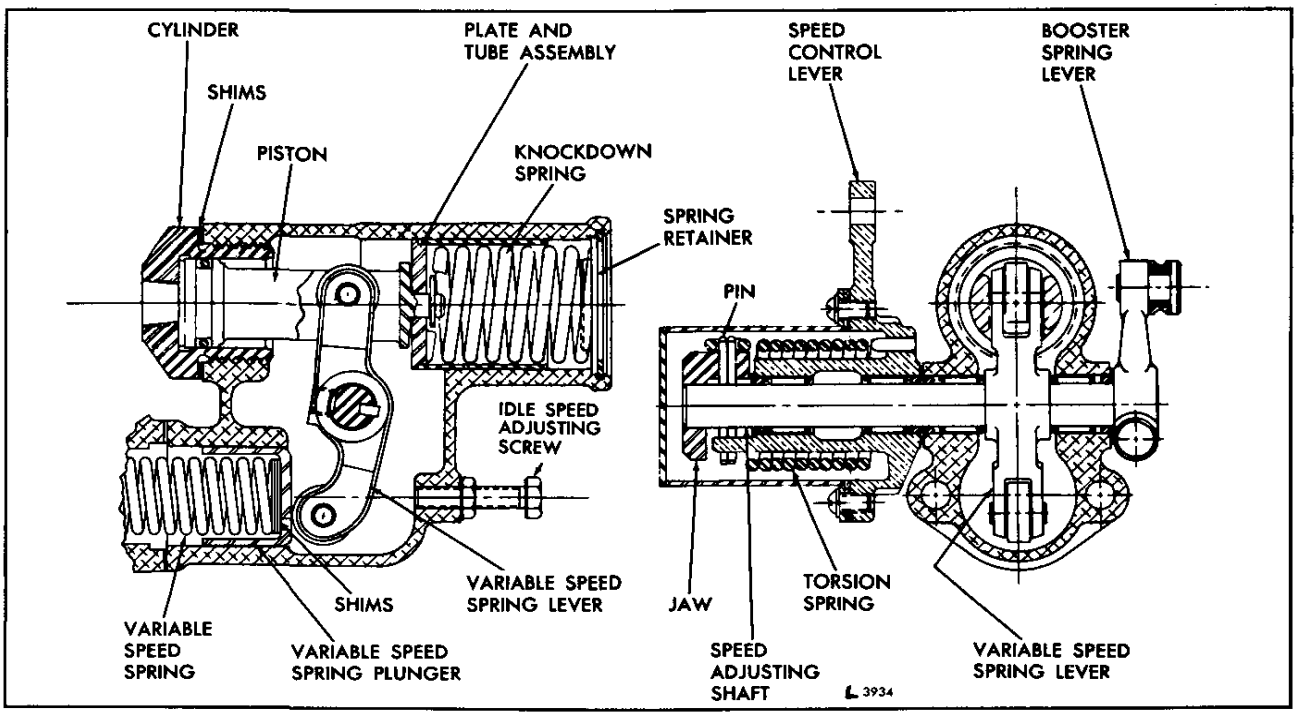


Fig. 1 - Cross Section of Variable Speed Governor with Throttle Knockdown

© 1983 General Motors Corp.

When the operator shifts the transmission, a valve operated by the shift lever opens, dumping the oil pressure behind the piston, permitting the spring to move the piston to the end of its cylinder and the speed adjusting lever to the knockdown speed position. At the completion of the shift the oil pressure is again applied automatically to the piston and the engine again operates at its maximum speed setting.

THROTTLE KNOCKDOWN ADJUSTMENT

Adjust engines with a variable speed mechanical governor and hydraulic knockdown assembly after adjusting the exhaust valves and timing the fuel injectors as follows.

Adjust Governor Gap

With the engine stopped, the governor gap may be adjusted as follows:

1. Remove governor cover.

2. Disconnect and plug the pressure line to the governor knockdown assembly.

> **NOTE:** Shift the transmission into neutral before removing the pressure line to the governor.

3. Install the special tool into the knockdown assembly and force the piston to the end of its travel (Fig. 2).

4. Place the speed control lever in the *full-speed* position.

> **NOTE:** To check if the variable speed spring is fully compressed, place a wrench on the upper end of the variable speed spring lever and force it toward the rear of the engine. If movement exists, increase the tension on the booster spring until movement ceases.

5. Insert a .006" feeler gage between the spring plunger and the plunger guide (Fig. 2). If required, loosen the locknut and turn the gap adjusting screw in or out until a slight drag is noted on the feeler gage.

6. Hold the adjusting screw and tighten the locknut. Recheck the gap and readjust, if necessary.

7. Install the governor cover.

Position Injector Control Racks

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Adjust No. 1 injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

The injector control racks may be adjusted after installing the special tool, outlined in Step 3 of "Adjust Governor Gap", as follows:

1. Disconnect any linkage attached to the governor control lever.

2. Loosen the locknut and back out the buffer screw approximately 5/8".

3. Loosen all the inner and outer injector rack control lever adjusting screws or adjusting screws and locknuts (Fig. 3). Be sure all the injector rack control levers are free on the injector control tube.

4. Move speed control lever to the FULL speed position and retain.

5. Move governor control lever to the *run* position and proceed as follows:

Two Screw Assembly -- Turn the inner adjusting screw of the No. 1 injector rack control lever down until a slight movement of the control tube is observed or a step-up in effort is noted. This will place the No. 1 injector rack in the full-fuel position. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws.

One Screw and Locknut Assembly -- Tighten the adjusting screw of the No. 1 injector rack control lever until the rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut. This will place the No. 1 injector rack in the full-fuel position.

Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

6. To be sure the control lever is properly adjusted, hold

© 1983 General Motors Corp.

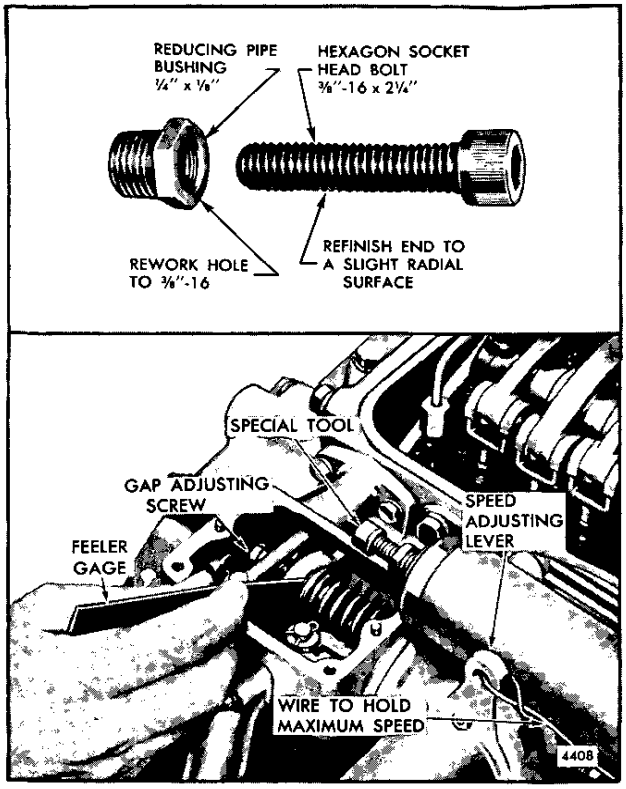


Fig. 2 - Adjusting Governor Gap Using Special Tool

the speed control lever in the maximum speed position and press down on the injector rack with a screwdriver or finger tip and note a "rotating" movement of the injector control rack when the speed control lever is in the maximum speed position (Fig. 4). Hold the speed control lever in the maximum speed position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward and when the pressure of the screwdriver is released, the control rack should "spring" back upward (Fig. 5).

7. If no movement is observed with the *Two Screw Assembly*, back off the inner adjusting screw approximately 1/8 of a turn and tighten the outer adjusting screw. To correct this condition with the *One Screw and Locknut Assembly*, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

If the movement exceeds that specified with the *Two Screw Assembly*, back off the outer adjusting screw approximately 1/8 of a turn and tighten the inner adjusting screw. To correct this condition with the *One Screw and Locknut Assembly*, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

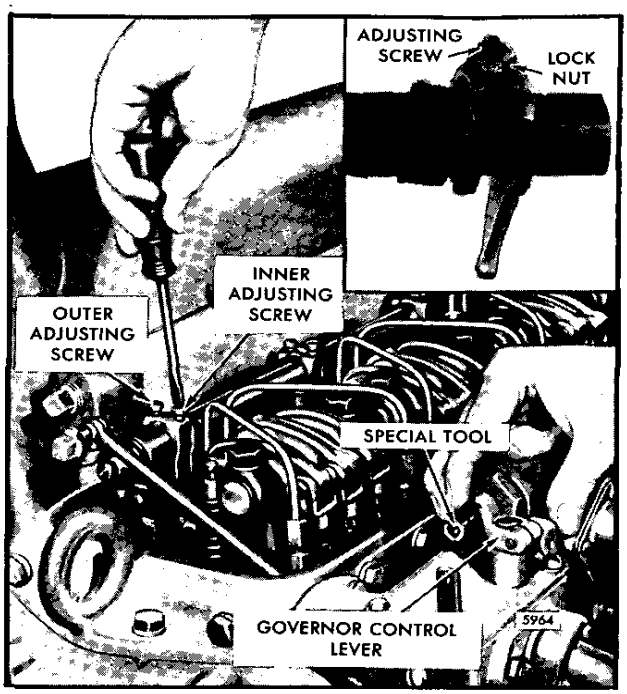


Fig. 3 - Positioning No. 1 Injector Control Rack

When the setting is correct, the injector rack will be snug on the pin of the rack control lever and still maintain the movement specified in Step 6.

Performing Steps 4, 5 and 6 will result in placing the governor linkage and control tube assembly in their same positions that they will obtain while the engine is running at full load. These positions are:

a. Speed control lever is at the maximum speed position.

b. Stop lever in the *run* position.

c. High-speed spring plunger on the seat in the governor control housing.

d. Injector fuel control racks are in the full-fuel position.

8. Remove clevis pin between the fuel rod and the injector control tube lever.

9. Manually hold No. 1 injector control rack in the *full-fuel* position and proceed as follows:

Two Screw Assembly:

a. Turn down inner adjusting screw of No. 2 injector until the injector rack of No. 2 injector has moved

© 1983 General Motors Corp.

into the *full-fuel* position and the inner adjusting screw is bottomed on the injector control tube. Turn outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws until tight.

NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Recheck the No. 1 injector rack to be sure that it has remained snug on the pin of the rack control lever while positioning No. 2 injector rack. If the rack of No. 1 injector has become loose, back off slightly the inner adjusting screw on No. 2 injector rack control lever and tighten outer adjusting screw.

One Screw and Locknut Assembly:

a. Tighten the adjusting screw of the No. 2 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

NOTE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Verify the injector rack adjustment of No. 1 as outlined in Step 6. If No. 1 does not "spring" back upward, turn the No. 2 adjusting screw counterclockwise slightly until the No. 1 injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 1 and No. 2 injectors. Turn clockwise or counterclockwise the No. 2 injector rack adjusting screw until both No. 1 and No. 2 injector racks are in the full-fuel position when the locknut is securely tightened.

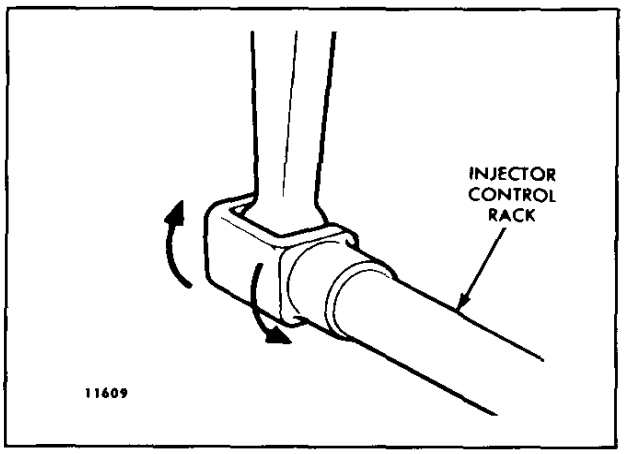


Fig. 4 - Checking Rotating Movement of Injector Control Rack

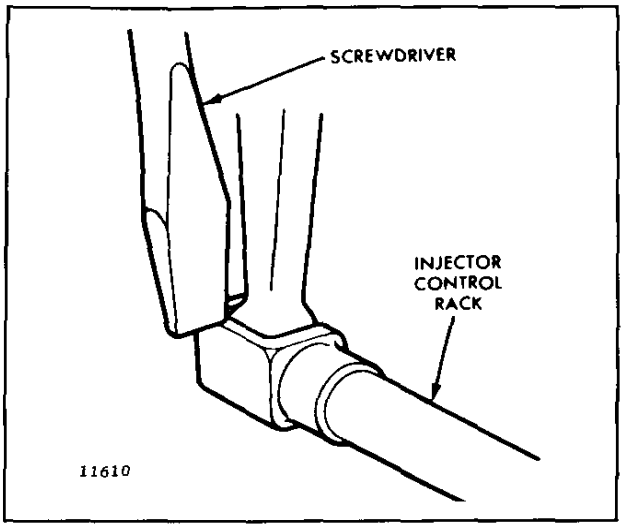


Fig. 5 - Checking Injector Control Rack "Spring"

While holding the injector control tube in the *full fuel* position, press straight down on the rack with a screwdriver. The rack should return to its original position.

10. Position the remaining injector control rack levers as outlined in Step 9.

When the settings are correct, the rack of all injectors must be snug on the pin of the control rack levers and still maintain that movement of the control tube lever specified in Step 6.

11. Insert the clevis pin between the fuel rod and the injector control tube lever.

12. Proceed with "Adjust Maximum No-Load Speed" or reconnect pressure line to governor.

Adjust Maximum No-Load Speed

The maximum no-load speed on units equipped with a variable speed governor must not be less than 125 rpm or more than 150 rpm above the full-load speed desired. The maximum no-load speed may be set as follows:

1. Remove and plug the pressure line to governor

© 1983 General Motors Corp.

assembly and then install the special tool as outlined in Step 3 of "Adjust Governor Gap".

NOTE: A check of the maximum no-load speed can be made in the vehicle without disconnecting the oil pressure line. The oil pressure will retain the piston in the maximum speed position when the engine is operating.

2. Start the engine and manually move the booster spring lever to the end of its travel, to the maximum speed position, and note the engine speed.

3. If the maximum no-load speed requires adjustment, remove the two bolts and withdraw the variable speed spring housing and variable speed spring plunger inside the spring housing.

4. Add shims between the governor spring and spring plunger to obtain the necessary maximum no-load speed. For each .001″ shim added, the operating speed will increase approximately 1 rpm.

Governor shims are available in .010″ and approximately .078″.

5. Reassemble the governor spring housing and spring plunger assembly to the governor.

6. Start the engine and recheck the engine maximum no-load speed as outlined in Steps 1 and 2. Readjust, if necessary.

7. Stop the engine and remove the special tool from the hydraulic throttle knockdown.

Adjust Knockdown Speed

After adjusting the maximum *no-load* engine speed, the knockdown speed may be adjusted as follows:

1. Remove and plug the pressure line to the governor assembly.

2. Start the engine and place the engine speed control lever in the maximum speed position.

3. Note the engine knockdown speed, and if adjustment is necessary, continue with Step 4.

4. Adjust the engine knockdown speed as follows:

a. Remove the cylinder from the piston.

b. Reduce the number of shims between the cylinder and the housing to increase the knockdown speed or increase the number of shims to reduce the knockdown speed.

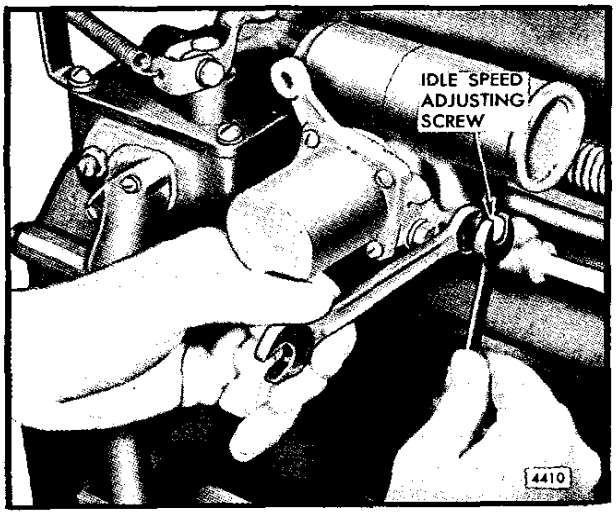


Fig. 6 - Adjusting Idle Speed

c. Reassemble the cylinder over the piston and into the spring housing and secure.

5. Start the engine and recheck the knockdown speed as outlined in Steps 1 and 2. Repeat adjustment, if necessary, until the desired knockdown speed is established.

6. Remove the plug from the governor pressure line and attach the line to the governor assembly.

Adjust Idle Speed

With the maximum no-load and knockdown speed properly adjusted, the idle speed may be adjusted as follows (Fig. 6):

1. Place the governor control lever in the *run* position and the speed control lever in *idle* position.

2. With the engine operating, loosen the idle speed adjusting screw locknut. Turn the idle adjusting screw until the engine idles at the recommended idle speed.

The recommended idle speed is 500 rpm, but may vary with special engine applications.

3. Hold the idle screw and tighten the locknut.

Adjust Buffer Screw

With the idle speed properly adjusted, the buffer screw may be adjusted as follows (Fig. 7)

1. With the engine at idle speed, screw in the buffer screw so that it contacts the differential lever as lightly as possible and still eliminates the engine roll.

© 1983 General Motors Corp.

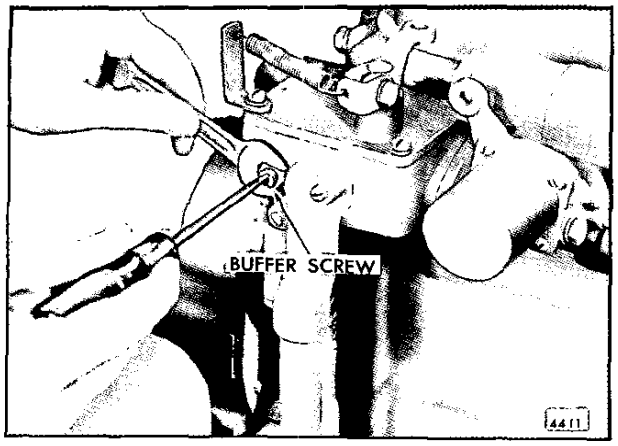


Fig. 7 - Adjusting Buffer Screw

NOTE: Do not raise the engine idle speed more than 15 rpm with the buffer screw.

2. Hold the buffer screw and tighten the locknut.

Adjust Booster Spring

With the idle spring properly set, the booster spring is adjusted as follows (Fig. 8)

1. If moved, position the booster spring lever on the speed control shaft in a horizontal position pointing toward the front of the engine.

2. Connect the booster spring, with the tension released, to the booster spring lever.

3. Start the engine and apply 125 psi (861 kPa) pressure to the governor knockdown assembly, then move the speed control lever to the full-speed position and release. The speed control lever should return to the idle position. If it does, continue to increase the spring tension until the point is reached that it will not return to idle position. Then, reduce the tension until it does return to idle position and tighten the locknut on eyebolt. This setting will result in the minimum force required to operate the speed control lever.

If difficulty is encountered in setting the booster spring tension, change the position of the booster spring lever slightly on the speed control shaft.

NOTE: If the speed returns from the maximum speed position satisfactorily but does not return from an intermediate speed position, moving the booster spring lever on the speed control shaft downward slightly may correct this condition.

When the spring tension and the position of the booster spring lever are adjusted properly, the force required to move the speed control lever to the maximum speed position should be between 4 and 12 pounds, at the hole position of the speed control lever. The force required to move the speed control lever should be nearly constant. The correct setting should result in the speed control lever moving rapidly to the idle position when released at any position in its arc of travel.

4. Recheck to see if the maximum no-load speed can be attained by the movement of the speed control lever into the maximum speed position.

5. Release the pressure to the throttle knockdown assembly and stop the engine.

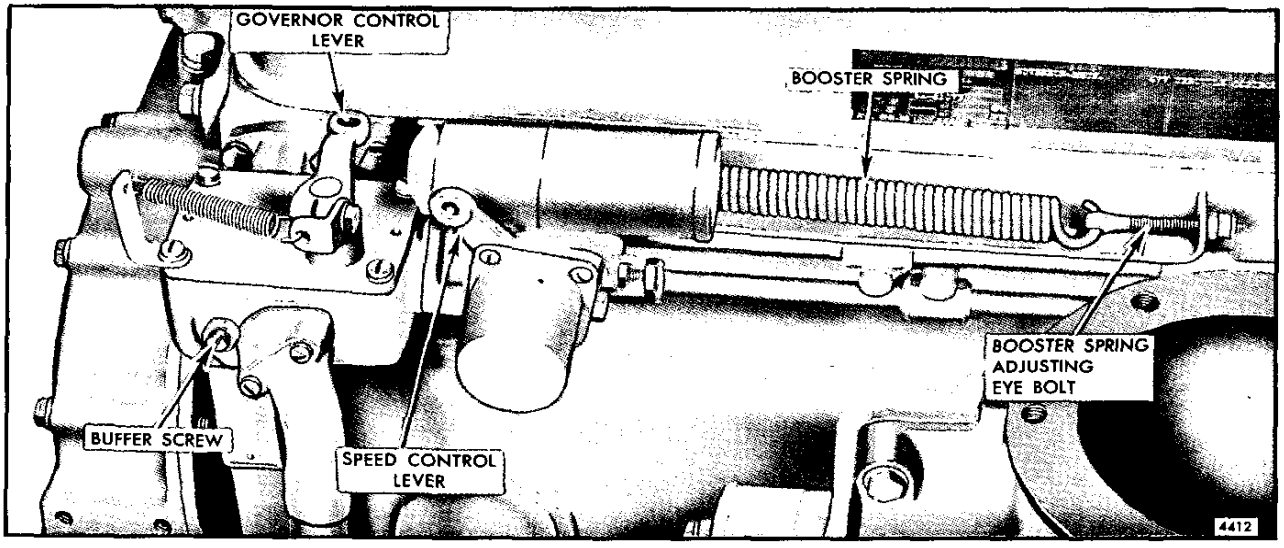


Fig. 8 - Governor Assembly Mounted on Engine

© 1983 General Motors Corp.

FUEL MODULATING GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

Governor adjustments should not be performed until the following engine tune-up procedures have been accomplished.

1. Start the engine and operate it at part throttle until engine is warmed up and the water temperature is at least 160° F (71° C).

2. Adjust the exhaust valve clearance.

3. Time the injectors - using a timing gage and adjust the follower height as described under *Time Fuel Injectors* in this manual.

Adjustment Sequence

The following seven (7) basic steps in setting a fuel modulating type governor must be performed in the order listed. Any deviation from this order may result in an improperly adjusted governor.

1. Set the fuel modulating spring tension.

2. Set the low-speed spring gap.

3. Check the fuel modulating gap closing space.

4. Set the fuel modulating cam.

NOTE: If the type of fuel modulating spring is not known (70, 95, 150, 175 or 225 lbs. per inch), consult the Chart on Fuel Modulating Governors, RPM and Springs in Section 2.7.1.

The type of spring is identified by color code (and must be known) before proceeding with preliminary adjustment "3" below.

5. Set the injector racks.

6. Set the no-load high speed.

7. Set the idle speed.

Only Settings 1, 3 and 4 are new and peculiar to the fuel modulating governor. Steps 2, 5, 6 and 7 are the same or similar to those of the limiting speed governors, however, the following adjustment procedures should be thoroughly studied and carefully followed.

No. 1 - Fuel Modulating Spring Tension Setting

Preliminary Adjustment

1. Remove the governor adjustment cover, control housing cover, housing plug and copper gasket (Fig. 1). Disconnect the governor external control linkage and remove the cylinder head cover.

2. Loosen the idle speed screw locknut and back out the idle screw until the low speed spring exerts no pressure on the low speed spring cap. This may be determined by moving the low speed cap in and out. Use care not to back the screw out too far as it is possible to turn it completely out of the low speed spring seat.

9. Housing Plug
31. Operating Lever
32. Torsion Spring Screw
35. Differential Lever
36. Torsion Spring
37. High Speed Lock Nut
38. High Speed Adjusting Screw
39. High Speed Spring Plunger
40. Modulating Screw Lock Nut
41. Modulating Speed Adjusting Screw
42. Idle Speed Screw Lock Nut
43. Idle Speed Adjusting Screw
44. Adjustment Cover
45. Buffer Screw Lock Nut
46. Buffer Screw
47. Modulating Cam
48. Cam Adjusting Screw
49. Screw Lock Nut
50. Cam Lock Screw
51. Plugging Screw
52. Retaining Spring Pin
53. Washer
54. Modulating Spring Seat
55. Modulating Spring
56. High Speed Spring
57. Modulating Spring Plunger
58. Low Speed Spring Seat
59. Low Speed Spring
60. Retainer Ring
61. Low Speed Spring Cap
62. Lock Nut
63. Low Speed Gap Adjusting Screw

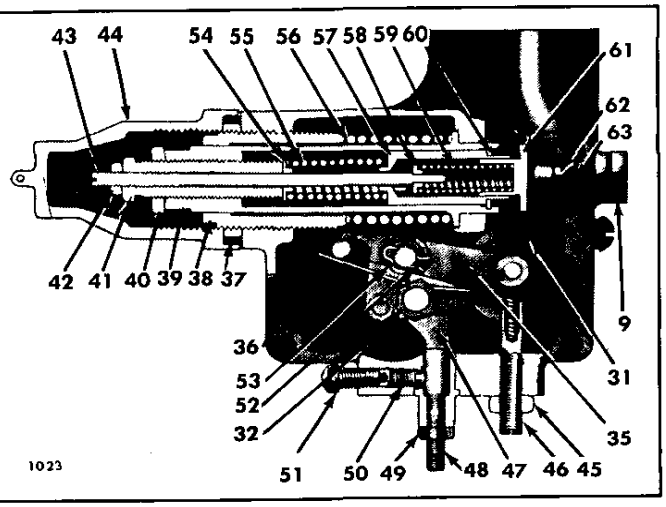


Fig. 1 - Fuel Modulating Governor Spring

© 1983 General Motors Corp.

3. Loosen the high-speed locknut and turn the high-speed adjusting screw into the body until the flats on the end of the high-speed spring plunger are fully exposed.

4. Loosen the modulating screw locknut and turn the screw out by hand until the modulating plunger may be moved back toward the high speed plunger 1/16" before touching the spring.

Adjustment of No. 1

Turn the screw in by hand until resistance indicates the spring has forced the plunger forward to contact the retainer ring. Repeat as necessary until sure that plunger is just contacting the ring with no tension on the spring, then turn the modulating adjusting screw in 1/3 of a turn (two flats). Lock the adjusting screw in position with the locknut.

NOTE: The high speed plunger and the fuel modulating spring adjusting screw should both be held securely in position with two wrenches when tightening the fuel modulating adjusting screw locknut to prevent screw and plunger relationship from being disturbed.

No. 2 - Low Speed Spring Gap Setting

Preliminary Adjustment

1. Reset the idle adjusting screw to 2" projection ("A" in Fig. 2) and replace the control housing cover. Secure it with the two screws.

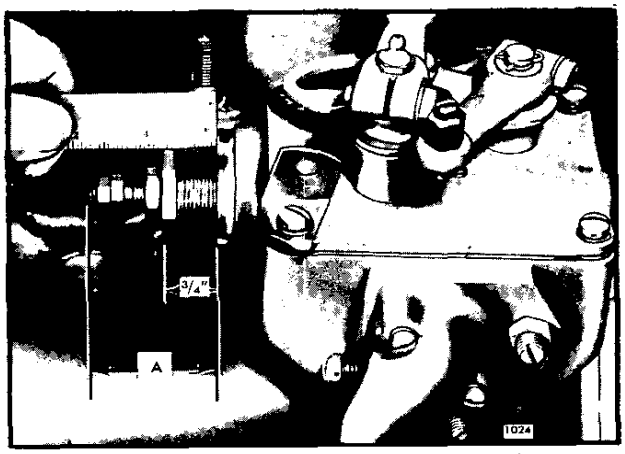


Fig. 2 - Preliminary Adjustment of Low and High Speed Springs

NOTE: Be sure that the throttle shaft pin is positioned between the torsion spring and end of the differential lever.

2. Start the engine and make a preliminary idle speed setting by setting the speed at 385 rpm with the low-speed screw and advancing the speed to 400 rpm by turning in the buffer screw. Tighten the low-speed locknut.

3. Stop the engine.

4. Remove the governor control housing cover and lever assembly. Remove the cover gasket. Disconnect the link rod between the differential lever and injector control tube lever, then remove the link through the governor.

5. Thread the buffer screw outward 4 or 5 turns.

6. Loosen the cam adjusting screw locknut. Remove the plugging screw, and use an Allen wrench to loosen the cam lock screw approximately 1/8 turn to permit the cam to be moved in and out without allowing it to turn in housing.

7. Thread the cam adjusting screw into the housing until the screw extends 3/8" beyond the locknut when the nut is against the sleeve (Fig. 3). Tighten the cam lock screw with the Allen wrench to hold the cam in position until adjusted later.

8. Start the engine and operate it between 600 and 700 rpm checking with the tachometer.

NOTE: Governor to control tube link is removed and engine speed must be controlled by hand or temporary adjustable link and spring at control lever tube (Fig. 4).

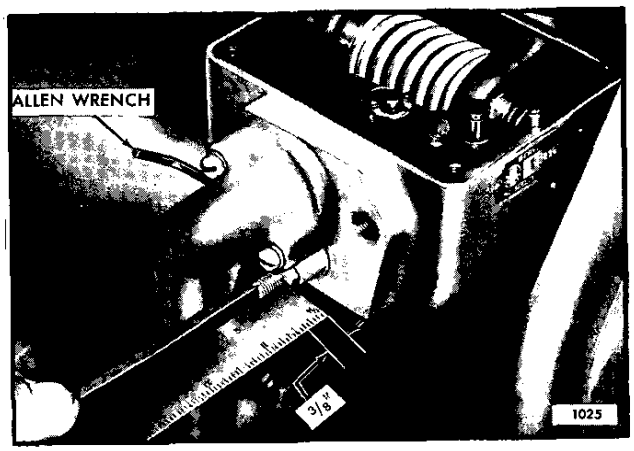


Fig. 3 - Preliminary Adjustment of Modulating Cam

© 1983 General Motors Corp.

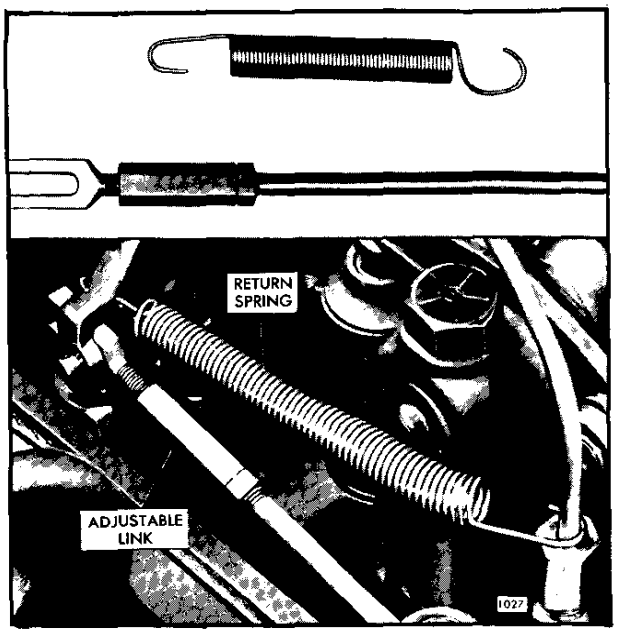


Fig. 4 - Injector Rack with Adjustable Link and Spring Installed

Adjustment of No. 2

Check the gap between the low-speed spring cap and modulating spring plunger with a .0015″ feeler gage (Fig. 5).

If the gap is not within .001″-.002″ at 600-700 rpm loosen the locknut and turn the low-speed gap adjusting screw, as necessary, to obtain the proper gap. Tighten the locknut and recheck the gap.

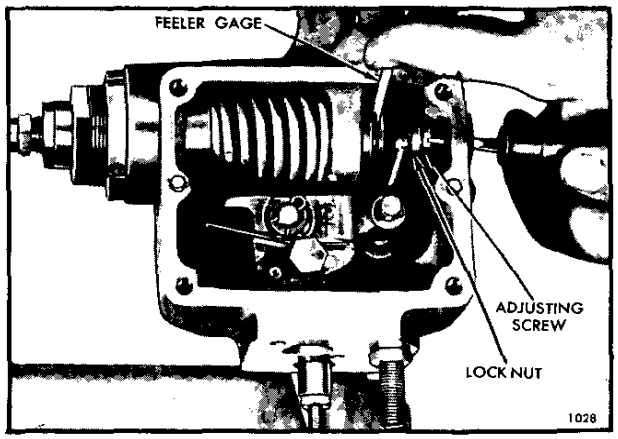


Fig. 5 - Low Speed Spring Gap Adjustment

No. 3 - Checking Fuel Modulating Gap Closing

Preliminary Adjustment

1. If an adjustable link has been used, it should be removed (Fig. 4).

2. Install the control link between the differential lever and injector control tube lever. The link is secured at the governor end with a flat washer and retaining spring pin. A straight pin and cotter pins are used at control tube. The link must be free with no binding.

3. Start the engine and control the speed manually by exerting force against the torsion spring with a finger.

NOTE: Care must be exercised to avoid overspeeding engine.

Adjustment of No. 3

Advance the engine speed gradually until the low speed spring cap contacts the high speed plunger. Do not exceed 2100 rpm. The gap closing speed should be checked with a .0015″ feeler gage between the mating surface of the low-speed spring cap and the high-speed plunger and will vary according to the Table:

F.M. Spring	Closing Speed Range
225#/inch-WHITE	1950-2040
175#/inch-GREEN	1850-1940
150#/inch-BROWN	1750-1840
70#/inch-YELLOW . . .	1525-1625

Fuel Modulator Spring Chart

If the closing speed does not fall within the correct range, then recheck the setting of No. 1 - or the setting of No. 2 (Step 2) - or check for the correct fuel modulating spring.

If, after rechecking the adjustments as indicated above, the closing speed still does not fall within the specified range, the modulating spring should be replaced.

No. 4 - Fuel Modulating Cam Setting

Preliminary Adjustment

1. Stop the engine.

2. Set the high-speed adjusting screw to extend 3/4″ beyond the high-speed screw locknut when the nut is tight against the housing (Fig. 2).

3. Temporarily install the cap screw (1/2″-13 x 2″)

© 1983 General Motors Corp.

into the front of the control housing and thread the screw inward until the gap between the low-speed cap and high-speed spring plunger just closes. Be careful that the high-speed spring plunger is not moved (Fig. 6).

4. Loosen the inner and outer injector rack control lever adjusting screws or adjusting screws and locknuts at each control rack lever until each lever is free on the control tube.

5. Install the cover to the governor control housing gasket. Install the control housing cover assembly being sure that the throttle shaft pin is between the differential lever and torsion spring. Secure the cover with the four screws and lock washers.

Adjustment of No. 4

Use an Allen wrench and loosen the cam lock screw only enough (1/8 turn) to permit turning the cam adjusting screw with the fingers. If the lock screw is backed out further, the cam may be released and turned by its own weight out of the operating position.

With the control lever in the full throttle position thread the cam adjusting screw outward with the finger tips until the cam can be felt bottoming against the roller on the bottom of the differential lever (Fig. 7). Thread the cam adjusting screw outward an additional 1/8 turn to provide positive engagement between the differential lever roller and cam. After making contact, it may be necessary to turn the screw very slightly *IN* or *OUT* to produce the final 1/64" clearance which is required after the Allen screw has been tightened (Fig. 7). Tighten the locknut and install the plugging screw.

NOTE: The adjustment of the modulating cam is extremely important and must be carefully and accurately performed.

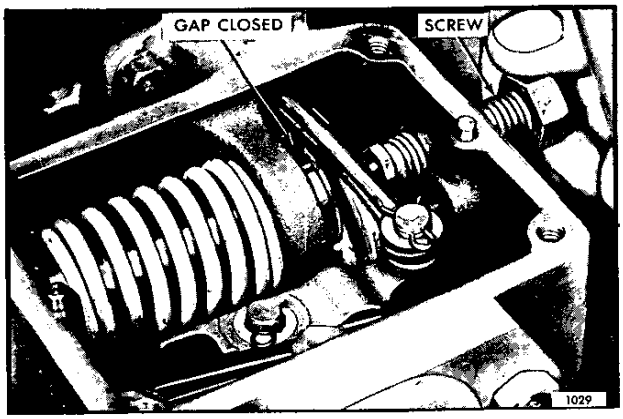


Fig. 6 - Closing Modulator Gap with Special Screw

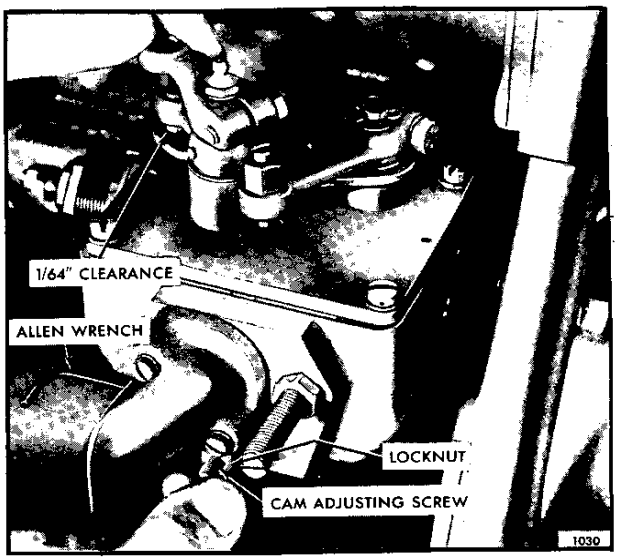


Fig. 7 - Modulating Cam Adjustment

No. 5 - Injector Rack Setting

Preliminary Adjustment

1. Loosen all the inner and outer injector rack control lever adjusting screws or adjusting screws and locknuts.

2. Manually hold the control lever in the full throttle position (Fig. 8).

Adjustment of No. 5

Two Screw Assembly -- Turn down the inner adjusting screw of the No. 1 injector rack control lever. Adjust the No. 1 injector rack control lever so that a very light finger tip pressure at the coupling will produce a tendency to roll, but the coupling should not be loose (Fig. 8). Turn down the outer adjusting screw until it bottoms on the control tube. After the outer adjusting



Fig. 8 - Adjusting No. 1 Rack to Governor

© 1983 General Motors Corp.

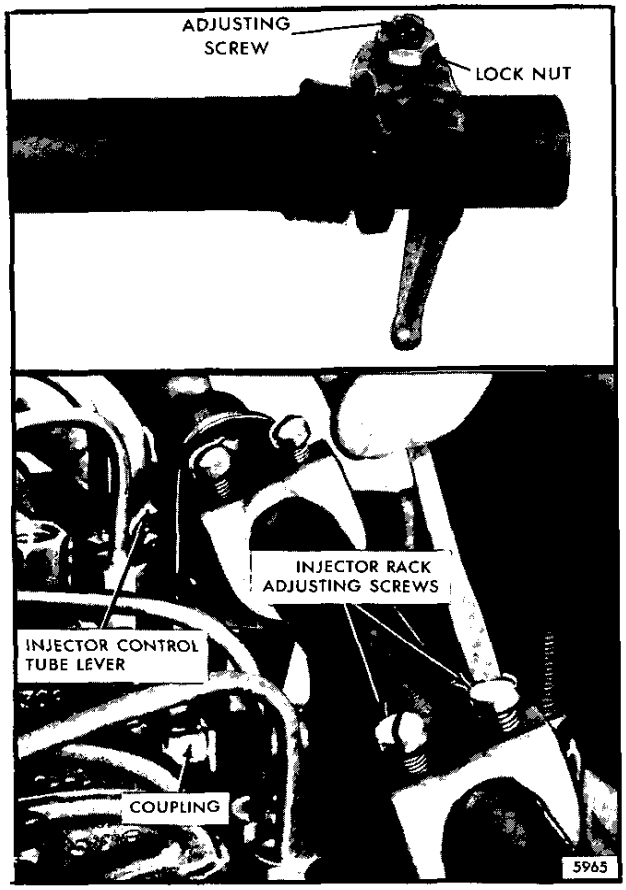


Fig. 9 - Adjusting No. 2 Rack to No. 1 Rack

screw has bottomed, tighten the inner and outer adjusting screws alternately until the injector control lever is held firmly in position.

One Screw and Locknut Assembly -- Tighten the adjusting screw of the No. 1 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut.

This will place the No. 1 injector rack in the full-fuel position.

NOTE: Do not set the No. 1 or any other rack too tight as this will produce clearance between the cam and differential roller and will result in delay and reduction of the fuel modulating action.

Holding the injector control tube lever for *feel* adjust the remaining control rack couplings (Fig. 9). Adjust the No. 2 rack control lever so that it has the same *feel*

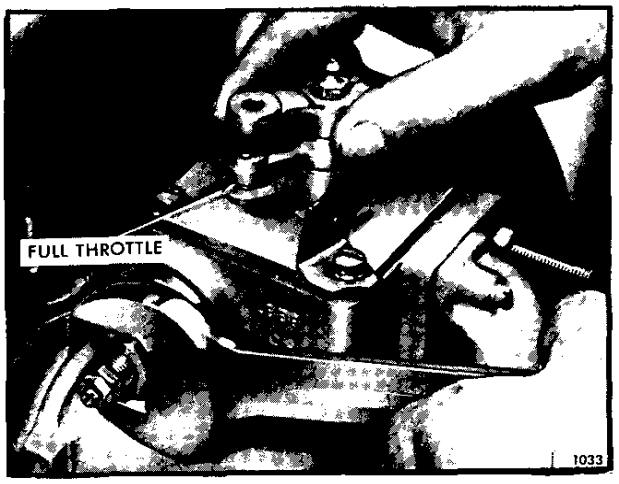


Fig. 10 - Adjusting High Speed

as the No. 1 coupling. Repeat this procedure on all the remaining racks. That is, compare the No. 3 rack with No. 1, etc., making certain no other injector is tighter than No. 1.

No. 6 - No-Load High Speed Setting

Preliminary Adjustment

1. Remove the temporarily installed cap screw, then install the control housing plug, with gasket.

2. Loosen the high-speed adjusting screw locknut, if tight.

3. Install the cylinder head cover.

Adjustment of No. 6

Start the engine and move the throttle lever toward the *full-fuel* position while observing the tachometer. Avoid overspeeding the engine more than 100 rpm above the desired speed.

Turn the high-speed adjusting screw until the desired no-load maximum speed is obtained with the throttle lever in a wide open position (Fig. 10). Lock the nut.

No. 7 - Idle Speed and Buffer Screw Setting

Adjustment of No. 7

With the engine running at idle speed, observe the engine rpm at the tachometer, then loosen the locknut and thread the idle adjusting screw *IN* to increase or

© 1983 General Motors Corp.

OUT to decrease until 385 engine rpm is obtained (Fig. 11). Tighten the locknut.

With the engine running at idle speed, thread the buffer screw in until the *surge* or *roll* of the engine just disappears, but not higher than 400 rpm. Any variation from this speed will affect fuel modulating action.

Do not raise the engine speed more than 20 rpm with the buffer screw, otherwise, it may not be possible to stop the engine. Hold the screw and tighten the locknut (Fig. 12). Stop and start the engine several times to be sure of its stopping.

Install Removed Parts

1. Install and tighten the governor adjustment cover.

2. Connect the throttle control rod to the throttle control lever at the governor cover.

3. Connect the linkage to the engine stop lever at the governor cover.

Adjust Fuel Shutoff Air Cylinder Linkage

After completing the adjustment of the engine governor, adjust the linkage between the air shutoff cylinder and the injector fuel control tube lever according to the following procedure (Fig. 13).

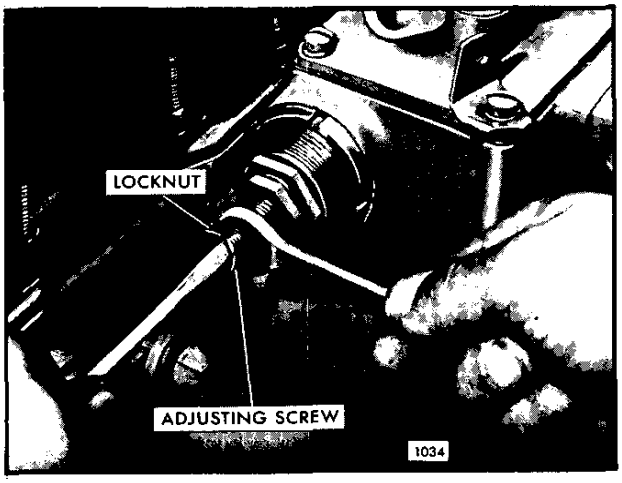


Fig. 11 - Adjusting Idle Speed

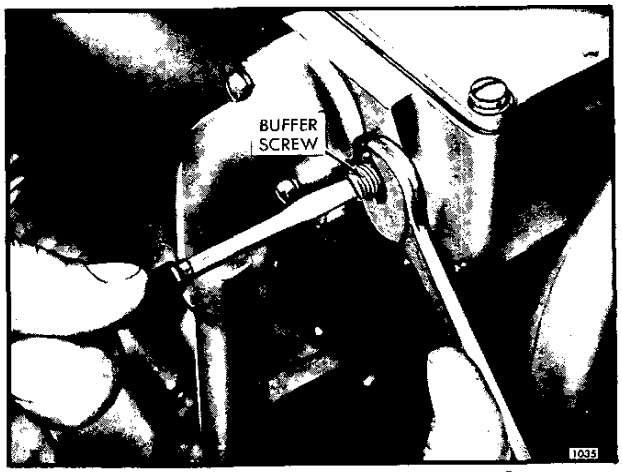


Fig. 12 - Adjusting Buffer Screw

1. Place the governor control lever into the full-speed position. The movement of the control lever to the full-speed position will move the injector racks to the *full-fuel* position.

2. Loosen the locknuts on the air cylinder fuel shutoff rod and lengthen the rod by turning the turnbuckle until the end of the slot contacts the pin in the end of the control tube shutoff lever. Then, shorten the rod one complete turn of the turnbuckle and tighten the locknuts.

Adjusting the rod in this manner will permit the engine's governor to move the injector fuel control rack onto the *full-fuel* position without coming to the end of the slot in the end of the air cylinder fuel shutoff rod.

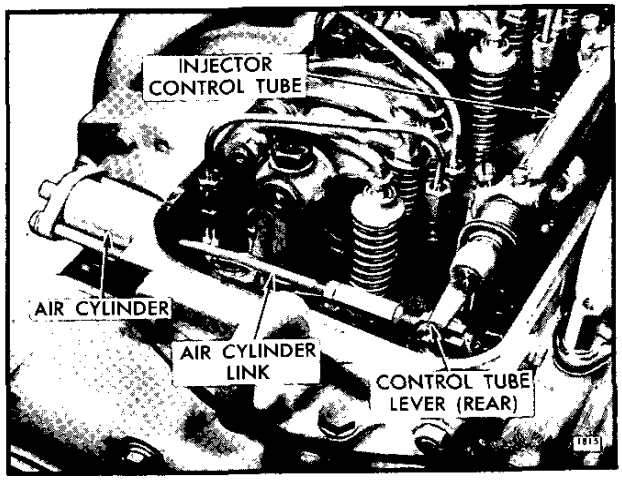


Fig. 13 - Air Cylinder Linkage

© 1983 General Motors Corp.

CONSTANT SPEED MECHANICAL GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

After adjusting the exhaust valves and timing the fuel injectors, adjust the governor and injector rack control levers.

Adjust Governor Gap

1. Stop the engine and disconnect any linkage attached to the speed control lever.

2. Remove the governor cover and lever assembly.

3. Remove the fuel rod from the differential lever and the injector control tube lever.

4. Check the governor gap by inserting a .006" feeler gage between the operating speed spring plunger and the governor boss (Fig. 1).

5. Loosen the locknut and adjust the gap adjusting screw until the gap is .006" (Fig. 1).

6. Hold the gap adjusting screw to prevent changing the setting, and tighten the locknut.

7. Recheck the gap and readjust it, if necessary.

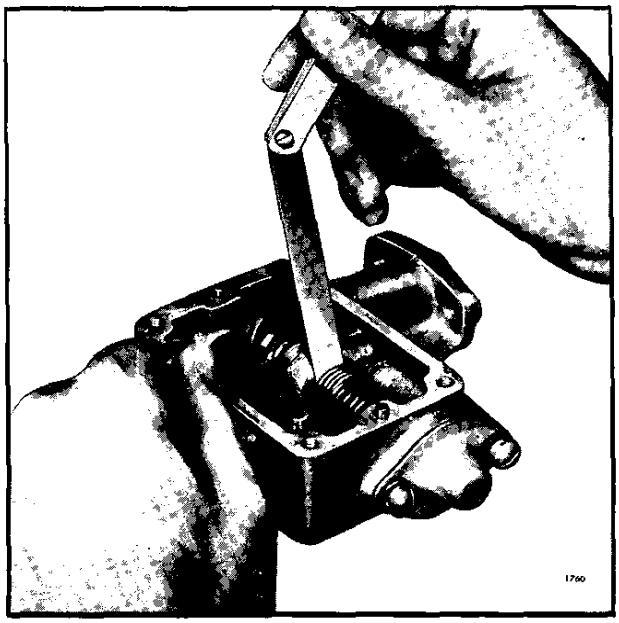


Fig. 1 - Adjusting Governor Cap

8. Install the governor cover.

   a. Secure the cover to the governor housing with three regular screws, one special screw and lock washers.

   b. Hook the torsion retracting spring to the special cover screw and the control lever. On former engines the governor cover is secured with four regular cover screws and lock washers. The former retracting spring is hooked between the control lever and the retracting spring clip mounted on the end of the spring housing.

Position Injector Control Racks

The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and ensures equal distribution of the load.

Adjust No. 1 injector rack control lever first to establish a guide for adjusting the remaining injector rack control levers.

1. Refer to Fig. 2 and disconnect any linkage attached to the control lever.

2. Loosen all the inner and outer injector control rack lever adjusting screws or adjusting screws and locknuts (Fig. 2). Be sure all the control levers are free on the injector control tube.

3. Move the control lever to the *maximum speed* position (Fig. 2).

Two Screw Assembly -- Turn the inner adjusting screw down until a step up in effort is noted. Turn down the outer adjusting screw until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws until they are tight.

One Screw and Locknut Assembly -- Tighten the adjusting screw of the No. 1 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut.

This will place the No. 1 injector rack in the full-fuel position.

© 1983 General Motors Corp.

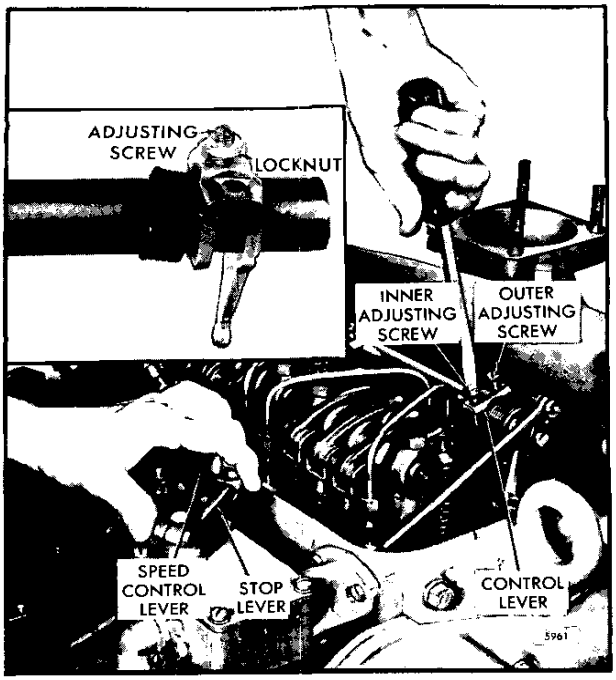


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

NOTE: Overtightening of the injector rack control lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

4. To be sure the control lever is properly adjusted, hold the speed control lever in the *maximum speed* position and press down on the injector rack with a screwdriver or finger tip and note "rotating" movement of the injector control rack when the speed control lever is in the *maximum speed* position (Fig. 3). Hold the speed control lever in *maximum speed* position and, using a screwdriver, press downward on the injector control rack. The rack should tilt downward (Fig. 4) and when the pressure of the screwdriver is released, the control rack should "spring" back upward.

5. If no movement is observed, back off the inner adjusting screw (Two Screw Assembly) approximately 1/8 of a turn and tighten the outer adjusting screw. Loosen the locknut (One Screw and Locknut Assembly) and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

If the movement exceeds that specified, back off the outer adjusting screw (Two Screw Assembly) approximately 1/8 of a turn and tighten the inner adjusting screw. Loosen the locknut (One Screw and Locknut Assembly) and turn the adjusting screw clockwise a slight amount and retighten the locknut.

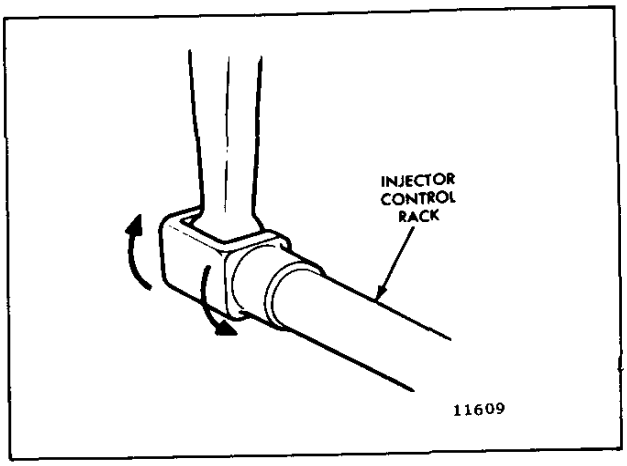


Fig. 3 - Checking Rotating Movement of Injector Control Rack

When the setting is correct, the injector rack will be snug on the pin of the rack control lever and still maintain the movement specified in Step 5.

NOTE: Performing Steps 3, 4 and 5 will result in placing the governor linkage and control tube assembly in the same positions that they will attain while the engine is running at full load. These positions are:

a. The governor speed control lever is at the *maximum speed* position.

b. The governor gap is closed.

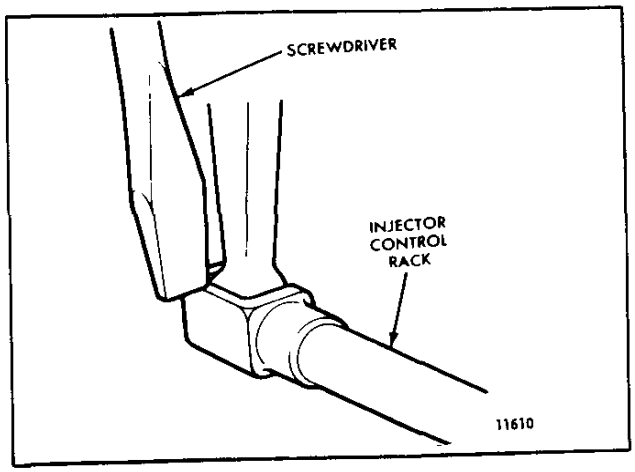


Fig. 4 - Checking Injector Control Rack "Spring"

© 1983 General Motors Corp.

c. The governor spring plunger is on its seat in the governor control housing.

d. The injector fuel control racks are in the *maximum speed* position.

6. Remove the clevis pin between the fuel rod and the injector control tube lever.

7. Manually hold the No. 1 injector in the *maximum speed* position.

Two Screw Assembly -- Turn down the inner adjusting screw of the No. 2 injector until the injector rack of the No. 2 injector has moved into the *maximum speed* position and the inner adjusting screw is bottomed on the injector control tube. Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws until they are tight.

One Screw and Locknut Assembly -- Tighten the adjusting screw of the No. 2 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

> **NOTE:** Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage of the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

8. Recheck the No. 1 injector fuel rack to be sure that it has remained snug on the pin of the rack control lever while adjusting No. 2 injector. If the rack of the No. 1 injector has become loose (Two Screw Assembly), back off slightly on the inner adjusting screw on the No. 2 injector rack control lever. Tighten the outer adjusting screw. Loosen the locknut (One Screw and Locknut Assembly) and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

When the settings are correct, the racks of both injectors must be snug on the pin of their respective rack control levers.

9. Position the remaining control rack levers as outlined in Steps 7 and 8.

10. Insert the clevis pin between the fuel rod and the injector control tube lever.

Adjust Maximum No-Load Speed

All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the unit name plate, the maximum no-load speed may be set as follows:

1. Start and warm up the engine.

2. With engine disconnected from the load, start the engine and observe the engine speed. Be sure the speed control lever is in the *run* position.

> **NOTE:** There must be no load on the engine during the maximum no-load speed adjustment.

3. Observe the engine speed and set it, if necessary, to the recommended speed with shims placed between the operating speed spring and spring plunger.

Since the engine performance and efficiency will be governed, to a large extent, by the accuracy with which the tune-up adjustments are made, the serviceman should always perform these operations carefully.

© 1983 General Motors Corp.

HYDRAULIC SG GOVERNOR AND INJECTOR RACK CONTROL

ADJUSTMENT

After adjusting the exhaust valves and timing the fuel injectors, adjust the hydraulic governor and injector rack control levers.

Adjust Fuel Rod

To be sure of a full travel between no-fuel and full-fuel adjust the fuel rod as follows:

1. Remove the governor cover and the valve rocker cover. Loosen all the inner and outer injector rack control lever adjusting screws or adjusting screws and locknuts (Fig. 2). Make sure all control levers are free on the injector control tube.

2. Loosen the fuel rod locknut and remove the fuel rod knob (Fig. 1).

3. Turn the locknut until 3/16" of the fuel rod extends beyond the nut. Then, reinstall the fuel rod knob and tighten the locknut.

Position Injector Rack Control Levers

After the fuel rod is properly adjusted, adjust the injector rack control levers in the no-fuel position as follows:

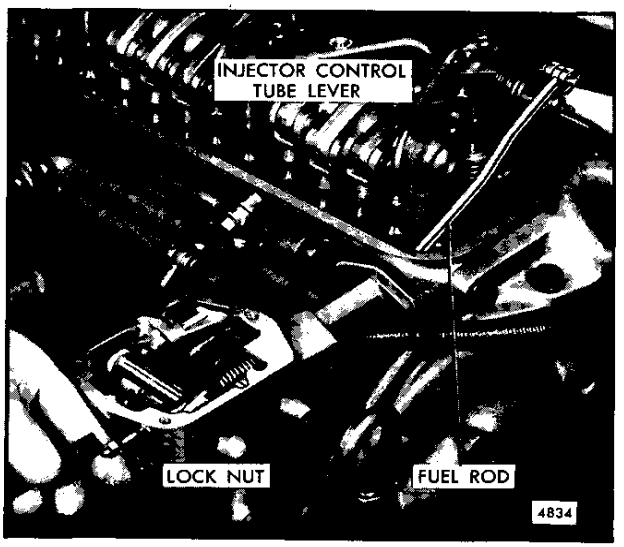


Fig. 1 - Adjusting Fuel Rod

1. Two Screw Assembly -- Turn the outer adjusting screw in until a slight movement of the injector control tube lever is observed (Fig. 2). Tighten the inner adjusting screw.

One Screw and Locknut Assembly -- Turn the adjusting screw in until a slight movement of the injector control tube lever is observed (Fig. 2). Then, turn the adjusting screw 1/8 of a turn more and lock securely with the adjusting screw locknut.

2. Pull the fuel rod out and check for 1/32" to 1/16" movement.

If the movement exceeds the distance specified with the *Two Screw Assembly*, back off the inner adjusting screw approximately 1/8 of a turn and tighten the outer adjusting screw. To correct this condition with the *One Screw and Locknut Assembly* loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

If the movement is less than the specified distance with the *Two Screw Assembly*, back off the outer adjusting screw approximately 1/8 of a turn and tighten the inner adjusting screw. To correct this condition with the *One Screw and Locknut Assembly* loosen the locknut and

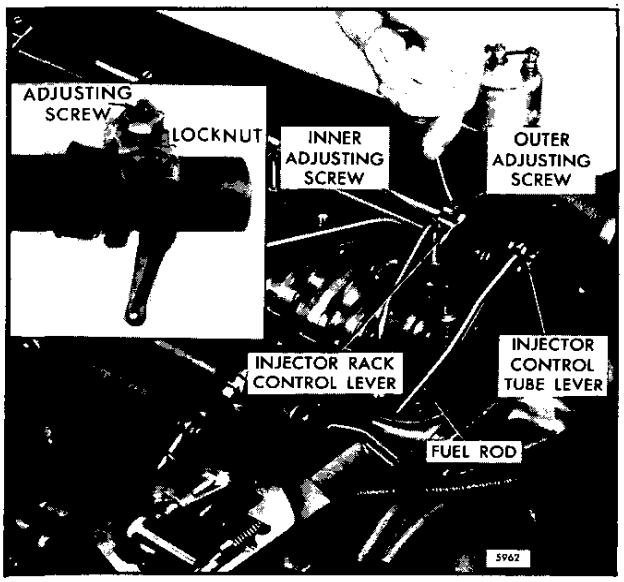


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

© 1983 General Motors Corp.

turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

3. Disconnect the fuel rod from the injector rack control tube lever.

4. Manually hold the No. 1 injector rack control lever in the full-fuel position and proceed as follows:

Two Screw Assembly:

a. Turn the inner adjusting screw into the No. 2 injector rack control lever until the injector rack has moved into the full-fuel position and the inner adjusting screw is bottomed on the injector control tube (Fig. 2). Turn the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws until they are tight.

NOTE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Recheck the No. 1 injector fuel rack to make sure that it has remained snug on the ball end of the injector rack control lever while adjusting the No. 2 injector rack. If the rack of the No. 1 injector has become loose, back off slightly on the inner adjusting screw on the No. 2 injector rack control lever. Tighten the outer adjusting screw.

One Screw and Locknut Assembly:

a. Tighten the adjusting screw of the No. 2 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

NOTE: Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

b. Verify the injector rack adjustment of No. 1 as outlined in Step 6. If No. 1 does not "spring" back upward, turn the No. 2 adjusting screw counterclockwise slightly until the No. 1 injector rack returns to its full-fuel position and secure the adjusting screw locknut. Verify proper injector rack adjustment for both No. 1 and No. 2 injectors. Turn clockwise or counterclockwise the No. 2 injector rack adjusting screw until both No. 1 and No. 2 injector racks are in the full-fuel position when the locknut is securely tightened.

When the settings are correct, the rack of both injectors must be snug on the pin of their respective rack control levers.

5. Position the remaining rack control levers as outlined in Step 4.

When the settings are correct, the racks of all injectors must be snug on the pins of the rack control levers when the control tube lever is held in the *full-fuel* position.

6. Reconnect the fuel rod to the injector rack control tube lever.

Adjust Load Limit

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be readjusted.

With the injector rack control levers properly adjusted, the load limit may be set as follows:

1. Loosen the load limit adjusting screw locknut and adjust the screw to obtain a distance of approximately 2″ from the outside face of the boss on the governor subcap to the end of the screw (Fig. 3).

2. Place the fuel rod and terminal lever in the full-fuel position (Fig. 3).

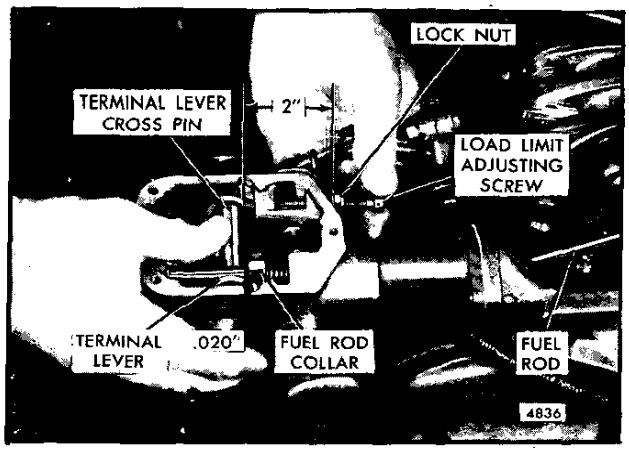


Fig. 3 - Adjusting Load Limit

© 1983 General Motors Corp.

3. Turn the load limit screw until a .020" space exists between the fuel rod collar and the terminal lever, then hold the screw and tighten the locknut.

Adjust Speed Droop

The purpose of adjusting the speed droop is to establish a definite engine speed at no load with a given speed at rated full load.

The governor is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs, the speed droop should be readjusted.

Use an accurate tachometer to determine the engine speed.

When a full rated load on the unit is established and the fuel rod, injector control rack levers, and load limit have been adjusted, the speed droop may be adjusted as follows:

1. Start the engine and operate at approximately one-half the rated no-load speed until the lubricating oil has had an opportunity to warm up.

> **NOTE:** When the engine lubricating oil is cold, the governor regulation may be erratic. The regulation should become increasingly stable as the temperature of the lubricating oil increases.

2. Stop the engine and remove the governor cover.

3. Loosen the locknut and back off the maximum speed adjusting screw approximately 5/8" (Fig. 5).

4. Refer to Fig. 4 and loosen the speed droop adjusting screw. Move the bracket so the screw is midway between the ends of the slot in the bracket. Tighten the screw.

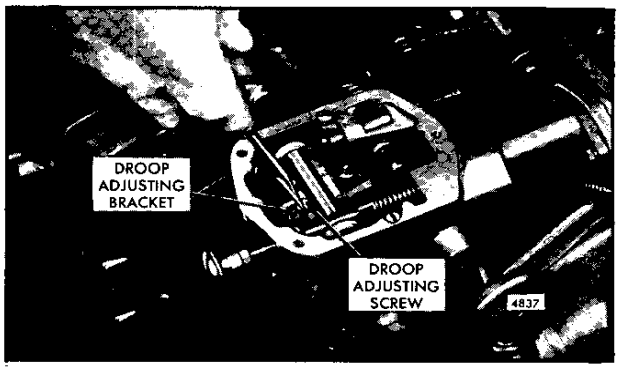


Fig. 4 - Adjusting Speed Droop

Be sure the bracket remains on the shoulder of the terminal lever.

5. With the throttle in the *run* position, adjust the engine speed until the engine is operating at 5% above the recommended full load speed.

6. Apply the full rated load on the engine and readjust the engine speed to the correct full-load speed.

7. Remove the rated load and note the engine speed after the speed has stabilized under no load. If the speed droop is correct, the engine speed will be approximately 5% higher than the full-load speed.

If the speed droop is too high, stop the engine, loosen the bolt again and move the speed droop adjusting bracket *in* (toward the engine). Tighten the screw. To increase the speed droop, move the droop adjusting bracket *out* (away from the engine).

If the speed droop in the governors of power generator engines are not the same, the electrical load will not be equally divided when the generators are operated in parallel.

The speed droop bracket in the governor of each engine must be adjusted to obtain the desired variation between the engine no-load and full-load speeds shown in Table 1.

Full Load	No-Load
50 cycles 1000 rpm	52.5 cycles 1050 rpm
60 cycles 1200 rpm	62.5 cycles 1250 rpm
50 cycles 1500 rpm	52.5 cycles 1575 rpm
60 cycles 1800 rpm	62.5 cycles 1875 rpm

TABLE 1

The recommended speed droop at full load for power generator units operating in parallel is 50 rpm (2-1/2 cycles) at 1000 and 1200 rpm. For units operating at 1500 and 1800 rpm the speed droop should by 75 rpm (2-1/2 cycles). The speed droop may be varied to suit the particular application.

© 1983 General Motors Corp.

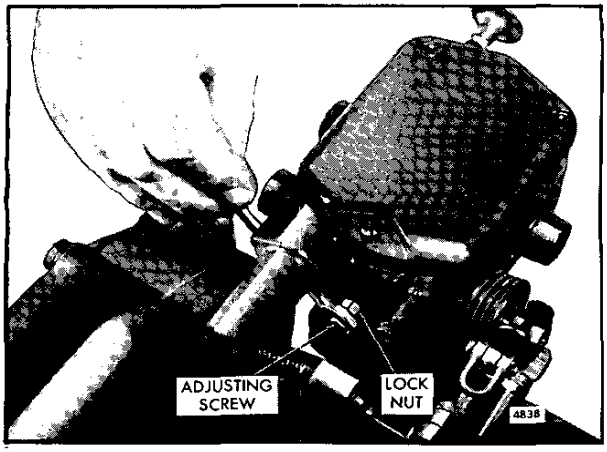


Fig. 5 - Adjusting Maximum No-Load Speed

Adjust Maximum No-Load Speed

After the speed droop is properly adjusted, set the maximum no-load speed as follows:

1. Loosen the maximum speed adjusting screw locknut and back the adjusting screw out three turns.

2. With the engine operating at no load, adjust the engine speed until the engine is operating approximately 8% higher than the rated full-load speed.

3. Turn the maximum speed adjusting screw in lightly until contact is felt with the linkage in the governor (Fig. 5).

4. Hold the adjusting screw and tighten the locknut.

5. Install the governor cover.

GOVERNORS WITH SYNCHRONIZING MOTOR

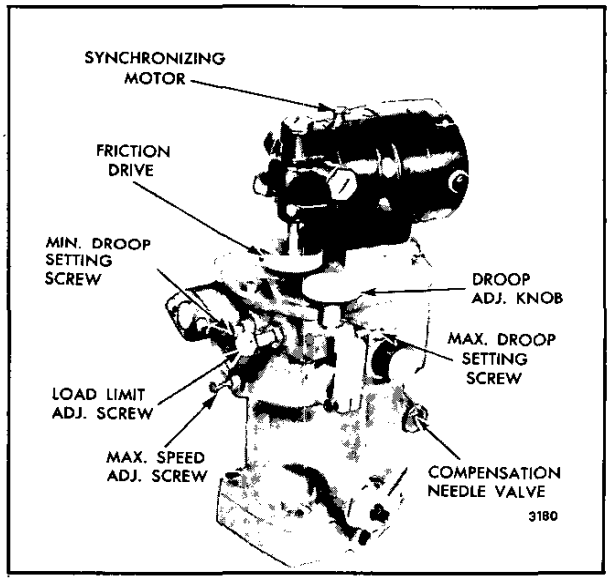


Fig. 6 - Typical Synchronizing Motor Mounting

Some hydraulic governors are equipped with a reversible synchronizing motor which is mounted on the governor cover (Fig. 6). This motor makes a close adjustment of the engine speed possible by remote control and is especially valuable for synchronizing two generators from a central control panel.

The motor is connected to the source of electrical supply through a two-way switch located on the control panel. When this switch is held in the desired position, the motor shaft turns the governor speed adjusting shaft by means of a reduction gear and slip coupling. The position of the switch determines the direction of rotation of the speed adjusting shaft. When the desired engine speed is indicated on a tachometer or frequency meter mounted on the control panel, the switch is placed in the *off* position.

> **NOTE:** If the switch is held in the *Lower Speed* position too long, the synchronizing motor will continue to lower the engine speed and the engine will ultimately stop. If the switch is held in the *Raise Speed* position too long the synchronizing motor will turn the speed adjusting shaft until it strikes the maximum speed adjusting screw. The clutch or slip coupling will slip and the motor will continue to run at a slightly reduced speed without effecting the governor after the shaft strikes the adjusting screw.

The adjustments on a governor equipped with a synchronizing motor are the same as on a governor without the motor. If the governor does not have an external droop setting screw the governor cover and motor assembly must be removed when the engine speed droop is set (Fig. 6). Reinstall the governor cover and motor to check the speed droop.

© 1983 General Motors Corp.

HYDRAULIC WOODWARD PSG GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

Adjust engines with hydraulic governor assemblies after adjusting the exhaust valves and timing the fuel injectors as follows:

Adjust Fuel Rod

1. Remove the governor cover and the rocker cover. Refer to Fig. 1 and loosen all inner and outer injector rack control lever adjusting screws or the adjusting screws and locknuts. Be sure all control levers are free on the injector control tube.

2. Loosen the fuel rod locknut and remove the fuel rod knob.

3. Turn the locknut to a position so that 3/16″ of the fuel rod extends beyond the nut. Install the fuel rod knob and tighten the locknut.

Position Injector Rack Control Levers

With the fuel rod properly adjusted, the rack control levers may be adjusted as follows:

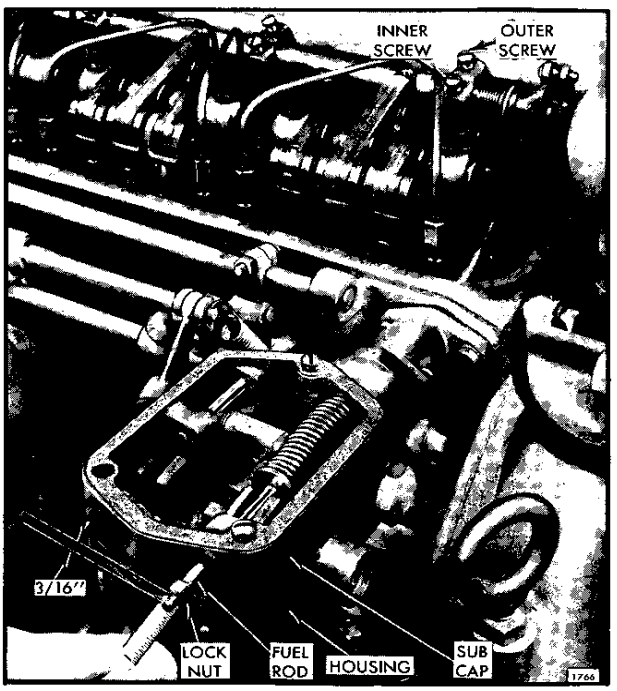


Fig. 1 - Adjusting Fuel Rod

1. Two Screw Assembly -- Adjust the No. 1 injector rack control lever by turning the outer adjusting screw in until a slight movement of the injector control tube lever is observed (Fig. 2). Tighten the inner adjusting screw.

One Screw and Locknut Assembly -- Adjust the No. 1 injector rack control lever by tightening the adjusting screw until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted (Fig. 2). Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut.

This will place the No. 1 injector rack in the full-fuel position.

2. Pull out on the fuel rod and check for 1/32″ to 1/16″ movement.

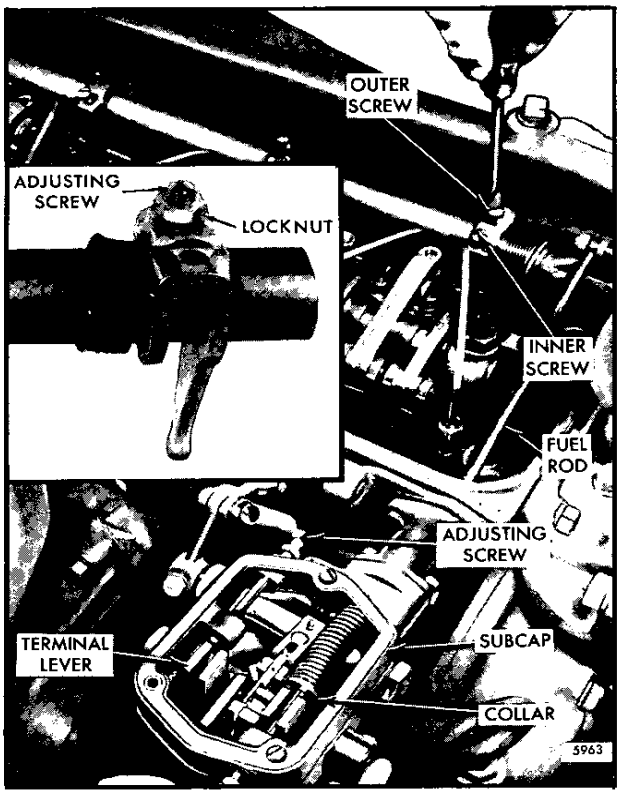


Fig. 2 - Positioning No. 1 Injector Rack Control Lever

© 1984 General Motors Corp.

When the settings are correct, the rack of both injectors must be snug on the pin of their respective rack control levers.

6. Position the remaining rack control levers as outlined in Steps 4 and 5.

When the settings are correct, the racks of all injectors must be snug on the pins of the rack control levers when the control tube lever is held in the full-fuel position.

Adjust Load Limit

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be readjusted.

With the injector rack control levers properly adjusted, the load limit may be set as follows:

1. Place fuel rod and terminal lever in the full-fuel position (Fig. 3).

2. Loosen the locknut and turn the adjusting screw until a .020" space exists between the fuel rod collar and the terminal lever. Hold the screw and tighten the locknut.

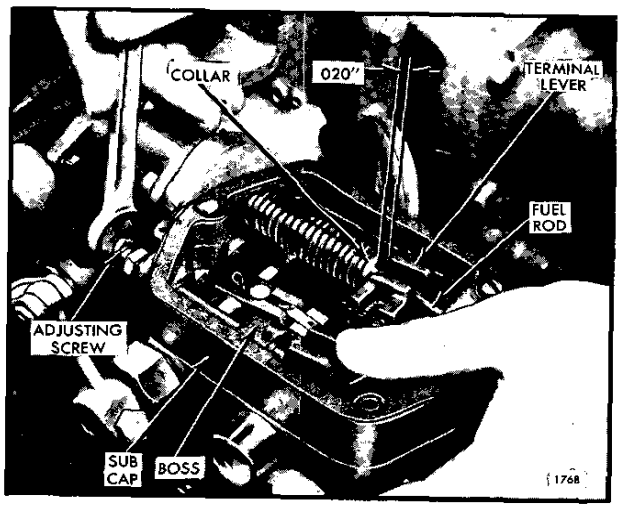


Fig. 3 - Setting Maximum Fuel Adjusting Screw (Load Limit)

If the movement exceeds that specified with the *Two Screw Assembly*, back off the inner adjusting screw approximately 1/8 of a turn and tighten the outer adjusting screw. To correct thes condition with the *One Screw and Locknut Assembly*, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

If movement is less than specified with the *Two Screw Assembly*, back off the outer adjusting screw approximately 1/8 of a turn and tighten the inner adjusting screw. To correct this condition with the *One Screw and Locknut Assembly*, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

3. Disconnect the fuel rod from the injector control tube lever.

4. Hold onto the clevis at the end of the injector control tube and position the No. 1 injector in the full-fuel position.

Two Screw Assembly -- Screw down the inner adjusting screw of the No. 2 injector until the injector control lever for that injector contacts the injector body. This may be felt at the clevis end by a slight movement as contact is made. Tighten the outer adjusting screw until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws until tight.

One Screw and Locknut Assembly -- Tighten the adjusting screw of the No. 2 injector rack control lever until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Securely lock the adjusting screw locknut.

> **NOTE:** Overtightening of the injector rack control tube lever adjusting screws during installation or adjustment can result in damage to the injector control tube. The recommended torque of the adjusting screws is 24-36 **lb-in** (3-4 Nm).

5. Make sure the rack remains snug on the pin of the rack control lever at the No. 1 injector.

Two Screw Assembly -- If the rack of No. 1 injector has become loose, back off slightly on the inner adjusting screw at the No. 2 injector rack control lever. Tighten the outer adjusting screw.

One Screw and Locknut Assembly -- If the rack of the No. 1 injector has become loose, loosen he locknut and turn the adjusting screw on the No. 2 injector rack control lever clockwise a slight amount and retighten the locknut.

© 1984 General Motors Corp.

Compensation Adjustment

After the temperature of the engine and the oil supplied to the governor reach their normal operating values, adjust the governor compensation, without load on the engine, as follows:

1. Open the compensating needle valve (Fig. 6) two or three turns with a screwdriver and allow the engine to "hunt" or "surge" for about one-half minute to bleed trapped air from the governor oil passages.

2. Gradually close the needle valve until "hunting" just stops. Do not go beyond this position. Check the amount of needle valve opening by closing the valve completely, noting the amount required to close. Open the valve to the previously determined opening at which "hunting" stopped. Test the action by manually disturbing the engine speed. The engine should return promptly to original steady speed with only a small overshoot. The correct needle valve setting will be between 1/8 and 1/2 turn open.

It is desirable to have as little compensation as possible. Closing the needle valve farther than necessary will make the governor slow to return to normal speed after a load change.

Adjust Speed Droop

The purpose of adjusting the speed droop is to establish a definite engine speed at no load with a given speed at rated full load.

The governor droop is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs, the speed droop should be readjusted.

The best method of determining the engine speed is by the use of an accurate hand tachometer.

If a full rated load on the unit can be established, the fuel rod, injector rack control levers and load limit have been adjusted, the speed droop may be adjusted as follows:

1. Start the engine and run it at approximately one-half the rated no-load speed until the lubricating oil temperature stabilizes.

> **NOTE:** When the engine lubricating oil is cold, the governor regulation may be erratic. The regulation should become increasingly stable as the temperature of the lubricating oil increases.

2. With the engine stopped, remove the governor cover.

3. Loosen the locknut and back off the maximum speed adjusting screw approximately 3/8" (Fig. 5).

4. Refer to Fig. 4 and loosen the droop adjusting bolt. Move the bracket so that the bolt is midway between the ends of the slot in the bracket. Tighten the bolt. Be sure the bracket remains on the shoulder of the terminal lever.

5. With the throttle in *run* position, adjust the engine speed until the engine is operating at 3% to 5% above the recommended full-load speed.

6. Apply the full rated load on the engine and adjust the engine speed to the correct full-load speed.

7. Remove the rated load and note the engine speed after the speed stabilizes under no load. If the speed droop is correct, the engine speed will be approximately 3% to 5% higher than the full-load speed.

If the speed droop is too high, stop the engine and again loosen the bolt and move the droop adjusting bracket *in* toward the engine. Tighten the bolt. To increase the speed droop, move the droop adjusting bracket *out*, away from the engine.

The speed droop in governors which control engines driving generators in parallel should be identical, otherwise, the electrical load will not be equally divided.

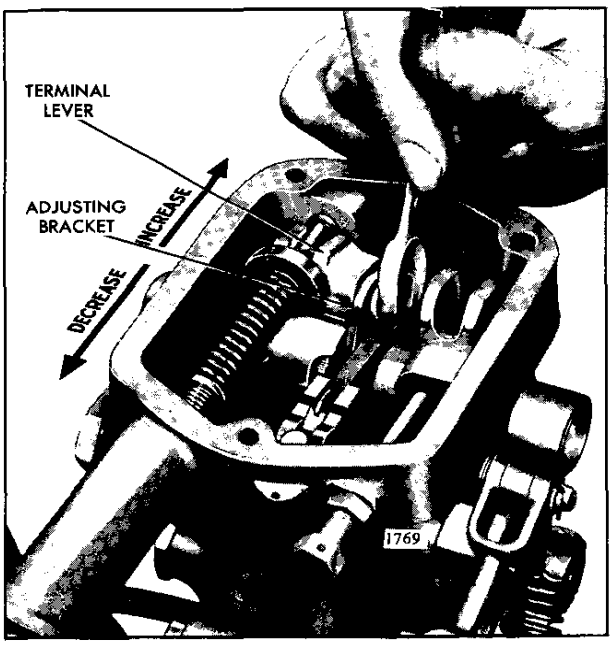


Fig. 4 - Adjusting Speed Droop

© 1984 General Motors Corp.

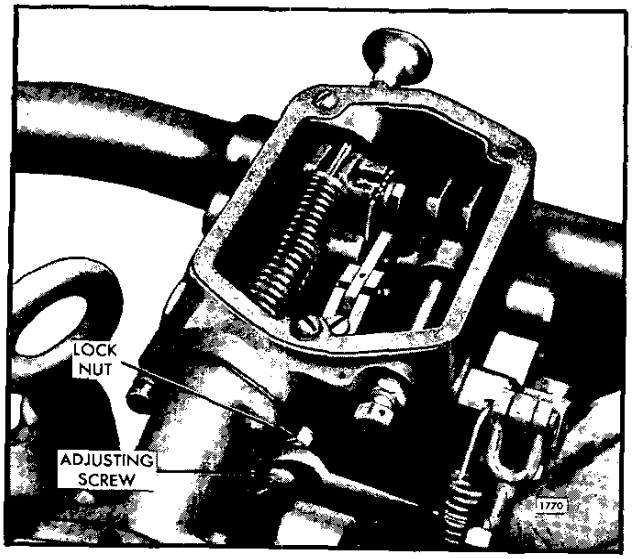


Fig. 5 - Setting Maximum Speed Adjusting Screw

Adjust the speed droop bracket in each engine governor to obtain the desired variation between the engine no-load and full-load speeds shown in Table 1.

Full Load	No-Load
50 cycles 1000 rpm	52.5 cycles 1050 rpm
60 cycles 1200 rpm	62.5 cycles 1250 rpm
50 cycles 1500 rpm	52.5 cycles 1575 rpm
60 cycles 1800 rpm	62.5 cycles 1875 rpm

TABLE 1

The recommended speed droop of generator sets operating in parallel is 50 rpm (2-1/2 cycles) for units operating at 1000 and 1200 rpm and 75 rpm (2 1/2 cycles) for units operating at 1500 and 1800 rpm full load. This speed droop recommendation may be varied to suit the individual application.

A single engine unit equipped with an isochronous type hydraulic governor may operate at a constant frequency by setting the governor droop to zero. However, when operating generator sets in parallel, the governor of each unit must be set with an equal amount of droop for stable operation and proper division of the load.

If required, the zero droop setting may be carried out by performing Steps 1 through 7 as outlined, except adjust for zero droop instead of 3% to 5% stated.

Adjust Maximum No-Load Speed

With the speed droop properly adjusted, set the maximum no-load speed as follows:

1. Loosen the locknut and back out the maximum speed adjusting screw three turns.

2. With the engine operating at no load adjust the engine speed until the engine is operating at approximately 10% higher than the rated full-load speed.

3. Turn the maximum speed adjusting screw in lightly until contact is felt with the linkage in the governor (Fig. 5).

4. Hold the screw and tighten the locknut. Install the governor cover.

© 1984 General Motors Corp.

GOVERNORS WITH SYNCHRONIZING MOTOR

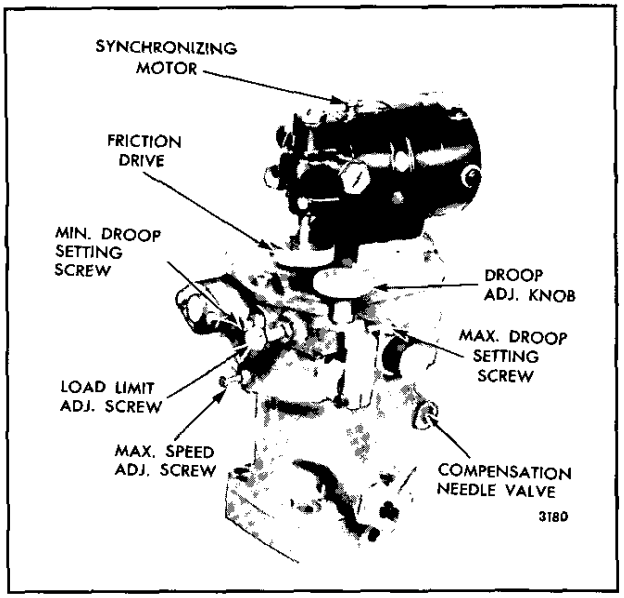


Fig. 6 - Typical Synchronizing Motor Mounting

On some hydraulic governors, a reversible electric synchronizing motor is mounted on the governor cover. This motor permits close adjustment of engine speed by remote control. This feature is especially valuable when synchronizing two generators from a central control panel.

When the two-way control switch for the unit on the central control panel is closed by the operator, the motor shaft turns the governor speed adjusting shaft by a reduction gear and slip coupling. The direction of rotation (clockwise or counterclockwise) is dependent upon the position of the switch. When the desired engine speed is indicated on a tachometer or frequency meter on the panel, the operator returns the switch to the *off* position.

Should the switch be held in the "Lower Speed" position too long, the synchronizing motor will continue to lower the unit speed until it ultimately shuts down the engine. Should the switch be held too long in the "Raise Speed" position, the motor will turn the governor shaft until the shaft strikes the maximum speed adjusting screw, after which the clutch will slip and the motor will continue to run at a slightly reduced speed without further effect.

The adjustments on the governor equipped with a synchronizing motor are the same as on units without a synchronizing motor. The synchronizing motor is used in place of the vernier throttle control knob to raise and lower the engine speed.

The governor cover and motor assembly must be removed when setting the engine droop. The desired engine speeds may be obtained by manually turning the worm drive while the cover is removed.

GOVERNORS WITH EXTERNAL DROOP CONTROL

Some PSG governors have an external adjustable droop control to enable droop adjustment without the removal of the governor cover. Units, having a governor with this feature, may be paralleled with another unit that is operating at constant frequency (zero droop). The incoming unit should have its droop bracket set in the maximum position while it is being paralleled and while operating in parallel. When it is desired to stop the unit operating at constant frequency, the load should be shifted to the incoming unit and its governor droop bracket moved to zero droop. The outgoing unit can then be adjusted to maximum droop, removed from the line and stopped. The incoming unit will not be carrying the load and operating at constant frequency (zero droop).

Adjustment of governor droop by the external adjustable droop control should be performed as follows:

1. Start the engine, and run it at approximately one-half the rated full-load speed until the lubricating oil temperature stabilizes.

2. Remove the load from the engine.

3. Back off the needle valve to release any air that may be trapped in the system. Turn the needle valve in slowly to reduce governor hunting. The correct needle valve setting will be between 1/8 and 1/2 turn open.

4. Back out the minimum and maximum droop setting screws.

5. Loosen the droop adjusting knob and move the slider all the way in toward the engine, and then tighten the knob (Fig. 7).

6. Loosen the locknut on the maximum speed adjusting screw and turn the screw out until 5/8" of the threads are exposed.

7. With the engine operating at the recommended full-load speed, apply the full rated load and recheck the engine speed. If required, readjust the engine to full-load speed by means of the synchronizing motor.

© 1984 General Motors Corp.

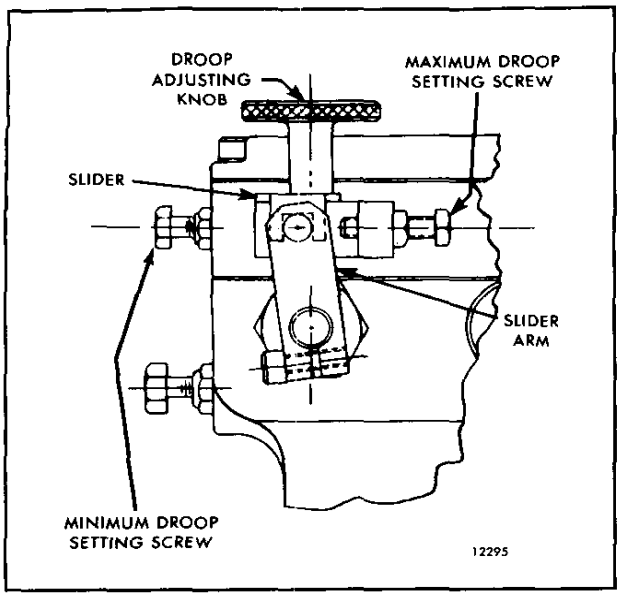


Fig. 7 - External Droop Control on PSG Isochronous Governor

8. Remove the load and note the engine speed. If the zero droop setting is correct, the engine speed will remain constant. If the engine speed is higher, loosen the drop adjusting knob and set the slider to a reduced droop position.

9. When the desired minimum droop setting is reached, loosen the locknut and turn the minimum droop setting screw inward until it contacts the droop linkage within the governor. This will be felt by a step-up of resistance while turning the adjusting screw. Lock the adjusting screw.

10. Loosen the droop adjusting knob and slide the droop bracket in a direction to increase the droop. Perform Steps 7 and 8 to check the droop until the desired maximum droop is attained.

11. When the desired maximum droop setting is reached, loosen the locknut and turn the maximum droop setting screw inward until it contacts the droop slider arm. Lock the adjusting screw.

12. Recheck the minimum and maximum droop setting as outlined in Steps 7 and 8 and adjust the adjustment screws, if necessary, until the correct settings are attained.

13. Adjust the maximum no-load speed.

© 1984 General Motors Corp.

DUAL HYDRAULIC WOODWARD SGT GOVERNOR AND INJECTOR RACK CONTROL ADJUSTMENT

A dual hydraulic governor assembly is used on certain torque converter applications. This governor consists of two sets of flyweights and pilot valve assemblies that are interconnected to operate a single servo piston. One set of flyweights is driven by the engine. The other set is driven through a flexible shaft by the ouptut shaft. The governor assembly used on a particular engine may have either single (Fig. 1) or dual (Fig. 3) speed control levers.

The single lever type governor control lever is attached to the output shaft governor speed adjusting shaft (Fig. 1). The engine and output shaft governor speed adjusting shaft arms are linked together by a "slip-joint" link (Fig. 2).

On the single lever type governor, the control lever has two distinct arcs of travel. In the first arc of travel (used to obtain the desired engine speed) the control lever moves the engine governor speed adjusting shaft arm between the engine idle and maximum speed positions. In the second arc of travel (used to set the desired output shaft speed) the output shaft governor speed adjusting shaft arm "picks-up" the output shaft governor floating lever assembly by means of the pin located at the lower end of the arm. The movement of the governor control lever in the second arc of travel is opposed by the "slip-joint" linkage spring.

The dual lever type governor assembly has one of the two control levers, attached to the engine governor speed adjusting shaft, used to control the engine governor. The other is attached to the output shaft governor speed adjusting shaft, used to control the output shaft governor (Fig. 3).

The path of oil within both types of governor assemblies is from the pump through the engine governor pilot valve to the output shaft governor pilot valve, then to a single common servo piston. The servo piston operates a terminal lever which in turn controls the position of the fuel rod connected to the injector racks.

The engine governor no-load speed setting must be equal to the no-load output shaft speed setting plus the amount of engine speed increase over output shaft speed plus the engine governor droop.

To stop the engine, pull outward (away from the engine) on the fuel rod knob.

Adjustment

Make the following linkage and governor adjustments with the engine stopped. Before adjusting the governor, be sure that adjustment is necessary. The injector racks, injector control tube and remote throttle control linkage should be checked for freedom of movement, excess play or binding. Adjustments should be made only after the engine has reached normal operating temperature.

Fuel Rod Adjustment (Engine Stopped)

Fig. 2 and 4 give the nomenclature of the parts in their approximate location and relation to each other. The following adjustments are made with the valve rocker cover off.

1. Loosen the inner and outer injector rack control lever adjusting screws or adjusting screws and locknuts so that all of the levers move freely.

2. Remove the governor cover.

3. Loosen the fuel rod locknut and unscrew the shutdown knob and rod extension (inset of Figs. 1 and 3).

4. Turn the locknut so that 3/16" to 1/4" of the fuel rod extends beyond the nut.

5. Replace the fuel rod extension and knob and tighten the extension against the locknut.

Position Injector Rack Control Levers (Engine Stopped)

After the fuel rod is properly adjusted, adjust the injector rack control levers as follows:

1. Two Screw Assembly -- Turn the outer adjusting screw of the No. 1 injector rack control lever in until a slight movement of the injector control tube lever is observed, then tighten the inner adjusting screw.

One Screw and Locknut Assembly -- Adjust the No. 1 injector rack control lever by tightening the adjusting screw until the injector rack clevis is observed to roll up or an increase in effort to turn the screwdriver is noted. Tighten the screw approximately 1/8 of a turn more and lock securely with the adjusting screw locknut.

© 1984 General Motors Corp.

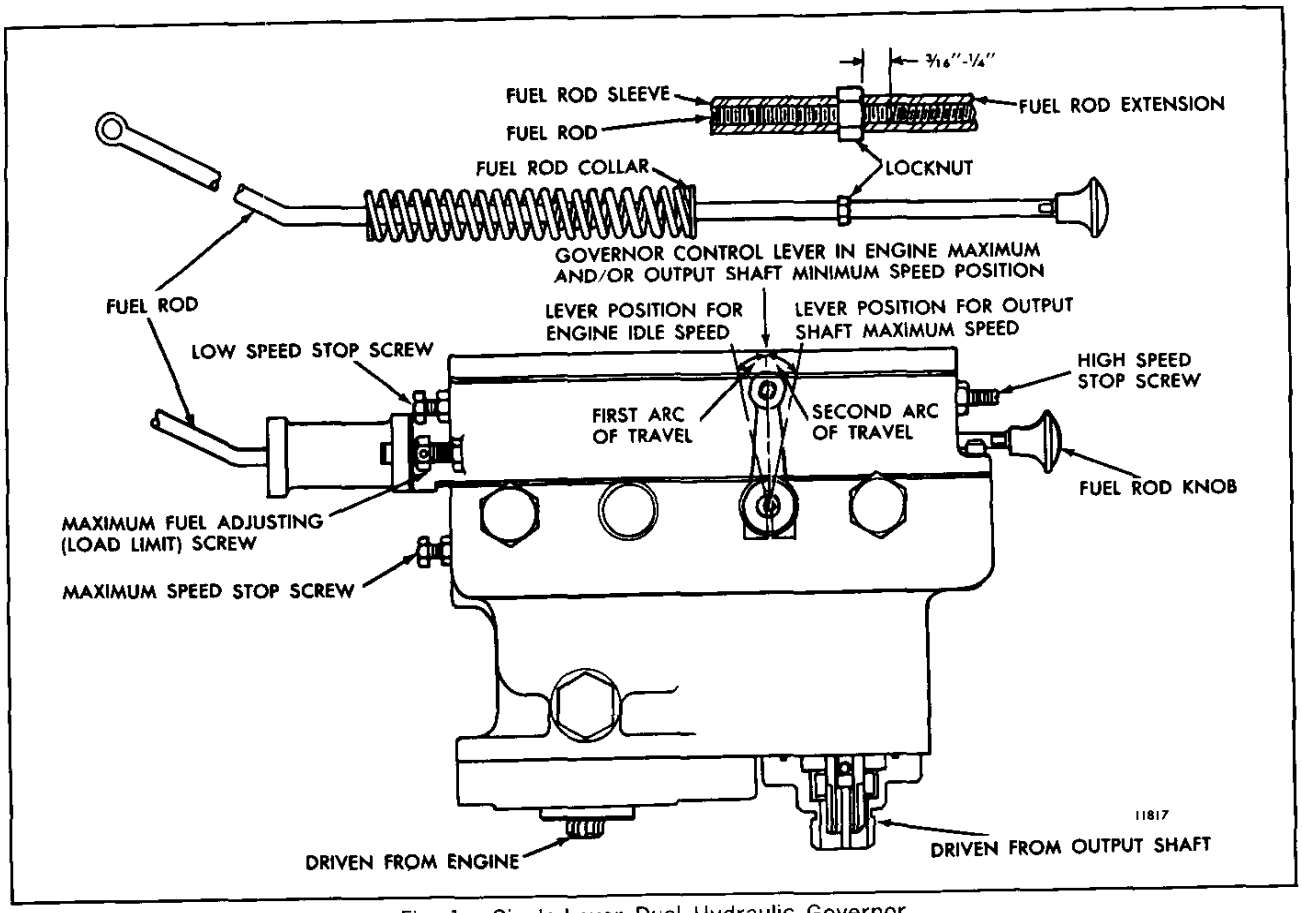


Fig. 1 - Single-Lever Dual Hydraulic Governor

This will place the No. 1 injector rack in the full-fuel position.

2. Pull out on the fuel rod and check for 1/16" movement.

Two Screw Assembly:

If the movement exceeds the distance specified, back off on the inner adjusting screw approximately 1/8 of a turn and tighten the outer adjusting screw.

If movement is less than the distance specified, back off on the outer adjusting screw approximately 1/8 of a turn and tighten the inner adjusting screw.

One Screw and Locknut Assembly:

If the movement exceeds the distance specified, loosen the locknut and turn the adjusting screw clockwise a slight amount and retighten the locknut.

If the movement is less that the distance specified, loosen the locknut and turn the adjusting screw counterclockwise a slight amount and retighten the locknut.

3. Remove the clevis pin and disconnect the fuel rod from the injector control tube lever.

4. Holding on to the clevis at the end of the injector control tube, position the No. 1 injector in the full-fuel position.

Two Screw Assembly -- Screw the inner adjusting screw of the No. 2 injector down until the rack tightens on the pin of the rack control lever. This may be felt at the clevis end by a slight movement as contact is made. Screw the outer adjusting screw down until it bottoms lightly on the injector control tube. Then, alternately tighten both the inner and outer adjusting screws.

One Screw and Locknut Assembly -- Screw the adjusting screw of the No. 2 injector down until the rack tightens on the pin of the rack control lever. This may be felt at the clevis end by a slight movement as contact is made. Tighten the locknut.

© 1984 General Motors Corp.

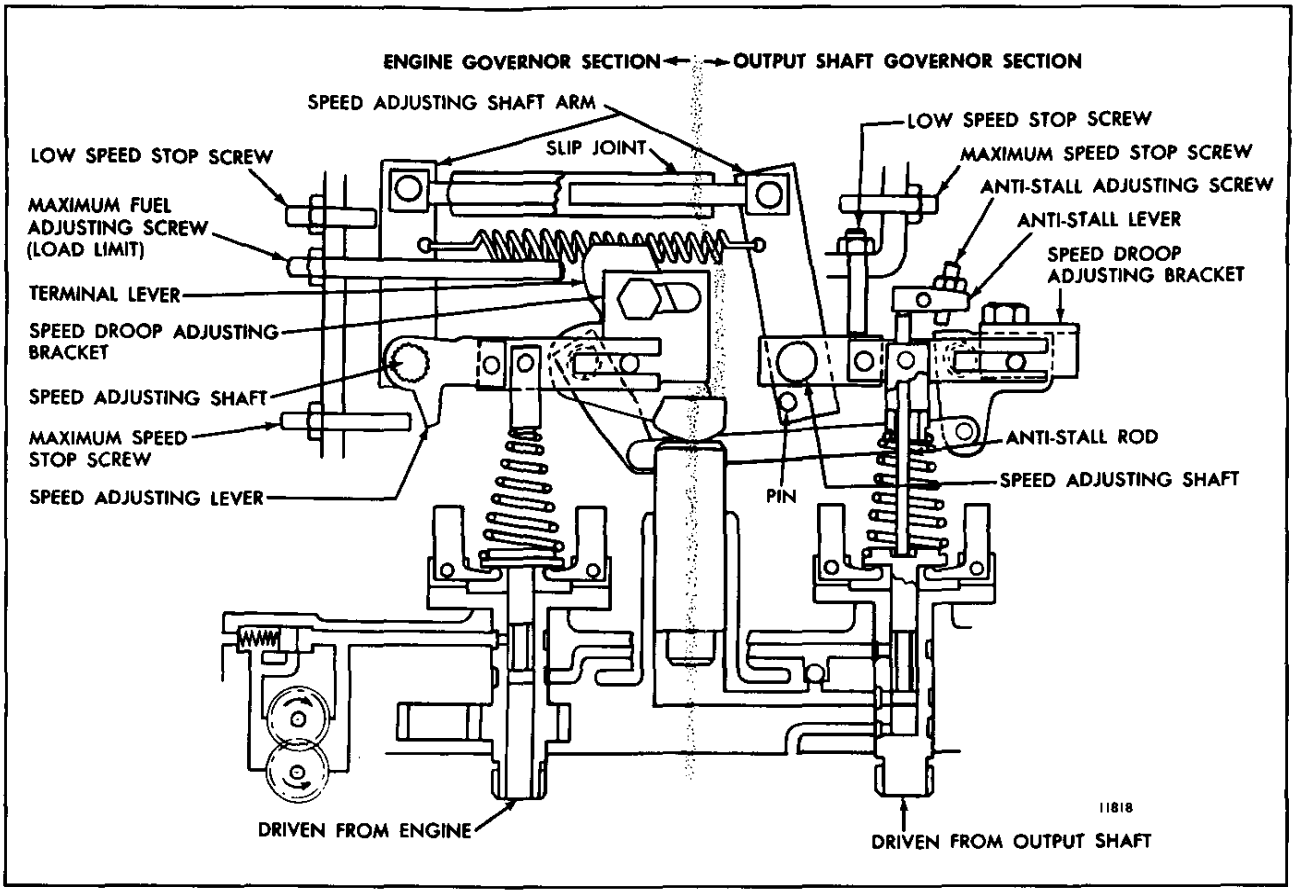


Fig. 2 - Schematic Diagram of Single-Lever Governor Assembly

5. Recheck the No. 1 injector rack to make sure that it has remained snug on the ball and of the rack control lever while adjusting the No. 2 injector rack. While holding the injector control tube in the full-fuel position, press straight down on the rack with a screwdriver. The rack should return to its original position with a rotary movement.

Two Screw Assembly -- If the rack of the No. 1 injector has become loose, back off slightly on the inner adjusting screw of the No. 2 rack control lever and tighten the outer adjusting screw.

One Screw and Locknut Assembly -- If the rack of the No. 1 injector has become loose, turn the adjusting screw on the No. 2 injector rack control lever clockwise a slight amount. Tighten the locknut.

When the settings are correct, the racks of both injectors must be snug on the ball end of their respective rack control levers.

Position the remaining injector rack control levers as outlined in Steps 4 and 5.

6. Connect the fuel rod to the injector control tube lever and replace the clevis pin. The clevis pin must rotate freely. Replace the valve rocker cover.

Adjust Load Limit

The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the load limit screw should be adjusted.

With the injector rack control levers properly adjusted, the load limit may be set as follows:

1. Place the fuel rod and the terminal lever in the full-fuel position (some improvised method may be employed to hold the fuel rod in the full-fuel position).

2. Loosen the locknut on the load limit adjusting screw. Turn the adjusting screw until a .020″ gap exists between the terminal lever and the fuel rod collar.

© 1984 General Motors Corp.

3. Release the fuel rod and tighten the locknut. Clearance must not exceed .020" to obtain full-fuel position of the injector racks.

Adjust Engine Governor (Engine Stopped)

1. Loosen the locknut and back out the output shaft governor maximum speed stop screw until it extends approximately 1" from the face of the locknut when the nut is tight against the housing (Fig. 2).

2. Back out the output shaft governor anti-stall adjusting screw until it projects 1/2" above the anti-stall lever.

3. Loosen the output shaft governor low-speed stop screw locknut and turn the screw until it projects 5/16" above the upper face of the locknut when the nut is tight against the governor body.

The weights of the output shaft governor ball head assembly should be fully collapsed. This ensures control of the engine by the engine governor since tension on the output shaft governor speeder spring will hold the output shaft governor pilot valve plunger in an open position, thus permitting the oil passing through the engine governor pilot valve to actuate the servo piston.

4. Disconnect the output shaft governor flexible drive shaft at the governor.

5. Position the engine governor droop adjusting bracket so the adjusting screw is an equal distance from either end of the slot.

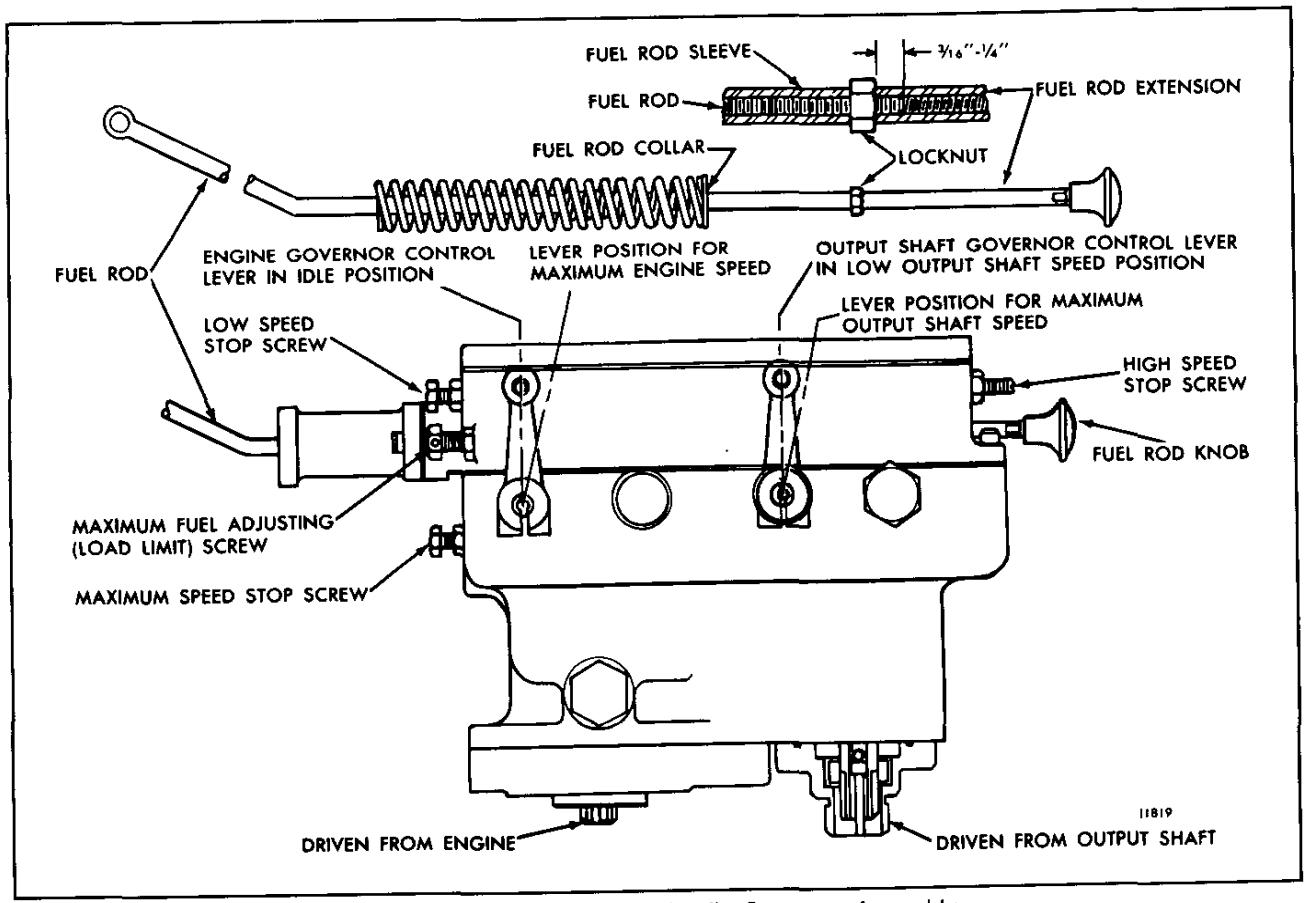


Fig. 3 - Two-Lever Dual Hydraulic Governor Assembly

© 1984 General Motors Corp.

Adjust Engine Governor (Engine Running)

1. Start and warm-up the engine.

2. Loosen the locknut on the engine governor maximum speed stop screw and back out the screw until it projects 5/8″ from the face of the locknut when the nut is tight against the governor body (Figs. 1 and 2).

3. Position the engine governor control lever, using the remote throttle control, so the engine is running at the specified maximum no-load speed shown on the engine name plate. Then, turn the maximum speed stop screw in until it contacts the speed adjusting lever. Tighten the locknut.

4. Loosen the locknut on the engine governor low-speed stop screw and turn the screw out until it projects 3/4″ from the governor body when the nut is tight against the governor body.

5. Position the governor speed control lever, using the remote throttle control, so the engine is running at the specified no-load idle speed. Then, turn the low-speed stop screw in until it contacts the governor speed adjusting shaft arm. Tighten the locknut.

NOTE: The idle speed should be 500 rpm or more.

6. Adjust the governor speed droop bracket, if necessary, to obtain the minimum droop to stabilize the engine. A decreasing engine speed as load is picked up and an increasing speed as load is dropped off is called the droop. Insufficient droop will cause "hunting" or "surging" and will result in an unstable engine. It must be remembered, however, that a stable engine may surge three or four times before stabilizing. Moving the droop bracket toward the engine decreases and away from the engine increases the amount of droop. Stop the engine.

Adjust Output Shaft Governor (Engine Running)

1. Connect the flexible drive shaft to the output shaft governor. Start the engine and make sure the ball head assembly of the output shaft governor is turning.

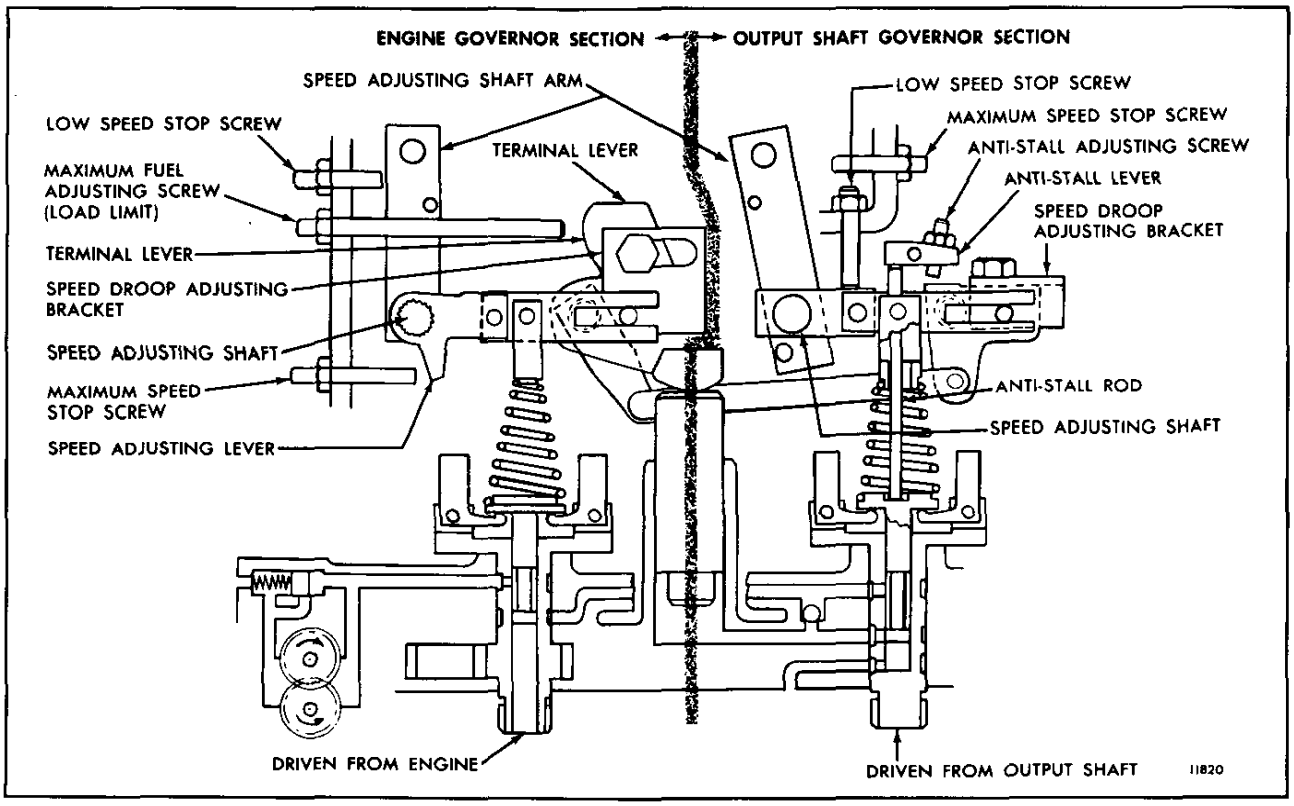


Fig. 4 - Schematic Diagram of Two-Lever Governor Assembly

© 1984 General Motors Corp.

2. Adjust the output shaft governor speed droop bracket, if necessary, to stabilize the engine. Moving the bracket toward the engine decreases and away from the engine increases the amount of droop.

3. On single lever type governor assemblies, position the governor control lever, using the remote throttle control, in the output shaft minimum speed position.

On dual lever type governor assemblies, position the output shaft governor control lever, using the remote throttle control, in the low output shaft speed position (Fig. 3).

Dual governor assemblies with the single control lever incorporating the "slip-joint" linkage, may have the linkage adjusted to provide a "lag" or "dwell" between the throttle position at which the no-load maximum engine speed is reached and the throttle position at which the output shaft speed begins to increase (as the governor control lever is moved toward the output shaft maximum speed position). This "lag" is usually governed by the type of application (or provided for the convenience of the operator) and permits movement of the control lever toward the full output shaft position, for a short distance, without a corresponding change in the output shaft speed. The "slip-joint" may be lengthened or shortened by loosening the locknut and turning the turnbuckle until the desired adjustment is made. Lengthening the linkage will decrease and shortening the linkage will increase the "lag".

4. On single lever type governor assemblies, position the governor control lever, using the remote throttle control, so that the output shaft is running at the maximum speed desired (usually shown on one of the unit name plates), then run the output shaft governor maximum speed stop screw in until it contacts the output shaft governor speed adjusting shaft arm. Tighten the locknut.

On dual lever type governor assemblies, position the output shaft governor control lever, using the remote throttle control, so that the output shaft is running at the maximum speed desired (usually shown on one of the unit name plates). Then, turn the output shaft governor maximum speed stop screw in until it contacts the output shaft governor speed adjusting shaft arm. Tighten the locknut.

5. Loosen the output shaft governor low-speed stop screw locknut and back out the screw until the desired minimum output shaft no-load speed is obtained. Tighten the locknut.

6. On single lever type governor assemblies, position the governor control lever, using the remote throttle control, in the minimum speed position. Then, turn in the anti-stall screw until the anti-stall lever just contacts the anti-stall rod (Fig. 2). This can be checked by lightly pressing the outer end of the anti-stall lever (side opposite the screw) with a screwdriver. The screw will be adjusted correctly when a slight increase in output shaft speed is noted when the lever is depressed slightly with the screwdriver.

On dual lever type governor assemblies, position the output shaft governor control lever, using the remote throttle control, in the minimum speed position. Then, turn the anti-stall screw in until the anti-stall lever just contacts the anti-stall rod. This can be checked by lightly pressing the outer end of the anti-stall lever (side opposite the screw) with a screwdriver. The screw will be adjusted correctly when a slight increase in output shaft speed is noted when the lever is depressed slightly with the screwdriver.

7. Replace the governor cover.

© 1984 General Motors Corp.

MECHANICAL OUTPUT SHAFT GOVERNOR AND LINKAGE ADJUSTMENT

A Pierce mechanical governor is used to maintain a near constant output shaft speed on engines equipped with a torque converter. The governor may be mounted at the front of the engine (Fig. 1) and driven by a flexible shaft from the converter output shaft, or may be mounted on the torque converter and gear driven from the output shaft (Fig. 2).

Lubrication for the direct driven governor is provided by an external oil line from the torque converter. The engine mounted governor is lubricated by engine oil contained within the governor housing. The governor sump is filled through the hinged cap oiler until the oil begins to drip out of the oil level hole. After filling, a plug is installed in the oil level hole to prevent leakage. The oil level should be checked every 8 service hours and changed every 500 hours.

The output shaft governor is connected to the engine governor by control rods and levers as illustrated in Figs. 1 and 2. The control rod end ball joints are sealed assemblies and do not require lubrication. However, the throttle control shaft bearings should be lubricated periodically with all purpose grease through the grease fittings. Other moving parts of the control linkage should be lubricated with engine oil.

The centrifugal force of the revolving output shaft governor flyweights is converted into linear motion which is transmitted through a riser, thrust bearing, operating fork and rocker shaft to an external speed adjusting spring. The speed of the torque converter output shaft is governed by the tension of the speed adjusting spring. This spring tension is established by the operator when he moves the output shaft governor speed adjusting lever to the desired speed setting.

The engine governor operating lever is positioned by the operator to limit the maximum fuel input to the engine. For most purposes, such as drag line and shovel operation, the lever is advanced to its maximum position to permit the output shaft governor to obtain full power from the engine. The lever may be used as an overrule lever when performing such jobs as laying of structural steel. A spring is used to return the lever to the idle position. Travel of the governor operating lever is limited by a stop (bolt).

The engine governor throttle control lever is pinned to the throttle shaft. The engine governor operating lever is mounted below the throttle control lever and rides on the throttle shaft boss on the governor cover. The output shaft governor lever is mounted above the throttle control lever and is retained on the shaft by a snap ring. A stop pin, pressed into the throttle control lever, transmits movement of the output shaft governor lever and/or engine governor operating lever through the throttle control lever to the injector racks. The torsion spring, used to retain the throttle control lever stop pin against the output shaft governor lever, yields to permit the governor operating lever to move the throttle control lever toward the idle position,

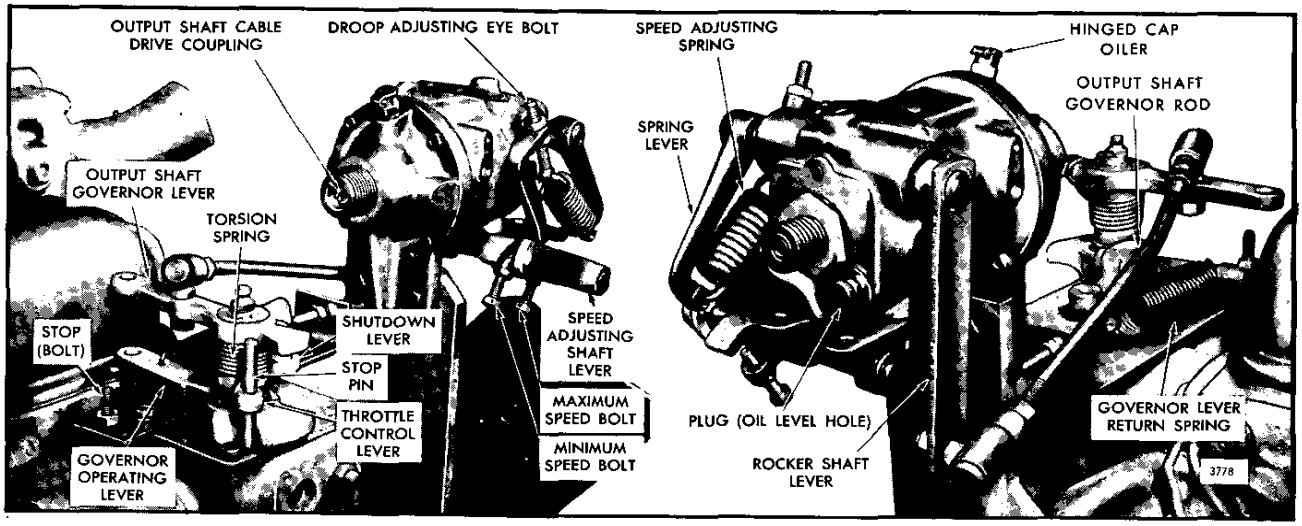


Fig. 1 - Front Mounted Output Shaft Governor (Driven by Flexible Shaft)

© 1973 General Motors Corp.

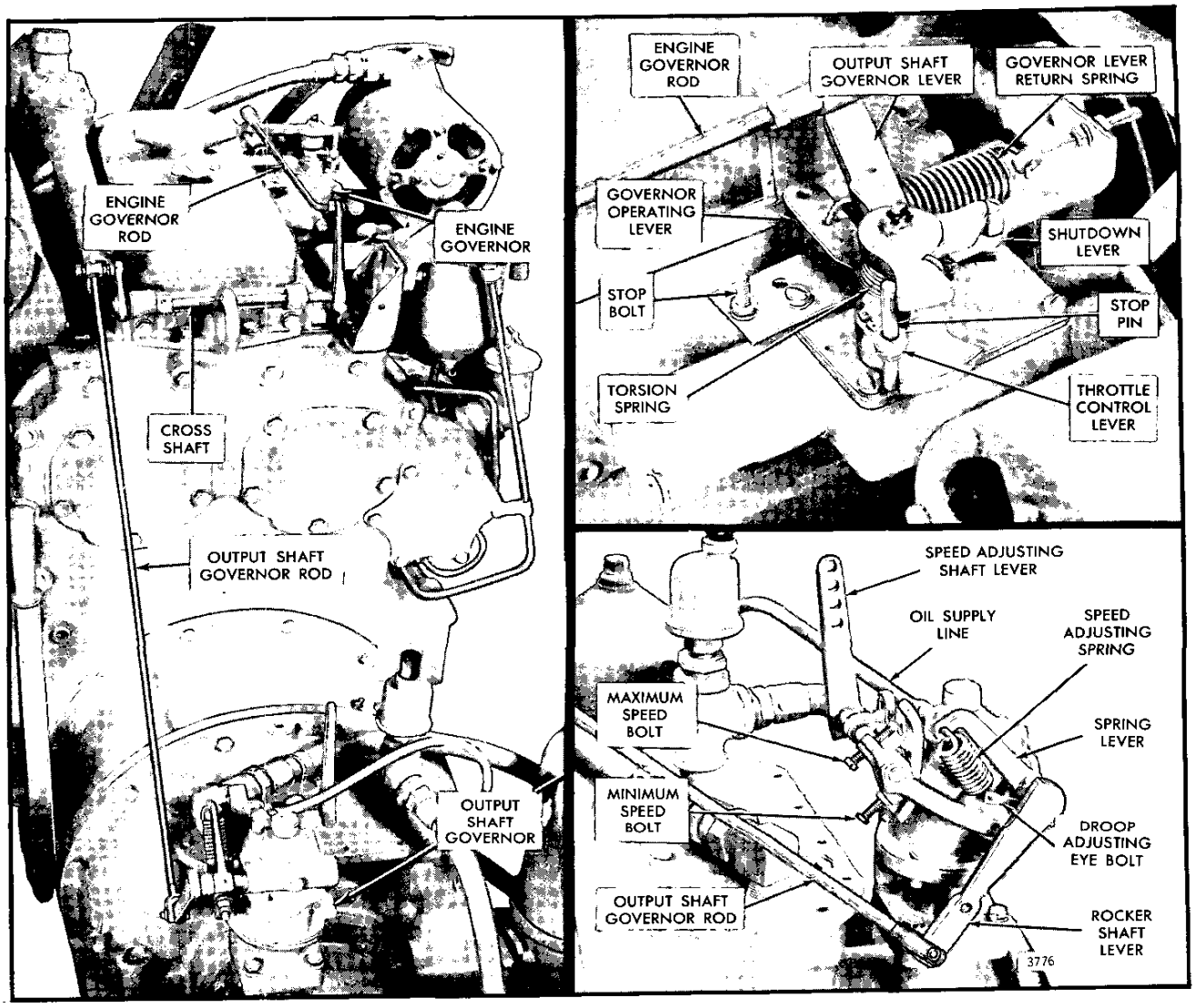


Fig. 2 - Rear Mounted Output Shaft Governor (Gear Driven from Output Shaft)

regardless of the position of the output shaft governor lever. A slot in the underside of the governor cover hub limits the travel of the throttle control lever in both its maximum and minimum speed positions.

Movement of the output shaft governor speed adjusting lever is limited by the maximum and minimum speed adjusting bolts.

The engine shut-down lever is connected through a shaft to another lever, under the governor cover, which bears against the pin in the differential lever. To stop the engine, the shut-down lever is used to move the differential lever to the no-fuel position.

Operation

When the output shaft governor speed adjusting lever is advanced, the tension on the speed adjusting spring is increased. The force resulting from the increased spring tension is transmitted through the rocker shaft lever and control linkage to the throttle control lever which advances the injector racks. Engine speed increases, as a result of the increased fuel, until the output shaft governor weight force is sufficient to balance the increased spring tension. The weights then move against the spring and reduce the injector rack fuel setting to an amount sufficient to maintain the higher engine speed setting.

© 1973 General Motors Corp.

Should the operator move the speed adjusting shaft lever to a decreased speed position, the tension on the speed adjusting spring will decrease and the governor weights will overcome the spring tension and move the rocker shaft lever to a decreased fuel position. The engine speed will be reduced until the force of the output shaft governor weights equals the tension of the speed adjusting spring. The engine will then operate at the desired reduced engine speed.

When a load is applied to the unit, the output shaft slows down and the force exerted by the governor flyweights is reduced, allowing the spring to move the rocker shaft lever to an increased fuel position to provide sufficient power to equal the new load.

When the load on the unit is removed, the output shaft speed will increase and the force exerted by the governor flyweights will increase, overcoming the spring tension and moving the rocker shaft lever to a decreased fuel position to reduce the power to match the reduced load.

Tune-Up

Adjust the exhaust valve clearance, time the injectors and adjust the engine and output shaft governors as follows:

1. Adjust the exhaust valve clearance and time the fuel injectors.

2. Disconnect the output shaft governor rod and the linkage to the engine governor operating lever. Then adjust the engine governor as outlined under *Limiting Speed Mechanical Governor and Injector Rack Control Adjustment.*

> **NOTE:** Set the no-load engine speed to that specified on the engine option plate. The no-load speed varies with the converter used and the maximum output shaft speed setting.

3. Reconnect the linkage to the governor operating lever and check the total travel of the operating lever. The lever should move to the stop (bolt) in one direction and the governor lever return spring should move the lever, in the other direction, until the throttle control lever reaches the end of its travel.

4. Move the governor operating lever to the maximum speed position (against the stop bolt).

5. Move the output shaft governor rocker shaft lever to the maximum fuel position and retain it by moving the speed adjusting lever to the full-speed position. Then move the output shaft governor lever and the throttle control lever together to the maximum speed position and retain there.

> **NOTE:** This operation closes the low speed gap which may require more torque than is available from the torsion spring between the above two levers. Thus, it is important that they be held together, permitting no space between the throttle control lever pin and the arm of the output shaft governor lever.

6a. Adjust the flexible-shaft driven output shaft governor rod length until it will just slide into the inner hole of the output shaft governor lever (Fig. 1). Then increase the length of the rod until there is approximately .020 " clearance between the stop pin and the output shaft governor lever, and the bend in the rod is positioned as shown in Fig. 1. Tighten the adjustment.

6b. To adjust the linkage between the output shaft governor (mounted on the torque converter) and the engine governor, loosen the output shaft governor rod clamping bolt in the ball joint in the rear cross shaft lever (Fig. 2). Next, move the output shaft governor rod until there is approximately .020 " clearance between the stop pin and the output shaft governor lever. Then tighten the clamping bolt securely.

> **NOTE:** The engine governor control rod is connected to the outer bolt hole in the output shaft governor lever on units equipped with a rear mounted output shaft governor.

7. Adjust the governor operating lever return spring by retaining the rocker shaft lever in the full-speed position and increasing the tension on the spring by adjusting the eye bolt and nuts, until the tension of the torsion spring is overcome and the throttle control lever is moved against its stop in the idle position.

8. Move the output shaft governor speed adjusting lever to the minimum speed position and start the engine.

9. Advance the output shaft governor speed adjusting lever to the desired maximum output shaft speed and adjust the maximum speed adjusting bolt to retain the lever.

10. Move the output shaft governor speed adjusting shaft lever to the desired minimum speed position and adjust the minimum speed adjusting bolt to retain the lever.

11. Recheck the output shaft maximum and minimum speeds and readjust the position of the speed adjusting bolts, if necessary.

12. To check the unit for stability as affected by governor speed droop, move the speed adjusting shaft lever, with the engine operating at no load, to the maximum speed position. Then move the output shaft

© 1973 General Motors Corp.

governor rod to cause a speed decrease of several hundred rpm. Release the rod and check for hunting when the governor returns the engine to the maximum speed setting. If the engine stabilizes in less than three surges, the droop may be set too high; if the engine does not stabilize in five surges, the droop may be set too low. Set the speed droop as follows:

a. If the engine hunts less than three surges, back off the inner speed adjusting spring eye bolt nut one full turn and tighten the outer nut one turn to retain the adjustment. If the engine hunts more than five surges, back off the outer speed adjusting spring eye bolt nut one full turn and tighten the inner nut one turn to retain the adjustment.

NOTE: The eye of the bolt must be in a horizontal plane to avoid twisting the spring.

b. Reset the maximum engine no-load speed, if necessary, as outlined in Steps 9 and 10.

c. Recheck the speed droop. The engine speed should be stable when the governor droop is 7-1/2% to 10% of the full-load speed. For example, at an output shaft speed setting of 1800 rpm full load, the output shaft speed droop should be 150 to 200 rpm. Therefore, the no-load output shaft speed should be set at 1950 to 2000 rpm.

MECHANICAL OUTPUT SHAFT GOVERNOR AND EARLY DESIGN LINKAGE

The Pierce output shaft governor is located at the rear of the engine (Fig. 3) and may be gear driven from the output shaft of the torque converter, or belt driven by a pulley on the torque converter output shaft. If the governor is belt driven, an internal oil sump is provided for lubrication; if it is gear driven by the torque converter output shaft, lubrication is through an external line from the torque converter to the governor.

On some applications where a very low speed is required, such as in structural steel setting, the output shaft governor may be equipped with an overrule lever which allows the operator to decrease the speed of the output shaft to zero or slightly above, depending on the load on the output shaft. The overrule lever is necessary because the output shaft governor will not function at very low output shaft speeds. If the operator moves the overrule lever, the ball bearing roller contacts the linkage operating lever, moving it towards the idle position, thereby reducing the torque converter output shaft speed as desired. Whenever the engine is to be shut down, the governor overrule lever should be positioned to move the engine governor throttle control lever into its idle position. The engine may then be shut down by moving the engine governor shut-off lever into the stop position.

Adjustments

Refer to Fig. 3 and adjust the governor and linkage as follows:

1. Adjust the exhaust valve clearance and time the injectors.

2. Disconnect the linkage from the output shaft governor to the engine governor. Then adjust the engine governor as outlined in Section 14.3. After the adjustments are completed, reconnect the linkage.

NOTE: The throttle shaft lever on the engine governor moves approximately 32-1/2 degrees from the idle to the full-fuel position. The throttle shaft lever should be adjusted so that when it is in the center of its travel, it is on an imaginary line through the center of the governor operating shaft perpendicular to the cylinder head. This will allow the throttle shaft lever on the engine governor and the speed control lever of the output shaft governor to move approximately the same distance. This adjustment can be made by loosening the bolt on the throttle shaft lever and the bolt on the throttle control shaft (short) lever (5), Fig. 3, then moving the engine governor throttle shaft lever to the desired position and retightening the bolts.

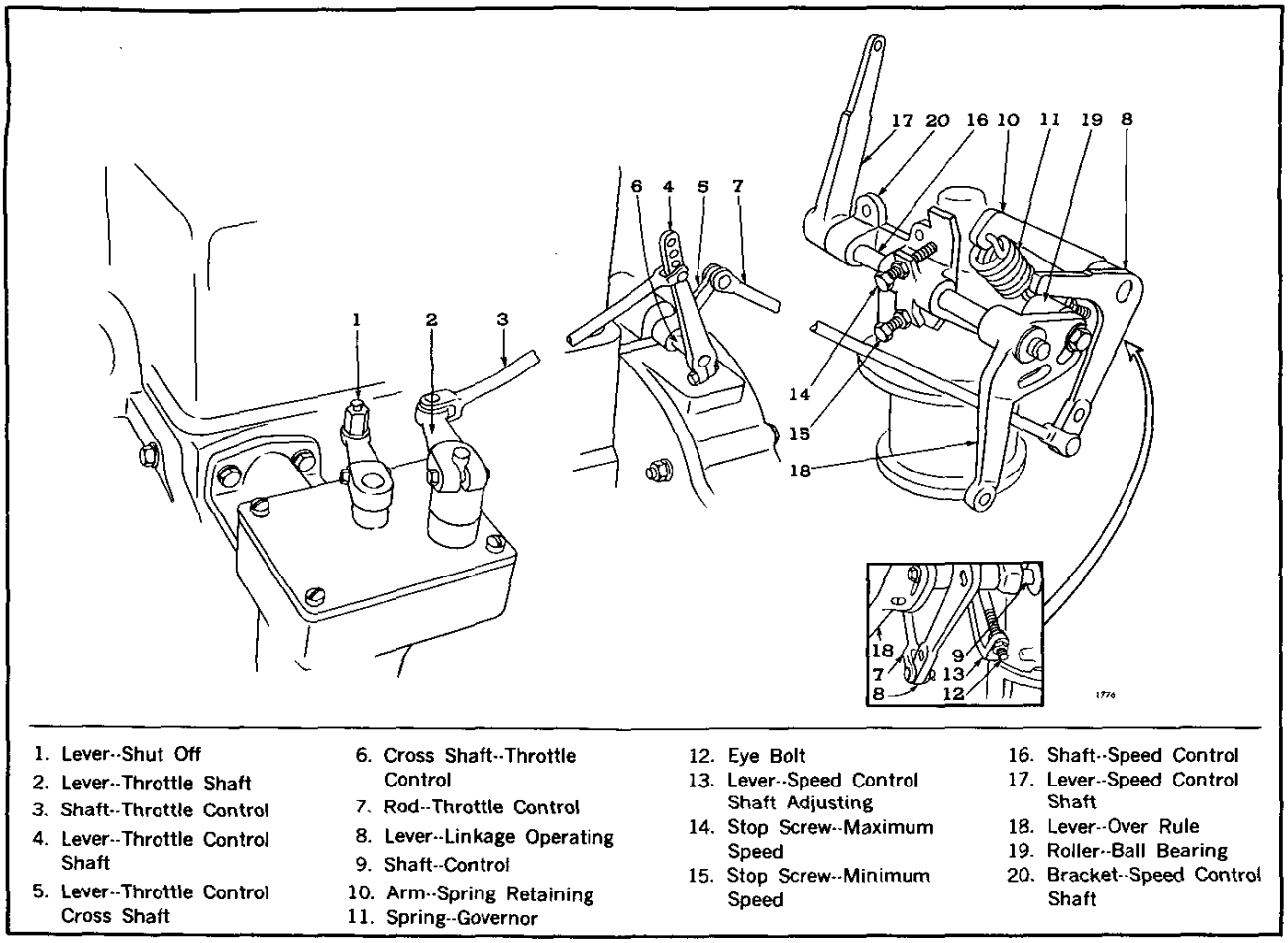
IMPORTANT: The throttle control shaft (3) should be attached to the bottom hole in the throttle control cross shaft (4 hole) lever (4).

3. Lubricate all joints of the throttle control linkage and make sure the linkage is free of any bind.

4. Loosen the lock nut and turn in the output shaft governor minimum speed stop screw (15) until sufficient spring force is applied to hold the linkage operating lever (8) in the full-fuel position.

5. Hold the throttle control cross shaft (4 hole) lever (4) in the full-fuel position and tighten the clamping bolt in the throttle control cross shaft (short) lever (5). This will put both the linkage operating lever (8) and the engine governor throttle shaft lever (2) in the full-fuel position.

© 1973 General Motors Corp.



1. Lever--Shut Off
2. Lever--Throttle Shaft
3. Shaft--Throttle Control
4. Lever--Throttle Control Shaft
5. Lever--Throttle Control Cross Shaft
6. Cross Shaft--Throttle Control
7. Rod--Throttle Control
8. Lever--Linkage Operating
9. Shaft--Control
10. Arm--Spring Retaining
11. Spring--Governor
12. Eye Bolt
13. Lever--Speed Control Shaft Adjusting
14. Stop Screw--Maximum Speed
15. Stop Screw--Minimum Speed
16. Shaft--Speed Control
17. Lever--Speed Control Shaft
18. Lever--Over Rule
19. Roller--Ball Bearing
20. Bracket--Speed Control Shaft

Fig. 3 - Mechanical Output Shaft Governor and Early Design Linkage

6. Back out the minimum speed stop screw (15) until it is flush with the rear face of the minimum speed screw retaining boss of the speed control shaft adjusting lever (13). Place the linkage operating lever (8) in the full-fuel position. Move the speed control shaft lever (17) towards the minimum speed position until the extension on the speed control shaft adjusting lever (13) contacts the lug on the spring retaining arm (10) forcing the throttle shaft lever on the engine governor into the idle position.

If there is no lug on the side of the spring retaining arm (10), the minimum speed stop screw may be backed off until the clearance between the eye bolt (12) and the bottom of the spring retaining arm (10) is 1/8 ".

NOTE: The above adjustments permit the engine to be returned to the idle position through the movement of the speed control shaft lever (17) towards the reduced fuel position. On some applications, the low-speed stop screw (15) may be used to maintain an engine speed above the idle setting. On these installations, it is necessary to use the overrule lever (18) to return the engine to the idle speed position before being shut-down.

7. Hold the speed control shaft lever (17) in the minimum speed position, established in Step 6 above, and screw the minimum speed stop screw in until it contacts the speed control shaft bracket (20). Retighten the lock nut.

8. Holding the speed control shaft lever in the minimum speed position, back off the inner nut on the eye bolt (12). Turn in the outer nut (clockwise) on the eye bolt (12) until the spring is just barely tight. Retighten the inner lock nut.

CAUTION: Do not pre-load the spring to the extent that it would prevent the shaft lever on

© 1973 General Motors Corp.

the engine governor from moving into the idle position.

9. Start the engine and move the speed control shaft lever (17) in a direction to provide the maximum desired no-load output shaft speed. The no-load speed of the output shaft should be approximately 200 rpm higher than the required full-load speed.

NOTE: Any remote throttle control linkage attached to the speed control shaft lever (17) must be very rigid and hold the speed control shaft firmly without permitting it to move in response to engine speed changes.

10. Turn in the maximum speed stop screw (14), until the screw contacts the speed control shaft bracket (20), to maintain the NO-LOAD speed setting.

11. Move the speed control shaft lever (17) to the idle position and then return to the full- fuel position, thereby bottoming the maximum speed stop screw (14) against the speed control shaft bracket (20). There should be no change in the high speed setting of the engine.

© 1973 General Motors Corp.

HYDRAULIC OUTPUT SHAFT GOVERNOR AND LINKAGE ADJUSTMENT

A hydraulic governor is used to maintain a near constant output shaft speed on engines equipped with a Series 500 or larger Torqmatic converter. The governor is mounted on the converter and gear driven from the output shaft.

The output shaft governor is connected to the engine governor by control rods and levers (Figs. 1, 2 and 3). The control rod end ball joints are sealed assemblies and do not require lubrication. However, the throttle control shaft bearings should be lubricated periodically with all purpose grease through the grease fittings. Other moving parts of the control linkage should be lubricated with engine oil.

In most applications, such as drag line and shovel operation, it is desirable to have the output shaft governor control the fuel input to maintain a relatively constant output shaft speed. The output shaft speed will be constant up to full power of the engine, except for the amount of governor droop. The speed setting of the engine governor must be sufficiently higher than the speed setting of the output shaft governor so the engine governor will not reduce the fuel input to the engine before full power is required by the output shaft governor. As load is applied to the output shaft, the output shaft speed will decrease gradually up to the amount of the output shaft governor droop at full load. At the same time, the engine speed will gradually increase until full load is reached.

In some types of operation, such as laying of structural steel, it is desirable to operate the unit with a very low output shaft speed. This speed could be so low that the output shaft governor ball head assembly would not actuate the governor pilot valve and spring seat assembly. In such applications, the engine governor operating lever (6), Fig. 1, or the remote throttle control lever (1), Figs. 2 and 3, used as an overrule lever, can be moved toward the idle speed position sufficiently to provide the desired low output shaft speed. Output shaft speeds down to zero can be obtained through this type of engine governor control. The engine governor would maintain control unless the output shaft speed increased to the speed setting of the output shaft governor.

Several types of governor control linkages are in use. The adjustment procedure for each type is outlined in the following paragraphs.

Adjustments (Type A - Fig. 1)

The engine governor throttle control lever (Fig. 1) is pinned to the throttle shaft. The engine governor operating lever is mounted below the throttle control lever and rides on the throttle shaft boss on the governor cover. The output shaft governor lever is mounted above the throttle control lever and is retained on the shaft by a snap ring. A stop pin, pressed into the throttle control lever, transmits movement of the output shaft governor lever and/or engine governor operating lever through the throttle control lever to the injector racks. The torsion spring, used to retain the throttle control lever stop pin against the output shaft governor lever, yields to permit the governor operating lever to move the throttle control lever toward the idle position, regardless of the position of the output shaft governor control lever. A slot in the underside of the governor cover hub limits the travel of the throttle control lever in both the maximum and minimum speed positions.

The engine shut-down lever is connected through a shaft to another lever, under the governor cover, which bears against the pin in the differential lever. To stop the engine, the shut-down lever is used to move the differential lever to the no-fuel position.

The following linkage and governor adjustments should be made with the engine stopped, and *after* the limiting speed engine governor has been adjusted as outlined in Section 14.3.

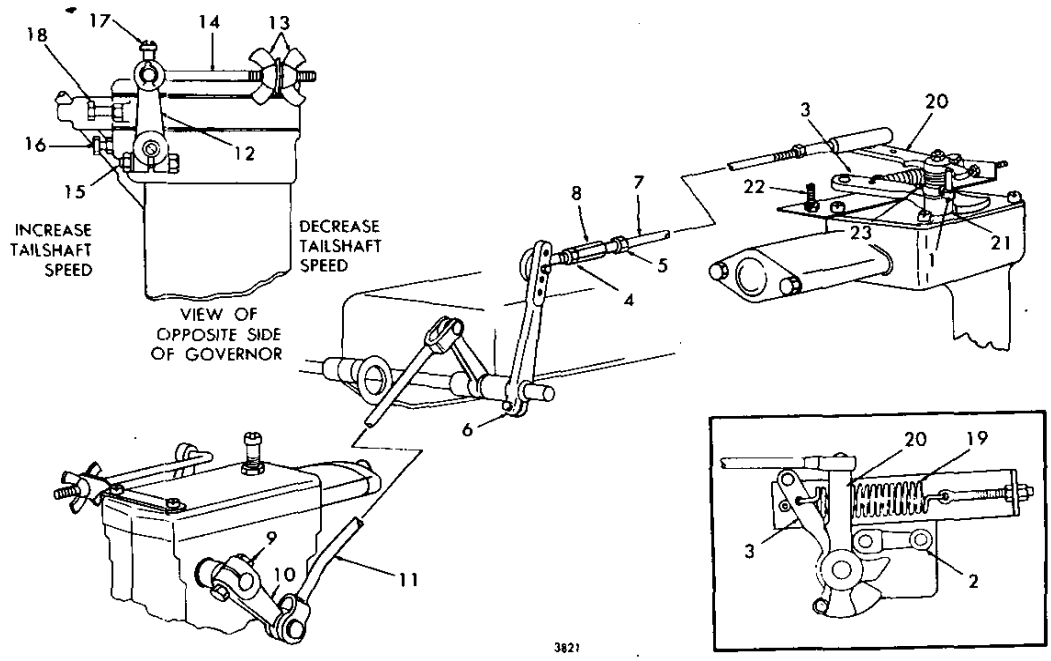
1. Connect the linkage to the governor operating lever (Fig. 1) and check the total travel of the lever. The lever should move to the stop bolt in one direction and the governor lever return spring should move the lever, in the other direction, until the throttle control lever reaches the end of its travel.

2. Move the governor operating lever to the maximum speed position (against the stop bolt).

3. Move the output shaft governor control lever to the full-fuel position and retain it by moving the speed control lever to the maximum speed position. Then move the output shaft governor lever (on the engine governor cover) and the throttle control lever together to the maximum speed position and retain there.

NOTE: This operation closes the low speed gap (in the engine governor) which may require more torque than is available from the torsion spring between the two levers. Thus, it is

© 1974 General Motors Corp.



1. Lever--Throttle Control
2. Lever--Shut Down
3. Lever--Governor Operating
4. Lock Nut--Turnbuckle
5. Lock Nut--Turnbuckle
6. Lever--Throttle Control Rear Cross-Shaft
7. Rod--Engine Governor
8. Turnbuckle
9. Bolt
10. Lever--Output Shaft Governor Control
11. Rod--Output Shaft Governor
12. Lever--Speed Control
13. Wing Nuts--Speed Adjusting
14. Link--Sliding
15. Bolt
16. Screw--Maximum Speed Limit Adjusting
17. Screw--Minimum Speed Limit Adjusting
18. Screw--Maximum Fuel Adjusting
19. Spring--Governor Lever Return
20. Lever--Output Shaft Governor
21. Pin--Stop
22. Bolt--Stop
23. Spring--Torsion

Fig. 1 - Hydraulic Output Shaft Governor and Linkage (Type A)

important that they be held together, permitting no space between the throttle control lever pin and the arm of the output shaft governor lever.

4. To adjust the linkage between the output shaft governor and the engine governor, loosen the output shaft governor rod clamping bolt in the ball joint in the rear cross-shaft lever. Next, move the output shaft governor rod until there is approximately .020 " clearance between the stop pin and the output shaft governor lever. Then tighten the clamping bolt securely.

NOTE: The engine governor control rod is connected to the outer bolt hole in the output shaft governor lever.

5. To adjust the governor operating lever return spring, retain the output shaft governor control lever in the full-fuel position and increase the tension on the spring by adjusting the eye bolt and lock nuts until the tension of the torsion spring is overcome and the throttle control lever is moved against the stop in the idle position.

Final Adjustments

Move the output shaft governor lever in the idle speed position and start the engine.

After the engine reaches normal operating temperature, advance the output shaft governor speed control lever to the maximum speed position and check the Torqmatic converter output shaft speed. This speed will vary depending upon engine application.

© 1974 General Motors Corp.

If it is necessary to adjust the output shaft speed, loosen the wing nuts on the sliding link and move the speed control lever to increase or decrease the speed as needed.

The output shaft governor is driven through the converter and there is a high droop. Therefore, the no-load speed setting should be at least 150 rpm higher than the desired full-load speed setting. Tighten the wing nuts after completing the adjustment.

> **CAUTION:** Do not set the Torqmatic converter output shaft speed in excess of the speed specified by the equipment manufacturer, to prevent damage to the driven machinery.

It will be noted during engine operation that the minimum droop will vary between 150 and 175 rpm. If the droop requires adjustment, move the droop bracket (inside the output shaft governor) to decrease or increase the amount of droop.

> **NOTE:** To compensate for the output shaft speed droop, the engine no-load speed must be set approximately 175 rpm above the required engine full-load speed.

Move the output shaft governor speed control lever to the idle speed position and adjust the idle speed by means of the minimum speed limit adjusting screw. The maximum fuel adjusting screw and the maximum speed limit adjusting screw are not used and should be backed out to prevent interference.

Adjustments (Type B - Fig. 2)

The linkage from the output shaft governor to the engine governor in Type B (Fig. 2) and Type C (Fig. 3) is similar. However, the SGXA Woodward hydraulic governor housing castings have been provided with integral bosses for the speed control and terminal lever shafts. As a result, the plate-type speed control lever locking mechanism (Type C) has been replaced by a sliding link and two wing nuts (Type B) mounted on a bracket fastened to the governor cover.

The following linkage and governor adjustments should be made with the engine stopped, and *after* the limiting speed engine governor has been adjusted as outlined in Section 14.3.

1. Place the remote throttle control lever (1), Fig. 2, in the maximum speed position.

2. Move the governor speed control lever (6) and governor stop lever (4) into the "idle" notch in the governor cam (5). The repulsing spring (7) should be fully compressed when the stop lever reaches the "idle" notch of the governor cam.

If the repulsing spring is not fully compressed, loosen the bolt (3) in the governor speed control lever and move the lever until the spring is compressed.

If the repulsing spring becomes fully compressed before the governor stop lever reaches the "idle" notch in the governor cam, loosen the bolt (3) in the governor speed control lever and manually move the stop lever into the "idle" notch.

3. Hold the governor stop lever (4) halfway between the *idle* and *maximum speed* positions and loosen the lock nuts (8) and (9). Adjust the turnbuckle (13) so the rear cross- shaft lever (11) is vertical.

4. Loosen the bolt (14) and remove the output shaft governor control lever (15). Place the governor stop lever (4) into the *idle* position by moving the rear cross shaft lever (11) and reinstall the output shaft governor control lever.

> **NOTE:** Move the rear cross shaft lever (11) into the *maximum speed* position and check to see that there is no binding between the clevis on the end of the throttle rod (21) and the output shaft governor control lever (15).

5. Move the governor stop lever (4) into the *maximum speed* position in the governor cam (5) and check to see that there is 1/32 " to 1/16 " clearance between the rod end bearing (20) and the hex head of the spring bolt (19). If the clearance is not correct, loosen the lock nut and adjust the spring bolt.

6. Manually hold the governor stop lever (4) in the *idle* position. Loosen the lock nuts (8) and (9) and adjust the turnbuckle (13) until the shoulder on the throttle rod (12) just contacts the rod end bearing (22) and holds the stop lever in the *idle* position.

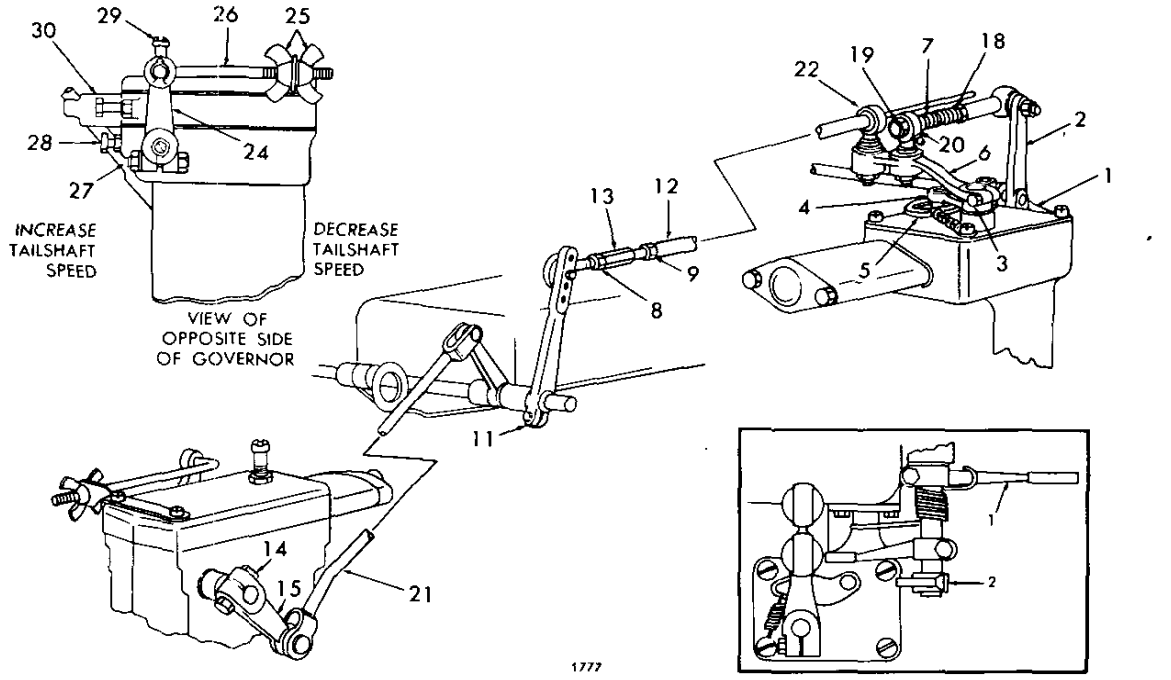
Final Adjustments

Place the remote throttle control lever (1) in the "mid-position", then start the engine. After the engine reaches normal operating temperature, place the remote throttle control lever in the *maximum speed* position and check the Torqmatic converter output shaft speed. This speed will vary depending upon engine application requirements.

If it is necessary to adjust the output shaft speed, loosen the wing nuts on the sliding link as needed and move the speed control lever to increase or decrease the speed.

The Torqmatic converter hydraulic output shaft governor is driven through the torque converter and there is a high droop. Therefore, the *no load* setting should be at least 150 rpm higher than the desired

© 1974 General Motors Corp.



1. Lever--Remote Throttle Control
2. Lever--Governor Throttle Control
3. Bolt
4. Lever--Governor Stop
5. Cam--Governor
6. Lever--Governor Speed Control
7. Spring--Repulsing
8. Lock Nut--Turnbuckle
9. Lock Nut--Turnbuckle
11. Lever--Throttle Control Rear Cross-Shaft
12. Rod--Throttle
13. Turnbuckle
14. Bolt
15. Lever--Output Shaft Governor Control
18. Lock Nut
19. Bolt--Spring
20. Bearing--Rod End
21. Rod--Throttle
22. Bearing--Rod End
24. Lever--Speed Control
25. Wing Nuts--Speed Adjusting
26. Link--Sliding
27. Bolt
28. Screw--Maximum Speed Limit Adjusting
29. Screw--Minimum Speed Limit Adjusting
30. Screw--Maximum Fuel Adjusting

Fig. 2 - Hydraulic Output Shaft Governor and Linkage (Type B)

full-load setting. Tighten the wing nuts after completing the adjustment.

CAUTION: Do not set the Torqmatic converter output shaft speed in excess of the speed specified by the equipment manufacturer, to prevent damage to driven machinery.

During engine operation, it will be noted that the minimum droop will vary between 150 to 175 rpm. If the droop requires adjustment, move the droop bracket (inside the hydraulic output shaft governor) to decrease or increase the amount of droop.

NOTE: To compensate for the output shaft speed droop, the engine no-load speed must be set approximately 175 rpm above the required engine full load speed.

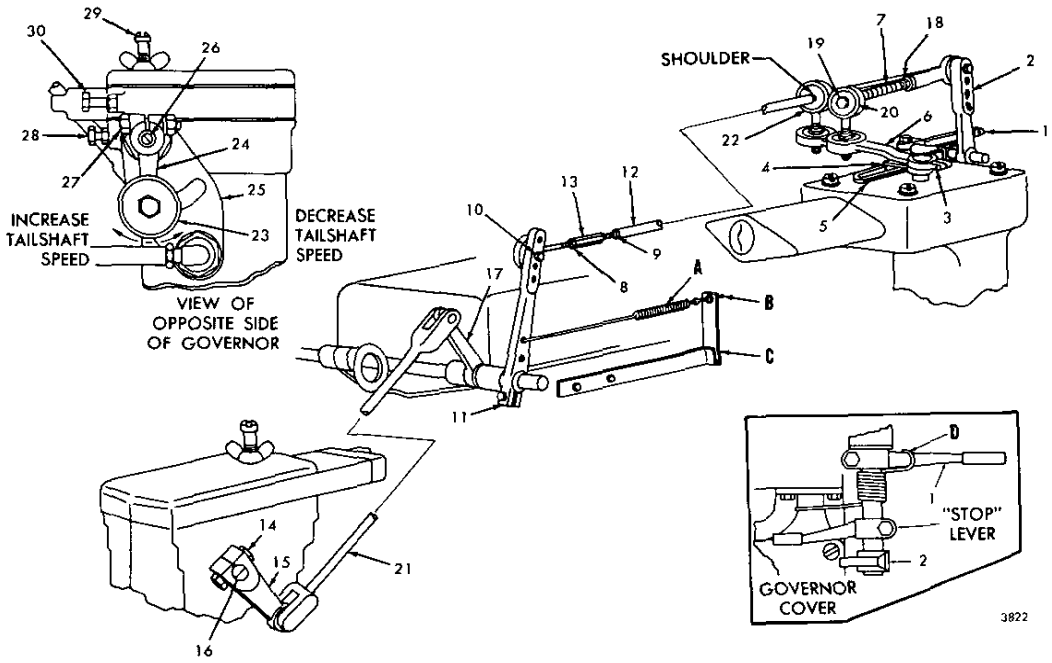
In this application of a hydraulic governor, the maximum fuel adjusting screw (30) and the maximum speed limit adjusting screw (28) are not used and, therefore, should be backed out to prevent any interference.

Adjustments (Type C - Fig. 3)

The following adjustments apply to units equipped with the former SGXA Woodward hydraulic output shaft governor which incorporates the knob and plate type speed control lever locking mechanism (Fig. 3).

This procedure applies to units incorporating keyed levers and a non-adjustable output shaft governor throttle rod and, with the revisions set forth under the paragraph entitled *Early Installations*, may be used to

© 1974 General Motors Corp.



1. Lever--Remote Throttle Control
2. Lever--Governor Throttle Control
3. Bolt
4. Lever--Governor Stop
5. Cam--Governor
6. Lever--Governor Speed Control
7. Spring--Repulsing
8. Lock Nut--Turnbuckle
9. Lock Nut--Turnbuckle
10. Bolt--End Bearing
11. Lever--Throttle Control Rear Cross Shaft
12. Rod--Throttle
13. Turnbuckle
14. Bolt and Nut--Clamp
15. Lever--Output Shaft Governor Control
16. Shaft--Governor Terminal
17. Lever--Throttle Control Rear Cross Shaft
18. Lock Nut
19. Bolt--Spring
20. Bearing--Rod End
21. Rod--Throttle
22. Bearing--Rod End
23. Knob--Speed Control
24. Lever--Speed Control
25. Plate--Speed Control Knob
26. Shaft--Speed Adjusting
27. Bolt--Clamping
28. Screw--Maximum Speed Limit Adjusting
29. Screw--Minimum Speed Limit Adjusting
30. Screw--Maximum Fuel Adjusting
- A. Spring--Pull Back
- B. Eyebolt--Pull Back Spring Adjusting
- C. Bracket--Pull Back Spring
- D. Spring--Throttle Control Return

Fig. 3 - Hydraulic Output Shaft Governor and Linkage (Type C - With Keyed Levers)

adjust former units equipped with a Torqmatic converter output shaft governor.

The following linkage and governor adjustments should be made with the engine stopped, and *after* the limiting speed governor on the engine has been adjusted according to the procedure outlined in Section 14.3.

1. Place the remote throttle control lever (1), Fig. 3, in the *maximum speed* position.

2. Move the governor speed control lever (6) and governor stop lever (4) in the "idle" notch in the governor cam (5). The repulsing spring (7) should be fully compressed when the stop lever reaches the "idle" notch of the governor cam.

If the repulsing spring is not fully compressed, loosen the bolt (3) in the governor speed control lever and move the lever until the spring is compressed.

If the repulsing spring becomes fully compressed before the governor stop lever reaches the "idle" notch in the governor cam, loosen the bolt (3) in the governor speed control lever and manually move the stop lever into the "idle" notch.

3. Hold the governor stop lever (4) halfway between the *idle* and *maximum speed* positions and loosen the

© 1974 General Motors Corp.

lock nuts (8) and (9). Adjust the turnbuckle (13) so the rear cross- shaft lever (11) is vertical.

4. Loosen the bolt (14) and remove the output shaft governor control lever (15). Place the governor stop lever (4) in the *idle* position by moving the rear cross shaft lever (11) and reinstall the output shaft governor control lever.

> **NOTE:** Move the rear cross shaft lever (11) into the *maximum speed* position and check to see that there is no bind between the clevis on the end of the throttle rod (21) and the output shaft governor control lever (15).

5. Move the governor stop lever (4) into the *maximum speed* position in the governor cam (5) and check to see that there is 1/32 " to 1/16 " clearance between the rod end bearing (20) and the hex head of the spring bolt (19). If the clearance is not correct, loosen the lock nut and adjust the spring bolt.

6. Manually hold the governor stop lever (4) in the *idle* position. Loosen the lock nuts (8) and (9) and adjust the turnbuckle (13) until the shoulder on the throttle rod (12) just contacts the rod end bearing (22) and holds the stop lever in the *idle* position.

Early Installations

In a few isolated cases, when the load was removed from the output shaft, the force exerted by the repulsing spring prevented the output shaft governor from moving the engine governor stop lever fully into the idle position; therefore, to eliminate the possibility of the recurrence of this difficulty, the force exerted by this spring was reduced. If the governor stop lever does not return to the idle position, loosen the governor speed control lever clamp bolt (3) and move the lever away from the governor a sufficient amount to very slightly relieve the tension on the repulsing spring (7). This reduction in spring force will permit the governor speed control lever (6) to return to the idle position; however, repeat Step 5 to obtain clearance between the head of the spring bolt (19) and the rod end bearing (20).

Early installations included a pull-back spring (A), one end of which was connected to an eye-bolt (B) in a bracket (C) attached to the cylinder head. The other end of the spring was hooked into the upper small hole drilled in the throttle control rear cross shaft lever (11). This spring is adjusted by means of the eye-bolt, to counteract the tension of the repulsing spring (7) which tends to move the governor speed control lever (6) into the full-fuel position. Spring (A) should be adjusted so its force solidly compresses the repulsing spring when the governor speed control lever is in the idle position. The function performed by the retracting spring (A) in the early installations is accomplished in current installations by a spring incorporated in the output shaft governor assembly.

In these early installations, the governor terminal shaft (16) must be rotated in a counterclockwise direction to the no-fuel position when installing the output shaft governor control lever on the terminal shaft. This can be accomplished with a screwdriver inserted into the slot provided in the end of the terminal shaft.

The remote control linkage installed in various engine Torqmatic converter and output shaft governor linkage installations may include a variety of bellcranks, levers, rods and flexible control cable. Due to the probability of moving the throttle control lever into various operating positions between stop, idle and run many times during the working day, any play in the linkage may gradually delay the instantaneous response of the linkage when moving the throttle control lever from one position to another. In view of this, a throttle control lever return spring has been added to the linkage arrangement to take-up any play (which may be caused by worn clevises or pins) by keeping the linkage *loaded* against the operator's control.

The new spring is installed on the front cross shaft--the long curved end of the spring bears against that portion of the engine governor housing which is connected to the cylinder head--the opposite end hooks over the throttle control lever as shown in the inset of the accompanying illustration and marked "D".

The throttle control lever return springs for use on "A" and "C" type engines may be incorporated in the output shaft governor linkage of former installations which do not include this feature. All that need be done is to remove the stop and governor throttle control levers from the front cross shaft and install the spring on the shaft so the long end bears against the governor housing and the short end is hooked over the throttle control lever.

The control rods and cross shafts used in the output shaft governor linkage have been revised from time to time in order to provide a more secure linkage, locate the levers in a fixed position, and thus simplify the procedure for adjusting the linkage.

Shortly after the advent of the keyed cross shafts, several minor revisions were incorporated in order to further improve the geometrical relationship between the rods and levers.

The revisions to the front cross shaft are as follows:

a. The addition of another key-slot for the governor

© 1974 General Motors Corp.

throttle control lever to permit its use on "C" type engines.

b. The relocation of the key-slot for the throttle control lever 180 ° from its former position, thus positioning the key-way on the shaft facing the key-way in the lever; formerly, the key-way in the shaft faced the "split" in the lever.

c. The addition of a key-slot for the stop lever.

The revisions in the rear cross shafts and one of the governor control rods are as follows:

a. The rear cross shaft with key-ways spaced 37-1/2 ° apart was revised by spacing the keyways 44 ° apart. This shaft is used only on engine units incorporating TCA type Torqmatic converters.

b. The output shaft governor control rod was shortened approximately 3/8 " to conform with the relocated key slots in the above described rear cross shaft. This rod is used only on engine units incorporating TCA type Torqmatic converters.

c. A new rear cross shaft with key-ways spaced 32 ° apart has superseded the former rear cross shaft with the key-ways spaced 37-1/2 ° apart. This shaft is used only on engine units incorporating TCDA type Torqmatic converters.

d. The output shaft governor control rod remains unchanged and is used only on engine units incorporating TCDA type Torqmatic converters.

Since the output shaft governor control lever may be removed from the terminal shaft and moved slightly in either direction and, the turnbuckle on the throttle rod or the spring bolt on the governor control shaft adjusted to compensate for any small variations in length caused by relocating the key slots, the foregoing revisions will in no way alter the procedure for adjusting the Torqmatic converter output shaft governor linkage (with keyed levers).

Final Adjustments

Place the remote throttle control lever (1) in the "mid-position", then start the engine. After the engine reaches normal operating temperature under no-load, place the remote throttle control lever in the *maximum speed* position and check the Torqmatic converter output shaft speed. This speed will vary depending upon engine application requirements.

If it is necessary to adjust the output shaft speed, loosen the speed-control knob and move the speed control lever toward the engine to increase speed, or away from the engine to decrease speed.

The high droop of the Torqmatic converter output shaft hydraulic governor is due to it being driven through the torque converter; therefore, the no-load setting should be at least 150 rpm higher than the desired *full-load* setting. Tighten the speed control knob when the required no-load speed is obtained.

CAUTION: Do not set the Torqmatic converter output shaft speed in excess of the speed specified by the equipment manufacturer, otherwise damage may result to the driven machinery.

During engine operation, it will be noted that the minimum droop will vary between 150 to 175 rpm. If the droop requires adjustment, move the droop bracket (inside the output shaft hydraulic governor) toward the engine to decrease or away from the engine to increase the amount of droop.

NOTE: To compensate for the output shaft speed droop, the engine no-load speed must be set approximately 175 rpm above the required engine full-load speed.

In this application of a hydraulic governor, the maximum fuel adjusting screw and the maximum speed adjusting screw are not used and, therefore, should be backed out to prevent interference.

© 1974 General Motors Corp.

THROTTLE LINKAGE ADJUSTMENT FOR LOAD EQUALIZATION

TWIN AND QUAD UNITS

Each twin unit consists of two engines and each quad unit consists of four engines connected by clutches to a common gear box. The throttle adjustment is made so that each engine of a twin or quad unit will carry its share of the load. Throttle adjustments are divided into three groups:

1. Throttle adjustments on twin or quad units with limiting speed mechanical governors.

2. Throttle adjustments on side by side twin or quad units with variable speed mechanical governors.

3. Throttle adjustments on tandem twin marine units with variable speed mechanical governors.

1. TWIN OR QUAD UNITS USING LIMITING SPEED MECHANICAL GOVERNORS

The individual engine tune-up is very important in the adjustment of twin and quad units as the engines must be closely synchronized to enable each to carry its full share of the load.

Therefore, disconnect the control rods from the control levers and perform the tune-up procedures for single engines before adjusting the throttle control linkage (Fig. 2). Then, with the engines stopped and the valve rocker covers removed:

1. Check the two levers on top of each governor for vertical alignment (i.e. one exactly over the other). If the levers are not in alignment, adjust the top lever on its shaft until the alignment is correct (Fig. 2).

2. Make sure that the individual throttle control levers are latched to their quadrant by the positioning pin (Fig. 1).

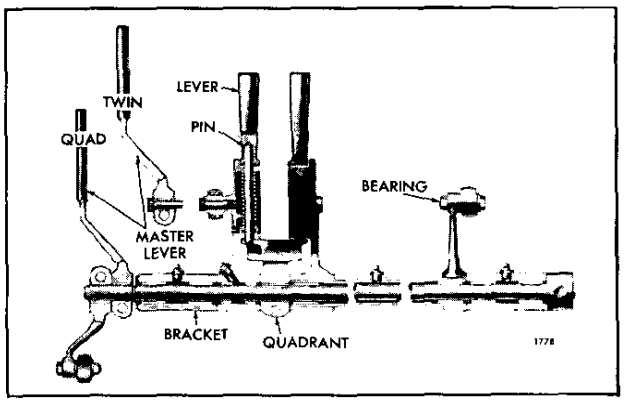


Fig. 1 - Throttle Control Shaft Assembly - Twin and Quad Units

3. Move the master throttle control lever to the *full-fuel* position.

4. Make sure each control lever is in the *full-fuel* position (Fig. 2). The pin of the lever must be just touching the end of the slot in the cam.

5. If the governor control levers are not in the *full-fuel* position, loosen the two turnbuckle nuts and adjust the turnbuckles until all levers are in their *full-fuel* position (Figs. 2 and 3).

6. Tighten the turnbuckle locknuts and check the position of the lever. When tightening the locknuts, be careful not to "cock" the end bearing (Figs. 2 and 3).

7. Move the master control lever to the *idle* position and start the engines.

CAUTION: Be sure the clutches are disengaged before starting the engines.

8. Run the engines until they are at normal operating temperature.

9. Move the master control lever to the *idle* position and check the idle speed of each engine.

10. Move the master control lever to the *full-fuel* position and check the no-load speed of each engine.

11. Move the master control lever to a position approximately 200 rpm below the no-load speed. Check the engine speed. The engines should be running within 50 rpm of each other.

a. Move the master control lever to a position approximately 200 rpm below Step 11. Check the engine speed again. The engines should be running within 50 rpm of each other.

© 1983 General Motors Corp.

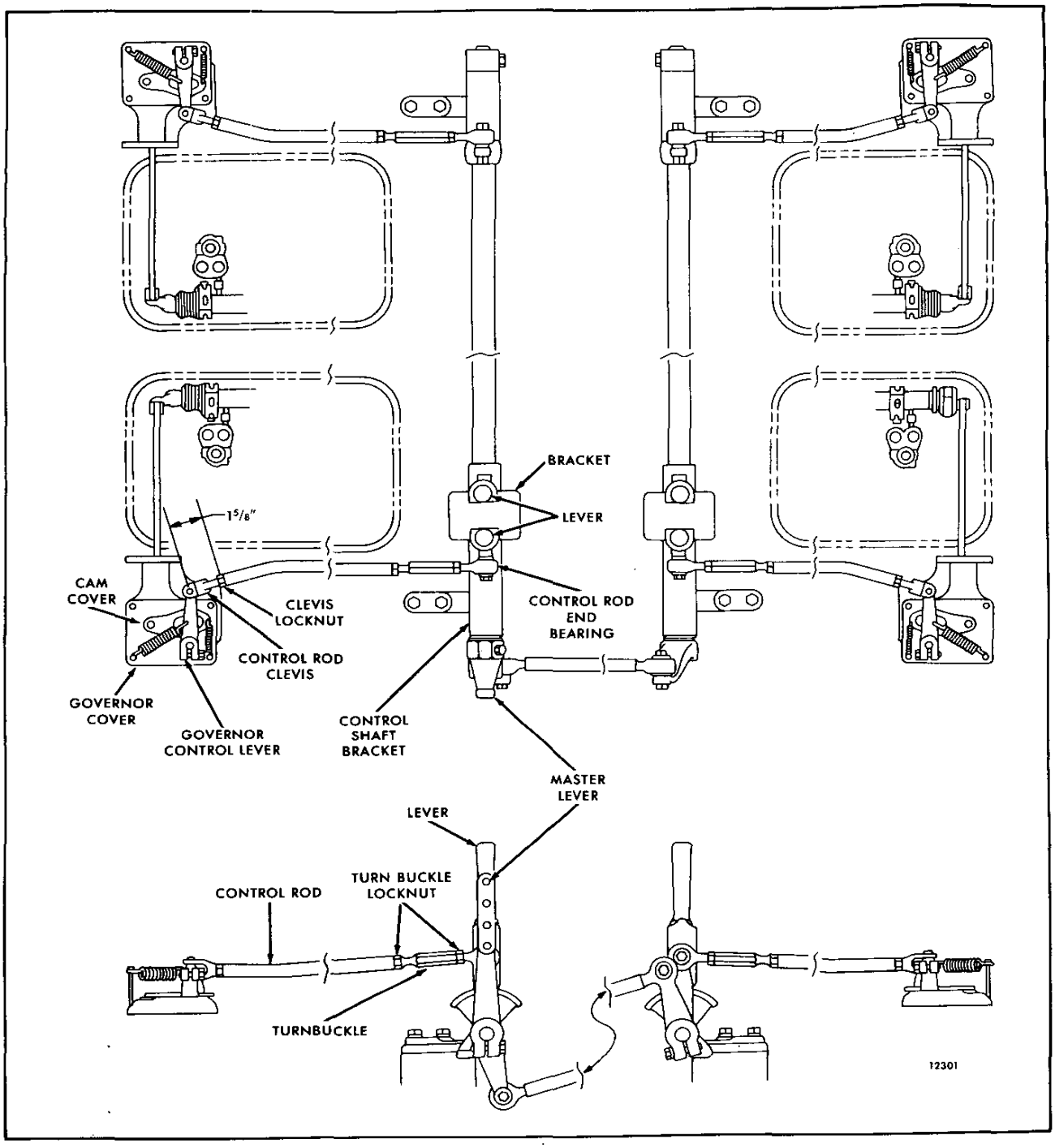


Fig. 2 - Diagram of Throttle Control Linkage for Quad Units with Limiting Speed Mechanical Governors

b. Move the master control lever to a position approximately 200 rpm below Step a. Check the engine speed again. They should be within 50 rpm of each other.

© 1983 General Motors Corp.

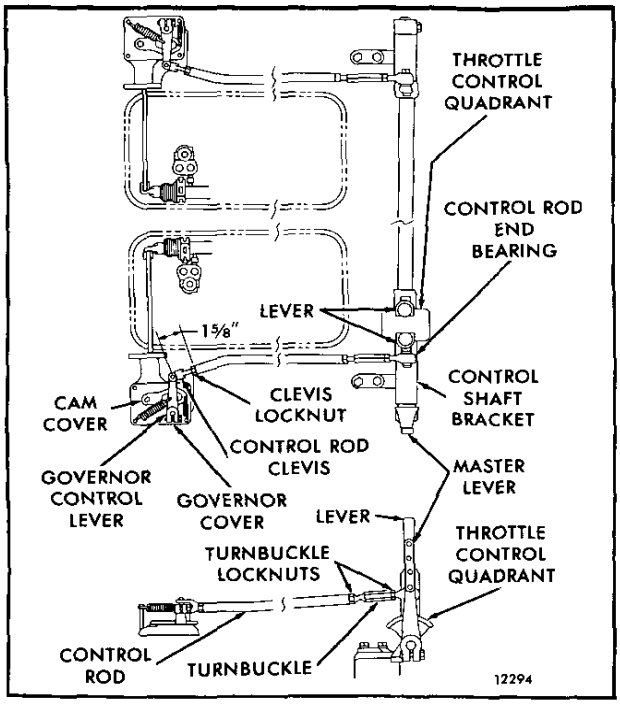


Fig. 3 - Diagram of Throttle Control Linkage for Twin Units with Limiting Speed Mechanical Governors

If this procedure does not bring the engines within close synchronization, recheck each engine for poor compression, faulty injectors, low fuel oil pressure or other conditions which may cause unsatisfactory engine operation. See *Trouble Shooting* in Section 15.2.

12. Install the valve rocker covers.

2. SIDE-BY-SIDE TWIN UNITS OR QUAD UNITS USING VARIABLE SPEED GOVERNORS

The individual engine tune-up is very important in the adjustment of twin and quad engine units as the engines must be closely synchronized to enable each to carry its full share of the load. Therefore, disconnect the control rods (30) from the control levers (4) and cross link equalizer spring (53) from the cross link (9)(Fig. 4). On quad units, loosen screw (29) and remove the master control equalizer spring (5) (Fig. 5). Then, with the engines stopped and the valve rocker covers removed:

1. Check the link (52) on each engine (Figs. 4 and 5). Be sure the bolt (6) is just touching the end of the link in the *idle* position.

2. Make sure that the individual throttle control levers (43) are latched to their quadrant (51) by the positioning pins (Fig. 1).

3. Move the master throttle control lever (32) to the *full-fuel* position (Figs. 4 and 5).

4. Make sure each control lever (4) is in the *full-fuel* position (all the way back).

5. If the governor control levers are not in the *full-fuel* position, loosen the two turnbuckle nuts (24) and adjust the turnbuckles (10) until all the levers are in their *full-fuel* position.

6. Tighten the turnbuckle locknuts (24) and check the position of each governor lever. Levers must be all the way back. Be careful not to "cock" the end bearing (22).

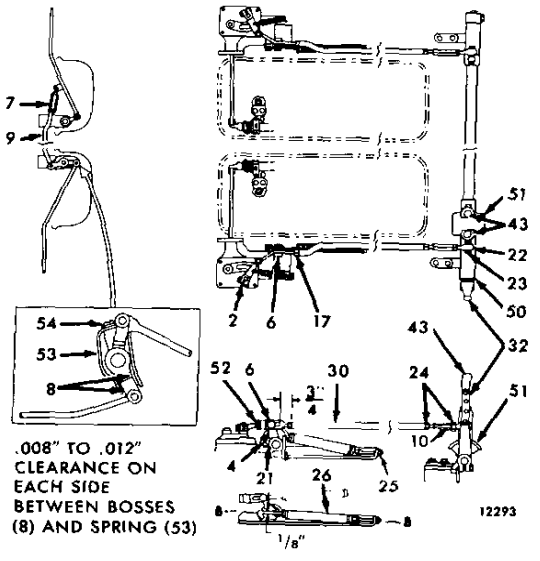
The following steps should be performed to adjust the booster spring (26), if necessary. With the idle speed set, the booster spring may be adjusted as follows:

a. Set the governor booster spring pin (21) 1/8" below over-center line B-B (Figs. 4 and 5).

b. Make sure the clutches are disengaged and start each engine.

c. Release each speed lever individually from the *full-fuel* position and note its return to the *idle* position. The lever should return quickly.

© 1983 General Motors Corp.



2. Lever--Governor Control
4. Lever--Speed Control
6. Bolt--Lever-to-Link
7. Turnbuckle--Cross Link Equalizer
8. Boss
9. Link--Equalizer
10. Turnbuckle
17. Locknut
21. Pin--Booster Spring
22. Bearing--Control Rod End
23. Bolt--Control Rod
24. Locknut--Turnbuckle
25. Locknut--Booster Spring Adjusting
26. Spring--Booster
30. Rod--Control
32. Lever--Master Throttle Control
43. Lever--Throttle Control
50. Bracket--Control Shaft
51. Quadrant--Throttle Control
52. Link--Control Rod End
53. Spring--Link Equalizer
54. Screw--Equalizer Spring

Fig. 4 - Diagram of Throttle Control Linkage for Twin Units with Variable Speed Mechanical Governors

d. Refer to Fig. 4 and loosen the booster spring retaining nut on the speed control lever (4). Loosen the nut and locknut on the eyebolt at the opposite side of the spring (26).

e. Move the bolt up or down in the slot of the lever (4) to a position that will allow the speed control lever to move from the *full-fuel* position to the *idle* position. Hold the bolt and tighten the spring retaining nut.

f. Turn the nut on the eyebolt to a position that will allow the speed control lever to be moved to the *full-fuel* position with the least amount of effort.

7. Connect each of the governor control rods (30) to the levers (4).

8. Set the gap between the end of link (52) and the governor control lever (4) at 1/16" to 1/8" by adjusting the lever (4) on its shaft. While setting the gap, the governor lever must be in the *idle* position, and the forward end of the slot in the link (52) must be contacting the lever-to-link bolt (6).

9. Secure the master throttle control lever (32) in the *full-fuel* position, then replace the equalizer spring (53) and secure it with screw (54).

10. Loosen the locknut (24) at turnbuckle (7). Adjust the turnbuckle until there is equal clearance between each leg of the equalizer spring (53) and lower boss (8), approximately .010" clearance on each side.

11. Tighten the turnbuckle locknut (24) and recheck the clearance. Readjust, if necessary.

12. Lubricate the link joints of the equalizer linkage with a few drops of engine oil. Move the master throttle control lever (32) back and forth to check for bind in the equalizer. Note if the equalizer link (9) rubs inside the tube. Correct any bind that may exist.

13. Disengage the clutches. Move the master throttle control lever (32) to the *idle* position and start the engines.

14. Run the engines until they are operating at normal temperature.

15. Move the master throttle control lever (32) to the *idle* position and check the idling speed.

The idling speed of the engine, not incorporating the equalizer spring (53), will probably be less than that of the engine which has the spring due to the expansion of the cross link (9). In such cases, remove the valve rocker cover and proceed as follows:

16. Loosen the equalizer turnbuckle locknut (24), and adjust the turnbuckle (7) until both engines are idling at the same speed. Clearance between each leg of the equalizer spring (53) and lower bosses (8) should be equal.

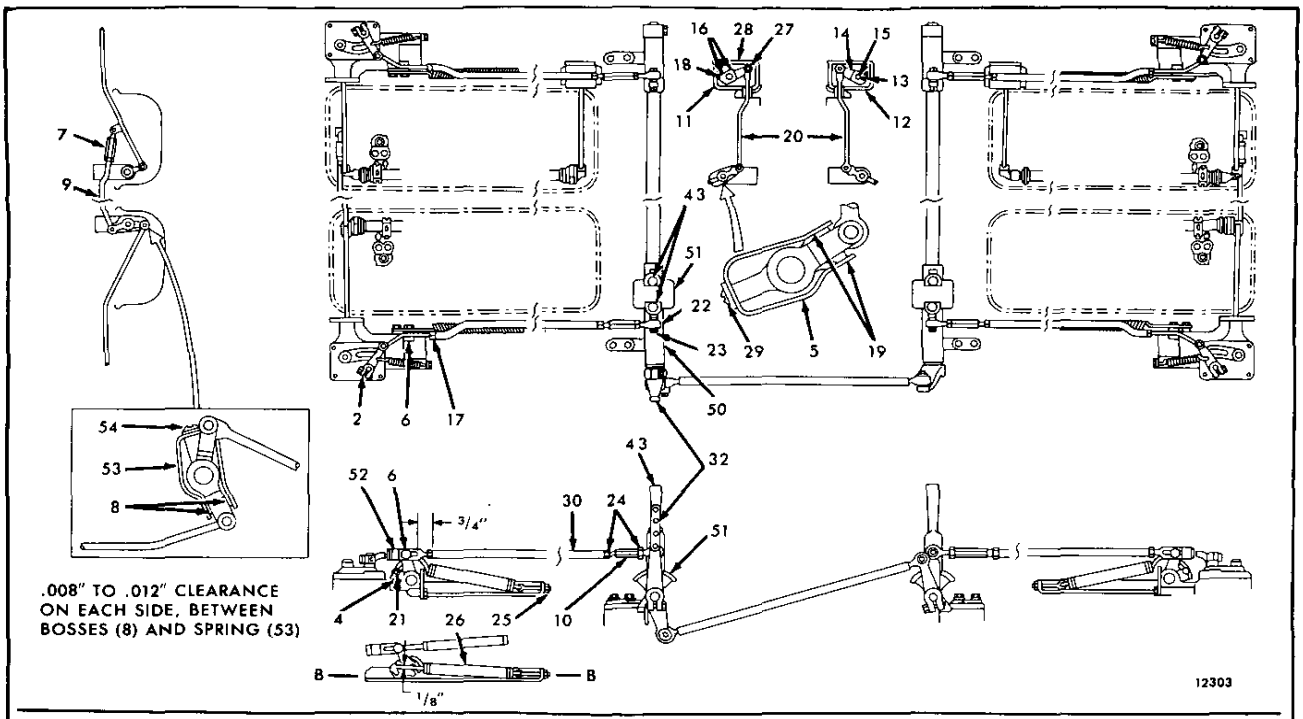
17. Install the valve rocker covers.

18. Start the engines and move the throttle control lever (32) to the full-fuel position and check the maximum no-load speed of each engine. The speed should now be the same as previously set. If not, check for bind in the equalizer.

19. With the clutches still disengaged, move the master throttle control lever until the engines are running approximately 200 rpm lower than the maximum no-load speed.

20. Use a hand tachometer to check the speed of the

© 1983 General Motors Corp.



2. Lever--Governor Control
4. Lever--Speed Control
5. Spring--Equalizer
6. Bolt--Lever-to-Link
7. Turnbuckle--Cross Link Equalizer
8. Boss
9. Link--Equalizer
10. Turnbuckle
11. Housing--Master Control Equalizer
12. Housing--Master Equalizer
13. Bolt
14. Lever--Master Equalizer
15. Shaft--Equalizer
16. Screw--Adjusting
17. Locknut
18. Lever--Master Control Equalizer
19. Boss--Master Control Equalizer
20. Link--Master Control Equalizer
21. Pin--Booster Spring
22. Bearing--Control Rod End
23. Bolt--Control Rod
24. Locknut--Turnbuckle
25. Locknut--Booster Spring Adjusting
26. Spring--Booster
27. Bolt--Equalizer Housing
28. Cover--Equalizer Housing
29. Screw--Master Control Equalizer Spring
30. Rod--Control
32. Lever--Master Throttle Control
43. Lever--Throttle Control
50. Bracket--Control Shaft
51. Quadrant--Throttle Control
52. Link--Control Rod End
53. Spring--Link Equalizer
54. Screw--Equalizer Spring

Fig. 5 - Diagram of Throttle Control Linkage for Quad Units with Variable Speed Governors

engines. They should be running within 25 rpm of each other.

21. If a variation of more than 25 rpm exists, check the tune-up of each individual engine as outlined in this manual. Then adjust the master control equalizer between the front and rear engine pairs comprising the quad unit (Fig. 5).

22. Remove the valve rocker covers, if not previously removed.

23. Remove bolts (27), covers (28) and gaskets from the equalizer housing (11) and (12).

24. Loosen bolt (13) until lever (14) swings freely on the equalizer shaft (15).

25. Adjust the screws (16) until they are threaded equally into the adjusting lever (18) and are contacting the flats in the equalizer shaft. The bolts should be fairly tight.

26. With the individual control levers (43) latched to their quadrants (51), move the master control lever (32) to the *full-fuel* position and secure the master lever.

27. Move the equalizer link (20) which is connected to the equalizer, and adjust each leg of the equalizer spring (5) and each boss (19). The clearance should be approximately .010" on each side.

28. Hold the equalizer link in this position and tighten the clamping bolt (13) on the equalizer lever (14).

29. Recheck the clearance between each leg of the equalizer spring (5) and the lower bosses (19). Readjust, if necessary.

© 1984 General Motors Corp.

30. Install the valve rocker covers.

31. Move the master throttle control lever (32) to the *idle* position and start the engines.

32. Move the master throttle control lever (32) to accelerate the engines until they reach normal operating temperatures.

33. Move the master throttle control lever to the *full-fuel* position and check the maximum no-load speed on each engine.

34. Move the master throttle control lever (32) to the *idle* position and check the idle speed of each engine. The maximum no-load speed and the idle speed of each engine should be the same as previously set.

35. If the speeds in Steps 33 and 34 are not as previously set, it will be necessary to readjust the master equalizer adjusting lever (18) by means of the adjusting screws (16).

36. After these adjustments have been satisfactorily completed, install the equalizer housing gaskets and covers.

If this procedure does not bring the engines within close synchronization, it is suggested that each engine be checked for possible causes of low power, such as poor compression, faulty injectors, low fuel pressure, etc. All engines must be in good operating condition to secure close synchronization, especially under load, as any of the mentioned conditions will prevent and engine from developing full power.

3. TANDEM TWIN UNITS USING VARIABLE SPEED MECHANICAL GOVERNORS

Figs. 7 and 8 illustrate the arrangement of the throttle and reverse gear controls on tandem twin units, while Figs. 6 and 9 illustrate the master control and individual throttle lever assemblies.

Master throttle levers and master reverse gear control levers are provided in both the engine room and the pilot house, thus permitting operation of the propulsion unit at either location through this dual control arrangement.

The individual engine tune-up is very important in the adjustment of these twin units as the engines must be closely synchronized to enable each to carry its full share of the load.

Therefore, refer to Fig. 8 and disconnect the control rods (30) from the control levers (4) and perform the tune-up procedures for single engines given in this manual before adjusting the throttle control linkage. Then, with engines stopped and the valve rocker covers removed:

1. Remove any bind or excess play from the clevis pins.

2. Refer to Figs. 7 and 9 and move the master throttle lever (18) toward the *full open* position until the two clevis pins in the upper and lower arms of the throttle lever shank are in a vertical straight line, as observed through the two holes at the side of the lever housing (31). Secure the throttle lever in this position by means of the knurled locknut (36).

3. Disconnect both master throttle control rods (38) from the cross shaft operating levers (45) of the individual throttle levers (43) at the "A" and "C" engines (Fig. 8).

4. Lock both throttle levers (43) to their quadrants (51) and fix them in a vertical position.

5. Loosen the clamp bolt on the quadrant (51), if necessary, and set both cross shaft operating levers (45) vertically with the holes for the clevis pins on an imaginary line extending through the centers of the cross shafts and the rod end bearings, and between these centers. Tighten the clamp bolts on the quadrants.

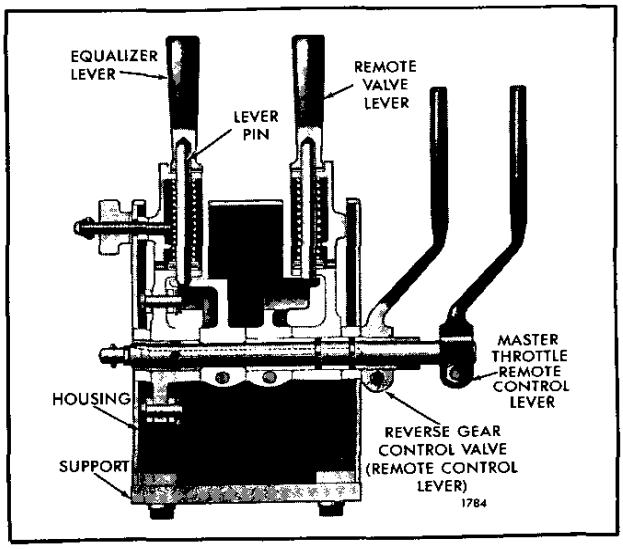
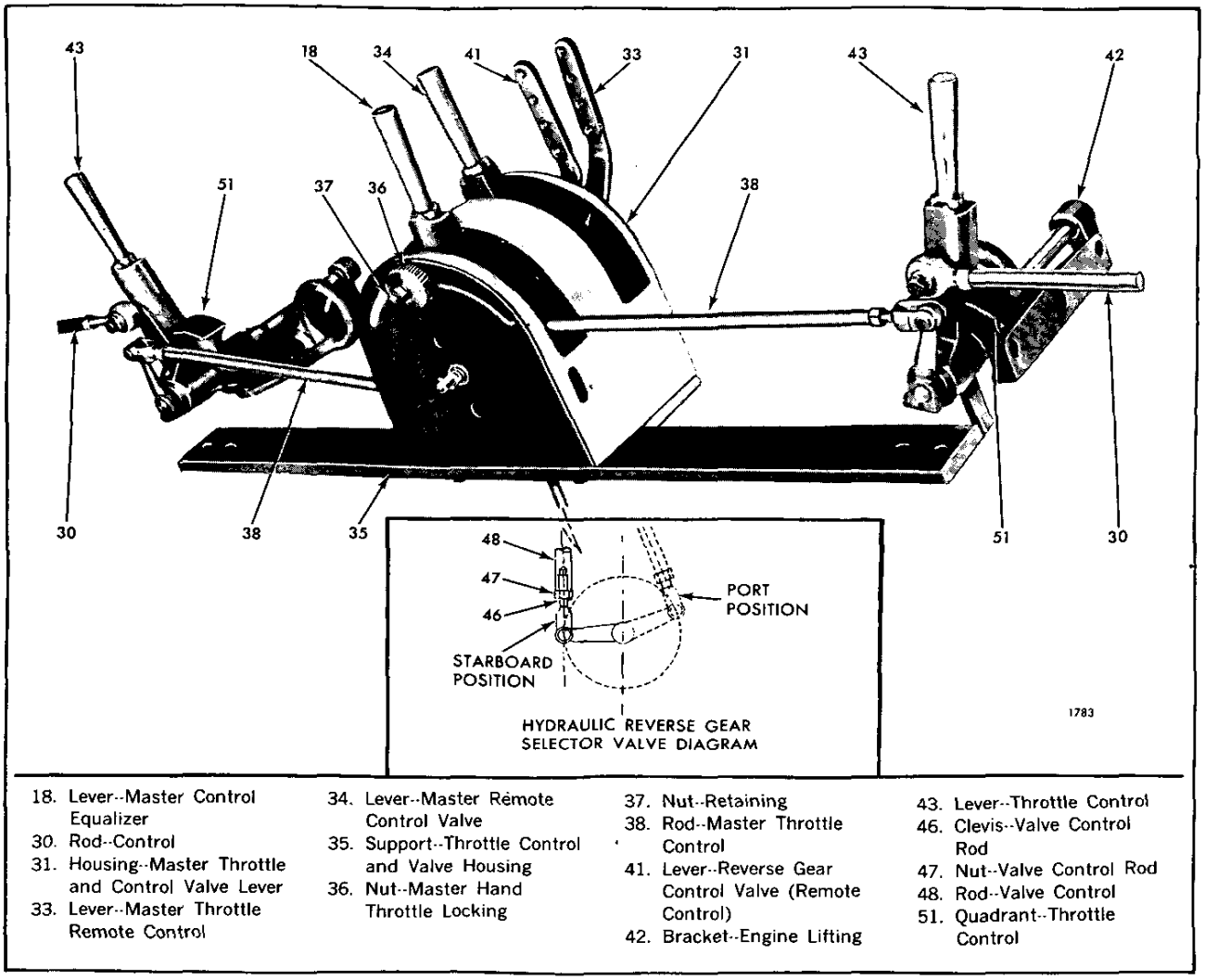


Fig. 6 - Master Throttle Assembly on a Tandem Twin Unit

© 1984 General Motors Corp.



18. Lever--Master Control Equalizer
30. Rod--Control
31. Housing--Master Throttle and Control Valve Lever
33. Lever--Master Throttle Remote Control
34. Lever--Master Remote Control Valve
35. Support--Throttle Control and Valve Housing
36. Nut--Master Hand Throttle Locking
37. Nut--Retaining
38. Rod--Master Throttle Control
41. Lever--Reverse Gear Control Valve (Remote Control)
42. Bracket--Engine Lifting
43. Lever--Throttle Control
46. Clevis--Valve Control Rod
47. Nut--Valve Control Rod
48. Rod--Valve Control
51. Quadrant--Throttle Control

Fig. 7 - Arrangement of Throttle Levers on a Tandem Twin Marine Unit

6. While maintaining levers (43) in a vertical position, adjust the master throttle control rods (38), by means of the clevises, to such a length that the clevis pins will just slide into position through the holes in the clevises and levers (45). Install the cotter pins.

7. Loosen the knurled locknut (36) and move the master throttle lever (18) toward the *full open* position until the locking stud (37) is within 3/8" to 1/2" from end of the slot in the housing (31). Tighten the locknut (36).

8. Adjust the length of the throttle control rods (30), by means of the turnbuckles (10), until the speed control levers (4) at the governor are fully open. Tighten the turnbuckle locknuts. When tightening the locknuts on the turnbuckles, be careful to keep the rod end bearings perpendicular to the bearing support bolt to avoid damage to the bearing seal.

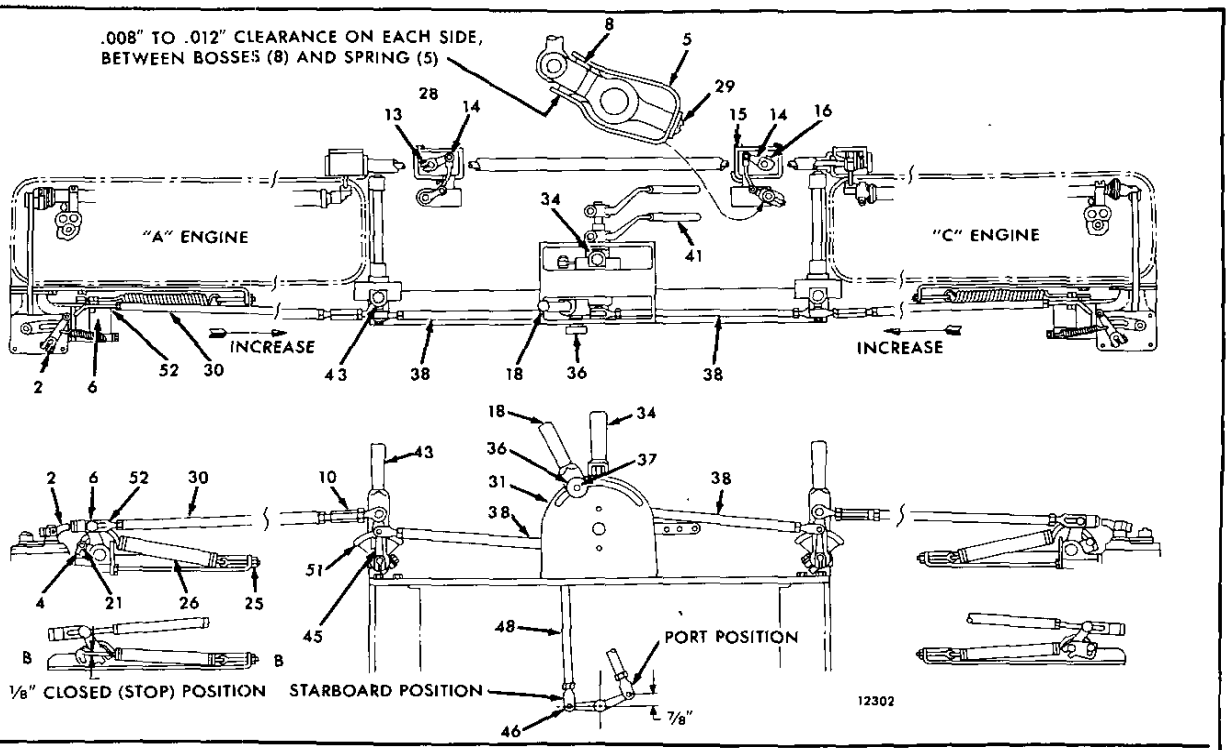
9. If all the above adjustments have been carefully made, the speed of each engine should be the same as when checked individually for top speed. To check the top speed of the individual engines:

a. Disconnect the equalizer link at the lever on the "A" engine.

b. Warm the engines up to operating temperature, then run each engine at top speed and compare the speeds with the original top speed to check for proper length of the control rod (30).

c. If the engine speeds are O.K., connect the equalizer

© 1983 General Motors Corp.



2. Lever--Governor Control
4. Lever--Speed Control
5. Spring--Equalizer
6. Bolt--Link
8. Boss--Master Equalizer
10. Turnbuckle
13. Bolt
14. Lever--Master Equalizer
15. Shaft--Equalizer
16. Screw--Adjusting
18. Lever--Master Control *Equalizer*
21. Pin--Booster Spring
25. Locknut--Booster Spring Adjusting
26. Spring--Booster
28. Cover--Equalizer Housing
29. Screw--Master Control *Equalizer Spring*
30. Rod--Control
31. Housing--Master Throttle and Control Valve Lever
34. Lever--Master Remote Control Valve
36. Nut--Master Hand Throttle Locking
37. Nut--Retaining
38. Rod--Master Throttle Control
41. Lever--Reverse Gear Control Valve (Remote Control)
43. Lever--Throttle Control
45. Lever--Throttle Control Cross Shaft
46. Clevis--Valve Control Rod
48. Rod--Valve Control
51. Quadrant--Throttle Control
52. Link--Control Rod End

Fig. 8 - Diagram of Throttle Control Linkage for Tandem Twin Marine Unit with Variable Speed Governors

link and install the cotter pin; if the speeds are unsatisfactory, adjust the length of the rod or rods (30) as necessary.

10. With the reverse gear control valve lever (34) set in a vertical position, check the position of the selector valve lever on the reverse gear. On a port propulsion unit, the center of the clevis pin hole in the selector valve lever will lie on a horizontal center line drawn through the center of the selector valve shaft and point forward (Fig. 8). On a starboard propulsion unit, the clevis pin hole in the selector valve lever will point aft and lie 7/8" above the horizontal center line drawn through the center line of the selector valve shaft.

11. Adjust the equalizer levers, so that each engine will carry its share of the load, as follows:

a. With the engines stopped and the master throttle lever (18) in the *full open* position and the equalizer links connected at the "A" and "C" engines, loosen the clamp bolt (13) in the equalizer shaft lever (14) at the "A" engine so that the lever can turn on the equalizer shaft.

b. Set the two adjusting screws (16) in the adjustable equalizer lever (14) at the "C" engine the same height in the lever so that the lever can be adjusted later, if necessary.

c. Rotate the lever (14) on the shaft until the free ends of the equalizer spring (5) are resting--without strain--against the two bosses on the injector control tube lever and are an equal distance from the bosses (8) at each side of the

© 1983 General Motors Corp.

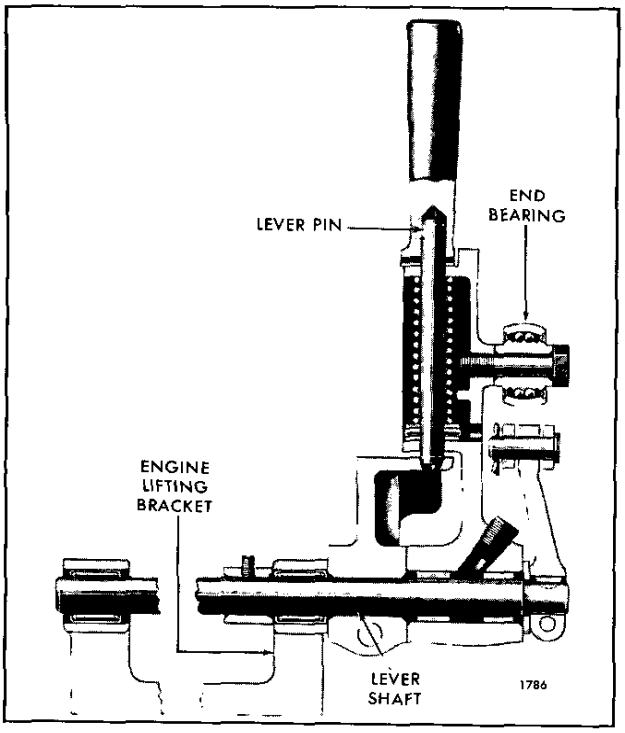


Fig. 9 - Individual Throttle Assembly on a Tandem Twin Unit

equalizer link lever. While maintaining the clearance between the lever bosses and the spring, tighten the clamp bolt in the lever (14).

d. Again check the clearance between the bosses and the spring and if the clearance was changed while tightening the clamp bolt in the lever, adjust the screws (16) and change the position of the lever (14) until the clearance between the bosses (8) and the spring (5) is the same on both sides of the equalizer link lever.

e. With the clutches disengaged, move the throttle to the *idle* position and start the engines.

f. With the engines up to operating temperature, the clutches still disengaged and the individual throttle levers (43) locked to their quadrants (51), move the master throttle lever (18) to the *full open* position and check the speed of each engine with a tachometer and record the speed. The speed of each engine should now be the same as the no-load top speed previously set on the individual engines.

g. Now move the master throttle to the *idle* position and check the speed of the individual engines. If either the idle speed or top speed is not the same as that previously established on the individual engines, readjust the clearance between the bosses (8), on the equalizer link lever and the spring (5) if necessary, as outlined in Step 4 above.

12. Install the valve rocker covers.

© 1983 General Motors Corp.

EARLY DESIGN THROTTLE LINKAGE USED ON INDUSTRIAL TWIN AND QUAD UNITS

The early design throttle linkage differs from the currently used linkage due to the use of bellcranks, small ball and socket joints, small quadrants, and thinner linkage rods used in the early linkages. The following linkage adjustment procedures cover the throttle adjustments for load equalization on twin and quad units having these early linkage arrangements.

Each twin unit consists of two engines and each quad unit consists of four engines connected by clutches to a common gear box. The object of the throttle adjustment is to cause each engine of either the twin or quad unit to carry its share of the load. The throttle adjustments on the twin and quad units have been divided into three groups, depending upon the type of governor used to control engine speed.

1. Throttle adjustment on twin or quad units with limiting speed mechanical governors.

Type "A" - Initial linkage (Fig. 10).

Type "B" - Later linkage (Fig. 11).

2. Throttle adjustments on twin or quad units with variable speed mechanical governors.

3. Throttle adjustments on twin or quad units with constant speed hydraulic governors.

1. TYPE "A" - QUAD UNITS USING LIMITING SPEED MECHANICAL GOVERNORS

The throttle control linkage should be adjusted *after* adjusting the engine exhaust valves, timing the fuel injectors and performing the tune-up covering the appropriate governors used on the unit as follows:

1. With the engines stopped, refer to Fig. 10 and remove any bind or excess play from the clevises and pins and ball joints. If ball joints need adjusting, remove the cotter pins from the various joints and turn the ball joint nut down until it bottoms. Then, back off on the nut to the nearest position where the slot in the nut aligns with the holes in the end of the ball joint. Replace and spread the cotter pin. Throttle adjustments cannot be made satisfactorily with loose joints or a bind in the mechanism.

2. Engage the throttle lever pins (65) of each individual throttle lever (43) with the quadrants (57).

3. Move the quadrant control lever (32) to such a position that the throttle control levers (43) set vertically, then, check the geometry of the linkage as follows: Set the outer arms of the four bellcranks (61) on brackets (49) and (62) parallel with and the inner arms crosswise of the engine center line. A straight edge or line (77) from brackets (49) and (62) (diagram - Fig. 10), will aid in making this check.

4. With the bellcranks positioned as outline in Item 3, the pins in all governor throttle control levers (64) should rest in the *idle* notch of the governor control cams (69). If the pins do not rest in the notches of all four cams, adjust the length of the throttle rods (4) at the turnbuckle (10) until this condition is brought about. Length of the rods (4) is adjusted by loosening the locknuts and turning the turnbuckle (10).

5. Now move the quadrant control lever (32) so that the throttle levers are in the *full open* position. Observe if the pins in the throttle control levers (64) all strike the extreme end of the slot in the governor control cams (69). If not, adjust the rods (4) slightly so that the pins in all levers just strike the extreme end of the slot in the cams simultaneously. Do not put any strain in the throttle linkage when making this adjustment.

6. Disengage the clutches and move the throttle levers to the *idle* position. Start all of the engines of the unit.

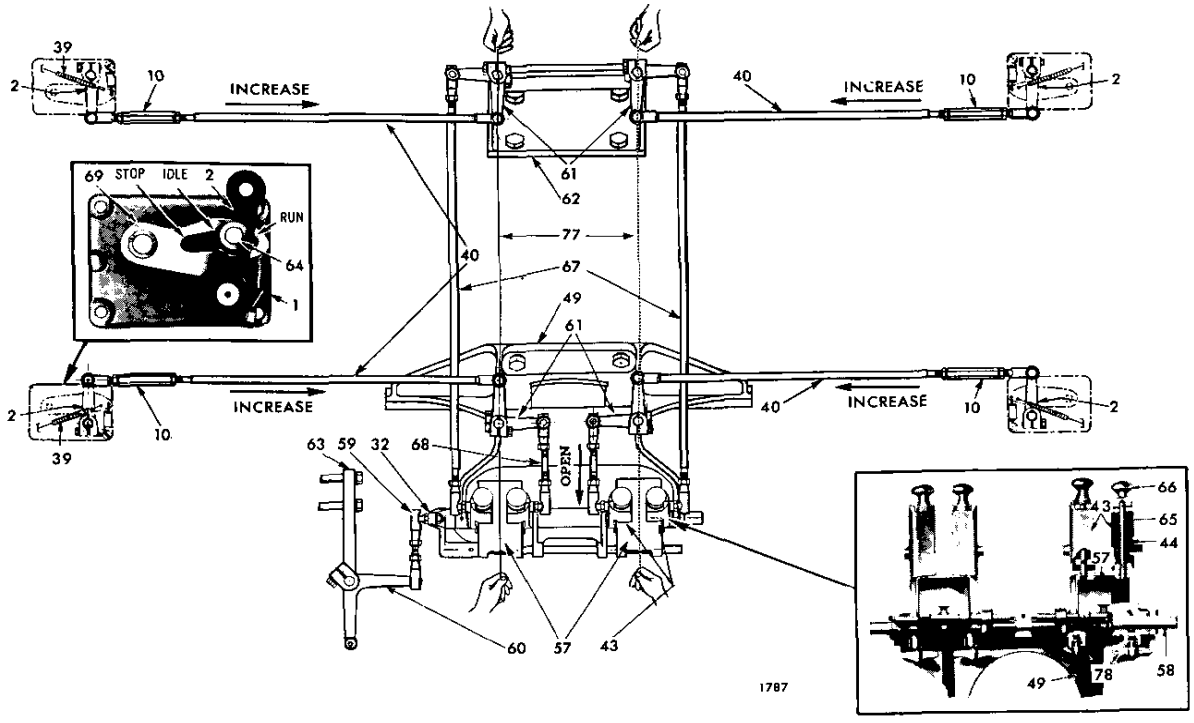
NOTE: When all engines of the unit are not equipped with starting motors, it will be necessary to first start the engine or engines so equipped; then engage the clutch on the running engine and the other clutches in turn to crank the engines.

7. Having started all the engines, disengage the clutches and bring the engines up to operating temperature.

NOTE: If conditions permit, the engines can be warmed up to operating temperature in less time by applying part load. If warmed up at part load, disengage the clutches afterward for the following steps.

8. With the individual throttle levers (43) locked to their quadrants (57), move the quadrant control lever

© 1983 General Motors Corp.



1. Governor
2. Lever--Governor Control
10. Turnbuckle
32. Lever--Master
39. Spring--Governor Control Lever Retracting
40. Rod--Throttle Control to Governor
43. Lever--Throttle Control
44. Spring--Throttle Lever
49. Bracket--Control Support
57. Quadrant--Throttle Lever
58. Shaft--Quadrant
59. Link--Quadrant Control to Bell Crank
60. Bell Crank--Quadrant Control Lever Link
61. Bell Crank--Throttle Lever and Throttle Control Rods
62. Bracket--Bell Crank (Rear)
63. Bracket--Governor Control Link Bell Crank
64. Lever--Governor Throttle Control
65. Pin--Throttle Control Lever
66. Knob--Throttle Control Lever
67. Rod--Throttle Lever to Bell Crank Control (Long)
68. Rod--Throttle Lever to Bell Crank Control (Short)
69. Cam--Governor Control
77. Taut Line
78. Wing Screw

Fig. 10 - Type"A" Throttle Control Adjustment Diagram for Quad Industrial Units Using Limiting Speed Mechanical Governors

(32) to the *full open throttle* position and check the speed of each engine with a tachometer. Record the speed. The speed of each engine should now be the same as the no-load top speed previously set on the individual engines.

NOTE: With the limiting speed mechanical governor, the no-load speed will be 125 rpm greater than the full-load speed unless otherwise stated on the unit name plate. For example, for a unit with a desired top full-load speed of 1600 rpm, the no-load speed would be approximately 1725 rpm.

9. With all clutches still disengaged, check the speed of the individual engines at approximately three-fourths (3/4) full-load speed. This check should show all engines running at the same speed, within 100 rpm, which is allowable. If any engine varies more than the allowable 100 rpm, then more than likely the governor spring plunger gap was not properly set on that engine. In this event, reset the governor spring plunger gap and then reposition the injector racks on that engine.

10. With the clutches disengaged, again check the speed of the individual engines at approximately three-fourths (3/4) full-load speed.

© 1983 General Motors Corp.

1. TYPE "B" TWIN OR QUAD UNITS USING LIMITING SPEED MECHANICAL GOVERNORS

The throttle control linkage should be adjusted *after* adjusting the engine exhaust valves, timing the fuel injectors and performing the tune-up covering the appropriate governors used on the unit as follows:

1. With the engines stopped, refer to Fig. 11 and remove any bind or excess play from the clevises and pins and ball joints. If ball joints need adjusting, remove the cotter pins (74) from the various joints (75) and turn the nut down until it bottoms. Then back off on the nut to the nearest position where the slot in the nut aligns with the holes in the end of the ball joint. Replace and spread the cotter pin. Throttle adjustments cannot be made satisfactorily with loose joints or a bind in the mechanism.

2. Lock the throttle levers (43) to the quadrants (57) on all engines by means of the pins (65).

3. If adjustments are being made on quad units, and the throttle levers for the forward engines do not align with those for the rear engines (lengthwise of the engines), loosen the clamp bolt (13) on one of the quadrants (57) and move the quadrant on the shaft until all four levers are in alignment lengthwise of the engine. Tighten the clamp bolt (13).

4. By means of the master lever (32), push all throttle levers toward the *full open* position until the stop bosses (70) on the back side of the quadrants (57) contact the brackets (49). Loosen the locknuts (72) and turn the stop screw (71) into the bosses (70) of the quadrants (57) until each screw projects 1/32", or slightly more, through its boss, but with the screws contacting the throttle brackets (49). Tighten the locknuts (72) temporarily.

5. While maintaing the throttle levers in the *full open* position as in Step 4 above, adjust the throttle to bell crank rods (68) and (67) to such length that the ball joint of the bell crank arms (61), that lie crosswise of the engines, are 1-1/4" off center--away from the front end of the engine--of a line drawn through the center of the bell crank fulcrums (Fig. 11).

To adjust the length of the short rod (68), remove the ball of the ball joint (75) from the bell crank (61), then loosen the locknut and turn the rod as desired. The long rod (67) may be adjusted without removing the ball joint by loosening the locknuts and turning the turnbuckle (10).

6. While maintaing the throttle levers in *full open* position, adjust all governor to bell crank throttle rods (40) to such length that the pins in all governor throttle control levers (64) just strike the extreme end of the slot in the governor control cams (69) simultaneously. When the pins in all governor throttle control levers (64) just strike the extreme end of the slot in the governor control cams (69), both stop screws (71) (two screws for quad or one stop screw for twin) will be resting against the throttle brackets (49).

7. Now loosen the locknuts (72) on both stop screws (71) of the quad or one on the twin and turn the bolts in 1/6 turn. Tighten the locknuts permanently.

8. With the throttle levers (43) locked to the quadrants (57), move the master lever (32) to the *idle* position. If adjustments of the throttle rods (40) as outlined in Step 6 above were carefully made, the pins in all governor throttle control levers (64) should rest in the idle notches of the governor control cams (69).

9. Disengage the clutches and start all of the engines of the unit.

> **NOTE:** When all engines of the unit are not equipped with starting motors, it will be necessary to first start the engine or engines so equipped; then engage the clutch on the running engine and the other clutches in turn to crank the engines.

10. Bring the engines up to operating temperature.

> **NOTE:** If conditions permit, the engines can be warmed up to operating temperature in less time by applying part load. If warmed up at part load, disengage the clutches afterward for the following steps.

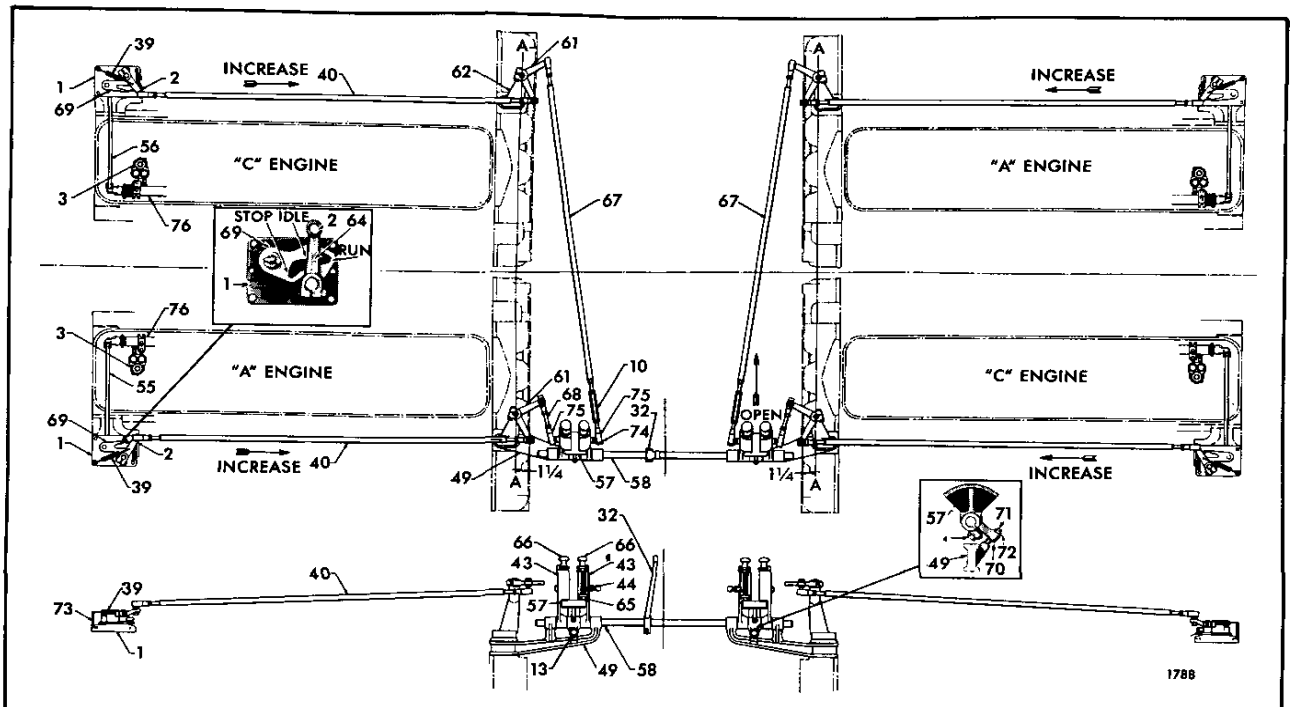
11. With the individual throttle levers (43) locked to their quadrants (57), move the master lever (32) to the *full open* throttle position and check the speed of each engine with a tachometer and record the speed. The speed of each engine should now be the same as the no-load top speed previously set on the individual engines.

> **NOTE:** With the limiting speed mechanical governor, the no-load speed will be 125 rpm greater than the full-load speed unless otherwise stated on the unit name plate. For example, for a unit with a desired top full-load speed of 1600 rpm, the no-load speed would be approximately 1725 rpm.

12. With all clutches still disengaged, check the speed of the individual engines at approximately three-fourths (3/4) full-load speed. This check should show all engines running at the same speed within 100 rpm, which is allowable. If any engine varies more than the allowable 100 rpm, then more than likely the governor spring plunger gap was not properly set on that engine. In this event, reset the governor spring plunger gap and then reposition the injector racks on that engine.

13. With clutches disengaged, again check the speed of

© 1983 General Motors Corp.



1. Governor
2. Lever--Governor Control
3. Injector
10. Turnbuckle--Throttle Control Rod
13. Bolt--Quadrant Clamp
32. Lever--Master
39. Spring--Governor Control Lever Retracting
40. Rod--Throttle Control
43. Lever--Throttle Control
44. Spring--Throttle Lever
49. Bracket--Support Control
55. Link--Governor Control (for "A" Engine)
56. Link--Governor Control (for "C" Engine)
57. Quadrant--Throttle Lever
58. Shaft--Quadrant
61. Bell Crank--Throttle Lever and Throttle Control Rods
62. Bracket--Bell Crank (Rear)
64. Lever--Governor Throttle Control
65. Pin--Throttle Control Lever Locking
66. Knob--Throttle Control Lever
67. Rod--Throttle Lever to Bell Brank Control (Long)
68. Rod--Throttle Lever to Bell Crank Control (Short)
69. Cam--Governor Control
70. Stop Boss--Quadrant
71. Screw--Quadrant Stop
72. Locknut--Quadrant Stop Screw
73. Clip--Governor Control Lever Retracting Spring
74. Cotter Pin--Ball Joint
75. Ball Joint
76. Tub--Injector Rack Control

Fig. 11 - Type "B" Throttle Control Adjustment Diagram for Twin or Quad Industrial Units Using Limiting Speed Mechanical Governors

the individual engines at approximately three-fourths (3/4) full-load speed and at full open throttle.

2. TWIN OR QUAD UNITS USING VARIABLE SPEED MECHANICAL GOVERNORS

Multiple engine units using variable speed governors are provided with a booster spring at each engine to assist in opening the throttle and with an equalizer (cross) link between each pair of engines to allow for the mechanical differences in the governors and to open the injector racks exactly the same distance on each engine. These devices must be suitably adjusted along with the setting of the throttle linkage. The booster spring is adjusted *before* adjusting the throttle linkage and the cross link is adjusted *after* adjusting the throttle linkage.

Fig. 12 illustrates the throttle control adjustment diagram applicable to either twin or quad units equipped with variable speed mechanical governors. The complete adjustment procedure for the booster spring, the throttle linkage and the cross link for load equalization is outlined below.

© 1983 General Motors Corp.

SET GOVERNOR SPEED CONTROL LEVER BOOSTER SPRING

EQUALIZER CROSS LINK DISCONNECTED - ENGINES RUNNING

1. With the engines running, set the governor speed control lever (4) in the *idle* position (Fig. 12).

2. Adjust the spring fulcrum pin (93) 1/8" below a line "BB" drawn through the center of the eyebolt hole (90) and the center of the speed lever control shaft (94)(Fig. 12).

3. Remove the nut from the link to the speed control lever bolt (13) and separate the link (79) from the bolt (13).

4. Tighten the eyebolt nut (89) until the speed control lever (4) will return from the *full-speed* to the *idle speed* position when the lever is jerked back and released. Back off the nuts until the lever returns quickly. Lock the nuts in position.

5. Check the force required to operate the speed control lever--a uniform force over the range of lever travel is desired. If the force is greatest at the beginning of lever travel, adjust the booster spring fulcrum pin (93) upward in the slot of the speed control lever (4). If the force seems too light at the beginning of lever travel, adjust the booster spring fulcrum pin downward in the slot at the speed control lever.

6. Reconnect the link (79) to the lever (4) with the bolt (13).

THROTTLE ADJUSTMENTS FOR LOAD EQUALIZATION AND ADJUSTMENT OF EQUALIZER (CROSS) LINK EQUALIZER LINK DISCONNECTED - ENGINES STOPPED

1. With the engines stopped, remove any bind or excess play from the clevises and pins and ball joints. If ball joints need adjusting, remove the cotter pins (74) from the various joints (75) and turn the nut down until it bottoms. Then back off on the nut to the nearest position where the slot in the nut aligns with the holes in the end of the ball joint. Replace and spread the cotter pin. Throttle adjustments cannot be made satisfactorily with loose joints or bind in the mechanism.

2. Lock the throttle levers (43) to the quadrants (57) on all engines by means of the pins (65).

3. If adjustments are being made on quad units and the throttle levers for the forward engines do not align with those for the rear engines (lengthwise of the engines), loosen the clamp bolt (13) on one of the quadrants (57) and move the quadrant on the shaft until all four levers are in alignment lengthwise of the engine. Tighten the clamp bolt (13).

4. By means of the master lever (32), push all throttle levers toward the *full open* position until the stop bosses (70) on the back side of the quadrants (57) contact the brackets (49). Loosen the locknuts (72) and turn the stop screw (71) into the bosses (70) of the quadrants (57) until each screw projects 1/32", or slightly more, through its boss, but with the screws contacting thr throttle brackets (49). Tighten the locknuts (72) temporarily.

5. While maintaining the throttle levers in the *full open* position, as in Step 4 above, adjust the throttle to bell crank rods (68) and (67) to such length that the ball joint of the bell crank arms (61), which lie crosswide of the engines, are 1-1/4" off center--away from the front end of the engine--of a line drawn through the center of the bell crank fulcrums (Fig. 12). To adjust the length of the short rod (68), remove the ball of the ball joint (75) from the bell crank (61), then loosen the locknut and turn the rod as desired. The long rod (67) may be adjusted without removing the ball joint by loosening the locknuts and turning the turnbuckle (10).

6. While holding all throttles (43) in *full throttle* position, adjust the four bell cranks to the governor throttle control rods (40) so that all governor speed control levers (4) reach full throttle simultaneously. All governor speed control levers (4) will be at the *wide open*, or the extreme *rear* position, when both stop screws (71) are resting against the throttle brackets (49).

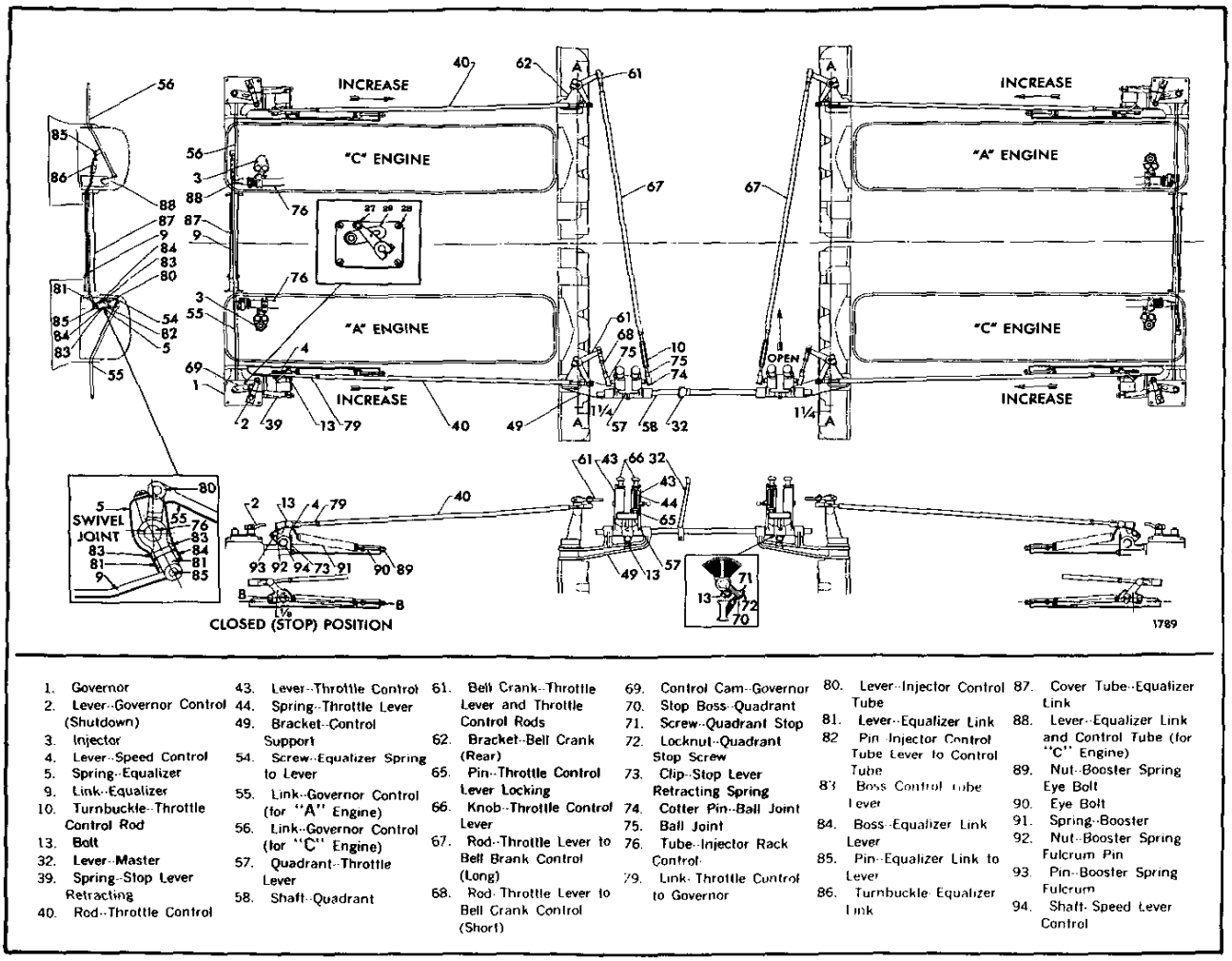
7. Now loosen the locknuts (72) on the stop screws (71) and turn the bolts in 1/6 turn. Tighten the locknuts permanently.

8. Refer to Figs. 16 and 17 and with the throttle linkage properly adjusted as outlined above, there should be 1/16" to 1/8" clearance between each link (79) and the shutdown lever (2) when the throttles are set in the *run* position--pin in the throttle control lever (64) at the rear end of the slot in the cam (69) and the speed control lever (4) in the *idle* position. If adjustment is necessary, loosen the clamp bolt in the lever (2), hold the pin of the lever (94) at the extreme rear end of the slot in the cam, move the lever (2) for proper clearance and tighten the clamp bolt.

9. Adjust the equalizer cross link (engines stopped):

a. With the engines stopped, the equalizer cross link

© 1983 General Motors Corp.



1. Governor
2. Lever--Governor Control (Shutdown)
3. Injector
4. Lever--Speed Control
5. Spring--Equalizer
9. Link--Equalizer
10. Turnbuckle--Throttle Control Rod
13. Bolt
32. Lever--Master
39. Spring--Stop Lever Retracting
40. Rod--Throttle Control
43. Lever--Throttle Control
44. Spring--Throttle Lever
49. Bracket--Control Support
54. Screw--Equalizer Spring to Lever
55. Link--Governor Control (for "A" Engine)
56. Link--Governor Control (for "C" Engine)
57. Quadrant--Throttle Lever
58. Shaft--Quadrant
61. Bell Crank--Throttle Lever and Throttle Control Rods
62. Bracket--Bell Crank (Rear)
65. Pin--Throttle Control Lever Locking
66. Knob--Throttle Control Lever
67. Rod--Throttle Lever to Bell Crank Control (Long)
68. Rod--Throttle Lever to Bell Crank Control (Short)
69. Control Cam--Governor
70. Stop Boss--Quadrant
71. Screw--Quadrant Stop
72. Locknut--Quadrant Stop Screw
73. Clip--Stop Lever Retracting Spring
74. Cotter Pin--Ball Joint
75. Ball Joint
76. Tube--Injector Rack Control
79. Link--Throttle Control to Governor
80. Lever--Injector Control Tube
81. Lever--Equalizer Link
82. Pin--Injector Control Tube Lever to Control Tube
83. Boss--Control Tube Lever
84. Boss--Equalizer Link Lever
85. Pin--Equalizer Link to Lever
86. Turnbuckle--Equalizer Link
87. Cover Tube--Equalizer Link
88. Lever--Equalizer Link and Control Tube (for "C" Engine)
89. Nut--Booster Spring Eye Bolt
90. Eye Bolt
91. Spring--Booster
92. Nut--Booster Spring Fulcrum Pin
93. Pin--Booster Spring Fulcrum
94. Shaft--Speed Lever Control

Fig. 12 - Throttle Control Adjustment Diagram for Twin or Quad Industrial Units using Variable Speed Mechanical Governors

(9) disconnected and all individual throttle levers (43) locked to their quadrants (57), push all throttle levers to the *full open* position and lock them in that position.

b. Connect the equalizer link (9) to the equalizer lever (88) at the "C" engine with the pin (85), then install and spread the cotter pin.

c. Loosen the locknuts and by means of the turnbuckle (86), adjust the length of the equalizer link (9) so that the clevis pin (85) will just slip through the clevis pin holes in the lever and through the hole in the link (9) at the "A" engine. The free ends of the equalizer spring (5) should be resting--without strain--against the bosses (83) and (84) at each side of the injector control tube lever (80) and the equalizer link lever (81), respectively. Tighten the turnbuckle locknuts and install the cotter pin in the clevis pin (85).

NOTE: If the equalizer link (9) is cold when installed and adjusted, undoubtedly the link will increase in length sufficiently, after the engines are warmed up, so that the "C" engine will stop when the throttle levers are moved to the *idle* position. Check this condition as follows:

d. With the clutches disengaged, move the throttles to the *idle* position and start the engines.

NOTE: When all engines of the unit are not equipped with starting motors, it will be necessary to first start the engine or engines so equipped; then engage the clutch on the

© 1983 General Motors Corp.

running engine and the other clutches in turn to crank the engines.

e. With the engines up to operating temperature, move the throttles to the *idle* poisition and, if the "C" engine does not stop, check its idling speed against that of the "A" engine. Idling speed of the "C" engine will probably be less than that of the "A" engine. To bring the idling speed the same on both engines:

With the equalizer link (9) disconnected at the "C" engine, and with both engines running at the same idle speed, adjust the length of the equalizer link (9) so that the clevis pin (85) just slips in place through the link and the holes in the clevis. Install the cotter pin.

10. With the individual throttle levers (43) locked to their quadrants (57), move the master lever (32) to the *full open throttle* position and check the speed of each engine with a tachometer and record the speed. The speed of each engine should now be the same as the no-load top speed previously set on the individual engines.

NOTE: With the variable speed mechanical governor, the no-load speed will be 150 rpm greater than the full-load speed unless otherwise stated on the unit name plate. For example, for a unit with a desired top full-load speed of 1600 rpm the no-load speed would be 1750 rpm.

11. With all clutches still disengaged, check the speed of the individual engines at approximately three-fourths (3/4) full-load speed. This check should show all engines running at the same speed, within 100 rpm which is allowable. If any engine varies more than the allowable 100 rpm, then more than likely the tune-up procedure for the individual engines, such as setting the spring plunger gap, positioning the injector racks, etc., was not properly performed or perhaps the governor linkage or control rack mechanism may be binding. In this event, the individual engine should be thoroughly checked and tuned up, as previously outlined.

12. After rechecking any engine that was performing improperly and again adjusting the throttle linkage, check the individual engine speeds at full open throttle and three-fourths (3/4) full-load speeds, as outlined in Steps 10 and 11 above.

TWIN OR QUAD UNITS USING CONSTANT SPEED HYDRAULIC GOVERNORS

ENGINES STOPPED

Illustrated in Fig. 14 is the throttle control adjustment diagram applicable to twin industrial units equipped with a constant speed hydraulic governor.

Since the throttle control rods (40)--leading to the governors--increase or decrease the fuel by a rotary motion, no bell cranks are needed for motion transfer between the throttle levers and the throttle rods as with the mechanical governors.

Check the individual engines according to the tune-up procedure for engines equipped with hydraulic governors, then, refer to Fig. 14 and carry out the throttle adjustments for load equalization, as follows:

1. With the engines stopped, remove any lost motion from clevises and pins and ball joints, or bind from the throttle linkage. Throttle adjustments cannot be made satisfactorily with loose joints or bind in the mechanism.

2. Refer to Fig. 14 and set the unit throttle lever (99) in the *idle* position in its quadrant (57) and lock the individual throttle levers (43) in their quadrant (57). Loosen the clamp bolt in the quadrant (57) and move the levers (43) to a vertical position, then tighten the clamp bolt.

3. With the throttle levers set as in Step 2, the throttle control rod levers (98) at the back end of the rods (40) should be at right angles to the rods (68) and (67) leading from the throttles (43) to the levers (98) (Fig. 14) when the bends in the throttle rods (40) are straight up. If the levers do not set at right angles to the rods, loosen the clamp bolts in the levers (98) at both engines and adjust the length of rod (68) on the "A" engine and rod (67) on the "C" engine to bring the levers at right angles to the rods. To adjust the length of the rod (68), remove the ball joint from the lever (98), then adjust the rod length as required. The length of the rod (67) may be adjusted by the turnbuckle (10) without disconnecting the ball joint from the lever.

4. With the throttle levers still set as in Step 2, refer to Fig. 13 and loosen the clamp bolt in the throttle control rod levers (97), on both engines, and move the outer end of the levers up as far as possible to remove all lost motion between the rods (40) and the levers (97).

© 1983 General Motors Corp.

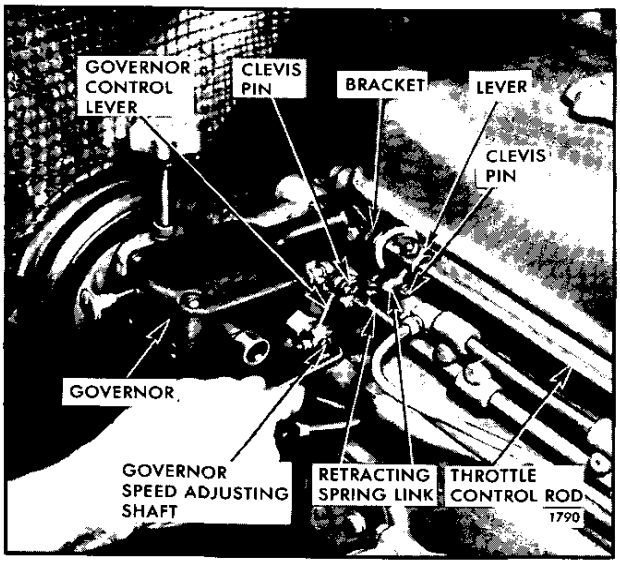


Fig. 13 - Setting Hydraulic Governor Speed Adjusting Shaft and Position of Throttle Control Rod Lever on Throttle Control Rod

5. With the unit throttle lever (99) (Fig. 14) still in the *idle* position and the individual throttle levers (43) in the *idle* position, start the engines. If the engines will not start, loosen the clamp bolt in the governor control lever and turn the speed adjusting shaft slightly with an offset screwdriver (Fig. 13). Turning the shaft counterclockwise on the "A" engine governor increases the engine speed, and turning the shaft clockwise on the "C" engine governor increases the engine speed.

6. With the engines warmed up to operating temperature, move the unit throttle lever (99) to the *run* position and lock it in its quadrant (57) (Fig. 14).

7. Again using an offset screwdriver (Fig. 13), turn the governor speed adjusting shaft to such a position that each engine is running 80 rpm higher than the full-load speed as recorded by a tachometer. Tighten the clamp bolt in the speed adjusting shaft.

NOTE: With the constant speed hydraulic governor, the no-load speed will be 80 rpm greater than the full-load speed unless otherwise stated on the unit name plate. For example, for a unit with a desired top full-load speed of 1600 rpm, the no-load speed will be approximately 1680 rpm. This difference represents the governor droop which was previously established when setting the governor droop on the individual engines.

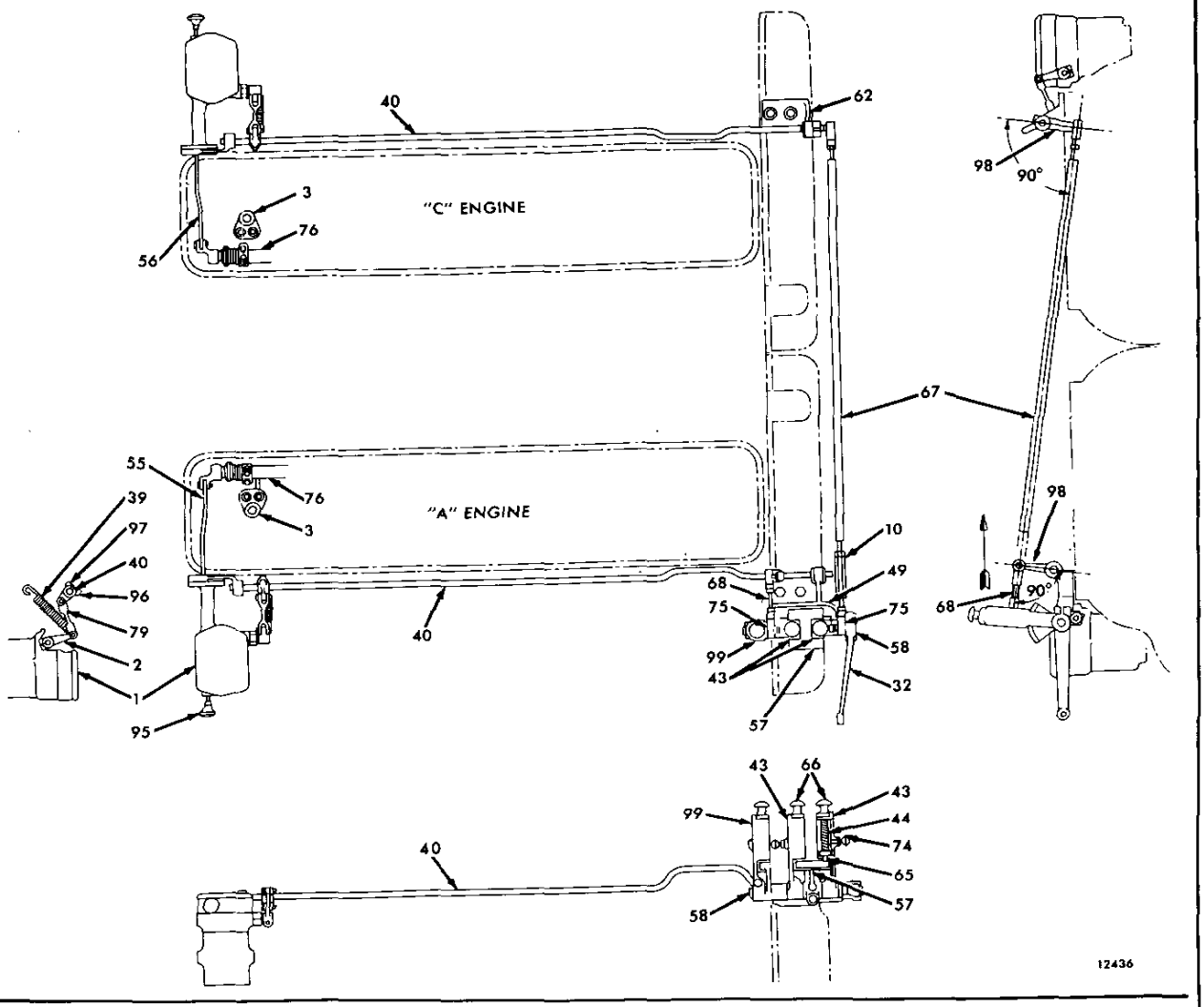
8. With unit throttle lever (99) set in the *run* position, release one of the individual throttles (43) and push the throttle open until the engine speed is 1925 rpm. While holding the throttle for this speed, set the governor maximum speed adjusting screw to allow this speed. Check and adjust the governor on the other engine in the same manner.

9. With the clutches disengaged and the individual throttle levers (43) locked to their quadrants, recheck the engine speeds by moving the unit throttle to the *run* position and checking the speed of the individual engines with a tachometer. The speed of each engine should be approximately 1680 rpm.

10. With the clutches still disengaged and the individual throttle levers (43) still locked to their quadrants, move the unit throttle to approximately 3/4 full-load speed and check the speed of each engine with a tachometer.

If the engine speeds differ more than the allowable 100 rpm, then more than likely the individual engines were not carefully checked or the throttle linkage was not properly set, in which case, a recheck of these items should be made.

© 1983 General Motors Corp.



1. Governor
2. Lever--Governor Control
3. Injector
10. Turnbuckle--Throttle Control Rod
32. Lever--Master
39. Spring--Governor Control Lever Retracting
40. Rod--Throttle Control
43. Lever--Throttle Control (Engine)
44. Spring--Throttle Lever
49. Bracket--Control Support
55. Fuel Rod (for "A" Engine)
56. Fuel Rod (for "C" Engine)
57. Quadrant--Throttle Lever
58. Shaft--Quadrant
62. Bracket--Bell Crank (Rear)
65. Pin--Throttle Control Lever Locking
66. Knob--Throttle Control Lever
67. Tod--Throttle Lever to Throttle Control Rod (Long)
68. Rod--Throttle Lever to Throttle Control Rod (Short)
74. Cotter Pin--Ball Joint
75. Ball Joint
76. Tube--Injector Rack Control
79. Link--Throttle Control
95. Shutdown Knob--Governor
96. Clamp Bolt--Throttle Control Rod Lever
97. Lever--Throttle Control Rod (at Governor)
98. Lever--Throttle Control Rod (at Flywheel Housing)
99. Lever--Throttle Control (Unit)

Fig. 14 - Throttle Control Adjustment Diagram for Twin Industrial Units Using Constant Speed *Hydraulic Governors*

© 1983 General Motors Corp.

EARLY DESIGN THROTTLE LINKAGE USED ON TWIN MARINE UNITS

The throttle linkage used on the early marine units differed from the early linkage on industrial units. The marine units did not use bellcranks, but had throttle rods similar to the current arrangement (Figs. 2 and 5) except for the equalizer spring used with variable speed governors and the lack of quadrants (Fig. 15 and 16).

1. TWIN MARINE UNITS WITH LIMITING SPEED GOVERNOR

The throttle linkage may be adjusted after setting the valves, timing the injectors and adjusting the governor and the injector operating linkage as follows:

1. With the engines stopped, set the throttle control cross shaft (100) so that the throttle control levers (43) are in a vertical position as shown at "A-A" (Fig. 15).

2. With the engines stopped, adjust the turnbuckles (10) on the two throttle control rods (40) so that the pins in the throttle control levers (64) at the governor cover rest against the shoulders of the control cams (69) in the *idle* position at the two governors.

3. Now move the master throttle (32) to *full open* position, at which setting the pin in the throttle lever (64) at both governors should just strike the extreme end of the slot in the cam (69) at the *run* position. If either or both pins do not reach the end of the slot in the cams, adjust the turnbuckles (10) to bring about this condition. The linkage must be so adjusted that the pins in the throttle levers at the governor covers reach the *run* position in the control cam at exactly the same time. Do not put any strain in the throttle linkage when making this adjustment.

4. Start and warm up both engines to operating temperature. Move the master throttle to the *idle* position. De-clutch both engines and set the idling speed of each engine to 500 rpm.

> **NOTE:** The engine may be brought up to operating temperature by de-clutching the engines and setting the throttle to approximately 1200 rpm.

If a quick warm-up is attempted by turning the propeller, the ship must be securely tied to the dock with no loose lines or floating obstructions to foul the propeller.

5. Set the governor no-load top speed:

Usually, the top no-load speed is set the same on both governors of twin units before the engines leave the factory. If a check as outlined below shows the top no-load speeds to be different on the two governors, correct as follows:

a. With both engines warmed up, stop the engines and disconnect the throttle control rod (40) for the "B" engine by removing the pin at the clevis (104).

b. Start the "D" engine, de-clutch and move the master throttle to the *full-open* position.

c. Note and record maximum no-load speed as indicated by a tachometer.

d. Stop the engine and connect the throttle control tube for the "B" engine and disconnect the "D" engine.

e. Start the "B" engine, de-clutch and, with the master throttle in the *full-open* position, note and record the speed.

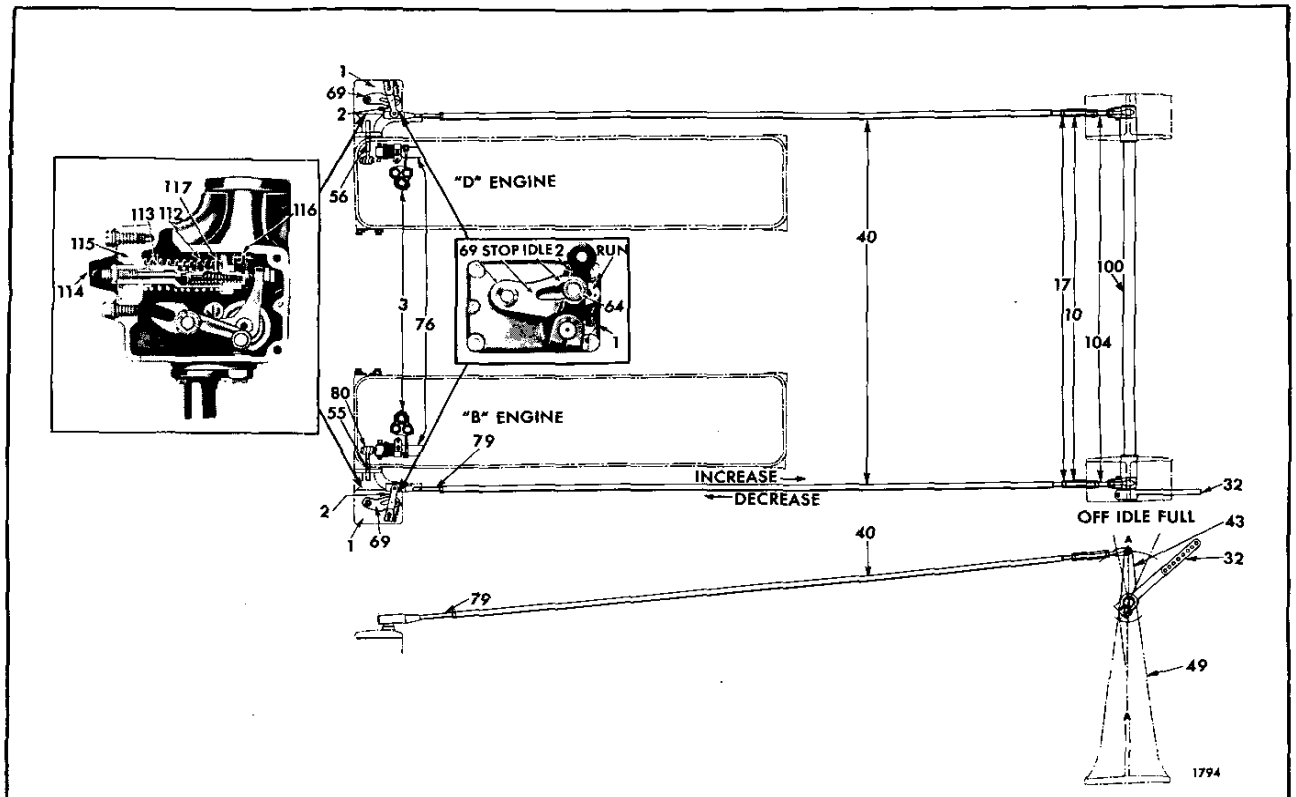
f. If the no-load speeds of the two engines are not the same, increase the speed of the low engine by adding shims (117) between the high-speed spring (112) and the spring plunger (113) (Fig. 17). To add shims, remove the low-speed adjusting screw cover (114), back out the nut (115) and place shims between the inner end of the spring and the shoulder on the plunger. Add one shim at the time and check the speed after each shim is added.

6. Synchronize the engine speeds at no-load. Speeds of the two engines must be synchronized to obtain, as nearly as possible, the same no-load speeds in the range just below the rated-load speed by adjusting the linkage to each governor. Thus, a unit rated at 1850 rpm should have the engines synchronized at 1700-1800 rpm. Synchronize as follows:

a. With the engines warmed up, de-clutch both engines and move the master throttle to such position that the speed of the "B" engine is 1750 rpm as recorded by the tachometer. Lock the master throttle in this position.

b. Note the speed of the "D" engine. If the speeds of the two engines are not the same, loosen the two locknuts at the turnbuckle (10) on the "D" engine and, by adjusting the turnbuckle, shorten the

© 1983 General Motors Corp.



1. Governor
2. Lever--Governor Control
3. Injector
10. Turnbuckle--Throttle Control Rod
17. Locknut--Throttle Control Rod
32. Lever--Master
40. Rod--Throttle Control
43. Lever--Throttle Control
49. Bracket--Throttle Control Support
55. Link--Governor Control (for "B" Engine)
56. Link--Governor Control (for "D" Engine)
64. Lever--Governor Throttle Control
69. Control Cam
76. Tube--Injector Rack Control
79. Link--Throttle Control to Governor
80. Lever--Injector Control Tube
100. Cross Shaft--Throttle Control
104. Clevis--Throttle Control Rod
112. Spring--High Speed
113. Spring Plunger
114. Cover--Low Speed Adjusting Screw
115. Nut--High-Speed Spring Retaining
116. Low-Speed Spring Gaps
117. Shims

Fig. 15 - Throttle Control Adjustment Diagram for Twin Engines Using Limiting Speed Governors

throttle rod (40) to increase or lengthen to decrease the engine speed.

c. Unlock and move the master throttle to the *full-open* position. In the *full-open* position, without strain on the throttle linkage, the pins in the throttle control levers (64) at the governor covers of both engines should be within 1/16" of the same distance from the end of the slot in the cam (69). If the levers are not within this limit, the chances are that the governor gaps or the injector rack adjustments are not identical on the two engines and should be rechecked.

The governor with the pin closest to the end of the cam slot may have a "close" gap or the governor with the pin farthest from the end of the cam slot may have the injector racks too "tight". If adjustments are necessary, recheck the engine speeds after making the adjustments.

© 1983 General Motors Corp.

2. TWIN MARINE UNITS WITH VARIABLE SPEED GOVERNORS

Fig. 16 illustrates the throttle control arrangement used on the six-cylinder, twin marine units using variable speed governors.

A variable speed governor is one which maintains uniform speed of the engine with varying load conditions, yet the desired speed may be varied at will by the operator.

Idling speed (500 rpm) may be varied by an adjusting screw. Maximum speed (2000 rpm) is controlled by the governor spring. The governor may be set at any speed between idle and maximum speed and held within the limits of the governor droop.

The entire speed range of the engine is controlled by the speed control lever (4), which varies the tension on the governor spring. A stop lever (2), on the governor cover, moves the injector links (55) and (56) to the *off or run* position as the case may be.

Two conditions must be met when two engines are coupled to and drive a common load where either engine may be de-clutched while the other engine is loaded, or partly loaded, as is the case in this discussion:

1. The two engines must divide the load equally under all conditions of load and speed.

2. Each governor must control its own engine independently should different loads be demanded from the two engines.

Condition 1 is met by using an equalizer (cross) link (9) between the injector control tube levers (80) and (88) on the two engines--hereinafter known as "B" and "D" engines (port and starboard) respectively. This link is adjusted so that the injector racks of the two engines reach *full-load* position simultaneously. It follows then, that in any intermediate position between *full and off* position, the same quantity of fuel oil will be injected into each engine.

Condition 2 is met by incorporating a swivel joint between the injector control tube lever (80) and the equalizer link lever (81) at the "B" engine. Lever (80) is pinned to the injector rack control tube (76), lever (81) swivels on the control tube (76).

An equalizer spring (5) is fastened to the injector control tube lever (80) and an adjusting screw (98) in the equalizer link lever (81) bears against the free end of the equalizer spring. A link (55) from the governor on the "B" engine attaches to the lever (80) on the injector control tube, while a similar link (56) attaches to the injector control tube lever (88) on the "D" engine.

Throttle control rods (40) to each engine governor (1) are connected to a common throttle control shaft (100), which in turn is manipulated by a lever (32). A slotted link (79), at the governor end of each control rod (40), moves the governor stop lever (2) to the *stop* position when the master throttle is moved to the *off* position; when the master throttle is moved to the *idle* position, link (79) allows the stop lever to move--by the retracting spring (39)--to the *run* position before engaging the governor spring with the speed control lever (4). Farther opening of the master throttle allows link (79) to pick up the speed control lever (4), increase the tension on the governor spring and increase the engine speed. *Idle* position of the master throttle is likewise idling speed on the governor. Any opening of the throttle past the idling speed engages the governor spring and increases the engine speed accordingly.

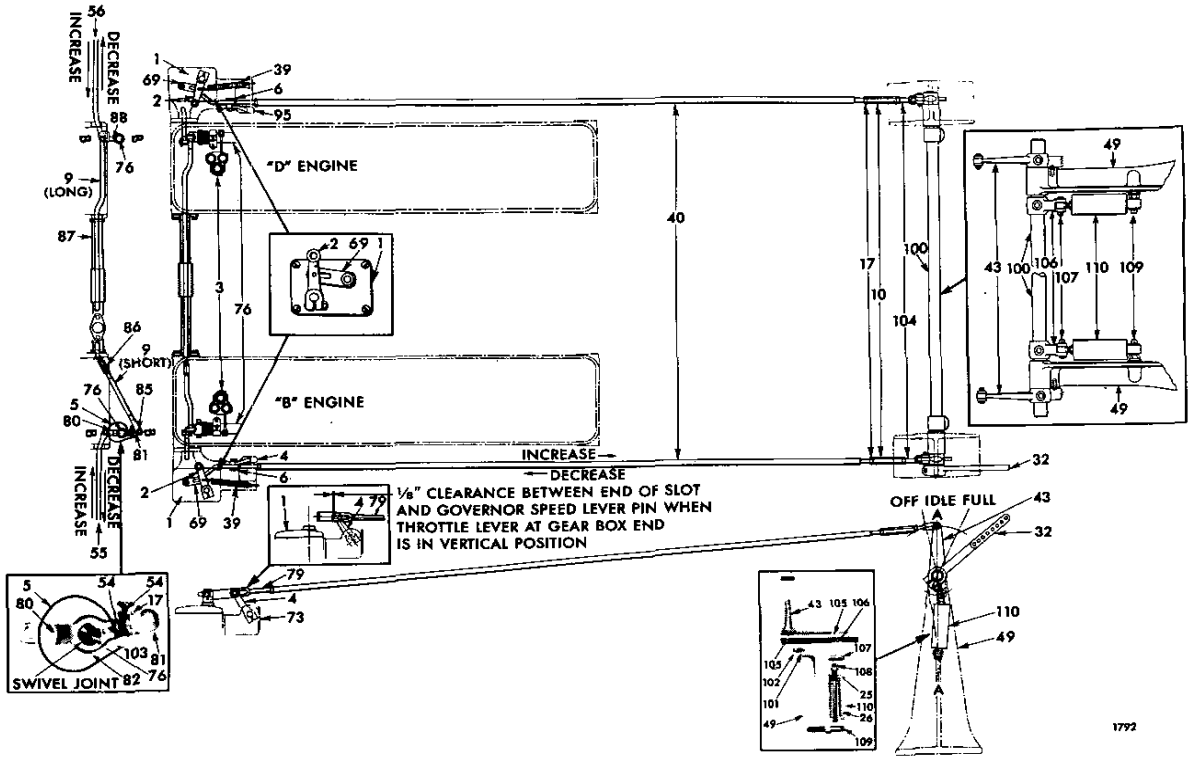
Opening the master throttle past the *idle* position brings two boosters (110) into play to assist in moving the throttle against the tension on the two governor springs. As will be seen from the illustration, the boosters are fulcrumed on studs (109) to the brackets (49) at the lever ends and attached to the throttle cross shaft (100) by the levers (106) at the upper end. The throttle control lever (43) is arrested in the *idle* position by a ball (102) and spring (101). The increase in effort to open the throttle against the governor springs past the *idle* position is counter-balanced by the boosters, which are also more effective the farther the throttle is opened.

Operation

The function of the link (9) between the two injector control racks, the swivel joint at the injector control tube on the "B" engine, and the equalizer spring (5) is best explained by reference to conditions (a), (b) and (c) in Fig. 17.

Condition (a) depicts the normal operating position when both engines are clutched to the common drive so that both governors allow the engines to run at exactly the same speed. The equalizer spring adjusting screw (111) is pressing against the free end of the equalizer spring (5), but the force is not sufficient to lift the spring from the spring stop (103). This force is obtained by setting the governors so that the "D" engine wants a little more fuel than the "B" engine, i.e., the "D" engine governor is set a little high with respect to the "B" engine governor. It is impractical to build two governors exactly alike as to spring rates, governor weight masses, linkage ratios and clearances so that when they are run at exactly the same speed they position the injector racks in the same location. Therefore, at various loads and speeds, the force on the equalizer spring (5) at the swivel joint on the "B" engine, will vary according to the differences in the two governors.

© 1983 General Motors Corp.



1. Governor
2. Lever--Governor Control
3. Injector
5. Spring--Equalizer
6. Bolt--Link to Speed Control Lever
9. Link--Equalizer
10. Turnbuckle--Throttle Control Rod
17. Locknut
25. Nut--Booster Spring Adjusting
26. Spring--Booster Compression
32. Lever--Master Throttle Control
39. Spring--Stop Lever Retracting
40. Rod--Throttle Control
43. Lever--Throttle Control
49. Bracket--Throttle Control Support
54. Screw--Equalizer Spring to Lever
55. Link--Governor Control (for "B" Engine)
56. Link--Governor Control (for "D" Engine)
69. Control Cam
73. Clip--Speed Control Lever Retaining Spring
76. Tube--Injector Rack Control
79. Link--Throttle Control to Governor
80. Lever--Injector Control Tube
81. Lever--Equalizer Link
82. Pin--Injector Control Tube Lever to Control Tube
85. Pin--Equalizer Link to Lever
86. Turnbuckle Equalizer Link
87. Cover Tube--Equalizer Link
88. Lever--Equalizer Link and Control Tube (for "D" Engine)
95. Lever--Speed Control
100. Cross Shaft--Throttle Control
101. Spring--Throttle Control Lever Stop
102. Ball--Throttle Control Lever Stop Spring
103. Stop--Equalizer Spring
104. Clevis--Throttle Control Rod
105. Pin--Throttle Booster Lever to Shaft
106. Lever--Throttle Booster
107. Pin--Booster to Throttle Booster Lever
108. Rod--Booster--Adjuster
109. Stud--Booster Support
110. Booster
111. Screw--Equalizer Spring Adjusting

Fig. 16 - Throttle Control Adjustment Diagram for Twin Marine Engines with Variable Speed Governors

Condition (b) illustrates the position of the linkage when the "B" engine is loaded more than the "D" engine. In this case, the clutch of the "D" engine has been disengaged and the governor on the "D" engine will withdraw the equalizer spring adjusting screw (111) away from the spring (5) in order to decrease fuel to the "D" engine.

Condition (c) shows the position of the linkage when the "D" engine is loaded more than the "B" engine. If the clutch on the "B" engine is disengaged for any reason, this engine will tend to run away. This condition is prevented by the governor on the "B" engine which overpowers the preload on the equalizer spring (5) through the swivel joint between the injector

© 1983 General Motors Corp.

control tube lever (80) and the equalizer link lever (81) to reduce the quantity of fuel to the free "B" engine.

NOTE: The "B" engine will have a higher no-load speed at wide open throttle than the "D" engine, because the governor of the "B" engine has the equalizer spring (5) at the swivel joint to overcome in addition to its own spring.

Adjustments

Throttle control adjustments are divided into three groups:

1. **Individual Governor Adjustments**

Adjust the engines individually as outline in *Variable Speed Mechanical Governor and Injector Rack Adjustment* before connecting the equalizer linkage and the throttle control linkage.

2. **Adjustments of Speed Lever Control Linkage--With Engines Stopped (Fig. 16).**

After adjusting the individual governors and connecting both speed lever links (79), adjust the speed lever control linkage as follows:

a. Set the throttle control cross shaft (100) so that the throttle control levers (43) are in a vertical position (Fig. 16). In this position the detent ball (102) will drop into position in the lever (43).

b. Adjust the turnbuckles (10) on the throttle control rods (40) so there is 1/8" between the forward end of the slot the throttle control link (79) and the bolt (6) in the speed control lever (4). This ensures that when the master throttle is returned to *idle* (detent position), each governor is free from the throttle linkage.

c. Move the master throttle (32) until the "B" engine link (79) just barely starts to pick up the governor speed lever (4). Lock the master throttle in this position.

d. Adjust the turnbuckle (10) on the throttle control rod (40) for the "D" engine until its link (79) starts to pick up its speed lever, then take not less than 1/4 nor more than 1/2 additional shortening turns on the turnbuckle (10) for the "D" engine only. Tighten the locknuts at the turnbuckles on both throttle control tubes.

3. **Adjustment of Equalizer (Cross Link)**

With the equalizer link cover (87) and the equalizer link (9) in place, adjust the link as follows, with the engine stopped (Fig. 16).

a. Back out the equalizer spring adjusting screw (111) so there is a definite clearance between the screw and the free end of the equalizer spring (5).

b. Loosen the locknut at the turnbuckle (86) on the equalizer link for the "B" engine and remove the pin (85) that connects the link (9) to the lever (81).

c. Set the equalizer link lever (81) at the "B" engine so that its clevis pin (85) center is directly over the center of the injector rack control tube (76). Set the equalizer link lever (88) at the "D" engine so that its clevis pin center is directly beneath the center of its injector rack control tube.

d. Adjust the length of the link (9) so that the pin (85) at the "B" engine can just be slipped in place with the levers (81) and (88) held in the positions given in Step c above. Tighten the turnbuckle locknut and install the cotter pin.

e. Check as follows: Rotate the injector rack control tube (76) of the "D" engine until the cross link clevis pin is directly under the center of the injector control tube, i.e., on an imaginary vertical line passing through the center of the two pieces. Holding this position, check to see that the clevis pin on the other end of the cross link is directly over the center of the injector rack control tube of the "B" engine. Careful adjustment of the cross link length, as closely as can be judged by the eye, is essential to proper operation.

f. Set the master throttle so that the governor speed control levers (4) are approximately vertical, in which position the governor springs will push the injector rack into the *full-fuel* position.

g. Carefully screw in the equalizer spring adjusting screw (111) in the equalizing link lever (81) at the "B" engine until the screw just touches the free end of the spring (5). Tighten the locknut and check the adjustment. If the mechanism is correctly adjusted, the spring (5) will touch the stop (103) and the adjusting screw (111) simultaneously, with all slack taken out of the cross link pin joints.

Starting

When starting, open the master throttle to any position greater than *idle* and press the starter button.

NOTE: If the master throttle is set in the *idle* position and the "B" engine is started first, difficulty may be encountered in attempting to start the "D" engine. This is because of the fast idle on the "B" engine after starting.

© 1983 General Motors Corp.

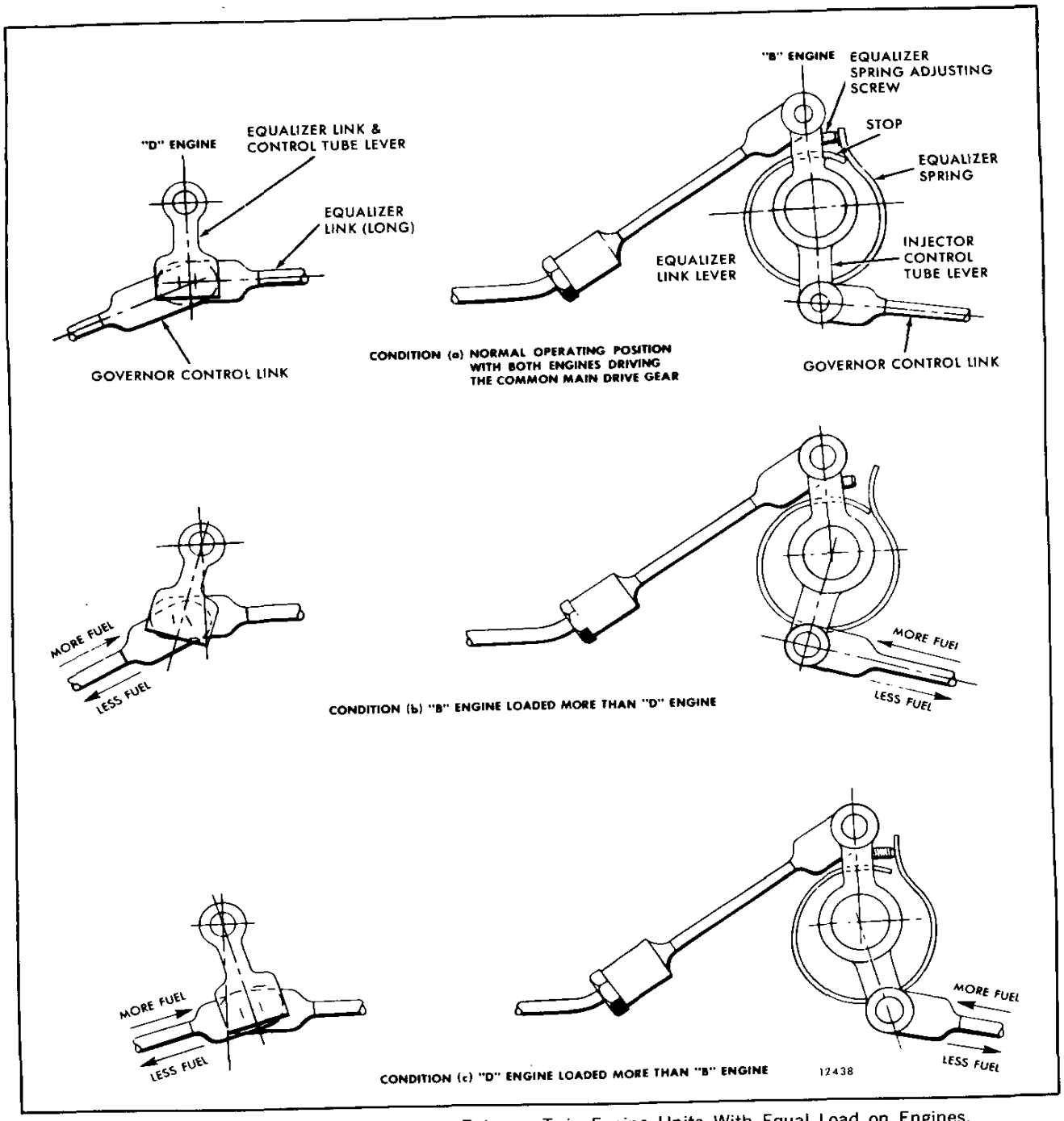


Fig. 17 - Positions of Throttle Linkage Between Twin Engine Units With Equal Load on Engines, Also, When Unequally Loaded

If the "B" engine only is to be used, hold the "D" engine stop lever (2) in the *off* position by unhooking the retracting spring (39) and fastening it toward the front of the engine.

Stopping

Stop the engines by moving the master throttle to the *off* position. This moves the stop lever to the *off* position by means of the link (79) on the throttle control rod (40).

© 1983 General Motors Corp.

WOODWARD UG8 HYDRAULIC GOVERNOR AND THROTTLE LINKAGE ADJUSTMENTS

The Woodward UG8 dial type governor is used to regulate the output shaft speed of units that require precise speed control and at times zero speed droop operation. Speed adjustment (synchronizer), speed droop and load limit controls are mounted on the dial of the governor.

The synchronizer, or speed adjusting control, is used to change the engine speed when running alone or to change the engine load when the engine has been paralleled with other units. The synchronizer indicator, located directly below the synchronizer, indicates the number of revolutions of the synchronizer knob.

A synchronizing motor may be mounted on the top of the UG8 governor to provide remote speed control. Its use enables the switchboard operator to match the frequency of an engine-driven alternator with that of other units, or a system, before paralleling and to change load distribution after paralleling.

A slip coupling is provided between the motor shaft and the synchronizer adjusting gear to allow the engine operator to adjust speed by turning the synchronizer control knob on the governor. This coupling is of the friction type.

The speed droop control can be set to permit automatic division and balance of the load between units driving the same shaft, or paralleled in an electrical system.

Droop is incorporated in the governor through a linkage which varies the compression of the speeder (speed adjusting) spring as the terminal shaft rotates. As the terminal shaft rotates toward the increased fuel position, the speeder spring tension is reduced, thus reducing the output shaft governor speed setting accordingly. The unit will gradually reduce its speed as load is applied. This relationship between load and speed permits the unit to operate in parallel with other units and properly share the load with these units.

As droop is reduced to zero, the unit is able to change load without changing speed. As a general rule, units running alone should be set on zero droop and interconnected units should be run at the lowest droop setting that will give satisfactory load division.

Alternating current generating units tied in with other units should have the droop set sufficiently high (30 to 50 on the dial) to prevent interchange of load between units.

The load limit control hydraulically limits the load that can be put on the engine by restricting the angular terminal shaft rotation of the governor and, consequently, the quantity of fuel supplied to the engine.

CAUTION: Do not manually force the engine linkage to increase fuel without first turning the load limit knob to 10.

When the governor is installed on the engine, particular care should be exercised to see that it is mounted squarely and that the drive connection to the engine is aligned properly. A gasket is placed between the base of the governor and the mounting pad on the engine.

CAUTION: Do not drop or rest the governor on its drive shaft.

The gear placed on the keyed type governor drive shaft should be checked to ensure that it is meshing properly. There should be neither excessive backlash nor binding. Irregularities caused by uneven gear teeth, shaft runout, etc., will be picked up by the

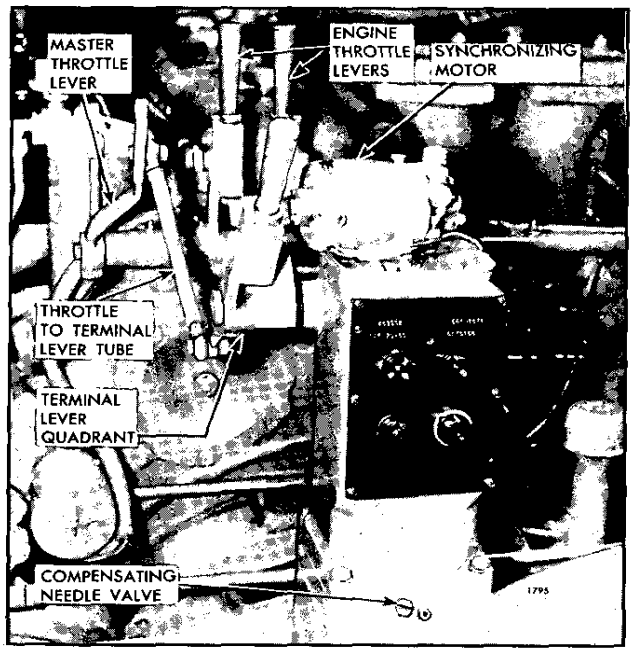


Fig. 1 - UG8 Governor and Throttle Linkage

© 1974 General Motors Corp.

governor, transmitted to the fuel control system and will result in erratic governing.

Since the load limit device operates hydraulically rather than mechanically, the load indicating pointer position cannot be changed by turning the load limit control unless the governor is running (or has oil pressure in its accumulators). When installing the governor, the terminal shaft must be rotated by a lever in order to obtain the zero load position.

> **CAUTION:** Do not manually force the engine linkage to increase fuel without first turning the load limit knob to 10.

The linkage from the UG8 governor terminal shaft to the fuel control lever on the engine governor should be free from lost motion or excessive friction.

Use SAE 20 or SAE 30 oil in the UG8 governor for ordinary temperature conditions. If governor operating conditions are extremely hot, use SAE 40 or SAE 50 oil; if extremely cold, use SAE 10 oil.

The oil must not contain additives which are used to free up engine piston rings, remove carbon, etc., unless a non-foaming additive is also present. The oil should not foam or sludge excessively when agitated or form gummy deposits when heated.

Dirty oil causes most governor troubles. Use clean, new oil or filtered oil. All containers must be clean and should be rinsed with light grade fuel oil before using.

Keep the governor oil at the correct level on the oil gage.

Adjust Throttle Linkage on Twin Units with UG8 Governor Assemblies

1. Remove the throttle lever to terminal lever tube (Fig. 1).

2. Remove the governor control rod from the governor control lever on top of each engine's limiting speed governor.

3. Adjust each engine according to the procedure in Section 14.3 for engines with limiting speed governor assemblies or Section 14.4 for constant speed governor assemblies.

The individual engine tune-up is very important when adjusting a twin unit since the engines must be closely synchronized to enable each to carry its full share of the load.

4. Adjust the throttle linkage between the engines as outlined in Section 14.12 for twin engine units.

5. Set the engine governors in the *idle* position, if limiting speed governors are used, or in the *off* position if constant speed governors are used. The handles of the engine throttle levers should be in a vertical position when the pin is in quadrant. If the throttle linkage to the engine governors requires alteration to move the handles to a vertical position, adjust the turnbuckle of each governor control lever an equal amount and then retighten. The engine speeds must be rechecked and the linkage adjusted, if necessary, as outlined in Section 14.12.

6. Rotate the governor terminal lever toward a decreased fuel position until the pointers on the load limit indicator point to zero at the end of its travel. Then turn the load limit knob to zero to lock the terminal lever in this position.

7. Adjust the throttle to terminal lever tube until it is 15" in length between the end bearing centers on units with standard twin transfer gear housings. If the unit has an "O" housing for mounting of a generator or torque converter, the tube should be adjusted to a length of 10 7/8". Tighten the nuts to retain the adjustment.

8. Loosen the clamping bolt retaining the quadrant to the governor terminal lever. Place the pin of the handle in the governor quadrant.

9. Attach the throttle to terminal lever tube to the master throttle lever, in the third hole from the top, and to the terminal lever quadrant. Tighten the retaining bolts securely.

10. Tighten the clamping bolt retaining the quadrant to the governor terminal lever.

> **CAUTION:** Do not manually force the engine linkage to an increased fuel position without first turning the load limit knob to 10.

Starting Engine

When starting the engine, set the load limit (fuel limit) at 10 on the dial. By means of the synchronizer, adjust the engine to its normal operating no-load speed.

Compensating Adjustments

Although the governor may appear to be operating satisfactorily because the engine runs at constant speed (without load), the governor still may not be adjusted correctly. High overspeeds and underspeeds after load changes and slow return to normal speed are results of incorrect compensation adjustments.

© 1974 General Motors Corp.

Make the following adjustments to be certain that the governor will give optimum control.

After the temperature of the engine and the oil in the governor have reached their normal operating values, the compensation should be adjusted without load on the engine as follows:

1. Loosen the nut holding the compensation adjusting pointer and set the pointer at its extreme downward position (Fig. 1).

2. Remove the plug, open the compensating needle valve two or three turns with a screw driver and allow the engine to hunt or surge for about one half minute to bleed trapped air from the governor oil passages.

3. Gradually close the needle valve until hunting just stops. Do not go beyond this position. Then check the amount of needle valve opening by closing the valve completely, noting the amount of a full turn required to close it. Open the valve to the previously determined opening at which hunting stopped. Test the action by manually disturbing the engine speed. If the needle valve is now less than 1/2 turn open and more than 1/8 turn open, the adjustment is satisfactory and Steps 4, 5, 6 and 7 should be ignored.

4. If hunting did not stop with the needle valve at least 1/8 turn open, raise the compensation pointer two divisions on the scale and continue with the following instructions.

5. Open the needle valve approximately one turn to allow the engine to hunt.

6. Proceed with Step 3.

7. If necessary, repeat Steps 4, 5 and 3 until the adjustment is satisfactory. The desirable needle valve opening is from 1/8 to 1/4 turn open.

8. It is desirable to have as little compensation as possible. Closing the needle valve farther than necessary will make the governor slow to return to normal speed after a load change.

Excessive dashpot plunger travel caused by adjustment of the compensation adjusting pointer too far toward maximum position will cause excessive speed change upon load change.

Speed Droop Setting

The governor speed droop is adjustable and may be changed by turning the knob on the face of the dial. When the pointer on the knob is on zero, the governor is set for isochronous operation. When the pointer is on 100, the governor is set for maximum governor speed droop.

It is recommended that units operting in parallel should have the speed droop set sufficiently high (30 to 50 on the dial) to permit interchange of load between the units.

© 1974 General Motors Corp.

SUPPLEMENTARY GOVERNING DEVICE ADJUSTMENT

ENGINE LOAD LIMIT DEVICE

Engines with mechanical governors may be equipped with a load limit device (Fig. 1) to reduce the maximum horsepower.

This device consists of a load limit screw threaded into a plate mounted between two adjacent rocker arm shaft brackets and a load limit lever clamped to the injector control tube.

The load limit device is located between the No. 1 and No. 2 cylinders of a three cylinder engine, between the No. 2 and No. 3 cylinders of a four cylinder engine or between the No. 3 and No. 4 cylinders of a six cylinder engine.

When properly adjusted for the maximum horsepower desired, this device limits the travel of the injector control racks and thereby the fuel output of the injectors.

Detroit Diesel Allison's naturally aspirated engines are designed to operate in most areas of the United States without any changes or modifications. However, as the engine is operated at higher elevations, the operator will begin to notice a loss of engine power and a noticeably darker exhaust smoke. This is due to the thinner air at the higher elevations not having enough oxygen to burn the fuel completely in the combustion chamber. This is generally not a problem if operation at the higher altitudes is only temporary and can be offset somewhat by reducing vehicle loads to compensate for the loss of engine power at the higher elevations. This may also result in cleaner exhaust smoke if the power demands on the engine are reduced. The exhaust smoke will also be cleaner if drivers avoid lubbing the engine by using lower gears to keep engine speed up.

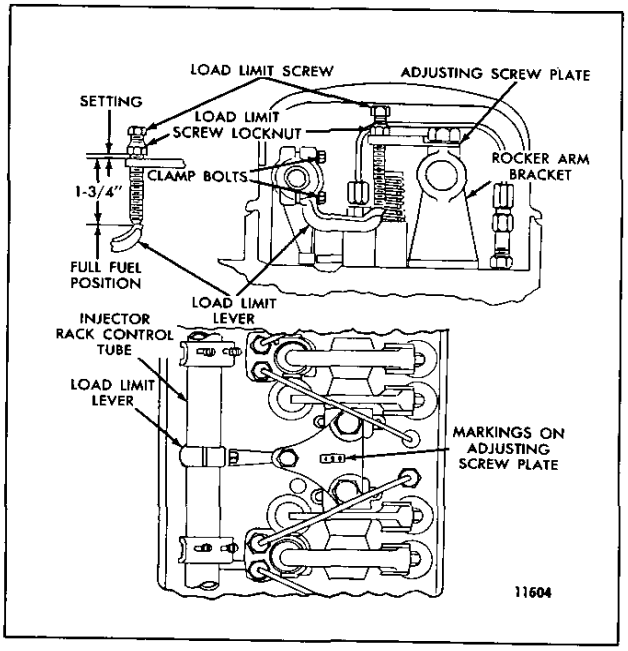


Fig. 1 - Engine Load Limit Device

If the engine is intended to be used continuously at higher elevations and the exhaust smoke is objectionable (excessively dark), you may wish to install a load limiter to restrict injector output or switch to a smaller injector for your Series 71 engine. Detroit Diesel Allison has certified with the U.S. EPA injector sizes ranging from 50 to 65 cu. mm output, depending on whether the engine is used in coach or truck applications. A listing of injectors which are available for these engines and their tune-up specifications is shown in Table 1.

ALTITUDE ADJUSTMENT INFORMATION

To reduce engine fuel input in order to reduce exhaust smoke density at high altitudes, remove injectors and replace with next smallest injector shown on chart. Adjust cam and gear timing as required.

ENGINE FAMILY	INJECTOR	INJECTOR TIMING	GEAR TRAIN TIMING (See Section 1.7.1)	FULL LOAD SPEED RANGE*
6L-71N	7E65	1.484	Std. Gear—Adv. Cam	2100 — 1900
	7E60	1.484	Standard	2100 — 1800
	7E55	1.496	Standard	2100 — 1800
	7E50	1.484	Standard	2100 — 1800

**2300 RPM full-load speed is permitted for certain emergency vehicles.*

TABLE 1

Adjustment

After the engine tune-up is completed, make sure the load limit device is properly installed as shown in Fig. 1. Make sure the counterbores in the adjusting screw plate are up. The rocker arm shaft bracket bolts which fasten the adjusting screw plate to the brackets are tightened to 75-85 lb-ft (102-115 Nm) torque (all other rocker arm shaft bracket bolts are tightened to 90-100 lb-ft or 122-136 Nm torque). Then adjust the load limit device as follows:

© 1982 General Motors Corp.

LOAD LIMIT DEVICE SETTINGS FOR REDUCED FUEL INPUTS AT HIGH ALTITUDES		
	LOCK NUT SETTING ABOVE PLATE	
INJECTOR	INCHES	NUMBER OF TURNS
7E65	.19	4-½
7E60	.12	3
7E55	.16	4
7E50	.20	5

TABLE 2

1. Loosen the load limit screw locknut and remove the screw.

2. Loosen the load limit lever clamp bolts so the lever is free to turn on the injector rack control tube.

3. With the screw out of the plate, adjust the load limit screw locknut so the bottom of the locknut is 1 3/4" from the bottom of the load limit screw (Fig. 1) for the initial setting.

4. Thread the load limit screw into the adjusting screw plate until the locknut *bottoms* against the top of the plate.

5. Hold the injector rack control tube in the full-fuel position and place the load limit lever against the bottom of the load limit screw. Then tighten the load limit lever clamp bolts.

6. Check to ensure that the injector racks will just go into the full-fuel position -- readjust the load limit lever, if necessary.

7. Hold the load limit screw to keep it from turning, then *set* the locknut until the distance between the bottom of the locknut and the top of the adjusting screw plate corresponds to the dimension (or number of turns) stamped on the plate. See Table 2 for high altitude settings. Each full turn screw equals .042", or .007" for each flat on the hexagon head.

> **NOTE:** If the plate is not stamped, adjust the load limit screw while operating the engine on a dynamometer test stand and note the number of turns required to obtain the desired horsepower. Then stamp the plate accordingly.

As experience is gained with the load limiter, you may wish to readjust the limiter to either improve performance or to further reduce smoke.

> **NOTE:** Remember that the load limiter is a device which limits both the fuel output of the injectors and the power output of the engine. Therefore, after the device is installed, the vehicle driver should be cautioned that the power output of his engine has been restricted.

8. Thread the load limit screw into the plate until the locknut *bottoms* against the top of the plate. Be sure the nut turns with the screw.

9. Hold the load limit screw to keep it from turning, then tighten the locknut to secure the setting.

© 1982 General Motors Corp.

POWER CONTROL DEVICE

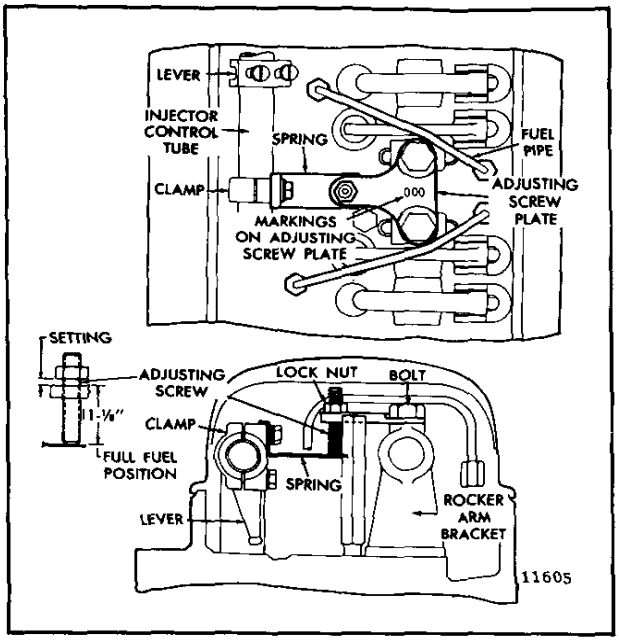


Fig. 2 - Power Control Device

The power control (torque limiting) device (Fig. 2) is used, on some vehicle engines, to limit the maximum horsepower output at the wheels without diminishing the performance at lower speeds where full power may be required. It limits the horsepower at, or just below, the normal full-load governed speed. These limiting characteristics are proportionately lessened as the engine speed is reduced and the horsepower required is reduced.

This device consists of an adjusting screw threaded into a plate mounted between two adjacent rocker arm shaft brackets and a spring attached to a clamp on the injector control tube.

NOTE: The rocker arm shaft bracket bolts that retain the adjusting screw plate are tightened to 75-85 lb-ft (102-115 Nm) torque. All other rocker arm shaft bracket bolts are tightened to 90-100 lb-ft (122-136 Nm) torque.

The power control device is located between the No. 1 and No. 2 cylinders on a three-cylinder engine, between the No. 2 and No. 3 cylinders on a four-cylinder engine and between the No. 3 and No. 4 cylinders on a six-cylinder engine.

Adjustment

After the engine tune-up is completed, adjust the power control device as follows:

1. Place the vehicle on a chassis dynamometer and check the maximum wheel horsepower.

2. Loosen the power control spring attaching bolts. Then adjust the spring until it projects parallel to the cylinder head when the injector control racks are held in the full-fuel position. Tighten the spring attaching bolts to 7-9 lb-ft (10-12 Nm) torque to retain the adjustment.

3. Set the power control device, while holding the injector control racks in the full-fuel position, by turning the adjusting screw down (clockwise) until it just touches the spring and the locknut is tight against the plate. Then release the injector control racks.

NOTE: Wipe the oil from the spring and the bottom of the adjusting screw so the point of contact can be seen readily.

4. Start the engine. Then, with the engine running at full governed speed, check the horsepower. If necessary, readjust the screw to obtain the specified horsepower. Turn the screw down to decrease the horsepower; turn the screw up to increase the horsepower. When the desired wheel horsepower is obtained, hold the screw from turning and tighten the locknut.

NOTE: If a dynamometer is not available, backup the lock nut the distance stamped on the plate. Then turn the screw and locknut down together until the locknut *bottoms* on the plate. Hold the screw from turning and tighten the locknut.

© 1982 General Motors Corp.

THROTTLE DELAY MECHANISM

The throttle delay mechanism is used to retard full-fuel injection when the engine is accelerated. This reduces exhaust smoke and also helps to improve fuel economy.

The throttle delay mechanism (Fig. 3) is installed between the No. 1 and No. 2 cylinders on the cylinder head. It consists of a special rocker arm shaft bracket (which incorporates the throttle delay cylinder), a piston, throttle delay lever, connecting link, orifice plug, ball check valve and U-bolt.

A yield lever and spring assembly replaces the standard lever and pin assembly on the front end of the injector control tube.

Operation

Oil is supplied to a reservoir above the throttle delay cylinder through an orifice plug in the drilled oil passage in the rocker arm shaft bracket (Fig. 3). As the injector racks are moved toward the no-fuel position, free movement of the throttle delay piston is assured by air drawn into the cylinder through the ball check valve. Further movement of the piston uncovers an opening which permits oil from the reservoir to enter the cylinder and displace the air. When the engine is accelerated, movement of the injector racks toward the full-fuel position is momentarily retarded while the piston expels the oil from the cylinder through an orifice. To permit full accelerator travel, regardless of the retarded injector rack position, a spring loaded yield lever and spring assembly replaces the standard lever on the front end of the injector control tube.

Inspection

The current throttle delay bracket has a closer tolerance on the piston and cylinder bore. The current check valve has a nylon check ball in place of the former brass ball. When inspecting the throttle delay hydraulic cylinder, it is important that the check valve be inspected for wear.

To inspect the check valve, fill the throttle delay cylinder with diesel fuel oil and watch for check valve leakage while moving the engine throttle from the idle position to the full-fuel position. If more than a drop of leakage occurs, replace the check valve.

Service Note

The current throttle delay cylinder rocker arm bracket has a 5/64" diameter fill hole. The former throttle delay cylinder with a 1/4" diameter fill hole can be modified as follows:

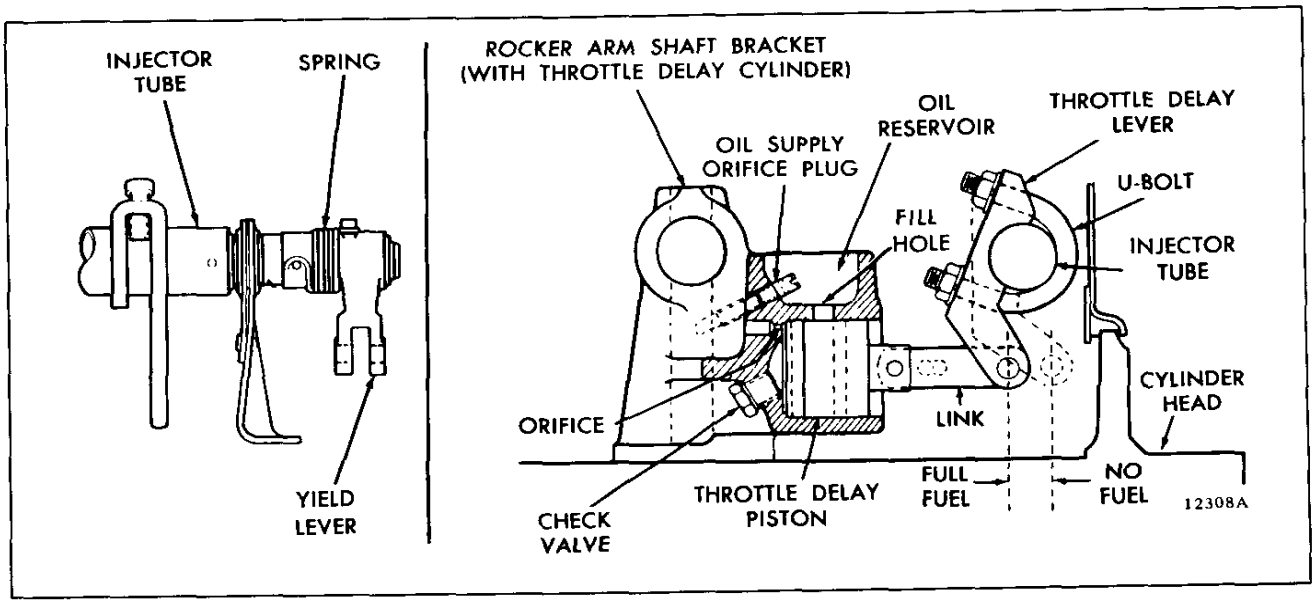


Fig. 3 - Throttle Delay Cylinder and Yield Link

© 1982 General Motors Corp.

1. Ream the fill hole to .2646"-.2666" diameter with a 17/64" reamer.

2. Remove any burrs formed in the throttle delay piston bore with fine emery cloth to be sure the piston moves freely.

3. Press a service bushing in the reamed hole and recheck the piston for free movement,

4. Remove and discard the original check valve. Install a new check valve.

5. Assemble and install the throttle delay cylinder. Then adjust as outlined under *Adjustment (Former Throttle Delay)*.

Adjustment (Current Throttle Delay)

Whenever the injector rack control levers are adjusted, disconnect the throttle delay mechanism by loosening the U-bolt which clamps the lever to the injector control tube. After the injector rack control levers have been positioned, the throttle delay mechanism must be readjusted. With the engine stopped, proceed as follows:

1. Disconnect the throttle delay mechanism by loosening the U-bolt which clamps the lever to the injector control tube (Fig. 4).

2. To provide adequate lubrication of mechanical components, fill the throttle delay reservoir with clean engine oil. The oil reservoir does not have to remain full during the entire adjustment procedure.

3. Insert the appropriate throttle delay timing gage (see charts in Section 14) on the rack between the injector body and the shoulder on the injector rack clevis (Fig. 1). This is the No. 2 injector on 6V and 8V engines, the No. 5 injector on 12V engines and the No. 6 injector on 16V engines.

4. Hold the governor throttle lever in the maximum speed position. This should cause the injector rack to move toward the full-fuel position.

5. Insert pin gage J 25558 with the "go" (green .069") end in the cylinder fill hole. If the throttle delay housing has multiple holes, use the hole indicated in Fig. 5.

6. Rotate the throttle delay lever in the direction shown in Fig. 4 until further movement is limited by the piston contacting the pin gage.

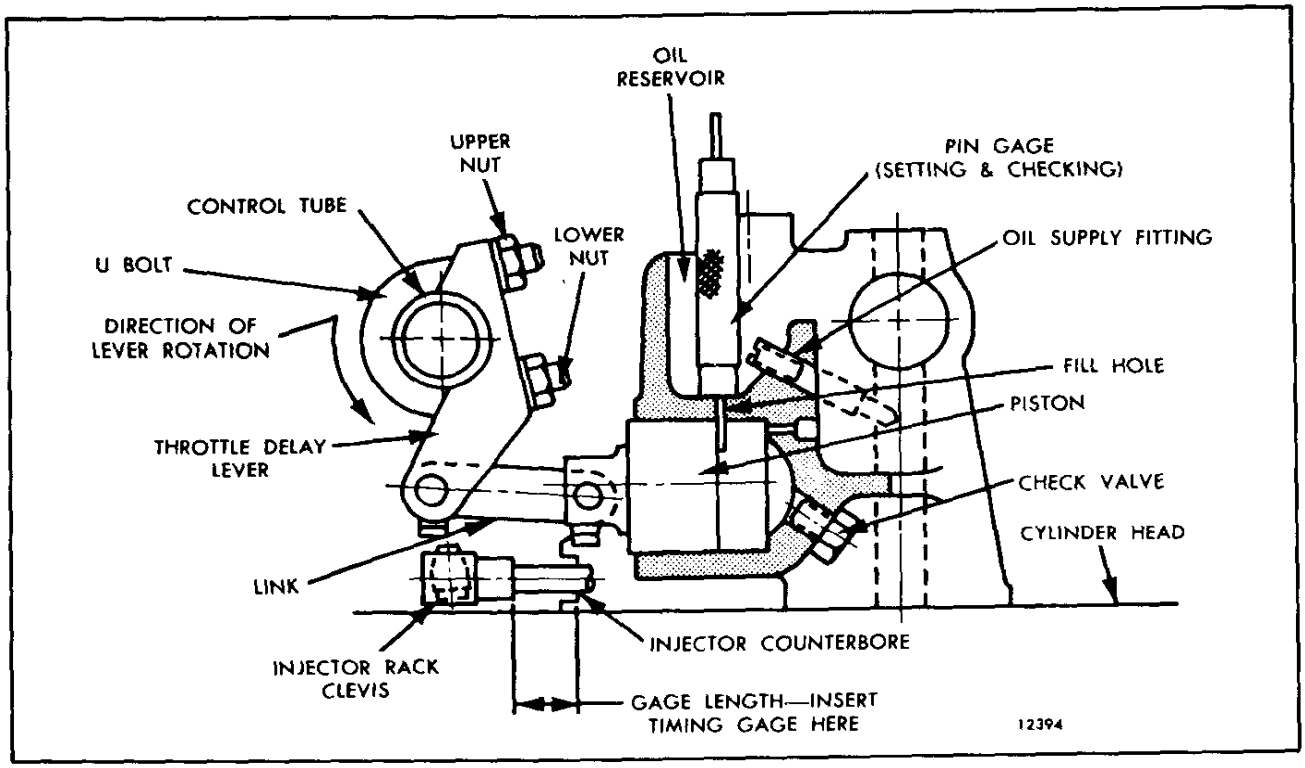


Fig. 4 - Adjusting Throttle Delay Cylinder (Current)

© 1982 General Motors Corp.

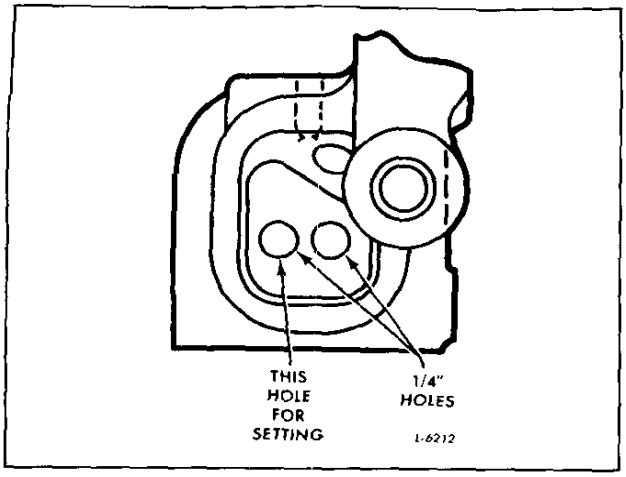


Fig. 5 - Throttle Delay with Multiple Fill Holes

7 Tighten the U-bolt while exerting a slight pressure on the lever in the direction of rotation.

8. Check the setting as follows:

a. Remove the pin gage.

b. Reinsert the "go" (green .069") end of the gage in the fill hole. If the gage will not go past the piston without resistance, increase the torque on the lower U-bolt nut. Remove the gage.

c. Reverse the pin gage and attempt to insert the "no go" (red .072") end in the fill hole. If the "no go" end of the gage enters the fill hole past the piston without resistance, increase torque on the upper U-bolt nut. It should not be possible to insert the agge past the piston without moving the injector racks toward the no-fuel position.

9. Release the governor throttle lever and remove the timing gage and pin gage. If either U-bolt nut is tightened without the pin gage being inserted, recheck the setting.

10. Move the injector control tube assembly between the no-fuel and the full-fuel position to make sure there is no bind.

Adjustment (Former Throttle Delay)

Whenever the injector rack control levers are adjusted, disconnect the throttle delay mechanism by loosening the U-bolt which clamps the lever to the injector

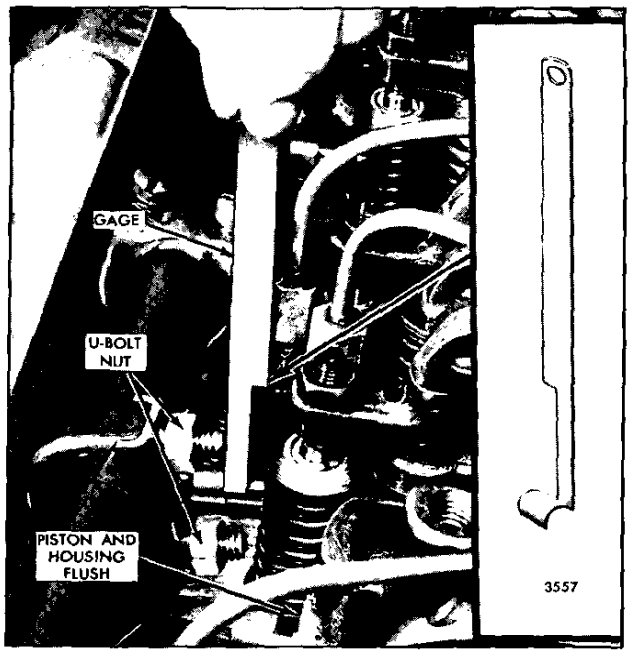


Fig. 6 - Adjusting Throttle Delay Cylinder (Former)

control tube. After the injector rack control levers have been positioned, the throttle delay mechanism must be readjusted. With the engine stopped, proceed as follows:

1. Refer to Fig. 6 and insert gage J 23190 (.454" setting) between the injector body and the shoulder on the injector rack. Then exert a light pressure on the injector control tube in the direction of full fuel.

2. Align the throttle delay piston so it is flush with the edge of the throttle delay cylinder.

3. Tighten the U-bolt on the injector control tube and remove the gage.

4. Move the injector rack from the no-fuel to the full-fuel position to make sure it does not bind.

5. Refer to *Engine Tune-Up* in Section 15.1 for maintenance.

© 1982 General Motors Corp.

FUEL MODULATOR

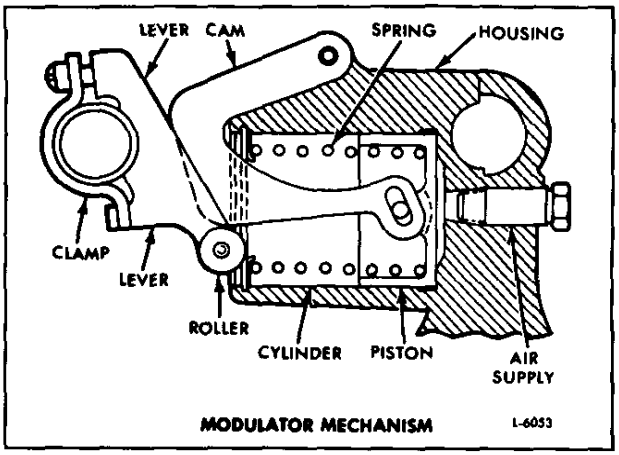


Fig. 7 - Fuel Modulator Assembly - 6-71T and 6-71TT Highway Vehicle Engines

Fuel modulators are now available for use on Federal-certified 6-71T and 6-71TT highway vehicle engines.

The fuel modulator (Fig. 7) is mounted on the cylinder head between the No. 5 and No. 6 cylinders and consists of a cast housing containing a cylinder, piston, cam and spring. A lever and roller assembly which controls the injector rack, is connected to the injector control tube. An air supply line runs from the turbocharger discharge on the air inlet housing to the modulator housing, providing pressure to activate the piston. On early industrial turbocharged engines, the fuel modulator is connected to the engine air box and is sensitive to the air box pressure.

The fuel modulator maintains the proper fuel-to-air ratio in the lower speed ranges where the mechanical governor would normally act to provide maximum injector output. It operates in such a manner that, although the engine throttle may be moved into the full-fuel position, the injector racks cannot advance to the full-fuel position until turbocharger speed is high enough to provide sufficient air for combustion.

Increased pressure forces the piston and cam out of the cylinder, allowing the rack to move toward full fuel. The spring behind the piston is calibrated to the pressure characteristics of the engine.

Inspection

At major repair or overhaul, inspect the roller and piston outer diameter and the cylinder bore inner diameter for wear. Also, inspect the operating surfaces, the lever roller, the roller pins at the cam pivot and the cam attachment to the piston. Replace parts, as required.

Adjust Fuel Modulator (Highway Vehicle Engines)

Before the fuel injector rack control levers are adjusted, the fule modulator lever and roller assembly must be positioned free of cam contact. This is done by loosening the clamp screw (Fig. 7).

After the injector rack control levers have been properly positioned, adjust the modulator as follows:

1. With the engine stopped, insert the proper rack gage between the injector body and the shoulder of the injector rack on the No. 4 cylinder. Fuel modulator specifications and setting tools are as follows:

2. Position the governor speed control lever in the maximum speed position and the governor run-stop lever in the *run* position.

3. Rotate the modulator lever assembly and clamp on the injector control tube until the lever roller contacts

CERTIFICATION	SETTING	TOOL	RATING	INJECTOR
1979 thru 1983 Federal Engines	6-71T .365*	J 28779	245 @ 2100 260 @ 2100	N65 7C70
	6-71TA .385	J 24882	275 @ 2100 260 @ 1800 270 @ 1950	7C75 7C75 (TA Engine) 7C75 (TA Engine)
1979 thru 1983½ Federal Engines	6-71TT & TTA .385*	J 24882	180 @ 1800 230 @ 1800 230 @ 1950 240 @ 2100	7E75 7E75 7E75 7E75

*The blower drive gear ratio must be 1.65:1 and 1.51:1 for the 6-71T and TT respectively.

© 1984 General Motors Corp.

the modulator cam with sufficient force to take up the pin clearances. Be sure that only the roller contacts the cam and not the lever stamping. Tighten the modulator lever and clamp screw. Check the setting by pushing on the cam directly over the roll pin. If the gage is tight *initially* and loosens when the cam is pushed, the setting is correct.

4. Remove the gage.

Adjust Fuel Modulator (Early Turbo. Industrial Engines)

After completing adjustment of the injector rack control levers, adjust the fuel modulator as follows:

1. Relocate the fuel modulator lever and roller assembly to its original position opposite the cam so the cam is centrally located on the roller (Fig. 8). Tighten the "U" bolt nuts until the lever and roller assembly is snug on the control tube. This will not only permit adjustment of the lever, but will retain the adjustment until the roller and lever assembly can be securely tightened.

2. Hold the fuel modulating piston and cam in the high speed position by applying not less than 20 psi (138 kPa) air pressure to the piston or by prying the cam out with a screwdriver.

3. Hold the injector rack in the full-fuel position.

4. While holding the cam and the injector rack, move the fuel modulating lever and roller assembly until the roller contacts the cam. Carefully, tighten the nuts on the "U" bolt alternately to avoid changing the position of the roller against the cam.

Check Fuel Modulator Setting

1. Pry the fuel modulating cam out with a screwdriver.

2. Move the injector control tube to the full-fuel position.

3. Release the pressure on the screwdriver slightly and allow the cam to move in slightly. If properly set, the roller of the fuel modulating lever and roller assembly will rotate as soon as the cam moves. Repeat this check several times to ensure the proper setting was not disturbed while tightening the "U" bolt clamping nuts.

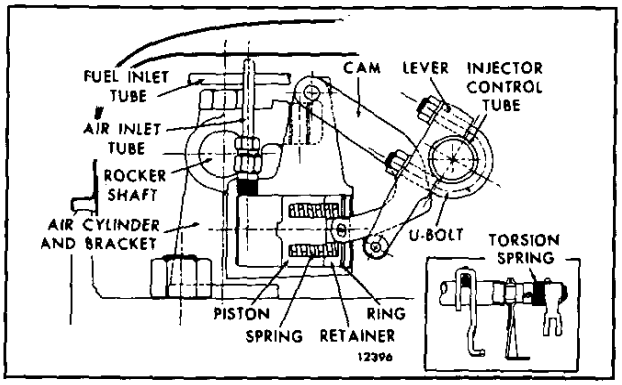


Fig. 8 - Fuel Modulator Assembly - Early Turbocharged Industrial Engines

FUEL SHUTOFF AIR CYLINDER ASSEMBLY

An air cylinder (Fig. 9) is mounted at the rear of the cylinder head on some engines to move the injector fuel control racks to the no-fuel position to stop the engine. The air cylinder permits the use of a governor with a single control lever, eliminating the need of an off-on lever and the necessary operating linkage.

The use of the air cylinder on an engine with a limiting speed governor requires a yielding fuel control rod (Fig. 10). An engine equipped with an air cylinder and a fuel modulating governor (Figs. 11 and 12) does not require the yielding rod because the torsion spring within the governor will perform the same purpose.

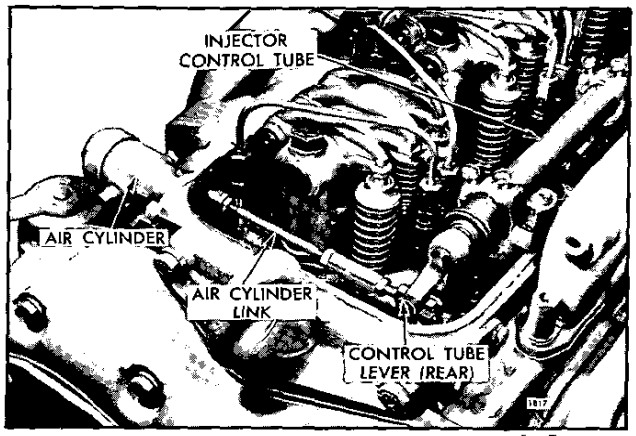


Fig. 9 - Air Cylinder Used with Limiting Speed Governor

© 1984 General Motors Corp.

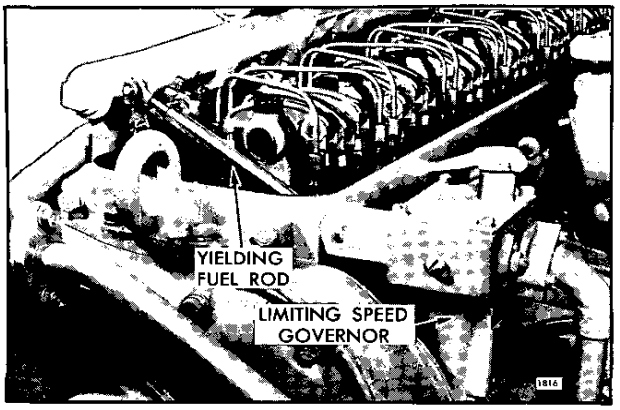


Fig. 10 - Yielding Fuel Rod Used with Limiting Speed Governor

Operation

The fuel shutoff cylinder is actuated by air pressure. The air enters the cylinder and forces the piston forward, thus overcoming the tension of the air cylinder spring; the yielding fuel rod is used to move the injector fuel control racks to the no-fuel position, shutting the engine down. When the air pressure is released, the spring within the air cylinder moves the piston to the end of its travel away from the engine allowing the yielding rod to expand, moving the injector racks into the full-fuel position required for engine starting.

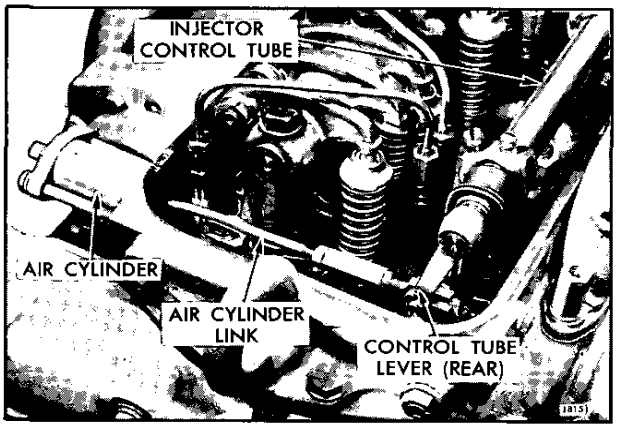


Fig. 11 - Air Cylinder Used with Fuel Modulating Governor

Adjust Air Cylinder Linkage

After completing adjustment of the governor, adjust the linkage between the fuel shutoff cylinder and the injector control tube lever as follows:

1. Place the governor speed control lever in the maximum speed position. Movement of the control lever will move the injector racks to the full-fuel position.

2. Loosen the locknuts on the air cylinder link (Fig. 9) and lengthen the rod by turning the turnbuckle until the end of the slot contacts the pin in the end of the control tube lever. Then shorten the rod one complete turn of the turnbuckle and tighten the locknuts.

Adjusting the rod in this manner will permit the governor to move the injector control racks into the full-fuel position without coming to the end of the slot in the air cylinder link.

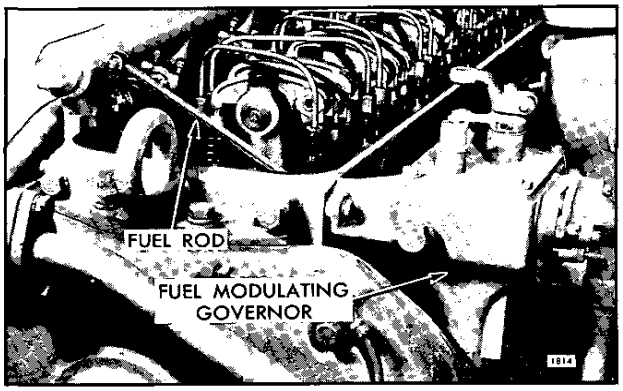


Fig. 12 - Standard Fuel Rod Used with Fuel Modulating Governor

© 1984 General Motors Corp.

ADJUSTMENT OF MECHANICAL GOVERNOR SHUTDOWN SOLENOID

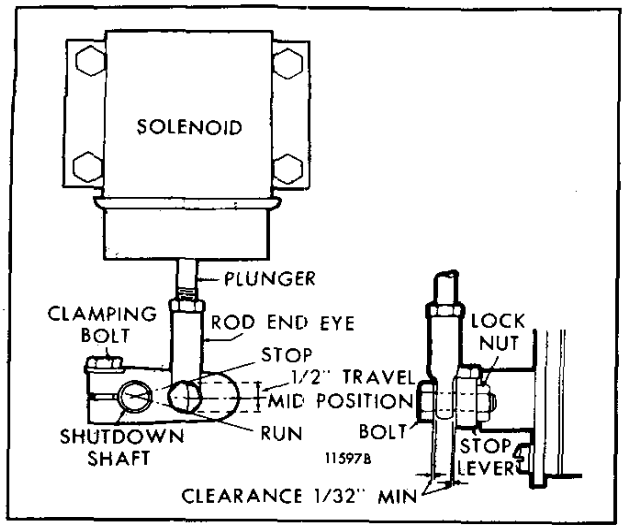


Fig. 13 - Typical Variable Speed Governor Lever Position

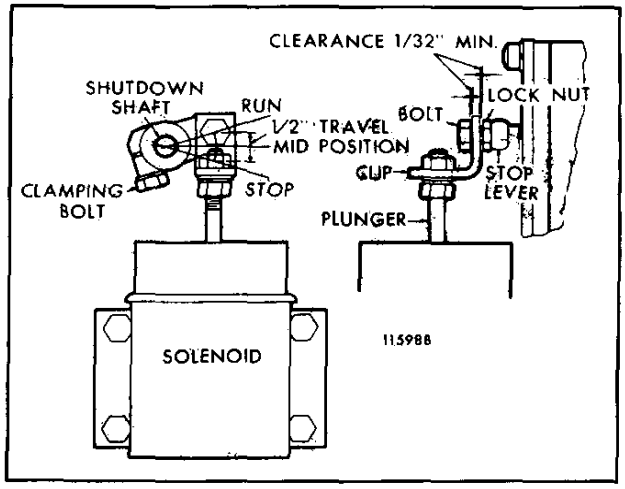


Fig. 14 - Typical Limiting Speed Governor Lever Position

When a governor shutdown solenoid is used on an engine equipped with a mechanical governor, the governor stop lever must be properly adjusted to match the shutdown solenoid plunger travel.

The solenoid plunger can be properly aligned to the governor stop lever as follows:

1. Remove the bolt connecting the rod end eye (variable speed governor) or the right angle clip (limiting speed governor) to the stop lever (Figs. 13 and 14). Align and clamp the lever to the shutdown shaft in such a way that, at its mid-travel position, it is perpendicular to the solenoid plunger. This assures that the linkage will travel as straight as possible. The solenoid plunger has available 1/2″ travel which is more than adequate to move the injector control racks from the full-fuel to the complete no-fuel position and shutdown will occur prior to attaining complete travel.

2. With the stop lever in the *run* position, adjust the rod end eye or right angle clip for minimum engagement on the solenoid plunger when the connecting bolt is installed. The oversize hole in the eye or clip will thereby permit the solenoid to start closing the air gap, with a resultant build-up of pull-in force prior to initiating stop lever movement.

3. The bolt through the rod end eye or the right angle clip should be locked to the stop lever and adjusted to a height that will permit the eye or clip to float vertically. The clearance above and below the eye or clip and the bolt head should be approximately 1/32″ minimum.

NOTE: The locknut can be either on top or below the stop lever.

4. Move the lever to the *stop* position and observe the plunger for any possible bind. If necessary, loosen the mounting bolts and realign the solenoid to provide free plunger motion.

© 1984 General Motors Corp.

SECTION 15

PREVENTIVE MAINTENANCE - TROUBLE SHOOTING - STORAGE

CONTENTS

Lubrication and Preventive Maintenance 15.1
Trouble Shooting 15.2
Storage 15.3

© 1978 General Motors Corp.

LUBRICATION AND PREVENTIVE MAINTENANCE

The *Lubrication and Preventive Maintenance Schedule* is intended as a guide for establishing a preventive maintenance schedule. The suggestions and recommendations for preventive maintenance should be followed as closely as possible to obtain long life and best performance from a Detroit Diesel engine. The intervals indicated on the chart are time or miles (in thousands) of actual operation.

MAINTENANCE SCHEDULE EXPLANATION

The time or mileage increments shown apply only to the maintenance function described. These functions should be coordinated with other regularly scheduled maintenance such as chassis lubrication.

The daily instructions pertain to routine or daily starting of an engine and not to a new engine or one that has not been operated for a considerable period of time. For new or stored engines, carry out the instructions given under *Preparation for Starting Engine First Time* under *Operating Instructions* in Section 13.1.

© 1983 General Motors Corp.

EMISSION CONTROL MAINTENANCE SERVICE CHART (VEHICLE ENGINES)

DAILY											
1. — Lubricating Oil	Ⓘ										
2. — Fuel Tank	Ⓘ										
3. — Fuel Lines and Flexible Hoses	Ⓘ										
4. — *Cooling System*	Ⓘ										
5. — Turbocharger	Ⓘ										
3000 MILE INTERVALS											
6. — Battery	Ⓘ										
7. — Tachometer Drive	Ⓘ										
4000-6000 MILE INTERVALS											
8. — Air Cleaner (oil bath)	Ⓘ										
9. — Drive Belts	Ⓘ										
10. — *Air Compressor*	Ⓘ										
11. — Throttle Control	Ⓘ										
15,000 MILE INTERVALS											
(2.) — Fuel Tank	Ⓘ										
(8.) — Air Cleaner (oil bath)	Ⓘ										
25,000 MILE INTERVALS											
12. — Lubricating Oil Filter	Ⓡ										
6 MONTHS OR 10,000 MILE INTERVALS	**MONTHS**	**6**	**12**	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**
	MILES (1000)	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
13. — Fuel Filter		Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ
14. — Coolant Filter & Water Pump*		Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ	Ⓡ
15. — Starting Motor		Ⓘ	Ⓘ	Ⓘ	Ⓘ	Ⓘ	Ⓘ	Ⓘ	Ⓘ	Ⓘ	Ⓘ
(2.) — Fuel Tank			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
(4.) — *Cooling System (hoses)*			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
(10.) — Air Compressor			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
16. — Air System			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
17. — Exhaust System			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
18. — Air Box Drain Tube				Ⓘ			Ⓘ			Ⓘ	
19. — *Emergency Shutdown*			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
20. — Engine (steam clean)			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
21. — Radiator			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
22. — Shutter Operation			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
23. — Oil Pressure			Ⓘ		Ⓘ		Ⓘ		Ⓘ		Ⓘ
24. — Governor						Ⓘ					Ⓘ
25. — Fuel Injector & Valve Clearance						Ⓘ					Ⓘ
26. — *Throttle Delay*						Ⓘ					Ⓘ
27. — Generator or Alternator*											
28. — Engine & Transmission Mounts							Ⓘ				
29. — Crankcase Pressure							Ⓘ				
30. — Air Box Check Valves											Ⓘ
(8.) — *Air Cleaners (dry)*											Ⓡ
(1.) — Lubricating Oil*											
31. — Fan Hub*											

ANNUALLY	
(3.) — Fuel Lines and Flexible Hoses	Ⓘ
(4.) — Cooling System	Ⓘ
(8.) — Air Cleaners	Ⓘ
32. — Thermostats & Seals	Ⓘ
33. — Blower Screen	Ⓘ
34. — Crankcase Breather	Ⓘ
35. — Fan (thermo-modulated)	Ⓘ
AS REQUIRED	
36. — Engine Tune-Up	

Ⓘ = **INSPECT, CORRECT OR REPLACE (IF NECESSARY)**

Ⓡ = **REPLACE**

* = **SEE ITEM**

© 1983 General Motors Corp.

INDUSTRIAL OFF HIGHWAY AND MARINE — HRS. / MILES	TIME INTERVALS									
	DLY.	8	50	100	150	200	300	500	700	1,000	2,000
		240	1,500	3,000	4,500	6,000	9,000	15,000	20,000	30,000	60,000
1. Lubricating Oil	X				X						
2. Fuel Tank	X							X	X		
3. Fuel Lines and Flexible Hoses	X							X		X	
4. Cooling System	X								X	X	
5. Turbocharger	X										
6. Battery				X							
7. Tachometer Drive				X							
8. Air Cleaners*		X						X			
9. Drive Belts		X				X					
10. Air Compressor						X			X		
11. Throttle and Clutch Controls						X					
12. Lubricating Oil Filter								X		X	
13. Fuel Strainer and Filter							X				
14. Coolant Filter & Water Pump*								X			
15. Starting Motor*											
16. Air System									X		
17. Exhaust System									X		
18. Air Box Drain Tube										X	
19. Emergency Shutdown									X		
21. Radiator									X		
22. Shutter Operation									X		
23. Oil Pressure									X		
24. Overspeed Governor								X			
26. Throttle Delay*											
27. Generator or Alternator				X		X		X			X
28. Engine and Transmission Mounts											X
29. Crankcase Pressure											X
30. Air Box Check Valves*											
31. Fan Hub*											
32. Thermostats and Seals*											
33. Blower Screen										X	
34. Crankcase Breather										X	
36. Engine Tune-Up*											
37. Heat Exchanger Electrodes								X		X	
38. Raw Water Pump	X										
39. Power Generator				X			X				
40. Power Take-Off		X	X					X			
41. Marine Gear	X					X					
42. Torqmatic Converter	X		X					X		X	
43. Reduction Gear (Single Engine)		X	X					X		X	
44. Reduction Gear (Multiple-Ind.)	X									X	
45. Reduction Gear (Multiple-Marine)	X					X					
46. Hydrostarter System*											
47. Transmission (Railcar)	X									X	
48. Oil Filter (Railcar)										X	

*See Item

© 1984 General Motors Corp.

Item 1 - Lubricating Oil

Check the lubricating oil level with the engine stopped. If the engine has just been stopped, wait approximately twenty minutes to allow the oil to drain back to the oil pan. Add the proper grade oil as required to maintain the correct level on the dipstick (refer to Section 13.3).

NOTE: Oil may be blown out through the crankcase breather if the crankcase is overfilled.

Make a visual check for oil leaks around the filters and external oil lines.

Change the lubricating oil at the intervals shown in the chart.

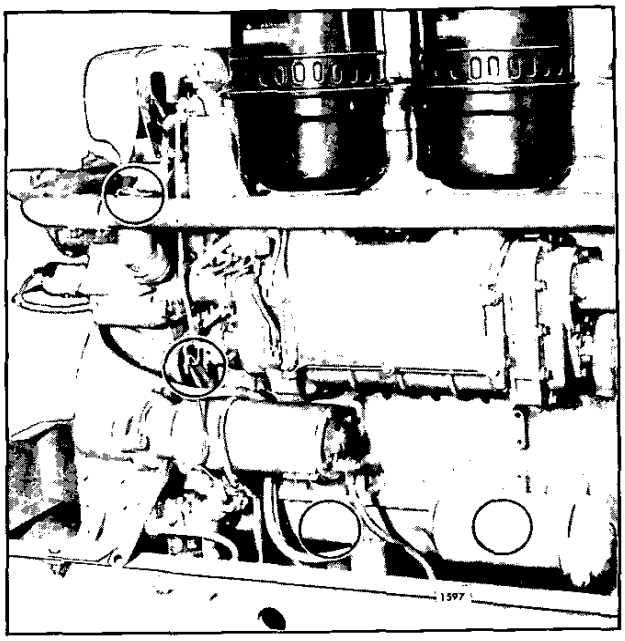
ENGINE OIL CHANGE INTERVALS

Service Application	Max. Engine Oil Change Interval		
	Diesel Fuel Sulfur Content % by Wt. Max.		
	0 to .50	0.51 to 0.75	0.76 to 1.00
Hwy. Truck (Long Distance Hauls) & Inter-City Buses	20,000 Miles**	20,000 Miles	10,000 Miles
City Transit Coaches & Pickup & Delivery Truck Service (Stop-and-go short distance)	12,500 Miles	2,500 Miles	1,250 Miles
Industrial & Marine	150 Hours	30 Hours	15 Hours*

*These oil change intervals are based upon worst case with chrome-faced rings. Oil change periods with plasma rings can be established by oil analysis.

**If supported by oil analysis at 10,000 mile intervals or when recommended fuel filter maintenance is performed.

The drain interval may be established on the recommendations of an independent oil analysis laboratory or the oil supplier (based upon the used oil sample analysis) until the most practical oil change period has been determined. Select the proper grade



Items 1 and 12

of oil in accordance with the instructions given in the *Lubrication Specifications* in Section 13.3.

NOTE: If the lubricating oil is drained immediately after an engine has been run for some time, most of the sediment will be in suspension and will drain readily.

Item 2 - Fuel Tank

Keep the fuel tank filled to reduce condensation to a minimum. Select the proper grade of fuel in accordance with the Fuel Specifications in Section 13.3.

Open the drain at the bottom of the fuel tank every 500 hours or 15,000 miles to drain off any water and/or sediment.

Every 12 months or 20,000 miles (700 hours) tighten all fuel tank mountings and brackets. At the same time, check the seal in the fuel tank cap, the breather hole in the cap and the condition of the crossover fuel line. Repair or replace the parts, as necessary.

Diesel Fuel Contamination

The most common form of diesel fuel contamination is water. Water is harmful to the fuel system in itself, but it also promotes the growth of mircobiological organisms (microbes). These microbes clog fuel filters with a "slime" and restrict fuel flow.

© 1984 General Motors Corp.

Water can be introduced into the fuel supply through poor maintenance (loose or open fuel tank caps), contaminated fuel supply or condensation.

Condensation is particularly prevalent on units which stand idle for extended periods of time, such as marine units. Ambient temperature changes cause condensation in partially filled fuel tanks.

Water accumulation can be controlled by mixing isopropyl alcohol (dry gas) into the fuel oil at a ratio of one pint (.5 liter) per 125 gallons (473 liters) fuel (or 0.10% by volume).

Marine units in storage are particularly susceptible to mircobe growth. The mircobes live in the fuel-water interface. They need both liquids to survive. These microbes find excellent growth conditions in the dark, quiet, non-turbulent nature of the fuel tank.

Microbe growth can be eliminated through the use of commerically available biocides. There are two basic types on the market.

The water soluble type treats *only the tank* where it is introduced. Microbe growth can start again if fuel is transferred from a treated to an untreated tank.

Diesel fuel soluble type, such as "Biobor" manufactured by U.S. Borax or equilvalent, treats *the fuel* itself and, therefore, the entire fuel system.

Marine units, or any other application, going into storage should be treated as follows: Add the biocide according to the manufacturer's instructions. This operation is most effective when performed as the tank is being filled. Add dry gas in the correct proportions.

If the fuel tanks were previously filled, add the chemicals and stir with a clean rod.

Item 3 - Fuel Lines and Flexible Hoses

Make a visual check for fuel leaks at the crossover lines and at the fuel tank suction and return lines. Since fuel tanks are susceptible to road hazards, leaks in this area may best be detected by checking for accumulation of fuel under the tanks.

The performance of engine and auxiliary equipment is greatly dependent on the ability of flexible hoses to transfer lubricating oil, air, coolant and fuel oil. Diligent maintenance of hoses is an important step in ensuring efficient, economical and safe operation of the engine and related equipment.

Check hoses daily as part of the pre-start up inspection. Examine hoses for leaks and check all fittings, clamps and ties carefully. Make sure that hoses are not resting or touching shafts, couplings, heated surfaces including exhaust manifolds, any sharp edges or other obviously hazardous areas. Since all machinery vibrates and moves to a certain extent, clamps and ties can fatigue with age. To ensure continued proper support, inspect fasteners frequently and tighten or replace them as necessary.

Leaks

Investigate leaks immediately to determine if fittings have looseded or cracked or if hoses have ruptured or worn through. Take corrective action immediately. Leaks are not only potentially detrimental to machine operation, but they also result in added expense caused by the need to replace lost fluids.

> **CAUTION:** Personal injury and/or property damage may result from fire due to the leakage of flamable fluids such as fuel or lube oil.

Service Life

A hose has a finite service life. The service life of a hose is determined by the temperature and pressure of the air or fluid within it, its time in service, its mounting, the ambient temperatures, amount of flexing and vibration it is subject to. With this in mind, all hoses should be thoroughly inspected at least every 500 operating hours (1,000 hours for the fire-resistant fuel and lube hoses and heat-insulating turbo/exhaust system blankets) and/or annually. Look for cover damage or indications of damaged twisted, worn, crimped, brittle, cracked or leaking lines. Hoses having the outer cover worn through or damaged metal reinforcement should be considered unfit for further service.

All hoses in or out of machinery should be replaced during major overhaul and/or after a maximum of five years service.

> **NOTE:** The new hose assemblies do not require automotive replacement after five years service or at major overhaul.

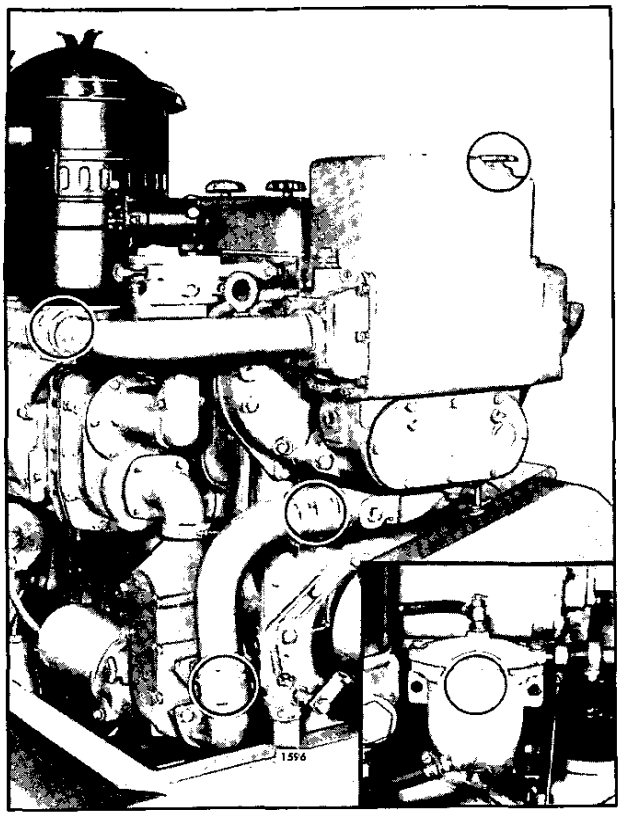
Item 4 - Cooling System

Check the coolant level daily and maintain it near the top of the heat exchanger tank or make sure it covers the radiator tubes. Add coolant, as necessary. *Do not overfill.*

Make a visual check for cooling system leaks. Check for an accumulation of coolant beneath the vehicle during periods when the engine is running and when the engine is stopped.

Clean the cooling system annually (vehicle engines) or every 1,000 hours or 30,000 miles (non-vehicle engines) using a good radiator cleaning compound in accordance with the instructions on the container. After the cleaning operation, rinse the cooling system

© 1984 General Motors Corp.

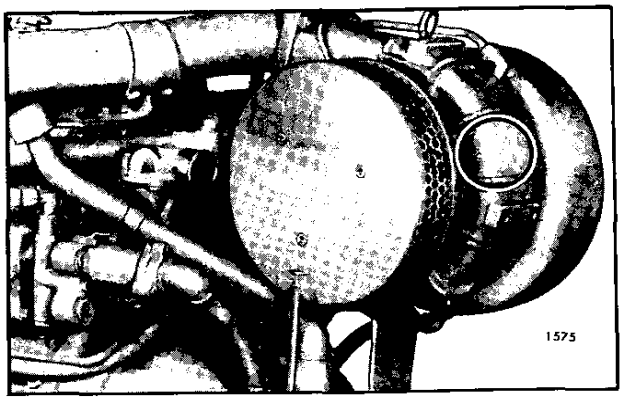


Item 4

thoroughly with fresh water. Then fill the system with soft water, adding a good grade of rust inhibitor or an ethylene glycol base antifreeze (refer to *Engine Coolant* in Section 13.3). With the use of a proper antifreeze or rust inhibitor, this interval may be lengthened until, normally, this cleaning is done only in the spring or fall. The length of this interval will, however, depend upon an inspection for rust or other deposits on the internal walls of the cooling system. When a thorough cleaning of the cooling system is required, it should be reverse flushed.

The coolant circulated through the intercoolers on a turbocharged intercooler engine is protected by a 20 mesh cone-shaped water filter (screen). The filter is located at the water connection in the water pump-to-engine oil cooler tube. The filter should be inspected for damage or clogging when the cooling system is cleaned. Disconnect the flexible water hose at the water connection and remove and clean the filter. If necessary, replace the filter. Reinstall the water filter (screen) in the water connection.

Inspect all of the cooling system hoses at least once every 700 hours or 20,000 miles to make sure the clamps are tight and properly seated on the hoses and



Item 5

to check for signs of deterioration. Replace the hoses, if necessary.

Item 5 - Turbocharger

Inspect the mountings, intake and exhaust ducting and connections for leaks. Check the oil inlet and outlet lines for leaks or restrictions to oil flow. Check for unusual noise or vibration and, if excessive, remove the turbocharger and correct the cause.

Item 6 - Battery

Check the specific gravity of the electrolyte in each cell of the battery every 100 hours or 3,000 miles. In warm weather, however, it should be checked more frequently due to a more rapid loss of water from the electrolyte. The electrolyte level should be maintained in accordance with the battery manufacturer's recommendations.

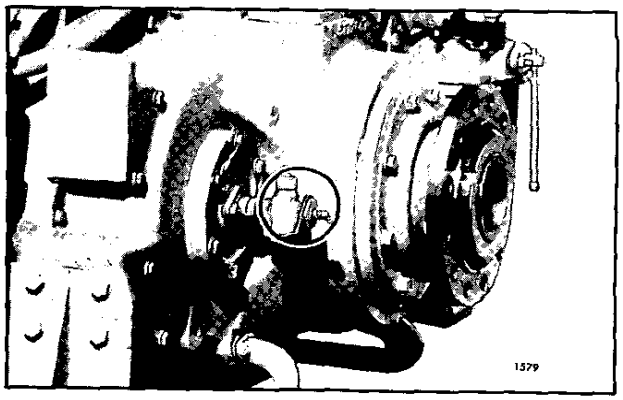
Item 7 - Tachometer Drive

Lubricate the tachometer drive every 100 hours or 3,000 miles with an all purpose grease at the grease fitting. At temperatures above +30°F (−1°C), use a No. 2 grade grease. Use a No. 1 grade grease below this temperature.

Item 8 - Air Cleaner

Under no engine operating conditions should the air inlet restriction exceed 25 inches of water (6.2 kPa) for non-turbocharged engines or 20 inches of water (5.0 kPa) for turbocharged engines. A clogged air cleaner element will cause excessive intake restriction and a reduced air supply to the engine.

© 1984 General Motors Corp.



Item 7

Oil Bath

Remove the dirty oil and sludge from the oil bath type air cleaner cups and center tubes every 8 hours (every 6,000 miles for highway vehicle engines), or less if operating conditions warrant. Wash the cups and elements in clean fuel oil and refill the cups to the level mark with the same grade and viscosity *heavy-duty* oil as used in the engine. The frequency of servicing may be varied to suit local dust conditions. If heavy rain or snow has been encountered, check the air cleaner for an accumulation of water.

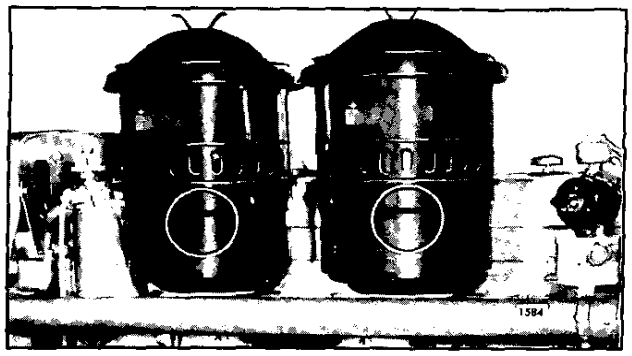
Remove and steam clean the air cleaner element and baffle annually.

It is recommended that the body and fixed element in the heavy-duty oil bath type air cleaner be serviced every 500 hours or 15,000 miles or as conditions warrant.

Dry Type

Dry type air cleaner elements (Donaldson, Farr, etc.) used in on-highway applications should be discarded and replaced with new elements after one year of service, after 100,000 miles (Donaldson's recommended mileage interval) or when the maximum allowable air intake restriction has been reached (see Section 13.2), whichever comes first. No attempt should be made to clean or reuse on-highway elements after these intervals.

Dry type elements used in off-highway applications should be discarded and replaced with new elements after one year of service or when the maximum allowable air intake restriction has been reached (see Section 13.2), whichever comes first. In cases where the air cleaner manufacturer recommends cleaning or



Item 8

washing off-highway elements, the maximum service life is still one year or maximum restriction. Cleaning, washing and inspection must be done per the manufacturer's recommendations. Secondary (safety) elements should **not** be cleaned or reused. Inspection and replacement of the cover gaskets must also be done per the manufacturer's recommendations.

Item 9 - Drive Belts

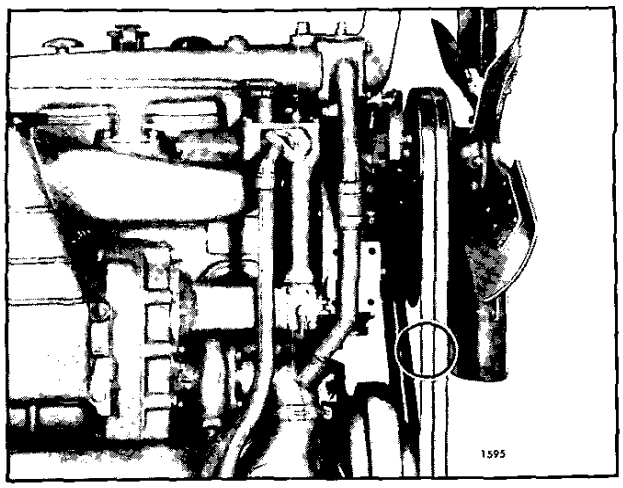
New standard V-belts will stretch after the first few hours of operation. Run the engine for 15 *seconds* to seat the belts, then readjust the tension. Check the belts and tighten the fan drive, pump drive, battery-charging generator or alternator and other accessory drive belts after 1/2 hour or 15 miles and again after 8 hours or 240 miles of operation. Thereafter, check the tension of the drive belts every 200 hours or 6,000 miles and adjust, if necessary. Belts should be neither too tight nor too loose. Belts which are too tight impose excess loads on crankshaft, fan and/or alternator bearings, shortening both belt and bearing life. Excessively overtightened belts can result in crankshaft breakage. A loose belt will slip.

Replace all belts in a set when one is worn. Single belts of similar size should not be used as a substitute for a matched belt set; premature belt wear can result because of belt length variation. All belts in a matched belt set are within .032" of their specified center distances.

Adjust the belt tension so that a firm push with the thumb, at a point midway between the two pulleys, will depress the belt 1/2" to 3/4". If belt tension gage J 23600-B or equivalent is available, adjust the belt tension as outlined in the chart.

NOTE: When installing or adjusting an accessory drive belt, be sure the bolt at the accessory

© 1983 General Motors Corp.



Item 9

MODEL	FAN DRIVE		GENERATOR DRIVE		
	2 or 3 belts	Single belt	Two 3/8" or 1/2" belts	One 1/2" belt	One Wide belt*
2, 3, 4-71	50-60	80-100	40-50	50-70	40-50
6-71	60-80	80-100	40-50	50-70	40-50
All	For 3 point or triangular drives use a tension of 90-120.				

*Belt tension is 60 - 10 lbs. for a single premium high capacity bolt (.785" wide) used to drive a 12 cfm air compressor.

BELT TENSION CHART (lbs/belt)

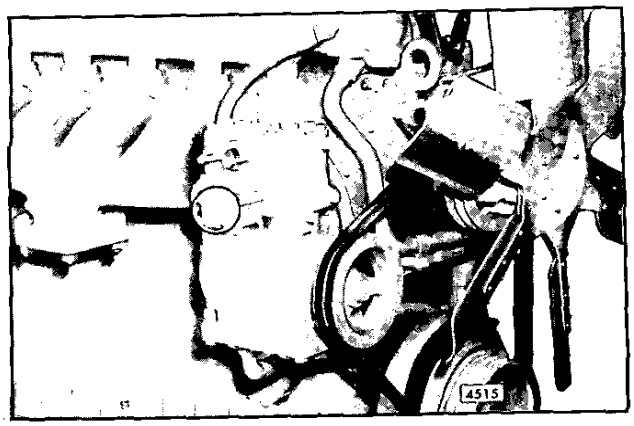
adjusting pivot point is properly tightened, as well as the bolt in the adjusting slot.

Item 10 - Air Compressor

Remove and clean all air compressor air intake parts every 200 hours or 6,000 miles. To clean either the hair polyurethane type air compressor air strainer element, saturate and squeeze it in fuel oil, or any other cleaning agent that would not be detrimental to the element, until dirt free. Then, dip it in lubricating oil and squeeze it dry before placing it back in the air strainer.

For replacement of the air strainer element, contact the nearest Bendix Westinghouse dealer; replace with the polyurethane element, if available.

Every 12 months or 20,000 miles tighten the air compressor mounting bolts. If the air compressor is belt driven, check the belts for proper tension.



Item 10

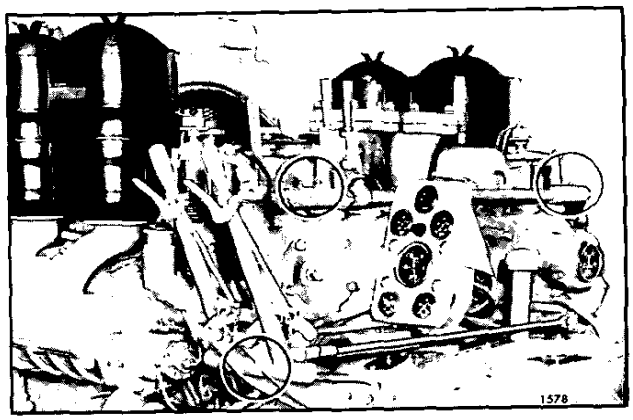
Item 11 - Throttle and Clutch Controls

Every 200 hours or 6,000 miles lubricate the limiting speed governor control shaft. Remove the plug in the end of the shaft and install a temporary grease fitting. Then, remove the governor cover to obtain a visual indication when greasing is complete. Use an all purpose grease (No. 2 grade) at temperatures +30° F (−1° C) and above. At temperatures below this use a No. 1 grade grease. After greasing the shaft remove the fitting and install the plug and governor cover using a new cover gasket.

Lubricate the clutch control levers and all other control mechanisms, as required, with engine oil.

Item 12 - Lubricating Oil Filter

Install new oil filter elements and gaskets at a *maximum* of 25,000 miles (vehicle engines) or 500



Item 11

© 1983 General Motors Corp.

hours (non-vehicle engines) or each time the engine oil is changed, whichever occurs first. Any deviation, such as changing filters every other oil change, should be based on a laboratory analysis of the drained oil and the used filter elements to determine if such practice is practical for proper protection of the engine.

Make a visual check of all lubricating oil lines for wear and chafing. If any indication of wear is evident, replace the oil lines and correct the cause.

When the engine is equipped with a turbocharger, pre-lubricate it as outlined under *Install Turbocharger* in Section 3.5.

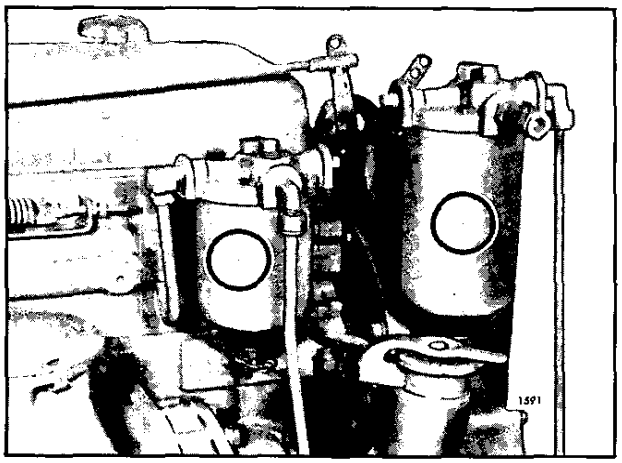
If the engine is equipped with a governor oil filter, change the element every 1,000 hours or 30,000 miles.

Check for oil leaks after starting the engine.

Item 13 - Fuel Strainer and Filter

Install new elements every 6 months or 10,000 miles (vehicle engines) and 300 hours or 9,000 miles (non-vehicle engines) or when plugging is indicated.

A method of determining when elements are plugged to the extent that they should be changed is based on the fuel pressure at the cylinder head fuel inlet manifold and the inlet restriction at the fuel pump. In a clean system, the maximum pump inlet restriction must not exceed 6 inches of mercury (20.3 kPa). At normal operating speeds (1600-2100 rpm), the fuel pressure is 45 to 70 psi (310 to 483 kPa). Change the fuel filter elements whenever the inlet restriction at the fuel pump reaches 12 inches of mercury (41 kPa) at normal operating speeds and whenever the fuel pressure at the inlet manifold falls to 45 psi (310 kPa).



Item 13

Item 14 - Coolant Filter and Water Pump

If the cooling system is protected by a coolant filter and conditioner, the filter element should be changed every 6 months or 10,000 miles (vehicle engines) and 500 hours or 15,000 miles (non-vehicle engines). Select the proper coolant filter element in accordance with the instructions given under *Engine Coolant* in Section 13.3. Use a new filter cover gasket when installing the filter element. After replacing the filter and cover gasket, start the engine and check for leaks.

Inspect the water pump drain hole every 6 months for plugging. If plugged, clean out the drain hole with a tool made from a front crankshaft seal or equivalent.

Replace the water pump seal after it has been in service for 200,000 miles or 6,000 hours.

Item 15 - Starting Motor

VEHICLE ENGINES

Starting motors which are provided with lubrication fittings (grease cups, hinge cap oilers oil tubes sealed with pipe plugs) should be lubricated every 6 months or 10,000 miles. Add 8 to 10 drops of oil, of the same grade as used in the engine, to hinge cap oilers; if sealed tubes are provided, remove the pipe plugs, addoil and reseal the tubes. Grease cups should be turned down one turn. Refill the grease cups, if necessary. However, some starting motors do not require lubrication except during overhaul.

NON-VEHICLE ENGINES

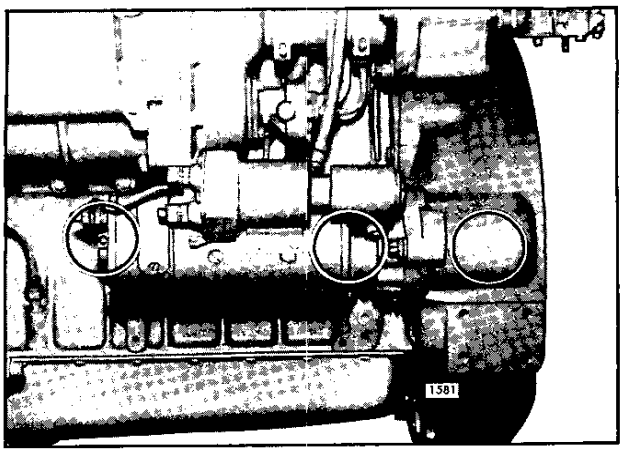
The electrical starting motor is lubricated at the time of original assembly. Oil can be added to the oil wicks, which project through each bushing and contact the armature shaft, by removing the pipe plugs on the outside of the motor. The wicks should be lubricated whenever the starting motor is taken off the engine or disassembled.

The Sprag overrunning clutch drive mechanism should be lubricated with a few drops of light engine oil whenever the starting motor is overhauled.

Item 16 - Air System

Check all of the connections in the air system to be sure they are tight. Check all hoses for punctures or other damage and replace, if necessary.

© 1983 General Motors Corp.



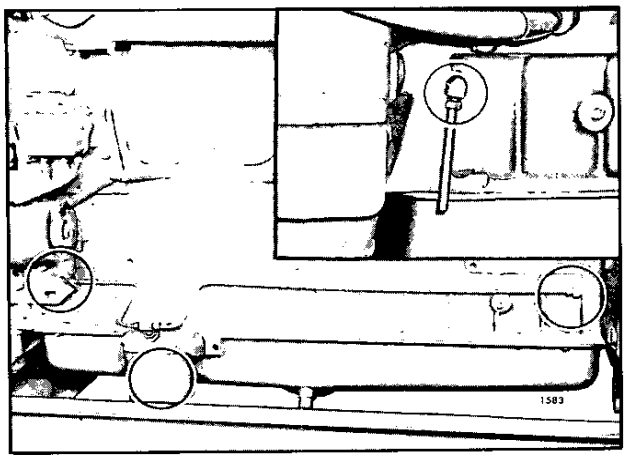
Item 15

Item 17 - Exhaust System

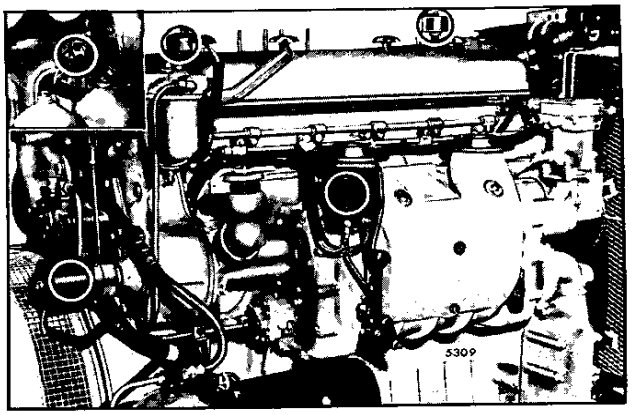
Check the exhaust manifold retaining nuts, exhaust flange clamp and other connections for tightness. Check for proper operation of the exhaust pipe rain cap, if one is used.

Item 18 - Air Box Drain Tube

With the engine running, check for flow of air from the air box drain tubes every 1,000 hours or 30,000 miles. If the tubes are clogged, remove, clean and reinstall the tubes. The air box drain tubes should be cleaned periodically even though a clogged condition is not apparent.



Item 18



Item 19

If the engine is equipped with an air box drain tank, drain the sediment periodically.

Item 19 - Emergency Shutdown

With the engine running at idle speed, check the operation of the emergency shutdown every 700 hours or 20,000 miles. Reset the air shutdown valve in the open position after the check has been made.

Item 20 - Engine (Steam Clean)

Steam clean the engine and engine compartment.

NOTE: Do not apply steam or solvent directly on the battery-charging generator/alternator, starting motor or electrical components as damage to electrical equipment may result.

Item 21 - Radiator

nspect the exterior of the radiator core every 12 months or 20,000 miles (700 hours) and, if necessary, clean it with a quality grease solvent such as mineral spirits and dry it with compressed air. *Do not use fuel oil, kerosene or gasloine.* It may be necessary to clean the radiator more frequently if the engine is being operated in extremely dusty or dirty areas.

Item 22 - Shutter Operation

Check the operation of the shutters and clean the linkage and controls.

© 1983 General Motors Corp.

Item 23 - Oil Pressure

Under normal operation, oil pressure is noted each time the engine is started. In the event the engine is equipped with warning lights rather than pressure indicators, the pressure should be checked and recorded every 700 hours or 20,000 miles.

Item 24 - Governor

Check and record the engine idle speed and no-load speed. Adjust as necessary.

An idle speed lower than recommended will cause the engine to be accelerated from a speed lower than the speed at which the engine was certified.

A no-load speed higher than recommended will result in a full-load speed higher than rated and higher than the speed at which the engine was certified.

Overspeed Governor

Lubricate the overspeed governor, if it is equipped with a hinge-type cap oiler or oil cup, with 5 or 6 drops of engine oil every 500 hours or 15,000 miles. Avoid excessive lubrication and do not lubricate the governor while the engine is running.

Item 25 - Fuel Injectors and Valve Clearance

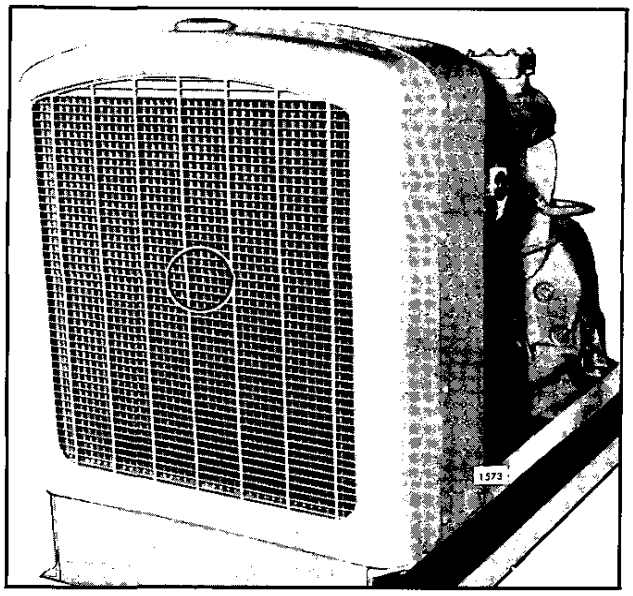
Check the injector timing and exhaust valve clearance as outlined in Section 14.2 and 14.1 every 50,000 miles. The proper height adjustment between the injector follower and injector body is of primary importance to emission control.

Item 26 - Throttle Delay

Inspect and adjust, if necessary, every 30 months or 50,000 miles.

The throttle delay system limits the amount of fuel injected during acceleration by limiting the rate of injector rack movement with a hydraulic cylinder. The initial location of this cylinder must be set with the proper gage to achieve the appropriate time delay (Section 14.14).

Inspect the check valve by filling the throttle delay cylinder with diesel fuel and watching for valve leakage while moving the throttle from the idle to the full-fuel position.



Item 21

Item 27 - Generator or Alternator

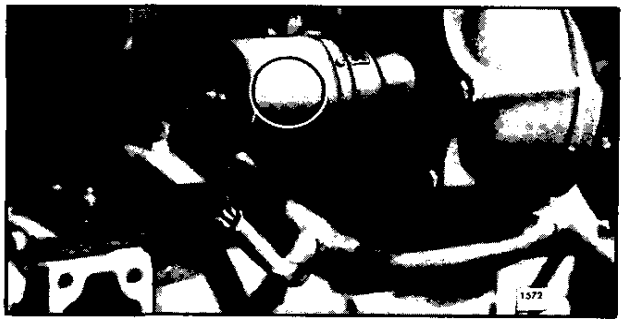
Inspect the terminals for corrosion and loose connections and the wiring for frayed insulation.

VEHICLE ENGINES

If the battery-charging generator or alternator is equipped with hinge cap oilers, add a few drops of medium grade engine oil to each oiler during the unit or vehicle lubrication period. Alternators having a built-in supply of grease or sealed bearings require no additional lubrication except during engine or unit overhaul.

NON-VEHICLE ENGINES

Lubricate the battery-charging generator (alternator) bearings or bushings with 5 or 6 drops of engine oil at the hinge cap oiler every 200 hours or 6,000 miles.



Item 24

© 1983 General Motors Corp.

On early generators equipped with grease cups, turn the cups down one full turn every 100 hours or 3,000 miles of operation. Keep the grease cups filled with *Delco-Remy Cam and Ball Bearing Lubricant*, or equvialent. Avoid excessive lubrication since this may cause lubricant to be forced onto the commutator.

Some generators have a built-in supply of grease, while others use sealed bearings. In these latter two cases, additional lubrication is not necessary.

On generators, inspect the commutator and brushes every 500 hours or 15,000 miles. Clean the commutator every 2,000 hours or 60,000 miles, if necessary, with No. 00 sandpaper or a brush seating stone. After cleaning reseat the brushes and blow out the dust.

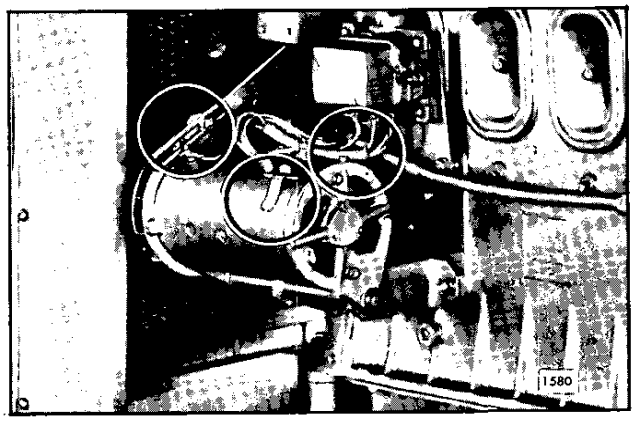
On alternators, the slip rings and brushes can be inspected through the end frame assembly. If the slip rings are dirty, they should be cleaned with 400 grain or finer polishing cloth. Never use emery cloth to clean the slip rings. Hold the polishing cloth against the slip rings with the alternator in operation and blow away all dust after the cleaning operation. If the slip rings are rough or out of round, replace them.

Item 28 - Engine and Transmission Mounts

Check the engine and transmission mounting bolts and the condition of the mounting pads every 2,000 hours or 60,000 miles. Tighten and repair, as necessary.

Item 29 - Crankcase Pressure

Check and record the crankcase pressure every 2,000 hours or 60,000 miles (refer to Section 15.2).



Item 27

Item 30 - Air Box Check Valves

Every 100,000 miles or approximately 3,000 hours remove the check valves, clean them in solvent and blow out the lines with compressed air. Inspect for leaks after servicing.

Item 31 - Fan Hub

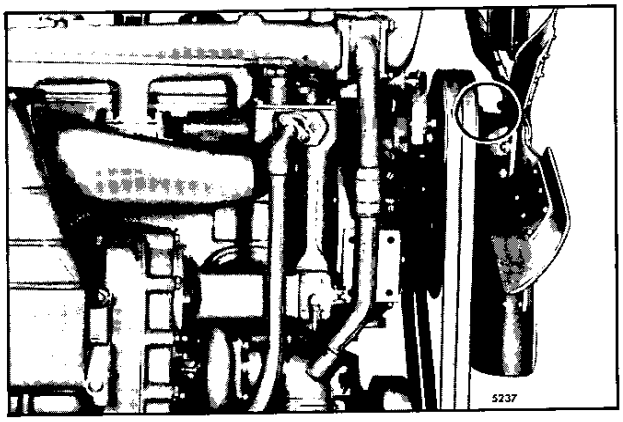
If the fan bearing hub assembly is provided with a grease fitting, use a hand grease gun and lubricate the bearings with one shot of Texaco Premium RB grease, or an equivalent Lithium base multi-purpose grease, every 20,000 miles (approximately 700 hours).

Every 2,500 hours or 75,000 miles (vehicle engines) and 4,000 hours (non-vehicle engines) clean, inspect and repack the fan bearing hub assembly with the above recommended grease (refer to Section 5.4).

At a major engine overhaul, remove and discard the bearings in the fan hub assembly. Pack the hub assembly, using new bearings, with Texaco Premium RB grease or an equivalent Lithium base multi-purpose grease.

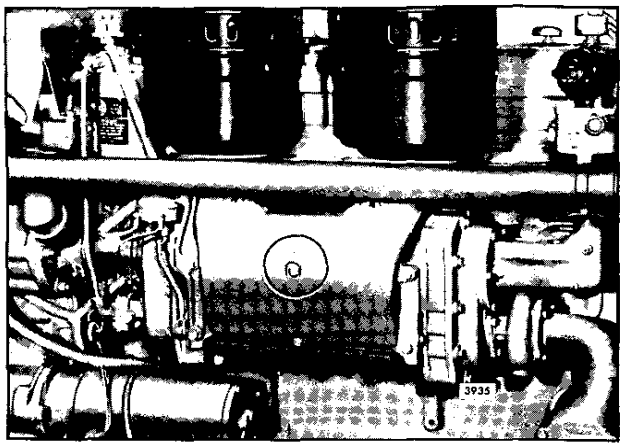
Item 32 - Thermostats and Seals

Check the thermostats (see Section 5.2.1) and seals at 5,000 hours (non-highway engines), 200,000 miles (highway engines) or once a year (preferably at the time the cooling system is prepared for winter operation). The thermostats should *always* be replaced at overhaul. Replace the seals, if necessary.

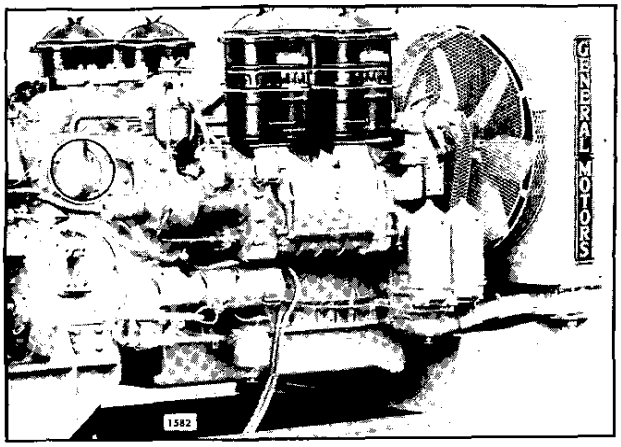


Item 31

© 1983 General Motors Corp.



Item 33



Item 34

Item 33 - Blower Screen

Inspect the blower screen and gasket assembly annually (vehicle engines) or every 1,000 hours or 30,000 miles (non-vehicle engines) and, if necessary, clean the screen in fuel oil and dry it with compressed air. Install the screen and gasket assembly with the screen side of the assembly toward the blower. Inspect for evidence of blower seal leakage.

Item 34 - Crankcase Breather

Remove the externally mounted crankcase breather assembly annually (vehicle engines) or every 1,000 hours or 30,000 miles (non-vehicle engines) and wash the steel mesh pad in clean fuel oil. This cleaning period may be reduced or lengthened according to severity of service.

Clean the breather cap, mounted on the valve rocker cover, in clean fuel oil every time the engine oil is changed.

Item 35 - Fan (Thermo-Modulated)

DRIVE FLUID LEVEL:

Check the fan drive fluid level to avoid improper operation and damage to the drive components.

Current modulated fan drive housings have an inspection plug for checking the fluid level. Formerly partial disassembly of the drive was necessary to make the fluid level check. Former units can be updated by installing a current drive housing which includes the fluid inspection plug and a grease fitting for lubricating the bearing.

1. Check the fan drive fluid level after the unit has been idle for at least 1/2 hour.

2. Turn the fan drive so that the inspection plug is 3/4" below the horizontal center line, then allow the silicone fluid to drain down an additional five minutes.

3. Remove the inspection plug. If fluid begins to flow from the inspection hole, the drive has sufficient fluid. Replace the inspection plug.

4. If the fluid does not flow from the hole, proceed as follows:

   a. Rotate the fan drive downward and observe when the fluid begins to flow from the hole. If it is necessary to lower the drain hole more than 2" below the horizontal center line, the fan drive should be removed from the engine, disassembled and inspected for possible damage to the components.

   b. Turn the fan drive back so the inspection hole is 3/4" below the horizontal center line and add fluid until the overflow point is reached. Replace the inspection plug.

   NOTE: Use only the manufacturer's Special 20 Cenistroke fluid.

DRIVE BEARING LUBRICATION:

The fan drive bearing should be lubricated as outlined in the chart with a Medium Consistency Silicone Grease (Dow Corning No. 44, or equivalent).

The bearing on current fan assemblies is lubricated through a grease fitting in the drive housing hub. Lubrication of the bearing in former assemblies

© 1982 General Motors Corp.

requires the removal of the fan assembly and partial disassembly. The former assemblies can be updated to include a grease fitting by installing the current housing.

Item 36 - Engine Tune-Up

There is no scheduled interval for performing an engine tune-up. As long as the engine performance is satisfactory, no tune-up should be needed. Minor adjustments in the valve and injector operating mechanisms, governor, etc. should only be required periodically to compensate for normal wear on parts.

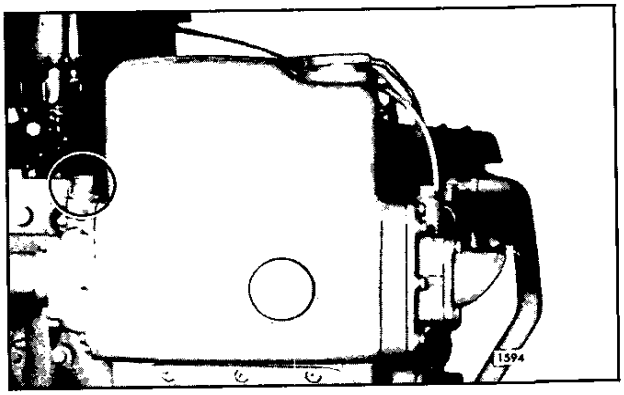
Item 37 - Heat Exchanger Electrodes and Core

Every 500 hours, drain the water from the heat exchanger raw water inlet and outlet tubes. Then remove the zinc electrodes from the inlet side of the raw water pump and the heat exchanger. Clean the electrodes with a wire brush or, if worn excessively, replace with new electrodes. To determine the condition of a use electrode, strike it sharply against a hard surface; a weakened electrode will break.

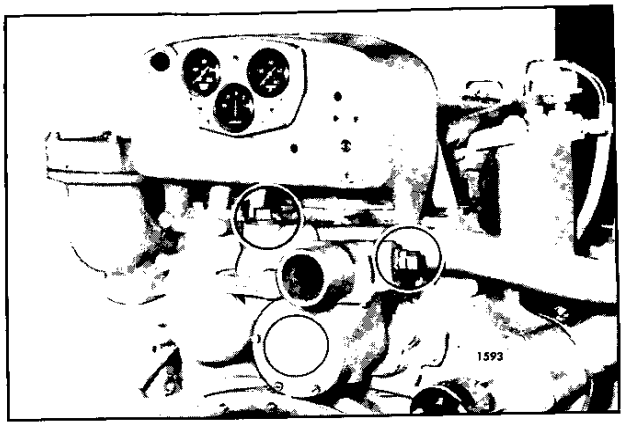
Drain the cooling system, disconnect the raw water pipes at the outlet side of the heat exchanger and remove the retaining cover every 1,000 hours and inspect the heat exchanger core. If a considerable amount of scale or deposits are present, contact a *Detroit Diesel Allison Service Outlet.*

Item 38 - Raw Water Pump

Check the prime on the raw water pump daily. The engine should not be operated with a dry pump. Prime the pump, if necessary, by removing the pipe plug



Item 37



Item 38

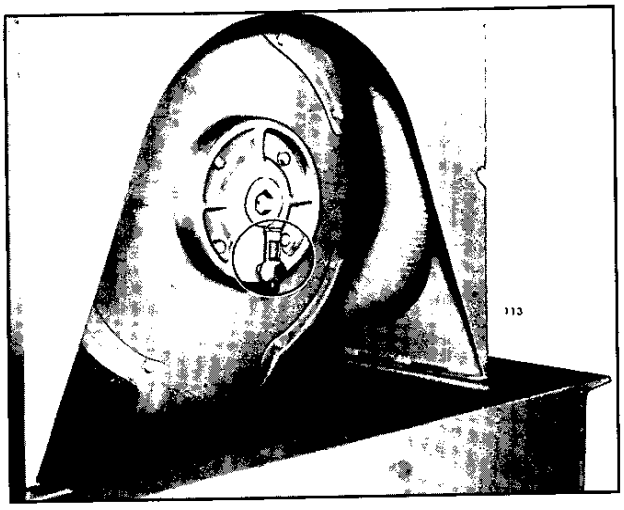
provided in the pump inlet elbow and adding water. Reinstall the plug.

Item 39 - Power Generator

The power generator requires lubrication at only one point -- the ball bearing in the end frame.

If the bearing is oil lubricated, check the oil level in the sight gage every 300 hours; change the oil every six months. Use the same grade and viscosity *heavy-duty* oil as specified for the engine. Maintain the oil level to the line on the sight gage. *Do not overfill.* After adding oil, recheck the oil level after running the generator for several minutes.

If the bearing is grease lubricated, a new generator



Item 39

© 1982 General Motors Corp.

has sufficient grease for three years of normal service. Thereafter, it should be lubricated at one year intervals. To lubricate the bearing, remove the filler and relief plugs on the side and the bottom of the bearing reservoir. Add grease until new grease appears at the relief plug opening. Run the generator a few minutes to vent the excess grease; then reinstall the plugs.

The following greases, or their equivalents, are recommended:

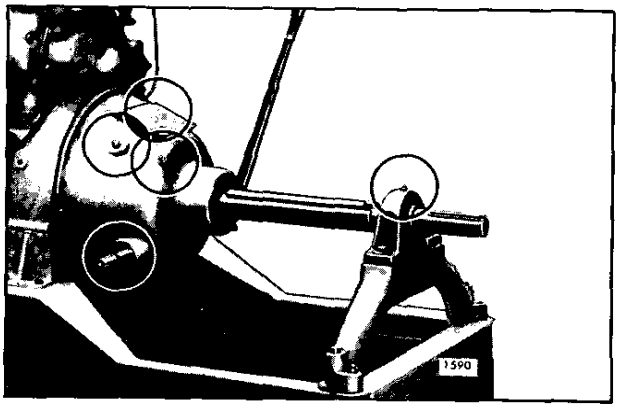
Keystone 44H .....Keystone Lubrication Co.
BRB Lifetime .....Socony Vacuum Oil Co.
NY and NJ F926 or F927 ....NY and NJ Lubricant Co.

After 100 hours on new brushes, or brushes in generators that have not been in use over a long period, remove the end frame covers and inspect the brushes, commutator and collector rings. If there is no appreciable wear on the brushes, the inspection interval may be extended until the most practicable period has been established (not to exceed six months). To prevent damage to the commutator or the collector rings, do not permit the brushes to become shorter than 3/4 inch.

Keep the generator clean inside and out. Before removing the end frame covers, wipe off the loose dirt. The loose dirt and dust may be blown out with low pressure air (25 psi or 172 kPa maximum). Remove all greasy dirt with a cloth.

Item 40 - Power Take-Off

Lubricate all of the power take-off bearings with an all purpose grease such as Shell Alvania No. 2, or equivalent. Lubricate sparingly to avoid getting grease on the clutch facings.



Item 40

Open the cover on the side of the clutch housing (8" and 10" diameter clutch) and lubricate the clutch release sleeve collar through the grease fitting every 8 hours. On the 11-1/2" diameter clutch, lubricate the collar through the fitting on the side of the clutch housing every 8 hours.

Lubricate the clutch drive shaft pilot bearing through the fitting in the outer end of the drive shaft (8" and 10" diameter clutch power take-offs) every 50 hours of operation. One or two strokes with a grease gun should be sufficient. The clutch drive shaft pilot bearing used with the 11-1/2" diameter clutch power take-off is prelubricated and does not require lubrication.

Lubricate the clutch drive shaft roller bearings through the grease fitting in the clutch housing every 50 hours under normal operating conditions (not continuous) and more often under severe operating conditions or continuous operation.

Lubricate the clutch release shaft through the fittings at the rear of the housing every 500 hours of operation.

Lubricate the clutch levers and links sparingly with engine oil every 500 hours of operation. Remove the inspection hole cover on the clutch housing and lubricate the clutch release levers and pins with a hand oiler. To avoid getting oil on the clutch facing, do not over lubricate the clutch release levers and pins.

Check the clutch facing for wear every 500 hours. Adjust the clutch if necessary.

Item 41 - Torqmatic Marine Gear

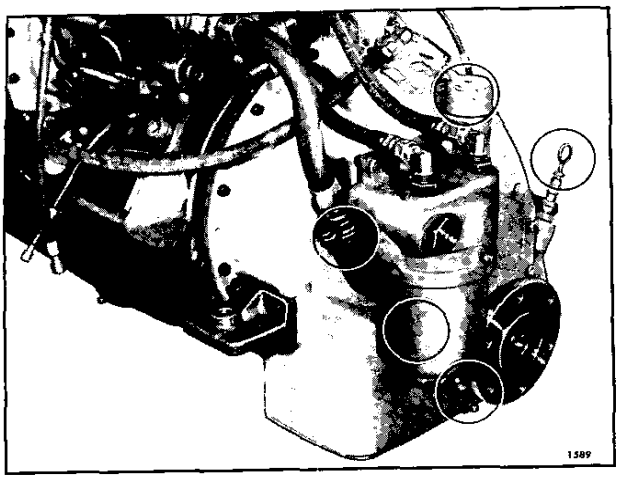
Check the oil level daily in the Torqmatic marine gear, with the controls in neutral and the engine running at idle speed. Add oil as required to bring it to the proper level on the dipstick. Use the same grade and viscosity *heavy-duty* oil as used in the engine. Drain the oil every 200 hours and flush the gear with light engine oil.

> **NOTE:** Series 3 oil should not be used in the marine gear.

When refilling after an oil drain, bring the oil up to the proper level on the dipstick - approximately 6 quarts (5.7 liters) in the M type and 8 quarts (7.6 liters) in the MH type gear. Start and run the engine at light load for three to five minutes. Then put the controls in neutral and run the engine at idle speed and check the oil level again. Bring the oil level up to the proper level on the dipstick.

Every time the marine gear oil is changed, remove the oil strainer element, rinse it thoroughly in fuel oil, dry

© 1982 General Motors Corp.



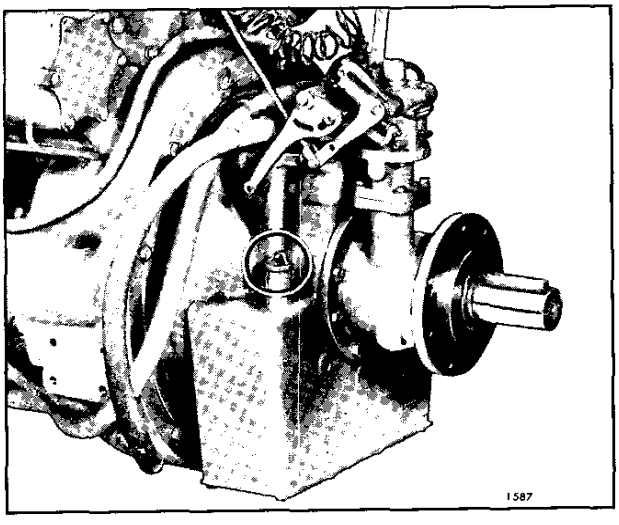
Item 41

it with compressed air and reinstall it. Also replace the full-flow oil filter element every time the marine gear oil is changed.

Item 42 - Torqmatic Converter

Check the oil level in the Torqmatic converter and supply tank daily. The oil level must be checked while the converter is operating, the engine idling and the oil is up to operating temperature (approximately 200°F or 93°C). If the converter is equipped with an input disconnect clutch, the clutch must be engaged.

Check the oil level after running the unit a few minutes. The oil level should be maintained at the proper level on the dipstick. If required, add hydraulic transmission fluid type "C-2" (see chart). *Do not overfill* the converter as too much oil will cause foaming and high oil temperature.



Item 42

Prevailing Ambient Temperature	*Recommended Oil* Specification
Above −10°F (−23°C)	Hydraulic Transmission Fluid, Type C-2.
Below −10°F (−23°C)	Hydraulic Transmission Fluid, Type C-2. Auxiliary preheat required to raise temperature in the sump to a temperature above −10°F. (−23°C)

OIL RECOMMENDATIONS

The oil should be changed every 500 hours for Series 300 converters and every 1,000 hours for Series 400 through 900 converters. Also, the oil should be changed whenever it shows traces of dirt or effects of high operating temperature as evidenced by discoloration or strong odor. If the oil shows metal contamination, contact an authorized *Detroit Diesel Allison Service Outlet* as this usually requires disassembly. Under severe operating conditions, the oil should be changed more often.

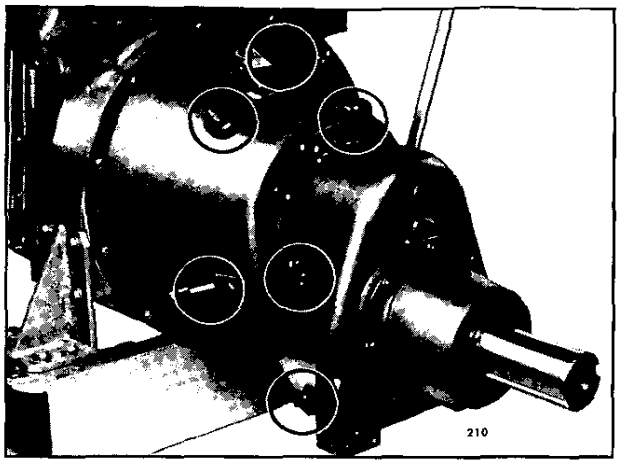
The converter oil breather, located on the oil level indicator (dipstick), should be cleaned each time the converter oil is changed. This can be accomplished by allowing the breather to soak in a solvent, then drying it with compressed air.

The full-flow oil filter element should be removed, the shell cleaned and a new element and gasket installed each time the converter oil is changed.

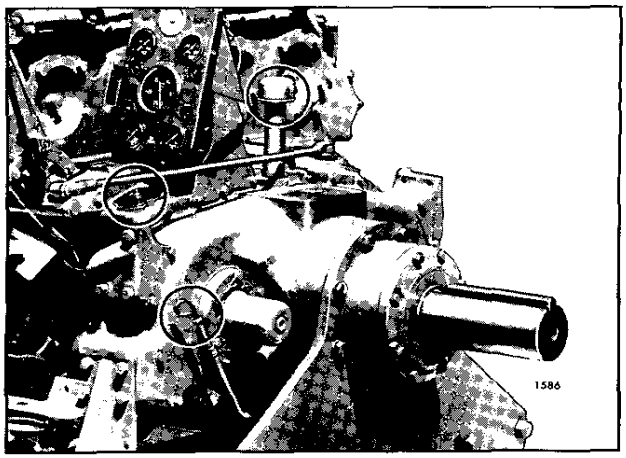
Lubricate the input clutch release bearing and ball bearing and the front disconnect clutch drive shaft bearing every 50 hours with an all purpose grease. Grease fittings are provided on the clutch housing. This time interval may vary depending upon the operating conditions. Over lubrication will cause grease to be thrown on the clutch facing, causing the clutch to slip.

The strainer (in the Torqmatic transmission) and the hydraulic system filters should be replaced or cleaned with every oil change.

© 1982 General Motors Corp.



Item 43



Item 44

Item 43 - Reduction Gear (Single Engine)

ROCKFORD REDUCTION GEAR:

Check the oil level in the reduction gear every 8 hours and add oil as required to bring the oil to the proper level on the dipstick. Drain the oil every 1,000 hours, flush the housing with light engine oil and refill to the proper level with the same grade and viscosity *heavy-duty* oil as used in the engine. This oil change period should be reduced under severe operating conditions.

Lubricate the clutch release bearing through the grease fitting on the side of the housing every 8 hours of operation. The clutch release bearing in the 18" diameter clutch is pre-lubricated and is not provided with a grease fitting, since no further lubrication is required. Lubricate the front reduction clutch pilot ball bearing through the fitting in the outer end of the drive shaft every 50 hours. One or two strokes with a grease gun should be sufficient.

Remove the inspection hole cover and oil the clutch release levers and link pins sparingly every 500 hours. Lubricate the clutch release shaft through the grease fittings on the front of the housing every 500 hours.

Item 44 - Reduction Gear (Multiple-Industrial)

Check the oil level daily in the power transfer or reduction gear of multiple engine industrial units. Add oil as required to bring it up to the proper level on the dipstick.

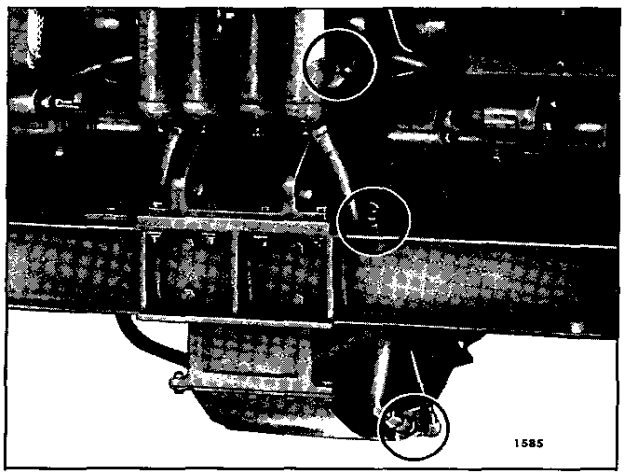
Drain the oil every 1,000 hours, flush with a light engine oil and refill to the proper level on the dipstick with the same grade and viscosity *heavy-duty* oil as used in the engine.

Item 45 - Reduction Gear (Multiple-Marine)

Check the oil level daily with the gear in operation. Add oil as required to bring it to the proper level on the dipstick. Use the same grade and viscosity *heavy-duty* oil as used in the engine.

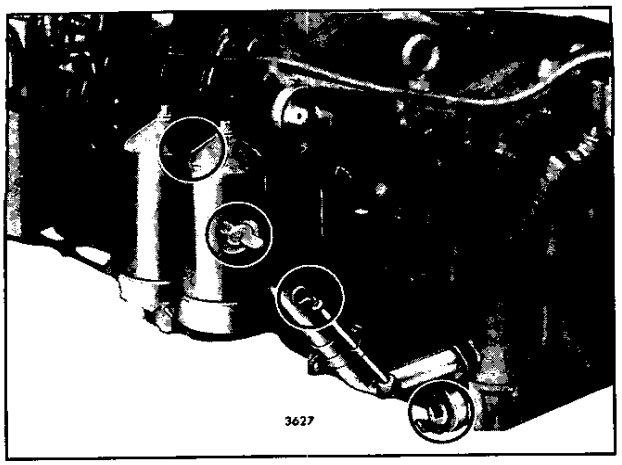
NOTE: Series 3 oil should not be used in the reduction

Drain the oil every 200 hours of operation and flush the gear housing with a light engine oil.



Item 45

© 1982 General Motors Corp.



Items 47 and 48

Every time the oil is changed, remove the element from each oil strainer, rinse it thoroughly in clean fuel oil, dry it with compressed air and reinstall it. Also install new full-flow oil filter elements and gaskets each time the oil is changed.

Refill the reduction gear with oil and bring it to the proper level on the dipstick. Then start and run the engines at light load for three to five minutes to fill the system with oil. With the engines running and the gear operating, check the reduction gear oil level. Add oil, if necessary to bring it to the proper level on the dipstick. *Do not overfill.*

Item 46 - Hydrostarter System

On engines equipped with a hydrostarter, refer to *Lubrication and Preventive Maintenance* in Section 12.6.1.

Item 47 - Transmission (Railcar)

Check the transmission oil level daily with the engine stopped and, if necessary, add oil to bring it to the proper level on the dipstick.

Change the transmission oil every 30,000 car miles (1,000 hours) of operation. Drain the oil by removing the drain plug in the sump pan directly under the oil filler pipe. Use hydraulic transmission fluid, Type "C-2". Run the unit a few minutes to fill the lubrication system. Then check the oil level immediately after stopping the engines to avoid a false reading due to the oil drain back from the converter. Add oil to bring it to the proper level on the dipstick.

Item 48 - Oil Filter (Railcar)

Install new oil filter elements and gaskets every time the transmission oil is changed. Check for oil leaks after starting the engine.

© 1982 General Motors Corp.

TROUBLE SHOOTING

Certain abnormal conditions which sometimes interfere with satisfactory engine operation, together with methods of determining the cause of such conditions, are covered on the following pages.

Satisfactory engine operation depends primarily on:

1. An adequate supply of air compressed to a sufficiently high compression pressure.

2. The injection of the proper amount of fuel at the right time.

Lack of power, uneven running, excessive vibration, stalling at idle speed and hard starting may be caused by either low compression, faulty injection in one or more cylinders, or lack of sufficient air.

Since proper compression, fuel injection and the proper amount of air are important to good engine performance, detailed procedures for their investigation are given as follows:

Locating a Misfiring Cylinder

1. Start the engine and run it at part load until it reaches normal operating temperature.

2. Stop the engine and remove the valve rocker cover.

3. Check the valve clearance (Section 14.1).

4. Start the engine. Then hold an injector follower down with a screwdriver to prevent operation of the injector (Fig. 1). If the cylinder has been misfiring, there will be no noticeable difference in the sound and operation of the engine. If the cylinder has been firing properly, there will be a noticeable difference in the sound and operation when the injector follower is held down. This is similar to short-circuiting a spark plug in a gasoline engine.

5. If the cylinder is firing properly, repeat the procedure on the other cylinders until the faulty one has been located.

6. If the cylinder is misfiring, check the following:

   a. Check the injector timing (refer to Section 14.2).

   b. Check the compression pressure.

   c. Install a new injector.

   d. If the cylinder still misfires, remove the cam follower (refer to Section 1.2.1) and check for a worn cam roller, camshaft lobe, bent push rod or worn rocker arm bushings.

Checking Compression Pressure

Compression pressure is affected by altitude as shown in Table 1.

Check the compression pressure as follows:

1. Start the engine and run it at approximately one-half rated load until normal operating temperature is reached.

2. Stop the engine and remove the fuel pipes from the injector and fuel connectors of the No. 1 cylinder.

3. Remove the injector and install an adaptor and pressure gage from Diagnosis Kit J 9531-01 (Fig. 2).

4. Use one of the fuel pipes as a jumper connection

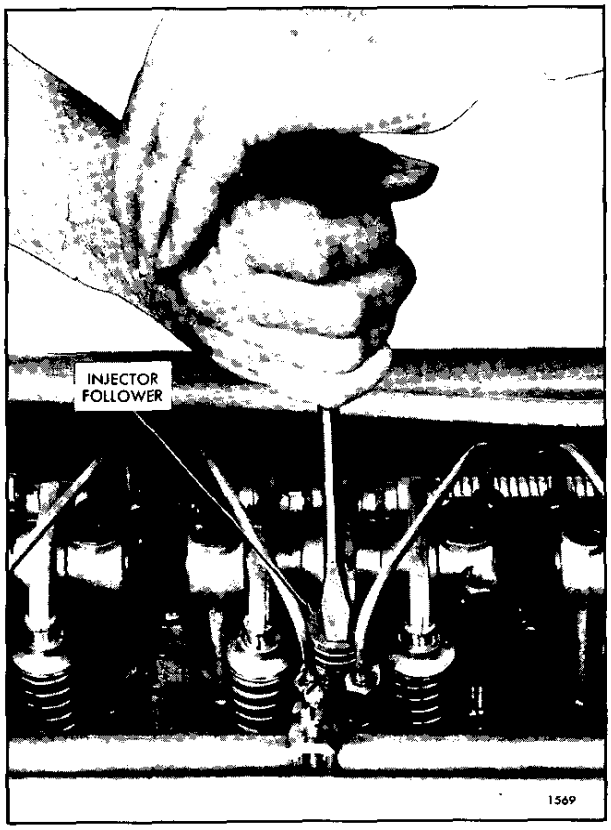


Fig. 1 - Locating a Misfiring Cylinder

© 1981 General Motors Corp.

Minimum Compression Pressure at 600 rpm										Altitude above Sea Level		† Air Density
Engine												
71		71E		71N		71M		71T				
psi	kPa	psi	kPa	psi	kPa	psi	kPa	psi	kPa	feet	meters	
390	2689	425	2930	515	3551	425	2930	400	2758	500	152	.0715
360	2482	395	2723	480	3310	395	2723	370	2551	2,500	762	.0663
335	2310	365	2517	440	3034	365	2517	340	2344	5,000	1,524	.0613
310	2137	340	2344	410	2827	340	2344	315	2172	7,500	2,286	.0567
285	1965	315	2172	380	2620	315	2172	295	2034	10,000	3,048	.0525

† Air density at 500 ft. altitude based on 85° F (29.4° C) and 29.38 in Hg (99.49 kPa) wet barometer.

TABLE 1

Cylinder	Gage Reading	
	psi	kPa
1	445	3066
2	440	3032
3	405	2791
4	435	2997
5	450	3101
6	445	3066

TABLE 2

between the fuel inlet and return manifold connectors. This will permit fuel from the inlet manifold to flow directly to the return manifold.

5. Start the engine and run it at a 600 rpm. Observe and record the compression pressure indicated on the gage. *Do not crank the engine with the starting motor to obtain the compression pressure.*

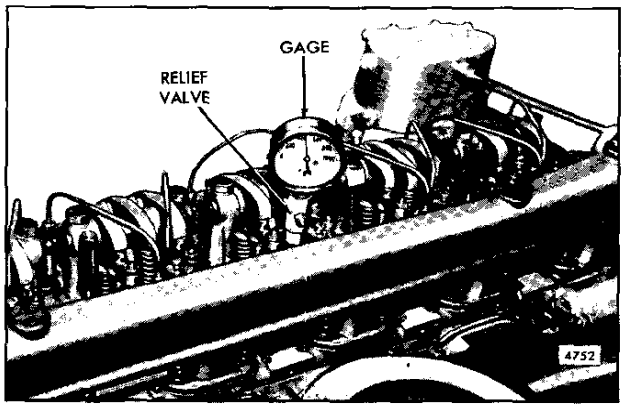


Fig. 2 - Checking Compression Pressure

6. Perform Steps 2 through 5 on each cylinder. The compression pressure in any one cylinder at a given altitude above sea level should not be less than the minimum shown in Table 1. In additon, the variation in compression pressures between cylinders must not exceed 25 psi (172 kPa) at 600 rpm.

EXAMPLE: If the compression pressure readings were as shown in Table 2, it would be evident that No. 3 cylinder should be examined and the cause of the low compression pressure be determined and corrected.

The pressures in Table 2 are for a 71E engine operating at an altitude near sea level. Note that all of the cylinder pressures are above the low limit for satisfactory engine operation. Nevertheless, the No. 3 cylinder compression pressure indicates that something unusual has occurred and that a localized pressure leak has developed.

Low compression pressure may result from any one of several causes:

A. Piston rings may be stuck or broken. To determine the condition of the rings, remove the air box cover and inspect them by pressing on the rings with a blunt tool (Fig. 3). A broken or stuck ring will not have a "spring-like" action.

B. Compression pressure may be leaking past the cylinder head gasket, the valve seats, the injector tube or a hole in the piston.

© 1981 General Motors Corp.

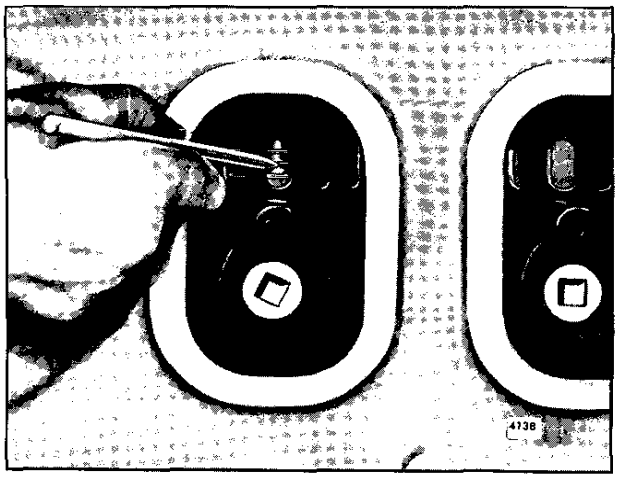


Fig. 3 - Inspecting Piston Rings

Engine Out of Fuel

The problem in restarting an engine after it has run out of fuel stems from the fact that after the fuel is exhausted from the fuel tank, fuel is then pumped from the primary fuel strainer and sometimes partially removed from the secondary fuel filter before the fuel supply becomes insufficient to sustain engine firing. Consequently, these components must be refilled with fuel and the fuel pipes rid of air in order for the system to provide adequate fuel for the injectors.

When an engine has run out of fuel, there is a definite procedure to follow for restarting it:

1. Fill the fuel tank with the recommended grade of fuel oil. If only partial filling of the tank is possible, add a minimum of ten gallons (38 litres) of fuel.

2. Remove the fuel strainer shell and element from the strainer cover and fill the shell with fuel oil. Install the shell and element.

3. Remove and fill the fuel filter shell and element with fuel oil as in Step 2.

4. Start the engine. Check the filter and strainer for leaks.

> **NOTE:** In some instances, it may be necessary to remove the valve rocker cover and loosen a fuel pipe nut to bleed trapped air from the fuel system. Be sure the fuel pipe is retightened securely before replacing the rocker cover.

Primer J 5956 may be used to prime the entire fuel system. Remove the filler plug in the fuel filter cover and install the primer. Prime the system. Remove the primer and install the filler plug.

Fuel Flow Test

The proper flow of fuel is required for satisfactory engine operation. Check the condition of the fuel pump, fuel strainer and fuel filter as outlined in Section 2.0 under *Trouble Shooting.*

Crankcase Pressure

The crankcase pressure indicates the amount of air passing between the oil control rings and the cylinder liners into the crankcase, most of which is clean air from the air box. A slight pressure in the crankcase is desirable to prevent the entrance of dust. A loss of engine lubricating oil through the breather tube, crankcase ventilator or dipstick hole in the cylinder block is indicative of excessive crankcase pressure.

The causes of high crankcase pressure may be traced to excessive blow-by due to worn piston rings, a hole or crack in a piston crown, loose piston pin retainers, worn blower oil seals, defective blower, cylinder head or end plate gaskets, or excessive exhaust back pressure. Also, the breather tube or crankcase ventilator should be checked for obstructions.

Check the crankcase pressure with a manometer connected to the oil level dipstick opening in the cylinder block. Check the readings obtained at various engine speeds with the *Engine Operating Conditions* in Section 13.2.

> **NOTE:** The dipstick adaptor must not be below the level of the oil when checking the crankcase pressure.

Exhaust Back Pressure

A slight pressure in the exhaust system is normal. However, excessive exhaust back pressure seriously affects engine operation. It may cause an increase in the air box pressure with a resultant loss of efficiency of the blower. This means less air for scavenging which results in poor combustion and higher temperatures.

Causes of high exhaust back pressure are usually a result of an inadequate or improper type of muffler, an exhaust pipe which is too long or too small in diameter, an excessive number of sharp bends in the exhaust system, or obstructions such as excessive carbon formation or foreign matter in the exhaust system.

Check the exhaust back pressure, measured in inches of mercury, with a manometer. Connect the manometer to the exhaust manifold (except on turbocharged

© 1978 General Motors Corp.

engines) by removing the 1/8 " pipe plug which is provided for that purpose. If no opening is provided, drill an 11/32 " hole in the exhaust manifold companion flange and tap the hole to accommodate a 1/8 " pipe plug.

On turbocharged engines, check the exhaust back pressure in the exhaust piping 6 " to 12 " from the turbine outlet (Fig. 1 of Section 13.2). The tapped hole must be in a comparatively straight pipe area for an accurate measurement.

Check the readings obtained at various speeds (at no-load) with the *Engine Operating Conditions* in Section 13.2.

Air Box Pressure

Proper air box pressure is required to maintain sufficient air for combustion and scavenging of the burned gases. Low air box pressure is caused by a high air inlet restriction, damaged blower rotors, an air leak from the air box (such as leaking end plate gaskets) or a clogged blower air inlet screen. Lack of power or black or grey exhaust smoke are indications of low air box pressure.

High air box pressure can be caused by partially plugged cylinder liner ports.

Check the air box pressure with a manometer connected to an air box drain tube.

Check the readings obtained at various speeds with the *Engine Operating Conditions* in Section 13.2.

Air Inlet Restriction

Excessive restriction of the air inlet will affect the flow of air to the cylinders and result in poor combustion and lack of power. Consequently the restriction must be kept as low as possible considering the size and capacity of the air cleaner. An obstruction in the air inlet system or dirty or damaged air cleaners will result in a high blower inlet restriction.

Check the air inlet restriction with a water manometer connected to a fitting in the air inlet ducting located 2 " above the air inlet housing (non-turbocharged engines) or the compressor inlet (turbocharged engines). When practicability prevents the insertion of a fitting at this point (non-turbocharged engines), the manometer may be connected to the engine air inlet housing. The restriction at this point should be checked at a specific engine speed. Then the air cleaner and ducting should be removed from the air inlet housing and the engine again operated at the same speed while noting the manometer reading.

The difference between the two readings, with and without the air cleaner and ducting, is the actual restriction caused by the air cleaner and ducting.

Check the normal air inlet vacuum at various speeds (at no-load) and compare the results with the *Engine Operating Conditions* in Section 13.2.

PROPER USE OF MANOMETER

The U-tube manometer is a primary measuring device indicating pressure or vacuum by the difference in the height of two columns of fluid.

Connect the manometer to the source of pressure, vacuum or differential pressure. When the pressure is imposed, add the number of inches one column of fluid travels up to the amount the other column travels down to obtain the pressure (or vacuum) reading.

The height of a column of mercury is read differently than that of a column of water. Mercury does not wet the inside surface; therefore, the top of the column has a convex meniscus (shape). Water wets the surface and therefore has a concave meniscus. A mercury column is read by sighting horizontally between the top of the convex mercury surface (Fig. 4) and the scale. A water manometer is read by sighting horizontally between the bottom of the concave water surface and the scale.

Should one column of fluid travel further than the other column, due to minor variations in the inside

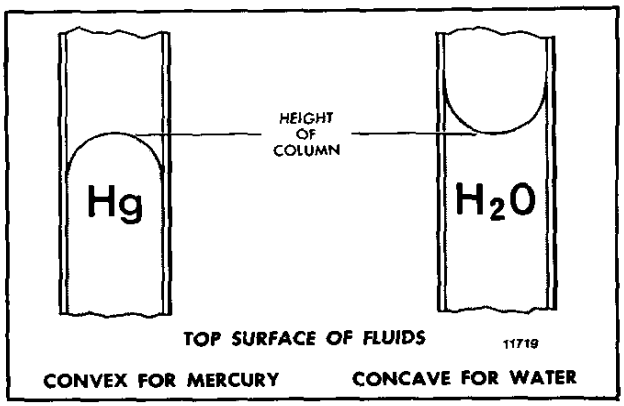


Fig. 4 - Comparison of Column Height for Mercury and Water Manometers

© 1978 General Motors Corp.

PRESSURE CONVERSION CHART		
1" water	=	.0735" mercury
1" water	=	.0361 psi
1" mercury	=	13.6000" water
1" mercury	=	.4910 psi
1 psi	=	27.7000" water
1 psi	=	2.0360" mercury
1 psi	=	6.895 kPa
1 kPa	=	.145 psi

TABLE 3

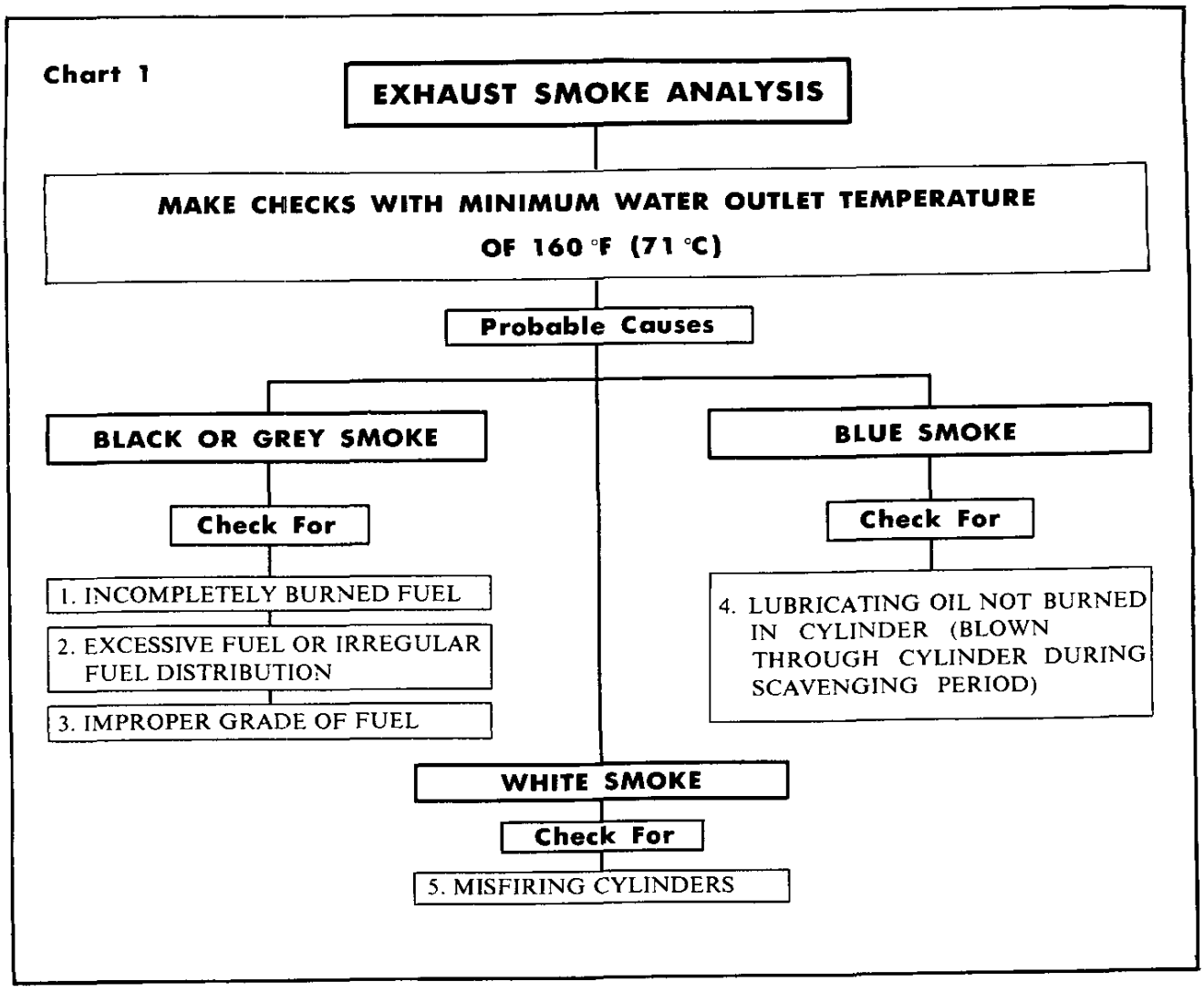
diameter of the tube or to the pressure imposed, the accuracy of the reading obtained is not impaired.

Refer to Table 3 to convert the manometer reading into other units of measurement.

SHOP NOTES

© 1978 General Motors Corp.

Chart 1



© 1978 General Motors Corp.

Chart 1

EXHAUST SMOKE ANALYSIS

SUGGESTED REMEDY

1. High exhaust back pressure or a restricted air inlet causes insufficient air for combustion and will result in incompletely burned fuel.

High exhaust back pressure is caused by faulty exhaust piping or muffler obstruction and is measured at the exhaust manifold outlet with a manometer. Replace faulty parts.

Restricted air inlet to the engine cylinders is caused by clogged cylinder liner ports, air cleaner or blower air inlet screen. Clean these items. Check the emergency stop to make sure that it is completely open and readjust it if necessary.

2. If the engine is equipped with a throttle delay, check for the proper setting, leaky check valve and restricted filling of the piston cavity with oil from the reservoir.

Check for improperly timed injectors and improperly positioned injector rack control levers. Time the fuel injectors and perform the appropriate governor tune-up.

Replace faulty injectors if this condition still persists after timing the injectors and performing the engine tune-up.

Avoid lugging the engine as this will cause incomplete combustion.

3. Check for use of an improper grade of fuel. Refer to *Fuel Oil Specifications* in Section 13.3.

4. Check for internal lubricating oil leaks and refer to the *High Lubricating Oil Consumption* chart.

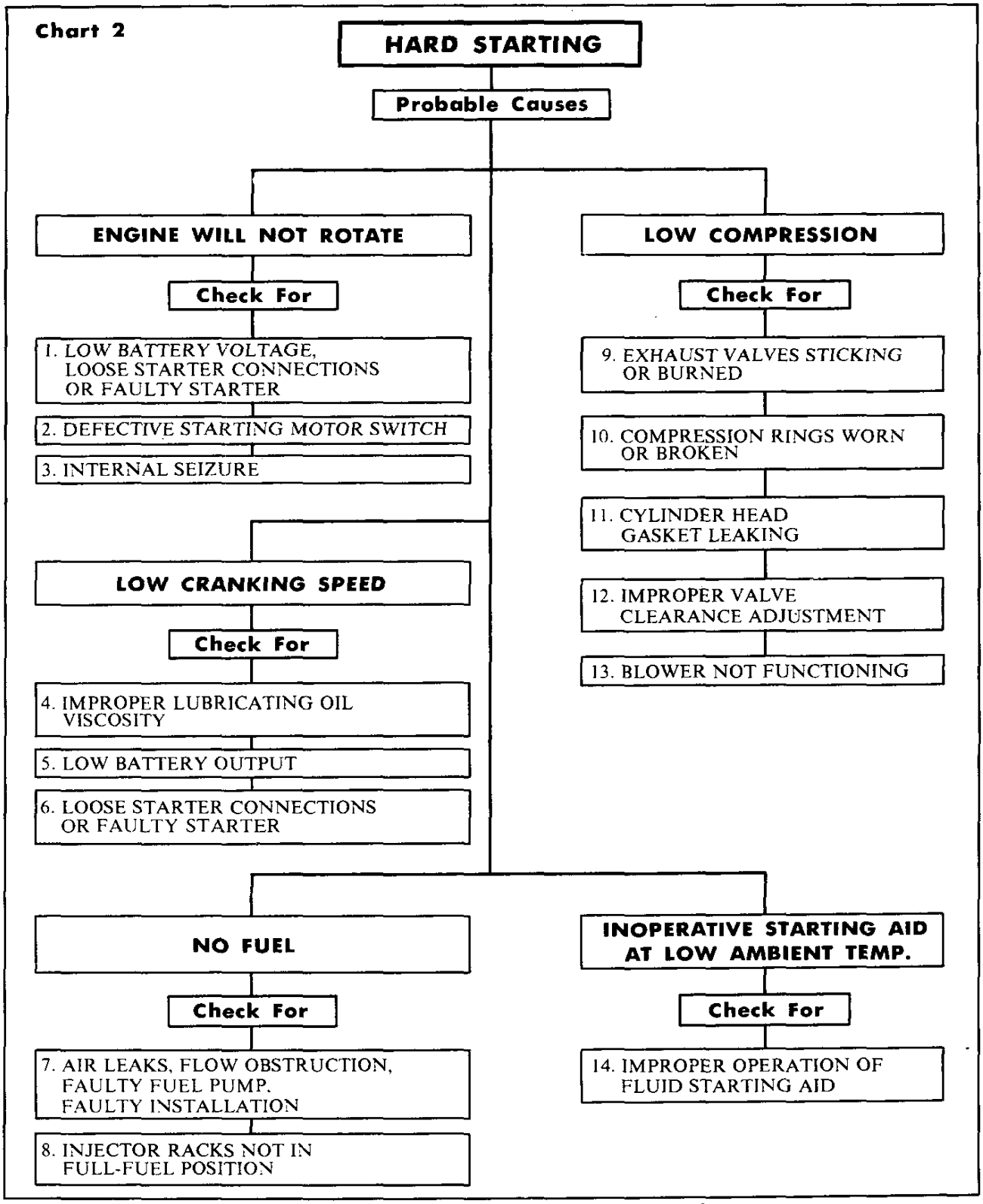
5. Check for faulty injectors and replace as necessary.

Check for low compression and consult the *Hard Starting* chart.

The use of low cetane fuel will cause this condition. Refer to *Fuel Oil Specifications* in Section 13.3.

© 1978 General Motors Corp.

Chart 2



© 1978 General Motors Corp.

Chart 2

HARD STARTING

SUGGESTED REMEDY

1. Refer to Items 2, 3 and 5 and perform the operations listed.

2. Replace the starting motor switch.

3. Hand crank the engine at least one complete revolution. If the engine cannot be rotated a complete revolution, internal damage is indicated and the engine must be disassembled to ascertain the extent of damage and the cause.

4. Refer to *Lubricating Oil Specifications* in Section 13.3 for the recommended grade of oil.

5. Recharge the battery if a light load test indicates low or no voltage. Replace the battery if it is damaged or will not hold a charge.

Replace terminals that are damaged or corroded.

At low ambient temperatures, use of a starting aid will keep the battery fully charged by reducing the cranking time.

6. Tighten the starter connections. Inspect the starter commutator and brushes for wear. Replace the brushes if badly worn and overhaul the starting motor if the commutator is damaged.

7. To check for air leaks, flow obstruction, faulty fuel pump or faulty installation, consult the *No Fuel or Insufficient Fuel* chart.

8. Check for bind in the governor-to-injector linkage. Readjust the governor and injector controls if necessary.

9. Remove the cylinder head and recondition the exhaust valves.

10. Remove the air box covers and inspect the compression rings through the ports in the cylinder liners. Overhaul the cylinder assemblies if the rings are badly worn or broken.

11. To check for compression gasket leakage, remove the coolant filler cap and operate the engine. A steady flow of gases from the coolant filler indicates either a cylinder head gasket is damaged or the cylinder head is cracked. Remove the cylinder head and replace the gaskets or cylinder head.

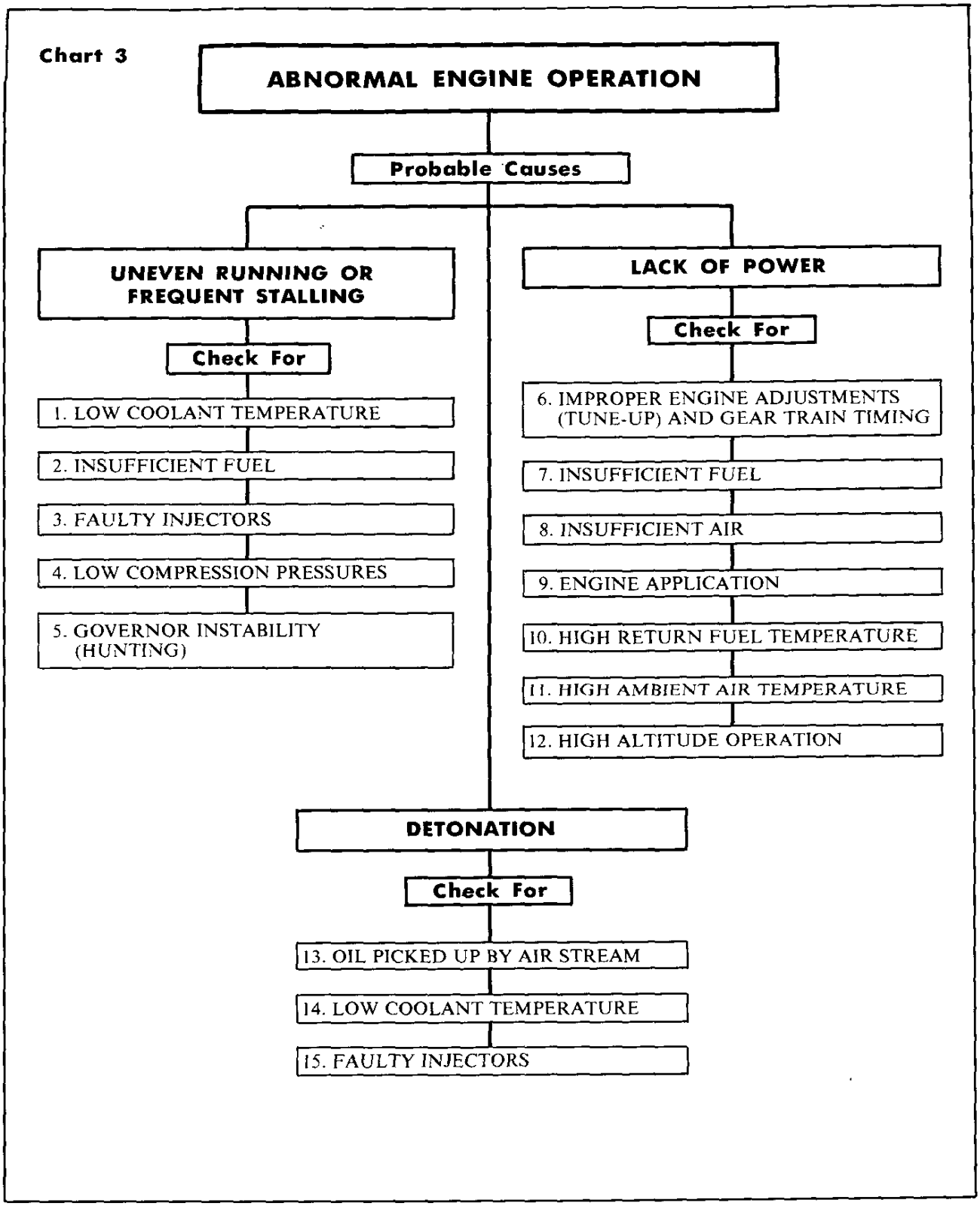
12. Adjust the exhaust valve clearance.

13. Remove the flywheel housing cover at the blower drive support. Then remove the snap ring and withdraw the blower drive shaft from the blower. Inspect the blower drive shaft and drive coupling. Replace the damaged parts. Bar the engine over. If the blower does not rotate, remove the air inlet adaptor and visually inspect the blower rotors and end plates. If visual distress is noted, remove the blower (refer to Section 3.4).

14. Operate the starting aid according to the instructions under *Cold Weather Starting Aids.*

© 1978 General Motors Corp.

Chart 3



© 1978 General Motors Corp.

Chart 3

ABNORMAL ENGINE OPERATION

SUGGESTED REMEDY

1. Check the engine coolant temperature gage and, if the temperature does not reach 160-185 °F (71-85 °C) while the engine is operating, consult the *Abnormal Engine Coolant Temperature* chart.

2. Check engine fuel spill back and if the return is less than specified, consult the *No Fuel or Insufficient Fuel* chart.

3. Check the injector timing and the position of the injector racks. If the engine was not tuned correctly, perform an engine tune-up. Erratic engine operation may also be caused by leaking injector spray tips. Replace the faulty injectors.

4. Check the compression pressures within the cylinders and consult the *Hard Starting* chart if compression pressures are low.

5. Erratic engine operation may be caused by governor-to-injector operating linkage bind or by faulty engine tune-up. Perform the appropriate engine tune-up procedure as outlined for the particular governor used.

6. If the engine is equipped with a throttle delay, check for the proper setting, binding or burrs on the piston or bracket, and a plugged discharge orifice.

Perform an engine tune-up if performance is not satisfactory.

Check the engine gear train timing. An improperly timed gear train will result in a loss of power due to the valves and injectors being actuated at the wrong time in the engine's operating cycle.

7. Perform a *Fuel Flow Test* and, if less than the specified fuel is returning to the fuel tank, consult the *No Fuel or Insufficient Fuel* chart.

8. Check for damaged or dirty air cleaners and clean, repair or replace damaged parts.

Remove the air box covers and inspect the cylinder liner ports. Clean the ports if they are over 50% plugged.

Check for blower air intake obstruction or high exhaust back pressure. Clean, repair or replace faulty parts.

Check the compression pressures (consult the *Hard Starting* chart).

9. Incorrect operation of the engine may result in excessive loads on the engine. Operate the engine according to the approved procedures.

10. Refer to Item 13 on Chart 4.

11. Check the ambient air temperature. A power decrease of .15 to .50 horsepower per cylinder, depending upon injector size, for each 10 °F (6 °C) temperature rise above 90 °F (32 °C) will occur. Relocate the engine air intake to provide a cooler source of air.

12. Engines lose horsepower with increase in altitude. The percentage of power loss is governed by the altitude at which the engine is operating.

13. Fill oil bath air cleaners to the proper level with the same grade and viscosity lubricating oil that is used in the engine.

Clean the air box and drain tubes to prevent accumulations that may be picked up by the air stream and enter the engine's cylinders.

Inspect the blower oil seals by removing the air inlet housing and watching through the blower inlet for oil radiating away from the blower rotor shaft oil seals while the engine is running. If oil is passing through the seals, overhaul the blower.

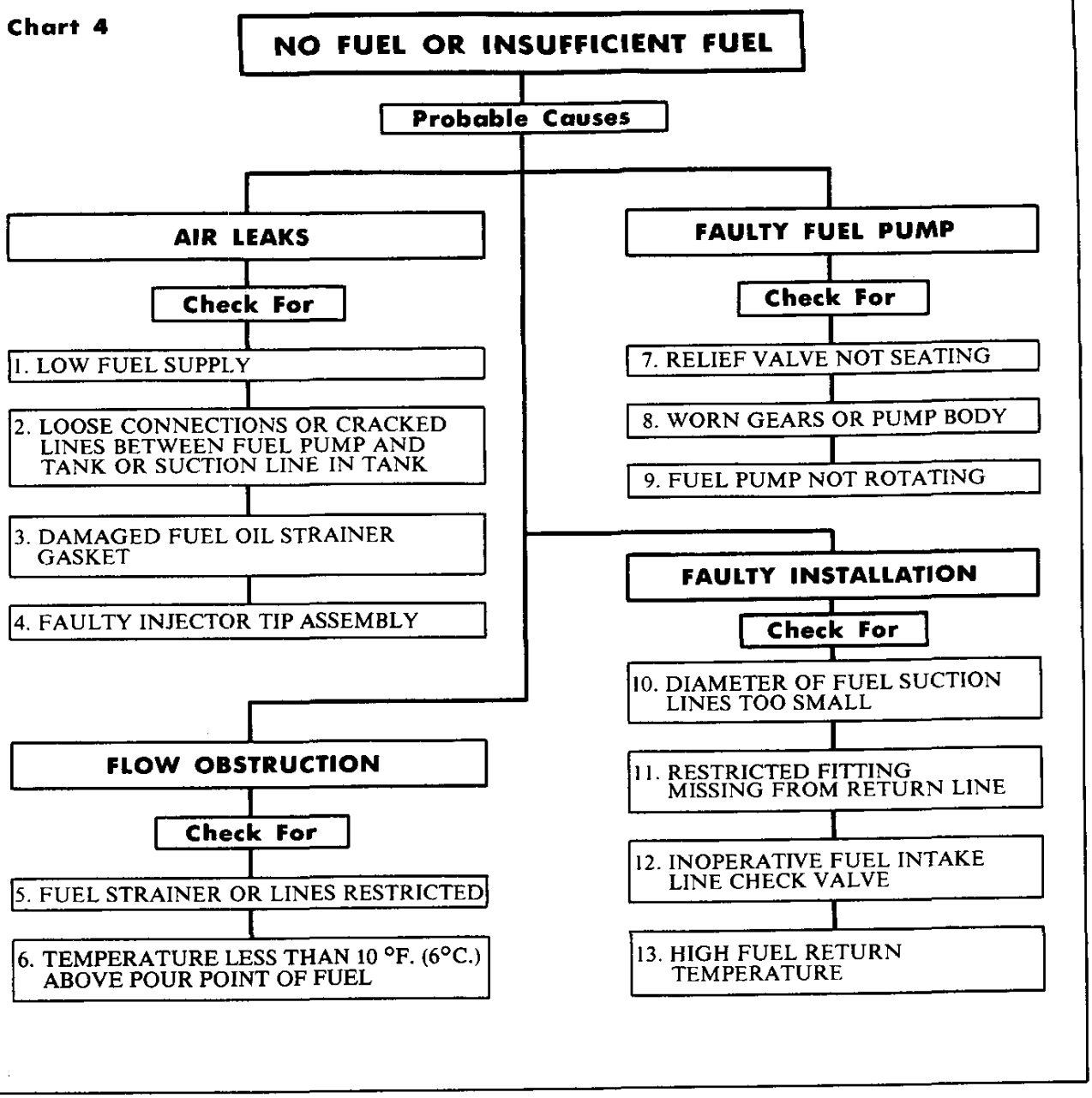
Check for a defective blower-to-block gasket. Replace the gasket, if necessary.

14. Refer to Item 1 of this chart.

15. Check injector timing and the position of each injector rack. Perform an engine tune-up, if necessary. If the engine is correctly tuned, the erratic operation may be caused by an injector check valve leaking, spray tip holes enlarged or a broken spray tip. Replace faulty injectors.

© 1978 General Motors Corp.

Chart 4



© 1978 General Motors Corp.

Chart 4

NO FUEL OR INSUFFICIENT FUEL

SUGGESTED REMEDY

1. The fuel tank should be filled above the level of the fuel suction tube.

2. Perform a *Fuel Flow Test* and, if air is present, tighten loose connections and replace cracked lines.

3. Perform a *Fuel Flow Test* and, if air is present, replace the fuel strainer gasket when changing the strainer element.

4. Perform a *Fuel Flow Test* and, if air is present with all fuel lines and connections assembled correctly, check for and replace faulty injectors.

5. Perform a *Fuel Flow Test* and replace the fuel strainer and filter elements and the fuel lines, if necessary,

6. Consult the *Fuel Oil Specifications* for the recommended grade of fuel.

7. Perform a *Fuel Flow Test* and, if inadequate, clean and inspect the valve seat assembly.

8. Replace the gear and shaft assembly or the pump body.

9. Check the condition of the fuel pump drive and blower drive and replace defective parts.

10. Replace with larger tank-to-engine fuel lines.

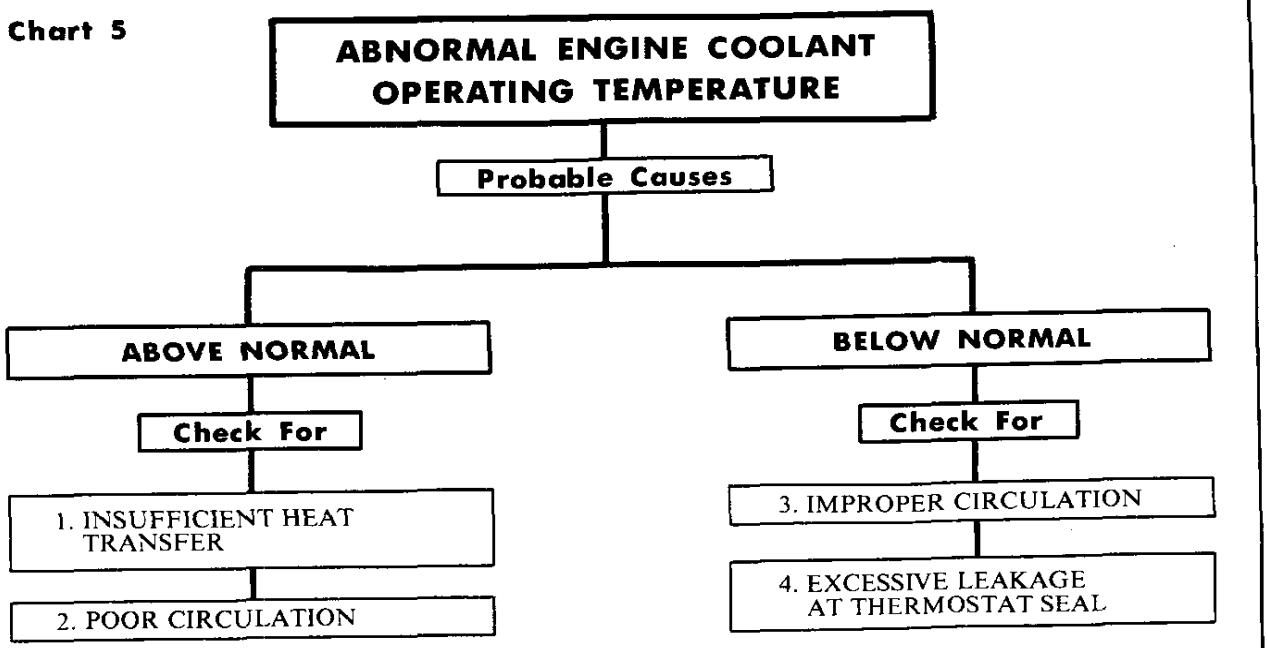
11. Install a restricted fitting in the return line.

12. Make sure that the check valve is installed in the line correctly; the arrow should be on top of the valve assembly or pointing upward. Reposition the valve if necessary. If the valve is inoperative, replace it with a new valve assembly.

13. Check the engine fuel spill-back temperature. The return fuel temperature must be less than 150°F (66°C) or a loss in horsepower will occur. This condition may be corrected by installing larger fuel lines or relocating the fuel tank to a cooler position.

© 1981 General Motors Corp.

Chart 5



SUGGESTED REMEDY

1. Clean the cooling system with a good cooling system cleaner and thoroughly flush to remove scale deposits.

Clean the exterior of the radiator core to open plugged passages and permit normal air flow.

Adjust fan belts to the proper tension to prevent slippage.

Check for an improper size radiator or inadequate shrouding.

Repair or replace inoperative temperature-controlled fan or inoperative shutters.

2. Check the coolant level and fill to the filler neck if the coolant level is low.

Inspect for collapsed or disintegrated hoses. Replace faulty hoses.

Thermostat may be inoperative. Remove, inspect and test the thermostat; replace if found faulty.

Check the water pump for a loose or damaged impeller.

Check the flow of coolant through the radiator. A clogged radiator will cause an inadequate supply of coolant on the suction side of the pump. Clean the radiator core.

Remove the coolant filler cap and operate the engine, checking for combustion gases in the cooling system. The cylinder head must be removed and inspected for cracks and the head gaskets replaced if combustion gases are entering the cooling system.

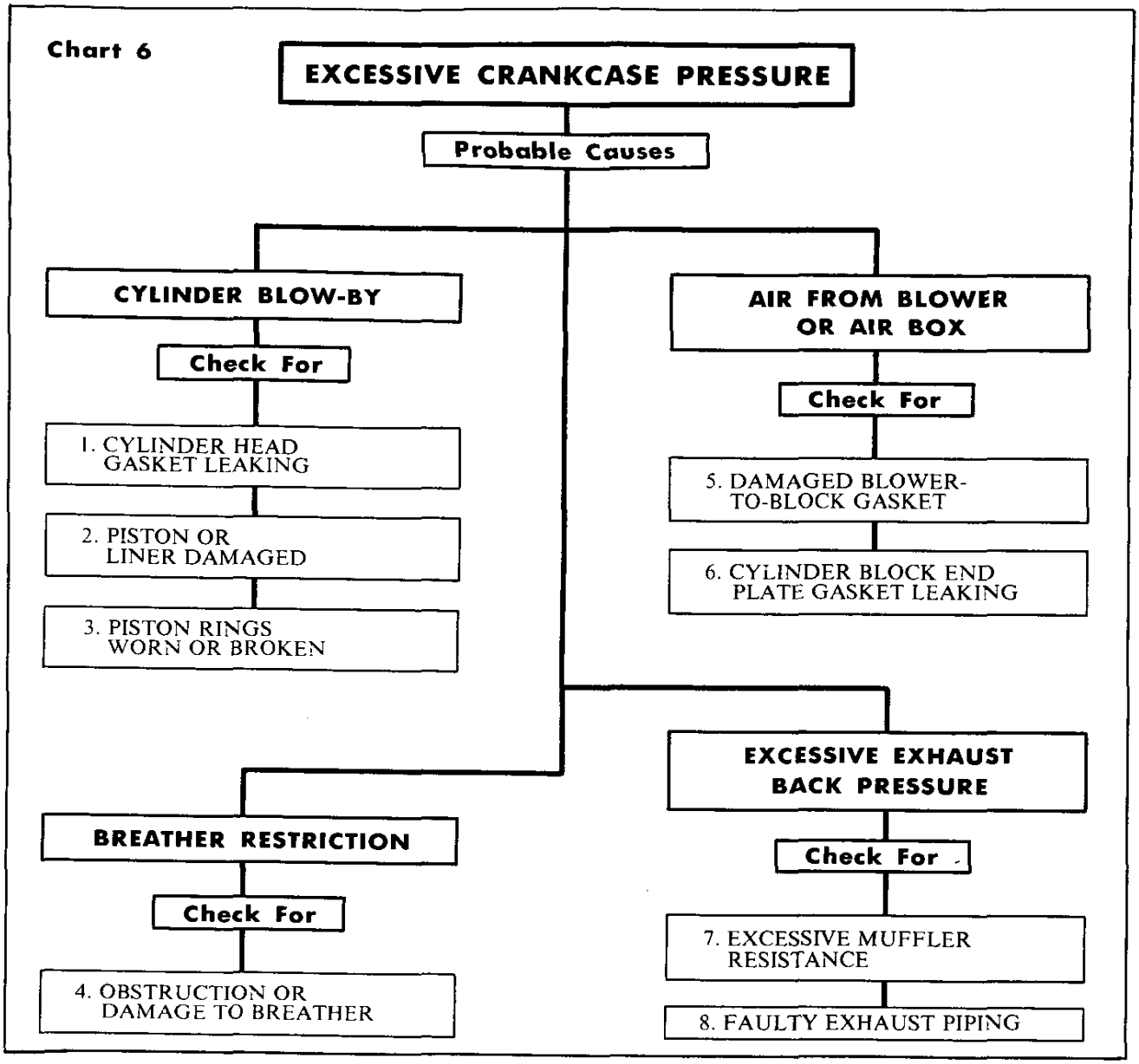
Check for an air leak on the suction side of the water pump. Replace defective parts.

3. The thermostat may not be closing. Remove, inspect and test the thermostat. Install a new thermostat, if necessary.

Check for an improperly installed heater.

4. Excessive leakage of coolant past the thermostat seal is a cause of continued low coolant operating temperature. When this occurs, replace the thermostat seal.

© 1981 General Motors Corp.



SUGGESTED REMEDY

1. Check the compression pressure and, if only one cylinder has low compression, remove the cylinder head and replace the head gaskets.

2. Inspect the piston and liner and replace damaged parts.

3. Install new piston rings.

4. Clean and repair or replace the breather assembly.

5. Replace the blower-to-block gasket.

6. Replace the end plate gasket.

7. Check the exhaust back pressure and repair or replace the muffler if an obstruction is found.

8. Check the exhaust back pressure and install larger piping if it is determined that the piping is too small, too long or has too many bends.

© 1981 General Motors Corp.

Chart 7

LOW OIL PRESSURE

MAKE CHECKS WITH MINIMUM WATER OUTLET TEMPERATURE OF 160 °F (71 °C)

Probable Causes

LUBRICATING OIL

Check For

1. SUCTION LOSS
2. LUBRICATING OIL VISCOSITY

PRESSURE GAGE

Check For

8. FAULTY GAGE
9. GAGE LINE OBSTRUCTED
10. GAGE ORIFICE PLUGGED
11. ELECTRICAL INSTRUMENT PANEL SENDING UNITS FAULTY

POOR CIRCULATION

Check For

3. COOLER CLOGGED
4. COOLER BY-PASS VALVE NOT FUNCTIONING PROPERLY
5. PRESSURE REGULATOR VALVE NOT FUNCTIONING PROPERLY
6. EXCESSIVE WEAR ON CRANKSHAFT BEARINGS
7. GALLERY, CRANKSHAFT OR CAMSHAFT PLUGS MISSING

OIL PUMP

Check For

12. INTAKE SCREEN PARTIALLY CLOGGED
13. RELIEF VALVE FAULTY
14. AIR LEAK IN PUMP SUCTION
15. PUMP WORN OR DAMAGED
16. LOOSE END COVER BOLTS
17. FLANGE LEAK (PRESSURE SIDE)

© 1981 General Motors Corp.

Chart 7

LOW OIL PRESSURE

SUGGESTED REMEDY

1. Check the oil and bring it to the proper level on the dipstick or correct the installation angle.

2. Consult the *Lubricating Oil Specifications* in Section 13.3 for the recommended grade and viscosity of oil.

Check for fuel leaks at the injector nut seal ring and fuel pipe connections. Leaks at these points will cause lubricating oil dilution. Refer to Fuel Leak Detection in Section 2.0.

3. A plugged oil cooler is indicated by excessively high lubricating oil temperature. Remove and clean the oil cooler core.

4. Remove the bypass valve and clean the valve and valve seat and inspect the valve spring. Replace defective parts.

5. Remove the pressure regulator valve and clean the valve and valve seat and inspect the valve spring. Replace defective parts.

6. Change the bearings. Consult the *Lubricating Oil Specifications* in Section 13.3 for the proper grade and viscosity of oil. Change the oil filters.

7. Replace missing plugs.

8. Check the oil pressure with a reliable gage and replace the gage if found faulty.

9. Remove and clean the gage line; replace it, if necessary.

10. Remove and clean the gage orifice.

11. Repair or replace defective electrical equipment.

12. Remove and clean the oil pan and oil intake screen. Consult the *Lubricating Oil Specifications* in Section 13.3 for the proper grade and viscosity of oil. Change the oil filters.

13. Remove and inspect the valve, valve bore and spring. Replace faulty parts.

14. Disassemble the piping and install new gaskets.

15. Remove the pump. Clean and replace defective parts.

16. Remove the oil pan and tighten the oil pump end cover bolts.

17. Remove the flange and replace the gasket.

© 1981 General Motors Corp.

Chart 8

HIGH LUBRICATING OIL CONSUMPTION

Probable Causes

EXTERNAL LEAKS

Check For

1. OIL LINES OR CONNECTIONS LEAKING
2. GASKET OR OIL SEAL LEAKS
3. AUTOMATIC OIL FILLER
4. OIL PULLOVER - AIR COMPRESSOR
5. OVER-FILLED CRANKCASE
6. PLUGGED BREATHERS
7. HIGH CRANKCASE PRESSURE
8. BLUE EXHAUST SMOKE
9. EXCESSIVE OIL IN AIR BOX

OIL CONTROL AT CYLINDER

Check For

14. LOW COMPRESSION
15. PISTON PIN RETAINER LOOSE
16. OIL CONTROL RINGS WORN, BROKEN, IMPROPERLY INSTALLED OR SCORED.
17. EXCESSIVE OIL IN AIR BOX
18. DIRT IN AIR INTAKE SYSTEM
19. SCORED LINERS OR PISTONS
20. EXCESSIVE INSTALLATION ANGLE
21. EXCESSIVE OIL IN CRANKCASE

INTERNAL LEAKS

Check For

10. BLOWER OIL SEALS LEAKING
11. TURBO OIL SEALS LEAKING
12. OIL COOLER CORE LEAKING
13. WORN EXHAUST VALVE GUIDES

© 1981 General Motors Corp.

Chart 8

HIGH LUBRICATING OIL CONSUMPTION

SUGGESTED REMEDY

NOTE: Lube oil consumption must be verified after each repair is made.

1 & 2. Repair oil leaks by replacing necessary gaskets, seals or tightening connections. Steam cleaning the engine and operating at no-load rpm, (engine at operating temperature) will often reveal excessive oil leaks.

3. Consult the original equipment manufacturer for proper repair of the automatic oil filler system.

4. Check the air compressor for oil pullover and/or remove and replace the compressor.

5. Check dipstick and tube for proper oil pan levels to correct overfilled crankcase.

6. Check crankcase pressure. Clean breathers and recheck crankcase pressure.

7. Overhaul blower, turbocharger or rekit engine (refer to Items 10, 11, 15 and 16). Also, refer to the *Excessive Crankcase Pressure* chart.

8. Remove and inspect exhaust manifolds and stacks for wetness or oil discharge. Excessive clearance between the valve stem and the valve guide can produce oil in the cylinders and stack. Repair the valve guides and/or install valve stem seals.

9. Refer to the *Abnormal Engine Operation* chart.

10. Remove the piping from the air inlet housing and remove from the to blower. Operate the engine at approximately one-half throttle and at idle and inspect blower end plates for evidence of oil leakage past the seals. Use a flashlight to illuminate the end plates. If excessive oil leakage is evident on the end plates, overhaul blower.

Extreme care should be taken to prevent personal injury.

11. Check for indications of oil on compressor or turbine sides of the turbocharger. Refer to Section 3.5 of the Service Manual for the proper procedure to determine turbocharger oil seal leakage.

12. Pressure test cooling system. If leak is found, remove and replace the oil cooler.

Inspect the engine coolant for lubricating oil contamination; if contaminated, replace the oil cooler core. Then use a good grade of cooling system cleaner to remove the oil from the cooling system.

13. Replace worn exhaust valve guides.

14. Take compression test - refer to Item 16.

15. Run engine at idle speed with the air box cover removed (one at a time) to determine if oil is uncontrolled as evidenced by slobbering out the liner ports. Inspect all cylinders as more than one may be slobbering. Repair affected cylinders. Slobbering can also be caused by worn oil control rings.

CAUTION: Extreme care should be taken to prevent personal injury.

16. Check for faulty engine air induction system allowing contaminated air to enter the engine. A compression test with excessively low readings will indicate worn out cylinders. Remove and replace cylinder kits.

17. Refer to Items 10, 11, 15 and 16.

18. Refer to Item 16.

19. Check the crankshaft thrust washers for wear. Replace wore and defective parts.

20. Decrease the installation angle.

21. Fill the crankcase to the proper level only.

© 1981 General Motors Corp.

STORAGE

PREPARING ENGINE FOR STORAGE

When an engine is to be stored or removed from operation for a period of time, special precautions should be taken to protect the interior and exterior of the engine, transmission and other parts from rust accumulation and corrosion. The parts requiring attention and the recommended preparations are given below.

It will be necessary to remove all rust or corrosion completely from any exposed part before applying a rust preventive compound. Therefore, it is recommended that the engine be processed for storage as soon as possible after removal from operation.

The engine should be stored in a building which is dry and can be heated during the winter months. Moisture absorbing chemicals are available commercially for use when excessive dampness prevails in the storage area.

TEMPORARY STORAGE (30 days or less)

To protect an engine for a temporary period of time, proceed as follows:

1. Drain the engine crankcase.

2. Fill the crankcase to the proper level with the recommended viscosity and grade of oil.

3. Fill the fuel tank with the recommended grade of fuel oil. Operate the engine for two minutes at 1200 rpm and no load.

NOTE: Do not drain the fuel system or the crankcase after this run.

4. Check the air cleaner and service it, if necessary, as outlined in Section 3.1.

5. If freezing weather is expected during the storage period, add an ethylene glycol base antifreeze solution in accordance with the manufacturer's recommendations. Drain the raw water system and leave the drain cocks open.

6. Clean the entire exterior of the engine (except the electrical system) with fuel oil and dry it with compressed air.

7. Seal all of the engine openings. The material used for this purpose must be waterproof, vaporproof and possess sufficient physical strength to resist puncture and damage from the expansion of entrapped air.

An engine prepared in this manner can be returned to service in a short time by removing the seals at the engine openings, checking the engine coolant, fuel oil, lubricating oil, transmission and priming the raw water pump, if used.

EXTENDED STORAGE (more than 30 days)

To prepare an engine for extended storage, (more than 30 days), follow this procedure:

1. Drain the cooling system and flush with clean, soft water. Refill with clean, soft water and add a rust inhibitor to the cooling system (refer to *Corrosion Inhibitor* under *Engine Coolant* in Section 13.3).

2. Remove, check and recondition the injectors, if necessary, to make sure they will be ready to operate when the engine is restored to service.

3. Reinstall the injectors, time them and adjust the exhaust valve clearance.

4. Circulate the coolant by operating the engine until normal operating temperature is reached (see Section 13.2).

5. Stop the engine.

6. Drain the engine crankcase, then reinstall and tighten the drain plug. Install new lubricating oil filter elements and gaskets.

7. Fill the crankcase to the proper level with a 30 weight preservative lubricating oil MIL-L-21260C, Grade 2.

8. Drain the fuel tank. Refill with enough clean No. 1 diesel fuel or pure kerosene to permit the engine to operate for about ten minutes. If it isn't convenient to drain the fuel tank (i.e., marine) use a separate portable supply of the recommended fuel.

NOTE: If engines in vehicles or marine units are stored where condensation of water in the fuel tank may be a problem, add pure, waterless isopropyl alcohol (isopropanol) to the fuel at a ratio of one pint (0.5 liter) to 125 gallons (473 liters) of fuel or .010% by volume. Where biological contamination of fuel may be a problem, add a biocide such as Biobor JF, or equivalent, to the fuel. When using a biocide, follow the manufacturer's concentration recommendations and observe all cautions and warnings.

© 1984 General Motors Corp.

9. Drain and disassemble the fuel filter and strainer. Discard the used elements and gaskets. Wash the shells in clean No. 1 diesel fuel or pure kerosene and insert new elements. Fill the cavity between the element and shell with No. 1 diesel fuel or pure kerosene and reinstall on the engine. If spin-on fuel filters and strainers are used, discard the used cartridges, fill the new ones with No. 1 diesel fuel or pure kerosene and reinstall on the engine.

10. Operate the engine for five minutes to circulate the clean fuel oil throughout the engine.

11. Refer to *Section 3.1* and service the air cleaner.

12. MARINE GEAR

a. Drain the oil completely and refill with clean oil of the recommended grade and viscosity. Remove and clean or replace the strainer and filter elements.

b. Start and run the engine at 600 rpm for 10 minutes to coat all of the internal parts of the marine gear with clean oil. Engage the clutches alternately to circulate clean oil through all of the moving parts.

NOTE: The performance of this step is not necessary on torque converter units.

13. TORQMATIC CONVERTER

a. Start and operate the engine until the temperature of the converter oil reaches 150°F (66°C).

b. Stop the engine, remove the converter drain plug and drain the converter.

c. Remove the filter element.

d. Start the engine and stall the converter for **twenty seconds** at 1000 rpm to scavenge the oil from the converter. *Due to lack of lubrication, do not exceed the 20 second limit.*

e. Install the drain plug and a new filter element.

f. Fill the converter to the proper operating level with a commercial preservative oil which meets specification MIL-L-21260C, Grade 2. Oil of this type is available from the major oil companies.

g. Start the engine and operate the converter for at least 10 minutes at a minimum of 1000 rpm. Engage the clutch, then stall the converter to raise the oil temperature to 225°F (107°C).

NOTE: Do not allow the oil temperature to exceed 225°F (107°C). If the unit does not have a temperature gage, *do not stall the converter for more than thirty seconds.*

h. Stop the engine and allow the converter to cool to a temperature suitable to the touch.

i. Seal the breather and all of the exposed openings with moisture proof tape.

j. Coat all exposed, unpainted surfaces with preservative grease. Position all of the controls for minimum exposure and coat them with grease. The external shafts, flanges and seals should also be coated with grease.

14. POWER TAKEOFF

a. Use an all purpose grease such as Shell Alvania No. 2, or equivalent, and lubricate the clutch throwout bearing, clutch pilot bearing, drive shaft main bearing, clutch release shaft and the outboard bearings (if so equipped).

b. Remove the inspection hole cover on the clutch housing and lubricate the clutch release lever and link pins with a hand oiler. *Avoid getting oil on the clutch facing.*

c. If the unit is equipped with a reduction gear, drain the gear box and flush with light engine oil. If the unit is equipped with a filter, clean the shell and replace the filter element. Refill the gear box to the proper level with the grade of oil indicated on the name plate.

15. TURBOCHARGER

Since turbocharger bearings are pressure lubricated through the external oil line leading from the engine cylinder block while the engine is operating, no further attention is required. However, the turbocharger air inlet and turbine outlet connections should be sealed off with moisture resistant tape.

16. HYDROSTARTER SYSTEM

Refer to Section 12.6.1 for the lubrication and preventive maintenance procedure.

17. Apply a *non-friction* rust preventive compound to all exposed parts. If convenient, apply the rust preventive compound to the engine flywheel. If not, disengage the clutch mechanism to prevent the clutch disc from sticking to the flywheel.

NOTE: Do not apply oil, grease or any wax base compound to the flywheel. The cast iron will absorb these substances which can "sweat" out during operation and cause the clutch to slip.

18. Drain the engine cooling system.

19. Drain the preservative oil from the engine crankcase. Reinstall and tighten the drain plug.

20. Remove and clean the battery and battery cables

© 1984 General Motors Corp.

with a baking soda solution and rinse them with fresh water. Do not allow the soda solution to enter the battery. Add distilled water to the electrolyte, if necessary, and fully charge the battery. Store the battery in a cool (never below 32°F or 0°C) dry place. Keep the battery fully charged and check the level and the specific gravity of the electrolyte regularly.

21. Insert heavy paper strips between the pulleys and belts to prevent sticking.

22. Seal all engine openings, including the exhaust outlet, with moisture resistant tape. Use cardboard, plywood or metal covers where practical.

23. Clean and dry the exterior painted surfaces of the engine and spray with a suitable liquid automobile body wax, a synthetic resin varnish or a rust preventive compound.

24. Protect the engine with a good weather-resistant tarpaulin and store it under cover, preferably in a dry building which can be heated during the winter months.

Detroit Diesel Allison does not recommend the outdoor storage of engines (or transmission). Nevertheless, DDA recognizes that in some cases outdoor storage may be unavoidable. If units must be kept out-off-doors, follow the preparation and storage instructions already given. Protect units with quality, weather-resistant tarpaulins (or other suitable covers) arranged to provide air circulation.

NOTE: *Do not use plastic sheeting for outdoor storage.* Plastic is fine for indoor storage. When used outdoors, however, enough moisture can condense on the inside of the plastic to rust ferrous metal surfaces and pit aluminum surfaces. If a unit is stored outside for any extended period of time, severe corrosion damage can result.

The stored engine should be inspected periodically. If there are any indications of rust or corrosion, corrective steps must be taken to prevent damage to the engine parts. Perform a complete inspection at the end of one year and apply additional treatment as required.

PROCEDURE FOR RESTORING AN ENGINE TO SERVICE WHICH HAS BEEN IN EXTENDED STORAGE

1. Remove the covers and tape from all of the openings of the engine, fuel tank and electrical equipment. *Do not overlook the exhaust outlet.*

2. Wash the exterior of the engine with fuel oil to remove the rust preventive.

3. Remove the rust preventive from the flywheel.

4. Remove the paper strips from between the pulleys and the belts.

5. Remove the drain plug and drain the preservative oil from the crankcase. Reinstall the drain plug. Then refer to *Lubrication System* in Section 13.1 and fill the crankcase to the proper level, using a pressure prelubricator, with the recommended grade of lubricating oil.

6. Fill the fuel tank with the fuel specified under *Fuel Specifications* (Section 13.3).

7. Close all of the drain cocks and fill the engine cooling system with clean soft water and a rust inhibitor. If the engine is to be exposed to freezing temperatures, fill the cooling system with a solution of water and an ethylene glycol base antifreeze (refer to Section 13.3).

8. Install and connect the battery.

9. Service the air cleaner as outlined in Section 3.1.

10. POWER GENERATOR

Prepare the generator for starting as outlined under *Operating Instructions* in Section 13.

11. MARINE GEAR

Check the marine gear; refill it to the proper level, as necessary, with the correct grade of lubricating oil.

12. TORQMATIC CONVERTER

a. Remove the tape from the breather and all of the openings.

b. Remove all of the preservative grease with a suitable solvent.

c. Start the engine and operate the unit until the temperature reaches 150°F (66°C). Drain the preservative oil and remove the filter. Start the engine and stall the converter for twenty seconds at 1000 rpm to scavenge the oil from the converter.

NOTE: A Torqmatic converter containing preservative oil should only be operated enough to bring the oil temperature up to 150°F (66°C).

© 1982 General Motors Corp.

d. Install the drain plug and a new filter element.

e. Refill the converter with the oil that is recommended under *Lubrication and Preventive Maintenance* (Section 15.1).

13. POWER TAKE-OFF

Remove the inspection hole cover and inspect the clutch release lever and link pins and the bearing ends of the clutch release shaft. Apply engine oil sparingly, if necessary, to these areas.

14. HYDROSTARTER

a. Open the relief valve on the side of the hand pump and release the pressure in the system.

b. Refer to the filling and purging procedures outlined in *Hydraulic Starting System* (Section 12.6.1). Then drain, refill and purge the hydrostarter system.

15. TURBOCHARGER

Remove the covers from the turbocharger air inlet and turbine outlet connections. Refer to the lubricating procedure outlined in *Preparation for Starting Engine First Time* in Section 13.1.

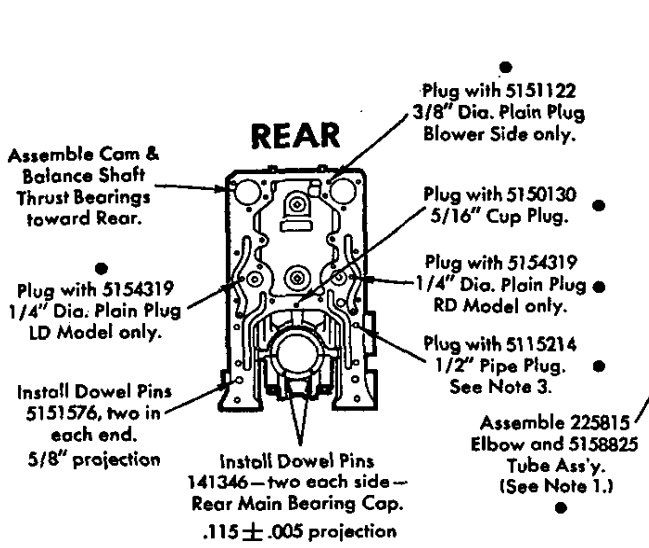
16. After all of the preparations have been completed, start the engine.

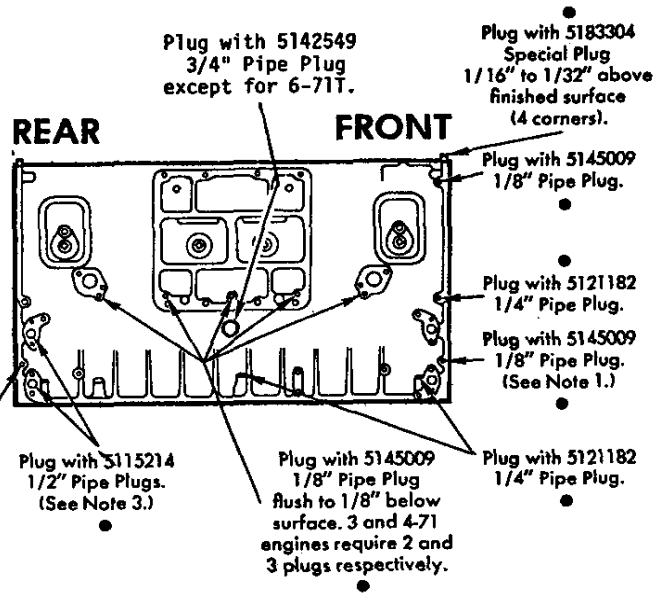
NOTE: Before subjecting the engine to a load or high speed, it is advisable to check the engine tune-up.

© 1982 General Motors Corp.

CYLINDER BLOCK PLUGGING INSTRUCTIONS for 3, 4, & 6—71 ENGINES

LD and RD ENGINES

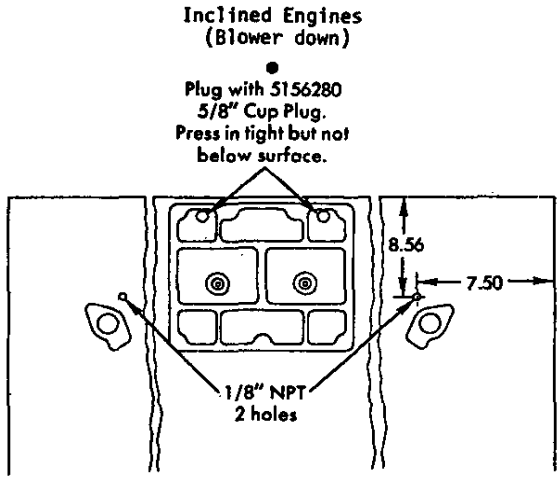




STANDARD PIPE PLUG TORQUE*

PIPE PLUG SIZE	TORQUE/FT. LBS.
1/8	10 - 12
1/4	14 - 16
3/8	18 - 22
1/2	23 - 27
3/4	33 - 37

*CAUTION—Do Not Over Torque Teflon Wrapped Pipe Plugs.
(See Note 2.)



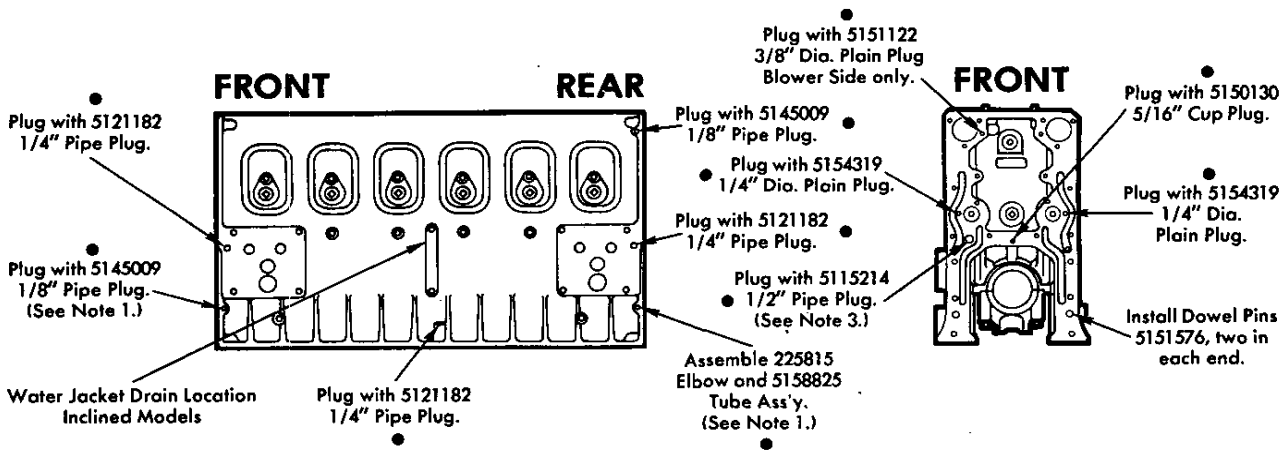
— NOTES —

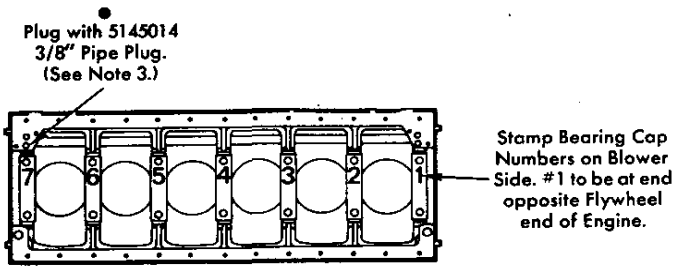
(1) Assemble 225815 Elbow and 5158825 Tube Ass'y to the front of the block for LD engine of Model 240018 and RD engine of Model 24002B. Assembly 5145014 Plugs to rear of block on aforementioned engines. On Truck engines, assemble 225815 Elbow and 5158825 Tube Ass'y to the front and to the rear on the Blower Side. Assemble 5145009 Plugs on the opposite side of the block.

(2) Apply Loctite J-26558-92 pipe sealer or equivalent with teflon prior to installation.

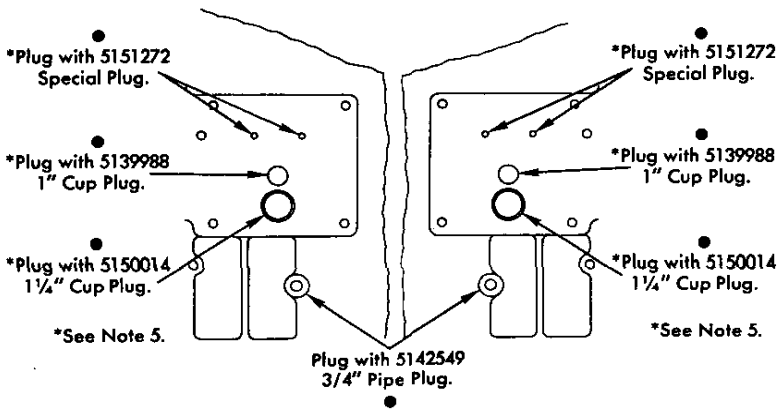
Rev. 3/81

LD and RD ENGINES (Cont'd)





Accessory Pads
4 & 6-71

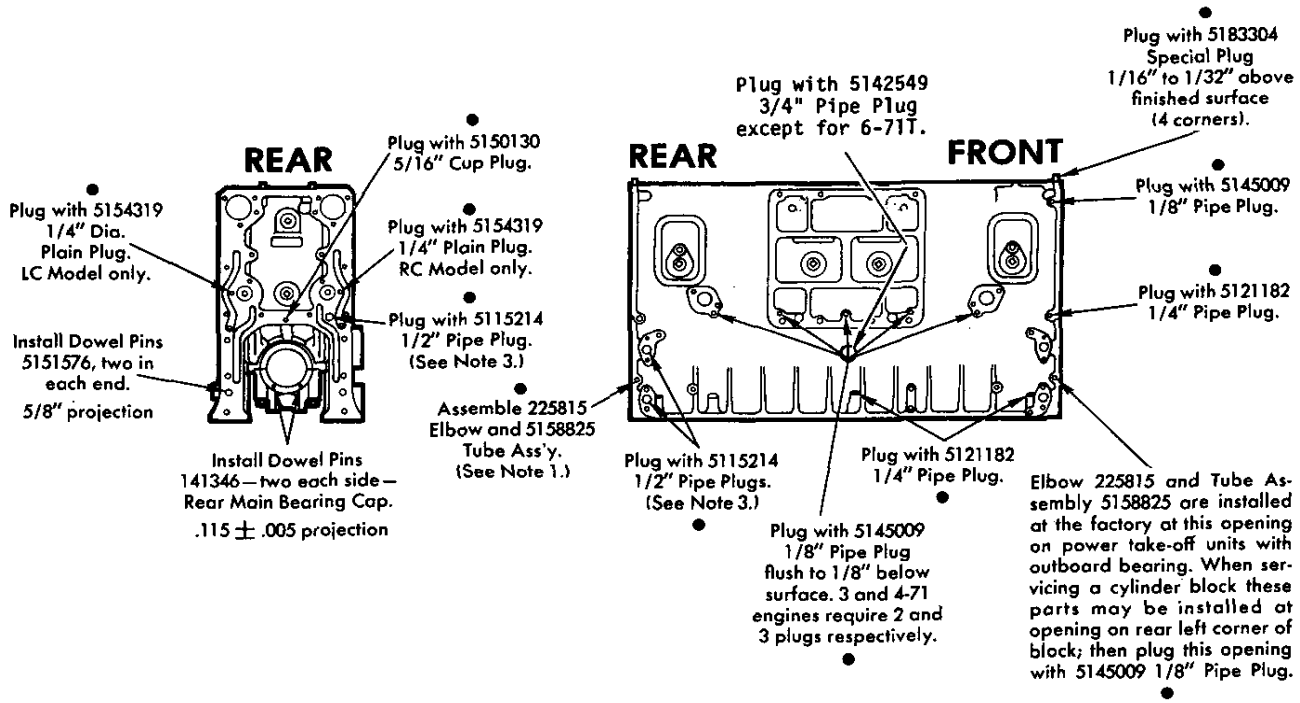


— NOTES —

(3) Replace Oil Cooler Pad and Oil Gallery End Plugs 5115214 by Plug 5173334 and Plug 5145014 in bottom of block by 5173333 when assembling an aluminum cylinder block.

(4) Do not install plugs when crankcase breather is to be installed on accessory pad.

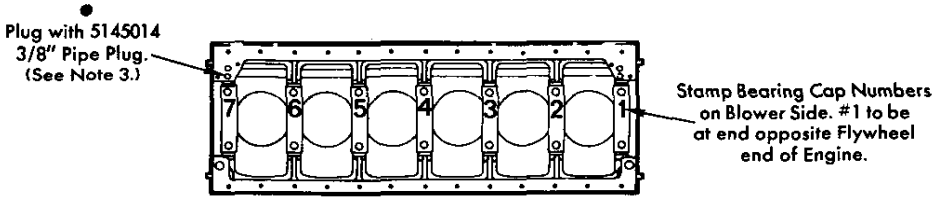
LC and RC ENGINES



STANDARD PIPE PLUG TORQUE*

PIPE PLUG SIZE	TORQUE/FT. LBS.
1/8	10 - 12
1/4	14 - 16
3/8	18 - 22
1/2	23 - 27
3/4	33 - 37

*CAUTION—Do Not Over Torque Teflon Wrapped Pipe Plugs.
(See Note 2.)



— NOTES —

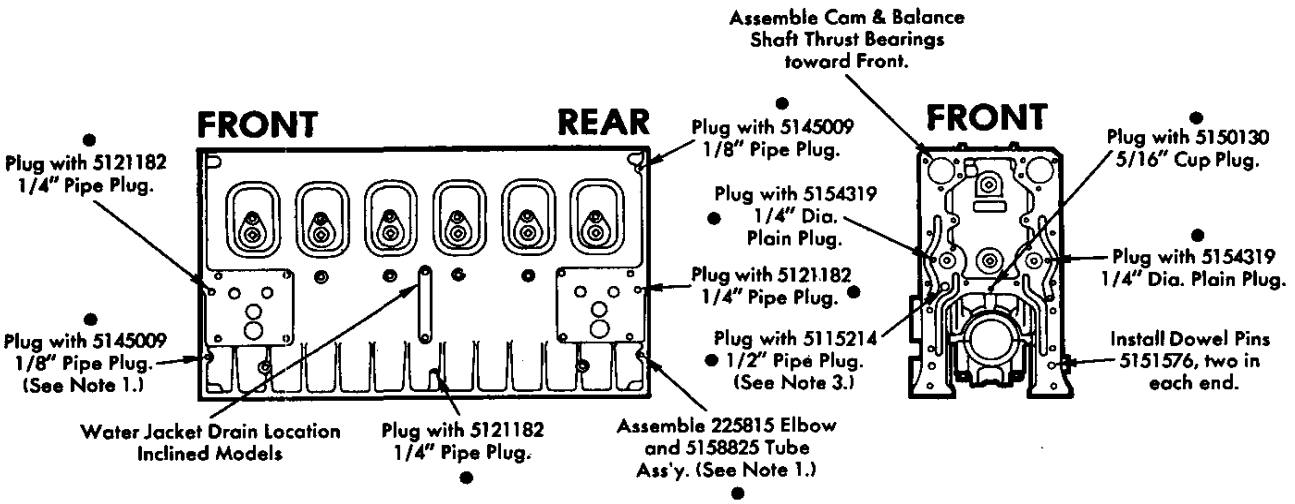
(1) Assemble 225815 Elbow and 5158825 Tube Ass'y in each of the two air box drain holes on the blower side of the block for G.M.C. Truck Models. Assemble 5145009 Plugs in the two corresponding holes on the opposite side of the block.

For single engine generator units assemble 225815 Elbow and 5171500 Tube Ass'y* to the front of the block on the handhole cover side. Assemble 225815 Elbow and Tube Ass'y 5171500 (for 3-Cyl.), 5171501 (for 4-Cyl.) or 5171502 (for 6-Cyl.) to the rear on the same side of the block. The front and rear tubes should then be connected to the common drain tank. Assemble 5145009 Plugs in the two corresponding holes on the opposite side of the block.

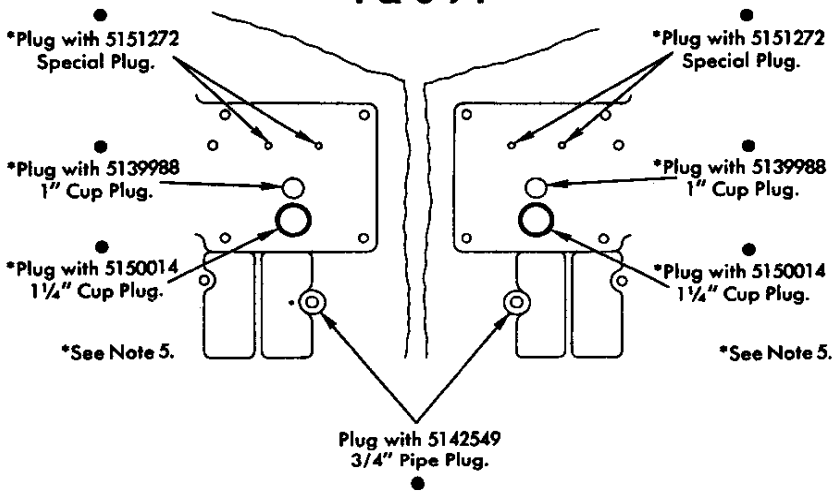
*Not included with service block.

Each engine of Model 12201 and 12202 units requires 2 Elbows 225815 and Tube Assemblies 5171500 (Front) and 5171502 (Rear) on the blower side of the block. For these Twin Generator Units, 2 Plugs 5145009 are, therefore, used on the handhole cover side of the block.

LC and RC ENGINES (Cont'd)



Accessory Pads 4 & 6-71



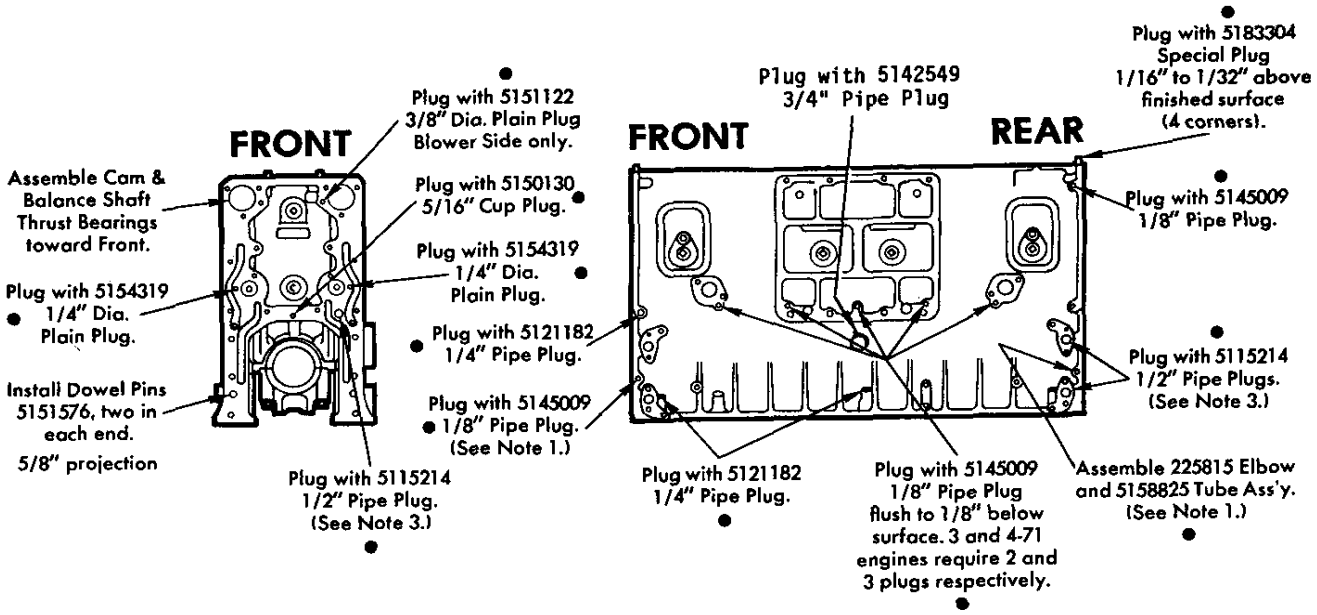
— NOTES —

(2) Apply Loctite J-26558-92 pipe sealer or equivalent with teflon prior to installation.

(3) Replace Oil Cooler Pad and Oil Gallery End Plugs 5115214 by Plug 5173334 and Plug 5145014 in bottom of block by 5173333 when assembling an aluminum cylinder block.

(4) Do not install plugs when crankcase breather is to be installed on accessory pad.

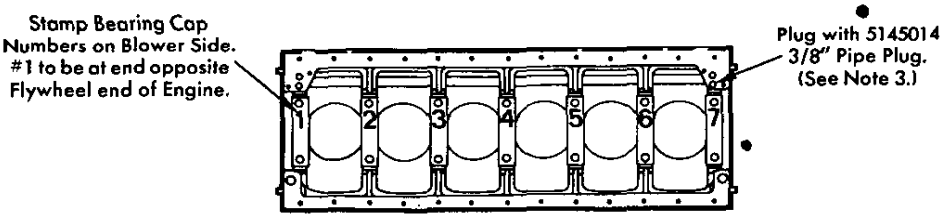
LB and RB ENGINES



STANDARD PIPE PLUG TORQUE*

PIPE PLUG SIZE	TORQUE/FT. LBS.
1/8	10 - 12
1/4	14 - 16
3/8	18 - 22
1/2	23 - 27
3/4	33 - 37

*CAUTION — Do Not Over Torque Teflon Wrapped Pipe Plugs.
(See Note 2.)

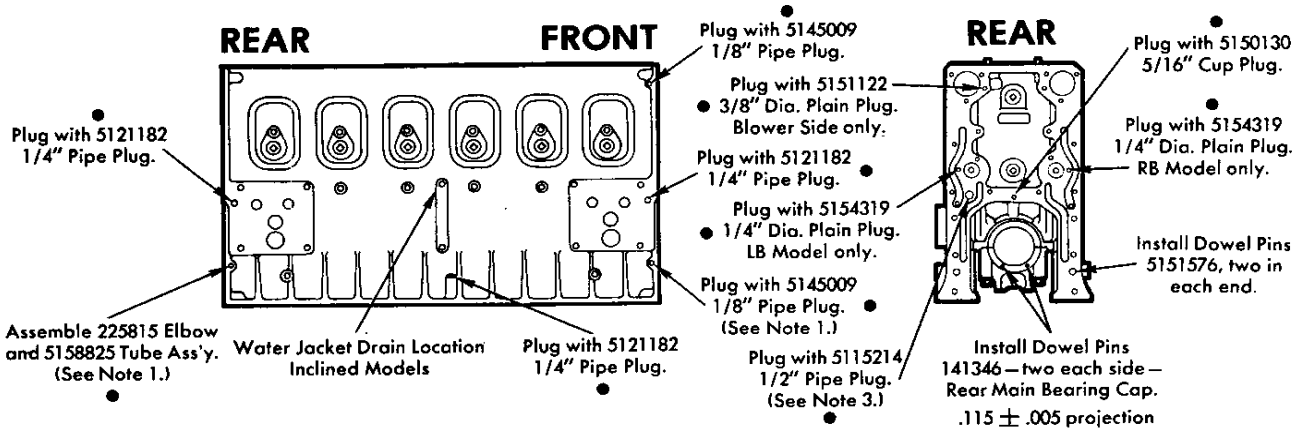


— NOTES —

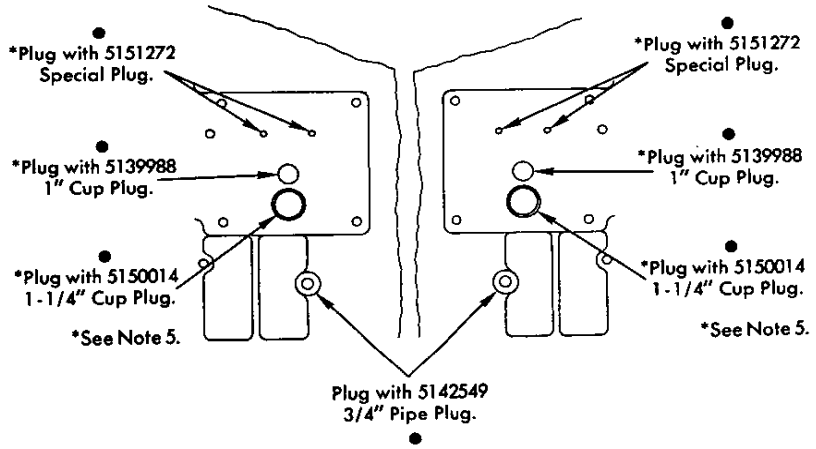
(1) Assemble 225815 Elbow and a 5158825 Tube Ass'y on each side and to the front of the block for LB engine of Model 24001B and RB engine of Model 24002B. Assemble 5145009 Plugs to rear of block on aforementioned engines.

(2) Apply Loctite J-26558-92 pipe sealer or equivalent with teflon prior to installation.

LB and RB ENGINES (Cont'd)



Accessory Pads 4 & 6-71

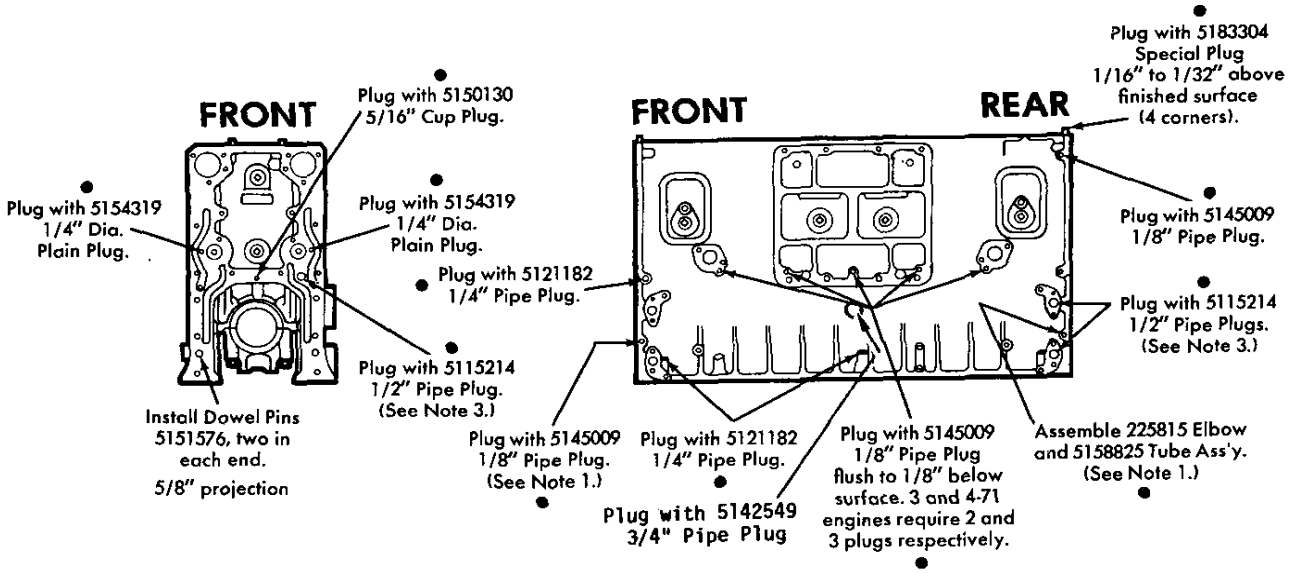


— NOTES —

(3) Replace Oil Cooler Pad and Oil Gallery End Plugs 5115214 by Plug 5173334 and Plug 5145014 in bottom of block by 5173333 when assembling an aluminum cylinder block.

(4) Do not install plugs when crankcase breather is to be installed on accessory pad.

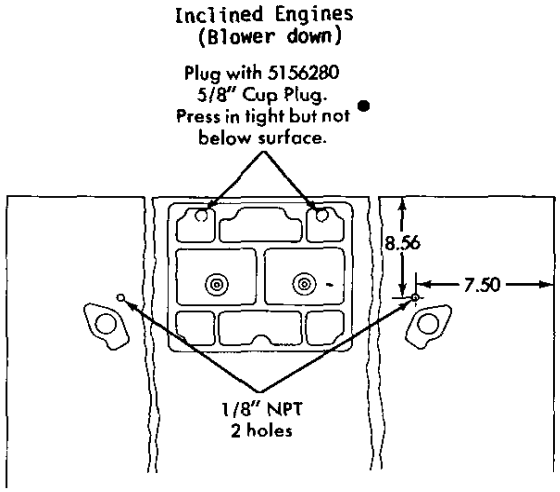
LA and RA ENGINES



STANDARD PIPE PLUG TORQUE*

PIPE PLUG SIZE	TORQUE/FT. LBS.
1/8	10 - 12
1/4	14 - 16
3/8	18 - 22
1/2	23 - 27
3/4	33 - 37

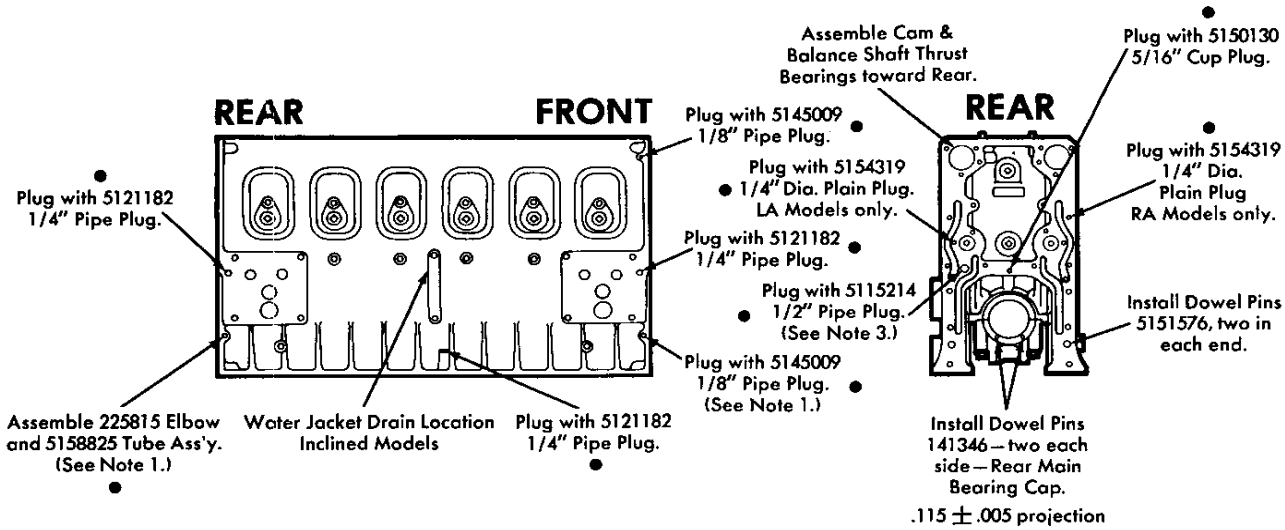
*CAUTION—Do Not Over Torque Teflon Wrapped Pipe Plugs.

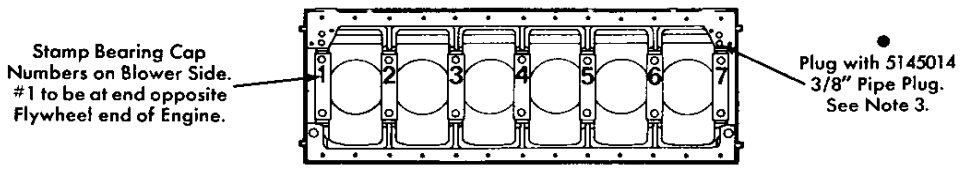


— NOTES —

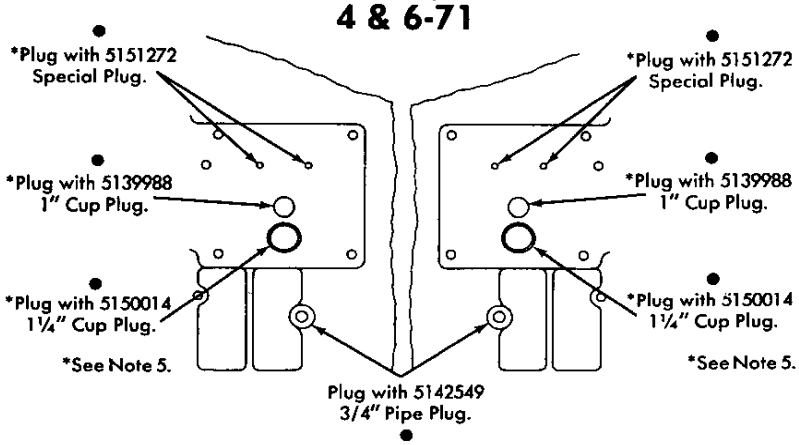
(1) On Coach engines, assemble 225815 Elbow and 5158825 Tube Ass'y to the front, and to the rear of the block—both on the blower side. On RA engine of Model 12004B, assemble 225815 Elbow and 5158825 Tube Ass'y on each side and to the front of the block. For the LA engine of Model 12201, assemble 225815 Elbow and 5171502 Tube Ass'y to the front and to the rear of the block — both on the blower side. On the aforementioned engines, assemble a 5145009 Plug in each of the two remaining corresponding holes.

LA and RA ENGINES (Cont'd)





Accessory Pads 4 & 6-71

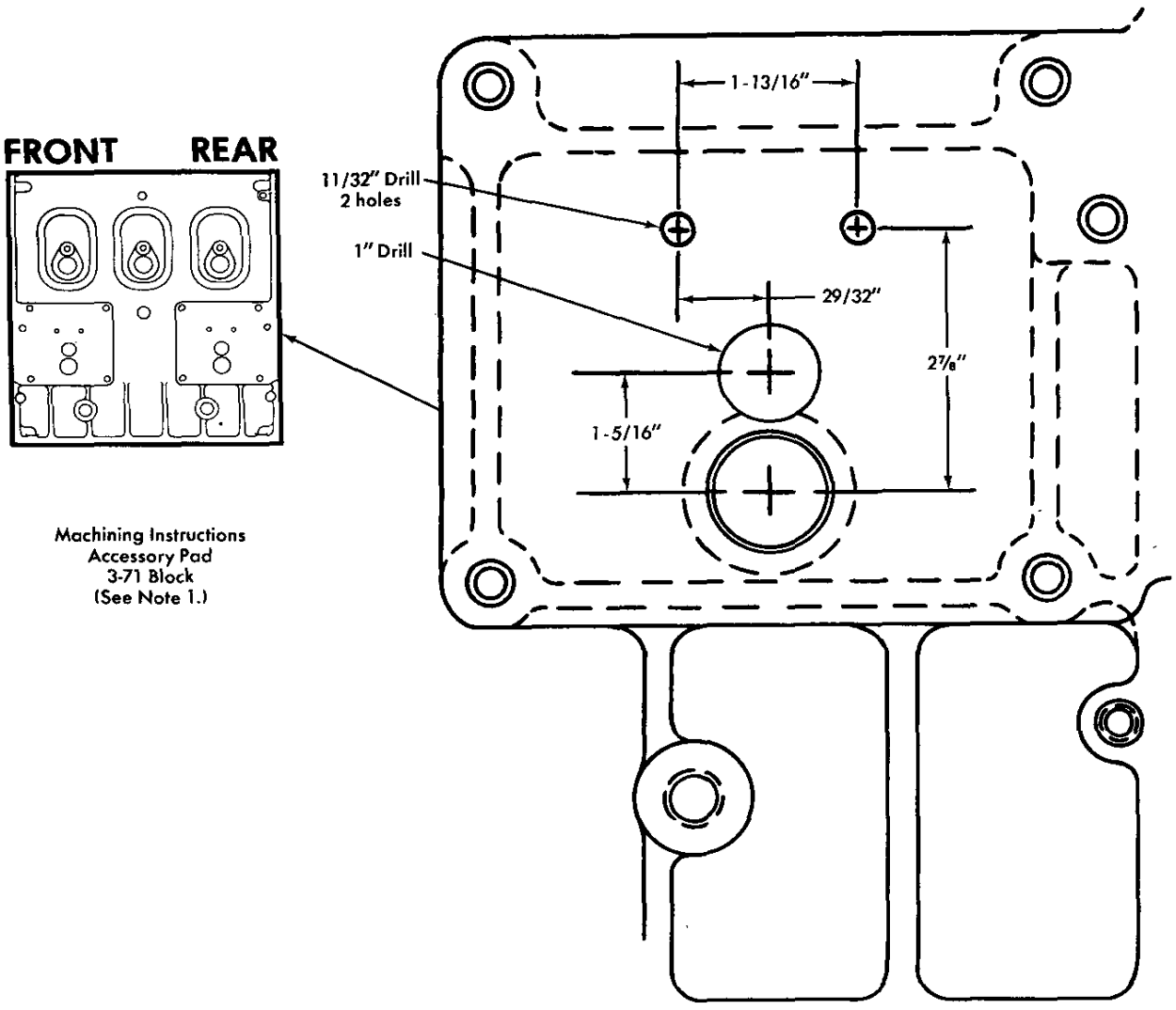


— NOTES —

●(2) Apply Loctite J-26558-92 pipe sealer or equivalent with teflon prior to installation.

(3) Replace Oil Cooler Pad and Oil Gallery End Plugs 5115214 by Plug 5173334 and Plug 5145014 in bottom of block by 5173333 when assembling an aluminum cylinder block.

(4) Do not install plugs when crankcase breather is to be installed on accessory pad.



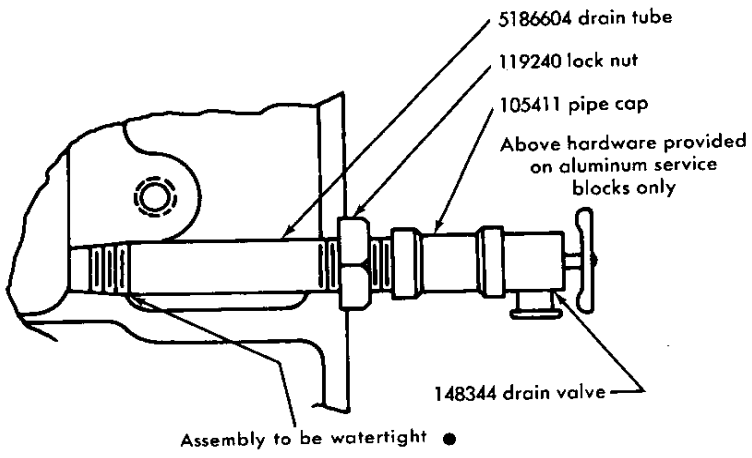
Machining Instructions
Accessory Pad
3-71 Block
(See Note 1.)

— NOTES —

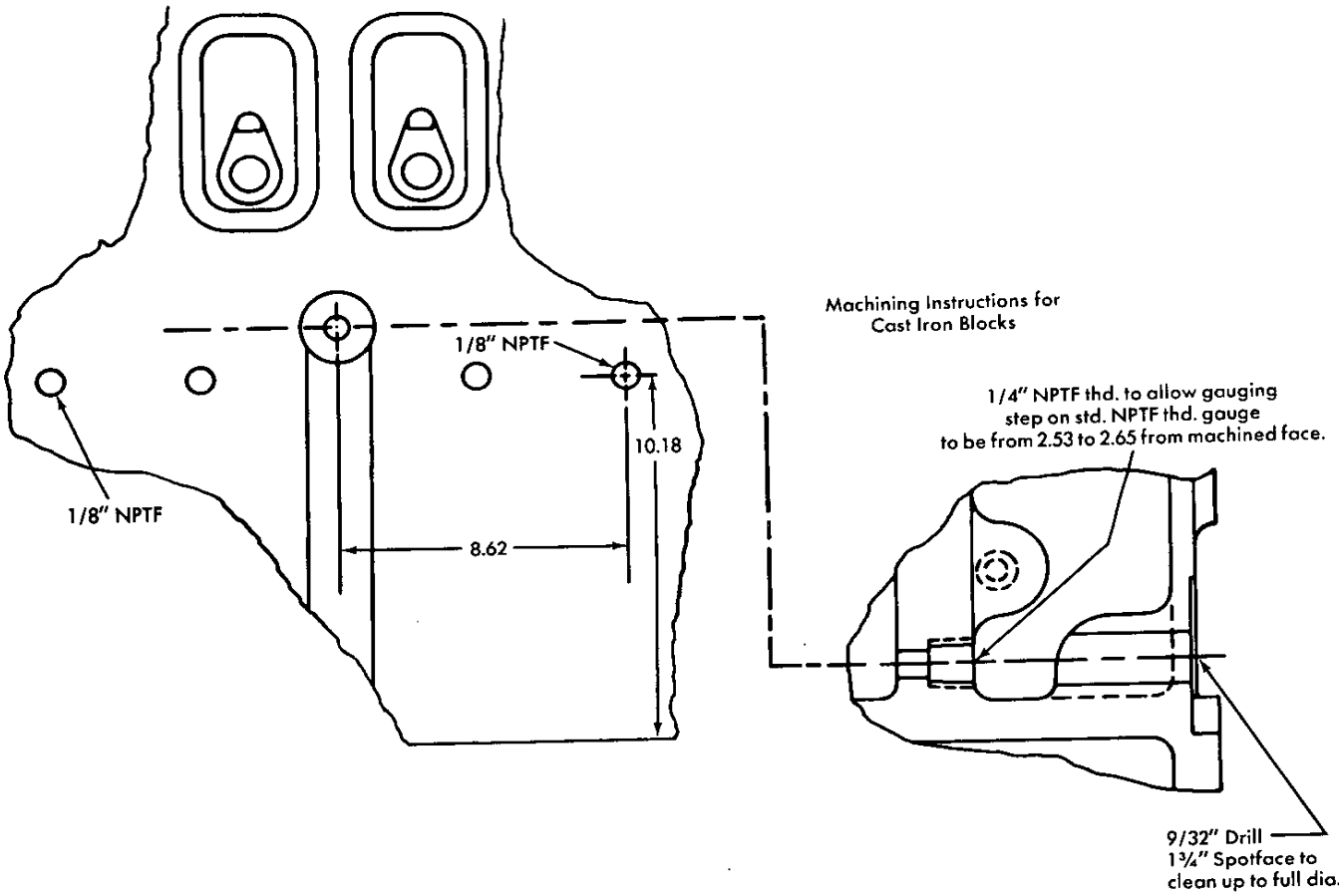
(1) For the 3-71 Engines with dry type air cleaners the crankcase breather must be mounted on the accessory pad—front or rear. Add 3 holes as shown; two for mounting the internal baffle plate and one for the drain.

● APPLY LOCTITE J-26558-92 PIPE SEALER WITH TEFLON OR EQUIVALENT TO BE APPLIED PRIOR TO INSTALLATION.

Water Jacket Drain
Horizontal Engines
(Blower Up)



Air Box Drains

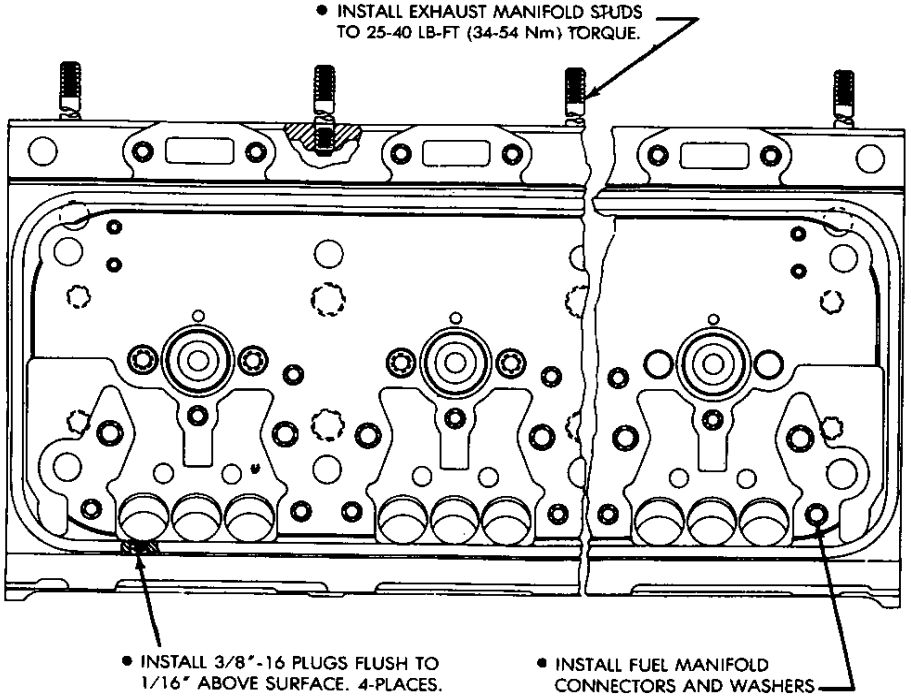


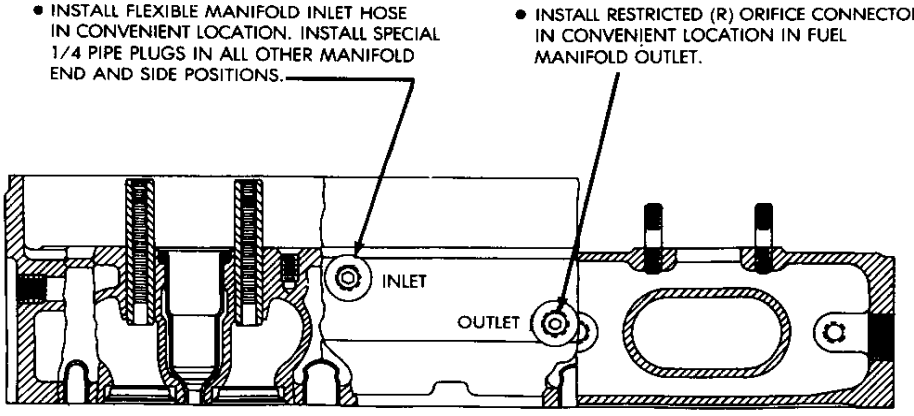
TWO VALVE CYLINDER HEAD ASSEMBLY INSTRUCTIONS

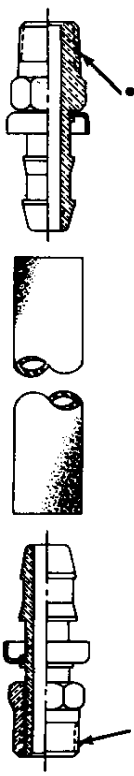
• **APPLY LOCTITE J 26558-92 PIPE SEALER WITH TEFLON OR EQUIVALENT TO BE APPLIED PRIOR TO INSTALLATION.**

STANDARD PIPE PLUG TORQUE*		
PIPE PLUG SIZE	lb-ft	Nm
1/8	10-12	14-16
1/4	14-16	19-22
3/8	18-22	24-30
1/2	23-27	31-37
3/4	33-37	45-50

*CAUTION — Do Not Over Torque Teflon Wrapped Pipe Plugs.







TO ASSEMBLE HOSE & FITTINGS

1. CUT HOSE TO REQUIRED LENGTH. LUBRICATE INSIDE OF HOSE AND OUTSIDE OF NIPPLE.
2. PUSH HOSE ON FITTING UNDERNEATH PROTECTIVE CAP.

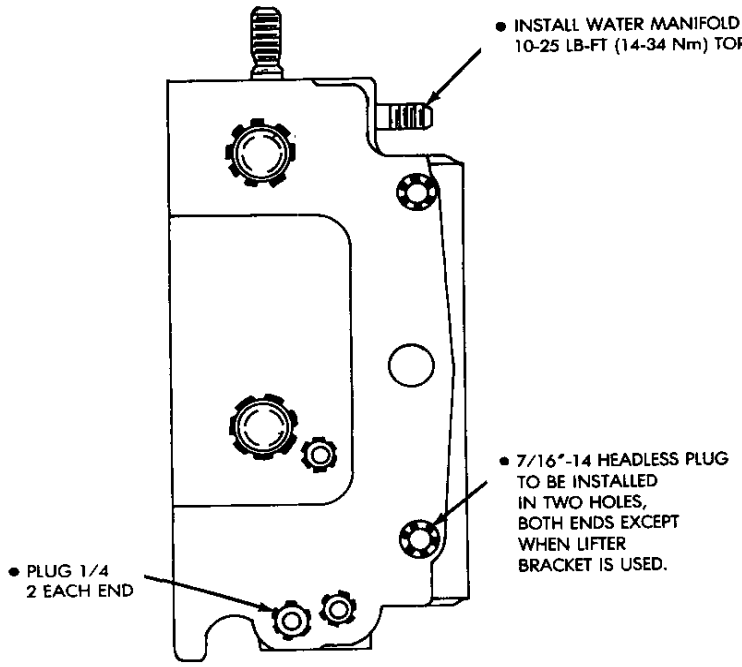
REV 9-77

TWO VALVE CYLINDER HEAD ASSEMBLY INSTRUCTIONS *(Continued)*

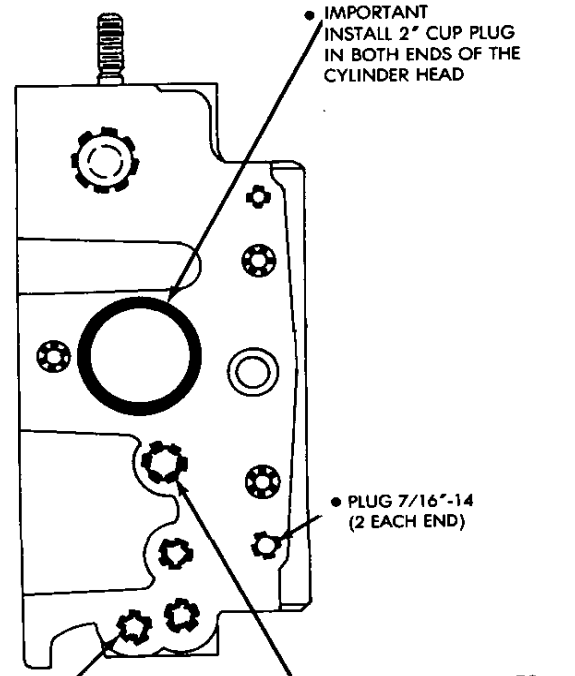
• **APPLY LOCTITE J 26558-92 PIPE SEALER WITH TEFLON OR EQUIVALENT TO BE APPLIED PRIOR TO INSTALLATION.**

STANDARD PIPE PLUG TORQUE*		
PIPE PLUG SIZE	lb-ft	Nm
1/8	10-12	14-16
1/4	14-16	19-22
3/8	18-22	24-30
1/2	23-27	31-37
3/4	33-37	45-50

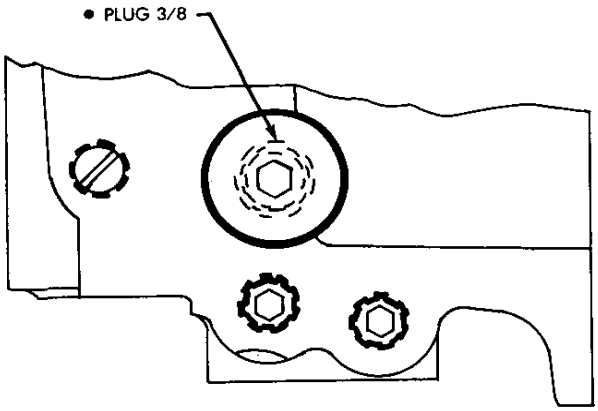
*CAUTION — Do Not Over Torque Teflon Wrapped Pipe Plugs.



OLD STYLE HEAD
END VIEW
4-71 IN-LINE ONLY



NEW STYLE HEAD
END VIEW
3-71 & 6-71 IN-LINE



NEW STYLE HEAD
END VIEW (OPPOSITE)
3-71 IN-LINE

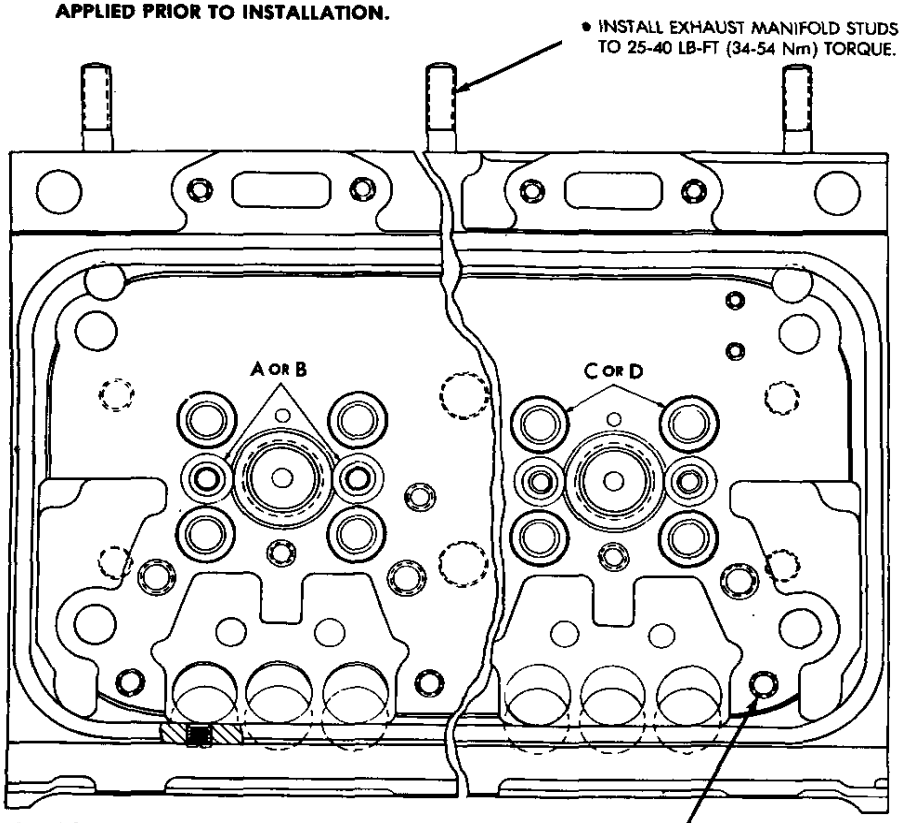
REV 9-77

FOUR VALVE CYLINDER HEAD ASSEMBLY INSTRUCTIONS

- **APPLY LOCTITE J 26558-92 PIPE SEALER WITH TEFLON OR EQUIVALENT TO BE APPLIED PRIOR TO INSTALLATION.**

STANDARD PIPE PLUG TORQUE*		
PIPE PLUG SIZE	lb-ft	Nm
1/8	10-12	14-16
1/4	14-16	19-22
3/8	18-22	24-30
1/2	23-27	31-37
3/4	33-37	45-50

*CAUTION — Do Not Over Torque Teflon Wrapped Pipe Plugs.

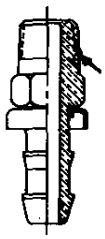


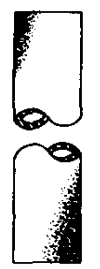
A — USE WITH THREE SPRING DESIGN (SPRING UNDER BRIDGE).

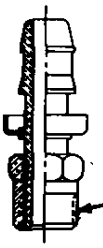
B — TWO SPRING DESIGN (NO SPRING UNDER BRIDGE).

C — USE WITH .581 I.D. VALVE SPRING.

D — USE WITH .645 I.D. VALVE SPRING.





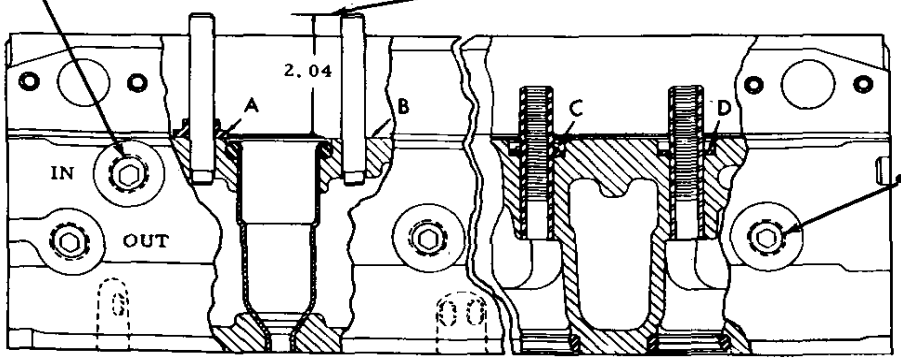


TO ASSEMBLE HOSE & FITTINGS

1. CUT HOSE TO REQUIRED LENGTH. LUBRICATE INSIDE OF HOSE AND OUTSIDE OF NIPPLE.
2. PUSH HOSE ON FITTING UNDERNEATH PROTECTIVE CAP.

• INSTALL SPECIAL 1/4 PIPE PLUGS IN ALL MANIFOLD END AND SIDE POSITIONS EXCEPT FUEL INLET AND OUTLET POSITIONS CONVENIENT FOR ASSEMBLY OF FLEXIBLE HOSE ON IN-LINE ENGINES.

BRIDGE GUIDES TO BE INSTALLED AS SHOWN.



• INSTALL RESTRICTED (R) ORIFICE CONNECTOR IN CONVENIENT LOCATION IN FUEL MANIFOLD OUTLET.

NOTICE: USE .1065" CONNECTOR (MARKED R10) WITH 90CMM INJECTORS. USE .080" CONNECTOR (MARKED R80, R08 OR R8) WITH ALL OTHER INJECTORS.

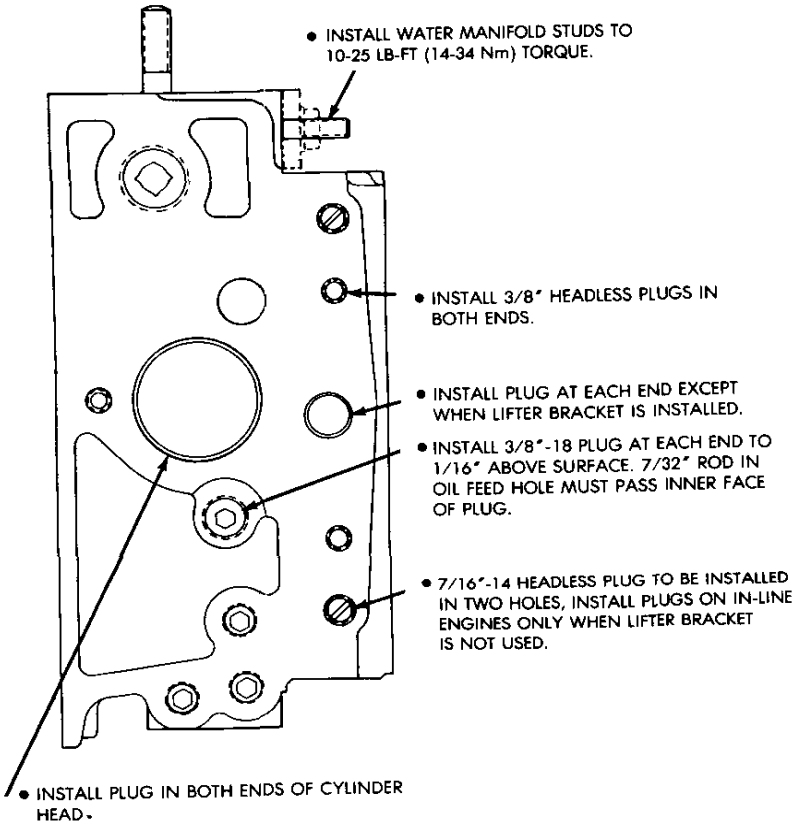
REV. 1-81

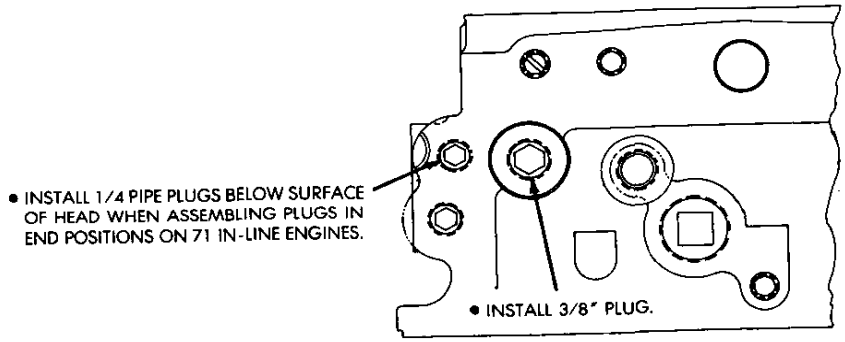
FOUR VALVE CYLINDER HEAD ASSEMBLY INSTRUCTIONS *(Continued)*

- **APPLY LOCTITE J 26558-92 PIPE SEALER WITH TEFLON OR EQUIVALENT TO BE APPLIED PRIOR TO INSTALLATION.**

STANDARD PIPE PLUG TORQUE*		
PIPE PLUG SIZE	lb-ft	Nm
1/8	10-12	14-16
1/4	14-16	19-22
3/8	18-22	24-30
1/2	23-27	31-37
3/4	33-37	45-50

*CAUTION — Do Not Over Torque Teflon Wrapped Pipe Plugs.





REV 1-81

Detroit Diesel Engines

In-Line 71 Service Manual

