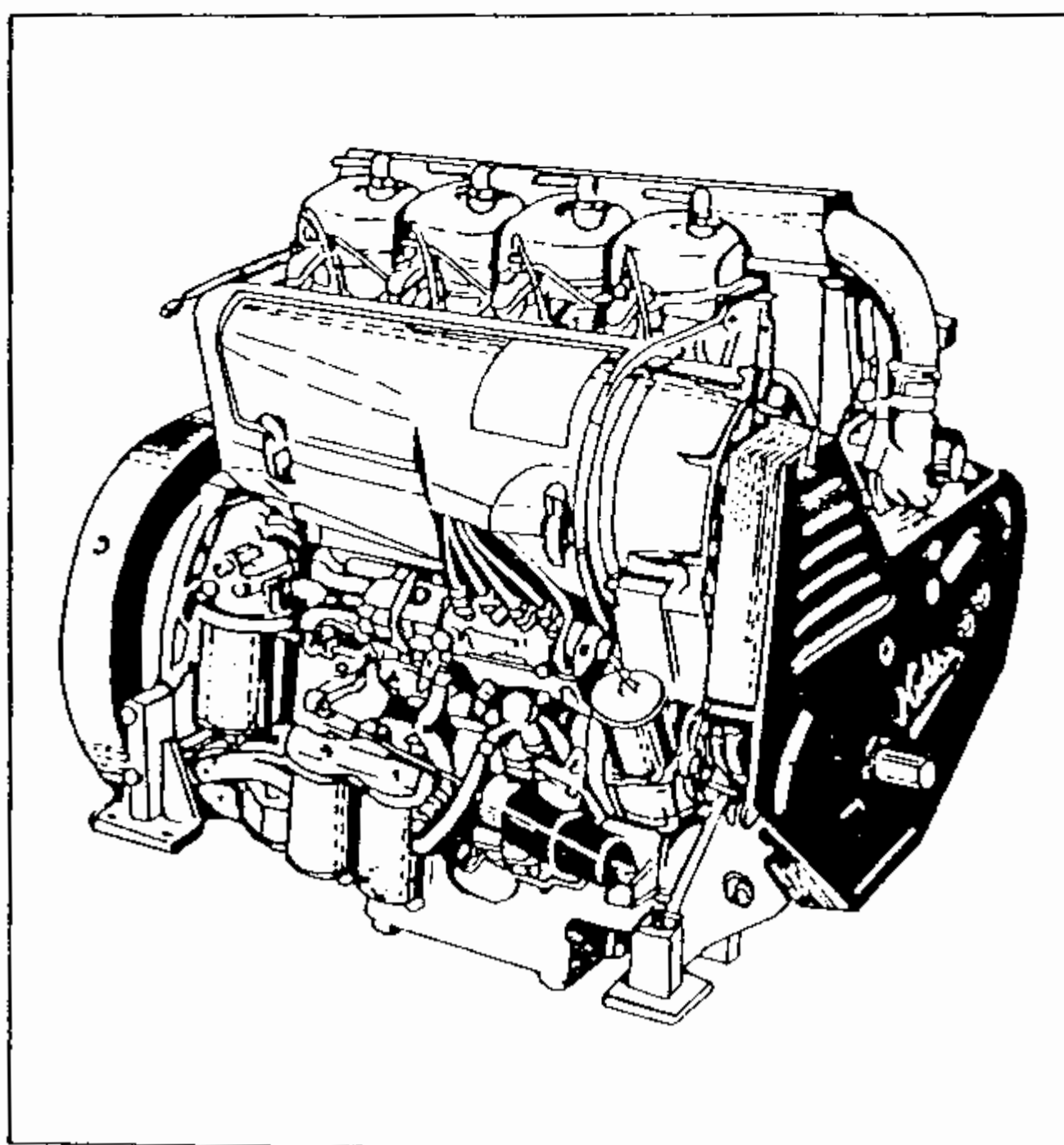




Enriching Lives

KIRLOSKAR DIESELS WORKSHOP MANUAL

HA – Series



KIRLOSKAR OIL ENGINES LIMITED

Khadki, Pune 411 003 (INDIA)

FOREWORD

This Workshop Manual has been prepared for use in service workshops of our distributors and authorised dealers. It contains all details of disassembly and assembly, necessary tolerances, clearances required for assembly and adjustments, reconditioning and overhauling.

It is presumed that these tasks will be carried out by trained technicians. Consequently detailed descriptions and instructions about basic repairs have been omitted. Anyone who uses a service procedure or tool which is not recommended in this Manual, will be held fully responsible for engine life and his personal safety.

Please refer to the Maintenance Manual regarding routine care and maintenance of engine for its best performance and optimum life. The lubricating oil circuit, fuel oil circuit, cooling system and electrical system are also explained in HA-Maintenance Manual.

While servicing, use only the genuine KIRLOSKAR spares for maintaining the excellent quality and reliability of the engines.

This Workshop Manual is subject to changes without notice, due to the improvements and alterations in the product designs. Necessary amendments will be laid down in the additional technical circulars issued from time to time. (These changes will be incorporated in the manual during reprinting).

While ordering the spare parts, always mention model, engine serial number punched on engine name plate and Publication number which is printed on the back side of Spare Parts List book. This will help us to supply correct parts to you.

KIRLOSKAR OIL ENGINES LIMITED,
LAXMANRAO KIRLOSKAR ROAD,
KHADKI, PUNE 411 003 (INDIA)

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SECTION - 1

BASIC ENGINE DETAILS

AND

SPECIFICATIONS

SECTION - 1

BASIC ENGINE DETAILS & SPECIFICATIONS

1.1 ENGINE DESCRIPTION.

Kirloskar 'HA' series engines are a family of 4 - stroke cycle, air cooled, in line, direct injection Diesel engines.

The engine models are :

HA294 - 2 cylinder
HA394 - 3 cylinder
HA494 - 4 cylinder
HA694 - 6 cylinder

A unit construction system with individual cylinder heads results in ease of servicing and ensures high degree of interchangeability of components throughout the series. Maximum economy and reliability combined with air cooling are the main features of these rugged diesel engines. This range uses the latest know-how. The power units are produced to meet the high precision and quality standards symbolised by the 'KIRLOSKAR' name.

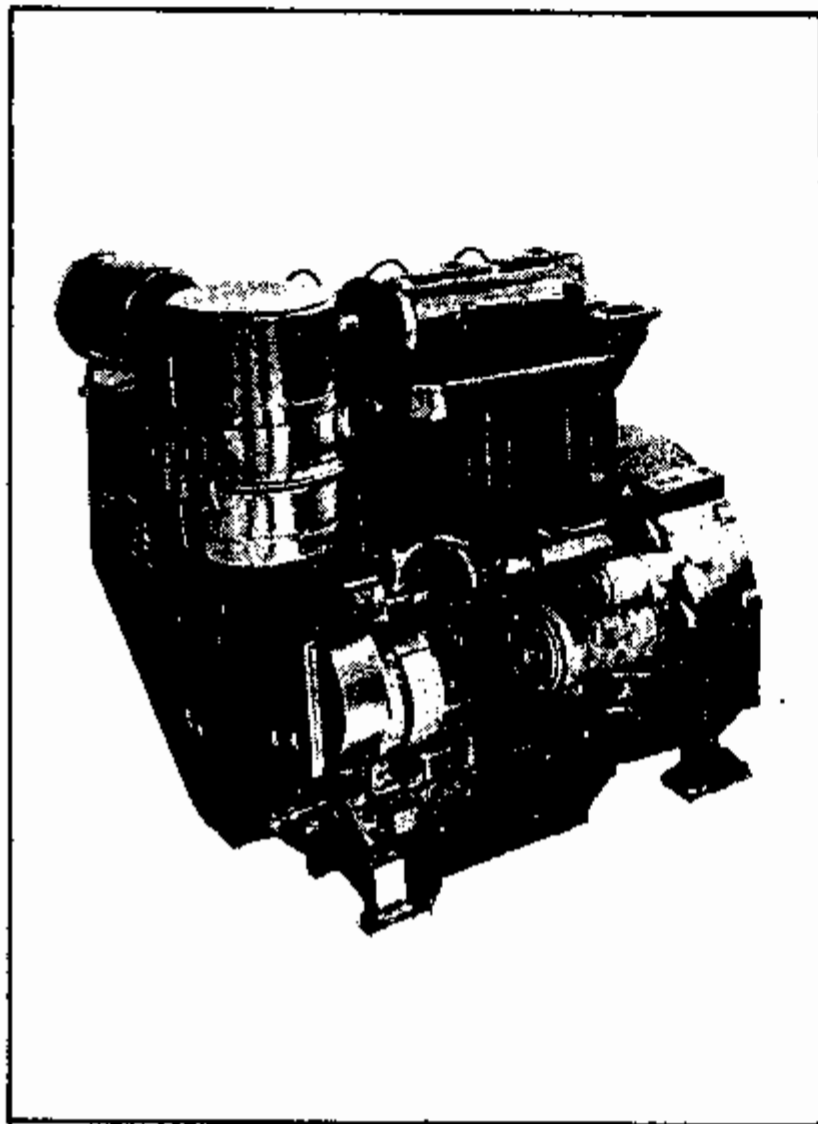


FIG - 1-1
HA394 ENGINE
gear end side view

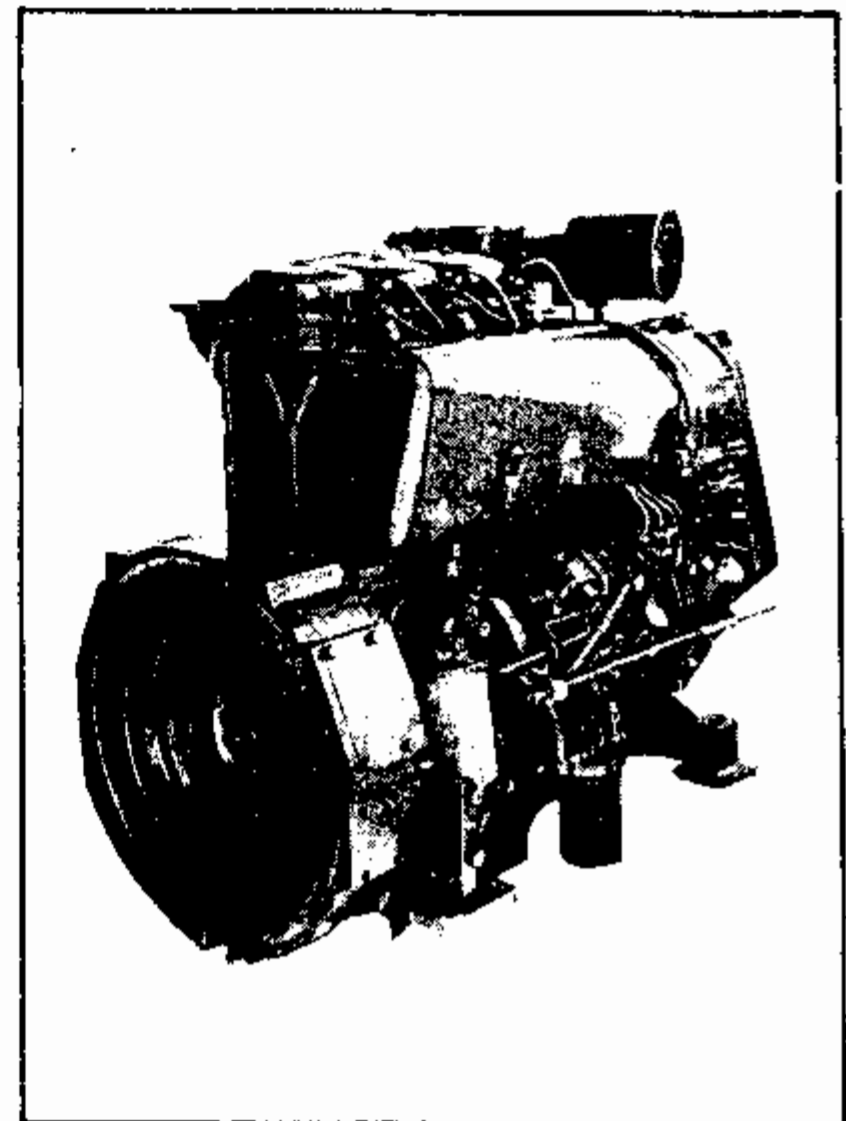


FIG - 1.2
HA394 ENGINE
flywheel end view

SPECIAL FEATURES

- . Heavy duty cast iron crankcase.
- . High quality steel forged crankshaft with journals and pins induction hardened and balanced dynamically.
- . High grade cast iron cylinder liners with fins for efficient cooling, individually replaceable.
- . Special aluminium alloy cylinder head with fins for adequate cooling. (Valve seat inserts are incorporated).
- . Forged carbon steel camshaft.
- . High silicon aluminium alloy piston with open type combustion chamber.
- . A highly efficient, quiet integral cooling fan having sufficient reserve capacity to cope with high ambient temperatures.
- . Box type lub. oil cooler.
- . Force feed lubrication by 'G' rotor type lub. oil pump.
- . An in-line multi cylinder block type fuel pump is mounted on crankcase, and driven through timing gears. Fuel pump feeds fuel to a long stem multiholes type nozzles resulting in low fuel consumption and easy starting.
- . Oil spray nozzles are provided for piston cooling.
- . Low noise and exhaust emission levels.
- . The versatility of this engine range makes it equally suitable for a vast range of applications such as tractors, agricultural equipment, construction machinery, power generators, compressors, cranes, hoists, automative applications, marine and other industrial units.

1.2 TECHNICAL SPECIFICATIONS.

1.2.1 GENERAL SPECIFICATIONS.

Sr. No.	DATA	Units	Specifications.			
			HA294	HA394	HA494	HA694
01	Cubic Capacity	cc	1884	2826	3768	5652
02	Working cycle	--	Four stroke diesel cycle			
03	Combustion system		Direct Injection			
04	Cooling system		Air cooled			
05	No. of cylinders		2	3	4	6
06	Bore	mm	100	100	100	100
07	Stroke	mm	120	120	120	120
08	Direction of rotation		Counter clockwise (Looking at flywheel end)			
09	Compression ratio		17:1	17:1	17:1	17:1
10	Compression pressure	kg/cm ²	24 - 28			
11	Max. firing pressure	kg/cm ²	(min. acceptable 20)			
12	Min. Operating speed	RPM	1500	1500	1500	1500
13	Max. Operating speed	RPM	2500	2800	2800	2800
14	Low idling speed	RPM	700	650	650	650
15	Bumping clearance	mm	1.0 to 1.2			
16	Valve clearance, cold for Inlet	mm	0.15			
	Exhaust	mm	0.15			
17	Valve timing					
	Inlet opens before T.D.C.	Degree	26	32	32	32
	Inlet closes after B.D.C.	Degree	67	60	60	60
	Exh. opens before B.D.C.	Degree	73	70	70	70
	Exh. closes after T.D.C.	Degree	30	32	32	32
18	Firing order		1-2	1-2-3	1-3-4-2	1-5-3-6-2-4

1.2.1 GENERAL SPECIFICATIONS (CONTINUED)

Sr. No.	DATA	Units	Specifications			
			HA294	HA304	HA494	HA694
19	Overall dimensions (Bare engine)					
	Total Length	mm	678	808	938	1277
	Total width	mm	704	704	704	704
	Total height	mm	872	868	868	922
	Height below crankshaft centre line	mm	301	297	297	300
20	Total weight without flywheel	kg	243	300	338	430
	Weight of Std. flywheel	kg	41	41	39	39
	Weight of flywheel for Genset appli- cation.	kg	83	83	47	47
21	Engine ratings	refer maintenance manual			

1.2.2 FUEL INJECTION EQUIPMENTS.

Sr. No.	DATA	HA294	HA394	HA494	HA694
01	Fuel injection pump make	MICO/Nippondenso			
02	Governor	MICO /Nippondenso RSV type, Mechanical			
03	Feed Pump (fuel lift pump)	MICO/Nippondenso Single acting, fitted on fuel pump.			
04	Injection nozzle	MICO Multihole, long stem type			
05	Nozzle pressure	175 + 8 bar			
06	Fuel injection timings before T.D.C. in relation to crank angle.				
	Without auto-timer unit				
	1500 - 1800 rpm	29°	26°	26°	29°
	1801 - 2300 rpm	32°	30°	30°	32°
	2301 - 2800 rpm	32°	32°	32°	35°
	Engine with auto-timer unit				
	2800 rpm	22°	22°	22°	25°
	2300 rpm (Tractor Application)	-	28°	28°	-

NOTE:

Fuel injection timing given in Degrees can be transformed to the length 'L' for marking on crank pulley or flywheel.

$$L = \frac{d \times 3.14 \times \text{Timing angle}}{360^\circ}$$

d = Outside diameters of crank pulley or flywheel.

1.3 DIMENSIONS AND RUNNING CLEARANCES OF IMPORTANT COMPONENTS
(INCLUDING CONDEMNATION LIMITS)

Component	Dimension in mm			
	HA294	HA394	HA494	HA694
1.3.1 CYLINDER HEAD				
Valve guide outside dia.	15	+0.056 +0.045		
Valve guide bore in head	15	+0.011 +0.000		
Valve guide inside bore (pressed in)	8	+ 0.015		
Valve stem dia. Inlet	7.96	-0.015		
Exhaust	7.94	-0.020		
Valve stem clearance, normal				
Inlet		0.04 to 0.07		
Limit value		0.3		
Valve stem clearance, normal				
Exhaust		0.060 to 0.095		
Limit value		0.5		
Valve seat outside dia-inlet	45.66	-0.02		
Counter bore in cyl. head	45.50	+0.025		
valve seat outside dia-exhaust	40.16	-0.02		
Counter bore in cyl head	40.0	+0.025		
Valve seat sealing width for Inlet and Exhaust	1.0	+ 0.5		
Valve head - Inlet	43	± 0.1		
Exhaust	37	± 0.1		
Seat angle	45°			
Rim thickness Inlet	1.0	-0.2		
Exhaust	1.5	-0.2		
Wear limit	0.5			

Component	Dimension in mm			
	HA294	HA394	HA494	HA694
Valve recess - Maximum (Distance between cyl. head seating face and valve face) Minimum		5.681		
		5.078		
Max. distance between cyl. head bottom and cyl.head seating face		6.3		
Limit value		5.8		
Valve spring total coils		7		
Free length		59 \pm 1.9		
Free length limit value (Fatigue limit)		56		
Nominal length of cylinder head bolt		211 \pm 0.5		
Limit value		212.5		
Valve rocker bush inside dia. (Pressed in lever)		18.014+ 0.049		
Steel bush outside dia.		18.0 - 0.006 - 0.017		
Clearance, normal		0.02 to 0.08		
limit value		0.3		
1.3.2 <u>CYLINDER LINER</u>				
Bore (Normal)		100 + 0.022		
Wear limit		0.2		
1.3.3 <u>PISTON</u>				
Dia. normal (as punched on the crown).		99.91		

Component	Dimension in mm			
	HA294	HA394	HA494	HA694
<u>Piston Dia</u>				
<u>At top of skirts</u>				
Along piston pin axis	99.58	± 0.02		
Across piston pin axis	99.78	± 0.009		
<u>At bottom of skirt</u> (17 mm from bottom)				
Along piston pin	99.71	± 0.02		
Across piston pin axis	99.91	± 0.009		
Bore for piston pin	35	+ 0.006		
Outside dia of Piston pin	35	- 0.005		
Piston ring groove width of 1st groove.	2.205	+0.12 +0.10	at 97	- 0.1 Ø
Width of 2nd & 3rd grooves	2.5	+0.11 +0.09		
Width of oil control ring groove	5.0	+0.050 +0.030		
1.3.4 <u>PISTON RINGS</u>				
Side clearance -				
1st compression ring	0.079	to 0.119		
Limit value		0.5		
2nd compression ring	0.1	to 0.132		
Limit value		0.3		
3rd compression ring	0.1	to 0.132		
Limit value		0.3		
4th oil control ring	0.04	to 0.072		
Limit value		0.15		
Butt gaps - (As measured in bore)	setting ring of 100 mm	+0.01 +0.00		
All compression rings	0.35	+ 0.2		
Gap limit value		4.0		
4th oil control ring	0.25	+ 0.15		
Gap limit value		2.5		

Components	Dimension in mm			
	HA294	HA394	HA494	HA694
1.3.5 <u>CONNECTING ROD</u>				
Big end bearing bore	64 + 0.019			
Bearing inside dia.	60 + 0.039			
Number of under sizes	6 under sizes with the step of 0.25 and with same tolerance for bore			
Minimum inside dia.	58.5 + 0.039			
Nominal wall thickness	1.995 ± 0.005			
Over size wall thickness in 6 steps	Each step of 0.25 O/S with tolerance of normal size.			
Width of bearing	25.0 - 0.2			
Width of connecting rod	33.6 -0.082 -0.142			
Big end bearing clearance	0.04 to 0.098			
Limit value	0.3*			
Side clearance normal	0.48 to 0.581			
Side clearance limit value	0.8			
Connecting rod small end bush inside dia. (Pressed in)	35.04 +0.046			
Clearance between bush & Piston pin - Normal	0.04 to 0.091			
Limit value	0.25			
* Replacement of bearing is governed by lub. oil pressure.				
1.3.6 <u>INTERMEDIATE GEAR & SUPPORT</u>				
Bearing inside dia.	40 + 0.041 + 0.025			
Journal dia.	40 - 0.009 - 0.025			
Bearing clearance	0.034 to 0.066			
Limit value	0.1			
1.3.7 <u>CAM SHAFT</u>				
Side clearance (end play)	0.2 to 0.3			

Component	Dimension in mm			
	HA294	HA394	HA494	HA694
Radial clearance	0.05 to 0.114			
Radial clearance limit value	(Replacement of bearing is governed by oil pressure) 0.2			
Bearing bush inside dia.	47.98 + 0.054			
1.3.8 <u>CRANKSHAFT</u>				
Crank pin dia.	59.97 - 0.010 - 0.029			
No. of under sizes	6 under sizes with each step of 0.25 mm on dia.			
Nominal Hardness	58 \pm 3 RC			
Limit value	50 RC			
Journal dia	70 - 0.010 - 0.029			
No. of undersizes	6 undersizes with each step of 0.25 on dia.			
Length of journal	34 + 0.039			
Hardness nominal	58 \pm 3 RC			
Limit value	50 RC			
Bore for main bearing	74.5 + 0.019			
Main bearing inside dia.	70.04 + 0.043			
No. of under sizes	6 under sizes with each step of 0.25 on dia.			
Radial clearance in main bearing normal	0.050 to 0.112			
Limit value	0.3*			
Thrust half rings				
Thickness	2.985 -0.05			
No. of over sizes	Could be made available in 0.25 & 0.50 mm O/S			
Crankshaft end play normal	0.15 to 0.314			
Limit value	0.8			
* Replacement of bearing is governed by lub. oil pressure.				

Component	Dimension in mm			
	HA294	HA394	HA494	HA694
1.3.9 <u>LUB. OIL PUMP</u>				
Pump speed RPM (corresponding to engine speed 2300 RPM).		2580		
Delivery at 4.5 kg/cm ² (l/min)	19	32	32	46
Side clearance of rotors				
Normal		0.038 to 0.083		
Limit		0.1		
Limit value for Radial clearance.		0.25		
Lub. oil pump outside gear back lash with crank shaft gear		0.1 to 0.2		
Relief valve opening on lub.oil pump kg/cm ²		5 to 6		
For grade of lub. oil to be used refer "Maintenance Manual".		-		

TO PREVENT THE FAULTY ASSEMBLY FOLLOWING INFORMATION ON TIGHTENING OF HIGH TENSILE BOLTS IS IMPORTANT AS THE TIGHTENING PROCEDURE DIFFERS FROM THAT NORMALLY EMPLOYED. THE TIGHTENING ANGLE IS PARTICULARLY IMPORTANT. HENCE FIG. NO. 1-3 INDICATES HOW THE VARIOUS ANGLES CAN BE READILY OBTAINED BY COMPARISON OF CLOCK FACE.

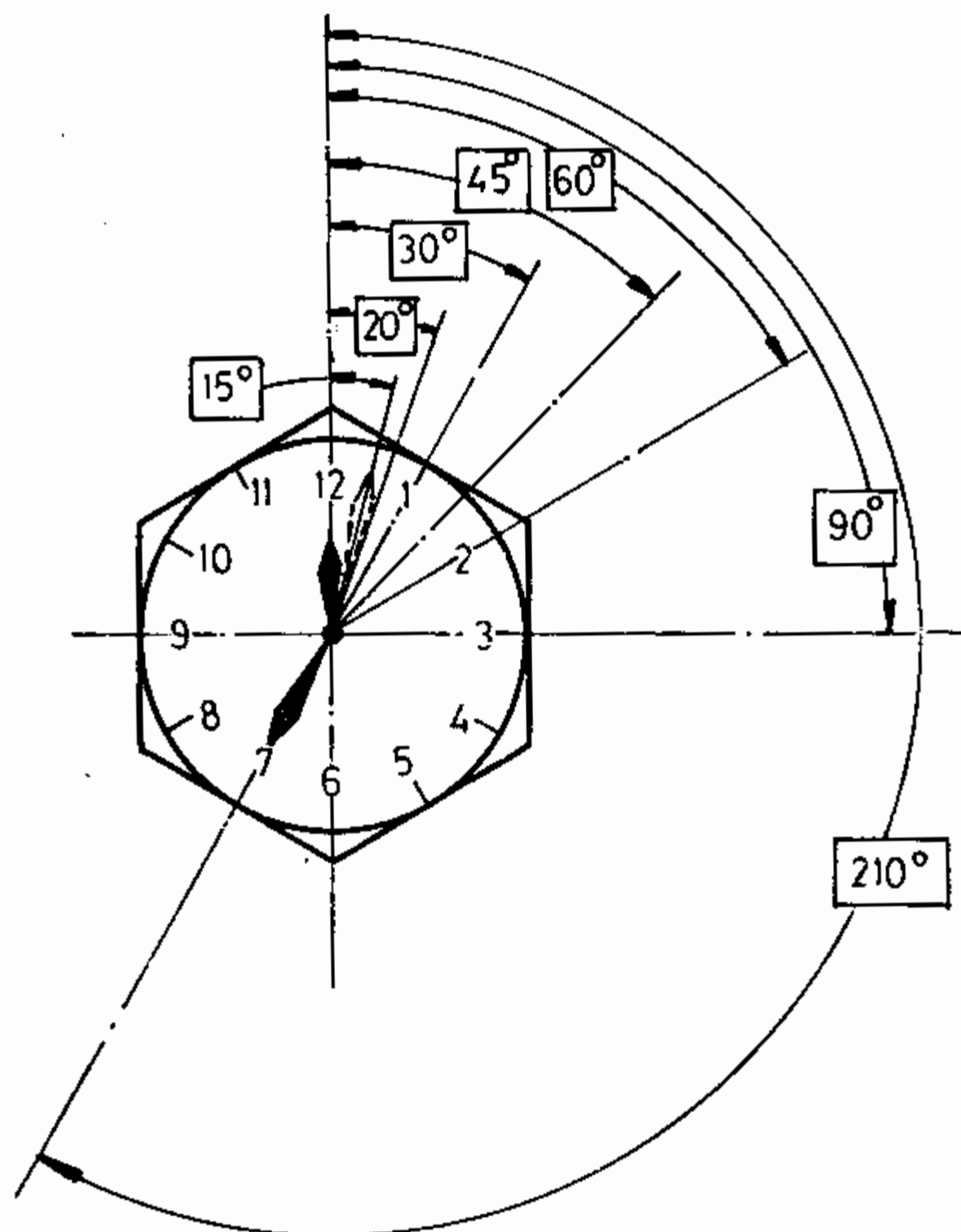


FIG.1-3

TOMMY BAR IS TO BE CLAMPED IN THE TOOL SLOT AND SPECIFIED ANGLE IS TO BE TURNED WITH REFERENCE TO THE INITIAL GRADUATION ON OUTER DIAL OF THE TOOL OR A RELATION OF HEX. HEAD OF BOLT CAN ALSO BE REFERRED.

- 1) LUBRICATE THREADS AND SEATING OF BOLT WITH ENGINE OIL BEFORE IT IS ASSEMBLED.
- 2) SCREW THE BOLT BY HAND TILL IT IS ENGAGED UPTO THE SEATING FACE.
- 3) APPLY INITIAL TORQUE AS SHOWN IN THE TABLE.
- 4) TIGHTEN THE BOLTS ACCORDING TO THE ANGLES, IF NECESSARY IN STAGES.

TIGHTENING TABLE FOR BOLTS (SCREWS, NUTS)

(ANGLE TORQUE METHOD)

DESCRIPTION	SIZE	INITIAL TORQUE Nm	TIGHTENING ANGLE			TOTAL ANGLE	REMARKS
			1st STAGE	2nd STAGE	3rd STAGE		
<u>CYLINDER HEAD BOLT</u>		30	45°	45°	45°	135°	
<u>CONNECTING ROD BOLT</u>	M12 x1.5 x55	30	30°	60°	-	90°	
<u>BEARING CAP BOLT</u>	M14 x110	30	45°	60°	-	105°	
<u>INTERMEDIATE GEAR BOLT</u>	M10 x60	30	60°	-	-	60°	
<u>BALANCE WEIGHT BOLT</u>	M12 x60	30	30°	30°	-	60°	
<u>FLYWHEEL BOLT</u>	M10 x1 x35	30	30°	60°	-	90°	
<u>FLYWHEEL BOLT</u>	M10 x1 x40	30	30°	60°	-	90°	
<u>FLYWHEEL BOLT</u>	M10 x1 x45	30	30°	60°	-	90°	
<u>FLYWHEEL BOLT</u>	M10 x1 x50	30	30°	60°	-	90°	
<u>CRANK PULLEY BOLT</u>	M24 x2 x110	50	210°	-	-	210°	
<u>COOLING BLOWER BOLT</u>	M12 x140	30	30°	60°	-	90°	
<u>COOLING (HA694) BLOWER BOLT</u>	M12 x180	30	30°	60°	-	90°	
<u>NUT FOR FUEL INJECTOR</u>	M10 x1.5	-	-	-	-	-	25 Nm

NOTE : IN CASE OF REPLACING MAIN & BIG END BEARINGS/
OVERHAUL /PISTON SEIZURES, FIT NEW BOLTS FOR MAIN
BEARING CAP AND CONNECTING ROD CAP.

1 Nm = 0.10197162 kgm
= 0.73756215 lb.ft.

1.5 ENGINE NUMBERING SYSTEM

Engine number is punched on the name plate which is fixed on crankcase.

0	3		1	0	0	4	/	8	3	1	0	2	5
Engine Number		Application code number				Year of Manu- facture			Engine serial number				

First two digits : Indicate engine type

No. 02 represents HA294 engine

No. 03 represents HA394 engine

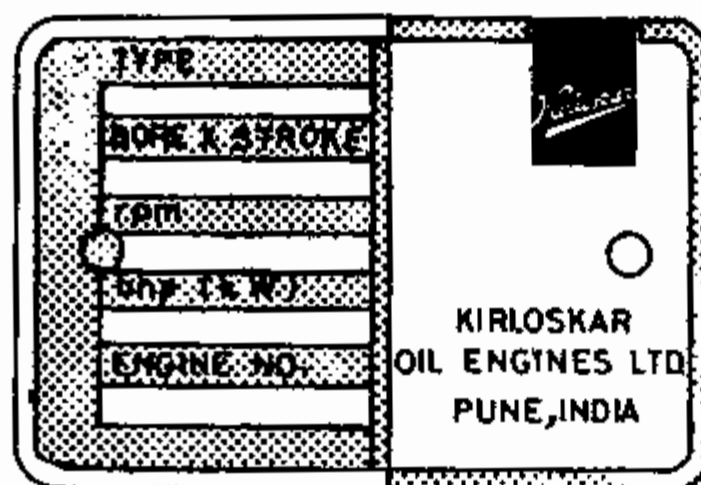
No. 04 represents HA494 engine

No. 06 represents HA694 engine

Next four digits : Indicate application code number for a particular scope of supply (i.e. build) (The build is defined by the complete number, including first two digits. For example 03.1002. The build of different engines, with identical code numbers is not necessarily identical. For example build of HA294 engine 02.1002 and HA394 engine 03.1002 may not be identical).

Two digits after slash : Indicate the year of manufacture.

Remaining four digits : Indicate engine serial number.



1-4

" ALWAYS FURNISH THE COMPLETE ENGINE NUMBER, PUNCHED ON ENGINE NAME PLATE, WHILE ORDERING PARTS ".

SECTION - 2

SERVICING AIDS

SECTION – 2

SERVICING AIDS

2.1 STANDARD TOOLS

SR. NO.	TOOL PART NO.	TOOL DESCRIPTION	SPECIFICATION
		Double ended open jaw spanner (open ended wrench)	
01	507 04/13	"	10mm x 12 mm
02	5 07 04/05	"	13 mm x 17 mm
03	5 0704 /14	"	14 mm x 17 mm
04	50704 /06	"	19 mm x 22 mm
		Ring spanners (Box end wrenches)	
05	-	"	12 mm x 13 mm
06	-	"	14 mm x 17 mm
07	-	"	19 mm x 22 mm
		Box spanner (Sockets)	
08	-	"	13 mm
09	-	"	17 mm
10	-	"	19 mm
11	-	"	22 mm
12	-	"	36 mm
		Adjustable spanner (Adjustable wrench)	6 in
13	-	Speeder	600 mm (24 in long)
14	-	Extension	225 mm (9 in long)
15	-	Ratchet	300 mm (12 in long)
16	-	Hammer	1 kg (2 lbs)
17	-	Soft face hammer	40 mm (1 1/2 in dia)
18	-	Inside circlip plier (Internal snap ring plier)	150 mm (6 in dia)
19.	-	Cutting plier (side cutter)	150 mm (6 in long)
20	-	Wire cutting plier for electrical wiring.	150 mm (6 in long)

2.1 STANDARD TOOLS (CONTINUED)

SR. NO.	TOOL PART NO.	TOOL DESCRIPTION	SPECIFICATION
21	-	Screw driver	150 mm (6 in long)
22	-	Screw driver	300 mm (12 in long)
23	-	Screw driver for electrical system.	100 mm (4 in long)
24	-	Torque wrench	EVT600RR 0 to 7 kgm (0 to 50 lb.ft)
25	-	Punch	225 mm (9 in long)
26	-	Micrometer	0 to 100 mm(0 to 4 in)
27	-	Feeler gauge set	-
28	-	Flat file	300 mm (12 in long)
29	-	Round file	10 mm dia(3/8 in dia)
30	-	Stud driver	M8 x 1.25
31	-	Stud driver	M10 x 1.5
32	-	Crow bar	20mm dia x 1000 mm long (3/4 in dia x 3 ft long)
33	-	Sheet metal trays	-
34	-	Oil pouring pan (To fill lub. oil in the sump).	-
35	-	Oil collecting pan(while draining engine oil)	-
36	-	Wire brush	-
37	-	Allen keys	5 mm A/F, 6 mm A/F & 12 mm A/F

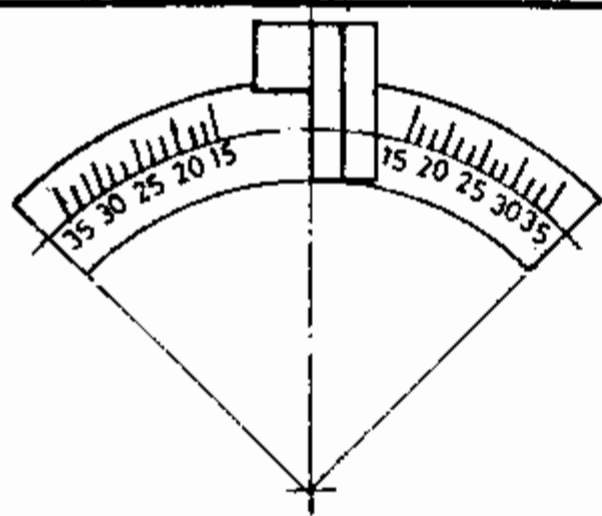
NOTE : WHERE THE TOOL PART NUMBER IS NOT MENTIONED, USE THE TOOL AVAILABLE IN THE LOCAL MARKET AS PER THE SPECIFICATION GIVEN ABOVE.

2 . 2 SPECIAL TOOLS

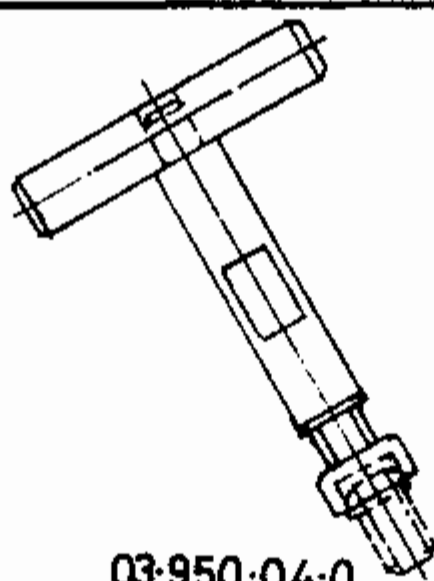
SR. NO.	TOOL PART NO.	TOOL DESCRIPTION
01	03.950.03.0	T.D.C. marking and fuel timing checking gauge.
02	03.950.04.0	Oil spray nozzle tightening and removing spanner for HA294/394/694 & 494 engine without secondary balancing arrangement.
03	03.950.05.0	Valve guide pressing and removing punch.
04	03.950.06.0	Oil control screw driver (in cam bore).
05	03.950.07.0	Cylinder head bolt tightening box spanner.
06	03.950.08.0	Push rod tube spring holder.
07	03.950.09.0	Flywheel puller.
08	03.950.10.0	Cam bush pressing and removing punch.
09	03.950.11.0	Nozzle holder guide pressing punch.
10	03.950.12.0	Valve rocker bush pressing punch.
11	03.950.13.0	Valve spring compressor.
12	03.950.14.0	Valve seat insert(in position)seat lapping tool.
13	03.950.15.0	Nozzle washer in cylinder head removing punch.
14	03.950.16.0	Piston inserting ring.
15	03.950.17.0	Crank pulley holding pipe spanner.
16	03.950.18.0	connecting rod small end bush pressing and removing punch.
17	03.950.19.0	Intermediate gear pressing and removing punch.

2 . 2 SPECIAL TOOLS (CONTINUED)

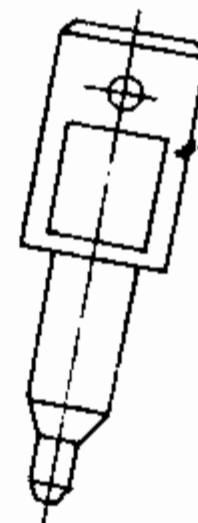
SR. NO.	TOOL PART NO.	TOOL DESCRIPTION
18	03.950.20.0	Cambore dish plug pressing punch.
19	03.950.21.0	Oil seal pressing mandrel in front cover.
20	03.950.22.01	Oil seal pressing mandrel in Flywheel end oil seal housing.
21	03.950.23.0	Bearing bushes in housing of belt tensioning unit pressing and removing punch.
22	03.950.24.0	Ball bearings in fan body pressing and removing punch.
23	03.950.25.0	Oil seal on front cover removing puller (without removing front cover).
24	03.950.26.0	Oil seal on front cover pressing mandrel (without removing front cover).
25	04.950.01.0	Oil spray nozzle removing 'C' clamp & bush for HA494 with secondary balancing arrangement.
26	04.950.02.0	Oil spray nozzle pressing tool for HA494 with secondary balancing arrangement.
27	05343	Tightening tool for fasteners.
28	02.021.01. 0/713	Connecting rod big end and small end bore parallelity checking gauge.
29	53300	Special reamer for HA V.R. lever bush reaming.
30	53301	Special reamer for HA intermediate gear bush reaming.
31	53302	Special reamer for HA Con. rod small end bush reaming.
32	02.950.01.0	Fixture for injector removal.
33	03.950.27.0	FUEL pump gear hub removing puller



03-950-03-0



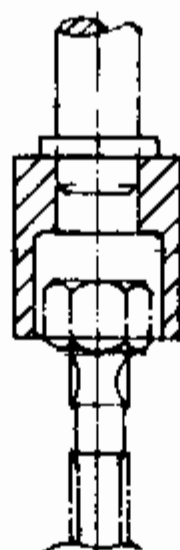
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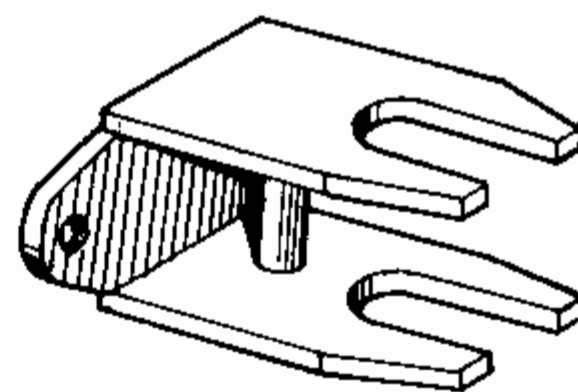
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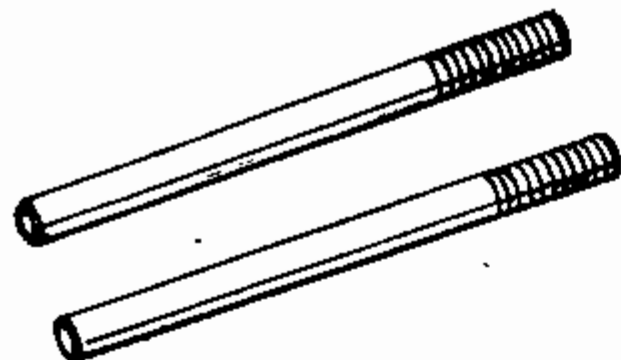
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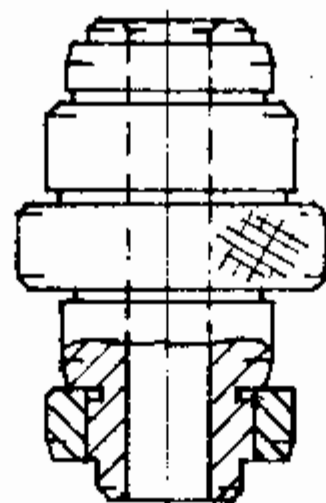
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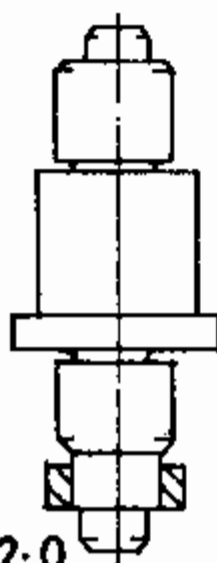
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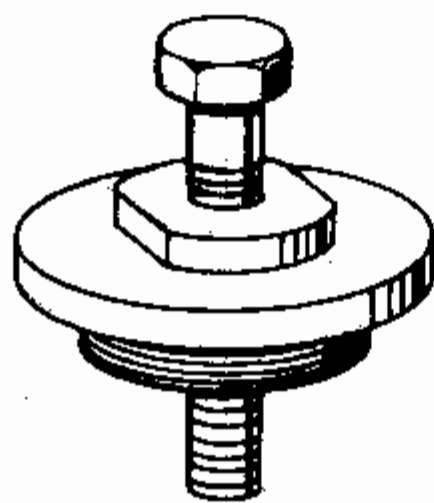
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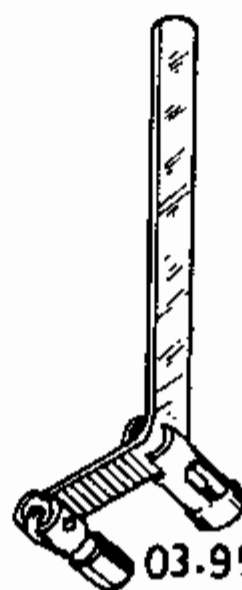
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03-950-12-0



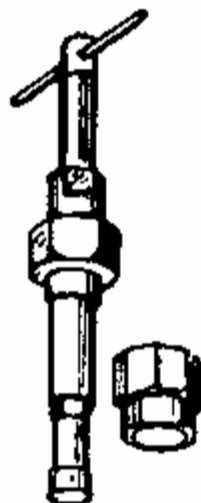
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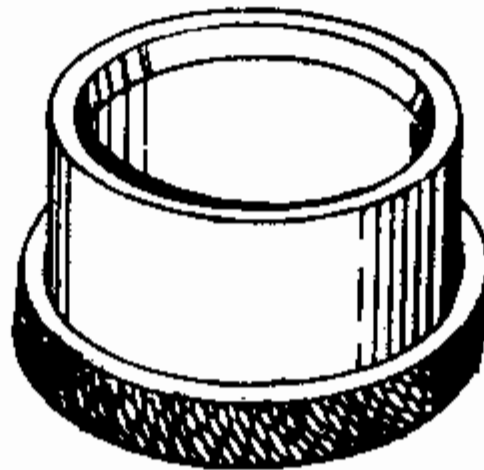
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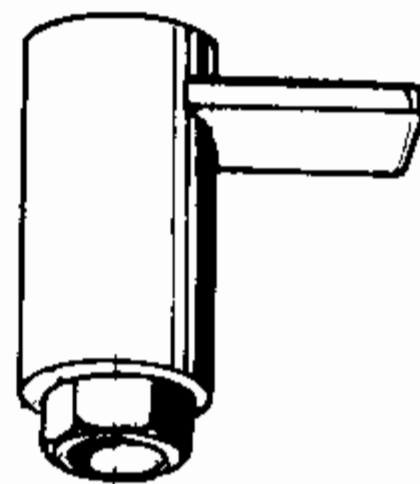
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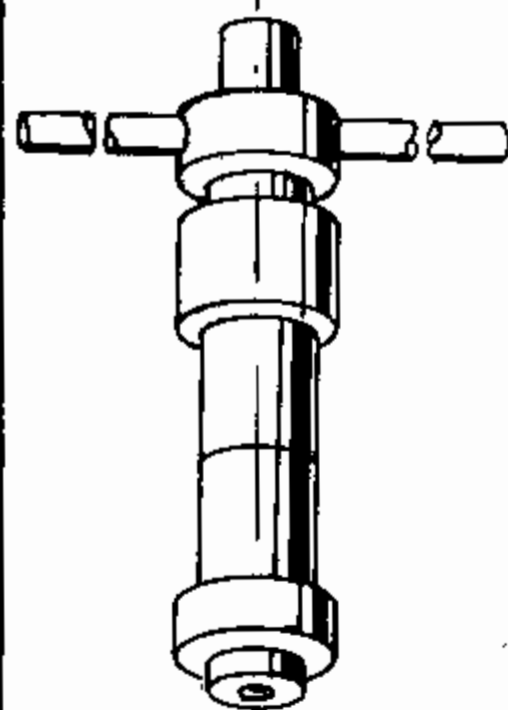
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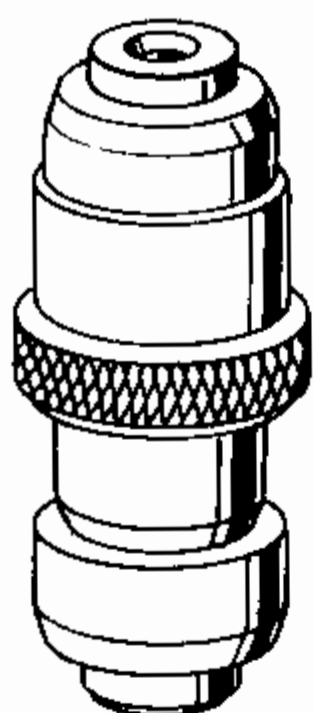
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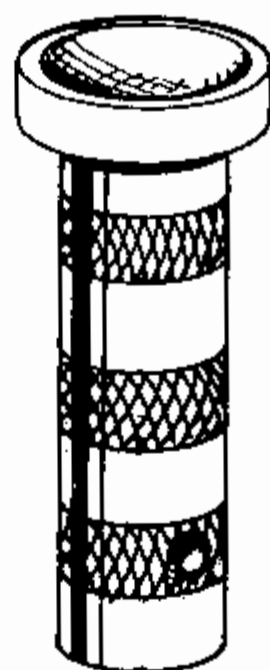
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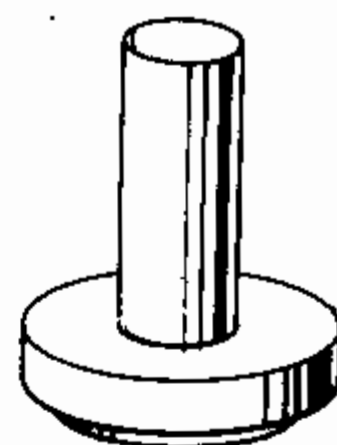
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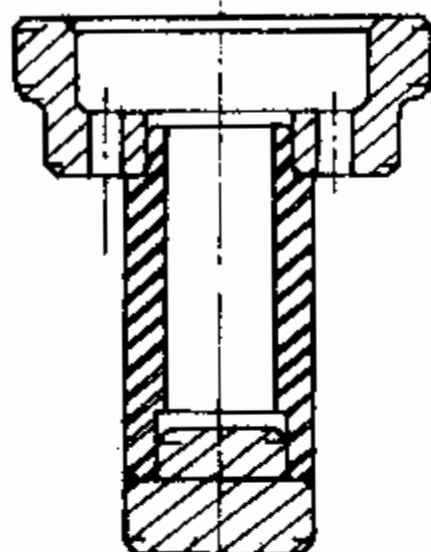
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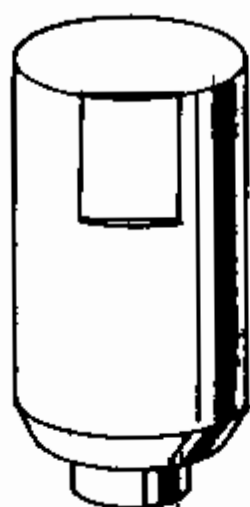
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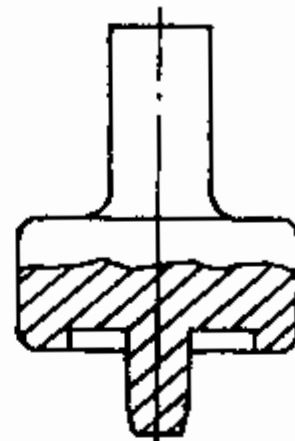
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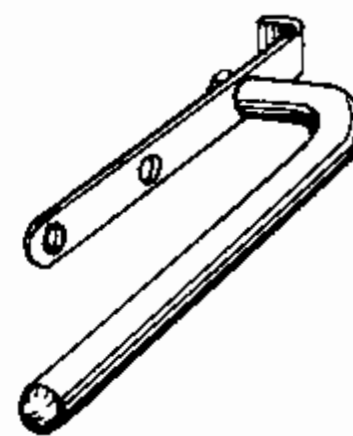
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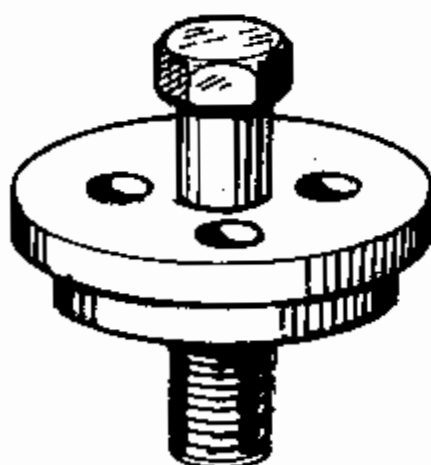
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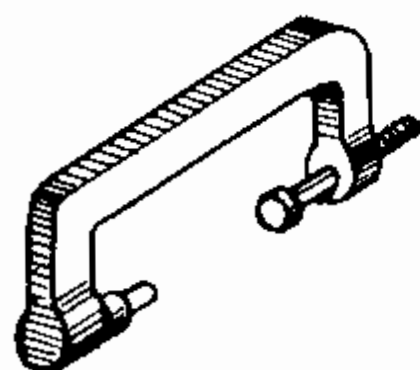
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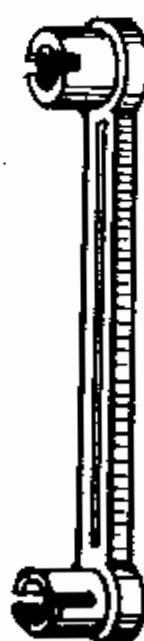
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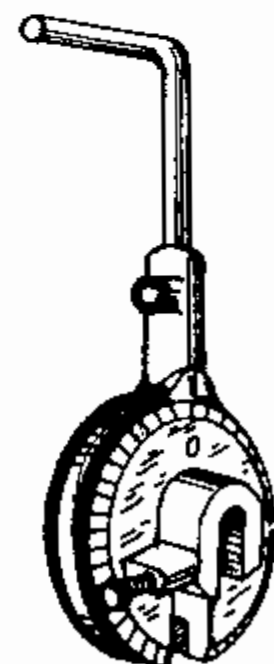
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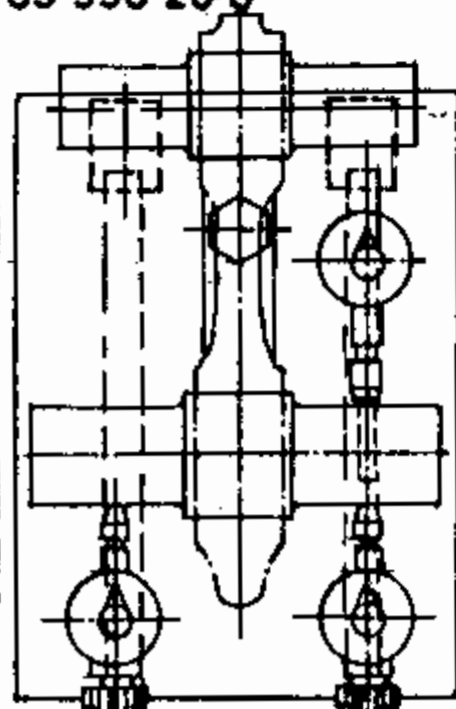
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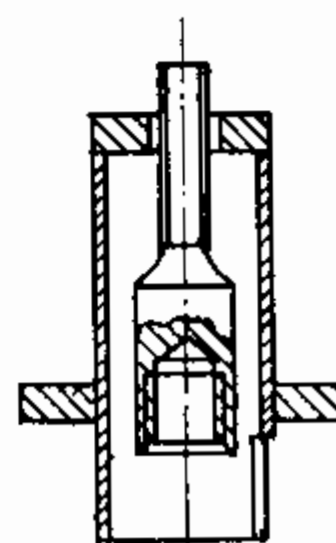
53300



53801



53302



02-950-01-0

2.3 ENGINE LIFTING DEVICE.

2.3.1 FOR BARE ENGINE -

To avoid the bending of the engine lifting studs, during lifting up of the engine, a steel plate as shown in the sketch (fig. 2-3) is to be used alongwith the standard bolt of size M8x70mm long.

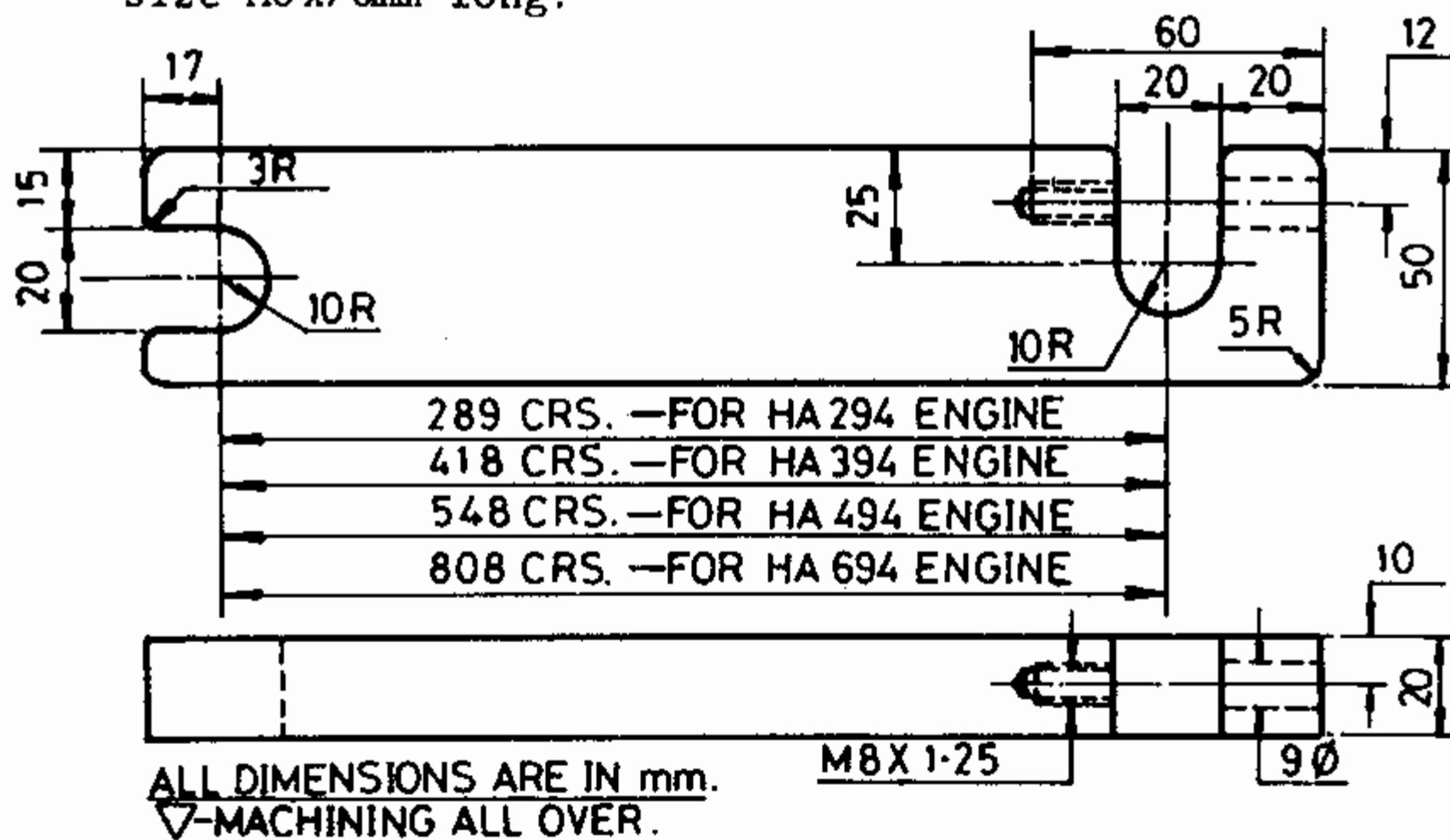


FIG 2-3

Before lifting the engine first fix the lifting hooks on the engine (lifting hooks are provided with the engine). Place the above plate on lifting hook by engaging two slots of the plates to the neck diameters of the hooks. Then screw-in bolt of M8x70 mm long in the tap hole provided on the plate. Insert the bar through lifting hooks, put the wire rope/chain on the bar and then lift the engine (see Fig. 2-4).

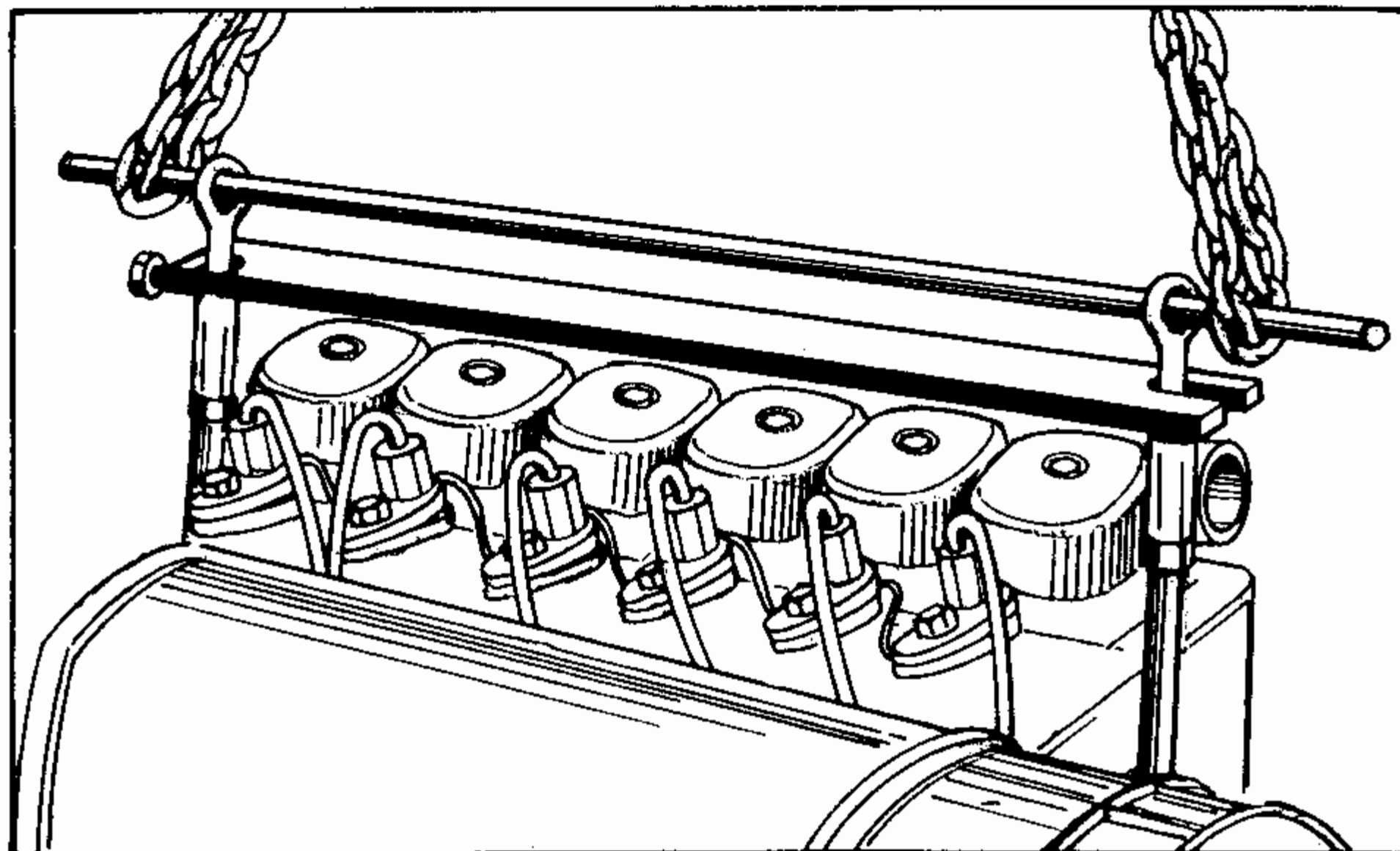
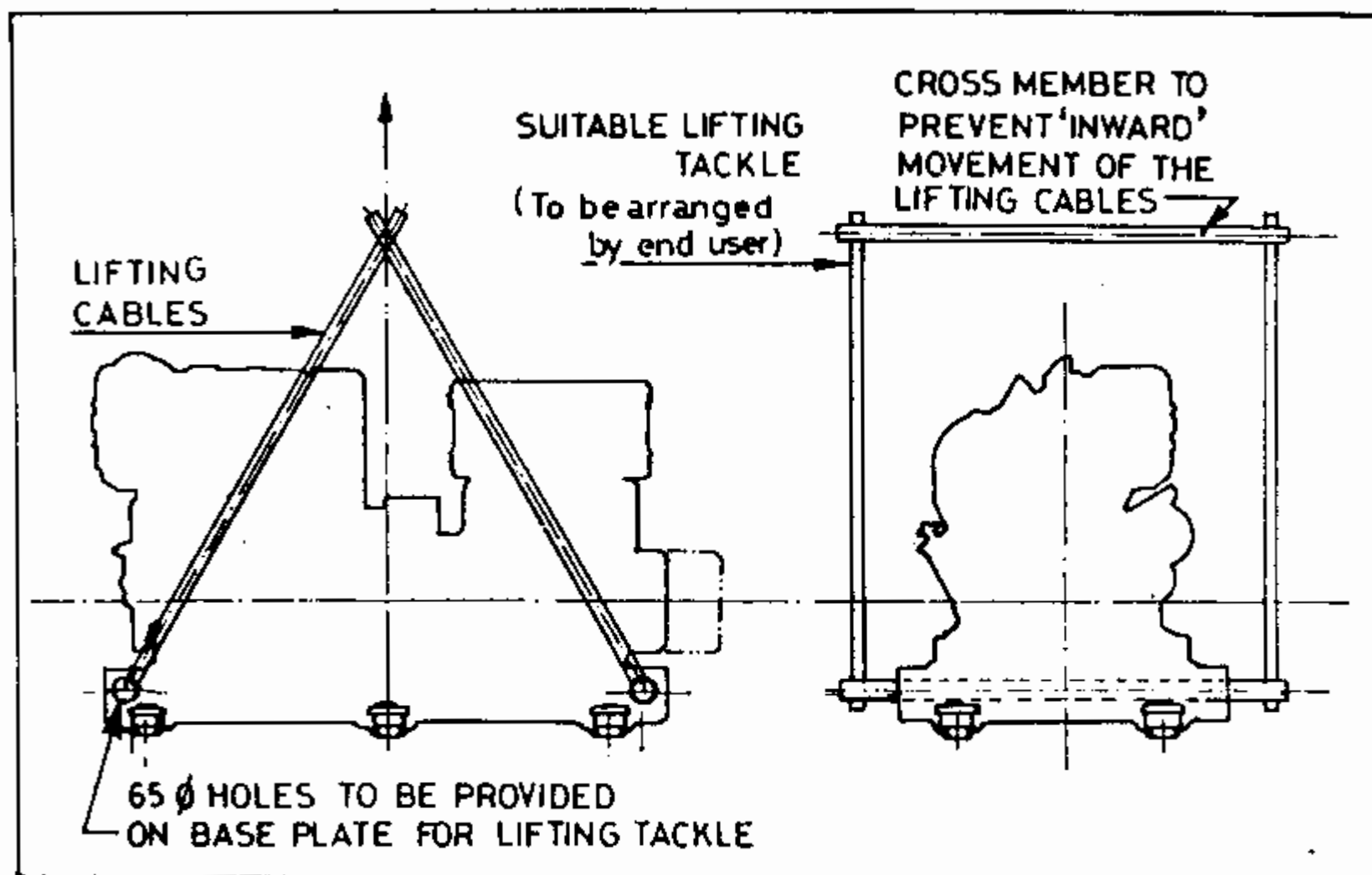


FIG 2-4

2.3.2 RECOMMENDED LIFTING ARRANGEMENT FOR GENSET, PUMP SET, MARINE AUX. GENSET OR ANY OTHER SIMILAR UNITS MOUNTED ON BASE PLATE -

The lifting hooks provided on engine are meant for lifting bare engines. Use of engine lifting hooks for lifting of Gensets, Pumpsets or any other similar sets mounted on base-plate, results in bending of the studs for lifting and can cause damage to engine/set in event of breakage. Hence, we recommend the use of proper sling/tackle arrangement for lifting of such baseplate mounted sets. Fig. 2-5 below shows the recommended lifting arrangement.



RECOMMENDED LIFTING ARRANGEMENT FOR GENSETS/PUMPSETS/
OTHER SIMILAR SETS

FIG. 2-5

SECTION - 3

ENGINE PRESERVATION SYSTEM

SECTION – 3

ENGINE PRESERVATION SYSTEM

If the engine is going to remain out of use for more than 4 to 6 months, following preservation procedure should be followed before storing the engine.

3.1 RECOMMENDED PRESERVATIVES

FUEL SYSTEM	- Auto-Prun 38 (Hindustan Petroleum)
LUBRICATING SYSTEM	- Bharat Rustrol engine oil corresponding SAE No. OR Auto-Prun 38 (HP).
RUST PROOF OIL FOR EXTERNAL SURFACES	- Bharat TCPF 60 OR Rustop 387/388 of Hindustan Petroleum.

NOTE : THE ABOVE PRESERVATIVES ARE THE RECOMMENDED BRANDS FROM HINDUSTAN PETROLEUM & BHARAT PETROLEUM. USE EQUIVALENT PRESERVATIVES OF OTHER MANUFACTURERS WHERE THE ABOVE BRANDS ARE NOT AVAILABLE.

3.2 PRESERVATION PROCEDURE

- 3.2.1 Run the engine for 15 minutes at idling speed. During this period speed up engine a few times to top speed.
- 3.2.2 After having stopping engine disconnect fuel connections. Drain fuel oil from all fuel lines, fuel pump and fuel filter. Fill in a suitable preservative and turn the engine slowly to fill in this in fuel pump, high pressure fuel lines and injectors.
- 3.2.3 Drain and flush lub. oil system and fill in a suitable preservative of same corresponding SAE number as of engine lub. oil.
- 3.2.4 Clean the exhaust silencer, spray Auto-Prun 38 into exhaust outlets. Similarly remove injectors and spray 1/4 lit. of Auto-Prun 38 into cylinder bores. Refit the injectors.

3.2.5 The battery, if any, to be kept in dry condition.

NOTE :DO NOT ROTATE CRANKSHAFT AFTER THE ABOVE MENTIONED CONDITIONS.

3.2.6 Drain off preservative oils.

3.2.7 Where applicable, as for example in the case of stationery and bare engines when piping and/or fittings have been removed for shipment, all the open flanged joints i.e. inlet and exhaust manifolds, etc. must be sealed with properly seating blind flange and gaskets after treatment with Bharat TCPF 60. The disconnected flange (s) on the piping or fitting(s) should similarly be treated with Bharat TCPF 60.

3.2.8 Treat all unpainted external ferrous metal parts with two coats of Bharat TCPF 60 allowing sufficient time for the first coat to thoroughly dry before applying the second coat.

3.2.9 All vents (i.e. engine exhaust pipe, inlet pipe, etc.) dynamo, starter motor, if any, and air filters to be carefully sealed with water proof paper and water proof adhesive tape.

3.2.10 Dipstick on engine to be sealed in place with water proof adhesive tape.

3.2.11 Oil and fuel tank filter caps to be air-tight sealed with water proof adhesive tape.

3.2.12 Attach, to each item concerned an appropriate label describing treatment effected and instructions for starting up the engine (labels to be water proof).

3.2.13 Spare parts and tools to be similarly treated with Bharat TCPF 60.

3.2.14 Instruction books and spare parts list to be packed in a soldered air tight tin fastened by bolts to the engine frame/packing box.

- 3.2.15 Store engine in place protected from weather and where air is dry and temperature uniform, if possible.

NOTE : THE ENGINE CAN BE KEPT MAXIMUM 1 1/2 YEARS IN PRESERVED STATE BEFORE INSTALLATION AND SUBSEQUENT TRIALS ETC. IF THE ENGINE IS TO BE KEPT MORE THAN 1 1/2 YEARS THE SAME PRESERVATION PROCEDURE MENTIONED ABOVE TO BE FOLLOWED AFTER EVERY 1 1/2 YEARS.

3.3 DE-PRESERVATION SYSTEM

In case of an engine which has been stored for some time, the first essential thing is to clean the engine internally and externally. Drain out preservatives from fuel and lub. oil system. Check the presence and tightening of all nuts, bolts, lock washers, etc. and adjustment of valve clearances.

Follow the instructions given in maintenance manual for starting the engine.

3.4 PROPERTIES OF PRESERVATIVE OILS

Recommended preservatives mentioned in section 3.1 are from local Indian Manufacturers. Where these oils are not available the suitable equivalent preservative oils from available local market are to be selected. For selection of oils following properties are given as a guide line.

- 3.4.1 Auto-Prun 38 (Hindustan Petroleum Corporation Ltd.) for fuel and lubricating systems.

A specially developed running-in oil for use in bench test operation in diesel engine manufacturing plants to permit a controlled amount of wear on rubbing surfaces, particularly the cylinder bore and piston rings, to smoothen out the microscopic irregularities and to obtain smooth and polished surfaces. A right balance of additives is incorporated in it to provide anti-rust properties and to obtain correct finish without undue wearing out or scratching of rubbing surfaces.

3.4.2 Bharat TCPF 60

Rust proof oil for external surfaces.

Blends of rust prevention material dissolved in a solvent for ease of application. On application the solvent evaporates leaving a protective coating deposited on the surface to be protected. Bharat TCPF 60 is of the water displacement type, i.e. if applied to wet surface it will displace the water and coat the surface with a protective film. This obviates the need for specially drying the parts to be protected. Bharat TCPF 60 gives the thick and medium hard film of 0.01 mm (0.0004 in). The protection period is 18 months for indoor storing and can withstand certain amount of rough handling.

3.4.3 Non-Asphaltic Rust Preventives Rustop 387/388

From Hindustan Petroleum Corporation Ltd.

These are greasy type rust preventives which are semi-solid at room remperature and should be melted prior to their application. The film obtained on the treated parts with the use of these products is soft, greasy and semi-transparent. These products are recommended for coating machined parts.

SECTION - 4

TOP OVERHAUL

SECTION – 4

TOP OVERHAUL

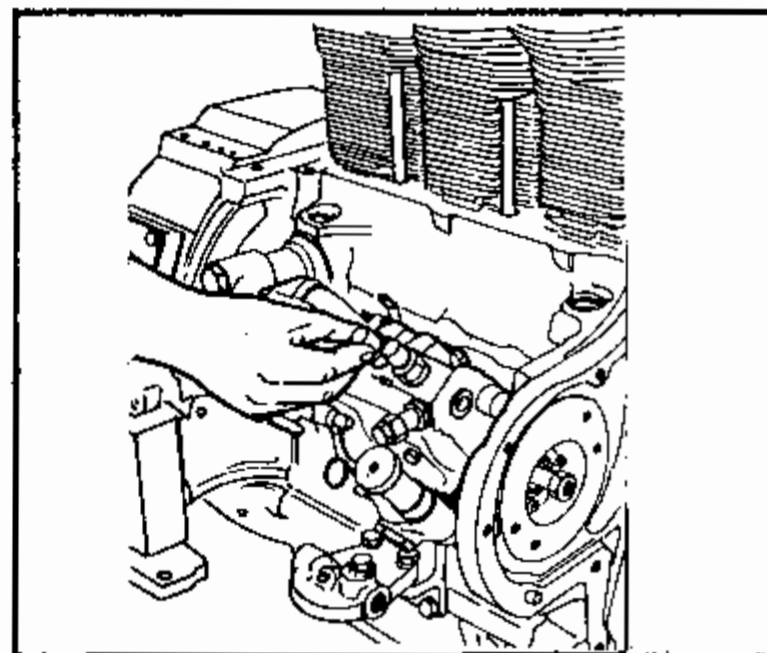
(SERVICING OF COMBUSTION SYSTEM)

- 4.1 GENERAL NOTES : During the running of the engine, carbon gets deposited over the parts exposed to the combustion chamber. Hence these parts are required to be cleaned periodically to get the optimum performance from the engine and to have longer life. Top overhaul is required after every 3 000 working hours of the engine.

4.2 REMOVAL OF CYLINDER HEAD, CYLINDER LINER, PISTON :

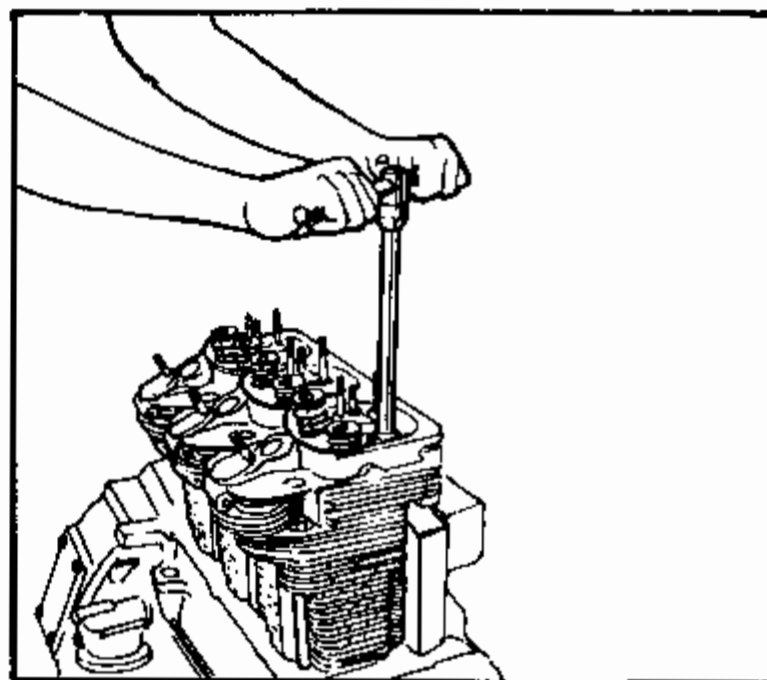
- 4.2.1 Dismantle the air cleaner with bracket, disconnect induction pipe for compressor (if on engine), disconnect the fuel line & electrical connection for flame heater. Dismantle Exhaust manifold, Inlet manifold, Air cowling, high pressure pipes and Nozzle leak off pipes.

NOTE : IMMEDIATELY AFTER DISCONNECTING FUEL PIPES, PLUG THE END CONNECTIONS WITH CAPS (Fig. 4-1).



4-1

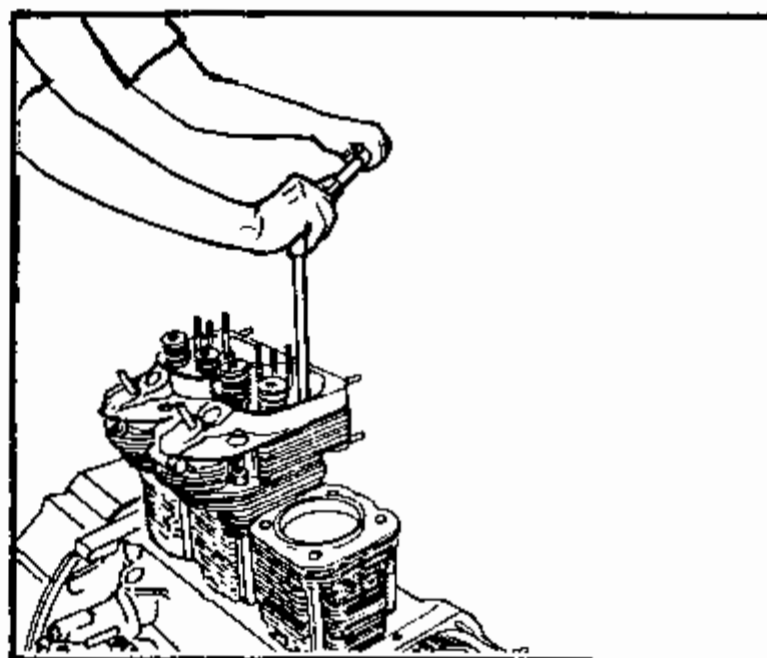
- 4.2.2 Dismantle rocker cover, rocker arm support. remove push rods. Unscrew brass plugs by using socket spanner (Fig.4-2). Remove fuel injectors. If it is found stuck in the cylinder head bore, use fixture No. 02.950.01.0.



4-2

- 4.2.3 To remove the cylinder head at Gear end, remove the set screw securing front cowling to cylinder head.

Slacken cylinder head bolts in stages with diagonal sequence. (Use socket spanner No.03.950.07.0). (Fig. 4-3).



4-3

4.2.4 Remove the cylinder head and push rod covering tubes.

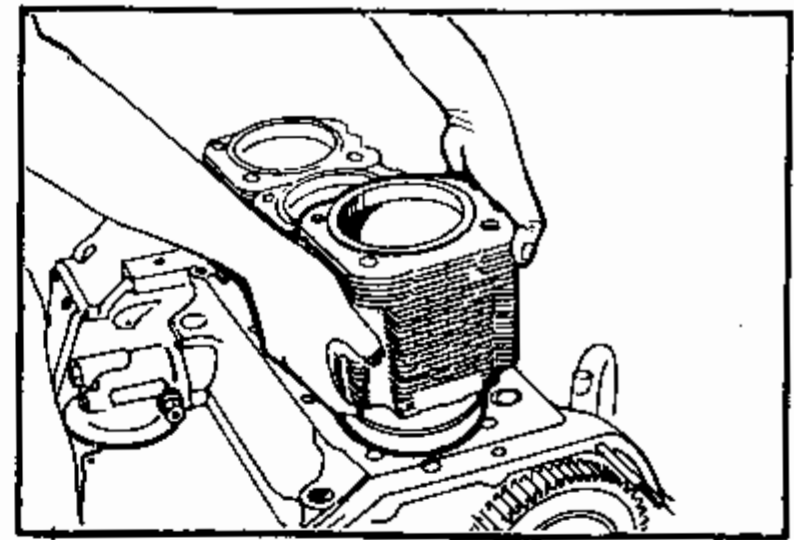
4.2.5 Removal of cylinder liner -
Position the piston at bottom dead centre. Turn the crank shaft to lift the cylinder liner out of crankcase. Remove the cylinder (Fig.4-4).

4.2.6 Remove shims below liner.

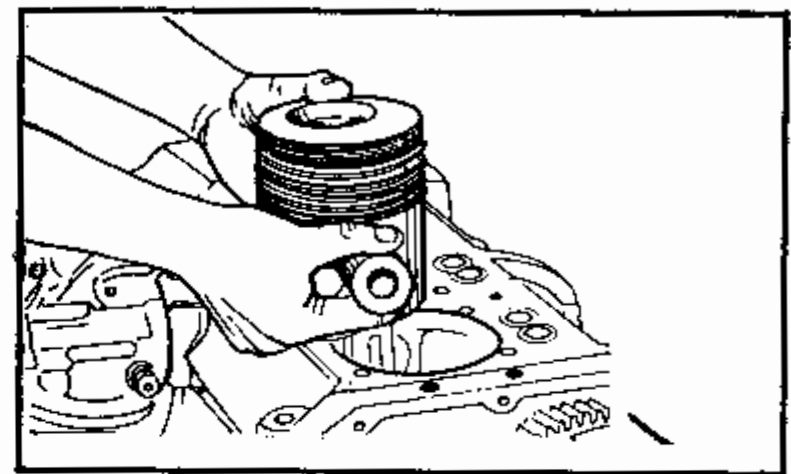
4.2.7 Removal of piston -
It is assumed that while removing the gear end piston, coolingblower and front cowling blower and front cowling are dismantled.

Compress the circlip with the circlip plier and remove the piston pin and lift the piston (Fig.4-5).

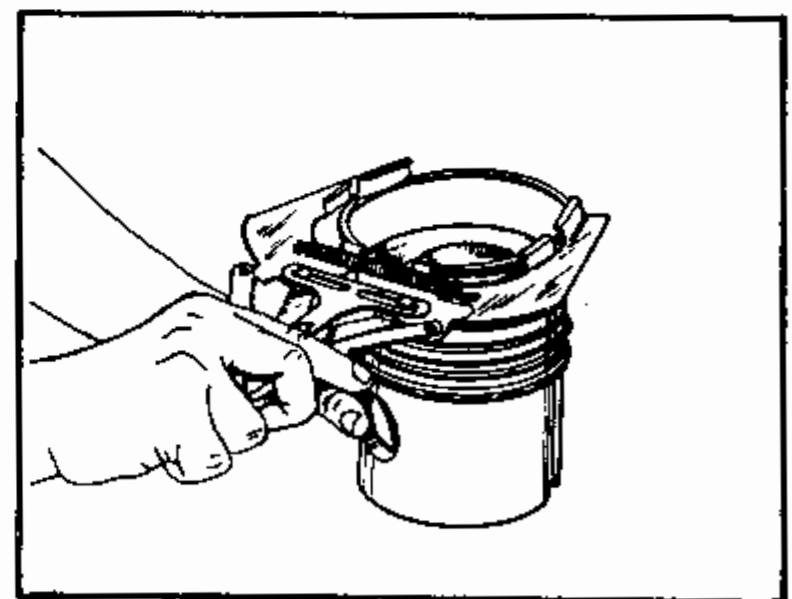
Remove piston rings with the help of ring expander (Fig. 4-6).



4-4



4-5



4-6

4.3 SERVICING OF CYLINDER LINER

4.3.1 Inspect liner for defects.
If necessary replace complete with piston.

- 4.3.2 Set dial gauge to the basic standard bore size of liner, (see Technical specification)

Measure bore size at the levels 1,2,3 & 4 and along centre line of crankshaft & across centre line of crankshaft.

(Fig. 4-7 & Fig. 4-8).

Compare these readings with the specification data. If wear limits are reached, replace the part.

- 4.3.3 Check that cylinder seating faces at bottom and top are flat and clean.

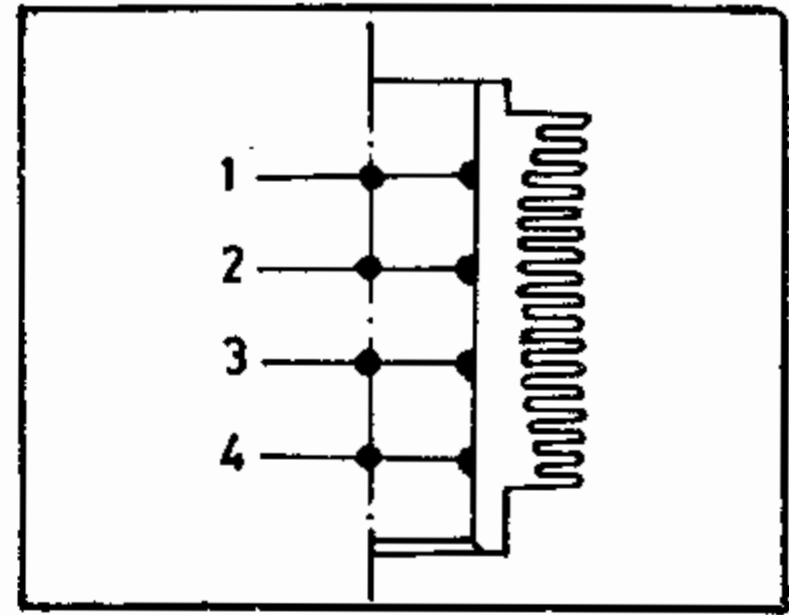
4.4 SERVICING OF CYLINDER HEAD

Dismantle both valves with springs, valve rotator or spacer by valve spring compressor.

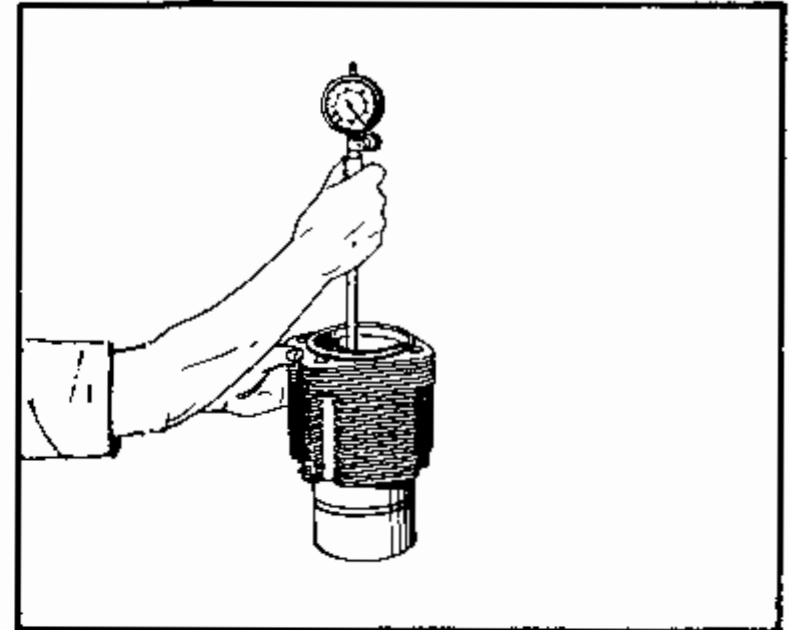
Tool No.03.950.13.0

(Fig. 4-9).

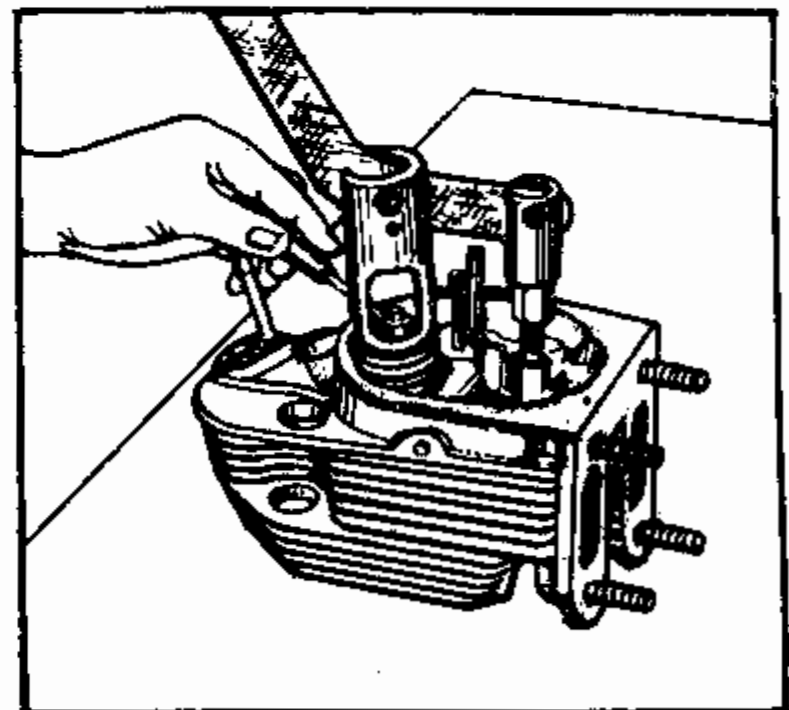
- 4.4.1 Inspect the cylinder head for external damage or cracks etc. renew if necessary.
- 4.4.2 Replace valves in any case, if repairs are extensive one.
- 4.4.3 Check the cylinder head seating face. It should be flat and square. If damaged severely, replace the same.



4-7



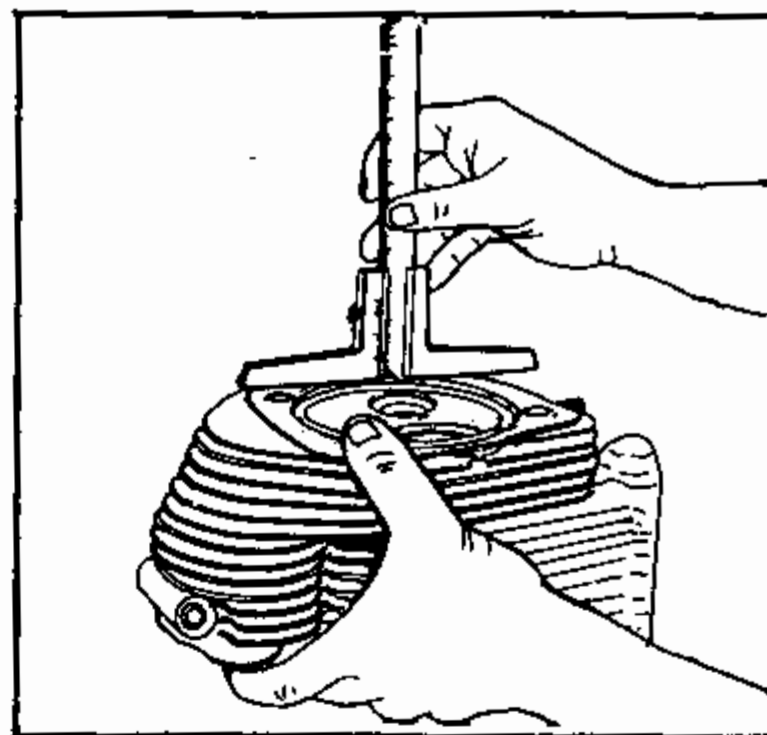
4-8



4-9

- 4.4.4 Slight damage to the head seating face can be removed by grinding cylinder head on liner, with fine abrasive paste.

After reworking the head, measure the distance from seating face to head crown and ensure that it is not less than the low limit given in specification. (Fig. 4-10).



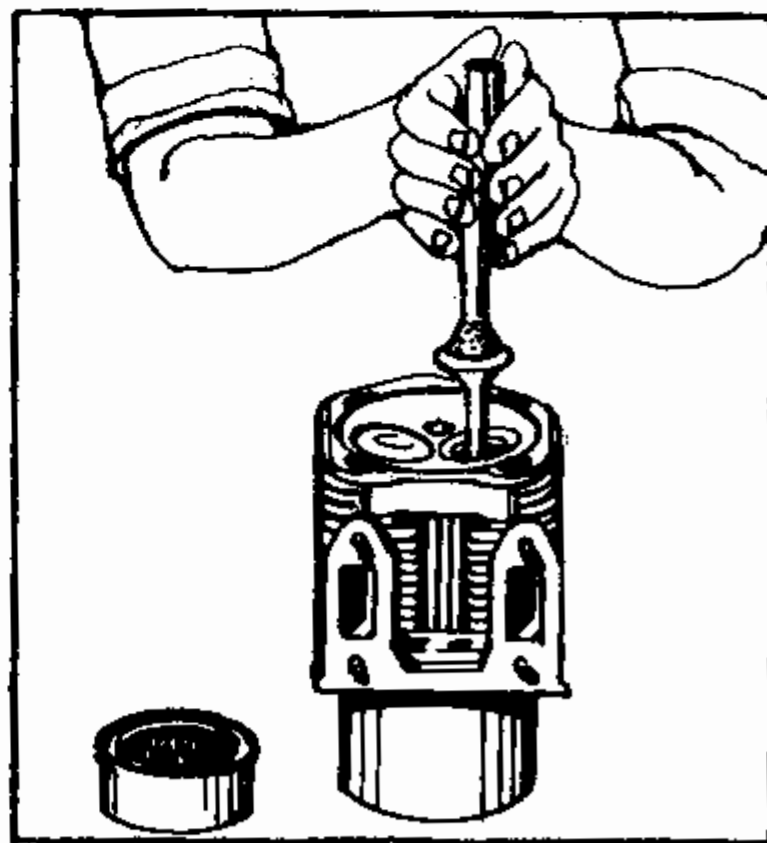
4-10

- 4.4.5 Similarly check valve face height from head seating face. It should not be less than low limit given in specification.

- 4.4.6 Inspect the valve faces and valve seats. There should not be pitting on either of them. Minor pitting can be eliminated by regrinding valves in their respective seats.

Regrinding of valves -

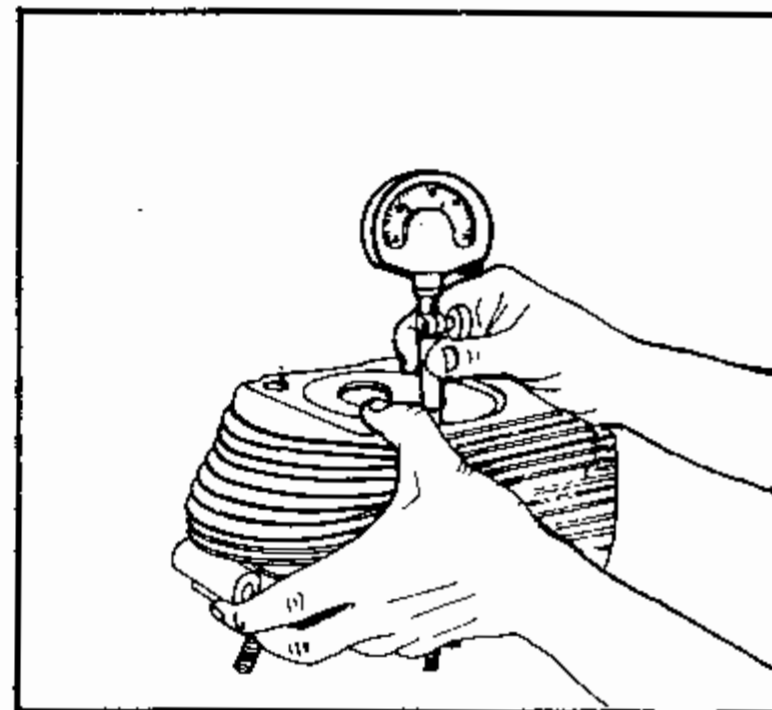
- a) Place the valves on their original seats.
- b) Apply a small quantity of valve grinding paste (Coarse) around the valve seat.
- c) Oscillate the valve on its seat by means of cupped valve grinding tool (No. 03.950.14.0). At the same time exert a gentle but uniform pressure on the valve (Fig. 4-11).
- d) After every few turns lift the valve off its seating and give it half a turn to ensure that the grinding paste spreads uniformly. The most convenient way to carry out this periodical lifting is to insert a light coil spring in the part below the valve head.



4-11

- e) Repeat the grinding operation using fine emery paste till the surfaces in contact give a smooth appearance without any scratches or depressions.
- f) If the pitting is very deep or if the valve seat indicates recesses or an edge it is necessary to recut the valve seat. The recutting angle is $45^{\circ} \pm 10'$ for exhaust and inlet.
- g) It is absolutely necessary to thoroughly clean the cylinder head and valves after the grinding operation.
- h) For discarding limits of valves and valve seats refer specifications given in Section 1.3.1.

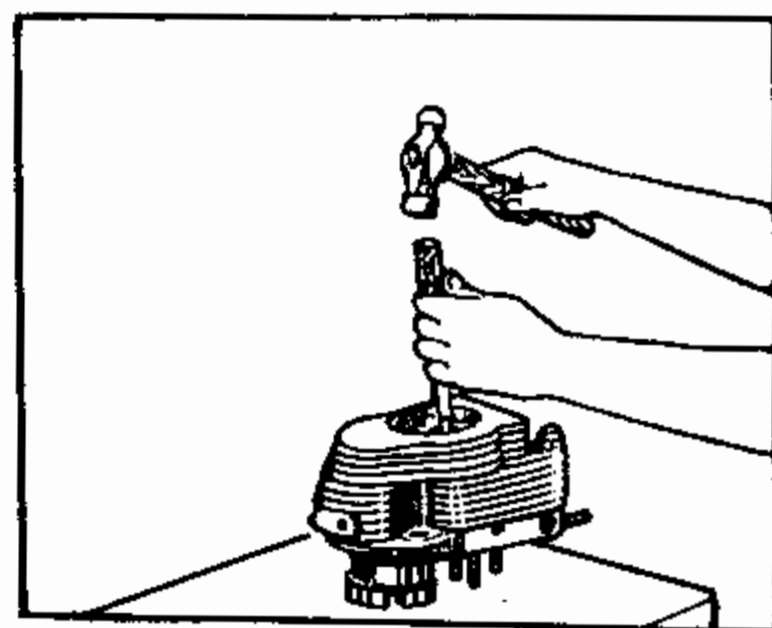
4.4.7 Check the clearance of valve stems in the valve guides. If it exceeds the permissible limit given in specifications refit the new valve guide. (Fig. 4-12).



4-12

4.4.8 Removing & Installing a valve guide-

- a) Uniformly heat the cylinder head upto 220°C . Do not heat longer than 30 minutes. Drive out valve guide from valve seat side with mandrel No.03.950.05.0 (Fig.4-13).



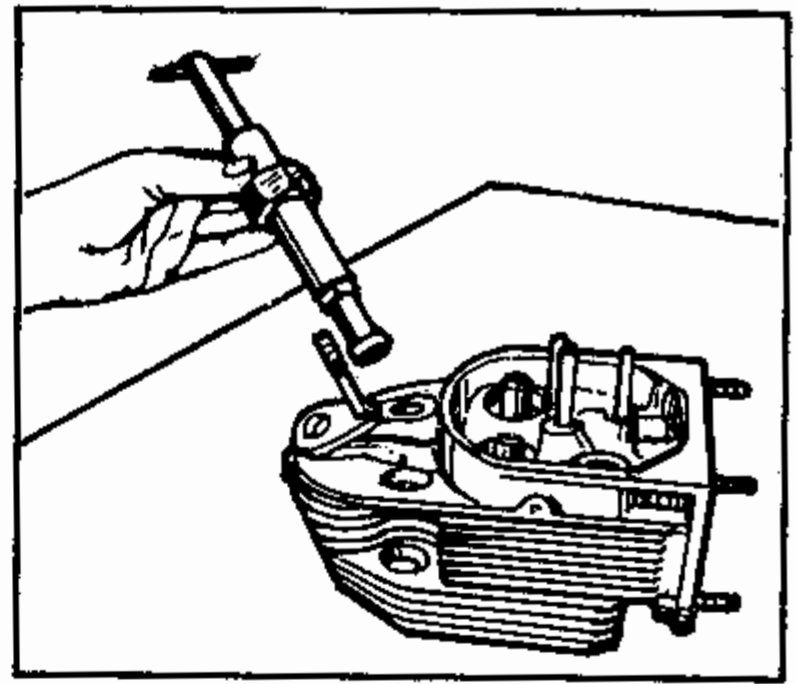
4-13

4.4.9 Replace the valve guide with new one. Replace new wire clip for valve guide.

With the cylinder head heated to 220°C drive in new valve guide from rocker arm side in the valve guide bore with the help of mandrel No. 03.950.05.0. Longer side of valve guide goes inside the head till it rests on wire clip.

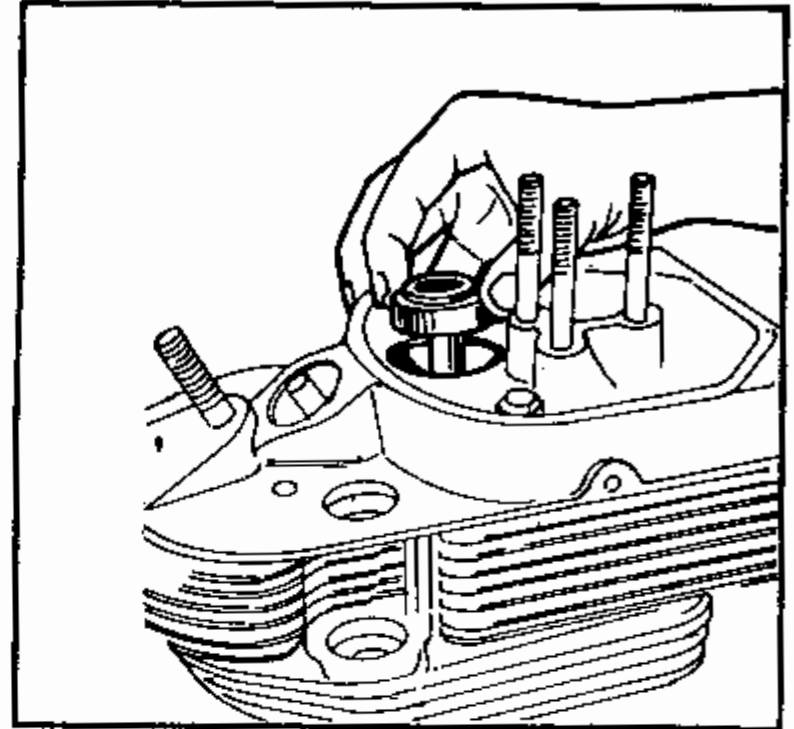
NOTE : IMPORTANT - TO REPLACE VALVE GUIDES, CYLINDER HEAD IS TO BE HEATED UP ONCE ONLY.

- 4.4.10 Remove the nozzle washer from nozzle bore in cylinder head if it is stuck in the bore. Use special tool No. 03.950.15.0 (Fig. 4-14).



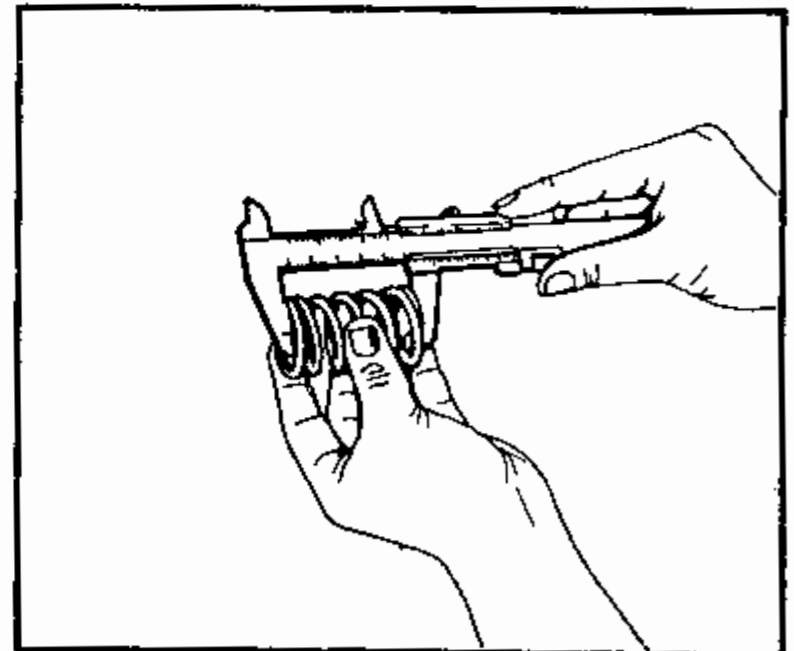
4-14

- 4.4.11 Check valve rotators for free in rotation. Renew if necessary. If spacer is supplied in place of rotator, fit the spacer. (Fig. 4-15).



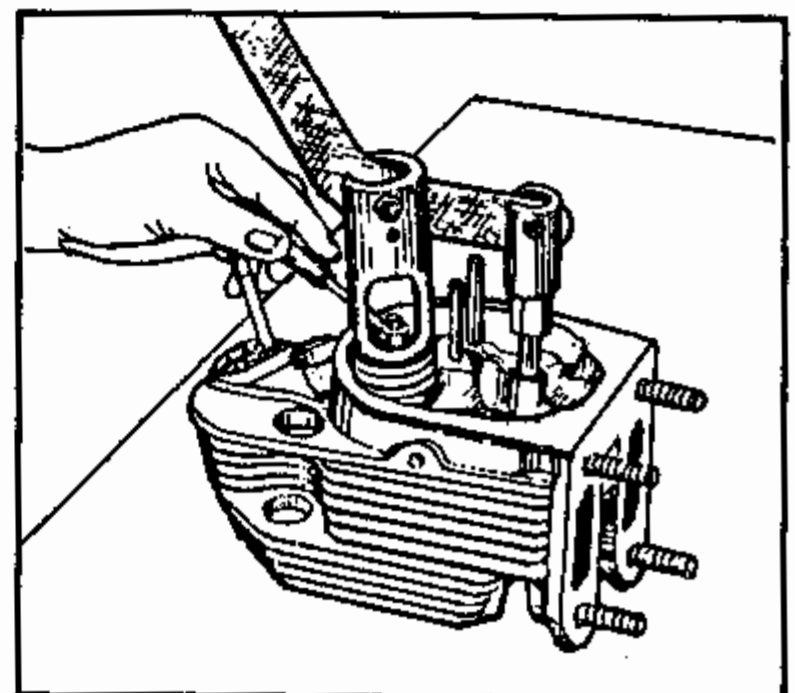
4-15

- 4.4.12 Check free length of valve spring. If it is less than the tolerance specified in specifications, replace with new one(Fig. 4.16).



4-16

- 4.4.13 Place the valve spring with close coils towards cylinder head and install with the help of spring compressor tool No. 03.950.13.0 (Fig. 4-17).



4-17

4.4.14 Overhauling of Rocker arm bracket -

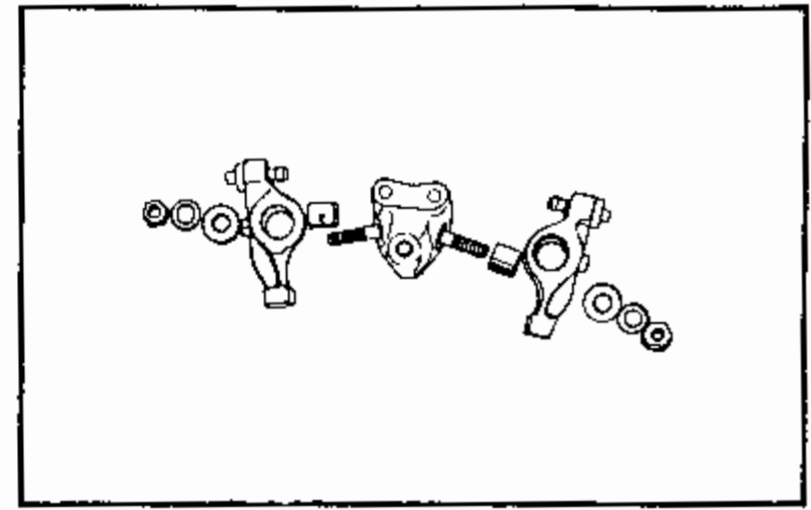
- a) Dismantle the valve rocker assembly. Clean thoroughly all components. Replace the worn parts, if any, (Fig. 4-18).
- b) Press the bearing bush in rocker lever with the help of mandrel No.03.950.12.0. Make sure that oil holes are properly aligned. (Fig. 4-19).
- c) Measure the diameter of bearing bush after pressing. If it is found less than the specified in the specification, then ream it with reamer.

NOTE: IN INITIAL ASSEMBLY OF OIL METERING SCREW, THE TAPERED FLAT PORTION OF SCREW SHOULD BE TOWARDS VALVE SIDE END OF THE ROCKER LEVER. APPROXIMATELY ONE THREAD IS TO REMAIN ABOVE LOCK NUT FACE. (Fig. 4-20).

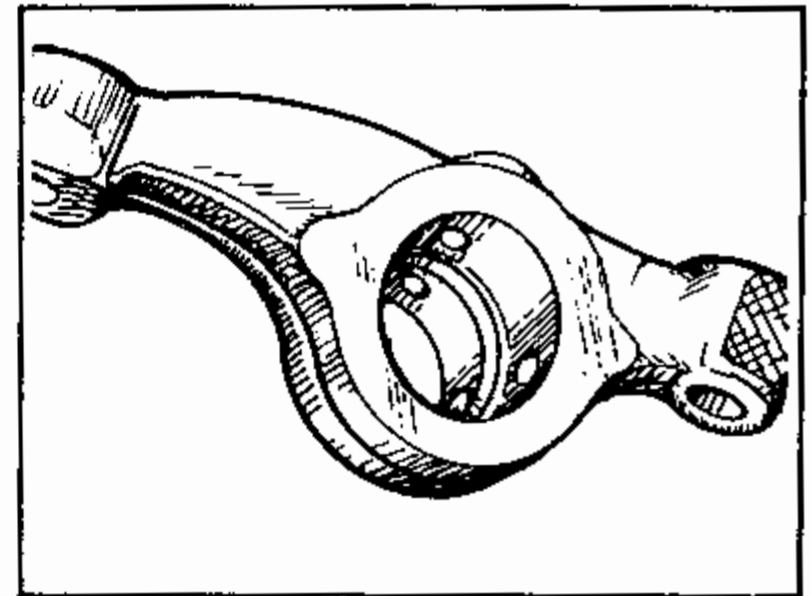
WHEN SCREW IS FINALLY ADJUSTED IN ASSEMBLY AT IDLING SPEED OR ON VEHICLE, THE POSITION OR TAPERED FLAT PORTION OF THE SCREW IS IRRELEVANT. WHILE ADJUSTING THE SCREW MAKE SURE THAT SMALL QUANTITY OF OIL (DROP BY DROP) TOWARDS VALVE SIDE IS VISIBLE.

4.4.15 Inspecting push rods, covers and tappets (Fig. 4-21).

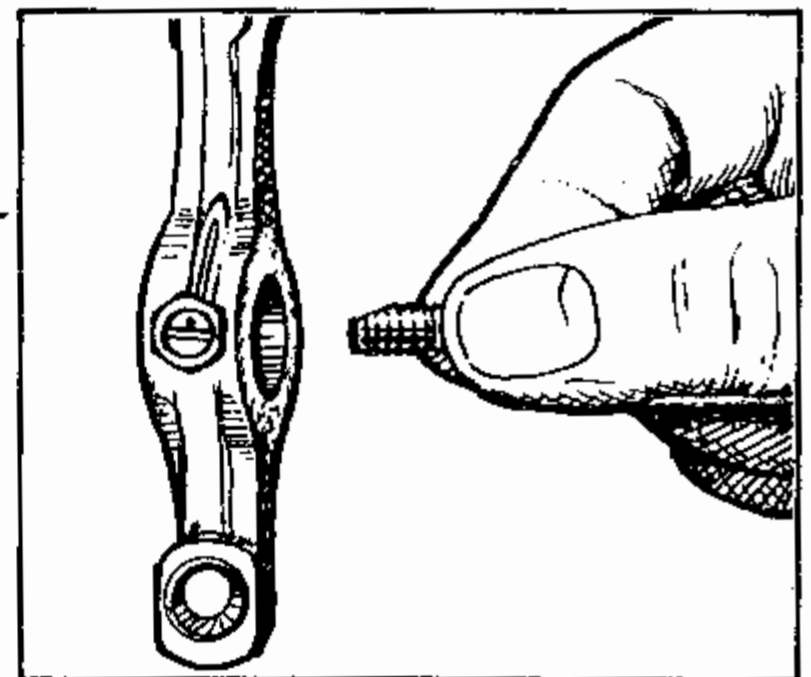
- . Check socket & toe pressed in push rod are tight and ensure that oil hole is clear. Check bend of push rods.
- . Check push rod cover tubes are straight and free from defects.
- . Check tappets for wear and see that the oil hole is clear.



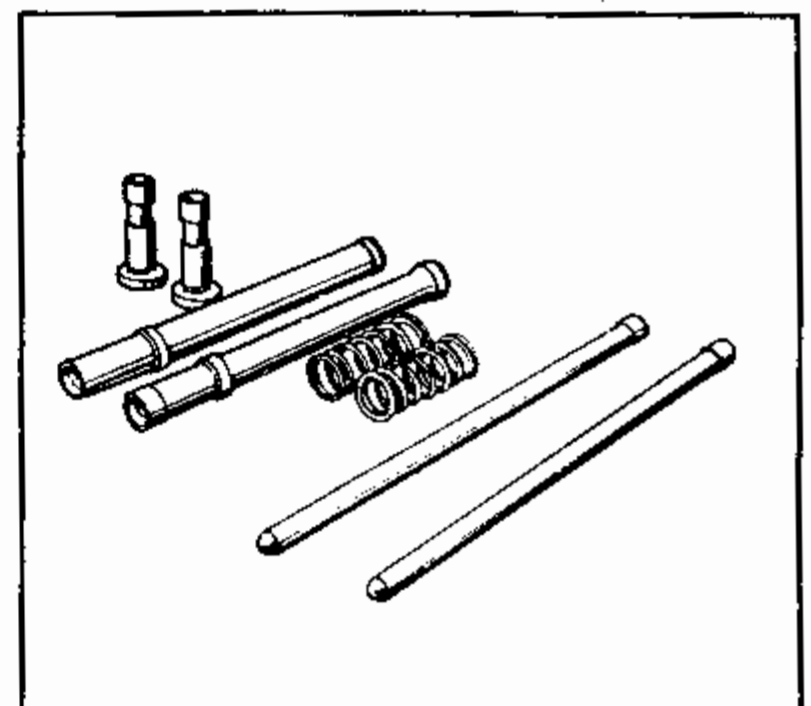
4-18



4-19



4-20



4-21

Replace parts wherever required.

4.5 SERVICING OF PISTON

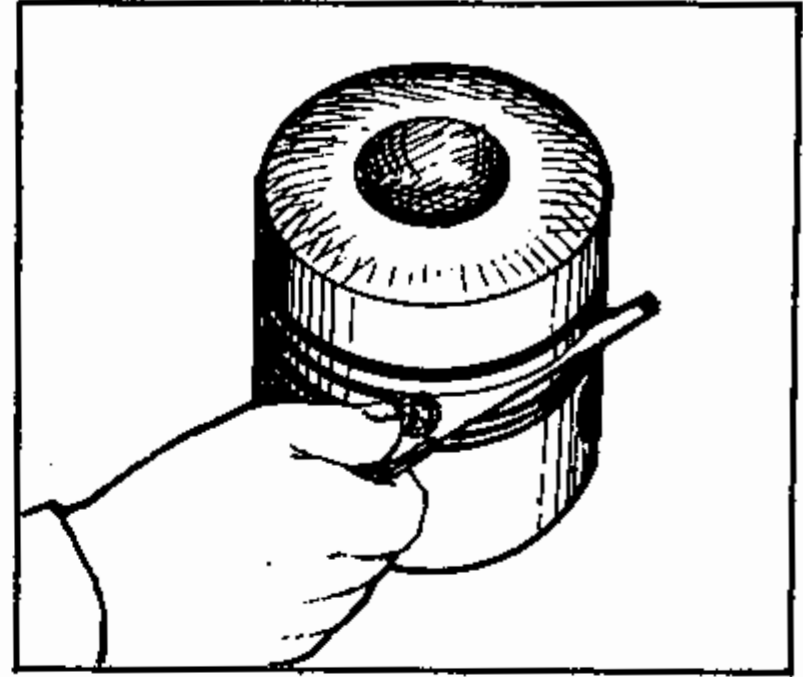
4.5.1 Inspect the piston for damage, wear or scarring, including the bosses for piston pin.

Remove compression rings and coil loaded oil control ring with ring expander.

Open the coil of oil control ring and remove.

Clean piston ring grooves and crown for inspection.

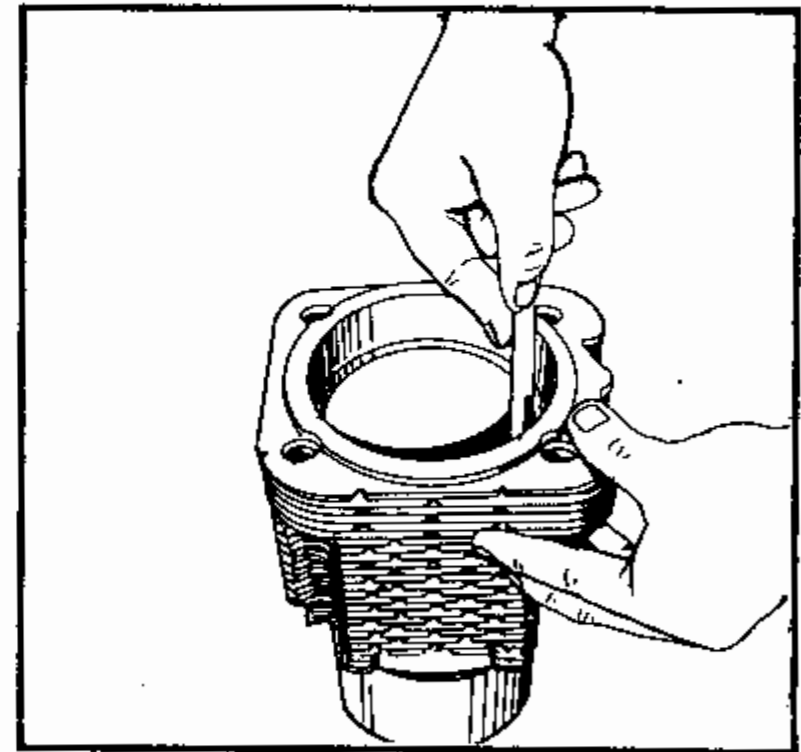
Check axial clearance of piston grooves with feeler gauge (Fig. 4-22). For discarding values refer specifications.



4-22

4.5.2 Checking of butt gap of piston rings -

Insert each ring in the cylinder liner from top, by about 30 mm distance & measure butt gap with feeler gauge. Compare the measured readings with technical specification & replace set of rings if necessary. (Fig. 4-23).

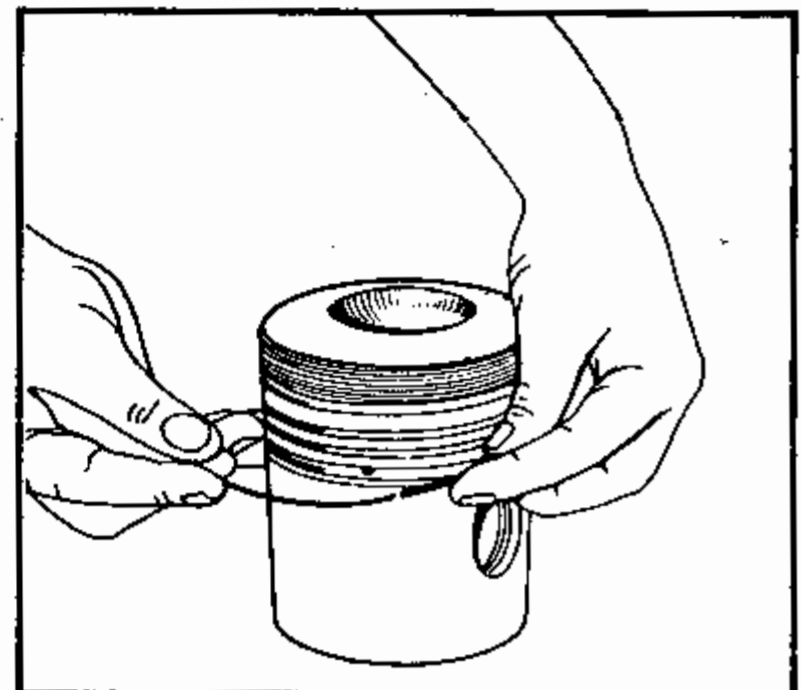


4-23

NOTE: WHILE REPLACING THE PISTON (IF NECESSARY) REPLACE IT ALONG WITH PISTON RINGS AND PISTON PIN.

4.5.3 Assembly of piston rings -

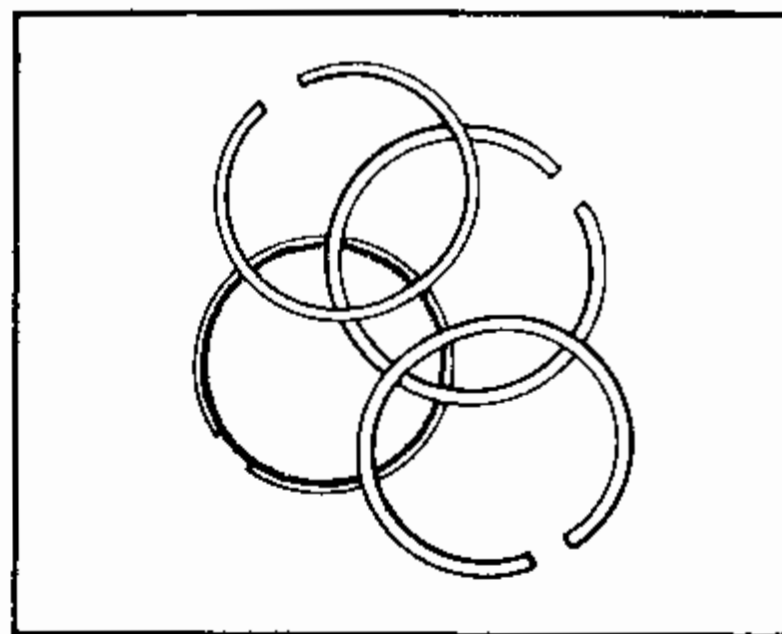
Ring No. 4 - Chrome plated coil loaded oil control ring. Place coil first in 4th groove. Oil control ring butt gap should be in 180° with coil joint end (Fig. 4-24).



4-24

Ring No. 3 & 2 - Tapered compression rings. Install in 3rd & 2nd groove with the "Top" mark towards piston crown.

Ring No. 1 - Trapezoidal chrome plated ring. Install with 'manufacturers' mark towards piston crown. Positioning of butt gaps to be as shown in (Fig. 4-25).

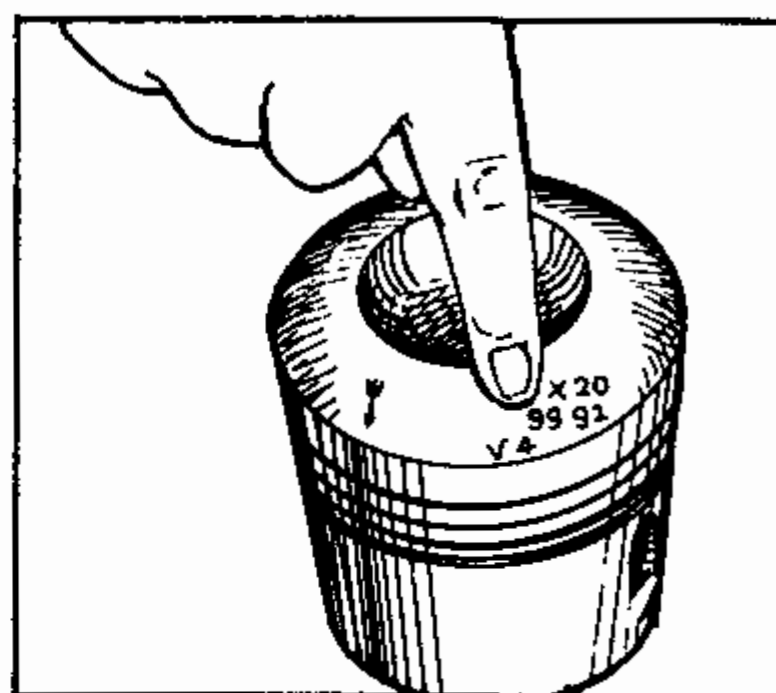


4-25

4.6 ASSEMBLY OF LINERS, HEADS, ROCKER ASSEMBLY, PUSH RODS, COWLINGS, ETC.

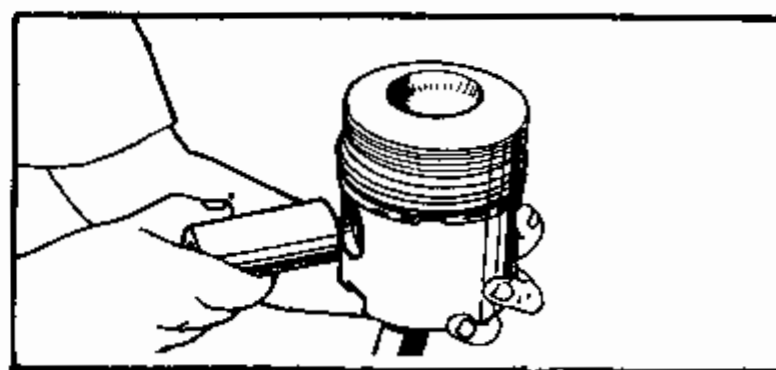
4.6.1 Assembly of piston -

Fit the first circlip in circlip groove which is facing the adjacent liner which is not removed from the crankcase. Piston should be in correct position, see arrow mark. (Arrow mark should be towards push rod side). (Fig. 4-26).



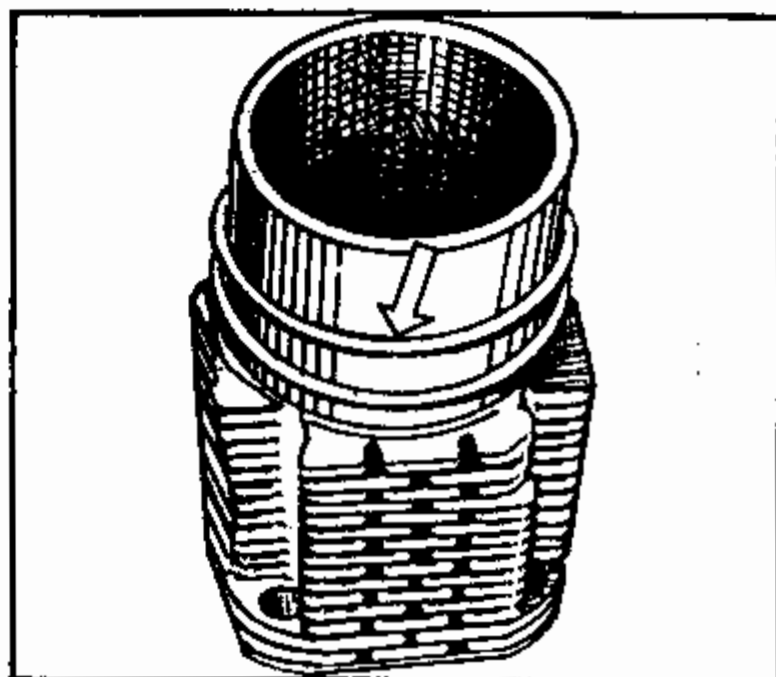
4-26

4.6.2 Press the piston pin in the piston boss and small end of the connecting rod & install the second circlip in the groove (Fig. 4-27).



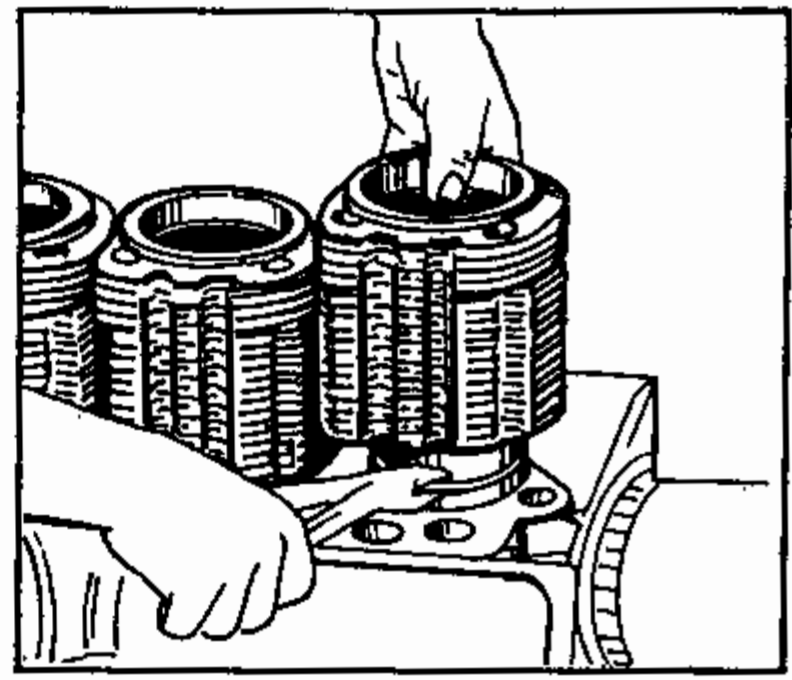
4-27

4.6.3 Insert 2 numbers of liner shims in the liner (Fig. 4-28). Apply grease on rings to retain their position on liner.



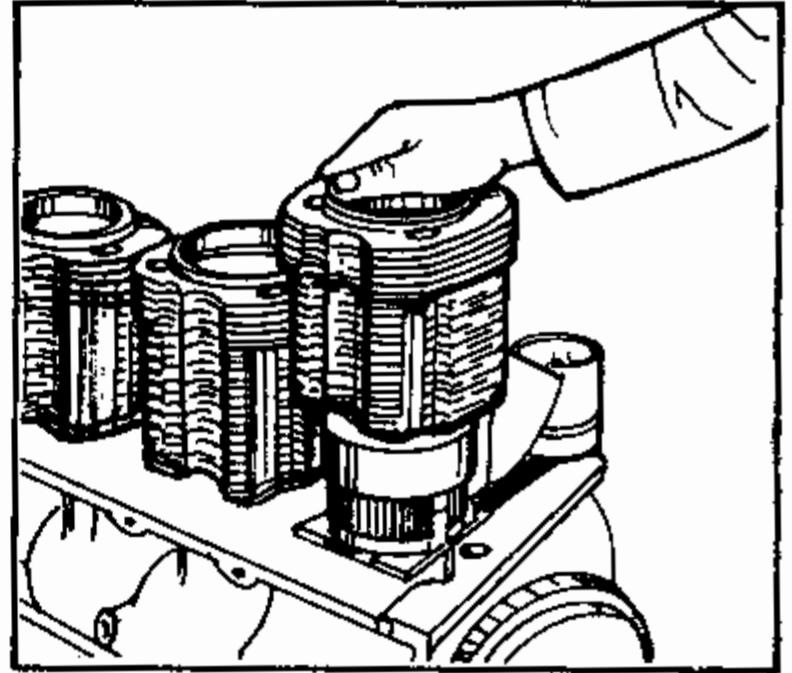
4-28

- 4.6.4 If the clearance is too large, raise cylinder, cut as through the surplus shims with side cutting plier and remove (Fig. 4-29), Use a thick shim of 0.5 mm instead of several thin ones of 0.2 mm.



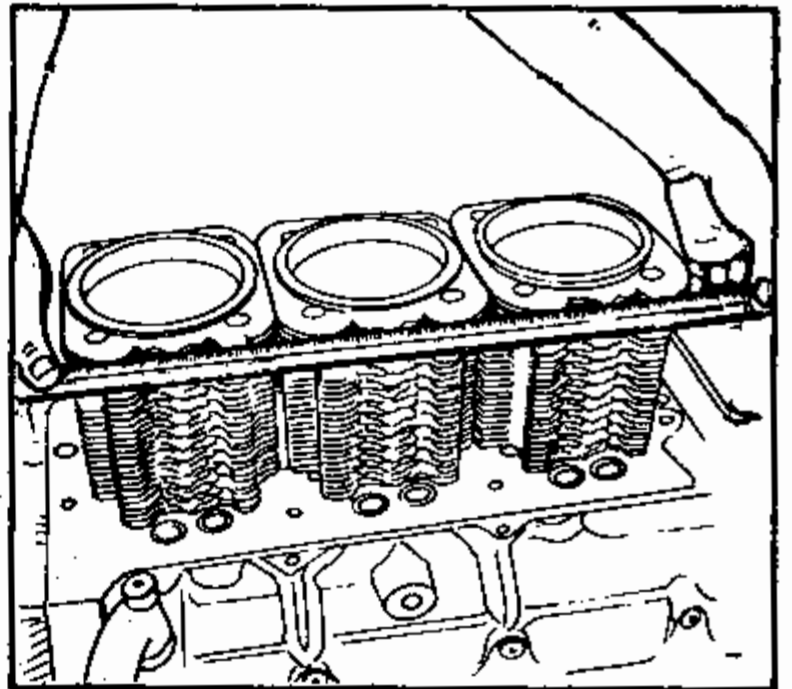
4-29

- 4.6.5 Squeeze the piston rings on piston with the help of piston inserting ring. Ensure the positioning of butt gaps in proper order as shown in Fig. 4-25. Insert cylinder liner, with the relieved portion of fins towards push rod side (Fig. 4-30).



4-30

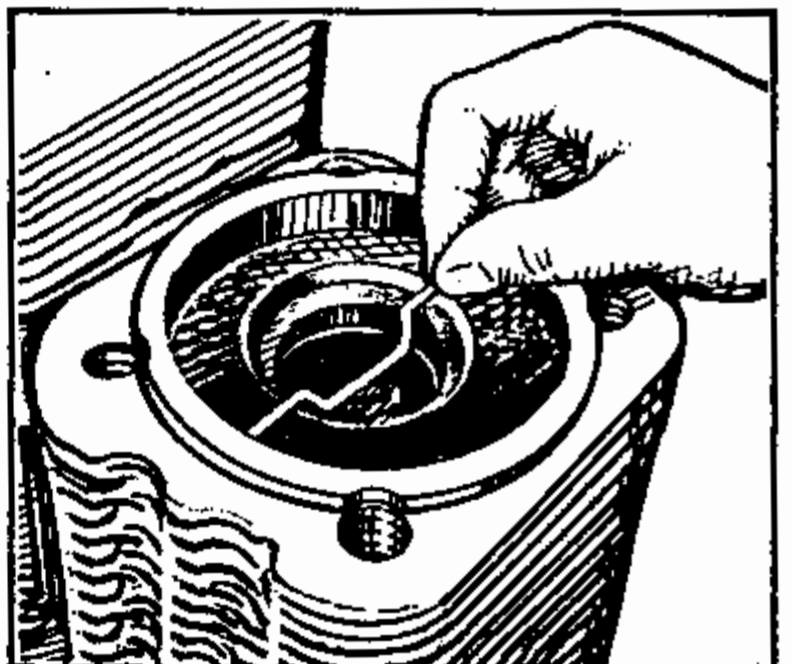
- 4.6.6 Bring the liner in alignment with the adjacent liner. Use straight steel edge for this as shown in Fig. 4-31.



4-31

- 4.6.7 Adjusting Bumping Clearance -

- a) Place a lead wire of 2 mm \varnothing on piston crown across the centre line of crankshaft. (Fig. 4-32).

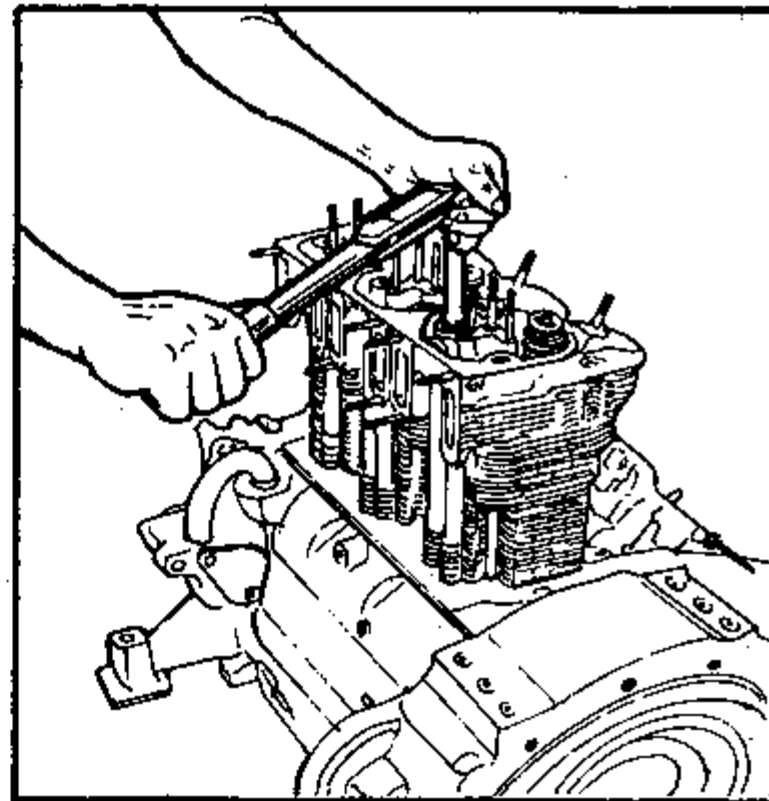


4-32

- b) Mount the cylinder head and align it with the adjacent head, without disturbing the alignment of liners.

Check cylinder head bolts for elongation. If necessary replace the new bolt with washer.

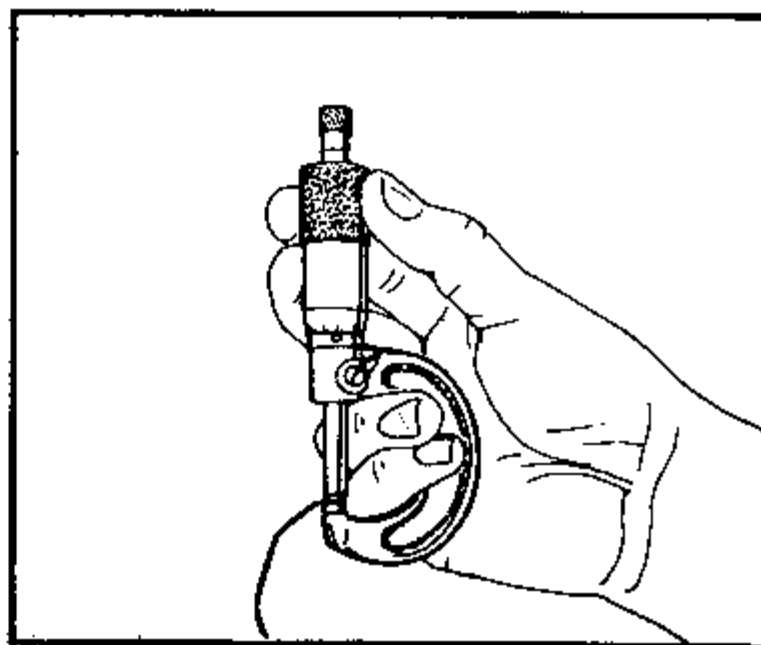
- c) Tighten the bolts in diagonal sequence. Use angle torque values given in specification (Use Tool No. 05343). (Fig. 4-33).



4-33

- d) Turn crank shaft through 360° in the direction of rotation of engine. Dismantle the cylinder head and remove the lead wire from piston. Measure the thickness of wire where it is flattened. (Fig. 4-34).

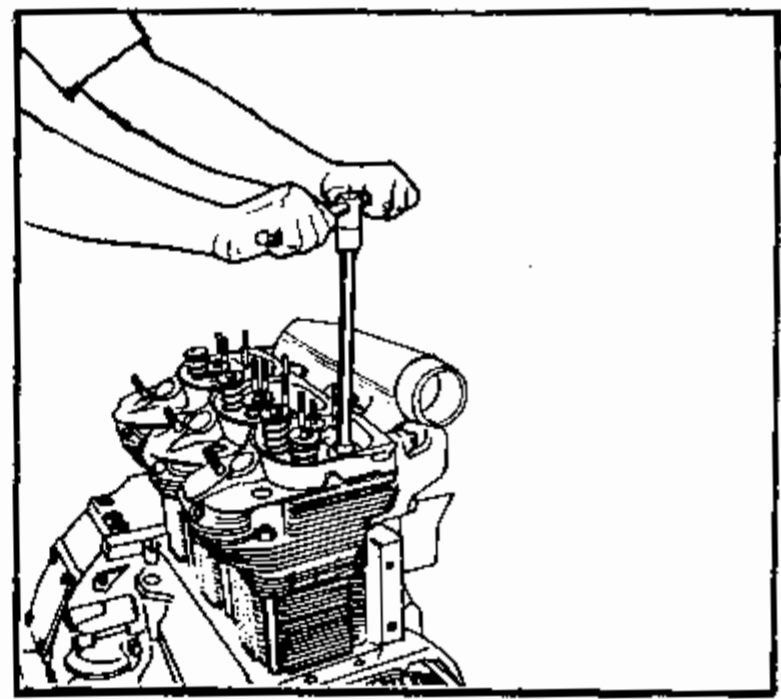
This average thickness should be within the specified limits in the specification. (Bumping clearance). If necessary, raise the liner by adding or removing shims below liner. Bumping clearance will vary according to the thickness of shim.



4-34

- e) Refit the cylinder head and tighten 4-bolts with washers in proper sequence.

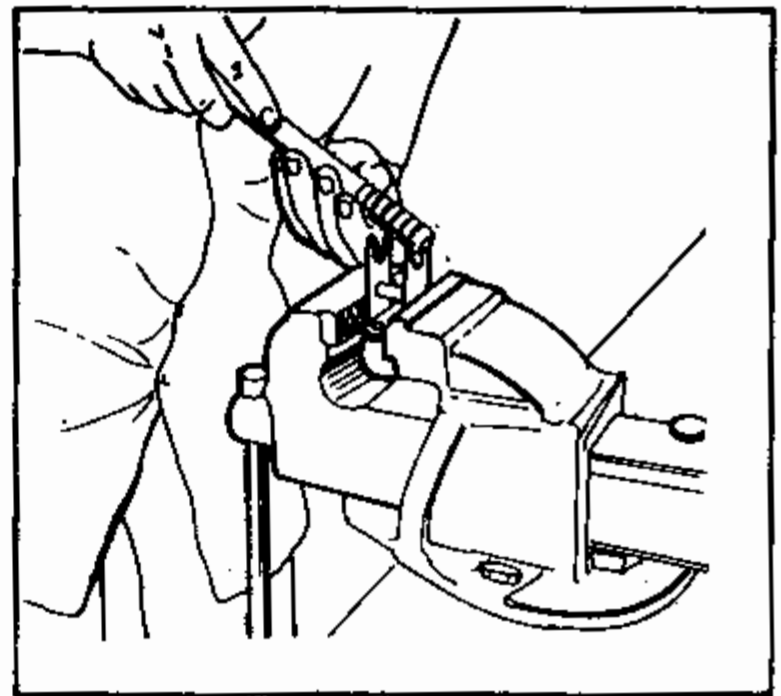
Fit brass screw plugs with copper washers and tighten it by 5-6 kgm torque. Plugs are provided with square sockets to match with standard tommy extension (Fig. 4-35).



4-35

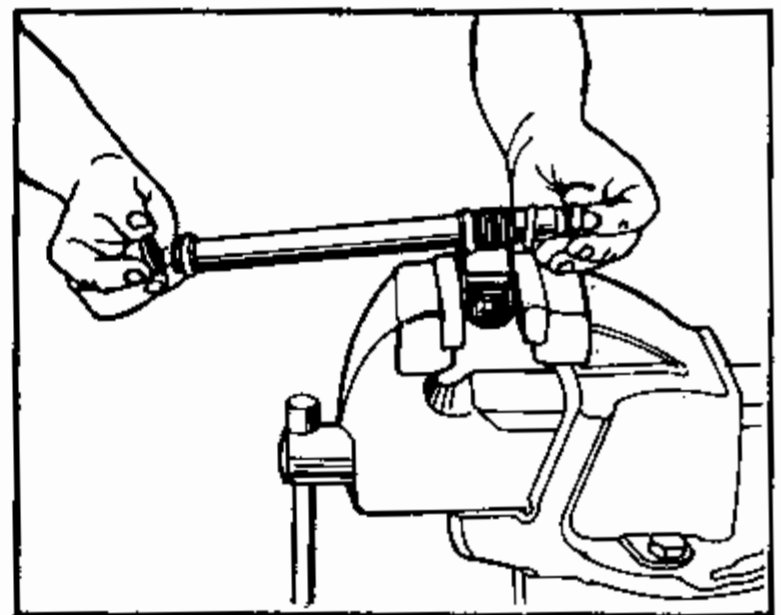
4.6.8 Assembly of push rod tube -

- a) Insert spring for push rod tube from bottom side and hold it with spring holder No. 03.950.08.0 (Fig. 4-36).



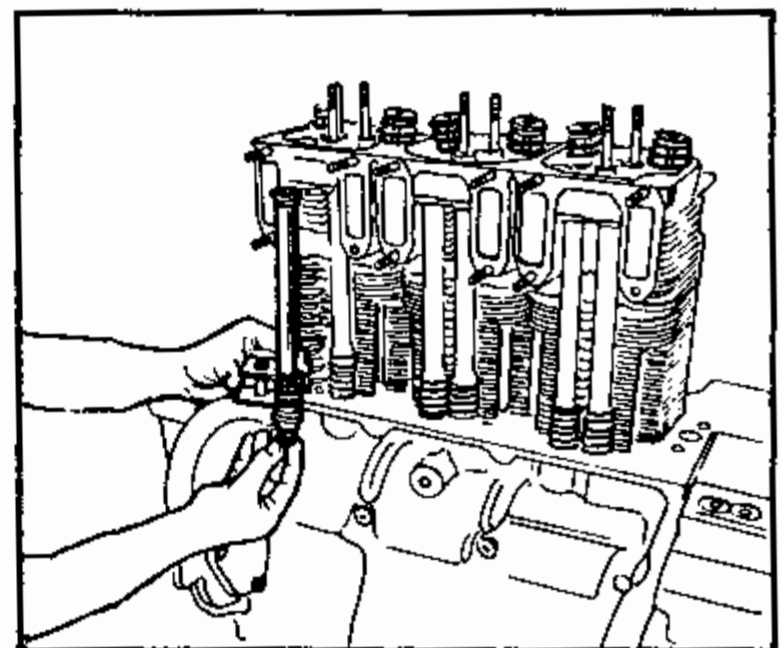
4-36

- b) Then insert collar and sealing ring (red) on push rod tube bottom side. Similarly place sealing ring (black) at the top of push rod. The flat face of the top sealing ring should rest against the push rod collar. Flat face of bottom sealing ring should be towards the bottom end of push rod tube (Fig. 4-37)



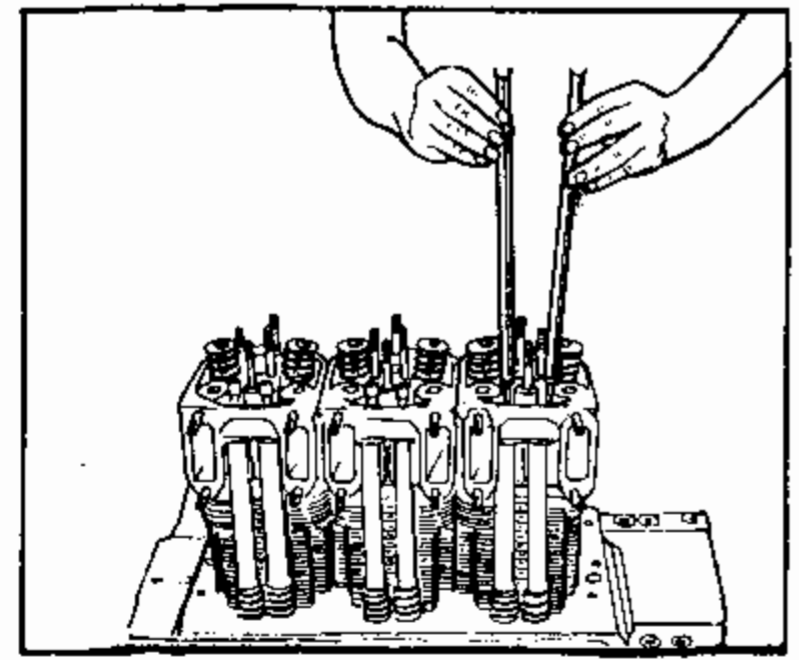
4-37

- c) Insert the push rod tube assembly with collar and sealing ring first in the tappet bore. Then position the upper end of push rod tube in cylinder head counter. Pull the spring compressor (Fig. 4-38).



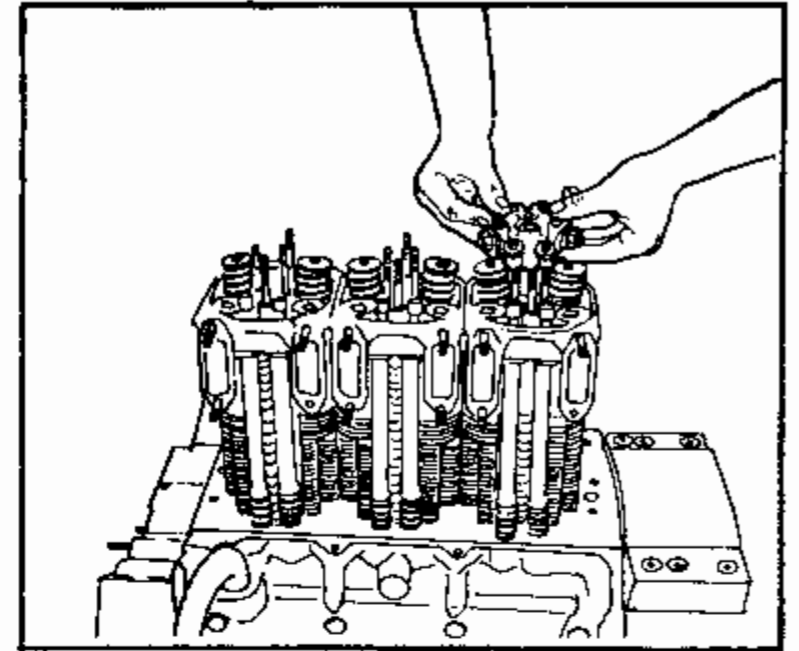
4-38

4.6.9 Insert push rods from top side, through push rod tubes (Fig. 4-39).



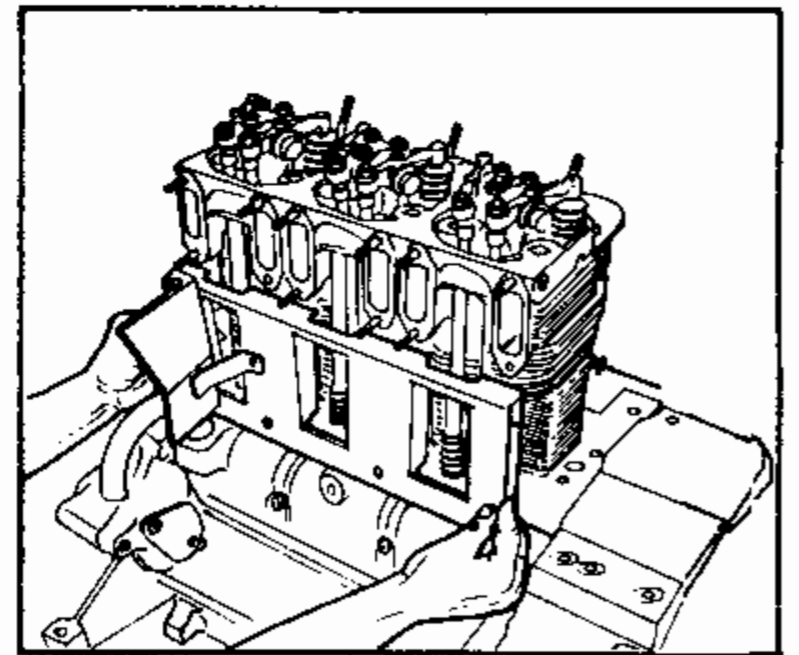
4-39

4.6.10 Mount the rocker arm assembly (Fig. 4-40).



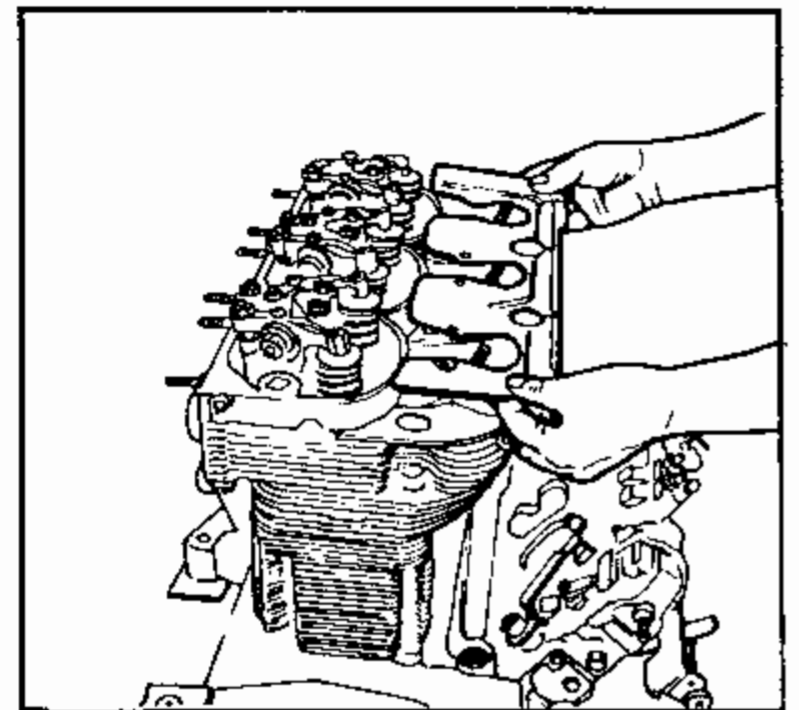
4-40

4.6.11 Fit exhaust air baffle at push rod side. (Fig. 4-41).



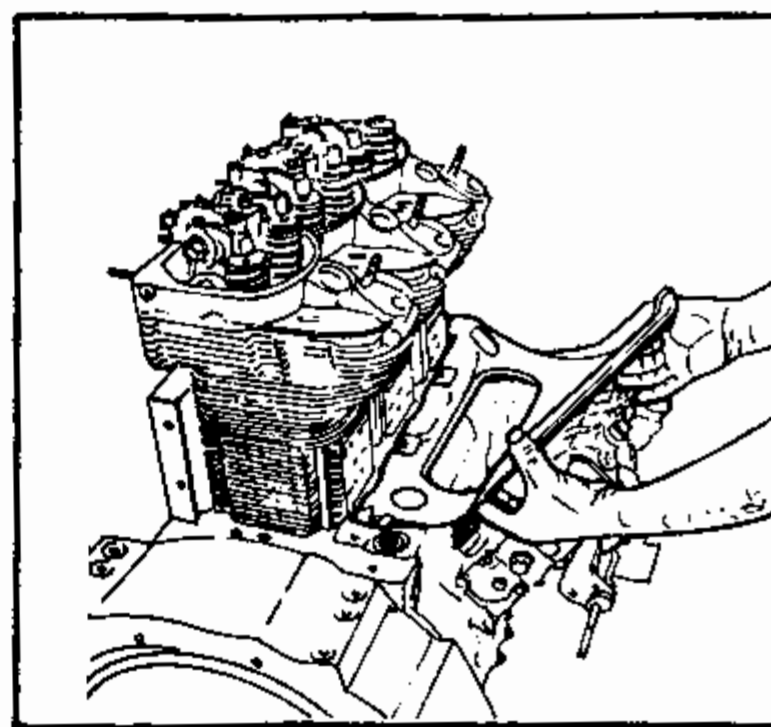
4-41

4.6.12 Fit top air baffle (Fig. 4-42).



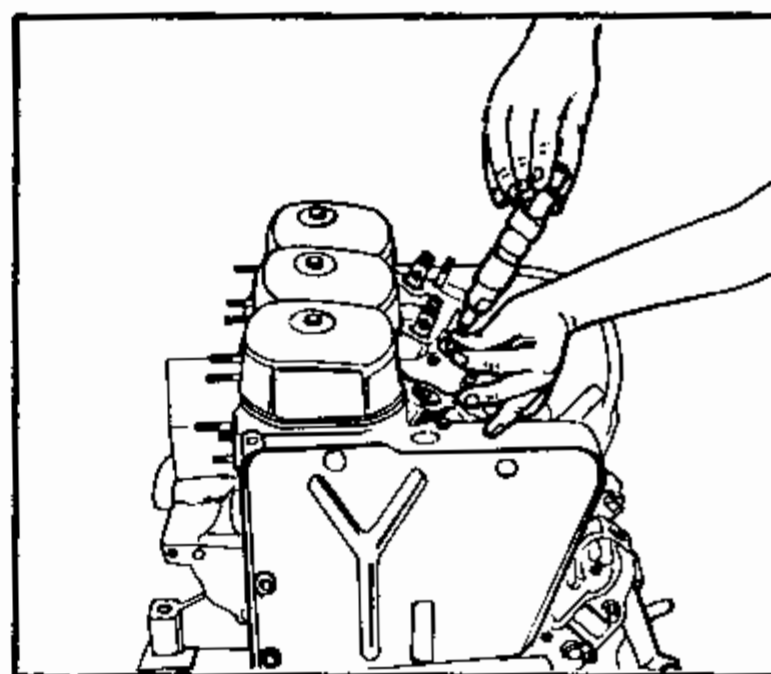
4-42

- 4.6.13 Fit the rear cowling and front cowling on crankcase (Fig. 4-43). Secure rear cowling with set screws on cylinder head and exhaust air baffle. Also, secure front cowling with a set screw on cylinder head.



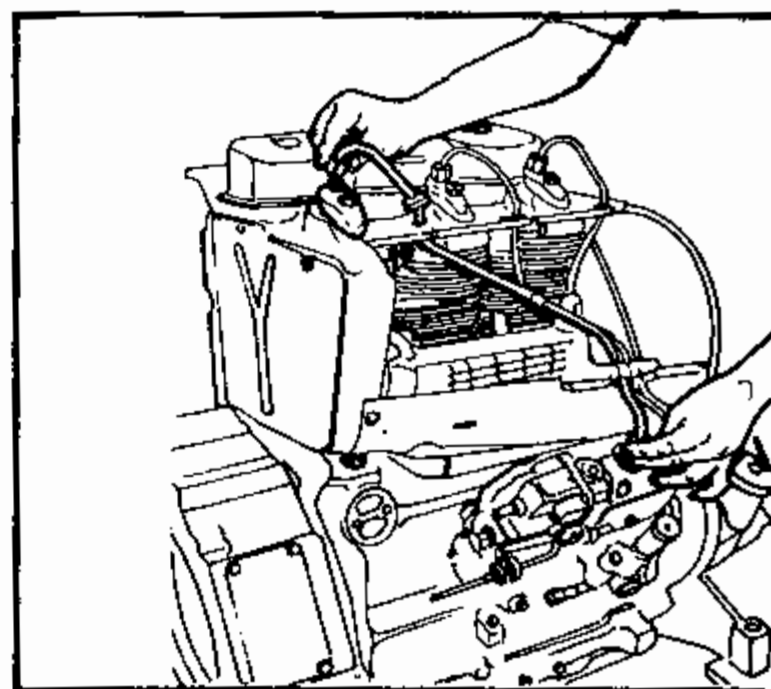
4-43

- 4.6.14 Fit fuel injector in the cylinder head nozzle bore. Use new sealing washer (Fig. 4-44). Clamp the injector with injector yoke and tighten the nut.



4-44

- 4.6.15 Install fuel injection pipes with new rubber mounting strip and grommets (Fig. 4-45).



4-45

- 4.6.16 Assemble nozzle leak off pipe and over flow pipe from fuel pump to nozzle leak off pipe.

Each engine has 2 Nos. of long banjo bolts for leak off pipe. One is at flywheel end nozzle. The others are as follows -

FOR -

HA294 - at No. 2 nozzle

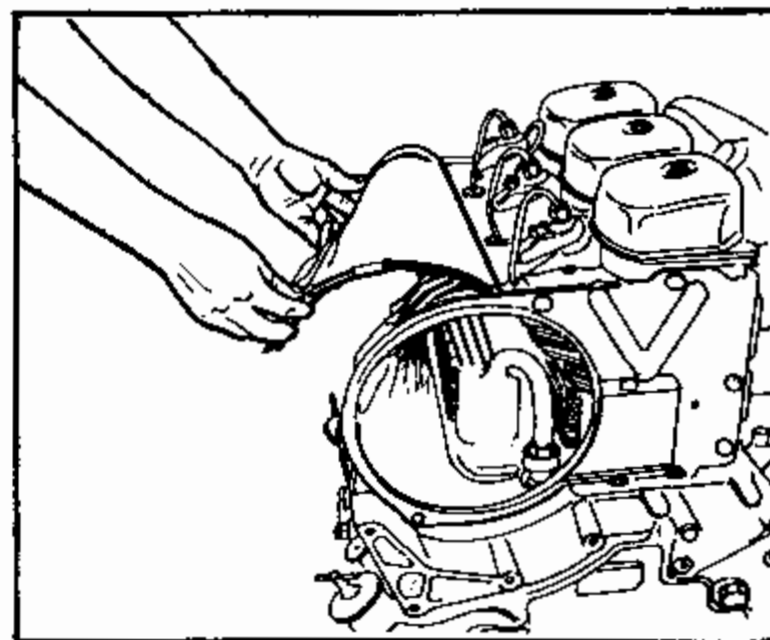
HA394 - at No. 3 nozzle

HA494 - at No. 4 nozzle

HA696 - at No. 6 nozzle

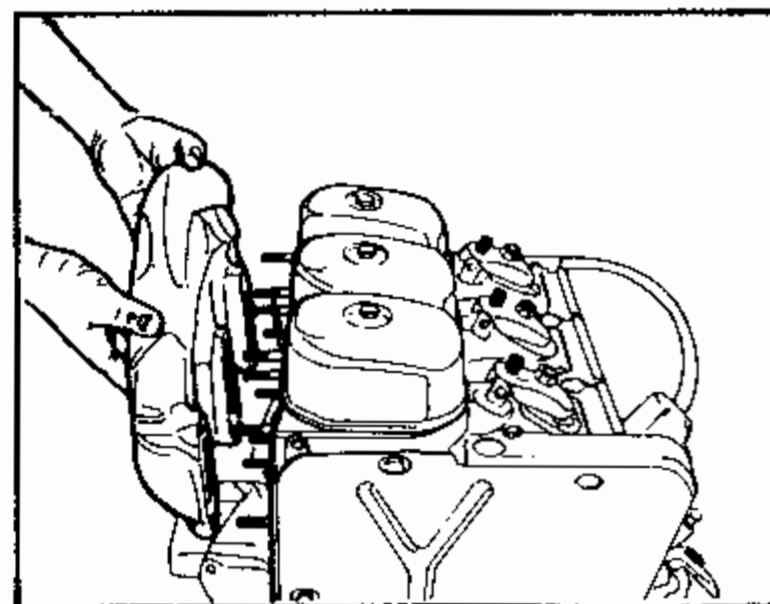
NOTE : CYLINDER NUMBERS TO BE COUNTED FROM
FLYWHEEL END SIDE.

- 4.6.17 Engage the upper cowl
in the hook of top air
baffle & clip the spring
clamps
(Fig. 4-46).



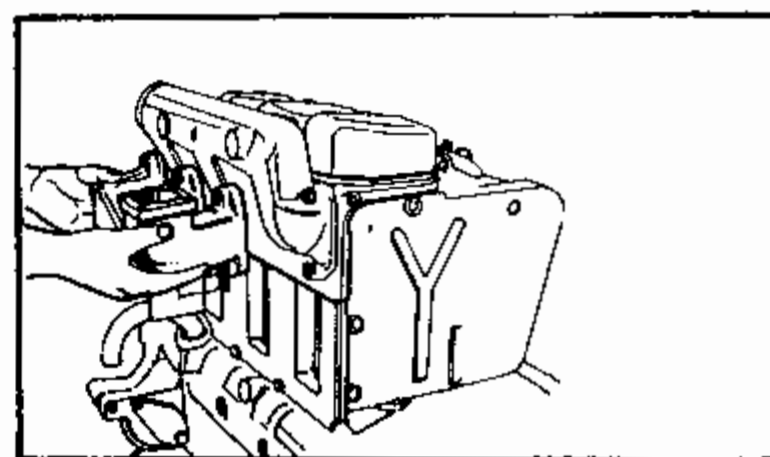
4-46

- 4.6.18 Mount Inlet manifold with
new gaskets on cylinder
head & tighten the nuts.
In case of inlet manifold
of HA694 engine, insert the
hose connecting two manifolds
with hose clips and tighten
the hose clips after fitting
the manifolds on cylinder
head (Fig. 4-47).



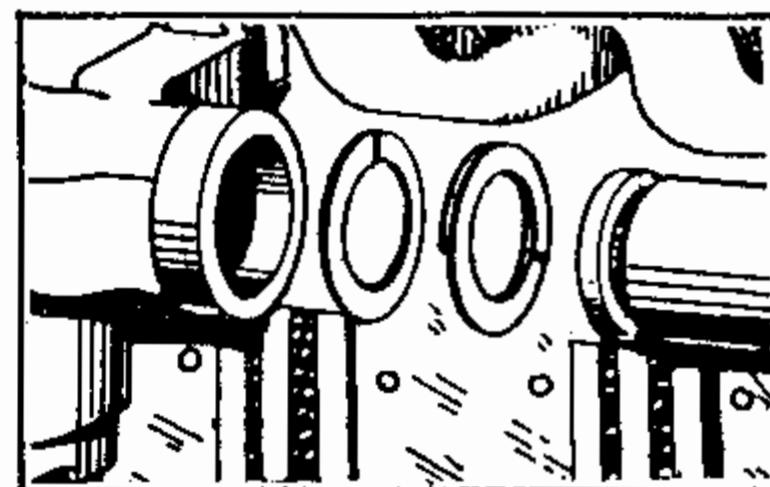
4-47

- 4.6.19 Engage exhaust manifold in
the studs of cylinder head
and tighten brass nuts
(Fig. 4-48).



4-48

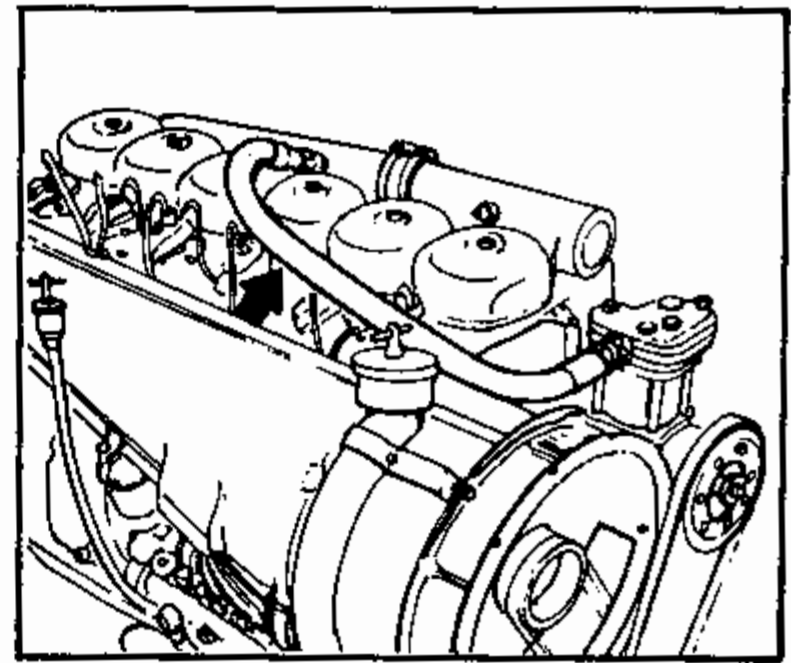
In case of HA694 engine steel
sealing rings are provided
for joining manifold pieces
of 4 cylinder and 2 cylinder.
While fitting sealing rings
in the manifold groove ensure
that these are free in groove.
Insert this manifold in to the
counter of 4 cylinder manifold
and then mount complete M'fold
assembly on the engine.
(Fig. 4-49).



4-49

4.6.20 Join compressor inlet pipe, wherever compressor is supplied (Fig. 4-50).

4.6.21 Connect fuel supply line to the inlet flame heater wherever heater is supplied.



4-50

SECTION - 5

MAJOR OVERHAUL

SECTION - 5

MAJOR OVERHAUL

5.1 GENERAL INSTRUCTIONS

The approximate period for Major Overhaul is about 9000 running hours, provided the engine is maintained properly as per the instructions given in HA-Maintenance Manual.

Before starting any major work on the engine, clean it thoroughly from outside with Kerosene, Diesel, Auto-thinner or trichloroethylene, taking all the usual safety precautions while handling such fluids.

For the best results, carry out servicing in a clean place and in clear dustfree atmosphere.

Servicing and dismantling would be faster if the engine is mounted on a service stand.

Keep the dismantled parts in clean receptacles. Whenever the parts are likely to get rusty after washing, due to corrosive atmosphere, do not forget to apply rust preventive or atleast lub. oil.

Parts with machined surfaces should be stored on wooden racks, blocks or in sheet metal trays.

5.2 SAFETY PRECAUTIONS

Use of recommended tools and installers while dismantling and assembling the engine will help the job progress faster and with efficiency.

Provide sufficient working space and proper lighting at the servicing site.

Keep the working space, tools, equipment and engine parts absolutely clean at all times.

Tighten all bolts and nuts with correct torques wherever specified.

Disconnect the battery from the starting system to prevent accidental starting of the engine.

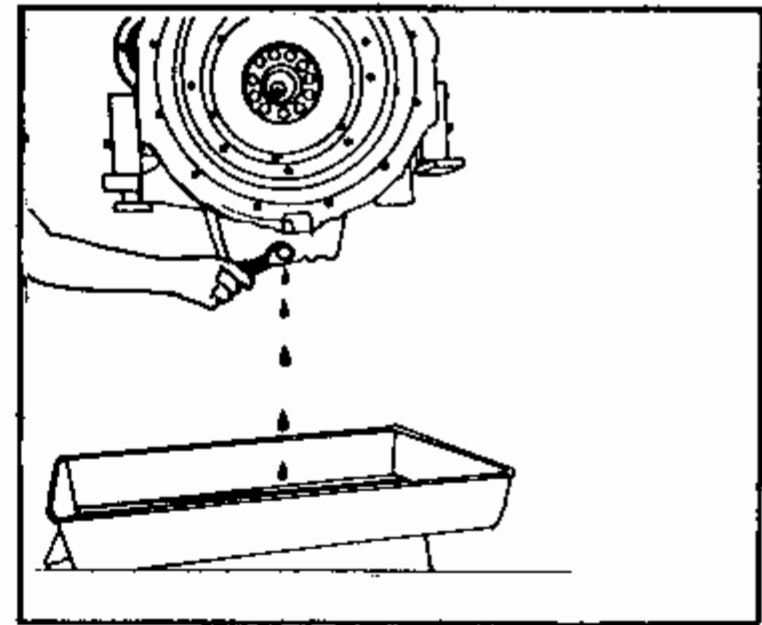
Use proper lifting devices for engine and heavy parts.

Wear the protective gear such as hard hat, safety glasses, safety shoes, hand gloves etc. considering the nature of work.

While operating an engine, be alert and keep safe distance from rotating parts like belts and pulleys etc. Avoid accidental contact with hot parts like exhaust manifold and muffler.

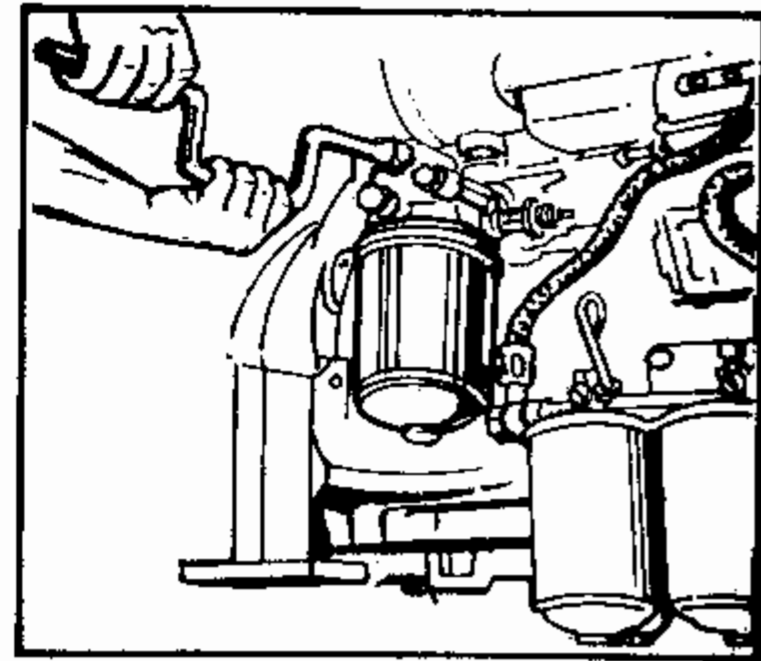
5.3 DISMANTLING THE ENGINE

- 5.3.1 Drain out lubricating oil from sump by removing drain plug provided at the bottom of the sump (Fig. 5-1).



5-1

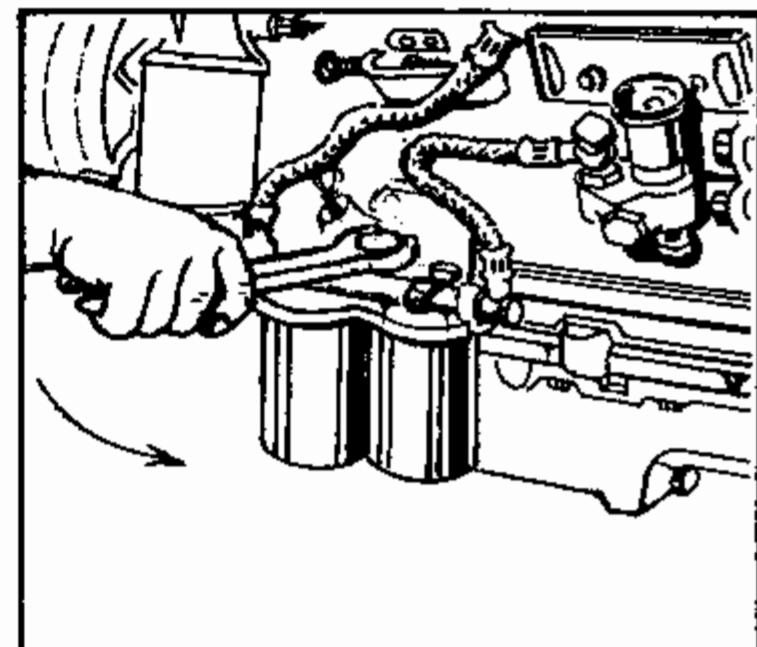
- 5.3.2 Disconnect fuel supply connections to the engine and remove all external fittings like fuel filters, lub. oil filter, electrical connections, engine stopping solenoid, alternator/dynamo and pannel board and keep them aside. Also remove starter, air compressor and oil cooler.



5-2

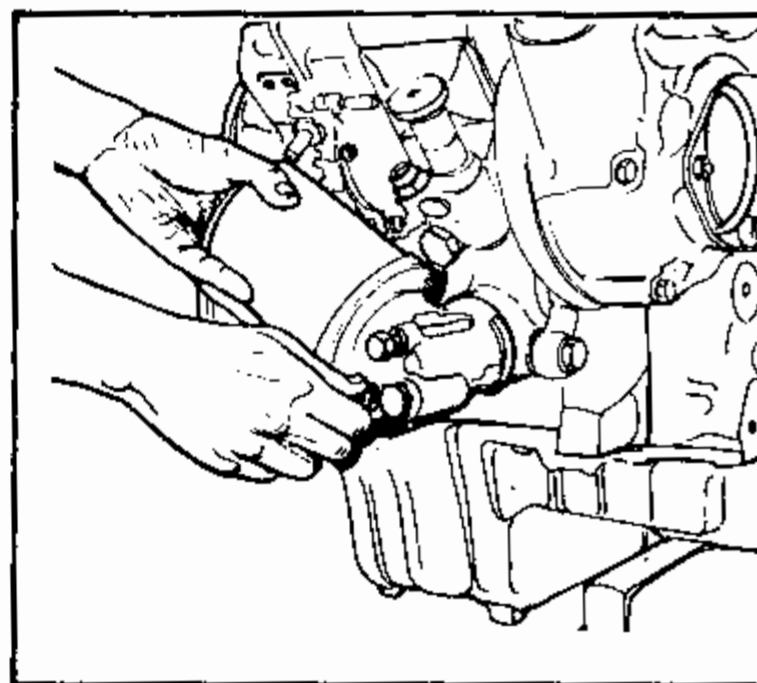
NOTE : IMMEDIATELY AFTER REMOVAL OF FUEL CONNECTIONS PLUG THEM WITH CAPS.

For removal of paper type lub. oil filter and fuel filter, refer Fig. 5-2 & 5-3.



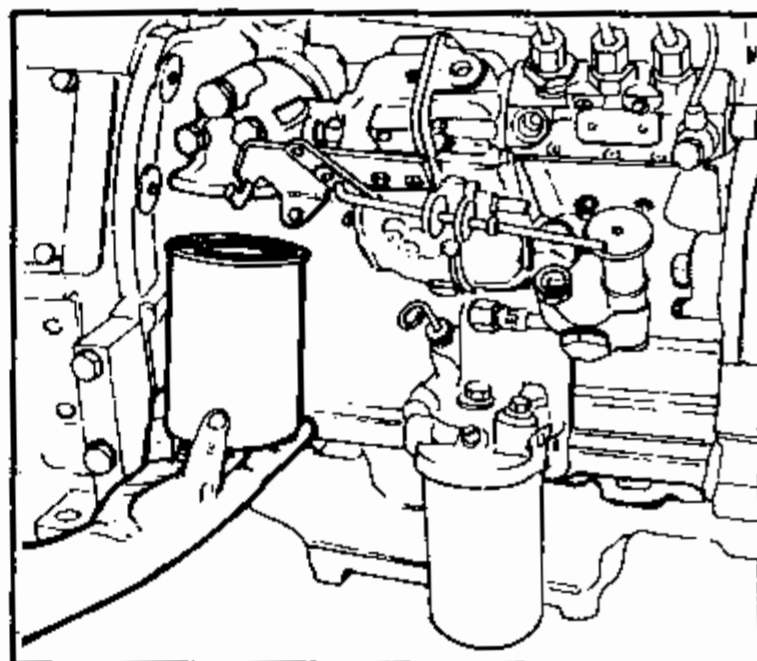
5-3

For removal of lub. oil filter on HA294 engine, refer Fig. 5-4.



5-4

Where spin on type fuel and lub. oil filters are provided. Refer Fig. 5-5 for removal of these filters.



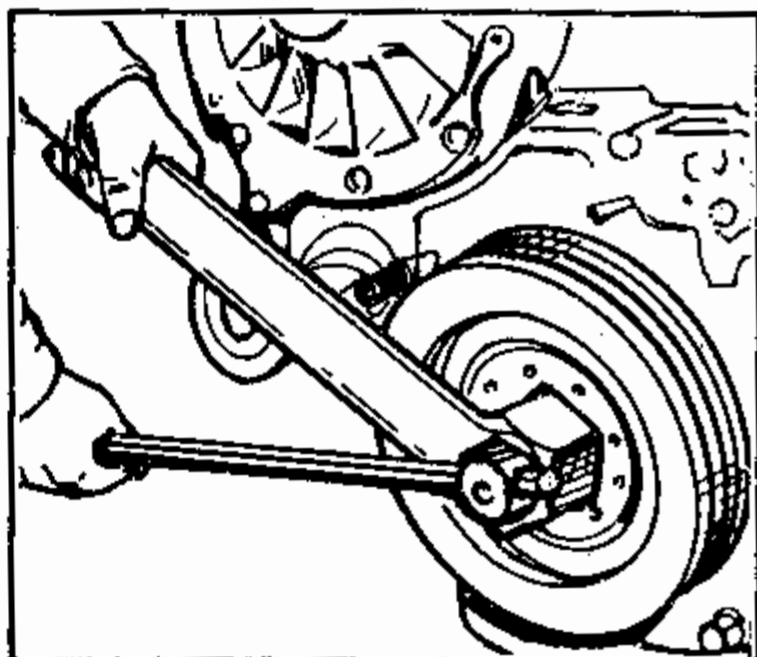
5-5

For dismantling, rocker covers manifolds, cowlings, high pressure pipes, overflow leak off pipes, nozzles, cylinder heads, liners and pistons, etc. refer Section - 4 "TOP OVERHAUL".

Remove bolt for crank pulley after taking out 'V' belts. Crank pulley bolt is having left hand threads. Hence rotate the bolt in clockwise direction (looking at the bolt) for removal.

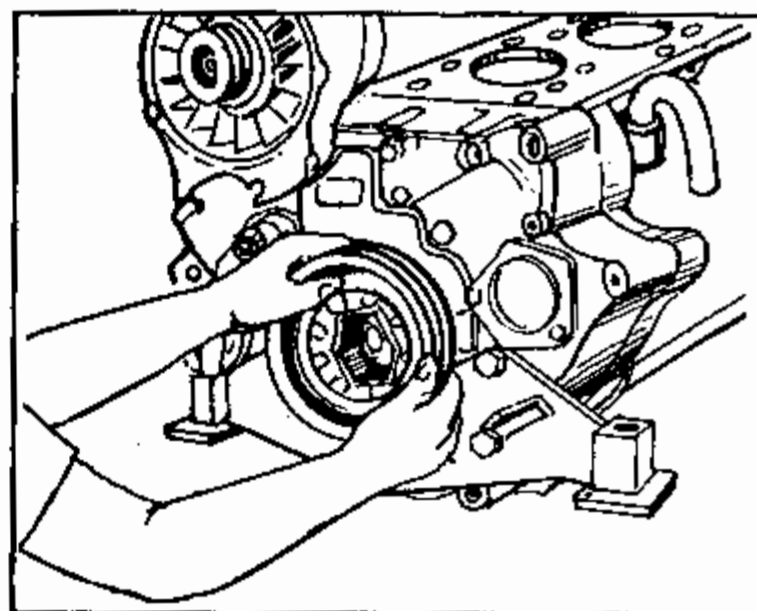
For locking the rotation of crank pulley use holding pipe spanner No. 03.950.17.0.

Use standard box spanner (Socket) 36 mm along with 9" long extension to remove the bolt (Fig. 5-6).



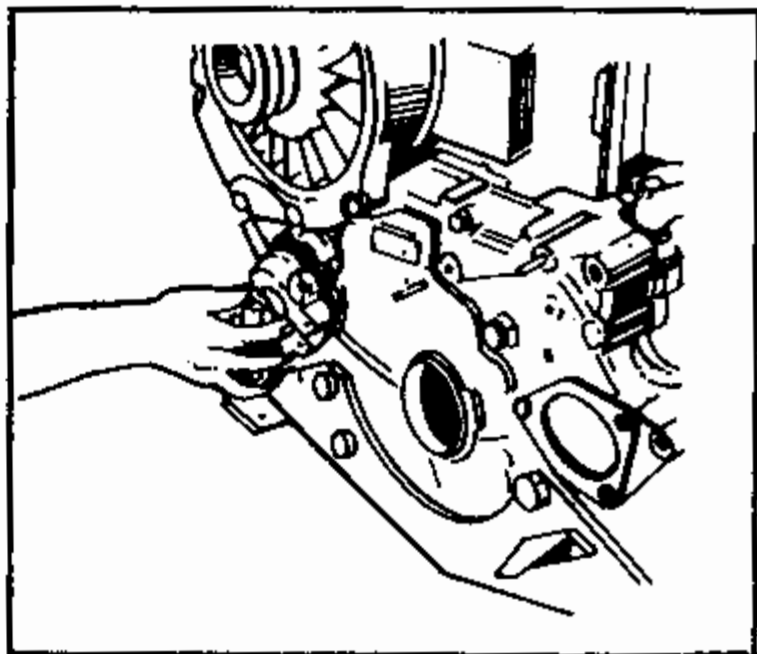
5-6

Pull out the pulley
(Fig. 5-7).



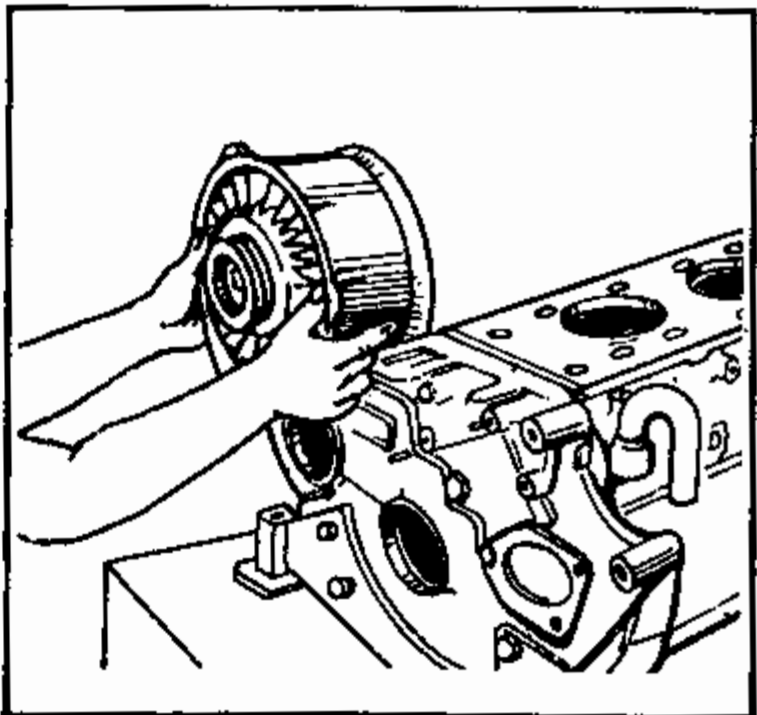
5-7

- 5.3.5 Remove automatic belt tension unit assembly from front cover (Fig. 5-8).
(Some engines are provided with belt failure switch).



5-8

- 5.3.6 Remove bolts for cooling blower clamping and remove cooling blower assembly (Fig. 5-9).

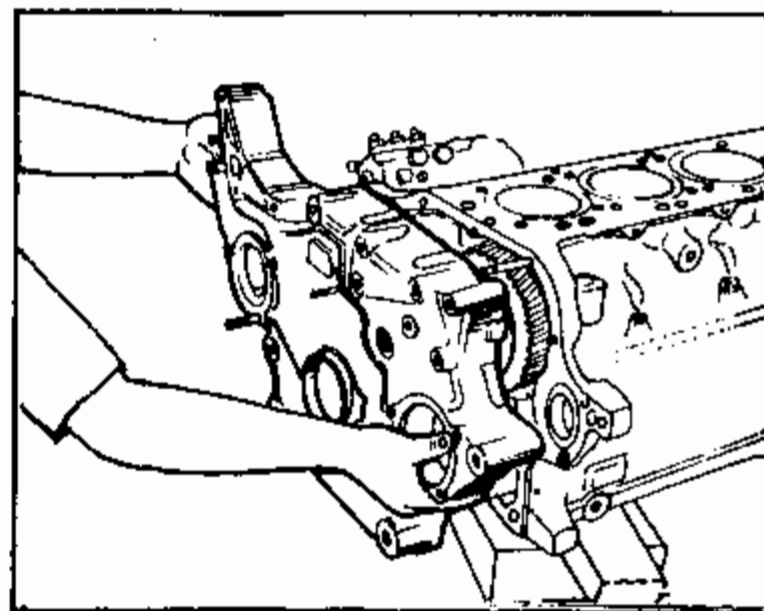


5-9

- 5.3.7 Mechanical shut down linkage if provided to be removed from pump, remove stopping bar, remove brackets and supports provided on crank case and front cover.

- 5.3.8 Unscrew the bolts securing front cover to crankcase & remove front cover. (Fig. 5-10).

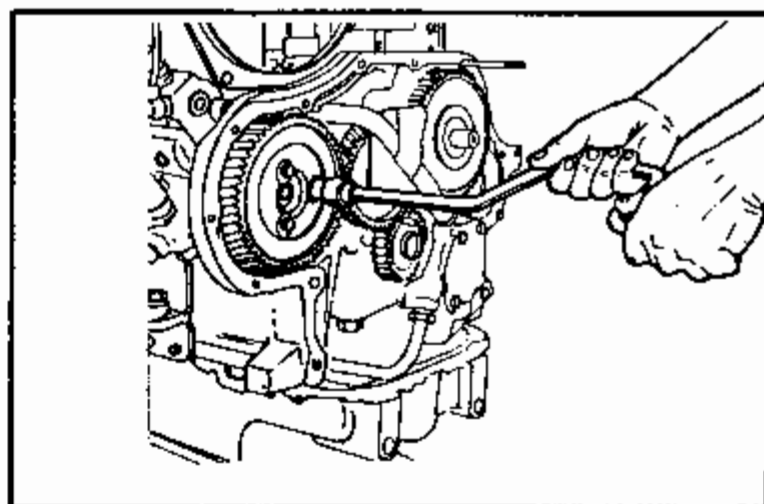
NOTE : PLEASE NOTE THAT BOLTS OF VARIOUS LENGTHS ARE USED. THESE SHOULD BE MARKED SUITABLY SO THAT THEY ARE FITTED BACK TO THEIR RESPECTIVE POSITIONS DURING REASSEMBLY.



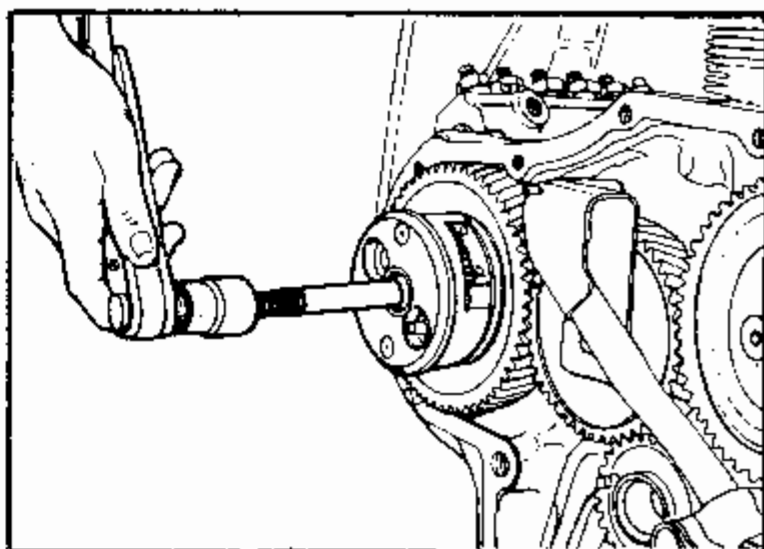
5-10

- 5.3.9 Removal of fuel pump -

- a) Loosen 3 set screws, for fuel pump gear and remove the gear. If fuel injection pump is provided with Autotimer, then remove central nut holding the Autotimer assembly to the fuel pump shaft & remove autotimer with gear. (Fig. 5-11 & 5-12).
- b) Loosen the nut for clamping fuel pump to the crankcase and remove the injection pump.

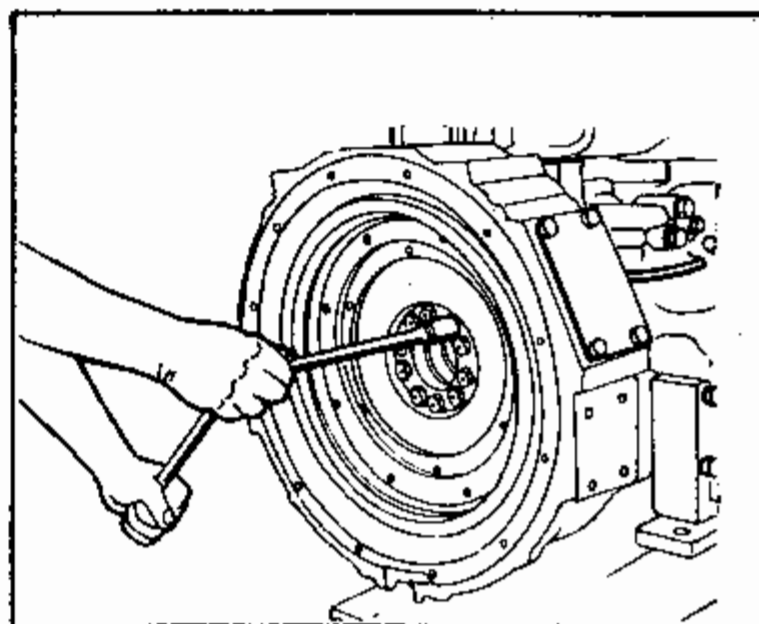


5-11



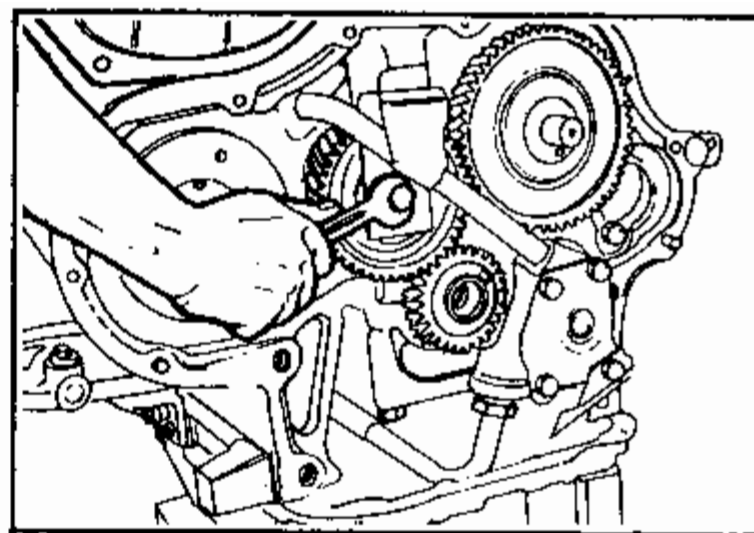
5-12

- 5.3.10 Remove flywheel from crankshaft. (Fig. 5-13).



5-13

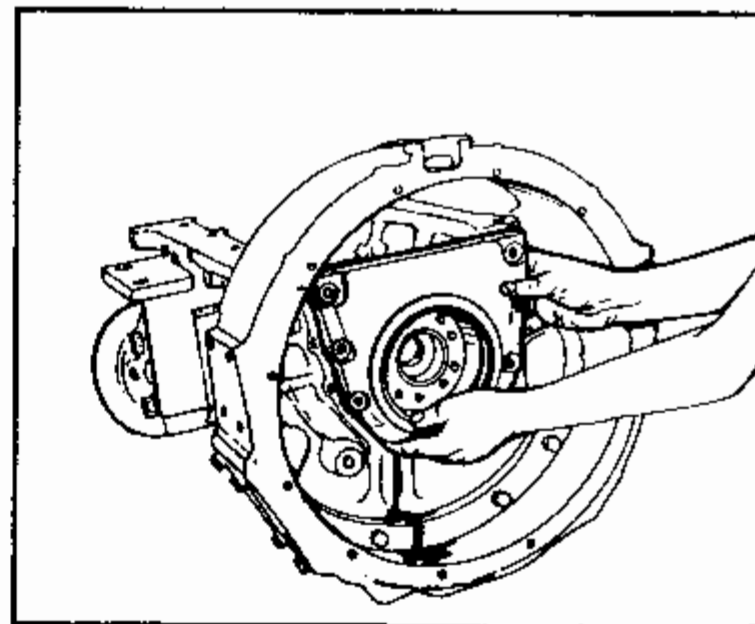
- 5.3.11 Loosen bolt for intermediate gear, which will allow removal of lub.oil delivery tube, intermediate gear and support.
(Fig. 5-14).



5-14

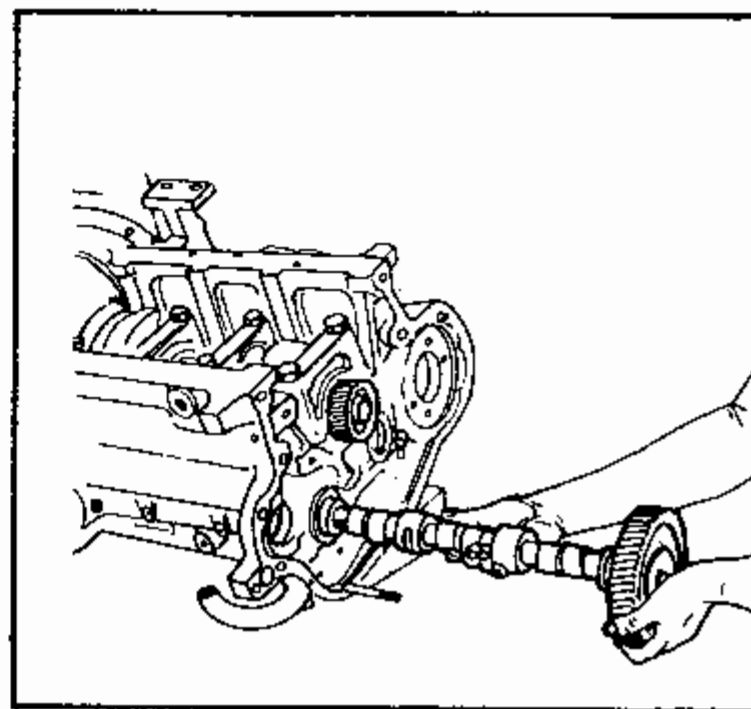
- 5.3.12 Turn the engine upside down. Remove lub. oil sump, oil seal housing at flywheel end, lub. oil suction tube and then lub. oil pump (Fig. 5-15).

NOTE :PREFERABLY USE ENGINE SERVICING STAND. IN CASE STAND IS NOT AVAILABLE, USE WOODEN BOARD & BLOCKS.



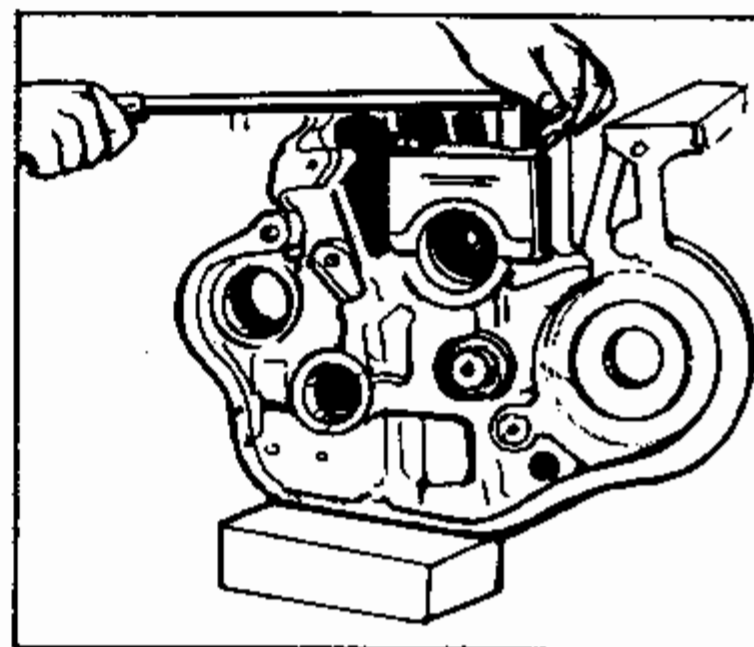
5-15

- 5.3.13 Pull out cam shaft with gear and take out tappets.
(Fig. 5-16).



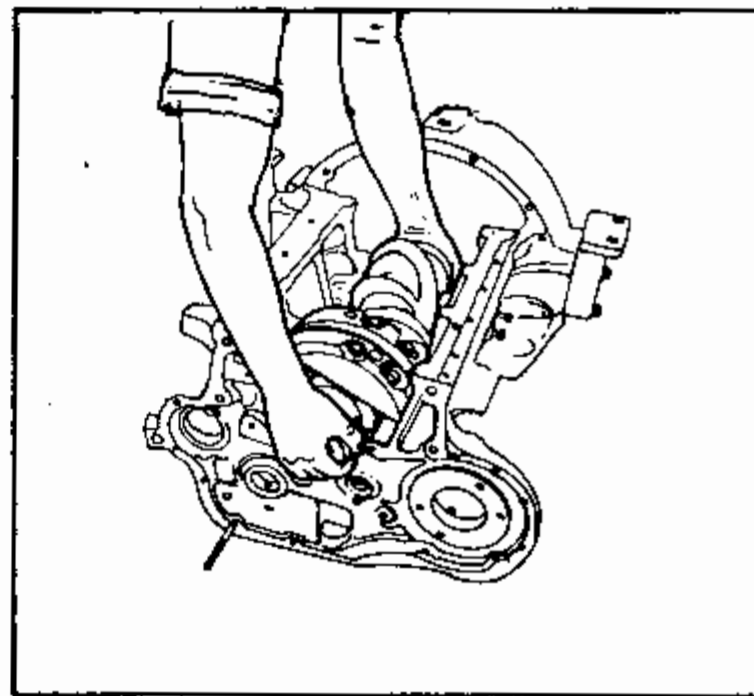
5-16

- 5.3.14 Loosen main bearing cap bolts, remove caps and bearing sheels (Fig. 5-17).



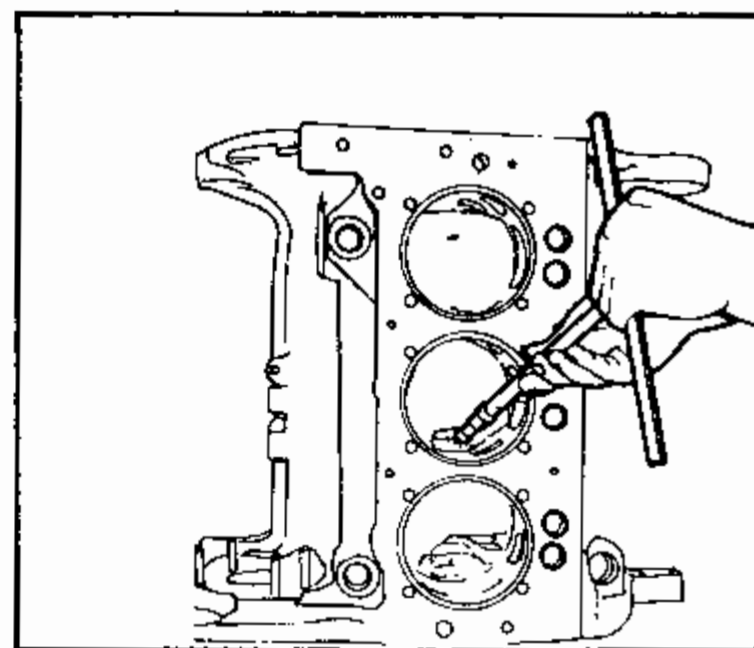
5-17

- 5.3.15 Take out crankshaft from the crankcase. (Fig. 5-18) and take out the bearing shells.



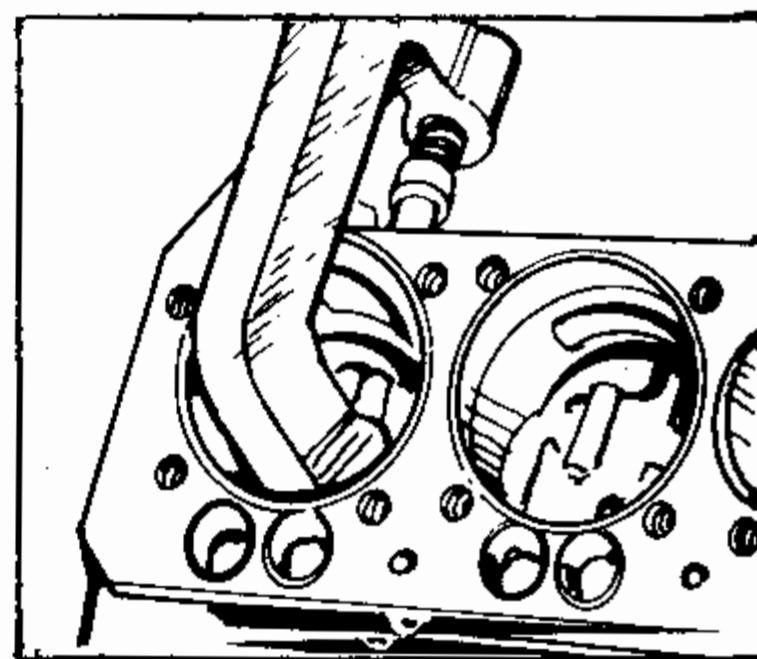
5-18

- 5.3.16 Unscrew all the plugs and reducers in lub. oil circuit. Remove oil spray nozzles with a special box spanner No.03.950.04.0 (Fig.5-19) for HA294/394/694 & HA 494 without secondary balancing arrangement.



5-19

For removing oil spray nozzle of HA494 engine with secondary balancing arrangement; use 'C' clamp No.04.950.02.0 (Fig.5-20).

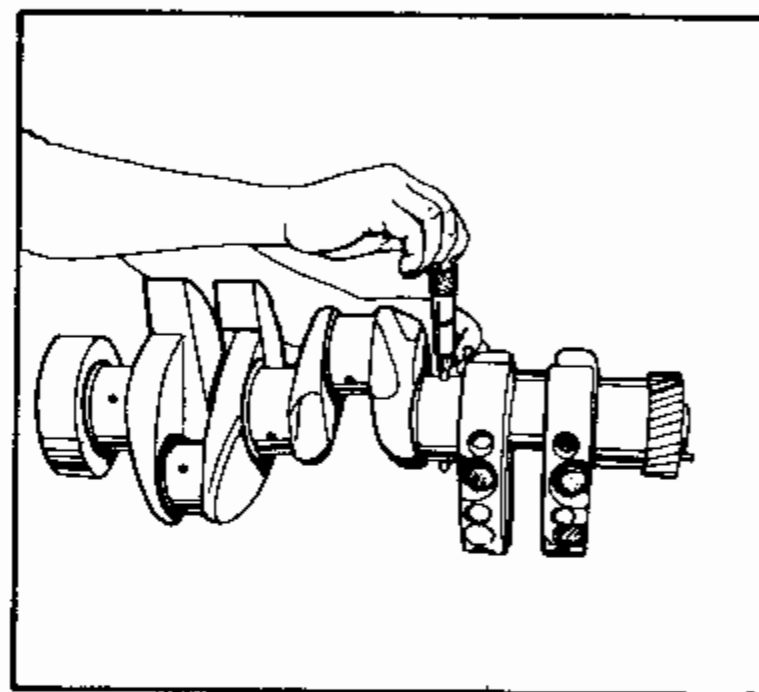


5-20

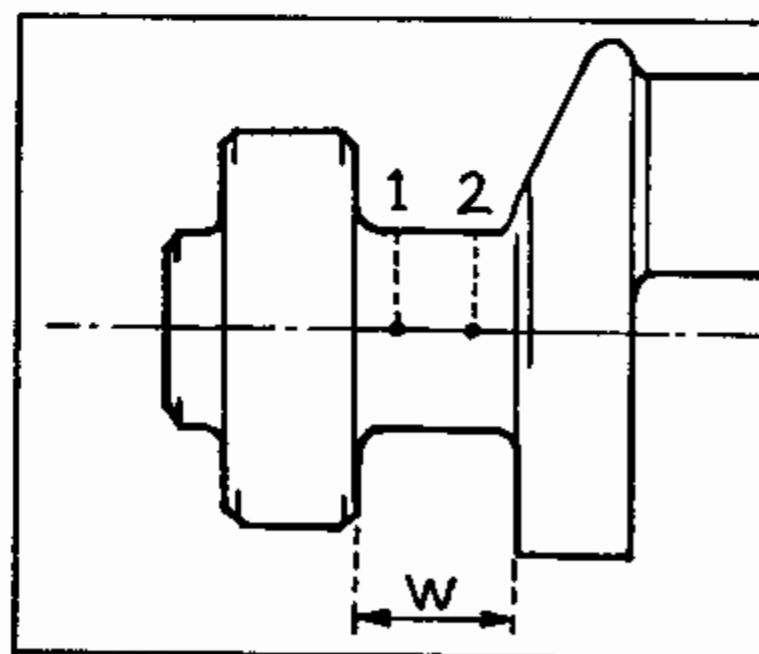
- 5.3.17 Check oil spray nozzles for opening pressure and check for suitability for reuse. Clean all the parts removed with diesel oil/trichloroethylene to carry out inspection & servicing of components.

5.4 CHECKING AND SERVICING OF CRANK SHAFT

- 5.4.1 Inspect the crankshaft for cracks, by magnaflux method.
- 5.4.2 Remove crank gear from crank shaft.
- 5.4.3 Support the crank shaft at outer main journals, on 'V' blocks.
- 5.4.4 Measure the hardness of all main journals and big end journals. Compare the measured values with the specification. (Hardness on 'Rockwell 'C' scale)
- 5.4.5 Measure diameters of all main journals and big end journals at the points 1&2 in vertical & in horizontal planes. Width 'W' is also to be measured at journal for thrust bearing. (Fig. 5-21 & 5-22).



5-21



5-22

Note all the readings in a tabular form and compare with the specifications. For details like straightness, out of roundness, parallelity of journal and pins. Please note that wear limit for ovality is 0.02 mm. Check all journals for dial trueness. Standard dimensions of main journal, big end journal and width of journal for thrust bearing are shown in Fig. 5-23.

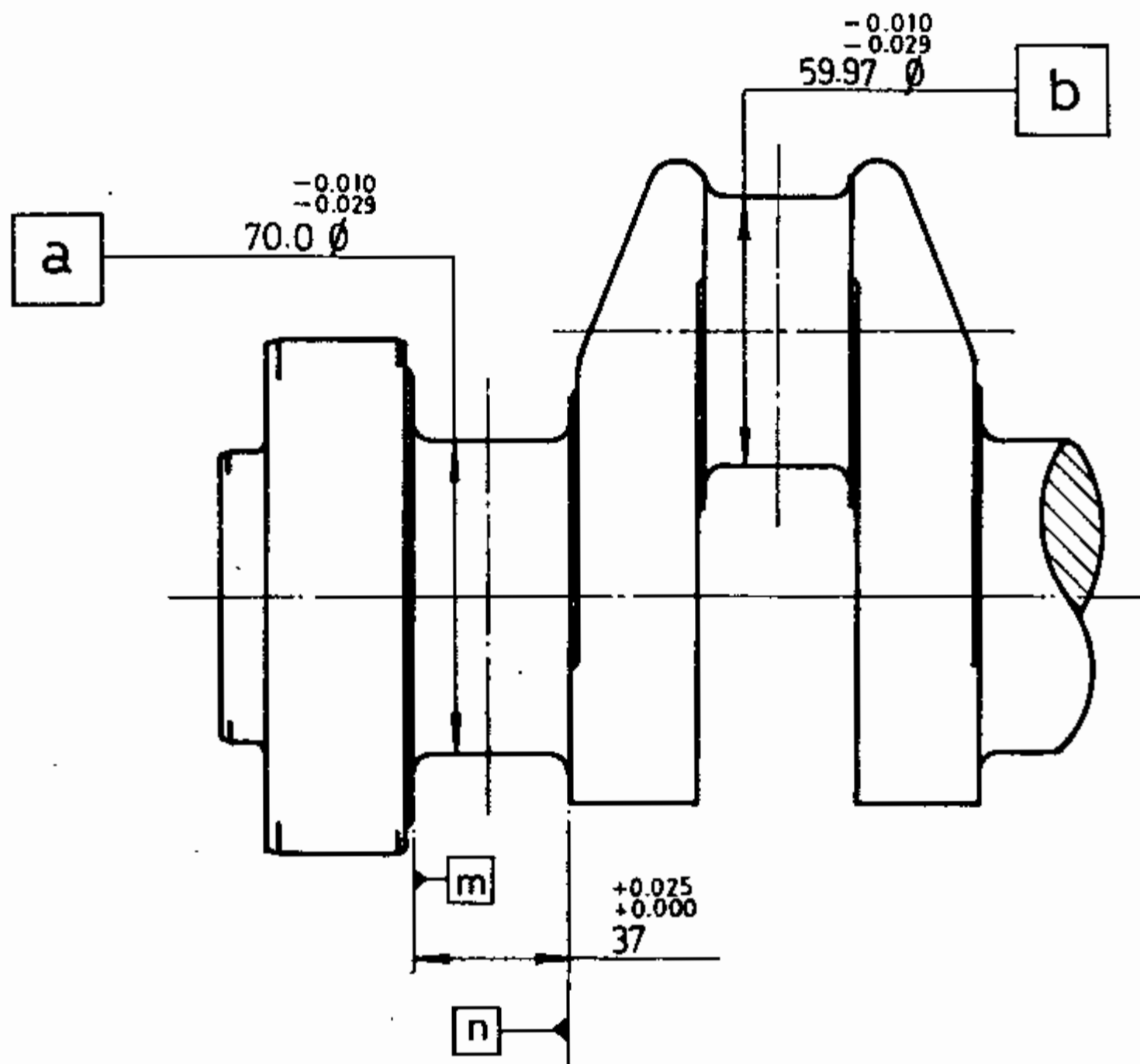


FIG. 5-23

ALL DIMENSIONS ARE IN mm.

FACE m AND n SHOULD BE SQUARE TO JOURNAL a WITHIN 0.025.

ALL PIN DIAMETERS SHOULD BE PARALLEL WITHIN 0.02 WITH RESPECT TO END JOURNALS.

ALL INTERMEDIATE JOURNALS SHOULD BE CONCENTRIC WITHIN 0.06 WITH RESPECT TO END JOURNALS.

THIS SKETCH SHOWS DIMENSIONS OF STANDARD SIZES. FOR UNDER SIZES OF JOURNALS AND PINS REFER TECHNICAL SPECIFICATION.

5.4.6 Check surface of journals in the zone where oil seal comes in contact. If the crankshaft is beyond the limits of reconditioning or found to be defective, replace the crankshaft.

5.4.7 Machining of crank shaft-
Before machining the shaft check it for cracks by magnaflux method.

Grinding the crank shaft-

Remove balance weights.
Before removing balance weights, punch mark on balance weight & corresponding crankshaft web for correct position while reassembly.
Grind shaft journals and pins to the next undersize, according to data sheet.
Reconditioned crank shaft should confirm to the dimensions according to specifications.

NOTE: 1. ROUND OFF OIL HOLES
FILLET/CORNERS
OVER THE JOURNALS
& PINS. DO NOT
SPOT FACE IN ANY CASE.

2. LOCATION DIAMETERS
FOR FLYWHEEL AND
DAMPER SHOULD NOT
BE MACHINED.

3. THRUST FACES OF MAIN
JOURNALS & PINS
SHOULD NOT BE
MACHINED WHILE
GRINDING. MACHINE
ONLY THE THRUST
FACES FOR LOCATING
JOURNAL. THRUST
WASHERS FOR CRANK
SHAFT IN 0.25 &
0.50 mm OVERSIZE
COULD BE MADE
AVAILABLE.

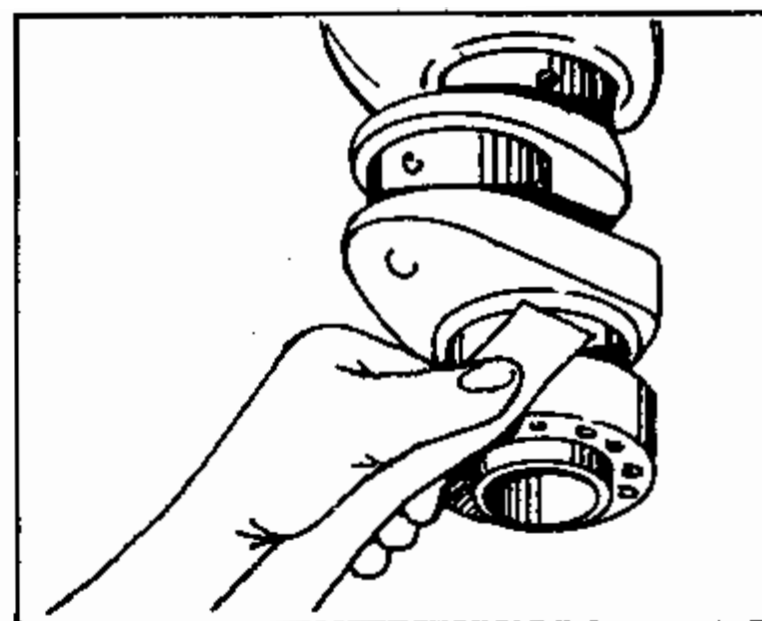
5.4.8 Refit the balance weights to the webs in proper order.
Tighten the bolts with angle torque as per specification.

- 5.4.9 Finish oil seal resting area on crank shaft (At flywheel end).

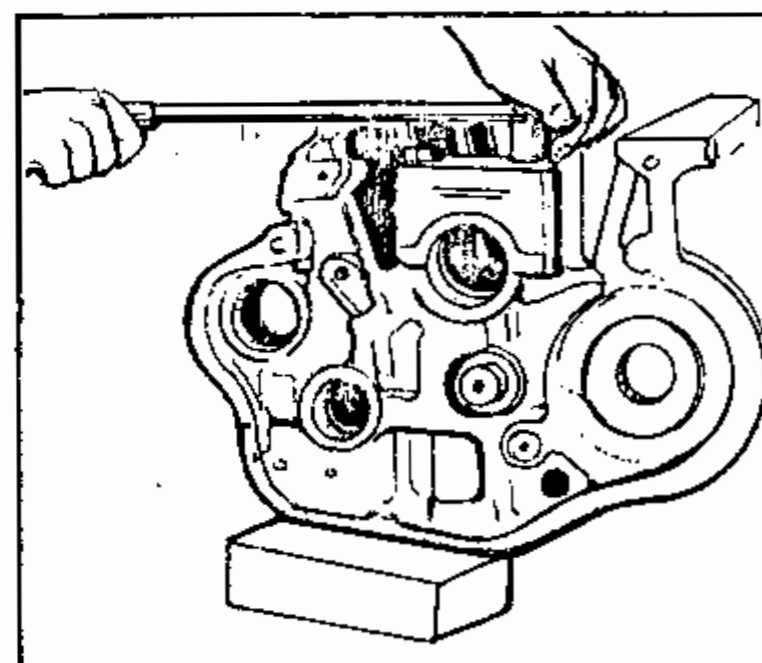
Use fine emery cloth to give oil repellent finish, in right hand direction. See Fig. 5-24.

5.5 CHECKING AND SERVICING OF CRANKCASE.

- 5.5.1 Engine is completely dismantled. Make sure that the crankcase is clean, particularly oil galleries. Check the crankcase for cracks. Clear all tapped holes by running taps. Apply grease while running taps in blind tapped holes.
- 5.5.2 Check cam bores for damage and visible wear. Check condition of the main bearing bore.
- 5.5.3 Main bearings (Thin walled) are pre-loaded in main bores. Bearing shells should not be touched for any adjustment.
- 5.5.4 Insert hollow dowels in crank case and then place main bearing caps (with bearing shells) in order to tally with marking on crankcase. Tighten bolts alongwith washers with the angle torque as given in specification. (Fig.5-25).

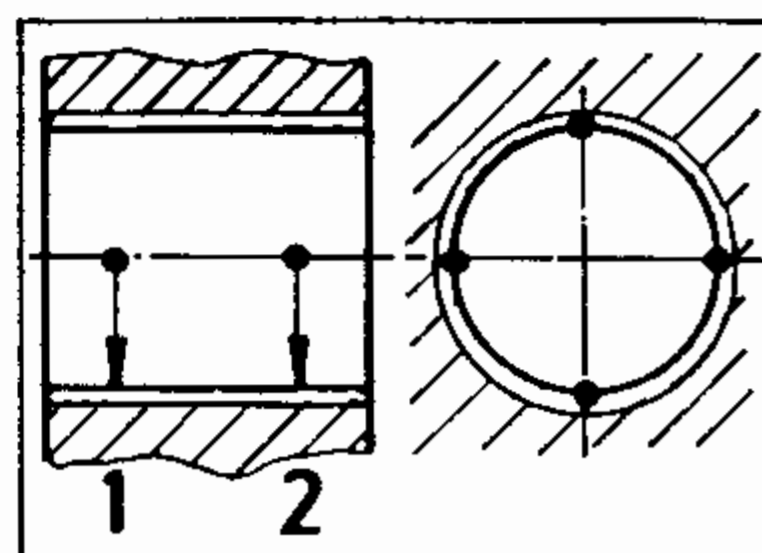


5-24



5-25

Set dial gauge to the correct size, (main bearing nominal and under size) on micrometer and measure main bearing bore sizes in planes '1' & '2' in vertical & horizontal direction. (Refer Fig. 5-26). If the recorded values correspond to those specified in specification, the respective bearing is in acceptable condition.



5-26

If the recorded bearing boare diameters differ slightly from the specified valves, repeat the measerement with the new bearing shells installed.

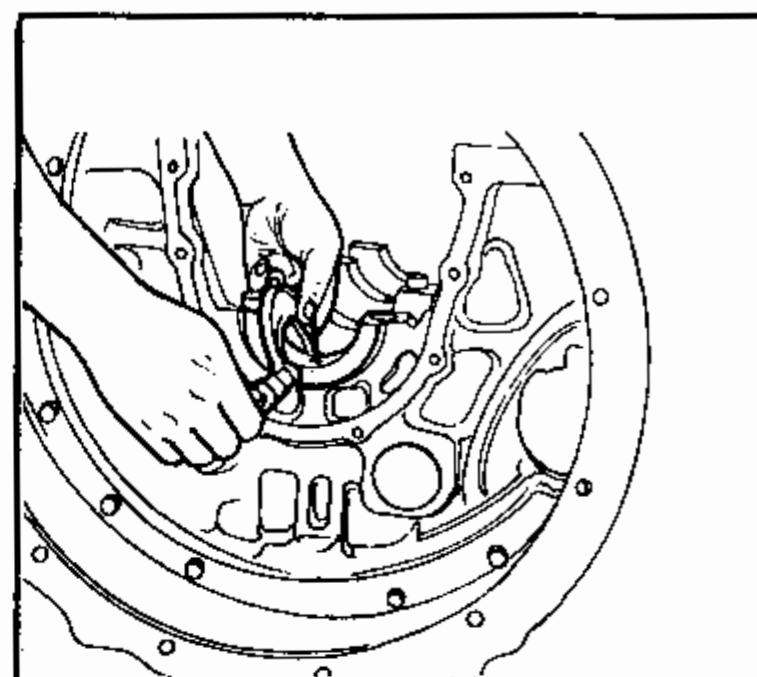
Insert new bearing shells, mount the cap then preload and tighten up according to instructions.

- 5.5.5 Measure the width of the side faces for locating bearing, in the crankshaft. (Refer Fig. 5-23 of Sect. 5.4.5).

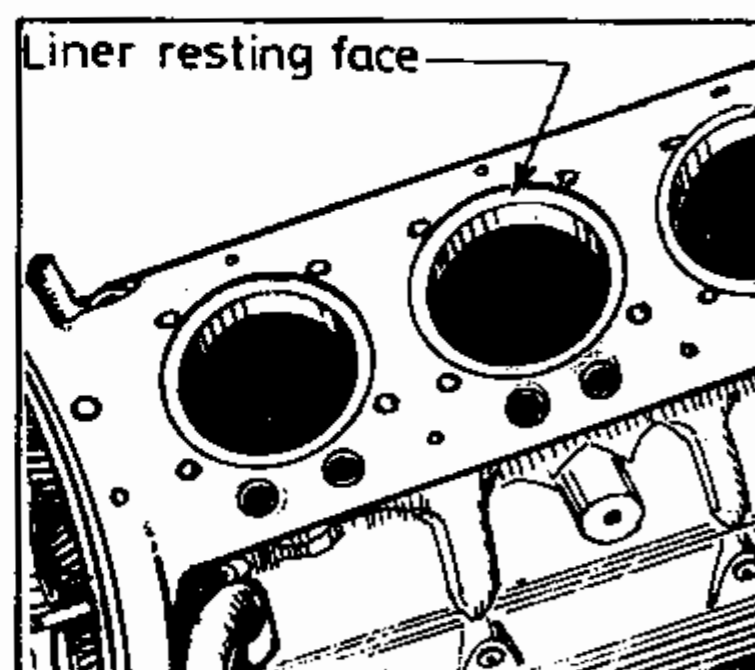
- 5.5.6 Assemble thrust rings on crankcase as shown and measure total thickness with micrometer (Fig.5-27).

Calculate the measured clearance & compare with the specification. If clearance is exceeding the limit use next over size thick thrust washer.

- 5.5.7 Inspect liner resting face on crankcase (Fig. 5-28). This must be flat and without any damage.



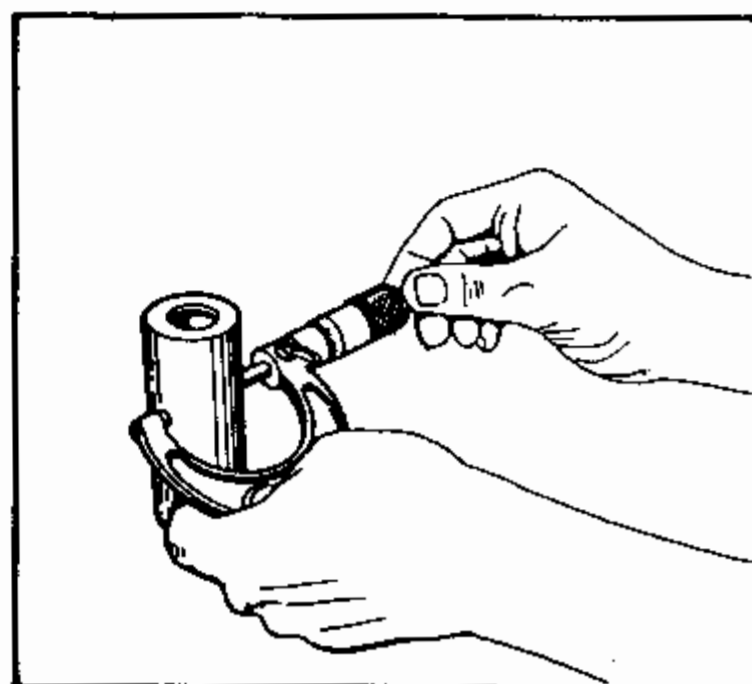
5-27



5-28

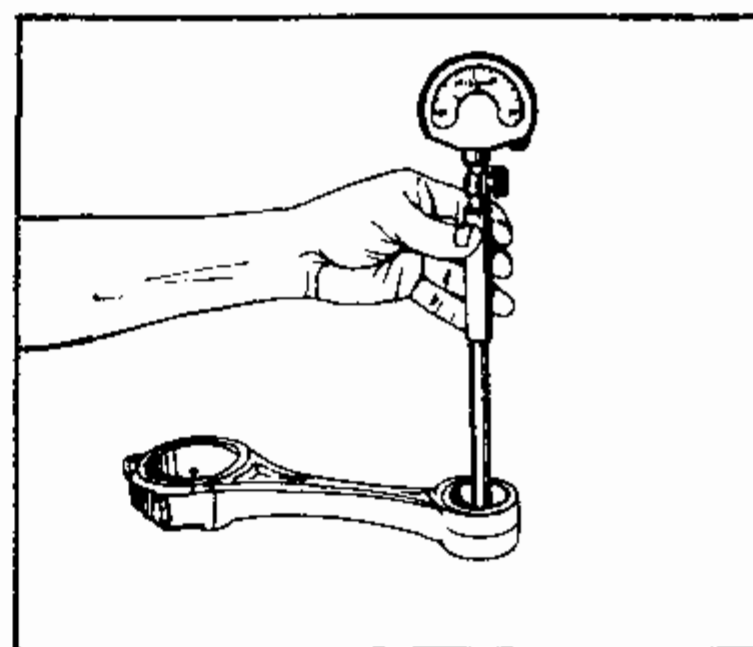
5.6 CHECKING AND SERVICING OF CONNECTING ROD AND PISTON PIN

- 5.6.1 Measure mid way diameter of the piston pin, with micrometer. (Fig. 5-29).



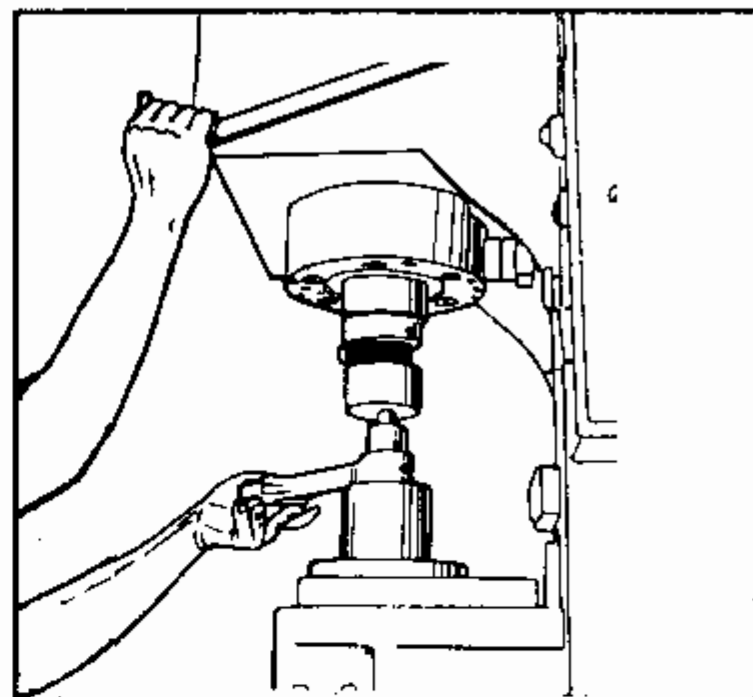
5-29

- 5.6.2 Set the dial gauge on micro-meter to the correct size of small end bearing bore. Measure the bearing bore in connecting rod. (Fig. 5-30).



5-30

- 5.6.3 Find out clearance between piston pin & small end bush bore. If it is exceeding the clearance specified in Technical Data, remove the small end bush with the help of mandrel No. 03.950.18.0 (Fig.5-31).

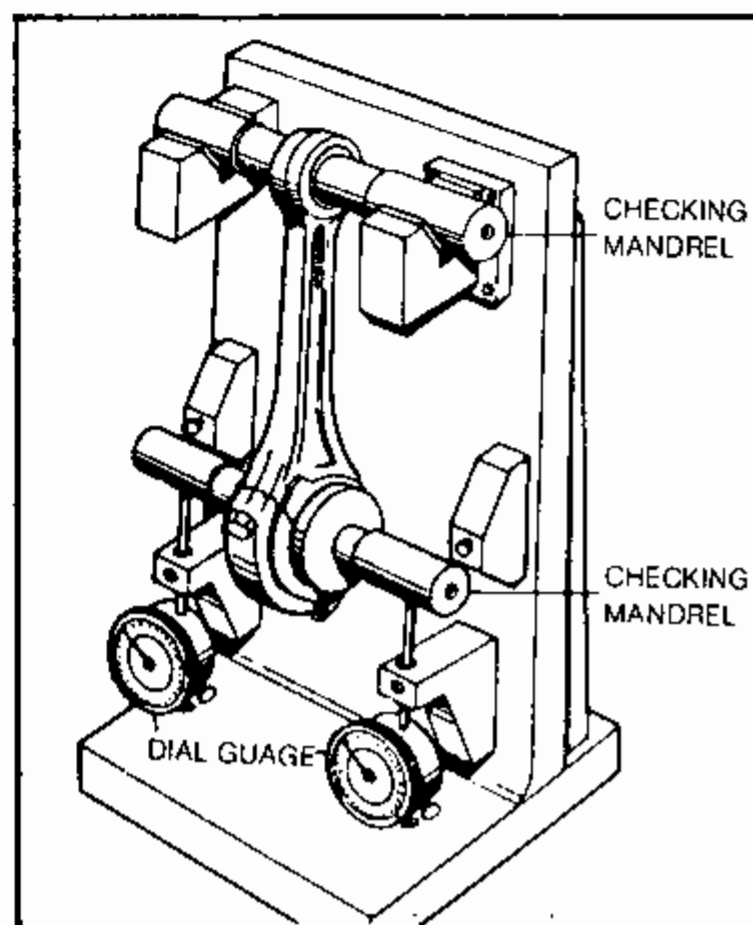


5-31

Press in, new small end bush with the help of mandrel No. 03.950.18.0. Ensure that the oil holes are matched.

Again measure the bore diameter. If it is found less than the specified standard bore, ream it with the special reamer No.53302.

- 5.6.4 For checking of parallelism of small end bore (with bush) & big end bore (without bearing shells) mount the connecting rod in a fixture with checking mandrels provided with fxture, both in small & big end bores, as shown in the Fig.5-32. Difference between two dial readings should not exceed 0.08 mm. If the dial reading is exceeding 0.08 mm, remove the connecting rod from fixture and give a slight blow on the web, to correct the bore axis. Repeat the process till reading shows within 0.08 mm.

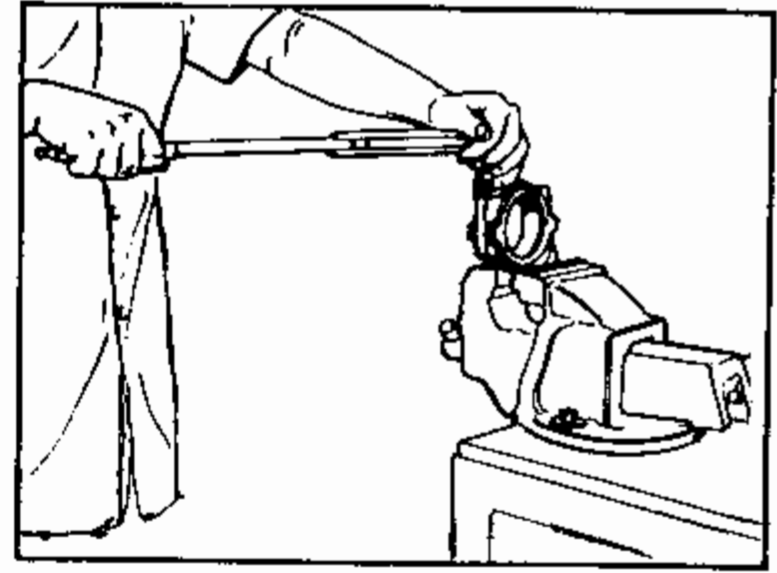


5-32

5.6.5 Checking & replacing big end bearings -

Big end bearings pair consists of two halves, and are supplied in finished condition. These cannot be reconditioned. Undersize bearings, according to the requirements, are available in 6 stages by 0.25 mm on diameter.

Assemble the big end bearing cap with connecting rod. Ensure that markings on con. rod and cap tally. Tighten the bolts with specified angle torque (Fig. 5-33).



5-33

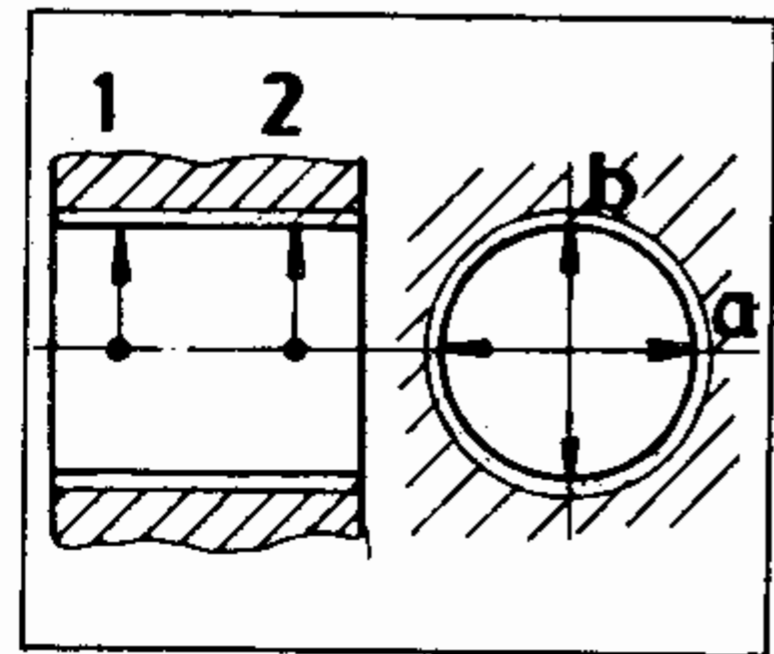
Set the dial gauge on micrometer to the correct size and measure big end bearing bore in planes 1 & 2 in direction 'a' & 'b'. Record the readings in tabular form & compare with the specification, (Fig. 5-34 & 5-35)

Note any ovality or taper is observed.

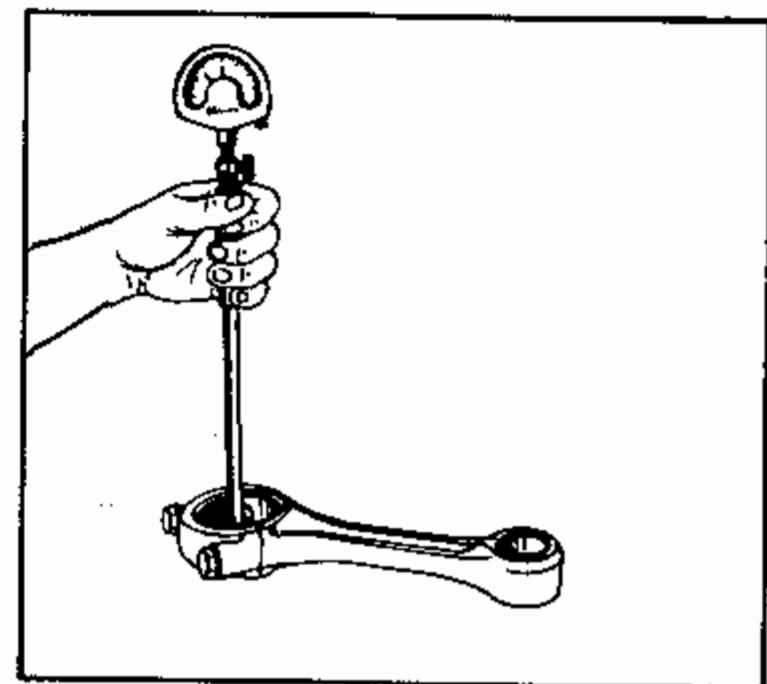
★

If the recorded values correspond to those specified in the specification, the respective bearing is in acceptable condition. If it differs than the specified value, replace the bearings (standard size or under size) and repeat the measurement same as above. If the readings show that the bearing tolerances with new installed bearings remain upto a max. of 0.020 mm above the values specified, the connecting rod is still fit for use. Otherwise it has to be replaced. Do not recondition bearing shells or big end bore of connecting rod.

★



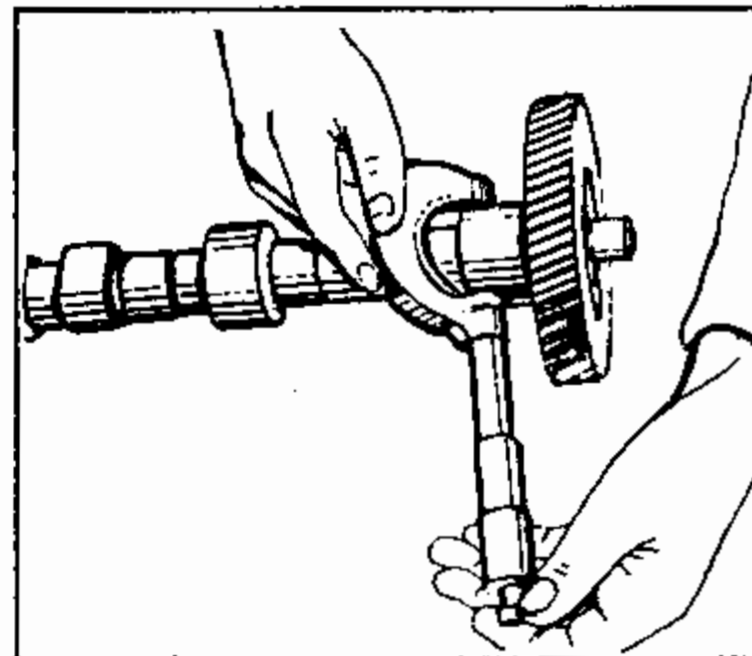
5-34



5-35

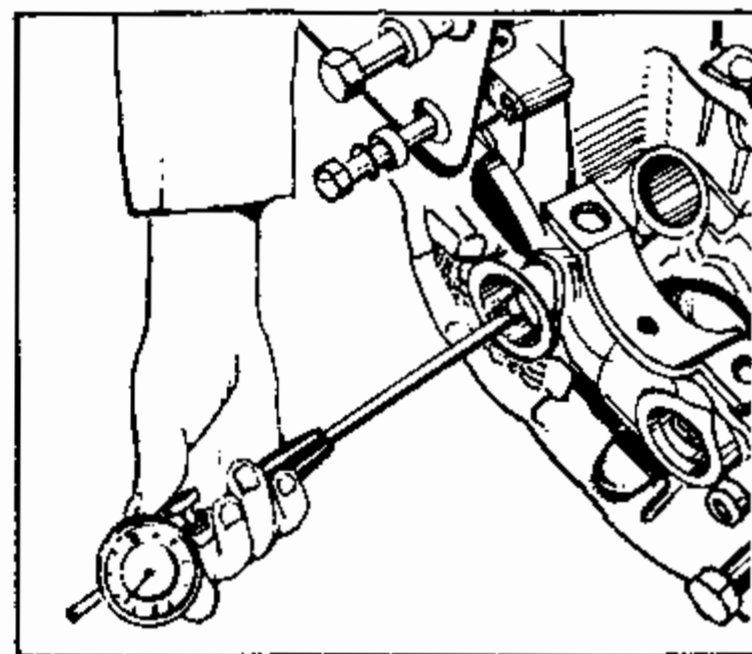
5.7 CHECKING AND SERVICING OF CAM SHAFT

- 5.7.1 Check the cam shaft with its gear (shrink fitted gear) for wear or any damage. Measure journal size of Gear end side. (Fig. 5-36). Journal size should not be less than the limit given in specification. Use new cam shaft assembly, if this is found to be defective.

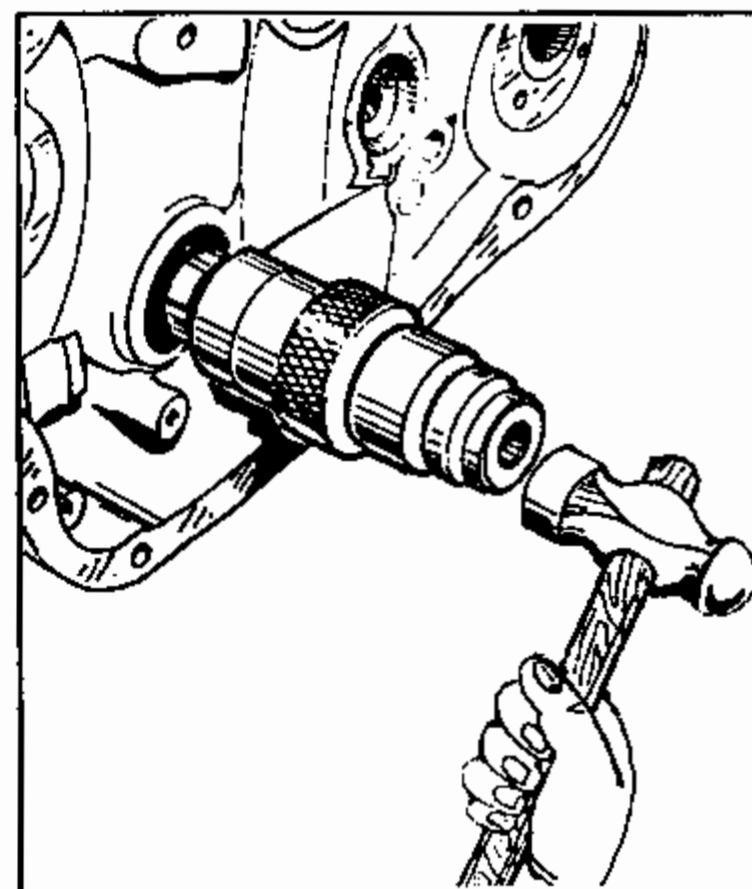


5-36

- 5.7.2 Set the dial gauge to the correct size of cam bush bore (Gear end side) and measure the bearing bore. If bearing bore is found to be on higher limit as compared to specification, remove the old bush from crankcase and replace it with the new one. Use mandrel No. 03.950.10.0. Note that cam bush is supplied in finished bore condition, hence need not be machined after pressing. (Fig. 5-37 & 5-38).



5-37

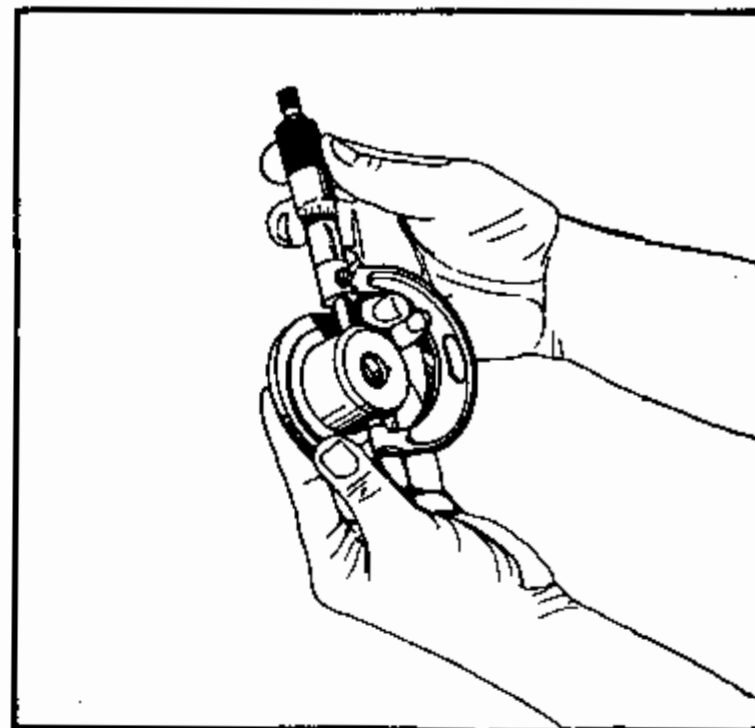


5-38

5.8 CHECKING AND SERVICING OF INTERMEDIATE GEAR ASSEMBLY

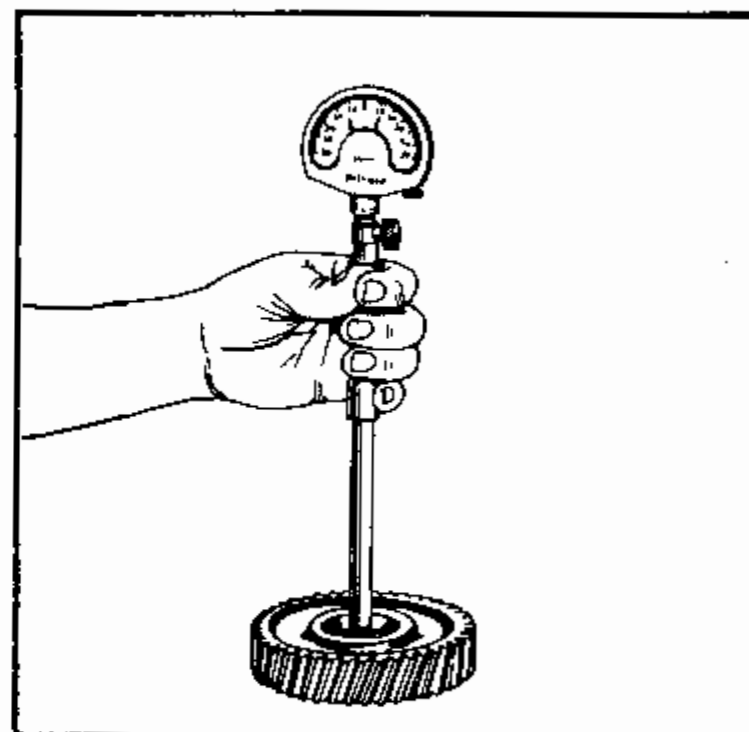
5.8.1 Check idler gear for wear and damage of teeth, if it is severe replace the gear with new one.

5.8.2 Check journal diameter of gear support. If the bearing surface is found damaged, replace the support. Measure journal diameter with micro-meter (Fig. 5-39).



5-39

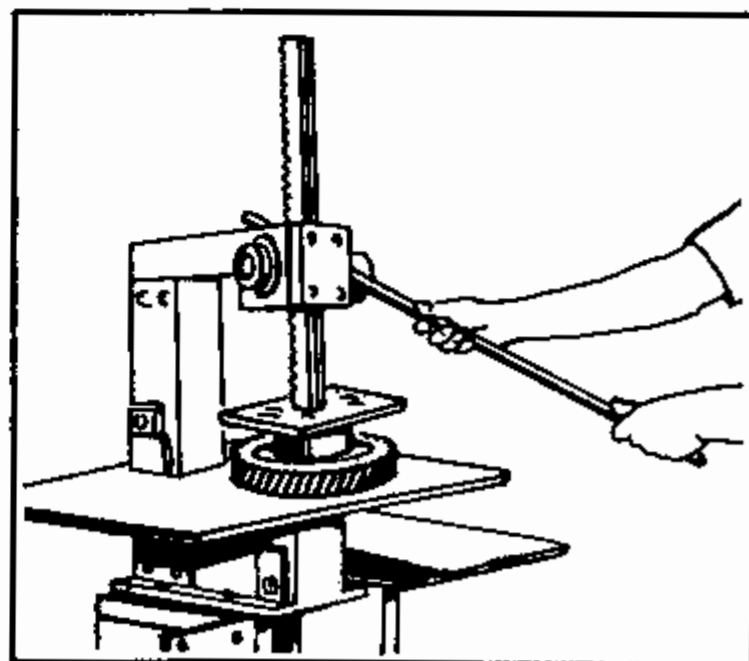
5.8.3 Set the dial gauge on micro-meter to the correct size given in specification for bearing bore (bearing installed in gear). If it is exceeding the limits as specified in the specifications, replace the bearing bush (Fig. 5-40).



5-40

For removing the old bush and pressing in new bush use mandrel No. 03.950.19.0 (Fig. 5-41).

After pressing the new bush in the gear, check the bore again. If it is found less than the standard specified bore size, ream it with the special tool No. 53301.

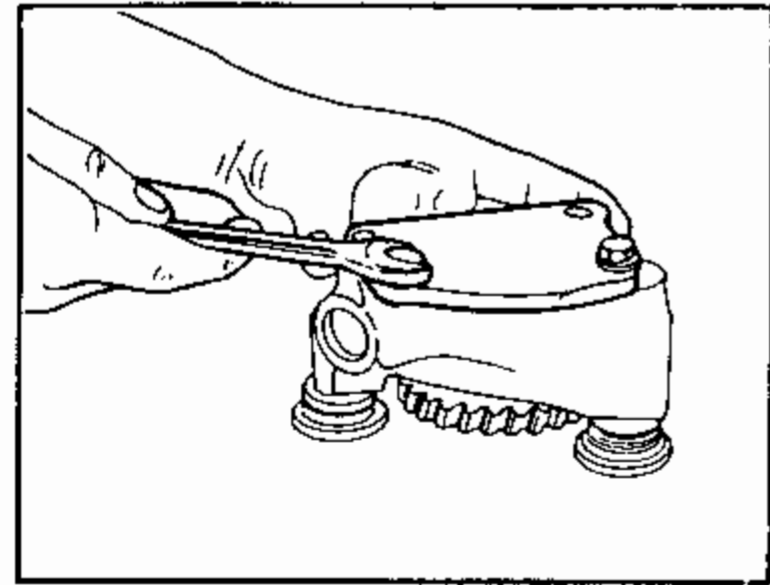


5-41

5.9 CHECKING AND SERVICING OF LUB.OIL PUMP

5.9.1 Checking of clearances -

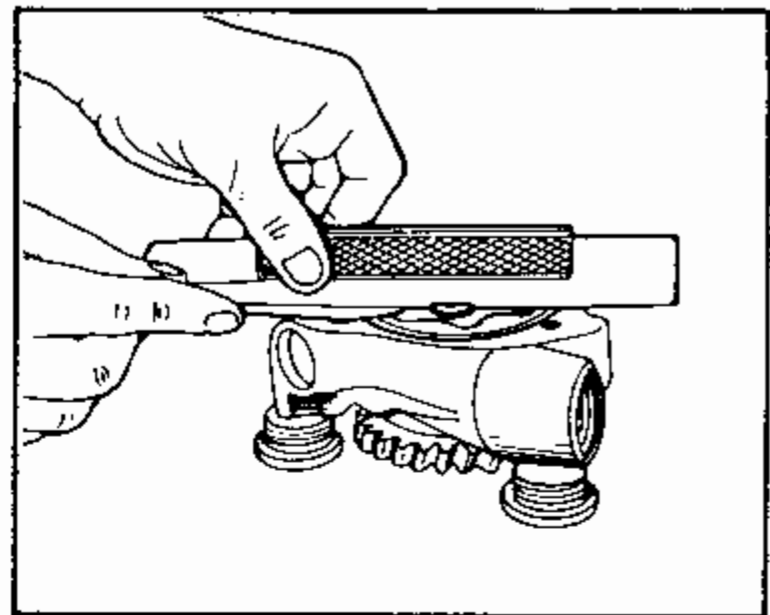
- a) Remove the cover plate. Remove the 'C' ring from pump body and check the condition of the ring. If it is found damaged or permanent set, replace the 'O' ring while assembly (Fig. 5-42).



5-42

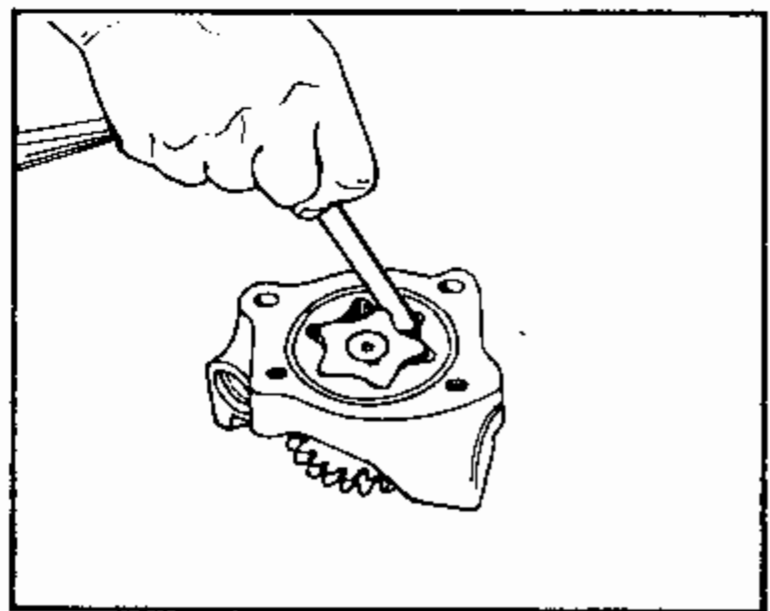
- b) Check side clearance of rotors with the help of straight edge (6" long) and feeler gauge as shown in Fig. 5-43.

If side clearance exceeds the limit value given in specification change the complete lub.oil pump.



5-43

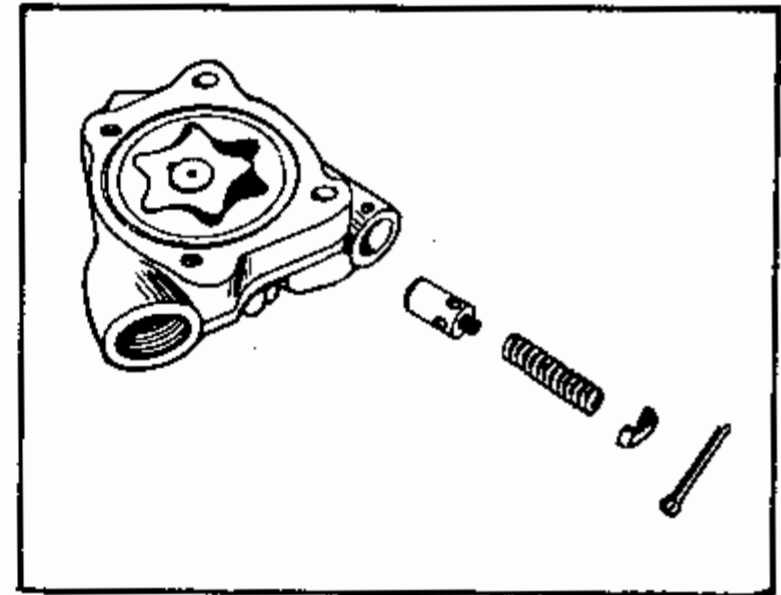
- c) Check radial clearance between rotors with feeler gauge. If it exceeds the limit value given in specification change the complete lub.oil pump. (Fig. 5-44).



5-44

NOTE : INNER AND OUTER ROTORS ARE NOT SUPPLIED AS SPARES AS THEY ARE IN MATCHED PAIRS TO SUIT THE LUB.OIL PUMP BODY. HENCE COMPLETE LUB.OIL PUMP ASSEMBLY IS TO BE REPLACED WHENEVER REQUIRED.

- 5.9.2 Take out split pin for relief valve and remove spring cup, spring and relief valve from the body. Clean thoroughly these parts with diesel oil. Clean also the lub.oil pump body from inside. Ensure that the relief valve is free in movement in its' bore. It should not be tight in bore. (Fig. 5-45).



5-45

- 5.9.3 Assemble relief valve components. Fit new split pin for locking. Replace the cover plate with 'O' ring.

Tighten 2 hex. set screws holding cover plate on body for HA394 & HA494 engines,

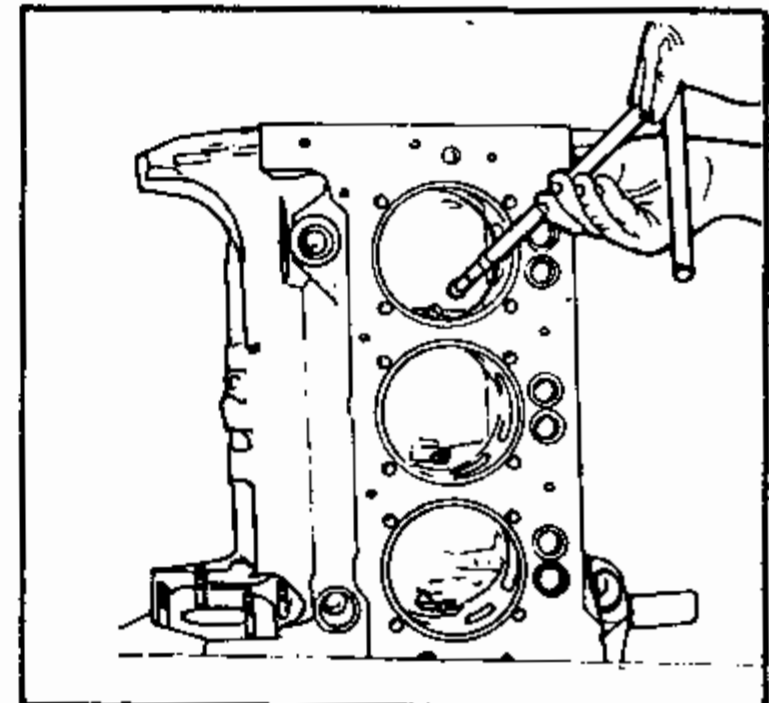
In case of HA294 & HA694 engines tighten 3 Nos. of socket head counter sunk screws holding cover plate to the body. Use allen key 5 mm A/F.

5.10 REASSEMBLING THE ENGINE

Engine components are ready for assembly after completion of inspection, servicing and cleaning. Follow the re-assembly sequence given below :

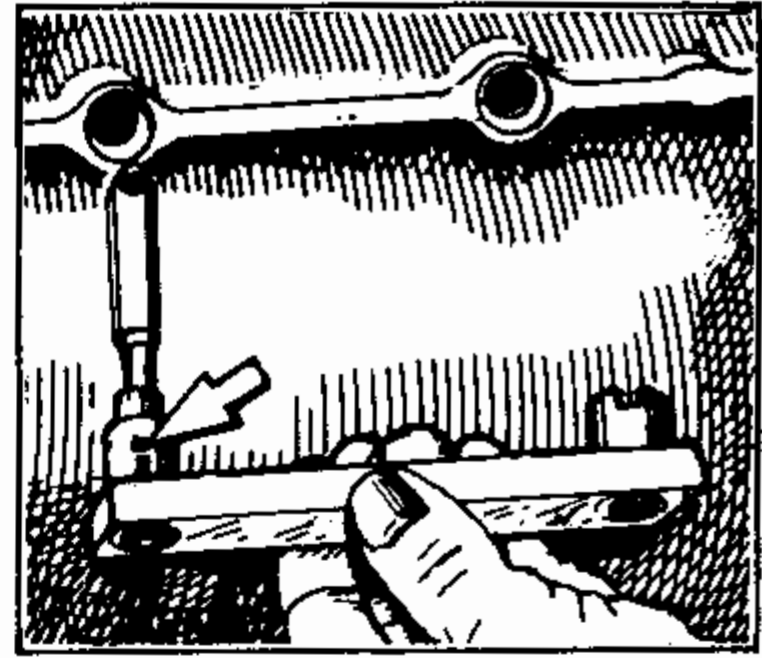
- 5.10.1 Fit oil spray nozzles in crank case. See Fig. 5-46 for HA294/394/694 & 494 without secondary balancing arrangement.

Use special tool No.03.950.04.0 check the nozzles for suitability for reuse and replace with new one if necessary.



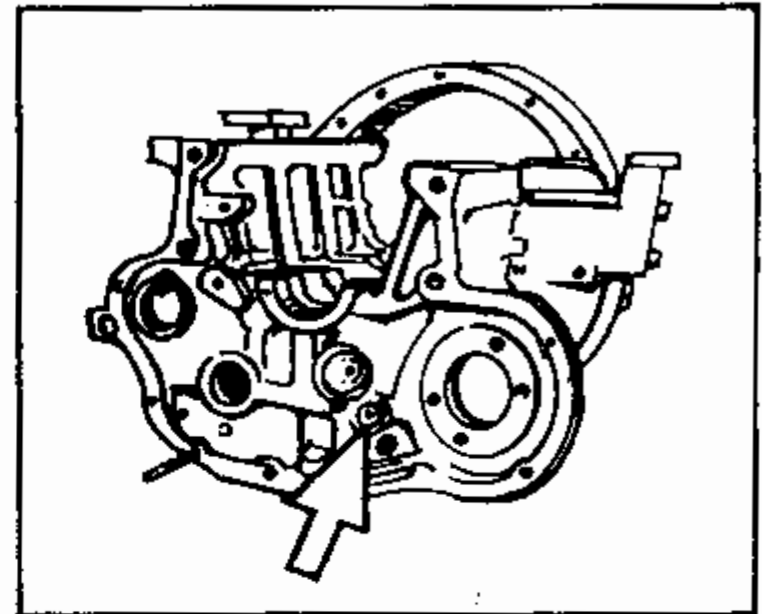
5-46

- 5.10.2 For HA494 engine with secondary balancing arrangement fit horizontal pencil type oil spray nozzles. Use new nozzles with 'O' rings. These are to be press fitted in crankcase. The position of the nozzle in crankcase is very important. Use tool No. 04.950.02.0 while fitting nozzles for proper positioning (Fig. 5-47).



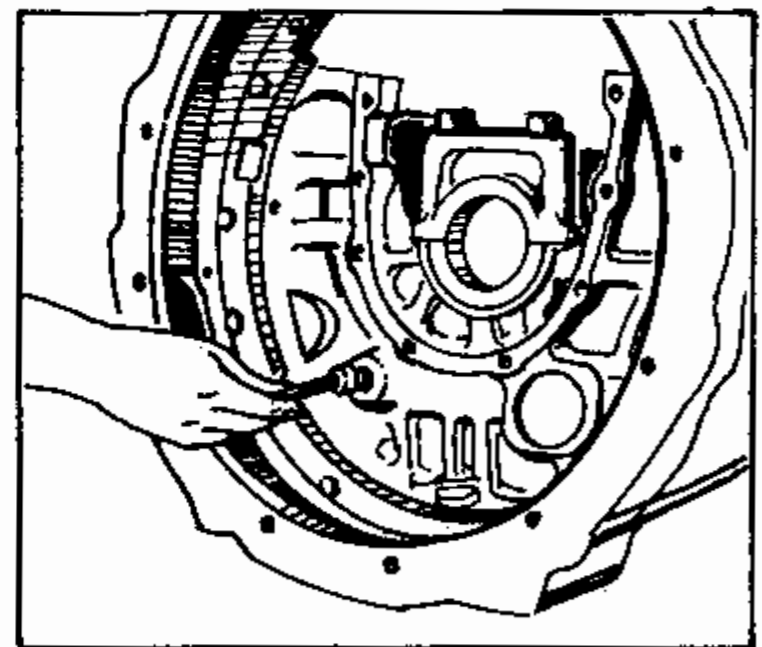
5-47

- 5.10.3 Place the crankcase with sump mating face upward. Use screw plugs with new copper washers for plugging main gallery at gear end and at flywheel end. (Ref. Fig. 5-48 & 5-49).



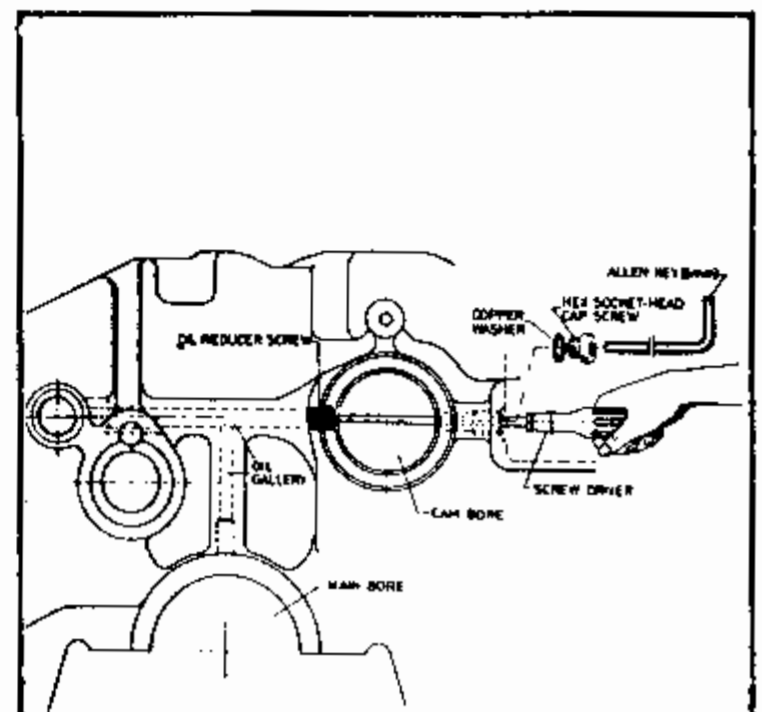
5-48

NOTE: ON HA394 ENGINE 3/8 NPTF PLUG IS FITTED INSTEAD OF PLUG AND COPPER WASHER AT FLYWHEEL END. REFIT THE SAME PLUG USING SUITABLE SEALING ADHESIVE.



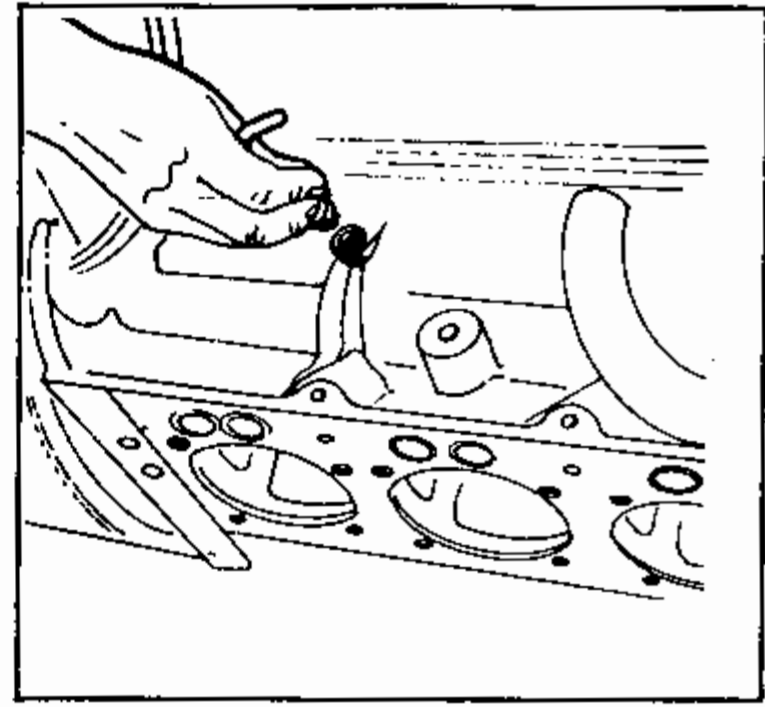
5-49

- 5.10.4 Fit oil reducer screw in oil gallery opening in cam bore with the help of screw driver. (Fig. 5-50)



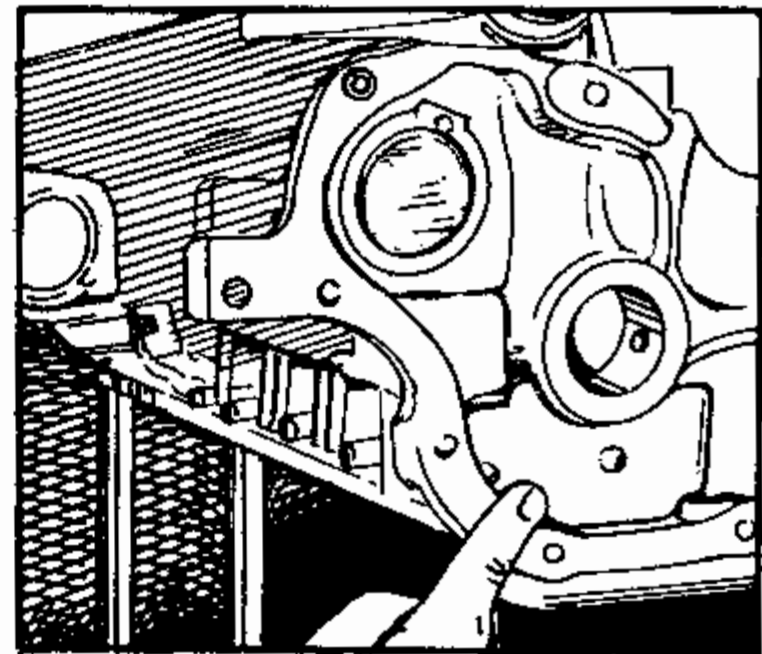
5-50

Fit hexagonal socket head screw with new copper washer with the help of allen key size 6 mm as shown in Fig. 5-51.



5-51

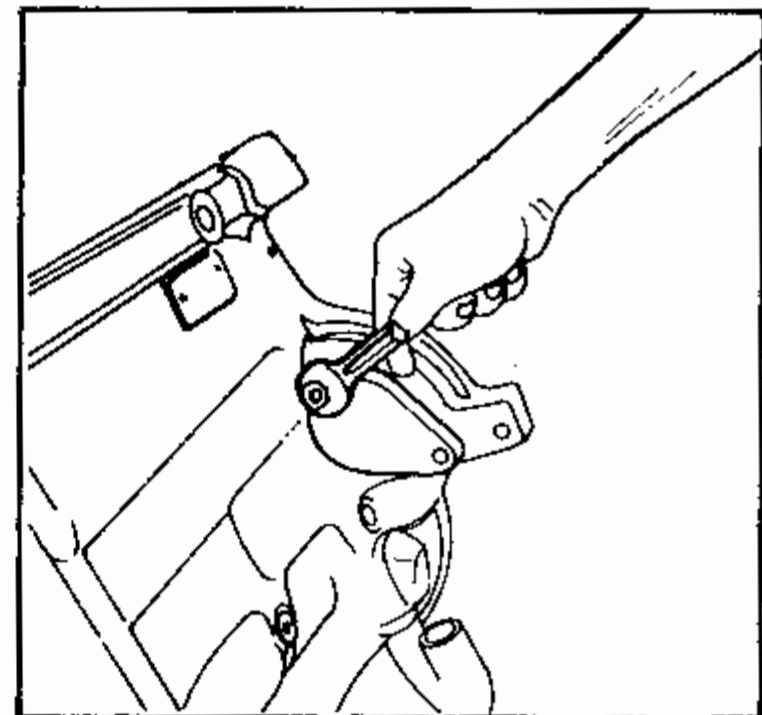
5.10.5 Press in cam bush with the mandrel No. 03.950.10.0 in the gear end cam bore. Remaining cam bores are without bearing bushes for removing and pressing cam bush ref. Fig.5-38 of Sect. 5.7.2.



5-52

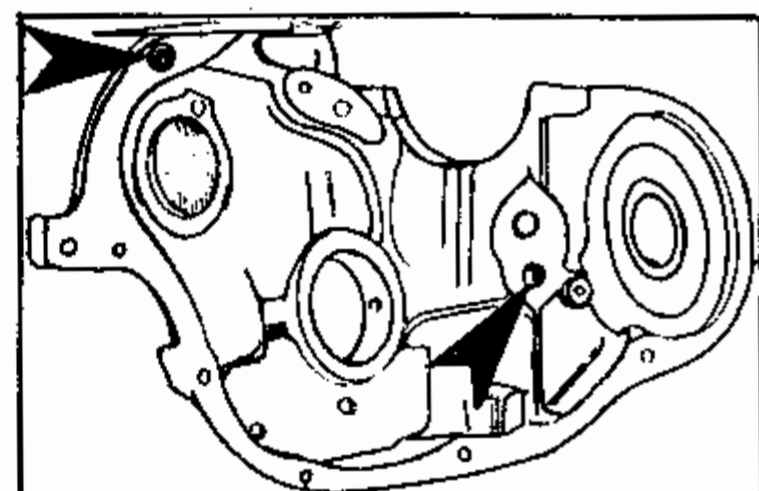
5.10.6 Check the condition of baffle plate for breather. If it is found damaged or loose, replace the new baffle and fit it with the new reivets(Fig.5-52).

5.10.7 If the hydraulic pump is not provided on engine, fit blanking plate along with its' joint for closing the bore as shown in Fig.5.53



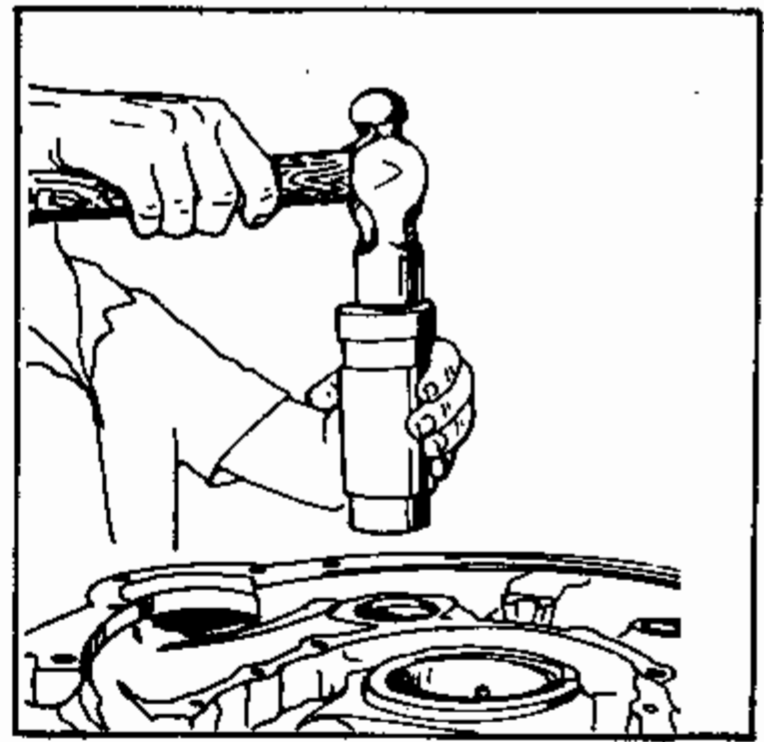
5-53

5.10.8 Ensure that locating dowels for front cover and locating dowel for intermediate gear support are fitted properly. (Fig. 5-54).



5-54

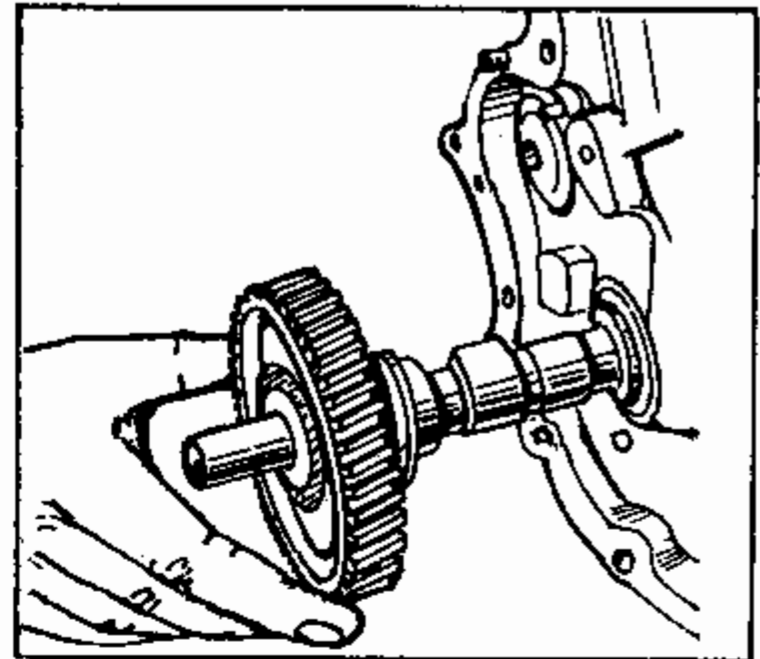
- 5.10.9 Fit dish type core plug in cam bore counter at flywheel end side. Use mandrel No. 03.950.20.0 (Fig.5-55).



5-55

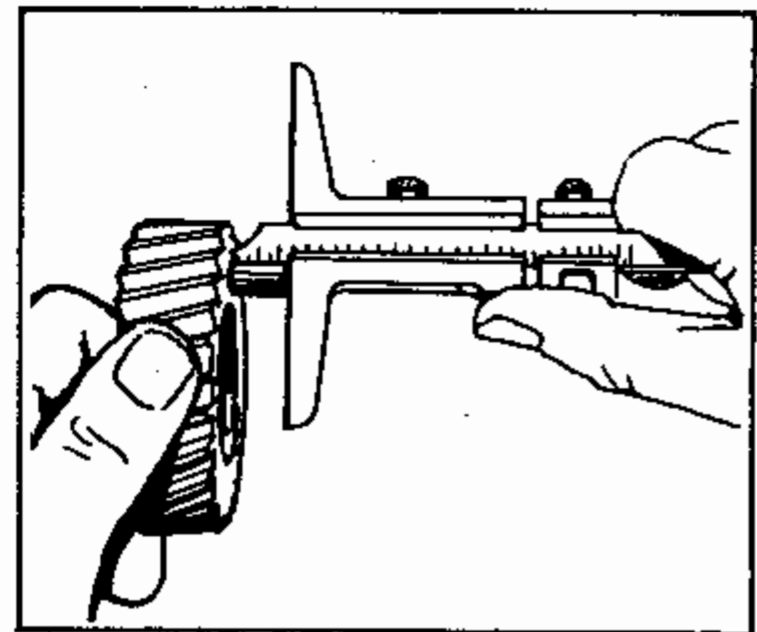
- 5.10.10 Apply oil to the tappets and place them in tappet bore in crankcase.

Insert the thrust washer behind the cam gear, apply lub. oil on all camshaft journals and installed the camshaft (Fig. 5-56).



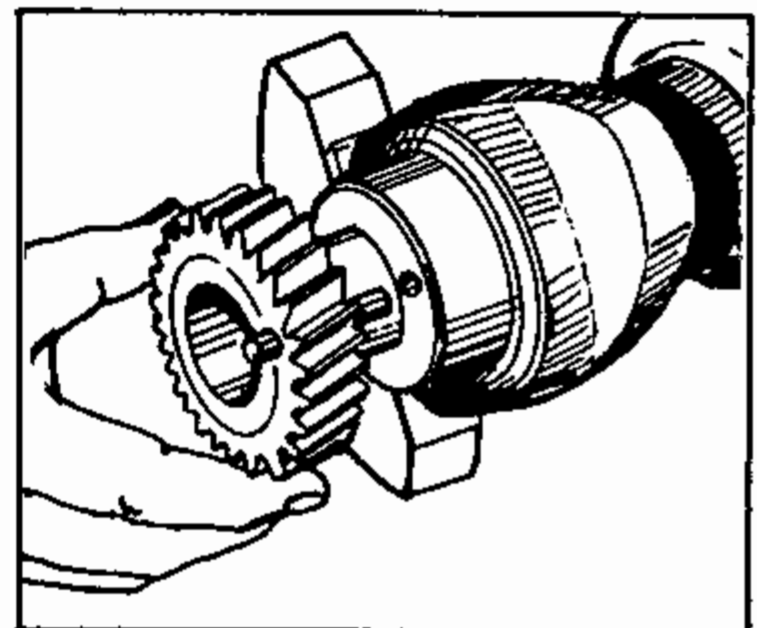
5-56

- 5.10.11 Check dowel pin in crankgear. If necessary fit new dowel, while fitting keep the dowel pin projected 17 mm opposite to the gear tooth mark on gear face (Fig. 5-57).



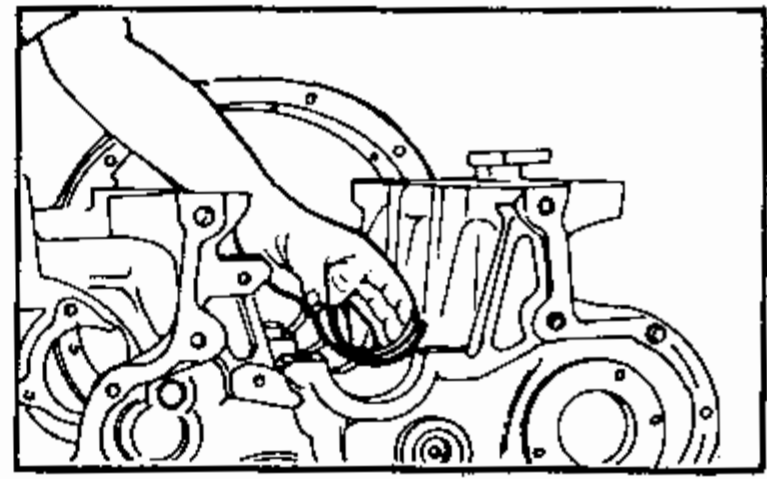
5-57

- 5.10.12 Locate the gear in crankshaft at gear end. Ensure that the gear tooth mark is on outside. Then drive the gear on crank shaft (Fig. 5-58).



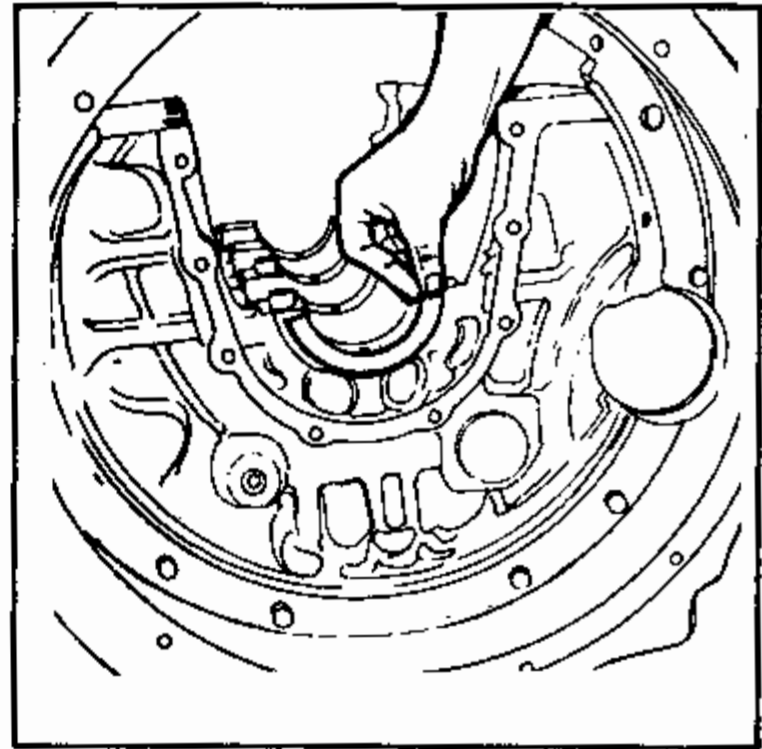
5-58

- 5.10.13 Install half bearing shell in crankcase and main bearing caps. Make sure that they are properly engaged in notches. (Fig. 5-59).



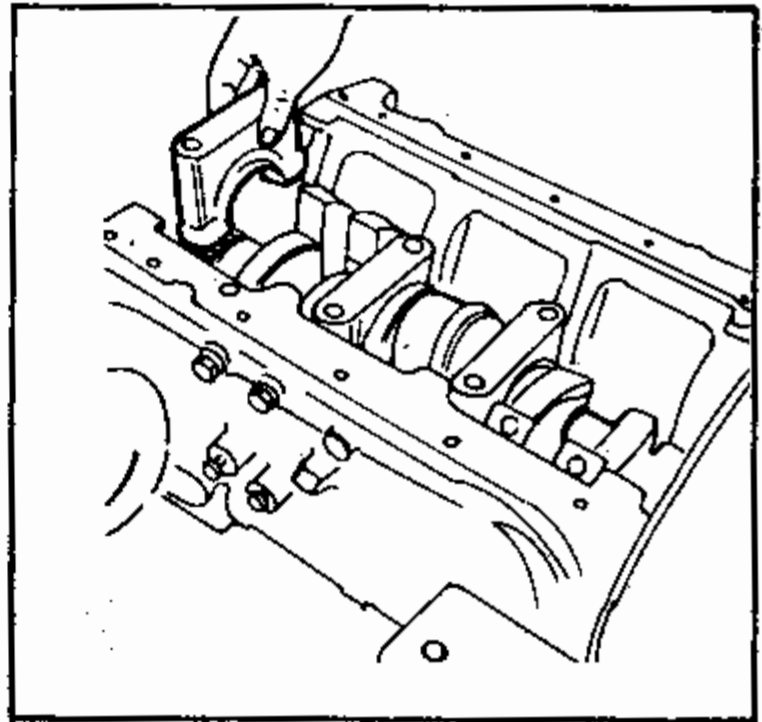
5-59

- 5.10.14 Place thrust half rings on flywheel end cap. Thrust ring should rest on the stop pin. (Fig. 5-60).



5-60

- 5.10.15 Oil all crankshaft journals and install the crankshaft in crankcase. Place main bearing caps with locating hollow dowels. While placing, be sure that identification marks on caps and on crankcase talley. (Fig. 5-61).

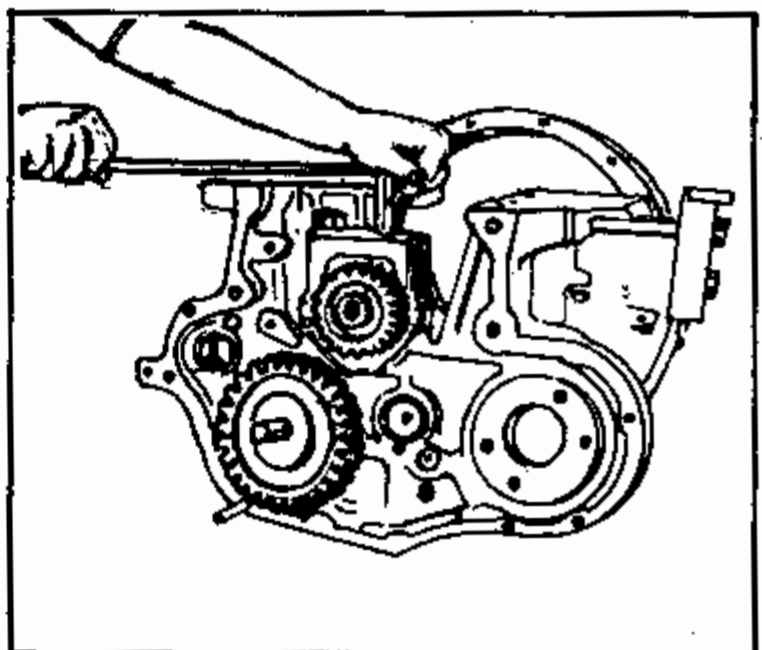


5-61

- 5.10.16 Assemble the bolts with washer with caps and tighten down as per angle torque instructions given in Sect. 1-4. While tightening follow sequence as given below -

1. Middle cap.
2. Either sides of the middle cap & onwards.
3. Flywheel end & gear end caps.

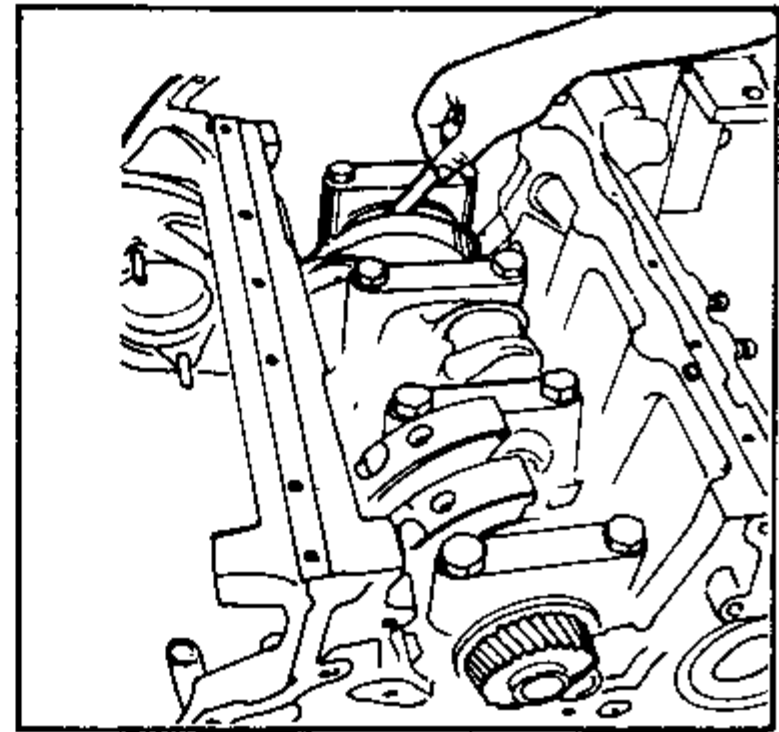
After tightening ensure that the crankshaft is free to rotate (Fig. 5-62).



5-62

5.10.17 Checking and adjusting end clearance of crankshaft-

- a) Push the crankshaft at gear end and measure the clearance with feeler gauge at flywheel end cap as shown in Fig. 5-63.
- b) If the clearance is more than the limit value given in specification, remove cap and fit suitable higher size (O/s thickness) stop half rings. Keep the smooth bearing faces of rings against crankshaft web & crankshaft flange. Refit the bearing cap and tighten the bolts.



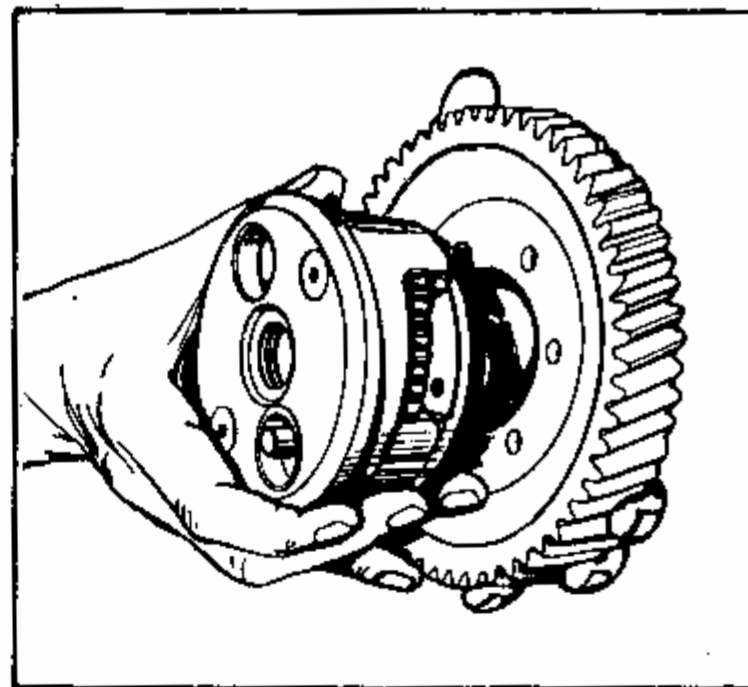
5-63

5.10.18 Duly tested and serviced fuel pump should be used for assembly. For servicing of fuel pump refer Section - 6.

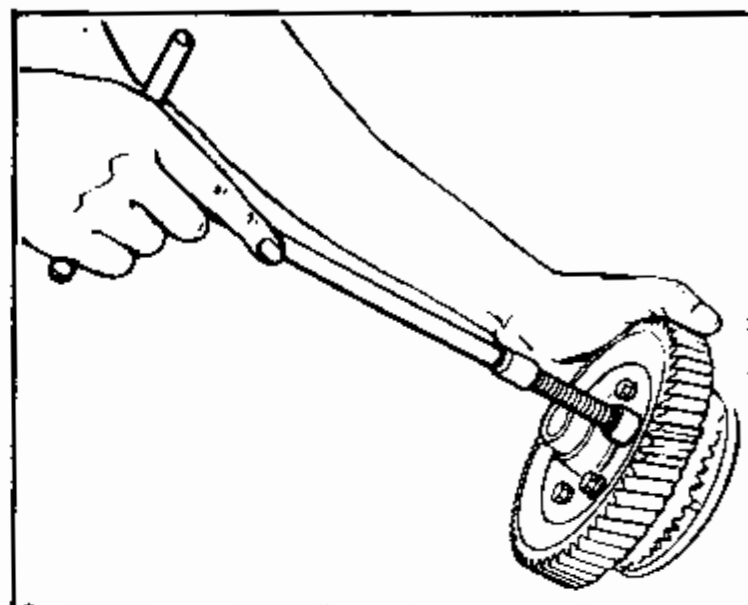
- a) Use new gasket for fuel pump assembly. Engaged the pump in crankcase bore and tighten nuts securing the pump to the crankcase.
- b) Assemble the fuel pump gear on hub and tighten three screws. Install hub with gear on fuel pump shaft. Ensure that woodruff key is properly fitted on fuel pump shaft.

- c) If the engine is supplied with autotimer, clamp the autotimer on fuel pump gear and then install the assembly on fuel pump shaft.
(Fig. 5-64 & 5-65)

- d) Tighten the centre nut on fuel pump shaft.



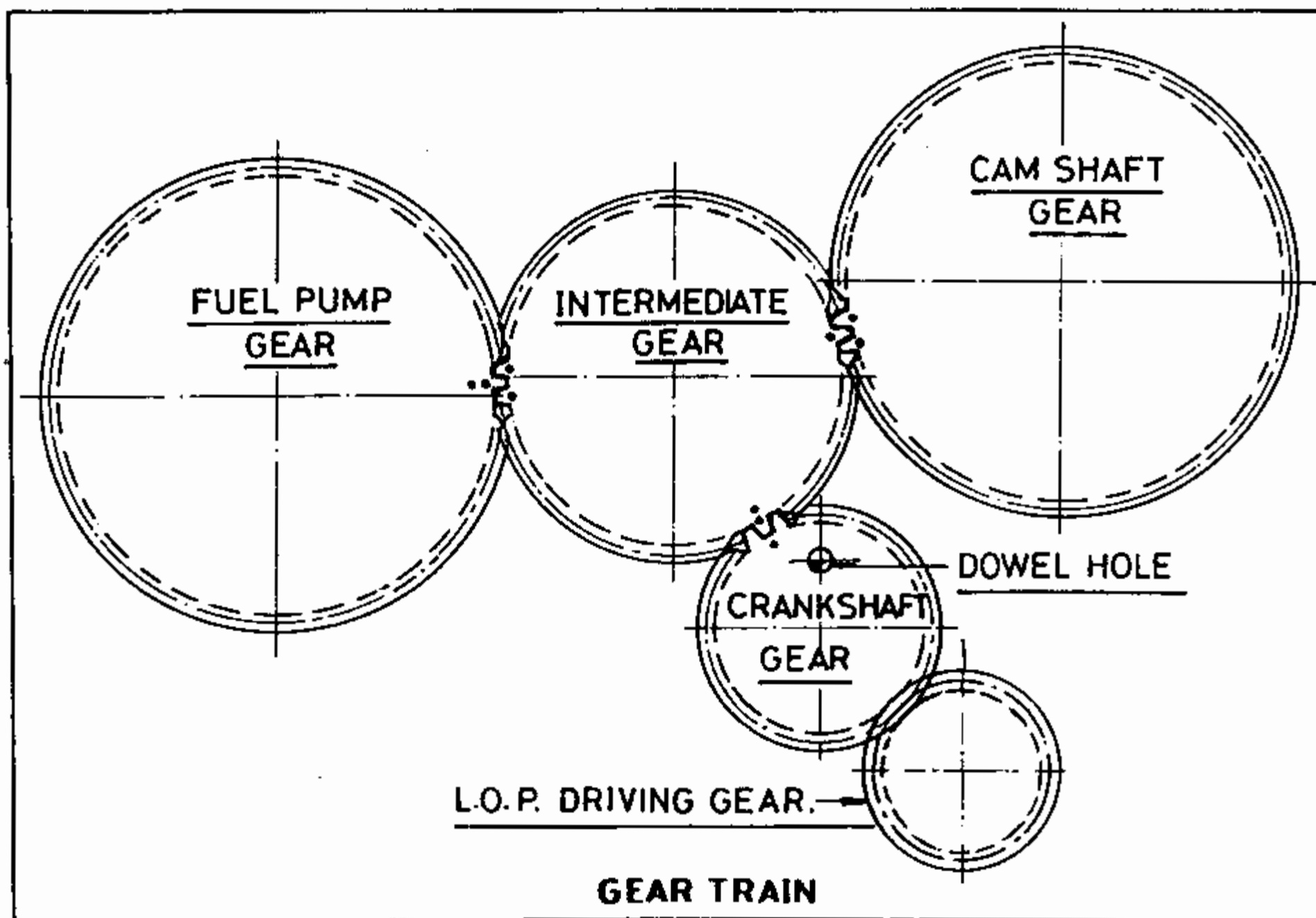
5-64



5-65

- 5.10.19 Locate the support for intermediate gear in crank case counter. Ensure that the locating hollow dowel is properly fitted. Apply engine oil over the journal before inserting intermediate gear over the support.

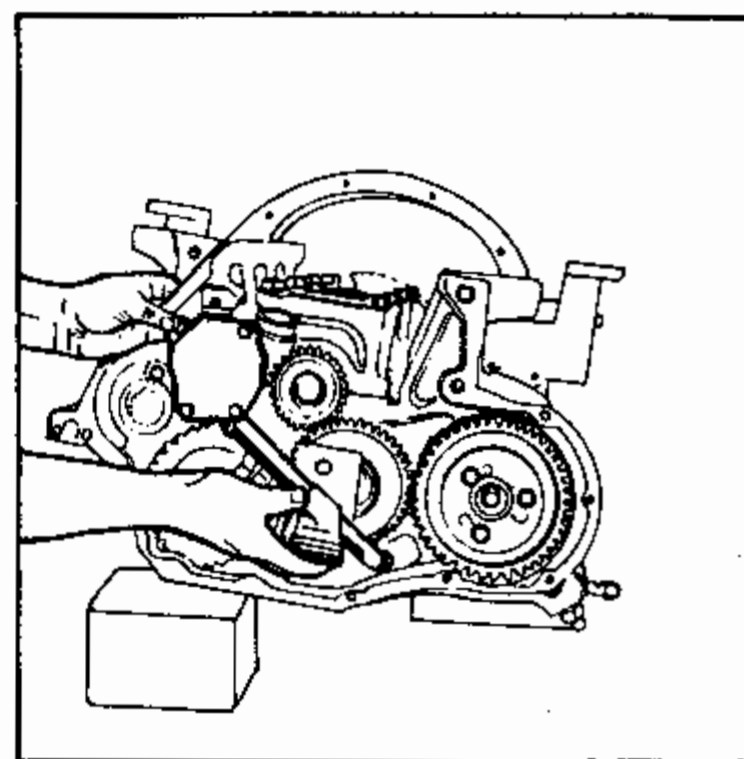
5.10.20 Before engaging the intermediate gear with crank gear, ensure that the gears are properly matched with respect to marking on gears as shown in Fig. 5-66.



5-66

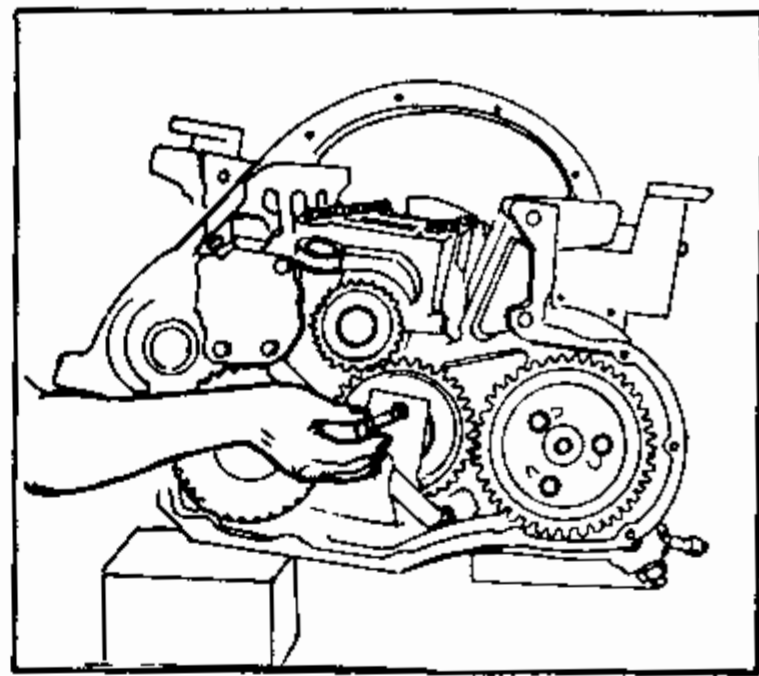
5.10.21 ASSEMBLY OF LUB.OIL PUMP AND DELIVERY TUBE

- a) Fit a new 'O' ring on delivery tube and insert the tube in lub.oil pump body. Position the lub. oil pump and delivery tube on crankcase and tighten slightly lub.oil pump holding bolts. Adjust the backlash of lub. oil pump gear with respect to crank gear within 0.1 mm, and then tighten fully the lub.oil pump holding bolts (Fig. 5-67).



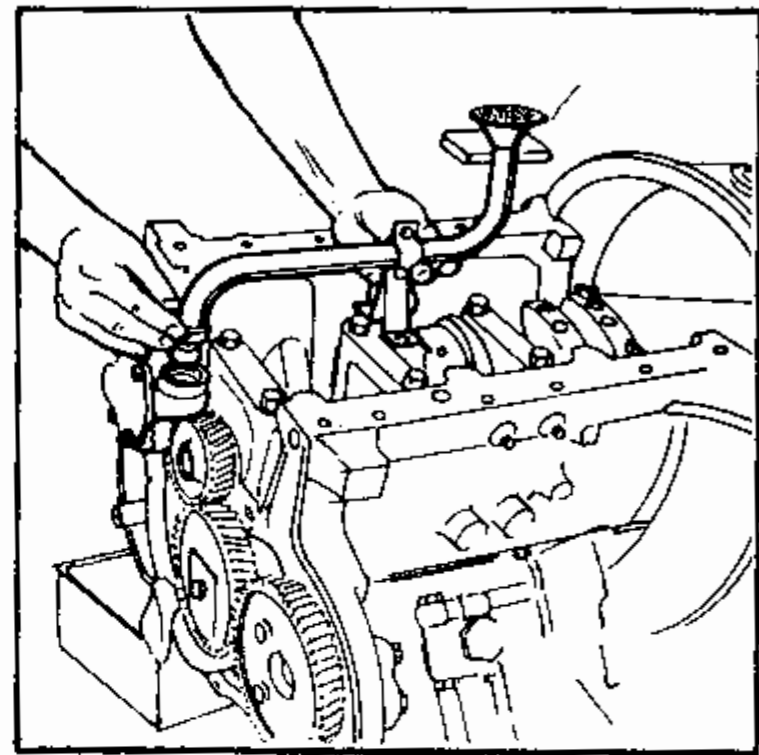
5-67

- b) Insert the spring clamp on delivery tube, which holds delivery tube and intermediate support. Tighten the bolt with angle torque as per specification. (Fig. 5-68).



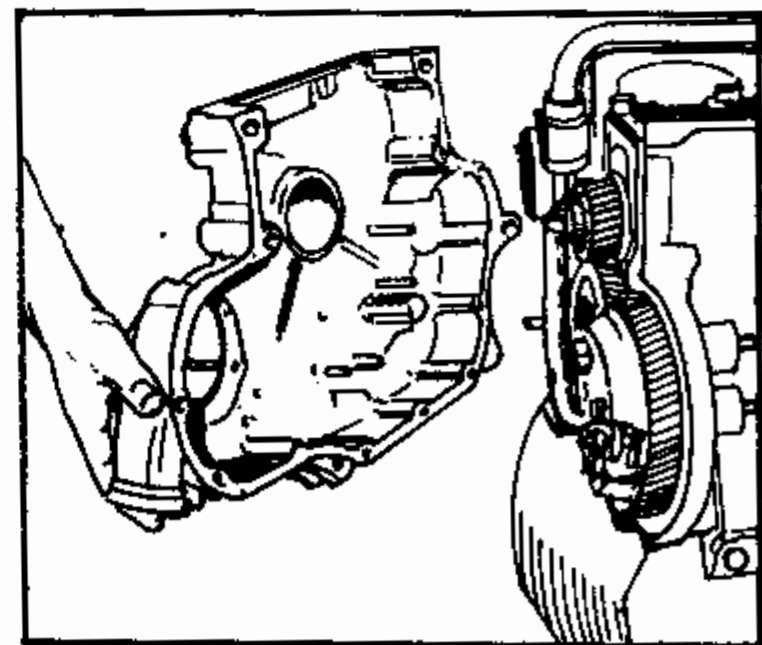
5-68

- 5.10.22 Connect the suction tube to the lub. oil pump and tighten union nut partially. Then engage holding brackets for suction tube and clamp them on main bearing cap with set screws. Now, tighten fully the union nut on lub. oil pump body and then tighten the upper side set screws of bracket holding suction tube (Fig. 5-69).



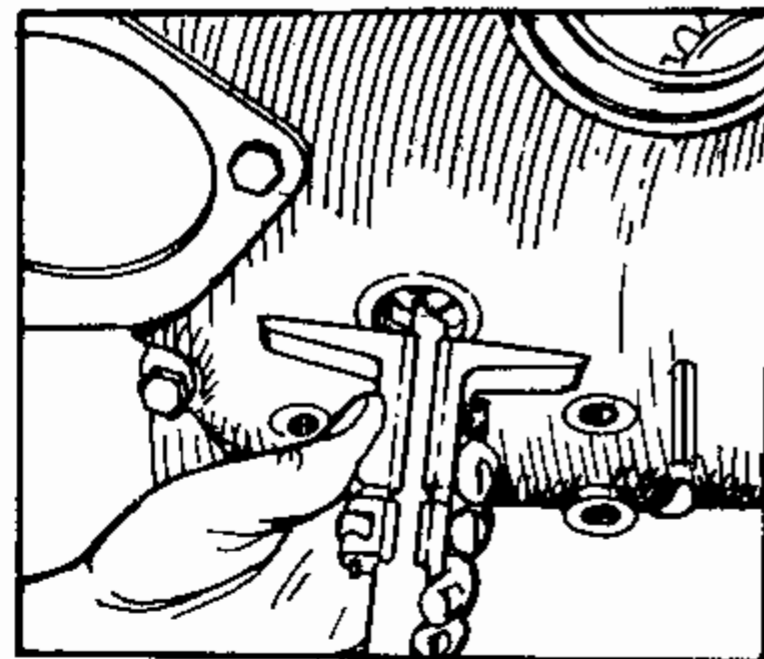
5-69

- 5.10.23 Fit a new joint for front cover. Use grease to retain the joint in position. Align front cover with locating dowels in crankcase. Tighten fasteners holding front cover and crankcase (Front cover is already fitted with oil seal). (Fig. 5-70).



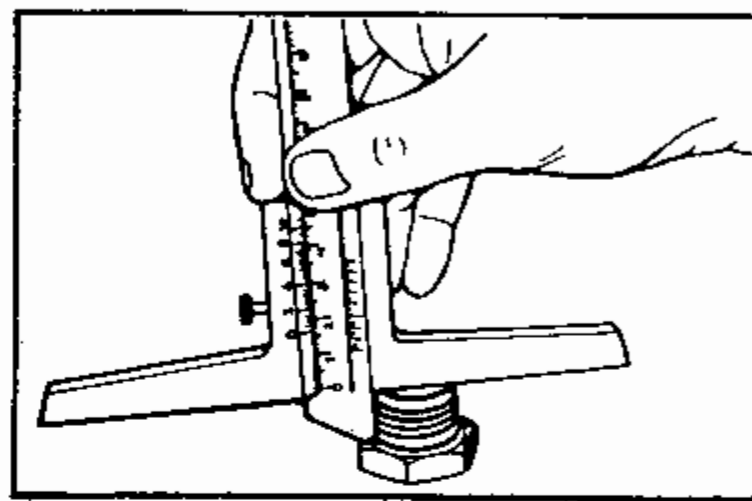
5-70

- 5.10.24 Press the cam shaft towards the flywheel end. Measure the distance from front cover adaptor sealing face to the camshaft thrust face. Use vernier depth gauge. (Fig. 5-71).



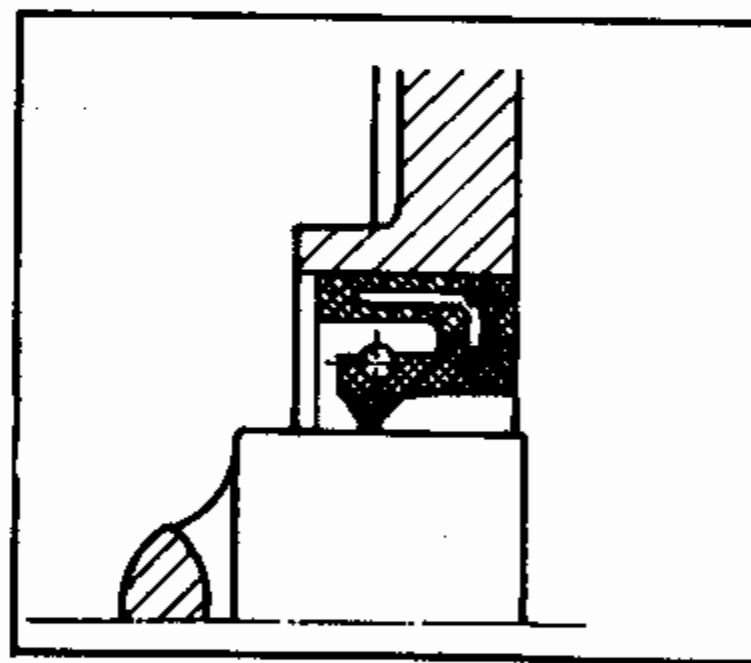
5-71

- 5.10.25 Measure the distance on adaptor sealing face to the end face (Fig. 5-72). Considering the difference in these readings, select proper sealing washers to have the end play as given in specification. Tighten the adaptor on front cover.

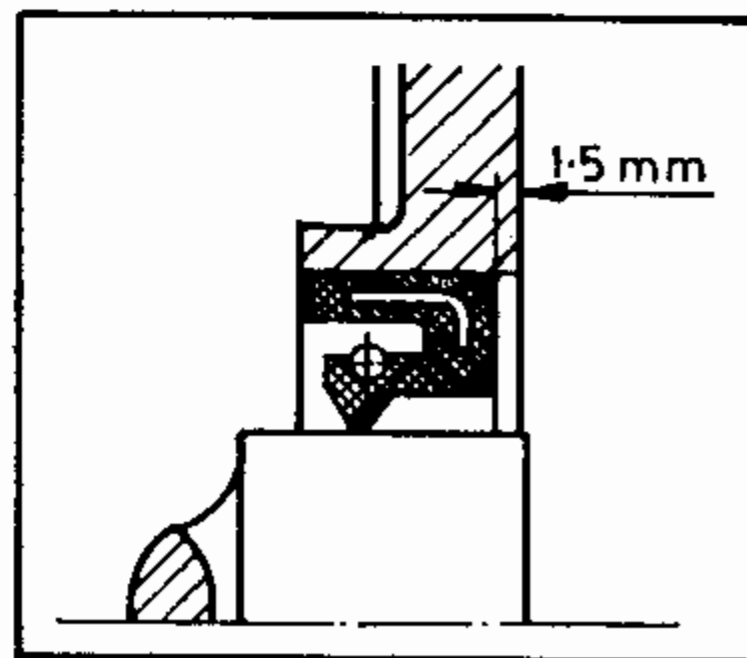


5-72

- 5.10.26 On a new engine, oil seal is pressed in front cover, flushed to the outside face of front cover. (Fig. 5-73). If a groove is observed (due to oil seal lip pressure) on crank pulley, to avoid the contact between lip and groove, shift the oil seal position inside by 1.5 mm maximum as shown in Fig. 5-74.



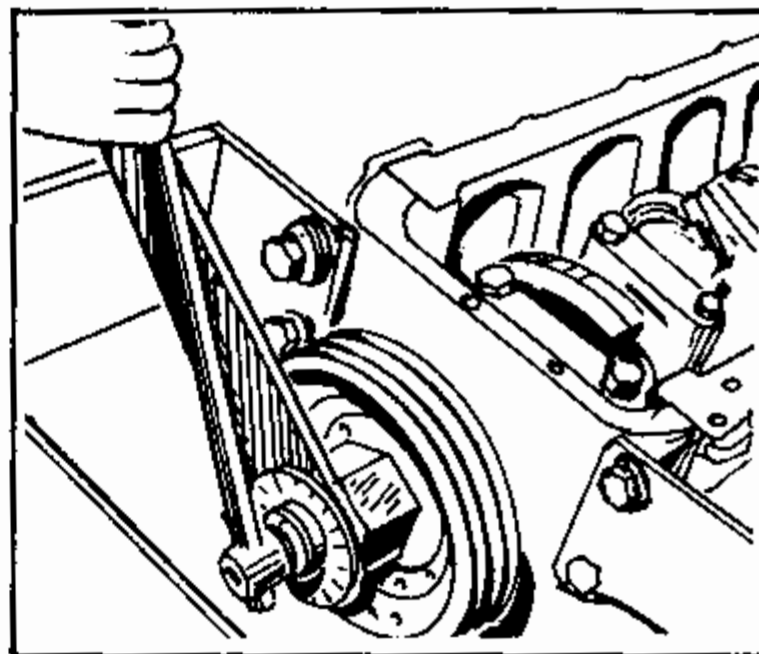
5-73



5-74

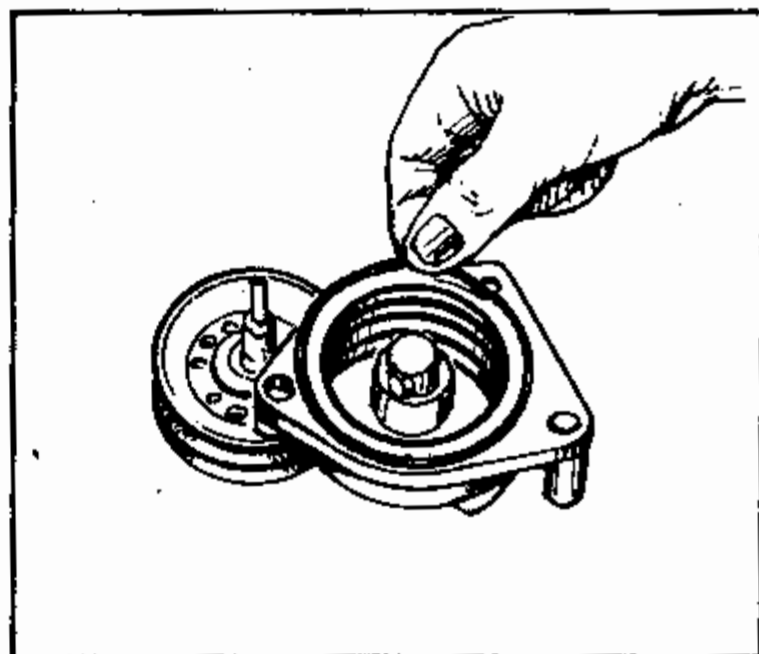
- 5.10.27 Insert the crank pulley in front cover, engage crank pulley hole with dowel on crank gear, fit the bolt with washer and tighten it with specified angle torque, Note that the bolt has left hand threads (Fig. 5-75).

If the engine is supplied with compressor, fit the compressor driving pulley on crank pulley and bolt it.



5-75

- 5.10.28 Fit the automatic belt tension unit on front cover. Before that see whether torsion spring is all right. If not, replace it with new one. Also, use new 'O' ring on housing of belt tension unit (Fig. 5-76).



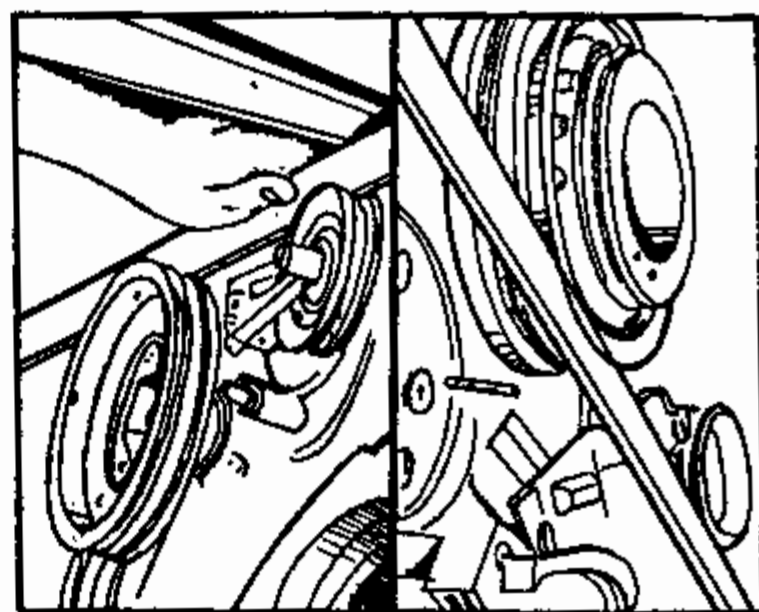
5-76

NOTE: ON SOME ENGINES INSTEAD OF AUTOMATIC BELT TENSION UNIT, THE MANUAL BELT TENSION ADJUSTING UNITS ARE FITTED. USE NEW 'O' RING FOR THIS UNIT ALSO.

- 5.10.29 If the engine is supplied with mechanical shut down unit, see that actuator lever is fitted on belt tension unit.

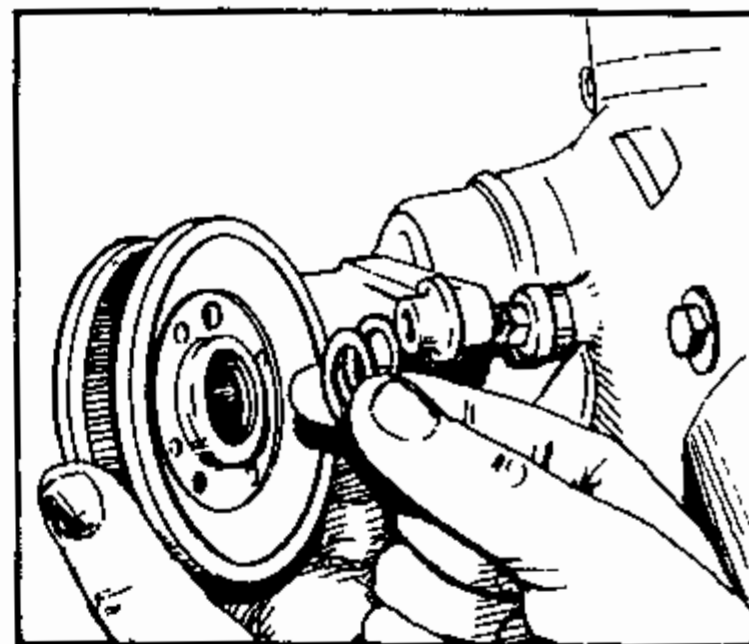
In case of HA694 engine, use spacers below actuator lever.

- 5.10.30 Check crank pulley and belt tension pulley alignment with straight edge. (Fig. 5-77).



5-77

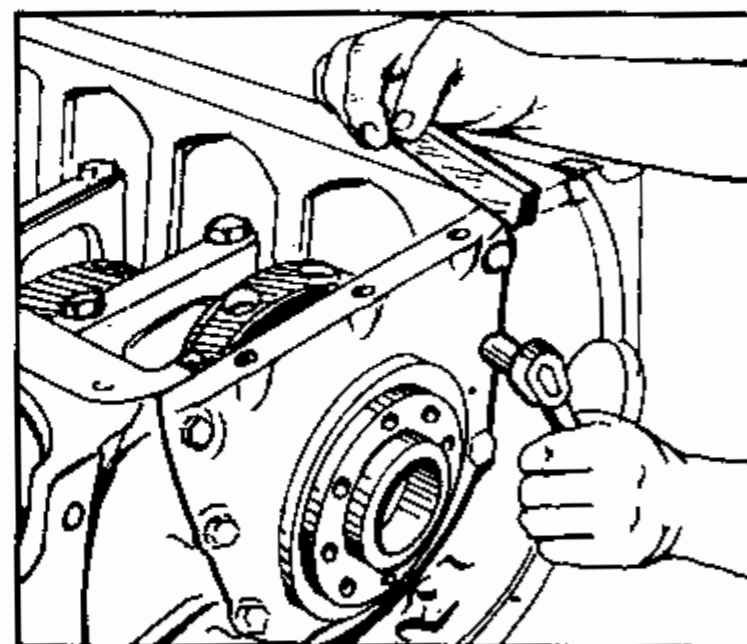
If necessary adjust alignment washers behind the pulley of belt tension unit, and correct the alignment. (Fig. 5-78).



5-78

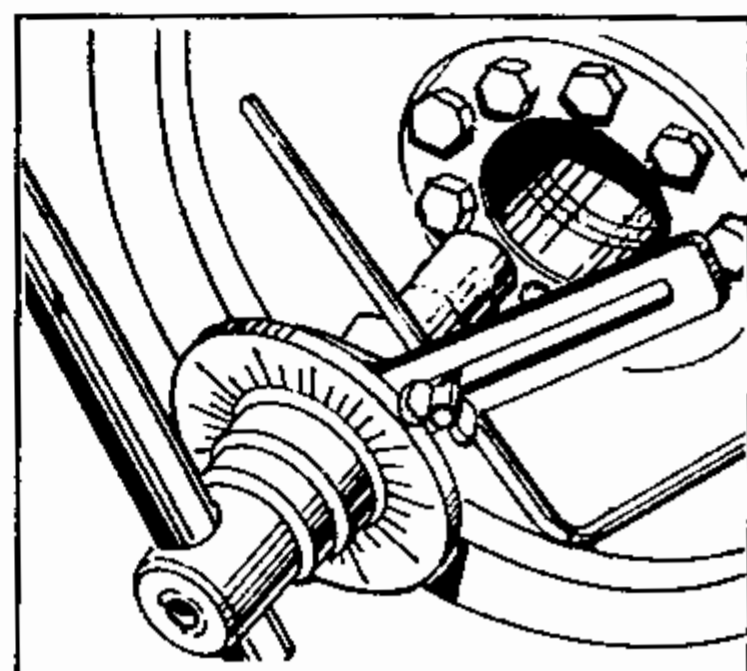
- 5.10.31 Observe condition of fly-wheel end oil seal. If it is found damaged or worn out, then fit a new oil seal. Use mandrel No. 03.950.22.0. If a groove is formed on crankshaft flange (due to oil leak pressure), shift the position of oil seal inside by 1.5 mm maximum, similar to the oil seal in front cover as shown in Fig.5-74 of Sect.5.10.26.

- 5.10.32 Apply grease to the lip of the oil seal and crankshaft face where oil seal rests. Position the oil seal housing on crankcase with a new joint in between. Bottom of crankcase and oil seal housing should be flushed. Check this with straight edge (6" long) and then tighten the set screws (Fig. 5-79). Trim off the joint which is projecting beyond the sealing faces.



5-79

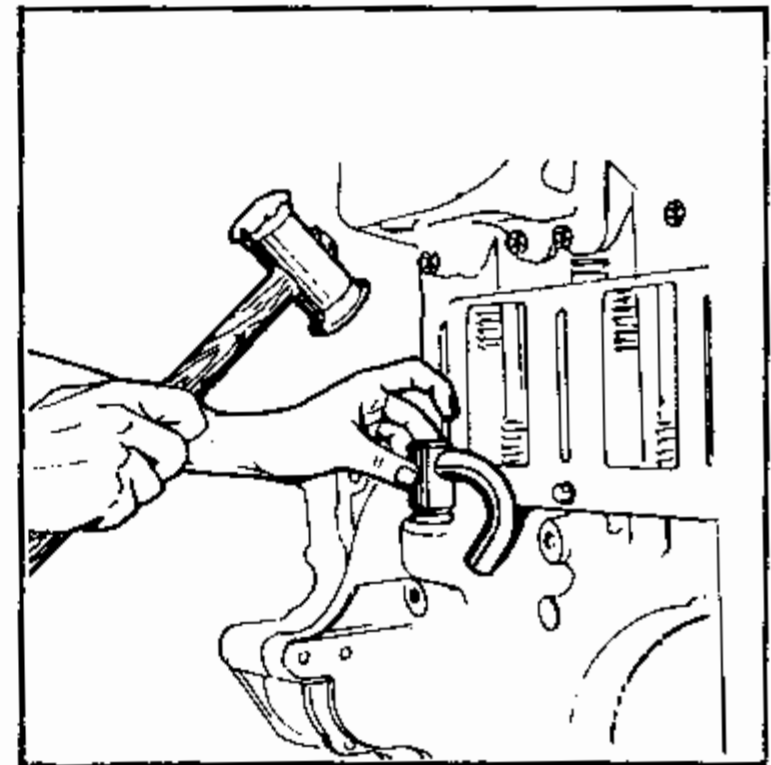
- 5.10.33 Now, install the flywheel on crankshaft. Match the holes of flywheel with crankshaft. Insert the dowel. Position the crank pulley and engage the pipe spanner (Tool No.03.950.17.0) in hex. of crank pulley to hold the crankshaft and then tighten the flywheel bolts to the specified angle torque (Fig. 5-80).



5-80

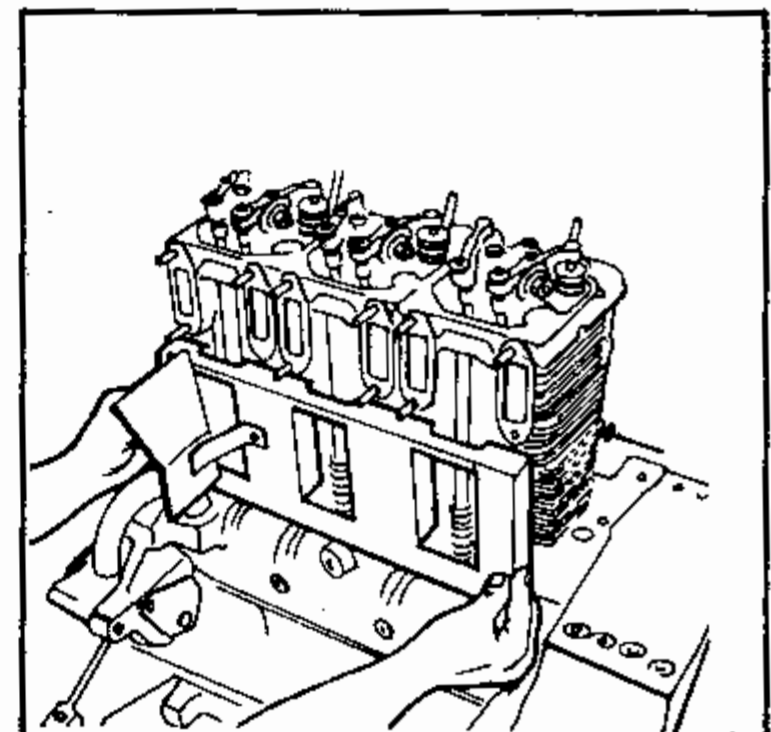
- 5.10.34 Apply grease to the new sump joint and locate it to the sump. Tighten sump screws gradually with diagonal sequence and then tighten fully by 3.5 Kgm torque.
- 5.10.35 Now, change the position of engine so that liner resting face of crankcase will be facing upwards. Preferably use engine assembly stand for ease of assembly. If stand is not available, the suitable wooden supports below the engine should be used.
- 5.10.36 Assembly of liner, piston cylinder head and manifolds- follow the procedure given in Section-4 for assembly of liner, piston, cylinder head and valve rocker.

- 5.10.37 Fit the breather tube in the crankcase. Apply sealing compound (shellac) to the conical portion of the tube while assembly. (Fig. 5-81). Insert the plastic tube in the outlet of breather tube and hold the bottom end of the plastic tube in the stopper plate.



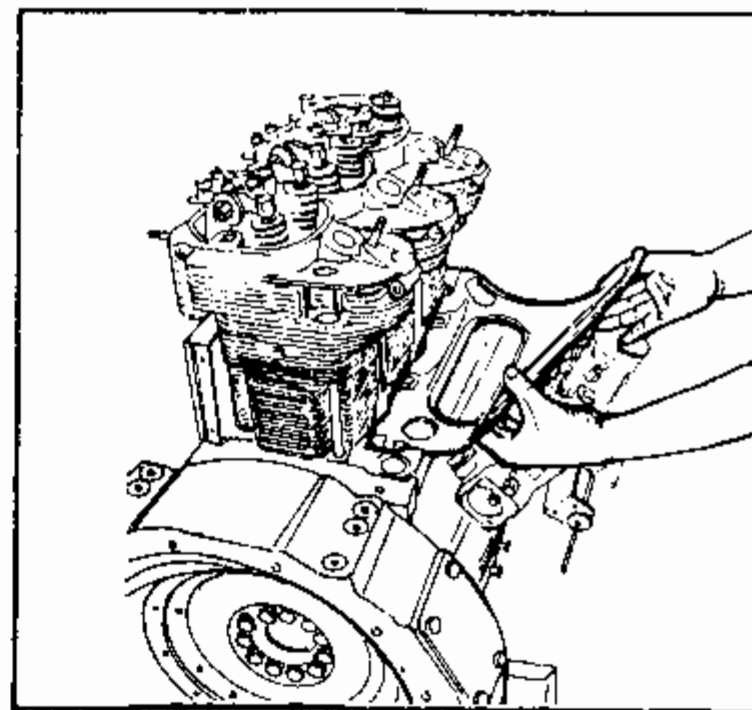
5-81

- 5.10.38 Fit front cowling and exhaust air baffle (Fig. 5-82). Tighten the pipe holding clip to front cowling for "Fuel supply pipe to flame heater" if flame heater is supplied with engine.



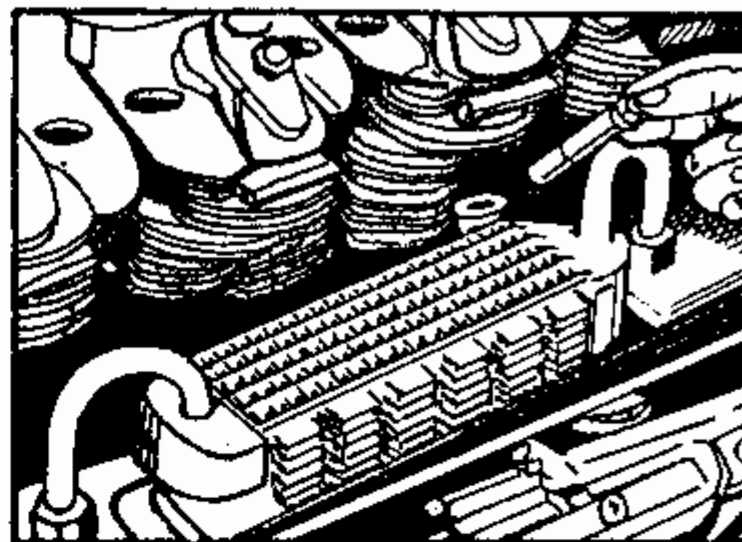
5-82

5.10.39 Fit the lower cowling
(Fig. 5-83).



5-83

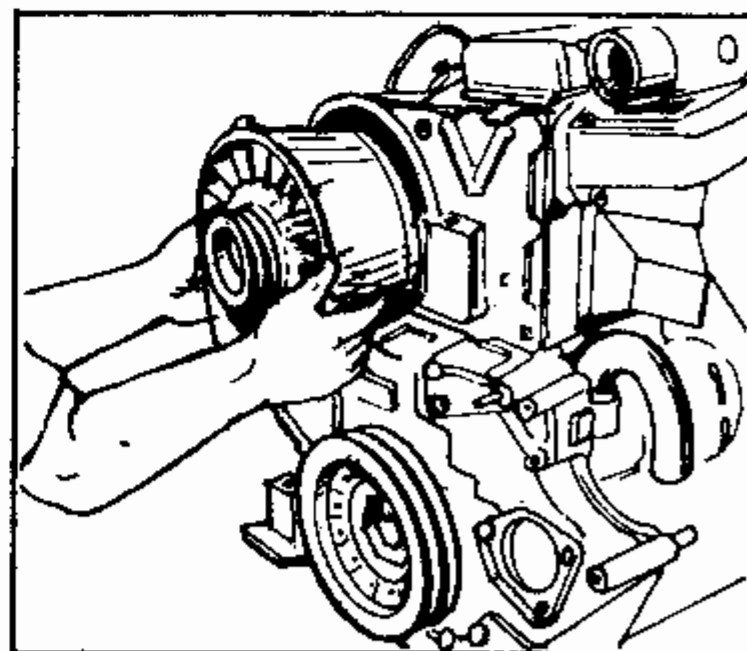
5.10.40 Install the lub.oil cooler
with new sealing ring.
Tighten union nuts for
inlet and outlet connections
of cooler. Tighten the bolt/
bolts for oil cooler to
crankcase (Fig. 5-84).



5-84

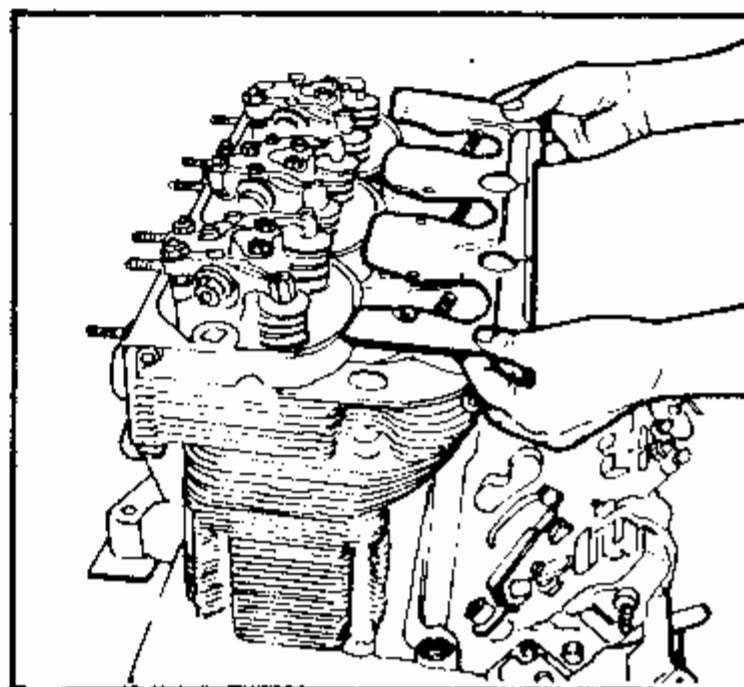
5.10.41 Fit cooling blower on the
front cover and secure it
with the bolts.
(Fig. 5-85).

NOTE: FOR SERVICING OF
COOLING BLOWER REFER
SECT. -6.



5-85

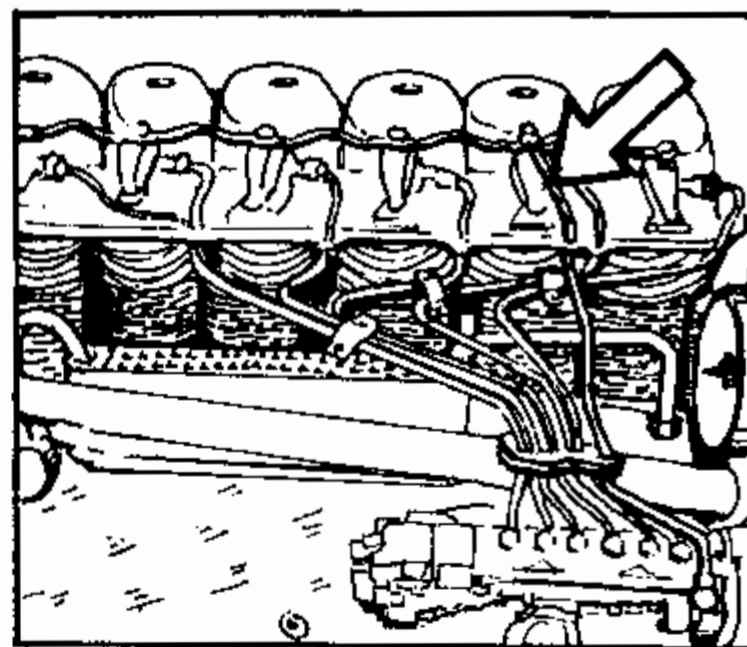
5.10.42 Position top air baffle
over cylinder heads and
cooling blower body and
tighten the bolts on
cylinder heads.
(Fig. 5-86).



5-86

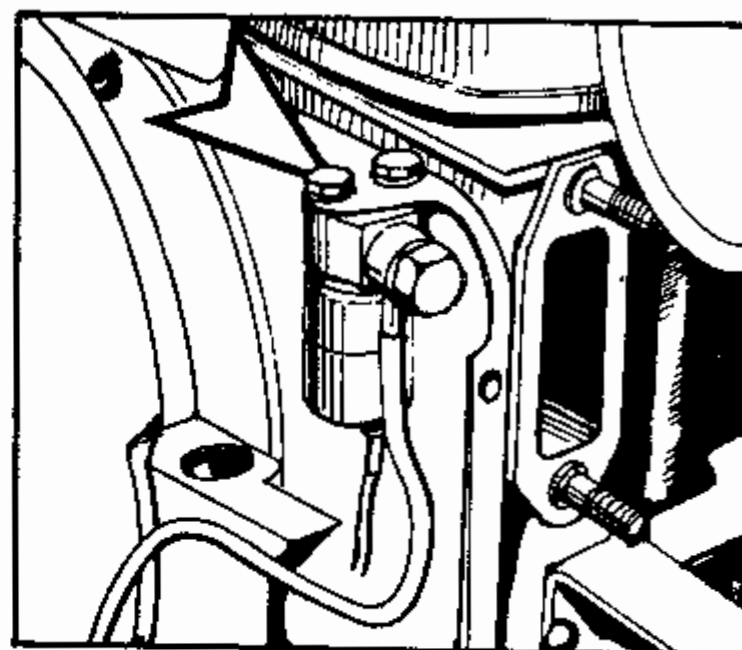
- 5.10.43 Connect fuel injection pipes. Use new rubber strip for lower cowling and new rubber grommets for top air baffle.

Hold the fuel injection pipes with pipe clamps. Connect leak-off pipe to nozzle overflow connections. Connect overflow pipe from fuel pump to the nozzle overflow. Also, fit leak-off connector pipe to the nozzle on No. 1 cylinder (Fig. 5-87).



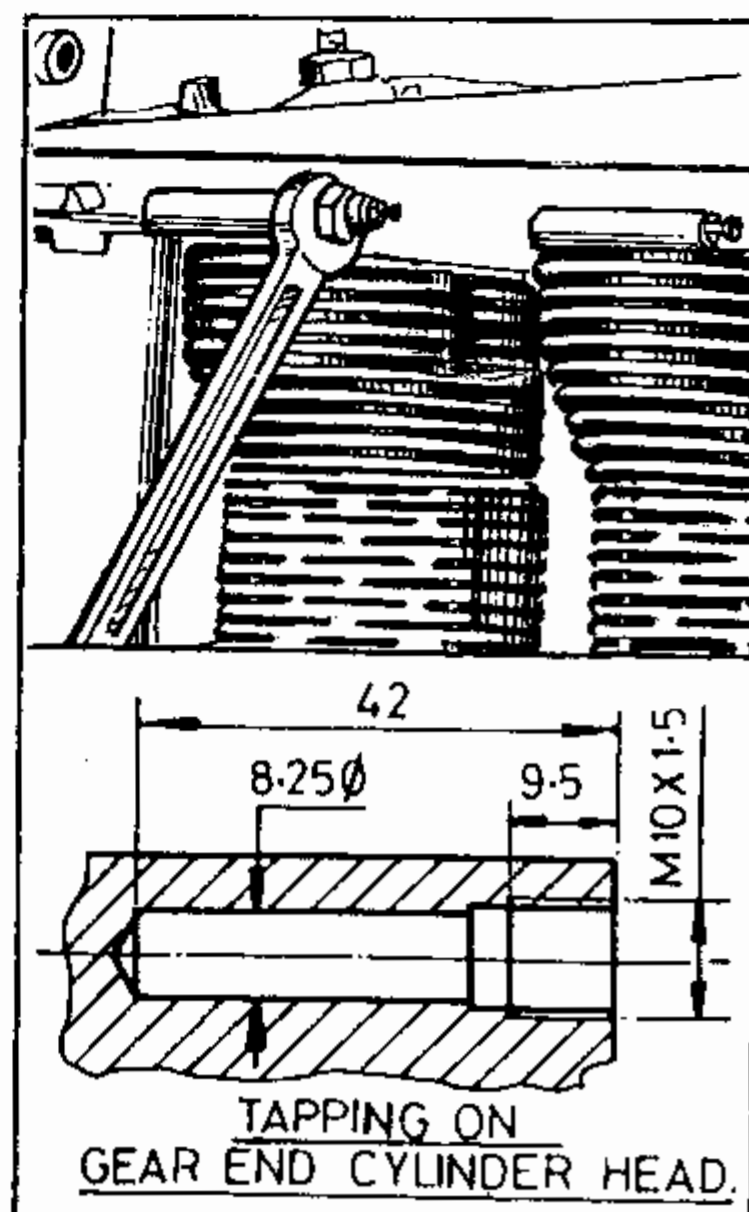
5-87

- 5.10.44 If the engine is supplied with flame heater system, the fuel solenoid valve is required to be fitted on front cowling. Connect fuel lines from fuel pump to solenoid valve and solenoid valve to flame heater as shown in Fig. 5-88.



5-88

- 5.10.45 If engine is supplied with sensor for high cylinder head temperature, refit the sensor to the cylinder head as shown in Fig. 5-89. The tapping M10 x 1.5 is provided on Gear end cylinder head for sensor probe.



5-89

SECTION - 6

ACCESSORIES

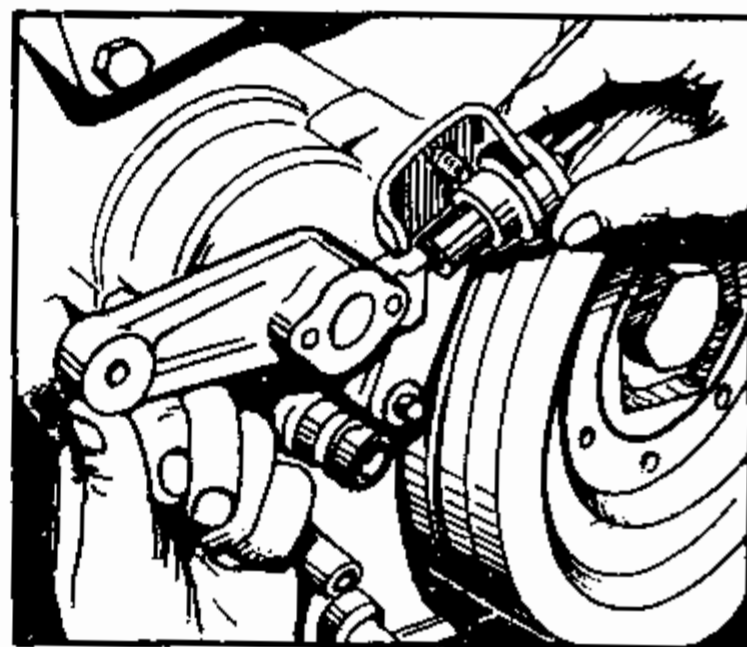
SECTION – 6

ACCESSORIES

6.1 AUTOMATIC BELT TENSION UNIT

6.1.1 Remove belts for driving cooling air blower.

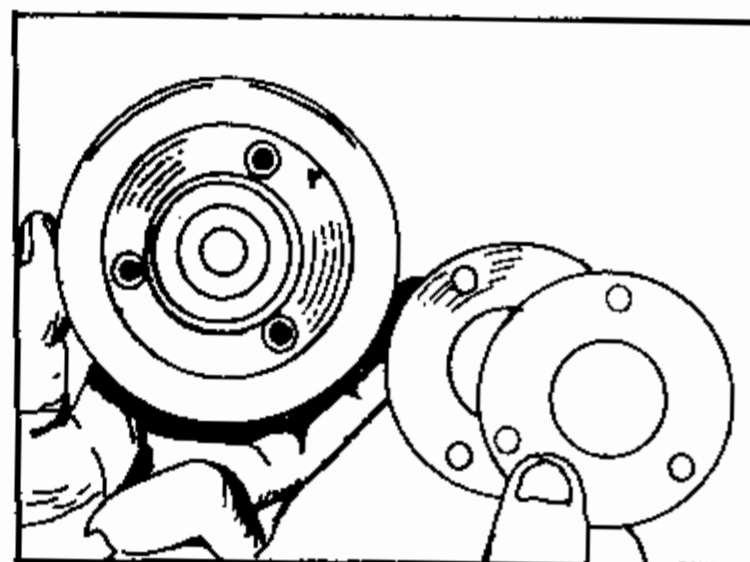
Remove bracket and electrical switch if fitted over the belt tension unit housing (Fig.6-1). Loosen the nuts holding belt tension unit and remove the unit from front cover.



6-1

6.1.2 If excessive play, radial or axial, is observed in the shaft or pulley the servicing of unit is essential.

a) Remove cover and joint fitted on the pulley. (Fig. 6-2).

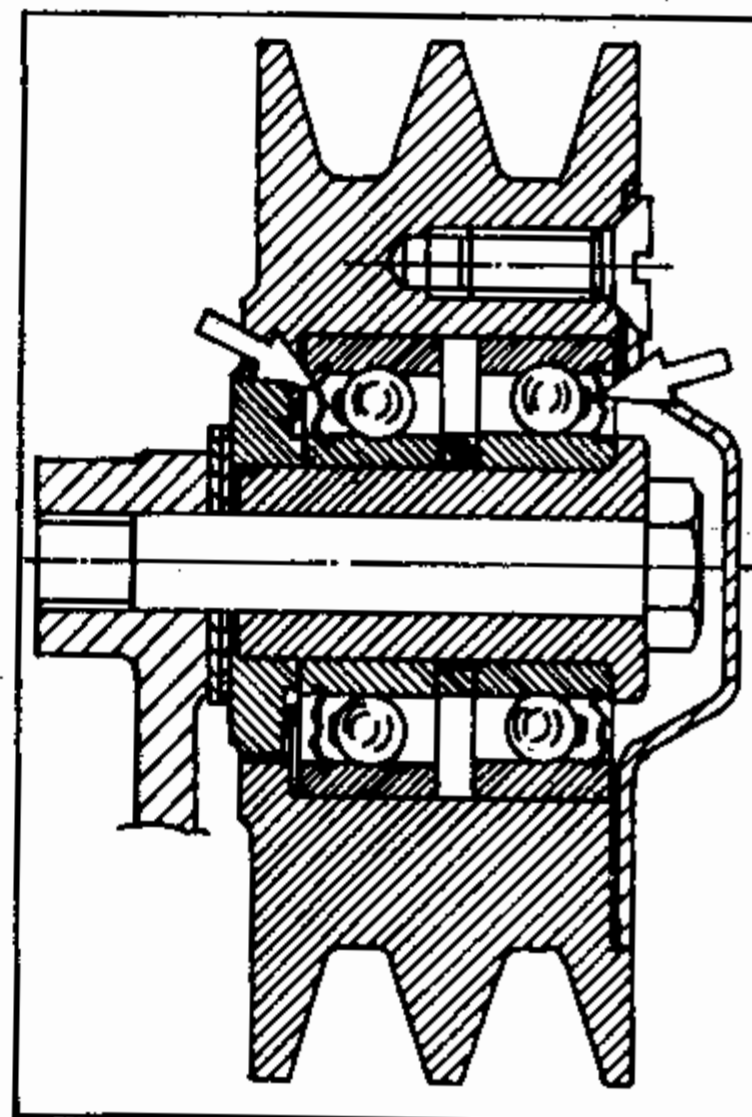


6-2

b) Loosen the centre bolt and remove pulley assembly.

c) Remove collared bush located in inner races of bearing. Check bearings for radial play or any damage. If necessary remove bearings from pulley and replace those with new bearings.

d) The bearings are of 1 RS type. While fitting, sealed sides should face outwards. (Fig. 6-3).



6-3

- e) Fill up the grease in the bearings before installation. The recommended grease is -

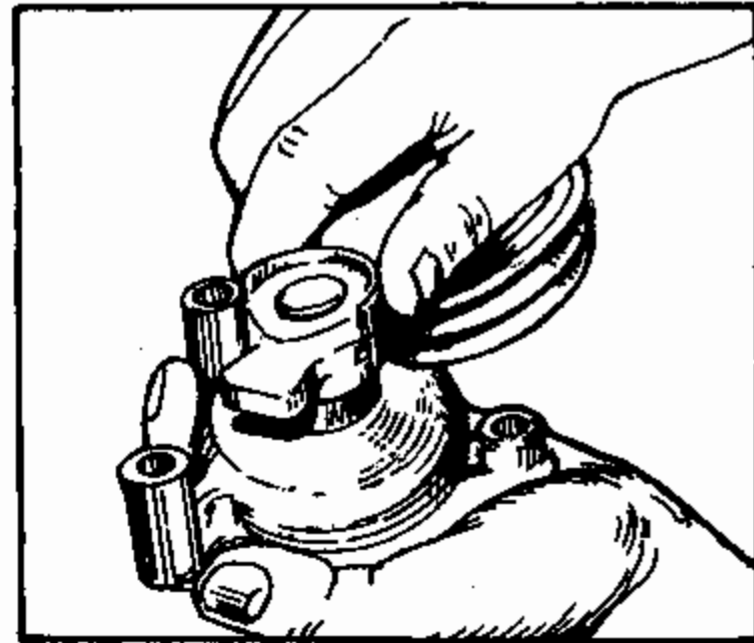
Bharat Multi purpose Grease no. 2. of Bharat Petroleum.
OR HP Multi purpose Grease of Hindustan Petroleum Corporation Ltd.

Use spacer in between two bearings, press the collared bush from cover side of the pulley and press the stepped washer from other side.

DO NOT FIT COVER FOR PULLEY RIGHT NOW. IT IS TO BE FITTED AFTER CORRECTING THE BELT ALIGNMENT.

- f) Now, check the centre shaft for radial and axial play. If necessary remove spring dowel securing lever and shaft (Fig. 6-4).

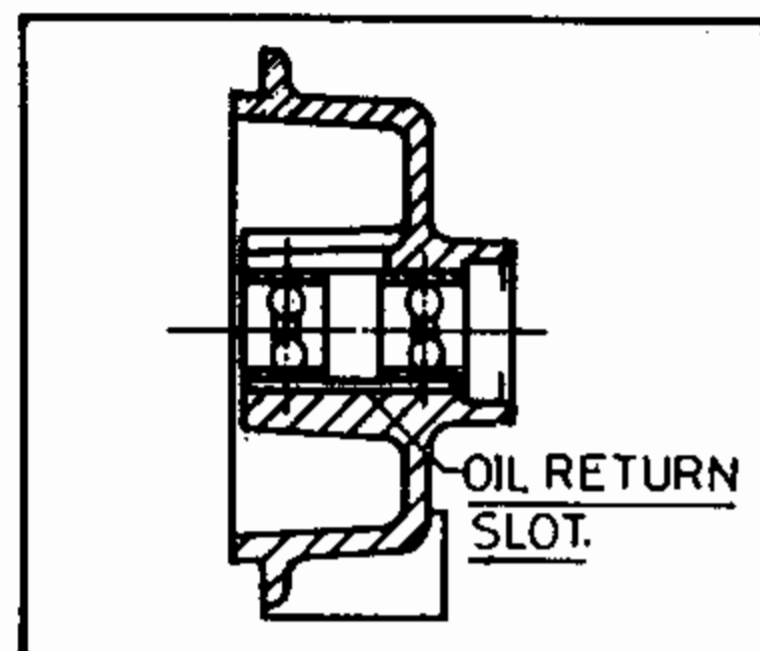
Remove spring and shaft from other side.



6-4

- g) Press out bush bearings from the housing. While pressing new bush bearings press inner bush flush to the hub and outer bush flush to the counter bore face as shown in Fig. 6-5. Use mandrel No.03.950.23.0 for pressing and removing bushes.

See that holes in bush bearings do not match with the oil return slot in the housing.

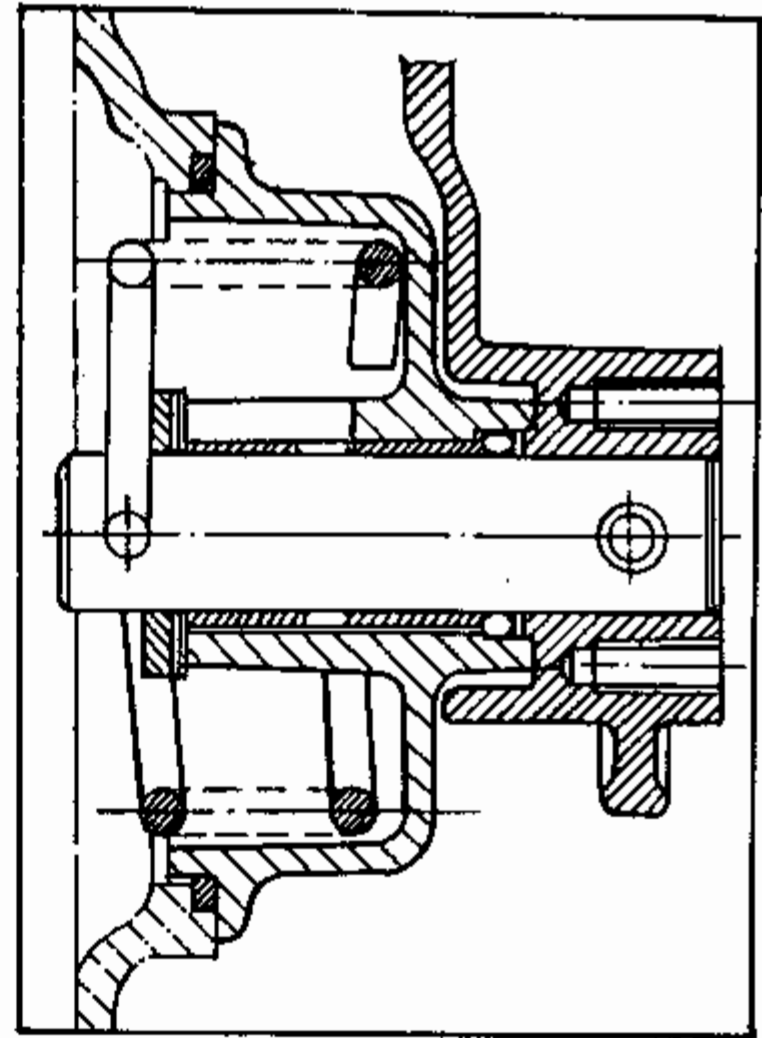


6-5

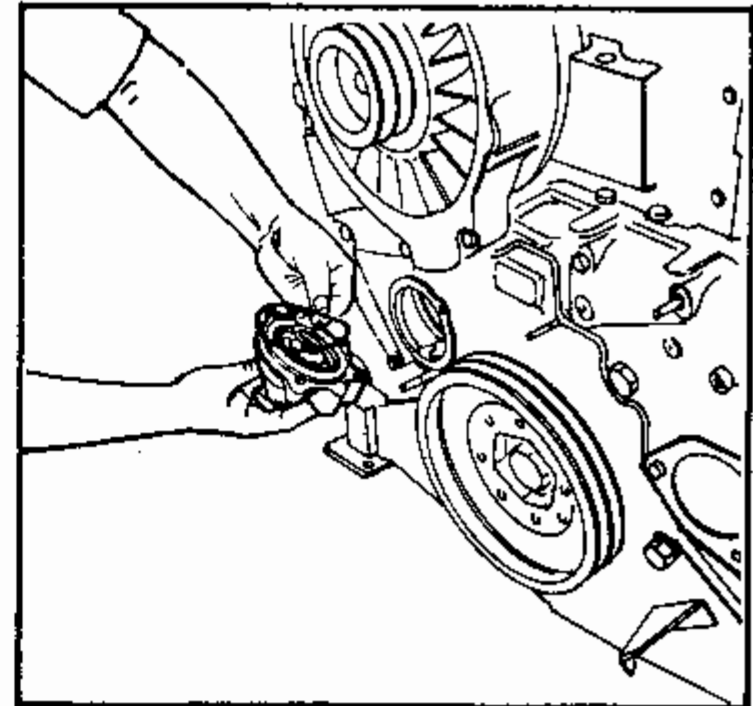
- h) For assembly of shaft and spring engage the spring lug in the shaft as shown in Fig. 6-6. Put the thick washer and insert the assembly in the housing.

Now, engage the lever on shaft from other side. See that the hole on lever and shaft are matching. If not, adjust the shims below the spring to have correct matching and axial play. Remove the lever and keep aside.

- i) To ascertain the initial position of the spring & lever, rotate the spring & shaft assembly counter clockwise, so that spring will get locked in the housing. Now, engage the lever and press the spring dowel securing the shaft and lever.
- j) Fix the pulley assembly on lever with centre bolt and nut.
- k) Fix the belt tension unit on front cover with a new rubber 'O' ring inbetween (Fig. 6-7).
- l) Fit the cover and joint with countersunk screws after correcting the alignment of belts.



6-6

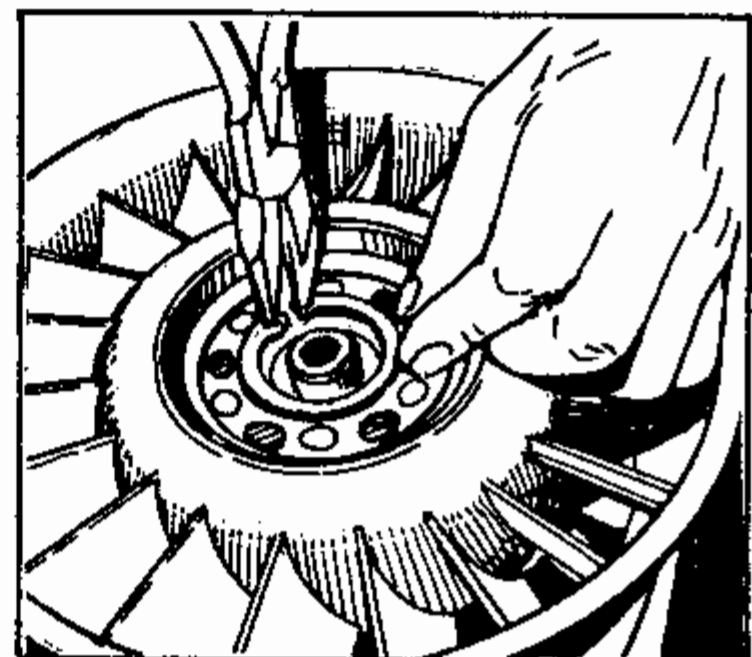


6-7

6.2 COOLING AIR BLOWER

6.2.1 If radial or axial play is observed in ball bearing, blower to be dismantled and repaired.

- a) Remove the cooling blower from front cover.
- b) Remove the centre bolt & nut and take out impeller from assembly. Also, take out the pulley from other end.
- c) Remove circlip from stator (Fig. 6-8).



6-8

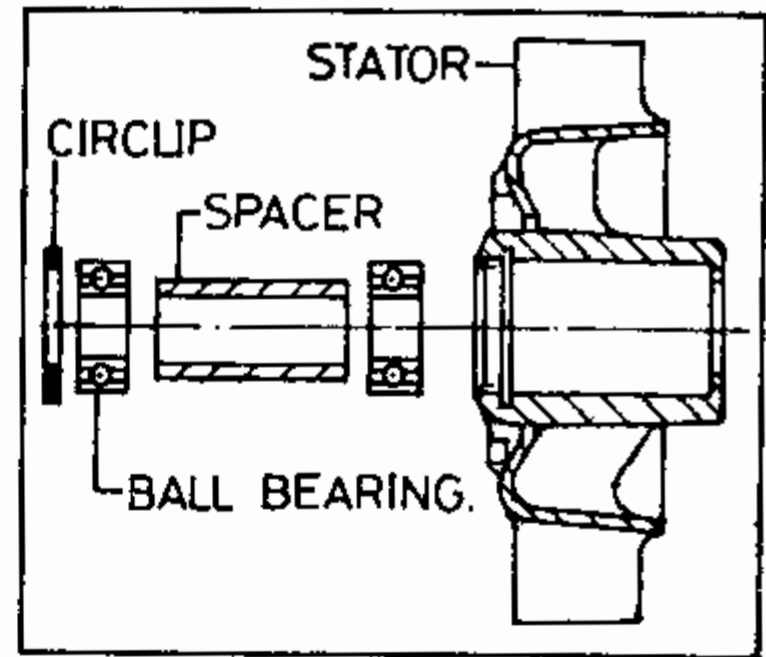
- d) Press out the ball bearings from the stator (Fig. 6-9)

Observe the condition of the bearings and replace them if necessary. Use mandrel No. 03.950.24.0.

Fill up the grease (100 cc) in between the bearings while assembly. Use grease as recommended in Sect. 6.1.2-e.

- e) Refit the circlip for outer bearing. Assemble pulley & impeller. Engage centre bolt and tighten it with 7.5 kgm torque.
- f) Mount the blower assembly on front cover. Slightly tighten the mounting bolts and check the belt alignment with crank pulley. Add shims between front cover and blower body if required for the adjustment of alignment.

Now, tighten the mounting bolts fully.



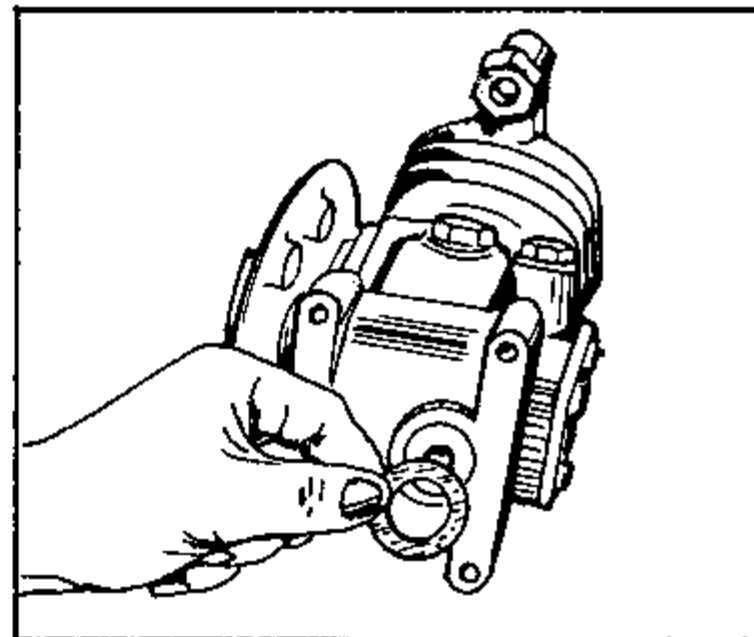
6-9

6.3 AIR COMPRESSOR

- 6.3.1 Disconnect inlet and delivery connections from compressor.
- 6.3.2 Disconnect lub. oil supply pipe from compressor.
- 6.3.3 Remove front end pulley half and shims from compressor pulley. Take out compressor driving belt.
- 6.3.4 Remove compressor mounting bolts and take out the compressor from bracket.

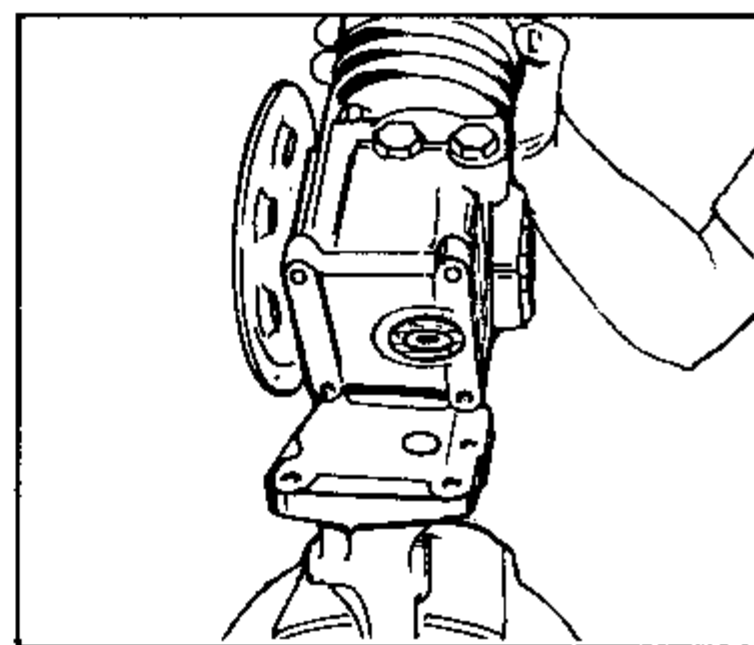
6.3.5 Remove the bolts from bracket to front cover and remove the bracket from front cover.

6.3.6 Clean the sealing faces of compressor and bracket. Apply grease on a new joint and stick it in position on the air compressor (Fig. 6-10).



6-10

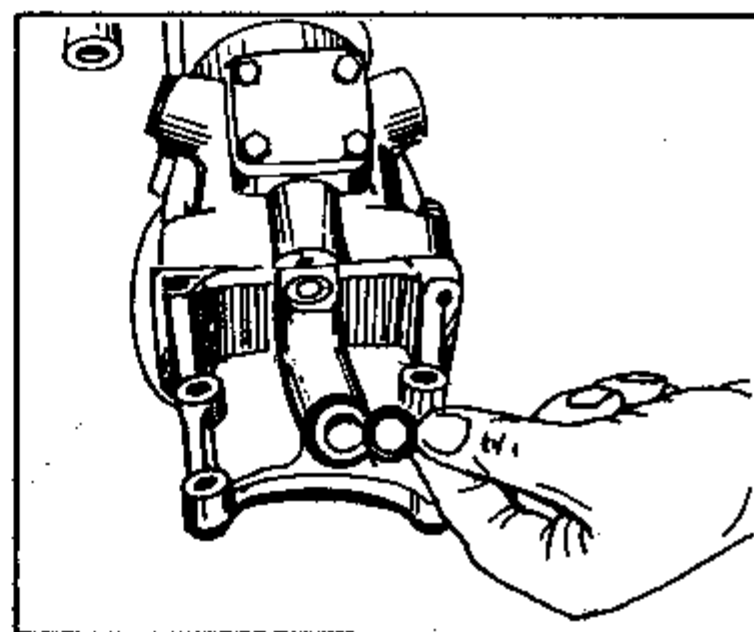
Mount the air compressor on bracket such that oil hole of the compressor matches with the hole on the bracket. (Fig. 6-11).



6-11

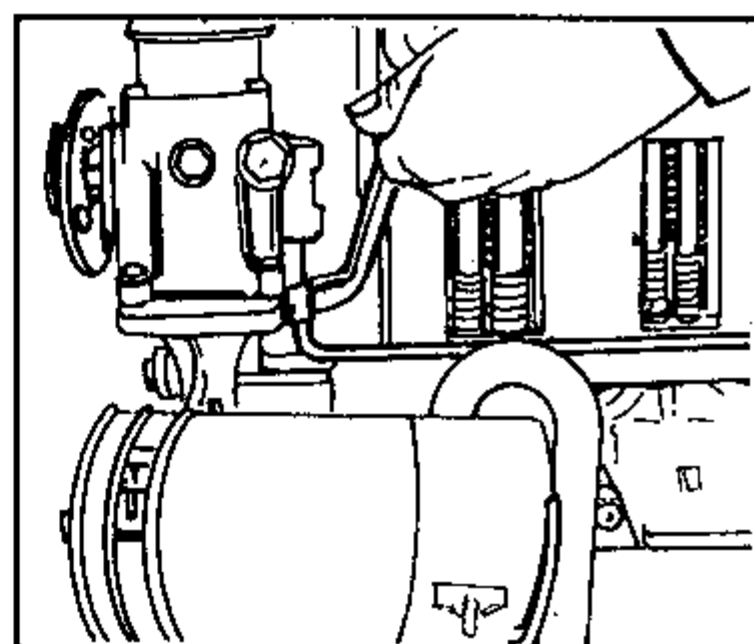
6.3.7 Apply grease to a new rubber 'O' ring and place it in position on bracket (Fig. 6-12).

Mount the bracket with compressor on front cover and fix the mounting bolts.



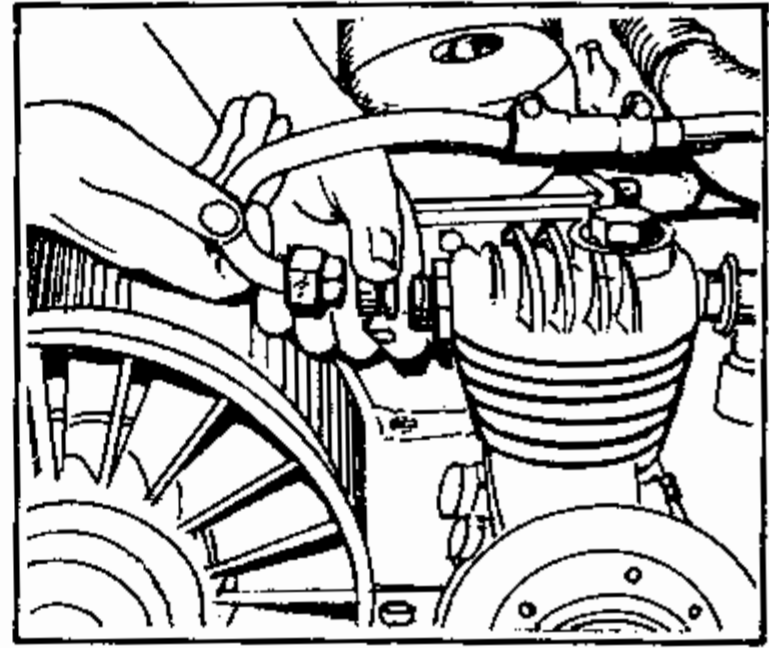
6-12

6.3.8 Using new copper washers, connect lub.oil supply line to the compressor body. (Fig. 6-13).



6-13

- 6.3.9 Connect inlet pipe to the compressor. While tightening union nut, see that cone ring is properly seated. (Fig. 6-14).



6-14

6.4 FUEL INJECTION EQUIPMENT

6.4.1 Fuel pump

Whenever fuel pump needs any repair work, follow the procedure given below for removing the fuel pump, refitting and setting of fuel pump timing.

Repairing of fuel injection equipment is a specialised job and can be undertaken only by MICO or BOSCH service stations equipped for that purpose. If it is suspected that the pump is faulty, detach the pump from the engine and take it to nearest MICO or BOSCH dealer.

Removing the fuel pump :

- a) Disconnect accelerator linkage (if provided).
- b) Disconnect the fuel connections and remove high pressure pipes on fuel pump.
- c) Rotate the crank pulley clockwise till the first piston (from flywheel end) is on top dead centre, after compression stroke. Make sure that the push rods of cylinder No.1 rotate freely and that the TDC mark on the crank pulley matches with the timing mark dowel fitted on front cover.

NOTE : IMPORTANT

DO NOT ROTATE THE CRANKSHAFT UNTILL FUEL PUMP IS REFITTED ON THE ENGINE.

- d) In case of HA394, remove the lub. oil filter in order to avoid the fouling of fuel pump while removing.
- e) Remove the belt tension unit/cover fitted on front cover opposite to fuel pump.

- f) Remove the nut and washer on fuel pump shaft through the bore on front cover.
- g) Fit the 'fuel pump gear hub removing puller'(No.03.950.27.0) on hub and go on screwing the centre bolt of the puller till the hub dislocates from the fuel pump shaft.

NOTE: IMPORTANT

BEFORE REMOVING FUEL PUMP MOUNTING NUTS, ENSURE THAT THE PREMARKED NOTCH, COMMON TO FUEL PUMP AND CRANKCASE, IS VISIBLE, OTHERWISE MARK IT WITH PENCIL OR CHALK. THIS WILL ENABLE THE CORRECT SETTING WHILE RE-FITTING THE FUEL PUMP ON CRACKCASE.

- h) Now remove the nuts used for mounting fuel pump on crankcase and remove the fuel pump.
Note that the fuel pump gear alongwith hub should remain in their position in front cover.

Refitment of Fuel pump and setting of Fuel timing :

After due repairs/calibration of the pump, follow the procedure given below while setting the fuel timing and refitting the pump.

- a) Coinside the keyway in hub and key on fuel pump shaft and insert the fuel pump shaft into the hub.
- b) Ensure that the pre-marked notch on fuel pump and crankcase are matched with each other and then tighten the four nuts of fuel pump mounting firmly.
- c) Now, tighten up the nut alongwith washer on fuel pump shaft (Use torque 5 kgm.)
- d) Rotate the crank pulley anti-clockwise till the timing mark matches with the timing mark dowel fitted on front cover.
- e) Connect the fuel supply connection to feed pump and bleed the system upto the pump.
- f) Unscrew the clamp for valve holder of the first plunger.
- g) Remove fuel delivery valve holder of the first plunger.
- h) Lift up the delivery valve and place it on a clean surface.
- i) Replace the holder on the first plunger without delivery valve. Care should be taken not to damage the valve seat.
- j) Fit the high pressure pipe on the holder such that the free end of the pipe is below the level of fuel pump.
- k) Loosen the three nuts of fuel pump gear and hub through 2-3 turns.

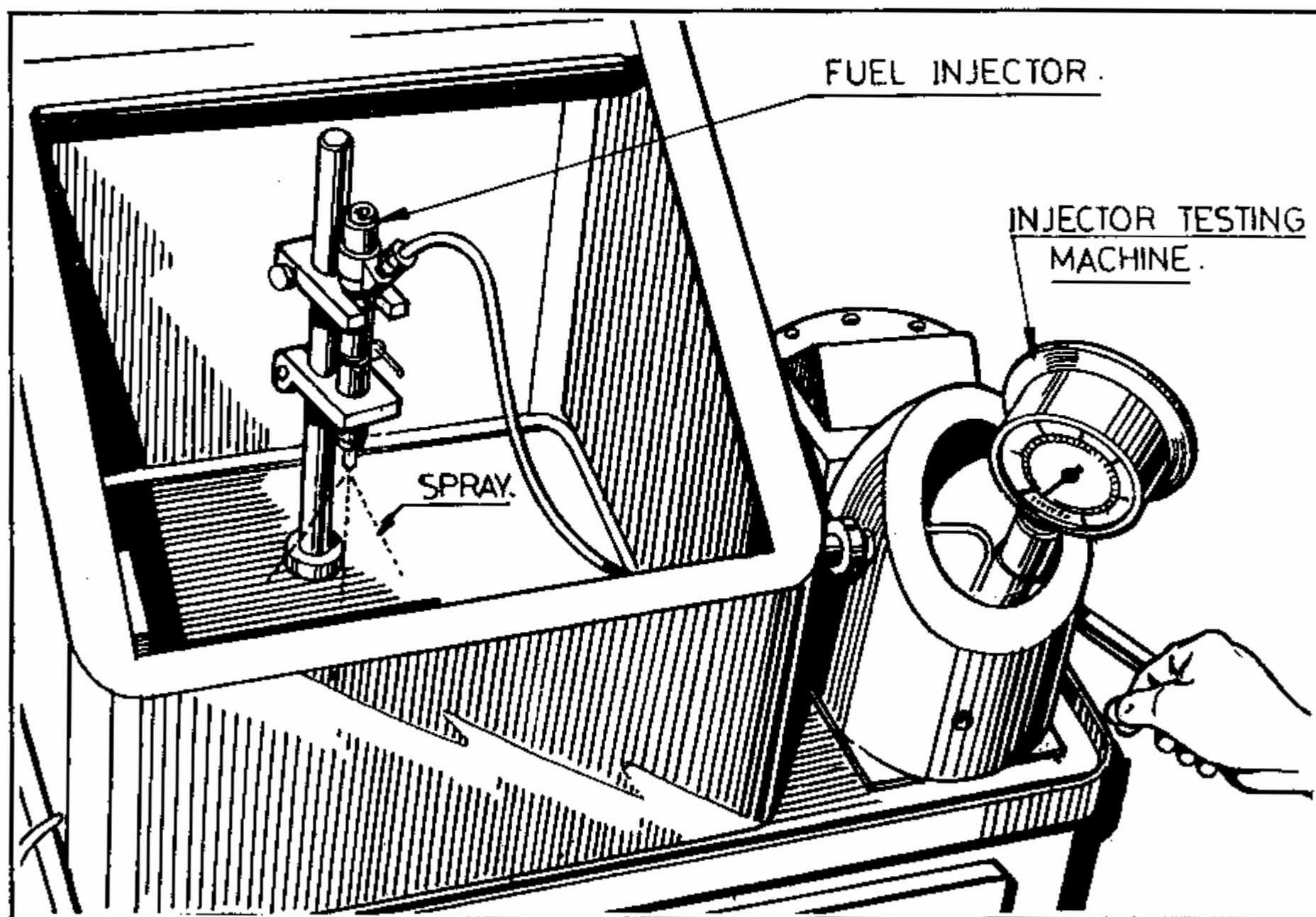
- l) Operate the hand priming pump till the fuel starts flowing out of the high pressure pipe. While still operating the pump rotate the pump shaft slowly in clockwise direction (with the help of pipe spanner) until the fuel flow stops. This cut-off is known as spill cut-off.
- m) Without disturbing the pump shaft position tighten the three bolts of fuel pump gear. The bolt should be tightened evenly one by one.
- n) Check the fuel pump timing again by rotating the crank pulley anticlockwise and then again rotating in clockwise direction. The spill cut-off and the timing mark on the crank pulley should match the timing mark dowel at the same time.
- o) If the timing is correct tighten the bolts of fuel pump gear fully.
- p) Remove the high pressure pipe and delivery valve holder. Replace the delivery valve and mount the holder back in position (Use torque 4 kg-m) and lock the valve holders with clamp).
- q) Now, fit the high pressure pipe from pump to the injector and put the clamps.
- r) In case of HA394, fit the lub. oil filter on engine.
- s) Fit the belt tension unit/cover and V-belt. Adjust the belt tension as given in Section 2-7, 1.8.
- t) Bleed the entire fuel system again before engine is ready to start.

6.4.2 Fuel Injector

- a) Disconnect fuel injection pipe. Remove the nut holding yoke for injector. Take out the injector. See that the sealing washer is with the injector. If it is stuck in nozzle bore, remove it with special tool No.03.950.15.0.
- b) Connect the injector to the nozzle pressure testing unit. Operate the lever of the unit by hand to built up the pressure. Read the opening pressure and compare it with nozzle opening pressure given in specification. Observe spray pattern. Individual spray should be in a conical form of fine mist of fuel (Fig. 6-15).

IMPORTANT :

NOZZLE SHOULD NOT DRIBBLE AT A PRESSURE OF 145 TO 150 kg/cm²
IF PRESSURE IS FOUND TO BE LOWER, INJECTOR NEEDS TO BE
SERVICED.



6-15

NOZZLE PRESSURE TESTING UNIT

- c) Dismantle injector and clean all the parts with diesel oil. Detail parts are shown in Fig. 6-16.
- d) Ensure that the fuel holes in the injector body and nozzle are clear.
- e) Take out the nozzle needle from the nozzle body. Slight tapping on needle valve point by wooden block will facilitate removal. The needle and stalk of the valve should be cleaned with brass wire brush. Emery paper or similar abrasive must never be used for cleaning the needle.

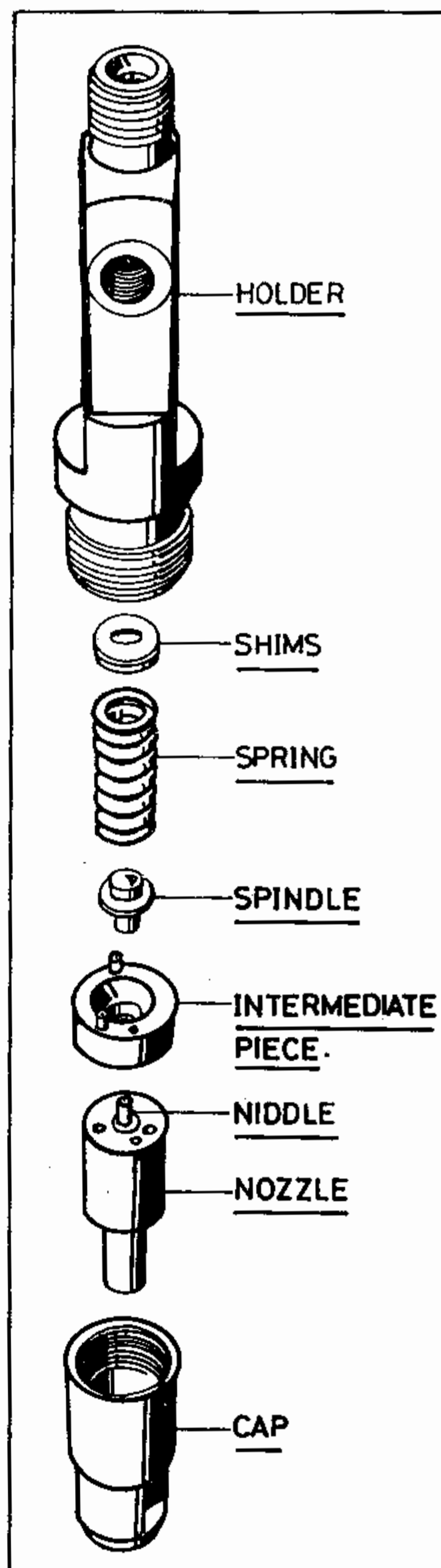
Do not touch the needle seat. Nozzle and needle are tapped together, hence they should not be interchanged with any other nozzle/needle.

- f) Nozzle needle should slide slowly in nozzle body by its own weight. If it does not slide clean again inside surface of nozzle body and the needle and check again. Still it found sticky change the nozzle and needle pair.
- g) Now assemble the nozzle by using the shims already there in the injector. Tighten the nozzle holder cap by torque wrench at a torque of 8 kg-m.

/CAUTION/

ANY OVER TIGHTENING WILL DISTORT THE NOZZLE AND CONSEQUENTLY WILL RESULT IN STICKING OF VALVE.

- h) Check the injector again for opening pressure and spray pattern. If required add shims for increasing pressure and for decreasing the pressure remove shims.

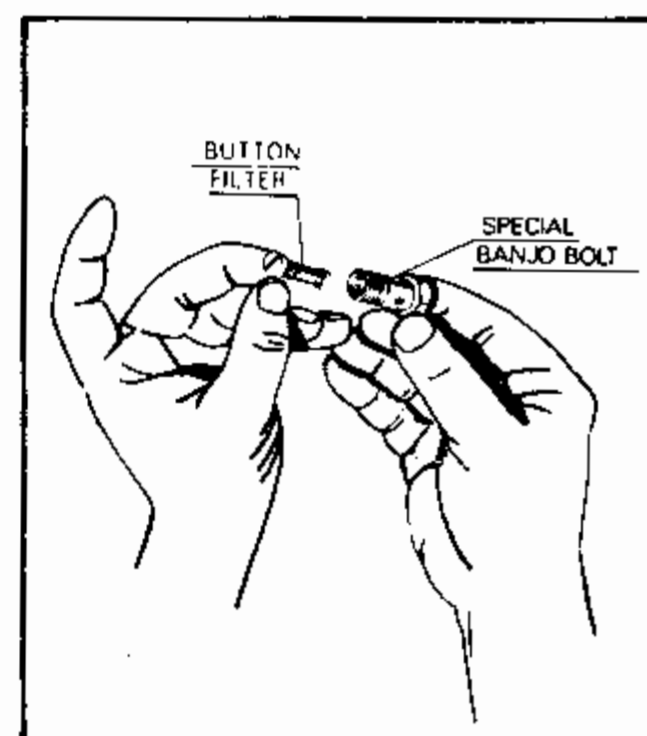


6-16

6.4.3 Feed pump (Fuel Lift Pump)

- a) Feed pump is mounted on the fuel pump body by 3 bolts. The function of feed pump is to feed the fuel oil to pump through fuel filter under constant pressure. This avoid air suction in fuel lines. Hand priming pump is also provided on feed pump to remove air, trapped in fuel circuit and to feed fuel to injector through filter and fuel pump whenever required. The maximum lift of the feed pump is 1 metre (3.2 ft.).

- b) A button filter with special banjo bolt is situated at the inlet of feed pump. The fuel from the fuel tank passes through this button filter. Clean the button filter with diesel oil at the time of servicing. The normal period for cleanings the filter is after every 500 hours running of the engine (Fig. 6-17).



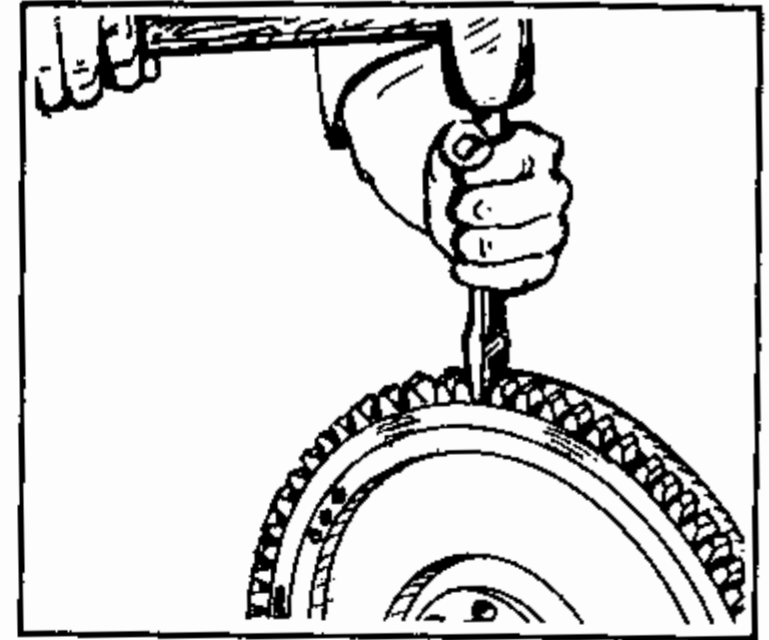
6-17

6.4.4 Fuel Filter

The change over period for fuel filter elements and its maintenance given in HA Maintenance Manual. Refer the same. Wherever spin-on type filter is provided see instructions for replacement given in Maintenance Manual/Sticker on engine cowling.

6.5 REMOVAL AND FITMENT OF NEW STARTER RING

- 6.5.1 Cut-off a damaged starter ring with a hard chisel and remove it from flywheel (Fig.6-18).

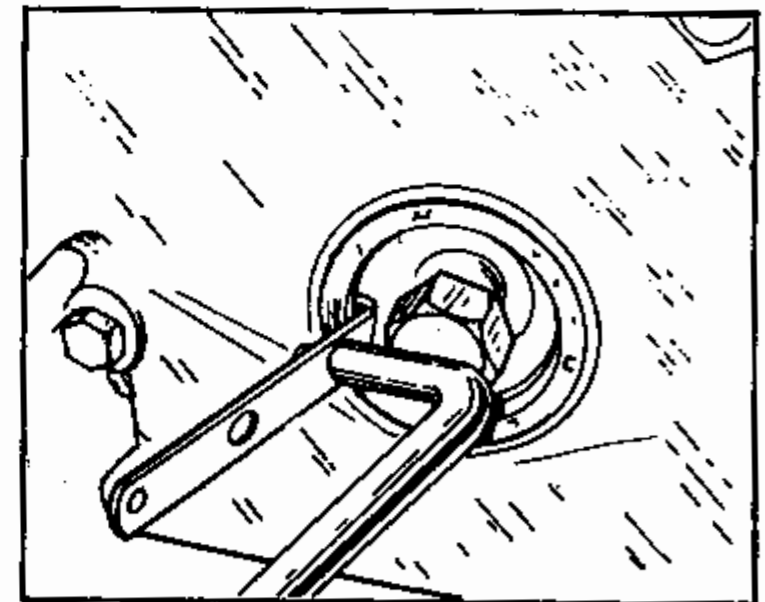


6-18

- 6.5.2 Heat the new starter ring to a temperature of 120°C - 150°C place it over the flywheel step.
- 6.5.3 Bevel side of the teeth should face upwards. Hit the starter ring slowly all around with hammer. Starter ring should rest fully on flywheel step.

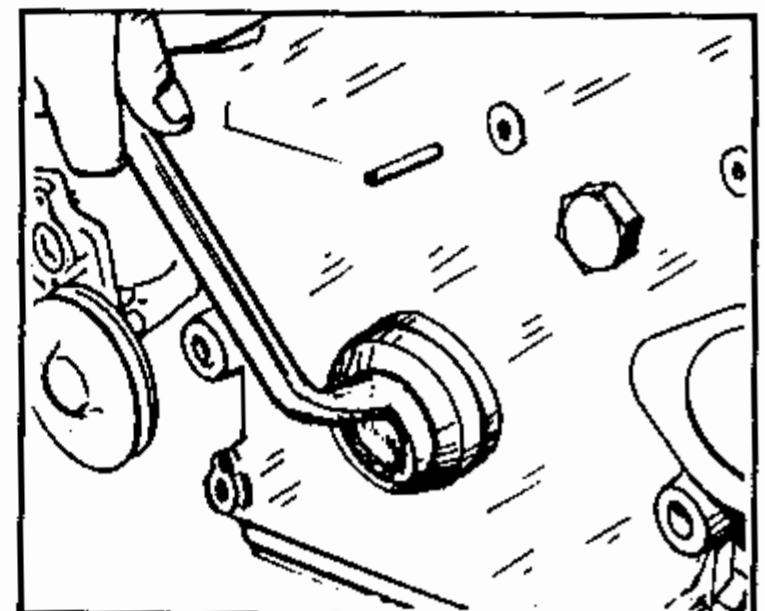
6.6 REMOVAL AND REFITTING OF GEAR END OIL SEAL WITHOUT REMOVING FRONT COVER

- 6.6.1 Remove crank pulley by loosening the centre bolt. Engage only centre bolt in the crankshaft.
- 6.6.2 Use special tool No.03.950.25.0 for removal of oil seal (Fig. 6-19).



6-19

- 6.6.3 Remove the centre bolt. Apply grease to the lip of new oil seal and position it on front cover. For pressing the oil seal in front cover use mandrel No. 03.950.26.0 (Fig. 6-20).



6-20

6.7 ALIGNMENT AND BELT TENSIONING OF DYNAMO & ALTERNATOR

6.7.1 Alternator

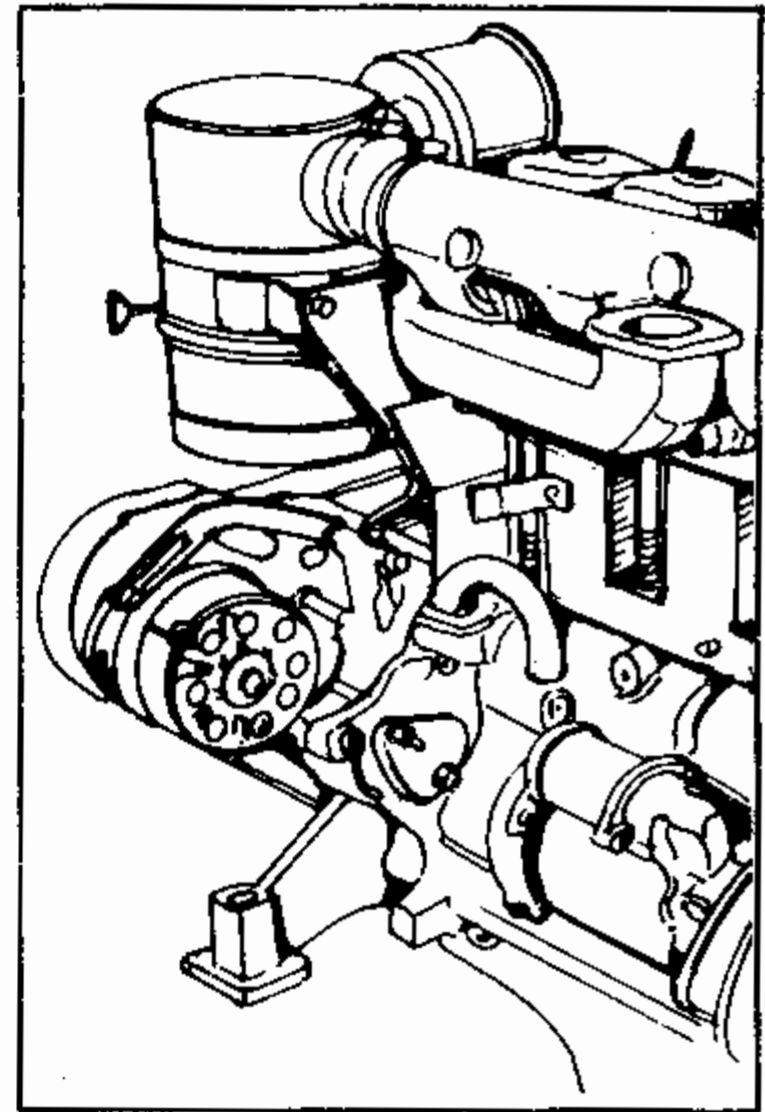
- a) Mount the bracket for alternator mounting on front cover.

Fix upper two bolts for bracket holding on front cover.

Use sleeves below the bracket.

- b) Position the alternator on bracket and insert centre bolt which passes the lower most hole on bracket, alternator, front cover & crankcase. Fix the nut from backface of the crank case.

Fig. 6-21 shows the alternator mounted on engine.



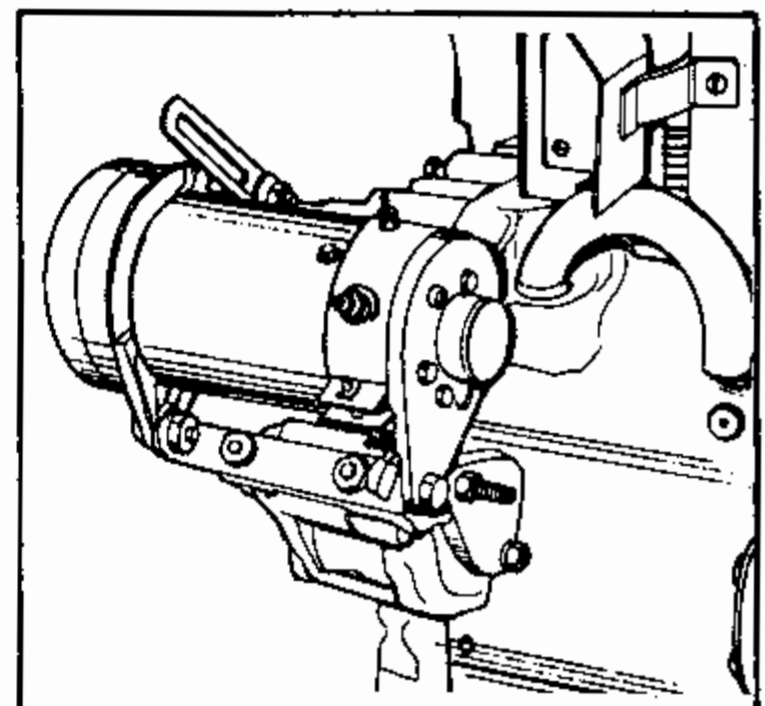
6-21

- c) Check the alignment of alternator pulley groove with crank pulley groove. If necessary adjust the plain washers between bracket and alternator.
- d) Now, fix one end of belt tension adjusting lever on front cover and bolt the other end to alternator using the spacer inbetween.
- e) Mount the belt on pulley & adjust the belt tension properly.
- f) Tighten all bolts fully.

6.7.2 Dynamo

- a) A sliding bracket is provided to facilitate the face alignment of dynamo with crank pulley.

Fig. 6-22 shows the mounting arrangement of dynamo on engine.

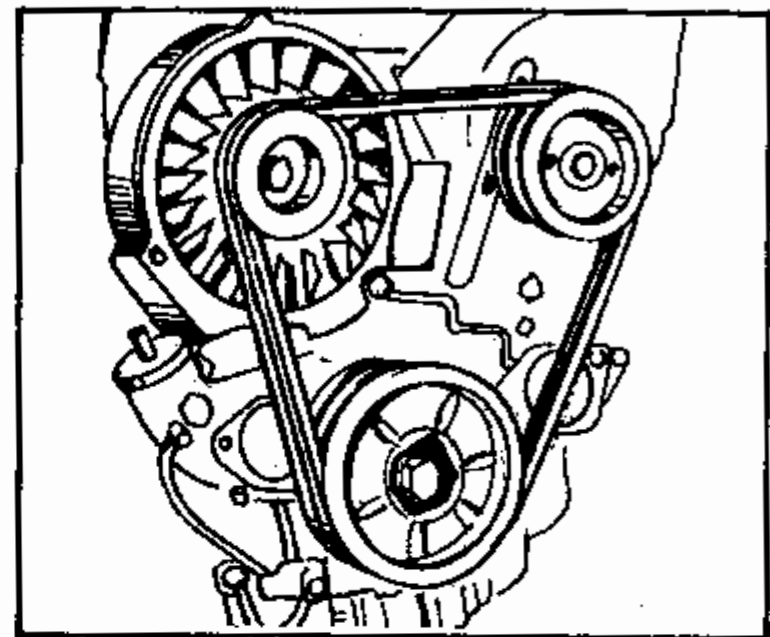


6-22

NOTE : FOR HA294 /394 /494 ENGINES, THE OUTERMOST GROOVE OF CRANK PULLEY IS MEANT FOR ALTERNATOR/DYNAMO BOLT.
FOR HA694 ENGINE CRANK PULLEY GROOVE NEAREST TO THE FRONT COVER IS TO FOR ALTERNATOR/DYNAMO BELT,
HENCE FIT THE ALTERNATOR/DYNAMO BELT FIRST ON THE CRANK PULLEY BEFORE FITTING BELTS FOR COOLING AIR BLOWER.

6.8 BELT ARRANGEMENT FOR TRACTOR ENGINE

Tractor engines are provided with common belts for crank pulley, cooling blower and dynamo. Belt tension unit is not provided on these engines. In place of belt tension unit a sheet metal unit with rubber 'O' ring is provided to blank the front cover opening. Belt tension is to be adjusted by dynamo. Belt arrangement is shown in Fig. 6-23.

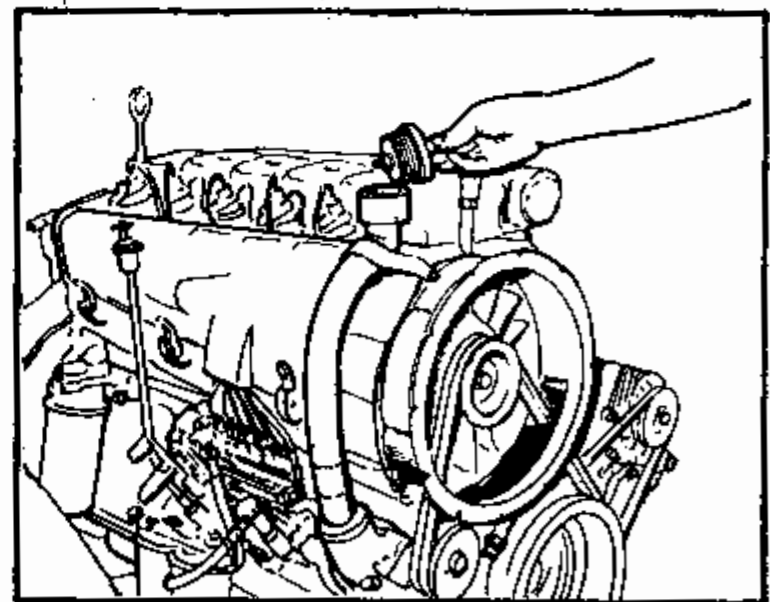


6-23

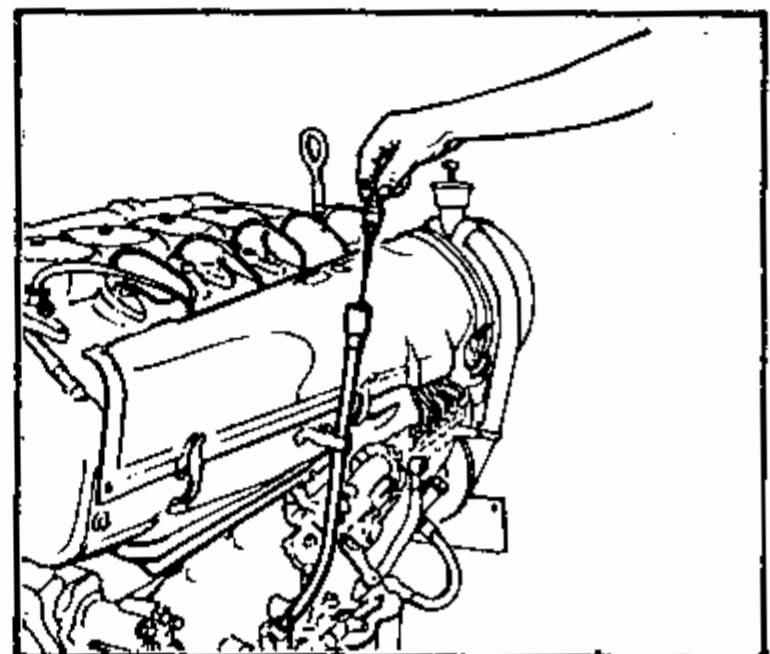
6.9 RAISED DIPSTICK AND RAISED OIL FILLING ARRANGEMENT

In case of some special application engines are provided with raised oil filling arrangement and raised dipstick, for easy accessibility.

Fig. 6-24, & 6-25 show these arrangements.



6-24



6-25

SECTION - 7

TROUBLE SHOOTING CHART AND RECOMMENDED SPARES

SECTION – 7

TROUBLE SHOOTING CHART & RECOMMENDED SPARES

7.1 RECOMMENDED SPARE PARTS FOR NORMAL MAINTENANCE OF THE ENGINE :

- a) The spare parts given in the list on the next page are required for routine maintenance of the engine as well as for safety purpose.
- b) The recommendation is based, provided the engine is properly maintained as per the instructions given in this manual as well as in the Maintenance Manual.
- c) Before replacing the piston and liner, check the liner bore diameter. If it is more than 100.22 mm then only replace the liner and piston with piston rings of standard size. (Reboring of liner and use of oversize piston is not recommended).

LIST OF SPARE PARTS RECOMMENDED FOR NORMAL MAINTENANCE OF 'HA' ENGINES
(WHEREVER PART NOS. FOR MARINE ENGINES DIFFER FROM STD. PARTS, THESE ARE SPECIFICALLY MENTIONED, REST OF THE PARTS ARE COMMON)

Sr. No.	Part No.	Description	QUANTITY REQUIRED PER ENGINE DURING															
			1st year(1500 hrs)				2nd year(3000 hrs)				3rd year(4500 hrs)				4th year(6000 hrs)			
			HA	HA	HA	HA	HA	HA	HA	HA	HA	HA	HA	HA	HA	HA		
			294	394	494	694	294	394	494	694	294	394	494	694	294	394	494	694
01a	02.019.01.0	Cylinder liner (Std.)	-	-	-	-	-	-	-	-	-	-	-	-	2	3	4	6
b	02.092.01.0	Cylinder liner (marine)	-	-	-	-	-	-	-	-	-	-	-	-	2	3	4	6
02	02.019.03.0	Copper joint/Shim ring	-	-	-	-	4	6	8	12	-	-	-	-	4	6	8	12
03	02.020.10.0	Piston assly. with piston rings (std.)	-	-	-	-	-	-	-	-	-	-	-	-	2	3	4	6
04		Piston ring set	-	-	-	-	2	3	4	6	-	-	-	-	-	-	-	-
05	03.007.06.0	Oil seal (Flywheel end)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
06	03.013.06.0	Oil seal (Gear end)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
07	02.022.17.0	Valve guide	-	-	-	-	-	-	-	-	-	-	-	-	4	6	8	12
08	02.022.12.0	Valve collet	-	-	-	-	4	6	8	12	-	-	-	-	4	6	8	12
09	02.022.13.0	Valve spring	-	-	-	-	-	-	-	-	-	-	-	-	4	6	8	12
10	02.022.22.0	Inlet valve	-	-	-	-	-	-	-	-	-	-	-	-	2	3	4	6
11	02.022.08.0	Exhaust valve	-	-	-	-	-	-	-	-	-	-	-	-	2	3	4	6
12	02.024.02.0	Sealing ring (bottom)	-	-	-	-	4	6	8	12	-	-	-	-	4	6	8	12
13	02.024.05.0	Sealing ring (top)	-	-	-	-	4	6	8	12	-	-	-	-	4	6	8	12
14	42.005.10.0	Nozzle (MICO No.9 430 034 210)	-	-	-	-	1	1	2	2	-	-	-	-	2	3	4	6
15	10.029.07.0	Nozzle sealing washer (MICO No. 2 439 999 032)	-	-	-	-	2	3	4	6	-	-	-	-	2	3	4	6
16a	34.032.02.0	Fuel filter element (pre) (MICO No. 9 451 037 404)	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
b	48.117.01.0	Fuel filter element, pre (for marine)(MICO No.1 457 431 003)	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
17a	34.032.03.0	Fuel filter element, Micro-coil type-MICO No.9 451 037 407 OR	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
	34.032.12.0	Star type-MICO No.9 451 037 405																

Sr. No.	Part No.	Description	QUANTITY REQUIRED PER ENGINE DURING											
			1st year(1500 hrs)			2nd year(3000 hrs)			3rd year(4500 hrs)			4th year(6000 hrs)		
			HA	HA	HA	HA	HA	HA	HA	HA	HA	HA	HA	HA
			294	394	494	694	294	394	494	694	294	394	494	694
17b	48.117.02.0	Fuel filter element, Micro (for marine)(MICO No.1 451 037 409)	2	2	2	2	3	3	3	3	3	3	3	3
18	34.032.01.0	Sealing ring (MICO No.1 450 109 042)	2	2	2	2	3	3	3	3	3	3	3	3
19a	03.040.19.0	Lub. oil filter element	9	9	9	-	10	10	10	10	10	10	10	-
b	06.040.01.0	Lub.oil filter element	-	-	-	9	-	-	-	10	-	-	-	10
20	03.040.03.0	Sealing ring between lub. oil filter cover & bowl	2	2	2	2	2	2	2	2	2	2	2	2
21a	60.139.01.0	V-Belt (A-45) for dynamo	-	-	-	-	1	1	1	-	-	1	1	-
b	19.182.01.0	V-Belt (A-46) for dynamo	-	-	-	-	-	-	-	-	-	-	-	1
22a	03.054.01.0	V-Belt (A-49) for blower	-	-	-	-	2	2	2	-	-	2	2	-
b	06.052.01.0	V-Belt (A-52) for blower	-	-	-	-	-	-	-	-	-	-	-	2
c	06.098.01.0	V-Belt (A-51) for blower (whenever Hydraulic oil cooler is fitted or for marine engine)	-	-	-	-	-	-	-	-	-	-	-	2
23a	M-093400003	Main bearing set (std size)	-	-	-	-	1	-	-	-	-	1	-	-
b	M-073400003	Main bearing set (std size)	-	-	-	-	-	1	-	-	-	-	1	-
c	M-074400003	Main bearing set (std size)	-	-	-	-	-	-	1	-	-	-	1	-
d	M-075400003	Main bearing set (std size)	-	-	-	-	-	-	-	1	-	-	-	1
24a	M-093400013	Main bearing set (0.25mm u/s)	-	-	-	-	-	-	-	-	-	1	-	-
b	M-073400013	Main bearing set (0.25mm u/s)	-	-	-	-	-	-	-	-	-	-	1	-
c	M-074400013	Main bearing set (0.25mm u/s)	-	-	-	-	-	-	-	-	-	-	1	-
d	M-075400013	Main bearing set (0.25mm u/s)	-	-	-	-	-	-	-	-	-	-	-	1
25a	B-093400003	Connecting rod bearing (std. size)	-	-	-	-	1	-	-	-	-	1	-	-
b	B-073400003	Connecting rod bearing (std. size)	-	-	-	-	-	1	-	-	-	-	1	-

Sr. No.	Part No.	Description	QUANTITY REQUIRED PER ENGINE DURING											
			1st year(1500 hrs)			2nd year(3000 hrs)			3rd year(4500 hrs)			4th year(6000 hrs)		
			HA	HA	HA	HA	HA	HA	HA	HA	HA	HA	HA	HA
			294	394	494	694	294	394	494	694	294	394	494	694
c	B-0744000003	Connecting rod bearing(St.sz)	-	-	-	-	1	-	-	-	-	-	1	-
d	B-0754000003	Connecting rod bearing (std.size)	-	-	-	-	-	1	-	-	-	-	-	1
26a	S-0935000003	Connecting rod small end bush, set	-	-	-	1	-	-	-	-	-	1	-	-
b	S-0735000003	Connecting rod small end bush, set	-	-	-	-	1	-	-	-	-	-	1	-
c	S-0745000003	Connecting rod small end bush, set	-	-	-	-	-	1	-	-	-	-	1	-
d	S-0755000003	Connecting rod small end bush, set	-	-	-	-	-	-	-	-	-	-	-	1
27a	V-0935000003	Valve rocker bush, set	-	-	-	1	-	-	-	-	-	1	-	-
b	V-0735000003	Valve rocker bush, set	-	-	-	-	1	-	-	-	-	-	1	-
c	V-0745000003	Valve rocker bush, set	-	-	-	-	-	1	-	-	-	-	-	1
d	V-0755000003	Valve rocker bush, set	-	-	-	-	-	-	-	-	-	-	-	1
28a	C-0936000003	Camshaft bush	-	-	-	-	-	-	-	-	-	1	-	-
b	C-0736000003	Camshaft bush	-	-	-	-	-	-	-	-	-	-	1	-
c	C-0746000003	Camshaft bush	-	-	-	-	-	-	-	-	-	-	-	1
d	C-0756000003	Camshaft bush	-	-	-	-	-	-	-	-	-	-	-	1
29a	G-0935000003	Intermediate gear bush	-	-	-	-	-	-	-	-	-	1	-	-
b	G-0735000003	Intermediate gear bush	-	-	-	-	-	-	-	-	-	-	1	-
c	G-0745000003	Intermediate gear bush	-	-	-	-	-	-	-	-	-	-	-	1
d	G-0755000003	Intermediate gear bush	-	-	-	-	-	-	-	-	-	-	-	1
30a	Z-0935000003	Lub. oil pump bush	-	-	-	-	-	-	-	-	-	1	-	-
b	Z-0735000003	Lub. oil pump bush	-	-	-	-	-	-	-	-	-	-	1	-
c	Z-0745000003	Lub. oil pump bush	-	-	-	-	-	-	-	-	-	-	-	1
d	Z-0755000003	Lub. oil pump bush	-	-	-	-	-	-	-	-	-	-	-	1
31a	W-0935000003	Thrust washer, set	-	-	-	-	-	-	-	-	-	1	-	-

Sr. No.	Part No.	Description	QUANTITY REQUIRED PER ENGINE DURING							
			1st year(1500 hrs)		2nd year(3000 hrs)		3rd year(4500 hrs)		4th year(6000 hrs)	
			HA	HA	HA	HA	HA	HA	HA	HA
			294	394	494	694	294	394	494	694
b	W-073500003	Thrust washer, set	-	-	-	-	-	-	1	-
c	W-074500003	Thrust washer, set	-	-	-	-	-	-	-	1
d	W-075500003	Thrust washer, set	-	-	-	-	-	-	-	1
32a	02.050.10.0	Set of joints	1	-	-	-	1	-	-	-
b	03.068.10.0	Set of joints	-	1	-	-	-	1	-	-
c	04.034.10.0	Set of joints	-	-	1	-	-	-	-	1
d	06.050.10.0	Set of joints	-	-	-	1	-	-	-	-
33	02.050.20.0	Set of joints (only for Tractor application)	1	-	-	-	1	-	-	-
34a	02.051.10.0	Set of rubber 'O' rings	1	-	-	-	1	-	-	-
b	03.069.10.0	Set of rubber 'O' rings	-	1	-	-	-	1	-	-
c	04.035.10.0	Set of rubber 'O' rings	-	-	1	-	-	-	-	1
d	06.051.10.0	Set of rubber 'O' rings	-	-	-	1	-	-	-	-

7.2 TROUBLE SHOOTING :

If trouble should occur, these will be frequently due to incorrect operation, improper lubrication or bad maintenance of the engines. This could be avoided if you follow the instructions given in this manual and Maintenance Manual of HA series engines. The common troubles, their causes and remedies on them are given in following table. However, if you cannot identify the cause of the trouble or are unable to put it right yourself, the best way is to contact your local "KIRLOSKAR" distributor.

TROUBLE	NO	CAUSE	REMEDY
Engine fails to start	1	Dirty/clogged air cleaner.	Clean air cleaner, change oil in air cleaner.
	2	High exhaust back pressure.	Clean exhaust silencer and manifold.
	3	Fuel tank empty	Fill up tank and air vent.
	4	Fuel tank cock closed	Open the cock and air vent if necessary.
	5	Air in fuel line	Bleed fuel system.
	6	Strainer in feed pump inlet banjo choked.	Clean the strainer
	7	Fuel line leaking	Check all fuel line connections for tightness, change copper washers.
	8	Faulty fuel injector nozzle	Check the nozzle spray, if necessary change the nozzle.
	9	Dirty/choked fuel filter	Change the filter elements and clean fuel filter bowls.
	10	Feed pump not working	Operate feed pump, if not working, send it to your dealer.

TROUBLE	NO	CAUSE	REMEDY
Engine fails to start	11	Wrong adjustment of valve clearance	Re-adjust the valve clearances correctly.
	12	Incorrect fuel timing.	Set to correct fuel timing.
	13	Battery runs down	Recharge battery
	14	Battery of wrong capacity	Use battery of correct capacity recommended in Maintenance Manual.
	15	Faulty starter	Repair starter.
	16	Loose or dislodged wiring	Tighten all loose wiring.
Engine is difficult to start.	17	High exhaust back pressure.	Clean exhaust silencer and manifold.
	18	Dirty/clogged air cleaner	Clean air cleaner, change oil in air cleaner.
	19	Air in fuel line	Bleed fuel system.
	20	Fuel line leaking	Check all fuel line connections for tightness, change copper washers.
	21	Faulty fuel injection nozzle	Check the nozzle spray, if necessary change the nozzle.
	22	Engine used after a long time.	Flush and service engine thoroughly.
	23	Incorrect fuel timing	Set it to correct fuel timing.
	24	Run down battery, terminals loose or oxidized causing starter motor to turn slowly.	Have battery inspected clean terminals, tighten and coat with acid-free grease.
	25	Grade of lub.oil used is too viscous (applies particularly at very low temp.in winter).	Used correct grade of lub.oil of recommended in lub. oil specifications.(Section 1.3.8)
	25	Fuel supply not sufficient	Renew fuel filter and then air-vent, clean strainer in fuel lift pump.

TROUBLE	NO.	CLAUSE	REMEDY
Engine starts but stops after some time.	27	Dirty/clogged air cleaner	Clean air cleaner, change oil in air cleaner.
	28	No fuel	Replenish with clean fuel.
	29	Air in fuel line	Bleed fuel system, tighten all fuel connections.
	30	Choked fuel injector holes.	Clean holes
	31	Dirty/choked fuel filter	Clean fuel filter bowls and replace the fuel filter element.
	32	Wrong adjustment of valve clearances.	Re-adjust valve clearances correctly.
	33	Water mixed with fuel.	Change fuel and clean fuel tank.
	34	Engine seized	Contact nearest distributor.
	35	One or more cylinders not working.	Contact nearest distributor.
Engine gives poor performance or engine lacks power	36	Dirty/clogged air cleaner	Clean air cleaner, refill lub. oil in air cleaner
	37	High exhaust back pressure	Clean exhaust silencer and manifold.
	38	Derating due to altitude and temperature	Calculate derating due to altitude and temperature and put correct load on engine.
	39	Choked fuel injector holes or nozzle needle sticking.	Clean injector and fuel line, have inspected by a specialist.
	40	Control lever setting wrong	Adjust to correct setting.
	41	Faulty fuel pump	Send pump for recalibration.

TROUBLE	NO.	CAUSE	REMEDY
Engine gives poor performance or engine lacks power	42	Fuel supply not sufficient	Renew fuel filter elements and air-vent, clean strainer in fuel lift pump, tighten fuel line connections.
	43	Overflow valve on fuel injection pump not working properly	Have inspected by a specialist.
	44	Valve clearance out of adjustment, valve spring broken	Re-adjust valve clearance, renew valve spring.
	45	Dirty air cooling fins on cylinder liners and cylinder heads.	Clean air fins.
	46	Loose fan belt	Tighten belts.
	47	Valve leakages	Regrind the valves.
	48	Broken/seized/worn out piston rings	Replace with new piston rings.
	49	Worn out liner and piston.	Replace with new one.
	50	Damaged main and connecting rod bearings.	Change bearings.
	51	Incorrect valve and fuel timings	Set to correct settings.
	52	Faulty governor setting	Set governor properly
	53	One or more cylinders not working.	Contact nearest distributor.
Exhaust smokes badly	54	Too much oil in sump.	Drain off until level reaches top mark on dipstick.
	55	Oil level in oil bath air cleaner too high	Pour off until level agrees with mark hole.
	56	Insufficient compression due to sticking or broken compression rings or incorrect valve clearances.	Have compression rings and pistons inspected by a specialist, readjust valve clearances.

TROUBLE	NO.	CAUSE	REMEDY
Exhaust Smokes badly	57	Derating due to altitude and temperature	Calculate derating due to altitude and temperature and reduce load on the engine if necessary.
	58	Poor quality of fuel	Change to quality fuel.
Engine overheats (shut down engine immediately)	59	Cooling fins on cylinders and cylinder heads very dirty	Clean cooling fins, particularly the vertical ones on the cylinder heads.
	60	Injectors defective	Have inspected by a specialist.
	61	Injection pump delivery out of adjustment	Have adjusted by a specialist.
	62	Insufficient cooling air input to blower.	Ensure free cooling air flow.
	63	Blower V-Belt broken	Renew V Belt
Engine oil pressure too low (shut down engine immediately)	64	Wrong grade of lub. oil used	Use lub. oil of recommended grade.
	65	Dirty/choked suction tube strainer.	Clean strainer thoroughly
	66	Dirty/clogged oil filter.	Clean oil filter and replace filter.
	67	Clogged oil passages	Flush oil passages.
	68	Defective relief valve in lub. oil filter.	Replace with new one.
	69	Leaks in lub. oil system.	Check connections on pump lines, filter, pressure, gauge and cooler for tightness.
	70	Faulty oil pump	Replace with new one.
	71	Engine oil not changed at recommended period.	Change the oil

TROUBLE	NO.	CAUSE	REMEDY
Engine oil pressure too low (shut down engine immediately:)	72	Excessive play on main bearing	Change bearings, consult specialist.
Battery runs down frequently	73	Faulty starter	Repair starter.
	74	Faulty generator	Repair generator.
	75	Faulty cut-out	Clean the contact points if necessary replace it.
	76	Loose wiring	Tighten all loose wiring.