INSTRUCTION BOOK No. 66

LX & HLX
LXB & HLXB
DIESEL ENGINES

INSTRUCTION MANUAL

OPERATION

MAINTENANCE

OVERHAUL

INSTALLATION

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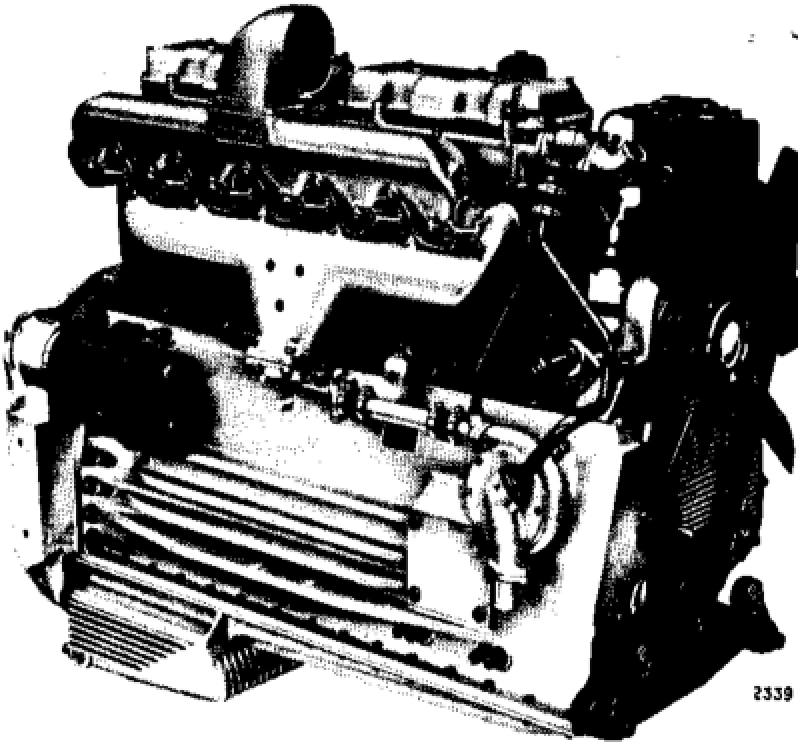

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	Frank Tucker (Commercials) Ltd., 91 Fore Street, Heavitree, Exeter EX1 2RN	55491-77333	—	—	42870
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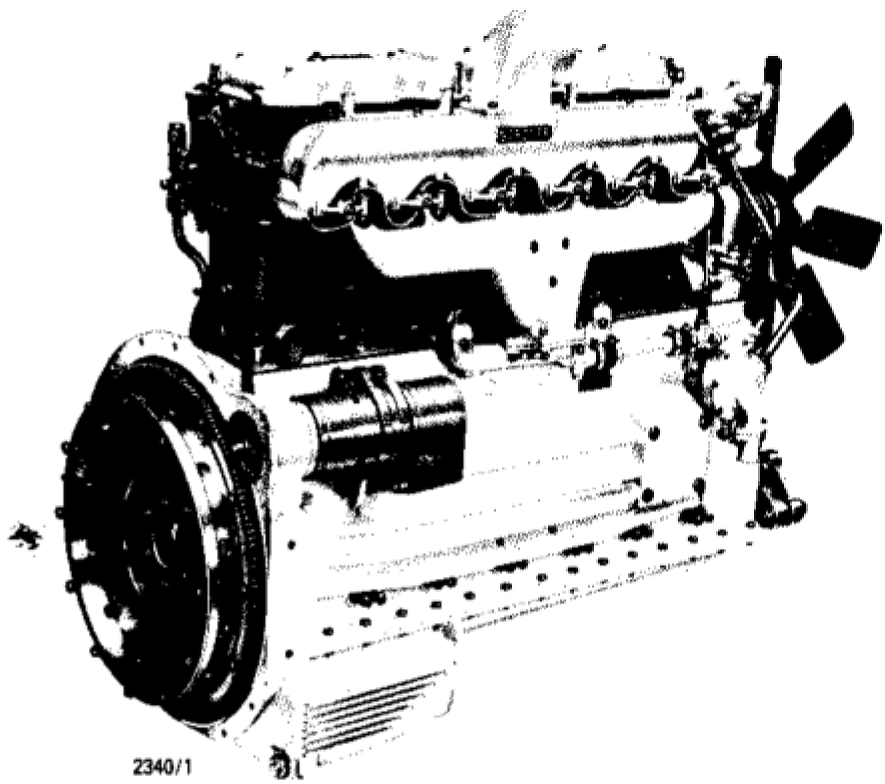

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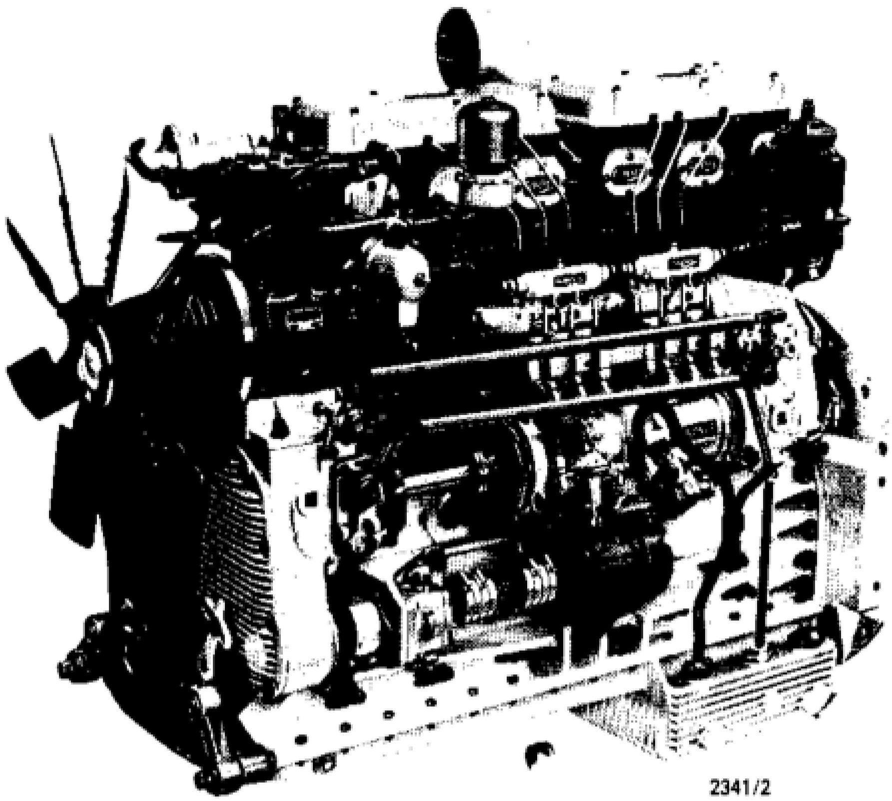

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6LXB AUTOMOTIVE DIESEL ENGINE

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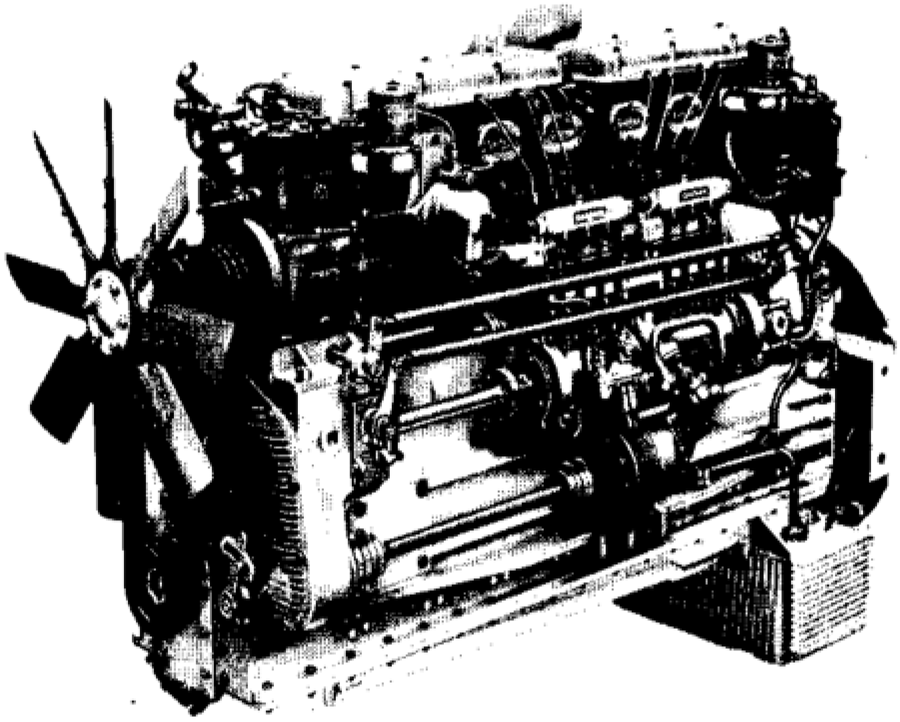
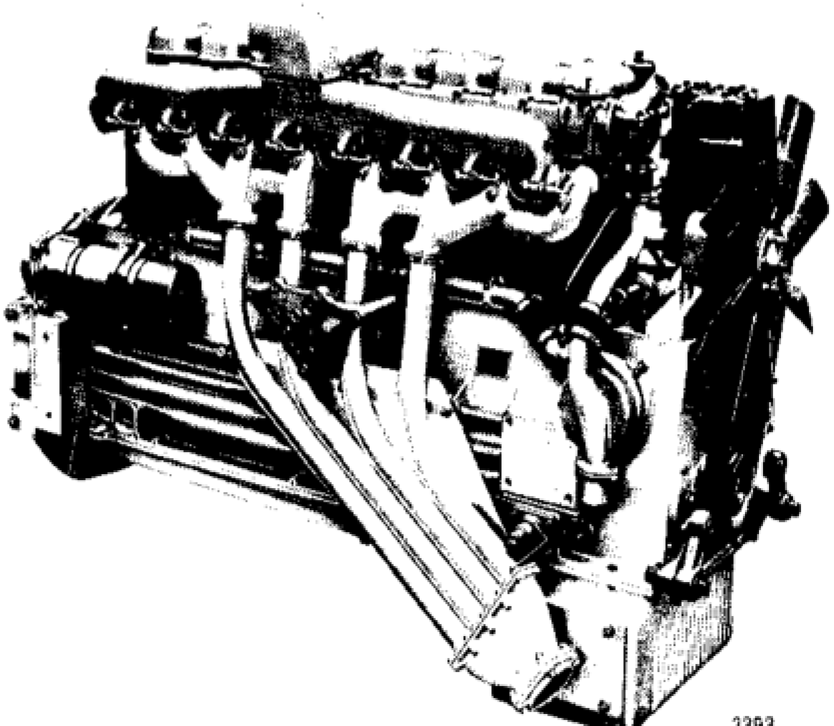


2381/2 **Rear Sump-Well Arrangement**



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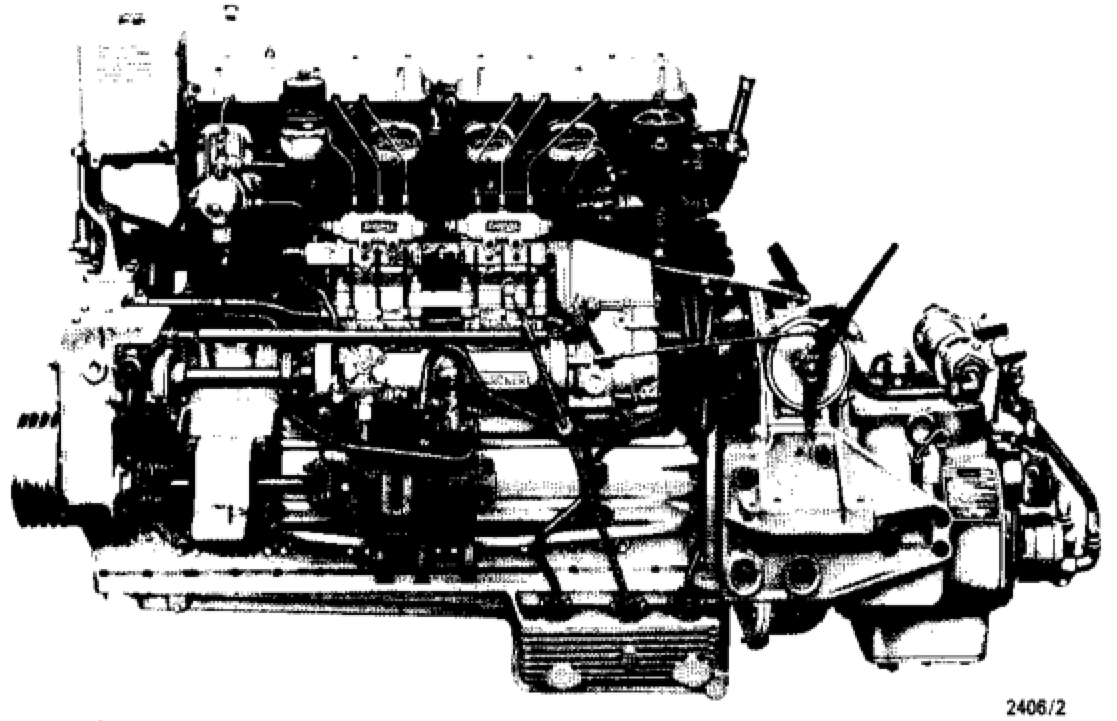
Forward Sump-Well Arrangement

8LXB AUTOMOTIVE DIESEL ENGINE



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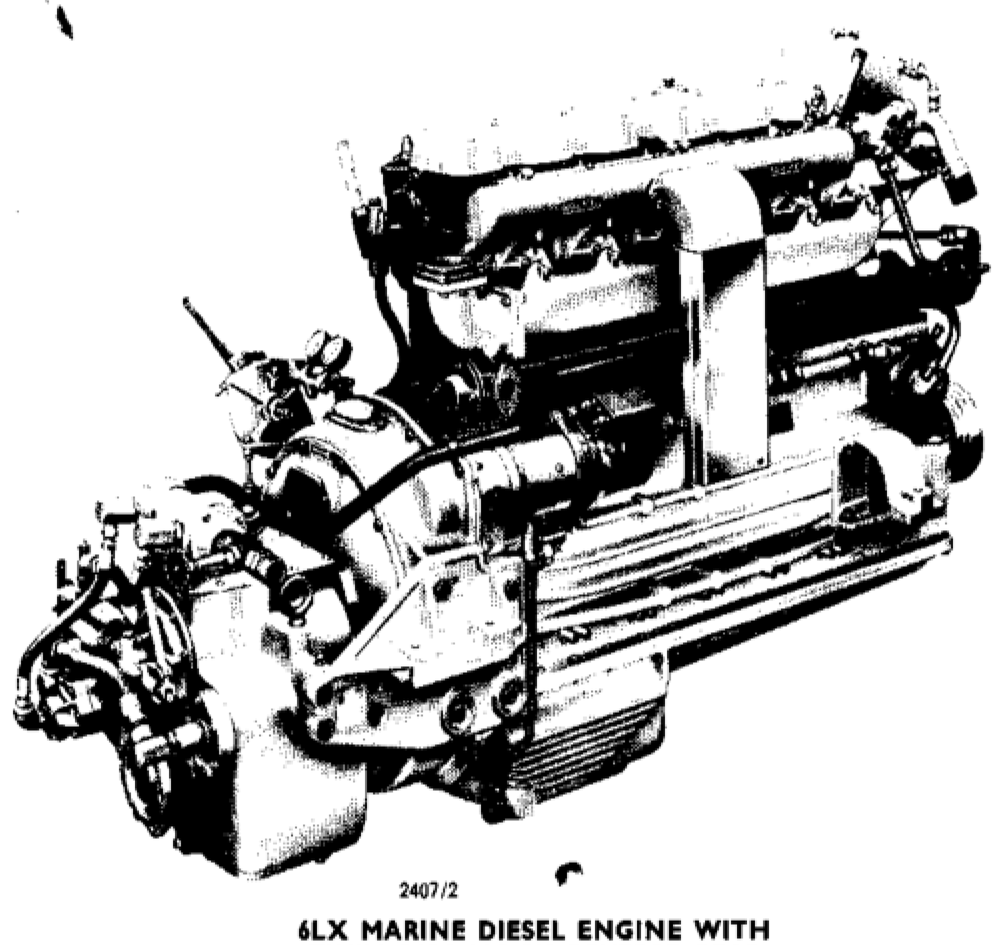

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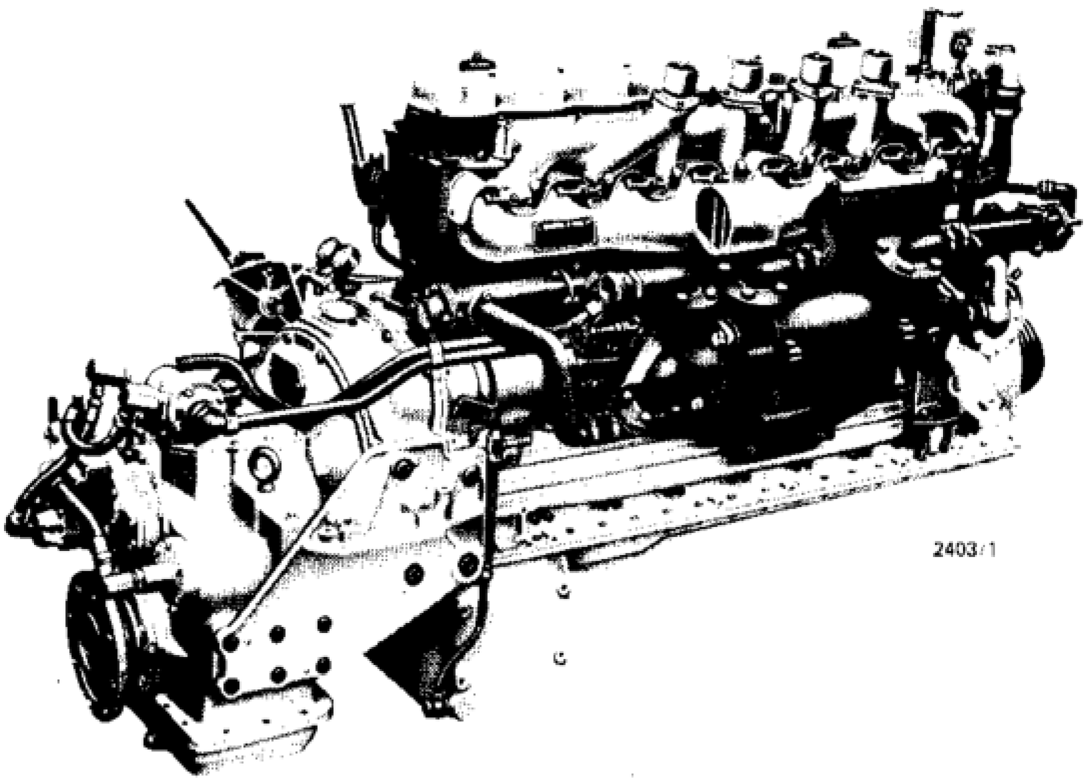
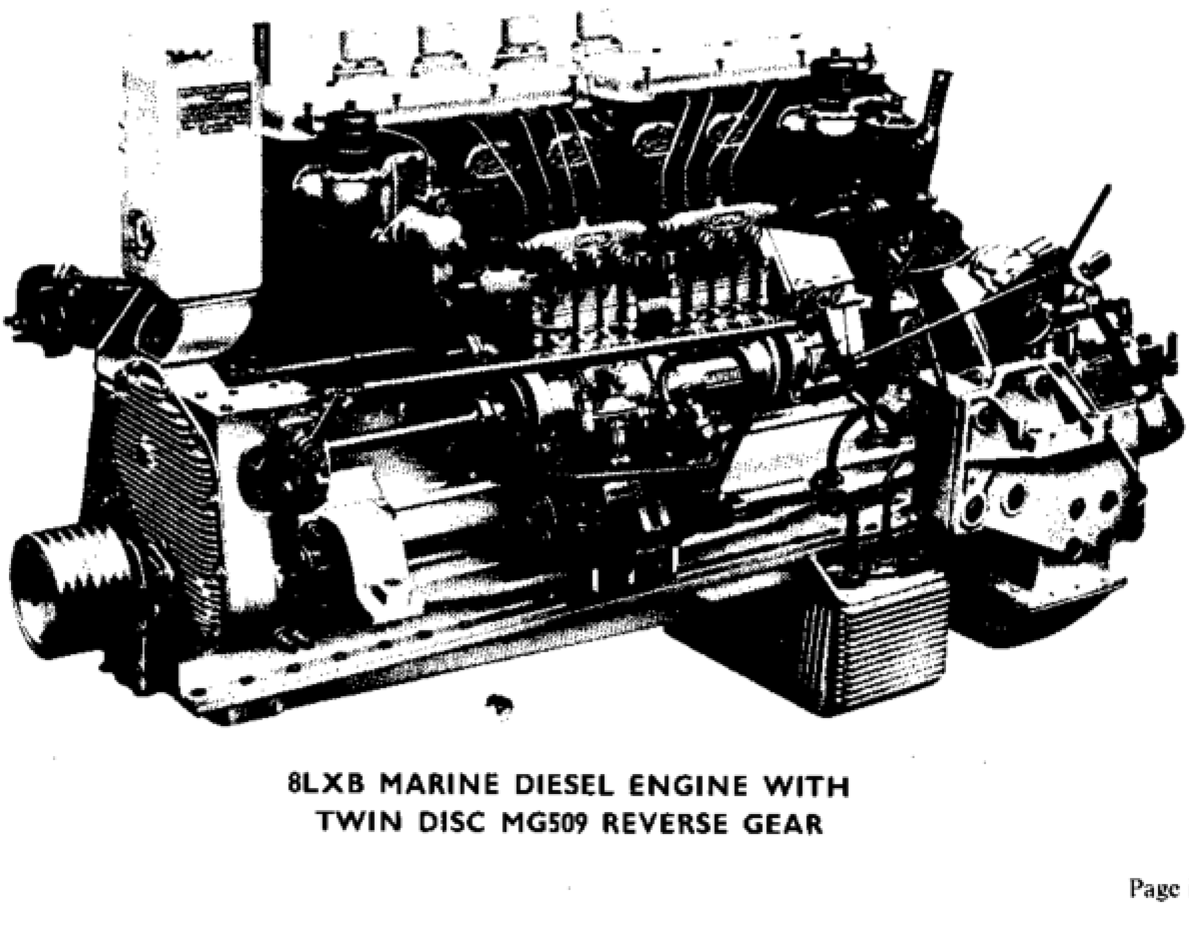
6LX MARINE DIESEL ENGINE WITH TWIN DISC MG 509 REVERSE GEAR





8LXB MARINE DIESEL ENGINE WITH TWIN DISC MG509 REVERSE GEAR

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FOREWORD

The Data contained in this Manual is based upon experience and has been compiled in an endeavour to facilitate efficient and durable operation of our engines in widely differing fields of application.

It will be readily understood that, due to continuing development and subsequent modifications, the illustrations contained herein may not in all instances depict precisely the arrangement embodied on the engine being serviced.

The Manual is divided into four Sections, the contents of which are based upon the following procedures:—

1. Operation **2. Maintenance** **3. Overhaul** **4. Installation**

The instructions contained within each Section are arranged under main subject headings and sub-divided into numbered paragraphs for reference purposes. In general the instructions apply to all engines except where the engine type or types are specified.

Should further information be desired concerning overhaul of the various engines and their component parts reference should be made to the Workshop Tools, Equipment and Instructional Drawings Book No. 63 and to the Gardner Fuel Pump Calibrating Machine Instruction Book No. 45.5 or later issues, copies of which can be supplied at a small charge.

In some instances the data contained herein may prove inadequate and in this event it is our wish that we be given the opportunity of offering our services and advice.

Production of 6LX and 6HLX engines has been discontinued but information on both engines is included in this manual to facilitate servicing and the fitting of replacement parts.

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CONTENTS

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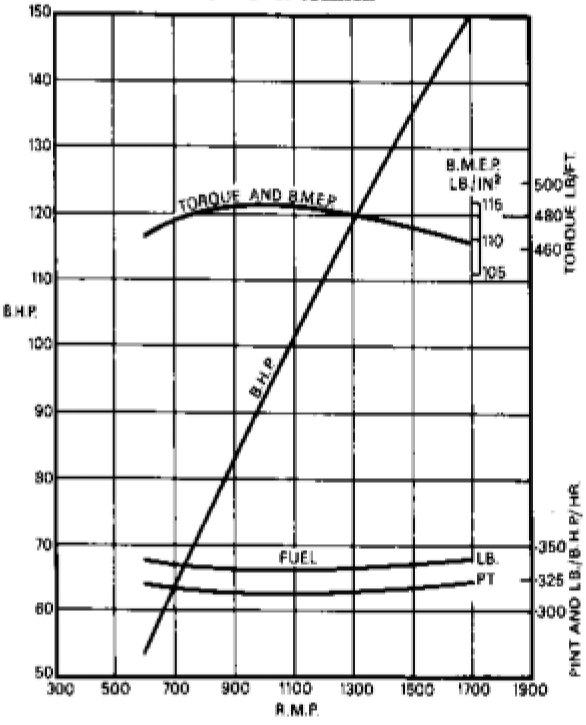
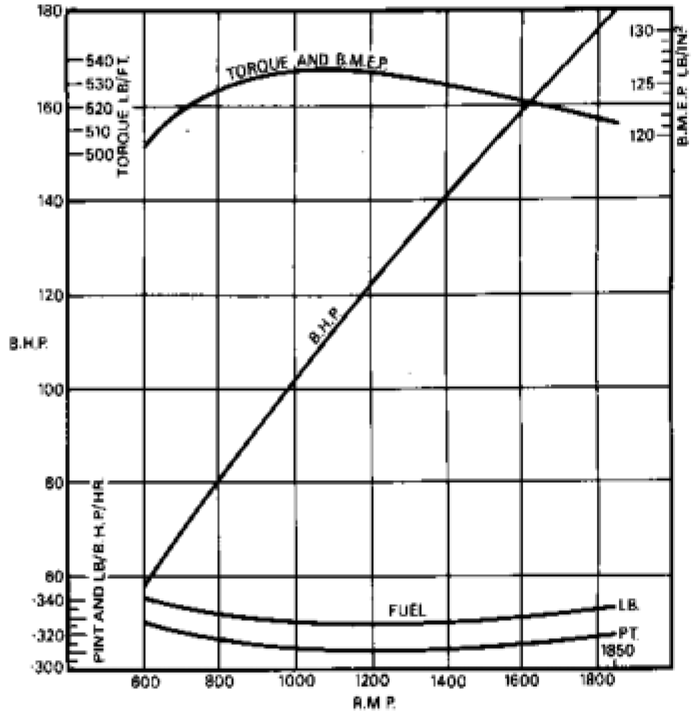
PERFORMANCE CURVES

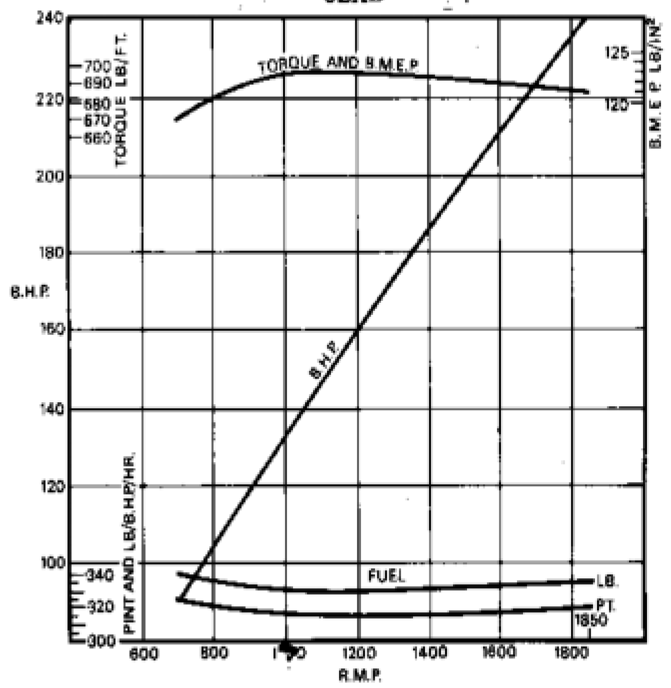
6LXB & 6HLXB



6LX & 6HLX



8LXB



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The above are the Performance Curves of the engines as set for Automotive Duty. They are the net values obtained without cooling fan, electrical generator, air compressor, hydraulic steering pump, etc.

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ENGINE DATA

6LX, 6HLX, 6LXB, 6HLXB, 8LXB

	6LX & 6HLX	6LXB & 6HLXB	8LXB
Bore	4¾ in. (120·65 mm.)	4¾ in. (120·65 mm.)	4¾ in. (120·65 mm.)
Stroke	6 in. (152·40 mm.)	6 in. (152·40 mm.)	6 in. (152·40 mm.)
Swept Volume	638 in.^{3} (10·45 litres)	638 in.^{3} (10·45 litres)	851 in.^{3} (13·93 litres)
Firing Order	1, 5, 3, 6, 2, 4.	1, 5, 3, 6, 2, 4.	1, 5, 2, 6, 8, 4, 7, 3.
Crankshaft Rotation (Standard) ..	Anti-clockwise viewed from flywheel end.		
B.H.P.	See Engine Rating Tables: Page xii.		
B.M.E.P.	See Fuel Pump Calibrating Tables: Page 78.		

LUBRICATION SYSTEM

Oil Pressure	35 lb./in.^{2} (2·5 kg./cm.^{2})	35 lb./in.^{2} (2·5 kg./cm.^{2})	32lb./in.^{2} (2·25 kg./cm.^{2})
Oil Temperature	140°F. (60°C.)	140°F. (60°C.)	140°F. (60°C.)
Oil Sump Capacities	See Page 22.		
Lubricating Oil Specifications ..	See Recommendations on Pages 6 and 7.		

FUEL FEED SYSTEM

Fuel Lift Pump Pressure	1·5 lb./in.^{2} (0·105 kg./cm.^{2})	1·5 lb./in.^{2} (0·105 kg./cm^2.)	1·5 lb./in.^{2} (0·105 kg./cm.^{2})
Fuel Oil Specification	See Recommendations on Pages 8 and 9.		

COOLING SYSTEM

Coolant Temperature (Outlet) ..	142°F. (61°C.)	142°F. (61°C.)	142°F. (61°C.)
Thermostat Opening Temperatures	See Engine Cooling Recommendations: Page 9.		
Radiator Hoses:			
Minimum Bore size	1·5 in. (38·1 mm).	1·5 in. (38·1 mm.)	1·75 in. (44·5 mm.)
Radiator Fan (All Engines)			
Distance from element tubes ..	1·75 in. (44·5 mm.)		
Cowling diametral clearance ..	Fan diameter plus 1·5 in. (38·1 mm.)		

AIR INDUCTION SYSTEM

Air Filters:			
Maximum Intake Depression ..	Not to exceed 12 in. (305 mm.) water gauge.		
Air Inlet Hose:			
Maximum length	Not to exceed 12 ft. (3,660 mm.)		
Minimum bore diameter	4·25 in. (108 mm.)	5 in. (127 mm.)	5 in. (127 mm.)

EXHAUST SYSTEM

Silencers and Pipes:			
Minimum bore diameter	3·375 in. (85·725 mm.)	3·375 in. (85·725 mm.)	3·875 in. (98·425 [illegible]
Exhaust System back pressure ..	Not to exceed 12 in. (305 mm.) water gauge.		

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GENERAL DATA AND POWER OUTPUT

The powers quoted in the following tables are those developed under normal atmospheric temperature and barometric pressure, i.e., 60°F, 30·0 in. Hg. respectively. When an engine is to operate at high altitude, or under adverse climatic conditions, we observe the de-rating data detailed on pages 4 and 5.

Conditions of duty may also necessitate some amendment to the powers quoted and further information in this respect will be provided by the Works upon receipt of the relevant details.

AUTOMOTIVE ENGINE DATA

For Passenger and Freight Road Vehicles, Locomotives, Shunters and Railcars, etc.

Engine Type	B.H.P.	kW	R.P.M.	Maximum Torque			Weight (dry)	
				lb. ft.	Kg.m.	R.P.M.	lb.	Kg.
6LXB	180 (188)	134.23 (140.19)	1,850	536	74.12	1,000 to 1,100	1,560	707.6
6HLXB	180 (188)	134.23 (140.19)	1,850	536	74.12	1,000 to 1,100	1,707	774.3
8LXB	240 (250)	178.97 (186.43)	1,850	695	96.12	1,000 to 1,200	2,045	927.6

Note: Engine weights are approximate only and include flywheel and endplate but do not include electrical equipment. The powers quoted indicate crankshaft B.H.P. and gross outputs to B.S. AU 141(a) are shown ( ) B.H.P. & kW.
The Radiator fan absorbs approximately 2.7 B.H.P.

MARINE ENGINE DATA

For Yachts, Cruisers, Launches, Fishing Boats, Life Boats, Ferries, Tugs, Barges and all Heavy Duty Commercial Craft.

Engine Type	B.H.P.	R.P.M.	Approximate Weight (dry) complete as installed			
			Shallow Gearcase		Deep Gearcase	
			lb.	Kg.	lb.	Kg.
6LXB	127	1,500	2,796	1,268	2,950	1,338
8LXB	170	1,500	3,380	1,533	3,530	1,601

Note: Engine weights include Twin Disc Reverse Gear, oil coolers, electrical equipment, etc.

ENGINE RATINGS FOR INDUSTRIAL AND MARINE AUXILIARY DUTIES

Engine Type	Intermittent Load and Speed			Variable Load, Constant Speed			Constant Load, Constant Speed		
	Cranes, Stonecrushers, Trenchers, etc.			Generator Sets, Saw Mills, Compressors, etc.			Pumping Sets, etc.		
	B.H.P.	kW	R.P.M.	B.H.P.	kW	R.P.M.	B.H.P.	kW	R.P.M.
6LXB	180	134.23	1,850	127	94.70	1,500	120	89.48	1,500
8LXB	240	178.97	1,850	170	126.77	1,500	160	119.31	1,500

GARDNER

ENGINE DATA

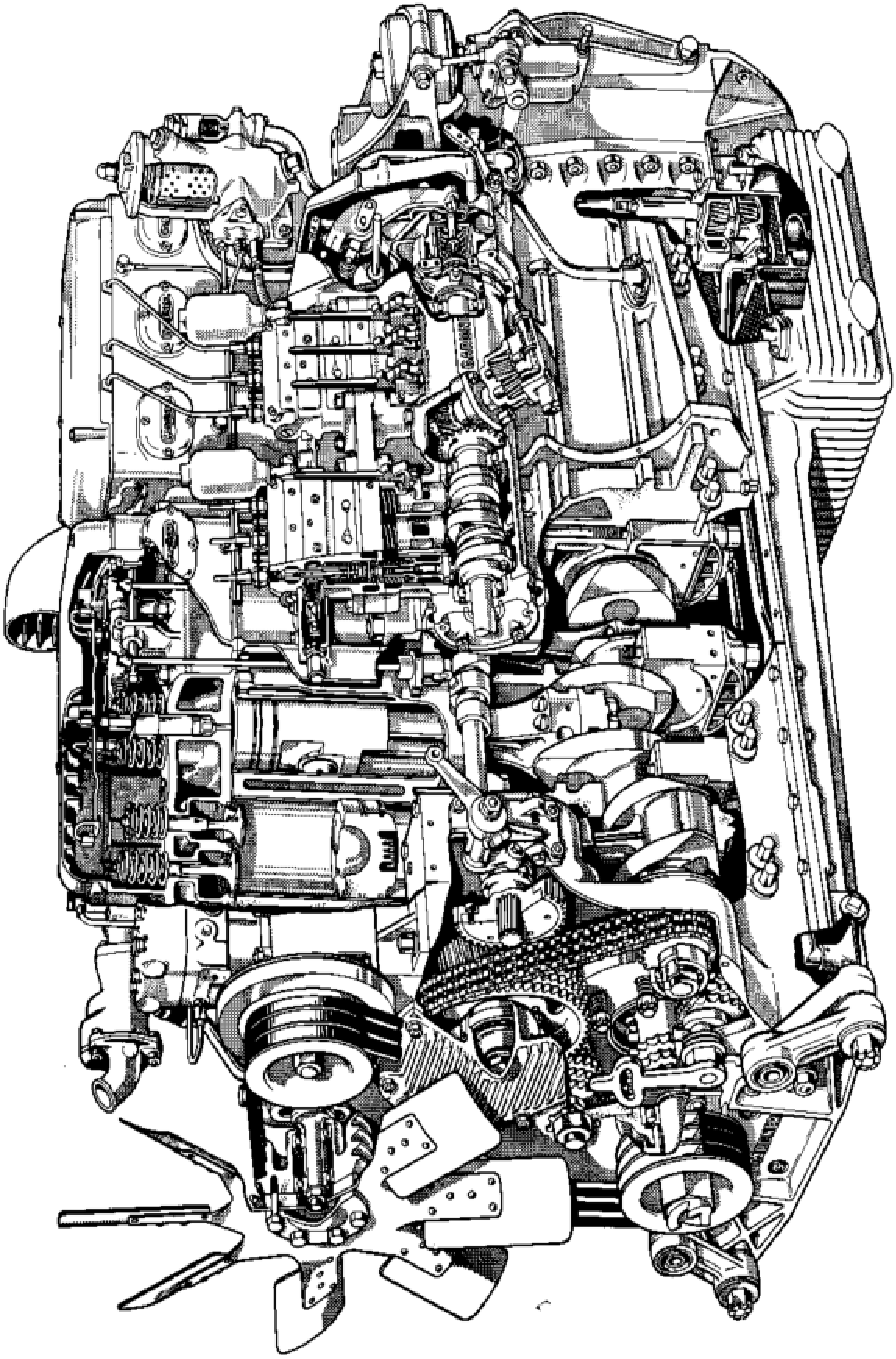
6LX, 6HLX, 6LXB, 6HLXB 8LXB

	6LX & 6HLX	6LXB & 6HLXB	8LXB
GOVERNOR			
Idling Speed Setting	420 r.p.m.	420 r.p.m.	420 r.p.m.
Maximum Governed No-load Speed	1,790 r.p.m.	1,980 r.p.m.	1,980 r.p.m.
Governor Spring Load at Maximum r.p.m.	107 lb. (48·5 Kg.)	130 lb. (58·9 Kg.)	130 lb. (58·9 Kg.)
FUEL INJECTION			
Fuel Injection Plunger Delivery	See Fuel Pump Calibrating Table: Page 78.		
Fuel Injection Timing: B.T.D.C.	30° at 1,700 r.p.m. 28·9° at 1,500 r.p.m.	31° at 1,850 r.p.m. 28·9° at 1,500 r.p.m.	32° at 1,850 r.p.m. 30° at 1,500 r.p.m.
Port Closing:			
Tappet Setting Disc Thickness	0·108 in. (2·743 mm.)	0·108 in. (2·743 mm.)	0·108 in. (2·743 mm.)
Sprayer Pipe Unions:			
Minimum bore size	0·069 in. (1·753 mm.)	0·069 in. (1·753 mm.)	0·069 in. (1·753 mm.)
Lift of Sprayer Valve	0·007 in. (0·178 mm.)	0·007 in. (0·178 mm.)	0·007 in. (0·178 mm.)
Spring Load on Sprayer Valve at working length of 1·007 in.	68·3 lb. (31·0 Kg)	68·3 lb. (31·0 Kg.)	68·3 lb. (31·0 Kg.)
Sprayer Valve: Hydraulic Opening Pressure	1,764 to 1,778 lb./in.² (124 to 125 kg./cm.²)	1,764 to 1,778 lb./in.² (124 to 125 kg./cm.²)	1,764 to 1,778 lb./in.² (124 to 125 kg./cm.²)
CYLINDER HEAD			
Cylinder Head to Piston Nominal clearance	0·029 in. (0·737 mm.)	0·032 in. (0·8128 mm.)	0·032 in. (0·8128 mm.)
VALVES AND VALVE TIMING			
Valve seat angle	45°	30°	30°
Valve Tappet Clearances (cold engine)			
Inlet	0·004 in. (0·102 mm.)	0·004 in. (0·102 mm.)	0·004 in. (0·102 mm.)
Exhaust	0·008 in. (0·203 mm.)	0·008 in. (0·203 mm.)	0·008 in. (0·203 mm.)
Timing Clearances:			
Inlet and Exhaust tappets (5B cams)	0·020 in. (0·508 mm.)	0·020 in. (0·508 mm.)	—
(5D cams.)	—	0·025 in. (0·635 mm.)	0·025 in. (0·635 mm.)
Valve Timing:			
Inlet valve opens	11° B.T.D.C.	16¼° B.T.D.C.	16¼° B.T.D.C.
Exhaust valve closes	11° A.T.D.C.	11¾° A.T.D.C.	11¾° A.T.D.C.

Note.—The above settings are with tappets adjusted to correct *timing clearances* and with timing chain *tight*.

Decompression:			
Lift of Inlet Valves	0·020 in. (0·508 mm.)	0·020 in. (0·508 mm.)	0·020 in. (0·508 mm.)

GARDNER



6LXB AUTOMOTIVE ENGINE

2188/5

INTRODUCTORY NOTES AND OPERATING INSTRUCTIONS

INDEX

INTRODUCTORY NOTES AND OPERATING INSTRUCTIONS

PACKING AND UNPACKING THE ENGINE

1. Before dispatch, all external unpainted parts of an engine are coated with a special preservative to prevent corrosion. On engines destined for delivery in the United Kingdom a clear preservative is used, whilst on engines packed for export this same base preservative carries blue dye. This coating is readily soluble in fuel oil or paraffin.

When unpacking, lay out all the loose parts in a suitable clean place, free from dust and grit and sheltered from the weather. These parts should be at once checked and identified by the Contents List, which is sent by post with the advice note of dispatch. In case these parts have to lie for any length of time before assembling them, it is not wise to remove the protective varnish or blanking caps.

If there is any work being carried on in the neighbourhood of the installation, it is advisable to keep the engine sheeted up as much as possible to retain the protective varnish until the last moment.

To remove the protective varnish, use clean, cotton cloths, soaked in paraffin (kerosene). Do not use cotton waste as it is rarely free from dust and particles of fluff. When assembling engines at the Works, we make free use of clean cloths and paraffin baths, and strongly recommend this practice when assembling on site. Take care that all oil holes and such places are thoroughly cleaned out before assembling and check that all joint faces and pipe connections are in good condition.

When returning unserviceable parts for exchange or repair ensure that the same parts are attached as those fitted to the replacement unit. This precaution will expedite dispatch of the exchange unit.

LIFTING THE ENGINE

2. **Vertical Engines.** Eye nuts are provided for screwing on to the cylinder head studs to form an attachment for lifting the complete engine. It will be observed that the appropriate cylinder head studs are extended beyond the normal nuts in order to receive the eye nuts. It is usual to remove the eye nuts after the engine is installed, and place them in the tool box. Protecting metal caps are provided to screw on the exposed portion of the stud on marine engines.

When lifting the engine the eye nuts must be screwed fully home *using the fingers only* and not tightened by means of a bar or lever. Past experience has shown that the practice of over-tightening the eye nuts in this manner may cause the cylinder head studs to become loosened or partially withdrawn when the eye nuts are ultimately removed.

Should the eye nuts require turning slightly in order to engage the sling hook *unscrew* the eye nut a portion of a turn but do not tighten further.

It is essential, when lifting the engine, that a spreader be used between the sling hooks in order to secure a straight pull on the lifting eye nuts. The apex of the sling must be mid-way between these points to maintain a level lift. Incorrect slinging or an unbalanced lift may cause bending of the studs due to sideways pull.

2.1. **Horizontal Engines.** The lifting arrangement on horizontal engines consists of a lifting eye on the front and rear cylinder head and one at each end of the crankcase to provide a four-point lift. These lifting eyes are not to be removed after installation.

When lifting the engine a spreader must be placed between each pair of sling hooks, i.e. one spreader between the two cylinder head eyes and the other between the two on the crankcase.

NOTE.—Engine weights will be found in the tabulated engine data on Page xii.

INTRODUCTORY NOTES AND OPERATING INSTRUCTIONS

GENERAL PRINCIPLES OF OPERATION

3. The complete working cycle of these engines requires four strokes of the piston, that is, two complete turns of the crankshaft. During the first stroke, a charge of air is drawn into the cylinder and is compressed during the second stroke. At or towards the end of this stroke, a charge of fuel is injected into the combustion space in the form of a spray which is at once ignited solely by the temperature of the compressed air charge. The resultant combustion causes a rise of pressure and a store of energy to be expended during the third stroke, or the power stroke. During the fourth and last stroke, the burned gases are expelled and this completes the cycle.

It is well known that when air is compressed, its temperature rises, and if the compression be high enough, the resultant temperature suffices to ignite readily the liquid fuel charge. This is the principle of the compression-ignition engine; to repeat, ignition is effected solely by the temperature of the compressed air charge, and this applies equally while the engine is running or while it is being started by hand when all is cold.

The injection of the fuel into the combustion chamber is effected by an injection pump, one to each cylinder, which forces the fuel through a sprayer situated at the summit of each combustion chamber. Each fuel charge is accurately measured by the injection pump, the amount of the charge being varied and controlled by the automatic governor to correspond with the load carried by the engine at any given moment.

HANDED ROTATION OF ENGINES

4. All current production vertical and horizontal engines rotate anti-clockwise, viewed from flywheel end.

The standard 6LX Marine Unit with Gardner No. 2UC Direct Drive Reversing Gear is a Starboard type engine with anti-clockwise rotation to suit a left-hand propeller or a right-hand propeller if fitted with the Gardner Reversing/Reducing Gear.

Current Marine Engines designed for use with the Twin Disc Reversing Gear are unidirectional, having anti-clockwise rotation, and in twin screw installations the Reverse Gear of the twin engine is arranged to provide opposite hand rotation of propellers.

ENGINE PERFORMANCE AT HIGH ALTITUDE AND HIGH ATMOSPHERIC TEMPERATURE

5. As is well known, the density of air is lower at both high altitude and high temperature and, since a given amount of fuel requires a given amount of air for its combustion, it is necessary that the injected fuel supply to an engine operating under conditions of lower air density be restricted to a value satisfactory for combustion and operation with a smokeless exhaust.

The powers quoted in the table on Page xii and shown on the graph Page xiii, are known as the 100% rating, and are those developed with a satisfactory fuel/air ratio under conditions of normal temperature and pressure. These conditions, namely, a barometric pressure of 30 in. Hg (762 mm. Hg), and an atmospheric temperature of 55°F. (13°C.) normally obtain at the manufacturers' Works at Patricroft, Lancashire.

Conditions of reduced air density encountered both as a result of high altitude and high atmospheric temperature, each separately have an effect on engine performance such that for every 1,000 feet (304·8 m.) altitude and each 10°F. increase over sea level and 55°F. (13°C.) mean annual temperature respectively, it is appropriate to reduce the fuel supply 2%.

EXAMPLE.—Given that an engine has to operate at 2,000 feet (609·6 m.) altitude with a mean annual atmospheric temperature of 75°F. (24°C.), from the graph, Page 5, we read the following reductions:

For altitude ..	4%	
For temperature ..	4%	
Combined Reduction	8%	or 0·92 normal temperature and pressure rating fuel supply.

When it is intended that an engine shall operate permanently at 1,000 feet (304·8 m.) altitude or 65°F. (18½°C.) mean annual ambient temperature, or in excess of either of these figures, it is necessary that the length of the fuel pump output control trigger be increased (see Page 79) in order to reduce the injected fuel supply appropriately, according to altitude and temperature shown on the graph on Page 5.

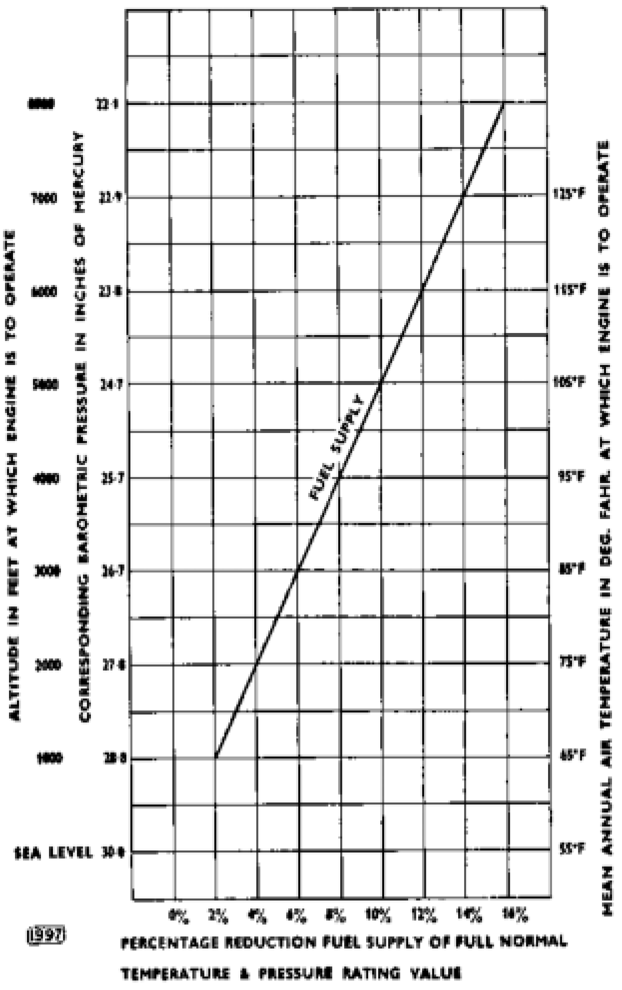
When site operating conditions are known, new engines are appropriately set during test at the maker's Works, and the setting is clearly stamped on the fuel pump rating plate. When, however, it is necessary to adjust spare or reconditioned fuel pumps, the work can be accomplished only by use of the Gardner Fuel Pump Calibrating Machine and by referring to the Gardner Fuel Injection Pump Calibrating Machine Instruction Book 45.4 or later issue. On Page 78 will be found the average delivery from each plunger in cubic centimetres and the values quoted are to be reduced according to the graph on Page 5.

On Page 5 will also be found a graph showing the approximate reduction in B.H.P. when the fuel supply is reduced under altitude and temperature conditions.

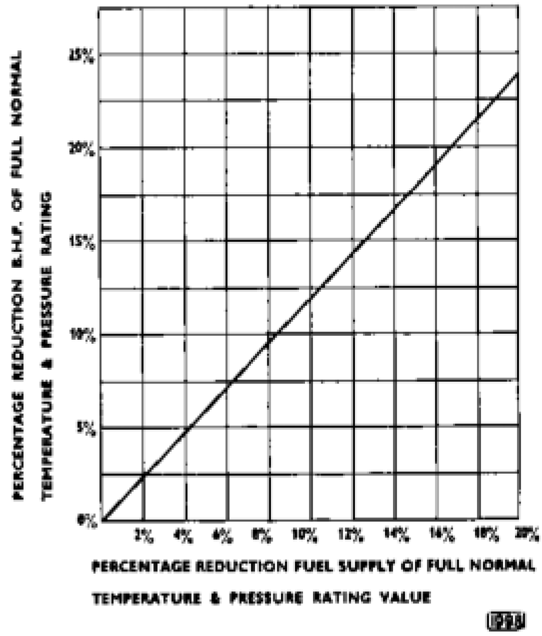
EXAMPLE.—Combined reduction fuel supply 10%
Reduction B.H.P. of full N.T.P. rating.. .. .. .. 12%

INTRODUCTORY NOTES AND OPERATING INSTRUCTIONS

ALTITUDE AND TEMPERATURE DIAGRAMS



Reduction in fuel supply for altitude and temperature conditions



Reduction in B.H.P. when fuel supply reduced under altitude and temperature conditions

LUBRICATING OIL SPECIFICATIONS

6. **LUBRICATING OIL.** The importance of using high quality lubricating oil and the draining and refilling of the engine oil sump at the recommended intervals cannot be over emphasized. These factors play a most important role in maintaining an engine in good and efficient condition and ensure a long engine life between overhauls.

Most oils available today are of the additive type; that is to say they all contain, to some degree, certain additives which ensure a minimum of deposits on internal parts of the engine and go a long way to combat the evils of sulphur present in varying amounts in almost all fuel oils. They also possess many other desirable properties.

These additive type lubricants are produced in compliance with various specification standards which are listed below in approximately descending order of additive level and, therefore, performance ability.

(1) Series 3 MIL-L-45199A

(2) Series 2

(3) ESE-M2C-101B

(4) MIL-L-2104B

(5) DEF-2101-D
2-104B Supplement 1

(6) MIL-L-2104A
DEF-2101-C

Of the above specifications the following are officially obsolete, but are still recognised by many oil companies.

Series 2

2-104B Supplement 1

MIL-L-2104A

DEF-2101-C

The higher the duty an engine is called upon to perform and/or the higher the sulphur content of the fuel oil the more desirable it becomes to use the best quality oil available.

Even when high quality oil is in use, we recommend that the sump is drained and refilled every 4,000 miles (400 hours) and more frequently if the engine operates in a dust laden atmosphere (some overseas territories, mines, quarries, etc.) and/or when using fuel of high sulphur content, say 0·5% and over.

LUBRICATING OIL SPECIFICATIONS—*continued*

7. **RECOMMENDED VISCOSITY.** As a general rule a lower viscosity lubricant should be used during cold weather, or in cold climates, than is used during hot weather or in hot climates.

The following tables show our recommendations for this purpose based on the mean ambient temperature prevailing during the operation of the engine.

VISCOSITY REDWOOD No. 1

Specification KW.
10° to 30°F. (-12° to -1°C.)
e.g., British Isles
Dec., Jan., Feb., Severe Winter

Temp. °F.		
70	Not exceeding	780 sec.
100	„ „	300 „
140	Not less than	112 „
200	„ „ „	52 „

Cold Test—Not Higher than 5°F. (-15°C.)

Specification BW.
30° to 55°F. (-1° to +13°C.)
e.g., British Isles
March, April, May, Oct., Nov.,
and
Dec., Jan., Feb., Normal Winter

Temp. °F.		
70	Not exceeding	1,250 sec.
100	„ „	420 „
140	Not less than	120 „
200	„ „ „	54 „

Cold Test—Not higher than 5°F. (-15°C.)

Specification BS.
55° to 90°F. (13° to 32°C.)
e.g., British Isles
June, July, Aug., Sept.

Temp. °F.		
70	Not exceeding	1,600 sec.
100	„ „	600 „
140	Not less than	160 „
200	„ „ „	64 „

Specification BT.
Over 90°F. (32°C.)

Temp. °F.		
70	Not exceeding	2,500 sec.
100	„ „	800 „
140	Not less than	220 „
200	„ „ „	74 „

NOTE 1—The Works will be pleased to advise in any case where operating conditions are particularly arduous or where temperature conditions are not covered by the above table, as for instance severe tropical and arctic conditions where oils heavier and lighter respectively than those quoted above should be used.

The use of ultra low viscosity lubricating oil is emphatically not recommended and indeed, we cannot accept responsibility for premature wear and failure of parts in an engine which has been operated on such oils. The only departure from the above tables which could be approved would be the use of oil to Specification KW in a public service vehicle engaged on a stage carriage service, provided the ambient temperature is not in excess of 70°F. (21°C.) **and provided that the vehicle does not have a transversely mounted engine at the rear.**

NOTE 2—Nowadays it is common practice to refer to S.A.E. numbers when considering the viscosity characteristics of an oil. Each S.A.E. number permits of a wide range of viscosity, however, the following is an approximate guide to the appropriate grades of oil for varying ambient temperature conditions.

Over 90°F. (32°C.)	S.A.E. 40
35°F. to 90°F. (2°C. to 32°C.)	S.A.E. 30
Below 35°F. (2°C.)	S.A.E. 20

FUEL OIL SPECIFICATIONS

8. **FUEL OIL.** The following is a laboratory specification of a typical example of the type of Fuel Oil which should be used in these engines. Whilst a selected fuel may conform to these figures, before it is finally approved it should if possible be the subject of an actual trial in an engine.

Any fuel for this purpose should be wholly distillate.

Specific Gravity at 60°F. (15·6°C.)	not exceeding	·845
Initial Boiling Point	not less than	356°F. (180°C.)
Distillation Test	not less than 90% at	675°F. (357°C.)
Flash point (Pensky-Martin)*	not less than	150°F. (65·6°C.)
Viscosity:		
Redwood No. 1 at 100°F. (37·8°C.)	not exceeding	40 secs.
Kinematic at 100°F. (37·8°C.)	not exceeding	5·5 cs.
Sulphur	not exceeding	0·4%
Cloud Point:		
Winter or say below 35°F. (1·7°C.)	not exceeding	14°F (–10·0°C.)
Summer	not exceeding	28°F. (–2·2°C.)
Ash	not exceeding	0·01%
Water		To be free from visible water
Calorific Value Btu/lb.		about 19,400 (10,800 kcal/kg)

*Local regulations may stipulate a higher Flash Point.

9. **IGNITION QUALITY.** A good quality fuel may have a Cetane value as high as 57, it is desirable that the Cetane value of the fuel approaches this figure and should not in any case fall below 52. Another unit in use is the Diesel Index Number which is usually several points higher than the Cetane number for any given fuel. The above figures quoted as Diesel Index numbers are:

Cetane 57	Diesel Index 62
Cetane 52	Diesel Index 56

10. **IGNITION QUALITY IMPROVER ADDITIVE.** Broadly speaking the best fuel is one having the minimum sulphur content and possessing the highest ignition quality. Fuels having a low sulphur content are usually of poor ignition quality.

It is established that the cylinder bore wear rate of engines with fuel containing less than 0·1% sulphur may be less than half that obtaining when the fuel contains 0·5% sulphur.

High ignition quality promotes quiet and smooth operation, durability and low maintenance, together with startability and smokeless cold running.

Fuel additive isopropyl nitrate marketed by Messrs. Imperial Chemical Industries Limited may be added to average fuels securing the following approximate Cetane Number Gain.

Addition	*Cetane Gain*
0·25% by volume	5–7 units
0·50% by volume	9–11 units
0·75% by volume	13–15 units
1·0% by volume	16–20 units

The gain in cetane number will vary with the source and quality of the fuel used but would be expected to fall within the above limits.

When using isopropyl nitrate observe manufacturer's recommended precautions with regard to storage, inflamability, handling, etc., of this product.

FUEL OIL SPECIFICATIONS—*continued*

11. **LUBRICATING OIL ADDITIONS TO FUEL.** It is permissible that a small quantity of lubricating oil, up to a maximum of 1% be added to the fuel. If paraffin is used as a fuel, this addition of lubricating oil is desirable. Used sump oil may be employed, disposing of it usefully in this way. It must be allowed to stand for a few days so that carbon and solid matter may settle, the oil then being drawn from near the top of the container. Periodically the container must be drained, to remove the accumulating sediment. Alternatively, the used oil may be cleaned by filtering or centrifuging. Whichever method is employed, cleanliness is essential.

NOTE.—Special attention is called to the fact that in certain countries, including the United Kingdom, it is an offence to use as fuel, hydro-carbon oils that have been rebated. Such rebated oils include lubricating oil, spindle oil and paraffin. Where any such use is contemplated, payment of the full duty will be required and if in any doubt the Local Customs and Excise Officer should be contacted.

ENGINE COOLING RECOMMENDATIONS

12. **COOLANT TEMPERATURES.** It is recommended that the temperature of the outlet from the engine be not allowed to exceed 175°F. (80°C.) and that in most cases a satisfactory operating temperature is 140°F. to 160°F. (60°C. to 71°C.). Engines used for Rail Traction duty and heavy duty vehicles should be operated at lower temperatures.

Generally, the higher the duty which an engine is called upon to perform the lower should be the temperature to which the water is controlled and arrangements made to achieve this end. Conversely, the water temperature of a short haul road vehicle or shunting locomotive, etc., should be maintained at a higher figure.

13. **TEMPERATURE CONTROL.** It is not normally necessary to fit shutters or blanking plates to the radiator under conditions of extreme cold providing an anti-freeze agent is added to the coolant in sufficient quantity, since the thermostatically controlled valve or valves, incorporated in the circulation system, will automatically govern the engine temperature to a suitable figure (provided the radiator pipes and bonnet ventilation, etc., are adequate), but under light duty and cold weather conditions, thermostatically controlled radiator shutters can be useful to enable the engine to attain optimum working temperature. Such shutters should be arranged to commence to open when the outlet water from the engine attains 140°F. (60°C.).

A suitable tapped boss is provided in the water outlet pipe to receive the bulb of the usual automotive type thermometer.

In general the application of these thermostat units according to engine duty and climatic conditions is as follows:—

Engine Duty or Application	Climatic Conditions	Thermostat Code Numbers	
		6LX & 6HLX 6LXB & 6HLXB	8LXB (2 per engine)
Passenger Carrying Road Vehicles, Locomotives, Earth Moving Equipment, Mobile Shovels, Cranes and Short Haul Road Vehicles.	Temperate	16/1–262–74 with 01–3502–82	16/1–262–74
	Sub-tropical or tropical	16/1–262–60 with 01–3502–82	16/1–262–60
Goods Carrying Road Vehicle, Rail Cars, Marine Propulsion and Auxiliary Units, Industrial and Electrical Generating Sets, Portable Welding and Compressor Sets.	All Climatic Conditions	16/1–262–60 with 01–3502–82	16/1–262–60

ENGINE COOLING RECOMMENDATIONS—*continued*

It is common practice on passenger vehicles to divert some of the engine cooling water through heaters in the saloon(s), but this is not always satisfactory, principally on account of the overall relatively low waste heat passed to the water from a Diesel engine and also the relatively low temperature of the coolant. Furthermore, it is always possible for the heaters to run almost cold whilst the engine is running slowly. As soon as the engine is accelerated to high speed all this cold water from the heating system is forced into the cylinder jackets. This "quenching" effect can be a source of danger to a hot engine. Furthermore the volume of water contained in such heater systems can delay the engine "warming up" process. All these difficulties can be overcome by the various proprietary makes of heating units which do not rely upon the engine for their source of heat or circulation.

14. **OPERATING UNDER CONDITIONS OF EXTREME COLD.** It is necessary that a reputable anti-freeze solution, containing a corrosion inhibitor, is added to the cooling water to prevent freezing and reduce internal corrosion. Radiators and water pipes can become frozen with consequent serious damage even when the engine is driving a vehicle on the road under very low temperature conditions.

Use only Ethanediol Anti-freeze conforming to British Standard Specification BS.3151—1959

To be safe down to + 15°F. (- 9°C.) add 20% (by volume) Anti-freeze.
To be safe down to - 3°F. (- 19°C.) add 33% (by volume) Anti-freeze.
To be safe down to - 14°F. (- 26°C.) add 40% (by volume) Anti-freeze.

To maintain the desired degree of frost and corrosion protection it is necessary to use the appropriate strength of solution (not plain water) for "topping-up" purposes.

If anti-freeze is used throughout the year it is desirable to drain and flush the system every six months—one period preferably coinciding with the onset of winter—and refill with the correct solution. In this way the internal corrosion will be largely prevented.

Do not mix one anti-freeze formulation with another.

15. **OPERATING UNDER CONDITIONS OF EXTREME COLD WHEN AN ANTI-FREEZE AGENT IS NOT AVAILABLE.** Under these conditions the risk of freezing the radiator, whilst the engine is running, may be greatly minimized by causing all the water circulation to pass through the radiator by removing the thermostat unit from its housing, and plugging with cork bung or blank packing the by-pass pipe between the housing and the water pump suction. In addition, and in order to further reduce the risk of freezing, and to enable the engine to attain a suitable operating temperature, blank off from the bottom upwards 50% or more of the radiator frontal area, until a temperature of 140°F. to 160°F. is attained in service. When a vehicle has to stand idle for any period sufficiently long for the radiator tubes to approach freezing point, drain away the water from the system as soon as possible after stopping the engine and leave all cocks open until the system is to be refilled. Hang suitable label on the radiator or take other precautions to ensure that the vehicle is not inadvertently put in service with a dry system. When filling the system preparatory to service, use hot water, since the combination of cold water and engine and radiator parts below freezing point may generate ice before the heat generated by running the engine is sufficient to prevent this.

16. **COOLING SYSTEM CORROSION INHIBITOR.** If anti-freeze as mentioned above is not used, it is essential to introduce one of the many effective corrosion inhibitors into the cooling water. By this means internal corrosion of engine water jackets, heat exchangers, radiators or marine keel coolers is greatly reduced.

In the absence of a corrosion inhibitor the resulting silt and scale interferes with the designed coolant flow provisions and in so doing reduces operational efficiency of the engine and introduces damaging heat strains in the casting.

The importance, therefore, of using a suitable corrosion inhibitor cannot be over emphasized.

Certain corrosion inhibitors are available in crystal form for the charging of dispensers, through which sea cooling water can be drawn, and so reduce the corrosion usually associated with "open" sea water cooling systems.

ENGINE COOLING RECOMMENDATIONS—*continued*

When "topping-up" a radiator or other "closed" system it is desirable to use the appropriate strength of solution (not plain water). Every six months cooling systems should be drained, flushed out with clean water and refilled with a new solution of water and corrosion inhibitor. This is desirable because after long use the corrosion inhibitor ceases to be effective. **Corrosion inhibitors of differing formulation should not be mixed.**

Many Oil Companies and Chemical Manufacturers market suitable inhibitors.

STARTING AND STOPPING THE ENGINE

17. **DECOMPRESSION GEAR.** The essential feature of these engines is that starting may be effected by a hand cranking handle when equipped with suitable flywheel. Hand starting may be utilised for all LX & LXB engines, electric starters are supplied when so ordered. As already explained, ignition of the fuel charge is effected solely by the temperature of compression, therefore all extraneous devices such as pre-heating, cartridges, electric plugs and such like, for starting from cold, are entirely dispensed with. Having regard to the high degree of compression necessary in engines of the compression-ignition type, starting by hand is quite an achievement and is greatly facilitated by the decompressing device fitted to each cylinder head. The relief of compression on all cylinders enabling the engine to be freely rotated is also a great help when carrying out routine service checks and adjustments.

When the engine is started by hand the levers are set in the upright position and must be returned to the horizontal position as soon as the engine commences running.

When starting the engine by electric starter motor the decompression levers must be in the horizontal position.

18. **PREPARATIONS FOR STARTING.** Before starting the engine it is first of all essential to check the level of the oil in the sump and to ensure that the radiator or cooling system is filled to maximum capacity as mentioned in detail under the headings Lubrication System and Cooling System in Section 2.

This routine should be followed Daily as indicated in the Maintenance Schedule on page 18.

It is necessary in a new installation and desirable after dismantling the pipework of the fuel system for any reason, to allow a copious amount of fuel to wash through the pipes in order to clear them of foreign matter and rid the system of air.

For systems incorporating the Amal Fuel Lift Pump and Gardner Overflow Return, it is also necessary to carry out the following priming operations before starting an engine which has not previously been in service, i.e. a new engine.

19. **PRIMING THE FUEL SYSTEM**

Step No.1. Rotate the engine by hand until the full stroke of the Amal Fuel Lift Pump diaphragm can be felt when operating the hand lever.

Step No. 2. Remove the vent plugs from the tops of the fuel volume chambers mounted on the front of the injection pumps. Operate the hand lever on the fuel lift pump until both chambers are fully charged with fuel. Replace the vent plugs and tighten securely.

Where fuel volume chambers are not fitted, release the vent screws fitted at the top of each block of pumps. Operate the fuel lift pump lever until a flush of air-free fuel emerges from the vent screws. Re-tighten the vent screws and continue to operate the hand lever of the fuel lift pump until a very much reduced resistance is felt. This will indicate that the system is fully primed up to the elements of the fuel injection pumps.

Note.—It may be necessary to again release the vent screws while the engine is running in order to liberate further air from the fuel.

Step No. 3. Work each injection pump charging lever until the elastic feeling, if any, has vanished, that is until a "solid feel" is obtained. This completes the operation of priming.

The object of Step No. 3 is to remove air from the sprayer pipes by forcing the imprisoned air through the

STARTING AND STOPPING THE ENGINE—*continued*

sprayer into the cylinder. When the last vestige of air has been discharged the "feel" of the lever suddenly becomes "solid". As soon as the "solid" feeling is obtained it is important to immediately cease working the charging levers, otherwise a harmful amount of fuel is liable to be injected into the cylinder.

Caution.—Do not inject more fuel into the cylinders by means of the charging levers than is necessary for sprayer testing purposes, or for the purpose of "easing" a stiff cold engine.

20. **STARTING FUEL PLUNGER.** This device is only used when starting an engine from cold, refer to paragraphs 37 and 38 on page 35. When pressed up by hand or actuated by means of the tool operated excess fuel device it releases the fuel pump slider bar and allows the bar to move to the "cold start" or excess fuel position.

It must not be held up by hand. It goes out of action automatically as soon as the engine begins to work.

On no account must this device be used for any other purpose than starting, e.g. it must not be used in order to give the engine extra fuel while running.

21. **HAND STARTING (COLD ENGINE) UNDER NORMAL TEMPERATURE CONDITIONS.** (This operation may require assistance for the driver.)

(1) Set the engine stopping lever to the running position.
(2) Open very slightly hand speed control if fitted.
(3) Press up the starting fuel plunger as far as it will go and release it.
(4) Set the decompression levers in the upright position (Decompression).
(5) Turn smartly at the starting handle, and when maximum speed is attained turn the decompression levers to the horizontal or 'running' position. The store of energy in the flywheel will overcome the compression and the engine will commence to work on all cylinders.
(6) Allow engine to run at a fast idle speed for some minutes to warm up before applying load.

22. **HAND STARTING (COLD ENGINE) UNDER COLD CONDITIONS.** (This operation may require assistance for the driver.)

(1) Set the decompression levers in position No. 1 (Decompression).
(2) Test if engine is stiff to turn.
(3) If engine is stiff to turn, but not unless, operate each hand charging lever five times after having set the engine stopping lever to the running position.
(4) Set the engine stopping lever to the engine "stop" position, so as to avoid injecting fuel and turn engine until it is free.
(5) Set the engine stopping lever to the running position.
(6) Open very slightly hand speed control if fitted.
(7) Press up the starting fuel plunger as far as it will go and release it.
(8) Set the decompression levers in the upright position (Decompression).
(9) Turn smartly at the starting handle. When maximum speed is attained, turn the decompression levers to the horizontal or 'running' position. The store of energy in the flywheel will overcome the compression and the engine will commence to work on all cylinders.
(10) Allow engine to run at a fast idle speed for some minutes to warm up before applying load.

Note.—If the driver and assistant cannot impart sufficient energy to the flywheel to overcome compression, a loop of rope may be put around the starting handle and by this means the two men can pull the engine over one full compression, i.e. without using the decompression levers. In this way the engine will start.

23. **HAND STARTING (WARM ENGINE) UNDER ALL TEMPERATURE CONDITIONS.** When the engine is warm it is unnecessary to operate the starting fuel plunger as the engine will start very readily with the fuel pump slider bar in the position to which it is limited by the full load stop trigger.

24. **ELECTRIC STARTING (COLD ENGINE) UNDER EXTREMELY COLD CONDITIONS.** Under extremely cold conditions, before attempting to start, follow the procedure as set out in paragraph 22 in order to "free" the engine.

Note 1.—In the event of the engine still being stiff to turn after the above steps have been taken, or if the battery is in a discharged state, give assistance to the electric starter by turning the crank handle at the same time as the starter is engaged.

INTRODUCTORY NOTES AND OPERATING INSTRUCTIONS

STARTING AND STOPPING THE ENGINE—*continued*

With all electric starters it is vital that the batteries and cables are as recommended in paras. 36 and 37, page 122; it is also of vital importance that all connections are clean and making perfect contact. The importance of adequate "earthing" of the engine and one pole of the battery is frequently overlooked and indeed, difficulty experienced in electric starting has many times been found to be due to faulty or inadequate earth connections.

Note. 2.—Where engines are operated under arctic conditions, it may be necessary to introduce special starting fluids into the intake manifold at the time of cold starting; the Works will be pleased to advise on this subject.

Starting under these conditions can of course always be facilitated by heat applied to the air intake in the form of a flame from a blow lamp or from a burning rag or waste previously soaked in fuel oil. Under arctic conditions engines and batteries should always be protected as far as practicable from the cold so that they may retain as much heat as possible from the previous running period.

25. **ELECTRIC STARTING (WARM ENGINE) UNDER ALL TEMPERATURE CONDITIONS.**

(1) Set the engine stopping lever to the running position.

(2) Set the decompression levers in normal running position, i.e. horizontal.

(3) Depress the electric starter button when the engine will instantly work on all cylinders after the first or second compression stroke.

26. **ELECTRIC STARTER BUTTON.** Do not keep this depressed for long periods if the engine fails to start readily. The button should also not be depressed when the engine is running, otherwise damage will be caused to the starter pinion and to the gear ring on the flywheel.

27. **AFTER STARTING.** See that the water circulating pump and the lubricating oil pump are operative. Check that correct oil pressure is registering on the gauge. If not, shut down at once and investigate. After starting, the engine is at once able and ready to take up full load, but a careful engineer will recognise that in all heat engines it is better practice to apply the load as gradually as circumstances will permit, especially after starting from cold, in order that the internal parts may become heated gradually. It is also advisable to follow this practice in order to permit the lubrication system to assume complete circulation.

With new installations it is desirable during the first run, when the ancillary equipment is subject to initial temperature and pressure changes, to examine all joints and pipe connections for leakage in particular, thermostat connections, radiator inlet and outlet hoses, oil cooler and heat exchanger pipework, oil and water connections to power steering pump and air compressors, fuel lines, etc.

28. **IDLE RUNNING.** It is not good practice to run an engine idle for long periods.

29. **TO STOP THE ENGINE.** Turn the stopping lever, in a clockwise direction so moving the governor control bar forwards as far as it will go. In this position the fuel injection pumps immediately cease to deliver fuel.

On no account should the engine be stopped by turning off the fuel supply, since this would empty the fuel pipes and would necessitate re-priming of the whole fuel system before the next start.

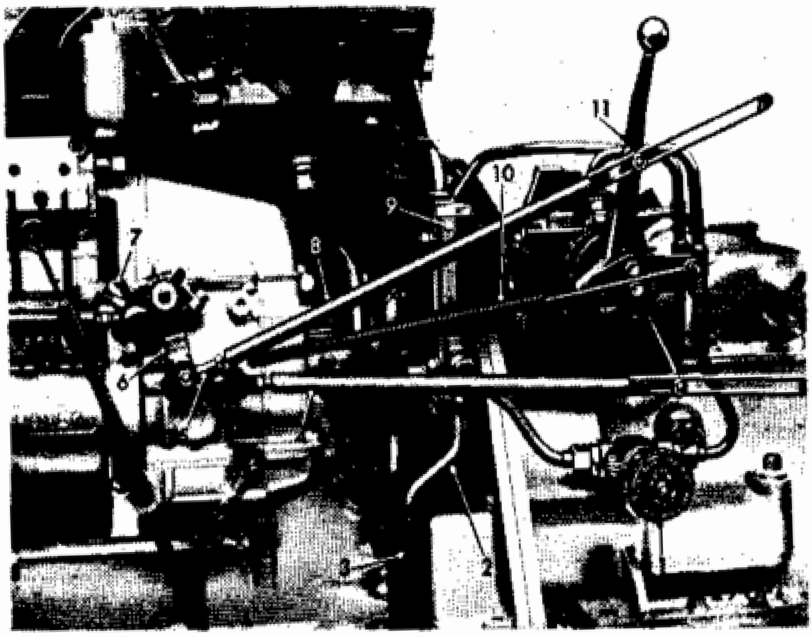
It is neither necessary nor advisable to turn off the fuel supply when the engine is standing idle.

30. **SINGLE LEVER CONTROL.** On Marine Units equipped with the Gardner Single Lever Control a knurl-headed screw and wing nut (Item 7, Fig. 1) are fitted to the accelerator control cam stop in place of the normal idling stop screw. This device enables engine idling r.p.m. to be increased above normal in order to prevent stalling when the engine is cold.

When normal running temperature is reached the knurl-headed screw should be released and locked out of operation, permitting normal idling to be resumed.

With the Single Lever arrangement a hand controlled isolating valve (Item 1, Fig. 1) is incorporated in the oil pressure line to the reverse gear control valve. When closed, this valve shuts off the pressure supply to the control valve and permits the Single Lever to be used solely as a speed control lever for purposes such as battery charging, winching or cargo pumping, etc.

CAUTION.—**Before starting or when running the engine always make sure that the Single Lever Control is in the Neutral position BEFORE opening the isolating valve.**



1. Isolating Valve
2. Pressure Valve
3. Pipe Clip
4. Speed Control Rod—Lower
5. Ball Joint
6. Accelerator Lever
7. Idling Speed Adjusting Screw and Wing Nut
8. Speed Control Rod—Upper
9. Relief Valve Assembly
10. Compensator Spring
11. Valve Lever

Fig. 1. Single Lever Control Linkage on 6LX/2UC Marine Units

GARDNER

TYPES

6LX, 6HLX, 6LXB, 6HLXB, 8LXB

SECTION 2

SERVICING AND MAINTENANCE

GARDNER

SERVICING AND MAINTENANCE

INDEX

INDEX—*continued*

GARDNER

MAINTENANCE SCHEDULE

The following Recommended Maintenance Schedule is based upon average conditions of service including the use of good quality fuel and lubricating oils, etc. It will be appreciated that heavy duty and adverse operating conditions compared with light duty and favourable conditions, may respectively reduce or considerably increase, the periods at which attention is required. It is intended therefore, that this schedule provides a basis only, upon which operators may formulate a schedule of inspection and maintenance to cover their own special requirements and conditions of service. The benefits to be obtained from the use of good quality "Supplement 1" type lubricating oil, low sulphur content fuel oil and frequent draining and refilling of engine oil sump, cannot be over emphasised —in fact, it can safely be said that the more frequently the sump oil is renewed the lower will be the rate of engine wear.

The inspections laid down are based on intervals of approximately 4,000 miles (400 hours) running time and are cumulative. Thus, when completing the inspections given at 12,000 mile periods, they must include the items given at 8,000 and 4,000 mile periods.

Operators are advised to add to this schedule any items of equipment which may have been introduced for special installations.

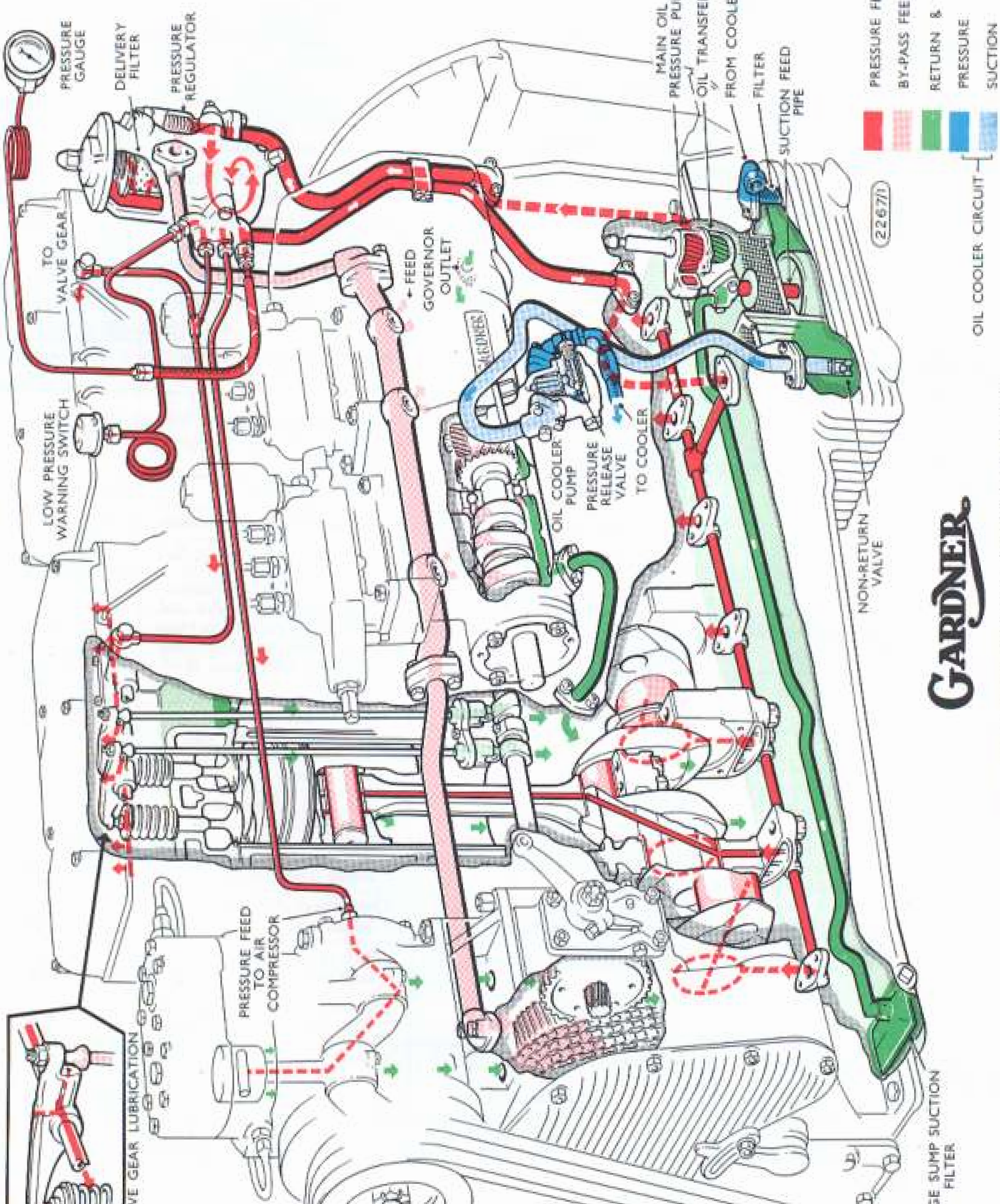
The final columns provide a cross-reference to detailed instructions—contained within this manual—covering the appropriate maintenance procedure.

* **NOTE.**—Top overhaul and Major overhaul periods are frequently more than doubled. This requirement is determined largely by operating duty and service conditions. For example an engine in a highly loaded tractor unit will require overhaul at a lower mileage than an engine in a passenger vehicle. Cylinder liners, piston rings and pistons may have a useful life varying from 100,000 miles (160,000 km.) to 200,000 miles (320,000 km.) or more and without removal from the engine.

PERIOD		OPERATING CONDITIONS	ITEM	PROCEDURE	Page	Para.
Miles	Hours					
DAILY		All Conditions	Lubrication System	Check oil level: Replenish if necessary	22	4 & 5
			Cooling System	Check Coolant level: Replenish if necessary	29	25
EVERY 1,000 (or less)	100	Extreme Dusty Conditions	Lubricating oil sump	Drain and refill sump	22	4 & 5
			Air Induction Filter (Dry Type)	Check for chokage with manometer and clean if necessary	45	63 to 65
EVERY 4,000	400	Average conditions	Lubricating oil sump	Drain and refill sump	22	4 & 5
			Lub. oil delivery filter	Examine and clean if necessary	23	7
			Fuel Filters	Examine and clean if necessary	30	28 to 32
			Air Induction Filters (Oil Bath Type)	Clean filter element/s: Clean and re-charge element container/s	45	62
			Air Induction Filter (Dry Type)	Clean the element or renew if manometer reading exceeds 7 in.	45	63 to 65
			Crankcase Breather Filter	Examine and clean if necessary	21	3
EVERY 8,000	800	Average conditions	Sprayers	Observe by feel and sound that sprayers are functioning correctly by operating hand charging levers on engine	38	45

MAINTENANCE SCHEDULE—*continued*

PERIOD		OPERATING CONDITIONS	ITEM	PROCEDURE	Page	Para.
Miles	Hours					
EVERY 12,000	1,200	After *first* 12,000 miles	Main Timing Chain	Check tension and adjust if necessary	41	56
		Every 12,000 miles Average conditions	Valve Tappets	Check clearances and adjust if necessary	43	58
			Lub. Oil Delivery Filter	Renew Paper Element	23	7
			Radiator Fan	Lubricate fan spindle bearing with grease gun	25	17
				Check driving belt tension and adjust if necessary	44	59
			Slow Running	Check and adjust if necessary	37	43
			Fuel Injection Pumps	Lubricate slider bar and quadrants	25	12
EVERY 24,000	2,400	Average conditions	Crankcase Breather Filter	Renew Filter Unit or paper element if removable	21	3
			Fuel Filters	Renew filter elements	31	30
EVERY *48,000	4,800	Average conditions	Top Overhaul	Decarbonise	71	31
			Lubricating oil sump	Remove and clean	68	25
			Oil Cooler Filter	Examine and clean if necessary	25	18
			Air Cooled Oil Cooler	Flush through with clean fuel oil or paraffin	26	19
			Fuel Injection Pumps	Check maximum output and balance on calibrating machine. Refer to Calibrating Machine Instruction Book No. 45.4	78	45
			Sprayer	Test by fast pull on hand charging levers, if sprayer valves do not vibrate fit service units	39	50 & 51
			Main Timing Chain	Check and adjust tension if necessary	41	56
			Governor Control Slider Bar	Check $\frac{1}{32}$ in. dimension and adjust if necessary	35	36
			Advance and Retard Friction Device	Check range of movement and adjust if necessary	34	35
			Accelerator Control	Check range of movement in relation to pedal mechanism	36–37	40 & 41
			Water Pump	Lubricate spindle bearing with one grease cup full of grease	25	15
EVERY *200,000	20,000	Or when a ·006 in. diametral clearance has developed in any one crankshaft main bearing.	Effect Major Overhaul	Resize crankshaft and fit new bearing shells;	56	8 & 9
				Gun Metal Bearings	58	12
				Pre-finished thin wall bearings	59	13



6 LX AUTOMOTIVE ENGINE LUBRICATION SYSTEM

SERVICING AND MAINTENANCE

LUBRICATION

1. The lubrication system of any internal combustion engine is of such importance that we would impress upon the users of our engines the necessity of exercising every care in rigorously following the recommendations and instructions set forth hereunder.

The grades of oil recommended for various duties and climatic conditions are detailed under Lubricating Oil Specifications on page 6. Our Agents have extensive lists of approved lubricating oils and can advise customers in this matter. In cases not covered by these lists, application should be made to the Works.

2. **LUBRICATION SYSTEM.** The system is such that the whole of the working parts of the engine are automatically lubricated from the main pressure system which is maintained by a gear pump carried by the crankcase immediately over the oil sump. This pump is driven by a vertical shaft from the camshaft. The oil sump is formed in the base-chamber which is readily removable for inspection. The sump is protected by a primary gauze filter of extremely large area and requires cleaning only after long intervals.

The oil is delivered from the pump through a passage formed in the crankcase and thence by an external pipe to the delivery filter and pressure regulator. It passes into the feed pipes of the main bearings and thence, by drilled passages, to the crank pins and gudgeon pins. From the same pressure system, oil is fed under pressure to the valve gear in the cylinder heads. The surplus oil, rejected by the pressure regulator, is separately circulated through the governor unit, the fuel injection pump cams, the tappet mechanism, and finally through the main timing drive of the valve camshaft. This surplus oil pipe is located externally on the fuel pump side of the engine. It runs along the base of the cylinders from the pressure regulator to the casing of the main drive. From the cambox and governor casing the oil is fed back into the crankcase through an external pipe located at the forward end of the cambox and by a short stub extension at the base of the governor casing.

When the engine is operating under conditions where steep gradients are encountered or when extreme forward or rearward inclination of the engine prevails for long periods, a scavenge pump is employed to scavenge any excess oil which may collect in the shallow portion of the sump and transfer this back to the main oil reservoir.

The scavenge pump is mounted in tandem with the main oil pressure pump and the scavenge oil passes through a gauze screen (attached to the end of the transfer pipe) before returning to the main oil reservoir.

In the horizontal engine the lubrication system is basically the same as that described above. The principal difference is in the oil pump, oil sump and the method of forming the joint between the valve covers and the cylinder heads. The oil sump is in two parts, a "wet" and a "dry" section. The "wet" portion carries the main supply of 5½ gallons (25 litres) at maximum level. Oil is drawn from this section and pumped to the various engine components as in the vertical engine. Surplus oil from the crankcase drains into a trough covered by a coarse gauze screen in the lower edge of the sump. Oil fed to the valve gear collects in an oil gallery attached to the underside of the cylinder heads and is also fed back to the scavenge trough through a large bore external pipe in which is embodied a thimble type gauze filter. A transfer pump, built in tandem with the main oil pressure pump, returns the oil from the scavenge trough to the "wet" portion of the sump.

It will be appreciated that with the horizontal engine it is essential to have an oil-tight joint between the valve covers and cylinder heads. This is obtained by a length of synthetic rubber cord located in a shallow groove cut in the joint face of the cover. The diameter of the rubber cord is greater than the depth of groove and thus protrudes above the joint face. When the cover is tightened down, making a metal-to-metal joint with the cylinder head, the rubber ring is compressed and produces a durable oil-tight seal. All sprayer pipes enter the valve covers on their upper edges and have their points of entry sealed by special rubber grummets.

3. **OIL FILLER AND CRANKCASE BREATHER FILTER.** On the 6LX & 6LXB engines this is mounted on the cylinder head on the fuel pump side of the engine or on the forward end of the crankcase, depending upon chassis requirements.

When the oil filler is located at the forward end of the crankcase the breather filter is attached to a separate casting mounted in the normal position on the cylinder head.

The 8LXB engine has two oil filler breather assemblies, one on each cylinder head, either of which may be used for replenishing the oil sump. See Para. 5 Page 22.

The breather contains a special impregnated paper filter element to prevent dirt and other foreign matter entering the oil sump. The filter element should be removed and washed in petrol, paraffin or fuel oil, or in water containing a detergent every 4,000 miles (400 hours) and renewed after 24,000 miles (2,400 hours).

On horizontal engines the oil filler is equipped with a spring loaded lid and is mounted on the main sump well. A cylindrical type gauze strainer of large area is incorporated in the oil filler and the crankcase breather filter is mounted externally on the side of the filler neck. The breather filter is a paper element type and should be removed and washed or, if necessary, renewed at the periods indicated above.

The frequency of this operation must depend largely on the service conditions under which the engine is operating.

LUBRICATION—*continued*

4. **DRAINING AND REPLENISHING THE OIL SUMP.** It is recommended that the oil be completely drained off and the sump replenished with fresh oil not less frequently than every 4,000 miles (400 hours) under average conditions.

Draining should be effected after a long run, while the oil is warm and fluid, by removing the plugs from both front and rear sections of the sump.

On horizontal engines a drain plug will be found on both front and rear corners of the main sump-well and two further plugs are situated in the scavenge trough or 'dry' portion adjacent to the crankcase. When draining the oil the two plugs situated at the *lower* end of each compartment should be removed.

On Marine engines and certain Industrial type engines, a hand operated pump is mounted at the aft end of the crankcase to facilitate evacuation of the oil sump. This draws oil from the sump and simultaneously transfers it into a conveniently placed receptacle by a simple pumping action. When evacuation is completed, the cap must be replaced on the pump outlet.

The use of "flushing" oil or washing out the sump with paraffin after draining is not recommended, since there is a liability of disturbing particles which might re-enter the lubrication system.

5. **MEASURING THE OIL LEVEL IN THE SUMP.** The dip-rod must always be used to check the sump contents. This is located on the fuel pump side of the vertical engine and is mounted on top of the main oil reservoir or 'wet' portion of the sump on the horizontal engine. The oil level indicated on the dip-rod will vary according to the elapsed time; often up to approximately 4 hours after stopping a hot engine the level indicated will increase. The corresponding period for a cold engine may extend to 12 hours. When replenishing the sump a few minutes must be allowed for the added oil to gravitate to the main reservoir before measuring the level in the sump.

To ensure accurate measurement of oil level in a road vehicle engine, it is essential that the vehicle be standing on level ground. To check the level correctly the dip-rod should be withdrawn and wiped perfectly dry, then reinserted and again withdrawn to observe the reading.

The MIN. mark on the dip-rod indicates the minimum level at which it is safe to run the engine and the MAX. mark indicates the level to which the sump must be charged and also the level that should be maintained.

The distance between MAX. and MIN. marks on the 6LX & 6LXB dip-rods represents approximately 6¾ pints (3·8 litres) of lubricating oil. On the 8LXB dip-rod the distance between marks represents approximately 9 pints (5 litres). **Do not overfill.**

The following capacities represent the volume of oil contained within the sump-well at maximum level in a 'wet' engine, i.e. with the filter chamber and oil cooler, etc., fully primed.

6LX (Marine)	..	5 gall. 7 pints (27 litres)
6LX & 6LXB (Auto.)		4 gall. 7 pints (22 litres)
6HLX & 6HLXB	..	5 gall. 4 pints (25 litres)
8LXB (Mar. & Auto)		6 gall. 4 pints (29·5 litres)

Initial Filling of Oil Sump. When initially filling a 'dry' engine newly installed in a vehicle it is necessary, in order to fill the oil cooler and filter chamber and wet the inside of the engine, to add approximately 1·0 gall. to the volume of oil contained in the sump-well at MAX. level.

The approximate total volume required for initial filling is as follows:—

6LX, 6LXB	Type 28 sump	Rear	6·0	gall. (27·3 litres)
6LX, 6LXB	Type 33 sump	Rear	5·9	gall. (26·8 litres)
6LX, 6LXB	Type 36 sump	F'ward	6·8	gall. (30·9 litres)
6HLX, 6HLXB	Standard sump		7·25	gall. (33·0 litres)
8LXB	Type 37 sump	Rear	7·5	gall. (34·1 litres)
8LXB	Type 38 sump	F'ward	7·5	gall. (34·1 litres)

Forward Sump-well Arrangement. When an engine is equipped with a forward type sump and is installed with its axis inclined downward to the flywheel end, small quantities added for "topping up" purposes do not reach the main sump-well and thus fail to record on the dip-rod until transferred thereto by the scavenge pump.

In this case the volume of oil required for "topping up" purposes has to be determined after the engine has been run for a short period and left standing as aforesaid.

SERVICING AND MAINTENANCE

LUBRICATION—*continued*

6. **LUBRICATING OIL DELIVERY FILTER.** This unit is situated on the fuel pump side of the vertical engines. It is of simple yet special construction, comprising a vertical cylinder in which is a special impregnated paper element, instantly detachable by removing the filter cover secured by a single nut. In the base of this unit is a sludge sump provided with a plug for drawing away any foreign matter extracted by the filter element, whilst at the top is a filler plug for priming purposes. Attached to the right-hand side is the pressure regulator and at the left-hand side is a fitting containing four separate connections, see Fig. 2.

The top connection "A" (fitted with a plug when not in use) is for connecting to an oil pressure warning light switch. The second connection "B" is used for the valve levers lubricating oil pipe. The third connection "C" (also fitted with a plug when not in use) is for the lubricating oil pipe to an air compressor when the engine is so equipped whilst the fourth connection "D" is for the lubricating oil pressure gauge.

Note: On current engines connections "C" and "D" are reversed, i.e., connection "C" is coupled to the oil pressure gauge.

The filter element is held on its seat by a spring so that, in the event of chokage, oil can by-pass the element and maintain lubrication. The whole of the lubricating oil passes through this filter so that it is of the greatest importance that the element be kept clean.

On the horizontal engines the lubricating oil delivery filter is mounted at the rear of the main oil reservoir. The pressure regulator and three branch connection which leads to the valve gear, compressor and oil pressure gauge is separately mounted on the crankcase wall.

Fig. 2. Lubricating Oil Delivery Filter

7. **DELIVERY FILTER CLEANING AND REPLACEMENT.** Under normal working conditions the filter element should have a useful life of about 12,000 miles or 1,200 hours.

A drop of 3 to 4 lb./sq. in. (·211 to ·281 Kg./sq. cm.) or more in the oil pressure will indicate that the element has become choked and in this event must be replaced by a new element. If a new element is not available it is permissible to wash the existing element with clean paraffin or fuel oil. When washing, a reverse flow of paraffin or fuel oil (from inside to outside) will assist in removing the sediment formation and make the element fit for further use.

Nevertheless, since there is a risk of foreign matter remaining inside the element which, if present, may reach the bearings, it is imperative that at the first opportunity, a new element Part No. LW/6/252 be fitted. These elements are inexpensive and quickly replaceable and are readily obtainable from the Works, Branch Office Depots and Official Spare Part Stockists.

Special Caution. After decarbonising or otherwise disturbing the engine, an increased collection may be formed on the element. Anticipate this by early inspection. Also when using a detergent oil for the first time in an engine which has been in service, it is advisable to inspect the filter element after a short period and pay due regard to engine oil pressure, since oils of this type will free deposited carbon, and if the filter does not receive attention it may suddenly, in the case of a dirty engine, become choked.

8. **DELIVERY FILTER REASSEMBLY.** Use a new joint ring and rotate the cover of the filter in order to minimise the chance of any foreign matter causing a leak. It is recommended that the filter be replenished with clean oil through the orifice closed by the square-headed plug.

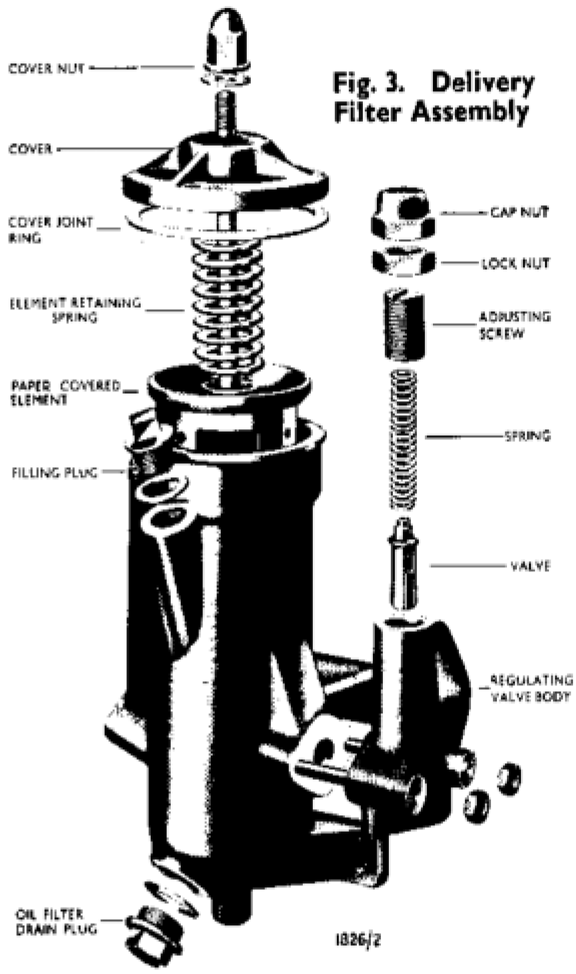


Fig. 3. Delivery Filter Assembly

9. **PRESSURE REGULATION VALVE.** The function of this unit is to maintain within certain limits the pressure of oil in the lubrication system. It consists of a spring-loaded valve. The correct amount of spring-loading is effected by an adjusting screw. Varying the spring-load will correspondingly vary the pressure at which the valve permits the surplus oil to escape through the surplus oil pipe described in para. 2. The pressure at which the valve is set to operate is stamped on the cap nut of the adjusting screw and is as follows:—

6LX, 6HLX, 6LXB, 6HLXB	35 lb./sq. in. (2·46 kg./sq.cm.)
8LXB	32 lb./sq. in. (2·25 kg./sq. cm.)

The above settings are correct with engine running at about 1,000 r.p.m. and lubricating oil temperature at about 140°F. (60°C.). At 110°F. (43°C.) the pressure recorded will be slightly higher. In a very hot engine, under idling conditions the oil pressure may fall as low as 25 to 30 lb./sq. in. (1·76 to 2·10 Kg./sq. cm.). If the regulation valve be dismantled for any reason it should be re-set to give the above pressures according to the temperature obtaining. A useful guide to the setting of the adjusting screw is to count and record before dismantling the number of screw threads that stand above the hexagon locknut. If correctly counted, this should prove a useful aid when reassembling.

If the pressure regulation valve is correctly adjusted, and if due to wear or other causes the pressure gauge records a drop of more than 5 lb./sq.in. (0·35 kg./sq. cm.) below normal at 1,000 r.p.m. and 140°F. (60°C.) the main bearings will receive sufficient lubricant but all auxiliaries fed by the surplus oil pipe will receive insufficient or no lubricant.

10. LOW OIL PRESSURE — CAUSES AND REMEDIES.

Oil Pressure Too Low. Possible Causes.

(1) Delivery filter requires replacing.
(2) Foreign matter under the seat of the pressure regulation valve.
(3) Fracture of the spring of the regulation valve.
(4) Sprayer pipe unions slack or pipe broken allowing fuel to reach the crankcase.
(5) The gauze filter over the sump is choked by sludge deposit.
(6) Shortage of oil in the sump.
(7) A pipe fracture somewhere in the system.
(8) Worn bearings or bearing failure.
(9) Excessive temperature or incorrect lubricant viscosity.

To Remedy the Above Defects.

(1) Dismantle, replace or clean and reassemble as in paras. 7 and 8.
(2) If foreign matter prevents the proper seating of the regulation valve, this may be indicated by the pressure gauge recording normal pressure when the engine is running at maximum r.p.m. and too low pressure at slow speeds. Sometimes a light tap on the body of this unit suffices to dislodge the obstruction; if not, the valve should be withdrawn, wiped clean and replaced, making the correct spring-load adjustment as described in para. 9.
(3) Replace with spare spring.
(4) Drain the base-chamber sump and replace with new oil of the correct grade. In any case, this

SERVICING AND MAINTENANCE

LUBRICATION—*continued*

operation should be carried out after every 4,000 miles or 400 hours.

(5) Remove and clean the base-chamber and refer to paras. 25 and 26, pages 68 and 69.

(6) The oil level in the sump should not be allowed to fall below the minimum mark on the dip-rod, nor should it be allowed to rise above the maximum mark, as described in para. 5, page 22.

(7) Renew defective pipe and see that it is properly secured against vibration and possible chafing.

11. **SECURITY OF PIPEWORK.** It is important to ensure that all pipework is effectively insulated against chafing and properly secured against vibration and consequent fracture.

For this purpose a length of flexible pipe is supplied for the remote reading oil pressure gauge which insulates from the engine the small bore solid pipe leading to the instrument panel. The solid pipe should be firmly secured throughout its length.

Similarly, the two oil pipes, one leading from the oil pump to the pressure regulator and the other from the delivery filter to the main bearings, must be properly secured by fitting the anti-vibration clip, together with the synthetic rubber spacers at a point where the two pipes run parallel.

12. **LUBRICATION OF FUEL PUMPS.** Every 12,000 miles or 1,200 hours a small quantity (about 30 c.c.) of engine lubricating oil should be injected through the 2 B.A. screw hole located in the front face of the fuel control box and also through a similar screw hole in the cast aluminium cover plate fitted to the rear set of pumps, see Fig. 13, page 33. This oil will assist in lubrication of the slider bars, quadrants and regulating sleeves inside the fuel pump housings.

13. **LUBRICATION OF EXHAUSTER.** This is effected by splash from oil which is collected via a trough in the timing case cover. Oil in the exhauster is returned through the muffler and drain pipe. No external lubrication attention is therefore required.

14. **LUBRICATION OF BILGE PUMP.** Inspection should be made regularly to see that the wick feed lubricator fitted to the body of the pump is kept filled with lubricating oil. See Fig. 25, page 48.

15. **LUBRICATION OF WATER PUMP.** The only attention which the pump requires is the lubrication of the ball bearing. This should be carried out by using not more than one grease cup full per 48,000 miles or 4,800 hours. Use a lithium base grease to No. 2 or 3 NLGI rating system or a good quality calcium base grease having a drop point of 100°C. nominal. *Do not fit grease nipple in order to use a grease gun. Grease is detrimental to carbon glands.*

16. **LUBRICATION OF AIR COMPRESSOR.** It is normal practice for the air compressor (when fitted) to be lubricated by the engine system and therefore no separate "topping-up" or attention is required except to ensure that all pipe unions are secure and no leakage is evident.

17. **LUBRICATION OF FAN SPINDLE AND JACK-SHAFT BEARINGS.** Every 12,000 miles (1,200 hours) inject a small quantity of grease into the grease nipple on the hub of the fan and, also where applicable, the two nipples provided on the fan jackshaft bearings.

18. **OIL COOLER SYSTEMS.** In many applications of the engine it is necessary to circulate the lubricating oil through some form of cooler from which the heat is extracted by a flow of water or air.

Generally speaking, with automotive or industrial engines the oil is pumped through a number of finned tubes which are cooled by an air stream, whilst on the marine engine the oil is pumped through an indented pipe encased in a gun metal jacket through which sea water passes before entering the heat exchanger.

A separate oil cooler pump is employed to circulate the oil in both cases. On the vertical engine this pump is mounted on the cambox and driven by helical gears from the fuel pump camshaft whilst on the horizontal engine it is mounted on the timing case cover and driven from the forward end of the alternator sprocket spindle. The pump draws oil from a foot-valve in the main sump, circulates it through the cooler and returns it to the sump. If the cooler is of the air-cooled type the oil is returned to the sump via a thimble type filter located in the sump at the junction of the oil cooler return pipe.

The oil cooler filter should be removed and cleaned at top-overhaul periods.

Under very cold conditions the oil cooler can offer considerable resistance to the oil and so create dangerously high pressures. To counter this possibility the

LUBRICATION—*continued*

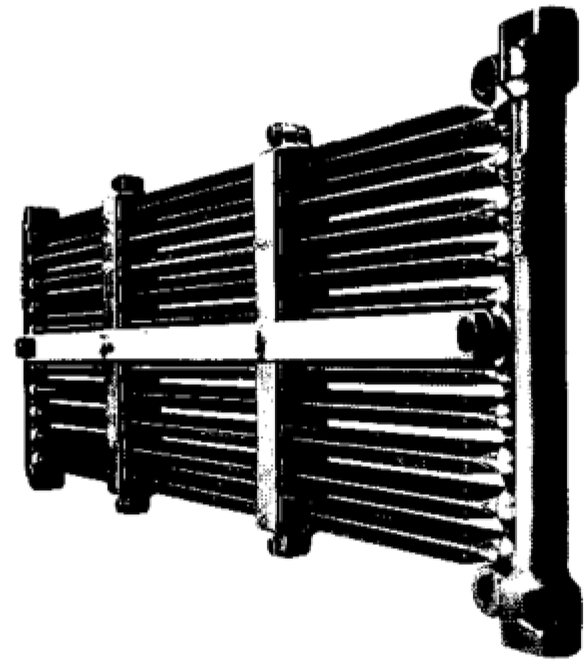


Fig. 4. Air Cooled Oil Cooler 2349

covers of the oil cooler pumps have been fitted with two relief valves. When the resistance of a cooler creates a pressure of 75 lb./sq. in. (5·3 kg./sq. cm.) or more, the relief valve on the delivery side of the pump lifts from its seat and permits the oil to by-pass from the delivery side to the suction side of the pump, until oil becomes warm and its viscosity thereby reduced sufficiently to lower the resistance of the cooler to something less than 75 lb./sq. in. (5·3 kg./sq. cm.) then of course all the oil will pass through the cooler. The second valve in the oil cooler pump cover provides protection against dangerous pressures which could be generated in the suction pipe if an engine is rotated in a reverse direction.

These spring loaded, thimble type relief valves are contained in the pump cover by hexagon-headed plugs on which are stamped the pressure at which the valves are set to operate. Normally they should not require any maintenance.

Covers fitted to earlier pumps contained ball type valves set to operate at 45 lb./sq. in. (3·2 kg./sq. cm.). These covers are no longer available and in the event of replacement being necessary, the new type cover complete with thimble type valves and springs will be supplied.

On 6LX Marine Engines fitted with the Gardner Single Lever Control System the oil cooler relief valve assembly is mounted on the crankcase end plate (see Fig. 1, Page 14). This contains a ball type valve, set to operate at 70 lb./sq. in. (4·9 kg./sq. cm.) and the relief valve plug is stamped accordingly. Previously this plug was unstamped and to convert the earlier relief valve assembly to the 70 lb./sq. in. setting, a new relief valve spring (Part No. 225 SP.) must be fitted in place of the existing spring.

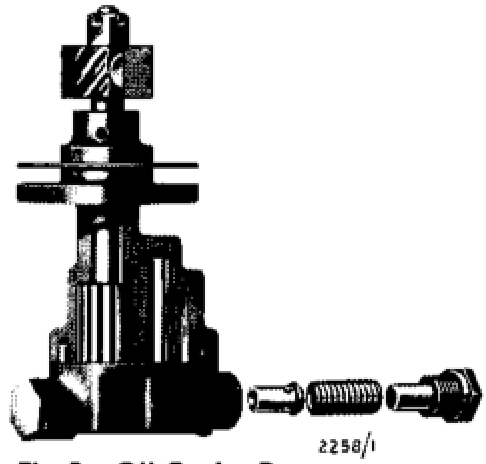


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Fig. 5. Oil Cooler Pump

19. **OIL COOLER CLEANING AND MAINTENANCE.** The oil cooler fitted to marine engines contains a full length longitudinal ribbon of sheet steel, the function of which is to provide corrosion protection for the non-ferrous components.

In time, dependent on the varying water quality, the ferrous wasting strip will corrode away and it is recommended that renewal be effected every twelve months or at more frequent intervals under adverse conditions. When the oil cooler is dismantled for inspection, the water jackets and indented oil cooler pipe should be thoroughly cleaned of any silt and scale which has accumulated, in order to ensure maximum conduction of heat from the oil. It will be noted that one end of the indented tube is brazed into a circular flange plate whilst at the other end, the water joint is made by a rubber ring to permit endwise movement created by expansion.

Radiator mounted air cooled oil coolers should be thoroughly flushed through with clean fuel oil or paraffin when the engine oil sump is cleaned at overhaul periods, or every 48,000 miles.

SERVICING AND MAINTENANCE

COOLING SYSTEM

20. Always ensure that the radiator or cooling system is filled to maximum capacity, preferably with rain water. This is particularly important in hard water districts in order to avoid deposits which will impair cooling efficiency. The addition of a corrosion inhibitor to all engine cooling systems will be found beneficial. Refer to Cooling Recommendations on Page 10, Para. 16.

21. **WATER CIRCULATION.** Coolant is circulated by a centrifugal type pump mounted on the manifold side of the engine and driven by helical gears from the valve camshaft. Inspection should be made regularly to confirm that circulation is taking place, especially if there has been any possibility of damage to the water pump impeller due to frost (see Para. 25, Page 29). It must be remembered that circulation does not take place until the temperature rises sufficiently to open the thermostat valve to the radiator or heat exchanger. At temperatures above 160°F. (71°C.) it should always be possible to observe this circulation.

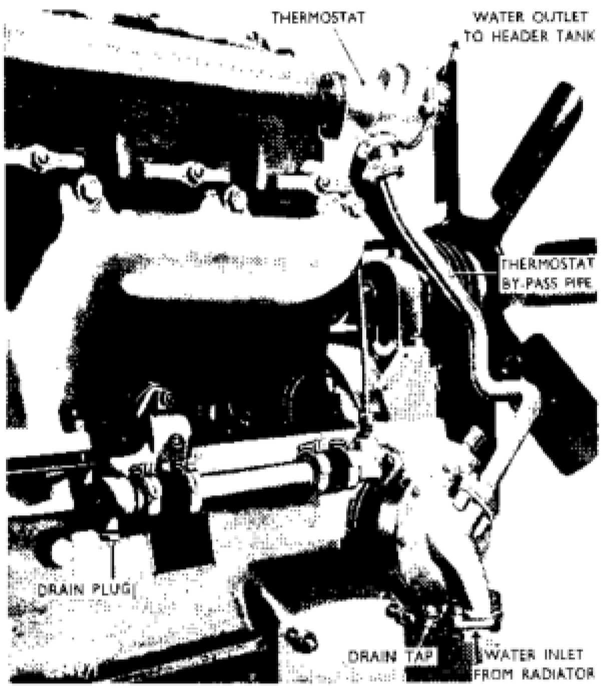

Fig. 6. Cooling System—Automotive Engine

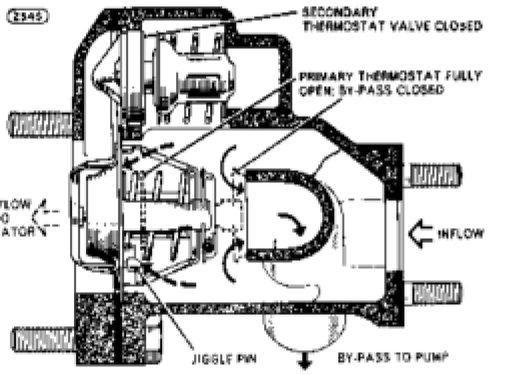

Fig. 7. Thermostat Unit

22. **AUTOMATIC TEMPERATURE CONTROL.** The design of the thermostat is such that until a predetermined temperature is exceeded, all the circulating water is diverted through a by-pass port in the thermostat housing (Fig. 7) and returned directly to the intake side of the pump. Thus when the engine is cold there is no circulation through the radiator or heat exchanger and "warming-up" time is thereby reduced to a minimum and normal running temperature achieved in the shortest possible time.

As the temperature increases, the temperature sensitive elements in the thermostat unit expand, gradually, opening the control valve or valves, whilst at the same time closing the by-pass port. This permits a progressively increasing volume of water to flow to the radiator or heat exchanger, where it is cooled before returning to the pump.

When a certain temperature is reached, depending upon the type of thermostat fitted, the by-pass port is finally closed and all circulating water then passes through the radiator or cooling device. The temperature at which this occurs is indicated in the following table under the heading "Full Open Temp."

Western Thompson Code No.	Crack Open Temp.		Full Open Temp.	
Primary Units 16/1-262-60 16/1-262-74	 140°F. 165°F.	 60°C. 74°C.	 163°F. 188°F.	 72·5°C. 86·5°C.
Secondary Units 01-3502-82	 180°F.	 82°C.	 203°F.	 95°C.

COOLING SYSTEM—*continued*

23. **THERMOSTAT ASSEMBLIES.** The thermostat assemblies fitted to the 6-cylinder vertical and horizontal engines incorporate two wax-type elements—a primary and secondary unit—each having a different temperature rating. The primary unit is the larger of the two and serves as the principal control in maintaining engine temperature at acceptable levels, whilst the secondary unit functions as a supplementary control to permit an increased volume of water to pass to the radiator or heat exchanger in the event of abnormally high temperatures. It also affords an alternative passage for coolant should the primary valve fail to operate due to some defect.

The 8LXB thermostat incorporates twin Wax-type elements of equal temperature value and thus operate in unison, permitting a greater volume of water comparable with engine size to pass to the radiator or cooling device.

The primary units incorporate a jiggle pin automatic vent valve which operates in an air release hole drilled in the main delivery valve body. This arrangement permits venting during filling or replenishment of the system whilst the engine is stationary. Immediately the engine commences running the coolant, circulated by the action of the centrifugal pump, forces the jiggle pin against the vent hole, closing the aperture. Operation of the thermostat valve can be readily observed by removing the unit from its housing and raising its temperature whilst immersed in water.

24. **WATER PUMP.** The centrifugal water circulating pumps fitted to 6LX, 6LXB and 8LXB engines are stamped with the impeller diameter and are identified by the letters LX, LXB and 8LXB respectively on the water outlet flange. These pumps are not interchangeable and must be fitted only to the engines for which they are stamped.

The current centrifugal pump is of "Unit Seal" Type in which a spring-loaded graphite impregnated phenolic seal housed within the pump body seats on the face of a sealing ring which revolves with the impeller. The letters U.S. adjacent to the engine stamping signifies that the pump is fitted with a Unit Seal. The only attention the pump requires is lubrication of the spindle bearing as described in Paragraph 15, Page 25.

Spare Parts for water pumps or new replacement pumps may be obtained from our Works and Service Depots. Service Exchange pumps are no longer available. When mounting the pump on the engine observe carefully the procedures laid down in Para. 72, Page 91.

Note: The covers fitted to the latest type pumps are assembled with setscrews.

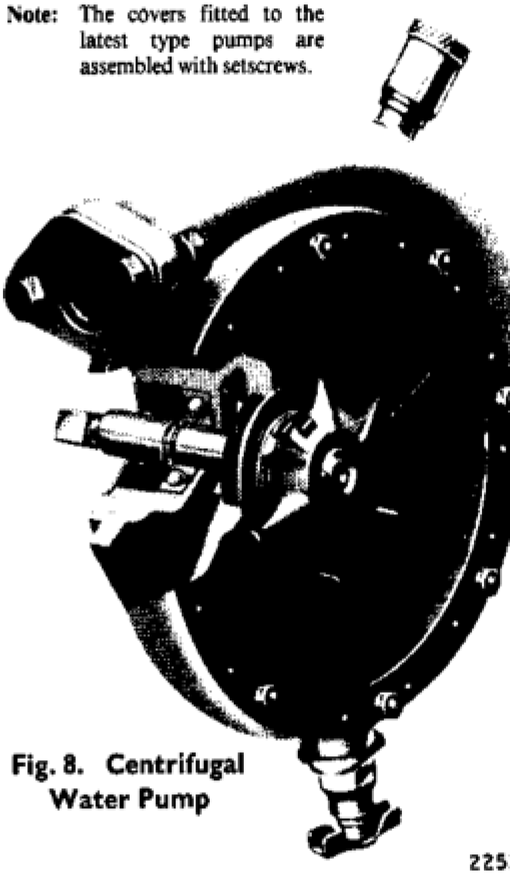

Fig. 8. Centrifugal Water Pump

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25. **DRAINING AND REPLENISHING THE COOLING SYSTEM.** As the pump is not, in all engine installations, automatically drained with the rest of the system, it may be necessary to drain it separately. The drain cock will be found at the lowest point on the pump body and an inspection of the shape of the pipe connecting the pump with the bottom of the radiator will reveal whether or not emptying the radiator will suffice to empty the pump. There is a small drain from the periphery of the water pump body into the pipe and on installations where the pipe has a continuous fall from pump to radiator, separate draining of the pump may be omitted.

SERVICING AND MAINTENANCE

COOLING SYSTEM—*continued*

If the engine installation is such that the engine is inclined rearwards, the water manifold from the water pump to the base of the cylinders will require to be drained separately by removing the plug at the rear end. See Fig. 9.

If water became frozen in the pump it is obvious that serious consequences would follow any attempt to start and run the engine. In order to guard against this contingency, so far as it be possible, the diameter of the impeller spindle is reduced for a short length near the driving square so that any undue load will fracture the reduced spindle by twisting and thus prevent more serious consequences in the form of damage to the driving gears. In this event the driving square can be withdrawn from the driving member after the water pump has been removed, by inserting a stud extractor or other implement, into the hole provided for this purpose in the centre of the square. A piece of wire or wood screw may also be used with equal effect.

Replenishing The Cooling System

Before replenishing the cooling system, refer to the Recommendations set out on Page 10 concerning the use of Anti-freeze Solutions and special Corrosion Inhibitors.

When replenishing the cooling system special precaution must be taken to ensure that the system is fully primed and that no air pockets remain in the water passages.

Automotive Installations

With Automotive or Radiator Cooled Installations it is very desirable to inspect the coolant level after filling the system, since the level may fall due to the gradual displacement of air trapped in the system. On starting the engine after initial filling, further venting will occur and additional coolant must be added to replenish that which has entered the cab or saloon heaters.

Marine Installations

On Marine Units with integral header tanks an air release cock will be found on the water outlet pipe adjacent to the thermostat unit. When filling the system this cock must be left open until all air is expelled and coolant commences to flow from the air vent. The cock is then closed and further coolant added until the whole system, including header tank, is filled to maximum capacity.

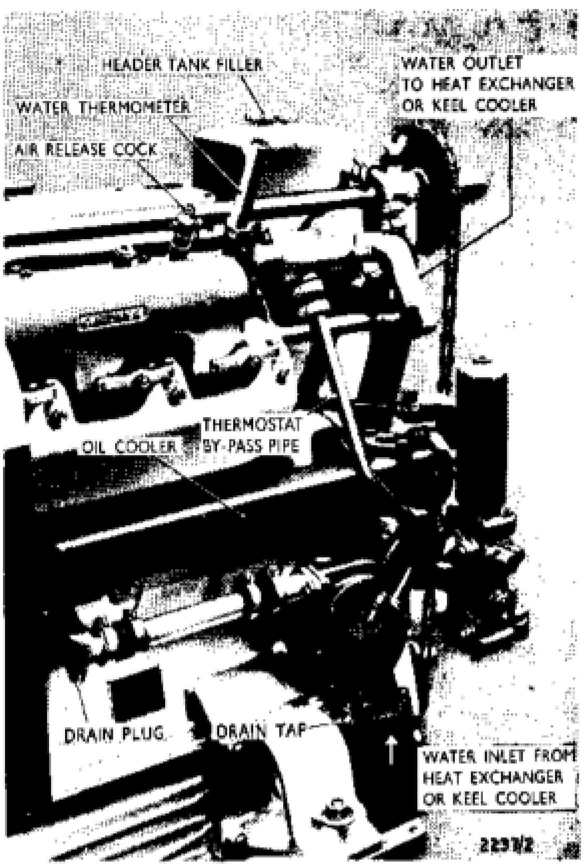


Fig. 9. Cooling System—Marine Engine

A length of polythene tubing fitted to the air release cock and fed into the filler neck in the header tank will help to avoid spillage and waste of coolant during this operation.

The correct level of coolant in the header tank coincides with the base of the filler neck and this is the level which should be maintained.

It is advisable to inspect the coolant level after the engine has run for a short time to ensure that the correct level has been maintained.

FUEL FEED SYSTEM

26. **FUEL SUPPLY.** Engines may be supplied with fuel by means of a gravity system, or diaphragm type pump system. When the latter system is employed the diaphragm pump is mounted on the fuel pump cambox and operated by an eccentric fitted to the camshaft. This pump lifts fuel through a paper element filter from the tank, and delivers to the fuel injection pump through another filter, also having a paper element, mounted on the cylinder head. With marine installations the first filter is of Duplex change-over type.

At the highest point on the second filter is a small "leak off" hole permitting the escape of any air which may have been drawn in at some point in the suction pipe line; a small amount of fuel also passes through this vent hole and is piped back to the fuel tank. In this way an air-free supply of fuel to the injection pumps is ensured. The pump is provided with a lever for operating by hand in order to initially fill the pipe system and prime the fuel injection pumps.

It is important that the overflow pipe should have a continuous fall from the outlet on the strainer to the fuel tank, otherwise the fuel injection pumps may become de-primed. Also it is of the greatest importance to prevent air leaks at any point in the suction pipe line between the fuel lift pump and the tank and to ensure that the suction filter does not become choked since this will induce an increased load on the flexible diaphragm which may precipitate failure of this component.

27. **SPRAYER DRAIN PIPE.** A minute quantity of fuel is allowed to leak past the piston valve of the sprayer, which leak is piped from each sprayer into a bus-pipe, whence it may be piped back to the fuel tank. With a gravity feed system the pipe should be led into the top of the tank, not the bottom; this is in order to avoid the necessity of using a cock or valve on the pipe which, if inadvertently closed, would impair the efficient working of the engine. When the Amal Fuel Lift Pump and Gardner Overflow return system is fitted, the sprayer leak is led into this system.

28. **FUEL FILTERS.** As described in para. 26 two filters are incorporated in the fuel system. One filter is always mounted on the chassis, bulkhead or machine frame, this filter (Fig. 11) is referred to as the "first" since the fuel passes through this filter before the "second" filter (Fig. 10) which is always mounted on No. 1 cylinder head on the vertical engines and on the forward end of the cylinder block on the horizontal engines.

Both filters contain special paper filtering elements which have to be replaced when they become choked. These elements, Part Nos. GFF3/10 and GFF2A/2 (first and second filters respectively) are inexpensive and readily obtainable from the Works, Branch Offices, Service Depots and Recommended Repairers, the first filter being supplied complete with inner sealing ring, Part No. GFF3/11.

The element in the first filter has a greater area than that fitted to the second filter, thus the two elements are not interchangeable. Both filter chambers are provided with a collecting sump to which a drain plug is fitted to enable the sumps to be readily drained prior to dismantling.

The first and second filters also have a vent plug and vent valve respectively when used in a gravity fuel feed system. Since, with the diaphragm-operated fuel overflow return system, air is automatically separated from the fuel feed, the vent valve is not required on the second filter and it is, therefore, replaced by a plug.

29. **CHOKED FUEL FILTERS.** Certain fuels have shown a tendency to form a deposit on the filter elements and so choke the filtering media. This occurrence necessitates the replacement of the affected elements. The deposit is more liable to occur during cold weather and therefore the first filter which is usually in an exposed position, is more likely to be affected before the second filter. When convenient this first filter should be mounted low down on the bulkhead under the bonnet where it may derive some heat from the engine.

The filter elements can be tested for obstruction by uncoupling the feed pipe from the filter to the fuel injection pump and observing the flow; for this test, the fuel lift pump if fitted, will have to be hand operated. Alternatively, the filter elements may be removed from the assembly and held in a vertical position, closing the hole at the lower end by holding it down on a flat surface

SERVICING AND MAINTENANCE

FUEL FEED SYSTEM—*continued*

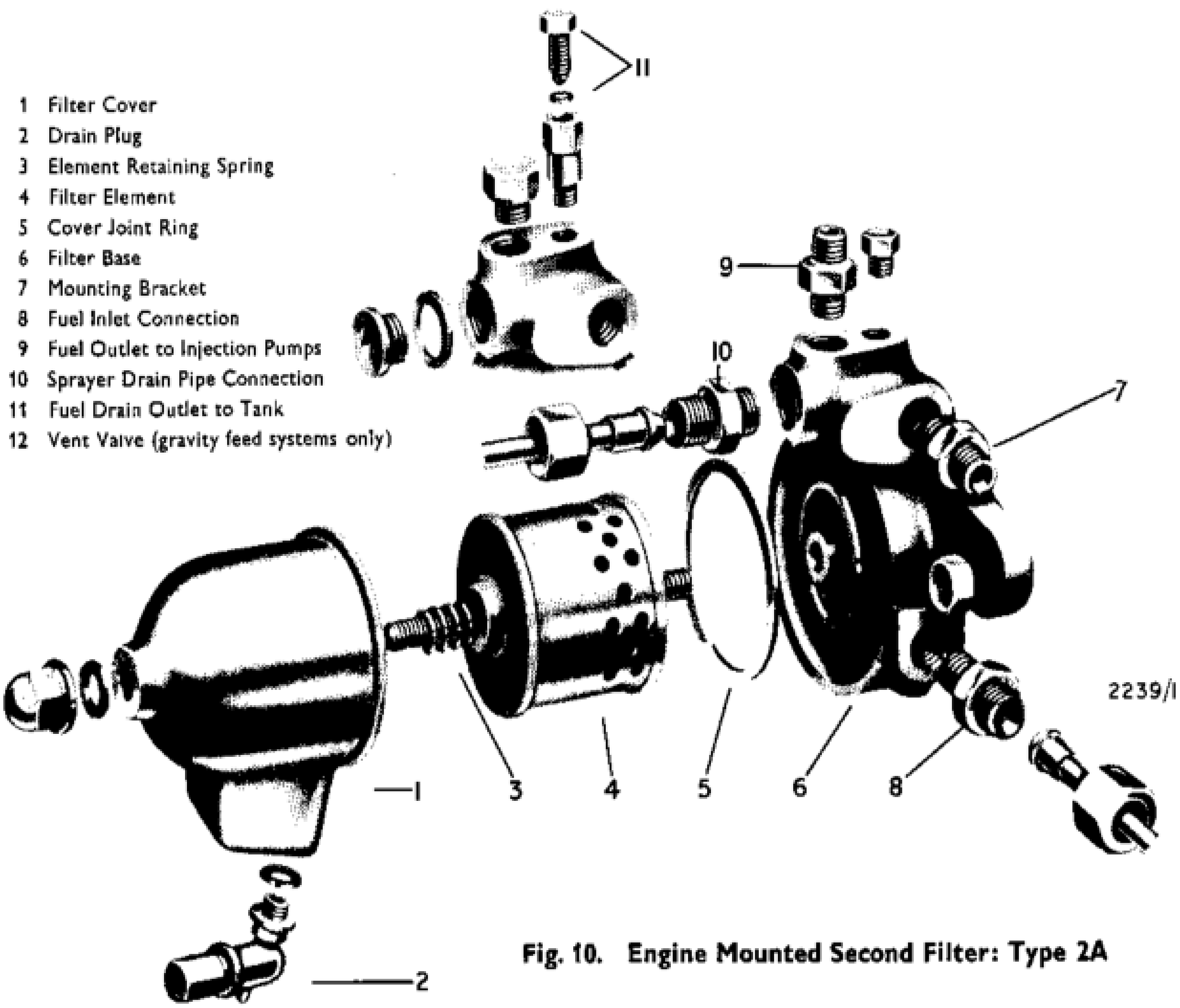


Fig. 10. Engine Mounted Second Filter: Type 2A

and pouring fuel into the upper open end. If fuel collects and does not run through the filter paper almost as quickly as it is poured in, the filter is probably choked sufficiently to cause erratic running of the engine and should be replaced. Our experience indicates that a large percentage of service calls are due to choked or partially choked fuel supply. Therefore we recommend the user to make quite sure that a copious flow of fuel is obtainable beyond both filters at regular intervals and that there are no air leaks at any point in the suction pipe between the fuel lift pump and the tank.

Apart from stoppages due to the causes outlined above, the filters are of course more usually liable to stoppage by foreign matter from the fuel in the form of solid particles; particularly does this apply to engines operated under dusty conditions and where good fuel storage facilities and filling conditions cannot be arranged.

30. **REPLACEMENT OF FILTER ELEMENTS.** Whilst the duty, location, cleanliness of fuel supply and system, can all have a profound influence on the "clean" life of the filter elements, they should, under average conditions, not require replacement before they have been in use for at least 24,000 miles or 2,400 hours. Generally speaking the second filter element should have a "clean" life longer than that of the first filter element.

31. **REASSEMBLING FILTER COVERS.** When replacing the filter covers gently rotate them on their

FUEL FEED SYSTEM—*continued*

joint faces so as to minimise the chance of foreign matter causing an unsound joint. Do not use a hammer to tighten the nut on the cover. Use a new standard specification joint ring to ensure absence of leakage.

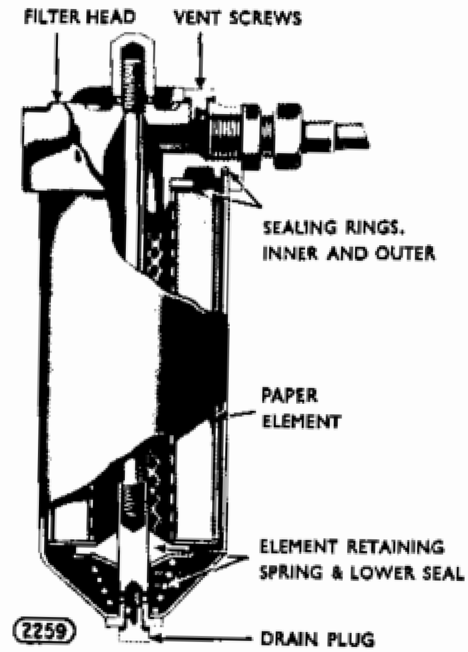


Fig. 11. First Fuel Filter

32. **DUPLEX TYPE FUEL FILTER.** This filter unit, designed primarily for marine installations, contains two paper filtering elements Part No. GFF3/10, either of which can be brought into operation by rotation of the change-over valve in the filter head. The change-over valve permits the cleaning and replacement of one element whilst the other element is still in operation and the vessel under way. See Fig. 12.

On the indicator plate are two stops labelled "RIGHT ON" and "LEFT ON" against which the pointer must lie when one or the other filter is in use. Also on the indicator plate will be seen two indented lines labelled "L" and "R". These marks indicate the position at which the pointer must be placed when priming or filling the Left Hand or Right Hand container after replacement.

When replacing a filter unit it is necessary to expel all air from the container as it becomes charged with fuel. For this purpose a bleed screw for each container is provided in the head of the filter unit.

33. **OPERATING THE CHANGE-OVER DUPLEX FUEL FILTER.** Operation of the change-over filter unit is as follows:—

Assuming that the right-hand filter has been removed for cleaning and is now reassembled, the change-over lever will be inclined to the left and the pointer will be against the stop labelled "LEFT ON". In this position a full flow of fuel will be passing through the left-hand filter to the fuel lift pump. By rotating the change-over valve to a position where the pointer coincides with the line mark "R", a port is opened permitting fuel to enter the right-hand filter whilst at the same time a full flow of fuel is maintained through the left-hand filter.

With the pointer in this position the right-hand bleed screw can be released, allowing the air to be exhausted from the container by the inflowing fuel. When fuel commences to flow from the bleed screw all air will have been exhausted. The bleed screw can then be tightened and the filter brought into operation by moving the lever to the position where the pointer lies against the stop labelled "RIGHT ON".

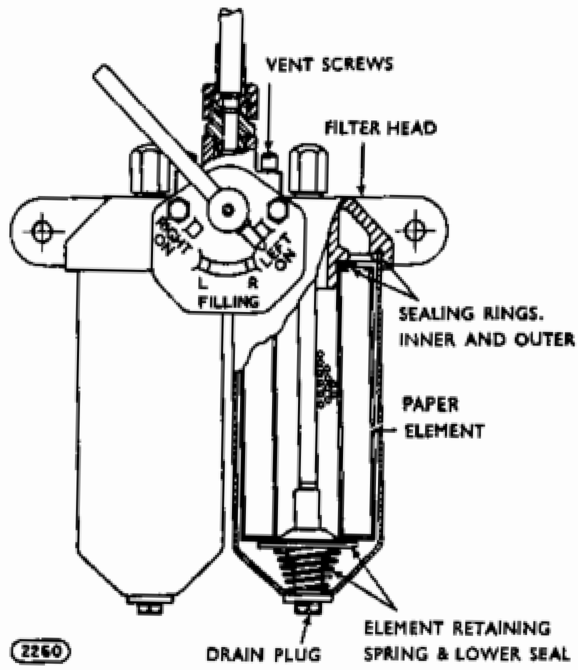


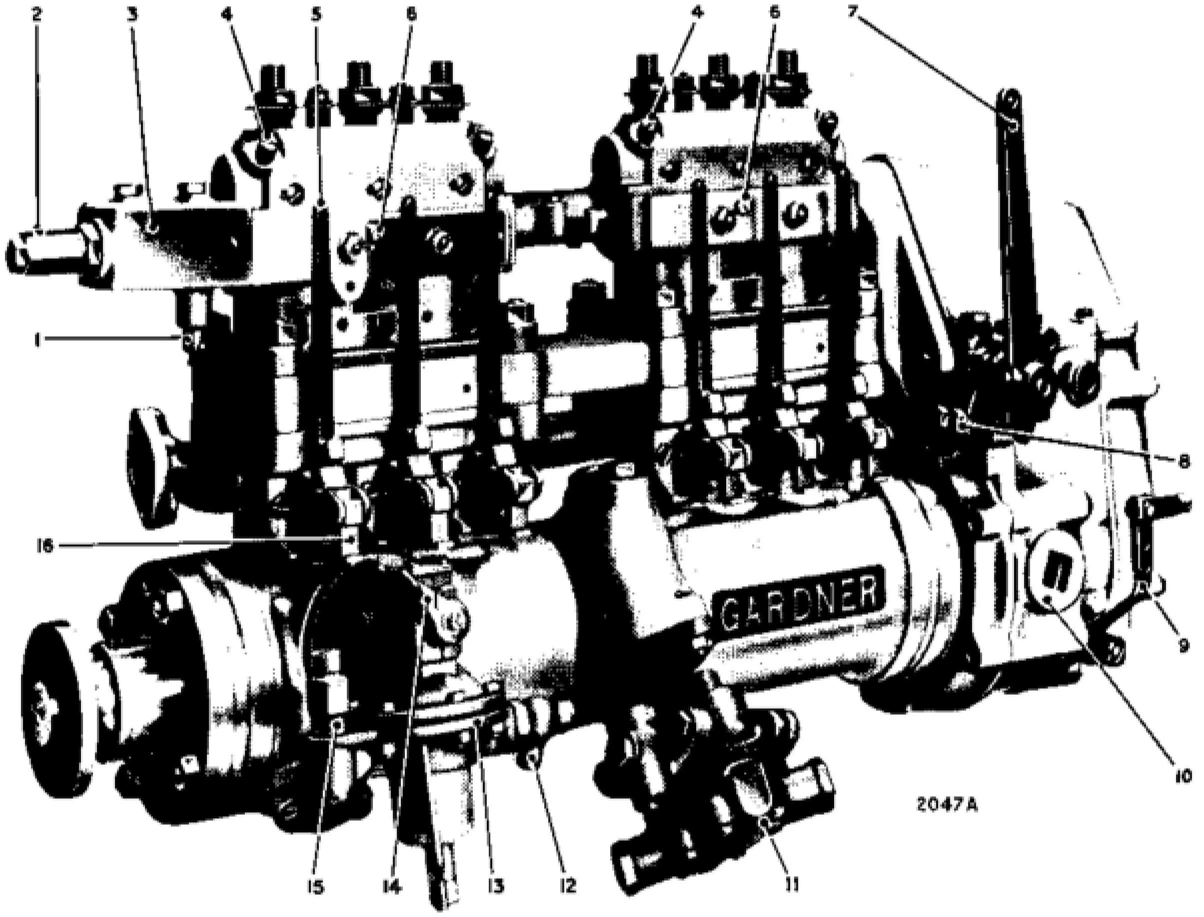
Fig. 12. Duplex Type Fuel Filter

SERVICING AND MAINTENANCE

FUEL INJECTION PUMPS

34. **FUEL PUMPS.** The fuel injection pump units are mounted in pairs each containing three pumping elements (rams and valves). Interposed between the pumps and the cam box is a light insertion plate to which the pump units are dowelled so that a pair of service pumps can readily be fitted to any engine. In addition to the ram return springs, each fuel pump tappet is also spring loaded. Individual fuel rams are provided with a hand operating lever for priming the system and testing the action of the sprayers without removing them from the engine. Each priming lever is provided with a latch to enable any plunger to be put into or out of action, whilst the engine is running.

The fuel pump camshaft is driven through a helical

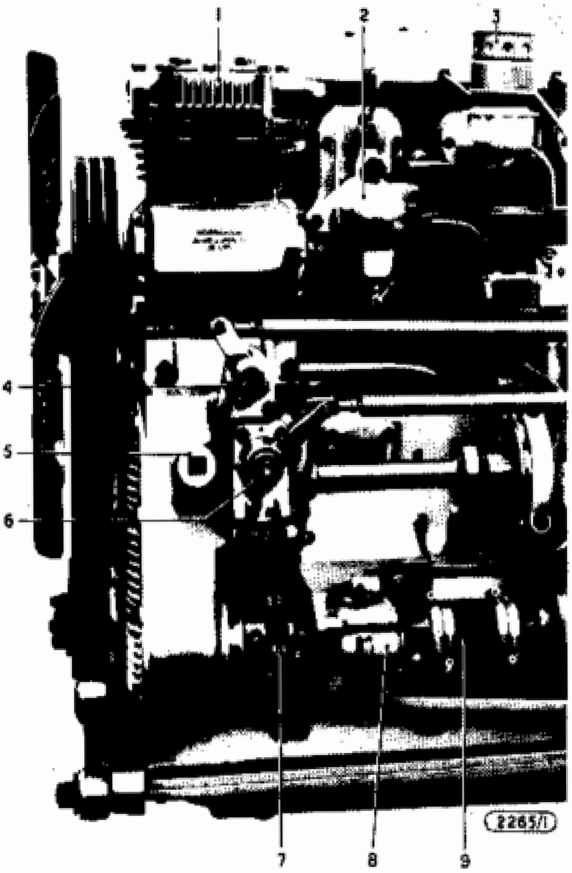


1 Starting Fuel Plunger
2 Slider Bar Buffer
3 Fuel Control Box
4 Air Bleed Screws
5 Fuel Pump Hand Operating Levers
6 2BA Screws (access for lubrication of slider bars and quadrants)
7 Accelerator Lever
8 Slow Running Adjustment Screw
9 Stopping Lever
10 Access Plug to Governor Weights
11 Lubricating Oil Cooler Pump
12 Fuel Inlet
13 Fuel Lift Pump
14 Priming Lever
15 Fuel Outlet and Non-return Valve
16 Hand Operating Lever Latch

Fig. 13. Fuel Pumps and Governor Unit

FUEL INJECTION PUMPS—*continued*

gear meshing with a similar gear mounted on the valve camshaft. The driven gear is free to slide on a helical spline on the fuel pump camshaft and, by means of a yoke coupled to the advance and retard lever can be moved axially and thus vary the timing of the fuel injection.



1 Compressor
2 Fuel Filter
3 Engine Breather Filter and Oil Filler Cap
4 Accelerator Control Cross-shaft
5 Timing Chain Access Plug
6 Injection Advance and Retard Friction Device
7 Flexible Coupling Drive
8 Plessy Pump for Power Steering
9 Dynamo Drive Hose Coupling

Fig. 14. Injection Control and Auxiliary Drives

35. **ADVANCE AND RETARD OF INJECTION: ADJUSTMENT.** Since the accelerator lever is essentially a speed control and not primarily a torque control, it is coupled by a connecting rod to the lever of the advance and retard mechanism, and thus the timing of the moment of injection is varied automatically according to the speed of the engine. The mechanism consists of a small lever adjacent to the accelerator lever which is coupled by a horizontal, forked end connecting rod to the lever of the advance and retard mechanism located on the chain case at the forward end of the engine. Should the mechanism become deranged it is a simple matter to readjust it since the maximum advance mark on the index plate corresponds to the maximum speed position of the accelerator lever. Occasional inspection should be made to see that this position is maintained. When driving the engine depress accelerator pedal progressively according to speed. This procedure will be found to provide the best acceleration and the quietest engine operation. Unlike throttle controlled or other engines, it is unnecessary to depress fully the pedal to obtain maximum torque unless maximum speed is attained whereupon it is necessary to fully depress the pedal. Slight acquaintance with the engine will automatically establish the facility of the preceding recommendations.

When the advance and retard mechanism moves the helical gear axially on the splines of the camshaft as described in paragraph 34, there is a slight reaction on the mechanism from the cams. To provide against this movement being transmitted to the accelerator lever and so wearing the connecting links, etc., an adjustable friction device is fitted, consisting of a cork disc clamped between the case and the advance pointer lever which is loaded by a castle nut and a spring washer. See Fig. 14.

To set the spring washer to the correct load the nut should be tightened until the spring washer is fully compressed, the nut should then be undone one hexagon flat and the split pin fitted. This friction device should be inspected and if necessary adjusted as indicated at 48,000 mile (4,800 hours) intervals. The castle nut should not be made tighter than stated, otherwise the accelerator lever will be made stiff in action and be prevented from returning to the slow-running position. The amount of friction applied by this means may be judged by operating the accelerator lever, but if this is done whilst

FUEL INJECTION PUMPS—*continued*

the engine is stopped the fuel pump levers must be latched back to relieve the fuel pump tappet spring load from the fuel pump camshaft. The friction disc should be renewed at major overhaul.

On horizontal engines the recess around the castle nut should be packed periodically with stiff grease to prevent possible entry of water at this point.

36. **FUEL PUMPS SLIDER BAR ADJUSTMENT** This slider bar is operated by the centrifugal governor and its function is to vary the amount of fuel injected into the cylinders and thus vary the delivered power of the engine. It is connected to the governor lever by the governor bar connecting link. The effect of moving the slider bar towards the flywheel is to increase the amount of fuel injected into the engine and vice versa. If the bar is moved to the full extent towards the timing case, there is no injection. The correct setting of the slider bar with relation to the governor weights is such that when the governor weights are parted to their full extent by inserting the fingers through the inspection opening in the governor case, the length of the governor bar connecting link is so adjusted as to give the slider bar a position approximately $\frac{1}{32}$ in. (·794 mm.) from its maximum stroke towards the timing case. Inspect that this dimension obtains every 48,000 miles (4,800 hours) in order that the governor may exercise complete control of engine speed. Inspect also governor weight pin securing split pins.

It is of the utmost importance that the governor bar connecting link be adjusted as above. Since, if the link be adjusted to such a length as to leave no clearance in the above position there is a grave risk of the small centre ball races sustaining damage with serious consequences. The governor weights are provided with a substantial abutment at their fulcrum to determine their maximum extended position and thus relieve the connecting link and small ball race of this duty. If $\frac{1}{32}$ in. (·794 mm.) clearance be not allowed, the full power of the governor weights may be transmitted through the small bearings, which normally carry only the load applied by the outside governor bar return spring.

In an engine which has operated for long periods with a very slack or badly worn timing chain and/or severely worn splines on the fuel pump camshaft the consequent very uneven drive to the governor can create serious wear on all parts of this mechanism.

These faults in the timing drive must not, therefore, be allowed to persist.

37. **STARTING FUEL PLUNGER.** Located underneath and at the end of the aluminium box attached to the front of the forward fuel pump unit is a vertical spring loaded plunger (see also paragraph 38). When pressed up as far as it will go, this plunger lifts the fuel limiting trigger and allows the fuel pump slider bar to move towards the flywheel in which position the pumps deliver an increased charge of fuel for starting from cold.

If the slider bar be sluggish in operation, it may be assisted by finger pressure on the return spring behind the fuel pumps. As soon as the engine is started, the slider bar automatically retakes its normal working position in which the pumps cannot give an excessive charge of fuel.

Important.—This plunger is to be used *only when starting from cold*; it must on no account be used when the engine is running in order to increase the power of the engine. If the plunger be held or propped up while the engine is working, the pumps may deliver more fuel to the engine than it can burn and serious trouble may occur.

38. **STARTING FUEL PLUNGER—ROAD VEHICLES.** Regulations under the United Kingdom Road Traffic Act make it necessary that any device which will facilitate the starting of a motor vehicle compression ignition engine by causing it to be supplied with excess fuel must be so arranged that the device cannot be readily operated while the vehicle is in motion on the road. We have accordingly produced a tool-operated excess fuel device which is shown in Fig. 15.

The device consists of an extension to the aluminium housing of the fuel control box fitted on the forward fuel injection pump. The housing extension contains a compression spring and plunger which carries two 90° screwdriver slots at its outer end and an eccentrically disposed peg at the inner end. The device is operated by lifting the dust flap and engaging the screwdriver in the plunger slot. The plunger is then pushed inwards and rotated approximately half a revolution. This engages

FUEL INJECTION PUMPS—*continued*

the eccentric peg with an arm on the fuel limiting trigger, thus lifting it and allowing the fuel pump slider bar to move to the excess fuel or cold starting position. When the screwdriver is removed, the internal compression spring moves the plunger outwards and disengages the eccentric peg. The only maintenance required is lubrication with a few drops of oil on the plunger and spring.

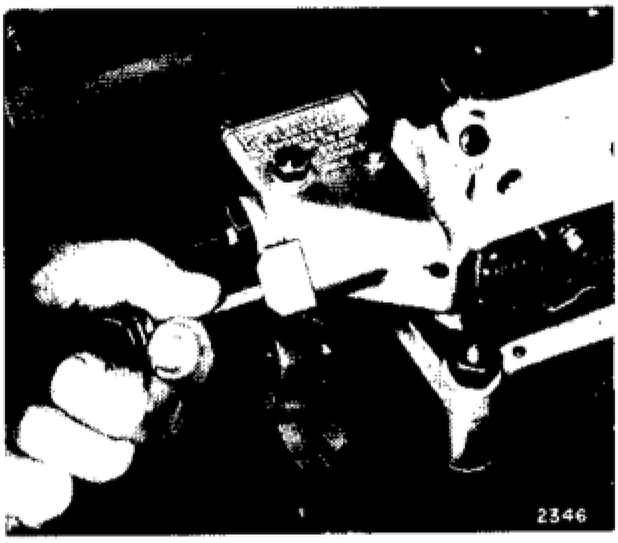


Fig. 15. Tool Operated Excess Fuel Device

39. **ADJUSTMENT OF FUEL PUMP SLIDER BAR BUFFER.** Located on the fuel control box will be seen the governor bar buffer, the purpose of which is to prevent stalling of the engine in the event of friction being generated in the fuel pump.

The governor bar buffer should be adjusted according to the following procedure when the engine has reached normal operating temperature. Adjust idling speed to 420 r.p.m. by means of flanged nut on governor case as described in paragraph 43, Page 37, screw buffer gradually towards bar until slight speed increase is experienced, withdraw buffer 2 hexagon flats and lock in position. If the buffer is set with insufficient clearance from the slider bar, unstable idling will result. Use only light pressure to lock the buffer in the fuel control box.

GOVERNOR AND GOVERNOR CONTROL

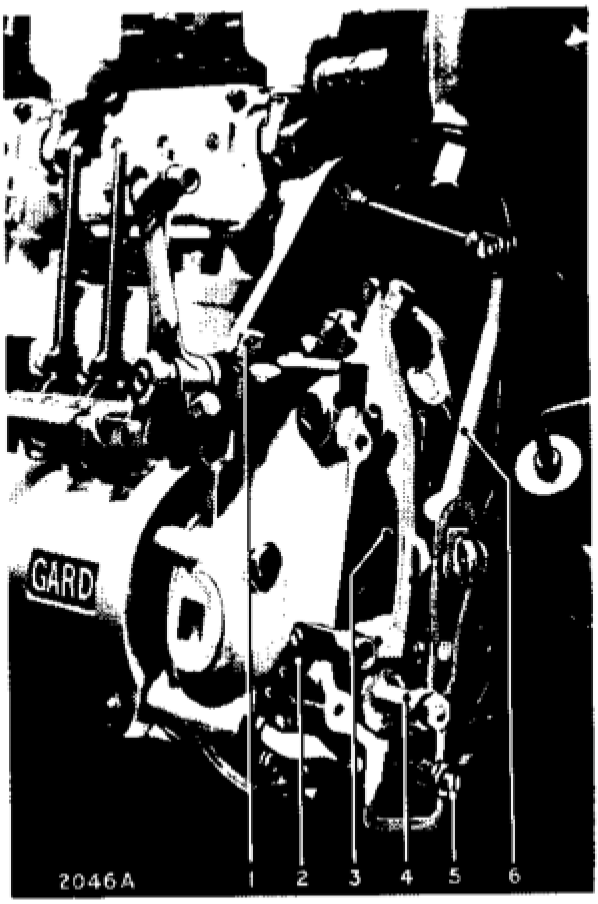
40. **ACCELERATOR CONTROL.** The speed of the engine is controlled by means of the usual pedal which is coupled to the lever provided on the governor case. This should be inspected every 48,000 miles (4,800 hours) to ensure that the pedal-operating mechanism is working the control throughout the whole of its range, that is, from idling to maximum speed. An inspection of the accelerator mechanism will reveal two stops to limit the angular travel of the accelerator lever in either direction; the setting of these two stops should not be deranged. When the accelerator lever is in its maximum speed position the two $\frac{5}{16}$ in. (7·938 mm.) dia. pegs at the lower end of the forked governor spring lever should be just touching the rear face of the governor case. Do not under any circumstances alter or interfere with these $\frac{5}{16}$ in. (7·938 mm.) pegs, or otherwise increase the maximum governed speed of the engine as set by the Makers during tests at the Works. When driving a passenger or goods vehicle, etc., and when accelerating from rest, do not, unless maximum acceleration is required, run engine up to maximum speed in the indirect gear ratios. More fuel is used, more noise is generated, more wear is occasioned.

SERVICING AND MAINTENANCE

GOVERNOR AND GOVERNOR CONTROL—*continued*

41. POSITION OF ACCELERATOR LEVER. In order that the foot control be "light" it is necessary to arrange the geometry of the accelerator linkage so that the rods and levers are mutually at an angle of 90° when the accelerator lever is in a position 40° from the idling speed position. This provides the greatest leverage when the greatest effort is required and avoids heavy pedal pressure.

42. GOVERNOR. The centrifugal type governor is totally enclosed by a cast aluminium cover which is easily removable to gain access for any simple adjustments which may be necessary after prolonged service. The governor consists primarily of two flyweights loaded through a ball thrust race by a compression spring. Movement or operation of the accelerator control increases or decreases the load which this spring exerts, thus varying the engine r.p.m. The engine is under complete control of the governor at all speeds ranging from the lowest idling speed to maximum r.p.m. At the rear of the governor is situated a flanged sleeve nut and locknut which provides the means for adjustment to the idling speed. Fig. 16.



1 Maximum Speed Limiting Screw
2 Stopping Lever
3 Governor Spring Lever (cam operated)
4 Idle Speed Adjustment Nut
5 Stopping Lever Cam Tappet Screw
6 Governor Lever

Fig. 16. Governor Control

43. SLOW RUNNING ADJUSTMENT. The engine is set to idle at approximately 420 r.p.m. during test and this speed should be adjusted accordingly every 12,000 miles or when necessary, since slight wear of parts may reduce speed and lead to unsteady idling.

After starting a cold engine, make use of the hand speed control (if fitted by main contractor) until the engine attains normal operating temperature, before adjusting the slow-running. If hand control is not fitted, ensure by pedal control that the engine speed is suitably maintained. Preliminary adjustment is effected by the hexagon headed setscrew and locknut located on the remote control cam stop mounted on the accelerator cam spindle, see Fig. 13. This is adjusted to give an idling speed of 415 r.p.m. Final slow running adjustment is then carried out by the flanged sleeve nut and locknut at the rear of the governor casing, access to which is obtained by removal of the governor casing rear cover. The flanged nut is screwed gently inwards until it bears on the governor spring guide and the idling speed thereby increased to 420 r.p.m. The adjusting sleeve nut is then held and locked by the locknut. When correctly adjusted the roller on the fork lever should be just clear of the cam, allowing the slightest rock to be felt at the lower end of the fork lever whilst the engine is idling.

Marine Propulsion Engines. Slow running adjustment on marine propulsion engines is similar in every respect to that described above but the setscrew and locknut are mounted on the friction-disc lever control plate, instead of on the remote control cam stop.

FUEL SPRAYERS

44. **FUEL SPRAYERS.** Illustrated in Fig. 17 the sprayer will be seen to be a very simple and robust piece of apparatus, and is designedly made non-adjustable, meaning that when the sprayer is re-assembled after being taken to pieces for cleaning or examination (as distinct from overhauling), it requires no adjustment of any kind. The sprayer may be said to be one of the most important components of the engine: its function is to receive the minute fuel charge and to convert it into a fine spray. To this end, the fuel charge is forced through fine passages which would be liable to become choked with any foreign matter which may find its way into the fuel were it not for the ample precautions taken by the makers to avoid this contingency. These are mentioned in paragraphs 26 and 28, Page 30.

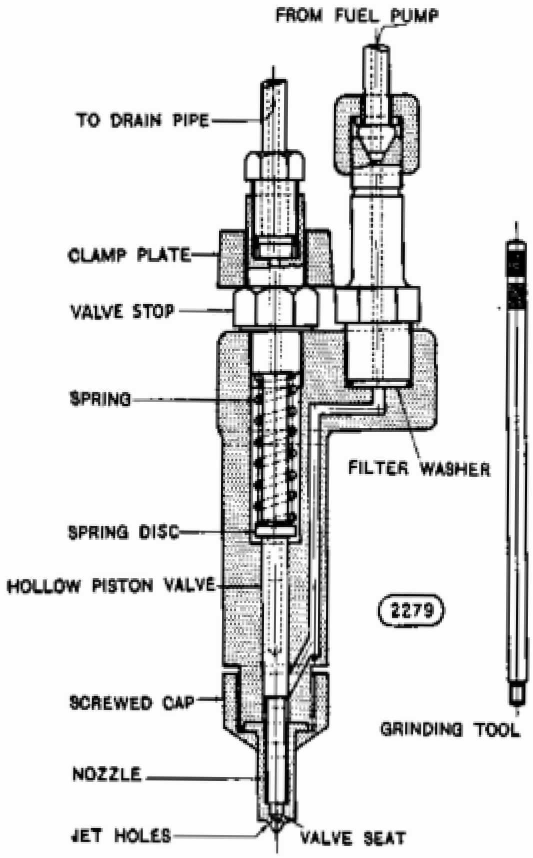


Fig. 17. Section through Fuel Sprayer

45. **FUEL SPRAYER TEST EVERY 8,000 MILES (800 HOURS).** These should be tested, without removal from the cylinder heads, by operation of the hand priming levers fitted to the fuel pumps on all Gardner engines. This test can be carried out in a few minutes and if the sprayer valve is not heard or felt to vibrate when the lever is pulled quickly the sprayer should be replaced by a service unit. This simple test will give a reliable indication of an imperfect sprayer valve seat or a friction bound valve. Continued use of a defective sprayer can have very undesirable results such as fuel dilution of lubricating oil, impaired fuel consumption, loss of power, burning of exhaust valves and even cracking of cylinder heads, etc., etc.

Fig. 18 illustrates the hand operation of the fuel pumps but shows the sprayer removed from the engine as would be the case when a corrected sprayer was being re-tested without the facility of bench testing equipment.

Every 48,000 miles (4,800 hours). Fit Gardner factory-reconditioned or other suitably inspected and serviced set of sprayers. Return unserviceable sets to Works or Depots for reconditioning or inspect and workshop-service as directed in paragraphs 51 to 62, pages 83 to 85.

46. **RECONDITIONING OF SPRAYERS.** Large-scale manufacture and reconditioning of sprayers facilitated by specialised machines, equipment and knowledge, is continuously in progress at our Works and it is recommended that sprayers be returned to the Works for overhaul since by adopting this procedure the user will be assured of obtaining the most efficient and durable sprayer operation at the most economical cost.

47. **ROUTINE CHANGE OF SPRAYERS.** In cases of large annual mileage, it is an excellent practice to stock a complete set of spare sprayers which may be changed every 48,000 miles (4,800 hours). This permits of systematic cleaning and examination without loss of mileage. In many duties it is commonly found that this period can be at least doubled.

48. **DEFECTIVE SPRAYERS.** If a sprayer is known to be defective, do not run the engine any longer than

FUEL SPRAYERS—*continued*

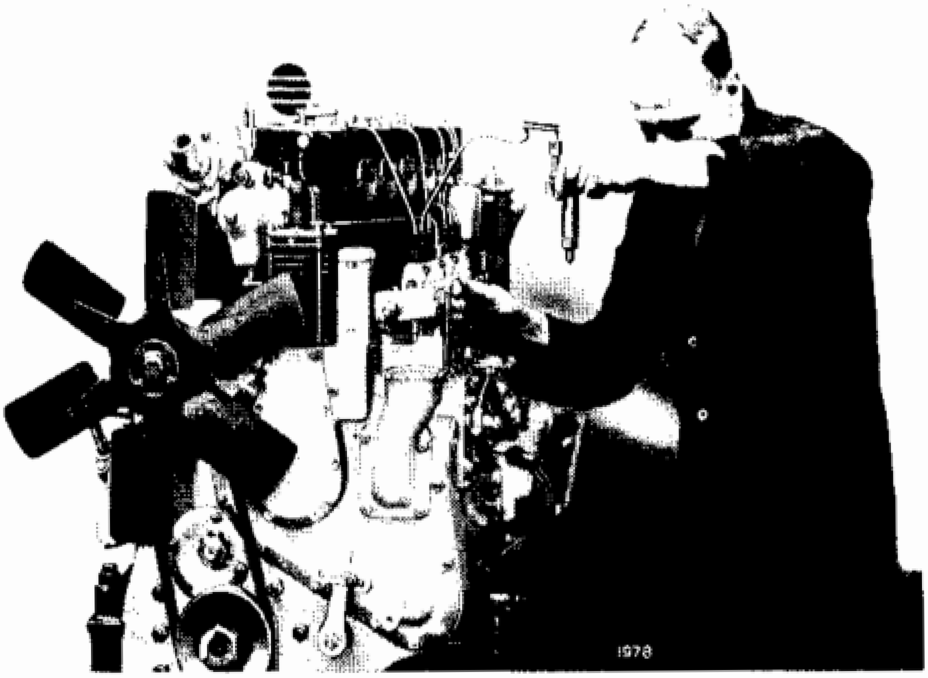


Fig. 18. Testing Sprayer Removed from Engine

is absolutely necessary since this will cause undue wear accompanied by other evils.

49. REMOVING THE SPRAYER FROM THE CYLINDER HEAD. A special key is provided in the tool kit for releasing the single castle type nut on the clamp lever which holds each sprayer in the cylinder head. Should the sprayer prove difficult to withdraw after releasing the nut and removing the clamp, there is supplied also with each engine special drawing tackle consisting of a bridge bar through which passes a screwed rod with nut. The end of the rod should be screwed into the drain pipe union on the sprayer, the bar set to bridge the top faces of the cylinder head and the nut screwed down against the bridge bar to draw out the sprayer.

50. FUEL SPRAYER INSPECTION. Make the following inspections and tests, etc.:

(1) Test for stoppage of jets and shape of issued jets of fuel.
(2) Test for leak of sprayer valve-nozzle seat.
(3) Test for satisfactory vibration of sprayer valve.
(4) Test for leakage of fuel past large diameter of valve.
(5) Test spring load on sprayer valve and/or hydraulic opening pressure.
(6) Observe sprayer cap nut for effective gas seal with cylinder head.

These tests can be carried out by removing sprayer from engine, reconnecting to sprayer pipe and hand operating the fuel pump priming lever.

51. TESTS FOR STOPPAGE OF JET HOLES AND SHAPE OF ISSUED FUEL JETS. Mount the sprayer on a fuel pipe connected to the engine fuel pump, see Fig. 18, or to a bench-mounted test pump in such a manner that the fuel jets are visible when the

FUEL SPRAYERS—*continued*

hand lever is operated. The jets of fuel emitted from the nozzle holes should all travel through the same distance and possess the same shape. If defective, prick out the holes with a pricker, and at the same time clean out the central bore of the nozzle. The size of holes is of great importance, therefore use only prickers of the correct diameter. These are available from the Works.

For further instructions refer to Pages 83 to 85.

52. **REPLACING A SPRAYER IN THE CYLINDER HEAD.** There is a clearance between the sprayer nozzle and the hole in which it fits in the cylinder head, consequently the space thus left becomes, in the course of time, filled with carbon. When, however, the sprayer is withdrawn, it leaves a liner of carbon which must be removed before replacing the sprayer: otherwise the carbon liner is liable to become disturbed and so prevent the sprayer body making a true gas-tight joint on the conical seat. The carbon liner is readily removed by the aid of the fluted reamer supplied with all engines, and which should also be used to clean the seat.

When clamping a sprayer in the cylinder head, do not tighten up the nut more than is necessary. The feeling of tightening up against the spring of a clamp is different from that of bolting two surfaces together, and thus is liable to deceive the engineer into screwing down harder than is necessary. It requires but comparatively little screw pressure to make a tight joint on the conical seat. The special key and short tommy bar, supplied with each engine, should be used to tighten the sprayer clamp nut. If excessive pressure is used the sprayer body may be distorted and its functioning impaired, in addition the cylinder head may suffer distortion and possible cracking. The correct tightening torque for these nuts is 150 lb. in. (1·7 kg.m.). This must not be exceeded.

53. **SPRAYER PIPE CONNECTIONS.** Ensure that the union nuts of the sprayer pipes are tight. It is imperative that these unions do not leak particularly at the sprayer end, since any leakage from these unions will drain into the crankcase and contaminate the lubricating oil. This applies equally to unions on the sprayer drain pipes.

54. **CHECKING FOR LEAKAGE.** When sprayers have been refitted to the cylinder head, run the engine with the valve covers removed and make careful inspection to ensure that there are no fuel leaks at the sprayer pipe unions (as mentioned in paragraph 53 above) and check that the sprayers make a gas-tight seal in the cylinder head by applying oil from an oil-can to the recess around the sprayer whilst the engine is running. In this way any leakage will be detected by the formation of bubbles.

55. **SPRAYER PIPE MAINTENANCE.** After long use the conical pipe ends may become reduced in bore by repeated tightening of the union nuts. This restriction of the fuel passage is detrimental to engine operation and may cause excessive fuel injection pump pressures. Therefore make inspection at overhaul that the minimum bore available at the unions is ·069 in. (1·753 mm.) for a length of ½ in. (12·7 mm.) from the end of the pipe. If the conical union ends of the pipe become deformed they may damage the sprayer and fuel pump stocks and in this event must be renewed. Before refitting the pipes inspect the valve cover rubber seals and renew if necessary.

SERVICING AND MAINTENANCE

TIMING CHAIN

56. **ADJUSTMENT OF TIMING CHAIN.** Wear of the timing chain is accelerated by lack of adjustment and undue slackness may promote noise and unsteady governing. Chain adjustment should be checked after the first 12,000 miles (1,200 hours) and every 48,000 miles (4,800 hours) inspect and adjust if necessary by means of the manual chain lever adjuster shown in Fig. 19. The chain is correctly adjusted when it is possible to move the middle of the nearly vertical run through approximately a distance of ⅛ in. (3·2 mm.) either side of the mean position, i.e. ¼ in. (6·35 mm.) maximum overall deflection with finger pressure. Do not run the engine with excessive chain slackness. Similarly, it is important to avoid over-tightening the chain as, of course, this also will create an abnormal rate of wear.

A ready method of checking whether slackness is present is by rocking the generator drive shaft back and forth by hand having first turned the crankshaft backwards a portion of a turn to relieve "pull" on the sprocket. If tension is correct, movement on the drive shaft should be only just visible.

An alternative and more accurate method is to remove the plug in the timing case (Fig. 14, Item 5) and insert a length of 10 gauge steel wire with a short right-angle bend at the end to engage the chain links. Movement of the wire inwards and outwards will accurately determine the amount of slack present.

TO ADJUST CHAIN TENSION

Chain Adjusters with Split Clamp Plate

(1) Loosen the ⅜ in. B.S.F. clamp nut using 5/16 in. hexagon socket spanner.

(2) Holding the chain adjuster locking lever, loosen the securing nut and turn the lever clockwise until the desired chain tension is achieved. Retighten the nut securing the adjuster locking lever.

(3) Tighten the ⅜ in. B.S.F. clamp nut to a torque of 350 lb.in. (4·025 kg.m.).

Important. Because the clamp plate is of necessity split, a "soft" feel is given to the ⅜ in. B.S.F. nut on tightening. This should not be interpreted as a thread stretching or stripping and tightening should proceed until the requisite torque has been reached.

Do not release hold on lever while nuts are slack otherwise the timing may be disturbed through the chain disengaging from the crankshaft sprocket. The washer fitted between the ⅜ in. B.S.F. nut and clamp plate is made of hardened steel and should be kept separate from other washers in the event of removal.

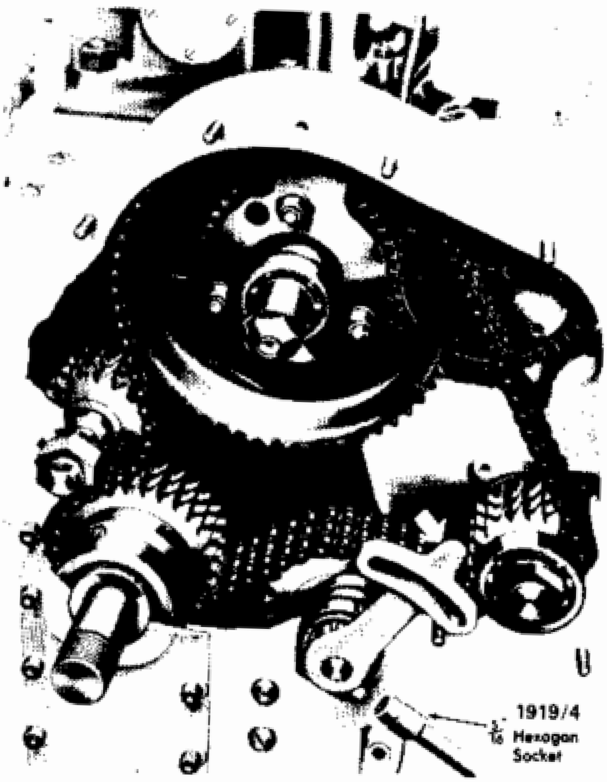


Fig. 19. Timing Chain Adjuster

Chain Adjusters with Large Hexagon Lock Nut

The procedure for adjustment is the same as described above, except that the large lock nut, which is used to secure the adjuster in the timing case, is slackened in order to effect adjustment.

The locking lever must always be moved clockwise to increase tension and anti-clockwise to release tension. If the reverse occurs, the adjusting idler will be incorrectly positioned between the crankshaft and alternator sprockets.

TIMING CHAIN—*continued*

Should it be found after long use that the stud in the locking lever slot prevents further movement, the lever may be removed and re-engaged on the spindle in the appropriate position permitted by the bi-hexagon hole in the lever arm.

If the split clamp type chain adjuster is dismantled it is essential when re-assembling that the large conical faced castellated nut be firmly screwed by finger pressure into contact with the split clamp plate whilst the ⅜ in. B.S.F. nut remains slack. The split pin should then be re-fitted to retain the castellated nut in position.

Providing our engine lubrication recommendations are followed and reasonable attention is paid to adjustment, the timing chain should not require renewal until the engine is completely overhauled.

56.1. **CORRECTION FOR WEAR OF TIMING CHAIN.** In the course of time the chain wears and consequently increases in length, which causes the timing of the valves and injection to become slightly retarded, resulting in appreciable reduction in engine efficiency. Every 48,000 miles (4,800 hours) the timing should be checked, as indicated in paras. 70 and 71, pages 88 and 89. With a standard rotation engine (anti-clockwise viewed from flywheel end) tightening of the chain by moving the chain adjuster lever in a clockwise direction automatically restores correct timing, but on opposite rotation engines (clockwise rotation viewed from flywheel end) it will be necessary to correct the timing as well as the chain tension since adjustment of the tension will further retard the timing of the valves and injection. To correct the timing it will be necessary to remove the chain case cover to gain access to the three nuts securing the valve camshaft chain wheel to the camshaft hub (see Fig. 19). Set the injection control pointer in the full speed position and turn the flywheel so that the injection timing mark coincides with the line on the crankcase end plate or flywheel housing. Slacken the three nuts on the chain wheel and rotate the camshaft slightly anti-clockwise (which also slightly rotates the fuel pump camshaft) until the timing lines on the fuel pump plunger guides coincide with the lines on the sides of the fuel pump body windows. The three nuts on the chain wheel should then be firmly retightened.

DECOMPRESSION GEAR

57. **DECOMPRESSION LIFT OF INLET VALVE.** The decompression levers at the rear of each cylinder head operate small shafts in which are fitted adjustable screws with locknuts located under each inlet valve lever. See Fig. 20.

The act of turning the decompression levers to the decompression position causes the adjustable screws of the shafts to bear upon the heel of each inlet valve rocker lever. This action lifts the heel and consequently holds open the inlet valve. The amount of opening is determined by the adjustable screw which, in case of derangement, should be adjusted so that it lifts the inlet valve ·020 in. (·508 mm.) from its seat. Decompression lift may be measured with a dial indicator, as shown in Workshop Tools Book No. 63.

The shafts are grooved at the lever ends and fitted with synthetic rubber sealing rings which prevent oil leakage at these points on the cylinder heads.

SERVICING AND MAINTENANCE

VALVE TAPPETS

58. **VALVE TAPPET ADJUSTMENT.** It is essential, in the interest of durability and efficiency, that the correct clearance is maintained between the end of the valve and the toe of the valve lever. Clearances should be checked and, if necessary, adjusted every 12,000 miles (1,200 hours).

Frequency of adjustment will vary according to engine duty and lubricant, etc., for example an engine operating continuously at high speed with heavy load in hilly country will require more frequent adjustment than one on lighter duty.

Excessive clearance increases stresses and noise in the valve and valve gear and reduces the efficiency of the engine. The importance, therefore, of regular inspection cannot be over emphasized.

The correct clearances for LX and LXB engines are:

Inlet ·004 in. (·102 mm.)
Exhaust ·008 in. (·203 mm.)

Adjustment should always be made with the piston at the top of the compression stroke and when the engine is cold. To find this position, de-compress all the cylinders and turn the flywheel until the inlet valve under consideration just closes, then turn the flywheel a further half-turn; the piston will now be at or near the end of the compression stroke. This position may also be verified by operating the injection pump belonging to the cylinder in question, the priming lever of which will indicate by ease of movement that the pump tappet is in the lifted position. When tightening the locknut of the tappet screw it is quite unnecessary to use great pressure.

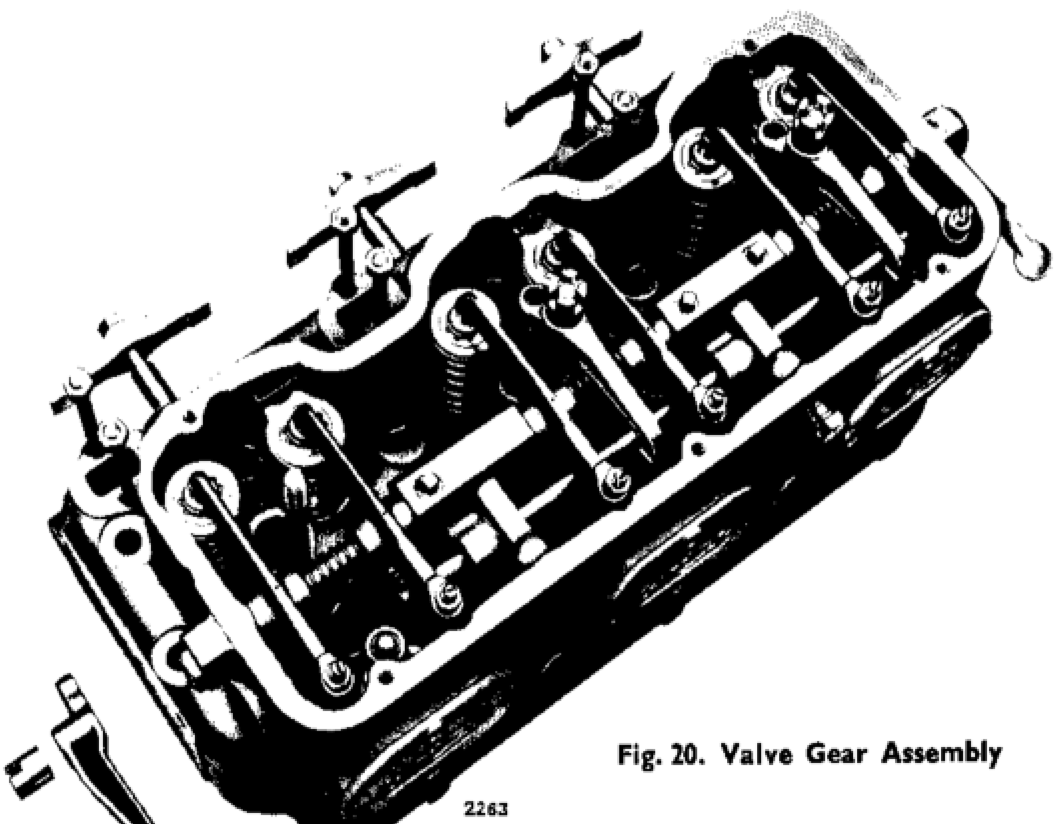


Fig. 20. Valve Gear Assembly

RADIATOR FAN

59. **FAN BELT ADJUSTMENT.** The belt drive should be inspected and the adjustment checked every 12,000 miles (1,200 hours). If properly maintained its useful life can be as much as 100,000 miles or more.

It is important that periodic inspection is maintained, since after prolonged use, stretch and wear will occur causing slackness. If this is allowed to become excessive it will result in rapid deterioration and eventual failure of the belt.

The fan mounting bracket incorporates an adjusting screw for tensioning the belt drive. Adjustment is effected by slackening the large nut at the rear of the fan spindle and turning the adjusting screw until the tension is such that a side movement of approximately 1 in. (25·4 mm.) is obtained on the longest run of the belt. After re-tightening the spindle nut, a final check should be made that correct adjustment has been maintained. Over-tensioning is to be avoided. It will be just as harmful as slackness and will overload the bearings of the fan spindle and also the compressor crankshaft, if a compressor is fitted.

Fig. 21. Fan Belt Adjuster

AIR INDUCTION FILTERS

60. **GARDNER UNIVERSAL OIL BATH TYPE AIR FILTER.** The filter body is attached to the mounting head by means of side bolts and incorporates inner and outer cavities both of which are made "air tight" by the use of sealing rings. The inner ring seals the cavity to the air cleaner element and the outer seals the cavity to the air cleaner body.

Dust laden air is drawn into the cavity "B" of the mounting head, and passes down the annulus "C". This annulus is reduced in area at the base, which results in an increased velocity where the dusty air impinges on the oil. The air flow is reversed upwards through the element into the inner cavity "D" thence through outlet "E" to the engine. See Fig. 22.

At the reversal of the air at oil level "A", dust particles are precipitated into the oil, and a small quantity of oil is picked up by the air stream and carried into the filter element. The oil wets the element and retains any dust remaining in the air. This dust is continually washed into the oil container as the oil drains back from the element. The dust eventually settles in the base of the oil container in the form of sludge, and the displaced oil enters the compensator chamber through a series of holes at "F" and finally through the centre hole "G".

61. **GARDNER TWIN OIL BATH TYPE AIR FILTER.** With this type of filter air enters through the aperture between the filter cover and body and is drawn downwards through the annular space between the filter body and filter element where it comes into contact with the oil. Dust particles are precipitated into the oil and the air flow is reversed upwards through the element carrying with it a small quantity of the oil which wets the element so extracting further dust from the air. The dust is washed back into the oil

SERVICING AND MAINTENANCE

AIR INDUCTION FILTERS—*continued*

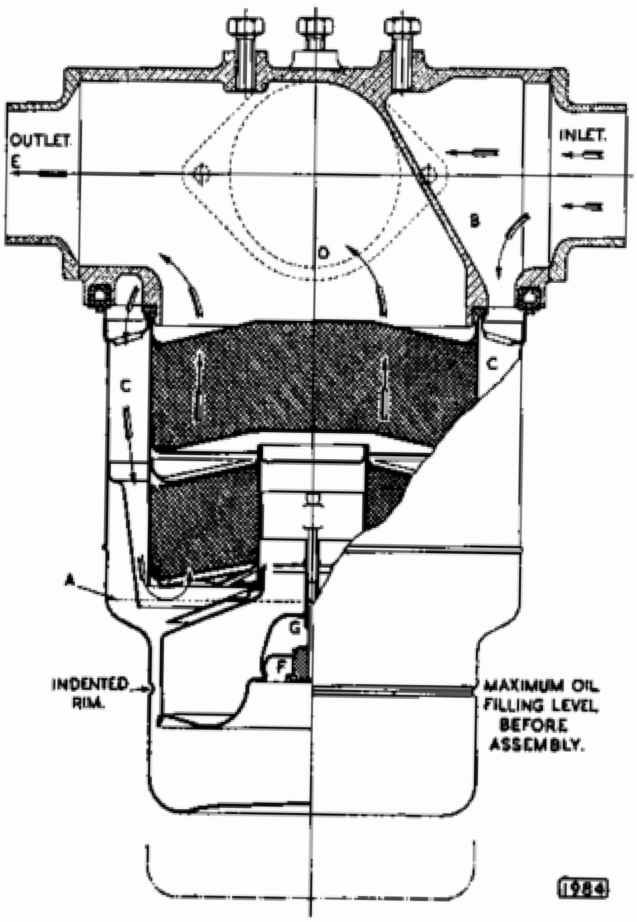


Fig. 22. Gardner Universal Air Filter

container as the oil drains from the element, and eventually settles in the base of the oil container in the form of sludge. The filters are easily and quickly removed as complete units by releasing the two wing nuts on top of the covers.

62. **CLEANING AND REPLENISHING CONTAINERS.** It is recommended that the elements of oil bath type filters be removed and washed in fuel oil and the container cleaned and replenished with fresh oil every 400 hours or 4,000 miles or alternatively at more or less frequent intervals depending upon the conditions under which the engine is operating.

When this type of filter is used on an engine which never exceeds say 1,200 r.p.m., the air velocity through the filter may be insufficient to cause adequate oil washing of the element. Under such conditions the element must be removed at more frequent intervals and washed in a hot water detergent solution, after which it must be blown through and thoroughly dried with a compressed air jet before reassembling.

The grade of oil used for replenishing containers must be of suitable viscosity according to the prevailing climatic conditions. The following grades of oil are recommended:—

Mean Annual Temperature	*Grade of Oil*
40°F. (4½°C.) to 70°F. (21°C.)	.. S.A.E. 30
Over 70°F. (21°C.)	.. S.A.E. 50

To remove the filter unit on the Universal Type Cleaner unscrew the two elongated brass nuts and withdraw the container downwards and away from the filter head. The filter unit may then be dismantled for cleaning by removing the filter element from the container and disconnecting the compensator chamber by unscrewing the thumb nut located in the recess underneath.

After cleaning the containers of both types of filters they should be filled to the level indicated with clean fresh oil and care taken to ensure that the oil does not rise above this level otherwise serious damage to the engine may result.

After washing the elements in fuel oil they must be allowed to drain before being replaced in the containers.

With routine attention of this nature, the filters may be expected to give trouble free service throughout the life of the engine.

63. **DRY TYPE INDUCTION AIR FILTERS.** The elements of dry type induction air filters are constructed with specially processed paper and they may, in service, be subject to rapid accumulation of filtered media which they have successfully prevented from passing to the engine.

CAUTION.—When such accumulation occurs, there is created an increased resistance to the passage of air to the engine. This condition is highly undesirable since it will cause smoke, high fuel consumption, loss of power, overheating, together with other attendant ills and high maintenance. **The importance, therefore, of regular and frequent cleaning of this type of filter cannot be over emphasised.**

SERVICING AND MAINTENANCE

AIR INDUCTION FILTERS—*continued*

Engine induction air should always be drawn from the coolest place and paper elements or filter units should be so positioned that they do not receive water, oil or oil vapour. If an element is to be mounted under the bonnet or engine casing it should be forward of the engine so that the air stream will carry engine fumes away from the filter.

64. **MEASURING RESISTANCE TO AIR FLOW.** Resistance to air flow develops during varied periods of time or mileage, according to duty and operating conditions, etc. Field experience indicates that a regular and frequent measurement of the resistance should be made in order to secure efficient and durable engine operation. A user will, from experience, readily determine the "check" periods necessary for his own service.

The resistance of the filter may be assessed by measuring the depression in inches of water with a simple water manometer coupled to the end of the engine induction manifold, when the engine is running at maximum speed.

The latest engines are permanently fitted with a $\frac{1}{8}$ in. BSP connection for this purpose and existing engines can be readily so equipped.

A simple manometer can be readily constructed comprising a parallel transparent P.V.C. plastic tube, approximately $\frac{5}{32}$ in. (4 mm.) bore $\frac{13}{32}$ in. (10 mm.) outside diameter and a total length of 15 in. (381 mm.). Manometers of this type, Part No. MA 563 are available from the Works, and if desired, can be carried in the driving compartment for use at any time.

Alternatively, it may be considered convenient to mount two tubes in a suitable position on a vertical or near vertical surface of the driving compartment so that it can be permanently connected to the air intake manifold to record manifold depression.

The lowest depression obtainable is desirable and with a well-designed layout less than 4 in. (102 mm.) of water is measurable.

Some filter assemblies incorporate a warning whistle, but it is advisable to make the above manometer test.

65. **CLEANING AND RENEWAL OF FILTER ELEMENT.** As mentioned earlier it is of vital importance that air cleaners receive regular and frequent attention and when an element becomes choked enough to create a depression of 12 in. (305 mm.) of water it should immediately be replaced or cleaned.

It is good practise to carry a spare element in the vehicle.

The cleaning of elements, which is only recommended when new ones are not immediately available, can be effected by washing in Cooper-Kleen or a non-sudsing detergent. The water must be no hotter than a hand can bear and, after rinsing, the element must be thoroughly dryed in warm circulating air—not in an oven.

It must be noted that the life of a cleaned element will be considerably less than that of a new one, since a life prolonging chemical will have been removed in the washing. In any case all serviced elements should be closely examined against a light for damage to the paper and sealing faces.

AUXILIARY UNITS

66. **ELECTRICAL EQUIPMENT.** The electric starter and alternator should be examined at regular intervals to ensure that mounting straps and all electrical connections are securely tightened.

Examine cables for looseness or fracture, particularly at the point where the cable enters the terminal lug and see that the cable insulation is free from chafing and deterioration.

Check periodically the alternator drive arrangement and see that the clips on the flexible coupling at each end of the shaft are firmly tightened.

Special care must be taken when tightening the two flexible hose type rubber couplings (See Para. 80, Page 93).

For full servicing instructions on electrical units, refer to the maker's handbook.

SERVICING AND MAINTENANCE

AUXILIARY UNITS—*continued*

67. **COMPRESSORS.** These are of proprietary manufacture and are fitted to engines for the operation of compressed air braking systems and other auxiliaries. They are driven from a treble groove pulley on the front end of the crankshaft by means of the triple belt which also drives the fan.

As already mentioned in Paragraph 16, Page 25, lubrication is effected through the engine lubrication system and for further maintenance instructions reference should be made to the maker's handbook.

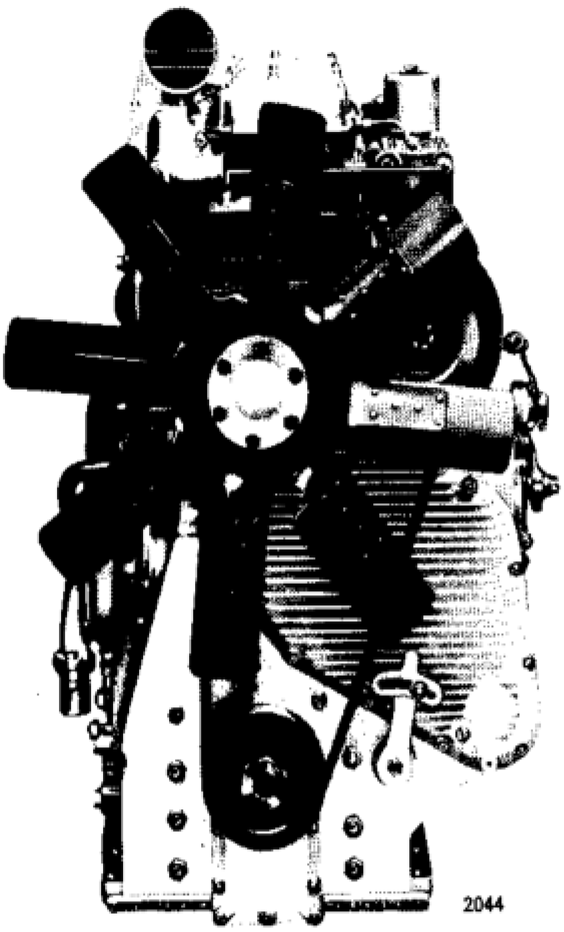


Fig. 23. 6LX Engine fitted with Compressor

68. **BILGE PUMP AND DRIVE (Marine).** This is a ram type pump and (when fitted) is mounted on the main timing chain cover.

On the outward end of the pump body will be found a small vent or snifting valve. This consists of a bronze ball resting on a seat and limited in lift by a knurled-headed screw. The purpose of this valve is to admit a small amount of air together with the water during the Suction Stroke of the pump and so prevent water hammer. To set the valve correctly the knurled screw should be screwed down by hand as far as it will go; and then unscrewed approximately quarter of a turn and locked in this position. If the valve is set too wide open, too much air will be drawn into the pump and so reduce the amount of water delivered.

When marine engines leave the Works the Snifting Valve and Safety Valve are removed from the Bilge Pump and securely attached to the pump by wire: this precaution is taken to avoid damage in transit.

The pump is driven by an eccentric on the valve camshaft through the intermediary of a friction clutch so that it may be put into or out of operation at will.

The friction clutch is operated by a hand-wheel located on the outside of the timing case cover. This hand-wheel is screwed on an externally threaded sleeve to which it is locked by a setscrew.

Clockwise rotation of the hand-wheel screws the threaded sleeve inwards, compressing the clutch spring which in turn loads the two halves of the cone clutch. When pressure is released by unscrewing the hand-wheel the driving cone is held out of engagement by a light spring.

69. **CLUTCH SPRING LOAD ADJUSTMENT: BILGE PUMP.** The designed loading on the clutch spring is such that, when the hand-wheel is in the fully engaged position, a pressure of 20 lb./sq. in. (1·406 kg./sq. cm.) is recorded on the output side of the pump.

If, after long use, it becomes necessary to restore the designed spring loading of the clutch, this can be effected by fitting thin shims between the brass thrust pad in the hand-wheel and the outer end of the screwed sleeve thus permitting additional inward movement of the sleeve by the hand-wheel to increase the spring pressure on the clutch cones.

From the commencement of clutch engagement to full load engagement requires between half and one complete turn of the hand-wheel. This must not be appreciably exceeded otherwise excessive load will be imposed on the camshaft end bearing resulting in undue wear of the bearing thrust face.

8LXB EXHAUST SYSTEMS

70. **8LXB AUTOMOTIVE EXHAUST PIPES ASSEMBLY.** When assembling the heat shield or shields, ensure that all "O" rings and cup washers are correctly positioned each side of the plate. Tighten the nuts just sufficient to prevent rotation of the "O" rings and cup washers and then further tighten by *one complete turn*.

Note that the two shouldered studs holding the shield adjacent to the sump joint face are longer than the upper three studs in the crankcase rib. These upper and lower studs must not be interchanged.

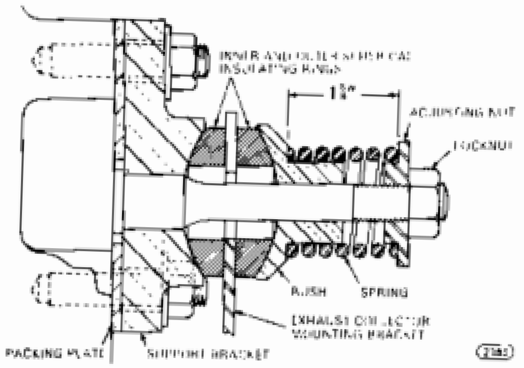
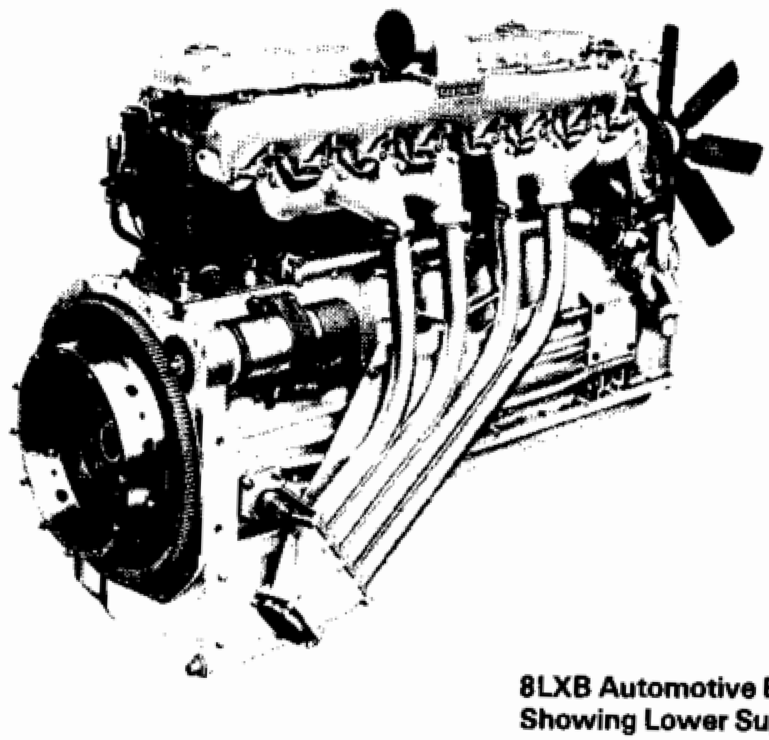


Fig. 24. Exhaust Pipes Lower Bracket Assembly

To assemble exhaust pipes:—

1. Couple the four pipes to the manifold outlet flanges using new packings and lightly secure all flange nuts.
2. Adjust the pipe assembly so that the lower mounting bracket and inner spherical insulating ring are in contact with the support bracket on the engine then firmly tighten the nuts on the manifold flanges.
3. Assemble the outer spherical insulating ring, bush, spring and nuts on the support bracket spindle (see diagram). Tighten the adjusting nut until the the spring is compressed to a length of $1\frac{3}{8}$ in. (34·925 mm.), and secure with the locknut.
   At this measurement the spring should exert a load of 80 lb. (36·3 kg.).

Important:—If, on tightening the manifold flange nuts there remains a gap clearance of more than $\frac{1}{16}$ in. (1·588 mm.) between the lower support bracket and inner spherical ring, a packing plate of appropriate thickness must be inserted behind the support bracket to establish contact at this point *before* completing the assembly and adjusting spring load.

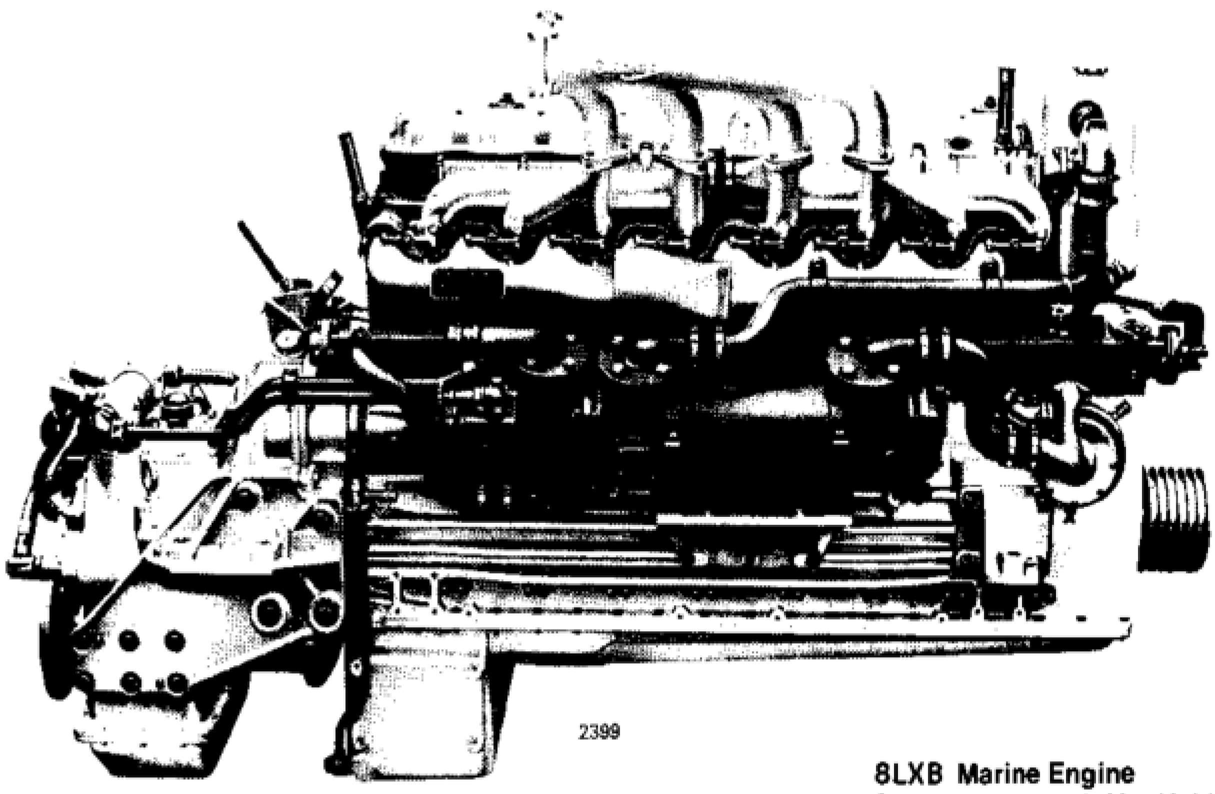


8LXB Automotive Engine Showing Lower Support Bracket

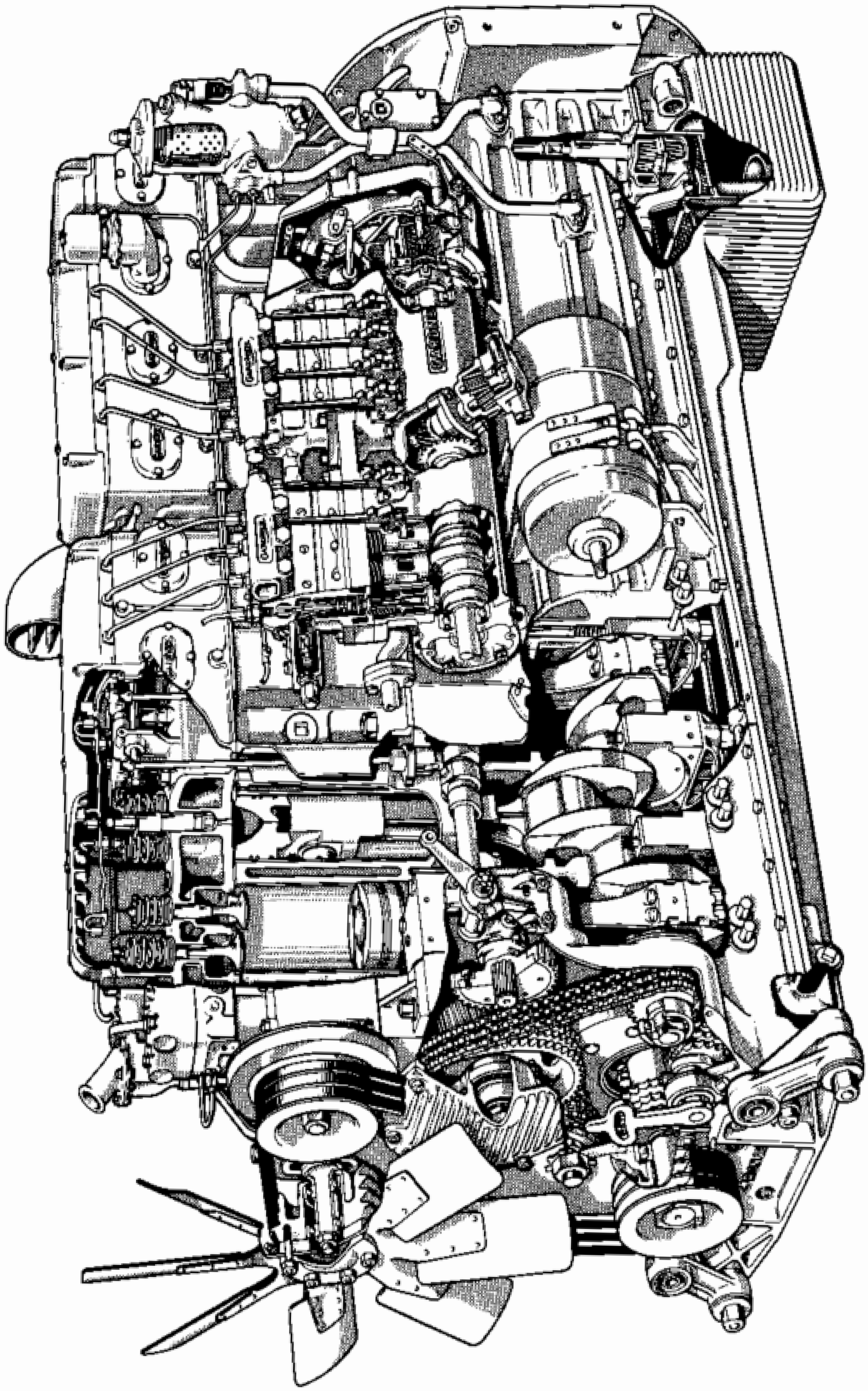
8LXB EXHAUST SYSTEMS

71. **8LXB MARINE EXHAUST MANIFOLDS ASSEMBLY.** To align the two cylinder head manifolds Type-21 to receive the outlet manifold Type-22 proceed as follows:

1. Assemble the two Type-21 manifolds onto the cylinder heads.
2. Lightly tighten the eight manifold clamps.
3. Assemble the Type-22 manifold onto the four upward pointing outlets of the two Type-21 manifolds, complete with packings—metal side up. Ensure joint faces and both sides of packing are clean. Liberally coat all faces with graphite (i.e., both manifold faces and both sides of packing). Also apply graphite to threads of setscrews.
4. Lightly tighten the twelve $\frac{5}{16}$ in. setscrews securing the Type-22 manifold.
5. Slack off the eight manifold clamps.
6. Fully tighten the twelve $\frac{5}{16}$ in. setscrews using a spanner no longer than 5 in. (127 mm.) overall in the same sequence as in 4.
7. Fully tighten the eight manifold clamps.
8. Wire-lock heads of setscrews.



8LXB Marine Engine Showing Type-22 Manifold



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8LXB AUTOMOTIVE ENGINE

GARDNER

TYPES

6LX, 6HLX, 6LXB, 6HLXB, 8LXB

SECTION 3

OVERHAUL AND ASSEMBLY

INDEX

INDEX—*continued*

OVERHAUL AND ASSEMBLY

SPECIAL SERVICING TOOLS, INSTRUCTIONAL DRAWINGS AND DATA, ETC.

1. This section of the Instruction Book should be read in conjunction with Workshop Tools Book No. 63 which contains an illustrated list of special tools to facilitate major servicing of the engines; it also contains drawings with brief operational instructions, etc., and is available at a small charge upon application to the Works.

SPARE PARTS

2. Spare Parts are readily available from the Works, also from our officially appointed Service Agents or Recommended Repairers in the United Kingdom. In addition, stocks of Spare Parts are carried by our Overseas Representatives in all parts of the world and lists of all such Agents, etc., will be found on pages ii to v. At the Depots in the United Kingdom and also overseas are Practical Engineers from whom users of Gardner Engines can obtain assistance and advice regarding their engines.

Enquiries or orders for spare parts should include the type and serial number of the engine. The serial number is stamped on the upper surface of the crankcase adjacent to No. 1 cylinder on the fuel pump side of the engine and on the Fuel Control Box on the forward pump unit.

Enquiries concerning fuel pumps should also include full particulars given on the data plate attached to the Fuel Control Box.

Spare Part Fitting Instructions. In all cases where it is necessary, Assembly Instructions for the fitting of spare parts accompany each consignment of spares. These instructions should always be carefully followed since all modifications to the engine receive the most careful consideration to ensure interchangeability and it is therefore necessary to closely follow the Assembly Instructions when fitting new parts. By this means it is also possible to ensure that the latest modification or additions to an engine can be incorporated in the oldest engines. Full instructions for the correct ordering of Spare Parts are contained in the appropriate Spare Parts Catalogue.

SERVICE EXCHANGE SCHEME

3. It is recommended that Home operators should avail themselves of the Service Exchange facilities which are offered. Special machines, equipment and knowledge are used in reconditioning of service units and the operator will be assured of the highest standard of workmanship at the lowest economical cost.

The following reconditioned components and assemblies are held in stock at the Works and Depots for immediate exchange, providing that the component or assemblies returned are not worn or damaged beyond satisfactory repair.

- Crankshafts
- Cylinder Blocks
- Cylinder Head Assemblies
- Fuel Injection Pumps
- Fuel Pump Cams
- Fuel Sprayer Assemblies
- Governor Unit Assemblies
- Lubricating Oil Relief Valve Assemblies
- Lubricating Oil Pumps
- Valve Cams

OVERHAUL AND ASSEMBLY

GENERAL INSTRUCTIONS

4. **CLEANLINESS.** Cleanliness is of vital importance, particularly in respect of the fuel system and every precaution should be taken to ensure that dirt is kept out of working parts during assembly.

Before removing a component or accessory from the engine, clean the area in the vicinity with paraffin to prevent dirt entering any exposed apertures and immediately after removal, cover all openings.

Thoroughly clean and inspect all parts after removal and make sure that all oil holes and passages are clear. Keep all serviceable components in a clean place until they are installed and flush through all pipes immediately before they are fitted.

5. **GASKETS AND SEALS.** Always fit new gaskets and sealing rings when reassembling. The practice of refitting used gaskets and rubber rings which have been disturbed may lead to trouble in the form of leaking joints, etc., with possible serious consequences.

Synthetic Rubber Seals require special mention, for example, those used in the Reversing/Reducing Gears of Marine Units. The effective life of these seals largely depends upon the care with which they are assembled since their lips may be easily damaged even by the lightest scratch. Therefore it is important to ensure that the surface finish of the metal parts which rotate in any of the synthetic rubber seals is of the highest quality and free from any bruises, scratches or imperfections. Also the profile of the metal surface over which the sealing lips will pass during assembly should be inspected for any roughness or sharp edges which may cause damage to the lips. When assembling, make sure that the spring garter is correctly positioned round the seal.

6. **LOCKING DEVICES.** Split pins, tab washers and locking plates when removed should be discarded and replaced by new ones. Once bent, these locking devices are no longer suitable for further use.

Split pins should be a good fit in the hole and should be sprung open slightly before insertion to prevent movement and consequent wear in service. The method of securing the split pin may vary according to its application but in all cases where they are utilised for locking slotted nuts, the head should always be firmly bedded in the slot of the nut, one leg turned over the end of the bolt or stud and the other against the flat of the nut. Where alternative methods of securing the pins are required these are specified in the appropriate assembly instructions.

7. **TIGHTENING TORQUES.** When reassembling the various components it is essential that nuts are tightened to the correct torque loading where specified, otherwise failure of studs and bolts may result and joints may be distorted due to uneven tightening. This is particularly important in respect of the cylinder head nuts which should be tightened down evenly in stages and in correct sequence, as detailed in the relevant instructions, in order to maintain a uniform pressure across the joint faces. See Tabulated Data, Page 93.

CRANKSHAFT AND MAIN BEARINGS

8. **CRANKSHAFT RE-SIZING.** When re-sizing a crankshaft it is essential that the work be effected with the greatest accuracy. The shaft must run truly about its axis and the bearing surfaces must be parallel and perfectly round. The axis of the crank pins must be parallel with the journal bearings in both planes and the radii where journals and crankpins join the webs must be accurately formed with high finish, free from lines or marks and be not smaller than the original dimension. If the above provisions are not observed failure of crankshaft and bearings may ensue. See Workshop Tools Book No. 63 for sizes and clearances. Before assembly clean thoroughly all passages and examine surfaces for abrasion; a scratch or indentation may be detected by rotating a half shell on the shaft. Any blemishes of this nature should be carefully removed by using an Arkansas marble or similar stone.

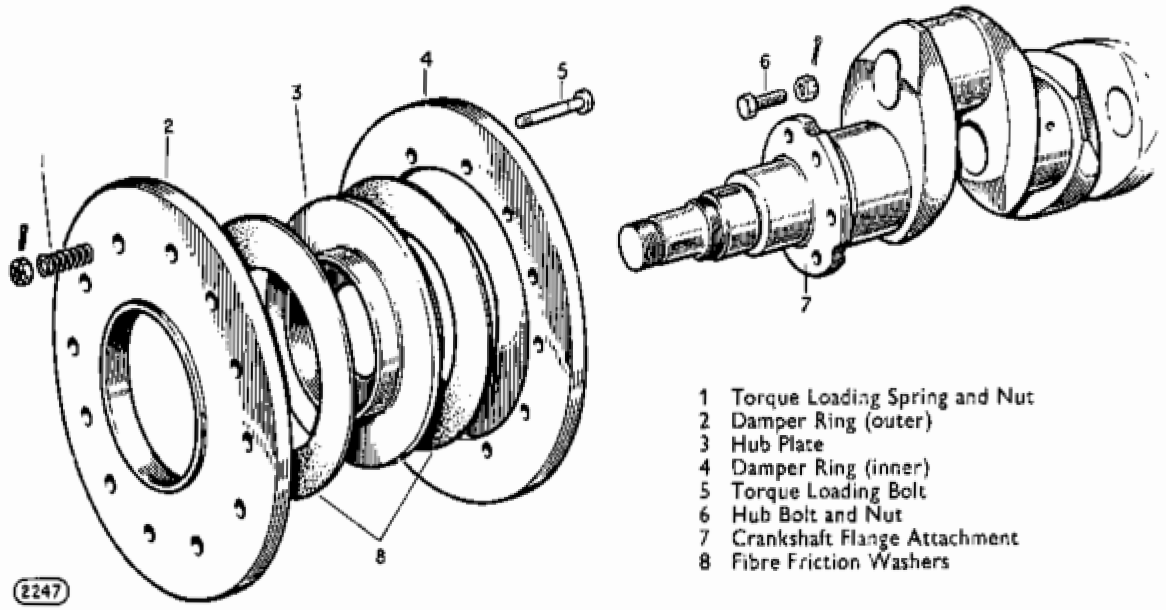
9. **FLATTING OF CRANKSHAFT OIL HOLES.** When a shaft is reground, sharp corners will be reproduced where the transverse oil holes emerge on the crankpins and journals. These sharp corners must be removed after grinding and also the original flatted portion around the circumference of the holes at each end must be restored. The flatted portion takes the form of a 1/16 in. (1·59 mm.) wide band around the circumference of the holes on pins and journals and can be formed by use of a small oil stone.

10. **CRANKSHAFT DAMPER.** The vibration damper is bolted to a flange at the forward end of the crankshaft and consists of two cast iron rings and two friction discs of hard red fibre clamped by 12 bolts and springs to the fore and aft faces of a central hub plate.

The damper should be inspected at major overhaul for signs of excessive wear.

The earlier Type 1 damper is now superseded by the Type 2 which is identified by grooves machined on the peripheries of the damper rings and hub plate. The component parts of the Type 1 and Type 2 dampers are not interchangeable and it is essential that the plain (Type 1) and grooved (Type 2) components are not mixed in any one damper assembly.

11. **ASSEMBLING THE DAMPER.** Before assembling the damper inspect the 12 bolts for security in the damper ring. These must be a driving fit. Check for any high spots on the ring bore by loosely assembling the two rings on the hub plate. The rings have a diametral clearance of ·002 in. (0·051 mm.) on the hub boss and it is important, before fitting the springs, to ensure that this clearance is uniform all round by inserting a ·001 in. (·0254 mm.) feeler gauge at four diametrically opposite points between hub and ring. The damper rings are stamped with a Zero mark on their peripheries and when finally bolted together these marks must be in alignment. Note that on 6LX and 6LXB dampers the rings are arranged so that the



1 Torque Loading Spring and Nut
2 Damper Ring (outer)
3 Hub Plate
4 Damper Ring (inner)
5 Torque Loading Bolt
6 Hub Bolt and Nut
7 Crankshaft Flange Attachment
8 Fibre Friction Washers

Fig. 26. Crankshaft Damper Assembly

OVERHAUL AND ASSEMBLY

CRANKSHAFT AND MAIN BEARINGS—*continued*

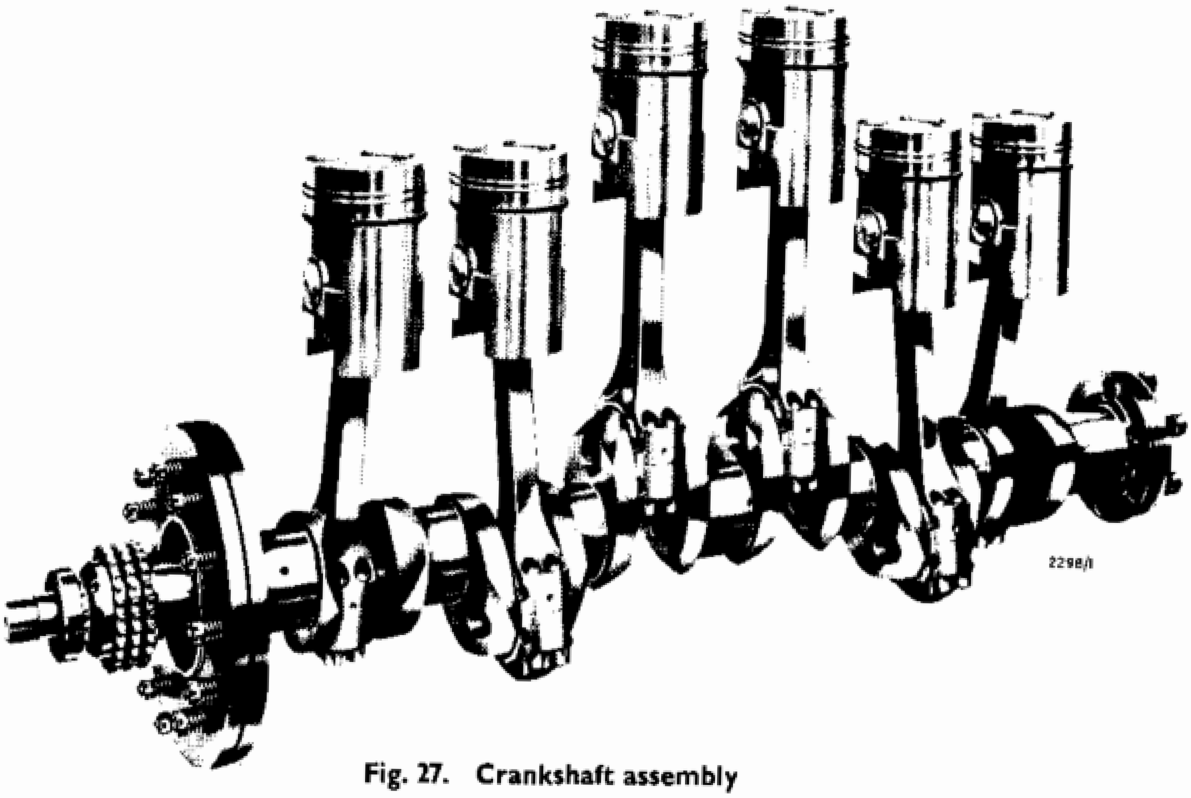


Fig. 27. Crankshaft assembly

springs project forward and on 8LXB dampers the springs project rearwards. Note also that in both cases the chamfered side of the central flange must face **rearwards** in order to mate with the crankshaft flange.

Always renew the fibre rings when reassembling. **Use only genuine Gardner replacements.**

Current fibre rings have radial grooves machined on their friction surfaces and are especially designed to produce the required damping. Do not use any other friction media since the co-efficient of friction may differ and upset the desired spring load and 'slip' torque.

Lightly lubricate all friction surfaces during assembly and make sure that the friction rings are correctly located in their recesses when tightening the nuts to the required loading.

Spring Load. It is essential that the damper springs are of correct type and that each spring exerts an equal load when assembled. The following Table gives the correct spring loading and colour identification according to engine type.

Since the springs are recessed in the ring, the required spring load can be determined more readily by measur-

Engine Type	Spring Load when compressed to working length	Colour Code
6LX, 6HLX 6LXB, 6HLXB	88 lb. at 1·07 in. (39·9 kg.) at 27·2 mm.	Red
8LXB	110 lb. at 1·11 in. (50·0 kg.) at 28·2 mm.)	Green/ Yellow

ing the distance from the back of the nut to the face of the ring. Using this method the correct loading will be achieved at the following measurements:—

6LX, 6LXB 6HLX, 6HLXB	0·664 in. ± 0·003 in. (16·866 mm. ± 0·076 mm.)
8LXB	0·704 in. ± 0·003 in. (17·000 mm. ± 0·076 mm.)

A suitable gauge made to the above dimensions will prove helpful when applying this method.

When assembling the damper on the crankshaft, the flange joints must be scrupulously clean and the securing nuts tightened to the correct torque of 650 lb.in. (7·5 kg.m.).

OVERHAUL AND ASSEMBLY

CRANKSHAFT AND MAIN BEARINGS—*continued*

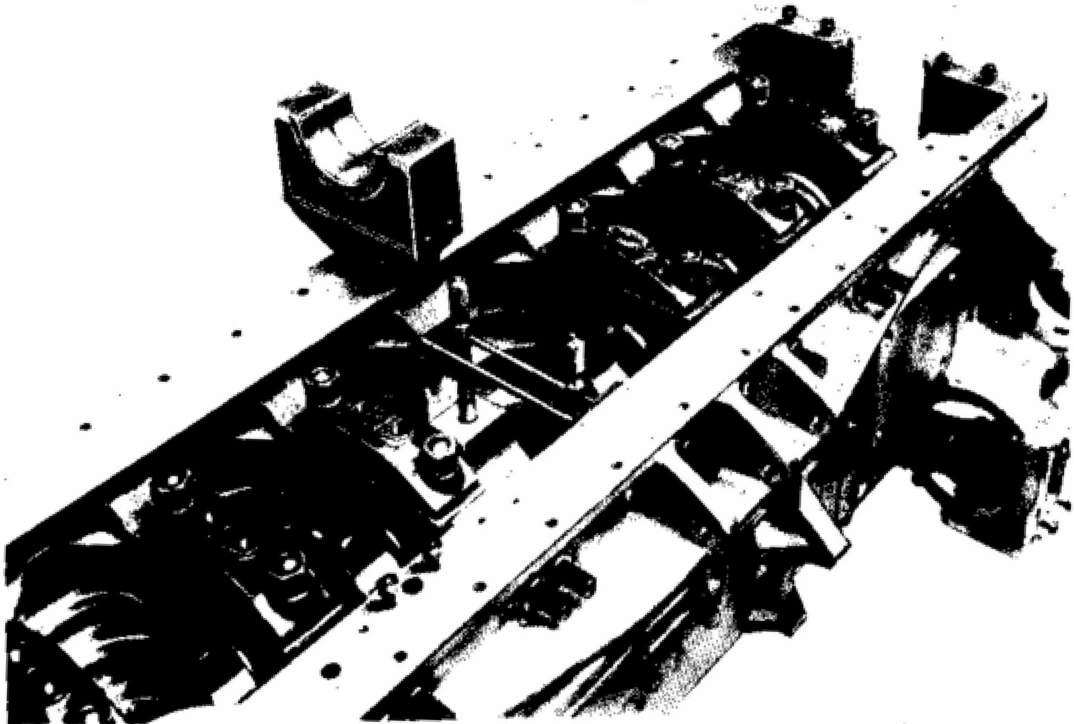


Fig. 28. 6LX Crankcase fitted with Gun Metal Main Bearings

12. **CRANKSHAFT MAIN BEARINGS**

Gun-metal Type Bearing Shells: 6LX and 6HLX engines up to No. 135274 were fitted with gun-metal main bearings lined with white metal. When fitting main bearing shells of this type, the following points should be observed:—

(*a*) The bearing shells must be a perfect fit in their housing.

(*b*) The main bearings are so designed that when bolted up, the faces of the shells butt against each other metal to metal, as also does the cap of the bearing and its housing.

(*c*) When tightened to full torque the shells must be firmly gripped in their housings and the bearings must be perfectly free on the journal.

To check the amount of 'nip' on the bearing shells proceed as follows:—

1. Assemble the bearings in housing and cap, fit the steel bridge pieces and tighten the nuts alternately, an even amount each side, to a torque of 2,100 lb. in. (24 kg.m).
2. Release each nut alternately by an even amount until they are no more than finger tight. Under this condition, if all is correct, the bearing cap will have sprung away from its abutment with the crankcase housing revealing a gap clearance at both sides of ·0055 to ·0075 in. (·139 to ·190 mm.) between cap and housing.
3. If, when fitting new bearing shells, the gap clearance is insufficient, metal must be removed by careful filing or other method from the butt faces of the cap until the required gap is obtained following the above procedure.
4. When finally assembling a set of main bearings it is desirable to tighten the cap nuts in the order and manner shown in the outline sketch and table on Page 61.

Crankshaft Endwise Location. Gun-metal Main Bearings: With gun-metal type bearings the crankshaft is located endwise by the babbitted ends of the centre bearing only. Endwise clearance of the crankshaft should be such that:—

(*a*) The crankshaft has ·0045 in. (·114 mm.) 'float' with the locating bearing in place.

(*b*) The crankshaft can move ·035 in. (·889 mm.) forward or rearwards from its located position with the locating bearing removed.

OVERHAUL AND ASSEMBLY

CRANKSHAFT AND MAIN BEARINGS—*continued*

End float can be checked by setting a dial indicator on the end of the crankshaft with all bearings *in situ*. Then by removing the two halves of the locating bearing only it should be possible to move the shaft ·035 in. (·889 mm.) in both directions from its located position, i.e. a total movement of ·070 in. (1·778 mm.).

Before checking end float make sure that the centre main bearing cap is in alignment with its housing by first tapping the crankshaft endwise from both front and rear with the centre bearing lightly nipped down but not tightened to full torque.

Line Boring Gun-metal Main Bearings: When the main bearings are line bored the size of the bore so produced should be such as to give ·00275 in. (·070 mm.) nominal clearance between the crankshaft journal and the bearing. Plug gauges used with Gardner line boring equipment are as follows:—

3·625 in. (92·075 mm.)+·00225 in. (·057 mm.) GO
3·625 in. (92·075 mm.)+·00275 in. (·070 mm.) NOT GO

Crankshaft diameter (original):—

3·625 in. (92·075 mm.)+·000 in. (0·0 mm.)
−·0005 in. (·0127 mm.)

Reference may also be made to Workshop Tools Book No. 63.

After line boring main bearings, the crankshaft must be fitted and all nuts finally tightened and check made for zones of hard or tight bearing, particularly adjacent to the raddii. If present, these must be removed by judicious use of a hand scraper until there remain no local high places and the shaft can be turned freely by hand pressure only, applied to the coupling flange with all bearing cap nuts fully tightened. On no account must any attempt be made to "burn in" the bearing by running an engine in which any bearings have been fitted with inadequate clearance, since this will cause certain failure.

The flywheel-end main bearing cap is fitted with two additional studs having threads ½ in. B.S.F. and these nuts must be tightened to the correct torque of 700 lb.in. (8 kg.m.).

As already stated, the correct tightening torque for all other main bearing cap nuts is 2,100 lb.in. (24 kg.m.) and AFTER this operation has been completed, the cross bolts should be fitted to Nos. 1 to 6 main bearing caps and the nuts tightened to a torque of 330 lb.in. (3.8 kg.m.).

The order and manner of tightening the main bearing cap nuts and cross bolts is shown on page 61.

13. CRANKSHAFT MAIN BEARINGS

Pre-Finished Thin Wall Steel Shell Bearings: Commencing Engine No. 135275 all LX and LXB engines are equipped with pre-finished thin wall bearings lined with copper lead overlay plated. These bearings are not, therefore, to be line bored when fitted.

The bearings must be replaced if damaged in any way, or if the lead overlay be worn to such an extent that the copper lead so exposed amounts to 20% of the bearing area.

Pre-finished main bearings are available in a range of undersizes to suit reconditioned crankshafts as follows:

in. − ·005, − ·010, − ·020, − ·040, − ·060
mm. − ·127, − ·254, − ·508, − 1·016, − 1·524

The above undersize bearings will give correct running clearance when fitted to crankshaft journals reduced in diameter by precisely these amounts below original nominal size. See Data on page 63.

Fig. 29. Centre Locating Bearing and Thrust Washers

OVERHAUL AND ASSEMBLY

CRANKSHAFT AND MAIN BEARINGS—*continued*

Assembling pre-finished Thin Wall Main Bearings: The two halves of the bearing are not interchangeable and the locating tongue on each half bearing ensures correct assembly in the centre of the housing and cap. Each half bearing is identified by the number of lines marked on the edge of the steel shell. The number of lines corresponds with the figure stamped on the bearing housing and cap to which they are fitted. When assembled these lines must face towards the **chaincase** end of the crankcase.

Before assembling the bearing shells see that all parts are scrupulously clean and that the bearing surfaces are free from any abrasions, scratches or indentations, etc. Any blemishes of this kind should be rolled out or 'ironed' smooth by means of a high finish hardened steel burnishing bar, e.g. a piston pin. **Under no circumstances must a hand scraper be used to bed the bearings to the crankshaft journal.** This would cause irreparable damage to the surface finish rendering the bearing unfit for use.

After thoroughly cleaning the bearing shells and housing bore, apply a thin film of engine oil to the housing and cap. Assemble the shells so that their butt faces are aligned with the abutment faces of both housing and cap and check coincidence of the oil holes in the lower half bearing shell and cap.

Checking for "Nip" on Thin Wall Bearing Shells: The two halves of the bearing should be firmly gripped in their housing when the cap nuts are tightened to full torque on final assembly. To ascertain that the correct amount of 'nip' is present proceed as follows:—

(1) Assemble the bearing cap and steel bridge and tighten the two nuts down evenly to the correct torque load of 2,100 lb./in. (24·15 Kg.m.).

(2) Slacken the nuts alternately from each side until fully released.

(3) Run down the nuts with fingers until they contact the bridge pieces, then with the special box key provided, slightly nip each nut to take up remaining slack, i.e. just less than "one-eighth" of a turn.

(4) Check the gap clearance between the abutment faces of cap and housing by inserting feeler gauges at each of the four corners adjacent to the bearing shell.

The average of these 4 dimensions should be ·007 to ·00875 in. (·178 to ·222 mm.). This means that when the bearing cap nuts are tightened to full torque the bearing shells will have a circumferential nip of ·014 to ·0175 in. (·356 to ·445 mm.) when the bearing cap nuts are tightened to full torque.

Crankshaft Endwise Location: Endwise location of the crankshaft is achieved by specially designed thrust washers positioned at the front and rear of the centre main bearing. These thrust washers are matched and sized in pairs and are not interchangeable.

Standard and Oversize replacement thrust washers are available in the following thicknesses:—

Standard	Oversize
0·121 in. (3·0734 mm.)	0·130 in. (3·3020 mm.)
0·123 in. (3·1242 mm.)	0·135 in. (3·4290 mm.)
0·125 in. (3·1750 mm.)	0·140 in. (3·5560 mm.)

Each pair of washers is identified for correct location by lines scribed on their peripheries adjacent to the abutment ends; the front pair (positioned at the chain case end of the bearing) each having one line and the rear pair having two lines. When assembled these identification marks must face towards the manifold side of the engine. The lower half thrust washers carry locating tongues which locate in recesses in the bearing cap. This locks both upper and lower halves and prevents rotation when the bearing cap nuts are tightened down. Before fitting the thrust washers examine carefully for any burrs which might impair correct seating in the housing and cap.

Checking Endwise Clearance: Crankshaft endwise clearance should be ·006 in. min. to ·009 in. max. (0·152 mm. to 0·229 mm.) and is checked by setting a dial indicator on the end of the crankshaft.

Having assembled the thrust washers and all main bearings, lightly nip down the cap nuts of the locating bearing and fully tighten all the remaining cap nuts to correct torque, set the crankshaft so that the centre line of the crankwebs adjacent to the locating bearing are in line with the split between the housing and cap. Tap the crankshaft endwise — first from the flange end and then from the chaincase end — to butt the crankweb thrust faces against the washers. This will ensure that

OVERHAUL AND ASSEMBLY

CRANKSHAFT AND MAIN BEARINGS—*continued*

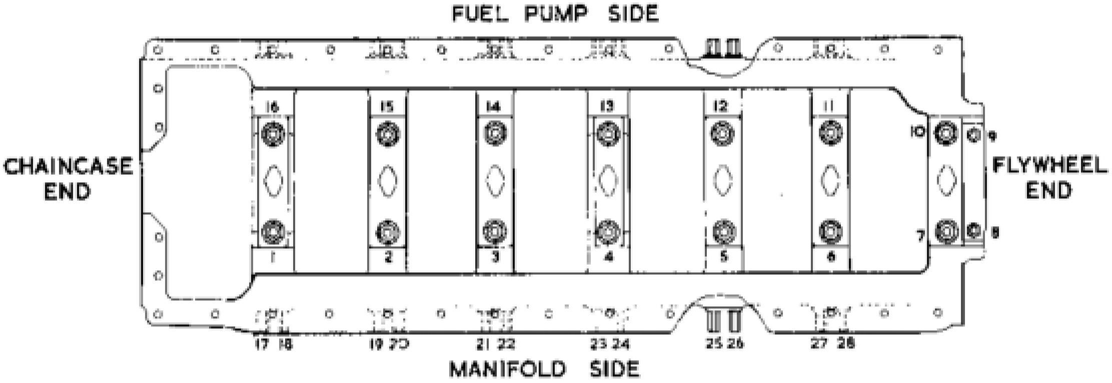
the bearing cap is in alignment with the crankcase bearing housing and that the thrust faces of each locating washer are also in alignment one with the other. The correct end clearance can then be recorded on the dial indicator.

13·1. **Tightening Sequence for Main Bearing Cap Nuts:** The size and roundness of the shell bore are dependent on the tightening procedure and it is essential that these nuts are re-tightened in exactly the same order and to the same degree of tightness every time the bearing caps and cross bolts are assembled. For this purpose it is necessary to establish a standard procedure which must be observed at each stage of the job. The outline sketch and table below show the order and manner of tightening respectively.

The tightening sequence for the 8LXB bearing caps follows the same pattern as that indicated, but the two additional bearings must be included in correct sequence, commencing 1 to 9.

The correct tightening torque for the main bearing cap nuts (whether castellated or current plain type) is 2,100 lb.in. (24 kg.m.) and the two additional ½ in. (12·7 mm.) B.S.F. nuts on the flywheel end main bearing

TIGHTENING SEQUENCE FOR MAIN BEARING CAP NUTS



Tightening Sequence	Main bearing cap nut torque	
	Nuts 1—7 and 10—16 ¾" B.S.F. (19 mm.)	Nuts 8 and 9 ½" B.S.F. (12·7 mm.)
1st stage	Fingertight	Fingertight
2nd stage	Approx. 25 lb.in. (0·3 Kg.m)	Approx. 50 lb.in. (0·6 Kg.m)
3rd stage	Approx. 175 lb.in. (2·0 Kg.m)	Approx. 150 lb.in. (1·7 Kg.m)
4th stage	Approx. 500 lb.in. (5·8 Kg.m)	Approx. 250 lb.in. (2·9 Kg.m)
5th stage	1050 lb.in. (12·0 Kg.m)	350 lb.in. (4·0 Kg.m)
6th stage	2100 lb.in. (24·0 Kg.m)	700 lb.in. (8·0 Kg.m)
	Cross bolt nut torque	
	Nuts 17—28 ⅜" B.S.F. (9·5 mm.)	
7th stage	Approx. 75 lb.in. (0·9 Kg.m)	
8th stage	165 lb.in. (1·9 Kg.m)	
9th stage	330 lb.in. (3·8 Kg.m)	

OVERHAUL AND ASSEMBLY

CRANKSHAFT AND MAIN BEARINGS—*continued*

cap should be tightened to a torque load of 700 lb.in. (8 kg.m.). The use of split pins with castellated nuts is now discontinued and providing these nuts are tightened to correct torque no additional locking device is required.

After the cap nuts have been tightened down the cross bolts should be fitted through the crankcase and main bearing caps with the nuts engaged by an equal amount of thread at each end. The nuts on the manifold side are then tightened to a torque of 330 lb.in. (3·8 kg.m) in correct sequence, commencing at the chaincase end of the crankcase.

When fitting the end plate to the crankcase, check the clearance between the oil return scroll on the crankshaft and the bore in the end plate. The correct diametral clearance is ·014 in. (·356 mm.), that is to say there should be a peripheral clearance of ·007 in. (·178 mm.) all round.

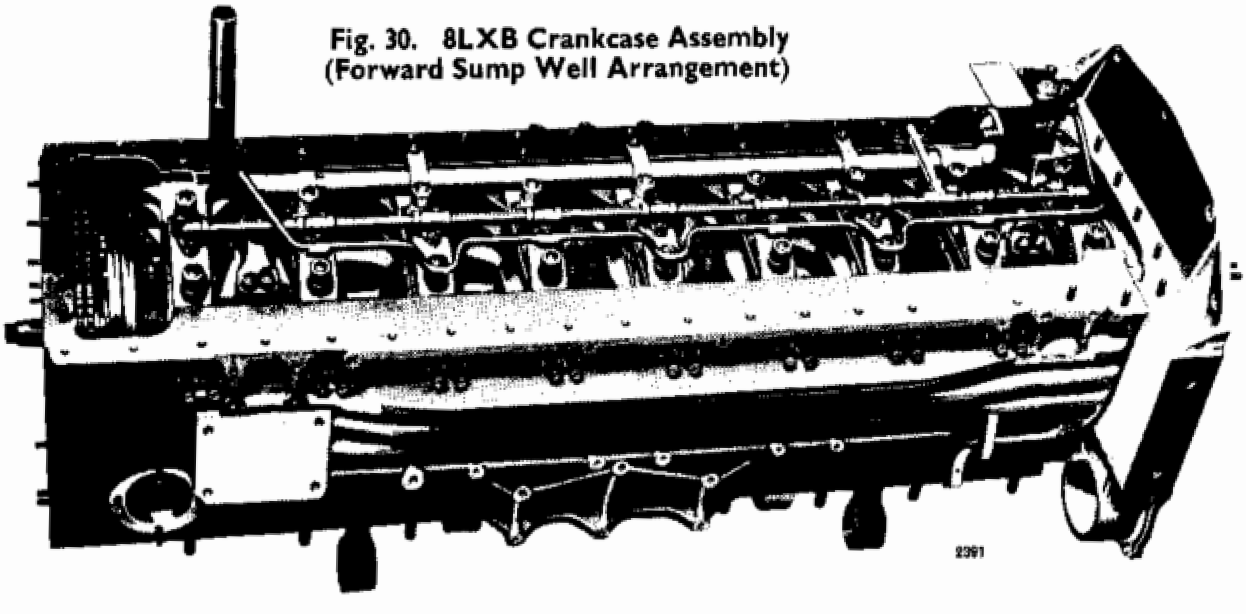
14. **MAIN BEARING OIL DISTRIBUTION PIPE.**
Brazed Copper Pipe Assembly. During major overhaul it is desirable to anneal the main oil distribution copper pipe before re-assembly on the main bearing bridge pieces. Always use new "O" rings at the flange connections when assembling.

When fitting the pipe, tighten each pair of securing nuts fully and evenly on to the locking plates (Part No. 126LP) at each connection and afterwards slightly ease-off each pair by one half-hexagon flat before finally locking with the locking plates. Note when locking, that the tabs must be bent over opposite sides at each end of the flange connection so that they lock against the projecting pipe union or "T" connection.

Steel Pipe Assembly. The main bearing oil distribution pipe fitted to LXB engines and later LX engines comprises separate inter-connecting steel pipes, the ends of which enter flanged "ties" and are sealed by "O" rings. "O" rings also form the joint between the flanged "ties" and the main bearing cap bridge pieces. When the pipework is assembled correctly it should be possible to rotate each inter-connecting pipe between the main bearing caps by hand and also obtain a 1/16 in. (1·588 mm.) minimum endwise movement, i.e. 1/32 in. (·794 mm.) each side of the mean position. This freedom of movement does not apply to the three branch pipes which are positively located in the "T" connection. When assembled there should be a minimum clearance of ·060 in. (1·524 mm.) between the "T" connection and the lowermost point of the connecting rod. If clearance is insufficient, the small boss on the connecting rod cap must be suitably filed. The correct tightening torque for the flanged "tie" setscrews and branch pipe connection nuts is 400 lb. in. (4·5 kg.m.).

NOTE: It is good practice always to pressure test the pipework (whether copper or steel pipe arrangement) after assembly to ensure absence of leakage.

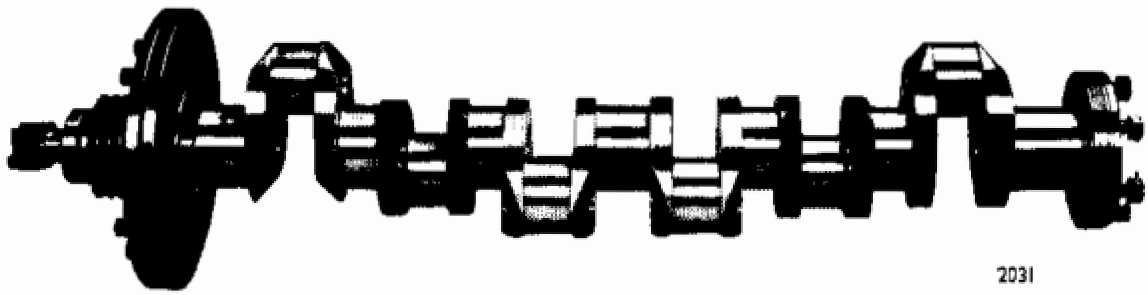
Fig. 30. 8LXB Crankcase Assembly (Forward Sump Well Arrangement)



OVERHAUL AND ASSEMBLY

CRANKSHAFT AND CONNECTING ROD DATA

	6LX & 6LXB	8LXB
Diameter of main journals	Max. 3·625 in. (92·075 mm.) Min. 3·6245 in. (91·062 mm.)	Max. 3·9375 in. (100·013 mm.) Min. 3·9370 in. (100·00 mm.)
Max. undersize for re-ground journals	0·060 in. (1·524 mm.)	0·060 in. (1·524 mm.)
Main bearing running clearance	Pre-finished Thin Wall Bearings.	
Crankshaft endwise clearance	Min. 0·006 in. (0·152 mm.) Max. 0·009 in. (0·229 mm.)	Min. 0·006 in. (0·152 mm.) Max. 0·009 in. (0·229 mm.)
Diameter of crankpins	Max. 3·1875 in. (80·963 mm.) Min. 3·1870 in. (80·950 mm.)	Max. 3·250 in. (82·550 mm.) Min. 3·2495 in. (82·537) mm.
Max. undersize for re-ground crankpins	0·060 in. (1·524 mm.)	0·060 in. (1·524 mm.)
Big-end bearing running clearance	Pre-finished Thin Wall Bearings	
Connecting rod sideways clearance	Min. 0·008 in. (0·203 mm.) Max. 0·016 in. (0·406 mm.)	Min. 0·008 in. (0·203 mm.) Max. 0·016 in. (0·406 mm.)
Small-end bush bore	1·8125 in. (46·038 mm.)	1·8125 in. (46·038 mm.)
Piston pin clearance in bush	Min. 0·00125 in. (0·032 mm.) Max. 0·00175 in. (0·045 mm.)	Min. 0·00125 in. (0·032 mm.) Max. 0·00175 in. (0·045 mm.)
Connecting rod centres	12·50 in. (317·5 mm.)	12·50 in. (317·5 mm.)



6LX Crankshaft

CONNECTING RODS

15. **CONNECTING ROD ASSEMBLY.** The connecting rods on all LX and LXB engines are equipped with pre-finished thin wall big-end bearings lined with copper lead overlay plated. These bearings are not, therefore, to be bored or hand scraped when fitted. The bearings must be replaced if damaged in any way or if the lead overlay be worn to such an extent that the copper lead so exposed amounts to 20% of the bearing area.

Pre-finished big-end bearing shells are available in a range of undersizes to suit re-ground crankpins as follows:—

in. - ·005, - ·010, - ·020, - ·040, - ·060
mm. - ·127, - ·254, - ·508, - 1·016, - 1,524

The above undersize bearings will give the correct running clearance when fitted to crankpins reduced in diameter by precisely these amounts below original nominal size. See Data on page 63.

Non-Interchangeability. It should be noted that the Type 2 and Type 3 4-bolt connecting rods are not interchangeable. These rods are of different weight and it is not permissible, therefore, to mix the Type 2 and Type 3 in any one engine assembly. Engine sets of rods must consist of all Type 2 or all Type 3. The two Types of rod are identified by the outside diameter of the bid-end side facings which measure 3·875 in. and 3·750 in. (98·425 mm. and 95·250 mm.) on Type 2 and Type 3 respectively.

The lighter Type 3 connecting rod can be used with the original Type 1 2-bolt rods, but not with Type 2 4-bolt rods.

Inspection and Overhaul. When inspecting connecting rods the following points should be noted:—

(*a*) Rods should be thoroughly cleaned and tested for cracks by any of the well-known methods during major overhaul.

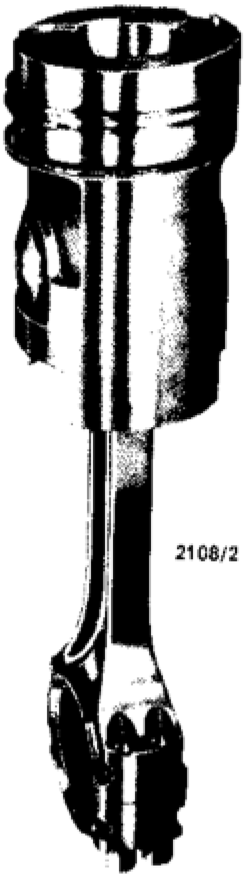


Fig. 31 Piston and Connecting Rod Assembly

OVERHAUL AND ASSEMBLY

CONNECTING RODS

(*b*) Small-end bushes which have ·003 in. (·0762 mm.) or more clearance with a new pin should be pressed out and new ones fitted. The running clearance between a new bush and a new pin is ·00125 to ·00175 in. (·0318 to ·0445 mm.). Should scraping be necessary this must be confined to the upper half of the bore so that the more accurate machined surface remains untouched on the heavily loaded bottom portion.

(*c*) Before final assembly, the oil duct through the centre should be thoroughly flushed out with paraffin or fuel oil.

(*d*) When the rod is assembled on the crankpin, the piston pin in the small-end bush should be parallel to the crankcase top surface to within ·001 in. (·0254 mm.) in the length of the pin.

Big-End Bearing Assembly. Connecting rods and caps are stamped with a number to correspond with the number of the respective cylinder. When assembling the connecting rod on the crankpin, these numbers must face the tappet side of the crankcase and lie towards the flywheel end of the engine. Rods and caps should not be interchanged, keep each cap to its respective rod.

Connecting rod bolts and nuts are also stamped 1 to 4, and these must be assembled number to number. Where big-end bolts and nuts are not numbered it is sound practice always to reassemble these in their original positions in order to maintain uniform accuracy and roundness of bore.

Big-end bearing shells also are identified by a series of lines on the edge of the steel shells near the abutment faces; the number of lines corresponding with the number on the connecting rod. When assembled, these lines must face towards the flywheel end of the engine. Fig. 32 illustrates the correct assembly for a standard rotation engine. Connecting rods for opposite rotation engines, i.e. clockwise rotation viewed from flywheel end, are stamped with the letter "C" after the cylinder number and the bearing shells are reversed so that the locating tongues are on the opposite side to the numbered side. It is important, therefore, to specify the direction of rotation when ordering a replacement rod.

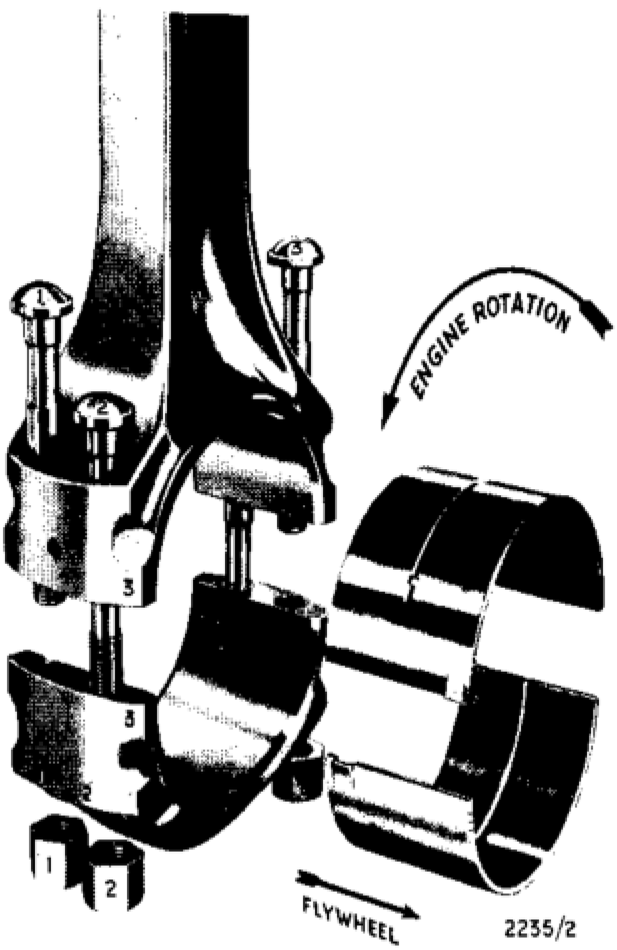


Fig. 32. Big-End Bearing Assembly

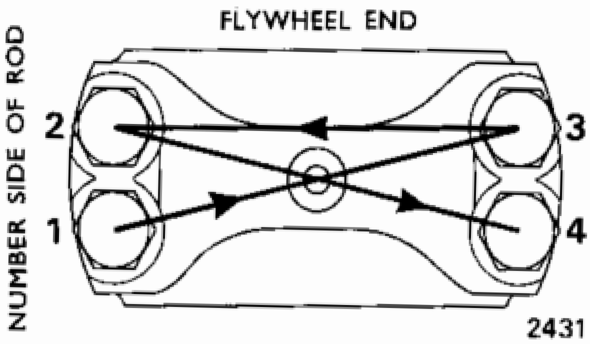
Before assembling the bearing shells see that all parts are scrupulously clean and that the bearing surfaces are free from abrasions, scratches or indentations. Any blemishes of this kind should be rolled out or 'Ironed' smooth by means of a high finish hardened steel burnishing bar, e.g. a piston pin. **Under no circumstances must a** hand scraper be used. This would cause irreparable damage to the surface finish and render the bearing unfit for use.

The two half bearings cannot be interchanged as a locating tongue on each half bearing ensures correct assembly. If incorrectly assembled the shells will not be central in the rod.

OVERHAUL AND ASSEMBLY

CONNECTING RODS—*continued*

As the procedure for tightening the big-end nuts has a slight but highly important effect on the bearing bore size and shape, it is essential that these nuts are tightened in exactly the same order and to the same degree of tightness every time the bearings and caps are assembled (See Fig. 33).



The numbers shown are those stamped on the nuts and bolts. These must be assembled number to number.

Fig. 33. Tightening sequence for Big-end Nuts

The standard procedure for tightening big-end nuts is as follows:—

1st Stage Run each pair of nuts down until they just slightly nip the bearing cap.

2nd Stage Tighten nut No. 1, followed by nut No. 3, to about half final tightness.

3rd Stage Tighten nut No. 2, followed by nut No. 4, as above.

4th Stage Tighten nut No. 1, followed by nut No. 3, to final tightness.

5th Stage Tighten nut No. 2, followed by nut No. 4, as above.

The correct tightening torque for each of the 4 nuts is 600 lb.in. (6·9 kg.m). For the Type i two-bolt connecting rods the correct tightening torque is 1,250 lb. in. (14·4 Kg.m).

When completing the big-end assembly, it is essential that the eccentric heads of the bolts are located correctly in the recesses in the rod and that the face of the bolt head seats on the base of the recess when tightened to full torque.

It should be noted that the use of split pins for castellated nuts is now discontinued and providing the nuts are tightened to correct torque no other locking device is required.

Checking for 'Nip'. The bearing shells should be firmly 'gripped' in the assembled rod. This can be ascertained by tightening each of the big-end nuts to the correct torque in the manner and sequence previously described with the bearing shells in position; afterwards releasing the nuts on one side only, when there should be ·006 to ·007 in (·152 to ·178 mm.) gap clearance between the abutment of the connecting rod and cap.

Connecting Rod Endwise Clearance. Location of the big-end of the connecting rod is attained directly by the side facings of the rod itself. The correct sideways clearance between crankwebs is ·008 to ·016 in. (·203 to ·406 mm.) i.e. ·004 to ·008 in. each side when the rod is central. The clearance should be checked around the full extent of the rod and cap, first at one side, then the other, with the adjacent crankwebs positioned horizontally.

PISTONS

16. **PISTON REMOVAL AND ASSEMBLY.** Unless operating conditions are known to produce unclean running do not remove pistons until cylinders require re-sleeving.

Access to the pistons is obtained by removal of the cylinder block from the crankcase (for engines fitted with two bolt connecting rods). On engines commencing number 119483, four bolt connecting rods were fitted and the pistons and connecting rods may be withdrawn upwards through the cylinder bores after removal of cylinder heads. Should the same method be used for reassembly, the entry of the piston into the top of the cylinder bore will be greatly facilitated if use is made of the special piston entering guide which is illustrated and described in Workshop Tools Book No. 63.

NOTE: This piston entering guide differs from that used when lowering the cylinder block on to the pistons, as described in paragraph 29.

The hollow gudgeon pin is free to rotate in the small end of the connecting rod and also in the piston and is located by aluminium pads fitted in the ends of the pin. The axis of the pin hole is slightly offset from that of the piston. The effect of this construction is greatly to reduce the noise generated at inner dead centre when the piston transfers from one cylinder wall to the other. Fitting of the piston pin is facilitated if the piston is slightly warmed before inserting the pin.

OVERHAUL AND ASSEMBLY

PISTONS—*continued*

Piston and Piston Pin Identification. LX & HLX, LXB & HLXB piston assemblies are identified by appropriate stampings on the top surface and are **not** interchangeable. On no account must LXB piston assemblies Part No. LXB/3/3500 be used on LXB engines fitted with Type '5D' cams, namely engine serial No. 170825 and from 171161 onwards.

LX piston pins fitted on engines up to serial No. 155257 had a 1¼ in. (31·75 mm.) bore and end pads had a ⅜ in. (9·53 mm.) dia hole. All subsequent LX engines, except Nos. 155312 and 155313, have a heavier type piston pin with 1⅛ in. (25·58 mm.) bore; the end pads having a ½ in. (12·7 mm.) dia. hole.

The heavy (1⅛ in. bore) and light (1¼ in. bore) piston pin and pad assemblies must **not** be fitted in the same engine, i.e. all the pins in any one engine must be of equal weight. It is worth noting that piston pin assemblies which differ in weight can be readily identified by the size of hole in the end pad.

All LXB and HLXB engines are fitted with the heavier type piston pin and under no circumstances must they be fitted with the lighter (1¼ in. bore) pin assemblies.

17. **CLEARANCE BETWEEN VALVE HEADS AND PISTON.** It will be seen that shallow recesses are formed on the top of the pistons to provide clearance for the valve heads and to allow of an overlap timing diagram. The diameter of the inlet valves and their recesses differ from those of the exhaust valves. When fitting the piston to the connecting rod ensure that the recesses are placed underneath the corresponding valves. The correct position for the piston is clearly indicated by the lettering, "TAPPET SIDE" on the top of the piston and by the arrow which must correspond to the direction of rotation of the crankshaft.

18. **CYLINDER HEAD TO PISTON CLEARANCE.** The Nominal, Maximum and Minimum clearances are illustrated diagrammatically in Workshop Tool Book No. 63. See also Engine Data on page xv.

19. **PISTON RINGS.** The pistons are equipped with two pressure rings and one oil conrol ring, all of hardened and tempered cast iron. On LX pistons the ring fitted to the first or top groove is chromium plated on its periphery and on both side faces, whilst the ring fitted to the second groove is plated on its periphery only. The second ring is identified by a phosphating etch on its side faces which takes the form of a dark stain extending about one inch (25·4 mm.) each side of the ring gap. The first and second pressure rings must **not** be interchanged on these pistons.

20. **PISTONS.** Unless operating conditions are known to produce unclean running, do not remove pistons until cylinders require re-sleeving (See Para 28, Page 70).

The useful life of a piston is determined almost wholly by (a) wear of the upper two ring grooves, and (b) by diametral wear. Owing to the peculiar shape assumed due to wear, the faces of the grooves will not make a satisfactory gas seal with new rings, therefore it is thoroughly recommended that the piston also be replaced.

Note: Oversize width rings are no longer available.

According to fuels, lubricants, duty, etc., pistons will run for 100,000 to 200,000 miles (160,000 to 320,000 km.) or more without dismantling and before replacement is necessary.

The above recommendations are based upon the use of genuine "Gardner" pistons, of "Gardner" manufacture with "Gardner" specification equipment and only by their use may optimum engine performance and durability be obtained.

21. **FITTING NEW PISTON RINGS IN WORN BORES.** Whenever new piston rings are to be used in worn cylinder liners it is very desirable that the surface of such liner bores is lightly lapped with fine carborundum on an old piston and ring, or honed to create a matt surface. If new rings are fitted in a worn and therefore polished bore the "bedding in" process will be protracted with consequent probable high oil consumption and "blow by".

VALVE CAMSHAFT, TAPPETS AND GUIDES

22. **CAMSHAFT TAPPET GUIDES.** Before fitting the tappet guides in the crankcase, check that each tappet moves freely in its guide over the full length of its stroke, and ensure, when assembling, that the tappet guide seats squarely on the face of the crankcase. Do not use excessive pressure when tightening the clamp nut. Re-check the free movement of each tappet *after* the clamp has been tightened.

NOTE: LXB tappets are marked LXB and are not interchangeable with LX or HLX tappets.

23. **CAMSHAFT ENDWISE LOCATION.** Endwise location of the camshaft is effected by a locating collar of suitable thickness interposed between the bearing bush at the chain case end of the crankcase and the exhaust cam of No. 1 cylinder.

Camshaft end float should be ·004 in. (·102 mm.) min. to ·006 in. (·152 mm.) max. and is ascertained by inserting a feeler gauge between the locating collar and No. 1 exhaust cam. If the clearance be greater than ·006 in. (·152 mm.) the locating collar must be replaced. Oversize collars of ·895 in. (22·733 mm.) thickness are readily obtainable from our Service Agents and Spares Stockists. These must be carefully faced off to give the desired clearance of ·004 in. (·102 mm.). It is advisable to rotate the collar through one or more complete turns when checking clearance.

24. **CAMSHAFT ASSEMBLY.** When assembling this component ensure that the cams are positioned under the correct tappet, i.e. the exhaust cam under the exhaust tappet and not under the inlet tappet, or vice versa. Ensure also that the locking screws engage correctly in the countersinks on the shaft and tighten to a torque of 600 lb.in. (6·9 kg.m.).

Cam Identification. The exhaust cam has a longer opening period than the inlet cam and is marked with an "EX" alongside the Type designation LX-5B or LXB-5D on the side face of the cam. Assemble the cam with this side facing the chain case. It is important to check before assembling that all cams are of the same type and that they correspond with the type being replaced. Type "5D" cams are fitted on LXB engine No. 170825 and all subsequent LXB and HLXB engines commencing serial No. 171161. On no account, must "5D" cams be used on other LXB engines unless fitted in conjunction with new pistons Part No. LXB/3/3502.

After prolonged service the tappets and possibly the cams may become slightly scored. This scoring can be removed by the use of an oil stone taking great care to reproduce the original radii. Should however, the hardened case be worn through it will be necessary to fit new parts. Exchange cams are readily available from our Works and Service Depots.

The valve camshaft bushes should not require renewal (unless they have been subject to accidental damage) until a unit receives its second major overhaul. When new, the clearance between shaft and bush bearings is ·0023 in. (·0584 mm.). Bushes are a light drive fit in the crankcase and are secured by cheese-head screws inserted from the outside of the crankcase wall.

Detailed instructions for the renewal and reaming of camshaft bushes are given in Workshop Tools Book No. 63.

Fitting the Timing Gear Hub to Valve Camshaft: Before fitting the hub, thoroughly clean and de-grease the camshaft, key, keyway and bore of hub. Apply LOCTITE "Nut Lock", Part No. MA. 1378, sparingly with the aid of a small brush to the shaft, key and hub bore and assemble the hub on the camshaft. Wipe the surplus LOCTITE from the exposed portion of shaft and assemble the distance collar with bearing. Clean and de-grease the set screw and washer and the threaded hole in the end of the shaft. Apply a small amount of LOCTITE to screw face, threads and washer. Assemble and tighten to a torque of 800 lb.in. (9·2 kg.m.).

BASE CHAMBER AND SUMP

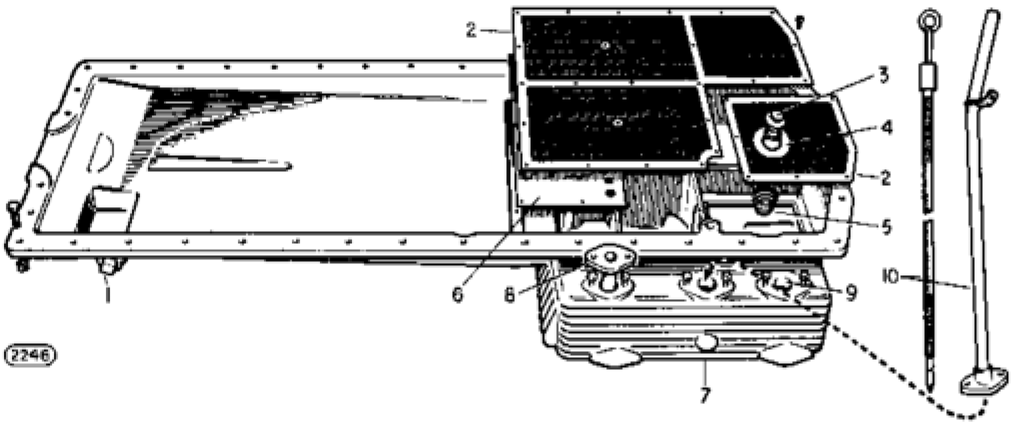
25. **REMOVAL AND CLEANING OF PRIMARY OIL FILTER (Vertical Engines).** It is recommended that this be effected not less frequently than every 48,000 miles (4,800 hours).

Remove the primary gauze filter which is secured by a number of cheese-headed screws and the oil cooler filter (if fitted). Wash the gauzes and surfaces of the base-chamber with clean fuel oil or paraffin. Allow the washed parts to drain in preference to wiping with a cloth which is liable to leave behind swarf.

Reassembling the Base Chamber. Make sure that the securing screws are perfectly tightened and that the making-up collar around the connection to the lubricating oil pump is in place.

OVERHAUL AND ASSEMBLY

BASE CHAMBER AND SUMP—*continued*



1 Scavenge Sump Drain Plug
2 Primary Gauze Filter
3 Suction Pipe Locating Collar
4 Collar Retaining Washer
5 Collar Retaining Spring
6 Dam Plate (Engines with transfer pump)
7 Main Oil Reservoir
8 Suction Pipe (Engines with Lub. oil cooler)
9 Oil Return from Cooler
10 Dip Rod and Tube

Fig. 34. 6LX Engine Lubricating Oil Sump: Type 28

The joint between the base-chamber and the crankcase is designed to be made by gold size or other suitable jointing compound. Clean the joint surfaces with meticulous care and apply the liquid with a brush. Do not use paper or other packing.

26. **REMOVAL AND CLEANING OF SUMP FILTER (Horizontal Engines).** The gauze filters should be removed and the scavenge trough and main oil reservoir cleaned at each major overhaul period.

To remove the base-chamber and main oil reservoir proceed as follows:—

(1) Disconnect and remove the oil feed pipes from the pump to the delivery filter and from delivery filter to pressure regulator.

(2) Remove the main oil reservoir complete with the delivery filter unit from the base-chamber.

(3) Disconnect and remove the bracket which attaches the oil transfer pipe and suction feed pipe to the base-chamber.

(4) Remove the two setscrews from the flange coupling on the oil scavenge pipe leading from trough to pump.

(5) Disconnect the cylinder head oil return pipe at the base of the scavenge trough.

(6) Remove all nuts holding the base-chamber to the crankcase including the three setscrews in the chain case splash door.

(7) Remove the base chamber, taking care not to bend or strain the oil transfer and suction pipes whilst lifting it clear.

Having removed the sump and base chamber the two gauze filters can be withdrawn by removing the cheese-headed screws. Wash the gauzes and surfaces of the base-chamber, scavenge trough and main oil reservoir as described in paragraph 25, page 68.

Reassembling the Oil Sump and Base Chamber. The sequence of assembly is the reverse of that described for removal. The joints between the main oil reservoir and base-chamber and between base-chamber and crankcase are designed to be made by gold size or other suitable jointing compound; do not use paper or other packing. Clean the joint surfaces with meticulous care before applying the liquid with a brush.

OVERHAUL AND ASSEMBLY

CYLINDER BLOCK

27. **REMOVAL AND CLEANING.** When removing or refitting the one-piece cylinder block with the pistons in position, it is essential that a straight and level lift is maintained throughout the operation. This is achieved by screwing the lifting eyes on to the two extended and centrally disposed cylinder head studs and seeing that the apex of the sling is positioned mid-way between these two slinging points.

Before lifting the block, rotate the crankshaft to bring No. 3 and 4 pistons to T.D.C. This will permit the block to be more easily manoeuvred and withdrawn from the remaining pistons.

With the four bolt type connecting rods, it may be found more desirable to disconnect the big ends and withdrawing the rods through the cylinder bores. This, of course, will depend upon the circumstances and the extent of the work being undertaken.

At major overhaul or whenever the cylinder block is removed for re-sleeving, etc., dismantle all inspection doors and plugs and clean out thoroughly all water spaces.

28. **CYLINDER LINERS.** When diametral cylinder bore wear exceeds ·012 in. (·305 mm.) cylinder blocks should be re-sleeved. In many instances this figure is exceeded but power and startability may then be adversely affected. Full instructions for the fitting of new cylinder liners are contained in Workshop Tools Book No. 63. Where facilities are not available for the re-linering of cylinder blocks, the customer's block can be exchanged, under the Service Exchange Scheme, for a replacement block which has been re-linered at our Works.

As already mentioned, whenever new piston rings are to be used in worn cylinder liners it is very important that the surface of the liner bores are lightly lapped with fine carborundum using an old piston and ring, or honed to create a matt surface.

When honing new liner bores a surface finish of 25 to 30 micro inches is desirable.

29. **REASSEMBLING THE BLOCK.** The cylinder block is fitted directly to the aluminium crankcase, i.e. there is no packing interposed between the block and crankcase. The face of the crankcase can with advantage, be lightly smeared with a "gasket compound" or other non-hardening medium which is insoluble in mineral oil and which has a high melting point. Two

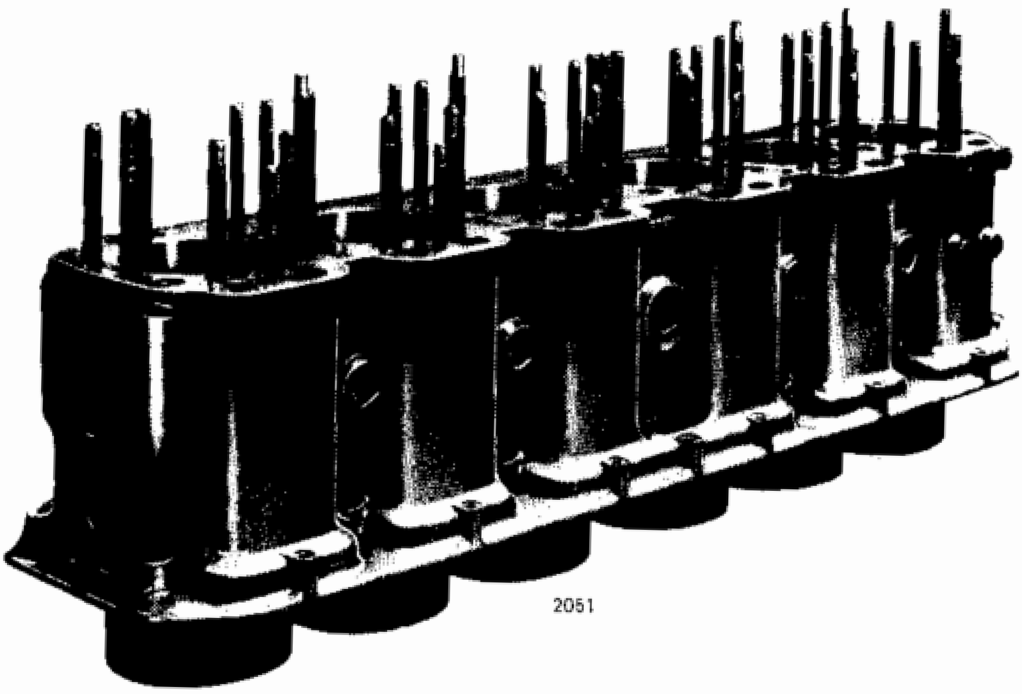


Fig. 35. 6LX Type 1 Cylinder Block

OVERHAUL AND ASSEMBLY

CYLINDER BLOCK—*continued*

such mediums are Gasket Compound 109B, manufactured by Messrs. Dalton & Co. Ltd., of Belper, Derbyshire, and "Wellseal", manufactured by Messrs. Wellworthy Ltd., of Lymington, Hants.

IMPORTANT Only cylinder blocks having the four additional ½ in. B.S.F. studs along the centre line of the bores are to be fitted to 6LXB and 6HLXB engines. The location of these studs is shown by the letter "C" on Fig. 37, Page 73.

To facilitate entry of the pistons into the cylinder bores during reassembly, a special piston entering guide is available. This is illustrated and described in Workshop Tools Book No. 63 and differs from that used when entering the connecting rod and piston assembly through the top of the cylinder block as described in paragraph 16, Page 66.

When tightening the foot nuts commence from the centre of the block and work towards each end, alternately tightening opposite side nuts evenly and in sequence, so that pressure is distributed uniformly across the joint face. The correct tightening torque for these nuts is 1,500 lb.in. (17·3 kg.m.).

With the block fully tightened down, the cylinder head-to-piston clearance must be checked as shown in Workshop Tools Book No. 63.

CYLINDER HEADS

30. **TO AVOID DAMAGE TO THE SPRAYER NOZZLE.** The sprayer nozzles project from the flat surface of the cylinder head and it is essential that they be withdrawn before removing the heads otherwise they may suffer severe damage.

31. **REMOVAL, DECARBONISING AND SERVICING.** In order to obtain the best results from the engine and to maintain it in its most efficient and economical condition, it is recommended that the heads be lifted off and the valves and other parts cleaned and serviced not less frequently than every 48,000 miles (4,800 hours). These mileages are commonly doubled and trebled, but this can be accompanied by reduced combustion efficiency and impaired internal cleanliness and under these conditions the rate of engine wear is increased. Wear and erosion of valves and seats, and carbon deposits in the valve ports are mainly responsible for loss of efficiency.

Valves should be accurately ground in the usual special purpose machine to the required angle, i.e. 45° (LX and HLX engines) and 30° (LXB and HLXB engines) removing as little metal as possible.

NOTE: LX and LXB valves are not interchangeable.

Valve seats are of hardened material and should be ground to the above corresponding angles by a special purpose machine—preferably of the generator type—removing the minimum of metal. For full details refer to Workshop Tools Book No. 63.

After grinding, lap valve and seat together with fine abrasive, say 400 grit Carborundum powder.

When after long use valve seats become enlarged, renew parts in order to maintain engine efficiency. Details of the valve seat insert assembly and of the special tools for withdrawal and fitting of the inserts are given in Workshop Tools Book No. 63.

32. **VALVE RENEWAL.** When re-assembling an engine for a further long period of service replace the inlet and exhaust valves if any of the following conditions obtain:-

1. The thickness of the valve head after re-surfacing is less than:-
   - LX & HLX — ·037 in. (·940 mm.) Exhaust.
   - — ·045 in. (1·143 mm.) Inlet.
   - LXB & HLXB — ·070 in. (1·778 mm.) Exhaust.
   - — ·078 in. (1·981 mm.) Inlet.
2. The diameter of the valve stem (on all LX & LXB models) is less than:-
   - ·370 in. (9·398 mm.) Exhaust.
   - ·371 in. (9·423 mm.) Inlet.
3. The flat face of the head shows any distortion when tested on a lapping plate.
4. The surface of the stem, neck or flat face exhibit imperfection of surface finish, scaling, pitting or corrosion.
5. Magnetic-flux flaw detection reveals any defects.

NOTE: Always fit new valve guides when fitting new valves.

Use only genuine "Gardner" replacement parts to ensure durability and freedom from failures which might seriously damage the engine.

OVERHAUL AND ASSEMBLY

CYLINDER HEADS—*continued*

33. **REASSEMBLING INLET VALVES AND GUIDES.** These valves are formed with deflectors and are secured by locking pins in specially shaped valve collars that prevent rotational movement of the valve. It is **essential** that these valves be assembled with the deflectors towards the manifold side of the engine. This is determined by the offset hole in the valve stem and the offset slot in the collar which, when aligned to receive the locking pin, ensure correct positioning of the valve in relation to the collar.

When renewing inlet valves and guides check the clearance between the stem and guide. The correct clearance for a new assembly is 0·00125 in. (·0318 mm.). If clearance is insufficient the guide must be reamed out *in situ* to obtain correct clearance.

Inlet valve guides for the horizontal engine are provided with an oil drain groove and hole at their outer ends. These must be pressed into the heads with the drain hole and groove towards the *manifold side*.

34. **REASSEMBLING EXHAUST VALVES AND GUIDES.** The current design of exhaust valve has a *plain head*, that is to say the screw-driver slot in the previous design has been deleted. When an engine is dismantled it is very desirable that *all* exhaust valves having *slotted heads* are replaced by valves of the current type with plain heads.

Before refitting the exhaust valves see that all traces of carbon are removed from the bores of the guides.

When renewing exhaust valves and guides check that there is sufficient clearance between the stem and guide. The correct clearance for a new assembly is 0·00275 in. (·070 mm.). If clearance is insufficient the guides must be reamed out *in situ* to obtain correct clearance.

When replacing exhaust valve guides in the horizontal engine they must be pressed into the head so that the hole and groove are towards the *push rod side*.

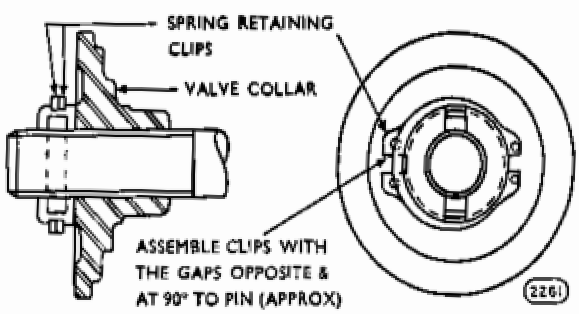


Fig. 36. Valve Collar and Spring Clip Assembly

35. **REFITTING INLET AND EXHAUST VALVE SPRINGS AND COLLARS.** When assembling new inner or outer valve springs of the latest design, the *closed coils* must be fitted adjacent to the cylinder head. Particular care should be taken to ensure that the spring collar is not screwed down the valve stem more than is necessary to insert the locking pin, otherwise the valve may not have sufficient lift and the operating mechanism may suffer damage. The locking pin is held in place by two spring clips located in a single groove (See Fig. 36). The groove is of sufficient width to accommodate spring clips of differing thickness in the event of standard clips not being readily available. The spring clips should be fitted with their gaps diametrically opposite one another and at 90° to the axis of the locking pin.

It is strongly recommended that all locking pins and spring clips be renewed during cylinder head overhaul and that care be taken to avoid overstretching the clips when assembling on the spring collar.

On engines prior to No. 134718 valves were located in their collars by a special split pin of the "drive-open" type. With this arrangement it is important to ensure that the new split pin is of correct type as supplied by our Service Depots and Spares Stockists.

When assembling make sure that the pin is a tight fit in its hole by slightly springing apart the legs before fitting. After fitting, bend the legs equally to form an included angle of 90°. See Workshop Tools Book No. 63.

NOTE: The new type collar complete with spring clips and locking pin is interchangeable with the earlier type.

36. **CYLINDER HEAD WATER JOINTS.** These are made by a series of small, synthetic rubber rings. It is good practice to renew these whenever the cylinder heads are removed. **Use standard "Gardner" spares which are made of special material.**

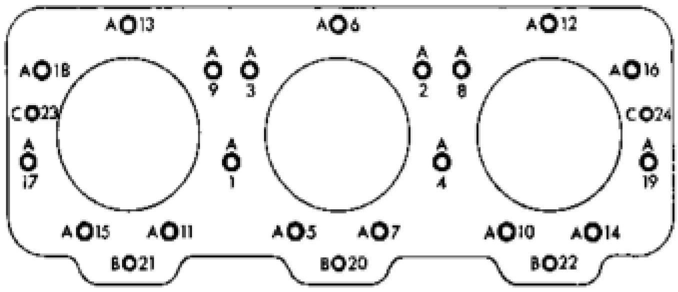
37. **REPLACING THE CYLINDER HEADS.** The gas joint between cylinder head and cylinder block is made with a thin steel packing or gasket which must be renewed whenever a cylinder head is removed. **Use only genuine "Gardner" factory supplied packings.**

When fitting these packings take all precautions to avoid foreign matter becoming entrapped between the joint faces of head and block.

Foreign matter entrapped can result in serious damage to these joint surfaces, necessitating resurfacing. Entrapped matter can cause leakage and surface erosion in service.

OVERHAUL AND ASSEMBLY

CYLINDER HEADS—*continued*



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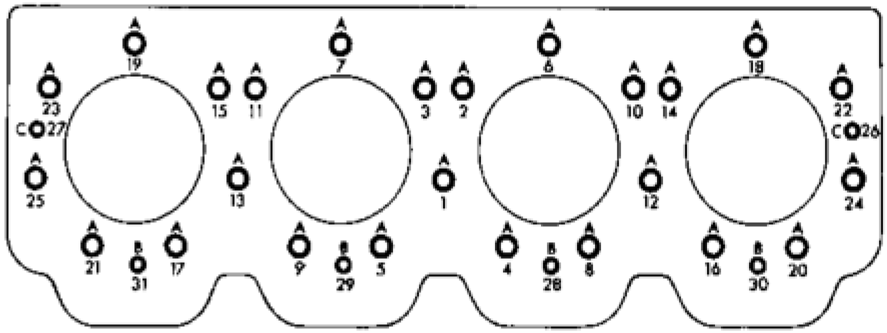
6LX and 6LXB Cylinder Head



8LXB Cylinder Head 2384

Cylinder head nuts; tightening torques.

'A'	¾ in. B.S.F.	1,200 lb.in.	(13·8 kg.m.)
'B'	⅜ in. B.S.F.	350 lb.in.	(4·0 kg.m.)
'C'	⅜ in. B.S.F.	450 lb.in.	(5·2 kg.m.)

Fig. 37. Cylinder Head Nut Tightening Sequence

Ensure that parts are scraped scrupulously clean without damaging the surfaces and finally clean away all loose particles with a compressed air jet, particular attention being paid to stud holes in the cylinder head.

If surfaces have become damaged it may be necessary to return the parts to the Works for precision regrinding. Alternatively, minimum damage and inspection of surface accuracy may be effected by lapping together with fuel oil and 400 grit abrasive, a cylinder head to a cylinder head or a cylinder head to a cylinder block, after withdrawing cylinder block studs. Ensure complete removal of abrasive from the threaded stud holes in the block and all other parts after lapping is completed.

When fitting the packing, lightly oil the surfaces. Do not use any jointing compound whatever.

Before lowering the cylinder head the last few inches on to the block, make thorough inspection to ensure that all the water joint sealing rings are in position and that the surface of the packing is completely free from any particles of dirt or carbon.

With the cylinder head nuts lightly nipped down, check the alignment of the two cylinder heads by placing a straight edge along the manifold ports. Adjust by tapping the heads in the direction required.

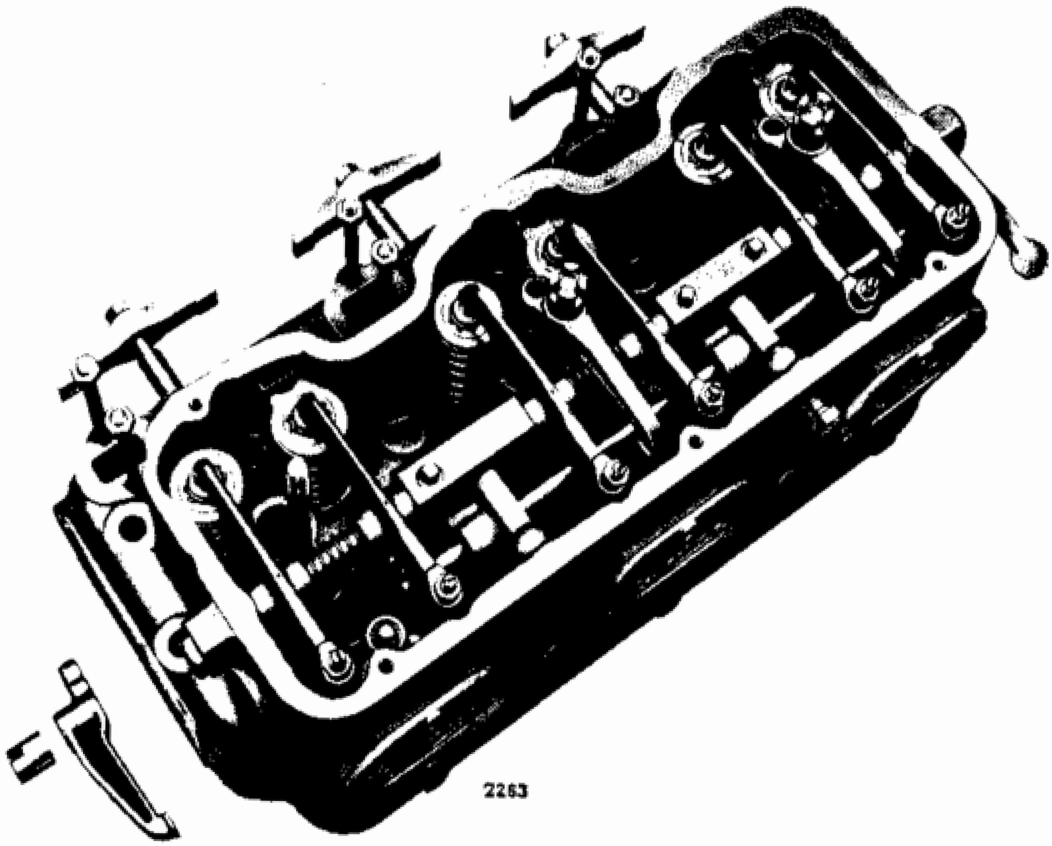
Tightening up must be carried out in three stages, i.e. three degrees of tightness as follows:

1st stage: screw up lightly in order shown in Fig. 37.
2nd stage: screw up medium tight in order shown.
3rd stage: screw up to final tightness in order shown.

Do not exceed the respective torque loadings given in Fig. 37.

OVERHAUL AND ASSEMBLY

CYLINDER HEADS—*continued*



Cylinder Head and Valve Assembly

Interchangeability of Cylinder Heads. With the introduction of the extra cylinder head studs "C" (Fig. 37) on 6LX and 6HLX engines, a new cylinder head was fitted, designated Type 2 with two corresponding additional holes.

The Type 1 and Type 2 cylinder heads on 6LX engines are interchangeable, i.e. the Type 2 head can be fitted to a Type 1 cylinder block, and similarly, the Type 1 cylinder head can be fitted to a Type 2 cylinder block after removal of the extra studs "C" from the block.

The 6LXB cylinder head assemblies are stamped LXB on the valve lever shafts and are **not** interchangeable with 6LX cylinder head assemblies.

38. **VALVE LIFT ADJUSTMENT: DECOMPRESSION.** After grinding and lapping of valve seats it will be necessary to reset the decompression valve lift by means of the adjusting screw and locknut as mentioned in paragraph 57, page 42.

39. **VALVE LUBRICATION.** After a cylinder head has been dismantled and the engine is started up again, observation should be made to ascertain that the oil feed on each valve lever is operating and that oil is reaching the valve ends via the specially constructed flat upper surface of the valve levers. The width of this surface regulates the amount of oil flowing to the valve ends.

OVERHAUL AND ASSEMBLY

FUEL INJECTION PUMPS AND GOVERNOR UNIT

40. **MOUNTING OF FUEL PUMP AND CAM BOX ASSEMBLY.** This unit is trunnion mounted in precision machined housings integral with the crankcase and held therein by four studs passing through two precision machined aluminium bridges. Although the bridges may be interchanged it will be noted that the rear bridge has two tapped holes in its side face. These are for attachment of a steady bracket, required on certain installations for an extended dip stick.

The fuel pump and cam box assembly on the vertical engines is inclined inwards towards the cylinder block at an angle of 9° from the vertical. This angle may be determined by comparing readings taken from an engineer's protractor placed on the cylinder head and on the insertion plate between the fuel pumps. Alternatively the correct angular position of the cambox can be determined by setting the cambox in such a position that the line scribed on the forward end locating diameter of the cambox is coincident with the inside upper edge of the cambox seating on the crankcase. The correct tightening torque for the cambox retaining nuts is 250 lb.in. (2·9 kg.m.).

On the horizontal engines the fuel pump and cambox assembly is mounted horizontally and **parallel** to the cylinder block.

41. **FUEL INJECTION PUMP CAMS.** As the profile of these cams is not symmetrical it is essential that they are assembled on the camshaft in their correct order and position. All cam profiles are of course alike, but numbers 1 and 4 are opposite hand to numbers 2, 3, 5 and 6. Thus the numbers 1 and 4 cams are fitted with their locating screw towards the driving end of the shaft whilst cam numbers 2, 3, 5 and 6 are so fitted that their locating screws lie towards the governor end of the shaft. In this way, when the camshaft is rotated in its running direction (anti-clockwise viewed on driving end) the smaller radius (marked "L") on the cam profiles will lead and the larger radius will trail. These cams are type 8/6.

42. **FUEL PUMP TAPPETS.** The setting of the fuel pump tappets should not be deranged. They are adjusted during engine test and will not require any further attention. Should this adjustment be inadvertently upset or a new part have to be fitted, due to accident or wear, reset as follows:—

Turn the flywheel until the tappet has lifted to its maximum, then turn the flywheel one more revolution, the tappet will now be resting on the base of the cam. Place on top of the tappet screw a small disc or washer of ·108 in. (2·74 mm.) thickness. Refit the fuel pump and tighten the holding down nuts, the lines in the windows of the fuel pump should now coincide, if they do not, adjust the tappet screw either up or down until this condition obtains. Remove the disc or washer, firmly lock the screw, and refit the pump. This operation must be carried out on each tappet in turn.

Important Note: Under no circumstances must the engine be revolved whilst the ·108 in. (2·74 mm.) gauge is in position on any of the tappets. **Very serious damage to the fuel pump will occur if this is not observed.**

43. **FITTING OF NEW TAPPET ROLLERS AND PINS.** The pin hole in the tappet is slightly smaller at one side than at the other, thus the plain unstepped pin is a shrink fit in one side only of the tappet.

To Remove Pins. Heat the tappet by holding in boiling water for a moment when the pin may be tapped out using a light hammer and brass drift.

To Fit New Pins. By using the new pin as a "go" and "not go" gauge determine which is the larger of the two holes in the tappet; this should be marked by pencil. Heat tappet in boiling water, enter pin through the larger of the two holes and through the roller, reheat tappet assembly and push pin into tappet until the pin projects an equal amount on either side.

Whilst tappet is still hot, turn pin until flats on ends of pin are square with bottom face of tappet.

NOTE: If these pins become slightly worn they may be given a second life by rotating them through 180°. The unworn side of the pin will then carry the load.

OVERHAUL AND ASSEMBLY

FUEL INJECTION PUMPS AND GOVERNOR UNIT—*continued*

44. **FITTING REPLACEMENT FUEL PUMPS.** In the event of this being necessary, due to a failure in either block of pumps, it is essential that **both** pumps are replaced by the spare pair, i.e., one pump of the spare pair will **not** replace one of the original pair. This is necessary because the pumps are calibrated when in pairs. To replace, proceed as follows:—

(1) Fit the pumps after having checked and corrected where necessary the tappet setting on each pump line as directed in paragraph 42, Page 75.

(2) Fit the eyed rod connecting the slider bar of the "aft" pump to the vertical governor lever. The length of this rod may have to be adjusted to suit the new pumps. The correct setting of the slider bar with relation to the governor weights is such, that when the governor weights are parted to their full extent, by inserting the fingers through the inspection opening (item 23, Fig. 39) in the governor case, the length of the eyed connecting rod is so adjusted as to give the slider bar a position approximately $\frac{1}{32}$ in. (·794 mm.) from its maximum stroke towards the timing case. Should it be necessary to make adjustment to this rod, great care should be exercised to see that the holes for the joint pins are parallel when the nuts are locked and that the slider bar moves freely.

(3) When the stopping lever is in the "stop" position the slider bar should still have a movement of $\frac{1}{32}$ in. (·794 mm.) before reaching the maximum "in" position as in No. (2). To obtain this, adjust the screw (10) Fig. 39, in the lower end of the governor lever.

(4) Connect all pipe-work and fit the return spring behind the "forward" pump.

Important Note: The fuel control box fitted to the pump must only be used on the pump to which it was fitted when delivered (unless the pump has been subject to full calibration procedure). The number of the pump to which a control box has been set is stamped on the box itself as is also the engine number.

Key to Fig. 38

1 Fuel Control Box Cover Plate
2 Slider Bar Stop
3 Fuel Control Trigger
4 Slider Bar Balance Spring
5 Slider Bar Buffer and Spring
6 Slider Bar Buffer Body
7 Fuel Control Box
8 Fuel Control Plunger
9 Plunger Return Spring
10 Fuel Injection Pump Units
11 Fuel Feed Pipe Unions
12 Slider Bar Dust Cover
13 Slider Bar Connecting Links
14 Fuel Injection Pump Inspection Cover
15 Dust Excluding Felt Seals
16 Felt Seal Clamping Plates
17 Insertion Plate
18 Tappet Spring
19 Tappet Adjusting Screw
20 Tappet Body
21 Tappet Roller and Pin
22 Sealing Ring
23 Cam Box End Plate (gear end)
24 Oil Dam Cross-bolt
25 Oil Feed Pipe Union
26 Cam Box Oil-passage Cover Plate
27 Anchor Post (slider bar balance spring)
28 Hand Operated Charging Lever
29 Cam Box
30 Cam Box End Plate (governor end)
31 Locking Plate
32 Charging Lever Compression Spring
33 Charging Lever Latch
34 Camshaft Ball Bearing
35 Fuel Injection Pump Cams
36 Driving Gear (lub. oil pump)
37 Fuel Lift Pump Eccentric
38 Drive Coupling
39 Fuel Pump Camshaft
40 Fuel Pump Camshaft (gear half)
41 Camshaft Helical Gear
42 Helically Splined Gear Carrier
43 Steady Peg
44 Camshaft Gear Stop-ring
45 Fuel Lift Pump
46 Priming Lever

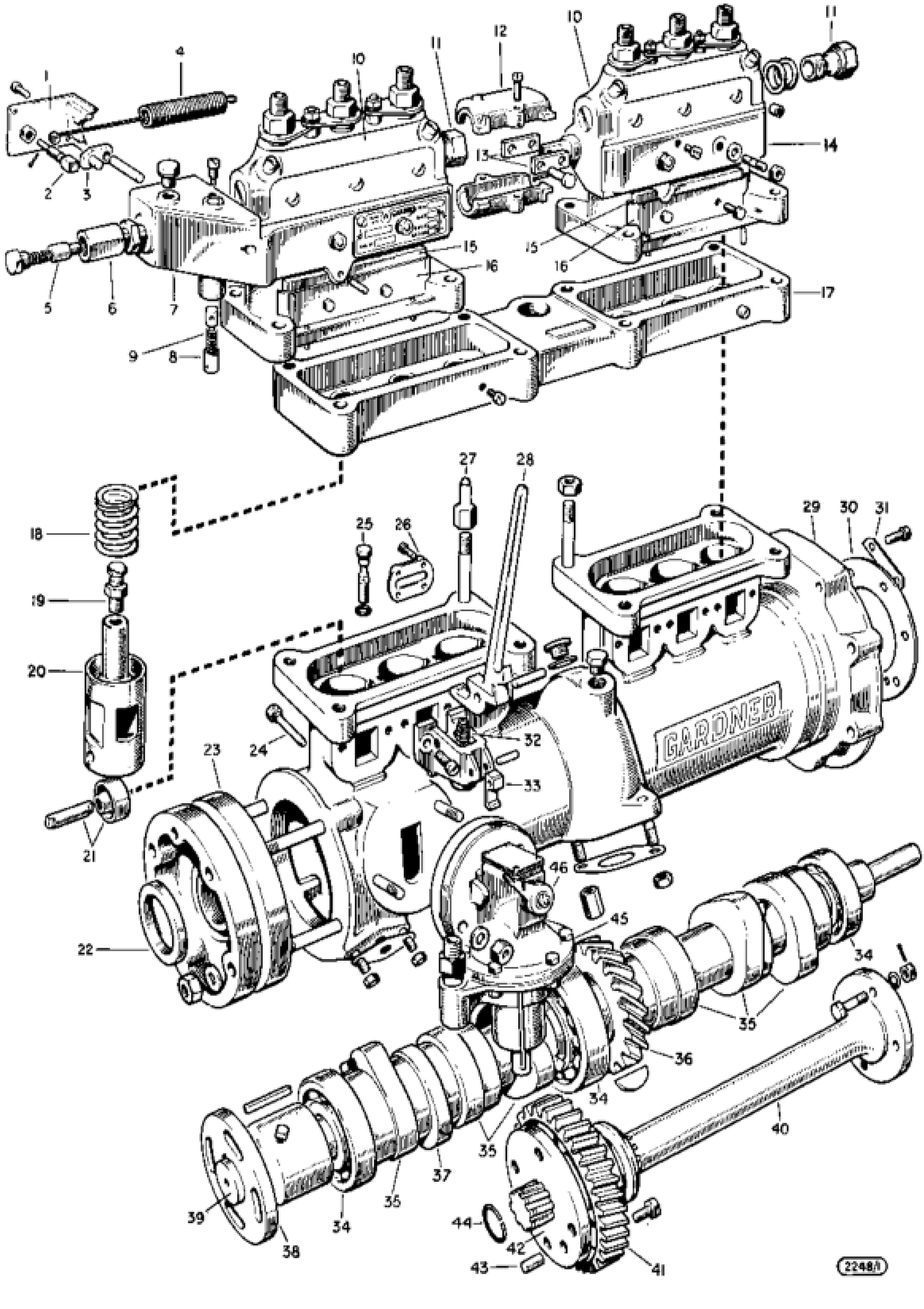


Fig. 38. Fuel Pump and Cam Box Assembly

OVERHAUL AND ASSEMBLY

FUEL INJECTION PUMPS AND GOVERNOR UNIT—*continued*

45. **FUEL INJECTION PUMP OUTPUT.** Every 48,000 miles (4,800 hours) remove the two pump units complete with mounting plate and fit to "Gardner" Calibrating Machine. Make test of maximum fuel delivery with slider bar in contact with control trigger and idling position balanced as described in Fuel Injection Pump Calibrating Machine Instruction Book No. 45.4.

In course of time maximum fuel delivery may tend to increase and the pumps should be reset to deliver the correct output in accordance with the table below.

Do not, for any purpose, increase the standard settings or operate the engine with excess fuel delivery from the injection pumps.

When taking final readings it is desirable always to interchange sprayers on individual pumps in order to establish whether an abnormal reading is due to an imperfect sprayer or to some defect or maladjustment in the pump.

In addition to the possibility of sprayers accumulating foreign matter they may, after long service, suffer wear of the actual injection holes in the nozzle, in which event calibration may be impaired and accurate setting of maximum output cannot be effected. It is advantageous, therefore, to use sprayers known to be in optimum condition when calibrating injection pumps.

Wear of the fuel pump delivery valve seat assembly adversely affects timing and hydraulic characteristics and it is recommended that these parts be renewed at major engine overhaul.

FUEL INJECTION PUMP MAXIMUM OUTPUT SETTINGS

Engine Governed Max. R.P.M.	B.M.E.P.		Camshaft R.P.M. during Calibration	Time in Seconds	Average Delivery from each Plunger cm³
	lb./in.²	Kg./cm.²			
6LX and 6HLX/1700 Road Vehicle and Rail Traction Duty ..	109·5	7·699	850	60	81·0
6LX/1500 Yachts, Cruisers Marine Duty	105·0	7·382	750	60	66·6
6LX/1400 Intermittent Duty, Air Compressors, Excavators, Saw Mills, etc.	105·5	7·417	700	60	62·4
6LX/1300 Heavy Marine Duty	105·0	7·382	650	60	58·2
6LX/1200 Generator Sets, Marine Auxiliary and Industrial Duty	100·3	7·052	600	60	51·3
6LXB and 6HLXB/1850 Road Vehicle and Rail Traction Duty ..	120·7	8·486	925	50	81·0
8LXB/1850 Road Vehicle and Rail Traction Duty ..	120·7	8·929	925	50	80·4
8LXB/1500 Yachts, Cruisers Marine Duty	109·2	7·804	750	60	69·9
8LXB/1300 Heavy Marine Duty	109·6	8·015	650	60	61·8

The above are the correct outputs under normal atmospheric temperature and pressure (N.T.P.) conditions, i.e. 60°F (15·6°C.) and 30·0 in. Hg. (762 mm. Hg.) respectively, and with fuel oil conforming to the Specification given on Page 8.

OVERHAUL AND ASSEMBLY

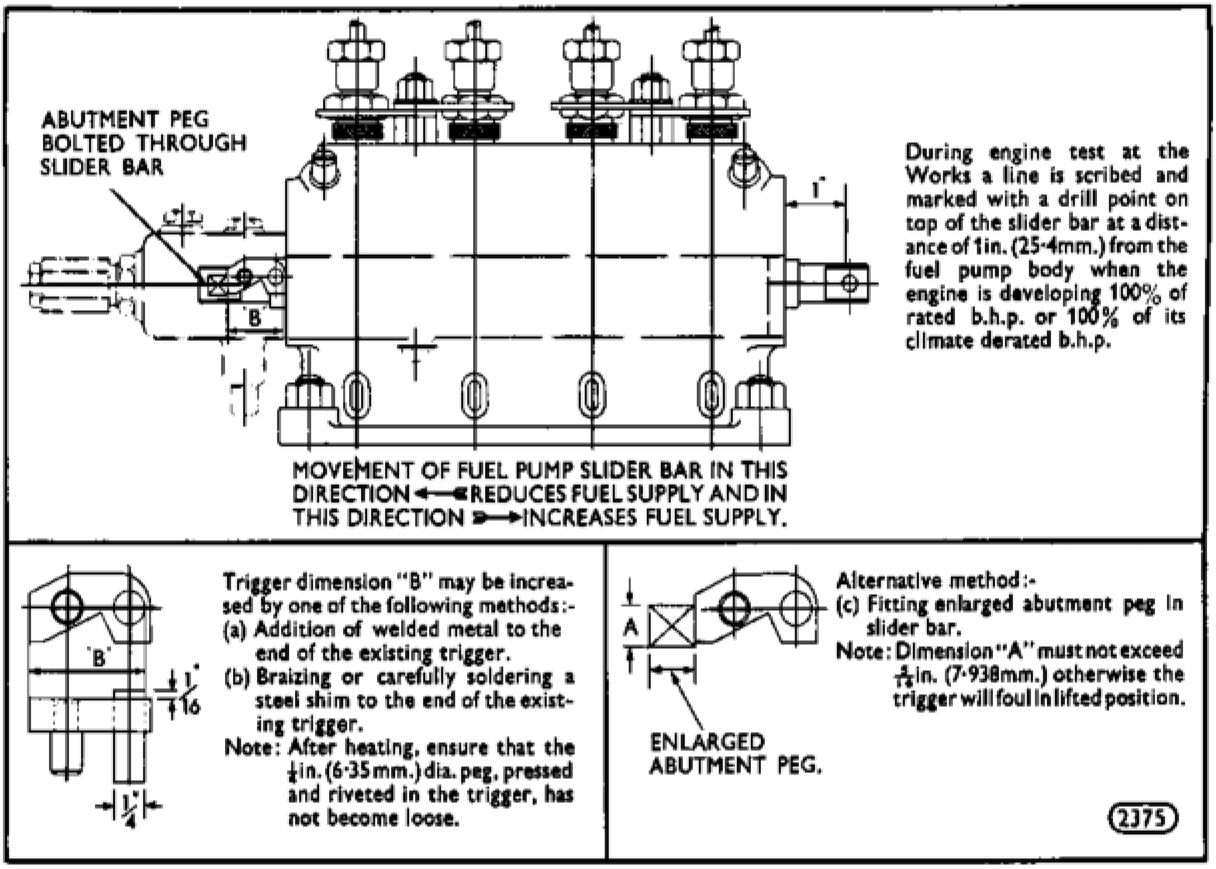
FUEL INJECTION PUMPS AND GOVERNOR UNIT—*continued*

46. **POWER REDUCTION BY LENGTHENING FUEL LIMITING TRIGGER.** Should it be desired to reduce the maximum power rating for special installations or to suit certain site conditions as prescribed on page 4, the trigger length must be increased in the manner described below or preferably a new trigger substituted of the correct length. The original trigger length (dimension "B") is stamped on the side of each trigger and may be accurately measured with a micrometer by inserting a fitting parallel ¼ in. (6·35 mm.) dia. pin into the hole in the trigger.

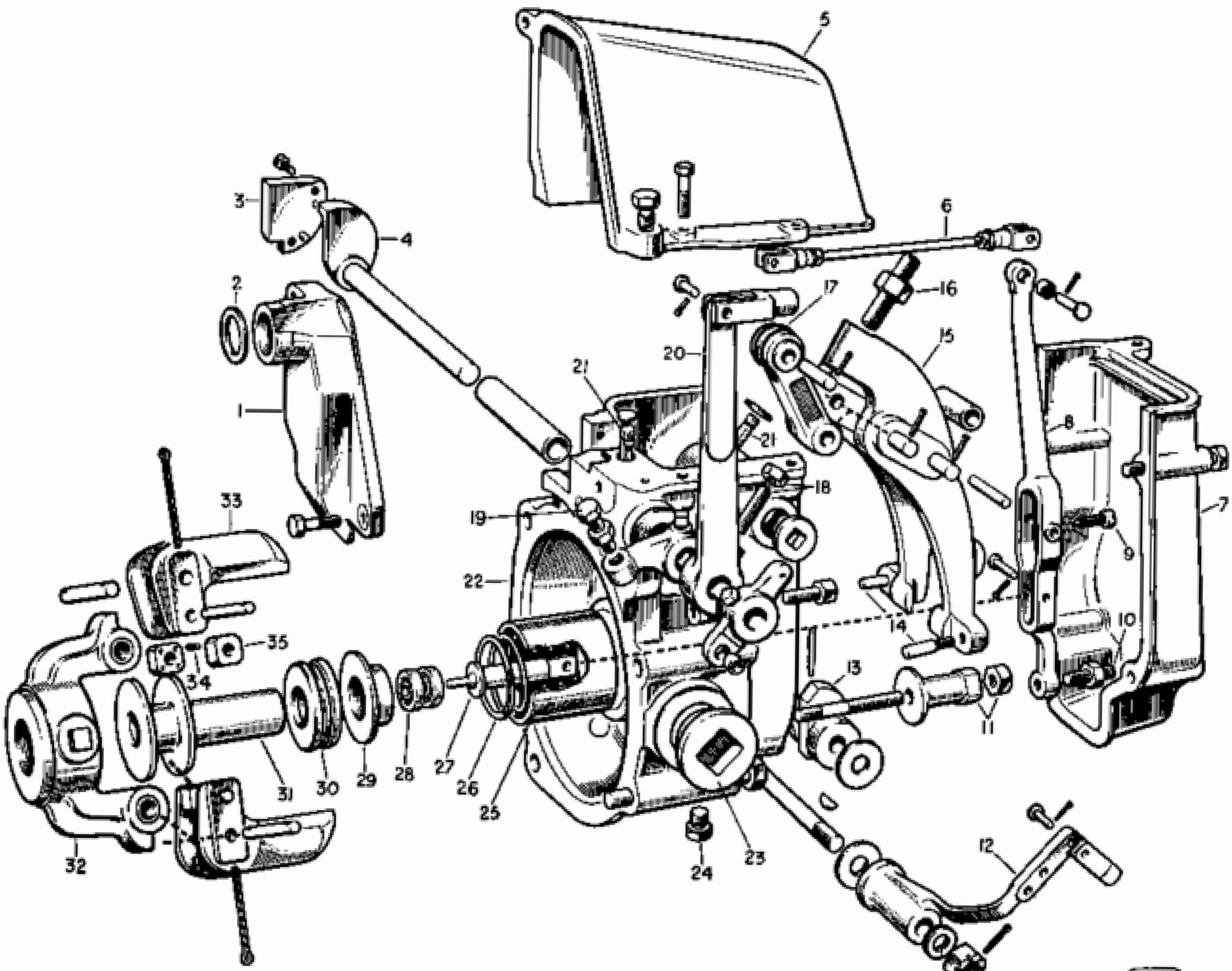
The accompanying table shows the percentage of full power available and approximate percentage of full power fuel supply when the trigger is lengthened by increments of ·010 in. (·254 mm.). On the LX engine for example, if the trigger length is increased by ·050 in. (1·27 mm.) to derate to 87% of its normal full power at 1,700 r.p.m. (850 r.p.m. camshaft speed)—see Table on page 78—the maximum fuel delivered in 60 seconds will be 87% of 81 cm.^{3}=70·5 cm^3.

Under no circumstances must a reduction in trigger length (or increase in fuel supply) be effected.

Trigger Length Increase		Percentage of full power available	
in.	mm.	LX	LXB
·010	0·254	97·5	97·6
·020	0·508	95·3	95·5
·030	0·762	92·5	93·0
·040	1·016	89·9	90·6
·050	1·270	87·0	88·3
·060	1·524	84·2	86·0
·070	1·778	81·2	83·5
·080	2·032	78·3	80·6
·090	2·286	75·4	78·6
·100	2·540	72·5	76·0



FUEL INJECTION PUMPS AND GOVERNOR UNIT—*continued*



1 Governor Casing Front Cover
2 Slider Bar Sealing Ring
3 Governor Casing Side Cover
4 Accelerator Cam
5 Governor Casing Upper Cover
6 Slider Bar Connecting Link
7 Governor Casing Rear Cover
8 Governor Lever
9 Fulcrum Pin Locking Screw
10 Stopping Cam Tappet Screw
11 Idle Speed Flanged Adjusting Nut and Locknut
12 Stopping Lever
13 Stopping Cam
14 Governor Spring Lever Stop Pegs
15 Governor Spring Lever (cam operated)
16 Spring Lever Adjusting Screw
17 Accelerator Cam Roller and Lever
18 Maximum Speed Limiting Screw
19 Slow Running Adjustment Screw
20 Accelerator Lever
21 Wick Lubricators
22 Governor Casing
23 Access Plug
24 Drain Plug
25 Governor Spring Guide
26 Governor Spring
27 Governor Push Rod
28 Ball Bearing
29 Governor Spring Collar
30 Thrust Bearing
31 Governor Sleeve
32 Governor Body
33 Governor Weight
34 Trunnion Block Compression Spring
35 Trunnion Blocks

Fig. 39. Governor Assembly

OVERHAUL AND ASSEMBLY

FUEL INJECTION PUMPS AND GOVERNOR UNIT—*continued*

47. **GOVERNOR ASSEMBLY.** For the governor to operate smoothly it is necessary that the various pins, bushes and trunnion blocks have a cumulative total of not more than about ·004 in. (·102 mm.) diametral slack. Where exceeded it will be necessary to fit new blocks and pins in the toes of the weights and new pins and bushes in the weights and body. As it is quite essential that the weights do equal work it will be understood that if one pin requires renewal all the pins and bearings will require restoration to their new state. To facilitate reassembly, the hinged ends of the governor body are stamped 1 and 2, as also are the corresponding governor weights and each pair of trunnion blocks. These parts should be reassembled number to number. Replacement trunnion blocks are not numbered and are stamped with a Zero Mark on their thrust faces.

Always use new split pins of correct size and length with equal legs when reassembling. Before fitting the split pins bend slightly about half way along their lengths to ensure a tight fit in their holes. After fitting, open the legs and bend them so that they are firmly bedded round the radius of the governor weight toe as shown in Fig. 40.

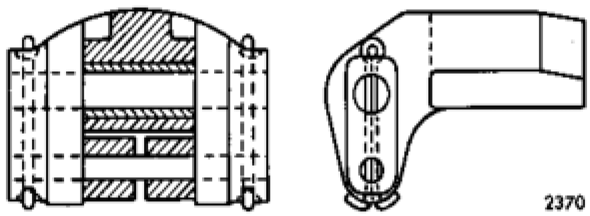


Fig. 40. Governor Weight Assembly

Service reconditioned bodies and weights assemblies can be obtained from our Works and Service Depots in exchange for worn parts.

Special withdrawal and extractor tools are available for removing the governor body from the fuel pump camshaft and for extracting the ball races (Item 28, Fig. 39) from the governor sleeve. The application of these tools is shown in our Workshop Tools Book No. 63.

48. **GOVERNOR WEIGHT TOE BEARINGS.** The toes of the governor weights are each equipped with a pair of rectangular spring loaded trunnion blocks (Item 35, Fig. 39). On engines used in generating sets these trunnion blocks are replaced by a tubular steel roller.

When assembling the trunnion blocks it is essential that the Zero Marks on each pair of blocks are coincident and facing towards the governor spring so that they bear on the loaded flange of the governor sleeve as shown in Fig. 41.

The quantity and location of springs fitted in the trunnion block assemblies is important and varies according to engine type. The following table indicates the correct number and location of springs:—

Engine	No. of springs per toe	No. of springs per engine	Spring location in holes
6LX, 6HLX 6LXB, 6HLXB 8LXB (Mar.)	1	2	a
8LXB (Auto.)	3	6	a, b, c

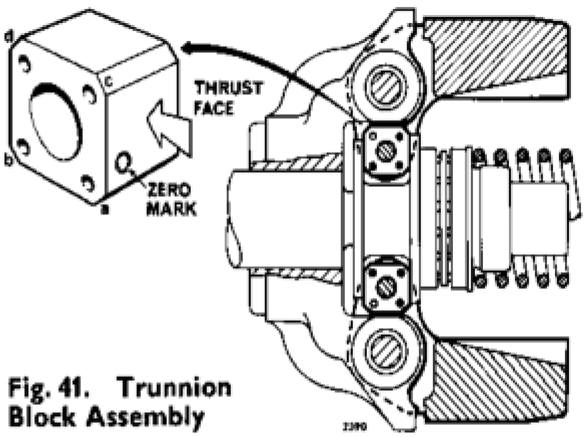


Fig. 41. Trunnion Block Assembly

49. **GOVERNOR READJUSTMENT.** After overhaul or when a new governor spring is fitted or the setting is otherwise disturbed, the governor and fuel pump slider bar connecting link must be readjusted in the manner described below.

The operation is normally carried out during the dynamometer tests of the engine after assembly but, if the following instructions are observed, adjustment may be effected before fitting the cambox assembly to the engine.

(1) With the governor weights parted to their full extent, adjust the length of the governor bar connecting link to give the slider bar a position approximately $\frac{1}{32}$ in. (·794 mm.) from its maximum stroke towards the timing case, as described in paragraph 44, sub-paragraph 2, Page 76.

OVERHAUL AND ASSEMBLY

FUEL INJECTION PUMPS AND GOVERNOR UNIT—*continued*

(2) By adjustment of the maximum speed limiting setscrew in the rocking lever on the accelerator cam spindle (See Fig. 42), set the straight flank of the accelerator cam at the appropriate angle, given in the following table, for the required maximum speed.

Cam Angle and Spring Measuring Load

Engine type	Maximum r.p.m. Full Torque	Maximum r.p.m. No Load	Spring Load lb.	Spring Load kg.	Cam Angle
6LX & 6HLX	1,700	1,760	107	48·5	+27°
	1,500	—	74	33·6	+9°
	1,300	—	50	22·7	—2·5°
6LXB 6HLXB	1,850	1,980	130	58·9	+27°
8LXB	1,850	1,980	130	58·9	+27°
	1,500	—	66·5	30·2	+4°
	1,300	—	42·0	19·0	—4°

NOTE: A "plus" sign before the angle given indicates that the straight flank is leaning towards the flywheel, whilst a "minus" sign indicates that the straight flank is leaning towards the forward end of the engine.

(3) Determine the length of the actual spring to be used, when loaded to the figure given in the table for the particular maximum speed concerned. Initial assembly is then made with a tubular distance piece in place of the spring. The length of this distance piece **MUST** be made precisely the same as that of the spring when compressed to the working load given in the table above.

(4) With the governor weights fully closed, the distance piece in position and the cam set as above, adjust the governor spring lever screw (Fig. 40), until the rounded toes at the lower end of the lever touch the end face of the spring guide. Fit the stop pegs in the lever arms and file each peg to give ·002 in. (·051 mm.) clearance from the face of the governor case.

(5) Fit the spring in place of the distance piece.

(6) Readjust the governor spring lever screw to restore the ·002 in. (·051 mm.) clearance between the stop pegs and governor case.

For automotive engines, which can be run in neutral gear at maximum speed and no load, the following alternative procedure may be adopted to readjust the governor control.

(*a*) Remove the governor bar buffer from the fuel pump control box.

(*b*) Proceed as described in the preceding sub-paragraphs 1 and 2 and start the engine.

(*c*) After the engine has attained normal working temperatures, set the accelerator cam to the maximum r.p.m. position at 27° then adjust the governor spring lever screw to obtain the appropriate maximum no-load speed. See table.

(*d*) Reduce the engine speed to idling, replace the buffer in the control box and adjust the slow running and slider bar buffer as described in paragraphs 39 and 43, pages 36 and 37 respectively.

NOTE: As indicated this method applies only to automotive type engines used in road vehicles, rail cars and locomotives. This method must **NOT** be applied to engines arranged for other duties where original maximum r.p.m. differs from those quoted above.

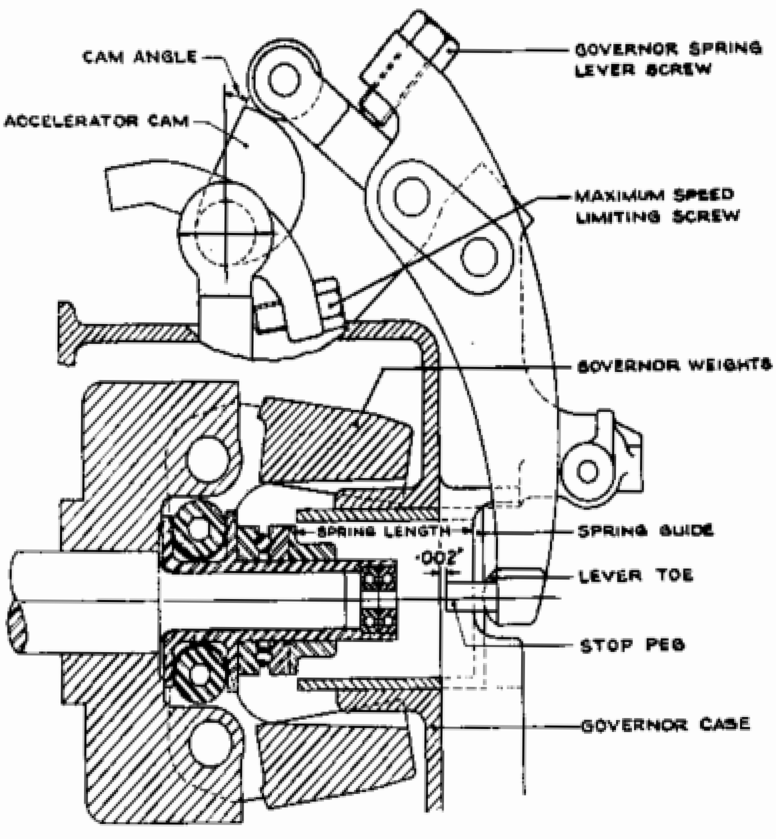


Fig. 42. Governor Re-adjustment

OVERHAUL AND ASSEMBLY

FUEL SPRAYERS

50. **SERVICE EXCHANGE SPRAYERS.** Gardner factory-reconditioned sprayers are available from the Works, Branch Offices, Service Depots and from our official Service Agents, at a modest cost in exchange for used sprayers.

It should be noted that 6LXB sprayers are stamped on the sprayer body and that these sprayers are not interchangeable with 6LX sprayers.

51. **FUEL SPRAYER TESTING.** Make the following inspections and tests, etc.:

(1) Test for stoppage of jets and shape of issued jets of fuel.
(2) Test for leak of sprayer valve-nozzle seat.
(3) Test for satisfactory vibration of sprayer valve.
(4) Test for leakage of fuel past large diameter of valve.
(5) Test spring load on sprayer valve and/or hydraulic opening pressure.
(6) Observe sprayer cap nut for effective gas seal with cylinder head.
(7) Renew filter washers.

Tests 1-6 can be carried out by removing sprayer from engine, reconnecting to sprayer pipe and hand operating the fuel pump priming lever.

52. **TESTS FOR STOPPAGE OF JET HOLES AND SHAPE OF ISSUED FUEL JETS.** Mount the sprayer on a fuel pipe connected to the engine fuel pump, see Fig. 18, Page 39, or to a bench-mounted test pump in such a manner that the fuel jets are visible when the hand lever is operated. The jets of fuel emitted from the nozzle holes should all travel through the same distance and possess the same shape. If defective, prick out the holes with a pricker, and at the same time clean out the central bore of the nozzle. The size of holes is of great importance, therefore use only prickers of the correct diameter. These are available from the Works.

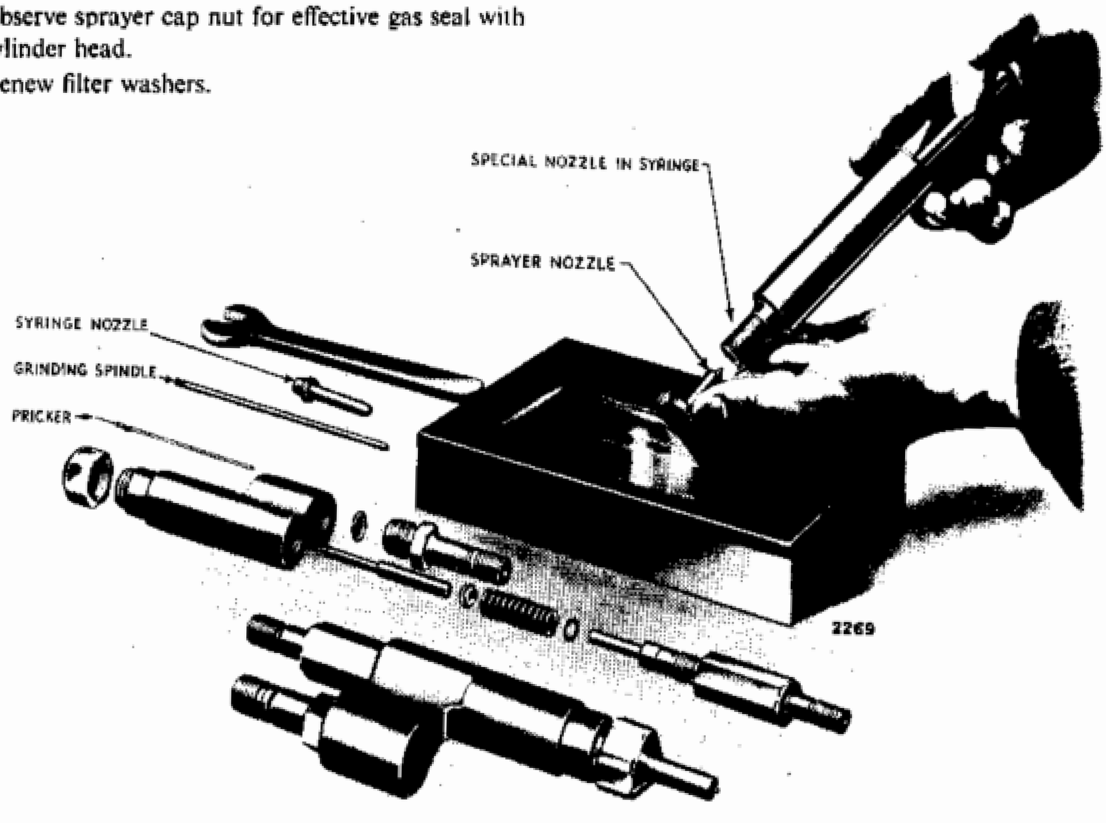


Fig. 43.
Cleaning the Sprayers

OVERHAUL AND ASSEMBLY

FUEL SPRAYERS—*continued*

53. **TO CLEAN SPRAYER NOZZLE.** Cut a piece of wood or cane to approximately the same shape as the sprayer valve tip and rotate same in bore on seat of nozzle, using metal polish or 600 grit Carborundum powder. Prick out the jet holes and finally wash out by forcing paraffin from outside to inside of nozzle. Supplied with the engine is a syringe complete with special fitting made to receive the nozzle, which enables paraffin to be forced through the jet holes in a direction **opposite** to that obtaining when the engine is in operation. See Fig. 43.

54. **TO TEST FOR LEAK OF SPRAYER VALVE SEAT, VIBRATION OF SPRAYER VALVE AND LEAK PAST LARGE DIAMETER OF VALVE.** Mount the sprayer on a fuel pipe connected to the engine fuel pump, or to a bench-mounted test pump having *the same diameter plunger as the engine pump.*

Operate hand priming lever and expel all air from the system; apply a force to the lever just short of that required to lift the sprayer valve from its seat. If the seat be unsound fuel will run from the nozzle. A valve seat may be accepted as satisfactory if, when approximately half the force necessary to lift the valve from its seat is applied to the lever, not more than two drops per minute fall from the nozzle.

Operate the priming lever rapidly and observe that the sprayer valve vibrates satisfactorily. This is indicated by feel and noise generated by the rapid opening and closing of the valve. The noise can be described as a squeak and sprayers may vary in this characteristic; those which make most noise are not of necessity operating more satisfactorily than those which make only a moderate noise. When making this test for valve vibration it is essential that any pressure recording means, which may be mounted between pump and sprayer, be omitted. Satisfactory vibration may be prevented by either a leaking valve seat, a worn and consequently wide valve seat, malalignment of valve and nozzle causing friction or, in rare instances, a leak past the large diameter of the valve itself.

Operate the priming lever in the manner described for testing valve seat. If a "solid feel" is not obtained observe whether fuel be leaking past the large diameter of valve into the leak pipe union bore. A slight leak is desirable and a considerable leak is permissible since on engine operation it has little effect. If a reasonably "solid feel" is not obtained return sprayer to Works for the fitting of a new valve.

NOTE: A leaking fuel pump plunger may also prevent the attainment of a "solid feel".

55. **TO CORRECT A LEAKING VALVE.** Dismantle the sprayer and examine minutely the seat on both the nozzle and the valve for dirt or anything which may prevent the correct seating of these faces. Whether or not any obstruction has been found, wash the parts in paraffin and replace without wiping, assembling the parts so that the nozzle is in correct alignment with the valve, as instructed in paragraph 62, Page 85. A leaking valve seat may be traced to mis-setting of the nozzle to the body (alignment). If, on further trial, the seat be still defective, they may require lapping together, but this should be effected only as a last resource, and as seldom as possible.

56. **TO LAP TOGETHER SPRAYER VALVE AND NOZZLE SEAT.** Remove valve stop, spring, screw cap and nozzle, mount sprayer body in vice with nozzle end to left hand. Screw into hollow end of valve the knurled lapping tool supplied with the engine and replace valve in body. Smear the valve seat with a minute quantity of 600 grit Carborundum powder mixed with oil. Hold the sprayer nozzle with the finger and thumb of the left hand up against the end of the sprayer body. Apply very light end load to the sprayer valve and rotate slowly both valve and nozzle in opposite directions. The absolute minimum of lapping should be performed as an excessive amount will seriously damage both valve and seat. The best seat is formed by little more than line contact and the more a valve is lapped into its nozzle the wider becomes its seat. A seat which has become too wide is prone to leak and can be rectified only by regrinding the valve and re-seating the nozzle. These operations are normally effected by the Works since specialised machines are required for this purpose.

57. **SCREWED CAP AND NOZZLE.** Before assembling after grinding or examination, see that the outside surface of the nozzle and the bore of the cap are perfectly clear of carbon or other matter which might interfere with the alignment mentioned in paragraph 62, Page 85.

58. **LIFT OF SPRAYER VALVE.** The maximum lift of this component is determined by an extension of the valve stop reaching inside the spring. The correct lift is ·007 in. (·178 mm.) which may be measured by means of a depth recording micrometer inserted in the sprayer body, resting on the valve stop face and measuring depth to spring disc and similarly measuring the length of the valve stop.

OVERHAUL AND ASSEMBLY

FUEL SPRAYERS—*continued*

59. **SPRAYER DELIVERY STOCK AND FILTER WASHER.** The filter washer located under the delivery union stock must be renewed when sprayers are reconditioned at routine change every 48,000 miles (4,800 hours).

Sprayers so fitted are identified by a plain hexagon or by a groove and drilled dimple on the hexagon of the delivery stock. Sprayers with the groove alone and without a dimple have a plain steel washer under the delivery stock. These sprayers must **not** be fitted with the filter washer unless assembled in conjunction with a new or modified delivery union stock.

The filter washer is incorporated in all new and Gardner-serviced sprayers.

The correct tightening torque for the delivery union stock with either type of washer, is 625 lb. in. (7·2 kg.m).

60. **SPRING LOAD ON SPRAYER VALVE.** The opening and closing pressure of the sprayer valve is largely determined by the load required to compress the spring a given amount. The correct spring load, which should be rigidly adhered to, is 68·3 lb. (31·0 kg.) and the spring should exert this load when compressed to its working length of 1·007 in. (25·578 mm.).

When fitting a replacement spring it may be necessary —if the correct loading does not register—to fit shim washers between the upper end of the spring and the screwed stop, in order to obtain the correct spring loading. These are available in thicknesses of ·003 in. (·076 mm.) and ·007 in. (·178 mm.).

61. **HYDRAULIC OPENING PRESSURE.** The following hydraulic opening pressures are quoted as a guide when using a hand test pump. The pump must be operated slowly and have a plunger diameter approximately equal to that of the engine injection pump.

(*a*) With the sprayer valve seats in new condition a load of 68·3 lb. (31·0 kg.) corresponds to a hydraulic opening pressure of 124-125 kg./cm.^{2}, i.e. 1,764-1,778 lb./in.^{2}.
A tolerance of plus or minus 1½% is regarded as permissible.

(*b*) When sprayer valves and seats have had long use the seat width is increased and the effective seat diameter becomes smaller. A 68·3 lb. spring load will then correspond to a hydraulic opening pressure of 122-123 kg./cm.^{2}, i.e. 1,735-1,749 lb./in.^{2}, and providing the needle valve *vibrates satisfactorily* and *does not leak*, it is unnecessary to increase the spring load to attain a greater opening pressure.

If, when testing by a rapid pull on a hand test pump, the needle valve does not vibrate or if the valve seat shows leakage of fuel, return the sprayer to the Works or any Gardner Service Depot in exchange for a service unit.

62. **TO REASSEMBLE THE SPRAYER.** Wash every part scrupulously clean with clean paraffin and, *without wiping*, reassemble in the following order:—

(1) Piston valve with grinding spindle attached.

(2) Nozzle and cap.
Hold the sprayer in a vice by the heavy end with the body horizontal, take the valve with grinding spindle attached in the right-hand fingers, insert the valve in the body and with the left-hand fingers on the cap nut gently tap the valve on the nozzle seat, gradually tightening the cap nut from slack to finger tight. This action will be found to align the nozzle with the valve. If correct alignment is obtained the valve will be perfectly free to be lifted from the seat. If incorrect alignment is obtained the valve will be found to stick in the seat. Finally, tighten the cap nut with spanner and re-check. **This procedure is of the utmost importance.**

(3) Spring disc.

(4) Spring and Valve Stop.
It is vitally important that the spring disc be fitted correctly, i.e. the larger diameter boss fitting into the spring and the smaller boss (on the chamfered side) locating in the valve. To assemble, hold the valve stop upside down (shank uppermost) and slide the shims and spring over the stop and up to abutment face. Place the disc on the end of the spring making sure that the spring collar or boss is located in the coil of the spring. Take the sprayer body in the other hand (having first removed the valve grinding spindle), and holding the nozzle end in a raised position, screw the assembled spring disc, spring and valve stop into the sprayer body.
This method of assembly will ensure correct positioning of the spring disc and prevent any possibility of the disc becoming inverted as might easily happen, if it is dropped into the sprayer body on top of the valve.
If the spring disc has been correctly fitted it will be possible to screw the stop up to the shoulder by hand only; this provides an additional check on the correct fitting of the spring collar or disc.

OVERHAUL AND ASSEMBLY

CHAIN CASE AND CHAIN DRIVE

63. **REMOVING AND FITTING CHAIN CASE COVER.** The camshaft roller bearing is located in the chain case cover and forms the support for the end of the camshaft. It is necessary therefore to avoid any excessive chain tension whilst the cover is removed, otherwise undue deflection of the camshaft will occur.

If a replacement cover is to be fitted it is essential to ensure perfect alignment of the cover with the camshaft roller race. To do this, first fit the outer race of the roller bearing into its housing in the chain case cover followed by the retaining circlip, bedding the latter firmly into its groove.

Fit the cover over the chain case studs and make sure that the outer race slides easily over the roller bearing on the camshaft. If any tightness is experienced when pressing the cover into position, the camshaft may be forced out of alignment. This can be remedied by easing the stud holes which are binding until sufficient clearance is obtained to permit the cover to be rocked slightly on the studs, using the bearing as a fulcrum.

Having verified that all is correct, position the cover midway between the limits of the stud hole clearances and holding it in this position tighten all nuts. Finally drill and peg the cover to the chain case, using oversize pegs.

64. **CHAIN DRIVE ARRANGEMENT.** Generator sprockets of 15, 18 and 20 teeth are available to provide alternative gear ratios for generator or alternator drives and the run of the timing chain round the fixed idler sprocket differed on earlier engines according to the size of generator sprocket and length of chain employed, see Fig. 44. Engines up to No. 135274 were fitted with an adjusting idler having a ½ in. (12·7 mm.) throw on its eccentric. With these engines therefore it is wise before removal to observe on which side of the fixed idler sprocket the chain is fitted, so that it may be re-assembled in the same position and thus ensure that full range of adjustment is preserved on the adjusting idler.

On the latest engines the adjusting idler has a ⅞ in. (22·225 mm.) throw and with these engines the timing chain is arranged to run round the inside of the fixed idler irrespective of the size of generator sprocket fitted.

When fitting the adjusting idler, check that the idler sprocket is in alignment with the crankshaft driving sprocket by placing a straight edge across the face of both sprockets. Any slight malalignment can be remedied by tapping the idler sprocket in the required direction on the outer race of its bearing.

When assembled, the adjuster eccentric must be so positioned that when the adjuster is rotated *clockwise*, chain tension is *increased*. In this way the idler sprocket will be positioned mid-way between the crankshaft and generator drive sprockets.

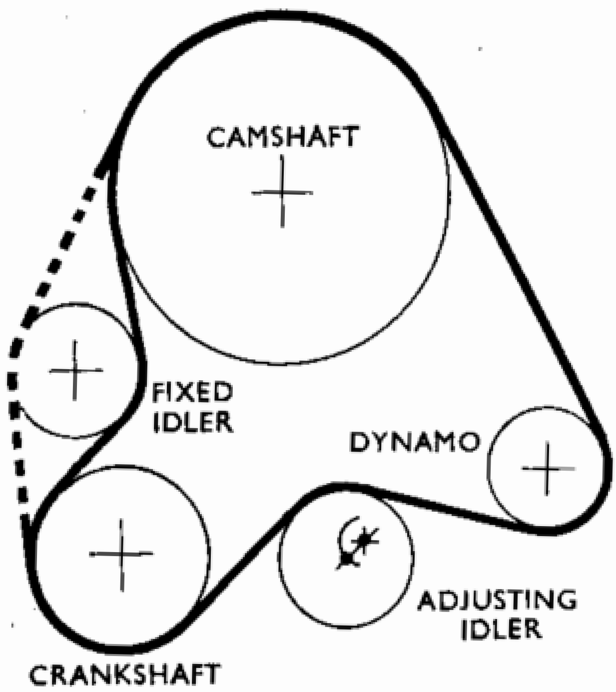


Fig. 44.
Chain Drives

65. **REMOVAL AND REPLACEMENT OF TIMING CHAIN.** The endless timing chain has a riveted joint link which can be recognised by the small indents in the stud ends and it is desirable that this link be removed to break the chain. The well-known standard Renold Stud Extractor may be used for this

OVERHAUL AND ASSEMBLY

CHAIN CASE AND CHAIN DRIVE—*continued*

purpose after removal of the chain case cover. Alternatively, if the sump and splash door have been removed, the engine may be turned until the joint link is engaging with the crankshaft sprocket, when the studs may be driven through the link plate, using a pin punch and hammer. **Under no circumstances should any of the other sprockets be used as an anvil for this operation.**

Special workshop tools are available for pressing on the outer plate and for indenting the studs when reassembling. See Fig. 45 and also Workshop Tools Book No. 63.

These tools greatly facilitate assembly but the work can also be done using a hollow punch obtainable from the Works. A light hammer can be used to rivet the stud ends whilst holding a small anvil block against the opposite ends of the studs.

66. **RENEWAL OF CHAINWHEELS.** These are unlikely to require renewal except after extremely long service and only if the teeth have become "hooked" to such an extent that they are liable to interfere with the smooth driving of the chain.

This can be checked by wrapping a new chain around the chainwheel and if slight impact can be felt at the engagement of each tooth, a replacement is indicated.

When renewing the camshaft chainwheel, ensure on assembly that it is in alignment with the crankshaft sprocket. Check by first recording the depth from the front face of the timing case to the crankshaft sprocket and then similarly measuring the depth to the camshaft chainwheel. Any difference recorded will indicate the thickness of shims required between the chainwheel and the camshaft hub. These shims are available in thicknesses of ·010 in. (·25 mm.) and ·020 in. (·50 mm.). A tolerance of —·000 in. to + ·010 in. (+ ·25 mm.) on the final dimension is permissible.

67. **ALTERNATOR DRIVE SPROCKET.** When a replacement sprocket is fitted it must be the same size as the one originally supplied.

Alignment of the sprocket is obtained by the use of shims interposed between the sprocket and the inner races of the front and rear ball bearings as indicated at "X" and "Y" in Fig. 46.

These shims are available in the following thicknesses:—

·004 in.	·012 in.	·019 in.
(·102 mm.)	(·305 mm.)	(·483 mm.)

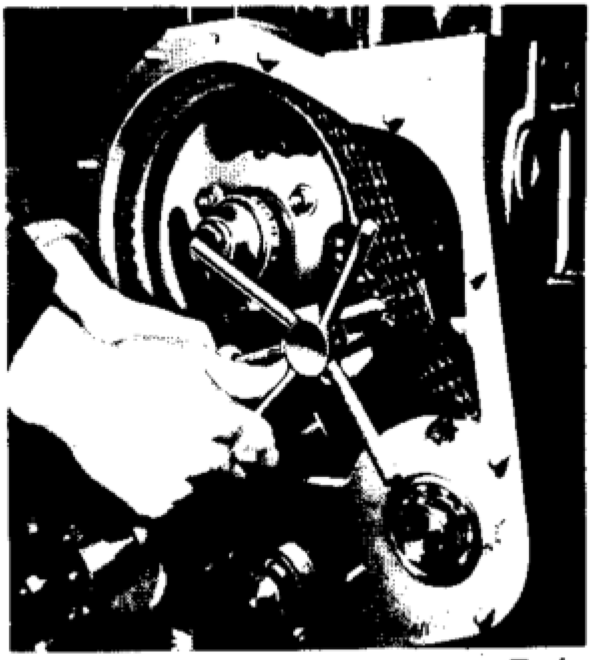


Fig. 45. Chain Riveter and Extractor Tool

Normally, the total thickness of shimming required amounts to ·040 in. (1·016 mm.) divided between points "X" and "Y" to give the required end clearance at "E" of ·010 in. (·254 mm.) to ·015 in. (·381 mm.).

Before commencing assembly of the alternator sprocket measure the distance from the front face of the chain case to the machined face of the crankshaft sprocket with a depth gauge.

Assemble the sprocket shaft, rear ball bearing and dust-excluding felt washer in the bearing housing and bolt the assembly in position at the rear of the chain case.

Fit the sprocket on the shaft, driving it against the inner race of the rear bearing. Measure the distance

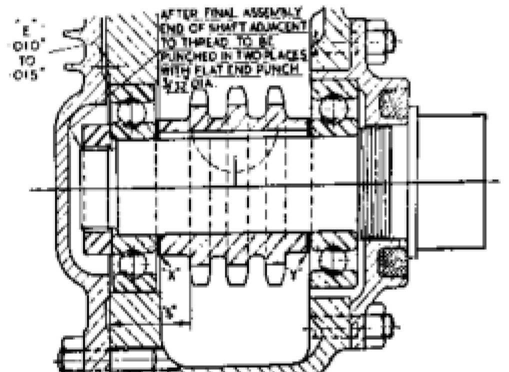


Fig. 46. Alternator Driving Sprocket Assembly

OVERHAUL AND ASSEMBLY

CHAIN CASE AND CHAIN DRIVE—*continued*

from the front face of the chain case to the front face of the sprocket at "S". The difference between this reading and the one taken on the crankshaft sprocket will determine the thickness of shims required at point "Y" to align the two sprockets.

As already mentioned the total amount of shimming required at points "X" and "Y" is ·040 in. (1·016 mm.) therefore having assessed the thickness of shims required at "Y", it is a simple matter, by subtraction, to determine the thickness of shims required at point "X" to provide the desired end clearance of ·010 in. (·254 mm.) to ·015 in. (·381 mm.) at point "E".

After final assembly with all shims in position, a final check should be made at point "E" to ensure that this clearance has been maintained.

Lock the retaining nut by punching the end of the shaft adjacent to the thread in two places with a small flat-end punch.

TIMING

68. **TIMING OF VALVES.** When reassembling an engine after overhaul, it is of the utmost importance to pay special attention to the timing of the valves with relation to the crankshaft, since if the timing be not in accordance with the timing marks on the flywheel (para. 69) and the timing gears (para. 71) the valves will foul the pistons and *serious consequences will result.* For this reason, it is desirable, on reassembly, to place the lower end of the tappet rod in the cam-tappet socket without the upper end engaging the valve lever, until all is verified. In this way, one can observe the vertical motion of the free end of the tappet rod as the flywheel is rotated to and fro.

When correctly set the timing of the valves should be such that, when the piston is towards the top of the exhaust stroke, the inlet valve will be on the point of opening while the exhaust valve will be on the point of closing; correct timing being as follows:-

LX & HLX Engines	
Inlet valve opens	11° before T.D.C.
Exhaust valve closes	11° after T.D.C.
LXB & HLXB Engines	
Inlet valve opens	16½° before T.D.C.
Exhaust valve closes	11½° after T.D.C.

The above timing must be set with the timing chain *tight* and with both inlet and exhaust valve tappets adjusted to the following clearances:-

LX & HLX Engines	·020 in. (·508 mm.)
LXB & HLXB Engines	Up to No. 171160, excluding 170825
with — 5B cams:	·020 in. (·508 mm.)
LXB & HLXB Engines	No. 170825 and from 171161-onwards
with — 5D cams:	·025 in. (·635 mm.)

NOTE: After timing has been completed the timing chain must be re-adjusted to the correct running tension (refer to paragraph 56, page 41) and the tappets re-adjusted to give the correct running clearances of ·004 in. (·102 mm.) for the inlet valves and ·008 in. (·203 mm.) for the exhaust valves.

69. **TIMING MARKS ON FLYWHEEL: FUEL INJECTION AND TOP DEAD CENTRE.** Drawn across the periphery of the flywheel will be found timing lines for each cylinder. A short line will also be observed on top of the crankcase at the base of the cylinders, called the **zero line.** Taking, for example, the lines on the flywheel for No. 1 cylinder, when the line marked "No. 1 T.D.C." registers with the zero line, crank No. 1 is exactly at top dead centre (T.D.C.) and when the line marked "No. 1 injection" (with the appropriate 'degree' marking) registers with the zero line on the compression stroke, the timing lines on the fuel injection pump should coincide, as described in paragraph 70. The line marks the position of maximum advance and the number denotes the number of degrees before T.D.C. In certain installations the upper portion of the flywheel and clutch housing is obscured; in such cases the timing marks will be observed through an oval aperture in the front face of the crankcase flanged end-plate on the fuel pump side of the engine.

It is to be understood that, whilst checking the timing in this way, the pointer of the advance and retard device must be turned to point to position of maximum advance; this of course, can be obtained by movement of the accelerator lever to maximum speed position.

NOTE: No. 1 cylinder is that situated at the forward end of the engine.

70. **TIMING MARKS FOR FUEL INJECTION.** Each fuel pump is provided with a sight hole or window through which can be seen the plunger guide moving up and down when the crankshaft is rotated. On the side of each window is a horizontal line and also one on the plunger guide. When these two lines coincide, the corresponding injection line on the flywheel should register with the zero line, as described in paragraph 69. When so checking the timing, the engine must of course

OVERHAUL AND ASSEMBLY

TIMING—*continued*

be rotated in its running direction and the plunger guide under observation must be ascending. On the fuel pump tappet are locked screws which should never be disturbed. See paragraph 42, Page 75.

71. **TIMING OF VALVE AND INJECTION PUMP CAMSHAFT.** The stud holes in the chain wheel are elongated to permit a small amount of rotation relative to the valve camshaft hub, for the purpose of accurate timing.

When the timing is correct, the position of the chainwheel relative to the valve camshaft gear is marked by tracing on the periphery of the camshaft hub the contour of a small lune shaped cut-out in the edge of one of the chainwheel apertures; the resulting mark forming an arc.

With the chaincase cover removed and flywheel set to bring No. 1 crank to T.D.C. at end of compression stroke (as directed in paragraph 69) the following conditions will obtain if chainwheel, gears and splines have been correctly meshed (See Fig. 47).

(1) The dots 1 and 2 on the gearcase and the dots 3 and 4 on the periphery of the valve camshaft gear will all lie on a straight line as indicated by the stretched cord in Fig. 47.

(2) Visible through one of the quadrant shape apertures in the chainwheel will be seen the dotted tooth on the valve camshaft gear lying between the two dotted teeth of the gear on the fuel pump camshaft.

(3) In the centre of the topmost chainwheel aperture the lune shaped cut-out will be seen to coincide with the lune shaped mark on the periphery of the valve camshaft hub. Should the chainwheel hub and gear be incorrectly bolted together this will be immediately visible as the scribed line on the hub will not coincide with the profile of the lune.

(4) The dotted spline on the fuel injection pump drive shaft will coincide with the dot on the splined hub (see dots 5 and 6 Fig. 47).

Note: All dots referred to in the foregoing description are countersinks made by the point of a drill.

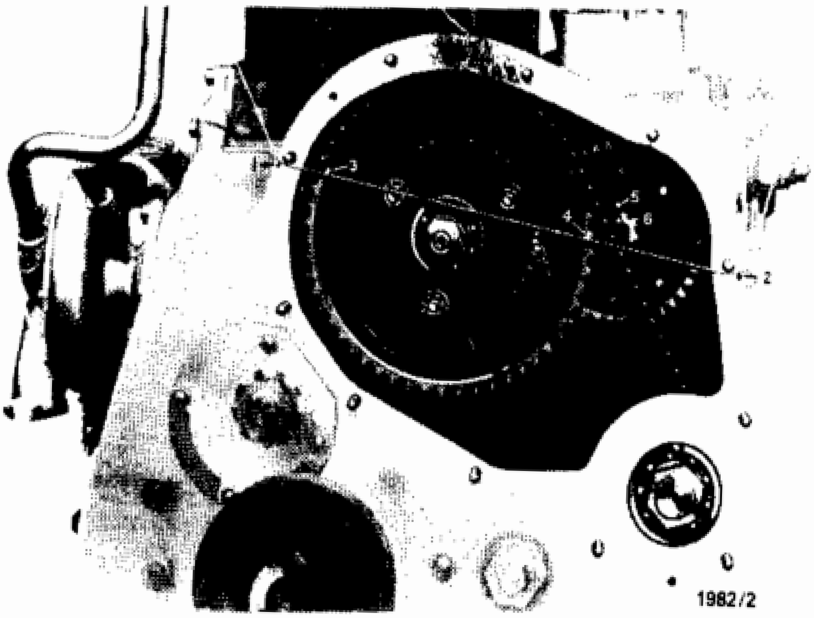


Fig. 47. Timing Marks for Valves and Fuel Injection

OVERHAUL AND ASSEMBLY

WATER PUMPS

72. **CENTRIFUGAL TYPE WATER CIRCULATING PUMP: DISMANTLING & ASSEMBLING.** The "Unit Seal" Type Pump can be readily dismantled by removing the grease retaining end-plate which is peened into the back of the pump by three equi-spaced punch marks. Removal of the end-plate reveals the two spring clips which retain the impeller spindle in its bearing.

It will be noted that there are two grooves on the impeller spindle and when reassembling this component it is important that the two spring clips be fitted in the correct groove. With the impeller pressed firmly against the unit seal the spring clips must be fitted in the groove *immediately behind the ball race* and arranged with their gaps diametrically opposite one another. The groove situated nearer the driving square is used only when a carbon gland type pump has been converted to accommodate the Unit Seal. Special kits for converting carbon gland type pumps to the new Unit Seal arrangement, together with necessary instructions, Ref. A.I. 262 are obtainable from our Works and Service Depots.

During manufacture the impellers are fitted to the spindles by special tools and are balanced as an assembly. For this reason impellers and spindles cannot be supplied separately. The sealing ring face on the impeller has a high surface finish and it is essential to avoid damage when handling or storing this component.

When assembling make sure that the sealing washer (Item 7, Fig. 48) is correctly located in the slot immediately behind the impeller casing. Repack the ball bearing with special water pump grease and fill the space between bearing and end-plate to about 30% capacity. Finally, recharge the grease cup with fresh water pump grease.

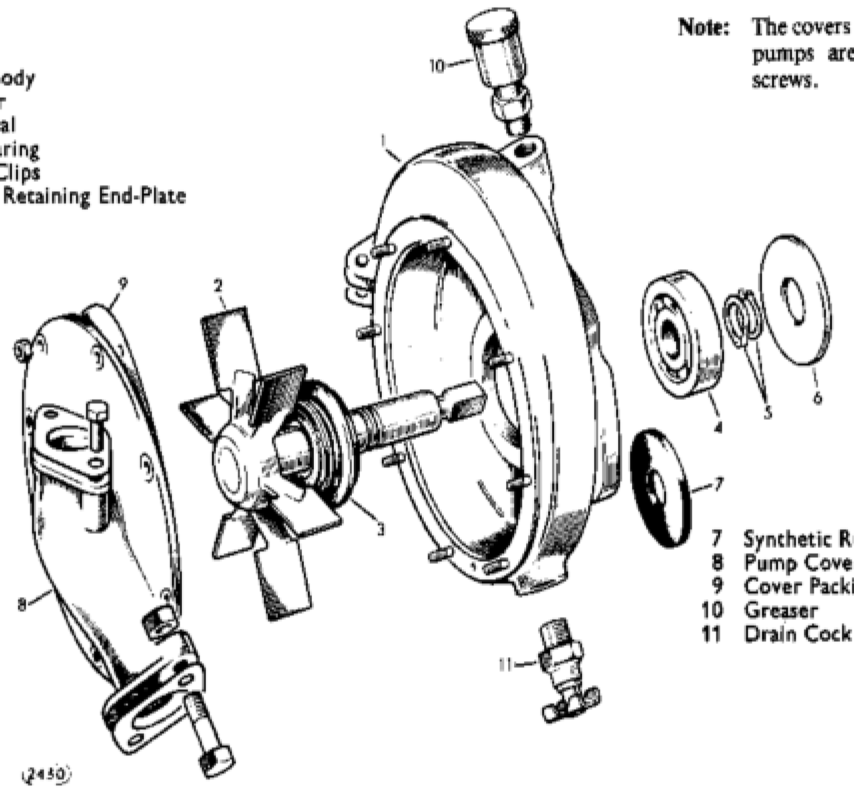
Before fitting the pump cover, clean out the small drain hole that crosses the joint face of the body and cover. Ensure that the two holes coincide when fitting the cover and that the passage is not blocked by the packing or jointing used.

Note.—On horizontal engines this procedure is unnecessary as the pump will drain completely via the inlet connection.

Also on horizontal engines, note that there is a dust excluder fitted between the pump body and flange to

Note: The covers fitted to the latest type pumps are assembled with set-screws.

1 Pump Body
2 Impeller
3 Unit Seal
4 Ball Bearing
5 Spring Clips
6 Grease Retaining End-Plate



7 Synthetic Rubber Sealing Ring
8 Pump Cover
9 Cover Packing
10 Greaser
11 Drain Cock

Fig. 48. Centrifugal Water Pump Assembly

OVERHAUL AND ASSEMBLY

WATER PUMPS—*continued*

protect the bearing and seal from exposure to dirt and grit. This must be refitted when completing the assembly.

Installation.

Under no circumstance should force be exerted when fitting the pump to the engine, otherwise distortion and possible leakage may occur. Before mounting the pump on the engine, clean out the square hole in the end of the driving spindle, removing any deposits that might impede entry of the impeller spindle. Check that the impeller spindle is not bent or damaged and that the square shank engages easily with the driving spindle. Do not attempt to ease by filing the corners. Apply a little water-pump grease to the square shank before mounting the pump on the engine. Always renew hoses when reassembling and ensure that all pipes are correctly aligned and all hose clips securely tightened.

72.1 **SERVICING THE CARBON GLAND TYPE PUMP.** If the clearance between the impeller blades and the inner face of the pump body is less than $\frac{1}{32}$ in. (0·794 mm.) the carbon gland must be renewed or a new body assembly fitted. Alternatively if circumstances permit, the pump with advantage may be modified to incorporate the new Unit Seal. Special conversion kits are available for this purpose and are supplied complete with Assembly Instructions. (Ref. A1.262).

Renewal of a carbon gland in an existing pump requires the use of a special extracting and fitting tool (Drawing No. 3496H). The application of this tool is described and illustrated in our LX/LXB Workshop Tools Book No. 63.1.

When fitting a new impeller to a carbon gland type pump, check the seating by pressing the impeller against the carbon ring and rotating by hand. If an unbroken line of contact is not obtained, the impeller may with advantage be lightly lapped against the carbon ring using a little fine pumice powder and water. When a satisfactory seating is obtained, thoroughly wash parts in petrol and make sure that all traces of abrasive are removed. Do not on any account use 'Carborundum' or equivalent abrasive and avoid lapping if a satisfactory seating is indicated by rubbing the parts together.

This bedding inspection operation is facilitated if a second ball race is temporarily fitted in the pump body to support and maintain the spindle on its approximate running axis.

Assembling the Pump.

Before assembling the impeller, pack the ball race in the pump body with suitable grease (See Para. 15, Page 25) and make sure that the sealing washer (Item 7, Fig. 48) is correctly located in the slot immediately behind the impeller casing. Do not allow grease to contact the carbon gland. *Grease is detrimental.*

After initial packing of the ball race with suitable grease it is unnecessary and, indeed, inadvisable to apply more than one occasional grease-cup full, as directed in Para. 15, Page 25.

When installing the pump on the engine, refer to the notes given in the previous paragraph 72.

73. **BILGE PUMP: SERVICING.** The pump valves are disc-like in form and are made of a special oil-resisting material. If, after long use, they buckle or become "Saucer-Shaped" they may be reversed so that what was originally the upper face becomes the lower.

If, in emergency, valves which are not of Gardner manufacture have to be used, it is important that they are of the same thickness for which the stop plates were designed; if they are thicker the edges will turn up when the through bolt is tightened. This, of course, will prevent them from seating.

The cup washers, of which there are two per pump, are fitted back to back on the ram.

The design of the ram is such that when the cup washers and distance washers are fitted and the castle nut screwed up, it first of all clamps up the cup washers, etc. and finally tightens up solidly metal to metal on the brass washers. If the nut was tightened only on to the rubber cup washers they could be seriously distorted and the nut would not remain tight. The designed "nip" on the standard Gardner cup washer is ·025 in. (·635 mm.). Excessive tightening of valve bolt is, in any case, to be avoided.

OVERHAUL AND ASSEMBLY

ELECTRICAL EQUIPMENT

74. **FITTING THE DYNAMO OR ALTERNATOR.** When fitting a dynamo or alternator which is driven by a flexible hose type coupling the coupling must be tightened up **before the clamp straps are tightened.** If the latter are tightened before the coupling clips, the expansion of the flexible rubber couplings will impose a heavy end load on the armature and timing case bearings. **Use only genuine Gardner replacement parts.**

75. **RENEWAL OF STARTER RING ON FLYWHEEL.** The standard toothed ring is retained in position on the flywheel by shrinking in place and is not retained by dowels or bolts. It may be removed by progressive light driving around the upstanding edge. A new ring may be fitted by heating until it assumes the first straw colour and then applying it to the flywheel.

RADIATOR FAN

76: **FAN PULLEY AND SPINDLE ASSEMBLY.** The design of the fan pulley assembly is such that the pulley retaining nut on the spindle exerts a high endwise clamping load on the inner races of the two ball journal bearings, the distance collar and the conical fan spindle collar.

When assembling the pulley on the spindle therefore, it is imperative that the retaining nut be tightened to the correct torque to secure complete durability of assembly.

Two sizes of nuts have been used depending on year of manufacture.

Spindle assemblies with ½ in. B.S.F. retaining nuts must be tightened to a torque of 1,100 lb. in. (12·65 Kg.m.) and the latest type, with ⅝ in. B.S.F. nut must be tightened to 1,500 lb. in. (17·25 Kg.m.).

When fitting the fan blade assembly on the pulley, test for static balance by spinning the blades with the driving belts removed.

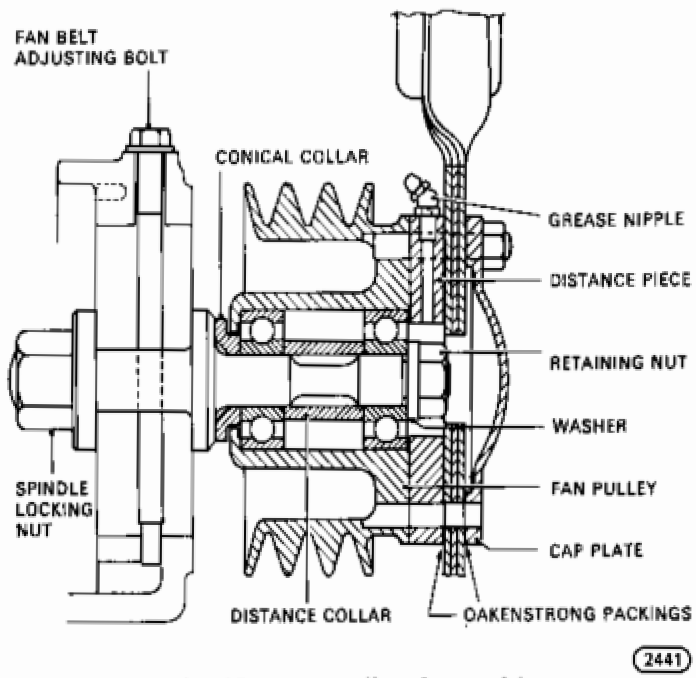


Fig. 49. Fan Pulley Assembly

NUT TIGHTENING TORQUES

77. **TORQUE SPANNERS.** All torque indicating spanners should be checked regularly by means of a spring balance used to apply a known load on the handle of the spanner, at a known distance from the nut centre.

The letter "E" against the torque figures in the table opposite indicates that the use of a torque spanner is essential.

TIGHTENING TORQUES

Nut	Thread Size	Correct Tightening Torque lb. in.	Kg. m.
Main Bearing Cap Nuts	¾ in. B.S.F.	E 2100	24·150
No. 7 Main Bearing Cap Nuts	½ in. B.S.F.	E 700	8·050
Crankcase Cross Bolts	⅜ in. B.S.F.	E 330	3·795
Main Oil Distribution Pipe Setscrews	⅜ in. B.S.F.	400	4·500
Damper to Crankshaft; Bolts	7/16 in. B.S.F.	E 650	7·475
Connecting Rod Big End—2 Bolt Rod	⅝ in. B.S.F.	E 1250	14·375
Connecting Rod Big End—4 Bolt Rod	7/16 in. B.S.F.	E 600	6·900
Cylinder Foot	⅝ in. B.S.F.	E 1500	17·250
Cylinder Head	⅝ in. B.S.F.	E 1200	13·800
Cylinder Head (Centre Line Stud)	⅜ in. B.S.F.	E 450	5·175
Cylinder Head (Tappet Side Stud)	⅜ in. B.S.F.	350	4·025
Valve Lever Shaft (Pointed Setscrew)	½ in. 28 T.P.I.	175	2·013
Valve Lever Shaft (Allen Screws)	1B.A.	25	0·288
Valve Tappet Adjuster	5/16 in. B.S.F.	200	2·300
Valve Camshaft (Forward end)	9/16 in. B.S.F.	900	10·350
Valve Cams (Pointed Setscrew)	7/16 in. 20 T.P.I.	600	6·900
Valve Camshaft Chainwheel	⅜ in. B.S.F.	400	4·500
Valve Tappet Guide Clamp	⅜ in. Whit.	280	3·220
Timing Chain Adjuster Clamp Nut (⅝ in. socket) ...	⅜ in. B.S.F.	E 350	4·025
Fuel Pump Cams (Pointed Setscrew)	5/16 in. 28 T.P.I.	350	4·025
Fuel Pump Tappet Screw Locknut	⅜ in. 24 T.P.I.	300	3·450
Fuel Pump Drive Shaft Driven Gear	7/16 in. B.S.F.	E 400	4·500
Fuel Pump Driving Shaft Coupling	5/16 in. B.S.F.	200	2·300
Fuel Pump Control Quadrant and Sleeve		150	1·725
Cambox Clamping Cap Nut	⅜ in. B.S.F.	E 250	2·875
Governor Body (Pointed Setscrew)	⅜ in. 24 T.P.I.	550	6·325
Fuel Strainer Cover	⅜ in. Whit.	180	2·070
C.A.V. Injection Pumps—Delivery Valve Holders ...	20 × 1½ mm.	E 720	8·280
Sprayer Clamp	5/16 in. B.S.F.	E 150	1·725
Sprayer Pipe Union (Pump end)	18 × 1½ mm.	300	3·450
Sprayer Pipe Union (Sprayer end)	¼ in. B.S.P.	300	3·450
Sprayer Delivery Stock	⅜ in. B.S.P.	625	7·188
Sprayer Leak Stock	9/16 in. B.S.P.	750	8·625
Sprayer Nozzle Cap	¾ in. 14 T.P.I.	380	4·370
Lubricating Oil Strainer Cover	7/16 in. Whit.	350	4·025
Lubricating Oil Strainer Drain Plug	¾ in. B.S.P.	450	5·175
Lubricating Oil Sump Drain Plug	¾ in. B.S.P.	450	5·175
Lubricating Oil Pump to Crankcase	⅜ in. B.S.F.	300	3·450
External Lubricating Oil Pump Gear and Spindle Nut	½ in. B.S.F.	E 500	5·750
Centrifugal Water Pump Driving Shaft	7/16 in. B.S.F.	E 500	5·750
Exhaust Manifold Clamp	⅜ in. Whit.	250	2·875
Rear Support Mounting Setscrew—HLX.	¾ in. B.S.F.	E 2100	24·150
Coupling Bolts (Flywheel to Crankshaft)	9/16 in. B.S.F.	E 1500	17·250
Starter Motor Strap	⅜ in. Whit.	180	2·070
Starter Gear Ring to Flywheel	⅜ in. B.S.F.	350	4·025
Alternator Drive Disc Coupling to Boss	5/16 in. B.S.F.	280	3·220
Alternator Strap	⅜ in. Whit.	150	1·725
Starting Dog	1½ in. 12 T.P.I.	2500	28·750
Radiator Fan Pulley Retaining Nut	½ in. B.S.F.	E 1100	12·650
Radiator Fan Pulley Retaining Nut	9/16 in. B.S.F.	E 1500	17·250

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

SPACE REQUIRED FOR REMOVAL OF COMPONENTS

78. To facilitate routine maintenance work and the removal and replacement of major components, the following clear space should be provided between points on the engine and fixed portions of the installation:—

(*a*)	Crankcase Sump (Standard: Type 28) Vertical Engines .. .. Space required for removal of non-standard types of sumps will be supplied upon request.	4½ in.	(114 mm.)
(*b*)	Crankcase Sump (Horizontal Engines) Main Oil Reservoir	1¼ in.	(32 mm.)
(*c*)	Crankcase Sump (Horizontal Engines) Base Chamber	11⅛ in.	(283 mm.)
(*d*)	Cylinder Heads	5⅛ in.	(130 mm.)
(*e*)	Cylinder Block (with pistons *in situ*)	10 in.	(254 mm.)
(*f*)	Pistons and Connecting Rods; four-bolt type, when withdrawn through cylinder bores	19 in.	(483 mm.)
(*g*)	Lubricating Oil Delivery Filter Element	8 in.	(203 mm.)
(*h*)	Fuel Filter Cover (on cylinder head)	4 in.	(102 mm.)
(*i*)	Centrifugal Water Circulating Pump	2 in.	(51 mm.)
(*j*)	Chain Case Cover	2⅞ in.	(73 mm.)
(*k*)	Chain Case Cover (clutch-driven bilge pump type)	3¾ in.	(95 mm.)
(*l*)	Bilge Pump Body (leaving plunger exposed *in situ*)	2½ in.	(63·5 mm.)
(*m*)	2 UC Reducing Gear Case Cover with shaft, half coupling and gear	5¼ in.	(133 mm.)
(*n*)	Twin Disc M.G. 509 Reversing Gear (movement aft.)	2 in.	(51 mm.)

79. **ACCESS TO TIMING MARKS ON FLYWHEEL.** Free access should be provided to the timing lines on the periphery of the flywheel at a point directly above the crankshaft, with a view of the zero line at the base of the cylinder block or on the flywheel housing. Alternatively, if this position cannot be made accessible, there is provided in the flange of the crankcase endplate, a port through which can be seen radial lines on the forward face of the flywheel for No. 1 cylinder T.D.C. and injection timing.

GARDNER

TYPES
6LX, 6HLX, 6LXB, 6HLXB, 8LXB

SECTION 4

INSTALLATION
INSTRUCTIONS AND RECOMMENDATIONS

for

AUTOMOTIVE, MARINE AND INDUSTRIAL APPLICATIONS

GARDNER

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

INDEX

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

INDEX—*continued*

GARDNER

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

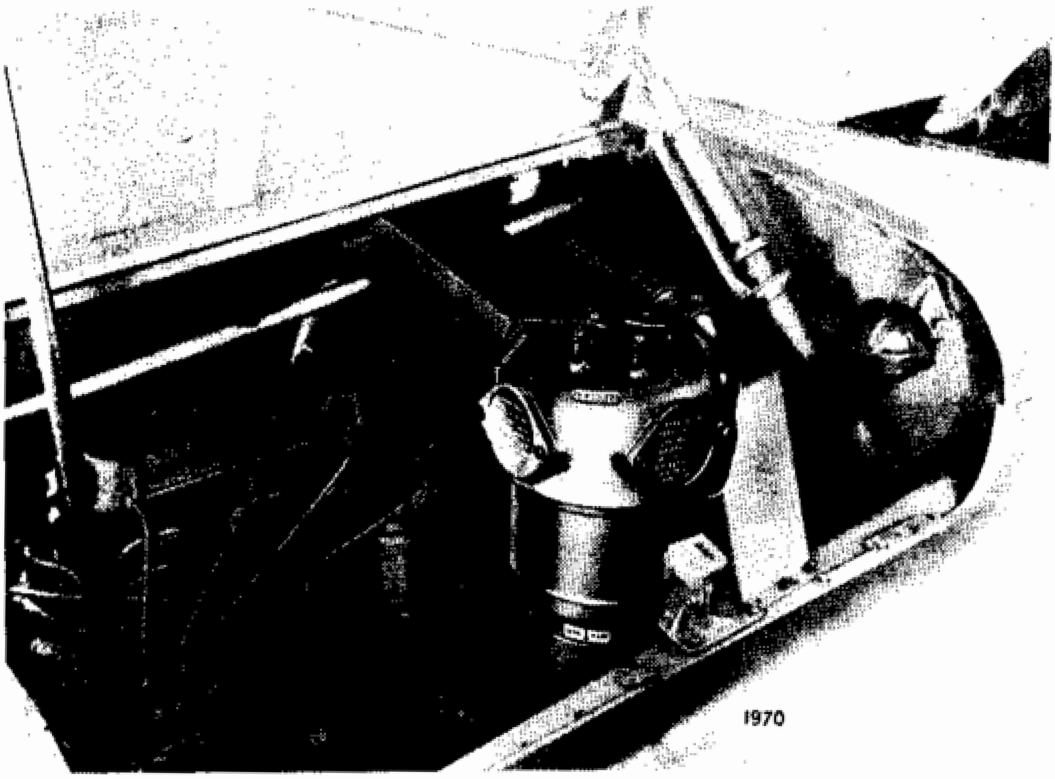
AIR INDUCTION FILTERS—*continued*

in the driver's cab without the introduction of objectionable noise created by open filters. The filter inlet may then be ducted to a hollow bulkhead or through the floor, whereby the cleanest cold air is obtained without the introduction of draughts and noise into the cab. (When coupled to a hollow bulkhead ensure that panels are not vibrated by the air pulsation and that the panels do not have direct communication with road wheel arches.)

Finally, when mounting the filter unit, ensure that there is a clear space of at least 3½ in. (88·9 mm.) below the container to permit removal for cleaning and inspection.

Below is illustrated the air filter mounted under the bonnet of a double-deck passenger vehicle, the inlet connection in this installation being ducted to a clean cold air position with suitable water excluding means on the top of the bonnet. The inlet connection may alternatively be ducted to the forward panel at the side of the radiator or other suitable position from which cold air may be inducted, as shown on Page 101. In this installation the cold air is inducted through a protecting grill in the bonnet side panel at a position below the intake head of the filter unit thus safeguarding against the ingress of foreign matter and water.

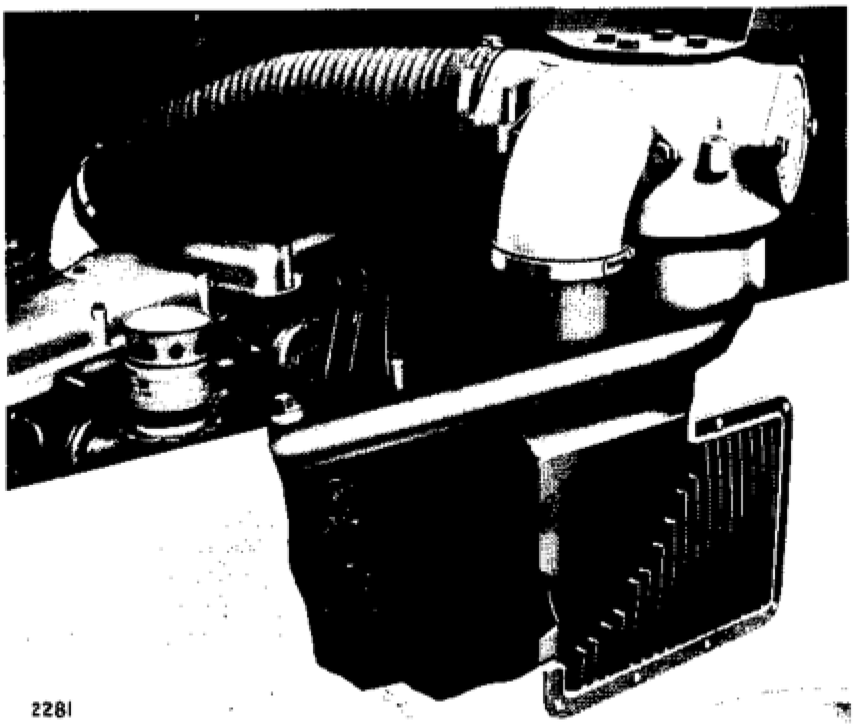
4. **SUCTION HOSES.** The suction hose used on both the inlet side and between the filter and engine manifold is of light canvas type with internal wire reinforcement. A total system length of up to 12 ft. (3,658 mm.) is permissible. The bore diameter must not be less than 5 in. (127 mm.) on LXB installations or 4¼ in. (108 mm.) on LX and HLX installations.



Under-bonnet Installation of Universal Oil Bath Type Air Filter on a Double-Deck Passenger Vehicle

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

AIR INDUCTION FILTERS—*continued*



Under-bonnet Installation of Universal Oil Bath Type Air Filter on a Semi-forward Cab Vehicle

DUST PROOFING

6. In overseas territory where engines are required to operate in dust laden atmosphere, all apertures on the engine must be sealed against the entry of dust which otherwise would create abnormal wear in all engine components. During construction the engines are completely dust proofed against such contingencies but during installation provision should be made to ensure that inducted air is properly and effectively filtered as described in paragraph 2, page 98.

ENGINE ROOM VENTILATION

MARINE INSTALLATIONS

7. Experience over many years has shown that frequently insufficient attention is given at the design stage to the vitally important matter of engine room ventilation.

The provision of adequate ventilation is an essential requirement in order that:—

(*a*) Engines shall not exceed their designed operating temperature.

(*b*) Engines may receive sufficient weight of air for their designed fuel delivery and output.

Furthermore, it is highly desirable to provide ventilation in order to prevent hull deterioration, especially in wooden vessels.

An engine in operation disposes of its waste heat in three ways:—

(*a*) By water circulation through cylinder jackets, heat exchangers and oil coolers.

(*b*) By the emission of its exhaust gases.

(*c*) By radiation from its outer surfaces to the air surrounding it.

If there is insufficient circulation of air at or near external air temperature around the outer surfaces of a marine engine unit, the temperature of the engine oil, reversing gear oil, reducing gear oil, etc., will be in excess of designed values. In addition, engine room "electrics", fuel, etc., will be undesirably heated.

The power rating of marine engines, which is regulated by the volume setting of the fuel injection pump, is set appropriately for the climatic conditions in which they are to operate (see page 4). If the air in the engine room becomes unduly heated, the engine is unable to induct sufficient weight of air to provide complete combustion of its designed fuel injection volume and it will not develop its designed horsepower and R.P.M. The British Standard derating for atmospheric temperature is 2% per 10° F. and it will readily be seen that if an engine be operated in a 120° F. atmosphere when it is designed for a 60° F. atmosphere it should have its fuel supply reduced by 12% and, consequently, its power output reduced.

The effects of incomplete combustion have a cumulative effect on engine room temperature, since the increased waste heat that is generated has to be disposed of by the engine. The products of incomplete combustion can manifest themselves in lubricant contamination, internal deposits and fouling, also high piston, valve and sprayer temperatures, etc., and may lead to unreliability and high maintenance.

Electrically driven induction and extraction fans, capable of changing the engine room air 30 to 35 times per hour, will ensure adequate cooling and ventilation of the engine compartment. Such equipment is available from the Works and is fully described and illustrated in our Publication No. 762.

In addition to the above, natural ventilation can be employed with advantage by means of weatherproof marine-pattern ventilators with rotatable cowls; the intake ventilators trunked to below floor plate level and the outlet ventilators terminating at engine room deckhead level.

In installations where a dry type silencer is used, the Gardner ventilating funnel type provides an effective additional outlet for heated air. See Paragraph 9, Page 103.

EXHAUST SYSTEMS

AUTOMOTIVE INSTALLATIONS

8. The exhaust system should impose a back pressure at the manifold of not more than approx. 12 in. (305 mm.) water gauge at full power. Ordinary baffle type silencers can create pressures in excess of this figure. Maximum power, economy and durability will not be available if the back pressure is in excess of this figure.

Any of the well-known "straight through" absorption type silencers are recommended. These can be used singly or, for long systems, in pairs. Where maximum silencing is required the Works will be pleased to offer an alternative arrangement of silencer and resonator.

The overall length of the system should be as short as possible; with a minimum number of bends. If in excess of 18 ft. (5,486 mm.) the double silencer arrangement is recommended.

Tail pipes should have a length of 10–15 pipe diameters for maximum silencing efficiency.

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

EXHAUST SYSTEMS—*continued*

AUTOMOTIVE INSTALLATIONS

The silencer should be mounted in a position from which heat cannot be radiated to the engine and under no circumstances placed beneath the crankcase sump, unless effectively heat insulated.

Any portion of the exhaust pipe in proximity to the crankcase and sump should be lagged.

Also, it is recommended that the exhaust manifold be given a fresh coat of heat-resistant aluminium paint at each top-overhaul period.

The bore of silencers and pipes for the 6 cylinder engines should be 3⅜ in. (85·725 mm.) minimum and for the 8LXB, 3⅞ in. (98·425 mm.) minimum when the engine is operating at its maximum rating. When the 6LX engine is used at a de-rated power, not exceeding 130 b.h.p. at 1,700 r.p.m., a 3 in. (76·2 mm.) bore straight-through system is permissible. The Works will be pleased to advise in this matter.

The 8LXB Automotive Engine exhaust pipe assembly is reversible to suit forward or rearward silencer installations. Suitable provision is made on the crankcase and oil sump to accommodate the appropriate heat deflector shields. Alternative mounting points are provided at front and rear for attachment of the exhaust pipe lower support bracket. The arrangement of the heat deflector shields depends upon the positions of the sump-well and exhaust collector box.

EXHAUST SYSTEMS

MARINE INSTALLATIONS

9. In marine installations it is recommended that exhaust piping, within the confines of the engine compartment, be lagged in order to reduce as far as possible the undesirable effects of heat radiation on engine room temperatures. See Engine Room Ventilation. Paragraph 7, Page 102.

In fishing vessels and similar craft some degree of engine room ventilation can be provided by a simple and inexpensive arrangement of placing the silencer inside a funnel which can be fitted either inside or outside the deck-house. With this arrangement the engine exhaust gases create a suction effect within the funnel and thus extract hot air from the engine room. This air, circulating around the silencer, also assists in reducing the engine room temperature.

Installation drawings are available upon request from the Works, and we shall be pleased to give any further advice that may be required in connection with this arrangement.

In all cases the exhaust system should be as short as possible, with the minimum number of bends which should be of maximum radius. Whenever possible the straight-through absorption type of silencer should be used and in no case must the pipe, or the silencer inlet and outlet bores be less than 3⅜ in. (85·725 mm.) for the 6LX engine or 3⅞ in. (98·425 mm.) for the 8LXB engine.

FLYWHEEL (AUTOMOTIVE)

10. It is recommended that the total inertia of the flywheel and clutch should be as small as is practicable. In general, the lightest assembly obtainable is more than sufficient to reduce cyclic irregularity to a satisfactory minimum and the advantages to be gained are very important.

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

FUEL FEED SYSTEM

11. The use of the Gardner Overflow Return system is recommended, incorporating an engine-operated Amal Fuel Lift Pump, as shown on Drawing No. 7221H in Workshops Tools Book No. 63. It is very important that the provisions of this instructional drawing be strictly followed to ensure an unfailing fuel feed arrangement. Fuel pipe sizes are important, and minimum sizes should be as follows:

Fuel Tank to 1st Filter	½ in. o.d. 16s Gauge
1st Filter to Fuel Lift Pump	⅜ in. o.d. 18s Gauge
Overflow Return to Tank	⅜ in. o.d. 18s Gauge

12. **OVERFLOW RETURN PIPE.** On **Automotive Installations** the overflow return pipe between the engine filter and fuel tank must be arranged to have a continuous fall throughout its length, i.e. it must not rise at any point *from* union to tank.

On **Marine Installations** the overflow return pipe should be fed into the top of the fuel tank in a steady upwards or downwards run dependent upon tank position.

13. **FIRST FUEL FILTER.** This is supplementary to the filter on No. 1 cylinder and it is intended to be fixed at low level in circuit with the pipe leading from the fuel service tank to the filter on No. 1 cylinder. This supplementary fuel filter is supplied as a standard with all engines and should be placed above maximum fuel level, but below the level of the lift pump thus avoiding the need for a stop cock. If pipes smaller than those shown in the table are used, or the suction filter becomes choked, the flexible diaphragm will receive increased load which may precipitate failure. For this reason it is also important to prevent air leaks at any point in the suction pipe line between the fuel lift pump and the tank.

It is advantageous and highly desirable to arrange a sludge trap in the main fuel tank, with suitable drain plug, so placed in relation to the suction pipe that only sludge free fuel is drawn into the system.

14. **DUPLEX TYPE FUEL FILTER.** In marine installations the Duplex fuel filter described in paragraph 32, page 32, is fitted in circuit between the fuel supply or "day tank" and the second filter mounted on the engine.

When installing the Duplex fuel filter, due regard must be paid to its accessibility for cleaning and for removal of the element containers. A minimum of 2·38 in. (60·452 mm.) clear space must be allowed below the element containers for this purpose.

SOUND INSULATION

15. In automotive installations we recommend that the bonnet and engine side of the bulkhead should be lined with one of the highly efficient materials specially developed for this purpose. Felt, rubber sheet, and sprayed-on sound deadening materials are very valuable if properly applied. The effectiveness of sound insulation is greatly enhanced by a fully flexible engine mounting and the advantages in the case of automotive installations amply justify additional costs. Refer to Paragraph 19, Page 105.

With marine installations also, it is advantageous in certain applications to line the deckhead and bulkheads of the engine room with sound absorbing material and to employ flexible engine mountings between the bearers and engine feet. **Refer to Paragraph 20, Page 107.**

AUXILIARY UNITS AND DRIVES

16. **AUXILIARY DRIVES.** The standard equipment for all LX and LXB engines consists of a double V-groove fan driving pulley mounted on the crankshaft, alternatively if specified, the engine can be supplied with a plain parallel forward extension of the crankshaft on which a multi-groove pulley may be fitted to provide an additional drive for auxiliaries.

When the engine is equipped with an air compressor for automotive compressed air braking systems, the radiator fan and air compressor are driven by a triple V-groove pulley and triple belt.

Horizontal engines are arranged at the forward end of the crankshaft for the mounting of a flexible coupling and, if required, a triple V-groove pulley for driving an air compressor.

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

AUXILIARY UNITS AND DRIVES

17. **FLEXIBLE COUPLINGS.** With flexible coupling drives, it is important to ensure accurate alignment between the driving and driven member. These couplings must not be regarded as a substitute for correct alignment.

Where flexible couplings are used for auxiliary drives, a minimum clearance of ¼ in. (6·35 mm.) *must* be provided between the driving and driven couplings and end movement of the driving pins must be unrestricted in order to ensure that endwise movement of the drive shaft, or any axial loads such as may be occasioned by a cone clutch, are not transmitted to the crankshaft thrust bearings.

It is essential that each non-standard arrangement on the forward end be submitted to the Works Technical Staff for consideration of its effect upon crankshaft torsional characteristics. Under no circumstances must a heavy mass be rigidly attached to the forward end of the crankshaft.

18. **LINK BELTS.** When laminated fabric rubber link belts are used for driving separate auxiliary equipment, such as a dynamo or centrifugal pump, etc., the following instructions must be carefully noted:—

(1) The belts are designed to rotate in either direction but the Manufacturers recommend that they be fitted to the pulleys in such a way that the wide ends of the links (i.e. the exposed ends on the *outside* contour) will lead in the direction of rotation.

(2) Careful alignment of the driving and driven pulleys is essential and, if possible, installation should be arranged so that the lower run of the belt becomes the driving side.

(3) When assembling the belts it is vitally important to ensure that the links are properly tucked under the top and bottom heads of the fasteners and that all fasteners are fitted the right way round.

(4) If multiple drive belts are used, they must be of equal lengths and contain exactly the same number of links.

(5) New belts must always be fitted tight, particularly so, when the smaller pulley is the driven pulley. Due to initial stretch when new, the belts may require tightening once or twice during the first period of running.

(6) If a guard is fitted to enclose the belt drive, it is essential that adequate clearance be allowed between belt and guard on the slack side of the run. The manufacturer's recommendation for a normal length of drive is a clearance of 2 in. (50·8 mm.) to 3 in. (76·2 mm.) between the belt and guard, or any projection, if a guard is not fitted.

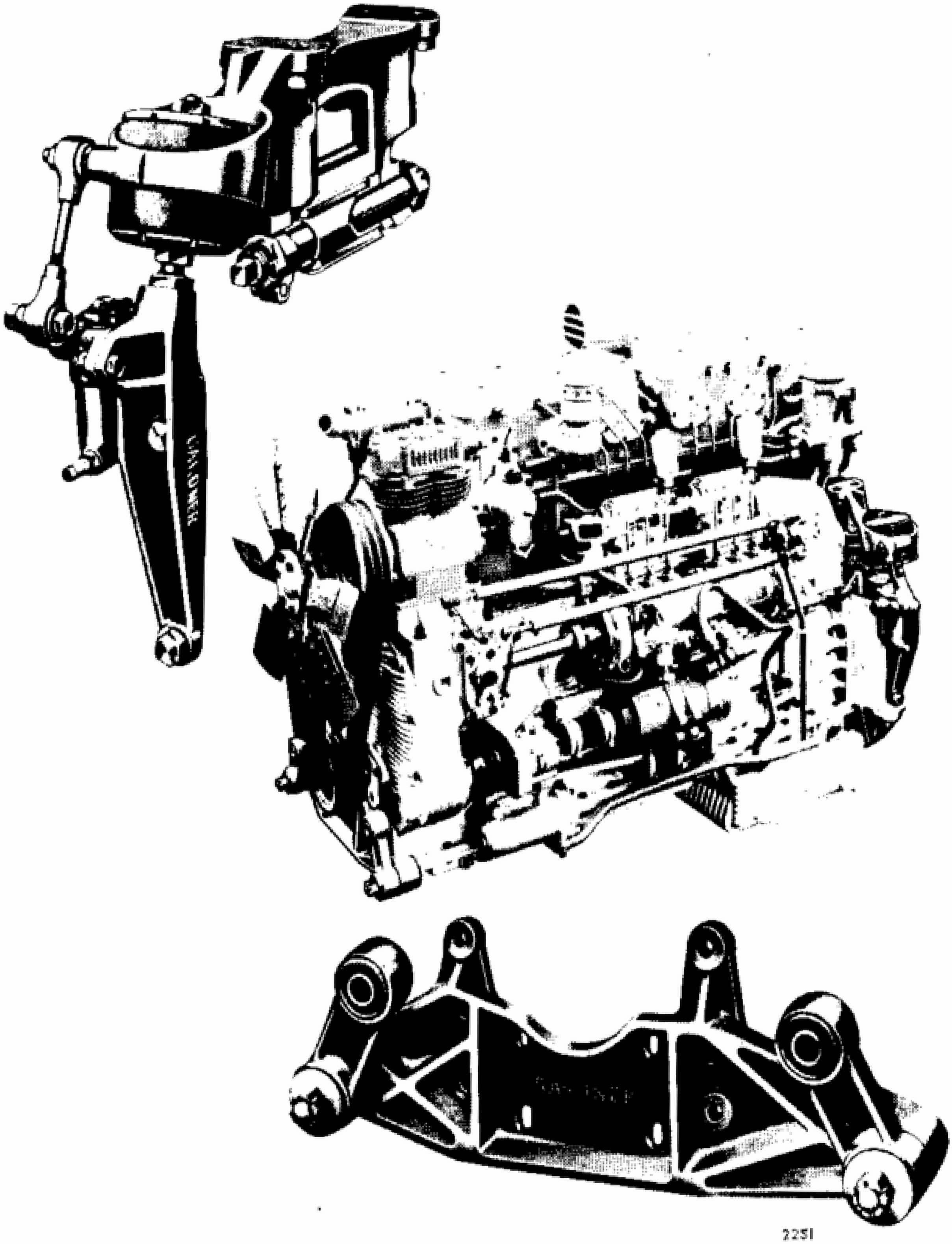
Insufficient clearance in this respect is a frequent cause of belt failure.

ENGINE MOUNTINGS

AUTOMOTIVE INSTALLATIONS

19. **GARDNER FLEXIBLE ENGINE MOUNTING ARRANGEMENT.** In order to avoid the transmission of sound and vibration from the engine to the chassis it is most desirable that the engine be supported by some flexible means permitting a sufficient degree of engine movement about its natural axis. Such a scheme also relieves the engine unit of dangerous strains which can be imposed by chassis deformation.

The Gardner flexible mounting is the result of many years' experience and development of this subject and is in common use. A typical example as applied to the LX engine is shown on Page 106.



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Gardner Flexible Engine Mounting and Torque Reaction Damper

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

ENGINE MOUNTINGS—*continued*

AUTOMOTIVE INSTALLATIONS

The forward end of the engine is supported by means of two rubber bushed "swing links". The upper end of each link is bolted to some member integral with the chassis frame.

At the rear end the engine is carried by the bracket, cross bolt and large rubber bush as shown in the illustration. The flat upper face of this bracket is bolted to one of the frame cross members. Combined with this bracket is an extended portion carrying a large circular upper and lower rubber collar. Torque reaction of the engine unit is contained by these rubber collars via the adjustable steel collars, stud and bracket attached to the side facing on the engine flanged end plate. The steel torque reaction stop collars should be adjusted as follows:

Screw each collar by hand only until they first come into definite contact with the rubber collars and lock in this position. Overtightening of these stop collars will defeat the whole object of the flexible mounting arrangement.

A small hydraulic damper will be seen opposite bolted to the side of the torque reaction bracket and coupled by means of a rubber bushed link to the frame bracket. The purpose of this damper is to avoid the build up of minor synchronous vibrations in the vehicle. After installation it is desirable to check that the damper is fully primed by disconnecting the link and moving the damper lever two or three times through its full travel. Beneath the damper body will be found a small cap nut which, when removed, will reveal a lock nut and adjusting screw. When delivered these dampers are adjusted to suit average requirements but for optimum results final adjustment must be carried out in individual installations.

ENGINE MOUNTINGS

MARINE INSTALLATIONS

20. **FLEXIBLE ENGINE MOUNTINGS FOR MARINE INSTALLATIONS.** The use of flexible engine mountings on marine installations helps to minimize transmission of sound and vibrations from the engine(s) to the structure of the vessel and the extent to which this is necessary will depend upon the type of vessel and the purpose for which it is designed.

In general, the owners of pleasure craft, from luxury Yachts to Cabin Cruisers and the operators of passenger carrying launches, including Pilot Vessels and Ambulance Vessels, are tending to demand higher standards of comfort and silence. It is, therefore, on vessels of this type, as distinct from commercial craft such as fishing boats, tugs, workboats and the like, that the use of flexible engine mountings would be justified and desirable.

The three sources of noise from a diesel engine are (1) Exhaust noise, (2) Combustion noise, (3) Mechanical noise.

The first can be dealt with by adequate silencing arrangements and the other two, which are of a remarkably low order on Gardner Engines, can largely be insulated from the structure of the vessel by a suitable choice of flexible engine mountings.

If maximum silence is to be achieved, it will be necessary in addition to the employment of flexible engine mountings, to line the deckhead and bulkheads of the engine room with sound absorbing material, in order to prevent these large predominantly flat surfaces from becoming energised by airborne sound waves.

The vibrations (which are in themselves a source of noise) set up by Gardner Engines are of low magnitude but even so if the Engines are rigidly mounted, particularly on steel bearers in a steel hull, the vibrations will be transmitted to other parts of the vessel and may be amplified by resonance effects. Suitably chosen flexible engine mountings will insulate the structure of the vessel from such vibrations and minimise their effect.

When flexible engine mountings are used it will, of course, be necessary to introduce flexible connections in all pipework to and from the engine and in some cases, depending upon the unsupported length of the intermediate shaft, to have one or more flexible couplings in the shaft line.

It is also most important that the use of flexible engine mountings should not be regarded as a substitute for perfect alignment of engine bearers, which must be parallel with the shaft line, perfectly flat and in the same plane with each other. It cannot be too strongly emphasised that flexible engine mountings are not

ENGINE MOUNTINGS—*continued*

MARINE INSTALLATIONS

intended to accommodate errors in the engine bearers because if such errors exist incorrect unit loading on the flexible mountings will ensue and this could result in synchronous vibration.

It is equally important that the Engine, when at rest, should be in perfect alignment with the Shaftline and that this condition is obtained without disturbing the calculated static deflection on each of the flexible engine mountings.

21. **ENGINE AND PROPELLER SHAFT ALIGNMENT.** It is of prime importance (except in installations where Hardy-Spicer Type universal joints are used) that the engine and gear unit be carefully and accurately aligned with the propeller shafting when initially installed. This alignment should also be very fully checked periodically and corrected as necessary by the fitting of suitable thickness shims between the engine/gear unit and engine bearers. Serious damage can occur in the reverse gear or reduction gear if correct alignment is not maintained. To facilitate adjustment of alignment, all supporting feet on the marine units are tapped to receive 7/16 in. B.S.F. (11·1125 mm.) jacking screws.

Alignment of the shafting is made in the usual manner by splitting the engine half-coupling from the shafting half-coupling and testing by feeler gauge to ensure that both faces meet solidly and spigot diameters enter freely when drawn together by hand, also that no gap is evident by testing with feeler gauge, irrespective of position of shafting couplings, when rotated separately to any position through one or more complete turns.

When adjusting the shim packings beneath the engine and reverse gear supporting feet, it is most important that all feet are carrying their share of the total weight. When checking the shaft alignment the craft should, of course, be afloat and on an even keel.

The quantity and sizes of shims supplied for each engine and gear unit are given in the table below.

22. **SELECTING ALIGNMENT SHIMS.** To obtain alignment within ·003 in. (·0762 mm.) and to obtain a total thickness of shims between ·003 in. (·0762 mm.) and 1/16 in. (1·59 mm.) with steps not greater than ·003 in. (·0762 mm.), it is necessary to have available shims of the thickness and quantity quoted below for each individual foot on the Engine/Reverse Gear Unit.

4 off shims ·003 in. (·076 mm.) thick
3 ,, ,, ·007 in. (·178 mm.) ,,
2 ,, ,, ·032 in. (·813 mm.) ,,

With the above shims it is possible by selection to make up the aggregate thicknesses given in the table on Page 109.

23. **STATIC INCLINATION AFT (Marine Installations).** Maximum static inclination aft for Gardner Marine Units is 7°. If greater inclination is necessary our Technical Staff should be consulted before installation is carried out.

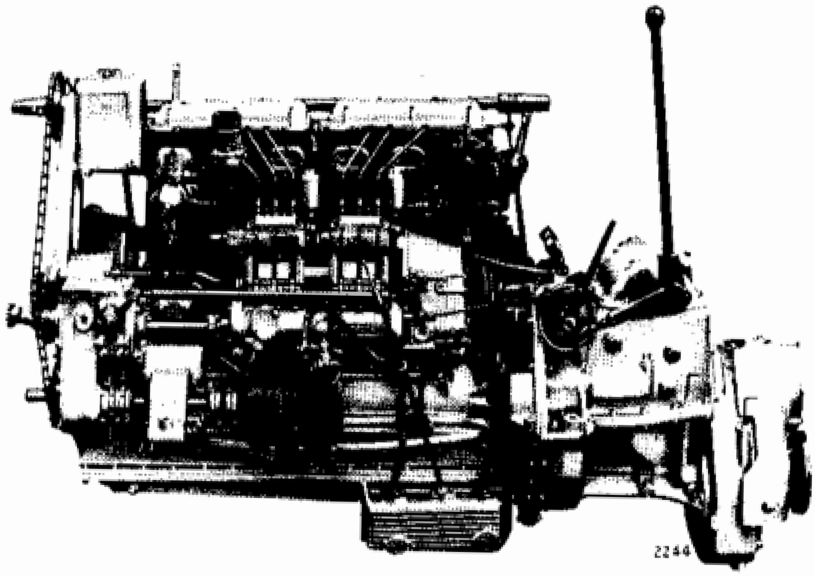
Quantity and sizes of shims supplied on request, for aligning engine and propeller shafting

Location of Shims	DIMENSION OF SHIMS			Drawing No.	Total number of Shims supplied
	Size	Thickness			
		in.	mm.		
ENGINE Supporting feet	4 in. × 2⅛ in. 101·600 mm. × 53·975 mm.	·003 ·007 ·032	·0762 ·1778 ·8128	J.7253 J.7254 J.7255	8 6 4
GEAR UNIT Supporting feet	5⅞ in. × 2 in. 149·225 mm. × 50·800 mm.	·003 ·007 ·032	·0762 ·1778 ·8128	J.7256 J.7257 J.7258	8 6 4

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

ENGINES MOUNTINGS—*continued*

TOTAL SHIMMING REQUIRED		SIZE & QUANTITY OF SHIMS TO BE USED			TOTAL SHIMMING REQUIRED		SIZE & QUANTITY OF SHIMS TO BE USED		
in.	mm.	·003 in. (·076 mm.)	·007 in. (·178 mm.)	·032 in. (·813 mm.)	in.	mm.	·003 in. (·076 mm.)	·007 in. (·178 mm.)	·032 in. (·813 mm.)
·003	·076	1	—	—	·035	·889	1	—	1
·006	·152	2	—	—	·038	·965	2	—	1
·007	·178	—	1	—	·039	·991	—	1	1
·009	·229	3	—	—	·041	1·041	3	—	1
·010	·254	1	1	—	·042	1·067	1	1	1
·012	·305	4	—	—	·044	1·118	4	—	1
·013	·330	2	1	—	·045	1·143	2	1	1
·014	·356	—	2	—	·046	1·168	—	2	1
·016	·406	3	1	—	·048	1·219	3	1	1
·017	·432	1	2	—	·049	1·245	1	2	1
·019	·483	4	1	—	·051	1·295	4	1	1
·020	·508	2	2	—	·052	1·321	2	2	1
·021	·533	—	3	—	·053	1·346	—	3	1
·023	·584	3	2	—	·055	1·397	3	2	1
·024	·610	1	3	—	·056	1·422	1	3	1
·026	·660	4	2	—	·058	1·473	4	2	1
·027	·686	2	3	—	·059	1·499	2	3	1
·030	·762	3	3	·	·062	1·575	3	3	1
·032	·813	—	—	1	·064	1·626	—	—	2
·033	·838	4	3	—					



6LX Marine Propulsion Unit with No. 2 U.C. Reversing and 3 : 1 Ratio Reducing Gears

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

COOLING SYSTEMS

AUTOMOTIVE AND INDUSTRIAL UNITS

24. **AIR COOLED RADIATORS.** To enable the engine to satisfactorily and reliably maintain full power for long periods it is essential that the engine cooling system be designed to control suitably the maximum water temperature under all conditions. The advice and co-operation of our Technical Staff will be offered willingly upon application to the Works.

Essential features are as follows:—

(*a*) The engine shall be equipped with an efficient fan, which will be supplied if specified on the order. The fan which is usually driven from the forward end of the crankshaft, shall be fully cowled with provision for belt adjustment.

(*b*) The radiator shall have a heat dissipating capacity capable of limiting the water temperature at the engine outlet to 80° F. (27° C.) above atmospheric temperature, under temperate climatic conditions, when the engine is developing full power in still air. Special consideration is required for service in climatic conditions less favourable than those obtaining in the British Isles.

25. **FAN AND RADIATOR INSTALLATION.** The following installation requirements must be observed since the deficiency of any one will impair the efficiency of the system.

(1) **RADIATOR FAN.** The distance from the tubes or element to the fan blades must not be less than $1\frac{3}{4}$ in. (44·45 mm.) and the fan blades must be enclosed by a cowl, the diameter of which is not greater than the fan blades plus $1\frac{1}{2}$ in. (38·10 mm.).

The standard fan fitted to the 6LX engine for passenger vehicles has six blades with a diameter of 20 in. (508mm) and for freight vehicles it has eight blades with a diameter of 24 in. (609 mm.).

The 6LXB engine has an eight blade, 24 in. diameter fan for all automotive duties.

(2) **WATER INLET AND OUTLET CONNECTIONS.** The minimum permissible bore of any portion of the connections between radiator, thermostat outlet and water pump inlet on the 6-cylinder engines is $1\frac{1}{4}$ in. (31·75 mm.) and the minimum bore size for hoses is $1\frac{1}{2}$ in. (38·10 mm.).

The equivalent minimum bore sizes for the 8LXB engine are $1\frac{1}{2}$ in. and $1\frac{3}{4}$ in. (38·10 mm. and 44·45 mm.) respectively.

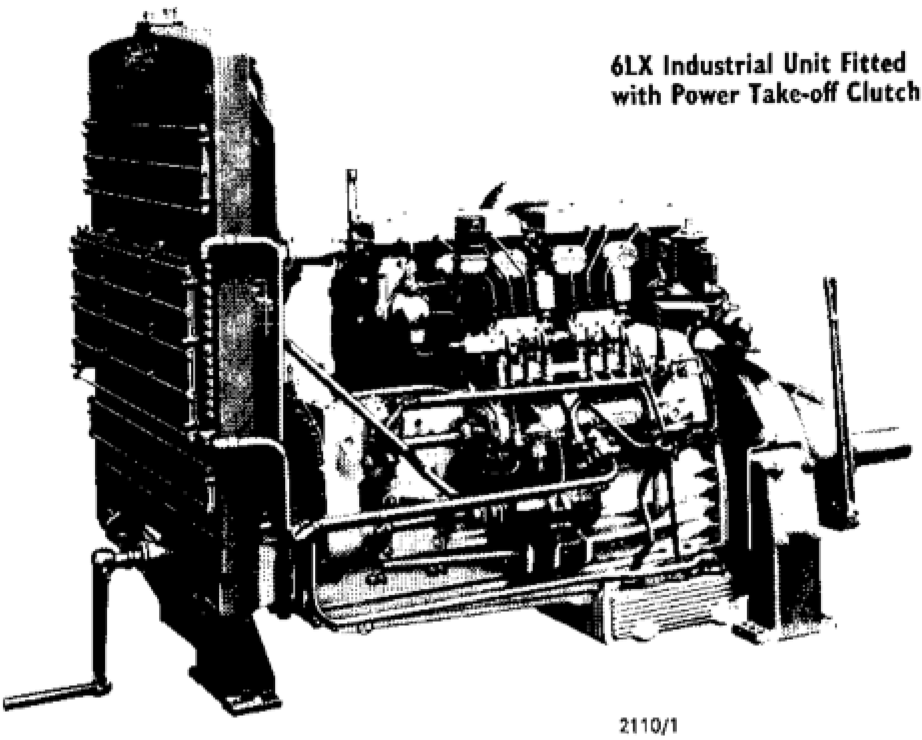
If smaller connections are used the water circulation rate will be reduced and the system will lose efficiency.

(3) **FREE ENTRY OF AIR TO RADIATOR.** Any ornamental grille or guard fitted in front of the radiator must offer the minimum resistance to air flow.

(4) **FREE EXIT OF AIR FROM ENGINE BONNET.** Any restriction offered to the escape of the heated air from under the bonnet will reduce the volume of cool air induced through the radiator, therefore, an adequate bonnet must be provided with large area exit.

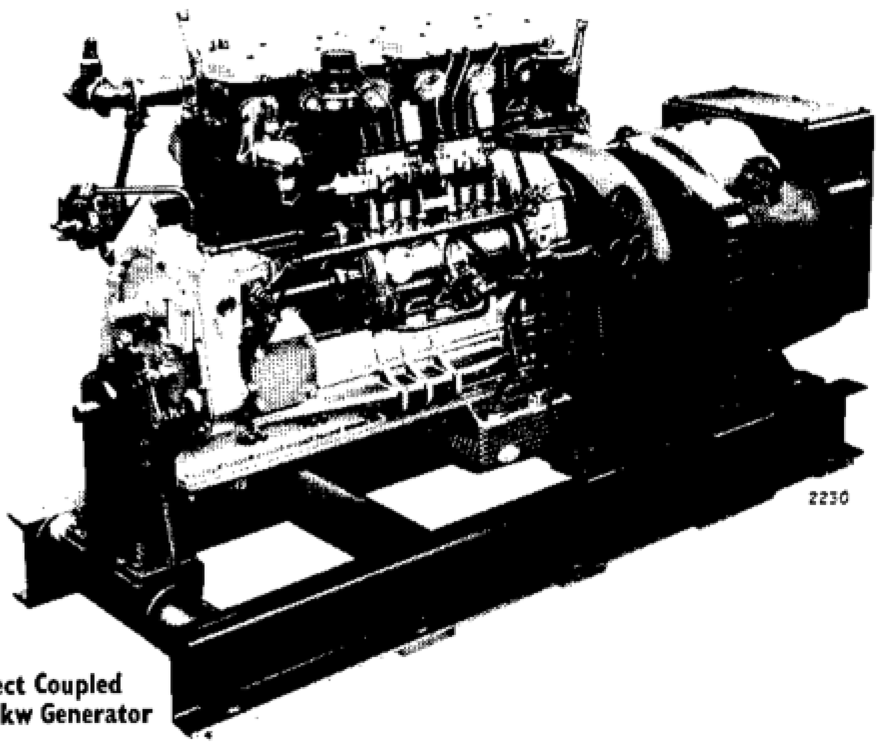
NOTE.—The Works will be pleased to advise and co-operate in the design and development of the cooling equipment generally required for the horizontal engine.

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS



6LX Industrial Unit Fitted with Power Take-off Clutch

2110/1



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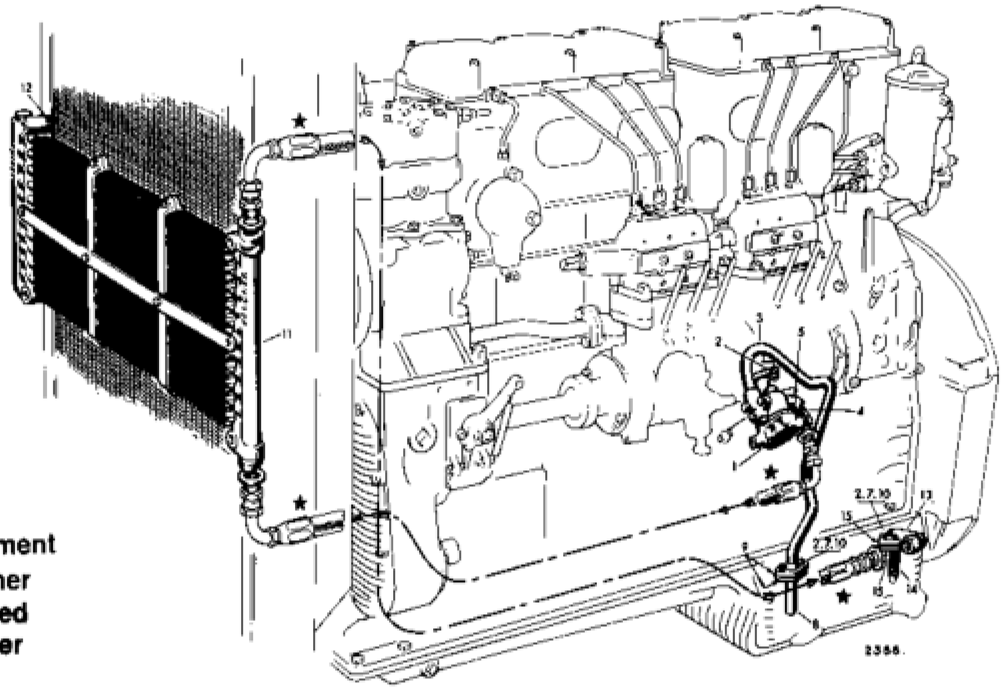
6LX Engine Direct Coupled to Mawdsley 45 kw Generator

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

COOLING SYSTEMS—*continued*

AUTOMOTIVE AND INDUSTRIAL UNITS



Typical Arrangement of Gardner Air Cooled Oil Cooler

26. **COOLING OF LUBRICATING OIL IN AUTOMOTIVE INSTALLATIONS.** The primary functions of an engine lubricant are twofold (a) to avoid so far as be possible actual metallic contact of the sliding surfaces within the engine and (b) to carry away the heat generated by such sliding motion. One means of avoiding metallic contact is to ensure that the lubricant has sufficient viscosity (thickness) and since lubricant viscosity falls rapidly with increasing temperature, it is essential to prevent it reaching undesirable values by limiting its temperature. The advent of increased output engines places emphasis on the provision of additional means for cooling of the lubricant. In addition the load carrying capacity and, therefore, durability of the engine components is increased by limiting their maximum temperature. **If it be known therefore, that any vehicle is to spend a large part of its life at high speeds on motorways, use of oil cooling equipment is desirable and beneficial.**

27. **AIR COOLED OIL COOLERS.** In order to meet such conditions Gardner oil cooling equipment has been designed and perfected for LXB and LX automotive type engines.

The equipment, which is described and illustrated in our Publication No. 762 comprises an oil to air heat exchange unit (air cooler) of either 10, 14 or 18 tube construction (according to climatic conditions) for mounting forward of the engine jacket coolant radiator on conventional forward engined vehicles and an additional engine driven high pressure pump for circulating oil through the cooler and returning it to the engine.

The correct application of these oil coolers for freight vehicles according to climatic conditions and duty are as follows:

Engine	Temperate Climate		Temperature in excess of Temperate
	Normal Duty	Special Heavy Load Duty	
8LXB	14 tube	18 tube	18 tube
6LXB	10 tube	14 tube	14 tube
6LX	—	10 tube	14 tube

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

COOLING SYSTEMS—*continued*

MARINE INSTALLATIONS

28. **MARINE PROPULSION AND MARINE AUXILIARY UNITS.** In order that corrosion scale and silt formation, etc., within the cooling system of marine propelling and marine auxiliary type engines shall be held to a minimum, it has long been our established practice to recommend a closed circuit fresh water system in preference to the circulation and discharge overboard of sea water.

Such a system may comprise:—

(1) A heat exchanger system with engine-driven sea water pump.

(2) A keel cooler system.

(3) An air-cooled radiator with engine-driven fan.

29. **CLOSED CIRCUIT HEAT EXCHANGER SYSTEM.** An inboard mounted heat exchanger system with engine-driven sea water circulating pump, filter, valves, etc. proves very satisfactory in service. It provides the only reasonably practicable closed circuit fresh water system for the cooling of engines in marine craft which have to operate at full power with the vessel at rest, except for an air cooler radiator system which is advantageous for certain special applications only.

30. **CLOSED CIRCUIT KEEL COOLER SYSTEM.** This system can be used in some installations and consists of a series of pipes of selected length and diameter, mounted externally and running fore and aft on the hull of the vessel, through which is passed the engine (fresh) cooling water by means of the inbuilt engine circulating pump.

The pipes, respective skin fittings and support bracket must be of suitable material in order to avoid so far as possible electrolytic or corrosive action and must be protected from grounding, etc., by hull features.

Our Technical Department will be pleased to supply full technical details on application.

31. **AIR-COOLED RADIATOR SYSTEM.** For the cooling of engines for example in barges, etc., used in inland waterways on which it may be impracticable to use an externally mounted keel cooler system, a Gardner combined radiator and oil cooler with engine-driven fan, is desirable equipment. Such a system is however, dependent upon the practicability of providing such ducting as will permit of an unrestricted flow of air at external atmospheric temperature to the radiator and the free exit of heated air from the engine room.

32. **COOLING OF LUBRICATING OIL IN MARINE INSTALLATIONS.** On engines equipped with a heat exchanger for water cooling, the raw water is piped through the engine oil cooler before reaching the heat exchanger.

In a keel cooler system however, a small auxiliary engine-mounted pump or separate inboard mounted belt-driven pump, provides a circulation of raw water through the engine oil cooler.

Where the engine water is cooled by means of a radiator and engine-driven fan, the oil is cooled by passing it from the oil cooler pump through a small auxiliary radiator, mounted in front of the main radiator and returning it to the engine sump.

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

ELECTRICAL EQUIPMENT

33. 24 volt electrical equipment is recommended for both the LX and LXB type engines, and is standard equipment on all Marine Units.

34. **ALTERNATOR.** The supporting cradle ribs on the fuel pump side of the crankcase are bored to receive alternators of up to 8 in. (203 mm.) diameter; the cradles being readily adapted to accommodate smaller diameter alternators by the provision of specially machined packing pieces that ensure positive and accurate alignment for the drive shaft arrangement.

The type of drive used depends upon the size of alternator fitted. In general alternators below 7 in. (178 mm.) diameter are driven by the well-proven Gardner flexible hose type couplings and a hollow steel shaft, whilst with alternators of 7 in. (178 mm.) diameter or larger the drive shaft embodies two disc type couplings, one at each end of the shaft.

When a Plessey or Hoburn Eaton hydraulic pump is incorporated in the drive arrangement flexible disc type couplings are interposed between the sprocket and pump and between the pump and alternator. All alternators, irrespective of size, are driven by a 15-tooth sprocket at 1·8 times crankshaft speed.

35. **STARTER.** Standard mounting parts are designed to accommodate the following starter motors:—

C.A.V. U624A/15M (6 in. or 152·4 mm. dia.)

C.A.V. SL524 (5 in. or 127 mm. dia.)

The above starters are suitable for use on a radio interference suppressed circuit.

36. **BATTERY.** The size of battery will usually be determined by the lamp load but for engine starting only, the following minimum capacity is recommended:

100 ampere-hour at 10-hour rate.

37. **CABLE SIZES.** The minimum sizes of cable should be not less than the following:—

Battery to Starter ..	61/·044 in.	10 ft. max.
Alternator to Control Board	226/·012 in.	15 ft. max.
Field	1/·044 in.	,,
Switch to Starter ..	14/·012 in.	,,
Control Board to Battery	19/·044 in. or 266/·012 in.	,,
Warning Light	14/·012 in.	,,

38. **EARTHING OF ELECTRICAL EQUIPMENT ON WOODEN VESSELS.** The effect of electro-chemical action causing corrosion of metal components can be reduced by ensuring that all electrical equipment is correctly installed and maintained and that adequate earthing is provided to permit small accumulations of static electricity and induced stray currents to be discharged to a common earthing point. This is particularly important in the event of leakage occurring from the power source which might provide a steady continuous current whenever the main batteries are connected. To this end it is important to see that all components and items of electrical equipment are properly bonded in order to ensure continuity of the earthing circuit between one component and another.

Under no circumstances must any electrical equipment be earthed through either the engine cooling system filter, sea water inlet or stern tube, etc., otherwise rapid deterioration will occur due to corrosion brought about by the dissimilarity of metals and other complex factors.

A most effective means of combating the effect of electrolytic action, and one which meets Lloyd's requirements for lightning conductor earths, is to secure an earth plate to the outside of the hull. Any equipment liable to generate a static charge through vibration or dissimilarity of metal should be connected by a suitable conductor to this single earthing plate.

The earthing plate should have an area of not less than 2 sq. ft. and may be manufactured from 14 SWG

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

ELECTRICAL EQUIPMENT—*continued*

brass, copper or stainless steel. It must be attached to the outside of the hull by small screws closely spaced around its edges so that the plate conforms to the curvature of the hull, and a brass terminal post of sufficient length to project through the hull to the inside of the vessel, must be brazed or welded to the centre of the plate. It is very necessary that the plate remains permanently submerged in, and exposed to, the water and is not insulated by paint or other protective covering.

ENGINE CONTROLS

AUTOMOTIVE INSTALLATIONS

39. **SPEED CONTROL.** Attention should be paid to the geometry of the accelerator linkage in order that the foot control be "light" in operation. To do this it is necessary to arrange the linkage so that the rods and levers are mutually at an angle of 90° when the accelerator lever is in a position 40° from the idling speed position. This provides the greatest leverage when the greatest effort is required and avoids heavy pedal pressure.

The optimum pedal travel, at the point of application of the toe, is 4½ in. (114·3 mm.).

40. **STOPPING CONTROL.** The flexible cable control is simple, reliable, easily installed and provides a satisfactory means for remote operation of the engine stopping lever.

ENGINE AND GEAR CONTROLS

MARINE INSTALLATIONS

41. **INTERLOCKING SPEED AND REVERSING CONTROL.** A manual speed control is mounted on all 6LX/2UC Marine Units and consists of a permanently loaded cork lined friction disc which will remain in any selected speed position.

This control can be connected to one or more control stations and does not require any additional locking device. The speed control can thus be effected from either the engine room or from a remote station such as the bridge or wheelhouse.

To prevent engagement of the reverse gear Ahead and Astern clutches at high engine speed, the engine speed and reverse gear controls are suitably interconnected. This allows maximum engine revolutions when the reverse gear lever is in the position Ahead or Astern but the return of the gear lever to Neutral position automatically reduces the engine speed.

The idling speed adjusting screw is fitted to the Speed Control Plate and the interlocking speed control is so arranged that, when changing from Ahead to Astern or vice versa, the engine speed is automatically reduced to 770 r.p.m. when the gear lever is in the Neutral position.

In the event of the adjustment between the Speed Control Interconnection Forked Eye and Interconnecting Link being disturbed it must be reset so that the speed in the Neutral position is limited to 770 r.p.m. There is, however, no reason to interfere with this setting which is interconnected with other intimate engine speed adjustments. Where necessary, certain adjustments are permanently set and suitably sealed before the engine is passed off test.

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

ENGINE AND GEAR CONTROLS—*continued*

MARINE INSTALLATIONS

42. **REVERSE GEAR HYDRAULIC REMOTE CONTROL: For 6LX/2UC Marine Units.** When specified the Hydraulic Remote Control may be supplied for operation of the No. 2UC Reverse Gear as fitted to the 6LX Marine Engine.

Installation details will be found in Figure opposite and the following instructions have been complied to facilitate installation of the remote control and indicator mechanism.

43. **HANDWHEEL CONTROL UNIT AND ROTATION OF HANDWHEEL.** The Handwheel Control Unit is identical for port and starboard engines of a twin screw installation. The "Ahead" rotation indicator engraved plate fitted, is available to suit either clockwise or anti-clockwise rotation of the handwheel for such engagement. The direction of rotation of the handwheel can be decided during installation to suit the requirements, and the appropriate rotation indicator engraved plate attached at that time.

When bolting the unit to a bulkhead or other structure, the surfaces in contact must be quite flat, and care exercised to avoid distortion of the unit due to irregular surfaces or undue tightening of the securing bolts.

44. **ARRANGEMENT OF PIPES AND CLIPS.** The Operating Cylinder Unit is hinged at point "D" and has a slight angular movement about this point when working. Therefore, the two pipes connected to this unit must be arranged so that they are free to move with it. Whenever possible, the pipes should be installed as shown in Diagram, the first clip should be fixed at some distance from the Operating Cylinder Units, as indicated.

Any alternative run of pipes, whether copper or nylon, must provide for equivalent flexibility, and the first clip must not be nearer the unit than shown on the drawing. If possible, the pipes should rise gradually from the Operating Cylinder Unit, to the Handwheel Control Unit, but this is not essential. It is also desirable that the length of pipes be kept to a minimum, consistent with reasonable facility of installation, and suitably clipped to avoid vibration.

45. **OPERATING CYLINDER UNIT: STOP ADJUSTMENT.** For the "Ahead" engagement, the cylinder cover "X" provides the stop for the piston within the cylinder. For the "Astern" engagement the cover "X" provides the stop for the collar "Y".

In order to avoid excessive hydraulic pressure being applied to the stops within the reverse gear case, it is very important that the forked eye "Z" and the collar "Y" be so adjusted that the stops on the unit make contact just before the stops within the reverse gear.

46. **INSTALLATION OF INDICATOR CONTROL.** This control comprises a pull-push type flexible cable which operates within a brass conduit and couples the unit on the reverse gear to the indicator incorporated in the handwheel control unit in the wheelhouse.

The cable conduit should be installed first between these two points, using the water-tight fittings shown at deck level in the Diagram, where necessary. It must be carefully bent to the required shape, using a minimum number of bends. *No bend should be made to a smaller radius than 5 in. or 127 mm. (8 in. or 203 mm. is preferable) and no bend should exceed 90°.*

A length of cable inserted in the conduit before bending will assist in maintaining the bore of the conduit and at the same time will ensure that the conduit has not been damaged during transit to destination. The cable should be capable of being push-pulled through the conduit freely.

Having bent the conduit to shape, the ends must be sawn off square at the required length. Remove the screwed nipples from the bottom of the indicator body and from the unit at the reverse gear end and slide these on to the ends of the conduit. Finally, with the special drift provided, bellmouth each end of the conduit.

Should the length of indicator run exceed 10 ft. (3,048 mm.), then two or more lengths of conduit will be necessary, and they must be coupled together with a greaser connector; exactly the same procedure is to be observed as for the extreme ends. The conduit should be clipped to the engine and elsewhere along the run with the special clips provided, when completing the installation.

The length of the flexible cable can only be determined after the conduit has been installed. Its length must be approximately 16 in. (406 mm.) longer than the fitted conduit. To do this push the cable through the conduit, and with one end flush with the end of the

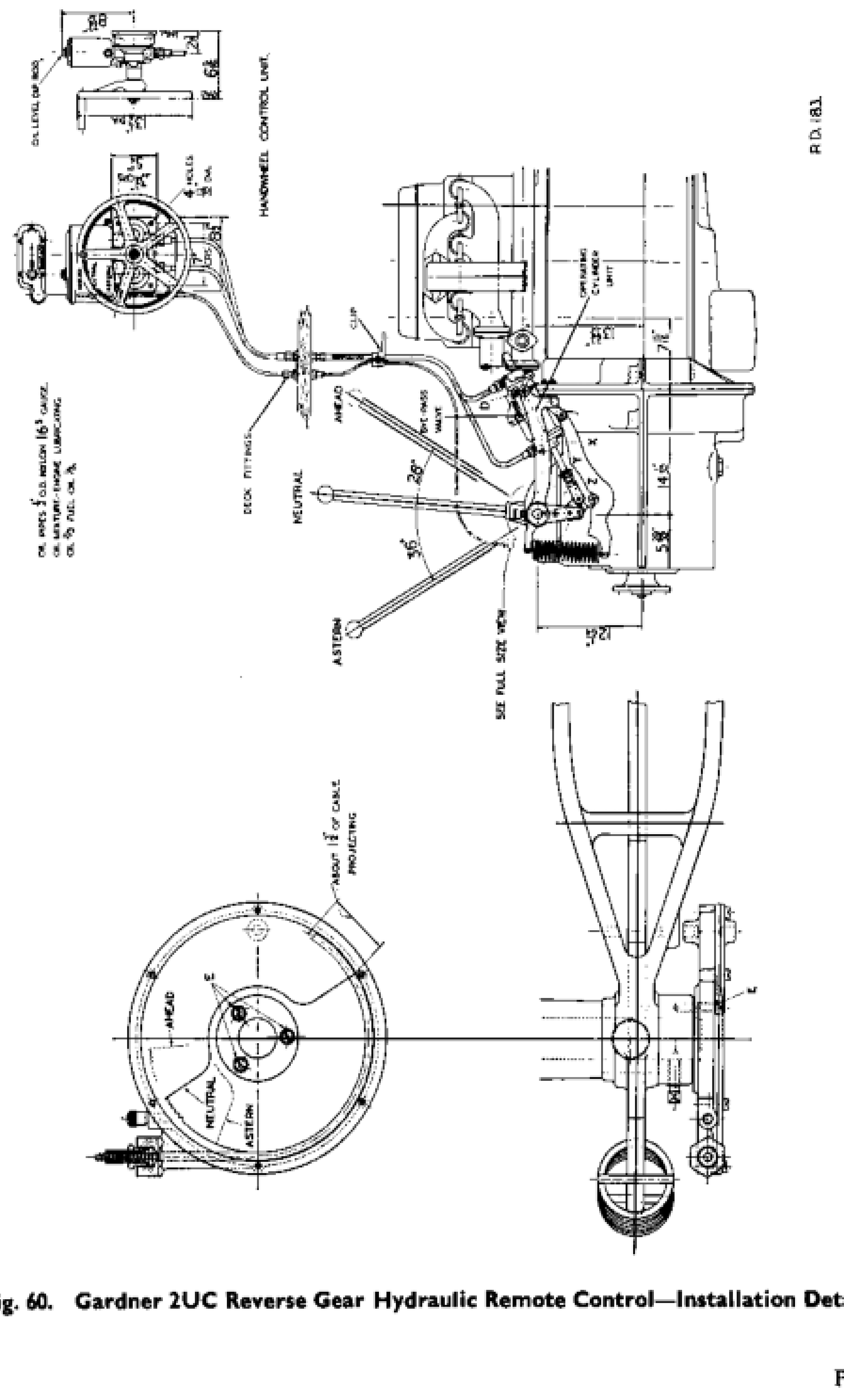


Fig. 60. Gardner 2UC Reverse Gear Hydraulic Remote Control—Installation Details

ENGINE AND GEAR CONTROLS—*continued*

MARINE INSTALLATIONS

conduit, cut off to give a 16 in. (406 mm.) projection at the opposite end.

The cable can be readily cut with a fine hacksaw and the ends will not unravel. It is essential that the ends are dressed and any sharp edges removed, especially at the reverse gear end. Otherwise damage may be caused to the inside of the unit casing when the cable gear quadrant is operating. Whilst the cable must be lubricated, this must be done sparingly since over-greasing can be responsible for creating undue friction and the locking of the cable within the conduit. Use only a thin anti-freeze grease when assembling.

Connect the bellmouthed end of the conduit to the reverse gear unit and screw home the nipple. The cable should temporarily be pushed up the conduit to make this connection.

Set the reverse gear lever in the "Neutral" position.

The 7½ in. (190 mm.) diameter cover of the unit on the reverse gear must be removed and also the three screws marked "E". The removal of these screws releases the cable gear on its shaft.

Rotate the cable gear to a position which will permit entry of the flexible cable through the vertical hole in the unit casing. Push the cable into the conduit and engage the teeth of the gear quadrant with the spiral wire coil on the cable by rotating the quadrant. This engagement must allow about 1¾ in. (44·5 mm.) of cable to project beyond the quadrant.

Re-assemble the cover and screws "E". It is important to ensure that the quadrant and cable are in the position shown in Diagram when the reverse gear lever is in "Neutral" position *before* the three screws are inserted in their tapped holes.

Remove the screwed plug at the base of the indicator unit in the handwheel control and also the sliding split collar from the indicator bored hole. Connect the conduit to the screwed plug. The cable should project 3 7/16 in. (87 mm.) beyond the screwed plug when in the "Neutral" position. Fit the split collar to the cable allowing the end of the cable to stand out from the collar about ¼ in. (6·35 mm.), and re-assemble in the indicator bored hole. The conduit nipple must be temporarily screwed out of its tapped hole to permit screwing in the plug. The indicator button should be in line with the "Neutral" marking.

Check up after assembly to ensure that the run is free and that the button indicates correctly.

47. **Operating Fluid.** The hydraulic medium is a mixture of two-thirds engine lubricating oil and one-third fuel oil.

48. **SINGLE LEVER HYDRAULIC/MECHANICAL REMOTE CONTROL: For 6LX/2UC Marine Units.** The Single Lever Control is a device which enables the operation of the Reverse Gear and change of engine revolutions to be controlled by one lever.

This Single Lever, mounted on the engine is linked mechanically with the Governor Unit and also operates a Reverse Gear Hydraulic Selector Valve.

Remote operation is effected by a Gardner Remote Control Unit, located in the wheelhouse, which may be coupled to the Single Lever by either of the following methods:—

(1) Roller chains and stainless steel wire ropes running over pulleys.

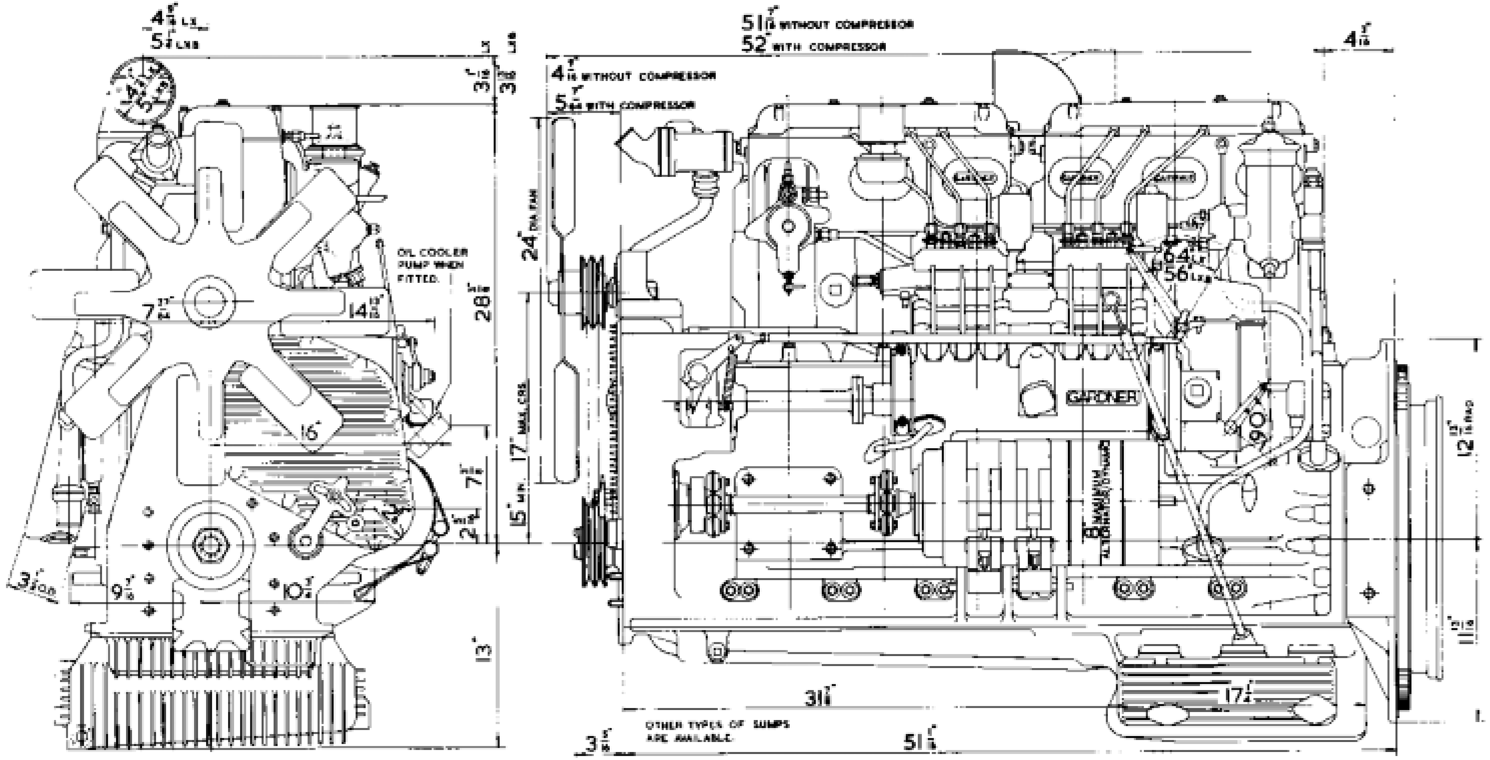
(2) Roller chains, chainwheels and a simple arrangement of rods and levers supplied by customer.

These methods are recommended where "the run" from wheelhouse to engine room is short and does not include more than four changes in direction.

Full instructions for the maintenance of the Single Lever Control System are contained in Instruction Book No. 64.

6LX & 6LXB AUTOMOTIVE ENGINE

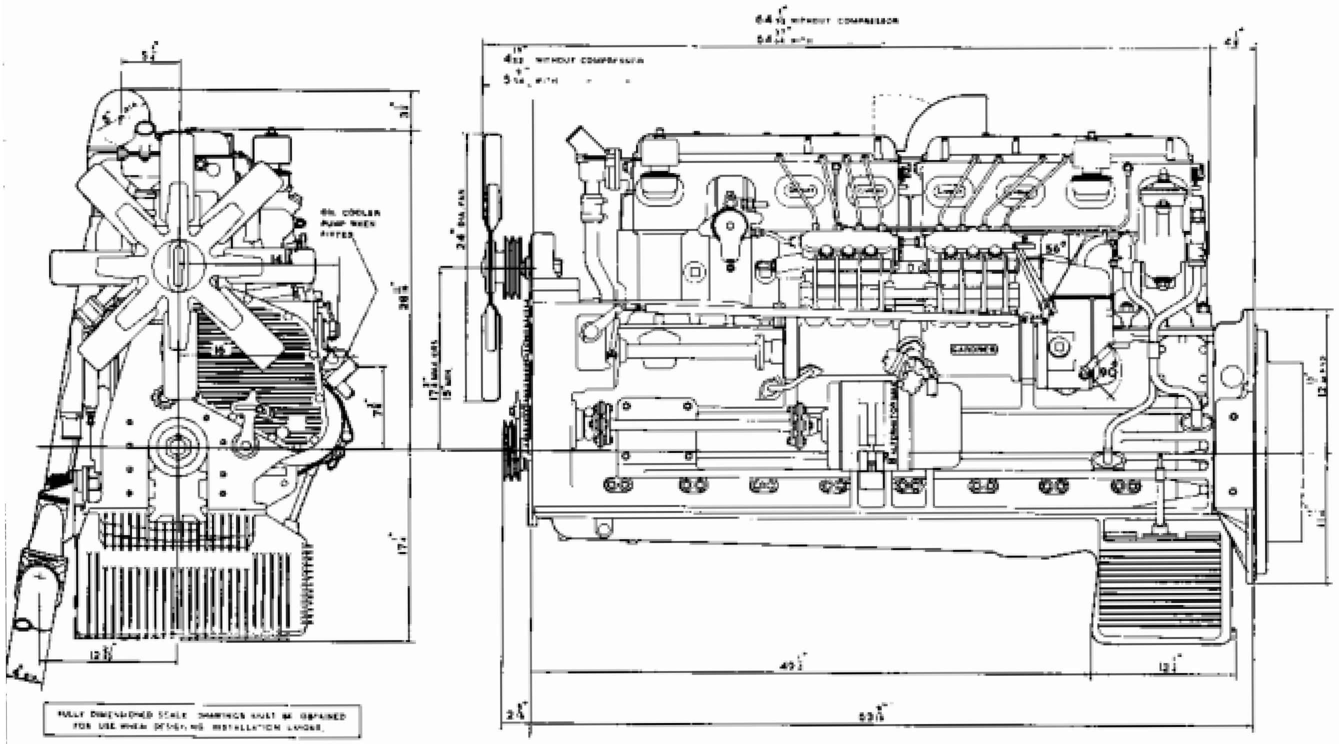
OUTLINE AND DIMENSIONS



FULLY DIMENSIONED SCALE DRAWINGS MUST BE OBTAINED FOR USE WHEN DESIGNING INSTALLATION LAYOUT.

(2347)

8LXB AUTOMOTIVE ENGINE
OUTLINE AND DIMENSIONS



Rear Sump-Well Arrangement

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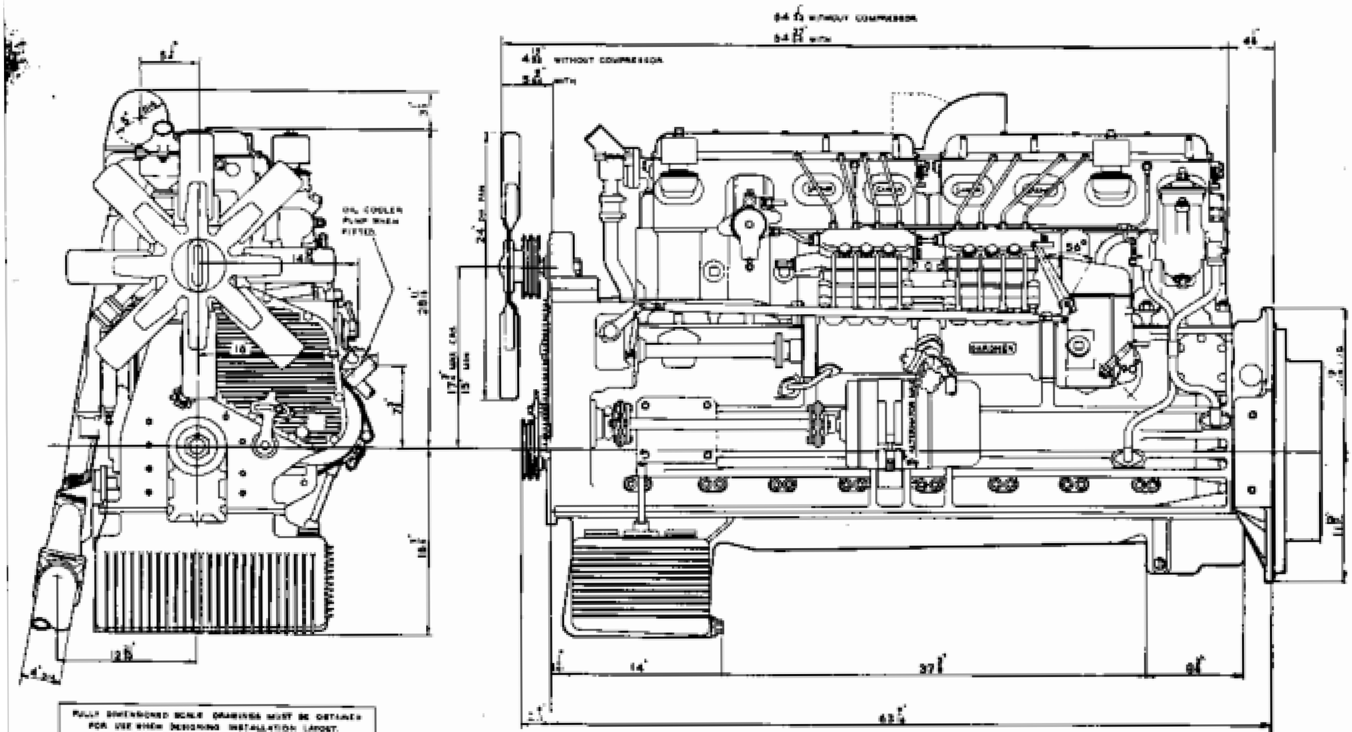

Forward Sump-Well Arrangement

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