workshop manual for 3.152 series diesel engines 3.152 D3.152 3.1522 3.1524 T3.1524 and D3.152M, 3HD46 marine engines.

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This Publication is written for world wide use. In countries where legislation controls engine smoke emission, noise, safety factors, etc., then all instructions, data and dimensions given must be applied so that, after service (preventive maintenance) or repair, the engine operation is correct to the local regulations.

Amendment status

Number	Description	Date
1	Note: Amendment page set number 1 is included in this manual.	November 1991

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* Operating and maintenance information can be found in section 3 of the multi-lingual 3.152 Series Users handbook

SECTION A

General Information

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GENERAL INFORMATION—A.2

Introduction

This manual has been written to give assistance to all personnel engaged in the maintenance and overhaul of Perkins 3.152 Series engines.

Most of the general information which is included in the multi-lingual 3.152 series Users Handbooks has not been repeated in this workshop manual and the two publications should be used together.

There are five engine types in the 3.152 Series for agricultural and industrial applications. These are the 3.152, D3.152, 3.1522, 3.1524 and T3.1524 engines. Information on two marine versions of the D3.152 engine, the D3.152(M) and the 3HD46 are also included in section W of this manual. The information applies to all engine types unless indicated. Where specific information is given for Massey Ferguson engines, A3.152 and AD3.152 etc. reference is made in the text.

Overhaul of the engine or components must only be done by personnel who have had the correct training.

When setscrews or studs are fitted into holes which are tapped through into the inside of the engine, a suitable sealant must be used on the threads. Some setscrews already have sealant coated threads. These can be identified by the colour of the threads which will be red or blue etc.

The left and right side of the engine are as seen from the rear.

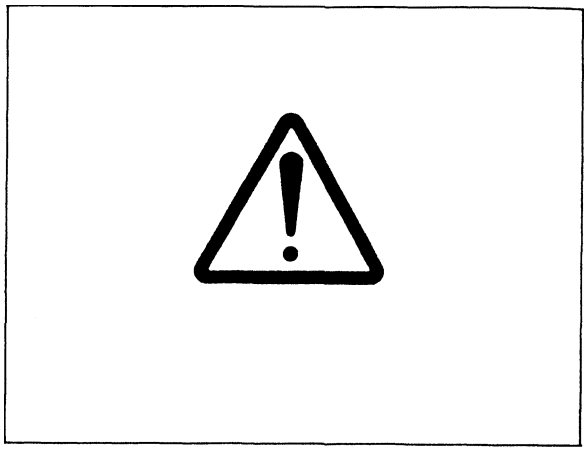
Parts and other services are available from your Perkins distributor.

Read and remember the Safety Precautions. These are given for your protection and must be used at all times.

Safety precautions

These safety precautions are important. You must refer also to the local regulations in the country of use. Some items only apply to specific applications.

- Only use these engines in the type of application for which they have been designed.
- Do not change the specification of the engine.
- Do not smoke when you put fuel in the tank.
- Clean away fuel which has been spilt. Material which has been contaminated by fuel must be moved to a safe place.
- Do not put fuel in the tank while the engine runs (unless it is absolutely necessary).
- Do not clean, add lubricating oil, or adjust the engine while it runs (unless you have had the correct training; even then extreme caution must be used to prevent injury).
- Do not make adjustments that you do not understand.
- Ensure that the engine does not run in a location where it can cause a concentration of toxic emissions.
- Other persons must be kept at a safe distance while the engine, or equipment, is in operation.
- Do not permit loose clothing or long hair near moving parts.
- Keep away from moving parts during engine operation. **Attention:** Some moving parts cannot be seen clearly while the engine runs.
- Do not operate the engine if a safety guard has been removed.
- Do not remove the filler cap of the cooling system while the engine is hot and while the coolant is under pressure, because dangerous hot coolant can be discharged.
- Do not use salt water or any other coolant which can cause corrosion in the closed coolant circuit.
- Do not allow sparks or fire near the batteries (especially when the batteries are on charge) because the gases from the electrolyte are highly flammable. The battery fluid is dangerous to the skin and especially to the eyes.
- Disconnect the battery terminals before a repair is made to the electrical system.
- Only one person must control the engine.
- Ensure that the engine is operated only from the control panel or from the operator's position.
- If your skin comes into contact with high-pressure fuel, obtain medical assistance immediately.
- Diesel fuel and lubricating oil (especially used lubricating oil) can damage the skin of certain persons. Protect your hands with gloves or a special solution to protect the skin.
- Do not wear clothing which is contaminated by lubricating oil. Do not put material which is contaminated with oil into the pockets.
- Discard used lubricating oil in a safe place to prevent contamination.
- Do not move mobile equipment if the brakes are not in good condition.



- Ensure that the control lever of the transmission drive is in the "out-of-drive" position before the engine is started.
- Use extreme care if emergency repairs must be made at sea or in adverse conditions.
- The combustible material of some components of the engine (for example certain seals) can become extremely dangerous if it is burned. Never allow this burnt material to come into contact with the skin or with the eyes.
- Read and use the instructions relevant to asbestos joints given on this page.
- Fit only genuine Perkins parts.

Asbestos joints

Some joints and gaskets contain compressed asbestos fibres in a rubber compound or in a metal outer cover. The "white" asbestos (Chrysotile) which is used is a safer type of asbestos and the risk of damage to health is extremely small.

The risk of asbestos from joints occurs at their edges or if a joint is damaged when a component is removed or if a joint is removed by abrasion.

To ensure that the risk is kept to a minimum, the procedures given below must be applied when an engine which has asbestos joints is dismantled or assembled.

- Work in an area with good ventilation.
- Do not smoke.
- Use a hand scraper to remove the joints - do not use a rotary wire brush.
- Ensure that the joint to be removed is wet with oil or water to contain loose particles.
- Spray all loose asbestos debris with water and put it in a closed container which can be sealed for safe disposal.

Engine identification

The first two letters of the engine number give an indication of the engine type as shown below.

CD 3.152 engine
CE D3.152, D3.152(M) and 3HD46 engines
CJ 3.1522 engine
CM 3.1524 engine
CN T3.1524 engine

The engine number is stamped on a machined pad on the right side of the cylinder block forward of the fuel lift pump (see fig. A1). A typical engine number is CJ30060U510251F.

If you need any parts, service or information for your engine, you must give the complete engine number to your Perkins distributor.

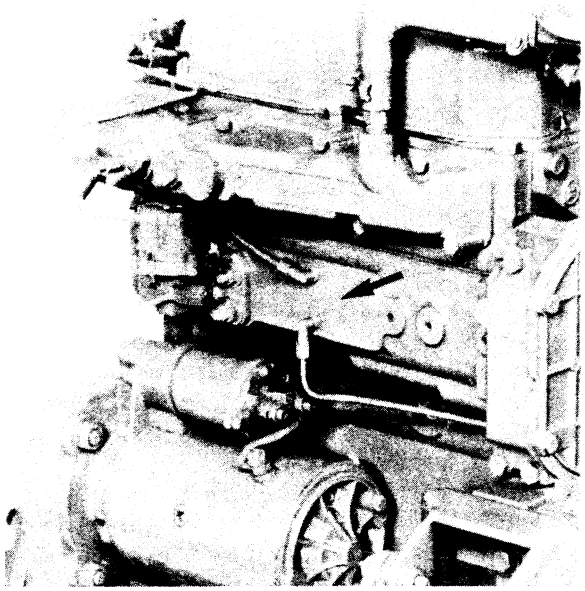


Fig. A1

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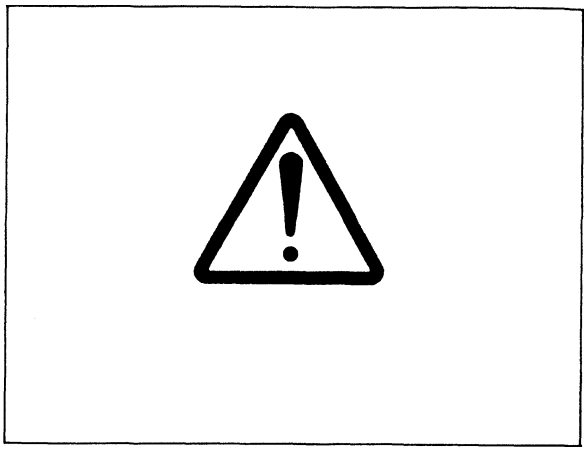

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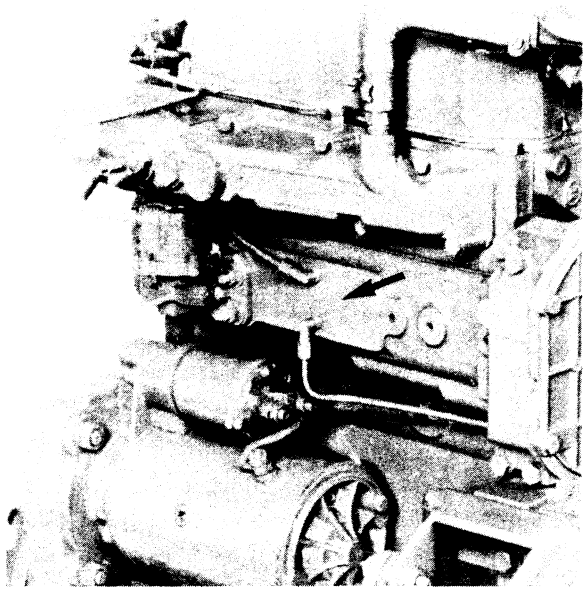


Fig. A1

SECTION B

Engine views

Perkins engines are made for specific applications and the views which follow are not necesarily correct for your engine specification.

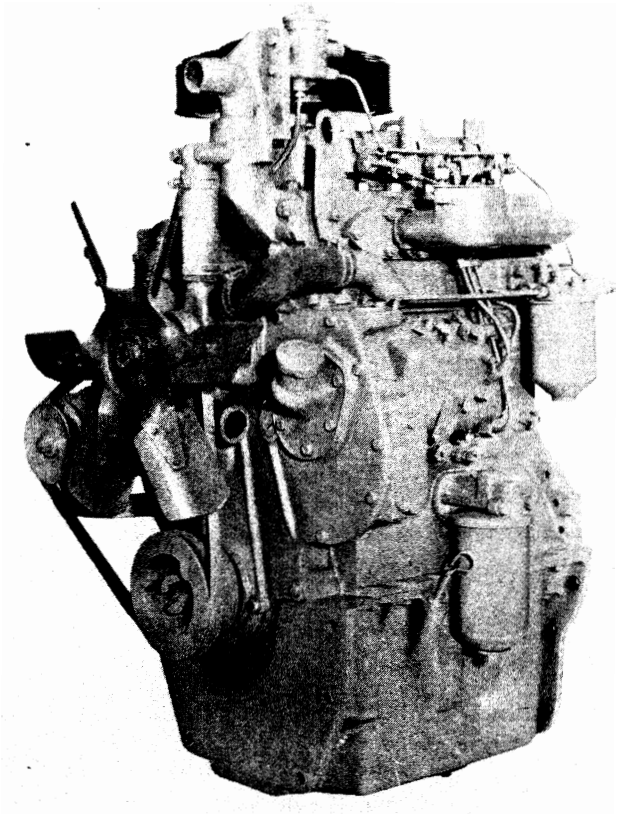


Fig. B1
Front/left side of 3.152 engine

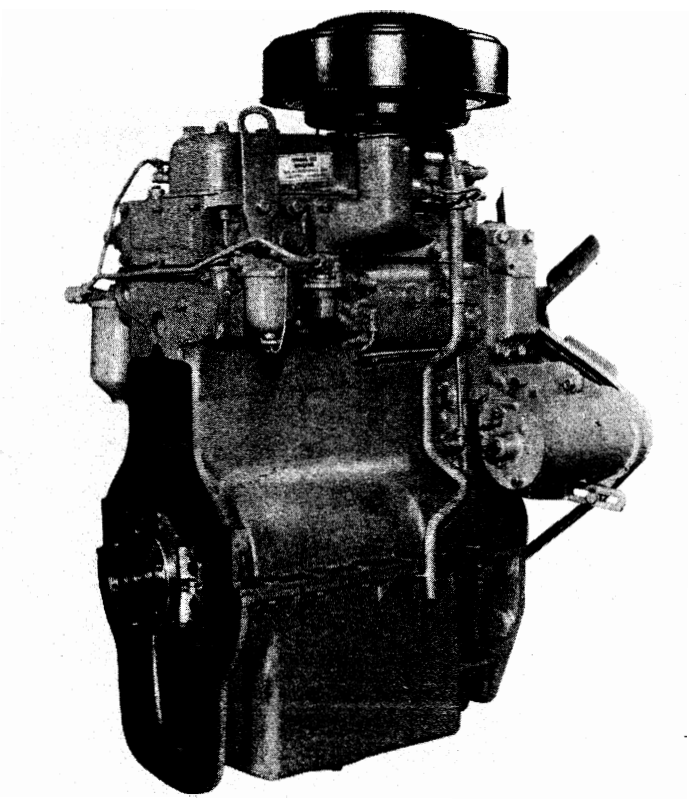


Fig. B2
Rear/right side of 3.152 engine

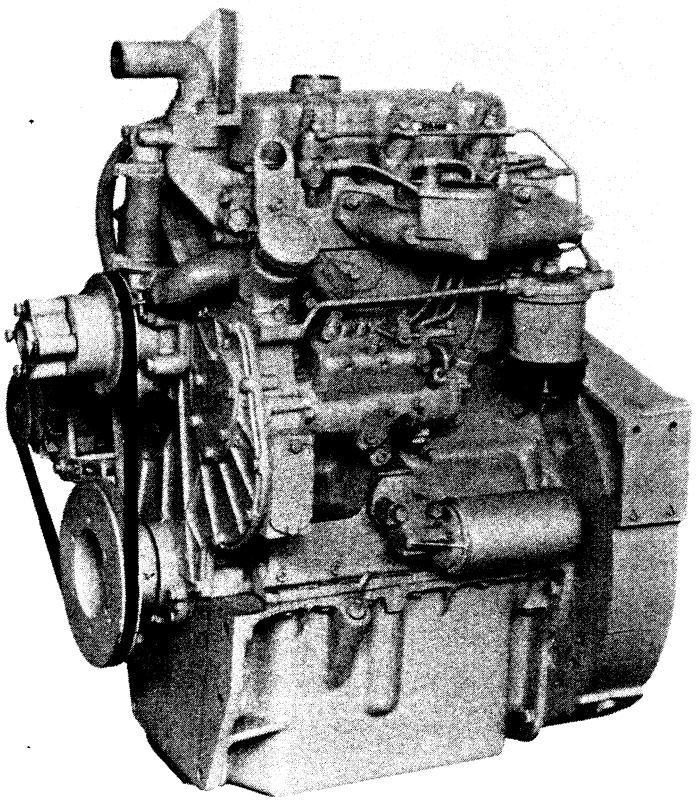


Fig. B3
Front/left side of D3.152 engine

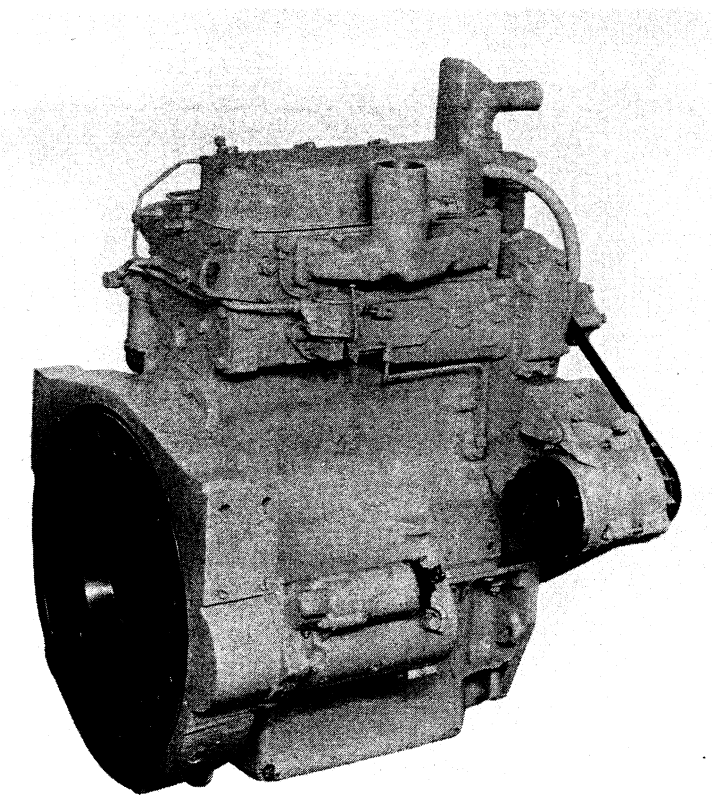


Fig. B4
Rear/right side of D3.152 engine

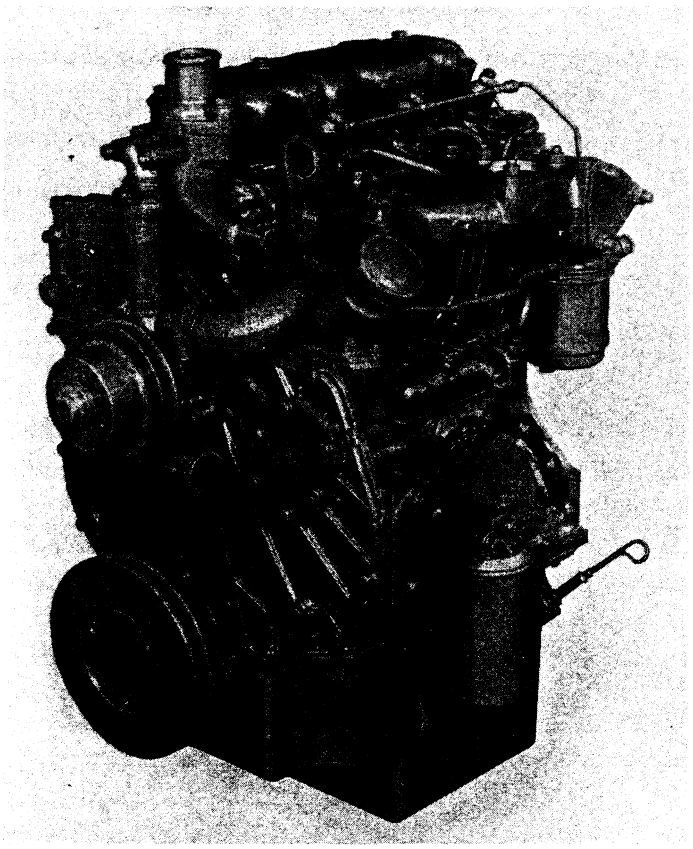


Fig. B5
Front/left side of 3.1522 engine

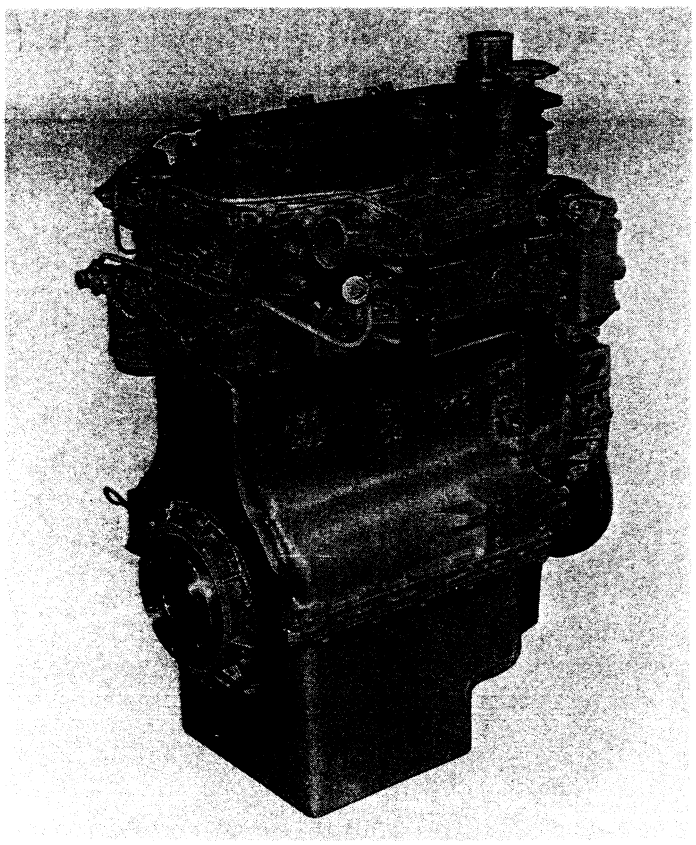


Fig. B6
Rear/right side of 3.1522 engine

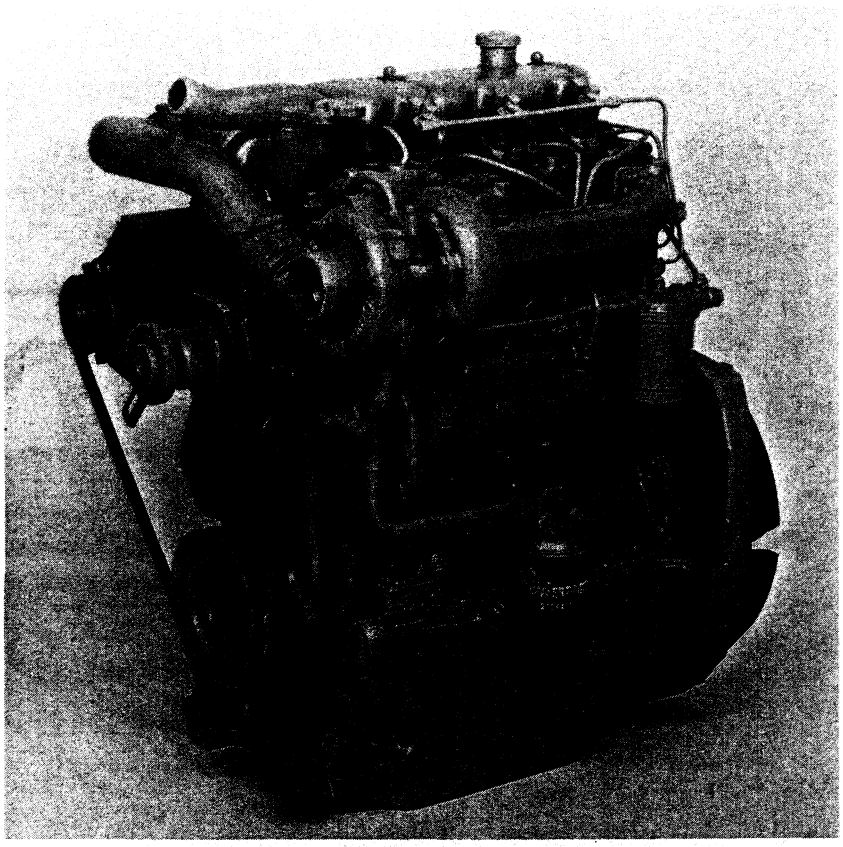


Fig. B7
Front/left side of T3.1524 engine

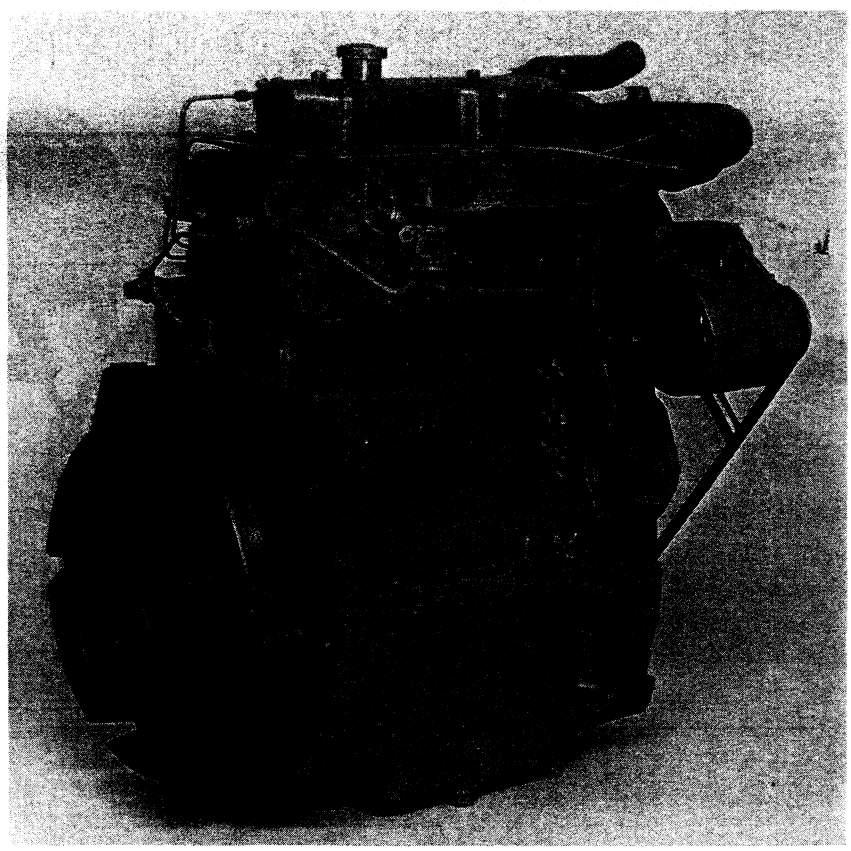


Fig. B8
Rear/right side of T3.1524 engine

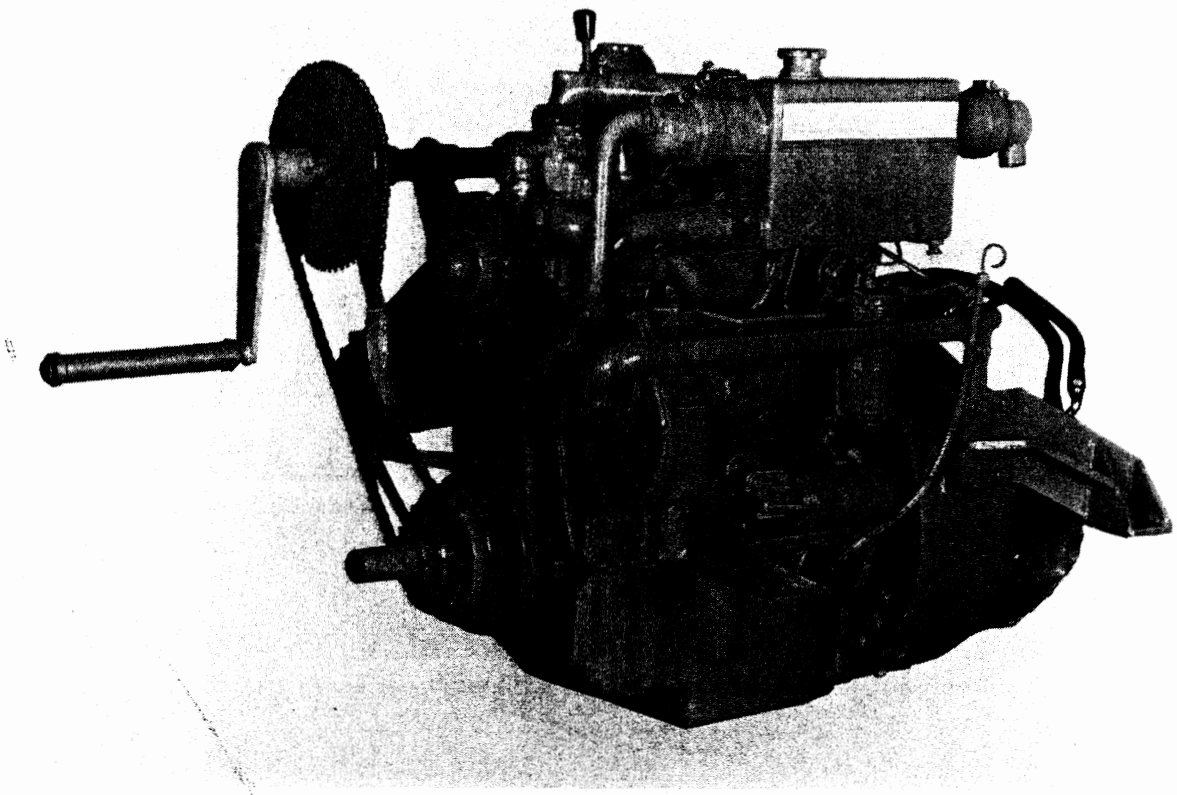


Fig. B9
Front left side of 3HD46 Mk2 engine

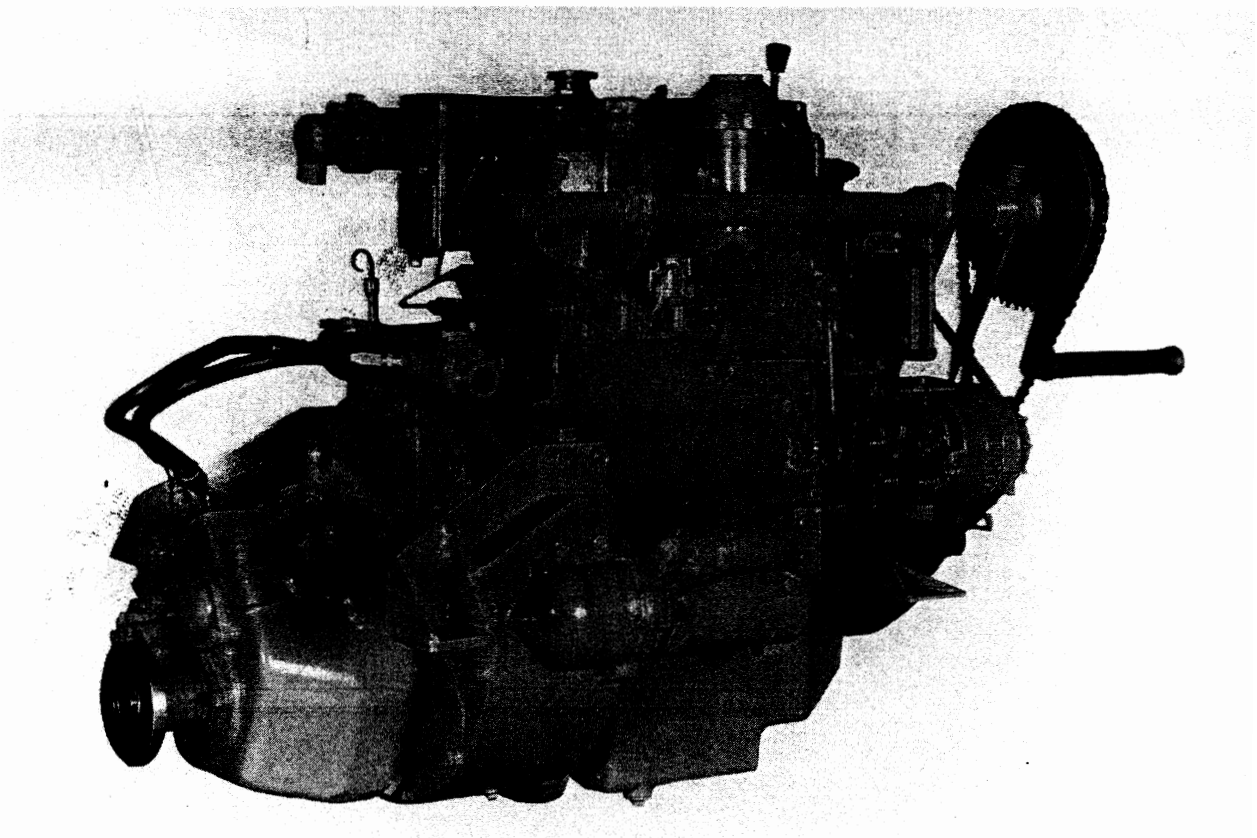


Fig. B10
Rear right side of 3HD46 Mk2 engine

SECTION C
Technical Data

Engine Data

No. of cylinders	3
Cycle	Four stroke
Combustion system 3.152	Indirect injection
Combustion system - All other engines	Direct injection
Nominal bore	91,44 mm (3,6 in)
Stroke	127 mm (5 in)
Compression ratio – 3.152	17.4:1
– D3.152	18.5:1
– Uprated D3.152	16.5:1
– 3.1522	19:1
– 3.1524	16.5:1
– T3.1524	15.5:1
Cubic capacity	2,5 litres (152 in^3)
Firing order	1, 2, 3
Tappet clearance (cold) – 3.152, D3.152	0,30 mm (0.012 in)
Tappet clearance (hot or cold) – 3.1522, 3.1524, – T3.1524	Inlet – 0,20 mm (0.008 in) Exhaust – 0,32 mm (0.0125 in)
Lubricating oil pressure	207 kN/m^2 (30 lbf/in^2) 2,1 kgf/cm^2 minimum at maximum engine speed and normal engine temperature
Direction of rotation	Clockwise from the front
Turbocharger boost pressure* (measured at induction manifold)	41 kN/m^2 (6.0 lbf/in^2) 0,42 kgf/cm^2

*Variable according to application, load and speed.

Approximate dry engine weights (with accessories but no flywheel or backplate)

3.152	202 kg (445 lb)
D3.152	204 kg (450 lb)
3.1522	210 kg (463 lb)
3.1524	210 kg (463 lb)
T3.1524	217 kg (478 lb)

Typical dry installed engine weights

Agricultural	290 kg (640 lb)
Industrial	310 kg (685 lb)

Rating details

3.152

Maximum gross rating	33.5 kW (45 bhp) at 2,500 rev/min
Maximum torque	155 Nm (115 lbf ft) 15,9 kgf m at 1,350 rev/min

D3.152

Maximum gross rating	36 kW (49 bhp) at 2,500 rev/min
Maximum torque	160 Nm (118 lbf ft) 16,3 kgf m at 1,400 rev/min

3.1522

Maximum gross rating	33.2 kW (44.5 bhp) at 2,500 rev/min
Maximum torque	160 Nm (118 lbf ft) 16,3 kgf m at 1,400 rev/min

3.1524

Maximum gross rating	39 kW (52.0 bhp) at 2,500 rev/min
Maximum torque	174 Nm (128 lbf ft) 17,8 kgf m at 1,350 rev/min

T3.1524

Maximum gross rating	45 kW (60.0 bhp) at 2,250 rev/min)
Maximum torque	210 Nm (155 lbf ft) 21,4 kgf m at 1,500 rev/min)

Note: The rating and torque information given above is general for BS. AU 141a:1971 conditions and can change with different applications. For more details, apply to Technical Services Department, Perkins Engines Limited, Peterborough, England or to one of the companies given on page A6.

Recommended torque tensions

The torque tensions given below will apply with the components lightly lubricated with clean engine lubricating oil before assembly.

Cylinder head nuts (cold)	81 Nm (60 lbf ft) 8,3 kgf m
Cylinder head nuts/setscrews (cold)	95 Nm (70 lbf ft) 9,7 kgf m
Connecting rod self locking nuts (not plated)	95 Nm (70 lbf ft) 9,7 kgf m
Connecting rod nuts (cadmium plated)	61 Nm (45 lbf ft) 6,2 kgf m
Connecting rod nuts (phosphated)	81 Nm (60 lbf ft) 8,3 kgf m
Main bearing setscrews	150 Nm (110 lbf ft) 15,0 kgf m
Idler gear hub setscrew	68 Nm (50 lbf ft) 6,9 kgf m
Camshaft gear setscrews	28 Nm (21 lbf ft) 2,9 kgf m
Balance weight setscrews	75 Nm (55 lbf ft) 7,6 kgf m
Flywheel setscrews	106 Nm (78 lbf ft) 10,8 kgf m
Flywheel housing/Adaptor plate setscrews	49 Nm (36.0 lbf ft) 5,0 kgf m
Atomiser flange nuts	16 Nm (12 lbf ft) 1,7 kgf m
Atomiser clamp nuts	12 Nm (9lbf ft) 1,2 kgf m
Crankshaft pulley setscrew with 4,8 mm (3/16 in) thick washer	142 Nm (105 lbf ft) 14,5 kgf m
Crankshaft pulley setscrew with 8,9 mm (0.35 in) thick washer	325 Nm (240 lbf ft) 33,2 kgf m
Dynamo pulley nut (7/16 in)	27 Nm (20 lbf ft) 2,7 kgf m
Dynamo pulley nut (5/8 in)	34 Nm (25 lbf ft) 3,5 kgf m
Alternator pulley nut (7/16 in)	41 Nm (30 lbf ft) 4,1 kgf m
Alternator pulley nut (9/16 in)	41 Nm (30 lbf ft) 4,1 kgf m
Alternator pulley nut (5/8 in)	51 Nm (42 lbf ft) 5,8 kgf m
High pressure fuel pipe nuts	20 Nm (15 lbf ft) 2,1 kgf m
Thermostart	13,6 Nm (10 lbf ft) 1,4 kgf m
Thermostart adaptor (where fitted)	13,6 Nm (10 lbf ft) 1,4 kgf m
Fuel injection pump with tapered shaft nut	81 Nm (60lbf ft) 8,3 kgf m

Shim washers and tab washers fitted under the main bearing setscrews have been discarded and need not be fitted in service.

Where self locking nuts are removed, they must not be used again.

Component Data and Dimensions

This information is given as a guide for personnel engaged on engine overhauls and the dimensions are mainly those used in the factory.

Where the information changes for different engine types, this is indicated in the text.

Cylinder block

Height of cylinder block between top and bottom faces	349,01/349,08 mm (13.7405/13.7435 in)
Parent bore diameter for cylinder liner	93,66/93,69 mm (3.6875/3.6885 in)
Depth of recess for liner flange (cast iron liners)	3,76/3,86 mm (0.148/0.152 in)
Depth of recess for liner flange (chromium faced liners)	1,17/1,24 mm (0.046/0.049 in)
Diameter of recess for liner flange (cast iron liners)	97,03/97,16 mm (3.820/3.825 in)
Diameter of recess for liner flange (chromium faced liners)	97,03/97,16 mm (3.820/3.825 in)
Main bearing parent bore diameter	74,08/74,10 mm (2.9165/2.9175 in)
Parent bore for No. 1 camshaft bearing bush (where fitted)	50,80/50,83 mm (2.000/2.0012 in)
Inside diameter of No. 1 camshaft bearing bush (where fitted)	47,55/47,60 mm (1.872/1.874 in)
Camshaft bore diameter – No. 1	47,60/47,68 mm (1.874/1.877 in)
Camshaft bore diameter – No. 2	47,35/47,42 mm (1.864/1.867 in)
Camshaft bore diameter – No. 3	46,84/46,91 mm (1.844/1.847 in)

Cylinder liners — cast iron, plain

Type	Dry-interference fit
Outside diameter	93,71/93,74 (3.6895/3.6905 in)
Inside diameter (finished size)	91,48/91,50 mm (3.6015/3.6025 in)
Length	215,77/216,03 mm (8.495/8.505 in)
Interference fit in cylinder bore	0,03/0,08 mm (0.001/0.003 in)
Relationship of top of liner to top face of cylinder block	0,05 mm (0.002 in) above to 0,10 mm (0.004 in) below

Cylinder liners — cast iron, flanged

Type – Factory fitted liner	Dry – interference fit
– Service liner	Dry – pre-finished – interference/clearance fit
Outside diameter of factory fitted liner	93,71/93,74 mm (3.6895/3.6905 in)
Outside diameter of service liner	93,66/93,69 mm (3.6875/3.6885 in)
Interference fit of factory fitted liner in cylinder block	0,03/0,08 mm (0.001/0.003 in)
Interference/clearance fit of service liner in cylinder block	0,03/0,03 mm (0.001/0.001 in)
Inside diameter of finished factory fitted liner in cylinder block	91,48/91,50 mm (3.6015/3.6025 in)
Inside diameter of pre-finished service liner in cylinder block	91,50/91,53 mm (3.6025/3.6035 in)
Outside diameter of liner flange	96,60/96,72 mm (3.803/3.808 in)
Flange thickness	3,76/3,81 mm (0.148/0.150 in)
Liner flange relationship to top face of cylinder block	+0,10/– 0,10 mm (+0.004/– 0.004 in)
Maximum bore wear (new liner needed)	0,18 mm (0.007 in)

Cylinder liners – chromium faced

Type	Dry – interference/clearance fit – pre-finished
Outside diameter of liner	93,66/93,69 mm (3.6875/3.6885 in)
Interference/clearance fit of liner in cylinder block	0,03/0,03 mm (0.001/0.001 in)
Inside diameter of liner in cylinder block	91,48/91,50 mm (3.6015/3.6025 in)
Flange thickness	1,07/1,14 mm (0.042/0.045 in)

Flange diameter	96,65/96,77 mm (3.805/3.810 in)
Depth of liner flange below top face of cylinder block	0,03/0,18 mm (0.001/0.007 in)

Pistons – 3.152

Type	Flat topped
Relationship of piston height to top face of cylinder block	0,00/0,13 mm (0.000/0.005 in) **BELOW**
Bore diameter of gudgeon pin	31,753/31,758 mm (1.2501/1.2503 in)
Ring groove width – top and 2nd	2,43/2,46 mm (0.0957/0.0967 in)
– 3rd	3,23/3,25 mm (0.127/0.128 in)
– 4th and 5th	6,40/6,43 mm (0.252/0.253 in)
Maximum top ring clearance (with new ring fitted)	0,18 mm (0.007 in)

Pistons – D3.152

Type	Toroidial cavity in top
Relationship of piston height to top face of cylinder block	0,10 mm (0.004 in) **ABOVE** to 0,03 mm (0.001 in) **BELOW**
Bore diameter for gudgeon pin	31,753/31,758 mm (1.2501/1.2503 in)
Ring groove width – top and 2nd	2,43/2,46 mm (0.0957/0.0967 in)
– 3rd	3,23/3,25 mm (0.127/0.128 in)
– 4th and 5th	6,40/6,43 mm (0.252/0.253 in)
Maximum top ring clearance (with new ring fitted)	0,18 mm (0.007 in)

Pistons – Up-rated AD3.152

Type	Cavity in top
Relationship of piston height to top face of cylinder block	0,03/0,15 mm (0.001/0.006 in) **BELOW**
Bore diameter for gudgeon pin	31,753/31,758 mm (1.2501/1.2503 in)
Ring groove width – top, 2nd and 3rd	2,43/2,46 mm (0.0957/0.0967 in)
– 4th	4,81/4,84 mm (0.1895/0.1905 in)
Maximum top ring clearance (with new ring fitted)	0,18 mm (0.007 in)

Pistons — 3.1522, 3.1524, T3.1524

Type 3.1524	Re-entrant bowl piston. Four ring piston has steel insert in top groove. Three ring piston has top ring groove machined in a hard insert.
Relationship of piston height to top face of cylinder block	0,03 mm (0.0012 in) **ABOVE** to 0,17 mm (0.0065 in) **BELOW**
Type 3.1524, T3.1524	Cavity in crown. Three ring piston
Relationship of piston height to top face of cylinder block	0,02/0,15 mm (0.001/0.006 in) **BELOW**
Centre point of gudgeon pin to top of piston ...	Grade H – 61,80/61,85 mm (2,3429/2,4349 in) Grade L – 61,66/61,69 mm (2.4274/4.4289 in)
Bore diameter for gudgeon pin	31,753/31,758 mm (1.2501/1.2503 in)
Top ring groove width (four ring piston only) ...	2,43/2,48 mm (0.0957/0.0977 in)
All other compression ring groove widths	2,43/2,46 mm (0.0957/0.0967 in)
Oil control ring groove width	4,81/4,84 mm (0.1895/0.1905 in)
Maximum top ring clearance (with new ring fitted)	0,18 mm (0.007 in)

Ring gaps

The ring gaps given are when checked in part of the cylinder bore which is not worn.

Piston rings – 3.152 with cast iron liners and D3.152 rated up to 2,250 rev/min

Type	top	Chromium plated compression
	2nd	Parallel face compression
	3rd	Laminated segment compression
	4th	Spring loaded laminated scraper
	4th – 3.152 rated above 2,250 rev/min	Slotted scraper
	5th	Slotted scraper
Ring width	top and 2nd	2,36/2,38 mm (0.0928/0.0938 in)
	scraper	6,32/6,35 mm (0.249/0.250 in)
Ring clearance in groove		
	top and 2nd	0,05/0,10 mm (0.0019/0.0039 in)
	scraper	0,05/0,10 mm (0.002/0.004 in)
Ring gap	top	0,36/0,76 mm (0.014/0.030 in)
Ring gap	2nd and scraper	0,28/0,69 mm (0.011/0.027 in)

Some D3.152 engines rated up to 2,250 rev/min use the piston rings as given for higher rated D3.152 engines. A fuel injection pump code (see pump data plate) which starts with TW50 or WW47E normally indicates this piston ring arrangement.

Piston rings – 3.152 with chromium faced liners

Type	top	Parallel face compression
	2nd	Tapered face compression
	3rd	Laminated segment
	4th and 5th	Slotted scraper
Ring width	top and 2nd	2,36/2,38 mm (0.0928/0.0938 in)
	4th and 5th	6,32/6,35 mm (0.249/0.250 in)
Ring clearance in groove –		
	top and 2nd	0,05/0,10 mm (0.0019/0.0039 in)
	4th and 5th	0,05/0,10 mm (0.002/0.004 in)
Ring gap	top, 2nd, 4th and 5th	0,28/0,61 mm (0.011/0.024 in)

Piston rings – D3.152 rated above 2,250 rev/min

Type	top	Chromium plated compression
	2nd	Parallel face compression
	3rd	Internally stepped compression
	4th	Chromium faced, coil spring loaded scraper
Ring width	top and 2nd	2,36/2,38 mm (0.0928/0.0938 in)
	3rd	2,35/2,38 mm (0.0927/0.0937 in)
	4th	6,32/6,35 mm (0.249/0.250 in)
Ring clearance in groove –		
	top and 2nd	0,05/0,10 mm (0.0019/0.0039 in)
	3rd	0,05/0,10 mm (0.002/0.004 in)
Ring gap	top	0,36/0,69 mm (0.014/0.027 in)
	2nd and 3rd	0,28/0,61 mm (0.011/0.024 in)
	4th	0,36/0,69 mm (0.014/0.027 in)

Piston rings – up-rated AD3.152

Type	top	Chromium plated compression
	2nd and 3rd	Internally stepped compression
	4th	Chromium faced, coil spring load scraper
Ring width	top	2,36/2,38 mm (0.0928/0.0938 in)
	2nd and 3rd	2,35/2,38 mm (0.0927/0.0937 in)
	4th	4,72/4,76 mm (0.1862/0.1975 in)
Ring clearance in groove –		
	top	0,05/0,10 mm (0.0019/0.0039 in)
	2nd and 3rd	0,05/0,10 mm (0.002/0.004 in)
	4th	0,05/0,11 mm (0.002/0.0045 in)
Ring gap	top	0,36/0,69 mm (0.014/0.027 in)
	2nd and 3rd	0,28/0,61 mm (0.011/0.024 in)
	4th	0,25/0,74 mm (0.010/0.029 in)

Piston rings – 3.1522

Type	top	Chromium insert, copper finished compression
	2nd or 2nd and 3rd	Internally stepped, copper finished compression
	3rd or 4th	Chromium faced, coil spring loaded scraper
Ring width	top	2,36/2,38 mm (0.0928/0.0938 in)
	2nd or 2nd and 3rd	2,35/2,38 mm (0.0927/0.0937 in)
	3rd or 4th	4,72/4,76 mm (0.1860/0.1875 in)
Ring clearance in groove –		
	top (4 ring piston only)	0,05/0,10 mm (0.0019/0.0039 in)
	all other rings	0,05/0,10 mm (0.002/0.004 in)
Ring gap	top	0,30/0,74 mm (0.012/0.029 in)
	2nd or 2nd and 3rd	0,20/0,64 mm (0.008/0.025 in)
	3rd or 4th	0,25/0,76 mm (0.010/0.030 in)

Piston rings – 3.1524, T3.1524

Top compression	Tapered semi inlay, chrome faced compression
Second compression	Tapered face compression
Oil control	Spring loaded, laminated scraper

Piston rings – 3.1522, 3.1524, T3.1524

Top ring width	2,36/2,38 mm (0.0928/0.0938 in)
2nd or 2nd and 3rd ring width	2,35/2,38 mm (0.0927/0.0937 in)
Oil control ring width	4,72/4,73 mm (0.1860/0.1865 in)
Top ring clearance in groove (4 ring piston only)	0,05/0,12 mm (0.0019/0.0049 in)
All other ring clearances in groove	0,05/0,10 mm (0.002/0.004 in)
Ring gap top	0,30/0,74 mm (0.012/0.023 in)
2nd or 2nd and 3rd	0,20/0,64 mm (0.008/0.025 in)
oil control	0,25/0,76 mm (0.010/0.030 in)

Gudgeon pins

Type	Fully floating
Outside diameter	31,744/31,750 mm (1.24975/1.25000 in)
Clearance fit in piston boss	0,003/0,015 mm (0.00012/0.00060 in)
Clearance fit in small end bush	0,01/0,04 mm (0.0005/0.00175 in)

Small end bushes

Type	Steel back, lead bronze face
Outside diameter	35,01/35,05 mm (1.3785/1.3800 in)
Length	26,62/26,87 mm (1.048/1.058 in)
Inside diameter when machined	31,76/31,79 mm (1.2505/1.2515 in)

Connecting rods

Type	H section
Big end parent bore diameter	60,83/60,85 mm (2.3950/2.3955 in)
Small end parent bore diameter	34,92/34,96 mm (1.37475/1.37620 in)
Big end width	39,38/39,43 mm (1.5502/1.5525 in)
Big end side clearance on crankpin	0,24/0,50 mm (0.0095/0.0198 in)
Length between bore centres (D3.152, 3.1522, 3.1524, T3.1524	223,80/223,85 mm (8.811/8.813 in)
Length between bore centres (3.152)	228,57/228,63 mm (8.999/9.001 in)

Connecting rod alignment

Large and small end bores must be square and parallel to each other inside the tolerance of ± 0,25 mm (0.010 in) measured 127 mm (5 in) each side of the axis of the rod on a test mandrel as shown in fig. C1. With the small end bush fitted, the tolerance of ± 0,25 mm (0,010 in) is reduced to ± 0,06 mm (0.0025 in).

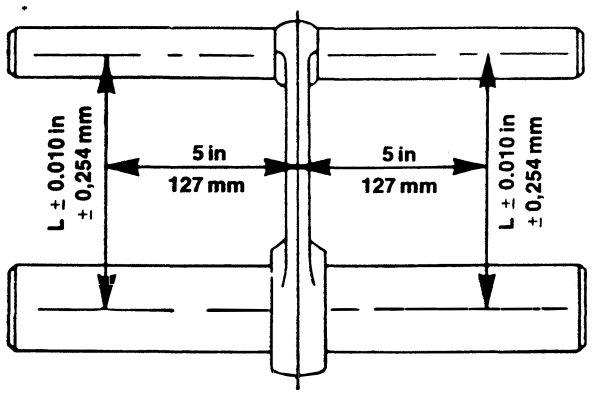


Fig. C1

Connecting rod bearings

Type	Steel back, aluminium tin face
Inside diameter	57,19/57,21 mm (2.2515/2.2525 in)
Clearance on big end	0,06/0,10 mm (0.0023/0.0041 in)
Shell thickness	1,816/1,822 mm (0.07150/0.07175 in)

Crankshaft

Main journal diameter	69,81/69,83 mm (2.7485/2.7493 in)
Main journal length – Nos. 2 and 3	30,85/31,06 mm (1.2147/1.2227 in)
Main journal length – No. 4 (rope seal)	47,60/47,68 mm (1.8742/1.8772 in)
Main journal length – No. 4 (lip seal)	46,80/46,88 mm (1.8427/1.8457 in)
Main journal fillet radii	2,38/2,78 mm (0.0937/0.1094 in)
Crankpin diameter	57,11/57,13 mm (2.2484/2.2492 in)
Crankpin length	39,75 mm (1.562/1.565 in)
Crankpin fillet radii	3,97/4,37 mm (0.1562/1.1719 in)
Finished surface – all main journals and crankpins	0,4 microns (16 micro inches) maximum
Finished surface – Fillet radii	1,3 microns (50 micro inches)
Rope seal helix depth	0,10/0,20 mm (0.004/0.008 in)
Rope seal helix width	1,27/2,03 mm (0.050/0.080 in)
Crankshaft end clearance	0,05/0,38 mm (0.002/0.015 in)
Main journals and crankpin diameters service grind undersizes	– 0,25 mm (0.010 in) – 0,51 mm (0.020 in) – 0,76 mm (0.030 in)
Maximum permissible main journal and crankpin wear	0,038 mm (0.0015 in)

Crankshaft thrust washers

Type	Steel back, aluminium tin face
Position	Each side of rear main bearing
Thickness – standard	3,07/3,12 mm (0.121/0.123 in)
Thickness – oversize	3,26/3,31 mm (0.1285/0.1305 in)

Crankshaft main bearings

Type	Steel back, aluminium tin face
Bearing width – No. 1	32,11/32,36 mm (1.264/1.274 in)
Bearing width – No. 2 and 3	23,55/23,80 mm (0.927/0.937 in)
Bearing width – No. 4	38,91/39,17 mm (1.532/1.542 in)
Bearing thickness	2,096/2,102 mm (0.08250/0.08275 in)
Inside diameter	69,88/69,91 mm (2.7510/2.7525 in)
Bearing clearance	0,04/0,10 mm (0.0017/0.0040 in)

Camshaft

No. 1 journal diameter	47,47/47,50 mm (1.869/1.870 in)
No. 2 journal diameter	47,22/47,24 mm (1.859/1.860 in)
No. 3 journal diameter	46,71/46,74 mm (1.839/1.840 in)
No. 1 journal clearance (with bush)	0,05/0,13 mm (0.002/0.005 in)
No. 1 journal clearance (no bush)	0.10/0.20 mm (0.004/0.008 in)
Nos. 2 and 3 journal clearance	0,10/0,20 mm (0.004/0.008 in)
Cam lift	7,90/7,98 mm (0.311/0.314 in)
Spigot diameter of gear	50,76/50,79 mm (1.9985/1.9995 in)
Maximum permissible camshaft journal wear	0,05 mm (0.002 in)

Cylinder head

Depth	75,82/76,58 mm (2.985/3.015 in)
Maximum permissible distortion	0,076 mm (0.003 in) across head 0,152 mm (0.006 in) along head
Permissible amount to machine off head face – 3.152	Head depth must not be less than 75,69 mm (2.980 in) minimum
Permissible amount to machine off head face – D3.152	0,30 mm (0.012 in) maximum. Nozzle protrusion must not be more than 4,67 mm (0.184 in) when machined
Permissible amount to machine off head face – Up-rated AD3.152	0,30 mm (0.012 in) maximum. Nozzle protrusion must not be more than 4,55 mm (0.179 in) when machined
Permissible amount to machine off head face – 3.1522, 3.1524, T3.1524	0,30 mm (0.012 in) maximum. Nozzle protrusion must not be more than 6,32 mm (0.249 in) when machined

Note: Shim washers or extra atomiser seating washers must not be used to reduce the nozzle protrusion.

Leakage pressure test	207 kN/m² (30 lbf/in²) 2,11 kgf/cm²
Valve seat angle – 3.152	45°
Valve seat angle – D3.152 before engine number CE.....U584638F	45° or 35° (variable with application)
Valve seat angle – D3.152 from engine number CE.....U584638F	35°
Valve seat angle – 3.1522, 3.1524,	35°
Valve seat angle – T3.1524	45° or 35° (variable with application)
Tappet bore in cylinder head	15,86/15,89 mm (0.6245/0.62575 in)
Valve guide bore in cylinder head	12,69/12,71 mm (0.4995/0.5005 in)

Valve guides – 3.152 and D3.152

Inside diameter	7,98/8,01 mm (0.3141/0.3155 in)
Outside diameter	12,73/12,75 mm (0.5013/0.5018 in)
Interference fit of guide in head	0,02/0,06 mm (0.0008/0.0023 in)
Length	61,60/62,36 mm (2.425/2.455 in)
Protrusion above spring seat face	14,73/15,09 mm (0.580/0.594 in)

Valve guides – 3.1522, 3.1524, T3.1524

Inside diameter	7,98/8,01 mm (0.3141/0.3155 in)
Outside diameter	12,73/12,75 mm (0.5013/0.5018 in)
Interference fit of guide in head	0,02/0,06 mm (0.0008/0.0023 in)
Length – inlet	55,98/56,74 mm (2.204/2.235 in)
Length – exhaust	61,54/62,31 mm (2.423/2.453 in)
Protrusion above spring seat face – inlet	9,19/9,55 mm (0.362/0.376 in)
Protrusion above spring seat face –exhaust	14,73/15,09 mm (0.580/0.594 in)

Inlet valves

Valve stem diameter	7,90/7,92 mm (0.311/0.312 in)
Clearance fit of valve in guide	0,05/0,11 mm (0.0021/0.0045 in)
Maximum permissible stem/guide clearance	0,15 mm (0.006 in)
Face angle – 3.152	45°
Face angle – D3.152 before engine number CE.....U584638F	45° or 35° (variable with application)
Face angle – D3.152 from engine number CE.....U584638F	35°
Face angle – 3.1522, 3.1524, T3.1524	35°
Valve head depth below cylinder head face	
– 3.152	1,68/2,03 mm (0.066/0.080 in)
– D3.152 with 45° seats	1,50/1,89 mm (0.059/0.074 in)
– D3.152 with 35° seats	1,32/1,63 mm (0.052/0.064 in)
– 3.1522, 3.1524, T3.1524	1,32/1,63 mm (0.052/0.064 in)
Maximum permissible valve head depth in service	
– 3.152	3,50 mm (0.140 in)
– D3.152 with 45° seats	2,40 mm (0.094 in)
– D3.152 with 35° seats	2,13 mm (0.084 in)
– 3.1522, 3.1524, T3.1524	2,13 mm (0.084 in)

Exhaust valves

Valve stem diameter	7,90/7,92 mm (0.311/0.312 in)
Clearance fit of valve in guide	0,05/0,11 mm (0.0021/0.0045 in)
Maximum permissible stem/guide clearance	0,14 mm (0.0055 in)
Face angle – 3.152	45°
Face angle – D3.152 before engine number CE.....U584638F	45° or 35° (variable with application)
Face angle – D3.152 from engine number CE.....U584638F	35°
Face angle – 3.1522, 3.1524,	35°
Face angle – T3.1524	45° or 35° (variable with application)
Valve head depth below cylinder head face	
– 3.152	1,68/2,03 mm (0.066/0.080 in)
– D3.152 with 45° seats	1,47/1,87 mm (0.058/0.073 in)
– D3.152 with 35° seats	1,60/1,92 mm (0.063/0.0755 in)
– 3.1522, 3.1524, T3.1524	1,60/1,92 mm (0.063/0.0755 in)
Maximum permissible valve head depth in service	
– 3.152	3,50 mm (0.140 in)
– D3.152 with 45° seats	2,40 mm (0.094 in)
– D3.152 with 35° seats	2,40 mm (0.094 in)
– 3.1522, 3.1524, T3.1524	2,40 mm (0.094 in)

Outer valve springs

Free length	45,29/45,80 mm (1.783/1.803 in)
Fitted length	38,10 mm (1.500 in)
Load at fitted length	10,34 kg ± 0,90 kg (22.75 lb ± 2 lb)

Inner valve springs (where fitted)

Free length	34,67/35,69 mm (1.365/1.405 in)
Fitted length	30,16 mm (1.1875 in)
Load at fitted length	3,63 kg ± 0,45 kg (8.0 lb ± 1 lb)

Tappets

Stem diameter	15,80/15,84 (0.6222/0.6237 in)
Clearance in cylinder head bore	0,02/0,09 mm (0.0008/0.0036 in)

Rocker shaft

Outside diameter	15,81/15,84 mm (0.6223/0.6238 in)

Rocker levers

Bore diameter	15,86/15,89 mm (0.62480/0.62610 in)
Clearance fit on rocker shaft	0,03/0,10 mm (0.0010/0.0038 in)
Maximum permissible clearance	0,13 mm (0.005 in)

Camshaft gear

Number of teeth	50
Gear bore diameter	50,79/50,83 mm (1.9995/2.001 in)
Clearance fit of gear on spigot	0,00/0,06 mm (0.0000/0.0025 in)

Idler gear and hub

Number of teeth	90
Gear bore diameter	53,98/54,02 mm (2.1250/2.1266 in)
Hub diameter	53,92/53,94 mm (2.1230/2.1238 in)
Clearance of gear on hub	0,03/0,09 mm (0.0012/0.0036 in)
Gear width	33,47/33,59 mm (1.3175/1.3225 in)
Length of hub	33,72/33,85 mm (1.3275/1.3325 in)
Gear end clearance	0,13/0,38 mm (0.005/0.015 in)
Maximum permissible gear end clearance	0,46 mm (0.018 in)

Crankshaft gear

Number of teeth	25
Bore diameter	38,09/38,13 mm (1.4995/1.5010 in)
Spigot diameter of crankshaft	38,10/38,11 mm (1.5000/1.5005 in)
Clearance/interference fit of gear on crankshaft	0,03/0,03 mm (0.001/0.001 in)

Fuel pump gear

Number of teeth	50
Bore diameter	44,45/44,48 mm (1.750/1.751 in)
Spigot diameter of pump	44,40/44,42 mm (1.7480/1.7488 in)
Clearance fit of gear on spigot	0,03/0,08 mm (0.0012/0.003 in)

Timing gear backlash

All gears	0,08 mm (0.003 in) minimum

Lubricating oil pump idler gear

Number of teeth	21
Bore diameter	19,05/19,08 mm (0.750/0.751 in)
Outside diameter of bush	19,10/19,14 mm (0.7520/0.7535 in)
Interference fit of bush in gear	0,03/0,09 mm (0.0010/0.0035 in)
Inside diameter of bush – fitted	16,67/16,69 mm (0.6562/0.6572 in)
Shaft diameter for gear	16,63/16,64 mm (0.6548/0.6553 in)
Clearance of gear on shaft	0,02/0,06 mm (0.0009/0.0024 in)
Gear end clearance	0,20/0,58 mm (0.008/0.023 in)

Lubricating oil pump drive gear

Number of teeth	19
Bore diameter	12,60/12,63 mm (0.4962/0.4972 in)
Pump drive shaft diameter	12,67/12,69 mm (0.4990/0.4995 in)
Interference fit of gear on shaft	0,05/0,08 mm (0.0018/0.0033 in)

Lubricating oil pump clearances

Pump part numbers 41314121, 41314124

Inner rotor to outer rotor	0,06/0,11 mm (0.0025/0.0045 in)
Inner rotor end clearance	0,04/0,09 mm (0.0015/0.0035 in)
Outer rotor end clearance	0,03/0,08 mm (0.001/0.003 in)
Outer rotor to pump body	0,25/0,30 mm (0.010/0.012 in)

Pump part numbers 41314026, 41314046 and 41314078

Inner rotor to outer rotor	0,01/0,06 mm (0.0005/0.0025 in)
Inner rotor end clearance	0,04/0,08 mm (0.0015/0.0030 in)
Outer rotor end clearance	0,01/0,06 mm (0.0005/0.0025 in)
Outer rotor to pump body	0,28/0,33 mm (0.011/0.013 in)

Pump part numbers 41314043, 41314079 and 41314081

Inner rotor to outer rotor	0,03/0,15 mm (0.001/0.006 in)
Inner and outer rotor end clearance	0,03/0,13 mm (0.001/0.005 in)
Outer rotor to pump body	0,14/0,25 mm (0.0055/0.010 in)

Pump part number 41314178

Inner rotor to outer rotor clearance	0,038/0,127 mm (0.0015/0.0050 in)
Inner rotor end clearance	0,038/0,089 mm (0.0015/0.0035 in)
Outer rotor end clearance	0,013/0,076 mm (0.0005/0.0030 in)
Outer rotor to pump body clearance	0,229/0,330 mm (0.0090/0.0130 in)

Lubricating oil relief valve

Bore diameter in pump body	14,24/14,29 mm (0.5605/0.5625 in)
Outside diameter of plunger	14,19/14,21 mm (0.5585/0.5595 in)
Clearance fit of plunger in bore	0,03/0,10 mm (0.001/0.004 in)
Load at 32,5 mm (1.28 in) spring length	35,59 N ± 1.07 N (8 lbf ± 0.24 lbf) 3,63 kgf ± 0,11 kgf
Setting pressure	345/448 kN/m² (50/65 lbf/in²) 3,52/4,57 kgf/cm²

Lubricating oil filter

Type	Full flow
Element type	Paper or canister
By-pass setting	55/83 kN/m² (8/12 lbf/in²) 0,56/0,84 kgf/cm²

Lubricating oil sump – 3.152 and D3.152

Capacity for agricultural engines to full mark ...	6,1 litres (10.7 imp. pints) 6.4 US quarts
Capacity for industrial engines to full mark	7,4 litres (13 imp. pints) 7.8 US quarts

Lubricating oil sumps – 3.1522, 3.1524 and T3.1524

Capacity for industrial engines to full mark	6,8 litres (12 imp. pints) 7.2 US quarts

Note: The above capacities are variable with application. Fill to "FULL" mark on dipstick.

Cooling system

Type	Thermosyphon – pump assistance
Coolant capacity – engine only	4,8 litres (8.5 imp. pints) 5.1 US quarts

Thermostat

Type		Bellows or wax
Starts to open	– bellows type	77/82°C (170/179°F)
	– wax type	81/84°C (177/183°F)
Full open	– bellows type	93°C (199°F)
	– wax type	98°C (208°F)

Water pump

Type	Centrifugal
Bore diameter in pulley	15,85/15,87 mm (0.6239/0.6247 in)
Shaft diameter	15,91/15,92 mm (0.6262/0.6267 in)
Interference fit of pulley on shaft	0,04/0,07 mm (0.0015/0.0028 in)
Bore diameter in impeller	15,88/15,89 mm (0.6250/0.6257 in)
Shaft diameter	15,91/15,92 mm (0.6262/0.6267 in)
Interference fit of impeller on shaft	0,01/0,04 mm (0.005/0.0017 in)
Clearance between impeller blades and pump body	0,25/0,51 mm (0.010/0.020 in)

Fuel lift pump

Type	AC Delco
Method of drive	Eccentric on camshaft
Static pressure – no delivery	41/69 kN/m² (6/10 lbf/in²) 0,4/0,7 kgf/cm²

Fuel injection pump

Make	CAV – DPA (distributor type)
Direction of rotation	Clockwise from drive end
Timing letter	E (earlier pumps only)
No. 1 outlet	W or Z

Make	Stanadyne (distributor type)
Direction of rotation	Clockwise from drive end
No. 1 outlet	at 11 o'clock position from rear

Engine check and fuel pump mark angles – static timing

The correct angles and static timing can be decided from the first letters and figures of the setting code next to the word "Set" on the fuel injection pump data plate. Angles are for use with timing tool MS67B and adaptors (PD.67B-6). For Stanadyne pumps the tool will have to be fitted to the pump in the reverse position to normal, the fuel pump mark angle has been adjusted to allow for this.

Note: The setting code of current pumps start with the pump part number, followed by two code letters, the governor spring number and the flight speed. For identification purposes, only the two code letters are used here for the new pumps.

Fuel pump setting code	Engine check angle (degrees) (with engine at TDC compression)	Fuel pump mark angle (degrees)	Static timing (BTDC-degrees)	Piston displacement mm	Piston displacement in
3.152					
LW45, LW49	32	40	16	3,15	0.124
LW51, LW52	29	38	18	3,94	0.155
LW58, LW59	29	40	22	5,84	0.230
PW43, PW44	30	38	16	3,15	0.124
PW50	29	38	18	3,94	0.155
D3.152					
AW	27	41	28	9,42	0.371
CW	27	35	16	3,15	0.124
MW47E, MW49, MW53E, MW57	25	37	24	6,93	0.273
RW50, RW52, RW54	25	37	24	6,93	0.273
SW (except below)	25	37	24	6,93	0.273
SW46	25	37	24	6,93	0.273
SW/8/1800*	22¼	37	29½	10,43	0.411
SW/8/1890*	22¼	37	29½	10,43	0.411
SW48	24	37	26	8,00	0.315
SW52, SW57, SW58	25	37	24	6,93	0.273
TW48E	27	37	20	4,88	0.192
TW50	26	37	22	5,84	0.230
WW (except below)	25	35	20	4,87	0.192
WW/3/2470	27	35	16	3,15	0.124
WW/6/2470	27	35	16	3,15	0.124
WW47E, WW48	27	35	16	3,15	0.124
*Lincoln Electric U.S.A.					
3.1522					
XW50E	29	36	14	2,37	0.092
3.1524					
EW (Stanadyne pumps)	26	322	24	6,98	0.275
WW47E	25	35	20	4,87	0.192
WW (except below)	25	35	20	4,87	0.192
WW/3/2470	27	35	16	3,15	0.124
WW/6/2200	27	35	16	3,15	0.124
WW/6/2470	27	35	16	3,15	0.124
ZW	25	37	24	6,98	0.275
T3.1524					
BW, YW	27	35	16	3,15	0.124
DW	26½	35	17	3,55	0.140

Atomisers

Code	Holder	Nozzle	Setting Pressure kgf/cm²	atm	lbf/in²	Check and Reset Pressure kgf/cm²	atm	lbf/in²
3.152								
DD	BKB35S5258	BDL110S6133	129	125	1840	124	120	1760
DE	BKB35S5258	BDL110S6267	129	125	1840	124	120	1760
GC	BKB35SD5259	BDL110S6709	191	185	2720	176	170	2500
GW	BKB35SD5258	BDL110S6709	191	185	2720	176	170	2500
D3.152								
BV	BKBL67SD5151	BDLL150S6513	191	185	2720	176	170	2500
CR	BKBL67S5151	BDLL150S6513	191	185	2720	176	170	2500
CS	BKBL67SD5151	BDLL150S6554	191	185	2720	176	170	2500
DF	BKBL67S5151	BDLL150S6558	181	175	2570	176	170	2500
DN	BKBL67S5299	BDLL150S6554	191	185	2720	176	170	2500
EE	BKBL67S5299	BDLL150S6602	196	190	2790	181	175	2570
FS*	BKBL67S5299	BDLL150S6674	191	185	2720	176	170	2500
GM	BKBL67S5299	BDLL150S6743	191	185	2720	181	175	2570
ND	2645L301	2645L604	196	190	2790	181	175	2570
UB	BKBL67S5151	BDLL150S6372	191	185	2720	176	170	2500
XC	OKLL67S2931	OLL150S6743	191	185	2720	181	175	2570
XG	2645C305	2645C620	196	190	2790	181	175	2570
*	When FS atomisers need service, they must be changed to DN type by the use of the correct nozzle.							
3.1522								
GS	BKBL67S5446	BDLL150S6771	258	250	3670	243	235	3450
3.1524								
EE	BKBL67S5299	BDLL150S6602	196	190	2792	181	175	2570
HN	BKBL67S5366	BDLL150S6771	263	255	3747	248	240	3530
ND	2645L301	2645L604	196	190	2790	181	175	2570
XG	2645C305	2645C620	196	190	2790	181	175	2570
T3.1524								
HM	LRB67015	JB6801029	258	250	3670	258	250	3670
HN	BKBL67S5366	BDLL150S6771	263	255	3747	248	240	3530
HX	LRB67015	JB6801029	217	210	3090	217	210	3090

Dynamo

Make	Lucas
Type	C40A
Maximum output	11A

Alternator

Make	Lucas, CAV, Motorola or Perkins
Type	15, 16, 17, 18, 23 ACR, A115/36, A115/45, A127, CA45, 9AR, LR135 or LR150
Maximum output (hot)	
15ACR	28A
16ACR	34A
17ACR	36A
17ACR (de-rated)	25A
18ACR	45A
23ACR	55A
A115/36	36A
A115/45	45A
A127	55/65A
9AR Series	70A
LR135 Series	35A
LR150 Series	50A

Starter motor

Make	Lucas, CAV or Perkins
Type	2M113, M45G, M50, M127, CA45, S12-84 or S12-85
Number of teeth on pinion	10
Starter cable resistance	0.0017 ohms maximum

Note: The above electrical data is general but is variable with application.

SECTION E
Fault Diagnosis

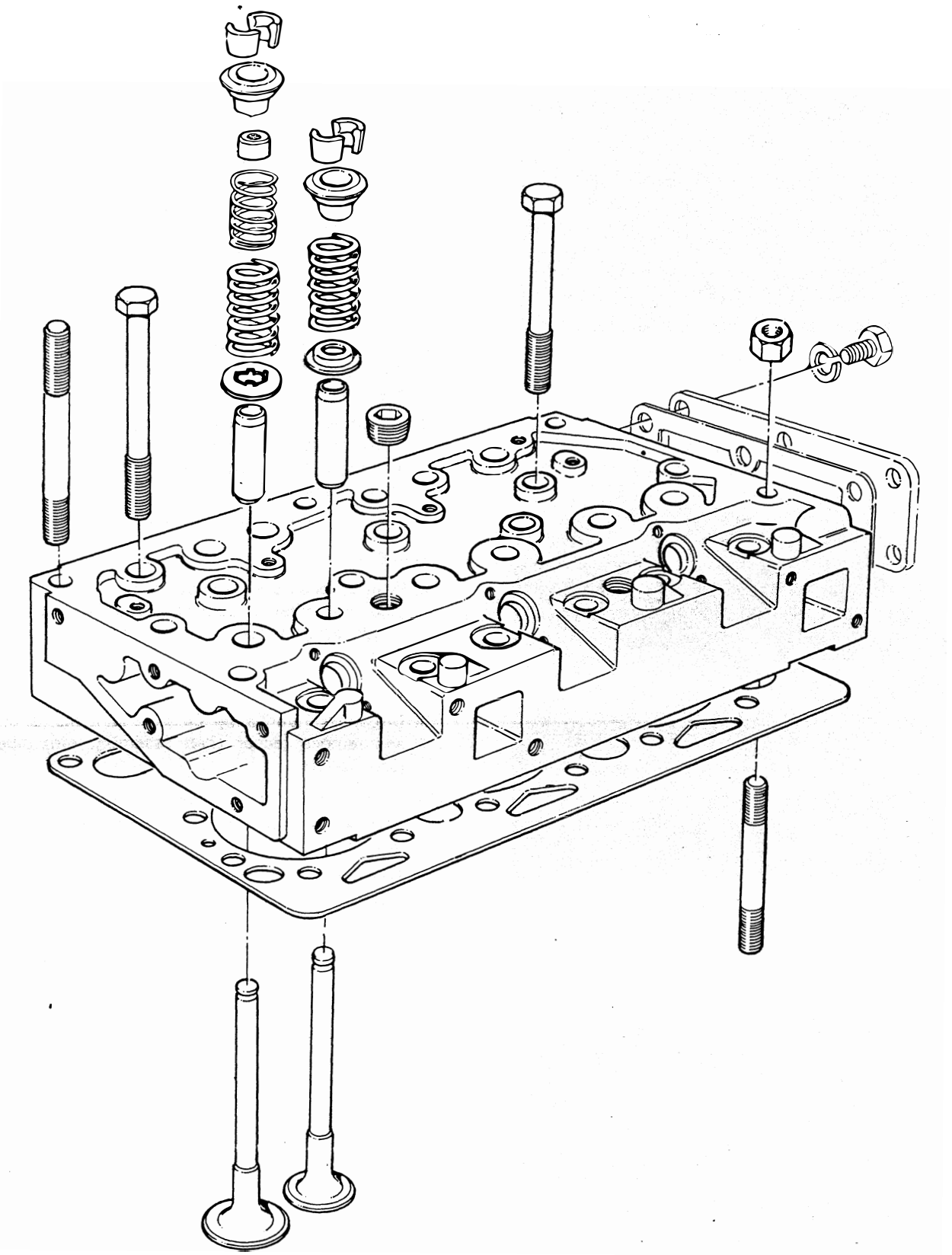
Fault diagnosis chart

Problem	Possible causes
Starter motor turns engine too slowly.	1, 2, 3, 4
Will not start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 31, 32, 33, 63
Difficult to start	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 29, 31, 32, 33, 63
Not enough power	8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 31, 32, 33, 60, 62
Misfire	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 30, 32
High fuel consumption	11, 13, 14, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 31, 32, 33
Black exhaust	11, 13, 14, 16, 18, 19, 20, 22, 24, 25, 27, 28, 29, 31, 32, 33, 60, 62
Blue/white exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56, 61
Low lubricating oil pressure	4, 36, 37, 38, 39, 40, 42, 43, 44, 58
Engine knocks	9, 14 16, 18, 19, 22, 26, 28, 29, 31, 33, 35, 36, 45, 46, 59
Runs erratically	7, 8, 9, 10, 11, 12, 13, 14, 16, 20, 21, 23, 26, 28, 29, 30, 33, 35, 45, 59
Vibration	13, 14, 20, 23, 25, 26, 29, 30, 33, 45, 47, 48, 49
High lubrication oil pressure	4, 38, 41
Engine temperature too high	11, 13, 14, 16, 18, 19, 24, 25, 45, 47, 50, 51, 52, 53, 54, 57
Crankcase pressure	25, 31, 33, 34, 45, 55
Bad compression	11, 19, 25, 28, 29, 31, 32, 33, 34, 46, 59
Starts and stops	10, 11, 12

Code list of possible causes

1 Battery capacity low.
2. Bad electrical connections.
3. Fault in starter motor.
4. Wrong grade of lubricating oil.
5. Low engine speed from starter motor.
6. Fuel tank empty.
7. Stop control fault.
8. Restriction in fuel pipe.
9. Fault in fuel lift pump.
10. Dirty fuel filter element.
11. Restriction in air filter or induction system.
12. Air in fuel system.
13. Fault in fuel injection pump.
14. Fault in atomisers or not correct type.
15. Cold start equipment not used correctly.
16. Fault in cold start equipment.
17. Broken fuel injection pump drive.
18. Fuel injection pump timing not correct.
19. Valve timing not correct.
20. Bad compression.
21. Restriction in fuel tank vent.
22. Type or grade of fuel not correct.
23. Restriction of engine speed control movement.
24. Restriction in exhaust pipe.
25. Cylinder head gasket leaks.
26. Engine temperature too high.
27. Engine temperature too low.
28. Valve tip clearances not correct.
29. Valves not free.
30. Wrong high pressure pipes.
31. Worn cylinder bores.
32. Valves and seats do not seal correctly.
33. Piston rings not free or are worn or broken.
34. Valve stems and/or guides worn.
35. Wet type air cleaner too full or wrong type of oil used.
36. Crankshaft bearings wear or damage.
37. Not enough lubricating oil in the sump.
38. Gauge not correct.
39. Lubricating oil pump worn.
40. Relief valve not free to close.
41. Relief valve not free to open.
42. Relief valve spring broken.
43. Fault in suction pipe of lubricating oil pump.
44. Dirty lubricating oil filter element.
45. Piston damage.
46. Piston height not correct.
47. Fan damage.
48. Fault in engine mounting (housing).
49. Flywheel housing or flywheel not aligned correctly.
50. Fault in thermostat or wrong type.
51. Restriction in coolant passages.
52. Water pump drive belt loose.
53. Restriction in radiator.
54. Fault in water pump.
55. Restriction in breather pipe.
56. Damage to valve stem oil seals (where used).
57. Not enough coolant in system.
58. Restriction in sump strainer.
59. Valve spring broken.
60. Turbocharger impellor damage, or dirty impellor.
61. Turbocharger lubricating oil leaks.
62. Leakage in induction system (turbocharged engines).
63. Fault in lubricating oil pressure switch or low lubricating oil pressure.

SECTION F
Cylinder Head



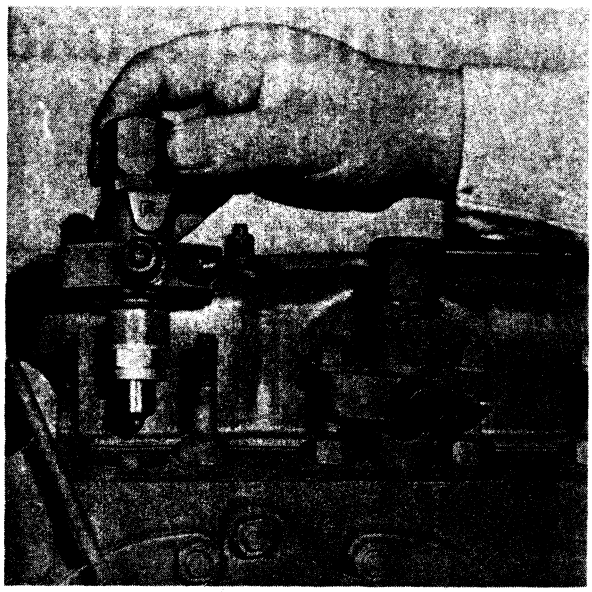


Fig. F1

Fig. F2

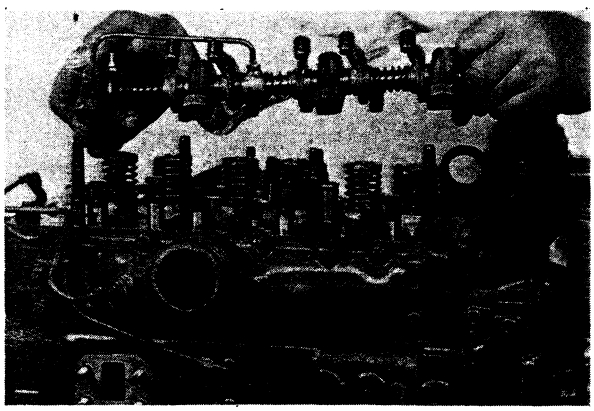


Fig. F3

To remove cylinder head

1. Drain the coolant from the radiator and cylinder block.
2. Disconnect the hose connection from the thermostat housing at the front of the cylinder head.
3. Remove crankcase vent valve and hose from cylinder head cover and induction manifold – 3.1522 engines only.
4. Remove coolant connections to and from exhaust manifold (flame-proof engines only).
5. Remove the air cleaner or filter, or disconnect the air inlet hose from the induction manifold.
6. Disconnect cold start equipment connections.
7. Remove the lubricating oil pipe from the camshaft housing to the cylinder head.
8. Disconnect the exhaust pipe from the exhaust manifold. Remove turbocharger (T3.1524 engines).
9. Disconnect and remove the high pressure fuel pipes from the fuel injection pump and atomisers. Fit suitable caps to the pump and atomiser connections.
10. Remove atomiser leak off pipes.
11. Remove atomisers (see figs. F1 or F2).
12. Where necessary, remove fuel filter and fuel pipe from filter to cold start aid. Remove clip which secures fuel pipe to rear of cylinder head.
13. Remove the cylinder head cover.
14. Disconnect lubricating oil pipe to rocker shaft and remove rocker shaft assembly with pipe (see fig. F3).
15. Remove the cylinder head nuts/setscrews in the reverse sequence to that given in figs. F15 or F16.
16. Remove the cylinder head (see fig. F4) and put it on a flat wood surface to prevent damage. Do not use a sharp tool between the cylinder head and the cylinder block.

To remove valves

Put a suitable mark on the face of each valve so that they can be fitted in their original positions if they are used again.

Compress the valve springs with a suitable valve spring compressor (see fig. F5) and remove the split collets. Tool 6118B with adaptor PD6118-3 can be used to compress the valve springs with the head on a flat surface.

Remove the spring caps, springs, seals and spring seats and the valves can be removed.

Valve and valve seat overhaul

Valve face and seat angles are as follows:-

Angle	Engine type
45°	All 3.152 engines. All D3.152 engines before engine number CU.....U584638F except for those shown below. All T3.1524 engines to lists CN31185, CN31195, CN31196, CN31198, CN31225, CN80444 use 45° exhaust valves.
35°	D3.152 engines rated above 2,250 rev/min. Some D3.152 engines rated below 2,250 rev/min. (A fuel injection pump setting code which starts with TW50 or WW47E usually indicates these engines. Up-rated AD3.152 engines. All D3.152 engines from engine number CE.....U584638F and all 3.1522, 3.1524 and T3.1524 engines except lists CN31185, CN31195, CN31196, CN31198, CN31225, CN80444 which use 45° exhaust valves.

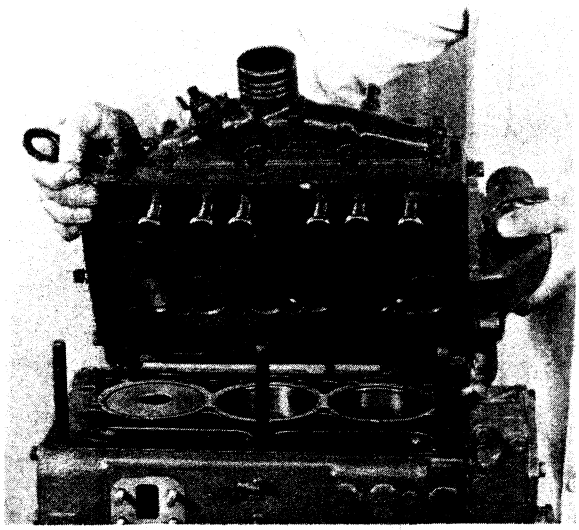


Fig. F4

Before any work is done on valves or seats, check the depth of the valves below the face of the cylinder head (see fig. F6).

Maximum permissible service valve head depths below the cylinder head face are as follows:-

Engine type	Valve and seat angle	Valve depth Inlet	Valve depth Exhaust
3.152	45°	3,50 mm (0.140 in)	3,50 mm (0.140 in)
D3.152	45°	2,40 mm (0.094 in)	2,40 mm (0.094 in)
D3.152	35°	2,13 mm (0.084 in)	2,40 mm (0.094 in)
3.1522, 3.1524	35°		
T3.1524	35°/45°	2,13 mm (0.084 in)	2,40 mm (0.094 in)

Where engines have to be to the smoke regulation BS. AU 141a:1971, then the maximum permissible service valve head depth for 3.152 engines must not be more than 2,15 mm (0.085 in). For D3.152 engines, the factory limits must not be extended (see page C10).

If the cylinder head face needs to be machined or the valve guides renewed, this must be done before the valve seats are corrected.

45° valve seats on 3.152 engines are lower than the cylinder head face and a groove is machined where the real valve seat ends in the recess in the cylinder head. When valves or seats have been corrected several times, this groove can be cut as given later.

Valve seats can be corrected by the use of the cutters which follow:-

Valve seat angle	Valve seat cutter Inlet	Valve seat cutter Exhaust
45° (3.152)	MS275*	MS285*
45° (D3.152)	MS281*	MS275*
35°	MS695	MS690

* These cutters are in the valve seat cutter kit MS73.

The pilot and handle used with 35° and 45° seat cutters are in the cutter kit MS73, but if this cutter kit is not available, then pilot MS150-8 and handle MS76 must be used.

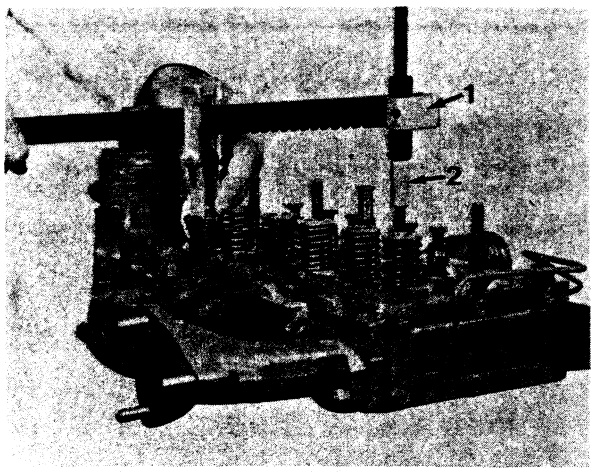


Fig. F5

1. Tool 21825020
2. Adaptor 21825022

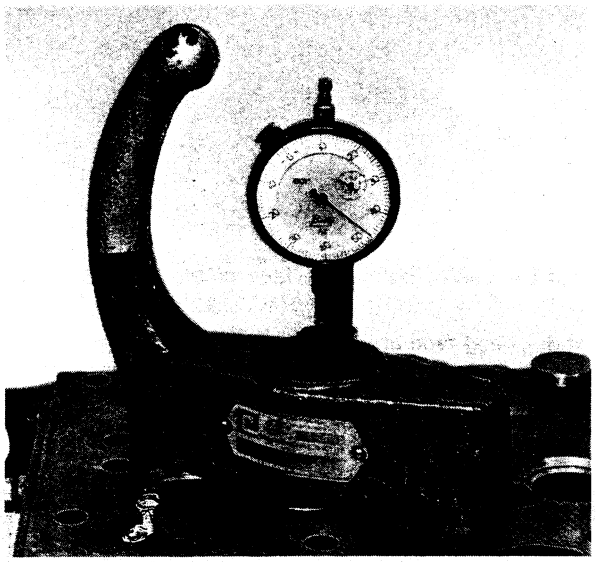


Fig. F6

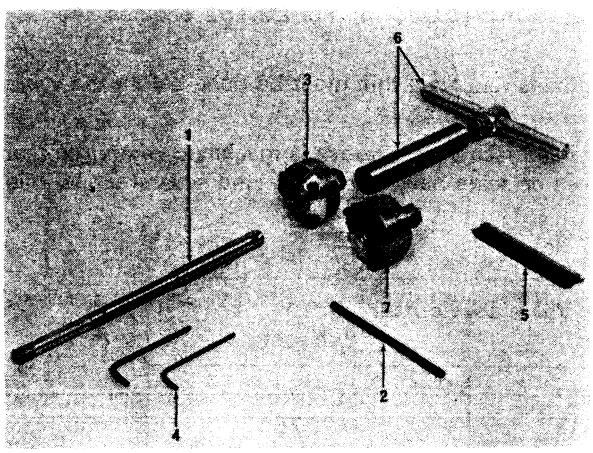


Fig. F7

1. Pilot
2. Puller Pin
3. Seat Cutter
4. Keys
5. Cleaning Brush
6. Cutter Handle
7. Valve Seat Width Reducer

Put the pilot (see fig. F7) in the valve guide with the expansion section inside the guide and the shoulder of the pilot approximately 3mm (⅛ in) above the guide. Tighten the pilot in the guide by use of the nut and a pin in the pilot hole. Adjust the blades of the cutter to approximately the same location in their slots with the square ends outside and tighten the blade screws, finger tight only. Make sure that the blades are clean before use.

Lower the cutter into position on the pilot with the blades towards the seat – do not drop the cutter on to the seat as damage can easily occur to the blades. Fit the handle to the cutter and cut the seat. Turn the cutter clockwise with the use of very light pressure and ensure that the pressure is applied directly above the pilot. Not many turns are necessary to get a good seat.

With 45° seats on 3.152 engines, the seat width can be reduced when the groove is corrected by the use of the suitable flat cutter from the cutter kit MS73.

Earlier D3.152 engines with 45° seats had a 30° flare between the seat and the cylinder head face.

After the seats have been cut, clean the cylinder head and check the contact between the valve and seat, which can be lapped if necessary. Check the valve head depth below the cylinder head face as given on page F3.

Rocker shaft assembly

Clean the rocker shaft assembly.

Check the bushes in the rocker levers for wear. The rocker levers must be an easy fit on the shaft without too much side movement.

If the rocker lever bushes are worn, it will be necessary to renew the complete rocker lever. The rocker levers are a complete assembly and new bushes cannot be fitted.

When the rocker shaft assembly is dismantled, make a note of the assembly of parts, so that when the assembly is put together, the left and right rocker levers are in their correct positions to locate with their respective tappets and valves. If there is a slot in the end of the rocker shaft, ensure that the slot is towards the front of the engine (see fig. F8). For correct location, later rocker shaft assemblies have a tapered pin that is fitted into a 4 mm diameter hole in the rocker shaft. Ensure that this pin fits into the slot in the second rocker lever bracket. (See 1. fig. F8A). Note: Later cylinder heads use shorter length tapped holes for the rocker shaft studs. Ensure that only the correct studs supplied with the cylinder head are used.

Valve guides

Check the valve guides for wear. If necessary, renew the guides.

Clean the new guides and check for damage.

With 3.152 and D3.152 engines, inlet and exhaust valve guides are the same length and the valve guide height above the spring seat face of the cylinder head must be 14,73/15,09 mm (0.580/0.594 in) when fitted.

With 3.1522, 3.1524 and T3.1524 engines the inlet valve guides are 5,5 mm (7/32 in) shorter than the exhaust valve guides. Ensure that the correct guide is fitted. When fitted, the valve guide height above the spring seat face of the cylinder head must be 9,19/9,55 mm (0.362/0.376 in) for inlet guides and 14,73/15,09 mm (0.580/0.594 in) for exhaust guides.

The inside of all guides have a counterbore at one end and this counterbore must be fitted towards the valve seat.

Fig. F9 shows a new valve guide being fitted.

Valve seat inserts

It is permissible to fit valve seat inserts to both inlet and exhaust valve seats of 3.152 engines and the 45° exhaust valve seat only of D3.152 and some T3.1524 engines where the original seat can not be corrected because of damage or the permissible service valve depth below the cylinder head is more than that already given. The valve seat insert recess dimensions are important and correct Perkins parts must be used.

The recess for an insert must not be cut with a worn valve guide fitted.

The recess must be cut from the bore of a new valve guide.

To fit valve seat inserts:-

1. Remove the old valve guide and clean the parent bore.
2. Fit a new valve guide to enable the bore to be used as a pilot to cut the recess.
3. By the use of a suitable tool, cut the old seats to the dimensions given in fig. F10.
4. Using a tool made to the dimensions given in fig. F11 and again by the use of the valve guide bore as a pilot, press in the insert. A hammer or lubrication must not be used.
5. Check to ensure that the insert is square and installed to the bottom of the recess, see fig. F12.
6. For D3.152 exhaust valve inserts, use the valve guide bore as a pilot to cut the flare to the dimensions given in fig. F13.
7. Cut the valve seats so that the valve head depths below the cylinder head face are to the dimensions given on page F3.

Note: Some T3.1524 engines have 45° exhaust valve inserts fitted in production. (See fig. F13A). Where necessary they can be renewed if the recess diameter is within the production limits of 37,224/37,249 mm (1.4655/1.4665 in).

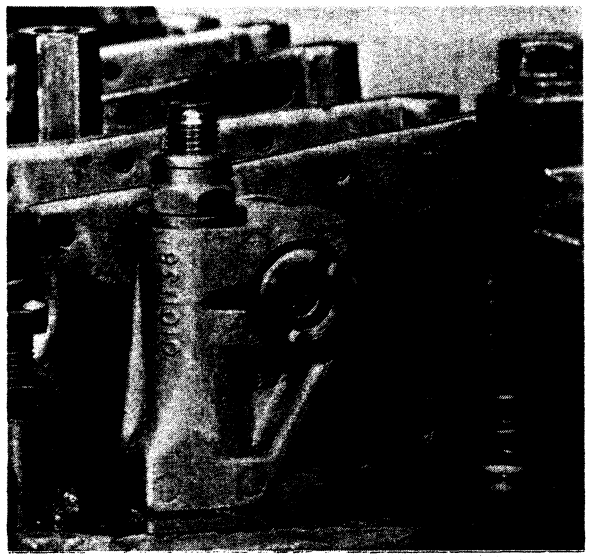


Fig. F8

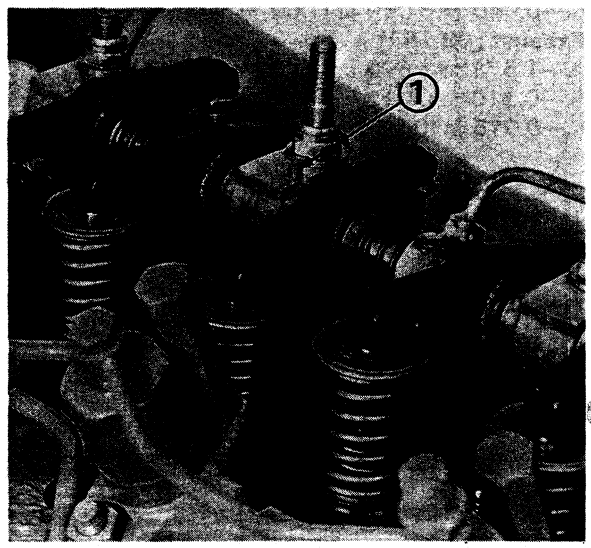


Fig. F8A

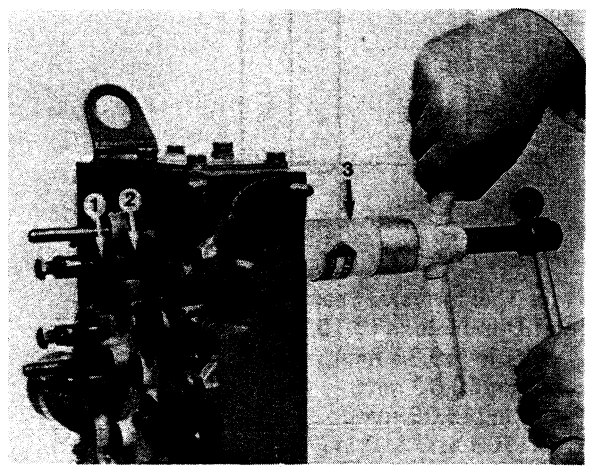


Fig. F9

1. Puller Bar PD1 D-A
2. Inlet Guide Stop PD1 D-9
   Exhaust Guide Stop PD1 C-4
3. Main Tool PD1 D

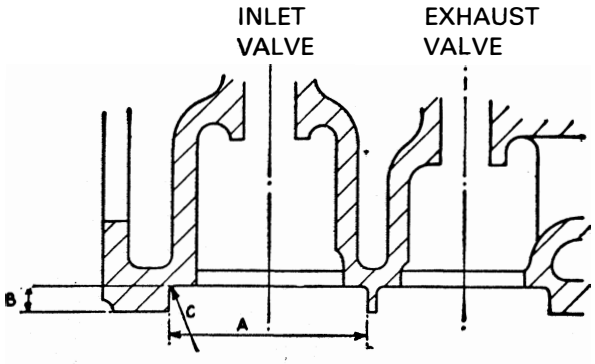


Fig. F10

Valve Seat Cutting Dimensions

Inlet (3.152)

A.—1.874 to 1.875 in (47,60 to 47,62 mm).
B.—0.248 to 0.250 in (6,30 to 6,35 mm).
C.—0.040 to 0.050 in (1,02 to 1,30 mm) Radius.

Exhaust (3.152)

A.—1.624 to 1.625 in (41,25 to 41,28 mm).
B.—0.248 to 0.250 in (6,30 to 6,35 mm).
C.—0.040 to 0.050 in (1,02 to 1,30 mm) Radius.

Exhaust (D3.152)

A.—1.678 to 1.679 in (42,62 to 42,64 mm).
B.—0.310 to 0.312 in (7,87 to 7,92 mm).
C.—0.015 in (0,38 mm) Maximum Radius.

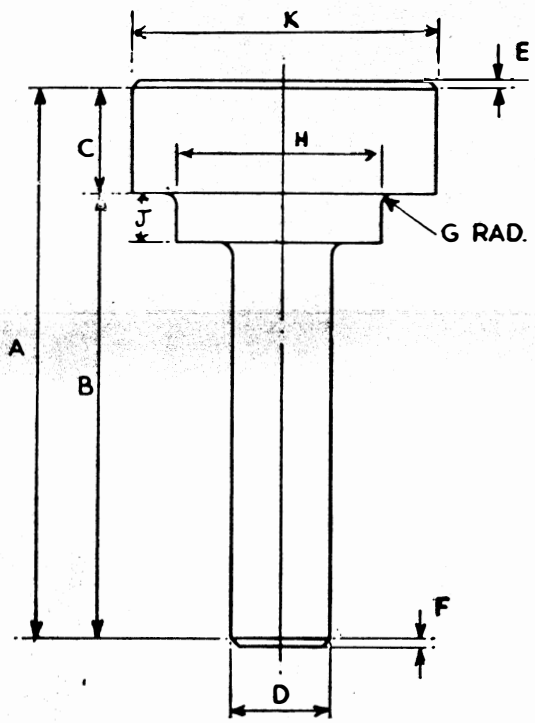


Fig. F11

Press Tool for Valve Seat Inserts

Inlet Dimensions (3.152)

A.—2¾ in (69,85 mm).
B.—2 in (50,80 mm).
C.—¾ in (19,05 mm).
D.—0.309 to 0.310 in (7,85 to 7,87 mm).
E.—1/16 in (0,06 mm) at 45°.
F.—1/16 in (0,06 mm) at 45°.
G.—1/32 in (0,03 mm) Radius.
H.—1.401 to 1.402 in (35,58 to 35,61 mm).
J.—0.212 to 0.215 in (5,38 to 5,46 mm).
K.—1.855 to 1.865 in (47,12 to 47,37 mm).

Exhaust Dimensions (3.152)

A.—2¾ in (69,85 mm).
B.—2 in (50,80 mm).
C.—¾ in (19,05 mm).
D.—0.309 to 0.310 in (7,85 to 7,87 mm).
E.—1/16 in (0,06 mm) at 45°.
F.—1/16 in (0,06 mm) at 45°.
G.—1/32 in (0,03 mm) Radius.
H.—1.182 to 1.183 in (30,02 to 30,05 mm).
J.—0.212 to 0.215 in (5,38 to 5,46 mm).
K.—1.605 to 1.615 in (40,77 to 41,02 mm).

Exhaust Dimensions (D3.152/T3.1524)

A.—3½ in (88,90 mm).
B.—2¾ in (69,85 mm).
C.—¾ in (19,05 mm).
D.—0.309 to 0.310 in (7,85 to 7,87 mm).
E.—1/16 in (0,06 mm) at 45°.
F.—1/16 in (0,06 mm) at 45°.
G.—1/32 in (0,03 mm) Radius.
H.—1.200 to 1.201 in (30,48 to 30,50mm).
J.—¼ in (6,35 mm).
K.—1.667 to 1.677 in (42,34 to 42,59 mm).
Material EN32A Case Hardened and Ground.
K.—1.4605 to 1.4615 (T3.1524 with 45° exhaust valves).

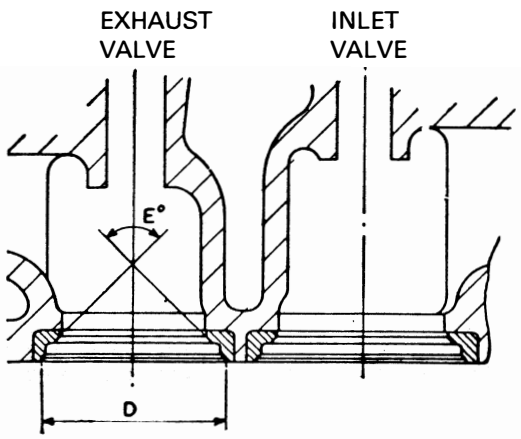


Fig. F12

Valve Insert Finished Dimensions (3.152).

Inlet

D.—1.704 to 1.714 in (43,28 to 43,53 mm).
E.—90°.

Exhaust

D.—1.485 to 1.495 in (37,72 to 37,97 mm).
E.—90°.

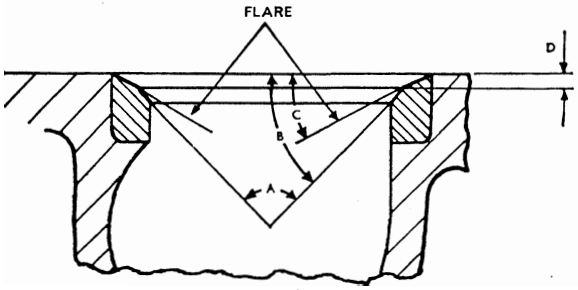


Fig. F13

Valve Insert Finished Dimensions (D3.152)

Exhaust

A.—90°. C.—30°.
B.—45°. D.—0.130 to 0.138 in (3,30 to 3,51 mm).

Tappets

The tappets operate in holes bored in the cylinder head. Wear is not normal.

The tappets can be removed through the bottom face of the cylinder head after the tappet adjustment setscrews and lock nuts have been removed.

Combustion chamber caps and joints (3.152)

It is not necessary to remove the combustion chamber caps during cylinder head overhaul as carbon deposits do not occur in these chambers.

If the caps are removed, new copper joints must be fitted when they are assembled.

If new copper joints are not available, the old joints can be used again if they are made soft before being fitted.

To make these joints soft, heat them to a dull red heat and then put them in cold water.

Ensure that there is no leakage from the joints when the caps are fitted.

Note: With flame proof applications, combustion chamber caps are not fitted. Steel inserts are fitted to the outer part of the chambers (see fig. F14) and these are sealed by the exhaust manifold.

Cylinder head inspection

Clean the cylinder head face and coolant and lubricating oil passages.

If possible, the cylinder head can be pressure tested with warm water for leakage at a pressure of 207 kN/m² (30 lbf/in²) 2,11 kgf/cm².

All studs on the cylinder head and the tapped holes in the top face of the cylinder block must be checked for damage or wear. The nuts and setscrews which fasten the cylinder head to the block must also be checked for damage or wear.

Check all joint faces, especially the bottom face of the cylinder head and the top face of the cylinder block for damage.

Check the bottom face of the cylinder head for distortion. The maximum permissible distortion is 0,08 mm (0.003 in) across the head and 0.15 mm (0.006 in) along the head.

Cylinder head faces can be machined (see page C9).

After the head has been machined, the valve depths must be checked and the seats recut if necessary as detailed under "Valve and Valve Seat Overhaul, page F3.

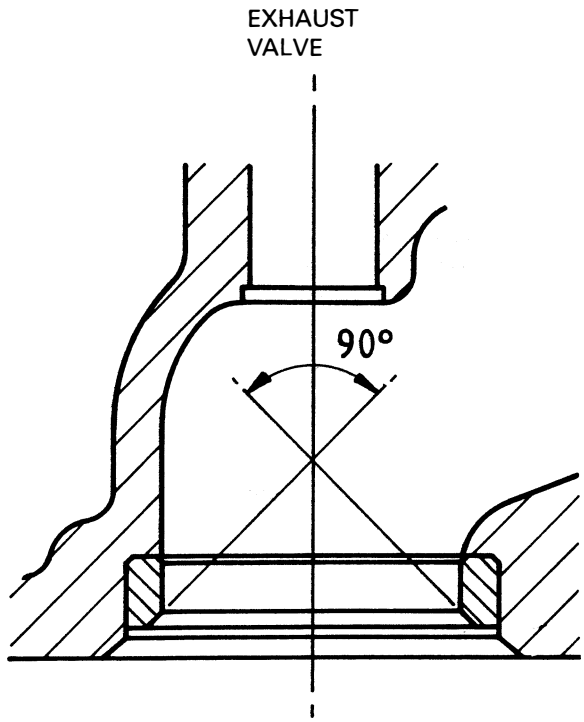


Fig. F13A

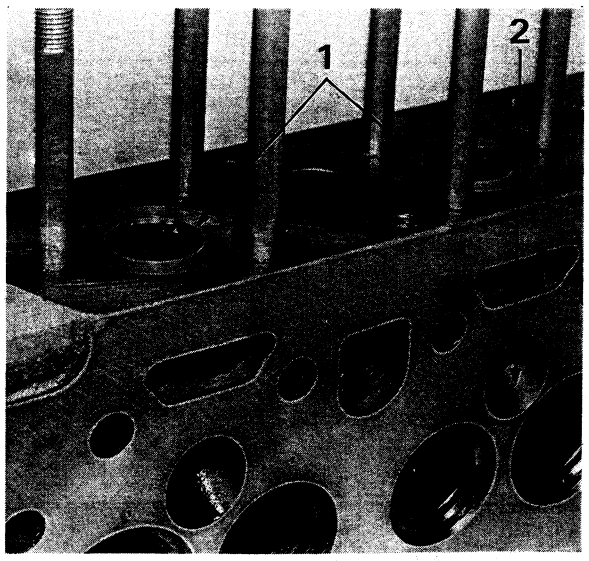


Fig. F14
3.152 Flameproof Engines only.
1. Combustion Chamber Inserts.
2. Combustion Chamber Throat.

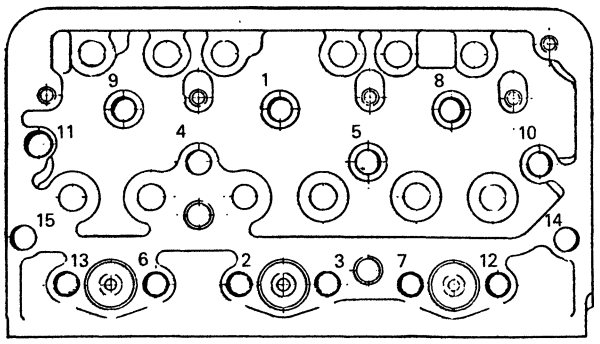


Fig. F15
Cylinder Head Tightening Sequence (3.152 engines)

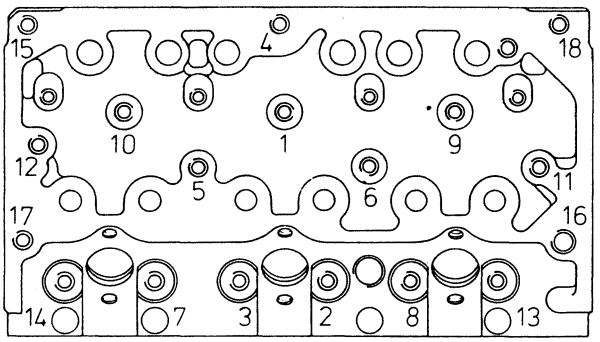


Fig. F16
Cylinder Head Tightening Sequence
(All engines except 3.152)

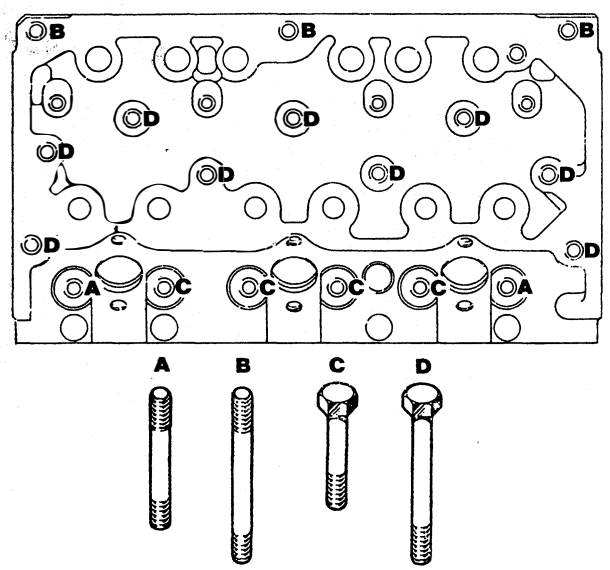


Fig. F17
Cylinder Head Stud/Setscrew Positions

Cylinder head fasteners

Different cylinder head fastners have been used on 3.152 and D3.152 engines.

Original cylinder heads were fastened to the cylinder block by studs and nuts.

As from the engine numbers which follow, cylinder head studs, nuts and setscrews were fitted.

152U21416CL
152U98250D
152UA28411DSL
152UA431805DL

On 3.152 engines, the studs were changed to setscrews except for the six which fasten the atomisers. These six studs which were not changed are fitted in positions 13, 6, 2, 3, 7 and 12 in fig. F15.

On D3.152 engines, all but two of the original studs were changed to setscrews. The two studs which were not changed were fitted to the holes marked 13 and 14 in fig. F16. Three different lengths of setscrew were used and it is important that these be fitted in their correct positions. The four short 82,5 mm (3¼ in) setscrews must be fitted in positions 7, 3, 2 and 8. The three 92 mm (3 5/8 in) setscrews must be fitted in positions 15, 4 and 18. The nine long 98,4 mm (3 7/8 in) setscrews must be fitted in positions 10, 1, 9, 12, 5, 6, 11, 17 and 16.

A later change of cylinder head fasteners was made to D3.152 engines from engine number CE.....U597494F when the setscrews in positions 15, 4 and 18 were changed to studs.

Nuts and setscrews fitted to later engines have an integral head washer.

Cylinder head fasteners for 3.1522 engines are shown in fig. F17.

Note: Where the cylinder head is fastened by all nuts, the torque is 81 Nm (60 lbf ft) 8,3 kgf m. Where the cylinder head is fastened by nuts and setscrews, the torque is 95 Nm (70 lbf ft) 9,7 kgf m.

To fit valves

1. Lubricate the valve stems with clean engine lubricating oil and fit them in their correct positions.

2. Fit the spring seat washers.

3. Put the valve stem seals in position on inlet guides only.

4. Put the valve springs into position.

   Note: With most D3.152, 3.1524, T3.1524 and 3.152 engines, only one spring is fitted to each valve, but some applications have two springs fitted. Different valve spring seat washers are fitted with the number of springs used. With 3.1522 engines, two springs are fitted to each inlet valve (see fig. F18) and a single spring to each exhaust valve. Inlet valve spring seat washers have tags on their inside diameters.

5. Fit the valve spring caps, compress the springs with a valve spring compressor and fit the split collets. Ensure that the valve spring cap is not tilted as the springs are compressed as this can cause damage to the valve stem.

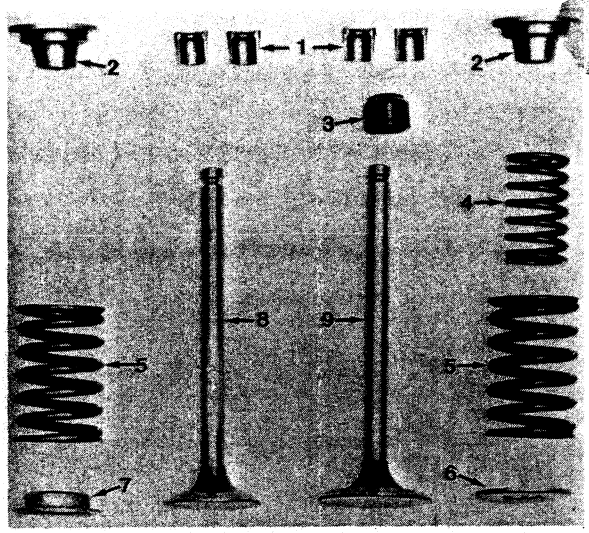


Fig. F18
Valve and Spring Assemblies.
1. Split Collets
2. Spring Cap
3. Stem Seal
4. Inner Spring
5. Outer Spring
6. Double Spring Seating Washer
7. Single Spring Seating Washer
8. Exhaust Valve
9. Inlet Valve

To fit cylinder head

A new cylinder head gasket must be used. The gasket has a mark to show how it should be fitted.

Ensure faces of the cylinder block and head are clean.

With 3.152 and D3.152 engines, the cylinder head gasket must be fitted with jointing compound on both sides. With all later 3.152 series engines, the cylinder head gasket (part number 3681E006) is fitted dry and does not need a tightness check at the 25/50 hour service.

Put the cylinder head in position and fit the nuts/setscrews as already described.

Tighten the cylinder head nuts/setscrews gradually in the sequence given in figs. F15 or F16 to the torque given on page C3. A different torque is used according to whether the cylinder head fasteners are all nuts, or nuts and setscrews.

Fit all components taken off during cylinder head removal. If the manifolds have been removed, ensure that the new joints are fitted correctly and do not cause restrictions in the ports.

Fit atomisers (see page P7).

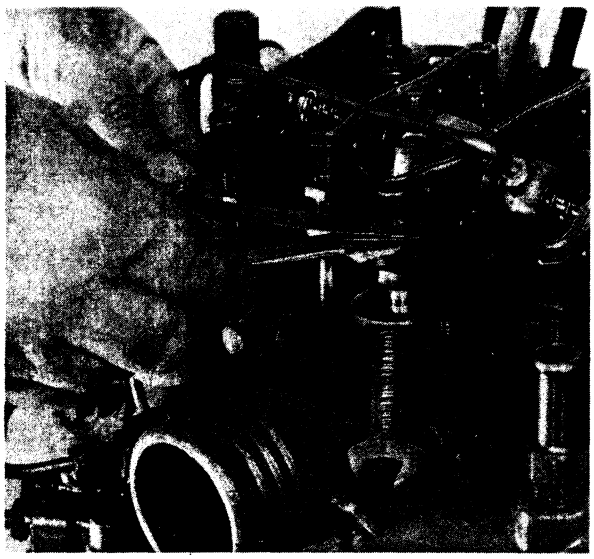


Fig. F19

Fit the rocker shaft assembly. Before the nuts which secure the rocker shaft are tightened, the shaft should be in a position to ensure correct lubrication of the assembly. The correct position for the shaft is when the slot in the end of the shaft is set 40° after the vertical position (see fig. F8). Later rocker assemblies will not have the slot in the end of the rocker shaft. On these rocker shaft assemblies, correct location is ensured by a tapered pin that fits into a hole in the rocker shaft and then into a slot in the second rocker shaft bracket (see fig. F8A).

When the rocker shaft is in the correct position, tighten the nuts which secure the shaft and set the tappet clearances as given later.

Fit cylinder head cover. Fit crankcase vent valve between cylinder head cover and induction manifold – 3.1522 only.

Connect pipes and make connections as given in 'To remove cylinder head'.

The thermostat in the cylinder head water outlet must be fitted. If the engine is run without a thermostat fitted, the engine temperature can be too high.

Run the engine and then remove rocker shaft and atomisers and tighten the cylinder head nuts/setscrews again as given below.

With the coolant outlet temperature higher than 77°C (170°F) tighten the nuts/setscrews in the order given in figs. F15 or F16 to the torque given on page F8.

If a nut/setscrew moves when checked, tighten it to the correct torque.

If a nut/setscrew does not move before the correct torque is reached, loosen the nut/setscrew by 1/12 to 1/6 (30° to 60°) of a turn and then tighten to the correct torque.

After all the nuts/setscrews have been tightened, check the first 10 positions again to ensure that they are still to the correct torque. During this last check, do not loosen the setscrews.

When the engine is cold, adjust the tappet clearances as shown below.

Fit all necessary components. It is advised that a new cylinder head cover joint is fitted.

Note: With earlier 3.152 and D3.152 engines, the cylinder head nut/setscrews must be tightened again to the correct torque after the engine has run 25/50 hours. This is not necessary with 3.1522, 3.1524, T3.1524 and all later 3.152 series engines fitted with cylinder head gasket part number 3681E006.
(Engines fitted with gasket 3681E006 can normally be recognised by the cylinder head fasteners which have integral head washers.)

To adjust tappet clearances

The clearances are checked between the rocker lever and the tappet adjustment screw.

For 3.152 and D3.152· engines, the tappet clearances for both inlet and exhaust are 0,30 mm (0.012 in), with the engine cold.

For 3.1522, 3.1524 and T3.1524 engines, the tappet clearances are 0,20 mm (0.008 in) for inlet and 0.32 mm (0.0125 in) for exhaust, with the engine hot or cold.

Adjust the clearances (see fig. F19) as follows:-

1. Turn the crankshaft in the normal direction of rotation, until the inlet valve of No. 1 cylinder has just opened and the exhaust valve of the same cylinder has not fully closed. Check and adjust clearances of Nos. 4 and 6 valves (No. 1 valve at front of engine).
2. Make a mark on the crankshaft pulley and timing case cover and turn the crankshaft one complete revolution (360°) until marks align again. Check and adjust clearances of Nos. 1, 2, 3 and 5 valves.

Crankcase vent valve – 3.1522 only

This is fitted between the cylinder head cover and induction manifold (see fig. F20).

To clean, seal the small breather hole in the top face and wash the unit in gasolene or kerosene. If air pressure is used to dry the unit, only low pressure must be used, because high pressure will damage the unit.

Fig. F20

Fig. G1

Pistons and connecting rods

Pistons for 3.152/A3.152 engines have a flat top.

Pistons for D3.152/AD3.152 engines have a toroidal cavity in the top and up-rated AD3.152 pistons have a flat bottom cavity in the top.

3.1522 engines have re-entrant bowl pistons.

3.1524 and T3.1524 engines have a semi-spherical cavity in the crown.

Five ring pistons are fitted to all 3.152 engines and to D3.152 engines rated up to 2,250 rev/min, except those given below.

Four ring pistons are fitted to D3.152 engines rated above 2,250 rev/min, up-rated AD3.152 engines and some D3.152 engines rated up to 2,250 rev/min. A fuel injection pump setting code (see pump data plate) which starts with TW50 or WW47E normally indicates a four ring piston on these D3.152 engines.

3.1522 engines fitted in fork lift truck applications have four ring pistons and other applications have three ring pistons.

3.1524 and T3.1524 engines have three ring pistons.

The piston rings are all fitted above the gudgeon pin except for the bottom scraper ring on five ring pistons.

To ensure the pistons are fitted correctly, they are stamped 1 to 3. No. 1 is at the front of the engine. The number is stamped on the top of each piston.

The connecting rods are also stamped on one side to indicate their position in the engine.

Fig. G2

To remove pistons and connecting rods

1. Remove the cylinder head assembly (Section F).
2. Remove the lubricating oil sump and lubricating oil pump (Section M).
3. Remove any carbon from the top of the cylinder liner bores.
4. Remove the big end caps (see fig. G1) and connecting rod bearings from the connecting rods and push the pistons and connecting rods out of the top of the cylinder block (see fig. G2).
5. Keep the bearings with the correct piston/connecting rod assembly.

To remove pistons from connecting rods

1. Remove the piston rings. Ensure that the ends of the rings do not cause damage to the piston.
2. Ensure that there are identification marks on the piston and connecting rods to ensure easy assembly.
3. Remove the circlips from the piston bore.
4. Push out the gudgeon pin. If the pin is tight, heat the piston to 40/50°C (100/120°F) for easy pin removal.

To renew small end bush

1. Press out old bush with a suitable adaptor.
2. Remove any sharp edges from the connecting rod bore.
3. Press in new bush so that the lubricating oil hole in the bush aligns with the lubricating oil hole in the top of the connecting rod (see fig. G3).
4. Ream the bush bore to get the correct clearance with the gudgeon pin (see page C7).
5. Check that the small end bore is parallel with the big end bore.

To assemble piston and connecting rod

If original pistons are to be used again, they must be assembled to their correct connecting rods, that is, piston stamped No. 1 must be fitted to connecting rod stamped No. 1.

Pistons must be fitted with the offset cavity in the top towards the side of the connecting rod that is stamped with the identification number (fig. G4 shows a 3.1522 piston).

If a new connecting rod is used, it must be stamped with the cylinder number on the side of the rod and cap which has the recess for the location tag for the connecting rod bearings.

Assemble the piston to the connecting rod and fit the gudgeon pin. Heat the piston to 40/50°C (100/120°F) for easy gudgeon pin assembly.

Ensure that the circlips are correctly fitted in their grooves.

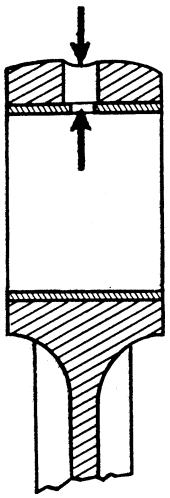


Fig. G3

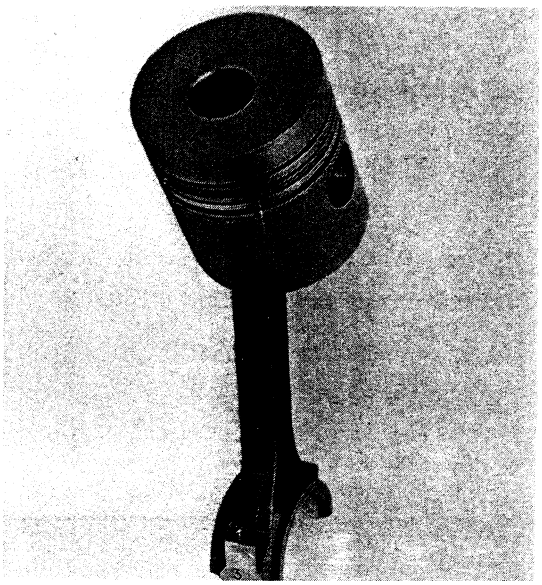


Fig. G4

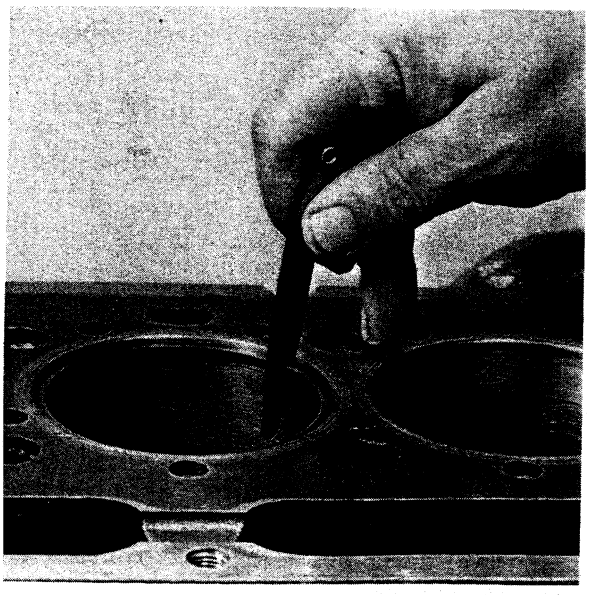


Fig. G5

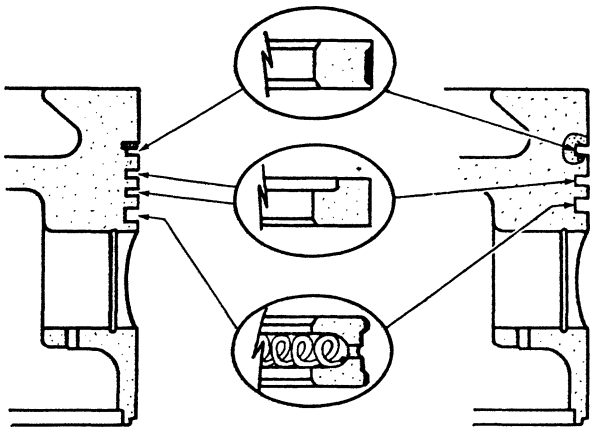


Fig. G6

To fit new rings

Check the piston rings for correct gap (see page C6). To check the gap of the coil spring loaded scraper ring, the spring must be fitted to push the ring against the cylinder liner bore.

In worn cylinder liners, gaps must be checked at the top of the bore which is not worn, after the carbon has been removed (see fig. G5).

With 3.1522 engines, the compression rings have a thin layer of copper on the outside surface to help the rings adjust to the bore. This layer will soon wear off in service. The ring gap will increase 0,08/0,15 mm (0.003/0.006 in) without the copper layer on the ring.

Fit the rings to the piston in the order which follows (from the top of the piston) as shown in fig. G6 for the 3.1522 engine.

3.152 engines fitted with chrome liners

1. Parallel face compression.
2. Tapered face compression.
3. Laminated segment compression.
4. Slotted scraper.
5. Slotted scraper.

3.152/A3.152 and D3.152/AD3.152 engines rated up to 2,250 rev/min fitted with cast iron liners

1. Chromium plated compression.
2. Parallel compression.
3. Laminated segment compression.

*4. Spring loaded laminated scraper.

5. Slotted scraper.

* With 3.152 engines rated above 2,250 rev/min, a slotted scraper is used.

Some D3.152 engines rated up to 2,250 rev/min use piston rings as given for higher rated D3.152 engines. A fuel injection pump setting code (see pump data plate) which starts with TW50 or WW47E normally indicates this piston ring arrangement.

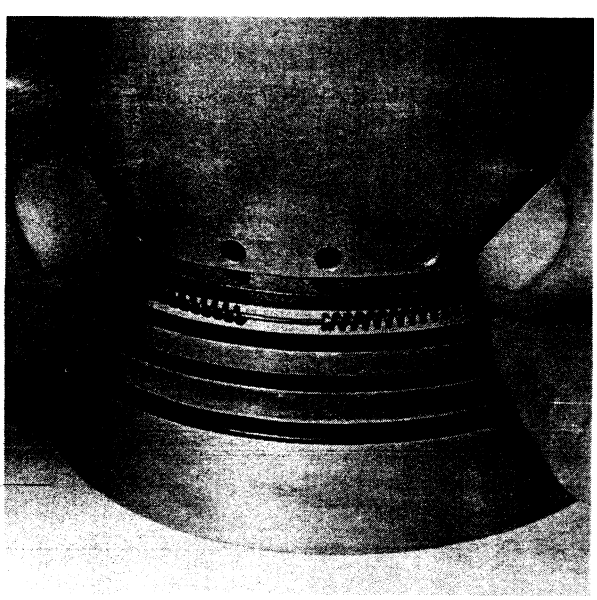


Fig. G7

D3.152 rated above 2,250 rev/min

1. Chromium plated compression.
2. Parallel compression.
3. Internally stepped compression.
4. Chromium faced, coil spring loaded scraper.

Up-rated AD3.152

1. Chromium plated compression.
2. Internally stepped compression.
3. Internally stepped compression.
4. Chromium faced, coil spring loaded scraper.

3.1522

1. Chromium insert, copper finished compression.

2 or

2 & 3 Internally stepped, copper finished compression.

3 or 4 Chromium faced, coil spring loaded scraper.

3.1524/T3.1524

1. Tapered semi-inlay, chrome face compression.
2. Tapered face compression.
3. Chrome face, coil spring loaded scraper.

The tapered face compression rings have a mark 'T' or 'TOP' to ensure that they are fitted correctly.

To fit the coil spring loaded scraper ring, fit the coil spring in the piston ring groove. Ensure that the location pin goes in both ends of the spring (see fig. G7) and then fit the ring over the spring. Ensure the spring goes into the inside groove of the ring and the ring gap is on the opposite side to the location pin.

Fit internally stepped rings with the step towards the top of the piston.

When new rings are fitted to original pistons, clean the piston ring grooves by the use of an old ring.

The pistons must be checked for damage of the ring grooves and to ensure that the rings move freely in their grooves. If the piston outside surface is damaged or badly worn, it must not be used again.

Laminated compression rings

The laminated compression ring fitted in the third groove is different on early and later engines.

On early engines, it consisted of three segments. On later engines, it consists of four segments.

It is important that the laminated compression ring is correctly assembled to the piston.

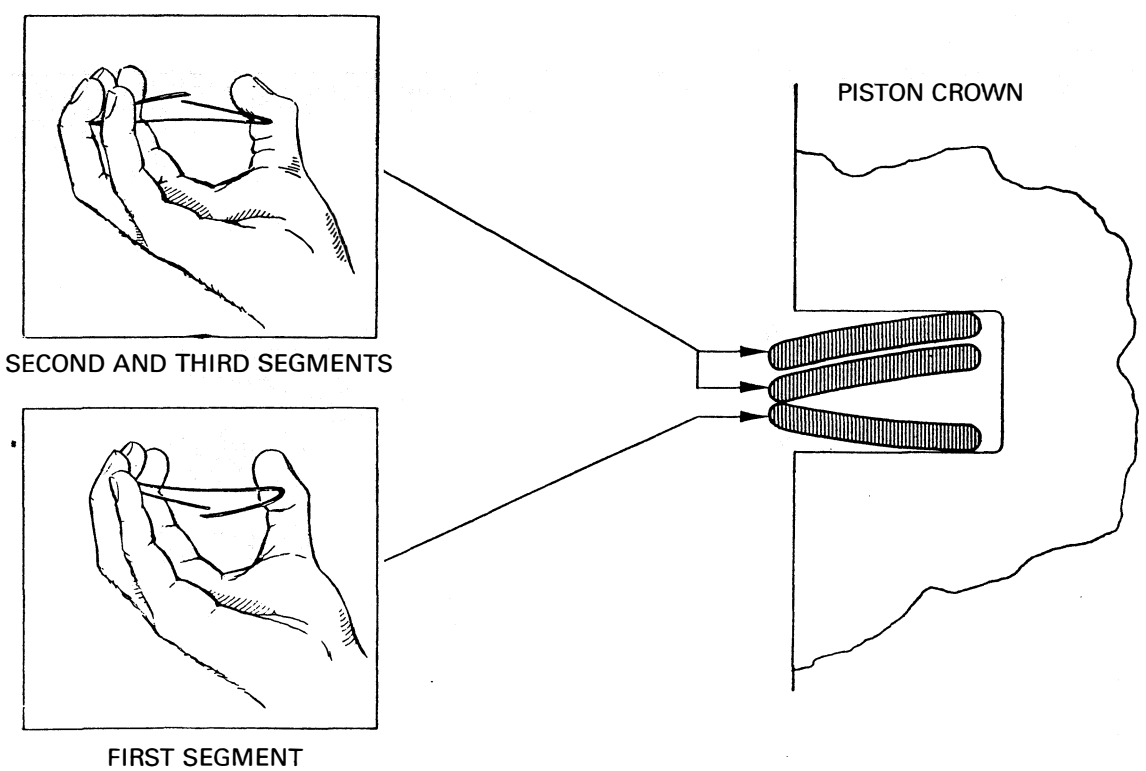


Fig. G8

To fit three segment type (see fig. G8)

1. Fit the first segment so that when held and lightly pressed by hand, the ends of the ring are in the down position. Put this ring at the bottom of the groove with the gap over the gudgeon pin bore.
2. Fit the second segment on the top of the first, so that when held and pressed as already given, the ends of the ring are in the up position. Put the gap at 180° to the first segment gap.
3. Fit the third segment on the top of the second with the ends of the ring in the up position. Put the gap above that of the first segment.

To fit four segment type (see fig. G9)

1. Fit the first segment so that when held and lightly pressed by hand, the ends of the ring are in the down position. Put this ring at the bottom of the groove with the gap over the gudgeon pin bore.
2. Fit the second segment on the top of the first so that when held and pressed as already given, the ends of the ring are in the up position. Put the gap 180° to the first segment gap.
3. Fit the third segment on the top of the second so that when pressed, the ends of the ring are in the down position. Put the gap above that of the first segment.
4. Fit the fourth segment on the top of the third with the ends of the ring in the up position. Put the gap above that of the second segment.

To fit spring loaded scraper ring (see fig. G10)

This ring consists of one inside expander ring (1) and two flat rings (2) each side of the wavy spring ring (3).

1. Fit the inside expander ring.
2. Fit the two lower flat rings.
3. Fit the wavy spring ring.
4. Fit the two upper flat rings.

To fit spring loaded scraper ring (see fig. G11)

This ring consists of four flat segments, one dished segment and a spacer.

1. Fit the two flat segments.
2. Fit the spacer.
3. Fit the flat segment on top of the spacer.
4. Fit the dished segment with the dish down. This segment has its end cut at an angle. The correct direction of the dish can be found if the ring is lightly pressed by hand and the ends move up. On later rings, a round area of the dull surface of the ring has been removed to give a bright area and this must be fitted towards the top.
5. Fit the flat segment on the top of the dished segment.

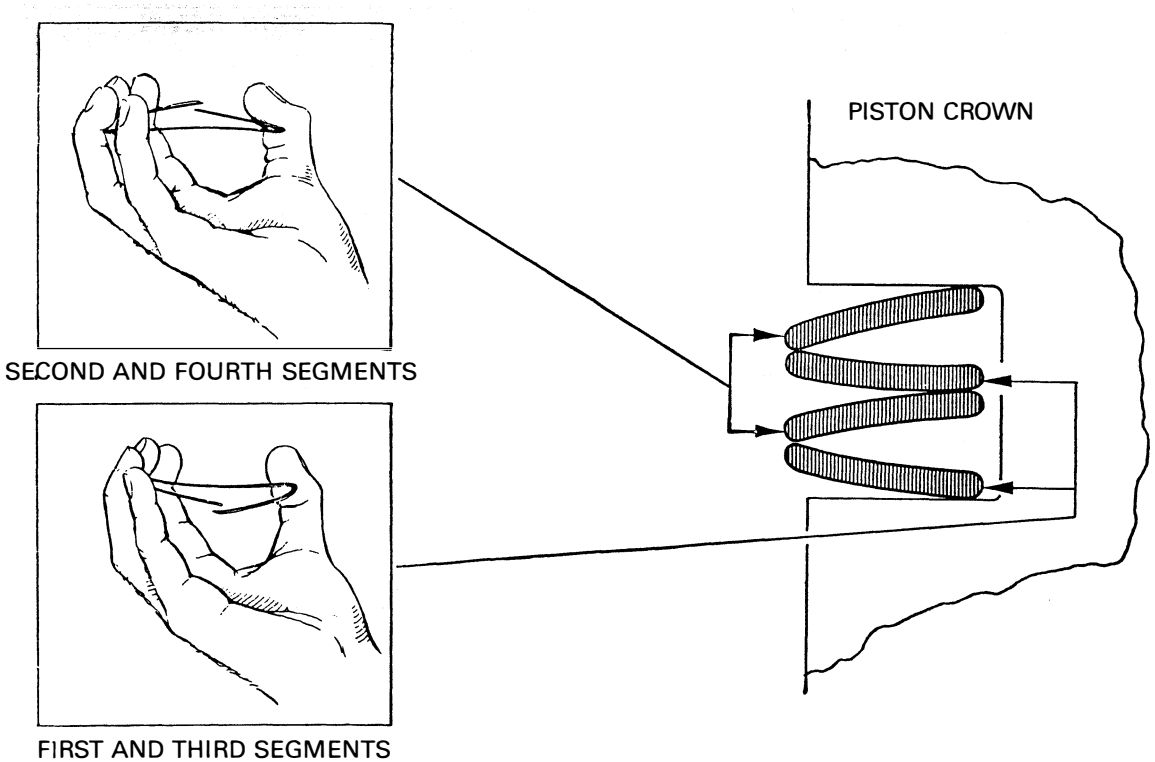


Fig. G9

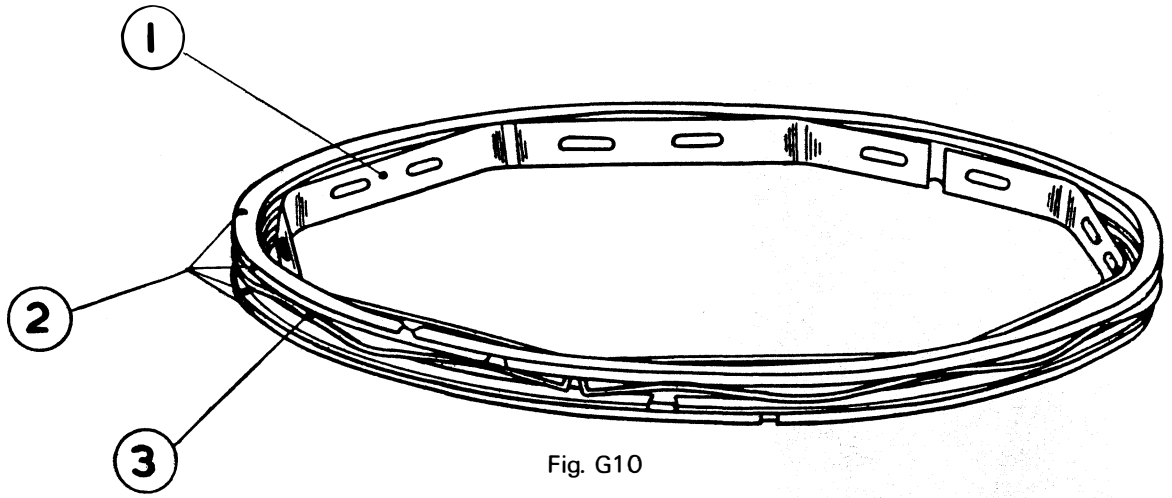


Fig. G10

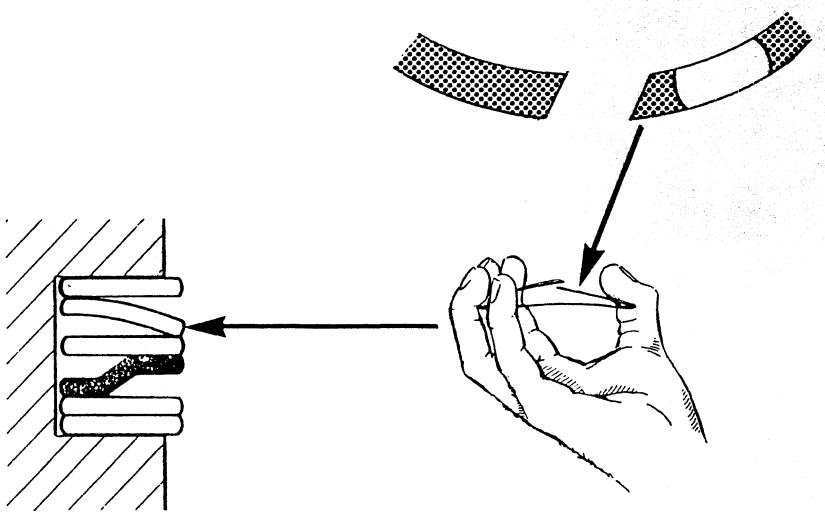


Fig. G11

To fit piston and connecting rod

Connecting rods and caps have marks to show their original position in the engine (see fig. G12). The numbers are stamped on the side of the connecting rod and cap which have the recesses for the location tags for the connecting rod bearings.

Ensure that the pistons, cylinder liner bore, crankpin and connecting rod big end are clean. Lubricate the piston and cylinder liner with clean engine lubricating oil.

When the pistons and connecting rods are fitted to the cylinder block and crankshaft, ensure that the side of the connecting rod which is stamped with the number goes to the fuel injection pump side of the engine.

Ensure that the letter 'F', word 'FRONT' or the arrow stamped on the top of the piston (see fig. G13) is towards the front of the engine. If the identification has been removed, ensure that the offset cavity in the piston top is towards the fuel injection pump side of the engine. Stamp the front of the piston top with a suitable identification mark.

Turn the crankshaft until the correct crankpin is at the bottom.

Space the ring gaps equally around the piston.

Compress the piston rings with a suitable tool (see fig. G14).

Push the pistons and connecting rods into the cylinder bores from the top. Ensure piston and rod stamped No. 1 are fitted into No. 1 cylinder and No. 2 into No. 2 cylinder etc. No. 1 cylinder is at the front of the engine.

Fit the bearings in the connecting rod and cap with the location tags correctly fitted in their recesses. Lubricate the bearings with clean engine lubricating oil and fit the connecting rod and cap to crankpin. Ensure that the cylinder numbers on the rod and cap are the same.

The nuts on the big end bolts must not be used a second time. New nuts must be fitted when they are removed.

Tighten the connecting rod nuts to the correct torque as given on page C3.

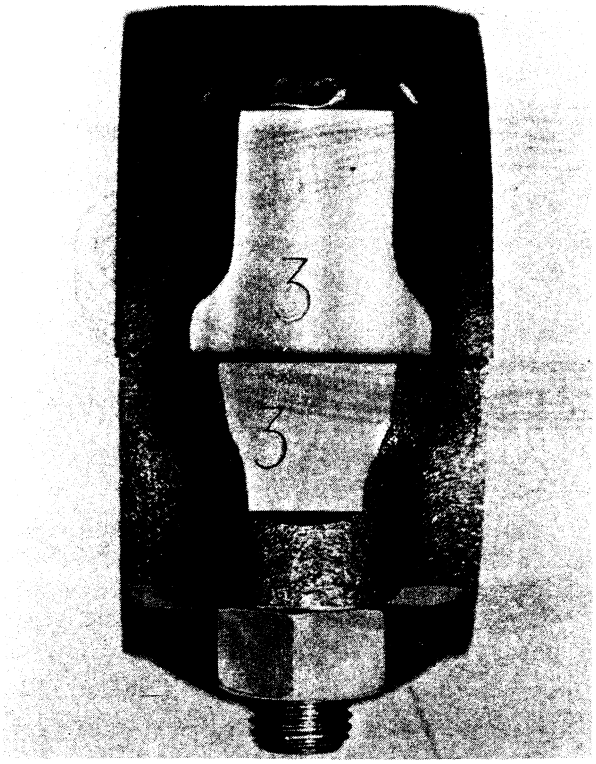


Fig. G12.

Three types of connecting rod nuts have been used. The original were self locking nuts. These were changed to cadmium plated nuts which have a bright finish. Current nuts are phosphated which have a dull black finish.

Check that the crankshaft will turn freely.

It is important that the correct piston height relationship to the cylinder block top face is checked when a new piston is fitted.

These piston heights at TDC are as follows:-

3.152	0,00/0,13 mm (0.000/0.005 in) below the top face of the cylinder block.
D3.152	0,10 mm (0.004 in) above to 0,03 mm (0.001 in) below the top face of the cylinder block.
Up-rated AD3.152	0,03/0,15 mm (0.001/0.006 in) below the top face of the cylinder block.
3.1522	0,03 mm (0.0012 in) above to 0,17 mm (0.0065 in) below the top face of the cylinder block.
3.1524, T3.1524	0,03/0,15 mm (0.001/0.006 in) below the top face of the cylinder block.

In the factory, the correct height is controlled by the use of three different grades of piston. The grade is stamped on the top of the piston. 'H' is for high. 'M' is for medium. 'L' is for low.

For service use with 3.152 and D3.152 engines, a piston to the finished height is available. Pistons are also available which are not finished to the correct height and the tops of these must be machined to give the correct heights as given above.

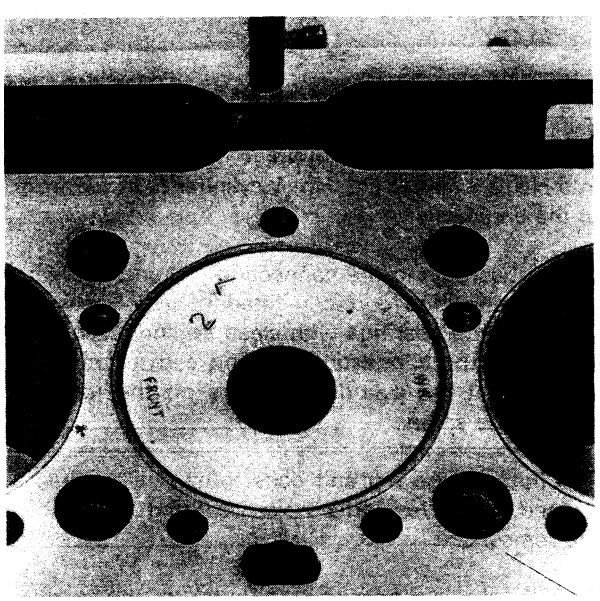


Fig. G13

For service use with 3.1522, 3.1524 and T3.1524 engines, 'H' and 'L' grades are available. 'L' grade pistons can be used in place of 'M' or 'L' grade pistons but, if used in place of 'H' grade pistons, they can be below the correct height and cause loss of power. 'H' grade pistons can be used in place of original 'H' grade pistons but, if use in place of 'M' or 'L' grade pistons, the top must be machined to give the correct height as already given.

To find the amount necessary to machine from the top of the piston, the piston and connecting rod assembly must be fitted to the cylinder block and crankshaft as already given.

When fitted, turn the crankshaft until the piston is at TDC and check the distance between the piston top and the top face of the cylinder block. Tool PD41B can be used to check the height (see fig. G15).

Do this with each piston in sequence. When the necessary amount has been removed from each piston top, fit the piston assemblies to the engine as already given. Check piston heights. If these are correct, stamp the top of the pistons with their cylinder numbers and a mark to indicate the front.

Note: After 3.1522 piston tops are machined, remove the sharp edge from the edge of the top of the cavity in the piston by the use of emery paper (360 grit size) to give a radius of 0,4 to 0,8 mm (1/64 to 1/32 in) as shown in fig. G16.

Fit the cylinder head (see page F9).

Fit the lubricating oil sump and lubricating oil pump (see pages M5 and M6).

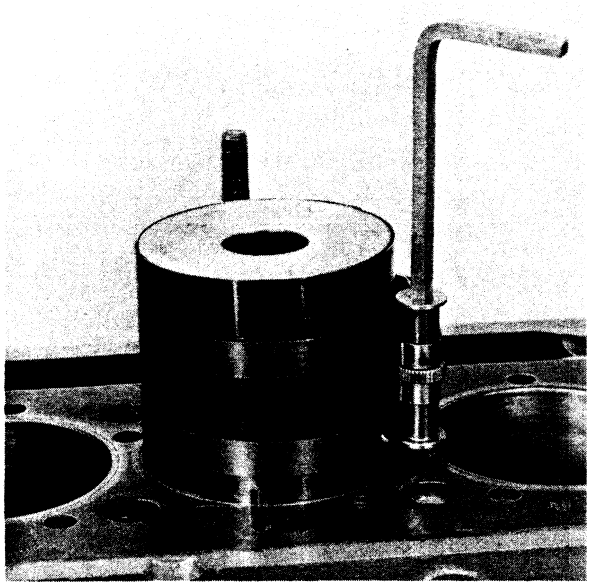


Fig. G14

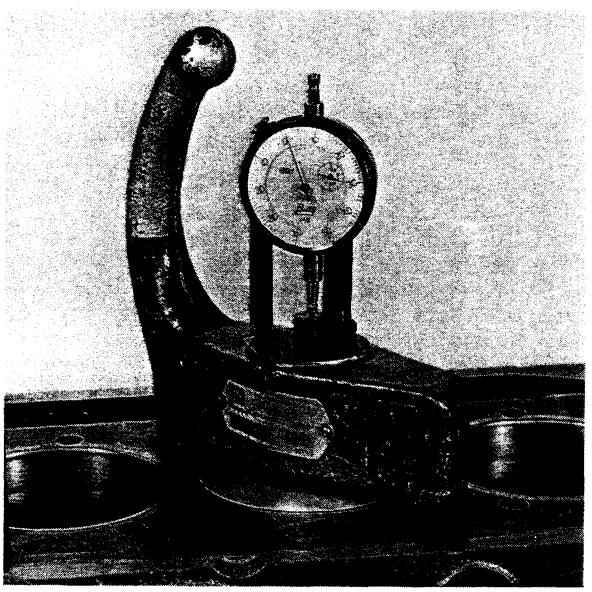


Fig. G15

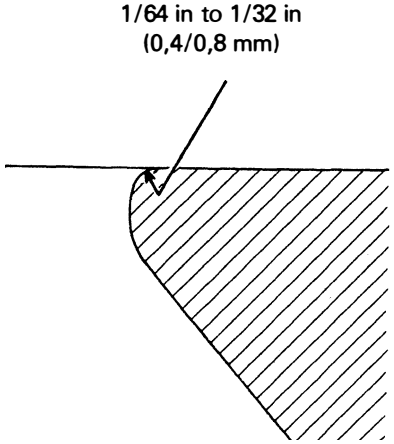


Fig. G16

SECTION H
Cylinder Block and Liners

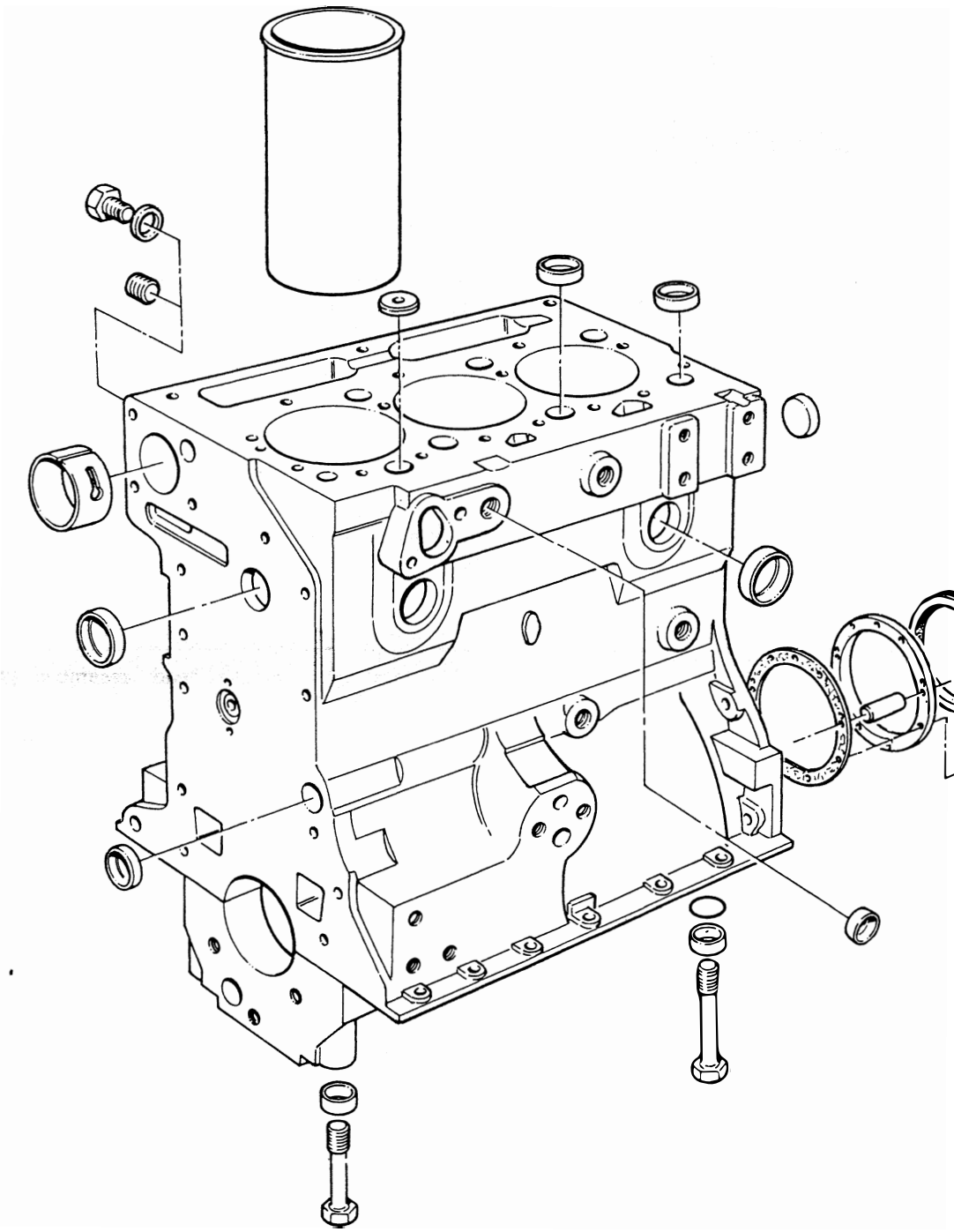


Fig. H1

Cylinder block and liners

The cylinder block is fitted with thin wall flanged cast iron or chromium faced dry cylinder liners. (Later T3.1524 engines are fitted with plain liners). They can be renewed in service. Factory cast iron liners are an interference fit and have to be bored and honed after they are fitted. Service flanged cast iron liners and all chromium faced liners are an interference/clearance fit and are pre-finished to correct size. They do not need to be machined after installation. (Pre-finished plain liners are not available).

Chromium faced liners are only fitted to 3.152 engines.

Factory and service cast iron liners are interchangeable, but cast iron and chromium faced liners are not interchangeable because the liner flange dimensions and the recess for the flange in the cylinder block are different.

Cylinder liners must not be bored oversize. When they are worn more than 0,18 mm (0.007 in) on the inside diameter, they must be renewed.

On some 3.152 and D3.152 engines and all 3.1522, 3.1524 and T3.1524 engines, a pre-finished bush is fitted in the cylinder block as a bearing for the front camshaft journal. To renew this bush, ensure that the oil hole in the bush aligns with the oil passage in the cylinder block and the end of the bush with the mark 'FRONT' is towards the front of the block.

To remove cylinder liners

1. Remove the cylinder head assembly (see Section F).
2. Remove piston and connecting rod assemblies, crankshaft and all component parts of the cylinder block as given in the other sections of this workshop manual.
3. Remove the cylinder head studs from the cylinder block.
4. Press out the liners through the top of the cylinder block (see fig. H1). Do not cause damage to the parent bores. Factory cast iron liners are an interference fit and must be removed with a heavy duty press.

Note: Cylinder liner removing/relacing tool PD.150B with adaptor PD.150-1B can be used for the removal of single liners without the removal of the engine from the application. The centre thread and ratchet of the tool must be lubricated with Shell Spirex Oil or a similar specification.

Preparation to fit new cylinder liners

Clean the top recess for the liner flange (flanged liners) and the parent bore.

Check that parent bores are free from damage or corrosion.

Ensure that the new liner is clean before it is fitted. If a fluid is used to clean the liner, it must be dried and lubricated with clean engine lubricating oil before it is fitted.

During the complete operation, all parts must be kept clean or local distortion of the liner bore can occur.

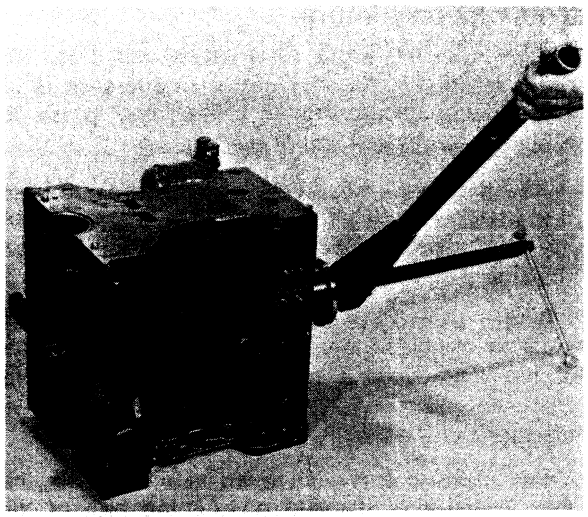


Fig. H2

To fit new service liners – flanged

1. Lubricate the outside diameter of the liners with clean engine lubricating oil which must be applied with a pressure container. Do not use a brush.

2. Press in new liners (see fig. H2) by the use of a suitable tool and adaptor. Ensure that the flanges of the liners are correctly located in their recesses at the top of the parent bore.

   When completely fitted, the top face of the liner flange must be between 0,10 mm (0.004 in) above to 0,10 mm (0.004 in) below the top face of the cylinder block for cast iron liners or 0,02/0,18 mm (0.001/0.007 in) below the top face of the cylinder block for chromium faced liners.

   To ensure correct liner height, it is permissible to use shims under the cylinder liner flange. These are 0,13 mm (0.005 in) thick, Part No. 33127107. Before a liner is fitted, the flange and recess must be measured to decide if shims are necessary to give the correct liner height relationship to the top face of the cylinder block.

   The new liners are a clearance/interference fit in the parent bore, that is – 0,03 mm (0.001 in) to + 0,03 mm (0.001 in).

3. Give the liner time to adapt to its fitted shape before the inside fitted bore diameter is checked (see fig. H3). The correct inside diameter of a pre-finished liner is 91,50/91,53 mm (3.6025/3.6035 in) for a cast iron liner or 91,48/91,50 mm (3.6015/3.6025 in) for a chromium faced liner. Each new liner must be checked in three positions – top, centre and bottom, both across and along the cylinder block at each position.

4. After new liners have been fitted, assemble remainder of components to cylinder block.

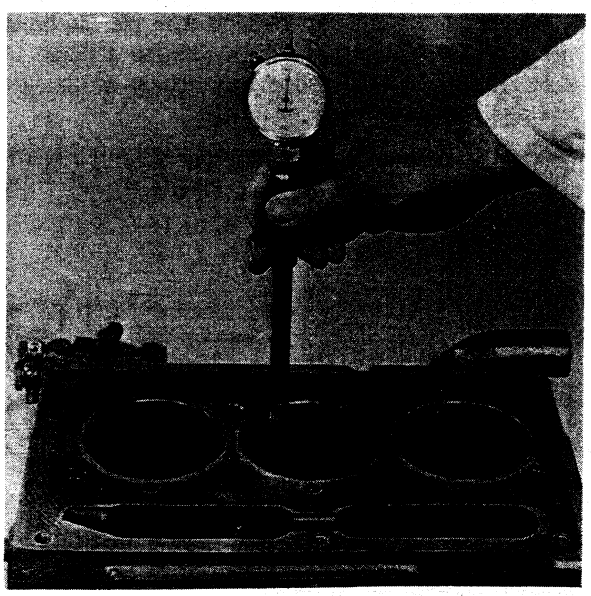


Fig. H3

To fit factory liners

Factory cast iron liners are available and these are not finished to size. They are an interference fit in the cylinder block and a heavy duty press is necessary to remove and fit them.

After they have been fitted, it is necessary to have the equipment to bore and hone the liners to an inside diameter of 91,48/91,50 mm (3.6015/3.6025 in).

Where a parent bore is made larger in service, it must be machined to the dimension by the addition of the liner oversize to the standard parent bore diameter given on page C4. A chamfer must be machined at the top of the new parent bore.

When oversize liners are fitted at the factory, the liner oversize is stamped on the top face of the cylinder block between the liner and the edge of the cylinder block.

To fit new liners – plain

Thoroughly clean the parent bore and the outside of the liner and remove all grease with 'Loctite Safety Solvent'.

Apply 'Loctite Retaining Compound' Grade 640 to the complete parent bore except for a 25 mm (1 in) high area around the top and bottom of the bore.

Enter the liner into the parent bore with the end that has an external chamfer at the bottom. With a suitable flat faced adaptor, press or pull in the liner until the top of the liner is 0,05 mm (0.002 in) above to 0,10 mm (0.004 in) below the top face of the cylinder block. Remove any 'Loctite' from around the bottom of the bore. The interference fit of the new liners in the parent bore is 0,03/0,08 mm (0.001/0.003 in).

Allow 15 minutes for the 'Loctite' to harden and then bore and hone the liner to the finished dimension of 91,48/91,50 mm (3.6015/3.6025 in). For best results, use a diamond hone – base hone at an inclusive angle of 30° to 35° and then plateau hone at an inclusive angle of 15° to 35° to a finish of 0,8/1,2 microns (32/48 micro inches) centre line average.

Clean the liner bore and the main journal housings, etc. and assemble the remainder of the components.

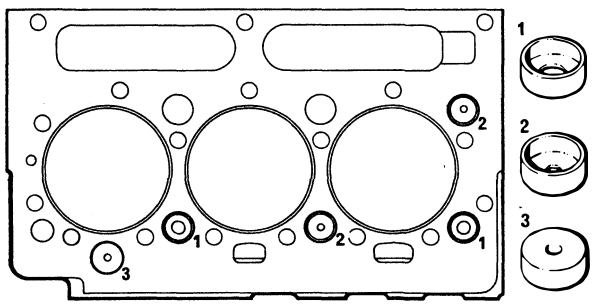


Fig. H4
Coolant Restriction Plug Positions

Oversize cylinder liners

Oversize outside diameter cylinder liners are available for service use if the standard parent bore has been made larger to remove damage.

They are available as follows:-

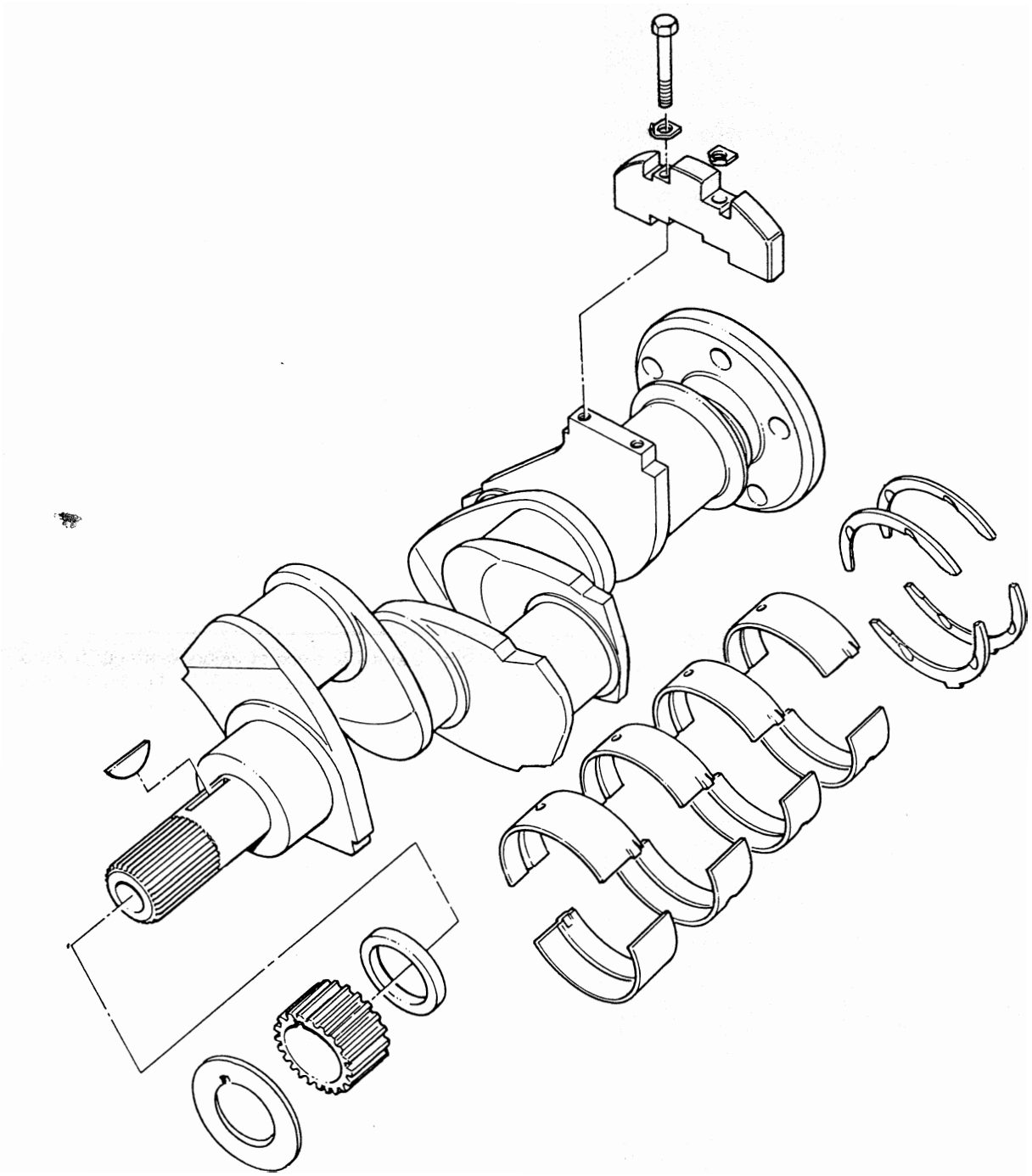
Oversize	Description
0,13 mm (0.005 in)	Chromium faced – prefinished
0,25 mm (0.010 in)	Cast iron – bore and hone
0,76 mm (0.030 in)	Cast iron plain – bore and hone
0,76 mm (0.030 in)	Cast iron flanged – prefinished

Coolant restriction plugs

On up-rated AD3.152 and some 3.1522, 3.1524 and T3.1524 engines, five of the water passages on the top of the cylinder block are fitted with restriction plugs. If these are removed, ensure that the correct size of plug is fitted in its correct position as shown in fig. H4. The plugs must not extend above the top face of the cylinder block.

The plug (3) is fitted in the cylinder block before the top face of the cylinder block is machined in the factory. If this plug is renewed in service, it must be machined so that it is on the same level with the top face of the block.

SECTION J
Crankshaft and Main Bearings



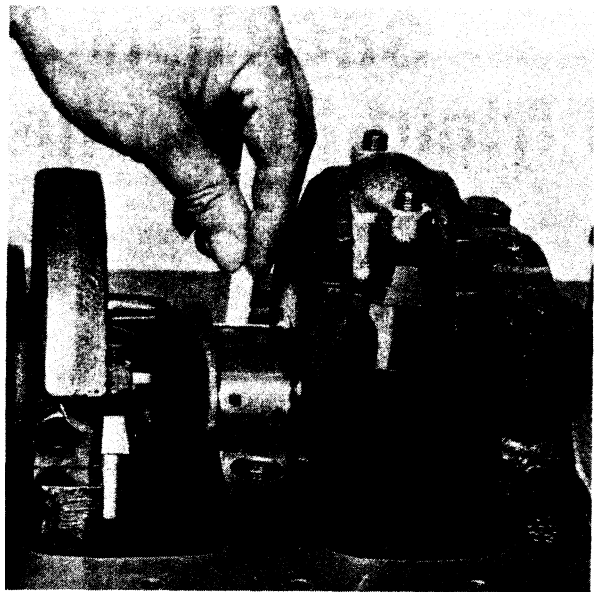


Fig. J1

Crankshaft and main bearings

The crankshaft runs in four pre-finished bearings which have a steel back and an aluminium tin face.

The crankshaft is fitted with two cast iron balance weights, one at the front crankshaft web and one at the rear crankshaft web, to give full rotation balance.

The main bearing location is by tags which fit into recesses machined in the bearing housings.

The seal at the rear end of the crankshaft is either a rope seal in a two piece housing or a lip seal in a one piece housing.

Note: The shim washers and tab washers fitted under the main bearing setscrews have been discarded and need not be fitted in service.

To fit new main bearings and thrust washers

If one or more of the main bearings or thrust washers have to be renewed or removed for inspection, it is not necessary to remove the crankshaft from the engine. With some applications, the engine will have to be removed.

1. To remove a main bearing, remove its cap. For the rear main bearing cap, see (1) below.
2. Do not remove more than one main bearing at a time.
3. Loosen the other main bearing cap setscrews one to two turns.
4. Remove the bottom half of bearing from cap.
5. With a suitable piece of wood, push out the top half of the bearing (see fig. J1). During this operation, turn the crankshaft in the correct direction and push the bearing on the opposite side to the bearing tag. The bearing tag is on the camshaft side of the engine.
6. Inspect the bearings and if they have to be renewed, fit a new half bearing in the top. Insert plain end first. Fit new half bearing to cap.
7. Fit main bearing cap and tighten setscrew lightly before the next bearing is removed.
8. When all main bearings and caps have been fitted, tighten the setscrews to the torque given on page C3.

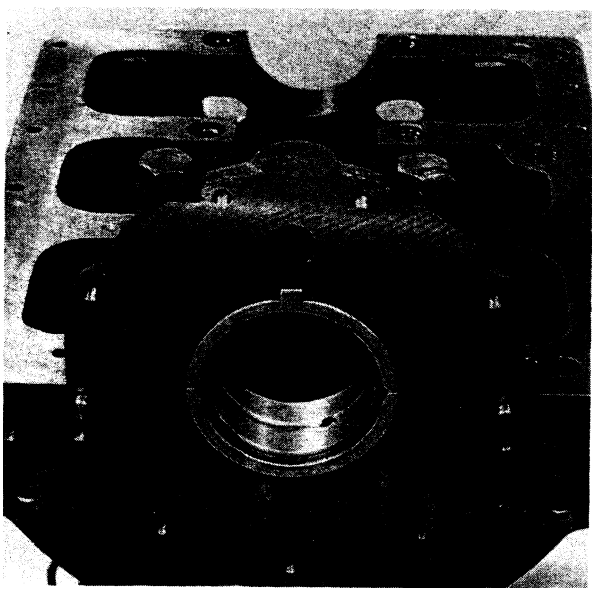


Fig. J2

The thrust washers fit in recesses machined on each side of the rear main bearing housing and cap (see fig. J2). Ensure the correct size thrust washers are fitted.

1. To renew the thrust washers, remove the rear main bearing cap. To do this, it is necessary to remove the two nuts which fasten the two halves of the rope seal housing or to release the lip seal housing.

2. Remove the two bottom half thrust washers from the rear main bearing cap.
3. The two top half thrust washers can be removed by the use of a suitable piece of wood to push them out when the crankshaft is turned (see fig. J3).
4. To fit new thrust washers, lightly lubricate the two top halves with clean lubricating oil and push one into the recess on each side of the rear main bearing housing. The steel side of the thrust washers must be towards the bearing housing.
5. Renew the main bearing cap 'O' rings (lip seal crankshafts only). Lightly apply Perkins POWERPART Hylomar jointing compound to the rear main bearing cap mounting faces, outside the grooves machined in the faces (see fig. J7). The jointing compound must not go into the grooves.
6. Fit a bottom half thrust washer on each side of the rear main bearing cap and fit the cap.
7. Tighten the main bearing setscrews to the torque given on page C3. Check crankshaft end clearance (see fig. J4).
8. Fit rear oil seal housing, flywheel, sump and other components as given in this workshop manual.

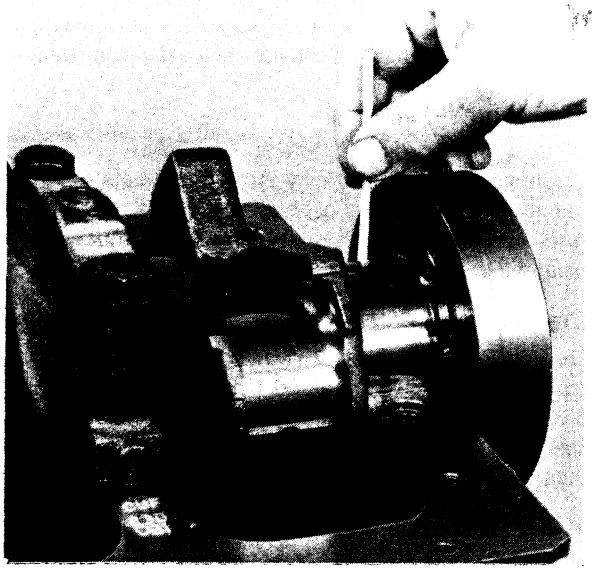


Fig. J3

To remove crankshaft

1. Remove sump and lubricating oil pump (see Section M).
2. Remove water pump (see Section N).
3. Remove crankshaft pulley.
4. Remove timing case front cover and remove idler gear.
5. Remove starter motor, flywheel and flywheel housing. Before the flywheel is removed, fit two guide studs in the crankshaft flange to give support when the flywheel is removed.
6. Remove connecting rod caps and big end bearings.
7. Remove the bolts which fasten the two halves of the rope seal housing or remove the lip seal 'housing.
8. Remove the main bearing setscrews and the main bearing caps and bottom half bearings. Keep the bearings and caps together.
9. Lift out the crankshaft (see fig. J5) and remove the top half main bearings. Make a mark on the bearings to ensure that they are fitted to their original positions.

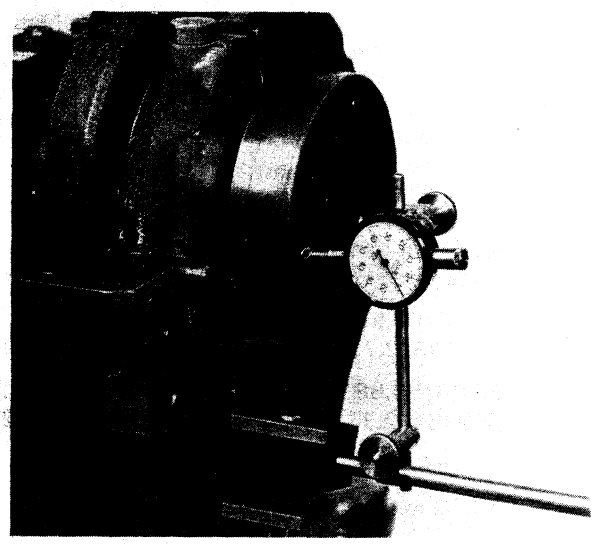


Fig. J4

If it is necessary to remove the crankshaft gear, ensure that the timing mark is to the front of the gear when it is fitted. The distance piece between the gear and crankshaft must be fitted with the chamfer to the inside.

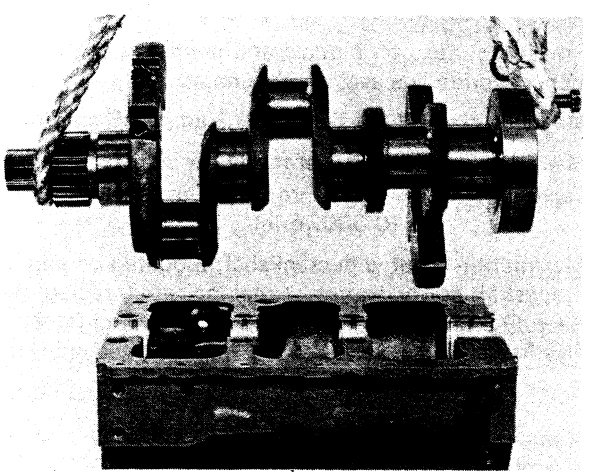


Fig. J5

If the main bearings are to be used again, they must be suitably marked to ensure they are fitted in that same positions from which they were removed.

Balance weights

If it is necessary to renew crankshaft balance weights. These are normally supplied in sets of two and must be fitted as a set. Where one weight is renewed, then the weight difference must not exceed 28.3 g (1 oz).

Crankshaft overhaul

The main journals and crankpins of a standard crankshaft can be machined 0,25 mm (0.010 in), 0,51 mm (0.020 in) or 0,76 mm (0.030 in) undersize on diameter. Special bearings are available for these undersize journals and pins.

Note: Crankshafts fitted to all 3.1522, 3.1524 and T3.1524 engines and crankshaft Part Nos. 31312718, 31312722 and 31313057 are Tufftrided and must be hardened by the Tufftrided process after they have been machined. If this is not possible, they can be nitrided for 20 hours, or if this is not possible, a new or Power Exchange crankshaft must be fitted.

Check the crankshaft for cracks before and after the crankshaft is machined.

Ensure that the fillet radii are machined correctly.

The finished sizes for corrected crankshafts are given below.

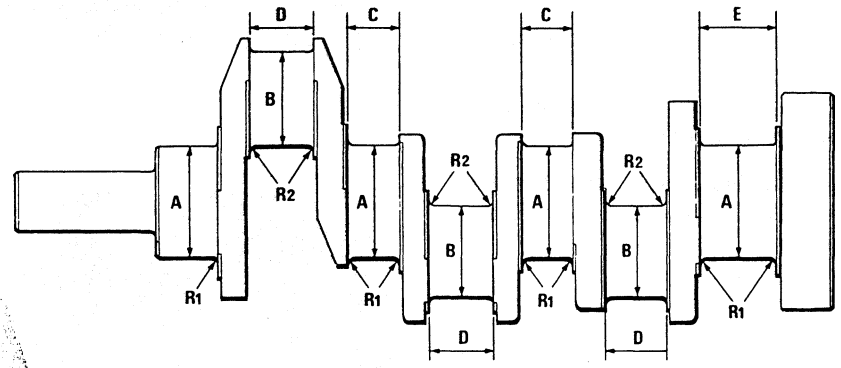


Fig. J6

	0,25 mm (0.010 in) Undersize	0,51 mm (0.020 in) Undersize	0,76 mm (0.030 in) Undersize
A	69,56/69,58 mm (2.7385/2.7393 in)	69,30/69,32 mm (2.7285/2.7293 in)	69,05/69,07 mm (2.7185/2.7193 in)
B	56,86/56,88 mm (2.2384/2.2392 in)	56,60/56,62 mm (2.2284/2.2292 in)	56,35/56,37 mm (2.2184/2.2912 in)

C 31,184 mm (1.22775 in) maximum

D 40,00 mm (1.575 in) maximum

E Crankshafts with rope seal – 48,06 mm (1.892 in) maximum

E Crankshafts with lip seal – 47,27 mm (1.861 in) maximum

R1 2,38/2,78 mm (0.0937/0.1093 in) all journals

R2 3,97/4,36 mm (0.1562/0.1718 in) all crankpins

Finished surface of journals and crankpins, 0,40 microns (16 micro inches). Fillet radii 1.3 microns (50 micro inches) centre line average maximum.

Magnetic crack check DC flow – 2 amps AC current – 1300 amps

Maximum taper and out of round for journals and crankpins —

Taper	0,009 mm (0.00035 in)	Out of round	0,010 mm (0.004 in)

Maximum run-out with crankshaft mounted on end journals —
Crankshaft pulley diameter (total indicator reading) 0,025 mm (0.001 in)
Rear oil seal diameter (total indicator reading) 0,025 mm (0.001 in)
Flywheel flange diameter (total indicator reading) 0,025 mm (0.001 in)

Journals (total indicator reading). Run-out must not be opposite.

Number 1	Number 2	Number 3	Number 4
Mounting	0,05 mm (0.002 in)	0,05 mm (0.002 in)	Mounting

After the crankshaft has been machined, removed any sharp corners from the lubricating oil holes.

To fit crankshaft

1. Ensure that all lubricating oil passages are free from restriction.
2. Check the main bearing setscrews for distortion and thread damage and renew them as necessary. Ensure that only the correct setscrews are used.
3. Clean the main bearing housings and fit the top half bearings in position with the location tags of the bearings in the slots of the housings. Lubricate the bearing surfaces with clean engine lubricating oil.
4. Put the crankshaft in position on the top half bearings.
5. Clean and lubricate the top half thrust washers and slide them into their recesses on both sides of the rear main bearing housing. The steel side must be towards the housing.
6. Renew the rear main bearing cap 'O' rings (lip seal crankshafts only).
7. Lightly apply Perkins POWERPART Hylomar jointing compound to the rear main bearing cap mounting faces, outside the grooves in the faces. The jointing compound must not go into the grooves (see fig. J7).
8. Fit the bottom half bearings to the main bearing caps with the location tags in their slots and lubricate the bearing surfaces. Put the main bearing caps in their correct positions and ensure that the bottom half thrust washers are correctly fitted to No. 4 cap (see fig. J7A). The inner caps are stamped 2 and 3 from the front of the engine. Each cap is stamped with a serial number and when fitted, this serial number must read in line with the serial number stamped on the cylinder block bottom face (see fig. J8).
9. Fit the main bearing cap setscrews and tighten them to the torque given on page C3.
10. Assemble the engine according to the instructions given in this workshop manual.
11. Tighten the crankshaft pulley setscrew to the torque given on page C3. With most applications, the pulley is fastened with a 38 mm (1.5 in) AF setscrew and a 8,9 mm (0.35 in) thick washer and this needs a higher torque than setscrews which use a 4,8 mm (3/16 in) thick washer.

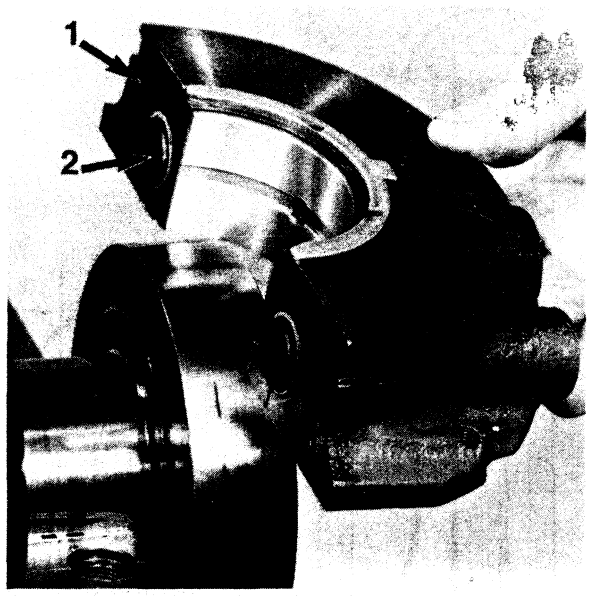


Fig. J7
1. Jointing Compound 2. 'O' Ring and Dowel

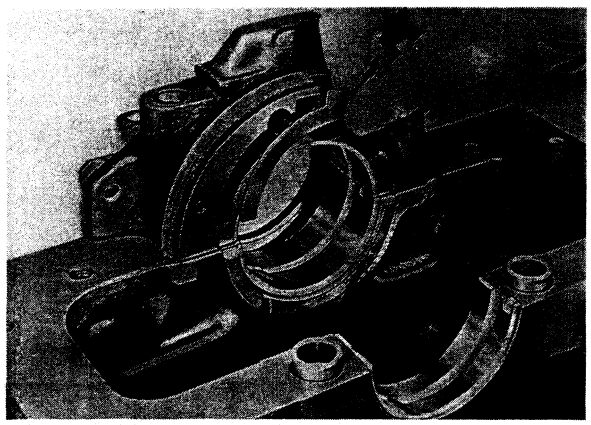


Fig. J7A

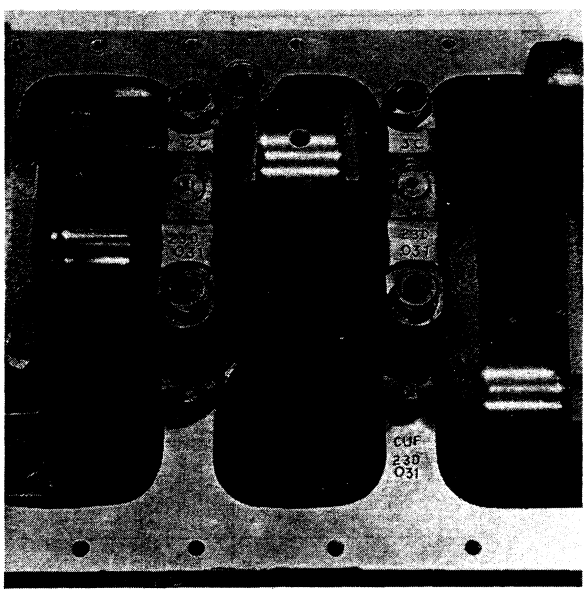


Fig. J8

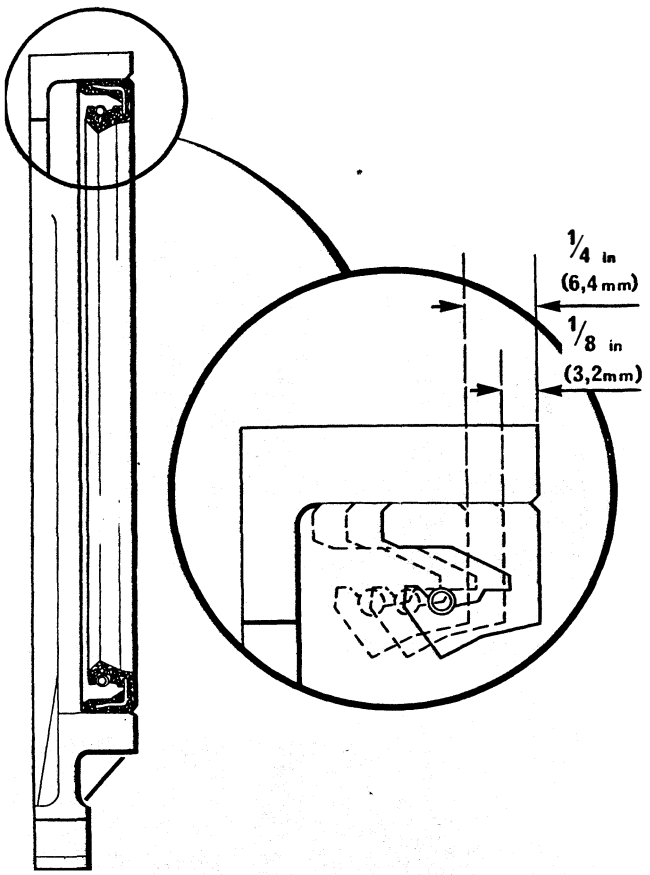


Fig. J9

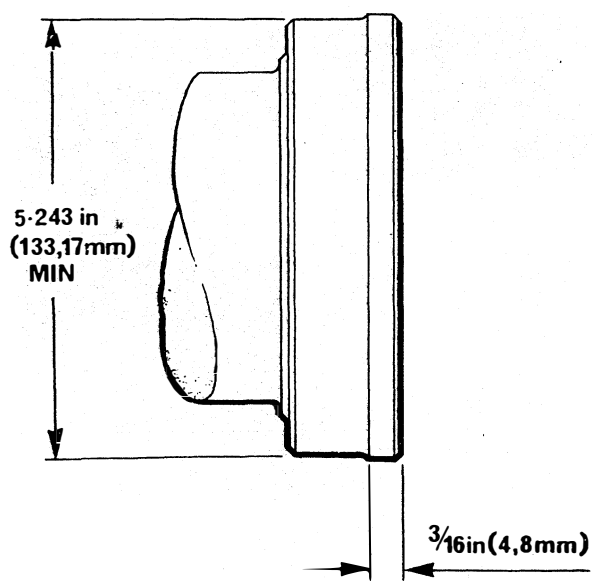


Fig. J10

Crankshaft rear end rope oil seal

This consists of a two piece housing which goes around the rear of the crankshaft which has a spiral oil groove machined to a depth of 0,10 to 0,20 mm (0.004 to 0.008 in) to return the lubricating oil to the inside of the housing. The bore of the housing is machined to take a rubber insert asbestos seal. The seal consists of two halves, one for each half of the housing.

Fit the seals as follows:-

1. Put one half housing in a vice with the seal recess to the top.
2. Fit 25 mm (1 in) of the seal at each end into the ends of the groove so that each end of the seal extends 0,25/0,50 mm (0.010/0.020 in) above the half housing end face.
3. Press the remainder of the seal into the groove by hand. Start this operation from the centre of the seal. Then use a round shaft to roll in the seal by the use of pressure on its inside diameter.
4. Fit seal to other half housing as already indicated.
5. Clean the half housing faces.
6. Lightly apply jointing compound to both sides of the joint and put the joint in position.
7. Lightly apply jointing compound to the end faces of the half housings.
8. Lubricate the inside diameter of the rope seal with graphite grease.
9. Lubricate the rear end of the crankshaft round the oil groove.
10. Put the half housing in position on the engine. Ensure that the half housing with the oil shroud is in the upper position. Fit all setscrews to cylinder block and bearing cap faces finger tight only.
11. Fit the two bolts which fasten the two housings together and tighten the nuts to 8,13 Nm (6 lbf ft) 0,83 kgf m.
12. Tighten the setscrews in the cylinder block and bearing cap to 16,3 Nm (12 lbf ft) 1,66 kgf m.
13. Tighten the two nuts to 16,3 Nm (12 lbf ft) 1,66 kgf m.

Crankshaft rear end lip seal (earlier type)

On later 3.152 and D3.152 engines and all 3.1522, 3.1524 and T3.1524 engines, a spring loaded lip seal is fitted round the rear flange of the crankshaft.

Damage can easily occur with the lip seal and extreme care must be used when the lip seal and housing are fitted.

With a new engine, the lip seal is fitted with its rear face in line with the rear face of the oil seal housing (see fig. J9). If a new seal is fitted to a worn crankshaft, the seal can be pressed further into the housing to 3 mm (1/8 in) below the housing rear face or, if this position has been used, to 6 mm (1/4 in) below the housing rear face. Lubricate the seal with clean engine lubricating oil before it is pressed into the housing and ensure that it is pressed in squarely. If all three positions have been used, the worn seal area of the flange (not the spigot area on which the flywheel fits) can be machined (see fig. J10).

Fit the seal and housing by the use of the seal guide PD.145 as follows:-

Clean faces of cylinder block, oil seal housing and outside diameter of the crankshaft flange.

Ensure that the two dowels are fitted in the cylinder block. Apply jointing compound to both sides of the joint and position the joint over the dowels.

Lubricate crankshaft flange, seal and seal guide with clean engine lubricating oil. Lubrication of the seal is necessary to prevent damage that can be caused if the seal is run dry.

Push seal and housing on seal guide, fit guide on crankshaft flange and press seal and its housing into position on flange. Ensure the housing fits on the dowels (see fig. J11).

Remove the guide and fasten the housing with setscrews and washers.

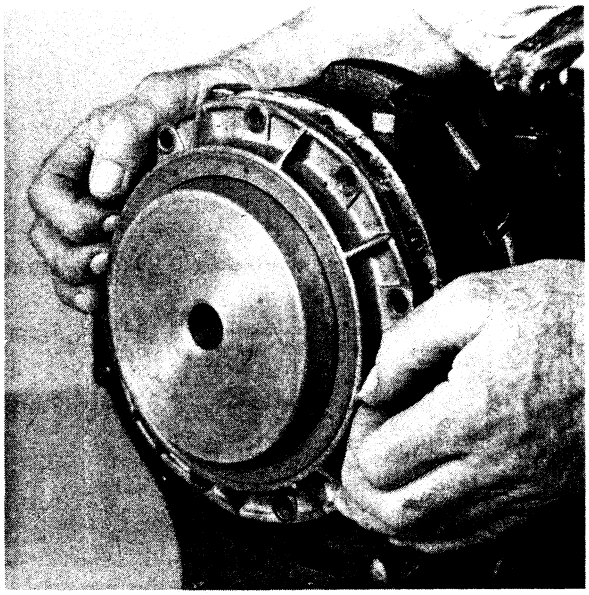


Fig. J11

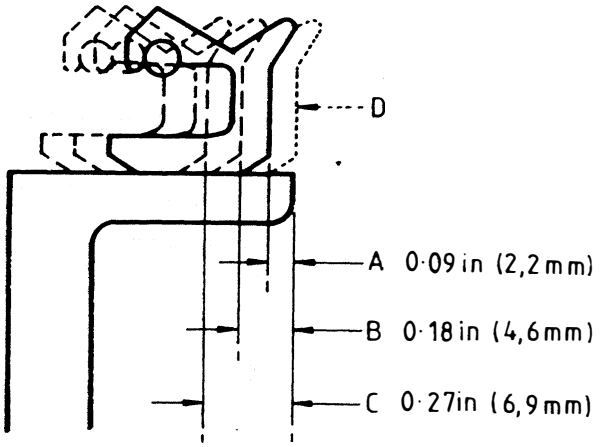


Fig. J12

Crankshaft rear end lip seal (later type)

The later type of spring loaded lip seal has a dust seal lip with a protrusion to the rear face. It is fitted similarly to the earlier lip seal, but the data which follows must be noted.

In the factory, the later seals will now be fitted below the rear face of the seal housing as shown in fig. J12 so that the standard housing assembly can be used on engine applications with an oil filled flywheel housing. Two new service positions have been introduced with the later seal position and these are also suitable for use with the earlier seal where it is fitted level with the rear face of the housing. Tool PD145C is suitable for both earlier and later seals. Tool PD145 can not be used with the later seals without modification.

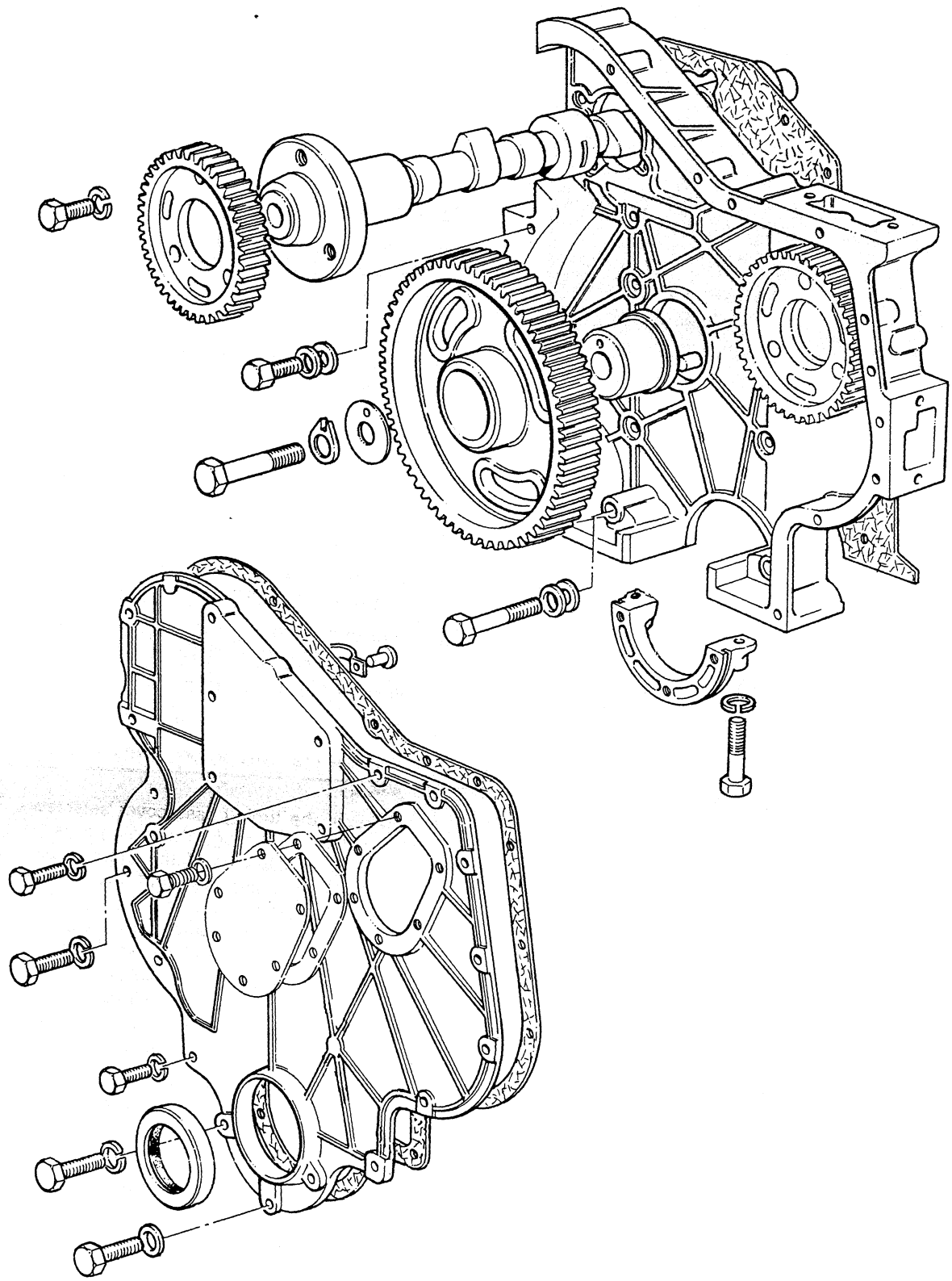
A. Seal position as fitted in the factory.

B. First service position.
This can be used when the original seal is renewed (original seal fitted at position A or level with rear face of the housing) without modification to the crankshaft palm. Do not use if the earlier seal has been fitted 3,2 mm (⅛ in) below the housing face.

C. Second service position.
This can be used when positions A and B have already been used without modification to the crankshaft palm. Do not use if the earlier seal has been fitted 6,4 mm (¼ in) below the housing face.

D. Extra service position.
This can be used for engines with dry flywheel housings if a new crankshaft is fitted or the crankshaft palm has been corrected, but ensure that the seal is fitted squarely in the housing.

SECTION K
Timing Case and Drive



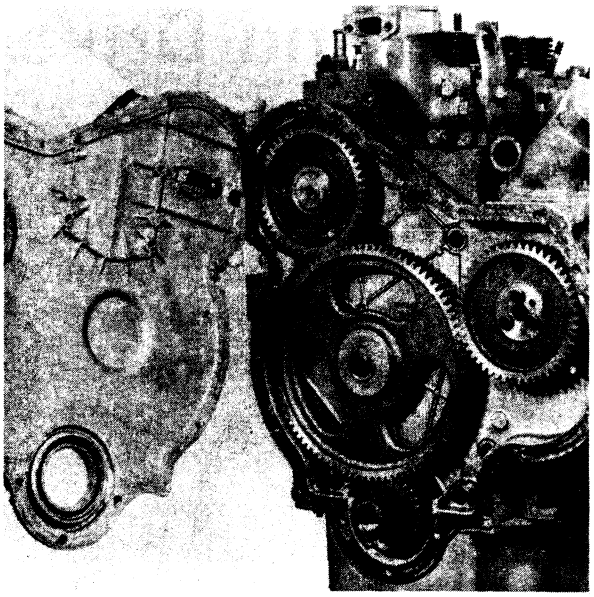


Fig. K1

Timing case and drive

The camshaft is installed in a high position on the right side of the cylinder block. This arrangement does not need push rods.

The camshaft and fuel pump drive are through an idler gear from the front of the crankshaft.

The timing gears are installed in a timing case and cover.

Camshaft bush – No. 1 bearing

With some D3.152 engines and all 3.1522, 3.1524 and T3.1524 engines, the No. 1 camshaft journal runs in a bush fitted in the front of the cylinder block.

This bush can be removed with a suitable tool and adaptor and a new pre-finished bush fitted. The bush must be fitted with the word FRONT to the front of the cylinder block and the hole drilled in the bush in line with the hole drilled in the cylinder block.

To remove timing case cover

1. Loosen the bolts which hold the dynamo or alternator and remove the fan belt.
2. Loosen the hose clips on hoses fitted to the water pump and remove the water pump.
3. Remove the crankshaft pulley.
4. Remove the dynamo or alternator.
5. Remove the dynamo or alternator bracket and linkage.
6. Remove the timing case cover setscrews. Two long bolts go through the timing case to fasten a cover at the rear of the timing case which seals off the power take off bore. There are also two long bolts which go through the timing case to fasten the dynamo or alternator bracket. There is another long bolt which goes through the timing case cover above the position of the dynamo or alternator bracket. The bottom setscrew below the front oil seal is fitted with an aluminium or copper washer.
7. Remove timing case cover (see fig. K1). Ensure that no damage occurs to the front oil seal.

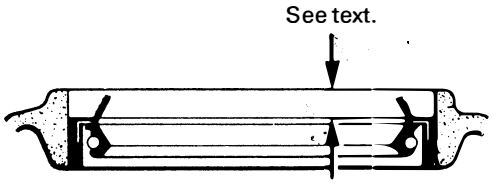


Fig. K2
Crankshaft Front Oil Seal Position

To renew crankshaft front oil seal

1. Press out old seal from timing case with a support under the seal housing.
2. Press in new seal with spring loaded lip towards inside of cover.

Note: Early engines were fitted with a black nitrile seal with no dust lip protrusion and a crankshaft oil thrower.

Later engines had a red silicone seal with a dust seal protrusion and a distance piece was fitted instead of an oil thrower.
The depths of these seals from the front of the cover must be as follows (see fig. K2).
3.152, D3.152 Ind., 3.1522, 3.1524 and T3.1524 engines – 15,88 mm (0.625 in)
D3.152 Ag. and marine engines – 11,91 mm (0.469 in)
AD3.152 and A3.152 engines – 11,43 mm (0.450 in)
Current engines are fitted with a black 'Viton' seal with a dust seal protrusion and the depths of these seals from the front face of the cover must be as follows (see fig. K2).
All engine types except marine – 9,35 mm (0.375 in)
All marine engines – 11,83 mm (0.465 in)

3. Fit the timing case cover to the timing case by the use of two opposite setscrews loosely tightened. Ensure that the cover is correctly aligned by the use of centralising tool PD159 on the crankshaft and in the seal housing and tighten the assembly by the crankshaft pulley setscrew and washer. Do not apply too much force on the setscrew. Tighten all the timing cover setscrews and nuts and remove the tool. If the centralising tool is not available, the crankshaft pulley can be used to align the cover, but as this method uses the inside diameter of the seal which is soft, the cover can be out of alignment which can cause leakage.

Timing gears

The camshaft and fuel injection pump gears are driven by an idler gear from the front of the crankshaft. All the gears are stamped with marks to ensure correct timing. These marks are made with No. 1 piston at TDC on its compression stroke. These timing marks will not align at every rotation of the crankshaft when No. 1 piston is at TDC on its compression stroke because the gears turn at different speeds.

If any of the timing gears are renewed, ensure that there is a minimum backlash of 0,08 mm (0.003 in) – see fig. K3.

To remove idler gear and hub

1. Turn the crankshaft until the timing mark teeth of the crankshaft and camshaft gears are in mesh with the idler gear.
2. Release locking washer on the setscrew which fastens idler gear and remove setscrew, locking washer and idler gear end plate.
3. Remove idler gear from its hub (see fig. K4).
4. Remove idler gear hub from its bore in the timing case. (See fig. K4A).

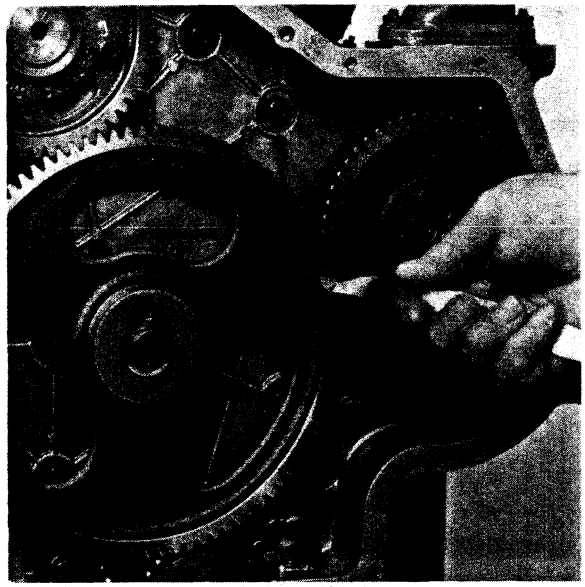


Fig. K3

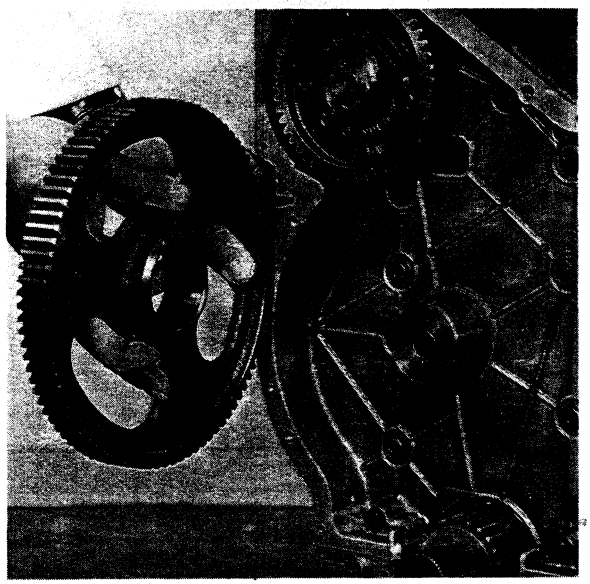


Fig. K4

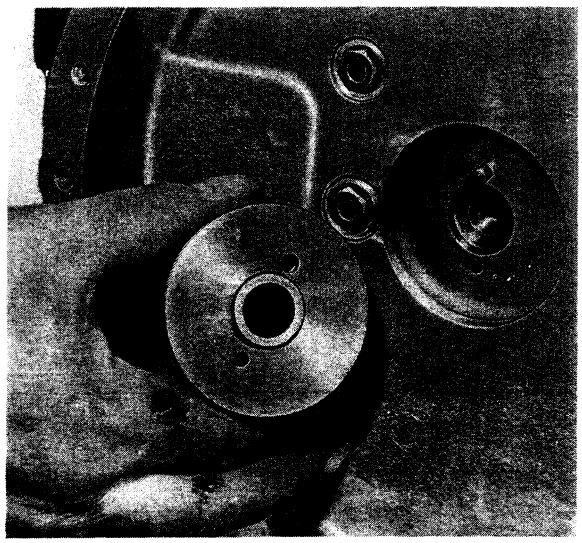


Fig. K4A

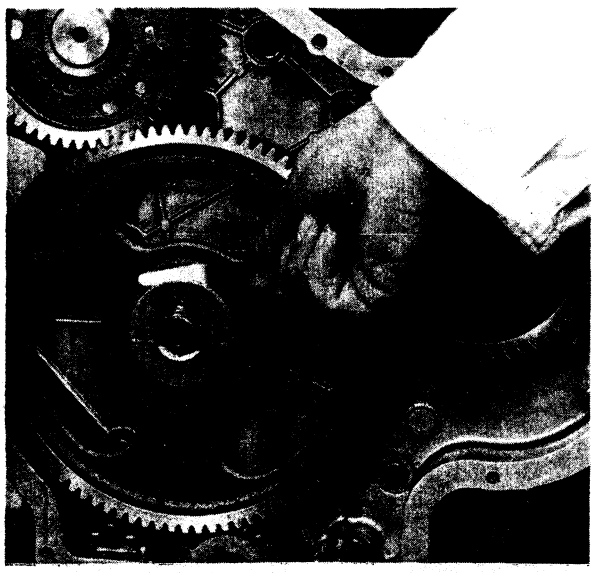


Fig. K5

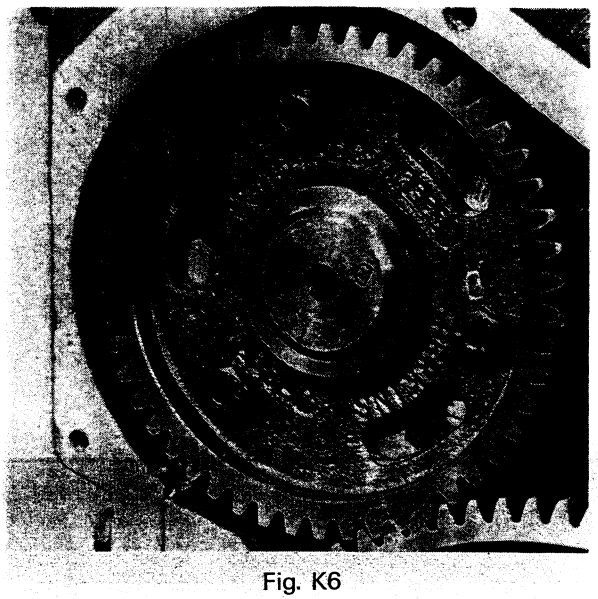


Fig. K6

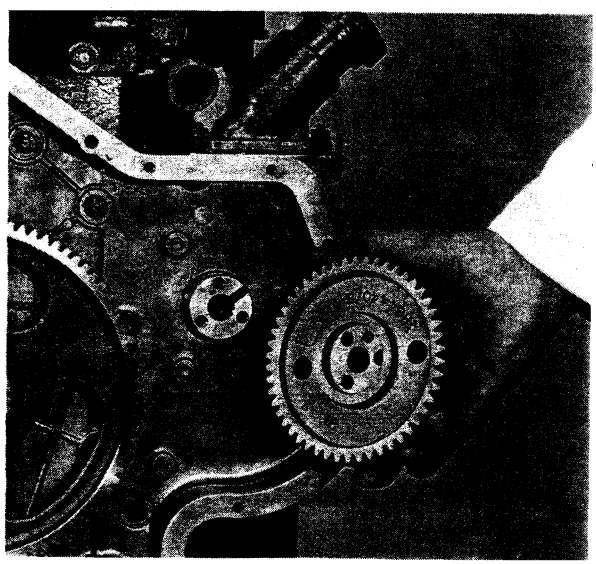


Fig. K7

To fit idler gear and hub

1. Ensure that the crankshaft, camshaft and fuel injection pump gears are in a position as shown in fig. L1 with the marks on the teeth towards the idler gear position. If the crankshaft or camshaft has to be turned, it will be necessary to remove the rocker shaft to ensure a piston does not contact a valve.
2. Fit idler gear hub so that small hollow dowel locates in hole in hub. The hub should be in its fully fitted position in the bore of the timing case.
3. Fit idler gear on hub with the long tapered centre boss towards the cylinder block and the timing marks aligned.
4. Fit idler gear end plate, locking washer and setscrew. Fully tighten setscrew and bend up locking washer. Ensure that idler gear has end clearance on hub (see fig. K5). End clearance must be 0,13 to 0,38 mm (0.005 to 0.015 in).

To remove camshaft gear

1. Turn crankshaft until timing mark teeth of crankshaft and camshaft gears are in mesh with idler gear.
2. Remove the three setscrews and washers which fasten gear to camshaft.
3. Remove camshaft gear from camshaft.

To fit camshaft gear

1. Remove idler gear and if necessary, remove rocker shaft to permit camshaft to be turned.
2. The spigot of the camshaft is stamped with the letter "D" and the camshaft gear is also stamped with the letter "D" (see fig. K6). Fit camshaft gear to camshaft with the letters "D" aligned. Do not fasten gear to camshaft by use of the slotted holes.
3. Fit and tighten the three washers and setscrews.
4. Turn camshaft until Nos. 4 and 6 cams are to the top. This can be checked by inspection of the tappets and this is the approximate position to align the timing marks.
5. Fit idler gear with all timing marks aligned and where necessary, fit rocker shaft.

To remove fuel injection pump gear

1. Turn crankshaft until timing mark tooth on fuel injection pump gear is in mesh with idler gear.
2. Remove the idler gear.
3. Remove setscrews or nut which fasten fuel injection pump gear.
4. Remove the fuel injection pump gear (see fig. K7). Ensure that no damage occurs to the dowel or key.

Note: Some engines are fitted with a fuel injection pump that has a tapered drive shaft which has a keyway and a single nut to fasten the gear. To remove the gear, use puller tool PD155B and metric adaptors PD155B-5.

To fit fuel injection pump gear

1. Where necessary, fit dowel to fuel injection pump gear.
2. Fit gear. Ensure dowel is in correct location between gear and fuel injection pump.
3. Fit and tighten washers and setscrews or nut. Tighten nut to the torque given on page C3.
4. Fit idler gear. Ensure all timing marks align.

To remove camshaft

1. Remove rocker shaft assembly.
2. Turn crankshaft until timing mark teeth of crankshaft and camshaft gears are in mesh with idler gear.
3. Remove fuel lift pump (see Section P).
4. Lift the tappets and remove the camshaft and gear from the cylinder block (see fig. K8). Ensure that no damage occurs to journals, cams or tappets.

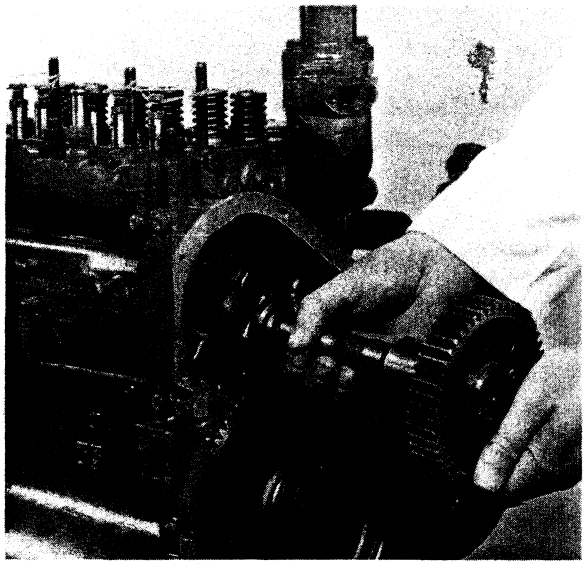


Fig. K8

To fit camshaft

1. Where necessary, remove idler gear and put into position with timing mark teeth aligned with timing mark teeth of crankshaft and fuel injection pump gears.
2. Lift tappets and carefully fit camshaft and gear. During this operation, the camshaft must be continuously turned. Ensure that no damage occurs to journals, cams or tappets. Ensure that the timing marks on idler gear and camshaft gear are correctly aligned.
3. Fit fuel lift pump.
4. Fit rocker shaft assembly and adjust tappet clearances.

Camshaft thrust

The camshaft end clearance is controlled by a steel spring fitted to the inside of the timing case cover. This is shown in fig. K1.

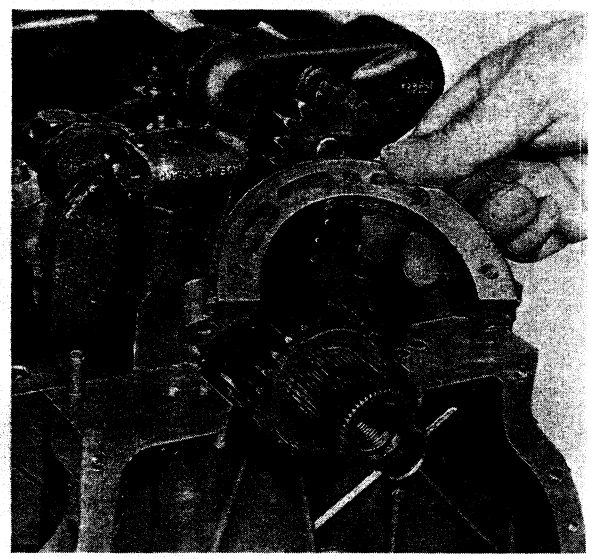


Fig. K9

To remove timing case

1. Remove timing case cover.
2. Remove rocker shaft aasembly.
3. Remove lubricating oil sump (see Section M).
4. Remove timing case bottom cover (see fig. K9).
5. Remove idler gear as already given. It is easier to remove the idler gear hub when the timing case has been removed.
6. Remove fuel lift pump.
7. Lift tappets and remove camshaft and gear. Ensure that no damage occurs to journals, cams or tappets.
8. Release the three setscrews or nut and remove the gear from the fuel injection pump.

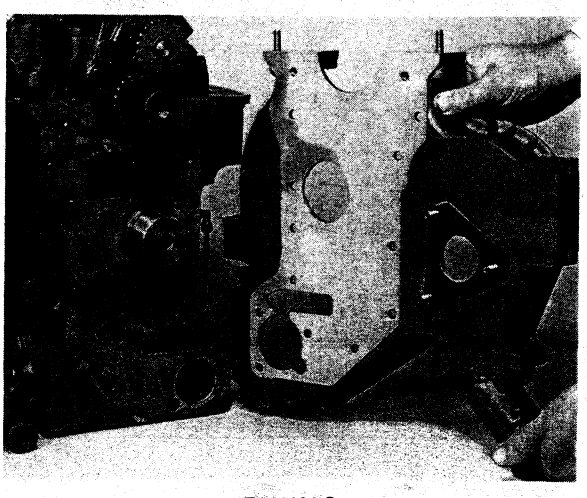


Fig. K10

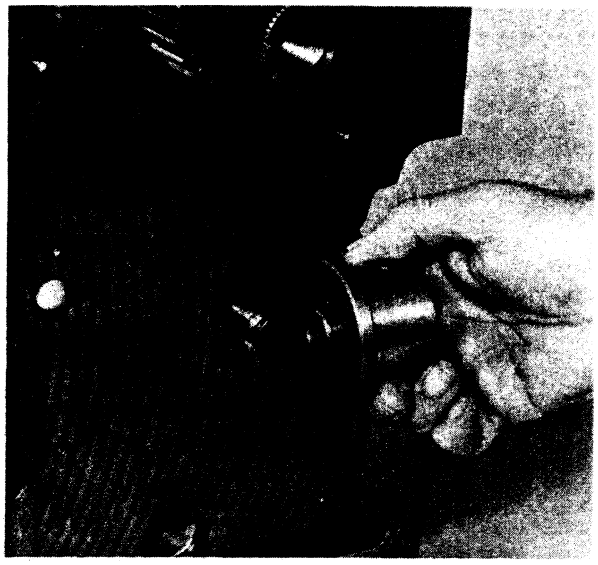


Fig. K11

Fig. K12

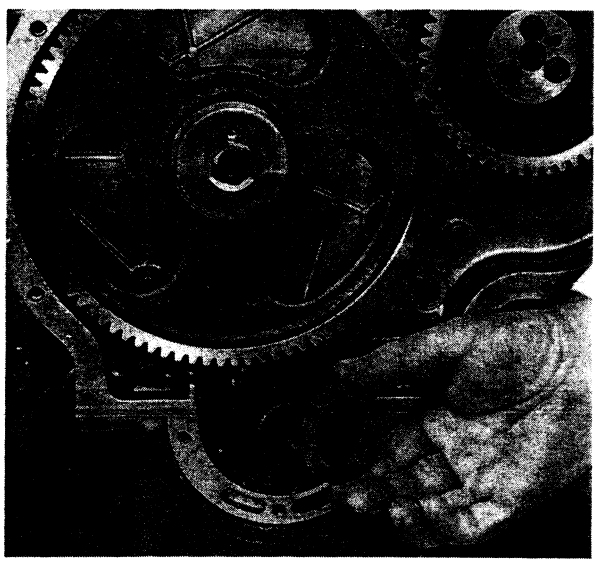


Fig. K13

9. Remove all controls and pipes from injection pump. To remove the high pressure pipes from the pump, release the pipes at the atomiser end first and then remove the pipes completely.
10. Remove the three nuts, spring washers and plain washers which fasten the fuel injection pump flange to the timing case and remove the pump. Ensure that all inlet and outlet connections of the fuel injection system are sealed to prevent dust or dirt contamination.
11. Remove setscrews and washers which fasten timing case to cylinder block and by means of light force, remove timing case from block (see fig. K10).
12. Remove idler gear hub (see fig. K11).

To fit timing case

1. To ensure correct location of timing case, fit and fully fasten idler gear hub to cylinder block (see fig. K11).
2. Use a new joint and fit the timing case to the front face of the cylinder block.
3. Fit timing case bottom cover. Ensure it is correctly aligned with front face of timing case (see fig. K12).
4. Fit fuel injection pump to rear face of timing case. Ensure that timing marks on pump flange and rear face of timing case are aligned.
5. Turn crankshaft until No. 1 piston is at TDC (key at front of crankshaft in top position).
6. Fit gear to fuel injection pump. Ensure dowel or key between gear and pump is in correct location.
7. Lift tappets and fit camshaft and gear.
8. Fit idler gear on its hub. Ensure that the timing mark teeth on crankshaft, fuel injection pump and camshaft gears are aligned with timing mark teeth of idler gear.
9. Fit lubricating oil sump (see Section M).
10. Where necessary, fit crankshaft pulley distance piece or oil thrower (see fig. K13).
11. Fit timing case cover.
12. Fit controls and pipes to fuel injection pump.

New timing case

When a new timing case is fitted, this will not be marked on the rear face for the correct alignment of the fuel injection pump.

After a new timing case has been fitted, the fuel injection pump timing must be checked by one of the two methods given in Section L and the rear of the timing case stamped with a timing mark to align with the timing mark on the fuel pump flange or straight edge of the timing tool pointer (see fig. L8).

SECTION L
Timing

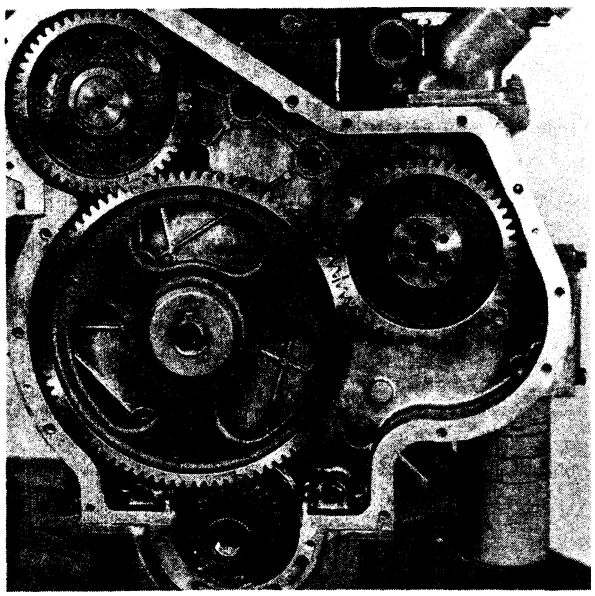


Fig. L1

Gear timing marks

The timing gears are stamped with timing marks to ensure correct assembly (see fig. L1).

See Section K for gear assembly instruction.

Fuel injection pump timing marks

A timing mark is stamped on the fuel injection pump flange and a further mark is stamped on the rear face of the timing case (see fig. L2). If these marks are in alignment and the fuel pump gear is in correct mesh, then the fuel pump timing is correct.

To set engine timing

1. Remove atomisers.
2. Remove rocker shaft assembly.
3. Turn crankshaft so that the crankshaft gear key is at TDC.
4. Fit camshaft gear with the letter "D" in alignment with the letter "D" on the camshaft hub.
5. Fit fuel injection pump gear. This has a dowel and will only fit in one position.
6. Ensure that fuel injection pump is fitted to engine with the timing mark on the flange in alignment with the timing mark on the rear of the timing case (see fig. L2).
7. Fit idler gear with all timing marks on teeth of gears aligned (see fig. L1).

To check valve timing

1. Turn engine until No. 3 cylinder exhaust valve is fully open.
2. In this position set the valve tip clearance on No. 1 inlet valve to 1,09 mm (0.043 in) for 3.152 and D3.152 engines or 0,80 mm (0.0315 in) for 3.1522, 3.1524 and T3.1524 engines.
3. Turn engine clockwise from front until tappet of No. 1 inlet valve just tightens.
4. In this position, No. 1 piston will be within 2½° of TDC. This can be checked by a mark on the flywheel or on some applications, a timing pin is fitted to the timing case front cover. When loosened, it locates in a hole in the rear of the crankshaft pulley.
5. There is no adjustment for valve timing. If the timing is more than 2½° out of position, the timing gears are probably not in correct mesh.
6. After the valve timing has been checked, adjust tappet clearance of No. 1 inlet valve to 0,30 mm (0.012 in) for 3.152 and D3.152 engines or 0,20 mm (0.008 in) for 3.1522, 3.1524 and T3.1524 engines.

Fig. L2

To check DPA fuel injection pump timing by use of pump rotor marks

A circlip is fitted inside the fuel injection pump and when the square end of this circlip is aligned with the correct mark on the fuel pump rotor (see fig. L3), it indicates when the injection starts to No. 1 cylinder (static timing point).

With earlier fuel injection pumps, the timing circlip is stamped with a line which aligns with the correct mark on the fuel pump rotor (see fig. L4).

To see these timing marks, remove the inspection plate on the left side of the fuel injection pump body.

To set the timing circlip, remove the fuel injection pump from the engine. Connect No. 1 cylinder outlet to an atomiser tester and operate the tester until it reaches 31 kgf/cm^2 (30 atm or 440 lbf/in^2). Turn the pump by hand, clockwise from the front until it stops. The square end or the line on the circlip can now be adjusted until it aligns with the line marked "E" on the fuel injection pump rotor.

Check the fuel injection timing as follows:-

1. Ensure fuel injection pump circlip is in its correct position as already given.
2. Turn the engine until No. 1 piston is at TDC on compression (exhaust valve of No. 3 cylinder fully open). Remove the valve springs from No. 1 inlet valve and permit it to be held by the top of the piston. Fit a suitable collar at the top of the valve stem so that the valve will not fall completely into the cylinder.
3. Put a dial test indicator on the top of the valve stem (see fig. L5) and use the indicator to find the accurate No. 1 piston TDC position. Set the dial to zero.
4. Turn engine counter-clockwise from the front by an eighth of a turn and then clockwise until the piston is at the static timing position as given on page C14.
5. Check the fuel injection pump rotor. The line with the letter "E" must be aligned with the square end or the line on the circlip (see figs. L3 or L4). If the line on the rotor does not align with the circlip, turn the fuel injection pump in either direction on the rear of the timing case to make the necessary adjustment.

The circlip on current pumps is not set and timing tool MS67B must be used, see page L4.

Note: The seals on the fuel injection pump must only be broken by approved personnel who must also fit new seals.

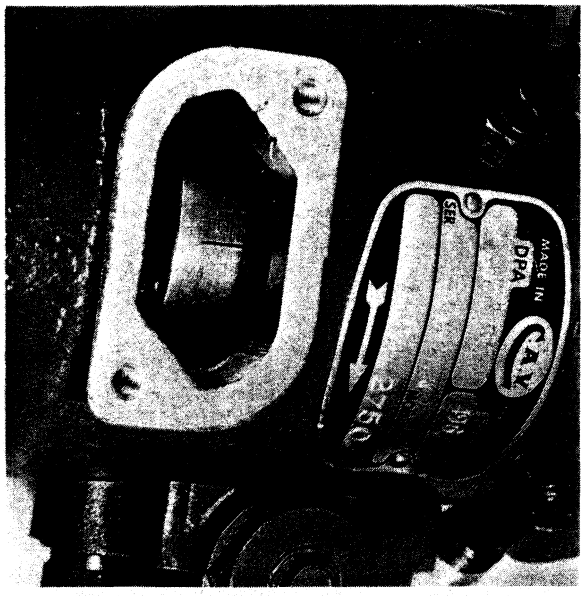


Fig. L3

Fig. L4

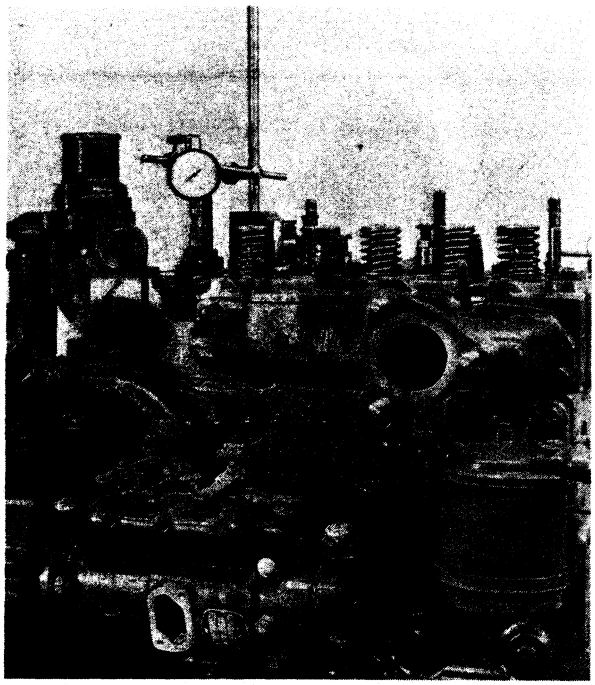


Fig. L5

Fig. L6

To check fuel injection pump timing by use of tools MS.67B and adaptor PD.67B-1 and PD.67-2

1. Turn engine clockwise from front until No. 1 piston is at TDC on compression (exhaust valve of No. 3 cylinder fully open). This position can be found on some applications by a mark on the flywheel, or a timing pin fitted to the timing case front cover which, when loosened, engages in a hole in the rear of the crankshaft pulley. If neither of these methods are available, TDC can be found by the use of a dial test indicator on the top of a valve stem as already given.
2. Remove fuel injection pump and fit adaptor PD.67B-1 (see fig. L6) to fuel injection pump gear. Ensure dowel is in corrct location between gear and adaptor. The shaft of the adaptor must be toward the rear of the engine.

   For pumps with tapered drive shafts, fit adaptor PD.67-2 through hole in rear of timing case and secure with nut to fuel pump gear.
3. Loosen screw (5, fig. L7) of timing tool MS.67B and remove splined shaft (6) (retain for tapered drive shaft pumps). The adaptor ring (1) is not used with this engine type.
4. Ensure pointer (2) of timing tool is in position with right angled straight edge to front of tool and notch at the bottom (see fig. L8). The end of the pointer with the straight edge must be kept away from the front of the body. Ensure that the flat of the washer fitted behind the screw (3) which fastens the pointer, is in position over pointer.
5. Loosen screw (4) which fastens bracket and set bracket so that the edge with a chamfer is in line with the correct engine check angle (see page C14).
6. Press fuel injection pump gear and adaptor towards rear and connect splined shaft of adaptor into timing tool with master spline engaged and lock adaptor shaft in timing tool with rear face of adaptor against front face of timing tool.
7. Move tool forward complete with gear so that spigot of the tool fits in the hole in the timing case. For pumps with tapered drive shafts, fit timing tool in fuel pump position, slide splined shaft (6) forward into adaptor and lock with screw (5) (see figs. L7/L8). If pointer is 180° out of position, the engine is on the wrong stroke. Remove the tool and set engine on correct stroke. The fuel injection pump gear must be held in mesh when the engine is turned.
8. Move the pointer forward to reach rear face of timing case and lock in position.
9. Turn tool clockwise from rear to remove backlash and check that mark on rear of timing case aligns with straight edge of the pointer (see fig. L8). Make a new line if necessary or, if there is

no line, make a line along the straight edge of the pointer. If line is 7° or more from the straight edge, this indicates that gears are probably not correctly fitted and the timing of the gears must be checked.

10. Remove tool and adaptor from the fuel injection pump gear and fit fuel pump to engine as given on page P7.

To check mark angle of DPA fuel injection pump by use of tool MS.67B and adaptor PD.67-3

1. Loosen screw (5, fig. L7) and put the splined shaft with the small diameter to the rear to fit in the centre of the fuel injection pump hub. For pumps with tapered drive shafts remove splined shaft.
2. Ensure that pointer (2) of timing tool is in a position with slot to rear of tool and sides of the slot with chamfers are on the outside. The end of the pointer with the slot must be kept toward body of tool. Ensure that the flat of the washer fitted behind the screw (3) which fastens the pointer is in position over pointer.
3. Release screw (4) which fastens bracket and set bracket so that the edge with a chamfer is in line with the correct fuel injection pump mark angle (see page C14).
4. Fit timing tool with splined shaft in fuel injection pump hub and move tool toward the fuel pump to connect on the end of the hub and lock shaft in tool (see fig. L9). For pumps with tapered drive shafts, fit adaptor PD.67-3 onto drive shaft key and then locate timing tool over adaptor and drive shaft.
5. Connect No. 1 cylinder outlet to an atomiser tester and operate the tester until it reaches 31 kgf/cm^2 (30 atm or 440 lbf/in^2). If pressure valve is fitted, this must be removed.
6. Turn pump clockwise from the front until it stops.
7. Move pointer forward until it is half over pump flange. Check that timing mark is central to slot in pointer. Make a new timing mark if necessary.

To check mark angle of Stanadyne Fuel injection pump by use of tool MS.67B and adaptor PD.67B-1 and PD.67B-6.

1. Fit the adaptor PD.67B-1 to the hub of the pump by use of the special setscrews (part of tool PD.67B-6). Ensure that the location slots of the hub and adaptor are together and in line (use the alignment gauge, part of tool PD.67-6) and that the adaptor is concentric with the hub.

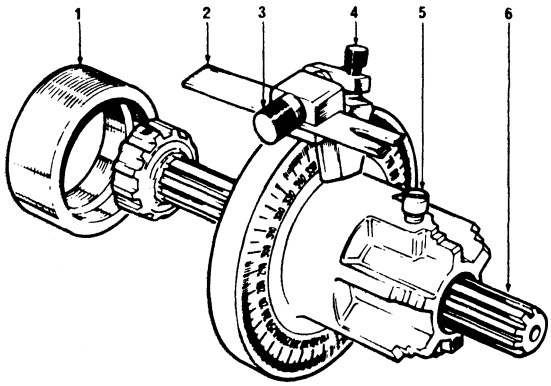


Fig. L7
Timing Tool

1. Adaptor Ring
2. Pointer
3. Pointer Securing Screw
4. Bracket Securing Screw
5. Shaft Securing Screw
6. Splined Shaft

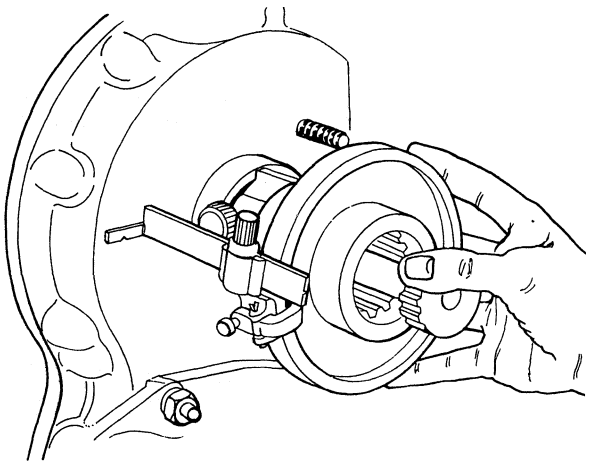


Fig. L8

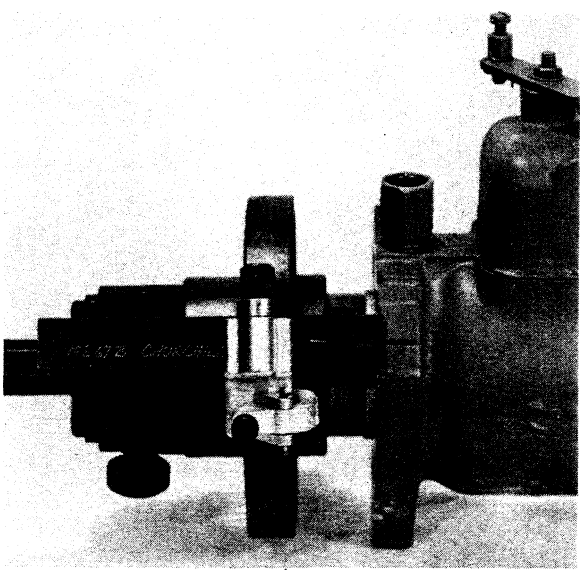


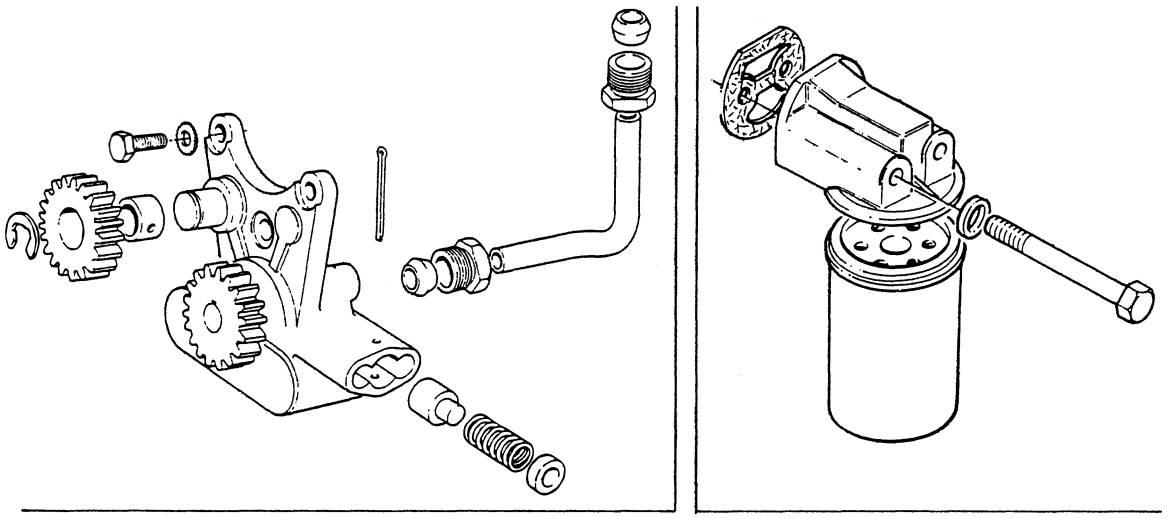
Fig. L9

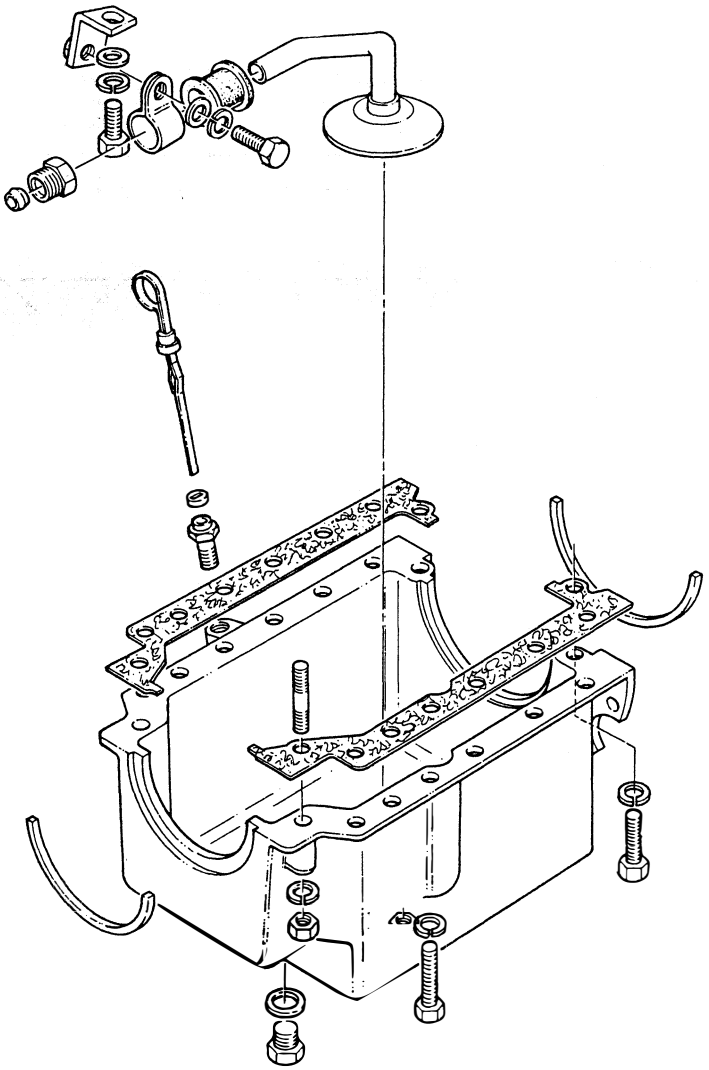
2. Remove the splined shaft from the timing tool (MS.67B) and slide the small splined open end of the timing tool onto the splined shaft of adaptor PD.67B-1. Lock the timing tool into position with securing screw (5, fig. L7).
3. Ensure the long pointer, part of tool PD.67B-6 is in position and sides of slot with chamfers are on the outside. Ensure that the flat of the washer fitted behind the screw (3, fig. L7) which fastens the pointer is in position.
4. Release screw (4, Fig. L7) which fastens bracket and set bracket so that the edge with a chamfer is in line with the correct fuel injection pump mark angle (see page C14).

Note: As the tool will have to be fitted in the reverse position to normal, the setting angle has been adjusted to allow for this (see page C14).

5. Connect No. 1 cylinder outlet to an atomiser tester and operate the tester until it reaches 31 kgf/cm^2 (30 atm or 440 lbf/in^2). If a pressure valve is fitted, this must be removed.
6. Turn pump clockwise from the front until it stops.
7. Move pointer forward until it is half over pump flange. Check that timing mark is central to slot in pointer. Make a new timing mark if necessary.

SECTION M
Lubrication System





Lubrication circuit

The lubrication circuit is shown in fig. M1.

Pressure lubrication is supplied by a rotor type pump driven through gears from the front of the crankshaft. The lubricating oil is sent through a full flow filter to the pressure rail which is horizontally drilled along the left side of the cylinder block. From the pressure rail, lubricating oil passes to the crankshaft main bearings and through the crankshaft to the big end bearings. On T3.1524 engines, lubricating oil is passed from the filter head/pressure rail connection, to the turbocharger bearings. The cylinder bores, pistons and small end bushes are lubricated by splash.

A hole is drilled across the front of the cylinder block which connects with the pressure rail. Lubricating oil comes out of this hole on the camshaft side of the engine and passes through an outside pipe to the lower connection of the centre camshaft bearing. With some engines, oil is also passed to the front camshaft bearing.

As the camshaft turns, a slot in the camshaft centre journal aligns with two holes in the camshaft bearing and a reduced lubricating oil supply passes to the cylinder head through another outside pipe to lubricate the rocker shaft assembly. From the rocker shaft assembly, oil falls from the cylinder head into the camshaft chamber and from the front of the chamber to the timing gears. The timing gears are also lubricated by oil which passes from the horizontal passage at the front of the cylinder block to the idler gear hub. Oil then passes from the hub through a hole in the idler gear boss.

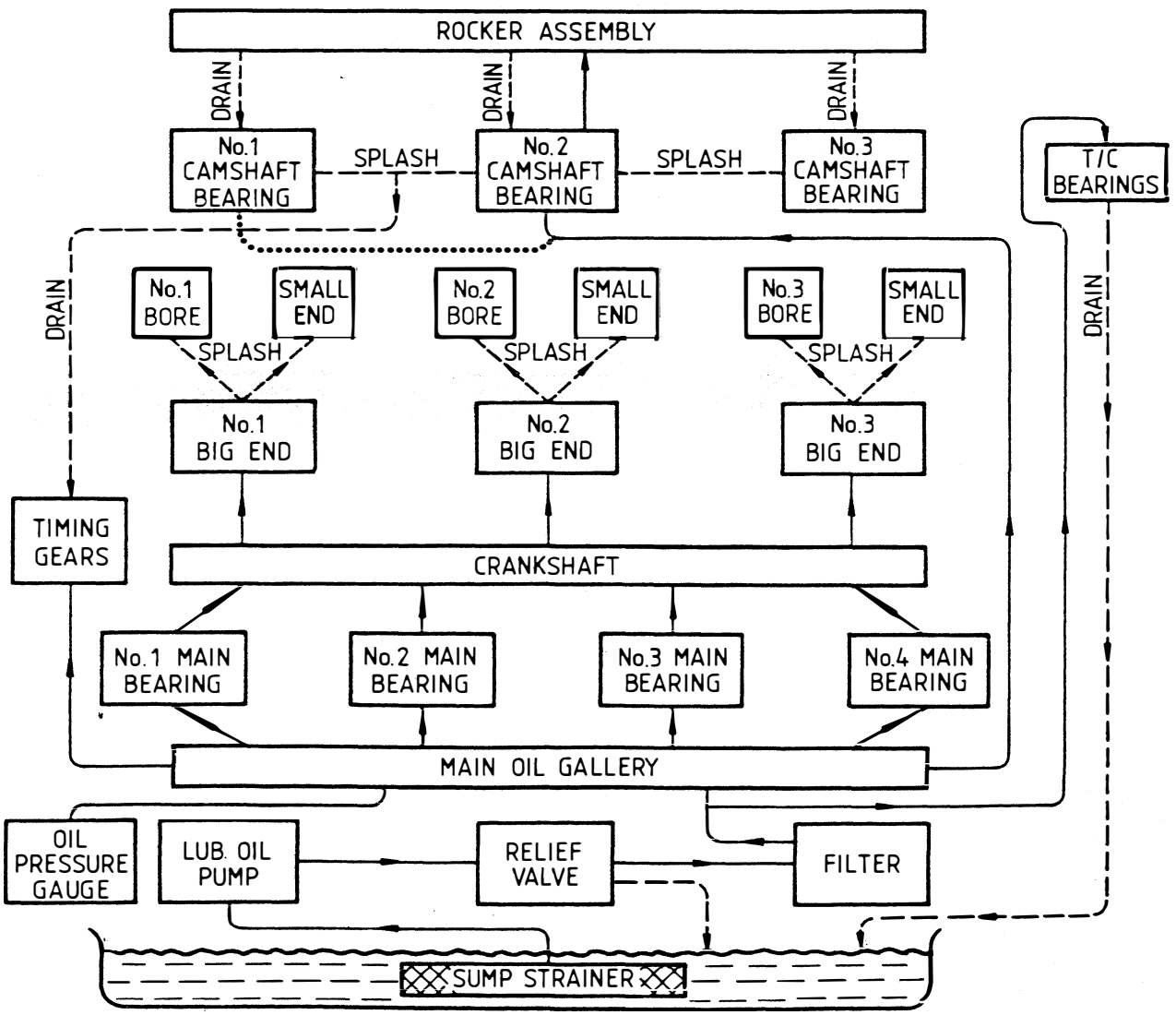


Fig. M1
Lubricating Oil Diagram

Lubricating oil pressure

Ensure that lubricating oil pressure is shown on the gauge.

The oil pressure can be variable with different engines, but the minimum pressure at maximum engine speed and normal engine temperature is 207 kN/m² (30 lbf/in²) or 2,1 kgf/cm².

There can be a decrease in pressure when idling and when the engine is hot.

If the lubricating oil pressure shown on the gauge is below normal, check for the reason in the order which follows.

1. Check for correct amount of lubricating oil in sump.
2. Check oil pressure for accuracy.
3. Ensure lubricating oil filter is not dirty. If necessary, fit new canister or element.
4. Ensure sump strainer is not dirty. Clean if necessary.
5. Ensure that suction and delivery pipes to and from lubricating oil pump are tight.
6. Dirt can keep the lubricating oil relief valve open.

Lubricating oil filters

It is important that the lubricating oil filter canister or element is renewed at the correct interval as given on page D2.

The strainer in the lubricating oil sump needs no special maintenance but can be cleaned every time the sump is removed.

With current engines, the main lubricating oil filter has an element which is integral with the canister.

Earlier engines had a separate element fitted in a filter bowl.

Both types of element must be renewed and not cleaned. The correct service interval is given on page D2.

To renew lubricating oil filter element

1. Remove centre bolt on filter head (see fig. M2).
2. Remove filter bowl (see fig. M3).
3. Remove the filter element and discard.
4. Clean inside of filter bowl and fit new element.
5. Ensure that felt seal and rubber joints are in good condition. Renew them if necessary.
6. Fit element and bowl to filter head and tighten centre bolt.
7. Run engine and check for leakage. Check amount of lubricating oil in sump and fill as necessary.

The bolt which fastens the filter bowl must be checked to ensure that it is still tight after the first 20 hours of operation.

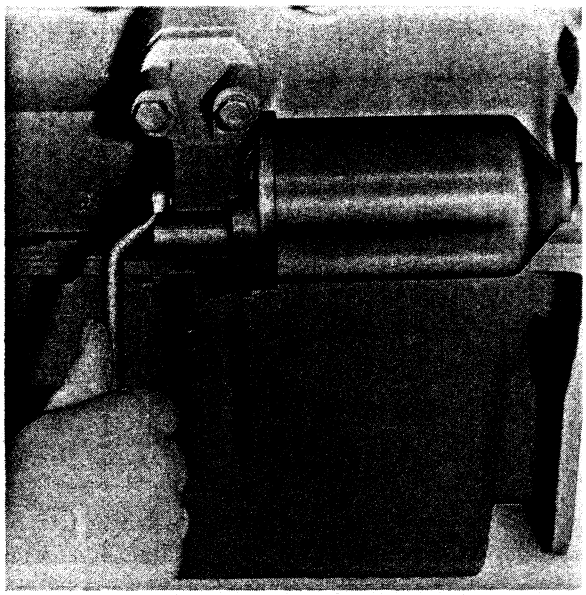


Fig. M2

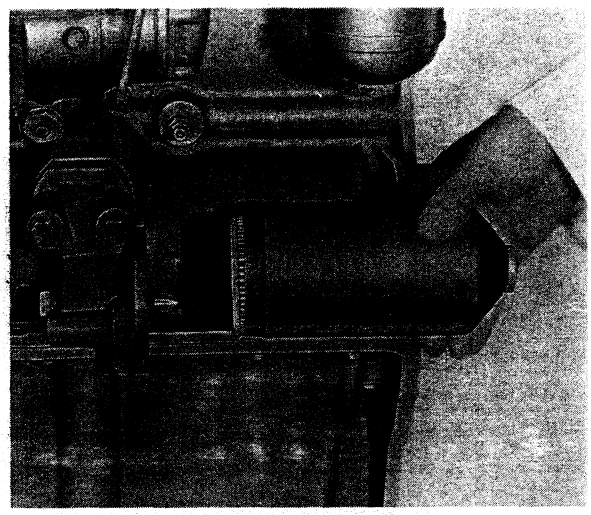


Fig. M3

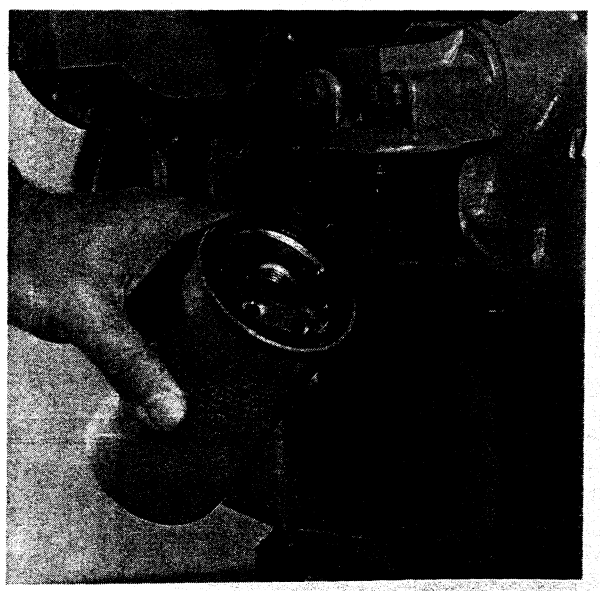


Fig. M4

Fig. M5

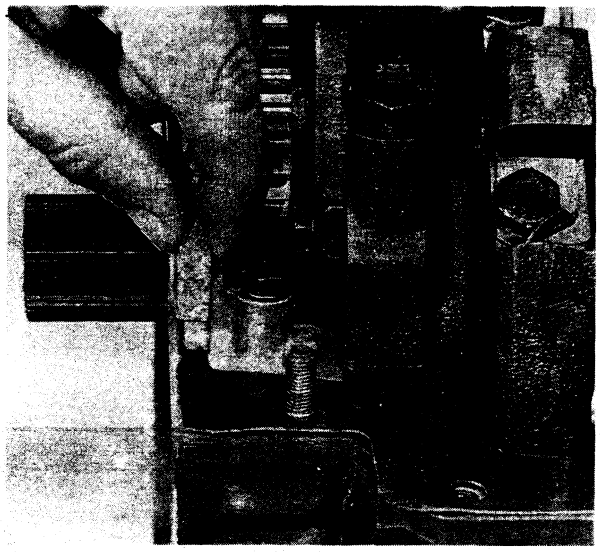


Fig. M6

Fig. M7

To renew lubricating oil filter canister

1. Remove the filter canister with a strap wrench or similar tool and discard the canister (see fig. M4).
2. Clean the filter head.
3. Add clean engine lubricating oil to the new canister. Give the oil time to fill the canister through the filter element.
4. Lubricate the top of the canister seal with clean engine lubricating oil.
5. Install the new canister and tighten it by hand only. Do not use a strap wrench.
6. Run engine and check for leakage. Check amount of lubricating oil in sump and fill as necessary.

Note: Always ensure that the correct type of canister is fitted.

Lubricating oil relief valve

The lubricating oil relief valve is fitted in the lubricating oil pump body (see fig. M5) and prevents too much pressure when the lubricating oil is cold.

It consists of a spring loaded plunger.

When the lubricating oil pressure is more than the valve setting pressure, the valve opens and some of the lubricating oil is released to return to the sump. When the oil gets warm and reaches the correct pressure, the valve then closes.

Only adjust the pressure setting by the use of new parts.

To remove lubricating oil sump

1. Remove the drain plug and drain the sump.
2. Remove the dipstick.
3. Where necessary, remove setscrews which fasten rear of sump to flywheel housing.
4. Remove all setscrews and nuts which fasten sump to cylinder block and timing case and remove sump.

To fit lubricating oil sump

1. Ensure that all joint faces are clean. Fit new joints with jointing compound applied.
2. Put sump joints in position. Ensure that the ends of the joints fit into the recesses for the cork joints.
3. Fit cork joints in the recesses in the timing case and rear main bearing cap (see fig. M6).
4. Fit sump and tighten all setscrews and nuts.
5. Fit the sump drain plug and dipstick.
6. Fill the sump to the correct level with engine lubricating oil. Run the engine and check for leakage.

To remove lubricating oil pump

1. Remove lubricating oil sump as shown earlier.
2. Remove the three setscrews at bottom of timing case front cover and the two nuts at bottom of timing case. Remove bottom half of timing case.
3. Remove pump suction pipe and strainer and disconnect delivery pipe from pump to cylinder block.
4. Remove circlip and move idler gear forward.
5. Remove the three setscrews which fasten lubricating oil pump to front main bearing cap and remove the pump (see fig. M7).

To dismantle lubricating oil pump

1. Remove idler gear.
2. The lubricating oil pump gear must not be removed as this can reduce the interference fit of the gear. A pump which is worn can not be corrected as separate parts are not available.
3. Remove the three screws with a special screwdriver and remove the pump end plate.
4. Remove rubber sealing ring – where fitted (see fig. M8).
5. Remove outer rotor from pump body.
6. The lubricating oil relief valve is fitted in the body of the oil pump. It is adjusted before the engine goes out from the factory.

Lubricating oil pump inspection

The clearances for new pumps are given in Section C.

1. Thoroughly clean all parts and check for cracks and other damage.
2. Install outer rotor in pump body. Ensure edge of rotor with chamfer is to the inside of the pump body. Check clearance between maximum diameter of inner rotor and minimum diameter of outer rotor at all positions (see fig. M9).
3. Check the clearances between top of rotors and end of pump body (see fig. M10).

Note: If an oil pump is worn so that it does not give the correct lubricating oil pressure, it must be renewed. Component parts are not supplied separately.

To assemble lubricating oil pump

1. Fit outer rotor in pump body with edge of rotor with chamfer to the inside of the body.
2. Fit rubber sealing ring – where fitted.
3. Fit end cover and tighten screws.

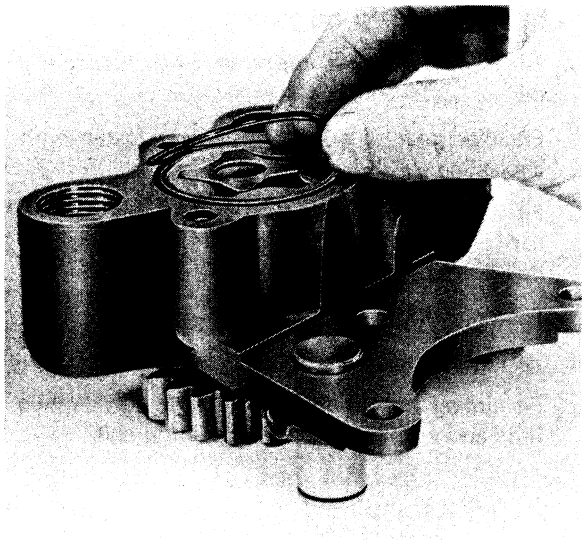


Fig. M8

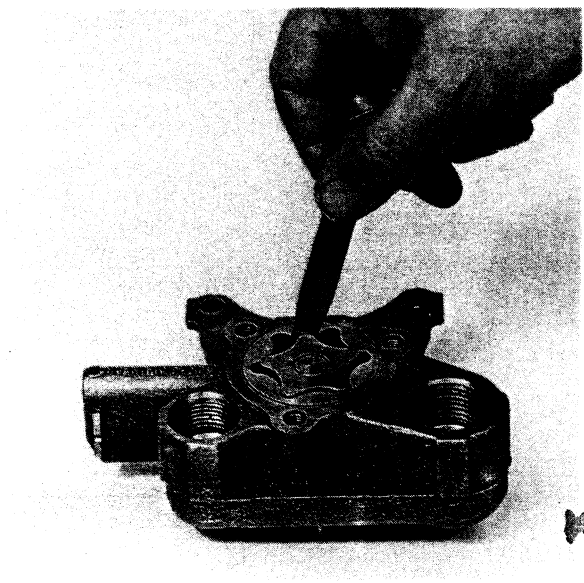


Fig. M9

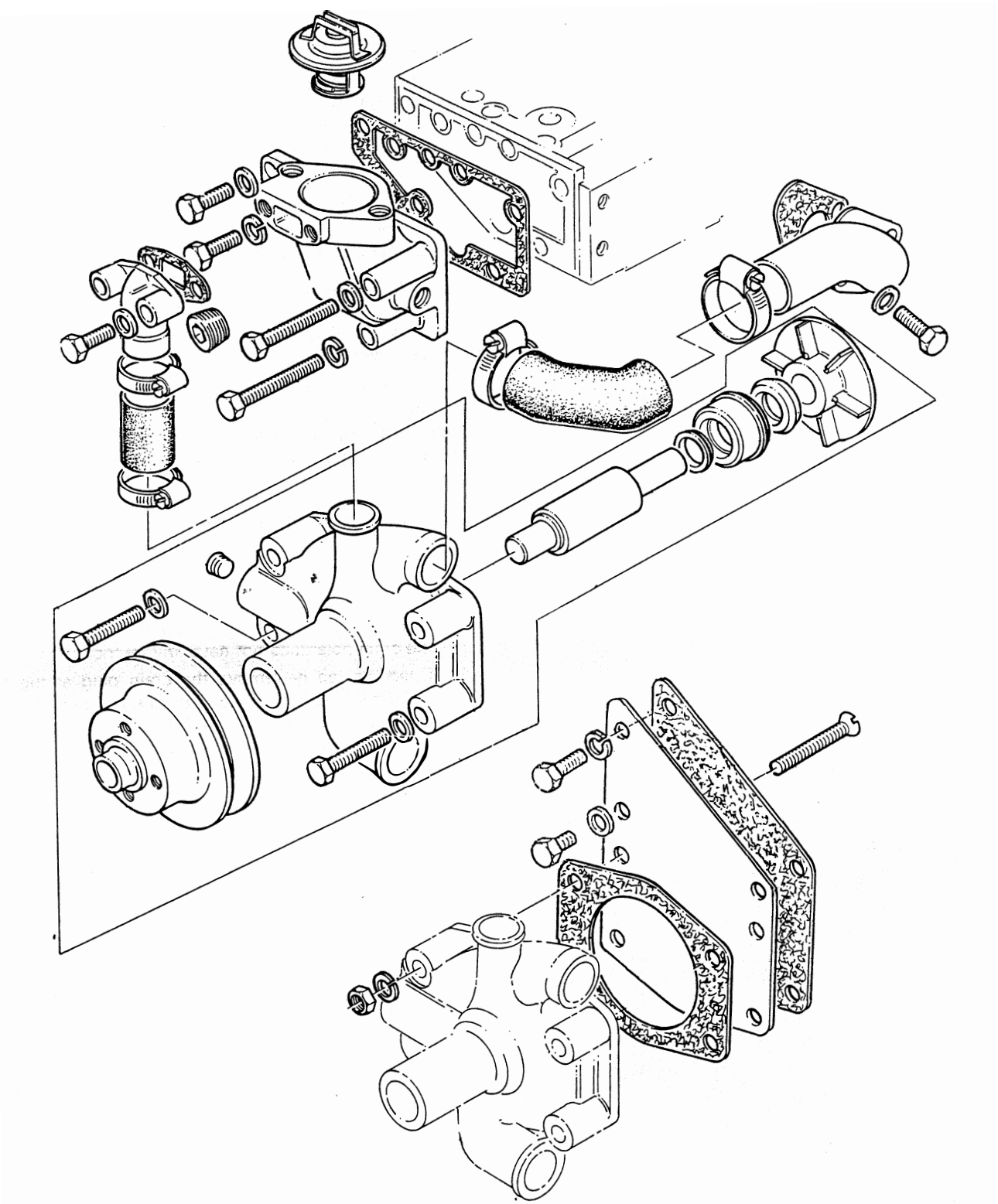
Fig. M10

To fit lubricating oil pump

1. Fill lubricating oil pump with clean lubricating oil.
2. Fit idler gear to shaft but do not fasten with circlip.
3. Fit lubricating oil pump to front main bearing cap and fasten with three setscrews. Connect delivery pipe from pump to cylinder block.
4. Fasten idler gear with circlip.
5. Fit suction pipe and strainer.
6. Fit timing case bottom half and tighten two nuts and washers to timing case top half.
7. Fit the three setscrews at the bottom of the timing case front cover.
8. Fit the lubricating oil sump as already given.

Note: Before the engine is started, it must be turned with the stop control operated until lubricating oil pressure is shown on the gauge.
If an electrical solenoid stop control is fitted, turn the start switch to the "R" position.

SECTION N
Cooling System



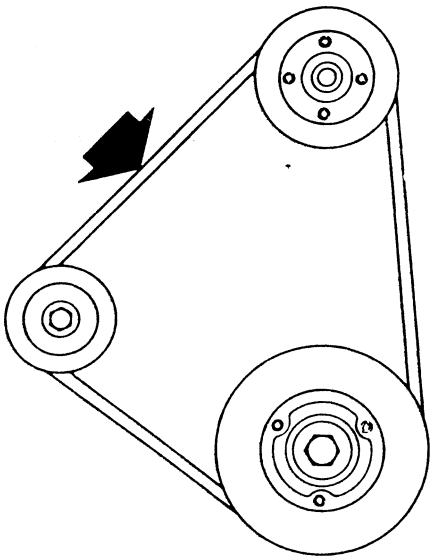


Fig. N1

Cooling system

The engine is supplied with coolant from a centrifugal type water pump installed on the front of the timing case cover. The drive is by belt from the front of the crankshaft.

The pump does not need to be lubricated as the bearings are packed with special quality grease at the factory.

To check and adjust fan belt tension

1. Renew the belt if it is worn or damaged.
2. With thumb pressure of approximately 10 kgf (22 lbf), press the fan belt down at the centre of the longest free length of the belt and check the belt movement (see fig. N1). The belt movement must be 10 mm (3/8 in). Where necessary, adjust the tension as given below.
3. Loosen the alternator or dynamo bolts and adjustment link setscrews.
4. Change the alternator or dynamo position to give the correct tension and tighten the alternator or dynamo bolts and adjustment link setscrew.
5. Check the belt tension again to ensure that it is still correct.

Note: If a new belt is fitted, the belt tension must be checked again after the first 25/50 hours of operation.

To drain cooling system

1. Ensure that the machine is on level ground.
2. Remove the radiator filler cap.
3. Remove the drain plug from the side of the cylinder block to drain the engine. Ensure that the drain hole does not have any restriction.
4. Open the tap or remove the drain plug at the bottom of the radiator to drain the radiator. If a tap or plug is not fitted to the radiator, disconnect the bottom radiator hose.
5. Where necessary, flush the system with clean water.
6. Fit the drain plugs and radiator cap. Where necessary, close the radiator tap or connect the radiator hose.

Fig. N2

To remove water pump

1. Drain the cooling system.
2. Remove fan belt and fan.
3. Disconnect water pump inlet and outlet hose connections.
4. Disconnect by-pass connection from thermostat housing.
5. Release the three setscrews which fasten backplate to timing case and cover and the two setscrews which fasten water pump to cover and remove pump complete with backplate (see fig. N2).
6. Release the two nuts and screws and remove water pump from backplate.

To dismantle water pump (see fig. N3)

1. Remove water pump pulley by the use of a suitable tool (see fig. N3). The holes tapped in the pulley can be used for this purpose.
2. Press water pump shaft (2) complete with bearings and impeller (7) out through rear of pump body (1).
3. Press shaft and bearing assembly out of impeller.
4. Remove ceramic counterface (6), seal (5) and thrower where separate, (4) from water pump shaft.

The water pump shaft and bearings are a complete assembly and can not be dismantled.

Note: Later water pumps are fitted with a one piece 'cassette' type seal which includes the counterface and thrower. (See fig. N4A).

To assemble water pump (see fig. N4)

1. With the shorter end of the water pump shaft to the front, press the shaft and bearing assembly (2) into rear of water pump (1) until the end of the bearing housing aligns with the front of the water pump body.
2. Fit thrower where separate, (4) and seal (5) with carbon face to rear of pump and flange against the inside face of water pump body.
3. Fit ceramic counterface (6) to shaft with ceramic insert towards seal.
4. With a support on the front end of the water pump shaft, press impeller (7), with blades inwards, on rear of shaft until there is a clearance of 0,25 mm (0.010 in) to 0,51 mm (0.020 in) between blades of impeller and pump body (see fig. N5).
5. Ensure pump turns freely.
6. Fit any setscrews that can not be put in position after the pulley is fitted. These setscrews have aluminium sealing washers.
7. With a support on the impeller end of the water pump shaft, press on water pump pulley until the front end of pulley aligns with front end of shaft. Where the fan mounting face is extended forward (see fig. N6), press the pulley on the water pump shaft until the fan mounting face is 140,49 mm (5.531 in) from the rear face of the pump body.
8. Check the clearance again between impeller blades and water pump body and ensure pump turns freely.

Note: Where a water pump is fitted with a ceramic seal and the engine is run without coolant in the water pump, the carbon seal and ceramic counterface can get very hot and will cause cracks in the ceramic. This can cause water to leak from the pump and does not always indicate that the seals have been fitted wrongly.

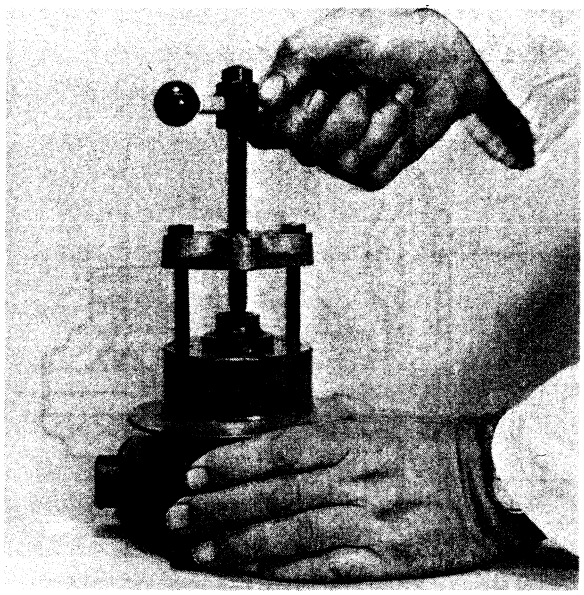


Fig. N3

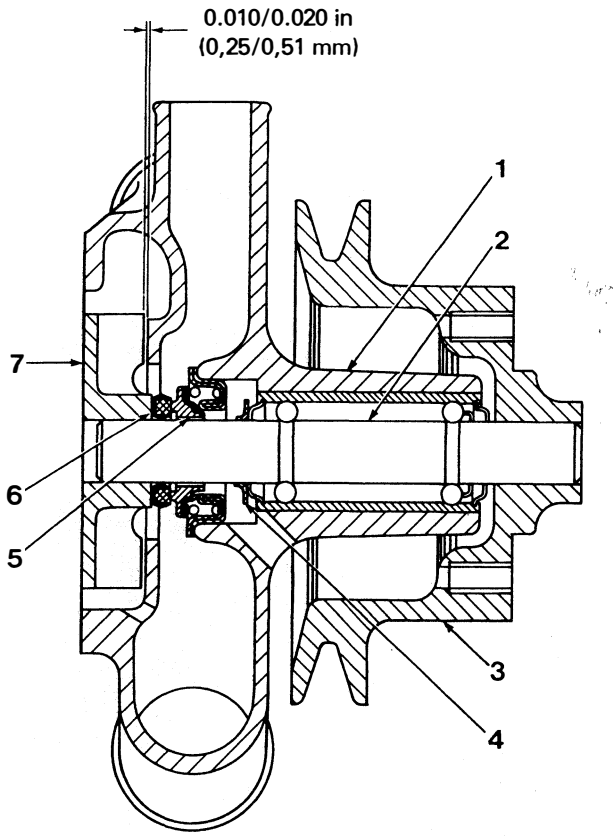


Fig. N4
Water Pump Assembly

1. Pump Body
2. Shaft and Bearing Assembly
3. Pulley
4. Thrower
5. Seal
6. Ceramic Counterface
7. Impeller

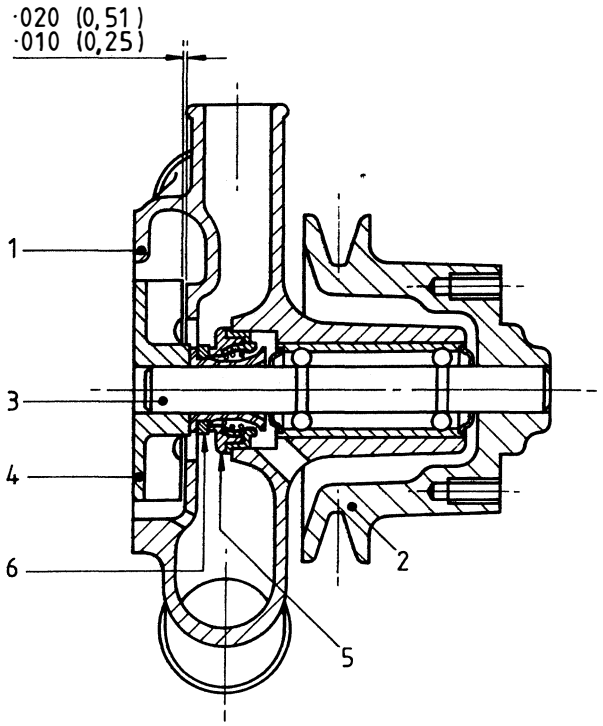


Fig. N4A
WATER PUMP ASSEMBLY
1. Pump Body
2. Pulley
3. Shaft
4. Impeller
5. Seal
6. Ceramic Counterface

Fig. N5

To fit water pump to engine

1. Fit new water pump joints with jointing compound.
2. Fit water pump to backplate and fasten with screws, spring washers and nuts.
3. Fit pump and backplate assembly to timing case cover and tighten the setscrews. The setscrews which fit in the timing case have spring washers and those which fit into the timing case cover have aluminium washers.
4. Connect water pump inlet and outlet hose connections and by-pass connection from thermostat housing.
5. Fit fan belt and adjust tension (see fig. N1).
6. Fit fan.

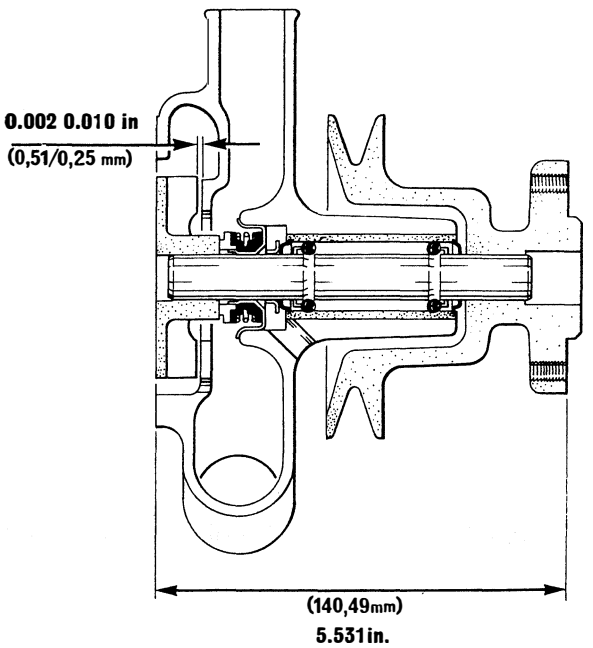


Fig. N6

Thermostat

A thermostat is installed in the cylinder head water outlet to enable the engine to reach its correct temperature faster.

The thermostat can be removed after the water outlet connection has been removed (see fig. N7).

When a thermostat is fitted, ensure that the jiggle pin in the top is free to move and the vent hole is free from restriction.

To check the thermostat, put it in water and heat gradually. With the use of a thermometer, check that the thermostat opens at the temperatures given in Section C. If there is a fault, it must be renewed. A thermostat can not be adjusted.

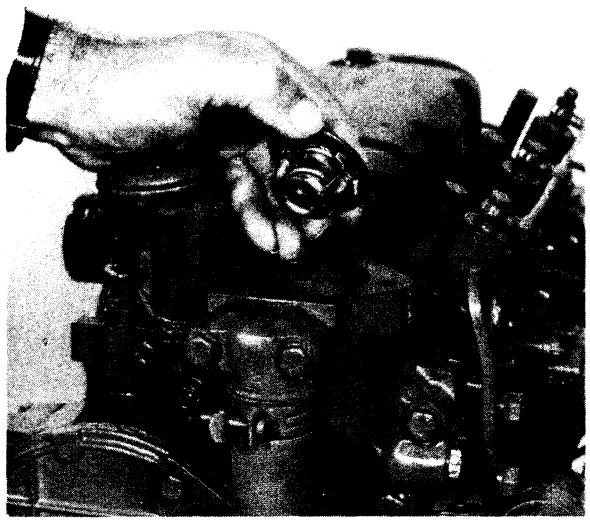
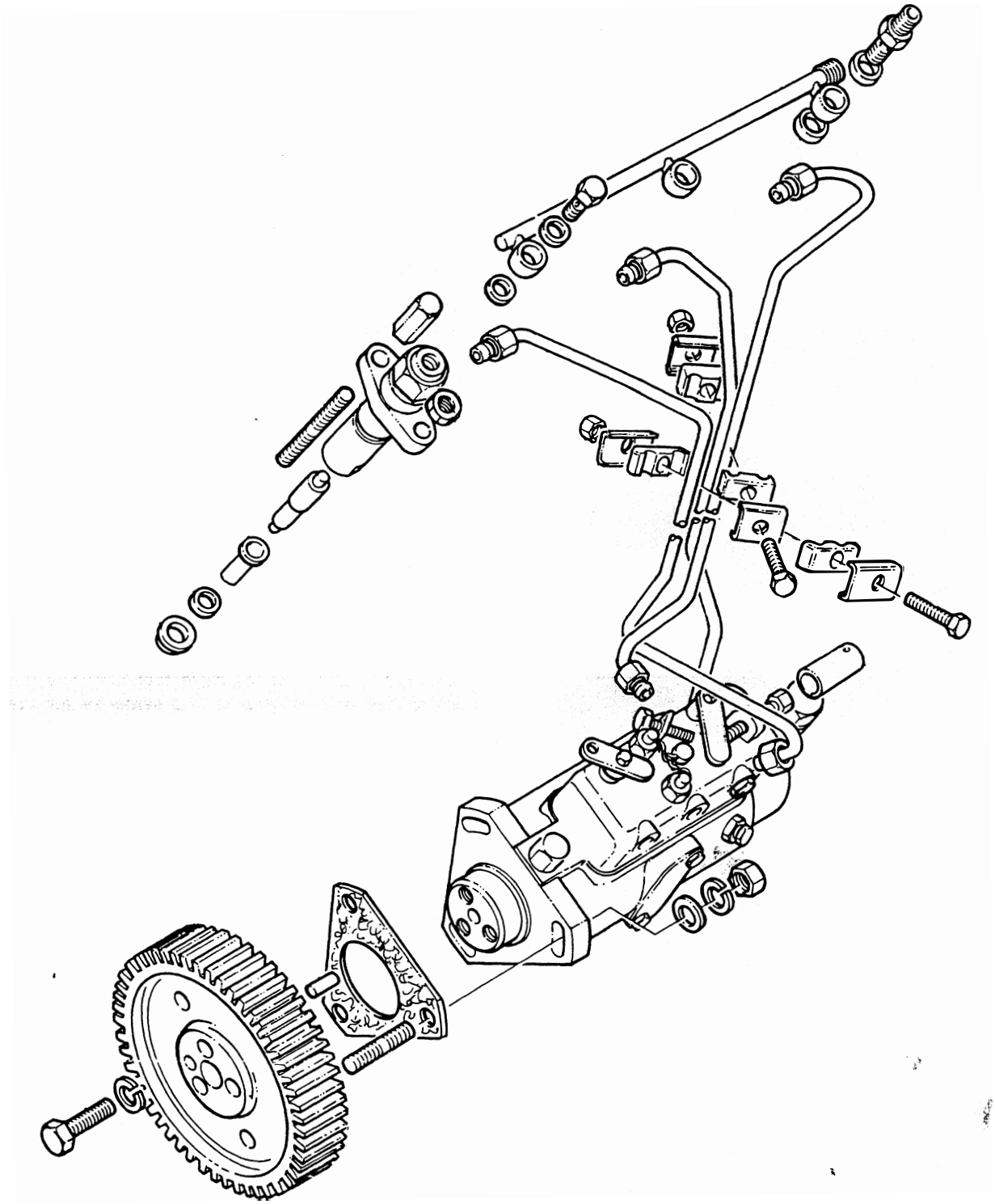


Fig. N7

SECTION P
Fuel System



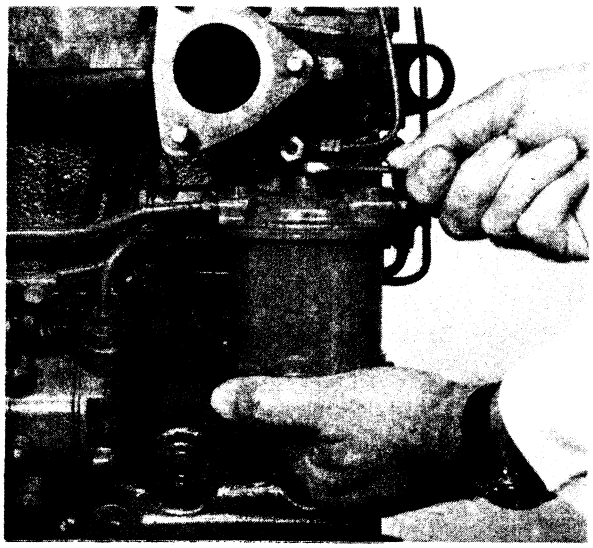


Fig. P1

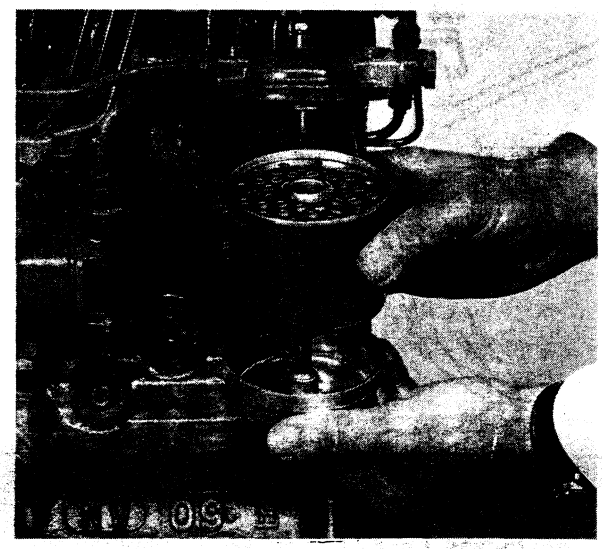


Fig. P2

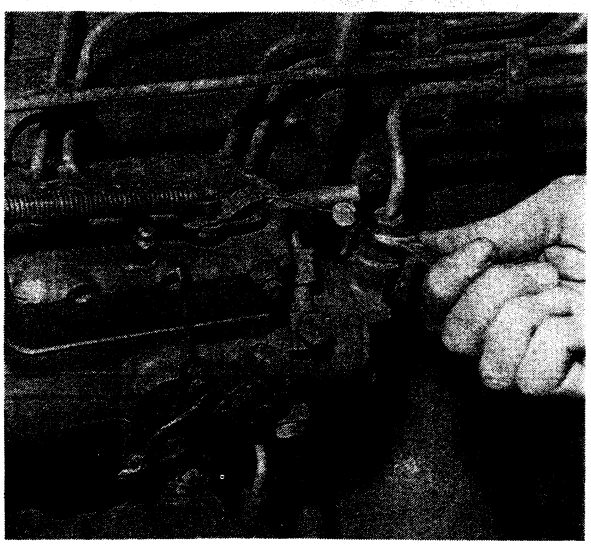


Fig. P2A

Fuel system

The main components of the equipment to supply fuel to the engine are as follows.

1. Fuel filters.
2. Fuel lift pump.
3. Fuel injection pump.
4. Atomisers.

The fuel lift pump supplies fuel from the tank through fuel filters to the fuel injection pump which passes it in measured quantities and at correct intervals to the atomisers.
Fuel must be clean, free from dirt and must be equal to one of the fuel specifications given on page C12.

Fuel filters

Precautions have been made to ensure that only clean fuel reaches the fuel injection pump.
Fuel filters are installed, also a dirt trap in the fuel tank.
The first fuel filter is a fine gauze type in the filler of the fuel tank. If there is no gauze filter in the filler, the tank must be filled through a fine gauze strainer.
The second fuel filter is a pre-filter fitted between the fuel tank and the fuel lift pump. This pre-filter must be dismantled and any water removed and the gauze strainer cleaned at the service interval given on page D2. Ensure that good joints are made when this filter is assembled or air leakage can occur on the suction side of the fuel system.
On some engines, there is an extra filter between the fuel lift pump and the main fuel filter and the maintenance of this filter is the same as for the main filter.
The main filter before the fuel injection pump is a paper element type. The element must not be cleaned but renewed at the service interval given on page D2.

To renew fuel filter element (current engines)

1. Remove setscrew in centre of fuel filter top cover (see fig. P1).
2. Lower filter bottom cover (see fig. P2).
3. Remove the element canister and discard.
4. Before new filter element canister is fitted, clean the top and bottom filter covers.
5. Check that the rubber joints are in good condition. Renew if necessary.
6. Fit element canister and bottom cover and tighten setscrew.

After the filter is assembled, remove air from the fuel system as given later.

To renew fuel filter element (earlier engines)

The earlier type main fuel filter contains a separate paper element in a bowl fastened by a bolt at the bottom of the bowl. A vent plug is fitted in the filter head.

Renew the element as follows:

1. Remove the bolt at the bottom of the filter bowl.
2. Lower the filter bowl.
3. Remove the element and discard.
4. Clean filter bowl and fit new element.
5. Check the washers and joints are in good condition. Renew if necessary.
6. Fit element and bowl and tighten bolt.

After the filter is assembled, remove air from the fuel system as given later.

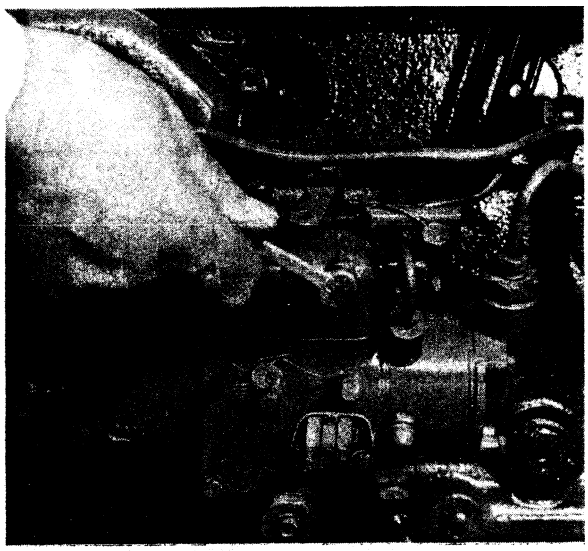


Fig. P3

To remove air from fuel system

If air gets into the fuel system, it must be removed before the engine can be started.

Air can get into the system if:

1. The fuel tank is drained during engine operation.
2. The low pressure fuel pipes are disconnected.
3. Any part of the low pressure fuel system leaks during engine operation.

Note: Some engines are fitted with Stanadyne fuel injection pumps. These pumps are self venting and will automatically remove air from the system.

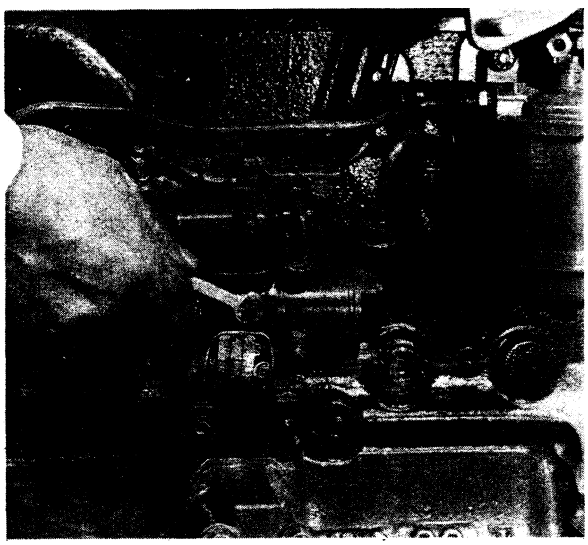


Fig. P4

Remove air from the fuel system as follows:

1. Remove air from the fuel filter through the filter vent plug. If a filter vent plug is not fitted, the return to tank banjo connection in the top of the filter can be loosened to reduce the time needed to fill the filter with fuel. Tighten the plug or connection.
2. Where the fuel filter is fitted lower than the fuel injection pump, loosen the inlet connection at the fuel pump (see fig. P2A) and operate the lift pump to remove any air (see fig. P5). Tighten the connection.
3. Ensure that the stop control is in the "Run" position. If an electrical solenoid stop control is fitted, turn the start switch to the "R" position.
4. Loosen the vent screw on the side of the governor control cover of the fuel injection pump (see fig. P3).

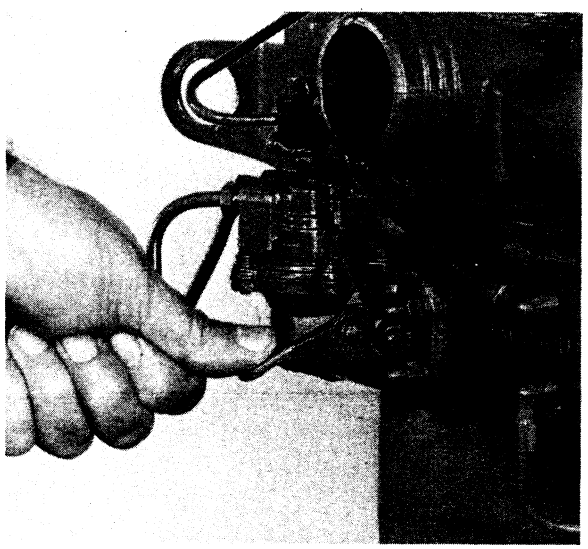


Fig. P5

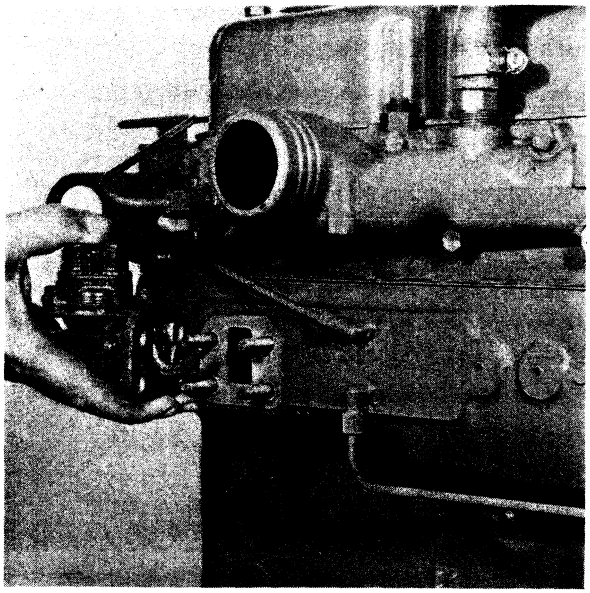


Fig. P6

5. Loosen the vent screw in the hydraulic head lock screw on the side of the fuel injection pump body (see fig. P4). Loosen vent screw on top of main fuel filter (where fitted).

6. Operate the priming lever of the fuel lift pump (see fig. P5) until fuel, free from air, comes from each vent point. If the fuel pump drive cam is on maximum lift, it will not be possible to operate the priming lever and the crankshaft must be turned through one revolution. Tighten the vent screw on filter head cover (where fitted), hydraulic head vent screw and then governor vent screw.

7. Loosen the unions at the atomiser ends of two of the high pressure pipes.

8. With the engine speed control in its maximum position and the engine stop control in the 'run' position, operate the starter motor until fuel, free from air, comes from the pipe connections. Tighten the unions of the high pressure pipes.

9. If fuel oil has drained from the Thermostart fuel supply pipe, the pipe must be disconnected at the Thermostart and the priming lever operated until air free fuel comes from the pipe before the Thermostart is operated.

The engine is then ready to start.

If the engine runs correctly for a short time and then stops or runs roughly, check for air in the fuel system. If there is air in the fuel system, there is probably leakage in the suction or low pressure system.

Fuel lift pump

The fuel lift pump is of the diaphragm type. It is fitted to the side of the camshaft chamber and is driven from an eccentric on the engine camshaft.

It is fitted with a hand priming lever so that the pump can be operated when the engine is stopped, to remove air from the fuel system.

To use this priming lever, operate by hand until fuel pipes, fuel lift pump, fuel filters and fuel injection pump are full of fuel oil.

Note: If the eccentric on the engine camshaft is in its maximum high position, it will not be possible to operate the hand pump. Turn engine until pump can be operated.

Earlier engines had an integral pre-filter fitted but on later engines, the pre-filter is separate.

To test fuel lift pump when fitted to engine.

Disconnect fuel lift pump outlet connection.

Turn engine or operate hand priming lever (see fig. P5). Fuel will be discharged from the outlet connection every second revolution of the engine or every time the hand priming lever is operated.

To check pressure output of fuel lift pump when fitted to engine

1. Fit a 0 to 0,7 kgf/cm² (0 to 10 lbf/in²) or 0 to 70 kN/m² pressure gauge to the fuel lift pump outlet connection. Ensure that there is no leakage at the connection between pump and gauge.
2. Operate starter motor to turn engine for ten seconds and read the maximum pressure on gauge.
3. If the pressure is below 0,3 kgf/cm² (4.5 lbf/in²) or 31 kN/m², the lift pump must be corrected.
4. Check the time for the pressure to fall to half the maximum pressure found under item (2) after the engine has stopped. If this is less than thirty seconds, correct the pump.

To remove fuel lift pump

1. Disconnect fuel pipes from fuel lift pump inlet and outlet connections.
2. Remove the nuts and washers or setscrews and plates which fasten the fuel lift pump to the cylinder block and remove the pump (see fig. P6).

To dismantle fuel lift pump (see fig. P7)

1. Loosen nut at bottom water trap filter (where fitted) and remove glass bowl and gauze strainer.
2. Make a mark across the two flanges for location purposes when the pump is assembled.
3. Remove the five cover screws and divide the two main parts of the pump.
4. Turn diaphragm 90° in either direction and remove diaphragm assembly from bottom half of pump.
5. Remove the valves with a screwdriver or other suitable tool.
6. Put rocker lever in a vice. Remove the fastener plates from the grooves in the casting. Remove rocker lever pin and rocker lever assembly. Check rocker, pin, lever and return spring for wear. Renew if necessary.

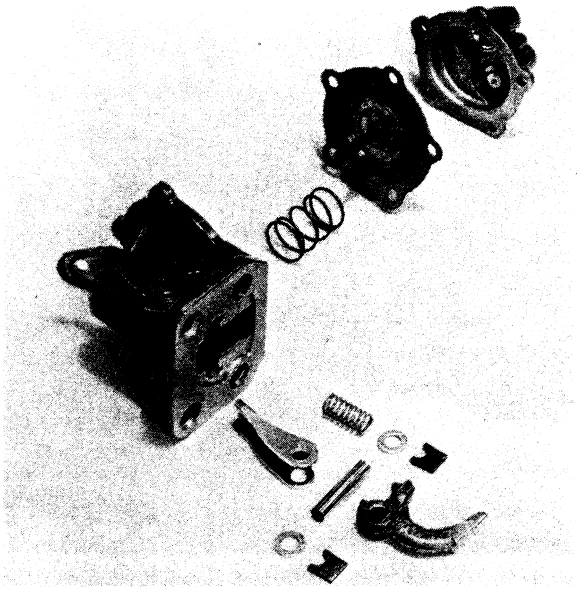


Fig. P7

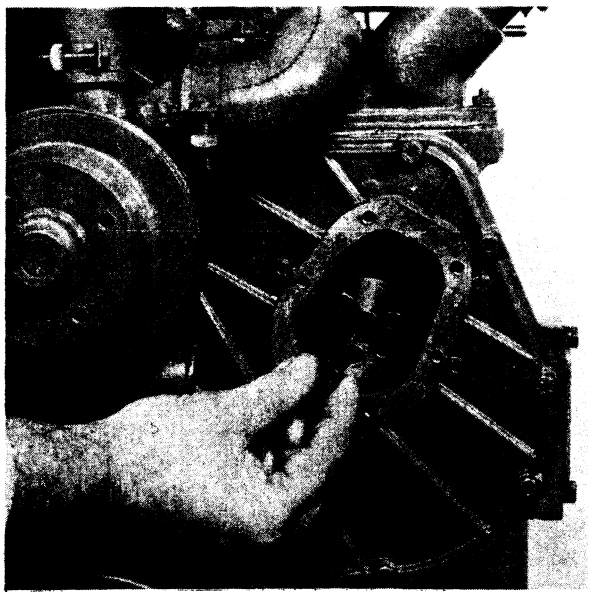


Fig. P8

To assemble fuel lift pump

1. Fit rocker lever assembly into bottom half of fuel lift pump.
2. Fit rocker lever spring. Ensure it is in its correct location.
3. Fit new fastener plates in grooves of casting. To make them secure, hit with centre punch over open ends of grooves.
4. Fit the valves into bottom half of pump. To fasten them in position, hit the casting round the valves in six places with a centre punch.
5. Fit diaphragm assembly over spring with pull rod to the bottom. Ensure top of spring is in correct position in diaphragm protection washer.
6. Ensure that correct end of pull rod engages into rocker lever link.
7. Press down on diaphragm assembly so that notches on pull rod align with rocker lever link. Turn diaphragm 90° in either direction to engage and connect pull rod in the end of the link.
8. When assembling the two halves of the pump, push rocker lever towards pump until diaphragm is aligned with body flanges. The cover assembly can now be fitted with the marks on the flanges aligned. With pressure still applied on rocker lever, fit and tighten screws and washers evenly.
9. Where necessary, fit the gauze strainer and glass bowl to water trap filter. Ensure that an air tight joint is made.

To fit fuel lift pump

1. Ensure that fuel lift pump flange and mounting face on cylinder block are clean.
2. Use a new joint and put pump operation lever into hole in cylinder block.
3. Fit fuel lift pump on studs and tighten nuts and spring washers, or setscrews and plates.

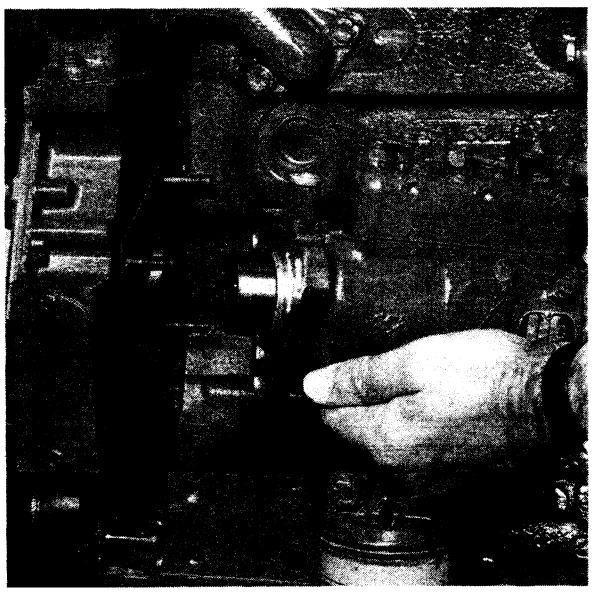


Fig. P9

Fuel injection pump

The fuel injection pump is a distributor type. It is made of very fine parts and any damage or the smallest amount of dirt can prevent its accuracy of operation. Ensure that fuel is thoroughly clean before it reaches the pump.

Where information is needed for the fuel injection pump, its type and number must be given.

If service is needed, this is available from your Perkins Distributor or the fuel injection pump manufacturers distributor.

To remove fuel injection pump

The fuel injection pump is fastened to the back of the timing case on the left side of the engine. The fuel injection pump gear is connected to the pump shaft by three setscrews and a dowel or keyway is fitted to ensure correct location.
Note: Some applications use a fuel injection pump with a tapered shaft and single nut to fasten the fuel pump gear.

To remove pump:

1. Remove fuel pipes from fuel injection pump. Seal open connections.
2. Disconnect engine speed and stop controls at pump.
3. Remove cover plate on left side of timing case front cover in front of fuel pump position.
4. Remove the three setscrews and washers or nut which secure gear to fuel pump shaft (see fig. P8). Do not drop them into timing case. For gears with a tapered drive shaft bore, use puller tool PD155B and adaptor PD155B-5. When gear is loose, ensure it does not drop on aluminium lug in timing case as this can break and fuel pump gear can come out of mesh with idler gear. If gears come out of mesh it will change the fuel pump timing.
5. Remove the three nuts and washers which secure fuel pump to back of timing case.
6. Remove fuel injection pump (see fig. P9). If gear is still tight on fuel pump shaft, hold gear so that it does not drop and break the lug in timing case and come out of mesh. **Do not turn crankshaft with pump removed and gear loose in timing case.**

To fit fuel injection pump

1. Ensure that slot or key in end of fuel pump shaft aligns with dowel or keyway in gear and put pump in position on back of timing case. Fit pump flange nuts but do not fully tighten.
2. Ensure that dowel or keyway in fuel pump gear fits in slot or key in pump shaft and fasten gear to pump shaft with three setscrews and washers or nut. Tighten nut to the torque given on page C3.
3. Adjust fuel injection pump so that line on flange aligns with line on back of timing case and tighten nuts.
4. Fit cover plate to timing case cover.
5. Connect fuel pipes to pump.
6. Remove air from fuel system as given on page P3.
7. Connect engine speed and stop control.
8. Run engine and check for fuel leakage. If a new fuel injection pump has been fitted, set the maximum no load speed as given below.

To set maximum no load speed

When the fuel injection pump is changed, the governor is set to a nominal maximum speed and it must be adjusted on the engine.

The maximum no load speed can be found from the fuel injection pump setting code. A typical code is XW50E600/8/2470. It is the last group of numbers which indicates the no load speed which, in this example, is 2,470 rev/min (engine speed).

Note: Current pump codes are now changed, for example: 2643B131BW/6/2370. (See page C14).
Run the engine until the coolant reaches its normal operation temperature.

With the use of an accurate tachometer, check the maximum speed with no load on the engine.

Where necessary, adjust the maximum no load speed by the adjustment screw on the fuel injection pump. Turn screw out to increase or turn screw in to decrease maximum no load speed.

When the maximum no load speed is correct, the adjustment screw must be sealed by approved personnel.

High pressure fuel pipes

If the union nuts on the high pressure fuel pipes are tightened too much, damage can occur to the olives and the complete pipe must be renewed.

Fit the pipe to the fuel injection pump and atomiser unions. Ensure that the pipe is correctly aligned at both ends. Do not fit one end and then bend the pipe to align it at the other end.

When a pipe is fitted, tighten the union nuts by small amounts until the correct torque of 30 Nm (15 lbf ft) 2,1 kgf m is reached.

When an atomiser is removed, always remove the whole high pressure pipe. Do not bend the pipe.

Atomisers

Each atomiser is fastened in the cylinder head by a flange and two studs.

The joint between the atomiser and the cylinder head is a special thin copper washer between the lower face of the nozzle cap nut and the bottom of the recess in the cylinder head. Only the correct copper washer must be used. The recess in the cylinder head, the faces of the copper washer and the bottom face of the nozzle cap nut must be thoroughly clean or leakage will occur. A new washer must be used every time an atomiser is fitted. Always ensure that the old washer has been removed.
Ensure that a serviceable dust seal is fitted to the atomiser. Earlier dust seals consisted of a single piece rubber seal, later arrangements use a two piece dust seal which consists of a plastic or aluminium sleeve and a rubber seal. The sleeve

must be fitted directly under the atomiser flange with the soft rubber seal up against the sleeve at the nozzle end of the atomiser.

When an atomiser is fitted in the cylinder head, ensure it fits freely on its studs. The nuts on the flange must be tightened by small amounts until a torque of 16 Nm (12 lbf ft) 1,7 kgf m is reached.

| If a separate clamp is fitted, tighten to 12 Nm
| (9lbf ft) 1,2 kgf m.

An atomiser must not be fitted in a tilted position or gas leakage will occur.

The maintenance periods for atomisers are given on page D2.

With 3.1522 engines, a thin metal heat shield is fitted around the atomiser nozzle and this shield must be renewed if an atomiser is dismantled.

Do not remove atomisers for correction unless an atomiser tester pump or other atomisers are available.

An atomiser fault can be shown by an engine misfire.

To find which atomiser is at fault, run the engine at fast idle speed and loosen and tighten the high pressure fuel pipe union at each atomiser. When the union nut of the atomiser at fault is loosened, it will have little or no effect on the engine speed. Do not let the fuel spray onto your skin.

Atomiser pressures are given on page C15 and can be decided from the code letters stamped either on the atomiser body or on the atomiser tab washer.

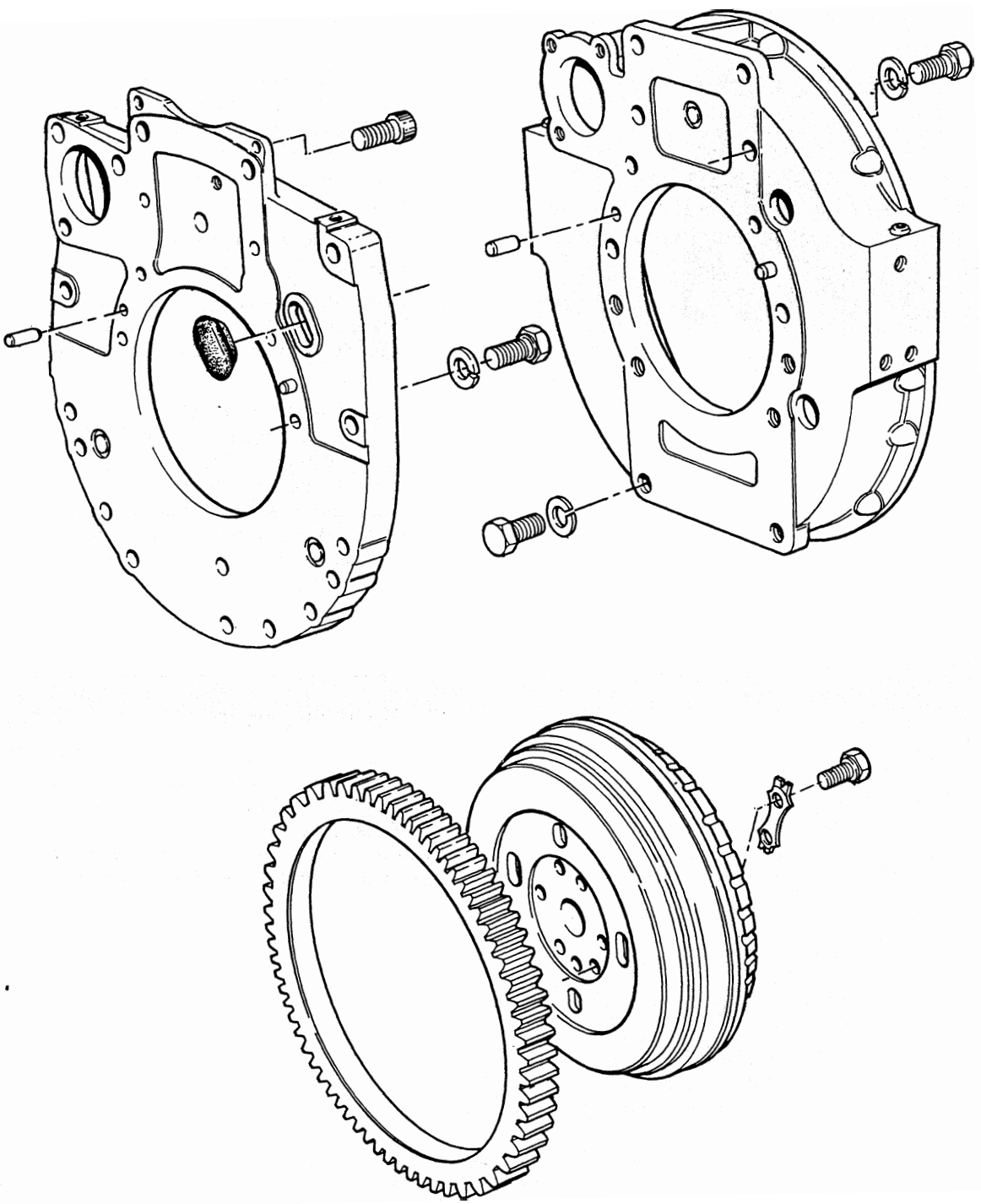
The 'Setting Pressure' is the pressure at which a new atomiser is set and is a little high due to the drop in pressure which occurs during the first hours of operation. The 'Check and Reset' pressure is the pressure at which an atomiser which has been used is checked or set.

After an atomiser has been corrected, it is set to the setting pressure if a new spring has been fitted or to the check and reset pressure if the old parts have been used.

Do not correct and set the pressure of an atomiser if the necessary equipment is not available.

Always ensure that the correct atomisers are fitted.

SECTION Q
Flywheel and Flywheel Housing



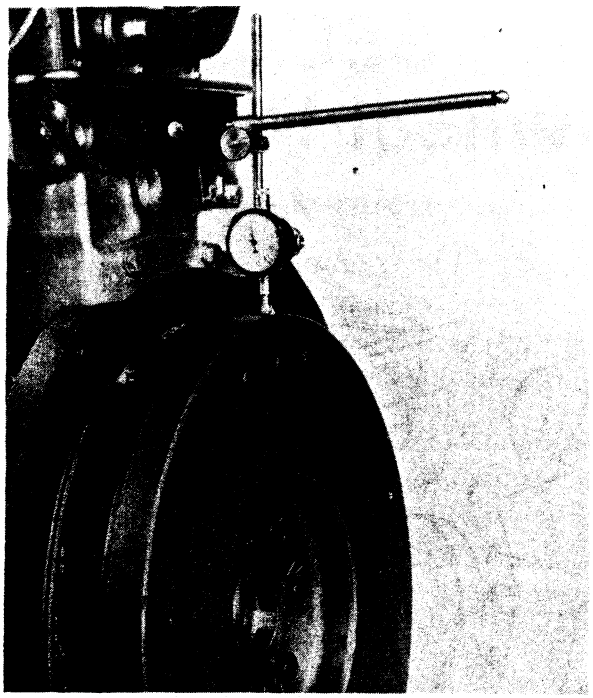


Fig. Q1

To remove and fit flywheel

1. Remove two opposite setscrews from the flywheel and temporarily fit two guide studs to ensure safe removal and assembly.
2. Remove the remainder of the setscrews and lock plates and remove flywheel.
3. Check the fywheel and ring gear for damage and renew as necessary.
4. Ensure that the location faces of the crankshaft and flywheel are clean and free from damage.
5. Fit the flywheel over the guide studs with the small hole in the flywheel aligned with the hole which is not tapped in the crankshaft flange. Fit the lock plates and setscrews in position, remove the guide studs and fit the other two setscrews.
6. Tighten the setscrews to the torque given on page C3.
7. Check the flywheel run-out with a dial test indicator (see fig. Q1). This must not be more than 0,30 mm (0.012 in) total indicator reading.
8. Check the alignment of the flywheel face (see fig. Q2). This must not be more than 0,03 mm (0.001 in) total indicator reading for every 25,4 mm (1 in) of flywheel radius from the crankshaft axis to the indicator plunger. During this check, keep the crankshaft pressed forward towards the front to remove the effect of the crankshaft end clearance.
9. Lock the flywheel setscrews with the ends of the lock plates, where fitted.

Flywheel ring gear

The ring gear is heated on to the flywheel. When a new gear is to be fitted, heat it to an approximate temperature of 246° (475°F). Ensure that the chamfered edges of the teeth are to the front of the flywheel except for some marine engines where they must be to the rear of the flywheel.

Alignment of flywheel housing

1. Ensure that the rear face of the cylinder block and the front face of the flywheel housing are clean and free from damage. Ensure that the location dowels are correctly fitted.
2. Fit the flywheel housing and tighten the setscrews.
3. Check the flywheel housing face alignment with a dial test indicator with the base fitted to the crankshaft flange. The maximum tolerance is given below. During this check, keep the crankshaft pressed forward towards the front to remove the effect of the crankshaft end clearance. Any necessary adjustment must be made on the front face of the housing and not on the cylinder block.
4. Check the run-out of the flywheel housing bore to ensure that it is within the limits given below. If adjustment is necessary, the dowels must be removed and new oversize dowels fitted after the adjustment has been made.

Diameter of flywheel housing	**Maximum tolerance**
Up to 362 mm (14 ¼ in)	0,15 mm (0.006 in)
362 to 511 mm (14 ¼ to 20 ⅛ in) ...	0,20 mm (0.008 in)
511 to 648 mm (20 ⅛ to 25 ½ in) ...	0,25 mm (0.010 in)
648 to 787 mm (25 ½ to 31 in) ...	0,30 mm (0.012 in)

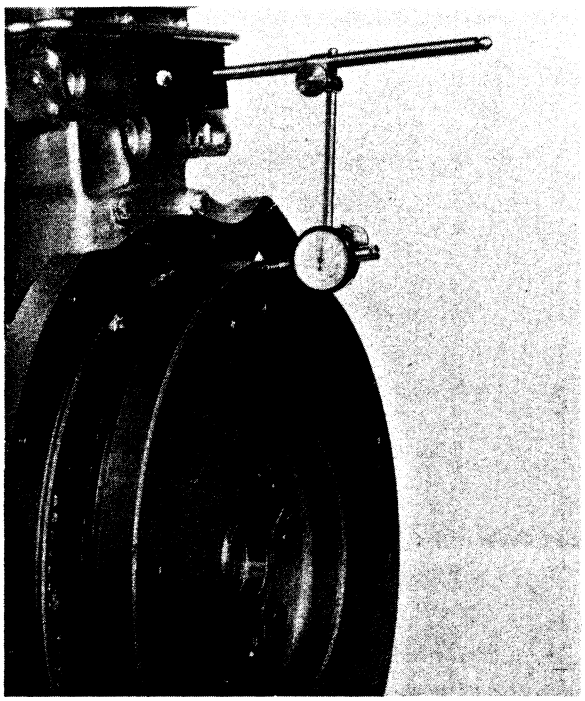
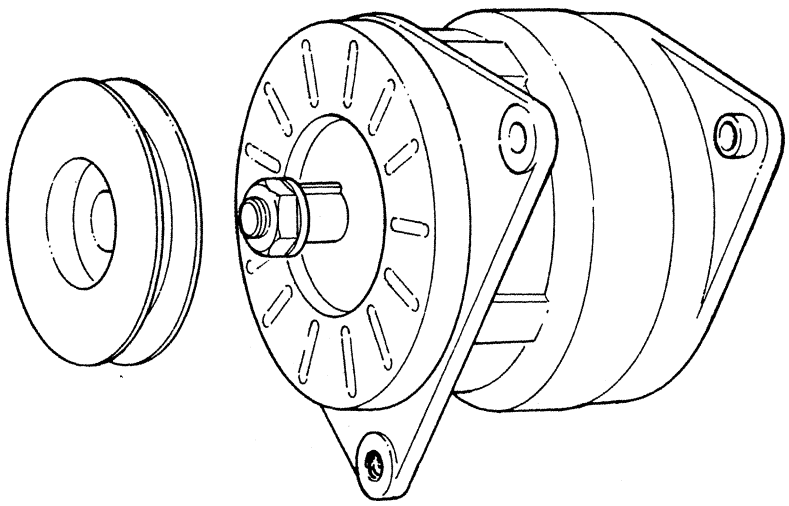
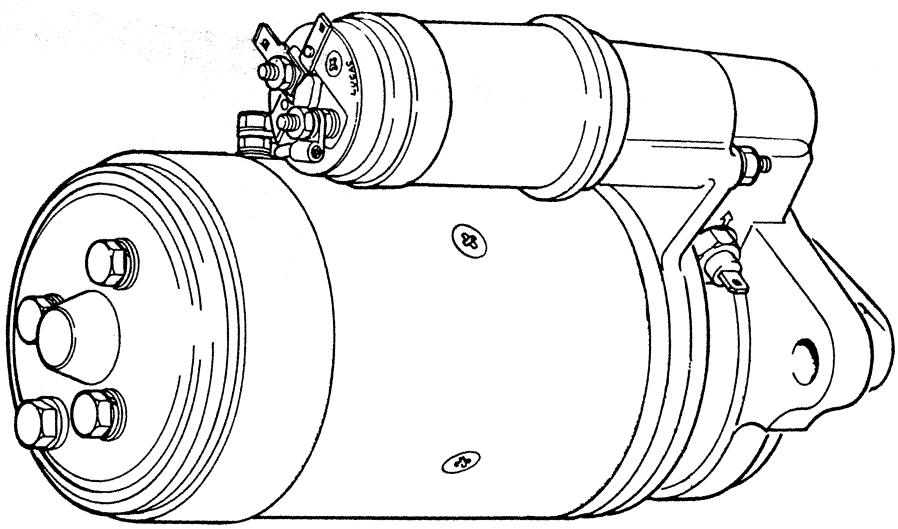


Fig. Q2

SECTION R
Electrical System





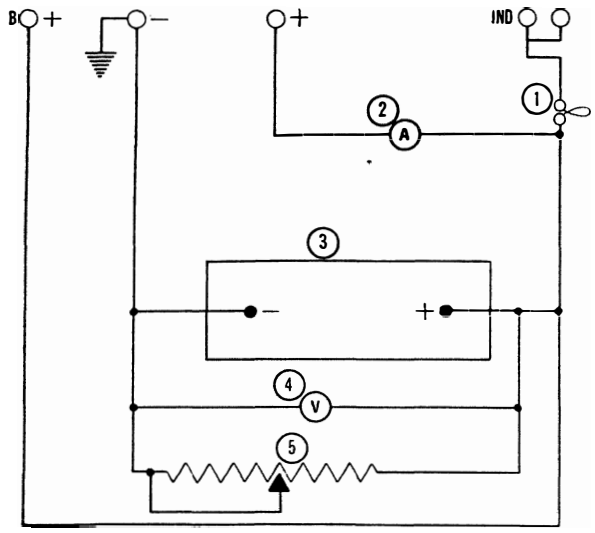


Fig. R1

Fig. R1 shows a test circuit for 15ACR and 17ACR alternators with standard terminals, battery-sensed.

Fig. R2 shows a test circuit for 15ACR and 17ACR alternators with standard terminals and two piece connection plug (machine-sensed).

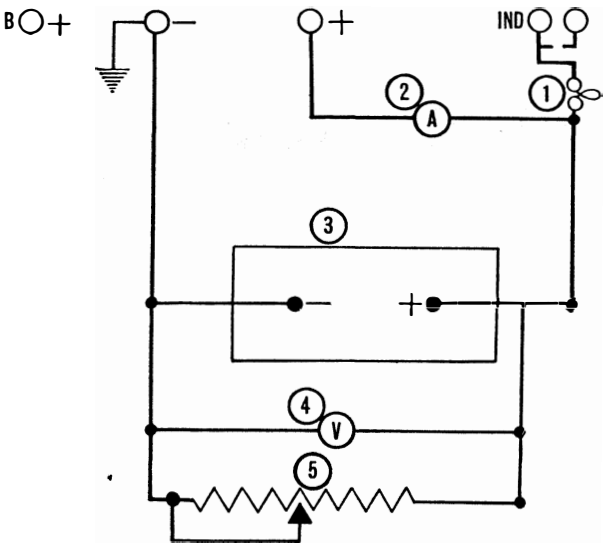


Fig. R2

Components in figs. R1 and R2.

1. 12 volt, 2.2 watt bulb.
2. 0 – 60 ammeter.
3. 12 volt battery.
4. 0 – 20 moving coil voltmeter.
5. 0 – 15 ohm 50 amp variable resistor.

ALTERNATORS
Models 15ACR, 16ACR, 17ACR, 18ACR, 23ACR, A115/36, A115/45, A127, 9AR and LR Series

Precautions

The diodes in the alternator operate as one way valves and the transistors in the regulator/control box operate as fast switches.

They do not wear or need adjustment, but the precautions which follow are necessary to ensure that no damage occurs.

1. **Do not** disconnect the battery while the engine is in operation. This will cause a high voltage in the alternator charge system and immediately burn out the diodes or transistors.
2. **Do not** disconnect a wire while the engine is in operation. Ensure all electrical switches are turned to the off position.
3. **Do not** cause a short circuit by the connection of wires to the wrong terminals. Always connect a wire to its correct terminal. A short circuit or wrong connection can give reverse polarity and burn out transistors or diodes.
4. **Do not** connect a battery into the system with wrong polarity or voltage.
5. **Do not** touch connections together to check for current flow. The transistors can be burnt out.

Maintenance

The alternator charge system needs little attention, but must be kept clean and a check must be made if it does not keep the battery charged.

1. Check the drive belt for correct tension or wear. Where two drive belts are used, they must both have the same tension. Loose belts will wear fast and will not turn the alternator at the correct speed.
2. Tight belts will cause too much of a load on the alternator bearings and wear will occur.
3. Where two drive belts are used, both must be renewed at the same time.
4. Clean the alternator with a cloth used with kerosene or similar fluid. Ensure that slots and air spaces for ventilation are open.
5. Remove any dirt from the regulator/control box and ensure that air can pass over the housing.

To test alternator on engine

Check drive belt for wear and tension. Check hot outputs at 6,000 rev/min (alternator speed) to the nominal values given below.

15ACR	–	28A
16ACR	–	34A
17ACR	–	36A
17ACR (de-rated)	–	25A
18ACR	–	45A
23ACR	–	55A
A115/36	–	36A
A115/45	–	45A
A127	–	55/65A
9AR Series	–	70A
LR135 Series	–	35A
LR150 Series	–	50A

The de-rated 17ACR alternator is used on some applications which operate under very dirty conditions.

These outputs can be more when the alternator is run cold. The test procedure given below must be used when the alternator is at its normal operation temperature.

Alternator output test – regulator disconnected

Remove the two part connector from the alternator, remove the cover (fastened by two screws) and connect the regulator green wire or connector to earth.

Connect a test circuit to the alternator output terminals as shown in figs. R1, R2, R3 or R4.

Carefully note the polarity of the battery and alternator terminals – reversed connections will cause damage to the alternator diodes.

The variable resistor across the battery terminals must not be left connected for more time than is necessary to do the test which follows.

Start the engine. At 1,500 rev/min (alternator speed), the light in the test circuit will go off. Increase engine speed until alternator runs at approximately 6,000 rev/min and adjust the variable resistor until the voltmeter shows 13.6 volts. The reading on the ammeter will then be approximately equal to the rated output as already given. If there is a large difference between the output reading and the rated output, the alternator must be removed from the engine for further inspection.

Failure of one or more of the diodes will be shown in the above test by effect on alternator output and can cause high alternator temperature and noise.

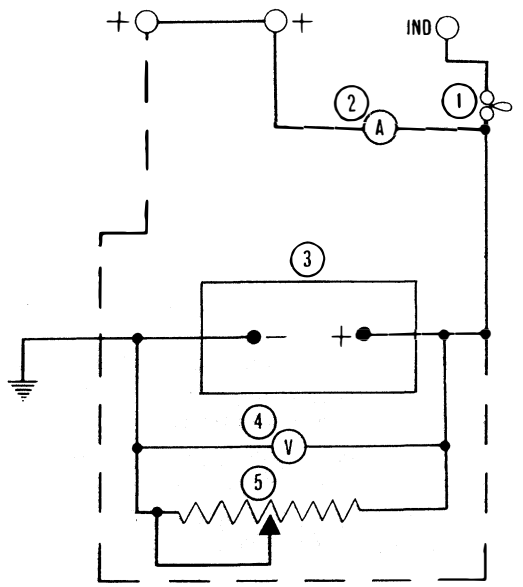


Fig. R3

Fig. R3 shows a test circuit for 15ACR, 17ACR, 18ACR, 23ACR, A115/45, A133/55 and LR series alternators with European terminals and single 3 terminal connector plug (machine-sensed).

Broken line cable connection applies to battery-sensed, in which case, the connections between the two '+' terminals will not apply and the broken line terminal will be marked "S" instead of '+'. (For LR series, 'IND' terminal is marked D+).

Fig. R4 shows a test circuit for Motorola 9AR series.

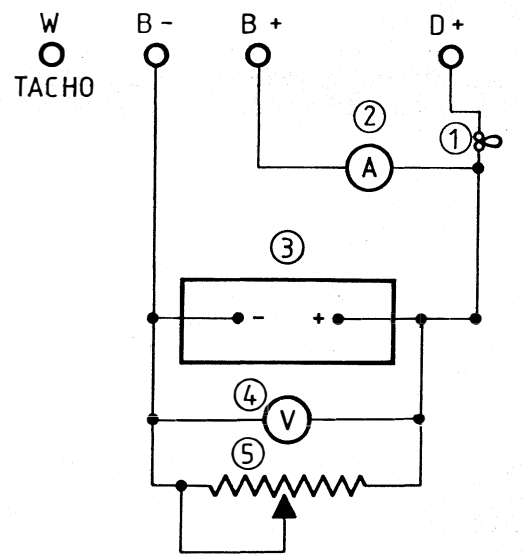


Fig. R4

Components in figs. R3 and R4.

1. 12 volt, 2.2 watt bulb.
2. 0 – 60 ammeter.
3. 12 volt battery.
4. 0 – 20 moving coil voltmeter.
5. 0 – 15 ohm 50 amp variable resistor.

To test regulator

The test which follows is where an alternator has been tested and found to be correct.

Disconnect the variable resistor and remove the earth connection from the regulator green wire or connector strip to frame.

With the remainder of the test circuit connected as for the alternator output test, start the engine and again run the alternator up to 6,000 rev/min until the ammeter shows an output current of less than 10 amperes. The voltmeter will then read 13,6 – 14,4 volts. If there is more than a small difference from this (regulating) voltage, there is a fault in the regulator and it must be renewed.

If the above tests indicate that the alternator and regulator operate correctly, disconnect the test circuit and connect the alternator terminal connector. Connect a (low range) voltmeter between the positive terminal of the alternator (the shaped terminal connector has an open end to permit this) and the positive terminal of the battery. Switch on battery load (headlights etc.), start the engine and increase speed until alternator runs at approximately 6,000 rev/min. Note the voltmeter reading.

Change the voltmeter connections to the negative terminals of the alternator and battery and again note the voltmeter reading.

If the reading is more than 0,5 volt on the positive connections or 0,25 volt on the negative connections, there is a high resistance in the charge circuit which must be corrected.

DYNAMO

Model C40A

The C40A dynamo is used with a compensated voltage control regulator. A ball bearing holds the armature at the drive end and a bronze bush at the rear holds the commutator end.

The output of the dynamo is controlled by a regulator which changes the amount of charge as needed by the battery and the load of the electrical equipment in use. When the charge of the battery is low, the dynamo gives a high output, but if the battery is fully charged, the dynamo gives a low output to keep the battery in good condition. The output is increased to give current for lights and other accessories when in use.

When the control box is renewed only the correct type must be used. A wrong type control box can cause damage to the dynamo.

Maintenance

1. Lubrication.
   Every 250 hours, put a little clean SAE 30 engine oil into the hole stamped 'OIL' at the commutator end bearing housing.
2. Brushes.
   Every 2,500 hours, the dynamo must be removed from the engine and the brushes inspected by an approved electrician.
3. Drive belt adjustment.
   Every 250 hours, check tightness of dynamo drive belt. If loose, make necessary adjustment of dynamo on its bracket.
   Do not tighten the belt too much (see page N2). Check nut which fastens dynamo pulley. Correct torque is given on page C3.

To test dynamo on engine

1. Check drive belt tension and adjust if necessary.
2. Check the connections on the commutator end bracket. The large connector is for the main dynamo output and the small connector is for the field current.
3. Switch off all lights and accessories, disconnect the cables from the terminals of the dynamo and connect the two terminals with a short pieces of wire.
4. Start the engine and set to run at normal idle speed.
5. Connect the negative lead of a 0 – 20 moving coil voltmeter to one dynamo terminal and the positive lead to a good earth point to the outside casing.
6. Gradually increase engine speed when the voltmeter reading must increase rapidly without intermittent movement. The voltmeter reading must not reach 20 volts. Do not run the engine at high speed to increase the voltage. Only run the dynamo up to 1,000 rev/min. If the voltage does not increase rapidly without intermittent movement, the dynamo must be removed from the engine for further inspection. Too many sparks at the commutator in the above test indicates a fault in the armature which must be renewed.

STARTER MOTOR

Maintenance

Maintenance is not necessary other than regular checks to ensure that the starter motor and terminal connections are securely fitted and that the connections are clean.

It is advised that the starter motor be dismantled for inspection during complete engine overhaul. The commutator must be inspected and the brushes and bearings renewed.

To test in service

If the starter motor does not operate correctly, check that the battery is fully charged and that all connections are clean and tight. Check that the voltage difference between battery, starter motor and starter switch is not too high.

If these checks show no fault, remove the starter motor for inspection.