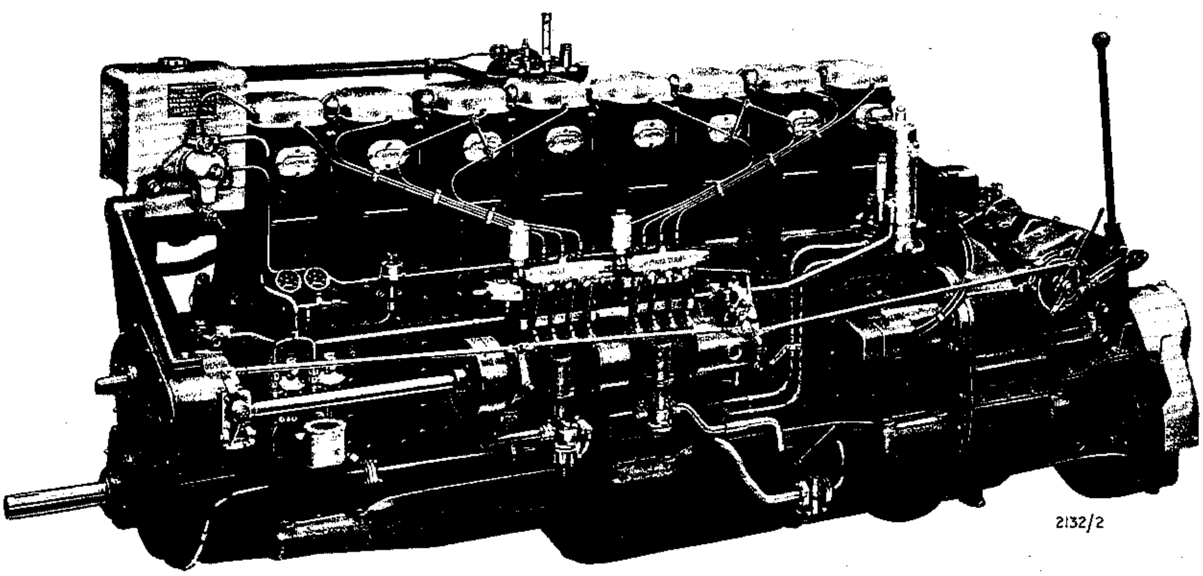
GENERAL DIRECTIONS

for the Management and Care of

GARDNER

L3B DIESEL ENGINES

Vertical — Four-Cycle — Compression-Ignition
Airless Fuel Injection



2132/2

THE 8L3B MARINE PROPULSION DIESEL ENGINE WITH No. 3 U.C. REVERSING AND 3 : 1 REDUCING GEARS

GARDNER ENGINES (SALES) LTD.

Head Office and Works:

BARTON HALL ENGINE WORKS, PATRICROFT, ECCLES, MANCHESTER

Telegrams: Gardworks, Eccles, Manchester. Telephones: ECCles 2201 (8 lines)

London Office: ABFORD HOUSE, WILTON ROAD, S.W.1.

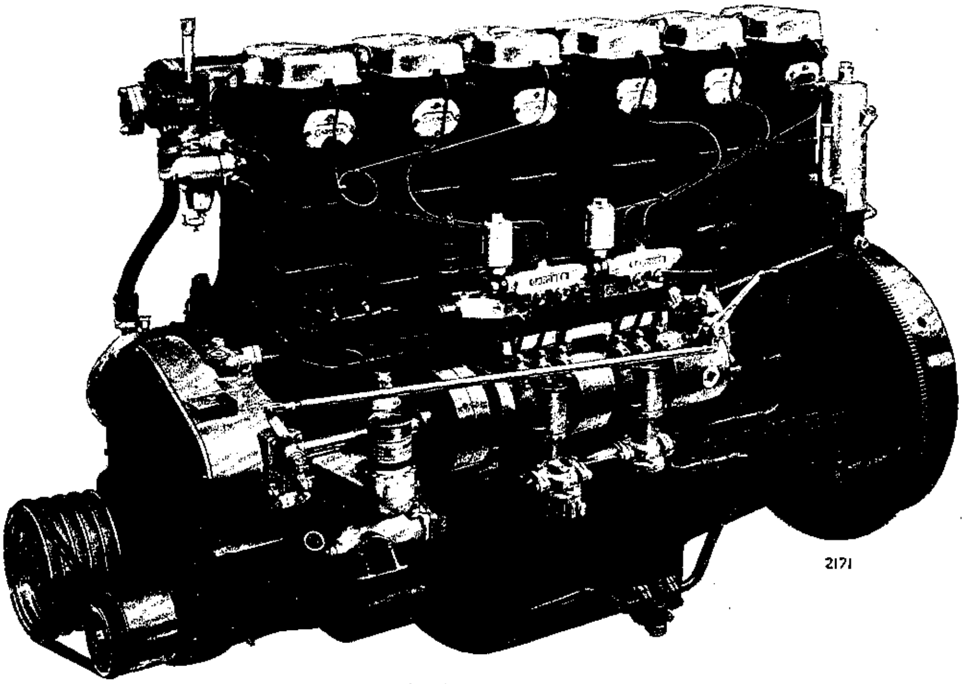
Inland Telegrams: Gardiesel, Sowest, London. Telephones: TATe Gallery 3315-6
Overseas Cables: Gardiesel, London, S.W.1.

SCOTTISH BRANCH:

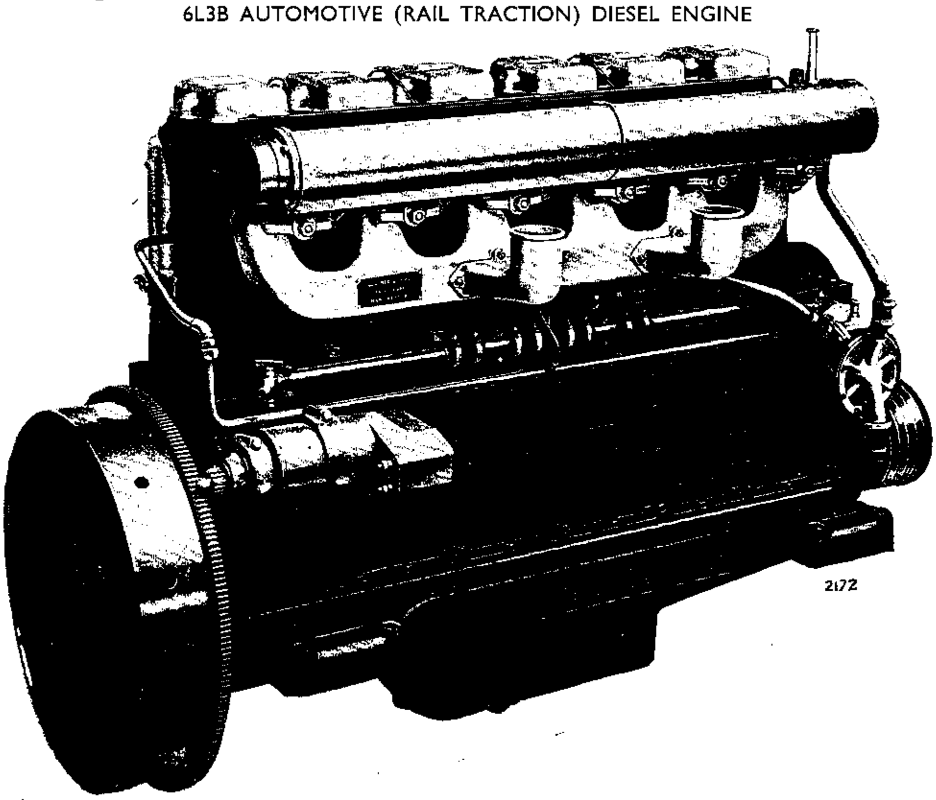
124 ST. VINCENT STREET, GLASGOW, C.2.

Telegrams: Glasgard, Glasgow. Telephones: Central 0887/8

Printed in England by The Cloister Press Ltd., Heaton Mersey, Stockport. 2m/10/63



6L3B AUTOMOTIVE (RAIL TRACTION) DIESEL ENGINE



GARDNER

SERVICE

UNITED KINGDOM

GARDNER ENGINES (SALES) LTD.

HEAD OFFICE AND WORKS
BARTON HALL ENGINE WORKS, PATRICROFT, ECCLES, MANCHESTER
Telegrams : Gardworks Eccles Manchester. *Telephones* : ECCles 2201 (8 lines).

LONDON OFFICE
ABFORD HOUSE, WILTON ROAD, S.W.1.
Telegrams : Gardiesel Sowest London. *Telephones* : TATe Gallery 3315 & 3316.

GLASGOW OFFICE
124, ST. VINCENT STREET, GLASGOW, C.2.
Telegrams : Glasgard Glasgow. *Telephone* : CENtral 0887 & 0888.

REPRESENTATION IN NORTHERN IRELAND AND EIRE
GARDNER ENGINES IRELAND LIMITED, 13, SYDENHAM ROAD, BELFAST.
Telegrams : Doxide Belfast. *Telephone* : Belfast 59522.

The following are officially appointed Service Agents or Recommended Repairers who carry Stocks of Spare Parts. At these Depots are Practical Engineers from whom users of Gardner Engines can rely upon obtaining assistance and advice regarding their Engines.

OFFICIAL SERVICE AGENTS AND DISTRICT STOCKISTS

County	Name and Address	Telephone Numbers		Telegraphic Address
		Day	Night	
ABERDEENSHIRE ...	James Bowen & Sons Ltd., Ashgrove Engineering Works, Ashgrove, Aberdeen	Aberdeen 43332 ...	—	Boweng Aberdeen
	J. S. Pirie, Harbour Road, Fraserburgh. (*Marine only*) ...	Fraserburgh 14 ...	—	Pirie, Engineer, Fraserburgh
AYRSHIRE	Armstrong & Marr, The Garage, Maidens. (*Marine only*)...	Turnberry 210 ...	—	Marr, Turnberry, 210
BEDFORDSHIRE ...	West Park Engineering Co. Ltd., 405 Dunstable Rd., Luton	Luton 52372/3/4 ...	Luton 52372/3/4 ...	Luton 52372/3/4
DERBYSHIRE ...	North Derbyshire Engineering Co. Ltd., Unity Garage, Darley Dale, near Matlock, Derbyshire	Darley Dale 3381/2/3	Darley Dale 3381/2/3	Darley Dale 3381/2/3
DEVONSHIRE ...	Autopart Engineering Co. Ltd., Haven Road, Exeter ...	Exeter 73429 ...	—	Exeter 73429

GARDNER

OFFICIAL SERVICE AGENTS AND DISTRICT STOCKISTS—Continued

County	Name and Address	Telephone Numbers Day	Telephone Numbers Night	Telegraphic Address
EDINBURGH ...	J. Bowen & Sons, Ltd., 45 to 59 Pitt Street, Edinburgh, 3	Edinburgh Waverley 4204 (7 lines)	Edinburgh Wav. 4204	Boweng Edinburgh Telex 72/235
GLAMORGANSHIRE	Fairwood Garages Ltd., 708, Gower Road, Upper Killay, Swansea ...	Swansea 23830 ...	Swansea 23519 ..	Swansea 23830
GLOUCESTERSHIRE	Watts (Factors) Ltd., High Street, Lydney ...	Lydney 392/3/4/5 ...	Lydney 392/3/4/5 ...	Watts Lydney
HAMPSHIRE ...	Fodens Ltd., Southern Depot, Cowplain, Portsmouth ...	Waterlooville 2108...	Waterlooville 2108...	Fodens Cowplain Hants
LANCASHIRE ...	Atkinson Vehicles Ltd., Winery Lane, Walton-le-Dale, Preston ...	Preston 84284/5/6/7	Preston 84284/5/6/7	Wagons Preston
	C.V.R. (Engineers) Ltd., 37 Virgil Street, Liverpool, 5 ...	North 1808/9 ...	Waterloo 5010	North 1808/9
LANARKSHIRE ...	Gardner Engines (Sales) Ltd., 124, St. Vincent Street, Glasgow, C.2, and 41, York Street, Glasgow, C.2.	Glasgow Cent. 0887/8	Glasgow, Giffnock 3754 (by arrangement)	Glasgard Glasgow
LEICESTERSHIRE ...	Parrs (Leicester) Ltd., Abbey Lane, Leicester ...	Leicester 61511/2/3...	Leicester 61511/2/3...	Garage Leicester
LONDON ...	Gardner Engines (Sales) Ltd., Abford House, Wilton Road, London, S.W.1, and	TateGallery3315&3316	—	Gardiesel Sowest London
	76 Gt. Suffolk St., Southwark, London, S.E.1 ...	Waterloo 7203 ...	Croydon 8086 (by arrangement)	Gardiesel London SE1
MORAYSHIRE ...	Henry Fleetwood & Sons, Baker Lane, Lossiemouth ... *(Marine only)*	Lossiemouth 3015 ...	—	Fleetwood Lossiemouth 3015
NORTHAMPTON-SHIRE ...	Sellars & Batty (Sales) Ltd., Fengate, Peterborough ...	Peterborough 67048/9	Peterborough 67048/9	Peterborough 67048/9
NORTHUMBERLAND	W. L. Paynter Ltd., 51/53 Melbourne St., Newcastle-on-Tyne, 1 ...	Newcastle 29594/5 ...	Newcastle 650382 ...	Paynter Newcastle 29594/5
STAFFORDSHIRE ...	Beech's Garage (Hanley) Ltd., Hope St., Hanley, Staffs. ...	Stoke-on-Trent 25249 and 25240 ...	Stoke-on-Trent 25249 and 25240 ...	Stoke-on-Trent 25249
	S. A. Satterthwaite, Chester Rd., Streetly, nr. Birmingham	Streetly 7290 ...	Streetly 78333 ...	Streetly 7290
WARWICKSHIRE ...	The Birmingham Garages Ltd., Navigation Street, Birmingham 5 ...	Midland 1023/4/5/6	Midland 1023/4/5/6	Garage Birmingham
	Scammell Lorries Ltd., New Wolverhampton Road, Langley, Oldbury, nr. Birmingham. ...	Broadwell 2805 ...	—	Leymotors, Birmingham
YORKSHIRE ...	Pelican Engineering Co. (Sales) Ltd., Wakefield Road & Wood Lane, Rothwell Haigh, near Leeds ...	Rothwell 2181/3 ...	Leeds 74693 ...	Pelican 2181 Rothwell Leeds

RECOMMENDED REPAIRERS

County	Name and Address	Telephone Numbers Day	Telephone Numbers Night	Telegraphic Address
BERKSHIRE ...	Amey's Engineering, Ltd., Besselsleigh Road, Abingdon	Oxford 35421 (12 lines)	—	Oxford 35421
CAERNARVONSHIRE	J. & A. Higginbottom, Ltd., The Quay, Conway ...	Conway 3108 ...	Conway 3108 ...	Conway 3108
CAMBRIDGESHIRE ...	King & Harper Ltd., Hills Road, Cambridge ...	Cambridge 3201 ...	—	Motors Cambridge
CORNWALL... ...	A. & J. E. Polmear, Island Works, St. Ives. *(Marine only)* ...	St. Ives 131 ...	—	Polmear Engineers St. Ives Cornwall
DORSETSHIRE ...	Wilkins & Wilkins Ltd., Quay Side, Hamworthy, Poole *(Marine only)* ...	Poole 174 ...	—	Poole 174
DUMFRIESSHIRE ...	A. C. Penman Ltd., Queensbury Motor Works, Dumfries	Dumfries 57 ...	—	Automobile Dumfries
ESSEX ...	Brookside Engineers Ltd., Springfield Drive, Fairfax Drive, Westcliff-on-Sea ...	Southend 44660 & 44590 ...	—	Brookside Engineering Westcliff
	F. G. Smith (Motors) Ltd., High Road, Goodmayes, Ilford	Seven Kings 6000 ...	—	Seven Kings 6000
GLOUCESTERSHIRE	Bristol Motor Co. Ltd., Ashton Gate, Bristol 3 ...	Bristol 64013/7 ...	—	Morservice Telex Bristol
HAMPSHIRE ...	Bevois Valley Engineering & Motors Ltd., Ancasta Road, Southampton ...	Southampton 27847/8 ...	—	Southampton 27847 —
HERTFORDSHIRE ...	C. & A. Roberts (Whitwell) Ltd., Whitwell, Hitchen ...	Whitwell 326 & 327	—	—
INVERNESS-SHIRE ...	MacRae & Dick Ltd., Academy Street, Inverness ...	Inverness 1000 ...	—	Dick Inverness
ISLE OF MAN ...	B. W. Kelly, Ltd., Bowring Road, Ramsey ...	Ramsey 2322 ...	Kirk Michael 202 ...	—
KENT ...	Robert Brett & Sons Ltd., Wincheap, Canterbury ...	Canterbury 3211 ...	—	Brett Canterbury 3211
	M. Drysdale & Co. Ltd., Bath Street, Gravesend. *(Marine only)*	Gravesend 208 ...	—	Drysdale Engineers Gravesend
LANARKSHIRE ...	J. Bowen & Sons, Ltd., 428 Helen Street, Glasgow, S.W 1	Goven 2611-2 ...	—	Boweng Glasgow
LONDON ...	W. J. Boyes & Son Ltd., Blenheim Grove, Peckham, London, S.E.15 ...	New Cross 3111/2/3	—	Breakdown Peck London
	Normand Ltd., Cumberland Avenue, Park Royal, London, N.W.10 ...	Elgar 7757 ...	—	Appoint Harles London
SUSSEX ...	Bailey & Noyce, Harbour Garages and Marine Works, Itchenor. *(Marine only)* ...	Birdham 374 ...	—	Birdham 374
YORKSHIRE ...	John Armstrong, Quay Street, Scarborough ...	Scarborough 5199 ...	—	—
	Rodwell's Motors Ltd., Woodside Garage, Wombwell ...	Wombwell 2307 & 2308	—	Wombwell 2307 & 2308
	Diesel Engineers (Bridlington) Ltd., Springfield Works, Springfield Avenue, Bridlington ...	Bridlington 5333 ...	—	—

GARDNER

SERVICE

OVERSEAS

GARDNER ENGINES (SALES) LTD.

HEAD OFFICE AND WORKS

BARTON HALL ENGINE WORKS, PATRICROFT, ECCLES, MANCHESTER

Telegrams : Gardworks Eccles Manchester. *Telephones :* ECCles 2201 (8 lines).

LONDON OFFICE AND EXPORT DEPARTMENT

ABFORD HOUSE, WILTON ROAD, S.W.1.

Inland Telegrams : Gardiesel Sowest London. *Telephones :* TATe Gallery 3315 & 3316.
Overseas Cables: Gardiesel London SW1.

GLASGOW OFFICE

124, ST. VINCENT STREET, GLASGOW, C.2.

Telegrams : Glasgard Glasgow. *Telephone :* CENtral 0887 & 0888.

REPRESENTATION IN NORTHERN IRELAND AND EIRE

GARDNER ENGINES IRELAND LIMITED, 13, SYDENHAM ROAD, BELFAST.

Telegrams : Doxide Belfast. *Telephone :* Belfast 59522.

AUSTRALASIAN REPRESENTATIVE

Mr. H. S. Driver, Box 284, Post Office, North Sydney,
N.S.W. Phone: XB. 7971.

OVERSEAS REPRESENTATION

AUSTRALIA:	Western Australia	Diesel Motors Pty., Ltd., 1089-1091 Albany Highway, Bentley. Phone: 68-2531.
	New South Wales, Papua, New Guinea, New Hebrides, New Caledonia, British Solomon Islands and South-West Pacific Islands	Ferrier & Dickinson Pty., Ltd., P.O. Box 21, Artarmon, Sydney, N.S.W. Phone: 43-1215.
	Victoria	Diesel Services Pty., Ltd., Cnr. Princes Highway & McNaughton Road P.O. Box 139 Clayton, Victoria. Phone: 746-3301-2-3.
	South Australia	Rasch Motors (S.A.) Ltd., 317-319 King William Street, Adelaide. Phone: LA 5371 & LA 5372.
	Queensland	Underhill, Day & Co. Pty., Ltd., 23-27 Lang Parade, Auchenflower, Brisbane, Box 1164P, G.P.O., Brisbane. Phone 70.2141.
	Tasmania	A. G. Webster & Woolgrowers Ltd., 60 Liverpool Street, G.P.O. Box 333D Hobart. Phone: 24031. (Also at Launceston).

OVERSEAS REPRESENTATION—Continued

ARABIA	The Arab General Trading Co., P.O. Box 4195, Aden. Phone: 3026 & 2479.
ARGENTINA...	Banham Hermanos y Compania, S.A. Calle Peru 362, Buenos Aires. Phone: 33-1325, 33-9044.
BELGIUM	Automobiles Miesse, S.A. 28-46 Rue des Goujons, Brussels. Phone: 22.25.00 (10 lines).
	Marine Motors Agencies, S.A., Verbindingsdok, Antwerp. (*Marine*). Phone: (03) 31.19.60.
CANADA: British Columbia	Dodwell Diesel & Equipment Ltd., 1729 West Georgia Street, Vancouver, 5.B.C. Phone: Mutual 3-7481.
Eastern Canada, Newfoundland and Maritime Provinces	Gardner Engines (Eastern Canada) Ltd., 6033 Hamilton Street, Montreal, 20, Que. Phone: Pontiac 6-7718.
CANARY ISLANDS...	Transportes Canarios, S.A. Perojo, 14-16 Las Palmas de Gran Canaria. Phone: 19208.
CEYLON	Taos Ltd., Kew Road, Colombo 2. (*Marine*). Phone. 79629.
CHINA	Dodwell & Co. Ltd., P.O. Box 36, Hong Kong. Phone: 28021.
DENMARK	Dansk Gardner Diesel, Uplandsgade, 72, Copenhagen, S. Phone: Sundby 6868.
EGYPT	Port Said Engineering Works (S.A.E.) P.O. Box 17, Port Said. Phone: 2322.
FINLAND	Industria Osakeyhtio, P.O. Box 206, S. Magasinsgatan 4, Helsinki, Helsingfors. Phone: 61 061 (14 lines).
GIBRALTAR	H. Sheppard & Co. Ltd., P.O. Box 130, Waterport, Gibraltar. Phone: 2183.
GREECE	Pan. Solomos & Co. Ltd., 5 Korai St., 4 & 6 Dragatsaniou St., Athens. Phone: 22.687-34.309-34.655.
INDIA	W. H. Brady & Co. Ltd., Brady House, 12-14 Veer Nariman Road, Post Box No. 26, Bombay, 1. Phone: 251337. *Branches at* Ahmedabad, Calcutta, Coimbatore, Kanpur and Madras.
JAMAICA	Motor Sales & Service Co. 159 Harbour Street, P.O. Box 78 Kingston. Phone 3666-5135
KENYA, TANGANYIKA, UGANDA.	African Transport Co. Ltd., P.O. Box 1001, Nairobi. (**Service Agent and Spares Stockist**).
FEDERATION OF MALAYA & SINGAPORE ...	Malayan Motors Ltd., 14-20 Orchard Road, P.O. Box 394 Singapore. Phone: 30321/3 (*Automotive & Marine*)
MALTA & GOZO	Canadian Bros., Mannarino Road, B'Kara, Malta. Phone: Central 4335.
NETHERLANDS	Handelscompagnie, N.V., P.O. Box 5050, Rotterdam. Phone: 176760 (10L).
NEW ZEALAND	John Chambers & Son Ltd., P.O. Box 934, Fort Street, Auckland. Phone: 32-090. (*Marine, Rail Traction & Industrial*). *Branches at* Christchurch, Dunedin, Invercargill, and Wellington.
South Island & Wellington, District	Atkinson Vehicles (New Zealand) Ltd., Post Office Box 17, Johnsonville, Nr. Wellington. (*Automotive*) South Island & Wellington District of North Island.
North Island excluding Wellington District	Fodenway Motors Ltd., 1010 Great South Head Road, Penrose, Auckland. (*Automotive*) North Island excluding Wellington district.
NIGERIA	C. T. Bowring Services (Nigeria) Ltd., 28 Burma Road, Apapa, P.O. Box 2366, Lagos. Phone: 22508.
NORWAY	Cato Holmsen & Co., A/S., Stortingstraat 8, Oslo. Phone: 41.11.69 (Marine & Marine Auxiliary).
PAKISTAN	Brady & Co. of Pakistan, Ltd., Shernaz House, West Wharf Road, Karachi, 2.
PERSIAN GULF: Bahrain & East Coasts of Kuwait, Saudi-Arabia, Qatar, also Trucial Oman & Oman Coast	Ahmad & Abdulla Fakhroo, P.O. Box No. 39, Bahrain. Phone: 3531.
PORTUGAL	Conde Barao, Lda., Avenida 24 de Julho 62-64, Lisbon 2. Phone: 671011/8.
RHODESIA	Samuel Osborn (Rhodesia) Ltd., P.O. Box 8097, Belmont, Osborn House, 26 Bristol Road, Light Industrial Site, Bulawayo. Branches at Salisbury, Kitwe and Lusaka.
SAMOA	I. H. Carruthers Ltd., Box P.O. 64, Apia, Western Samoa. (*Marine*). Phone: Apia 88.
SOUTH AFRICA	Gardner Engines South Africa (Pty) Ltd., 350 Main Reef Road, P.O. Box 25619, Denver, Transvaal. Phone: 25-8311 (10 lines).
SPAIN...	Mecanizacion De Obras Sociedad Limitida, Paseo de Onesimo Redondo, 32, Madrid-8. (*Industrial*) Phone: 2.47.17.07.
SWEDEN	Thos. W. Ward (*Scandinavia*) A/B, Birger Jarlsgatan, 131A, Stockholm Va.. Phone: 34.25.85, 34.25.86. (**Service Agent and Spares Stockist only**).
TURKEY	M. Mustafa Çidam, Postbox 214, Beyoglu, Istanbul. (*Automotive*) Phone: 42.02 Motorlu Vasitalar Bonmarsesi Ticaret ve Sanayi T.A.S., Sirkeci Nobethane, Caddesi No. 8-10, Istanbul. (*Marine*.) Phone: 22.47.10.

GARDNER L3B ENGINES

INSTRUCTION BOOK No. 62

FOREWORD

The data contained in this Manual is based upon long experience and has been compiled in an endeavour to facilitate efficient and durable operation of our engines in widely differing fields of application. To many who are familiar with our products much may be superfluous; to others the data may prove inadequate and in this event it is our earnest wish that we be given the opportunity of offering our service and advice.

WARNING
SPECIAL NOTE

The L3B Engines supersede our well-known six and eight cylinder L3 units and offer greatly increased power, efficiency, and refinement. The bore and stroke are $5\frac{1}{2}''$ and $7\frac{3}{4}''$ respectively, the same as the L3 series engines.

It must be stressed, however, that many vital components such as crankshafts, piston assemblies, connecting rods, inlet and exhaust valves, sprayers, cylinder heads, cams, etc., **are not interchangeable** between L3B and L3 engines **even though many component parts may be similar in appearance, form and dimensions.**

CONTENTS

Engine Data

6L3B AND 8L3B DIESEL ENGINES

These engines are constructed in two sizes only and provide greatly increased power per unit. For their weight and overall dimensions they also offer increased efficiency with additional refinement and greater durability.

The 6L3B engine has six cylinders while the 8L3B engine has eight cylinders, all cylinders having a common Bore of $5\frac{1}{2}$ in. (139·70 mm.) and Stroke of $7\frac{3}{4}$ in. (196·85 mm.).

Engine Type	Swept volume		MARINE PROPULSION DUTIES						RAIL TRACTION DUTY					INTERMITTENT DUTY					INDUSTRIAL DUTIES	
	cu. ins.	litres	Heavy duty craft		Yachts, cabin cruisers, etc.		High speed craft		Locomotives, railcars, etc.		Maximum torque			Air compressors excavators, saw mills, etc.		Maximum torque			Electric generating sets, marine auxiliaries, etc.	
			b.h.p.	r.p.m.	b.h.p.	r.p.m.	b.h.p.	r.p.m.	b.h.p.	r.p.m.	lb. ft.	kg.m.	r.p.m.	b.h.p.	r.p.m.	lb. ft.	kg.m.	r.p.m.	b.h.p.	r.p.m.
6L3B	1105	18·103	**150**	1000	**172**	1150	**195**	1300	**195**	1300	823	113·8	850	**158**	1100	783	108·2	800	**139**	1000
8L3B	1473	24·138	**200**	1000	**230**	1150	**260**	1300	**260**	1300	1097	151·8	850	**210**	1100	1041	144·0	800	**185**	1000

MARINE PROPULSION ENGINES — Approximate Weights (lb.)						
Engine type	Direct Drive		2:1 Reducing—Reversing Gears (Actual ratio is 1·962:1)		3:1 Reducing—Reversing Gears (Actual ratio is 2·960:1)	
	Heavy duty, Yachts	High speed craft	Heavy duty, Yachts	High speed craft	Heavy duty, Yachts	High speed craft
6L3B	6170 lb.	5990 lb.	6590 lb.	6410 lb.	6700 lb.	6520 lb.
8L3B	7290 lb.	7110 lb.	7710 lb.	7530 lb.	7820 lb.	7640 lb.

SPECIAL NOTES:

For marine propulsion duty the normal maximum static inclination aft is 7° and the Works must be consulted if the engine installation demands a static inclination of more than 7°.

The powers quoted in the above table are those developed under normal conditions of atmospheric temperature and barometric pressure. When an engine is to operate at high altitude, or under adverse climatic conditions, we observe the de-rating data detailed on pages 14 and 15.

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 all relevant details.

Engine performance curves are reproduced on pages 10 to 13. These curves are prepared from figures regularly observed during normal engine production tests.

Large-scale prints of all performance curves are available upon application to the Works.

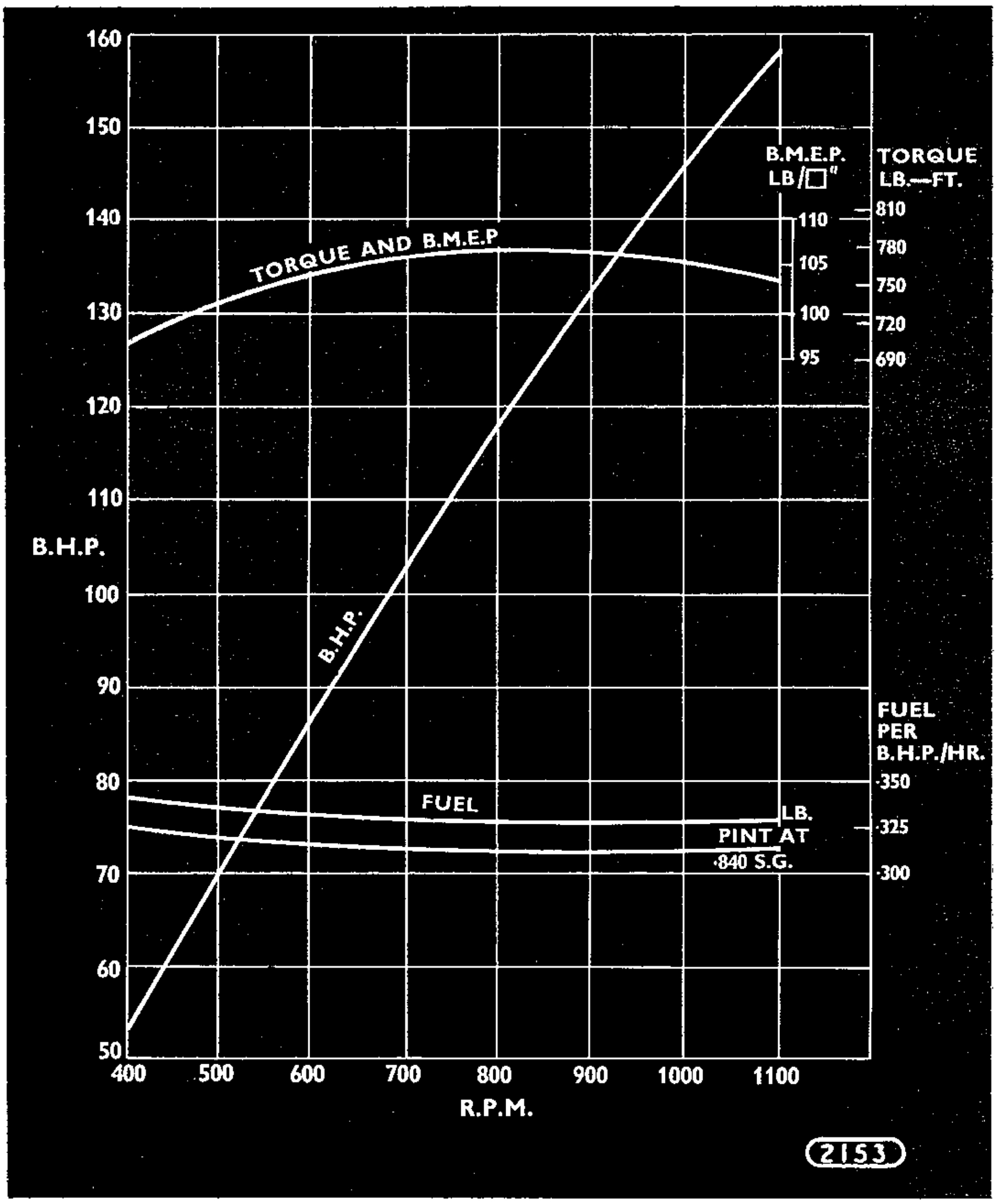
HANDED ROTATION OF ENGINES

These engines are built with either hand of rotation according to customer's requirements. Marine propulsion engines can be built as either Starboard or Port units. The standard engine for a single screw installation with reducing gear is a Starboard engine with crankshaft rotating anti-clockwise when viewed from the flywheel end; reducing gear shafts rotate in the opposite direction.

Performance Curves

6L3B UNITS

For Engines used in Intermittent duty applications such as the driving of air compressors, and as motive power units in saw mills, excavators, earth moving machinery, etc., where the maximum engine speed is set at 1,100 r.p.m.



The above curves are produced from figures regularly recorded during standard production tests of 6L3B Engines. They indicate consistent efficiency and torque over a wide speed range. Large-scale prints are available upon request to the Works.

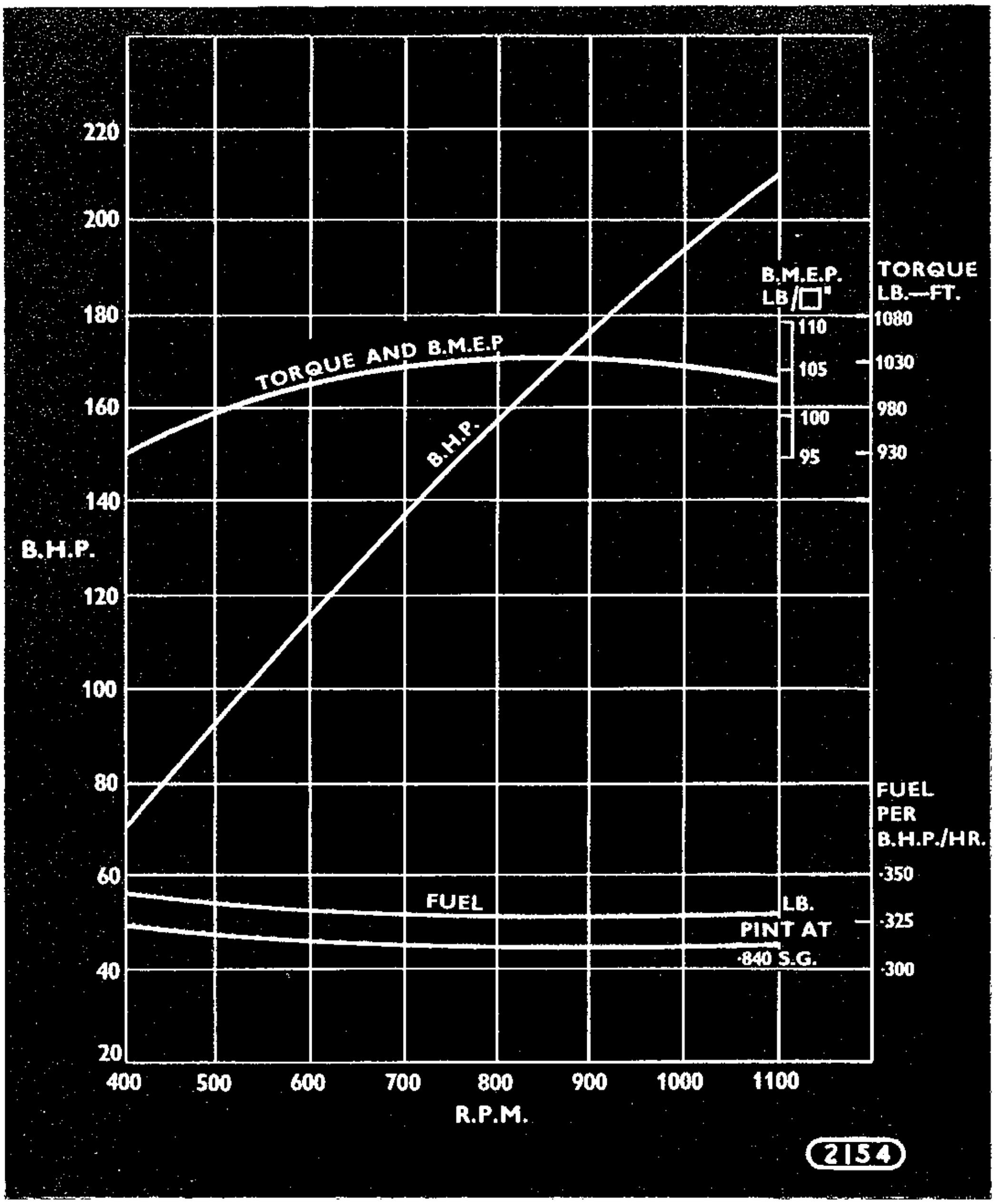
GARDNER
L3B
ENGINES

INSTRUCTION BOOK No. 62

Performance Curves

8L3B UNITS

For Engines used in Intermittent duty applications such as the driving of air compressors, and as motive power units in saw mills, excavators, earth moving machinery, etc., where the maximum engine speed is set at 1,100 r.p.m.

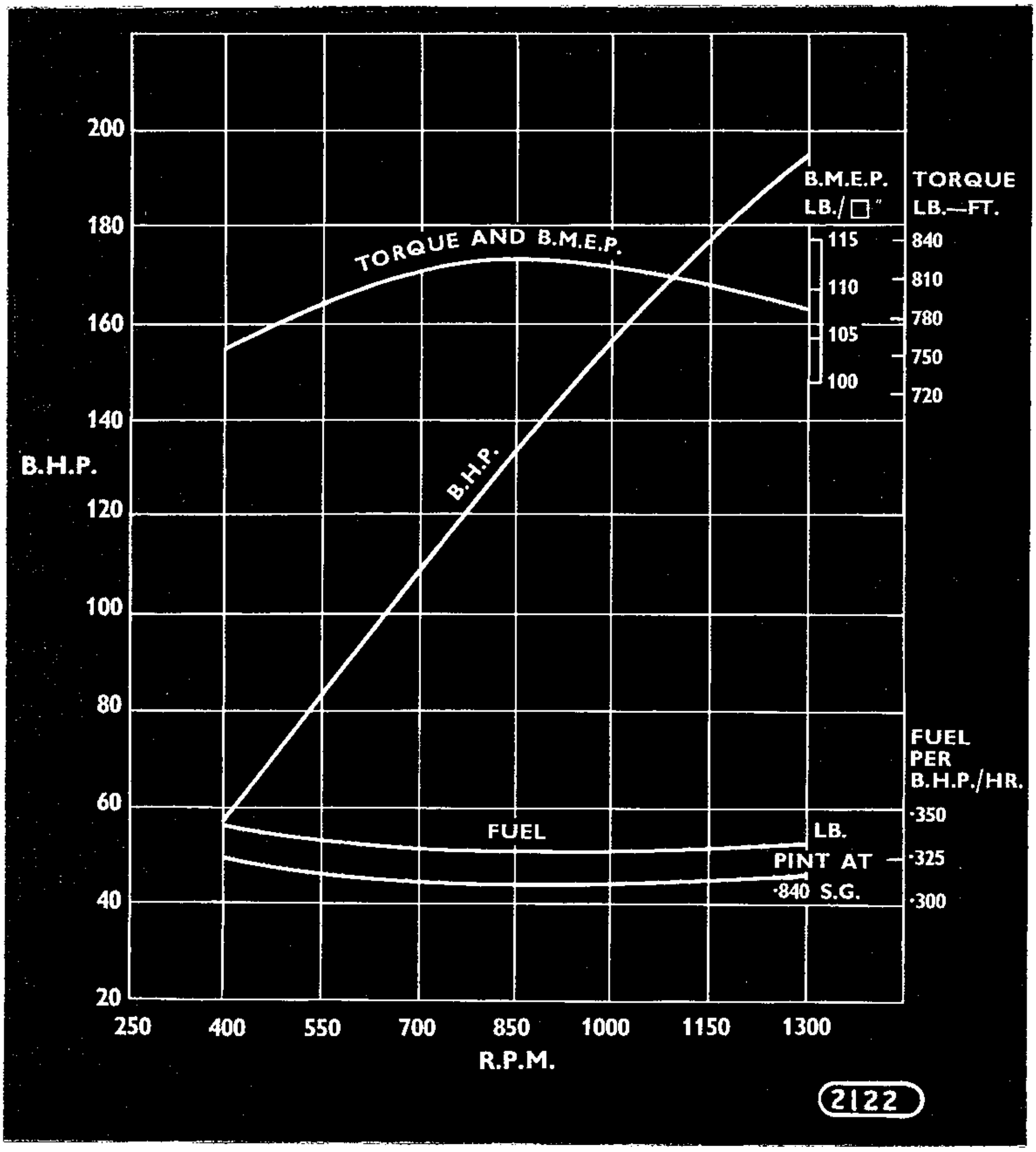


The above curves are produced from figures regularly recorded during standard production tests of 8L3B Engines. They indicate consistent efficiency and torque over a wide speed range. Large-scale prints are available upon request to the Works.

Performance Curves

6L3B UNITS

For Engines used as Marine Propulsion units in high-speed craft, or as motive power units in locomotives and railcars, where the maximum engine speed is set at 1,300 r.p.m.

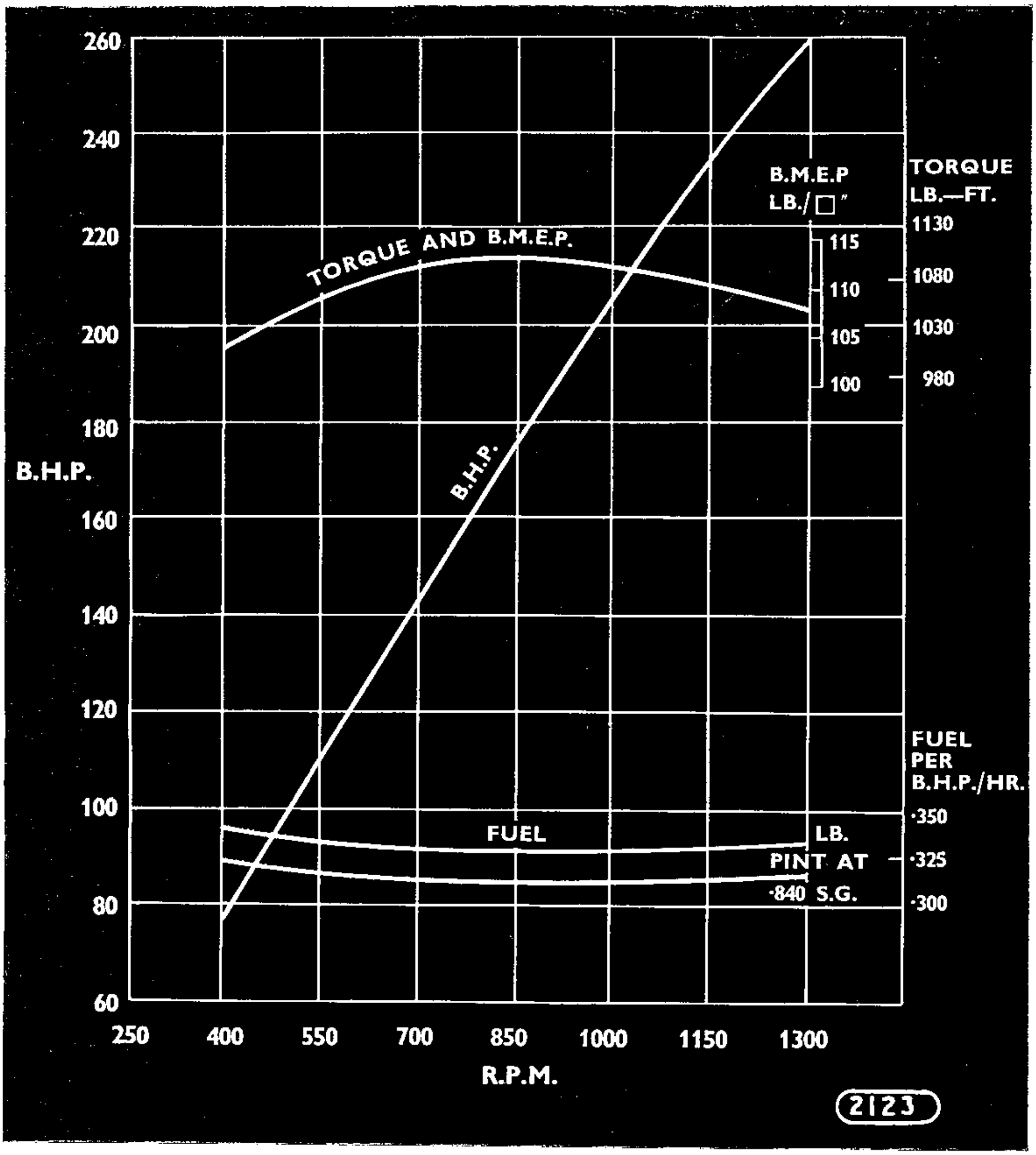


The above curves are produced from figures regularly recorded during standard production tests of 6L3B Engines. They indicate consistent efficiency and torque over a wide speed range. Large-scale prints are available upon request to the Works.

Performance Curves

8L3B UNITS

For Engines used as Marine Propulsion units in high-speed craft, or as motive power units in locomotives and railcars, where the maximum engine speed is set at 1,300 r.p.m.



The above curves are produced from figures regularly recorded during standard production tests of 8L3B Engines. They indicate consistent efficiency and torque over a wide speed range. Large-scale prints are available upon request to the Works.

Engine Performance at High Altitude and High Atmospheric Temperature

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 performance curves on pages 10 to 13 show the 100% ratings, 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″ HG., and an atmospheric temperature of 55° F. normally obtain at the manufacturer's 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 altitude and each 10° F. increase over sea level and 55° F. 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 altitude with a mean annual atmospheric temperature of 75° F., from the graph, page 15, we read the following reductions:

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

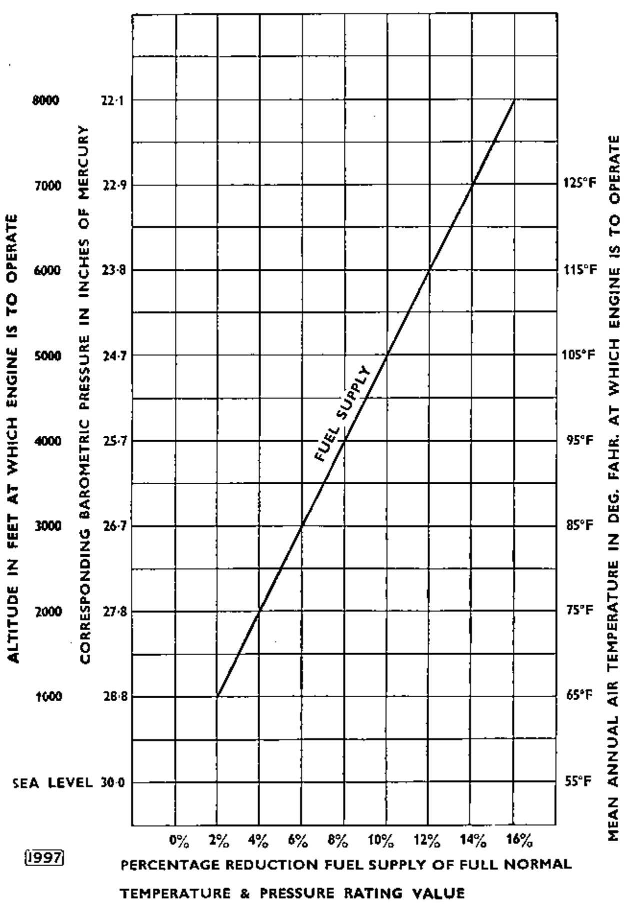
When it is intended that an engine shall operate permanently at 1,000 feet altitude or 65° F. mean annual ambient temperature, or in excess of either of these figures, it is necessary that the length of the fuel pump output control trigger be increased in order to reduce the injected fuel supply appropriately according to altitude and temperature shown on the graph on page 15.

When site operating conditions are known, new engines are appropriately set during test at the maker's works, and the setting 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 observing precisely the provisions of Instruction Book 45·4. On page 9 of Book 45·4 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 15.

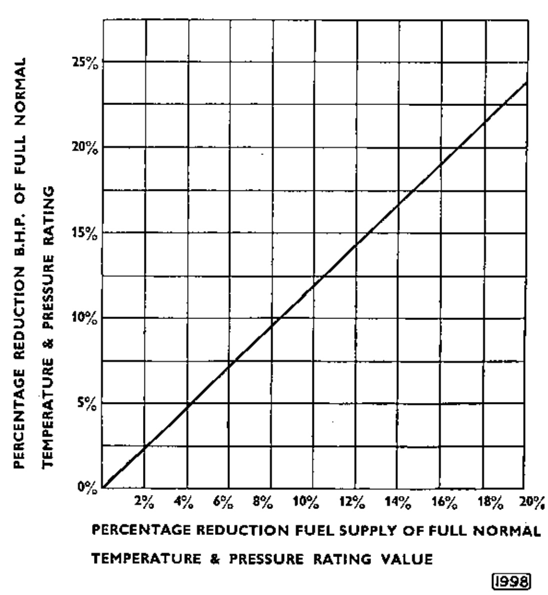
On page 15 will also be found a graph showing the approximate reduction in B.H.P. when the fuel supply is reduced under altitude and temperature conditions.

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

Altitude and Temperature Diagrams

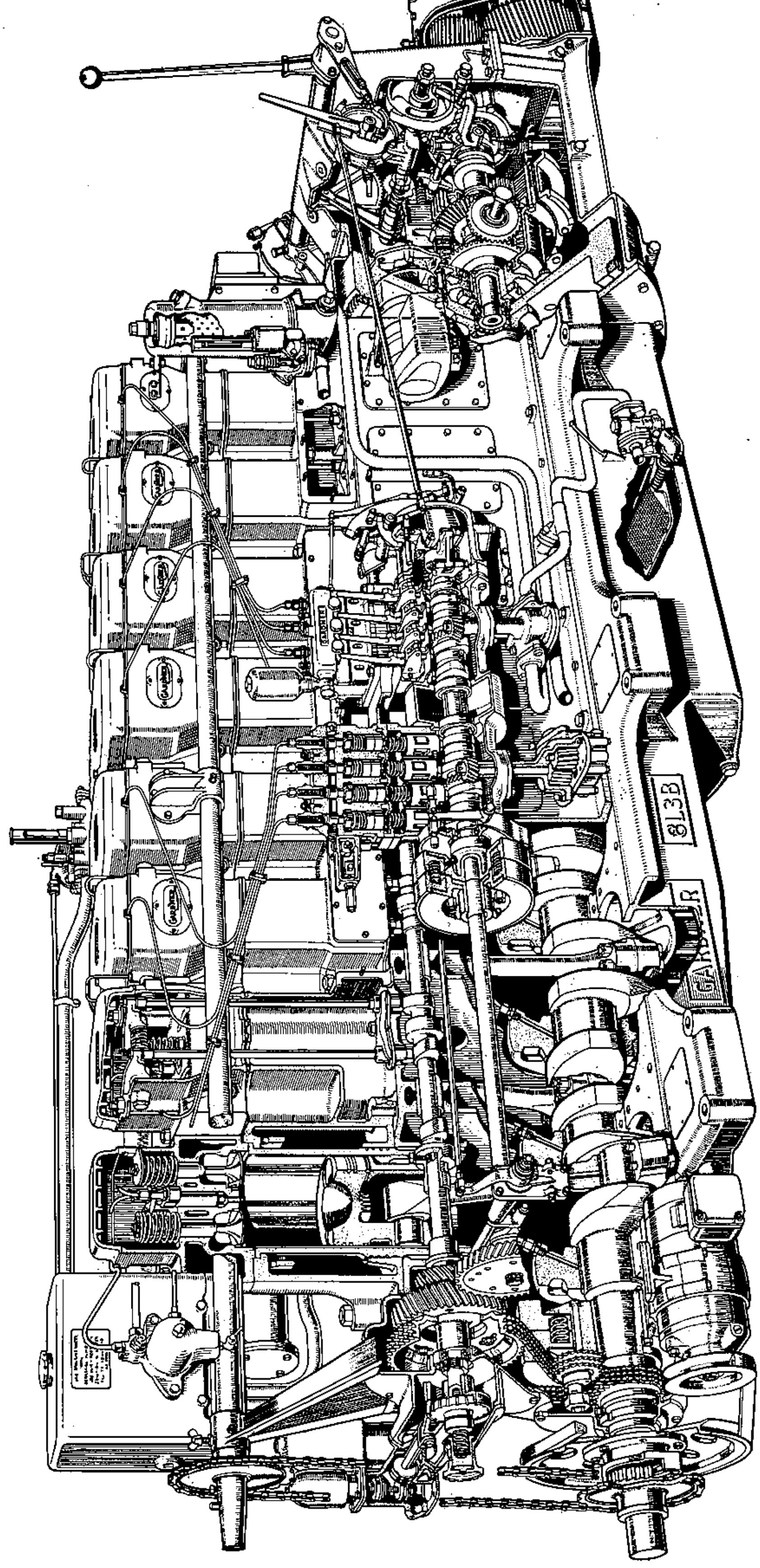


REDUCTION IN FUEL SUPPLY FOR ALTITUDE AND TEMPERATURE CONDITIONS



REDUCTION IN B.H.P. WHEN FUEL SUPPLY REDUCED UNDER ALTITUDE AND TEMPERATURE CONDITIONS

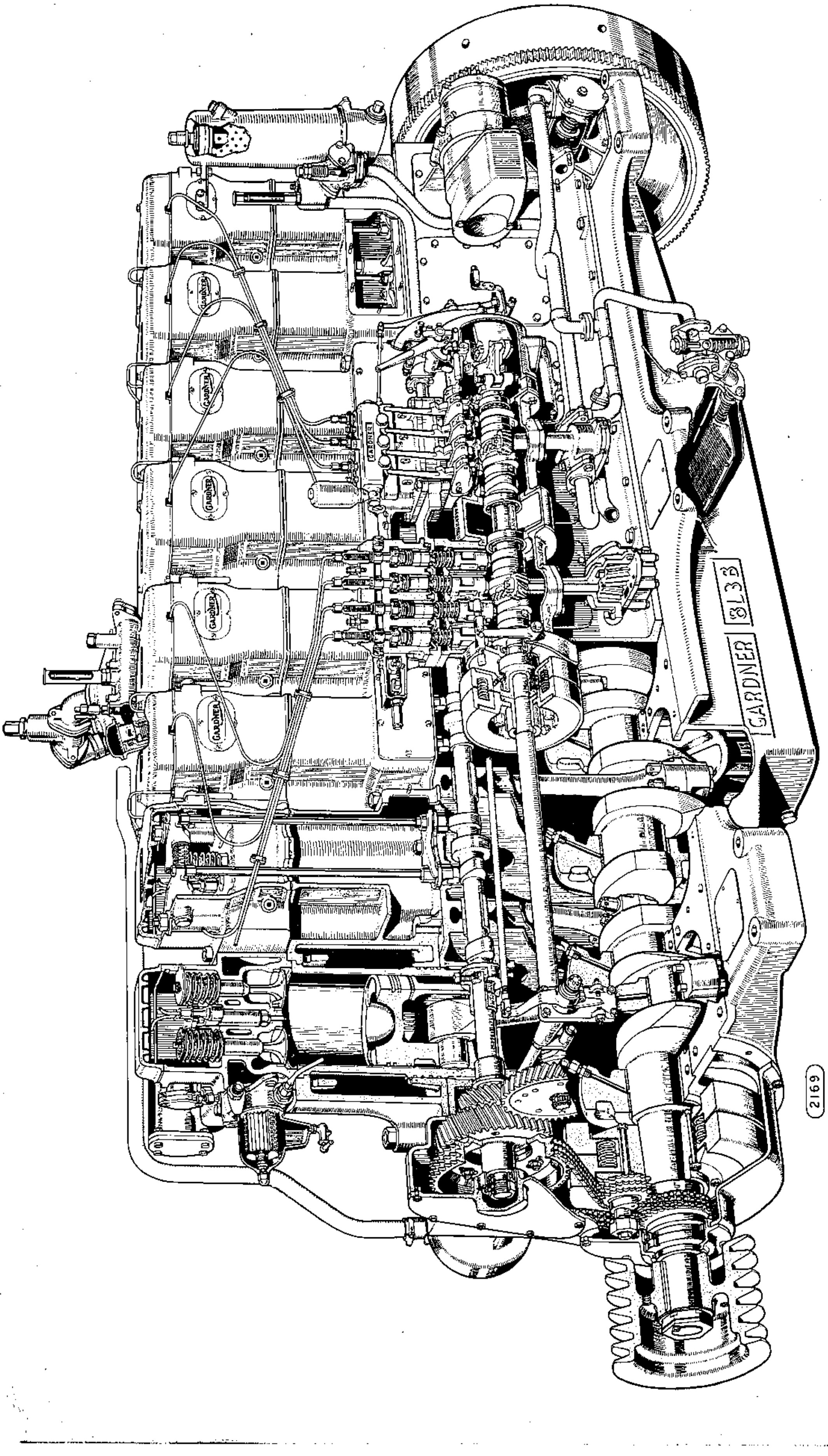
GARDNER



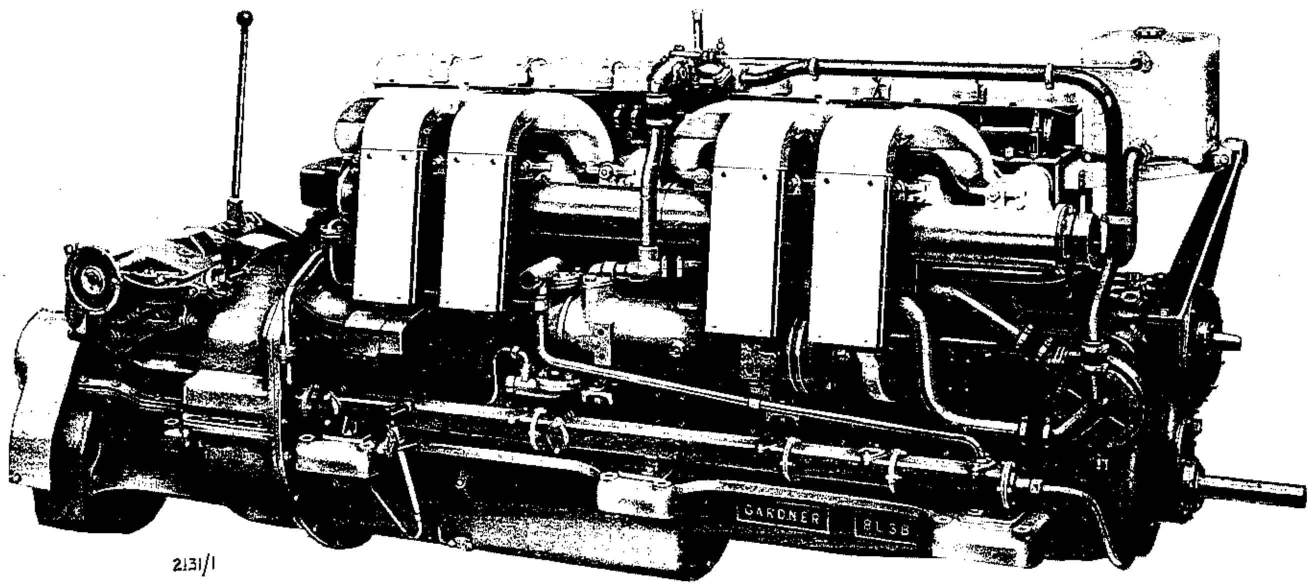
2158/1

8L3B MARINE ENGINE WITH REVERSING AND REVERSING-REDUCING GEAR

GARDNER

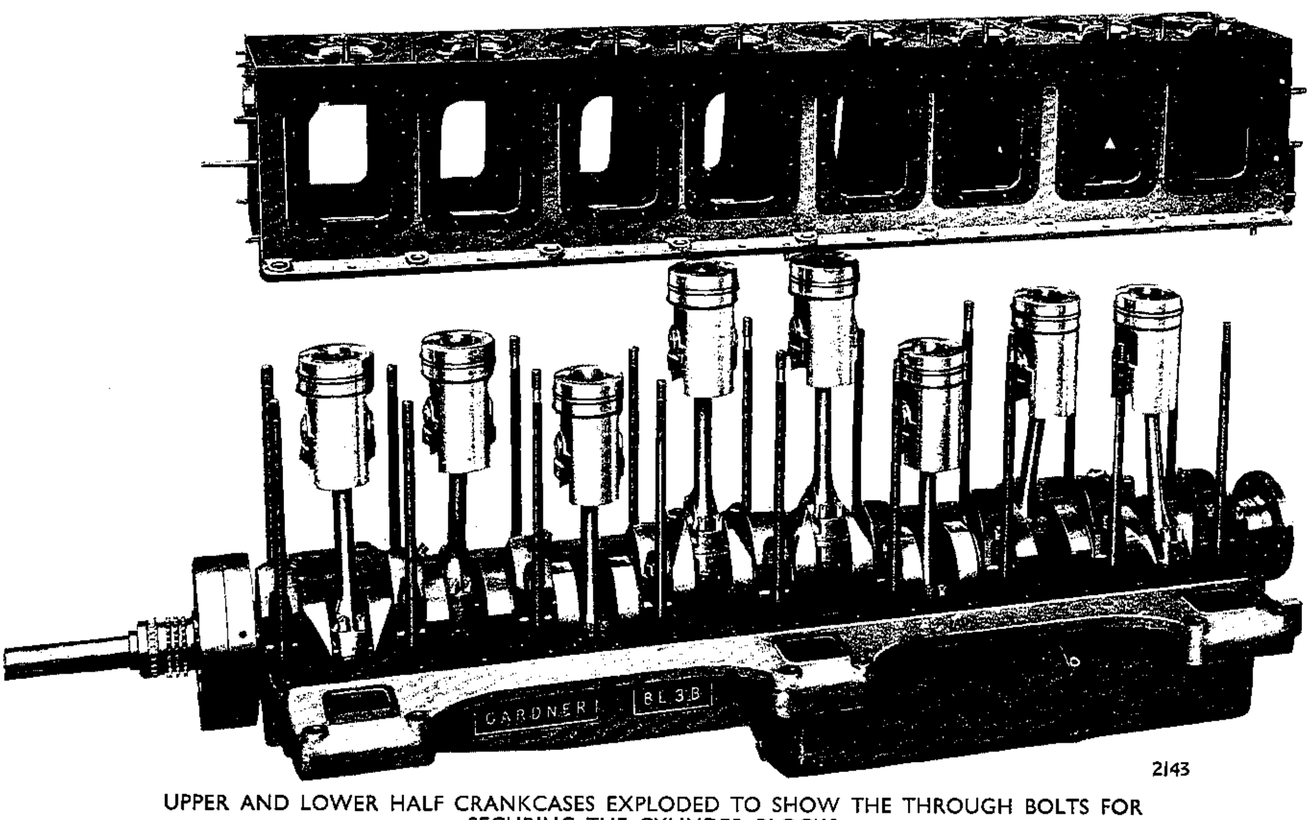


8L3B AUTOMOTIVE (RAIL TRACTION) ENGINE



2131/1

MANIFOLD SIDE OF 8L3B MARINE ENGINE



2143

UPPER AND LOWER HALF CRANKCASES EXPLODED TO SHOW THE THROUGH BOLTS FOR SECURING THE CYLINDER BLOCKS

INTRODUCTORY NOTES AND GENERAL DETAILS

ASSEMBLING AND INSTALLATION

The complete working cycle of the engine 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 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 L3B compression-ignition engines or, as they are now more generally known, Diesel engines: 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 pump plunger 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 governor to correspond with the load carried by the engine at any given moment.

Preservation.—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.

Unpacking.—When unpacking, lay out all loose parts in a suitable clean place, free from dust and grit and sheltered from the weather. These parts should be checked and identified by the Contents List which is normally sent separately with the Advice Note of dispatch. It is not wise to remove the protective varnish if the parts have to lie for any length of time before assembling.

If any work is being carried out in the neighbourhood of the installation, it is advisable to keep the engine sheeted up as much as possible and to retain the protective varnish as long as possible.

Assembling.—To remove the protective varnish, use clean cotton cloths soaked in paraffin (kerosene). Do not use cotton waste since 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. Clean fuel oil is nearly as effective. Take care that all oil holes and other similar places are thoroughly cleaned during assembling.

AIR INDUCTION SYSTEMS

It is *very important* that provision be made for the induction of the coolest available air into the engine. If necessary, fittings can be supplied to couple the air inlet manifold by means of flexible suction hose, to a point at which cool air may be drawn directly from the atmosphere, or through a remotely mounted air filter or silencer. It is necessary that means be provided to eliminate any possibility of the entry of hose or flood water into the induction system, and the system must be designed to operate at a manifold depression of not more than 5 in. 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 air. In certain installations oil bath air filters are considered essential to prevent undue wear of all engine components, particularly pistons, liners and valves.

ALIGNMENT OF ENGINE OUTPUT SHAFT

(Marine Installations)

It is very important that the engine and reversing gear, or the engine with reversing gear and reducing gears, be carefully and accurately aligned with the propeller shafting during initial installation. This alignment must also be carefully checked periodically and corrected as necessary by the fitting of suitable thickness packings between engine unit and the engine bearers. Serious damage can occur in the reversing and reducing gear if correct alignment is not maintained and to facilitate adjustment of alignment certain of the engine holding down bolt holes are tapped to receive $\frac{7}{8}$ in.—11 t.p.i. jacking screws. Four of these holes are tapped on 6L3B engines and six holes on 8L3B engines. Shims of varied thickness are available for fitting beneath the engine unit supporting feet to ensure that accurate alignment can be obtained. They are listed in detail in the No. 3UC reversing gear Instruction Book which accompanies all new marine engines dispatched from these Works.

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 proper proportion of the total weight. When checking the shaft alignment the craft should, of course, be afloat and on an even keel.

AUXILIARY UNITS AND DRIVES

The forward end of the crankshaft is extended outside the crankcase and, as will be seen from various illustrations on the following pages, is used for the mounting of multi-groove pulleys, flexible couplings or a dog-clutch, etc. The flexible coupling can be used, in some installations, for driving an extension shaft supported in two independently mounted bearings.

On no account must a heavy mass be rigidly attached to the forward end of the crankshaft and all such drives must be approved by the Works in view of the technical problems involved. The pulleys may be used for belt-driving an engine mounted dynamo located on a special facing provided under the timing chain casing. The vee-belt pulleys may also be used for driving an independent centrifugal type water pump for circulating sea water through the engine mounted Gardner design Serck heat exchanger in certain marine installations. A single or multi-groove pulley can be used for driving the fan in Industrial or Marine Auxiliary applications where a radiator is employed for the engine cooling water.

COOLING SYSTEM

In order that L3B engines may satisfactorily and reliably maintain full power at all times it is essential for the cooling system design to suitably control the recommended water temperatures under all conditions of operation. All engines are fitted with a centrifugal type water circulating pump driven through helical gears from the main camshaft.

Marine propulsion engines are fitted with a centrifugal circulating pump of bronze construction, while for Rail Traction units and Industrial applications the centrifugal pumps are fitted with aluminium alloy bodies. A "closed" fresh water cooling system is used in all applications and 6L3B and 8L3B marine engines are now equipped with an engine mounted fresh water header tank and a Gardner-design Serck sea water cooled heat exchanger. The sea water is circulated through the heat exchanger by a separately mounted, engine driven, centrifugal pump.

Installation drawings will be made available for marine applications of L3B engines and the Works will be pleased to advise and co-operate in the design of water cooling installations that may be required for any other applications.

DUST PROOFING

In territories where engines are required to operate in heavily dust-laden atmospheres, all apertures on the engine should be sealed against the entry of dust which would otherwise create abnormal wear in all engine components. The Works will be pleased to advise and supply the necessary items for the dust proofing of engines as required.

ELECTRICAL EQUIPMENT

Electric Starter.—This is of proprietory manufacture and normally of 24 volts, but engines supplied for automotive duties (e.g., as motive power units for railcars, locomotives, tractors or wheeled vehicles) can be equipped with 32 volt starter motors when required.

A single starter motor is fitted to the 6L3B engine. Twin electric starters are used for 8L3B engines. Full engagement of both starter pinions is ensured by the fitting of a C.A.V. solenoid arrangement, before the main switch makes contact in either of the starter motors of the 8L3B engine.

Batteries.—The standard battery capacity for all engine applications, with the exception of engines for automotive duties, is:—

6L3B engine	148 amp/hrs. at 10 hour rate.
8L3B engine	185 amp/hrs. at 10 hour rate.

Cable Sizes.—The minimum cable sizes should be as follows:—

	24 Volts
Battery to Starter	61/·044 in.
(This cable should not exceed 8 ft. in length. If longer than 8 ft. the cable will need to be of greater cross section area.)	
Dynamo to Battery	98/·012 in.
Field	35/·012 in.
Switch to Starter	35/·012 in.
Ammeter	65/·012 in.

All terminals must be kept tight and clean, and suitably protected against corrosion, etc., by covering liberally with petroleum jelly. A slight drop in voltage will cause a considerable reduction in the power of the starter motor.

Dynamo.—A 384 watt lamp-load, type H55, suppressed dynamo is fitted as standard to all L3B engines with the exception of units supplied for automotive duties.

ELECTRICAL EQUIPMENT—*continued.*

Earthing of Electrical Equipment on Wooden Vessels.—The effect of electrochemical 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 throughout the time 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.

The 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 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

Accelerator Control Lever.—Engines supplied for automotive duties and as motive power units in railcars, locomotives, etc., are equipped with a lever type speed (r.p.m.) control. When the engine has been installed it is necessary to arrange the geometry of the accelerator linkage so that the operating rods and levers are mutually at an angle of 90° when the accelerator lever on the engine is in a position of approximately 45° from the idling speed location of the lever. This provides the greatest leverage when the maximum effort is required and also avoids excessive pressures on the operating linkage. See Fig. 8.

EXHAUST SYSTEM

Due to the very many different conditions under which the L3B engines are used it is not possible, in the compass of this book, to give full particulars of specific exhaust systems. The Works will, however, be pleased to give their recommendations for any installation.

In all cases the system should be as short as possible, with the minimum number of bends which should be of maximum radius. Whenever possible the straight-through absorption type of silencer should be used and in no case must the pipe, or the silencer inlet and outlet bores be less than 4 in. for the 6L3B and 8L3B engines.

FUEL SUPPLY SYSTEM

Amal Fuel Lift Pumps and Gardner Overflow Return Feed System.—This system is widely used for most applications of L3B engines and incorporates Amal fuel lift pumps operated from the valve camshaft. The 6L3B has one fuel lift pump. Two fuel lift pumps are fitted to 8L3B engines. The pumps deliver about 60% more fuel than the engines demand on maximum load. To ensure an uninterrupted fuel supply to the engine it is essential that our installation drawing be strictly followed and it is most important that the correct bore and gauge of copper piping be used. In this system the fuel supply is delivered by the lift pumps to the fuel filter mounted on No. 1 cylinder head, or on the header tank, at a pressure of about 2 lb./sq. in.

The fuel in this filter, together with any air that may be present, is allowed to return to the supply tank via an ·025 in. diameter hole in the filter body, together with the minute quantity of fuel which leaks past the sprayer piston valves. By this means it is ensured that any air which may find its way into the fuel supply on the suction side (through joints, taps, etc.) is separated from the fuel which feeds the injection pumps on the engines. Each fuel lift pump is provided with a lever for operating by hand. This facilitates filling the pipe system and priming the fuel injection pumps in new installations or after overhaul etc.

Other arrangements for supplying fuel to the injection pumps of the engines can be made by:—

(*a*) Gravity Feed Fuel Service Tank.
(*b*) Vacuum Feed Fuel Tank operated from the vacuum brake system in certain Rail Traction installations.

Fuel Filters.—In circuit with the fuel system are two filters of special design. One filter, referred to as the first filter, is always mounted on the chassis, bulkhead or machine frame, etc. The second filter is mounted on No. 1 cylinder head or on the header tank and forms a component part of the engine.

FUEL SUPPLY SYSTEM—*continued.*

When installing the first filter due regard must be paid to its accessibility for cleaning and examination.

Both fuel filters employ a special form of paper filtering element which are inexpensive and readily replaced. The element in the first filter has a greater area than that fitted to the second filter, thus the two elements are not interchangeable. The engine mounted second filter carries a drain cock to enable the filter sump to be readily drained prior to dismantling. A plug is provided at the lowest point of the first filter for this purpose.

The first and second filters also have a vent plug and cock respectively when used in a gravity feed fuel system. In the diaphragm operated fuel overflow return system air is automatically separated from the fuel feed and under these conditions the vent cock on the second strainer is replaced by a plug.

Sprayer Drain Pipe.—A minute quantity of fuel is allowed to leak past the piston valve of the sprayer and this leak is piped from each sprayer into a bus-pipe from which it may be piped back to the fuel tank. With a gravity feed fuel 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 in the pipe which, if inadvertently closed, would impair the efficient working of the engine.

LIFTING THE ENGINE

For convenience of lifting the engine, certain of the nuts which bolt down the cylinder heads are temporarily replaced by eye-nuts. Before attempting to run the engine see that these eye-nuts are removed and replaced with the permanent nuts which will be found attached to their respective studs.

Incorrect slinging or application of eye-nuts can result in damaging or loosening the cylinder head holding down studs. This can be caused in three ways. One is bending of the studs due to sideways pull caused by failure to use a sling spreader. Sideways pull can also be caused by a heavy component attached to the end of an engine and thus create unbalance. Thirdly, if the eye-nuts are screwed down tightly with a bar or lever this may cause the studs to be slackened or withdrawn on removal of the eye-nuts. To avoid this, do not use bar or lever, but screw the eye-nuts fully home to cylinder heads with fingers only. Slacken the eye-nut a portion of one turn if required to engage sling or hook. Do not omit to replace and re-tighten the cylinder head nuts after lifting the engine with the eye-nuts.

In order to avoid sideways pull it is essential that a spreader be used between the slings in order to secure a straight pull on the eye-nuts and to arrange the apex of the sling midway between these points.

A warning label is attached to all engines despatched from the Works in respect of these matters.

SPACE REQUIRED FOR REMOVAL OF COMPONENTS

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*) Cylinder Heads—10 in.
- (*b*) Cylinder and Head as one unit—$12\frac{7}{8}$ in.
- (*c*) To draw Piston and Connecting Rod through Cylinder Bore (from top of block)—$22\frac{1}{2}$ in.
- (*d*) Lubricating Oil Delivery Filter Cover—$10\frac{1}{4}$ in.
- (*e*) Fuel Filter Cover—4 in.
- (*f*) Centrifugal Water Circulating Pump—$2\frac{11}{16}$ in.

SPACE REQUIRED FOR REMOVAL OF COMPONENTS—*continued.*

(*g*) Timing Case Cover (Rail Traction type)—1¾ in.
(*h*) Timing Case Cover (Clutch driven Bilge Pump type)—1¼ in.
(*i*) Timing Case Cover (Non-clutch, Constant Drive, Bilge Pump type)—4½ in.
(*k*) Reducing Gear Half-coupling—5 in. minimum.
(*l*) Reducing Gear Half-coupling complete with Gear Case Cover, Secondary Shaft and Driven Gear—7½ in. minimum.

VENTILATION OF ENGINE ROOM

MARINE INSTALLATIONS

In many boats installed with Gardner engines it has been observed that the engine-room ventilation is inadequate. It is of importance 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; also allowing the required quantity of air to enter the engine compartments.

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

Equipment for this purpose is available from the Works if specially requested. The engine room ventilation arrangement we supply comprises an 8¾ in. diameter 150 watt Induction fan and a 5 in. diameter 23 watt Extractor fan. Weatherproof cowls for this equipment are also available.

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 air circulating around the silencer assists in reducing the engine room temperature.

Installation drawings are available upon request from the Works, and we shall be pleased to give any further advice that may be required in connection with this arrangement.

LUBRICATING OIL

Lubrication.—Of recent years it has become established that the sulphur content of fuel oil has a very important 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-B	(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 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 following approximate conditions:—

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

From the foregoing it will be seen that not only do we advocate the use of detergent oils but also the use of detergent oils of the 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 is not obtained 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 operating 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."

Note.—U.S. Army Ordnance Specification 2-104B Supplement 1 is officially obsolete, but oil of "Supplement 1" type is still generally recognized as referring to a superior lubricant.

LUBRICATING OIL—*continued*

Special Caution.—When using a detergent oil for the first time in an engine which has been in service with a straight oil it is advisable to inspect the lubricating oil filter after a short period and pay due regard to engine oil pressure. Detergent oils will free deposited carbon and if the filter does not receive attention it may suddenly, in the case of a dirty engine, become choked.

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

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.

VISCOSITY REDWOOD No. 1	
Specification KW. 10° — 30° F. *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.	**Specification BW.** 30° — 55° F. *e.g.* British Isles March, April, May, Oct., Nov., and Dec., Jan., Feb., Normal Winter. **Temp. °F.** 70 Not exceeding 1250 sec. 100 „ „ 420 „ 140 Not less than 120 „ 200 „ „ „ 54 „ Cold Test—Not higher than 5° F.
Specification BS. 55° — 90° F. *e.g.* British Isles June, July, Aug., Sept. **Temp. °F.** 70 Not exceeding 1600 sec. 100 „ „ 600 „ 140 Not less than 160 „ 200 „ „ „ 64 „	**Specification BT.** Over 90° F. **Temp. °F.** 70 Not exceeding 2500 sec. 100 „ „ 800 „ 140 Not less than 220 „ 200 „ „ „ 74 „

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 above table, as for instance severe tropical and arctic conditions where oils heavier and lighter respectively than those quoted above should be used. The use of ultra low viscosity lubricating oil is emphatically not recommended and indeed, we cannot accept responsibility for premature wear and failure of parts in an engine which has been operated on such oils. The only departure from the above tables which could be approved would be the use of oil to KW specification in a machine engaged on special service, provided the ambient temperature is not in excess of 70° F.

FUEL OIL

Specification.—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.

Specific Gravity at 60° F.	Not exceeding	·850
Initial Boiling Point	,, ,, ...	180° C.
Distillation Test	Not less than	85% at 350° C.
Flash Point (Pensky-Martin)	,, ,, ,, ...	170° F.
Viscosity Redwood No. 1 at 100° F.	Not exceeding	45 secs.
Sulphur	,, ,, ...	·5%
Ash	,, ,, ...	·01%
Water	To be free from visible water.	
Calorific Value: B.Th.U./lb.		19,400
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 it is unsuitable for compression ignition engines since it has low ignition quality.

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 and 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, also 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.

FUEL OIL—*continued*

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.

Lubricating Oil Additions to Fuel.—It is permissible for a small quantity of lubricating oil, up to a maximum of 1%, to be added to the fuel. If paraffin is used as a fuel, this addition of lubricating oil is desirable.

Used sump oil may be employed, disposing of it usefully in this way. It must be allowed to stand for a few days so that carbon and solid matter may settle, the oil then being drawn from near the top of the container. Periodically the container must be drained, to remove the accumulating sediment. Alternatively, the used oil may be cleaned by filtering or centrifuging. Whichever method is employed, cleanliness is essential.

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

STARTING THE ENGINE

PREPARATIONS FOR STARTING

Priming the Fuel System.—In a gravity feed installation it is necessary, after opening the fuel supply valve on the storage tank, to open the drain tap, Fig. 7, on the cover of the engine mounted second fuel filter and allow a copious flush of fuel to pass—preferably into a suitable container to avoid wastage, etc.

The drain tap should then be closed and the vent valve opened on the filter base to allow a further flush of fuel to emerge.

After closing the vent valve it is essential to remove the venting plugs from the fuel volume chambers, Fig. 8, to permit an additional flow of fuel and also to get rid of any air that may be present in the system. The venting plugs should then be replaced and this completes the priming up to the summit of the fuel injection pumps.

Note. After starting a newly installed engine for the first time it may be necessary to again slacken the venting plugs while the engine is running to liberate any remaining traces of air.

Fuel Lift Pump System.—In this system it will be necessary to work the operating (priming) levers of the Amal fuel lift pump, or pumps, by hand whilst the drain tap on the fuel filter is open and until such time as the venting plugs in the fuel volume chambers have been replaced.

To allow the fuel lift pump hand priming lever to impart maximum stroke to the diaphragm spindle, it may be necessary to first turn the engine until the pump rocker arm is resting on the base of the cam. This position will be at once evident by the increased resistance to movement when the hand lever is operating the diaphragm spindle.

Engine Stopping Lever.—This should now be turned to the running position and the starting fuel plunger pressed up to allow the slider bar to move to the "excess fuel position."

This facilitates the final operation of priming the fuel system which is now completed by working **each** priming lever on the fuel injection pumps until the sprayer pipes are filled and the "elastic" feeling disappears as the fuel reaches the sprayers. The feel of the lever then suddenly becomes "solid" and all that is then necessary is to give a few rapid strokes to each priming lever. This will force fuel, and any bubbles of air that may be present, through the sprayer nozzles into each cylinder.

It is important to cease working of the priming levers at this stage otherwise a harmful amount of fuel would be injected into the cylinders. See Figs. 2 and 8.

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

Sprayer Pipe Unions.—After the preceding priming operations are complete, ensure that the union nuts of the sprayer pipes are tight, particularly at the sprayer end, since any leakage from these unions will fall into the crankcase and contaminate the lubrication oil. This applies equally to the unions on the drain pipes of the sprayers. Inspection for leakage is readily made by removing the valve covers whilst the engine is running.

Note.—It is of the utmost importance to avoid such leakage.

Filling the Sump.—To charge the sump in the lower crankcase, remove the cover of the oil filler box and pour in lubrication oil until the level reaches the maximum mark on the dip rod which will be found in the lower crankcase on the governor side. See Fig. 15.

The **Dip Rod** passes obliquely through a hole in the crankcase and the lower end of the rod is marked "Max. Level" and "Min. Level." It is not safe to run the engine when the lubricating oil is below the minimum level and the **sump oil should be maintained at the maximum level.**

Checking the Sump Oil Level.—The oil level indicated on the dip rod will vary according to the elapsed time; often up to approximately 4 hours after stopping a hot engine the level as indicated on the dip rod will tend to show an increase. The corresponding figure for cold engines may reach 12 hours. When making accurate measurement of oil level in rail traction applications it is essential that due regard be paid to gradient and camber. Remove the screwed plug (Fig. 8) on the suction pipe of the main lubrication pump and, by the aid of the large syringe supplied with the engine, fill the pipe with oil until it overflows at the plug hole. The object of this is to prime the pump and suction pipe from the foot valve upwards. There are also screwed plugs in the oil cooler pump and these should also be removed to prime the lubrication system.

STARTING THE ENGINE—*continued.*

A certain amount of oil will be used to fill all the oil pipes during the first run after installation and to wet all the internal surfaces. This will, of course, reduce the oil level in the sump, hence the necessity of an additional make-up charge of oil after the initial run.

Formed in the crankshaft are oblique ducts which lead lubrication oil from the main bearings to the crank pins and hence to the gudgeon pins by way of the central ducts in the connecting rods. All these ducts will have to be filled before the pressure gauges register.

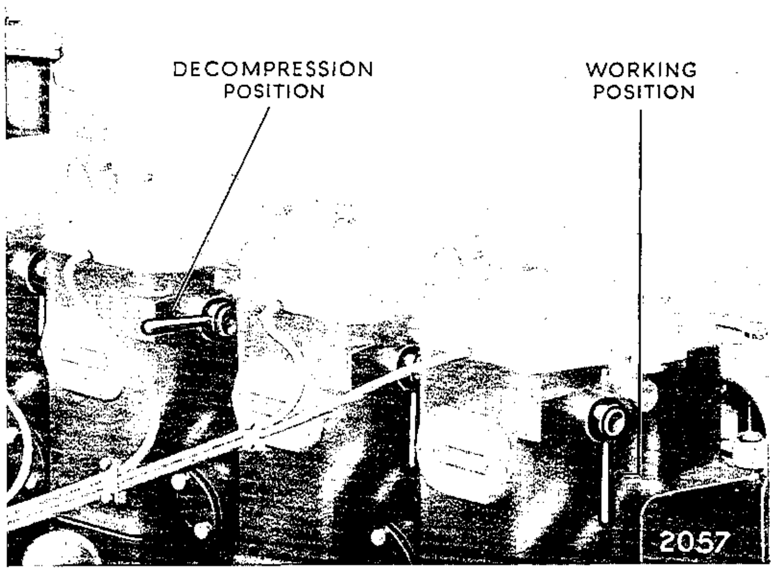
When starting for the first time or after a prolonged stop, see that the oil pressure gauge registers pressure; if it does not, shut down at once and investigate—see page 63 for further details.

Decompression Gear.—An essential feature of these engines is that they can be started by hand cranking handles, although electric starting is fitted to the 6L3B and 8L3B engines as standard equipment.

Hand starting equipment can be fitted in all cases where the installation arrangements permit this method of starting. In an emergency the 8L3B engine can be started by hand and this equipment is fitted to both the six and eight cylinder engines at extra cost when so specified.

As already mentioned, ignition of the fuel charge is effected solely by the temperature of the air compressed in each cylinder; therefore all extraneous devices such as pre-heating, cartridges, electric plugs and similar devices for starting are entirely dispensed with. Having regard to the high degree of compression necessary with engines of the compression-ignition type, starting by hand is quite an achievement and is greatly facilitated with L3B type engines by the decompression device fitted to each inlet valve. This device is operated by a small lever fitted at the rear end of each cylinder head.

The relief of compression on all cylinders enables the engine to be freely rotated and is invaluable when carrying out routine service checks and making adjustments. The decompression levers on the cylinder heads rest vertically downwards when the engine is running and in this position the levers cease to be functional. When moved to the horizontal (decompression) position, however, the levers prevent the Inlet valves from closing completely and thus preclude full compression. When all the levers are in the horizontal position the engine can be freely rotated, either for starting by hand, should this be necessary, or for making service checks as previously mentioned. See Fig. 1.



DECOMPRESSION LEVERS ON CYLINDER HEADS **Fig. 1**

STARTING THE ENGINE—*continued.*

Starting Fuel Plunger.—Underneath, and at the end of the aluminium box attached to the front of the fuel pumps, will be found a vertical spring-loaded plunger. When pressed up as far as it will go, this plunger releases the fuel pump slider bar and allows it to move towards the flywheel end of the engine in which position the pumps deliver an increased charge of fuel for starting from cold. If, when starting the engine the slider bar does not move freely, help it by pressing on the governor lever. As soon as the engine is started the slider bar automatically resumes 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: on no account must it 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 than the engine can burn and serious trouble may occur.

Variable Speed.—The speed of marine, rail traction and industrial engines can be varied from idling r.p.m. to maximum r.p.m. and the engine is under governor control at all times. The governing mechanism responds immediately to all fluctuations of load or to operation of the speed control lever. Marine propulsion engines are normally equipped with a friction-disc, lever type, speed control which permits the lever to remain in any selected position between idling and maximum r.p.m. Apparatus for remote speed control, or for fitting of the Gardner Single-Lever engine speed and reverse gear control for marine propulsion engines can be arranged when specified. Engines used for rail traction or intermittent duty applications are equipped with a lever type, cam operated, speed control arrangement mounted on the governor casing. See Fig. 8. The speed of industrial type engines is normally controlled by a knurled-headed screw mounted on the governor spring lever. When screwed down to its limit this enables the engine to operate continuously at a fixed speed which is normally set by the Works to 1,000 r.p.m.

LUBRICATING OIL PRESSURES

(Also water outlet temperatures)

As soon as an engine has been started it is essential to ascertain that the lubricating oil gauges register pressure. The correct oil pressures, together with other related data, is given in the following table.

Engine Duty	Oil Pressure	[redacted] Oil Temperature	Approx. Water Outlet Temp.
Automotive and Rail Traction	**30 lb. p.s.i. at 1300 r.p.m.**	138° F.	150° F.
MARINE PROPULSION —High speed craft	**30 lb. p.s.i. at 1300 r.p.m.**	135° F.	142° F.
—Yachts, cruisers, etc.	**29 lb. p.s.i. at 1150 r.p.m.**	130° F.	142° F.
—Heavy duty craft	**28 lb. p.s.i. at 1000 r.p.m.**	124° F.	142° F.
Industrial, Generating sets and Marine Auxiliary sets	**28 lb. p.s.i. at 1000 r.p.m.**	124° F.	142° F.
Industrial intermittent duty	**29 lb. p.s.i. at 1100 r.p.m.**	130° F.	142° F.

With a newly installed, or an overhauled engine it will probably be necessary to wait 10 to 15 seconds before the gauges register oil pressure. When an engine is cold, slightly higher pressures will be noticed due to the higher viscosity of the oil. If, however, the oil pressure falls 2 lb. per sq. in. below the desired figure, the filter element will probably require changing and should be replaced with a new element Part No. MA 587. A warning plate to this effect is attached to the cover of the lubricating oil delivery filter.

STARTING

(A.) HAND STARTING (COLD ENGINE) UNDER NORMAL TEMPERATURE CONDITIONS.

(This operation may require assistance for the engine driver.)

The 6-cylinder 6L3B engine is the largest unit which it is practicable to start by hand. In an emergency, and with assistance, the 8-cylinder 8L3B engine can also be started by hand. It is opportune to mention that when an engine is fitted with a very light flywheel as, for example, in automotive (rail traction) engines where maximum acceleration is desirable, the ability to hand start has to be sacrificed.

1. Set the engine stopping lever to the running position.
2. Open very slightly the hand speed control (if fitted).
3. Press up the starting fuel plunger, thus allowing the fuel pump slider bar to move to "maximum fuel" position. Fig. 8.
4. Move the decompression levers on ALL cylinders to the horizontal (decompression) position. Fig. 1.
5. Turn smartly at the starting handles and, when a good speed is attained, turn the most conveniently located decompression lever (the nearest preferably) vertically downwards to the engine running position. The store of energy in the flywheel will overcome the compression and this cylinder should immediately give power.
6. Turn the remaining decompression levers vertically downwards to the engine running position without delay. The engine will then immediately commence to work on all cylinders.
7. It is desirable to run the engine at a fast idle speed for some minutes to allow warming up before applying load.

(B.) HAND STARTING (COLD ENGINE) UNDER COLD CONDITIONS

(This operation may require assistance for the engine driver.)

1. Move the decompression levers on ALL cylinders to the horizontal (decompression) position. Fig. 1.
2. Test if the engine is stiff to turn.
3. If the engine is stiff to turn, but not unless, operate each hand priming lever on the fuel injection pump five times after having set the engine stopping lever to the running position.
4. Set the engine stopping lever to the "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 the hand speed control (if fitted).
7. Press up the starting fuel plunger. Fig. 8.
8. Turn smartly at the starting handles and, when a good speed is attained, turn the most conveniently located decompression lever (the nearest preferably) vertically downwards to the engine running position. The store of energy in the flywheel will overcome the compression and this cylinder should immediately give power.
9. Turn the remaining decompression levers vertically downwards to the engine running position without delay. The engine will then immediately commence to work on all cylinders.
10. It is desirable to run the engine at a fast idle speed for some minutes to allow warming up before applying load.

(C.) HAND STARTING (WARM ENGINE) UNDER ALL TEMPERATURE CONDITIONS

Proceed as at (A) but when the engine is warm it is unnecessary to press up 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.

STARTING—*continued.*

(D.) ELECTRIC STARTING (COLD ENGINE) UNDER EXTREMELY COLD CONDITIONS

(This operation may require assistance for the driver.)

Under extremely cold conditions, before attempting to start, follow the procedure as set out at (B) in order to "free" the engine.

Note 1. In the event of the engine still being stiff to turn after the steps in operation 3 (B) 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.

With all electric starters it is vital that the batteries and cables are as recommended in page 21, 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. See page 22 also.

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.

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.

(E.) ELECTRIC STARTING (WARM ENGINE) UNDER ALL TEMPERATURE CONDITIONS

1. Set the engine stopping lever to the running position.
2. Move the decompression levers on ALL cylinders vertically downwards to the engine running position. Fig. 1.
3. Press the electric starter button when the engine will instantly work on all cylinders after the first or second compression stroke.

Do not keep the starter button depressed for long periods if the engine fails to start readily, or keep pressing the button when engine is running.

AFTER STARTING

See that the water circulation pump and lubrication pump are operative and that the lubricating oil pressure gauges register correctly. If not, shut down at once and investigate: probably the suction pipe from the foot valve to the pump will need re-priming.

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 and so expand gradually, and to permit the lubrication system to assume complete circulation.

STOPPING THE ENGINE

Move the stopping lever, Fig. 8, so that the cam engages with the tappet screw and moves the slider bar towards the chain case end of the engine thus cutting off the fuel supply.

When the engine stops, the flow of circulation water naturally stops: it is therefore recommended that the engine be allowed to run light for a minute or two just before stopping.

The engine may also be stopped by pulling forward all the pump handles to engage with the lifting latches. This puts the pump rams out of action but, of course, the use of the stopping lever is obviously preferable, and should always be used except under emergency conditions.

On no account should the engine be stopped by turning off the fuel supply stop cock or valve. This would empty the fuel pipes and 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.

SUMMARY OF ATTENTION BY RUNNING TIME

DAILY

(Full details of the necessary routine attention is given on the page numbers quoted.)

Lubrication System.—Check level of oil in sump and replenish if necessary. Fig. 15.

Cooling System.—Check level of coolant and replenish if necessary.

Lubricating Oil Pressure.—Observe that the gauges indicate the correct lubricating oil pressure within a few seconds of starting the engine. See page 32.

AFTER EVERY 400 HOURS

Lubricating Oil Sump.—Drain and refill sump with first class high duty lubricating oil.

Note.—Where engines are operated under dusty conditions it is highly desirable to change sump contents very frequently. Under extreme conditions this may be necessary after periods of less than 100 hours regardless of fuel and lubricating oil quality.

Lubricating Oil Delivery Filter.—Examine, and clean if necessary. See page 65.

Lubricating Oil Suction Filter in Sump.—Examine, and clean if necessary. See page 64.

Fuel Filters.—Examine and clean if necessary. See page 50.

Sprayers.—Operate fuel pump priming levers and observe by feel and sound that sprayers are functioning correctly. See page 55.

Air Induction Filters (when fitted).—Examine, and service as required, dependent on site conditions. See page 41.

Crankcase Breather Filter (when fitted).—Wash in petrol or detergent and allow to dry. This requirement is also dependent on site conditions. See page 45.

Fuel Pump Driving Shaft Damper.—Fill and screw down grease cup as required.

AFTER EVERY 1,600 HOURS

Timing Chain.—Inspect, and adjust if necessary. See page 68.

Slow Running Adjustment.—Inspect, and adjust if necessary. See page 59.

Fuel Injection Pump.—Inject small quantity (about 30 c.c.) of engine lubricating oil through the 2 B.A. screw holes in fuel control box and in cover plate on rear block of pumps.

SUMMARY OF ATTENTION BY RUNNING TIME—*continued.*

Valve Tappet Clearance.—Inspect and, if necessary, adjust clearance as mentioned on page 72.

Injection Timing.—Inspect, and adjust if necessary as mentioned on page 69.

Advance and Retard Friction Mechanism (Variable Speed Engines only).—Inspect and adjust if necessary as mentioned on page 41.

AFTER EVERY 3,200 HOURS

Decarbonising and Top Overhaul.—See page 49.

Sprayers.—Inspect and service if necessary. See page 54.

Centrifugal Water Pump.—Inject not more than one grease-cupful of grease. See page 73.

Fuel Pump Slider Bar.—Inspect and adjust as necessary. See page 52.

Pistons.—Under particularly arduous operation and, or when, fuel and lubricating oil conditions are very unfavourable it may also be necessary to remove and clean the pistons. See page 65.

Fuel Injection Pump.—Check maximum output and balance on calibrating machine as detailed in Instruction Book No. 45.4 or subsequent issues.

AFTER 20,000 HOURS OR WHEN 0·007″ CLEARANCE HAS DEVELOPED IN ANY ONE CRANKSHAFT MAIN BEARING

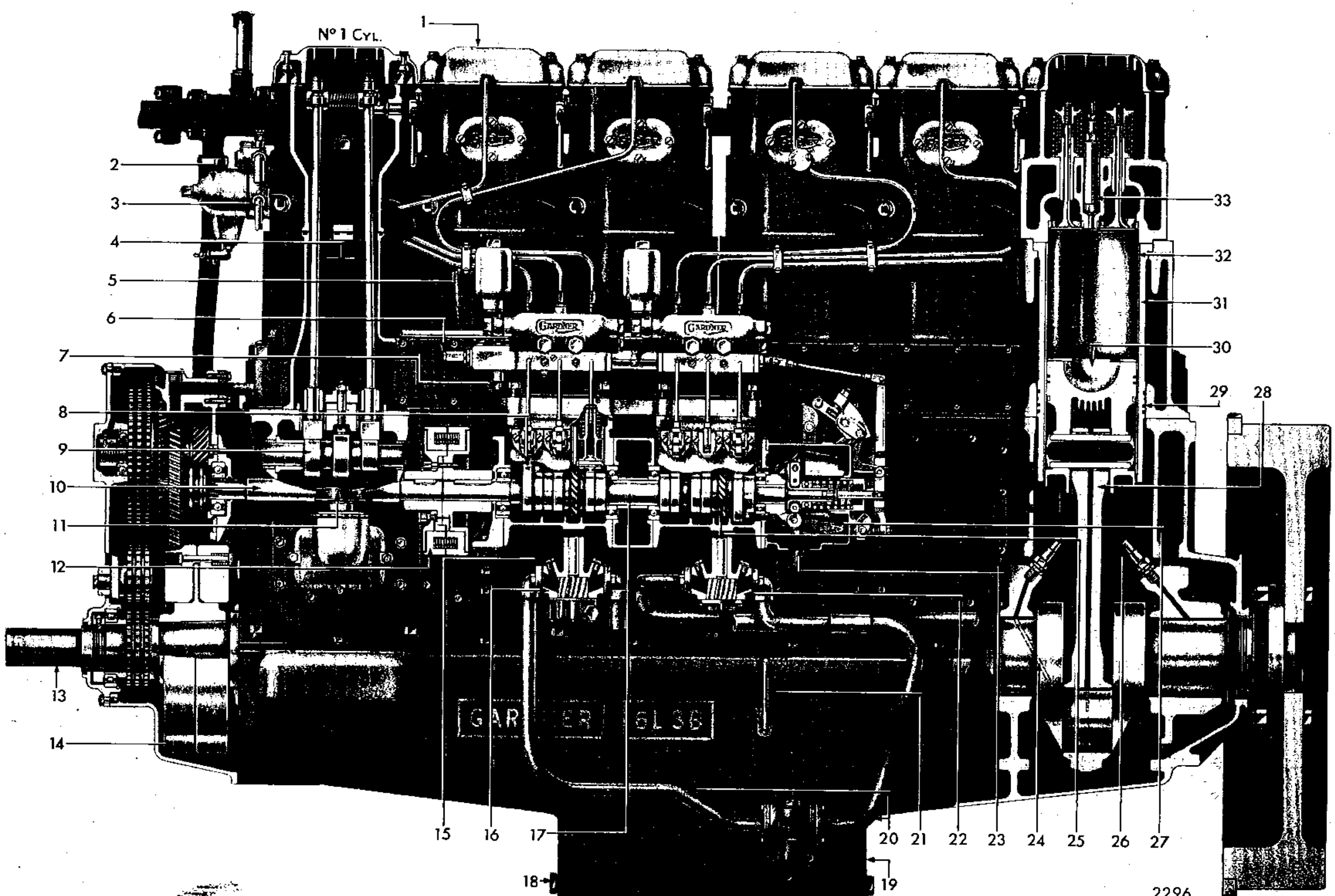
Effect major overhaul of engine involving re-sizing of crankshaft and the fitting of new bearing shells, etc., etc.

NOTE

The preceding summary of recommended attention is based upon average conditions of operation, including fuel, lubricants, duty, etc., and it is to be appreciated that heavy duty and adverse conditions and light duty and favourable conditions may respectively reduce, or considerably increase, the periods at which attention is advisable.

For example, it is not unusual that 25,000 hours be attained or exceeded before a major overhaul is effected. Cylinders, piston rings and pistons may have a useful life of, and run without removal, for periods from 10,000 hours to 20,000 hours or more.

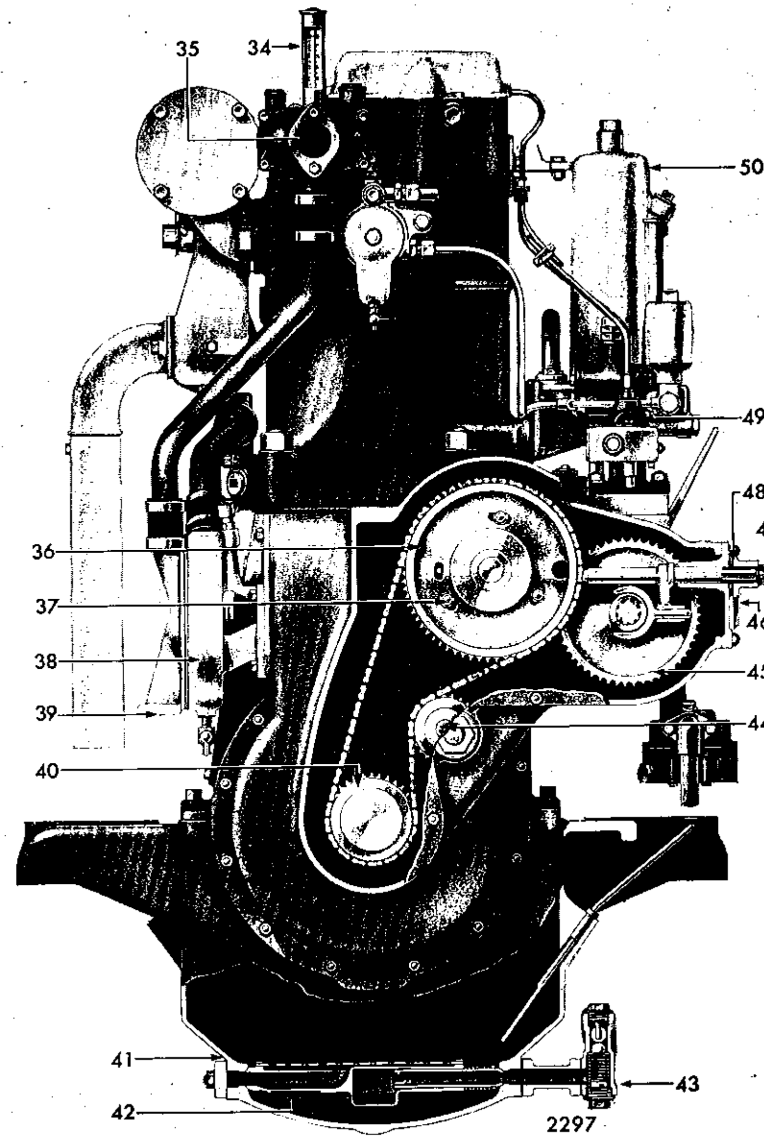
GARDNER



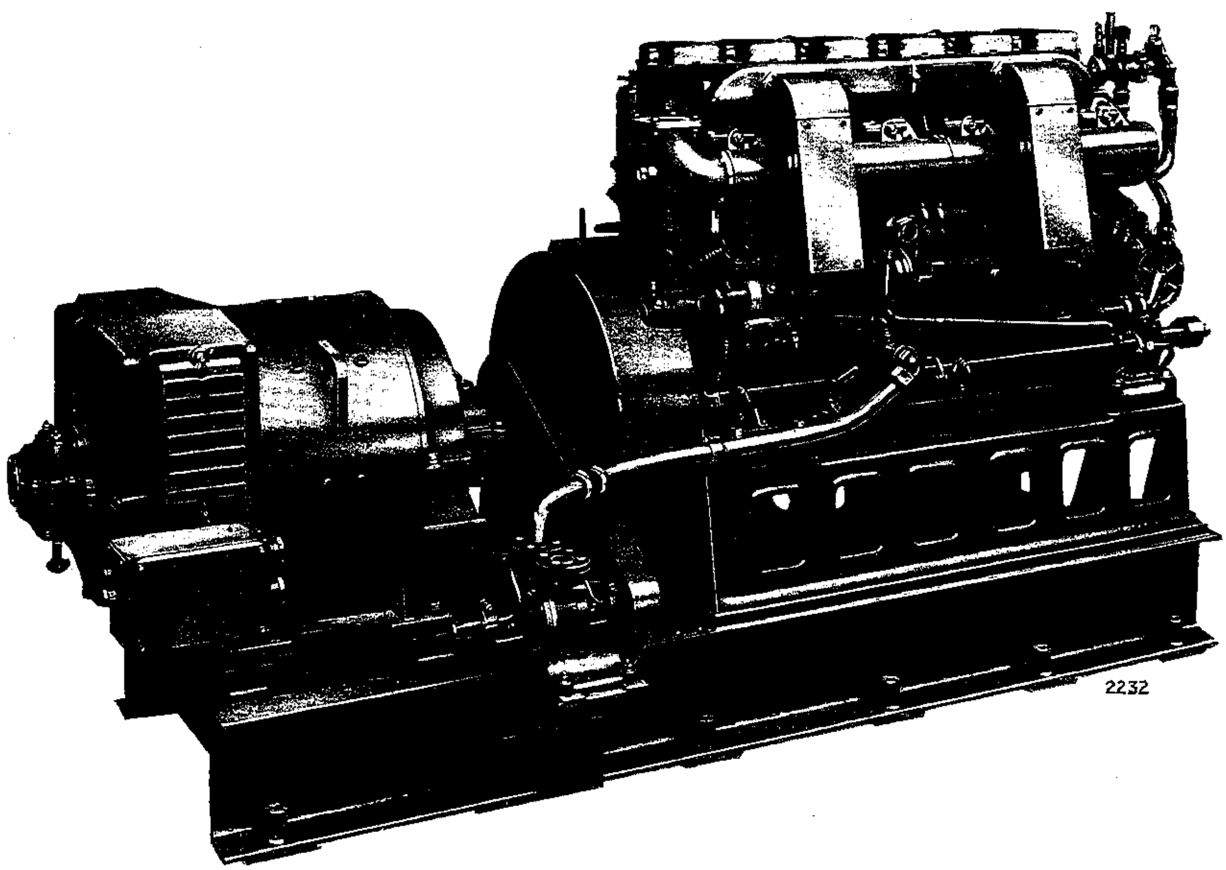
PART SECTION OF 6L3B AUTOMOTIVE ENGINE

Fig. 2

1 Valve and Cylinder Head Covers
2 Second Fuel Filter
3 Fuel Outlet Pipe to Injection Pumps
4 Valve Lever Push Rods
5 Sprayer Pipes
6 Slider Bar Buffer
7 Starting Fuel Plunger
8 Fuel Injection Pump Cam
9 Inlet and Exhaust Valve Cams
10 Fuel Injection Pump Camshaft—Gear Half
11 Crankcase Breather
12 Fuel Injection Pump Camshaft Damper
13 Forward end of Crankshaft
14 Crankshaft Damper
15 Oil Suction Pipe Priming Hole Plug
16 Lubricating Oil Cooler Pump
17 Fuel Injection Pump Camshaft
18 Oil Sump Drain Plug
19 Lower Half Crankcase
20 Lubricating Oil Pumps—Suction Pipes
21 Dip Rod
22 Engine Lubricating Oil Pump
23 Lubricating Oil Return Passage
24 Oil Feed to Crankpin
25 Lubricating Oil Pump Driving Gear
26 Main Bearing Oil Feed Pipe
27 Governor Weights
28 Connecting Rod
29 Liner Joint Rings
30 Piston
31 Cylinder Wet Liner
32 Cylinder Dry Liner
33 Fuel Sprayer
34 Water Thermometer
35 Water Outlet
36 Valve Camshaft Chain Wheel
37 Valve Camshaft Chain Wheel Stud & Nut
38 Water Circulating (Coolant) Pump
39 Water Inlet
40 Crankshaft Sprocket
41 Lubricating Oil Sump
42 Lubricating Oil Suction Filter
43 Pressure Return Foot Valve Assembly
44 Timing Chain Adjuster
45 Fuel Injection Pump Camshaft Gear
46 Timing Injection Pointer
47 Friction Device Nut
48 Friction Washer
49 Fuel Injection Pump
50 Lubricating Oil Delivery Filter



FORWARD END OF AUTOMOTIVE TYPE ENGINE SHOWING CHAIN CASE ARRANGEMENT Fig. 3



6L3B GENERATING SET

ACCELERATOR CONTROL AND ADVANCE AND RETARD OF FUEL INJECTION

(Variable speed engines only)

Accelerator Control.—This should be inspected from time to time to make sure that any remote control mechanism which may be fitted is operating the accelerator lever through its full range, that is, from idling to maximum speed. Inspection of the lever on the accelerator spindle will reveal the limiting stops, the one for idling being the "slow running" screw, while that for maximum speed consists of two $\frac{5}{16}$in. diameter pegs at the end of the governor spring lever.

Advance and Retard of Injection. Inspection and Adjustment.—The accelerator lever being a speed control and not a torque control, is coupled by connecting rods to the lever of the advance and retard mechanism, consequently, the timing of injection is varied automatically with the speed of the engine. The mechanism consists of a small lever adjacent to the accelerator lever which is coupled by horizontal, forked-end, connecting rods to the lever of the advance and retard mechanism located on the chain case at the forward end of the engine. Should this mechanism become deranged it is a simple matter to readjust since the maximum advance mark on the injection control plate corresponds to the maximum speed position of the accelerator lever. Occasional inspection should be made to see that this position is maintained.

The advance and retard mechanism controls the axial position of a helical gear which is moved along the splined camshaft of the fuel injection pumps. There is consequently a slight reaction of the cams on the mechanism. To provide against this movement being transmitted to the accelerator lever, and so wearing the connecting links, etc., an adjustable friction device is fitted. This consists of a cork washer clamped between the chain case facing and the timing injection pointer. It is loaded by a castle nut with spring washer. See Figs. 3 and 5.

This should be inspected every 1,600 hours and if, while the engine is idling, the pointer lever is seen or is felt to move slightly backward and forward, the castle nut should be tightened by the minimum amount required to damp out the vibration. If the friction device is over-tightened it will make the accelerator lever stiff to move and prevent it returning to the slow running position. The amount of friction applied can be judged by operating the accelerator lever, but if this is done when the engine is stopped it is necessary to pull back all priming levers on the injection pump to liberate the pump cams from all spring load.

AIR FILTERS

Air Filters.—When an engine is fitted with oil-wash type air filters it is most important to clean them when and as stated on the instruction plates attached. It is also imperative that the oil level is correctly maintained and does not rise above the maximum mark.

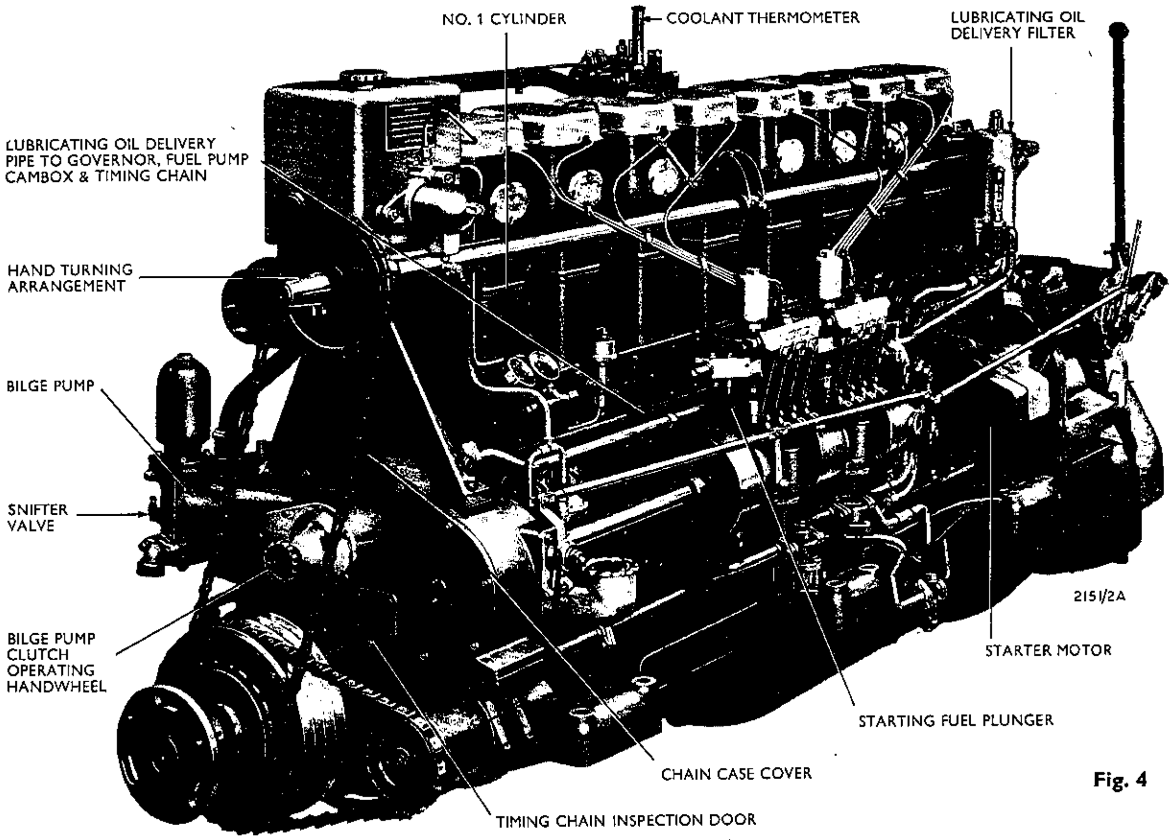
It is highly injurious to run an engine with choked or partially choked filters.

Dry Type Induction Air Filter.—These filters may have been fitted to some L3B engines as an alternative to the oil-wash type filter. It is of the utmost importance that the dry type filter should be given regular and frequent cleaning to ensure maximum efficiency.

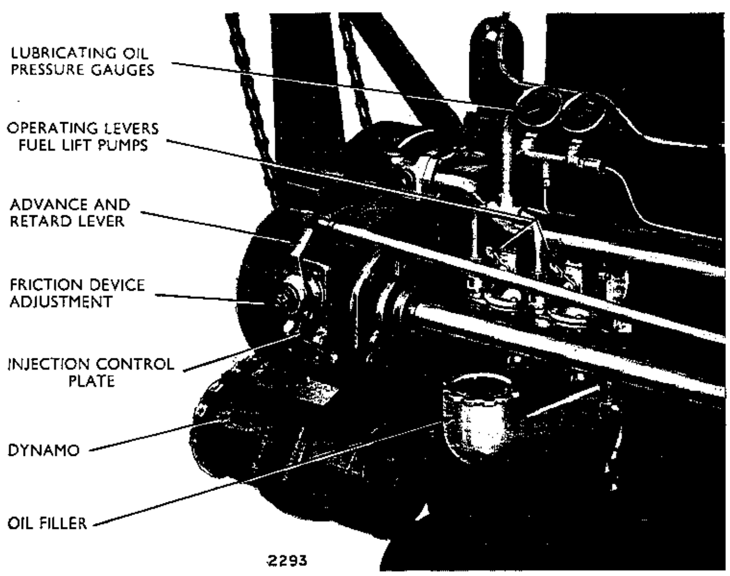
The elements of dry type induction air filters are constructed with specially processed paper and they may, in service, be subject to rapid accumulation of filtered media which they have successfully prevented from passing to the engine.

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, over-heating, together with other attendant ills and high maintenance.

Such resistance is developed 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.



8L3B MARINE PROPULSION ENGINE **Fig. 4**



FORWARD END OF 8L3B MARINE ENGINE **Fig. 5**

AIR FILTERS—*continued.*

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 design of the air inlet manifold at the chain case end of the engine embodies a small boss which can be drilled and tapped to take a $\frac{1}{8}$ in. BSP. connection for this purpose.

The lowest depression obtainable is desirable and with a well designed layout less than 3 in. of water is measureable.

If chokage of the element is sufficient to create a depression of 6 in. of water, the filter element must be replaced or cleaned immediately. It is good practice to always have a new element readily available.

Elements may be successfully cleaned (*a*) by tapping gently on the sealing face 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. In some cases process (*a*) satisfactorily cleans the element; in others, perhaps associated with an oily atmosphere, (*b*) produces better results.

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.

A simple parallel transparent PVC plastic tube, approximately $\frac{5}{32}$ in. bore and $\frac{13}{32}$ in. outside diameter, 15 in. total length, manometer can be readily constructed. If desired it can be carried in the driving compartment for use at any time. Alternatively, it may be considered convenient to mount two tubes on a vertical or nearly vertical surface of the driving compartment and for them to be permanently connected for the purpose of recording manifold depression.

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

BILGE PUMP

Marine engines are equipped with an engine-mounted Heat Exchanger for a closed circuit fresh water cooling system and can also be fitted with a ram type bilge pump. This is driven from the valve camshaft by an eccentric. The pump is operated by a hand wheel and friction clutch so that it may be started and stopped as desired. Engines are not supplied with a bilge pump unless expressly ordered; they are then the subject of an extra charge.

When an engine is cooled by means of the Gardner keel cooler, however, this ram type pump is constantly driven and there is no friction clutch. In such cases the pump is used for circulating sea water through the engine-mounted lubricating oil cooler. In this case an alternative arrangement would have to be provided for driving a separately mounted bilge pump.

On the outward end of the pump body will be found a small vent or snifter 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 one-eighth of a turn and the lock nut tightened in this position. If the valve is set incorrectly, too much air will be drawn into the pump and so reduce the amount of water delivered.

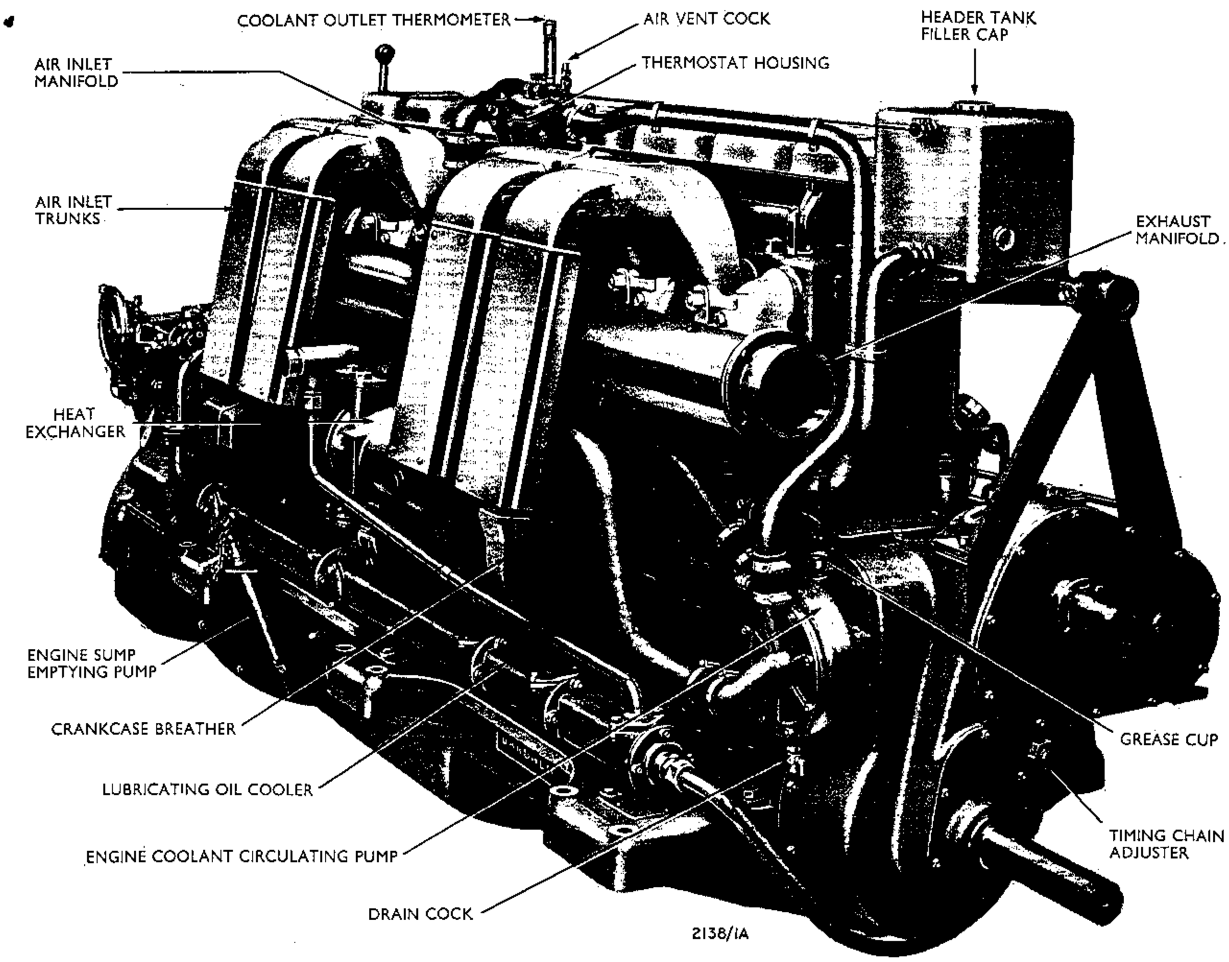
Bilge Pump Clutch Adjustment.—The designed loading on the clutch spring is such, that when the hand wheel is in the fully engaged position, a pressure of 20 lb./sq. in. (1·406 kg./sq. cm.) is recorded on the output side of the pump.

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

BILGE PUMP—*continued.*

Ram type Bilge Pump Valves and Cup Washers.—These valves are disc-like in form and made of a special oil-resisting compound. If, after long use, they buckle, or become saucer-shaped, they may be reversed so that the original upper face becomes the lower. If, in emergency, valves have to be used which are not of Gardner manufacture, 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 and this will prevent the valve from seating. There are two cup washers on the bilge pump ram and they are fitted back-to-back.

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 clamps up the cup washers, etc. and finally tightens up solidly on the brass washers. If the nut were only to tighten up on the cup washers it would soon become slack in service and rapidly wear away the thread.



8L3B MARINE PROPULSION ENGINE **Fig. 6**

CRANKCASE VENTILATION

Crankcase Ventilation—Breather Cleaner.—Rail Traction engines, and engines which are equipped with Air Filters, are also fitted with a crankcase Twin Breather Assembly. This assembly is normally mounted on the cambox side of the engine; No. 6 door on the 6L3B engine and No. 2 door on the 8L3B engine. These breathers will periodically require washing in petrol or detergent and allowed to dry. Site and also operating conditions have a great influence on the rate at which these breathers become choked. As a general guide the instructions on the breather should be observed; only actual experience in any particular duty and location will indicate when servicing is necessary.

A choked breather will create pressure in the crankcase thus causing oil leaks at various points on the engine. On Marine engines crankcase ventilation is provided by means of a special pipe bolted to one of the crankcase doors. This pipe is lead near to the lower end of one of the induction air trunks. This system requires no servicing.

CRANKSHAFT AND MAIN BEARINGS

Crankshaft.—The journal and crankpin diameters are $4\frac{1}{2}$ in. and $3\frac{5}{8}$ in. respectively and the crankshaft runs in pre-finished bearing shells. Under average conditions and correct maintenance the crankshaft will not require attention until after a minimum of 20,000 hours running time. The shaft may then require removal and regrinding to a suitable undersize in order to restore roundness and alignment of the main journals. The crankpins will, of course, require similar attention at the same time.

When re-sizing a crankshaft it is essential that the work be effected with scrupulous accuracy. The shaft must run truly about its axis and the bearing surfaces must be parallel and perfectly round. The axis of the crankpins must be parallel with the journal bearings in both planes and the radii where journals and crankpins join the webs must blend perfectly, be accurately formed with high finish, free from lines or marks and be not smaller than the original dimensions. If these provisions are not observed failure of crankshaft and bearings must ultimately occur.

Before final assembly, all passages must be thoroughly cleaned and the surfaces examined for abrasions, scratches or indentations which may have been accidentally caused when lifting the crankshaft into position, etc. Any such blemishes should be carefully removed by using an Arkansas marble or similar stone.

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 the original flatted portion around the circumference at each end of the holes must also be restored. The flatted portion takes the form of a $\frac{1}{16}$ in. wide band around the circumference of the holes on pins and journals and can be suitably formed by using a small, smooth, oil stone.

Main Bearings.—The crankcases of 6L3B and 8L3B engines are equipped with steel shell, pre-finished, specially surfaced copper-lead, main bearings and **under no circumstances whatever** must any attempt be made to line-bore these bearings. **The bearings must be replaced if they are in any way damaged or if the lead plating is worn to such an extent that the copper lead so exposed amounts to 20% of the bearing area.** A new or reground crankshaft should be assembled in the crankcase into new bearing shells which are available in the undernoted sizes from the Works, or from our authorised Agents in the United Kingdom and Overseas.

(1) For journals of standard size—e.g. 4·500 in. +·0000 in. —·0005 in.

(2) For journals up to ·020 in. undersize in steps of ·005 in.

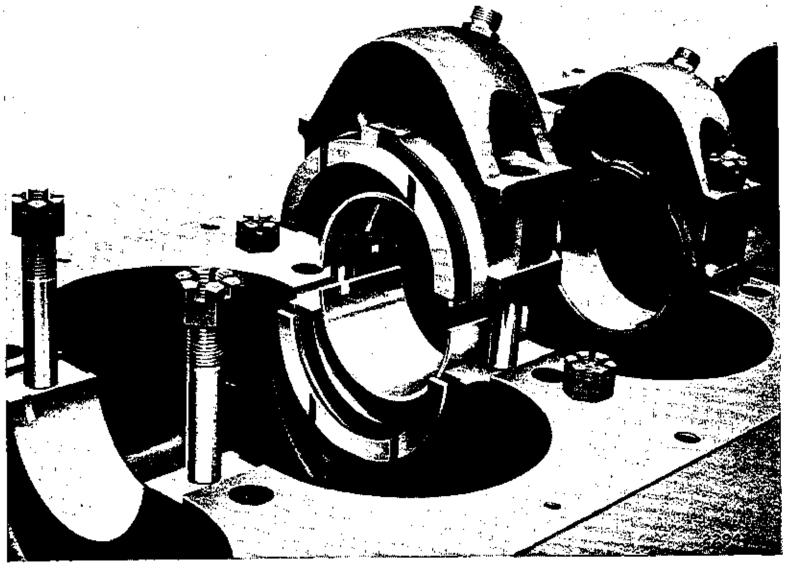
(3) For journals from ·030 in. to ·060 in. undersize in steps of ·010 in.

Main bearing shells will therefore give the correct running clearances when assembled for crankshaft journals which have been reduced in diameter by precisely the correct amount of undersize from the original nominal diameter of 4·500 in.

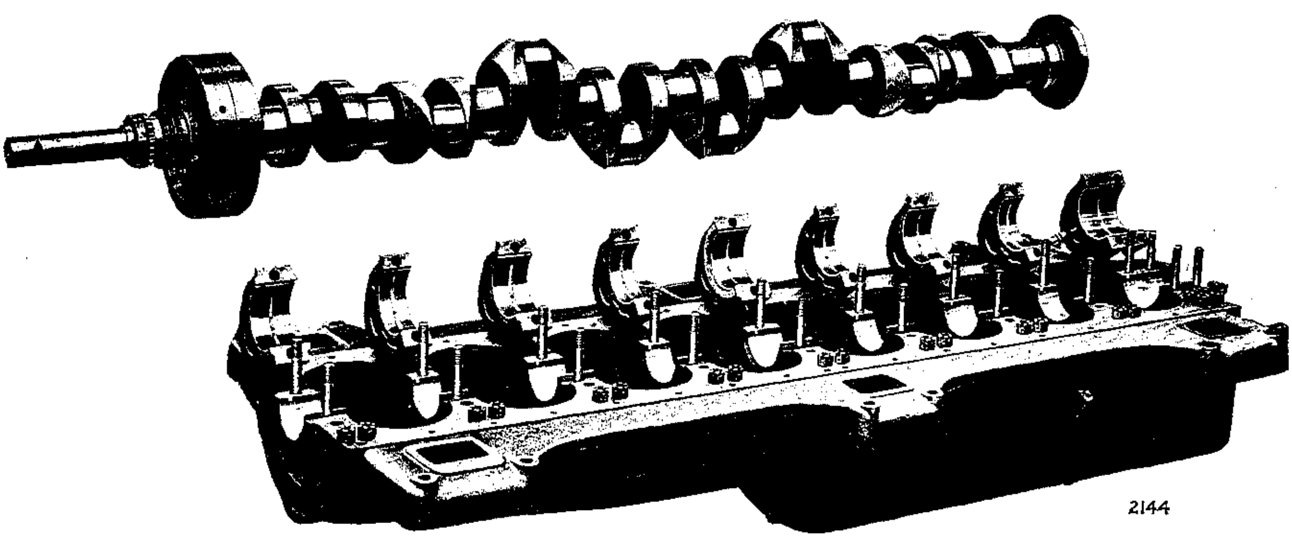
When assembling the main bearing shells it is imperative that the following notes and instructions are carefully followed:—

(a) Number 1 cylinder is situated at the forward or chaincase end of the engine. The main bearing caps are numbered 1 to 7 or 1 to 9 respectively with 6L3B and 8L3B engines. The numbers are stamped on the top of the main bearing caps. The caps and bearing shells must not be interchanged. It is possible to incorrectly assemble the bearing caps and it will be noticed that caps Nos. 1 to 8 of an 8L3B engine and Nos.

CRANKSHAFT and MAIN BEARINGS—*continued.*



CRANKSHAFT CENTRE MAIN BEARING SHOWING PRE-FINISHED BEARING SHELLS AND THRUST WASHERS



8L3B CRANKSHAFT AND LOWER HALF CRANKCASE WITH MAIN BEARING CAPS REMOVED SHOWING CRANKSHAFT THRUST WASHERS FITTED TO TOP AND BOTTOM HALVES OF CENTRE MAIN BEARING

CRANKSHAFT and MAIN BEARINGS—*continued.*

1 to 6 in a 6L3B engine are equipped with lubricating oil stocks which point to the flywheel end of the engine when correctly assembled. The lubricating oil stock of the flywheel end main bearing caps of both engines point the opposite way and these caps cannot be assembled incorrectly.

When a crankshaft is assembled in an engine at the Works the steel shells of the main bearings are marked on the edge with a line, or lines, to correspond with the bearing number; 1 to 7 for 6L3B engines and 1 to 9 for 8L3B engines. These marked lines lie at the flywheel end of the engine (flywheel end bearings excepted) when all bearings are correctly assembled.

(b) Pre-finished bearing shells are not provided with flanges and crankshaft location is therefore obtained by the use of specially designed thrust washers. These are fitted in pairs at each end of the centre main bearings —No. 4 main bearing on 6L3B engines and No. 5 main bearing on 8L3B engines. The lower half of each pair of thrust washers is assembled against a machined surface on the crankcase and abuts with matching upper-half thrust washers fitted in the main bearing cap. The upper-half thrust washers carry a locating tongue which firmly locks the upper and lower halves when the main bearing cap nuts are tightened.

The thrust washers are matched and sized in pairs, the chaincase end washers having a single line filed on the edge near the abutment of the upper and lower halves. The flywheel end thrust washers are marked with two lines in a similar manner.

The exact thickness of all thrust washers is recorded at the Works and in the event of replacements being necessary these can be supplied promptly and correctly.

With the thrust washers in position and the cap nuts of No. 4 or No. 5 bearing tightened to about half the final tightness, **and with the cap nuts of all other bearings tightened to full torque,** the crankshaft should be pushed hard-up against the washers—first from the flanged end and then from the chaincase end. Rotate the shaft a few turns each time. This will ensure that the thrust washer faces match-up properly and also enable the end float to be measured. This can be checked by a clock gauge which should record an end float of ·003 in. to ·006 in.

Thrust washers are **not interchangeable** and spare sets **must** be obtained from the Works.

(c) Before assembling a pair of main bearing shells see that all parts are scrupulously clean and that the wearing 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 to the bearing shells and render them unfit for use.**

Each pair of bearing shells are a perfect fit in their respective housings and a specially positioned locating tongue on each half-bearing ensures correct assembly.

To ensure that the two halves are firmly "gripped" when finally assembled it is desirable to first fully-tighten both nuts to a torque of 2,100 lb. in. and then slacken off one nut. This should allow the bearing cap to spring "open", on one side only, ·006 in. to ·012 in. as measured by feeler gauges inserted between the machined surfaces of the cap and crankcase as close to the bore as possible.

In addition to the stamping of the main bearing caps with a number, all studs and nuts are also stamped with numbers to facilitate re-assembly. The studs and nuts of No. 1 main bearing are stamped with Nos. 1 and 2, those for No. 2 main bearing being stamped Nos. 3 and 4 and so on with all other studs and nuts. The stamping of these numbers is so arranged that all **ODD** numbers appear on one side of the engine and all **EVEN** numbers on the opposite side. This stamping is done at the Works **after** each nut has been fully tightened to torque and the split pins inserted. The numbers on the stud and the nuts coincide and therefore make it a simple matter to insert the split pins when the nuts are re-tightened to full torque.

The correct tightening of the main bearing cap nuts has a slight but highly important effect on the bearing bore size and shape. It is therefore essential that these nuts are re-tightened in exactly the same order and to the same degree of tightness every time the bearings and caps are assembled. For this purpose it is necessary to establish a standard procedure which must be observed at each stage of the job as follows:—

CRANKSHAFT and MAIN BEARINGS—*continued.*

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

2nd Stage. Commencing at No. 1 main bearing cap tighten all nuts stamped with **odd** numbers to about half final tightness.

3rd Stage. Continue by tightening opposite side nuts stamped with **even** numbers to about half final tightness. Commence at No. 14 nut (6L3B engines) or No. 18 nut (8L3B engines).

4th Stage. Repeat as stage 2 and tighten all nuts with **odd** numbers to full torque.

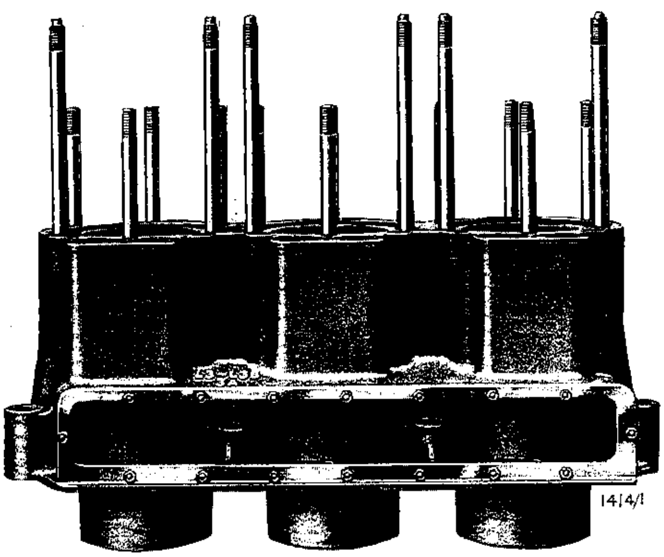
5th Stage. Finally, repeat stage 3 and tighten all nuts with **even** numbers to full torque.

The correct tightening torque for the main bearing cap nuts is 2,100 lb. in. After final tightening, new split pins of the correct size should be fitted. The pins should be sprung open before insertion; this prevents movement and consequent wear when the engine is in service.

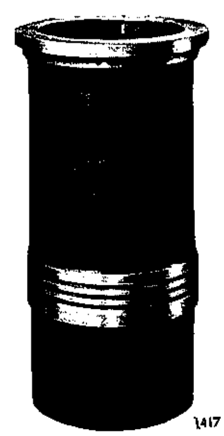
There is a lubricating oil return scroll at the flywheel end of L3B crankshafts. When assembling a new or re-ground crankshaft it is important to ensure by means of suitable feeler gauges that there is ·004 in. to ·006 in. clearance all round between the crankcase and journal diameter at this point.

CYLINDER BLOCKS AND CYLINDER LINERS

Cylinder Water Jackets.—After lengthy periods of use the water jackets may accumulate a certain amount of sediment. The amount, and time taken to accumulate, vary considerably according to the condition of the water used for cooling. It is therefore advisable to observe from time to time that it has not accumulated sufficiently to impede the flow from the water inlet holes near the base of the cylinders. Each time a cylinder block is removed from the engine the water jacket should be flushed out from the top.



THREE-BORE CYLINDER BLOCK FOR 6L3B ENGINE



CYLINDER LINER

Cylinder Liners—Relinering.—The wet liners are fitted with dry liners. This enables the wet liner to be reclaimed and so assist servicing. To this end the Works operate a system of exchange whereby credit is allowed for worn liners in exchange for relined ones.

Removal and Refitting of Wet Cylinder Liners.—The liners are a push fit in the cylinders (water jackets) and held in place by the cylinder head. The water joints at the lower end of the liner are made by three synthetic rubber rings, the first of which is fitted in the upper groove turned in the liner. Between this groove and the second and third grooves, which house the remaining two rubber rings, is turned a special groove having no ring but forming a channel which collects any cooling water which may leak past the first rubber ring. This particular groove communicates with a small hole drilled in the water jacket so that visible warning is evident

CYLINDER BLOCKS AND CYLINDER LINERS—*continued.*

on the outside of the cylinder block of any cooling water leakage. The top water joint is metal to metal, and is made with the addition of a little paint or jointing compound.

To remove a liner without dismantling the cylinder from the engine proceed as follows: Lift the cylinder head and remove the crankcase doors of the cylinder in question, uncouple the big-end bolts and withdraw the piston and connecting rod together as a unit through the upper end of the liner. With the aid of a baulk of timber and heeling off the edge of the crankcase door opening, lever the liner upwards. If the cylinder complete has been removed from the engine the liner will have to be tapped out of the cylinder with a lead hammer or mallet, etc.

To refit a wet liner proceed as follows:—

(1) Remove any sediment or deposit which might restrict the water space, particularly at the top and bottom of the cylinder block.

(2) The bore and recess in the top face and the bore in the bottom face of the cylinder block must be scraped clean with a blunt tool which will not cut the metal.

(3) Lap the top flange of the liner into the block using a small amount of very fine abrasive. Wash the two faces with paraffin or fuel oil and dry off. Avoid fouling the cylinder stud threads with grinding compound.

(4) Fit new rubber rings on the liner taking care that they fit evenly in the grooves and that the periphery of each ring presents a smooth uniform surface.

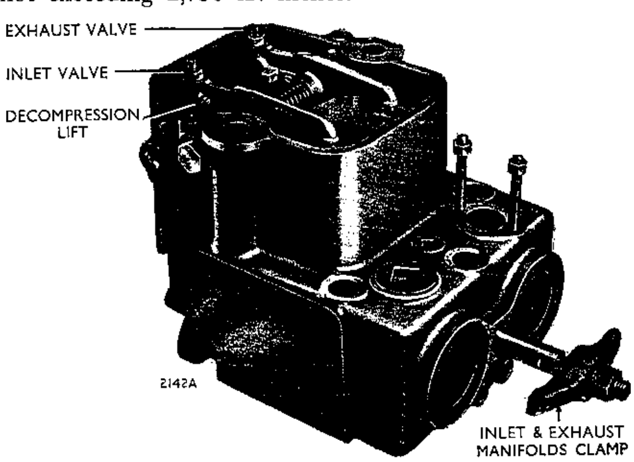
(5) Paint the bore and recess in the top face of the cylinder block. Also paint the external machined portions of the liner at the upper end. The machined portion at the lower end **and the sealing rings down to the second sealing ring** should also be painted. The third sealing ring and the remaining lower portion of the machined surface should be smeared with tallow to preserve these parts and to facilitate assembly of the liner.

(6) Fit the liners into the block whilst the paint is still wet.

(7) Wipe away any paint present on the cylinder head joint face of the liner.

The painting of these machined surfaces materially reduces corrosion and assists in making the joint water tight, in fact, if the cylinder blocks can be thoroughly dried, the whole of the inside surfaces of the water jacket should be painted before the liners are fitted, to reduce corrosion of this area. A good quality slow drying enamel may be used, or, when ordered, the Works will supply paint suitable for this work.

Cylinder Blocks and holding down nuts.—Before replacing cylinder blocks, the lower faces, which make a metal to metal contact with the upper half crankcase, should be smeared with Wellseal Jointing compound. This is obtainable from Wellworthy Ltd., Lymington, Hampshire. The nuts should be tightened with a torque not exceeding 2,750 lb. inches.



CYLINDER HEAD SHOWING VALVE LEVER ADJUSTING SCREWS

CYLINDER HEADS

Cylinder Heads. Removal. Decarbonising.—In order to obtain the best results from the engine and to maintain it in an efficient and economical state, it is recommended that the heads be lifted off and the valves and other parts cleaned not less frequently than every 3,200 hours. These intervals have, to our knowledge, commonly been doubled and trebled, but we do not recommend such intervals because, unless the engines be running under proper conditions, undue wear of parts takes place. Little need be said about the removal of carbon deposits which will be found chiefly in the valve ports; the deposit on the piston and cylinder heads being of little consequence. The operation of removing the heads is very simple and straightforward. The holding down nuts are accessible

CYLINDER HEADS—*continued.*

by means of a box spanner from the top of the head. Those which cannot be so reached are accessible by an ordinary spanner after removing the small aluminium doors from the fuel pump side of the cylinder head.

To Avoid Damage to the Sprayer Nozzles which project from the flat surface of the cylinder head, it is strongly recommended that the sprayers be withdrawn before removing the heads.

Cylinder Heads, Water and Oil Joints.—These are made by a series of small, inexpensive, synthetic rubber rings. It is good practice to renew them whenever the cylinder heads are removed.

Replacing a Cylinder Head.—The gas joint of head to cylinder liner is made by a metal to metal joint, i.e., there is no joint packing. When replacing a head it is only necessary to see that all the rubber rings are in correct position and that the gas joint faces are scrupulously clean. Then smear with a little lubricating oil. Tighten the nuts evenly and a little at a time. The correct tightening torque is 1,800 lb. in. This must not be exceeded.

FUEL FILTERS

Choked Fuel Filters.—Certain fuels may show 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 in some unexposed position and preferably where it may receive some heat from the engine.

The filter elements can be tested for obstruction, either 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

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

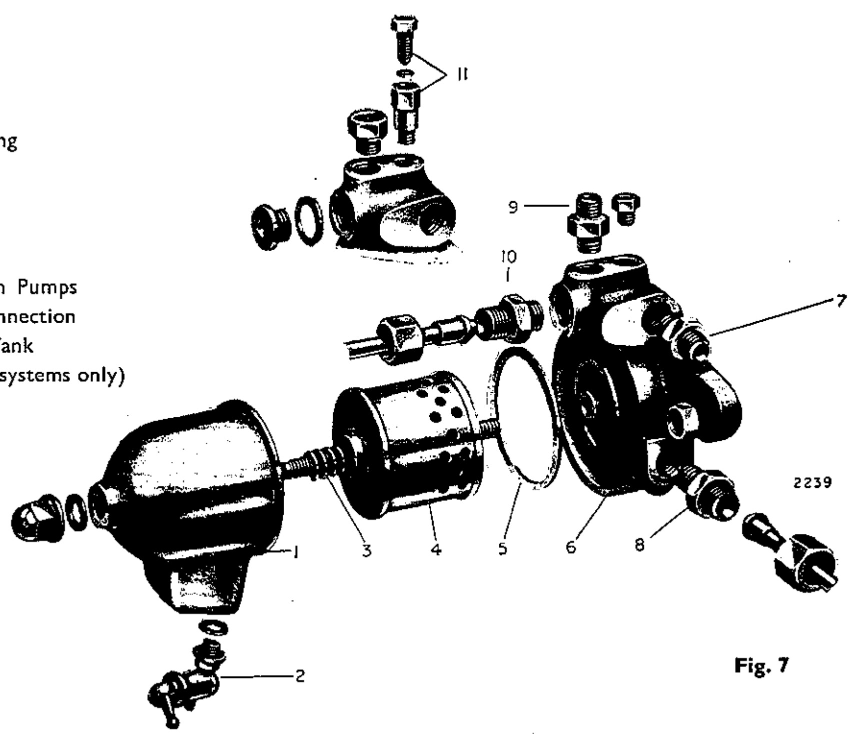


Fig. 7

ENGINE MOUNTED FUEL FILTER SHOWING COMPONENT PARTS
(Alternative Vent Valve Arrangements are shown for Gravity and Overflow Return Systems)

FUEL FILTERS—*continued.*

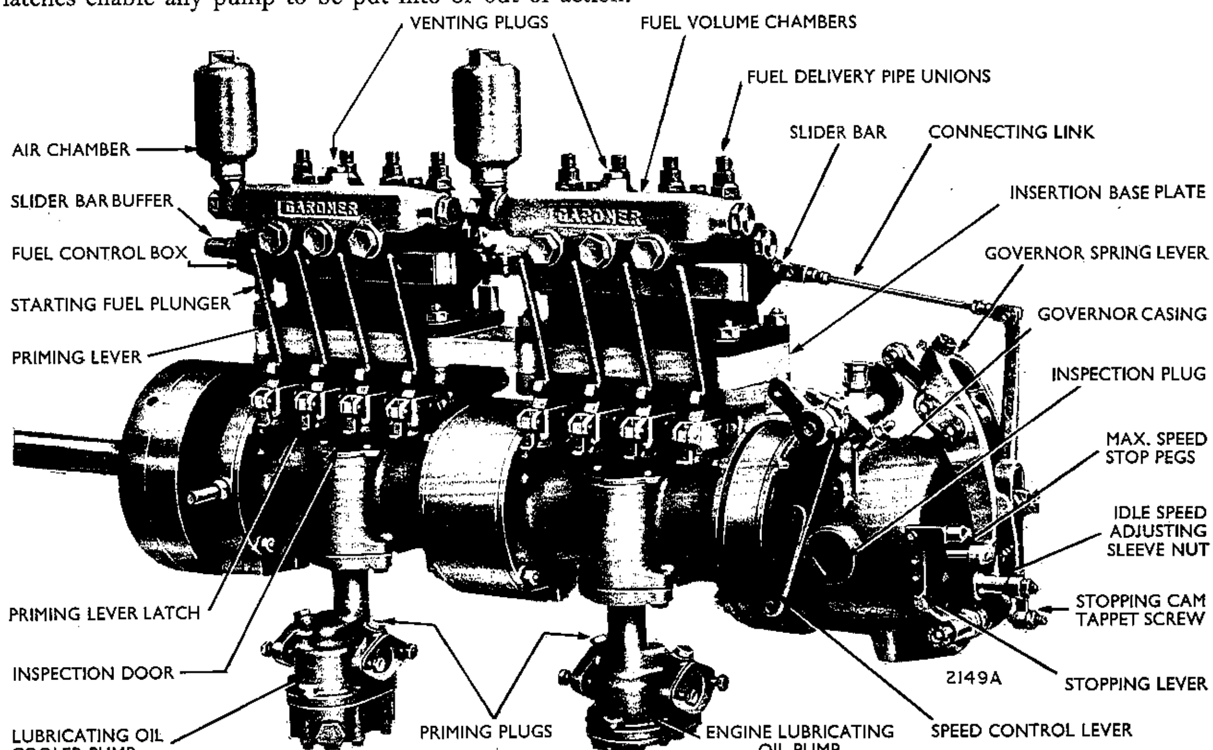
the lower end and pouring fuel into the upper open end. If fuel collects and does not run through the filter paper almost as quickly as it is poured in, the filter is probably choked sufficiently to cause erratic running of the engine and should be replaced. Experience indicates that a large percentage 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.

Replacement of Filter Elements.—Apart from stoppages due to the causes already mentioned, the filters are more liable to stoppage by foreign matter from the fuel in the form of solid particles. This applies in particular to engines operated under dusty conditions and where good fuel storage and filling cannot be arranged. 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 3,200 hours. Generally speaking the second filter element should have a "clean" life longer than that of the first filter element.

When Replacing the Filter Covers gently rotate them on their joint faces so as to minimise the chance of foreign matter causing an unsound joint. Use a new standard specification joint ring to ensure absence of leakage. The correct tightening torque for the cover nut is 180 lb. inches.

FUEL INJECTION PUMPS—GOVERNOR AND GOVERNOR CONTROL

Fuel Injection Pumps.—These are built in units each containing as many pump plungers as there are cylinders on the engine. The 6-cylinder engine has two 3-pump units, and the 8-cylinder engine two 4-pump units. Each pump is operated by its own cam on the camshaft and, in addition, is furnished with a hand lever and latch enabling the pumps to be worked by hand for priming the injection system or for testing the sprayers. The latches enable any pump to be put into or out of action.



FUEL INJECTION FUMPS, GOVERNOR AND CAMBOX ASSEMBLY OF 8L3B ENGINE **Fig. 8**

FUEL INJECTION PUMPS, GOVERNOR AND GOVERNOR CONTROL—*continued.*

Fuel Pump Slider Bar.—This slider bar (Fig. 8) is linked to and operated by the centrifugal governor and its function is to vary the amount of fuel injected into the cylinders and thus vary the power of the engine. The effect of moving the slider bar towards the flywheel is to increase the amount of fuel injected into the cylinders and *vice versa.* If the bar is moved its full extent towards the timing case, there is no injection. The correct setting of the slider bar with relation to the governor is such that, when the governor weights are parted to their full extent by inserting the fingers through the inspection plug opening in the governor casing, the length of the slider bar connecting link is so adjusted as to give the slider bar a position approximately $\frac{1}{32}$ in. from its maximum stroke towards the timing case. If the link has thus to be adjusted at any time care should be exercised in seeing that the holes of the joint pins are parallel and that the slider bar moves freely.

Before making this check it is necessary to relieve the main governor spring of all load. This should be done by removing the hinge pin from the aluminium forked governor-spring-lever and unscrewing by several turns the idle speed adjusting sleeve nut on the after end of the governor casing.

Engines which may have operated for long periods with a slack or badly worn timing chain and/or excessively worn splines on the fuel pump camshaft will cause very uneven drive to the governor. This will create excessive wear of all parts of the governor mechanism particularly to the split cotter pins which retain in position the steel pins of the governor weights. Worn cotter pins should be replaced with pins of the correct size and, before fitting, bend down the legs from about half way lengthwise for approximately $\frac{3}{32}$ in. This ensures that they will fit tightly in their holes. After fitting, the ends of the legs should also be fully opened out to prevent the pins from rotating. Any faults in the timing drive must not be allowed to persist.

Fuel Pump Slider Bar Sticking.—If at any time the slider bar shows a tendency to stick or only move sluggishly, it may cause the engine to stop when the speed control is moved from full speed to idle.

There are five possible causes for this trouble, as follows:—

(1) The unions on top of the fuel pumps may have been tightened excessively thus distorting the fuel pump elements.

(2) Fracture of one of the fuel pump plunger springs. This should be replaced at once by the spare spring supplied with the engine. For this purpose the pump has to be removed from the engine and the particular plunger withdrawn from the pump. The plunger is retained by a spring circlip or ring which has to be removed before the plunger can be withdrawn.

(3) The idling speed adjustments referred to on page 59 have been set incorrectly and prevent the governor from having control of the speed when the engine is set to idle.

(4) The use of a fuel which has poor lubricating properties. In this case a small quantity of lubricating oil should be mixed with the fuel as recommended in page 29.

It is of the utmost importance that the slider bar connecting link (Fig. 8) be adjusted as previously mentioned. Should the link be adjusted to such a length as to leave no clearance in the above position there is grave risk of the small central ball races sustaining damage with serious consequences. This will be readily understood when it is realised that the governor weights are provided with a substantial abutment at their fulcrum to determine their maximum extended position and so relieve the connecting link and small ball races of this duty. To amplify this further, if $\frac{1}{32}$ in. clearance is not allowed, the full power of the governor weights is transmitted through these small bearings which normally only carry the load applied by the slider bar return spring.

Fuel Pump Slider Bar—Slider Bar Buffer and Adjustment.—The slider bar buffer is located on the fuel control box and prevents stalling of the engine in the event of friction being generated in the fuel pump. When the engine has attained normal operating temperature and the idling speed has been correctly set to 250 r.p.m. as instructed on page 59, the buffer should be screwed in towards the slider bar until a slight speed increase is felt. The buffer should then be screwed **away** from the slider bar for six hexagon flats and the lock nut tightened. If the buffer is set with insufficient clearance from the slider bar, unstable idling will result. Use only light pressure to lock buffer.

Fuel Injection Pump Output.—Every 3,200 hours remove both pumps complete with aluminium base plate and fit to Gardner calibrating machine. Make test of maximum fuel delivery with slider bar in contact with

FUEL INJECTION PUMPS, GOVERNOR AND GOVERNOR CONTROL—*continued.*

control trigger and idling position balance as described in Fuel Injection Pump Calibrating Machine Instruction Book No. 45·4 (or later issue). In course of time maximum fuel delivery may tend to increase and the pump should be re-set to the standard output. 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 PUMP CALIBRATION.—The calibrating details for L3B type engines are as follows and these figures are based upon the use of Gardner sprayers in optimum condition, sprayer pipes of the same length and bore as used on the engine from which the pumps were removed, diesel fuel between ·820 and ·850 S.G. @ 60°F. and the use of No. 7 profile cams with which all Gardner calibrating machines are equipped.

Fuel Camshaft Type	Engine Governed Max. R.P.M.	B.M.E.P. lb./sq. in.	Camshaft R.P.M. During Calibration	Time in seconds	Average Delivery from each Plunger. Cubic Centimetres
10	6 & 8L3B/1300 Rail Traction, High Speed Marine Duty	107·8	650	45	79·6
10	6 & 8L3B/1150 Yacht, Cruiser Marine Duty	107·8	575	50	77·5
10	6 & 8L3B/1100 Intermittent Duty, Air Compressors, Excavators, Saw Mills	103·3	550	50	71·4
10	6 & 8L3B/1000 Heavy Marine Duty	107·8	500	60	80·2
10	6 & 8L3B/1000 Generator Sets, Marine Auxiliary & Industrial Duty	100·0	500	60	75·2

Fuel Pump Tappets.—As mentioned in page 70, the adjustment of the fuel pump tappets should not be deranged. They are adjusted during engine test and will not require further attention. Should, however, this adjustment be inadvertently upset, or a new part has to be fitted, re-set as follows:—

Turn the flywheel round until a tappet has lifted to its maximum, then turn the flywheel one more exact revolution, this tappet will now be resting on the base of the cam. Place on top of the tappet screw a small disc or washer of 0·140 in. 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 0·140 in. gauge is in position on any of the tappets. Very serious damage will occur if this is not observed.

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.

FUEL INJECTION PUMPS, GOVERNOR AND GOVERNOR CONTROL—*continued.*

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, re-heat 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.

Instructions for Fitting Spare Fuel Injection 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 a spare pair, i.e., one pump of a spare pair will **not** replace one of the original pair. This is necessary because the pumps are calibrated in pairs.

To replace, proceed as follows:—

No. 1. Fit the pumps after having checked and corrected where necessary the tappet setting on each pump line as mentioned above.

No. 2. Fit the slider bar connecting link to the vertical governor lever at the flywheel end of the engine. 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, the length of the forked ended connecting link is so adjusted as to give the slider bar a position approximately $\frac{1}{32}$ in. from its maximum stroke towards the timing case. Should it be necessary to make adjustment to this connecting link, 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.

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

No. 4. Fit the pipe-work and the return spring behind the "forward" pump.

Important Note (1).—The fuel limiting 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 limiting box has been set is stamped on the box itself as is also the engine serial number.

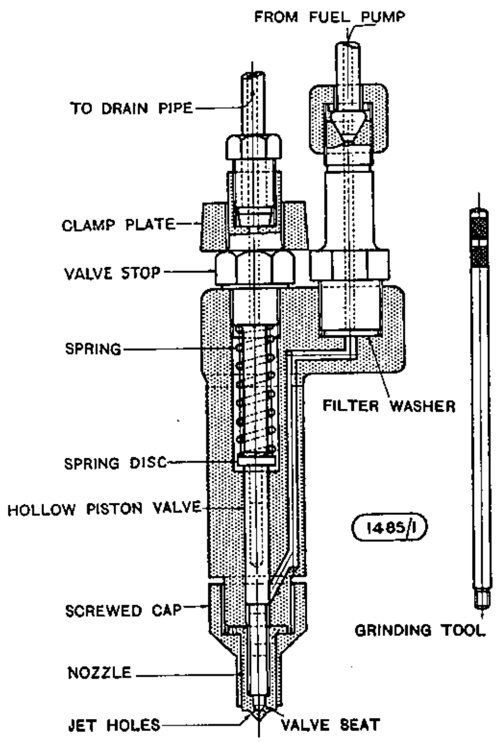
Important Note (2).—It will be observed that all fuel injection pumps are dowelled to an aluminium base plate. It is essential that the pumps are fitted to the engine with the base plate on which they were supplied. This will ensure that when fitted to the engine the two blocks of pumps will be in the same relative position to each other as they were when being calibrated.

Governor Springs.—The governor loading spring controls engine speed by means of the varying load it exerts. This depends upon the position of the accelerator cam and control lever. The Governor Springs vary in design according to the engine duty and springs supplied for rail traction engines cannot, for example, be used for marine engines or vice-versa. It is therefore essential for the engine serial number to be quoted when replacement governor springs are required.

FUEL SPRAYERS

Fuel Sprayers. (See Fig. 9)—The sprayer is a very simple and robust component and is designedly made non-adjustable. When the sprayer is reassembled after taking to pieces for cleaning or examination (as distinct from overhauling), it requires no adjustment of any kind. The sprayer is 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 on page 50 which deals with fuel filters.

FUEL SPRAYERS—*continued.*



FUEL SPRAYER **Fig. 9**

Fuel Sprayer Test every 400 hours.—These should be tested, without removing 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 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. 10 illustrates the hand operation of the fuel pumps, and also 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.

It should be noted that 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.

Every 3,200 hours.—Fit Gardner factory-reconditioned or other suitably inspected and serviced set of sprayers. Return removed set to Works or Depots for reconditioning, or inspect and workshop service as indicated in the following appropriate paragraphs:—

Fuel Sprayer Inspection.—Make the following inspections and tests, etc.:—

(1) Test for stoppage of jet holes and shape of issued jets of fuel.

(2) Test for leak of sprayer valve seat.

(3) Test for satisfactory vibration of sprayer valve.

(4) Test for leakage of fuel past large diameter of valve.

(5) Test for spring load on sprayer valve and/or hydraulic opening pressure.

(6) Observe sprayer cap nut for effective gas seal with cylinder head.

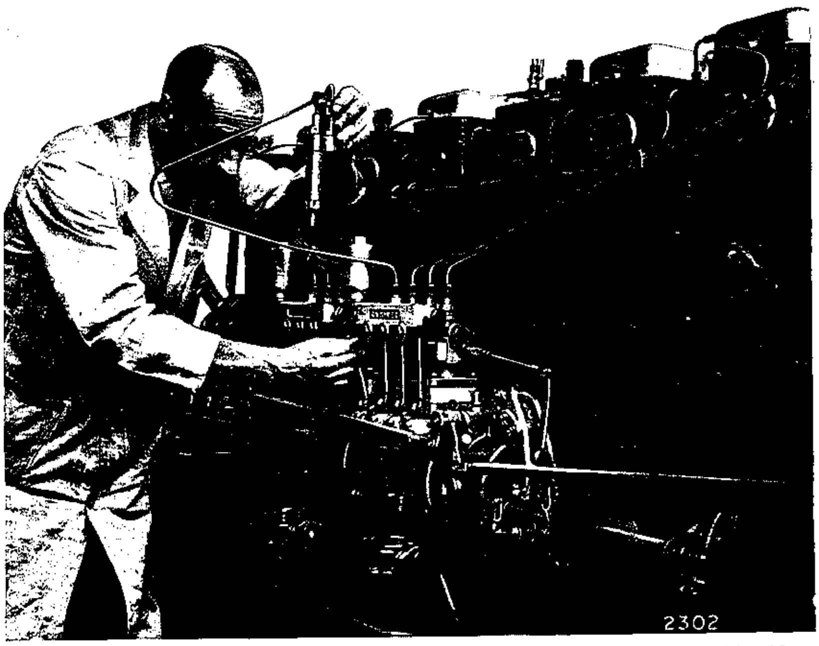
(7) Renew filter washers.

Test 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. 10 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 the holes is of great importance, therefore use only prickers of the correct diameter.

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

FUEL SPRAYERS—*continued.*

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. 11.



TESTING A SPRAYER WHEN REMOVED FROM AN ENGINE **Fig. 10**

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 **same diameter plunger as engine pump.** Operate hand priming lever and expel all air from system; apply a force to the lever just short of that required to lift sprayer valve from its seat. If the seat be unsound fuel will run down 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. A leaking valve seat, a worn and consequently wide valve seat, malalignment of valve and nozzle causing friction, and in rare instances a leak past the large diameter of the valve may prevent satisfactory vibration.

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

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. A leaking valve may be traced to mis-setting of the nozzle to the body (alignment). If, on further trial, the seats be still defective, they may require lapping together, but this should be effected only as a last resource, and as seldom as ever possible.

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 previously mentioned.

FUEL SPRAYERS—*continued.*

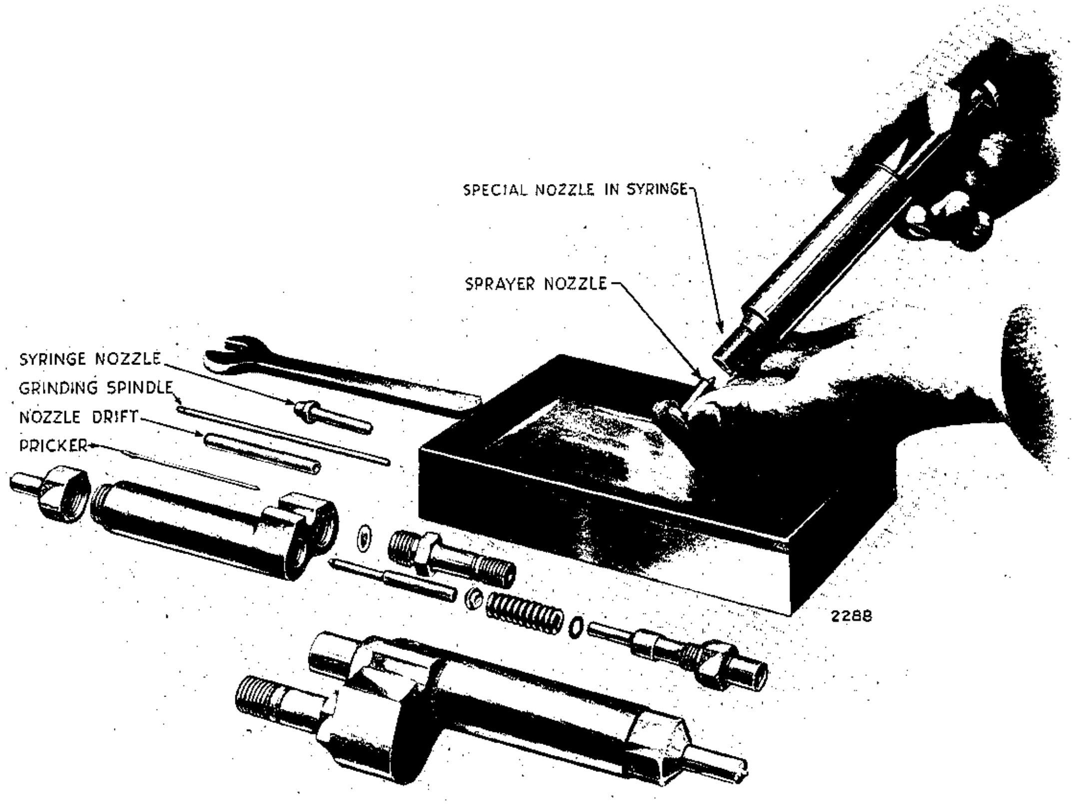


Fig. 11

CLEANING A SPRAYER NOZZLE

To Re-assemble 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.

(2*a*) 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

FUEL SPRAYERS—*continued.*

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.

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 sent to the Works for this purpose since by adopting this procedure the user will be assured of the most efficient and durable sprayer operation being obtained at the most economical cost. A system of exchange is operated and stocks are held at the Works and Depots for immediate use.

Spring Load on Sprayer Valve.—The correct spring load for the L3B sprayer is 65 lb. when compressed to its working length of 1·008 in. Should it become necessary to restore the spring load to this figure shim washers of ·003 in. and ·007 in. thickness are available for this purpose, **but a spring load of 65 lb. must not be exceeded.**

Hydraulic Opening Pressure of Sprayers.—With sprayer valve seats in new condition a spring load of 65 lb. corresponds to a hydraulic opening pressure of 130-131 Kg. per square centimetre; 1,849-1,863 lb. per square inch. When sprayer valves and seats have had long use and are free from leakage, a spring load of 65 lb. will correspond to an opening pressure of 127-128 Kg. per square centimetre; 1,806-1,820 lb. per square inch and if the pressure falls below this value the sprayer should be replaced by a service unit.

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 ·014 in. 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.

Sprayer Pipe Unions.—It is imperative that these unions do not leak, especially those in the valve gear chambers on the cylinder heads. In course of time the conical pipe ends may become reduced in bore by the action of the conical seat. 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 ·080 in.

Defective Sprayers.—If a sprayer is known to be defective, do not run the engine any longer than is absolutely necessary since this will cause undue wear accompanied by other evils.

Replacing a Sprayer in the Cylinder Head.—When a sprayer is withdrawn it leaves a liner of carbon in the cylinder head sprayer nozzle hole. This carbon must be removed before replacing the sprayer and all engines are supplied with a fluted reamer for this purpose. This reamer also cleans the conical seat in the cylinder head and permits the sprayer body to make a true gas-tight joint.

When clamping a sprayer in the cylinder head, do not tighten the nuts 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 is liable to deceive the engineer into screwing down harder than necessary. It requires little pressure on the nuts to make a

FUEL SPRAYERS—*continued*

tight joint on the conical seat. The special box key with short tommy bar supplied with each engine should be used to tighten the sprayer clamp nuts. 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 80 lb. in.

Routine Change of Sprayers.—When an engine has to operate for a great number of hours per annum, it is excellent practice to stock a complete set of spare sprayers which may be changed every 3,200 hours. This permits of systematic cleaning and examination without loss of running time.

Withdrawal of Sprayer.—Should the sprayer prove difficult to remove from the cylinder head, there is supplied with each engine special drawing tackle, consisting of a flat bar, passing through which is a screwed rod with nut. The end of the rod should be screwed into the union on the sprayer, the bar set to bridge the top faces of the cylinder head, and the nut screwed down, to draw out the sprayer.

IDLING SPEED ADJUSTMENT

Slow Running—Adjustments.—The speed of L3B engines is always under the control of the governor and the idling speed is set at the Works during test. On marine propulsion engines the idling speed can be regulated by an adjustable screw mounted on the friction-disc lever control plate. The screw is fitted with a locking nut. During test at the Works the idling speed is adjusted by this means to approximately 245 r.p.m. and the locknut tightened. Final setting is effected by the adjusting sleeve-nut and locknut located on the rear face of the governor casing. The no load idling speed is set to 250 r.p.m. by this means. See Figs. 8 and 13.

L3B engines must not be set to run at less than 250 r.p.m.

In Rail Traction and certain other engines the idling speed adjustment is effected by a hexagon-headed screw and locknut located in the remote control cam stop on the accelerator cam spindle. See Fig. 12. In all cases the final setting is made by means of the adjusting sleeve-nut located on the governor casing.

Compensation for Wear in Speed Control Mechanism.—It will be found that after long service there will be slight wear in the governor and control mechanism. This may cause reduced idling speed and erratic running. This can be corrected by use of the adjusting sleeve-nut on the governor casing.

Regular inspection should be made and the adjusting sleeve-nut used as necessary to regulate the idling speed. Always tighten the locknut after this adjustment.

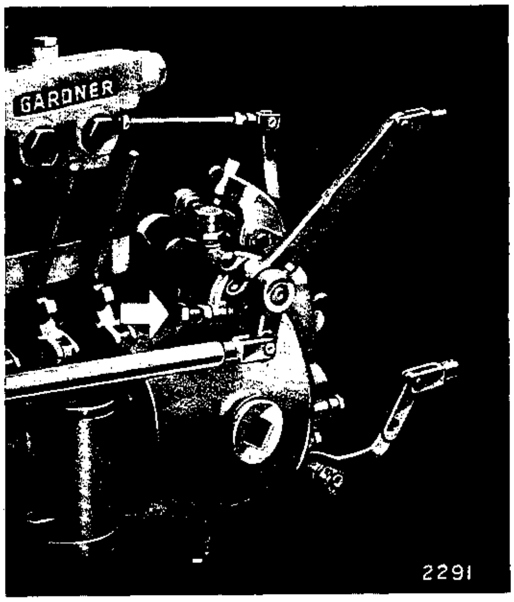
Single Lever Control.—Marine propulsion engines equipped with the Gardner Single Lever engine speed and reverse gear Control are also provided with a knurled head adjusting screw and a wing type locking nut. This is fitted in the governor remote control cam stop. See Fig. 14.

This adjusting screw and wing nut enables engine idling speed to be temporarily increased when starting from cold. Engine speed is increased by turning the knurled head screw in a clockwise direction.

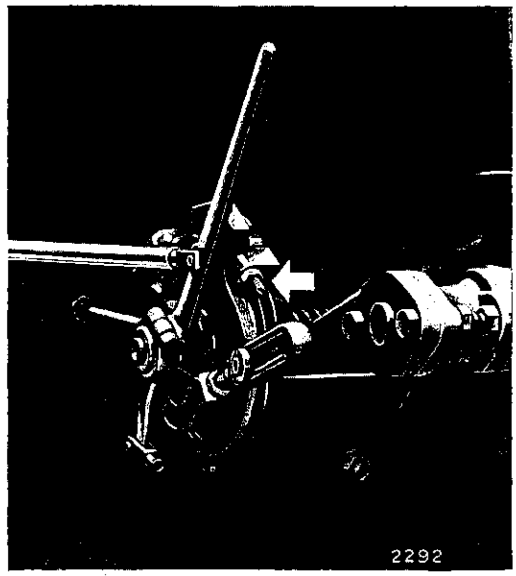
When the engine has attained normal running temperature, care must be taken to ensure the knurled head screw is screwed right back so that correct idling speed is restored.

An isolating valve, Fig. 14, is fitted to permit the Single Lever to be used solely as a Speed Control lever for the purpose of winching, cargo pumping, deck washing, etc. It is important to ensure that the Single Lever Control is in the neutral position before opening the isolating valve.

IDLING SPEED ADJUSTMENT—*continued*

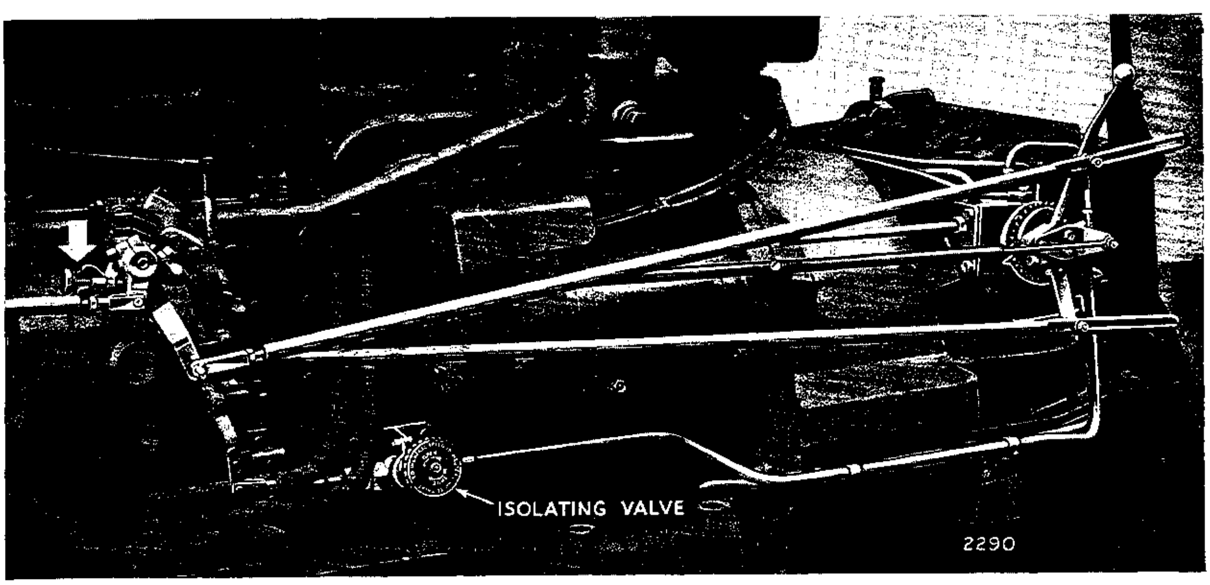


AUTOMOTIVE & RAIL TRACTION ENGINES **Fig. 12**



MARINE PROPULSION ENGINES **Fig. 13**

THE IDLING SPEED ADJUSTING SCREW ON THE VARIOUS TYPES OF ENGINES IS SHOWN BY THE WHITE ARROW HEAD



MARINE PROPULSION ENGINES WITH SINGLE LEVER CONTROL **Fig. 14**

INLET AND EXHAUST VALVES

Replacing the Inlet Valves in Cylinder Heads.—It will be noticed that the inlet valves are formed with a patent deflector. They are also prevented from turning around by the specially formed valve collars and split pins. These spring collars have a flat side which locates the valve heads, with their deflectors, by operating against a flat bearing surface machined on the inside of the cylinder heads.

As a further precaution, the split-pin hole in the valve stem is drilled slightly away from the centre line and the split-pin slots in the valve collar are likewise off centre line. With this design it is not possible to screw the valve into the collar and insert the split pin through the hole if the collar is half-a-turn wrong.

It is **absolutely essential** that the valves be replaced in their correct position with the deflectors on the same side of the valve spindle as are the manifolds. They must be definitely positioned by the split pin in the valve collar as explained above.

Care must be taken when assembling the inlet valves to ensure a clearance of ·002 in. to ·003 in. between the stems and guides.

When new, and assembled on the Inlet Valve, the clearance between the flat surface of the valve collar and the machined surface inside the cylinder head is ·003 in. to ·004 in. The valve collar surface should be parallel with the cylinder head surface when checking this clearance.

Replacing the Exhaust Valves in Cylinder Heads.—When the exhaust valves are replaced, care should be taken to remove the carbon from the holes in the guides; also see that there is a clearance of ·00325 in. to ·00425 in. between the stems and guides. Should the valve stems be a closer fit than this the guides must be reamered out until the ·00325 in. clearance is obtained.

Refitting Inlet and Exhaust Valve Spring Collars.—It will be observed from the foregoing paragraphs that particular care must be taken to ensure that the spring collars are not screwed farther down the valve stems than is necessary to thread in the split pin. Apart from the considerations given above, it must also be mentioned that the valves would not have sufficient lift and that the operating mechanism would suffer damage if the valve spring collars are screwed too far down. New split pins should always be used and they should be sprung open before insertion to prevent movement in service. They should be firmly locked by thoroughly spreading the ends.

LUBRICATION SYSTEM

Description.—A sump integral with the lower half crankcase of 6L3B and 8L3B engines forms the lubricating oil reservoir and all parts of the engines are continuously lubricated by a circulation-pressure system. The main gear type pump, driven from the governor end of the fuel injection pump camshaft (Fig. 8), draws lubricating oil through a removable suction filter in the sump via a pressure-return foot valve mounted externally. (Fig. 15). The oil is then delivered to a second filter comprising a vertical cylinder inside which is fitted a special impregnated paper element. This delivery filter is mounted on the flywheel end cylinder block and incorporated with the filter body is a by-pass valve and lubricating oil pressure regulator.

After passing through the second filter the lubricating oil feeds into the main service pipe, running along the base of the cylinder blocks, and mounted outside the crankcase on the manifold side of the engine. Internal feed pipes distribute the oil from the main service pipe to the main bearings. From the main bearings the oil passes via drilled passages to the crankpins and piston pins.

A supplementary pipe from the main service pipe feeds lubricating oil under pressure to the valves and valve tappet mechanism in the cylinder heads.

From the by-pass valve and pressure regulator on the delivery filter a surplus oil pipe runs near the base of the cylinders from the pressure regulator to the timing chain casing. This pipe circulates the surplus oil to the governor unit, the fuel injection pump camshaft and tappet mechanism and, finally, to the main timing chain and valve camshaft drive. (Fig. 4).

The main oil pump is of such large capacity that approximately 50% of the pump output is surplus. This ensures copious lubrication of the timing chain, governor and fuel pump camshaft in addition to allowing for wear in the various bearings.

All lubricating oil delivered by the main oil pump returns to the crankcase sump by various openings formed in the crankcase, through channels formed in certain component parts and, from the cylinder heads, via the valve tappet push rod openings embodied in the cylinder blocks.

LUBRICATION SYSTEM—*continued.*

Oil Cooler Systems.—In all applications of the 6L3B and 8L3B engines 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.

In marine engines the cooling water, before it enters the cylinders, is made to pass around the outside of an indented pipe through which the oil is pumped, whilst in an automotive engine the oil is pumped through a number of finned tubes which are cooled by an air stream. On L3B engines a separate pump is fitted to the forward cam box specifically for circulating oil through the cooler. This pump draws oil from the same suction pipe foot valve as the main pump and delivers through the oil cooler of either types just described. If the cooler is of the air cooled type, mounted on the engine, the oil returns from the cooler via a filter to the suction side of the main pump. In this way it is ensured that the coolest possible oil is provided for lubrication.

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 cover of the oil cooler pump is fitted with two relief valves. Only one valve operates in any one engine, but the cover is fitted with two valves so that they will suit either hand of engine. When the resistance of a cooler creates a pressure of about 35 lb./sq. in. 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 the oil becomes warm and its viscosity thereby reduced sufficiently to lower the resistance of the cooler to something less than 35 lb./sq. in., then of course all the oil will pass through the cooler.

These relief valves are formed by simple steel balls spring loaded on a narrow seat and contained by hexagon headed plugs. Normally they should not require any maintenance. The oil filter, which as mentioned, is only fitted to automotive oil cooler return pipes should be inspected and cleaned if necessary when the main system delivery filter receives attention.

In some stationary installations the problem is somewhat different, and if the oil tends to rise to or above the maximum of 145° F., endeavours should be made to create a draught about the engine either by doors or windows in the engine room, or even a small fan to circulate air around the oil sump.

Should the oil temperature in a rail traction engine rise to 145° F., the engine casing should be adequately ventilated and full use made for this purpose of the draught created by the motion of the car or locomotive. Should there be difficulty, in spite of the above, in keeping the oil temperatures below 145° F., an oil radiator should be fitted. The Works will be pleased to make recommendations for this purpose.

An oil temperature thermometer is fitted as standard equipment on all L3B engines and is located near the pressure regulating valve.

We would emphasise that the value of a draught around the engine is very great and often avoids costly and complicated oil cooling systems, also it is very beneficial for the air drawn into the engine to be as cool as possible.

Lubricating oil pressures.—The pressure gauge, or gauges are mounted on the delivery side of the lubricating oil system and should indicate the readings detailed on page 32 whenever the engine is running.

Pressure Regulation (Relief) Valve (Fig. 16).—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. It will be easily understood that varying the spring-load will correspondingly vary the pressure at which the valve permits the surplus oil to escape through the surplus oil pipe.

During engine tests the valve is set by means of the adjusting screw to maintain the lubricating oil pressures mentioned on page 32. In certain installations, or until the engine has attained maximum working temperature, the lubricating oil may not attain the temperatures and pressures shown in the table on page 32. The pressures recorded when the oil is cool may therefore be about 2 lb./sq. in. more than the figures given on page 32. This should be taken into consideration if the relief valve has to be adjusted.

A useful guide to the re-setting of the adjusting screw is to count and record the number of screw threads that stand above the hexagon locknut. This, of course, should be done before dismantling and should prove a useful aid when reassembling. On no account should the engine be run if the oil pressure is 2 lb./sq. in. less than normal.

LUBRICATION SYSTEM—*continued.*

Oil Pressure Too Low. Possible Causes.

(1) Delivery filter requires cleaning.
(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 in 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.
(9) Bearing failure.
(10) Defective pressure gauge or stoppage in the pipe line.

To Remedy the Above Defects.

(1) Dismantle, clean and reassemble as described on page 65.
(2) If foreign matter prevents the proper seating of the regulation valve, this is usually indicated by the pressure gauge recording normal pressure when the engine is running at maximum r.p.m. and too low a 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 on page 62.
(3) Replace with spare spring.
(4) Drain the crankcase sump and replace with new oil of the correct grade. See page 64 for further details. In any case, this operation should be carried out at periods of approximately 400 hours.
(5) Remove and clean the suction filter. See page 64 for details.
(6) The oil level in the sump should not be allowed to fall below the minimum mark on the Dip Rod, nor in passing, should it be allowed to rise above the maximum mark. See Fig. 15.

Note.—If a small oil pipe from the pressure gauge mount is led to a pressure gauge on the instrument panel or bulkhead, it is important to secure the pipe from all vibration and consequent possible fracture. When a flexible pipe is used, it should be fitted between the first fixing clip on frame or bulkhead and the engine, or, expressed in another way, the flexible pipe should be used so as to accommodate any movement there may be between the engine and frame or between engine and hull.

Lubrication of Fuel Injection Pumps.—After every 1,600 hours it is advantageous for a small quantity (about 30 c.c.) of engine lubricating oil to be injected, in the form of a spray mist from an almost empty syringe, through the two B.A. screw holes which will be found in the fuel control box and in the aluminium cover plate on the flywheel-end block of pumps. This assists in lubrication of the fuel pump slider bar, the quadrant teeth and the regulating sleeves inside the fuel pump housing.

Lubrication of Fuel Injection Pump Camshaft, Governor mechanism and Timing Chain, etc.—As already mentioned, these components are lubricated by the surplus oil pipe from the by-pass valve. This pipe is mounted externally and should be dismantled and examined for any signs of stoppage every 1,600 hours.

Verification that these components are receiving an adequate supply of lubricating oil can also be made by opening the inspection doors on the fuel pump camboxes while the engine is running and looking into the vertical well on the front of each cambox. A similar inspection can also be made by removing the screwed plug on the side of the governor casing, and another plug of the same type located over the timing gears at the chain case end of the engine. These inspection openings will enable the viewer to see the oil splashing from the moving parts.

Crankcase Sump—Lubricating Oil Capacity.—The 6L3B sump requires approximately 5¼ gallons; the 8L3B sump holds about 10½ gallons. These amounts are required for the normal design of sump used on marine and rail traction units.

LUBRICATION SYSTEM—*continued.*

Crankcase Sump. Renewal of Lubrication Oil.—It is recommended that the sump oil be completely drained after periods of about 400 hours. This should be done after a long run while the oil is warm and fluid. It is not recommended to wash out the sump or crankcase with paraffin as this is liable to disturb particles which might re-enter the lubrication system.

As the duty of an engine has considerable bearing on the desirable length of time between renewal of sump oil, the Works will be pleased to report on any samples of used oils which are submitted, and make recommendations as to whether it is fit for further use or has already been used for a longer period than is desirable. By this means it will be possible to arrive at the most economical periods between sump oil renewal.

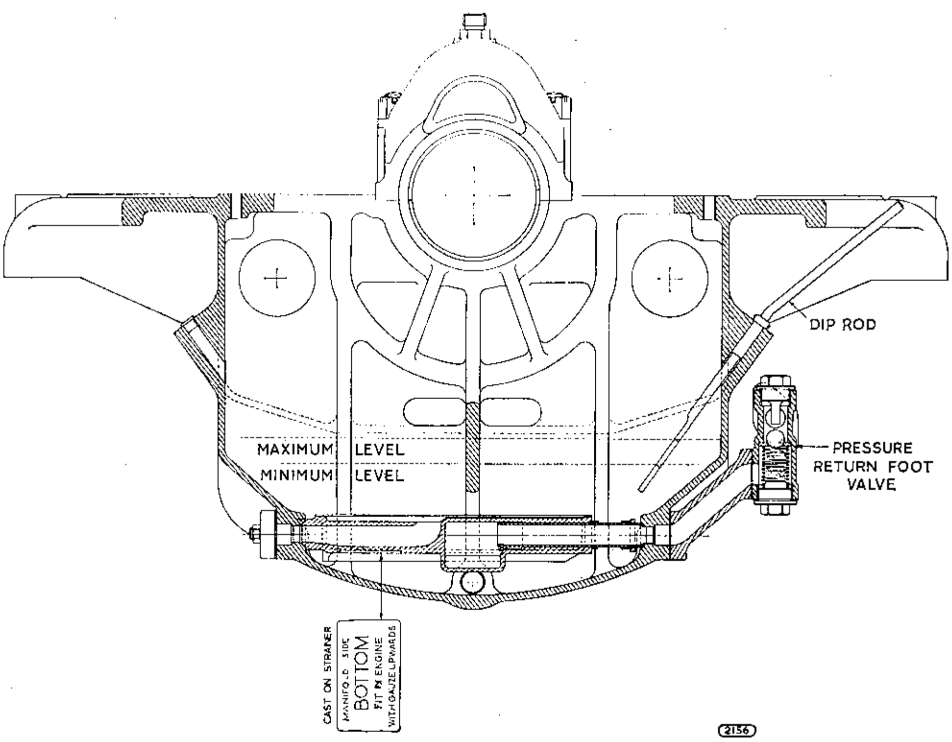
If advantage is taken of this offer please supply the following information:—

(1) Make and grade of the oil. If possible send also a sample of the oil before it was used in the engine.

(2) Number of hours (or miles) for which the oil has been in use.

Lubricating Oil Filler.—This is mounted on one of the crankcase doors, usually on the fuel pump side of the engine (Fig. 5). On Marine propulsion units which are equipped with our single-lever reverse gear and engine speed control the oil filler box and dip rod are mounted on the manifold side of the engine.

Suction Filter.—This is located in the oil sump (Fig. 15) and can be removed by reaching down through the crankcase door identified by a plate reading—"Remove this door for access to lubricating oil suction strainer". This door is on the exhaust manifold side of the engine and the filter should be removed and cleaned on each occasion the sump oil is drained.



LUBRICATING OIL SUCTION FILTER **Fig. 15**

LUBRICATION SYSTEM—*continued.*

The filter comprises a shallow rectangular box, the upper side of which is covered with gauze. At one end of the strainer a spherical ended pipe projects and has a certain amount of free movement to slide in and out. On this pipe is a spring and collar which holds the pipe in an extended position. At the end of the filter remote from the pipe, a small spherical ended hollow boss projects. The pipe end fits in the countersunk opening of the suction pipe hole in the sump. The hollow boss engages with a small countersink in the opposite side of the sump.

From the foregoing it will be seen that to remove the filter it will have to be pushed towards the fuel pump side of the engine to release the boss from its countersink; this end of the strainer can now be lifted up and the strainer withdrawn from the sump. When refitting, the pipe must be entered in its countersink first, the spring compressed and then the boss entered in its countersink. The above will be readily understood if reference is made to Fig. 15.

When refitting the suction filter make certain that both the spherical end pipe and boss are seated properly. The suction filter should be examined and cleaned, as necessary, every 400 hours.

Lubricating Oil Delivery Filter.—This unit is mounted on the fuel pump side of the engine at the flywheel end and contains a special impregnated paper filtering element which is held on its seat by a spring so that, in the event of chokage, the oil can by-pass the element and maintain lubrication of the engine.
Under normal working conditions the filter element should have a useful life of about 2,000 hours.

A drop of 2 lb./sq. in. or more in the oil pressure will indicate that the element has become choked and in this event must be replaced by a new element. If a new element is not available it is permissible to wash the existing element with clean paraffin or fuel oil. When washing, a reverse flow of paraffin or fuel oil (from inside to outside) will assist in removing the sediment formation and make the element fit for further use.

Nevertheless, since there is a risk of foreign matter remaining inside the element which, if present, may reach the bearings, it is imperative that at the first opportunity, a new element Part No. MA.587 be fitted.

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

Delivery Filter—Reassembling.—A new joint ring should be used and the filter cover should be gently rotated on the face joint to minimise the chance of any foreign matter causing a leak. It is also recommended that the filter be replenished with clean oil through the orifice closed by the square headed plug at top of filter cover.

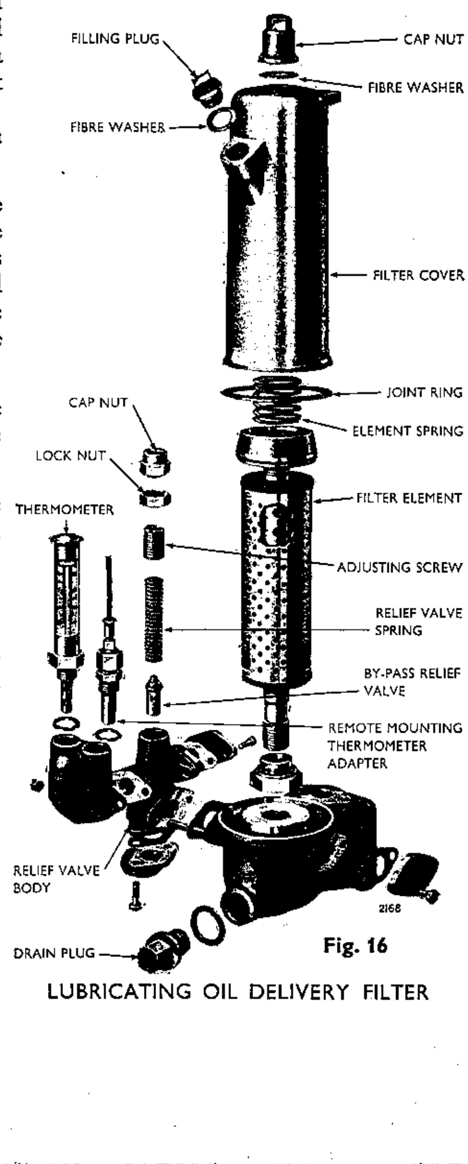


Fig. 16

LUBRICATING OIL DELIVERY FILTER

PISTONS AND CONNECTING RODS

Pistons.—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 10,000 to 20,000 hours or more without dismantling and of course without the need to re-machine the upper two grooves to receive standard bore 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

PISTONS AND CONNECTING RODS—*continued.*

to be fitted the grooves be re-sized. Before fitting new rings the worn bores should be 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 highly polished bore, the "bedding in" process will be protracted with consequent probable high lubricating oil consumption and "blow by." When honing new liner bores a surface finish of 25 to 30 micro inches is desirable.

Diametral wear mainly affects piston noise and pistons which have been re-grooved may be used for a total of 30,000 hours or more. The foregoing 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. *Unless operating conditions are known to produce unclean running do not remove pistons until cylinders require re-sleeving.*

L3B pistons are fitted with two pressure rings and one oil scraper ring. The top or first pressure ring is chromium-plated on its side faces and periphery. The second ring is chromium-plated on its periphery only.

Withdrawal of Pistons and Connecting Rods and Cleaning of Piston Ring Grooves.—The pistons and connecting rods can be withdrawn in two ways. One is through the cylinder bores after removing the cylinder heads and uncoupling the big-end bolts; the other is by lifting the cylinder blocks from the crankcase. A piston ring sleeve is provided with each engine to facilitate entry of the pistons from the top of the cylinder bores. The gudgeon pins are fully floated and are free to turn in the pistons and connecting rods. It is sometimes necessary to lightly drive out the gudgeon pin by use of a wooden drift. The correct clearance between piston pin and connecting rod small end bush is 0·0015 in. and the parts **must not be assembled** unless this clearance obtains.

When the cylinder heads have been removed for decarbonising it is recommended that, in the case of constant load and speed installations, the pistons are withdrawn to make examination for piston rings which may have become fast in their grooves. The pistons may be withdrawn by uncoupling the big-end bolts, access to which is gained through the crankcase doors and drawing the piston and connecting rod assembly upwards through the cylinder bore. It may be found from experience that the recommended 3,200 hours period between piston withdrawal and decarbonising can be increased with safety. Any piston ring removed for examination must be re-fitted to its original groove with the same face upwards as before removal.

Piston to Cylinder Head clearance.—The minimum clearance is ·041 in. and the maximum ·059 in. The desired clearance is ·050 in.

Pistons—Offset Pin Hole Type.—The piston pin is offset from the axis of the piston and pistons bear the word Gardner on the side panels. In addition to having the word Gardner on the side panels L3B pistons are also marked on the top, in the valve recess, with an arrow indicating engine rotation and pistons MUST be assembled in the engine with the arrow pointing in the direction of the rotation. The effect of this construction greatly reduces the noise generated at inner dead centre when the piston transfers from one cylinder wall to the other.

Fitting New Piston Rings.—If, for any reason, new rings have to be fitted to an engine, the cylinder liners of which have not been renewed, **a non-plated** ring must be used in the top groove so that a 45° chamfer about $\frac{3}{64}$ in. wide can be filed on the ring. This chamfer is necessary to prevent the upper corner of the new unworn ring fouling the step which has been worn in the bore by the old ring. Also, when new piston rings are fitted to an engine, they should have a gap clearance of 0·016—0·023 in. when inserted in the mouth or lower end of the cylinder liner.

PISTONS and CONNECTING RODS—*continued.*

BIG END BEARINGS

Big End Bearings.—The connecting rods are equipped with pre-finished big end bearing shells and these shells **must not** be bored out when fitted to the rods. The bearing shells are available in various undersizes to suit reground crankpins as follows:—

·005 in., ·010 in., ·015 in., and ·020 in., and then in steps of ·010 in. undersize up to a maximum of ·100 in.

These bearing shells will give the correct running clearances when fitted to crankpins which have been reduced in diameter by precisely the required amount of undersize from the original nominal crankpin diameter of 3·625 in.

The following instructions must be observed when assembling the bearing shells in the connecting rod:—

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

(*b*) Connecting rod bolts and nuts are also stamped with the appropriate numbers 1—1 to 24—24 for the six cylinder and 1—1 to 32—32 for the eight cylinder engines and these must be assembled number to number.

(*c*) The correct torque and order of tightening for the four bolts of the connecting rod is as follows:—

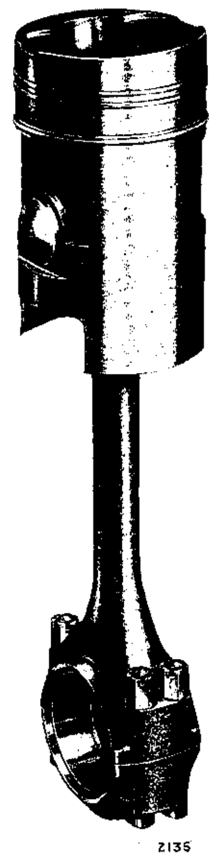
1st Stage. Run each pair of nuts down until they just slightly nip the bearing cap.

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

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

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

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



CONNECTING ROD AND PISTON ASSEMBLY

General use of this method will ensure that the size and shape of the bearing bore will be maintained, which is of course vital.

The correct tightening torque for each of the nuts is 980 lb. in.

(*d*) Before assembling a pair of big end bearings in the connecting rod see that all parts are thoroughly clean and that the surfaces are free from abrasions, scratches or indentations, etc. **The bearings must NOT be touched with a hand scraper.** The two halves cannot be interchanged as a locating tongue on each half-bearing ensures correct assembly. 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 nuts on one side only when there should be ·006 in. to ·0075 in. gap clearance between the abutment of connecting rod and cap. It will be noted that no shims are fitted between the connecting rod and cap. Nuts must be fully tightened to the correct torque and new split pins of the correct size fitted. The pins should be sprung open before fitting in order to prevent movement and consequent wear in service.

PISTONS and CONNECTING RODS—*continued*

The nominal clearance in a correctly assembled big end bearing is ·003 in. and the side location of the big end of the rod is obtained directly by the side facings of the rod itself. At the Works, a number of lines are scribed on the edge of the steel shells and these correspond with the rod number and cylinder number, i.e. 1 to 6 for 6L3B and 1 to 8 for 8L3B. As indicated under (*a*) above, these numbers also lie to the flywheel end of the engine. When the connecting rod is assembled on the crank pin it should have a minimum endwise clearance of ·003 in.

Small end bushes which have ·003 in. or more clearance with a new pin should be pressed out and new ones fitted. The running clearance between a new bush and new pin is ·00125 in. to ·00175 in. 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 central oil duct should be thoroughly flushed out with paraffin or fuel oil.

After assembling a rod on its crankpin, the piston pin in the small end bush should be parallel to the crankcase top to within ·001 in. in the length of the pin.

SPARE PARTS

Spare Parts are readily available from the Works and from our officially appointed Service Agents and Recommended Repairers in the United Kingdom. Spare part stocks are also carried by our Overseas Agents, a list of whom will be found on pages 3 to 6. 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.

See also special warning note on page 7.

Spare Part Fitting Instructions.—Where necessary, Assembly Instructions for the fitting of spare parts accompany each consignment of spares. These instructions should be carefully followed since modifications to component parts receive the most careful consideration to ensure interchangeability.

TIMING CHAIN

Timing-Chain Drive. Adjustment for Slack.—Engines should not be operated with an unduly slack chain; it is, however, essential that there should be a certain amount of slack. If correctly adjusted it should be possible to move the trailing slack backwards and forwards about ½ in. with the thumb and forefinger. The chain case cover would have to be removed to make a proper examination of the run of chain and adjustment is effected by an idler sprocket (Fig. 3) which runs on a stud eccentrically mounted in the timing case. After adjustment, the locking nut on the stud must be securely tightened and the tab washer turned up against the appropriate hexagon flat.

The chain should be inspected for slack every 1,600 hours and on no account should the engine be operated unless the chain is properly adjusted.

Timing Chain. Renewal and re-fitting.—Timing Chains do not normally require renewal before a major overhaul (20,000 hours). To measure the chain for stretch, it should first be washed in paraffin and then laid on a flat surface; preferably a surface plate. A fitting pin about 2 in. long should then be inserted at each end of the chain in the last link. When stretched by hand to its maximum on the surface plate, the length of the chain between the **inner sides** of the fitting pins should not be greater than 47 $\frac{9}{16}$ in. The chain has had a useful life after about 20,000 hours and must be renewed if the length is more than 47 $\frac{9}{16}$ in.

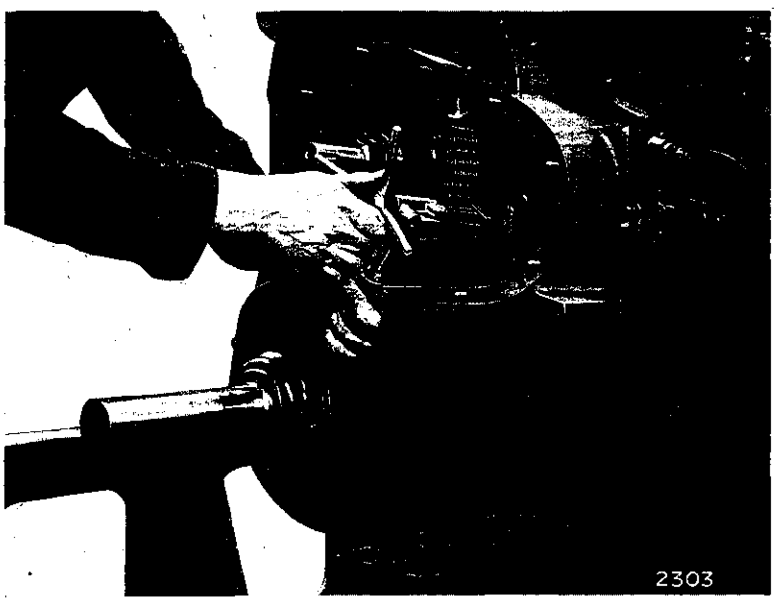
TIMING CHAIN—*continued.*

Timing Chain wear—Correction of Injection Timing.—The timing chain wears and consequently increases in length after long usage. This can affect the timing of the valves and the timing of fuel injection. To compensate for this condition it will be necessary to inspect the timing, as instructed on page 70, after about 1,600 hours working. If it is found that the timing is not correct the flywheel should be turned until the injection timing line on the fuel pump registers with the pointer, or the timing line marked on the flywheel housing. The three hexagon nuts on the valve camshaft chain wheel (Fig. 3) should then be slackened and the valve camshaft turned, by using a spanner on the brass nut at the front end of the shaft, until the lines scribed on the windows of the fuel injection pump register with the lines marked on the plunger guides. The valve timing is automatically corrected at the same time and, after tightening the three nuts on the chain wheel, the timing of fuel injection should be re-checked before finally replacing the chain case cover.

Wear, or chain stretch, can give rise to noisy running and unsteady governing.

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 standard Renold Stud Extractor may be used for this purpose after removal of the chain case cover.

When re-assembling the chain, special workshop tools are available for pressing on the outer plate and for indenting the stud ends. See Fig. 17. These tools greatly facilitate assembly, but the work can also be done by using a hollow punch obtainable from the Works. In this event it is necessary to remove the Fuel Pump Cambox to obtain access to the timing chain. An assistant will be required to hold a small anvil block behind the chain against the ends of the two studs to facilitate assembly of the plate and the riveting of the stud ends with a light hammer.



USING THE TIMING CHAIN SPECIAL WORKSHOP TOOL **Fig. 17**

TIMING OF FUEL INJECTION AND TIMING OF INLET AND EXHAUST VALVES

Timing Marks of Fuel Injection (Variable Speed Engines).—Marked across the periphery of the flywheel will be found timing lines for each cylinder. When checking the timing of valve and fuel injection pump camshafts these lines should register with a **Zero Line** marked on the flywheel housing of marine or industrial engines. This zero line is visible when the Timing Line Inspection Door is removed. Rail Traction and other engines having an exposed flywheel are fitted with a fixed pointer for checking the timing. Taking, for example, the lines

TIMING OF FUEL INJECTION AND TIMING OF INLET AND EXHAUST VALVES—*continued.*

for No. 1 Cylinder, when the longer line, marked "No 1 T.D.C." registers with the zero line or pointer, crank No. 1 is exactly at top dead centre (T.D.C.), and when the shorter line marked "No. 1 cylinder injection" registers with the zero line or pointer on the compression stroke, the timing lines on the fuel pump should coincide, as described below. The number denotes the number of degrees before T.D.C. and the line marked is the position of maximum advance. These advance figures are liable to be varied slightly to suit individual engines.

Whilst checking the timing in this way, the timing injection pointer (Fig. 3) of the advance and retard device must, of course, be turned to point to position of maximum advance.

Note.—No. 1 cylinder is situated at the forward end of the engine and farthest from the flywheel.

Timing Marks of Fuel Injection (Industrial Type Engines).—The point of injection of these engines is fixed, that is to say there is no maximum and minimum advance.

On the periphery of the flywheel of these engines there are marks in the same way as those mentioned above. The advance and retard mechanism is set and fixed during test and should not be moved in any way.

Timing of Fuel Injection.—Each fuel pump is provided with a sight hole or window through which can be seen a plunger moving up and down when the crankshaft is rotated. On the sides of the window is a horizontal line, also one on the plunger guide.

When the flywheel is turned in its running direction and these two lines (the one on the window and the one on the plunger guide) coincide, the corresponding injection line on the flywheel registers with the zero line or pointer as already described. When so checking the timing be careful not to be misled by turning the flywheel in the wrong direction. Also if the engine is of the variable injection type care should be taken to see that the injection control pointer is at maximum advance, and observe the corresponding line on the flywheel. On the fuel pump operating tappets are locked screws which should not be disturbed. See page 53 with reference to these tappets.

Timing of Valve and Injection Pump Camshafts.—Remove the cover from the chain case at the front end of the engine; this will give access to the chain, camshaft chain wheel and fuel pump driving gears (Fig. 3). The chain wheel and valve camshaft gear 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 camshaft gear, for the purpose of accurate timing. When this timing position has been set by the Works, a marker is inserted in the sight hole and a line forming an arc of a circle inscribed on the camshaft gear. Turn the flywheel until No. 1 crank comes to the T.D.C. after the compression stroke as previously directed. If the timing is correctly set the following events will take place:—

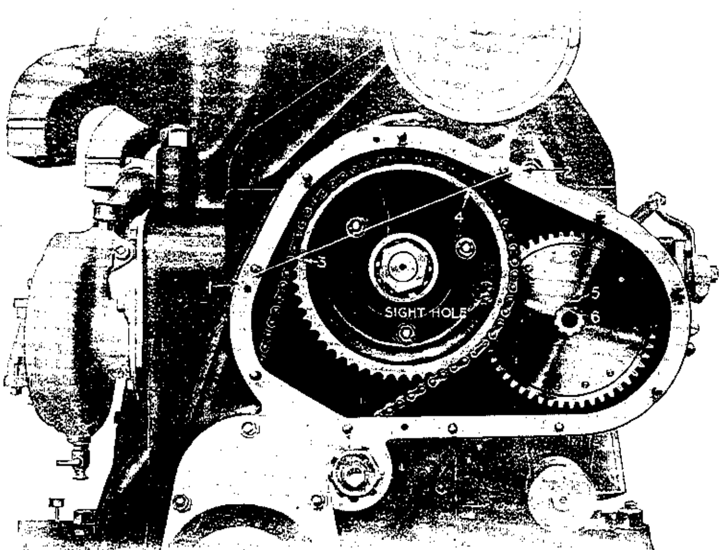


Fig. 18

TIMING OF VALVE AND INJECTION PUMP CAMSHAFTS
SHOWING TIMING CHAIN DRIVE, CAMSHAFT CHAIN WHEEL AND FUEL PUMP DRIVING GEAR

TIMING OF FUEL INJECTION AND TIMING OF INLET AND EXHAUST VALVES—*continued.*

(1) The dots 1 and 2 on the gear case and the dots 3 and 4 on the periphery of the camshaft chain wheel will all lie on a straight line as indicated by the stretched cord in Fig. 18.

(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 of the valve camshaft lies between the dotted teeth of the fuel-pump camshaft.

(3) Through the same sight hole will be verified that the lune on the edge of the gear of the valve camshaft (described above) is in its correct position, in which case the lune will not be very conspicuous but should the gears be incorrectly bolted together, the lune will exhibit the defect very conspicuously.

(4) The dotted spline on the camshaft of the fuel pump will register with the dot on the camshaft gear, see dots 5 and 6 in Fig. 18.

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

TIMING OF VALVES AND FUEL INJECTION

Inlet Valve Opens 11°—48′ before T.D.C. and **closes** 27°—48′ after B.D.C.

Exhaust Valve Opens 37°—48′ before B.D.C. and **closes** 11°—48′ after T.D.C.

The above valve timings are correct when the engine is turning in an **anti-clockwise** direction **when viewed from chaincase end, with valve tappet clearance of ·020 in.**

FUEL INJECTION TIMING

6L3B and 8L3B Engines set to a maximum speed of:—

1,000 r.p.m. for Marine Heavy Duty and Industrial Duty.	22°—0′ before T.D.C.
1,100 r.p.m. for Intermittent Duty.	23°—0′ before T.D.C.
1,150 r.p.m. for Yachts, Cruisers, etc.	23°—30′ before T.D.C.
1,300 r.p.m. for Rail Traction and High Speed Craft.	25°—0′ before T.D.C.

VALVE CAMSHAFT AND CAMS

Valve Camshaft—Assembly of Cams.—The inlet and exhaust valve cams are made as one unit per cylinder, each pair of cams being secured to the valve camshaft by a centrally positioned, pointed setscrew of special design and having immense strength. The setscrews also locate each pair of cams in their correct position on the camshaft. A tee-shaped box spanner must be used for fitting the setscrews and they must be thoroughly tightened whenever it is necessary to replace the cams.

When fitting the cams to the camshaft care must be taken that they are correctly assembled so that the Inlet and Exhaust cams come under the inlet and exhaust tappets respectively. Each pair of cams can be inadvertently assembled the wrong-way-round since the inlet and exhaust cam profiles are very similar. A preliminary inspection will reveal, however, that the Inlet cam profile is slightly more pointed than the Exhaust cam. In addition, **the Exhaust cam is stamped EX on the side face.** When an engine is viewed from the Fuel Injection Pump side the cams must be assembled with side faces stamped EX on the left-hand side. If a cam unit is correctly placed in the palm of the hand, the face stamped EX will be to the left and, of course, the Inlet cam will be on the right.

Assembly of Valve Lever Push Rods.—When reassembling an engine after an overhaul, it is of the utmost importance to pay special attention to the timing of the valves with relation to the crankshaft, for if the timing is 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, during timing, to place the lower end of the push rod in the cam-tappet socket and not to push the upper end of the push rod under the valve rocker until all is verified. In this way, one can observe the vertical motion of the free end of the push rod as the flywheel is rotated to and fro. This motion should be such that when the piston is towards the top of the exhaust stroke, if all is correct, 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.

VALVE TAPPET CLEARANCES
(Inlet and Exhaust Valves)

Tappet Clearance.—After replacing a cylinder head, or after every 1,600 hours, the clearance between the toe of the valve rocker lever and the end of the valve stems should be adjusted as necessary. This examination and adjustment has an important influence in the maintenance of correct valve timing and smooth running of the engine. The correct clearances **for all engines irrespective of duty** are as follows:—

INLET VALVES .. .. ·005 in. when engine is cold
EXHAUST VALVES.. .. ·012 in. when engine is cold

When tightening the locknuts it is unnecessary to use great pressure. The adjustment should be made with the piston at the top of the compression stroke. To find this position, decompress all cylinders and turn the flywheel until the Inlet Valve under examination just closes. Then turn the flywheel a further half-turn when the piston will now be at, or near, the end of the compression stroke. This position can be verified by using the index finger and lightly operating the priming lever of the fuel injection pump plunger belonging to the cylinder in question. This priming lever will, by its ease of movement when compared with the adjacent priming levers, indicate that the pump tappet is on the lifted position; that is, at the end of the fuel injection stroke. The decompression lever must then be returned to the running position otherwise it will not be possible to check the tappet clearance.

Firing Order.—

6L3B Engine rotating anti-clockwise **when viewed from Flywheel End**.........1, 5, 3, 6, 2, 4.
6L3B Engine rotating clockwise **when viewed from Flywheel End.** ....1, 4, 2, 6, 3, 5.
8L3B Engine rotating anti-clockwise **when viewed from Flywheel End**.........1, 5, 2, 6, 8, 4, 7, 3.
8L3B Engine rotating clockwise **when viewed from Flywheel End.** ....1, 3, 7, 4, 8, 6, 2, 5.

Inlet Valve Adjusting Screw for Decompression.—The action of moving the decompression levers into the horizontal (decompression) position causes a cam to operate upon an adjustable screw fitted in the heel of the inlet valve rocker lever. This cam lifts the heel and consequently holds open the inlet valve; i.e., the valve cannot close and thus permits the engine to be turned by hand for the purpose of examination, etc.

The amount of opening is determined by the adjustable screw.

In case of derangement, the screw should be adjusted so that it lifts the inlet valve 0·040 in. (forty thousandths of an inch) from its seat. See illustration page 49.

WATER COOLING SYSTEM
AND
CENTRIFUGAL TYPE WATER CIRCULATING PUMP

Water Cooling Systems.—The 6L3B and 8L3B engines are designed for fresh water, closed circuit, cooling systems only. The cooling installation arrangements may incorporate one of the following:—

(*a*) A sea water cooled heat-exchanger through which the cooling medium is circulated by a separately mounted centrifugal pump of proprietary design. This pump can be belt driven from the L3B engine. All L3B marine propulsion engines are fitted as a standard with a Serck heat exchanger designed to comply with our special requirements.

L3B marine propulsion units in current production are also fitted with an engine mounted header tank as standard equipment. This supersedes the earlier arrangements employing a separate remotely mounted header tank with its associated pipework and air separating vessel.

(*b*) An outboard mounted keel cooler of Gardner design and manufacture. When a keel cooler is used the engine driven, plunger type bilge pump, is employed for circulating sea water through the engine mounted lubricating oil cooler. A separately mounted independently driven pump is therefore required for emptying the bilges under these conditions.

(*c*) An air-cooled radiator of Gardner design complete with fan, fan drive and cowling.

(*d*) Fresh water storage tanks can be used under certain conditions in power house or industrial engine installations.

Engine Water Circulating Pump.—L3B marine propulsion engines are fitted with a centrifugal type water circulating pump of bronze construction. When used for Rail Traction or Industrial type engines the pump body is cast in aluminium alloy.

WATER COOLING SYSTEM—*continued*

The pump is an integral component of the engine and is driven from the valve camshaft by carefully designed gearing. It operates at approximately 1·227 times crankshaft speed. The fresh water cooling supply is contained in the engine mounted header tank when systems (*a*) or (*b*) are used. Cooling arrangement installation drawings are available upon request.

Operating Temperatures.—All engines are equipped with thermostatic arrangements which automatically maintain the cooling water outlet temperature within the desired limits. These are given in detail on page 32.

Water Circulation.—Before starting the engine regular inspection should be made to see that the header tank, radiator or cooling tanks, etc., are full. After initial filling of the engine mounted header tank further venting occurs on starting the engine. The water level in the tank will therefore fall and additional fresh water must be added until maximum level is maintained. This procedure will take a few minutes, but is very important.

Thermostat Units.—A vent cock is provided on the thermostat housing to facilitate elimination of air locks during filling or replenishment of the water system.

The thermostat unit also 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. As soon as the engine is started however, the cooling water, 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 cooling water to the radiator, heat exchanger or keel cooler, etc. This reduces to a minimum the "warming-up" period on initial starting from cold.

Earlier engines were fitted with thermostats having a ·052 in. diameter air release hole drilled in the annulus which 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 the cooling water level when filling the system, the ·052 in. diameter hole may, with advantage, be reduced to ·040 in. diameter. This will further reduce the "warming-up" period.

When making inspection of 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 bellows and main delivery valve can be readily observed by removing the unit from its housing and raising its temperature by immersion in water.

In the event of the thermostat bellows becoming damaged the valve will assume a full open position and dangerously high temperatures would not therefore occur. Severe bore wear would however possibly develop due to prolonged "warming-up" periods and low temperatures, except when operating at full load. A damaged thermostat should, of course, be replaced by a new unit without delay.

Centrifugal Water Pump, Gland and Greaser.—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 of slight mal-alignment between the pump and its driving member. The routine attention required is lubrication of the ball bearing. This should be carried out by using not more than one grease cup full per 4,800 hours. Use a good quality calcium or a lithium base grease to No. 2 or 3 N.L.G.I. rating system having a drop point of 100° C. nominal. **Do not fit grease gun nipple in order to use a grease gun. Grease is detrimental to the carbon gland.**

Centrifugal Water Pump Service.—Spare parts for the water pump and complete service pumps may be obtained from our Service Depots and from the Works.

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.

WATER COOLING SYSTEM—*continued.*

When fitting a new impeller and spindle the sealing faces of the carbon gland and spindle may be lightly lapped together with pumice powder and water. Do not on any account use "Carborundum" or equivalent abrasive. Do not lap parts if satisfactory seating is indicated after rotating spindle whilst lightly pressed on gland face. This bedding inspection operation is facilitated if a second ball race is temporarily fitted in the pump housing thereby supporting the spindle on its approximate running axis.

Centrifugal Water Pump.—Draining of Cooling System.—As the pump is exposed and is not, in all engine installations, automatically drained with the rest of the system, it may be necessary to drain it separately. The drain cock will be found at the lowest point on the pump body and an inspection of the shape of the pipe connecting the pump with the bottom of the radiator will reveal whether or not emptying the radiator will suffice to empty the pump. There is a small drain from the periphery of the water pump body into the pipe and in an installation where the pipe has a continuous fall from pump to radiator, separate draining of the pump may be omitted.

When the pump is dismantled this small drain hole will be found crossing the joint face of the cover to the body and care should be taken to avoid blanking this hole with any packing or jointing used. 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. 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 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 effectively used.

Water Drain Cocks, Plugs, etc.—In addition to the drain cock fitted to the water circulating pump there are other points on the engines where drain cocks or plugs are fitted. Their use is essential when dismantling and washing out water spaces during overhauls, etc.

Drain plugs are fitted underneath the lubricating oil cooler casing on marine engines, also under the Gardner design Serck heat exchanger. A cock is mounted at the after end of the water inlet pipe of marine engines for draining the cylinder blocks and there is also a drain cock on the after end cylinder block for this purpose.

Operating under Conditions of Extreme Cold.

Closed Circuit Fresh Water Cooling System.—Under these conditions 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 since, even whilst the engine is running, radiators and water pipes can become frozen.

Use only Ethanediol Anti-Freeze conforming to one of the following British Standard Specifications:—
BS.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.

When an Anti-Freeze Agent is not Available

When an engine has to stand idle for any period sufficiently long for the cooling system to approach freezing point, drain away the water from the system as soon as possible after stopping the engine, and leave the cocks open until the system is to be refilled. Take precautions to ensure that the engine is not inadvertently put into service with a dry water system.

WATER COOLING SYSTEM—*continued.*

When filling the water system preparatory to service, use hot water, since the combination of cold water and engine parts below freezing point may generate ice before the heat generated by running the engine is sufficient to prevent this.

In the case of radiator cooled sets, when anti-freeze additive is not available, 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. In addition, and in order to further reduce the risk of freezing, and to enable the engine to attain a suitable operating temperature, blank off from the bottom upwards 50% or more of the radiator frontal area, until a temperature of 140° F. to 160° F. is attained in service.

Note.—Continued operation of an engine without a thermostat unit must be avoided as far as possible. Severe cylinder liner and piston ring wear is likely to occur due to corrosive action as a result of increased length of "warming-up" periods. Thermostat units should only be removed as an emergency measure.

Cooling System Corrosion Inhibitor.—If anti-freeze solution 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 dispensers, through which sea 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.
A number of approved corrosion inhibitors are available and the Works will be pleased to further advise in this matter. One example is "Aqua-Clear," the Sole U.K. Concessionaires for which are Messrs. Kinnis and Brown Ltd., 54/62 New Broad Street, London, E.C.2.

Water Outlet Pipe—Chokes.—L3B marine engine water outlet pipes are fitted with gun metal cadmium plated chokes and it is necessary, when fitting a new pipe, to see that it is equipped with the same number and correct bore of chokes as those already fitted to the water pipe which is being replaced. If new chokes are fitted to an existing water pipe it is also important that the aperture in the chokes is of the same size as the holes in the existing chokes. The correct size of the holes in the chokes is:—

6L3B—½ in. dia.

8L3B—19/32 in. dia.