OPERATING and MAINTENANCE INSTRUCTIONS

for the

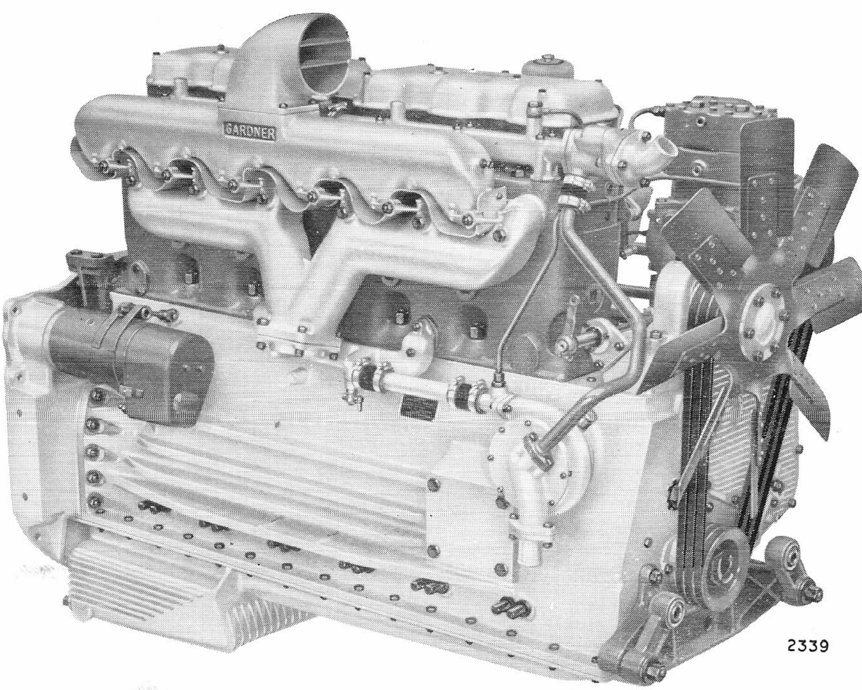
GARDNER

VERTICAL and HORIZONTAL

DIESEL ENGINES

TYPES

6LX, 6HLX, 6LXB, 6HLXB



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GARDNER ENGINES (SALES) LTD

BARTON HALL ENGINE WORKS
PATRICROFT, ECCLES, MANCHESTER

Telephone: ECCles 2201 (8 lines). **Telegrams: GARDWORKS, ECCLES, MANCHESTER**

GARDNER

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ENGINE RATINGS 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.

6LX & 6HLX AUTOMOTIVE DUTY

APPLICATION	B.H.P.	R.P.M.	Maximum Torque			Approx. Weight	
			lb. ft.	Kg. m.	R.P.M.	6LX	6HLX
Road Vehicles, Rail Cars, Light Locomotives, etc.	150	1,700	485	67·0	1,000 to 1,100	1,583 lb. 718 kg.	1,730 lb. 785 kg.

NOTE.—The weights quoted above include flywheel but do not include electrical equipment or other auxiliaries. The radiator cooling fan absorbs approximately 2·8 b.h.p.

6LX MARINE PROPULSION DUTY

APPLICATION	B.H.P.	R.P.M.	Approximate Weight		
			Direct Drive	2 : 1 Reversing Reducing Gear	3 : 1 Reversing Reducing Gear
Heavy Duty Commercial Craft ..	110	1,300	2,480 lb. 1,125 kg.	2,620 lb. 1,188 kg.	2,660 lb. 1,206 kg.
Yachts, Cruisers, Auxiliary Vessels, etc.	127	1,500	2,480 lb. 1,125 kg.	2,620 lb. 1,188 kg.	2,660 lb. 1,206 kg.
High Speed Craft	144	1,700	2,368 lb. 1,074 kg.	2,508 lb. 1,138 kg.	2,548 lb. 1,156 kg.

NOTE.—The weights quoted above include:
1,300 and 1,500 r.p.m. Units—Hand Starting Equipment only and heavy design flywheel.
1,700 r.p.m. Units—Electrical Starting Equipment and light design flywheel.

6LX INDUSTRIAL AND INTERMITTENT DUTY

INTERMITTENT DUTY					INDUSTRIAL DUTY	
Air Compressors, Saw Mills, Excavators, Cranes, Earth Moving Equipment, etc.					Electric Generating Sets, Power Drives, Marine Aux.	
B.H.P.	R.P.M.	Maximum Torque			B.H.P.	R.P.M.
		lb. ft.	Kg. m.	R.P.M.		
119	1,400	455	62·9	1,050	97	1,200

GARDNER

ENGINE RATINGS AND POWER OUTPUT

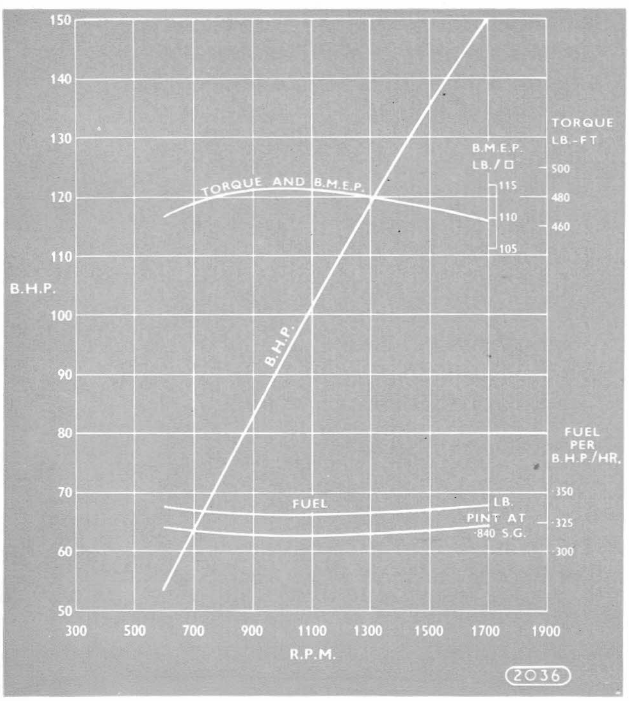
6LXB & 6HLXB AUTOMOTIVE DUTY

APPLICATION	B.H.P.	R.P.M.	Maximum Torque			Approx. Weight	
			lb. ft.	Kg. m.	R.P.M.	6LXB	6HLXB
Road Vehicles, Rail Cars, Light Locomotives, etc.	180	1,850	536	74·12	1,000 to 1,100	1,560 lb. 707·6 kg.	1,707 lb. 774·3 kg.

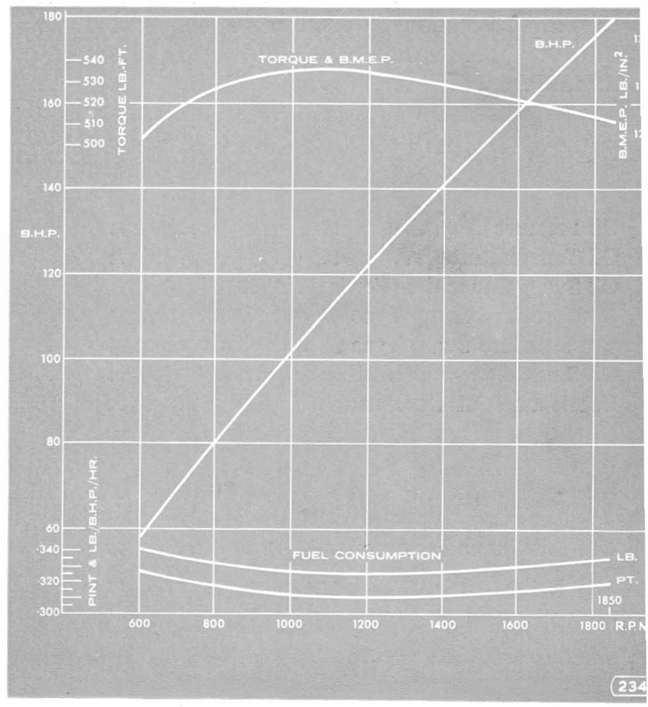
NOTE.—The weights quoted above include flywheel but do not include electrical equipment or other auxiliaries. The radiator cooling fan absorbs approximately 2·7 b.h.p.

PERFORMANCE CURVES

6LX & 6HLX



6LXB & 6HLXB



The above are the performance curves of the engines as set for Automotive Duty. They are Net Values and represent "installed" performance, except for deductions on account of Radiator Fan, Air Compressor, Dynamo, etc., or inadequate induction or exhaust systems.

When the 6LX engine is set at the maximum marine rating of 144 b.h.p. at 1,700 r.p.m. the above powers and torque values are reduced 4%.

ENGINE DATA

The engines are of ALUMINIUM construction for ALL purposes.

Marine Propulsion Units—comprising engines, reverse gear and reducing gear—are suitably protected from corrosion to specification accepted by the Royal National Lifeboat Institution.

Normal maximum static inclination aft for Marine Units is 7°. For greater inclination please consult the manufacturers.

GENERAL DATA

6LX, 6HLX, 6LXB, 6HLXB

Bore	$4\frac{3}{4}$ in. (120·65 mm.)
Stroke	6 in. (152·40 mm.)
Swept Volume	638 $in.^3$ (10·45 litres)
Firing Order	1, 5, 3, 6, 2, 4.
Crankshaft Rotation (Standard engine)	Anti-clockwise viewed from flywheel end.
B.H.P.	See Engine Rating Tables: Pages x and xi.
B.M.E.P.	See Fuel Pump Calibrating Tables: Page 72.

LUBRICATION SYSTEM

Oil Pressure	35 $lb./in.^2$ (2·5 $Kg./cm.^2$) at 1,000 r.p.m.
Oil Temperature	140°F. (60°C.)
Oil Sump Capacities (Vertical Engines)	
Standard Sump Type 28 with double pump	4 galls. 7 pints (22 litres)
Standard Sump Type 28 with single pump	5 galls. 7 pints (27 litres)
Oil Sump Capacity (Horizontal Engines)	5 galls. ($22\frac{1}{2}$ litres)
Lubricating Oils Specification	See Recommendations: Pages 6 and 7.

FUEL FEED SYSTEM

Fuel Lift Pump Pressure	1·5 $lb./in.^2$ (0·105 $Kg./cm.^2$)
Fuel Oil Specification	See Recommendation: Pages 8 and 9.

COOLING SYSTEM

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

ENGINE DATA

(CLASSIFIED)

GOVERNOR

	6LX & 6HLX	6LXB & 6HLXB
Idling Speed Setting	420 r.p.m.	420 r.p.m.
Maximum Governed no-load speed	1,760 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.)

FUEL INJECTION

	6LX & 6HLX	6LXB & 6HLXB
Fuel Injection Plunger Delivery	See Fuel Pump Calibrating Table: Page 72	
Fuel Injection Timing	30° B.T.D.C. at 1,700 r.p.m. 28·9° B.T.D.C. at 1,500 r.p.m. 27·7° B.T.D.C. at 1,300 r.p.m.	31° B.T.D.C. at 1,850 r.p.m. 26° B.T.D.C. at 1,000 r.p.m.
Port Closing: Thickness of Tappet Setting Disc	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.)
Lift of Sprayer Valve	0·007 in. (0·178 mm.)	0·007 in. (0·178 mm.)
Spring Load on Sprayer Valve when compressed to working length of 1·007 in. (25·578 mm.)	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})

CYLINDER HEAD

	6LX & 6HLX	6LXB & 6HLXB
Cylinder Head to Piston Clearance (Nominal)	0·029 in. (0·737 mm.)	0·032 in. (0·8128 mm.)

VALVES AND VALVE TIMING

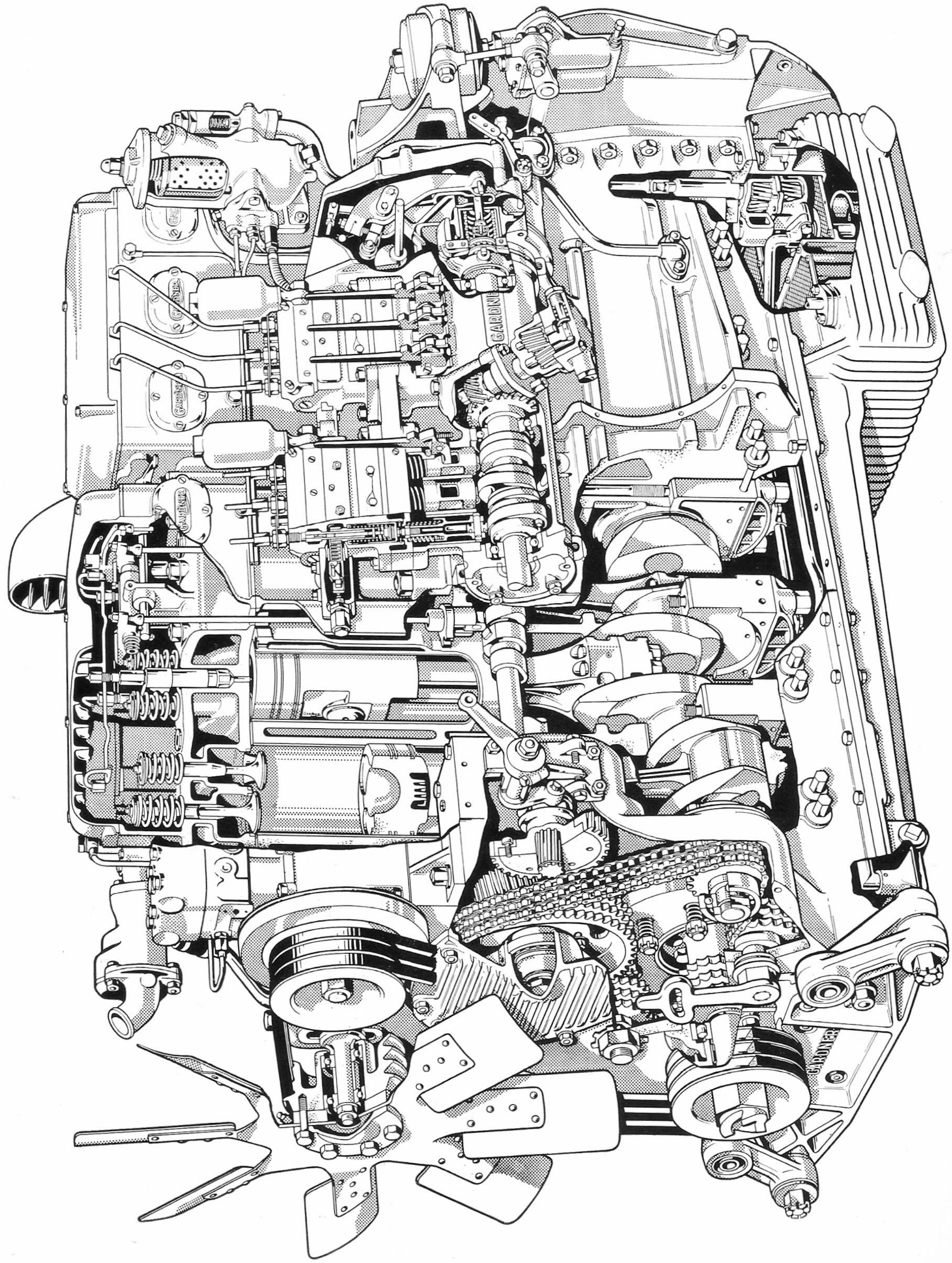
	6LX & 6HLX	6LXB & 6HLXB
Angle of valve faces and valve seats	45°	30°
Valve Tappet Clearance (cold engine)	Inlet 0·004 in (0·102 mm.) Exhaust 0·009 in. (0·229 mm.)	Inlet 0·004 in. (0·102 mm.) Exhaust 0·009 in. (0·229 mm.)
Timing Clearances (Inlet and Exhaust Valves)	0·020 in. (0·508 mm.)	0·020 in. (0·508 mm.)
Decompression: Lift of Inlet Valves	0·020 in. (0·508 mm.)	0·020 in. (0·508 mm.)
VALVE TIMING: Inlet valve opens	11° B.T.D.C.	16$\frac{1}{4}$° B.T.D.C.
Exhaust valve closes	11° A.T.D.C.	11$\frac{3}{4}$° A.T.D.C.

NOTE.—The above settings are with tappet clearances at 0·020 in. (0·508 mm.) and the timing chain tight.

AIR INDUCTION SYSTEM

	6LX & 6HLX	6LXB & 6HLXB
Suction Hose: Maximum length	12 ft. (3,660 mm.)	12 ft. (3,660 mm.)
Minimum diameter of bore	4·25 in. (108 mm.)	5 in. (127 mm.)

GARDNER



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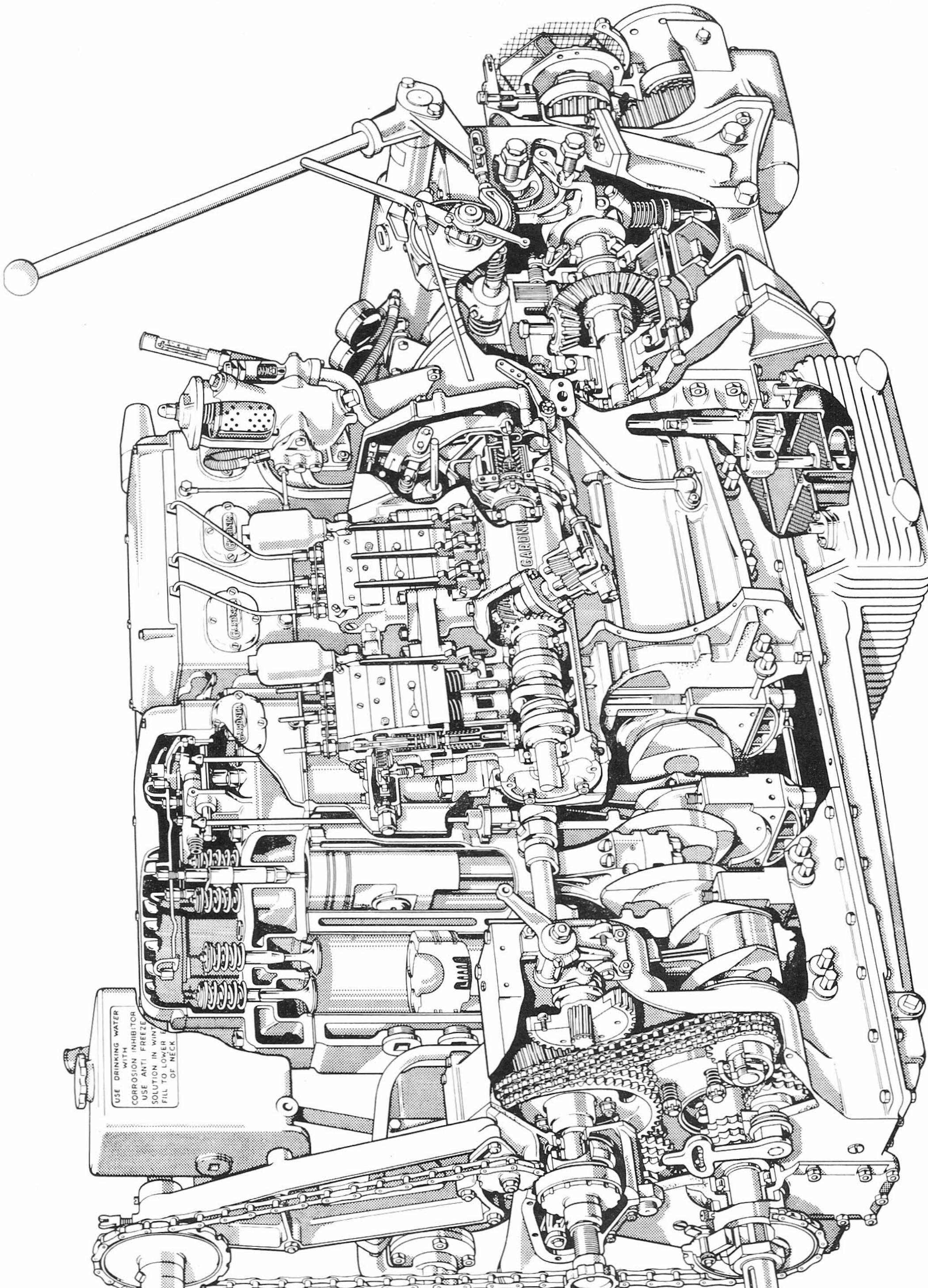
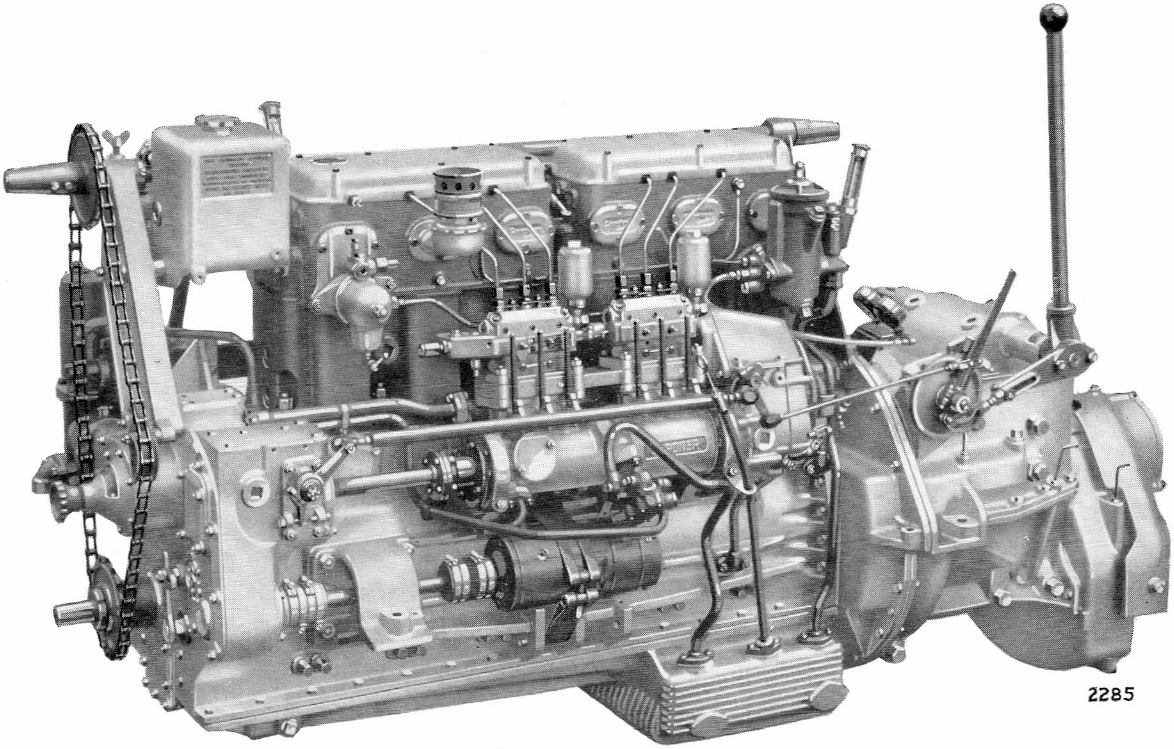
THE AUTOMOTIVE ENGINE

GARDNER



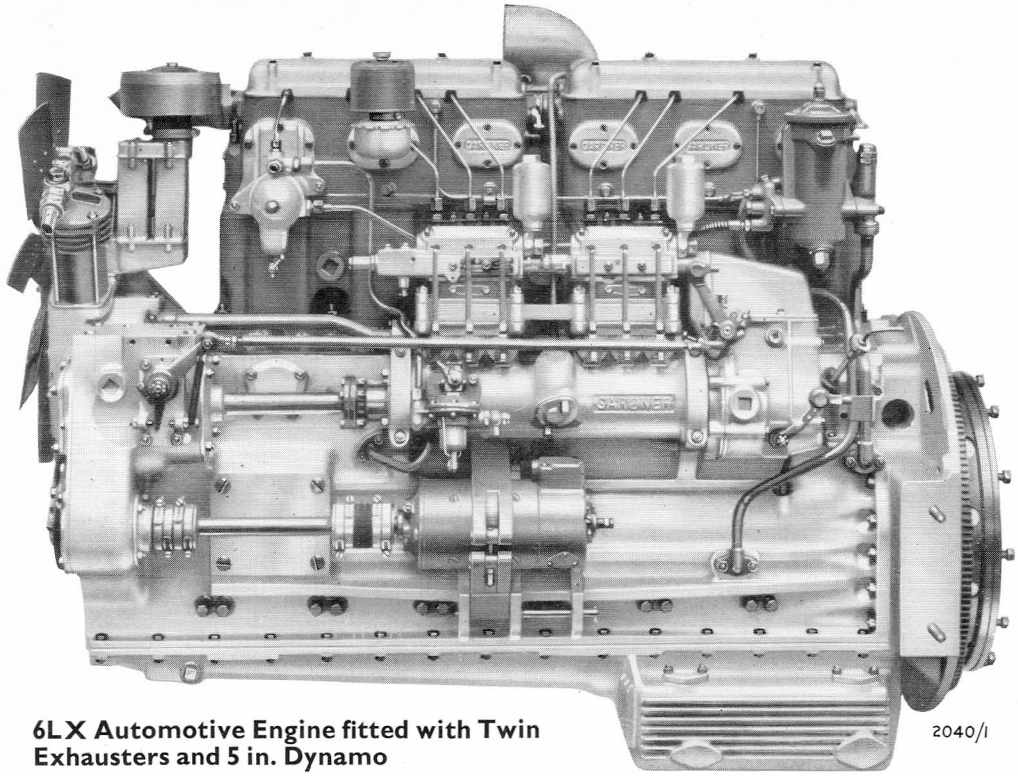
THE MARINE PROPULSION UNIT WITH REVERSING AND REDUCING GEARS



THE 6LX MARINE PROPULSION DIESEL UNIT
WITH No. 2 U.C. REVERSING AND 3 : 1 RATIO REDUCING GEARS

SECTION 1

INTRODUCTORY NOTES AND OPERATING INSTRUCTIONS



6LX Automotive Engine fitted with Twin Exhausters and 5 in. Dynamo

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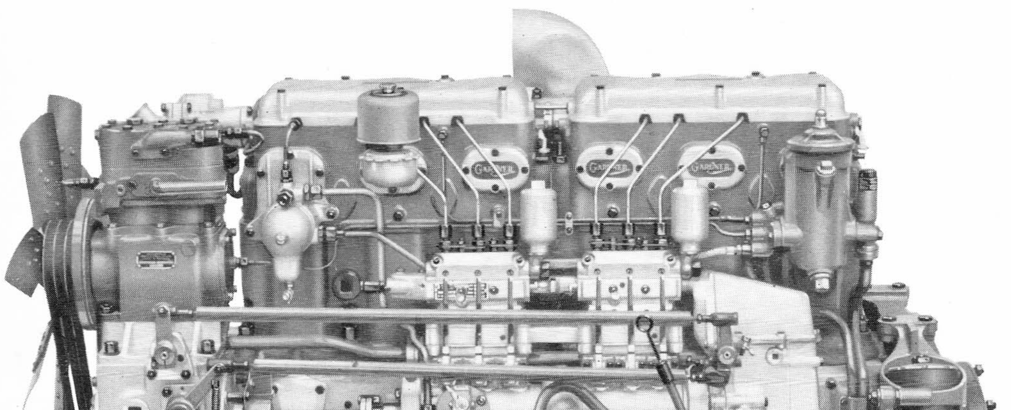

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6LXB Automotive Engine fitted with Water Cooled Air Compressor, Hydraulic Pump for power-assisted steering, $6\frac{1}{4}$ in. dia. Alternator, Oil Cooler Pump and Filter, Accelerator Control Cross Shaft, and Pick-up Assembly for Electrical Impulse Tachometer.

INTRODUCTORY NOTES AND OPERATING INSTRUCTIONS

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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. On 6LXB and 6LX 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.

On the horizontal engines the lifting arrangement 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, a spreader must be placed between each pair of sling hooks, i.e. between the two on the cylinder heads and between the two on the crankcase.

NOTE.—Engine weights will be found in the tables of Engine Ratings on Page x and xi.

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.

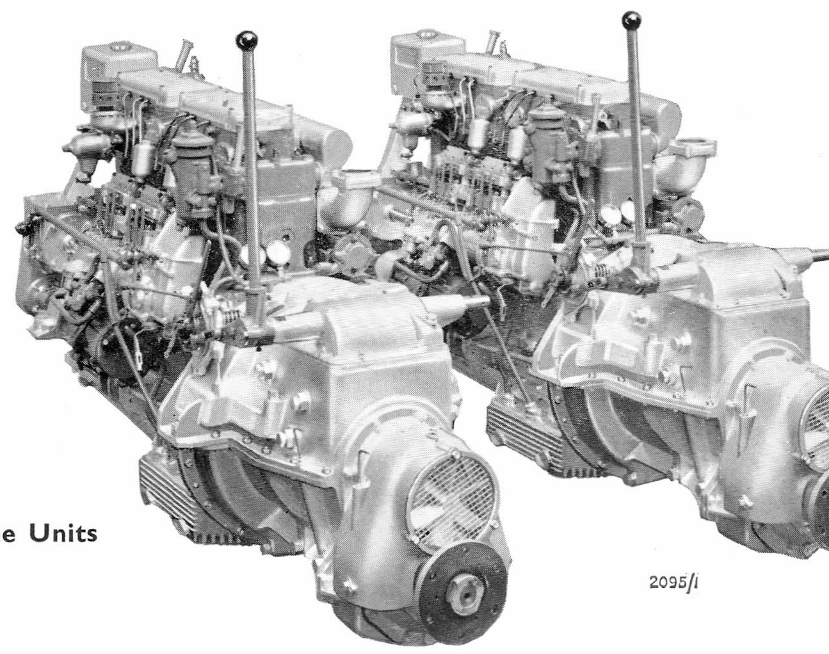
HANDED ROTATION OF ENGINES

4. The standard vertical and horizontal engines rotate in an anti-clockwise direction when viewed from the flywheel end.

The standard Marine Propulsion Engine for single screw installations is a Starboard type engine with anti-clockwise rotation to suit a left-hand propeller (direct drive) or a right-hand propeller when a reversing/reducing gear is fitted.

In twin screw installations, the twin engine can be built with opposite hand rotation to suit either inboard or outboard turning propellers according to customers' requirements.

The external appearance of the twin engines are identical, both having the fuel pumps on the left-hand side, but the direction of rotation of the final drive is clearly indicated by an arrow on the top of the reversing gear case and on the reducing gear case adjacent to the propeller shaft coupling.



Twin 6LX Marine Units

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 in order to reduce the injected fuel supply appropriately, according to altitude and temperature shown on the graph on Page 5.

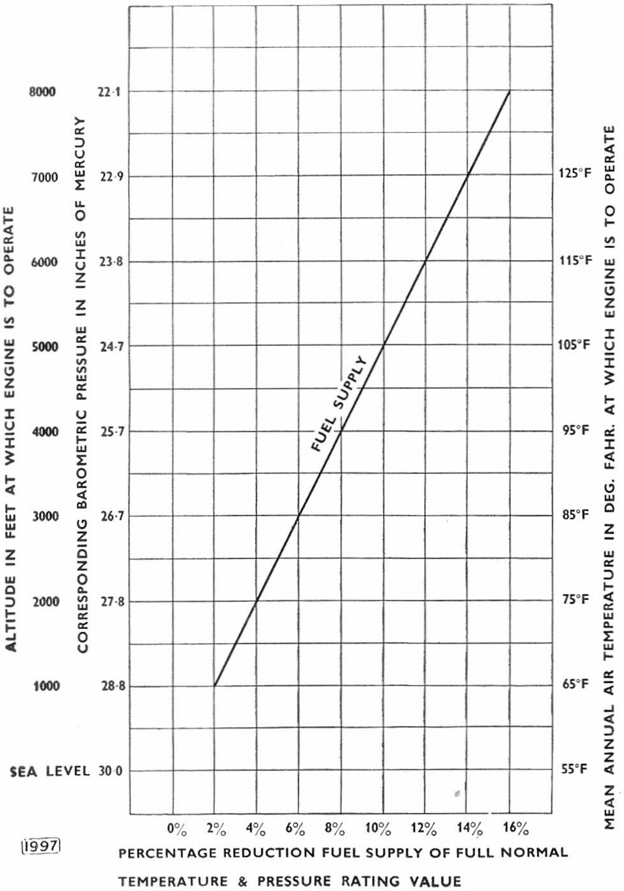
When site operating conditions are known, new engines are appropriately set during test at the maker's Works, and the setting is clearly stamped on the fuel pump rating plate. When, however, it is necessary to adjust spare or reconditioned fuel pumps, the work can be accomplished only by use of the Gardner Fuel Pump Calibrating Machine and by referring to the Gardner Fuel Injection Pump Calibrating Machine Instruction Book 45.4 or later issue. On Page 72 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.

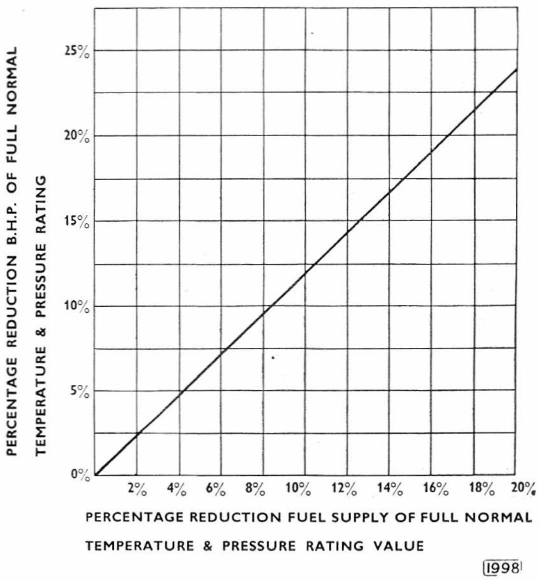
EXAMPLE.—Combined reduction fuel supply 10%
Reduction B.H.P. of full N.T.P. rating.. .. .. .. 12%

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 SPECIFICATION

6. **DETERGENT OILS.** It is well established that the sulphur content of fuel oil has a very harmful effect on the internal cleanliness and wear rate of an engine—in particular the question of lacquer formation on cylinders and piston rings, etc.—and accordingly the following are our recommendations:—

The use of approved first-class detergent oils to any of the following specifications is highly desirable. It is false economy to use the cheaper grades of lubricants.

(1) "Supplement 1." (U.S. Army Ordnance), see Note below.
(2) MIL-L-2104B (U.S. Army Ordnance).
(3) DEF-2101-C (British Ministry of Supply).
(4) MIL-L-2104A (U.S. Army Ordnance).

Their use is particularly desirable when one or more of the following conditions obtain:—

(1) The fuel oil in use contains more than ·3% sulphur.
(2) The engine is operating under continuous load, e.g. stationary electricity generating plant, or is used for prolonged periods at low speed as in certain marine installations.
(3) High atmospheric, coolant and lubricant temperature.
(4) The engine duty is insufficient to promote rapid attainment of optimum coolant temperature (e.g. short haul road delivery vehicles, shunting locomotives, etc.).

Oils to the above specifications possess a remarkable ability to combat the evils of sulphur in the fuel both from a wear (corrosion) and cleanliness point of view (lacquer), and we recommend that use be made of the high quality "Supplement 1" oil wherever possible. This oil promotes the lowest rate of wear and remarkably clean running which likewise applies even when the fuel oil has a low sulphur content.

Additionally the lubricating oil consumption rate of an engine is thereby under many conditions considerably reduced. Should "Supplement 1," however, not be available, oils to the other specifications may be used and the engines are capable of sustained performance under the approximate conditions given in the table below.

From this it will be seen that not only do we advocate the use of detergent oils but also advocate a detergent oil of highest quality.

We do not, however, do so to the extent of saying that their use is essential, but nevertheless, the lowest rate of wear, the greatest cleanliness, and the best maintained engine condition are not under any conditions obtainable without them.

In addition, when considering detergent oil versus straight oil the questions of drainage period and lubricating oil consumption assume much importance in arriving at costs and we claim that the low lubricant usage rate of our engines enables a high quality lubricant to be considered and also a more frequent drainage period with beneficial results in regard to the removal of internal "wearings".

FUEL	OIL	DRAIN PERIODS
(*a*) ·8% sulphur fuel of good ignition quality.	(1) "Supplement 1" or MIL-L-2104B (2) DEF-2101-C or MIL-L-2104A	4,000 miles (400 hours) 3,000 miles (300 hours)
(*b*) Low sulphur fuel say less than ·3% of good ignition quality.	First class straight oil.	3,000 miles (300 hours)
(*c*) Low sulphur fuel say less than ·3% of good ignition quality.	(1) "Supplement 1" or MIL-L-2104B (2) DEF-2101-C or MIL-L-2104A	6,000 miles (600 hours) 4,000 miles (400 hours)

NOTE.—U.S. Army Ordnance Specification 2104B Supplement 1 is officially obsolete, but oil of Supplement 1 type is still generally recognized as referring to a superior lubricant.

LUBRICATING OIL SPECIFICATION—*continued*

SPECIAL CAUTION.—When using a detergent oil for the first time in an engine which has been in service it is advisable to inspect the lubricating oil filter 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 case of a dirty engine, become choked

Suitable oil is supplied by any of the well-known makers.

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 upon the mean ambient temperature prevailing during the operation of the engine.

NOTE.—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 table below, as for instance severe tropical and arctic conditions where oils heavier and lighter respectively than those quoted below 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 tables given which could be approved would be the use of oil to KW specification in a public service vehicle engaged on stage carriage service, provided the ambient temperature is not in excess of 70° F. (21° C.).

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 ,,

FUEL OIL SPECIFICATION

8. 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 be the subject of an actual trial in an engine. Any fuel for this purpose should be wholly distillate.

Specific Gravity at 60° F. (16° C.)	not exceeding ·850
Initial Boiling Point	not exceeding 356° F. (180° C.)
Distillation Test	not less than 85% at 662° F. (350° C.)
Flash Point (Pensky-Martin)	not less than 170° F. (77° C.)
Viscosity Redwood No. 1 at 100° F. (38° C.)	not exceeding 45 secs.
Sulphur	not exceeding ·5%
Ash	not exceeding ·01%
Water	To be free from visible water
Calorific Value	19,400 B.Th.U./lb. (10,778 kcal./kg.)
Ignition Quality	See below

NOTE.—Paraffin, as used in lamps and heating appliances, is an excellent fuel having a high ignition quality, and therefore particularly suitable under conditions of extreme cold, but if blended for use in spark ignition engines, is unsuitable for compression ignition engines since it has low ignition quality.

9. **IGNITION QUALITY.** This is an extremely important factor. An accepted criterion of ignition quality of a Diesel Fuel is its Cetane Value expressed as a number.

A good quality fuel has a Cetane Value of not less than 57, it is desirable that the Cetane Value of the fuel used should not be less than this figure and should not in any case fall below 52.

Another unit in use is the Diesel Index Number. This is always several points higher than the Cetane Number for any given fuel. The above figures if quoted as Diesel Index Numbers are:—

Cetane 57	Diesel Index 62
Cetane 52	Diesel Index 56

Generally speaking, the higher the ignition quality, the better will be the startability and general maintenance, and the quieter will be the operation of the engine. It should be noted that the addition of coal oil derivative to the normal petroleum fuel can result in a mixture of lowered ignition quality which gives rise to noisy operation, misfiring and objectionable exhaust fumes, particularly from a cold engine. On this account it is essential that the petroleum fuel is of the highest quality and that only small amounts of coal oil are added.

Fuels corresponding to the above specification are readily obtainable from most of the fuel companies.

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, inflammability, handling, etc., of this product.

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

INTRODUCTORY NOTES AND OPERATING INSTRUCTIONS

FUEL OIL SPECIFICATION—*continued*

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. 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.

All engines have a label attached to the thermostat housing at time of delivery indicating the code number of the unit fitted to it. This number is also stamped on the thermostat housing.

The identification or code numbers of the various thermostat units with their corresponding operating temperatures are given in the following tables:—

Smith's Bellows Type Thermostat Units

Thermostat Unit Code No.	Crack Open Temperature		Full Open Temperature	
TH 2001/00/68	153°F.	68°C.	188°F.	87°C.
TH 2001/00/59	137°F.	59°C.	172°F.	78°C.

Western-Thomson Dual Wax Type Thermostat Units

Identification No.	Crack Open Temperature		Full Open Temperature	
Primary Units				
6B-1030-74	165°F.	74°C.	189°F.	87°C.
6B-1030-60	140°F.	60°C.	163°F.	73°C.
Secondary Unit S-3501-82-375	180°F.	82°C.	200°F.	93°C.

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

Passenger Carrying Road Vehicles, Locomotives, Earth Moving Equipment, Mobile Shovels, Cranes and Short Haul Road Vehicles	*Temperate Climates* TH 2001/00/68 or 6B–1030–74 with S–3501–82–375
	Sub-tropical or Tropical Climates TH 2001/00/59 or 68–1030–60 with S–3501–82–375
Goods Carrying Road Vehicles Rail Cars, Marine Propulsion and Auxiliary Units, Industrial and Generating Sets Portable Welding and Compressor Sets	*All Climatic Conditions* TH 2001/00/59 or 6B–1030–60 with S–3501–82–375

When the duty is further defined as light or heavy, or when it is known that an engine is to operate in a cold or hot climate, it may be possible to specify a

ENGINE COOLING RECOMMENDATIONS—*continued*

thermostat unit deviating with advantage from the above:—

Example (A) A goods vehicle operating at low duty or in a cold climate: use TH 2001/00/68, or 6B-1080-74 with S 3501-82-375.

Example (B) A Stationary Unit or Marine Auxiliary operating at low duty or in a cold climate: use TH 2001/00/68 or 6B-1080-74 with S 3501-82-375.

Example (C) Earth Moving Equipment operating in a cold climate e.g. Norway: use TH 2001/00/68 or 6B-1030-74 with S 3501-82-375.

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 one of the following British Standard Specifications:—

B.S.3150–1959, BS.3151–1959 or BS.3152–1959.

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 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 the by-pass pipe between the housing and the water pump suction, with a cork bung or blank packing. 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. (60° C. to 71° C.) 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 a suitable label on the radiator or take some other precaution 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 produce 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 very desirable 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.

Certain corrosion inhibitors are available in crystal form for the charging of dispensors, through which sea

ENGINE COOLING RECOMMENDATIONS—*continued*

cooling water can be drawn, and so reduce the corrosion usually associated with "open" sea water cooling systems.

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. The engine should be rotated by hand until the full stroke of the Fuel Lift Pump diaphragm can be felt when operating the hand lever.

Step No. 2. Slacken the front vent screw at the top of each block of pumps and operate the hand lever of the Amal Fuel Lift Pump until a flush of fuel emerges from the vent screws. Then re-tighten the screws. Continue to operate the hand lever until a very much reduced resistance is felt at the lever, 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 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 clear out the air from the sprayer pipes. Each stroke of the charging lever forces some of the imprisoned air through the

STARTING AND STOPPING THE ENGINE—*continued*

sprayer into the cylinder. When the last vestige of air has been forced out, the "feel" of the lever suddenly becomes "solid". It is important to cease working the charging levers as soon as the "solid feeling" is attained, otherwise, one is liable to inject a harmful amount of fuel into the cylinders.

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 it releases the fuel pump slider bar and allows it 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.
(4) Set the decompression levers in position No. 1 (Decompression).
(5) Turn smartly at the starting handle, and when maximum speed is attained turn the decompression levers to the engine running position, No. 2. 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.
(8) Set the decompression levers in position No. 1 (Decompression).
(9) Turn smartly at the starting handle. When maximum speed is attained, turn the decompression levers to the engine running position, No. 2. 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.

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 116; 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 position No. 2 (Normal Running).

(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 pump are operative and that the pressure gauge of the latter registers not less than 35 lb./sq. in. (2·5 kg./sq. cm.) at about 1,000 r.p.m. 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.

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 to such a position that it moves the governor control bar towards the radiator 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.

SECTION 2

SERVICING AND MAINTENANCE

GARDNER

SERVICING AND MAINTENANCE

INDEX

INDEX—*continued*

GARDNER

SERVICING AND MAINTENANCE

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.

—Continued opposite

PERIOD		OPERATING CONDITIONS	ITEM	PROCEDURE	Page	Para.
Miles	Hours					
DAILY		All Conditions	Lubrication System	Check oil level: Replenish if necessary	22	5
			Cooling System	Check Coolant level: Replenish if necessary	28	25
1,000 (or less)	100	Extreme Dusty Conditions	Lubricating oil sump	Drain and refill sump	22	5
			Air Induction Filter (Dry Type)	Check for chokage with manometer and clean if necessary	46	64 & 65
4,000	400	Average conditions	Lubricating oil sump	Drain and refill sump	22	5
			Lub. oil delivery filter	Examine and clean if necessary	23	7
			Oil Cooler Filter	Examine and clean if necessary	25	18
			Fuel Filters	Examine and clean if necessary	30	29–32
			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. of water	46	64 & 65
			Crankcase Breather Filter	Examine and clean if necessary	22	4
8,000	800	Average conditions	Sprayers	Observe by feel and sound that sprayers are functioning correctly by operating hand charging levers on engine	39	45
			Lub. Oil Delivery Filter	Renew Paper Element	23	7
12,000	1,200	After *first* 12,000 miles	Main Timing Chain	Check tension and adjust if necessary	42	56
		Every 12,000 miles Average conditions	Radiator Fan	Lubricate fan spindle bearing with grease gun Check driving belt tension and adjust if necessary	25 44	17 59
			Slow Running	Check and adjust if necessary	37	43
			Fuel Injection Pumps	Lubricate slider bar and quadrants	25	12
			Exhauster Breather Filter	Examine and clean if necessary	22	4

SERVICING AND MAINTENANCE

MAINTENANCE SCHEDULE—*continued*

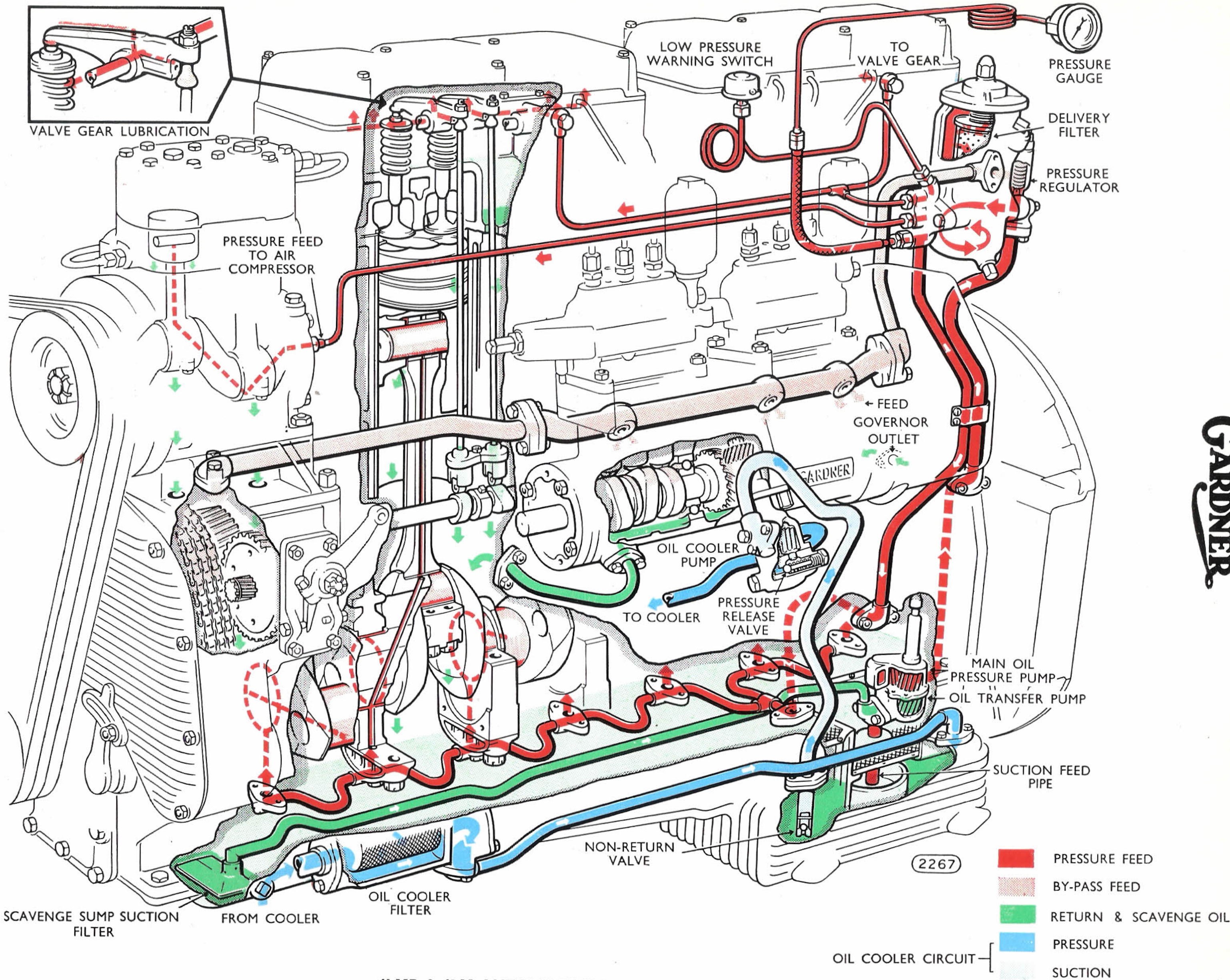
The inspections laid down are based on intervals of approximately 4,000 miles (400 hours) running time and are cumulative. Thus, when completing the inspections given at 12,000 mile periods, they must include the items given at 8,000 and 4,000 mile periods.

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.

PERIOD		OPERATING CONDITIONS	ITEM	PROCEDURE	Page	Para.
Miles	Hours					
24,000	2,400	Average conditions	Valve Tappets	Check clearances and adjust if necessary	43	58
			Crankcase Breather Filter	Renew Filter Unit or paper element if removable	22 22	4 4
			Exhauster Breather Filter	Renew filter unit	22	4
			Exhauster Suction Union Filter	Remove and clean	47	68
			Fuel Filters	Renew filter elements	31	30
*48,000	4,800	Average conditions	Top Overhaul	Decarbonise	67	30
			Lubricating oil sump 6LX	Remove and clean	64	25
			Fuel Injection Pumps	Check maximum output and balance on calibrating machine. Refer to Calibrating Machine Instruction Book No. 45.4	71	44
			Sprayer	Test by fast pull on hand charging levers, if sprayer valves do not vibrate fit service units	40	50 & 51
			Main Timing Chain	Check and adjust tension if necessary	42	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	40
			Water Pump	Lubricate spindle bearing with one grease cup full of grease	25	15
*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, etc. etc.	56 57 & 59	8 & 9 12 & 13

* **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.) and without removal from the engine.



6LXB & 6LX 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 Specification on page 7. 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. This oil then drains down through a long narrow coarse gauze screen into a trough in the lower edge of the sump. Oil fed to the valve gear drains into an oil gallery attached to the underside of the cylinder heads and this oil also feeds back into the trough through a large bore external pipe. 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 on the horizontal engine an oil-tight joint is necessary between the valve covers and the cylinder heads. This is obtained by means of a small groove which is cut in the joint face of the covers into which is lightly pressed a length of synthetic rubber cord. The diameter of the rubber cord and the depth of groove in the covers are such that the rubber when fitted in the groove projects slightly beyond the cover face, in this way the tightening of the cover screws pulls the covers down on to the cylinder heads making a metal to metal joint, at the same time compressing the rubber cord to produce a durable oil-tight seal. All sprayer pipes enter the covers on their upper edges and their points of entry are sealed with special rubber grummets.

3. **OIL FILLER AND CRANKCASE BREATHER FILTER.** On the vertical engines this is mounted either on the crankcase or cylinder head on the fuel pump side of the engine. The filler cap embodies a special crankcase breather filter incorporating an impregnated paper element to prevent the entry of dust and other foreign matter into the engine sump. See Fig. 13, page 34.

When, to suit certain chassis requirements, the oil filler is mounted on the crankcase, the breather is fitted

LUBRICATION—*continued*

to a casting mounted on the cylinder head—similar in shape to the oil filler.

The horizontal engine is fitted with a combined oil filler and crankcase vent mounted on the upper face of the sump.

The oil filler cover or lid is held in the closed position by means of a simple leaf spring. Contained in the oil filler is a gauze screen of large area and on the forward side of the filler neck is mounted a breather filter containing a special impregnated paper element.

4. **BREATHER FILTER CLEANING AND REPLACEMENT.** The breather filter element should be washed thoroughly in either petrol, paraffin, fuel oil or in water containing a detergent every 4,000 miles (400 hours) and renewed after 24,000 miles (2,400 hours).

Where the filter has a non-detachable element the complete unit should be immersed in the cleaning fluid, blown through with an air jet, and allowed to drain off before re-assembly.

Replacement units of this type are obtainable cheaply from the Works, Branch Offices and official Stockists.

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

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

On marine, and in some cases industrial engines, a hand pump is provided to facilitate sump emptying operations. A pipe leading to the lowest point in the base chamber is permanently attached to the end of this pump which, when operated, transfers the oil from the sump to any suitable receptacle or container conveniently placed nearby. The dust cap must always be replaced on the pump outlet after draining has been completed.

The use of a "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.

The oil level dip rod is normally fitted in the base chamber on the fuel pump side of the engine and must always be used to check the sump contents. When replenishing an oil sump a few minutes must be allowed to lapse after adding oil and before the level is checked as of course this time is required to allow the added oil to gravitate to the reservoir portion of the sump. The correct oil level is indicated on the dip rod which shows the minimum level at which it is safe to run the engine.

The maximum level is also marked on the dip rod and this is the level to which the sump should be charged and also the level which should be maintained. In other words, 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.

The oil level indicated on the dip rod will vary according to the elapsed time; often up to approximately four hours after stopping a hot engine the level indicated will increase. The corresponding figure for cold engines may reach 12 hours. When making accurate measurement of oil level in a road vehicle engine, it is essential that due regard be paid to gradient and camber.

To check the level correctly, withdraw the rod and wipe perfectly dry, then re-insert and withdraw again to take the reading.

The capacity of the standard oil sump (Type 28) on 6LXB & 6LX engines fitted with single gear pump is 5 gallons 7 pints (27 litres) and with double gear pump 4 gallons 7 pints (22 litres).

For engines fitted with sumps of other pattern, the charge may vary, and the quantity required must be determined by the markings on the dip rod.

Horizontal Engines. The main oil reservoir or "wet" portion of the sump has two drain plugs, one at each corner, and two further plugs are located in the base of the scavenge trough or "dry" portion.

These four drain plugs are fitted to provide adequate means for draining the oil from both compartments, due consideration being given to varying installation factors including accessibility and rearward inclination of engine, etc.

To ensure complete drainage of oil from the engine the two plugs situated at the *lowest* point in each compartment must be removed.

The oil level dip rod is mounted in the top of the main oil reservoir or "wet" portion.

SERVICING AND MAINTENANCE

LUBRICATION—*continued*

The horizontal engine has one type of sump for all applications and has a capacity of 5 gallons (22½ litres).

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. 1.

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.

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.

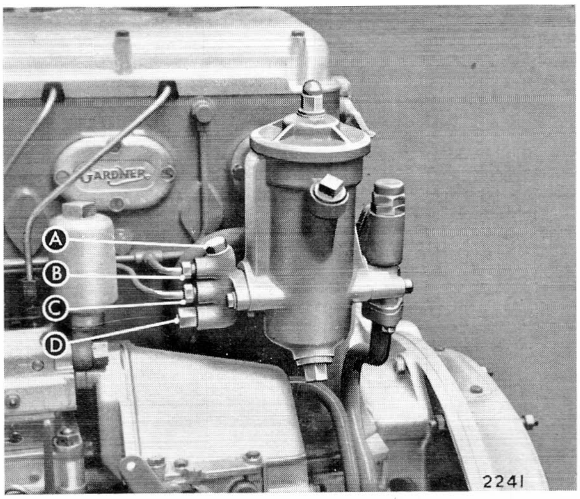


Fig. 1. Lubricating Oil Delivery Filter

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.

7. **DELIVERY FILTER CLEANING AND REPLACEMENT.** This unit *must* be thoroughly cleaned after every 4,000 miles (400 hours). To this end, first remove the drain plug of the sludge sump and so drain away the contents. Next remove the filter cover, take out the paper element and wash it thoroughly in clean paraffin or fuel oil. A reverse flow (from inside to outside) will assist in removing some of the sediment formation and make the element fit for further use. Since the second life is shorter than the first and as there is some risk of foreign matter remaining inside the element which, if present, will reach the bearings, it is recommended that a new element, Gardner Part No. LW/6/252, be fitted at about 8,000 miles (800 hours) under normal working conditions.

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 case of a dirty engine, become choked. A drop of 3 to 4 lb./sq. in. (·211 to ·281 kg./sq. cm.) in the oil pressure will indicate that chokage has occurred.

These elements are inexpensive and readily obtainable from the Works, Branch Office Depots and Official Spare Part Stockists.

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.

LUBRICATION—*continued*

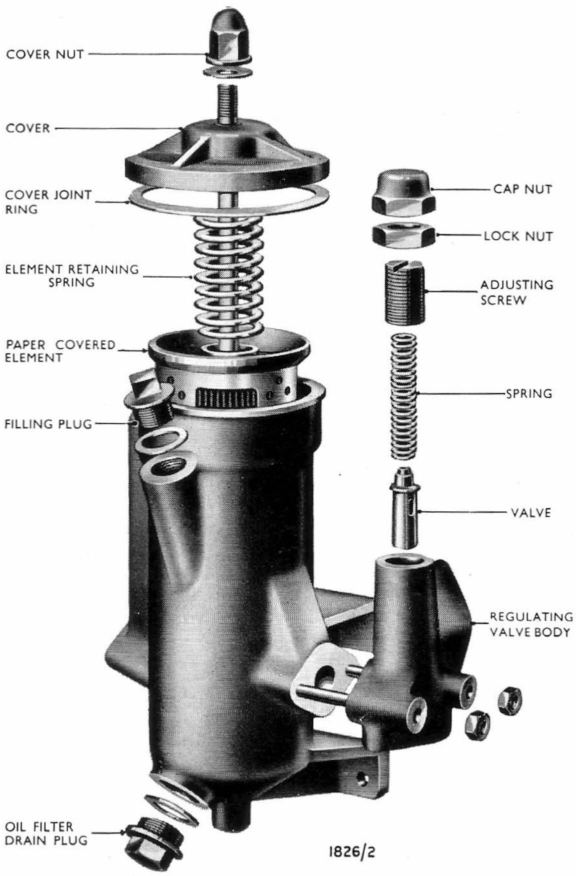


Fig. 2. Delivery Filter Assembly

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 adjusting screw is set during test to 35 lb./sq. in. (2·46 kg./sq. cm.) at about 1,000 r.p.m. with lubrication oil at a temperature of about 140° F. (60° C.). At 110° F. (43° C.) the pressure will read approximately 36 lb./sq. in. (2·53 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 records approximately 30 lb./sq. in. (2·1 kg./sq. cm.) at 1,000 r.p.m.–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

LUBRICATION—*continued*

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

(5) Remove and clean the base-chamber and read paras. 25 and 26, pages 64 and 65.

(6) The oil level in the sump should not be allowed to fall below the minimum mark of 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.

A length of flexible pipe is supplied for this purpose 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. 12, 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 BEARINGS.** Every 12,000 miles (1,200 hours) inject a small quantity of grease into the grease nipple provided on the hub of the fan spindle.

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 cupro-nickel pipe encased in a gun metal jacket through which the cooling water passes before entering the cylinder block.

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 dynamo 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 filter mounted on the engine. Fig. 3. overleaf.

The oil cooler filter, which is only fitted to automotive oil cooler return pipes, should be inspected—and cleaned if necessary—when the main system delivery filter receives attention.

LUBRICATION—*continued*

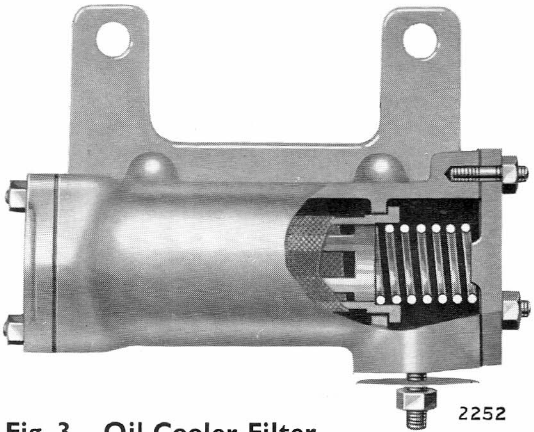


Fig. 3. Oil Cooler Filter

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 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. 16, Page 38). 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.

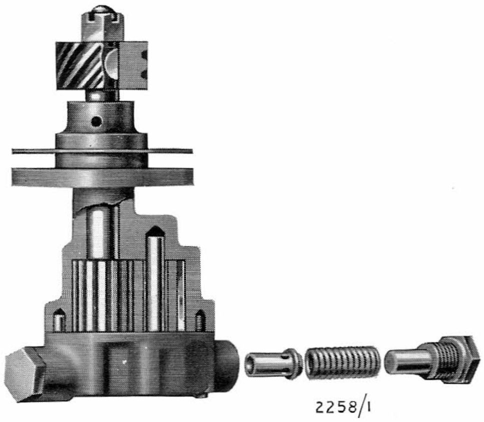


Fig. 4. Oil Cooler Pump

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.

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.

21. **WATER CIRCULATION.** This is effected by a centrifugal type pump mounted on the manifold side of the engine and driven by helical gears from the valve camshaft. Temperature is automatically controlled by a thermostat unit situated at the forward end of the engine and mounted on the water outlet pipe from the cylinder heads. Inspection should be made regularly in order to ascertain if circulation is taking place, especially if there has been any possibility of damage to the water pump impeller due to frost. Above 160° F. or 71° C. it should always be possible to observe this circulation through the radiator header tank filler cap.

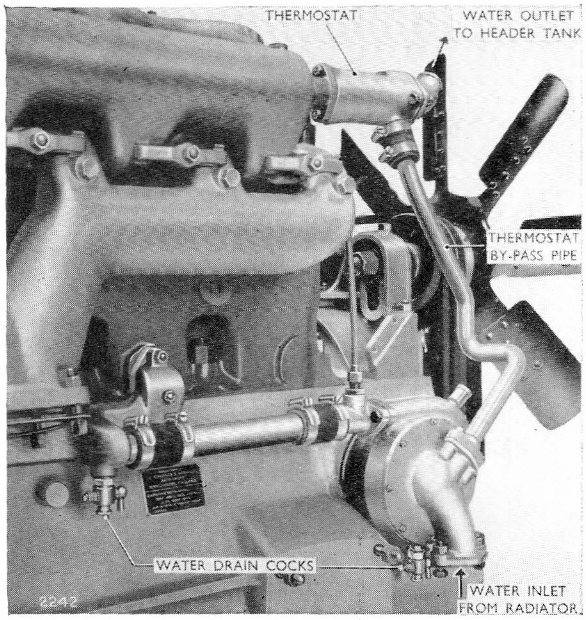


Fig. 5. Cooling System—Automotive Engine

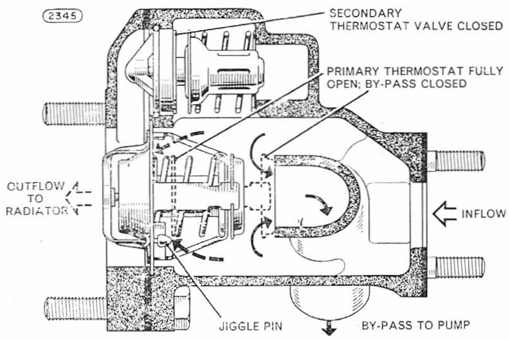


Fig. 6. Thermostat Unit

22. **AUTOMATIC TEMPERATURE CONTROL.** Until a pre-determined temperature is exceeded all the circulating water is diverted through a by-pass port in the thermostat and returned to the intake side of the pump. Thus there is no circulation through the radiator or, in the case of marine units, the heat exchanger or keel cooler so enabling "warming-up" time to be reduced to a minimum and normal running temperature to be achieved in the shortest possible time.

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

When a certain temperature is reached, dependent on the type of thermostat fitted, the by-pass port is finally closed and all the circulating water is pumped through the radiator or cooling device. This temperature, for the various duty thermostats mentioned on Page 9 is as follows:—

Smith's Bellows Type Thermostat
TH 2001/00/68 — 188° F. (87° C.)
TH 2001/00/59 — 172° F. (78° C.)

Western-Thomson Wax Type Primary Thermostat
6B-1030-74 — 189°F. (87°C.)
6B-1030-60 — 163°F. (73°C.)

SERVICING AND MAINTENANCE

COOLING SYSTEM—*continued*

23. **THERMOSTAT UNIT.** The Thermostat Unit incorporates a jiggle pin automatic vent valve which operates in an air release hole drilled in the main delivery valve.

This arrangement permits venting during filling or replenishment of the system whilst the engine is stationary. Immediately the engine commences running however, the coolant, circulated by the action of the centrifugal pump, forces the jiggle pin against the vent hole, closing the aperture and thereby shutting off any flow of coolant to the radiator, heat exchanger or keel cooler. This reduces to a minimum the "warming-up" period on initial starting from cold.

Earlier engines were fitted with thermostats having a ·052 in. (1·321 mm.) diameter air release hole drilled in the annulus that forms the seating for the main delivery valve, to prevent air locks forming in the system during filling and replenishing. This hole was of necessity small in diameter, in order that optimum temperature could be more readily attained in low duty engine applications.

It is recommended that these thermostats be exchanged for the later type at the first opportunity. Alternatively, on Marine Propulsion Engines, *if due regard is paid to coolant level when filling the system* (see Para. 25), the ·052 in. (1·321 mm.) diameter hole may, with advantage, be reduced to ·040 in. (1·016 mm.) diameter and in this way further reduce the "warming-up" period.

When inspecting the Thermostat Unit ensure that the jiggle pin (if fitted) is free in the hole and seats properly against the aperture. Operation of the temperature sensitive element and delivery valve can be readily observed by removing the unit from its housing and raising its temperature when immersed in water.

With the bellows type thermostat, in the event of the bellows becoming damaged the valve will assume a full open position and therefore dangerously high temperatures do not occur. In fact, severe bore wear will possibly develop due to prolonged "warming-up" periods and low temperature, except when on full load.

With the dual wax type thermostats the reverse is the case and in the event of failure of the primary element the main valve will remain shut resulting in a rise in coolant temperature. The subsequent increase in temperature will cause the secondary element to expand and open the secondary valve, which then passes the coolant through to the radiator, heat exchanger or keel cooler, thus preventing the engine attaining a dangerously high temperature.

The secondary valve cracks open at 180°F. (80°C.) and is fully open at 200°F. (93°C.).

24. **WATER PUMP.** This is of special spring loaded carbon gland type, in which the carbon ring is fixed in the pump case and forms a spherical seating for the sealing ring which revolves with the impeller. The impeller spindle is carried on a self-aligning ball bearing which, together with the spherical sealing ring, permits a slight malalignment between the pump and its driving member. 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 is 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

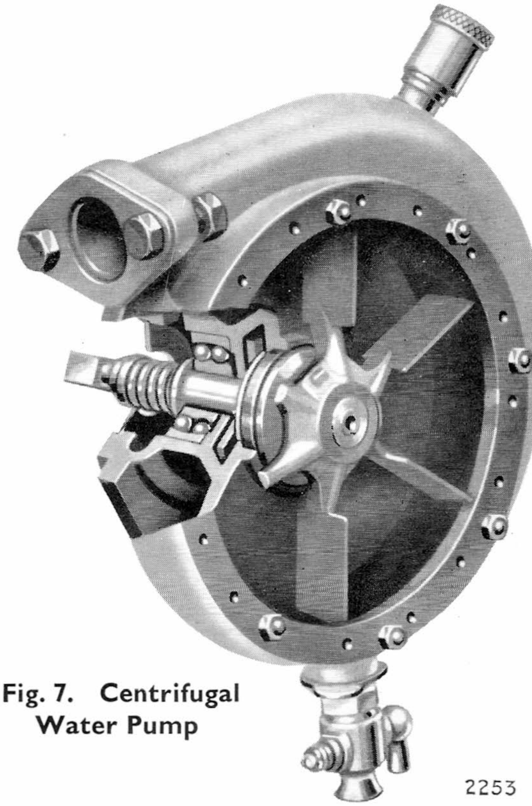


Fig. 7. Centrifugal Water Pump

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SERVICING AND MAINTENANCE

COOLING SYSTEM—*continued*

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 for this purpose. Spare parts for the water pump and complete service pumps may be obtained from our Service Depots and from the Works.

25. **DRAINING AND REPLENISHING THE COOLING SYSTEM.** As the pump is not, in all engine chassis 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 in an installation where the pipe has a continuous fall from pump to radiator, separate draining of the pump may be omitted.

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 separate draining by means of the cock provided at the rear end. See Fig. 8.

Before replenishing the cooling system, reference should be made to Engine Cooling Recommendations on Page 10 for information concerning the use of Anti-Freeze Solutions in conditions of extreme cold and the addition of special Corrosion Inhibitors.

When replenishing the cooling system special precautions are necessary to ensure that the system is fully primed and no air pockets remain in the water passages.

On marine units an air release cock is fitted to the water outlet pipe adjacent to the thermostat unit at the highest point on the engine cooling system. When filling the system, the 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 and header tank are filled to maximum capacity.

A length of polythene tubing fitted to the air release valve and fed into the filler neck of the header tank will assist during this operation and avoid wastage of

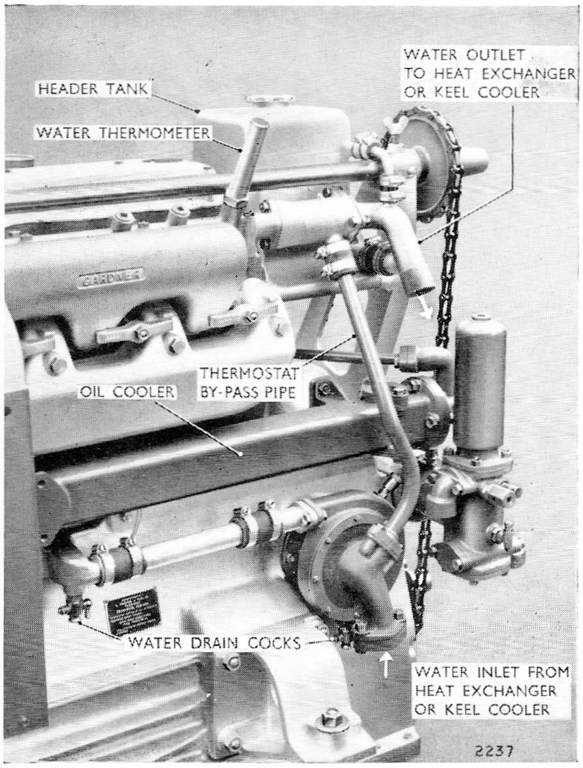


Fig. 8. Cooling System—Marine Engine

coolant and unnecessary mess.

With marine units embodying an engine mounted header tank it is essential to inspect the coolant level in the tank a few minutes after filling the cooling system, since the level will 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 until maximum level is maintained and preserved.

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

With Automotive or radiator cooled installations similar precautions must be taken to allow the trapped air to be expelled when filling the system, and it is very desirable to inspect the water level after the engine has run a short time and add coolant if necessary to replenish that which has entered the cab or saloon heaters.

FUEL FEED SYSTEM

26. **FUEL SUPPLY.** Engines may be supplied with fuel by means of a gravity, 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. This diaphragm pump is capable of delivering approximately three times the amount of fuel required by the engine at maximum demand, thus it is never called upon to operate at full capacity. 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. 10) is referred to as the "first" since the fuel passes through this filter before the "second" filter (Fig. 9) 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 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 and

SERVICING AND MAINTENANCE

FUEL FEED SYSTEM—*continued*

1 Filter Cover
2 Drain Plug
3 Element Retaining Spring
4 Filter Element
5 Cover Joint Ring
6 Filter Base
7 Mounting Bracket
8 Fuel Inlet Connection
9 Fuel Outlet to Injection Pumps
10 Sprayer Drain Pipe Connection
11 Fuel Drain Outlet to Tank
12 Vent Valve (gravity feed systems only)

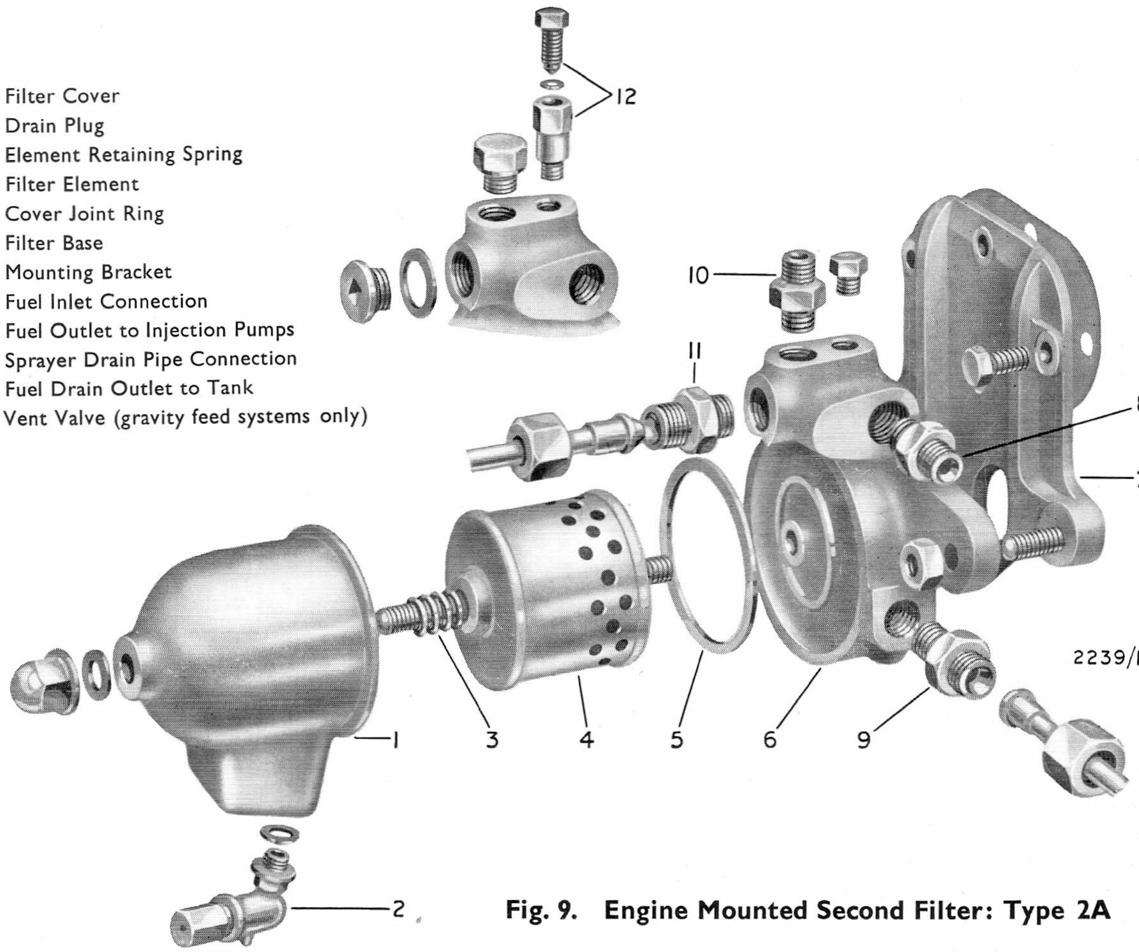


Fig. 9. Engine Mounted Second Filter: Type 2A

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 48,000 miles or 4,800 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.

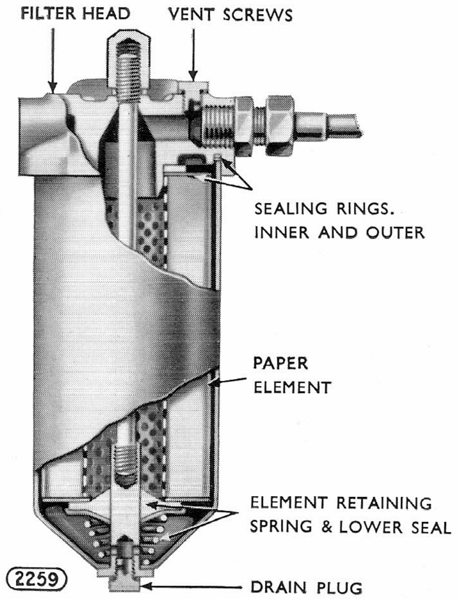


Fig. 10. First Fuel Filter

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. 11.

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".

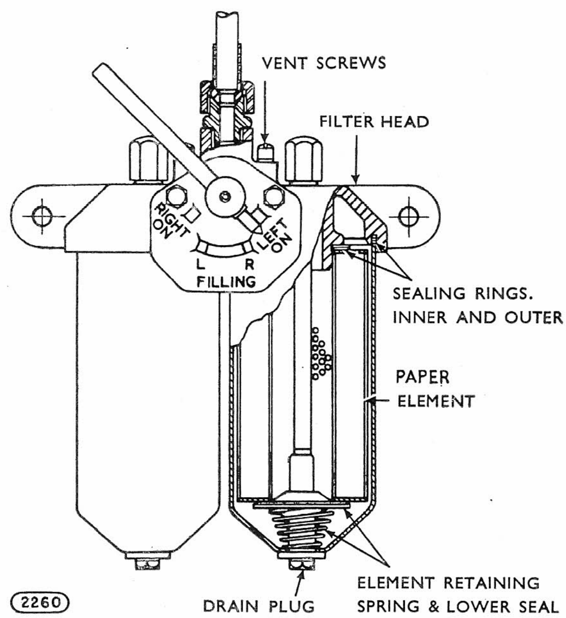


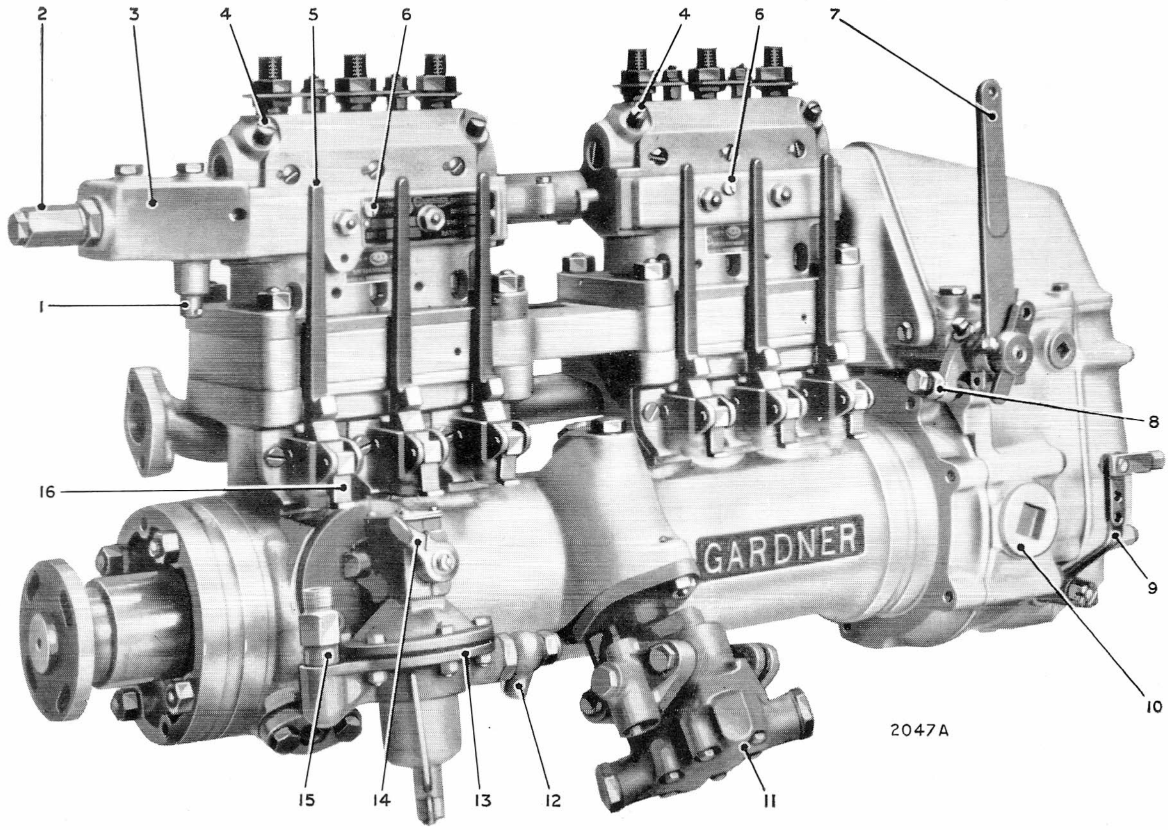
Fig. 11. Duplex Type Fuel Filter

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



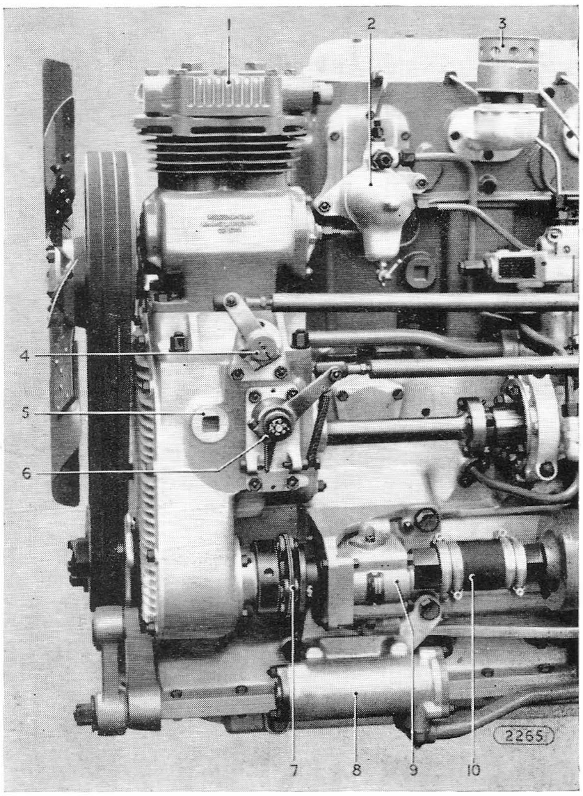
1 Starting Fuel Plunger
2 Slider Bar Buffer
3 Fuel Control Box
4 Air Bleed Screws
5 Fuel Pump Hand Operating Levers
6 2BA Screws (access for lubrication of slider bars and quadrants)
7 Accelerator Lever
8 Slow Running Adjustment Screw
9 Stopping Lever
10 Access Plug to Governor Weights
11 Lubricating 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. 12. Fuel Pumps and Cam Box

SERVICING AND MAINTENANCE

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 Lubricating Oil Cooler Filter
9 Plessy Pump for Power Steering
10 Dynamo Drive Hose Coupling

Fig. 13. 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. 13.

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 adjusted if necessary 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 periodically be packed 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 governor lever. 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. 14.

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.

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

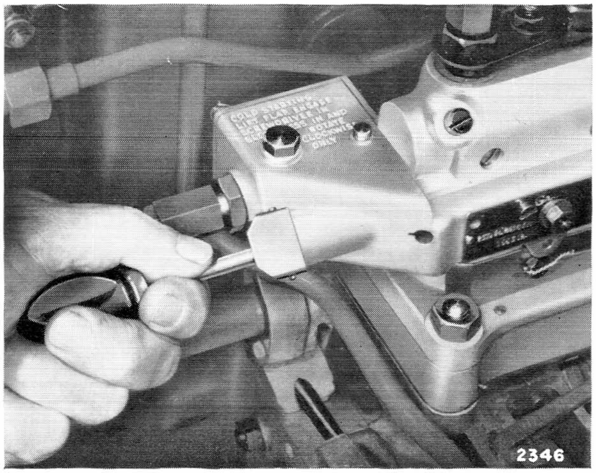


Fig. 14. Tool Operated Excess Fuel Device

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

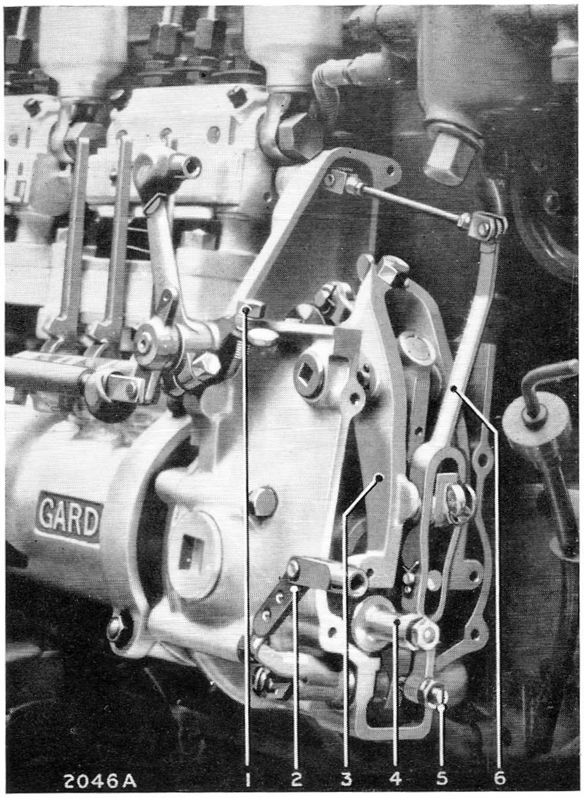
GOVERNOR AND GOVERNOR CONTROL—*continued*

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. 15.

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. 12. 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



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. 15. Governor Control

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. The sequences of operation for adjusting the slow running on marine propulsion engines is similar in every respect to that described above except that the setscrew and locknut are mounted on the friction-disc lever control plate and not on the remote control cam stop.

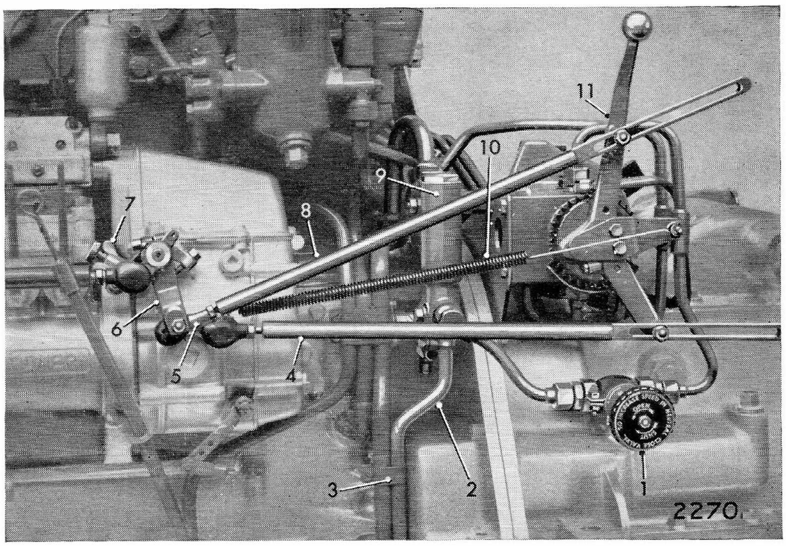
GOVERNOR AND GOVERNOR CONTROL—*continued*

Single Lever Control. Marine engines equipped with the Gardner Single Lever Control for engine speed and reverse gear operation are fitted with a knurl-headed screw and wing nut (in place of the standard setscrew and locknut) on the remote control cam stop, see Fig. 16, item 7.

This device enables the normal idling speed of 420 r.p.m. to be readily increased to a faster idling speed in order to prevent the possibility of stalling a cold engine when the gear is engaged. When the engine has reached normal running temperature the knurl-headed screw should be released and locked in the normal idling position by its wing nut.

An isolating valve (item 1) is fitted in the pressure line to the reverse gear valve to permit the single lever to be used solely as a speed control lever for the purpose of winching, cargo pumping, etc.

NOTE:—Before opening the isolating valve ensure that the single lever control is in the neutral position.



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. 16. Single Lever Control Linkage

SERVICING AND MAINTENANCE

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.

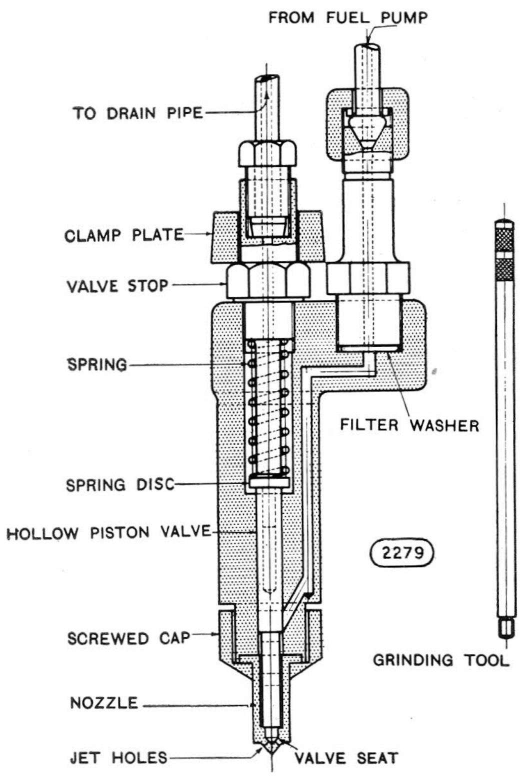


Fig. 17. Section through Fuel Sprayer

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 77 to 79.

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

GARDNER

FUEL SPRAYERS—*continued*

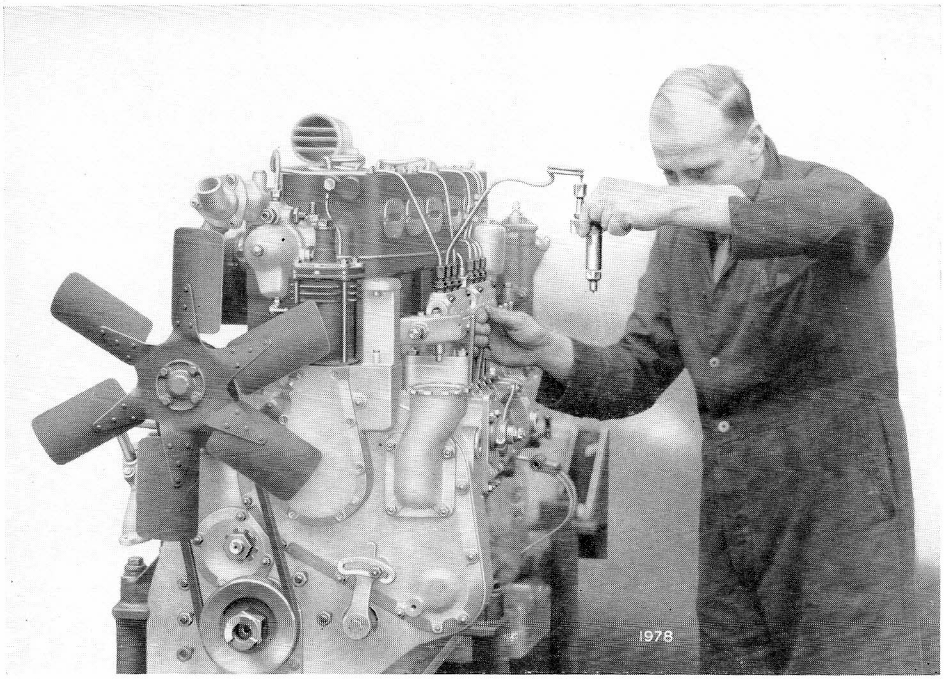


Fig. 18. Testing Sprayer Removed from Engine

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

SERVICING AND MAINTENANCE

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 the standard pricker supplied with the engine, 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.

For further instructions refer to Section 3, paragraphs 53 to 62.

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 fall 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.

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 ¼ in. (6·35 mm.)

TIMING CHAIN—*continued*

on either side of the mean position. Do not run the engine with excessive chain slackness or without slackness. Chain slack may be estimated by rotating the dynamo drive by hand in either direction after having turned the engine backwards a portion of a turn in order that its tension be relieved.

Adjacent to the injection timing pointer will be found a large diameter plug; access to the timing chain may be gained by removal of this plug, so providing a further means of judging chain tension. Item 5, Fig. 13.

A piece of 10 gauge (3·251 mm.) steel wire with a short length at one end bent to form a right angle and inserted through this hole will be found to form a convenient means of assessing the slack.

It is important to avoid overtightening a chain as of course this also will create an abnormal rate of wear.

To adjust the timing chain, first slacken the large hexagon locknut behind the adjusting lever, then release the lever clamp nut and rotate the lever clockwise (if increased tension is required) until correct adjustment is attained. Holding the lever in this position, secure it by tightening the clamp nut. Finally tighten the large locknut to secure the adjusting idler in the chain case.

NOTE.—To increase tension the lever must always move clockwise and to release tension it must move anti-clockwise: if this does not obtain the adjusting idler sprocket will be incorrectly positioned between the crankshaft sprocket and dynamo sprocket and the eccentric must be rotated until the above condition is achieved.

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, page 83. With a standard rotation engine (anti-clockwise viewed from flywheel end) tightening of the chain by moving the chain adjuster lever in a clockwise

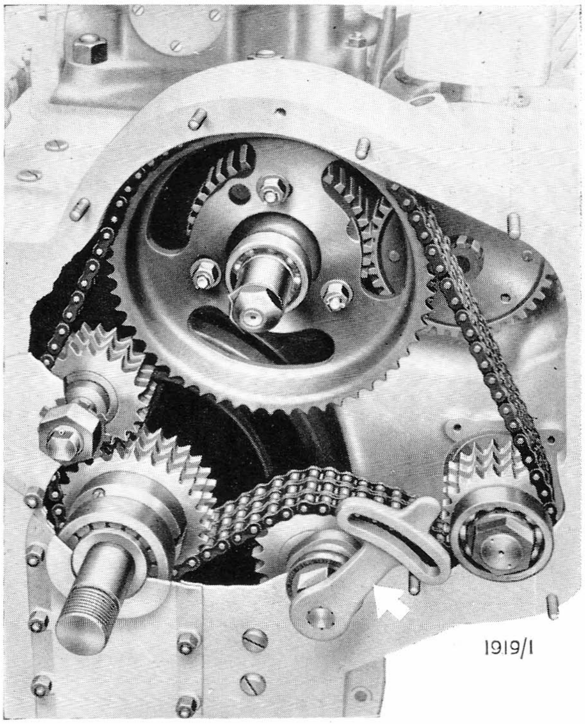


Fig. 19. Timing Chain Adjuster

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.

SERVICING AND MAINTENANCE

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 adjacent to each inlet valve. 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. Access to the adjustable screws is obtained by removal of the cylinder head doors. 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.

VALVE TAPPETS

58. **TAPPET ADJUSTMENT.** After every 24,000 miles (2,400 hours) adjust, if necessary, the clearance between the end of the valve and the toe of the valve lever. The correct clearance for inlet valves is ·004 in. (·102 mm.) and for exhaust valves ·009 in. (·229 mm.). When tightening the locknuts, it is quite unnecessary to use great pressure. The 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 that the pump tappet is in the lifted position by the lack of resistance to its movement.

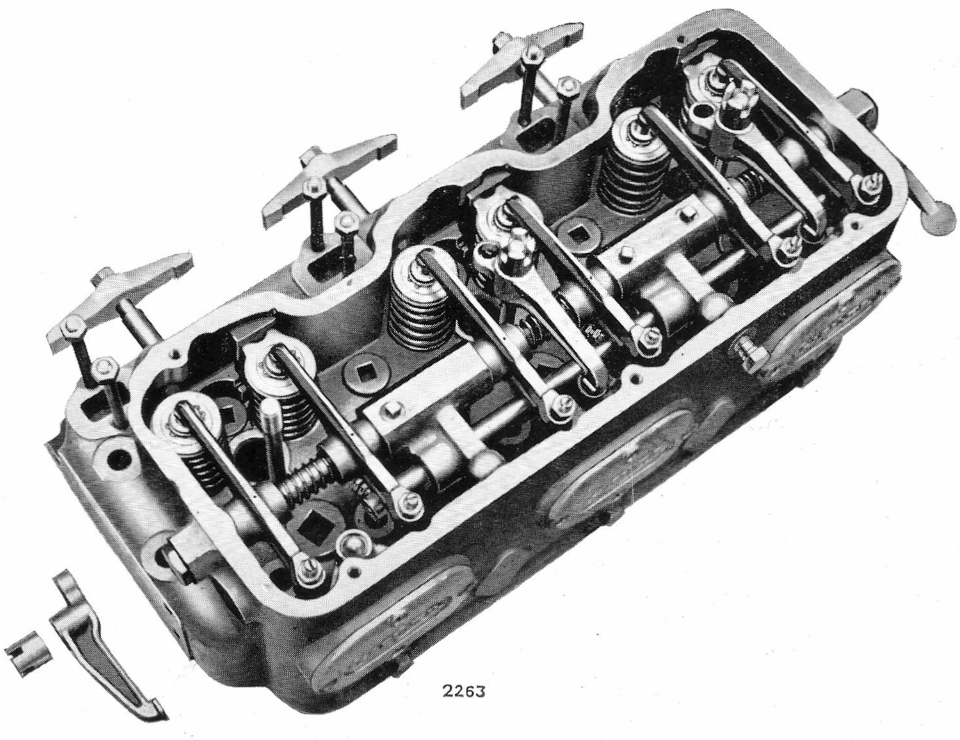


Fig. 20. Valves, Valve Levers and Decompression Gear

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, since the act of tightening this nut may tend to increase the tension. 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.

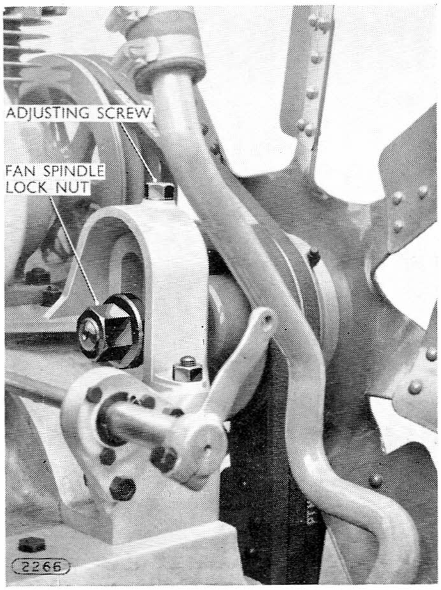


Fig. 21. Fan Belt Adjuster

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*

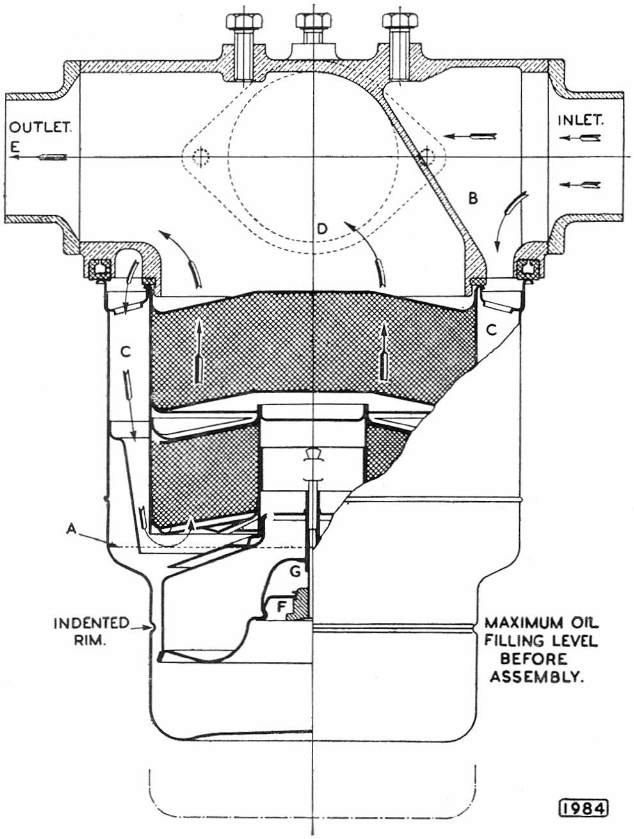


Fig. 22. Gardner Universal Air Filter

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. ($4\frac{1}{2}$° 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.**

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 536 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 the element receives regular and frequent attention and if, during use, chokage of the element occurs sufficiently to create a depression of 7 in. (178 mm.) of water, immediately replace or clean the filter element. It is good practice to carry a new or clean element in the vehicle.

Elements may be successfully cleaned (*a*) by tapping gently on the sealing faces and blowing out from inside to out with a compressed air jet directed up and down each pleat, and (*b*) by washing in a hot water detergent solution and blowing out with an air jet as above. After washing it is advisable to dry the element in an oven or by other means in order to secure the lowest resistance. The temperature should not exceed 250° F. (121° C.). In some cases process (*a*) satisfactorily cleans the element; in others perhaps associated with an oily atmosphere, (*b*) produces better results.

Under certain circumstances it is sometimes found that after a paper element has been cleaned a few times, either by washing or compressed air, its satisfactory clean life becomes rapidly shorter. When this condition arises the old element should be discarded and replaced by a new one.

AUXILIARY UNITS

66. **ELECTRICAL EQUIPMENT.** The electric starter motor is located on the manifold side of the engine and held in place by metal straps.

The dynamo is mounted in a similar manner on the Fuel Pump side of the engine and is driven through a length of tubular shaft and two spigoted flexible hose-type rubber couplings from a sprocket incorporated in the timing chain drive.

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.

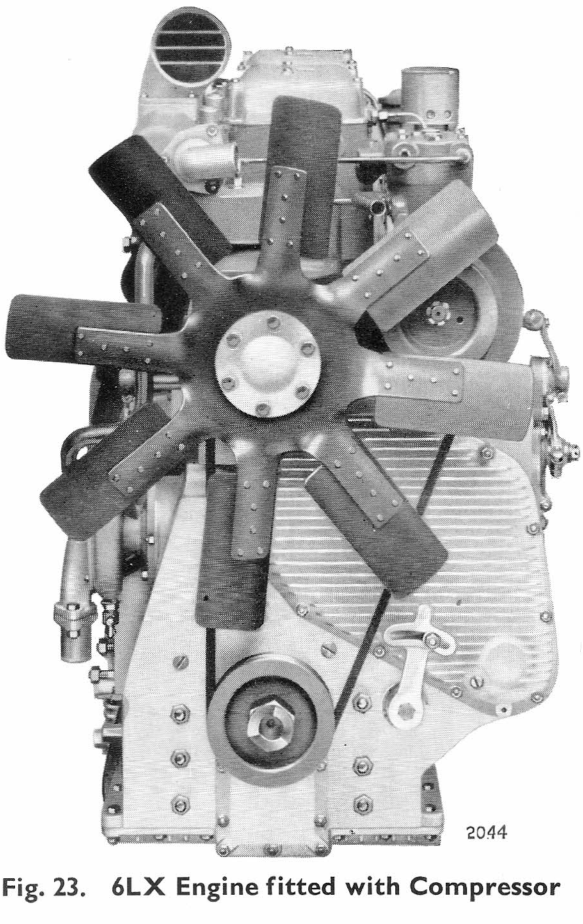


Fig. 23. 6LX Engine fitted with Compressor

68. **EXHAUSTERS.** These are only fitted to the 6LX engine when specified, for the operation of a vacuum servo brake system. The exhausters are of the simple reciprocating type, the two pistons being driven by connecting rods from a single crank fitted to the forward end of the valve camshaft. The suction valve is of the "flat" type and is fitted over the port in each cylinder cover plate.

The delivery valve is formed by the piston ring which has approximately ·013 in. (·330 mm.) vertical slack in its groove. On the upward stroke of the piston, air in the cylinder is forced past the top face of the ring and through small holes in the piston behind the ring into the exhauster crankcase. From there it passes to atmosphere through the combined oil separator and breather. On the downward stroke the piston ring makes contact with the top face of the groove and automatically seals the discharge holes. Any air which is in the vacuum tank and pipes is therefore drawn into the exhauster cylinder through the suction valve. Clean periodically the filter located inside the suction union on the cylinder head and if in so doing, a quantity

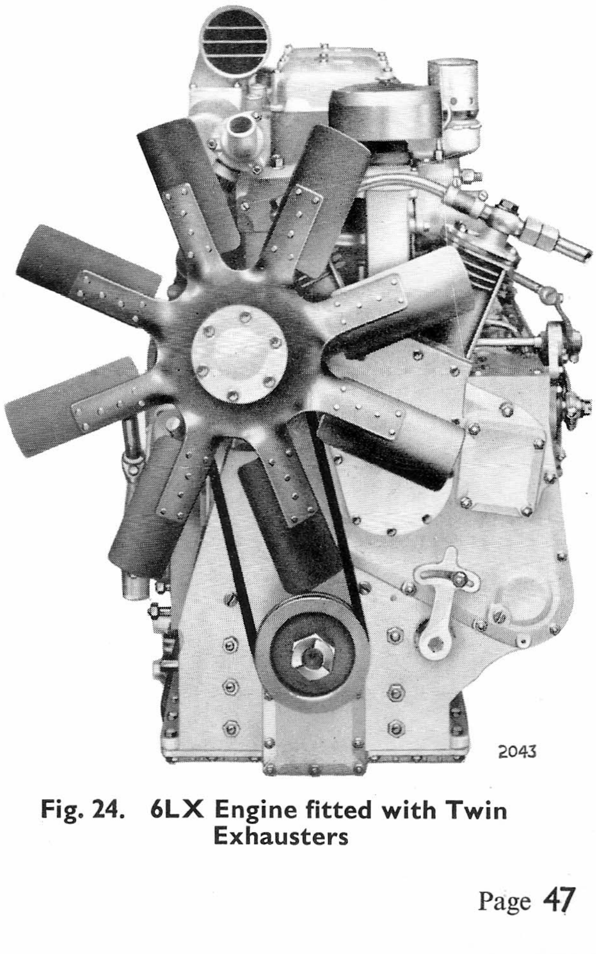


Fig. 24. 6LX Engine fitted with Twin Exhausters

AUXILIARY UNITS—*continued*

of matter is disturbed, remove the cylinder head and clean thoroughly to avoid fouling the piston. Refer to paragraph 75, page 85.

69. **EXHAUSTER BREATHER FILTERS.** These contain inexpensive replaceable paper elements which can be washed as indicated in para. 4, page 22, but should be renewed after 24,000 miles (2,400 hours) use. They are readily obtainable, as also indicated in paragraph 4, page 22, from our Works, Service Depots and Stockists.

70. **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.

71. **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.

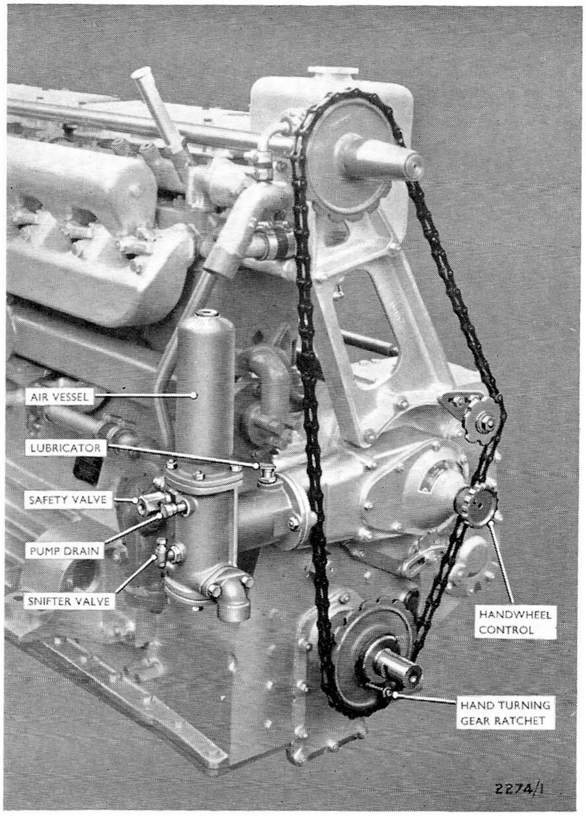
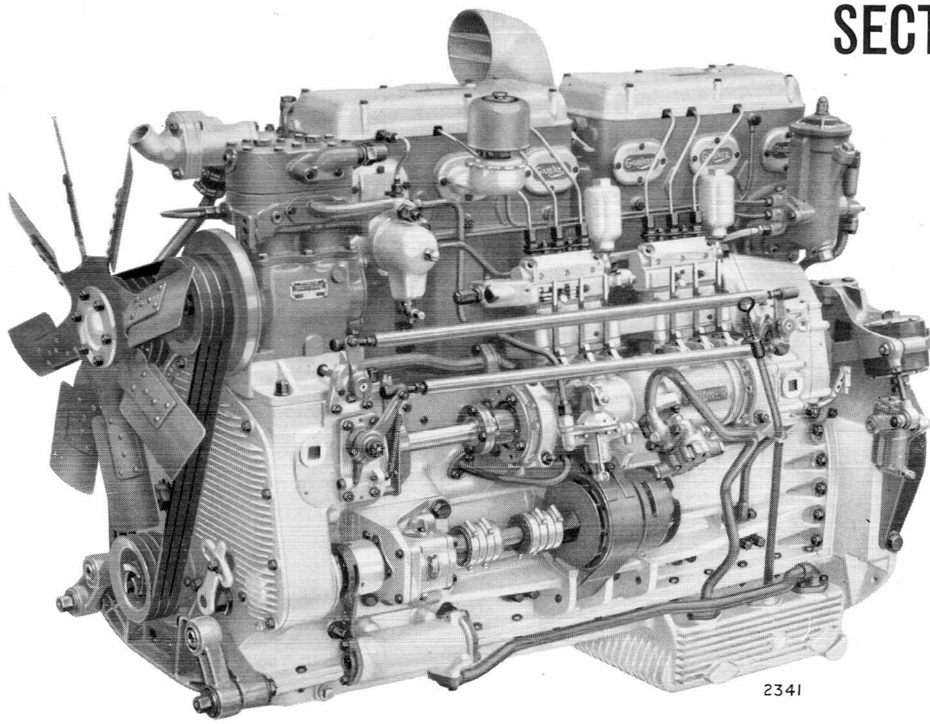


Fig. 25. Bilge Pump and Handwheel Control

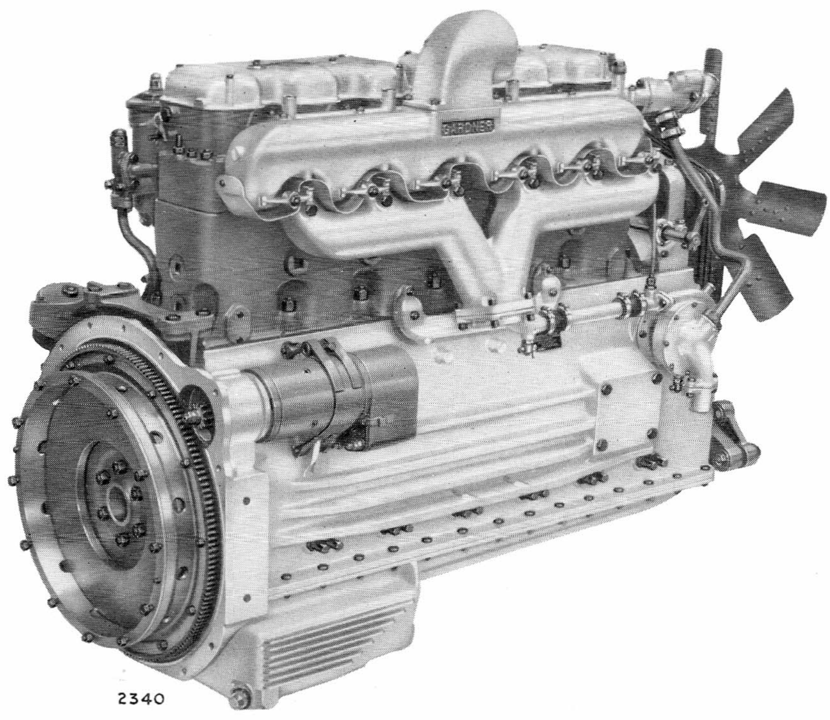
If, after long use, it becomes necessary to restore the designed spring loading of the clutch, this can be effected by fitting thin shims between the brass thrust pad in the hand-wheel and the outer end of the screwed sleeve thus permitting additional inward movement of the sleeve by the hand-wheel to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



2341

6LXB Automotive Engine showing Westinghouse TU-FLO-500 Air Compressor, C.A.V. 6¼ in. dia. 24 volt. Alternator Type AC.524-74, Plessey Hydraulic Pump Type 24 for power-assisted steering, Amal Fuel Lift Pump, Oil Cooler Pump and Filter Unit.



2340

6LXB Automotive Engine showing Dual Wax Type Thermostat and Centrifugal Water Circulating Pump, Accelerator Control Cross-shaft, C.A.V. 5 in. dia. 24 volt. Electric Starter and Flywheel for Borg & Beck 17 in. dia. Clutch.

SECTION 3

OVERHAUL AND ASSEMBLY

GARDNER

OVERHAUL AND ASSEMBLY

INDEX

OVERHAUL AND ASSEMBLY

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.

It will be appreciated that many parts in the 6LXB engine differ, or are additional to, those employed in the 6LX engine. When ordering Spare Parts for the 6LXB engine, reference must be made to the 6LXB/6LX Spare Parts Catalogue.

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 exchange unit is not worn or damaged beyond satisfactory repair limits.

- Crankshafts
- Cylinder Blocks
- Cylinder Heads (Bare)
- Cylinder Head Assemblies
- Exhauster Connecting Rods
- Fuel Injection Pumps
- Fuel Lift Pumps
- Fuel Pump Cams
- Fuel Sprayer Assemblies
- Governor Unit Assemblies
- Lubricating Oil Relief Valve Assemblies
- Lubricating Oil Pumps
- Valve Cams and Tappets
- Water Pumps (Centrifugal type only)

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. **TORQUE LOADINGS.** 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 described in Para. 37, Page 70, in order to maintain a uniform pressure across the joint faces.

Recommended Tightening Torques for the various component assemblies are given in the following assembly instructions and are also listed in Workshop Tools Book No. 63.

OVERHAUL AND ASSEMBLY

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 $\frac{1}{16}$ 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 is composed of two friction surfaces of hard red fibre bearing on the flange faces of a hub plate which is interposed between two cast iron rings loaded by 12 bolts and springs.

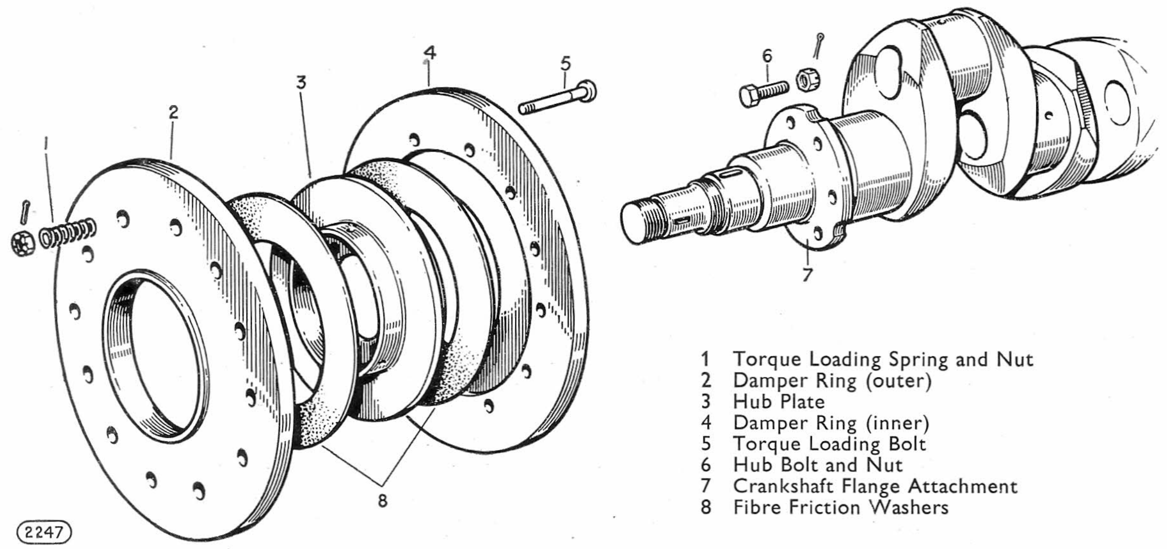
The damper should be inspected at major overhaul period for any sign of excessive wear or possible spring failure.

If the damper is dismantled, it is recommended that new friction fibres be fitted on reassembly since, after long periods of service, the old fibres will age-harden and become brittle and when disturbed may be liable to cracking. **Use only genuine "Gardner" replacements.** Do not use any other friction medium since the coefficient of friction may differ, upsetting the designed loading and pre-determined "slip" torque.

The Type 1 damper fitted to earlier engines is now superseded by the Type 2 which is identified by the peripheral grooves machined on the outer flange of the hub plate and on the inner and outer damper rings.

The component parts of the two 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, make sure that each of the 12 bolts is a driving fit in the steel ring and that the hub rotates



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*

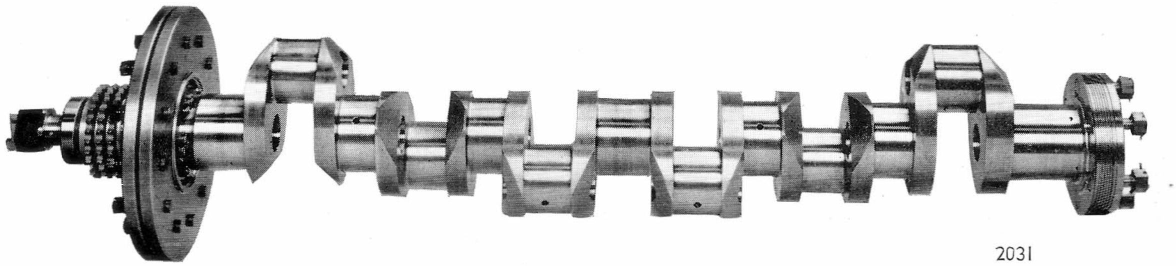


Fig. 27. 6LX Crankshaft Assembly

freely in the ring bores, removing any burrs which may be present. There is a design clearance of ·002 in. (·051 mm.) between the hub boss and the steel rings. Check also that the fibre rings have adequate clearance at their inner and outer circumferences on the hub and steel ring respectively. Lightly lubricate all friction surfaces during assembly.

Assemble the hub plate so that the bevel edge on its inner flange will lie against the crankshaft flange when bolted in position and the springs face towards the timing case cover.

When assembled, each spring should exert a load of 88 lb. at 1·07 in. (39·9 kg. at 27·2 mm.). Since the springs are recessed in the steel ring, the loading can more readily be determined by measuring the distance from the back of the nut to the face of the steel ring. If the nut is tightened until a distance of ·664 in. (16·866 mm.) plus or minus ·003 in. (·076 mm.) is obtained, the correct spring load will be achieved.

The "slip" torque of the damper at first "break" from rest when newly assembled should be approximately 127 lb.ft. (17·5 kg.m.).

When initially assembled at the Works the hub flange is lapped to the crankshaft flange, ensure therefore on reassembly that the mating faces are perfectly clean and free from abrasions or burrs which might impair a perfect seating of the two faces.

The correct tightening torque for nuts securing the damper hub to the crankshaft is 650 lb.in. (7·5 kg.m.).

12. **CRANKSHAFT MAIN BEARINGS (ALL ENGINES UP TO No. 135274).** These engines were fitted with white metal lined bronze shell main bearings, the crankshaft being located by the centre bearing only. End clearances 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 ·035 in. (·889 mm.) rearward from its located position, with the locating bearing removed.

This can be checked by setting a dial indicator on one 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 of ·070 in. or 1·778 mm.).

When checking the end float of ·0045 in. (·114 mm.) make sure that the centre main bearing and cap are in alignment by first tapping the crankshaft endwise at both front and rear with the centre bearing cap nipped down but not tightened to full torque.

12.1. **FITTING NEW BRONZE SHELL BEARINGS.** Whenever new bearing shells have to be fitted to any of these bearings the following points should be observed:—

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

(*b*) The main bearings are so designed that when bolted up, the face of the bearing shells butt against each other metal to metal, as also does the cap of the bearing and its housing and when finally bolted up the bearing must be perfectly free on the journal.

(*c*) To ensure that the main bearing shells are securely held in their housings proceed as follows:—

With the main bearing shells in place in the crankcase the main bearing cap nuts should be evenly tightened to a torque of 2,100 lb./in. (24 kg.m.). These nuts should then be

OVERHAUL AND ASSEMBLY

CRANKSHAFT AND MAIN BEARINGS—*continued*

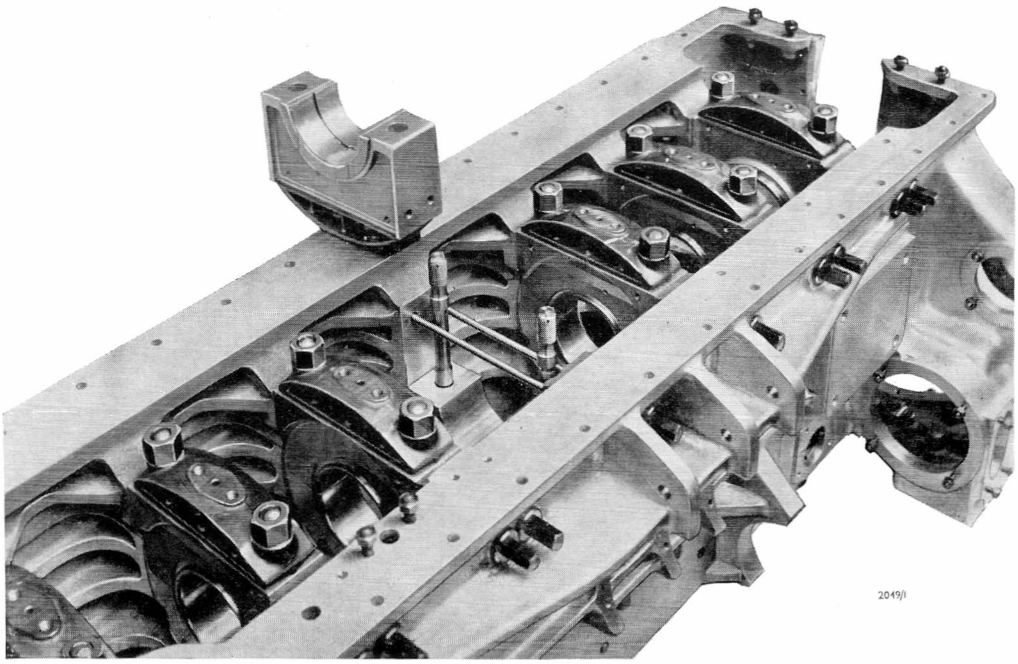


Fig. 28. Crankcase fitted with Bronze Shell Main Bearings

released until they are no more than finger tight. Under this condition the cap should have sprung away from the bearing shell revealing a gap of ·0055 in. to ·0075 in. (·139 mm. to ·190 mm.) adjacent to each stud, i.e. at both sides between the aluminium bearing cap and crankcase.

If, when reconditioning an engine with new bearing shells, these gaps are not present, the metal should be removed by careful filing or other method from the butt faces of the cap, until these correct gaps are obtained following the above procedure.

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 radii. 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.).

OVERHAUL AND ASSEMBLY

CRANKSHAFT AND MAIN BEARINGS—*continued*

The order and manner of tightening the main bearing cap nuts and cross bolts is shown on page 60a.

NOTE: The use of split pins for locking main bearing cap nuts is now discontinued and providing the nuts, whether plain or castellated, are fully tightened to correct torque, no additional locking device is required.

13. **CRANKSHAFT MAIN BEARINGS (FROM ENGINE No. 135275 ONWARDS).** These engines are equipped with pre-finished steel shell main bearings, lined with a lead overlay on copper lead and 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.

Replacement bearings are available up to ·060 in. (1·524 mm.) undersize and are supplied in steps of ·005 in. (·127 mm.) undersize up to ·020 in. (·508 mm.) and thereafter in steps of ·010 in. (·254 mm.) undersize up to ·060 in. (1·524 mm.).

13.1. **CRANKSHAFT ENDWISE LOCATION.** Crankshaft endwise location 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.** In the event of replacements being required, they **must** be obtained from the Works. The exact thickness of all thrust washers is recorded during initial assembly and correct thickness washers can be supplied from stock to suit the original crankshaft/crankcase assembly, providing the crankshaft thrust faces are not worn beyond permissible limits. Any alteration to the original assembly may necessitate the fitting of non-standard washers to obtain correct endwise clearance.

Each pair is stamped with 1 and 2 lines on the periphery near the abutment faces and these identification marks must be towards the manifold side of the engine when assembled; No. 1 pair positioned at the chain case end and No. 2 pair at the flywheel end of the centre main bearing.

The lower half thrust washers carry locating tongues which locate in recesses in the bearing cap. This firmly locks the upper and lower halves and prevents rotation when the bearing cap nuts are tightened down.

Crankshaft endwise clearance should be ·004 in. (·102 mm.) to ·007 in. (·178 mm.) and this is checked by setting a dial indicator on the end of the crankshaft.

Before fitting the thrust washers examine carefully their thrust surfaces and edges for any burrs which might affect the true end-float reading.

With the thrust washers in position and the bearing cap nuts just nipped down, set the crankshaft so that the centre line of Nos. 3 and 4 crankpins is in line with the split between crankcase and cap. Tap the crankshaft endwise—first from the flanged end and then from the chain case end—to butt the crank web thrust faces against the washers. This will ensure that the bearing cap and the two half thrust washers are aligned with the crankcase bearing housing and the thrust faces of each washer are matching up properly. The true end-float reading can then be recorded.

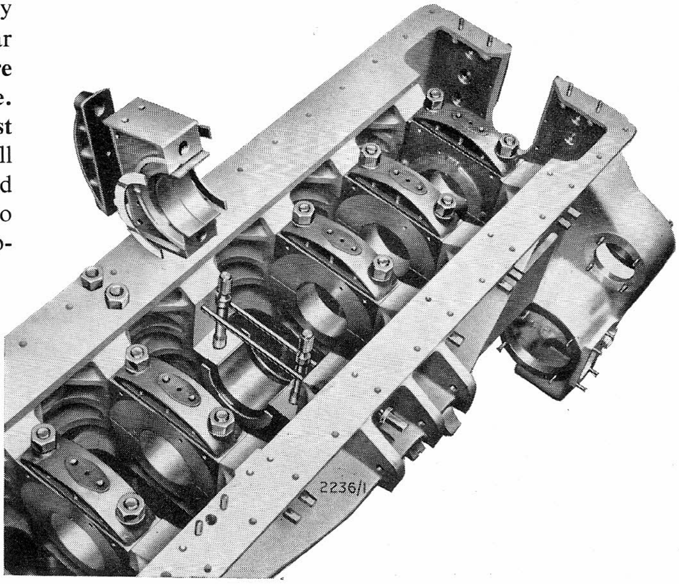


Fig. 29. Crankcase fitted with Pre-finished Steel Shell Bearings

CRANKSHAFT AND MAIN BEARINGS—*continued*

13.2. **FITTING PRE-FINISHED STEEL SHELL BEARINGS.** Before assembling a pair of main bearing shells, see that all parts are scrupulously clean and that the bearing surfaces are free from abrasions, scratches or indentations, etc. Any blemishes of this kind should be rolled-out, or "ironed" smooth, by means of a hardened steel burnishing bar. **DO NOT use a hand scraper to bed the bearings to the crankshaft journals.** This would cause irreparable damage and render the bearings unfit for use.

The two halves of the bearing cannot be interchanged as a locating tongue on each half-bearing ensures correct assembly in the housing and bearing cap. Each half-bearing is also marked by a number of lines scribed on the edge of the steel shell and these identification lines (from 1 to 7) must correspond with the number stamped on the bearing housing and cap and must face towards the chain case end of the crankcase.

Having thoroughly cleaned both the bearing shells and housing bore, apply a film of engine oil to housing and cap. Assemble the shells in their housings with their butt faces aligned with the cap joint face at both sides, and check coincidence of the oil holes in bearing shell and cap.

The two halves of the bearing should be firmly "gripped" in their housing when finally assembled. To ascertain this, 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 kg.m.).

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

(3) Run down the nuts with fingers until they contact the bridge piece, 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 with feeler gauges the clearance between the abutment faces of cap and housing; this check should be made at the four corners adjacent to the bearing shell. The average of these four dimensions should be ·007 in. (·178 mm.) min., ·00875 in. (·222 mm.) max.

This means that, when the bearing cap nuts are tightened to full torque, the shells have a circumferential nip of ·014 in. (·356 mm.) min., ·0175 in. (·445 mm.) max.

13.3. **TIGHTENING SEQUENCE FOR MAIN BEARING CAP NUTS.** Since the tightening of the main bearing cap nuts has a slight but highly important effect on the bearing bore size and shape it is desirable that these nuts be re-tightened in exactly the same order and to the same degree of tightness every time the bearing caps are assembled. For this purpose it is necessary to establish a standard procedure which must be observed at each stage of the job.

The standard Works procedure for tightening the main bearing cap nuts and cross bolt nuts is detailed in the outline sketch and table on the facing page.

The correct tightening torque for the main bearing cap nuts (whether castellated or current plain type nut) 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 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 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.). Ensure that the nuts are engaged by an equal amount of thread at each end of the bolt.

There is a lubricating oil return scroll at the flywheel end of the crankshafts. When fitting the end plate, check the clearance between this scroll and the bore in the end plate with suitable feeler gauges, to ensure that there is an overall diametral clearance of .014 in. (.356 mm.) that is to say .007 in. (.178 mm.) all round.

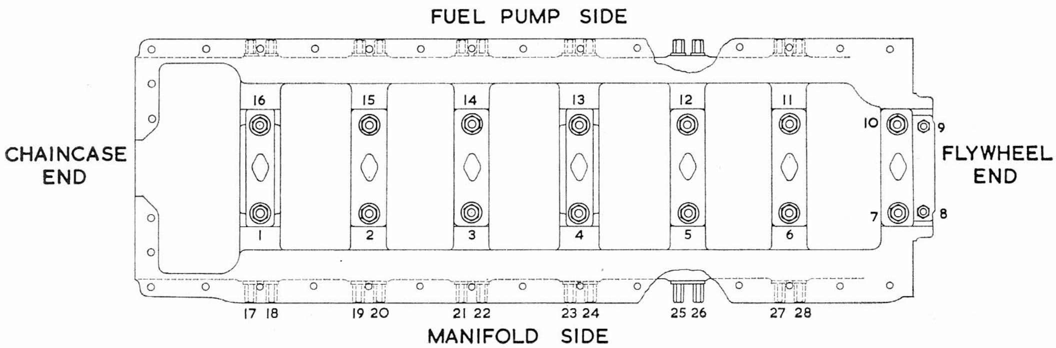
Fitment of Main Bearing Oil Pipe (Brazed copper pipe assemblies only). When fitting the main oil distribution copper pipe to the main bearing cap bridges the securing nuts and/or setscrews are to be fully and evenly tightened on to the locking plates (Part No. 126 LP) at each connection and afterwards eased off in pairs by one half hexagon flat before being locked by the locking plate. Note when locking that the tab is to be bent over the correct side at each end of the flange so that it locks against the projecting pipe union or 'T' connection.

OVERHAUL AND ASSEMBLY

CRANKSHAFT AND MAIN BEARINGS—*continued*

TIGHTENING SEQUENCE OF MAIN BEARING CAP NUTS

The outline sketch and table below show the order and manner of tightening respectively:—



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)	

NOTE.—Bearing caps must not be interchanged and must be kept with the crankcase to which they were originally fitted.

Crankshaft assembly

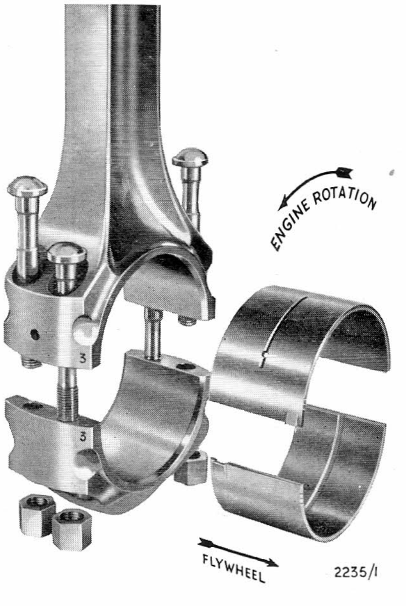


Fig. 30. Big End Bearing Assembly

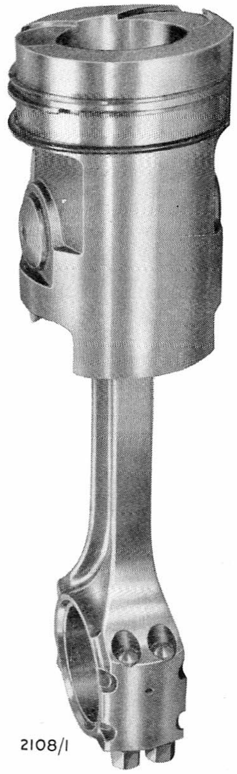


Fig. 31. Piston and Connecting Rod Assembly

OVERHAUL AND ASSEMBLY

CONNECTING RODS

14. **NON-INTERCHANGEABILITY OF CONNECTING RODS.** Engines up to No. 119482 were equipped with Type 1 connecting rods having 2 bolts per rod. The Type 1 rods were later superseded by Type 2 connecting rods having 4 bolts per rod and these were fitted to engines from Serial No. 119484 to 140066. Subsequently a new and lighter 4 bolt connecting rod was introduced, designated Type 3, and these were first used in engine Serial No. 140067 and have been fitted to all subsequent engines except Nos. 140104/5, 140414/5, 6, 7, 8 and 140672/3, 4, 5, 6.

Similar in appearance to the Type 2, the Type 3 rods can be identified by the outside diameter of the big end side facings which measure $3\frac{3}{4}$ in. (95·25 mm.) compared with $3\frac{7}{8}$ in. (98·43 mm.) on the Type 2 rod.

The big end bearing shells, small end bush, bolts and nuts are interchangeable between the Type 2 and Type 3 rods, but due to the weight factor, it is **not** permissible to mix the Type 2 and Type 3 connecting rod **assemblies** in any one engine. Engine sets of rods must consist of either all Type 2 or all Type 3. It is permissible, however, to use the original two-bolt rod (Type 1) with the new Type 3 rod in any one engine, but **not** with the Type 2 rod.

14.1. **INSPECTION AND OVERHAUL.** The rods should be thoroughly cleaned and tested for cracks by any of the well-known methods during major overhaul. Big end bolts must be examined for stretch and renewed if necessary. Small end bushes which have ·003 in. (·076 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 ·0025 in. (·0635 mm.) to ·00175 in. (·045 mm.). Should scraping be necessary this should be confined to the upper half of the bore so that the more accurate machined surface remains untouched on the heavily loaded bottom portion. Before finally assembling the rod, the oil duct through the centre should be thoroughly flushed out with paraffin or fuel oil.

When the rod is assembled on its crankpin, the piston pin in the small end bush should be parallel to the crankcase top surface to within ·001 in. (·025 mm.) in the length of the pin.

Connecting rods and caps are stamped with a number to accord with the number on the respective cylinders. When assembling, it is important that these numbers lie to the flywheel end of the engine (see Fig. 30). Rods and caps should **not** be interchanged; keep each cap to its respective rod.

NOTE: When ordering a replacement rod it is important to specify the direction of rotation of the engine. This will ensure that the rod and bearings will be assembled correctly when fitted in accordance with the above instructions. Rods for opposite rotation engines are stamped with a letter "C" after the cylinder number.

15. **BIG END BEARINGS.** The connecting rods are fitted with pre-finished big end bearing shells lined with a lead overlay on copper lead and are not, therefore, to be bored or hand scraped when fitted to the rods. These bearings are available in various undersizes to suit reconditioned crank pins as follows:—
From ·005 in. (127 mm.) to ·020 in. (·508 mm.) undersize in steps of ·005 in. (·127 mm.) and thereafter in steps of ·010 in. (·254 mm.) up to ·090 in. (2·286 mm.) undersize.

These bearing shells will give the correct clearance when fitted to crank pins which have been reduced by precisely this amount from the original nominal size of 3·1875 in. (80·963 mm.) + ·000 in. (0·0 mm. — ·0005 in. (0·0127 mm.).

15.1. **ASSEMBLING THE BIG END.** When assembling, the following instructions must be carefully observed:—

(*a*) At the Works a number of lines are scribed on the edge of the steel shells and these correspond with the cylinder number and rod number to which they are fitted, i.e. 1 to 6. As with the rod and cap these numbers also lie to the flywheel end of the engine.

(*b*) Before assembling a pair of big end bearings in the connecting rod see that all parts are thoroughly cleaned and that the surfaces are free from abrasions, scratches or indentations, etc. As mentioned previously, it is quite unnecessary to use a hand scraper to bed the bearings to the crank pins. The two halves cannot be interchanged as a locating tongue on each half bearing ensures correct assembly.

(*c*) The correct tightening torque for each of the two nuts on a Type 1 connecting rod is 1,250 lb.in.

OVERHAUL AND ASSEMBLY

CONNECTING RODS—*continued*

(14·4 kg.m.). On the Type 2 and Type 3 rods the correct tightening torque for each of the four nuts (whether castellated or plain type nuts) is 600 lb.in. (6·9 kg.m.).

(*d*) The bearing shells should be firmly "gripped" in the assembled rod; this can be ascertained by tightening each big end nut to the correct torque, afterwards releasing the nut or nuts on one side only when there should be ·006 in. to ·007 in. (·152 mm. to ·178 mm.) gap clearance between the abutment of the connecting rod and cap.

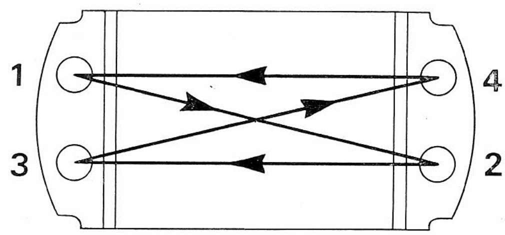
(*e*) The nominal clearance in a correctly assembled big end bearing is approximately ·0028 in. (·071 mm.) and the side location of the big end of the rod is obtained directly by the side facings of the rod itself. When assembled on the crank pin, the rod should have an endwise clearance of ·005 in. to ·012 in. (·127 mm. to ·305 mm.): this clearance to be checked around the full extent of the side facings of rod *and* cap and measured against the crank-web face, rotating the crankshaft to two positions, (1) at top dead centre and (2) at bottom dead centre.

(*f*) A standard procedure for tightening the 4 bolt rods is essential to ensure that the size and roundness of the bearing shell bore is maintained during tightening operations. The nuts should be tightened in exactly the same order and to the same degree of tightness at each stage, as described and illustrated below.

1st Stage Run each nut down until it just slightly nips the bearing cap.

2nd Stage Tighten each nut consecutively to half final tightness working diagonally across the abutment face, corner to corner.

3rd Stage Commencing with the same nut as in Stage 2 and following exactly the same sequence, tighten each nut to full torque.



Tightening sequence for Big End Assembly

(*g*) When completing the big end assembly, it is essential that the eccentric heads of the bolts are correctly located in the eccentric recesses of the rod, in order to ensure that the face of the bolt-head mates with its seating at the base of the recess when tightened to full torque.

(*h*) It should be noted that the use of split pins for castellated nuts is now discontinued, consequently the established practice of assembling the bolts and nuts number to number is no longer necessary.

15.2. **FITTING A REPLACEMENT CONNECTING ROD AND PISTON ASSEMBLY.** When the connecting rod and piston assembly is being lowered through the cylinder bore, the greatest care must be taken to ensure that the projecting ends of the big end bolts do not come into contact with, or in any way damage, the polished surface of the crank pin. Any bruises or indentations thus caused will in turn result in serious damage to the specially surfaced copper-lead lining of the bearing shells.

It is of utmost importance, therefore, to see that the rod half, as it emerges into the crankcase, is securely held and guided carefully into position over the crank-pin while the piston is lowered through the bore, or alternatively, while the crankshaft is rotated to engage the crankpin with the rod half of the big end.

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.

OVERHAUL AND ASSEMBLY

PISTONS—*continued*

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.

Non-interchangeability of Pistons and Piston Pins. LXB pistons are identified by a stamping on the top surface and are **not** interchangeable with LX pistons. The piston pins fitted to LXB engines have a bore of 1⅛ in. (25·58 mm.) and the piston pin end-pads have a ½ in. (12·7 mm.) diameter hole, whereas LX piston pins fitted to LX engines up to serial No. 155257 had a bore of 1¼ in. (31·75 mm.) and the piston pin pads had a hole diameter of ⅜ in. (9·53 mm.). These pads are **not** interchangeable with the ½ in. (12·7 mm.) hole pads. All subsequent LX engines, except Nos. 155312 and 155313, have been fitted with the new and heavier (1⅛ in. bore) piston pin assemblies.

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 pins in any one engine must be of equal weight.

LXB and HLXB engines must not be fitted with the lighter 1¼ in. (31·75 mm.) bore pins.

It is worth noting that if the end pads are already assembled, pins of different weight can be readily identified by the size of hole in the end pad.

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 xiii.

19. **PISTON RING GROOVES.** The useful life of a piston is determined almost wholly by (*a*) wear of the upper two ring grooves, and (*b*) by diametral wear. 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 of course without the need to re-machine the upper two grooves to receive available standard oversize width rings. 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 essential that when new rings are to be fitted the grooves be re-sized.

Diametral wear mainly affects piston noise and pistons which have been re-grooved may be used for a total of 300,000 miles (480.000 km.) or more. 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.

20. **PISTON RINGS.** The pistons are equipped with two pressure rings and one oil control 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.

On LXB pistons both pressure rings are identical and are chromium plated on their peripheries and side faces.

Oversize width pressure rings are available in two sizes: ·109 in. (2·769 mm.) wide and ·125 in. (3·175 mm.) wide and are gapped to suit the standard cylinder bore. These are readily obtainable upon application to the Works.

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 AND TAPPETS

22. **VALVE TAPPETS AND 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 examine carefully the outside diameter and edges of the guide slots for any burrs or abrasions which might impair its free entry and seating in the crankcase.

When fitting the guide ensure that there is adequate clearance between its locating lug and the shank of the clamp stud; excessive tightness at this point may prevent the guide seating squarely on the face of the crankcase when clamped in position.

Do not use excessive pressure when tightening the tappet guide clamp nut. It is good practice to again check the freedom of each tappet in its guide **after** the clamp has been tightened down.

NOTE: 6LXB tappets are marked LXB and are not interchangeable with 6LX or 6HLX 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 may be 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 ·886 in. (22·504 mm.) thickness are readily obtainable from our Service Agents and Spares Stockists and 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 this clearance.

24. **CAMSHAFT ASSEMBLY.** When assembling these components ensure that the cams are assembled under the correct tappet, e.g., that the exhaust cam is under the exhaust tappet and not under the inlet tappet or vice versa. The exhaust cam has less rise than the inlet cam, but gives a longer opening period and is stamped with an "EX" on the side face. Assemble the cams with this side facing the chain case. Ensure that the locking screws engage in the countersink in the shaft and are thoroughly tightened home. A special square box key is supplied with the engine for this purpose. See relative pages in Workshop Tools Book No. 63.

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 and 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 ·001 in. (·025 mm.). Bushes are a light drive fit in the crankcase and are located by means of cheese-head screws inserted from the outside of the crankcase wall.

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).

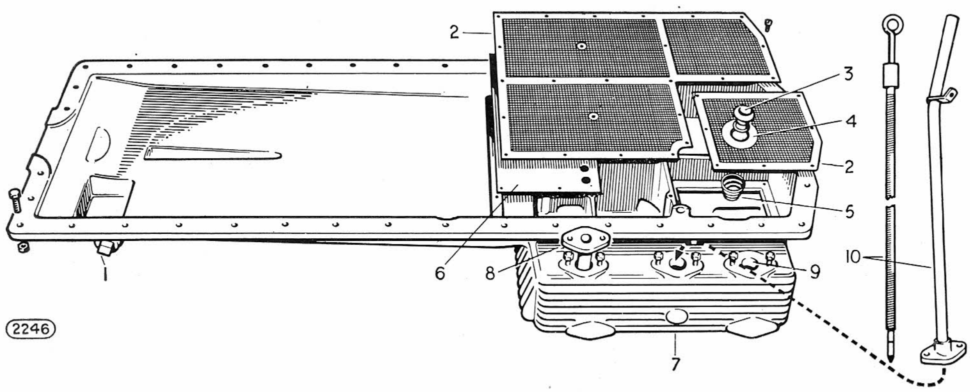
Remove the primary gauze filter which is secured by a number of cheese-headed screws. Wash the gauze and surfaces of the base-chamber with clean fuel oil or paraffin. Allow the washed parts to drain in preference to wiping with a cloth which is liable to leave behind swarf.

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.

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.

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. 32. 6LX Engine Lubricating Oil Sump: Type 28

26. **REMOVAL AND CLEANING OF SUMP FILTER (Horizontal Engines).** The gauze filter 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 64.

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 guided free from the remaining pistons and lessen the possibility of the pistons becoming wedged in the cylinder bores.

With the four bolt type connecting rods, it may be found more desirable to remove the block **after** dis-connecting the big ends and withdrawing the rods through the cylinder bores.

This, of course, will depend upon the circumstances and 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 ad-vantage, 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

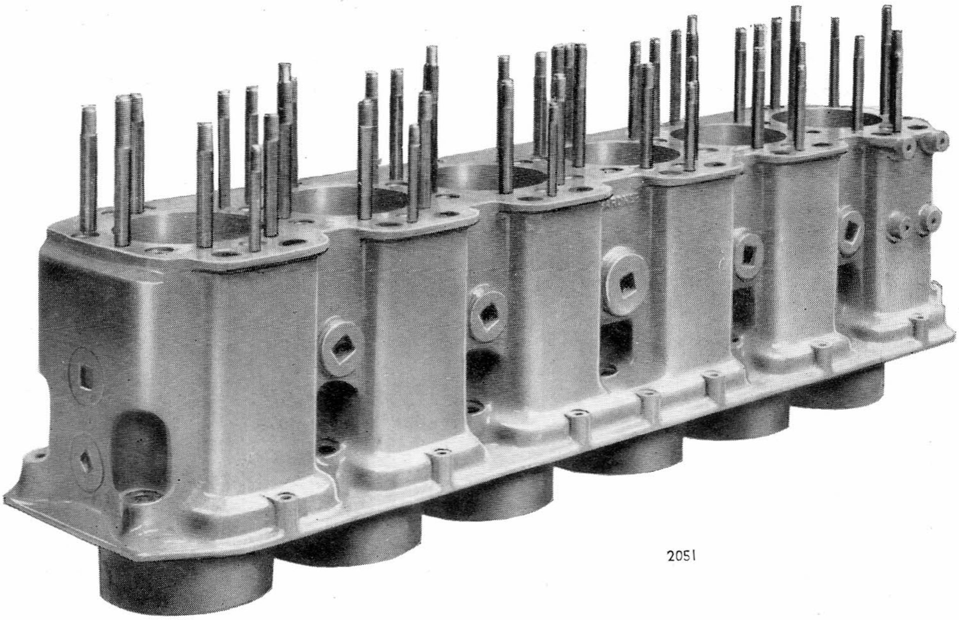


Fig. 33 Cylinder Block

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.

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 62.

When tightening the foot nuts, commence from the centre of the block and tighten each nut evenly and in sequence working towards the ends of the block, distributing the pressure uniformly across the joint face whilst doing so. 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. **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. On engine No. 122288 and subsequent engines the exhaust valves were "Stellite" faced and this further increased their resistance to wear and erosion.

The valves should be accurately ground in the usual special purpose machine to the required angle, i.e. 45° (6LX and 6HLX engines) and 30° (6LXB and 6HLXB engines) removing as little metal as possible.

The valve seats which are of hardened material should be ground to the above corresponding angles, according to engine type, 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 heads become thin and valve seats become enlarged, renew parts in order to maintain engine efficiency. Renew valves and guides when stem wear exceeds ·005 in. (·127 mm.).

It should be noted that the valves on the 6LXB engine are marked LXB. These are not interchangeable with 6LX valves.

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

31. **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.

32. **VALVE SEAT INSERTS.** 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.

33. **REPLACING THE INLET VALVES AND GUIDES.** These valves are formed with deflectors and are prevented from turning around by the specially shaped valve collars and locking pins. It is **essential** that these valves be replaced in the correct position, that is, with the deflectors towards the manifold side of the engine, the precise position being determined by the cotter pin in the valve collar.

To prevent incorrect assembly, the slot in the valve collar and the hole in the valve stem are offset from the centre line of the valve stem. With this design it is impossible to insert the cotter pin through the slot in the collar and the hole in the valve stem with the valve rotated half a turn out of its correct position.

When the inlet valves and guides are replaced care must be taken to ensure that there is a suitable clearance between the stem and guides. The correct clearance for a new assembly is 0·00125 in. (·0318 mm.) and should the valve stems be a closer fit than this the guides must be reamed out until the 0·00125 in. (·0318 mm.) clearance is obtained.

OVERHAUL AND ASSEMBLY

CYLINDER HEADS—*continued*

Inlet valve guides for the horizontal engine are provided with an oil drain groove and hole at their outer ends. These guides must be pressed into the heads so that when the heads are fitted to the engine the drain holes are **downwards,** i.e. towards manifold side of engine.

34. **REPLACING THE EXHAUST VALVES AND GUIDES.** When the exhaust valves are refitted care should be taken to see that the carbon is removed from the bore of the guides. When the exhaust valves and guides are replaced ensure that there is suitable clearance between the stems and guides. The correct clearance for a new assembly is 0·00275 in. (·070 mm.) and should the valve stems be a closer fit than this, the guides must be reamed out until the 0·00275 in. (·070 mm.) clearance is obtained. When replacing exhaust valve guides in the horizontal engine it should be noted that these guides are provided with an oil hole and groove at their outer end. The guides must be pressed in the head so that, when the heads are fitted to the engine, the hole and grooves in the guides are **upwards**, i.e. towards push rod side of the heads.

35. **REFITTING INLET AND EXHAUST VALVE SPRING COLLARS.** Particular care should be taken to ensure that the spring collar is not screwed farther down the valve stem than is necessary to thread in the cotter pin, otherwise the valve may not have sufficient lift and the operating mechanism may suffer damage.

The cotter pin is held in place by two spring clips, both located in a single groove, see Fig. 34. This groove is of sufficient width to accommodate circlips of varying thicknesses in the event of standard spring clips not being readily available. The spring clips should be fitted so that their gaps are diametrically opposite each other and at 90° to the axis of the cotter pin.

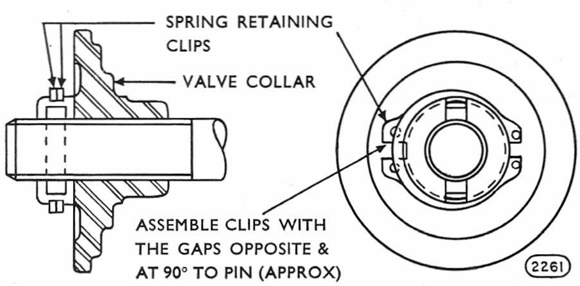


Fig. 34. Valve Collar and Spring Clip Assembly

On earlier engines prior to No. 134718 the valves were located in their collars by a special split pin of the "drive-open" type and 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 steel cotter pin is interchangeable with the earlier type collar and split pin.

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.

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.

OVERHAUL AND ASSEMBLY

CYLINDER HEADS—*continued*

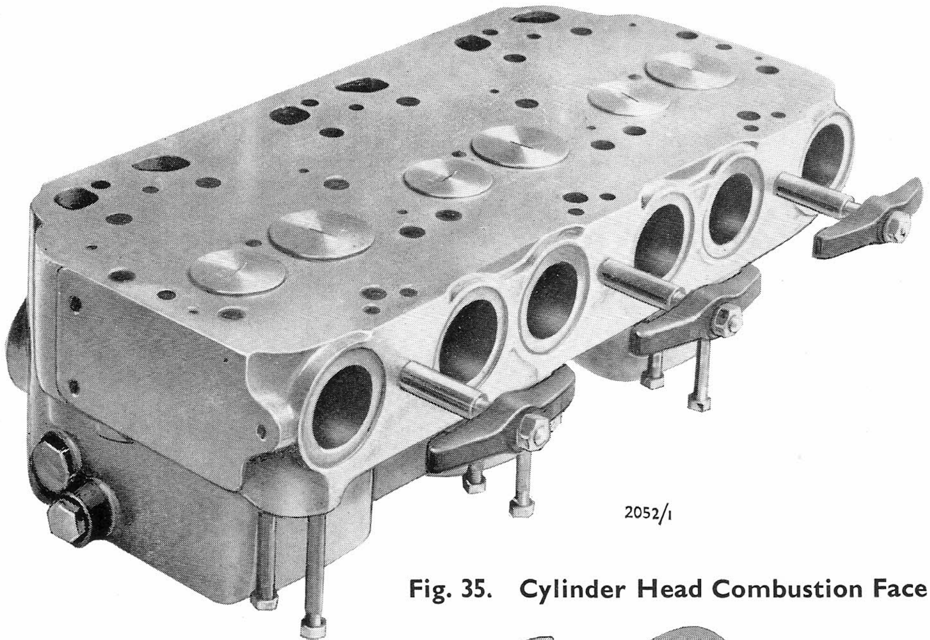


Fig. 35. Cylinder Head Combustion Face

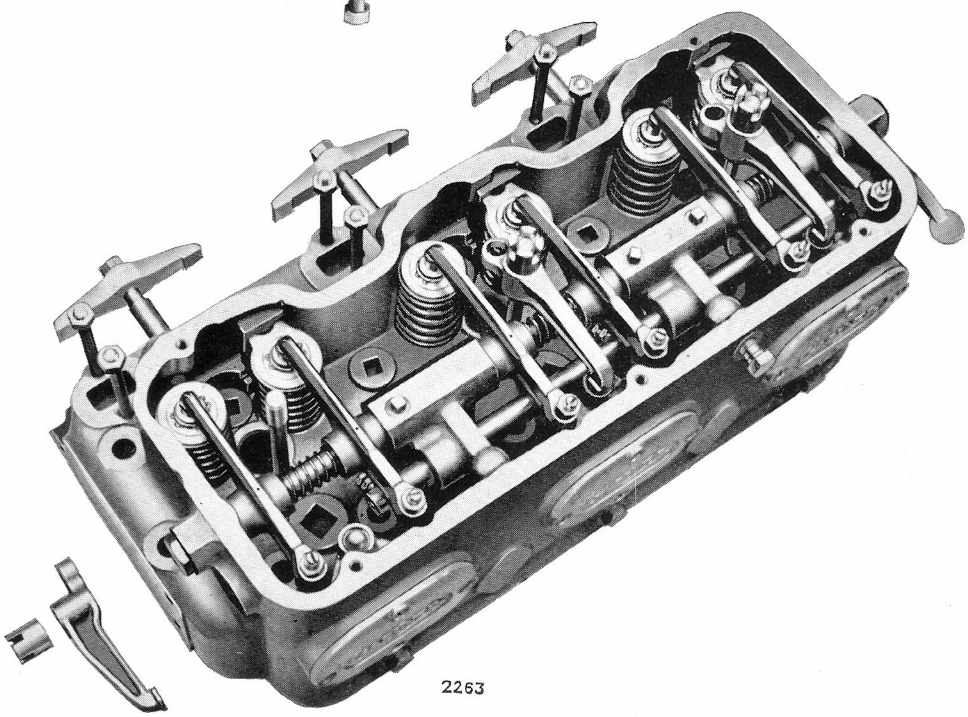
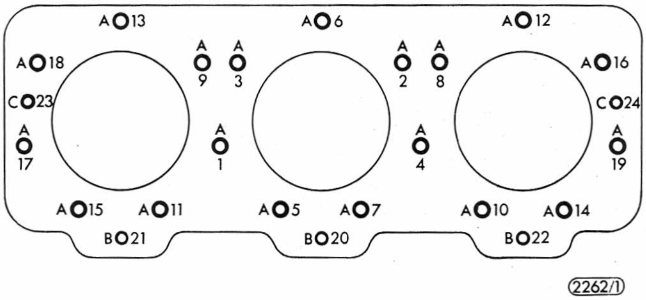


Fig. 36. Cylinder Head and Valve Assembly

CYLINDER HEADS—*continued*

Note: Studs 'C' are fitted to latest engines only



Cylinder head nuts; tightening torques.

'A'	½ 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

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 no loose particles have been disturbed by the studs when entering their holes, and subsequently fallen on to the surface of the packing.

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.

Tightening up of the nuts is to be carried out whilst the engine is **cold; No** tightening is to be done after warming up the engine.

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 designated Type 2 was fitted, with two corresponding additional holes.

The Type 1 and Type 2 cylinder heads 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 43.

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 is regulated to provide the desired flow to the valve ends.

FUEL INJECTION PUMPS AND GOVERNOR UNIT

40. **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.

41. **FUEL PUMP TAPPETS.** The adjustment of these 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.**

42. **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.

43. **FUEL INJECTION PUMP OUTPUT.** Every 48,000 miles (4,800 hours) remove pump or pair of pumps 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 balance 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 pump should be reset to the standard output, see table (page 72). Do not, for any purpose, increase the standard setting or operate the engine with excess fuel delivery from the injection pump. Wear of 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 PUMPS AND GOVERNOR UNIT—*continued*

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

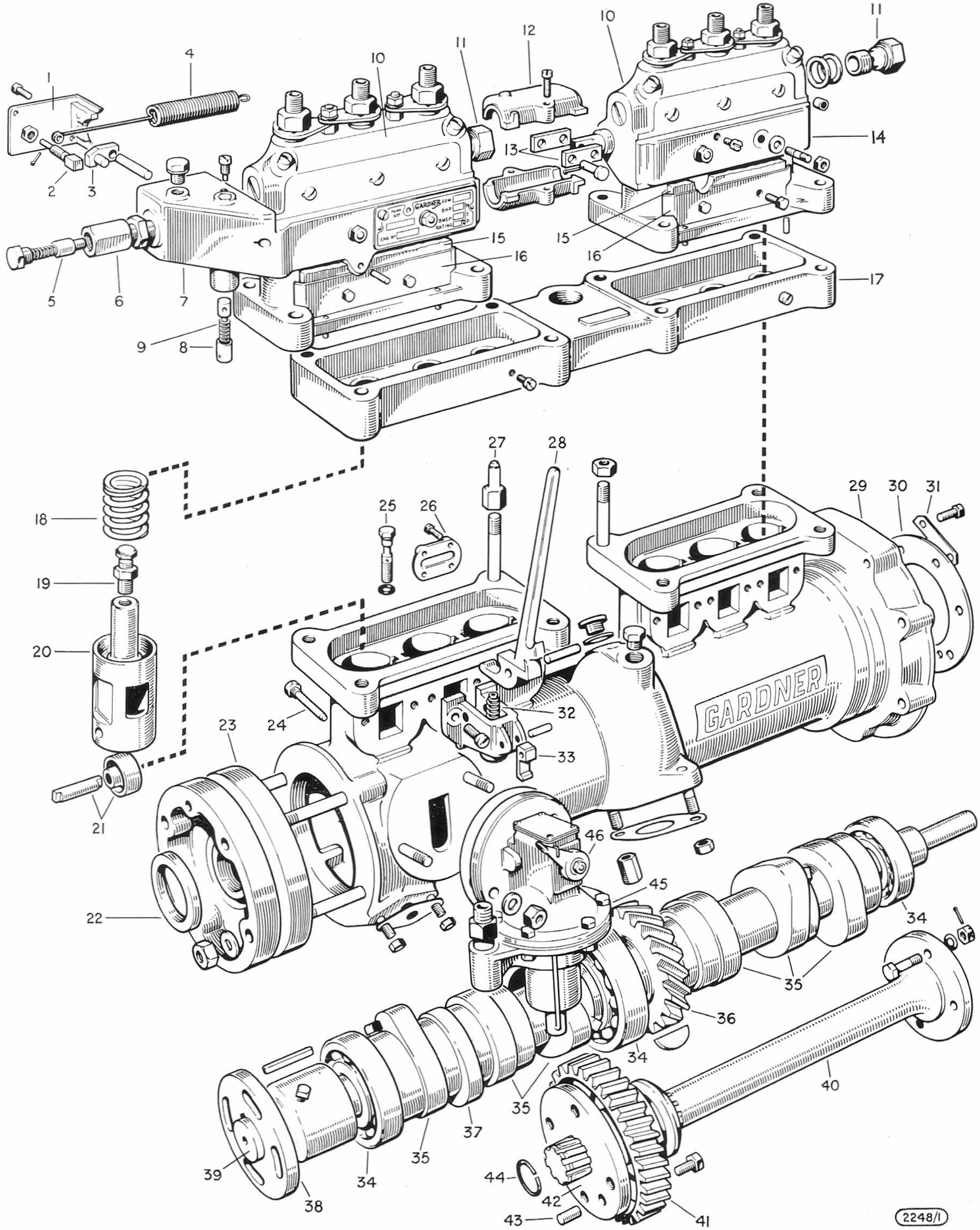


Fig. 38. Fuel Pump and Cam Box Assembly

FUEL INJECTION PUMPS AND GOVERNOR UNIT—*continued*

OVERHAUL AND ASSEMBLY

44. **FUEL INJECTION PUMP CALIBRATION.** The following tables refer to the maximum power setting under conditions of Normal Temperature and Pressure (N.T.P.).

Power Reduction by Lengthening of Fuel Limiting Trigger. Should it be desired to reduce the power output of the engine, reference to Workshop Tools Book No. 63 or to the table opposite will show the power reduction for increase in trigger length; the % column gives the percentage of full power available and approximate percentage of full power fuel supply when the trigger length is increased by the amount shown.

Trigger Length Increase		
in.	mm.	%
·010	·254	97·8
·020	·508	95·3
·030	·762	92·5
·040	1·016	89·9
·050	1·270	87·0
·060	1·524	84·2
·070	1·778	81·2
·080	2·032	78·3
·090	2·286	75·4
·100	2·540	72·5

6LX and 6HLX Engines	R.P.M.	B.M.E.P.		Camshaft R.P.M. during Calibration	Average Delivery from each Plunger cm.³/min.
		lb./in.²	kg./cm.²		
Road Vehicle and Rail Traction duty	1,700	109·5	7·699	850	81·0
High Speed Marine Duty ..	1,700	105·0	7·382	850	78·1
Yachts, Cruisers Marine Duty ..	1,500	105·0	7·382	750	66·6
Intermittent Duty, Air Compressors, Excavators, Saw Mills, etc.	1,400	105·5	7·417	700	62·4
Heavy Marine Duty	1,300	105·0	7·382	650	58·2
Industrial Duty, Generator Sets, Marine Auxiliary, etc.	1,200	100·3	7·052	600	51·3

6LXB and 6HLXB Engines	R.P.M.	B.M.E.P.		Camshaft R.P.M. during Calibration	Average Delivery from each Plunger in cm.³
		lb./in.²	kg./cm.²		
Road Vehicle and Rail Traction duty	1,850	121·0	8·507	925	81·0 in 50 secs.

See Fuel Pump Calibrating Machine Instruction Book No. 45.4 or later issue for detailed instructions on fuel pump calibration.

OVERHAUL AND ASSEMBLY

FUEL INJECTION PUMPS AND GOVERNOR UNIT—*continued*

45. **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 41, Page 70.

(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 in the governor case (item 23, Fig. 39), 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.

46. **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. Always use new split pins of the correct diameter and length and see that they are properly opened after assembly; this is described in para. 47.

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

Governor Body Withdrawal Tool. A special tool is available for removing the governor body from the fuel pump camshaft and details are given in Workshop Tools Book No. 63.

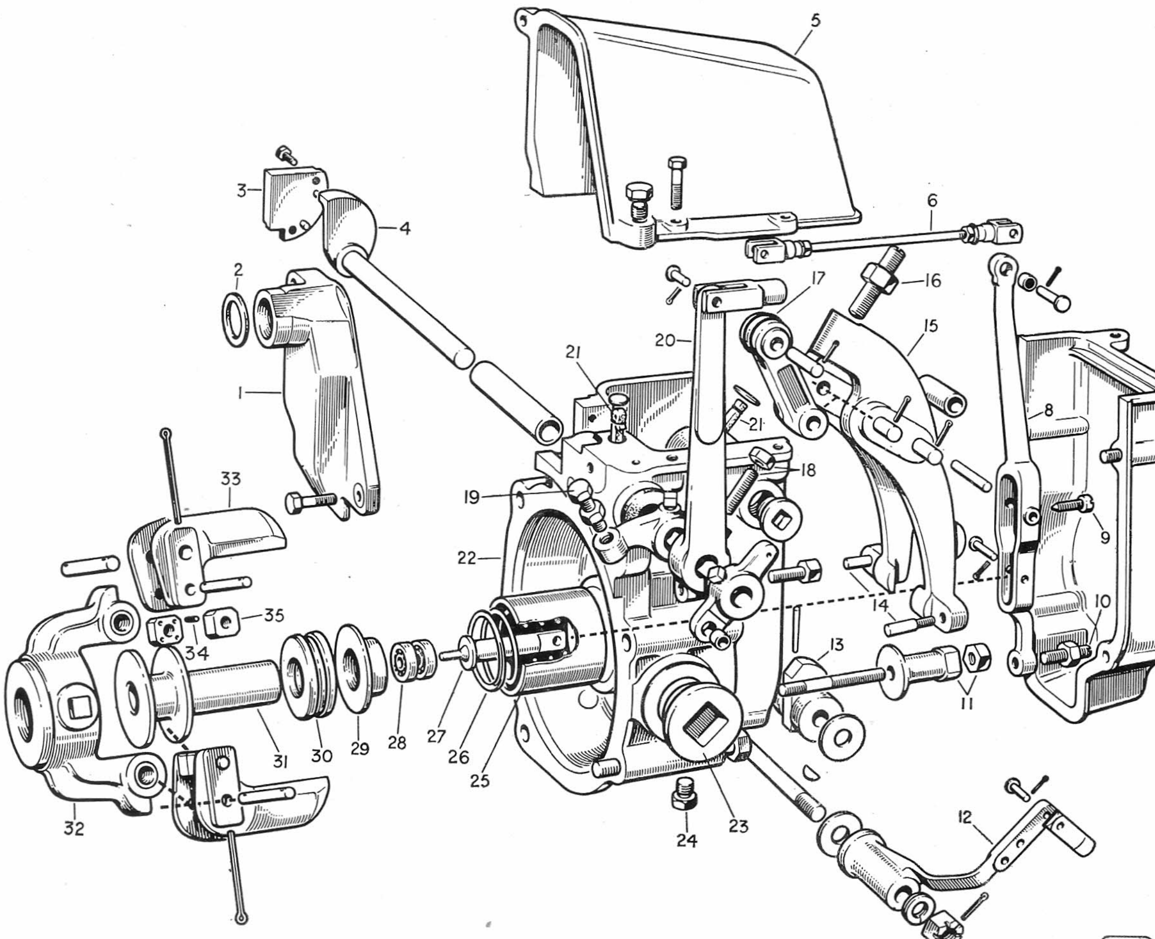
47. **GOVERNOR WEIGHT TOE BEARINGS.** The toes of the governor weights fitted to standard engines (anti-clockwise rotation) are equipped with rectangular spring-loaded bronze trunnion blocks having one spring per toe, i.e. two springs per engine, whilst on engines prior to No. 135275 arranged for clockwise rotation, the trunnion blocks were equipped with two springs, i.e. four per engine. All subsequent engines are now fitted with one spring per toe.

It is desirable that the two trunnion blocks be assembled in each governor weight with the zero marks coincident and pointing towards the governor spring, i.e., the zero marks are to be on the loaded flange of the governor sleeve. The single spring should be positioned in the hole nearest to the governor sleeve and adjacent to the zero face of the block. When two springs are fitted the second spring is positioned in the hole diagonally opposite the first spring.

If it is necessary to remove or fit springs in the trunnion blocks, use new split pins of correct size and length with equal legs when reassembling. Before fitting the split pin, bend it slightly about half way along its length to ensure a tight fit in the hole. After fitting, open the legs and bend them so that they are firmly bedded around the radius of the governor weight toe. This is illustrated in Workshop Tools Book No. 63.

48. **GOVERNOR READJUSTMENT.** After overhaul or when a new governor spring is fitted or the setting is otherwise disturbed, the governor and fuel

FUEL INJECTION PUMPS AND GOVERNOR UNIT—*continued*



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

Fig. 39. Governor Assembly

OVERHAUL AND ASSEMBLY

FUEL INJECTION PUMPS AND GOVERNOR UNIT—*continued*

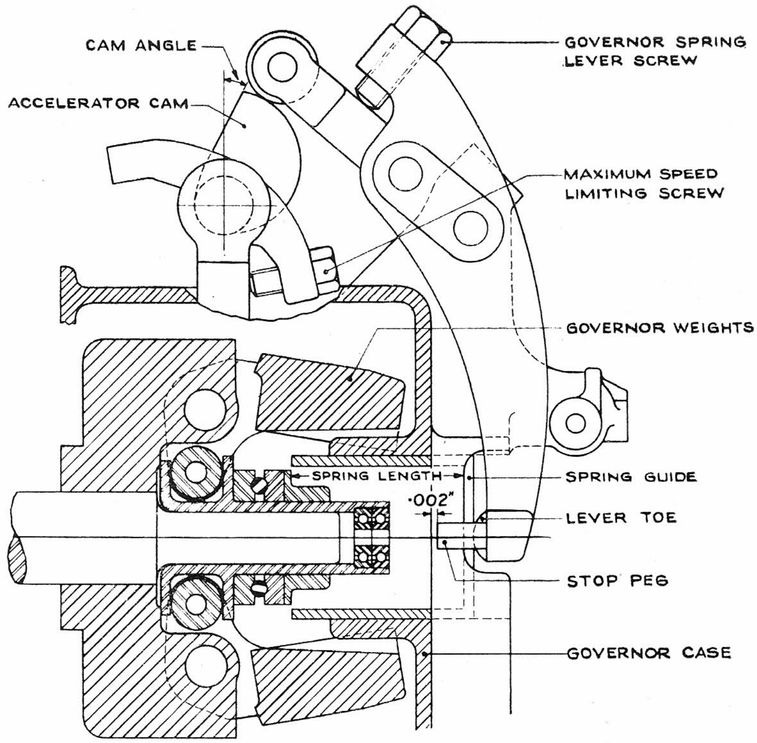


Fig. 40. Governor Re-adjustment

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 45, sub-paragraph 2, Page 73.

(2) By adjustment of the maximum speed limiting setscrew in the rocking lever on the accelerator cam spindle (See Fig. 40), 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.		Spring Load		Cam Angle
	Full Torque	No Load	lb.	kg.	
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°

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.

FUEL INJECTION PUMPS AND GOVERNOR UNIT—*continued*

(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 sub-paragraphs 1 and 2 above 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 on preceding page.

(*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.

49. **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.

Timing Marks on Fuel Pump Camshaft Flange Coupling. Timing marks will be found on the peripheries of the camshaft and drive shaft coupling flanges to facilitate re-timing of fuel injection during re-assembly.

When the two lines coincide, timing will automatically be restored when bolting the two half couplings together, providing the main timing drive has not been disturbed.

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 40, 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 the standard pricker supplied with the engine, 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.

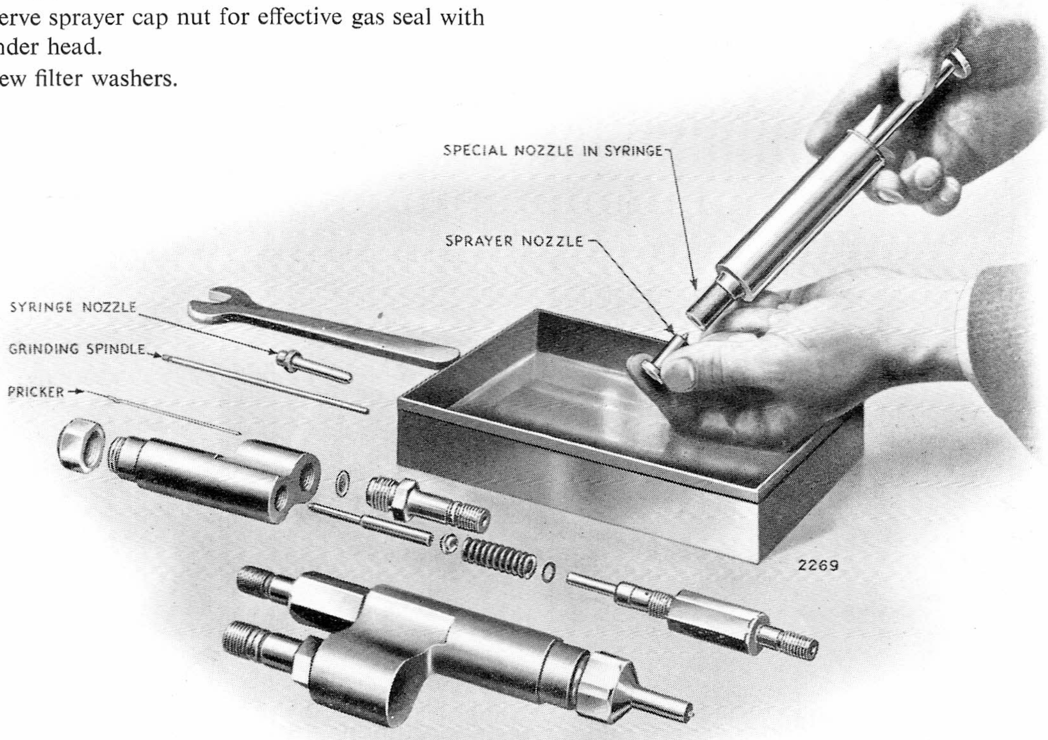


Fig. 41.
Cleaning the Sprayers

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. 41.

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 79. 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 reseating 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 79.

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.

FUEL SPRAYERS—*continued*

59. **SPRAYER DELIVERY STOCK AND FILTER WASHER.** The filter washer in the sprayer body is held in position by the delivery union stock (see Fig. 17, Page 39) and must be renewed during reconditioning of the sprayer at routine change every 48,000 miles (4,800 hours).

The latest sprayers and all Gardner serviced sprayer assemblies are now modified and incorporate a plain steel washer in place of the copper filter washer. This modification is identified by a groove machined on the hexagon of the delivery union stock. Assemblies **not** so identified must continue to be fitted with the copper filter washer; conversely the copper filter washer must not be fitted in conjunction with a grooved delivery stock.

The tightening torque for the delivery stock 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 $1\frac{1}{2}\%$ 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 instruction 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.

CHAIN CASE AND CHAIN DRIVE

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

For this reason also, chain adjustment must only be carried out *when the chain case cover is bolted in position.*

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. To remedy this, the stud holes which are binding must be eased 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. 42. Engines up to No. 135274 were fitted with an adjusting idler having a $\frac{1}{2}$ 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 engine No. 135275 and later engines the adjusting idler has a $\frac{7}{8}$ in. (22·225 mm.) throw and with these engines the timing chain is arranged to run round the outside 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

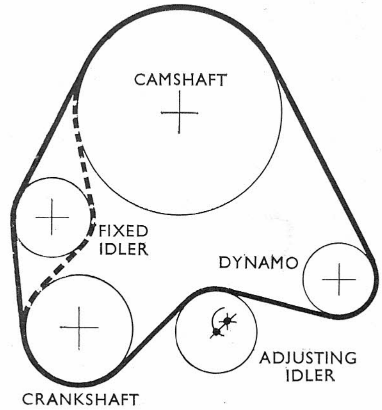


Fig. 42. Chain Drives

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.

Details of the various timing chain and sprocket assemblies are given in the table below:—

	Chain Drive Arrangement			
	Run of Chain Round Fixed Idler	No. of Pitches in Chain	Type and Throw of Adjuster	No. of Teeth on Dynamo Sprocket
All Engines up to No. 135274	Inside	98	Type 1 $\frac{1}{2}$ in. throw (12·7 mm.)	20
	Inside	98	,,	18
	Outside	96	,,	15
	Inside	96	,,	12*
All Engines From No. 135275 Onwards	Outside	98	Type 2 $\frac{7}{8}$ in. throw (22·225mm.)	20
	Outside	98	,,	18
	Outside	96	,,	15

* 12-tooth sprockets were only used on a few special engines and are now discontinued.

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. 43 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. **DYNAMO DRIVE SPROCKET.** When a replacement dynamo sprocket is fitted it must be the same size as the one originally supplied for the particular dynamo. See preceding table on page 80 and paragraph 33, page 116. Alignment of the dynamo 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. 44.

These shims are available in the following thicknesses:—

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

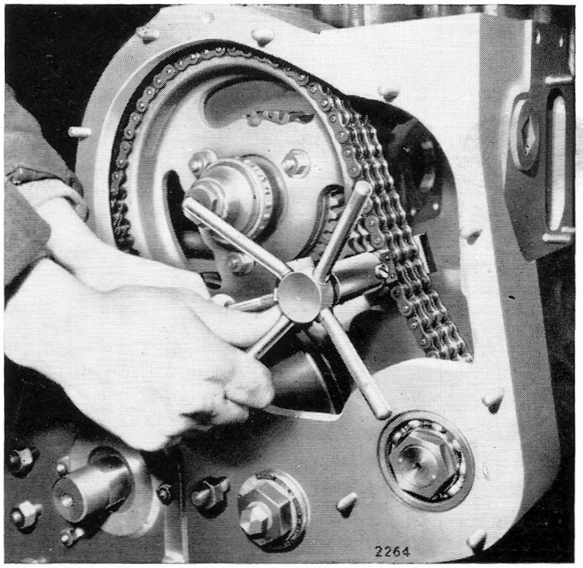


Fig. 43. Chain Riveter and Extractor Tool

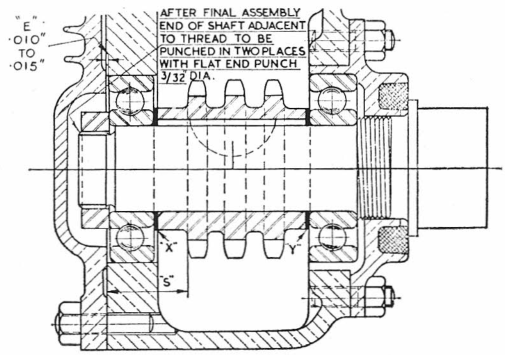


Fig. 44. Dynamo Driving Sprocket Assembly

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 dynamo 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 dynamo drive 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

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 and the timing gears, 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 rocker, 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 motion 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. In other words, the centre of the overlap between the inlet opening and the exhaust closing should occur when the piston is approximately on the top dead centre after the exhaust stroke.

With the tappet clearances adjusted to ·020 in. (·508 mm.) and the timing chain tight, the valve timing should be as follows:—

6LX and 6HLX Engines

Inlet valve opens	11° before T.D.C.
Exhaust valve closes	11° after T.D.C.

6LXB and 6HLXB Engines

Inlet valve opens	16¼° before T.D.C.
Exhaust valve closes	11¾° after T.D.C.

Special Caution: After timing has been completed the timing chain must be re-adjusted to the correct running tension (refer to paragraph 56, page 42) and the tappets re-adjusted to give the correct running clearances of ·004 in. (·102 mm.) for the inlet valves and ·009 in. (·229 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 30°" (or 31° in the case of the 6LXB engine) 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 sides of the 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 41, Page 71.

71. **TIMING OF FUEL INJECTION PUMP CAMSHAFT.** The large chain wheel and the hub and gear of the valve camshaft are bolted together face to face by three studs. The stud holes in the chain wheel are elongated to permit a certain small amount of rotation relative to the valve camshaft hub, for the purpose of accurate timing. When the timing is correct, the relative position of the two gears is marked by tracing on the periphery of the camshaft hub the contour of the sight hole in the chain wheel, the resulting mark forming a lune or arc of a circle. When the cover of the chain case is removed and the flywheel set to bring No. 1 crank to T.D.C. at end of compression stroke, as directed in paragraph 69, and if chain, gears and spline have been correctly meshed the following conditions will obtain.

(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. 45.

(2) Through the sight hole in the large chain gear will be visible the teeth of the gears of the valve and fuel pump camshafts and it will be found that the dotted tooth of the gear on the valve camshaft lies between the dotted teeth of the gear on the fuel pump camshaft.

(3) Through the same sight hole it will be seen that the lune on the edge of the hub of the valve camshaft (described above) is in its correct position. Should the gears be incorrectly bolted together, this defect will, of course, be immediately visible.

(4) The dotted spline on the camshaft of the fuel pump will register with the dot on the splined hub (see dots 5 and 6 in Fig. 45).

NOTE: All the dots referred to in the above are countersinks made by the point of a drill.

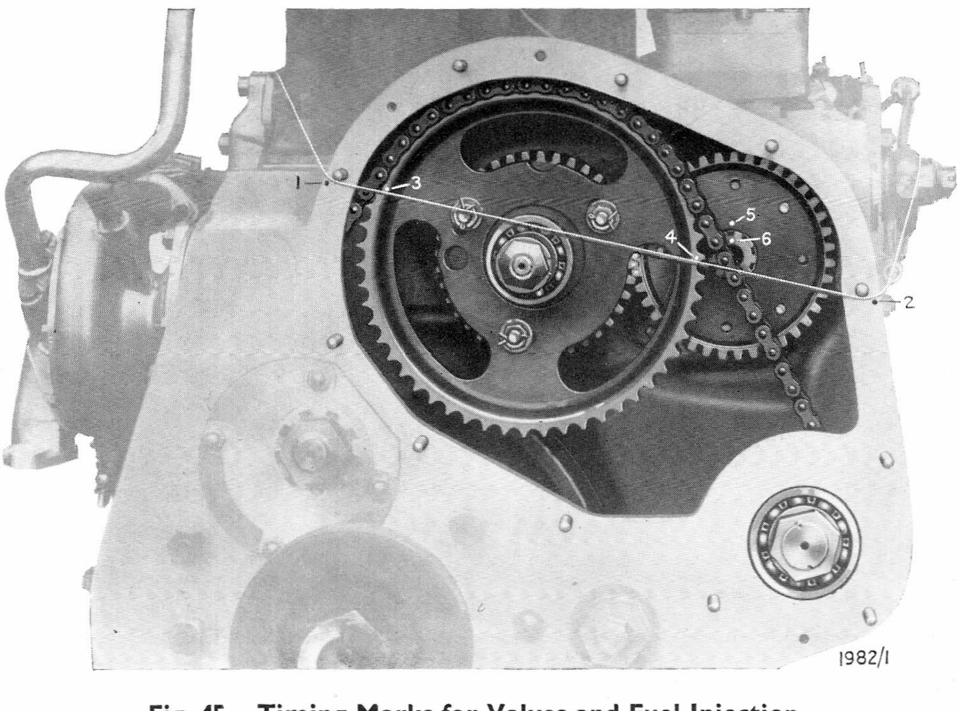


Fig. 45. Timing Marks for Valves and Fuel Injection

OVERHAUL AND ASSEMBLY

WATER PUMPS

72. **CENTRIFUGAL TYPE WATER CIRCULATING PUMP ASSEMBLY.** Spare parts for the water pump and complete service pumps may be obtained from our Service Depots and from the Works. The 6LXB centrifugal water circulating pump is stamped LXB and is not interchangeable with the 6LX water pump as the impeller is of smaller diameter.

Special tools are used for the fitting of impellers to the spindles, which are balanced as an assembly, and for this reason impellers and spindles cannot be supplied separately.

If the carbon ring has worn so that the blades of the impeller are less than $\frac{1}{32}$ in. clear of the internal face of the pump body it should be renewed. At the same time any score marks in the mating face of the impeller spindle should be removed by skimming in a lathe.

If, after pressing the impeller against the carbon and rotating by hand, an unbroken line of contact is not obtained, the spindle may with advantage, be lightly lapped against the carbon ring using a little fine pumice powder and water which of course must be carefully removed prior to final assembly.

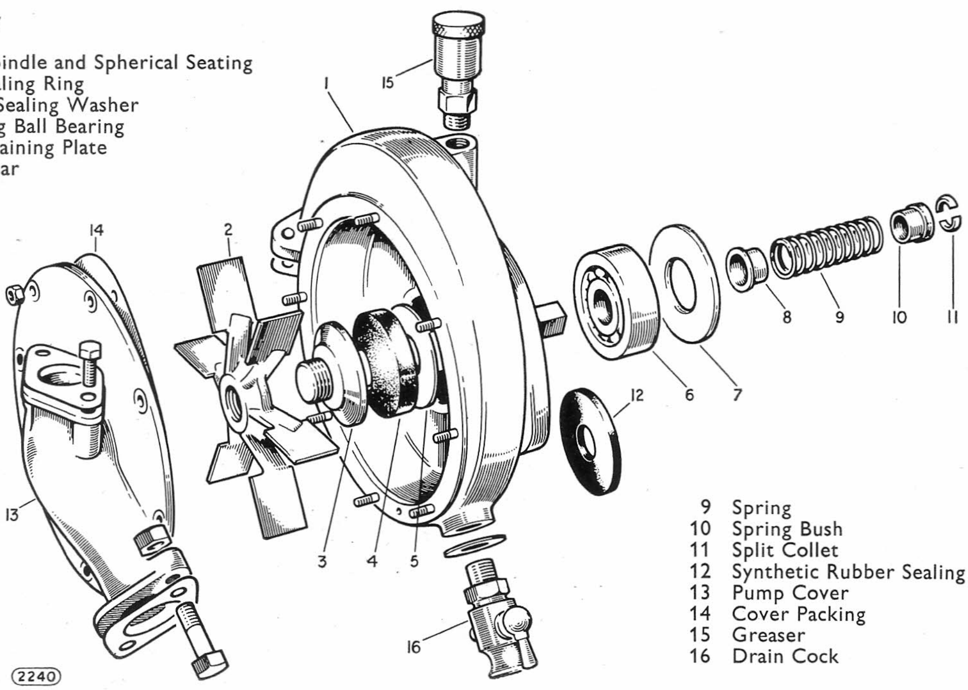
Do not on any account use "Carborundum" or equivalent abrasive and do not lap the parts if satisfactory seating is indicated by rubbing the parts together.

The self-aligning ball bearing which supports the spindle has a long life and is not likely to require renewal until the second major overhaul.

Should it be necessary to replace the carbon gland, it is desirable that the pump be returned to the Works since a special tool is necessary for this purpose. Under certain circumstances this procedure may be impracticable, in which case the Works will be pleased to supply the necessary tool and instructions to enable the operator to carry out this work. Further details in this respect will also be found in Workshop Tools Book No. 63 which contains drawings and instructions depicting the use of the carbon gland fitting and extracting tool.

The spherical seat on the spindle is accurately formed and it is essential to avoid accidental damage in handling and storage of this component.

1 Pump Body
2 Impeller
3 Impeller Spindle and Spherical Seating
4 Carbon Sealing Ring
5 Polythene Sealing Washer
6 Self-aligning Ball Bearing
7 Grease Retaining Plate
8 Spring Collar



9 Spring
10 Spring Bush
11 Split Collet
12 Synthetic Rubber Sealing Ring
13 Pump Cover
14 Cover Packing
15 Greaser
16 Drain Cock

Fig. 46. Centrifugal Water Pump Assembly

OVERHAUL AND ASSEMBLY

WATER PUMPS—*continued*

Before assembling, wash parts in petrol.

Do not allow grease to contact 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 of grease as directed in paragraph 15, Page 25.

When reassembling the pump, care must be taken to refit the synthetic rubber washer on the impeller spindle; this washer (item 12, Fig. 46), is located in the water and grease drain slot.

NOTE: With the vertical engines, when reassembling the pump, make sure that the small drain hole which crosses the joint between the pump cover and the pump body is clear from obstruction and properly registered and avoid blanking this hole with any packing or jointing used.

On the horizontal engines the pump lies horizontally and will drain completely via the pump inlet connection. It is therefore unnecessary for these holes to be in alignment.

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.

EXHAUSTERS

74. **SUCTION AND DELIVERY VALVES.** If the suction valve has to be replaced care should be taken to avoid bending the valve and to see that, when clamped by its stop plate, it is in contact with the cover plate over the whole of its area.

The metal of the valve stop plate should be lightly punched into the screw slots to provide a means of locking the countersink head screws.

The delivery valve is formed by the piston ring as described in paragraph 68, Page 47 and should not require any attention until major overhaul, when a new piston assembly may be desirable.

75. **AIR SUCTION FILTER.** The filter located inside the suction union on the cylinder head should be cleaned periodically as mentioned in paragraph 68, Page 47. The filter is capable of preventing entry into the cylinder of large particles only and is incapable of arresting fine dust or scale, etc. which may cause undue wear or piston seizure. It is therefore essential to ensure that the complete vacuum tank and pipe system be thoroughly cleaned with compressed air, steam, or other means during overhaul.

76. **REMOVAL OF EXHAUSTER CRANK.** A special tool is available for withdrawing the exhauster crank from the valve camshaft and this is illustrated and described in Workshop Tools Book No. 63.

77. **REASSEMBLING THE CHAIN CASE COVER: TWIN EXHAUSTER.** If the chain case cover has been removed, see that the locating pegs are in position before reassembly. The locating pegs ensure true alignment of the exhauster crankcase bearing with the end of the camshaft, and it is important

OVERHAUL AND ASSEMBLY

EXHAUSTERS—*continued*

that this alignment is maintained otherwise difficulty may be experienced when fitting the exhauster crank. The slightest malalignment or eccentricity may result in damage to the casing or roller race when driving the crank into position on the camshaft.

If a new chain case cover is to be fitted proceed by first fitting the outer race of the roller bearing in its housing in the exhauster crankcase followed by the retaining circlip, pressing the latter firmly into its groove. Place the cover in position over the studs on the chain case. Place the roller bearing with inner race over the camshaft, so that it just enters its outer race in the cover. Next slide the exhauster crank on to the camshaft aligning the key-way and key and entering the boss of the crank in the inner race of the bearing. Then with a suitable hollow drift drive the crank with the roller race on to the camshaft until it is hard against the collar on the boss of the chainwheel assembly. Check that the bearing is free by rocking the cover to the limit of the stud hole clearances. Finally, centralise the studs in their holes in the cover plate then drill and peg the cover to the chain case, using oversize pegs.

78. **REASSEMBLING EXHAUSTER PISTONS AND CONNECTING RODS.** The piston pin is located and locked in the connecting rod by a pinch bolt and the ends rotate freely in the piston bosses. Assembly of the piston on its connecting rod is facilitated if carried out before fitting the rods to the engine.

It will be observed that the outer periphery of the piston ring is bevelled and the ring must always be fitted with this bevel facing downwards. A note to this effect is stamped on the top of each piston and both pistons must be assembled on their rods so that this stamping may be read from the front of the engine. It should be noted that the connecting rods are assembled, one to the other, with the extended big end bosses inwards towards the crank and the off-set connecting rod positioned to operate in the near side or right-hand cylinder (looking on the front of the engine).

79. **CHECKING EXHAUSTER CYLINDER HEAD TO PISTON CLEARANCE.** With the connecting rod and piston assemblies correctly positioned as described in paragraph 78, fit the exhauster cylinders and check the cylinder head to piston clearance with a dial indicator or with a straight edge and feeler gauges.

The nominal clearance is ·0156 in. (·396 mm.) + ·011 in. (·279 mm.) — ·004 in. (·102 mm.) see also Workshop Tools Book No. 63. This clearance, measured along the axis of the piston pin at both front and rear of the piston crown, should be equal at both sides.

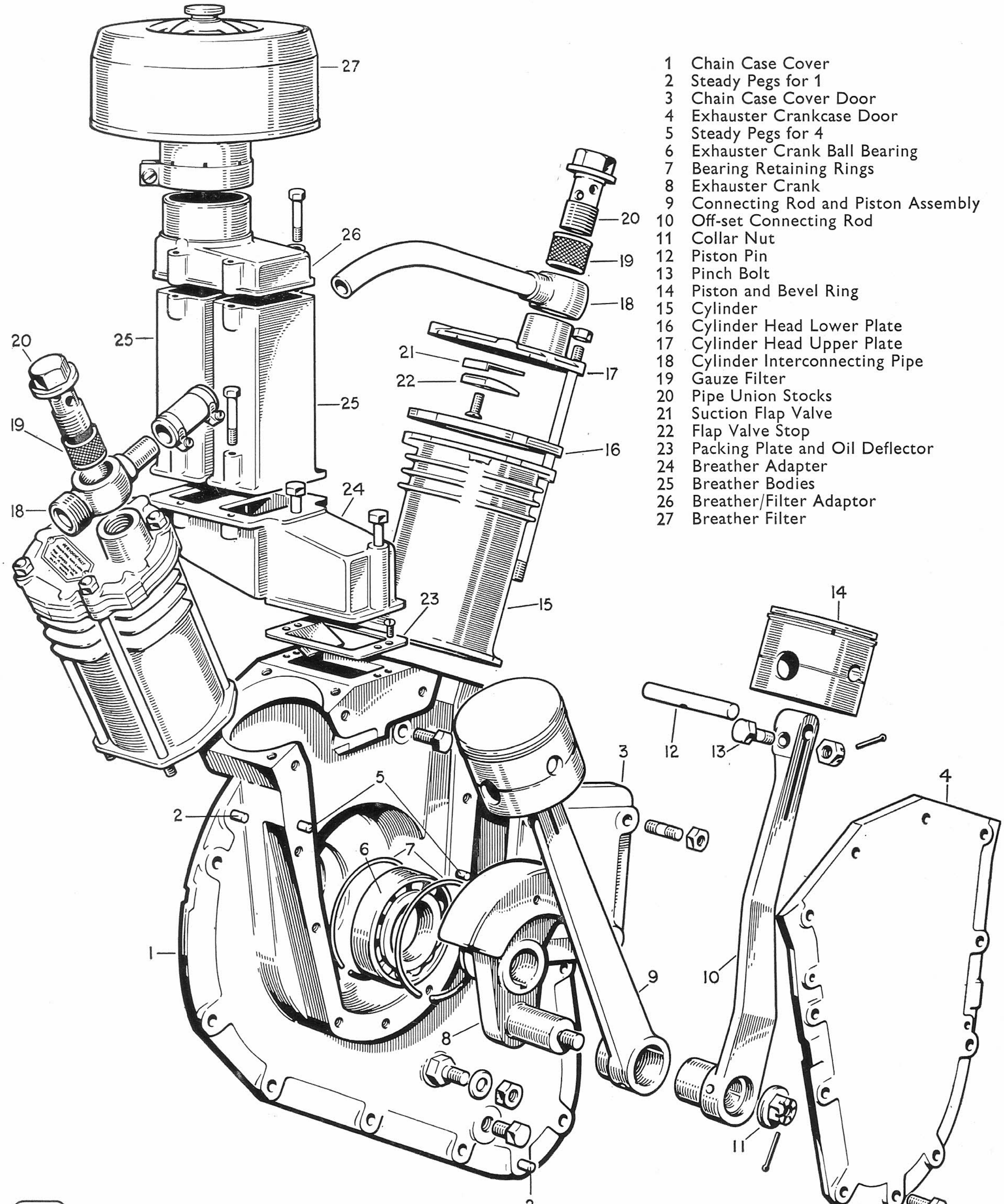
Having checked the cylinder head to piston clearance, fit the cylinder cover plates with the suction valves positioned over the forward half of each cylinder.

NOTE: The breather cases are embossed with the words "NEAR SIDE" and must always be assembled accordingly, that is, with this side facing the fuel pump side of the engine.

ELECTRICAL EQUIPMENT

80. **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.**

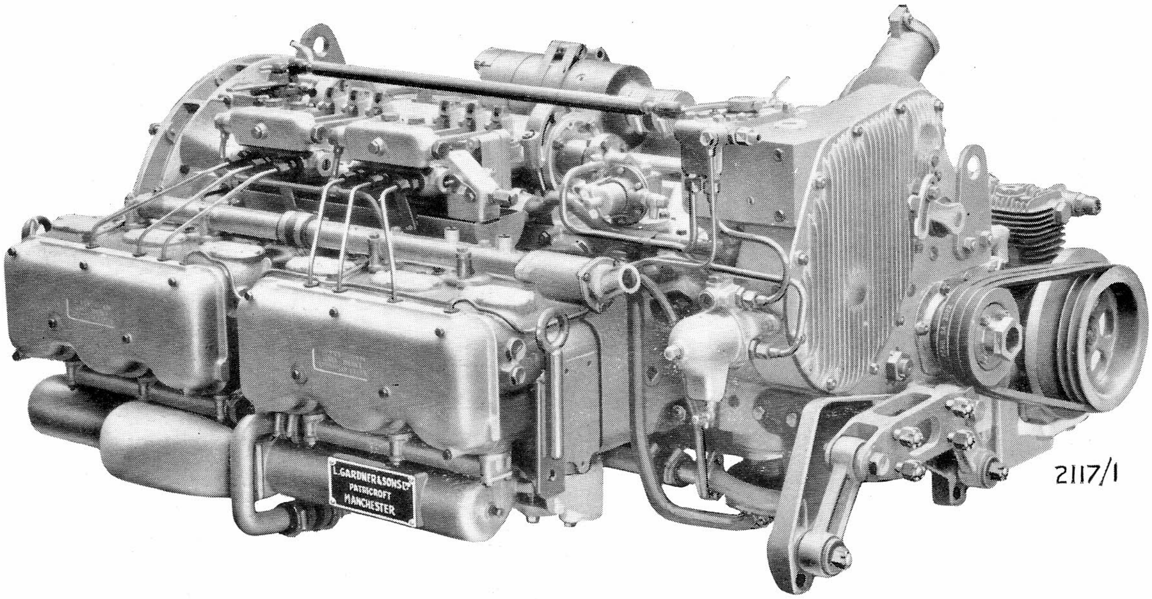
81. **RENEWAL OF STARTER RING ON FLYWHEEL.** The standard toothed ring is retained in position on the flywheel by shrinking in place and is not retained by dowels or bolts. It may be removed by progressive light driving around the upstanding edge. A new ring may be fitted by heating until it assumes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



1 Chain Case Cover
2 Steady Pegs for 1
3 Chain Case Cover Door
4 Exhauster Crankcase Door
5 Steady Pegs for 4
6 Exhauster Crank Ball Bearing
7 Bearing Retaining Rings
8 Exhauster Crank
9 Connecting Rod and Piston Assembly
10 Off-set Connecting Rod
11 Collar Nut
12 Piston Pin
13 Pinch Bolt
14 Piston and Bevel Ring
15 Cylinder
16 Cylinder Head Lower Plate
17 Cylinder Head Upper Plate
18 Cylinder Interconnecting Pipe
19 Gauze Filter
20 Pipe Union Stocks
21 Suction Flap Valve
22 Flap Valve Stop
23 Packing Plate and Oil Deflector
24 Breather Adapter
25 Breather Bodies
26 Breather/Filter Adaptor
27 Breather Filter

(2250)

Fig. 46. Twin Exhauster and Drive Assembly



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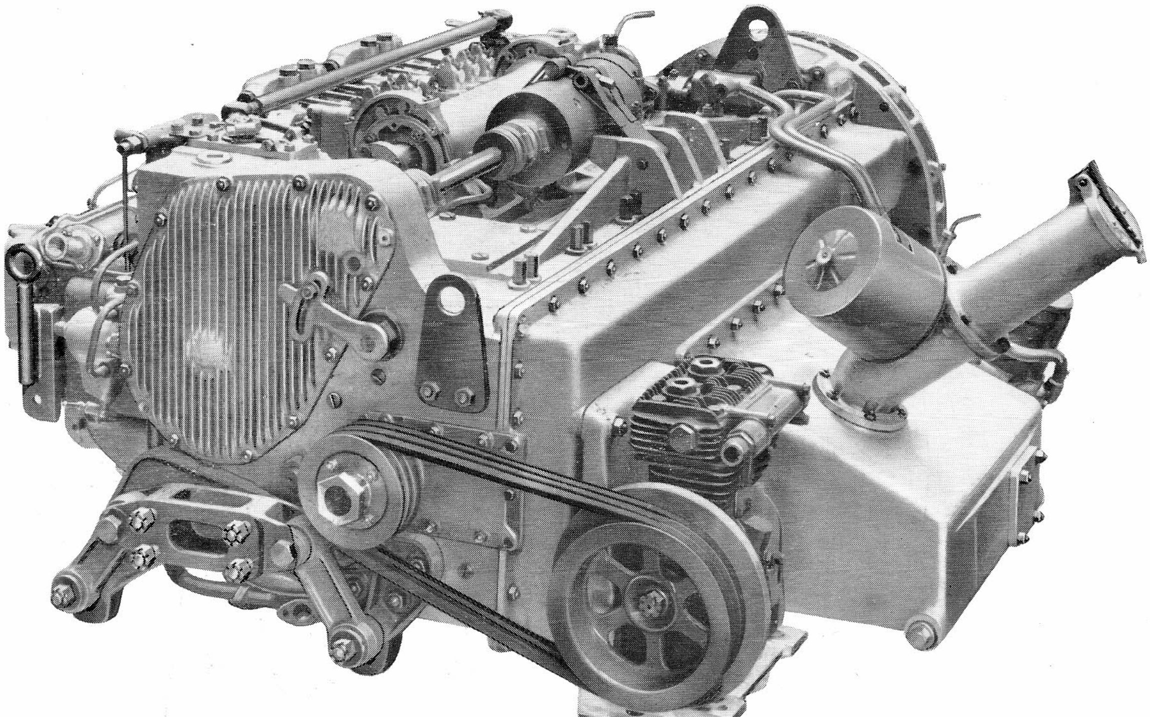

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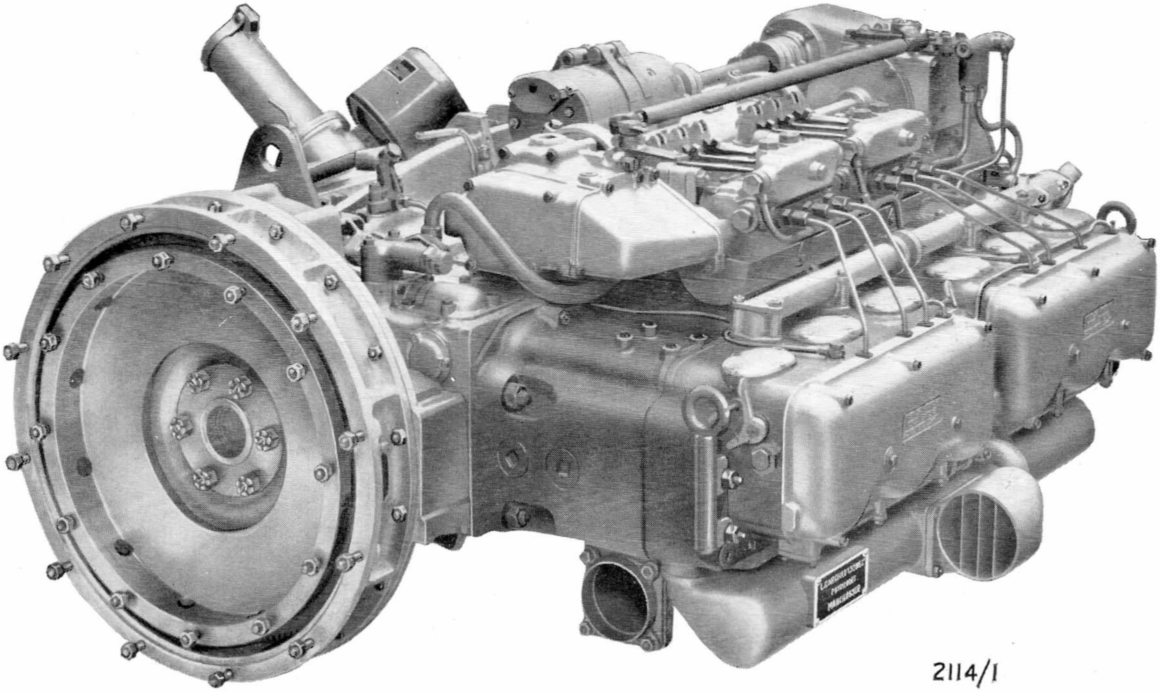
6HLX Automotive Engine (Chain Case end)



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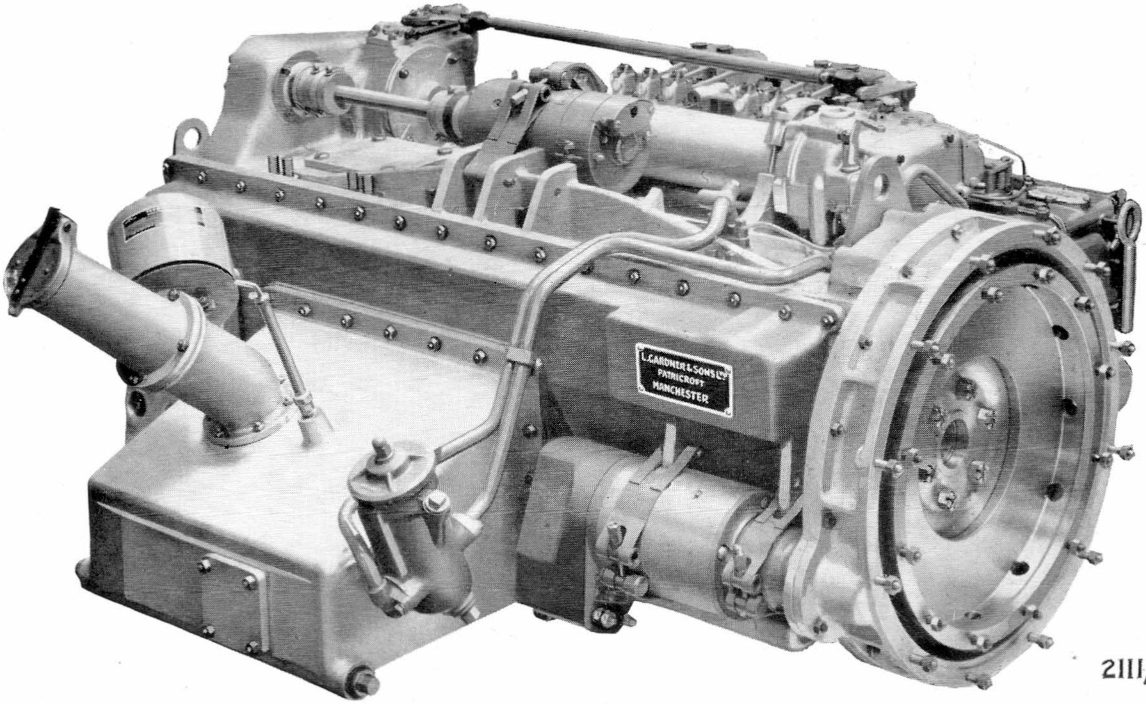

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6HLX Automotive Engine (Flywheel end)

SECTION 3

ADDENDUM

GARDNER

6LX, 6HLX, 6LXB, 6HLXB

SECTION 4

INSTALLATION
INSTRUCTIONS AND RECOMMENDATIONS

for

AUTOMOTIVE, MARINE AND INDUSTRIAL APPLICATIONS

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

INDEX

INDEX—*continued*

AIR INDUCTION SYSTEM

1. It is *very important* that provision be made for the induction of the coolest available air into the engine. Fittings can be supplied to couple the air inlet manifold by means of a flexible suction hose, to a point at which cool air may be drawn directly from the atmosphere through a remotely mounted air filter. It is necessary that means be provided to eliminate any possibility of the entry of hose of flood water into the induction system, and the system must be designed to operate at a manifold depression of not more than 5 in. (127 mm.) water gauge at full speed of the engine. Maximum power, economy and durability will not be available if the engine is permitted to induct heated under-bonnet air.

AIR INDUCTION FILTERS

2. There is ample evidence to show that even when operating under conditions which are regarded as dust free, the employment of oil-washed air filters can have a very beneficial effect in reducing the wear rate of many engine components, particularly cylinder bores, pistons, rings and grooves. For this purpose there is available the Gardner Universal Air Filter which can be mounted close to or remote from the engine, and the Twin Oil Bath Type Air Filter for under-bonnet installation. Instructions and recommendations concerning the installation of these filters are contained in the following paragraphs.

In some parts of the world air filters are necessary on marine engines. Similarly, air filters are also a necessity in some industrial engine applications.

3. **INSTALLATION OF GARDNER UNIVERSAL OIL BATH FILTERS.** This air filter is a totally enclosed weatherproof unit combining fully efficient filtration at low resistance with ease of installation and the provision of "cold air" induction. Automatic control of the oil level in the container compensates for accumulation of foreign matter in the filter sump, and uniform filtering conditions are maintained.

The cast aluminium alloy mounting head receives the A.C. Delco filter body and incorporates three alternative inlet ports and one outlet port. The latter is fitted with a connection or elbow of suitable size and is coupled by means of flexible hose directly to the engine air inlet manifold. The inlet ports are fitted with suitable size straight type or elbow connections to suit the installation. The head is provided with four setscrews for attachment to the supporting member on the chassis; one of the setscrews is offset to prevent incorrect assembly.

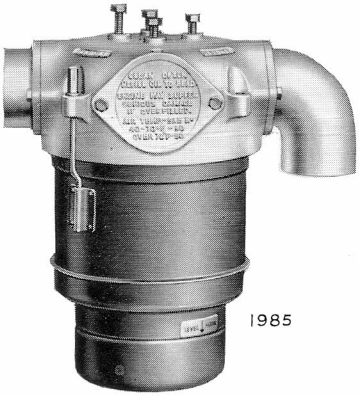
The filter is so designed that it may be mounted in any convenient position between engine and point of air entry (preferably adjacent to the engine). The inlet then being coupled by flexible hose to a point from which the *cleanest cold air* is available, due regard being paid to the location of the entry end of the intake on vehicles which may encounter flood water and the embodiment of a rigid flared metallic sleeve in order to avoid deformation of the conduit and facilitate entry of the air.

The unit may be mounted externally on the forward facing bulkhead outside the engine bonnet on certain passenger vehicles or rear of, or in, the driver's cab on commercial vehicles; the downward pointing elbow may then provide protection against the entry of rain or foreign matter. Referring to Fig. 48, it will be seen that a variety of elbows and connections can be fitted to the filter head, to satisfy installation requirements. For under floor mounting, the inlet connection to the filter is conveniently ducted to a point below the vehicle floor, as high as is practicable and forward of the front axle.

Since the filter is totally enclosed, it may be mounted

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

AIR INDUCTION FILTERS—*continued*



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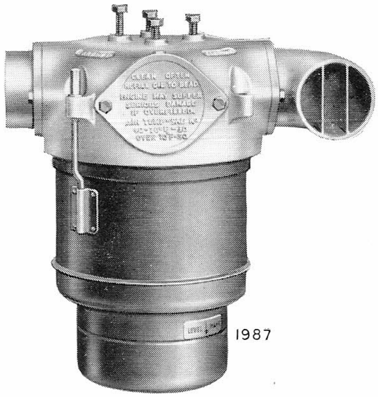

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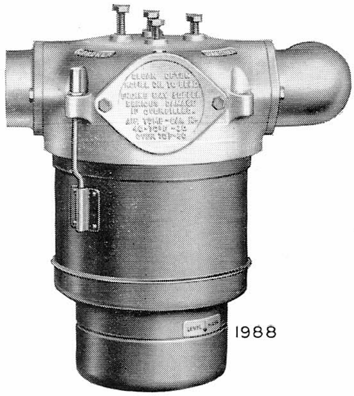

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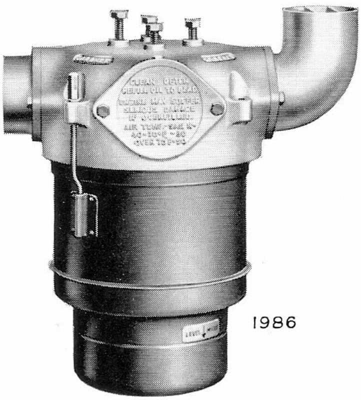

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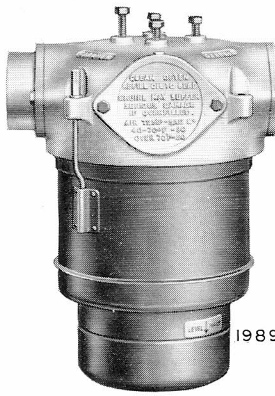

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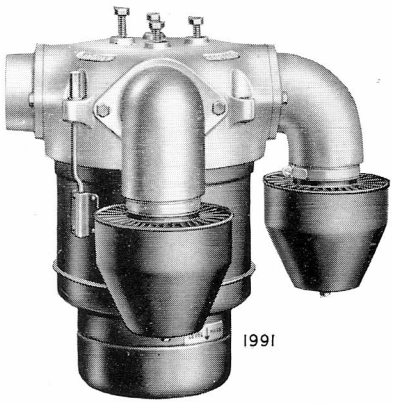

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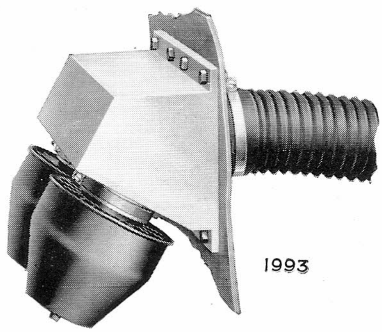
Illustrating a variety of straight and elbow connections for the inlet and outlet ports to suit various installations.



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1993 shows the remote mounting of pre-cleaners on bulkhead or cab wall.

Fig. 48. The Gardner Universal Oil Bath Type Air Filter

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.

Fig. 49 illustrates 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 in Fig. 50. 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.

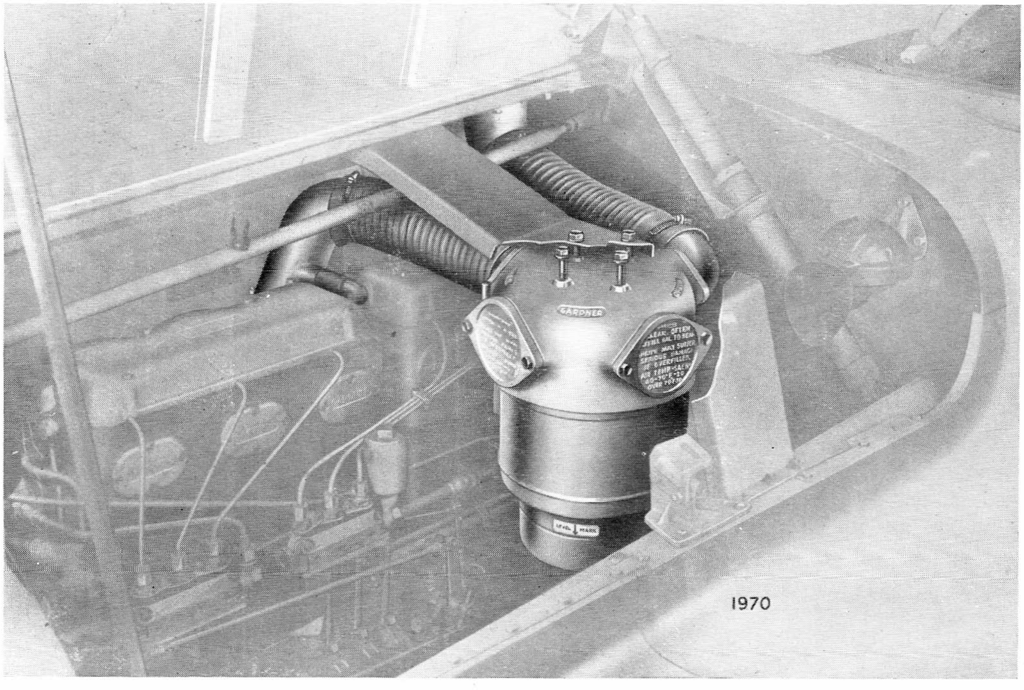


Fig. 49. Under-bonnet Installation of Universal Oil Bath Type Air Filter on a Double-Deck Passenger Vehicle

AIR INDUCTION FILTERS—*continued*

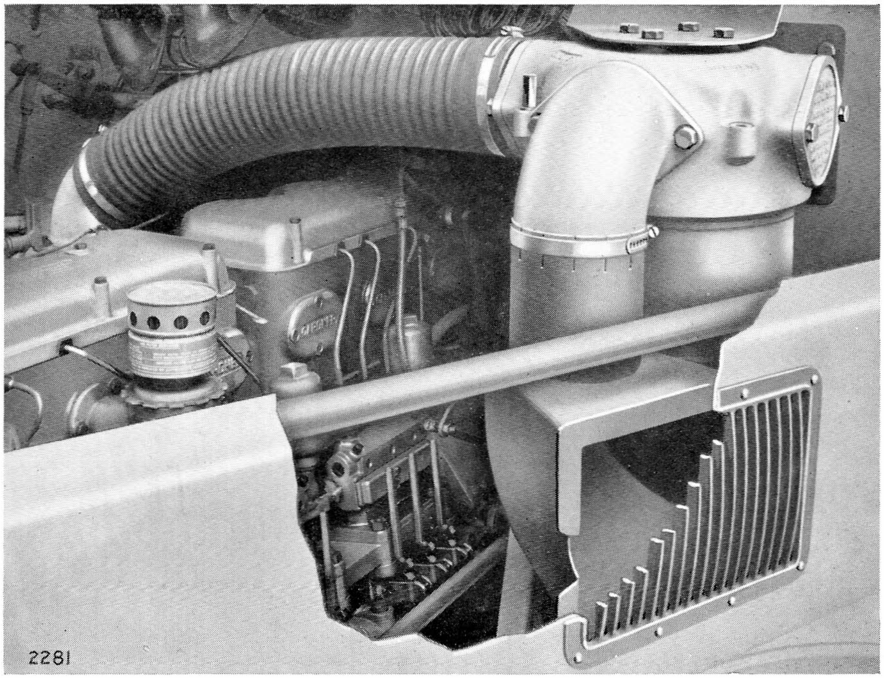


Fig. 50. Under-bonnet Installation of Universal Oil Bath Type Air Filter on a Semi-forward Cab Vehicle

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 6LXB installations or 4¼ in. (108 mm.) on 6LX and 6HLX installations.

5. **PRE-CLEANERS FOR EXTREME DUST CONCENTRATIONS.** Overseas experience dictates that a satisfactory installation for operation in a heavily dust laden atmosphere is one in which the air is additionally drawn (through pre-cleaners) from inside the driver's cab or passenger accommodation; 6 in. (152·4 mm.) diameter pre-cleaners are shown on two of the illustrations in Fig. 48. These remove a large proportion of the heavier dust particles and are recommended for use in a heavily dust laden atmosphere in order to lengthen the intervals between which cleaning of the main filter becomes necessary. Dust laden air entering the pre-cleaner is caused to rotate within the body and in so doing dust particles are ejected at their peripheral slots.

6. **INSTALLATION OF TWIN OIL BATH TYPE FILTERS.** The twin oil bath type air cleaner is designed for under-bonnet installation on passenger vehicles where space is limited but where suitable protection from weather is available, for example in forward engine double-deck passenger vehicles, see Fig. 51. The unit is easily and quickly adaptable to any under-bonnet arrangement and combines fully efficient filtration with simplicity and ease of maintenance.

AIR INDUCTION FILTERS—*continued*

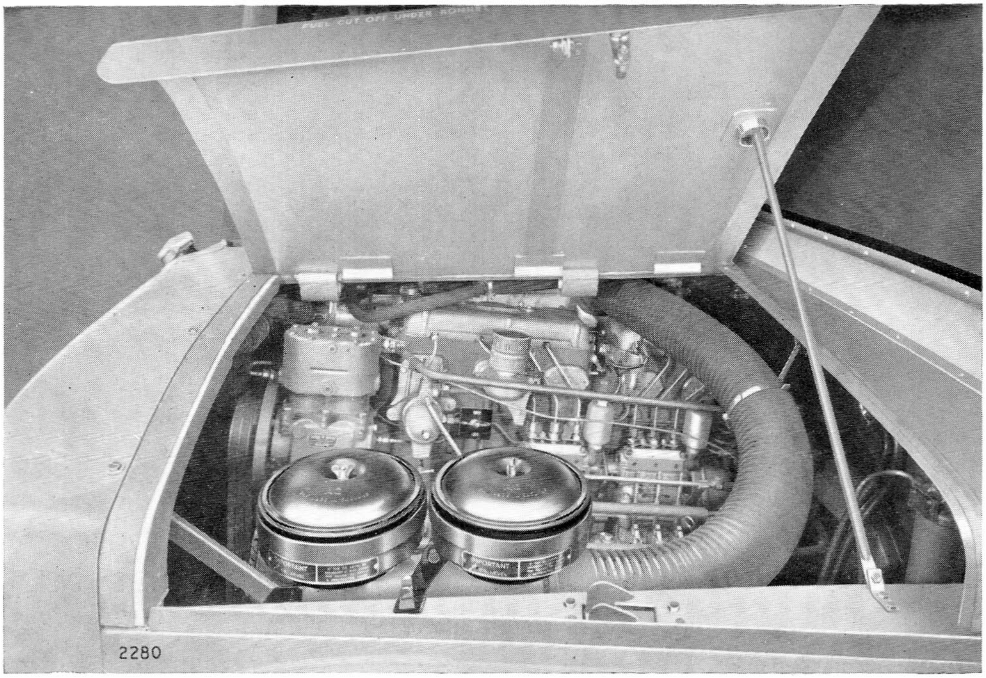


Fig. 51. Under-bonnet Installation of Twin Oil Bath Type Air Filter on a Passenger Carrying Vehicle

The manifold must be mounted horizontally with the inlet ports uppermost and attached by suitably rigid brackets to any convenient point on a side panel or bulkhead (preferably remote from the exhaust manifold and where the cleanest and coolest air is available). It is so designed that it may be reversed, thus enabling the suction hose to lead off in either direction.

The mounting brackets must be so arranged that when installed, the filter units containing the oil are maintained upright on a level plane.

Details of the suction hose are given in Paragraph 4, Page 97.

DUST PROOFING

7. 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 94.

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

ENGINE ROOM VENTILATION

MARINE INSTALLATIONS

8. It is important that provision be made to permit hot air to pass out and cool air to pass into the engine room thus assisting in general cooling and ventilation.

Inlet and outlet cowls and trunks creating natural draft accomplish this in some vessels. In others, electrically-driven extractor fans will change the engine room air some 30 to 35 times per hour.

Such extractor fans are available from the Works and can be supplied with or without weatherproof cowls.

In fishing vessels and similar craft some degree of 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. In addition to the engine exhaust gases creating a suction effect within the funnel and thus extracting hot air from the engine room, the convection currents around the silencer assist in reducing the engine room temperature. These arrangements are shown in Figs. 52 and 53 on pages 100 and 101.

Installation drawings are also available upon request from the Works, and we shall be pleased to give any further advice that may be required in this connection. It must be remembered that adequate engine-room ventilation is also vital for the well-being of the hull.

EXHAUST SYSTEMS

9. The exhaust system should impose a back pressure at the manifold of not more than approx. 10 in. water gauge at full power. Any form of baffle type silencer will create pressure 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.

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 6LX and 6LXB engines should be $3\frac{3}{8}$ in. (85·725 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.) straight through system is permissible. The Works will be pleased to advise in this matter.

FLYWHEEL (AUTOMOTIVE)

10. It is recommended that the total inertia of the fly-wheel 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.

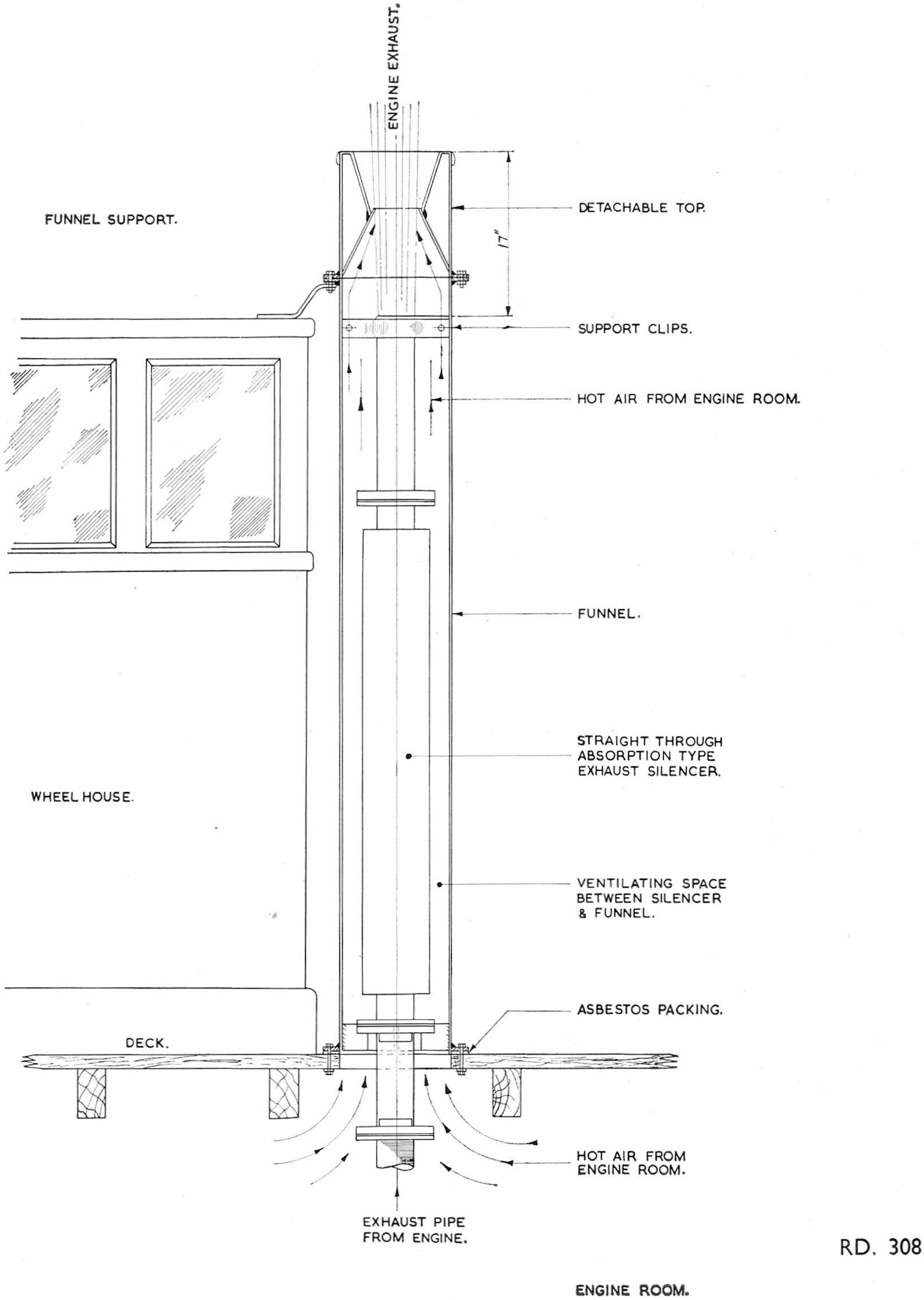


Fig. 52. Installation of Engine Room Ventilating Funnel and Silencer (Outside Deck House Type)

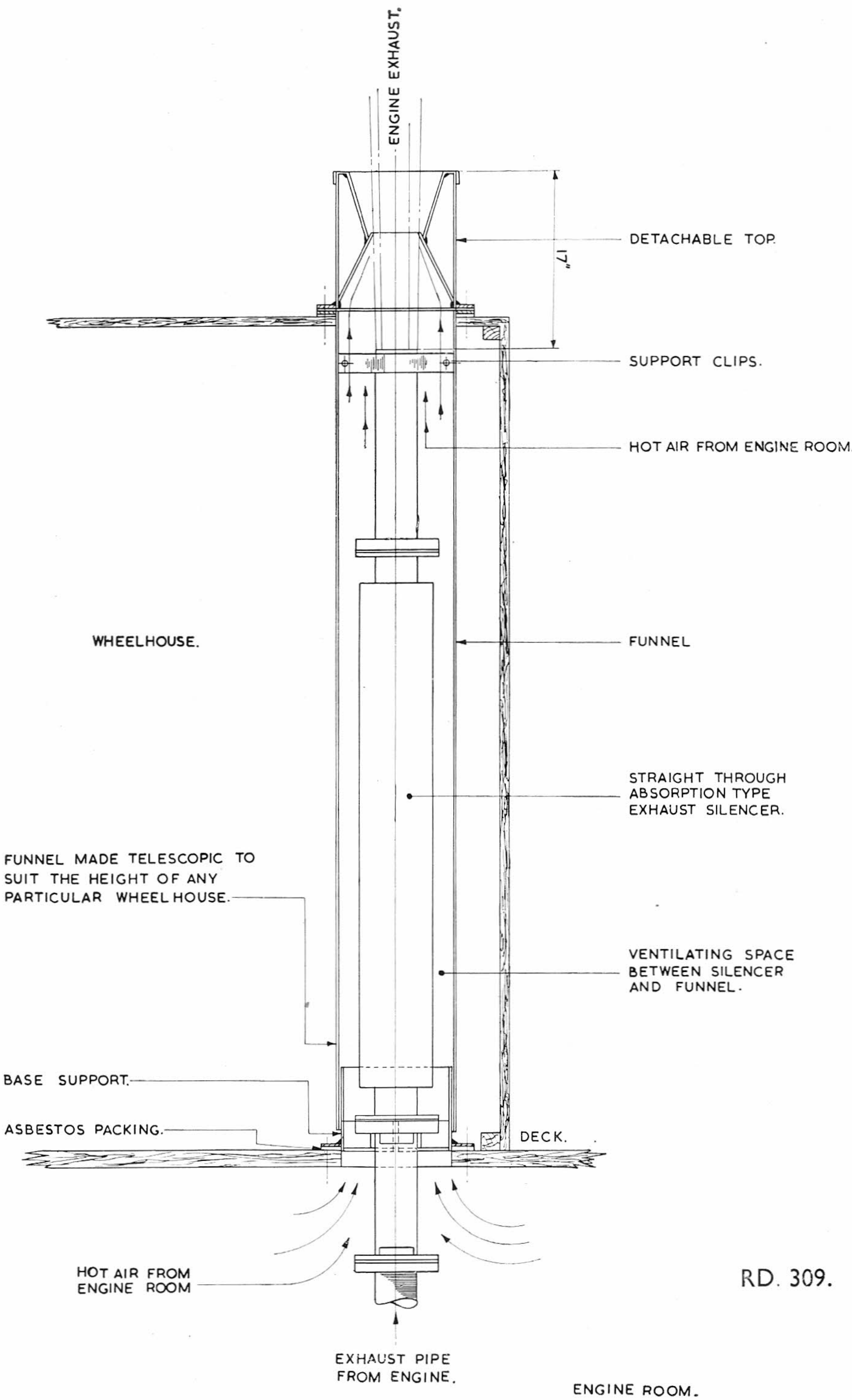


Fig. 53. Installation of Engine Room Ventilating Funnel and Silencer (Inside Deck House Type)

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

FUEL FEED SYSTEM

11. We recommend the use of the Gardner Overflow Return system, incorporating an engine-operated Amal Fuel Lift Pump, as shown on Drawing No. 3387H in Workshop 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:—

LENGTH OF PIPE RUN	WITH FEED PUMP	WITHOUT FEED PUMP
Up to 10 ft.	$\frac{3}{8}$ in. o.d. — 18G	$\frac{1}{2}$ in. o.d. — 16G
Up to 18 ft.	$\frac{7}{16}$ in. o.d. — 18G	$\frac{1}{2}$ in. o.d. — 16G
Overflow return pipe to fuel tank	$\frac{3}{8}$ in. o.d. — 18G	

12. **INSTALLATION.** The overflow return pipe between the engine filter and the fuel tank must be arranged to have a continuous fall and to feed into the top of the tank, otherwise the fuel injection pumps may become de-primed due to syphon effect of the return pipe.

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.

AUTOMOTIVE INSTALLATIONS

GEAR RATIOS

15. The Works Technical Staff are always ready to offer advice upon the selection of gear box and axle ratios to provide optimum performance with minimum fuel consumption.

SOUND INSULATION

16. 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 para. 20, page 105.

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

AUXILIARY UNITS AND DRIVES

17. **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 pulley for driving an air compressor.

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.

19. **EXHAUSTER.** When so ordered, a vacuum pump (exhauster) may be fitted to automotive engines for operating a Vacuum Servo Brake System. Mounted on the timing case, the pump is crank driven from the valve camshaft and is positively lubricated from the engine system.

The diagrammatic arrangement of vacuum Servo brake pipes is shown on Drawing No. 3387H in Workshop Tools Book No. 63 and the sizes of pipes are as follows:—

Between Exhauster and Check Valve or Vacuum Tank—

Single Cylinder: ⅝ in. (15·875 mm.) o.d.—
18G. (1·219 mm.)

Twin Cylinder: ¾ in. (19·05 mm.) o.d.—
18G. (1·219 mm.)

Between Vacuum Tank and Servo Unit—
1 in. (25·4 mm.) o.d.—16G. (1·626 mm.)

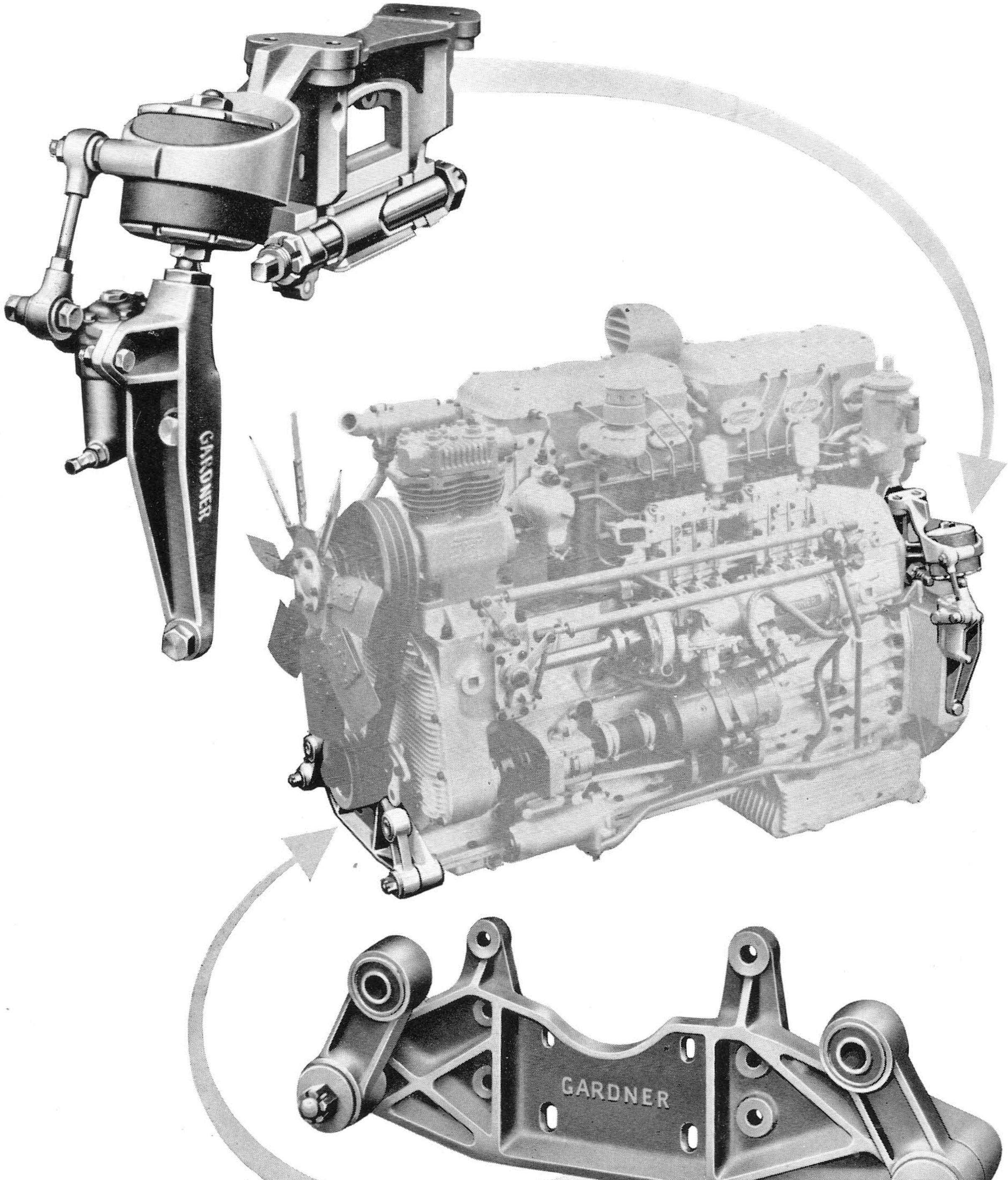


Fig. 54. Gardner Flexible Engine Mounting and Torque Reaction Damper

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

ENGINE MOUNTING

AUTOMOTIVE

20. **GARDNER FLEXIBLE MOUNTING.** 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 in Fig. 54.

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 part section in Fig. 54. 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 in Fig. 54 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.

MARINE

21. **STATIC INCLINATION AFT.** Normal maximum static inclination aft for the 6LX Marine Unit with 2UC Reversing Gear 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. × $2\frac{1}{8}$ 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	$5\frac{7}{8}$ in. × 2 in. 149·225 mm. × 50·800 mm.	·003 ·007 ·032	·0762 ·1778 ·8128	J.7256 J.7257 J.7258	8 6 4

ENGINE MOUNTING—*continued*

MARINE INSTALLATIONS

22. **ENGINE AND PROPELLER SHAFT ALIGNMENT.** It is of prime importance that the engine and reverse gear or the engine with reversing and reducing gears 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 6LX marine units are tapped to receive $\frac{7}{16}$ 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 on page 105.

23. **TABLE OF ALIGNMENT SHIMS.** To obtain alignment within ·003 in. (·0762 mm.) and to obtain a total thickness of shims between ·003 in. (·0762 mm.) and $\frac{1}{16}$ 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 these shims it is possible to obtain a total thickness as per the table below.

TOTAL THICKNESS OF SHIMS		QUANTITY OF SHIMS TO BE USED			TOTAL THICKNESS OF SHIMS		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	—					

GARDNER

NOTES ON FLEXIBLE MOUNTING ARRANGEMENTS FOR GARDNER ENGINES IN MARINE INSTALLATIONS.

The objects of installing engines on flexible mountings in marine craft are to insulate the structure of the vessel from noise and vibration generated by the engines and the extent to which an attempt to attain these objectives can be justified should be considered against the type of vessel involved.

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.

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.

If maximum silence is to be achieved, it will, in addition to the employment of flexible engine mountings, be necessary 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.

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 should 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 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.

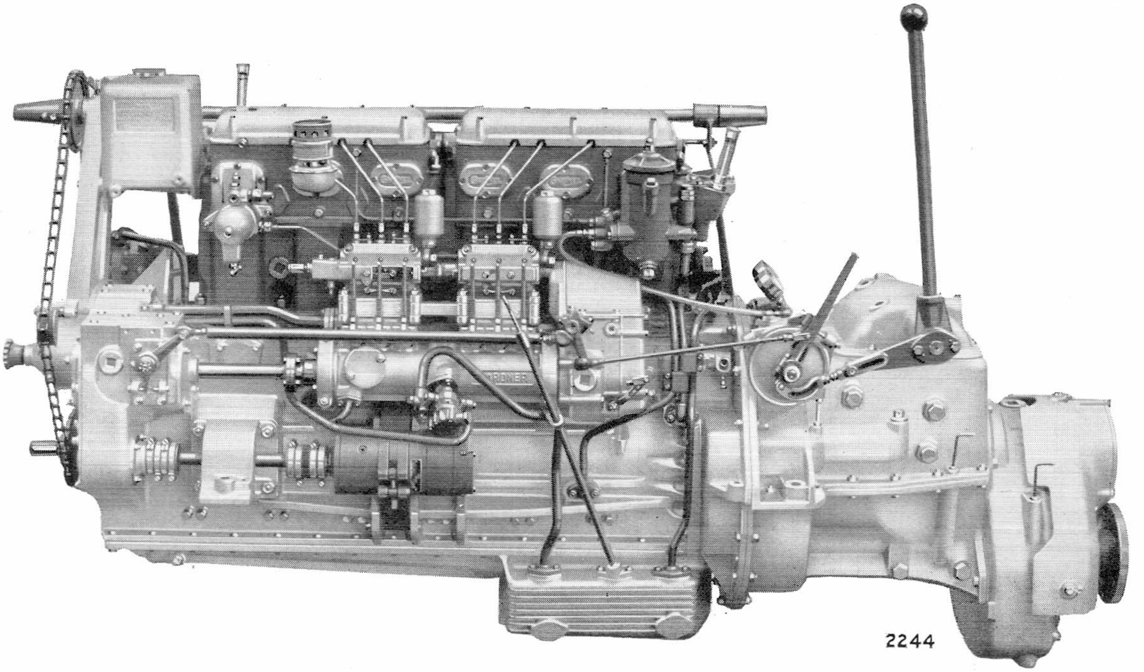
It is equally important that the Engine, when at rest, should be in perfect alignment with the Shaftline and that this condition is obtained without disturbing the calculated static deflection on each of the flexible engine mountings.

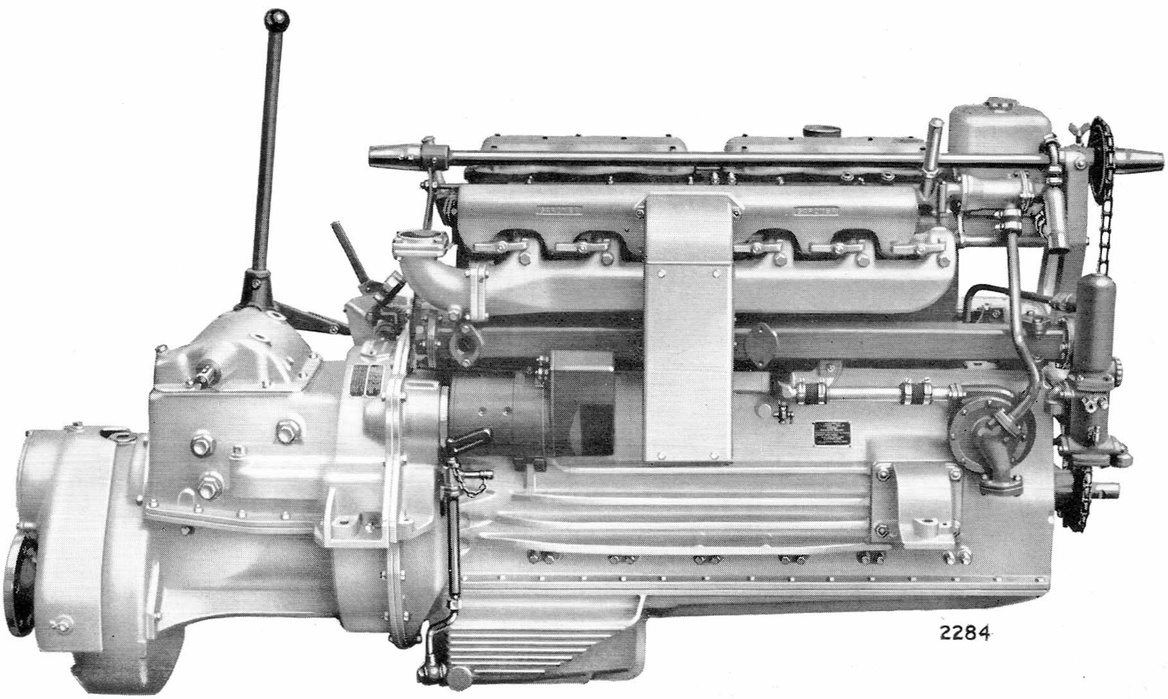
Detailed instructions as to how this condition can be obtained will be included on drawings obtainable from the Works on request.

In all cases where it is intended to install Gardner Engines on flexible mountings the following scale drawings, with principal dimensions included, should be submitted.

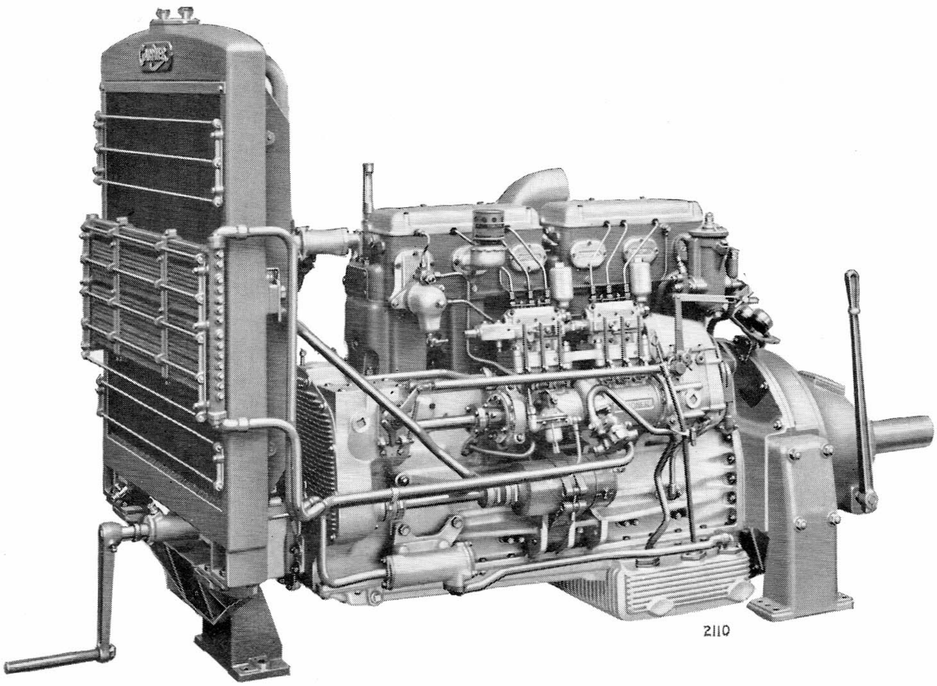
1. Machinery arrangement, including exhaust system.
2. Propeller Shaftline arrangement.
3. Details of engine seatings.

Only on receipt of these drawings can detailed proposals for flexible engine mounting arrangements be put forward.





6LX Marine Propulsion Unit with No. 2 U.C. Reversing and 3 : 1 Ratio Reducing Gears



6LX Industrial Unit fitted with Power Take-off Clutch

COOLING SYSTEMS

24. **AUTOMOTIVE ENGINES, INDUSTRIAL UNITS AND GENERATING SETS.** 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. See also paragraph 18, page 25.

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 1¾ 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 1½ in. (38·10 mm.).

The standard fan fitted to the 6LX engine has six blades with a diameter of 20 in. (508 mm.) for passenger vehicles and eight blades with a diameter of 24 in. (609 mm.) for freight vehicles.

The 6LXB engine has an eight blade, 24 in. diameter fan for all automotive duties.

COOLING SYSTEMS—*continued*

(2) **WATER INLET AND OUTLET CONNECTIONS.** The minimum permissible bore of any portion of the connections between radiator, thermostat outlet and water pump inlet is $1\frac{1}{2}$ in. (38·10 mm.) and the minimum bore size for hoses is $1\frac{3}{4}$ in. (44·45 mm.).
If any 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.

26. RADIATOR CONSTRUCTIONAL DETAILS

Particulars and dimensions of wire wound tube type radiators for various climatic conditions are given in the table below: further details are as follows:—

Tubes. Brass tube $\frac{3}{8}$ in. (9·525 mm.) o.d. 22 gauge (·711 mm.) wire wound type $1\frac{3}{16}$ in. (30·162 mm.) o.d. (approx.).

Tube Layout. Pitch of tubes $1\frac{1}{2}$ in. (38·1 mm.), in rows spaced $1\frac{5}{32}$ in. (29·369 mm.) alternate rows staggered.

Alternative Tubes. The above dimensions of radiators and tube layout are based on the performance of wire-wound tubes. Other types of tube are in regular use, for which modified layout is required or permitted. In general these have lower heat dissipating capacity and radiator dimensions must be increased proportionately, but the Withnell tube, manufactured by Messrs. Norman Isherwood & Co. Ltd., Bolton, to quote one particular example, is highly efficient and permits the use of radiators having approximately 20% less frontal area than given in the table.

WIRE-WOUND TUBE RADIATORS

PARTICULARS AND DIMENSIONS					
Climatic Conditions and Mean Annual Temperature	Tubes		Effective Area	Typical Dimensions	
	No.	Rows		Width	Height
TEMPERATE 40° F. to 60° F. 5° C. to 15° C.	68	3	1,210 in.² (7,806 cm.²)	$34\frac{1}{4}$ in. (870 mm.)	35 in. (889 mm.)
SUB-TROPICAL 60° F. to 70° F. 15° C. to 21° C.	74	3	1,390 in.² (8,968 cm.²)	$37\frac{1}{4}$ in. (946 mm.)	37 in. (940 mm.)
TROPICAL 70° F. to 80° F. 21° C. to 27° C.	80	3	1,630 in.² (10,516 cm.²)	$40\frac{1}{4}$ in. (1,022 mm.)	40 in. (1,016 mm.)

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

COOLING SYSTEMS—*continued*

MARINE INSTALLATIONS

27. **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.

28. **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.

Diagrammatic arrangement drawings of fresh water cooling systems comprising Heat Exchanger, Engine-driven Centrifugal Sea Water Pump and engine mounted Fresh Water Header Tank, etc., for our marine engines, are shown on pages 114 and 115. These drawings show arrangements for engines having a dry exhaust system, also for engine installations with a quenched (water cooled) exhaust system.

29. **CLOSED CIRCUIT KEEL COOLER SYSTEM.**

On page 112 will be found diagrammatic arrangement drawings of the closed circuit fresh water cooling system employing a Keel Cooler design.

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.

Accordingly there has been established a range of complete Gardner keel cooling equipment matching the complete range of Gardner marine propulsion engine units for temperate and tropical conditions possessing the following advantages:—

(1) The provision of a fresh water system at minimum expense, of minimum weight, minimum bulk and maximum simplicity.

(2) The provision of a system free from silting and corrosion.

(3) The provision of a system of maximum reliability independent of sea water circulation by separate pump and strainer equipment, etc.

The pipes, respective skin fittings and support bracket, which are of suitable material in order to avoid so far as possible electrolytic or corrosive action, may be protected from grounding, etc., by hull features.

On page 113 will be seen Fig. 56 showing diagrammatically two suggested arrangements of keel cooler and pipes. The inside diameter and total length of pipe is dependent on the prevailing climatic conditions and sea water temperature. Air mean ambient, sea water temperature, frame spaces and width of frames, should be stated at time of ordering.

The length "X" as shown on this drawing is the total length of exposed pipe which is divided in four equal parts, and which should be shaped to follow the hull design as closely as possible before final assembly.

The standard lengths and bores of pipes established are based on a minimum full power boat speed of 5 knots. For vessels having a design speed of less than 5 knots and for other engine duty, special consideration is required and such application should be referred to our Technical Department.

30. **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.

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

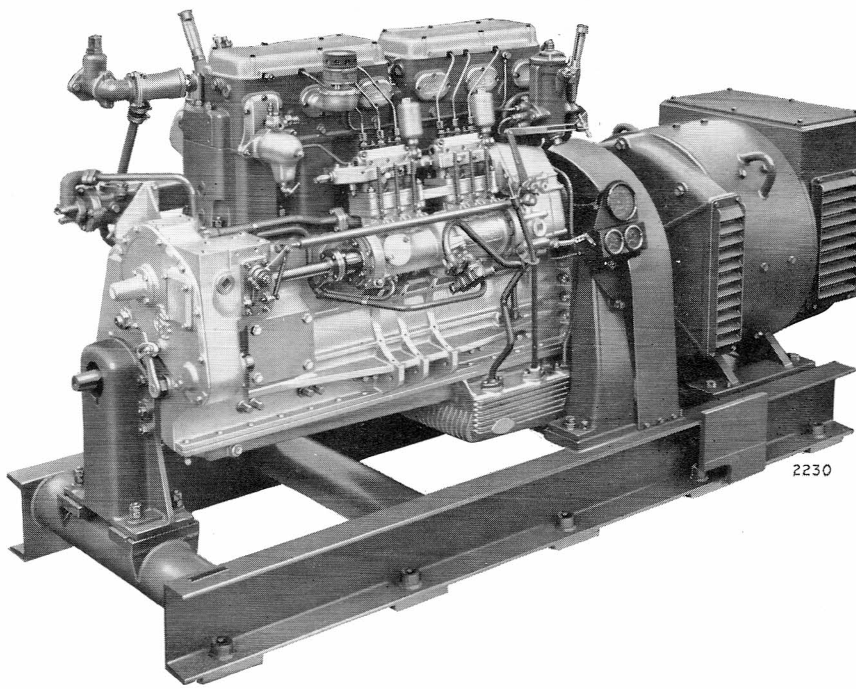
COOLING SYSTEMS—*continued*

MARINE INSTALLATIONS

31. **COOLING OF LUBRICATING OIL.** 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.



6LX Engine Direct Coupled to Mawdsley 45 kw Generator

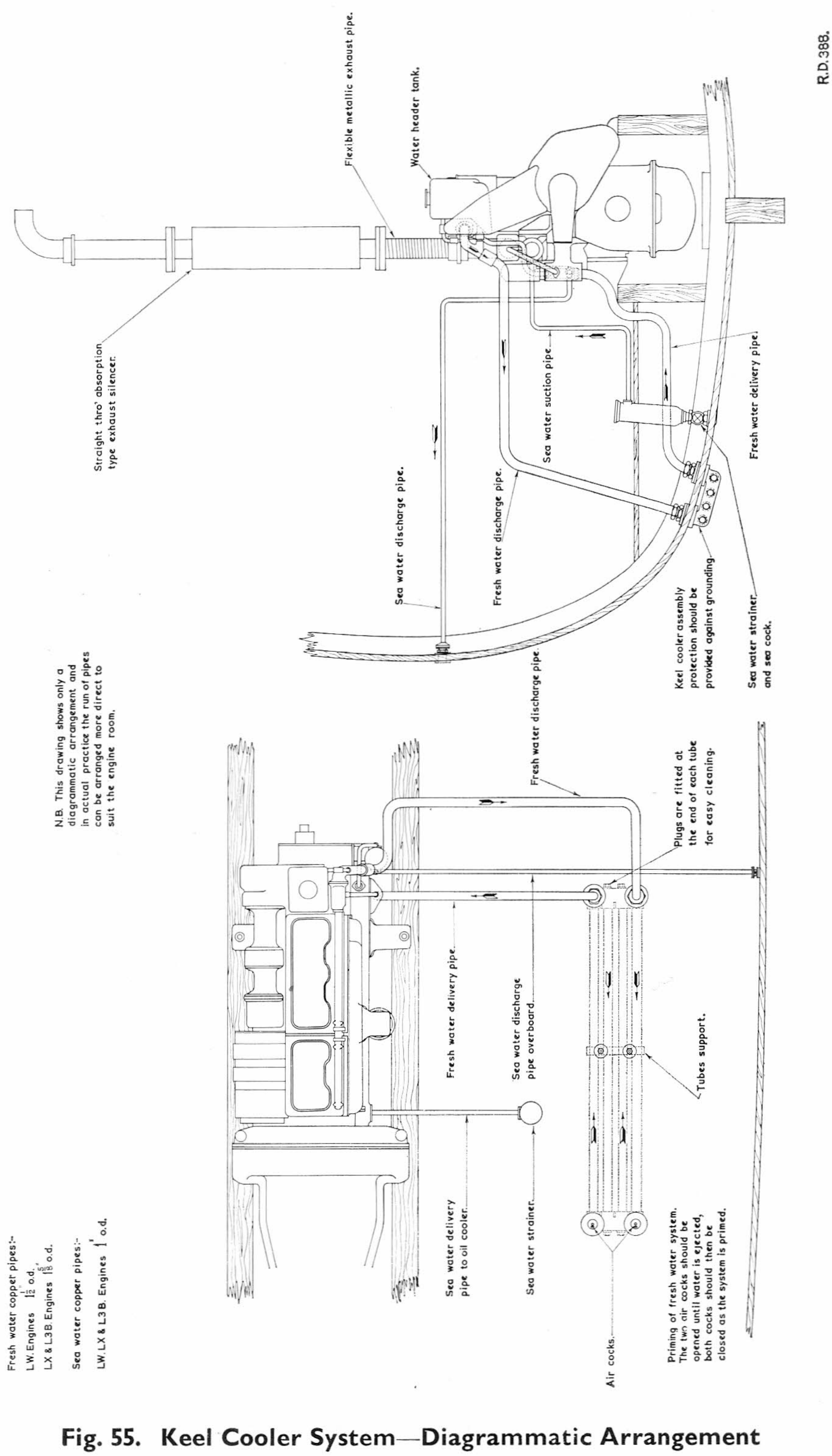


Fig. 55. Keel Cooler System—Diagrammatic Arrangement

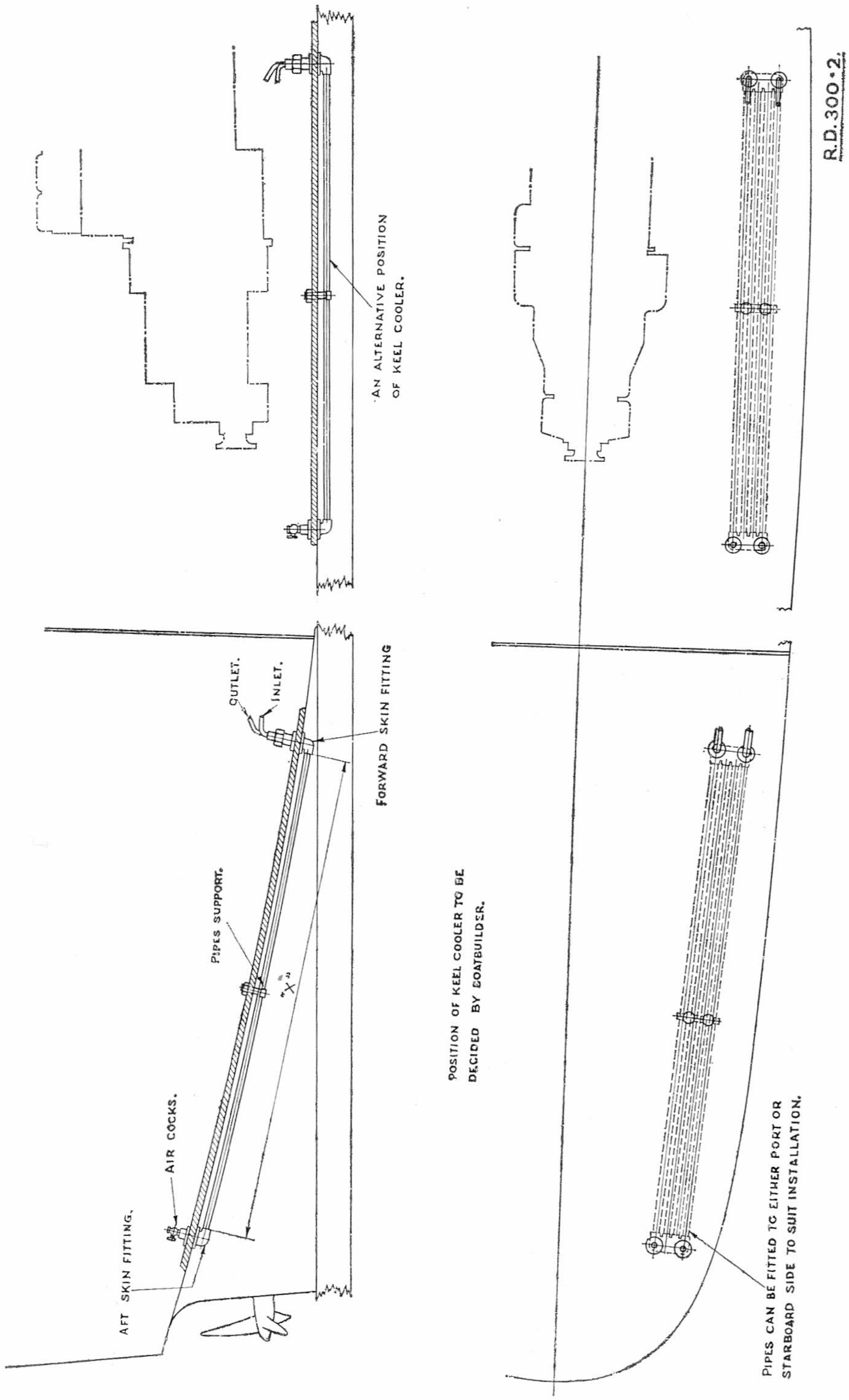


Fig. 56. Keel Cooler—Installation Details

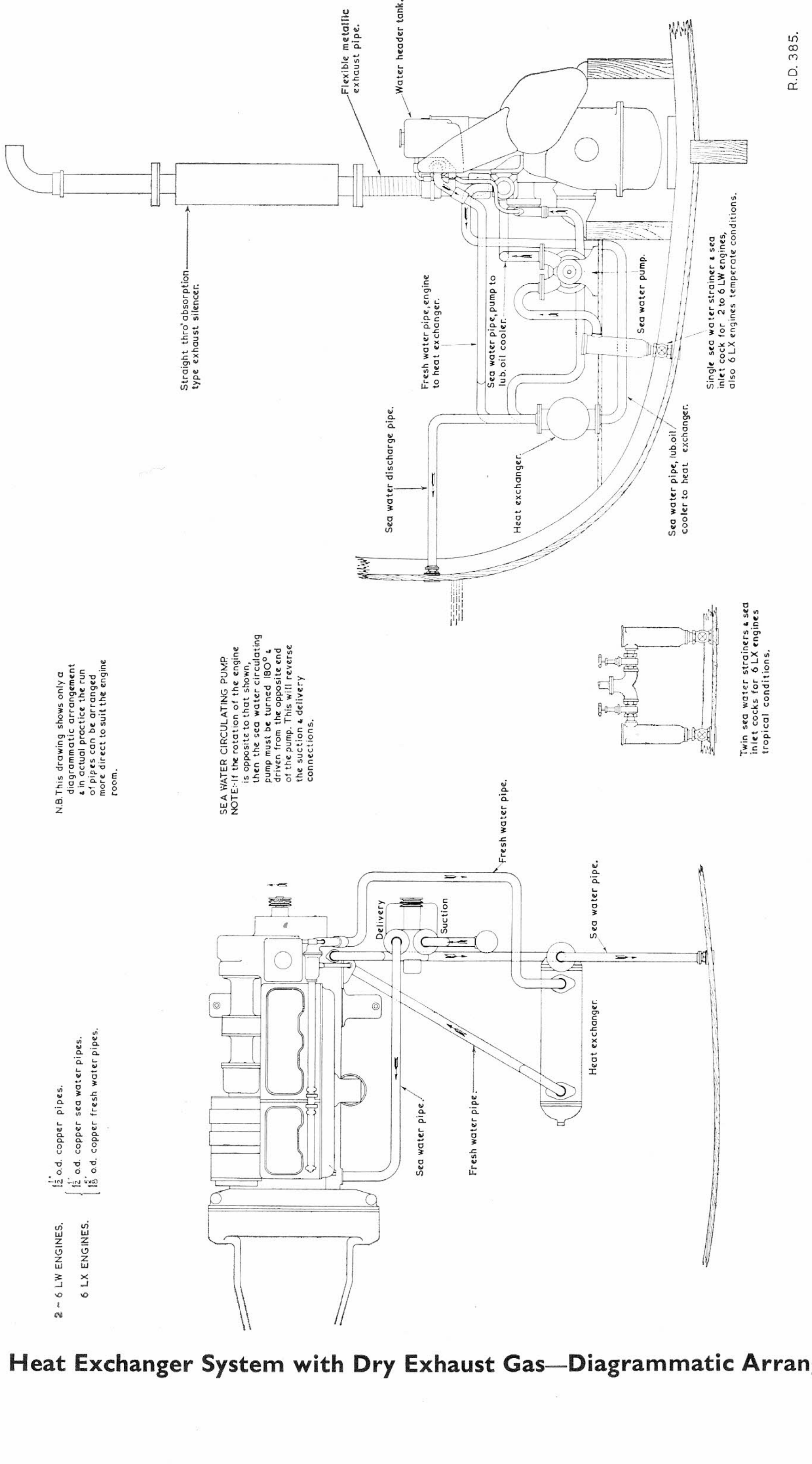


Fig. 57. Heat Exchanger System with Dry Exhaust Gas—Diagrammatic Arrangement

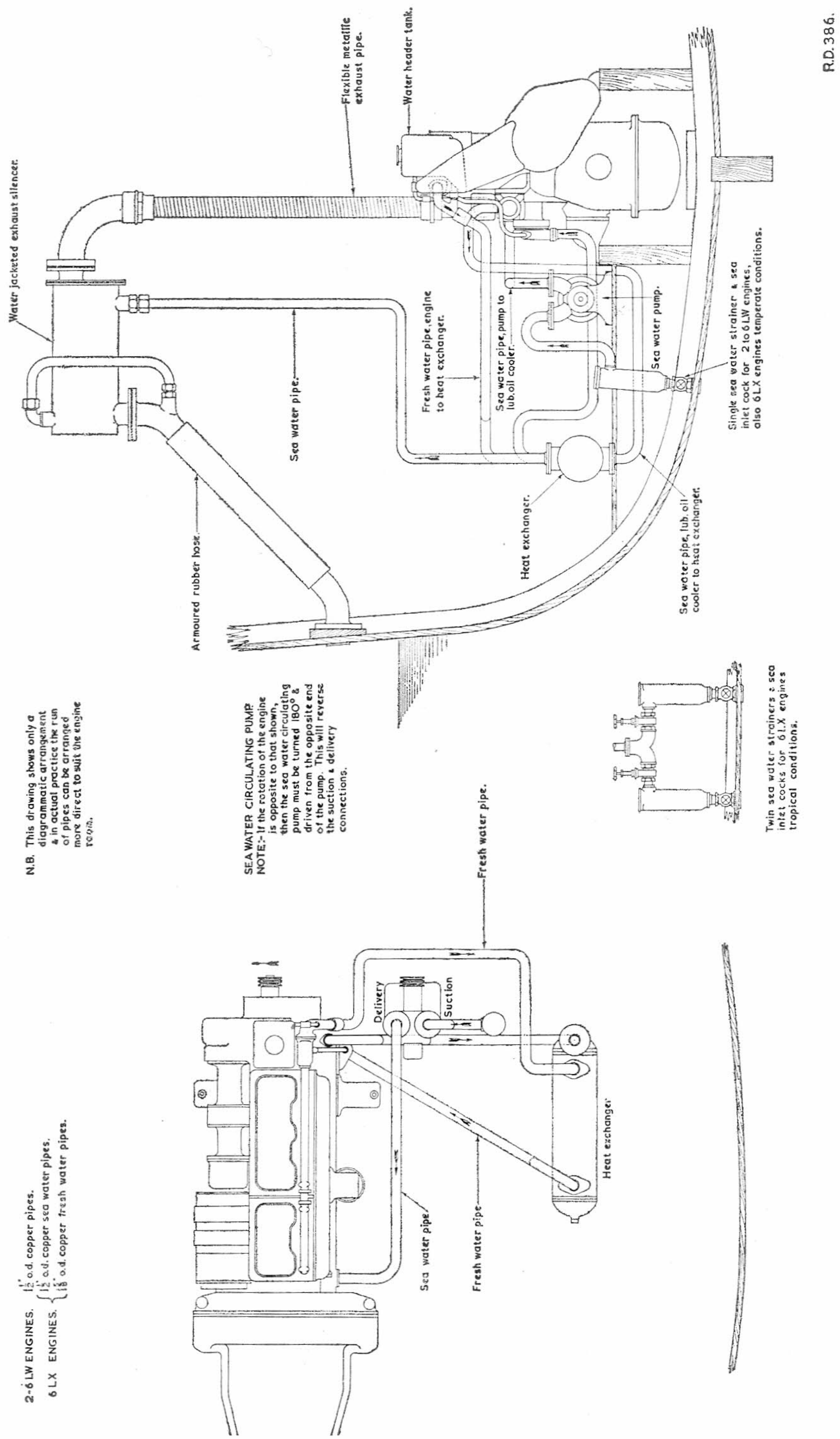


Fig. 58. Heat Exchanger System with Quenched (water cooled) Exhaust Gas —Diagrammatic Arrangement

ELECTRICAL EQUIPMENT

32. 24 volt (min.) equipment is recommended for both the LX and LXB type engines.

33. **DYNAMO.** The dynamo supporting cradle ribs on the fuel pump side of the crankcase are bored to suit dynamos of 8 in. (203·2 mm.) diameter maximum. All engines can be readily arranged to accommodate dynamos of smaller diameter by the provision of special packing pieces machined to ensure perfect alignment of the dynamo drive.

As will be seen from the various illustrations, the dynamo is positively driven through flexible hose type couplings from a sprocket around which passes the main timing chain.

All dynamos up to and including 7 in. (177·8 mm.) are now driven by a 15-tooth sprocket at 1·8 times crankshaft speed except the following:—

C.A.V. Dynamos D5L24A and G524

These dynamos require an 18-tooth sprocket and run at 1·5 times crankshaft speed.

All dynamos over 7 in. (177·8 mm.) diameter are driven by a 20-tooth sprocket at 1·35 times crankshaft speed.

34. **ALTERNATOR.** The alternator is mounted and driven in a similar manner to the dynamo. 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. SL524/7M (5 in. or 127 mm. dia.)
Simms 624 SGRE 52M (6 in. or 152·4 mm. dia.)
Simms 524 SGRH 251/8 (5 in. or 127 mm. dia.)

Mounting parts are also available for Delco Remy and other starters. 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: not exceeding 8 ft. (2,743 mm.) long	61/·044 in.
Dynamo to Battery	98/·012 in.
Field	35/·012 in.
Switch to Starter	35/·012 in.
Ammeter	65/·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

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 Amal flexible 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 marine engine 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.

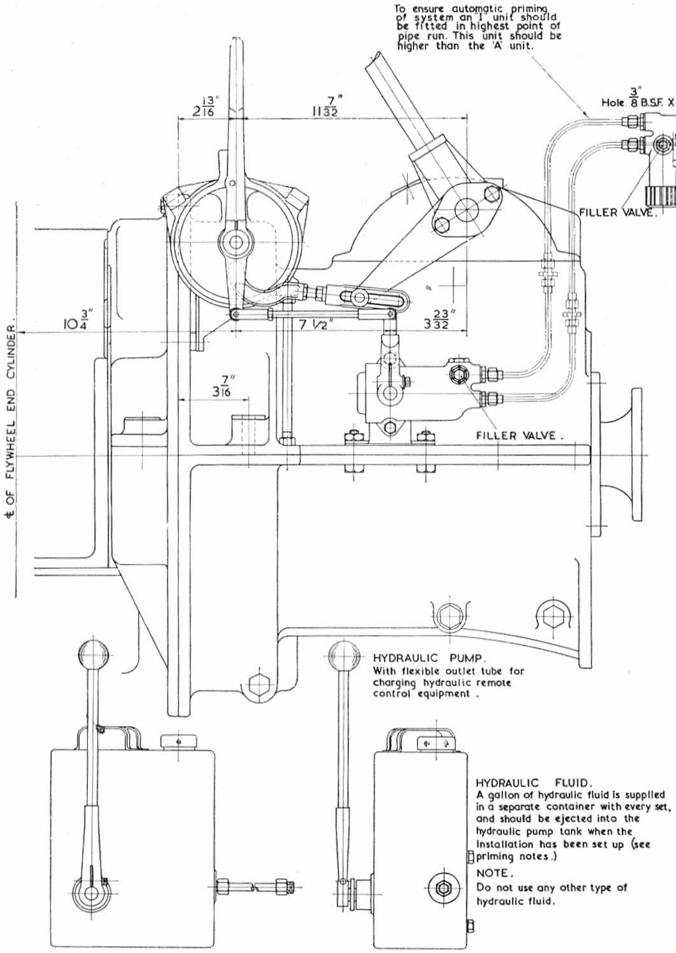
The idling speed adjusting screw is fitted to the Speed Control Plate and the interlocking speed control is so arranged that, when changing from Ahead to Astern or vice versa, the engine speed is automatically reduced to 770 r.p.m. when the gear lever is in the Neutral position.

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.

42. **HYDRAULIC REMOTE SPEED CONTROL.** This equipment can be fitted to new engines or to engines already in service. General arrangement and operational details of the system are shown in Fig. 59 on page 118 and installation drawings will be supplied upon request.

Very little servicing is necessary with this system since there are practically no working parts which are subject to wear.

Fig. 59. Engine Speed Hydraulic Remote Control—Installation Details



CHARGING THE INSTALLATION.
It is desirable to prime the set from the 'B' unit, this is to ensure that the system is free from air. But if necessary priming can be carried out from the 'A' unit.

WHEN THE INSTALLATION HAS BEEN COMPLETED.
Fit vent plug and washer in the 'A' unit, leaving the plug unscrewed about three turns. A drip tray should be placed below the 'A' unit to collect excess oil when priming begins.

Adjust compensator knob to mid-position. i.e. Screw knob till the top is level with the red line marked on the side of the 'A' unit.

Unseat the synchronising screw in the 'A' unit, this is concealed in the base of the compensator knob. Remove the chrome nut from the filler valve in the 'B' unit, and fit the connection on the end of the flexible tube of the hydraulic pump to the filler valve.

Fill the hydraulic pump with oil provided. (If supplied empty). Screw home firmly the synchronising screw in the 'B' unit, this is positioned in the centre of the large nut in the 'B' unit.

Commence pumping until all air is cleared through the vent plug. While pumping, the levers on both units should be repeatedly moved slowly through their full stroke. Unseat the synchronising screw in the lower unit by approximately three turns.

Commence pumping and moving the levers again untill all air is expelled through the vent plug. Continue pumping for a short while after all air is dispelled. Screw home vent plug on the upper unit. Move levers on both units to mid-operating position. Reseat both synchronising screws making sure they are both hard on their seats.

Disconnect the hydraulic pump.
Replace the chrome nut & washer on the 'B' unit.

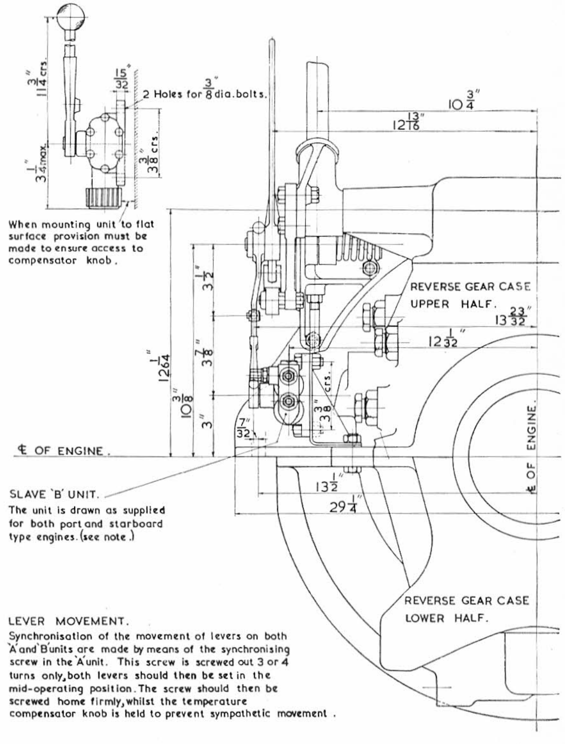
NOTE.
It is essential that the correct type of hydraulic fluid is used.

CLIMATIC CONDITIONS.
Hydraulic slackness or stiffness of the installation due to fluid contraction or expansion brought about by temperature changes can be adjusted by means of the temperature compensator knob.

HYDRAULIC FLUID.
A gallon of hydraulic fluid is supplied in a separate container with every set, and should be ejected into the hydraulic pump tank when the installation has been set up (see priming notes.)

NOTE.
Do not use any other type of hydraulic fluid.

NOTE.
This drawing shows the engine reverse gear with the clutch operating lever and engine speed control. This arrangement will suit both port and starboard type marine engines.



When mounting unit to flat surface provision must be made to ensure access to compensator knob.

SLAVE 'B' UNIT.
The unit is drawn as supplied for both port and starboard type engines. (see note.)

LEVER MOVEMENT.
Synchronisation of the movement of levers on both 'A' and 'B' units are made by means of the synchronising screw in the 'A' unit. This screw is screwed out 3 or 4 turns only, both levers should then be set in the mid-operating position. The screw should then be screwed home firmly, whilst the temperature compensator knob is held to prevent sympathetic movement.

PIPING.
1/4" O.D. Copper pipes are supplied. The advised maximum run (i.e. The distance along twin pipes between units) is 100 feet (30 metres) and the maximum height 30 feet (9 metres.)

The pipe run should be laid out with a steady rise from the lower unit. Pipe bends should be as few in number as possible and should have a radius as large as practicable.

The pipe bend should be smooth and formed without crimping. As an alternative to aid installation nylon pipes can be supplied.

R.D. 327.

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

ENGINE AND GEAR CONTROLS—*continued*

MARINE INSTALLATIONS

The speed control arrangement comprises a hand-lever operated master hydraulic unit connected by copper or nylon piping to a "slave" unit bolted to a support bracket mounted on the reverse gear casing. The "slave" unit is connected by rod and lever to the standard friction disc speed control. Any movement of the hand-lever is therefore instantaneously transmitted to the "slave" unit which is connected to the engine speed control.

The hydraulic system must be initially primed by a priming unit consisting of a small hand-operated plunger type pump complete with hydraulic fluid tank of one gallon capacity. No further attention is required after the initial priming unless of course, the piping, etc. has been dismantled for any reason.

It is not anticipated that it will be necessary for the priming pump, etc. to be supplied with each set of speed control equipment. If a number of vessels belonging to one owner are operating from one port, it would only be necessary to utilise one priming pump and the question of the number of priming units required in other cases would have to be considered on their merits. We shall be glad to advise in this matter whenever necessary.

43. **TELEFLEX REMOTE SPEED CONTROL.** This control system may be supplied with a new engine or for installation on an existing marine unit. When installing this remote control system the following instructions should be carefully observed to ensure smooth, light and positive control of engine speed. Installation details are shown in Fig. 60 on page 120.

Installation. At the operating end secure the swivel assembly to the board in the position shown on drawing. Similarly, at the engine end, the swivel body should be secured to a bracket bolted on the reverse gear casing.

Two fork assemblies are provided. Each fork body should be unscrewed from its tube and plug, and inside the fork bodies will be found a lock spring; these should be removed from the bodies and retained. The outer slide tubes of these fork assemblies should then be pushed on to the slide tubes of the swivel assemblies.

Having secured the end fittings, the run of conduit can now be arranged. This should be as direct as possible with the minimum number of bends, and no bend should exceed 90°. If the run requires a bend, it is preferable that the main length of conduit is straight, with the bend at the ends, rather than have a continuous curve all the way.

Before using any conduit a length of cable should be pushed through to verify that the conduit has not been dented or distorted.

It is preferable to pre-set the conduit wherever bends are involved to avoid straining the ends when connecting them together. Always make a bend by using the circular former supplied. A length of cable inserted in the conduit when making the bend, will act as a flexible mandrel and maintain the bore of the conduit during this operation. The ends of the conduit should be faced off square before bellmouthing. When installed, the conduit should be secured by the clips provided, and these should be fitted about 3 ft. (914 mm.) apart.

Assembly of the conduit can be commenced from either end. Unscrew the nipple from the swivel and slide it over the end of the first length of conduit. This end should then be bellmouthed with the special drift provided. Inserting the end in the swivel body, screw home the nipple and the joint is made.

If the length of run exceeds 10 ft. (3,048 mm.) a connector will be necessary for each additional length, and the same procedure applies for connectors as for the swivels. Proceed until the whole run is installed.

Having completed the run, the cable should be pushed through the conduit from one end until about 2 in. (50·8 mm.) is projecting beyond the plug and slide tube at the remote end. Proceed at this end by screwing the lock spring anti-clockwise on to the end of the cable until there are two helices of the cable visible beyond the end of the lock spring. Push the cable and lock spring into the fork body and screw the plug and outer slide tube in tightly. The end of the cable is now positively locked within the fork body.

Remove the pin and split pin from the fork and connect the fork to the remote lever. Set this lever to its extreme travel, either full open or shut and at the other end set the friction disc lever in the **same relative position** as the remote lever. With the levers so positioned, fit the fork body to the friction disc lever.

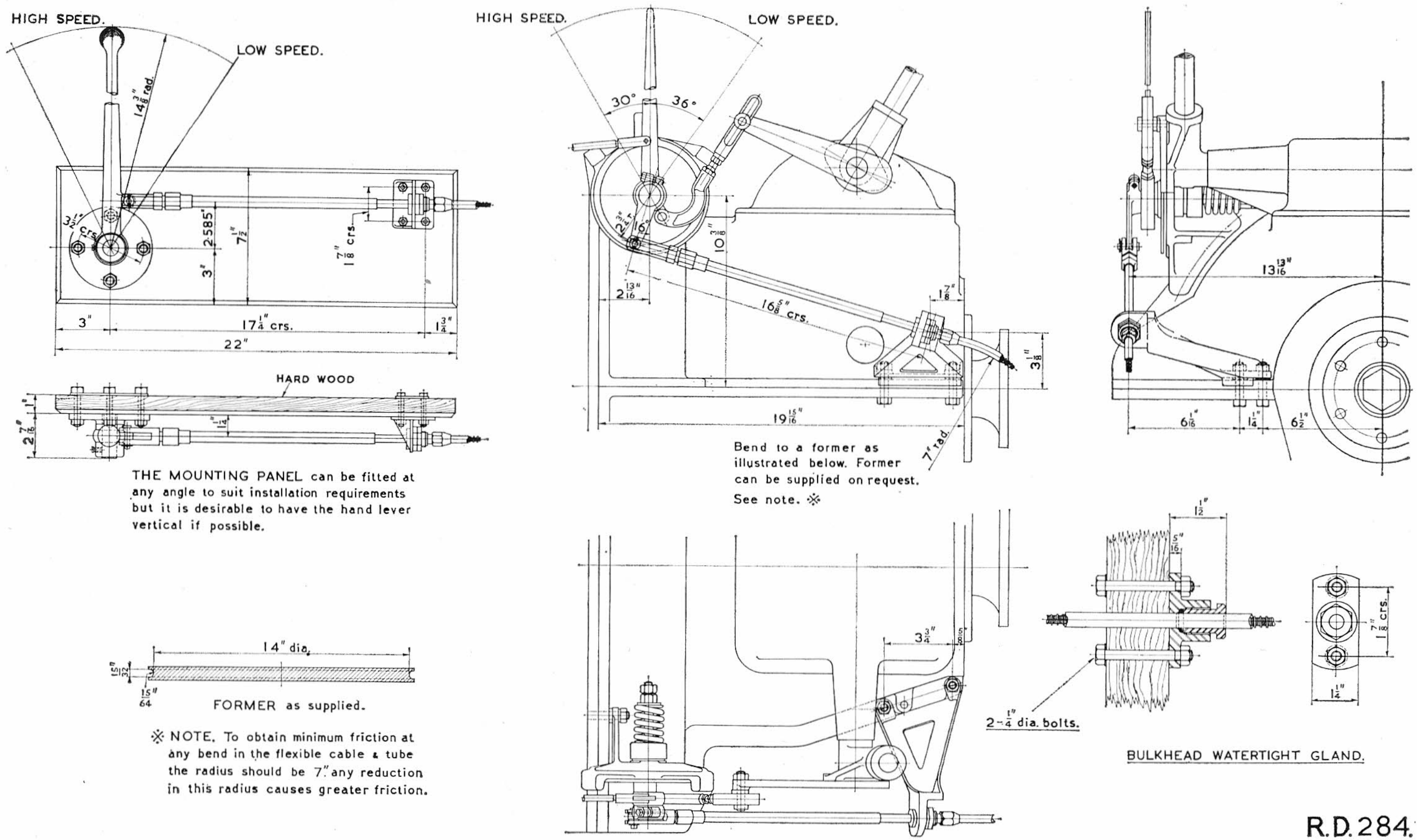


Fig. 60. Teleflex Remote Speed Control—Installation Details

ENGINE AND GEAR CONTROLS—*continued*

MARINE INSTALLATIONS

The cable must now be cut to length so that, when the lock spring is screwed on the cable and the body of the fork is screwed to its slide tube, any movement of one lever will operate the other without backlash.

It might be noted that if the cable has been cut too long, all that need be done is to screw the lock spring further along the cable and cut off a corresponding length from the end. The cable however, cannot be lengthened after cutting, as it is essential that two turns of the cable helix must protrude beyond the end of the lock spring.

Teleflex cables can be easily cut with a fine hacksaw and the ends will not unravel. It is preferable to grind the end of the cable to a conical point to assist in screwing on the lock spring.

When the cable is inserted in the conduit, it should be liberally greased with an anti-freeze grease.

Check after assembly, to ensure that the run is free, that the two levers synchronise throughout their range of movement, and that there is no backlash. Finally, go over each connection and see that all nipples, etc. are tight.

44. **REVERSE GEAR HYDRAULIC REMOTE CONTROL.** 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 Fig. 61 on page 122 and the following instructions have been compiled to facilitate installation of the remote control and indicator mechanism.

45. **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.

46. **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 Fig. 61 on page 122, and the first clip should be fixed at some distance from the Operating Cylinder Unit, 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.

47. **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.

48. **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 Fig. 61, 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*

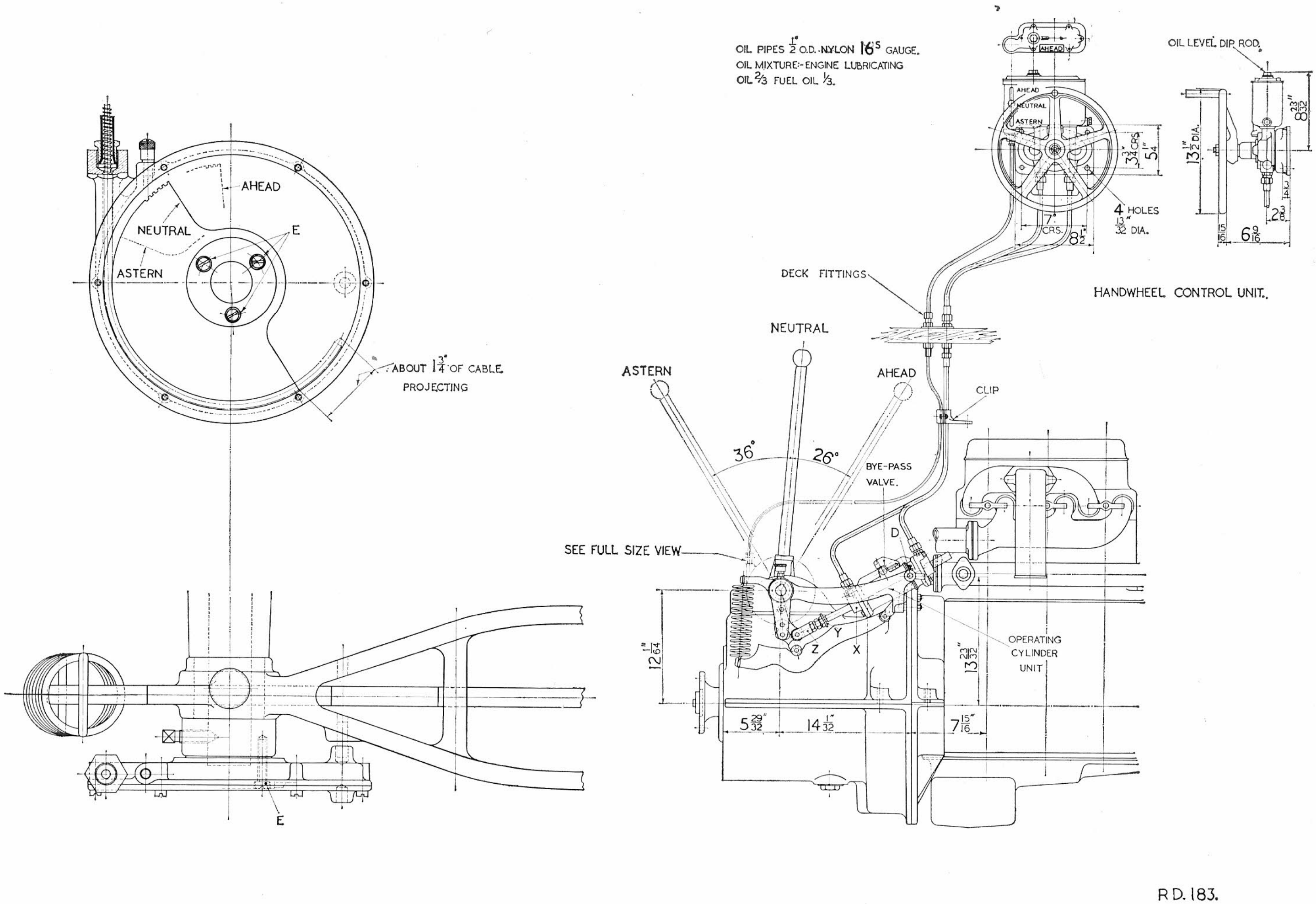


Fig. 61. Reverse Gear Hydraulic Remote Control—Installation Details

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

ENGINE AND GEAR CONTROLS—*continued*

MARINE INSTALLATIONS

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 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" in Fig. 61. 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, as shown in Fig. 61.

Re-assemble the cover and screws "E". It is important to ensure that the quadrant and cable are in the position shown in Fig. 61 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 $3\frac{7}{16}$ 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.

49. **Operating Fluid.** The hydraulic medium is a mixture of two-thirds engine lubricating oil and one-third fuel oil.

50. **SINGLE LEVER HYDRAULIC/MECHANICAL REMOTE CONTROL.** 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.

ENGINE AND GEAR CONTROLS—*continued*

MARINE INSTALLATIONS

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.

A third alternative that may be used for remote operation is the Hydraulic Remote Control System. This comprises a Gardner Handwheel Hydraulic Pump Unit, located in the wheelhouse, which operates the Reverse Gear Valve and Single Lever by means of a Slave Unit mounted on the Reverse Gear.

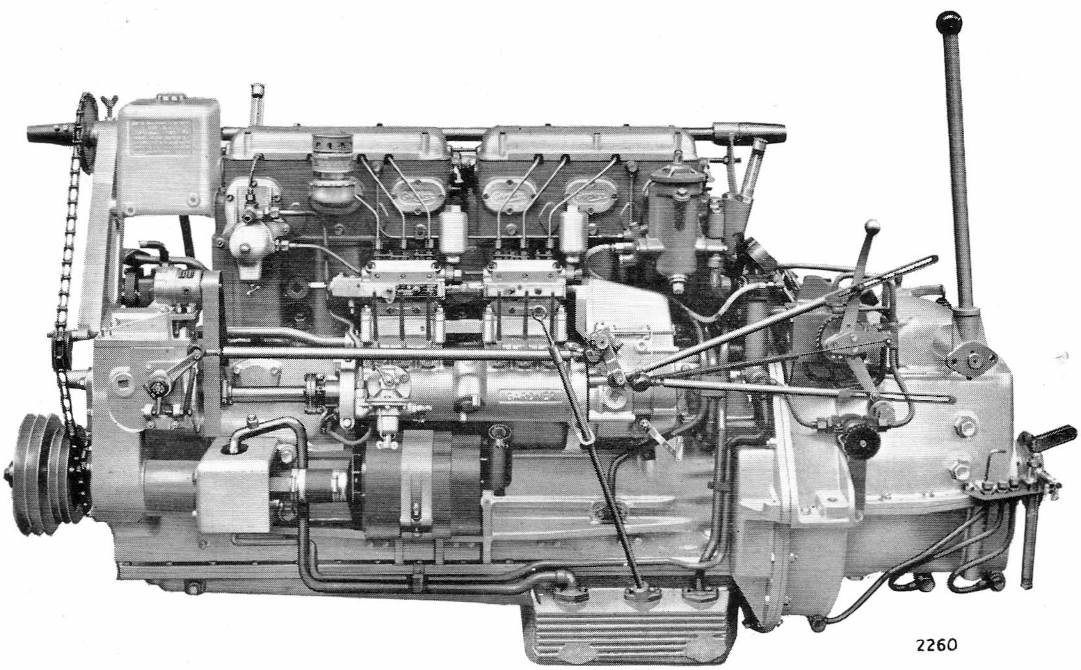
With this system of remote control the Ahead, Neutral and Astern positions of the reverse gear are indicated by coloured lights on an indicator panel in the wheelhouse.

Methods (1) and (2) are recommended where "the run" from wheelhouse to engine room is short and does not include more than four changes in direction.

The Hydraulic Remote Control System is recommended where "the run" from wheelhouse to engine room is long and/or complicated, or when Dual Station Control is to be installed.

The advice and co-operation of our Technical Staff will be willingly offered upon receipt of any enquiry concerning installation details.

Full instructions covering the service and maintenance of the Single Lever Control System are contained in Instruction Book No. 64.



6LX Marine Propulsion Unit with No. 2 U.C. Direct Drive Reversing Gear and Single Lever Control for Engine Speed and Reverse Gear

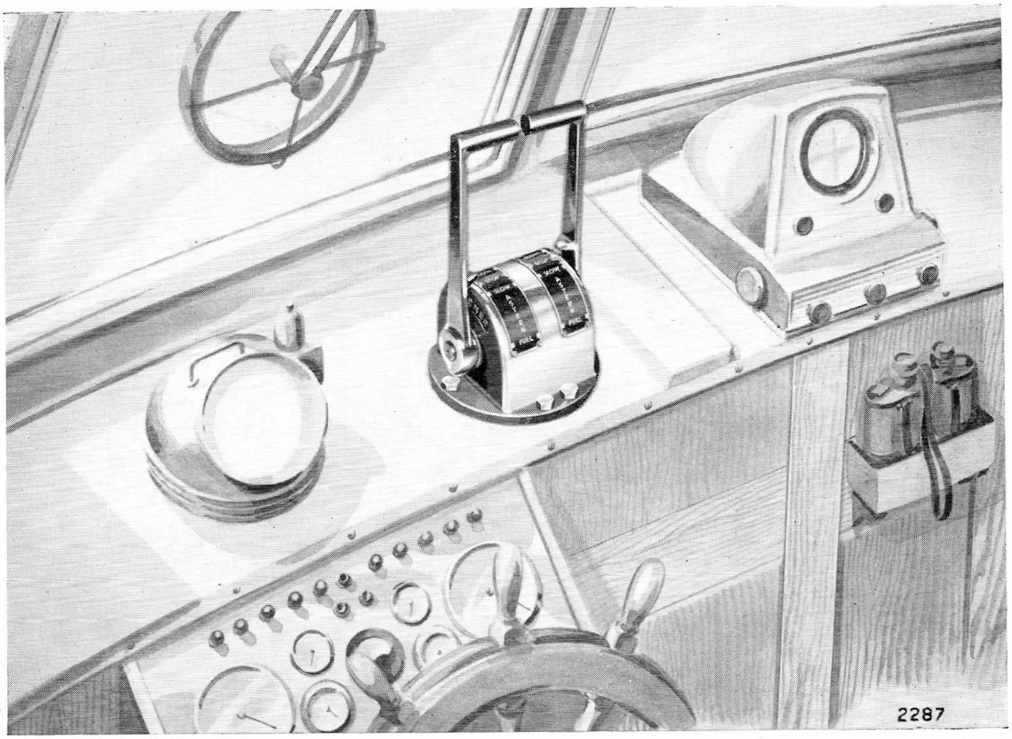


Fig. 62. Gardner Wheelhouse Control Unit for Twin Engine Installations

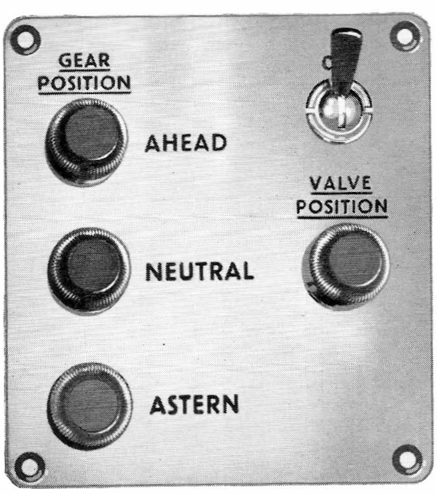


Fig. 63. Indicator Lights Panel

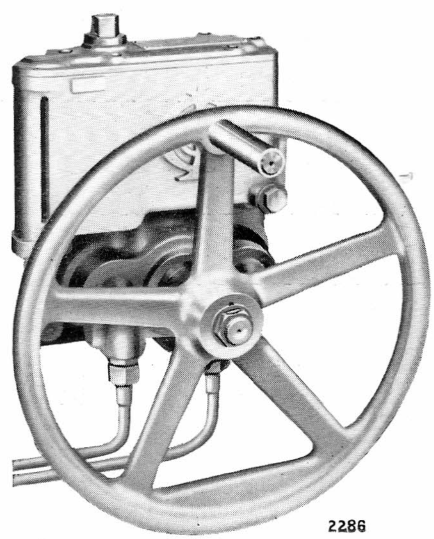


Fig. 64. Handwheel Hydraulic Pump Unit

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

STERNGEAR AND PROPELLER SIZES

51. **SHAFT SIZES.** To conform to Lloyd's Rules, the intermediate and tail shaft diameters are to be not less than those given in the following tables. The sizes quoted in Table "A" are for shafts not fitted with continuous liners and made of ordinary mild steel, having an ultimate tensile strength of 28 to 32 tons per sq. in. (44 to 50 kg. mm.).

Table "B" gives the equivalent sizes for bronze tail shafts and intermediate shafts.

Alternative sterngear specifications can be supplied to suit customers' special requirements.

52. **STERNTUBES.** The dimensions given in Table "C" are for bronze sterntubes having white metal lined bearings and are approximate only. Confirmation and precise dimensions must be obtained from the Works before installation.

53. **PLUMMER BLOCKS.** Intermediate shafts having lengths in excess of 6 ft. (1,829 mm.) should be supported by a plummer block.

The plummer block should be positioned not less than 4 ft. (1,219 mm.) from the reducing gear intermediate shaft half couplings. A certified sterngear arrangement drawing will be provided for all installations where propeller equipment is supplied with the engine.

TABLE "A"

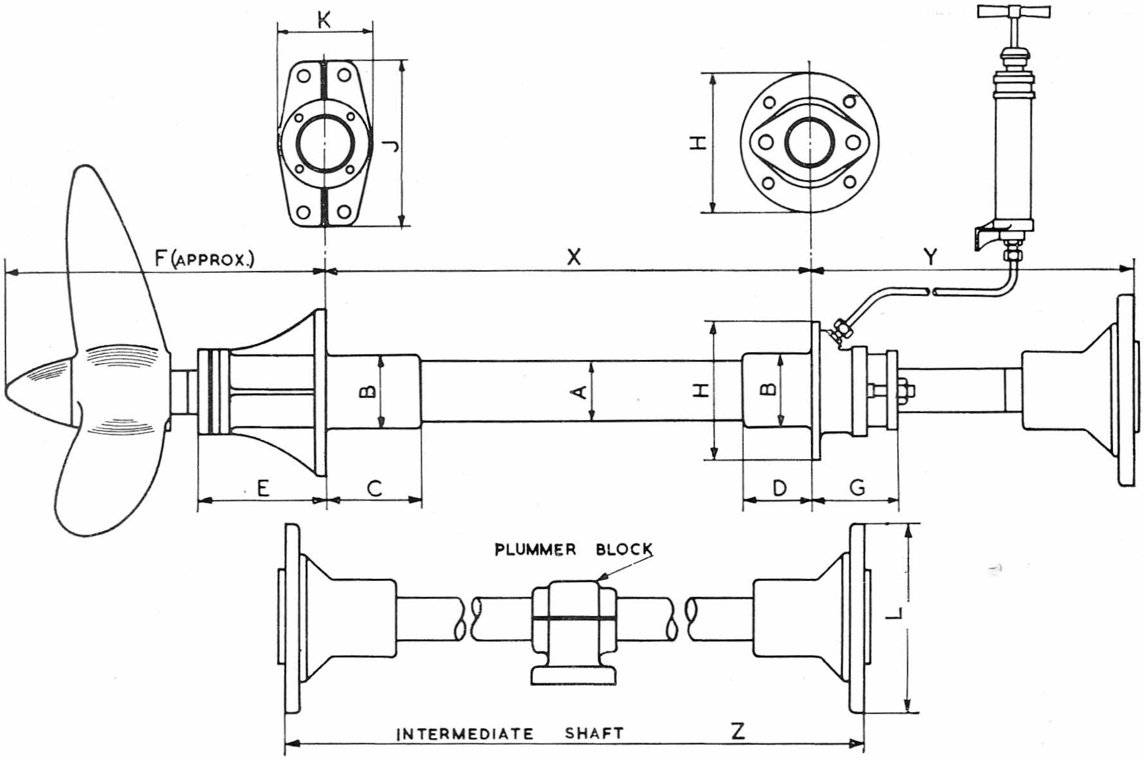
STEEL SHAFT SIZES							
ENGINE RATING		DIRECT DRIVE		2:1 REDUCING GEAR		3:1 REDUCING GEAR	
B.H.P.	R.P.M.	Intermediate Shaft	Tail Shaft	Intermediate Shaft	Tail Shaft	Intermediate Shaft	Tail Shaft
110	1,300	1·712 in. (43·485 mm.)	2·058 in. (52·273 mm.)	2·143 in. (54·432 mm.)	2·600 in. (66·040 mm.)	2·459 in. (62·459 mm.)	3·011 in. (76·479 mm.)
127	1,500	1·714 in. (43·536 mm.)	2·060 in. (52·324 mm.)	2·143 in. (54·432 mm.)	2·601 in. (66·065 mm.)	2·459 in. (62·459 mm.)	3·011 in. (76·479 mm.)
144	1,700	1·713 in. (43·51 mm.)	2·059 in. (52·298 mm.)	2·145 in. (54·483 mm.)	2·602 in. (66·09 mm.)	2·460 in. (62·484 mm.)	3·013 in. (76·53 mm.)

TABLE "B"

BRONZE SHAFT SIZES							
ENGINE RATING		DIRECT DRIVE		2:1 REDUCING GEAR		3:1 REDUCING GEAR	
BH.P.	R.P.M.	Intermediate Shaft	Tail Shaft	Intermediate Shaft	Tail Shaft	Intermediate Shaft	Tail Shaft
110	1,300	2·037 in. (51·739 mm.)	2·399 in. (60·934 mm.)	2·55 in. (64·77 mm.)	3·027 in. (76·885 mm.)	2·925 in. (74·295 mm.)	3·502 in. (88·95 mm.)
127	1,500	2·039 in. (51·790 mm.)	2·401 in. (60·985 mm.)	2·551 in. (64·795 mm.)	3·028 in. (76·911 mm.)	2·925 in. (74·295 mm.)	3·502 in. (88·95 mm.)
144	1,700	2·038 in. (51·765 mm.)	2·4 in. (60·96 mm.)	2·552 in. (64·82 mm.)	3·03 in. (76·962 mm.)	2·927 in. (74·345 mm.)	3·503 in. (88·975 mm.)

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

BRONZE STERNGEAR



DIMENSIONS X & Y MUST BE SUPPLIED BY CLIENTS WHEN ORDERING STERNGEAR, ALSO DIMENSION Z IF INTERMEDIATE SHAFT IS REQUIRED

TABLE "C"

DESCRIPTION	A	B	C	D	E	F	G	H	J	K	L
Direct Drive	3 in. (76 mm.)	$3\frac{3}{8}$ in. (86 mm.)	$4\frac{3}{8}$ in. (111 mm.)	$3\frac{7}{8}$ in. (98 mm.)	6 in. (152 mm.)	16 in. (406 mm.)	$4\frac{1}{8}$ in. (105 mm.)	$7\frac{1}{8}$ in. (181 mm.)	$7\frac{5}{8}$ in. (194 mm.)	$4\frac{1}{4}$ in. (108 mm.)	$6\frac{1}{2}$ in. (165 mm.)
2:1 Reduction	$3\frac{1}{2}$ in. (89 mm.)	$3\frac{7}{8}$ in. (98 mm.)	$6\frac{7}{8}$ in. (175 mm.)	$5\frac{1}{4}$ in. (133 mm.)	$6\frac{1}{2}$ in. (165 mm.)	$17\frac{1}{2}$ in. (445 mm.)	5 in. (127 mm.)	$7\frac{3}{4}$ in. (197 mm.)	$8\frac{3}{4}$ in. (222 mm.)	5 in. (127 mm.)	$8\frac{1}{2}$ in. (216 mm.)
3:1 Reduction	4 in. (102 mm.)	$4\frac{3}{4}$ in. (121 mm.)	$8\frac{1}{2}$ in. (216 mm.)	$5\frac{3}{4}$ in. (146 mm.)	$6\frac{3}{4}$ in. (171 mm.)	$19\frac{3}{4}$ in. (502 mm.)	$5\frac{1}{4}$ in. (133 mm.)	9 in. (229 mm.)	$10\frac{1}{2}$ in. (267 mm.)	$6\frac{3}{4}$ in. (171 mm.)	$8\frac{1}{2}$ in. (216 mm.)

STERNGEAR AND PROPELLER SIZES—*continued*

54. **PROPELLER SIZES.** The propeller sizes given in Table "D" are average figures as stated by manufacturer and may vary according to the lines of the vessel. Unqualified approval cannot be given without full knowledge of the complete shaft line and propeller design.

Four-bladed propellers are not recommended for shaft speeds in excess of 700 to 800 r.p.m.

Direct Drive standard engines require left-hand propellers and standard engines with Reducing Gears require right-hand propellers.

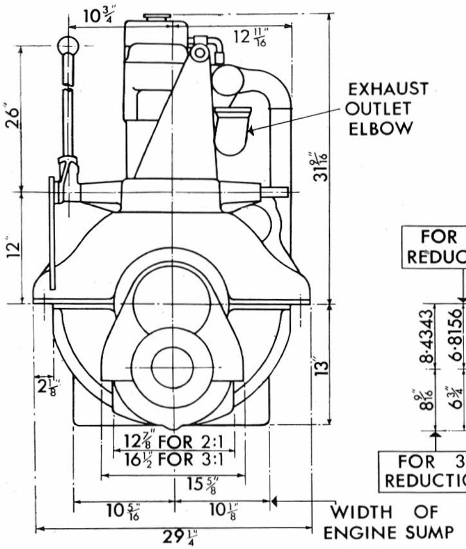
NOTE.—The Reduction gear ratios referred to in the dimension tables as 2:1 and 3:1 are actually 1·962:1 and 2·960:1 respectively.

TABLE "D"

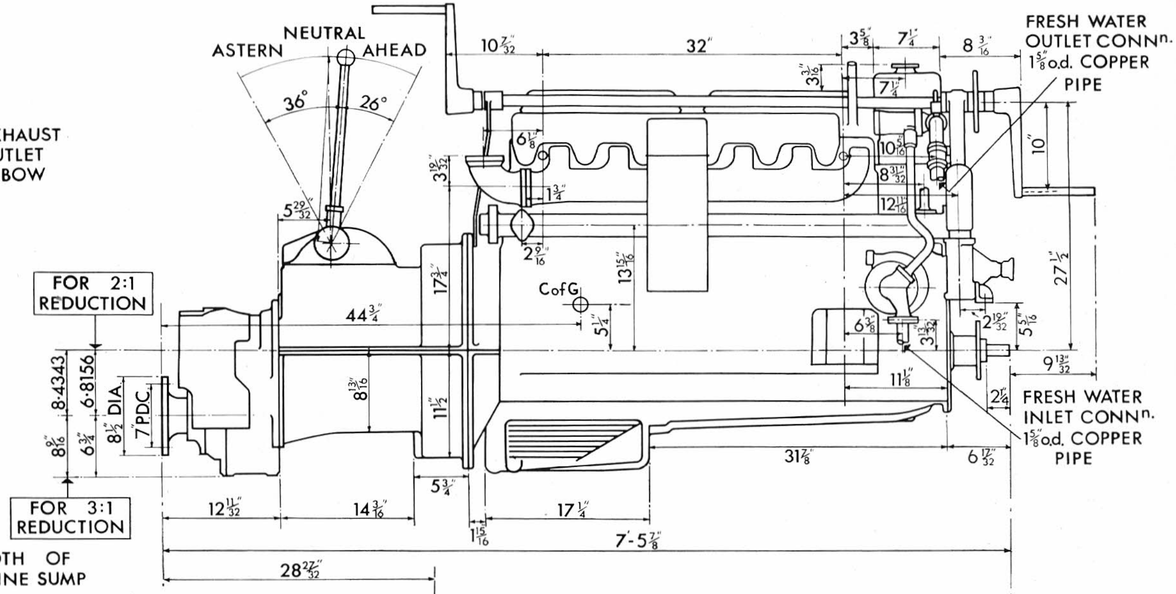
APPROXIMATE PROPELLER SIZES							
ENGINE RATING		DIRECT DRIVE		2:1 REDUCING GEAR		3:1 REDUCING GEAR	
B.H.P.	R.P.M.	3-Bladed	4-Bladed	3-Bladed	4-Bladed	3-Bladed	4-Bladed
110	1,300	26 in. (660·4 mm.)	—	35 in. (889 mm.)	32·5 in. (825·5 mm.)	43 in. (1,092·2 mm.)	40 in. (1,016 mm.)
127	1,500	23·5 in. (596·9 mm.)	—	31·5 in. (800·1 mm.)	30 in. (762 mm.)	38 in. (965·2 mm.)	35 in. (889 mm.)
144	1,700	23 in. (584·2 mm.)	—	31 in. (787·4 mm.)	—	37 in. (939·8 mm.)	35 in. (889 mm.)

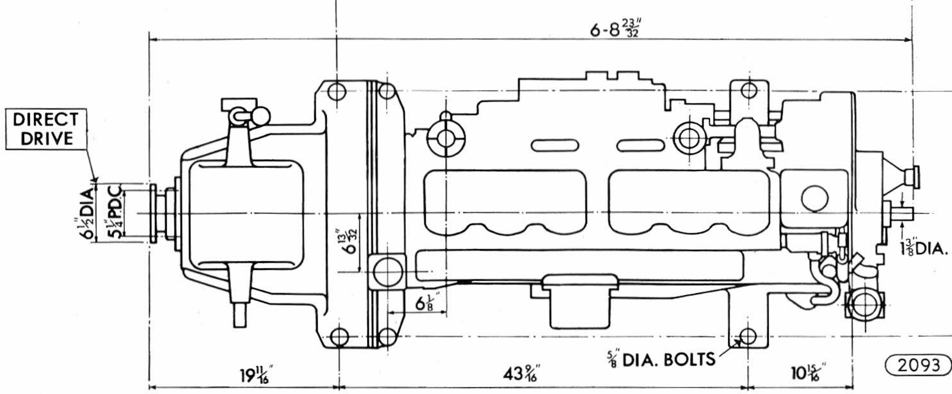
6LX MARINE ENGINE WITH No. 2 U.C. REVERSING AND REDUCING GEARS

OUTLINE AND DIMENSIONS



VIEW LOOKING FORWARD



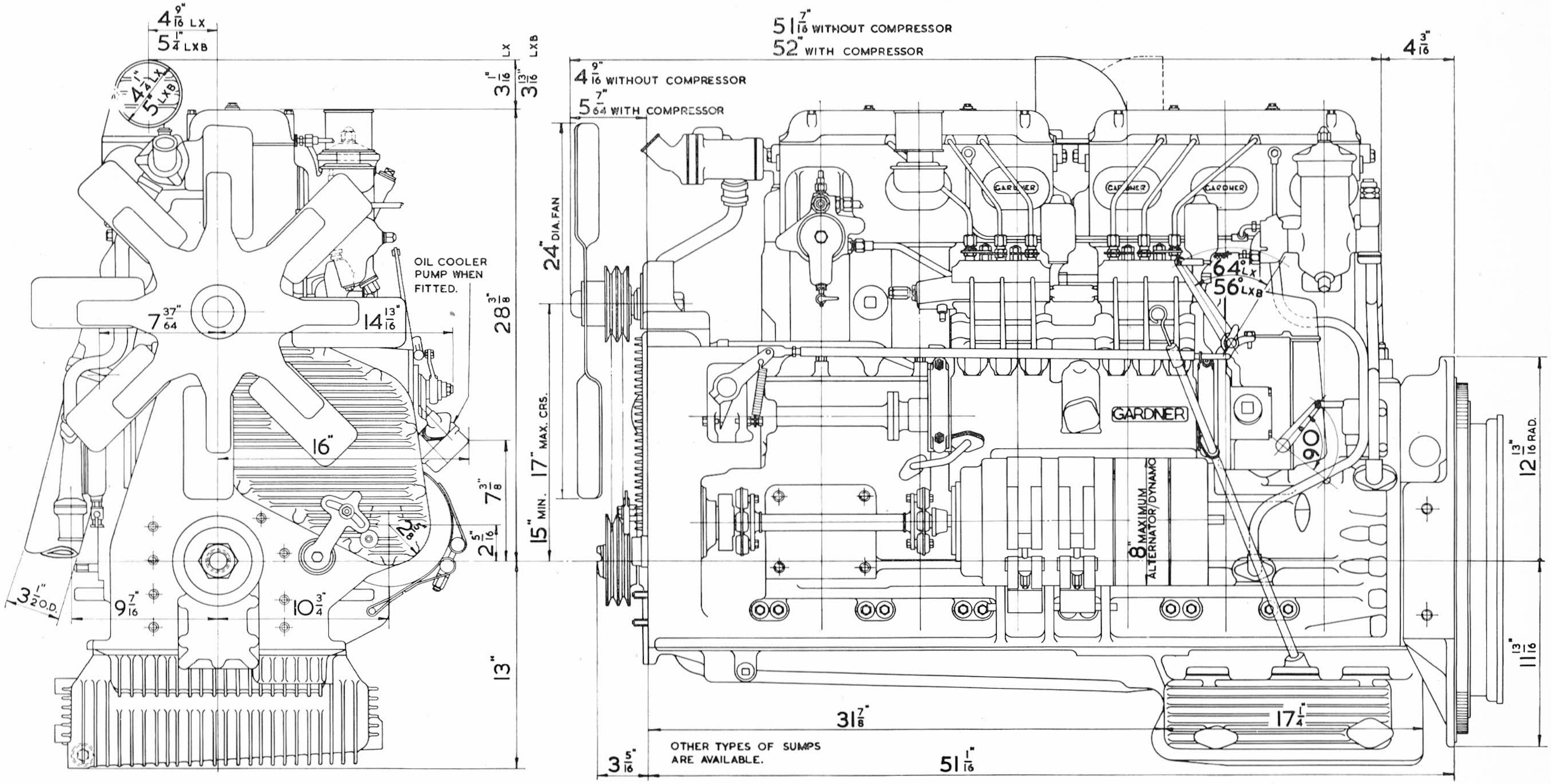


NORMAL STATIC INCLINATION AFT 7°
FOR GREATER INCLINATION CONSULT
MANUFACTURES

FULLY DIMENSIONED SCALE
DRAWINGS MUST BE OBTAINED
FOR USE WHEN DESIGNING
INSTALLATION LAYOUT

6LX & 6LXB AUTOMOTIVE ENGINE

OUTLINE AND DIMENSIONS

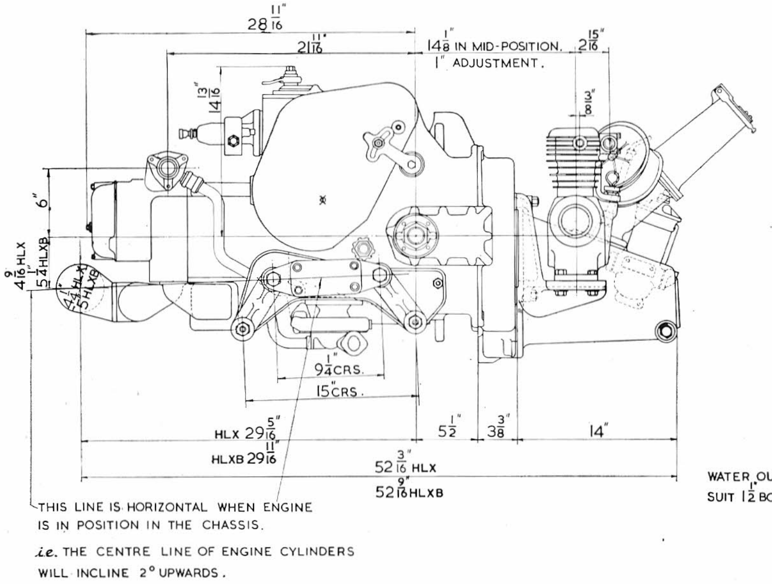


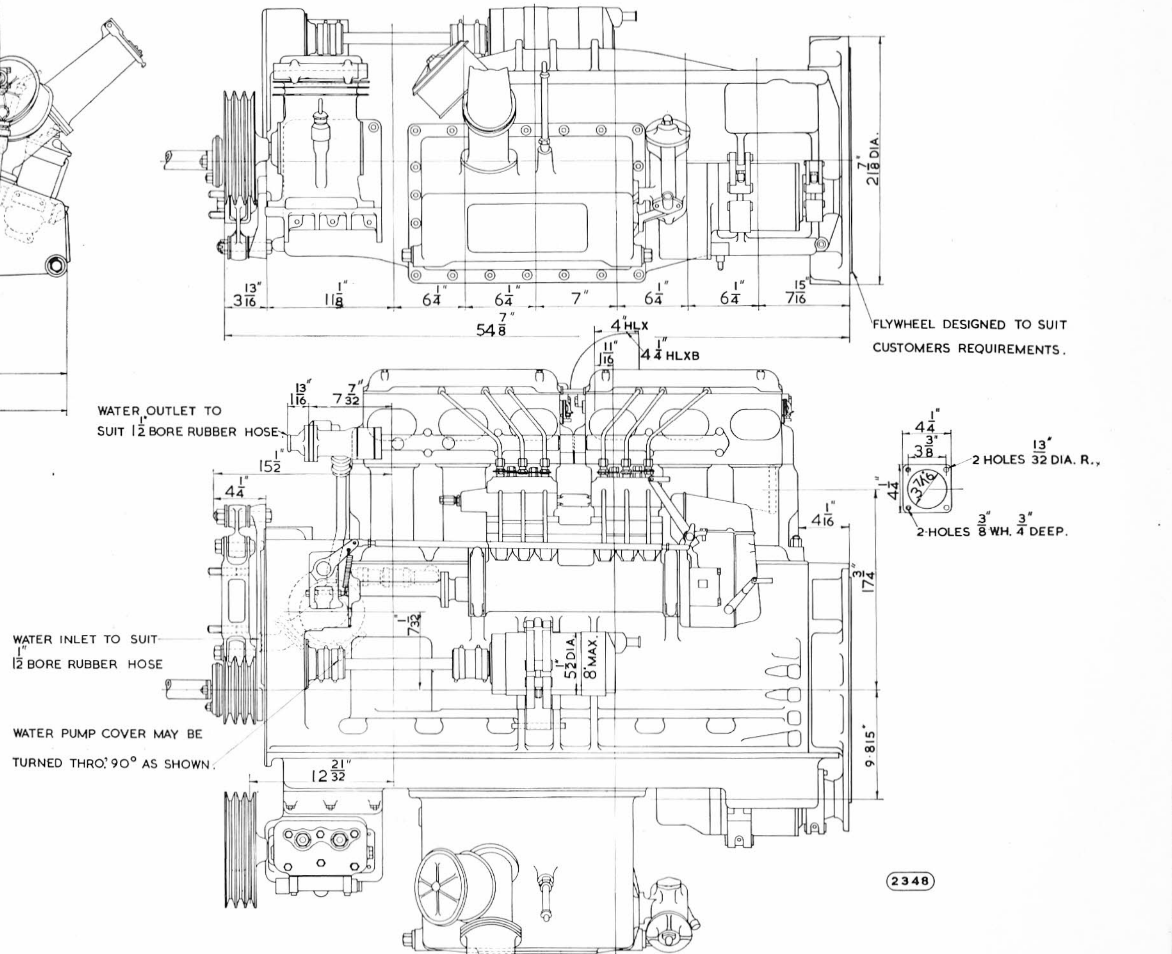
FULLY DIMENSIONED SCALE DRAWINGS MUST BE OBTAINED
FOR USE WHEN DESIGNING INSTALLATION LAYOUT.

(2347)

6HLX & 6HLXB AUTOMOTIVE ENGINE

OUTLINE AND DIMENSIONS

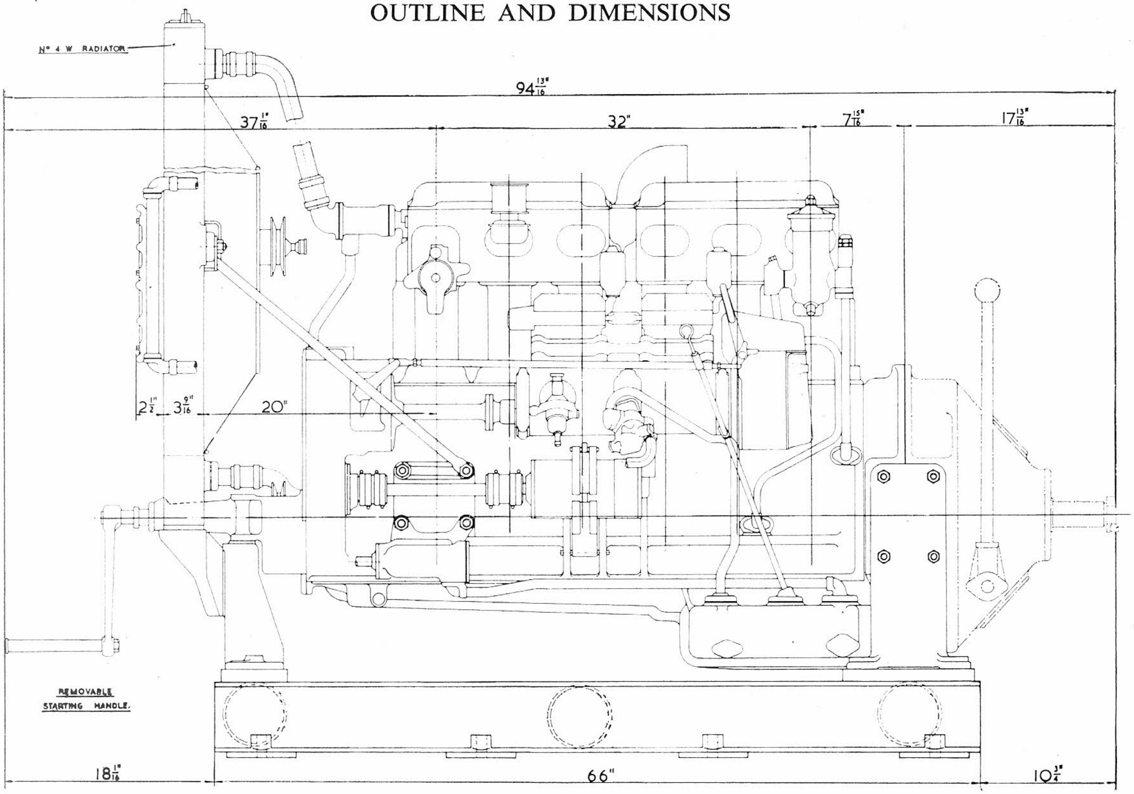


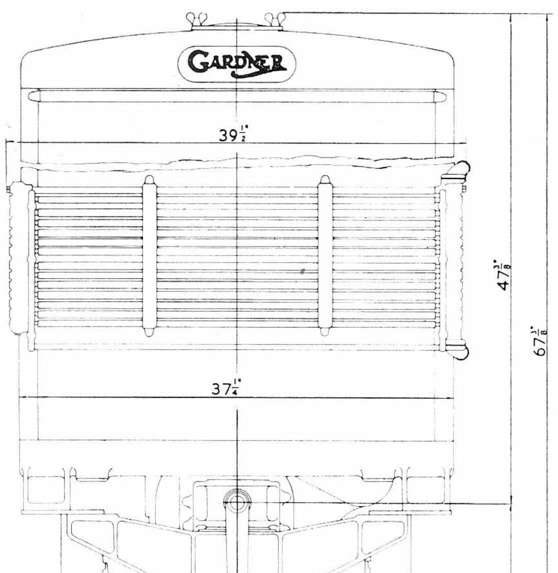


FULLY DIMENSIONED SCALE DRAWINGS MUST BE OBTAINED FOR USE WHEN DESIGNING INSTALLATION LAYOUT

INDUSTRIAL UNIT

OUTLINE AND DIMENSIONS





FULLY DIMENSIONED SCALE
DRAWINGS MUST BE OBTAINED
FOR USE WHEN DESIGNING
INSTALLATION LAYOUT

OUTLINE DRAWING SHOWING BASIC DIMENSIONS OF 6LX ENGINE WITH UNIT - CONSTRUCTION CLUTCH AND POWER TAKE - OFF.

NON - UNIT CONSTRUCTION ASSEMBLIES WITH AND WITHOUT CLUTCH CAN BE SUPPLIED.

INSTALLATION INSTRUCTIONS AND RECOMMENDATIONS

SPACE REQUIRED FOR REMOVAL OF COMPONENTS

55. 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	4½ in.	(114 mm.)
	Space required for removal of non-standard types of sumps will be supplied upon request.		
(*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.	(203 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*)	Chase 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*)	Reducing Gear Case Cover with shaft, half coupling and gear	5¼ in.	(133 mm.)

56. **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.