Perkins engines

WORKSHOP MANUAL FOR DIESEL ENGINES

T6.354M HT6.354M

6.354M H6.354M

PRINTED U.S.A.

workshop manual for 6.354 turbocharged and normally aspirated marine series diesel engines

(includes contra rotating engines)

U.S.A.

24175 Research Drive
Farmington, Michigan 48024
~~Phone: 313/477-3900~~

515 11th Street S. E.
Canton, Ohio 44707
Phone: 216/489-6000

CANADA

7 Meridian Rd.
Rexdale, Ontario M9W 4Z6
Phone: 416/675-3540

Publication No. 601 SER 0277 1060

"1977"

This publication supersedes the previous edition numbered 601SER9751060.

Published by the Service Publications Department of Perkins Engines Limited and Printed in England by Peterborough Central Printers Limited.

PERKINS COMPANIES

AUSTRALIA
Perkins Engines Australia Pty. Ltd.
P.O. Box 156, Dandenong, Victoria 3175, Australia.
Telephone : 792-0431. Telex : AA 30816. Cables : 'Perkoil'.

BRAZIL
Motores Perkins S.A.
Caixa Postal 30.028, c Sao Paulo, CEP 09700, Estado de Sao Paulo, Brazil.
Telephone : 443-1499. Telex : 23715. Cables : 'Perkoil' Sao Paulo.

CANADA
Perkins Engines Canada Ltd.
7 Meridian Road, Rexdale, Ontario, Canada.
Telephone : 677/4960. Telex : 0221225. Cables 'Perkoil' Toronto.

FRANCE
Moteurs Perkins S.A.
55 Boulevard Ornano, 93203 Saint-Denis, France.
Telephone : 243-04:40. Telex : 62251 Saint-Denis. Cables : 'Perkoil' Paris.

GERMANY
Perkins Motoren G.m.b.H.
8752 Kleinostheim, Postfach 12, Germany.
Telephone : 06027/8081. Telex : 4188869.

GREAT BRITAIN
Perkins Engines Limited
Peterborough, England, PE1 5NA.
Telephone : Peterborough 67411. Telex : 32501. Cables : 'Perkoil' Peterborough.

ITALY
Motori Perkins S.p.A.
22100 Como-Camerlata, Via Pasquale Paoli 9/A, Italy.
Telephone : 504885. Telex : 38063. Cables : 'Perkoil' Camerlata.

JAPAN
Perkins Engines (North Pacific) Ltd.
6th Floor, Reinansaka Building, 14-2 Akasaka 1-Chome, Minato-Ku, Tokyo 107, Japan.
Telephone : (03) 586-7377. Telex : 24292 Tokyo.

SOUTH AFRICA
Perkins Engines (Pty.) Ltd.
P.O. Box 31285, 6th Floor, Noswal Hall, Braamfontein, Johannesburg, South Africa.
Telephone : Johannesburg 725-5715. Telex : 5430037. Cables : 'Perkoil'.

U.S.A.
Perkins Engines Inc.
P.O. Box 283, 24175, Research Drive, Farmington, Michigan 48024, U.S.A.
Telephone : 313-477-3900. Telex : 023-5300. Cables : 'Perkoil' Farmington.

Perkins Engines Latin America Inc.
2600 Douglas Road, Suite 600, Coral Gables, Florida 33134, U.S.A.
Telephone : (305) 4484884. Telex : 515880. Cables : 'Perklac'.

ASSOCIATE COMPANIES & MANUFACTURING LICENSEES

ARGENTINA
Perkins Argentina S.A.I.C.
Bolivar 368, Buenos Aires, Argentina.
Telephone : 33-8231/36. Telex : 121162. Cables : 'Perkinsa'.

INDIA
Simpson & Co. Ltd.
P.O. Box 303, 202/203 Mount Road, Madras 2, India.
Telephone : Madras 83091 (PABX-10 lines). Telex : 41-538. Cables : 'Simpsons'.

KOREA
Hyundai Motor Co.
Bae Jae Building, 55-4 Seosomoon-Dong, Seodaemoon-Ku, Seoul.
Telephone : 27-5111/9. 27-6111/9. Telex : [illegible]. Cables : Hyundaimotor, Seoul.

MEXICO
Motores Perkins S.A.
Tiber No. 68 1er Piso, Mexico 5DF.
Telephone : 528-61-67. Telex : Perkoil Mex 071-71-347. Cables : 'Perkoilmex'.

SINGAPORE
Perkins Engines Eastern Ltd.
549 Upper Thomson Road, Singapore 20.
Telephone : 594471, 2, 3. Telex : Perkoil R23360.

SPAIN
Motor Iberica S.A. (Division Zona 2)
Carretera del Aero-Club, Carabanchel Alto, Madrid, Spain.
Telephone : 208 52-40, 208 96-40, 208 98-40. Telex : 27324. Cables : 'Perki-e' Madrid.

URUGUAY
Perkins Rio de la Plata S.A.
Av. Juan Carlos Gomez 1492, Montevideo, Uruguay.
Telephone : 916254/88844. Telex : 278.

YUGOSLAVIA
Industrija Motora Rakovica
Patrijarha Dimitrija 7-13, Rakovica, Belgrade, Yugoslavia.
Telephone : 562-043/562-322/562-992. Telex : 11341 YU IMR.
Cables : 'Indmotor' Belgrade.

In addition to the above, there are Perkins Distributors in the majority of countries throughout the world. For further details, apply to Perkins Engines Ltd., Peterborough, or to one of the above companies.

CONTENTS

Unified Threads and Engine No. Location

All threads used on the 6.354 engine, excepting for proprietary equipment, are Unified Series and American Pipe Series.

Unified threads are not interchangeable with B.S.F. threads and although B.S.W. have the same number of threads per inch as Unified Coarse, interchanging is not recommended, due to a difference in thread form.

With earlier engines the engine number is stamped on the side of the auxiliary drive housing. This number should be quoted when requesting information or ordering parts. It consists of seven digits commencing with the figure '8.'

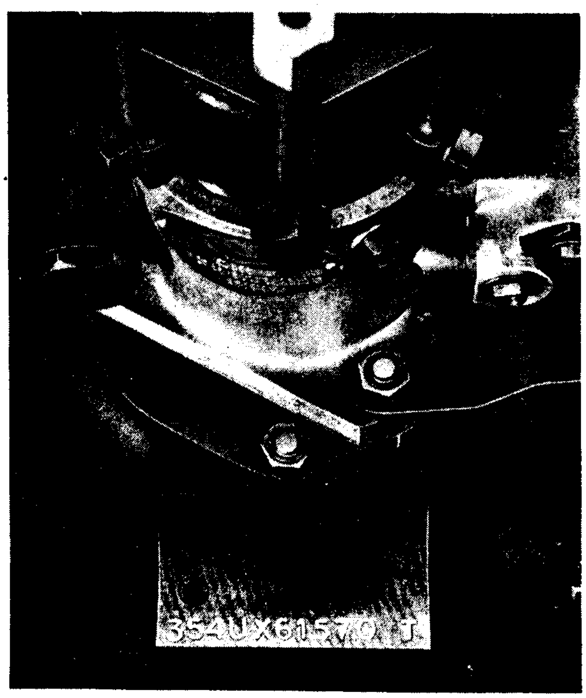
With current engines, the engine number consists of figures and letters, e.g. 354U251. In this instance the first three figures represent the cubic capacity, i.e. 354 in^3 (6.354 engine), the letter "U" signifies that the engine was built in the United Kingdom and the last group of figures comprises the engine serial number.

Normal engines have a left hand rotation when viewed from the rear of the engine.

Contra-rotating engines having right hand rotation when looking at the rear of the engine, have the letter "X" following the letter "U", e.g., 354UX251.

Other letters may follow the serial number denoting specific information, e.g. a letter "H" indicates a horizontal engine, whilst a letter "T" indicates a turbocharged engine.

Another and later system of numbering will where possible be standardised on a pad located on the left hand side of the engine viewed from the rear, near the fuel injection pump. A typical number for this later system is TC14421U500123D.



Location of Engine Number.

Foreword

This Workshop Manual has been compiled for use in conjunction with normal workshop practice. Mention of certain accepted practices, therefore, has been purposely omitted in order to avoid repetition.

Reference to renewing joints and cleaning off joint faces, has to a great extent been omitted from the text, it being understood that this will be carried out where applicable.

Similarly, it is understood that in reassembly and inspection, all parts are to be thoroughly cleaned, and where present, burrs and scale are to be removed.

It follows that any open ports of high precision components e.g. fuel injection equipment, exposed by dismantling, will be blanked off until reassembled, to prevent the ingress of foreign matter.

Users of Turbocharged engines should read the contents of Section "P" BEFORE STARTING their engine. Particular reference should be made to Sections 5 and 6.

Abbreviated Terms

Throughout this manual where it is considered necessary to use abbreviations, they are in accordance with those recommended by the British Standards Institute. A Glossary of Terms for reference purposes is included at the back of this publication.

Engine Designation

Two types of 6.354 Engines are available, i.e., Turbo-charged and Normally Aspirated. Turbocharged engines have the letter "T" prefixed to the engine designation, i.e. T6.354, and Normally Aspirated engines are known as 6.354 engines.

Vertical and Horizontal engines are also available, Horizontal engines have the letter "H" prefixed to the engine designation, e.g., H6.354.

All references to 6.354 engines in this Workshop Manual may be taken to refer to all types unless otherwise stated.

High rated turbocharged engines have the letters "GT" following the engine designation.

Approved Service Tools

The tools referred to in this manual are manufactured and supplied by V. L. Churchill and Co. Ltd. For further details, see appendix.

PERKINS PARTS
for
PERKINS PRODUCTS

TO ENSURE YOU OBTAIN THE BEST RESULTS FROM YOUR ENGINE AND TO SAFEGUARD YOUR OWN GUARANTEE, FIT ONLY GENUINE PERKINS PARTS. THESE ARE READILY OBTAINABLE THROUGHOUT THE WORLD.

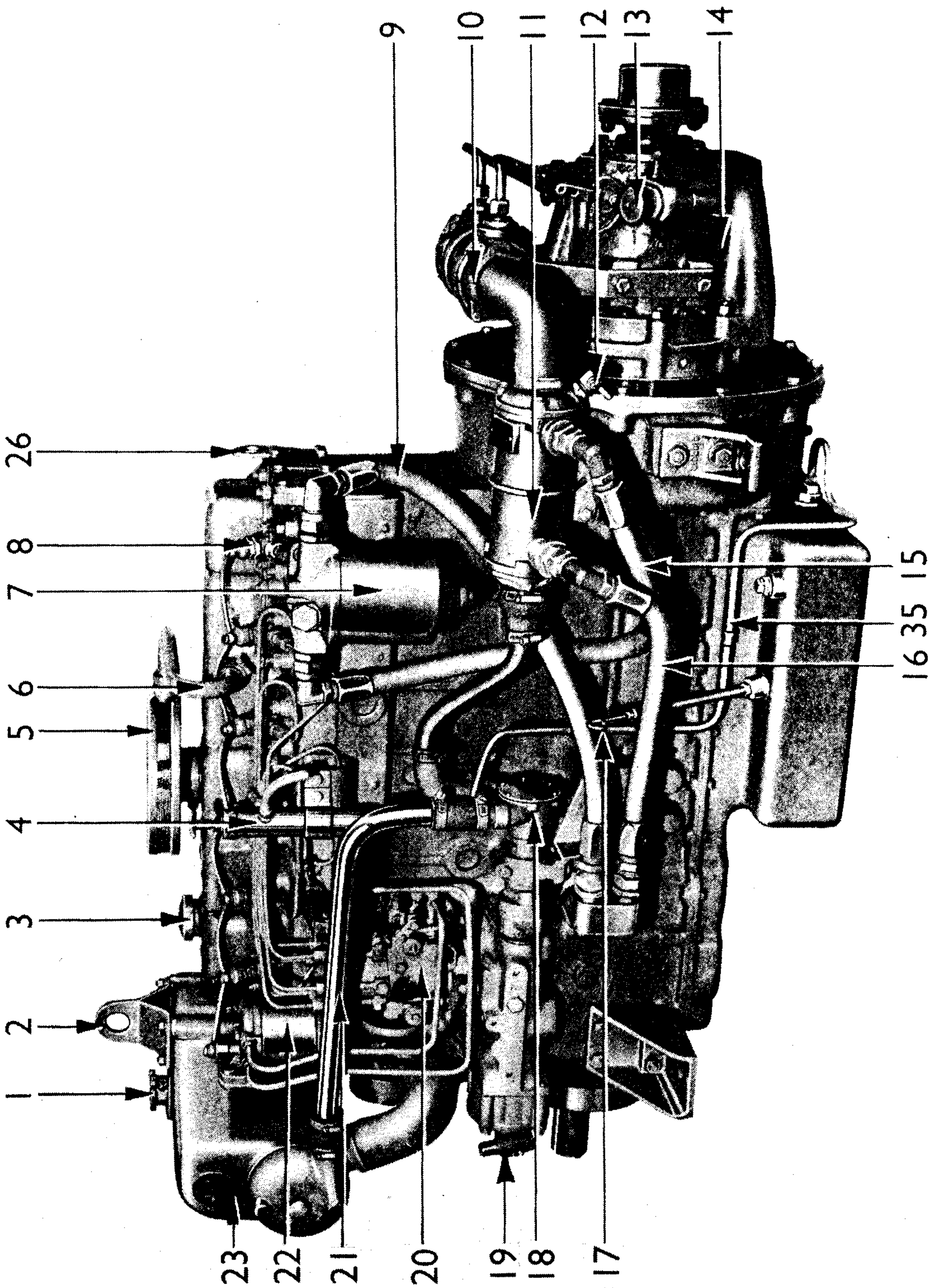
This engine manual is to guide you in dismantling and re-assembly. For information regarding the application of the engine, the reader should refer to the Perkins "MARINE INSTALLATION KNOW-HOW" Publication No. 235 — published by Group Public Affairs Department.

SECTION A
Engine Photographs

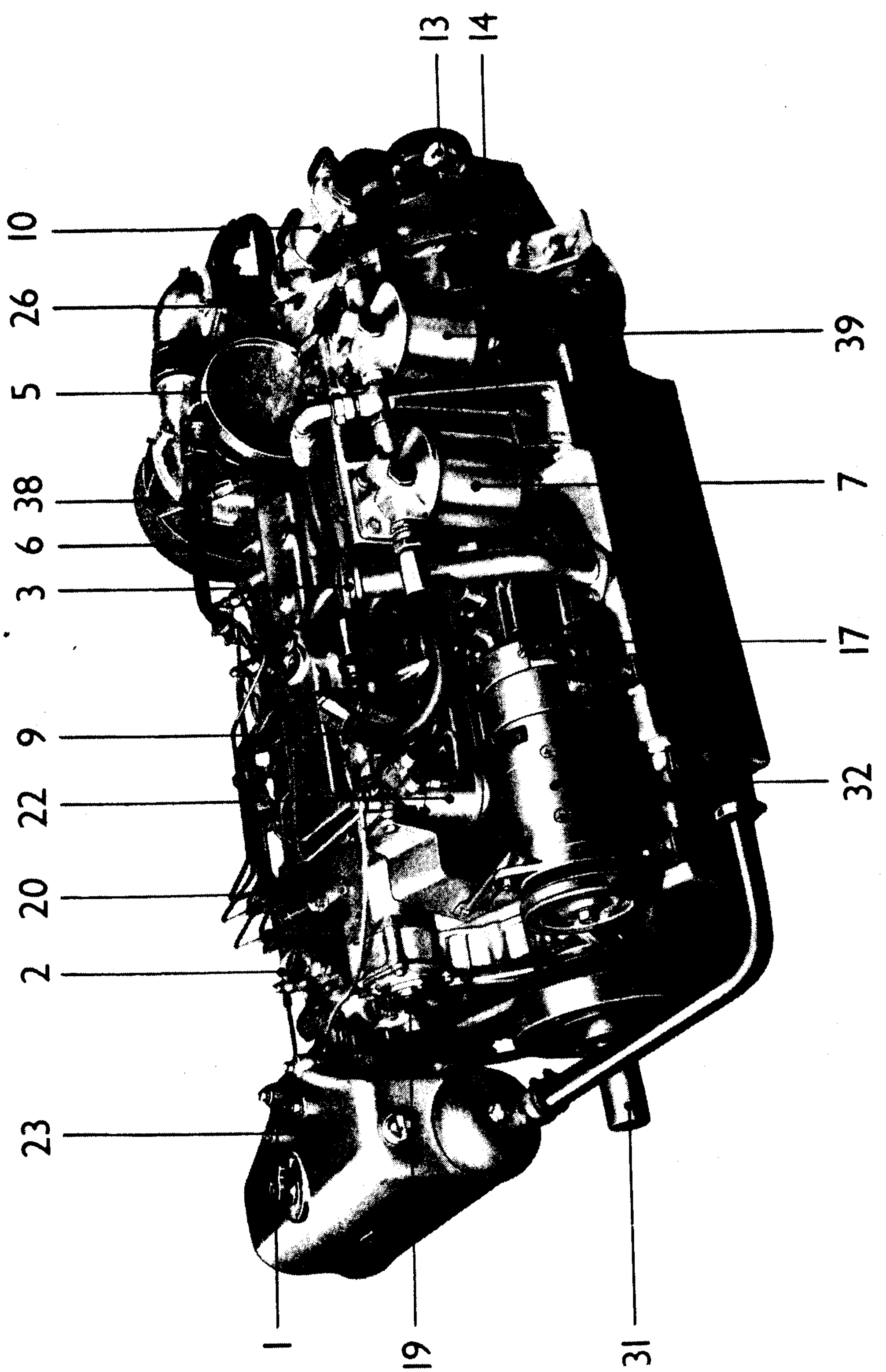
INDEX TO ENGINE PHOTOGRAPHS

1. Heat Exchanger Filler and Pressure Cap.
2. Front Engine Lifting Eye.
3. Engine Oil Filler Cap.
4. Sump Drain Pump (hand operated).
5. Air Filter.
6. Breather Pipe between Cylinder Head Cover and Air Filter.
7. Engine Lubricating Oil Filter.
8. Atomiser.
9. Pipe from Lubricating Oil Filter to Adaptor.
10. Gearbox Oil Cooler.
11. Engine Oil Cooler.
12. Engine Oil Cooler Drain Tap.
13. Gearbox Oil Filler Cap and Dipstick.
14. Gearbox.
15. Pipe from Engine Oil Cooler to Oil Filter.
16. Pipe from Adaptor to Engine Oil Cooler.
17. Engine Oil Dipstick.
18. Sea Water Pump.
19. Tachometer Drive Connection.
20. Fuel Injection Pump.
21. Pipe from Sea Water Pump to Heat Exchanger.
22. Final Fuel Filter.
23. Heat Exchanger.
24. Cold Start Aid.
25. Inlet Manifold.
26. Rear Engine Lifting Eye.
27. Exhaust Manifold Drain Tap.
28. Gearbox Oil Cooler Drain Tap.
29. Starter Motor.
30. Fuel Lift Pump.
31. Power Take off from front of Crankshaft.
32. Dynamo.
33. Fresh Water Pump.
34. Pipe from Heat Exchanger to Exhaust Manifold.
35. Pipe from Sump Drain Pump to Sump.
36. Water cooled Exhaust Manifold.
37. Turbocharger.
38. Inlet Oil Pipe to Turbocharger.
39. Turbocharger Oil Filter.
40. Water Outlet Pipe from Turbocharger to Fresh Water Pump.
41. Water Outlet Pipe from Exhaust Manifold and Turbocharger Exhaust Outlet.
42. Turbocharger Exhaust Outlet.
43. Pipe from Turbocharger to Inlet Manifold.
44. Water Inlet Pipe from Fresh Water Pump to Turbocharger.
45. Reduction Gear.
46. Return Oil Pipe from Turbocharger to Sump.
47. Intercooler between Turbocharger and Inlet Manifold.
48. Alternator.

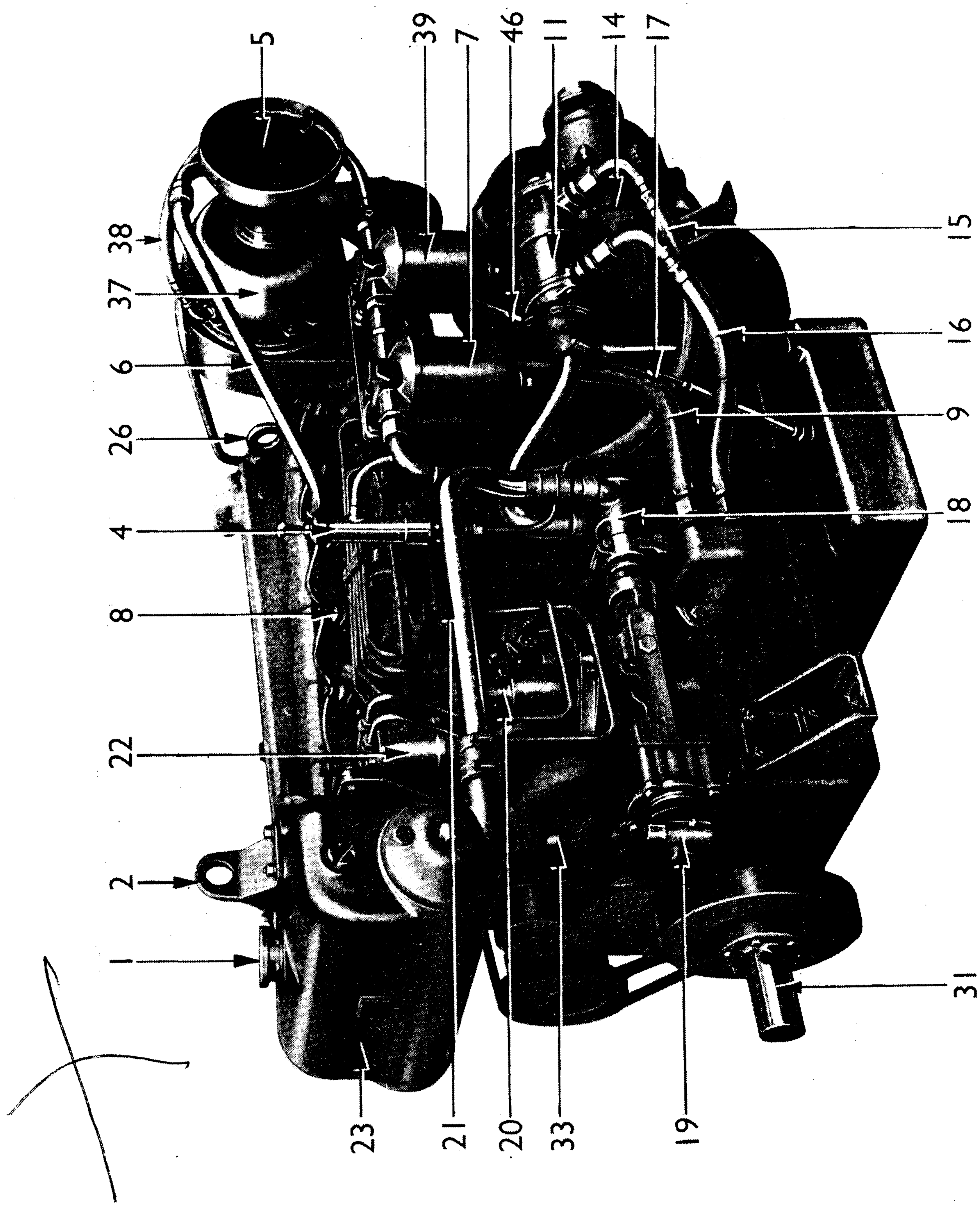
Perkins Engines are built to individual requirements to suit the applications for which they are intended and the following engine views do not necessarily typify any particular specification.



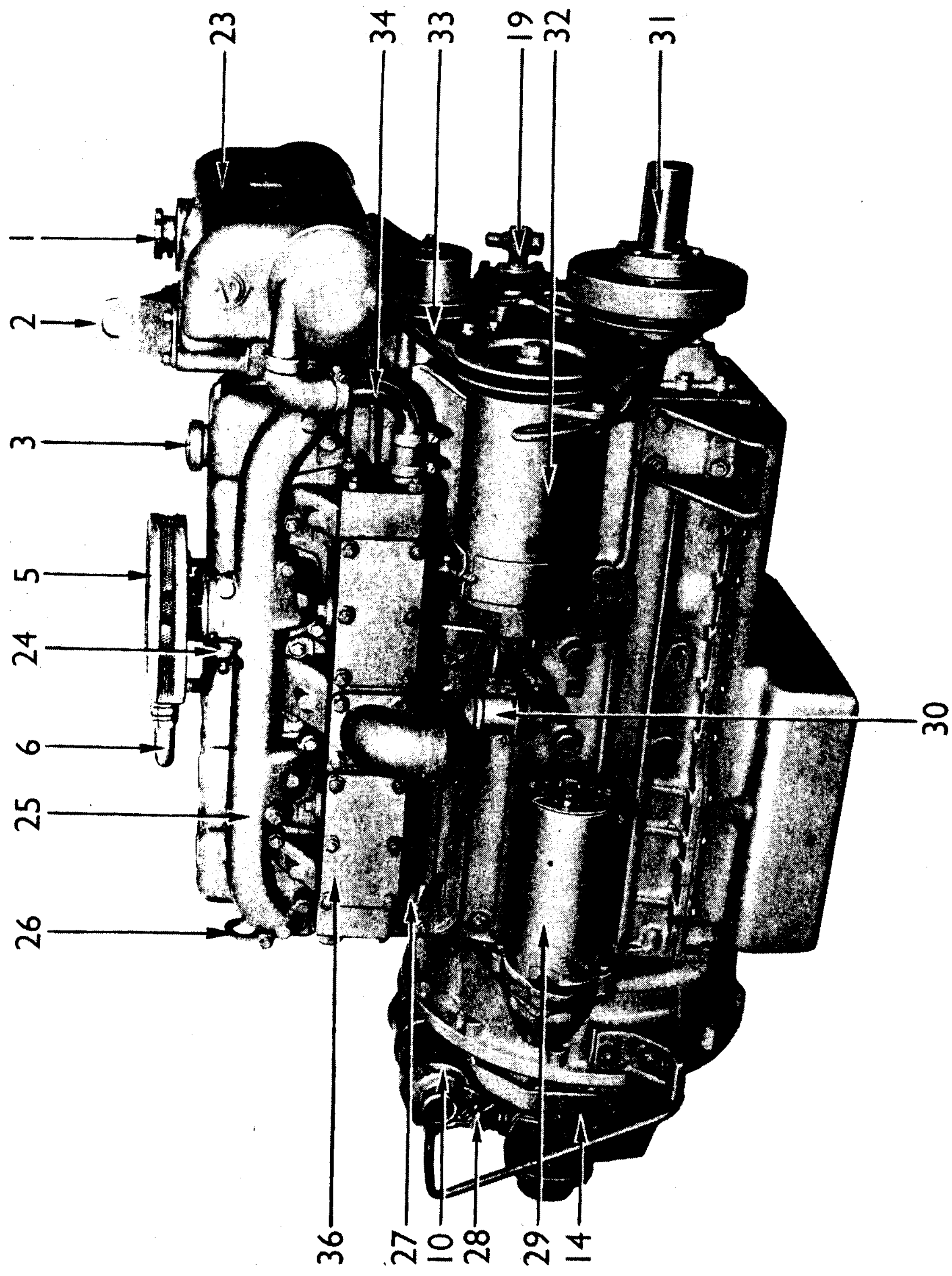
Port View of Normally Aspirated Vertical 6.354 Marine Engine.



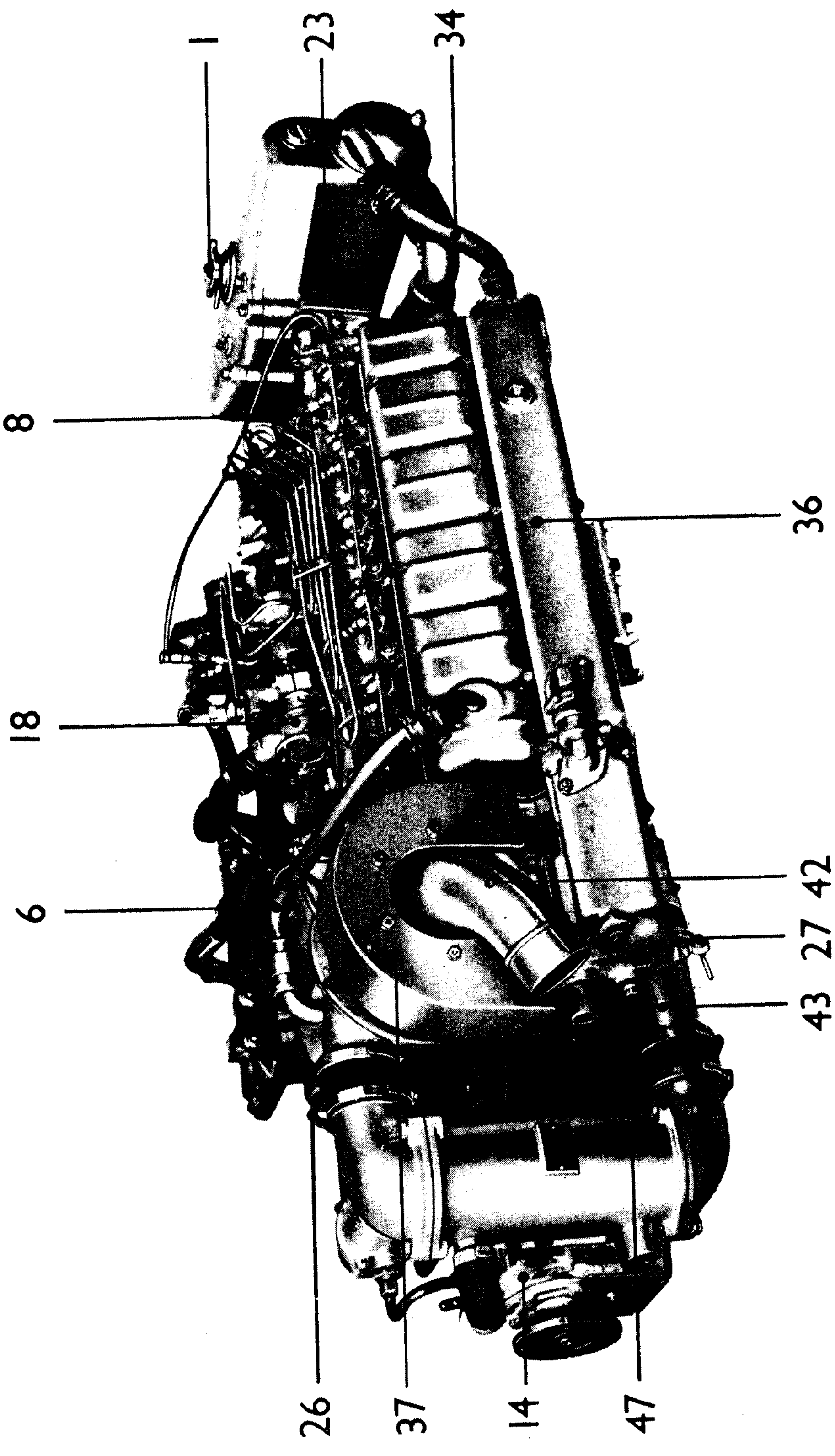
Port View of Horizontal Turbocharged 6.354 Marine Engine (HT6.354). (Fitted with Mk. 1/5 Turbocharger).



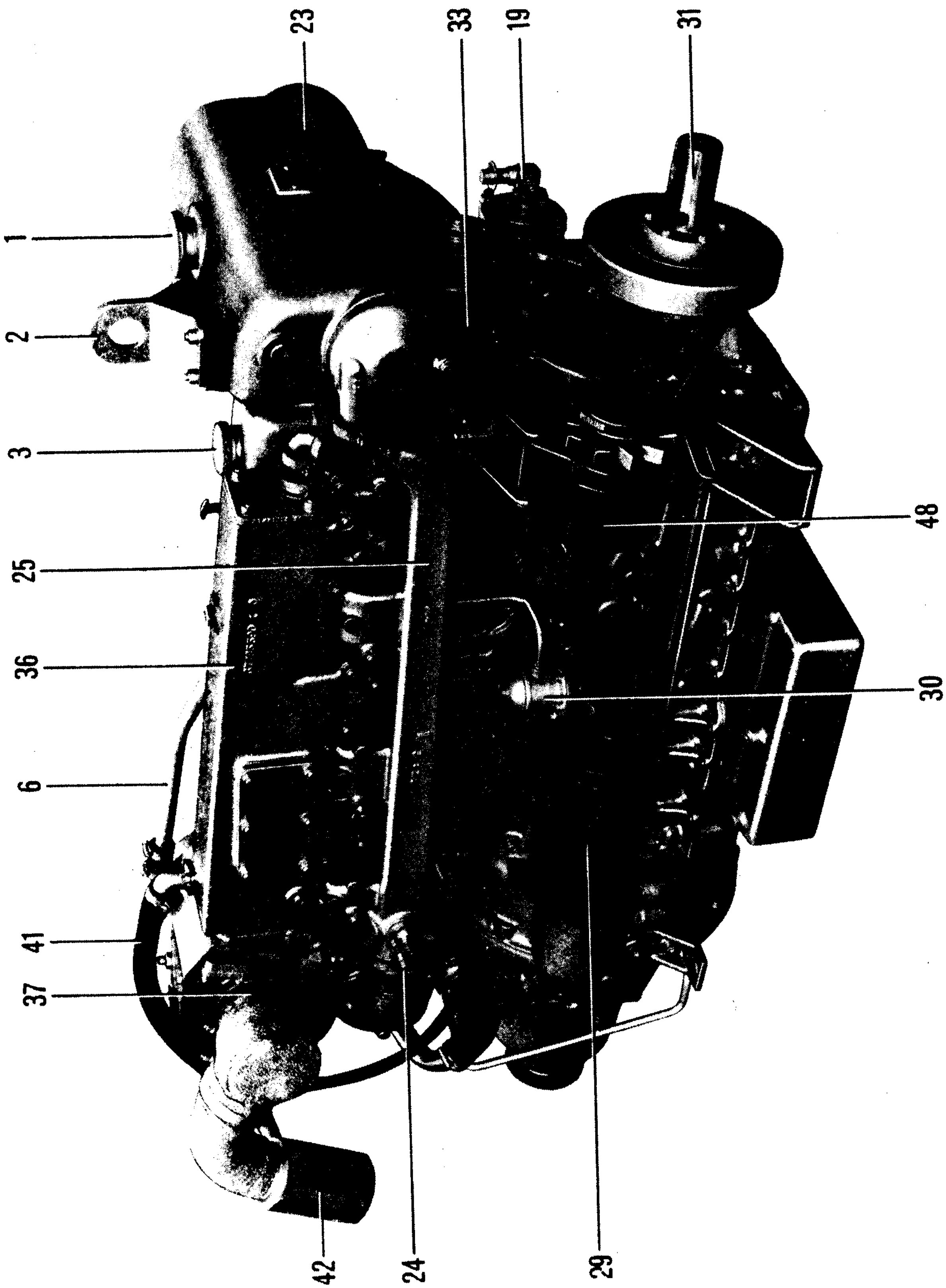
Port View of Turbocharged Vertical T6.354 Marine Engine. (Fitted with Mk 1/2 Turbocharger).



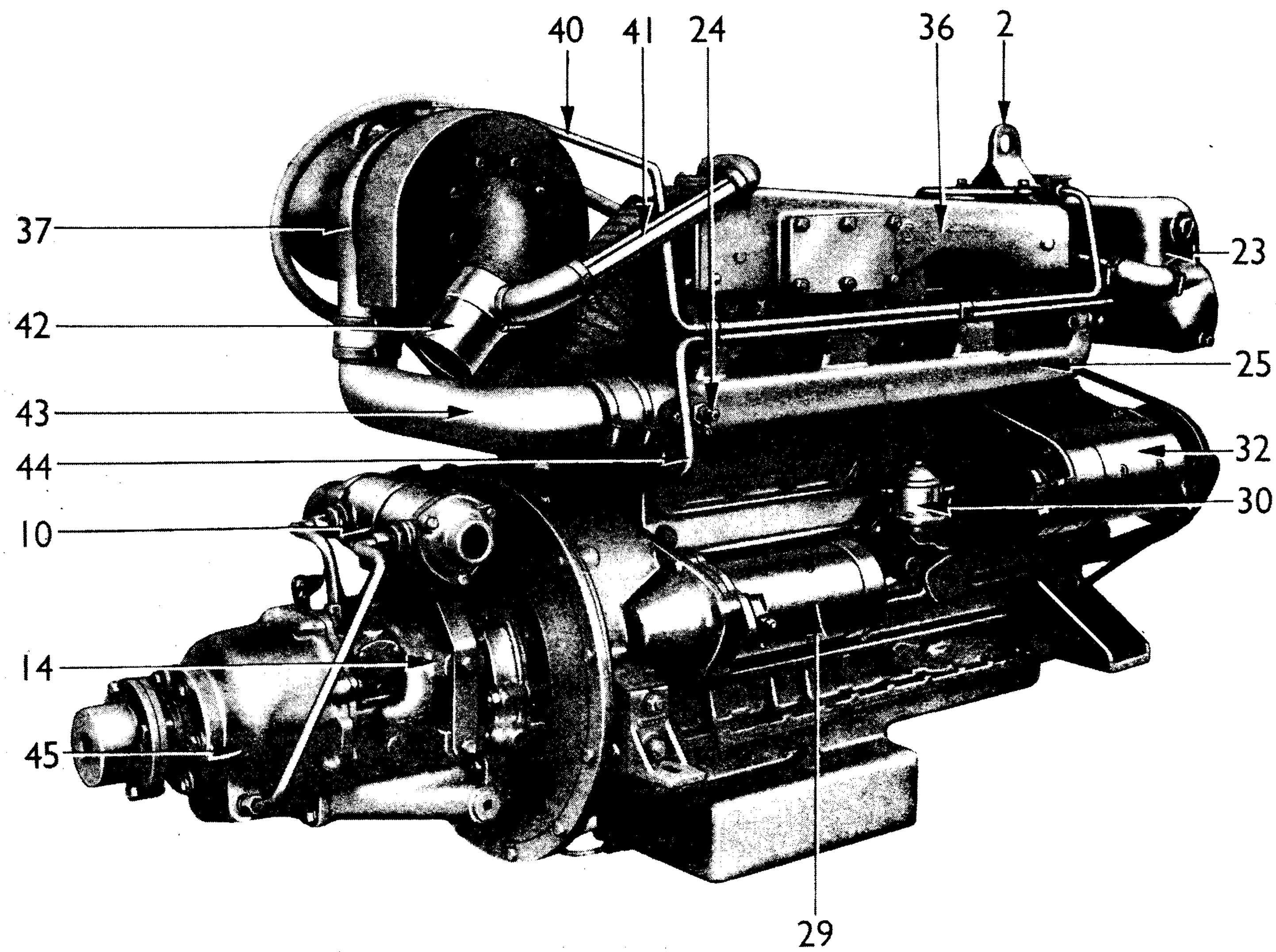
Starboard View of Normally Aspirated Vertical 6.354 Marine Engine.



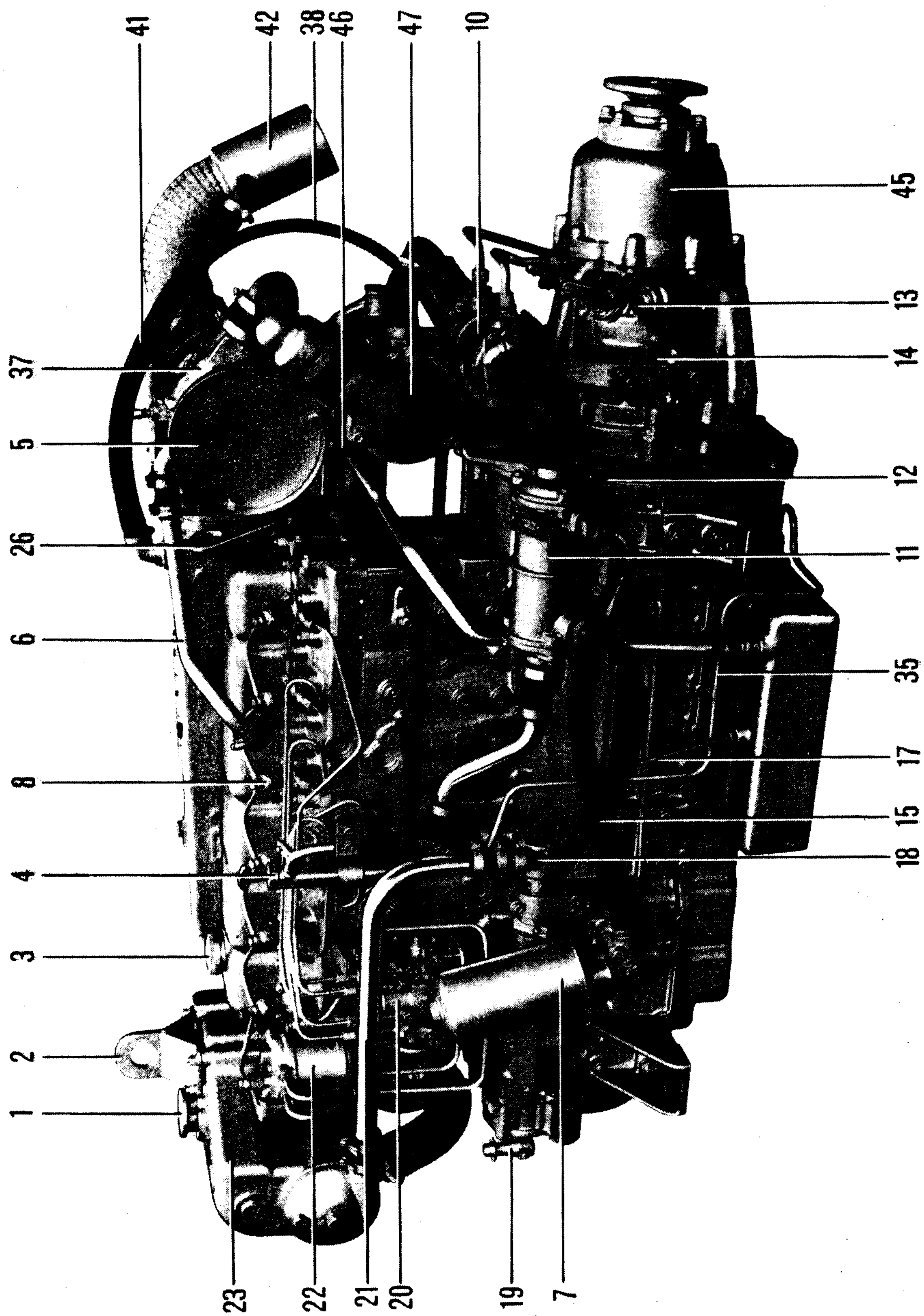
Starboard View of Horizontal Turbocharged 6.354 Marine Engine (HT6.354). (Fitted with Mk. 1/5 Turbocharger).



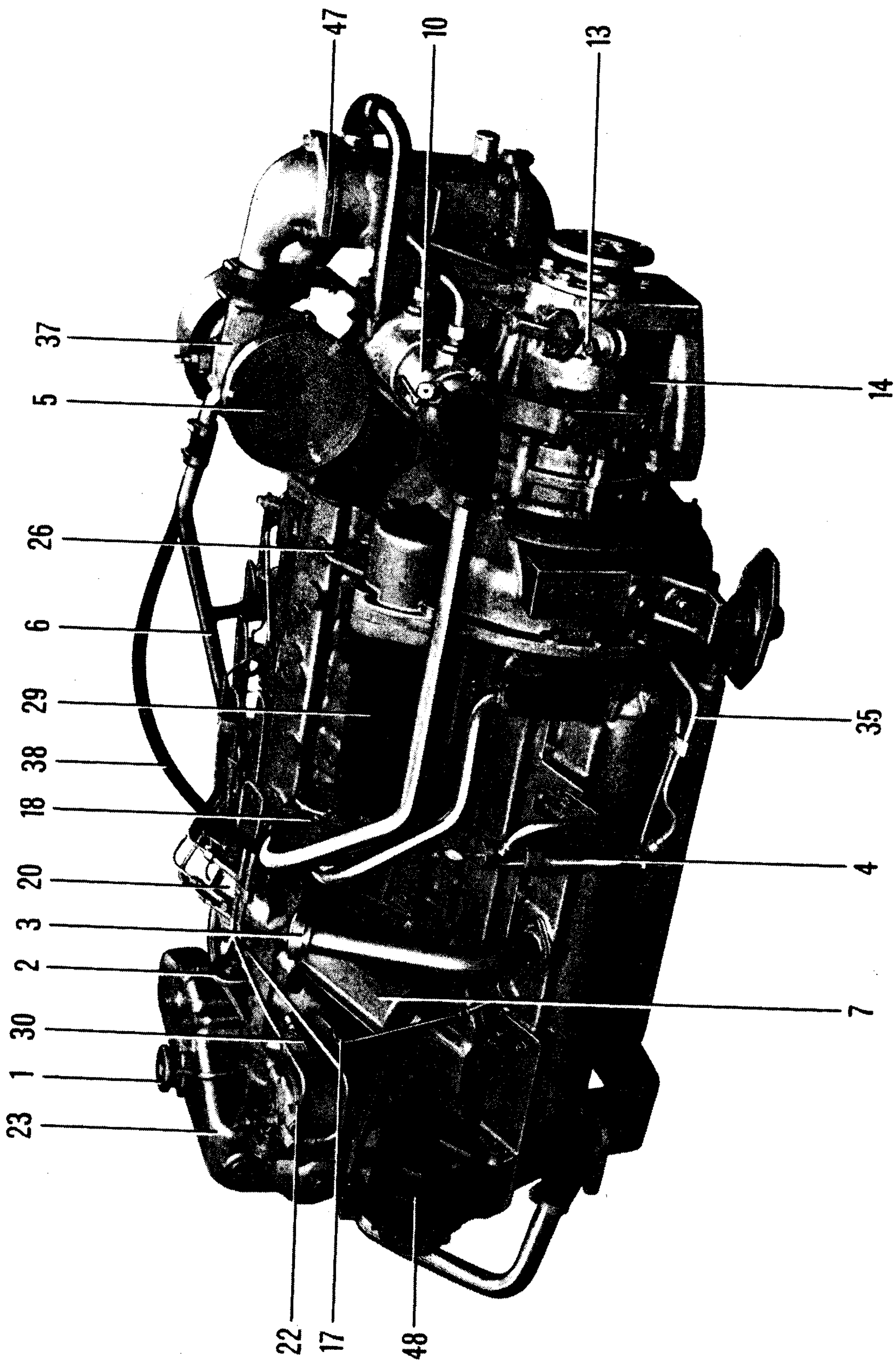
Starboard View of Turbocharged Vertical T6.354 Marine Engine. (Fitted with Holset 3LD Turbocharger).



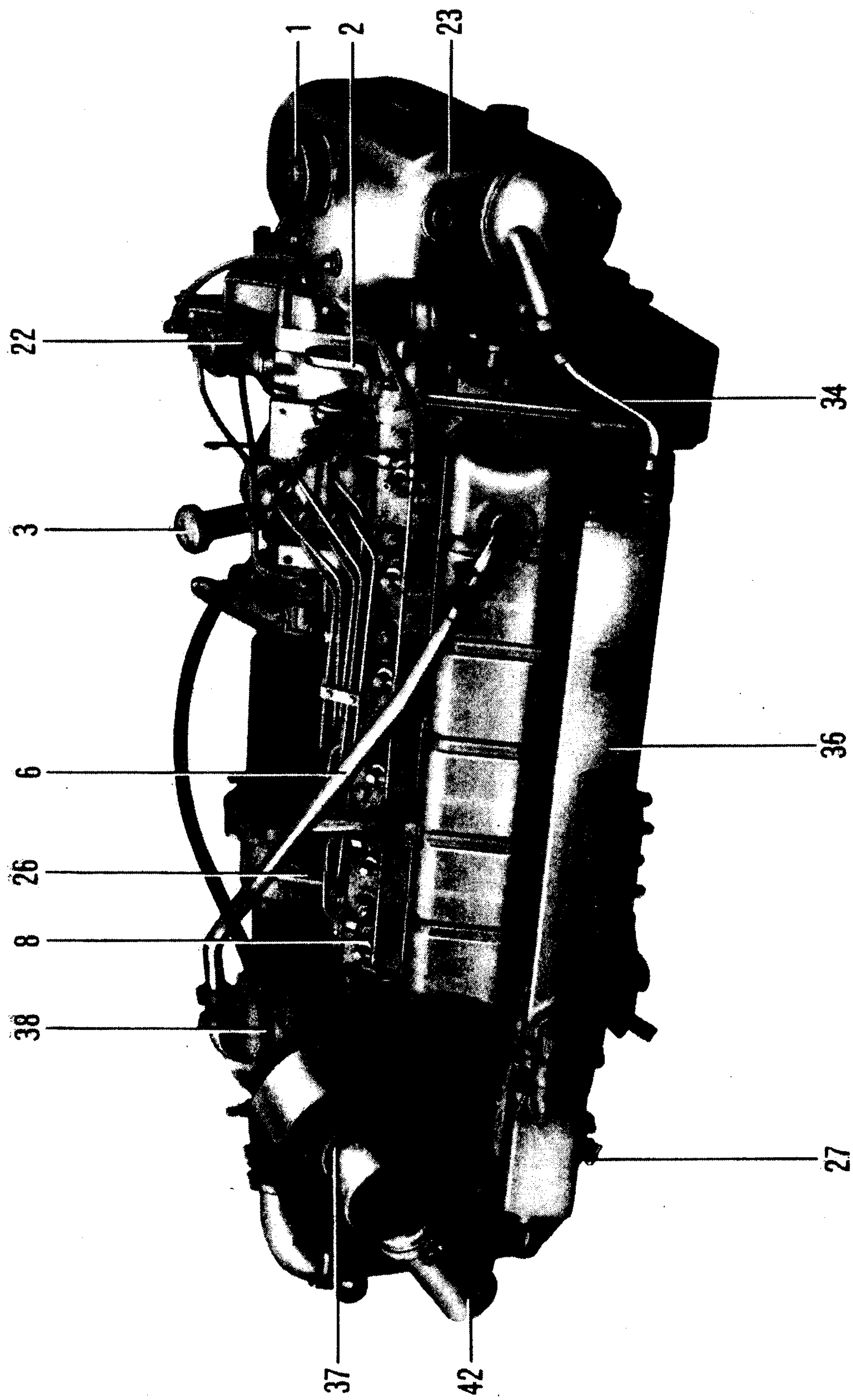
Starboard View of Turbocharged Vertical T6.354 Marine Engine. (Fitted with Mk 1/2 Turbocharger).



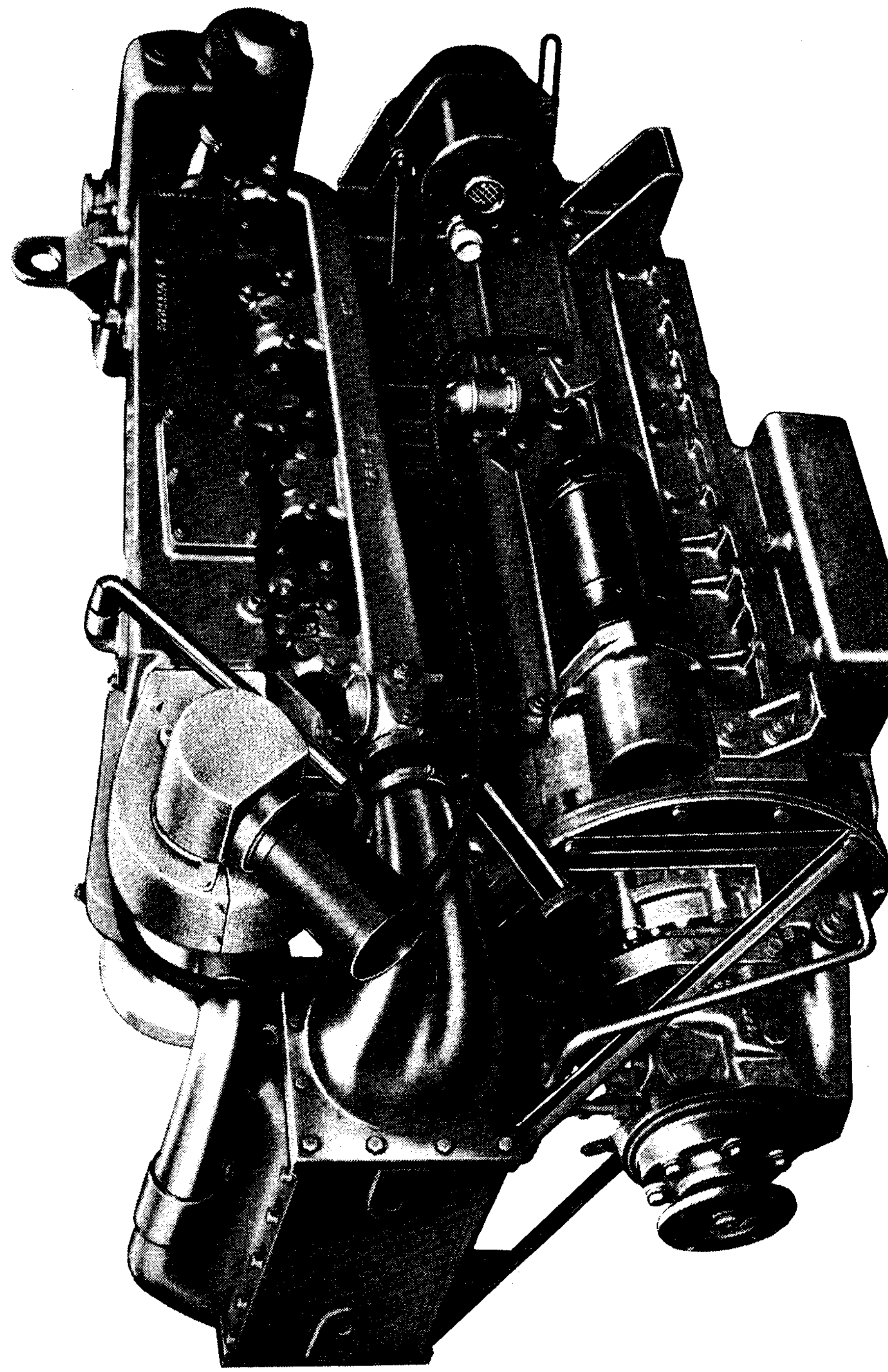
Port View of Turbocharged Vertical T6.354 Marine Engine. (Fitted with Holset 3LD Turbocharger).



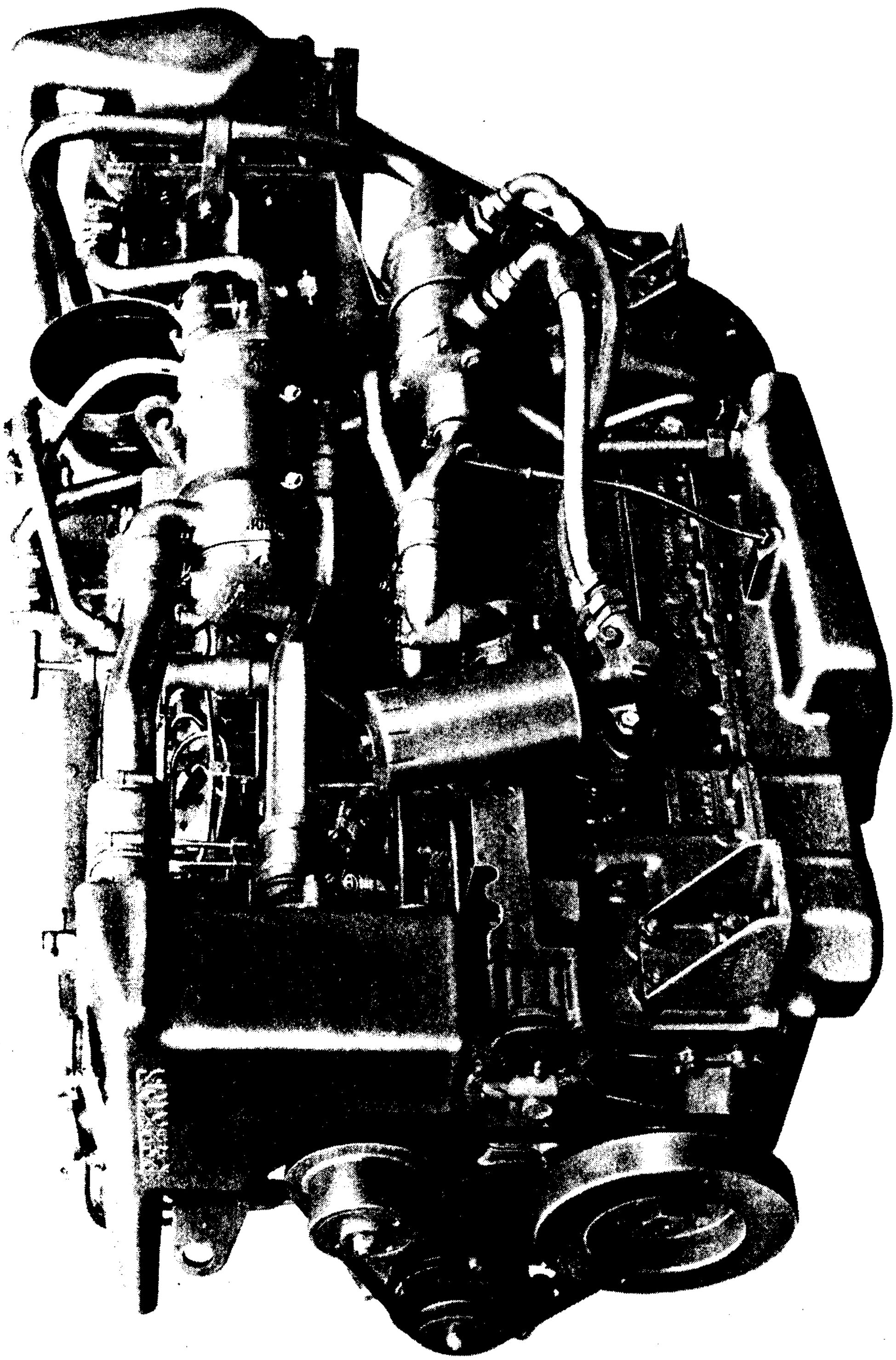
Port View of Horizontal Turbocharged 6.354 Marine Engine (HT6.354). (Fitted with Holset 3LD Turbocharger).



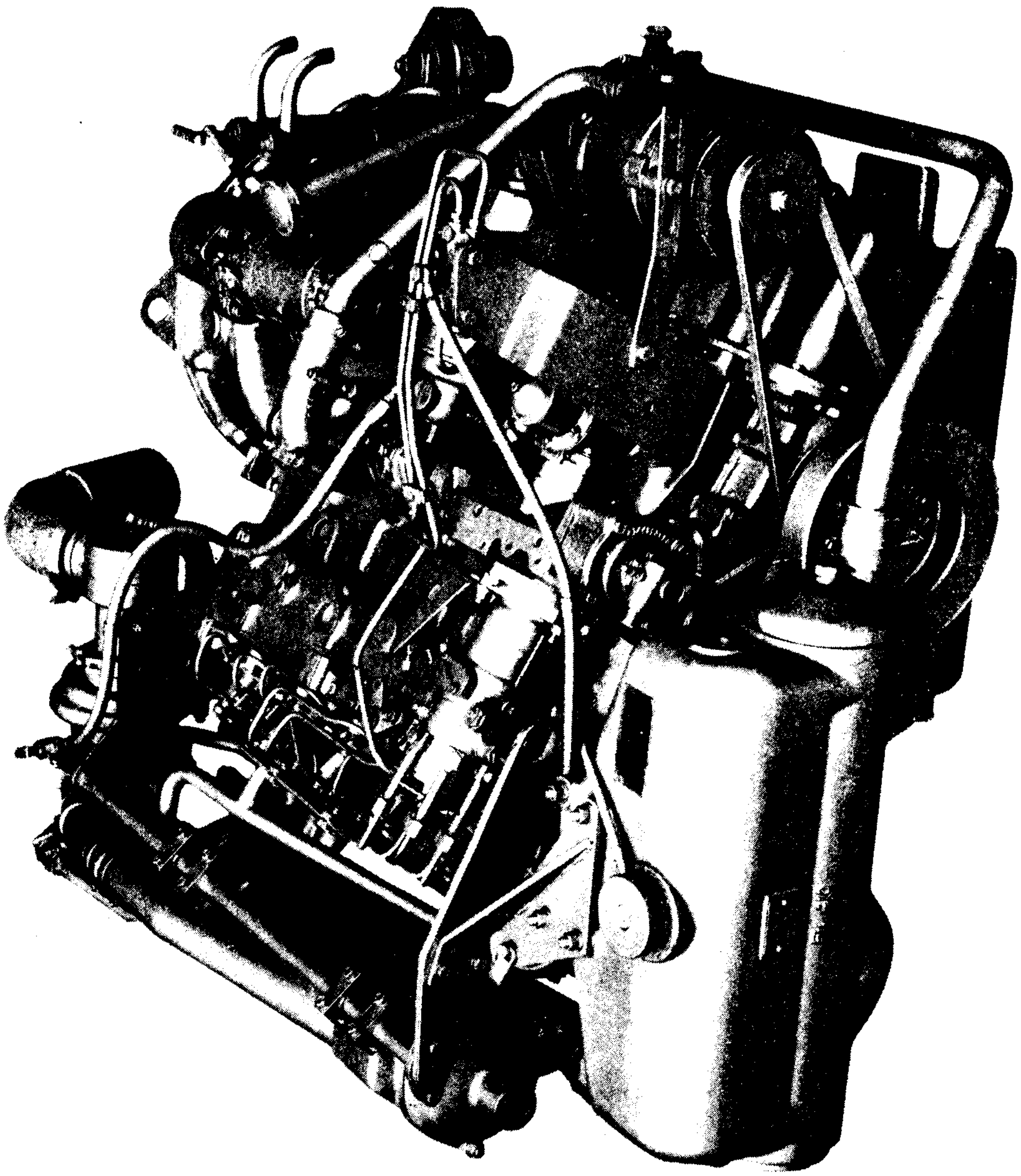
Starboard View of Horizontal Turbocharged 6.354 Engine (HT6.354). (Fitted with Holset 3LD Turbocharger).



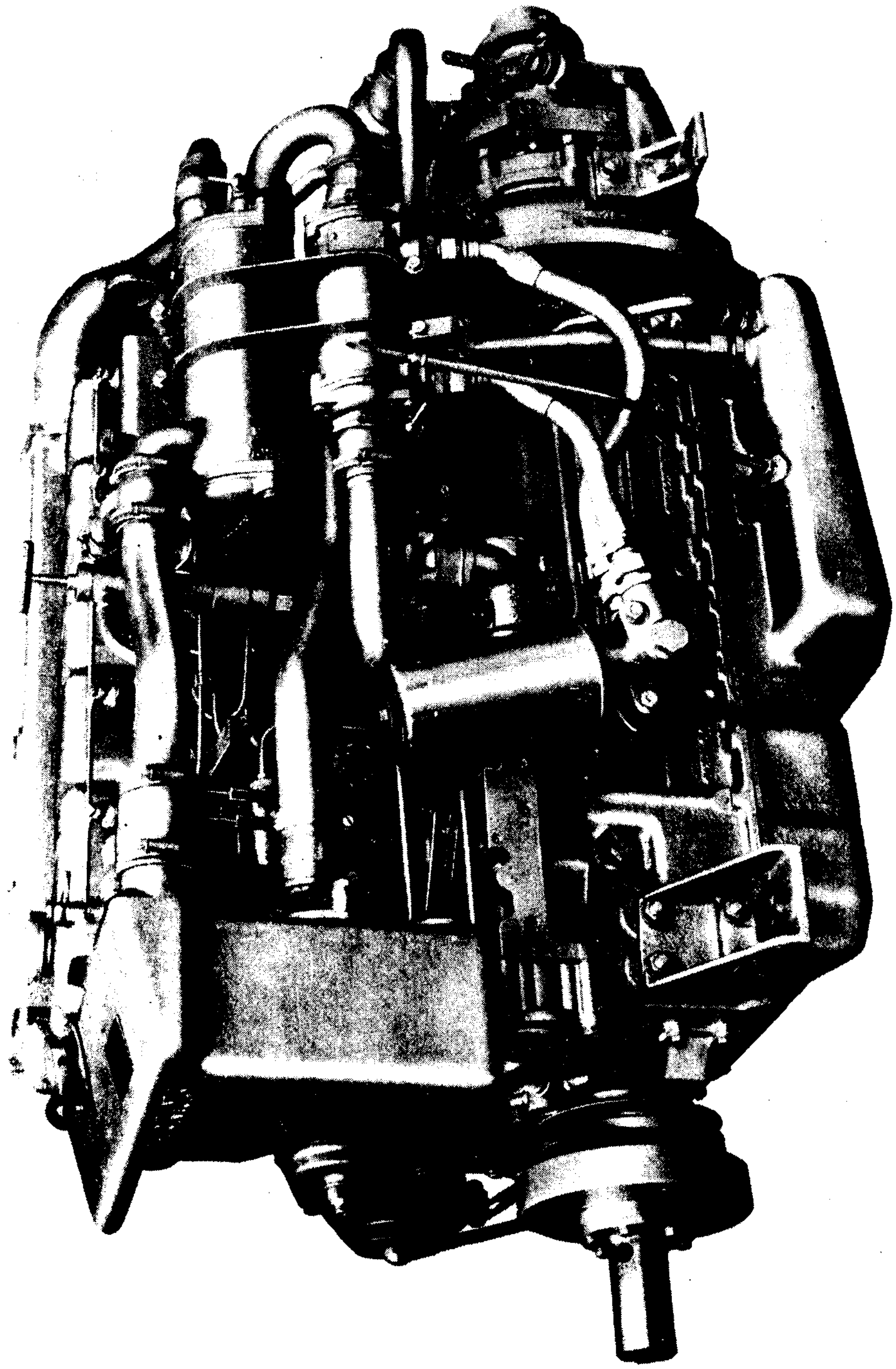
Starboard View of High Rated Turbocharged Engine (T6.354) Fitted with Holset 3LD Turbocharger)



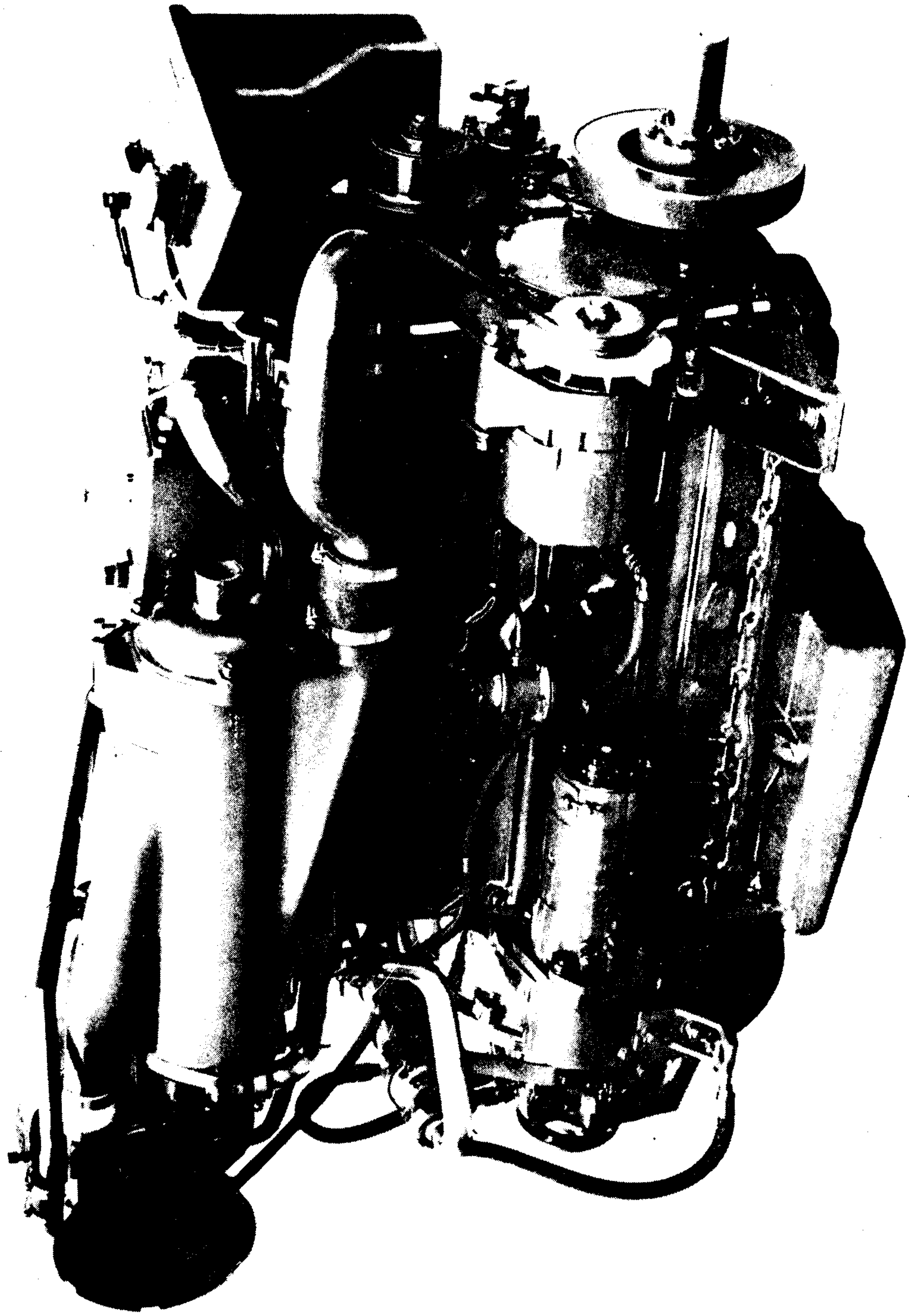
Port View of Low-Line Turbocharged Engine (T6.354). (Fitted with Holset 3LD Turbocharger).



Top side view of HT6.354 G.T.M.



Port side view of 6.354M Low-line



Starboard side view of T6.354 G.T.M. Low-line

SECTION B
Technical Data

Bore (nominal) .... 3.875 in (98,4 mm)
(For actual bore size see page B.3).

Stroke .... 5 in (127 mm)

No. of cylinders .... Six (in line)

Cubic capacity .... 354 in^3 (5,8 litres)

Compression ratio 16:1

Firing order (normal direction) 1, 5, 3, 6, 2, 4

Firing order (contra-rotating) 1, 4, 2, 6, 3, 5

Tappet clearance .... 0.012 in (0,30 mm) cold

Oil Pressure at maximum engine speed and normal operating temperature .... 30 to 60 lbf/in^2 (2,11 to 4,22 kgf/cm^2) — 207 to 414 Kn/m^2

Lubricating Oil Capacities

6.354M/T6.354MGT

Sump	...	16 IMP pints — 9,1 litres — 9.6 US quarts
Total	...	18 IMP pints — 10,2 litres — 10.8 US quarts

***T6.354M**

Sump	...	19 IMP pints — 10,8 litres — 11.4 US quarts
Total	...	21 IMP pints — 11,9 litres — 12.6 US quarts

H6.354M/HT6.354M/HT6.354MGT

Sump	...	16.5 IMP pints — 9,4 litres — 9.9 US quarts
Total	...	23 IMP pints — 13,1 litres — 13.8 US quarts

*Early T6.354M engines had a total oil capacity of 23 IMP pints (approx).

DETAILS OF RATINGS

Engine Ratings

Very Early T6.354 Marine
125 shp at 2,400 rev/min

Early T6.354 and early HT6.354 Marine
135 shp at 2,400 rev/min

Current T6.354 and HT6.354 Marine (for fast planing craft only)
145 shp at 2,400 rev/min

Current T6.354GT Marine (High Rated engines for fast planing craft)
175 shp at 2,600 rev/min

Early 6.354 Marine
105 shp at 2,400 rev/min

Current 6.354 Marine
115 shp at 2,800 rev/min

NOTE: Maximum rev/min is dependant on hull design as the correct engine rating should be matched to the duty of the boat.

Recommended Torque Tensions	Screw Size U.N.F.	lbf ft	Nm	kgf m
*Cylinder Head Nuts or Setscrews	$\frac{1}{2}$ in.	100	136	13,8
Cylinder Head Nuts	$\frac{7}{16}$ in.	60	81	8,3
Connecting Rod Nuts, Self Locking (plain) ...	$\frac{1}{2}$ in.	90	122	12,4
Connecting Rod Nuts (cadmium plated) — see Page F.4	$\frac{1}{2}$ in.	70	94	9,7
Connecting Rod Nuts (cadmium plated) — see Page F.4	$\frac{1}{2}$ in.	75	101	10,4
Main Bearing Setscrews (early engines) — see Page H.2	$\frac{5}{8}$ in.	150	203	20,7
Main Bearing Setscrews (current engines) — see Page H.2	$\frac{5}{8}$ in.	180	244	24,9
Idler Gear Hub Nuts	$\frac{7}{16}$ in.	50	68	6,9
Idler Gear Hub Nuts	$\frac{1}{2}$ in.	65	88	9,0
Sump to Cylinder Block Setscrews	$\frac{5}{16}$ in.	15	20	2,1
Flywheel Setscrews	$\frac{1}{2}$ in.	80	108	11,1
Camshaft Gear Retaining Setscrews	$\frac{1}{2}$ in.	50	68	6,9
Crankshaft Damper Setscrew	$\frac{5}{16}$ in.	15	20	2,1
Crankshaft Pulley Setscrew	$\frac{7}{8}$ in.	300	406	41,5
Atomiser Securing Nuts	$\frac{5}{16}$ in.	12	16	1,66
Dynamo Pulley Nut	$\frac{7}{16}$ in.	20	27	2,7
Dynamo Pulley Nut	$\frac{5}{8}$ in.	25	34	3,46
Alternator Pulley Nut	$\frac{7}{16}$ in.	30	41	4,1
Filter Bowl Retaining Setscrew		10	14	1,38
Induction Manifold Setscrews (with corrugated joints) — see Page E.8		24	33	3,3
High Pressure Fuel Pipe Nuts		15	20	2,1

*$\frac{1}{2}$ in studs were introduced as from Engine No. 8060000.

Note: Connecting rod nuts should be renewed whenever the big ends are disturbed. Self locking type nuts may be replaced by cadmium plated non self locking nuts.

Humidity and Temperature

A small loss of power will occur when humidity and temperature conditions are particularly adverse and allowance for this should be made when choosing the propeller.

De-Rating for Altitude

Few marine engines operate at high altitudes, but where these are called upon to operate in rarefied atmospheres occasioned by altitude, such engines should be de-rated.

The following table is given as a general guide for normally aspirated engines, which may be applied on a percentage basis, where specific figures for a particular engine rating are not available.

Altitude	Maximum fuel delivery de-rating measured at 800 rev/min pump speed
0 — 2,000 feet (600 metre)	No change
2,000 — 4,000 feet (1,200 metre)	6%
4,000 — 6,000 feet (1,800 metre)	12%
6,000 — 8,000 feet (2,400 metre)	18%
8,000 — 10,000 feet (3,000 metre)	24%
10,000 — 12,000 feet (3,600 metre)	30%

It should be noted that the above information only applies to **normally aspirated engines.**

In the case of turbocharged engines, where these are required to operate at altitudes over 4,000 feet, de-rating data in each individual case should be obtained from the Service Department, Perkins Engines Ltd., Peterborough, England.

When requesting such information, details should be supplied concerning engine number, rating and operating requirements.

Any necessary adjustments in this respect to the fuel pump should be carried out by the C.A.V. dealer, Perkins Marine Distributor or Perkins Overseas Distributor for the territory concerned.

For any further information apply to Service Department, Perkins Engines Limited, Peterborough, or to those Overseas Companies listed on page 2.

MANUFACTURING DATA AND DIMENSIONS

The data regarding clearances and tolerances are given for personnel engaged upon major overhauls.

Further information can be obtained on request from the Service Department, Perkins Engines Ltd., Peterborough.

Cylinder Block

Height between Top Face and C/L of Crankshaft	13.869/13.873 in (352,27/352,37 mm)
Parent Bore Diameter for Cylinder Liner	4.0625/4.0635 in (103,39/103,44 mm)
Main Bearing Parent Bore Diameter	3.166/3.167 in (80,42/80,44 mm)
Camshaft Parent Bore Diameter No. 1	2.000/2.001 in (50,8/50,83 mm)
Camshaft Parent Bore Diameter No. 2	1.990/1.992 in (50,55/50,6 mm)
Camshaft Parent Bore Diameter No. 3	1.980/1.982 in (50,30/50,34 mm)
Camshaft Parent Bore Diameter No. 4	1.970/1.972 in (50,04/50,09 mm)
Recess Dia. for Cyliner Liner Flange	4.205/4.210 in (106,73/106,93 mm)
Recess Depth for Cylinder Liner Flange	0.150/0.152 in (38,10/38/38,15 mm)

Cylinder Liners—Flangeless

Type	Dry—Interference Fit
Interference Fit of Liner	0.003/0.005 in (0,076/0,127 mm)
Inside Diameter of Liner after Finish Honing	3.877/3.878 in (98,48/98,50 mm)
Depth of Liner in relationship to Cylinder Block Top Face (Early Type)	0.005/0.013 in (0,125/0,33 mm) Below
Height of Liner in relationship to Cylinder Block Top Face (Later Type)	0.030/0.035 in (0,76/0,89 mm) Above
Maximum Oversize (Rebore) — **not** for turbocharged engines	+0.030 in (+0,76 mm)
Overall Length of Liner (Early Type)	8.963/8.973 in (227,7/227,9 mm)
Overall Length of Liner (Later Type)	9.005/9.015 in (228,7/229mm)

Cylinder Liners—Flanged

Type	Dry—Interference Fit (Production)—Transition Fit (Service)
Interference Fit of Liner (Production)	0.001/0.003 in (0,025/0,076 mm)
Inside Diameter of Production Liner after Finish Honing	3.877/3.878 in (98,48/98,50 mm)
Fit of Liner (Service)	−0.001/+0.001 in (−0,025/+0,025 mm)
Inside Diameter of Service Liner after Fitting	3.877/3.8795 in (98,48/98,54 mm)
Flange Thickness	0.144/0.146 in (3,66/3,71 mm)
Height of Liner above Cylinder Block Top Face	0.028/0.035 in (0,71/0,89 mm)
Depth of Liner Flange below Top Face of Cylinder Block	0.004/0.010 in (0,1/0,25 mm)
Overall Length of Liner	8.941/8.954 in (227,1/227,43 mm)

Pistons

Note: The piston heights quoted are Production limits. Where service pre-topped pistons are used, the piston height can be lower than that quoted. This is satisfactory, but piston heights should never be above these limits.

Type	
Normally Aspirated and Early Turbocharged ...	Toroidal Cavity in Crown
Later Turbocharged	Dished Cavity in Crown
Piston Height in relation to Cylinder block (Turbocharged)	0.000/0.005 in (0,00/0,127 mm) Below
Piston Height in relation to Cylinder block (Normally Asp.)	0.0026/0.0103 in (0,07/0,26 mm) Above
Bore Diameter for Gudgeon Pin (Current Turbocharged)	1.49985/1.50005 in (38,096/38,101 mm)
Bore Diameter for Gudgeon Pin (Normally Asp. and Early Turbocharged)	1.37485/1.37505 in (34,92/34,93 mm)
Compression Ring Groove Width No. 1 (Turbocharged)	0.127/0.128 in (3,23/3,25 mm)
Compression Ring Groove Width Nos. 2 and 3 (Turbocharged)	0.0957/0.0967 in (2,43/2,46 mm)
Scraper Ring Groove Width (Turbocharged) ...	0.2525/0.2535 in (6,41/6,44 mm)
Compression Ring Groove Width Nos. 1, 2 and 3 (Normally Asp.)	0.0957/0.0967 in (2,43/2,46 mm)
Scraper Ring Groove Width (Normally Asp.) ...	0.2525/0.2535 in (6,41/6.44 mm)
Weight of Piston (Turbocharged)	2 lb 8¾ oz ± 6 Drams (1,155 Kg ± 10,63 Grammes)
Weight of Piston (Normally Asp.)	2 lb 8¾ oz ± 4 Drams (1,155 Kg ± 7,08 Grammes)

Piston Rings

The ring gaps quoted are for a bore diameter of 3.877 in (98,48 mm). When checking ring gaps in worn cylinder bores, 0.003 in (0,08 mm) should be added to these gaps for every 0.001 in (0,03 mm) increase in bore diameter.

Turbocharged Engines (Other Than those Rated at 175 shp)

Compression Ring Width—Top Ring	0.124/0.125 in (3,15/3,175 mm)
Ring Clearance in Groove	0.002/0.004 in (0,051/0,1 mm)
Ring Gap	0.012/0.017 in (0,30/0,43 mm)
Compression Ring Width—2nd and 3rd Rings ...	0.0928/0.0938 in (2,36/2,38 mm)
Ring Clearance in Groove	0.0019/0.0039 in (0,05/0,1 mm)
Ring Gap	0.012/0.017 in (0,30/0,43 mm)
Scraper Ring Width—4th Ring	0.249/0.250 in (6,33/6,35 mm)
Ring Clearance in Groove	0.0025/0.0045 in (0,06/0,11 mm)
Ring Gap	0.012/0.017 in (0,30/0,43 mm)

Turbocharged Engines (Rated At 175 shp)

Compression Ring Width—1st, 2nd and 3rd Rings ...	0.0928/0.0938 in (2,36/2,38 mm)
Ring Clearance in Groove	0.0019/0.0039 in (0,05/0,1 mm)
Scraper Ring Width—4th and 5th Rings	0.249/0.250 in (6,33/6,35 mm)
Ring Clearance in Groove	0.0025/0.0045 in (0,06/0,11 mm)
Ring Gap—All Rings	0.012/0.017 in (0,30/0,43 mm)

Normally Aspirated Engines

Compression Ring Width—1st, 2nd and 3rd Rings	0.0928/0.0938 in (2,36/2,38 mm)
Ring Clearance in Groove	0.0019/0.0039 in (0,05/0,1 mm)
Ring Gap—Top Ring	0.016/0.021 in (0,41/0,53 mm)
Ring Gap—2nd and 3rd Rings	0.012/0.017 in (0,30/0,43 mm)
Scraper Ring Width—4th and 5th Rings	0.249/0.250 in (6,33/6,35 mm)
Ring Clearance in Groove	0.0025/0.0045 in (0,06/0,11 mm)
Ring Gap	0.011/0.016 in (0,28/0,41 mm)

Small End Bush

Type	Steel Backed, Lead Bronze Lined
Outside Diameter (Normally Asp. and Early Turbocharged)	1.535/1.536 in (38,99/39,01 mm)
Outside Diameter (Current Turbocharged)	1.660/1.661 in (42,16/42,19 mm)
Length	1.326/1.336 in (32,78/33,03 mm)
Inside Diameter before Reaming (Normally Asp. and Early Turbocharged)	1.359/1.363 in (34,52/34,62 mm)
Inside Diameter before Reaming (Current Turbocharged)	1.489/1.493 in (37,82/37,92 mm)
Inside Diameter after Reaming (Normally Asp and Early Turbocharged	1.3765/1.37575 in (34,96/34,94 mm)
Inside Diameter after Reaming (Later Turbocharged)	1.5015/1.50075 in (38,14/38,12 mm)
Clearance Between Small End Bush and Gudgeon Pin	0.0017/0.00075 in (0,038/0,024 mm)

Gudgeon Pin

Type	Fully Floating
Outside Diameter (Normally Asp. and Early Turbocharged)	1.3748/1.375 in (34,92/34,93 mm)
Outside Diameter (Current Turbocharged)	1.4998/1.500 in (38,09/38,1 mm)
Length (Normally Asp. and Early Turbocharged)	3.297/3.312 in (83,74/84,12 mm)
Length (Current Turbocharged)	3.250/3.2599 in (82,55/82,8 mm)
Fit in Piston Boss	Transition

Connecting Rod

Type	"H" Section
Cap Location to Connecting Rod	Serrations
Big End Parent Bore Diameter	2.646/2.6465 in (67,21/67,22 mm)
Small End Parent Bore Diameter (Normally Asp. and Early Turbocharged)	1.53125/1.53225 in (38,9/38,92 mm)
Small End Parent Bore Diameter (Current Turbocharged)	1.65625/1.65725 in (42,07/42,09 mm)
Length from C/L of Big End to C/L of Small End	8.624/8.626 in (219,05/219,1 mm)
Connecting Rod Side Play	0.0095/0,0145 in (0,24/0,36 mm)

Connecting Rod Alignment

Large and small end bores must be square and parallel with each other within the limits of ±0.010 in (0,25 mm) measured 5 in (127 mm) each side of the axis of the rod on test mandrel as shown in Fig. B.1. With the small end bush fitted, the limit of ±0.010 in (0,25 mm) is reduced to ±0.0025 in (0,06 mm).

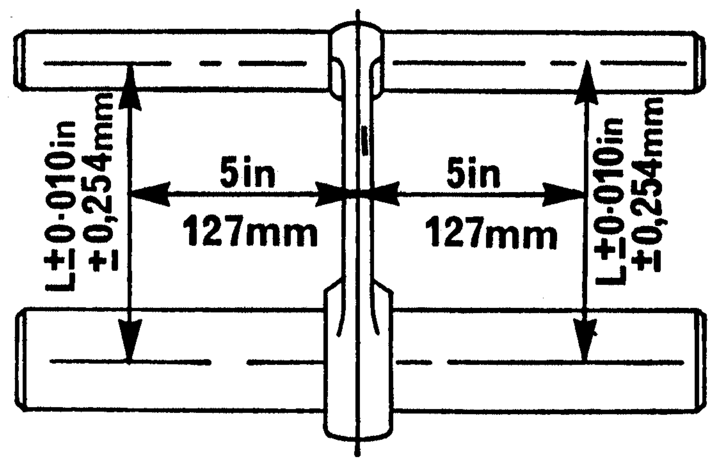


Fig. B.1.

Crankshaft

Overall Length	33.83375/33.85375 in (859,38/859,89 mm)
Main Journal Diameter	2.9984/2.9992 in (76,16/76,18 mm)
Main Journal Length—No. 1	1.454/1.485 in (36,91/37,69 mm)
Main Journal Length—Nos. 2, 3, 5, 6 and 7	1.545/1.549 in (39,24/39,34 mm)
*Main Journal Length—No. 4	1.738/1.740 in (44,15/44,20 mm)
*Fillet Radius—Main Journal	0.145/0.156 in (3,68/3,96 mm)
Crankpin Diameter	2.4988/2,4996 in (63,47/63,49 mm)
*Crankpin Length	1.5885/1.590 in (40,37/40,39 mm)
*Fillet Radius—Crankpins	0.145/0.156 in (3,68/3,96 mm)
Surface Finish—All pins and journals	16 micro-inches (0,4 microns)
Main Journal and Crankpin—Regrind Undersizes	−0.010, 0.020 and 0.030 in (−0,25, 0,51 and 0,76 mm)
Oil Seal Helix Diameter (rope seal only)	3.124/3.125 in (79,35/79,38 mm)
Oil Seal Helix Width	0.050/0.080 in (1,27/2,03 mm)
Oil Seal Helix Depth	0.004/0.008 in (0,1/0,2 mm)
Flange Diameter	5.248/5.250 in (133,3/133,35 mm)
Flange Width	0.500 in (12,7 mm)
Spigot Bearing Recess (Depth)	0.781 in (19,84 mm)
Spigot Bearing Recess (Bore)	1.849/1.850 in (46,96/47,0 mm)
Crankshaft End Float	0.002/0.015 in (0,05/0,38 mm)

*Fillet radius and surface finish must be maintained during crankshaft regrinding. Length of No. 4 main journal not to exceed 1.759 in (44,68 mm) after regrinding; where necessary use oversize thrust washers to suit. Length of crankpins not to exceed 1.635 in (41,53 mm) after regrinding.

For regrinding of Tufftrided or Nitrided crankshafts see Page H.1.

Crankshaft Thrust Washers

Type	Steel Backed, Lead Bronze Faced
Position in Engine	Centre Main Bearing
Thrust Washer Thickness (Standard)	0.089/0.091 in (2,26/2,36 mm)
Thrust Washer Thickness (Oversize)	0.0965/0.0985 in (2,45/2,51 mm)
Thrust Washer Outside Diameter	4.088/4.098 in (103,84/104,09 mm)
Thrust Washer Inside Diameter	3.42/3.43 in (86,87/87,12 mm)

Main Bearings

Type	Pre-finished, Steel Backed, Aluminium Tin Faced
Shell Width—Nos. 1, 2, 3, 5, 6 and 7	1.245/1.255 in (31,62/31,88 mm)
Shell Width—No. 4	1.435/1.445 in (36,45/36,7 mm)
Outside Diameter of Main Bearing	3.166/3.167 in (80,42/80,44 mm)
Inside Diameter of Main Bearing	3.0015/3.003 in (76,24/76,28 mm)
Main Bearing Running Clearance	0.0025/0.0045 in (0,064/0,11 mm)
Steel Thickness	0.070 in (1,78 mm)
Aluminium Thickness	0.012/0.0125 (0,30/0,32 mm)

Connecting Rod Bearings

Type	Pre-finished, Steel Backed, Aluminium Tin Faced
Shell Width	1.245/1.255 in (31,62/31,88 mm)
Outside Diameter of Con-Rod Bearing	2.646/2.6465 in (67,21/67,22 mm)
Inside Diameter of Con-Rod Bearing	2.501/2.502 in (63,53/63,55 mm)
Con-Rod Bearing Running Clearance	0.0015/0.003 in (0,038/0,076 mm)
Steel Thickness	0.050 in (1,27 mm)
Aluminium Tin Thickness	0.02225/0.0225 in (0,56/0,57 mm)

Camshaft

No. 1 Journal Length	1.148 in (29,16 mm)
No. 1 Journal Diameter	1.9965/1.9975 in (50,61/50,64 mm)
No. 1 Journal Running Clearance	0.0025/0.0045 in (0,064/0,11 mm)
No. 2 Journal Length	1.375 in (34,93 mm)
No. 2 Journal Diameter	1.9865/1.9875 in (50,36/50,38 mm)
No. 2 Journal Running Clearance	0.0025/0.0055 in (0,064/0,14 mm)
No. 3 Journal Length	1.375 in (34,93 mm)
No. 3 Journal Diameter	1.9765/1.9775 in (50,1/50,13 mm)
No. 3 Journal Running Clearance	0.0025/0.0055 in (0,064/0,14 mm)
No. 4 Journal Length	1.125 in (28,58 mm)
No. 4 Journal Diameter	1.9665/1.9675 in (49,85/49,87 mm)
No. 4 Journal Running Clearance	0.0025/0.0055 in (0,064/0,14 mm)
Cam Lift	0.3035 in (7,71 mm)
Oilways for Rocker Shaft Lubrication	No. 2 Journal
Width of Spigot for Thrust Washer	0.222/0.232 in (5,638/5,892 mm)
Camshaft End Float	0.004/0.016 in (0,1/0,41 mm)

Camshaft Thrust Washer

Type	360°
Thrust Washer Outside Diameter	2.872/2.874 in (72,95/73,0 mm)
Cylinder Block Recess Diameter for Thrust Washer	2.875/2.885 in (73,03/73,28 mm)
Clearance Fit of Washer in Recess	0.001/0.013 in (0,025/0,33 mm)
Thrust Washer Internal Diameter	1.75 in (44,45 mm)
Thrust Washer Thickness	0.216/0.218 in (5,47/5,54 mm)
Cylinder Block Recess Depth for Thrust Washer (Early Engines)	0.154/0.156 in (3,86/3,91 mm)
Cylinder Block Recess Depth for Thrust Washer (Later Engines)	0.213/0.216 in (5,41/5,49 mm)
Protrusion of Thrust Washer above Cylinder Block Front Face (Early Engines)	0.062/0.066 in (1,53/1,68 mm)
Protrusion of Thrust Washer above Cylinder Block Front Face (Later Engines)	0.000/0.005 in (0,00/0,13 mm)

Cylinder Head

Cylinder Head Length	29.28125 in (743,74 mm)
Cylinder Head Depth	3.235/3.265 in (82,17/82,93 mm)
Skimming Allowance on Cylinder Head Face	0.012 in (0,30 mm)*
Leak Test Pressure	30 lbf/in^2 (2,11 kgf/cm^2)
Valve Seat Angle	45°
Valve Guide Bore in Cylinder Head	0.625/0.6255 in (15,87/15,89 mm)

*Providing nozzle protrusion does not exceed 0.114 in (3,66 mm) after skimming. (See Page E.6 for earlier engines.

Valve Guides

Internal Diameter	0.375/0.376 in (9,53/9,55 mm)
Outside Diameter	0.626/0.6265 in (15,9/15,91 mm)
Internal Diameter of Counterbore (Exhaust Valve Guide Only)	0.421/0.441 in (10,69/11,20 mm)
Depth of Counterbore (Exhaust Valve Guide Only)	0.40625 in (10,32 mm)
Interference Fit of Guide in Cylinder Head Bore	0.0005/0.0015 in (0,013/0,038 mm)
Overall Length of Guide (Inlet)	2.281 in (57,94 mm)
Overall Length of Guide (Exhaust)	2.406 in (61,11 mm)
Overall Protrusion	0.594 in (15,08 mm)

Inlet Valves

Valve Stem Diameter	0.3725/0.3735 in (9,46/9,49 mm)
Clearance Fit of Valve in Guide	0.0015/0.0035 in (0,04/0,09 mm)
Valve Head Diameter	1.742/1.746 in (44,25/44,35 mm)
Valve Face Angle	45°
Valve Head Depth below Cylinder Head Face—Production Limits	0.029/0.039 in (0,74/0,99 mm)
Valve Head Depth below Cylinder Head Face—Max. Permissible after Servicing	0.050 in (1,27 mm) Three Exhaust Port Head 0.060 in (1,52 mm) Four Exhaust Port Head
Overall Length	4.830/4.845 in (122,68/123,06 mm)
Sealing Arrangement	Rubber Deflector

Exhaust Valves

Valve Stem Diameter	0.372/0.373 in (9,45/9,47 mm)
Clearance Fit of Valve in Guide	0.002/0.004 in (0,051/0,1 mm)
Valve Head Diameter	1.438/1.442 in (36,54/36,64 mm)
Valve Face Angle	45°
Valve Head Depth below Cylinder Head Face—Production Limits	0.029/0.039 in (0,74/0,99 mm)
Valve Head Depth below Cylinder Head Face—Max. Permissible after Servicing	0.050 in (1,27 mm) Three Exhaust Port Head 0.060 in (1,52 mm) Four Exhaust Port Head
Overall Length	4.845/4.862 in (123,03/123,54 mm)

Inner Valve Springs

Fitted Length	1.5625 in (39,7 mm)
Load at Fitted Length	15.4 lb ± 2 lb (7 kg ± 0,91 kg)
No. of Active Coils	9
No. of Damper Coils	2
Coiled	R.H.—Damper Coils to Cylinder Head

Outer Valve Springs

Fitted Length	1.78 in (45,22 mm)
Load at Fitted Length	40 lb ± 2 lb (18,1 kg ± 0,91 kg)
No. of Active Coils	7.5
No. of Damper Coils	2
Coiled	L.H.—Damper Coils to Cylinder Head

Tappets

Overall Length	2.96875 in (75,41 mm)
Tappet Shank Diameter	0.7475/0.7485 in (18,99/19,01 mm)
Cylinder Block Tappet Bore Diameter	0.750/0.75125 in (19,05/19,08 mm)
Running Clearance of Tappet in Bore	0.0015/0.00375 in (0,04/0,09 mm)
Outside Diameter of Tappet Foot	1.1875 in (30,16 mm)

Rocker Shaft

Overall Length	26.3125 in (668,38 mm)
Outside Diameter of Shaft	0.7485/0.7495 in (19,01/19,04 mm)

Rocker Levers

Internal Diameter of Rocker Lever Bore	0.7505/0.752 in (19,06/19,1 mm)
Clearance of Rocker Lever to Rocker Shaft	0.001/0.0035 in (0,025/0,09 mm)

Push Rods

Gauge Length of Push Rod	10.648/10.708 in (270,46/271,98 mm)
Shank Diameter	0.310/0.312 in (7,87/7,93 mm)

TIMING GEARS

Camshaft Gear

Number of Teeth	56
Inside Diameter of Gear Boss	1.375/1.376 in (34,93/34,96 mm)
Outside Diameter of Camshaft Hub	1.3751/1.3757 in (34,93/34,95 mm)
Transition Fit of Gear to Hub	−0.0007/+0.0009 in (−0,018/+0,023 mm)

Auxiliary Drive Gear

Number of Teeth	8
Internal Diameter of Gear Bore	1.000/1.001 in (25,4/25, 3 mm)
Maximum Adjustment in Slotted Locating Holes	10°

Crankshaft Gear

Number of Teeth	28
Internal Diameter of Crankshaft Gear Bore	1.875/1.876 in (47,63/47,65 mm)
Crankshaft Diameter for Gear	1.875/1.8755 in (47,63/47,64 mm)
Fit of Crankshaft Gear to Crankshaft	−0.0005/+0.001 in (−0,012/+0,025 mm)

Idler Gears and Hubs

Number of Teeth	37
Inside Diameter of Gear	1.53125/1.53225 in (38,89/38,92 mm)
Outside Diameter of Bush	1.53125/1.53225 in (38,89/38,92 mm)
Inside Diameter of Bush	1.3755/1.3771 in (34,95/34,98 mm)
Outside Diameter of Hub	1.374/1.3745 in (34,91/34,92 mm)
Fit of Hub inside Bush	0.001/0.003 in (0,025/0,076 mm) clearance
Diameter of Oil Hole Drilling in Gear	0.073 in (1,85 mm)

Timing Gear Backlash

All Gears	0.003/0.006 in (0,076/0,15 mm)

Auxiliary Drive Shaft Assembly

Drive Shaft—Overall Length	10.25 in (260,35 mm)
Number of Teeth on Worm	11
Outside Diameter of Worm—Early	1.619/1.624 in (41,12/41,25 mm)
—Current	1.870 in (47,5 mm)
Diameter of Front Journal—Early	1.748/1.749 in (44,4/44,42 mm)
—Current	1.9355/1.9365 in (49,16/49,19 mm)
Diameter of Rear Journal	1.248/1.249 in (31,7/31,72 mm)

Drive Shaft Bush—Front

Outside Diameter of Bush—Early	1.9375/1.9385 in (49,21/49,24 mm)
—Current	2.1283/2.1303 in (54,06/54,11 mm)
Housing Bore current	2.125/2.1262 in (53,98/54,00 mm)
Interference Fit in Housing	0.002/0.0053 in (0,05/0,13 mm)
Inside Diameter of Bush—Fitted—Early	1.750/1.7516 in (44,45/44,49 mm)
—Current	1.9375/1.9397 in (49,21/49,27 mm)
Running Clearance of Shaft in Bush—Early	0.001/0.0036 in (0,025/0,09 mm)
—Current	0.001/0.0042 in (0,025/0,11 mm)

Drive Shaft Bush—Rear

Outside Diameter of Bush	1.4086/1.4105 in (35,78/35,83 mm)
Housing Diameter for Bush	1.4063/1.4076 in (35,72/35,75 mm)
Interference Fit in Housing	0.001/0.0042 in (0,03/0,11 mm)
Internal Diameter of Bush—Fitted	1.25/1.2519 in (31,75/31,81 mm)
Running Clearance of Shaft in Bush	0.001/0.0036 in (0,025/0,09 mm)

Auxiliary Drive Thrust Washers

Thickness	0.1875/0.1905 in (4,76/4,84 mm)
Cylinder Block Recess Depth for Thrust Washer	0.188/0.191 in (4,77/4,85 mm)
Outside Diameter	2.806/2.812 in (71,27/71,42 mm)
Groove Width on Drive Shaft	0.193/0.1965 in (4,9/4,99 mm)
Groove to Washer Clearance	0.0025/0.009 in (0,064/0,23 mm)

Fuel Pump Drive Shaft (early engines)

Overall Length	3.875 in (98,43 mm)
Outside Diameter of Shaft for Wormwheel	1.0002/1.0006 in (25,4/25,42 mm)
Outside Diameter of Shaft for Adaptor Plate	2.3095/2.3115 in (58,66/58,71 mm)

Wormwheel (early engines)

Number of Teeth	22
Internal Diameter	1.000/1.0008 in (25,4/25,42 mm)
Transition Fit of Wormwheel to Drive Shaft	−0.0006/+0.0006 in (−0,015/+0,015 mm)
Distance between Centres—Wormwheel to Auxiliary Drive Shaft	1.95 in (49,53 mm)—Early 2.375 in (60,33mm)—Current

Fuel Pump Adaptor Plate Bush (early engines)

Internal Diameter of Plate for Bush	2.50/2.5012 in (38,1/38,13 mm)
Internal Diameter of Plate for Fuel Pump	1.8141/1.8125 in (46,08/46,04 mm)
Width of Datum Slot	0.121/0.129 in (3,07/3,28 mm)
Outside Diameter of Bush	2.5053 in (38,23 mm)
Internal Diameter of Bush (requires boring in situ)	2.3125/2.3143 in (58,74/58,78 mm)
Running Clearance of Fuel Pump Drive Shaft in Bush	0.001/0.0048 in (0,02/0,122 mm)

Hydraulically Loaded Wormwheel (later engines)

Bore Dia. in Cylinder Block for Fuel Pump Adaptor Plate and Upper Thrust Collar	3.500/3.5014 in (88,90/88,94 mm)
Fuel Pump Adaptor Plate Dia.	3.4986/3.4995 in (88,86/88,89 mm)
Fit of Adaptor Plate in Cylinder Block	0.0005/0.0028 in (0,01/0,07 mm)
Outer Dia. of Upper Thrust Collar	3.496/3.498 in (88,80/88,85 mm)
Clearance of Upper Thrust Collar in Cylinder Block	0.002/0.0054 in (0,05/0,14 mm)
Width of Groove in Upper Thrust Collar	0.0957/0.0967 in (2,43/2,46 mm)
Upper Thrust Collar Sealing Ring Thickness	0.0928/0.0938 in (2,36/2,38 mm)
Clearance of Sealing Ring in Groove	0.0019/0.0039 in (0,05/0,10 mm)
Inner Dia. of Bush in Fuel Pump Adaptor Plate	1.8750/1.8766 in (47,63/47,67 mm)
Upper Dia. of Fuel Pump Drive Shaft	1.8714/1.8730 in (45,53/47,57 mm)
Clearance of Drive Shaft in Adaptor Plate Bush	0.002/0.0052 in (0,05/0,13 mm)
Inner Dia. of Upper Thrust Collar	1.886/1.890 in (47,90/48,01 mm)
Clearance of Drive Shaft in Upper Thrust Collar	0.013/0.0186 in (0,33/0,47 mm)
Inner Dia. of Bush in Lower Thrust Collar	1.625/1.6266 in (41,28/41,32 mm)
Lower Dia. of Fuel Pump Drive Shaft	1.6214/1.6230 in (41,18/41,22 mm)
Clearance of Drive Shaft in Bush	0.002/0.0052 in (0,05/0,12 mm)

LUBRICATION SYSTEM

Normal Lubricating Oil Pressure at Maximum Engine Speed and Normal Working Temperature	30/60 lbf/in^2 (2,11/4,22 kgf/cm^2) —207/414 Kn/m^2

Sump

Sump Capacity	See Page B.1
Strainer Position	On suction pipe of Lubricating Oil Pump

Oil Pump

Type of Pump	Rotor Type
No. of Lobes—Inner Rotor	Four or Three
No. of Lobes—Outer Rotor	Five or Four

Oil Pump Clearances

Concentric pumps have 3 lobe rotors. Hobourn Eaton pumps have 4 lobe rotors. High capacity pumps can be identified by the pump body length of approximately 4½ in (114 mm) as compared with a body length of 3½ in (89 mm) for the standard pump.

Pump Part No. 41314044 (Hobourn Eaton)	
Inner Rotor to Outer Rotor	0.001/0.006 in (0,02/0,15 mm)
Outer Rotor to Pump Body	0.0055/0.010 in (0,14/0,25 mm)
Inner and Outer Rotor End Clearance	0.001/0.005 in (0,02/0,13 mm)
Pump Part No. 41314053 (Concentric)	
Inner Rotor to Outer Rotor	0.001/0.0035 in (0,02/0,09 mm)

Outer Rotor to Pump Body	0.006/0.013 in (0,15/0,33 mm)
Inner Rotor End Clearance	0.0015/0.003 in (0,04/0,08 mm)
Outer Rotor End Clearance	0.0005/0.0025 in (0,01/0,06 mm)
Pump Part No. 41314058 (Concentric—High Capacity)	
Inner Rotor to Outer Rotor	0.003/0.005 in (0,08/0,13 mm)
Outer Rotor to Pump Body	0.006/0.013 in (0,15/0,33 mm)
Inner Rotor End Clearance	0.0015/0.003 in (0,04/0,08 mm)
Outer Rotor End Clearance	0.0005/0.0025 in (0,01/0,06 mm)
Internal Diameter of Shaft Bore	0.6875/0.6885 in (17,46/17,49 mm)
Outside Diameter of Shaft	0.6855/0.686 in (17,41/17,42 mm)
Clearance of Shaft in Bore	0.0015/0.003 in (0,038/0,076 mm)
Pump Part No. 41314067 (Concentric—Turbocharged Engines only)	
Inner Rotor to Outer Rotor	0.001/0.005 in (0,02/0,13 mm)
Outer Rotor to Pump Body	0.006/0.013 in (0,15/0,33 mm)
Inner Rotor End Clearance	0.0015/0.003 in (0,04/0,08 mm)
Outer Rotor End Clearance	0.0005/0.0025 in (0,01/0,06 mm)

Note: For replacement purposes the whole pump assembly must be replaced.

Relief Valve

Pressure Setting	50/60 lbf/in² (3,52/4,22 kgf/cm²)
Length of Plunger	0.875 in (22,23 mm)
Outside Diameter of Plunger	0.747/0.749 in (18,91/18,96 mm)
Inside Diameter of Valve Housing Bore	0.750/0.751 in (19,05/19,08 mm)
Clearance of Plunger in Bore	0.001/0.004 in (0,025/0,1 mm)
Outside Diameter of Spring	0.679/0.695 in (17,25/17,65 mm)
Solid Length	1.56 in (39,62 mm)
Fitted Length	2.0625 in (52,39 mm)
Fitted Load (Normally Asp.)	13.33 lb ± 5½ oz (6,05 kg ± 155 grammes)
Fitted Load (Turbocharged)	18.4 lb ± 8½ oz (8,37 kg ± 240 grammes)
Load at 1$\frac{13}{16}$ in (45,04 mm) Spring Length (Normally Asp.)	21.47 lb ± 9½ oz (9,75 kg ± 270 grammes)
Load at 1$\frac{13}{16}$ in (45,04 mm) Spring Length (Turbocharged)	26.6 lb ± 12½ oz (12,0 kg ± 355 grammes)

Engine Lubricating Oil Filter

Type of Filter	Full Flow
Element Type	Paper or Replaceable Canister
By-Pass Valve Setting	8/12 lbf/in² (0,56/0,84 kgf/cm²)—55/82 Kn/m²
Type of Valve	Pressure Differential Spring Loaded Ball
Torque Tension for Filter Bowl Retaining Setscrew	10 lbf ft (1,38 kgf m)—14 Nm

Lubricating Oil Scavenge Pump (Horizontal Engines only)

Type	Gear
Inside Diameter of Scavenge Pump Body	1.760/1.762 in (44,70/44,75 mm)
Outside Diameter of Gears	1.749/1.751 in (44,43/44,47 mm)
Radial Clearance Between Gears and Body	0.0045/0.0065 in (0,114/0,165 mm)
Depth of Scavenge Pump Body	1.248/1.250 in (31,70/31,75 mm)
Length of Gears	1.250/1.252 in (31,75/31,80 mm)
Scavenge Pump Gear end Float	0.004 in (0,01 mm) Maximum

Inside Diameter of Driven Gear Bush	0.626/0.6265 in (15,89/15,91 mm)
Outside Diameter of Driven Gear Shaft	0.6258/0.6262 in (15,89/15,90 mm)
Running Clearance of Driven Gear on Shaft	−0.0002/+0.0007 in (−0,005/+0,018 mm)
Bore Diameter of Driver Gear	0.750/0.751 in (19,05/19,07 mm)
Outside Diameter of Drive Gear Shaft for Gear	0.75075/0.75125 in (19,07/19,08 mm)
Transition Fit of Driver Gear on Shaft	−0.00125/+0.00025 in (−0,03/+0,006 mm)
Inside Diameter of Drive Gear Shaft Bush—Front	0.6245/0.62575 in (15,86/15,88 mm)
Outside Diameter of Drive Gear Shaft—Front	0.6230/0.6238 in (15,82/15,84 mm)
Running Clearance of Drive Gear Shaft—Front	0.0007/0.00275 in (0,018/0,059 mm)
Inside Diameter of Drive gear Shaft Bush—Rear	0.6245/0.62575 in (15,86/15,88 mm)
Outside Diameter of Drive Gear Shaft—Rear	0.623/0.6238 in (15,82/15,84 mm)
Running Clearance of Drive Gear Shaft—Rear	0.0007/0.00275 in (0,018/0,059 mm)

Lubricating Oil Scavenge Pump Drive Gear (Horizontal Engines only)

No. of Teeth	23
Bore Diameter of Gear	0.622/0.6225 in (15,80/15,81 mm)
Outside Diameter of Drive Gear Shaft	0.623/0.6238 in (15,82/15,84 mm)
Interference Fit of Drive Gear on Shaft	0.0005/0.0018 in (0,01/0,05 mm)

Lubricating Oil Scavenge Pump Idler Gear (Horizontal Engines Rotating in Normal Direction only)

No. of Teeth	31
Inside Diameter of Idler Gear Bush	0.6245/0.62575 in (15,86/15,88 mm)
Outside Diameter of Idler Gear Shaft	0.623/0.6238 in (15,82/15,84 mm)
Running Clearance of Idler Gear on Shaft	0.0007/0.00275 in (0,018/0,059 mm)

Lubricating Oil Scavenge Pump Idler Gears (Horizontal Engines Rotating in contra-rotation only)

No. of Teeth	21
Inside Diameter of Idler Gear Bush	0.6245/0.62575 in (15,86/15,88 mm)
Outside Diameter of Idler gear Shaft	0.623/0.6238 in (15,82/15,84 mm)
Running Clearance of Idler Gear on Shaft	0.0007/0.00275 in (0,018/0,059 mm)

COOLING SYSTEM

Type of Cooling System

Cylinder Head	Water Pump Circulation
Cylinder Block	Thermo-Syphon
Fresh Water Coolant Capacity (Closed Circuit System)	4 gallons 4 pints (20,5 litres)

Thermostat

Type	Bellows
Opening Temperature	168/176°F (75/80°C)
Fully Open at	189/195°F (87/90°C)
Valve Lift	0.312/0.469 in (7,92/11,91 mm)

Sea Water Pump

Type	Rubber Impeller

Fresh Water Pump

Type	Centrifugal
Outside Diameter of Shaft for Pulley	0.7501/0.7506 in (19,053/19,065 mm)
Inside Diameter of Pulley Bore	0.7500/0.7508 in (19,05/19,07 mm)
Transition Fit of Pulley on Shaft	−0.0006/+0.0007 in (−0,015/+0,018 mm)
Outside Diameter of Shaft for Impeller	0.6262/0.6267 in (15,9/15,92 mm)
Diameter of Impeller Bore	0.6249/0.6257 in (15,87/15,89 mm)
Interference Fit of Impeller on Shaft	0.0005/0.0018 in (0,013/0,046 mm)
Impeller Blade to Body Clearance	0.012/0.035 in (0,3/0,89 mm)

FUEL SYSTEM

APROVED FUEL OIL SPECIFICATIONS

United Kingdom	BS.2869: 1967	Class A.1 or A.2
United States	VV–F–800a	Grades DF–A, DF–1 or DF–2
	A.S.T.M./D975–66T	Nos. 1–D or 2–D
France	(J.O. 14/9/57)	Gas Oil or Fuel Domestique
India	IS: 1460/1968	Grade Special or Grade A
Germany	DIN–51601 (1967)	—
Italy	CUNA–Gas Oil NC–630–01 (1957)	—
Sweden	SIS. 15 54 32 (1969)	—
Switzerland	Federal Military Spec. 9140–335–1404 (1965)	—

Fuel oils available in territories other than those listed above which are to an equivalent specification may be used.

Fuel Lift Pump

Type of Pump	A.C. Delco—U.F. Series
Method of Drive (Vertical Engines)	Eccentric on Camshaft
Method of Drive (Horizontal Engines)	Eccentric on Auxiliary Drive Shaft
Delivery Pressure	5/8 lbf/in^2 (0,35/0,56 kgf/cm^2)-34/69kn/m^2
Diaphragm Spring Colour	Blue

Fuel Filter

Element Type	Paper
Pressure Valve	Gravity Vent Valve

Fuel Injection Pump

Make	C.A.V.
Type	D.P.A.
Pump Rotation	Anti-Clockwise
Timing Letter (Hydraulic)	'H'
Timing Letter (Mechanical)	'F'
No. 1 Cylinder Outlet	'X'

ATOMISERS

Make CAV

Engine Type	Code	Holder	Nozzle	Setting Pressure	Working Pressure
Normally Aspirated Engines (115 shp Rating)	ZZ	BKBL67S5151	BDLL150S6395	175 atm	170 atm
Normally Aspirated Engines (Earlier 105 shp rating)	Y	BKBL67S5151	BDLL150S6329	175 atm	170 atm
Turbocharged Engines	DH	BKBL67S5299	BDLL150S6385A	210 atm	195 atm
Turbocharged Engines (175 shp at 2,600 rev/min rating)	DZ	BKBL67S5299	BDLL150S6318	215 atm	200 atm
	FE	BKBL67S5299	BDLL150S6654	210 atm	195 atm

STATIC TIMING POSITION

Engine Type	Piston Displacement	Static Timing B.T.D.C.
Normally Aspirated	0.372 in (9,45 mm)	28°
Turbocharged	0.325 in (8,26 mm)	26°
Turbocharged (175 shp)		
F.I.P. Setting Code ET97/2400/0/2900*	0.325 in (8,26 mm)	26°
F.I.P. Setting Code JR91/700/4/2920	0.230 in (5,84 mm)	22°
F.I.P. Setting Code DX92/700/4/2920	0.426 in (10,82 mm)	30°

* In service use DR110/800/0/2690.

ELECTRICAL SYSTEM (24 Volt)

Dynamo

Make	C.A.V.
Type	GL4524-18MXA—2 Brush Shunt Wound
Rotation	Clockwise
Maximum Output	15 amps
Cut-In Speed	675 Rev/Min

Alternator

Make	Prestolite
Type	B2430 C5
Rotation (Normal Engine)	Clockwise
Rotation (contra-rotation engine)	Anti-Clockwise
Maximum Output	30 amps
Cut-In Speed	1150 Rev/Min

Make	C.A.V.
Type	AC5
Rotation (Normal Engine)	Clockwise
Rotation (Contra-Rotating Engine)	Anti-Clockwise
Maximum Output	31 Amps
Cut-In Speed	1,125 Rev/Min

Starter Motor

Make	C.A.V.
Type	CA45
Maximum Current	1150 amps
Starter Cable Resistance	0.0017 ohms
No. of Teeth on Pinion	10

Note: The above data is general and can vary with individual applications.

Starting Aid

Make	C.A.V. Type 357–6
Voltage	12 Volt (with resistor in circuit)
Maximum Current Consumption	12.9 amps
Flow Rate through Thermostart	4.9 cm^3/min
Height of Reservoir above centre of Thermostart	4½/10 in (114,3/254 mm)

Service Wear Limits

The following "wear limits" indicate the condition when it is recommended that the respective items should be serviced or replaced.

Cylinder Head Bow	Transverse	0.005 in (0,13 mm)
	Longitudinal	0.010 in (0,25 mm)
Maximum Bore Wear (when reboring or new liners are necessary)		0.008 in (0,2 mm)
Crankshaft Main and Big End Journal Wear, Ovality		0.0015 in (0,04 mm)
Maximum crankshaft End Float		0.015 in (0,38 mm)
Valve stem to Bore/Guide Clearance	Inlet	0.005 in (0,13 mm)
	Exhaust	0.006 in (0,15 mm)
Valve Head Thickness between run-out of valve seat and face of valve		1/32 in (0,79 mm)
Rocker Clearance on Rocker Shaft		0.005 in (0,13 mm)
Camshaft Journals (Ovality and Wear)		0.002 in (0,05 mm)
Camshaft End Float		0.020 in (0,51 mm)
Idler Gear End Float		0.012 in (0,30 mm)

PREVENTIVE MAINTENANCE

Daily

Check coolant level.
Check sump oil level.
Check oil pressure.
Check gearbox oil level.
Check boost pressure — turbocharged engines only.

Every 200 hours or 4 months (whichever occurs first)

Clean air intake gauze of screen.
Grease tachometer angle drive connections (where nipple fitted).
Drain and renew engine lubricating oil (see lubricating oils in appendix).
Renew lubricating oil filter element or canister.
Check drive belt tension.
Clean water trap.
Check engine for leakage of oil and water.
Lubricate dynamo rear bush (where fitted).

Every 400 hours or 12 months (whichever occurs first)

Clean lift pump gauze strainer.
Renew final fuel filter element.
Check hoses and clips.
Drain and clean fuel tank.
Renew gearbox lubricating oil (Borg Warner).

Every 800 hours

Clean turbocharger impeller, diffuser and oil drain pipe.
Renew gearbox lubricating oil (MRF 350).

Every 2,400 hours

Arrange for examination and service of proprietary equipment, i.e., starter, dynamo etc.
*Service atomisers.
Check and adjust valve tip clearances.
NOTE: For engines fitted with air charge coolers, see Page L.7.

*Where T6.354 and HT6.354 engines are rated at 175 shp GT for fast planing craft, the atomisers must be serviced every 100 hours.

POST DELIVERY CHECKOVER

After a customer has taken delivery of his Perkins Diesel engine, a general checkover of the engine must be carried out after the first 25 hours in service.

The checkover should comprise the following points :—

1. Drain lubricating oil sump and refill to full mark on dipstick with new oil. Renew lubricating oil filter element or canister.
2. Remove rocker assembly and check cylinder head nuts are to correct torque (See Page B.2).
3. Refit rocker assembly and set valve clearance to 0.012 in (0,30 mm) cold.
4. Check coolant level in header tank and inspect for coolant leaks.
5. Check external nuts, setscrews, mountings etc., for tightness.
6. Check water pump belt tension.
7. Check electrical equipment and connections.
8. Check for lubricating and fuel oil leaks.
9. Check general performance of engine.

PRESERVATION OF LAID-UP ENGINES

Where an application is to be laid up for several months it must be protected as follows :—

1. Clean all external parts.
2. Run engine until warm. Stop and drain the lubricating oil sump.
3. Throw away paper element in the lubricating oil filter, clean bowl and fit a new element or replace canister. Part fill bowl with new oil of an approved grade, a list of which appears in the Appendix.
4. Clean out breather pipe.
5. Fill lubricating oil sump to correct level with new oil of an approved grade.
6. Drain all fuel oil from fuel tanks and filters. Put into the fuel tank at least one gallon of one of the oils listed under "Recommended Oils for the Fuel System." If because of the construction of the fuel tank, this quantity of oil is inadequate, break the fuel feed line before the first filter and connect a small capacity auxiliary tank.
7. Prime the system as detailed on page M.7.
8. Start engine and run it at half speed for 15 minutes when the oil will have circulated through the injection pump, pipes and injectors.
9. Seal the air vent in the tank or filler cap with waterproof adhesive tape.
10. Drain water from heat exchanger and engine cylinder block.

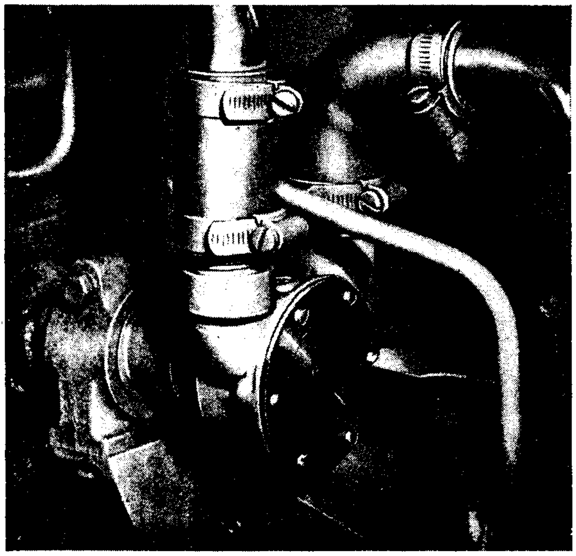


Fig. C.4.
Removing Screws securing Sea Water Pump End Plate.

11. Remove end plate from the sea water circulating pump and lubricate the interior of the pump body with MARFAK 2HD grease (see Figs. C.4 and C.5).

12. Remove the atomisers, and spray into the cylinder bores ¼ pint (0,14 litre) of lubricating oil, divided between all cylinders.
Rotate the crankshaft one complete revolution and replace atomisers.

13. Remove the air cleaner and any piping. Seal the air intake with water proofed adhesive tape.

14. Remove the exhaust pipe and seal the manifold port.

15. Remove cylinder head cover, lubricate the rocker assembly and replace the cover.

16. Remove water pump driving belt.

17. **Batteries**
   (a) Remove the battery and top up the cells with distilled water.
   (b) Recharge.
   (c) Clean terminals and lightly smear with petroleum jelly.
   (d) Store in a cool, dry, dust free place. Avoid freezing risk.
   (e) Recharge once a month.

18. **Starters and Generators**
Clean terminals and lightly smear with petroleum jelly. The generator, starter and control board must be protected against rain.

RECOMMENDED OILS FOR THE FUEL SYSTEM*

	Lowest Temperature During Lay Up
Esso IL 815	+25°F (— 4°C)
Esso IL 1047	0°F (—18°C)
Shell Calibration Fluid "C" (U.K.)	0°F (—18°C)
Shell Calibration Fluid "B" (Overseas)	—70°F (—57°C)
Shell Fusus "A"	—15°F (—26°C)
Shell Fusus "A" R1476 (Old Type)	25°F (— 4°C)

No attempt should be made to restart the engine until the temperature has been at least 15°F (9°C) above that shown in the table for not less than 24 hours, otherwise there may be difficulty in obtaining a free flow of fuel.

*The proprietary brands of oils listed are recommended for the purpose by the oil companies. They may not be available in all parts of the world, but suitable oils may be obtained by reference to the oil companies. The specification should include the following :—

Viscosity : Should not be greater than 22 centistokes at the lowest ambient temperature likely to be experienced on re-starting.

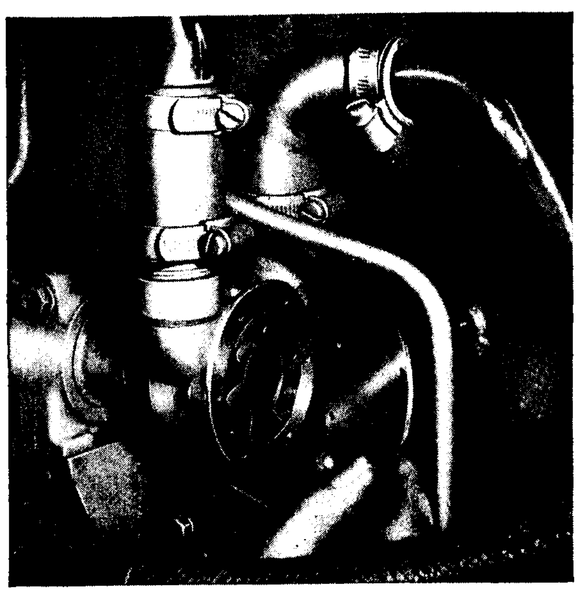


Fig. C.5.
Removing Sea Water Pump End Plate.

Pour Point : Must be at least 15°F (9°C) lower than the lowest ambient temperature to be experienced on restarting and should be lower than the lowest temperature likely to be met during the lay-up period

The oils selected are not necessarily suitable for calibrating or testing pumps.

PREPARING THE ENGINE FOR RETURN TO SERVICE

When the engine is to be returned to service, the following procedure must be observed :—

1. Thoroughly clean all external parts.
2. Remove adhesive tape from the fuel tank vent or filler cap.
3. Drain fuel tank to remove any remaining oil and condensed water and refill the tank with fuel oil.
4. Fit new filter element and vent the filter.
5. Vent and prime the fuel injection pump (See Page M.7).
6. Close all coolant drain taps and fill the system with clean coolant. Check for leaks.
7. Rotate fresh water pump by hand to ensure freedom of water pump seals.
8. Refit water pump driving belt.
9. Remove the rocker cover, lubricate rocker assembly with engine oil and replace cover.
10. Remove adhesive tape from the air intake, refit the air cleaner and any air intake pipe. Clean the gauze and if it is the oil bath type, fill with engine oil to the correct level.
11. Remove adhesive tape from the exhaust manifold port and refit exhaust pipe.
12. Connect the battery.
13. **Starter and Generator**
    Wipe the grease from the terminals and check that all connections are sound. If the starter is fitted with a Bendix type of drive, lubricate with a little light engine oil. CA45 co-axial starters, except where they are fitted with dust cover, should be given the same treatment.
14. Check the level and condition of the oil in the sump. Change the oil if necessary.
15. Start the engine in the normal manner, checking for oil pressure and electrical rate of charge.
    Whilst the engine is reaching normal running temperature check that it is free from water and fuel leaks.

Note :

If the foregoing instructions are observed, the laying up and returning to service should be carried out efficiently and without adverse affect on the engine. Perkins Engines Ltd., however, cannot accept liability for direct or consequential damage that might arise following periods of laying-up.

FROST PRECAUTIONS

Precautions against damage by frost should be taken if the engine is to be left exposed to inclement weather. An anti-freeze of reputable make and incorporating a suitable corrosion inhibitor may be used in the closed circuit system.

It is advisable that the manufacturers of the relevant mixture be contacted to ascertain whether their products are suitable for use in Perkins engines and also to ensure that their products will have no harmful effect on the cooling system generally, especially in respect of the water pump impeller. It is our experience that the best results are obtained from anti-freeze which conforms to British Standard 3151 or has been approved by testing in accordance with British Standard 5117 Clause 5 to give at least as good a result as BS3151.

The coolant solution containing 25 per cent anti-freeze manufactured to BS3151 in water in a properly maintained engine should maintain its anti-freeze and anti-corrosive properties throughout the winter season in the U.K. and in general, a safe life of 12 months may be reasonably expected.

After an anti-freeze solution has been used, the cooling system should be thoroughly flushed in accordance with the manufacturer's instructions before refilling with normal coolant.

If the engine is to be laid up for the winter season, the raw water circuit should be drained. Before commencing draining, the sea cock should be turned off, then all drain cocks opened and drain plugs removed. The removal of a sea water hose at the lowest point of the engine will assist in complete drainage of the raw water.

If the foregoing action is taken, no harmful effects should be experienced, but Perkins Engines Ltd., cannot be held responsible for any frost damage or corrosion which may be incurred.

SECTION D
Fault Diagnosis

Fault Finding Chart

Fault	Possible Cause
Low cranking speed	1, 2, 3, 4.
Will not start	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 31, 32, 33.
Difficult starting	5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 24, 29, 31, 32, 33.
Lack of power	8, 9, 10, 11, 12, 13, 14, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 31, 32, 33, 60.
Misfiring	8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 25, 26, 28, 29, 30, 32.
Excessive fuel consumption	11, 13, 14, 16, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 31, 32, 33.
Black exhaust	11, 13, 14, 16, 18, 19, 20, 22, 24, 25, 27, 28, 29, 31, 32, 33, 60.
Blue/white exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56, 61.
Low oil pressure	4, 36, 37, 38, 39, 40, 42, 43, 44, 58.
Knocking	9, 14, 16, 18, 19, 22, 26, 28, 29, 31, 33, 35, 36, 45, 46, 59.
Erratic running	7, 8, 9, 10, 11, 12, 13, 14, 16, 20, 21, 23, 26, 28, 29, 30, 33, 35, 45, 59.
Vibration	13, 14, 20, 23, 25, 26, 29, 30, 33, 45, 47, 48, 49.
High oil pressure	4, 38, 41.
Overheating	11, 13, 14, 16, 18, 19, 24, 25, 45, 50, 51, 52, 53, 54, 57.
Excessive crankcase pressure	25, 31, 33, 34, 45, 55.
Poor compression	11, 19, 25, 28, 29, 31, 32, 33, 34, 46, 59.
Starts and stops	10, 11, 12.

Key to Fault Finding Chart

1. Battery capacity low
2. Bad electrical connections
3. Faulty starter motor
4. Incorrect grade of lubricating oil
5. Low cranking speed
6. Fuel tank empty
7. Faulty stop control operation
8. Blocked fuel feed pipe
9. Faulty fuel lift pump
10. Choked fuel filter
11. Restriction in air cleaner
12. Air in fuel system
13. Faulty fuel injection pump
14. Faulty atomisers or incorrect type
15. Incorrect use of cold start equipment
16. Faulty cold starting equipment
17. Broken fuel injection pump drive
18. Incorrect fuel pump timing
19. Incorrect valve timing
20. Poor compression
21. Blocked fuel tank vent
22. Incorrect type or grade of fuel
23. Sticking throttle or restricted movement
24. Exhaust pipe restriction
25. Cylinder head gasket leaking
26. Overheating
27. Cold running
28. Incorrect tappet adjustment
29. Sticking valves
30. Incorrect high pressure pipes
31. Worn cylinder bores
32. Pitted valves and seats
33. Broken, worn or sticking piston ring(s)
34. Worn valve stems and guides
35. Overfull air cleaner or use of incorrect grade of oil
36. Worn or damaged bearings
37. Insufficient oil in sump
38. Inaccurate gauge
39. Oil pump worn
40. Pressure relief valve sticking open
41. Pressure relief valve sticking closed
42. Broken relief valve spring
43. Faulty suction pipe
44. Choked oil filter
45. Piston seizure/pick up
46. Incorrect piston height
47. Damaged fan
48. Faulty engine mounting (Housing)
49. Incorrectly aligned flywheel housing, or flywheel
50. Faulty thermostat
51. Restriction in water jacket
52. Loose fan belt
53. Choked radiator
54. Faulty water pump
55. Choked breather pipe
56. Damaged valve stem oil deflectors (if fitted)
57. Coolant level too low
58. Blocked sump strainer
59. Broken valve spring
60. Dirty or damaged turbocharger impeller.
61. Leaking turbocharger oil seals.

SECTION E
Cylinder Head

Removal

The removal of the cylinder head is a straight forward operation and no difficulties should be experienced.

When removing the rocker shaft assembly, the push rods may stick to the rockers and if they drop off, they can drop through to the sump. To avoid this, lift the rocker shaft assembly a small amount and pull each push rod down to its seat in the tappet, then lift the push rod straight off.

For instructions concerning the dismantling and removal of the heat exchanger, see Page L.5.

With earlier engines, the valves are marked 1 and 1, 2 and 2 etc., commencing at the front of the engine. On very early engines, valves are numbered 1 to 12 commencing at the front of the engine. The cylinder head is marked with corresponding numbers opposite the valve seats.

With current engines, valves and seats are not numbered, and where a valve is to be used again, it should be suitably marked to ensure it is replaced in its original position.

An exploded view of the valve assemblies is shown in Fig. E.10.

1. Compress spring caps and springs (Fig. E.4) and remove the two half conical collets.

2. Remove spring caps, springs and rubber oil deflectors from valve stems. Remove valves.

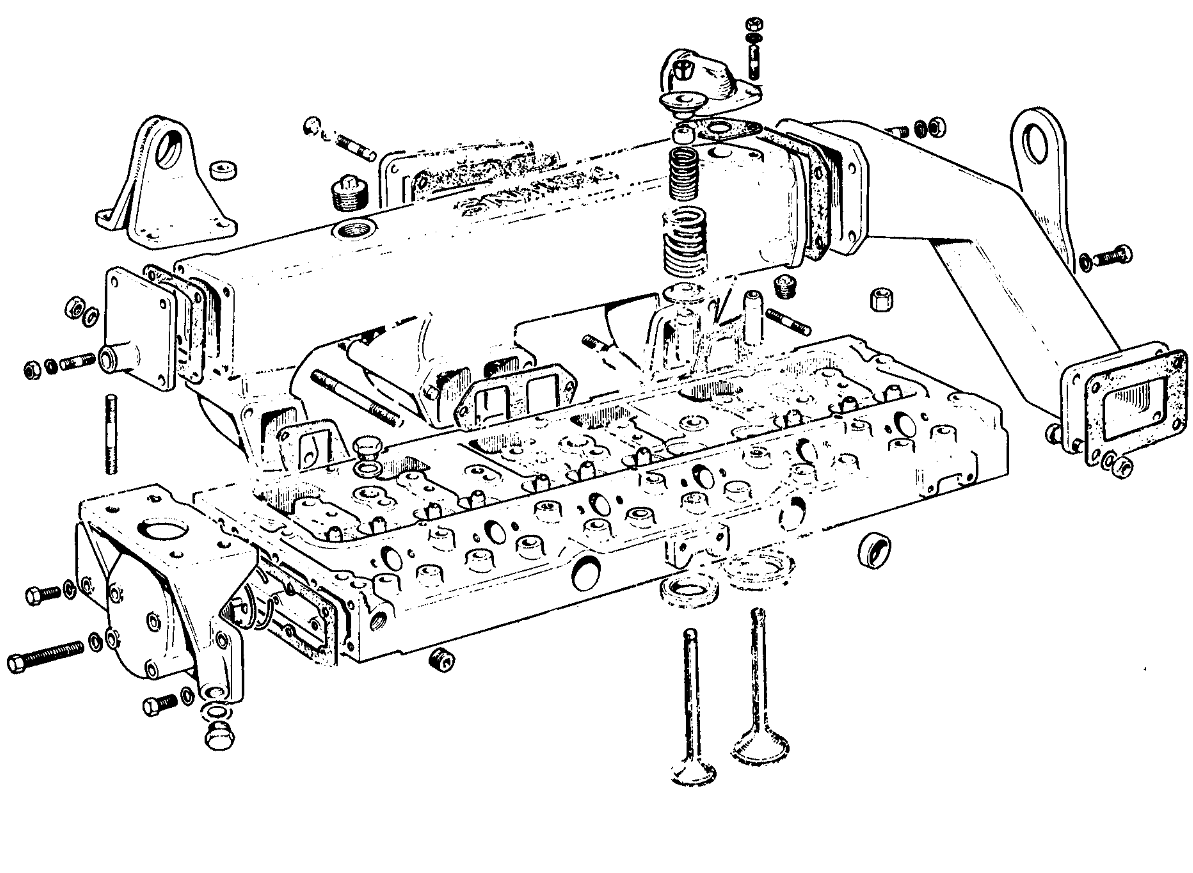


Fig. E.1. Exploded view of Cylinder Head Assembly.
(Exhaust Manifold Adaptor is for Mk. 1/2 Turbocharger)

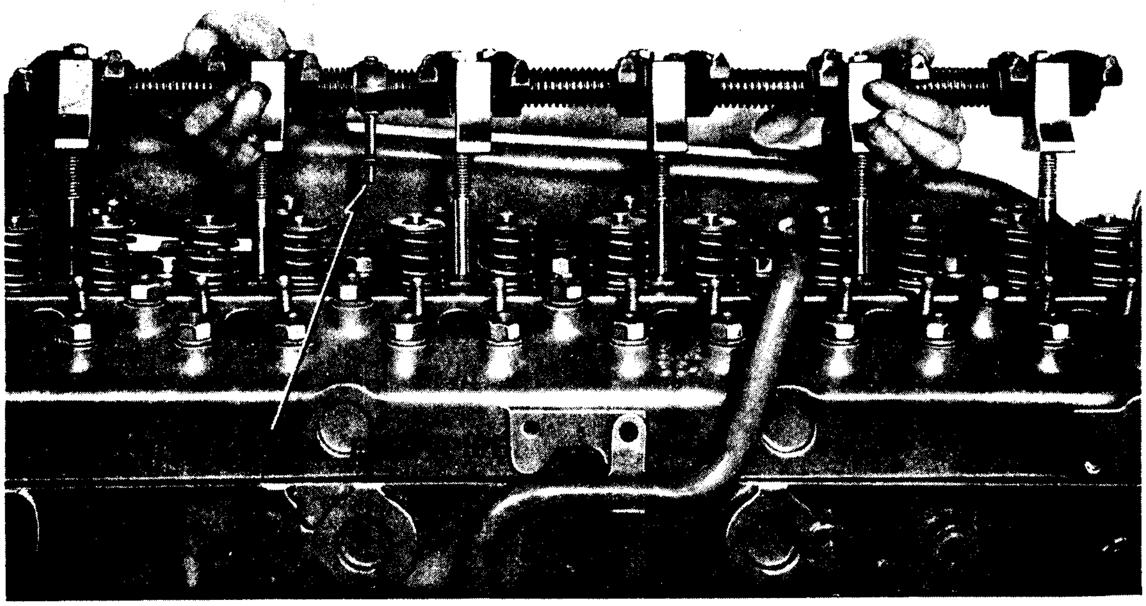


Fig. E.2. Removing Rocker Shaft Assembly.

Cleaning

1. Clean cylinder head.
2. If the water jacket of the cylinder head shows signs of scale, a proprietary brand of descaling solution should be used.
3. Blank off rocker oil feed between Nos. 2 and 3 cylinders and remove carbon from pistons and cylinder block face.
4. After valve seat machining and valve grinding operations have been carried out, all parts should be washed in cleaning fluid.

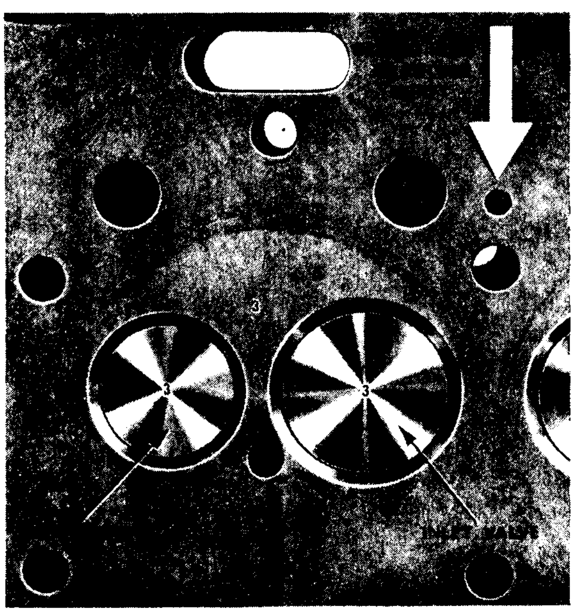


Fig. E.3. Valve Numbering.

Valve Guides

Examine valve guides for wear and, if necessary, renew.

To fit new guides, smear the outer surface with clean oil and using a suitable press, drive home until 0.594 in (15,08 mm) of the guide is protruding above the bottom face of the valve spring recess.

(Figs. E.6 and E.7 show the guides being removed and replaced by a special service tool).

Valves and Valve Seats

Examine valves for cracks. Check wear of valve stems and their fit in the valve guides.

Number all new valves to correspond with the numbering of the old valves. When fitting new valves in production, the clearance between the valve head and cylinder head bottom face is not less than 0.029 in (0,74 mm) for inlet and exhaust and not greater than 0.039 in (0,99 mm).

In service, the maximum clearance for both inlet and exhaust valves should not exceed 0.050 in (1,27 mm) for cylinder heads with three exhaust ports or 0.060 in (1,52 mm) for cylinder heads having four exhaust ports. Valve seat inserts can be fitted (Page E.4).

The valve seats in the cylinder head should be reconditioned, by means of valve seat cutters or specialised grinding equipment at an angle of 45°.

As narrow a seat as possible should always be maintained.

Hand Grinding

When grinding in valves, it is essential that no signs of pitting are left on the seatings. At the same time care should be taken to avoid unnecessary grinding away of the seat.

After grinding operations have been completed, check the valve head depths relative to the cylinder head face, and wash the cylinder head.

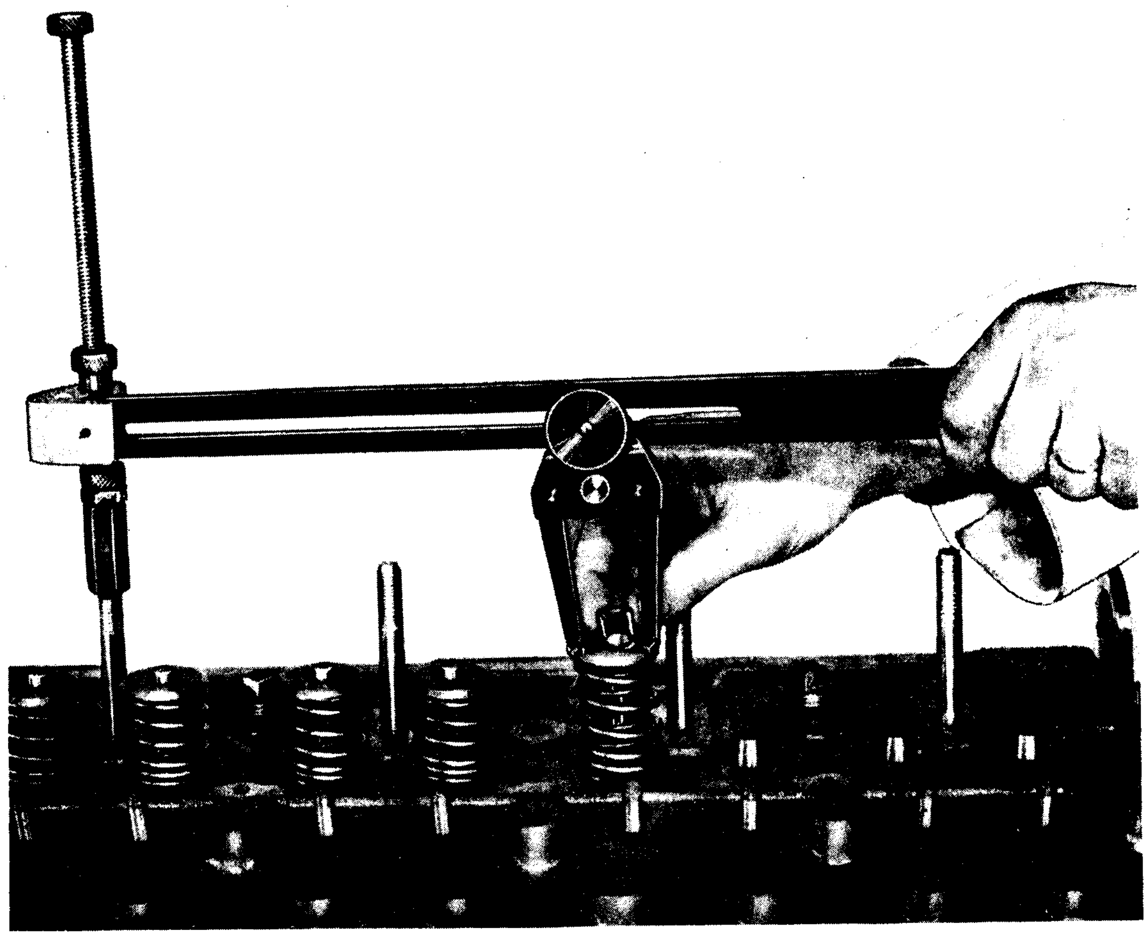


Fig. E.4. Removing Valve Assembly.

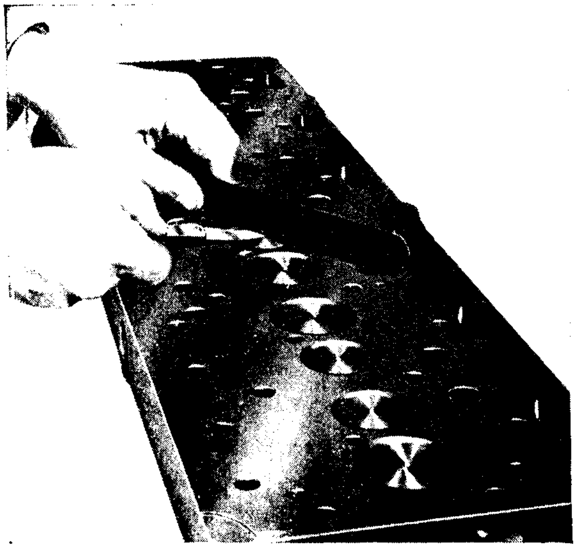


Fig. E.5. Checking Valve Depth.

Valve Seat Inserts

Valve seat inserts are not fitted to normally aspirated 6.354 production engines. They are fitted to turbocharged engines.

In the case of the 6.354 engine, inserts can be fitted.

When fitting inserts, ensure that genuine Perkins Parts are used and proceed as follows :—

1. Press out the existing guide and clean the parent bore.
2. Press in new guide.
3. Using the valve guide bore as a pilot, machine the recess in the cylinder head to the dimensions in Fig. E.8.

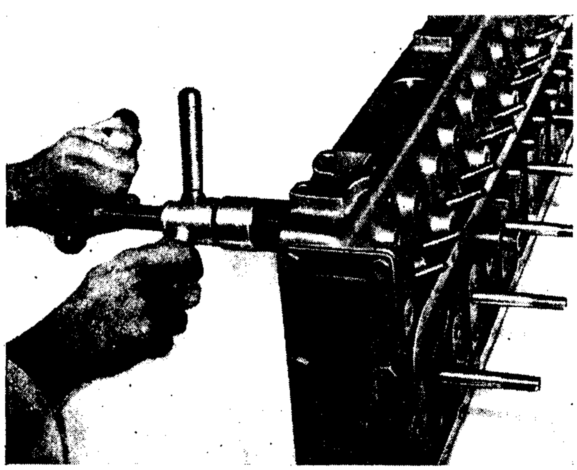


Fig. E.6. Replacing Valve Guides.

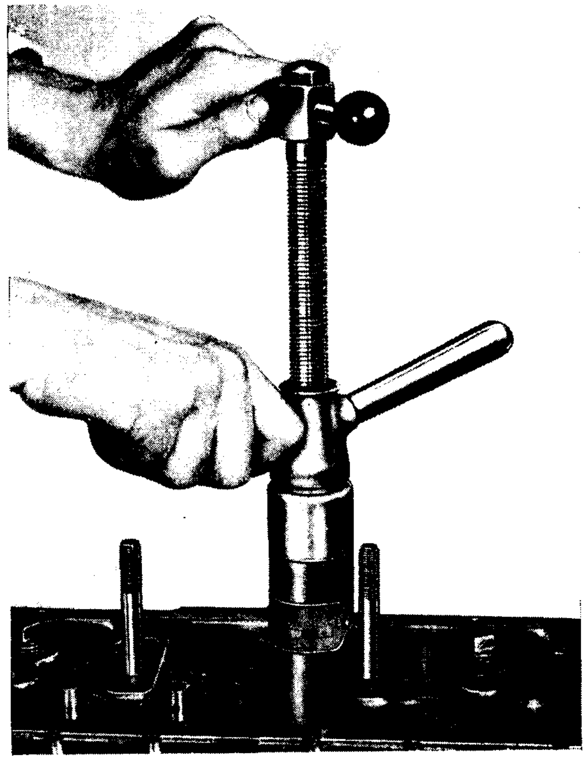


Fig. E.7. Removing Valve Guides.

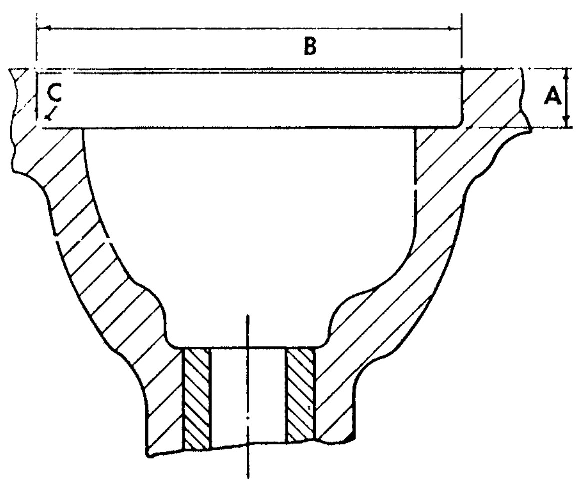


Fig. E.8.
Valve Seat Cutting Dimensions.

Inlet
A—0.283/0.288 in (7,19/7,31 mm)
B—2.0165/2.0175 in (51,22/51,24 mm)
C—Radius 0.015 in (0,38 mm) Max

Exhaust
A—0.375/0.380 in (9,52/9,65 mm)
B—1.678/1.679 in (42,62/42,64 mm)
C—Radius 0.015 in (0,38 mm) Max.

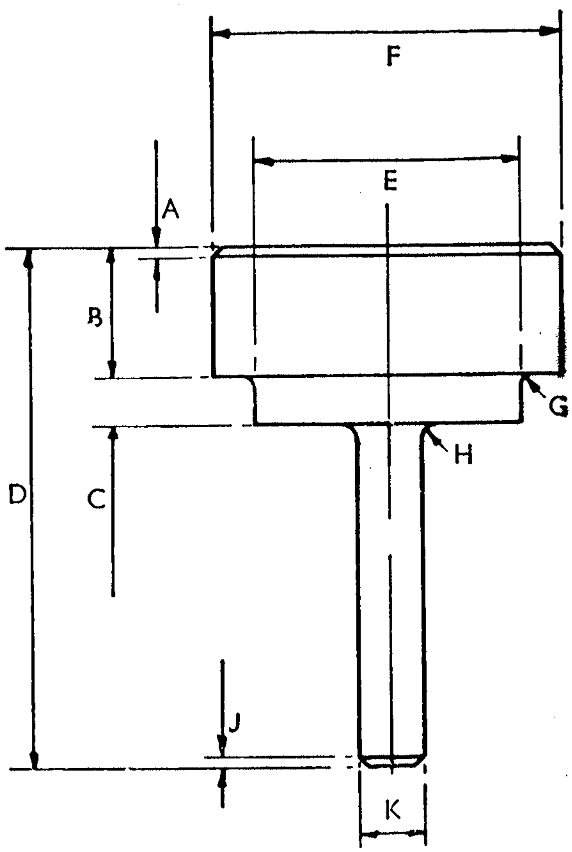


Fig. E.9. Press Tool for Valve Seat Inserts.

Key to Fig. E.9.

Inlet

A—$\frac{1}{16}$ in (1,59 mm) at 45°
B—$\frac{3}{4}$ in (19,05 mm)
C—0.250 in (6,35 mm)
D—3 in (76,20 mm)
E—1.582/1.583 in (40,18/40,21 mm)
F—2.009/2.019 in (51,03/51,28 mm)
G—$\frac{1}{32}$ in (0,79 mm) radius
H—$\frac{1}{16}$ in (1,59 mm) radius
J—$\frac{1}{16}$ in (1,59 mm) at 45°
K—0.372/0.373 in (9,45/9,47 mm)

Exhaust

A—$\frac{1}{16}$ in (1,59 mm) at 45°
B—$\frac{3}{4}$ in (19,05 mm)
C—0.312 in (7,92 mm)
D—3 in (76,20 mm)
E—1.248/1.249 in (31,70/31,72 mm)
F—1.670/1.680 in (43,42/43,67 mm)
G—$\frac{1}{32}$ in (0,79 mm) radius
H—$\frac{1}{16}$ in (1,59 mm) radius
J—$\frac{1}{16}$ in (1,59 mm) at 45°
K—0.372/0.373 in (9,45/9,47 mm)

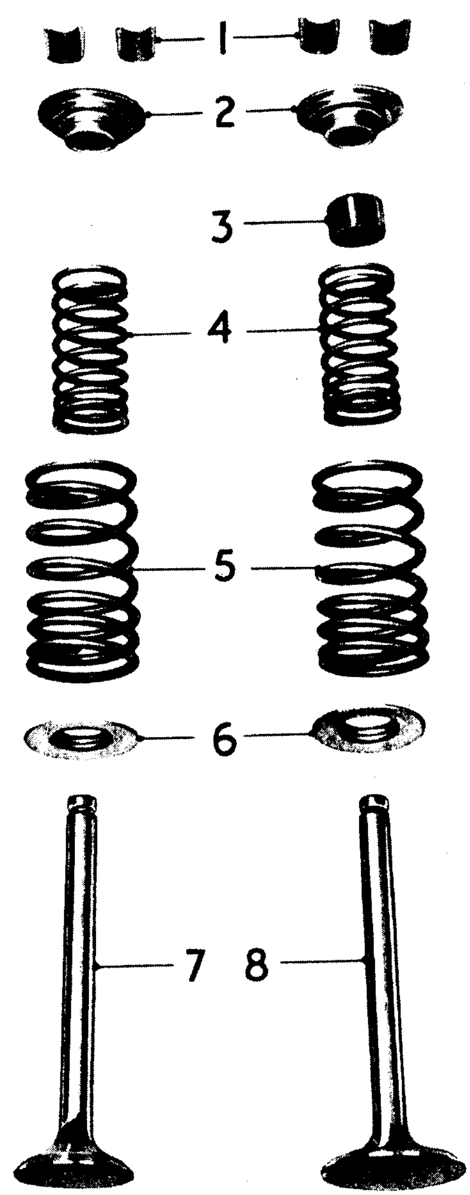


Fig. E.10.
Exploded view of Valve Assemblies.

1. Collets.
2. Valve Spring Cap.
3. Oil Deflector.
4. Inner Valve Spring.
5. Outer Valve Spring.
6. Valve Spring Seat.
7. Exhaust Valve.
8. Inlet Valve

4. Remove all machining swarf and clean the insert recess. Using the valve guide bore as a pilot, press the insert home with the inserting tool (Fig. E.9). Under no circumstances should the insert be hammered in, neither should lubrication be used during pressing in.
5. Inspect to ensure that the insert has been pressed fully home and is flush with the bottom of the recess.
6. Using the valve guide bore as a pilot, machine the "flare" to the dimensions in Fig. E.11.
7. Remove all machining swarf and burrs.
8. Re-cut the valve seat at an included angle of 90° so that the valve head depth below the cylinder head face is within the production limits of 0.029/0.039 in (0,74/0,99 mm).

Note: Work as closely as possible to the minimum figure to allow for re-seating at a later date. When re-facing a valve the included angle of the contact face is 90°.

If the cylinder head face has been skimmed since the fitting of valve seat inserts, then the following is allowed:

(a) Machine to the dimensions given in Fig. E.11 and continue as in stages 7 and 8.

(b) If the insert is damaged or unserviceable through wear, it must be removed and replaced with a new one. Before fitting, however, the back of the insert should be surface ground, removing sufficient material to give a flush fitting. Do not forget to re-chamfer the insert as it was prior to grinding, i.e. 0.020/0.030 in (0,508/0,762 mm) at 45°. Then proceed as in stages 4—8.

Skimming of Cylinder Head

A maximum of 0.012 in (0,30 mm) may be removed from the cylinder head face providing the nozzle protrusion does not exceed 0.144 in (3,66 mm). This applies as from the following engine numbers:—

354U329416L
354UX4278HTL.

Prior to these engine numbers, the maximum nozzle protrusion was 0.224 in (5,69 mm).

Nozzle protrusion must not be obtained by the use of additional atomiser washers.

Valve Springs

A new set of valve springs should always be fitted at every major overhaul.

Two springs per valve are provided.

Examine the valve springs with regard to squareness of ends and pressures developed at specified lengths, details of which can be found in "Manufacturing Data and Dimensions." Each spring incorporates damper coils at one end and these must be towards the cylinder head.

Rocker Shaft Assembly (Fig. E.12)

To Dismantle:

1. Remove circlips and washers from each end of the rocker shaft.
2. Withdraw the rocker levers, springs and support brackets.
3. Remove the locating screw from the rocker oil feed connection and withdraw the connection. Examine the rocker lever bores and shaft for wear. Rockers should be an easy fit on the shaft without excessive side play.

To Re-assemble:

1. Fit oil feed connection to rocker shaft and secure with the locating screw, ensuring that the screw enters the locating hole in the shaft.

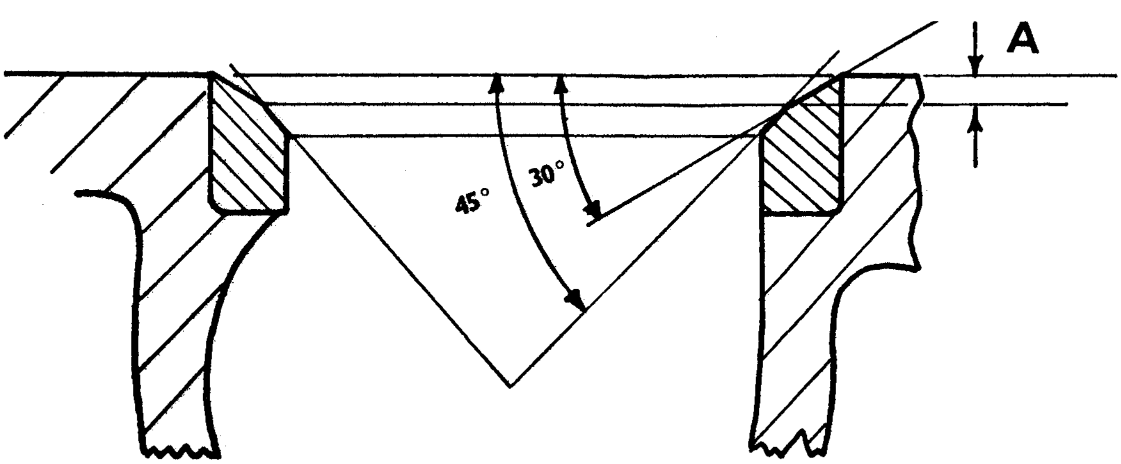


Fig. E.11. Showing Flare to be cut at 30°.

Dimension A—0.094/0.099 in (2,39/2,52 mm).

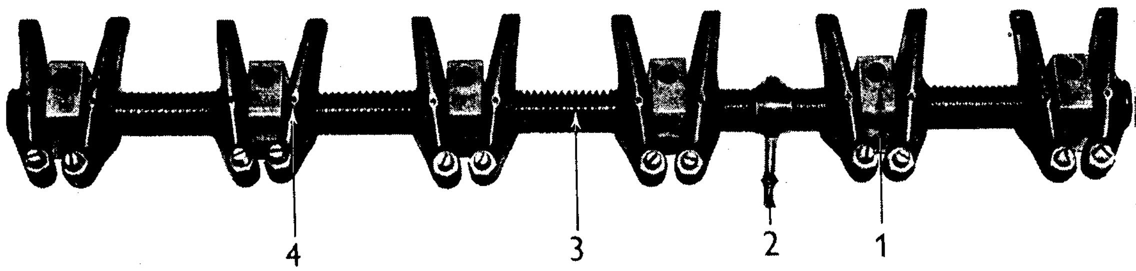


Fig. E.12. Rocker Shaft Assembly.

1. Rocker Shaft Bracket.
2. Oil Feed Connection.
3. Spring.
4. Rocker Arm.

2. Refit the support brackets, springs and rocker levers in the correct order (Fig. E.12).
3. Fit securing washer and circlip to each end of the shaft.

Push Rods

Check push rods for straightness. If any are bent, fit replacements.

To Re-Assemble the Cylinder Head

1. Lightly oil valve stems.
2. Fit valve to its correct guide.
3. Locate spring washers.
4. Fit the inlet valve oil deflector rubbers with open end towards cylinder head.
5. Fit valve springs and spring caps in position.
6. Compress each valve spring and fit the valve collets.

Cylinder Head Gasket

There are two sizes of cylinder head studs, i.e., $\frac{7}{16}$ in and $\frac{1}{2}$ in, this has necessitated different cylinder head gaskets. Gaskets also differ with flanged and flangeless cylinder liners. **It is very important** therefore to refer to the Parts List, making sure the correct engine number is applied, in order to select the correct cylinder head gasket.

All gaskets are marked "Top Front."

To Replace the Cylinder Head

The recess in the top face of the cylinder block around each liner must be clean. To clean the top face of the cylinder block, remove the cylinder head studs. Clean the studs. Studs and nuts should be examined for damaged threads. Ensure that the rocker assembly oil feed passage in the cylinder head is clean.

1. KLINGER or VICTOR type cylinder head gaskets should be fitted DRY. Jointing compound must not be used with these gaskets. The earlier copper/asbestos gasket

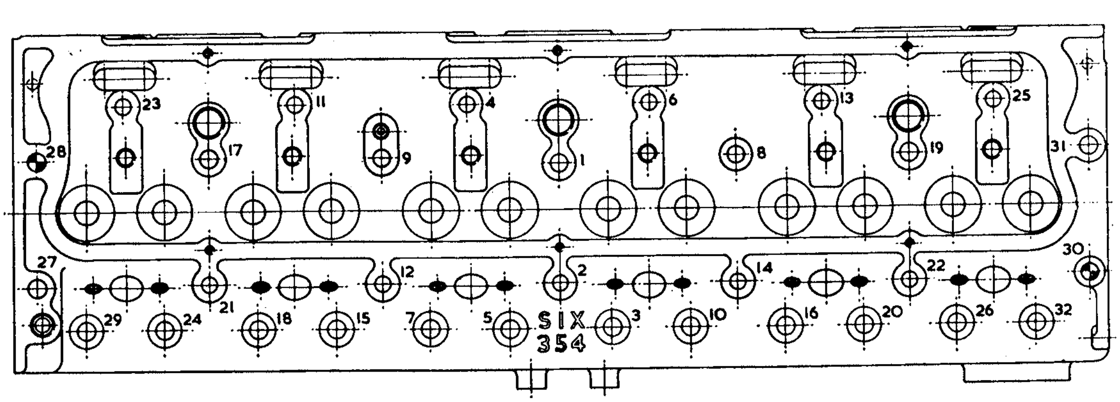


Fig. E.13. Cylinder Head Tightening Sequence.

should have both sides lightly coated with non-hardening jointing compound. Position the beading of the gasket in the recess around the cylinder liner.

Where steel laminated cylinder head gaskets are used, both sides of the gasket should be coated with Perkins Hylomar jointing compound.

With current turbocharged engines, the steel laminate gasket has been replaced by a Coopercor, but the fitting sequence is the same for both types. Whilst the steel laminate gasket did not require a re-torque after 25 hours service, the Coopercor does require re-torquing.

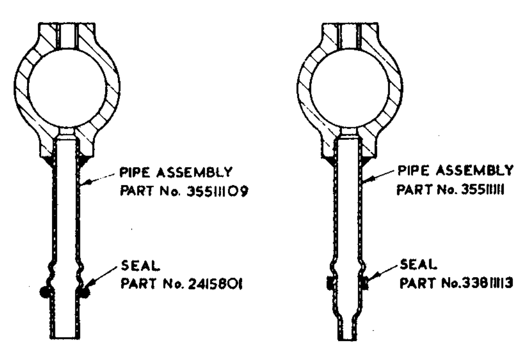
2. Fit cylinder head to cylinder block. Lightly oil nuts and studs before fitting. Tighten cylinder head nuts progressively in three stages in the order as shown in Fig. E.13, until a torque of 60 lbf ft (8,30 kgf m) for $\frac{7}{16}$ in studs or 100 lbf ft (13,8 kgf m) for $\frac{1}{2}$ in studs is achieved. The final stage should be repeated.

Refit remaining components to cylinder head, noting the following :—

The rocker assembly securing nuts should be tightened down progressively from the centre outwards to a torque of 28/32 lbf ft (3,87/4,43 kgf m).

When fitting the seal to the rocker oil feed connection, the seal should be positioned immediately below the bottom convolution so that when the pipe is inserted into the cylinder head, the "O" ring will roll up and over the lower convolution and locate itself between the two convolutions. With current engines, the seal should be fitted to butt up against the single convolution. (see Fig. E.14).

Valve clearances should be set to 0.012 in (0,30 mm) cold.



LOCATION OF SEAL PRIOR TO INSERTING PIPE IN POSITION. PREVIOUS ARRANGEMENT.
FIG. I.

SEAL IN FITTED POSITION CURRENT ARRANGEMENT.
FIG.2.

Fig. E.14.
Fitting Seal to Rocker Shaft Oil Feed Pipe.

When refitting atomisers, ensure that new copper washers are used and that the atomisers seat squarely on these washers.

Corrugated inlet manifold joints should always be fitted dry with the notches to the top and tightened to a torque of 24 lbf ft (3,3 kgf m). After at least ten minutes following fitting, re-torque the setscrews to the original figure. **THIS IS IMPORTANT.**

Starting the Engine

When re-building is complete, bleed the fuel system as described on Page M.7 and start the engine.

1. Check the oil flow to the rocker shaft assembly and allow the engine to warm up.
2. After warming through, the engine should be shut down and the cylinder head nuts again tightened to the correct torque and in the correct sequence. as shown in Fig. E.13.
3. Reset the valve clearance to 0.012 in (0,30 mm) cold (Fig. E.15). Fit the rocker cover.

   Note : It is most important that the cylinder head be tightened down to the correct torque in the correct sequence after the engine has completed 25 hours service. This procedure is not necessary where a steel laminated gasket is fitted.

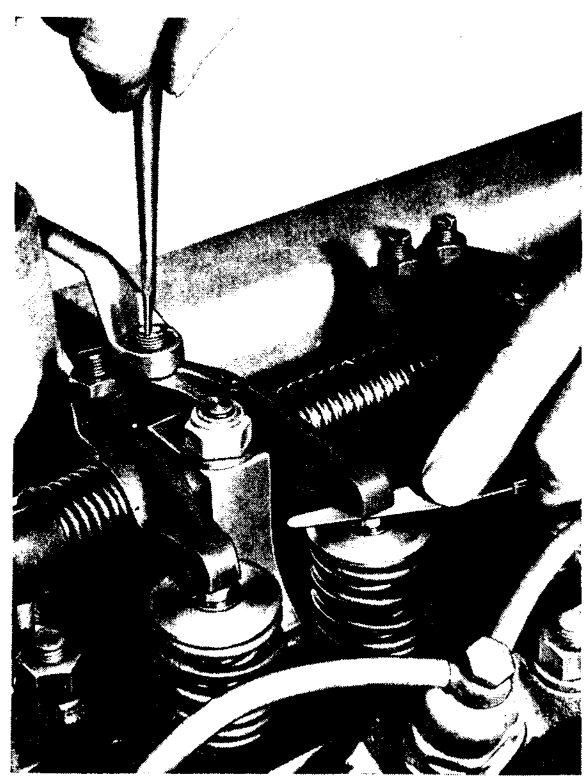


Fig. E.15. Adjusting Valve Clearance.

SECTION F
Pistons & Connecting Rods

Pistons fitted to later type turbocharged engines have a dished cavity in the centre of the piston crown whereas pistons fitted to all normally aspirated engines and early turbocharged engines rated at 125 shp have a toroidal cavity offset in the piston crown as shown in Fig. F.2.

Pistons fitted to later type turbocharged engines also have a larger diameter gudgeon pin.

Turbocharged engines other than those rated at 175 shp have only four piston rings per piston.

The gudgeon pins which are fully floating work in a bush fitted to the connecting rod small end, and are held in position by circlips in the piston.

Each piston is fitted with three compression rings and two oil control scraper rings. The top compression ring is chrome plated on normally aspirated engines and cast iron on turbocharged engines.

To ensure the correct positioning of pistons with toroidal cavities within the cylinder bore each piston has the word " FRONT " stamped on its crown. When fitting the piston and connecting rod to the engine always ensure that portion stamped " FRONT " on the piston crown faces the front of the engine (See Fig. F.2).

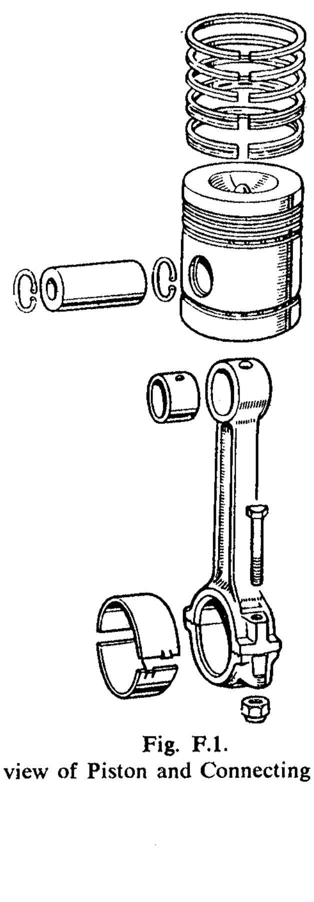


Fig. F.1.
Exploded view of Piston and Connecting Rod Assembly.

Fig. F.2. View of Piston Top Face
(Later Turbocharged Engines have a Dished Cavity)

Pistons are numbered 1 to 6 commencing with No. 1 at the front of the engine.

The Connecting rods and caps are also numbered, 1 and 1, 2 and 2, etc., (See Fig. F.3).

To ensure the correct positioning of the connecting rod and cap, their seating faces are serrated and should on no account be filed.

The big end bearings are of the thin wall type, consisting of a thin steel shell with an aluminium tin lining and pre-finished to size. All big end bearings are interchangeable when new, the rod with the cap and vice versa. When refitting the serviceable old bearings, care must be taken to return them to their original position.

To Remove Pistons and Connecting Rod Assemblies

Remove cylinder head assembly.

Remove sump.

Turn the engine crankshaft until two big ends are at bottom centre then remove the nuts.

Remove caps, bearing shells and big end bolts (See Fig. F.4).

Fig. F.3.
Numbering of Connecting Rod and Cap.

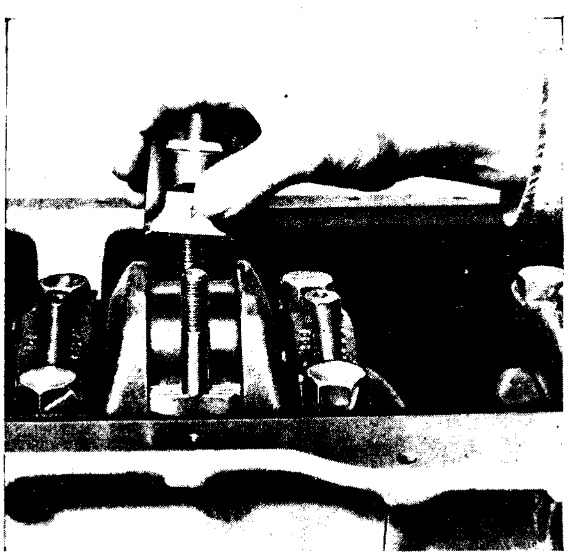


Fig. F.4 Removing Connecting Rod Caps.

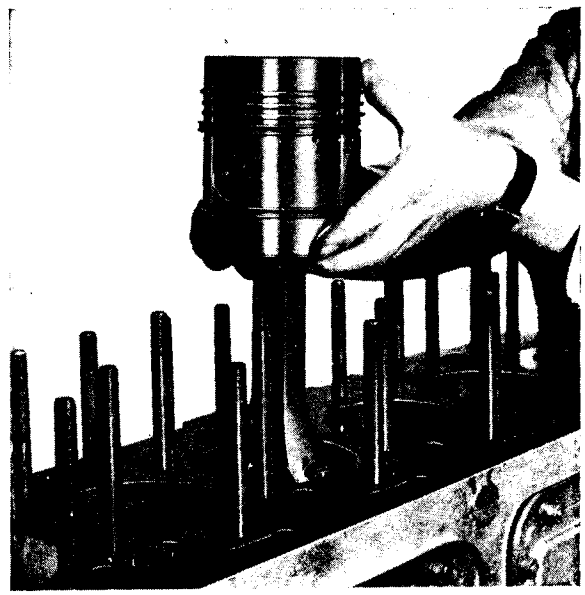


Fig. F.5. Removing Piston and Connecting Rod Assembly from Cylinder Bore.

Push pistons and connecting rods out of the top of the cylinders (See Fig. F.5).

Turn the engine crankshaft until the next two big ends are at bottom centre and repeat removal operations.

Further turn the crankshaft and repeat removal operations for the third pair of pistons and connecting rods.

Should there be carbon ridges at the top of the cylinder bores, they should be removed before attempting to remove the pistons.

Keep each piston and connecting rod assembly separate, each to each as marked.

To Remove Gudgeon Pins

Using circlip pliers, remove the circlips from the pistons.

The gudgeon pins can then be pushed out if the pistons are warmed in clean liquid to a temperature of 100°F to 120°F. (38°C to 49°C).

To Fit Small End Bush

Remove piston and rod from engine.

Remove gudgeon pins (See above).

The small end bushes are a press fit in the connecting rods.

Press out old bush using suitable tool.

Remove any sharp edges around the small end parent bore.

Press in new bush, ensuring that the oil hole in the bush coincides with the hole in the connecting rod. Ream out new bush to suit gudgeon pin and check for parallelism.

To Assemble Piston and Connecting Rod

First warm the piston in clean liquid to a temperature of 100°F.—120°F. (38°C—49°C). Then with the stamped mark "FRONT" on the piston crown away from you and the toroidal cavity towards the left hand side, place the connecting rod in position, taking care to note that the number on the rod is to the left-hand side. Insert gudgeon pin into position and fit circlips ensuring that they fit correctly into the grooves in the piston.

The above remarks do not apply with pistons having a dished cavity as fitted to later type turbocharged engines. These pistons may be fitted either way although it should be noted that where a worn piston is being refitted to an engine, it should be replaced in its original position relative to the cylinder bore.

If the original pistons are being used they must be assembled to the same connecting rods, e.g. piston stamped 1 must go with the connecting rod marked 1. For markings of connecting rod see Fig. F.3.

It is advisable to fit new circlips even if the old ones do not appear damaged or strained.

Fitting New Rings

In the top ring groove, fit the chrome plated compression ring (normally aspirated engines) or cast iron compression ring (turbocharged engines). In the next two ring grooves fit the internally stepped compression rings. When fitting internally stepped compression rings, ensure they are fitted the correct way up by observing the marking "BTM" which should be at the bottom of the ring.

Earlier engines were fitted with taper faced compression rings in the 2nd and 3rd ring grooves. These were fitted with the letter "T" to the top of the ring.

Fit the oil control rings one above and one below the gudgeon pin.

Piston rings should be arranged so that their gaps are equally spaced around the piston and not in line with one another.

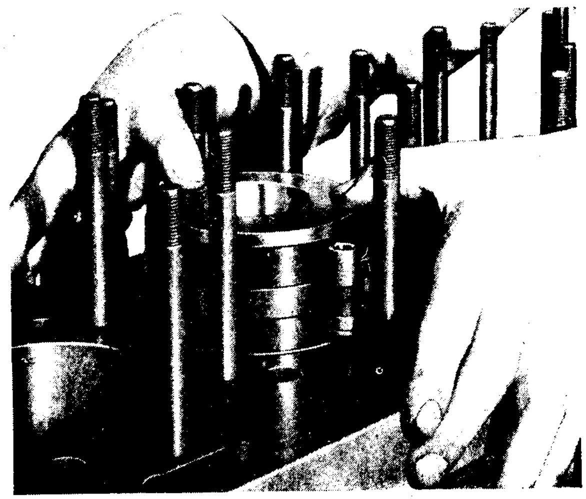


Fig. F.6. Piston fitting with the aid of a Ring Guide.

NOTE :— When fitting new rings to worn cylinder liners, the ring gaps should be checked at a bore diameter of 3.877 in (98,48 mm).

Allow 0.003 in (0,08 mm) extra gap for every 0.001 in (0,02 mm) dia. above this size.

To Fit the Piston and Connecting Rod Assemblies

Before fitting the piston and connecting rod assemblies to their respective cylinder bores, liberally coat each bore and piston with clean engine oil.

Using a ring guide, insert each assembly into the top of the respective cylinder bore (Fig. F.6). The piston and rod number must relate to the cylinder into which it is being fitted and the rod identification number must be opposite to the camshaft. The word "Front" marked on the piston crown must be towards the front of the engine.

Fit the bearing shells and cap with the numbers on the same side of the rod and cap (Fig. F.3). On turbocharged engines the top half bearing is grooved and drilled.

Refit the two securing bolts so that the flat on the head of each bolt is located against the shoulder on the rod. Fit new connecting rod cap nuts and tighten to the torque of 70 lbf ft (9,7 kgf m) for engines preceding the following numbers :—

T6.354/6.354	354U197798
HT6.354/H6.354	354U3660HT

As from the above engine numbers, the torque for the connecting rod nuts is 75 lbf ft (10,4 kgf m). Under no circumstances, should the earlier type caps be tightened to the higher torque as this can lead to the big end bearings locking on the crankpins.

Refit the lubricating oil pump and sump and fill with oil (Page K.6 and K.7).

The lubricating oil pump should be primed with oil before fitting.

Replace the cylinder head (Page E.7).

Fitting New Pistons

Before pulling the connecting rod to the crankshaft, check that the word " FRONT " stamped on the piston crown (pistons with offset toroidal cavities) is towards the front of the engine (See Fig. F.2).

Pistons when correctly fitted to normally aspirated engines should not be less than 0.003 in (0,08 mm) or more than 0.010 in (0,25 mm) above the top face of the cylinder block (see Fig. F.7).

In the case of turbocharged engines, the piston crown should be 0.000 in to 0.005 in (0,00 mm to 0,13 mm) below the top face of the cylinder block (see Fig. F.7).

When using service pre-topped pistons it may be found that the piston height is lower than that quoted. This is satisfactory, but the piston height should not be above these limits.

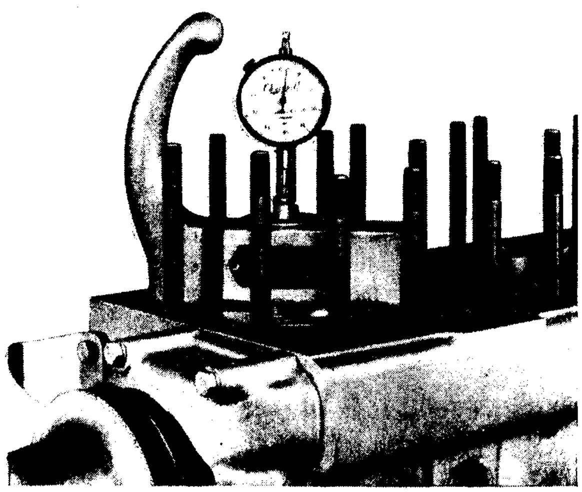


Fig. F.7. Checking Height of Piston.

SECTION G
Cylinder Block & Liners

An exploded view of the cylinder block assembly is shown in Fig. G.1.

The cylinder block is fitted with renewable high duty cast iron dry liners. Two types of liners are fitted, i.e., normally aspirated engines are fitted with flangeless liners whereas turbocharged engines are fitted with flanged liners, but some earlier turbocharged engines may be fitted with flangeless liners.

Replacement flangeless liners are supplied unbored and must therefore be finished bored to the dimensions given on Page B.3 after fitting. They are an interference fit and a heavy duty press or special tool is required for removal and replacement.

Production flanged liners are also an interference fit and have to be finished bored after fitting. Replacement service flanged liners are a transitional fit and are supplied prefinished to size.

Flangeless cylinder liners can be rebored to +0.030 in (+0,76 mm) oversize, but flanged liners cannot.

It is not permissible to rebore any cylinder liners fitted to turbocharged engines.

To Renew Cylinder Liners (Cast Iron Flangeless)

1. Remove all components from the cylinder block.
2. Remove the cylinder head studs.
3. Press out the liners from the bottom.
4. Lubricate the outside diameter of the liners with clean oil and press them in. When inserting new liners, the load should be released several times during the first inch, so as to allow the liner to centralise itself in the parent bore. The liner should be pressed in until 0.030/0.035 in (0,76/0,89 mm) of the liner is protruding above the cylinder block face (Fig. G.3). Shim washers or a solid stop washer, 0.030/0.035 in (0,76/0,89 mm) thick should be used to give the correct protrusion.

Important Note :

Earlier liners should be fitted 0.005/0.013 in (0,125/0,33 mm) below the cylinder block top face.

Earlier liners can be identified by their length which is 8.963/8.973 in (227,7/227,9 mm) compared with 9.005/9.015 in (228,70/229,00 mm) for the current type. The correct

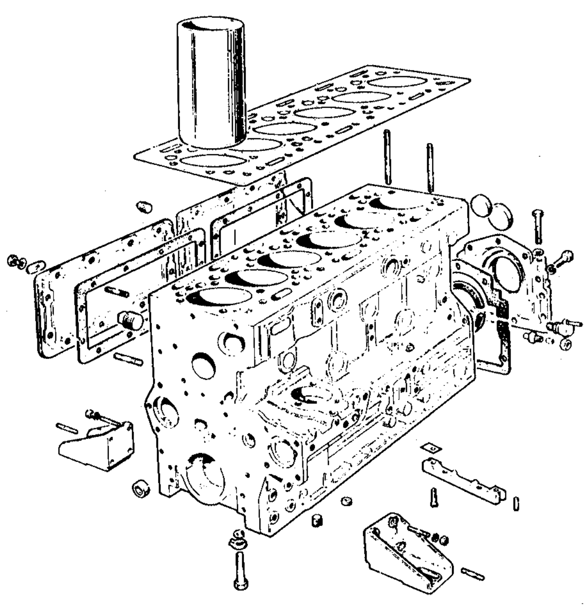


Fig. G.1.
Exploded view of Cylinder Block Assembly.

Fig. G.2.
Checking Cylinder Liner Protrusion above top face of Cylinder Block.

cylinder head gasket must be used. Earlier type gaskets are only suitable for the earlier liners, but the latest type gasket is suitable for both types of liner. The earlier liner must not be fitted to give a protrusion of 0,030/0.035 in (0,76/0,89 mm) as the bottom piston ring may clear the bottom of the liner when the piston is at bottom dead centre.

5. Bore and hone finish the liners to the dimensions given in "Manufacturing Data and Dimensions."

   When using a boring bar on the top face of the cylinder block, fit a parallel plate between the boring bar and cylinder block face.

To Renew Cylinder Liners (Cast Iron Flanged)

When fitting flanged liners to turbocharged 6.354 marine engines, the following procedure should be adopted.

1. Remove all components from cylinder block.
2. Remove the cylinder head studs.
3. The old liners should be pressed out from the bottom.
4. Generally clean the parent bore and de-grease the top 2 in (50 mm) and the liner flange recess using "Loctite" safety solvent (aerosol can) as per the instructions on the can.
5. Apply oil to the cylinder block parent bore except for the top 2 in (50 mm).
6. Generally clean the outside surfaces of the liner and de-grease using "Loctite" safety solvent (aerosol can) as per instructions on the can.
7. Locate the liner in the bore and press in to within approximately 2 in (50 mm) of its final position.
8. Further de-grease the flange area of the liner using "Loctite" safety solvent to remove handling contamination.
9. Apply a band of "Loctite" Retaining Compound Grade 602, 1 in (25 mm) wide around the top of the liner immediately under the flange. Also liberally apply the "Loctite" to the base of the flange recess.
10. Press the liner fully home into the fully fitted position and wipe the top of the cylinder block to remove any surplus "Loctite".
11. Check the top face of the liner which should protrude 0.028/0.035 in (0,71/0,89 mm) above the cylinder block top face.
12. It is advisable to allow a settling period to elapse before checking the fitted internal bore diameter of the liner. The acceptable limit is 3.877/3.8795 in (98,48/98,54 mm).
13. However, allow at least fifteen minutes to elapse before commencing to fit pistons as this time lag is required to allow the "Loctite" to reach handling strength. Full cure strength is achieved after 3 hours.

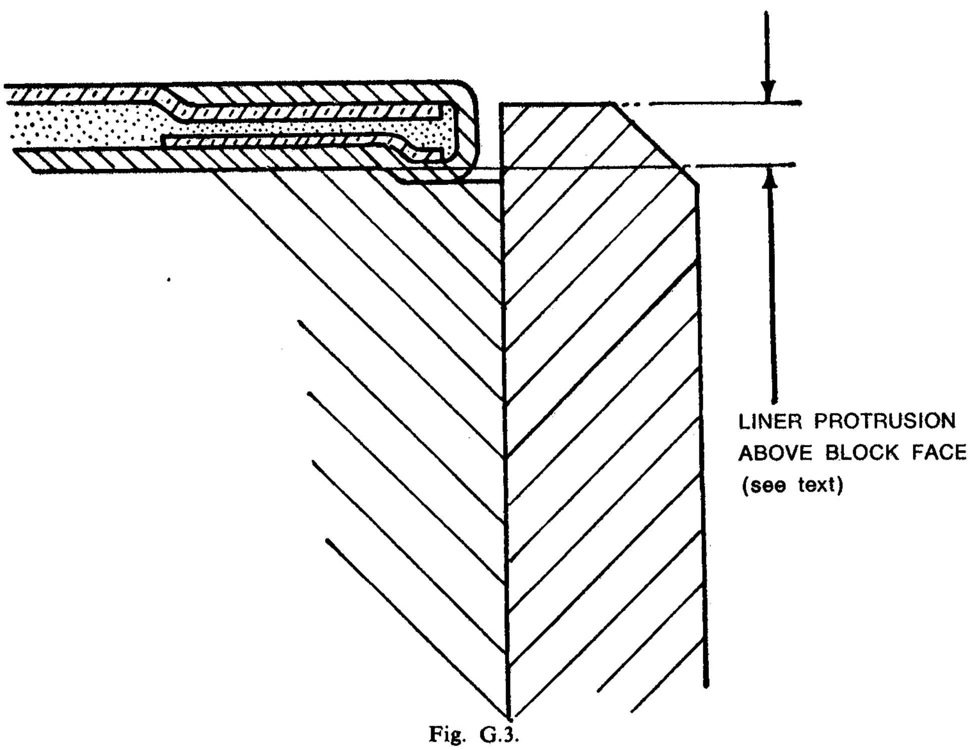


Fig. G.3.
Showing protrusion of Cylinder Liner.
(Later Types only).

SECTION H
Crankshaft & Main Bearings

An exploded view of the crankshaft and main bearings is shown in Fig. H.1.

The crankshaft runs in seven pre-finished replaceable shell bearings lined with copper lead or alternatively aluminium tin.

End float of the crankshaft is controlled by four thrust washers which are located on both sides of the centre main bearing housing. 0.0075 in (0,19 mm) oversize thrust washers are available which may be combined with standard thrust washers to give an adjustment of 0.0075 in (0,19 mm) or when used on both sides of the bearing housing give an adjustment of 0.015 in (0,38 mm).

Note: Crankshafts differ with left hand and right hand rotation engines, inasmuch as different oil feed drillings and oil return groove on the rear of the crankshaft are called for. Crankshaft gears also differ as the helical teeth are cut at an opposite angle.

The servicing procedure for both types of crankshaft is identical.

To Remove the Crankshaft

It will be necessary to remove the engine from the boat.

1. Remove the sump, sump strainer and the oil pump suction pipe.
2. Remove the crankshaft pulley.
3. Remove the camshaft gear, auxiliary drive gear and timing case (Page J.1).
4. Remove the flywheel and flywheel housing.
5. Remove the rear main oil seal housing.
6. Remove the front and rear bridge pieces from the cylinder block bottom face.
7. Remove the connecting rod caps and big end bearings.
8. Remove the main bearing caps and half bearings.
9. Lift out the crankshaft and remove the upper half bearings.

Regrinding the Crankshaft

Crankshafts are either induction hardened, 20 hour Nitrided, 60 hour Nitrided or Tufftrided.

Induction hardened crankshafts can be reground without any subsequent re-hardening.

20 hour Nitrided crankshafts cannot be reground to 0.010 in (0,25 mm), 0.020 in (0,51 mm) or 0.030 in (0,76 mm) undersize without re-Nitriding for a 20 hour period after each regrinding operation.

60 hour Nitrided crankshafts may be reground to 0.010 in (0,25 mm) undersize without re-Nitriding. Subsequent regrinding to 0.020 in (0,51 mm) or 0.030 in (0,76 mm) undersize calls for re-Nitriding for a 60 hour period after each regrinding operation.

If a 60 hour Nitrided crankshaft is found to be suitable for further service, but necessary to grind down to 0.020 in (0,51 mm) or 0.030 in (0,76 mm) undersize, grind down to 0.0015/0.002 in (0,04/0,05 mm) above finished size leaving an allowance to grind off the white compound layer formed by the 60 hour Nitriding process.

When regrinding, the operation calls for specialised equipment and great care.

Using a Prince type grinder with a Universal Grinding Wheel Company wheel to Grade WA-80 JE (or equivalent), remove the white compound layer formed by the Nitriding process to achieve finished size. The collar faces of the crankshaft should be lightly flashed but not be ground at this operation and the fillet radii should be maintained within 0.156/0.162 in (3,96/4,12 mm). This will leave the compound layer in the radii and collars. When removing the compound layer, a grinding wheel speed of 880 rev/min and a

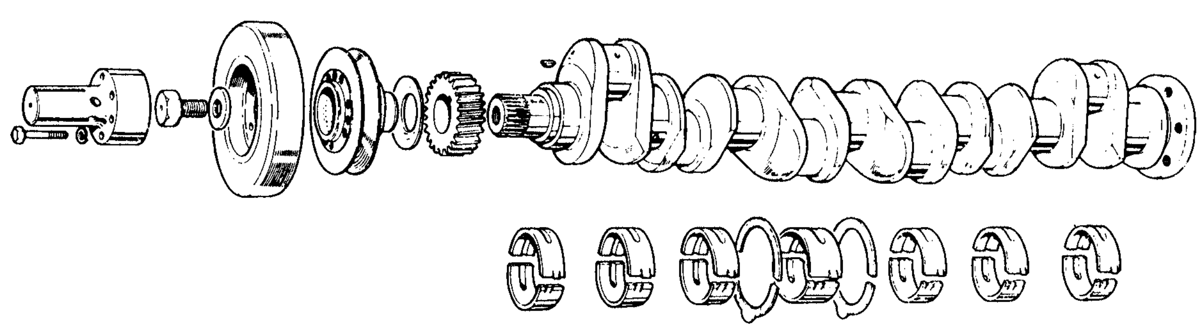


Fig. H.1.
Exploded view of Crankshaft and Main Bearings.

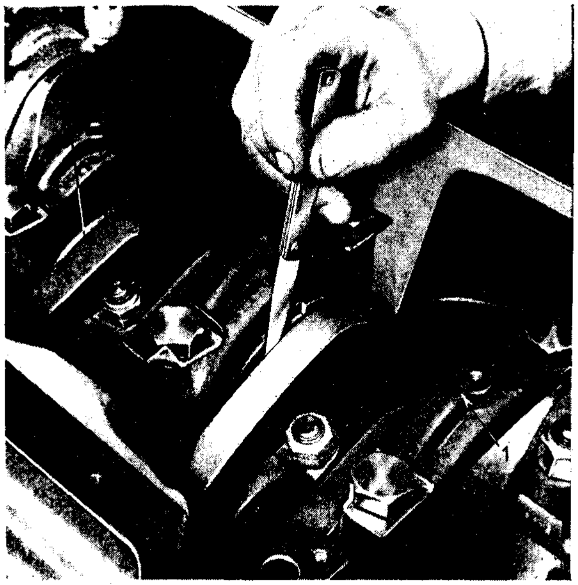


Fig. H.2. Checking Crankshaft End Float.
1. Main Bearing Cap.
2. Crankshaft.

crankshaft working speed of 16 rev/min for main journals and 8 rev/min for pins should be observed and a hand feed of approximately 0.0005 in (0,01 mm) per revolution of crankshaft. An adequate supply of coolant (Walker Century A305) should be used.

Tufftrided crankshafts must be re-Tufftrided after each regrinding operation. If facilities for Tufftriding are not available, then the crankshaft may be re-Nitrided by the 20 hour process.

Where facilities are not available for re-Nitriding or re-Tufftriding, then a factory replacement crankshaft should be fitted.

Tufftrided and Nitrided crankshafts cannot be straightened.

Generally speaking, Nitrided or Tufftrided crankshafts are fitted to turbocharged engines.

Nitrided or Tufftrided crankshafts can be identified by the machining part number which will be found on the nose of the crankshaft or stamped on No. 1 web. In some cases, only the last three figures will be found.

20 Hour Nitrided Crankshafts

31322317	31325016
31322321	31325022
31322322	31325023
31322421	31325042
31323207	31325036
31323251	31325028
31322351	31325025
31323202	31325019
31323254	31325032
31322422	31325041

60 Hour Nitrided Crankshafts

31322318	31325017
31323201	31325024
31323204	31325041
31323203	31325032
31322363	31325033
	31325037
31322372	31325006
31322381	31325007
31322362	31325004
31322393	31325045
31322392	31325201
31322391	31325202
31322306	31325211
31322307	31325221
	31325222
31322371	31325223
31323264	31325304
31323266	31325306
31323281	31325311
31323282	31325312
31323301	31325321
31323302	31325322
31323331	31325331

Tufftrided Crankshafts

31322314	31325013
31322315	31325014
31322373	31323262
31322364	31322311
31322365	31325008
31322309	31325011
31323284	31325009
31322312	31325046
31323265	31325047
31323303	31325203
	31325302
	31325305
	31325314
	31325323

Before regrinding the crankshaft it should be crack detected. Demagnetise after crack detecting.

Data for crankshaft regrinding is given on Page H.7.

After regrinding, the sharp corners on the oil holes should be removed and the crankshaft crack detected and de-magnetised.

Note: It is most important that the radii on the main journals and crankpins are maintained.

To Refit the Crankshaft

1. The oilways in the cylinder block and crankshaft must be free from obstruction.
2. Check the main bearing setscrews for stretch or damage. Only setscrews supplied by the engine manufacturers should be used as they are of a special heat treated high grade steel.

Fig. H.3. Fitting Main Bearing Bridge Piece Oil Seal.
1. Front Main Bearing Cap.
2. Bearing Bridge Piece.
3. Bearing Bridge Piece Oil Seal.

3. Clean the bearing housings, place the top half bearings in position and liberally oil.
4. Position the crankshaft.
5. Oil the two upper thrust washers and slide into the recesses on either side of the centre main bearing housing.
6. Liberally oil and fit the lower halves of the main bearings to the bearing caps. Fit the caps to their respective positions so that the lower halves of the thrust washers are correctly positioned on either side of the centre main bearing cap. The main bearing caps are numbered, No. 1 commencing at the front of the engine. Each cap is also marked with a serial number as stamped on the cylinder block bottom face. These should read in line.
7. Fit the setscrews.
   Note: On earlier engines, the main bearing cap setscrews were locked with tabwashers. It is not necessary to replace these after removal. Shim washers fitted between the setscrew head and the main bearing cap have also been deleted.
8. Tighten the main bearing setscrews to a torque of 150 lbf ft (20,74 kgf m) for engines preceding the following Engine Nos.
   T6.354(M)/6.354(M) 354U175383
   HT6.354(M)/H6.354(M) 354UX3141HT

As from the above Engine Nos. the torque for main bearing cap setscrews is 180 lbf ft (24,9 kgf m).

9. Check the crankshaft end float for a clearance of 0.002/0.015 in (0,05/0,38 mm) (Fig. H.2). Oversize thrust washers may be fitted.

Fig. H.4. Aligning Bridge Piece to Block Face.

10. Refit the connecting rod caps and big end bearings.
11. Refit the front and rear bridge pieces to the cylinder block (Fig. H.3). Check that the end faces of the bridge pieces are flush with the end faces of the cylinder block (Fig. H.4).
12. Fit new seals in the rear main oil seal housings and refit the housings, as described in "Crankshaft Rear End Oil Seal."
13. Refit and correctly align the flywheel housing and flywheel (Page N.2).
14. Refit the timing case, camshaft gear and auxiliary drive gear.
15. Replace the crankshaft pulley, so that the punch mark on the inside face of the pulley is in line with the scribed line on the end face of the crankshaft (Fig. H.5).
    When fitting the pulley it is recommended that "Loctite" be used, in the following manner.

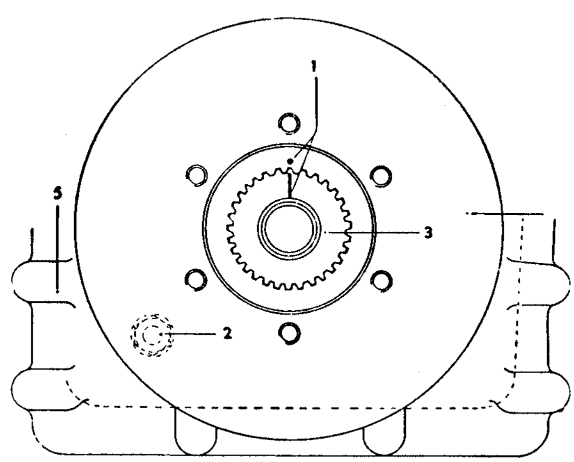


Fig. H.5.
1. T.D C. Marks on Pulley and Crankshaft.
2. Timing Pin.
3. Crankshaft.

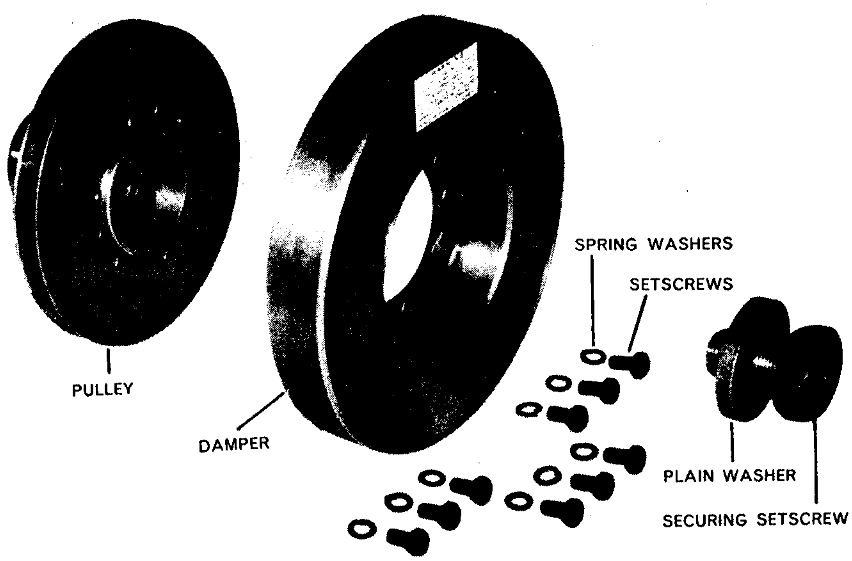


Fig. H.6.
Viscous Type Crankshaft Damper.

(a) Thoroughly clean the crankshaft and pulley serrations, removing all traces of dirt and oil, Locquic 'Q' Activator, supplied in a pressurised aerosol may be used for this purpose and its use will considerably reduce the curing time

(b) When using Locquic 'Q,' spray over the serrations of both crankshaft and pulley, then wipe clean. Spray again with Locquic 'Q' and allow to dry. Locquic as well as being an activator, is a mild degreasing agent, capable of dissolving light oil films. Should the crankshaft or pulley be particularly greasy, they should be brushed with Loquic on the first application. Complete absence of grease and oil is essential. For best results the second application of Loquic must be allowed to dry completely. Evaporation is complete when the surfaces are free of odour.

(c) Apply Loctite, grade "CVX BLUE" to the serations and fit the pulley, split retainer, washer and dognut or setscrew.

(d) Two types of washer are in service, varying in thickness. Where a ¼ in (6,35 mm) washer is used, the dognut or setscrew should be tightened to a torque of 200/250 lbf ft (27,7/34,6 kgf m), whilst a torque of 270/300 lbf ft (37,3/41,5 kgf m) should be applied where a ⅜ in (9,53 mm) washer is used.

IMPORTANT

Where Locquic 'Q' Activator has been used, as in (b) above, a curing period of one hour at room temperature is necessary before the engine is run.

If Locquic Activator has not been used, the curing period is 24 hours.

16. Replace the oil pump suction pipe, sump strainer and sump.

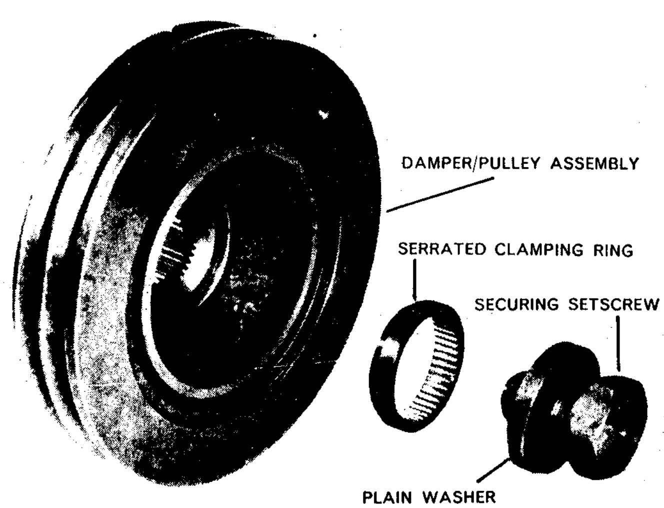


Fig. H.7.
Rubber Bonded Type Crankshaft Damper.

CRANKSHAFT DAMPER

There are two types of crankshaft damper used on the 6.354(M) engine, i.e., the viscous (oil filled) type or the rubber bonded type (see Figs. H.6 and H.7).

The viscous damper is secured to the crankshaft pulley with nine setscrews. The rubber bonded damper is part of the pulley itself and is not detachable.

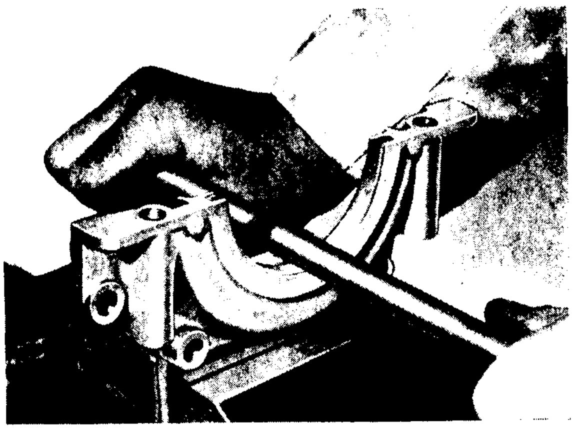


Fig. H.8. Rolling in Rear Main Oil Seal.

The early viscous type was secured by a plain washer and setscrew directly to the crankshaft but the internal bore of the rubber bonded type has a tapered recess at the outer end to allow for an internally serrated clamping ring which is fitted before the plain washer and setscrew. The clamping ring being externally tapered must be fitted with the tapered end entering the recess in the damper/pulley assembly.

The latest type of viscous damper now incorporates a clamping ring as in the rubber bonded damper.

ROPE TYPE CRANKSHAFT REAR END OIL SEAL

The housing consists of two halves bolted around the rear of the crankshaft which has a shallow spiral oil return groove machined in it to a depth of 0.004/0.008 in (0,10/0,20 mm). The bore of the housing accommodates a rubber cored asbestos strip, comprising two sections.

When fitting the seal the following procedure should be adopted :

1. Set up a half housing in the vice with the seal recess uppermost and settle approximately 1 in (25 mm) of the strip, at each end, into the ends of the groove, so that each end of the strip protrudes 0.010/0.20 in (0,25/0,5 mm) beyond the half housing joint face.
2. With the thumb or finger press the remainder of the strip into the groove working from the centre. Use a round bar to further bed in the strip by rolling and pressing its inner diameter (Fig. H.8).
3. Fit the sealing strip to the other half housing in a similar manner.
4. Fit a new joint using jointing compound applied both sides.

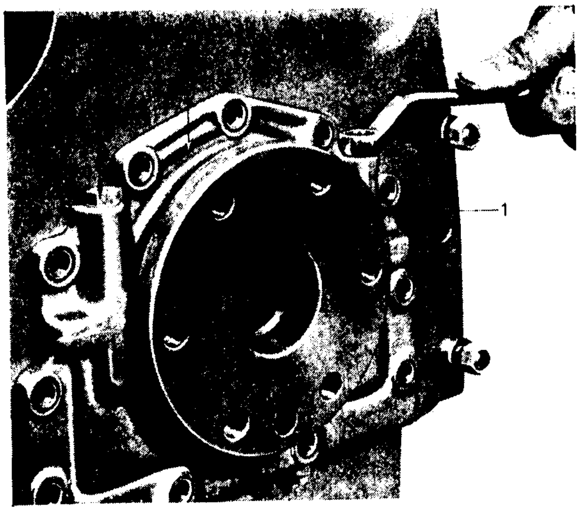


Fig. H.9. Tightening Oil Seal Housing Setscrew.
1. Crankshaft.
2. Oil Seal Housing.
3. Oil Seal Housing Setscrew.

5. Spread a film of graphite grease over the exposed inside diameter of the strip.
6. Assemble the half housings to the cylinder block and tighten setscrews and housing clamping setscrews finger tight only.
7. Tighten clamping setscrews to a torque of 4/6 lbf ft (0,55/0,83 kgf m).
8. Tighten setscrews in cylinder block to a torque of 12 lbf ft (1,66 kgf m).
9. Finally tighten the clamping setscrews to a torque of 12 lbf ft (1,66 kgf m).

LIP TYPE CRANKSHAFT REAR END OIL SEAL

On some engines, a circular, spring loaded, lip seal is fitted, which locates on the periphery of the flange of the crankshaft. On production, this seal is fitted with its rear face flush with the rear face of the single piece housing.

This type of seal is easily damaged and extreme care should be taken when handling and fitting it to its housing or to the crankshaft. Any visual damage across the lip of a new seal will cause leakage and prevent bedding in of the new seal.

The seal is designed to function correctly with the direction of rotation of the engine and for identification purposes, the seal is marked with an arrow.

On production the seal is fitted with its rear face flush with the rear face of the housing. In service, when a new seal is to be fitted to a worn crankshaft, it should be pressed further into the housing, in the first instance to $\frac{1}{8}$ in (3,2 mm) or, if this position has been used, to $\frac{1}{4}$ in (6,4 mm) from the rear face of the housing — see Fig. H.10.

If all three positions have been used, it may be possible to machine the worn sealing area of the crankshaft flange, but not the spigot area on which the flywheel locates — see Fig. H.11. When a new seal is fitted to a new or reconditioned crankshaft, it should be fitted with its rear face flush with the housing.

The seal is designed to function correctly with the direction of rotation of the engine and for identification purposes, the seal is marked with an arrow.

Before fitting the seal in the housing, carefully examine the seal for damage, especially on the lip and outside diameter.

Using clean engine lubricating oil, lubricate the outside diameter of the seal and the inside diameter of the housing.

Press the seal into the housing to the required position, taking care that the seal is entered and pressed in squarely, otherwise damage to the outside diameter of the seal may occur, or if it is not square in the housing when fitted to the engine, it may leak.

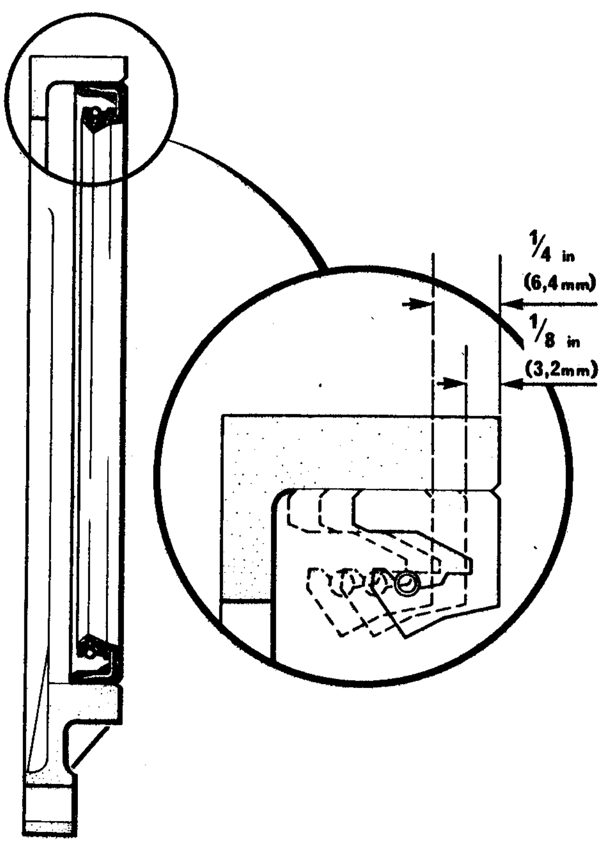


Fig. H.10
Three Positions for Seal.

The seal and housing should be fitted, using seal guide PD 145 (Churchill Tool) as follows:—

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

Check that the seal and the outside diameter of the crankshaft flange are not damaged. Where a new seal has been fitted, check that it is in the correct position as previously detailed.

Ensure that the two dowels are fitted in the cylinder block. Coat both sides of the housing with Perkins Hylomar jointing compound and position the joint over the dowels in the block.

Using clean engine lubricating oil, lubricate the crankshaft flange, the seal and the seal guide. The lubrication of the seal is necessary to prevent damage that may be caused by initial dry running.

Position the seal and housing on the seal guide, locate the guide on the crankshaft flange and gently press the seal and its housing into position on the flange, locating the housing on its dowels.

Withdraw the guide and secure the housing with setscrews and washers.

In order to identify engines fitted with the lip type rear main oil seal, a letter "L" is added at the end of the engine number. The lip type seal assembly and its counterpart crankshaft are not interchangeable with previous types.

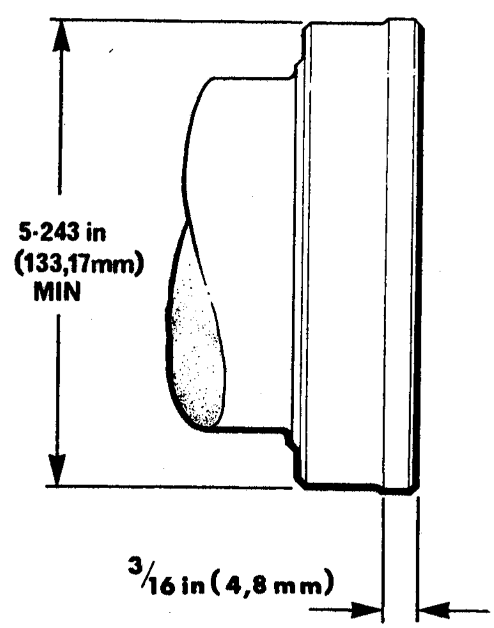
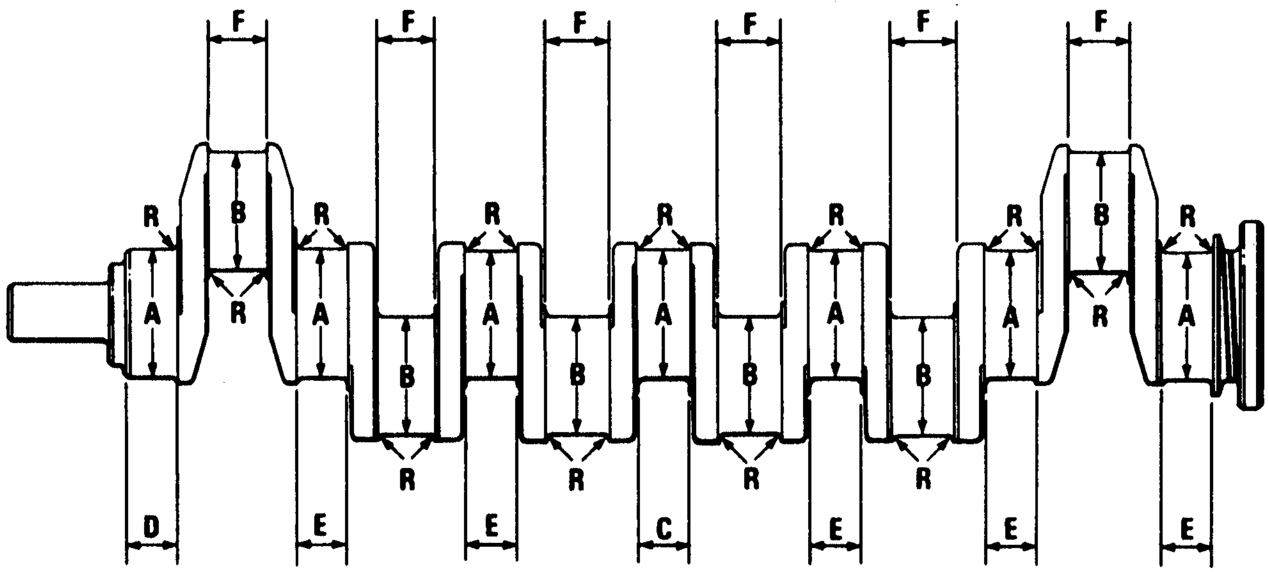


Fig. H.11
Grinding of Crankshaft Flange.

Crankshaft Regrind Data



	0.010 in (0,25 mm) Undersize	0.020 in (0,51 mm) Undersize	0.030 in (0,76 mm) Undersize
A	2.9884/2.9892 in (75,91/75,93 mm)	2.9784/2.9792 in (75,65/75,67 mm)	2.9684/2.9692 in (75,40/75,42 mm)
B	2.4888/2.4896 in (63,22/63,24 mm)	2.4788/2.4796 in (62,96/62,98 mm)	2.4688/2.4696 in (62,70/62,72 mm)

C 1.759 in (44,68 mm) maximum

D 1.489 in (37,82 mm) maximum

E 1.554 in (39,47 mm) maximum

F 1.5965 in (40,55 mm) maximum

R 0.145/0.156 in (3,68/3,96 mm) all journals and crankpins

R (60 hour Nitrided only) 0.156/0.162 in (3,96/4,12 mm) all journals and crankpins

Surface finish of crankpins, journals and fillet radii 16 to 8 micro inches (0,4/0,2 microns) C.L.A.

Magnetic crack detection D.C. Flow—4 amps A.C. Current—1600 amps

Limits of taper and out of round of pins and journals :—

Taper 0.00035 in (0,008 mm) Out of Round 0.0004 in (0,010 mm)

Maximum Run-out with the crankshaft mounted on the end main journals

Independent Readings :—

Crankshaft Pulley Diameter T.I.R.	Rear Oil Seal Diameter T.I.R.	Flywheel Flange Diameter T.I.R.
0.002 in (0,05 mm)	0.002 in (0,05 mm)	0.002 in (0,05 mm)

Journals T.I.R.—Run-out must not be opposed :—

Number 1. Mounting	Number 2. 0.004 in (0,10 mm)	Number 3. 0.008 in (0,20 mm)	Number 4. 0.010 in (0,25 mm)
Number 5. 0.008 in (0,20 mm)	Number 6. 0.004 in (0,10 mm)	Number 7. Mounting	

The difference in Run-out between any two adjacent bearings must not be greater than 0.004 in (0,10 mm).

SECTION J
Timing Case and Drive

An exploded view of the timing case and drive is shown in Fig. J.1.

With contra-rotating engines, the crankshaft and timing gears will be operating in reverse direction and consequently the helical teeth on the timing gears will be cut at an opposite angle. To ensure that the lubricating oil pump and fuel injection pump operate in the correct direction, the worm gear on the auxiliary drive shaft and the wormwheel on the fuel pump drive shaft are also cut at an opposite angle. The camshaft also differs to those fitted to normal rotation engines.

To Remove the Timing Case, Camshaft Gear and Auxiliary Drive Gear

1. Slacken the dynamo/alternator mounting bolts and remove the drive belt.
2. Where necessary, remove water pump.
3. Remove the crankshaft pulley.
4. Remove the camshaft gear cover and auxiliary drive gear cover.
5. Remove the camshaft gear securing setscrew and washers and extract the gear from the camshaft (Fig. J.2).

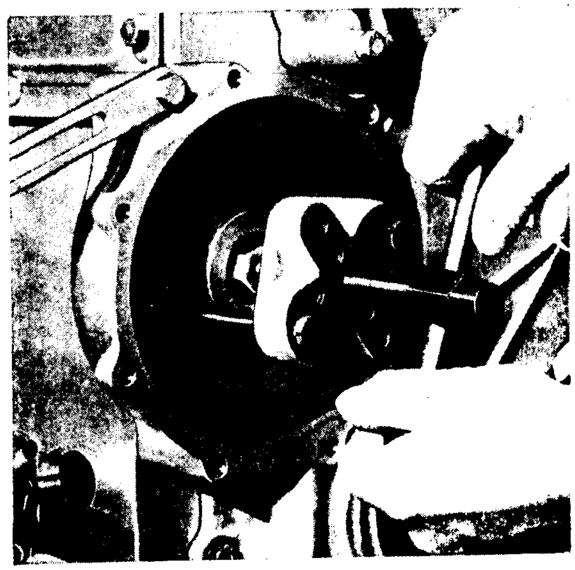


Fig. J.2. Removal of Camshaft Gear.

6. Remove the retaining plate securing the auxiliary drive gear to the auxiliary drive shaft hub and withdraw the gear (Fig. J.3).
7. Remove the timing case and oil thrower.

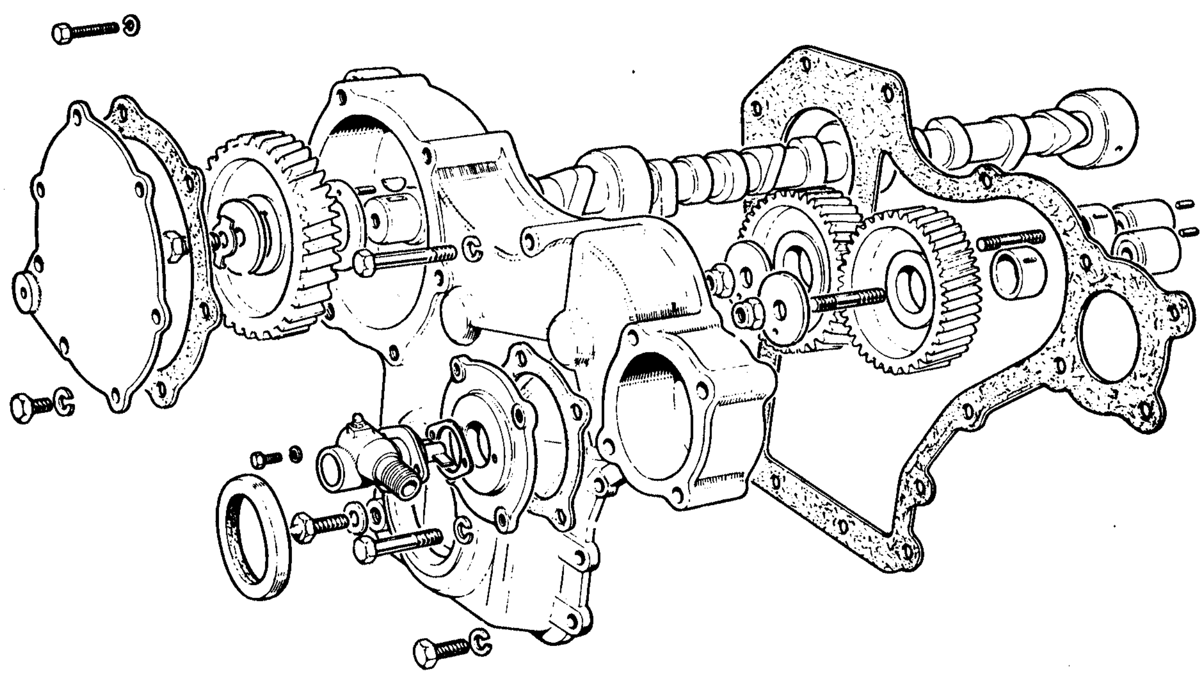


Fig. J.1.
Exploded view of Timing Case and Drive.

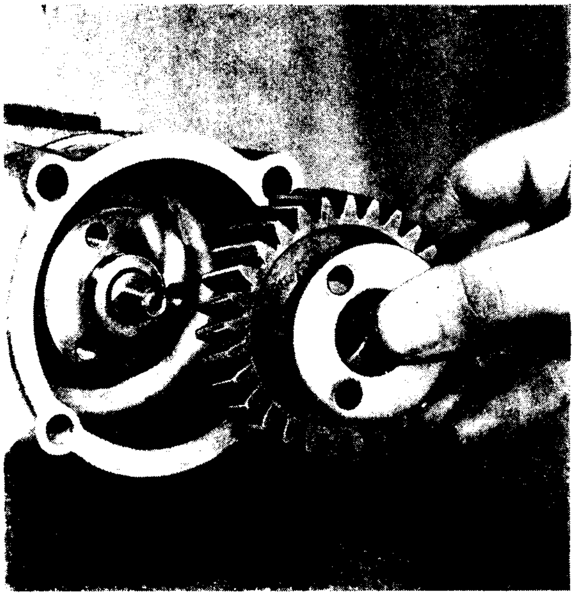


Fig. J.3.
Removing Fuel Pump Drive Gear.

To Renew the Crankshaft Front Oil Seal

1. Using a press and dolly, remove the oil seal from the timing case.
2. Press the new seal into position from the front until the front face is 3/32 in (2,38 mm) below the front face of the timing case (Fig. J.4).

   The seal is designed to function correctly with the direction of rotation of the engine and for identification purposes, the seal is marked with an arrow.

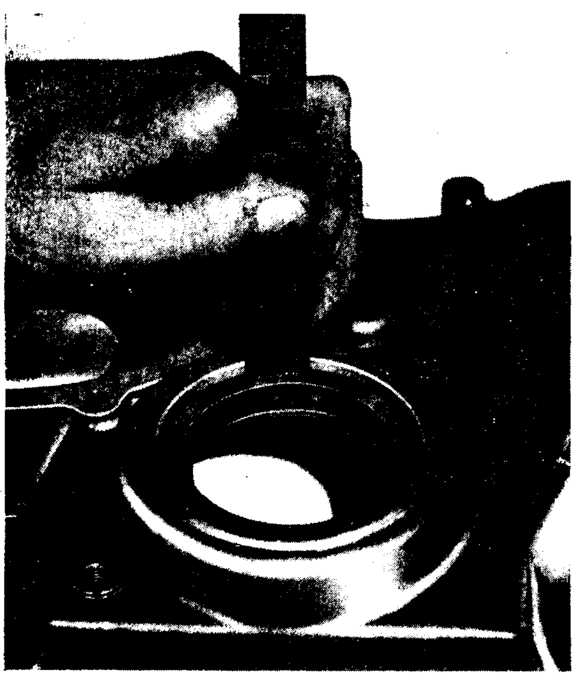


Fig. J.4.
Checking Depth of Front Oil Seal.

To Refit the Timing Case, Camshaft Gear and Auxiliary Drive Gear

1. Remove the rocker cover and release the rocker shaft.
2. Turn the crankshaft until Nos. 1 and 6 pistons are at T.D.C., i.e. with the keyway in the crankshaft gear at 12 o'clock.
3. If the double dot mark on the lower idler gear is not in line with the single dot on the crankshaft gear, remove the idler gear and replace with the marks in line.
4. Replace the crankshaft oil thrower with the dished face outwards.
5. Refit the timing case and slide the crankshaft pulley into position thus centralising the case. Tighten all exposed setscrews and then remove the pulley to gain access to the nuts at the bottom of the timing case. Evenly tighten all the securing setscrews.
6. Align the keyway in the camshaft gear with the key in the camshaft, align the double dot timing mark on the camshaft gear teeth with the single dot on the lower idler gear. Draw the gear onto the camshaft by fitting the gear retaining washer, tabwasher, shimwasher and setscrew. Tighten the setscrew to a torque of 45/50 lbf ft (6,2/6,9 kgf m), and lock with the tabwasher.
7. Replace the camshaft gear cover plate.
8. Remove the fuel injection pump (Page M.6). Turn the auxiliary drive shaft until the slot in the vertical fuel pump drive hub aligns with the slot in the fuel pump adaptor plate (Fig. M.11). With the engine set in this position, fit the auxiliary drive gear so that the holes in the auxiliary drive shaft are central within the three slots of the auxiliary drive gear. Secure the gear with the retaining plate and setscrews and replace the auxiliary drive gear cover plate.
9. Refit the fuel injection pump (Page M.6). Tighten down the rocker assembly and adjust the valve clearances to 0.012 in (0,30 mm) cold.
10. Replace the crankshaft pulley (Page H.4), so that the dot on the inside of the pulley is in line with the scribed line on the end of the crankshaft. Replace the split retainer, washer and pulley retaining setscrew and tighten to the correct torque (Page B.2).

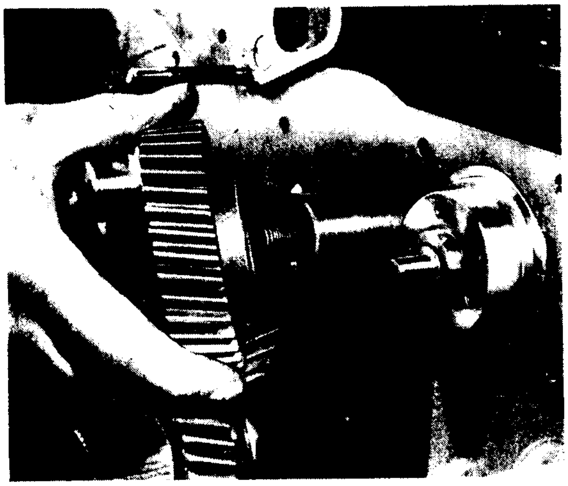


Fig. J.5. Removing Idler Gear (contra rotating engine).

11. Fit the drive belt and retighten (Page L.7).

To Remove Idler Gears and Hubs

1. Remove the timing case.
2. Remove the self locking nut securing each idler gear.

   Note: With earlier engines, the idler gear hub retaining studs were 7/16 in whereas later engines have ½ in studs.
3. Withdraw the retaining plate and the idler gears (Fig. J.5 and J.6). Withdraw the hubs (Fig. J.7).

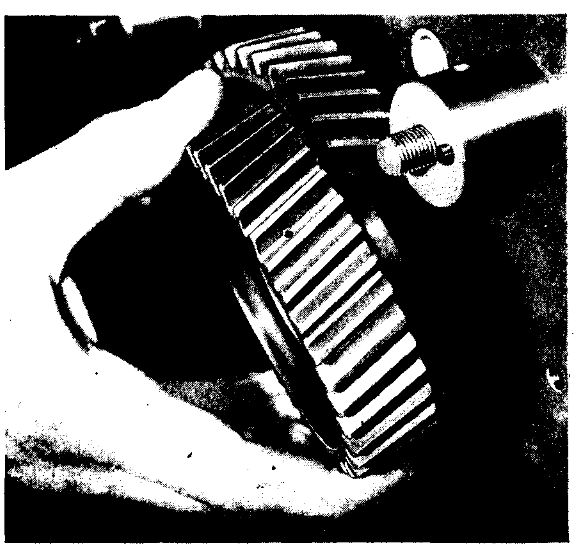


Fig. J.6. Removing Idler Gear (normal rotating engine).

4. Examine the gear and hub for wear, cracks and pitting, etc. The oilways in the hubs and gears must be clean.

To Replace Idler Gears and Hubs

1. Remove the rocker cover and slacken off the rocker assembly securing nuts.
2. Turn the crankshaft to T.D.C. on Nos. 1 and 6 pistons.
3. Remove the fuel injection pump (Page M.4), and turn the auxiliary drive shaft until the slot in the vertical fuel pump drive hub aligns with the slot in the fuel pump adaptor plate.
4. Refit the idler gear hubs.
5. Refit the idler gears and retaining plates, so that the timing marks on the lower idler gear align with the timing marks on the crankshaft gear. Using new self locking nuts, secure the gears to a torque of 45/50 lbf ft (6,2/6,9 kgf m) for $\frac{7}{16}$ in studs or 60/65 lbf ft (8,3/9,0 kgf m) for ½ in studs.
6. Refit the timing case, camshaft gear and auxiliary drive gear.
7. Replace the fuel pump (Page M.4).
8. Tighten down the rocker assembly, adjust the valve clearance to 0.012 in (0,30 mm) cold and refit the rocker cover.

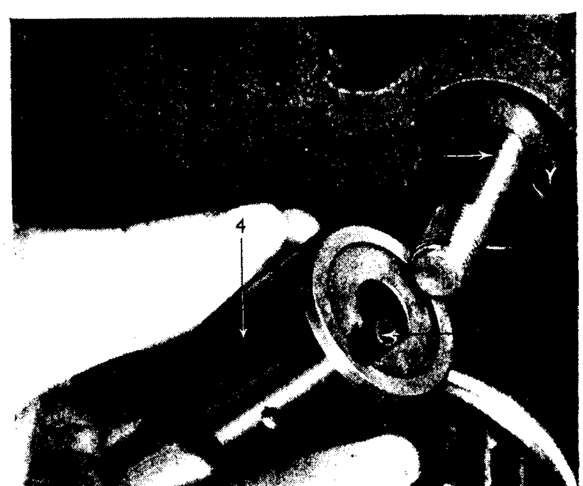


Fig. J.7. Removing Idler Gear Hub.

1. Idler Gear Hub Retaining Stud.
2. Oil Passage.
3. Hollow Dowel.
4. Idler Gear Hub.

To Remove the Camshaft and Tappets

1. Remove the timing case.
2. Remove the rocker cover, and rocker assembly. Withdraw the push rods.
3. Release the connections to the fuel lift pump and remove the pump (vertical engines only). **Note:** Before removing the camshaft, it is advisable to lay the engine on its side to prevent the tappets from falling out.
4. Remove the sump.
5. Withdraw the camshaft (Fig. J.8) and its thrust ring (Fig. J.9). The tappets can now be withdrawn.

To Replace the Camshaft

1. Refit the tappets (Fig. J.10).
2. Refit the camshaft.
3. Refit the sump.
4. Fit the camshaft thrust ring so that it is correctly positioned on the dowel (Fig. J.9). Check the protrusion beyond the front face of the cylinder block. This should be within the limits quoted on Page B.8.
5. Refit the fuel lift pump. Attach the connections.
6. Replace the timing case and refit the timing gears.
7. Refit the push rods and rocker assembly. Adjust the valve clearances to 0.012 in (0,30 mm) cold. Refit the rocker cover.

Fig. J.8. Camshaft Removal.

1. Camshaft. 2. Crankshaft Gear.
3. Camshaft Oil Reducer Drillings.

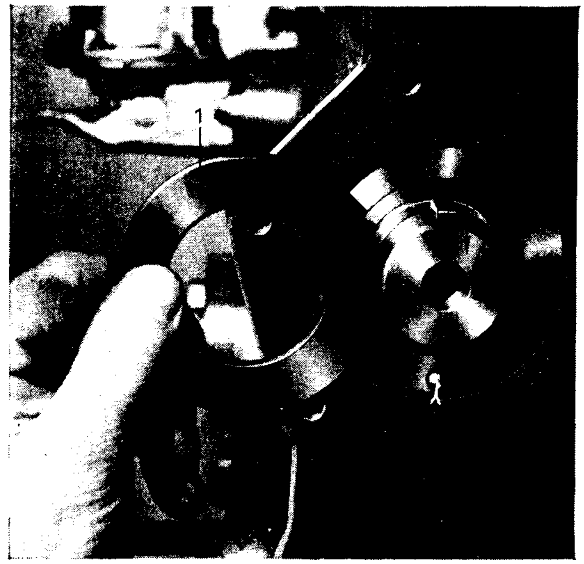


Fig. J.9. Removing Camshaft Thrust Washer.

1. Camshaft Thrust Washer.
2. Camshaft.
3. Thrust Washer Dowel Pin.

To Remove the Auxiliary Drive Shaft and Fuel Pump Drive Shaft

1. Remove the timing case.
2. Remove the water pump and coupling from the rear of the auxiliary drive shaft.
3. Remove the fuel pump.
4. Withdraw the auxiliary drive shaft (Fig. J.11 or J.12), with a twisting motion, and the two 180° half thrust washers.

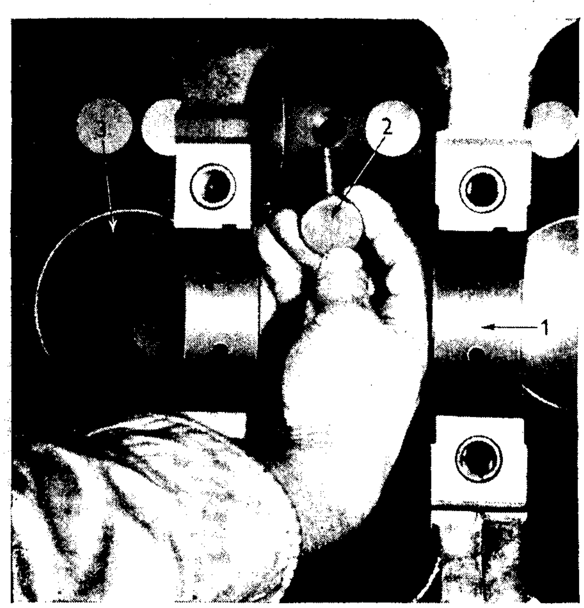


Fig. J.10. Removing Tappets.

1. Main Bearing Housing. 2. Tappet.
3. Cylinder Liner.

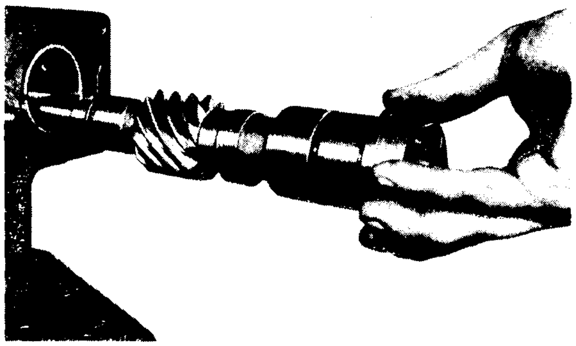


Fig. J.11. Removing Auxiliary Drive Shaft. (contra rotating engine).

5. Remove the fuel pump adaptor plate.
6. Remove the sump and oil pump (Page K.6 and K.7) and tap the fuel pump drive shaft up out of the crankcase. Remove any shims that may be present at the bottom of the bearing recess. An exploded view of the normally aspirated and early turbocharged fuel pump drive assembly is shown in Fig. J.13. Current engines have an hydraulic wormwheel assembly which is described later.
7. All parts should be examined for damage and wear. If the bronze gear requires renewing, remove the bearing from the fuel pump drive shaft by removing four cap screws. The four cap screws should be coated with a film of "Loctite" Grade "C" before refitting.

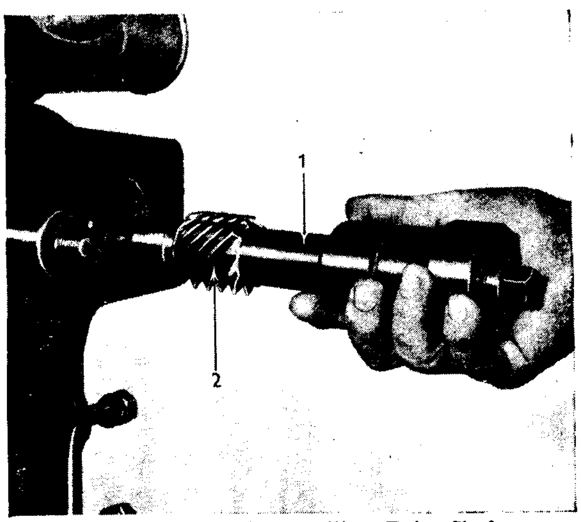


Fig. J.12. Removing Auxiliary Drive Shaft. (normal rotating engine).

1. Auxiliary Drive Shaft.
2. Fuel Pump Drive Gear.

To Replace the Auxiliary Drive Shaft and Fuel Pump Drive Shaft

1. Adjacent to the engine number, on the auxiliary drive housing, is stamped the amount of shimming required to be placed at the bottom of the fuel pump drive shaft bearing recess. The amount of shimming may vary from 0.002/0.008 in (0,05/0,2 mm) and 0.002 in (0,05 mm) shims are available. If there is no stamping, shims are not required.
2. Replace the fuel pump drive shaft assembly, bearing end first, into the crankcase and press into position.
3. Replace the lubricating oil pump and sump (Page K.6).
4. Replace the fuel pump adaptor plate, so that the timing mark scribed on the periphery is adjacent to the outside securing stud.
5. Slide the auxiliary drive shaft into position in the cylinder block, until the two halves of the thrust washer, fitted in the groove around the drive shaft, seat in the recess in the cylinder block and the butt faces are located by the dowel. End float of the drive shaft is controlled by the clearance between the thrust washers (held in position by the timing case) and the groove in the drive shaft. This clearance is between 0.0025/0.009 in (0,064/0,23 mm).
6. Replace the timing case, timing gears (Page J.2) and fuel pump (Page M.4).

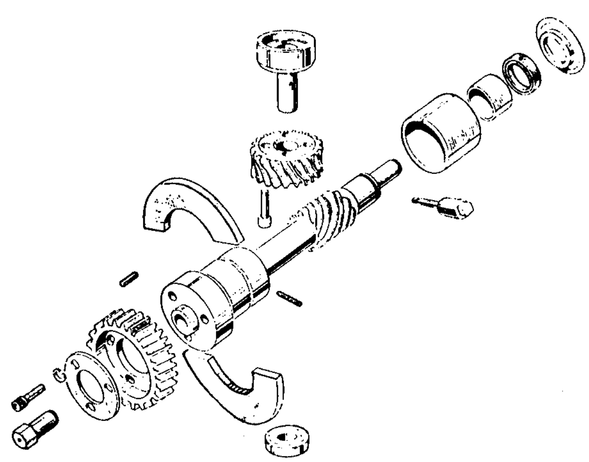


Fig. J.13.
Exploded view of Fuel Pump Drive Assembly. (early engines).

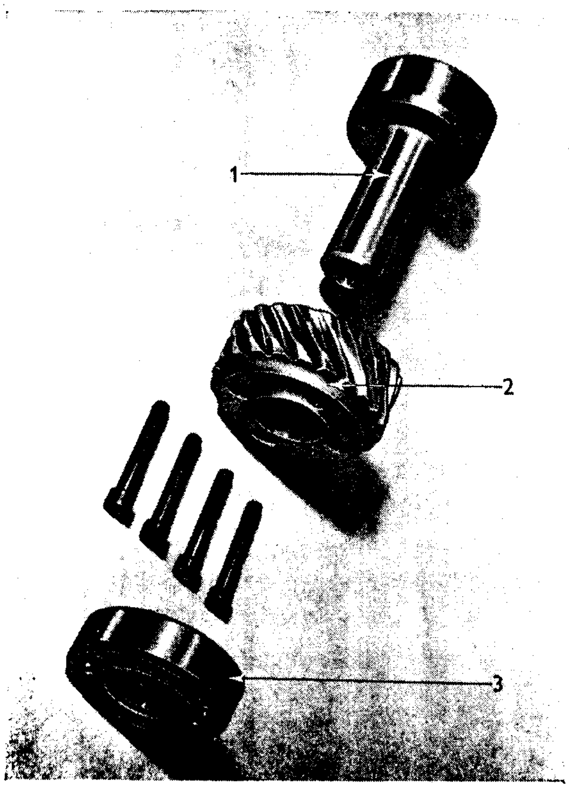


Fig. J.14. Exploded view of Fuel Pump Drive.

1. Drive Shaft.
2. Bronze Gear.
3. Ball Race.

7. Refit the water pump to rear of auxiliary drive shaft.

   Note: As from engine No. 8020251 Vertical, and 8420251 (Horizontal), wider gear centres were provided between the fuel pump worm drive and wormhead. This necessitated a larger diameter for the auxiliary drive shaft front bearing. It should be noted that with this alteration, the following parts are not interchangeable — cylinder block, auxiliary drive shaft, auxiliary drive shaft front bush, thrust washers and the lubricating oil pump and fuel pump drive shaft assembly.

Hydraulic Wormwheel Assembly

Later engines with the exception of contra-rotating engines are fitted with an hydraulic wormwheel assembly. Removal and replacement can be carried out in the following manner.

To Remove the Auxiliary Drive Shaft and Wormwheel Drive Assembly

1. Remove the timing case.
2. Remove the water pump and coupling from the rear of the auxiliary drive shaft.
3. Remove the fuel pump.

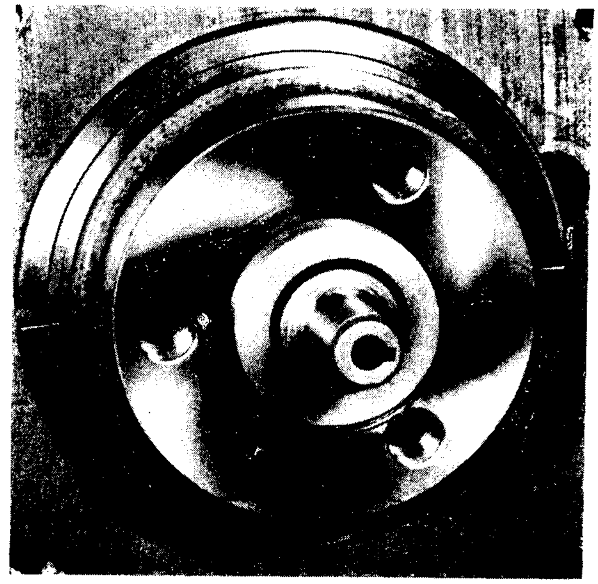


Fig. J.15.

Showing method of Auxiliary Drive Shaft Thrust Washer Location.

4. With a twisting motion, withdraw the auxiliary drive shaft and two half (180°) thrust washers.
5. Remove the fuel pump adaptor plate.
6. The wormwheel and fuel pump drive shaft assembly can now be pulled up and out, bringing with it, the thrust sleeve and piston ring seal.

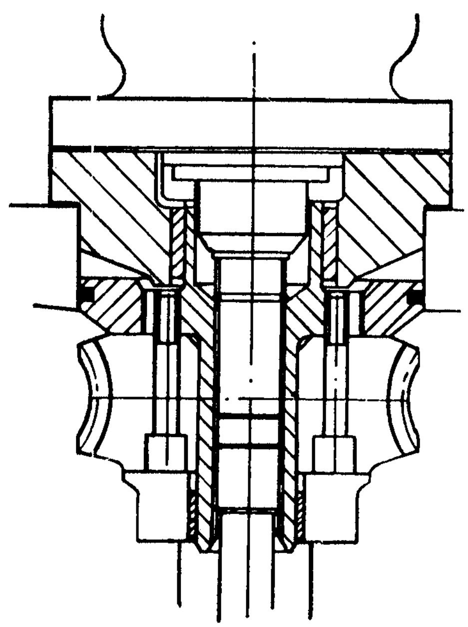


Fig. J.16.

Sectional view of Hydraulic Wormwheel Assembly.

7. The thrust collar assemby will remain in its location in the cylinder block and can be removed by removing the sump and oil pump and tapping the collar up out of the crankcase.

All parts should be examined for damage and wear. If the bronze wormwheel requires renewing, remove the four cap screws securing the gear to the drive shaft and withdraw the gear. The four cap screws and the shaft should be coated with a film of Loctite Grade RC. Fit a new gear so that the oil groove is in line with the slot in the shaft and tighten the screws. Latest gears are shrunk on and punch peened to the drive shaft. In the event of the gear requiring renewal, the gear and shaft assembly should be replaced. If the bush in the thrust collar requires renewing, press out the old bush and fit a new one. The new bush will require boring out after fitting, to a diameter of 1.625/1.6266 in (41,28/41,32 mm). The piston ring seal will not normally require renewing unless it is damaged.

NOTE: The hydraulic wormwheel calls for a lubricating oil pump with an oil drain channel in the drive end of the body casting. It is important to note that lubricating oil pumps without this drain channel must not be used to replace those with the drain channel as this will prevent the drain of oil from the hydraulic loading within the auxiliary drive housing.

Auxiliary Drive Spray Tube

The auxiliary drive gears are lubricated by oil directed on to them by a spray tube in the auxiliary drive housing (See Fig. J.17). With early engines, this spray tube was screwed into the cylinder block, but with current engines, it is a push fit sealed with a "D" type plug.

PART SIDE VIEW ON AUX. DRIVE HOUSING

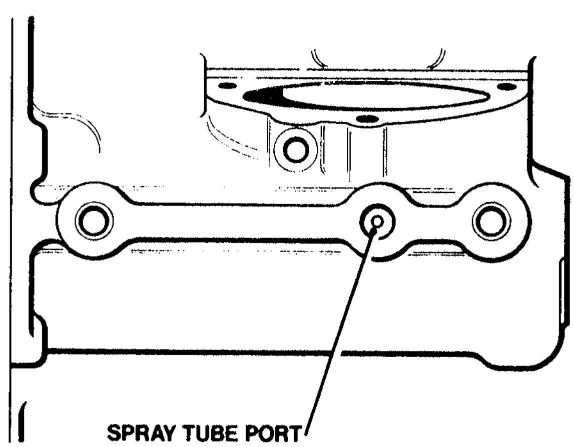


Fig. J.17

This spray tube should be removed and cleaned during engine overhaul. Spares blocks are not fitted with this spray tube, therefore when replacing a block, always ensure that the tube is transferred from the old block to the new one.

To Replace the Auxiliary Drive Shaft and Wormwheel Drive Assembly

1. Replace the thrust collar assembly and press into position.
2. The wormwheel and fuel pump drive assembly can now be replaced.
3. With the piston ring seal assembled on the thrust sleeve, replace the assembly.
4. Replace the oil pump and sump.
5. Replace the fuel pump adaptor plate, so that the timing mark scribed on the periphery is adjacent to the outside securing stud.
6. Slide the auxiliary drive shaft into position in the cylinder block, until the two halves of the thrust washer, fitted in the groove around the drive shaft, seat in the recess in the cylinder block and the butt faces are located by the dowels. End float of the drive shaft is controlled by the clearance between the thrust washers (held in position by the timing case) and the groove in the drive shaft. This clearance is between 0.0025 to 0.009 in (0,064/0,23 mm).
7. Replace the timing case, timing gears and fuel pump.
8. Replace water pump and coupling to rear of auxiliary drive shaft.

Contra-Rotating Engines

On contra-rotating engines, there is no hydraulic loading of the auxiliary drive wormwheel as the auxiliary drive shaft rotates in the opposite direction and the thrust of the wormwheel, being reversed, is taken on the bottom of the fuel pump adaptor plate. Float is controlled by shims where necessary.

Important: On contra-rotating engines, when fitting a replacement wormwheel and shaft assembly or thrust plate, the dimension 'A' (Fig. J.18), i.e. from the top face of the wormwheel to the top face of the auxiliary drive housing, should be checked and related to the following table of dimensions. This will determine the amount of shimming (if any) which must be fitted between the fuel pump adaptor plate and the auxiliary drive housing, to give the required clearance.

Three thicknesses of shim are available and should be fitted in multiples where necessary, to give the required clearance. The part numbers of the shims are as follows :—

Thickness		Part No.
0.002 in (0,05 mm)	...	36255526
0.003 in (0,08 mm)	...	36255527
0.005 in (0,13 mm)	...	36255528

Note: No joint is fitted between the fuel pump adaptor plate and the cylinder block. Sealing is effected by an 'O' ring.

When removing and replacing existing auxiliary drive parts, the original shims should be refitted. It is not necessary to check the dimension 'A'.

Dimension 'A'		Shim Thickness Required
1.323 in (33,60 mm)	...	None
1.322 in (33,58 mm)	...	None
1.321 in (33,55 mm)	...	0.002 in (0,05 mm)
1.320 in (33,53 mm)	...	0.003 in (0,08 mm)
1.319 in (33,50 mm)	...	0.004 in (0,10 mm)
1.318 in (33,48 mm)	...	0.005 in (0,13 mm)
1.317 in (33,45 mm)	...	0.006 in (0,15 mm)
1.316 in (33,43 mm)	...	0.007 in (0,18 mm)
1.315 in (33,40 mm)	...	0.008 in (0,20 mm)
1.314 in (33,38 mm)	...	0.009 in (0,23 mm)
1.313 in (33,35 mm)	...	0.010 in (0,25 mm)
1.312 in (33,32 mm)	...	0.011 in (0,28 mm)
1.311 in (33,30 mm)	...	0.012 in (0,30 mm)
1.310 in (33,27 mm)	...	0.013 in (0,33 mm)

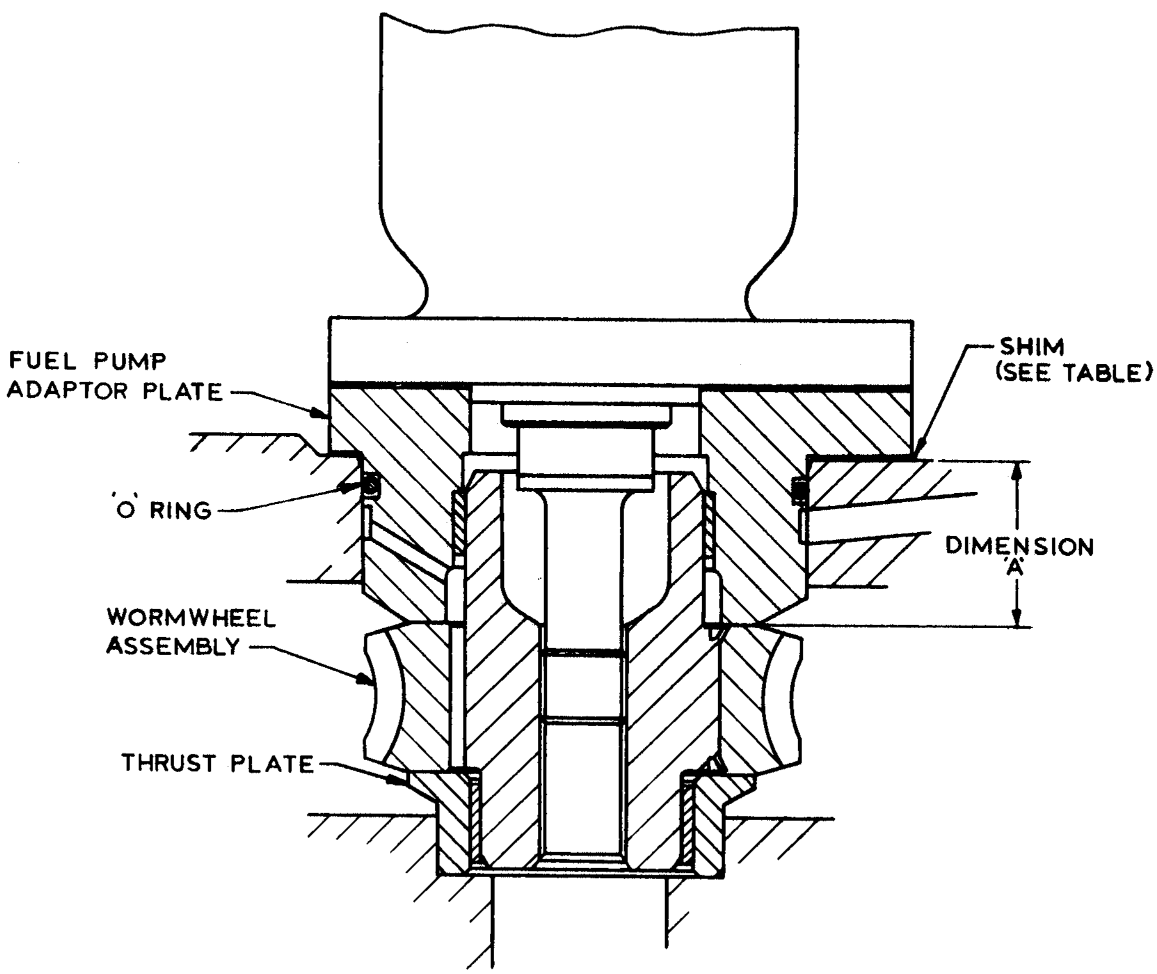


Fig. J.18

Checking the Timing Gear Backlash

1. Remove the camshaft gear and auxiliary drive gear covers.

2. Check the backlash between the timing gears using a clock gauge or feeler gauges. The back lash should be between 0.003/0.006 in (0,08/0,15 mm) if not, replace the gears affected.

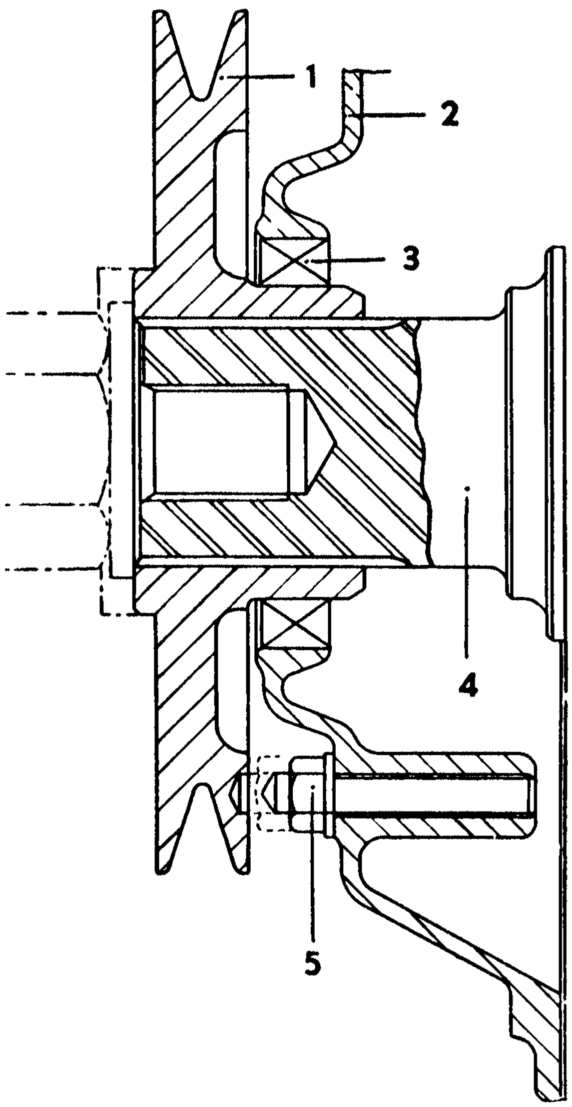


Fig. J.19.

1. Crankshaft Pulley.
2. Timing Case.
3. Timing Case Seal.
4. Crankshaft.
5. Timing Pin (not fitted to current engines).

CHECKING VALVE TIMING

1. Turn the crankshaft until the valves on No. 6 cylinder are rocking. Set the clearance on No. 1 inlet valve to 0.047 in (1,19 mm).

2. Turn the crankshaft in the normal direction of rotation until the push rod of No. 1 inlet valve just tightens.

3. Check that Nos. 1 and 6 pistons are at T.D.C. by unscrewing the timing pin, in the lower half of the timing case, until it locates in the hole in the rear of the crankshaft pulley. The valve timing tolerance is plus or minus $2\frac{1}{2}°$.

4. When the valve timing is found to be correct, release the timing pin in the crankshaft pulley and rest valve clearance to 0.012 in (0,30 mm) cold.

Current engines have a timing pointer which denotes T.D.C. when aligned with a mark on the crankshaft pulley.

Note: The only error possible is in the fitting of the timing gears.

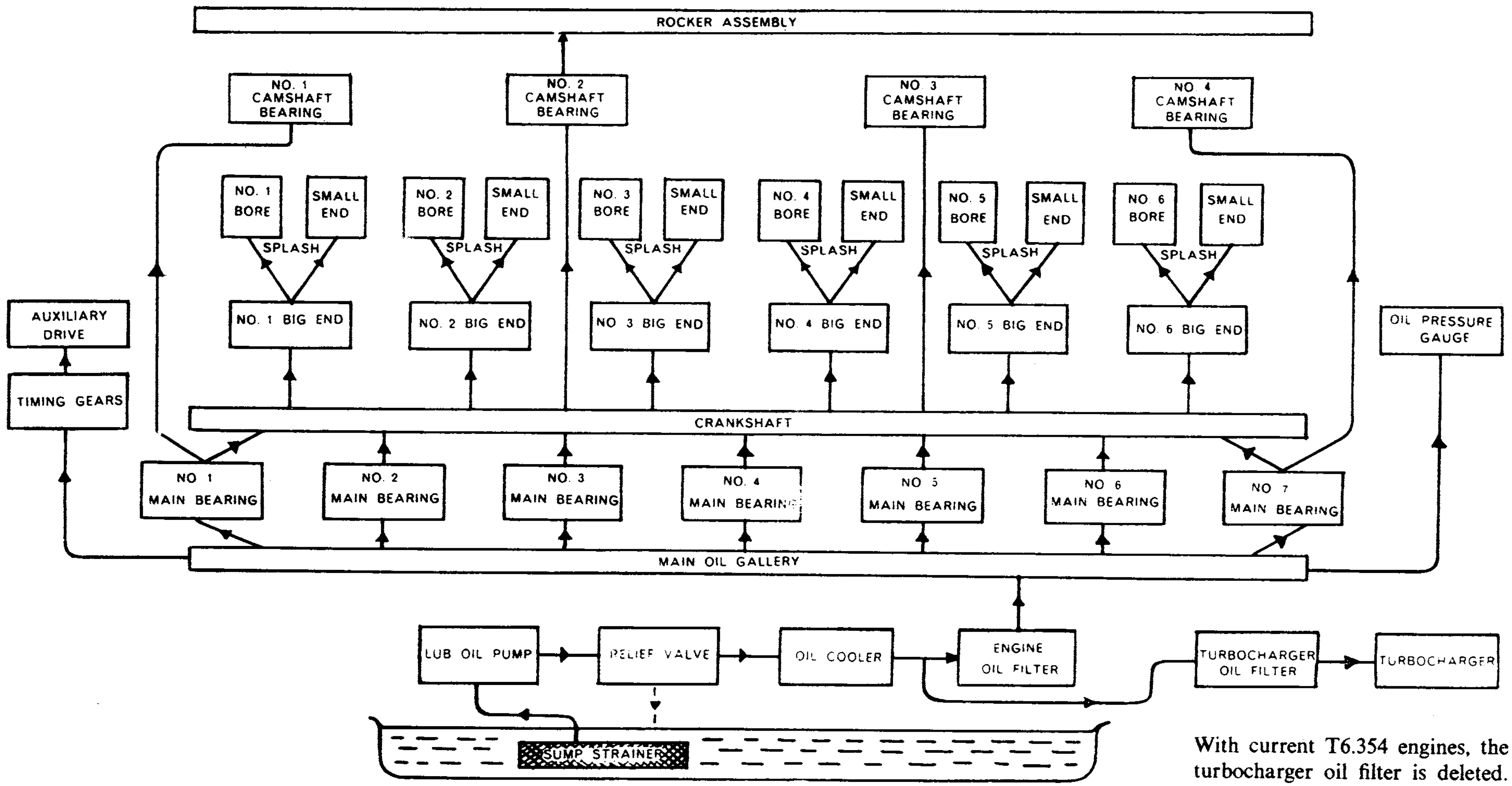
Tachometer Drive

The tachometer angle drive mounted on the timing case front cover should be greased with a high melting point grease in accordance with Preventive Maintenance given on Page C.3.

Grease starvation of the angle drive gears can result in overloading and subsequent failure, but overloading is more frequently caused by the flexible drive itself due to its corrosion resulting from the drive cable lying in bilge water or being allowed to arc on battery terminals etc. No bend in the flexible drive should be less than one foot radius.

With earlier engines, failure of the angle drive could result in fragments of the drive tag falling into the timing gear train and as a protective measure, a sleeve shield was introduced around the tachometer drive shaft and tag. It would be of advantage to introduce this safety shield on early engines whenever it becomes necessary to remove the timing case cover.

LUBRICATING OIL SYSTEM
(Vertical Engines)



With current T6.354 engines, the turbocharger oil filter is deleted.

SECTION K
Lubricating System

NOTE : Lubricating oil Data in appendix.

The importance of correct and clean lubrication cannot be stressed too highly and all references to engine oil should be taken to mean lubricating oil which falls within the specifications given in the appendix. Care should be taken that the oil chosen is that specified for the climatic conditions under which the engine is operated.

The sump should be filled with a suitable lubricant to the correct level but do not attempt to overfill above the full mark.

The sump capacity remains constant irrespective of the engine installation angle.

Certain interim engines were not fitted with sump strainers, but when overhauling an engine, it is advantageous that the appropriate type strainer be fitted.

Oil Circulation
(See Page K.2 for Horizontal Engines).

The system of lubrication comprises pressure feed to main and big end bearings, camshaft bearings, rocker shaft and timing drive.

The pump draws oil through the strainer from the sump (or separate sump well in the case of horizontal engines) and delivers it through a short tube to the oil delivery housing; from the housing, oil is delivered to the adaptor on the port side of the cylinder block.

From this adaptor, oil is piped to the engine oil cooler and then to the engine oil main full flow filter. From here, it is piped back to the adaptor where it is fed through an internal drilling in the cylinder block to the pressure rail which is an internal passage within the crankcase.

Holes drilled in the crankcase webs feed oil from the pressure rail to the main bearings and holes in

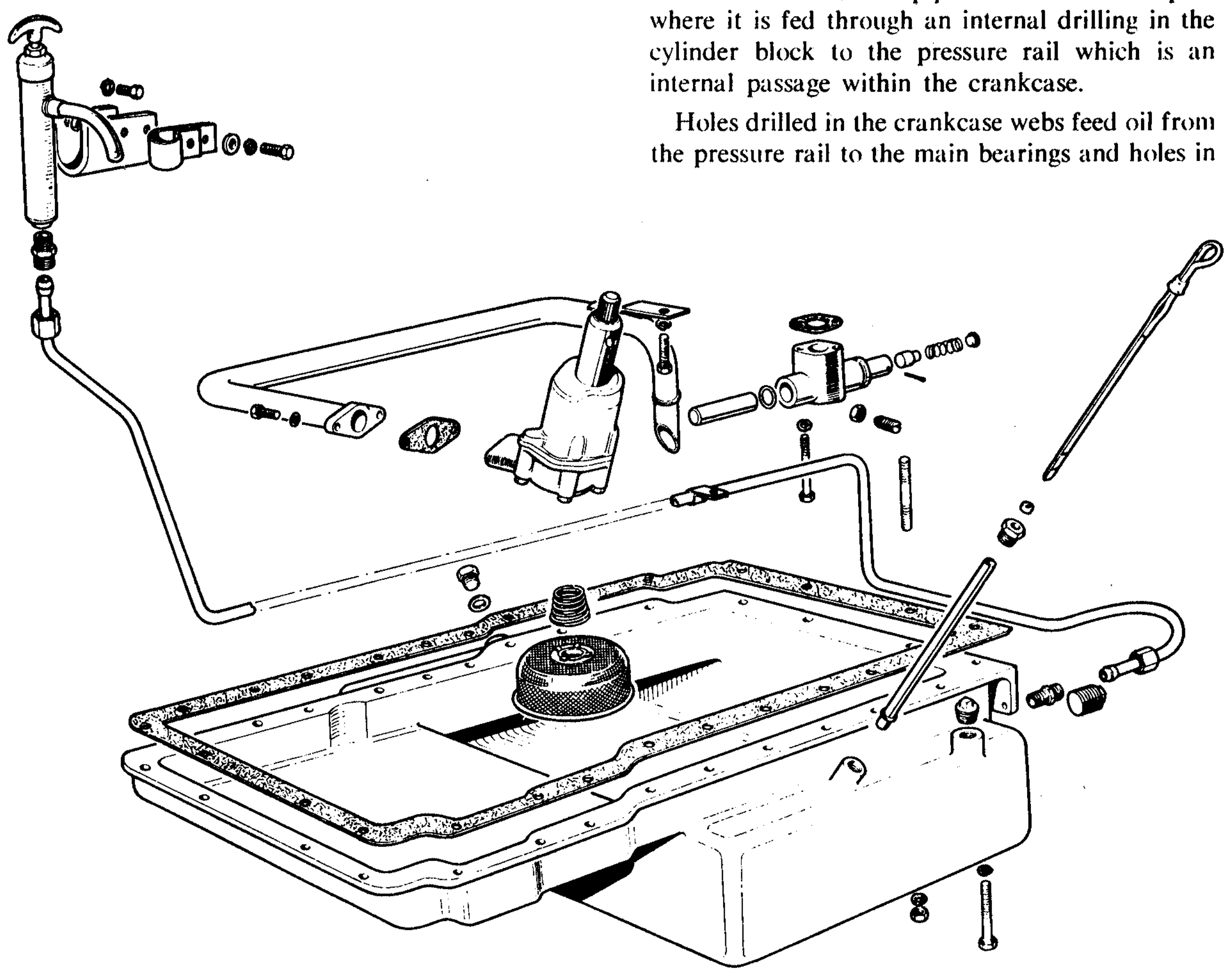


Fig. K.1.
Exploded view of Lubricating Oil Sump and Oil Pump (Vertical Engines).
Note : Current engines have a rose type or tube type strainer on the end of the suction pipe.

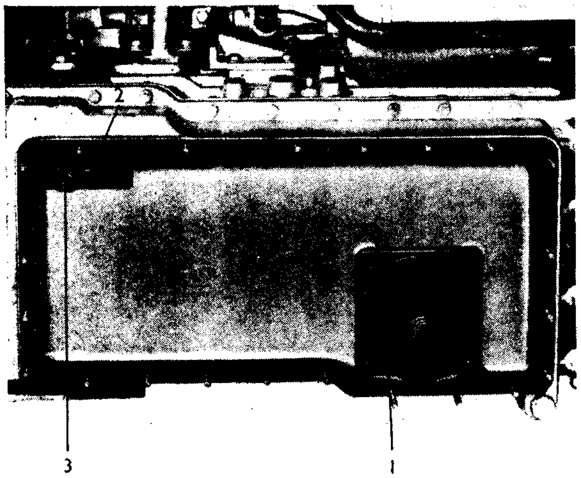


Fig. K.2.
View of Sump with Well removed.
(Horizontal Engines only).

1. Sump Strainer.
2. Oil Return from Relief Valve.
3. Oil Return from Scavenge Pump.

the crankshaft webs carry oil to the big end bearings. Surplus oil returns to the sump.

An oil seal prevents oil leaking along the crankshaft at the rear end and oil thrown from this seal returns to the sump.

The small end bushes are lubricated by splash and lubricating oil mist.

With later turbocharged engines the small end bush is pressure lubricated by means of a drilling in the connecting rod.

Oil is passed through drillings in Nos. 1, 3, 5 and 7 crankcase webs from the main bearings to lubricate the four camshaft bearings.

The rocker shaft is lubricated through a vertical drilling in the cylinder block and cylinder head from No. 2 camshaft bearing. To obtain a reduction in oil pressure to the rocker shaft, No. 2 camshaft bearing journal has three oil passages drilled in it. When one of the drillings is in line with the inlet drilling in the crankcase web another of the three drillings is in line with the outlet drilling leading to the rocker shaft. Owing to the short time that any one of these drillings in the camshaft journal is in line with the oil inlet drilling in the crankcase web, only a reduced quantity of oil is supplied to the oil outlet drilling leading to the hollow rocker shaft. Drillings in this shaft allow the oil to pass to the rockers, the overflow being returned to the sump by way of the push rod chamber.

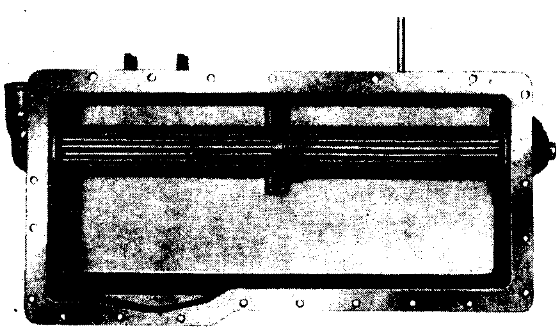


Fig. K.3.
Sump Well showing Engine Oil Cooler.
(Horizontal Engines only).

The auxiliary drive shaft bearings are lubricated by a drilling from the pressure rail to the front auxiliary drive bearing. The oil then passes around an annular groove in the bearing journal and through a further drilling along the outer side of the auxiliary drive housing to the rear auxiliary drive shaft bearing. Lubricant for the upper fuel pump drive bearing is also taken from this drilling.

Lubrication for the timing gears is taken from the oil passages of the front main bearing and auxiliary drive. The two idler gear spigots intersect these drillings. Oil is passed through the idler gear hubs and then through radial drillings in the gears where it escapes and lubricates the teeth of the gear train.

Horizontal Engines

Whilst the oil circulation on horizontal engines is similar to that employed for vertical engines, it does differ inasmuch as a "dry sump" lubricating system is employed.

The lubricating oil is contained in a separate sump well mounted on the side of the sump and contains a water cooled oil cooler. Lubricating oil is drawn from this sump well by the lubricating oil pump for the lubrication of the engine as previously described. When the lubricating oil drains back to the sump, it is pumped back to the sump well by means of the scavenge pump mounted on the front main bearing cap which is gear driven through an idler gear from the front of the crankshaft. With contra-rotating engines, two idler gears are used to give correct rotation of the scavenge pump.

Oil Pressure

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

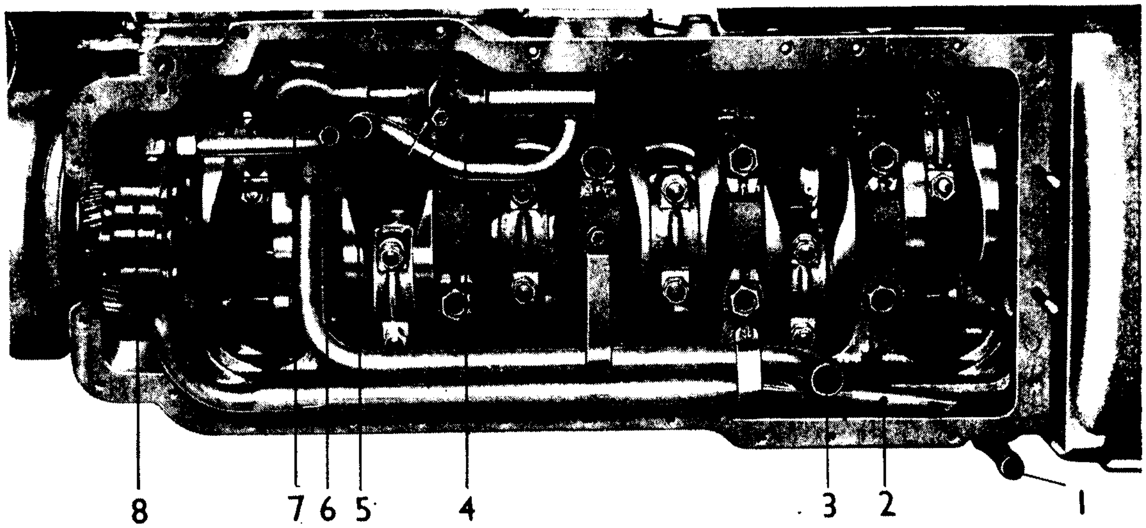


Fig. K.4.
View of Crankcase with Sump removed.
(Horizontal Engines only).

1. Oil Return from Turbocharger (Turbocharged Engines only).
2. Scavenge Pump Suction Pipe.
3. Lubricating Oil Pump Suction Pipe.
4. Oil Relief Valve.
5. Oil Relief Valve Return Pipe.
6. Scavenge Pump Return Pipe.
7. Lubricating Oil Pump.
8. Scavenge Pump.

but should be 30 to 60 lbf/in^2 (2,11 to 4,22 kgf/cm^2) at max. engine speed and normal operating temperature.

If the oil pressure, as registered on the gauge, is below normal check the following in the order given below.

1. Dipstick. Ensure that there is sufficient oil in the sump.
2. Oil pressure gauge. Check for accuracy with master gauge.
3. Lubricating oil filter. May be choked, renew element (See Preventive Maintenance, Section C).
4. Sump strainer. This may be choked, remove clean and replace (for removal instructions see page K.5).
5. Lubricating oil pump. Ensure that suction pipe and oil delivery housing joints are tight.
6. Oil pressure relief valve. Foreign matter may be preventing the valve from closing. For cleaning instructions see Page K.8.

The Oil Pressure Relief Valve

The oil pressure relief valve which is incorporated in the oil delivery housing prevents the pressure becoming excessive as might happen when the engine is cold.

When the predetermined pressure is exceeded the valve opens against the spring and some of the oil is by-passed back into the sump. That continues until the oil warms up and flows at the desired pressure. The valve then closes.

Renewing the Oil

The oil in the sump must be drained in accordance with the Preventive Maintenance Section C, and replaced by new oil of a specification suitable for the climate in which the engine is operated (See Appendix).

Draining may be effected by means of a hand operated sump pump.

In the case of earlier horizontal engines, two drain plugs are provided, one for the engine sump and one for the engine sump well.

Due to the variance in delivery of the lubricating oil pump and scavenge pump, the following procedure is recommended with horizontal engines when renewing the lubricating oil.

1. Fill engine sump well to full mark on dipstick.

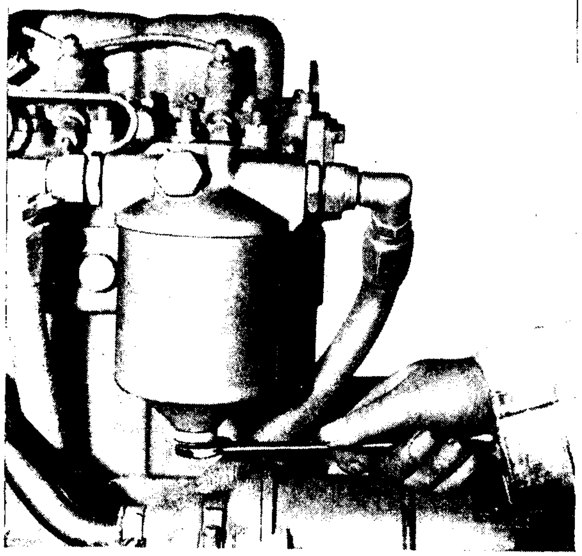


Fig. K.5.
Unscrewing Lubricating Oil Filter Bowl Securing Bolt.

2. Run engine until oil temperature is at normal operating temperature. Then idle engine for two minutes and shut down.
3. Top up sump well to full mark on dipstick. (This replaces residual oil remaining in the crankcase).

For routine oil level checks, horizontal engines should be idled for two minutes before checking the oil level.

N.B. The most accurate results are obtained with the engine running at idling speed. The oil level should not be checked with the engine running at speeds in excess of 1,000 rev/min, or if the engine has been shut down from speeds of over 1,000 rev/min without the two minutes idling period.

If it is necessary for safety purposes to shut down completely, i.e., boat at sea in adverse condition; pitching or rolling badly; inaccessibility to dipstick or rotating ancilliary equipment being dangerous to life or limb, the engine should still be idled for two minutes before shutting down and the oil level should be checked as soon as the engine stops.

General

Particular care must be taken to wipe off any water which may have splashed onto the engine at any time, since water which may find its way into the sump from the exterior, will tend to form sludge.

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

Lubricating Oil Filters

It is imperative that the lubricating oil filters are not neglected. To ensure cleanliness of the lubricating oil, the following filters are fitted to the engine.

1. Sump strainer.
2. Engine Main (full flow) filter.
3. Turbocharger (full flow) filter.

Note: With latest engines fitted with the Holset turbocharger, the separate turbocharger filter has been deleted. Where it is fitted, it is mounted adjacent to the engine main filter.

The sump strainer consists of a gauze wire container which fits over the suction pipe of the lubricating oil pump. All oil must pass through this filter before it reaches the oil pump and is delivered to the bearings. It should be cleaned every time the engine is removed from the boat.

The main (full flow) filters are a paper element or canister type filter. The oil passes through these filters after it has left the oil pump and before it reaches the bearings and turbocharger (where fitted). The element should not be cleaned, but renewed in accordance with Preventive Maintenance — Page C.3.

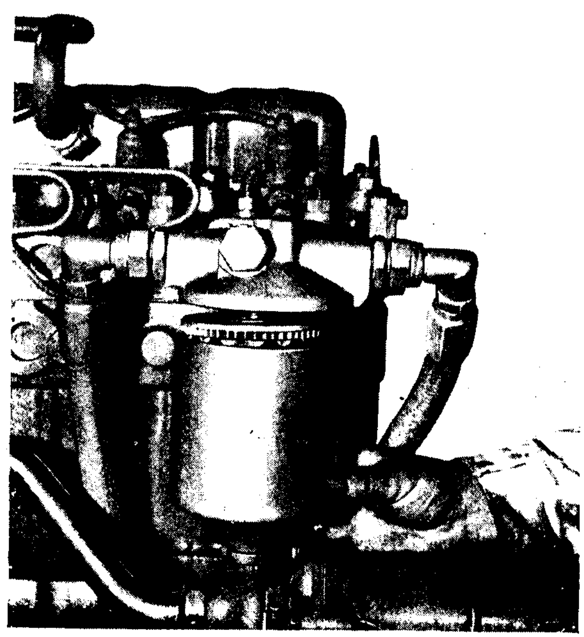


Fig. K.6.

Removing Lubricating Oil Filter Bowl.

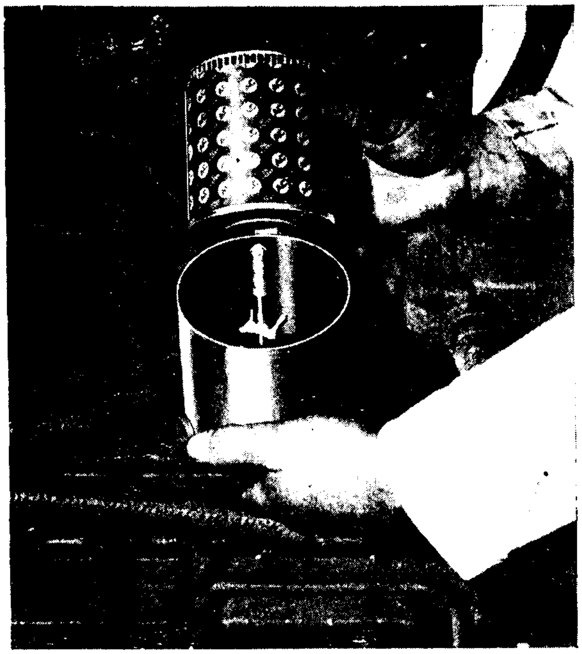


Fig. K.7.
Removing Lubricating Oil Filter Element.
Normally Aspirated Engines.

To Renew the Element (Paper Type)

1. Unscrew the bolt at the bottom of the filter bowl (see Fig. K.5).
2. Lower filter bowl clear (see Fig. K.6).
3. Remove element and discard (see Fig. K.7).
4. Before replacing new element into filter bowl, clean inside of filter with cleansing fluid.
5. Ensure that the rubber joint is in good condition. If not, replace with new joint.

The bolt securing the filter bowl should be checked for tightness after the first 50 hours running.

Vertical Turbocharged Engines

An inverted type filter is fitted to Vertical Turbocharged engines with a one piece bowl/element.

When removing this type filter element, the standpipe could remain in the engine adaptor as in Fig. K.8. or it may come away with the element, as in Fig. K.9.

The standpipe must be fitted back by screwing it into the new replacement filter element before fitting the assembly to the engine.

Horizontal Turbocharged Engines

This filter is similar in appearance to the one described above but an adaptor is fitted in place of the standpipe. Removal and fitting of the element should be carried out in the same manner.

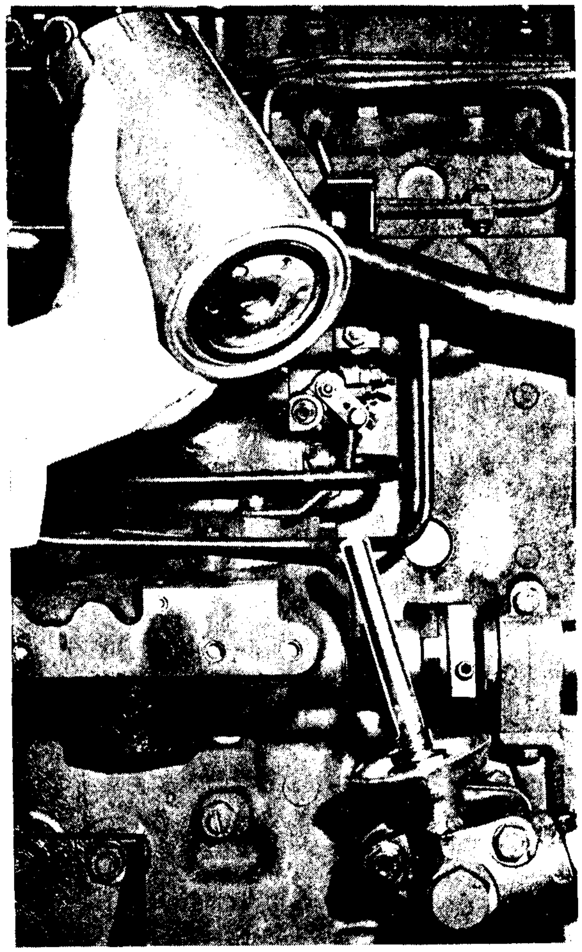


Fig. K.8.
Removing Lubricating Oil Filter Element
Vertical Turbocharged Engines.

Note: Whilst the engine and turbocharger filters may be similar in appearance, it should be noted that there is no by-pass valve in the turbocharger filter and the filter elements and bowls are not always interchangeable.

Screw On Type Oil Filter

All later engines employ a screw on type filter. The canister consists of a combined casing and element. With early canisters, a standpipe was screwed into the element and the standpipe was threaded at its lower end which screwed into the filter head. With current canisters, the standpipe is an integral part of the canister and a threaded adaptor secures the canister to the filter head.

The later type screw on filter canister will fit over the standpipe which was designed for the earlier canister, making the two canisters interchangeable in this respect.

Under no circumstances may an earlier screw on canister without an integral standpipe, be fitted in an inverted position on an engine without a standpipe, as this would allow the oil to drain from the filter when the engine is at rest. If there is no standpipe fitted to the filter head casting, then you must always fit the later type canister with the inbuilt standpipe.

The earlier type canister can be identified by a number of small holes which can be seen on the inside of the element within the canister, whilst on the later canister, the integral standpipe can be seen.

Always fit the correct Perkins filter canister as the following features are incorporated in current canisters which may not be included in other types.

1. A filter by-pass valve set to a pressure to suit the applicable engine type.
2. An integral standpipe to prevent drainage of the filter through the engine bearings.
3. A rubber flap valve to prevent drainage of the filter through the oil pump.

To Renew the Canister

1. Unscrew the filter canister from filter head.
2. Discard old canister.
3. Clean filter head.
4. Using clean engine oil, liberally oil top seal of replacement canister.
5. Fill the new canister with clean lubricating oil allowing time for the oil to filter through the element.
6. Screw replacement canister onto filter head until seal just touches head and then tighten by hand as per instructions on canister. Where a tool is available, tighten to 12—15 lbf ft (1,66—2,07 kgf m).
7. Run engine and check for leaks.

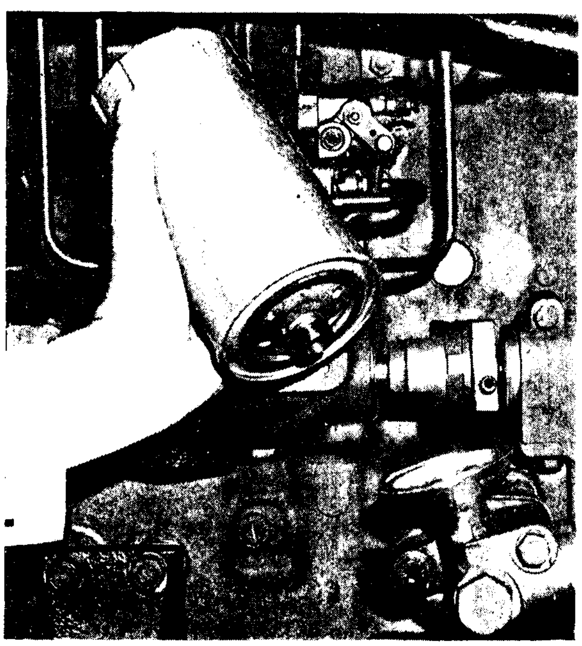


Fig. K.9.
Fitting Lubricating Oil Filter Element
Vertical Turbocharged Engines

To Remove Sump and Sump Strainer (Vertical Engines)

Note: The removal of the engine sump will depend on the engine installation. In some cases, it will be necessary to remove the engine from the boat before the sump can be removed.

Remove engine oil by means of the sump drain pump.

Remove dipstick and dipstick tube.

Disconnect pipe between sump and sump drain pump.

Remove all setscrews securing sump to crankcase and flywheel housing and drop sump clear.

With the sump will come the sump strainer. It is recommended that this strainer be cleaned every time the sump is removed. It should be washed in cleaning fluid.

To Replace Sump (Vertical Engines)

Assemble new joints.

Lightly smear crankcase and flywheel housing faces with a thin coating of jointing compound and place joints in position ensuring all holes line up.

To facilitate replacement of sump, screw two guide studs into the crankcase, one on each side. The studs will position the sump accurately and prevent displacement of the joints.

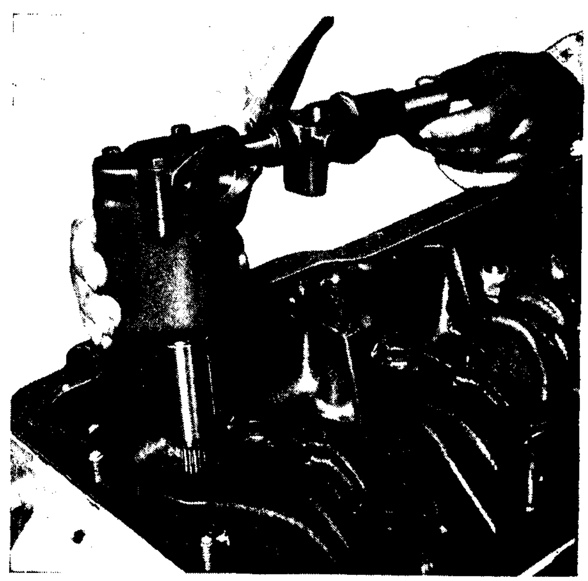


Fig. K.10.
Removing Lubricating Oil Pump.

Place sump strainer in bottom of sump.

Fit sump to crankcase, ensuring oil pump suction pipe enters the hole in the sump strainer. remove guide studs.

When all the setscrews have been inserted, tighten evenly all round. Do not overtighten setscrews.

Finally, replace dipstick and dipstick tube and connect up pipe between sump and sump drain pump.

To Remove Sump Well and Strainer (Horizontal Engines).

Remove generator complete with bracket.

Uncouple oil pipes to and from oil filter(s) and remove oil filter(s) complete with bracket.

Remove oil filler body.

Remove dipstick.

Uncouple water cooling connections to oil cooler.

Unscrew nuts securing sump well to sump and remove sump well complete with oil cooler.

The sump strainer which is bolted to the wall dividing the sump from the sump well can now be removed.

Remove sump well (see previous heading).

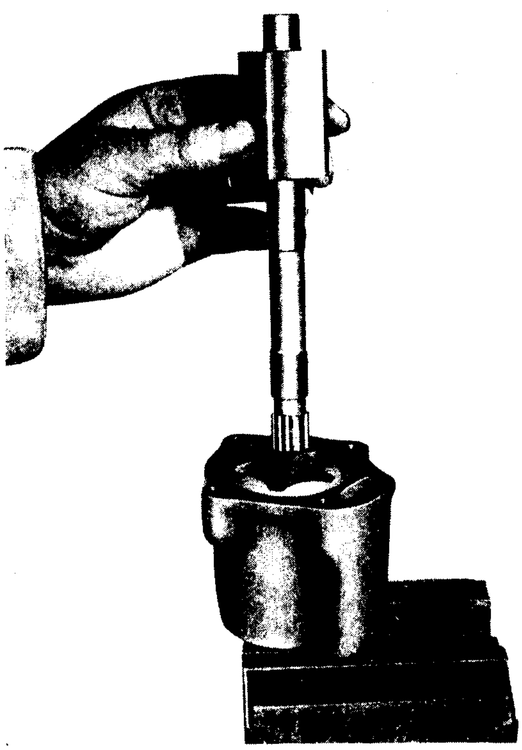


Fig. K.11.
Removing Lubricating Oil Pump Inner Rotor and Shaft.

To Remove Sump (Horizontal Engines).

Uncouple oil return pipe from turbocharger to bottom of sump (turbocharged engines only).

Unscrew setscrews and remove lubricating oil sump.

To Replace Sump Well and Sump (Horizontal Engines).

The replacement of these items may be effected by reversing the order of dismantling. New joints should be used where applicable.

Easy replacement of the sump may be facilitated by using two guide studs screwed into each side of the crankcase which will ensure correct positioning of the sump and joints. These studs should be removed and replaced by setscrews once the sump has been secured to the crankcase.

When replacing the sump, it should be ascertained that the oil pump suction pipe correctly enters the grommet in the wall dividing the sump from the sump well. It should also be ascertained that this grommet is in good condition and not damaged as any leakage here will permit lubricating oil to leak from the sump well into the crankcase.

To Remove and Refit Oil Pump and Oil Delivery Housing

Remove sump and sump strainer (see previous headings).

Disconnect oil delivery housing from the crankcase by removing the two securing setscrews.

Fig. K.12.
Removing Lubricating Oil Pump Outer Rotor

Unscrew the lubricating oil pump locating setscrew. This screw is situated outside the cylinder block.

The oil pump and oil delivery housing may now be removed (See Fig. K.10).

The two parts of this assembly are connected by a short pipe which is a push fit in each component (See Fig. K.10). A rubber 'O' ring is recessed into the bore of both the lubricating oil pump and the delivery housing to ensure an oil tight joint.

It is advisable to renew these seals whenever the connecting pipe is disturbed.

To refit, reverse the above order of operations.

The lubricating oil pump should be primed with oil before fitting.

To Remove and Clean Oil Pressure Relief Valve

The oil pressure relief valve is contained in the oil delivery housing, the removal of which together with the lubricating oil pump, is explained elsewhere in this section. Wash the valve in clean fuel oil or kerosene and blow dry with compressed air.

To Dismantle the Oil Pump

Remove pump from engine (See previous headings).

Remove the suction pipe.

Fig. K.13.
Checking clearance between Inner and Outer Rotor.

Remove the setscrews securing the bottom cover.

The shaft, inner and outer rotor can then be removed. (See Fig. K.11 and K.12).

An alternative type oil pump has been fitted on some engines which can be readily identified when inspecting the rotors.

Instead of a five lobed outer and four lobed inner rotor assembly, a four lobed outer and three lobed inner rotor assembly is used. The principle of operation is the same and the same checks and clearances are applicable.

Inspection

Thoroughly clean all parts and inspect the rotors for cracks or scores.

Install the drive and driven rotors in the pump body making sure the chamfered edge of the outer rotor enters the pump body first.

Check the clearance between the inner and outer rotors at all points (See Fig. K.13), the end float of the inner and outer rotors (See Fig. K.14) and outer rotor to pump body clearance. The relevant clearances for these dimensional checks are given on page B.11. They are the clearances applicable to a new pump and are intended to be used as a guide.

Should a lubricating oil pump be worn to such an extent that adversely affects the working oil pressure, then a replacement pump should be obtained.

SPECIAL NOTE: If the oil pump is considered faulty then it must be replaced by a complete unit, as component parts will not be supplied.

The hydraulic wormwheel assembly as described on page J.7 calls for a lubricating oil pump with an oil drain channel in the drive end of the body casting. It is important to note that lubricating oil pumps without this drain channel must not be used to replace pumps with a drain channel as this will prevent the drain of oil from the hydraulic loading within the auxiliary drive housing.

To Reassemble the Oil Pump

Fit the drive and driven rotors in the body entering the chamfered end of the outer rotor to the body first and replace the end cover. Using a new "O" ring, secure with the four setscrews.

Refit the suction pipe with new joint.

Reassemble pump to engine as described under previous heading in this section.

To Remove Scavenge Pump (Horizontal Engines).

Remove sump well and sump (see previous headings).

Remove timing case (see Page J.1).

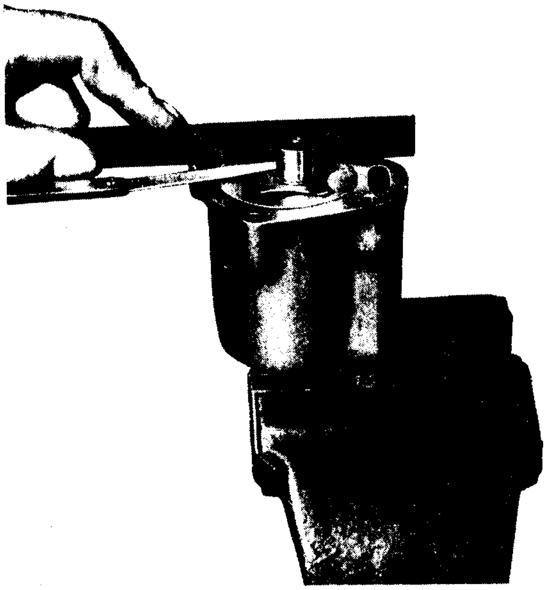


Fig. K.14.

Checking End Float of Rotors.

Remove inlet and outlet pipes to and from scavenge pump.

Remove idler gear between scavenge pump gear and crankshaft gear.

Unscrew setscrews and remove scavenge pump from front main bearing cap (see Fig. K.15).

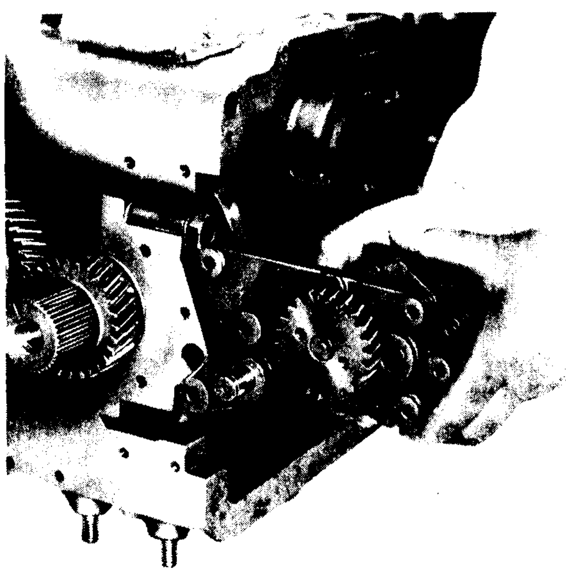


Fig. K.15.

Removing Scavenge Pump.

(Horizontal Engines only).

Dismantling Scavenge Pump (Horizontal Engines).

Place scavenge pump mounting bracket in a vice and remove six setscrews securing end plate to scavenge pump body.

Remove end plate.

At this stage of dis-assembly, it is possible to check the end float of the oil scavenge pump gears and the clearance between the gears and the pump body. (see Figs. K.16 and K.17). End float should not exceed 0.004 in (0,10 mm) and outer clearance should not exceed 0.0065 in (0,16 mm).

The pump may now be completely dismantled by removing the drive gear and removing the pump body from the mounting bracket. Two extractor holes are provided in the scavenge pump drive gear to facilitate removal.

Re-assembly of the scavenge pump may be effected by reversing the sequence of dis-assembly. New joints should be used with a proprietary make of jointing compound.

Check that the pump turns freely before fitting to engine.

Prime with lubricating oil before fitting.

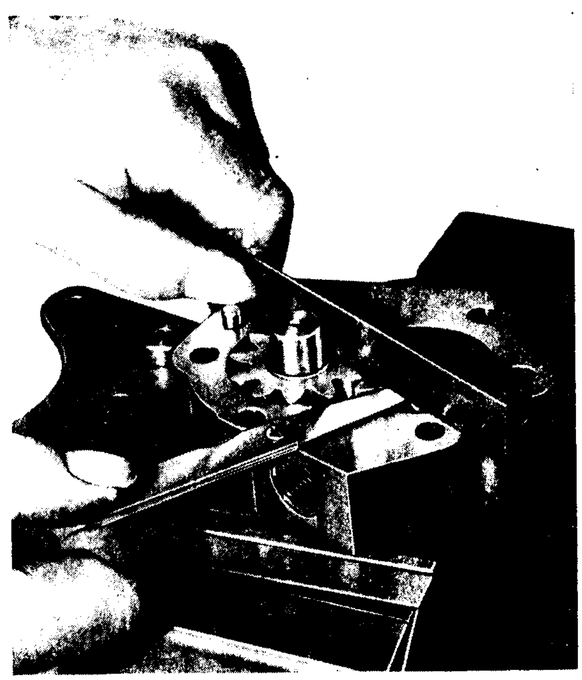


Fig. K.16.

Checking End Float of Gears in Scavenge Pump.

(Horizontal Engines only).

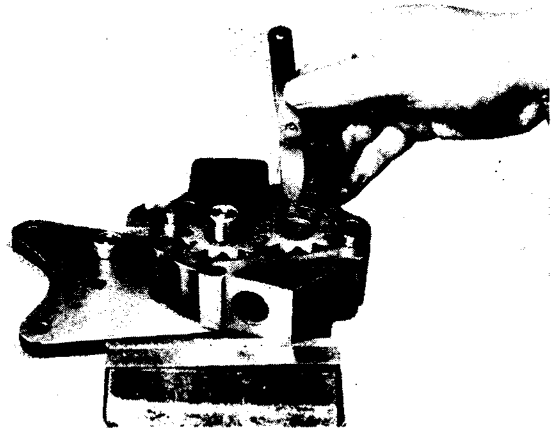


Fig. K.17.

Checking clearance between Gears and Scavenge Pump Body. (Horizontal Engines only).

To Remove Oil Cooler (Vertical Engines)

1. Uncouple inlet and outlet water connections to oil cooler.
2. Remove inlet and outlet oil pipes.
3. Remove oil cooler by unscrewing the two nuts on the ends of the oil cooler securing bar.

Replacement of an oil cooler is effected by reversing the above procedure.

Dismantling an Oil Cooler

1. Remove the oil cooler end covers by unscrewing the securing setbolts.
2. Remove the rubber "O" rings at each end of the cooler.
3. Drive tube stack out of oil cooler casing.

Cleaning an Oil Cooler

Under normal circumstances, oil coolers will require little attention, providing the sea water inlet strainer is efficient and is kept clean.

After a lengthy period of service, it may be necessary to clean the tube stack and this may be effected in a similar manner as given for the heat exchanger on Page L.7.

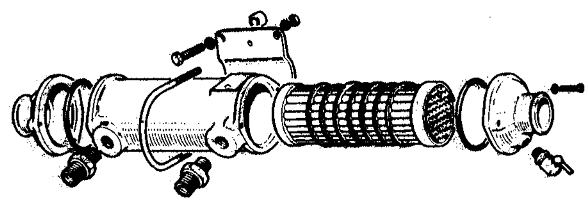


Fig. K.18.

Exploded View of Lubricating Oil Cooler. (Vertical Engines).

Oil Coolers (Horizontal Engines)

With the majority of horizontal engines, the oil cooler is mounted in the lubricating oil pump well (see Fig. K.3).

Very latest horizontal lowline engines, the oil cooler may be mounted externally and these cases, removal and cleaning is similiar to that for vertical engines.

SECTION L
Cooling System

The 6.354 Marine engine is indirectly cooled. This type of system employs two separate water circuits. One is the fresh water (closed) circuit which circulates around the cylinder block and head and the other is the sea or river water (open) circuit which circulates externally around the engine. Heat is interchanged between circuits by a heat exchanger unit. Two separate water pumps are employed.

Lowline Engines

A neoprene impeller type pump is used to circulate the coolant on the open side of the system. The raw water is drawn in through the gearbox oil cooler to the water pump. From the water pump, it is delivered to the engine oil cooler and then to the intercooler (where fitted to turbocharged engines only). From the intercooler, it is pumped to the heat exchanger and then to the exhaust manifold. From the manifold, it is passed to the water injection bend and is discharged via the engine exhaust.

Circulation of the closed fresh water system is effected by a centrifugal pump mounted on the front of the cylinder block, the pump being belt driven from the crankshaft. Water is pumped from the header tank mounted on the front of the engine to the cylinder block where both the block and head are cooled by thermosyphon action. From the block and head, water is returned to the lower half of the header tank. In the lower half of the header tank at the rear is a thermostat and as the fresh water temperature rises, the thermostat opens and allows the water to flow through the heat exchanger (which is cooled from the water in the open side of the cooling system) and then back to the upper part of the header tank. The upper and lower halves of the header tank are separated by an integral baffle plate.

The header tank is fitted with a pressurised filler cap and the coolant operating temperature of the closed circuit system should be in the region of 190°F (88°C).

The water pumps for both circuits are described later in this section.

Standard Engines

The rubber impeller type water pump is used to circulate the coolant on the open side of the cooling system. With vertical engines the water is drawn in through the gearbox and engine oil coolers to the water pump. From the water pump, it

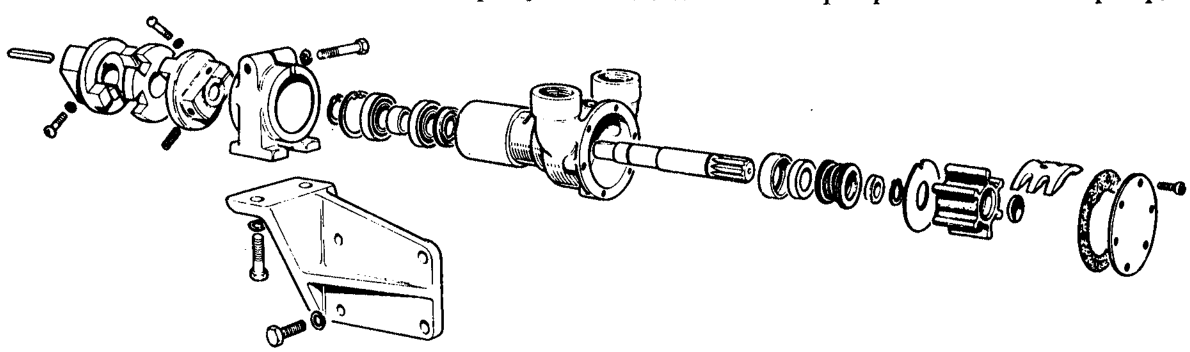


Fig. L.1.
Exploded View of Sea Water Pump.

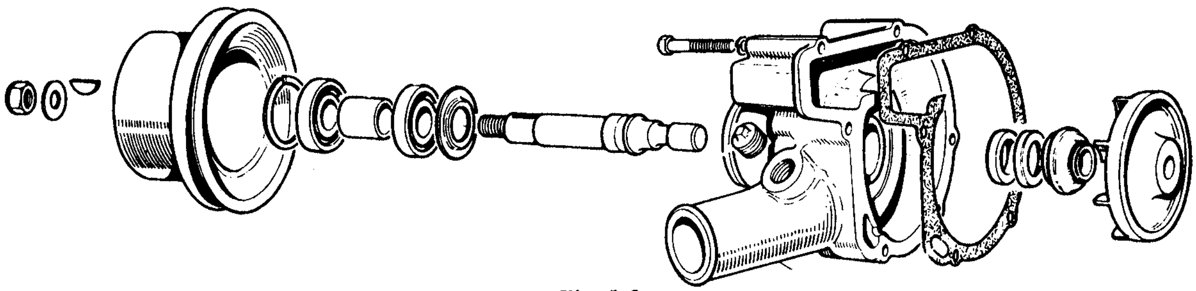


Fig. L.2.
Exploded View of Fresh Water Pump.

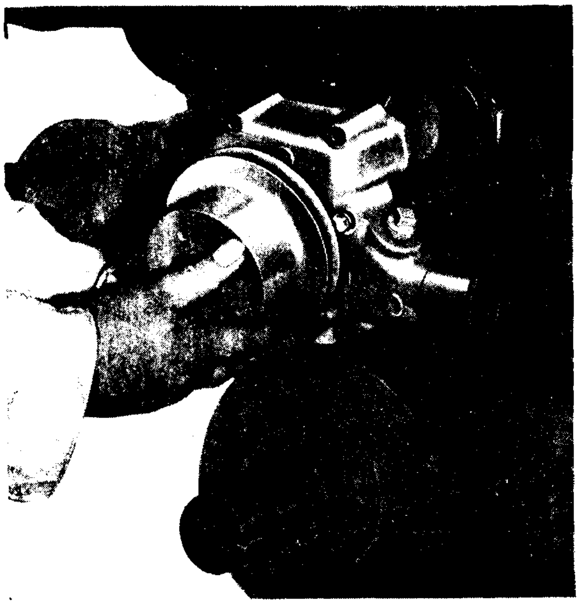


Fig. L.3.
Removing Fresh Water Pump.

is delivered to the heat exchanger mounted on the front of the cylinder head and from the heat exchanger to the water cooled exhaust manifold. From the water manifold, the water is discharged overboard.

With horizontal engines, the water is drawn in through the intercooler and gearbox oil cooler to the water pump. From here it is delivered to the engine oil cooler in the sump well and then to the heat exchanger. From the heat exchanger, the water is pumped to the water cooled exhaust manifold and finally overboard.

Circulation of the closed fresh water system is effected by means of the centrifugal water pump mounted on the front of the cylinder head and belt driven from the crankshaft. Water is drawn from the heat exchanger and delivered to the cylinder block by means of an integral water manifold. Cooling of the cylinder block and head is then effected by impeller assisted thermo-syphon action. After circulation through the engine, the water is discharged at the front of the cylinder head back into the heat exchanger.

The top part of the heat exchanger forms a header tank for the fresh water and a pressurised filler cap set at 4 lbf/in² (0.28 kgf/cm²) is provided.

The operating temperature of the closed water systems at the outlet should be in the region of 190°F. (88°C).

Centrifugal Type Water Pump

This water pump is mounted on the front of the cylinder block and is belt driven from the front of the engine crankshaft. The bearings are prepacked with a special grease during assembly and do not require any attention in service.

With contra-rotating engines, the centrifugal fresh water pump operates in a reverse direction and to ensure correct flow of coolant, the volute in the pump is cast in the opposite direction (See Fig. L.7).

To Remove the Pump

1. Slacken dynamo securing and adjusting setscrews and remove drive belt.
2. Remove inlet connection to water pump.
3. Unscrew the six setscrews securing the pump to the cylinder block and remove the water pump (See Fig. L.3).

To refit the pump, reverse the sequence of removal, ensuring the joint faces on the pump and cylinder block are clean and a new sealing joint is fitted.

To Dismantle the Pump

1. Unscrew the self locking nut securing the pulley to the pump shaft and remove nut with plain washer.
2. Using a suitable withdrawal tool, remove pulley from shaft (see Fig. L.4) and remove pulley driving key.
3. Press the water pump shaft complete with impeller out of water pump body from front of pump.
4. By means of a suitable press, remove the impeller from the pump shaft.

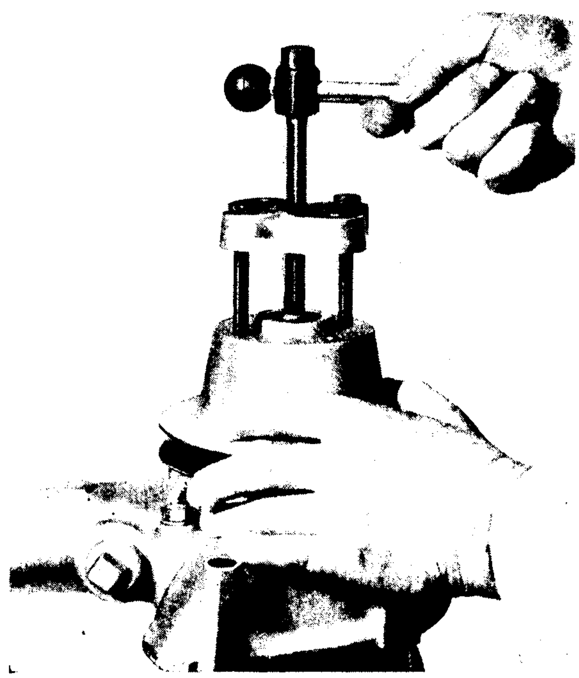


Fig. L.4.
Removing Fresh Water Pump Pulley.

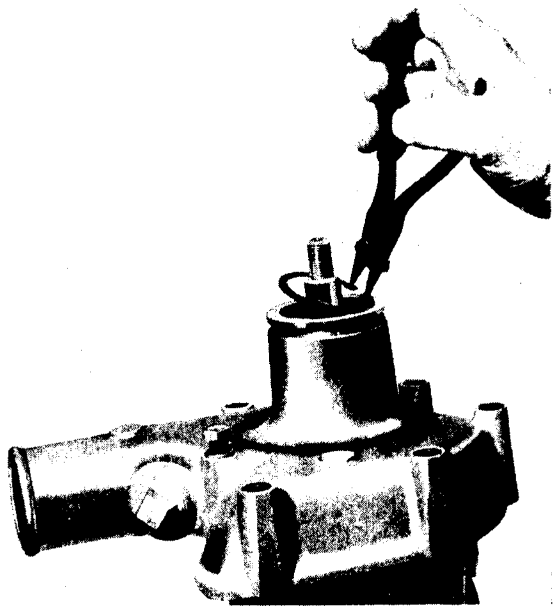


Fig. L.5.
Removing Bearing Retaining Circlip.
(Fresh Water Pump).

5. Remove rear seal from pump shaft.
6. Remove bearing retaining circlip using a pair of circlip pliers (see Fig. L.5).
7. Press the two bearings and distance piece out of pump body.
8. Finally remove front seal and seal retainer flange.

Inspection

Examine pump housing for cracks, damage or corrosion.

Examine drive shaft for wear ensuring the inner bearing races are a satisfactory fit on the shaft. The shaft should be renewed if wear in this area is sufficient to allow races to rotate on the shaft.

Remove rust and scale from the impeller and visually inspect for cracks or damage. Examine impeller hub sealing face for excessive wear or scoring. Renew if unserviceable.

Examine rear seal for damage. Excessive wear, scoring or cracks in the carbon face will necessitate renewal.

Wash bearings in thin lubricating oil and inspect for pitting, corrosion or wear. Renew if necessary.

To Re-assemble Water Pump

1. Press rear bearing onto shaft, fit bearing distance piece and then press on front bearing. Ensure that each bearing end cover faces outwards towards the front and rear of shaft.
2. Fit the front seal retaining plate in position against the back face of the rear bearing. This retaining plate is dished and when positioned, the centre plate must not be in contact with the bearing.
3. Fit the felt seal and seal retainer housing so that these bear on the retaining plate.
4. Half fill the space between the bearings with a high melting point grease and press the complete assembly into the pump housing from the front end. Securely position the retaining circlip in the recess of the housing immediately forward of the front bearing.
5. Fit the rear seal into the housing ensuring that the carbon face is positioned towards the rear. When fitted, the seal must rest squarely on its seat and not be canted in any way.
6. At this stage, the shaft should be turned by hand to ensure that no undue resistance to rotation exists.
7. Replace setscrew which goes behind water pump pulley.
8. Fit pulley driving key and press on pulley making certain that no rearward axial movement of the shaft is incurred.
9. Press the impeller onto the shaft ensuring that a clearance of 0.012 to 0.035 in (0,30 to 0,89 mm) is maintained between the inner edge of the impeller and the pump body (see Fig. L.6).
10. Refit plain washer and pulley retaining self locking nut, tightening to a torque of 55 to 60 lbf ft (7,6 to 8,3 kgf m).

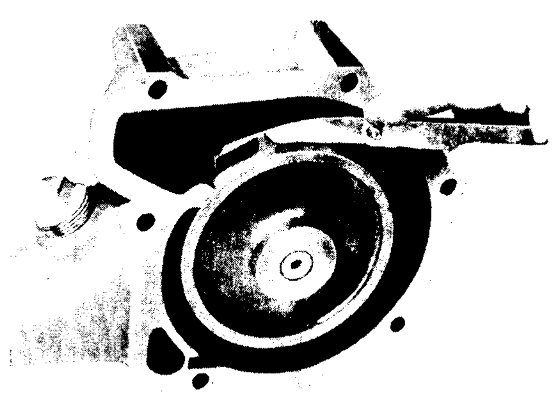


Fig. L.6.

Checking Impeller Clearance on Fresh Water Pump

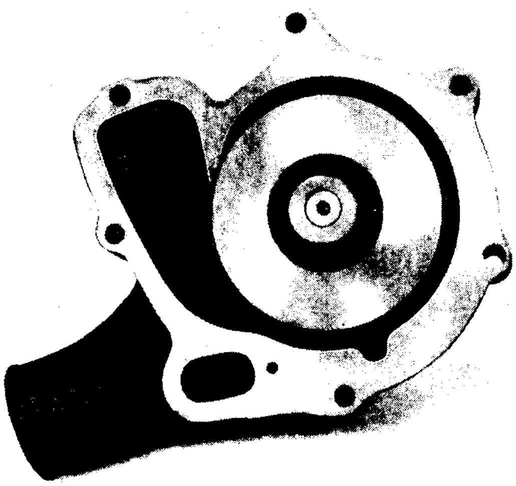


Fig. L.7.
Rear View of Fresh Water Pump fitted to Contra Rotating Engines.

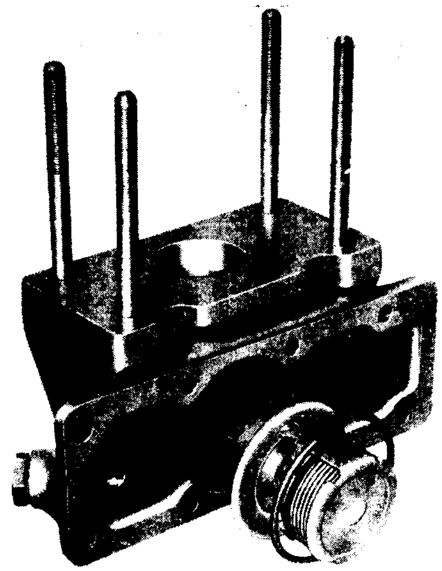


Fig. L.8.
Exploded View of Thermostat Housing and Thermostat. (earlier engines)

Thermostatic Operation

A thermostat is incorporated in the closed water cooling system to allow the engine to reach the most efficient working temperature quickly.

When the correct temperature is reached, the thermostat valve opens and allows the water to circulate normally.

On earlier engines the thermostat is situated in the water outlet connection fitted on the front of the cylinder head and secured in position by means of a circlip (see Fig. L.8).

With lowline engines, the thermostat is fitted at the rear of the header tank at the outlet connection to the heat exchanger.

Rubber Impeller Type Water Pump

This type of water pump is mounted on the port side of the engine and is driven at the rear of the auxiliary drive shaft.

It should be noted that with contra-rotating engines, the sea water pump also rotates in reverse direction and to provide correct flow of coolant, the inlet and outlet connections to the water pump are reversed.

This water pump should never be run in a dry condition and if the engine is withdrawn from service for a length of time, it will be necessary to effect lubrication of the rubber impeller at the commencement of the storage period. This may be effected by removing the water pump end plate when the interior of the pump should be lubricated with MARFAK 2HD grease.

This treatment is carried out before the engine leaves the works and is usually effective for about three months.

To Remove the Pump

1. Uncouple inlet and outlet water connections.
2. Loosen clamp bolt in pump mounting bracket.
3. Loosen clamp bolt in rear half of water pump coupling.
4. Remove the pump by withdrawing it rearwards and out of its mounting bracket. (See Fig. L.10).

Replacement of the pump may be effected by reversing the above procedure.

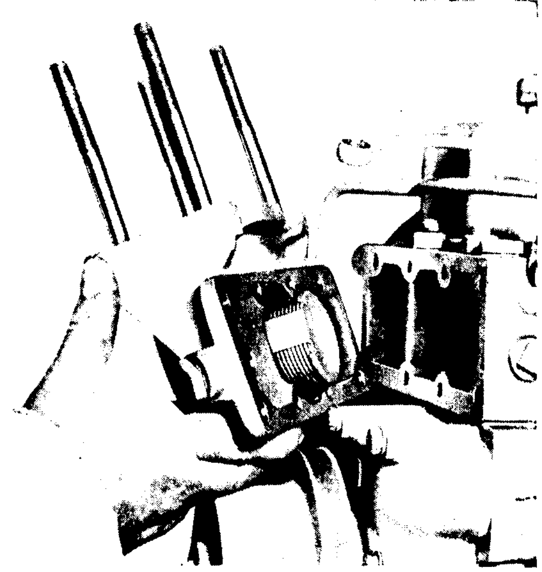


Fig. L.9.
Removing Thermostat Housing. (earlier engines)

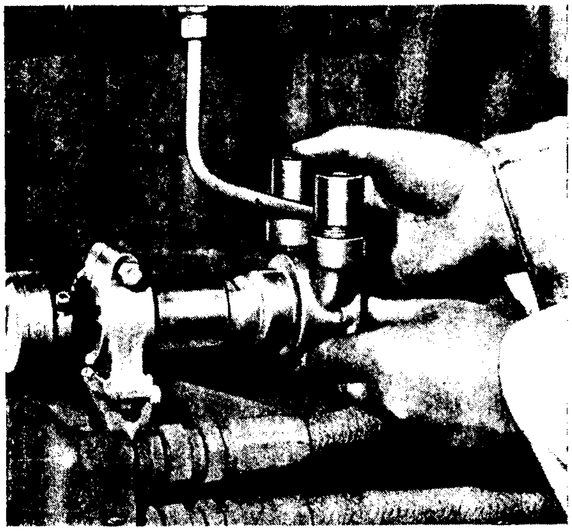


Fig. L.10

Removing Sea Water Pump.

Dismantling the Pump

1. Remove the water pump end plate.

2. Remove the impeller by means of a pair of pliers. If it is tight on the shaft, loosen it by holding impeller and twisting shaft backwards and forwards. In difficult cases, it is best to wait until the water pump shaft is removed.

3. Loosen the cam locking screw a few turns then lightly tap securing screw downwards to loosen cam in pump body.

4. Remove cam locking screw and cam.

5. Remove wear plate from inside of impeller housing.

6. Remove circlip on the water pump shaft and withdraw the spring loaded seal and seal seat.

7. Remove the seal from the driving end of the water pump.

8. Remove the outer bearing retaining circlip from the bearing housing.

9. A suitable press may then be used to press out the water pump shaft together with the water pump bearings.

10. Remove the inner retaining circlip and press bearings off the water pump shaft.

In the event of wear being present on the impeller wear plate or water pump end plate, both these parts may be reversed. In the case of the end plate, it may be necessary to remove the stamped instructions by means of emery paper. This will remove the arrows showing the rotation of the impeller, but this rotation can be ascertained by turning the engine and noting the rotation of the pump coupling.

To re-assemble the water pump, the reverse order of dismantling should be adopted.

When replacing the cam fitted in the impeller housing, be certain to coat the entire top surface, rear face and securing setscrew with a suitable jointing compound.

Note that the cam will go into position one way only.

Care should be taken when replacing the rubber impeller that all the blades lay in the same direction relative to the rotation of the pump i.e., blades trailing.

When re-assembling, ensure that the rubber impeller is coated with MARFAK 2HD grease.

Dismantling the Heat Exchanger

It is suggested that the heat exchanger be dismantled in the following order :—

1. Remove the open circuit pipes from their respective end covers.

2. Remove the brass cap nut or setscrews securing end cover.

3. This end cover can now be removed.

4. The other end cover complete with rod (early engines) can now be withdrawn. With current low-line engines, the other end cover is removed by unscrewing the two retaining setscrews.

5. Remove the 'O' seals from the ends of the tube stack and withdraw the latter from its casing.

6. The main aluminium casing can now be removed from the engine if necessary.

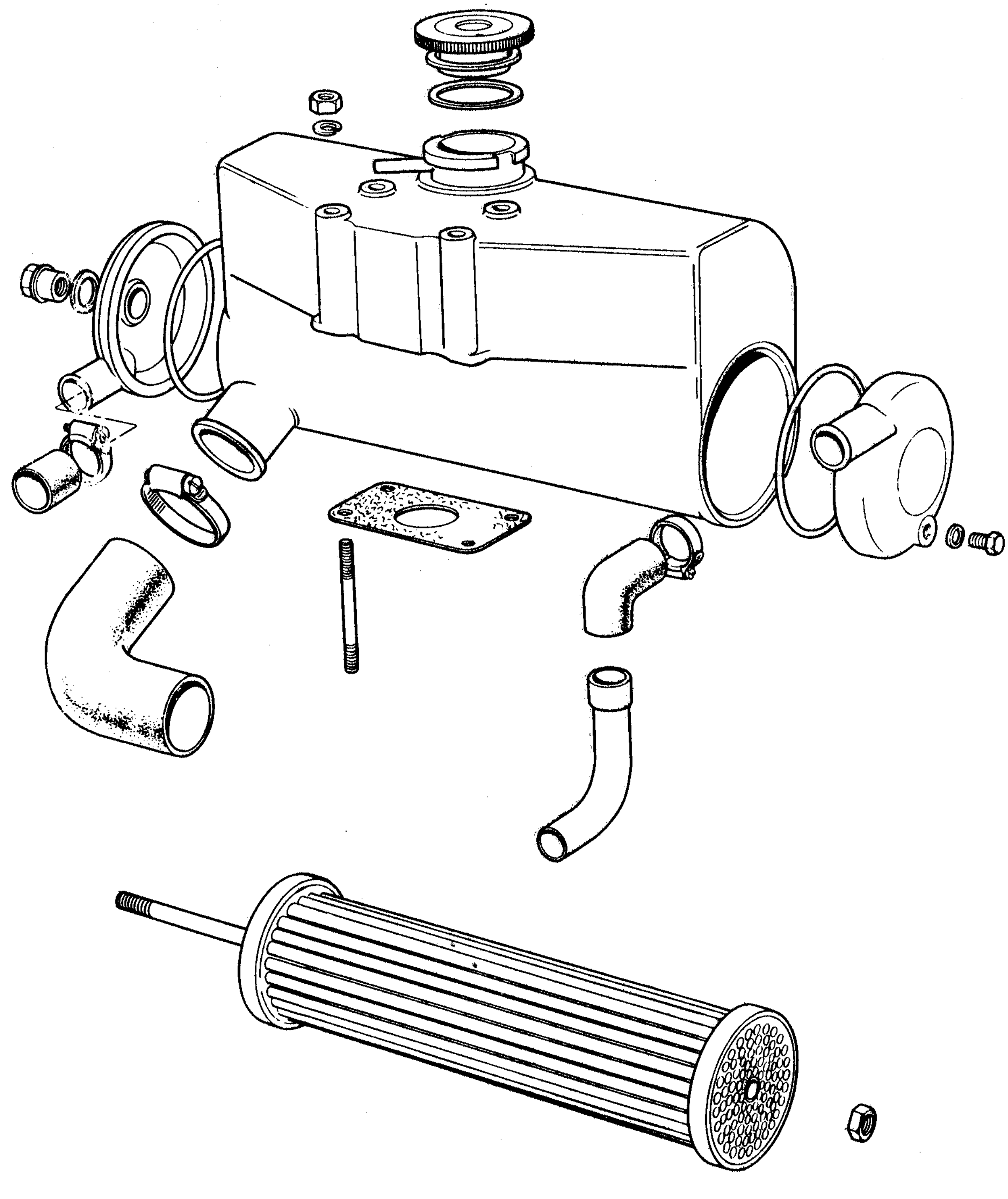


Fig. L.11.
Exploded View of a Heat Exchanger Assembly when combined with Header Tank — early engines.

INSIDE
SALT SIDE

Cleaning the Heat Exchanger

If the tube stack appears to be badly choked, the best method of cleaning is to place the assembly in a hot (preferably boiling) caustic soda solution. This will loosen all foreign matter adhering to the unit.

Generally speaking however, the fresh water side, i.e., the outside of the tubes should be relatively clean as these are on the closed circuit. The inside of these tubes which may have salt water passing through them are more likely to require cleaning. If these are not badly scaled enough to require the caustic soda solution treatment described above, they can be cleaned by pushing a length of ⅛ in (3,2 mm) diameter steel rod down the tubes so as to dislodge all foreign matter. It is important to note that when doing this, the rod should be pushed through the tubes in the opposite direction to that in which the water flows. Do not use undue force to push the rod through the tubes.

The other components of the unit should be cleaned before re-assembly and as these have no hidden surfaces, no special instructions are considered necessary.

Re-Assembly of the Heat Exchanger

If the main aluminium casing has been removed completely, it is best to refit this to the engine first before re-assembling the heat exchanger itself, although if conditions are too cramped, it is quite possible to re-assemble the heat exchanger first and then attach it to the engine.

1. Place the tube stack in its casing and fit the 'O' seals over each end cover. It is advisable to renew these seals if they appear to be badly worn or deformed.
2. Tie rod and end cover assembly (early engines) should now be replaced.
3. Refit the other end cover and connect up open circuit water pipes.
4. Replace the copper/asbestos washer and tighten the cap nut to a torque of 25 lbf ft (3,46 kgf m).
5. With current low-line engines, replace the two end covers, secure with setscrews and connect up open circuit water pipes.

Air Charge Coolers

These should be serviced every season. According to operating conditions, this period may have to be reduced.

The method of cleaning is similar to that given for heat exchangers.

Water Pump and Generator Belt Adjustment

To prevent premature wear and eventual failure, correct tension of the belt should be maintained by periodical checking and adjustment. See Periodical Attentions Section C.

Excessive belt tension, and consequent overloading of water pump bearings, is detrimental both to belt and bearings and may cause complete failure of one or other of these components.

Insufficient belt tension, allowing belt slip, will impair the efficiency of the engine cooling system and adversely affect generator output.

Method of Checking Adjustment

Check the belt for tension at the longest unsupported length. If correctly adjusted, a free sideways movement of approximately ⅜ in (9 mm) should exist at this point.

Method of Adjustment

Slacken off the generator adjusting lever setscrew, the adjusting lever to timing case setscrew and the generator bracket support bolts.

The generator is now free to be moved on its support bracket toward or away from the engine to obtain the correct belt tension.

Hold the generator in the desired position and tighten the adjusting lever setscrew, the lever to timing case setscrew and the bracket support bolts.

In the case of horizontal engines, a separate drive belt is provided for driving the water pump. This water pump drive belt is adjusted by means of a jockey pulley mounted on the front of the timing case.

NOTE: When a new belt is fitted it is advisable to re-check adjustment after a short running period. New belts are subject to initial stretch and early readjustment may be necessary.

SECTION M
Air Filters and Fuel System

Air Filter

The air filter fitted to 6.354 marine engines consists of a gauze type filter.

This should be removed in accordance with Preventive Maintenance (Page C.3) and washed in a suitable cleansing fluid.

FUEL FILTER

Fuel oil filters are provided as well as a dirt trap in the fuel tank.

The first filter is a gauze trap in the filler of the fuel tank. This must not be removed when fuel is being poured into the tank. It should be periodically cleaned.

If there is no filter in the filler, the fuel should be poured through a fine gauze strainer when filling the tank.

The second filter is a gauze type fitted in the fuel lift pump. It should be removed, by unscrewing the bolt securing the domed cover on top of the fuel lift pump, and cleaned in accordance with Preventive Maintenance (Page C.3) unless condition of the fuel calls for more regular attention.

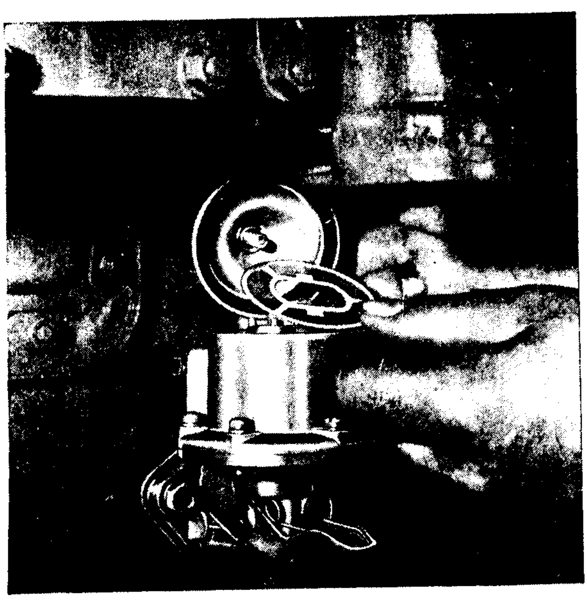


Fig. M.1.
Removing Gauze Filter in Fuel Lift Pump.

Fig. M.2.
Unscrewing Final Fuel Filter Bowl Securing Bolt.

Reassemble, so that a good joint is made between the cover and the fuel lift pump body.

The third and final filter is a paper element type fitted between the top and bottom covers of the filter. It is not possible to clean the element; it should be renewed in accordance with Preventive Maintenance (Page C.3).

To Renew the Fuel Filter Element

1. Remove filter element as in figs. M.2 & M.3.
2. Discard the element.
3. Clean the filter top and bottom cover.
4. Reassemble the filter and vent the fuel system as on Page M.7.

FUEL LIFT PUMP (Fig. M.5.)

The diaphragm type fuel lift pump is operated by an eccentric on the camshaft and is mounted on the right hand side of the cylinder block. It is fitted with a hand priming lever.

With horizontal engines, the fuel lift pump is mounted on the auxiliary drive housing, driven by an eccentric on the auxiliary drive shaft.

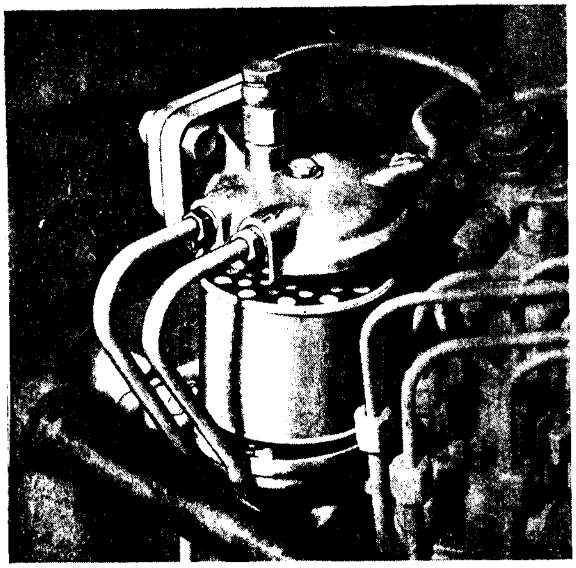


Fig. M.3.
Removing Final Fuel Filter Element.

To Remove the Pump from the Engine

1. Disconnect the pipes.
2. Remove the pump and joint (Fig. M.4).

Dismantling the Pump

Remove the domed cover from the top of the lift pump, also the gasket and gauze filter.

Make a file mark across the two flanges for guidance in reassembly.

Separate the two halves of the pump.

Turn the diaphragm assembly through 90° and lift the diaphragm and pull rod assembly from the body. The diaphragm and rod are serviced as an assembly and no attempt should be made to separate the layers of the diaphragm.

If any of the diaphragm layers are stuck together or appear cracked, replace the unit. It must also be replaced if there appears to be undue wear in the link engagement slot of the pull rod.

The diaphragm spring should be replaced bv one of the same identifying colour if it is corroded or distorted.

The rocker arm pin, spring and washers, together with the rocker arm and connecting link may now be removed.

Prise out the valves with a screwdriver or other suitable tool.

Cleaning and Inspection of Parts

Upper and lower pump castings should be examined for cracks or damage and where the diaphragm or engine mounting flanges are distorted these should be lightly linished to restore their original flatness.

Reassembly

Examine the casting and ensure that there is sufficient material to provide a sound staking when new valves are fitted.

Clean the valve recesses to allow the new valves to be correctly seated.

Insert a new valve gasket in each valve recess.

Place new valves in the recesses. The valve in the inlet port should be fitted with the spring outwards (i.e., towards the diaphragm flange) and the valve in the outlet port fitted in the reverse position.

Press the valves home with a suitable piece of steel tubing, approximately 9/16 in (14.29 mm) inside diameter and $\frac{3}{4}$ in (19.05 mm) outside diameter.

Stake the casting in six places (between the original stakings) round each valve, with a suitable punch.

NOTE: The valves fitted to earlier lift pumps were held in position by a retaining plate and two screws. On no account should attempts be made to stake the valves of this earlier type pump.

Replace the filter gauze, gasket and domed cover, to the top of the upper casting.

Assemble the link, packing washers, rocker arm and rocker arm spring, insert the rocker arm pin and place the assembly into the pump body.

Fig. M.4.
Removing Fuel Lift Pump.

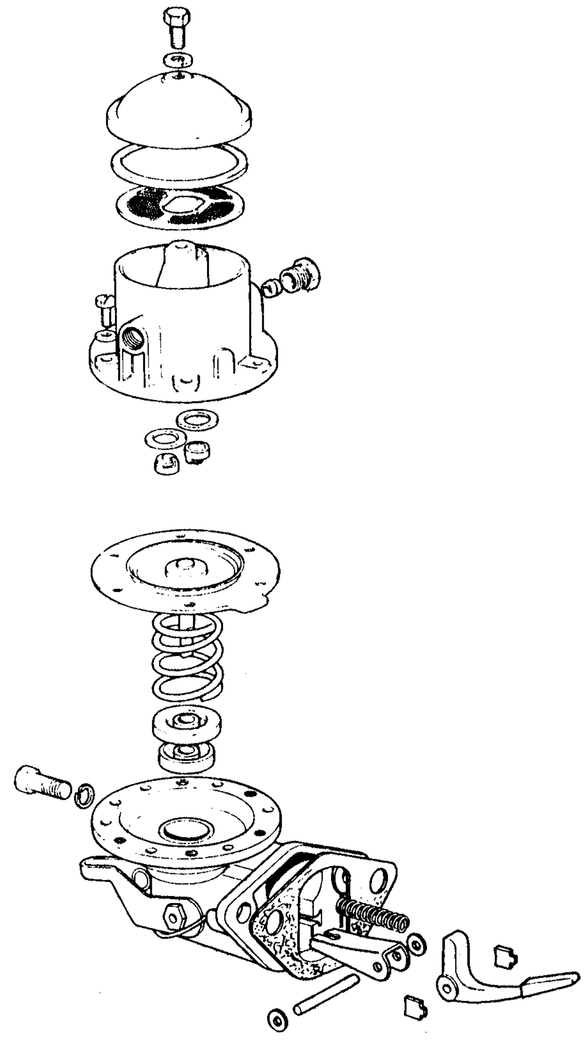


Fig. M.5.
Exploded view of Fuel Lift Pump.

Place the rocker arm retainers in position on each end of the pin and tap them into the pump body. Renew the diaphragm seal if worn. Place the seal retainer in position.

Replace the diaphragm spring and the diaphragm assembly over the spring (the pull rod being downwards) and centre the upper end of the spring in the lower protector washer.

When fitting the diaphragm assembly, the small locating tabs should be at position 'A' as shown in Fig. M.6. The diaphragm assembly should then be pushed down until the flattened end of the pull rod enters the slot in the link and then turned a quarter of a turn to the left until the diaphragm locating tabs are at position 'B' (Fig. M.6) and then they will be in line with the locating mark cast on the pump body. The sub-assemblies are now ready for fitting together.

Push the rocker arm towards the pump until the diaphragm is level with the body flanges. Place the upper half of the pump into position, as shown by the mark made on the flanges. Install the screws and washers and tighten until the heads just engage the washers.

Before tightening the screws, the rocker must be held at its inward position. Sufficient pressure must be exerted to draw the diaphragm inwards until its edges no longer protrude beyond the pump flanges.

While the rocker arm is so held, the cover screws should be securely tightened, working from side to side so as to keep the pressure even.

To Refit the Lift Pump to the Engine

1. Refit the pump to the cylinder block.
2. Reconnect the fuel lines and vent the system of air as detailed on Page M.7.

FUEL INJECTION PUMP

Description

The fuel injection pump is of the D.P.A. distributor type, vertically mounted on the auxiliary drive housing and is spline-coupled to the auxiliary drive wormgear.

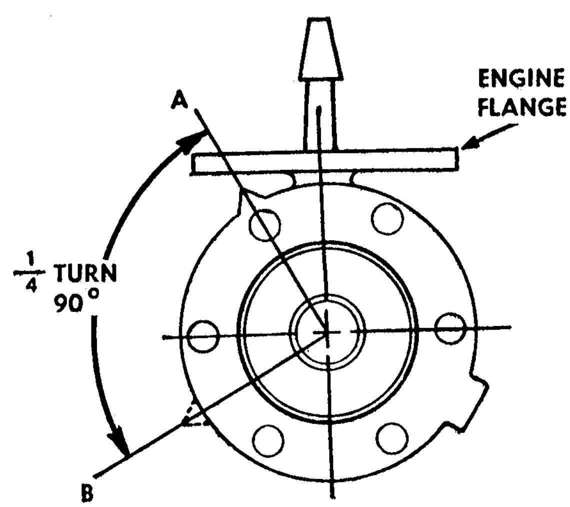


Fig. M.6.
Diaphragm Locating Tab Positions for Reassembly.

The pump is a compact, oil tight unit, lubricated throughout by fuel oil and requiring no separate lubrication system.

Sensitive speed control is maintained by a governor of the hydraulic operated type and automatic variation of the commencement of injection is obtained with an automatic advance unit.

Note: Unless proper test equipment and the relevant Test Plan for the fuel pump is available, adjustment or maintenance of the fuel pump should not be contemplated.

To Remove the Fuel Pump

1. Disconnect the stop and throttle controls from the pump and remove the return springs.
2. Remove the high and low pressure fuel pipes from the fuel pump.
3. Remove the fuel pump (Fig. M.7).

To Refit the Fuel Pump

1. Replace the fuel pump ensuring that the master spline on its quill shaft will enter the female spline within the vertical drive shaft.
2. Position the fuel pump so that the scribed line on the fuel pump flange aligns with the mark on the fuel pump adaptor plate (Fig. M.8). Secure the pump to the adaptor plate.
3. Refit the high and low pressure pipes to the fuel pump.
4. Reconnect the throttle and stop lever controls and attach the return springs.
5. Vent the fuel system of air (Page M.7).
6. Adjust the maximum and idling speeds (Page M.6).

Fuel Pump Timing

There are a number of timing marks appertaining to the fuel pump, which when aligned in the correct manner, ensure the fuel pump is timed correctly.

With No. 1 piston at T.D.C. on compression and with the fuel pump removed, the slot in the fuel pump drive hub should be aligned with the slot in the fuel pump adaptor plate, see Fig. M.9. If these slots are not in line, remove the auxiliary drive gear cover plate from the front of the timing case, release the three securing setscrews of the gear and turn the auxiliary drive shaft by means of the hexagon plug in the front end of the shaft.

On the fuel pump rotor, inside the fuel pump, are a number of scribed lines, each one bearing an individual letter. A timing circlip is positioned inside the pump body which has to be set so that when the appropriate scribed line on the fuel pump rotor aligns with the squared end of the circlip, it denotes commencement of injection (static timing). Fig. M.10.

Fig. M.7.
Removing Fuel Pump.

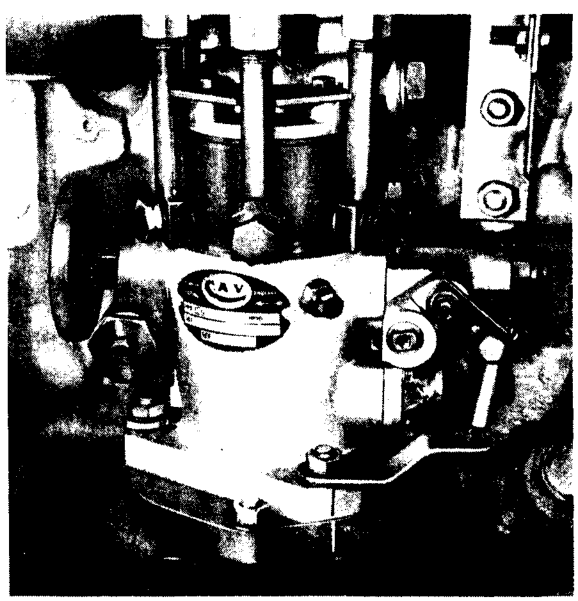


Fig. M.8.
Scribed Line on Fuel Pump and Adaptor Plate.

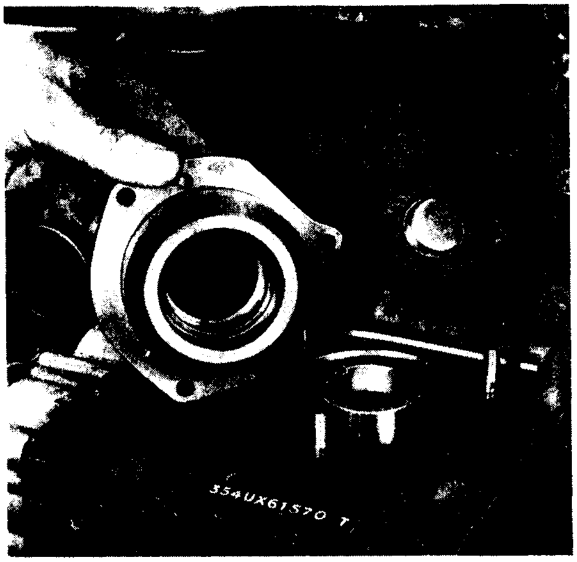


Fig. M.9.
Timing Slots in Fuel Pump Adaptor Plate and Fuel Pump Drive Hub.

On earlier engines the timing circlip bears a scribed line. On these engines the scribed line on the rotor should be aligned with the scribed line on the circlip (See Fig. M.11).

To set the timing circlip, it is necessary to remove the pump from the engine and fix the position of the circlip by connecting No. 1 cylinder outlet connection on the pump to an atomiser tester and pump up to 30 atm (31 kgf/cm^2 or 440 lbf/in^2). Turn the pump by hand in the normal direction of rotation until it locks up. The squared end of the circlip should now be adjusted until it lines up with the relative letter on the pump rotor (see Page B.14).

A line is scribed on the fuel pump mounting flange and another on the fuel pump adaptor

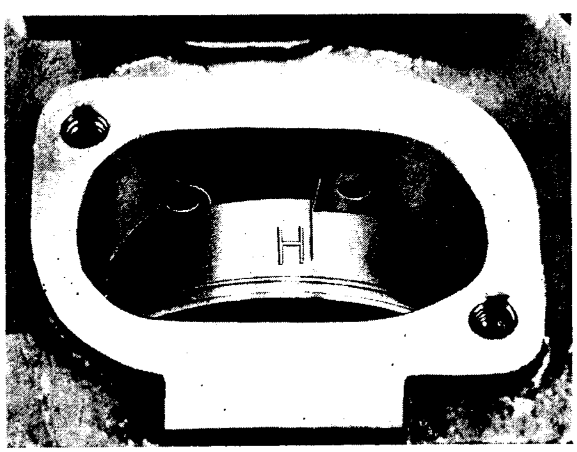


Fig. M.10.
Static Timing Mark—Later Pump Circlip.

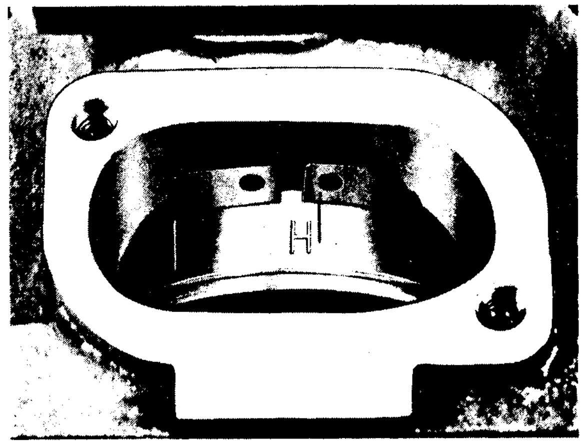


Fig. M.11.
Static Timing Mark—Early Pump Circlip.

plate. When the fuel pump is fitted to the engine, before tightening the securing nuts, these two scribed lines should be aligned.

Checking Fuel Pump Timing

1. Ensure the fuel pump timing circlip is correctly positioned as described previously.
2. Ensure the fuel pump is correctly fitted with the scribed line on the mounting flange aligning with the mark on the fuel pump adaptor plate.
3. Position the crankshaft so that No. 1 piston is at T.D.C. on its compression stroke.
4. Remove the rocker cover.
5. Remove the collets, spring cap and springs from No. 1 inlet valve and allow the valve to rest on top of the piston.
6. With the aid of a clock gauge in contact with the end of the valve now resting on No. 1 piston, it will be necessary to position the crankshaft so that the piston will be 0.372 in (9,45 mm) B.T.D.C., this being an equivalent of 28° B.T.D.C. on the flywheel.
   To do this, turn the crankshaft in the opposite direction to normal rotation, approximately an eighth of a turn and then forward until the required position is registered on the clock gauge. This enables the backlash in the timing gears to be taken up.
   Note: This setting is for normally aspirated engines. For turbocharged engines, see Page B.14.
7. Remove the inspection plate on the fuel pump enabling the rotor to be seen (Figs. M.10 and M.11).

8. With No. 1 piston at the static timing point the rotor marked 'H' for hydraulically governed pumps or 'F' for mechanically governed pumps, should align with the scribed line or straight edge on the timing circlip.
9. If it does not, release the three nuts securing the fuel pump and twist the pump body until the marks align. Further adjustment can be made by turning the auxiliary drive shaft, after first releasing the auxiliary drive gear securing setscrews.
10. If after both these adjustments, the timing marks do not align, it could mean the auxiliary drive gear has been fitted incorrectly; see Page J.2 for correct fitting.

Maximum Speed Setting

IMPORTANT NOTE:

The maximum speed screw seal of original fuel pumps must not be broken or tampered with in any way unless factory authority is first obtained. Failure to do so may result in the guarantee becoming void.

When fitting a replacement pump, or in the event of the maximum speed screw having been moved, the maximum no load speed must be checked and reset as necessary.

The maximum no load speed will vary according to application. For details, reference should be made to the code stamped on the fuel pump data plate. The last four numbers in the code indicate the speed required and in the case of the example below, this would be 3130 rev/min.

Code Example: CR62/900/0/3130.

Note: If the fuel pump data plate is damaged or defaced so as to make it impossible to read the code, or if the code is not stamped on the plate, it is advised that the nearest Perkins Marine Distributor, Perkins Overseas Distributor or C.A.V. Dealer is contacted, or alternatively, Service Department, Perkins Engines Limited, Peterborough, to obtain the correct setting.

Important: Under no circumstances should the engine be allowed to operate at higher rev/min than specified or severe damage to the engine may result.

Idling Speed Setting

The engine idling speed is adjustd by the idling screw (See Fig. M.12).

With the engine warm, turn the screw clockwise to increase the engine speed or anti-clockwise to decrease.

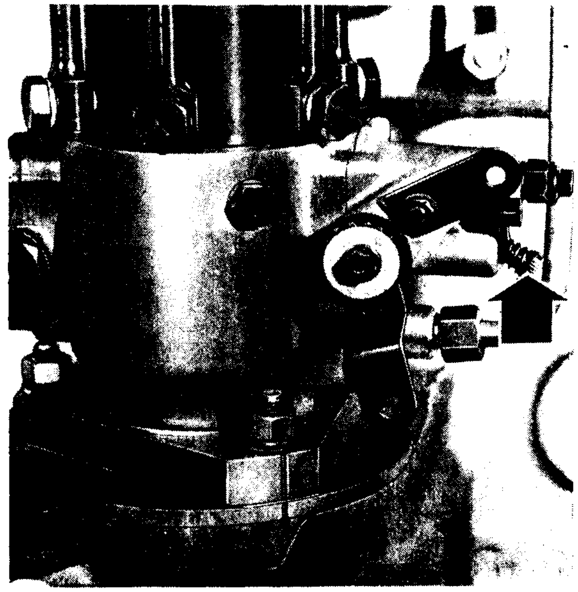


Fig. M.12.
Fuel Injection Pump Idling Speed Adjusting Screw.

The idling speed will vary, according to application. For details, apply to the nearest Perkins Marine Distributor, Perkins Overseas Distributor or C.A.V. Dealer, alternatively Service Department, Perkins Engines Ltd., Peterborough.

ATOMISERS

General

When replacing atomisers in the cylinder head it is essential that a new, correct type copper washer is fitted between the nozzle cap and the cylinder head.

Troubles in Service

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

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

The particular faulty atomiser or atomisers may be determined by releasing the pipe union nut on each atomiser in turn, with the engine running at a fast "tick-over." If after slackening a pipe union nut the engine revolutions remain constant, this denotes a faulty atomiser. The complete unit should be withdrawn from the cylinder head and inverted, atomiser nozzle outwards and the unions retightened. After slackening the unions of the other atomiser pipes (to avoid the possibility of the engine starting), the engine should be turned until the nozzle sprays into the air, when it will be seen if the spray is in order. If the spray is unduly "wet" or "streaky" or obviously to one side, or the nozzle "dribbles" it may only be necessary to probe the nozzle holes to remove carbon.

Note: Care should be exercised to prevent the hands or face from coming into contact with the spray, as the working pressure will cause the fuel oil to penetrate the skin.

Maintenance

Atomisers should be taken out for examination at regular intervals.

For detailed times refer to periodical maintenance, Section C.

NO ATTEMPT SHOULD BE MADE TO ADJUST THE INJECTION PRESSURE WITHOUT A PROPER TESTING PUMP AND PRESSURE GAUGE. IT IS QUITE IMPOSSIBLE TO ADJUST THE SETTING OF ATOMISERS WITH ANY DEGREE OF ACCURACY WITHOUT PROPER EQUIPMENT.

A perfect atomiser, when tested by pumping fuel through it in the open air gives a short "pinging" sound as the fuel emerges from the holes. After the atomiser has been in service for some time, the "pinging" changes to a crackling sound. It is not until the atomiser sounds "dead" that its condition is likely to affect the running of the engine.

FUEL PIPES

No two of the pressure pipes, from the fuel pump to the atomisers are alike.

If the union nuts have been overtightened there is a risk that the olives will have cracked or been unduly compressed, when leakage will result.

The working pressure which these joints must sustain is several thousand pounds per square inch.

If the union is tightened excessively the olive may collapse and split. The same danger exists if the pipe is not square to and central with the union.

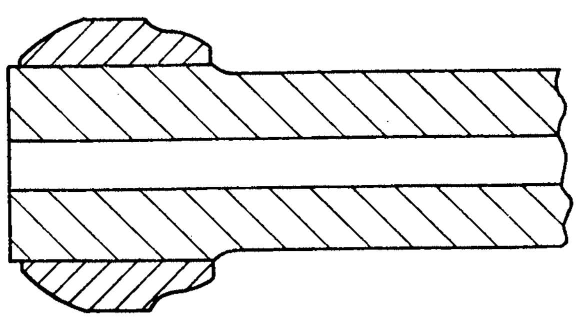


Fig. M.13. High Pressure Fuel Pipe Olive.

When changing an atomiser always remove the pipe entirely. Never bend the pipe.

For standardisation purposes, high pressure fuel pipe assemblies are now supplied with olives fitted as shown in Fig. M.13. The earlier type pipe assemblies with olives fitted in the reversed position are still satisfactory. The exception is T6.354(M) engines where the olives should always be fitted as illustrated.

PRIMING THE FUEL SYSTEM

The air must be vented from the fuel system whenever any part of the system between the fuel tank and injection pump has been disconnected for any reason, or when the system has been emptied of fuel.

No attempt must be made to start the engine until the injection pump has been filled and primed as serious damage can be caused to the pump due to lack of lubrication.

The method of priming detailed below, ensures that only fuel which has passed through the paper filter element can reach the interior of the pump.

1. Slacken the air vent valve on the side of the governor housing (hydraulic governor), Fig. M.14, or on the top of the governor control cover (mechanical governor) Fig. M.15.
2. Slacken the vent valve fitted on one of the two hydraulic head locking screws (see Fig. M.16).

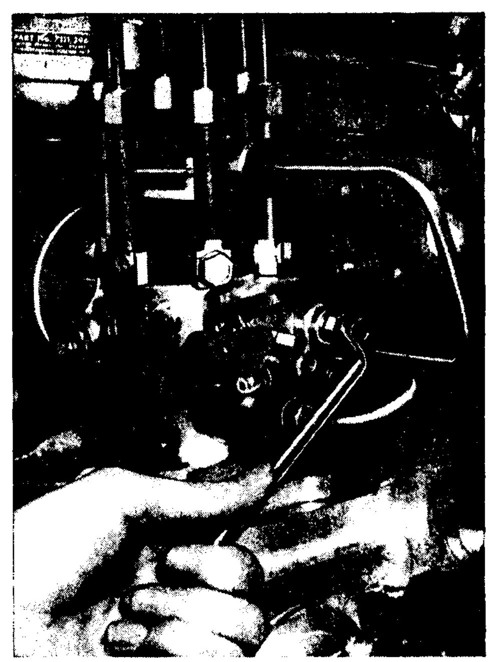


Fig. M.14.
Slackening Bleed Screw on Governor Housing.

Fig. M.15
Slackening Bleed Screw on Governor Housing.
(Mechanical Governor).

3. Operate the priming lever on the fuel feed pump (see Fig. M.17) and when fuel, free from air bubbles, issues from each venting point, tighten the screws in the following order :—
   1. Head locking screw vent valve.
   2. Governor cover vent valve.

4. Slacken the pipe union nut (see Fig. M.18) at the pump inlet, operate the priming device and retighten when oil, free from air bubbles, issues from around the threads.

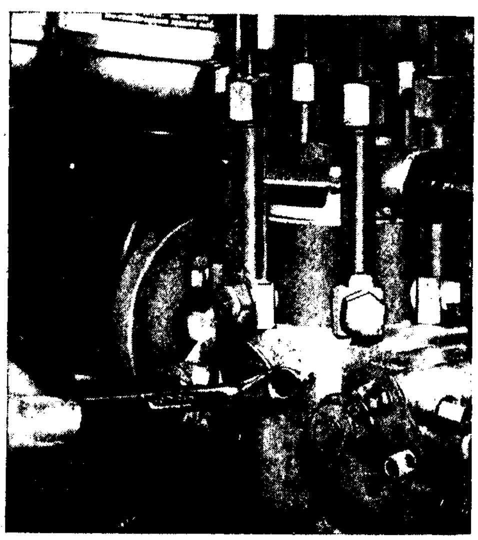


Fig. M.16
Slackening Bleed Screw at Hydraulic Head Locking Screw.

Fig. M.17
Operating Fuel Lift Pump.

5. Slacken the unions at the atomiser ends of two of the high pressure pipes.

6. Set the accelerator at the fully open position and ensure that the "stop" control is in the "run" position.

7. Turn the engine until fuel oil, free from air bubbles, issues from both fuel pipes.

8. Tighten the unions on both fuel pipes, and the engine is ready for starting.

Fig. M.18
Slackening Inlet Pipe Union Nut.

SECTION N
Gearbox, Flywheel Housing and Flywheel

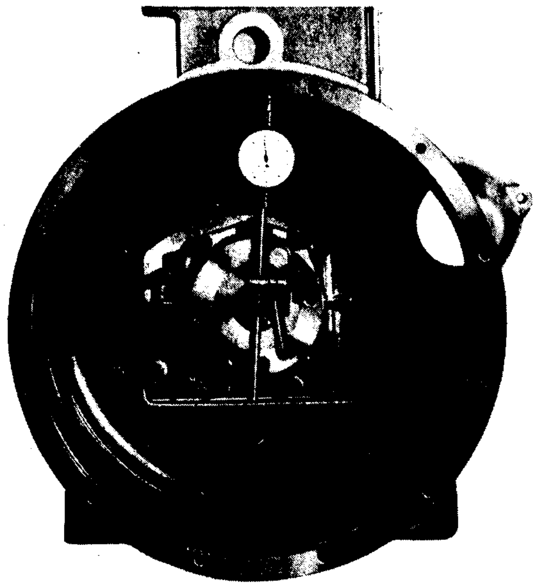


Fig. N.1.
Checking Alignment of Flywheel Housing Bore.

Gearbox

The gearbox fitted to the 6.354 Marine engine is a lightweight hydraulic direct drive type incorporating a reverse gear. An epicyclic reduction gear with $1\frac{1}{2}$: 1, 2 : 1 or 3 : 1 ratios (approximate) can be supplied. The output shaft of the gearbox or reduction gear is on the same centre-line as the crankshaft.

For standard gearboxes and reduction gear, a left handed propeller is required, but with a 2 : 1 reduction gear, provision can be made for handed rotation, the exact ratios being 2.1 : 1 for left hand propellers and 1.91 : 1 for right hand propellers.

Important Note

When filling the Borg-Warner gearbox as fitted to the 6.354 Marine engine, Automatic Transmission Fluid Type "A" must be used.

The gearbox should be filled to the full mark on the dipstick and the unit turned over at low speed by idling the engine for a short period in order to fill all the circuits including the cooler and cooler piping.

The oil level should then be checked immediately after shutting off the engine and sufficient oil added to bring the level to the full mark again.

To Remove the Gearbox

Remove lubricating oil pipes to and from gearbox oil cooler.

Remove water connections to and from gearbox oil cooler.

Remove gearbox oil cooler.

Uncouple propeller shaft from gearbox output shaft and move clear of box.

Remove nuts securing gearbox to adaptor plate.

The gearbox can then be removed by withdrawing it to the rear.

Remove nuts securing gearbox adaptor plate to flywheel housing.

Remove adaptor plate.

The driving plate connecting the gearbox to the flywheel can now be removed. It should be noted that if either flywheel or flywheel housing is removed, it must be re-aligned on replacement in accordance with the instruction given later in this Section.

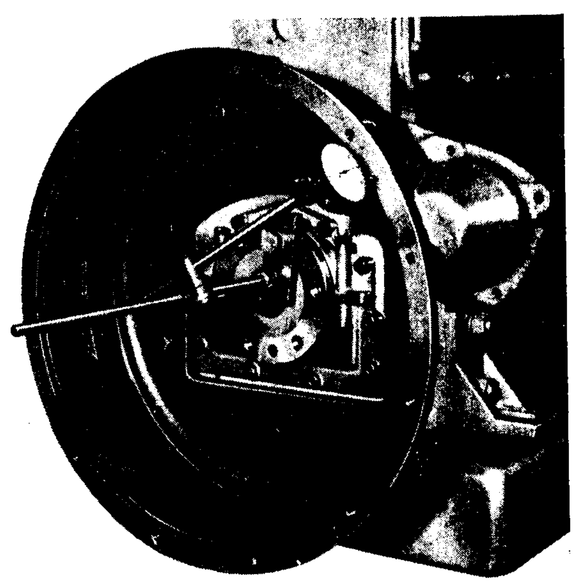


Fig. N.2.
Checking Alignment of Flywheel Housing Face.

Replacement of the gearbox is the reverse procedure to removal but the splines on the gearbox input shaft should be lubricated with anti-fretting grease before the unit is replaced.

Alignment of the Flywheel Housing and Flywheel

It is most important that the flywheel housing be correctly aligned with the crankshaft. If the housing has been removed, as is necessary for a complete overhaul, the greatest care must be taken on replacement to ensure accuracy of alignment. The appropriate procedure is as follows :—

See that the face of both the rear of the cylinder block and flywheel housing are perfectly clean and free from burrs.

Set the housing on to the studs and tighten, but not overtight so as to allow adjustment.

Alignment of the Flywheel Housing Bore

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

Set the needle of the gauge to the inner circumference of the flywheel housing. (See Fig. N.1).

For convenience in turning the engine it is advisable to release (but not remove) the nuts holding the atomisers in place.

Turn the crankshaft and check the inner circumference of the flywheel housing for concentricity.

Adjust the flywheel housing if necessary until it is concentric with the crankshaft within the limit of 0.008 in (0,20 mm) total indicator reading.

Alignment of the Flywheel Housing Face

With the face of the "clock gauge" still bolted to the crankshaft flange, adjust the "clock" so as to set the needle against the vertical machined face of the flywheel housing, and again, turning the crankshaft, check that this face is perpendicular to the crankshaft axis (see Fig. N.2).

This facing should be within the limit of 0.008 in (0,20 mm) (total indicator reading) of being truly at right angles to the crankshaft axis.

All adjustments to bring the flywheel housing within the limits must be on the flywheel housing and under NO CONDITIONS must the rear of the cylinder block be interfered with.

When the housing is properly aligned to the above limits, tighten the securing nuts evenly.

To Renew the Flywheel Ring Gear

1. Place the flywheel in a suitable container of clean cold water and support it by positioning four metal blocks under the ring gear. Arrange the flywheel assembly so that, when submerged in the water, the ring gear is uppermost and clear of the water line by approximately $\frac{1}{4}$ in (6,5 mm). Heat the ring gear evenly, around its circumference, thus expanding it. This will allow the flywheel to drop away from the ring gear.
2. Heat the new ring gear to an approximate temperature of 475°F (246°C). Fit the gear over the flywheel with the lead-in on the teeth facing towards the front of the flywheel and allow the ring to cool.

Fitting Flywheel and Checking Alignment

With the flywheel and crankshaft flange perfectly clean and free from burrs and with aid of guide studs, place the flywheel on the crankshaft flange.

Insert the setscrews complete with tab washers into the flywheel holes and tighten evenly.

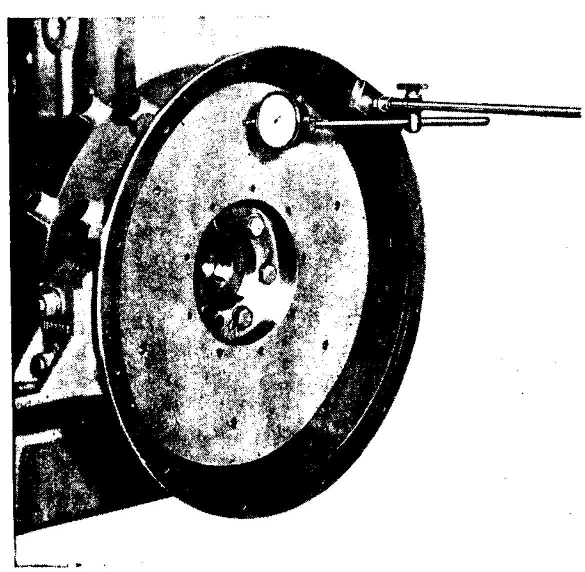


Fig. N.3.
Checking Alignment of Flywheel Face.

Secure the base of the "clock" gauge to the flywheel housing and set the needle of the gauge against the vertical machined face of the flywheel. (see Fig. N.3).

Press the crankshaft one way, to take up the end float, and turn the flywheel. The run out on the flywheel face should be within 0.001 in (0,025 mm) total indicator reading per inch (25,4 mm) of flywheel radius from the crankshaft axis to the clock gauge plunger.

When the flywheel is correctly aligned, lock the securing setscrews by means of the tab washers.

Finally grease the spigot ball race if fitted.

SECTION P
Turbochargers

PERKINS 1/5 AND HOLSET 3LD TURBOCHARGERS

CONTENTS

These instructions are issued for the general guidance of those concerned with the turbocharged 6.354 diesel engine. Please read carefully before starting a turbocharged engine.

In all correspondence or communications dealing with a turbocharger of this type, the date and serial number to be found on the body of the unit must be quoted clearly and fully.

In the event of an accident causing damage to the turbocharger, the unit must be removed, carefully packed and returned to the nearest Perkins Distributor or Overseas Company, where a replacement unit should be obtained. If this is impossible the instructions given on pages P.12 to P.17 should be carefully followed.

It is not permissible to fit a Turbocharger unit to a naturally aspirated engine.

SECTION 1

General Information

On early production Perkins Turbocharged Engines, three types of Mk. 1/5 turbochargers were fitted, namely the Mk. 1/5N, Mk. 1/5Q and Mk. 1/5R. Currently, the Holset 3LD model turbocharger is fitted in production to marine type engines.

All the turbochargers fitted to Perkins engines are self-contained units mounted directly, or by an adaptor, to the exhaust manifold and consist of a gas turbine and a centrifugal compressor fitted to a common shaft with the necessary surrounding casings. The exhaust gas from the diesel engine is directed through manifolding to the turbine, which utilises some of the energy in the exhaust gas to drive the compressor. The air required by the engine is supplied at a pressure above atmospheric through the conventional air intake manifold, and enables a higher output to be obtained from the engine.

No control over the turbocharger is necessary, the speed and output varying automatically with changes in load and speed of the engine.

Whilst all three Mk. 1/5 turbochargers are similar in design it should be noted that the rotating assemblies and certain individual parts are not interchangeable due to internal design changes. The main internal differences are as follows :—

Mk. 1/5N

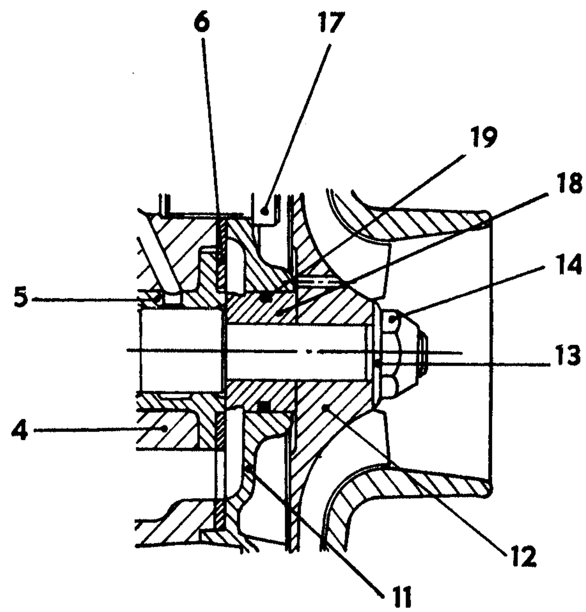
This turbocharger was manufactured by Engineering Productions (Clevedon) Ltd., and has a labyrinth oil seal at the impeller end of the rotor shaft as shown in Fig. P.4. The turbine nozzle unit has 23 blades. It can be identified by the marking "1/5N" on the casing.

Mk. 1/5Q

This turbocharger was originally manufactured by Engineering Productions (Clevedon) Ltd., and later by Simms Motor Units Ltd. It has a piston ring oil seal at the impeller end of the rotor shaft as shown in fig. P.1. The turbine nozzle unit has 14 blades. Those manufactured by Engineering Productions (Clevedon) Ltd., can be identified by the marking "1/5Q" on the casing. Those manufactured by Simms Motor Units Ltd. can be identified by the figures "1501" on the casing.

Mk. 1/5R

This turbocharger which is manufactured by Simms Motor Units Ltd. is identical to the Mk. 1/5Q with the exception of the turbine nozzle unit which has 23 blades. It can be identified by the figures "1502" on the casing.



Sectional View of Mk. 1/5Q and Mk. 1/5R Turbocharger showing Piston Ring Oil Seal.

Fig. P.1.

4. Centre Casing	13. Washer
5. Bearing	14. Nut
6. Retaining Plate	17. Cap Screw
11. Plain Diffuser	18. Compressor Seal Sleeve
12. Impeller	19. Piston Ring Seal

Holset 3LD

The Holset 3LD turbocharger can be identified by the 'V' clamp securing the bearing housing to the turbine housing and by the manufacturers plate attached to the compressor cover.

Interchangeability

The Mk. 1/5N and 1/5Q turbochargers were fitted to marine engines rated at below 135 shp.

The Mk. 1/5R turbocharger was used on Marine engines of all ratings.

The Holset 3LD model turbocharger is used on all current 6.354 production Turbocharged engines and may be used as a service replacement for all the three Mk. 1/5 turbochargers mentioned above, as these are no longer available as replacement items.

Replacement of Mk. 1/5 Turbochargers with the Holset 3LD Model

When it is necessary to replace in service a Mk. 1/5N, Q or R model turbocharger with the Holset 3LD, it will be necessary to obtain the appropriate conversion kit which includes conversion instructions. The kit and turbocharger type will vary according to the installation.

SECTION 2

Details of Construction

Mk. 1/5 Turbocharger

(Numbers in brackets refer to numbers in fig. P.4).

The engine exhaust manifold conducts the exhaust gases to the turbine casing (1). Clamped to the turbine casing is the nozzle unit (2), which contains guide vanes and these direct the exhaust gases to the turbine rotor (3).

The centre casing (4) is bolted to the turbine casing and houses the one piece bearing (5) which is restrained by the retaining plate (6).

The bearing lubricating oil is directed through oil seal (7) which is integral with the rotor shaft (8) and the removable seal (9).

The compressor casing (10) bolts directly on to the centre casing and contains a plain diffuser (11) bolted to the centre casing. Air enters the compressor casing axially and after passing through the impeller (12) is discharged tangentially to the engine induction piping.

The complete rotating assembly, which is dynamically balanced as one unit, consists of the rotor (3) which is integral with the rotor shaft (8), the oil seals (9) and the impeller (12) which is secured by a washer (13) and nut (14).

Holset 3LD Turbocharger

(Numbers in brackets refer to numbers in fig. P.6).

The engine exhaust manifold conducts the exhaust gases to the turbine housing (8).

The bearing housing (14) is secured to the turbine housing by a 'V' clamp (7) and locknut (6) and houses the one piece bearing (11) which is restrained by the thrust plate (5).

The compressor insert (19), spacer sleeve (16), oil deflector (13) and thrust ring (12), are retained in the centre bearing housing (14) by a large retaining ring (20). The compressor wheel (18) is secured to the rotor shaft (10) by a locknut (17).

The compressor cover (21) bolts directly on to the centre bearing housing (14). Air enters the compressor cover axially and after passing through the compressor wheel (18) is discharged tangentially to the engine induction piping.

The shaft and turbine wheel assembly (10) and the compressor wheel (18) rotate as one assembly and are as one unit dynamically balanced.

SECTION 3

Lubrication System

The turbocharger bearing is lubricated with oil taken from the engine lubricating oil system.

The oil is piped to the oil inlet connection located at the top of the centre bearing housing and through a drilling in the casing to the bearing.

On some installations, the bottom end of the oil feed pipe is attached to a separate full flow filter which is mounted adjacent to the main engine oil filter. No by-pass valve is incorporated in the turbocharger filter.

Alternatively, the bottom end of the oil feed pipe is attached to the cylinder block, at the opposite end of the cross-drilling to which the engine lubricating oil filter is located.

The oil return flow to the engine is by way of a drain pipe attached to the outlet connection in the bottom of the centre bearing housing of the turbocharger. Oil is returned either to the tappet inspection cover or the engine sump.

SECTION 4

Installation

When the turbocharger is supplied either as a separate unit or mounted to an engine, the openings are plugged to prevent entrance of dirt and the exposed surfaces are protected against rust. No dismantling is necessary before installation.

Before removing seals, clean with suitable cleaning compound. Care must be taken to prevent the solvent entering the openings of the turbocharger.

The unit is mounted on to the engine by bolting the turbine inlet flange directly on to the engine exhaust manifold with a jointing gasket or, in some cases, to an adaptor secured to the manifold by four studs, nuts and washers and two appropriate gaskets, after which the following connections should be made :—

(1) Turbine Outlet.

(2) Compressor Inlet.

(3) Compressor Outlet.

(4) Lubricating Oil System (see notes in Section 3).

The following general points should be observed :—

Exhaust System

If the turbocharged engine is being fitted in place of a normally aspirated engine it is highly improbable that the existing silencing system will be adequate, even if the difference in pipe diameter is remedied by a local modification at the turbocharger exhaust connection.

In order to get the best and most efficient service out of the turbocharger it is very important that the exhaust system should be free of restrictions and large enough to cope with the increased gas flows. Rather than making an unsatisfactory job out of existing piping, it is strongly recommended that a completely new pipe is made up incorporating the following suggestions.

It is very important that the exhaust pipe should not impart any strain on the turbocharger exhaust outlet. In order to ensure this, the exhaust pipe should be firmly fixed by a suitable bracket to the lower part of the engine in the region of the sump and between this bracket and the turbocharger outlet a length of flexible pipe at least one foot long should be introduced.

On installations using long exhaust systems it is advisable to fit an additional piece of flexible piping between the above mentioned fixing bracket on the engine and the silencer.

The Mk. 1/5 turbocharger only is fitted with an exhaust box incorporating an exhaust outlet connection which fits onto the turbine exhaust flange. This is arranged so that it can be fitted in a number of different positions in the same plane, thus enabling the exhaust pipe to be led away at different angles to suit the particular installation.

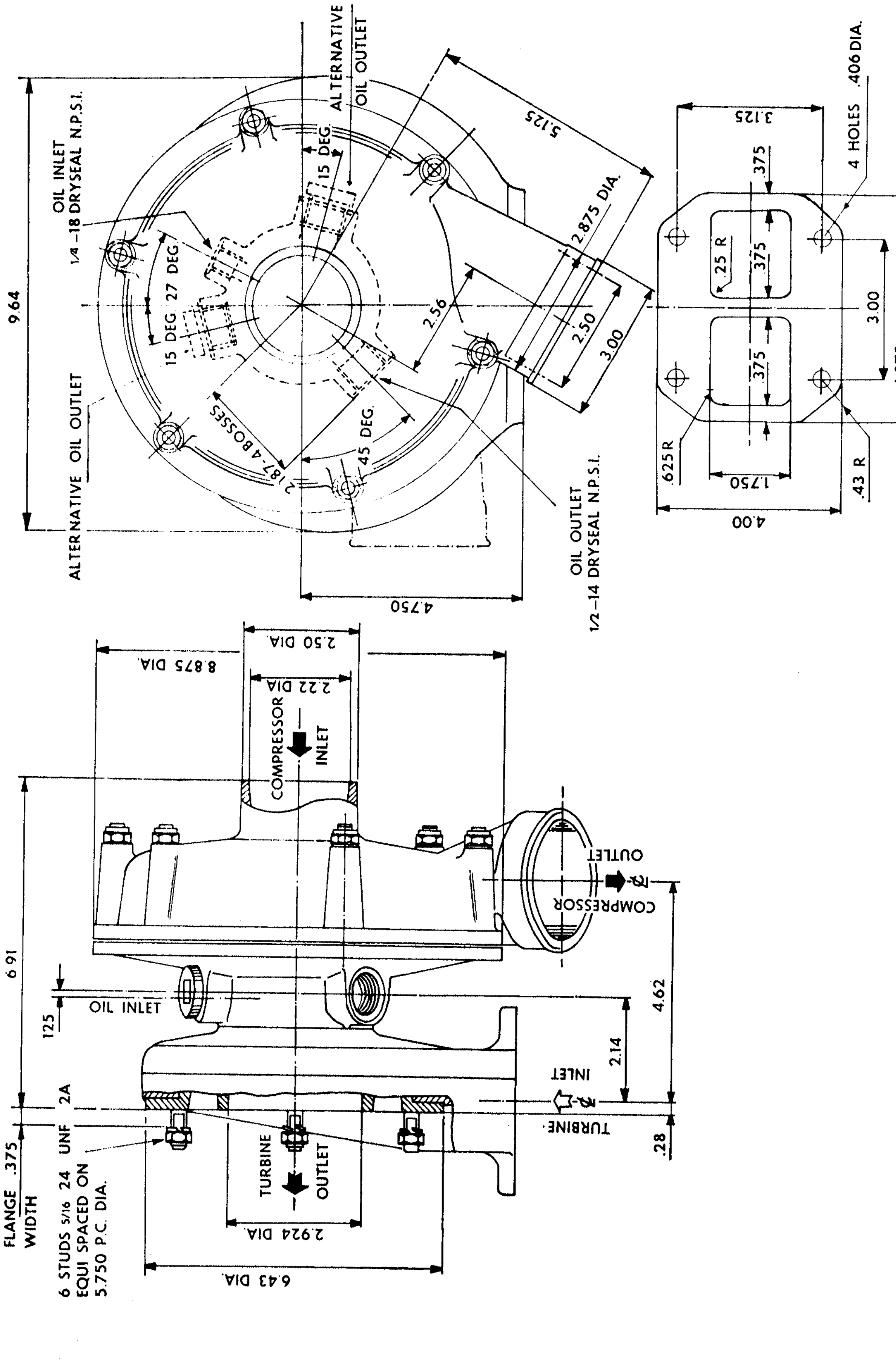
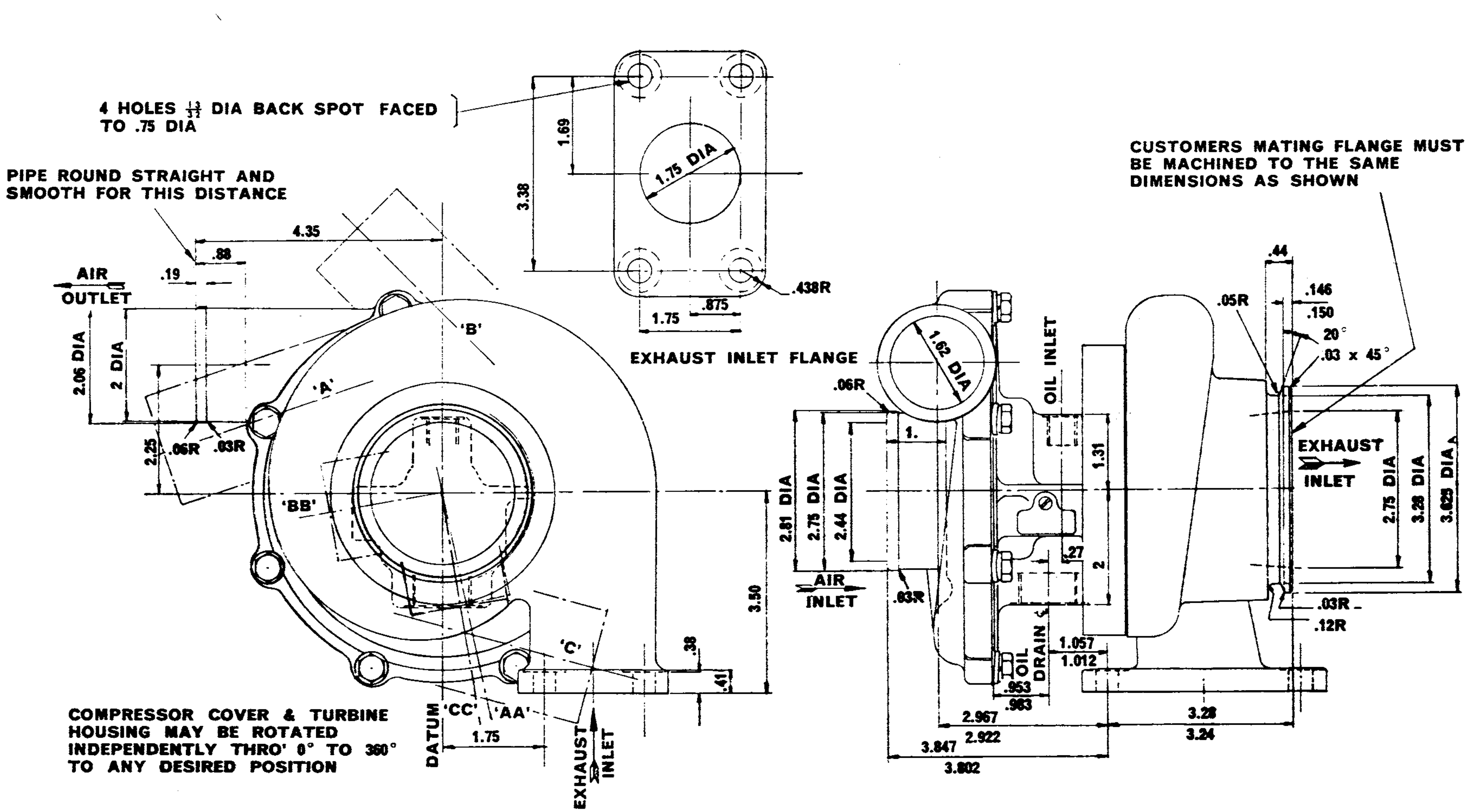


Fig. P.2.
All dimensions are inches.
Installation details of Mk. 1/5 Turbocharger.



Compressor Position	Angle Anti-clock	Oil Drain Position	Angle Anti-clock
A	289°	AA	12°
B	225°	BB	280°
C	75°	CC	9½°

Fig. P.3.
Installation Details of Holset 3LD Turbocharger.
All dimensions are in inches.

The pipe should be made up so that the turbine outlet box just fits onto the turbocharger exhaust flange without any forcing when the pipe is clamped in position by the lower bracket. This will ensure that no strain is imparted to the turbocharger.

The exhaust pipes from either the Mk. 1/5 or Holset 3LD turbocharger should have the minimum of restrictions due to bends, small diameter piping, inadequate silencers and right angle bends are to be avoided. A pipe size of 3 in. diameter is recommended.

The back pressure in the exhaust system should not be more than 13 in (330 mm) water at maximum rated full load speed. If this is to be measured, a tapping should be made as close to the turbine outlet as possible.

The pipe layout should be such that it does not run close to the fuel filter or fuel pump, as this will lead to unnecessary heating of the fuel and injection equipment. If this is unavoidable, a suitable anti-radiation shield should be fitted between the exhaust pipe and the injection equipment such as a steel plate lagged with asbestos.

When the exhaust system is finally fitted to the engine, the compressor rotor should be spun with the finger to see that it turns freely.

SECTION 5

Starting Instructions. From New Installation.

(1) Slacken the lubricating oil feed pipe union at the centre casing of the turbocharger, or the plug in the banjo bolt if fitted. Turn the engine over on the battery with the fuel control off until oil leaks from the union; re-tighten the union and then start the engine.

(2) Start the engine and operate at idling or light load conditions. A minimum oil pressure of 10 lbf/in² is required during idling conditions and if this pressure does not show on the pressure gauge in 12 to 15 seconds, shut down and check for the cause. Note : The engine should not be run at more than 1,000 rev/min no load speed until the oil pressure has reached 20 lbf/in².

(3) Operate the engine at a fast idling speed (1,200 rev/min no load), for 10 minutes checking the lubricating oil pressure in the engine system. When normal engine oil pressure has been developed, the oil pressure to the turbocharger must be a minimum of 30 lbf/in². If this is not achieved, shut down and investigate.

(4) The unit should be checked during the 10 minutes of operation to make certain that neither oil, nor exhaust gas leaks have developed.

(5) After the above steps have been taken, the turbocharger is ready for continuous operation.

It is adviseable NOT to run up to maximum speed and boost during the first 25 hours of running.

NOTE : The power output of the turbocharged engine should never be increased beyond its manufactured rating as this will create an overload condition, increased exhaust temperatures and high turbocharger speed which may lead to failure.

SECTION 6

Service Operation

Performance of the turbocharger should be checked at every oil filter change (See paragraph 3 below).

1. Oil Pressure

Lubricating oil pressure should be a minimum 30 lbf/in^2 at normal engine working speeds. Check this pressure regularly.

2. Oil Temperature

As the turbocharger has been designed to operate satisfactorily when lubricated within the normal range of engine oil temperature, no additional gauge is necessary.

3. Boost Pressure

Boost Pressure should be checked daily.

Boost pressure will vary according to engine rating, speed and load applied.

4. Turbocharger Speed

No attention need be paid to the speed of the turbocharger since this varies automatically with the speed and load of the engine.

5. Vibration

Ensure that excessive vibration from the engine mountings does not cause damage to the turbocharger connections.

6. Oil Drainage

The oil drain pipe should be cleaned every 800 hours. A partially blocked drain will restrict the flow of oil from the bearing housing, causing it to flood through the seals into the compressor and turbine casings. This will result in excessively dirty exhaust smoke, and loss of power.

7. Emergency Operation

Should an accident or damage occur to some part of the turbocharger preventing operation of the unit, the engine can operate slowly with a small throttle opening for a short period with care.

8. Smoke

Excessive exhaust smoke may be caused by the following :—

(1) Air cleaner choked.

(2) Turbocharger not operating correctly due to dirt build-up on the compressor.

(3) Restriction in the pipe from air cleaner to compressor inlet.

(4) Fuel pump incorrectly calibrated.

(5) Excessive back pressure in the exhaust system.

9. Stopping the engine

Do not shut the engine down rapidly from full throttle.

SECTION 7

Maintenance Instructions

NOTE: The only maintenance necessary, providing the foregoing instructions have been adhered to, is the cleaning of the impeller and, in case of the Mk. 1/5 turbocharger, the diffuser, also the replacement of the element when a separate turbocharger oil filter is provided and the cleaning of the oil drain pipe.

1. Mk. 1/5 Turbocharger

(Numbers in brackets refer to numbers on the Sectional Drawing, fig. P.4).

The impeller (12) and diffuser (11) may require cleaning every 800 hours. This can be achieved without removing the turbocharger from the engine.

Disconnect the blower discharger piping and remove the nuts (15) holding the compressor casing (10) to the centre casing (4). The compressor can then be carefully pulled out along the rotational axis of the unit, care being taken to avoid damaging the impeller blades. The impeller, diffuser and compressor casing should then be cleaned with a suitable solvent sucb as trichloroethylene to remove any dirt, grease or carbon deposits. Never use a caustic solution, wire brush or scraper on these parts. Visually examine all components, before reassembling in the reverse order.

2. Holset 3LD Turbocharger

The impeller and impeller cover may be cleaned without removing the turbocharger from the engine if the following instructions are carried out.

(Numbers in brackets refer to numbers on the Sectional Drawing, fig. P.6).

(1) Mark relative positions of turbine housing (8), bearing housing (14), compressor cover (21) and "V" clamp (7).

(2) Remove the eight bolts (3) and associated lockwashers (2) fastening compressor cover (21) to bearing housing (14) and lift off cover (21).

(3) Remove the "V" clamp locknut and spring the "V" clamp (7) back onto the bearing housing (14). Lift the core assembly clear of the turbine housing (8).

(4) Holding the turbine wheel at the hub, remove the compressor locknut (17).

(5) Slide compressor wheel (18) off the shaft.

The compressor wheel and cover may be washed in non-caustic cleaning fluid. A non-metallic brush or plastic scraper blade should be used to avoid scoring these parts.

Following cleaning, the parts removed should be examined and if found to be in a satisfactory condition, should be re-assembled in reverse order of the stripping sequence outlined above.

3. Oil Drain Pipe

This should be cleaned and blown through with compressed air every 800 hours.

4. Replacement of Oil Filter Element

The element of the separate oil filter (where fitted) which feeds the turbocharger must be renewed every 200 hours. Unlike the engine lubricating oil filter, the turbocharger oil filter does not incorporate a by-pass valve and care must be taken to ensure that this filter is always kept clean, otherwise the turbocharger will be starved of lubricating oil. When replacing this filter element take care to prevent dirt and metal particles entering the filter casing. Fill the casing with clean engine oil before replacing. Bleed as Section 5, paragraph (1).

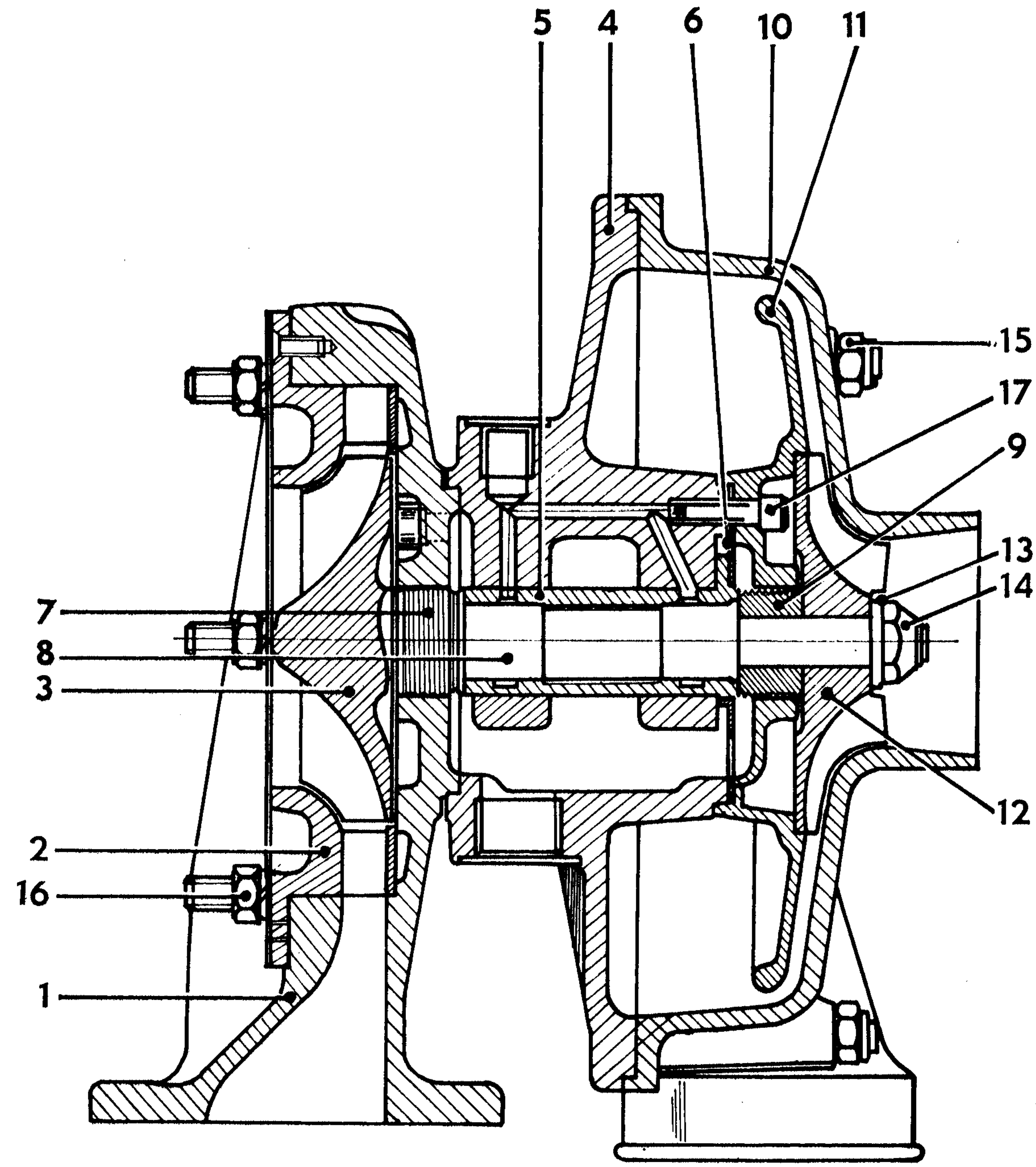


Fig. P.4.

Sectional view of Mk. 1/5 Turbocharger.

1. Turbine Casing.
2. Nozzle Unit.
3. Turbine Rotor.
4. Centre Casing.
5. Bearing.
6. Retaining Plate.
7. Shaft Oil Seal.
8. Rotor Shaft.
9. Removable Oil Seal.
10. Compressor Casing.
11. Plain Diffuser.
12. Impeller.
13. Washer.
14. Nut.
15. Compressor Nuts.
16. Nozzle Unit Nuts.
17. Cap Screws.

SECTION 8

Fault Diagnosis

If the performance of the turbocharger is suspect, check the installation for the following faults :—

Excessive air inlet depression.

Low or high air delivery pressure.

Low oil pressure and/or low oil flow.

Restricted exhaust from turbine.

Fuel pump or injection faults.

Check and rectify in accordance with the procedure given in the following paragraphs :

(1) Excessive air inlet depression : The air depression at the entry to the compressor, that is, in the ducting after the air filter and immediately before the compressor cover, should not exceed a 20 in (500 mm) head of water.

If the depression is excessive, the cause will be due to a restriction of inlet air by dirty air filters.

Service air filters.

(2) Low or high air delivery pressure: The pressure will vary according to engine rating, speed and load.

If the pressure is low, the probable cause is a dirty or damaged compressor, incorrect fuelling of the engine pump, or leaking manifold joints.

Check that the injection pump fuelling has not been disturbed and if satisfactory, remove the turbocharger from the engine for inspection.

A high reading may also indicate incorrect injection pump fuelling but may be due to fouling or damage to the turbine.
Action as for low pressure.

(3) Low oil pressure and/or oil flow : The oil delivery pressure should not be less than 30 lbf/in^2 (2,1 kgf/cm^2) under normal conditions of load.

If the oil pressure is low refer to Section K for action, check engine oil filter (and turbocharger filter if fitted), clean the bores of the feed and return pipes and check the connections for obstruction.

Ensure that the oil drain pipe when assembled has a continuous slope downwards to the inlet on the engine.

Restricted exhaust from the turbine : A restriction of the exhaust from the turbine will affect engine performance. If the back pressure is more than 20 in (500 mm) head of water, check the exhaust system for obstruction and rectify as necessary.

SECTION 9

Reconditioning Instructions

Important

(1) When a turbocharger is removed from an engine, it is imperative that all terminations of oil connections are sealed immediately, to prevent the entry of dirt.

(2) During all stages of turbocharger dismantling, examination and rebuilding, care must be taken to ensure that no damage is caused to components. In the case of the Mk. 1/5 turbocharger, this applies especially to the rotor and impeller blades which, if damaged, will necessitate replacement and re-balancing of the complete rotating assembly. No attempt should be made to correct damage to components of the rotating assembly.

Mk. 1/5 Turbocharger

(Numbers in brackets refer to numbers on the Sectional Drawing, fig. P.4).

Dismantling

(1) Clamp unit upright in vice on turbine inlet flange.

(2) Remove the compressor casing nuts (15) fastening compressor casing (10) to centre casing (4) and lift off casing (10).

(3) Remove the nozzle unit nuts (16) and then, by means of jacking screws, withdraw the nozzle unit (2) axially.

(4) Remove the impeller (12) by standing the centre assembly, with the shaft vertical, and resting the centre assembly on a locating tool (see fig. 5), the pegs of which must locate in the scallops of the turbine rotor and be in good condition, otherwise they will slip out of the rotor scallops and cause damage to the blades. Slacken the impeller nut (14) keeping a steady downward pressure on the assembly; remove impeller nut and washer (13).

(5) Place the centre casing (4) on its side, and withdraw the shaft and rotor (3) from the turbine end. (After removal of the shaft, it is adviseable to protect the journals by wrapping them with tape).

(6) Remove the compressor oil sleeve (9) from the diffuser (11).

(7) Remove the cap screws (17) from the diffuser (11) — the bearing retaining plate will then be exposed and this should be removed.

(8) Remove the bearing (5).

Cleaning Procedure

(1) Use a commercially approved cleaner only. Caustic solutions will damage certain parts and should NOT be used.

(2) Soak parts in cleaner until all deposits have been loosened.

(3) Use a plastic scraper or bristle type brush on aluminium parts. Vapour blast may also be used providing the shaft and other bearing surfaces are protected.

(4) Clean all drilled passages with compressed air jet.

(5) Make certain that surfaces adjacent to wheels on stationary housing are free of deposits and are clean and smooth.

Internal Parts Inspection

(1) Shaft and Turbine Rotor Assembly (3).

(a) Inspect bearing journals for excessive scratches, pitting and wear. Minor scratches may be tolerated.

(b) Check carefully for cracked or damaged blades, **but do not attempt to straighten blades.**

(2) Bearing (5).
Replace bearing if excessively scratched or worn.

(3) Centre Casing (4).
Replace casing if bearing bore is excessively scratched or worn.

(4) Retaining plate (6).
Inspect for excessive wear on bearing face.

(5) Compressor Impeller (12).
Check carefully for cracked, bent or damaged blades **but bo not attempt to straighten blades.**

(6) Nozzle Unit (2).
Examine for distortion of the side plate and damage to the blades.

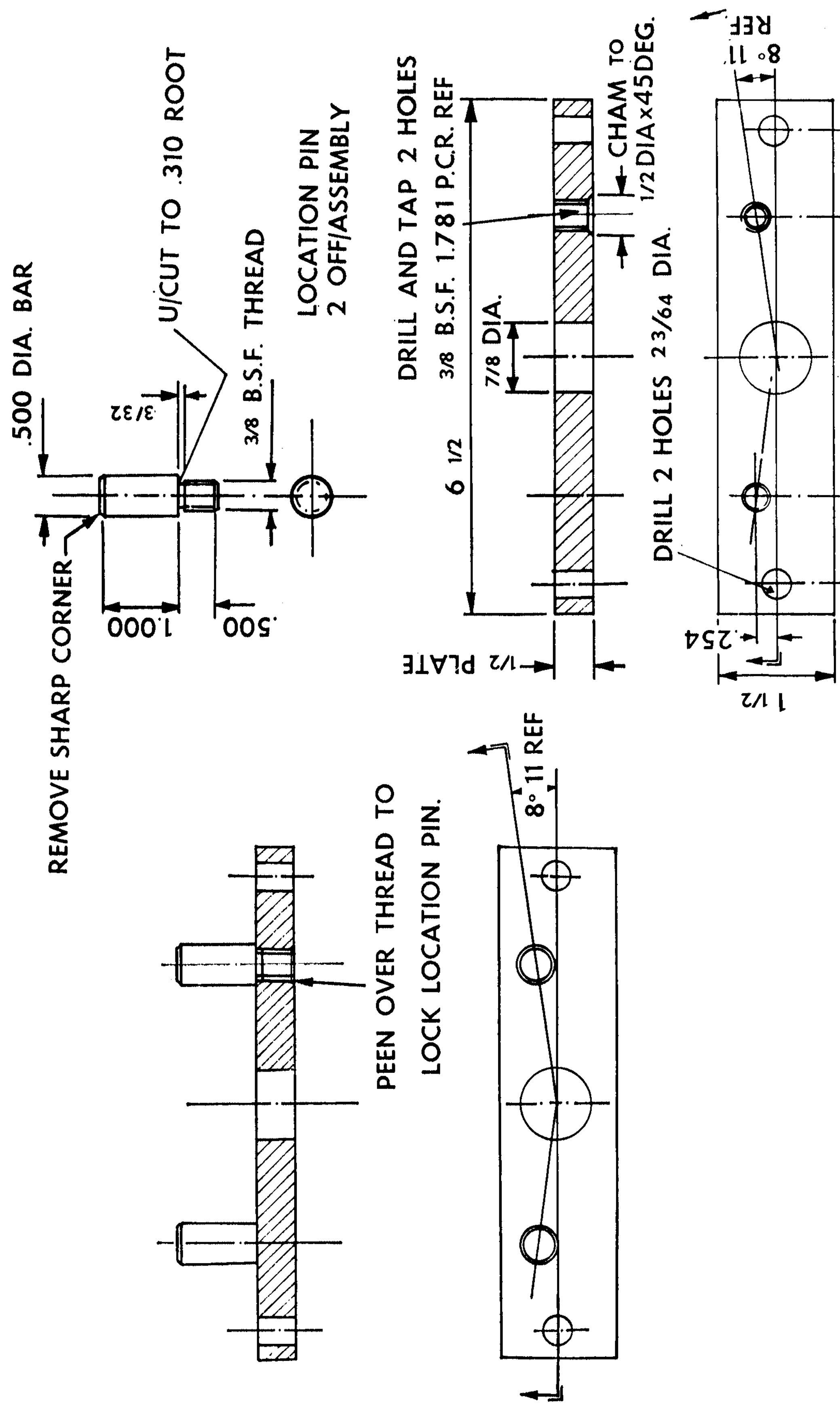


Fig. P.5.
Impeller Removing Tool. (Mk. 1/5 Turbochargers).
All dimensions are in inches.

Re-assembly

When the turbocharger has been thoroughly cleaned, inspected, passages blown out with air and any damaged parts replaced, re-assembly can commence.

NOTE: If during inspection, any part of the rotating assembly is found to be damaged, a replacement assembly which has been dynamically balanced must be obtained and fitted.

Before a replacement rotating assembly is installed, it should be dismantled, examined and cleaned as necessary. The assembly will consist of a rotor and shaft (3), bearing (5), removable oil seal (9), impeller (12), washer (13) and nut (14).

To rebuild a turbocharger which has been dismantled, using either the original or a replacement rotating assembly, the following procedure should be followed:

(1) Lightly oil the bearing and shaft, and fit the bearing into the centre casing; then slide the shaft carefully into the bearing.

(2) Place the unit with the shaft vertical with the turbine rotor underneath, resting it on the tool previously used for dismantling. Fit the retaining plate (6) and the diffuser (7) coating the mating surfaces with a suitable jointing compound, and then secure the latter with the cap screws (17) which should be lightly coated with locking liquid. Fit the seal (9) impeller (12) and washer, taking care that the location marks on all three correspond with the location mark on the shaft. Finally coat the thread on the end of the shaft with locking liquid, fit the nut and tighten to a torque of 310 lbf in (3,56 kgf.m).

(3) Fit the compressor casing (10), tighten the securing nuts.

(4) Turn the assembly over so that the rotor is uppermost. Fit the nozzle unit. The mating flanges should close easily, if they fail to close, remove and rectify. **Do not** attempt to pull them together by tightening the securing nuts (16).

(5) Tighten the turbine casing nuts (16) and check that the rotating assembly turns easily.

The unit is now ready for fitting to the engine. If it is not intended to mount the turbocharger on the engine immediately after assembly, then the oil and gas passages must be sealed off to prevent entry of dirt.

Holset 3LD Turbocharger

(Numbers in brackets refer to numbers on Sectional Drawing, fig. P.6).

Dismantling

(1) Clamp unit upright in vice on turbine inlet flange.

(2) Mark relative positions of turbine housing (8), bearing housing (14), compressor cover (21) and "V" clamp (7).

(3) Remove the eight bolts (3) and associated lockwashers (2) fastening compressor cover (21) to bearing housing (14) and lift off cover (21).

(4) Remove the "V" clamp locknut and spring "V" clamp (7) back onto the bearing housing (14). Lift the core assembly clear of the turbine housing (8).

(5) Holding the turbine wheel at the hub, remove the compressor locknut (17).

(6) Slide compressor wheel (18) off the shaft.

(7) Using circlip pliers, remove the large retaining ring (20) which retains compressor insert (19). Two screw drivers should be used to lift insert (19) from bearing housing (14). Remove "O" ring (4) from insert (19).

(8) The individual parts of the thrust assembly can now be lifted out.

   (a) Spacer sleeve (16) which can be gently pushed out of the insert (19).

   (b) Oil deflector (13) positioned by two groove pins.

   (c) Thrust ring (12).

   (d) Thrust plate (5).

   Note. The groove pins are a press fit in the bearing housing (14) and should not be removed.

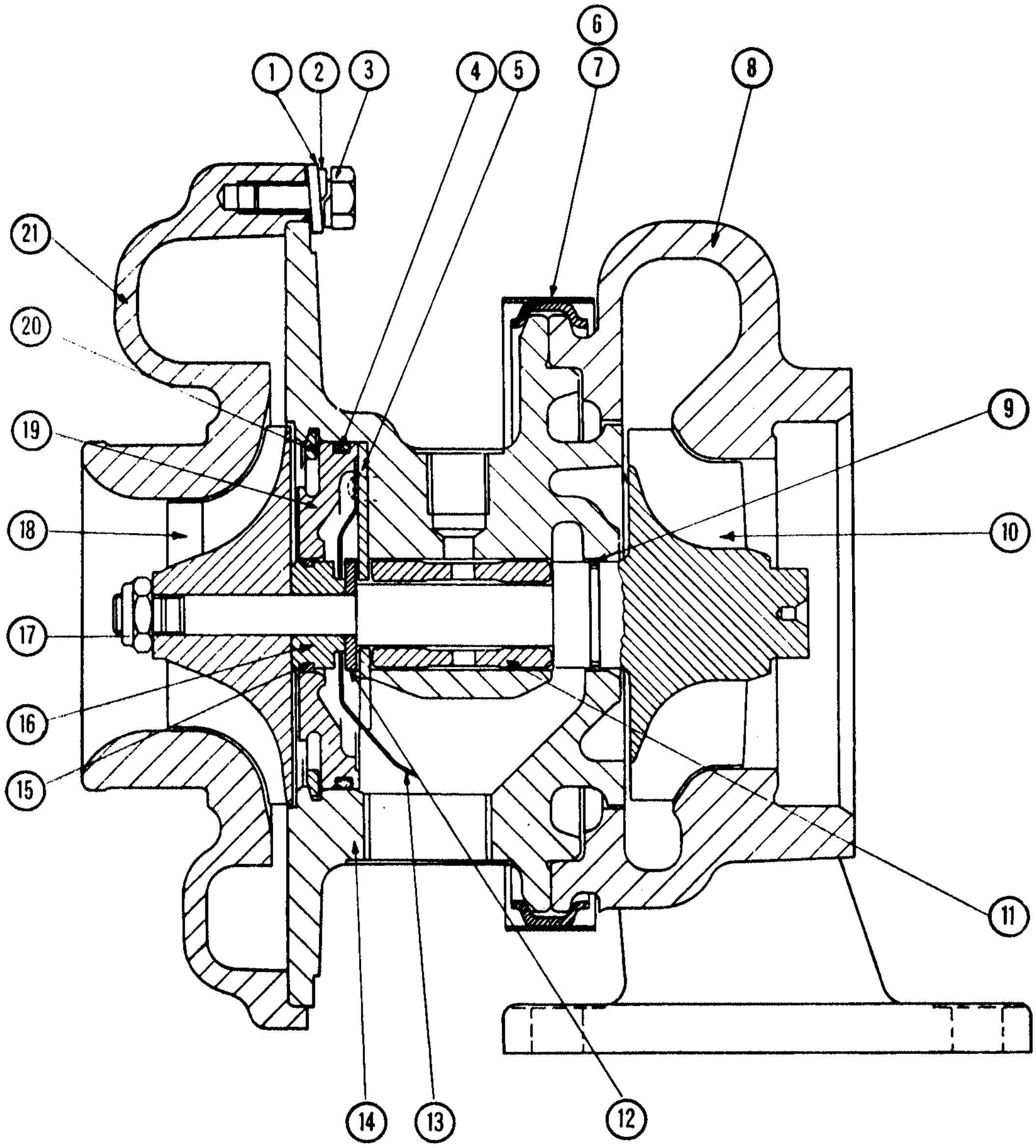


Fig. P.6.

Sectional View of Typical Holset Model 3LD Turbocharger.

1. Washer.
2. Lockwasher.
3. Bolt.
4. 'O' Ring.
5. Thrust Plate.
6. 'V' Clamp Locknut.
7. 'V' Clamp.
8. Turbine Housing.
9. Piston Ring.
10. Shaft and Turbine Wheel Assembly
11. Bearing.
12. Thrust Ring.
13. Oil Deflector.
14. Bearing Housing.
15. Piston Ring.
16. Spacer Sleeve.
17. Compressor Locknut.
18. Compressor Wheel.
19. Compressor Insert.
20. Retaining Ring.
21. Compressor Cover.

(9) Remove shaft and turbine wheel assembly (10) together with its piston rings (9) and (15).

(10) Insert fingertip into bore of bearing (11) and remove.

(11) Carefully expand and remove piston rings (9) and (15) from both the spacer sleeve and turbine wheel and shaft assembly.

Caution. Over expansion of piston ring will cause a permanent set or break the ring.

Cleaning Procedure

(1) Use a commercially approved cleaner only. Caustic solutions will damage certain parts and should NOT be used.

(2) Soak parts in cleaner until all deposits have been loosened.

(3) Use a plastic scraper or bristle type brush on aluminium parts. Vapour blast may also be used providing the shaft and other bearing surfaces are protected.

(4) Clean all drilled passages with compressed air jet.

(5) Make certain that surfaces adjacent to wheels on stationary housings are free of deposits and are clean and smooth.

Internal Parts Inspection

(1) Shaft and turbine wheel assembly (10).

(a) Inspect bearing journals for excessive scratches and wear. Minor scratches may be tolerated.

(b) Inspect piston ring groove walls for scoring. Minor scratches are acceptable.

(c) Check carefully for cracked, bent or damaged blades, but **do not attempt to straighten blades.**

(2) Bearing (11).
Replace bearings if excessively scratched or worn.

(3) Bearing Housing (14).
Replace housing if bearing or piston ring bores are excessively scratched or worn.

(4) Spacer sleeve (16).
Replace if piston ring groove or spacer are damaged.

(5) Thrust ring (12) : thrust plate (5).

(a) Replace if thrust faces are damaged. Minor scratches are acceptable.

(b) Replace thrust plate (5) if faces are worn excessively, unevenly, severely scratched or otherwise damaged.

(c) The small feed grooves in the thrust plate (5), must be clean and free from obstruction.

(6) Compressor wheel (18).
Check carefully for cracked, bent or damaged blades, but **do not attempt to straighten blades.**

(7) 'O' ring (4).
Replace if Section through ring has taken a permanent set, indicated by flats on the sides of the ring.

Re-assembly

When the turbocharger has been thoroughly cleaned, inspected and any damaged parts replaced, assembly can commence.

Assembly of the unit is the reverse of dismantling, but the following points should be noted :

(a) Lubricate bearings, thrust assembly, piston rings and rotor shaft, with clean engine oil.

(b) When replacing turbine wheel and shaft (10) into bearing housing (14), and spacer sleeve (16) into insert (19), do not force piston rings into bore, as an off-centred ring will fracture, causing the shaft to bind.

(c) The large retaining ring (20) should have bevelled side facing outwards.

(d) Torque locknut (17) to 13 lbf ft (1,8 kgf m), bolt (3) to 5 lbf ft (0,7 kgf m) and "V" clamp locknut (6) to 10 lbf ft (1,4 kgf m).

(e) On completion spin shaft to ensure that it rotates freely.

NOTE : If during the dismantling of the turbocharger the lubricating oil feed and drain pipe adaptors were removed from the bearing housing, these should, on re-assembly, be torqued to 25—30 lbf ft (3,46—4,15 kgf m) and 60—65 lbf ft (8,3—8,99 kgf m) respectively.

The unit is now ready for fitting to the engine. If it is not intended to mount the turbocharger on the engine immediately after assembly, then the gas and oil connections must be sealed off to prevent the entry of dirt.

Installation Check List

Mk. 1/5 and Holset 3LD Turbochargers

(1) Inspect the air intake system and the exhaust manifold for cleanliness and foreign matter.

(2) Inspect the oil drain line and make sure it is not clogged.

(3) Inspect the oil supply line for clogging, deterioration or possibility of leaking under pressure.

(4) Inspect the turbocharger mounting pad on the manifold to make certain that all of the old gasket has been removed. On some applications, an adaptor is fitted between the turbocharger and exhaust manifold assembly. The adaptor is secured to the manifold by four studs, nuts and washers and it should be ascertained that all traces of the old gasket have been removed from it.

(5) Install a new gasket between the turbocharger and exhaust manifold. In cases where an adaptor is fitted, it will be necessary to install a gasket between the adaptor and the manifold assembly before placing the turbocharger gasket over the four turbocharger locating studs fitted into the adaptor. Ensure that the gaskets do not protrude into the openings of the manifold (and adaptor when fitted). The opening(s) in the gaskets should be preferably 1/16 in (1.6 mm) away from the edge of the openings in the manifold and adaptor.

(6) Install turbocharger and tighten mounting bolts or securing nuts.

(7) Connect the oil supply line but leave the oil drain line disconnected.

(8) Connect the compressor inlet and outlet piping. Check all joints for possible leaks. Make certain that the piping is not exerting a strain on the compressor cover.

(9) Motor the engine without firing (i.e. by operating stop control), until a steady flow of oil comes from the oil drain line.

(10) Stop motoring and connect oil drain pipe connection.

NOTE : When the turbocharger is put into service it must be "run-in" in accordance with the instructions given in Section 5.

HOLSET 3LD TURBOCHARGER

SCHEDULE OF TOLERANCES

	Manufactured Dimensions	Allowable Dimensions after Service	Remarks
Total turbine wheel clearance	0.047/0.057 in (1,19/1,45 mm)	0.024 in (0,61 mm) min.	
Back turbine wheel clearance	0.015/0.0027 in (0,38/0,68 mm)	As Manufactured	Wheel pushed to compressor end.
Front turbine wheel clearance	0.024/0.038 in (0,61/0,96 mm)	0.024 in (0,61 mm) min.	
Total compressor wheel clearance	0.049/0.062 in (1,24/1,57 mm)	As Manufactured	
Back compressor wheel clearance	0.026/0.043 in (0,66/1,09 mm)	As Manufactured	Wheel pushed to turbine end.
Thrust clearance	0.004/0.008 in (0,10/0,20 mm)	As Manufactured	
Radial float at compressor wheel hub	0.015/0.021 in (0,38/0,53 mm)	0.024 in (0,61 mm) max.	
Bearing outside diameter	0.8714/0.8719 in (22,13/22,14 mm)	As Manufactured	
Bearing inside diameter	0.4815/0.4818 in (12,23/12,24 mm)	As Manufactured	
Thrust bearing width	0.105/0.107 in (2,67/2,72 mm)	0.104 in (2,64 mm) min.	
Squareness of back face of turbine wheel	0.002 in T.I.R. (0,05 mm T.I.R.)	As Manufactured	On Vee block at 1.375 in radius.
Eccentricity of small diameter of shaft	0.0006 in T.I.R. (0,01 mm T.I.R.)	As Manufactured	
Piston ring grooves on shaft	0.066/0.068 in (1,68/1,73 mm)	0.066/0.070 in (1,68/1,79 mm)	
Piston ring groove on spacer sleeve	0.066/0.068 in (1,68/1,73 mm)	0.066/0.070 in (1,68/1,79 mm)	
Piston ring width at turbine end	0.062/0.063 in (1,57/1,60 mm)		Replace at each service.
Piston ring width at compressor end	0.062/0.063 in (1,57/1,60 mm)		Replace at each service.
Bearing housing bore for piston ring	0.8750/0.8755 in (22,22/22,24 mm)	0.877 in (22,28 mm) max.	
Compressor insert bore	0.875/0.876 in (22,22/22,25 mm)	0.877 in (22,28 mm) max.	
Bearing housing bore at bearing	0.8750/0.8755 in (22,22/22,24 mm)	As Manufactured	
Turbine wheel outside diameter	2.977/2.975 in (75,62/75,56 mm)	2.980 in (75,69 mm) max.	
Shaft diameter at bearing	0.4803/0.4800 in (12,20/12,19 mm)	0.4799 in (12,19 mm) min.	

SECTION Q
Alternator and Starter Motor

Alternator

An Alternator charging system is employed on later 6.354 Marine engines and typical wiring circuits are shown in Figs. Q.1. and Q.2.

Important

Where an alternator is fitted, it is essential that the following precautions are observed :—

1. Do not connect battery or alternator with leads reversed. Battery polarity should be checked with a voltmeter before connections are made. All alternator electrical systems on Perkins engines employ a negative earth. Reversed battery connections can damage the rectifiers, wiring or other parts of the charging system.
2. The field circuit should never be earthed. Earthing of the alternator or the regulator field terminal will result in damage to the rectifier.
3. The alternator should never be run on an open circuit with the field winding energised. It may result in damage to the rectifiers.
4. Never attempt to polarise an alternator. It is unnecessary and may result in damage.
5. Where a battery charger is used, ensure that it is correctly connected. Incorrect polarity can cause damage to the rectifiers. When charging a battery in situ, disconnect the battery cables.
6. Do not earth alternator output terminals or damage to the alternator, circuit wiring or components in the system may be incurred.
7. Never connect the battery direct to the regulator or alternator field terminals or damage to the transistorized regulator may result.
8. Always disconnect the alternator output terminal before carrying out any electric welding process on the application to which the engine is fitted. A very strong magnetic field is set up by striking or breaking the electric arc which is sufficient to damage the rectifiers.
9. Don't check a complete alternator for insulation with an insulation tester as this can also damage the rectifiers.
10. Care should be taken in confined marine installations to ensure that the regulator is mounted in a position where the ambient temperature will not exceed 180°F. (80°C.). Under no circumstances should the regulator be mounted directly or indirectly to the engine as it would be subject to radiant heat and also the full engine vibrations.
11. Finally, always disconnect the battery before connecting or disconnecting test instruments (except voltmeter) or before removing or replacing any unit or wiring. Accidental earthing or shorting at the regulator, alternator, ammeter or accessories will cause severe damage to the units and/or wiring. Do not disconnect the battery whilst the engine is running.

CORFIELD PRESTOLITE
B2430 C5 ALTERNATORS

INSTALLATION TESTING

1. Before any tests are made on the Alternator system the battery should be checked and the circuit inspected for faulty wiring or insulation, loose or corroded connections, and poor "earth" circuits.
2. Check the Alternator belt tension (see page L.7) to be sure belt is tight enough to prevent slipping under load.
3. Any unfavourable conditions noted in these inspections must be corrected before proceeding with electrical tests.

   NOTE : The "Ignition" switch should be OFF and the battery earth lead disconnected before making any test connections. Failure to observe these precautions may result in damage to the Alternator system.
4. Test the battery with hydrometer and/or voltmeter. If not fully charged, it should be removed and recharged, or replaced by a fully charged unit.
5. A Voltmeter should be used to test for any excessive voltage drops in the system wiring. (In particular, the drop between battery and Regulator should not exceed 0.1 Volt).

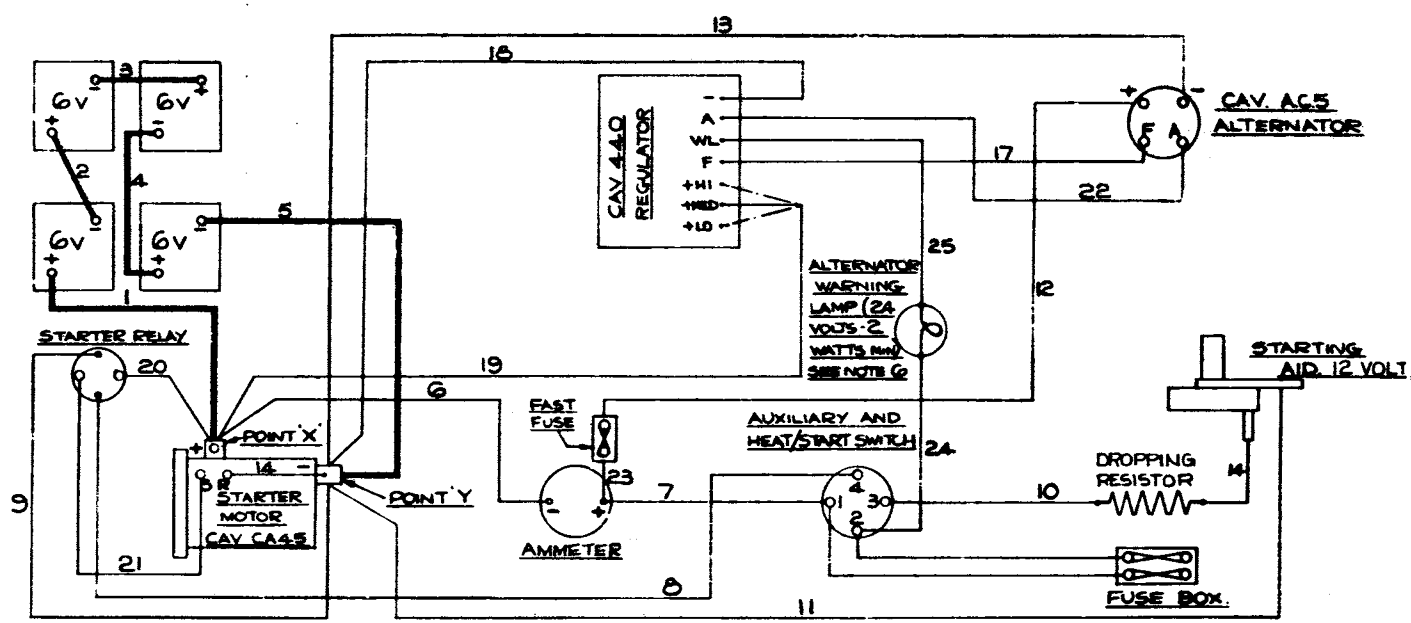


Fig. Q.2. Wiring Diagram for C.A.V. Type A.C.5 Alternator - 24 Volt System

Permissible Voltage Drops

(A) Starter solenoid circuit – between points 'X' and 'Y', via cables 20, 21 and 14, 0.5 Volts for a current of 14 Amperes.

(B) Starter relay circuit – between point 'X' and point 'Y', via cables 6, 7, 8 and 9, 0.25 Volts for a current of 2.1 Amperes.

(C) Starting aid circuit – between points 'X' and 'Y', via cables 6, 7, 10, 14, and 11, 0.6 Volts for a current of 15 Amperes.

(D) Alternator circuit – between points 'X' and 'Y', via cables 6, 12, 13 and 23, 0.5 Volts for a maximum current of 30 Amperes.

(E) Alternator field circuit – between alternator 'F' terminal and regulator 'F' terminal, via cable 17, 0.5 Volts for a current of 2.5 Amperes.

(F) Regulator circuit – to ensure optimum regulator performance, cables 18 and 19 must be separate from any other cables and the voltage drop must not exceed 0.5 Volts for a current of 2.5 Amperes.

(G) Total resistance of battery cables 1, 2, 3, 4, and 5 not to exceed 0.0017 Ohms and total length up to but not exceeding 12 feet of 61/.036 (0.062 in²) or 20 feet of 61/.044 (0.090 in²).

(H) Recommended minimum cable sizes – Cable Nos. 6, 12, 13 and 23, 120/.012 (0.013 in²).
Cable Nos. 24 and 25, 14/.012 (0.0015 in²).

(I) Warning lamp – it is desirable that a warning lamp or a 300 Ohm, 5 Watt resistance be used to allow initial excitation of the alternator.

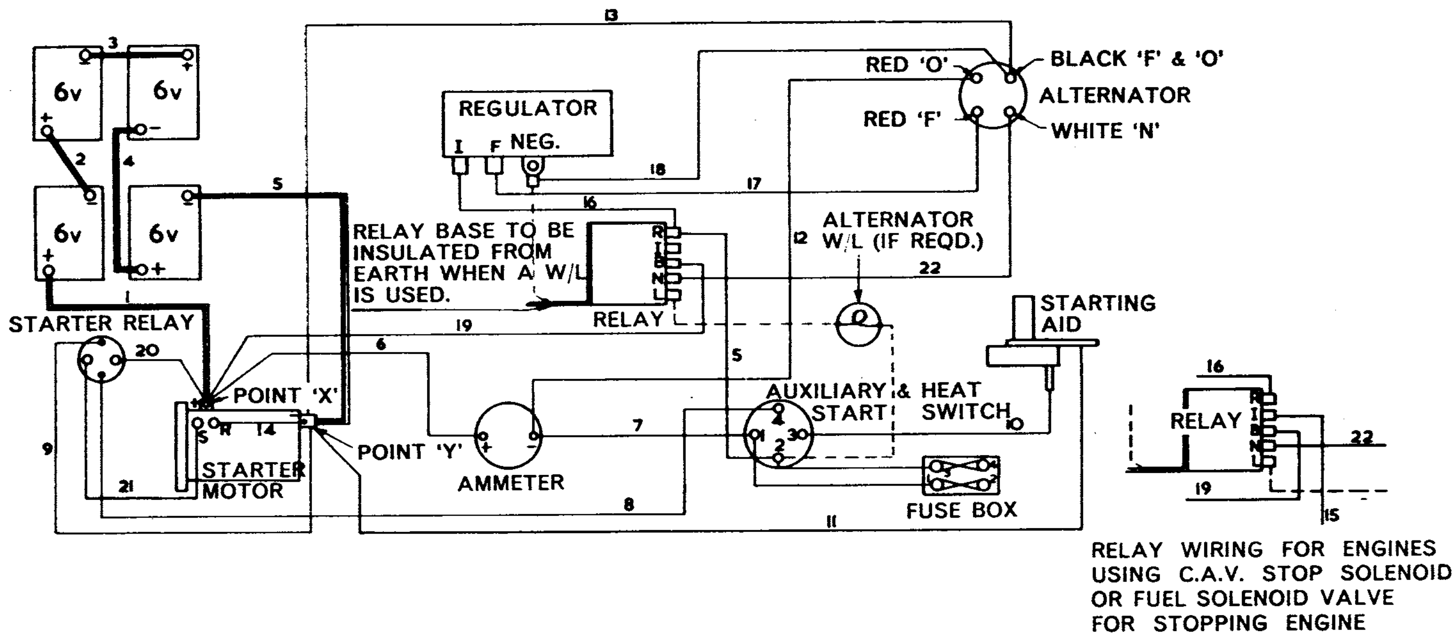


Fig. Q.1. Wiring Diagram for Prestolite Alternator — 24 Volt System

Permissible Voltage Drops

(A) Starter relay circuit – between point 'X' and point 'Y', via cables 6, 7, 8 and 9, 0.25 Volts for a current of 2.1 Amperes.
(B) Starting aid circuit – between points 'X' and 'Y', via cables 6, 7, 10 and 11, 0.6 Volts for a current of 7.5 Amperes.
(C) Alternator circuit – between points 'X' and 'Y', via cables 6, 12 & 13, 0.5 Volts for maximum alternator ouptut.
(D) Starter solenoid circuit – between points 'X' and 'Y', via cables 20, 21 & 14, 0.5 Volts for a current of 14 Amperes.
(E) When calculating voltage drops, note on heat start position of heat/start switch that cables 6 & 7 carry both starter solenoid and starting aid currents.

Total Resistance of Battery Cables 1, 2, 3, 4 and 5 Not to Exceed 0.0017 Ohms.

Guide to Size and Total Length of Battery Cables

Maximum Length	Size		
20 feet	61/.044	0.090 in²	58,0 mm²
12 feet	61/.036	0.060 in²	38,75mm²
Minimum Size of Cables Recommended for 24 Volt System			
Cables 15 and 19	28/.012	0.003 in²	2,0 mm²
Cables 16, 17 & 18	14/.012	0.0015in²	1,0 mm²

All cable runs to be kept as short as possible

6. **ALTERNATOR OUTPUT TEST**

This is made to determine whether the Alternator is capable of delivering its **Rated** output. The Alternator must meet the output specification before Regulator testing is attempted.

First disconnect battery earth lead, then disconnect Alternator output lead, insert test **ammeter** between Alternator output terminal and disconnect lead. Insert test **voltmeter** across Alternator output terminal and earth (or opposite the polarity terminal). Disconnect field lead from Regulator and Alternator. Fit jumper lead from battery to Alternator Field Terminal, reconnect battery earth lead.

Start and run engine to give approximately 4,200 Alternator rev/min and switch ON installation loads to give a voltmeter reading of 28.4 for 24 Volt systems when the ammeter should indicate the rated output as shown on the Alternator label. Note, in some cases it will be necessary to add to the installation load to achieve rated output, this may be done by connecting an external load (carbon pile, additional lamps etc.) across the main battery terminals.

Low output, 5—10 amperes down usually indicates one or more diodes open-circuit.

Low output, 30—40 amperes down, accompanied by a hum or a growl from the Alternator indicates one or more diodes short-circuit.

Similar results may indicate stator winding open or short-circuit.

No output usually indicates failure of the field current within the Alternator. A steel screwdriver or similar item held near the Alternator roller (tail-end) bearing will be magnetically attracted if the field coil is energised.

7. **Quick Check — Diodes and Stator**

Disconnect all Alternator leads, and using ohmeter (AVO or similar).

(a) Check resistance between Neutral Terminal and Output Terminal.

(b) Reverse meter leads and re-check. The value in one direction must be infinity (No circuit) and in the other a circuit must be indicated (the value of this resistance depends on the type of meter used).

(c) Check Resistance between Neutral Terminal and other Output Terminal (this may be "earth").

(d) Reverse meter leads and re-check. Again the value in one direction must be infinity and in the other a resistance similar to that found in (a) or (b) should be indicated.

A circuit in both directions in either pair, (a and b) or (b and c), of tests indicates a short circuit. A widely varying resistance in either pair indicates an open circuit, and the Alternator should be removed for full investigation.

8. **Quick Check — Rotor**

Disconnect leads from Alternator, using ohmmeter (AVO or similar) check resistance between Alternator 'F' Terminal and "Earth" or opposite polarity output terminal.

All 24 volt models should indicate approximately 16 ohms.

If this value resistance is not found, the Alternator should be removed for full investigation.

9. **REGULATOR TESTING**

Having established a serviceable Alternator, remove the jumper lead from battery to Alternator 'F', and reconnect the Field lead to Alternator and Regulator in this order.

The ammeter remains connected as in the output test, but the voltmeter should be connected across Regulator 'I' Terminal and Base (mounting foot or third terminal of insulated return Models).

Start engine and run at approximately 2,000 Alternator rev/min. Switch ON lights etc. to give a 10 ampere charge rate, and run under these conditions for 15 minutes to normalise the temperature.

Cycle the system by stopping and re-starting the engine, then note the voltmeter reading. For 24 Volt systems this should be 28.0—29.4 Volts.

Both at normal ambient temperature.

If this voltage is not found ; disconnect battery earth lead, remove Regulator and replace, these are sealed units and cannot be dis-assembled.

Remake battery connection and check new Regulator.

10. **RELAY TESTING**

When an SY.T Series Relay is fitted to give warning light indication, this should be checked at the same time as the Regulator.

With Ignition Switch ON, check the warning light, if the lamp fails to light check the bulb and wiring, carry out Relay serviceability check as given below.

With ignition Switch ON, and lamp lit, start and run engine at fast idle speed when lamp should be extinguished. If lamp fails to go out, carry out Relay serviceability check as follows :

NOTE : These Relays are used on Alternator output to Neutral voltage and must **not** be connected to full system voltage, otherwise the unit will be damaged.

Using an ohmeter (AVO or similar) check that when Relay is de-energised there is continuity between 'L' Terminal and earth (the mounting foot) and resistance between Terminals 'R' and 'I' of approximately 40 ohms for 24 Volt Relays.

When the Relay is energised (apply 12 Volts for 24 Volt Relay, across terminals 'B' and 'N') check that there is continuity between terminals 'B' and 'R' and open circuits between 'L' terminal and earth.

If a fault is indicated the Relay should be removed and replaced by a serviceable item, these are sealed units and cannot be disassembled.

C.A.V. AC5 ALTERNATOR

INSTALLATION TESTING

The AC 5 alternator is so designed that a flow of current indicated either by the extinguishing of the warning light, or as shown on the ammeter, is sufficient evidence that the system is in proper working order. Therefore, no open circuit, voltage or current output checks should be performed on the installation UNLESS :—

(a) The warning light fails to illuminate when the generator is stationary, and the switch is closed OR fails to become extinguished when the alternator is running.

(b) No charging current is shown on ammeter.

(c) The battery is flat.

(d) The battery is "boiling," indicating loss of voltage control.

If any of the above symptoms occur, the procedure indicated below should be followed.

(a) Connect a good quality moving coil voltmeter 0—50 volts range across the battery or regulator negative terminal, and one of the three positive terminals marked LO, MED, HI. If an ammeter is not part of the applications circuit, fit a good quality moving coil 0—100 amp ammeter in the alternator to battery positive line. **The battery should be in a charged condition.**

(b) Close the warning light switch (master electric switch on dashboard) when the warning lamp should light up.

(c) Switch on a 10—15 amperes load such as lights, fans, etc.

(d) Start engine and run at fast idle speed when
   1. The warning light should go out.
   2. The ammeter records a small charge dependant on engine speed.

(e) Increase engine speed momentarily to maximum speed, when the charging current should be about 30 Amperes for 24 Volt systems.

(f) With the alternator running at approximately half speed, (engine speed about 1,500 rev/min) switch off electrical load. Depending on the connection selected for the positive sensing wire LO, MED or HI, the voltage should rise to between 26 and 28 volts on 24 volt systems and then remain constant. At the same time the current reading should drop appreciably.

Any variance in the above data could indicate a fault and the following procedure should be adopted before disconnecting any components.

The regulator is a sealed unit and is non-repairable and if found to be faulty it must be replaced.

Warning Lamp does not light up when switched "On."

Check the bulb.

If no fault

Check all wiring connections at regulator, alternator and battery.

If no fault

Switch off, disconnect 'F' lead at regulator and connect it to the negative terminal. Switch on. If warning lamp lights up, the regulator is faulty. If lamp fails to light up, the alternator is faulty.

Warning Lamp does not go out and Ammeter shows no output when running.

Check all regulator, alternator and battery connections.

If no fault

Switch off, disconnect 'F' lead at regulator and connect to regulator negative terminal.

Switch on, and run at fast idle.

If no output, alternator is faulty.

If output appears, regulator is faulty.

Warning Lamp does not go out when running and Ammeter shows reduced output with full output only at maximum speed or Warning Lamp goes out but Alternator delivers reduced output. Full output only at maximum speed.

Alternator faulty. Remove from installation and apply open circuit diode check.

Warning Lamp flashes intermittently and Ammeter needle oscillates when Battery is fully charged and no loads are switched in.

Check for excessive resistance in regulator negative sensing lead.

If no fault, regulator is faulty.

Batteries overcharging and Ammeter indicates high or full output all the time.

Check regulator positive sensing lead and its connection at regulator.

If no fault, regulator is faulty.

STARTER MOTOR

Model — CA45

GENERAL DESCRIPTION

Designed for flange mounting, the C.A.45 starter motor has a uniform cylindrical shape with no surface protrusions. This is because the solenoid and main switch assemblies are housed within the drive end-shield, around (i.e, co-axially with) the armature shaft.

The essential feature of the co-axial starter is that, **the Pinion alone** moves axially to engage the engine flywheel. There is no longitudinal movement of the whole armature assembly, as in the axial types.

Smooth engagement of the pinion with the engine flywheel is constantly ensured by using two-stage operation of the solenoid and switch mechanisms. Thus the risk of damage to both pinion and flywheel, through faulty meshing, is practically eliminated.

In construction, the starter consits of three main sections, into which it can be easily dismantled.

1. The solenoid switch-gear and pinion assembly housed in the drive end-shield.
2. The armature, shaft and commutator assembly.
3. The yoke, pole-piece and field-coil assembly.

Ready access is possible therefore, to those parts most likely to require adjustment, such as the switchgear and commutator assemblies.

Testing on the Vehicle

Ensure that the battery is in a charged condition.

Switch on the lamps and operate the starter button. If the starter fails to function, but the lights maintain full brilliance, check the switch and battery connections to the starter and all external leads. Sluggish action of the starter can be caused by a poor or faulty connection.

Difficulty in smooth engagement between starter and engine flywheel is probably due to dirt on the starter-shaft helices preventing free pinion movement. The shaft should be thoroughly cleaned with cleaning fluid followed by the application of a small quantity of Aero Shell 6B or its equivalent.

MAINTENANCE

Brush Gear and Commutator

Inspect the brushes at intervals to ensure that they are free in their guides and that the leads are quite free for movement, by easing back the brush springs and pulling gently on the flexible connections. If a brush is inclined to stick, remove it from its holder and clean the sides with a petrol moistened cloth.

Be sure to refit the brushes in their original positions to retain the "bedding." The brushes should be well bedded (i.e. worn to the commutator periphery) but if not, wrap a strip of very fine glass or carborundum paper firmly around the commutator with the abrasive side outwards. With the brushes in position, rotate the armature by hand in the normal working direction of rotation ; until the correct brush shape is obtained. If the brushes are worn down so that the springs are no longer providing effective pressure, they should be renewed. Check the brush spring pressure by hooking a spring balance under the spring lip. The correct tension is 30/40 ozf (0,85/1,13 kgf).

It is essential that replacement brushes are the same grade as those originally fitted. Genuine spares should always be used. To remove the brushes, unscrew the four fixing screws, one to each brush. In re-assembling care must be taken to re-connect the field coil and interconnector leads, held by two of the fixing screws. Before inserting brushes in their holders, it is advisable to blow through the holders with compressed air or clean them with a cloth moistened with petrol.

The commutator should be clean, entirely free from oil or dirt. Any trace of such should be removed by pressing a clean dry **fluffless cloth** against it, while armature is hand rotated.

If the commutator is dirty or discoloured, tilt the brushes and wrap a strip of fine glass or carborundum paper (not emery cloth) round the commutator, with the abrasive side inwards. Rotate the armature by hand until the surface is even. Clean with a petrol moistened cloth.

If repair is necessary to the commutator or switch gear etc., the starter must be exchanged or repaired by an authorised agent.

LUBRICATING OILS

Lubricating oils for normally aspirated engines should meet the requirements of the U.S. Ordnance Specification MIL-L-46152 or MIL-L-2104C. Lubricating oils for turbocharged engines should meet the U.S. Ordnance Specification MIL-L-2104C.

Some of these oils are listed below. Any other oils which meet these specifications are also suitable.

MIL-L-46152 OILS

Company	Brand	S.A.E. Designation		
		0°F (-18°C) to 30°F (-1°C)	30°F (-1°C) to 80°F (27°C)	Over 80°F (27°C)
B.P. Ltd.	Vanellus M	10W	20W	30
	Vanellus M		20W-50	20W-50
Castrol Ltd.	Castrol/Deusol CRB	10W	20	30
	Castrol/Deusol CRB	5W/20		
	Castrol/Deusol CRB	10W/30	10W/30	10W/30
	Castrol/Deusol CRB		20W/50	20W/50
	Deusol RX Super	—	20W/40	20W/40
A. Duckham & Co. Ltd.	Fleetol HDX	10	20	30
	Q Motor Oil		20W/50	20W/50
	Fleetol Multi V		20W/50	20W/50
	Fleetol Multilite	10W/30	10W/30	10W/30
	Farmadcol HDX		20	30
Mobil Oil Co. Ltd.	Delvac 1200 Series	1210	1220	1230
	Delvac Special	10W/30	10W/30	10W/30
Shell	Rotella TX	10W	20W/20	30
	Rotella TX		20W/40	20W/40

MIL-L-2104C OILS

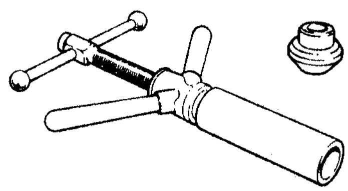
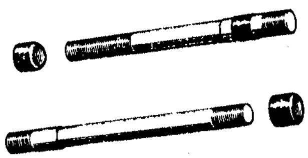
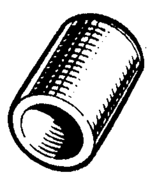
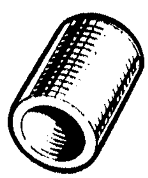
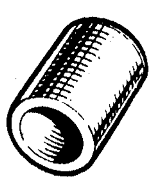
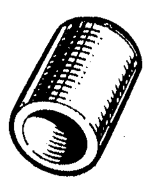
Company	Brand	S.A.E. Designation		
		0°F (-18°C) to 30°F (-1°C)	30°F (-1°C) to 80°F (27°C)	Over 80°F (27°C)
B.P. Ltd.	Vanellus C3	10W	20W/20	30
Castrol Ltd.	Castrol Deusol CRD	10W	20	30
	Deusol RX Super	—	20W/40	20W/40
	Agricastrol HDD	10W	20	30
	Agricastrol MP	—	20W/30	20W/30
	Agricastrol MP	—	20W/40	20W/40
A. Duckham & Co Ltd.	Fleetol 3	3/10	3/20	3/30
	Farmadcol 3	3/10	3/20	3/30
Esso Petroleum Co. Ltd.	Essolube D3- HP	10W	20W	30
Mobil Oil Co. Ltd.	Delvac 1300 Series	1310	1320	1330
Shell	Rimula CT	10W	20W/20	30
	Rotella TX	10W	20W/20	30
	Rotella TX		20W/40	20W/40

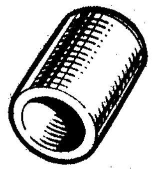
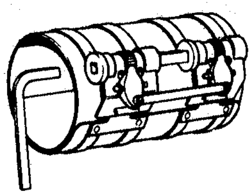
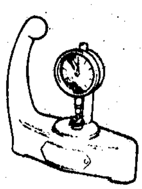
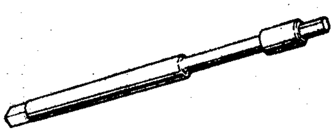
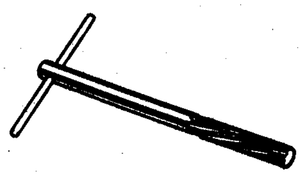
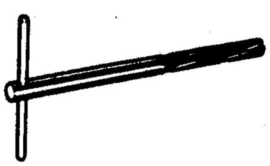
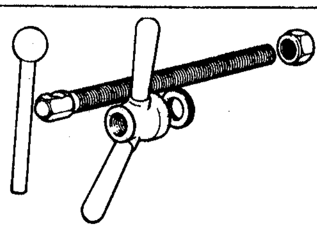
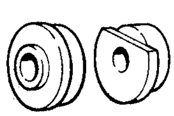
Where oils to the MIL-L-46152 or MIL-L-2104C specification are not available, then oils to the previous specification MIL-L-2104B for normally aspirated engines and MIL-L-45199B or Series 3 specification for turbocharged engines may continue to be used providing they give satisfactory service.

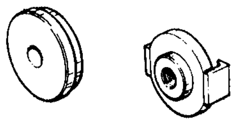
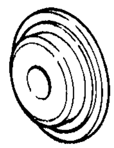
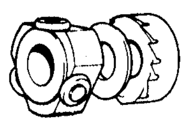
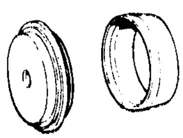
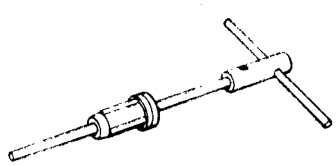
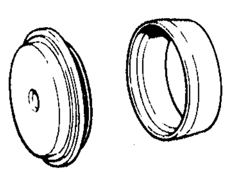
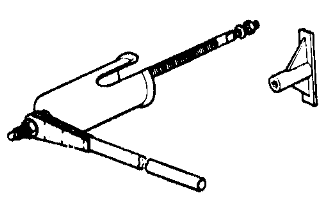
Lubricating oils for use in Perkins Diesel engines should have a minimum viscosity index of 80.

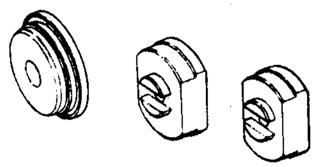
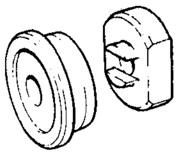
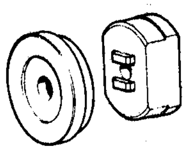
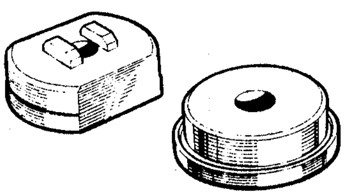
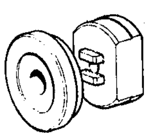
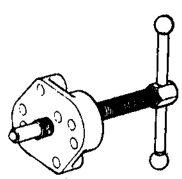
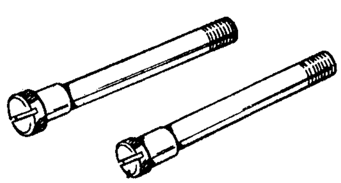
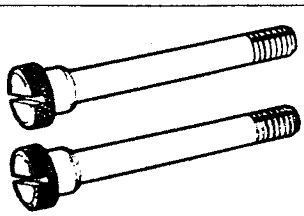
APPROVED SERVICE TOOLS

Available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, NN11 4NF, England.

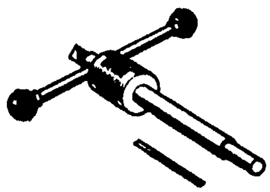
	Tool No.	**Description**	**Application**
	PD.1D	VALVE GUIDE REMOVER AND REPLACER (MAIN TOOL)	All Types
	PD.1D-1A	ADAPTOR FOR PD.1D A pair of puller bars fitted with knurled nuts. Suitable for 5/16" and 3/8" guides. The necessary distance piece from the adaptors below should also be used.	All Types
	PD.1D-2	ADAPTOR FOR PD.1D A 20.5 mm (13/16") distance piece used to replace valve guides to a set height.	4.99 4.107 4.108
	PD.1D-4	ADAPTOR FOR PD.1D A 15 mm (19/32") distance piece used to replace valve guides to a set height.	P3.144 3.152 4.192 4.203 6.288 6.305
	PD.1D-5	ADAPTOR FOR PD.1D A 22.5 mm (7/8") distance piece used to replace valve guides to a set height.	V8.510 (Early)
	PD.1D-6	ADAPTOR FOR PD.1D A 15 mm (19/32") distance piece used to replace valve guides to a set height.	6.354 After engine No. 8522198 general. M/F. 883981 Horizontal Turbo 8430754 6.372
	PD.1D-7	ADAPTOR FOR PD.1D A 16.5 mm (21/32") distance piece used to replace valve guides to a set height.	4.154

	Tool No.	Description	Application
	PD.1D-8	SHORT VALVE GUIDE REPLACER/ADAPTOR 20 mm (0.787")	V8.510 (Current) V8.540
	No.8	PISTON RING SQUEEZER	All Types
	PD.41B	PISTON HEIGHT AND VALVE DEPTH GAUGE A simple method of quickly checking piston height.	All Types
	PD.130A	FUEL PUMP ALLEN SCREW KEY Assists access to the otherwise inaccessible screws on D.P.A. pump	4.99 4.107 4.108 4.192 4.203
	PD.137	VALVE GUIDE REAMER .015" O/size	4.236 4.212 4.248
	PD.138	VALVE GUIDE REAMER .030" O/size	4.236 4.212 4.248
	PD.140	CAMSHAFT BUSH/THRUST COLLAR REMOVER	V8.510 V8.540 6.354 Series 6.372
	PD.140-1	ADAPTOR FOR PD.140	V8.510 V8.540

	Tool No.	Description	Application
	PD.140-2	FUEL PUMP THRUST COLLAR REMOVER/REPLACER ADAPTORS	6.354 Series 6.372
	PD.141	TIMING COVER OIL SEAL REPLACER Used with 550 Driver Handle	V8.510
	PD.143	VALVE SEAT RETAINING CUTTER AND ROLLER HANDLE Use with the appropriate valve seat cutter pilot.	V8.510 V8.540
	PD.143-1	ADAPTOR FOR PD.143	V8.510 V8.540
	PD.145	CRANKSHAFT REAR OIL SEAL REPLACER ADAPTOR (LIP TYPE SEAL)	All engines with 5¼" lip type seal.
	LC.173 (top) PD.146 (bottom)	INJECTOR SLEEVE EXPANDER Expands the copper sleeve into the cast iron head to give watertight seal prior to injector fitting.	T6.354-3
	PD.147	CRANKSHAFT REAR OIL SEAL REPLACER (LIP TYPE SEAL)	All engines with 4" lip type seal.
	PD.150A	CYLINDER LINER REMOVER/ REPLACER (MAIN TOOL) For Field Service replacement of single liners. Not advised for complete overhaul. For this work use adaptors with a hydraulic ram unit.	All types

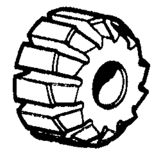
	Tool No.	Description	Application
	PD.150-1B	ADAPTORS FOR PD.150 Suitable for cylinders of 3.6" dia. and 3.87" dia. Removal and replacement.	3.152 4.203 A4.212 4.236 6.305 6.354 Series
	PD.150-5	ADAPTORS FOR PD.150 Suitable for cylinders of 3.125" dia. Removal and replacement.	4.107 4.108
	PD.150-6A	ADAPTORS FOR PD.150 Used for removal and replacement.	V8.510 V8.540
	PD.150-7A	ADAPTORS FOR PD.150 Used for removal and replacement.	4.248 6.372
	PD.150-10	ADAPTORS FOR PD.150 Used to remove and replace cylinder liners with crankshaft in or out of the block.	4 154
	155B	BASIC PULLER The cruciform head with multiple holes at different centres is used with adaptors listed below.	All types
	PD.155-1	ADAPTORS FOR PD.155A Used to remove water pump pulleys. Also suitable to remove Camshaft Gears on 4.236, 6.354 and 4.154.	All types
	PD.155-4A	ADAPTORS FOR PD.155A Used to remove Oil Pump Gear.	3.144 4.203 4.192 3.152

VALVE SEAT CUTTERS

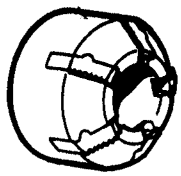


316X BASIC HANDLE

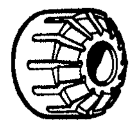
PILOT



VALVE SEAT CUTTER



GLAZEBREAKER



VALVE SEAT CUTTER

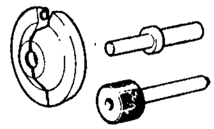
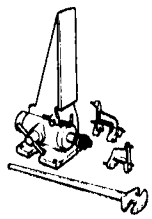
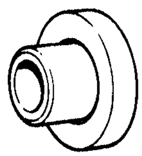
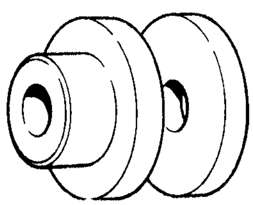
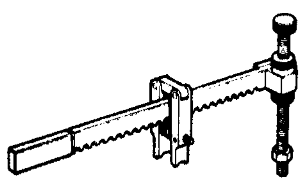
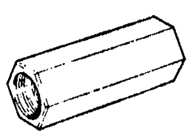
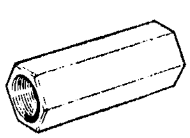
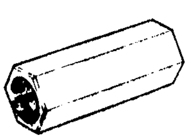
VALVE SEAT CUTTERS

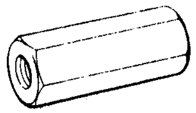
The basic tool is the 316X HANDLE

The following cutters and pilots are all designed to be used with this handle.

Tool No.	Description	Application	
316-10	Pilot (5/16" dia. Valve Guide)	P3.144	
		3.152	
		4.192	
		4.203	
		6.288	
		6.305	
		4.99	
		4.107	
		4.108	
		4.154	
316-12	Pilot (3/8" dia. Valve Guide)	4.270	
		4.300	
		4.236	(With Valve Guides)
		6.354	
		6.372	
		4.212	
		4.248	
		A4.300	
		A4.318	
		V8.510	
		V8.540	
316-13	Pilot	4.236	(Without Valve Guides)
		4.212	
		4.248	
316-125	Pilot (.015" O/size on 3/8" Guide)	4.236	
		A4.212	
		A4.248	
316-130	Pilot (.030" O/size on 3/8" Guide)	4.212	
		4.236	
		4.248	
PD.317-18	Valve Seat Cutter	4.99	Exhaust
		4.107	„
		4.108	„

Tool No.	Description	Application	
PD.317-22	Valve Seat Cutter	4.99	Inlet
		4.107	,,
		4.108	,,
		4.212	Exhaust
		4.248	,,
		4.236	,,
		6.354	,,
		6.372	,,
PD.317-23	Valve Seat Cutter	3.152	Exhaust
		P3.144	,,
		4.192	.
		4.203	,,
		6.288	,,
		6.305	,,
PD.317-25A	Valve Seat Cutter	4.270	Exhaust
		4.300	,,
		A4.318	,,
		A4.300	,,
PD.317-29	Valve Seat Cutter	3.152	Inlet
		P3.144	,,
		4.192	,,
		4.203	,,
		6.288	,
		6.305	,,
PD.317-26	Valve Seat Cutter	4.270	Inlet
		4.300	,,
		A4.300	,,
		A4.318	,,
PD.317-35M	Valve Seat Cutter Exhaust	D3.152	35° Seats
PD.317-37M	Valve Seat Cutter	4.154	Exhaust
317-30	Valve Seat Cutter	D3.152 }	Inlet and
		D4.203 }	Exhaust
		V8.510 }	Inlet and
		V8.540 }	Exhaust
		4.154	Inlet
		4.212	,,
		4.236	,,
		4.248	,,
		6.354	,,
		6.372	,,
PD.317-40M	Valve Seat Cutter Inlet	D3.152	35° Seats
317G-19	Valve Seat Glazebreaker	4.99	Exhaust
		4.107	,,
		4.108	,,
317G-22	Valve Seat Glazebreaker	4.99	Inlet
		4.107	,,
		4.108	,,
		P3.144	Exhaust
		3.152	,,
		4.192	,,
		4.203	,,
		4.212	,,
		4.236	,,
		4.248	,,
		6.288	,,
		6.354	.
		6.372	,,

	Tool No.	Description	Application
	MF.200-26	WATER PUMP OVERHAUL KIT Used with 370 Taper Base and Press.	All engines except V8.510 V8.540
	335	CON ROD JIG & 336 MASTER ARBOR	All types
	336-101	ARBOR ADAPTOR Used with 335	4.99 4.107 4.108
	336-102	ARBOR ADAPTOR Used with 335	A4.212 4.236 A4.248 6.354 A4.270 6.372 A4.300 V8.510 A4.318 V8.540
	6118B	VALVE SPRING COMPRESSOR	All types
	PD.6118-1 •	ADAPTOR FOR 6118B	4.99 4.107 4.108 4.154
	PD.6118-3	ADAPTOR FOR 6118B	3.144 3.152 4.192 4.203 4.270 4.300 V8.510 V8.540
	PD.6118-4	ADAPTOR FOR 6118B	4.236 6.354 4.212 4.248

	Tool No.	Description	Application
	6118B-5	ADAPTOR FOR 6118B	T6.354-3

Tool No.	Description	Application	
317G-25	Valve Seat Glazebreaker	P3.144	Inlet
		3.152	,,
		4.192	,,
		4.203	,,
		6.288	,,
		6.305	,,
		4.270	Exhaust
		4.300	,,
		A4.318	,,
317G-30		D3.152 D4.203 V8.510 V8.540	Inlet and Exhaust
		4.212	Inlet
		4.236	,,
		4.248	,,
		A4.300	,,
		A4.318	,,
		6.354	,,
		6.372	,,
		4.270	Exhaust

INDEX

INDEX (continued)

Abbreviations of Technical Terms Applicable to Service Literature

Where it is found necessary to use abbreviations in Service Literature the units and symbols adopted are those laid down in British Standards Publications 1991.

A glossary of such terms with their British Standard equivalent is given below for reference purposes.

GLOSSARY OF TERMS

TERM	BRITISH STANDARD	REMARKS
ampere	A	or ampere if confusion may arise
atmosphere	atm	
brake horse power	b h p	
British Thermal Unit	B t u	
centimetre	cm	
Cubic centimetre	cm^3	similarly for millimetre, etc.
cubic inch	in^3	similarly for foot, etc.
foot	ft	
foot pounds per minute (work)	ft lbf/min	
gallon	gal	
gallons per minute	gal/min	similarly for pint, litre, etc.
gramme	g	when referring to gramme mass
gramme	gf	when referring to gramme force
hour	h	
inch	in	or inch if confusion may arise
kilogramme	kg	
kilogramme metre (torque)	kgf m	
kilogrammes per square centimetre	kgf/cm^2	similarly for gramme, etc.
kilometre	km	
litre	l	or litre if confusion may arise
mile	mile	
millimetre	mm	
miles per gallon	mile/gal	similarly for pint, litre, etc.
miles per hour	mile/h	similarly for kilometre, etc.
minute	min	
ounce	oz	
pint	pt	
pound	lb	when referring to pound mass
pound	lbf	when referring to pound force
pounds feet (torque)	lbf ft	
pounds per square inch	lbf/in^2	similarly for ton, etc.
revolutions per minute	rev/min	
second (time)	s	
shaft horse power	s h p	
square centimetre	cm^2	similarly for millimetre, etc.
square inch	in^2	
ton	ton	
tonne (1000 kg)	t	
volt	V	
yard	yd	similarly for foot, yard, etc.

EXAMPLES OF SERVICE FACILITIES

Service Publications

The following Service Literature may be purchased through your local Perkins Distributor.

Workshop Manuals
Workshop Data
Operators Handbooks
Turbocharger Service Instructions
Crankshaft Regrinding
Valve Seat Inserting and Cylinder Head Skimming
Fault Finding Guide
Installation and Maintenance Guide for Static Standby Engines
Etcetera

Service Instruction

Perkins Engines, Inc.
24175 Research Drive
P.O. Box 283 • Farmington, Michigan 48024 • U.S.A.
Tel. (313) 477-3900 • Telex: 023-5300

ENGINE #
TE 20696 U 539 661 E

PARTS (1993)
MAC BORING - 908 964 0700 - ASK FOR DESCO
(KEVIN PENDALTON)

AL