SECTION 9A

ENGINE — DIESEL

SERVICE BULLETIN REFERENCE

NUMBER	DATE	SUBJECT	CHANGES

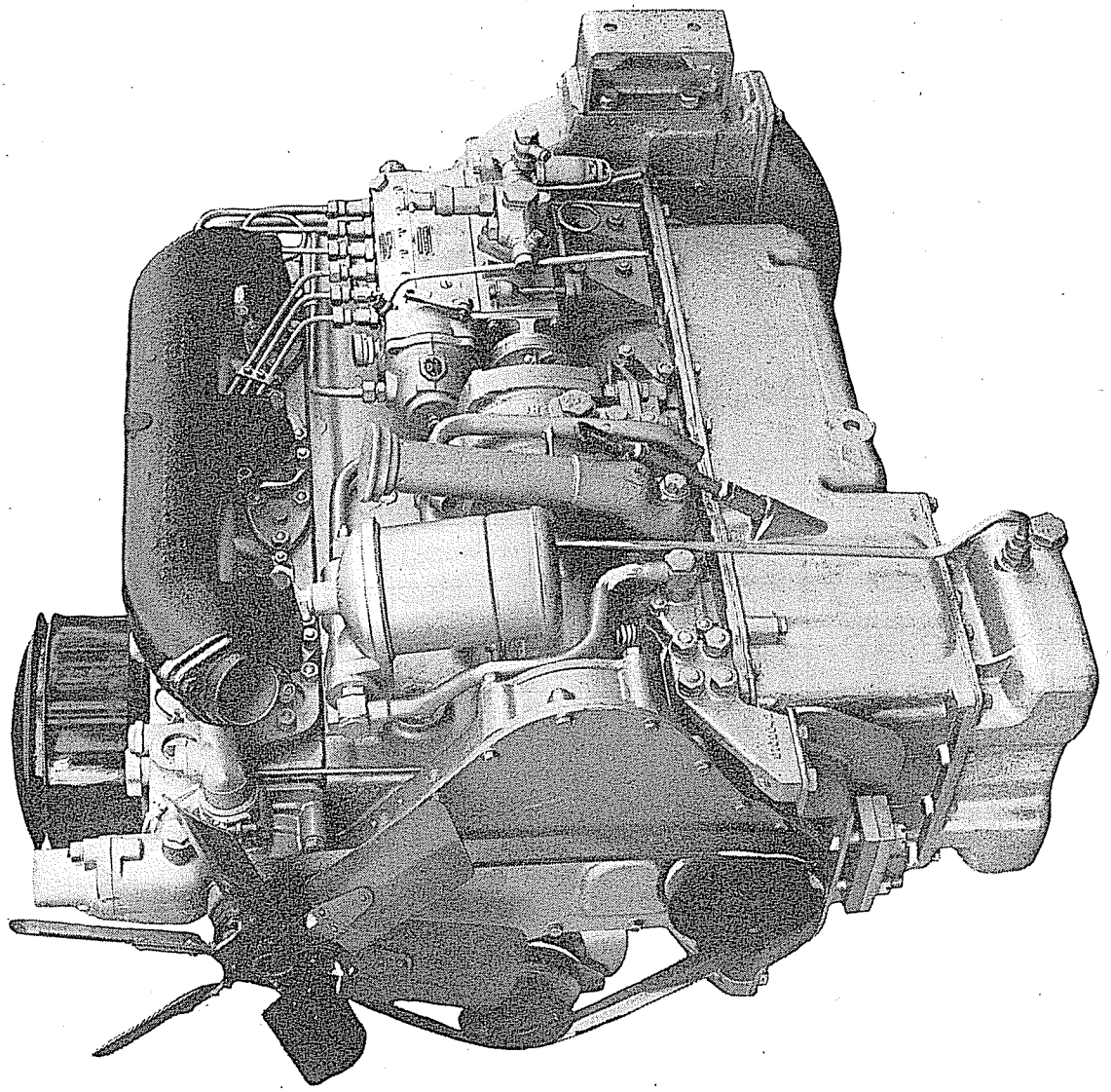


FIG. 1—NEAR SIDE VIEW OF DIESEL ENGINE.

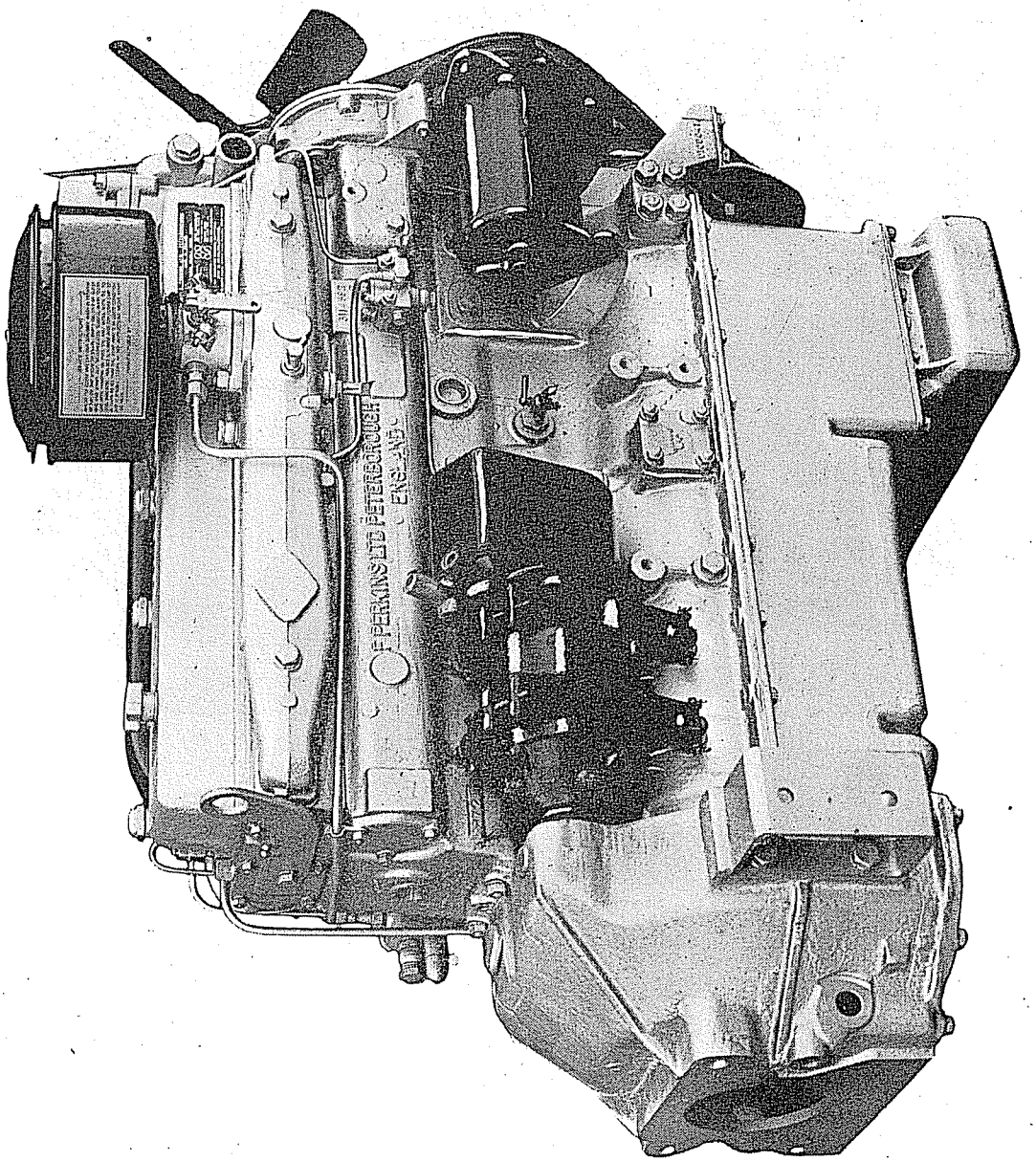


FIG. 2—OFF SIDE VIEW OF DIESEL ENGINE

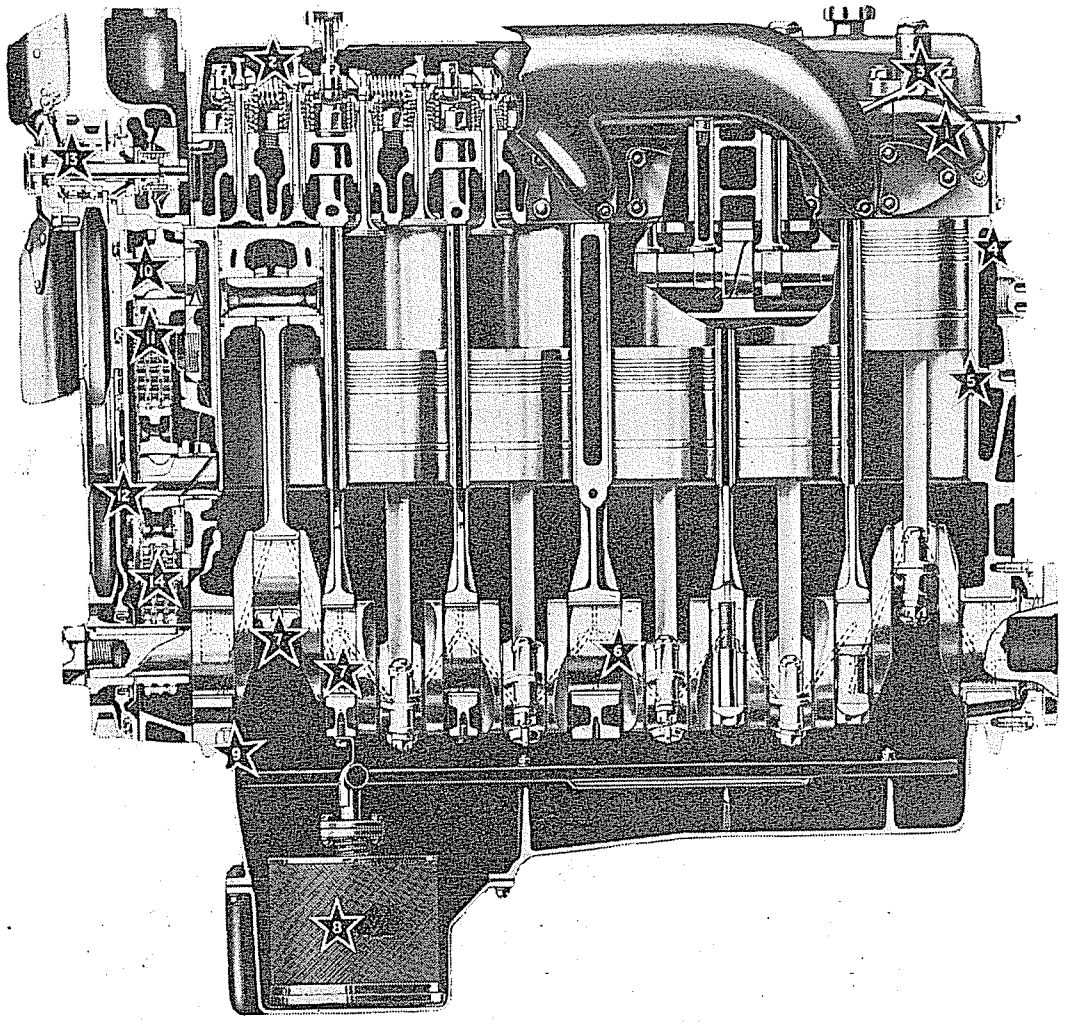


FIG. 3—LONGITUDINAL SECTION OF DIESEL ENGINE.

1 — Cylinder head—one piece chromium iron casting. (Br. Pat. 401.703).

2 — Die cast cylinder head cover in aluminium.

3 — Atomiser efficiently cooled and located vertically for accessibility.

4 — Cylinder block and crankcase — one piece high duty cast iron.

5 — Dry cylinder liners.

6 — Efficient high pressure forced lubrication.

7 — Main and big end bearing — steel back flashed copper lead.

8 — Strainer, removable with sump well.

9 — Die cast lubricating oil sump in aluminium.

10 — Camshaft (Br. Pat. 404.943).

11 — Adjustable camshaft timing sprocket.

12 — Die cast timing case cover in aluminium.

13 — Fan and water pump (Speed — 1.1/3 engine speed).

14 — Triple roller timing chain.

SERVICE STANDARDS

ENGINE - DIESEL, MODEL 8-71A-D

Bore	$3\frac{1}{2}$ inches.
Stroke	5 inches.
Number of Cylinders	6.
Firing Order	1, 5, 3, 6, 2, 4.
Horse Power (Nett)	77 B.H.P. at 2,400 r.p.m.
Taxable H.P.	29.4.
Torque at 1,500 r.p.m.	196 lbs./ft.
Displacement, Cub. Ins.	288.6 cubic inches.
Compression Ratio	16.8 to 1.
Inlet Valve Opens B.T.C.	13 degrees.
Exhaust Valve Closes A.T.C.	10 degrees.
Valve Lift	.36 inch.
Spill Timing	29 degrees.
Atomiser: Body	B.K.B. 35 S 87.
Nozzle	B.D.L. 110 S 6036.
Injection Pressure	120 Atmospheres.
Valve Spring: (Inner) Free Length	$1\frac{3}{8}$ inches.
(Outer) Free Length	$1\frac{3}{4}$ inches.
Tappet Clearances	.010 Hot.
Piston Type	Light Alloy.
Sump Capacity	21 pints.

TIGHTENING REFERENCE

PART NAME	TORQUE (Pounds feet)
Cylinder Head Nuts	55 — 60
Con. Rod Nuts	70
Main Bearing Set Screws	120
Flywheel Set Screws	75

ENGINE — DIESEL

The Diesel engine closely resembles its petrol prototype inasmuch as the mechanism is essentially the same. Its cylinders are arranged above its closed crankcase, its crankcase is one of the same general type as that of a petrol engine; it has the same sort of valves, camshaft, pistons, connecting rods and lubrication system.

It follows, therefore, that to a great extent, it requires the same treatment as that which any intelligent and careful operator would accord to a petrol engine and that gross negligence such as running the engine short of oil, with sludged oil, or with the water boiling will have the same expensive consequences.

Where the Diesel engine does differ from the petrol motor, however, is in the method of handling and firing its fuel. Carburettor and ignition systems are done away with and in their place is a single component, the fuel pump, which performs the functions of both. This confers upon the Diesel a quite exceptional reliability, since the chances of breakdown are halved. In fact, it may be axiomatically stated that a Diesel engine never has an involuntary stop (other than one caused through mechanical damage due to abuse) unless there is a shortage of fuel.

The fuel pump, though very simple in principle, must necessarily be a piece of precision engineering. Many years of experience and many hundreds of thousands of miles of running ensure that the fuel pump fitted to the Diesel engine will, given only ordinarily decent treatment, continue to function faultlessly. It must, however, be regarded in the same light as a magneto inasmuch as it should not be interfered with and that its repair, should it need attention, is definitely beyond the skill of any but specially trained workmen. Like the magneto it is built as a unit, so that in the rare event of failure, it can be replaced en bloc.

Unremitting care and attention at the factory have resulted in an engine capable of hundreds of hours profitable service. WHAT THE MANUFACTURER CANNOT, HOWEVER, CONTROL IS THE TREATMENT THAT HIS PRODUCT WILL RECEIVE IN SERVICE. That part rests with you.

This Section is designed to be a guide to the distributors of, and dealers in, vehicles equipped with the Diesel engine.

An essential factor in the attainment of that object is efficient servicing. This section of the manual will assist distributors and dealers with an effective aid in the servicing of the Diesel engine.

Reference will be made in the Section to C.A.V. depots where specialised service and equipment is available and capable of carrying out the specific operations described.

1. ENGINE DESCRIPTION.

The Diesel engines are vertical four-stroke power units. They are entirely of British design and manufacture, and are protected under Perkins British and World Patents.

The engine embodies the results of experience gained in the production of Diesel engines over a period of many years. The materials and workmanship throughout are of the highest class. Most parts are guaranteed interchangeable, jigs being used everyhere in course of manufacture, and all parts pass through a system of thorough inspection where they are checked to the closest limits.

Each engine is subjected to stringent tests before leaving the works.

2. GENERAL.

The Perkins P-type Diesel, with which this Section is concerned, is a 6-cylindered unit, having a bore and stroke of $3\frac{1}{2}$ inches and 5 inches respectively.

Cylinder Block.

The cylinder block and crankcase are comprised in a one-piece high duty cast iron alloy casting, scientifically designed to gixe maximum strength and rigidity. The camshaft chamber is situated high up in this casting. The water jackets are carried down the length of the cylinders, which are fitted with renewable high duty cast iron alloy dry liners to give maximum resistance to wear.

Cylinder Head.

The cylinder head is a one-piece chromium iron casting, secured by a large number of through studs. Valves and tappets are carried directly in the head on the top of which the rocker gear is mounted. The whole is enclosed in a light alloy die cast cover. It is possible to remove the head completely without disturbing the timing. All valves are of special alloy steel, the inlet being larger to ensure maximum volumetric efficiency. No masks or deflectors are fitted. The spherical combustion chamber is formed half in the head and half by a detachable steel cap.

Camshaft.

The camshaft is carried high up on the offside of the cylinder block, and is provided with journals of generous bearing area. This construction eliminates push rods.

Crankshaft.

Seven main bearings. The crankshaft is extremely rigid, being supported by a bearing between each cylinder, and is statically and dynamically balanced. The crankshaft is machined from a solid nickel chrome molybdenum steel forging and has a large flange formed solid at the rear end for mounting the flywheel.

Main Bearings.

Anti-friction metal. These provide generous bearing area, and consist of removable thin steel shells, lined with copper lead metal, and are locked in position by dowels in the crankcase and caps.

The main bearing caps are located in position by two large diameter dowels and are securely fastened to the crankcase by large high tensile steel set bolts.

Connecting Rods.

Alloy steel. Light "H" section nickel chrome molybdenum steel stampings are used and are kept as light as possible to reduce inertia stresses consistent with ample strength. The big end bearings are pre-finished thin wall bearings. They are steel backed with a lead bronze lining and an idium coating.

Pistons.

The pistons are flat-topped. They are of special light aluminium alloy, with ample metal in the crown to carry off the heat of combustion. They are suitably ribbed to take the load directly to the gudgeon pin bosses. Three compression rings of which one is of laminated steel and one scraper ring, are fitted above the gudgeon pin. There is one scraper ring below that pin.

Timing Gear.

The camshaft and fuel pump shaft are driven by a triple roller chain enclosed in the timing case at the front of the engine. Chain whip is taken up by a fibre damper, and an automatic chain tensioner is provided. The camshaft sprocket is provided with an arrangement whereby close adjustment of the timing may be made when necessary.

Owing to the characteristics of the Perkins patented combustion system no advance and retard device is required.

Lubrication.

The lubrication is high pressure forced feed throughout the engine. The pump is driven through gears from the fuel pump drive shaft by steel spindles which are of robust construction. It is fully capable of maintaining an adequate pressure at all running speeds. The pump itself is of aluminium.

There is a large capacity gauze full flow filter in the engine sump well and another filter in the pressure system mounted in an accessible position on the engine.

Crankcase Ventilation System.

To relieve the crankcase of excess pressure and fumes a system of pipes is used to connect the interior of the engine to atmosphere.

Fuel Pump and Atomisers.

The fuel pump is of the V unit type, fitted with pneumatic governor. Idling speed can be varied at will from the driver's seat.

The atomisers are located in a very accessible position on top of the cylinder head and have two sprays, one into the combustion chamber and the other into the cylinder itself, giving the engine the easy starting qualities associated with a direct injection engine.

Cooling.

The cooling water is pump circulated, the pump, of the impeller type, being located in an accessible position on the front end of the cylinder head. It is belt driven from a pulley on the crankshaft at one and a third times engine speed. Provision is made for fitting a fan on the front end of the pump pulley.

Cooling water from the pump is delivered to a manifold feeding connection in the cylinder head. The cooling surfaces in the cylinder block and head are of ample area. Large passages between the block and head allow the former to be cooled by thermo-syphon.

Air Intake.

A large air cleaner is fitted through which must pass all air drawn into the engine. Harmful dust is thus excluded and the life of the cylinders correspondingly prolonged.

The air cleaner is mounted on a venturi inlet, housing the butterfly throttle valve, which, apart from the stopping lever, is the only control on the engine.

Engine Mounting.

The engine is mounted at four points and incorporates flexible mountings.

Ki-gass and Induction Heater.

Comprises Ki-gass pump, atomiser, priming tank, piping, induction heater and starter-heater switch. The induction heater is not in contact with the burning gases in the cylinder. It is located in the inlet manifold and is in use only during starting under very cold conditions.

Electric Starting Equipment.

Electric starting equipment comprises electric starter 12-volt axial type. This is mounted on the offside of the cylinder block beneath the camshaft chamber, and does not, in this position, materially increase the width of the engine.

Dynamo.

12-volt (earth return) type, complete with control box and fuse box. A facing is provided on the offside of the cylinder block for mounting the dynamo, the drive being by V-belt from the crankshaft.

Exhauster.

Where a servo system is required a sliding vane exhauster is fitted, driven in tandem with the fuel pump and supplied complete with vacuum tank, non-return valve, piping and vacuum gauge, as required.

Air drawn through the snifter valve is circulated round the pump via a passage in the exhauster bracket, and therefore avoids raising the pressure in the engine sump.

Note: The manufacturers reserve the right to alter this specification without notice.

3. SCHEDULE OF CLEARANCES AND TOLERANCES

(1) The data regarding clearances and tolerances are given as a guide for personnel engaged upon major overhauls.

(2) The figures in the column "Permissible Dimensions" are the drawing sizes to which the parts are made. These dimensions are given in limit form and represent the minimum and maximum sizes to which parts may be accepted when new, as, for example:

$$\frac{1.298}{1.2985}$$ quoted for a shaft diameter.

(3) The difference between the minimum and maximum dimensions quoted in Paragraph 2 is known as the manufacturing tolerance. This tolerance is necessary as an aid to manufacture and its numerical value is an expression of the accuracy of the design; it may also be considered as a numerical expression of the desired quality of workmanship. For the example referred to in Paragraph 2, the tolerance is 0.0005.

(4) If, when carrying out a major overhaul, it is found that a bush and corresponding shaft have worn and that the majority of wear has taken place in the bush, it may be necessary to renew the bush only. Similarly, if the majority of wear has taken place on the shaft, it might only be necessary to renew the shaft.

(5) During the overhaul of worn components, personal initiative must be excercised at all times. It is obviously uneconomical to return worn parts to service with an expectation of life which may involve labour costs again at an early date.

SCHEDULE OF BUILDING CLEARANCES AND TOLERANCES TO BE ADHERED TO WHEN OVERHAULING ENGINES TO FACTORY STANDARDS

Part No.	DESCRIPTION	PERMISSIBLE DIMENSION		PERMISSIBLE CLEARANCE	
		inches	mm.	inches	mm.
	OIL PUMP AND AUXILIARY DRIVE				
0440004	Gear Housing (Dia. of pocket) ..	1.982 1.984	50.34 50.39	.008	.2032
0410003 0410004	Gears (Internal, Idler and Driver) (Dia. over teeth)	1.972 1.974	50.09 50.14	.012	.3048
	Ditto (Length of gears) with joints ..	.872 .871	22.15 22.125	.002	.0508
0440004	Housing (Depth of Gear Pocket)	.876 .874	22.25 22.20	.005	.127
0050015	Bush, Oil Pump gear (Bore Dia.) ..	.6245 .62575	15.864 15.895	.00075	.019
0750003/ 0750004	Shaft, Oil Pump gear (Dia.)	.62225 .62375	15.807 15.844	.0035	.0889
0750106	Shaft (Internal, Idler) (Dia.)	.999 .998	25.375 25.35	.001	.0254
0410004	Gear (Internal, Idler) (Hole Dia.) ..	1.00075 1.000	25.42 25.40	.00275	.0698
0050013	Bush, Fuel Pump Drive (Bore Dia.) ..	1.25325 1.254	31.83 31.85	.00175	.0444
0750001	Shaft, Fuel Pump Drive (Journal Dia.)	1.251 1.2515	31.775 31.787	.003	.0762
	CAMSHAFT				
0140002	Camshaft. No. 1 Journal Dia.	1.869 1.870	47.47 47.50	.004	.1016
	No. 1 Hole for Shaft in Cylinder Block	1.874 1.877	47.60 47.68	.008	.2032
	No. 2 Journal Dia.	1.859 1.860	47.22 47.24	.004	.1016
	No. 2 Hole for Shaft in Cylinder Block	1.864 1.867	47.345 47.422	.008	.2032
	No. 3 Journal Dia.	1.849 1.850	46.965 46.99	.004	.1016
	No. 3 Hole for Shaft in Cylinder Block	1.854 1.857	47.092 47.168	.008	.2032

SCHEDULE OF BUILDING CLEARANCES AND TOLERANCES TO BE ADHERED TO WHEN OVERHAULING ENGINES TO FACTORY STANDARDS

Part No.	DESCRIPTION	PERMISSIBLE DIMENSION		PERMISSIBLE CLEARANCE		REMARKS
		inches	mm.	inches	mm.	
	CAMSHAFT (cont.)					
	No. 4 Journal Dia.	1.839 1.840	46.71 46.74	.004 .008	.1016 .2032	
	No. 4 Hole for Shaft in Cylinder Block	1.844 1.847	46.84 46.914			
	Cam Lift	.3145 .310	7.98 7.87			
30602	Chain, Timing (Length between centres of extreme rollers)	46.125	1171.57			Measured without master link.
30601	Tensioner, Chain (Clearance between slider and retaining Plate) ..			.001 .0035	.0254 .0889	
	CYLINDER BLOCK					
0280001	Cylinder Block (for Camshaft bores see Camshaft Assembly) ..	13.7395 13.7445	348.98 349.11			
	Height of Block between top and bottom faces					
	Cylinder bores (finished Dia.) ...	3.501 3.502	88.925 88.95			Add .030″ or .762 mm. to these dimensions when rebored
	Parent bore (Dia. before fitting liners)	3.6865 3.6875	93.637 93.662	.002 tight	.0508 tight	
0530002	Cylinder Liner (Outside Dia.) ..	3.6895 3.6905	93.710 93.742	.004 tight	.1016 tight	
0630028	Piston (Depth of Crown below top face of cylinder block)			.002 .010	.0508 .254	Measured with crank and piston at T.D.C.
	Comp. Ring Grooves (Width) $\frac{3}{32}$″ .. (2.38 mm.)	.09575 .09675	2.43 2.455	.002	.0508	
0640011	Compression Ring (Width) $\frac{3}{32}$″ .. (2.38 mm.)	.09375 .09275	2.38 2.355	.004	.1016	
	Comp. Ring Grooves (Width) $\frac{1}{8}$″ .. (3.175 mm.)	.127 .128	3.226 3.251	.002	.0508	
0640001	Compression Ring (Width) $\frac{1}{8}$″ .. (3.175 mm.)	.124 .125	3.15 3.175	.004	.1016	
	Gaps (Closed) ..			.009 – .013 ($\frac{3}{32}$″) .005 – .009 ($\frac{1}{8}$″)	.2286 – .3302 ($\frac{3}{32}$″) .1270 – .2286 ($\frac{1}{8}$″)	Permissible gap in unworn cylinder, see footnote for gap in worn cylinder.

SCHEDULE OF BUILDING CLEARANCES AND TOLERANCES TO BE ADHERED TO WHEN OVERHAULING ENGINES TO FACTORY STANDARDS

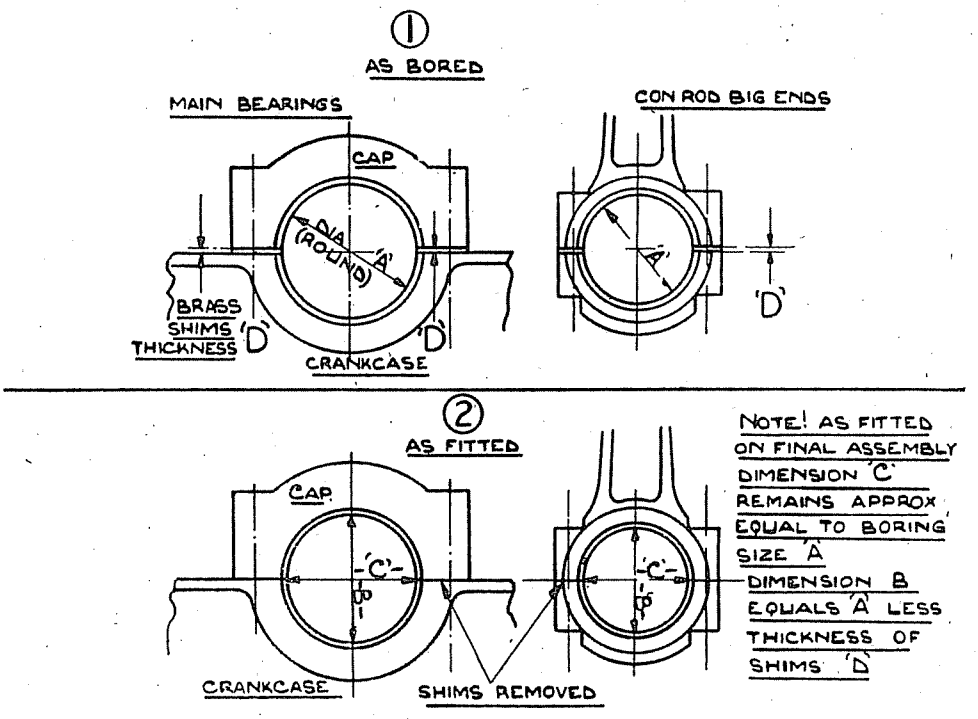


FIG. 4

Part No.	DESCRIPTION	PERMISSIBLE DIMENSION		PERMISSIBLE CLEARANCE		REMARKS
		inches	mm.	inches	mm.	
	CYLINDER BLOCK (cont.)					
0640003	Piston (Scraper ring groove) (width)	.252 / .253	6.4 / 6.426	.002	.0508	
0640004	Ring, Scraper (width)	.249 / .250	6.324 / 6.35	.004	.1016	
	Gap			.009 / .013	.2286 / .3302	
	CRANKSHAFT AND CONNECTING ROD					
0050026/7	Bearing, Connecting Rod, Big End (Finished bore)	2.25225 / 2.25325	57.207 / 57.232	.00325	.0825	Measured along axis of rod. Does not apply with strip type bearings.
0260001 0260002	Crankshaft, Crankpins (Dia.) ..	2.2485 / 2.249	57.112 / 57.125	.00475	.1206	

NOTE :—When fitting Piston Rings to a worn cylinder, ring gaps should be checked at *bottom* of cylinder.

SCHEDULE OF BUILDING CLEARANCES AND TOLERANCES TO BE ADHERED TO WHEN OVERHAULING ENGINES TO FACTORY STANDARDS

Part No.	DESCRIPTION	PERMISSIBLE DIMENSION		PERMISSIBLE CLEARANCE		REMARKS
		inches	mm.	inches	mm.	
	CRANKSHAFT AND CONNECTING RODS (cont.)					
0260010 0260009	Crankshaft, Crankpins (Width) ..	1.562 1.5635	39.675 39.713	.0095	.2413	Standard Crankshafts only.
	Bearing, Connecting Rod, big end (Width)	1.5505 1.5525	39.383 39.433	.013	.3302	Does not apply with strip type bearings.
0050009	Bush, Connecting Rod, small end (Bore Dia.)	See Remarks		.001	.0254	NOTE: Bushes reamed to suit individual pins.
0610516	Pin, Gudgeon (Dia.)	1.24975 1.250	31.743 31.75			Bushes provided with reaming allowance.
0210001/4	Rod, Connecting, alignment between small and large end bearing bores. (Parallelism)					Alignment measured between mandrels through large and small end bores. See Fig. 5.
	Ditto. (Twist)					
0050018/19	Bearing, No. 7 Main (Width) ..	1.873 1.872	47.574 47.549	.00125	.0317	
0260010	Crankshaft, No. 7 Journal (Width) ..	1.87425 1.87625	47.606 47.657	.00425	.1079	
	Bearings, Main, Boring Dia. "A" (See Fig. 4)	2.7555 2.7565	69.983 69.996			
	Do. Finished size "B" (See Fig. 4) measured vertically	2.7525 2.7535	69.901 69.926			
0050023/22	No. 1					Bored with brass shims in position.
0050020/21	Nos. 2, 3, 5, 6			.0035	.0889	Removed on final assembly.
0050024/25	No. 4			.005	.1270	Shim thickness D—.00275" .0698 mm. .00325" .0825 mm.
0050018/19	No. 7					
0260010	Crankshaft, Main Journals (Dia.) ..	2.7485 2.749	69.812 69.824			(See Fig. 4).
0240005	Cover, Crankshaft, rear end	3.001 2.9995	76.225 76.187	.0055	.1397	
	Crankshaft, thread	2.994 2.992	76.047 75.997	.009	.2286	
0210007	Rod, Connecting, Parent Bore Dia. (for strip type bearings) ..	2.3955 2.3950	60.846 60.833			
0050118	Bearing, Strip, Connecting Rod, Big Ends, Bore Dia.	2.251 2.252	57.175 57.200			Measured in position.
0210007	Rod, Connecting, Parent Bore (for small end bush)	1.37475 1.37550	34.917 34.938			
0050119	Bush, Connecting Rod, Small end, Bore Dia.	1.2505 1.2515	31.763 31.788			Bushes provided with reaming allowance.

SCHEDULE OF BUILDING CLEARANCES AND TOLERANCES TO BE ADHERED TO WHEN OVERHAULING ENGINES TO FACTORY STANDARDS

Part No.	DESCRIPTION	PERMISSIBLE DIMENSION inches	PERMISSIBLE DIMENSION mm.	PERMISSIBLE CLEARANCE inches	PERMISSIBLE CLEARANCE mm.	REMARKS
	CYLINDER HEAD AND VALVE GEAR					New clearance of valve face below cyl. head face .070″ or 1.778 mm. Ex. and inl. Seat should not be re-cut unless essential when clearance must not exceed .140″ or 3.048 mm. Exh. and inlet.
0050016	Bush, Rocker Lever (Bore Dia.) ..	.6245 / .62575	15.862 / 15.894	.00075 / .0035	.0195 / .0889	
0750006	Shaft, Rocker (Dia.)	.62225 / .62375	15.805 / 15.843			
0420002	Guide, Valve (Bore Dia.)	.314 / .315	7.972 / 8.00	.002 / .004	.0508 / .1016	
0910001/2	Valves, Inlet and Exhaust (Stem Dia.)	.311 / .312	7.895 / 7.925			
0860007	Tappet, Valve (Shank Dia.)	.62225 / .62575	15.805 / 15.843	.00075 / .0035	.0195 / .0889	
	Hole in Cylinder Head for Tappet (Dia.)	.6245 / .62575	15.862 / 15.894			
0780007	Spring, Valve, Inner (Free length) ..	1.365 / 1.405	34.67 / 35.68			
0780006	Spring, Valve, Outer (Free length) ..	1.803 / 1.783	45.80 / 45.29			
	WATER PUMP					
0750007	Shaft, Water Pump	.498 / .499	12.649 / 12.674	.001 / .0035	.0254 / .0889	
0050017	Bush, Water Pump Support Shaft ..	.500 / .5015	12.70 / 12.738			

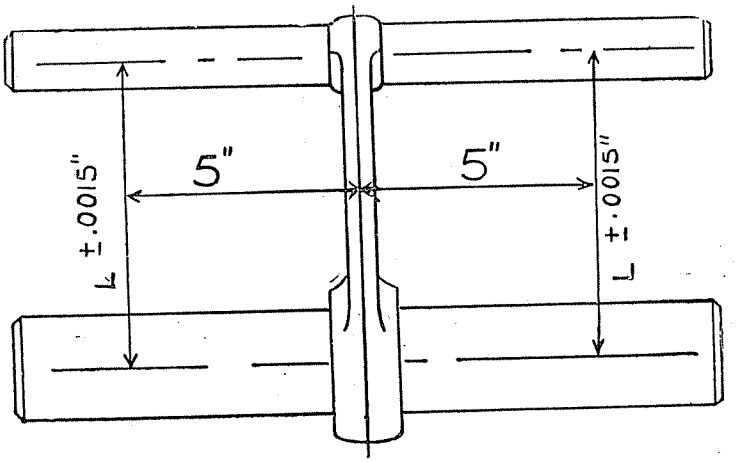


FIG. 5

Large and small end bores must be square and parallel with each other within the limits of plus or minus .0015″ measured 5″ each side of the axis of the rod on test mandrel as shown in Fig. 5.

NOTE :—The manufacturers reserve the right to alter this Specification without notice.

(1) The two halves of the housing bolted together are offered up to the diameter marked "Z". The face of the housing is then coated with jointing compound and the joint is fitted. The gauge is then inserted into the two rear main bearings and the housing secured by six set screws and shakeproof washers. Ensure that the gauge is capable of rotation.
(2) The through bolts on the housing are then removed, and the rear mains are dismantled leaving one half of the housing on the block, the other coming away with the rear main bearing cap.
(3) If the housing has worn through contact with the oil return thread, it is possible to file the butt faces of the two halves and then re-machine or scrape to the right dimension to give a .0055 concentric air gap round the oil return thread on the crankshaft.
(4) Finally, after fitting a new or reconditioned rear end oil seal housing, assemble crankshaft in the ordinary way.
(5) The through bolts securing the two halves of the oil seal housing together should be finally pinned.

Note: As the front and rear main bearings are exposed, i.e., not covered by the sump, care should be taken when re-assembling to ensure that no oil leakage can take place. A light coating of jointing compound or the like should be smeared on the faces of the main bearing caps. In no case should set screws other than those supplied by the manufacturer be used as they are all of special heat treated high grade steel.

E. Connecting Rods.

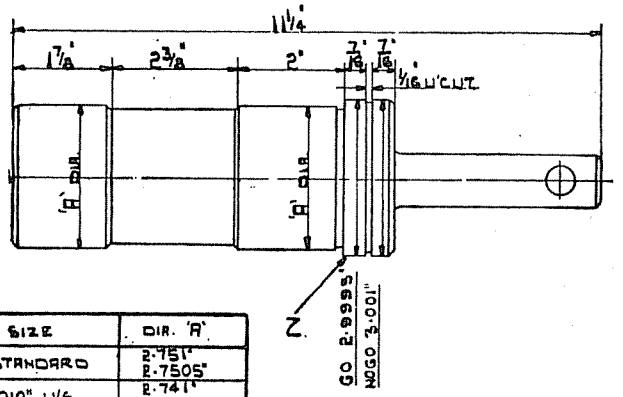
(1) The big end bearings and small end bushings should be carefully washed, cleaned and examined.
(2) The gudgeon pin should be a free working fit in the small end bush. (See para. 3.) If either the pin or bush are worn beyond the degree specified they should be renewed.
(3) The beddings of the bearings on the crankshaft and pins should be checked and any high or low spots noted. The surface of the bearings should be further examined for any sign of "picking up" or the embedding into the metal of foreign material.
(4) On no account must connecting rod caps be filed as there is not sufficient metal in the bearing to allow that.

If the connecting rod caps have been filed and, at a later date, it is desired to fit new bearings, the connecting rods will have to be scrapped because the rods are not interchangeable.

(5) If the bearings and the surfaces are not unduly scored or marked, they may be used again (see para. 3 for permissible wear).
(6) All connecting rods and caps, as well as their bolts and nuts, are plainly marked with a number, corresponding to their position in the engine (see Figure 8). The numbers on caps, rods, bearings, nuts and bolts coincide.
(7) On one side of the rod are numbers with dots (thus 2.), on the other side just numbers (thus 2). The side with the dots is on the camshaft side of the engine.
(8) The original connecting rod bearing shells are also numbered and care should be taken to see that the shells are assembled with the number in the correct position as described above. New bearing shells must be numbered as those which they replace.
(9) Bearing shells, caps and rods must be scrupulously clean before assembly.

Before fitting big end bearing shells to the crankshaft, they should be assembled and the connecting rod caps bolted into place, so that the following can be checked.

(1) The bolts are a good fit and do not distort the bearing shell.
(2) The shells have the correct "nip" of .004 inch to .008 inch in the rod.
(3) The faces of the rod and cap are meeting squarely when the nuts are tightened.



SIZE	DIA. 'A'
STANDARD	2·751" 2·7505"
·010" U/S	2·741" 2·7405"
·020" U/S	2·731" 2·7305"
·030" U/S.	2·721" 2·7205"

Fig. 7—Rear Oil Seal Location Gauge.

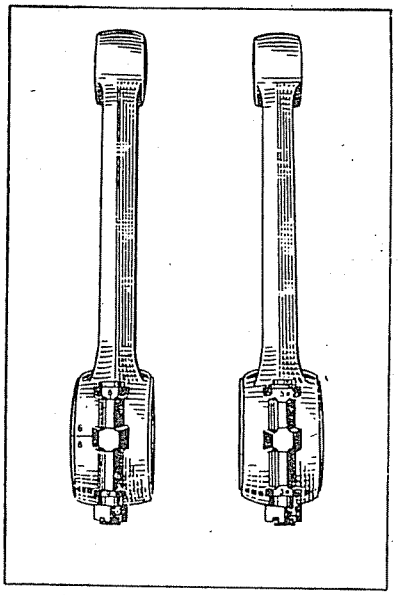


Fig. 8.—Showing the markings on the connecting rods.

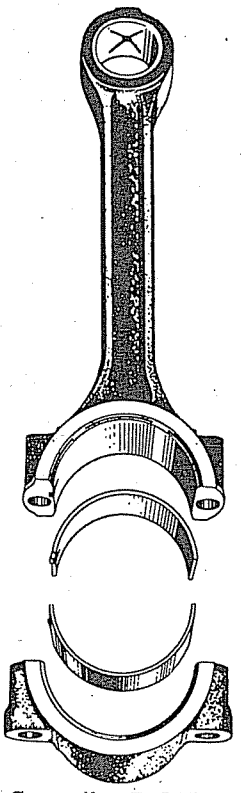


Fig. 9—Connecting Rod disassembled.

(4) The gudgeon pins are in alignment with the big end bearings; this should be checked in two directions as shown in Figures 10 and 11.

(10) When the above has been carried out, dismantle the rods again and fit the bearing shells to the crank pins, taking care a good marking is obtained.

For information regarding clearances—
(a) between connecting rod big end shells and crankpins, and
(b) between shells and crank cheeks, see Paragraph 3.

(11) Examine connecting rod bolts carefully for damaged threads or "stretch". Doubtful ones must be scrapped. All connecting rod nuts and bolts should be renewed during a major overhaul. In no case should bolts be used other than those supplied by the manufacturer, as they are of special heat treated high grade steel.

(12) When refitting bearings to connecting rods and caps take care that the dowels are not preventing the bearing shells from seating properly in the connecting rod caps. They must bed well down.

(13) Fit each connecting rod to its appropriate crank pin, bearing in mind the marking as described above.

(14) Should it be necessary to replace one connect-rod in a set, the weight of this connecting rod must be within plus or minus $\frac{1}{4}$ oz. of the weight of the other rods, as all connecting rods are made up in sets to within this limit.

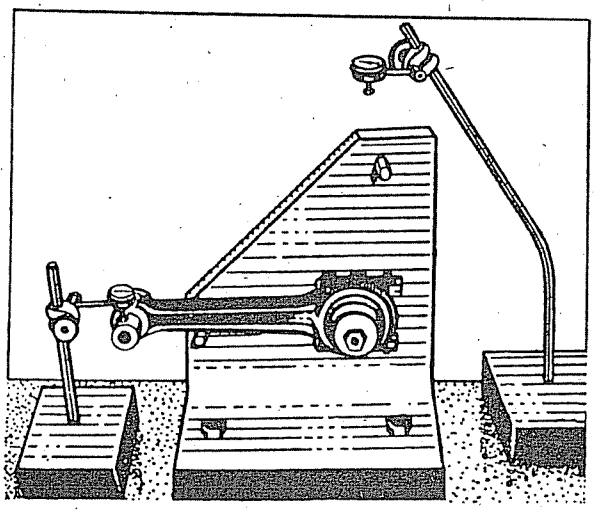


Fig. 10—Checking alignment of Connecting Rod (horizontal)

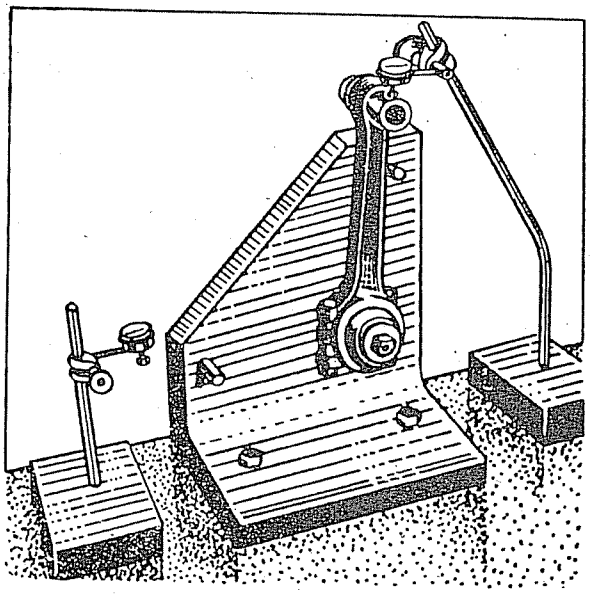


Fig. 11—Checking alignment of Connecting Rod (vertical).

F. Pistons and Rings.

The arrangement of pistons and rings is as follows:

Light alloy pistons have two $\frac{3}{32}$ inch plain compression rings, four steel segment rings in one groove and two scrapers, one above and one below the gudgeon pins.

10. FITTING NEW RINGS.

Pistons should be thoroughly washed and the rings examined for any tendency to stick in their grooves. Wear is most likely to occur in numbers 1 and 2 pressure ring grooves.

Information is contained in Paragraph 3 (Schedule of Clearances and Tolerances) as to the permissible amount of wear in the piston ring grooves. This determines whether the piston should

be renewed or whether it may continue to be used. In addition, however, the piston skirt should be examined and if there is any scoring, the piston should be discarded. When fitting new pistons, take care that there is minimum side clearance between piston bosses and connecting rod small end, as specified in Paragraph 3.

(1) Examine the piston carefully for bruising of the ring groove and ensure that the rings move freely in their grooves. Refer to Paragraph 3 for the correct ring gap in the cylinder bore.
(2) Make certain that the ring gaps are equally spaced round the piston. The gaps in the laminated ring should be at 180 degrees and over the gudgeon pin bosses.
(3) When preparing to assemble the gudgeon pin, piston and connecting rod, warm the piston in oil at a temperature of 100 to 120 degrees F.
(4) Whilst still warm, insert the gudgeon pin.
(5) The pistons are numbered consecutively, No. 1 being that belonging to the cylinder nearest the timing case. They must be replaced accordingly.
(6) Each piston must be assembled on its connecting rod so that the recess in the piston crown is on the side opposite to that on which are the numbers with the dots on the rods. The side of the rod with dots is on the same side of the camshaft.

The procedure ensures that the recesses in the pistons come beneath the atomisers, which is essential.

(7) When assembling gudgeon pins and pistons, new circlips must be fitted. Ensure the circlips are fitted correctly and bedded in their grooves in the piston bosses.

11. FITTING NEW PISTONS. (See also Paragraph 10, "Fitting New Rings.")

It is important when fitting pistons to check the distance from the crown of the piston to face of the cylinder block.

(1) When the crank is at top dead centre, the crown of the piston must not be less than .002 inch below the cylinder block face and preferably not more than .010 inch below block face. This must always be checked when assembling new pistons. The method is shown in Figure 13. If the piston stands higher than this, the crown must be reduced accordingly, if lower, that piston must be rejected if first class performance is required.

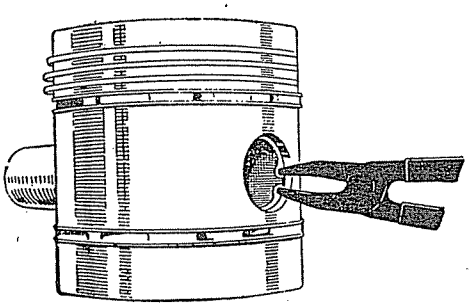


Fig. 12—Showing arrangement of piston rings, also method of removing circlips.

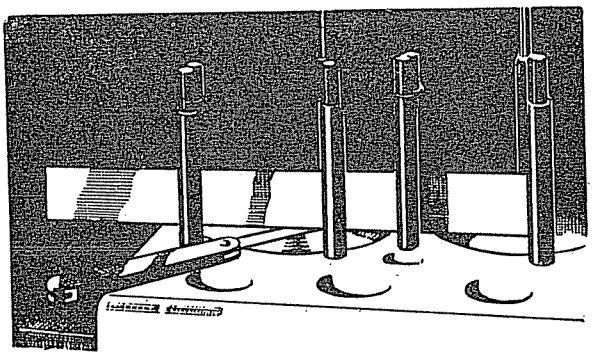


Fig. 13—Checking distance from crown of piston to face of cylinder block.

(2) The pistons and connecting rods may now be fitted in the cylinder. It is first, of course, necessary to remove the connecting rod caps.
(3) Insert the pistons in the cylinders from the top, dealing with them in the order, 1 and 6, 2 and 5, 3 and 4.
(4) Take care not to damage the rings. Should the piston accidently drop partly into the bore and be held suspended by a piston ring, it must be taken out again, and the ring examined to see if it is cracked or broken.
(5) Having fitted all pistons in their respective cylinders, the connecting rod bolts should be tightened down to the recommended torque.
(6) Fit the split pins so that the heads are toward the front of the engine.
(7) Rotate the crankshaft by hand and note that all parts move freely.

12. FITTING TIMING CASE.

(1) Fit new joint using jointing compound.
(2) Fit first upper part and then lower part of the timing case.
(3) Be careful to tighten the set screws holding the timing case, using shakeproof washers.

13. AUTO-TENSIONER.

It is advisable to assemble the auto-tensioner before fitting to the engine; to test for full movement of the sprocket guide, also that the ratchet plates and plungers are working correctly.

To assemble the auto-tensioner:

(1) Place base of the body support tight in a vice and slide on the sprocket and guide.
(2) Screw in position to the guide, the two ratchet plates, the teeth pointing to the left.
(3) Screw the plunger retaining housing plate complete with the two plungers and springs to the body support, the plunger teeth pointing to the right.
(4) Slide the sprocket and guide to the right and place the tensioner spring between the body support and the inside of the guide.
(5) With the plungers depressed, slide the sprocket and guide to the left, testing the free movement of the guide by allowing the tensioner spring to re-assert the sprocket and guide.
(6) Lock the two set screws on each ratchet plate with wire.

(7) Remove the plunger retaining housing plate and tensioner spring.
(8) Fit the body support to the engine and secure into position, using countersunk set screws and shakeproof washers.
(9) Place on the body support the sprocket and guide complete with ratchet plates.
(10) Insert the tensioner spring in the same position as described above.
(11) Screw the plunger retaining housing plate, complete with plunger and springs to the body support and lock the set screws with wire.

14. OIL PUMP AND DRIVE GEARS.

(1) Dismantle, clean and examine for wear the oil pump gears and end cover.
(2) Check the bushes for excessive wear (see Tolerances, Paragraph 3).
(3) If new parts are required, thoroughly clean all parts before final assembly.
(4) Replace oil pump joint and oil pump to cylinder block, tightening the set screws evenly.
(5) Fit the suction pipe and joint to oil pump ensuring the joint is tight and the flange is not bent.
(6) Take care that wire or shakeproof washers are used to the set screws on the oil pump and the suction pipe flange.
(7) Examine the oil pump driving and driven skew gear for wear. These gears may be put back in the engine if the bronze gear is not excessively worn. If the bronze gear is excessively worn a new matched pair of gears must be fitted.
(8) Fit gasket for auxiliary drive gear casing.
(9) Fit sleeve, springs and packing washers for oil pump drive spindle and then fit auxiliary drive gear assembly.
(10) Care must be taken to ensure that the oil pump vertical drive is carefully aligned. A rocker shaft may conveniently be used as a mandrel.
(11) For the test, it is of course necessary temporarily to remove the pump driving spindle.
(12) Before finally tightening nuts holding pump cover in place, see that the pump will work freely. Use a hacksaw blade, engaging the driving dog of the pump, to test for ease of running. It should be possible to turn the blade with finger and thumb.
(13) Wire the nuts on the pump cover after they have been finally tightened.
(14) Also wire nuts securing body to cylinder block.
(15) Fit the intermediate pump spindle.
(16) Fit cap and spiral gear.
(17) Replace oil relief valve.
(18) Place joint and oil relief valve cover in position and tighten the three nuts securing cover to block.
(19) Replace oil filter and main oil feed pipes, relief valve cover to filter, filter to main pressure rail.

15. CAMSHAFT.

Refit the camshaft sprocket if this has been removed. It is a press fit on the end of the camshaft. The camshaft sprocket incorporates 6 holes equispaced at 60 degrees; this provides for an adjustment to be made to the valve timing in multiples of 3 degrees of crankshaft angle. It should be carefully noted that the two threaded withdrawal holes in the camshaft sprocket are nothing to do with the camshaft adjustment. Only three set screws are used for securing the sprocket to the hub and these should be wired after making an adjustment.

Small arrow marks are stamped on the crankshaft sprocket and hub. When the arrow marks are in line, this denotes original setting.

Adjustment—Section 1.

Note the position of the sprocket in relation to the camshaft. If the open holes in the hub are 1½° retarded to those in the sprocket determine the amount of alteration required to the valve timing and proceed as follows:

All angular references are for crankshaft degrees.

(a) **To advance 3° or retard 15°.**

To advance the valve timing 3°, remove the three set screws from their present position and replace them in the alternate set of tapped holes, thus moving the sprocket through 1½° of camshaft angle.

To retard 15°, now retard the sprocket complete with camshaft one tooth.

(b) **To advance 6° or retard 12°.**

To advance 6°, remove the set screws and advance the sprocket through seven teeth without moving the camshaft and place the set screws back in the same tapped holes.

To retard the timing 12°, now retard the sprocket complete with camshaft one tooth.

(c) **To advance 9° or retard 9°.**

Proceed as in (b) above, but replace the set screws in the alternate set of tapped holes.

(d) **To advance 12° or retard 6°.**

To advance 12°, remove the set screws and retard the sprocket through 6 teeth without moving the camshaft and place the set screws back in the same tapped holes.

To retard 6° now retard the sprocket complete with camshaft one tooth.

(e) **To advance 15° or retard 3°.**

Proceed as in (d) above, but replace set screws in alternate set of tapped holes.

Section 2.

Should the relationship of the sprocket and hub show the open holes in the hub 1½° advanced to those in the sprocket, as follows:

(a) **To advance 3° or retard 15°.**

To advance 3°, remove the set screws and advance the sprocket through 7 teeth without moving the

camshaft and replace the set screws in the alternate set of tapped holes.

To retard 15° now retard the sprocket complete with camshaft one tooth.

(b) **To advance 6° or retard 12°.**

Proceed as in (a) above but place set screws back in the same set of tapped holes.

(c) **To advance 9° or retard 9°.**

To advance 9°, remove the set screws and retard the sprocket through 6 teeth without moving the camshaft and replace the set screws in the alternate set of tapped holes.

To retard 9°, now retard sprocket complete with camshaft one tooth.

(d) **To advance 12° or retard 6°.**

Proceed as in (c) above but place set screws back in the same set of tapped holes.

(e) **To advance 15° or retard 3°.**

To advance 15°, advance sprocket one tooth without moving the camshaft, and replace the set screws in the alternate set of tapped holes.

To retard 3°, replace the set screws in the alternate set of tapped holes without advancing the sprocket.

It must be noted that after making an adjustment as previously described, it is now possible to re-set the valve timing, using the arrow mark on the camshaft sprocket.

This should be erased and when the timing is found to be correct, re-stamped to coincide with the arrow mark on the timing case.

16. REFITTING AUXILIARIES.

In the case of the exhauster type engine it is advisable to fit the exhauster and bracket at this stage and line up as recommended in the exhauster section of this manual.

(1) Fit bracket for fuel pump and check alignment in the same way as for the exhauster bracket.
(2) With the three "0's" on the coupling in line, fit the fuel pump.
(3) Refit cylinder head (see Cylinder Head section).
(4) Wear in the timing chain is inevitable, but comparatively slow. There is no need to renew the chain until its total length has increased by half a link. If worn to that extent the chain should be renewed.
(5) Replace the chain, being careful not to disturb the sprockets. The best way is to lay one end on the auto-tensioner and wind it round camshaft sprocket, round the fuel pump drive sprocket, crankshaft sprockets, and back to the auto-tensioner.
(6) Insert the old spare link, comprising plate and two rivets, from the front.
(7) When the rivets are through the front rollers, insert one thick link between the front and middle rollers.
(8) Press the spare link further in until the rivets are into the middle rollers, then insert the second thick link.
(9) Press the link right home.
(10) Release the chain tensioner by removing the wedge.
(11) Do not force the chain tensioner as, in doing so, undue strain would be placed on the pump drive bearings.
(12) Now turn the engine until the old spare link comes exactly above the camshaft sprocket. Insert the new spare link from behind, using the old spare link as a guide, i.e., push the old link out with the new one.
(13) Press the new link right home until the rivet heads protrude at the front of the chain.
(14) After completing this operation the accuracy of the timing should be checked. The chain should then be riveted securely in position. To do this, proceed as follows:
(15) Turn the engine backwards until the spare link is as near as possible to the chain tensioner sprocket, without being on it.
(16) Wedge the link for riveting by inserting a flat piece of steel between the back of the link and the timing case. Make sure the link is fully home in the chain and that the link is fully supported by the metal plate.
(17) Place the medium thick link over the two protruding ends of the rivets.
(18) Close the links up tightly.
(19) Check the valve timing as instructed in Paragraph 53.
(20) Now check the fuel pump as instructed in Paragraph 53.

17. REPLACING THE SUMP.

(1) Place the cork strip over the front and rear end crankshaft bearings, using jointing compound to make the joints.
(2) Place gasket and jointing compound on face of sump, taking care all surfaces are clean.
(3) Place the sump in position and screw all set screws lightly home.
(4) Tighten all set screws securely.
(5) Replace the oil strainer, taking care it registers on the suction pipe.
(6) Replace separate sump well.
(7) Fit the oil filter body, noting the gauze strainer is sandwiched between the body and cylinder block.
(8) Replace the timing case cover.
(9) Set the adjustment of tappets to .012 inch.
(10) Replace oil pipes to rocker gear.
(11) Replace cylinder head cover.
(12) Replace dynamo.

When replacing the starter motor, no distance or oil seal is used, the following should be checked:

With the flywheel in position, the starter pinion should be approximately $\frac{1}{8}$ inch from the flywheel teeth.

(13) Replace the auxiliary oil pipes.
(14) Replace pipe between venturi and pneumatic governor on the fuel pump. If care has been taken when handling the venturi and fuel pump and care has been taken not to disturb the adjustments to these components, they may be replaced with the certainty that the engine will function as before. In the event

of a disturbance or of a new fuel pump being required, arrangements should be made for the fuel delivery of the pump to be set by a C.A.V. agent so that the engine speeds and control will be as they were previously.

(15) Replace water pump, fan and fan belt.

18. STARTING THE ENGINE.

Proceed in accordance with the instructions given in Paragraph 81.

19. CYLINDER HEAD MAINTENANCE.

The Diesel engine rarely, if ever, needs periodical decarbonising. Carbon, beyond a superficial coating, does not form and accumulate in the combustion chambers and on the pistons.

Owing to its higher thermal efficiency, the valves on the Diesel engine are, providing the engine is reasonably maintained, free from troubles due to overheating. After a period, depending upon conditions under which the engine operates, the valves may need attention. This will become apparent by loss of compression, indicating a top overhaul is necessary.

Preparation.

(1) Begin by assembling all the joints and other parts required, as called for in the Perkins Spare Parts List.
(2) Drain all water from the cylinder head and jackets.
(3) Disconnect the exhaust pipe from the engine exhaust manifold.
(4) Uncouple external connections to cylinder head.

20. REMOVAL OF CYLINDER HEAD.

(1) Remove the air cleaner.
(2) Take off cylinder head cover.
(3) Uncouple unions on oil pipe to rocker gear.
(4) Take away nuts holding rocker shaft assembly.
(5) Lift off the rocker shaft, bringing abovenamed oil pipe with it.
(6) Remove leak off pipe to atomisers.
(7) Remove pressure pipe to atomisers.
(8) Remove atomisers.
(9) Release clip holding lower end of main leak off pipe.
(10) Take away leak off pipe.
(11) Remove the pipe between the venturi and the pneumatic governor on the fuel pump. There is a clip holding this pipe secured by a nut. Replace this nut after freeing clip.
(12) Remove the pipe connecting the inlet manifold to the breather.
(13) Take off cylinder head nuts and then cylinder head complete with manifold, venturi, etc.

21. REMOVAL OF VALVES.

(1) Place the cylinder head with the machined face downwards on a bench.
(2) Depress the spring cap and springs by means of a valve lifter and remove the two half conical cotters.
(3) Remove the spring caps and springs, thus liberating the valve, which can be taken out when the cylinder head is turned upside down.

22. GRINDING VALVES.

The valve and valve seats should be reconditioned in the orthodox way, using grinding compound or by means of specialised equipment.

The valve seat is recessed into the cylinder head and a groove is cut where the valve seat proper ends in the mitred recess in the head.

When valves have been reconditioned several times, it is possible that the valve may become masked by sinking too low in the head and in these circumstances the groove referred to should be re-cut accordingly.

Should suitable cutters not be available, these can be obtained from your nearest Perkins Diesel distributor.

23. EXAMINATION.

Examine all parts for wear, bearing in mind the following points:

(a) **Valve Springs.**

Valve springs deteriorate because of the fatigue resulting from the combined effect of heat and the normal working of the spring. After a period the spring becomes weaker and then is prone to fail. A new set of springs should be fitted whenever the engine undergoes a MAJOR overhaul.

(b) **Rocker Levers and Bushes.**

(1) Wash the rocker shaft assembly thoroughly in kerosene.
(2) Examine the rocker shaft bushes for wear. The rockers should be an easy fit on the shaft without excessive side play.

If, as a result of inadequate lubrication, any rocker bushes have seized on the rocker shaft, the rockers will have worked loose on the bushes. Each rocker should be examined for this condition. Whenever it is present, new rockers and/or bushes should be fitted.

When dismantling rocker shaft assemblies, make careful note of the order of the assembly of the various parts, supports, distance pieces, springs and rockers, so that reassembly may be facilitated and that left and right rockers are correctly placed and come opposite their respective tappets and valves.

(c) **Valves and Guides—Valve Seatings.**

There will be little wear of the valve stems, or their guides, providing that lubrication of these parts has always been adequate.

(1) Examine the valves for cracks.
(2) Check wear of valve stems and their fit in guides. If stems are worn fit new valves.
(3) Number all new valves to correspond with the numbering of the old valves.

When fitting new valves take care that the clearance between the valve head and cylinder bottom face is not less than .070 inch. Check this by putting

a straight edge across the face of the cylinder bottom face and measuring the distance between the straight edge and the top of the valve.

The efficiency of operation of the Diesel engine depends largely on the maintenance of good compression. Contact between valves and seatings must therefore be the best possible.

When grinding in valves make certain that no signs of pitting are left on the seating. Valves should be ground until a continuous "high mark" is present the full way round the seating, both on the valve and on the valve seating in the head.

Care should be taken to avoid unnecessary grinding away of the seat.

24. VALVE GUIDES.

(1) Examine the valve guides for wear.
(2) If the bore is greater than that specified in Paragraph 3, replace with new guides.
(3) Clean the new guides, removing any burrs.
(4) Smear the outer surface with clean oil and, using a suitable press, drive home hard up to the collar.
(5) The guides are made of cast iron and are, therefore, comparatively brittle. Care should be exercised as the collar approaches the cylinder head.

25. TAPPETS.

The tappets slide in holes bored in the cylinder head. The wear under normal conditions is negligible.

The running clearance between the top of the tappet and the rocker should be .010 inch when the engine is hot.

When adjusting this clearance, tighten tappet lock nut effectively, so that it does not slacken in service.

26. CYLINDER HEADS.

Wash out and thoroughly clean the water passages in the head, subsequently drying out and finally cleaning with compressed air. If the water jacket of the cylinder head shows signs of excessive scale, a propriety brand of descaling solution should be used.

27. COMBUSTION CHAMBER JOINTS.

It is not, as a rule, necessary to remove the covers of the combustion chamber during top overhaul, as carbon rarely forms in these chambers.

If for any reason these covers are removed new copper gaskets should be fitted when they are replaced.

If new copper gaskets are not available, the old ones may be used provided they are softened before being refitted. To soften these copper gaskets heat them to a dull red heat and quench in cold water. Again bearing in mind the importance of good compression for efficient operation of the Diesel engine. Special care is necessary when refitting these covers to ensure there is no leakage at the joints.

28. RE-ASSEMBLY OF CYLINDER HEAD.

(1) Replace valves, collars and cotters, taking care that the collars and valves are of the correct type.
(2) Place the combustion chamber cap gasket in position and fit the caps.
(3) Lightly smear water manifold inlet joints and joint for water pump with jointing compound.
(4) Refit water manifold and water pump.
(5) Similarly, fit exhaust manifold gaskets, and exhaust manifold, then inlet manifold.

29. REPLACING CYLINDER HEAD.

Before replacing the cylinder head, it is extremely important to ensure the faces of the cylinder block and cylinder head are perfectly clean.

It is recommended that a new gasket be used. When replacing the gasket take care that it is of the correct width and fits the head, also that it is placed correctly. The gasket is marked "top" to indicate how it should be replaced.

(1) Cover both sides of the gasket with a thin coating of jointing compound.
(2) With the under face of the cylinder head perfectly clean, the head may be lowered into position on its studs and the nuts tightened down in the order shown in Figure 14. The cylinder head nuts should be pulled down tight.
(3) Replace the atomisers (see Paragraph 45).
(4) Replace the rocker shafts and adjust the tappets to approximately .012 inch.
(5) Thoroughly clean the oil feed pipes to the rocker gear and blow clean air through them.
(6) Examine the unions to see they are in good condition.
(7) Replace these pipes, taking care to screw the union up tightly.
(8) Replace the hose connections to the water pump, the pipe between the venturi and the pneumatic governor, also the ventilation pipe between induction pipe, cylinder head cover, oil filter, leak off gallery, ki-gass pipes, etc.

Note: For instructions regarding the fitting of fuel pipes, see Paragraph 51.

(9) Start the engine as instructed in Paragraph 81.
(10) After warming up, the engine should be shut down and the rocker shafts removed and the cylinder head nuts can again be tightened down, the nuts being tightened in the sequence as shown in Figure 14.
(11) Refit the rocker shafts and reset the tappets. After warming up, the tappets should be finally set with a clearance of .010 inch.
(12) Replace the cylinder head cover, using a new joint. Care should be taken to see that it is correctly placed, otherwise oil may leak away in considerably quantity, enough to starve the engine of oil if left unchecked.

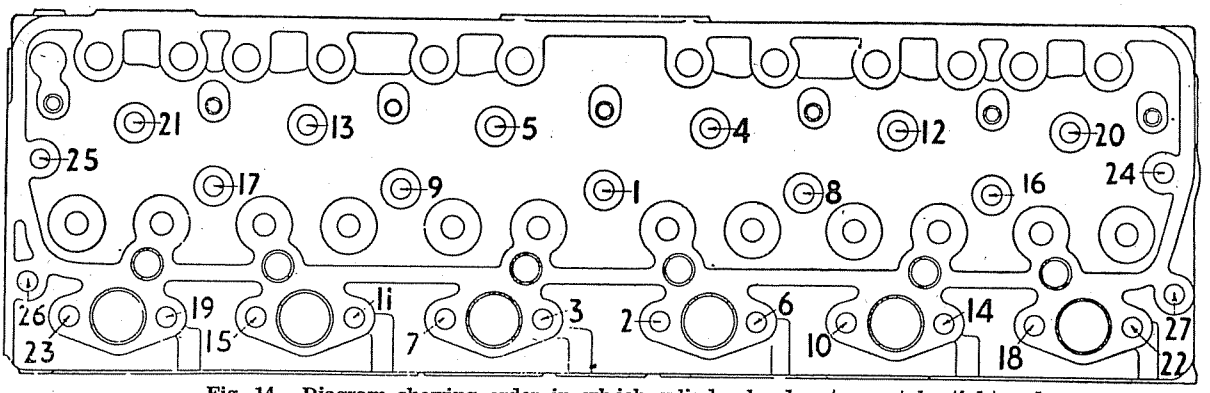


Fig. 14.—Diagram showing order in which cylinder head nuts must be tightened.

30. SERVICING THE WATER PUMP.

Removal of the Water Pump.

(1) Remove the fan, fan belt, and water inlet and outlet pipe.
(2) Remove the three $\frac{1}{4}$ inch Whitworth set screws from the rear of mounting plate, and slacken the clip securing the water manifold to the water pump.
(3) Finally remove three $\frac{3}{8}$ inch Whitworth set screws, one on the left, looking at the engine from the front, can be removed completely, but the remaining two must be slacked and left in position as the water pump is pulled away from the cylinder head.
It is not necessary to remove any other parts.
(4) Remove circlip and cover plate from front pulley cover. Remove circlip and bakelite drive member from pump shaft.

31. DISASSEMBLY OF WATER PUMP.

(1) With a suitable bar press the pump shaft out from the pump body complete with impeller, distance piece, spring, driving tube and water pump seal.
(2) Detach the pulley cover from the pulley by removing four $\frac{5}{16}$ inch Whitworth set screws, also the felt seal and seal retainer.
(3) Remove the circlip from the pulley support and press off the pulley, using a suitable mandrel.
(4) Finally remove the pulley support from the body and press out the carbon seal.

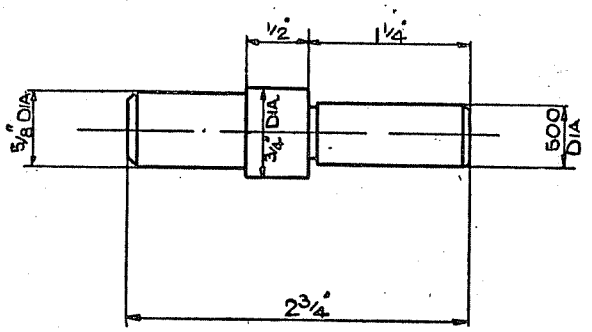


FIG. 15.

The ball and roller race can be removed if required for inspection by pressing out, using a suitable mandrel.

32. INSPECTION.

(1) Inspect the pump shaft for wear and check the pulley support bushes. See Paragraph 3 for bushes and shaft sizes as new, also the permissible clearance figures.
(2) If the bushes are excessively worn, remove and press new bushes in, using tool as shown in Figure 15. By using this tool, a true and free running fit is ensured for the pump shaft.
(3) Carefully inspect the driving tube slots and corners of the impeller blades for wear.
(4) Inspect the spring for corrosion, tension and twisting.
(5) If the ball and roller race require replacing, always ensure that the ball race is pressed in first, followed by the large and small distance pieces and finally the roller race.
(6) It is advisable that the carbon thrust pad and water pump seal be scrapped and replaced with new ones, as it is difficult to maintain a watertight seal after disturbing.

33. ASSEMBLING.

Place on the threaded end of the pump shaft in the following sequence:

(1) Brass distance piece, five shims, impeller, tab washer and locking nut.
(2) Tighten locking nut and bend over tab washer.
(3) Slide on the plain end spring, driving tube and water pump seal. The driving pump slots must fit into the impeller blades and the arms into the grooves of the water pump seal.
(4) Ensure that the small end of the water pump seal is nearest to the driving tube.

Note: It is advisable to lap the face of the water pump seal before fitting.

(5) With a suitable jointing compound on the outer edge of the carbon thrust pad, place it on the outside aperture of the pump body, place the pulley support on the studs and tighten down evenly.
(6) With the carbon thrust pad now in position, inspect for an even fit, fractures, and ensure there is no jointing compound on the face.

(7) Press the pulley on to the pulley support and secure with a circlip. It is advisable to grease the ball and roller bearings with high melting paint grease before pressing the pulley on to the pulley support.
(8) Place the seal retainer felt seal and front pulley in position and tighten down.
(9) Wire the four $\frac{5}{16}$ inch set screws.
(10) Fit the plain end of the pump shaft through the carbon thrust pad and pulley support, securing in position with the bakelite driving member and small circlip.
(11) Lightly tap the plain end of the pump shaft to test for end float. The maximum amount of end float is .030 inch. This is measured between the small circlip and the bakelite driving member. End float is adjusted by removing or adding shims on to the threaded end of the pump shaft.

Caution: If the circlip on the pump shaft is tight against the driving member, it will have a tendency to spring off, which will obviously cause the pump shaft and impeller to slide back, causing the water pump to cease functioning.

(12) Finally, replace cover plate and circlip into the front pulley cover.
(13) Lubricate via the two nipples in the front pulley cover.
(14) The water pump can be checked for water leaks under running conditions.

34. THERMOSTAT OPERATION.

When cold, the thermostat closes a valve and restricts the flow of water into the radiator, therefore the water must flow through the by-pass tube so as to allow the water to circulate without passing through the radiator.

This allows the engine to reach the most efficient working temperature quickly. When the correct temperature is reached, the thermostat valve opens and allows the water to circulate normally.

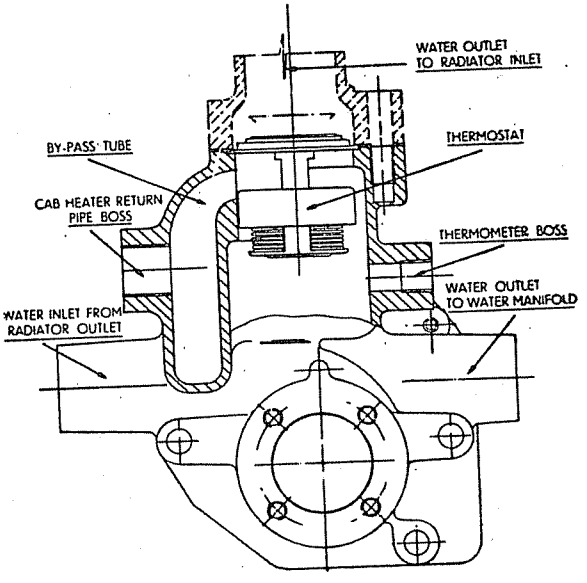


Fig. 16—View of Water Pump and Thermostat.

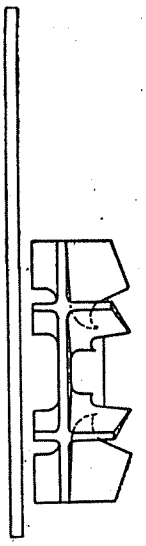


Fig. 17—View of Water Pump Impeller.

The amount of water circulating through the by-pass tube is negligible compared with that circulating through the larger pipes of normal circulating system..

35. SPECIAL FROST PRECAUTIONS.

MOPAR anti-freeze should be used in the cooling system at the approach of freezing weather. After the cold season is past, drain the cooling system and discard the old anti-freeze. Then, put in MOPAR rust resistor with a fresh filling of water to protect the system against corrosion during warm weather driving.

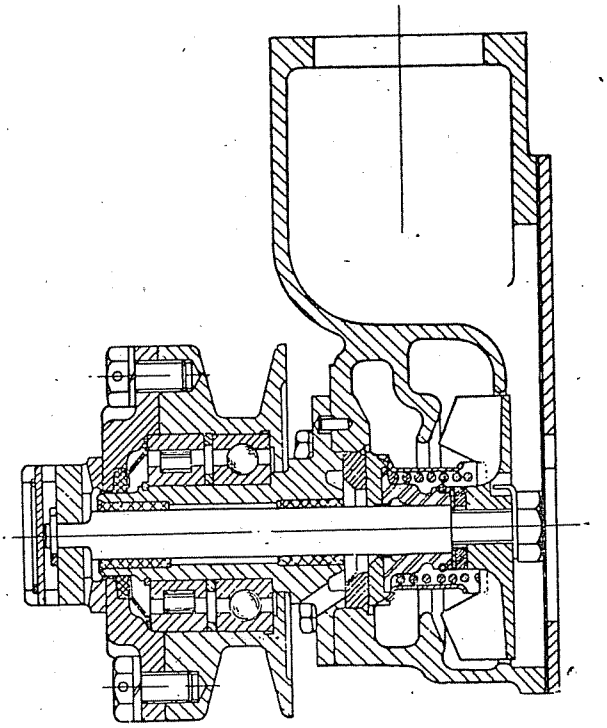


Fig. 18—Cross Section of Water Pump.

36. FUEL INJECTION SYSTEM.

It is recommended that whenever maintenance attentions are required, especially to the pumps and atomisers, that these parts be sent to a C.A.V. depot where specialised equipment and skilled operators are available to undertake the work.

The principal components of the equipment for delivering the fuel oil to the cylinders are: filters, fuel lift pump, fuel pump and atomisers.

The fuel pump "lifts" the fuel from the tank to the fuel pump, which conveys it in measured quantities, and at appropriate intervals to the atomisers.

The normal course of the fuel from the tank to the engine is by way of:

(a) The fuel lift pump.
(b) Intermediate type filter.
(c) A final filter.
(d) The fuel pump and atomisers.

Both the intermediate and final filters are of the type in which the oil is passed through felt elements.

Two conditions are essential for efficient operation:

(1) The fuel oil should be clean, free from water, suspended dirt, sand or other foreign matter.
(2) That the fuel reaches the fuel pump in a perfectly clean state.

Fuel should be filtered before entering the tank.

Given these conditions, ninety per cent, at least, of potential engine troubles would be eliminated. The attention of the operator is on that account earnestly directed towards those paragraphs of this Section which refer to the care and upkeep of the filtering apparatus.

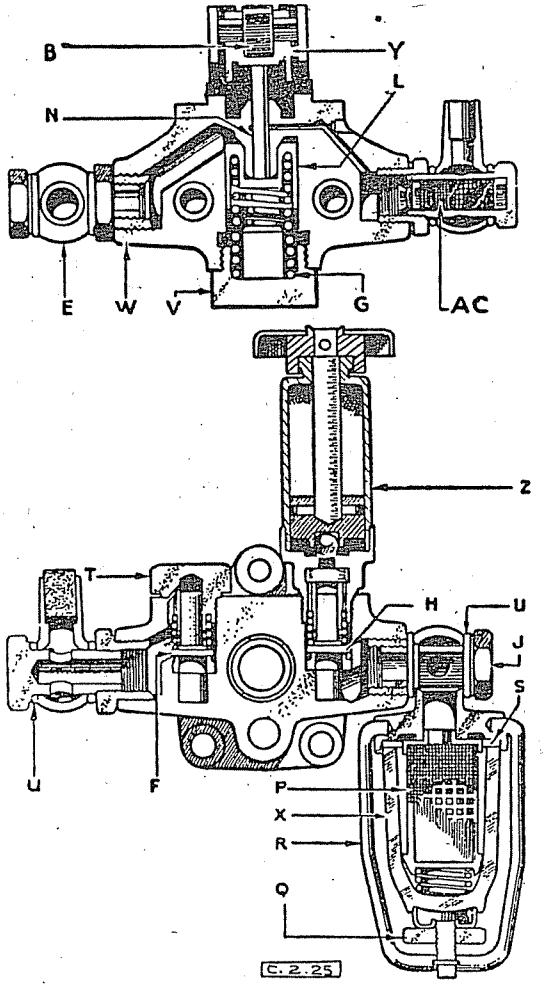


Fig. 19—Fuel Lift Pump.

B. Tappet Roller.
E. Fuel Outlet.
F. Outlet Valve.
G. Plunger Spring.
H. Inlet Valve.
J. Inlet.
L. Plunger.
N. Guide Spindle.
P. Preliminary Filter Gauze.
Q. Clamping Nut.
R. Fixing Strap.
S. Packing Washer.
T. Valve Plug.
U. Copper-Asbestos Sealing Washers.
V. Spring Chamber Cap.
W. Lift Pump Body.
X. Preliminary Filter Gauze Container.
Y. Spindle Guide.
Z. Primer.
AC. Inlet Plug Filter Gauze.

37. THE FUEL LIFT PUMP.

The lift pump is of the simple spring-returned plunger type. It is driven by its own cam on the camshaft of the fuel pump, on the side of which it is fitted, as shown in Figure 19.

A hand primer is fitted (Figure 19) for use if the supply of fuel from the tank at any time failed.

To use this primer, unscrew the handle which is free to lift and then pump by hand until the pipes, lift pump and fuel pump are full of fuel oil. The inlet valve of the lift pump is accessible after removal of the hand primer. The outlet valve is under the plug T, Figure 19. These valves and their seals must be perfectly clean. The following are possible troubles with the lift pump and the way in which they can be remedied.

(1) **Lift Pump does not deliver fuel.**
(Refer Figure 19.)

Possible Cause.	Location.	Condition or Suggested Remedy for correct working.
(a) Fuel tank empty.	Fuel tank.	Must contain an adequate supply.
(b) Fuel cock closed.	Fuel cock.	Must be open to its full extent.
(c) Preliminary filter choked.	Preliminary filter gauze P.	Remove by loosening round nut Q and lifting fixing strap R. Wash in clean fuel oil or kerosene. If damaged replace. Take care to replace washer S.
(d) Inlet or outlet valves fouled or damaged.	Valves F and H.	Remove by unscrewing hexagon plug T, and primer Z. Clean in fuel oil or kerosene. Take care to screw plug T and primer Z in to its full extent when replacing.
(e) Plunger or tappet spindle fouled or damaged.	Plunger L and tappet spindle N.	Extract after unscrewing cap V. Clean in fuel oil or kerosene.

Note: If damaged, return complete with body to nearest C.A.V. agent.

(2) **Lift Pump does not deliver sufficient fuel.**

Possible Cause.	Location.	Condition or Suggested Remedy for correct working.
(a) Connection or pipes between the lift pump and fuel pump leaking.	Connection pipe.	See that all joints and pipes are perfectly air-tight.
(b) Inlet or outlet valves leaking.	Valves F and H.	Treat as for 1d.
(c) Plunger leaking.	Plunger L.	Treat as for 1e.
(d) Plunger spring damaged.	Plunger Spring G.	Replace.
(e) Preliminary filter obstructed.	Preliminary filter Gauze P.	Treat as for 1c.
(f) Main pipe line filter obstructed.	Main filter.	Clean and air vent as instructed in para. 38.
(g) Air locked system.	Main filter.	Air vent by opening vent screw on main filter and allowing fuel to flow until perfectly free from bubbles. See below.

38. AIR VENTING THE FUEL SYSTEM.

If the fuel system has been opened at any time, say, for overhaul, it is necessary to ensure that all air has been removed before attempting to start the engine. This should be done as follows:

(1) Slacken the small plug on top of the final filter and operate the hand primer on the fuel lift pump until bubbles issue from the plug hole. Tighten the plug.

(2) Slacken the bleed cock on top of the fuel pump.

(3) Again operate the hand primer on the fuel lift pump until fuel issues from the bleed cock and all signs of air have disappeared.

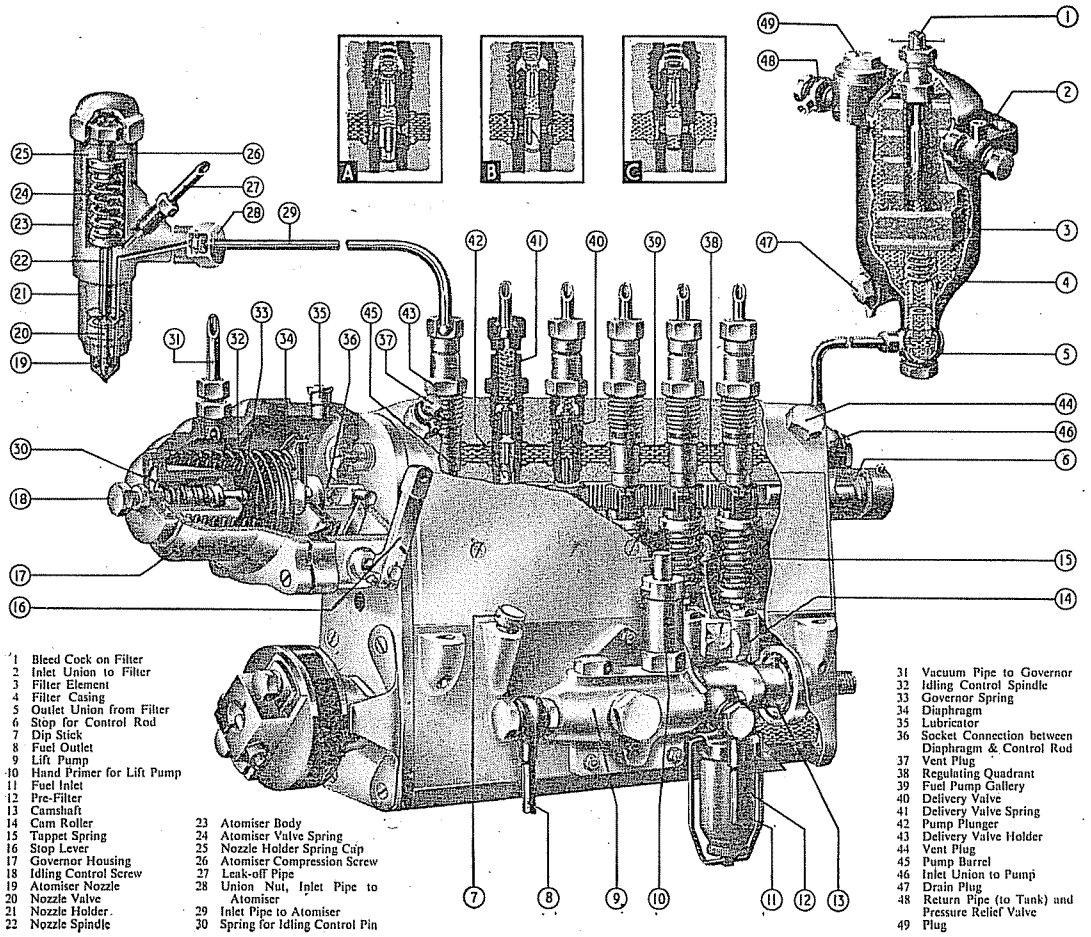
(4) Tighten the bleed cock securely and give the primer a few more strokes in order to deliver the fuel through the relief valve on the final filter, clearing this part of the system of air.

39. FUEL PUMP.

The fuel pump is an instrument that meters and delivers fuel to the engine in the exact quantity required at the exact time required by the engine during its working cycle.

The fuel pump is an instrument of precision. Its working parts are made to extremely fine limits and mishandling in any shape or form or the entry of

FIG. 20. GHOST DRAWING OF FUEL INJECTION EQUIPMENT



1 Bleed Cock on Filter
2 Inlet Union to Filter
3 Filter Element
4 Filter Casing
5 Outlet Union from Filter
6 Stop for Control Rod
7 Dip Stick
8 Fuel Outlet
9 Lift Pump
10 Hand Primer for Lift Pump
11 Fuel Inlet
12 Pre-Filter
13 Camshaft
14 Cam Roller
15 Tappet Spring
16 Stop Lever
17 Governor Housing
18 Idling Control Screw
19 Atomiser Nozzle
20 Nozzle Valve
21 Nozzle Holder
22 Nozzle Spindle
23 Atomiser Body
24 Atomiser Valve Spring
25 Nozzle Holder Spring Cap
26 Atomiser Compression Screw
27 Leak-off Pipe
28 Union Nut, Inlet Pipe to Atomiser
29 Inlet Pipe to Atomiser
30 Spring for Idling Control Pin
31 Vacuum Pipe to Governor
32 Idling Control Spindle
33 Governor Spring
34 Diaphragm
35 Lubricator
36 Socket Connection between Diaphragm & Control Rod
37 Vent Plug
38 Regulating Quadrant
39 Fuel Pump Gallery
40 Delivery Valve
41 Delivery Valve Spring
42 Pump Plunger
43 Delivery Valve Holder
44 Vent Plug
45 Pump Barrel
46 Inlet Union to Pump
47 Drain Plug
48 Return Pipe (to Tank) and Pressure Relief Valve
49 Plug

the smallest particle of dirt into its working parts may damage it and diminish its accuracy of operation. Hence the importance of ensuring that the fuel is thoroughly filtered before the pump is reached.

Due to the construction of the fuel pump and the precision tools and instruments needed to carry out any repairs that may be necessary, it is strongly recommended that all servicing of the fuel pump be carried out by an approved C.A.V. agent or depot.

Figure 20 has been included to give distributors, dealers and operators an insight to the internal arrangement of the fuel pump.

40. PNEUMATIC GOVERNOR.

(Refer Figure 20.)

The position of the control rack, by means of which the quantity of fuel delivered to the engine is regulated, is determined by a pneumatic governor. This governor, part of which is in the form of a venturi in the engine induction manifold, operates the control rack according to the degree of vacuum in the venturi passage.

There is a butterfly valve in the venturi. When that valve is closed or nearly closed, the suction on the engine side of it is considerable, lessening as the valve opens. A pipe (31) connects this venturi passage with a governor casing which is mounted on the fuel pump.

Reference to the illustration of the pneumatic governor, Figure 20, will enable its operation to be understood.

The important element is the flexible leather diaphragm (34), which divides the space inside the governor casing into two compartments, one of which, that on the left, is air tight. This air tight compartment is in communication with the venturi by means of a pipe (31). The vacuum in the venturi is thus communicated to the air-tight compartment and the left hand side of the diaphragm.

The chamber, to the right of the diaphragm, is not subject to vacuum.

The diaphragm, therefore, is constantly subject to pressure, tending to move it to the left against the resistance of the light spring within the left hand chamber.

It will be appreciated that as the vacuum increases, as it does when the butterfly valve is nearly closed, the diaphragm moves to the left. The centre of the diaphragm is coupled to the control rod of the fuel pump. Movement of this rod to the left tends to reduce the supply of fuel to the atomisers. Thus, closing the butterfly valve increases the vacuum in the chamber, moves the diaphragm to the left, and reduces the supply of fuel to the engine. The butterfly valve is operated by the ordinary throttle valve lever and in that way the speed of the engine is controlled.

Now, here is a point of the very greatest importance:

Any leaks in the joints of the pipe (31), on the pipe itself, or in the diaphragm, will diminish the degree of vacuum and cause the engine to run faster and idle erratically.

Hence the instructions given later urging care in ensuring that there are no leaks in the system. If the pipe (31) were to become detached or to be left uncoupled, and the engine run, it would race, and very serious damage might be caused. Hence the warning, repeated later, that the engine must never be run unless the venturi control unit, pipe and induction manifold, are in position and all joints tight.

41. ADJUSTMENT OF PNEUMATIC GOVERNOR.

Adjustment of the governor is effected at the factory when the engine is erected.

It is an operation requiring considerable skill. The idling stop on the butterfly valve and the adjusting screw on the cap of the governor have to be manipulated simultaneously until smooth running at the desired idling speed is achieved. No subsequent adjustment is, in fact, needed. Any deterioration in the smoothness of idling is due to some defect which has arisen elsewhere and should be looked for under the paragraphs in this section devoted to the care of the fuel system generally.

42. MAINTENANCE OF PNEUMATIC GOVERNOR.

The tiniest pin hole or crack in the leather diaphragm will effect the operation of the governor. If such a fault is suspected, test in this way:

(1) Remove vacuum pipe (31), Figure 20.
(2) Move the stop lever (16) into "Stop" position.
(3) Place a finger over the diaphragm housing union in order to seal it.
(4) Release the stop lever.
(5) The control rod should then slowly return to the maximum speed position after a quick initial movement for a fraction of the distance. If it returns quickly for the whole movement and the housings are clamped firmly together, then the diaphragm is leaking and should be replaced. Instructions for replacement are given below. If the diaphragm appears to be sound, as indicated by this test, suspect the vacuum pipe and test in a similar way. Replace the union of this pipe on the governor casing and uncouple it at the butterfly end. Repeat the tests as before by placing the finger on the uncovered end of the vacuum pipe.

43. TO RENEW LEATHER DIAPHRAGM.

(1) Disconnect the vacuum pipe.
(2) Take out the screws holding the pneumatic governor in place.
(3) The diaphragm will then be accessible. It is held in a light U section metal rim, which must be prised from the casing. (See Figure 21.) Great care should be exercised when carrying out this operation.
(4) For preference, use a piece of sheet metal about ¾ inch wide, shaped at the end to fit the curve of the rim and sharpened to an edge similar to a screw driver.
(5) Lift the edge of the rim carefully all round.
(6) When the rim is free, slide the socket at the back of the diaphragm off the pin in the control rod. Be careful not to mark the face

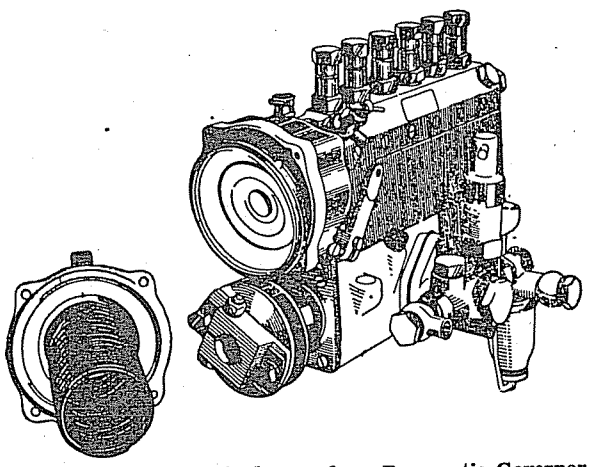


Fig. 21—Removing Diaphragm from Pneumatic Governor.

of the fuel pump on to which the governor casing fits.

(7) To replace the diaphragm, first place the socket on the pin in the control rod.

(8) Press the rim firmly into place.

(9) Replace the governor casing, being careful to tighten the set screws tightly and evenly in position.

Caution: The pneumatic governor depends for its action upon pressure variations set up in the air intake of the engine by the venturi control valve. If this should be removed either by itself or with the inlet manifold during overhaul, or if the vacuum pipe union is not always kept perfectly tight, then the governor may fail to operate, causing damage to the engine.

IN NO CIRCUMSTANCES SHOULD THE ENGINE BE RUN WITHOUT VENTURI CONTROL UNIT, VACUUM PIPE OR INLET MANIFOLD.

44. ATOMISERS. (Refer Figure 20.)

After leaving the fuel pump, the fuel passes through short steel pipes (29 to the atomisers).

Atomisers perform the function of injecting the fuel, in the form of fine sprays, into the cylinders at the moment when the air in the cylinder has been compressed and at a temperature sufficient to ignite the incoming fuel.

An atomiser consists of two principal parts, the nozzle (19) with its valve (20) and the atomiser body (23).

The nozzle and nozzle valves are the important parts. They are shown in Figure 26. Fuel is fed from the upper channel in the nozzle from the atomiser body and travels thence along a number of drilled holes to the lower circumferential channel. The outlet for the latter is normally closed by the valve as shown. The atomiser body, complete with its nozzle and nozzle valve, is shown in Figure 20. The nozzle is held in place by the nozzle holder cap nut (21). This holds the upper face of the nozzle in close contact with the corresponding lower face of the atomiser body. A metal to metal contact is made here.

Fuel is supplied through the fuel inlet connection (28), and passes through the drilled holes down to the channel in the face of the nozzle.

In the centre of the atomiser body is the spindle (22), surmounted by a spring washer, on top of which bears the compression screw (26). There is a lock nut on this screw. A covering nut protects the upper part of the atomiser body and the compression screw. The small quantity of fuel which by-passes the nozzle valve and accumulates within the atomiser body, lubricates the mechanism and is led away by a pipe (27) connected to the leak off nipple stud. At the moment of injection, the fuel pump delivers fuel at a high pressure into the channel round the lower end of the nozzle. The pressure of this fuel on the end surface of the cone of the valve lifts it against the tension of the spring and fuel passes through two small holes in the end of the nozzle as two fine sprays.

45. FITTING ATOMISERS.

Each atomiser consists of a steel body held to the cylinder head by means of a flange and two studs.

The joint between the atomiser and cylinder is made by a special copper washer between the lower face of the nozzle cap nut and the metal of the cylinder.

When preparing to fit the atomiser into place in the cylinder head, care should be taken that only this special type of copper washer (obtained from any C.A.V. service station) is used to make this joint. The metal of the cylinder head, the faces of the copper ring joint and the corresponding face of the nozzle holder cap should be perfectly clean if a leak proof joint is to result.

It is advisable to fit a new joint washer when the atomiser is replaced after having been removed for any reason. Ensure that the old washer has been removed from the atomiser or cylinder head. The joint washer should be an easy, but not loose, fit for the atomiser nozzle, and it is because this is such an important feature that the washers especially made for this purpose should be used and none other. On no account should ordinary sparking plug type washers be used. The atomiser can now be fitted into place, care being taken to see that it is an easy fit in the cylinder head and on holding down studs, so that it can be placed down on the copper joint without force of any kind. The nuts on the flange should be tightened down evenly in order to prevent the atomiser nozzle being canted and so "nipped" in the cylinder head. This is very important, since any unevenness in tightening down may cause distortion of the atomiser nozzle, resulting in its failure and will certainly result in blow-by.

46. ATOMISER MAINTENANCE.

Atomisers should be taken out for examination at regular intervals. How long this interval should be is difficult to advise because of the different conditions under which the vehicle operates.

When combustion conditions in the engine are good and the fuel tank and filtering system are maintained in first class order, it is often sufficient if atomisers are tested twice yearly.

It is no use taking atomisers out for attention unless the equipment described later is available or spare atomisers are at hand for substitution. The nearer the ideal conditions of good fitting with adequate cooling and absolutely clean fuel are realised, the less attention the atomisers will need, and so the longer their efficient life. In this connection since there is no other item of the equipment upon which the performance of the engine depends so much, it pays the operator handsomely to see the engine never runs with any of its atomisers out of order.

47. TROUBLES IN SERVICE.

The first symptoms of atomiser troubles usually fall in one or more of the following headings:

(1) Knocking in one (or more) cylinders.
(2) Engine overheating.
(3) Loss of power.
(4) Smoky exhaust (black).
(5) Increased fuel consumption.

Often the particular atomiser or atomisers causing trouble may be determined by releasing the pipe union nut on each atomiser in turn, with the engine running at a fast "tick-over". This will prevent fuel being pumped through the nozzle to the engine cylinder, thereby altering the engine revolutions. If after slackening a pipe union nut the engine revolutions remain constant, this denotes a faulty atomiser. The nuts from the flange of the doubtful atomiser should be removed and the complete unit withdrawn from the cylinder head and turned round atomiser nozzle outwards, "unwiped" on its pipe and the unions retightened. After slackening the unions on the other atomiser pipes (to avoid the possibility of the engine starting) the engine should be turned until the nozzle sprays into the air, when it will be seen at once if the spray is in order. If the spray is unduly "wet" or "streaky" or obviously to one side, or the atomiser nozzle "dribbles", the spray holes should be probed with special tool E.T. 120. See Figure 22. If, after probing the spray holes, the condition of the atomiser is still faulty, remove the complete unit.

Great care should be taken to prevent the hand from getting in contact with the spray as the working pressure will cause the oil to penetrate the skin with ease. A spare atomiser should be fitted and the faulty unit securely wrapped in grease proof paper or rag for attention on the maintenance bench.

48. EXAMINATION AND TESTING.

A bench suitable for working with atomisers is preferably linoleum covered with a glass top. It should be reserved for this work and kept absolutely free from dirt.

The use of cotton waste or fluffy rags must be absolutely forbidden.

The bench should have a dust proof drawer for holding the atomiser cleaning tools and equipment described in detail below:

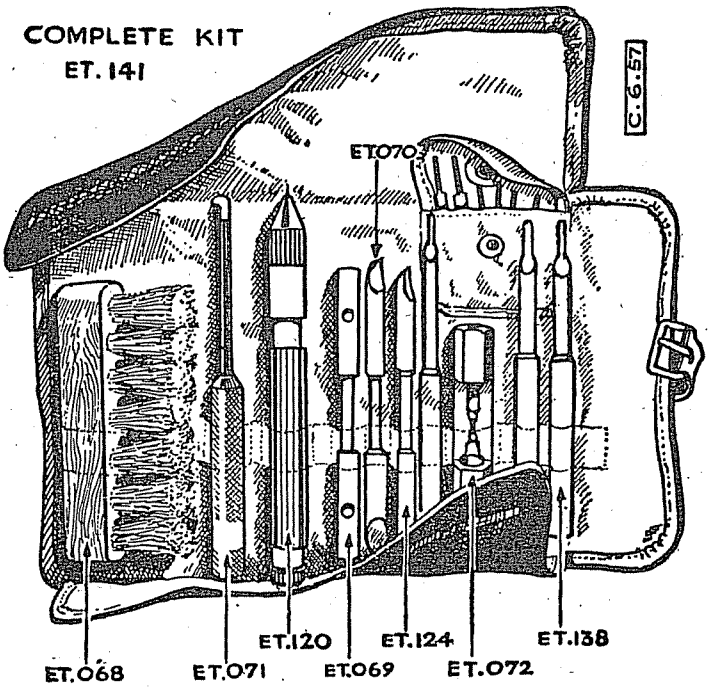


Fig. 22—Complete Kit of Tools for use when cleaning and overhauling Atomisers.

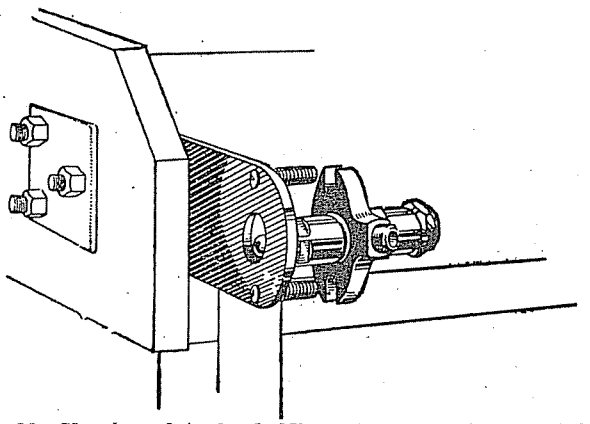


Fig. 23—Showing plate for holding Atomiser while is is being dismantled.

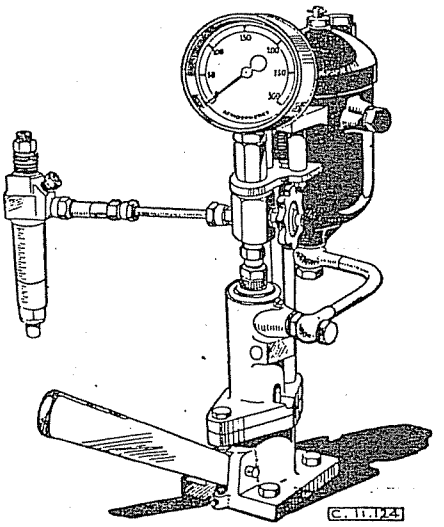


Fig. 24—Atomiser Testing Pump.

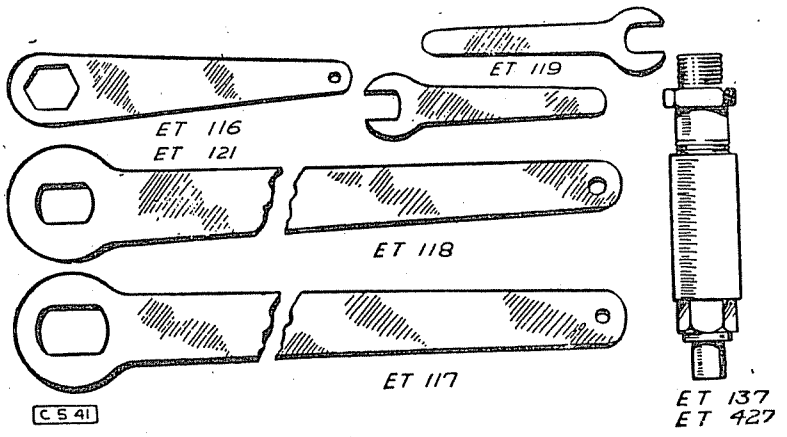


Fig. 25—Spanners and Cleaning Tools for use with Atomisers.

A plate made as shown in Figure 23 should be secured to the bench. Its purpose is to hold the atomiser securely whilst various maintenance work is proceeding.

An atomiser testing pump No. ET.122A (Figure 24) which can be obtained from a C.A.V. service depot should be available.

This outfit also has been specially designed to provide a reliable means of testing and setting the nozzles. It is made up of parts similar to the injection equipment fitted to engines.

(1) Remove the doubtful atomiser from its wrappings and fit atomiser downwards, still unwiped, to the testing pump.
(2) No observations should be made until at least ten full strokes of the hand pump have been given to expel the air.
(3) The pressure at which the spray breaks should then be recorded and checked against the recommended pressure which is 120 atmospheres.
(4) The spray should now be observed for uniformity at a rate of pumping not less than 20 strokes per minute.
(5) Each should be a misty spray spreading to about 3 inches diameter at about one foot away from the atomiser nozzle, then breaking into a very fine mist. There should be two sprays from each atomiser nozzle, one pointing outwards from the top hole and the other pointing downwards from the lower hole, when the atomiser is in a position corresponding to its working position.

An atomiser is good for service if, when operating the atomiser testing pump at the above speed, it gives two effective sprays as described above.

An atomiser is dirty and requires reconditioning if:

(a) When proceeding as above, it throws out solid wet jets and not broken up spray.
(b) If either the holes are choked or partially choked so that the spray issues from one hole in the atomiser only or appreciably more spray issues from one hole than the other.

In this connection, as the diesel engine idles at about 500 r.p.m., the atomiser is never called upon to work in the engine more slowly than 200 injections per minute. Thus, by taking the atomiser spray at 20 strokes per minute, ample margin is allowed.

When removing the atomiser from the testing pump, close valve by rotating the hand wheel and screw off the union nut a little at a time so that the pressure falls gradually.

All atomisers are set to operate at the pressure described above before leaving the factory. If a new atomiser nozzle is fitted to an atomiser body, it is not necessary to reset the pressure. After the atomiser has been in service for some time, the opening pressure tends to fall, but provided that the atomiser holes do not choke up, there is no need to adjust the pressure.

No attempt should be made to adjust the injection pressure without a proper testing pump and pressure gauge as described and illustrated. It is quite impossible to alter the settings of atomisers with any degree of accuracy without such proper adjustment.

If the atomisers are interfered with, on the assumption that so many turns of the adjusting screw represents so many pounds, they may vary as much as 200 pounds as between one and another. With such differences between atomisers, the engine cannot possibly give of its best.

If the spray is still unsatisfactory, even after trying the effect of drawing the carbon away from around the atomiser nozzle mouth with a fine wire brush especially designed for the purpose and illustrated in Figure 22, the atomiser should be placed on the atomiser holding plate already described. (See Figure 23).

Proceed as follows:

(1) Slacken off the nozzle holder cap nut (21), Figure 20, with a special ring spanner for this purpose, E T.116, Figure 25. To hold the nozzle holder cap nut in a vice, or to use ill-fitting, "packed" or adjustable spanners or wrenches is to invite disaster.
(2) Examine the pressure face of the nozzle holder cap nut to see it is not damaged so as to have "nipped" the atomiser nozzle in any way.
(3) The nozzle holder cap nut should now be removed and the atomiser nozzle completely lifted from the atomiser body for examination.

The surfaces of "A" and "B", Figure 26, on the top of the atomiser nozzle should be clean and

bright, free from damage, likewise the under surface "C" of the flange, the face of the atomiser body "D", and the retaining shoulder of the nozzle holder cap nut. All of these must register together absolutely cleanly and squarely to form a high pressure joint between the atomiser body and nozzle.

(4) The atomiser body should now be removed from the plate, and together with the the cap nut immersed in clean kerosene and left to soak in a suitable container.

(5) The nozzle valve should be grasped by the stalk between finger and thumb and withdrawn carefully for examination. The stem of the nozzle valve should be clean and bright and free from high spots, bad scratches or dull patches, and the grooves free from dirt, metal particles and other foreign matter.

(6) The stem and valve seat of the nozzle valve should now be examined, and if dirty, or "coked", cleaned until bright metal is shown.

49. CLEANING.

Assuming that the nozzle valve has been soaking and the two surfaces "A" and "B" on the top of the atomiser nozzle flange already mentioned are clean and free from damage, the inside of the atomiser nozzle should be examined. The kit of tools shown in Figures 22 and 25 are recommended. They can be obtained from a C.A.V. service depot.

(1) Explore the three small drilled passages "G", Figure 26, to see they are clear and clean.

(2) Examine the valve stem bore in which the nozzle valve slides. This surface should be bright and clean and free from scratches or dull patches.

(3) The valve seating "J", Figure 26, should now come under observation under a strong light to ascertain whether or not it is free from dirt and carbon. It is always advisable to use the soft brass seat scraper No. ET.070, Figure 22, to remove any carbon or particles that may be imprisoned on the seat.

(4) The gallery "H", Figure 26, should now be cleaned with the aid of the special soft brass scraper No. ET.071, Figure 22, to ensure that it is free from dirt or carbon.

(5) The spray holes in the atomiser nozzle should be probed with the special tool ET.120, Figure 22.

In cases where the holes cannot be cleaned in this process, the complete atomiser should be securely wrapped and forwarded to a C.A.V. service station.

(6) Assuming the spray holes have been cleaned satisfactorily, the atomiser can be placed into the container to soak in kerosene, or preferably assembled to atomiser flushing tool No. ET.427, Figure 25, and thoroughly flushed through to ensure that all carbon particles are removed from the inside of the atomiser nozzle.

(7) The nozzle valves should now be polished by rubbing with an absolutely clean cloth. A piece of used boiled cotton is best, upon which there is no suggestion of fluff.

(8) Pay particular attention to the valve seat. This and the smaller cylindrical portion above it, called the "stem" and "cone" in Figure 26, can be cleaned with a fine brass wire brush. To ensure the stem and cone are free from any particles, the soft brass brush stem cleaner No. ET.072 should be applied with a rotary action, pressing the nozzle valve into the cleaning tool with the fingers.

(9) The valve and atomiser may be assembled after ensuring that exterior of the atomiser is clean and free from carbon.

This should be after the two parts have been thoroughly washed in clean kerosene or fuel oil, and placed together, preferably with the fingers whilst submerged in the clean oil.

(10) Wash the atomiser body in clean kerosene, care being taken to ensure that the highly ground face "D" Figure 26, is clean and free from scratches. This face must register with the atomiser nozzle flange cleanly and squarely to form a high pressure joint, and must, therefore, be handled in such a way as to avoid damage to the surface.

(11) The exterior of the atomiser body must, of course, be cleaned thoroughly from dirt and grease in the usual manner.

Periodically, it is advisable to dismantle the interior of the atomiser body to examine the springs (24) Figure 20, spring plate, and nozzle spindle (22). When dismantling a special spanner Nos. ET.117 and ET.118 (see Figure 25) should be applied for the removal of the nozzle holder spring cap (25) Figure 20, which is revealed after the removal of the covering protection cap. The interior of the atomiser body and the parts removed should be washed carefully to remove any dirt or moisture. If the spring and the parts are in good condition, they should be re-assembled carefully,

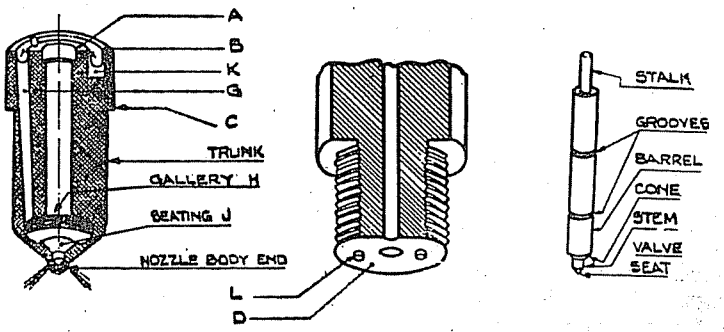


Fig. 26—Diagrams of Atomiser and Atomiser Body; the letters have reference in the text.

and preferably after they have been slightly coated with lubricating oil. The serviceable life of an atomiser valve spring can be considerably enhanced by careful treatment, and great care should be taken to avoid the damage likely to be caused by careless treatment and great care should be taken to avoid the damage likely to be caused by moisture, corrosion arising in storage, handling, or by reason of condensation owing to temperature changes in service.

It is recommended that these valve springs be inspected, cleaned and greased whenever the atomisers are removed for cleaning, whilst care should be taken in storing spares to preclude all possibility of the access of moisture.

50. RE-ASSEMBLY OF ATOMISERS.

(1) Carefully assemble the atomiser nozzle to the atomiser body after having immersed the pressure faces of each in clean fuel oil.

(2) The nozzle holder cap nut (21), Figure 20, should be screwed on to the body by use of the special spanner. Excessive tightening of the nozzle holder cap may result in constriction or distortion of the atomiser nozzle and its subsequent failure. Care should be exercised to ensure the leverage applied is not excessive.

(3) After cleaning, the atomiser should be tested always on the atomising testing pump as previously described.

(4) If the pressure at which the spray breaks is not as previously quoted, it can be adjusted by the spring adjusting screw and lock nut using spanner ET.119 Figure 25.

A perfect atomiser when tested by pumping fuel through it in the open air gives a short "pinging" sound as the fuel emerges from the holes, no matter how slowly the fuel be pumped. After the atomiser has been in service for some time, the "pinging" changes to a crackling sound. It is not until the atomiser sounds "dead" that its condition is likely to effect the running of the engine.

When placing the atomisers in the cylinder head, follow carefully the instructions in Paragraph 45.

51. FUEL PIPE (FUEL PUMP TO ATOMISER).

No two of the pressure pipes from fuel pump to atomisers are alike. Keep this in mind when replacing. When fitting fuel pipes, follow the procedure as outlined below:

(1) Examine the brass nipples which will be found on each end of the pipes.

(2) If the union nuts have at any time been overtightened there is a risk that the nipples will have cracked or been unduly compressed. If so, leakage will result.

(3) In this connection, bear in mind that the working pressure which these joints must sustain is several thousand pounds per square inch. Only a perfect joint is satisfactory, and if any doubt exists, it is recommended that the nipple be replaced.

(4) First clean up a length of pipe near the end, using a fine cut file for the purpose until the nipple will slide on to it.

(5) Remove the nipple and replace the union nut and steel washer. The latter must have its countersunk face towards the nipple.

(6) Now press the nipple on to the pipe leaving 1/64 inch of the latter protruding.

(7) Hold the pipe in a vice so that the nipple rests on the washer and the washer rests on the top of the vice.

(8) Rivet the protruding portion of the pipe over the nipple. Take care that the hole in the pipe is not closed while rivetting.

(9) Clean off with a fine cut file.

(10) When refitting take care that it is the brass nipple which makes the joint and not the actual rivetted portion of the pipe.

(11) After fitting new nipples, WASH THE FUEL PIPE WITH CLEAN FUEL OIL, using either the atomiser testing pump, or the engine fuel pump, thus removing any filing that may be in the pipe.

(12) Offer up the pipe to the delivery valve and atomiser unions to check that the pipe fits square at both ends. Do not fit one end and then bend the pipe to square it with the other union.

(13) When fitting the pipe, tighten the unions alternately, first one end and then the other.

(14) If the nipples have been properly fitted and the pipe is square to the unions at each end as described above, no force will be needed to make a good joint. No force should be used.

(15) Use only a standard open ended $\frac{3}{8}$ inch by $\frac{7}{16}$ inch spanner for tightening purposes.

(16) If the union is excessively tightened the nipple may collapse and split. The same dangers exist if the pipe is not square to, and central with, the union.

When changing an atomiser, always remove the pipe entirely. Never undo only one end, leaving the other tight. Never bend the pipe.

52. ENGINE TROUBLES.

Fuel injection difficulties can arise on the engine from several causes, some of which may be traced to the fuel pump. Such difficulties, with the likely cause and suggested cure, are set out on the following table.

First move when a fuel pump is suspected should be to uncouple the piping between the fuel pump and the atomisers. If the engine is then rotated with the pump control rod set at full load position it will be seen whether or not the fuel is being delivered. Observe each discharge outlet on the fuel pump to see if all discharge outlets are in order. On the following table the word "pump" applies to the pump unit block as a whole or to individual elements, and the numbers referred to are shown in Figure 20.

(1) Engine will not start, or stops after a short time.

Possible Cause	Location	Condition or suggested remedy for correct working.
Pump does not deliver fuel.	(a) Fuel cock.	Must be open.
	(b) Fuel tank.	Must contain an adequate supply.
	(c) Fuel inlet or filter elements.	Clean pipes, examine filter elements and, if choked, clean.
	(d) Air in pump.	Air vent filter and pump.
	(e) Delivery valve 40.	Clean and inspect. If worn or damaged replace both valve and seating.
	(f) Pump plunger 42.	Return the pump intact to the nearest C.A.V. service station.
Pump does not deliver fuel uniformly.	(g) Air in pump.	Air vent filter and pump.
	(h) Delivery valve spring 41.	Replace if broken.
	(i) Delivery valve.	If damaged on face or guide replace.
	(j) Tappet spring 15.	See (f) above.
	(k) Pump plunger 42.	See (f) above.
	(l) Fuel inlet pipes or filter elements.	Proceed as (c).
	(m) Fuel lift pump	This pump may not be operating efficiently. (See instructions in Para. 37.)
	(n) Tappet adjusting screw.	Proceed as in (f) above.
	(o) Cam profiles.	Proceed as in (f) above.

(2) Engine does not pull.

Possible Cause	Location	Condition or suggested remedy for correct working.
Quantity of fuel delivered per stroke insufficient.	(a) Delivery valve 40.	Proceed as in (f) above.
	(b) Pressure system joints.	If leaking, clean joint faces and tighten.

(3) Engine emits black smoke.

Possible Cause	Location	Condition or suggested remedy for correct working.
Quantity of fuel delivered per stroke excessive.	(a) Regulating quadrant 38.	If moved, due to screw being loose, proceed as in (f) above.

(4) Maximum speed of engine too high.

Possible Cause.	Location.	Condition or Suggested Remedy for correct working.
Control rod has jammed.	(a) Pump plunger 42.	Proceed as in (f) above.
	(b) Control Rod.	Proceed as in (f) above.

NOTE.—If air is in system, the suction side of lift pump should first be examined.

53. TIMING.

The timing or re-setting of the timing on the diesel engine can be simply and expediently carried out if the following instructions are followed. It is well to remember that if the cylinder head has been removed it does not, in any way, affect the timing of the engine.

The diagram, Figure 27, accurately shows the opening and closing of exhaust and inlet valves, and the periods for which they are opened and closed.

(1) The first operation is to set tappets to .012 inch.
(2) Turn the crankshaft to bring Nos. 1 and 6 pistons to the top, No. 1 piston being on the compression stroke, the rockers on No. 6 cylinder being just rocking.
(3) That T.D.C. on Nos. 1 and 6 pistons has been obtained can be checked by examining the flywheel or the crankshaft at the front end where the key for the fan belt pulley should be at the top of its periphery.
(4) To ensure that the fuel pump is timed in conjunction with the engine, and provided the engine is still set as mentioned above, place the fuel pump on the fuel pump platform, with the three "O's" across the coupling line.
(5) Screw in the two locating set screws below the fuel pump platform.
(6) Tighten down the four securing bolts.
(7) The scribed line on the coupling should coincide with the scribed line on the pre-set plate (See Figure 28), but if the lines are slightly out of line, the fuel pump coupling can be adjusted to correct this difference.

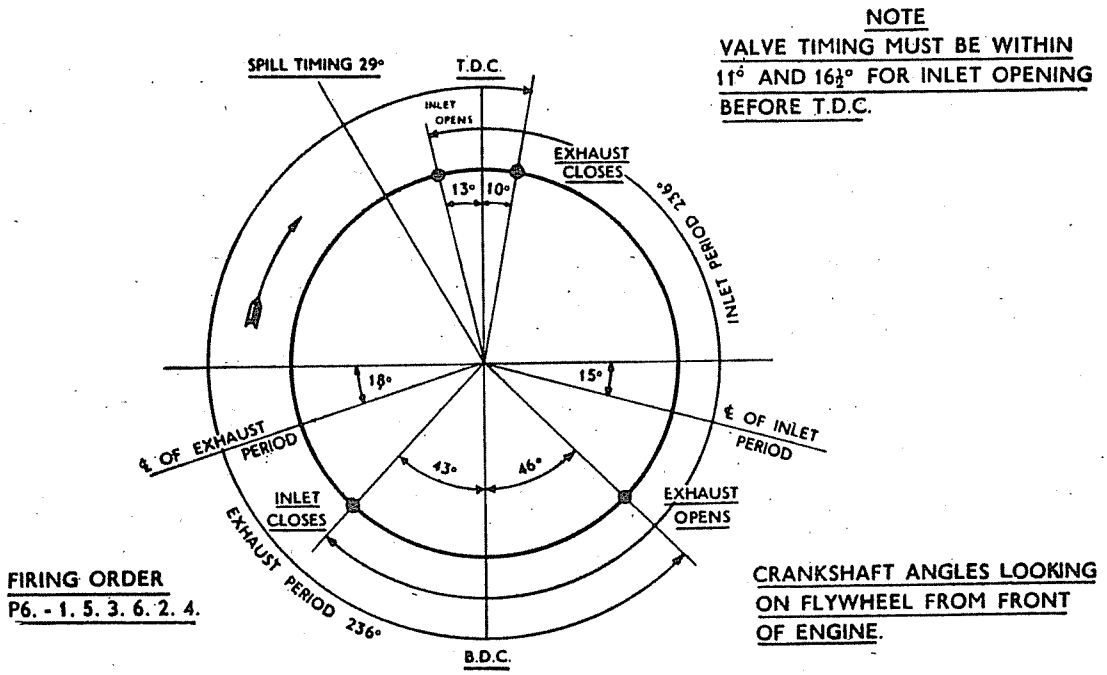
On certain engines the pre-set plate is larger and extends to the outside diameter of the flange on the fuel pump half of the coupling (See Figure 29). The scribed line stamped with the letter "S" is provided for service use, and when in line with the scribed line on the pre-set plate, denotes the fuel pump position relative to the engine with the No. 1 piston at T.D.C. on its compression stroke.

(8) Having timed the engine, the tappets should be re-adjusted if necessary to .010 inch with the engine warm.

54. RE-SETTING ORIGINAL TIMING.

Re-setting the timing to the original markings, if for any reason the timing chain has been removed, can easily and quickly be carried out if the following procedure is adopted.

(1) Remove atomisers and rocker gear.



Flywheel Diameter	1" on Flywheel Rim	ANGLE IN DEGREES						
		10°	11°	13°	16½°	20°	43°	46°
15"	7.65°	1.31"	1.44"	1.7"	2.16"	2.62"	5.63"	6.02"

One inch on the rim of flywheel 15 in. diameter is equivalent to 7.65 degrees.

Fig. 27.—Valve Timing Diagram, P. Series.

(2) Release the pawls in the automatic tensioner and push as far to the left as it will go. Wedge it there with a piece of wood.
(3) Bring No. 1 and 6 pistons to the top. That T.D.C. has been obtained can be checked by examining the flywheel or the front end where the key for the fan belt pulley should be at the top of its periphery.
(4) Turn the camshaft sprocket until the arrow stamped on the sprocket is in line with the arrow stamped in the timing case.

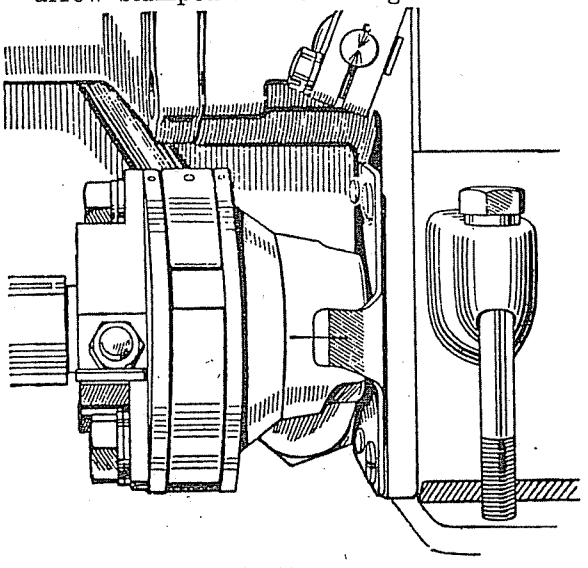


Fig. 28.

(5) Turn the fuel pump drive sprocket until the arrow stamped on the sprocket is in line with the arrow stamped in the timing case. The scribed lines on the fuel pump coupling and pre-set plate should be in line. See Figures 28 and 29.
(6) Fit timing chain and rivet up master link.
(7) See Paragraph 16 for fitting of the timing chain.

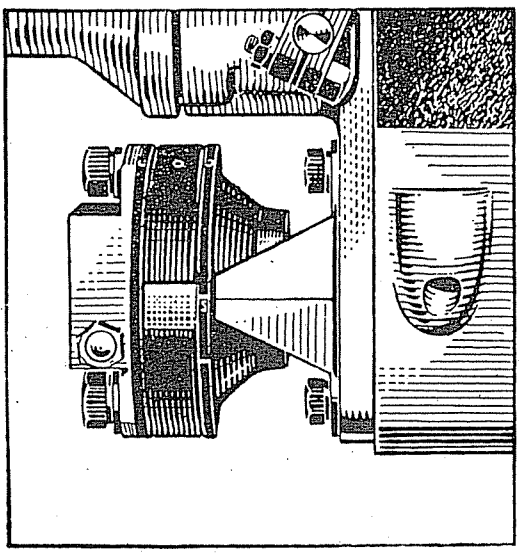


Fig. 29.—Showing alternative pre-set plate.

(8) Remove wedge from automatic tensioner.

(9) With the timing chain in its tensioned position check the four points as mentioned above to ensure they are in the correct position.

(10) Replace the rocker gear and adjust the tappets to .012 inch.

(11) Replace the atomisers.

(12) The tappets should be re-adjusted if necessary to .010 inch with the engine warm.

55. ALIGNMENT OF THE CLUTCH HOUSING AND FLYWHEEL.

It is most important that the clutch housing be correctly aligned with the crankshaft. Misalignment may give rise to difficulty in changing gear, etc.

If the housing has been removed, as is necessary for a complete overhaul, the greatest care must be taken on replacement to ensure accuracy of alignment. The appropriate procedure is as follows:

(1) See that the face of both the rear of the cylinder block and clutch housing are perfectly clean and free from burrs.

(2) Set the housing on the $\frac{3}{8}$ inch studs and tighten, but not overtight, so as to allow adjustment.

56. ALIGNMENT OF CLUTCH HOUSING BORE.

(1) Secure the base of a "clock" gauge to the flange of the crankshaft.

(2) Set the needle of the gauge to the interior of the bored hole in the clutch housing. (Figure 30.)

(3) Turn the crankshaft and check that this hole is truly central. The housing is adjusted until the bored hole is central.

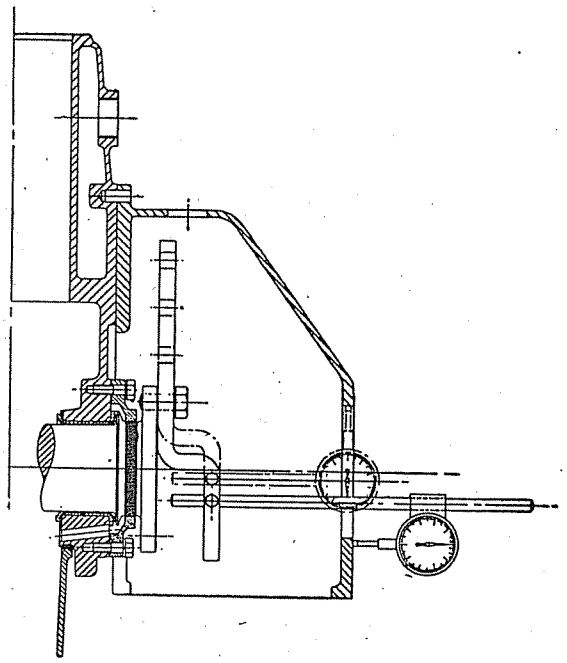


Fig. 30.

(4) For convenience in turning the engine it is advisable to release the centre plug combustion chamber caps.

The hole in the clutch housing should be truly central with the crankshaft within the limits of plus or minus .0025 inch.

57. ALIGNMENT OF THE CLUTCH HOUSING FACE.

(1) With the face of the "clock" gauge still bolted to the crankshaft flange, adjust the "clock" so as to set the needle against the vertical face on the clutch housing, and, again turning the crankshaft, check that this face is perpendicular to the crankshaft axis. (Figure 30.)

(2) This facing should be within .0025 inch plus or minus of being truly at right angles to the crankshaft axis.

(3) This degree of accuracy should prevail in any position of the indicator clock.

(4) All adjustments to bring the clutch housing within the limits must be on the clutch housing and under NO CONDITION must the rear of the cylinder block be interfered with.

(5) When the housing is properly aligned to the above limits, tighten the eight securing nuts evenly.

(6) Ream the three $\frac{3}{8}$ inch dowel holes and fit the correct length and size dowels.

58. FITTING FLYWHELL AND CHECKING ALIGNMENT.

(1) With the flywheel and crankshaft flange perfectly clean and free from burrs, place the flywheel on the crankshaft flange ensuring that the two thimbles in the flange fit into the two recesses machined in the flywheel holes.

(2) Insert the eight set screws complete with flat washers into the flywheel holes and tighten evenly.

(3) Secure the base of the "clock" gauge to the clutch housing. With the flywheel at top centre, set the needle of the gauge on the periphery at T.D.C. (See Figure 31).

(4) Turn the crankshaft and check the "clock", the flywheel should run truly within the limits of plus or minus .0025 inch.

(5) With the base of the "clock" gauge still bolted to the clutch housing, adjust the "clock" so as to set the needle against the vertical machined face of the flywheel.

(6) Again turn the crankshaft and check the "clock", the flywheel should be within the limits of plus or minus .0025 inch at right angles to the crankshaft axis.

(7) When the flywheel has been checked for the correct limits, lock wire in pairs the eight set screws.

(8) Finally grease the spigot ball race.

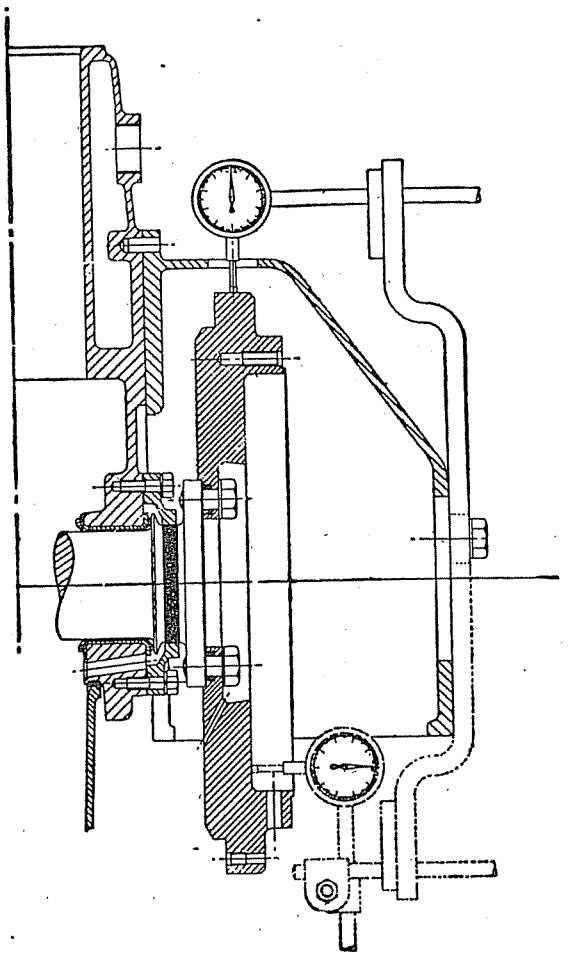


Fig. 31.

59. FAN AND DYNAMO BELT ADJUSTMENT.

Incorrect adjustment of the fan and dynamo belt can result in the fraying of the belt and eventual failure. To ensure the belt is correctly adjusted, it should be checked every 50 hours or 1,000 miles. Tight adjustment will tend to overload the bearings in the dynamo and water pump which consequently may result in damage to these components.

If adjustment is too slack, belt slip will occur. This could result in overheating of the engine due to the reduced efficiency of the water pump, and the inability of the fan to draw cool air through the radiator.

The output of the dynamo would also be considerably reduced.

A. Method of Checking Correct Adjustment.

(1) Press the fan belt with the thumb at the centre point between the water pump pulley and the crankshaft pulley in a sideways direction (See Figure 32).

(2) Check the amount of movement of the fan belt which should be $\frac{3}{4}$ inch if correctly adjusted.

B. Method of Adjustment.

(1) Unscrew the dynamo adjusting lever bolt and dynamo support bracket bolts (See Figure 33).

(2) The dynamo can then be moved inwards towards the engine to slacken the belt or in an outwards direction to tighten it.

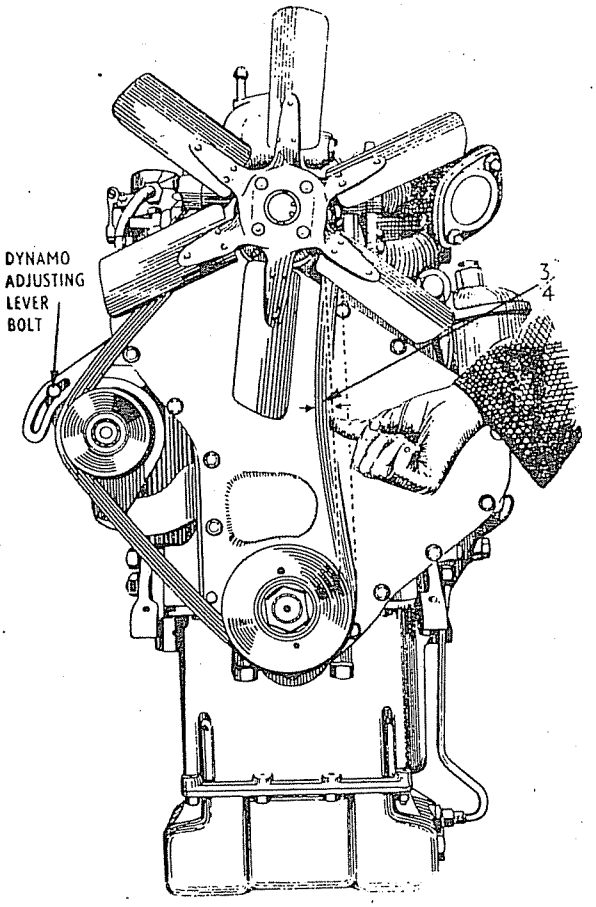


Fig. 32.

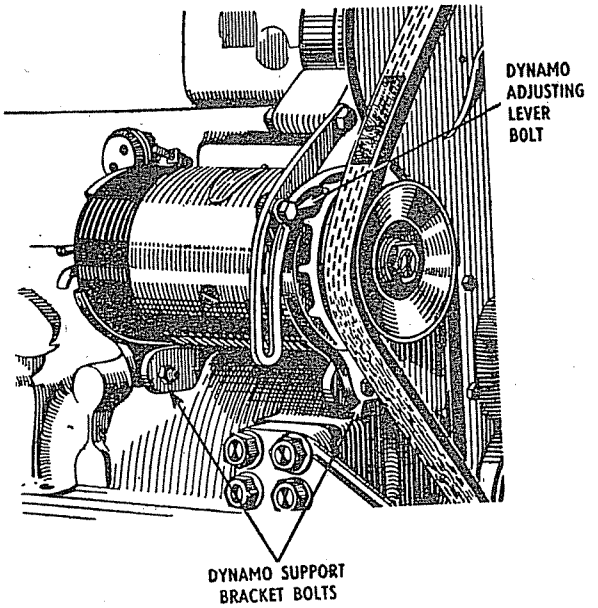


Fig. 33.

(3) When the position of the dynamo provides correct tension of the belt, tighten dynamo adjusting lever bolts and support bracket bolts.

C. Fitting New Belt.

In the event of a new belt being fitted, it is advisable to check the adjustment again after a few hours running to ensure no initial stretching has occurred. Should this have developed, re-adjust as already described.

60. FILTERS.

A prime condition in the maintenance of diesel engines is that of cleanliness. The air and fuel oil which enters the cylinders must be scrupulously clean as also must be the lubricating oil. Particular attention has been paid to the provision of means for ensuring cleanliness in respect of these three. Filters are provided and all that the operator needs to do is to take steps to ensure that these filters are kept in such a state that they will most effectively perform their functions.

In this section, the question of air filtration is considered, the filters supplied with the engine are described and instruction is given how to maintain these filters and keep filtration to a high level of efficiency.

Air is filtered as it enters the inlet manifold by use of an oil bath type filter.

The time for cleaning the air cleaner depends entirely on operating conditions, therefore under extremely dusty conditions, the time limit recommended in Paragraph 92 regarding periodical attentions should be decreased.

The correct maintenance of the air cleaner will greatly assist in reducing bore wear, thereby extending the life of the engine. When fitting the air filter to the venturi, see that the slots in the base of the filter body are blanked by the venturi, also that the securing clip is square and tight.

61. OIL BATH FILTER.

In the oil bath filter the incoming air impinges upon the surface of the oil carried in a reservoir in the lower part of the filter casing (See Figure 34). As a result of this, particles of foreign matter are carried into the oil by their own momentum and there trapped. The air next passes through a steel wire element before reaching the induction manifold and in that element are deposited any other particles of foreign matter which still remain in the air after its contact with the oil.

62. MAINTENANCE.

The method of maintaining the oil bath filter is as follows:

Examine and replenish oil and clean in accordance with periodical attentions, Paragraph 92. To do this, proceed as follows:

(1) Remove top cover and lift out element.

(2) Wash element in kerosene or fuel oil and allow to drain.

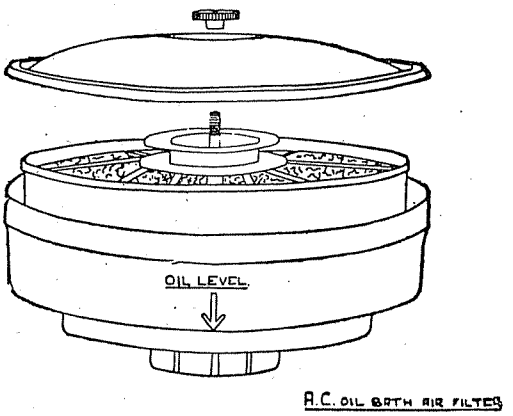


Fig. 34—Oil Bath Type Filter.

(3) Empty the oil out of the outer case and scrape out accumulated sludge.

(4) Wash out case with kerosene or fuel oil and refill with oil to the indicated level. Do not overfill.

(5) Replace element and top cover, taking care to see that the joint ring is in good condition and is sealing, also the felt washer beneath the steel washer is in position.

(6) Tighten the cover down.

IMPORTANT.

The efficiency of the cleaner is such that if the cleaning of the element is not carried out at appropriate intervals, engine performance will be seriously affected, because the presence of impurities on the cleaner will restrict the air passage. In the event of the engine performance being below par it is a good plan first to check up on the cleaner to ascertain if clogging of the filter is the cause.

63. FUEL OIL FILTERS.

Of all the factors on which satisfactory operation of a diesel engine depends, cleanliness of the fuel oil is most important. The efficient operation and length of life of the fuel pump elements and of the atomisers depends on:

(1) The use of clean fuel oil.
(2) The provision of suitable filters.
(3) Attention to the filters.

Protection of the engine is provided by the following filters, leading from the tank to the fuel pump:

(1) Pre-filter.
(2) Intermediate filter.
(3) Final filter.

64. PRE-FILTER.

The main purpose of this filter is to protect the fuel lift pump. It has a comparatively coarse filter.

The element is contained in an easily removed bowl and should be cleaned in accordance with periodical attentions, Paragraph 92. When re-assembling after cleaning, take care that a good joint is made between the top of the bowl and the

filter body, as any leakage of air here, that is on the suction side of the fuel pump, may cause air locks in the system.

65. INTERMEDIATE FILTER.

This filter contains a star shaped felt element which should be washed in kerosene or clean fuel oil (See periodical attentions, Paragraph 92).

It is advisable to have a spare felt element in stock in order to allow for thorough cleaning of this element, thus saving time which may be lost waiting for the element to be cleaned and replaced.

66. FINAL FILTER.

It is not possible to clean the paper element in this filter. It should be renewed every 10,000 miles. Every 2,500 miles unscrew the drain plug at the bottom of the filter bowl and allow the fuel to flow until clean fuel oil appears.

(1) Replace the drain plug.
(2) To remove the element, unscrew the larger nut in the centre of the cover and drop the filter bowl clear.
(3) Remove the element.
(4) Before putting new element in position clean the filter bowl and inspect the relief valves.
(5) Ensure the rubber joints are in good condition, if not, replace by new.

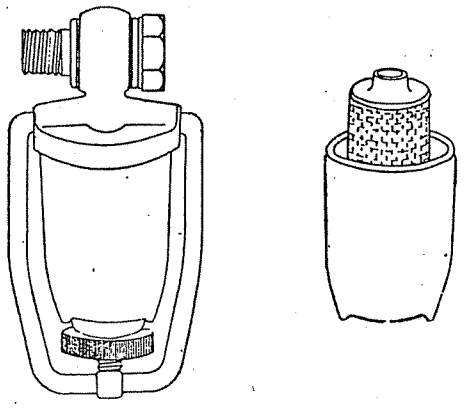


Fig. 35—Pre-filter.

67. LUBRICATING OIL FILTERS.

The importance of using clean lubricating oil in the first place, and providing means to ensure that it is always clean in use, is hardly second to the importance of cleanliness in respect of the fuel.

It is imperative, therefore, that lubricating oil filters are not neglected. Moreover, if the periodical attentions herein recommended are carried out and the correct grade of clean oil used, a very long life can be obtained from the diesel engine.

To ensure cleanliness, three filters are incorporated:

(1) Oil filter strainer.
(2) Sump strainer.
(3) Main (Full Flow) filter.

The purpose of the oil filter strainer is to prevent large objects entering the sump when the engine is being filled with lubricating oil. Clean in accordance with periodical attentions, Paragraph 92.

The sump strainer consists of a perforated gauze wire container which fits over the suction pipe to the oil pump.

After a time, there may be a tendency for sludge to collect and restrict the supply of oil to the pump. This strainer therefore should be thoroughly washed with fuel oil in accordance with the periodical attentions, Paragraph 92.

68. MAIN (FULL FLOW) FILTER.

To Renew Element.

(1) Unscrew the nut on the filter head and drop case.
(2) Remove element complete with cage from filter bowl, care being taken not to damage the cork sealing washer.
(3) Unscrew the knurled nut from centre support.
(4) Remove bottom cover plate from cage.
(5) Remove element from cage.
(6) Slide off metal clip from element.
(7) Spread out element for cleaning.
(8) An alternative method of securing the element together is by using staples in place of the metal clip. To clean an element of this type without removing the staples, stretch element out, clean with kerosene and refold before replacing in cage. Ensure the cage is perfectly clean before replacing element.
(9) Replace felt pad on top cover plate.
(10) Replace felt pad to bottom cover plate before replacing cage and element complete.
(11) Before replacing into filter bowl ensure that the bowl is clean.

Lubricating Oil Filter Joints.

There are two joints in the lubricating oil filter.

The first is a rubber joint between the filter head in the filter bowl, it fits in a recess in the filter head.

The second is a cork joint between the filter head and the top cover of the filter element cage.

When dismantling the filter for cleaning purposes, care should be taken not to damage these joints. If it is found that either of these joints is damaged it should be replaced by a new joint.

Spare Element.

It cannot be too frequently emphasised that in all filters a spare unit should be kept at hand for use when the element in use requires cleaning or replacing. This simplifies "periodical attentions" whilst the vehicle is being serviced and saves time.

69. EXHAUSTERS.

(a) Description of Operation.

The main parts are a body, a rotor, heavy duty ball bearings and spring loaded piston ring sealing plates. The rotor carries six blades and rotates about an axis which is eccentric to the bore of the body. The spaces between the blades, rotor and body thus increase and decrease as rotation occurs. The inlet port is situated on the side where the spaces are increasing, and the exhaust or outlet port on the side where they are decreasing. Air is

thus drawn in at a low pressure and expelled at a higher (atmospheric) pressure.

The rotor and blades are of the same length and the ends of the working spaces between the blades are sealed by the cast iron sealing plates pushed axially against the rotor by means of six small springs which are housed in the pockets in the end covers.

The sealing plates are located in the bore of the body and are sealed radially by a piston ring. A peg rivetted to the plate and fitted in one of the spring pockets prevents the sealing plates from turning with the rotor.

At normal speeds the blades are kept in contact with the body bore by centrifugal force, but at engine "tick-over" speed, particularly when the oil is cold, the blades have insufficient centrifugal force to keep them in their true motion. This condition is overcome by the action of the cam rings, which contact the inside edges of the blades and force them to move out radially in their grooves, thus maintaining contact with the bore of the body. The cam rings are a "push" fit in the sealing plates.

Ball races located in each end cover, and large enough to take a certain amount of end thrust, are mounted on the rotor shaft and held in position by hardened steel collars.

During operation the pressure inside the end covers of the machine is below atmospheric, since the mean pressure of the working spaces is below atmospheric. On the other hand, at starting with the vacuum reservoir at atmospheric and for a few seconds until a sufficient vacuum is generated there is a tendency to blow oil out at the shaft ends.

For these reasons double seals are fitted back to back and run on hardened shaft collars.

The oil used for lubricating the exhauster is engine oil and is drawn from the engine sump to the exhauster by vacuum, returning to the engine sump via the outlet port, and thus lubricating the moving parts of the exhauster. The oil connection is located on the body, in the form of a banjo connection for $\frac{3}{8}$ inch O/D pipe.

An exhauster in good condition will easily generate a vacuum to within an inch of the barometric height, but prolonged running at such a vacuum tends to create unnecessary heat in the machine. Furthermore, it is not normally desirable to employ such a high vacuum for braking purposes

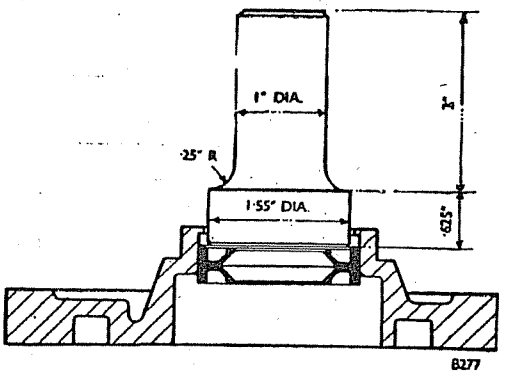


Fig. 36—Punch to remove Seals from Exhauster.

since time is taken to attain the last few inches of the working range, which is normally between 20 inches and 25 inches of mercury. This valve consists of a ball, spring loaded on a seat, and is fitted in the top cover of the block.

When the vacuum in the reservoir is greater than the vacuum generated by the exhauster, due to slowing down of the engine r.p.m., the non-return valve seats, and prevents leakage of vacuum from the system.

70. DISMANTLING INSTRUCTIONS.

(1) Remove coupling and keys from shaft ends.

(2) Remove four end cover bolts and ease off end covers. With the end cover will come the oil seals, seal back plates and springs.

(3) To remove seals from end covers use a punch as shown in Figure 36.

(4) Withdraw rotor, sealing plates, bearings, cam rings, blades and shaft collars from body in one assembly.

(5) Remove blades from rotor.

(6) Remove sealing plates.

ONLY IF IT IS REALLY NECESSARY MUST THE FOLLOWING DISMANTLING OF THE ROTOR BE CARRIED OUT.

(7) To remove bearings, cam rings and shaft collars, an extractor tool is necessary, and is illustrated in Figure 37. The claws of the extractor should be inserted between the bearings and cam ring. On screwing the bolt up against the rotor shaft end, the ball race and shaft collar will then be extracted together. The cam rings can then be removed from the rotor.

71. INSPECTION OF DISMANTLED PARTS.

(a) Body.

After a long period in service the bore of the body may show markings in the form of lines or ripples running longitudinally and coinciding with the end of the port openings. This is usual, and if of slight extent will do no harm. If the ripple is pronounced, however, and extends for most of the circumference, the body should be replaced. This condition may also be caused if the exhauster has been operated without adequate supply of oil.

(b) Bearings.

Worn bearings should be replaced immediately. If a premature failure is experienced the cause may be due to end thrust on the rotor shaft, this can be imposed by swollen rubber in the flexible coupling or coupling malalignment. Shortage of oil will also cause early bearing failure.

(c) Rotor Blades.

The blades wear on the outer edge, but a certain amount of wear here is permissible; if, however, the inner edges are appreciably "stepped" where they contact the cam ring, the blades should be replaced.

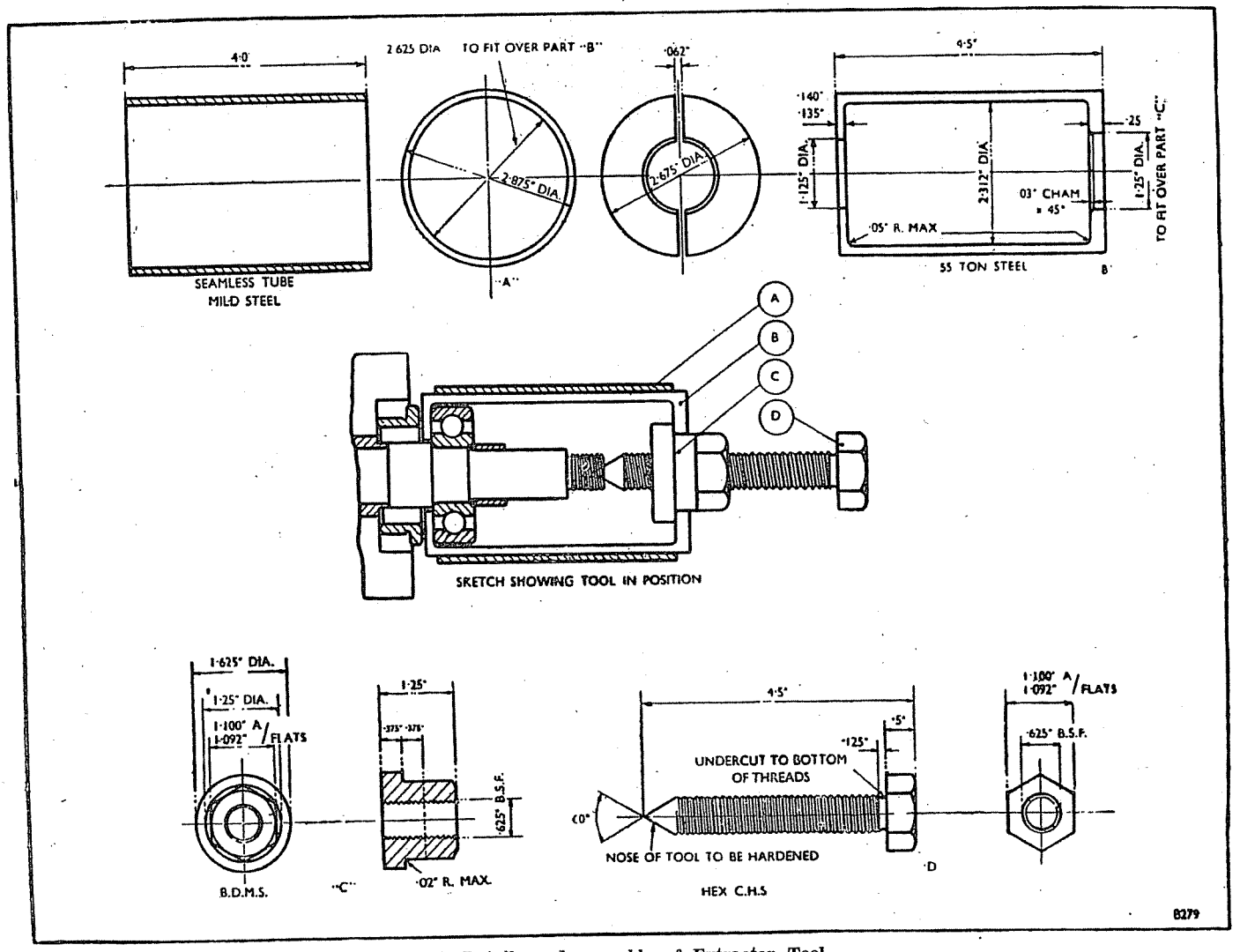


Fig. 37—Details and assembly of Extractor Tool.

(d) Piston Rings.

These should only be removed from the sealing plates when the rings or the plates need replacing. The rings should last the lifetime of the exhauster if handled with care.

(e) Sealing Plate and Peg.

If the faces of the sealing plates become scored after a long period of service, they should be renewed. Locating pegs are rivetted to the sealing plates and are supplied together as an assembly.

(f) Oil Seals.

Oil seals are adversely affected by dirty oil and dirty conditions generally, as the particles of grit cause wear. If troublesome, a complete new set of four seals should be fitted. Great care must be taken with withdrawing and replacing the shaft seals as the delicate sealing edges are easily damaged, the seal guide must always be used during this operation.

(g) Snifter Valve.

If necessary, the snifter valve can be re-seated by tapping the ball on its seat, using a brass drift. The

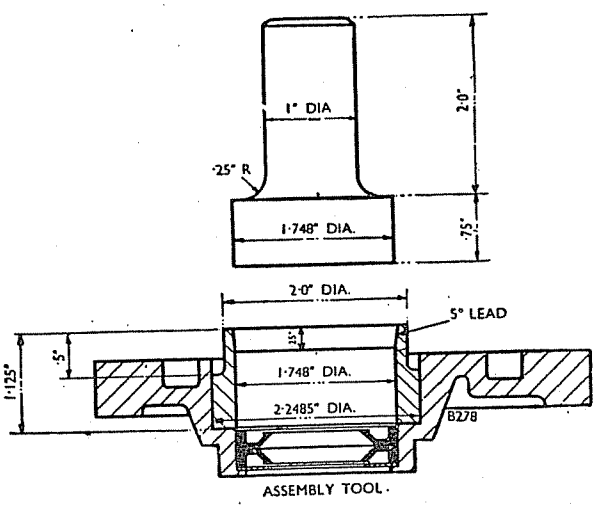


Fig. 38—Method of replacing seals.

non-return valve is rubber-seated, and a new rubber disc can be fitted if necessary. The metal part of the valve seat should be lightly skimmed if any pitting is apparent.

(h) Oil Filter.

This is fitted at the bottom of the oil suction pipe in the sump and should be cleaned periodically to ensure a good flow of oil. Renew if necessary.

(i) Joints.

It is advisable to fit new joints whenever the exhauster has been dismantled, to obviate risk of leakage.

(j) General.

All parts not specifically mentioned should be inspected for damage or deterioration and renewed if necessary.

72. ASSEMBLING AN EXHAUSTER.

(1) The seals should be fitted in the end covers. Figure 38 illustrates the correct method of assembly.
(2) Slide cam rings on rotor and replace bearings, making certain they butt against the shoulder on the rotor shaft. Drive on shaft collars up to bearings. Check bearings for "tightness". Fit piston rings into grooves in sealing plates, ensuring they seat below bore diameter. Pass sealing plates over bearings and locate them on the cam ring spigots. Replace blades in rotor slots and check for freedom of movement.
(3) Slide rotor assembly into body.
(4) Replace sealing plate springs in pockets of end covers, using grease to hold them in position.
(5) Smear end cover joints with grease and "stick" them on covers in their correct positions.
(6) Place the large seal back plates in end cover making certain they drop to the bottom of the ball race seats.
(7) With the rotor in position in the body, the end covers should be slipped over the shaft ends and pushed home, taking care that the sealing plate peg fits in one of the sealing plate springs. During this operation a protecting sleeves, as shown in Figure 39, must be used to prevent the seal edges being damaged by the seal collars.
(8) Replace end cover bolts and tighten. Check rotor to ensure free rotation.
(9) Replace keys and couplings.
(10) The snifter valve is assembled and set to operate at a pressure of 25 inches of mercury, in the following manner:
(a) Replace spring with its larger diameter coil to the inside of the body.
(b) Drop in steel ball.
(c) Screw in valve seat.
(d) Connect exhauster to vacuum reservoir, which should be equipped with a reliable gauge.
(e) Run the exhauster at 200 r.p.m. and allow vacuum gauge to settle at a steady reading. If the vacuum is too low it is necessary to fit new parts to the valve and reseat as required for efficient operation.

73. END THRUST.

All the following points are of great importance for trouble free running, but it is desired to emphasise that to function effectively, the rotary exhauster must have its rotor revolving freely and centrally between the spring loaded end plates.

If the rotor is displaced endwise, one of the sealing plates is lifted away from the end of the body and leak paths round the faces of the sealing plates are brought into existence. These leak paths will cause a loss of vacuum.

The first and most important service attention, therefore, is to see that, when assembled on the engine, there is not the least end thrust on the rotor shaft. The couplings should be assembled with about .030 inch clearance in an axial direction and it should be checked that this clearance is still there if for any reason the exhauster performance is unsatisfactory. This check can be made by levering with a screwdriver or small chisel ended bar at the coupling ends and in doing this, care should be taken to avoid damage to the shaft oil seals.

Causes of end thrust include:

(a) Swelling of Flexible Couplings due to Impregnation by Fuel Oil.

Certain types of flexible couplings after having been in service for a time may get oil on the rubber or fibre insert, causing it to swell and imposing a thrust upon the exhauster shaft. If this condition is found to exist, the insert should be renewed immediately, or if this is not possible, it is necessary to reduce the width of the coupling by say 2 m.m., at the same time ensuring that the coupling ends as fixed on the exhauster rotor are free to move axially in the rubber or fibre portion of the coupling.

(b) Difficulties arising during transit of Exhauster.

A similar condition sometimes occurs when exhausters have been packed for transport and the full weight of the exhauster may have rested upon one end of the shaft. This causes the rotor to be forced to the opposite end inside the housing and

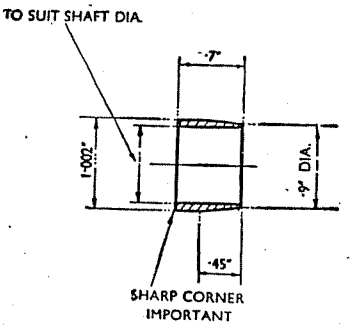


Fig. 39.

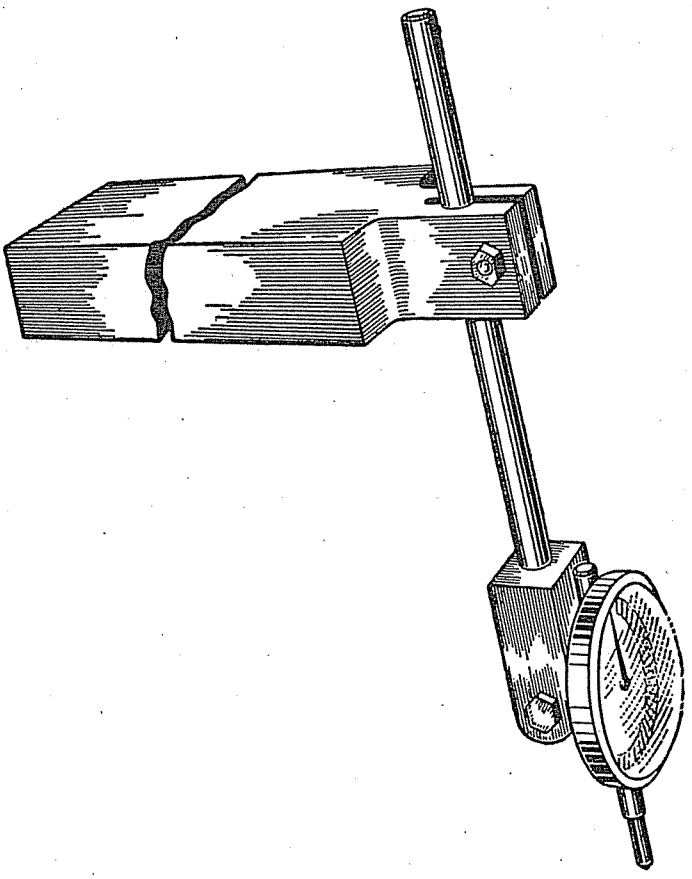


Fig. 40—Dial Gauge for use when aligning Exhauster Platform.

when unpacked may remain in this position owing to the fact that the shaft races are new and may be a little stiff in their housings. If this occurs both ends of the shaft should be lightly tapped with a piece of wood until the rotor centralises itself.

Correct Alignment of Exhauster Drive.

Special care should also be taken when mounting the exhauster to see that there is no mal-alignment as this will cause severe loading of the ball bearings and wear of driving couplings. This initial fitting is most important in the case of the base-mounted exhauster.

A satisfactory method of checking for alignment in this case is by running the engine at approximately 400 r.p.m. (idling speed) then slack off the four bolts at the base of the exhauster. These bolts are used for fixing the unit to the engine platform, and as the holes in the base of the exhausters have clearance, the unit can be moved to either side, or endwise, and shims fitted if necessary to obtain the correct position. For maximum generating figures, an endwise clearance in each direction is essential. The fixing bolts should then be finally tightened. If at any time the platform is disturbed in relation to the cylinder block it will be necessary to check the alignment.

The alignment of the exhauster platform is carried out at the factory by means of a very accurate jig of special design. For the normal workshop however, the dial gauge and stand, as shown in Figure 40, is quite satisfactory if used with care.

74. PROCEDURE FOR USE OF GAUGE.

(1) Remove the coupling halves from the exhauster shaft and fuel pump drive shaft.
(2) With cylinder head removed and with the base of the jig flat on the top face of the cylinder block, set the gauge from the fuel pump drive shaft.
(3) Take the readings from each end of the exhauster shaft and adjust the exhauster platform as necessary to give equal readings.

NOTE: This must be done with the joint in position between exhauster and platform.

(4) When the platform has been lined up, the exhauster can be lined up in relation to the fuel pump as above, by slackening off the four holding bolts.

75. LUBRICATING SYSTEM.

The importance of correct and clean lubrication cannot be stressed too highly.

The sump should be filled with a suitable lubricant to the correct level but do not attempt to overfill above the full mark. Before filling or checking the dipstick, ensure the vehicle is on level ground.

76. OIL CIRCULATION.

The system of lubrication comprises pressure feed to the main and big end bearings, to camshaft bearings and to the rocker shaft and auxiliary drive. It is illustrated in Figure 41.

KEY TO FIG. 41 — LUBRICATING DIAGRAM

1 — Oil thrower.
2 — Oil return passage to sump.
3 — Oil holes in crankshaft webs.
4 — Oil holes in crankcase webs.
5 — Sump.
6 — Inlet union to pressure rail.
7 — Pressure rail.
8 — Oil pipe from sump to exhauster.
9 — Sump strainer.
10 — Oil pump.
11 — Outlet passage from oil pump.
12 — Oil relief valve cover.
13 — Oil return passage from timing case.
14 — Main oil pipe — relief valve to oil filter.
15 — Timing chain.
16 — Inlet union to auxiliary drive.
17 — Oil filter.
18 — Outlet union from filter to auxiliary drive.
19 — Inlet union to oil filter.
20 — Outlet union from filter to camshaft reducer.
21 — Rocker shaft.
22 — Outlet union from oil filter.
23 — Connection to pressure gauge.
24 — Camshaft reducer outlet to cylinder head.
25 — Camshaft reducer inlet connection.
26 — Main oil pipe — oil filter to pressure rail.
27 — Camshaft bearing.
28 — Slot in No. 2 camshaft bearing journal.
29 — Camshaft.
30 — Relief valve.
31 — Relief valve spring.
32 — Outlet union on relief valve cover.

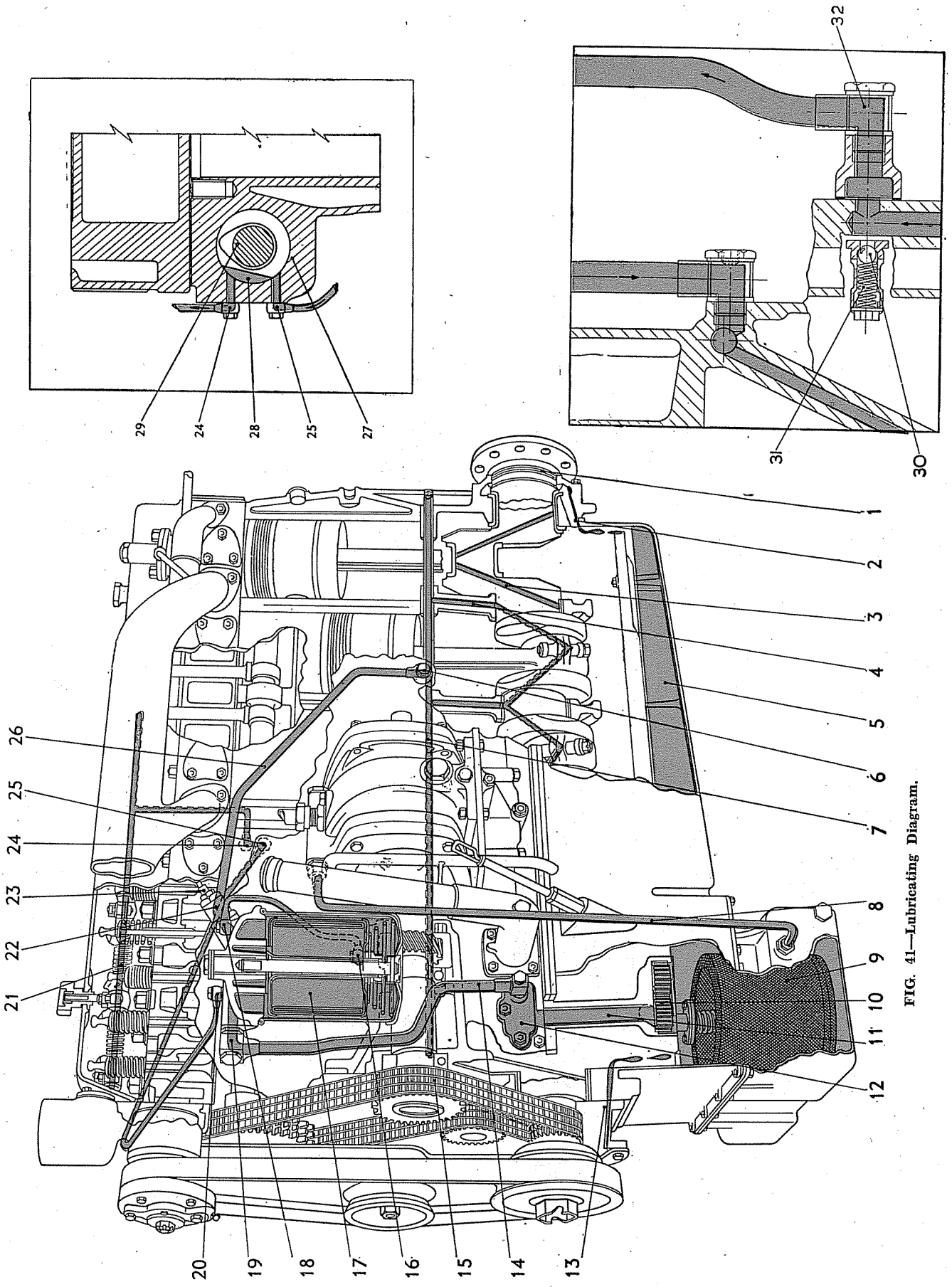


FIG. 41—Lubricating Diagram.

Referring to Figure 41:

(1) The pump, 10, draws oil through the strainer, 9, from the sump, 5. It delivers to the relief valve cover, 12, through the outlet passage, 11.
(2) The oil then flows along pipe, 14, to filter, 17.
(3) At the outlet, 22, from this filter the flow passes along pipe, 26, to the pressure rail, 7. The outlet union on the filter is drilled to allow for the connection of the oil pressure gauge pipe.
(4) The pressure rail, 7, is an internal passage within the crankcase. Holes, 4, drilled in the crankcase webs lead from this pressure rail to the crankshaft bearings and holes, 3, in the crankshaft carry the oil to the big end bearings. Surplus oil is returned to the sump, 5.
(5) An oil thrower ring, 1, prevents oil from leaking along the crankshaft at its rear end and any oil thrown from this ring returns by the passage, 2, to the sump.
(6) Two oil feeds are taken from the oil filter head.
(7) One pipe carries oil at full pressure to the auxiliary drive body, See Figure 42.
(8) The other pipe carries oil to the lower of the two drillings in the camshaft tunnel on the centre line of No. 2 camshaft bearing, See Figure 43.
(9) As the camshaft revolves, oil is picked up and carried around the narrow slots machined on No. 2 camshaft journal until it escapes through the upper drilling in the camshaft tunnel. The oil then flows through the pipe to the cylinder head where a pipe conveys it to the hollow rocker shaft which feeds oil to the rocker shaft lever bushes, etc.
(10) It will be appreciated that owing to the small capacity of the slot on the camshaft journal, only a reduced quantity of oil can pass to the rocker shaft during each revolution of the camshaft.
(11) A further oil circuit is provided on engines fitted with an exhauster. When the maximum degree of vacuum is reached in the vacuum tank, the exhauster ceases to operate in the normal way. Instead it draws oil from the sump through the pipe 8 and delivers it through a passage in the wall of the crankcase.

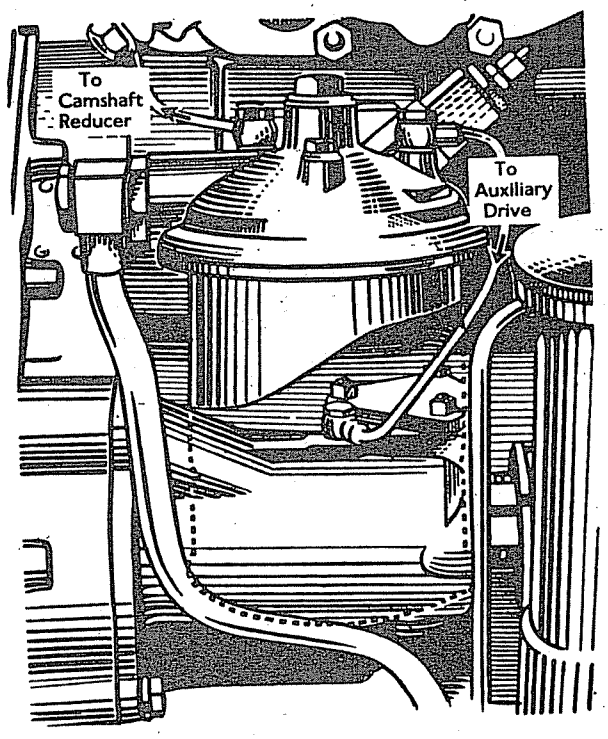


Fig. 42.

77. OIL PRESSURE.

See that oil pressure is registered on the gauge. The actual pressure may vary with individual engines and under different operating conditions.

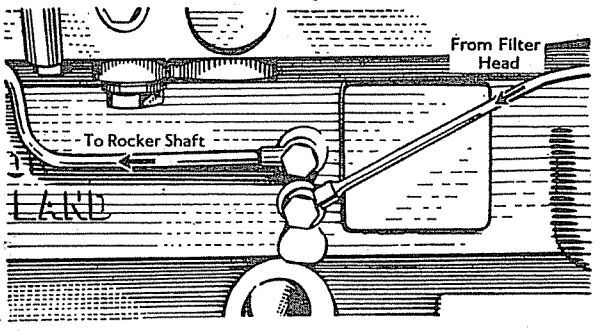


Fig. 43.

The pressure will drop considerably whilst idling and to a certain extent when the engine is hot, but, should never be below 30 lbs. per sq. in. when the engine is running at normal speed.

78. THE OIL RELIEF VALVE.

The oil relief valve, 30, Figure 41, prevents the pressure becoming excessive as might otherwise happen when the oil is cold.

When the predetermined pressure is excessive, the valve opens against the spring 31, and some of

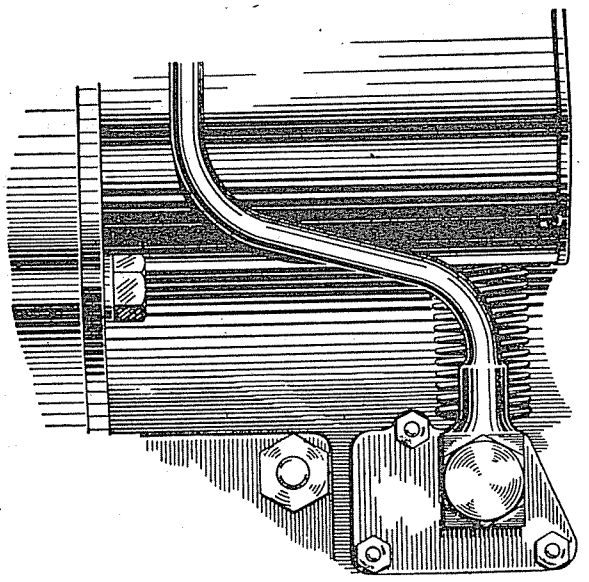


Fig. 44—Showing position of Adaptor.

the oil is passed back into the sump. That continues until the oil warms up and flows at the desired pressure. The valve then closes.

If the oil pressure as registered on the gauge is less than it should be, the cause may be foreign matter on the seat of this relief valve preventing it from closing.

To obtain access to the valve, proceed as follows:

(1) The oil pressure relief valve is located behind a small aluminium cover into which is screwed the lower banjo bolt of the main feed pipe to the lubricating oil filter, see Figure 44.
(2) Remove the pipe from the block to the lubricating oil filter.
(3) Remove the small cover plate which is held by three nuts and the oil relief valve will be exposed.
(4) Remove the oil pressure relief valve from the block.
(5) Wash the valve in fuel oil and blow dry with compressed air. See that the ball and ball seat are perfectly clean and bedding correctly.

If, after the foregoing points have been checked, the oil pressure fails to register or is below normal, it may be:

(1) That one or more joints in the piping are leaking.
(2) The strainer in the sump may be choked.
(3) The oil suction pipe may be loose.
(4) The fuel flow filter may be choked.

The remedy for the above is to trace the whole system of piping right through, tightening each union in turn. The strainer can be removed from the sump without disturbing the sump.

79. WHEN TO RENEW OIL.

The oil in the crankcase must be drained in accordance with periodical attentions (Paragraph 92) and replaced by new oil of a specification suitable to the climatic conditions under which the vehicle operates.

80. CYLINDER HEAD COVERS AND ROCKER LUBRICATION.

The rocker cover must be removed and the oil flow valve spring checked periodically, see paragraph 92. Any sludge which may be found must be cleaned off the covers and heads and away from the valve springs. This is important.

Particular care must always be taken that when any water is splashed on to the engine at any time, it is wiped off.

GENERAL.

Any water which may find its way into the sump from the exterior will form sludge.

Failure to change the oil in the sump at recommended intervals is false economy, even if the oil seems good at the time of the recommended change.

Dirty lubricating filters aggravate the formation of sludge which in turn will further choke the filters. Regular filter inspection and cleaning at the specified periods is essential.

81. STARTING THE ENGINE.

Preparation for Starting.

(1) Fill the radiator.
(2) Fill engine sump to "full" mark on dipstick, using an approved oil.

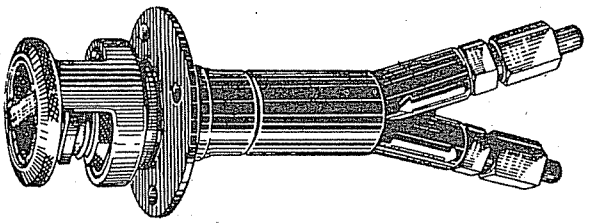


Fig. 45—Ki-gass Pump.

(3) See that there is fuel oil in the tank.
(4) Put about ¼ pint lubricating oil into the fuel pump camshaft chamber after a major overhaul or at the initial fill.

This is done by removing the inspection cover plate after care is taken to remove exterior dirt, etc., to prevent its entry into the fuel injection pump.

(5) Prime the fuel system as follows:

(a) Remove small plugs on the top of the final fuel filter and operate the hand primer on the fuel lift pump until fuel free from air bubbles issues from the plug holes. Replace the plug.
(b) Slack off the bleed cock on the top of the fuel pump.
(c) Again operate the hand primer on the fuel lift pump until fuel issues from the bleed cock and all signs of air have disappeared.
(d) Tighten the bleed cock securely and give the primer a few more strokes in order to deliver the fuel through the relief valve on the filter, clearing this part of the system of air.

82. INDUCTION HEATER.

(1) Check the Ki-gass tank to see that it contains fuel oil.
(2) Turn on Ki-gass supply tap at tank.
(3) Press "Heater" and hold for about half a minute (count 40 fairly slowly). Then, press "starter" and "heater" simultaneously, and move the speed control lever (accelerator) to the "fully open" position, at the same time giving short strokes of about half an inch to the Ki-gass pump.
(4) The engine should then start.
(5) If it does not, repeat the operations just described.
(6) If the engine does not start at the third attempt, examine for faults. See Paragraph 94.
(7) The induction heater and Ki-gass are required only when very cold. Normally switch to "starter" only.

NOTE: Always be sure that the starter pinion has come to rest before again attempting to start, otherwise the starter ring and pinion may be damaged.

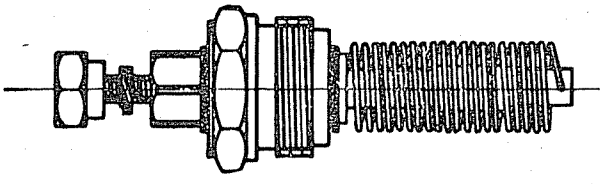


Fig. 46—Plug Heater, single pole.

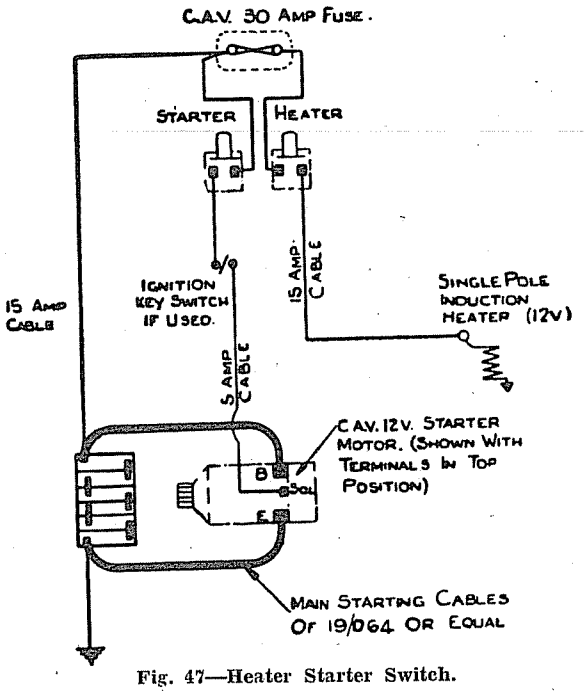


Fig. 47—Heater Starter Switch.

(8) After using the Ki-gass primer always screw the handle down tightly. On no account must this be forgotten.
(9) Allow the engine to run for 15 minutes at fast tick over. During this period examine all water connections and check for leakages.
(10) Check that the oil pressure is registering on the gauge.
(11) Check for leakage, particularly of water.
(12) Check that the dynamo is charging.

After 15 minutes, and when satisfied that all foregoing points are in order, the engine may be put in service.

83. RUNNING INSTRUCTIONS.

Difficult Starting.

No Fuel at Atomisers:

(a) No fuel in tank.
(b) Fuel lift pump not working.
(c) Slack connections in the fuel system.
(d) Air in the fuel system. (Trace from suction side).

Go over the whole of the above and make sure that the atomisers are fully primed and that the "pinging" or "squeaking" noise is heard from each atomiser when the engine is turned over by hand.

84. Engine not being turned over quickly enough. (Particularly in cold weather).

(a) Lubricating oil too thick.
(b) Battery not fully charged. Fit fully charged battery.
(c) Engine "gummy" due to standing in the cold. Use the heater or Ki-gass equipment (See Paragraph 82).

85. Low Compression.

This may be due to dry cylinders and piston rings, worn piston rings, worn cylinders, or leaky valves. For any other than the dry cylinder, the proper course is to have the engine overhauled, but as a temporary expedient, starting may be assisted by injecting about a dessert spoonful of lubricating oil into the inlet port by means of a suitable syringe through the nipple or union for the Ki-gass pipe. If this is done, the engine should be turned over steadily four or five times so as to allow any excess oil, inadvertently introduced, to escape.

86. Dirt Between Valve and Seat.

Remove cylinder head cover and turn the engine. Note which valves leak. Bring corresponding piston to beginning of compression stroke, turn engine over compression at same time bouncing valve open by hitting valve rocker end down with a block of hardwood or the like. Repeat until dirt is blown out and the valve holds compression.

87. Atomisers Faulty.

Test atomisers for "ping" or "squeak" as already mentioned. If any atomiser fails to give this "pinging" or "squeaking" noise when that cylinder is pulled smartly over compression and it has been made certain that the atomiser is fully primed, then the atomiser should be tested by removing it from the cylinder head (See Paragraph 48).

Disconnect pipes on other atomisers while making this test.

88. Sticking Valves.

Trouble with sticking valves may be due to overheating, the result of choked atomisers, or the use of unsuitable lubricating oil.

Test the atomisers as recommended in Paragraph 48 and clean them if necessary.

The lubricating oil used should be of an approved type.

To free a valve, squirt a small quantity of kerosene down the valve guide and allow it to seep right through. The valve may then be given a sharp tap. This process will invariably free the valve. A quantity of clean oil should then be poured down the guide to lubricate the valve stem before again starting up the engine.

89. Sticking Rocker.

If the rockers stick, the cause may be the use of unsuitable oil, shortage of oil, or sludging. Use only oil of an approved type. If there is a shortage of lubricant, the passages and pipes to and from the reducing valve, 24 (Figure 41) should be cleaned.

To free the rocker, squirt a little kerosene into the bearings, allow it to seep through then gently tap the rocker arm. This will free the rocker. Thoroughly lubricate with clean oil and the engine may be re-started.

90. Fuel Oil.

It is essential to use clean fuel oil free from water, dirt or sand. Providing clean fuel is used, no trouble should be experienced with the fuel system, but dirty oil will lead to trouble due to choked pipe, choked filters, damaged fuel pump and faulty atomisers. If the engine tends to run well for a short period and then to die away or stop altogether, the fuel system should immediately be suspected.The trouble may be due to the lift pump not working properly, to a loose pipe joint allowing air to get into the fuel system, to a dirty fuel filter, or to a choked fuel pipe. The pre-filter in the fuel lift

pump and the intermediate filter element should be cleaned by washing in clean fuel oil, but the final filter should not need attention more than once in 10,000 miles, when a completely NEW filter element should be fitted. If the conditions lead to dust or contamination of the fuel, decrease the maintenance interval.

Always, after disturbing fuel line washers, replace with new washers to ensure the joints are air tight.

91. Air Cleaner.

In accordance with periodical attentions, Paragraph 92, clean the filtering element in kerosene, and, if an oil bath type, dip in oil. In those filters which need it, fresh engine oil should be poured into the base, up to the level mark.

For maintenance instructions, see "Filters" Paragraph 60.

92. PERIODICAL INSTRUCTIONS.

Keep Engine Clean.

Daily

Check water in radiator.
Check oil level in sump.

Every 1,000 Miles.

Grease water pump.
Top up batteries with distilled water.
Drain oil from sump and renew.
Clean pre-filter of fuel lift pump.
Clean element in lubricating oil filter.
Examine air cleaner (See Note).

Every 5,000 Miles.

Clean intermediate fuel filter.
Clean and grease battery terminals.

Every 10,000 Miles.

Clean out crankcase ventilation pipes. Remove, clean and attend to air cleaner (See Note).
Clean strainer in crankcase sump.
Renew element in intermediate fuel filter.
Remove and clean exhauster strainer.
Renew felt element in lubricating oil filter.
Inspect commutator and brushes of dynamo.
Renew element in final fuel filter.
Remove cylinder head cover.
Examine valve springs and tappets.
Check oil flow to valve rocker gear.
Service atomisers.
Oil diaphragm on pneumatic control (3 drops).

NOTE.

The time for cleaning the air cleaner depends on operating conditions, therefore, under extremely dusty conditions, the time limit recommended above for cleaning should be decreased.

The correct maintenance of the air cleaner will greatly assist in reducing bore wear, thereby extending the life of the engine.

DO ——— AND ——— DO NOT

DO KEEP THE ENGINE CLEAN.

DO keep this book where it is conveniently accessible.

DO read the Instruction Book before putting the engine into service.

DO pay particular attention to lubrication.

DO use only approved grades of oil and grease.

DO use only GENUINE PERKINS SPARE PARTS.

DO keep all bolts and nuts tight.

DO eliminate all air from the fuel system and keep all fuel oil unions AIR TIGHT.

DO examine engine oil level in sump daily and replenish if necessary.

DO completely change engine oil in accordance with periodical attentions, Paragraph 92.

DO check oil flow to rocker gear and examine the valve springs in accordance with periodical attentions, Paragraph 92.

DO use only filtered fuel oil. Never tip into the tank a half-empty barrel of fuel oil, the bung of which may have been out for weeks.

DO keep a check on the temperature of the cooling water. It should not be allowed to boil. The best temperature is 140° F.- 170°F.

DO attend immediately to fuel and lubricating oil leaks.

DO grind in valves when necessary.

DO check tappet clearance from time to time (.010 in.) with warm engine.

DO tighten cylinder head nuts in correct order (See Figure 14).

DO quote engine number when ordering spares.

DO keep essential spares in store.

DO NOT guess. For additional information, contact suppliers of the vehicle.

DO NOT neglect the routine attentions specified in Paragraph 92.

DO NOT race the engine in neutral gear.

DO NOT run the engine unless the gauge shows OIL PRESSURE.

DO NOT unnecessarily interfere with any adjustments.

DO NOT break the fuel pump seal—remember, if broken, your Guarantee is void.

DO NOT continue to run the engine if the cooling water boils.

DO NOT forget to grease the water pump.

DO NOT forget to keep the fan belt tight.

DO NOT continue to run the engine if black smoke is coming from the exhaust.

DO NOT if the engine stops without apparent reason, fail to make sure, first of all, that fuel is reaching the fuel pump.

DO NOT omit to wipe the engine over occasionally with a clean rag.

DO NOT take the fuel pump to pieces.

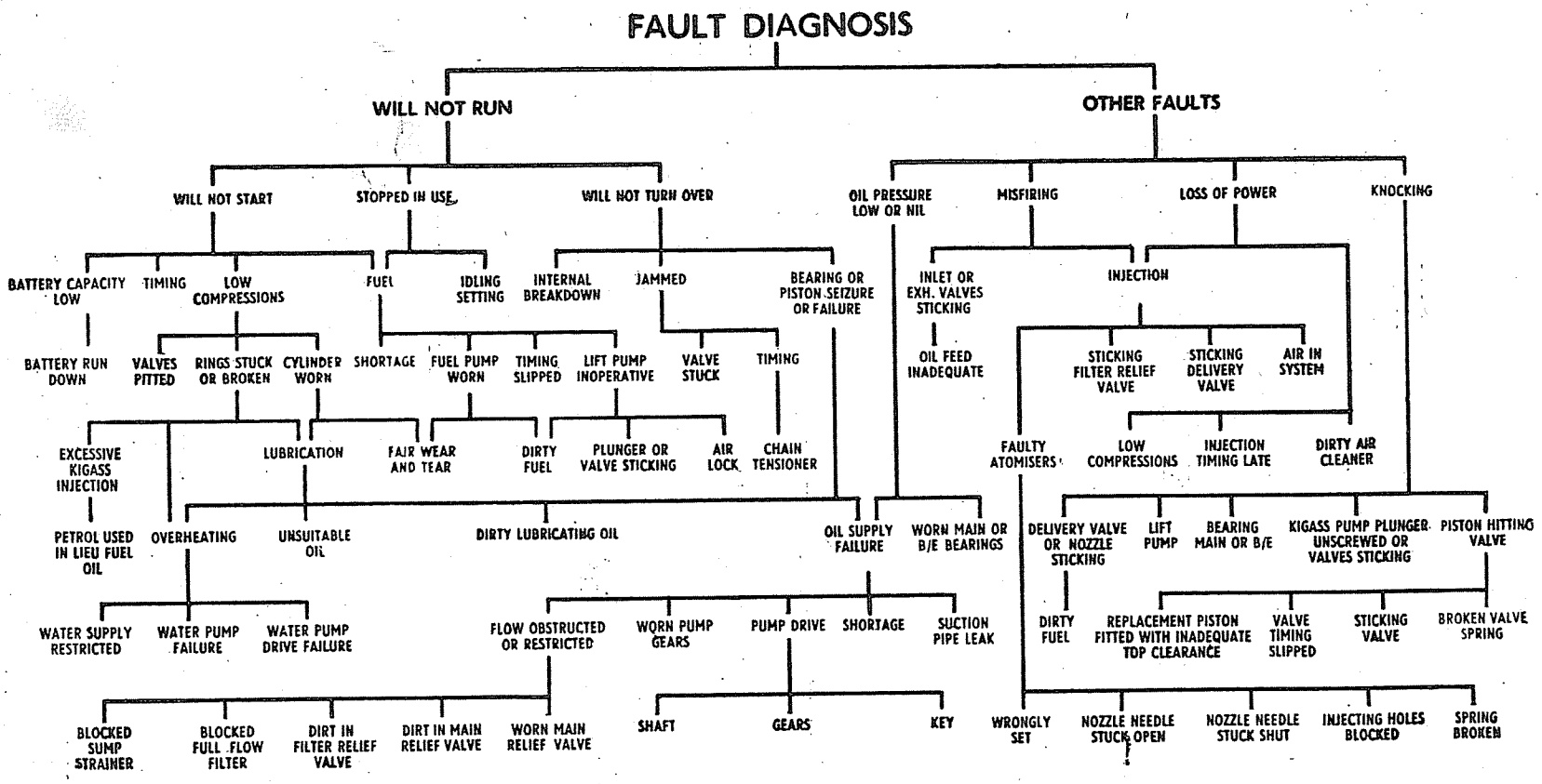
DO NOT use cotton waste or any fluffy cloth when cleaning.

DO NOT use any but suitable brands of fuel or lubricating oil.

DO NOT subject any engine or vehicle to continuous overloading.

DO NOT load the vehicle to which this engine is fitted beyond the manufacturers' stipulated pay load: it does not pay.

DO NOT coast when travelling down hill.



There is no machine made that is not liable to suffer occasional stoppage and/or failure. Sometimes the machine is at fault, but more often it is due to some human omission or neglect. Every effort is made to ensure that the Diesel engine is as near as possible fault proof, but for the benefit of those whose object it is to look after engines in service, the accompanying chart has been produced.. The main value of this chart is to help maintenance staff to consider any engine fault with which they are confronted, in a logical and organised manner. Prevention is better than cure, but if the fault has not been prevented, find it on this chart and follow it back to its cause.