Perkins engines

WORKSHOP MANUAL FOR DIESEL ENGINES

4.108M

4.107M

4.99M

PRINTED U.S.A.

workshop manual for 4.108 4.107 and 4.99 marine engines

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MEXICO	Motores Perkins S.A., Antiguo Camina San Lorenzo S/N., (Apartado Postal 194) Toluca, Mexico. Telephone : Toluca 4-44-55. Telex : 0-17-84-93 Mopesa Tol.
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SPAIN	Motor Iberica S.A. (Division Zona 2), Carretera del Aero-Club, Carabacnhel 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 : 290-726. 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

Unified Threads

All threads used on 4.99, 4,.107 and 4.108 Marine engines, except on proprietary equipment are Unified Series and American Pipe Series.

Engine Number

The engine number is stamped on the top edge of the facing on the cylinder block to which the fuel injection pump is secured as shown in the accompanying diagram. The number should be quoted when requesting information or ordering Parts.

Three systems of engine numbering have been used.

On early engines, the serial number consisted of seven digits i.e.:—

Engine Type	Typical Engine No.
4.108	7300269
4.107	7100399
4.99	7000251

On later engines, the number consisted of figures and letters i.e.:—

Engine Type	Typical Engine No.
4.108	108U251
4.107	107U251
4.99	99U251

The first three figures represent the capacity of the engine in cubic inches, the letter "U" signifies the engine was built in the United Kingdom and the last group of figures comprises the engine number.

With current engines, up to fifteen figures and letters are used, a typical number being ED13541U510256D. For further details, see Page 5.

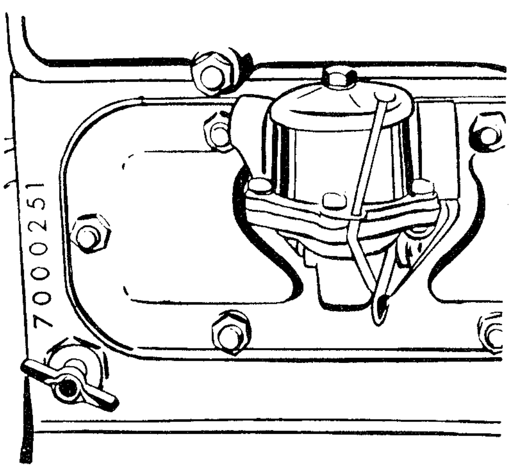
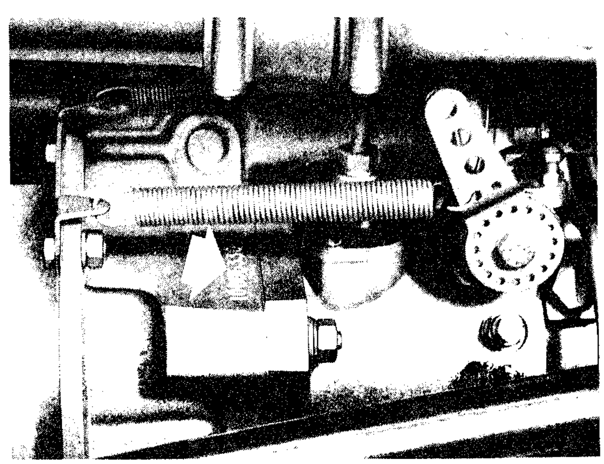


Diagram showing location of Engine No. on earlier 4.99 Engines.



Engine Number Location on Current Engines.

Engine Identification — New Series

A new system of Engine Identification is being introduced into various Manufacturing Operations throughout the world, within the Perkins Group of Companies.

This new number consists of up to fifteen letters and numbers which represent:

Engine Family
Engine Type and Phase
Parts List
Country of Origin
Production Serial Number
Year of Manufacture

ENGINE FAMILY AND TYPE CODES

The first two characters are letters, the first of which indicates the engine FAMILY and the second letter is the engine TYPE and PHASE

FAMILY	TYPE	CODE
D2.101		A
	D2.101	AA
3.152		C
	P3	CA
	3.144	CB
	P3.144	CC
	3.152	CD
	D3.152	CE
	G3.152	CF
	P3.152	CG
4.108		E
	4.99	EA
	4.107	EB
	T4.107	EC
	4.108	ED
4.154		G
	4.154	GA
4.165		H
	4.165	HA
4.203		J
	P4	JA
	4.192	JB
	P4.192	JC
	4.203	JD
	D4.203	JE
	G4.203	JF
	4.2032	JG
4.236		L
	4.212	LA
	G4.212	LB
	4.224	LC
	4.236	LD
	G4.236	LE
	4.248	LF
4.270		N
	4.270	NA
	4.300	NB
	4.318	NC
6.305		P
	P6	PA
	6.288	PB
	6.305	PC
	PF6.305	PC
6.247		R
	6.247	RA
6.354		T
	6.306	TA
	6.335	TB
	6.354	TC
	H6.354	TD
	T6.354	TE
	HT6.354	TF
	6.3541	TG
	T6.3541	TH
	6.3542	TJ
	C6.3542	TK
	6.3543	TL
	C6.3543	TM
	H6.3543	TN
	T6.3543	TP
	HT6.3543	TQ
	6.372	TR
	6.3723	TS
	TC6.3541	TT
	T6.3544	TU
	6.3724	TV
	6.3544	TW
	C6.3544	TX
6.357		V
	6.357	VA
	6.3572	VB
	C6.3572	VC
	6.358	VD
V8.510		X
	V8.510	XA
	TV8.510	XB
	V8.540	XC
	V8.605	XD
V8.640		Z
	V8.640	ZA
	TV8.640	ZB

COUNTRY OF ORIGIN CODE

A code, as below, indicates the country in which the basic engine was manufactured

A =	ARGENTINE	N =	U.S.A.
B =	BRAZIL	P =	POLAND
C =	AUSTRALIA	R =	
D =	GERMANY	S =	INDIA
E =	SPAIN	T =	TURKEY
F =	FRANCE	U =	UNITED KINGDOM
G =	GREECE	V =	
H =		W =	IRAN
J =	JAPAN	X =	PERU
K =	KOREA	Y =	YUGOSLAVIA
L =	ITALY	Z =	
M =	MEXICO		

YEAR OF MANUFACTURE CODE

The last character indicates the **calendar** year of manufacture: –

B = 1975
C = 1976
D = 1977
E = 1978
Etc.

The letters I, O and Q, will not be used.

EXAMPLE OF MAIN ENGINE NUMBER

Example : ED13541U510256D

THUS

E	=	4.108 Family
D	=	4.108 Type
13541	=	Parts List Number
U	=	Built in United Kingdom
510256	=	Serial Number
D	=	Built in 1977

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.

FOREWORD

This Workshop Manual has been compiled for use in conjunction with normal workshop practice. Therefore, certain accepted practices have 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.

Where left hand or right hand is referred to in this manual, it is that side when viewed from the flywheel end.

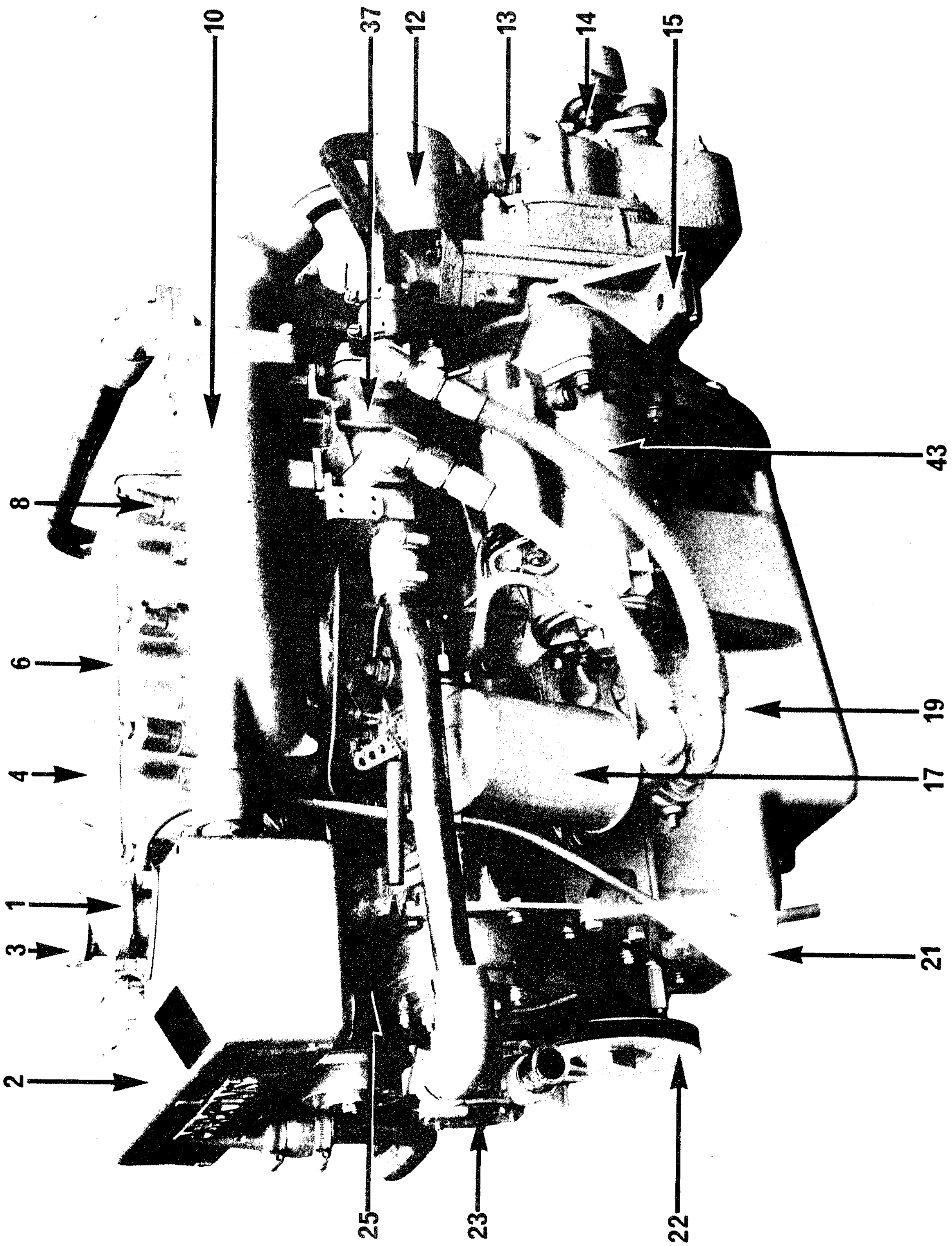
This engine manual is to guide you in dismantling and re-assembly. For information regarding the application of the engine, the reader should refer to the Perkins "MARINE INSTALLATION KNOW-HOW" Publication No. 235.

SECTION A
Engine Photographs

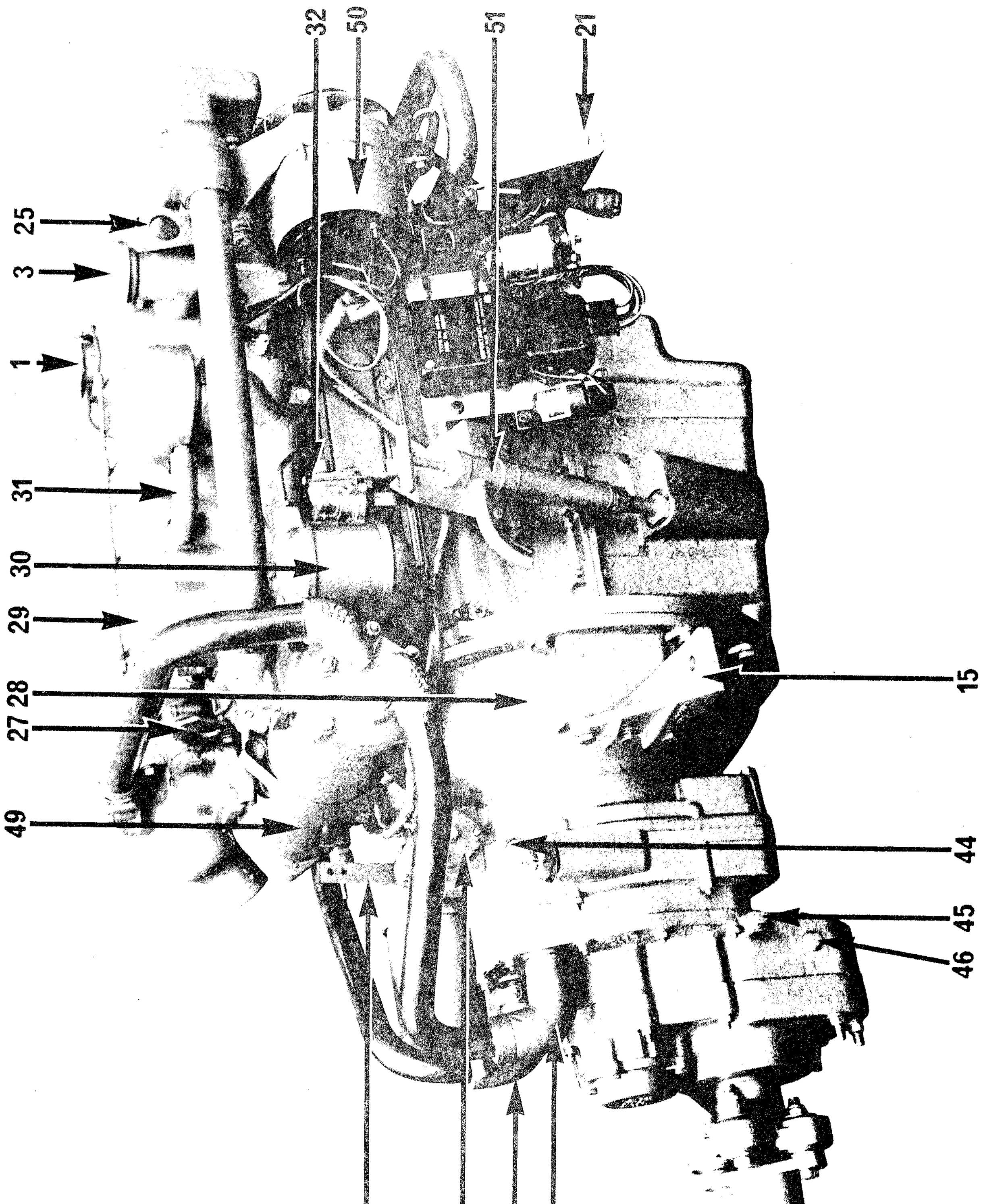
Perkins engines are built to individual requirements to suit the applications for which they are intended and the following engine views do not necessarily typify any particular specification.

Index to Engine Photographs

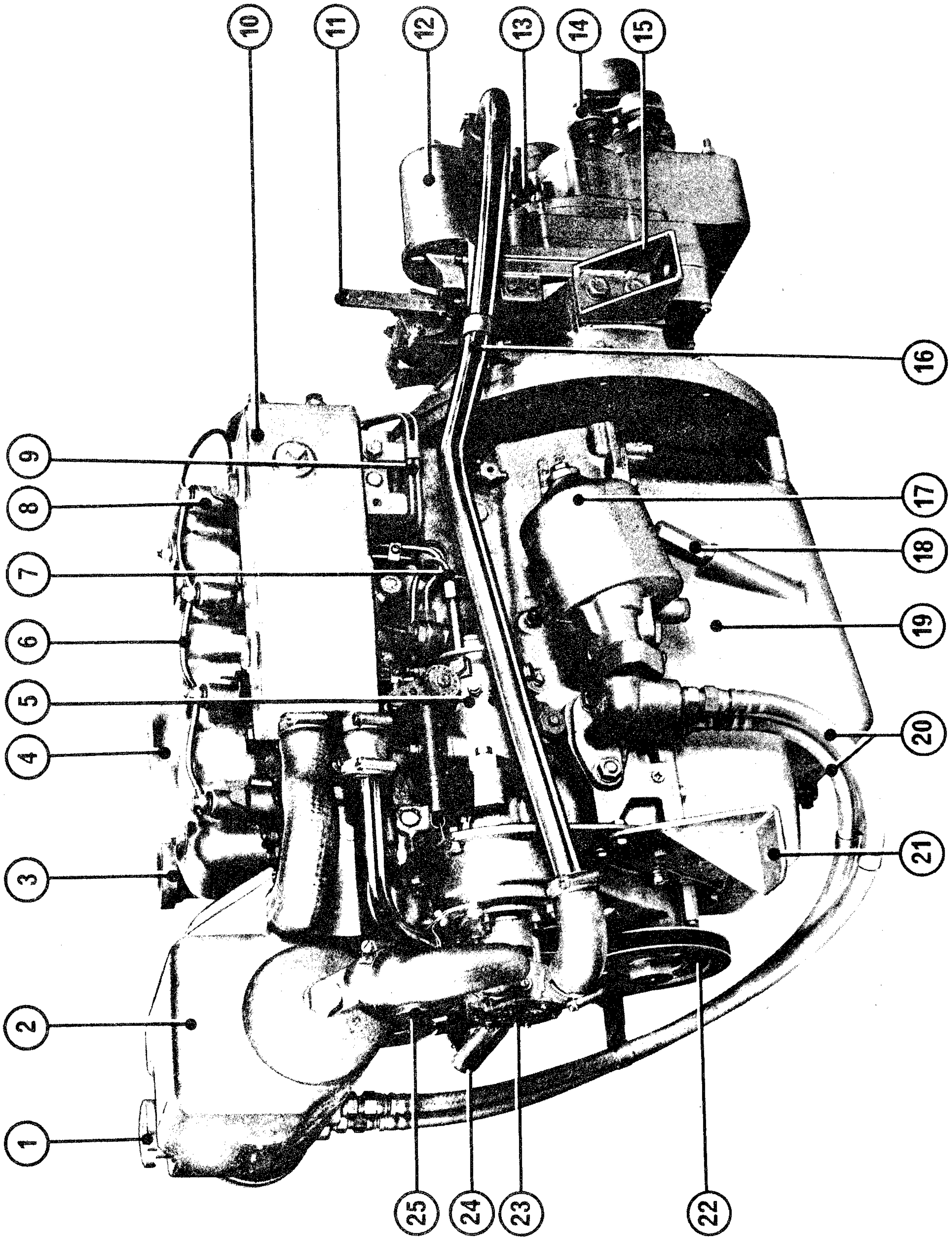
1. Fresh Water Filler Cap.
2. Header Tank.
3. Oil Filler.
4. Air Filter.
5. Fuel Injection Pump.
6. Atomiser Leak off Pipe.
7. Pressure pipes, Injection Pump to Atomisers.
8. Atomiser.
9. Fuel Pipes, Filter to Injection Pump.
10. Exhaust Manifold.
11. Ahead and Astern Engagement Lever.
12. Gearbox Oil Filter.
13. Reduction Gearbox Oil Filler.
14. Output Flange.
15. Rear Engine Support.
16. Water Pipe, Gearbox to Sea Water Pump.
17. Lubricating Oil Filter.
18. Connection for Oil Sump Pump*
    *Where a "Z" Drive Transom unit is fitted, the sump drain pump is connected to the dipstick tube.
19. Sump.
20. Oil Cooler Pipes.
21. Front Engine Support.
22. Crankshaft Pulley.
23. Sea Water Pump.
24. Water Pipe Exhaust Manifold to Cylinder block.
25. Fresh Water Pump.
26. Gearbox Pressure Gauge Connection.
27. Rear Lifting Eye.
28. Flywheel Housing.
29. Cylinder Head Cover.
30. Fuel Filter.
31. Breather Pipe.
32. Fuel Lift Pump.
33. Induction Manifold.
34. Cold Starting Aid.
35. Front Lifting Eye.
36. Sea Water Outlet Connection.
37. Engine Oil Cooler.
38. Dynamo Driving Belt.
39. Dynamo.
40. Tappet Inspection Cover.
41. Tachometer Drive.
42. Dipstick.
43. Starter Motor.
44. Gearbox Dipstick.
45. Gearbox Water Drain Plug.
46. Reduction Gearbox Oil Level Plug.
47. Gearbox Water Inlet Connection.
48. Gearbox Water Outlet Connection.
49. Heat Exchanger.
50. Alternator.
51. Sump Drain Pump.



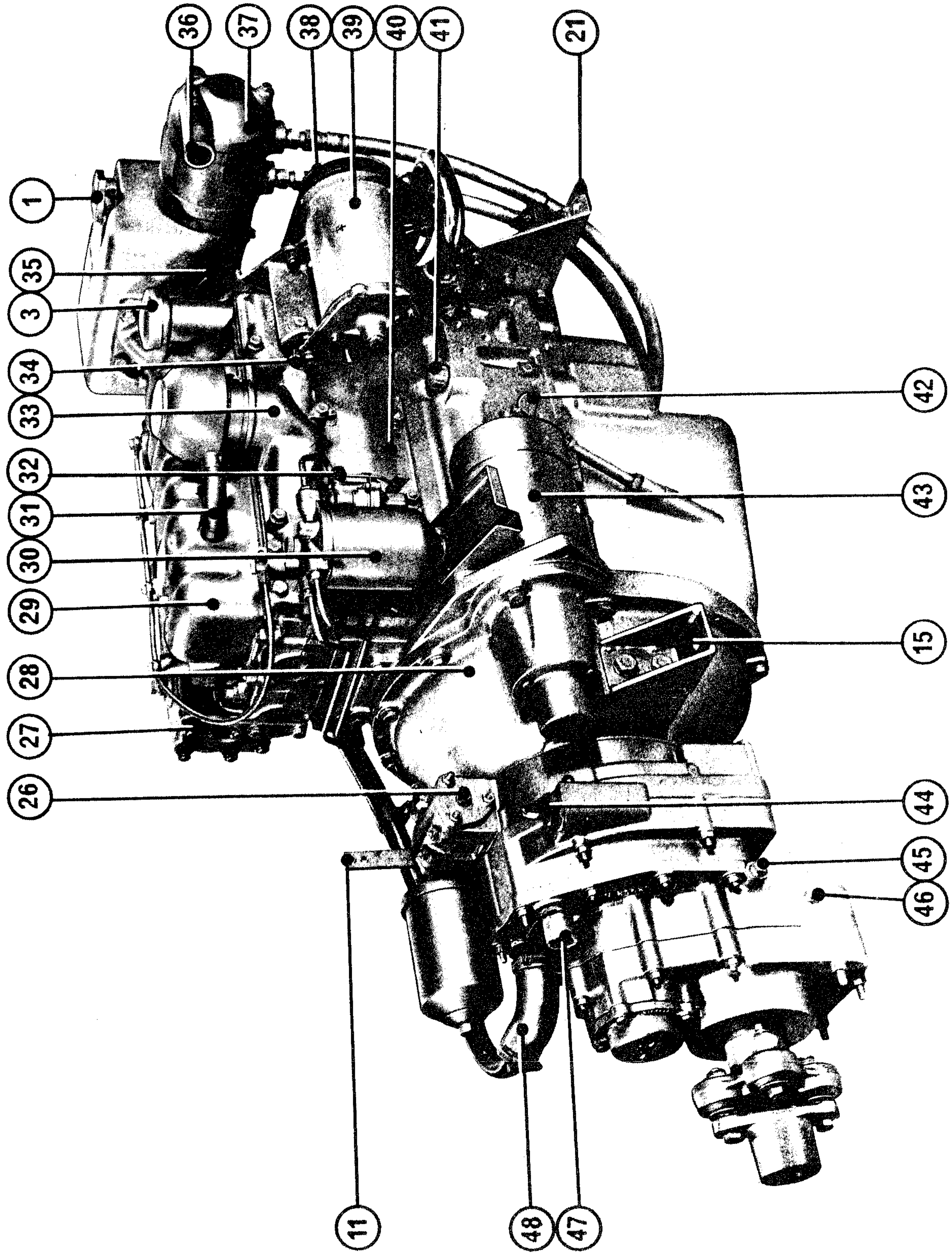
View of Fuel Pump Side of Low-Line Engine.



View of Camshaft Side of Low-Line Engine.



View of Fuel Pump side of Engine.



View of Camshaft side of Engine.

SECTION B
Technical Data

Engine Data

	4.108 and 4.107	4.99
Bore (Nominal — see Page B.4)	3.125 in (79,37 mm)	3.00 in (76,2 mm)
Stroke	3.5 in (88,9 mm)	3.5 in (88,9 mm)
No. of Cylinders	Four	Four
Cubic Capacity	107.4 in³ (1,760 litre)	99 in³ (1,621 litre)
Compression Ratio	22 : 1	20 : 1
Firing Order	1, 3, 4, 2	1, 3, 4, 2
Cycle	Four-Stroke	Four-Stroke
Combustion System	Indirect Injection	Indirect Injection
Engine Rotation	Left Hand viewed from rear	Left Hand viewed from rear

Rating Details

	4.108	4.107	4.99
Pleasure Craft (high speed)	47 shp (38 kW) at 4,000 rev/min	48 shp at 4,000 rev/min	43 shp at 4,000 rev/min
Pleasure Craft	45 shp (36 kW) at 3,600 rev/min	45 shp at 3,600 rev/min	40 shp at 3,600 rev/min
Commercial Craft	37 shp (30 kW) at 3,000 rev/min	36 shp at 3,000 rev/min	33 shp at 3,000 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.

ENGINE WEIGHTS (Dry Approx.)

Direct cooled engine with mechanically operated direct drive gearbox	520 lb (236 kg)
Heat exchanger cooled engine with mechanically operated reduction gearbox	590 lb (268 kg)
Direct cooled engine with hydraulically operated direct drive gearbox	505 lb (229 kg)
Heat exchanger cooled with hydraulically operated reduction gearbox	570 lb (259 kg)

4.108 (Low line)

Indirect cooled engine with hydraulically operated direct drive gearbox	575 lb (261 kg)
Indirect cooled engine with hydraulically operated reduction gearbox	605 lb (275 kg)
Direct cooled engine with hydraulically operated direct drive gearbox	505 lb (229 kg)
Direct cooled engine with hydraulically operated reduction gearbox	535 lb (243 kg)

De-Rating for Altitude

This is not usually necessary for 4.99, 4.107 and 4.108 marine engines. A small loss of power will occur when temperature and humidity are particularly adverse and allowance for this should be made when designing the propeller.

Where engines 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, 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%

Any necessary adjustments in this respect to the fuel pump should be carried out by the C.A.V. dealer 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.

Recommended Torque Tensions

The following torque figures will apply with the components lightly oiled before assembly: —

	4.108			4.107 and 4.99		
	lbf/ft	kgf/m	Nm	lbf/ft	kgf/m	Nm
Cylinder Head Nuts	60	8,3	81	42	5,8	57
Connecting Rod Setscrews	42	5,8	57	42	5,8	57
*Main Bearing Setscrews	85	11,75	115	85	11,75	115
Flywheel Setscrews	60	8,3	81	60	8,3	81
Idler Gear Hub Setscrews	36	5,0	49	36	5,0	49
Crankshaft Pulley Setscrew	150	20,7	203	150	20,7	203
Atomiser Securing Nuts	12	1,7	16	12	1,7	16
Fuel High Pressure Pipe Nuts	15	2,1	20	15	2,1	20
Dynamo Pulley Nut	20	2,8	27	20	2,8	27
Alternator Pulley Nut	30	4,1	41	30	4,1	41
Thermostart Unit	10	1,38	13	10	1,38	13
Thermostart Insulating Adaptor	10	1,38	13	10	1,38	13

*The tab and shim washers may be discarded where used on earlier engines, but the setscrews must be tightened to the torque loading indicated.

All threads used, except on proprietary equipment are Unified Series and American Pipe Series.
The crankshaft and pulley retaining setscrew are threaded 5/8 in U.N.F. (18 T.P.I.).

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 Longitudinal	0.006 in (0,15 mm)
Transverse	0.003 in (0,08 mm) concave
	0.005 in (0,13 mm) convex
Maximum Bore Wear (when new liners are necessary)	0.006 in (0,15 mm)
Crankshaft Main and Big End Journal Wear	0.001 in (0,03 mm)
Ovality	0.0005 in (0,01 mm)
Maximum Crankshaft End Float	0.020 in (0,51 mm)
Valve Stem to Guide Clearance Inlet	0.005 in (0,13 mm)
Exhaust	0.006 in (0,15 mm)
Valve Head Thickness at outer edge	0.025 in (0,64 mm)
Rocker Clearance on 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	0.010 in (0,25 mm)

MANUFACTURING DATA AND DIMENSIONS

The following data of clearances and tolerances are given as a guide for personnel engaged upon major overhauls and the figures are those used in the factory for production purposes.

Cylinder Block

Total Height of Cylinder Block between Top and Bottom Faces	4.108, 4.107, 4.99	9.936/9.939 in (252,374/252,451 mm)
Parent Bore Dia. for Cylinder Liner	4.108	3.249/3.250 in (82,525/82,550 mm)
Parent Bore Dia. for Cylinder Liner	4.107, 4.99	Wet Liners
Main Bearing Parent Bore	4.108, 4.107, 4.99	2.3950/2.3955 in (60,833/60,846 mm)
Camshaft Bore Dia. No. 1	4.108, 4.107, 4.99	1.794/1.7955 in (45,568/45,606 mm)
Camshaft Bore Dia. No. 2	4.108, 4.107, 4.99	1.784/1.787 in (45,314/45,390 mm)
Camshaft Bore Dia. No. 3	4.108, 4.107, 4.99	1.776/1.778 in (45,110/45,161 mm)
Tappet Bore Dia.	4.108, 4.107, 4.99	0.562/0.56325 in (14,275/14,307 mm)
Fuel Pump Drive Hub Bearing Bore Dia.	4.108, 4.107, 4.99	1.8125/1.8141 in (46,037/46,078 mm)

Cylinder Liner 4.108 — Cast Iron

Type ...	Dry — Interference Fit
Interference Fit of Liners ...	0.003/0.005 in (0,076/0,127 mm)
Inside Dia. of Liner after Finish Boring and Honing ...	3.125/3.126 in (79,375/79,40 mm)
Height of Liner in relation to Cylinder Block Top Face ...	0.023/0.027 in (0,584/0,686 mm) above
Overall Length of Liner ...	6.495/6.505 in (164,973/165,227 mm)

Cylinder Liner 4.107 and 4.99 — Cast Iron

Type ...	Wet — Push Fit
Inside Dia. of Liner Pre-Finished 4.99 ...	3.00/3.001 in (76,20/76,225 mm)
Inside Dia. of Liner Pre-Finished 4.107 ...	3.125/3.126 in (79,374/79,4 mm)
Thickness of Top Flange 4.99 ...	0.3125/0.3145 in(7,937/7,988 mm)
Depth of Recess in Block for Liner Flange 4.99 ...	0.3115/0.3135 in (7,912/7,963 mm)
Thickness of Top Flange 4.107 ...	0.250/0.252 in (6,35/6,4 mm)
Depth of Recess in Block for Liner Flange 4.107 ...	0.249/0.251 in (6,325/6,375 mm)
Height of Liner in relation to Cylinder Block Top Face 4.107 and 4.99 ...	0.003 in (0,076 mm) Above, 0,001 in (0,025 mm) Below
Liner Flange Outside Dia. 4.99 ...	3.618/3.621 in (91,898/91,973 mm)
Cylinder Block Top Bore for Liner Flange 4.99 ...	3.625/3.627 in (92,075/91,125 mm)
Clearance Fit of Liner Flange to Block Bore 4.107 and 4.99 ...	0.004/0.009 in (0,102/0,229 mm)

Pistons 4.108

Type ...	Flat Topped
Overall Height (Skirt to Crown) ...	3.147/3.150 in (79,934/80,010 mm)
Piston Height in relation to Cylinder Block Top Face ...	0.002/0.006 in (0,051/0,152 mm) Above
Bore Dia. for Gudgeon Pin ...	1.06255/1.06275 in (26,989/26,994 mm)
Compression Ring Groove Width — Top ...	0.0805/0.0815 in (2,045/2,070 mm)
Compression Ring Groove Width — 2nd ...	0.0645/0.0655 in (1,638/1,664 mm)
Compression Ring Groove Width — 3rd ...	0.0645/0.0655 in (1,638/1,664 mm)
Oil Control Ring Groove Width — 4th ...	0.126/0.127 in (3,200/3,225 mm)
Oil Control Ring Groove Width 5th ...	0.190/1.191 in (4,826/4,851 mm)

Pistons 4.107 and 4.99

Type	Flat Topped
Overall Height (Skirt to Crown)	3.146 in (79,91 mm)
Piston Height in relation to Cylinder Block Top Face ...	0.0085/0.012 in (0,22/0,30 mm) Above
Bore Dia. for Gudgeon Pin	
later 4.99 and all 4.107 engines	0.93755/0.93775 in (23,81/23,82 mm)
Early 4.99 engines	0.87505/0.87525 in (22,22/22,23 mm)
Compression Ring Groove Width — Top	0.0801/0.0811 in (2,034/2,06 mm)
Compression Ring Grooves Width 2nd and 3rd ...	0.0645/0.0655 (1,638/1,664 mm)
Oil Control Ring Grooves Width 4th and 5th ...	0.190/1.191 in (4,826/4,851 mm)

Piston Rings 4.108

Top — Compression	Parallel Faced
Second and Third Compression	Internally Stepped
Fourth — Oil Control	Laminated Segment
Fifth — Oil Control	Slotted Scraper
Top Compression Ring Width	0.0771/0.0781 in (1,958/1,984 mm)
Ring Clearance in Groove	0.0024/0.0044 in (0,061/0,112 mm)
Second and Third Compression Ring Width	0.0615/0.0625 IN (1,562/1,587 mm)
Ring Clearance in Groove	0.002/0.004 in (0,051/0,102 mm)
Fifth Scraper Ring Width	0.1865/0.1875 in (4,737/4,762 mm)
Ring Clearance in Groove	0.0025/0.0045 in (0,063/0,114 mm)
Ring Gap — Top Compression	0.009/0.014 in (0,229/0,356 mm)
Ring Gap — Second and Third Compression	0.009/0.014 in (0,229/0,356 mm)
Ring Gap — Fifth Scraper	0.009/0.014 in (0,229/0,356 mm)

Piston Ring Gaps quoted are measured in a Ring Gauge of 3.125 in (79,38 mm) Bore. In practice for every 0.001 in (0,254 mm) difference in Cylinder Bore Diameter from Gauge size, 0.003 in (0,762 mm) should be allowed.

Piston Rings 4.107 and 4.99

Top Compression	Parallel Faced Chrome Plated
Second and Third Compression	Internally Stepped
Fourth and Fifth Oil Control	Slotted Scraper
Top Compression Ring Width	0.0771/0.0781 in (1,96/1,984 mm)
Ring Clearance in Groove	0.002/0.004 in (0,051/0,102 mm)
Second and Third Compression Ring Width	0.0615/0.0625 in (1,562/1,587 mm)
Ring Clearance in Groove	0.002/0.004 in (0,051/0,102 mm)
Fourth and Fifth Scraper Ring Width	0.1865/0.1875 in (4,737/4,762 mm)
Ring Clearance in Groove	0.0025/0.0045 in (0,064/0,114 mm)
Ring Gap — Compression Rings Chrome	0.012/0.017 in (0,30/0,43 mm)
Ring Gap — Oil Control Rings Cast Iron	0.009/0.014 in (0,229/0,356 mm)

Piston Ring Gaps quoted are measured in a Ring Gauge of 3.000 in (76,20 mm) Bore for 4.99 engines and 3.125 in (79,38 mm) Bore for 4.107 engines. In practice, for every 0.001 in (0,254 mm) difference in Cylinder Bore Diameter from Gauge size, 0.003 in (0,762 mm) should be allowed.

Gudgeon Pin 4.108

Type	Fully Floating
Outside Dia. of Gudgeon Pin	1.0625/1.0627 in (26,987/26,993 mm)
Length of Gudgeon Pin	2.673/2.687 in (67,894/68,250 mm)
Fit in Piston Boss	Transition

Gudgeon Pin 4.107 and 4.99

Type	Fully Floating
Outside Dia. of Gudgeon Pin	0.9375/0.9377 in (23,812/23,817 mm)
Earlier Engines	0.875/0.8752 in (22,225/22,23 mm)
Fit in Piston Boss	Transition

Small End Bush 4.108

Type	Steel Backed, Lead Bronze Lined
Length of Small End Bush	0.935/0.955 in (23,749/24,257 mm)
Outside Dia. of Small End Bush	1.221/1.222 in (31,013/31,039 mm)
Inside Dia. before Reaming	1.0495/1.0545 in (26,657/26,784 mm)
Inside Dia. after Reaming	1.06315/1.0632 in (27,004/27,005 mm)
Clearance between Small End Bush and Gudegon Pin	0.00045/0.0007 in (0,0114/0,0178 mm)

Small End Bush 4.107 and 4.99

Type	Steel Backed Lead Bronze Lined
Length of Small End Bush	0.865/0.885 in (22,00/22,48 mm)
Outside Dia. of Small End Bush	
Later 4.99 and all 4.107 engines	1.065/1.066 in (27,05/27,08 mm)
Early 4.99 engines	1.0025/1.0035 in (25,46/25,49 mm)
Inside Dia. after Reaming on later 4.99 and all 4.107 engines	0.9382/0.93875 in (23,83/23,84 mm)
Early 4.99 engines	0.8757/0.87625 in (22,24/22,26 mm)
Clearance between Small End Bush and Gudgeon Pin	0.0005/0.00125 in (0,01/0,03 mm)

Note. Bushes to be reamed to suit respective Gudgeon Pins, and are provided with a reaming allowance.

Connecting Rod 4.108

Type	'H' Section
Cap Location to Connecting Rod	Serrations, Offset 45° to the Horizontal
Big End Parent Bore Dia.	2.146/2.1465 in (54,508/54,521 mm)
Small End Parent Bore Dia.	1.21875/1.21975 in (30,956/30,981 mm)
Length from Centre Line of Big End to Centre Line of Small End	6.217/6.219 in (157,912/157,963 mm)
Connecting Rod End Float	0.0065/0.0105 in (0,165/0,267 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).

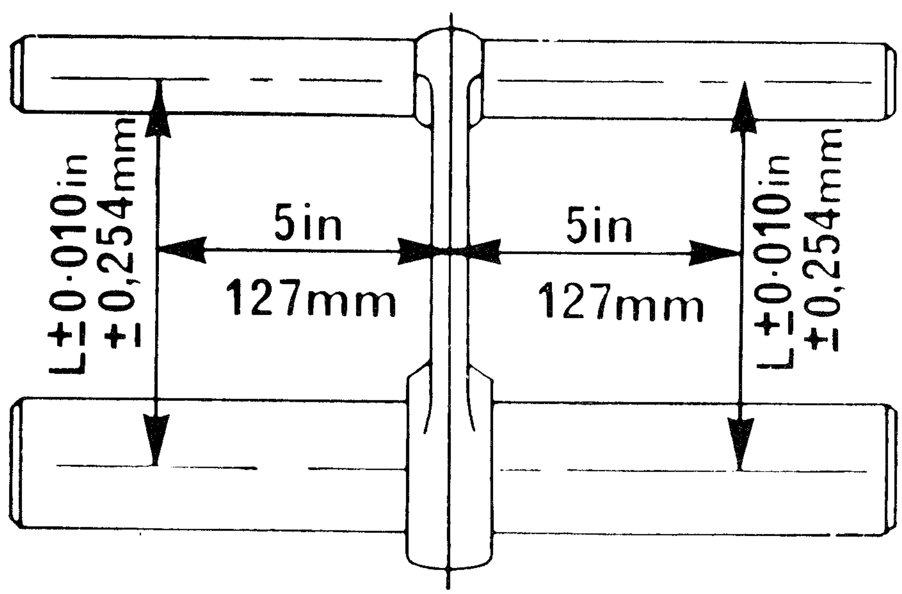


Fig. B.1.
Connecting Rod Alignment Test Mandrel.

Connecting Rod 4.107 and 4.99

Type	'H' Section
Cap Location to Connecting Rod	Serrations, Offset 45° to the Horizontal
Big End Parent Bore Dia.	2.146/2.1465 in (54,508/54,521 mm)
Small End Parent Bore Dia.	
later 4.99 and all 4.107 engines	1.0625/1.0635 in (26,99/27,01 mm)
Early 4.99 engines	1.00/1.001 in (25,4/25.43 mm)
Length from Centre Line of Big End to Centre Line of Small End	6.405/6.407 in (162,69/162,74 mm)
Connecting Rod End Float	
later 4.99 and all 4.107 engines	0.0065/0.0105 in (0,16/0,27 mm)
Early 4.99 engines	0.0075/0.0105 in (0,19/0,27 mm)

Crankshaft

Overall Length	21.125 in (536,575 mm)
Main Journal Dia. Nos. 1 and 2	2.248/2.2485 in (57,099/57,112 mm)
Main Journal Dia. No. 3	2.2475/2.248 in (57,086/57,099 mm)
Main Journal Length No. 1	1.40625 in (35,719 mm)
Main Journal Length No. 2	1.496/1.504 in (37,998/38,202 mm)
Main Journal Length No. 3	1.499/1.502 in (38,075/38,151 mm)
Main Journal Fillet Radii	0.125/0.141 in (3,175/3,581 mm)
Crankpin Dia.	1.9993/2.0001 in (50,78/50,80 mm)
Crankpin Length	1.1875/1.1895 in (30,162/30,213 mm)
Crankpin Fillet Radii	0.15625/0.17187 in (5/32/11/64 in) (3,969/4,366 mm)
Surface Finish — All Journals	8 - 16 micro-in (0,2-0,4 micron)
Main Journal and Crankpin Regrind Undersizes	0.010, 0.020, 0.030 in (0,25, 0,51, 0,76 mm)
Oil Seal Helix Dia.	2.21075/2.21175 in (56,153/56,178 mm)
Oil Seal Helix Width	0.050/0.080 in (1,270/2,032 mm)
Oil Seal Helix Depth	0.004/0.008 in (0,102/0,203 mm)
Flange Dia.	3.9985/3.9995 in (101,562/101,587 mm)
Flange Width	0.500 in (12.700 mm)
Spigot Bearing Recess Depth	0.875 in (22,225 mm)
Spigot Bearing Recess Bore	1.250 in (31,750 mm)
Crankshaft End Float	0.002/0.015 in (0,0508/0,381 mm)

Main Bearings

Type	Pre-finished, Steel Backed, Aluminium Tin Lined
Shell Width	1.245/1.255 in (31,623/31,877 mm)
Outside Dia. of Main Bearing	2.3955 in (60,846 mm)
Inside Dia. of Main Bearing	2.2505/2.2515 in (57,163/57,188 mm)
Running Clearance — Nos. 1 and 2	0.002/0.0035 in (0,051/0,089 mm)
Running Clearance — No. 3	0.0025/0.004 in (0,063/0,102 mm)
Steel Thickness	0.060 in (1,524 mm) Max.
Aluminium Thickness	0.012/0.01225 in (0,305/0,311 mm)

Crankshaft Thrust Washers

Type	Steel Backed — Lead Bronze Faced
Position in Engine	Rear Main Bearing
Thrust Washer Thickness (STD)	0.089/0.091 in (2,261/2,311 mm)
Thrust Washer Thickness (O/S)	0.0965/0.1005 in (2,451/2,553 mm)
Thrust Washer Outside Dia.	3.245/3.255 in (82,423/82,677 mm)
Thrust Washer Inside Dia.	2.590/2.600 in (65,786/66,040 mm)

Connecting Rod Bearings

Type	Pre-finished, Steel Backed, Aluminium Tin Lined
Shell Width	0.870/0.880 in (22,098/22,325 mm)
Outside Dia, of Con. Rod Bearing	2.1465 in (54,521 mm)
Inside Dia. of Con. Rod Bearing	2.0015/2.0025 in (50,838/50,863 mm)
Running Clearance	0.0015/0.003 in (0,038/0,076 mm)
Steel Thickness	0.060 in (1,524 mm) Max.
Aluminium Thickness	0.012/0.01225 in (0,305/0,311 mm)

Camshaft

No. 1 Journal Length	1.347/1.351 in (34,214/34,315 mm)
No. 1 Journal Dia.	1.791/1.792 in (45,491/45,517 mm)
No. 1 Cylinder Block Camshaft Bore Dia.... ...	1.794/1.7955 in (45,568/45,606 mm)
No. 1 Journal Running Clearance	0.002/0.0045 in (0,051/0,114 mm)
No. 2 Journal Length	1.250 in (31,750 mm)
No. 2 Journal Dia.	1.781/1.782 in (45,237/45,263 mm)
No. 2 Cylinder Block Camshaft Bore Dia.	1.784/1.787 in (45,314/45,390 mm)
No. 2 Journal Running Clearance	0.002/0.006 in (0,051/0,152 mm)
No. 3 Journal Length	1.000 in (25,400 mm)
No. 3 Journal Dia.	1.773/1.774 in (45,034/45,060 mm)
No. 3 Cylinder Block Camshaft Bore Dia.	1.776/1.778 in (45,110/45,161 mm)
No. 3 Journal Running Clearance	0.002/0.005 in (0,051/0,127 mm)
Cam Lift	0.266 in (6,766 mm)
Oilways for Rocker Shaft Lubrication	No. 2 Journal

Camshaft Thrust Plates

Type	180° Oil Impregnated Sintered Iron
Thrust Plate Outside Dia....	2.555/2.557 in (64,897/64,948 mm)
Cylinder Block Recess Dia. for Thrust Plate	2.5585/2.5685 in (64,986/65,240 mm)
Clearance Fit of Thrust Plate in Recess	0.0015/0.013 in (0,038/0,330 mm)
Thrust Plate Inside Dia.	1.500 in (38,100 mm)
Thrust Plate Thickness	0.160/0.162 in (4,060/4,115 mm)
Cylinder Block Recess Depth for Thrust Plate ...	0.158/0.164 in (4,009/4,116 mm)
Thrust Plate Height in relation to Cylinder Block Face	0.004 in (0,102 mm) Above or Below
Camshaft End Float	0.003/0.013 in (0,076/0,330 mm)

Cylinder Head

Overall Length of Cylinder Head	20.000 in (508,000 mm)
Overall Depth of Cylinder Head	2.617/2.633 in (66,472/66,878 mm)
Skimming Allowance on Cylinder Head Face ...	NIL—On no account can the cylinder head face be skimmed.
Pressure for Water Leakage Test	20 lbf/in² (1,4 kgf/cm²) — 138 kN/m²
Valve Seat Angle	45°
Bore in Cylinder Head for Guide	0.4995/0.5005 in (12,687/12,713 mm)
Bore in Cylinder Head for Combustion Chamber Inserts	1.250/1.252 in (31,750/31,801 mm)
Depth of Bore in Cylinder Head for Combustion Chamber Inserts	0.373/0.376 in (9,474/9,550 mm)

Combustion Chamber Inserts

Outside Dia. of Insert	1.248/1.249 in (31,699/31,724 mm)
Length of Insert...	0.374/0.375 in (9,499/9,525 mm)
Height of Insert in relation to Cylinder Head Face	0.002 in (0,051) Above or Below
Clearance Fit of Insert in Cylinder Head Bore ...	0.001/0.004 in (0,025/0,102 mm)
Method of Location in Cylinder Head	By Cylinder Block Face and Expansion Washer.

Valves Guides (Inlet)

Inside Dia.	0.3141/0.3155 in (7,978/8,014 mm)
Outside Dia.	0.5021/0.5026 in (12,753/12,766 mm)
Interference fit of Guide in Cylinder Head Bore	0.0016/0.0031 in (0,041/0,079 mm)
Overall length of Guide	2.130 in (54,102 mm)
Guide Protrusion Above Top Face of Cylinder Head	0.800/0.815 in (20,320/20,701 mm)

Valve Guides (Exhaust)

Inside Dia.	0.3141/0.3155 in (7,978/8,014 mm)
Outside Dia.	0.5021/0,5026 in (12,753/12,766 mm)
Interference fit of Guide in Cylinder Head Bore	0.0016/0.0031 in (0,041/0,079 mm)
Depth of Counterbore	0.380 in (0,650 mm)
Overall Length of Guide	2.440 in (61,98 mm)
Guide Protrusion above Top Face of Cylinder Head	0.800/0.815 in (20,320/20,701 mm)

Valves (Inlet)

Valve Stem Dia.	0.312/0.313 in (7,925/7,950 mm)
Clearance fit of Valve Stem in Guide	0.0011/0.0035 in (0,028/0,089 mm)
Valve Head Dia.	1.410/1.414 in (35,814/35,916 mm)
Valve Face Angle	45°
Valve Head Depth Below Cylinder Head Face	0.028 in (0,711 mm) Minimum 0.048 in (1,220 mm) Maximum
Overall Length of Valve	4.592/4.608 in (116,637/117,043 mm)
Sealing Arrangement	Rubber Oil Seal

Valves (Exhaust)

Valve Stem Dia.	0.3115/0.3125 in (7,912/7,937 mm)
Clearance Fit of Valve Stem in Guide	0.0016/0.004 in (0,041/0,102 mm)
Valve Head Dia.	1.191/1.195 in (30,251/30,353 mm)
Valve Face Angle	45°
Valve Head Depth Below Cylinder Head Face	0.021 in (0,53 mm) Minimum 0.048 in (1,220 mm) Maximum
Overall Length of Valve	4.600/4.616 in (116,840/117,246 mm)
Sealing Arrangement	No Seal fitted to Exhaust Valve

Outer Valve Springs

Fitted Length	1.780 in (45,212 mm)
Load at Fitted Length	56.0 lbf +/— 2.8 lbf (25,4 kgf +/— 1,27 kgf)
Fitted Position	Damper Coil to Cylinder Head

Inner Valve Springs Where fitted

Fitted Length	1.530 in (38,862 mm)
Load at Fitted Length	28.6 lbf +/— 2 lbf (13,0 kgf +/— 0,91 kgf)
Fitted Position	Damper Coil to Cylinder Head

Rocker Levers

Length between Centre Line of Adjusting Screw and Centre Line of Rocker Shaft	1.042/1.058 in (26,467/26,873 mm)
Length between Centre Line of Rocker Lever Pad and Centre Line of Rocker Shaft	1.567/1.583 in (39,802/40,208 mm)
Inside Dia. of Rocker Lever Bore	0.71825/0.71950 in (18,243/18,275 mm)
Outside Dia. of Rocker Lever Bush	0.7205/0.7215 in (18,301/18,326 mm)
Interference Fit of Bush in Rocker Lever	0.001/0.00325 in (0,025/0,082 mm)
Finished Inside Dia. of Rocker Lever Bush	0.6245/0.62575 in (15,862/15,894 mm)
Clearance of Rocker Lever Bush on Rocker Shaft ...	0.00075/0.0035 in (0,019/0,089 mm)

Valve Clearances

Clearance between Valve Stem Tip and Rocker Lever ...	0.012 in (0,30 mm) Cold

Rocker Shaft

Overall Length of Shaft	14.5625 in (369,887 mm)
Outside Dia. of Shaft	0.62225/0.62375 in (15,805/15,843 mm)
Lubrication	Oil Feed from Cylinder Head through Central Passage to Individual Rocker Levers

Push Rods

Overall Length	8.527/8.560 in (216,58/217,42 mm)
Outside Dia.	0.250 in (6,350 mm)

Tappets

Overall Length	2.250 in (57,150 mm)
Outside Dia. of Tappet Shank	0.560/0.561 in (14,224/14,249 mm)
Cylinder Block Tappet Bore Dia.	0.562/0.56325 in (14,275/14,307 mm)
Tappet Running Clearance in Cylinder Block Bore ...	0.001/0.00325 in (0,025/0,082 mm)
Outside Dia. of Tappet Foot	1.245/1.255 in (31,623/31,877 mm)

TIMING GEARS

Camshaft Gear

Number of Teeth	48
Inside Dia. of Gear Boss	1.750/1.7514 in (44,450/44,486 mm)
Outside Dia. of Camshaft Hub	1.7496/1.7509 in (44,430/44,473 mm)
Transition Fit of Gear and Hub	0.0009/0.0018 in (0,023/0,046 mm)

Fuel Pump Gear

Number of Teeth	48
Inside Dia. of Cylinder Block Bore for Fuel Pump Drive Hub Bearing	1.8125/1.8141 in (46,037/46,078 mm)
Outside Dia. of Fuel Pump Drive Hub Bearing ...	1.8145/1.8152 in (46,088/46,106 mm)
Interference Fit of Drive Hub Bearing in Cylinder Block Bore	0.0004/0.0027 in (0,010/0,069 mm)
Inside Dia. of Fuel Pump Drive Hub Bearing	1.3125/1.3135 in (33,34/33,78 mm)
Outside Dia. of Fuel Pump Gear Drive Hub	1.3105/1.3115 in (33,287/33,312 mm)
Running Clearance of Drive Hub in Bearing	0.0031/0.0051 in (0,079/0,129 mm)
Drive Hub End Float	0.002/0.010 in (0,051/0,254 mm)

Idler Gear and Hub

Number of Teeth ...	57
Inside Dia. of Gear Boss ...	1.7187/1.7197 in (43,655/43,680 mm)
Inside Dia. of Gear Boss with Bush Fitted ...	1.5625/1.5641 in (39,687/39,728 mm)
Outside Dia. of Gear Hub ...	1.5612/1.5619 in (39,654/39,668 mm)
Running Clearance of Gear on Hub ...	0.0003/0.0016 in (0,008/0,041 mm)
Idler Gear Width ...	1.3105/1.3135 in (33,287/33,363 mm)
Hub Width ...	1.3165/1,3195 in (33,439/33,52 mm)
Idler Gear End Float ...	0.003/0.008 in (0,076/0,208 mm)

Crankshaft Gear

Number of Teeth ...	24
Inside Dia. of Gear ...	1.250/1.2512 in (31,750/31,780 mm)
Crankshaft Dia. for Gear ...	1.250/1.2506 in (31,750/31,756 mm)
Transition Fit of Gear on Crankshaft ...	0.0006/0.0012 in (0,015/0,030 mm)

Timing Gear Backlash

Clearance between Crankshaft/Idler and Camshaft/Idler Gear ...	0.0015/0.0025 in (0,038/0,064 mm) at the tightest point

LUBRICATING SYSTEM

Lubricating Oil Pressure ...	30/60 lbf/in² (2,1/4,2 kgf/cm²) —207/414 kN/m² at maximum engine speed and normal working temperature.

Sump

Dipstick Position ...	Camshaft side of engine opposite No. 2 cylinder
Strainer Location ...	End of suction pipe to lubricating oil pump.

Sump Capacities

	Imp. Pints	U.S. Quarts	Litres
Standard Engines (refill) ...	7	4.2	4
Standard Engines (total) ...	8.5	5.1	4,8
Low line Engines (refill) ...	7.9	4.8	4,5
Low line Engines (total) ...	9.4	5.7	5,3

Note: The above sump capacity is intended to be used as a guide and actual capacities should be governed by the level indicated on the dipstick.

When refilling the engine after an overhaul has been carried out a further 2½ imp. pints, 1½ U.S. quarts 1.4 litre approximately should be added to the capacities quoted, to allow for filling the pipes, oilways filter assembly, etc.

Lubricating Oil Pump

Type ...	Rotor Type
Number of Lobes — Inner Rotor ...	Three or Four
Number of Lobes — Outer Rotor ...	Four of Five
Method of Drive ...	By Spiral Gears from the Camshaft

Pump Clearances

Inner Rotor to Outer Rotor ...	0.0005/0.0025 in (0,013/0,063 mm)
Outer Rotor to Pump Body ...	0.011/0.013 in (0,28/0,33 mm)
Inner Rotor End Clearance ...	0.0015/0.003 in (0,038/0,076 mm)
Outer Rotor End Clearance ...	0.0005/0.0025 in (0,013/0,063 mm)
Inside Dia. of Bore for Pump Shaft ...	0.500/0.501 in (12,700/12,725 mm)
Outside Dia. of Pump Shaft ...	0.4983/0.4986 in (12,655/12,664 mm)
Running Clearance, Shaft in Bore ...	0.0014/0.0027 in (0,036/0,069 mm)

Lubricating Oil Pump Drive Gear

Number of Teeth	12
Inside Dia. of Gear Bore	0.4965/0.4970 in (12,611/12,624 mm)
Outside Dia. of Oil Pump Drive Shaft	0.4983/0.4986 in (12,655/12,664 mm)
Interference Fit of Gear on Shaft	0.0013/0.0021 in (0,033/0,053 mm)
Lubricating Oil Pump Drive Gear Backlash	0.0155/0.019 in (0,394/0,483 mm)

Relief Valve

Type	Spring Loaded Plunger
Pressure Setting	50/65 lbf/in² (3,5/4,6 kgf/cm²) 345/448 kN/m²
Length of Plunger	0.9375 in (23,813 mm)
Outside Dia. of Plunger	0.5585/0.5595 in (14,19/14,21 mm)
Inside Dia. of Valve Housing Bore	0.5605/0.5625 in (14,24/14,29 mm)
Clearance of Plunger in Bore	0.001/0.004 in (0,025/0,102 mm)
Outside Dia. of Spring	0.368/0.377 in (9,347/9,576 mm)
Spring —Free Length	1.5 in (38,10 mm)
Spring—Solid Length	0.754 in (19,15 mm)

Lubricating Oil Filter

Type	Full Flow
Element Type	Paper Canister
By-Pass Valve Setting	Opens between 13/17 lbf/in² (0,91/1,2 kgf/cm²) 90/117 kN/m² pressure differential
Type of Valve	Spring Loaded Ball

COOLING SYSTEM

Type	Water Cooled
Cylinder Block and Head (Indirect Cooled Engine)	Thermo-Syphon Impeller Assisted
Cylinder Block and Head (Direct Cooled Engine)	Pump Circulation
Engine Coolant Capacity	
4.99	10.5 Imp. Pt, 6.3 U.S. Qt, 6 Litre
4.107 and 4,108	13 Imp Pt, 7.8 U.S. Qt, 7,4 Litre

Thermostat (Indirect Cooled Engine)

Type	Wax Capsule
Opening Temperature	156°F (69°C)
Fully open at	188°F (87°C)
Minimum Travel at Fully Open Temp.	0.281 in (7,06 mm)

Thermostat (Direct Cooled Engine)

Type	Bellows
Opening Temperature	125°F (52°C)
Fully Open at	150°F (66°C)
Minimum Travel at Fully Open Temp.	0.281 in (7,04 mm)

Water Pump (Fresh Water, Direct Cooled Engine)

Type	Centrifugal - Belt driven from Crankshaft Pulley
Outside Dia. of Shaft for Pulley	0.5905/0.5908 in (14,999/15,006 mm)
Inside Dia. of Pulley Bore	0.588/0.589 in (14,935/14,961 mm)
Interference Fit of Pulley on Shaft	0.0015/0.0028 in (0,038/0,071 mm)
Outside Dia. of Shaft for Impeller	0.498/0.499 in (12,649/12,675 mm)
Inside Dia. of Impeller Bore	0.497/0.4975 in (12,624/12,636 mm)
Interference Fit of Impeller on Shaft	0.0005/0.002 in (0,013/0,051 mm)
Outside Dia. of Impeller	3.094/3.125 in (78,588/79,375 mm)
Water Pump Seal Type	Synthetic Rubber—Carbon Faced

FUEL SYSTEM

Approved Fuel Oil Specifications

United Kingdom	BS. 2869:1967	Class A1 or A2
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	1S: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.	
	9140-355-1404 (1965)	—

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

Fuel Lift Pump

Type	AC Delco Diaphragm 'YJ' Series
Spring Colour Code	Green
Method of Drive	From Eccentric on Camshaft via Push Rod
Total Stroke of Operating Lever	0.192 in (4,877 mm)
Static Pressure No Delivery	6/10 lbf/in² (0,42/0,7 kgf/cm²) 41/70 kN/m²
Pump to Distance Piece Gasket Thickness	0.018/0.022 in (0,457/0,559 mm)
Distance Piece Lift Pump to Tappet Inspection Cover	0.256 in (6,502 mm)

Final Fuel Filter

Element Type	Paper
Overflow Valve Type	Gravity Ball Check Valve
Valve in Fuel Pump Drain Connection	Spring Loaded Non-Return Valve set at 0.71/1.25 lbf/in² (0,0522/0,0875 kgf/cm²) – 5/9 kN/m²

Fuel Injection Pump

Make	C.A.V.
Type	D.P.A.
Rotation	Clockwise (viewed from drive end)
Plunger Dia.	6 mm

Fuel Injection Pump Timing

The fuel injection pump static timing, engine checking and fuel pump marking angles can vary according to engine type but can be obtained by referring to the first group of letters and figures of the fuel pump setting code (stamped adjacent to the fuel injection pump identification plate):

First Group of Fuel Pump Code	(Using Timing Tool MS67B) Engine Checking Angle (Degrees)	Fuel Pump Marking Angle (Degrees)	Alternative Valve Drop Method Static Timing (Degrees BTDC)	Piston Displacement in	mm
4.99 Engines					
AH28	282	295	26	0.226	5,74
BH26	287	300	26	0.226	5,74
DH19	287	300	26	0.226	5,74
4.107 Engines					
CH35	280½	290	19	0.120	3,05
4.108 Engines					
EH34E	281	290	18	0.108	2,75
PH30	281	290	18	0.108	2,75

Atomisers	4.108	4.107	4.99
Make	C.A.V.	C.A.V.	C.A.V.
Holder Type	BKB40SD5224	BKB40SD5224	BKB40S5146
Nozzle Type	BDN12SD6236	BDN12SD6236	BDN4S6236
Code Letter	BG	BG	E
Min. Working Pressure (atm)	135	135	125
Setting Pressure (atm)	150	150	130

ELECTRICAL SYSTEM (12 volt)

Alternator

Make	C.A.V. or Lucas
Type	AC5, 11AC
Maximum Output AC5	55A (hot)
Maximum Output 11AC	43A (hot)

Dynamo

Make	Lucas
Type	C40, 2 pole, 2 brush shunt wound, voltage control
Rotation	Clockwise
Output	22A

Starter Motor

Make	Lucas
Type	M45G
Maximum Current	900A
Starter Cable Resistance	0.0017 ohms
No. of Teeth on Pinion	10

Starting Aid

Make	C.A.V.
Type	Thermostart
Voltage	12 Volt
Maximum Current Consumption	12.9 Amperes at 11.5 Volts
Fuel Flow Rate through Unit	4.3-4.9 cm^2/min at 70°F (21°C)
Height of Reservoir above Centre of Thermostart	4.5-10 in (11,4-25,4 cm)

SECTION C
Operating and Maintenance

Preparation for Starting

Check the header tank water level, when fitted.

Check the engine sump oil level.

Check there is sufficient fuel oil in the tank.

Check that the starter battery is fully charged and that all electrical connections are properly made and all circuits are in order.

Check that sea cock is open, when fitted.

Priming the Fuel System

For new engines or engines which have been standing idle for any length of time bleed the fuel system, as described on page N.8.

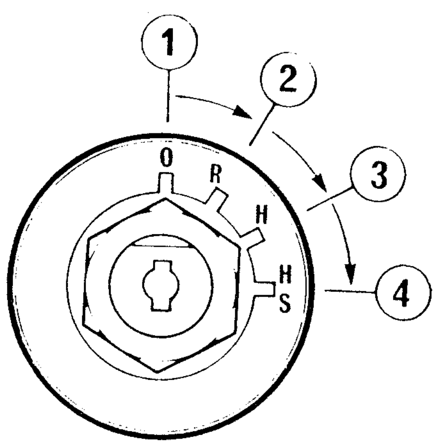
Starting the Engine

If the engine is warm, with the throttle in the fully open position, engage the starter motor by turning the starter switch in a clockwise direction to the "HS" position (See Fig. C.1).

Following initial start, check coolant water flow from discharge pipe and lubricating oil pressure.

To Operate the Cold Start Aid

Turn on the fuel supply tap of the cold starting aid reservoir (where fitted).



C1

Current Heat/Start Switch.

1. Off Position.
2. Run Position.
3. Heat Position.
4. Heat and Start Position.

Turn the starter switch to the "H" position and hold it there for fifteen to twenty seconds (see Fig. C.1).

With the throttle in the fully open position, turn the starter switch to the "HS" position, thereby engaging the starter motor.

If the engine does not start within fifteen seconds, return the switch to the "H" position for ten seconds and then re-engage the starter motor by switching to the "HS" position.

As soon as the engine starts, the switch should be turned to the "R" position and the tap on the cold starting aid reservoir (where fitted), turned off.

Alternative Method

With some engines a different starter switch is provided and the cold start aid is operated by means of a separate push button switch.

The cold starting procedure is the same i.e.:—

Switch on by turning the starter switch in a clockwise direction to the first position.

Press the heater button for fifteen to twenty seconds and then, with the heater button still pressed, turn the starter switch in a further clockwise direction to engage the starter motor, as soon as the engine starts, release starter switch and heater button.

Earlier Heat Start Switch

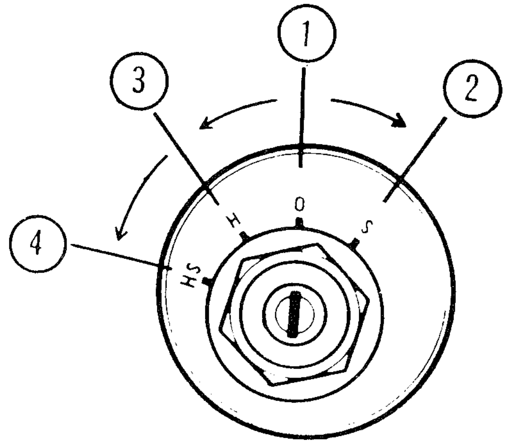
The cold start switch fitted to earlier engines is shown in Fig. C.2.

With this switch, starting a warm engine is effected by turning the switch in a clockwise direction to the "S" position.

In cold weather, the switch should be turned to the "H" position for fifteen to twenty seconds and then to the "HS" position in order to engage the starter motor.

As soon as the engine starts, the switch should be returned to the "O" Position.

Where this type of switch is used, it was customary to have a separate switch for the electrical circuits and this should be turned on before starting the engine and turned off after stopping the engine.



C2

Earlier Heat/Start Switch.

1. Off Position.
2. Start Position.
3. Heat Position.
4. Heat and Start Position.

Things to Note

Always be sure that the starter pinion and flywheel have stopped revolving before re-engaging the starter, otherwise the ring or pinion may be damaged.

Ensure that the electrical connection to the cold starting aid is correctly made.

Always ensure that the chamber feeding fuel to the cold starting aid is full and not leaking.

Extended use of the cold starting equipment above the time periods already stated should be avoided, otherwise the cold start aid in the induction manifold may be damaged.

In the event of difficult starting, check that fuel is reaching the cold starting aid in the induction manifold by unscrewing the inlet fuel union. If fuel is reaching it satisfactorily, then it may be that the cold starting aid itself is not working correctly. This can be checked by removing the air filter and observing the cold starting aid while the equipment is used. When the starting switch is turned to the heat position, the element should glow and on engagement of the starter motor fuel becomes ignited.

To prevent thermostart (cold starting aid) damage, it is essential that the thermostart is not operated dry. After an operation that allows fuel to drain from the thermostart feed pipe, the pipe must be disconnected at the thermostart and all air bled from the pipe before the thermostart is operated.

Where a thermostart cold starting aid has to be replaced, care must be taken not to exceed the torque load into the manifold given on Page B.3. Excessive torque loading can crack the insulating adaptor causing an electrical short and cold starting difficulties.

4.99, 4.107 and 4.108 MArine engines are fitted with efficient cold starting equipment and no responsibility can be accepted for any damage arising from the use of unauthorised starting aids.

Auxiliary yacht installations may require the engine to be run while beating to windward. Under these conditions, the boat may heel up to 25° without adverse effect on the lubricating system providing the boat is righted occasionally in order to lubricate the valve assembly.

Stopping the Engine

A spring loaded stop control is located near the normal engine controls and functions by cutting off the fuel at the fuel injection pump.

To operate, pull the knob and hold in this position until the engine ceases to rotate. Ensure that the control returns to the "run" position, otherwise difficulty may be experienced in re-starting the engine.

Running In

It is not necessary to gradually run-in a new or factory replacement engine and any prolonged light load running during the early life of the engine can in fact prove harmful to the bedding in of piston rings and liners.

Full load can be applied on a new or factory replacement engine as soon as the engine is used **provided that the engine coolant is first allowed to reach a temperature of 140°F (60°C).**

preventive maintenance

KEEP ENGINE CLEAN

Daily or every 8 hours (whichever occurs first)

Check water in header tank (closed circuit cooling).
Check oil level in sump.
Check oil level in gearbox.
Check oil pressures (where gauges fitted).

Every 100 hours or 2 months (whichever occurs first)

Drain oil from sump and renew using an approved oil — see appendix.
Renew paper element or canister in lubricating oil filter.
Clean air intake gauze.
*Check belt tension.
Clean water trap.
Check engine for leakage of oil or water.
Lubricate dynamo rear bush (where fitted).

Every 400 hours or 12 months (whichever occurs first)

Drain and clean fuel tank.
Renew final fuel filter.
Check hoses and clips.
Change gearbox oil.
Service atomisers.
Arrange for examination and service of proprietary equipment, i.e. starter, dynamo etc.
Check and adjust valve tip clearance.

An operator is usually familiar with the type of water he is operating in. It is therefore left to his own discretion to check the weed trap in the water intake at appropriate intervals.

*Drive belt tension should be checked monthly on engines rated above 3,000 rev/min.

POST-DELIVERY CHECKOVER

After a customer has taken delivery of his engine, it is advisable, in his own interests, that a general check-over of the engine be carried out after the first 25/50 hours in service.

This checkover should comprise the following points:

1. Drain the lubricating oil sump and re-fill up to the full mark on the dipstick with clean new oil (Do not overfill).
2. Renew element or canister in lubricating oil filter.
3. Check external nuts for tightness.
4. Check cylinder head nuts are to the correct torque and reset valve clearances (0.012 in (0,30 mm) cold).
5. Check for fuel and lubricating oil leaks, and rectify if necessary.
6. Check cooling system for leaks and inspect water level (closed circuit cooling).
7. Check generator belt for tension.
8. Carry out test to check general performance of engine.
9. Check engine mounting bolts for tightness.

Thereafter maintenance periods should be in accordance with those given on this page.

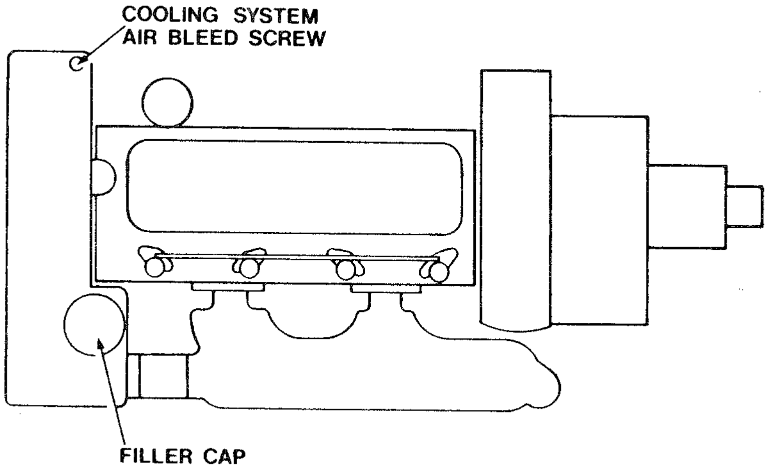
It is assumed that electrical equipment will have already been checked for such points as generator rate of charge, effectiveness of connections and circuits, etc.

preservation of laid-up engine

Where a craft which is powered by a Perkins engine is to be laid-up for several months it is advisable that some measure of protection be afforded to the engine to ensure that corrosion does not occur during the intervening period before operations are re-commenced.

It is recommended, that the following procedure be adopted and applied immediately the unit is with-drawn from service.

1. Clean all external parts of the engine.
2. Run engine until warm. Stop engine and drain lubricating oil sump.
3. Drain cooling system.
   To ensure complete draining of fresh water systems, remove filler cap from header tank then open cylinder block drain tap. Hose securing clips between cylinder block connection and copper pipe to header tank (keel cooled applications) or between cylinder block connection and copper pipe to exhaust manifold (heat exchanger applications) should be slackened and hose pulled away from connection to drain this area.
4. Renew paper element in full flow lubricating oil filter or renew canister.
5. Clean out engine breathing pipe.
6. After renewing filter element, fill sump to correct level with clean, new lubricating oil or with a suitable preservative fluid.



C3

7. Remove atomisers and spray into cylinder bores a 1/8 pint (0,19 litres) of lubricating oil divided between the cylinders.
8. Turn crankshaft to lubricate cylinder bores and replace atomisers using new washers.
9. Remove air filter and any intake pipe which may be fitted between the air filter and air intake. Seal air intake orifice with water-proofed adhesive tape.
10. Remove exhaust pipe and seal opening in manifold as in '9'.
11. Disconnect battery and before storing in a fully charged condition, preserve the battery terminals to prevent corrosion.
12. When rubber impeller type water pump is fitted, remove water pump end plate and pack pump with MARFAK 2HD GREASE. Where this grease is not available glycerine may be used as an alternative.

The fuel system should be charged with a suitable preservation fuel.

Before re-commencing operations prime the fuel system.

Preparations for starting the engine should be in accordance with instructions given on page C.2.

Note:—
Preservative used in the lubricating oil sump should be replaced by normal lubricant prior to re-starting the engine at the end of the storage period. Preservative utilised to charge the fuel system need not necessarily be drained off before returning the engine to service.

Recommended Oils for the Preservation of the Fuel System*

	Lowest Temperature during Lay-up
Esso IL815	25°F (— 4°C)
Esso IL1047	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 (8°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 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.

Pour Point: Must be at least 15°F (8°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. Clean external parts of the engine.
2. Bleed the fuel pump as described on Page N.8.
3. Ensure that the cylinder block and heat exchanger drain taps are closed and fill the system with coolant as described on next page.
4. Rotate water pump by hand to ensure freedom of pump seals.
5. Lubricate rocker assembly with engine oil.
6. Remove adhesive tape from air intake orifice and ensure that the gauze is clean.
7. Remove adhesive tape from exhaust manifold orifice and refit exhaust pipe using new joints.
8. Connect batteries, fully charged, into circuit.

Keel Cooled and Heat Exchanger Cooled Engines

The following instructions should be followed when putting the engine back into service following the winter lay-up period, or at any time the fresh water cooling system has to be refilled. The initial 'bleeding' of the cooling system must be affected when the engine is first installed by the boat builder but air venting is necessary following complete or partial draining for lay-up, top overhaul or other engine repairs.

With the 4.108M low line engine, air-venting the cooling system is provided for by a single air bleed screw situated on the top right hand side of the header tank — see Fig. C.3.

When refilling or topping up the cooling system, remove the bleed screw and pour in coolant through the filler until it issues from the bleed point.

Replace the bleed screw and continue to fill the header tank to a level approximately 1 in (25 mm) below the pressure sealing cap.

Recheck for presence of air by unscrewing the bleed point after the engine has been run at about half throttle for a few minutes or if overheating occurs on the first run under normal load conditions.

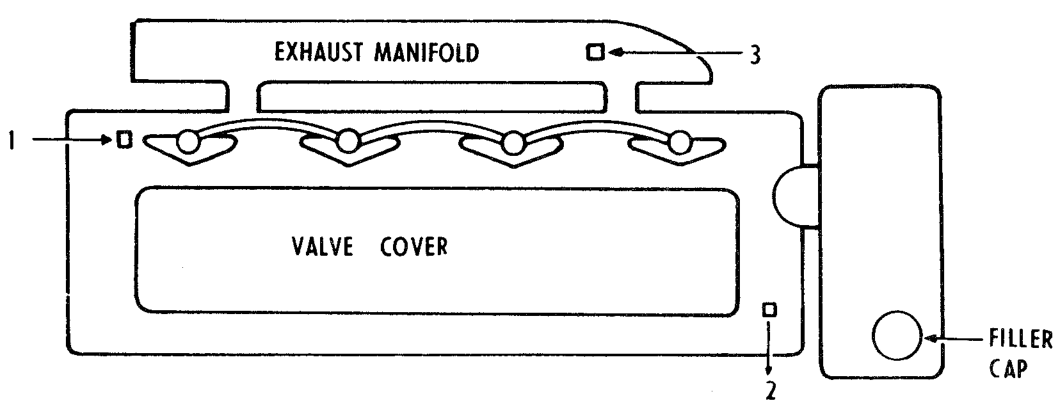
Keel Cooled Engines. Under certain conditions of outboard pipe installation, an air lock can occur where the pipes bridge the keel at their ends farthest from the inlet and outlet connections. This air should be removed and the pipes left completely full of water before the engine is started, and the following procedure adopted:—

1. Disconnect the pipe hose (water outlet to keel pipe) at the upper stub at the forward end of the exhaust manifold and the pipe connection (water inlet to engine) on the header tank.
2. Fill pipe through the connection taken from the exhaust manifold by means of a funnel, until pipes are full to the header tank connection, and secure connection. After water has been added to fill the pipe to the manifold connection, this pipe can also be re-connected. In the event of a bridge connection between the keel pipes being inside the hull, and the connections being of the type that can be loosened, air can be removed more easily by loosening an inboard connection on the pipe bridge, topping up through the pipe as described above and re-tightening the connection when free of air.

Heat Exchanger Cooled Engines

To ensure that no air is trapped in the cylinder block or cylinder head on fresh water cooled engines, the following procedure should be adopted on heat exchanger cooled units and in addition to the above on keel cooled units.

1. Remove the square headed plugs in the top faces of the cylinder head and exhaust manifold marked 1, 2 and 3 in Fig. C.4 and add water steadily to the cooling system header tank.
2. Replace plug 1 at rear end of cylinder head as water appears.
3. Start engine and run in neutral at about 700—800 rev/min.
4. Continue topping up header tank, replacing plug 2 at front end of cylinder head, and later plug 3 at front end of exhaust manifold as the water appears at these points in turn. Finally topping the header tank to a level approximately 1 in (25,4 mm) below the pressure cap sealing flange.
5. Re-check for the presence of air at plugs 2 and 3 by gently unscrewing after engine has been run at about half throttle for a period of a few minutes, or if a tendency to overheat is observed on the first run under normal load conditions.



frost precautions

Precautions against damage by frost should be taken if the engine is to be left exposed to inclement weather either by adequately draining the water system or where this is not convenient an anti-freeze of reputable make and incorporating a suitable corrosion inhibitor may be used.

Should it be the policy to protect engines from frost damage by adding anti-freeze to the cooling system, it is advisable that the manufacturers of the relevant mixtures 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.

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 BS5117, 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 antifreeze 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.

When draining the water circulating system, the tap on the cylinder block must be opened. This tap is on the fuel injection pump side of the cylinder block, near the flywheel housing.

The pressurised filler cap should be removed before draining the cooling system.

When the engine is drained, the fresh water pump is also drained but the rotation of the pump may be prevented by:

(a) locking of the impeller by ice due to the pump hole being blocked by sediment.

(b) locking of the seal through the freezing of globules of moisture between the seal and the gland.

Operators are therefore advised to take these precautions when operating in temperatures below freezing point.

1. Before starting the engine, turn water pump by hand; this will indicate if freezing has taken place. If freezing has taken place, this should free any ice formation.
2. If it is impossible to turn the pump by hand, the engine should be filled with warm water.

After an anti-freeze solution has been used, the cooling system should be thoroughly flushed in accordance with the manufacturers 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 the sea water hose at the lowest point on the engine will assist in complete drainage of the raw water.

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

SECTION D
Fault Finding

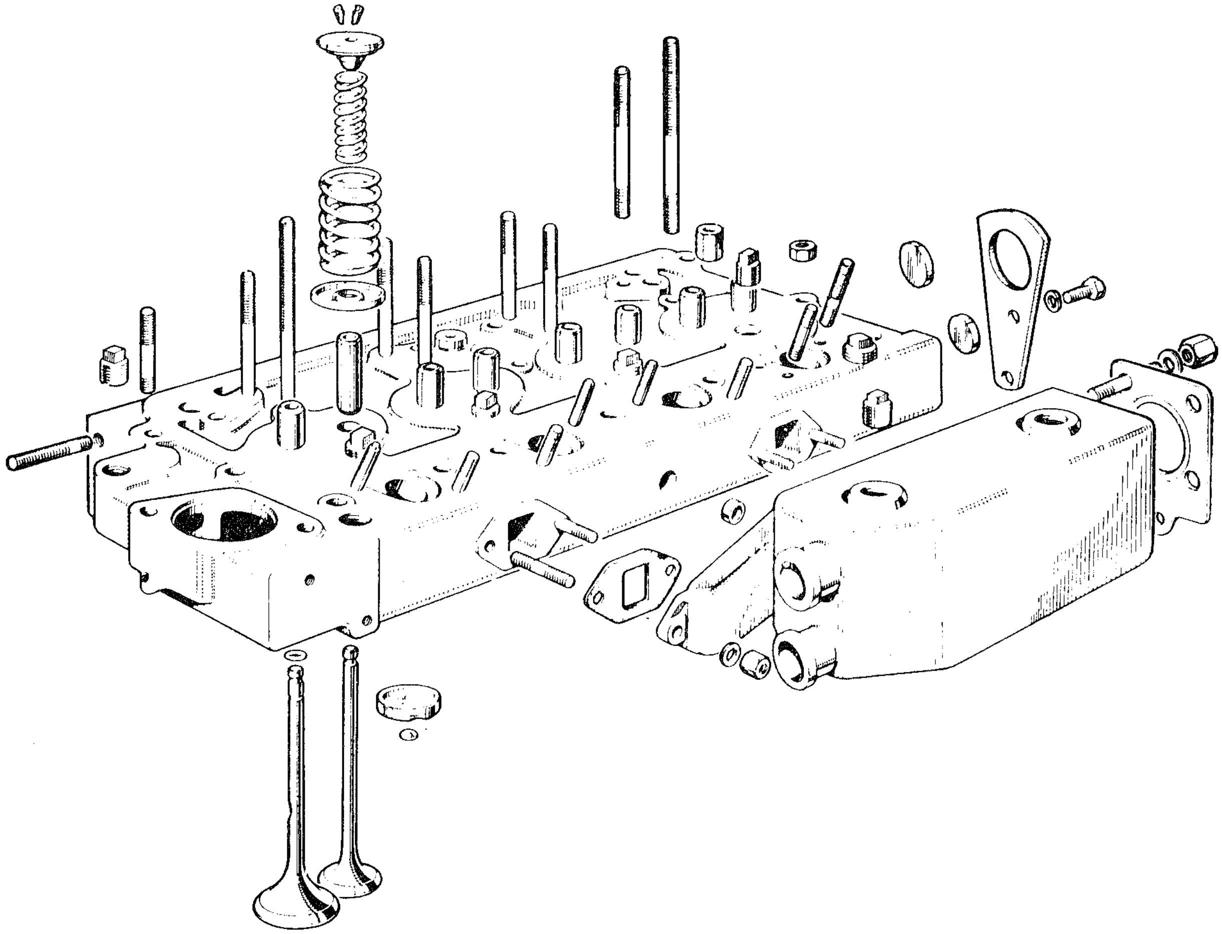
fault finding chart

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,
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,
Blue/white exhaust	4, 16, 18, 19, 20, 25, 27, 31, 33, 34, 35, 45, 56,
Low oil pressure	4, 36, 37, 38, 39, 40, 42, 43, 44, 53, 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.

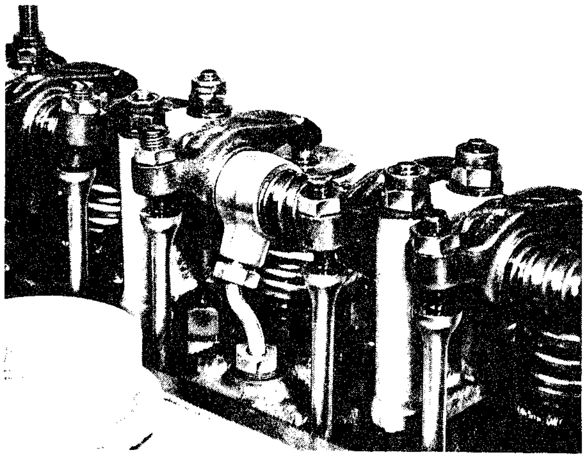
Key to Fault Finding Chart

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 or induction system
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. Sea cock strainer or heat exchanger blocked
48. Faulty engine mounting (Housing)
49. Incorrectly aligned flywheel housing, or flywheel
50. Faulty thermostat
51. Restriction in water jacket
52. Loose water pump drive belt
53. Gearbox or engine oil cooler choked
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

SECTION E
Cylinder Head



E1 Exploded view of Cylinder Head Assembly. (Standard Engine).



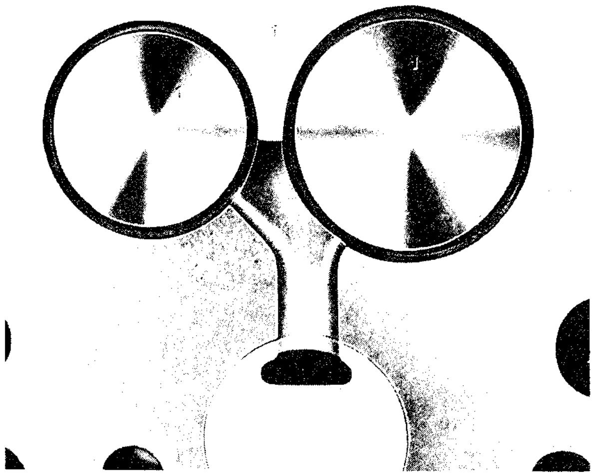
E2 Oil Feed Pipe to Rocker Shaft.

To Remove the Cylinder Head

1. Drain cooling system.
2. Disconnect battery terminals.
3. Detach exhaust pipe from exhaust manifold.
4. Uncouple water outlet connection on the front of the cylinder head.
5. Remove heat exchanger or header tank complete with pipes.
6. Remove air cleaner.
7. Disconnect fuel pipe and electrical connection to the starting aid.
8. Remove cylinder head cover.
9. Unscrew oil feed pipe to rocker shaft at cylinder head end (Fig. E.2).
10. Remove rocker shaft bracket nuts **evenly** and remove rocker shaft complete with oil feed pipe.
11. Remove push rods.
12. Remove atomiser leak off pipe.
13. Remove low pressure fuel pipes between fuel filter and fuel pump, remove fuel filter after disconnecting feed pipe from lift pump.

14. Remove high pressure fuel pipes.
15. Remove atomisers.
16. Uncouple generator adjusting link.
17. Remove cylinder head securing nuts and lift off cylinder head complete with inlet and exhaust manifolds.

NOTE. On 4.99 and 4.107 engines, to prevent liner movement, when rotating the crankshaft with the cylinder head removed, the liners should be secured in position by suitable tubing placed over two of the cylinder head studs and locking with nuts and washers.



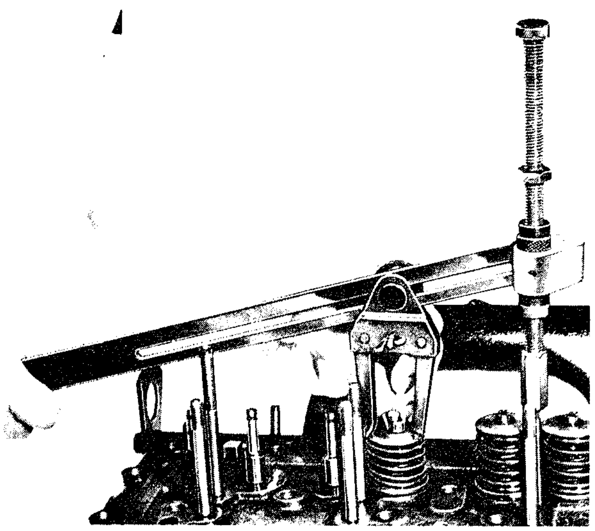
Method of Valve and Valve Seat numbering. E3

To Remove the Valves

With earlier engines, the valves were numbered and the cylinder head was marked with corresponding numbers (see Fig. E.3).

With current engines, the 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.

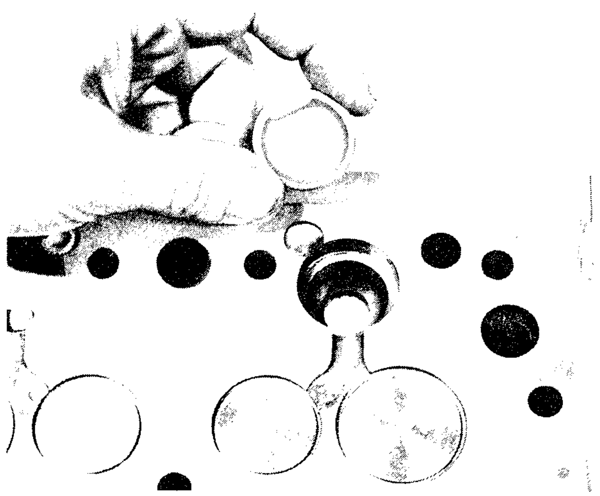
1. Remove collets by compressing valve springs. (Fig. E.4).
2. Remove spring caps, springs, seals (where fitted) and spring seats. Remove valves.



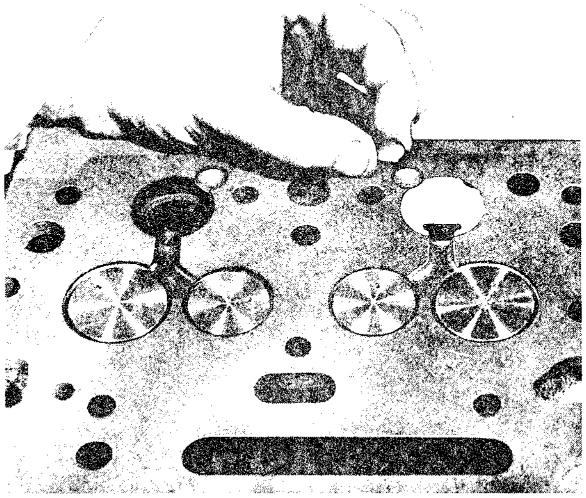
Removing the Valve Retaining Collets. E4

Combustion chamber inserts

These can be gently tapped out of their locations by means of a short length of curved bar through the atomiser bore. When refitted they must be located by means of expansion washers in the recesses provided. (Figs. E.6 and E.7).



Combustion Chamber Insert. E5



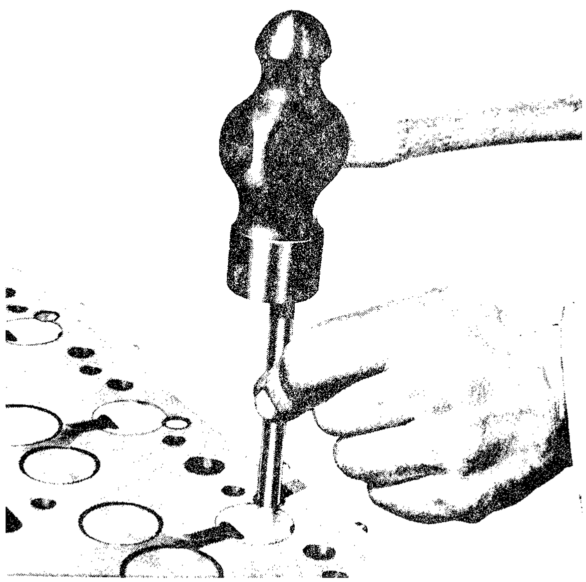
E6 Fitting the Combustion Insert Locating Washer.

Cleaning

Remove all traces of carbon from the cylinder head. If the water jacket within the cylinder head shows signs of excessive scale, then a proprietary brand of descaling solution may be used, if possible the cylinder head should be tested for water leakage after such treatment at the pressure given on Page B.8.

VALVE SPRINGS

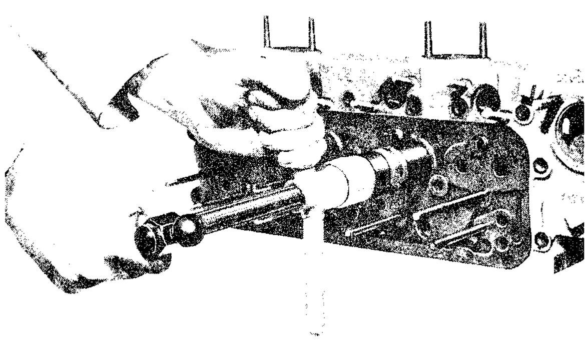
It is advisable to fit new valve springs whenever the engine undergoes a major overhaul. Where a top overhaul only is being carried out the springs should be examined, paying particular attention to squareness of ends and pressures developed at specific lengths, the details of which can be found on Page B.9. Marine engine valve springs are zinc plated.



E7 Securing Combustion Chamber Insert.

VALVE GUIDES

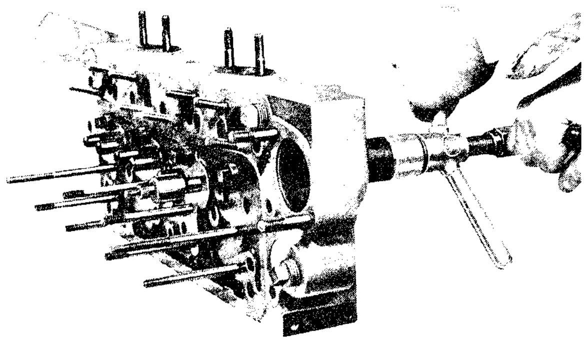
Worn guides should be removed either by means of a press and a suitable "dolly" or the valve guide removal tool shown in Fig. E.8.



E8 Removing a Valve Guide.

Before fitting the new guides remove any burrs from the cylinder head parent bores, then smear the bores with clean oil and either press in the new guides or pull them in by means of the tool shown in Fig. E.9, until the guide protrusion above the head top face is that quoted on Page B.9.

NOTE: Because the guides are made of cast iron and are comparatively brittle, special care, should be exercised during this operation.

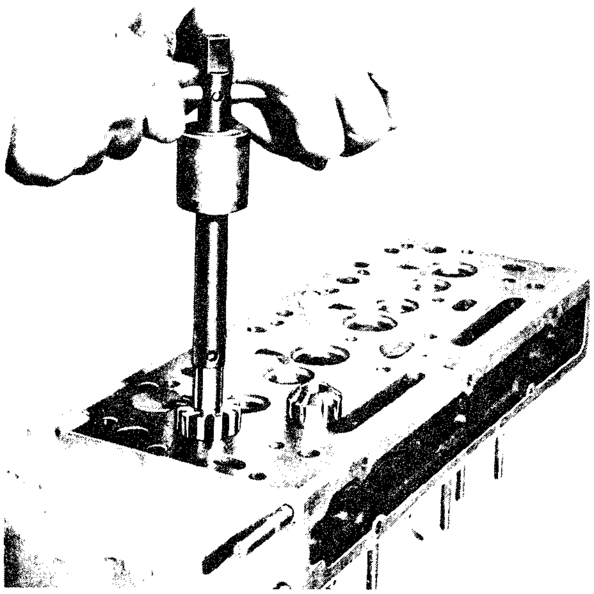


Fitting a Valve Guide. E9

VALVES AND SEATS

The valves should be checked in their respective guides for wear.

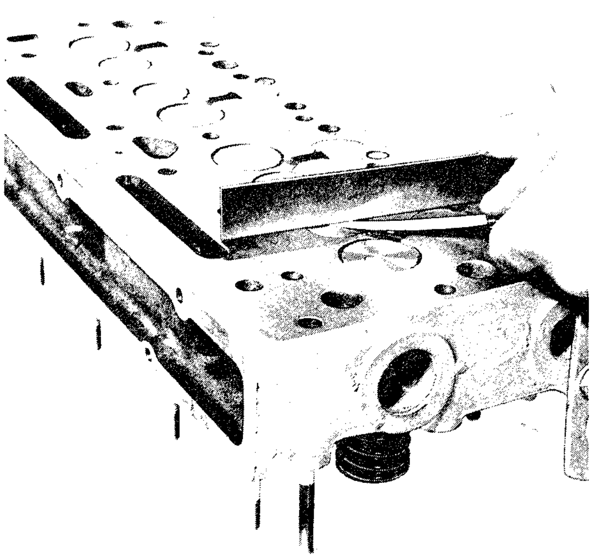
The valve and valve seat faces should be reconditioned in the normal way using specialised equipment or with grinding compound, according to their condition. A valve seat cutting tool is shown in Fig. E.10. Valves should always be refitted to their original seats and any new valve fitted should be marked to identify its position. (See Fig. E.3).



Recutting a Valve Seat. E10

Before refitting the valves it should be ascertained whether the valve head depth relative to the cylinder head face is within the limits given on Page B.9. This depth can be checked, as shown in Fig. E.11.

Where this depth exceeds the maximum limit and even the fitting of a new valve does not reduce this depth below the maximum limit, then fit a valve seat insert. See page E.6.



Checking the Valve Depth. E11

Hand Grinding

When grinding or lapping-in valves make certain that all signs of pitting are removed from the seats. Check valve head depths after lapping.

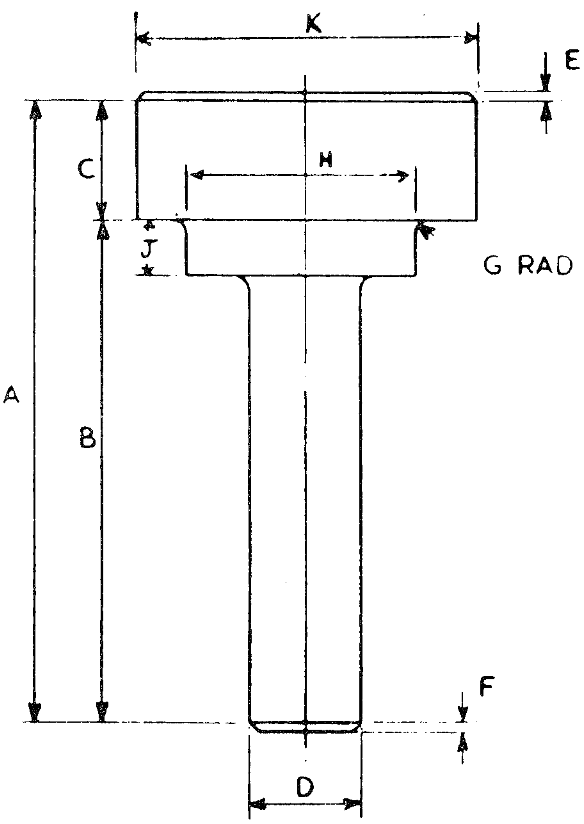
VALVE SEAT INSERTS

Valve seat inserts are not fitted to 4.99, 4.107 and 4.108 series production engines, but may be fitted in service.

When fitting inserts proceed as follows:—

1. Fit new valve guides as described on Page E.4.
2. Using the new valve guide bore as a pilot, machine the insert recess in the cylinder head face to the dimensions shown in Fig. E.12.
3. Clean the insert recess.
4. Using the valve guide bore as a pilot press the insert home with the inserting tool (Fig. E.13).

   Note: The insert must not be hammered in nor may lubrication be used.
5. Inspect to ensure that the insert has been pressed fully home.
6. Recut the valve seat at an included angle of 90° until the valve head depth reaches the minumum limit which is given on Page B.9. Lightly lap the valve to its new seat.

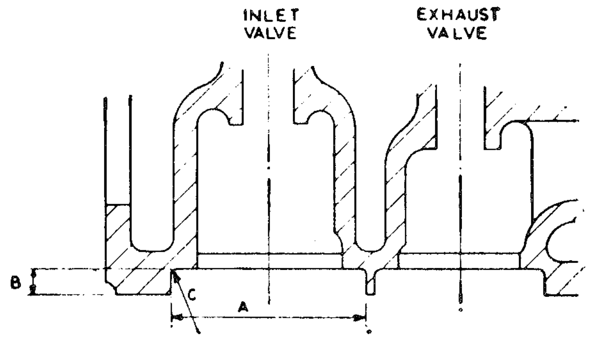


E13

Press Tool for Valve Seat Inserts.
Material EN32A Case Hardened and Ground.

Exhaust Dimensions
A.—2.75 in (69,85 mm)
B.—2 in (50,8 mm)
C.—0.75 in (19,05 mm)
D.—0.309/0.310 in (7,85/7,87 mm)
E.—1/16 in (1,59 mm) at 45°
F.—1/16 in (1,59 mm) at 45°
G.—1/32 in (0,79 mm) Radius
H.—1.018/1.019 in (25,86/25,88 mm)
J.—0.222/0.225 in (5,64/5,72 mm)
K.—1.287/1.297 in (32,69/32,94 mm)

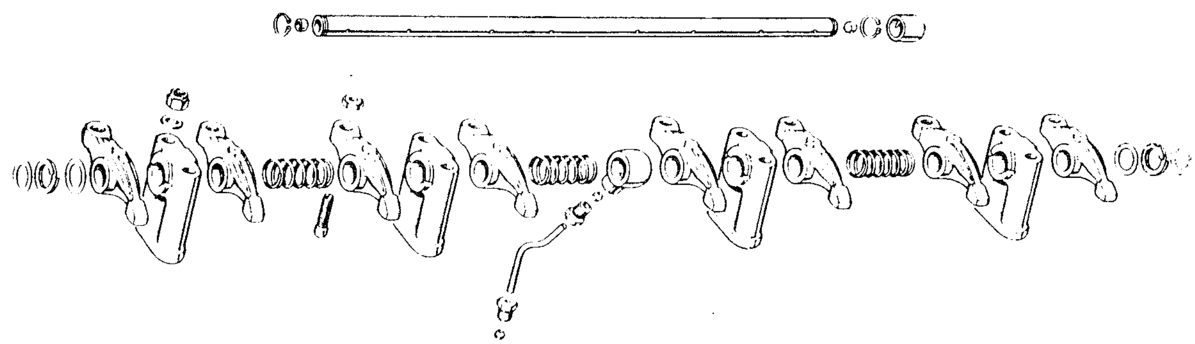
Inlet Dimensions
A.—2.75 in (69,85 mm)
B.—2 in (50,8 mm)
C.—0.75 in (19,05 mm)
D.—0.309/0.310 in (7,85/7,87 mm)
E.—1/16 in (1,59 mm) at 45°
F.—1/16 in (1,59 mm) at 45°
G.—1/32 in (0,79 mm) Radius
H.—1.238/1.239 in (31,45/31,47 mm)
J.—0.222/0.225 in (5,64/5,72 mm)
K.—1.523/1.533 in (38,68/38,94 mm)



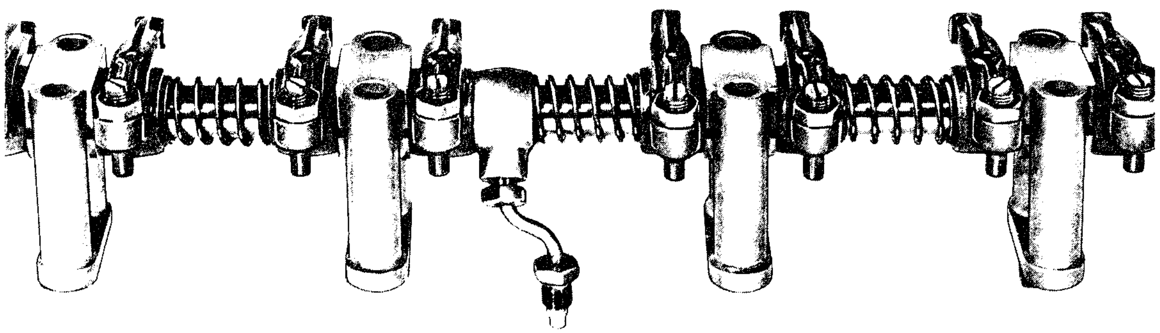
E12

Exhaust
A.—1.296/1.297 in (32,92/32,94 mm)
B.—0.3125/0.3175 in (7,94/8,06 mm)
C.—0.015 in (0,38 mm) chamfer at 45° (Max)

Inlet
A.—1.530/1.531 in (38,86/38,89 mm)
B.—0.3125/0.3175 in (7,94/8,06 mm)
C.—0.015 in (0,38 mm) chamfer at 45° (Max.)



Exploded view of Rocker Shaft Assembly. E14



Rocker Shaft Assembly E15

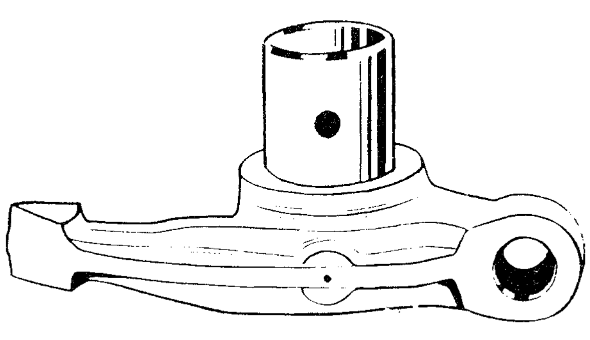
To Dismantle the Rocker Shaft Assembly

1. Remove retaining circlips from each end of shaft and withdraw rocker levers, springs and support brackets from rocker shaft.
2. Unscrew oil feed pipe from banjo and remove banjo. (When refitting this feed pipe it should be noted that the end of the pipe locates banjo position on the shaft).

Examine the rocker bushes and shaft for wear. The rocker levers should be an easy fit on the rocker shaft levers without excessive side play.

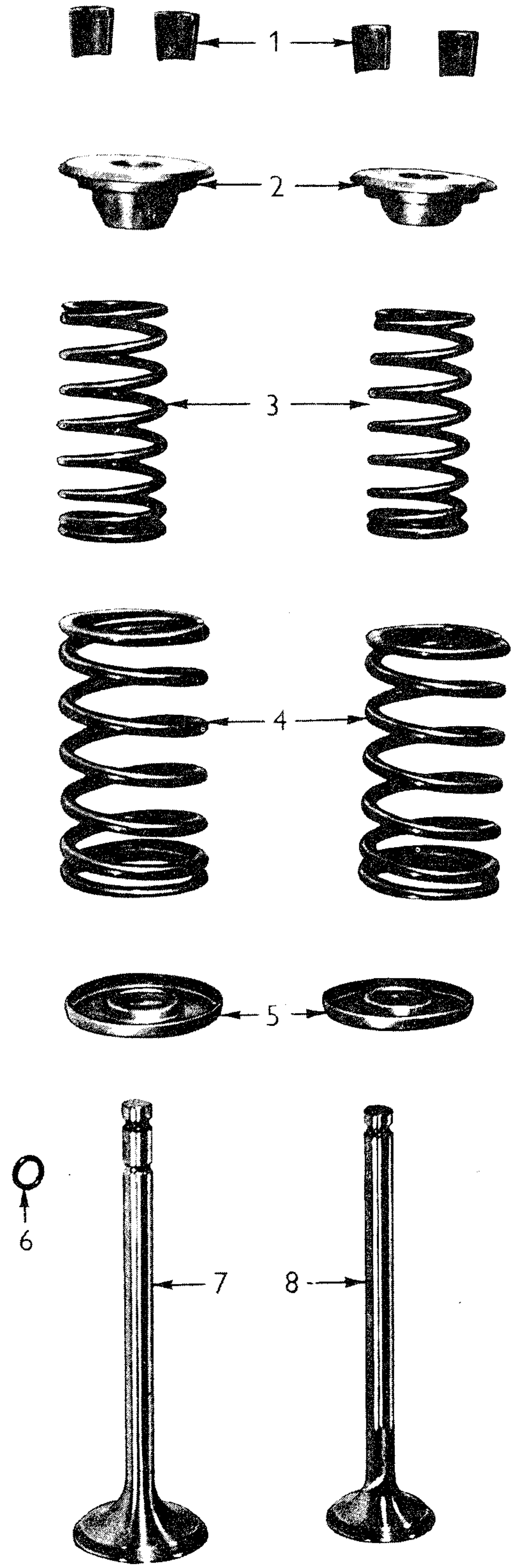
New rocker levers are supplied complete with bush fitted and reamed to size. If new rocker bushes are required they can be supplied separately.

NOTE: When fitting new bushes ensure that the oil feed holes are in alignment before pressing home, and when pressed fully home that the holes coincide. (Fig. E.16).



E16

Showing position in which rocker lever bush should be inserted.



E17

Exploded view of an Inlet and Exhaust Valve Assembly.
1. Retaining Collets 3. Inner Valve Springs
2. Spring Caps 4. Outer Valve Springs
5. Spring Seating Washers
6. 'O' Sealing Ring (Inlet Valves only)
7. Inlet Valve 8. Exhaust Valve

To Re-Assemble the Rocker Shaft Assembly

1. Refit oil feed banjo and locate with feed pipe.
2. Refit rocker levers, springs and support brackets in the opposite order to which thet were removed. (Fig. E.14). Lightly oil the components during re-assembly and ensure that each rocker lever does not bind on the shaft.

PUSH RODS

Check the push rods for straightness, if any are bent then fit new replacements.

To Refit the Valves

1. Oil valve stems and insert each valve into its respective guide.
2. Locate the spring seat washers, valve springs and spring caps in position.

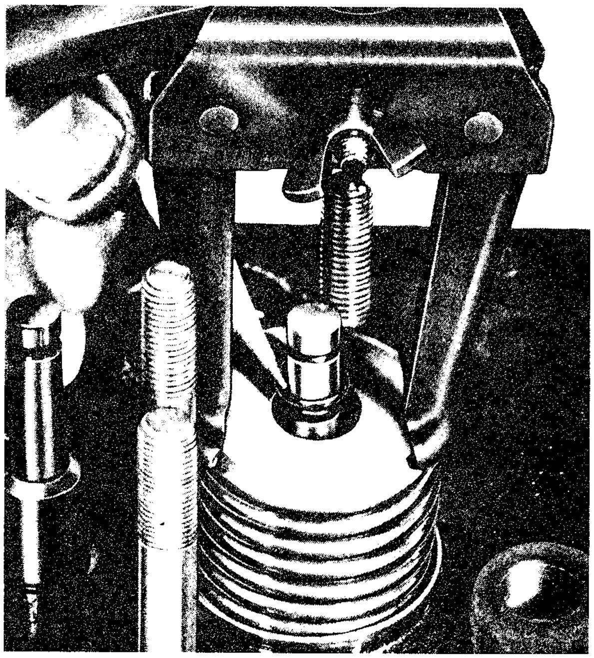
   NOTE: The valve springs should be fitted with damper coils towards the cylinder head top face. The longer spring caps fit on the inlet valve springs.
3. Compress the valve springs in turn and locate the retaining collets.

Valve Seals

Rubber 'O' ring seals are fitted on the inlet valves only. They fit inside the valve spring cap bore and register with an annular groove on the valve stem. (Fig. E.17). Re-assembly of the inlet valve assemblies should be carried out as follows:

1. Place spring seating washer in position.
2. Position valve springs correctly on the seating washer.
3. Place valve spring cap in position.

4. Compress valve spring until valve stem protudes through cap sufficiently to allow the 'O' ring to be fitted.
5. Fit 'O' ring over valve stem and slide down until it locates in annular groove. (Fig. E.18).
6. Locate retaining collets.



Locating a rubber 'O' Ring. E18

CYLINDER HEAD GASKET

Always use a **new** cylinder head gasket. Ensure the correct type is used.

4.108 Engines

The gasket is made of a black composite material and is known as the Klinger type. It must be fitted DRY, jointing compound is **not** used.

Gaskets differ for direct cooled and indirect cooled engines.

It is very important that the gasket is placed correctly, otherwise the steel beading may be 'nipped' between the cylinder head face and the top of the liner.

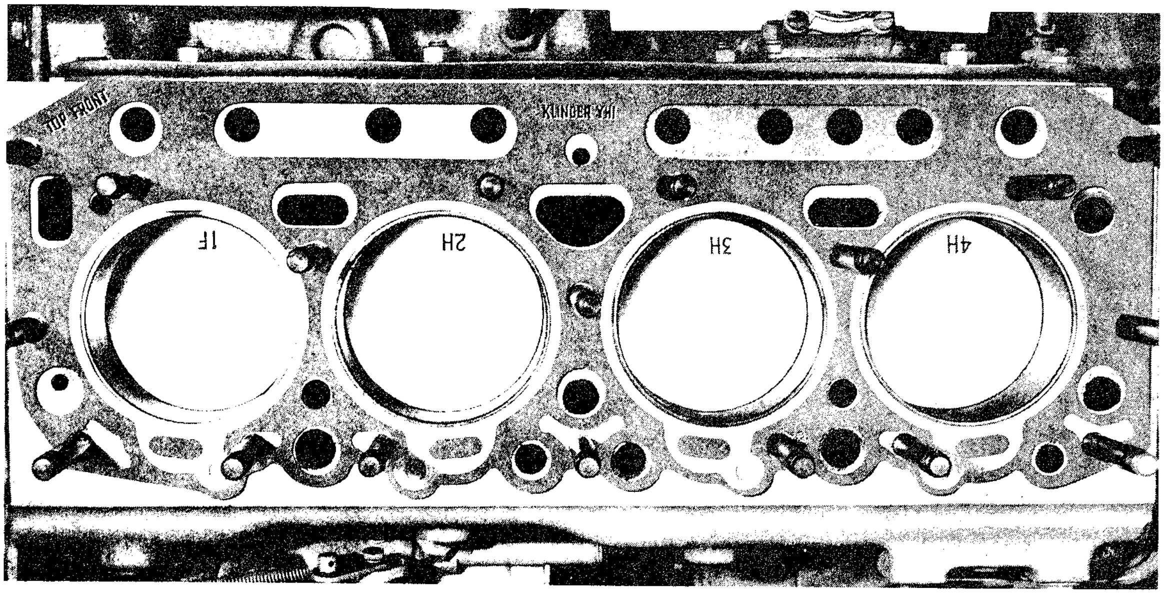
4.99 and 4.107 Engines

These engines use a copper and asbestos or a copper, steel and asbestos gasket. These gaskets should be fitted with a light coating of Perkins Hylomar jointing compound on both sides.

To Refit the Cylinder Head

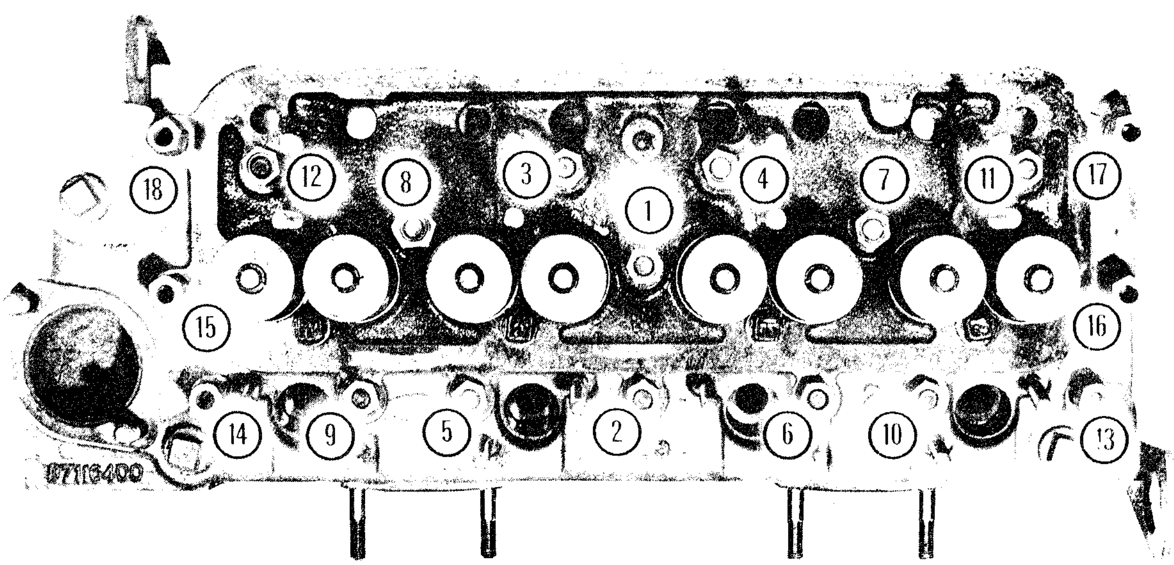
Check that the rocker assembly oil feed passage in the cylinder head is free from obstruction.

1. Place cylinder head gasket in position (the gasket is marked "TOP FRONT"). (Fig. E.19 shows a 4.108 engine gasket).
2. Lower cylinder head into position.
3. Lubricate cylinder head studs and nuts, then tighten nuts progressively in three stages in the



Cylinder Head Gasket correctly positioned. E19 sequence shown in Fig. E.20 to the torque given on page B.3. This final torque tightening stage should be repeated.

4. Fit push rods in their locations and fit rocker shaft assembly, noting that the oil feed to the rocker shaft is located correctly.
5. Locate oil feed pipe nut finger tight at this stage, then evenly tighten rocker shaft bracket securing nuts to a torque of 15 lbf ft (2 kgf m) --20 Nm now tighten the oil feed pipe nut. When correctly located the oil feed pipe will be as shown in Fig. E.2.
6. Adjust valve clearances (Page E.11) to 0.012 in (0,3 mm).
7. Replace generator adjusting link and tension belt (Page M.10).
8. Replace atomisers but do not tighten the securing nuts.
9. Replace leak off pipe assembly and four high pressure fuel pipes to atomisers. Tighten atomiser securing nuts. Tighten high pressure fuel pipe nuts to 15 lbf ft (2,1 kgf m) – 20 Nm and the atomiser securing nuts to 12 lbf ft (1,7 kgf m) – 16 Nm.
10. Replace fuel oil filter and low pressure fuel pipes between filter and lift pump, and filter and fuel pump.
11. Reconnect electrical and fuel supplies to starting aid.
12. Reconnect exhaust pipe to manifold.
13. Reconnect water outlet connection at the front of the cylinder head.
14. Fill the cooling system and check for water leaks.
15. Bleed air from fuel system as described on Page N.8.
16. Reconnect battery.
17. After warming up, the engine should be shut



E20 Torque tightening sequence for Cylinder Head Nuts.

down and the cylinder head nuts again tightened to the correct torque in the sequence shown in Fig. E.20. (Refer to Note below).

18. Reset the valve clearances to 0.012 in (0,30 mm) cold (Fig. E.21). Fit the cylinder head cover.

NOTE

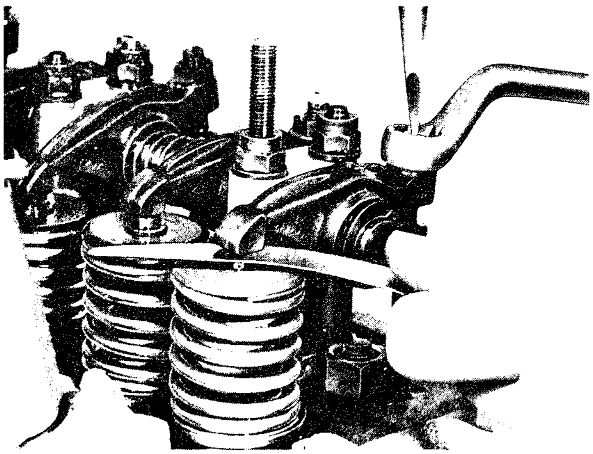
It is important that the cylinder head nuts are re-tightened to the correct torque, in the correct sequence after 25/50 hours service following head fitment

Adjusting Valve Clearances

Check valve tip clearances by placing the appropriate sized feeler gauge between valve stem and rocker lever tip, if any adjustment is necessary, slacken locknut and turn adjusting screw to increase or decrease the clearance as shown in Fig. E.21. When correct clearance is obtained, lock the adjusting screw and re-check the clearance. Proceed to next valve in the adjusting sequence.

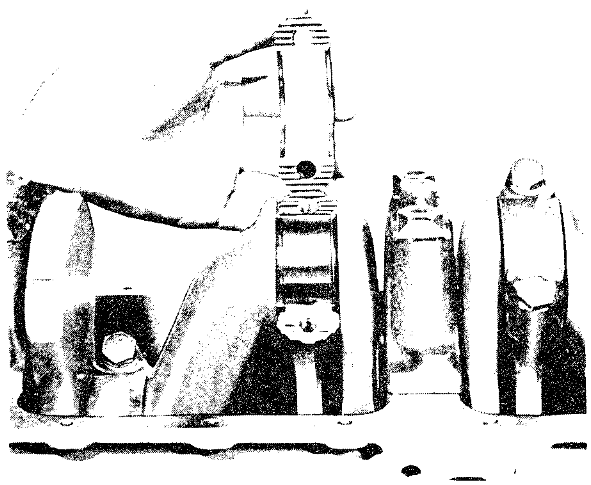
Valve Adjusting Sequence

Turn engine so that valves of No. 1 cylinder are in position of 'valve overlap', i.e. period between opening of the inlet valve and closing of exhaust valve. In this position adjust clearances of No. 4 cylinder; similarly with No. 3 cylinder valves in the 'valve overlap' position adjust valves of No. 2 cylinder, with No. 4 cylinder on 'valve overlap' adjust clearances of No. 1 cylinder and finally with No. 2 cylinder valves on 'valve overlap' adjust clearances of No. 3 cylinder.

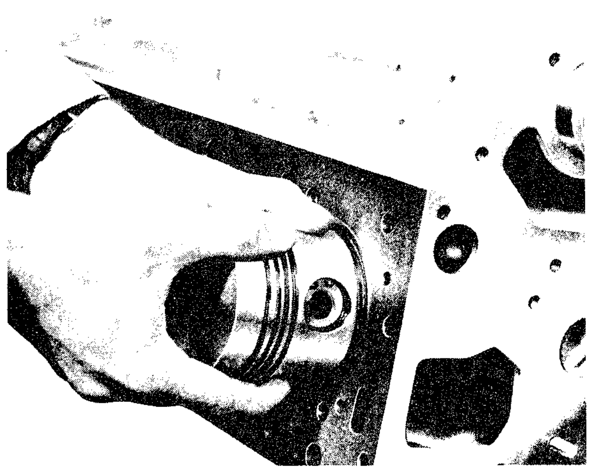


Adjusting Valve Tip Clearance. E21

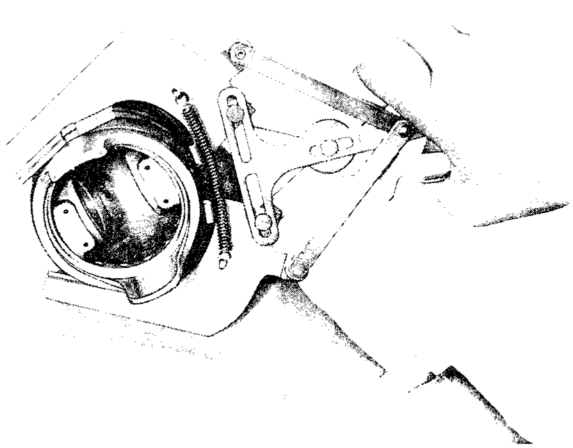
SECTION F
Pistons and Connecting Rods



F1 Removing a Connecting Rod Bearing Cap.



F2 Removing a Piston from the Cylinder Block.



F3 Removing a Piston Ring.

To Remove Pistons and Connecting Rods

1. Remove cylinder head assembly (Refer to Page E.2) and oil sump. (Refer to Page L.3).

   NOTE: Any ridges or carbon deposits around the top of the cylinder bores should be removed with a suitable scraper before piston removal is attempted.

2. Rotate the crankshaft until one pair of big ends are at bottom centre, and remove their respective connecting rod cap securing bolts.

3. Remove the connecting rod caps and bearing shells. (Refer to Fig. F.1).

   NOTE: If the bearing shells are serviceable, they should be suitably marked to identify them to their original locations.

4. Push the pistons and connecting rods through the top of the block and remove as shown in Fig. F.2.

5. Rotate the crankshaft through 180° to bring the remaining pair of big ends to bottom centre and repeat removal operations.

   When piston removal has been carried out keep each piston and rod assembly separate, each to each as marked. Mark the pistons on the crown (before removing the gudgeon pin) to indicate the 'FRONT' in relation to the 'FRONT' marking cast on the connecting rods.

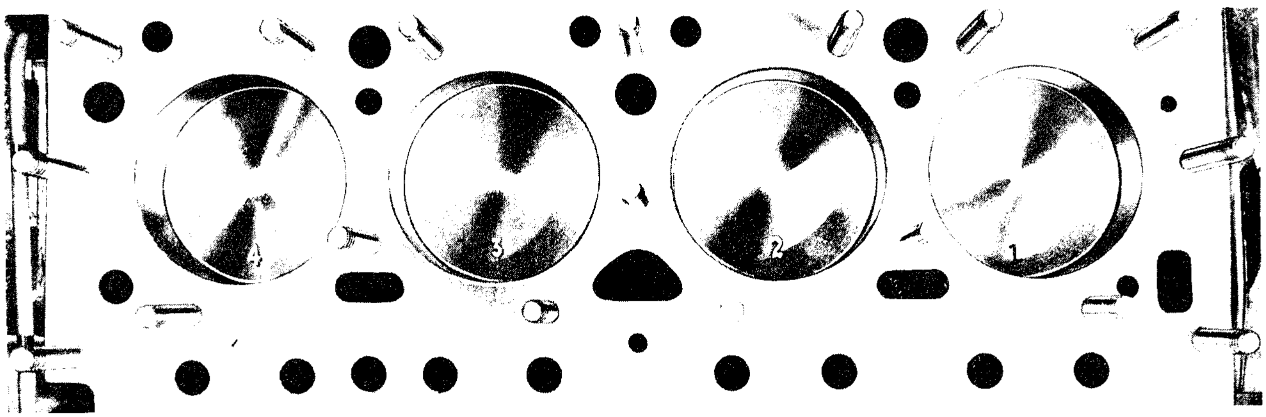
To Remove Pistons and Rings from the Connecting Rods

1. Remove piston rings from each piston, using a suitable piston ring tool. Fig. F.3.

   NOTE: The laminated segments fitted in the fourth ring groove on 4.108 engines should be removed by hand.

   With 4.108 Pistons there is a steel insert rolled into the top ring groove during piston manufacture, it should be regarded as an integral part of the piston and no attempt should be made to remove it from its location.

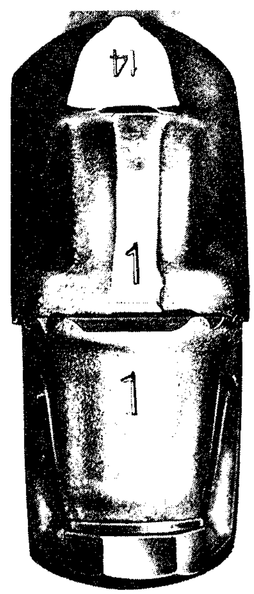
2. Remove gudgeon pin retaining circlip and push out gudgeon pin. Should difficulty be experienced in removing it, warm the piston in a suitable clean liquid to a temperature of 100 120°F, (40 50°C), this will then enable the pin to be pushed out quite easily.



Showing numbering of Pistons. F4

Inspection

1. Examine pistons for scoring and any signs of groove damage.
2. Check clearance of piston rings in their respective grooves by placing ring outer face into groove and a suitable sized feeler between ring and groove face.
3. Check fitted gaps of piston rings. See Page B.5.
4. Check fit of the gudgeon pin and small end bush, if excessive, replace small end bush.
5. To renew small end bush, remove the old one by means of a suitable press and 'dolly'. Press in the new bush ensuring that the oil holes coincide when fitted. Ream out to suit gudgeon pin, then check rod for parallelism and twist. (refer to Page B.6).
6. Examine big end bearing shells for wear, or pitting.

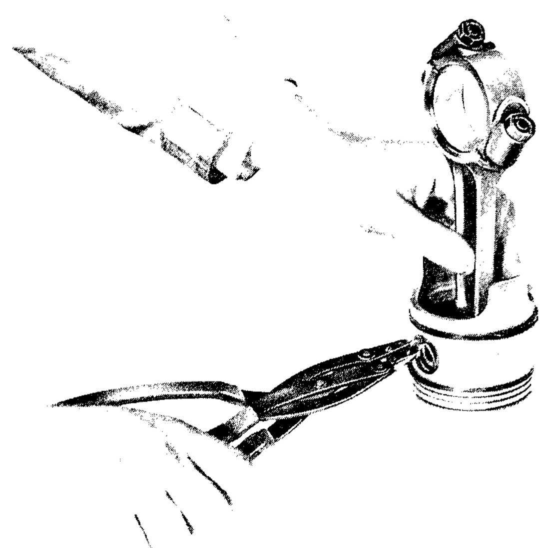


Method of marking Connecting Rod and Cap. F5

To Refit Pistons to Connecting Rods

If original pistons are to be refitted they must be re-assembled to their respective connecting rods. Refer to Figs. F.4 and F.5 for location of piston and rod numbering. Any new components fitted should be numbered similarly.

1. Place No. 1 piston onto its head, noting the position of the mark previously made to indicate the "FRONT".
2. Hold No. 1 connecting rod with the small end between the gudgeon pin bores so that the word "FRONT" cast on the rod is towards the same side.
3. Warm piston in a suitable clean liquid to a temperature of 100–120°F (40–50°C) which will enable the gudgeon pin to be easily pushed into the piston bore.
4. Fit the two retaining circlips ensuring that they locate correctly in their recesses. (Refer to Fig. F.6).



Fitting a Gudgeon Pin Retaining Circlip. F6

Fitting the Piston Rings

The piston ring layout is given on Page B.5.

NOTE: All the rings except the laminated type may be fitted by means of an expanding tool of the type shown in Fig. F.3.

Internally stepped compression rings should be fitted with the step **uppermost.**

The top compression and slotted oil control rings may be fitted either way up.

After an appropriate period of service, when indications of piston ring and/or bore wear become apparent, a replacement ring pack has been made available for 4.107 and 4.99 Marine Service engines and includes a taper faced ring for the top groove. This ring is marked "T" or "TOP".

Earlier 4.99 Marine engines had a different ring layout to that already quoted. This consisted of a chrome plated compression ring in the top groove, two taper faced compression rings in the second and third grooves and two slotted scraper rings in the fourth and fifth grooves.

The procedure for fitting the laminated type is different, as the ring comprises four separate segments; these may be fitted by hand in the following sequence with the piston crown uppermost.

1. Fit the first segment to the piston so that when held horizontally between the thumb and fingers and radially compressed the ring ends point downwards (see Fig. F.7).

   Place this ring on the bottom face of the fourth ring groove with the gap over the gudgeon pin bore.

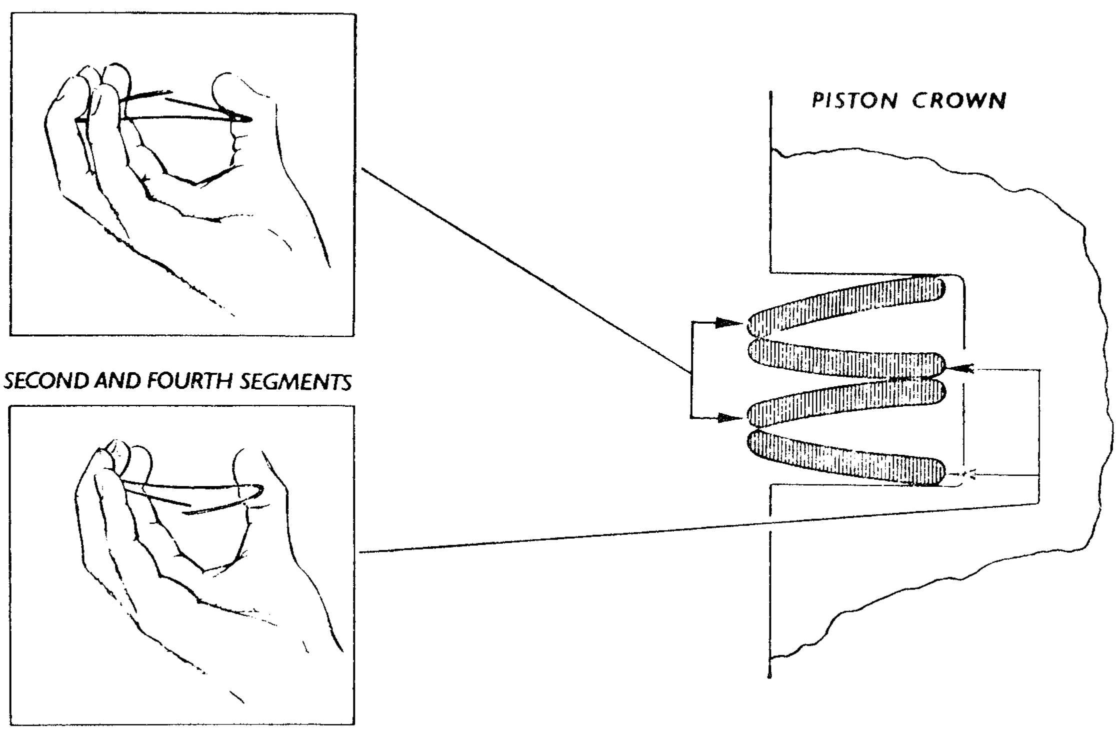
2. Fit the second segment on top of the first, so that when compressed as described above the ends point upwards. Position the gap at 180° to that of the first segment.

3. Fit the third segment as in (1) above with the gap immediately above the gap of the second ment.

4. Fit the fourth segment as in (2) above with the gap immediately above the gap of the second segment. If all the segments have been fitted correctly then they will be positioned as shown above.

   The gaps of the remaining rings should be staggered alternately.

   Lubricate the rings in their grooves and see that they can move freely in their locations, this does not apply to the laminated type in the fourth groove (4.108 engine), which if correctly fitted should **not** move freely due to the outward pressure of the top and bottom segments on the ring groove walls.



FIRST AND THIRD SEGMENTS

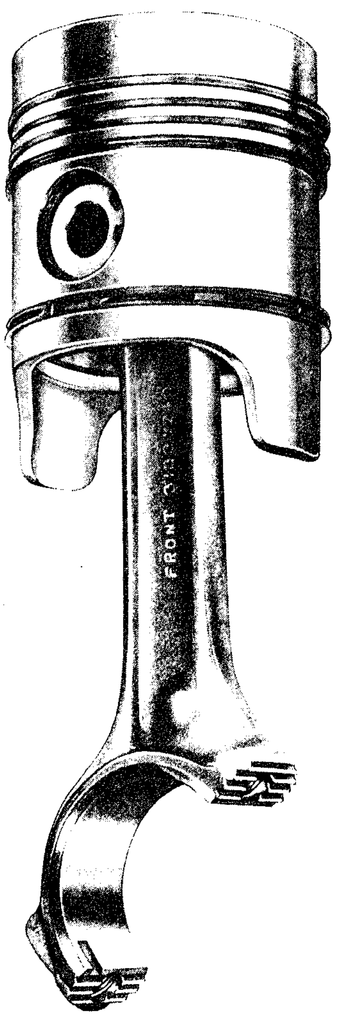
F7 Method of fitting Laminated Segment Piston Rings.

When all the rings have been fitted, they should be as shown in Fig. F.8 (4.108 engine) or Fig. F.9 (4.99 and 4.107 engines).

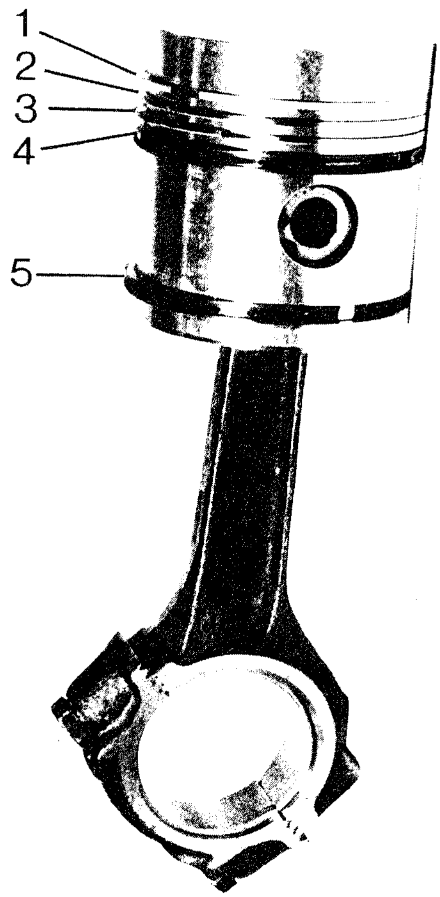
To Fit Piston and Connecting Rod Assemblies

1. Turn engine until crankpins of numbers 1 and 4 cylinders are at bottom centre.
2. Using a suitable ring clamp of the type shown in Fig. F.10, compress rings of No. 1 piston and hold in this position.
3. With the word 'FRONT' on the connecting rod facing the front of the engine, insert rod into No. 1 cylinder bore.

NOTE: The cylinders are numbered 1, 2, 3, 4 starting from the front (water pump) end of the engine. It is extremely important that these components (marked as shown in Figs. F.4 and F.5), are returned to their original locations.

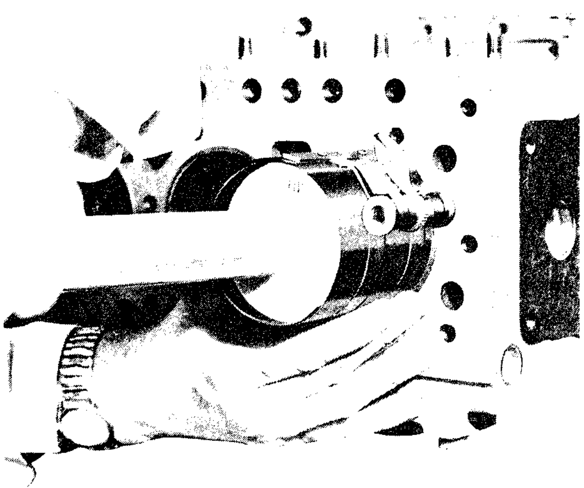


Showing Piston Ring Layout. F8



Piston and Connecting Rod Assembly. F9

1. Plain Parallel Faced Compression Ring.
2. Internally Stepped Compression Ring.
3. Internally Stepped Compression Ring.
4. Slotted Scraper Ring.
5. Slotted Scraper Ring.

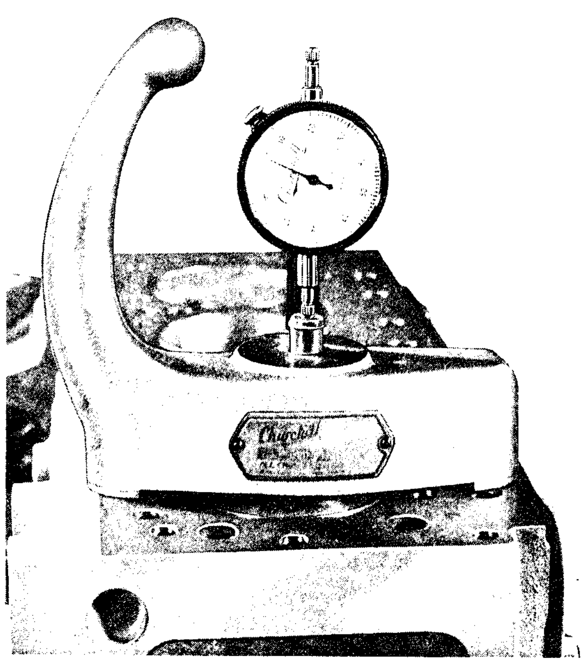


F10 Fitting the Piston into the Cylinder Block.

4. The piston crown may be gently tapped with the shaft of a hammer as shown in Fig. F.10 until all the rings have entered the cylinder bore.
5. Draw the rod towards the crankpin, place the top half bearing shell in position, locating the tag in the machined slot, oil and draw rod onto crankpin.
6. Fit lower half bearing shell to the connecting rod cap, locating tag in the machined slot, oil and fit cap to crankpin, ensuring that numbers on rod and cap coincide as shown in Fig. F.5.
7. Fit connecting rod securing bolts and tighten evenly to the torque quoted on Page B.3
8. Repeat this procedure for No. 4 piston and connecting rod assembly.
9. Rotate crankshaft to bring numbers 2 and 3 crankpins to bottom centre.
10. Repeat procedures 2—7 to fit the two remaining assemblies. Refit sump and cylinder head.

Piston Grading

Production Grade	Equivalent Service Grade
A to F	F
G to L	L
N to P	P



F11 Method of checking Piston Height.

Fitting New Pistons

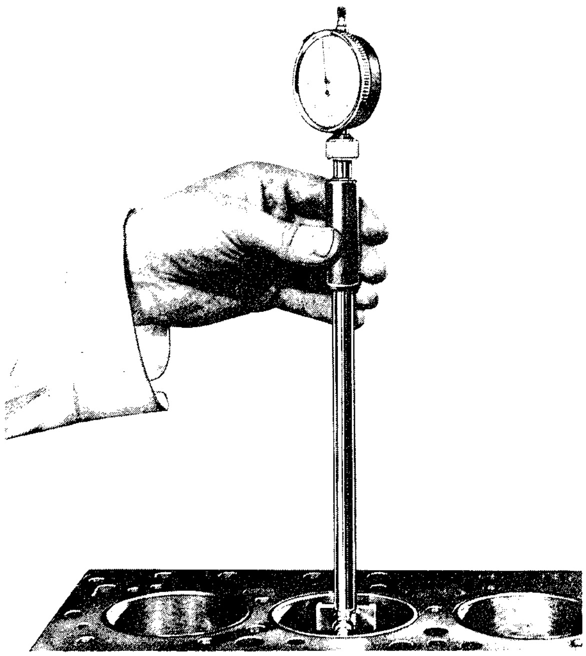
New 4.107 pistons have a machining allowance for piston topping so that when fitted, the piston height above the cylinder block top face will be within the limits quoted on Page B.5.

To determine the exact amount to be removed from the piston crown, the piston, connecting rod and bearing assembly will have to be fitted to its respective cylinder bore as previously described, and the piston height above the cylinder block top face measured with the piston at top centre. This can be measured by means of a piston height gauge shown in Fig. F11. Repeat for each new piston to be fitted and mark each piston with the number of the cylinder bore it will be fitted to —(not on the top as any marking here will be removed by the machining). When each piston has been skimmed it should be checked again when finally refitted. Once the piston height is correct, mark any such piston on the crown with the number of its respective bore. (Refer to Fig. F.4).

In the case of new 4.108 and 4.99 engines, pre-topped pistons are available in three grades (see separate table). For identification purposes, the grade letter is stamped on the piston crown.

Grade F pistons are suitable for topping to give other grades.

SECTION G
Cylinder Block and Liners



G1 Dimensional check of Cylinder Bore.

CYLINDER LINERS (4.108 ENGINES)

The cylinder liners are centrifugally cast alloy iron and an interference fit in the cylinder block parent bore.

Reboring of these liners is not possible and new liners should be fitted when a rebore would normally be considered necessary.

Dimensional checks of the cylinder bore are carried out by means of the gauge tool shown in Fig. G.1. When checking liners each one should be measured in three positions — top, centre and bottom; the readings being taken parallel and at right angles to the centre line of the cylinder block giving six readings for each cylinder bore.

When checking the fitted internal bore of a new thin-wall liner it is advisable to allow a period of time to elapse for the liner to settle.

To Renew Cylinder Liners

1. Remove all components from the cylinder block.
2. Using a shouldered metal disc slightly smaller on the outside diameter than the parent bore diameter, press the liners carefully out through the top of the cylinder block.

   NOTE: Support the block locally in the area of the top of the liner.
3. Lightly lubricate the outside of the new liner with clean engine oil.
4. As the liner must protrude above the cylinder block top face and not be pressed fully home a solid stop washer should be available designed to give the correct liner protrusion.
   NOTE: The limits for liner protrusion are given on page B.4 and may be checked as shown in Fig. G.2.
5. Press liner into bore, releasing the load several times during the first inch to allow the liner to centralise itself until it reaches the solid stop washer.
6. Bore and finish hone the liners to the dimension quoted on Page B.4

   NOTE: When boring equipment is mounted on the top face of the cylinder block, fit a parallel plate between the boring bar and cylinder block face. Such a plate should be thicker than 0.027 in (0,686 mm).
7. Re-assemble engine components to the cylinder block.

G2 Method of checking Liner protrusion.

CYLINDER LINERS (4.99 and 4.107)

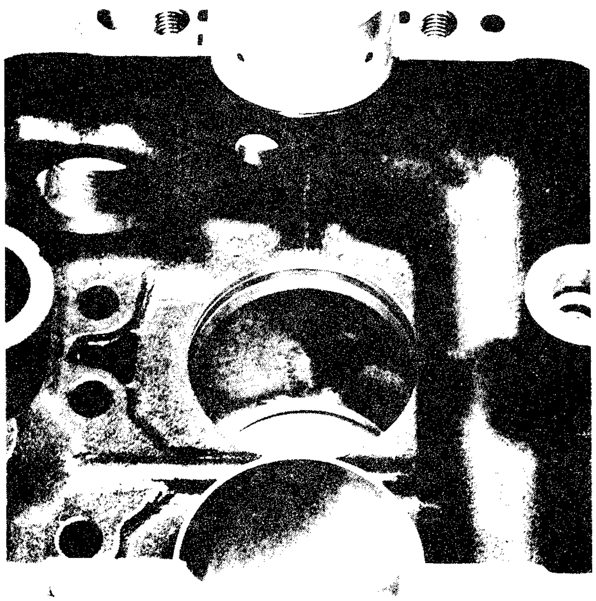
Cylinder liners fitted to 4.107 and 4.99 Marine engines are of the centrifugal cast iron wet type. They have flanges at the top and are sealed at the bottom by means of two rubber sealing rings which fit in machined recesses in the cylinder block.

Earlier 4.99 engines had only one sealing ring at the bottom of the liner.

4.99 and 4.107 cylinder liners have a pre-finished bore.

The cylinder liners can be removed without removal of the crankshaft.

Liners to be removed and refitted must be suitably marked so that they may be refitted to their original parent bore and in the same position in that bore, that is, thrust side of the liner to the thrust side of the cylinder block.



Liner Sealing Ring Recess in Cylinder Block. G3

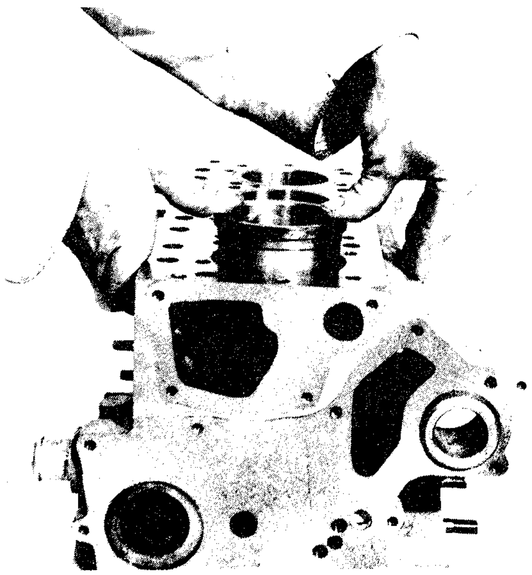
To Remove Liners

Remove all components from cylinder block.

Remove liners using a suitable liner removing tool (See Fig. G.4).

Once the liner has cleared the rubber sealing ring in the cylinder block, the liner can be removed by hand.

Removing Cylinder Liner. G4



G5 Fitting Cylinder Liner.

To Fit New Liners

Over a period of service, corrosion may have taken place at the inner ends of the landings. This corrosion and any burrs which may be present should be removed.

Fit new rubber sealing rings in the grooves provided in the bottom land of the cylinder block.

In order to facilitate the fitting of the liners when the rings have been placed in position, smear them with soft soap.

Place liner in position and press home by hand, ensuring that the rubber sealing rings remain in their grooves (See Fig. G.5).

The liners are a push fit and no force is required.

After fitting the liners, the cylinder block should be water tested to a pressure of 20 lbf/in^2 (1,4 Kgf/cm^2) — 138 kN/m^2.

Reassemble engine as required and to instructions given for the various components.

All 4.107(M) and later 4.99 engines have four small holes drilled along the fuel pump side of the cylinder block, each one breaking through into the area between the two sealing rings at the bottom of each cylinder liner. These holes permit any coolant which may have leaked past the upper sealing ring to escape, thus relieving the bottom sealing ring of any pressure above it and preventing coolant from entering the engine sump.

In the case of a new engine, or where new cylinder liners and/or sealing rings have been fitted, it is possible that a slight leakage of coolant could occur from these holes. This should cease as the liners and sealing rings settle down after the initial period of running, but where difficulty is experienced, then the use of BARSEAL in the cooling system (in accordance with the manufacturers instructions) is approved for use in engines using closed circuit cooling systems.

SECTION H
Crankshaft and Main Bearings

CRANKSHAFT AND MAIN BEARINGS—H.2

Description

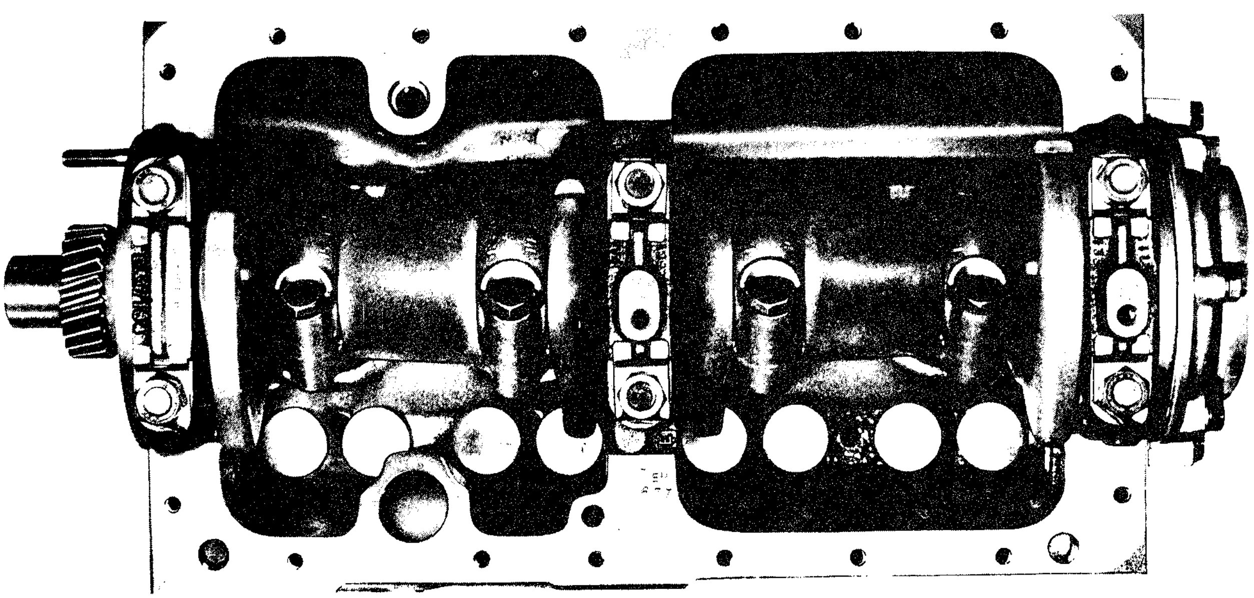
The crankshaft runs in three pre-finished replaceable thinwall, steel backed, aluminium tin lined bearings. Crankshaft end float is controlled by thrust washers located both sides of the rear main bearing. 0.0075 in (0,19 mm), oversize thrust washers are available, which, if used on one side of the rear main bearing only, will reduce crankshaft end float by 0.0075 in (0,19 mm) and by 0.015 in (0,38 mm) if used on both sides. The limits for the crankshaft end float are given on Page B.7.

The main bearing caps are numbered and are not interchangeable. The main bearing shells are located by tabs which locate in slots in the bearing housings.

NOTE: Before renewal of the main bearing ensure that the correct replacements are available, reference to the relevant parts list will ensure this, but for identification purposes the new bearings should have an annular groove machined in the inner (bearing) face along the centre line of the feed holes, when the bearings are correctly located these feed holes will correspond exactly with those machined in the cylinder block.

On later 4.107 engines the annular oil groove in the main bearing parent bore (cylinder block and bearing cap) has been deleted. Adequate lubrication is maintained by repositioning the oil feed holes radially in the shell bearings and continuing to machine the annular groove in the bearing on the centre line of these feed holes.

These later type shell bearings may be used on both early and later type engines, whereas the early type of



H1 View of Crankcase showing serial number locations on Cylinder Block and Main Bearing Caps.

shell bearing must NOT, on any account, be fitted to the later engines where the annular groove in the main bearing parent bore has been deleted.

To Renew Main Bearings and Thrust Washers

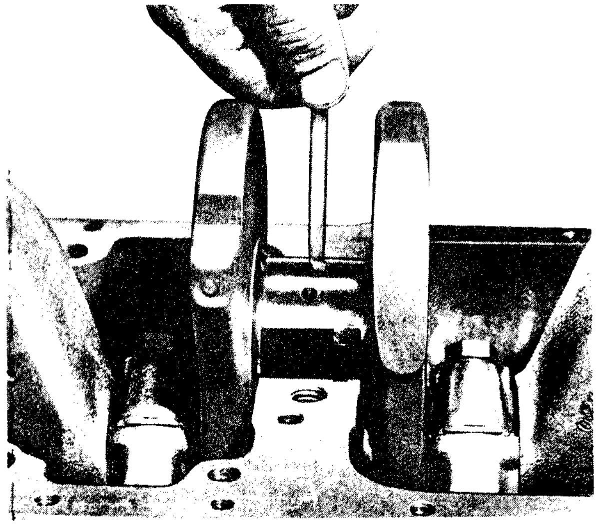
Removal of the main bearings and thrust washers can be carried out without removing the crankshaft as follows.

1. Remove sump and suction pipe assembly.
2. Slacken main bearing cap setscrews.
3. Remove one of the main bearing caps and remove bearing shell from cap.
4. Remove top half of bearing shell by pushing it, on the opposite side to the one having the locating tag, with a suitable strip of wood and rotating it on the crankshaft as shown in Fig. H.2.
5. Inspect bearing shells and if replacements are necessary continue by lightly lubricating and inserting the new top half bearing shell, plain end first, into the side having the tag location in the block.
6. Rotate bearing shell on crankshaft until it locates correctly with the tag in the machined slot.
7. Locate lower half bearing shell in main bearing cap, lubricate and refit.
8. Tighten the two securing setscrews to positively locate the bearing shells then slacken a turn or two.
9. Repeat items 3—8 for the remaining two bearings.

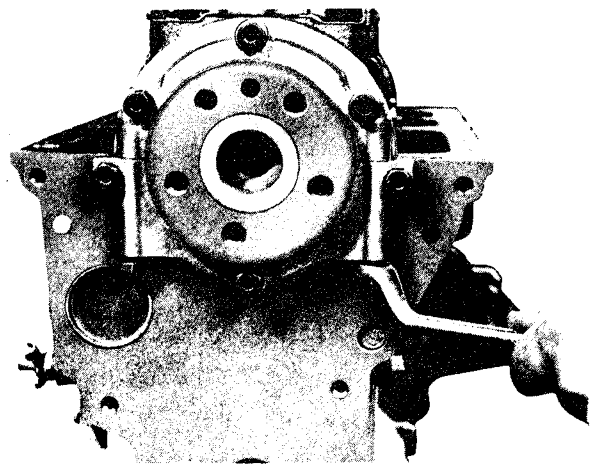
   NOTE: To enable the **rear** main bearing cap to be removed, first remove the two oil seal housing setscrews as shown in Fig. H.3.
10. Finally tighten the main bearings to the torque given on Page B.3.

Renewal of thrust washers is carried out as follows:—

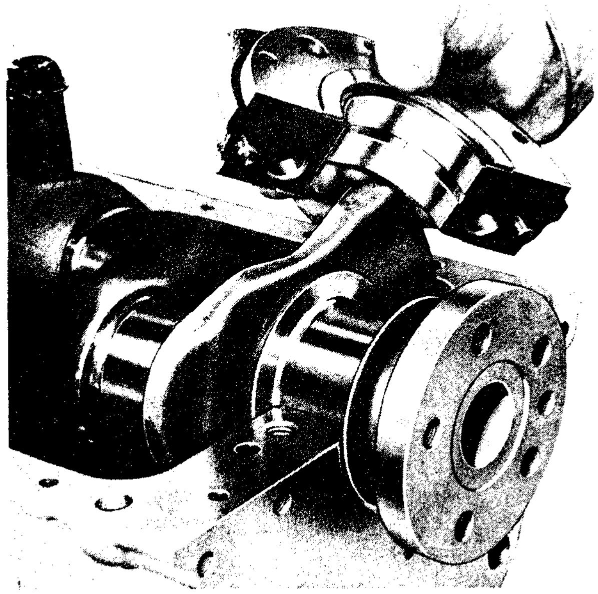
1. Remove the two setscrews securing the two rear main bearing oil seal half housing as shown in Fig. H.3.
2. Remove rear main bearing cap securing set-screws.
3. Remove rear main bearing cap and from it the two lower half thrust washers. (Refer Fig. H.4).



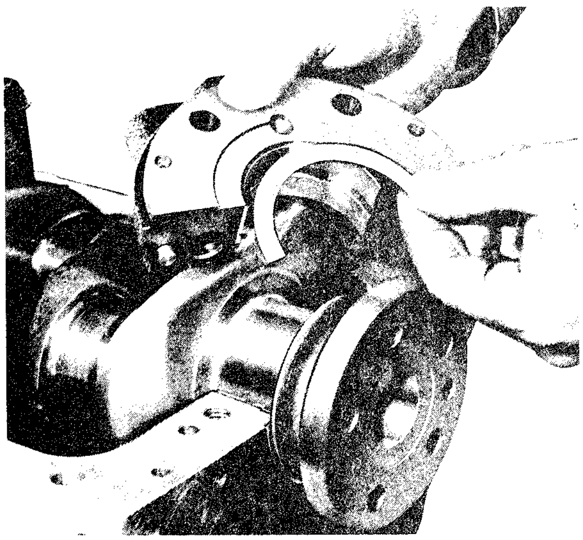
Removing a Main Bearing Shell with the Crankshaft "in situ". H2



Removing Oil Seal Housing Setscrews. H3

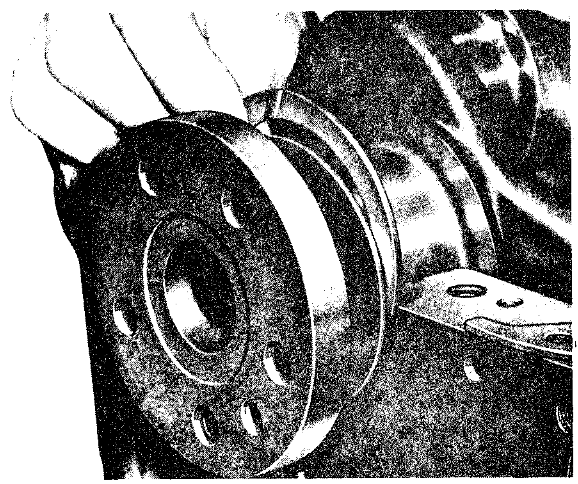


Removing the rear Main Bearing Cap complete with Thrust Washers. H4



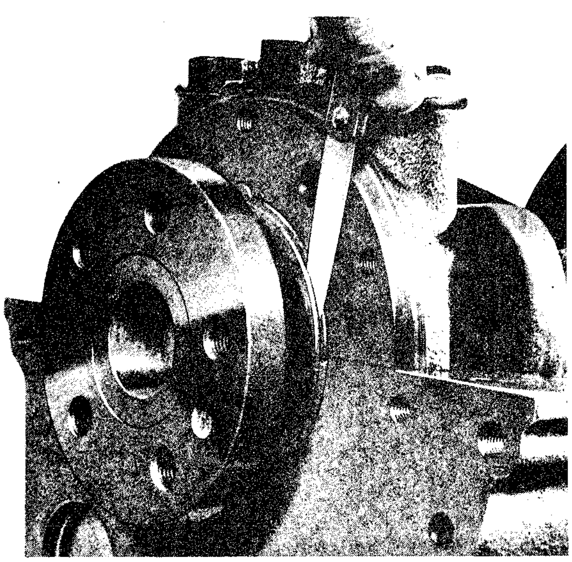
H5 Locating a lower Thrust Washer half in its recess.

4. The single upper half thrust washer is removed by rotating it with a thin piece of wood until it can be lifted out of its recess.
   NOTE: The steel faces of the lower thrust washers should face inwards towards bearing cap (Refer Fig. H.5), the steel face of the upper thrust washer should also face inwards.



H6 Locating the upper Thrust Washer Half.

5. Locate upper thrust washer half as shown in Fig. H.6, place lower half either side of rear main bearing cap as described and refit cap.



H7 Checking Crankshaft end float.

6. Tighten setscrews evenly and finally to torque given on Page B.3.
7. Check that the crankshaft end float is within the limits given on Page B.7 by means of feeler gauges as shown in Fig. H.7. If incorrect, oversize thrust washers are available to give an overall reduction of 0.0015 in (0,38 mm). (Refer to Page H.2.
8. Refit the two setscrews securing rear main oil seal half housing.

   NOTE: If any leakage of oil is apparent from this seal then new seals should be fitted to the half housings as described under the heading "Crankshaft Rear End Oil Seal" or fit a new assembly.
9. Refit suction pipe assembly and sump.

To Remove the Crankshaft

To remove the crankshaft it will be necessary to remove the engine from the boat.

1. Remove gearbox, starter motor, flywheel and fly wheel housing (see Section P).
2. Remove crankshaft front pulley, timing case cover, timing gears and fuel pump drive hub. (Refer to Page J.2. for details of their removal).
3. Remove setscrews (also any studs) and remove timing case back plate.
4. Remove sump and lubricating oil pump complete with suction and delivery pipes. (Refer to Page L.3 for removal of these)..
5. Remove connecting rod setscrews, caps and bearing shells. (Refer to Page F.2).

   NOTE: All bearing shells should be marked to indicate "top" or "bottom" and number of the rod assembly.
6. Unscrew main bearing cap setscrews.

   NOTE: The rear seal half housing securing setscrews will require removal to enable rear main bearing cap to be removed. (Refer to Fig. H.3).
7. Lift out crankshaft.
8. Remove top half main bearing shells.
9. Finally, remove the top half oil seal housing.

Crankshaft Regrinding

Crankshafts fitted to 4.108 and some 4.107 engines are Tufftrided and these crankshafts must be re-hardened by the Tufftriding process after regrinding. If facilities for Tufftriding are not available, the crank-shaft can be re-hardened by the 20 hour Nitriding process, but if this cannot be carried out, then a replacement crankshaft should be fitted. Tufftrided crankshafts can be identified by the part number stamped on the crankshaft nose or No. 3 web.

Crankshafts fitted to 4.99 and most 4.107 engines are induction hardened and do not require re-hardening after regrinding.

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

To Refit the Crankshaft

1. Ensure that crankshaft oilways are clear.
2. Place the three top bearing shells in position then oil.

   NOTE: Unless a new set of main bearings is being fitted, those removed must be returned to their original locations.
3. Place crankshaft in position.
4. Locate upper thrust washer in position as shown in Fig. H.6.
5. Fit the three lower bearing shells, oil and fit the three main bearing caps in their respective locations.

   NOTE: Ensure at this stage that the two lower thrust washer halves are positioned correctly either side of the rear main bearing cap when fitted.
6. Check main bearing setscrews prior to fitting for signs of stretch or thread damage. Replace where necessary.

   NOTE: Steel shim washers fitted beneath the setscrew heads are fitted to maintain torque settings.
7. Fit setscrews using new shim washers and tighten to torque tension given on Page B.3.
8. Check that crankshaft can be rotated freely, and check crankshaft end float as shown in Fig. H7. Should it be outside the limits quoted on Page B7, then oversize thrust washers are available to give the necessary adjustment. (Refer to Page H.2).
9. Fit new sealing strips to rear main bearing oil seal housings and refit housings as described under the heading "Crankshaft Rear End Oil Seal" on this page.'
10. Oil crankpins, locate connecting rod bearing shells, ensuring their correct relative positions, then fit connecting rod caps as described on Page F.6. The crankcase should now be as shown in Fig. H.1.
11. Refit lubricating oil pump. (Refer to Page L.5) and sump (Refer to Page L.3).
12. Refit timing case back plate, fuel pump drive hub, timing gears, timing cover and crankshaft front pulley. (Refer to later text commencing on Page J.2 for their reassembly).
13. Refit and correctly align the flywheel housing, (See Page P.2) flywheel, starter motor and gearbox.

CRANKSHAFT REAR END OIL SEAL

This sealing arrangement consists of two half housings bolted around the rear of the crankshaft. The bore of these housings is machined to accommodate a rubber cored asbestos strip which, in conjunction with a helix machined between the thrust collar and the flywheel mounting flange, acts to return surplus oil reaching the seal. The two half housings fit over this helix and the contact of the sealing strips with the crankshaft prevents leakage beyond this point.

NOTE: When traces of oil become apparent from behind the flywheel and a faulty rear oil seal is suspected, first ensure that the crankcase is breathing normally. Any build up in crankcase pressure could cause oil to be forced past the rear sealing arrangement. If crankcase pressure is normal and new seals require to be fitted the following procedure should be adopted with crankshaft in position.

1. Set up a half housing in the vice with the seal recess uppermost.
2. Settle approximately 1 in (25 mm) of the strip, at each end, into the ends of the groove ensuring that each end of the strip projects 0.010/0.020 in (0,25/0,50 mm) beyond the half housing joint face. Allow middle of seal to bulge out of groove during this operation.
3. With thumb or finger press remainder of strip into groove, working from the centre, then use any convenient round bar to further bed in the strip by rolling and pressing its inner diameter as shown in Fig. H.8. This procedure takes advantage of the friction between the strip and the groove at the ends to compact the rope, whilst ensuring that the projections of the end faces of the rope remain as set.
4. Fit sealing strip to other half housing in a similar manner.
5. Remove all traces of the old joint from cylinder block rear face and fit a new joint treated with a suitable jointing compound.

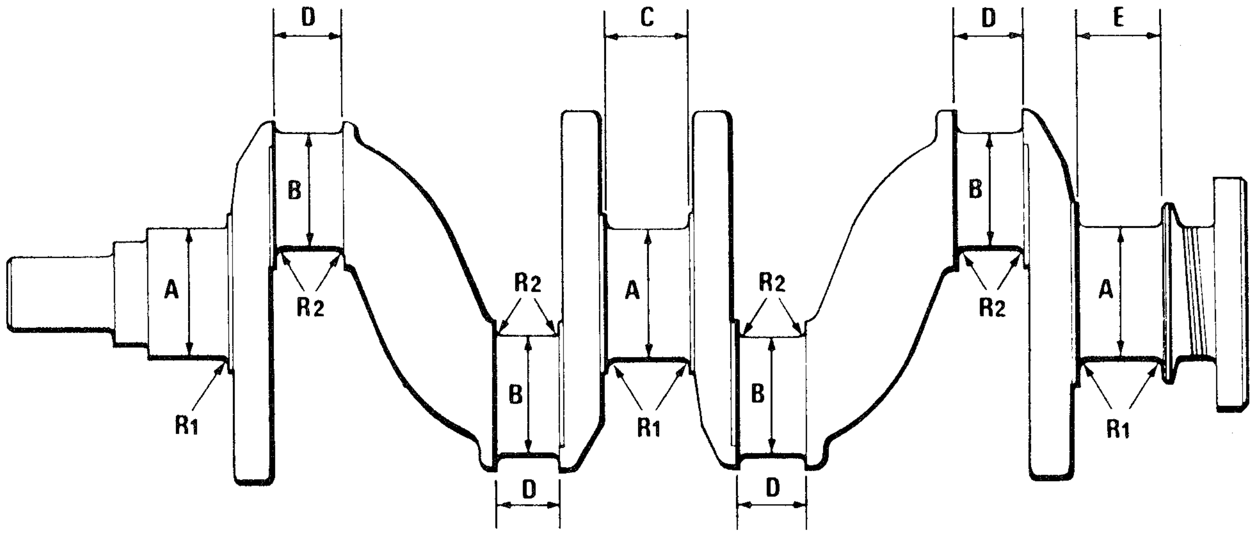
   Lightly coat the faces of the housing with a suitable jointing compound and spread a film of graphite grease over the exposed inside diameter surface of the strip.
6. Assemble half housings around crankshaft rear journal and fasten together by the two setscrews (See Fig. H.3).
7. Swivel the complete seal housing on the shaft to bed in the strips, and to establish that the assembly turns on the crankshaft. Bolt the seal housing in position on the block and the rear main bearing cap and tighten securing setscrews.

H8 Bedding in the rear Main Oil Seal.

Crankshaft Regrind Data

Tufftrided crankshafts — Part numbers

31315827	31315831	31315838	31316112	31316114	31316128
31315828	31315836	31316111	31316113	31316122	31316121
31315829	31315741				



H9

	0.010 in (0,25 mm) Undersize	0.020 in (0,51 mm) Undersize	0.030 in (0,76 mm) Undersize
A	Front and Centre Journals 2.238/2.2385 in (56,85/56,86 mm)	2.228/2.2285 in (56,59/56,60 mm)	2.218/2.2185 in (56,34/56,35 mm)
A	Rear Journal 2.2375/2.238 in (56,84/56,85 mm)	2.2275/2.228 in (56,58/56,59 mm)	2.2175/2.218 in (56,33/56,34 mm)
B	1.9893/1.9901 in (50,53/50,55 mm)	1.9793/1.9801 in (50,27/50,29 mm)	1.9693/1.9701 in (50,02/50,04 mm)

C 1.509 in (38,33 mm) maximum

D 1.1945 in (30,34 mm) maximum

E 1.516 in (38,51 mm) maximum

R1 0.125/0.141 in (3,17/3,58 mm) all journals

R2 0.156/0.172 in (3,96/4,37 mm) all 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—2 amps A.C. Current—1000 amps

Limits of taper and out of round for 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.	Number 2.	Number 3.
Mounting	0.003 in (0,08 mm)	Mounting

SECTION J
Timing Case and Drive

TIMING CASE AND DRIVE

To Remove the Timing Case Cover

1. Slacken generator mounting bolts, release adjusting arm setscrew and remove generator driving belt.
2. Remove sea water pump (see Page M.3).
3. Remove crankshaft pulley retaining setscrew or dognut and withdraw pulley which is a keyed fit on the crankshaft.
4. Remove securing setscrews and nuts from the timing case and remove cover, taking care not to damage oil seal rubber lip on the crankshaft pulley locating key.

To Remove the Crankshaft Front Oil Seal

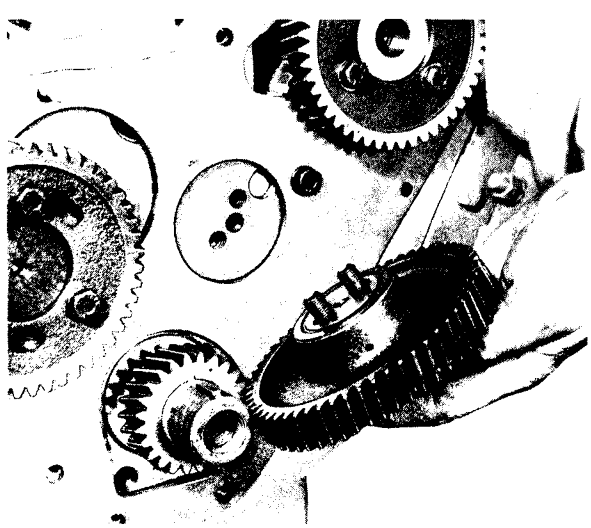
1. Using a suitable dolly and press, remove the oil seal from the timing case cover by pushing out through the front.
2. Locate the new seal in position so that the lip faces inwards.
3. Press in new seal from front until it just butts against seal retaining lip, giving local support to cover as seal is pressed home.

To Refit the Timing Case Cover

1. Using a new joint, lightly coated with a suitable jointing compound, place front cover in position taking care not to damage oil seal rubber lip on crankshaft pulley key.
2. Loosely fit front cover securing setscrews and nuts.
3. Fit crankshaft pulley to centralise seal, then tighten securing setscrews and nuts.
4. Fit the crankshaft pulley retaining setscrew or dognut and torque to value given on Page B.3.
5. Refit sea water pump.
6. Refit generator driving belt and tension as described on Page M.10.

To Remove the Idler Gear and Hub

1. Remove timing case front cover.
2. Tap back locking tabs and unscrew idler hub securing setscrews.
3. The setscrews, idler gear and hub may now be removed together as shown in Fig. J.1.



J1 Removing Idler Gear and Hub.

4. Examine gear and hub for signs of excessive wear, cracks, pitting etc.

To Refit the Idler Gear and Hub

1. After ensuring that the oilways in the hub and gear are clear, hold the gear in position with the timing marks correctly aligned.

   NOTE: If cylinder head assembly has not been disturbed, then cylinder head cover and rocker shaft should be removed in order to allow the camshaft to be turned to facilitate the aligning of the timing marks.

2. Insert hub as shown in Fig. J.2 so that the holes in the hub and cylinder block are in alignment and secure setscrews.

   NOTE: Clearance is provided in the setscrew holes of the idler gear hub, to provide the necessary backlash adjustment for the timing gears.

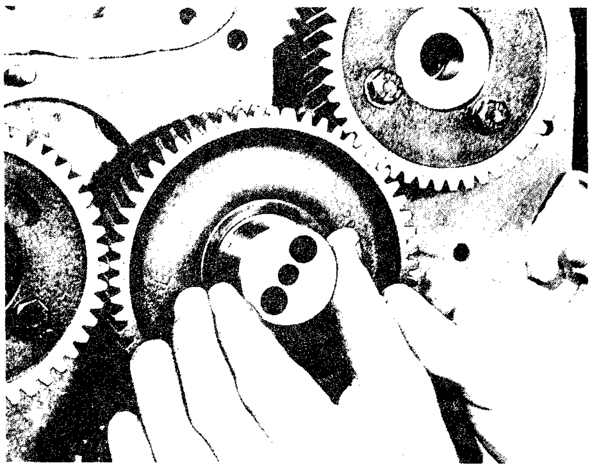
3. Using the adjustable idler gear, backlash between both crankshaft gear/idler gear and camshaft gear/idler gear should be set within the range given on Page B.11 with the gears held together in order to take up the effect of bearing clearance. Backlash may be checked by the use of feeler gauges as shown in Fig. J.3.

4. When backlash has been correctly set, finally tighten idler gear hub setscrews to torque given on Page B.3.

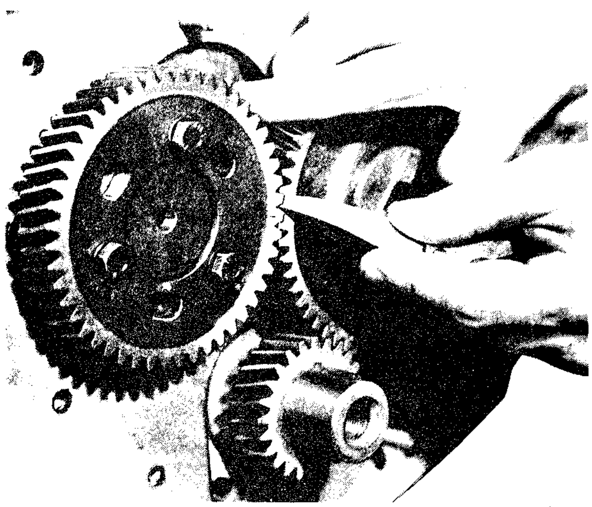
5. Check idler gear end float as shown in Fig. J.4, the limits are given on Page B.11 and lock idler gear hub setscrews with tabwashers.

   NOTE: The timing gears when correctly set should appear as shown in Fig. K.1.

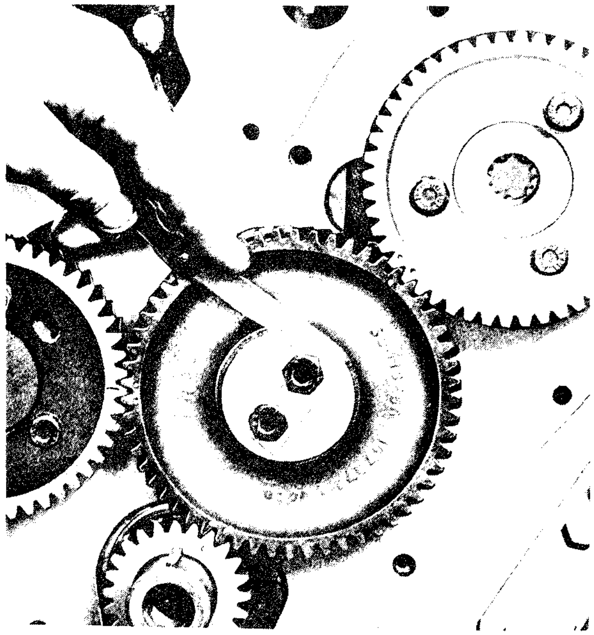
6. Refit the timing case front cover, etc.



Refitting Idler Gear and Hub. J2



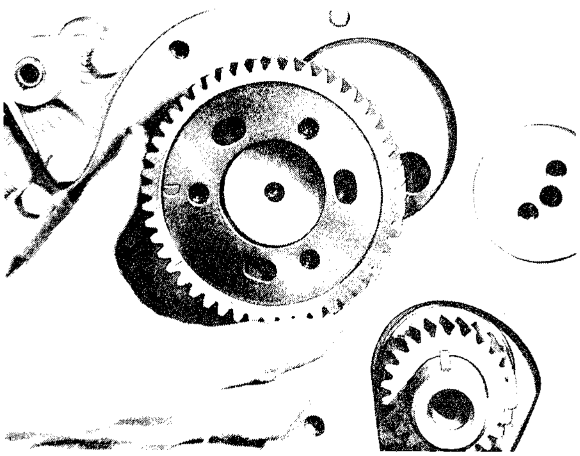
Checking Timing Gear Backlash. J3



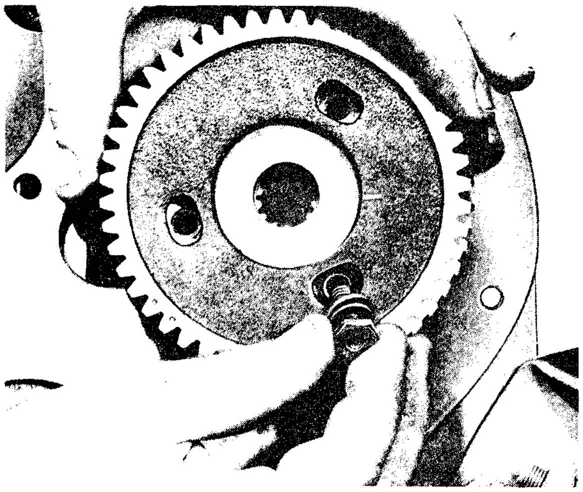
Checking Idler Gear end float. J4

To Remove the Camshaft Gear

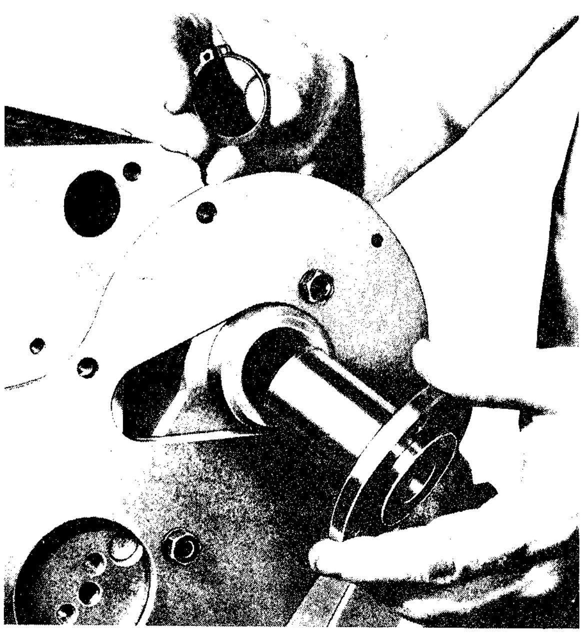
1. Remove timing case front cover.
2. Remove securing setscrews and ease gear away from its location.
3. Examine gear for signs of excessive wear, cracks, pitting, etc.



J5 Refitting Camshaft Gear.



J6 Refitting Fuel Pump Gear.



J7 Removing Fuel Pump Gear Drive Hub.

To Refit the Camshaft Gear

1. Remove idler gear and hub, cylinder head cover and rocker shaft (if not previously removed).
2. Refit gear to camshaft ensuring that 'D' marks on gear and camshaft hub align as shown in Fig. J.5. Refit the three securing setscrews and tighten to a torque of 21 lbf ft (2,9 kgf m) —28 Nm.
3. Refit idler hub and gear, timing case front cover etc.

To Remove the Fuel Pump Gear

1. Remove timing case front cover and remove idler gear hub.
2. Remove setscrews and withdraw gear from its location.
3. Clean and thoroughly examine the gear for signs of excessive wear, cracks, pitting, etc.

To Refit the Fuel Pump Gear

1. Refit fuel pump gear so that timing marks on gear and hub respectively are in alignment as shown in Fig. J.6.
2. Refit setscrews and tighten to a torque of 21 lbf ft (2,9 kgf m) —28 Nm.
3. Refit the idler gear and hub, timing case front cover, etc.

To Remove the Fuel Pump Drive Hub

1. Remove timing case front cover and fuel pump gear.
2. Remove low and high pressure fuel pipes from fuel injection pump.
3. Remove fuel pump securing setscrews and with draw pump.
4. Remove drive hub locating circlip and withdraw drive hub from its bearing (Refer Fig. J.7).
5. Examine drive hub and bearing for signs of excessive wear, surface cracks, pitting, etc.

   NOTE: The bearing is an interference fit in the cylinder block and replacement is carried out by means of a suitable dolly and puller or press if the block is completely stripped, the new one being fitted in the reverse manner.

   The earlier bronze service bearing had a 0.010 in (0,25 mm) allowance for machining in situ. The current steel bearing is fitted with 2 pre-finished wrapped bushes.

To Refit the Fuel Pump Drive Hub

1. Replace drive hub in bearing and locate with circlip as shown in Fig. J.8.
2. Check drive hub end float by means of feeler gauges placed between front face of the bearing and rear face of the drive hub. Limits are given on Page B.10.
3. Refit fuel pump, low and high pressure fuel pipes.
4. Refit fuel pump drive gear, idler gear and hub, timing case front cover etc.

To Remove the Timing Case Back Plate

1. Remove timing case front cover, timing gears, fuel pump and drive hub.
2. Remove securing setscrews and studs (where fitted).
3. Lift timing case back plate clear from the camshaft hub and crankshaft gear.

   NOTE: The crankshaft gear is an interference fit on the crankshaft and can be removed using a suitable puller.

To Refit the Timing Case Back Plate

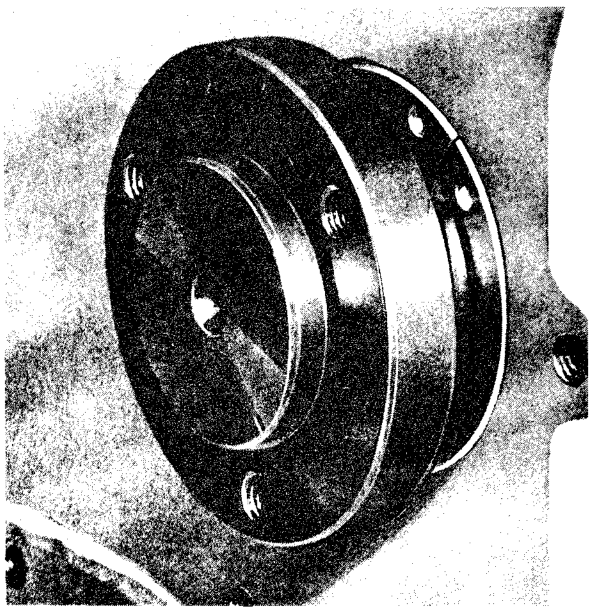
1. Fit timing case back plate to cylinder block using a new joint and suitable jointing compound.
2. Refit any studs removed and secure backplate with setscrews.
3. Refit fuel pump drive hub and fuel pump.
4. Refit timing gears, timing case front cover etc.

To Remove the Camshaft and Tappets

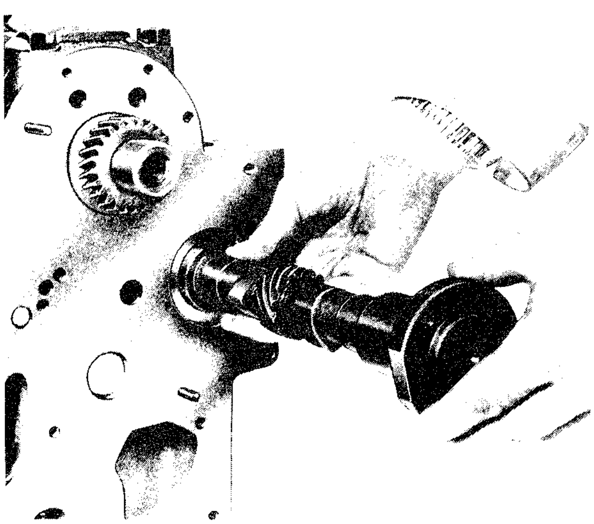
To remove camshaft it may be necessary to remove the engine from the vessel and place in a dismantling stand where it can be inverted. This is to prevent the tappets from falling out of their locations when the camshaft is removed. If, however, it is not possible to turn the engine over in this manner, then this problem may be overcome by attaching suitable clips (when the tappet inspection cover has been removed) to each tappet to hold them in their locations when the camshaft is withdrawn from the block.

1. Remove cylinder head cover, rocker shaft, push rods, timing case front cover and timing gears.
2. Remove fuel lift pump, tappet inspection cover and fuel lift pump operating push rod.
3. Turn engine over so that sump is now uppermost.

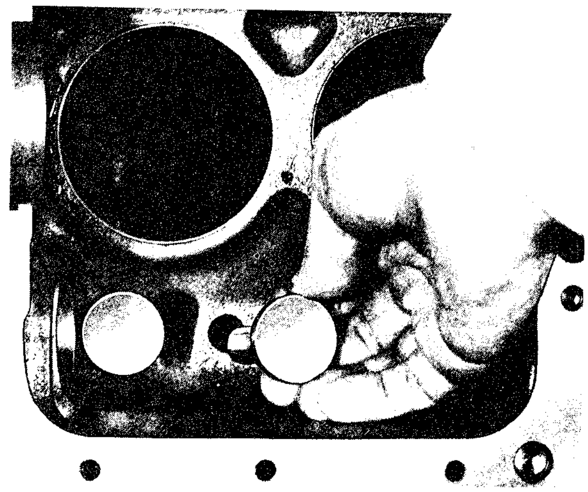
Circlip securing Fuel Pump Driving Hub. J8



Showing location of Camshaft Thrust Plates. J9



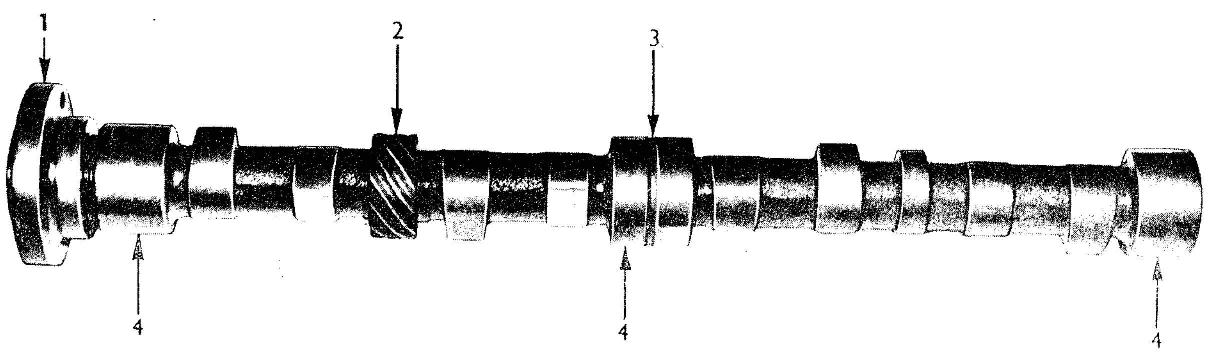
Removing the Camshaft from the Cylinder Block. J10



J11 Removing a Tappet from its location.

NOTE: At this stage if it is not possible to turn the engine over then the tappets should be lifted to the top of their locations and secured with suitable clips.

4. Remove sump and lubricating oil pump assembly.
5. Remove timing cover back plate, this will show the camshaft and thrust plates as illustrated in Fig. J.9. Withdraw camshaft from block as shown in Fig. J.10 ensuring that cams and journals are not damaged, during this operation.
6. The tappets may now be removed by lifting them out of their locations (Refer to Fig. J.11) or by removal of retaining clips if the engine is still the normal way up.
7. Examine camshaft and tappets for signs of excessive wear, surface cracks, pitting, etc.

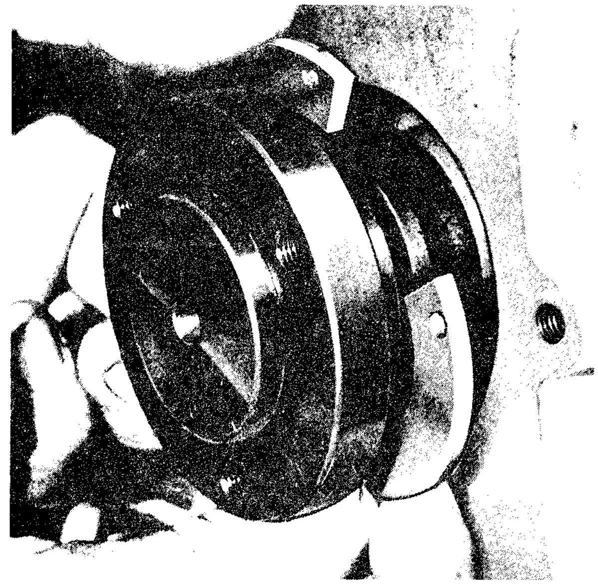


J12 Camshaft.

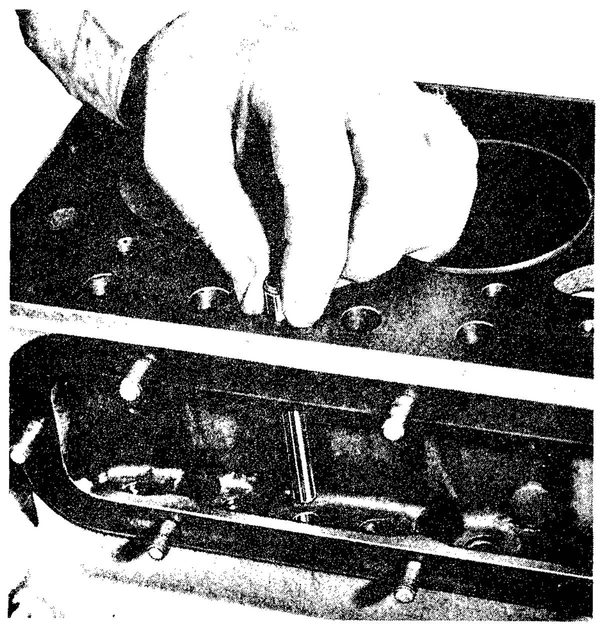
1. Drive Hub.
2. Lubricating Oil Pump Drive Gear.
3. Groove for reduced oil pressure feed to Rocker Shaft.
4. Bearing Journals.

To Refit the Tappets and Camshaft

1. If tappets have been removed, oil and return to their respective locations. Secure with clips (if applicable).
2. Refit camshaft into cylinder block exercising the same care as used during its removal.
3. Before camshaft is pushed fully home locate the two thrust plates (Refer to Fig. J.13) (one of which locates on the dowel in the recess) in position, either side of the camshaft hub, when correctly located the camshaft can be pushed fully home and will appear as in Fig. J.9.
4. Refit timing case back plate, lubricating oil pump assembly and sump.
5. Turn engine over so that cylinder head is uppermost.
6. Refit timing gears, timing case front cover, etc.
7. Refit fuel lift pump operating push rod (See Fig. J.14), tappet inspection cover, (after removing any retaining clips) and fuel lift pump. Refer to Fig. N.6.
8. Re-assemble remainder of engine components.

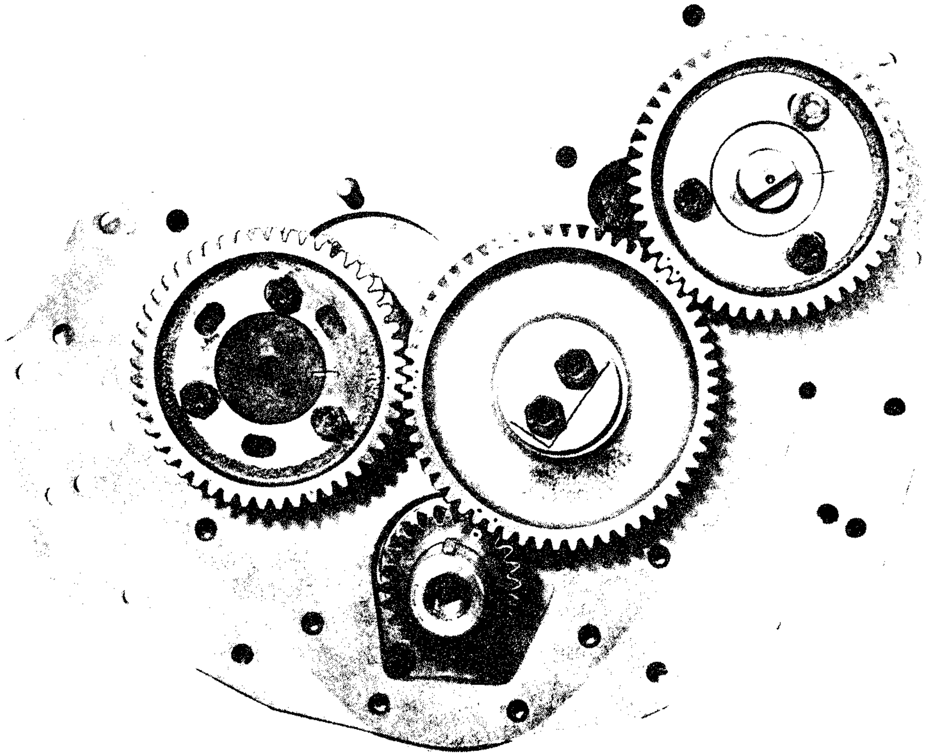


Refitting Camshaft Thrust Plates. J13

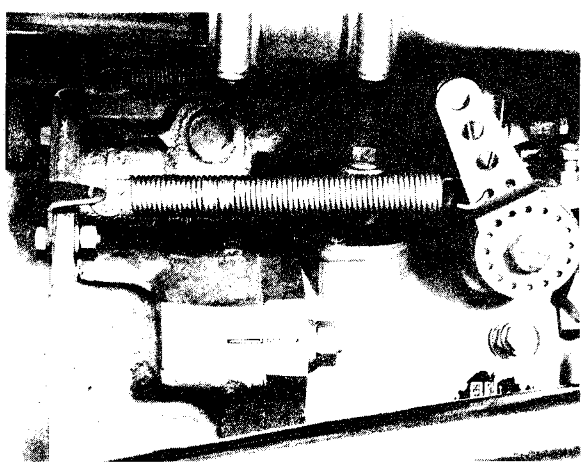


Refitting the Fuel Pump Operating Push Rod J14

SECTION K
Timing



K1 Timing Marks on Drive Gears.



K2 Timing Marks on Fuel Pump Mounting Flange.

General

As timing gears are employed on 4.99, 4.107 and 4.108 marine engines, the factory setting remains constant.

Removal of the cylinder head does not affect timing of engine.

Timing Marks

When the engine is timed at the factory, certain marks are stamped on the gears.

The method of marking is as follows:—
With the engine timing correctly set, the engine is turned until No. 1 piston is at Top Dead Centre on compression stroke. In this position markings are made on the idler gear which align with corresponding marks on the camshaft, fuel pump and crankshaft gears respectively. (See Fig. K.1).

Fuel Pump Timing Marks

There is a scribed line on the fuel pump mounting flange which should align with a scribed line on the mounting flange of the cylinder block (see Fig. K.2). Providing these two scribed lines are in line and the fuel pump gear fixing has not been altered, then the fuel pump timing should be correct. For the fitting of the fuel pump only, see page N.4.

On the fuel pump rotor inside the pump body are a number of scribed lines, each one bearing an individual letter.

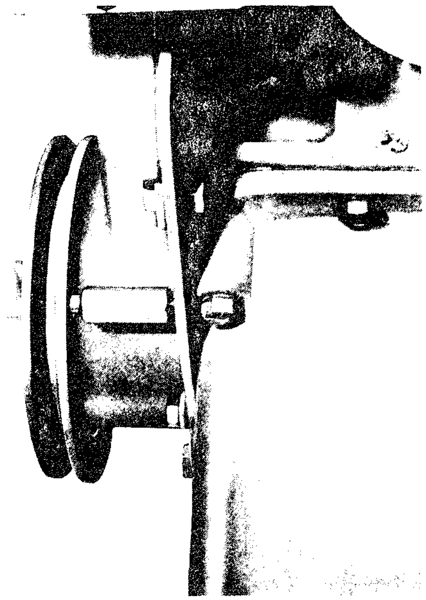
When the squared end of the timing circlip which has to be set coincides with the appropriate scribed line on the fuel pump rotor (see Fig. K.8), it denotes commencement of injection B.T.D.C.

With fuel pumps fitted to earlier 4.107 and 4.99 engines, the timing circlip bears a scribed line and when this scribed line coincides with the appropriate line on the fuel pump rotor (see Fig. K.7), it denotes commencement of injection B.T.D.C.

In the case of hydraulically governed Marine engines the letter "A" is utilised on the rotor.

To obtain access to the fuel pump rotor markings, remove the inspection plate on the top of the hydraulically governed pump which also embodies the fuel pump return connection to fuel filter.

With the timing case removed a further scribed line will be seen on the fuel pump driving gear; this line should coincide with the scribed line on the fuel pump driving hub.



Location of Timing Pin. K3

To Reset Engine to its Original Timing

Remove atomisers.

Bring No. 1 piston to top centre, on its compression stroke. That T.D.C. has been obtained can be checked by examining the flywheel or the front of the crankshaft where the key for the crankshaft pulley should be at the top of its periphery.

With camshaft and fuel pump gear fitted, replace idler gear, ensuring timing marks align (See Fig. K.1).

Replace idler gear setscrews and retaining plate, tighten setscrews to torque given on page B.3. and lock with tab-washer.

It will be noted that due to the clearance in the idler gear hub setscrew holes, the hub can be moved, varying the amount of backlash in the timing gears.

When tightening the hub securing setscrews it should be ascertained that the backlash (see page B.11) between crankshaft and idler gear and between idler and camshaft gear be maintained. This can be checked by feeler gauges or a clock gauge with gears held together to take up effect of bearing clearance.

Having reset the timing, it should then be checked as follows:—

Check Valve Timing

Turn engine until valves of No. 4 cylinder are "on the rock".

In this position set valve clearance of No. 1 inlet valve to 0.039 in (0,99 mm).

NOTE: Prior to approximate engine numbers 7061328 and 7106799 for 4.99 and 4.107 engines respectively, the valve clearance should be set to 0.035 in (0,89 mm).

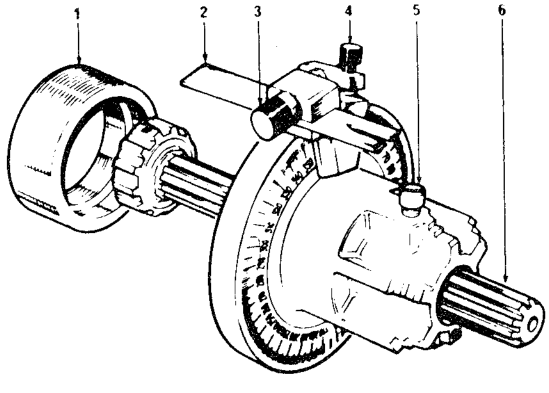
Turn engine in the normal direction of rotation until the valve clearance of No. 1 inlet valve is just taken up.

At this point the pistons of Nos. 1 and 4 cylinders should be at T.D.C. $+/-$ 2½°.

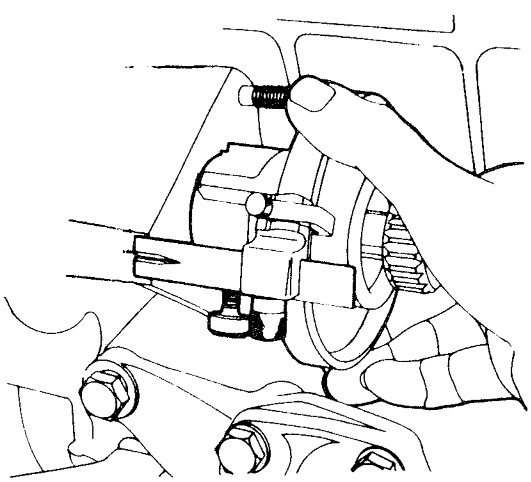
A timing peg is provided to determine T.D.C. and is located in the timing case back plate. It should be unscrewed until it locates in the hole in the rear of the crankshaft pulley (See Fig. K.3).

No adjustment is possible to valve timing. If the valve timing is found to be incorrect and the gear is correctly fitted to the camshaft with the two "D's" in line then the timing can only be one or more teeth out.

When the valve timing is found to be correct, set the valve clearance on No. 1 inlet valve to 0.012 in (0,30 mm) cold.



K4 Timing Tool MS67B



K5
Checking Timing Mark on Fuel Pump Mounting Flange.

Checking Fuel Pump Timing using Tool MS67B (see Fig. K.4).

To check timing marks on fuel pump mounting flange:

Turn engine in normal direction of rotation and position No. 1 piston at T.D.C. on compression stroke as previously detailed.

Remove fuel injection pump.

Release screw (5), Fig. K.4 and position splined shaft (6) in tool so that relevant spline is to the front of tool.

Ensure that slotted pointer (2) is positioned with slot to front of tool and chamfered sides of slot outwards. At this stage, slotted end of pointer should be kept well back from front of body. Ensure that flat in washer fitted behind pointer securing screw (3) is located over pointer.

Release bracket screw (4) and set bracket so that the chamfered edge is in line with relevant engine checking angle, see Page B.13.

Fit timing tool to engine in fuel pump position ensuring firstly that splined shaft with master spline is fully located in pump drive shaft and then that the register of tool is seated in fuel pump locating aperture. Lock splined shaft in tool. If pointer is 180° from timing mark, engine is probably on wrong stroke, in which case, remove tool and set engine on correct stroke.

Slide slotted pointer forward so that slot is half way over fuel pump mounting flange.

Turn timing tool by hand in opposite direction to pump rotation (as shown on pump nameplate) to take up backlash and check that the timing mark on flange is central in slot of pointer, see Fig. K.5.

If timing mark is not central, position of fuel pump drive shaft relative to its drive gear should be altered as detailed in Section J so that mark is central in slot with backlash taken up.

When engine timing mark is correct, remove tool and refit fuel injection pump.

To check fuel injection pump timing mark:—

Release screw (5), Fig. K.4 and remove splined shaft (6).

Ensure that slotted pointer (2) is positioned with slot to rear of tool and chamfered sides of slot outwards. At this stage, the slotted end of pointer should be kept well back towards body of tool. Ensure that flat in washer fitted behind pointer securing screw (3) is located over side of pointer.

With fuel pump removed, connect No. 1 outlet of pump body (marked "W") to an atomiser test rig and pump up to a maximum pressure of 30 atm (31 kgf/cm^2) or 440 lbf/in^2. If pressurising valve is fitted, this must be removed.

Release bracket screw (4) and set bracket so that the chamfered edge is in line with the relevant marking angle, see Page B.13.

Position timing tool on pump drive shaft with master splines engaged and tool locating on spigot.

Turn pump in normal direction of rotation as shown on nameplate until pump locks.

In this position, slide pointer forward until it is halfway over pump flange and check that timing mark is central to slot in pointer, see Fig. K.6.

Remove tool and replace fuel injection pump ensuring that both timing marks align as shown in Fig. K.2.

Where the timing tool MS67B is not available, fuel pump timing can be checked as follows:—

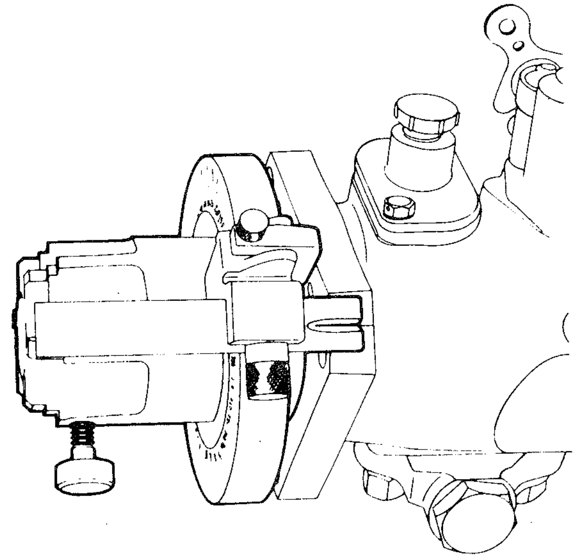
Remove fuel injection pump from engine.

Remove fuel pump inspection plate enabling scribed lines on fuel pump rotor to be seen.

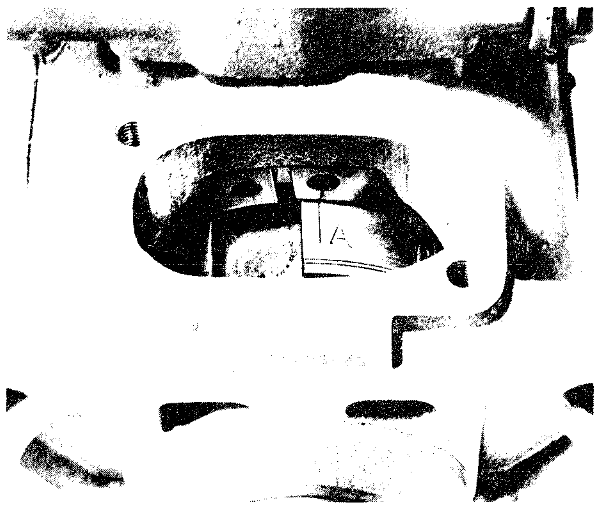
Check the position of the circlip by connecting No. 1 cylinder outlet (marked "W") to an atomiser tester and pump up to 30 atm (31 kgf/cm²) or 440 lbf/in². Turn pump by hand in its normal direction of rotation until it locks up. The squared end of the circlip can now be adjusted until it lines up with the letter "A" on the pump rotor. Refit fuel pump to engine.

Turn engine in normal direction of rotation until the scribed line marked "A" coincides with the squared end (or in cases of earlier engines, the scribed line see Fig. K.7) of the timing circlip (see Fig. K.8).

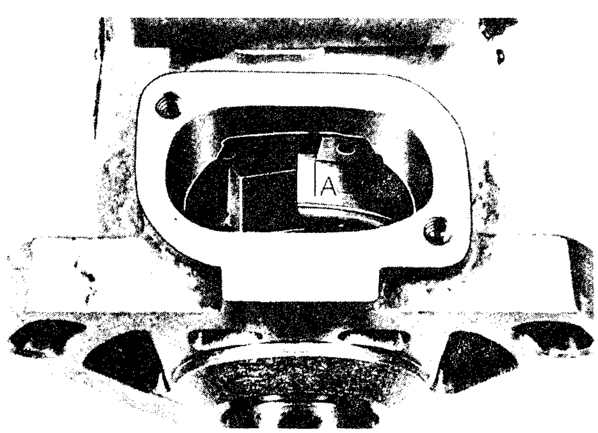
This is the point of static timing for No. 1 cylinder which should be 18° B.T.D.C. for 4.108M engines, 19° B.T.D.C. for 4.107M engines or 26° B.T.D.C. for 4.99 engines.



Checking Marking Angle on Fuel Pump Flange. K6

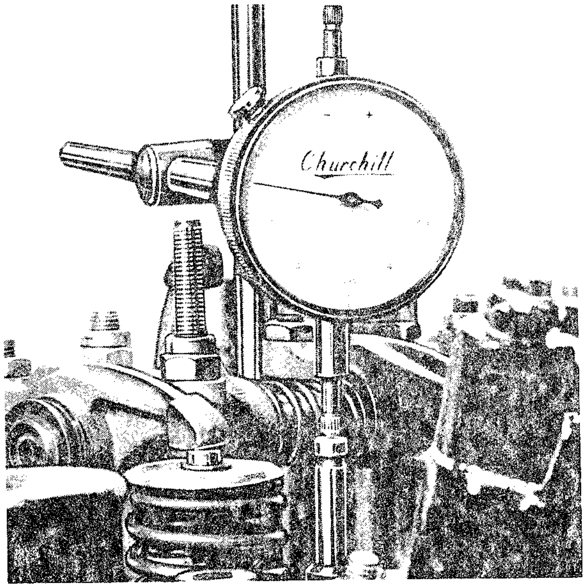


Showing marking on Fuel Pump Rotor and Timing Circlip (Earlier Type). K7



K8

Showing Scribed Line on Rotor Aligned with end of Circlip.



K9 Clock gauge mounted on Valve Stem for checking Pump Timing.

The point of injection can be checked by dropping a valve onto the top of No. 1 piston and by means of a clock gauge, (see Fig. K.9) checking the piston movement B.T.D.C. which should be 0.108 in (2,74 mm) for 4.108M engines, 0.120 in (3,05 mm) for 4.107M engines or 0.226 in (5,74 mm) for 4.99M engines.

Take care not to drop the valve into the cylinder

Timing gear backlash can be eliminated by turning engine backwards and then forwards in normal direction of rotation until the timing point is reached.

Make any necessary adjustments to fuel pump timing. The holes in the fuel pump gear are slotted to allow adjustment.

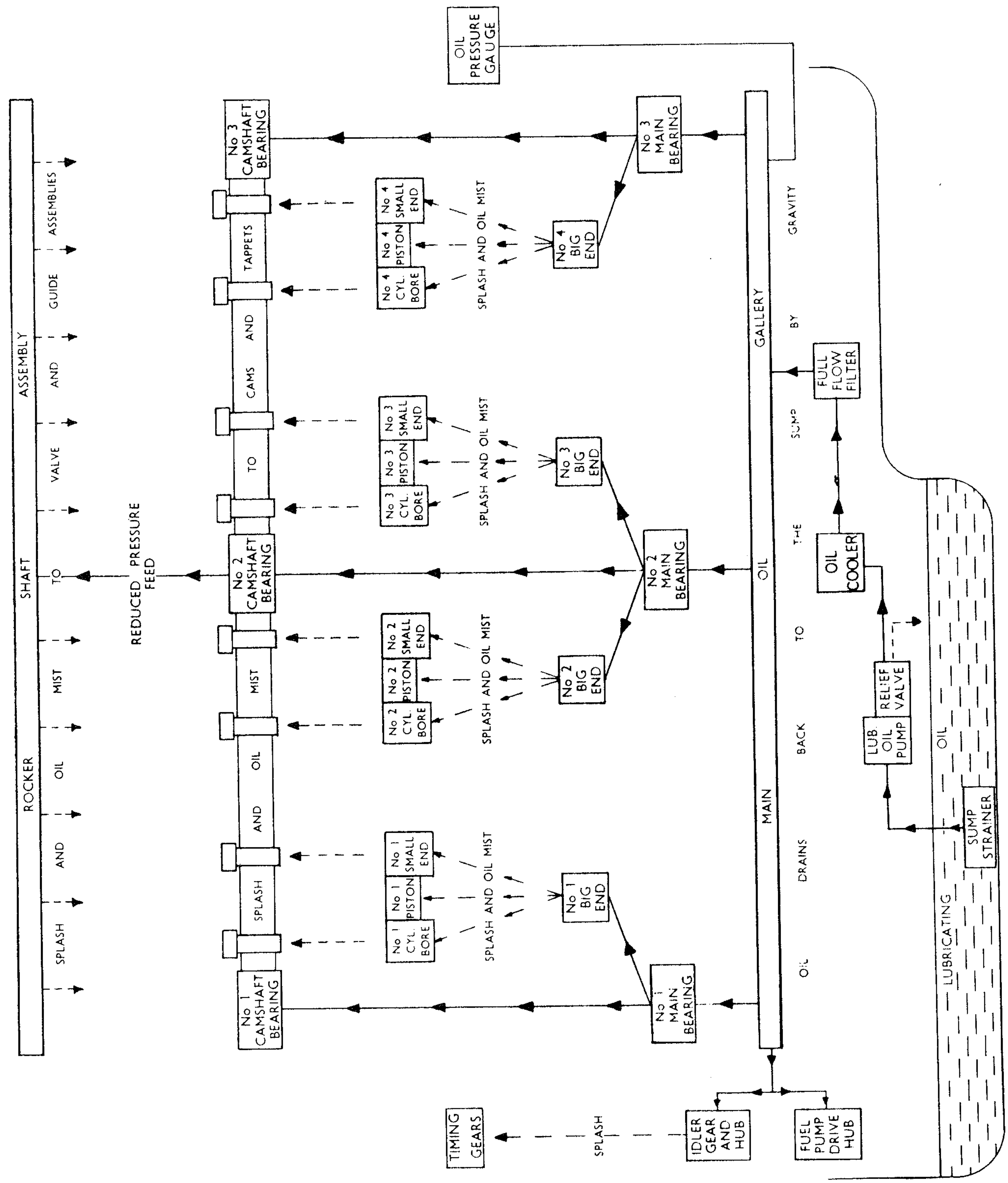
Re-mark fuel pump drive gear and fuel pump driving hub.

The holes in the fuel pump mounting flange are also slotted and fuel pump timing adjustment may be effected by releasing the securing nuts and turning fuel pump in the direction required.

After testing the engine, final adjustments may be necessary to find the perfect injection point.

NOTE: It is important to note that the breaking of the seals of the fuel injection pump should only be carried out by authorised personnel who must reseal with suitable identifiable seals.

SECTION L
Lubricating System

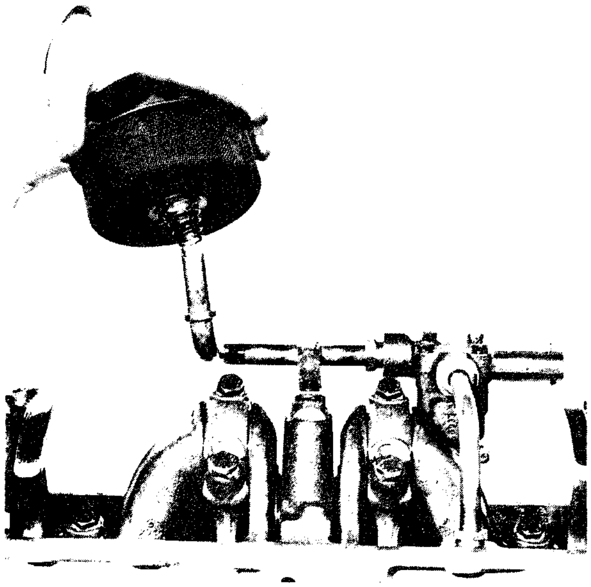


L1 Lubrication Diagram.

Draining the Sump

A drain plug is provided at the rear of the sump, although in most installations, this is not accessible.

A hand operated drain pump is therefore available and fits to the connection on the sump on the opposite side to the dipstick. The exception is 4.107/4.108 engines fitted with a "Z" drive transom unit where the pump connects to the dipstick tube.



Removing Sump Strainer. L2

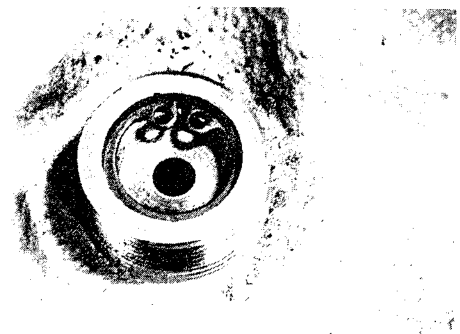
THE LUBRICATING OIL PUMP

The oil pump fits into a machined bore in the cylinder block and is located by means of a screw locked by a tab washer on the right hand side of the cylinder block below the tachometer drive.

The oil pump is driven through spiral gears from the camshaft, on the other end of the drive shaft is pressed and pinned a three or four lobed rotor. This rotor meshes with and drives a four or five lobed rotor which is free to rotate within the cast iron pump body.

To Remove the Sump

1. Drain Oil.
2. Remove dipstick, sump securing setscrews and remove sump.



Tachometer Drive Shaft Retaining Circlip. L3

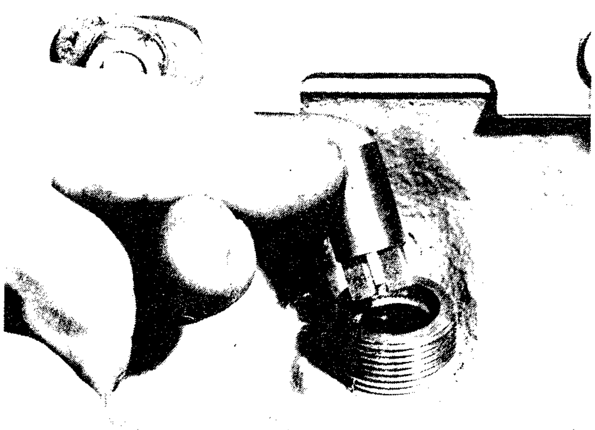
To Refit the Sump

1. Apply a coating of suitable jointing compound to crankcase and sump faces.

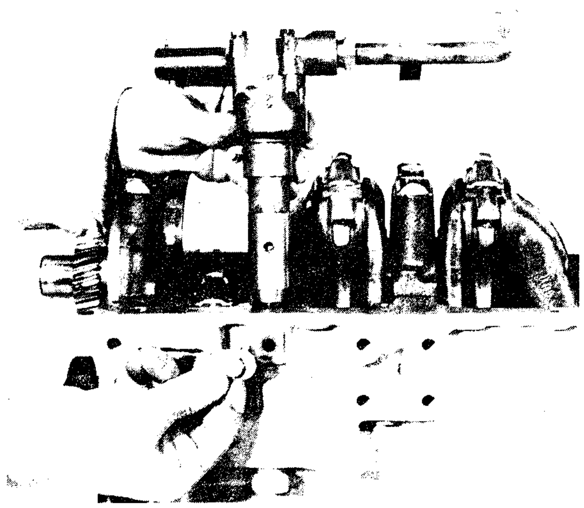
   When the joints are being placed in position it is important that the mitred ends go right up into the recesses in the front and rear main bearing caps.
2. Apply a coating of jointing compound to the cork strips, then press these strips into the grooves provided in the main bearing caps.
3. Place sump in position and fit retaining setscrews, tightening evenly.
4. Replace dipstick and sump drain plug, then refill with new oil of an approved grade to the correct level. Do not overfill.

To Remove the Oil Pump

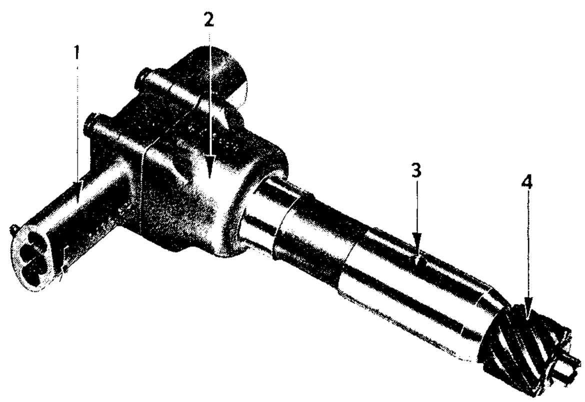
1. Drain engine oil and remove sump.
2. Remove strainer from end of lubricating oil suction pipe. (Refer to Fig. L.2). Remove tachometer drive shaft retaining circlip. See Fig. L.3. Withdraw tachometer drive shaft, See Fig. L.4.



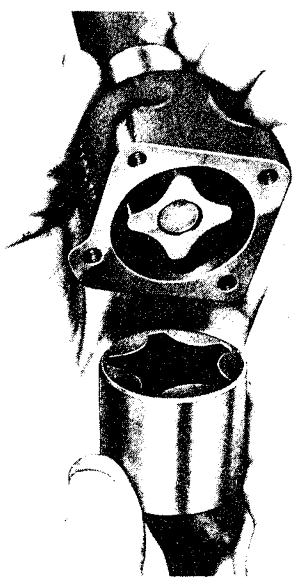
Removing Tachometer Drive Shaft. L4



L5 Removing Lubricating Oil Pump.



L6 Lubricating Oil Pump Assembly.
1. Relief Valve Housing.
2. Rotor Housing.
3. Hole for Locating Screw.
4. Pump Drive Gear.



L7 Assembling Outer Rotor to Pump Body.

3. Unscrew delivery pipe securing nut to cylinder block, and setscrew securing suction pipe assembly to main bearing cap.
4. Tap back tab washer locking locating screw and after removing locating screw remove the lubricating oil pump assembly.

To Dismantle the Oil Pump

1. Remove delivery and suction pipes. Pump will now be as shown in Fig. L.6.
2. Withdraw drive gear by means of a suitable puller.
3. With pump suitably held in a vice, remove end cover assembly, which also incorporates the relief valve housing.
4. Withdraw drive shaft complete with inner rotor.
5. Withdraw outer rotor.

Inspection

1. Inspect for signs of wear, cracks, pitting, etc.
2. Install drive shaft complete with inner rotor, then outer (driven) rotor, ensuring that the face which carries the chamfered edge enters the pump body first (Fig. L.7), now carry out the following dimensional checks.
   (a) Check clearance between inner and outer rotors (Fig. L.8).
   (b) Check clearance between outer rotor and pump body (Fig. L.9).
   (c) Check clearance between rotors and end cover assembly using a straight edge and feeler gauges (Fig. L.10).

   NOTE: The relevant clearances for these dimensional checks are given on Page B.11, they are 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 it adversely affects the working oil pressure, then a replacement pump should be obtained.

To Re-Assemble the Oil Pump

1. Insert outer rotor ensuring that face which carries chamfered edge enters pump body first. (Fig. L.7).
2. Insert drive shaft complete with inner rotor into pump body.
3. Replace end cover assembly and fit securing setscrews. Ensure correct positioning so that suction and delivery pipes will locate correctly.
4. Press oil pump drive gear onto shaft and rotate pump by hand to ensure that it turns quite freely.

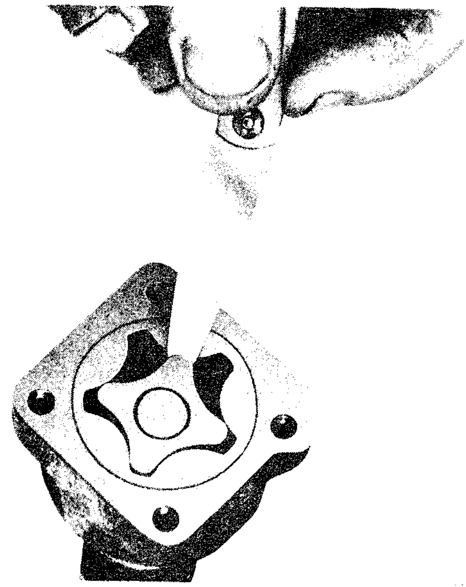
To Refit the Oil Pump

1. Refit suction and delivery pipes, do not tighten the pipes at this stage.
2. Prime pump with clean lubricating oil.
3. Place lubricating oil pump assembly in position, locate with the securing screw and lock it with tab washer.
4. Tighten delivery pipe at both ends, refit setscrew securing suction pipe assembly.
5. Tighten suction pipe at pump end then refit strainer on end of suction pipe.

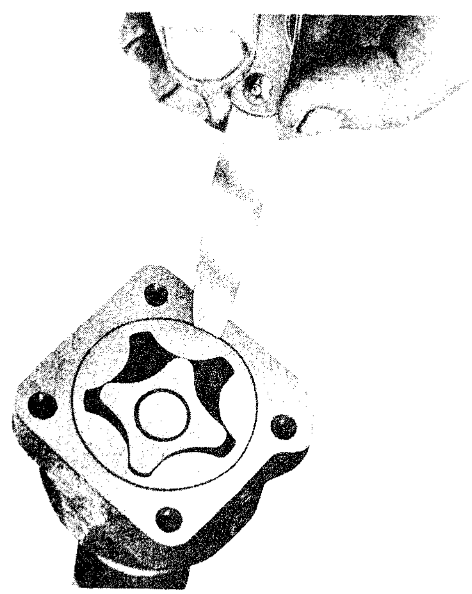
   NOTE: The strainer which fits on the end of the suction pipe should be thoroughly cleaned before being refitted. It is good practice to remove this strainer and clean it every time the sump is removed.
6. Replace sump as previously detailed and secure with setscrews.
7. Fill sump to correct level with clean oil of an approved grade.

To prime the lubricating system, motor the engine on its starter motor for 10-20 seconds before allowing the engine to fire.

On starting the engine, keep its speed to a minimum until oil pressure is registered.



Checking the Clearance between Inner and Outer rotors. L8



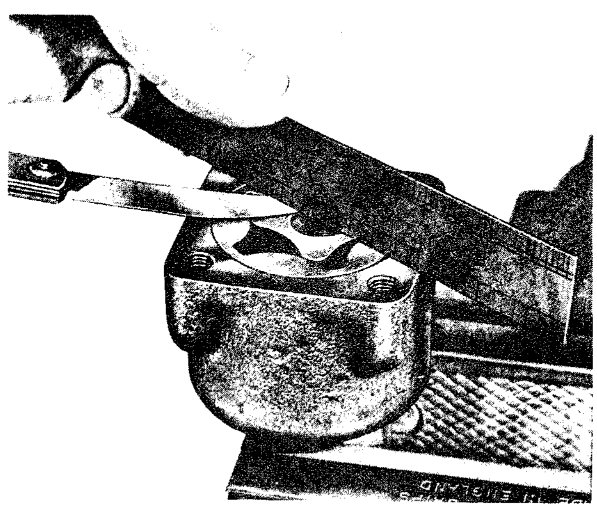
Checking Outer Rotor to Pump Body Clearance. L9

OIL PRESSURE RELIEF VALVE

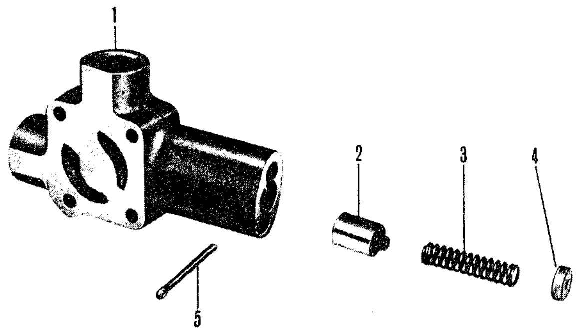
The oil pressure relief valve is contained in a housing integral with the oil pump end cover. This relief valve controls the maximum oil pressure by allowing a spring loaded plunger to move and by-pass excess oil back to the sump when the pre-determined spring pressure given on page B.12 is exceeded.

To Dismantle the Oil Pressure Relief Valve

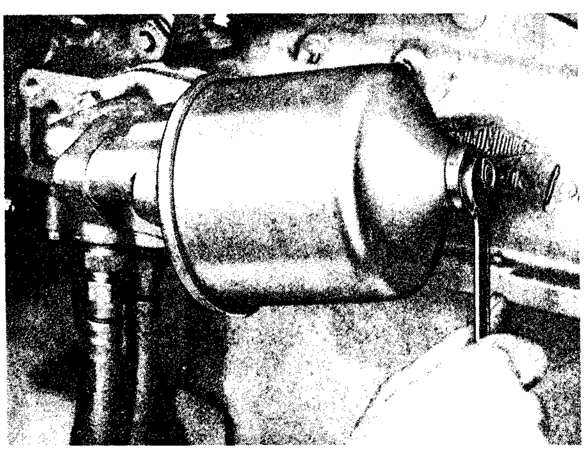
1. Drain engine oil and remove sump.
2. Remove suction and delivery pipes and remove oil pump assembly end cover setscrews releasing relief valve housing.



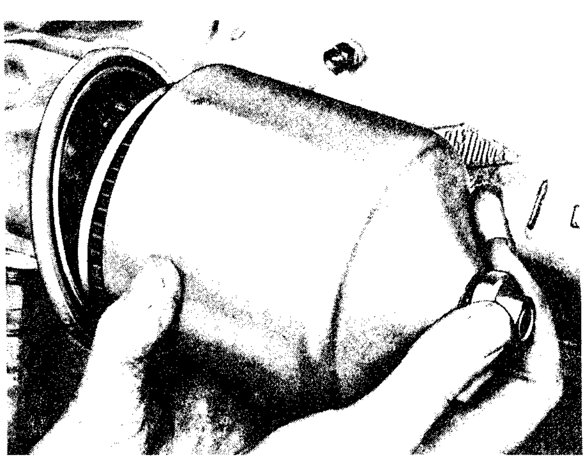
Checking Rotor End Clearance. L10



L11 Exploded view of Pressure Relief Valve Assembly.
1. Outlet to Main Oil Filter.
2. Relief Valve Plunger.
3. Plunger Spring.
4. Spring Cap.
5. Retaining Splitpin.



L12 Unscrewing Lubricating Oil Filter Bowl Securing Screw.



L13 Removing the Lubricating Oil Filter Bowl.

3. Remove split pin from end of housing and withdraw spring cap, spring and plunger. Exploded view of assembly shown in Fig. L.11.
4. Inspect for wear or damage and renew if necessary.

To Re-Assemble the Oil Pressure Relief Valve

1. Replace plunger, spring and spring cap then secure with split pin.
2. Secure to lubricating oil pump body.
3. Continue as detailed for refitting lubricating oil pump.

OIL PRESSURE

Always ensure that with the engine running, oil pressure is registering on the gauge or the oil pressure warning light is extinguished.

Pressures do vary according to climatic conditions and even between individual engines, but the oil pressure range at normal working speed and temperature is given on Page B.11. The pressure will drop whilst the engine is idling, also a slight drop will be experienced when the oil is hot. If the oil pressure is suspected of being too high or too low then refer to the possible faults listed on Page D.2.

LUBRICATING OIL FILTERS

To ensure cleanliness of the lubricating oil a sump strainer and a full flow type oil filter are fitted.

The sump strainer consists of a gauze wire container which is fitted over the end of the lubricating oil pump suction pipe.

The full flow type oil filter is mounted externally on the side of the cylinder block. All the oil passes through this filter after it leaves the pump, but before it reaches the bearings. The filter can be either the renewable element type in which the filtering element is housed in a separate bowl or the screw type in which the element is an integral part of the bowl or canister.

To Remove the Filter Element

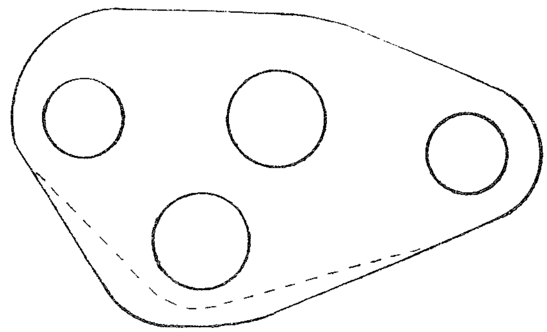
1. Unscrew filter bowl securing setscrew as shown in Fig. L.12.
2. Ease filter bowl clear, Fig. L.13, lift out old element and discard.

To Remove the Oil Filter Head Casting

If any oil leakage is apparent between the head casting and the cylinder block then a new joint should be fitted.

In order to improve the sealing of the lubricating oil filter bracket to the cylinder block, the joint face on the filter bracket has been extended in the vicinity of the lower oil hole.

The joint has been extended similarly and is shown in Fig. L.14, the earlier joint being shown in dotted relief.



L14

Important

In the event of an oil leak on engines incorporating the earlier type filter bracket and joint, the later type should be fitted.

It is emphasised that the later filter bracket and later joint **must both** be fitted to take advantage of the improvement.

1. Remove oil cooler pipes and the two securing nuts and remove the head casting.
2. Refit head casting using a new joint (ensuring that joint is fitted correct way round).
3. Secure with two nuts and refit oil cooler pipes.

To Renew the Filter Element

1. Renew sealing ring which is located in the recess on outer edge of head casting.
2. Place correct replacement element in filter bowl.
3. Offer bowl to head casting squarely and firmly, locate securing setscrew and tighten. Ensure that top edge of filter bowl is central on seal within head casting recess. Do not overtighten.
4. After engine has been run and filter assembly checked for oil leaks, restore oil to correct level.

To Renew Screw Type Oil Filter Canister

1. Unscrew filter canister from filter head (see Fig. L.15).
2. Discard old canister.
3. Clean filter head.
4. Using clean engine oil, liberally oil top seal of replacement canister.
5. Prime the new canister with clean lubricating oil allowing time for the oil to fill the bowl through the filter element. 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 15 lbf ft (2,07 kgf m) — 20 Nm.
6. Run engine and check for leaks.

By-Pass Valve

Should the lubricating oil filter element be allowed to become contaminated to the extent where the lubricating oil has difficulty in passing through the element, then a pressure difference will build up between the inlet and outlet sides of the filter assembly. When this pressure reaches the figure given on Page B.12, a ball valve will open in the filter head-casting and allow unfiltered oil to by-pass the filter element to prevent the engine being starved of oil.

Removing Lubricating Oil Filter Canister (Low-line Engines). L15

SECTION M
Cooling System

Two methods of cooling are available for the 4.99, 4.107 and 4.108 Marine engine, these being open circuit and closed circuit cooling.

Open Circuit Cooling

With this system water from a source outside the boat is utilised, i.e. sea or river water. The coolant is fed by a rubber impeller type water pump into the exhaust manifold water jacket. The coolant then flows from the exhaust manifold into the front of the cylinder block where it circulates around the cylinder liners and the cylinder head water jacket by means of thermo syphon action. The coolant is finally discharged via a connection on the front of the cylinder head.

With earlier engines, the coolant was controlled by a hand operated valve on top of the water outlet connection, in order that the water temperature could be maintained at a maximum of 140°F (60°C). With sea water cooling, this temperature should not be exceeded otherwise salt deposits are liable to form in the water jackets of the cylinder block and head, thus causing a restriction.

With later engines, the coolant temperature is controlled by a thermostat and a pressure relief valve relieves the excess water pressure when the thermostat is closed.

Where conditions necessitate the use of an oil cooler, this is mounted on the front of the cylinder block and the coolant passes through the cooler before entering the block.

Closed Circuit Cooling

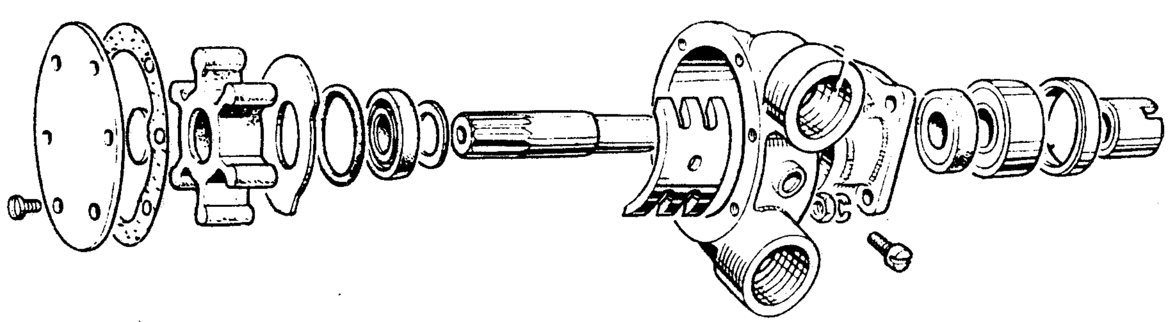
With this system a heat exchanger or keel pipes are utilised to cool the coolant after it has circulated round the water jackets.

When keel pipes are used the coolant is drawn from the pipes into the cylinder block on the right hand side, where it circulates round the cylinder liners and the cylinder head water jacket, movement being assisted by a centrifugal type water pump. The coolant is discharged from the front of the cylinder head into the header tank, which embodies a cooler for the lubricating oil. From the header tank the coolant flows to the exhaust manifold and finally returns to the keel pipes.

With standard engines employing a heat exchanger, a combined header tank and heat exchanger is mounted at the front of the cylinder head. Coolant is drawn from the heat exchanger into the exhaust manifold water jacket. The coolant then flows from the manifold to the right hand side of the cylinder block where it is circulated round the cylinder liners and cylinder head water jacket, being assisted by a centrifugal type water pump. The coolant is discharged from the front of the cylinder head into the heat exchanger, which in some cases also embodies an oil cooler. In the combined heat exchanger, the oil and water, in their respective compartments, are passed over a series of tubes running the length of the unit. Sea or river water is pumped, by a rubber impeller type pump, through these tubes and cools both the engine coolant and the lubricating oil.

With low-line engines incorporating heat exchanger cooling, the header tank is mounted at the front of the cylinder head and a separate heat exchanger at the rear of the cylinder head. On the open side of the system, water is delivered by the seawater pump through the engine oil cooler to the gearbox. From the gearbox, the water is delivered to the heat exchanger where it cools the fresh water coolant. The sea water then flows to the exhaust outlet and is discharged overboard. On the closed circuit side, fresh water flows from the heat exchanger to the header tank and then to the water cooled exhaust manifold and back to the heat exchanger. Coolant also flows from the header tank to the cylinder block. The block and cylinder head are cooled by thermosyphon action being assisted by the fresh water pump mounted on the front of the cylinder block. The coolant is then discharged from the front of the cylinder head back to the header tank.

With a closed circuit cooling system, a thermostat is provided at the cylinder head outlet connection to



M1 Exploded view of Sea Water Pump.

ensure that the correct operating temperature is maintained. The normal operating temperature measured at the cylinder head outlet connection is 150/200°F (65/93°C).

SEA WATER PUMP

The water pump, used for open circuit cooling, or in conjunction with a heat exchanger is mounted on the front of the timing gear cover and is driven at half engine speed from the fuel pump gear. The pump is self priming but it is advisable to prime it when first commencing service or after the engine has been laid up for any considerable period.

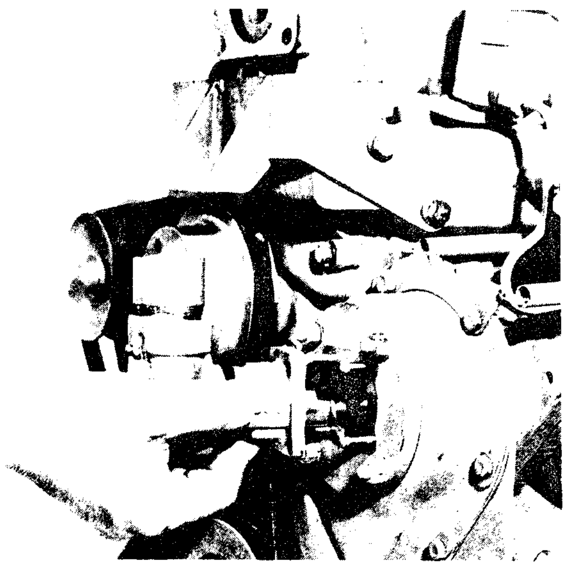
To Remove Pump

Uncouple inlet and outlet connections.

Unscrew the four nuts, thereby enabling the pump to be lifted away from the timing case (See Fig. M.2).

NOTE: Do not remove sea water pump adaptor plate from front of timing case as this will require special re-alignment upon refitting. See page M.4.

The pump may be replaced by reversing the above procedure.



Removing Sea Water Pump. M2

Dismantling

To dismantle the pump, proceed as follows: —

Remove front end cover, impeller and wear plate.

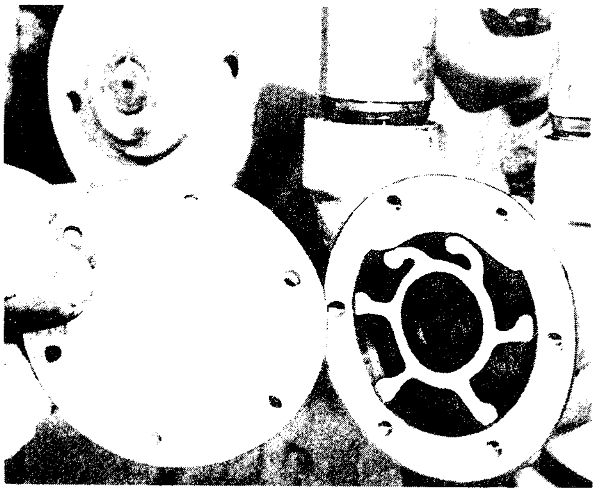
A suitable press may be used to press out impeller shaft together with water pump bearing.

The cam in the impeller housing may then be detached by removing the single securing setscrew.

Remove rubber seal in impeller housing, 'O' ring and seal in bearing housing.

In the event of wear being present on the impeller wear plate or water pump end plate, both these 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 reassemble the water pump, the reverse order of the above procedure should be adopted, care being taken when replacing the rubber impeller that the blades all lay in the same direction relative to the rotation of the pump i.e. blades trailing.



Removing Sea Water Pump End Plate. M3

When reassembling ensure that the rubber impeller is coated with MARFAK 2HD Grease or glycerine as an alternative.

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

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

IMPORTANT NOTE:

As the water pump contains a rubber impeller, on no account must it be run in a dry condition. If the engine is to be laid up for any period, the water pump should be packed with MARFAK 2HD grease or coated with glycerine.

Alignment of Sea Water Pump Adaptor Plate

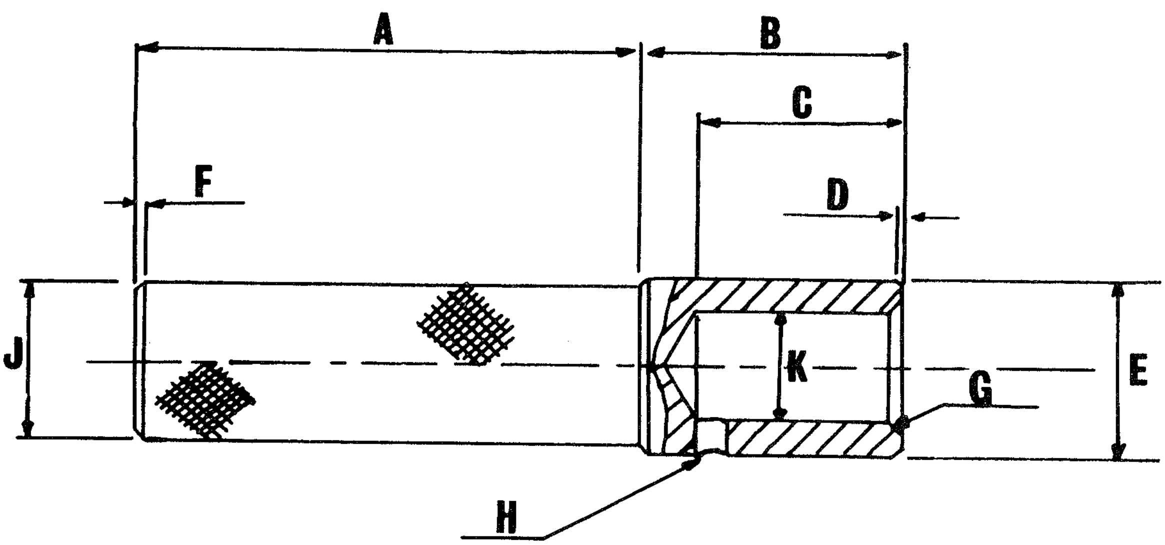
Should it be necessary to remove the sea water pump adaptor plate, it must be aligned on refitting by means of the tool shown in Fig. M.4.

To line up the adaptor plate, loosen the holding nuts and insert the tool in the water pump drive position to centralise the adaptor plate to the sea water pump driving shaft. Once the tool is located, the adaptor plate securing nuts should be tightened. The tool can then be removed and the sea water pump fitted.

To cover conditions where a centralising tool is not available, the following interim measure can be taken.

Loosen the adaptor plate securing nuts so that they just support the weight of the sea water pump.

Rotate the engine two or three turns by hand: this



M4 Tool for Alignment of Sea Water Pump Adaptor Plate.

A—4 in (101,60 mm)
B—2.215 in (54,00 mm)
C—1.625 in (41,30 mm)
D—0.0625 in (1,60 mm) at 45°
E—1.3725 in (34,90 mm)
F—0.0625 in (1,60 mm) at 45°
G—0.0937 in (2,38 mm) at 45°
H—Drill 0.25 in (6,35 mm) dia air hole
J—1.250 in (31,75 mm)
K—0.8768/0.8778 in (22,27/22,30 mm)

will ensure that the adaptor plate/sea water pump will centralise to the fuel pump gear shaft. Then retighten the adaptor plate securing nuts.

It should be remembered that the latter procedure should only be used as an interim measure as it is not as an accurate alignment when using the tool previously described.

FRESH WATER PUMP

The water pump for closed circuit cooling is mounted on the front of the cylinder block and is belt driven from the crankshaft.

Two different pumps have been used, the later type having two separate bearings and earlier pumps having integral bearings combined with the impeller shaft. Different water pump seals are also used. The latest arrangement incorporates a stationary seal that registers on a ceramic counterface revolving with the impeller. The earlier type has a revolving seal which registers on a stationary counterface in an insert fixed to the pump body (see Fig. M.7).

Fresh Water Pump Seals

Where ceramic counter face water pump seals are fitted, if the engine is run without coolant, even for a few seconds, the heat build-up between the carbon seal and ceramic counter face is very rapid, resulting in the cracking of the ceramic. This often creates the misunderstanding that the cause of leakage is due to the incorrect assembly of the sealing arrangement of the water pump.

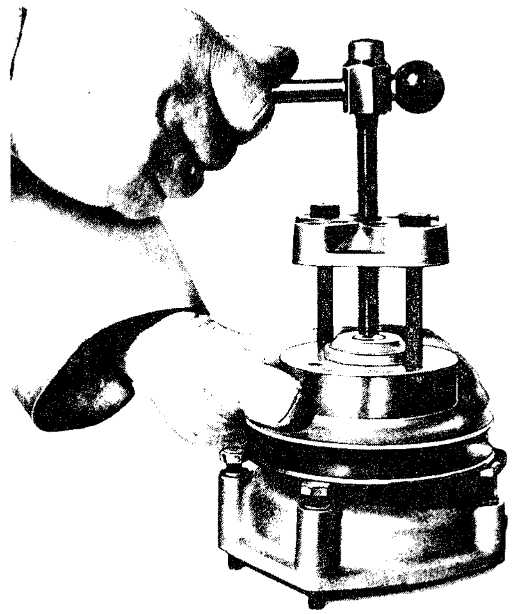
To Remove Water Pump

Slacken generator securing setscrews and remove driving belt.

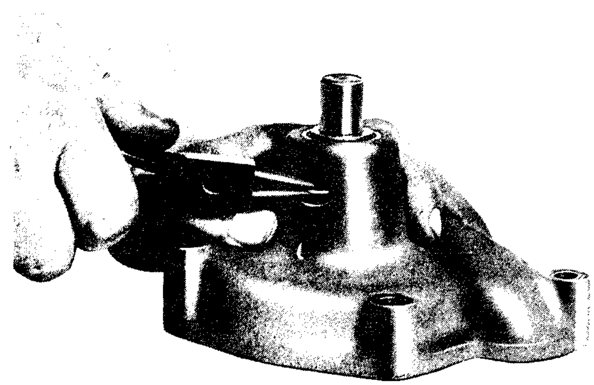
Unscrew the four setscrews securing the water pump and backplate to cylinder block and remove.

To Dismantle Water Pump

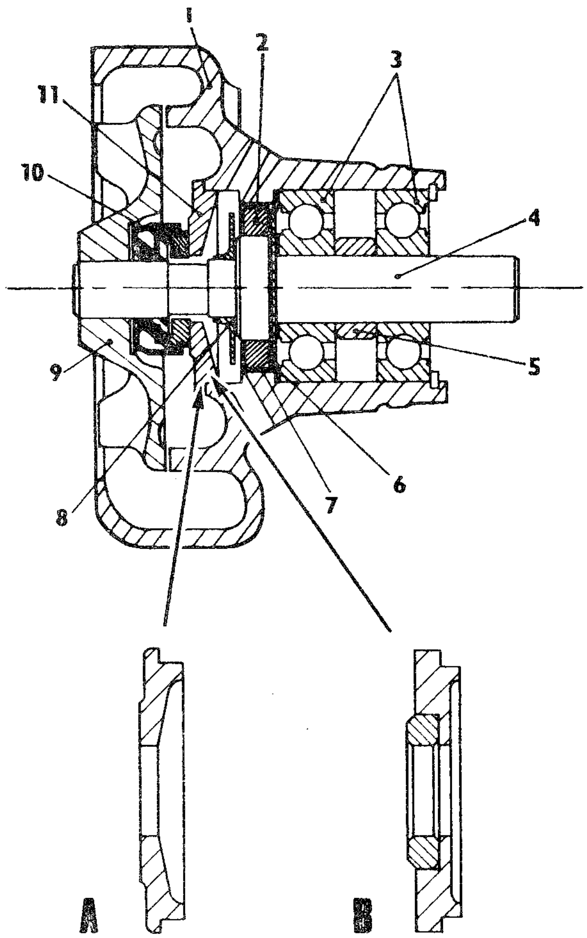
1. Remove pulley securing circlip (4.108 engines).
2. Remove water pump pulley by means of a suitable puller, the holes in the pulley face may be utilised for this purpose. (See Fig. M.5).
3. Remove drive shaft locating clip (early engines) see Fig. M.6, and press shaft out of pump body from pulley end complete with water pump thrower, insert, seal and impeller.
4. Remove impeller from pump drive shaft by means of a suitable puller or press.
5. Remove bearing retaining circlip (later engines) then using a suitable mandrel press the two shaft bearings complete with distance piece out through the front of the pump body.
6. Remove felt seal and retaining flanges.



Removing the Water Pump Pulley. M5



Removing Shaft Locating Clip. M6



M7 Sectional view of Water Pump. (Earlier Seal).

1. Pump Body.
2. Seal.
3. Shaft Bearings.
4. Pump Shaft.
5. Distance Piece.
6. Flange—Oil Seal Retaining.
7. Retainer—Oil Seal.
8. Flange—Water Pump Thrower.
9. Impeller.
10. Seal.
11. Insert (A) Plain. (B) Ceramic Faced.

Inspection

1. Examine pump body for cracks, corrosion or any other damage.
2. Examine shaft and bearing assembly for wear.
3. Examine the water thrower flange for damage.
4. Examine water pump seal counterface or insert for excessive wear, scoring or cracks on sealing faces.
5. Remove rust and scale from impeller and examine for excessive corrosion or other damage.
6. Examine pump pulley for damage.

To Re-Assemble the Water Pump

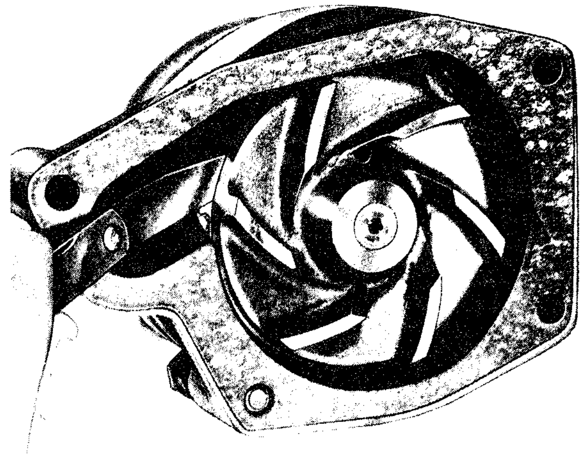
(Refer to Fig. M.7).

1. Insert oil seal retainer (7) and oil seal (2) followed by oil seal retaining flange (6).
2. Fit the two bearings (3) and distance piece (5) onto shaft (4) and pack space between the two bearings approximately ¾ full of high melting point grease (Later engines only).
3. Press bearings and shaft assembly into pump body, impeller end first and locate with circlip (Later engines). Fit locating clips (earlier engines).
4. Press water thrower flange (8) into position on drive shaft.
5. Where seal registers on insert clean insert recess and drain hole in pump body with cleaning spirit of Locquic "Q".
6. Lightly coat inner diameter of insert recess and outside diameter of insert (11) with Loctite Retaining Compound.
7. After removing any traces of oil or grease from insert, press if fully home. Remove all traces of surplus Loctite.
   NOTE:—Special care must be taken during this operation not to mark the face upon which the seal registers.
8. Place seal (10) on the drive shaft so that this face registers with insert face.
9. With the latest water pump seal, ensure the carbon sealing face of the seal is clean and fit the seal squarely in its housing. Check that the sealing face of the counterface is clean and position counterface by hand only with the sealing insert registering with the carbon face of the seal.
10. Press impeller onto shaft over seal or counterface until correct impeller clearance is obtained. With the latest water pump sealing arrangement, this is when the rear face of the impeller vanes is 0.000/0.006 in (0,00/0,15 mm) below the rear face of the body. With earlier sealing arrangements and the insert has a ceramic face, the rear face of the impeller vanes should be 0.029/0.033 in (0,74/0,84 mm) below the rear face of the pump. Where a plain insert is fitted, the clearance between the

front face of the impeller and the water pump body should be 0.005/0.010 in (0,12/0,25 mm). This can be checked by means of a feeler gauge through the outlet channel of the pump body (see Fig. M.8).

11. Before fitting pulley ensure that pump body to cylinder block securing setscrews are placed in respective holes. Press pulley fully onto shaft and fit the securing circlip (where fitted).

    NOTE:—When the pulley is originally pressed onto the shaft during production, a pressure of 2½—3 ton/in² (390-470 kgf/cm²) or 38,6-46,3 N/mm² is required. Therefore it is recommended that if pulley interference on shaft is such that a substantially reduced pressure will press the pulley back onto shaft, then a replacement pulley and/or shaft should be fitted.



Checking Impeller tp Pump Body Clearance. M8

To Refit the Water Pump

Fit new back plate joint to cylinder block, followed by water pump back plate and then water pump joint, using jointing compound.

Fit water pump to cylinder block and secure with four setscrews.

Replace driving belt and tension as described on page M10.

HEAT EXCHANGER AND OIL COOLER
General

The purpose of the Heat Exchanger is to provide:—

(a) A reservoir of fresh water in the header tank to allow for expansion and contraction, evaporation, and unavoidable loss.

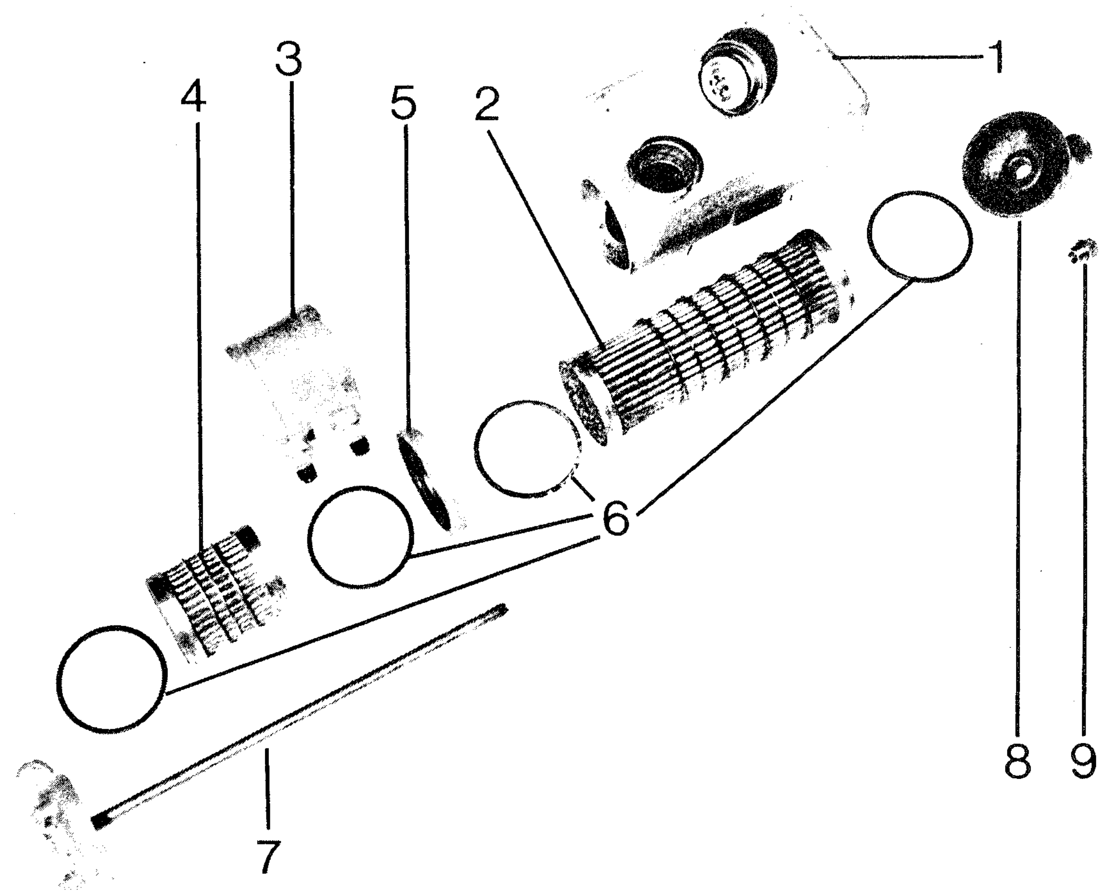
(b) A method of cooling the fresh water by means of sea water. This is accomplished by passing the sea water through a series of small bore tubes and flow the fresh water over the tubes with the aid of a number of circular shaped brass baffles.

(c) A method of cooling the engine lubricating oil by means of sea water. This is accomplished by passing the sea water through a series of small bore tubes and flowing the oil over the tubes with the aid of a number of circular brass baffles.

With standard engines, the unit therefore basically comprises:—

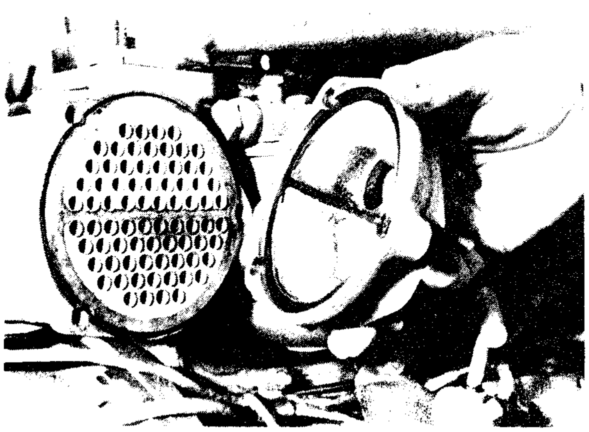
(a) An aluminium casing providing the header tank and a machined bore into which the heat exchanger tube stack is located.

(b) A smaller aluminium cylinder into which the oil cooler tube stack is located.



M9 Exploded view of Heat Exchanger. (Standard Engine).

1. Heat Exchanger Casing.
2. Tube Stack for Engine Coolant.
3. Oil Cooler Casing.
4. Tube Stack for Lubricating Oil.
5. Spacer.
6. "O" Rings.
7. Tie Rod.
8. End Cover.
9. Cap Nut.



M10 Removing Heat Exchanger End Cover (Low-line Engines).

(c) Two tube stacks each comprising a number of small bore tubes running between two tube plates.

(d) Two sea water end covers.

(e) A tie rod which passes between the end covers and secures the assembly together.

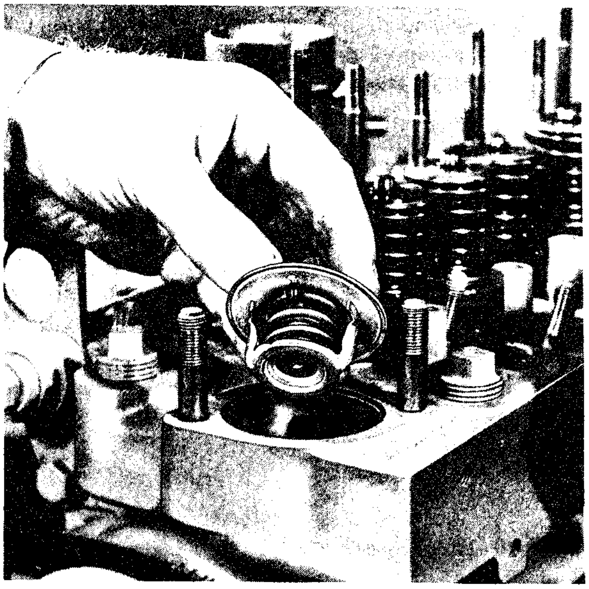
With low-line engines, both the engine oil cooler and heat exchanger are separate from the header tank, but the servicing of these items is similar to that described.

Fig. M.10 shows the removal of the end cover on heat exchangers fitted to low-line engines.

Where engines are operated under light load or at low speeds, which can result in sludging of the lubricating oil, the oil cooler can be removed or by-passed on 4.108 low line engines providing the raw water temperature does not exceed 100°F (38°C) and that the engine speed does not exceed 3,000 rev/min.

Dismantling

1. Remove the two sea water pipes from their respective end covers.
2. Disconnect the two oil pipes.
3. Remove brass cap nut.
4. This end cover can now be removed.
5. The other end cover complete with tie rod can now be withdrawn. Care should be taken to support oil cooler and spacing ring after tie rod has been removed, as this will not be attached to main casing.
6. The "O" ring seals can now be removed from the end of the tube stacks allowing the latter to be withdrawn.
7. The main aluminium casing can now be removed from the engine if necessary; this will entail disconnection of the fresh water flanges.



Removing the Thermostat. M11

Cleaning

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. The fresh water side and the oil side, i.e. the outside of the tubes, should be relatively clean as these are on the closed circuit. The inside of the tubes, which have salt water passing through them, are more likely to require cleaning. If these are not choked enough to require the Caustic Soda treatment detailed above, they can be cleaned by pushing a length of 1/8 in (3,18 mm) dia. steel rod down the tube so as to dislodge all foreign matter. **It is IMPORTANT when doing this, not to push the rod into the wall of the tubes.** Ensure that the rod is pushed through the tubes in the opposite direction to that in which the sea water flows. The other components of the heat exchanger should be cleaned before assembly, and as these contain no hidden surface no special instructions are required.

Re-assembly

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

1. Place the two tube stacks in their respective casings and fit new "O" ring seals, over each end.
2. The complete oil cooler should now be slid along the tie rod, taking care that the tube stack is located in the end cover.

3. The spacing ring should be replaced in position and the tie rod complete with oil cooler assembly fitted to the main casing.
4. The other end cover can be replaced and the cap nut complete with its copper and asbestos washer refitted. Tighten cap nut to a torque of 25 lbf ft (3,46 kgf m) — 34 Nm.

Where no oil cooler is fitted in the cooling system, the heat exchanger may still be serviced in a similar manner to that described above, though it will of course have only one tube stack.

To Remove Thermostat

1. Drain coolant from system.
2. Remove heat exchanger.
3. Remove water outlet casting and joint from cylinder head.
4. Lift out thermostat (see Fig. M.11).

To Test Thermostat

1. Immerse thermostat in water and slowly heat.
2. Note the temperature at which valve opens. The correct temperature is stamped on the unit by the manufacturer.
3. If the unit does not function properly a replacement will be required as thermostats cannot be adjusted.

To Refit Thermostat

Replacing the thermostat is a reversal of the removal procedure. On later engines where cylinder head nuts are utilised for holding down the water outlet connection casting, the washers of the same thickness as the outlet joint must be fitted on the long head studs under the casting, and the cylinder head nuts torqued down to their correct value.

Water Pump Belt Adjustment

Incorrect adjustment of the belt can result in the fraying of the belt and eventual failure. The belt adjustment should be checked every 100 hours.

Where engines are rated above 3,000 rev/min, the belt tension should be checked monthly.

Tight adjustment will tend to overload the bearings in the generator and the water pump.

If the adjustment is too slack, belt slip will occur. Where the water pump is belt driven this could result in overheating of the engine due to the reduced efficiency of the pump. The output of the generator would also be considerably reduced.

Checking for Correct Adjustment

Check the depression of the longest run of the belt, the amount of movement should be 3/8 in (10 mm).

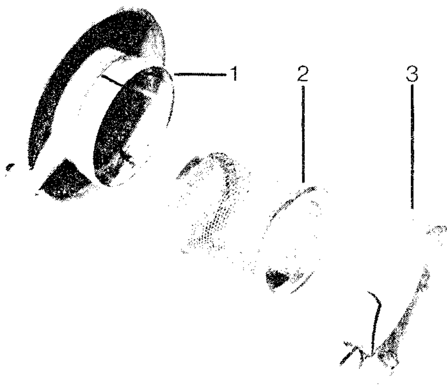
Adjustment

Unscrew the generator adjusting lever bolt and generator support bracket bolts. The generator can then be moved inwards towards the engine to slacken the belt or in an outwards direction to tighten it. When the position of the generator provides correct tension of the belt, tighten generator adjusting lever bolt and support bracket bolts.

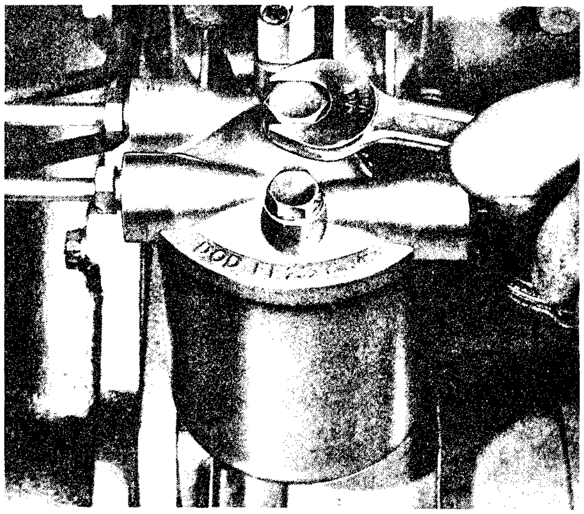
New Belts

Check the adjustment of a new belt after a few hours running to ensure no initial stretching has occured.

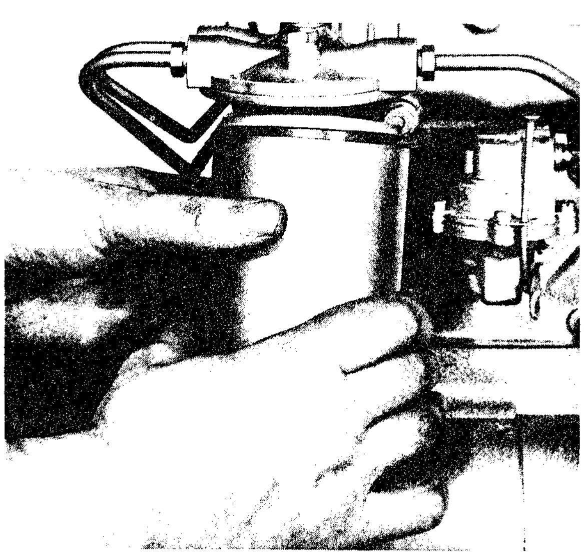
SECTION N
Air Filter and Fuel System



N1 Exploded view of Air Filter.
1. Filter Cover.
2. Gauze Strainer.
3. Filter Securing Clip.



N2 Unscrewing Filter Bowl Securing Setscrew.



N3 Removing the Filter Bowl.

AIR FILTER

The time period for cleaning the air filter depends on operating conditions, therefore, under extremely dirty conditions, the time limits recommended should be decreased.

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

Remove and wash gauze in cleaning fluid every 150 hours. An exploded view of the air filter is shown in Fig. N.1.

FUEL OIL FILTERS

The element in this filter is of the paper type and therefore no attempt should be made to clean it. Its life will be governed by the quality and condition of the fuel passing through it, but under average conditions the element should be renewed in accordance with the recommended Preventive Maintenance given on Page C.4. This period should be reduced if it was apparent from the condition of the element.

To Renew the Filter Element

1. Remove filter bowl as shown in Figs. N.2 and N.3.
2. Discard old element and clean filter bowl.
3. Inspect sealing rings and replace if damaged in any way.
4. Place new element in position inside filter bowl offer up bowl firmly and squarely so that top rim of filter bowl locates centrally against sealing ring in filter head casting. Secure the locating screw.
5. Prime fuel system (See Page N.8).

Fuel Lift Pump

Testing the Pump in Position

1. Disconnect outlet pipe (lift pump to filter) leaving a free outlet from pump.
2. Rotate engine and note if there is a spurt of fuel from outlet port once every two revolutions. The pump may be operated by means of the hand primer as shown in Fig. N.4. However should the

engine happen to have stopped in such a position that the eccentric operating the lift pump is in the maximum lift position, then it will not be possible to operate hand primer properly. If such a condition arises the remedy is to rotate the engine one complete revolution.

Pressure Testing of Fuel Lift Pump in Position

Fit a 0-10 lbf/in² (0-0,7 kgf/cm²) or 0-70 kN/m² pressure gauge to an outlet of the pump. Ensure that there are no leaks at the connections between pump and gauge. Crank the engine for 10 seconds and note the maximum pressure on the gauge. If the pressure recorded is less than 75% of the minimum production static pressure shown below, then rectify the pump. Also observe the rate at which the pressure drops to half the maximum figure obtained when cranking has ceased. If less than 30 seconds, rectify the pump.

Minimum Production Static Pressure			Minimum Test Pressure (75% of Min. Production Pressure)		
lbf/in²	kgf/cm²	kN/m²	lbf/in²	kgf/cm²	kN/m²
6	0,42	41	4.5	0,31	31

To Remove the Lift Pump

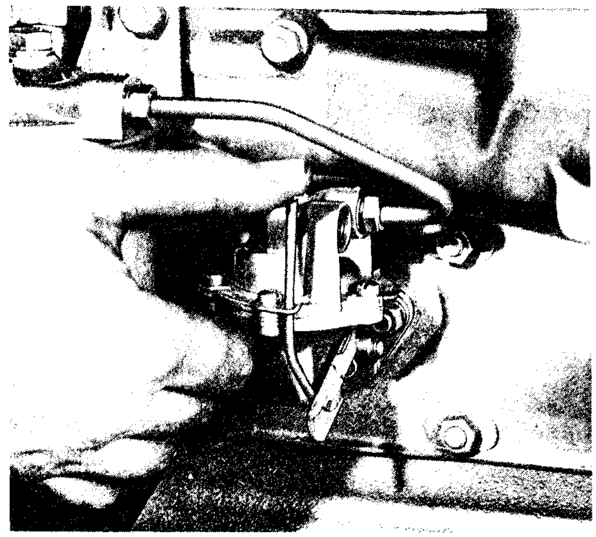
Disconnect pipes and remove pump, distance piece and joints.

To Dismantle the Lift Pump

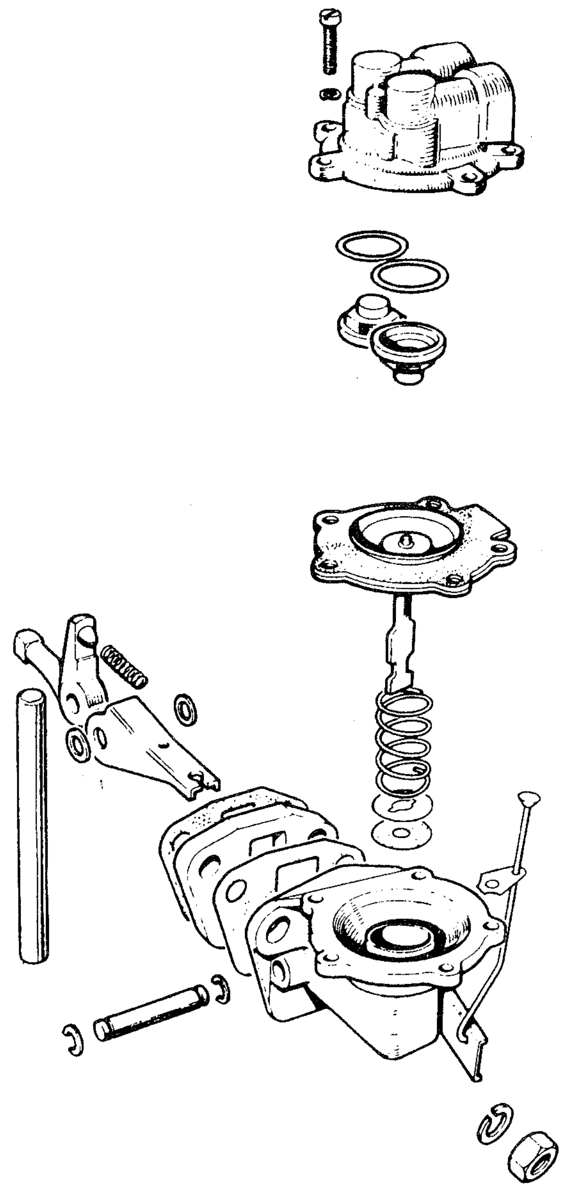
1. Before dismantling, make a file mark across the two flanges for location purposes on re-assembly.
2. Separate the two main castings, then remove diaphragm assembly from lower half by turning diaphragm through 90° in either direction.
   NOTE: The diaphragm and pull rod is a permanent assembly and no attempt should be made to separate the parts.
3. Remove retaining clip from one side of pump body and push out rocker arm retaining pin. With draw rocker arm, etc., from the body.
4. Prise out the valves with a screwdriver or other suitable tool.

Inspection

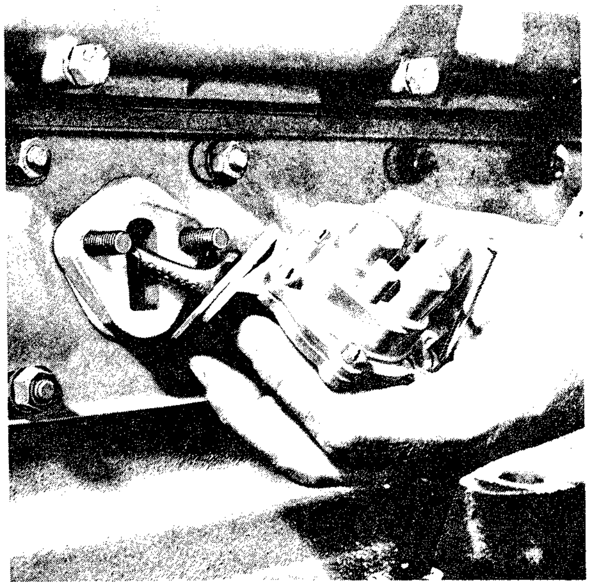
1. Check diaphragm assembly and renew if split or cracked, or if serious wear is apparent in the link engagement slot.



Operating Priming Lever on Fuel Lift Pump. N4



Exploded view of Fuel Lift Pump. N5



N6 Refitting the Fuel Lift Pump.

2. The diaphragm spring should be renewed if faulty or corroded. A new spring should have the same colour identification (Refer to Page B.13.
3. Renew valves to housing joints and valves themselves unless they appear to be in perfect condition. Examine the casting and ensure that there is sufficient material to provide a sound staking when new valves are fitted.
4. Examine rocker arm, operating lever, rocker arm retaining pin and rocker arm return spring for wear.
5. Examine upper and lower castings for wear or distortion. If necessary lightly linish to restore flatness.

To Re-Assemble the Lift Pump

1. Clean the valve recesses to allow the new valves to be correctly seated.
2. Insert a new valve gasket in each valve recess.
3. 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 outlet port fitted in the reverse position.
4. Press the valves home with a suitable piece of steel tubing, approximately 9/16 in (14,29 mm) inside diameter and ¾ in outside diameter.
5. Stake the casting in six places (between the original stakings), round each valve, with a suitable punch.
   NOTE: The valves fitted to earlier pumps were held in position with a retaining plate and two screws. On no account should attempts be made to stake the valves of this earlier type pump.
6. Place rocker arm retaining pin in appropriate hole in lower casting and push through until it protrudes inside.
7. Fit one packing washer and link into casting moving pin in slightly to retain them.
8. Fit rocker arm and return spring and retain by moving pin in further.
9. Fit remaining packing washer, then push rocker arm retaining pin through link, washer and casting until ends protrude equally beyond outside of casting. Retain with clips.
10. Insert new rubber sealing washer followed by steel seating washer and diaphragm return spring.
11. Place diaphragm assembly over spring with pull rod downwards, locating top of spring in diaphragm protector washer.
12. Position pull rod so that flat notched blade has one of its thin edges facing rocker arm. Press downwards on diaphragm assembly and twist it through 90°' in either direction, this action will engage and retain pull rod in fork of link.
13. Operate rocker arm against diaphragm spring pressure until diaphragm is level with body flange.
14. Place cover assembly in position and line up file marks made on flanges.
15. Still holding diaphragm level with body flanges, fit flange securing screws, tighten evenly.

To Refit the Lift Pump

1. Enter pump operating lever into recess in tappet inspection cover as shown on Fig. N.6 and secure.
2. Reconnect fuel pipes.
3. Bleed fuel system (see page N.8).

FUEL INJECTION PUMP

Description

The fuel injection pump is of the D.P.A. distributor type. It is a precision built unit incorporating a simple hydraulic governor.

The pump is flange mounted and is driven from the engine timing case.

To Remove the Fuel Injection Pump

1. Remove high and low pressure fuel pipes.
2. Disconnect stop and throttle controls.
3. Remove the two nuts and setscrew. Remove fuel pump.

To Refit the Fuel Injection Pump

1. Replace fuel pump, ensuring that master spline on its quill shaft is positioned to engage with female spline within drive hub.
2. Before tightening, align timing marks scribed on fuel pump mounting flanges as shown in Fig. K.2.
3. Refit low and high pressure fuel pipes.
4. Reconnect throttle and stop controls.
5. Prime fuel system as detailed on Page N.8.

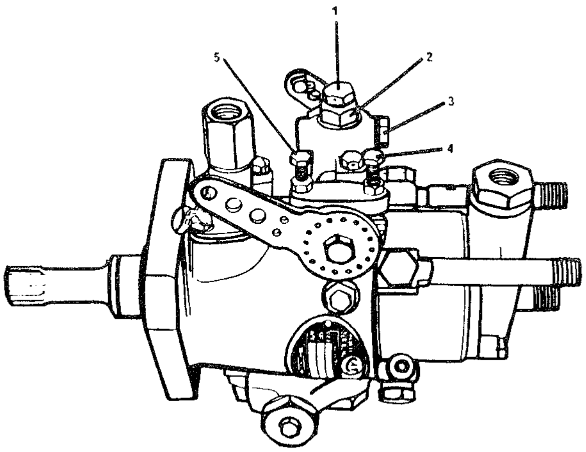
Maximum Speed Setting (Refer to Fig. N.7).

The maximum speed screw (5) is set and sealed by the manufacturers and must not be altered unless factory authority is first obtained. As with all seals on the pump unauthorised removal may render the guarantee void.

The maximum no load speed may vary and reference may be made to the code number stamped on the fuel pump data plate. The last four numbers in the code indicate the maximum no load engine speed, therefore in the case of the following example it would be 4480 rev/min. Code Example EH39/1200/4480.

NOTE: If the fuel pump data plate is damaged or defaced so as to make it impossible to read accurately, or if there is no code stamped on the plate you are advised to contact your nearest C.A.V. Distributor, or alternatively, Service Dept., Perkins Engines Limited, to obtain the required information.

NOTE: The engine must not be allowed to operate at a speed in excess of that specified.

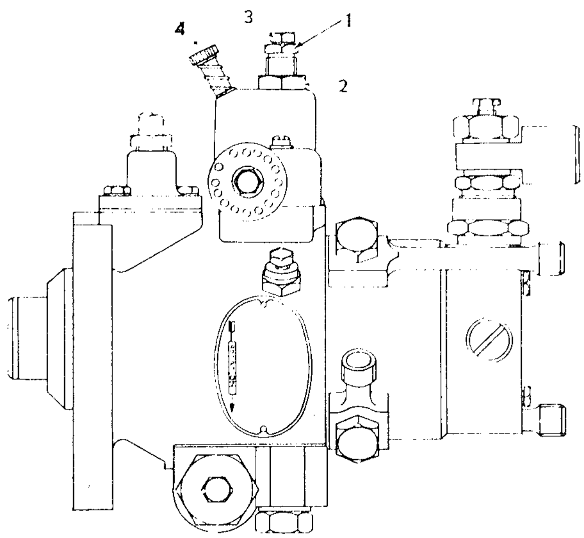


Hydraulically Governed Fuel Pump (interim type). N7

1. Anti-stall device body.
2. Anti-stall device body locknut.
3. Air vent screw.
4. Idling adjustment screw.
5. Maximum Speed Screw.

IDLING SPEED ADJUSTMENT

This adjustment is carried out by means of the idling adjustment screw (4), in conjunction with the setting of the anti-stall device with the engine warmed through as detailed in the following text.



N8 Hydraulically Governed Fuel Pump (early and current type).

1. Anti-stall Device Body.
2. Anti-stall Device Locknut.
3. Air Vent Screw.
4. Idling Adjustment Screw.

Anti-Stall Device (Refer to Figs. N.7 and N.8).

As from Engine No. 7005061 4.99 marine engines and all 4.107 and 4.108 marine engines an anti-stall device was fitted to all engines incorporating a hydraulically governed fuel injection pump. This device is situated on the top of the fuel pump governor housing. (see Fig. N.8).

When slackening or tightening the air vent screw (3), two spanners should be used, one to unlock the air vent (3) and one to hold the anti-stall device body (1), to prevent it from turning and therefore upsetting the adjustment.

(a) Slacken locknut (2) sufficiently to enable anti-stall device body (1) to be unscrewed two complete turns.

(b) Adjust idling speed to 625 rev/min* with idling adjustment screw (4).

(c) Now screw down anti-stall device body (1) until there is a very slight increase in engine sdpeed, bring back half a turn and lock with lock nut (2).

(d) Accelerate engine to maximum no load rev/min and immediately return to idling.

Should period of return from maximum rev/min to idling exceed three seconds the device has been screwed in too far.

However should stalling occur, then the device has not been screwed in far enough. Therefore necessary adjustment should be made to suit whichever is the case.

On some hydraulically governed fuel pumps a reversible governor is fitted. The bleed screw position (3) has been moved from above the anti-stall device on the top of the housing to a position on the side of the housing as shown in Fig. N.7.

*This idling speed may vary according to application, refer to relevant manufacturers service literature or to Perkins Engines Limited, Peterborough if in doubt.

ATOMISERS

General

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

The correct tightening torque for the atomiser securing nuts is 12 lbf ft (1,7 kgf m) or 16 Nm.

Atomisers should be taken out for examination at regular intervals.

The first symptoms of atomiser trouble usually come under 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.

Testing for Faulty Atomiser

If an atomiser is suspected of being faulty use this method to isolate it.

By slackening the union nut at the atomiser end of the high pressure fuel pipes in turn and 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 replaced with a new one.

Atomiser Pressures

Details of holder and nozzle type, together with the pressure settings applicable are given on Page B.13.

NO ATTEMPT SHOULD BE MADE TO ADJUST THE INJECTION PRESSURE WITHOUT AN ATOMISER TESTING PUMP OF THE TYPE ILLUSTRATED. IT IS QUITE IMPOSSIBLE TO ADJUST THE SETTING OF ATOMISERS WITH ANY DEGREE OF ACCURACY WITHOUT PROPER EQUIPMENT.

Warning

Care should be taken to prevent the hands or face from getting into contact with the spray, as the working pressure will cause the oil to penetrate the skin.

Atomiser Identification

Atomisers fitted to 4.108 and 4.107 marine engines have the letters 'BG' stamped on the tab washer fitted beneath the spring cap nut. 4.99 engines have the letter 'E'.

Fuel Pipes (High Pressure)

High pressure fuel pipes are now supplied with formed ends in place of olives. Earlier pipes were supplied with olives fitted as shown in Fig. N.10. Originally, the olives were fitted in the reverse position, but both positions are still satisfactory if undamaged.

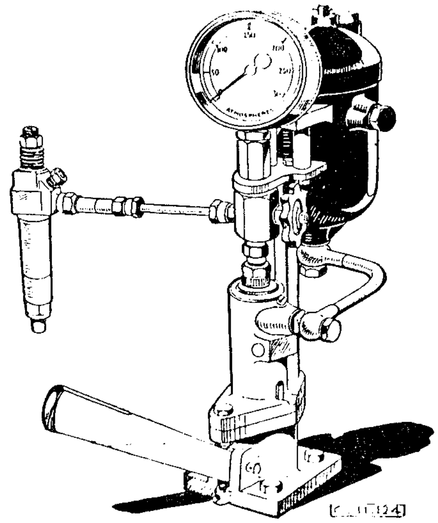
The correct tightening torque for the high pressure fuel pipe nuts is 15 lbf ft (2,1 kgf m) or 20 Nm.

When replacing fuel pipes it should be noted that no two pipes are the same.

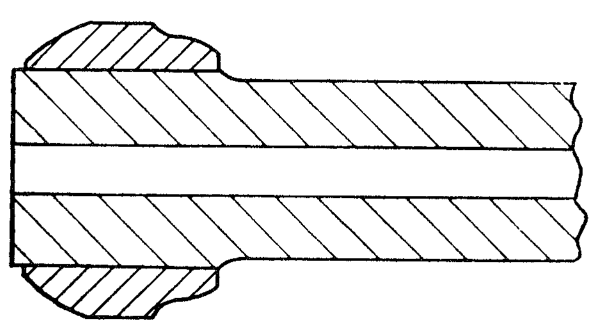
The pipes should be clean, the olives at each end where fitted, should not be split or unduly compressed, otherwise leakage will result and a new pipe will be needed.

Ensure when fitting, that the pipe fits squarely at both ends and that the union nuts are tightened firmly but not over-tightened.

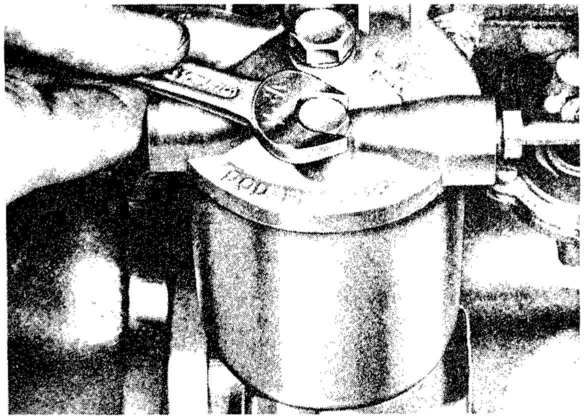
When changing an atomiser always remove the pipe completely.



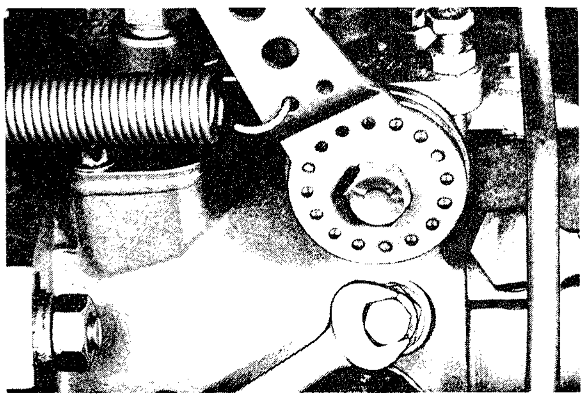
Atomiser Testing Pump. N9



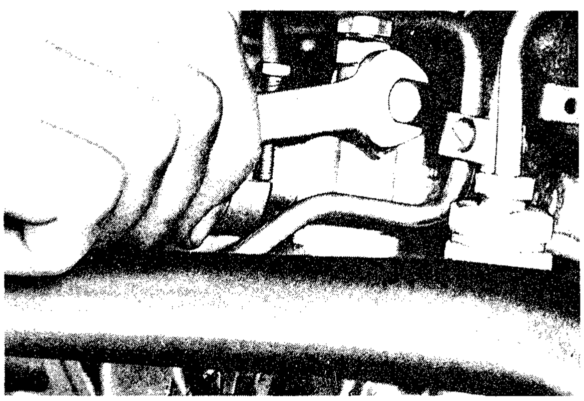
Fuel Pipe Olive. N10



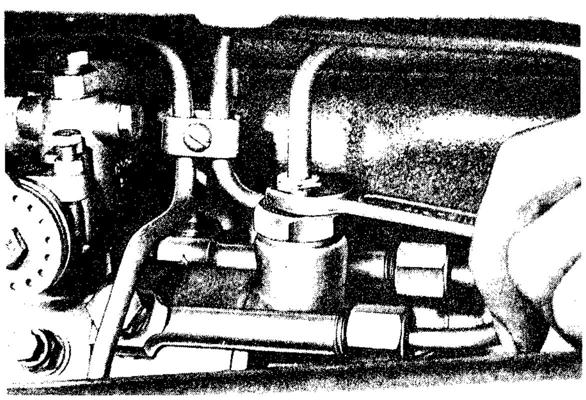
N11 Slackening Vent Screw on Filter Head Casting.



N12 Slackening Vent Screw on Hydraulic Head Locking Screw.



N13 Slackening Vent Screw on Governor Housing.



N14 Slackening Pipe Union Nut at Fuel Injection Pump Inlet.

Bleeding the Fuel System

In the event of air entering the fuel system, it will be necessary to bleed the whole fuel system before starting can be effected. Air in the fuel system can be either due to running out of fuel or leakage on the suction side of the fuel supply line.

To bleed the system, proceed as follows: —

Unscrew by two or three turns vent plug (where fitted) on top of fuel filter cover (not return pipe to tank) (see Fig. N.11).

Slacken vent screw on hydraulic head locking screw on the side of the fuel injection pump body (see Fig. N.12).

Slacken air vent screw near top of governor housing on fuel injection pump (see Fig. N.13). (For earlier and current engines see Fig. N.8. Ensure anti-stall device is not disturbed, see page N.6).

Operate priming lever of fuel lift pump (see Fig. N.4). (Note. If the cam on engine camshaft driving fuel lift pump is on maximum lift, it will not be possible to operate hand primer, and the engine should be turned one complete revolution). When fuel, free from air bubbles, issues from each vent point, tighten the connections in the following order: —

1. Filter head venting screw (if fitted).
2. Head locking screw on fuel injection pump.
3. Governor vent screw on fuel injection pump.

Slacken pipe union nut at fuel injection pump inlet (see Fig. N.14), operate priming lever on lift pump and re-tighten when fuel, freee from air bubbles, issues from around threads.

Slacken the unions at the atomiser ends of the high pressure fuel pipes.

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

Turn engine with starter motor until fuel oil, free from air bubbles, issues from all fuel pipes. Some 30 to 60 seconds of rotation may be necessary before this condition is reached, and the time will be dependent upon speed of rotation and effectiveness of bleeding operation described previously. A fully charged battery in a temperate or warm climate will rotate engine at upwards of 280 rev/min, and under these conditions, the remaining air should be expelled in under 30 seconds. Cold conditions or partially discharged batteries may take longer.

Tighten unions on fuel pipes and engine is ready for starting.

If after bleeding fuel system the engine starts and runs satisfactorily, but after a few minutes it stops, then it can be assumed that air is trapped in the fuel injection pump and the bleeding procedure, should be repeated, at the same time checking for air leaks on the suction side, such as loose connections or faulty joints.

Priming Procedure after Changing a Filter Element

Note: Where the fuel filter cover does not incorporate a vent screw, the priming of the fuel filter is automatic.

1. With vent screw (if fitted) on filter cover removed, and the union at the filter end of the return pipe (filter to tank) slackened, operate feed pump priming lever until fuel, free from air bubbles, issues from filter cover vent.
2. Replace vent plug, and continue to operate priming lever until fuel, free from air bubbles, issues from arounf threads of return pipe union.
3. Tighten return pipe union.
4. Slacken union at filter end of filter to injection pump feed pipe, and operate priming lever until fuel, free from air bubbles, issues from around the union threads.
5. Tighten feed pipe union. Pump and filter are now filled and primed.

Fuel Oil

The fuel used in the engine must be clean and should conform to the specification given in 'Data and Dimensions for Fuel System'.

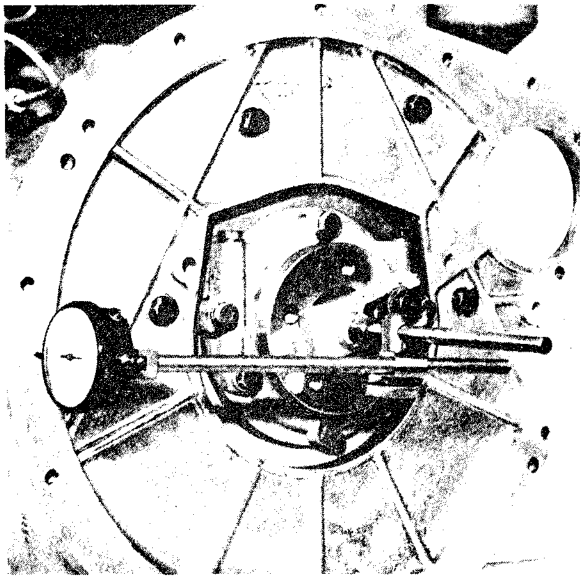
The importance of clean fuel passing through your fuel injection pump and atomisers cannot be too strongly emphasised.

Some applications have a gauze trap in the filler of the fuel tank. This must not be removed when fuel is being poured into the tank.

If there is no filter in the filler and any doubt exists as to the cleanliness of the fuel, the fuel should be poured through a fine gauze strainer.

Do not store fuel oil in a galvanised container.

SECTION P
Flywheel and Flywheel Housing



P1 Checking Alignment of Adaptor Plate.

Alignment of the Adaptor Plate, Flywheel Housing and Flywheel

It is most important that the adaptor plate, flywheel housing and flywheel be correctly aligned with the crankshaft. If the plate and housing have 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: —

Secure adaptor plate to cylinder block with setscrews and spring washers.

Alignment of the Adaptor Plate Face

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

Set needle of gauge against vertical face of adaptor (See Fig. P.1).

Turn crankshaft and check that this face is perpendicular to crankshaft axis.

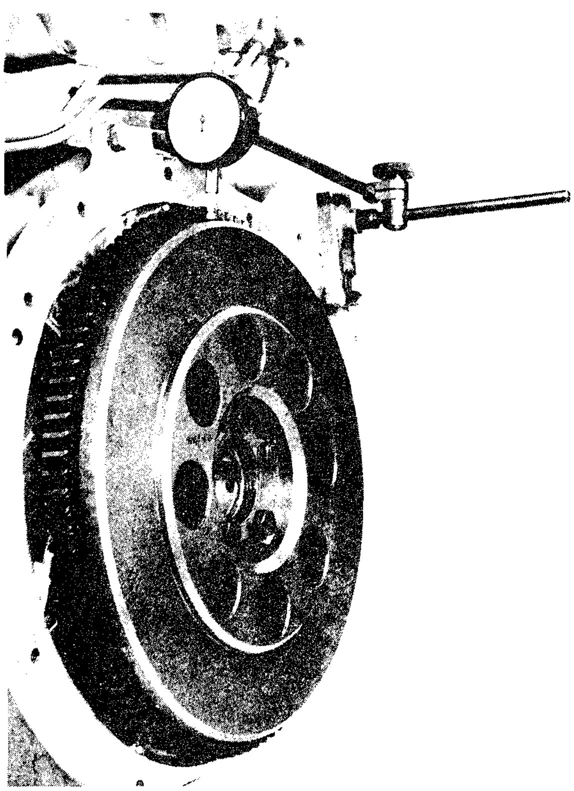
This facing should be within the following limits (total indicator reading) of being truly at right angles to crankshaft axis.

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

Adaptor Plate Diameter	Deviation
Up to 14½ in (362 mm)	0.006 in (0,15 mm)
Over 14¼ in (362 mm) to 20 1/8 in (511 mm)	0.008 in (0,20 mm)
Over 20 1/8 in (511 mm) to 25½ in (648 mm)	0.010 in (0,25 mm)
Over 25½ in (648 mm) to 31 in (789 mm)	0.012 in (0,30 mm)

When the adaptor plate is properly aligned to the above limits, tighten the setscrews evenly.

Ream the dowel holes and fit the correct length and size of dowels.



P2 Checking Alignment of Flywheel Periphery.

Fitting Flywheel and Checking Alignment

With the aid of guide studs, place flywheel on crankshaft flange and insert setscrews complete with tab washers into flywheel holes. Tighten evenly.

Secure base of "dial" gauge to adaptor plate. Set needle of gauge on periphery of flywheel (See Fig. P.2).

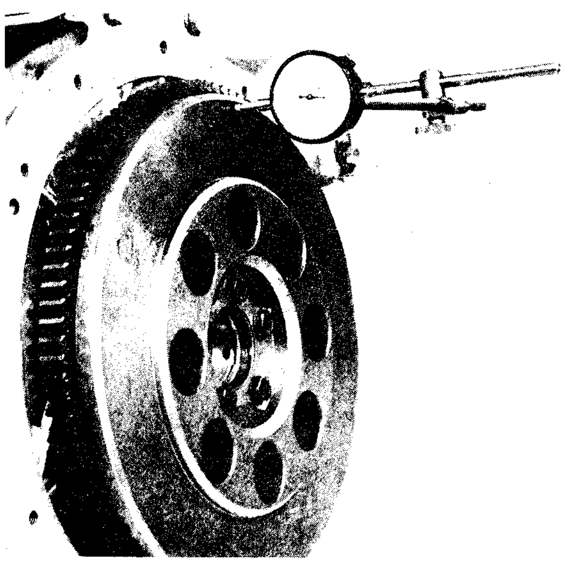
Turn crankshaft and check dial, flywheel should run truly within 0.012 in (0,30 mm) (total indicator reading).

With base of "dial" gauge still bolted to adaptor plate adjust dial so as to set needle against vertical machined face of flywheel. (See Fig. P.3).

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

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

Finally grease spigot bush or bearing if fitted.



Checking Alignment of Flywheel Face. P3

Alignment of Flywheel Housing Bore

Secure housing to adaptor plate with setscrews and spring washers, but not overtight to allow for adjustment.

Attach dial gauge to flywheel centre and set needle of gauge to interior of bored hole in flywheel housing (See Fig. P.4).

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

The hole in the housing should be truly central with the crankshaft within the following limits (total indicator reading).

Flywheel Housing Diameter	Deviation
Up to 14¼ in (362 mm)	0.006 in (0,15 mm)
Over 14¼ in (362 mm) to 20 1/8 in (511 mm)	0.008 in (0,20 mm)
Over 20 1/8 in (511 mm) to 25½ in (648 mm)	0.010 in (0,25 mm)
Over 25½ in (648 mm) to 31 in (789 mm)	0.012 in (0,30 mm)

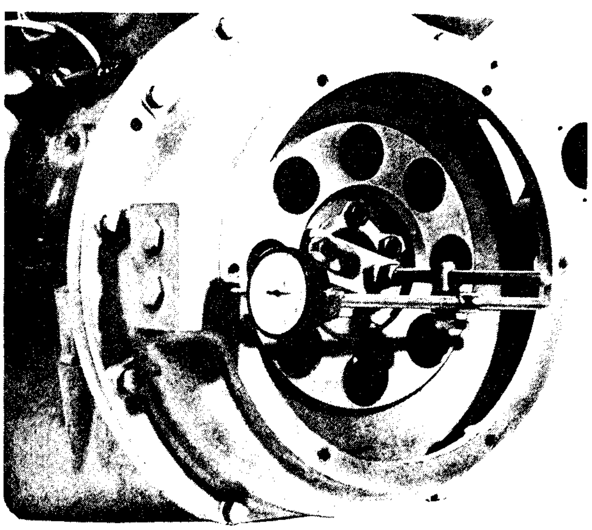
Checking Alignment of Flywheel Housing Bore. P4

Alignment of the Flywheel Housing Face

With base of dial gauge still bolted to flywheel centre, adjust dial to set needle against vertical machined face of flywheel housing, and again turning crankshaft, check that this face is perpendicular to crankshaft axis (See Fig. P.5).

The limits for this facing are the same as those given for the adaptor plate facing. When the housing is properly aligned to the above limits, tighten the securing setscrews evenly.

Ream dowel holes and fit correct length and size dowels.



Checking Alignment of Flywheel Housing Face. P5

SECTION Q
Electrical System

ALTERNATOR
Models AC5 and 11AC

1. Precautions

The diodes in the alternator function as one-way valves and the transistors in the regulator/control box operate as fast switches. Both are accurate and sensitive.

They do not wear out and seldom require adjustment, but because they are sensitive to voltage changes and high temperature, the precautions are vital to prevent them from being destroyed.

(a) DO NOT disconnect the battery whilst the engine is running. This will cause a voltage surge in the alternator charging system that will immediately ruin the diodes or transistors.

(b) DO NOT disconnect a lead without first stopping the engine and turning all electrical switches to the off position.

(c) DO NOT cause a short circuit by connecting leads to incorrect terminals. Always identify a lead to its correct terminal. A short circuit or wrong connection giving reverse polarity will immediately and permanently ruin transistors or diodes.

(d) DO NOT connect a battery into the system without checking for correct polarity and voltage.

(e) DO NOT "flash" connections to check for current flow. No matter how brief the contact the transistors may be ruined.

2. Maintenance

The alternator charging system will normally require very little attention, but it should be kept free from build-up of dirt, and a check made if it fails to keep the battery charged.

(a) Regularly inspect the driving belts for wear and correct tension. It is important to ensure that all belts on a multiple belt drive have equal tension and are each carrying their share of the load. Slack belts will wear rapidly and cause slip which will not drive the alternator at the required speed. Drive belts which are too tight impose severe side thrust on the alternator bearings and shorten their life. Periodically ensure that the alternator is correctly aligned to the drive.

(b) Do not replace faulty belts individually in a multi-belt system. A complete matched set of drive belts must always be used.

(c) Keep the alternator clean with a cloth moistened in kerosene or cleaning fluids. Ensure that ventilation slots and air spaces are clear and unobstructed.

(d) Remove any dirt accumulated on the regulator/control box housing, and ensure that cooling air can pass freely over the casing.

3. Fault Finding on AC5

The AC5 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. Disconnect alternator output terminal. Fit a good quality moving coil 0—100 amp ammeter in series with the alternator terminal and output lead. **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, etc. for fifteen minutes.

(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 55 Amperes for 12 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 13 — 14 volts on 12 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.

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.

4. Fault Finding on 11 AC

If the alternator does not produce its rated output of 44 amperes for 12 volt circuit, the failure may be due to any unit or the associated wiring, and the following procedure should be followed.

TEST 1
Checking the Field Isolating Relay

Disconnect the earthed battery terminal and the cable from the alternator main output terminal. Connect a 0—60 DC ammeter between the terminal and disconnect cable. Link terminals 'C1' and 'C2' on the field relay. Reconnect the battery cable. Close the master switch and start engine and run at charging speed. If ammeter shows a charge the relay is faulty, or its wiring and connections.

If ammeter shows no charge, carry on with Test 2.

TEST 2
Checking the Alternator and Control Box

Leave the test ammeter connected, and disconnect cables 'F' and '—' from control unit and join them together. Remove link from field relay terminals and ensure they are connected to 'C1' and 'C2'. Start engine and run at charging speed.

Ammeter should indicate current values of 35 amps or more for 12 volt circuit. A zero or low reading indicates a faulty alternator.

If satisfactory output is recorded, a faulty control unit is indicated.

TEST 3
Checking or Adjusting the Voltage Setting

The regulator of the 4 TR control unit must be set on CLOSED CIRCUIT, when the alternator is under load. Also, the system must be stabilised before checking or resetting is carried out, and the battery must be in a well charged condition. Check the battery to control unit wiring, to ensure that the resistance of the complete circuit does not exceed 0.1 ohm. Any high resistance must be traced and remedied. Connect a test DC voltmeter (suppressed zero type) scale 12—15 volts for 12 volt installations, between the battery terminals, and note the reading with no electrical load. Disconnect battery earth cable and connect test ammeter between alternator main, terminal and disconnected cable. Reconnect battery earth cable, and switch on an electrical load of approximately two amps, such as, lights. Start engine and run at about 2000 rev/min for at least eight minutes. If the charging current is still greater than ten amps, continue to run engine until this figure is reached. Then compare the voltmeter reading with the appropriate setting limits, as specified for the particular control unit as follows:

12V (37423)/(37449)	13.9—14.3 volts
12V (37429)	13.7—14.1 volts

(Part No. marked on upper edge of the moulded cover of Control Unit).

If reading obtained is stable but outside the appropriate limits the unit can be adjusted as follows:

ADJUSTMENT OF VOLTAGE SETTING

Stop the engine and remove the control unit from its mounting. At the back of the unit is a sealed potentiometer adjuster. Carefully scrape away the sealing compound. Then start the engine, and while running the alternator at charging speed, turn the adjuster slot—CLOCKWISE to INCREASE the setting or ANTI-CLOCKWISE to DECREASE it—until the required setting is obtained.

Recheck the setting by stopping the engine, then start again and slowly "run-up" to charging speed. If setting is now correct, remount the control unit, disconnect test meters and restore original wiring connections. If, after adjustment, the voltmeter read ing remains unchanged, or increases in an uncontrolled manner, then the control unit is faulty and a replacement must be fitted.

TEST 4

Check of Alternator Output

Disconnect battery earth cable, and connect test ammeter between the alternator main terminal and disconnected cables. Reconnect battery earth cable, and switch on the full electrical load and leave on for 3 or 4 minutes. Leave load on and start engine and run at approximately 2000 rev/min. The alternator output should balance the load, and at the same time show a charge to the battery.

Check Warning Light Control

If warning light does not function either by remaining "on" or "off", but the system is charging satisfactorily, connect voltmeter between the alternator "AL" terminal and earth. Reading should be 7.0—7.5 max (12 volt alternator). Connect leads 'E' and 'WL' together. If warning lamp lights the warning light control is faulty and should be replaced.

5. Fault Diagnosis Procedure for 11 AC Alternator Fails to Charge

(a) Check driving belt for correct tension and wear.

(b) Apply Tests 1 and 2.

Low-Unsteady Charging Rate

(a) Check driving belt for correct tension and wear.

(b) Check for high resistance at battery terminals and in the circuit wiring and connection.

(c) Check all connections made to earth.

(d) Apply Test 2.

Flat Battery or Low State of Charge

(a) CHECK condition of battery with hydrometer and high rate discharge tester.

(b) Check driving belt for correct tension and wear.

(c) Check that the field isolating relay contacts open when master switch is off, otherwise battery will discharge through rotor winding.

(d) Check that flat or low battery is not caused by insufficient electrical output caused by abnormal electrical loads by applying Test 4.

Excessive Charge Rate to a Fully Charged Battery

(a) ,Apply Test 3.

Noisy Alternator

(a) Alternator loose in mounting brackets.

(b) Worn frayed or loose drive belt.

(c) Worn bearings, fully out of alignment.

(d) Rotor damaged or pulley fan loose on shaft.

(e) Open circuited, or short circuited rectified diodes, or stator winding open-circuit.

(f) Loose pulley.

DYNAMO

1. General

The following information is concerned with the dynamo fitted to the 4.99, 4.107 and 4.108 marine engines, namely the Lucas C40-A model. Should information be required in connection with any other type of dynamo then the relevant manufacturer should be contacted.

Description

The C40A is a non-ventilated unit.

It is shunt wound, two pole, two brush machine designed to work in conjunction with a compensated voltage control regulator unit. A ball bearing supports the armature at the driving end and a porous bronze bush at the rear supports the commutator end.

The output of the dynamo is controlled by the regulator unit and is dependent on the state of charge of the battery and the loading of the electrical equipment in use. When the battery is in a low state of charge, the dynamo gives a high output, whereas if the battery is fully charged, the dynamo gives only sufficient output to keep the battery in good condition without any possibility of overcharging. An increase in output is given to balance the current taken by lamps and other accessories when in use.

When fitting a new control box, it is important to use only an authorised replacement. An incorrect replacement can result in damage to the dynamo.

2. Routine Maintenance

(a) Lubrication

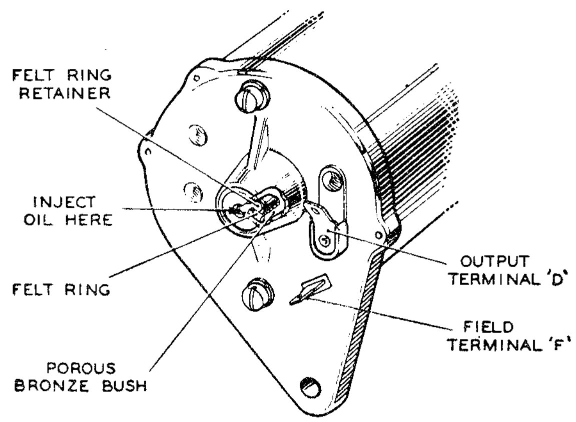
Every 100 running hours, inject a few drops of high quality S.A.E. 30 engine oil into the hole marked "OIL" at the commutator end bearing housing (Refer to Fig. Q.1).

(b) Inspection of Brushgear

Every 2,400 running hours, the dynamo should be removed from the engine and the brushgear inspected by a competent electrician.

(c) Belt Adjustment

Occasionally inspect dynamo driving belt, and if necessary, adjust to take up any slackness by turning the dynamo on its mounting. Care should be taken to avoid overtightening belt (see Page M.10).



Lubricator in Commutator End Bracket. Q1

3. Performance Data

Cutting in and maximum output speeds quoted below are production test figures and refer to cold machines with brushes only partly bedded.

Model	C40A
Maximum output	11A
Maximum output speed	1650 rev/min
Cutting in speed	1050 rev/min
Rotation	Clockwise

4. Servicing

(a) Testing in Position

1. Inspect driving belt and adjust if necessary. (Refer to Page M.10).
2. Check connections on commutator end bracket. The larger connector carries the main dynamo output, the smaller connector the field current.
3. Switch off all lights and accessories, take off cables from terminals of dynamo and connect the two terminals with a short length of wire.
4. Start engine and set to run at normal idling speed.
5. Clip negative lead of a moving coil type voltmeter, (calibrated 0-20 volts) to one dynamo terminal and positive lead to a good earthing point on the yoke.
6. Gradually increase engine speed, when voltmeter reading should rise rapidly and without fluctuation. Do not allow volt meter reading to reach 20 volts, and do not race engine in an attempt to increase voltage. It is sufficient to run dynamo up to a speed of 1,000 rev/min (approx. 750 engine rev/min).

If voltage does not rise rapidly and without fluctuation, the unit must be dismantled for internal examination.

Excessive sparking at commutator in above test indicates a defective armature which should be replaced.

NOTE: If a radio suppression capacitor is fitted between output terminal and earth, disconnect this capacitor and re-test dynamo before dismantling. If a reading is now given on the voltmeter, then the capacitor is defective and must be replaced. If dynamo is in good order, remove link from between terminals and restore original connections.

(b) Brush Gear

Checking with Yoke Removed

1. Lift brushes up into brush boxes and secure them in that position by positioning brush springs at the sides of the brushes.
2. Fit commutator end bracket over commutator and release brushes.
3. Hold back each of the brush springs and move brush by pulling gently on its flexible connector. If the movement is sluggish, remove brush from its holder and ease the sides by lightly polishing on a smooth file. Always refit brushes in their original positions.

   If brushes are badly worn, new brushes must be fitted and bedded to the commutator. The minimum permissible length of brush is 9/32 in (7,14 mm) i.e. when the spring arm reaches the brush box.

   NOTE: Brushes of grade B carbon are specified for the model C40-A dynamo.

STARTER MOTORS

General

Two types of drive are available and both are covered in the following section. Should information be required in connection with any other type of starter motor then the relevant manufacturer should be contacted.

STARTER MOTOR—Run-off Helix Drive

1. Description—Model M45G Type RF 17

This electric starter motor is a four-pole four-brush machine having an extended shaft which carries the engagement gear, or starter drive as it is more generally known.

The starter motor is of a similar construction to the dynamo except that heavier copper wire is used in the construction of the armature and field coils. The field coils are series-parallel connected between the field terminal and the insulated pair of brushes.

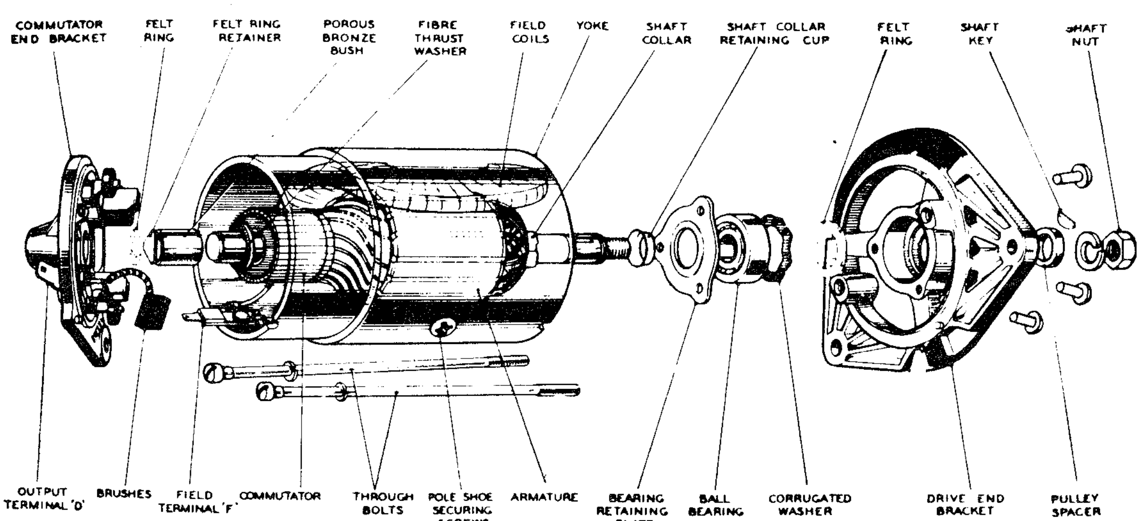
The armature has 23 winding slots. The drive portion incorporates a special overload protective device known as the Run-off Helix.

2. Routine Maintenance

(a) The starter motor requires no routine maintenance beyond the occasional inspection of the electrical connection, which must be clean and tight, the brush gear, and the commutator.

(b) After the starter motor has been in service for some time, remove the starter motor from the engine and submit it to a thorough bench inspection.

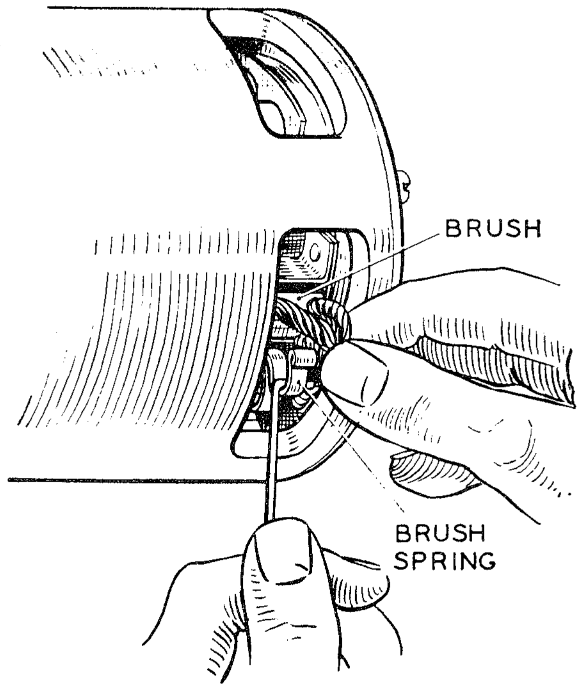
MODEL C40-1 GENERATOR DISMANTLED



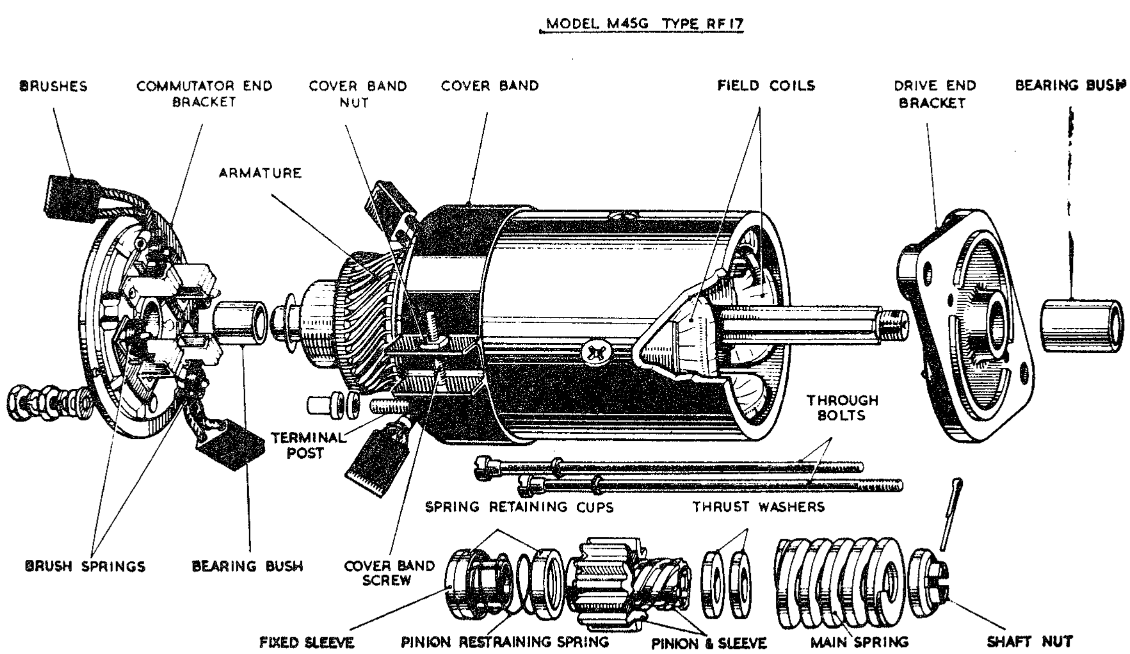
1. Check that brushes move freely in their holders by holding back brush springs and pulling gently on the flexible connectors (Refer to Fig. Q.3). If movement is sluggish, remove brush from its holder and clean its sides with a fluffless petrol moistened cloth. Replace brush in its original position. Brushes which are worn to less than 9/16 in (14 mm) long must be renewed.

   NOTE: This is the length when half the available wearing length has worn away. The time taken to reach this stage normally extends well beyond that to reach the point of major engine overhaul.

2. The commutator must be clean and have a polished appearance. If necessary clean it by pressing a fine dry cloth against it whilst the armature is turned by hand. If the commutator is very dirty, moisten the cloth with petrol.
3. Keep all electrical connections clean and tight. Any which have become dirty should be cleaned and contacting surfaces lightly smeared with petroleum jelly.



Checking freedom of Brush Movement. Q3



Starter Motor Dismantled. Q4

3. Servicing

(a) Testing in Position

If starter motor does not operate or fails to crank engine when starting button is used, connect a good quality 0-20 voltmeter across battery terminals, operate starter button and watch for the following symptoms:

1. Voltmeter reading falls appreciably but motor does not crank engine.

   This may be caused by starter drive pinion being jammed in mesh with engine flywheel.

   It is advisable to remove starter motor from engine and inspect starter drive.

   Sluggish action of the starter motor may be due to a discharged battery, check this by replacing with a battery known to be fully charged. If starter motor now functions normally then the battery must be examined. Should starter motor still not function normally then it should be removed from engine and examined.

2. The voltmeter reading remains unaffected and the motor does not crank the engine.

   Check first that the circuit up to the supply terminal on the starter motor is in order.

   If no voltage is indicated, check circuit from battery to motor via starter switch. Ensure that all connections are clean and tight. If switch is found to be faulty fit a serviceable replacement.

   A normal voltage supply reaching the starter motor terminal indicates that starter motor has an internal fault and must be removed for examination.

   If starter motor operates but does not crank engine, starter drive may require cleaning or may have developed some other fault. In either case starter motor requires removal from engine for a full examination.

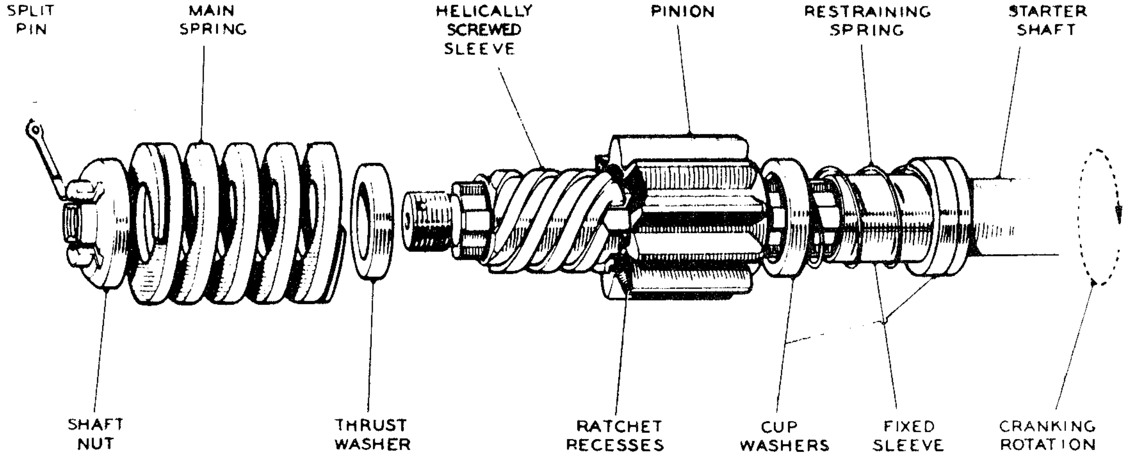
'S' TYPE STARTER DRIVE ASEMBLY

(a) OPERATION

This drive incorporates a protective feature known as the 'Run-off Helix'. The purpose of this feature is to prevent possible damage occuring to starter motor through excessive torque being applied while pinion is in engagement, as would arise for example in the event of an engine back-fire during starting.

Under normal conditions of engagement, axial movement of pinion is arrested when, in the one direction, the first cup washer has fully compressed the restraining spring and is abutted hard against the second cup washer and, in the opposite direction, the helically screwed sleeve is pressing the thrust washer hard against the main spring.

In the 'Run-off Helix' drive, the main spring is capable of greater compression than is the equivalent



Q5 'S' Type Starter Drive.

standard 'S' pattern drive spring. In addition, the trailing faces of the pinion and helically screwed sleeve are machined to form indented ratchet recesses.

In the event of a back-fire occuring during starting, the pinion (being able to rotate but incapable of further axial movement) forces the helically screwed sleeve along the straight-splines of the starter shaft. This further compresses the main spring and permits axial movement of the screwed sleeve to continue until it is clear of the interior of the pinion. At this stage, axial movement of the screwed sleeve ceases and the pinion, now jointly supported by the fixed sleeve and the recessed end of the screwed sleeve, is free to be rotated by the engine ring gear. In this way, excessive torque is harmlessly dissipated by the ratchetting action of the pinion and screwed sleeve against the reaction pressure of the main spring.

The operation of a 'Run-off Helix' drive can be checked by securing armature and drive assembly in a vice (using wooden vice-clamps) and applying a torque wrench to the pinion. The ratchet action must occur at a torque of not less than 36 lbf ft (5 kgf m).

(b) ROUTINE MAINTENANCE

If any difficulty is experienced with the starter motor not meshing correctly with the flywheel, it may be that the drive requires cleaning.

The pinion should move freely on the screwed sleeve; if there is any dirt or other foreign matter on the sleeve it must be washed off with cleaning fluid.

LUBRICATING OILS

Lubricating oils should meet the requirements of the U.S. Ordnance Specification MIL-L-46152 or 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 D-3 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 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.

The above specifications are subject to alteration without notice.

EXAMPLES OF SERVICE FACILITIES

Service Publications

The following Service Literature may be purchased through your local Perkins Distributor

Workshop Manuals,

Workshop Data,

Operators Handbooks,

Valve Seat Inserting and Cylinder Head Skimming,

Crankshaft Regrinding,

Fault Finding Guide,

Installation and Maintenance Guide for Static Standby Engines

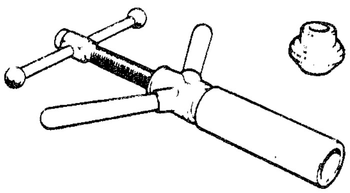
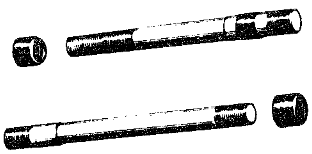
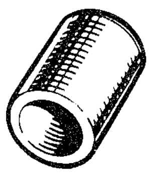
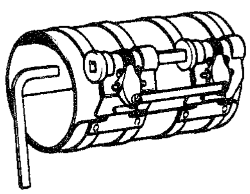
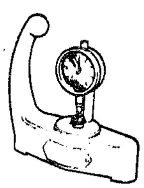
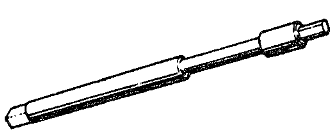
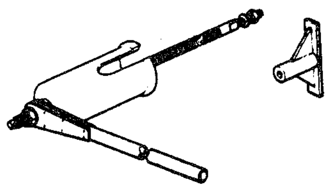
Etcetera.

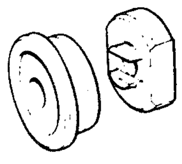
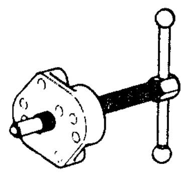
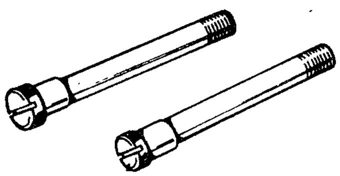
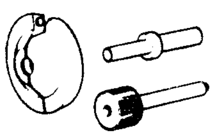
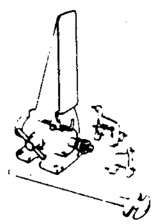
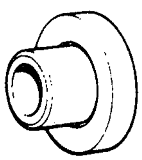
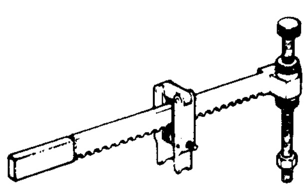
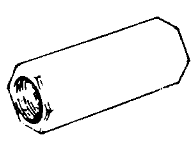
Service Instruction

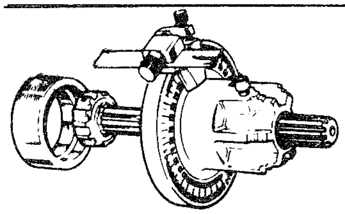
Perkins Engines, Inc.
24175 Research Drive
P.O. Box 283 • Farmington, Michigan 48024 • U.S.A.
Tel. (313) 477-3900 • Telex: 023-5300

APPROVED SERVICE TOOLS

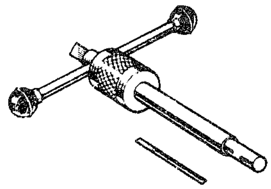
Available from V. L. Churchill & Co. Ltd., Daventry, Northamptonshire, NN11 4NF, England.

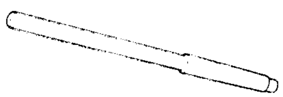
	Tool No.	Description
	PD.1D	VALVE GUIDE REMOVER AND REPLACER (MAIN TOOL)
	PD.1D-1A	ADAPTOR FOR PD.1D A pair of puller bars fitted with knurled nuts. Suitable for 5/16" and 3/8" guides The necessary distance piece from the adaptors below should also be used.
	PD.1D-2	ADAPTOR FOR PD.1D A 20.5 mm (13/16") distance piece used to replace valve guides to a set height
	No. 8	PISTON RING SQUEEZER
	PD.41B	PISTON HEIGHT AND VALVE DEPTH GAUGE A simple method of quickly checking piston height.
	PD.130A	FUEL PUMP ALLEN SCREW KEY Assists access to the otherwise inaccessible screws on D.P.A. pump.
	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.

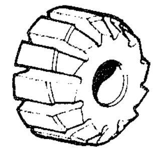
	Tool No.	Description
	PD.150-5	ADAPTORS FOR PD.150 Suitable for cylinders of 3.125" dia. Removal and replacement.
	155B	BASIC PULLER The cruciform head with multiple holes at different centres is used with adaptors listed below.
	PD.155-1	ADAPTORS FOR PD.155A Used to remove water pump pulleys.
	MF.200-26	WATER PUMP OVERHAUL KIT Used with 370 Taper Base and Press.
	335	CON ROD JIG & 336 MASTER ARBOR
	336-101	ARBOR ADAPTOR Used with 335
	61118B	VALVE SPRING COMPRESSOR
	PD.6118-1	ADAPTOR FOR 6118B

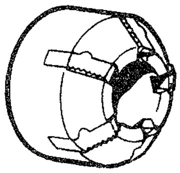
	Tool No.	Description
	MS67B	TOOL FOR CHECKING FUEL PUMP TIMING

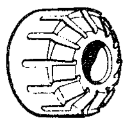
VALVE SEAT CUTTERS


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
316-10	Pilot (5/16" dia. Valve Guide)
PD.317-18	Valve Seat Cutter — Exhaust
PD.317-22	Valve Seat Cutter — Inlet
317G-19	Valve Seat Glazebreaker — Exhaust
317G-22	Valve Seat Glazebreaker — Inlet

INDEX

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