



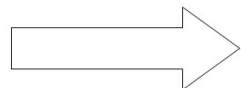
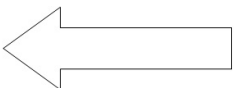
भारत सरकार —GOVERNMENT OF INDIA
रेल मंत्रालय— MINISTRY OF RAILWAYS
(कार्यालयीन प्रयोग हेतु) — (For official use only)



MAINTENANCE MANUAL FOR NDM5/ZDM5 NG LOCOMOTIVES



MAHARAJPUR, GWALIOR – 474 005





सदस्य यांत्रिक, रेलवे बोर्ड
एवं
पदेन सचिव, भारत सरकार
रेल मंत्रालय
नई दिल्ली-११० ००१
MEMBER MECHANICAL, RAILWAY BOARD
&
EX-OFFICIO SECRETARY,
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
NEW DELHI-110001

FOREWORD

Narrow Gauge Diesel Hydraulic Locomotives fitted with 450 HP were introduced by CLW for improving passenger services on narrow gauge routes on Indian Railways.

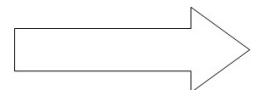
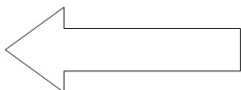
The need for proper maintenance of Narrow Gauge Diesel Hydraulic Locomotives for providing safety and comfort to the travelling public cannot be over-emphasised. It is necessary that correct practices are followed during maintenance schedules so that Narrow Gauge Diesel Hydraulic Locomotives give trouble-free and comfortable service on line.

The persons involved in maintenance must appreciate the importance of right maintenance at the right time, so that the Narrow Gauge Diesel Hydraulic Locomotives do not come for unscheduled repairs frequently. The effort should be to minimise overall maintenance time, reduce maintenance costs and improve reliability.

The instructions for maintenance of Narrow Gauge Diesel Hydraulic Locomotives have been issued by RDSO from time to time. "CAMTECH" has prepared a well documented and comprehensive manual for the use of our engineers. CAMTECH and RDSO deserve all praise for this effort.

Date: 09.04.2013


(Keshav Chandra)
Member Mechanical
Railway Board



Preface

“Maintenance Manual for NDM5/ZDM5 Narrow Gauge Diesel Hydraulic Locomotive” is being published first time in Indian Railways to standardize maintenance practices of NDM5/ZDM5 Narrow Gauge Diesel Hydraulic Locomotive. The NDM5/ZDM5 NG Diesel Hydraulic Locomotive was introduced by CLW to replace the NG steam locomotive working on Narrow Gauge routes of Indian Railways.

Railway Board nominated a committee of officers, comprising of Director/Mech/CAMTECH/GWL, Director/Motive Power/RDSO/LKO and Sr. DME/JHS /North Central Railway vide letter No. 2007/M(L)/101(2)/Pt. dated 23.05.2011 for preparation of “Maintenance Manual for NDM5/ZDM5 NG Diesel Hydraulic Locomotive”. The manual has been completed with detailed coverage on various aspects.

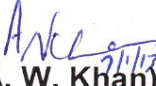
The salient features of the manual are as follows:

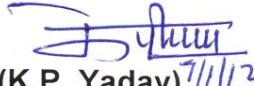
- ❖ The manual has been divided in to 06 chapters covering various sub-assemblies and systems. The constructional details and functioning has been explained before describing the detailed maintenance procedures.
- ❖ The important dimensions, clearances, drawing references etc. have been given immediately after the paragraphs where they have been referred to while describing maintenance procedures.
- ❖ Clear sketches of the important sub-assemblies/components have been given in the manual.

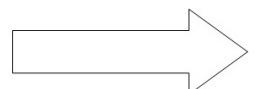
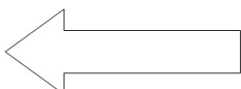
The page numbers in each chapter in this manual starts from 1 of total numbers of pages in the chapter. This scheme of page numbering is adopted to provide flexibility of easily revising the chapters in future, on account of design or procedure changes without disturbing the page numbers of succeeding chapters.

The Committee is thankful to Shri O.P. Sharma, ADME/GWL, Shri S. K. Sharma, ADME/O&F/GWL/NCR, Shri A.K. Sharma, SSE/Diesel/NG Loco shed/Gwalior, Shri R.K. Meena, SSE/NG Diesel Shed/ Pratap Nagar/ WR and Shri R.K. Dixit, SSE/CAMTECH/GWL, Shri Sanjeev Kumar, SSE/CAMTECH/GWL and those who gave their valuable suggestions in finalization of this manual.


(Sudhanshu Panwar)
Director/M P
RDSC/LKO


(A. W. Khan)
Sr. DME/JHS
N. C. Railway


(K.P. Yadav)
Director/Mech
CAMTECH/GWL



MAIN CONTENTS

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CORRECTION SLIPS

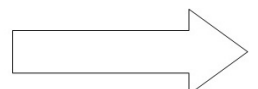
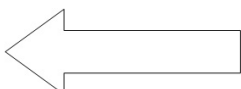
The correction slips to be issued in future for this Maintenance Manual for Diesel Locomotive will be numbered as follows:

Maintenance Manual for NDM5/ZDM5 Narrow Gauge Diesel Hydraulic Locomotive. # XX date -----

Where “XX” is the serial number of the concerned correction slip (starting from 01 onwards).

CORRECTION SLIPS ISSUED

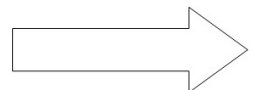
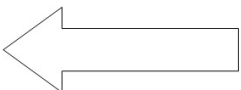
Sr. No. of Correction Slip	Date of issue	Page No. and Item no. modified	Remarks



Chapter-1



INTRODUCTION

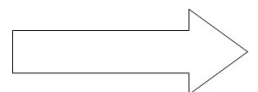
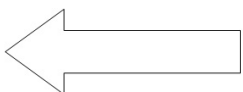


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Chapter-1

INTRODUCTION

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1	Introduction	1
2	Parameters of Locomotive	3
3	Specifications of Diesel Engine	4
4	Annexure (Important Drawings, Figures & Parameters	5 to 13



Chapter – 1

INTRODUCTION

On the narrow gauge (762mm Gauge) sections of the Indian Railways where permissible axle load is limited to 6t. To meet the requirement of these section a locomotive, N/ZDM5 class, B' – B' Type, 450 HP, with axle load of 5.55t has been designed and built by CLW.

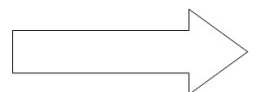
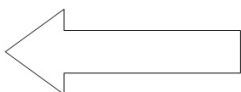
The power pack of this locomotive consists of Kirloskar – Cummins make diesel engine model KTA- 1150 L, 6 cylinders, 4 stroke, turbocharged and cooled, set to deliver 450 HP at 1900 rpm. NDM5 locos and all ZDM5 locos have been fitted with L4r2U2 – 450 type of transmission manufactured by Kirloskar Pneumatic Company, Pune. The power transmission from transmission to axle drives is by means of cardan shaft . The maximum permissible speed of the locomotive is 50 Kmph.

The NDM5 version of this locomotive, for operation on 610 mm (2' -0") gauge, is achieved at the manufacturing stage with modifications to underframe, bogie frame, wheel axle sets, brake gear and pneumatic system. (NDM5 version is suitable for operation on 610 mm gauge section of the Indian Railways other then Neral- Matheran and Himalayan- Darjeeling sections).

While ZDM5 version of this locomotive is fitted with one exhaustor and one compressor, to operate air brakes on locomotive and vacuum brakes on trailing stock, NDM5 locomotive is fitted with two compressors to operate air brakes on the both locomotive and trailing stock. The cardan shaft driven is taken from the rear side of input shaft for driving compressor and exhaustor.

ZDM5/ NDM5 Locomotive is fitted with 2 axled bogies having two stage suspension arrangement, primary suspension is of helical spring and secondary of magi- rubber springs. Hydraulic shock absorbers were fitted across the secondary suspension. Wheel sets are attached to the bogie frame with leaf spring guide plates and by means of serrated joints. These guide plates being laterally stiff and vertically flexible, maintain relative alignment of the wheel sets with bogie frame and also transmit traction and braking forces. The bogie pivot pin is fitted oil lubricated spherical bearing. Bogie axle boxes are fitted with FAG cylindrical roller bearings. These bogies are similar to those of ZDM3/ZDM4 locomotives except for the modifications to suit 610 mm (2' - 0") narrow gauge.

Two fuel tanks of 350 liters capacity are provided between the bogies below the under frame and are the interconnected. The tank is provided with graduated scale to assess the

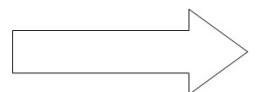
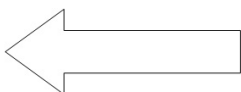


fuel level in the tank. The under frame and bogie frames are fabricated from steel plate sections to IS:2062.

Super structure of the locomotive is in three parts – Long hood, drivers Cabin and Short hood. Long hood is further divided in 3 parts for easy assembly and removal, to facilitate maintenance of the equipment. The long hood compartment accommodates power equipment and main auxiliaries like compressor and exhauster. Battery boxes and air reservoirs are housed in short hood compartment. The driver's cab is sufficiently large and equips all controls, instruments and gauges.

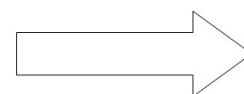
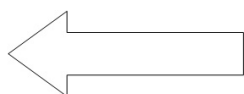
The control stand consists of the following:-

1. Starting key
2. Engine starting push button
3. Transmission 'OFF- ON' control
4. Master control valve at either end of control deck
5. Emergency and service brake handles at either end of control deck
6. Ammeter
7. Water temperature gauge
8. Lube oil temperature gauge
9. Transmission oil temperature gauge
10. Lube oil pressure gauge
11. Duplex pressure gauge
12. Brake pipe pressure gauge
13. RPM Digital counter
14. Engine reversing control oil pressure gauge
15. Head light switches
16. Pilot switch for charging
17. Sanding Buttons
18. Pneumatic horn control switches
19. Wind screen wiper control switches
20. Auto alarm for safety warning
21. Speedometer
22. Emergency engine stop handle
23. Green indicating lamp



PARAMETERS OF LOCOMOTIVE

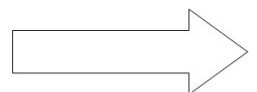
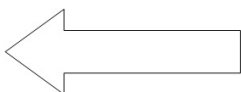
Gauge	: 610/762 mm
Class	: NDM5/ ZDM5
Bogie Type	: B' – B'
Service	: Mixed
Max. Axle load	: 5.5 t
Weight of loco in working order	: 22 t
Adhesive weight in working order	: 22 t
Wheel diameter	: 700 mm (New), 640 mm (Cond.)
Max. Operating speed	: 50 Kmph
Diesel engine make	: KCL make
Model	: KTA 1150 L
Installed HP	: Std. 490 HP and site 450 HP at 1900 rpm
Engine idle speed	: 600 rpm
Weight of engine (Dry)	: 1693 Kg.
Transmission	: Voith / KPC
Type	: L4r2U2 – 450
Weight of Transmission (Dry)	: 2200 Kg.
Axle drive (Primary)	: SAN
Gear Ratio	: 3.52 : 1
Weight of Axle drive	: 410 Kg.
Axle drive (Secondary)	: 3.09: 1
Weight (Dry)	: 234 Kg.
Total length over buffer beam	: 8800 mm
Height	: 2886 mm (NDM5), 3086 mm (ZDM5)
Width	: 2120 mm
Compressor	: ELGI make Model TRC- 1000
Capacity	: 1000 Liters/min at 1000 rpm
Weight	: 110 Kg.
Exhauster	: SLM VL -30
Capacity	: 7188 Liters/min at 1450 rpm
Weight	: 450 Kg.

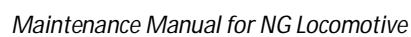


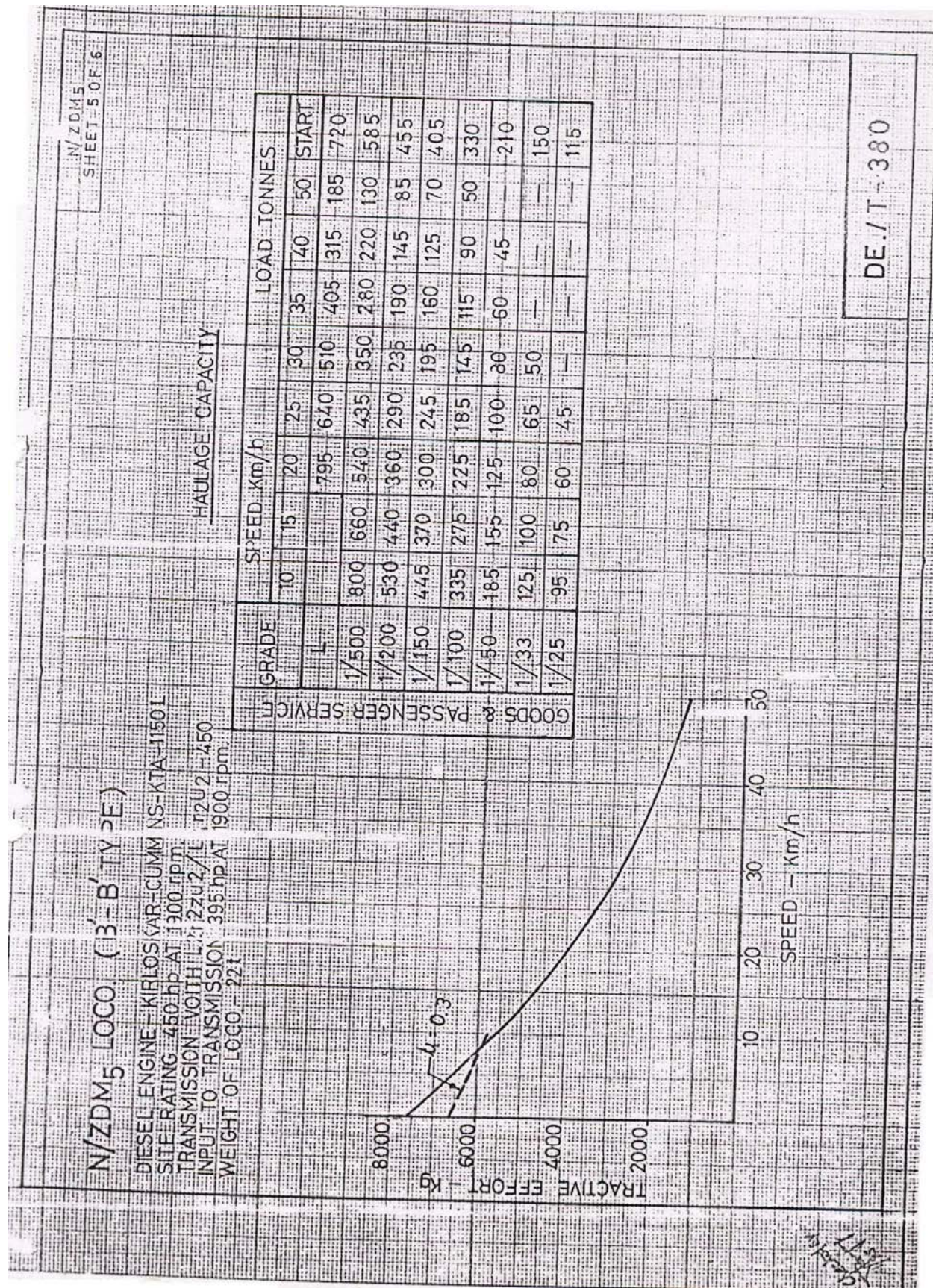
SPECIFICATIONS OF DIESEL ENGINE

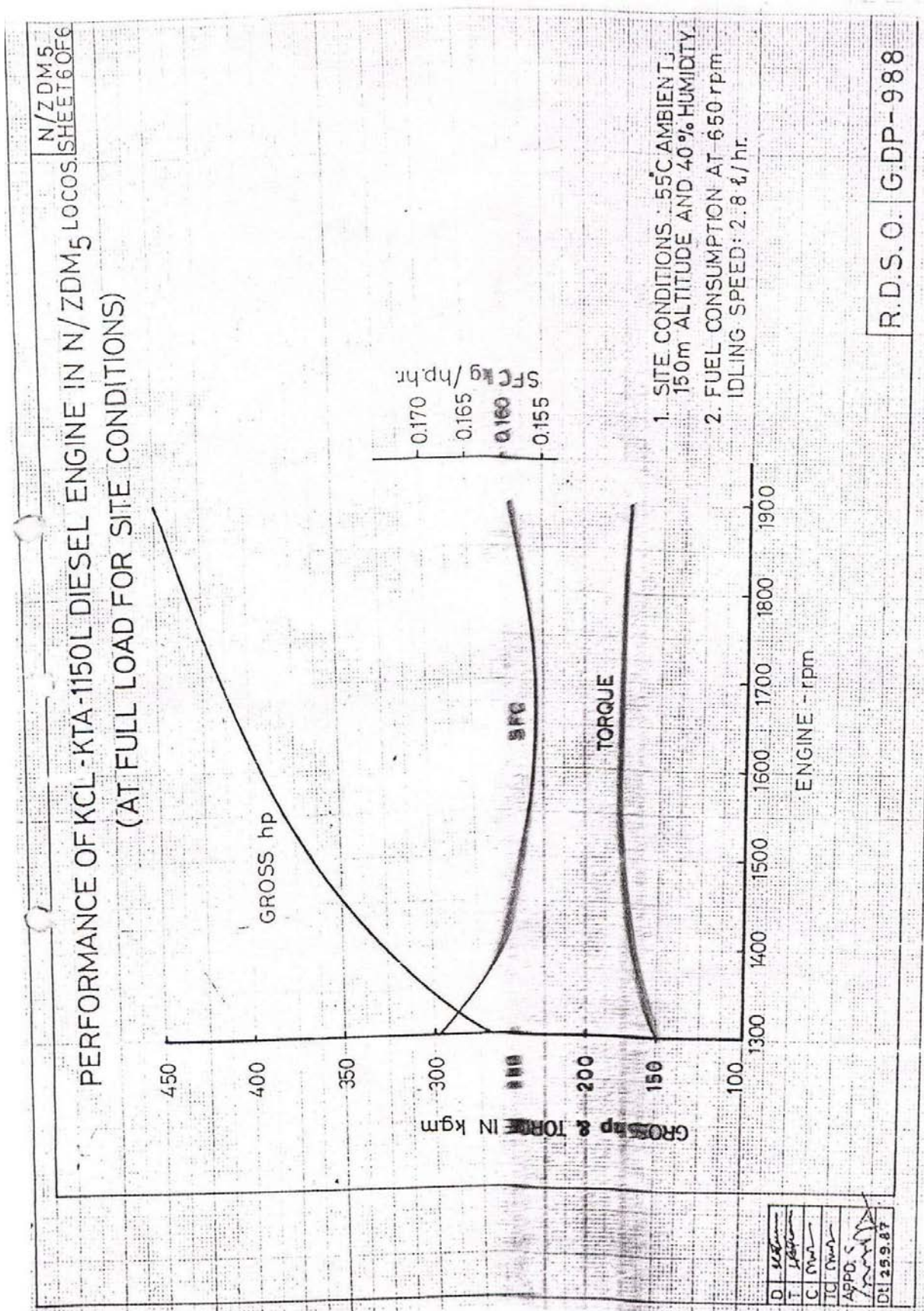
Model	: KTA 1150 L
Working Method	: 4 Stroke
No. of Cylinders	: 6 in line
Bore and Stroke	: 159 mm X 159 mm
Displacement	: 1150 Cubic inches
Firing Order	: 1-5-3-6-2-4
Injection	: PT system
Compression ratio	: 14.5 : 1
Horse power	: 490 HP (Std.), 450 HP (Site)
Rated speed	: 1900 rpm
Idling speed	: 600 rpm
Pressure charging	: Turbo charged and after cooled
Weight of Engine	: 1693 Kg.
Weight of water in engine	: 30 Kg.
Weight of oil in engine	: 49 Kg.
Cooling system	: Pressurized
Max. speed of TSC at rated output	: 63000 rpm
Coolant Temp. at engine outlet	: 93 ⁰ C

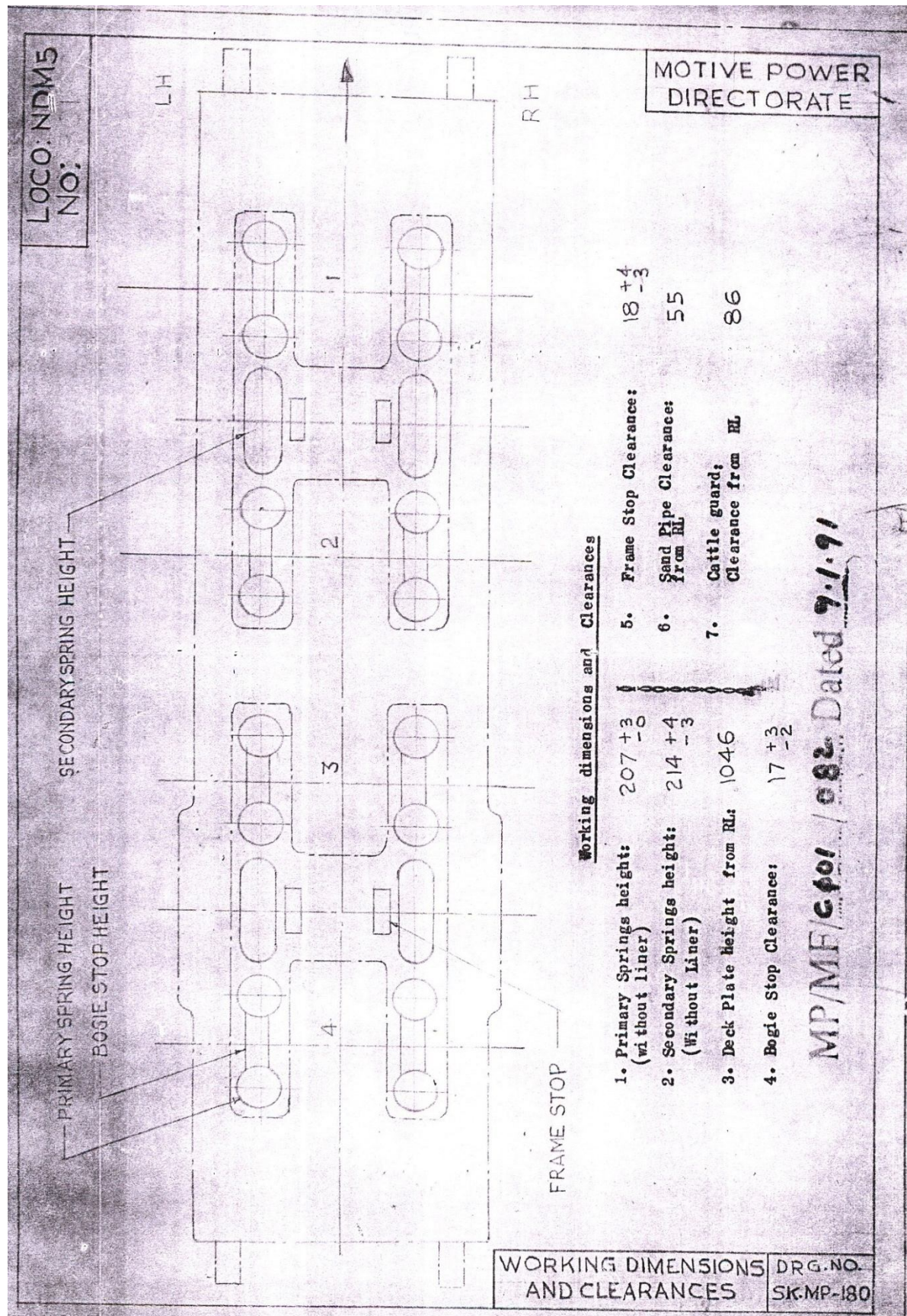
Important Drawings, Figures and Parameters given in Annexure below-





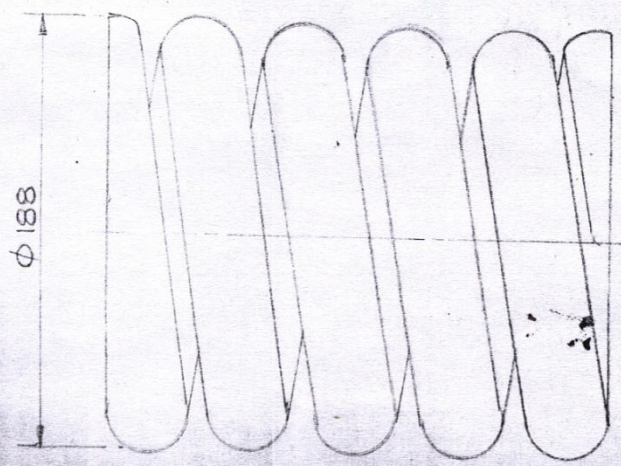






Maintenance Manual for NG Locomotive

INDIAN RLYS		APPLICABLE FOR		BOGIE SUSPENSION SPRINGS	
RD 50 (MP)		ZDM2R, ZDM3 ZDM4A, N/ZDM5			
SPRING DATA					
1	DIAMETER OF WIRE - mm			34	
2	FREE HEIGHT - mm			219.2	
3	SOLID HEIGHT - mm			170	
4	TOTAL No. OF TURNS			5.5	
5	SPRING WORKING LOAD - Kg			1936	
6	SOLID CAPACITY - Kg			4585	
7	SPRING RATE - Kg/mm			93.2	
8	WORKING HEIGHT - mm			198.5	
DIMENSIONAL TOLERANCES					
1	VARIATION IN WIRE DIA. - mm			± 0.17	
2	VARIATION OF OUT SIDE DIA. - mm			± 1.8	
3	VARIATION IN FREE HEIGHT - mm			± 2.5	
4	VARIATION IN LOADED HEIGHT WITH WORKING LOAD - mm			± 1.5	
5	OUT OF SQUARE OF SPRING MAX.			57° (2.2 mm)	
6	PARALLELISM OF THE GROUND ENDS TO BE WITHIN			9° (2.8 mm)	
7	VARIATION IN SPRING RATE			± 5%	
PAIRING OF SPRINGS					
GROUP	COMPRESSED HEIGHT MEASURED AT 1936 Kg LOAD		COLOUR TO BE PAINTED		
	FROM	TO			
A	197	198	WHITE		
B	198.5	199.5	RED		
<p>NOTE:- FOR MANUFACTURE, INSPECTION AND TESTING OF HOT COILED HELICAL COMPRESSION SPRINGS REFER TO TECHNICAL SPECIFICATION No. MP-0-4700-01.</p>					




Φ 188

MP/MP/cto/ /056. Dated 9.1.91

MATL: & SPEC Gr: 50 Cy4 V2, IS: 3195

No./LOCQ:- 16

SCALE:-		REF. SK. MP-	
		DRG. No. SK.MP-113	
ALT. NO.	SIGN.	DATE	FIRST ISSUED
SUPERSEDES SK. DL-		SUPERSEDED BY	

ALT.	No. OF PLACES	REF. NO.	DESCRIPTION	ALT. NOTE NO.	SIGN.	DATE	FIRST ISSUED	SUPERSEDES SK. DL-	SUPERSEDED BY
1/86									

RD 50
MOTIVE POWER
DIRECTORATE

MAINTENANCE INSTRUCTION FOR
FRICTION DAMPING ARRGT. - NDM 5

ALT.

MP/MF/c901/080 Dated 9.1.91

AXLE NO.	ACTION	LHS			RHS			DATE
		DIMENSION			DIMENSION			
		A	B1	B2	A	B1	B2	
1	RECORDED							
	ADJUSTED TO							
2	RECORDED							
	ADJUSTED TO							
3	RECORDED							
	ADJUSTED TO							
4	RECORDED							
	ADJUSTED TO							

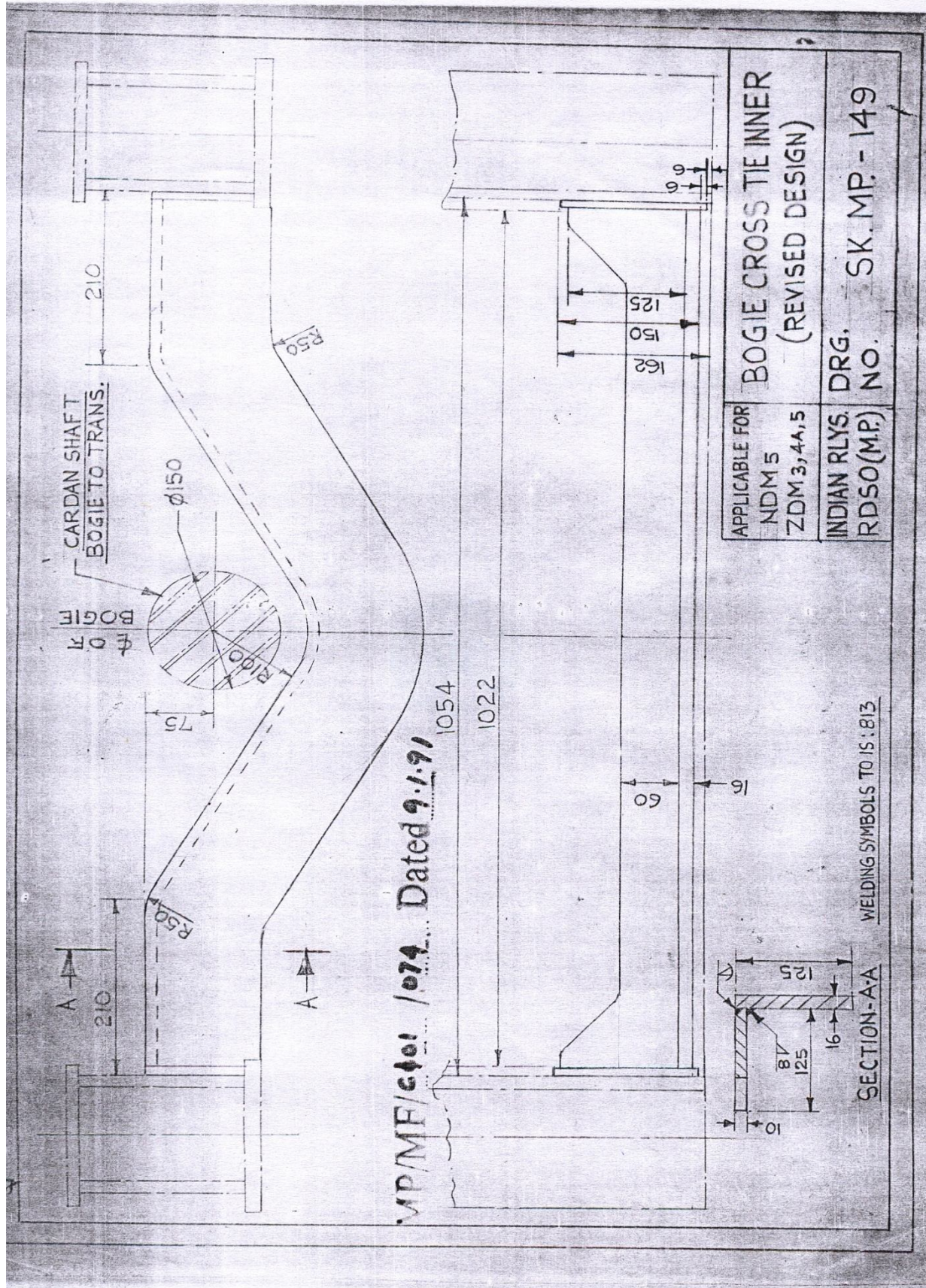
NOTE:-

1. WHEN DIMENSION 'A' OF SPRING BECOMES 33 mm DUE TO WEAR OF FRICTION LINERS, REF. NO. (2), ADJUST IT TO 30 ± 0.5 mm BY TIGHTENING NUT, REF. NO. (1)
2. CONDEMN THE LINERS, REF. NO. (2), WHEN CLEARANCE B1 OR B2 IS REDUCED TO 3 mm.

REF:- SK.MP-160 & 161 ALT. @

MAINTENANCE INSTRUCTION SK.MP - 188

APPD. WDN 06/6/89



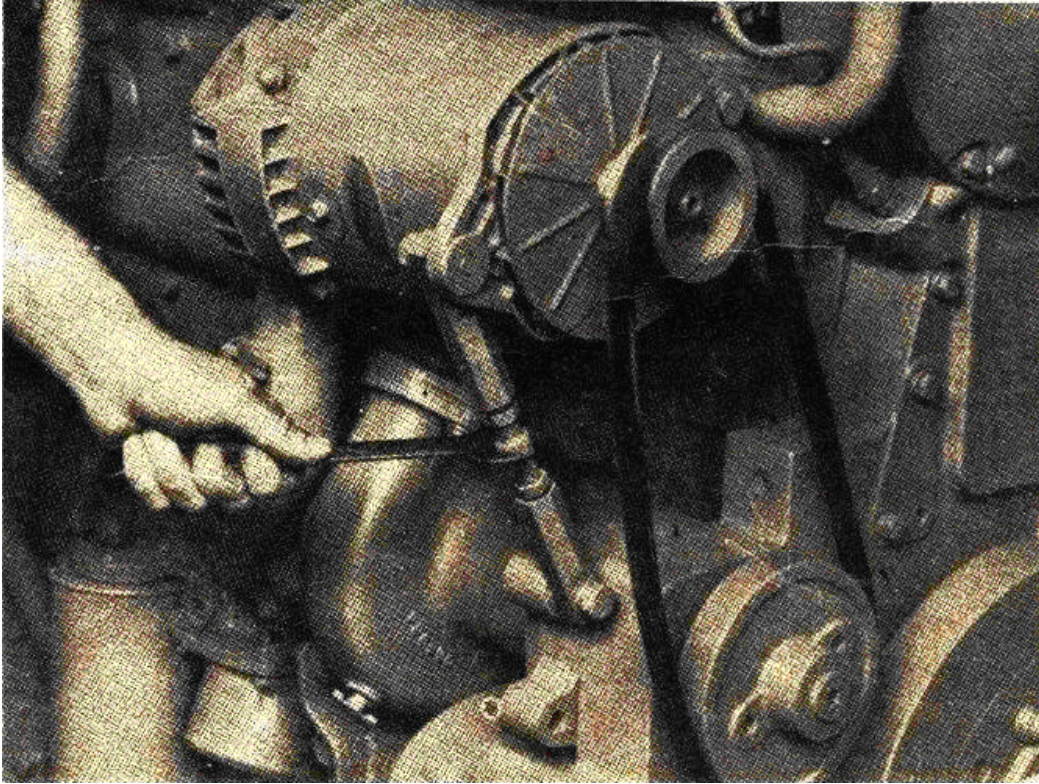
**WHEEL WEAR DATA
OF NDM5 LOCOS**

(Collected from GWO Shed on)

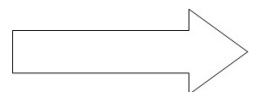
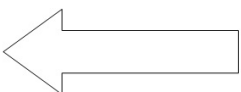
LOCO NO.	Date of Commission	Km. Earned	On Date	Date of Last Wheel turning	Axle NO.	WEAR (mm)					
						Tread Wear	Root Wear	Flange Wear	Flange Wear	Root wear	Tread Wear
801											
802											
803											
804											
805											
806											
807											
808											
809											
810											
811											

SK MP-187

Chapter-2



DIESEL ENGINE & ITS SYSTEMS



CONTENTS

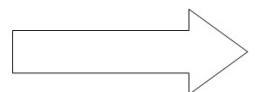
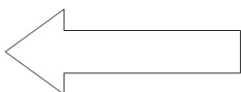
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DIESEL ENGINE AND ITS SYSTEMS

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(L) Electrical Equipment	139
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(P) Wear Limits, Specifications and Torque	196



Chapter -2

DIESEL ENGINE (POWER PACK) & ITS SYSTEMS

2.0 INTRODUCTION

Narrow Gauge Diesel Locomotive NDM5/ ZDM5 is fitted with 6 cylinders Turbo super charged Cummins Diesel Engine Model No. KT(A) 1150L.

2.1 SYSTEM DESCRIPTION

The various systems of the KT(A) 1150L , power pack used in Narrow Gauge Locomotives are described in this section. The various systems of diesel engines are as follows:

1. Air Intake and Exhaust system
2. Fuel system
3. Lube oil system
4. Cooling water system
5. Hydraulic oil system

2.2 AIR INTAKE AND EXHAUST SYSTEM

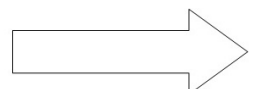
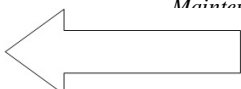
Air is drawn through the supercharger portion of the turbo supercharger which compresses and feeds the compressed air to the cylinders via an after cooler which cools the air.

The air filter is provided to remove harmful dust, abrasive particles from the air. If these particles are permitted to enter the engine, the particles mix with the lubricating oil to form an abrasive paste which will quickly wear out piston rings, cylinder liners, pistons, valve guides etc. causing high lubricating oil consumption and blow by.

The cooling of air helps in increasing the density. A vacuum indicator is available in the air filter that indicates a red band when the accumulated dust is beyond the permitted level and it is necessary to service the air cleaner element.

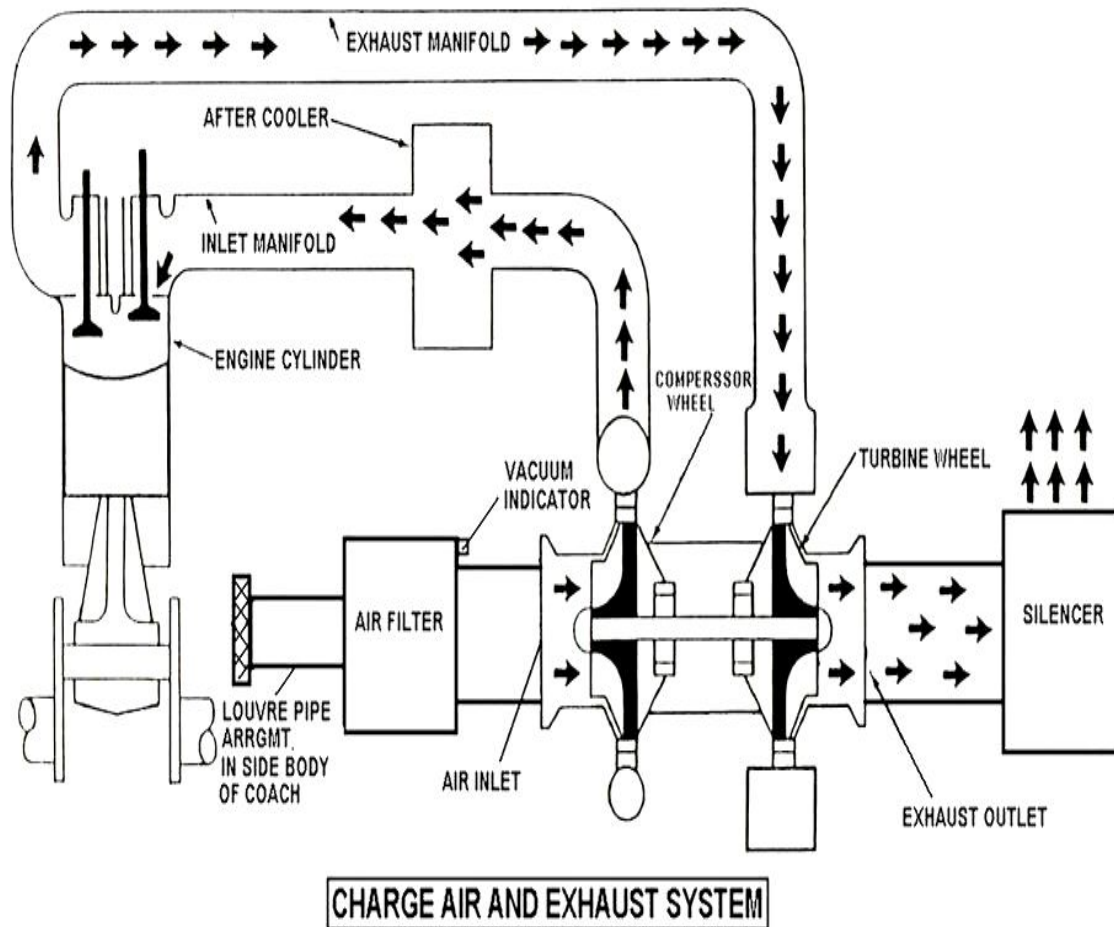
Air cleaner element can be cleaned with the use of pressurized air at not more than 30 PSI.

The exhaust air from the cylinder drives the turbine portion of the turbo super charger, which helps in utilisation of residual heat of exhaust gases. The exhaust gases are exhausted through a silencer kept on the dished rooftop of the Locomotive. Flexible



stainless steel connection between the turbo supercharger and silencer allows for expansion due to heat of the exhaust gases.

A schematic of air intake and exhaust system of Locomotive is shown in figure below.



Checking of Inlet Air Restriction

This unit is mounted on the air filter outlet. The red flag in indicator gradually rises as cartridge loads with dirt. After changing or replacing cartridge, reset indicator by pushing reset button.

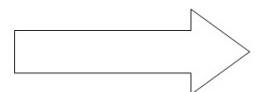
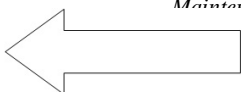


Fig. Vacuum indicator for air restriction

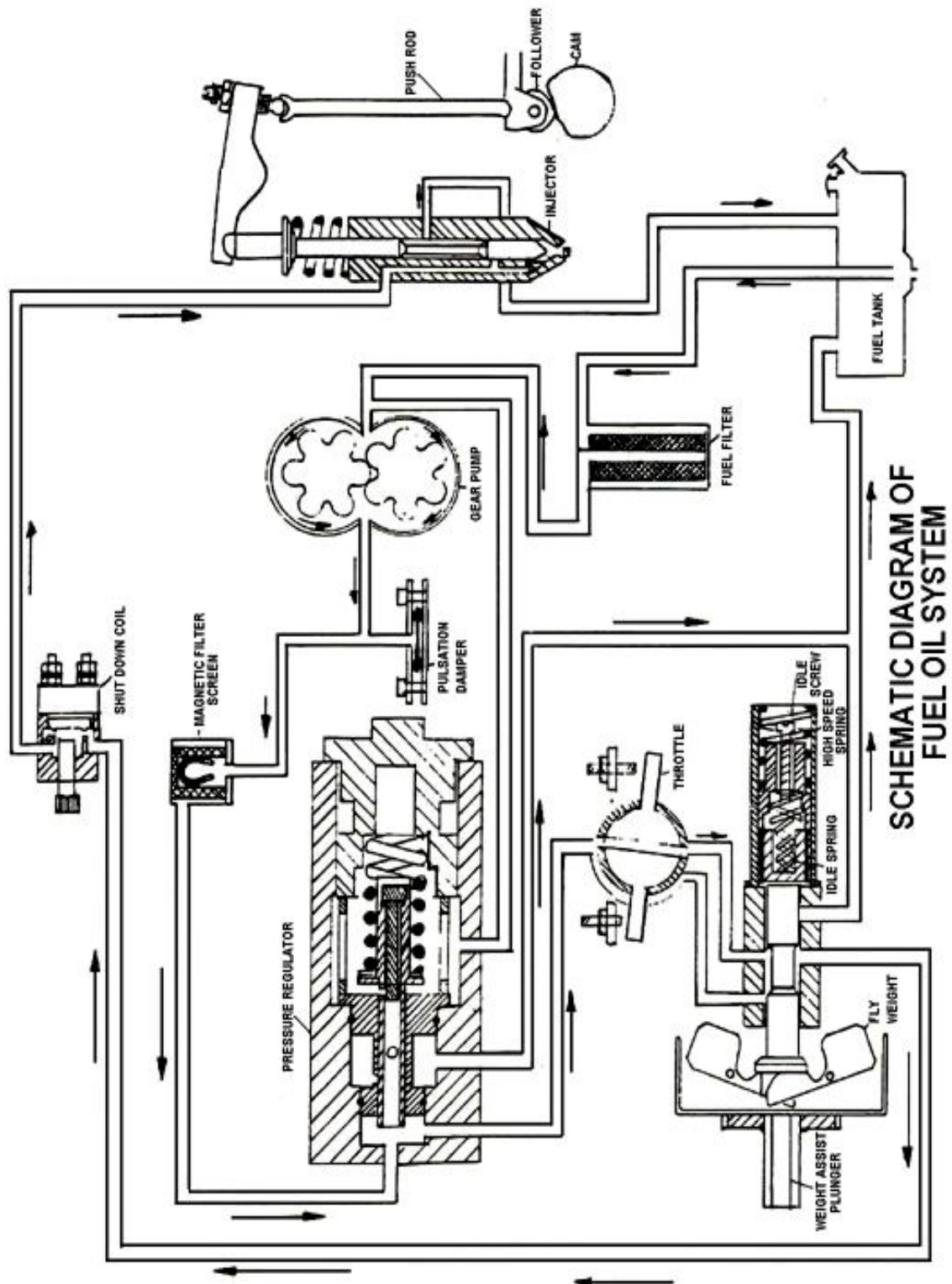
Air restriction on turbocharged / after cooled engines must not exceed 25 inches (635 mm) of water column. Air restriction for naturally aspirated engines must not exceed 20 inches (508 mm) of water column.

Filter Element Replacement:

- Remove the old filter element gently. Do not bump it while still inside, otherwise it will lead to dropped dirt and dust that will contaminate the clean side of filter housing, before the new filter element has a chance to do its job.
- Clean the inside of the housing carefully. Dirt left in the air cleaner housing is harmful for engine. Use a clean, damp cloth to wipe all surface clean. Check it visually to make sure it's clean before putting in a new filter.
- Clean the gasket sealing surface of the housing. An improper gasket seal is one of the most common causes of engine contamination. Make sure that all hardened dirt ridges are completely removed, both on the bottom and top of the air cleaner.
- Check for uneven dirt patterns. The old filter has valuable clues to dust leakage or gasket sealing problems. A pattern on the element clean side is a sign that the old filter element was not firmly sealed or that a dust leak exists. Identify the cause of that leak and rectify it before installing a new filter.
- Press new gasket to see that it springs action. Make sure that new filter is made with a highly compressible gasket that springs back (promptly) when finger pressure is released.
- Ensure air-tight fit on all connections and ducts. Check that all clamps and flange joint are tight, as well as the air cleaner mounting bolts, Seal any leaks immediately, any leakages mean dirt is directly entering in the engine.



2.3 FUEL OIL SYSTEM



**SCHEMATIC DIAGRAM OF
FUEL OIL SYSTEM**

The main components of the fuel system of KT(A)1150L engine are described below:

1. Gear Pump

Fuel enters the rear side of gear pump housing. Gear pump has two spur gears. One of the gear shafts is a drive shaft, which is driven by the accessory drive gear shaft and rotates at engine speed. It creates a vacuum to draw fuel, but adds no pressure to the flowing fuel (only about 2-psi).

2. Cooling kit

In all Cummins PT fuel pumps a drilling runs up along the back of all shafts bores to a fitting on top of the gear pump housing. Fuels from the shafts bores passes out through the valve in the fitting and through the drain line to the fuel tank. During normal operation only a small amount of the fuel passes through his “Cooling Kits”.

3. Pulsation Damper

As the gear pump teeth mesh and unmesh, considerable turbulence is created in the fuel. To eliminate this roughness a pulsation damper is connected through a drilling, to the gear pump cavity. As the fuel first is drawn into the pump, the drilling fills. Thereafter, as pressure waves come off the gears, they travel through the fuel in the drilling and as are absorbed by movement of the thin metal diaphragm against the air space behind it.

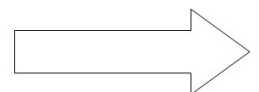
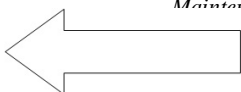
4. Filter Screen

Pressurized fuels flows into the center of the filter screen, which is located at the top of the fuel pump. Dirt and other materials are removed at by this filter. If the filter screen is clogged to restrict the fuel flow and the pressure is 5 to 7 psi greater on fuel coming in at the bottom of the screen, because of the added restriction the spring above the screen will allow the screen to lift and by-pass fuel.

5. Governor

The pressure in the fuel as it reaches the governor plunger is hydraulic pressure. The restriction to fuel flow which creates most of this pressure, is built into the PT pump by placing the surface of the idler plunger against the end of the governor plunger.

In this manner fuel is being held in the governor plunger by the surface of the idler plunger. However, the idler gear is only under spring pressure, so as volume of flow increases, fuel will soon push the idler plunger back, if no other outlet is found. But there are two other outlets for governor plunger fuel.



- ♦ The idler port which allows fuel to escape during low speeds.

The amount of fuel by-passed depends upon the resistance offered to fuel flow. This resistance is developed by the position of the governor plunger and idler plunger and it is controlled by the forces which try to hold them together during fuel flow as they are, when the pump is not operating and the size of the idler plunger counter bore.

The governor plunger is acted upon by the two forces. One of the forces is by the governor weight forces which depends on the engine speed. As the accessory drive shafts rotates, it revolves the PT pump shaft which in turn rotates the governor weight carrier. And thus the weight force governor plunger towards the governor barrel.

6. Weight Assist Plunger

At low speeds, governor weight force is not strong enough to move the plunger back very far. So a force is built into the pump with a short plunger known as weight assist plunger, which is held against the governor plunger by its spring and shim pressure while engine speed is slow and remains in contact so long as low speed prevents the weight feet from pushing back on the governor plunger.

Another force is acting upon governor plunger, which is opposing the force of the governor weight and weight assist plunger. This force comes from the following:

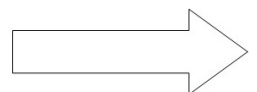
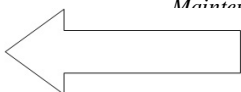
1. Idle spring behind idler plunger (button).
2. The torque spring over the governor plunger. As the fly weights fly apart and exert force on the plunger, this spring is pressed against the barrel. Depending upon the length and strength of the torque spring.
3. The large governor (high speed) spring. The fuel pressure is controlled on the principle of liquid flow through the least resistance path. When a lot of fuel is required to go to the engine for high speed for high torque operation, the idler plunger must be forced close to the end of the governor plunger so that very little fuel can escape there.

This will create high pressure on the fuel in the governor plunger and barrel and lot of it through the throttle opening and on to the injectors.

If the operator closes the throttle more fuel escapes immediately from the end of the plunger.

Slower engine speed immediately decreases weight pressure on the governor plunger permitting fuel to escape even more easily at the end of the plunger.

Fuel thus escaping is returned to the suction side of the gear pump and re-circulated.



Pressure in the barrel depends upon the strength of the opposing forces built into the pump. Another control over fuel flow restriction is the size of the counter bore in the idler plunger surface.

If the counter bore in the idler plunger is small, fuel has much difficulty in escaping thus pressure increases. If the pressure is larger, fuel can escape more easily and consequently pressure will be lower in the governor plunger and barrel.

7. Throttle Shaft

From the governor plunger fuel passes to the throttle shaft which has a restriction plunger. Under this plunger there are a few shims. This restriction plunger controls the fuel passage in the throttle shaft. When shims are removed from the plunger, it reduces the fuel passage in the shaft and reduces fuel flow to the injector by reducing the fuel pressure. If shims are added, it increases the fuel passage and increases the fuel flow by increasing the fuel pressure.

8. Shut down Valve

The shut down valve has final control of the flow from the pump to the injector. Fuel flow can be controlled by mechanically or electrically operated solenoid. The valve is activated by closed electrical contacts when ignition switch is moved to 'ON' position. The electrical coil draws the metal plate off the sealing edges and allows fuel to flow from the pump to the injectors.

When the ignition switch is moved to 'OFF' position, the metal plate sits on sealing edge thus stopping the fuel flow to the injector.

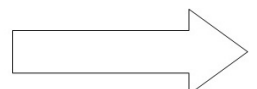
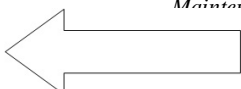
9. How Auto Governor controls engine speed

During cranking of an engine the engine speed should reach 190 to 250 RPM at 150 RPM, a good gear pump will be able to pick up fuel, at these speeds, the idle spring and weight assist spring will hold the governor plunger and idler plunger together, but fuel pressure is not height.

As engine fires and speed increases, gear pump delivery also increases. But governor weight force also increases. Fuel pressure continues to rise and increase fuel flow to the engine.

As engine speed reaches 800 to 1000 RPM approximately, resistance to governor weight force increases, as idle spring and torque spring start getting compressed.

The high resistance presented by these two springs keeps the plunger surfaces very close together and continually increases fuel to engine- raising engine speed or torque.



Fuel flow continuous to increase, as the throttle comes to full open, until the high speed governor spring is compressed enough that its resistance will balance the force exerted on the governor plunger.

At this point the engine's governor cut off speed has been reached, and unless position is changed to reduce it, fuel flow will continue at this 'governed' rate.

A wide open throttle will soon allow engine speed to increase beyond a safe speed in order to save the engine from such a damaging high speed and consequent failure (particularly valve and injector train damage, governor plunger is provided with small four holes through which fuel is dumped and speed decreases.

As the throttle is closed, the engine speed reduces to idle speed. Reduced governor weight speed moves the plunger back until it aligns idle port.

10. PTD Injector

The PTD injector is the latest model and features an advanced design. Its function is exactly the same as the other Cummins cylindrical injector. The injectors consists of a short rigid plunger barrel and adapter. The injector cup is a separate piece. The adaptor, barrel and cup are attached by a long threads sleeve.

The injector plunger is a steel plunger fitted into the barrel with very close tolerance. The fact that the barrel and cup are separate makes excellence alignment possible.

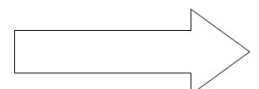
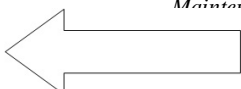
1. Closer plunger fit with the new shorter barrel reduces erosion and carboning and increases service life.
2. Possibility of plunger seizures is minimized by relocating threads from injector cup area to the plunger housing attachment point.

A. Startup stroke (Fuel Circulates) See figure below

Fuel at low pressure enters the injector and flow through the inlet orifice through internal drillings around the annular groove in the injector cup and up the drain passage to the fuel tank. The amount of fuel flowing through the injector is determined by the fuel pressure at the inlet orifice and the inlet orifice diameter. Fuel pressure is also determined by engine speed, governor and throttle.

B. Upstroke complete (Fuel enter injector cup) See figure below

As the injector plunger moves upward, the metering orifice is uncovered and fuel enters the injector cup. The amount is determined by the fuel pressure the drain passage is blocked momentarily, stopping circulation of fuel and isolating the metering orifice from pressure pulsation's.



C. Down Stroke (Fuel Injection) See figure below

As the plunger moves down and closes the metering orifice, fuel entry into the cup is cut off. As the plunger continues down, it forces fuel out of the cup through tiny holes at high pressure as a fine spray. This assures complete combustion of fuel in the cylinder. When the drain passage is uncovered by the plunger under cut, fuel again begins to flow through the return passage to the fuel tank.

After injection is complete the plunger remains seated until the next metering and injection cycle. No fuel is reaching the injector cup. However it does flow freely through the injector and returns to the fuel tank.

Injector identification is an essential factor when trouble shooting an engine or fitting new injectors. Each type of injector has markings which indicate the characteristics of the injector.

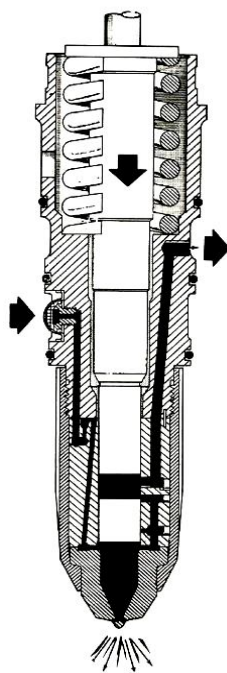


Fig. "A"

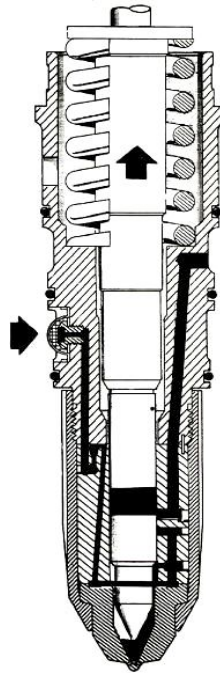


Fig. "B"

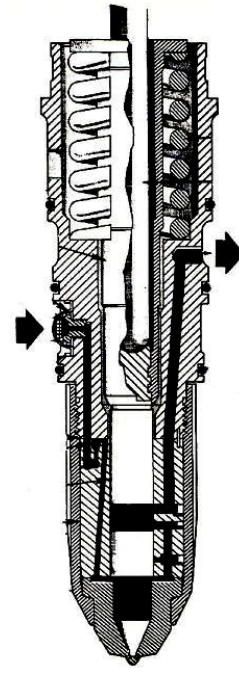
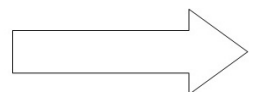
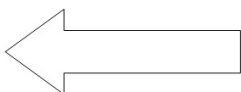


Fig. "C"

A check ball is fitted to PTD injectors to prevent back pressure flowing up the inlet line feeding other injectors. The back pressure is created by the down traveling injector plunger closing the inlet orifice before the drain drillings is open. The back pressure acts on the check ball which is snapped down against its seat, thereby preventing this pressure feeding the next injector.



A defective check ball or seat would cause slow deceleration and more noticeably slow engine shut down. From low idle to stop should take about 1-2 seconds. If a check ball is not seating this time can be up to 3-5 minutes. The defective injector can be detected by holding down each injector in turn until the engine stops in the recommended time.

As with the fuel pump, injectors are coded for identification. On flange injectors the numbers are stamped on the flange above the inlet orifice and across the face. On cylindrical injectors, the numbers are stamped round the body on the drain area.

There are four numbers in which we are interested.

- (a) the flow code
 - (b) The number of spray holes
 - (c) The diameter of each hole
 - (d) The angle of spray into the cylinder
- (a) The flow code is the quantity of fuel which passes the orifice under constant conditions. These are 1000 strokes of the plunger when the fuel pressure at the orifice is 120 PSI and the fuel temperature is 90°F.

Previously the orifice was described as being at the bottom of the injector. Actually there are two orifices as described as being at the bottom of the injector. Actually there are two orifices, one fixed and identified by body or barrel number, the other is adjustable and located in the upper body at the fuel inlet. Should the flow code not be achieved by an injector when calibrated on a test stand, is necessary for this operation.

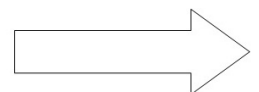
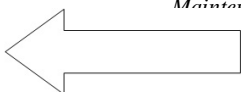
- (b) The number of holes is dependent upon the atomization characteristics required by an engine.
- (c) The diameter of the spray holes is given in thousandths of an inch and also affects the atomization qualities.
- (d) The angle of spray is given in degrees to the horizontal and is selected to suit the bore and compression ratio of an engine.

Data B, C, and D, are also found on the injector cup.

At no time should an engine set of injectors have different data from each other. If in doubt the relevant manual should be referred to for injector details.

Injector Operation

There are basically three operation functions which affect the injectors in an engine.



1. Adjustment

As with any moving any parts no matter how well they are lubricated wear takes place. When we talk of injector adjustment we mean the amount of movement between the maximum lift and maximum down position also the load on the injector plunger, against the cup on the fuel down position, If the total travels or loading are incorrect, then the important metering and atomization qualities are affected.

It is therefore necessary each 'C' check to ensure that the injectors and valves are adjusted correctly. This can be done by either a torque wrench or preferably with an indicator tool ST-1270. Full instruction for these adjustments are in the relevant operation and maintenance manual.

2. Calibration

From the previous notes we know that the flow factor controlled by the flow orifice is an important point in the performance in an engine. Although this should not after in service, it is recommended that each half yearly Schedule, all injectors are removed and recalibrated by a repair shop.

3. Non Operation

Should one injector cease to inject fuel, then of course, a misfire results. To detect which cylinder is causing the trouble, the most accurate method is to check exhaust manifold temperature with a pyrometer or thermal chalk. The injector plungers can also be held down, in turn until the faulty injector is isolated.

There are reasons why an injector will not operate:

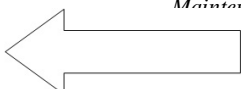
- ◆ Seized plunger
- ◆ Blocked inlet orifice or filter
- ◆ Blocked spray holes

To detect if the spray holes are open, remove the injector from the head and withdraw the plunger spring. Put a few drops of fuel into the cup and replace the plunger. Force the plunger down to inject fuel from the spray holes.

The spray pattern can be formed on a piece of white paper; If one or more holes blocked, then a new cup should be fitted.

Cleaning of an orifice filter screen may be done with compressed air.

When installing a new or the original injector the following points should be



observed.

- Clean injector sleeve with a clean rag.
- Check body cup detail against engine performance.
- Renew injector body 'O' rings.
- Lubricate body 'O' rings with clean engine oil.
- Always adjust valves and injectors as described in this manual after refitting injectors.

Water Separator

Water Separator uses centrifuging principle for separating out the water or sludge from diesel.

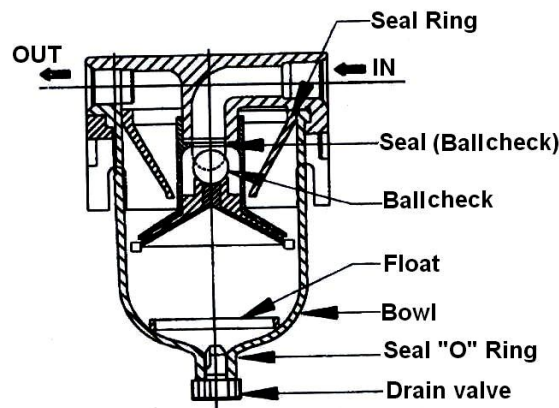


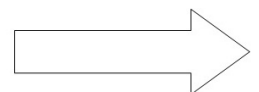
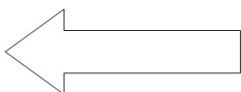
Fig. Water Separator

The water or sludge is collected in the bottom of the housing and is drained out manually by operating the drain valve provided at the bottom. For this operation, the engine should be shut down and upper handle is required to be unscrewed so as to induct atmospheric pressure on the housing. Close the drain valve and tighten the top "T" handle.

This water separator should be connected in between fuel tank and fuel filter. When vacuum drop is 8.00 inches (203.2 mm) of mercury column replace the filter assembly.

Changing of fuel filter element

- Loosen cap screw which holds shell to head
- Discard 'O' rings and discard fuel filter element.
- Install new 'O' rings and. Install new element.



- Fill can with fuel and assemble shell to head with cap screw.

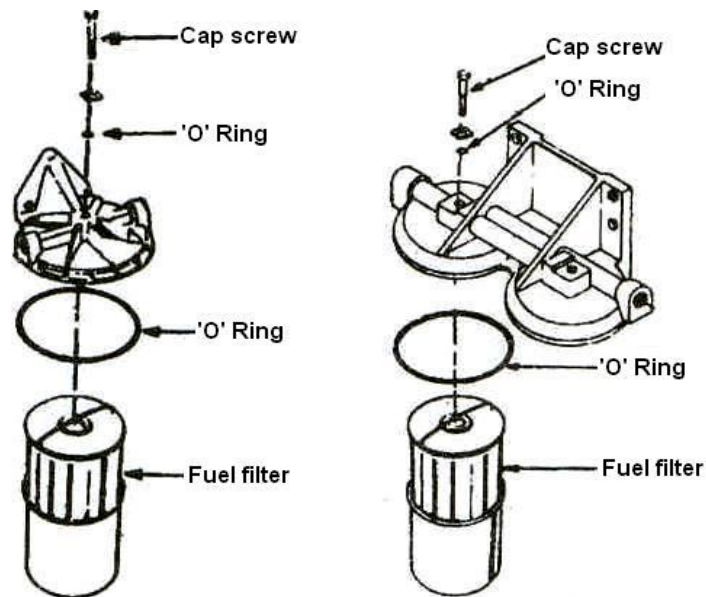
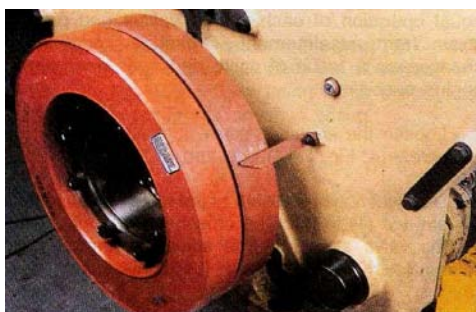


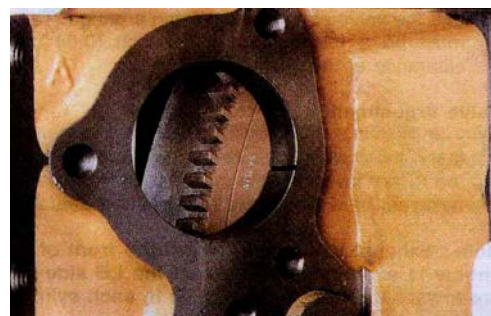
Fig. Exploded view of Fuel Filter

Valve Set Mark Alignment

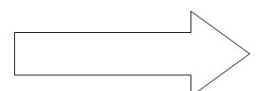
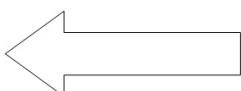
- There are three locations in the engine where valve and injector alignment marks may be viewed.
- Injector plunger travel and valves both may be set on one cylinder at the same valve set location.
- The crankshaft must be turned through two (2) complete revolutions to properly set all injector plunger travel and valves.



VS Mark on Vibration damper

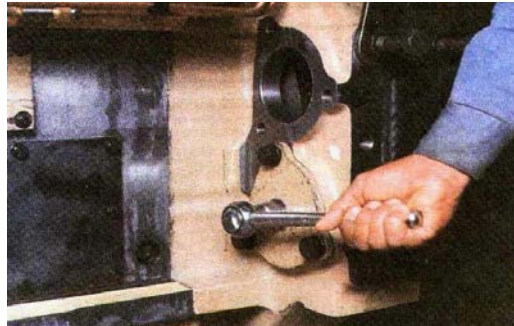


VS Mark on right bank flywheel



Note: The barring mechanism may be located on either the left bank or right bank at the flywheel housing. The cover plate on opening "A" or "C" directly above the barring mechanism must be removed when viewing the timing marks at the flywheel housing.

- When viewing the engine at the vibration damper, align the timing marks on the damper with the pointer on the gear case cover.
- When barring the engine from the right bank at the flywheel housing "A" VS timing marks on the flywheel must align with the scribe mark when viewed through the opening marked "A" on the flywheel housing.
- When barring the engine from the left bank at the flywheel housing "C" VS timing marks on the flywheel must align with the scribe mark when viewed through the opening marked "C" on the flywheel housing.



Engine barring device

Injector Plunger Adjustment

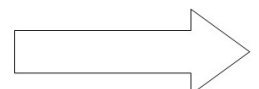
- Bar the engine in the direction of rotation until the appropriate valve set mark is aligned with the scribe mark on the flywheel housing or until a valve set mark on the vibration damper is aligned with the pointer on the gear case cover

Note: Any valve set position may be used as a starting point when adjusting the injectors, crossheads and valves. Determine which of the two (2) cylinder indicated have both valves closed (rocker levers free). This cylinder is in position for injector plunger travel, crosshead and valve adjustment.

- Set up support block on the rocker lever housing, of the cylinder selected, with the dial indicator extension on the injector plunger top.

Note: Make sure that Dial Indicator extension is secured in the indicator stem and is not touching the rocker lever.

- Using the rocker lever actuator, depress the lever toward the injector until the plunger is bottomed in the cup to squeeze the oil film from the cup. Allow the



injector plunger to rise, bottom again, hold in the bottom position and set the indicator zero. Check the extension contact with the plunger top.

- Allow the plunger to rise then bottom the plunger again, release the lever, the indicator must show travel as indicated in Table.

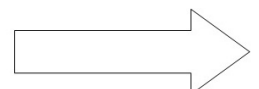
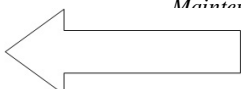
Table for Adjustment Limits Using Dial Indicator Method and adjust in Inch or mm.

Injector Plunger Travel	Valve Clearance	
	Intake	Exhaust
0.308" \pm 0.001"	0.014"	0.027"
(7.82 \pm 0.03) mm	(0.36) mm	(0.69) mm

- If the adjusting screw locknuts were loosened for adjustment tighten to 40 to 45 ft-lbs torque and actuate the plunger several times as a check of the adjustment. Tighten the locknuts to 30 to 35 ft-lbs torque.
- Remove Dial Indicator Kit.

Crosshead Adjustment

- Crossheads are used to operate two valves with one rocker lever. An adjusting screw is provided to assure equal operation of each pair of valves and prevent strain from misalignment. Crosshead adjustment changes as a result of valve and seat wear during engine operation.
- Loosen the adjusting screw locknut, back off the screw one turn.
- Use light finger pressure at the rocker lever contact surface to hold the crosshead in contact with the valve stem. The adjusting screw should not touch the valve stem at this point.



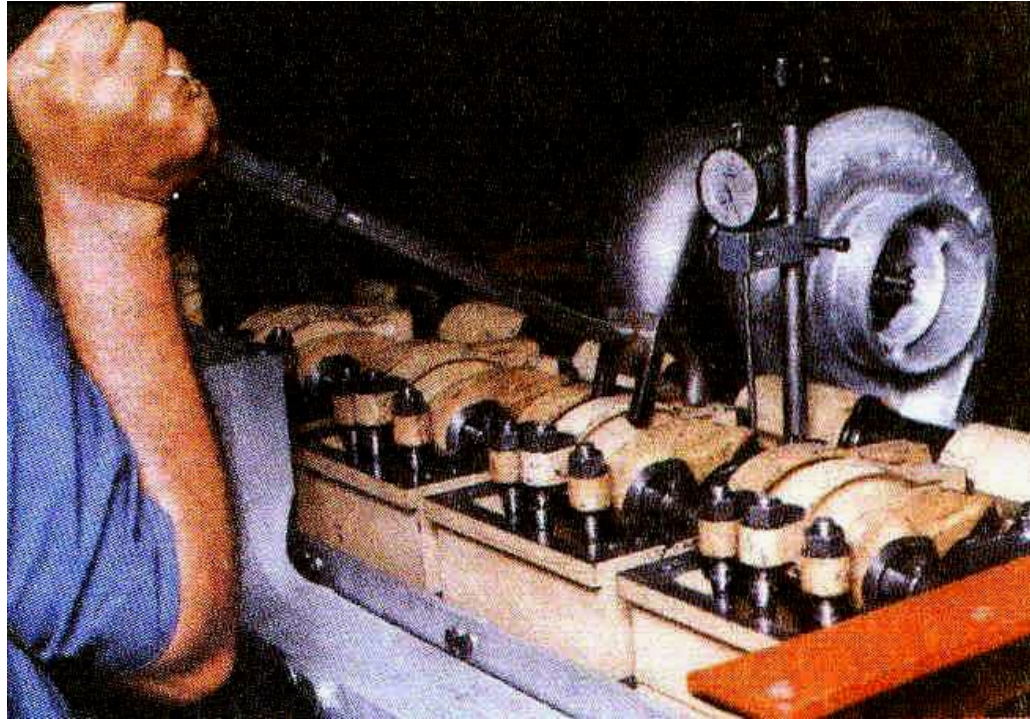


Fig. Actuating rocker lever

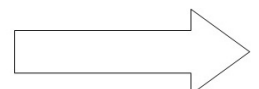
- Turn down the adjusting screw until it touches the valve stem.
- Using Torque Wrench Extension to hold the adjusting screw in position, tighten the locknut to 22 to 26 ft-Ibs torque. If the torque wrench adapter is not used, hold the adjusting screw with a screwdriver; tighten the locknut to 25 to 30 ft-Ibs torque.
- Check the clearance between the cross head and the valve spring retainer with a gauge. There must be a minimum of 0.025 inch (0.64 mm) clearance at this point.

Valve Adjustment

- Insert the correct thickness feeler gauge between the rocker lever and the cross head for the valves being adjusted. See above Table for valve clearance.

Note: Exhaust valves are toward the front of the engine in each cylinder head on the LB side and are toward the rear of the engine in each cylinder head on the RB side.

- If adjustment is required, loosen the locknut and turn the adjusting screw down until the rocker lever just touches the feeler gauge; lock the adjusting screw in this position with the locknut.



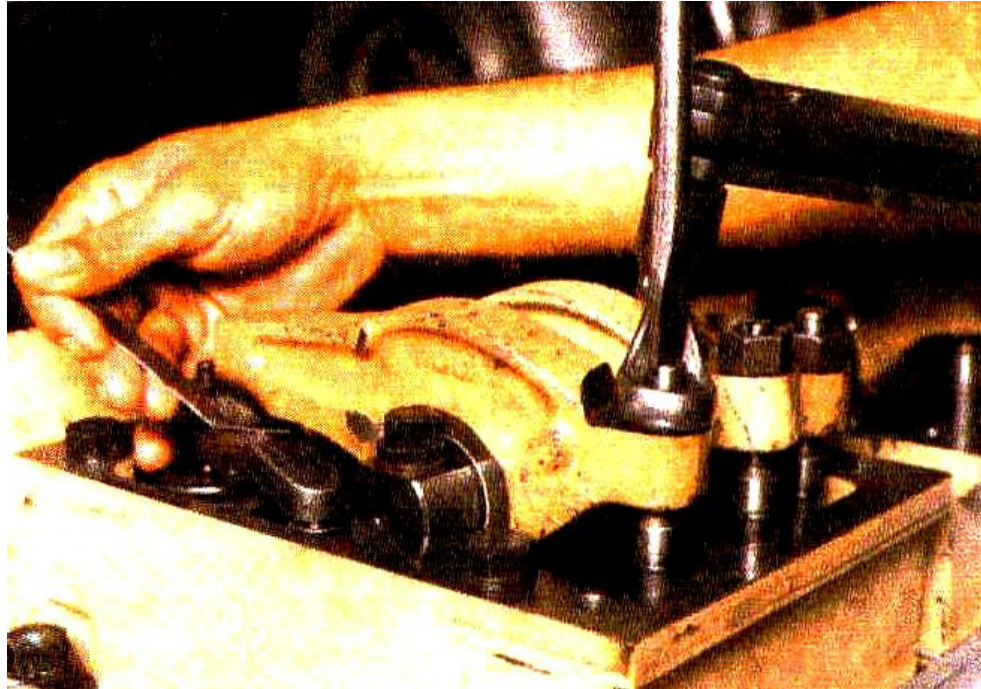
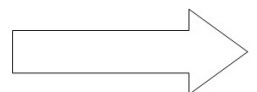
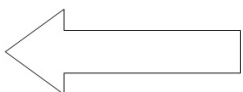


Fig. Adjustment of cross head clearance

- Tighten the locknut to 40 to 45 ft-Ibs torque. When using torque wrench adapter tighten the locknuts to 30 to 35 ft-Ibs torque.
- After completing the injector plunger travel, cross head and valve adjustment on this cylinder, bar the engine in the direction of rotation until the next valve set mark is aligned with the scribe mark at the flywheel housing or the pointer on the gear case cover; repeat the procedure. (See Fig's for cylinder arrangement and engine firing order).
- Discard old rocker cover gaskets and use new gaskets. Mount rocker covers and tighten cap screws 30 ft-Ibs.



2.4 LUBRICATING OIL SYSTEM

KT(A) 1150L diesel engines have force-feed lubricating oil system with low lube oil protection device. The lube oil system is four fold.

- To lubricate all the moving parts in an engine.
- To help in seal combustion chamber from the crankcase.
- To clean the engine by picking up foreign particles.
- To cool the parts that it contacts.

The main components of the lube oil system are described below:

1. Lubricating Pump

The lubricating pump used in engine is gear type positive displacement pump. This has two gears meshing with each other which when rotated draws oil from engine sump and delivers it at a pressure for lubrication.

2. Lube oil Full Flow Filters

Lube oil filters play a very important role in protecting engines. When the lube oil passes through the filter element, most of the larger foreign particles suspended in the oil are trapped in the element. The purpose of lube oil filters is to remove this foreign matter before it can harm the engine.

3. Bypass Filter

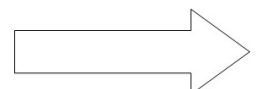
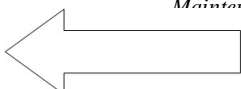
The function of bypass filter is to assist the full flow filter by trapping the finer dirt particles that get through the full flow filter. Lubricating oil bypass filter plumbed, parallel to full flow filter, into the engine, has much finer filtering media with less porous passages than the full flow filter element.

4. Lube Oil Cooler

In lube oil cooler, the coolant passages through tubes. The lubricating oil circulates around outside all these tubes. Water passage through tubes and absorbs heat from oil when its temperature is higher than it but heats oil when its temperature is lower than that of water.

5. Piston Cooling Nozzle/Jets

The piston cooling nozzle/jets make up another important part of the engine lubricating system. Combustion heats generated by supercharging the engine, the piston cooling jets are used on the engine to cool the pistons.



WORKING

The lubricating oil circulating pump, mounted on the free end side of the engine sump, draws the lubricating oil from the engine sump and feed it into the system. A relief valve at the discharge side of the pump protects the pump from high pressure and controls the discharge pressure by passing a portion of the oil back to the sump. The remainder of the oil flows on through the regulating valve set at 70 psi and then passes through full flow filter, which is equipped with a differential pressure by-pass valve to hold a relatively constant pressure across the filter. From the filter the oil flows on through the lube oil cooler and then into the main lubricating oil header of the engine to provide pressure lubrication to the bearing surfaces.

A pipe connection from lube oil cooler goes to the both turbo super charger for cooling and lubricating the of the TSC and drain in the sump. A branch line of the lube oil goes for by pass filter for filtration of lubricating oil.

Branch lines leading from the main header supply lubricating oil to the main bearings, connecting rods, cylinder heads, piston cooling jets and return to the sump. Another branch feeds the oil to camshaft bearings & cam follower. Sub header supplies oil to accessory drive like PT fuel pump & water pump etc.

A small line leads to the pressure gauge and the low lube oil pressure switch for engine safety. The normal lube oil pressure of the engine is 3.4 Kg/ cm² to 6.2-kg/ cm² at the rated speed and normal temp.

Checking of Lube Oil level by dipstick.

- Oil gauge dipstick is located on the engine. For accurate readings, oil level should not be checked for approximately 15 minutes after engine shutdown.
- Keep dipstick with the pan with which it was originally fitted. Keep oil level as near "H" (high) mark as possible.

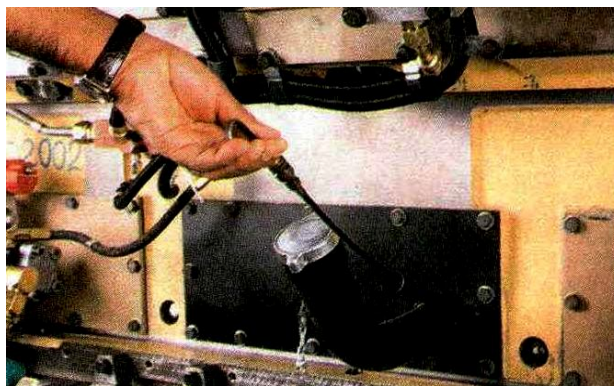
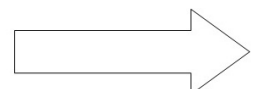
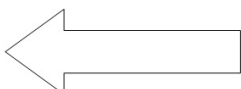


Fig. Checking of engine lube oil level



Changing procedure of lube oil filter elements

- Loosen centre bolt securing lube oil filter housing to lubricating oil pump.
- Remove filter element, cut it open and check for metal particles, if found check for source. Discard "O" ring and element. Insert new filter element into the housing.

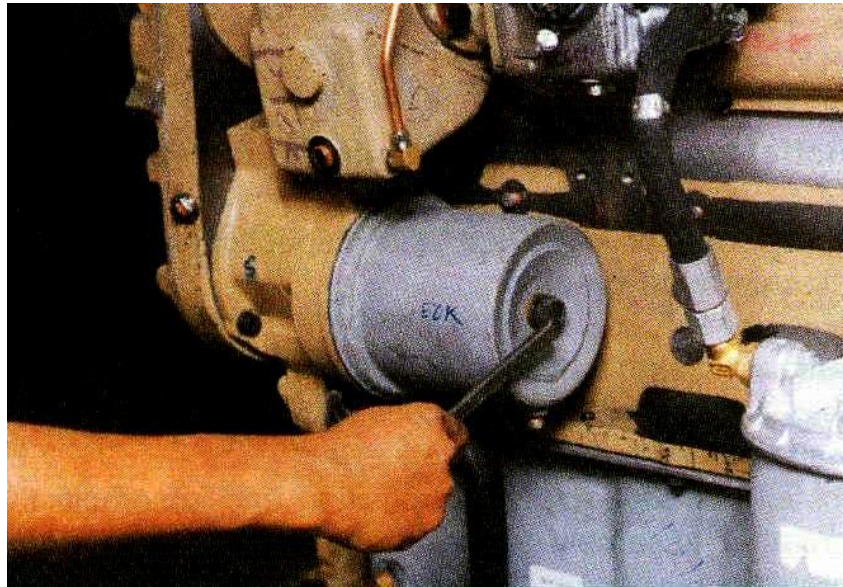
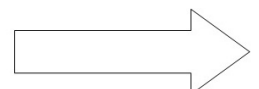
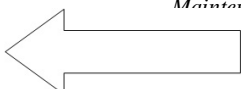


Fig. Changing of pump mounted lube oil filter element

- Install new rectangular seal on the pilot located on the lube pump.
- Install housing and element assembly with its mounting bolt and washers.
- Remove plug on housing, fill clean oil and replace the plug.
- Torque the housing retaining bolt to 30 to 35 ft. lbs.
- Check for leaks when engine start, recheck engine oil level; add oil as necessary to bring the oil level to "H" mark on the dipstick.

Cleaning/ changing of engine breather

- Remove the wing nut, lock washer and plain washer.
- Remove washer and gasket.
- Lift off the cover and lift out the breather baffles.
- Discard baffles, clean cover and body. Inspect the body and cover for cracks, dents or breaks.
- Clean the baffles in suitable solvent and replace if necessary.



- Inspect gasket. Replace if necessary. Install the rubber gasket in the Cover position the cover assembly to the body.
- Inspect gasket. Replace if necessary. Install the gasket, washer and wing nut Tighten securely.

Changing of lube oil by-pass filter element

- Loosen four cap screws from head and remove head of L.O. by-pass filter.
- Takeout element and remove ring sealing between head and shell.
- Replace ring sealing and element. Fill filter with some oil and reassemble.
- When the engine runs check for leaks, shut down the engine. Add oil as necessary to bring the oil level to the "H" mark on the dipstick.



Fig. Lube oil by-pass filter element

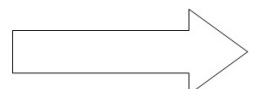
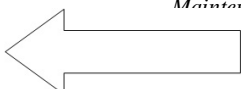
Oil Sample Collection

Three methods are commonly used to collect oil samples for analysis. They are:

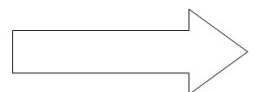
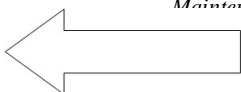
1. Sample Valve Method:
2. Vacuum Pump Method:
3. Oil Drain Method:

Engine Oil changing procedure

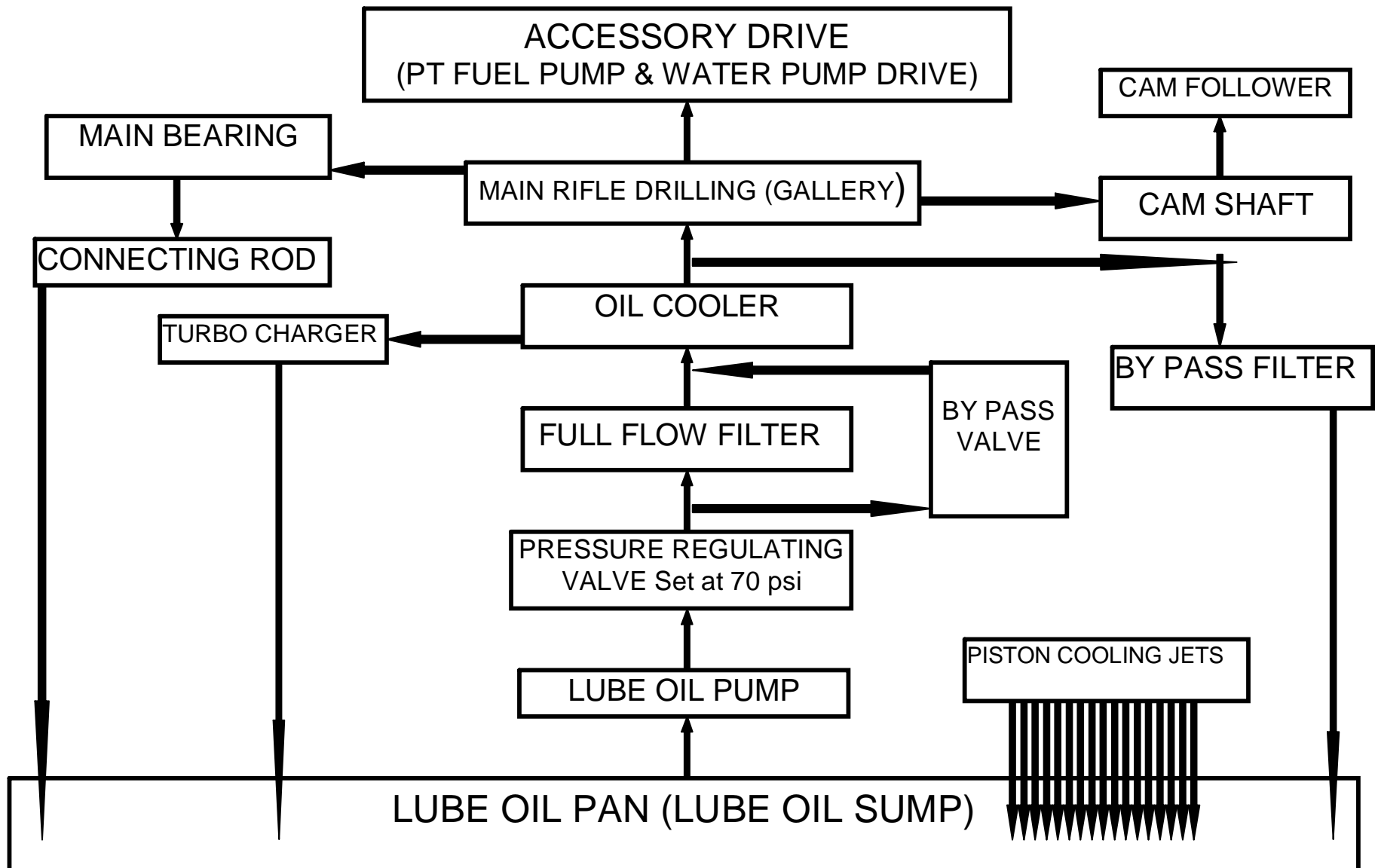
- Start the engine and bring engine to operating temperature, now shut down the engine.



- Remove drain plug from bottom oil pan, and drain oil
- Install drain plug in oil pan. (Torque to 65 to 70 ft-Ibs for cast iron or sheet metal oil pans. Apply 40 to 45 torque ft-Ibs for aluminium oil pans).
- Fill the crankcase to "H" (high level) mark on the dipstick.
- Start engine and visually check for oil leaks.
- Shut down the engine; allow 15 minutes for oil to drain back into the pan, recheck the oil level with the dipstick. Add oil, as required.



SCHEMATIC DIAGRAM OF LUBRICATING OIL SYSTEM



2.5 COOLING WATER SYSTEM

The cooling system is with side-mounted radiators. Cooling system is pressurized by 7PSI pressure cap and vacuum valve. A schematic of the cooling water system is shown in schematic diagram of the cooling water system.

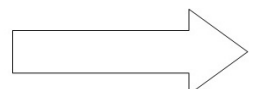
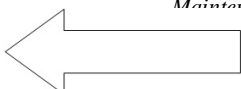
MAJOR COMPONENTS IN THE COOLING SYSTEM:

a) Radiators:

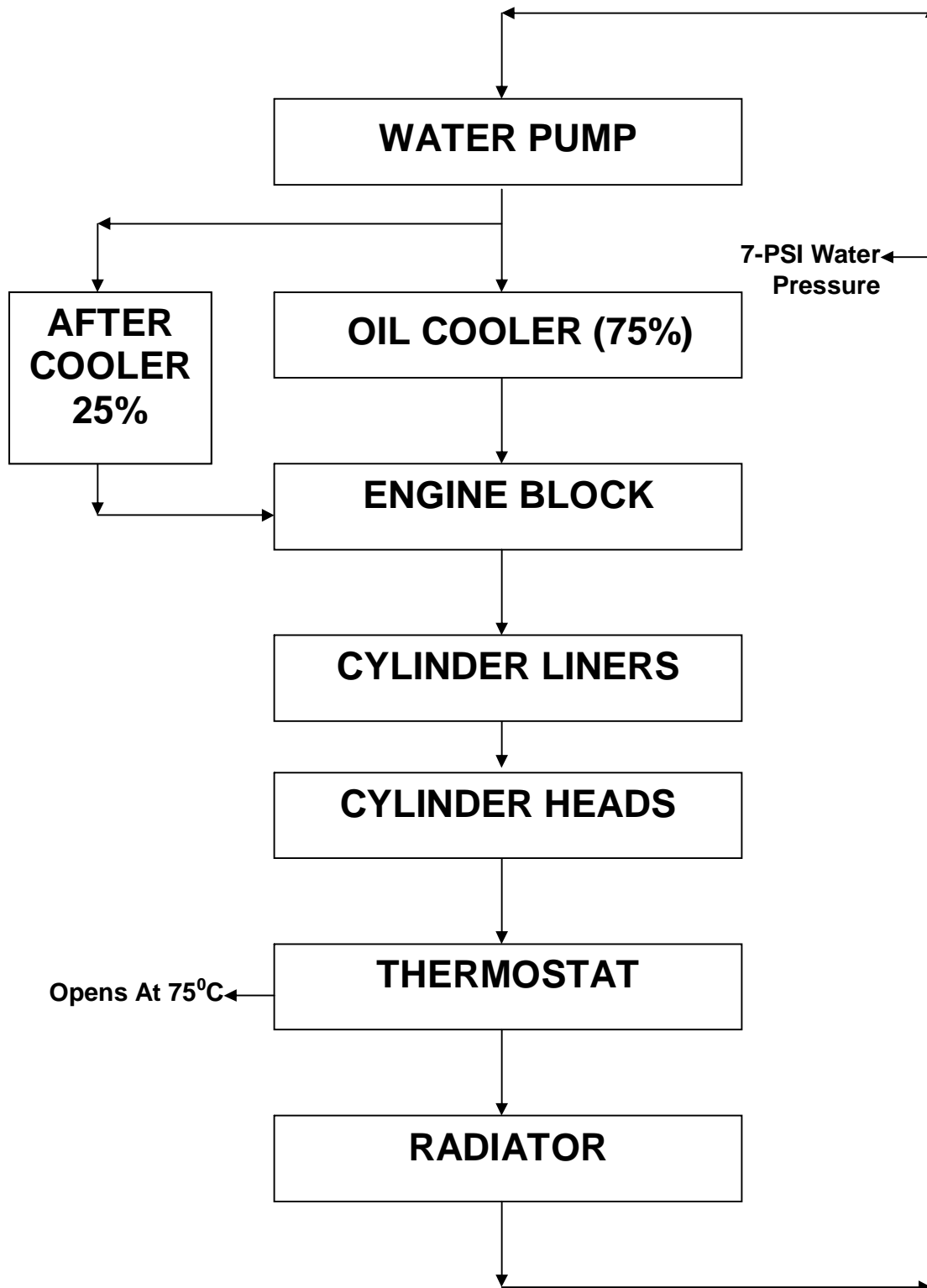
Radiator is front mounted radiator. Radiators can be cleaned easily by air / water jet from inside to out of radiator compartment. Radiators are supported with anti-vibration mountings to guard against rail vibrations.

b) Radiator Fans:

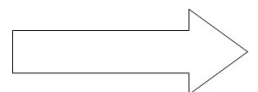
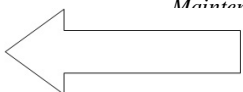
Radiator fan is located on long hood compartment and fitted vertically at the center of the radiator. The radiator fan is driven by “V” belts. Radiator fan sucks air and throws out the hot air to the atmosphere.



SCHEMATIC DIAGRAM OF COOLING WATER SYSTEM



OVER HAULING OF POWER PACK



(A) Engine Disassembly

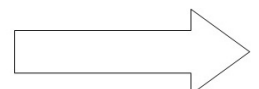
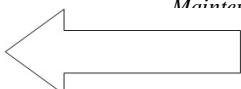
The following Cummins service tools or equal quality tools are required to disassemble the KT (A)-1150 Series Cummins Diesel Engine.

SNo.	Tool Name	Tool Number
Essential Service Tools		
1	Camshaft Gear Puller	3375016
2	Engine Lifting Hook	ST-1286 (2)
3	Lifting Fixture	ST-1258
4	Engine Rebuild Stand	3375193
5	Engine Stand Adapter	ST1307
6	Camshaft Pilot.	ST-1313
Desirable Service Tools		
1	Puller (Pulley)	ST-647
2	Injector Removal Tool	3376000
3	Main Bearing Cop Puller	ST- 1116
4	Liner Puller	ST-1209
5	Liner Puller Bridge	3375629
6	Cup Plug Driver	S1-1281
7	Filter Wrench	3375049
8	Connecting Rod guide Pins	3375098
9	Tube Driver	ST-1319
10	Gear Puller Assembly	3375834
11	Jaw	3375835
Standard Tools		
1	Hoist (Power or Chain)	
2	Steam Cleaner	
3	Cleaning Tank	
4	Rinsing Tank	
5	Impact Wrench	
6	Glass Bead Cleaner	

Note: During unit removal, time and labor will be saved if the steps outlined are followed. Precautions are included that may help prevent accidents and/or damage to the parts.

Removal and Cleaning

Before the disassembly of an engine or any unit used on the engine, an inspection of the overall engine condition should be made. Information noted before and during disassembly can save considerable time when the engine is reassembled.



Inspection of each unit and tagging of the electrical wires, components, bearing shell positions and other parts identification will help insure correct assembly.

Remove the units and component parts from the cylinder block in a convenient order by removing mounting hardware, such as clamps, mounting brackets, cap screws, flat washers, lock washers, drive belt, etc. Mark or identify mounting components, as removed, for the mounting location. Place the parts and units (except electrical parts) for cleaning. Discard the hose, O-rings, gaskets and lock plates.

Note: The cap screw length should be noted as cap screws are removed from the components, such as oil cooler housing, lubricating oil pan adapter, front gear cover and steel plate etc. to assure proper thread engagement during assembly.

Engine Data plate

Engine data plates are located on the topside of the lubricating oil cooler housing. Another data plate is located at the rear of the engine block above the flywheel housing. Information on data plates should be used when ordering parts. Data plates may not be changed.

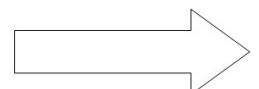
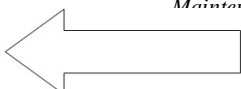


Fig. 0-1. Engine dataplate location

Draining of Water and Oil

Drain the complete engine of water, lubricating, oil and fuel oil. Bleed the compressed air system, if used.

1. Open the vent cock in the thermostat housing and drain the cocks in the oil cooler housing and water pump.
2. Remove the drain plugs in oil pan sump, (1, Fig. 0-3) and pan adapter cover plate (2).



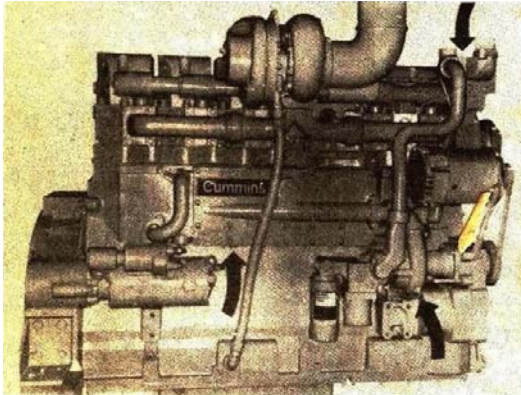


Fig. 0-2. Cooling system drain points

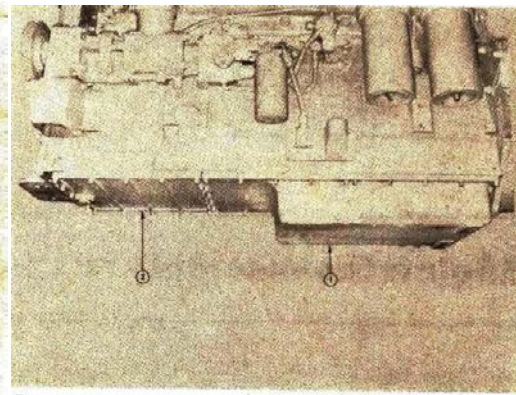


Fig. 0-3. Lubricating oil pan

Note: It is necessary to remove the drain plug in the adapter cover plate when draining lubricating oil.

3. Drain the fuel oil from the pump, filter(s) and fuel lines, if petcock is located below the fuel filter can.

Cleaning of Engine Exterior by Steam

Prior to steam cleaning, remove all electrical components, such as the alternator and adjusting link (Fig. 0-4), cranking motor (Fig. 0-5) and electrical controls, as used. Tag the wire leads as removed. Cover all the openings with moisture proof tape.

In addition to the actual time saved by cleaning: prior to disassembly, inspections can be made more quickly and accurately if the surfaces are clean.

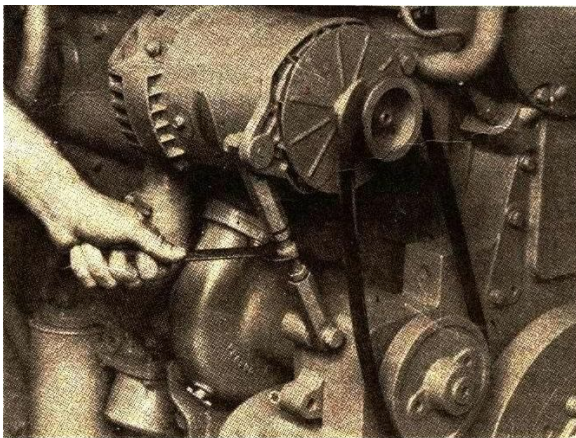


Fig. 0-4. Remove the alternator and adjusting link

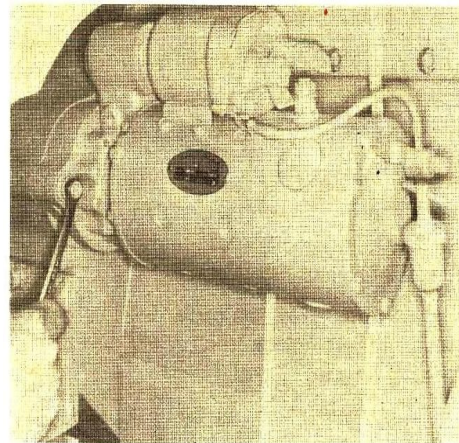


Fig. 0-5. Remove the cranking motor

Disassembly of Engine

Before mounting the engine to the rebuild stand, several components on the exhaust manifold side of engine must be removed.

Removal of Turbocharger

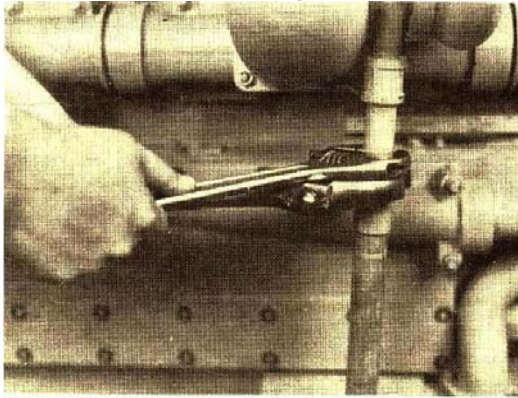


Fig. 0-6. Remove the turbocharger oil lines

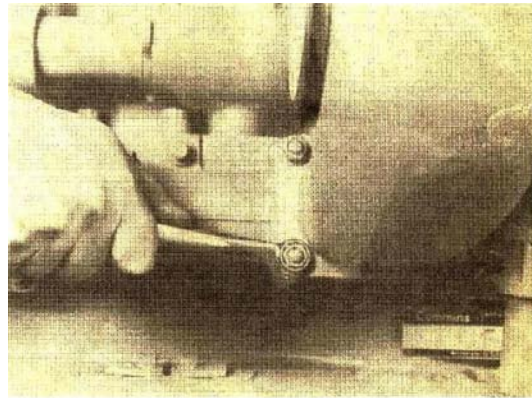


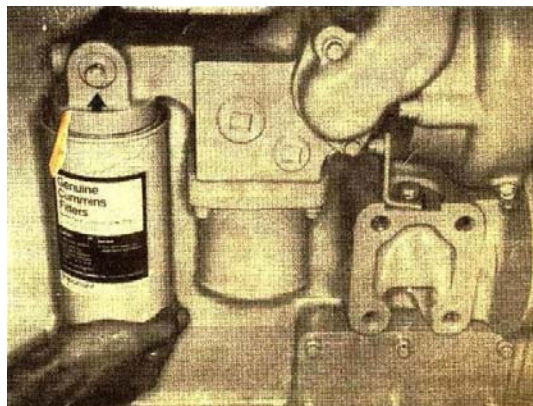
Fig. 0-7. Remove the turbocharger

1. Remove the oil supply and drain lines.
2. Remove the strap connecting the air crossover to the turbocharger.



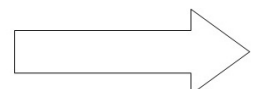
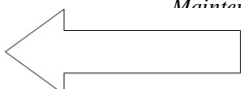
Fig. 0-8. Remove the crossover tube

3. Remove the air crossover tube connecting the turbocharger to the intake manifold connection. Remove the four turbocharger mounting stud nuts.
4. Lift the turbocharger off the mounting studs.



Removal of Water Pump

1. Close the valve above the water filter. Remove and discard the water filter.
2. Remove the by-pass tube assembly connecting the water pump to the thermostat housing.



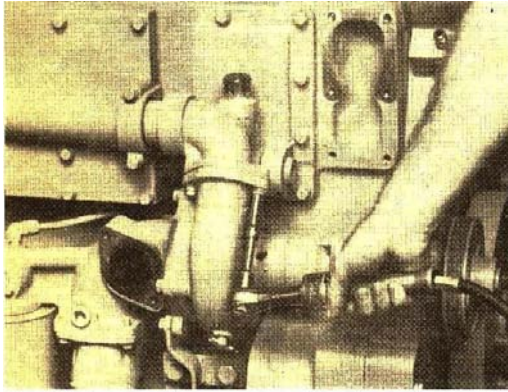


Fig. 0-10. Remove the water pump from the cooler transfer tube

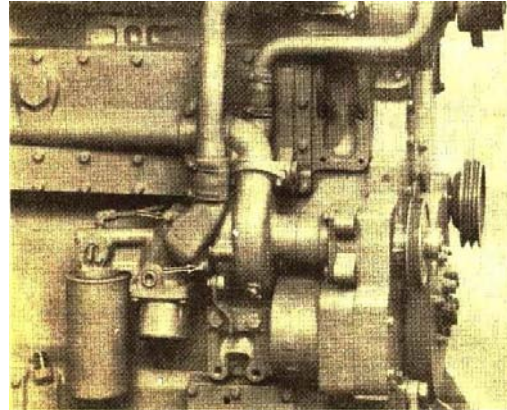


Fig. 0-11. Remove the water by-pass tube assembly

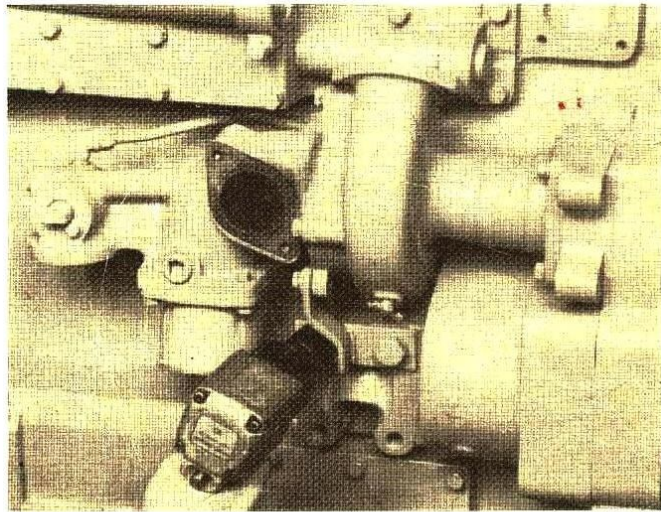


Fig. 0-12. Remove the water pump assembly

3. Remove the tube assembly connecting the water pump to the cooler housing.
4. Remove the bracket from the water pump.
5. To remove water pump, remove the stud nut & three cap screws that are directly above word "Pump" in the caption.

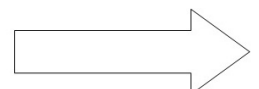
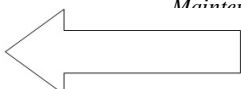
Note: The water pump must be moved parallel with the engine or straight back during the removal to clear the drive shaft and stud.

Alternator Mounting Bracket

Remove the alternator mounting -bracket from the block.

Removal of Lubricating Oil Cooler

1. Remove the heater elements from the housing and cover plate, if used.
2. Remove the cooler cover and the cooler housing.



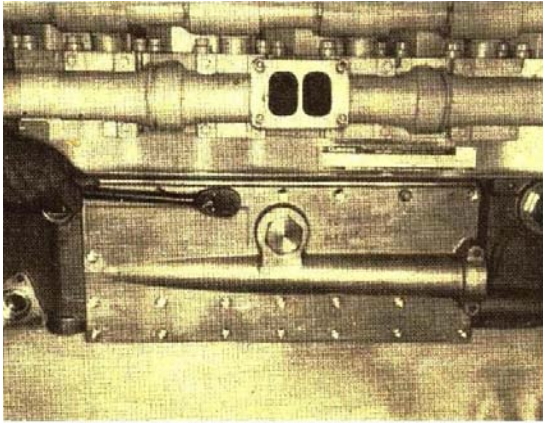


Fig. 0-13. Remove the lubricating oil cooler cover plate

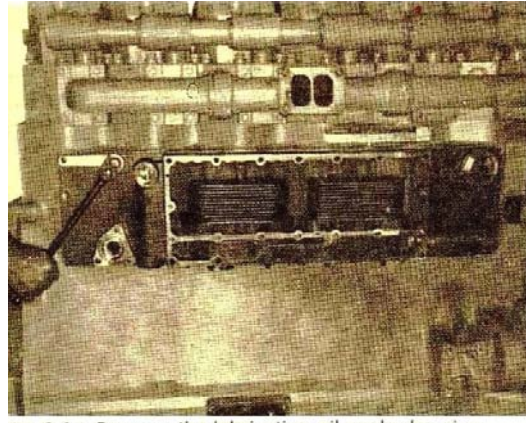


Fig. 0-14. Remove the lubricating oil cooler housing

Removal of Exhaust Manifold

The exhaust manifolds may be removed as an assembly or in separate sections. The hand hole cover & the turbocharger drain hose fitting must be removed from oil pan adaptor to mount engine on rebuild stand.

Mount Engine on Rebuild Stand

1. Secure the ST-1307 Engine Stand Adapter to the 3375193 Engine Rebuild Stand.

Caution: The ST-548 Engine Rebuild Stand is not recommended for use with the "K" Engine.

2. Use the ST-1258 Lifting Fixture, two (2) ST-1286 Lifting Hooks and a suitable hoist to position the engine to the stand adapter. Start in the center and tighten the cap screws alternately while securing the engine" to the adapter.

Note: Use 3/8-16 x 3-1/2 inch cap screws to secure 'the engine to the adapter plate.

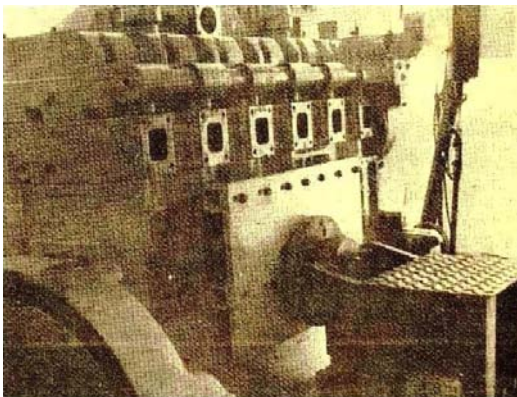


Fig. 0-15. Mount the engine to the rebuild stand

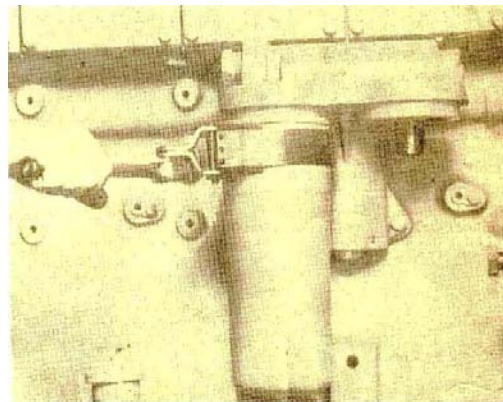


Fig. 0-16. Remove the lubricating oil filter

Removal of Lubricating Oil Filter

1. Remove the discard the oil filters.

2. Remove the filter head

Note: The filter heads on early style engines have four (4) mounting cap screws concealed inside the head.

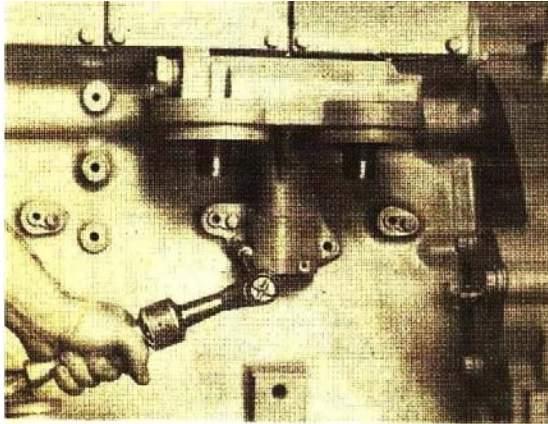


Fig. 0-17. Remove the lubricating oil filter mounting head

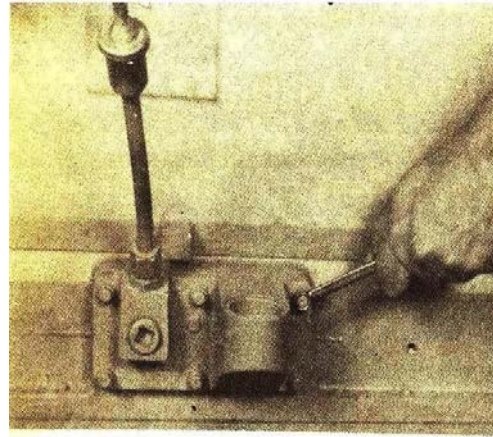


Fig. 0-18. Remove the oil dipstick and bracket

Aneroid (If Used)

Disconnect the air and fuel lines. The aneroid and mounting bracket may be removed as an assembly.

Removal of Oil Gauge and Bracket

Remove the oil gauge tube and mounting bracket.

Note: The oil gauge tube may be removed from the mounting bracket allowing the bracket to remain on the oil pan adapter if so desired.

Removal of Fuel Filter (Remote Mount)

1. Remove and discard the filter element (s)
2. Remove the hose connecting the filter to the fuel pump.
3. Removal the filter head and mounting bracket.

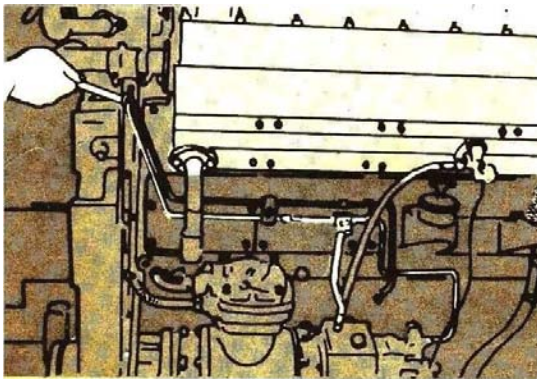


Fig. 0-19. Remove the fuel tubing

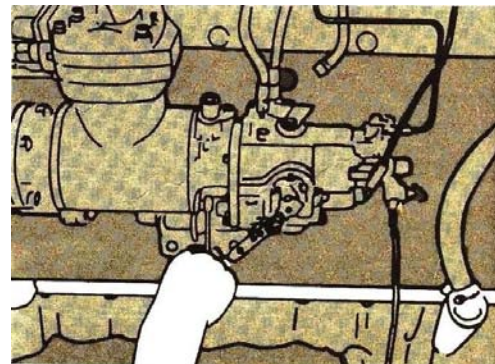


Fig. 0-20. Remove the fuel pump

Removal of Fuel Pump

1. Remove the fuel supply and drain the tubes from the fuel manifold and fuel pump.

Note: There are engines with front end mounted fuel supply and drain tubing.

2. Remove the throw-away filter if fuel pump mounted.
3. Remove the fuel pump from the accessory drive housing or air compressor. Lift out the drive buffer or splined coupling.

Removal of Air Compressor

1. Loosen the hose clamps and remove the air supply from the intake manifold when used.
2. Remove the water inlet and drain the tubing hose and connections.
3. Remove the air compressor support bracket.
4. Remove the air compressor from the "accessory drive housing lift out the splined drive.

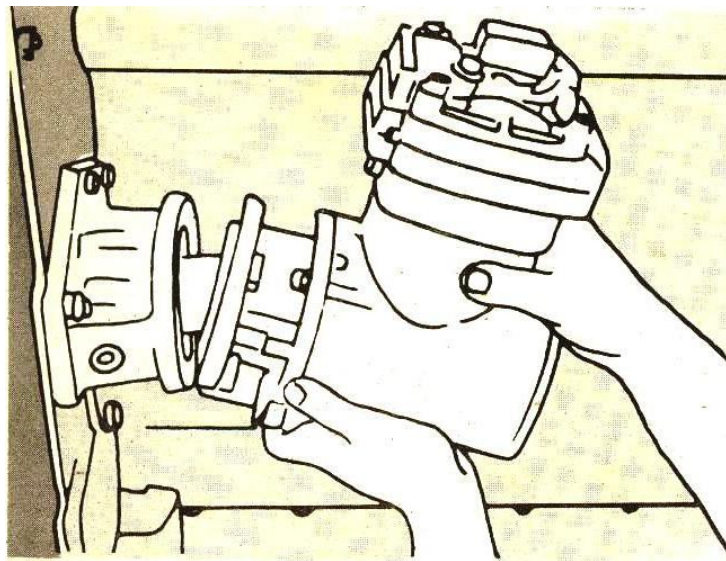


Fig. 0-21. Remove the air compressor

Removal of Accessory Drive

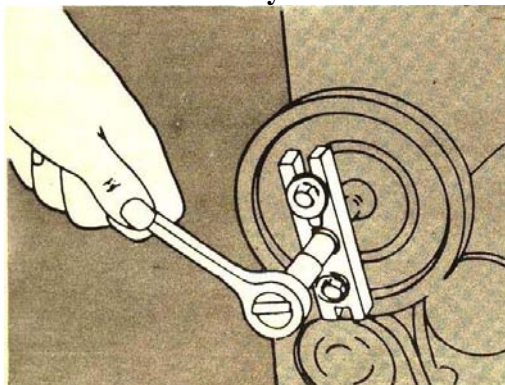


Fig. 0-22. Remove the accessory drive pulley

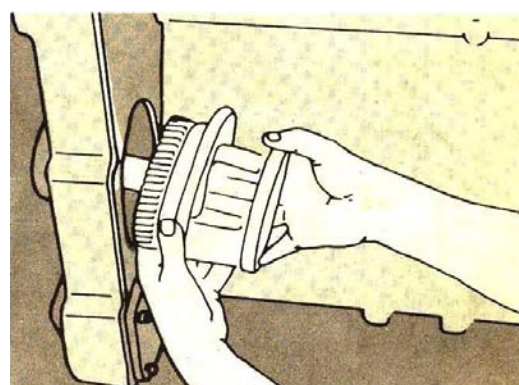


Fig. 0-23. Remove the accessory drive assembly

1. Use the 5T-647 P011er to remove the accessory drive pulley.
2. After removing the cap screws and stud nut (Fig. 0-23), tap the pulley end of the shaft with a soft hammer to remove the drive assembly.

Removal of Air Intake Manifold and Air Crossover

1. Remove the air crossover connection if not previously removed.
2. Remove the intake' air manifold or after cooler.

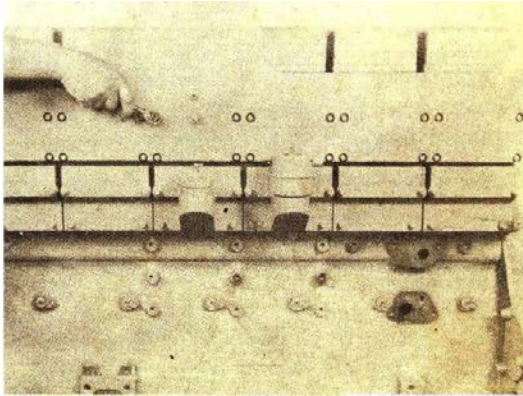


Fig. 0-24. Remove the intake manifold

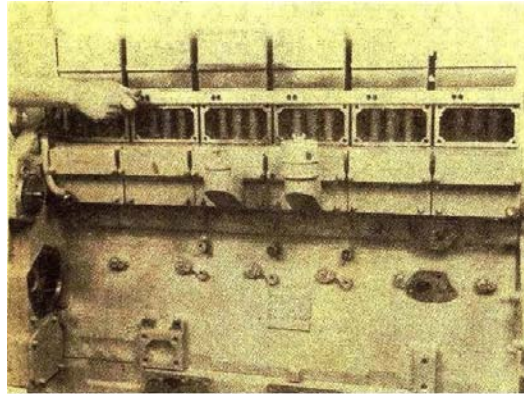


Fig. 0-25. Remove the fuel manifold

Removal of Fuel Manifold

The fuel manifold is attached to each individual cylinder head; remove the screws. Discard the O-rings.

Removal of Cam Follower Covers

Two of the follower covers have crankcase breather and / or oil filler cap openings. The covers are interchangeable.

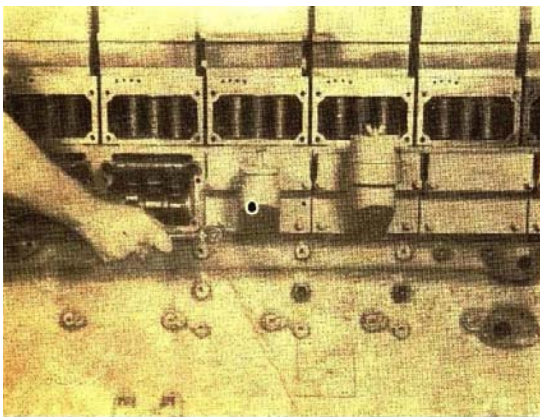


Fig. 0-26. Remove the cam follower covers

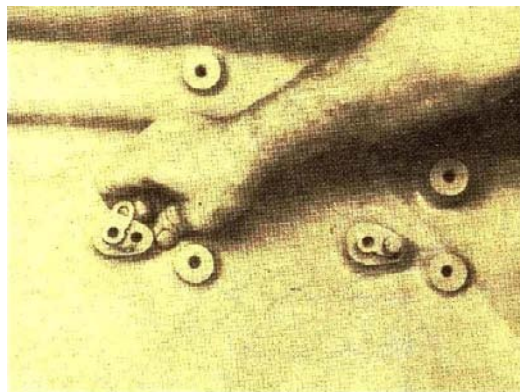


Fig. 0-27. Remove the piston cooling nozzles

Removal of Piston Cooling Nozzles

Remove the slotted screws or cap screws securing each nozzle to the block. Remove the nozzles.

Removal of Rocker Levers and Housing Cover

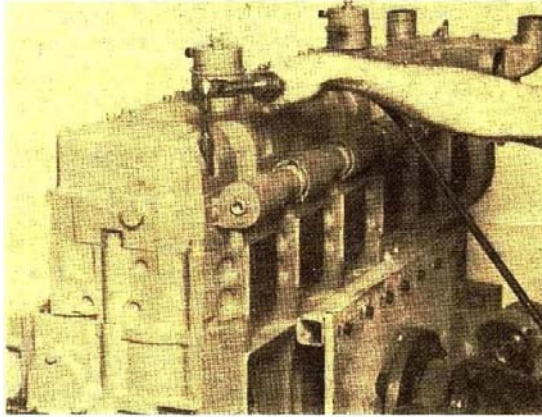


Fig. 0-28. Remove the rocker lever housing covers

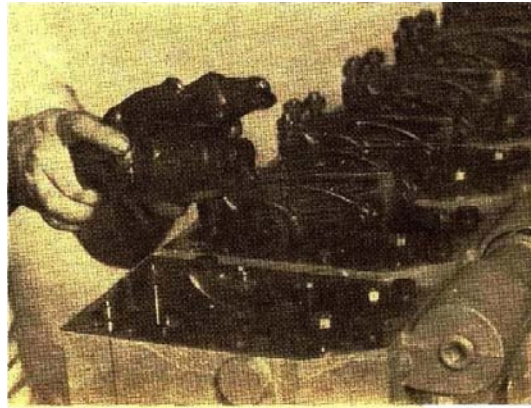


Fig. 0-29. Remove the rocker lever assemblies

1. Remove the rocker lever housing covers.
2. Loosen the valve and injector adjusting screw locknuts and back out the adjusting screws to remove the tension from the push rods.
3. The rocker lever shafts are mounted on top of the housings and have ring dowels under one cap screw. When removing, pull straight up to clear the ring dowel.

Removal of Valve Crossheads

1. Remove all the valve crossheads.

Removal of Injector Plunger Links and Push Rods

It is recommended that the push rods, injector links, rocker levers, cam followers, etc. be marked for position as removed. If these parts are to be reused, more accurate adjustments will result due to the wear pattern established.

Remove the injector plunger links, and the push rods.

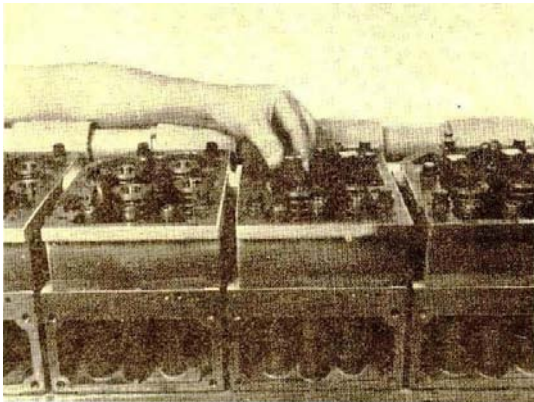


Fig. 0-30. Remove the crossheads

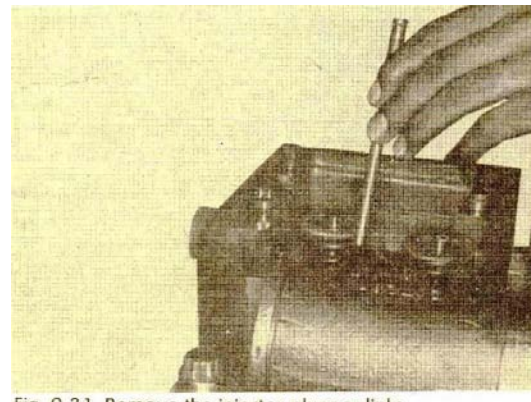


Fig. 0-31. Remove the injector plunger links

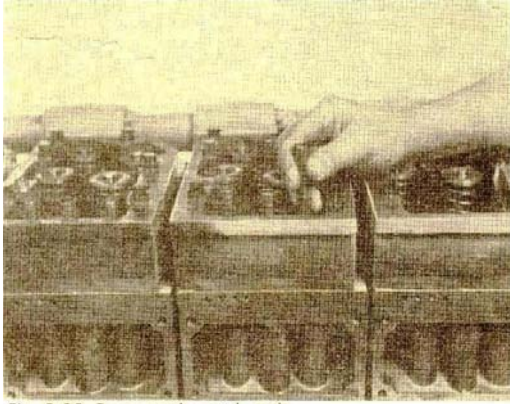


Fig. 0-32. Remove the retaining ring.



Fig. 0-33. Remove the retaining ring.

Removal of Rocker Lever Housing/Water Manifold and Thermostat Housing

The water passages which are cast in the rocker housings and the water transfer tubes sealed with a-rings are held in position with the retaining rings which make up the water manifold.

The housings are dowel fit to the cylinder heads. When removing the rocker housings from the rear of the cylinder block:-

1. "Remove the water transfer tube retaining ring between the No.5 and No.6 cylinders.
2. Use a tube driver ST-1319 to drive the transfer into the No.5 rocker housing far enough to clear flange of the No.6 housing.
3. Remove the rocker housing cap screws and. lift the housing from the cylinder head.
4. Remove the water transfer tube from the No. 5 housing. Discard the O-rings.
5. Follow the same procedure when removing housing No's. 5, 4, 3 and 2.

Note: The thermostat housing must be removed before the No.1 rocker housing is removed.

6. Remove the by-pass tube, turbocharger, supply line and air compressor drain tube from the housing, if not previously removed.

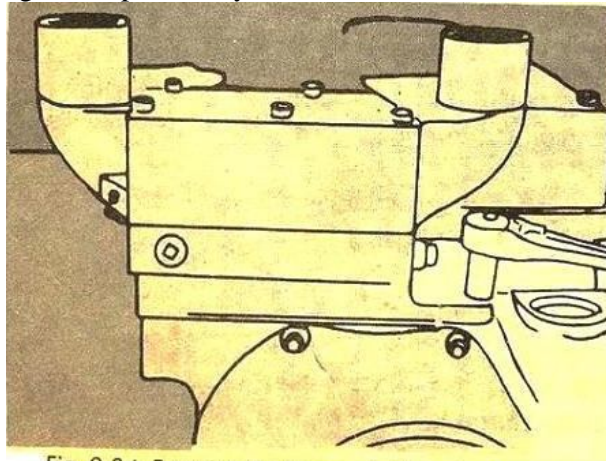


Fig. 0-34. Remove the thermostat housing

7. Remove the housing support bracket.
8. Remove the cap screws securing the thermostat housing to the gear housing.
9. If the fan hub has not been removed, cock the thermostat housing enough to clear the hub support. Pull the thermostat housing and transfer tube from rocker housing.
10. Remove the remaining rocker housings from the cylinder head.

Removal of Injectors

1. Remove the injector hold-down plate.
2. Use the 3376000 Injector Removal Tool or a suitable prying tool to remove the injectors.

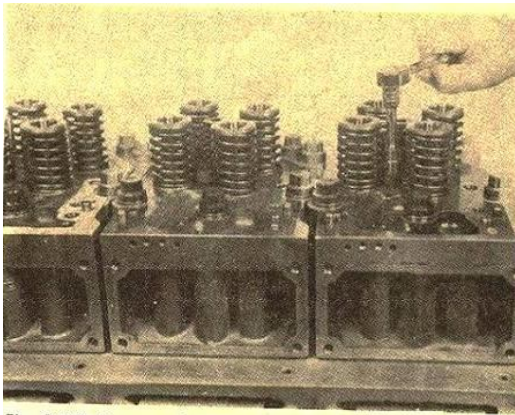


Fig. 0-35. Remove the injector hold-down clamp

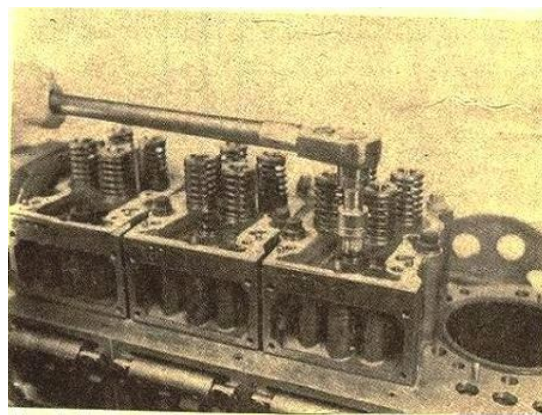


Fig. 0-36. Remove the cylinder head cap screws

Caution: To avoid getting dirt in the injector barrel and cup, do not remove the plunger and the spring.

Removal of Cylinder Heads

The cylinder heads are dowel fit to the block. Remove the cap screws. Lift cylinder heads straight up from the block to clear the dowels. Discard the gaskets.

Note: The rocker lever housings and cylinder heads may be removed individually follow the procedure outlined above.

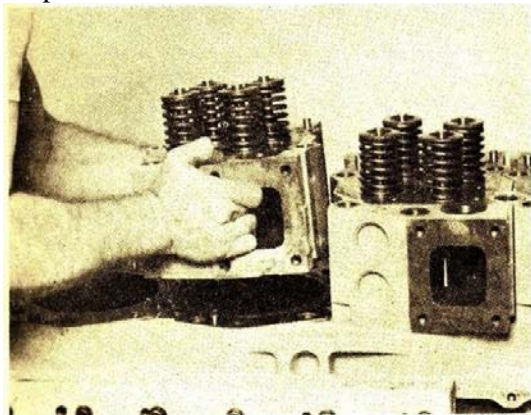


Fig. 0-37. Remove the cylinder head

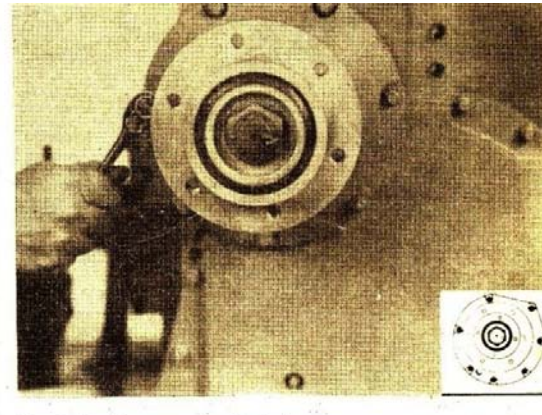
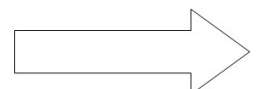
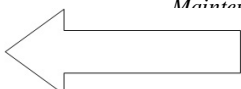


Fig. 0-39. Remove the fan hub



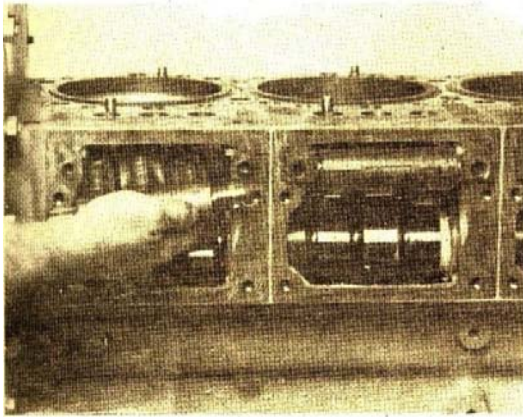


Fig. 0-38. Remove the cam followers

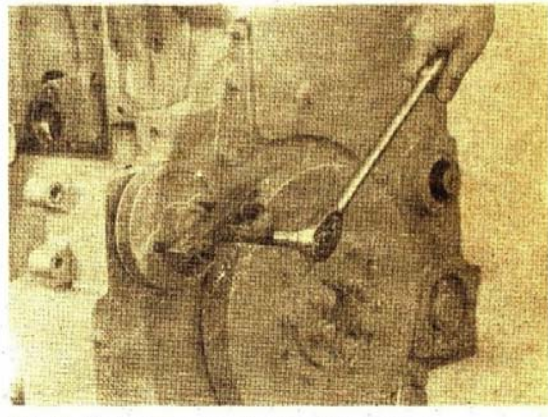


Fig. 0-40. Remove the alternator drive pulley

Removal of Cam Followers

Remove the cap screws securing the cam followers to the cylinder block. Remove the shaft from the ring dowels.

Removal of Fan Hub (Gear Driven)

1. Remove the cap screws securing the fan hub to the gear front cover.
2. Pull the hub assembly forward until the gears are disengaged.

Removal of Alternator Drive Pulley

The alternator drive pulley is mounted on the water pump drive shaft. Use the ST-647 Puller to remove the pulley from the shaft.

Removal of Water Pump Drive Support

Use a soft hammer on the front of the shaft, to drive the support from the gear front housing.

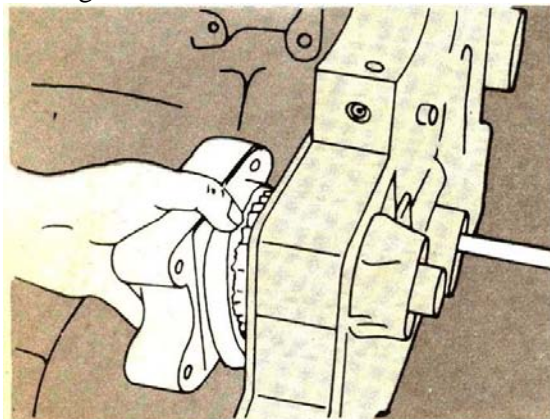


Fig. 0-41. Remove the water pump drive support

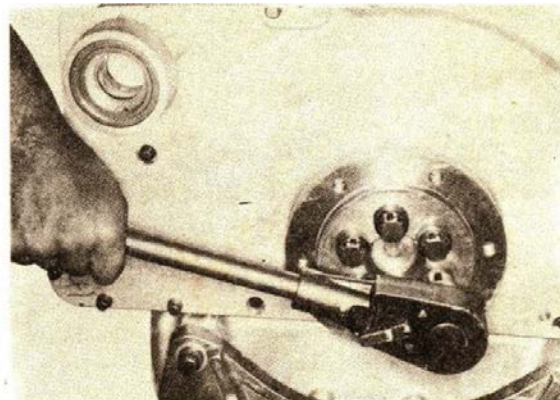
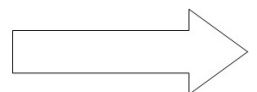
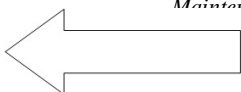


Fig. 0-43. Remove the crankshaft adapter



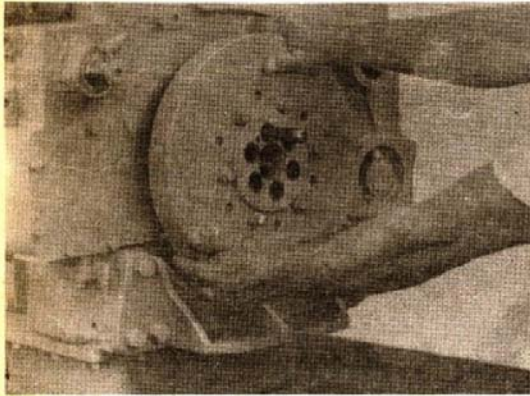


Fig. 0-42. Remove the vibration damper

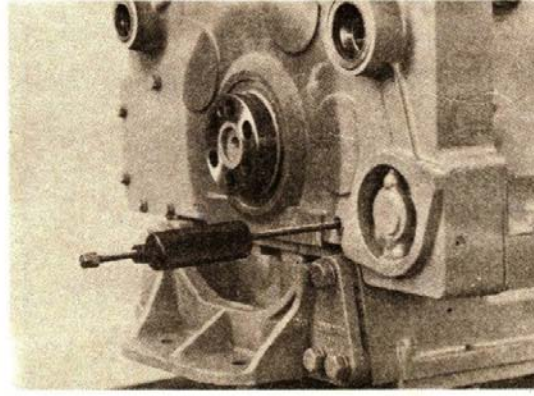


Fig. 0-44. Remove the master dowel

Removal of Vibration Damper

1. The vibration damper and the crankshaft adapter may be removed separately or as an assembly by removing the cap screws securing the adapter to the crankshaft.
2. During removal pry and/or tap on adapter.

Caution: Do not pry or pound on the viscous damper. Denting on the outer shell will make the damper ineffective.

Removal of the Front Gear Cover

1. Remove the front cover cap screws.
2. Use a suitable puller to remove the master dowel.
3. Remove the front gear cover.

Removal of Idler Gears

1. Remove the three idler shaft to block cap screws.
2. Use a cylinder head bolt, washer and a weight to make a slide hammer - type puller like the one shown in Fig. 0-44.

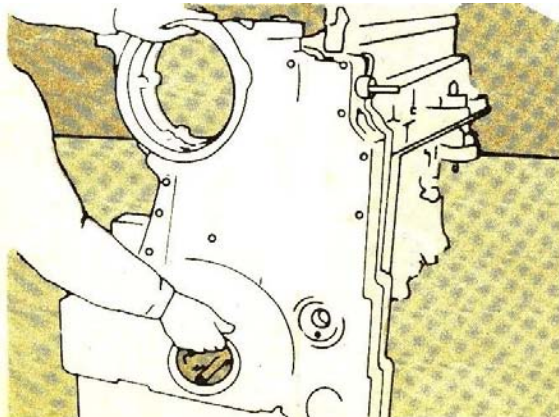


Fig. 0-45. Remove the front gear cover

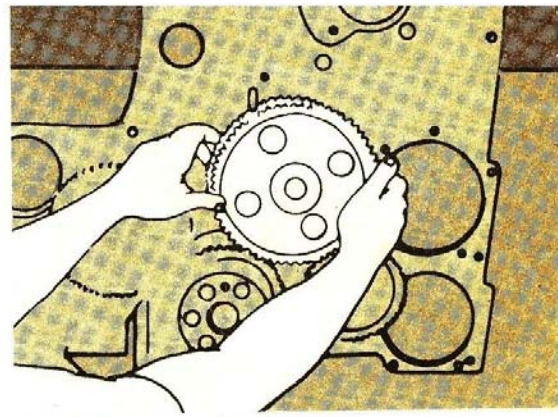


Fig. 0-46. Remove the idler gear

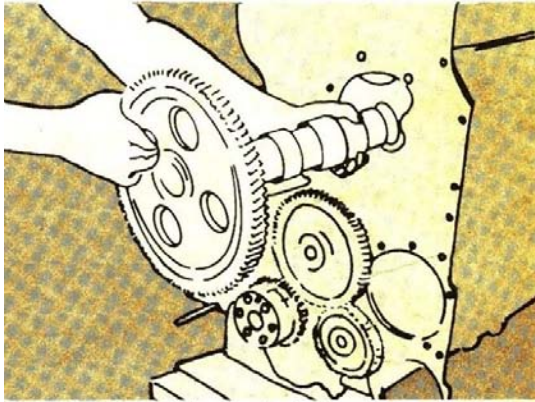


Fig. 0-47. Remove the camshaft

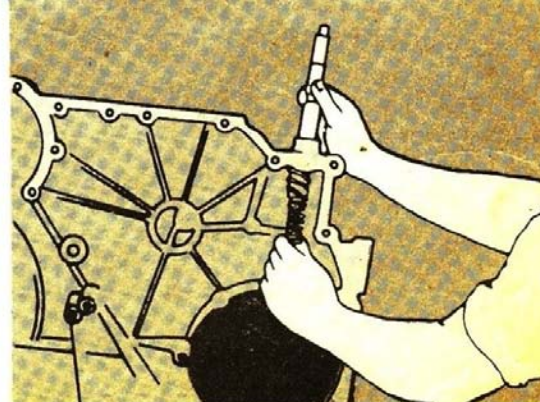


Fig. 0-48. Remove the barring device shaft

3. Install the head bolt into the threads in the idler shaft about 0.5 inch (12.7 mm).
4. Use the slide hammer to pull the idler shaft. Be careful and not drop the gear.
5. Remove the block-side thrust washer. Keep the shaft, gear and thrust washers together.

Removal of Camshaft

1. Remove the camshaft rear cover at the rear of the block. Attach the ST - 1 313 Camshaft Pilot to the rear of the camshaft.
2. Straighten the lock plate and remove the cap screws securing the camshaft thrust plate to the block.
3. Rotate the camshaft gear, lifting slightly while removing the camshaft and pilot from the block.

Caution: Due to the length of the camshaft two men may be required when removing the camshaft to avoid damage to the camshaft and the bushings.

4. Remove the camshaft pilot. Do not remove the camshaft gear.

Removal of the Barring Device

1. Remove the retaining ring from the barring device shaft.
2. Pull out on the shaft to remove the barring device shaft. This will remove the spring and the worm gear.
3. Remove the barring shaft guide assembly.

Removal of Lubricating Oil Pump

1. Remove the three (3) outer cap screws securing the pump body to the block.
2. Remove the pump from the block.

Note: A small pry bar may be required to remove the pump.

3. Remove the sealing ring which seals the pump cover to the cylinder block. Discard the sealing ring and O-rings.

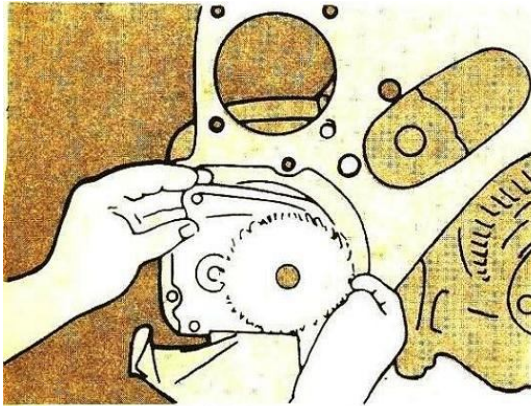


Fig. 0-49. Remove the lubricating oil pump

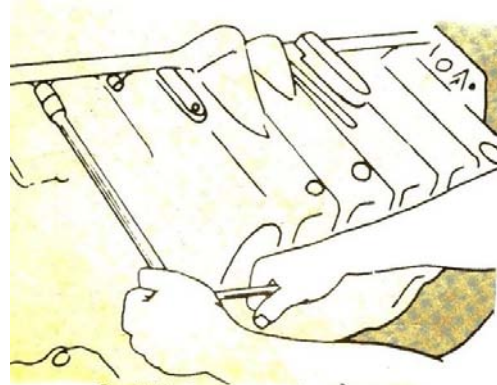


Fig. 0-50. Remove the lubricating oil pan

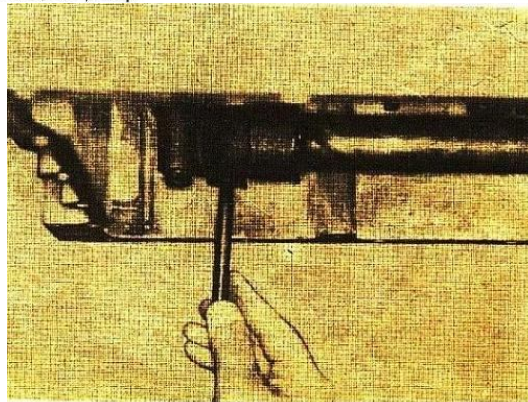


Fig. 0-51. Remove the suction tube cap screw

Removal of Lubricating Oil Pan and Adapter

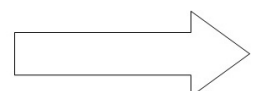
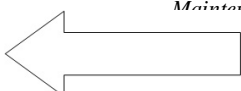
1. Remove the oil pan adapter cover.
2. Remove the lubricating oil pan (sump) from the adapter.
3. Remove the cap screws securing the adapter to the cylinder block and the oil pan baffle (if used) to the adapter.

Note: The cap screws securing the suction tube connection to the adapter and the block must be removed before the adapter is removed.

4. Remove the cap screws securing the adapter to the flywheel housing and front gear cover.
5. Remove the adapter and the suction tube assembly.
6. Remove the suction tube assembly from the adapter.

Removal of Steel Plate

1. Remove the steel plate cap screws.
2. Remove the steel plate.



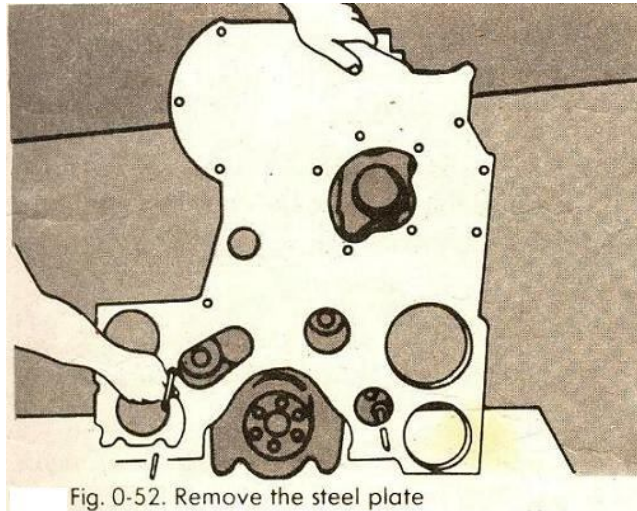


Fig. 0-52. Remove the steel plate

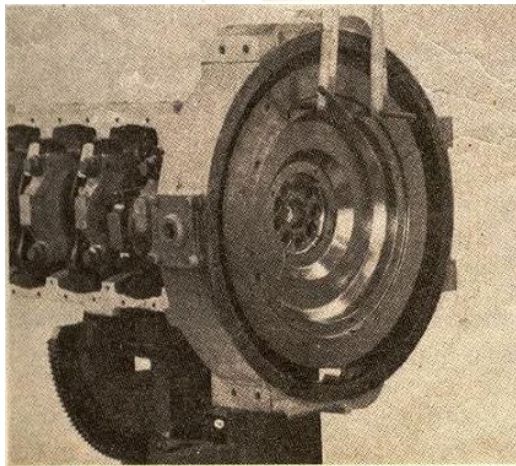


Fig. 0-53. Remove the flywheel

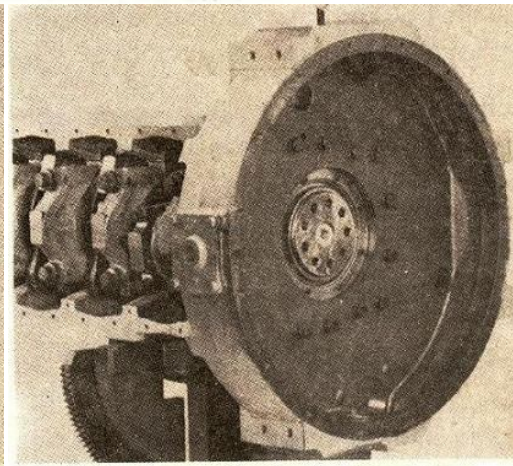


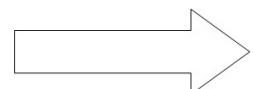
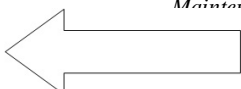
Fig. 0-54. Remove the flywheel housing

Removal of Flywheel

1. Remove the two (2) flywheel mounting cap screws on the opposite sides of the flywheel.
2. Remove the two (2) 5/8.18 guide studs in the crankshaft flange to provide support for the flywheel during removal.
3. Remove the remaining mounting cap screws and install the two (2) 1/2-13 cap screws, threaded their entire length, to act as jackscrews when removing the flywheel from the crankshaft.
4. Remove the flywheel.

Removal of Flywheel Housing and Seal

1. Remove the oil seal plate and discard the oil seal and O-ring.
2. Remove the mounting cap screws securing the flywheel housing to the cylinder block.
3. Install the two (2) 5/8-11 guide studs through the housing into the block to provide support for the housing during removal.



4. Drive the housing from the dowels by tapping on the back side with a soft hammer.
5. Use a suitable lifting device and hoist to lift the housing from the guide studs.

Removal of Connecting Rod and Piston Assemblies

1. Rotate the engine until the head surface is up. Clean all the carbon from the top of the cylinder liner wall. Polish with a fine emery cloth. Clean area thoroughly.
2. Remove the connecting rod bolts and caps.

Note: The connecting rod caps are aligned to the rods with four dowel pins or two ring dowels. To separate the rod and cap back the rod bolts out about 0.250 inch (6.35 mm) and lightly tap on the bolts with a soft nose hammer until the cap is off the dowels.

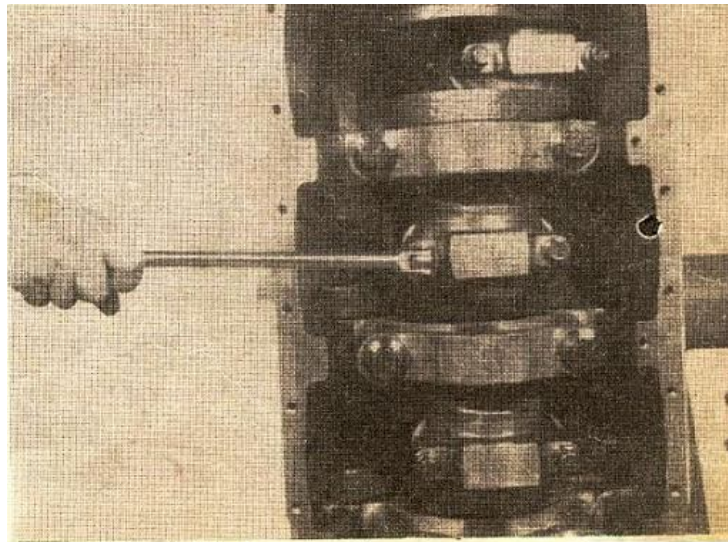


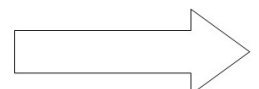
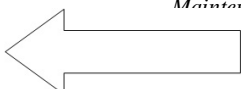
Fig. 0-55. Remove the connecting rod

3. Use care not to damage the cylinder liners as the connecting rods are withdrawn. Reassemble each connecting rod cap to its mating rod, with the numbered side of the cap to the numbered side of the rod.
4. Use the ST-1269 Ring Expender to remove and discard the piston rings.
5. Remove the piston pin snap rings.
6. To facilitate the removal of the piston pins, heat the pistons in hot water to approximately 200°F [93 °C]. Use thumb pressure to push the pin from the piston. Do not drive or otherwise force the pin from the piston.

Caution: Care must be taken when removing and/or installing the piston/connecting rod assemblies that damage to the piston cooling nozzles does not occur. Inspect the piston cooling nozzles to insure no damage has occurred.

Removal of Cylinder Liners

Use 3375629 Liner Puller Bridge and ST-1209 liner Puller Assembly with an impact wrench or ratchet to remove the cylinder liners. Discard the O-rings.



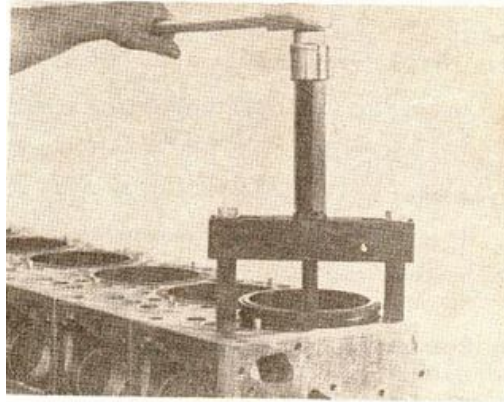


Fig. 0-56. Remove the cylinder liner

Removal of Crankshaft and Main Bearings

1. Remove the main bearing cap screws.
2. Use the ST-1116 Main Bearing Cap Puller to remove the caps.

Caution: Care" must be taken when removing No.6 main bearing cap to avoid damage to the dowels. "

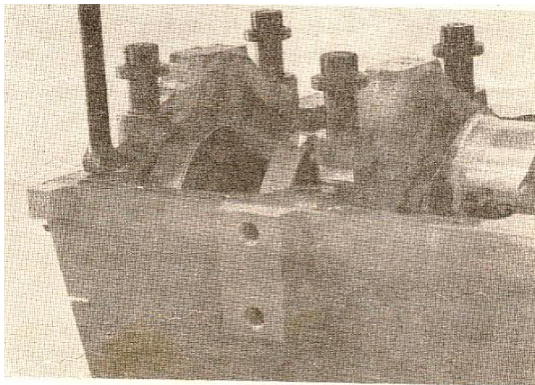


Fig. 0-57. Pull the main bearing caps

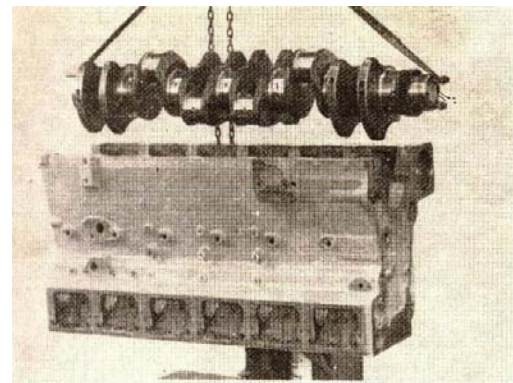


Fig. 0-58. Lift the crankshaft from the cylinder block

3. Remove the lower main bearing shells. Remove the thrust ring halves from the No.6 bearing cap.
4. Remove the upper thrust ring halves from the cylinder block.
5. Use a lifting strap or hooks protected with rubber hose to lift the crankshaft from the cylinder block.

Note: Rotate the crankshaft slightly, if necessary, to facilitate the removal.

6. Remove the upper main bearing shells from the cylinder block.

Note: If bearing shell inspection is to be performed, tape the upper and lower shells together. Identify the shells as removed. Discard the bearings after inspection, as required.

Steam Cleaning

1. Place the parts in trays (except parts listed in following note) and clean with steam jet to remove exterior dirt, etc. Dry thoroughly with moisture-free compressed air.

2. Cover plates, pipe plugs, etc., should be removed as applicable to facilitate the cleaning of oil and water passages.

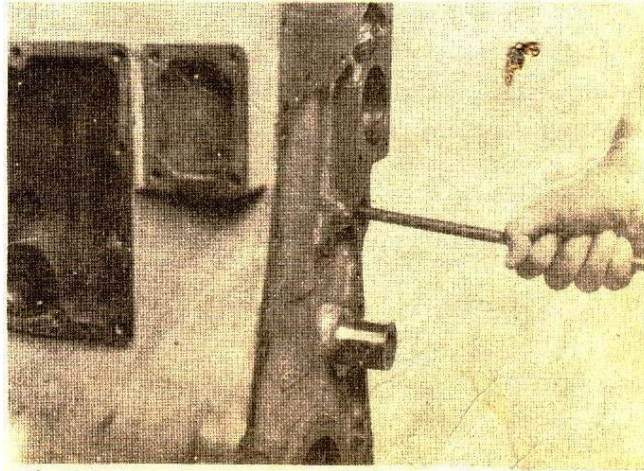


Fig. 0-59. Clean the cylinder block oil passages

Note: Do not steam clean the followings:

1. Electrical components
2. Wiring
3. Injectors
4. Fuel pump
5. Belts and rubber hose f. Bearing shells

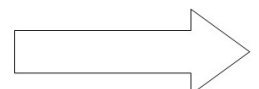
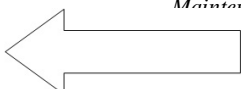
Solvent/Acid Cleaning

Several solvent and acid type cleaners are effective cleaning solutions; always follow the OEM recommendations as to concentration and use.

Remove all gasket material, O-rings and deposits of sludge, carbon, etc., with a wire brush or scraper, from units such as cylinder heads, oil pan, rocker lever housing and cover, etc. before submerging these units in the wash tank.

Caution: Do not damage the gasket surfaces.

1. The solvent solution should be heated to approximately 180 to 200°F [82 to 93° C] and kept in constant agitation. With sufficient heat, the agitation can be accomplished by" built- in baffle plates.
2. After unit disassembly, put all small) parts in wire mesh baskets, steam clean and then immerse in cleaning tank for as long as necessary. Larger parts can be lowered directly by a hoist into the tank.
3. The cylinder block must have all pipe and expansion plugs removed from oil and water passages, etc. Run rods with bristle brushes through all oil passages. Scrape the liner counter bore lightly to remove scale; sand the lower liner bore or use emery cloth to remove any nicks or burrs that might damage the packing rings as the liner is installed.
4. To remove the heavy deposits of lime, use a circulated acid type cleaner.



Warning: The use of acid may be extremely dangerous to workmen and injurious to machinery. Always provide a tank of strong soda water as a neutralizing agent.

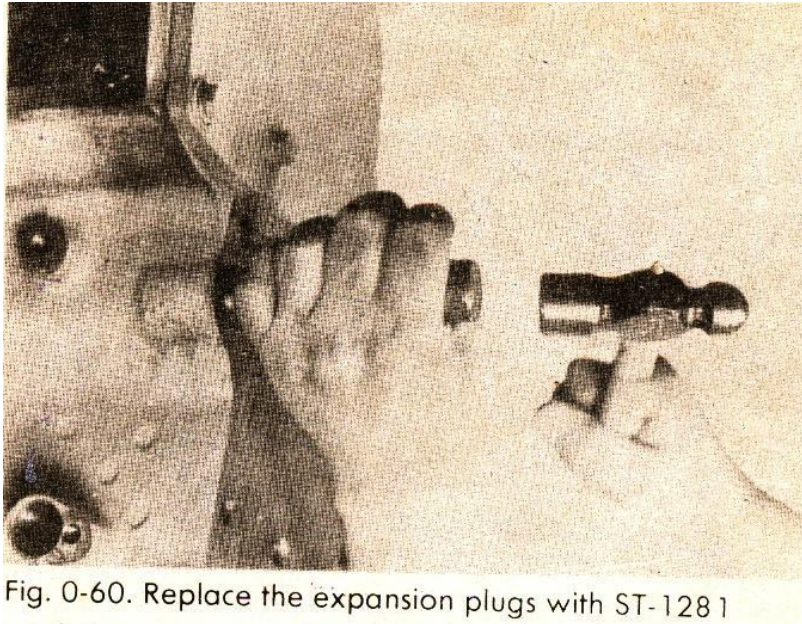


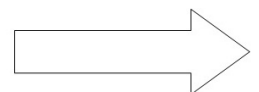
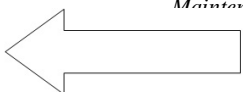
Fig. 0-60. Replace the expansion plugs with ST-128 1

5. Rinse all parts in hot water and dry with compressed air. Blow the cleaning fluid or water from the cap screw holes to prevent damage when the cap screws are tightened.
6. Replace the pipe and expansion plugs removed for cleaning; tighten the pipe plugs to the specifications.

Note: Coat the surface of the new cup plugs with Cup Plug Sealant or equivalent before installation. If rebuild machining is required clean the affected area again and replace the pipe plugs after the machining is completed

7. If the ports are not to be reused immediately after cleaning, dip them in a suitable rust proofing compound.

Note: The rust proofing compound must be removed before installing the parts in the engine.

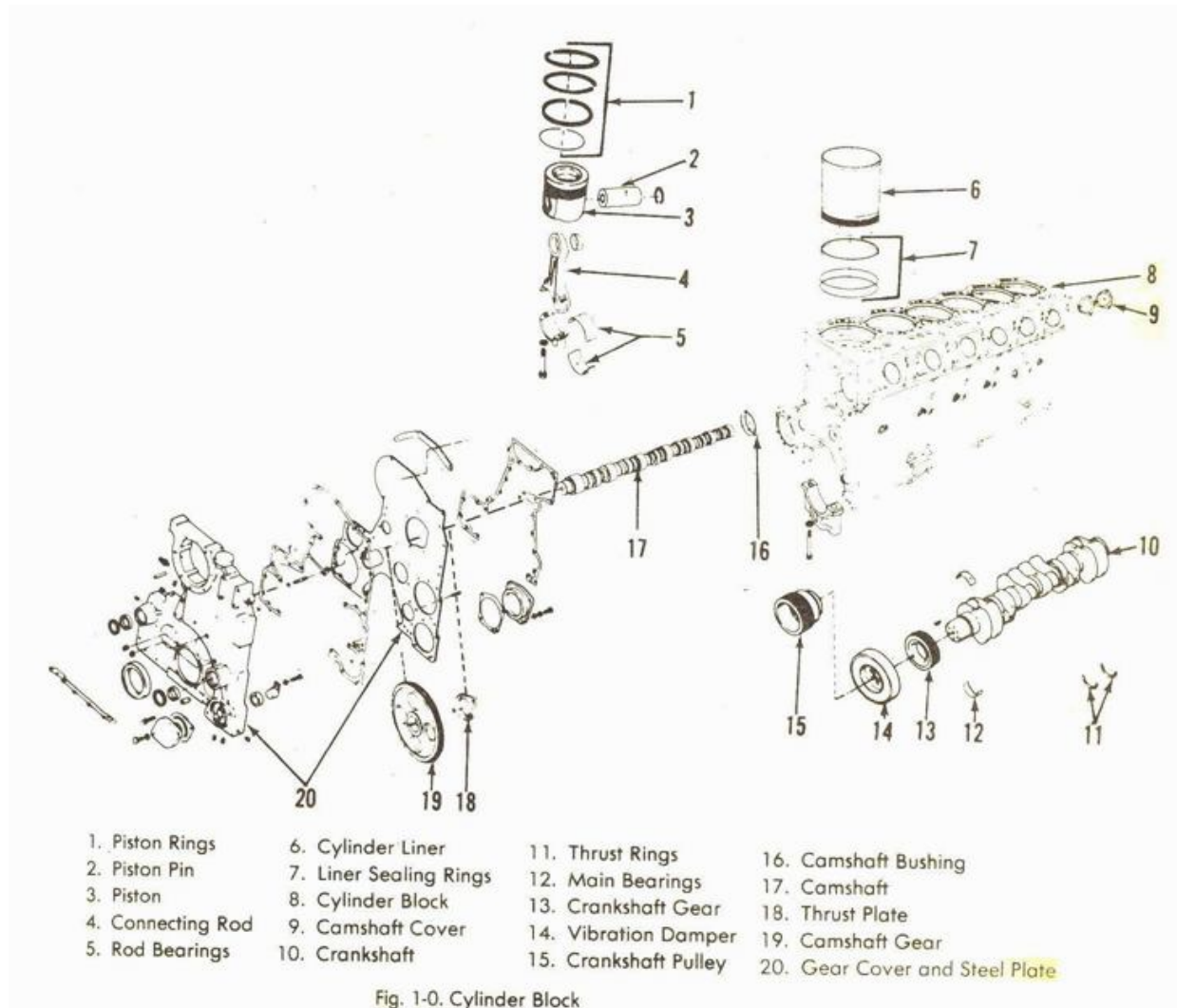


(B) CYLINDER BLOCK

This chapter covers the cylinder block, cylinder liners, crankshaft, bearings, vibration damper, connecting rods, piston, rear seal, camshaft, steel plate and front cover.

The following service tools or tools of comparable quality are necessary to repair or rebuild the cylinder heads as described in this section.

SNo.	Tool Name	Tool Number
Essential Service Tools		
1	Liner counter bore Tool	ST-1168
2	Counter bore conversion Kit	3375442
3	Adopter Kit	3375444
4	Boring Machine	3375115
5	Boring Tool (Main bearing Bore)	ST- 1177
6	Camshaft Bushing Drive Kit	ST-1228
7	Concentricity Gauge	ST-1252
8	Counter bore Tool	ST-1309
9	Counter bore Tool Holder	3375980
Desirable Service Tools		
1	Thread insert Kit	3375196
2	Gauge Block	ST-547
3	Checking Fixture (Connecting Rod)	ST- 561
4	Plug Driver	ST- 1281
5	Locating Mandrel (Connecting Rod)	ST- 1305
6	Plug Gauge	ST- 1296
7	Bushing Mandrel (Gear Cover)	ST-598
8	Ring Gauge	ST-1290
9	Bushing Mandrel (Accessory Drive)	ST-1171
10	Ring Gauge	ST-1292
11	Ring Gauge	ST-1291
12	Puller (Main Bearing Cap)	ST-1116
13	Cylinder Liner Hold Down Tool	ST-1267
14	Mandrel Set	ST-1285
15	Idler Shaft Puller	3375290
16	Dowel Puller	ST- 1134
Standard Tools		
1	Dial Bore Gauge	
2	Dial Bore Indicator's	
3	½" Electric Drill	
4	Micro meters	



Cylinder Block

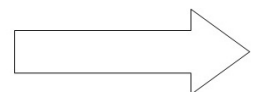
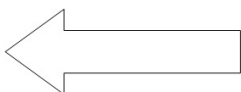
Inspection: Before parts are reused, an inspection must be taken. The inspection is to include wearing surfaces and general conditions.

Note: Inspection and machining of cylinder block must be performed on a flat surface to prevent distortion. Do not attach to the engine stand.

Check for oil cooler element interference with the cylinder block.

When installing the oil cooler assemblies or elements, the block to element clearance should be checked with a 0.030 inch (0.76 mm) feeler gauge at the locations indicated before tightening the cooler assemblies or elements in position. If there is contact or insufficient clearance, grind the block surface in the area shown to obtain the specified clearance. Grinding must be done so that no sharp corners or notches exist which can cause stress risers. Ground surfaces must blend into unground surfaces with smooth radii. Do not grind away excessive material or the block will be weakened.

The letter "C" should be steel stamped on the upper right hand corner of the oil cooler cover if the block is ground.



Using Dye penetrates to locate Cracks

After cleaning defective area, apply dye penetrant, allow time for it to enter into the defect; do not “force” dry. Apply developer so that defect will stand out. Caution must be observed as area may be a non-damaging forging lap.

Corrosion

Corrosion normally occurs at areas of the block nearest the cylinder liners and is shown by pitting. Discard block if the area can not be cleaned, or if the area is distorted and cannot be repaired by sleeving as described under “parts Replacement and Repair” following.

Camshaft Bushings

Use micrometers or dial bore gauge to measure the cam shaft bushing inside diameter. Fig. 1-1. Mark the bushings for replacement if worn larger than “Worn Limit” (Table 1-1) (1) or are chipped, or scratched. If the bushings have turned in the bore, check the bore size ; see table 1-1 (1). If bushing replacement is necessary, see parts Replacement and Repair”.

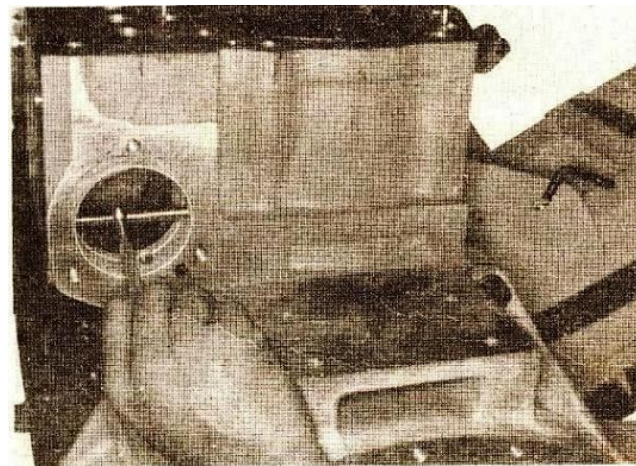


Fig. 1-1. Measure camshaft bushing

Cylinder Liner Counter bore

- a. There have been six liner and block configurations since this engine was introduced. Not all liners are interchangeable in between the different vintage block assemblies. Before taking any counter bore measurements, determine what vintage block assembly you have b referencing to the engine serial number or the cast part number on the side of the block. Table 1-1, ref. number (2) lists the engine serial number ranges and critical dimensions of the six liner and block configurations.

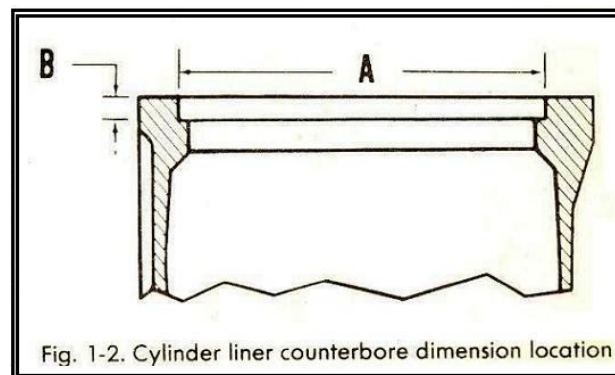


Fig. 1-2. Cylinder liner counterbore dimension location

- b. Inspect the upper liner counter bore and remove the sharp edges and dirt so that the liner will enter without distortion (A, Fig. 1-2). If the counter bore exceeds limits listed in Group 18, mark the blocks for counter bore repair. The counter bore edge must be smooth and perpendicular with the liner bore to within 0.005 inch (0.13 mm) total indicator reading. Use a straight edge to check the flatness of the top of the block. Refer to "Top Surface Refinishing".
- c. Check the counter bore depth so the installed liner will be assembled to the correct protrusion and to determine if a refinish of the counter bore surface is necessary. Depth of the counter bore on a few block is listed in Group 18. IF worn to or beyond limit, the cylinder block may be salvaged. If worn less than the worn limit, the surface can be refinished and shims installed under the cylinder liner to restore the proper protrusion.
- d. Installed cylinder liners must protrude 0.003 to 0.006 inch (0.08 to 0.15 mm) above the block. To check for proper protrusion without installing liner:
 - i. Measure the liner flange, outside bead with a micrometer. DO not include the bead on top of the liner flange in taking the measurement. Fig. 1-3.

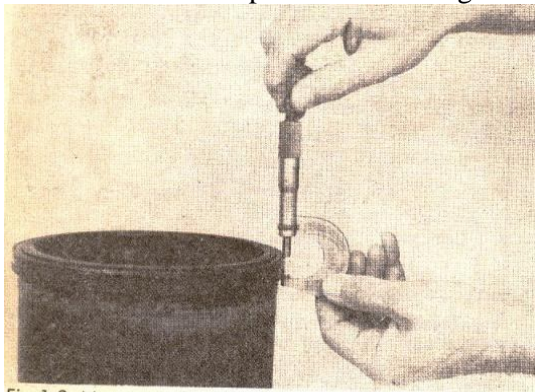


Fig. 1-3. Measuring liner flange

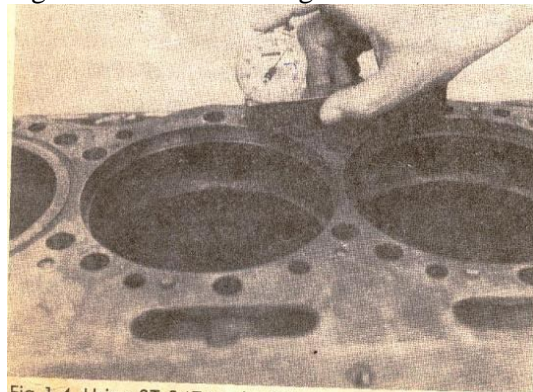


Fig. 1-4. Using ST-547 to check liner counterbore depth

- ii. Measure the block counter bore depth with a dial indicator depth gauge or ST – 547 Gauge block. Always measure the counter bore depth on the ledge at the edge of liner bore. Fig. 1-4.
 - iii. Check the depth at four equidistant locations. The edge must not be "cupped" more than 0.0014 inch (0.036 mm). The depth must not vary more than 0.001 inch (0.03 mm) throughout the counter bore circumference.
 - iv. The counter bore must always be resurfaced if it slants downwards towards the center or if the dimensions do not meet the standards. See "Parts Replacement and Repair".
 - v. Subtract the counter bore depth from the liner flange thickness to determine the amount of the shims and depth of the counter bore cut that must be used to provide 0.003" to 0.006" (0.08 to 0.15 mm) liner protrusion; 0.007" (0.18 mm) shims are thinnest available.
- e. The most accurate method of checking protrusions is as follows:
 - i. Install the liner in the block with the proper number of liner shims beneath the flange. Shims are available from 0.007" to 0.031" (0.18 to 0.7 mm). Use ST-1267 Cylinder Liner Hold-Down Tool. Tool should be spaced so even load will be applied. Torque to 50 ft-lbs (68 Nm).
 - ii. Use a ST-547 Gauge Block and check the liner protrusion above the cylinder block at four equidistant points outside the bead. Fig. 1-5 Add or remove shims

from beneath the liner flange as needed to reach 0.003" to 0.006" (0.08 to 0.15 mm) protrusion.

- iii. With the liner installed, check for out-of round as described under "Install Liner in Block", Group 14.

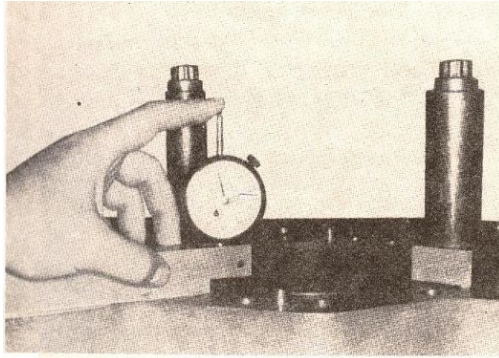


Fig. 1-5. Checking the liner protrusion

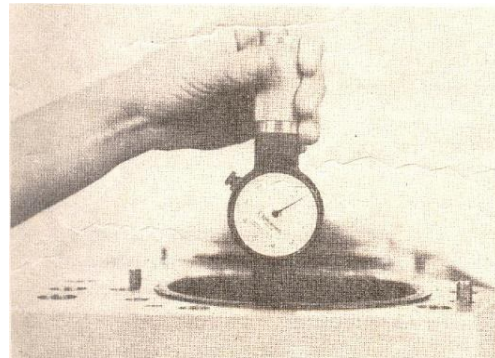


Fig. 1-6. Check the liner for out-of-round

Cylinder Liner Lower Bore

1. Install a new cylinder liner into the block, without packing rings or crevice seal.
2. Clearance between the liner and block should be as listed, but liner contact with the block is permissible as long as it does not cause liner out-of-round. Fig. 1-6
3. If clearance do not fall within limits, recheck after counter boring; limits do not apply with cylinder head installed and tightened to operating torque. Check the lower block packing ring bore inside diameter. Fig.1-7.
4. The common center of the lower liner bore should be measured with a ST-1252. If a piston seizure has occurred or after counter boring the cylinder block, measure the common centers of the counter bore to lower cylinder liner bore. Follow service tool instructions. The liner bore should be centered within 0.005" (0.13 mm) total indicator reading.

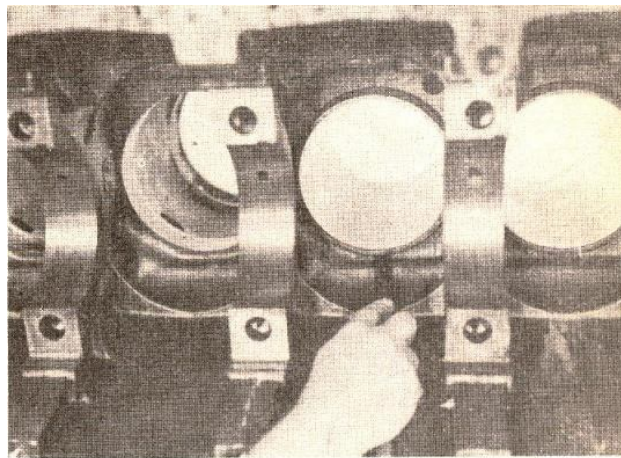


Fig. 1-7. Check the liner to block clearance

Main Bearing Caps

Caps are press fit in block with no clearance permitted. Machined areas of cap must meet like areas of the block to prevent distortion during tightening. Replacement caps are available as service parts.

Main Bearing Bore

1. Assemble the main bearing caps to block in operating position. Tighten the cap screws to the operating tension. See Table in Group (P) Wear Limits, Specifications and Torque.
2. Measure the main bearing bores vertically and then every 45 degrees with the dial bore gauge. (Fig 1-8) or inside micrometers properly adjusted.
The ST-1177 Boring Tool can also be used to check the main bearing bore alignment; see Service Tool Instructions. If it is definitely determined that a main bearing has been distorted, mark the block for reaming.

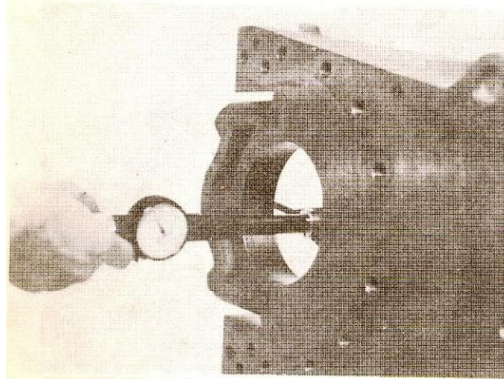


Fig. 1-8. Check the main bearing bore

Water Passages

1. Inspect all the cylinder block water passages to see they are open. Also check for eroded water holes, which will prevent seating of the head gasket or grommet retainers.
2. Water holes not eroded more than 1/16 inch (1.59 mm) from the edge of the hold can be sleeved.
3. Check for erosion within 1/32" to 3/32" (0.79 to 2.38 mm) from the liner counter bore. A maximum of 0.010" (0.25 mm) material can be removed.

Parts Replacement & Repair**Camshaft Bushing Replacement**

No repair work may be performed on the camshaft bushings. The bushings may be removed and installed with a ST-1228 Camshaft Bushing Driver Kit. Drive in the bushings so the oil holes in the block are aligned. Fig. 1-9.

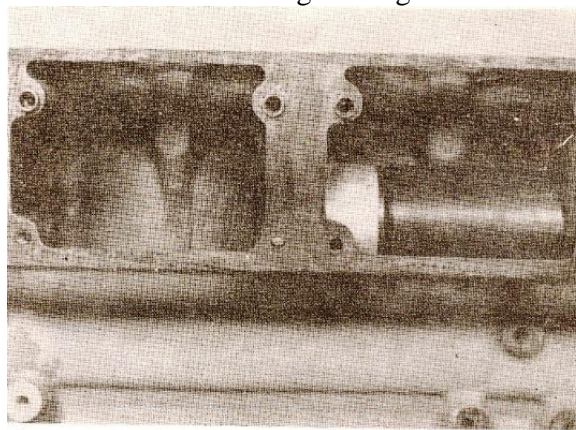
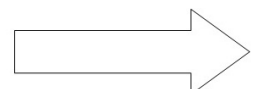
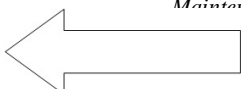


Fig. 1-9. Install the camshaft bushing



Main Bearing Cap Replacement

1. Replacement main bearing caps have 0.015" (0.38 mm) additional material in the bore. Other dimensions are the same as finished main bearing caps. Number six placement cap does not have cap-to-block dowel holes and must be machined to match the block.
2. Semi-finished main bearing caps provide 0.002" to 0.005" (0.05 to 0.13 mm) pressed fit in the block.
3. When the cap is Number Six.

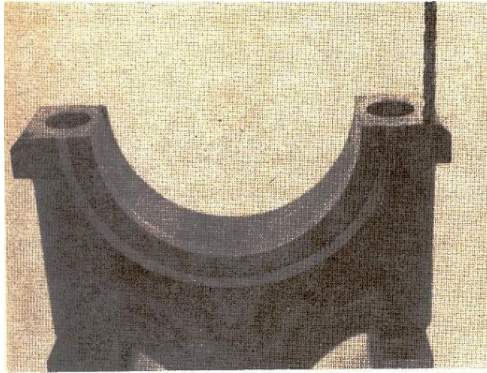


Fig. 1-10. Drill the main bearing cap dowel hole

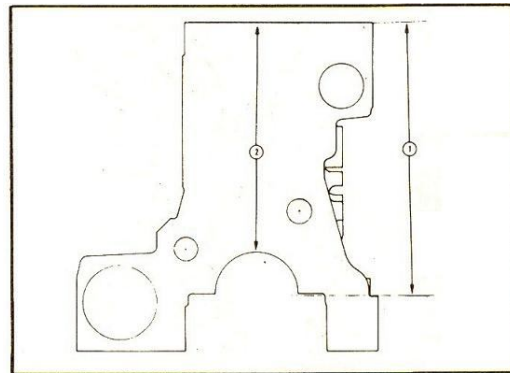


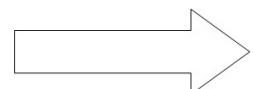
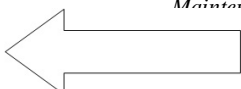
Fig. 1-11. Cylinder block height checking location

- i. Remove the dowels from the block. Locate the cap so that the thrust faces of the cap and block are even. Use blueing on the block surface to locate the dowel holes in the cap.
 - ii. Remove the cap. Drill dowel holes. Fig. 1-10. Install the cap and ream the dowel holes to the smallest available over size. Install the dowels in the block.
4. Install all caps on the block and ream the bore as described in Service Tool Instructions.

Top Surface Machining

If necessary, a cylinder block can be repaired by removing a maximum of 0.010" (0.25 mm) of material from the top surface.

1. Use a milling machine or large surface grinder. Locate the block on the main bearing pads.
2. Use ST-1134 Dowel Pin Extractor to remove the dowels from the head mounting surface. Make cuts of 0.001" to 0.003" (0.03 to 0.08 mm) deep. Remove only enough material to make the block usable.
3. Measure the distance from centerline of main bearing bore (1, Fig. 1-11) to the top of the block. See Table 1-1 (3).
 1. Find the dimension by positioning the block, top down, on a surface plate and measuring from the main bearing bore center line to the plate.
 2. Another method is to measure the distance from the installed main bearing bore alignment tool to the top surface of the block (2, Fig. 1-11).
 3. The distance from the head surface to the main bearing bore center line must be within 0.002" (0.05 mm) throughout the length of the block. Head surface flatness must be within 0.002" (0.05 mm).
 4. Machine the surface to a smoothness of 125 R.M.S.
 5. Machine the counter bore to correct the liner protrusion. Inspect for liner to block contact in the crevice seal area.



Machine Cylinder Block Lower Bore

Liner Chamfer

If the lower bore of the liner lower bore chamfer is beyond the tolerances, or damaged by corrosion, one of the following operations can be performed to salvage the cylinder block.

If the corrosion damage has occurred only on the chamfer and not in the packing ring drive sealing area, the chamfer can be corrected by the use of a plastic steel material such as Devcon Plastic Steel, Type "A". The manufacturer's instructions are to be followed for this procedure. Check the chamfer depth after this operation and machine the chamfer if beyond acceptable tolerances.

Cylinder Liner Counter bore

Machine the correct counter bore to the correct liner protrusion if the block has been resurfaced, or the ledge is uneven.

Inspection

1. Check for cracks in the cylinder liners just under the top flange, at bottom of the liner, or above the top seal ring groove as follows:
 - a. Magnetic Method
 - b. Dye Method
 2. Discard any liner with corrosion 1/16" (1.59 mm) deep or more, or if marks or defects on under side of liner flange cannot be removed by lapping.
- Measure the worn liners with a dial bore gauge. Replace if worn more than the Worn Limit as shown in Table 1-1(5).

Cleaning

Liners must be cleaned with solvent, steam or hot soap and water. The cleaning operation is to be finished by cleaning the bore with a bristle brush to remove as much foreign material as possible. Dry the liners with compressed air. Lubricate the bore of the liners with lubricating oil. Let the liners stand five or ten minutes. Use white cloths to clean lubricating oil from the liner bores. Note gray and even black material that is left with oil on white cloths. Repeat the application of lubricating oil and clean again with white cloths.

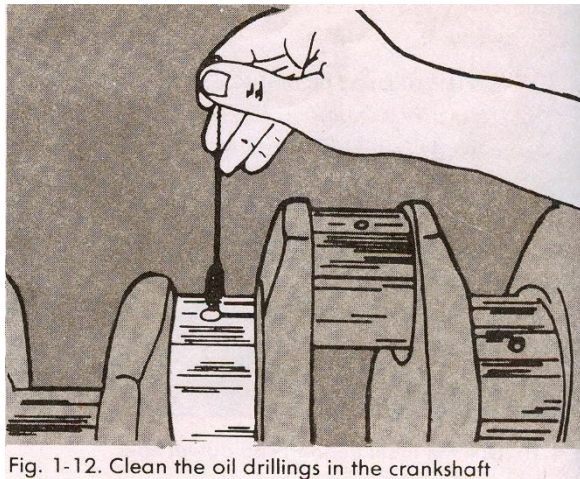


Fig. 1-12. Clean the oil drillings in the crankshaft

Crankshaft

Clean and drilled oil passages in the crankshaft with a bristle-brush. Fig. 1-12

Disassembly and Inspection

1. If the crank shaft gear is chipped, cracked, or worn, replace the gear.

Note: If the crankshaft gear condition meets requirements, do not remove the gear.

2. Attach 3375076 Puller Jaw behind the crankshaft gear along with 3375075 Bridge Assembly.

Caution: The maximum torque is not to exceed 350 ft-lbs. (475 N-m). Apply heat as necessary to loosen the press fit of the gear if the torque exceeds 350 ft-lbs. (475 N-m). When heat is necessary to remove gear, discard the gear.

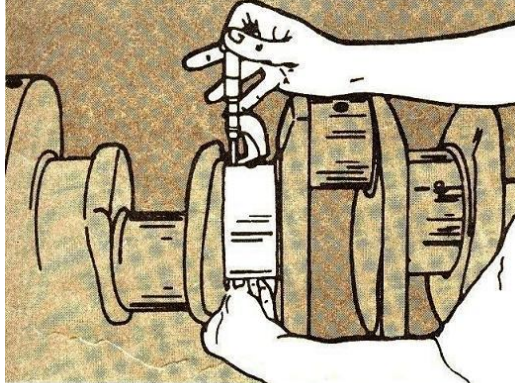


Fig. 1-13. Measure the crankshaft main journal

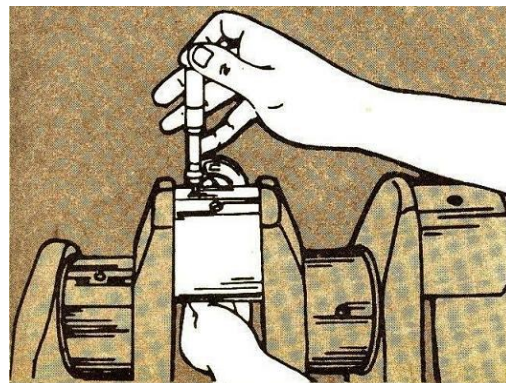


Fig. 1-14. Measure the crankshaft connecting rod journal

3. Check the crankshaft for scratches, cracks and wear pattern. Measure the crankshaft journals with micrometers See Fig's. 1-13 and 1-14 and Table 1-1(6).
4. Measure the crankshaft for out-of-round condition. End crankshaft journals are worn out of round more than 0.002" (0.05 mm).
5. Measure and check visually crankshaft thrust flange at Number Six main bearing. See Fig. 1-15 and Table 1-1. If the surfaces are damaged, regrind the crankshaft and install oversize thrust rings.
6. When regrinding crankshafts or when under size bearings and or/ oversized thrust rings are used, mark the crank shaft so that the correct bearing shells and thrust rings can be installed in correct position. Fig's. 1-16 and 1-17.
7. The marking for undersize rod and main bearings should be on the front counter weight, oversize thrust ring size on the rear counter weight. Both thrust ring size and ring must be included in markings as shown in Fig. 1-17.

For example: Front – Standard and rear – 0.010" (0.25 mm).

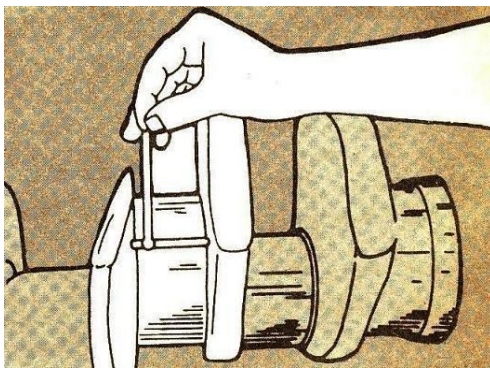


Fig. 1-15. Check the thrust flanges for wear

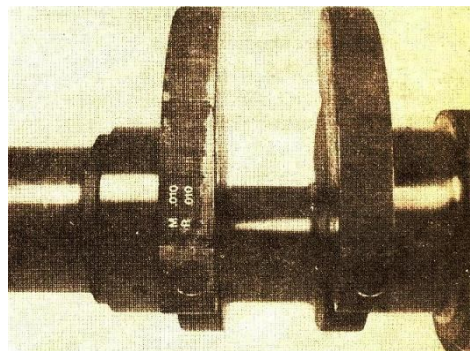


Fig. 1-16. Undersize main and connecting rod marking on the crankshaft

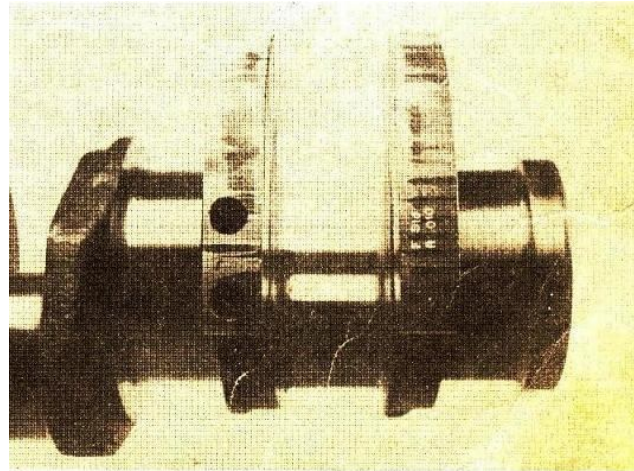


Fig. 1-17. Oversize thrust bearing mark on the crankshaft

Assembly

Installed the crankshaft gear, if removed.

Note: Check the parts catalog for the correct gear part number.

- i. Install the key in the shaft.
- ii. Heat the gear in an oven heated to 205 °C (400° F) for a minimum of one hour. Do not use a torch to heat the gear.
- iii. Lubricate the flange with high pressure grease and drive the gear on to the shaft with a piece of tubing.

Note: The engine timing marks on the gear face the front of the crankshaft.

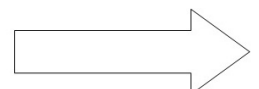
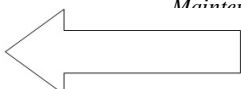
Bearings:

Main and connecting rod bearings (or shells) are two piece units. The upper main bearing shells contain oil holes for lubrication. Connecting rod bearing shells both contain oil holes for lubrication and are interchangeable. Thrust rings are used at the number Six main bearing.

Inspect Bearing Shells

1. Measure the shell with a ball point micrometer (Fig.1-18), dial indicator thickness gauge or comparator. Discard shells that are worn more than 0.001 inch (0.03 mm) or if chipped or otherwise damaged. See Table 1-1 (7-8) for thickness of standard shells.
2. The total worn maximum oil clearance is not to be more than 0.002" (0.05 mm) between main bearings. See Table 1-1 (7-8).

Note: Do not scrap bearing shells, fitted to increase oil clearances. A properly fitted bearing will look dull gray after a period of service, indicating it is running on an oil film. Bright spots indicate metal-to-metal contact and black spots indicate excessive clearance.



Crankshaft Thrust Rings

- a. The best measurement of wear on the crank shaft thrust rings is the crankshaft end clearance check. See “Engine Assembly” Group (M) & Table 1-1 (9-10), Fig.1-19.

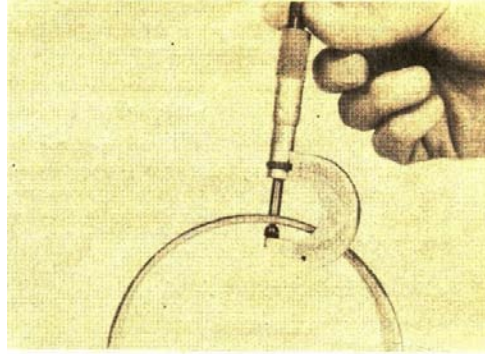


Fig. 1-18. Measure the bearing shell

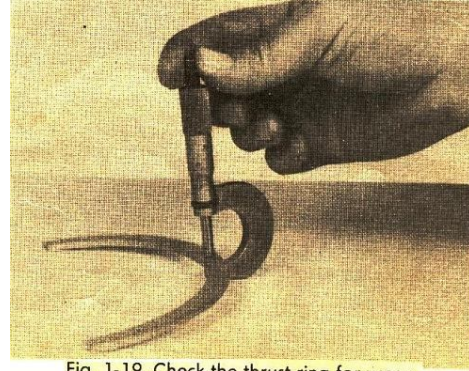


Fig. 1-19. Check the thrust ring for wear

- b. Oversize thrust rings are available. Use the same size (thickness) half-ring on both the upper and lower positions. Mark

Note: The maximum amount of wear on the thrust ring is figured by wear of the crankshaft surfaces with the crankshaft in a cylinder block, the crankshaft end clearance is not to exceed 0.021” (0.53 mm) at rebuild. Fig. 1-20.

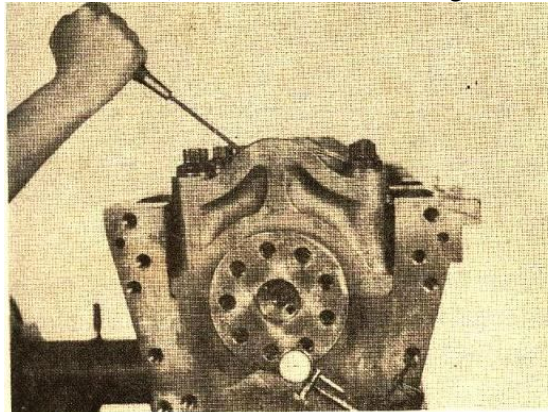


Fig. 1-20. Check the crankshaft end clearance

Vibration Dampers

Cleaning

- Rubber element dampers are to be cleaned in hot detergent soap and water.
- Viscous dampers are to be cleaned of rust, dirt or grease with a solvent cleaner.

If inspection shows dampers to be defective, install new dampers.

Rubber Element Damper

Rubber element dampers are metal units separated by rubber. The dampers are designed to protect the engine when the components are connected in a suitable manner.

- Inspect the damper for cracks, and the rubber member for cracks and weathering that will impair its effectiveness.
- Check for alignment of index marks on damper hub and inertia member. If out of alignment more than 1/16” (1.59 mm), discard the damper.
- Measure for run out on the inner edge of the inertia “Outer” member. Run out is not to exceed 0.005” (0.13 mm) per inch (25.4 mm) of radius. Discard the dampers

not meeting all the above specifications. See the Crankshaft flange and Vibration Damper Installation, Group 14.

Viscous Damper

- a. Check the damper for defects as in 1 & 2 Fig. 1-21. Discard if these defects show up.

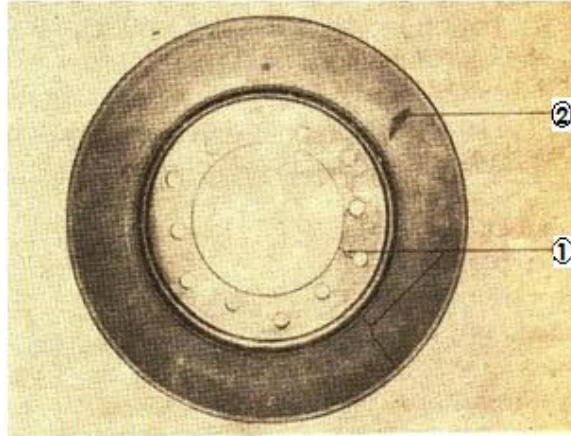


Fig.1-21. Inspect the viscous damper

- b. Spray the damper with dye penetrants, Type SKD-NF, or equivalent. Heat the damper in an oven heated to 200° F (93° C).
- c. Remove the damper from the oven and inspect for oil smudges or fluid leakage. If oil shows, discard the vibration damper.
- d. Remove paint, dirt and grit from the front and rear surface of damper in four (4) equally spaced areas. Clean the surface with paint solvent and fine emery cloth.
- e. Use a micrometer to measure and record the thickness of the dampers at the four areas cleaned in Step 'e'. Take a reading approximately 0.125" (3.18 mm) from the outside edge of the front cover plate.
- f. Replace the damper if the difference of the four readings exceeds 0.010" (0.25 mm).

Vibration Damper Mounting Flange

1. Check the damper mounting capscrew hole threads.
2. Maximum run out of the mounting flange, measured on the outside diameter of pilot, is not to exceed 0.004" (0.10 mm) total indicator reading. Face of the flange, measured at 2-3/4" (69.85 mm) radius, is not to exceed 0.003" (0.08 mm). The above readings are to be taken after assembly to the engine. The crankshaft must be kept to the front or rear thrust limit while the face is checked.

Connecting Rods

Inspection

1. Inspect all connecting rods, caps and bolts with magnetic flux crack detecting tool.
- Note:** Rod and cap are to be kept mated at all times.
- i. Check rods for cracks with 1800 ampere current AC equipment or 1500 ampere current DC or rectified AC equipment longitudinally between plates.
 - ii. Check the rods for cracks with 300 to 3400 ampere-turns with the AC equipment or 2600 to 2800 ampere-turns with DC or rectified AC equipment in a coil. Give special attention to the shaded critical areas shown in Fig. 1-22.

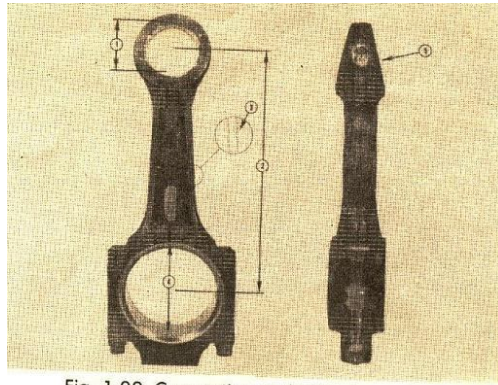


Fig. 1-22. Connecting rod critical areas

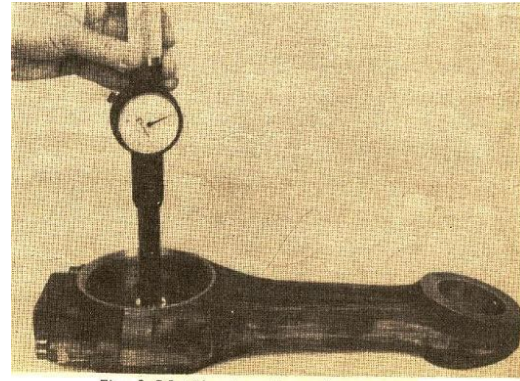


Fig. 1-23. Check rod crankpin bore

Note: Ampere turns are the amperage flowing through the coil, multiplied by the number of turns in the coil. Most coil contain four turns. Only 700 amperes need to be applied with DC equipment, or 850 amperes with AC equipments.

- iii. Apply one and one-half percent wet solution while the current is on. Visually inspect after each application of current.
2. Assemble the cap to the rod with the ring dowels in position and tighten the bolts to the torque described in Table 1-1.
3. Measure the crankpin bore with a dial bore gauge or inside micrometer Fig. 1-23.
 - i. The bore diameter must be within 4.2520" to 4.2535" (108.00 to 108.038 mm) up to thirty degrees on either side of the parting line. Fig. 1-24.
 - ii. The bore diameter must be within 4.2517" to 4.2527" (107.993 to 108.018 mm) beyond 30 degrees on either side of the parting line.
 - iii. If the limits are not met, the rod must be replaced.
4. Measure the piston pin bushing diameter with the dial bore gauge. See Table 1-1 (1.1) Fig. 1-25.
5. Use ST-561 Checking Fixture and ST-1305 Locating Mandrel to check rod alignment.
6. Scrap a rod with defects in excess of 1/32" (0.80 mm) deep on the "I" beam.

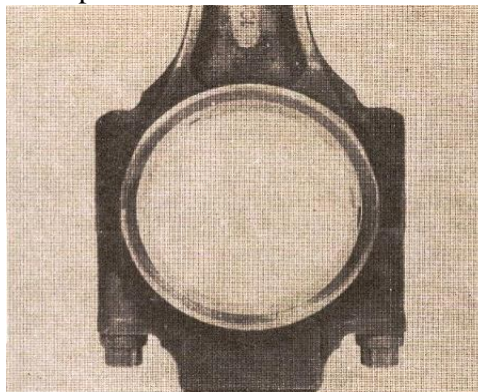


Fig. 1-24. Connecting rod wear limits



Fig. 1-25. Check the piston pin bushing in the rod

Calibrate ST-561 Checking Fixture for Rod Size

1. Select a new rod that has been measured for correct absolute center to center length, 11.406" (289.71 mm) between centers. New production rods measurement are from 11.405 to 11.407" (289.69 to 289.74 mm).
2. Assemble the cap to the rod as described in Step 2 under inspection.
3. Install the piston pin, from the ST-1305 Locating Mandrel Set, into piston pin bore. Install and tighten, expanding the arbor into the crankpin bore.

Caution: The expanding arbor must be installed with locking pin down and on center line of rod.

4. With rod in fixture, set the dial holder so the dials indicate on the piston pin. Turn dial indicators to zero (0).
5. Lift the rod, arbor and pin assembly from the fixture; turn horizontally 180 degrees; reinstall into the fixture. Adjust the dial indicators to divide the difference between the first and second readings. The fixtures is now calibrated.

Measure rod Bend, Twist and Center to Center Distance.

1. Measurement read directly from the dial indicator compare the length and alignment of bores. Measurements apply with or without bushing installed.
2. Assemble the ST-1305 Locating Mandrel into the rod to be checked. Put the rod on the fixture. Be sure the pin of the mandrel is down and in locked position with the center line of the rod.
3. Take center to center readings for length (compared to length set up on calibration of fixture) and alignment of bores (difference in reading from one indicator to other).
4. Rotate the rod 180 degrees. The reading must not exceed 0.008" (0.20 mm) when the connecting rod does not contain a bushing or 0.0015" (0.038 mm) with the bushing installed and bored to size. Center to center distance must be 11.405" (289.687 mm) to 11.407" (289.737 mm).
5. Measure the rod twist with a thickness gauge between the piston pin and dial holding plate. When measuring the connecting rod twist in a ST-561 and the rod does not contain the piston pin bushing, the twist must not exceed 0.001" (0.10 mm) with the bushing in place and bore to size Fig. 1-27.

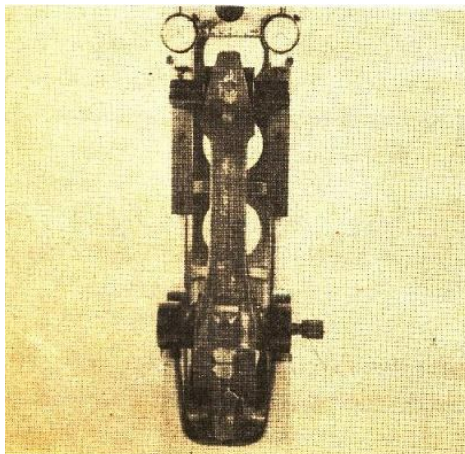


Fig. 1-26. Measure the connecting rod bend

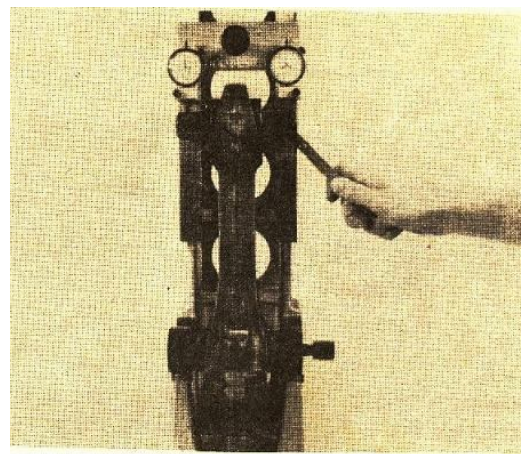
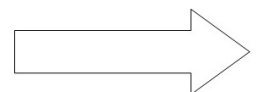
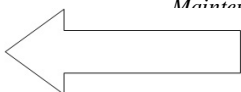


Fig. 1-27. Measure the connecting rod twist

Inspect the Bolts, Bolt Pads and Ring Dowels

- a. If the connecting rod bolts have been tightened excessively, they may be permanently stretched, if so they are to be discarded. Discard the bolts if the smallest diameter is less than listed in the specifications. Fig. 1-28.
- b. Discard all bolts that have distorted threads.
- c. Inspect the bolts pad radius. See 1, Fig. 1-29 for damage.
- d. Remove the ring dowels, if damaged Fig.1-30.



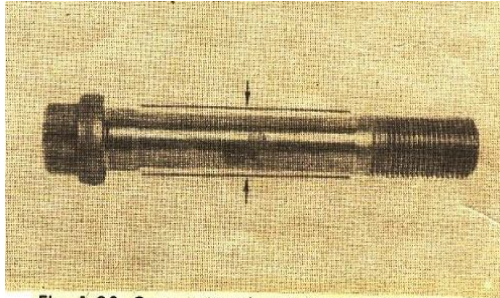


Fig. 1-28. Connecting the rod bolt dimensions

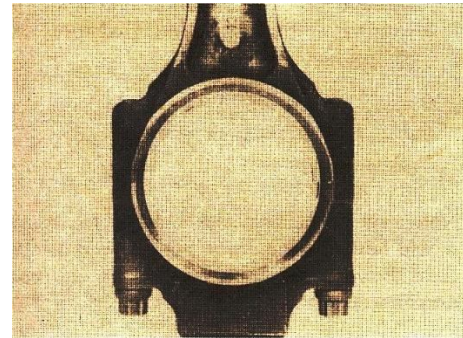
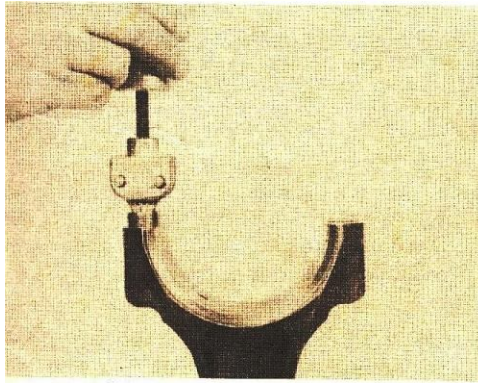


Fig. 1-29. Connecting the rod bolt pad radius



1-30. Pull the connecting rod ring down

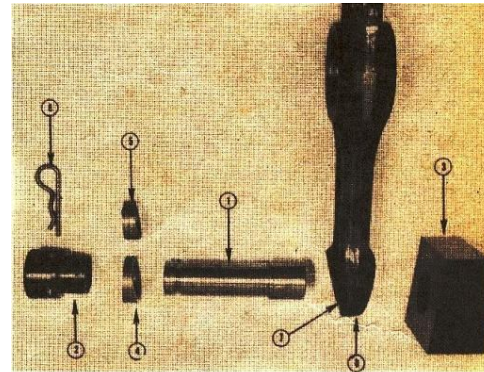


Fig. 1-31. Piston pin and bushing mandrel set

Repair

Cap Fillet and Rod Repair

- A dimension of 0.020" to 0.025" (0.51 to 0.64 mm) (Fig. 1-29) fillet radius must be present at all corners where the cap is machined for the bolt head. The maximum 1/16" (1.59 mm) depth of the metal may be machined off the pad to restore the radius. Polish the fillet to 16 M.U.AA.
- Remove damage areas in the rod which are less than 1/16" (1.59 mm) deep by grinding or filling with a half-round file. The radius must be 1/2" (12.7 mm) or more. Blend radius at the ends of the cut. Discard the rod if the damage is deeper than 1/16" (1.59 mm) (Fig. 1-22).
- Replace the ring dowels, if removed.

Replace Piston Pin Bushing

- Use the ST-1285 Mandrel to remove worn bushing (Fig.1-31). Remove the tool.
- To install the standard size bushing (7) in rod: assemble the bushing (7) on the mandrel (1) position sleeve (4), then the cup (2) on the mandrel (1). Hold in position with the locking pin (6).
- Put the connecting rod on the block (3) and support it in horizontal position.
- Install the mandrel with all the components listed in step 2 into the connecting rod bushing bore.
- Align the sleeve (4) with the middle of the boss on the rod.

Note: Line up the oil holes in the bushing.

- Use on arbor press to install the bushing into the bore until the sleeve (4) contacts the side of the rod pin boss.

7. To install thick-wall bushings in the rods which have been sized at cap end, install by the same method as described in Steps 2 through 6 above.

Bore Rod Piston Pin Bushing End

1. Fill the lubricating holes with soap to keep out the shavings.
2. Position the connecting rod on the ST-526 Boring Machine.

Note: The lower mandrel is to have only the two horizontal blades

3. Follow the instruction book kept with ST – 526 for the operating instruction.
4. Bore the bushing to 2.401” to 2.4015” (60.98 to 60.993 mm) inside diameter. Remove the rod from the ST – 526 & measure with the dial bore gauge. Fig. 1-32.

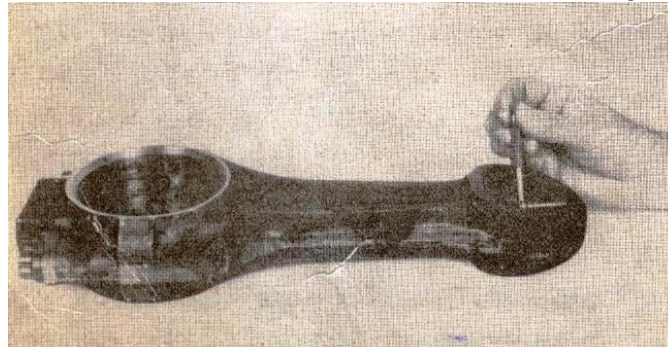


Fig. 1-32. Miking the piston pin bushing

5. Remove the sharp edge with a scraper. Remove foreign material and soap by washing in mineral spirits and dry with compressed air.
6. Compare all dimensions on the reconditioned rods on the ST-561. Checking fixture as described.

Note: All connecting rods used in engine should have the same part number and number code. Never attempt to interchange cap from another rod.

Chamfer Piston Pin Bore

1. The ST-861 Chamfering Tool is used to chamfer the piston pin bushing bore, if required.
2. Install the proper bushing tool by use of a flathead screw.
3. Adjust the guide screw holder into position. There are three notches, so that guide screw will follow the face of the bore.
4. Adjust the tool bit until the point just clears the guide screw and tighten in position with the two set screws.
5. Install the unit into the bore and adjust the guide screw until the tool bit just engages the bore.

Note: A slight pressure is required against the guide screw. Tighten the set screw in the end of the holder against the guide screw.

6. Use the drive ratchet to turn the tool one complete turn to clean the edge of the bore.
7. Loosen the guide screw and again turn the tool one or more complete turns to give a clean cut.

Note: Repeat until a uniform chamfer of 0.020 to 0.030" (0.508 to 0.772 mm) depth is reached.

8. Remove the tool from the bore. Turn the rod over and chamfer the other side of the bore with both sides chamfered, remove the tool.
9. Use entry cloth to remove sharp edges which may have been left on the chamfer. Wash the rod before installing the bushing.

Piston Rings

New rings are to be measured in the cylinder liner in which they are to be used to make sure the end gaps are correct.

1. Install each ring in to the cylinder liner. Position the ring with the head of the piston so it seats horizontally in the ring area of the liner.
2. Measure the ring gap with a feeler gauge. The gap is to be within the limits listed in Table-1-1 (13). Fig. 1-33.
3. Never fill or alter the end gap of the chrome-plated rings and never use chrome-plated rings in chrome-plated cylinder liner.
4. Check the parts catalogs to be sure of the proper ring/ piston combination.

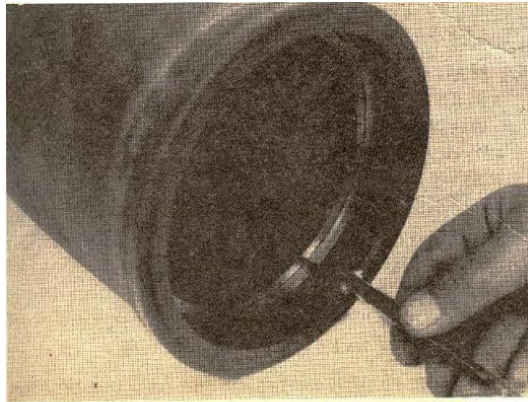


Fig. 1-33. Measure the piston ring gap in the liner

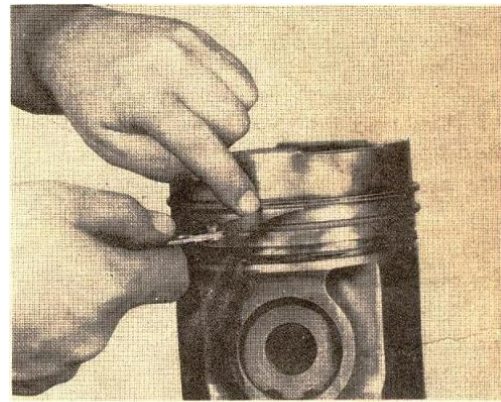


Fig. 1-34. Check the piston ring groove for wear

Piston

Inspection

1. Measure the top and second ring grooves with a new ring and feeler gauge.
1. Hold the ring in the groove, even with the side of piston, and insert a 0.006" (0.15 mm) feeler gauge. Fig. 1-34.
2. If the gauge enters the groove without forcing or disengaging the ring, the wear is excessive and the piston is not to be used.
2. Measure the piston skirt diameter with a micrometer at a right angle to the piston pin bore. Piston are not be used if worn more than 6.235" (158.37 mm). Fig. 1-35.
3. Piston should be measured at a temperature of 70 to 90°F (21 to 32°C). After measuring the piston and comparing it with the liner inside diameter, the piston-to-liner clearance may be computed if desired.

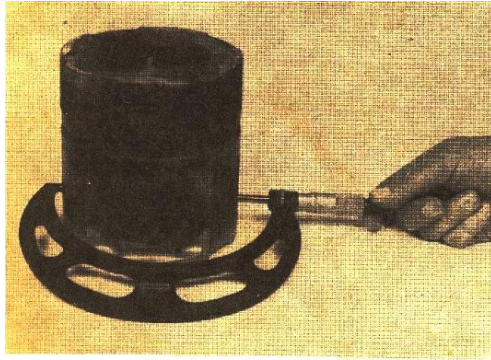


Fig. 1-35. Miking piston skirt



Fig. 1-36. Miking the piston pin bore in the piston

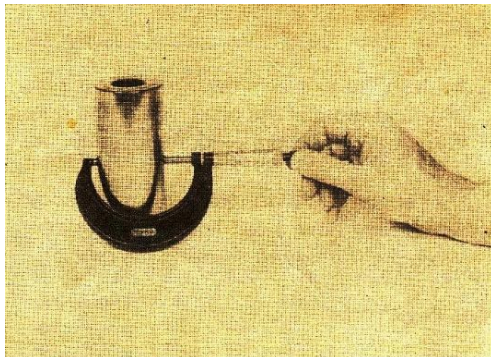


Fig. 1-37. Miking the piston pin

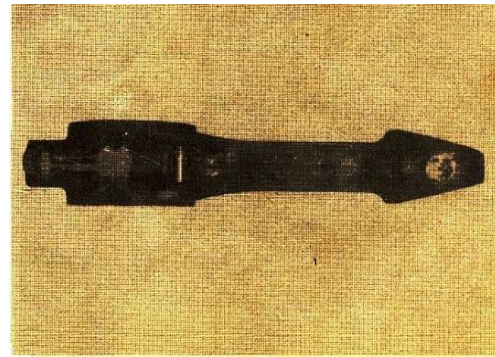


Fig. 1-38. Connecting rod and cap cylinder number

4. Measure the piston pin bore at 70°F (21°). It is to be within the limit given in Table 1-1, add 0.005 inch (0.013 mm) per 10°F (-12°) up to 90°F (32°C). Fig. 1-36.
5. Measure the piston pin outside diameter with a micrometer. Fig. 1-37. Pins are not to be used if out-of-round more than 0.001 inch (0.03 mm) or worn smaller than the figures given Table 1-1 (13). Boring of the piston pin bores and oversize pins are not done because the misalignment that results from such procedures will cause seizure of a piston or failure of connecting rod bearings.

Piston to Connecting Rod assembly

1. The pistons are machined to a very close eight tolerance. As long as the same part number piston is used throughout the engine, the weight does not affect engine operation.

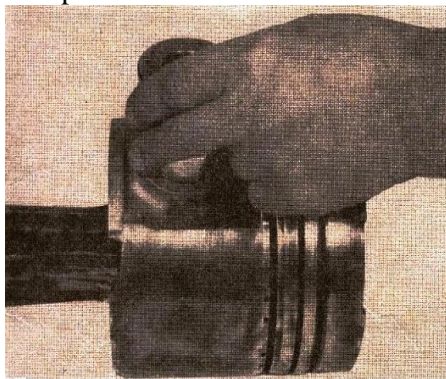


Fig. 1-39. Install the piston pin

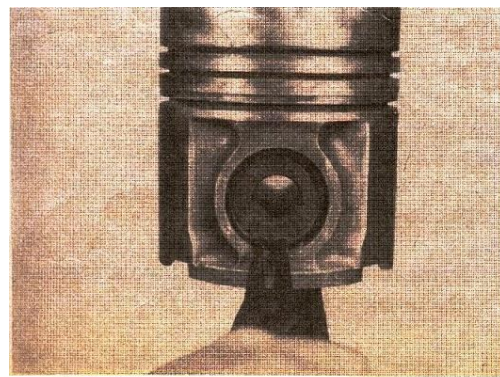
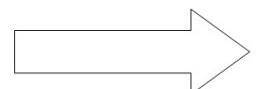
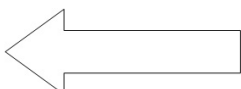


Fig. 1-40. Install the piston pin snap ring

2. Be sure the rod and cap are stamped with the cylinder number from which they were removed before disassembly to prevent mixing the parts. Fig. 1-38.



3. Install one piston pin retaining ring in to the groove of the piston pin bore.
4. Heat the aluminum pistons in boiling water or in an oven at or below 200°F (93°C) for approximately thirty minutes and install the pin through the piston and connecting rod pin bores before the piston cools. At 70°F (21°C) the pin fit is 0.0001" to - 0.0005" (0.003 to 0.013 mm) which prevent the pin assembly for fitting unless the piston is heated. Secure the pin with a second retaining ring in the groove at the opposite end of the pin bore Fig. 1-38 and Fig.1-40.

Caution: Never drive a piston pin into the pistons. Driving will cause distortion of the piston, causing piston seizure in the cylinder liner.

Rear Oil Seal

The rear seal is a unit which requires replacement of the "O" rings only. Damaged oil seal retainers require replacement by a new assembly.

Alignment during engine assembly is the biggest factor for correct performance of the rear seal unit. See Group 14.

Camshaft

Inspection

Measure the camshaft bushing journals with micrometers Fig. 1-41. Replace the camshaft if the journals are worn beyond the limits given in Table1-1 (14).

Replace the camshafts that have damaged or badly worn camshaft lobes. Check for possible cracks my magnetic inspection.

Cummins Engine Company, Inc. does not approve or grinding camshaft lobes.

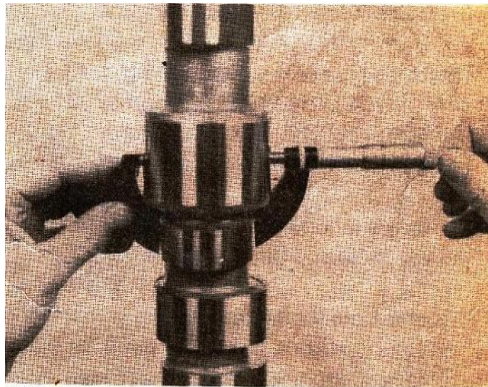


Fig. 1-41. Miking the camshaft journal

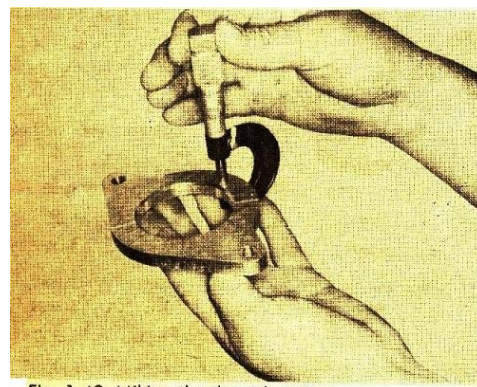


Fig. 1-42. Miking the thrust bearing

Camshaft Gear

- a. Remove the gear if the thrust bearing is scored or the gear is damaged or visibly worn. The gear is press-fit on to the camshaft.
- b. Press the camshaft from the gear. Remove the key. Lift off the thrust bearing.
- c. Use a micrometer to measure the thrust bearing for wear. Fig. 1-42. Replace if worn to less than 0.359" (9.12 mm).
- d. Heat the camshaft gear in an oven heated to 425°F (151°C) for a minimum of one hour.

Note: Do not use torch to heat the gear

- e. Note the type of key used. See Fig. 1-43. Key “A” advances the engine timing, key “B” is a straight key and key “C” retards engine timing.

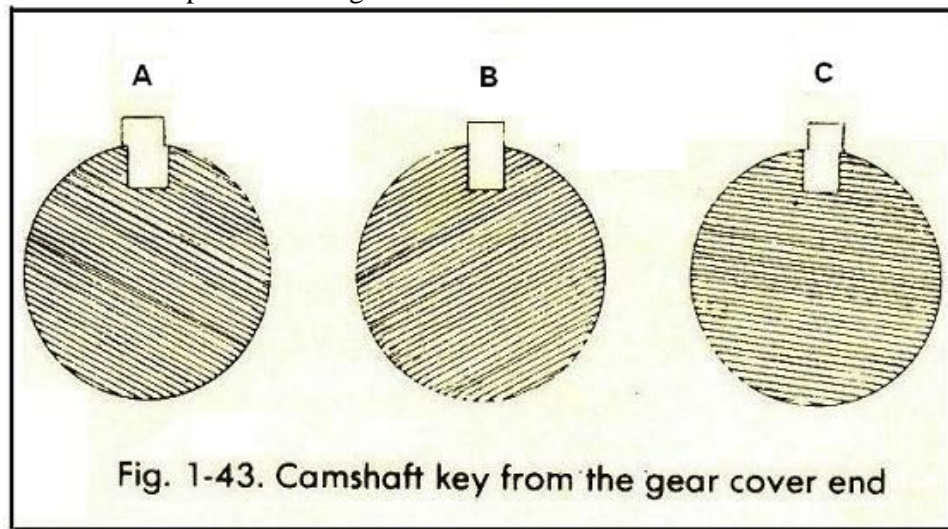
Note: The camshaft key part number is stamped on the key for identification purposes.

- f. Coat the camshaft thrust bearing with a high pressure lubricant. Install the thrust bearing on the camshaft.
- g. Coat the camshaft gear hub area with a high pressure lubricant.
- h. Place the camshaft into a press. Install a key in the camshaft. Install the camshaft gear while hot.

Note: Checking the timing when a new camshaft or gear is installed in an engine.

Gear Housing

1. Inspect for cracks, leaks or other damage. Repair as necessary.
2. Check the stud threads; replace if damaged.
3. Inspect the capscrew threads and repair with threads inserts, if the threads are damaged.
4. If the dowels are damaged, replace or ream out for the next over size.
5. The one piece gear cover requires a blind plug when the power steering plump is not used in the power steering shaft hole.



Gear Cover

Inspection

1. Remove and discard all oil seals. Measure the bushing for wear.
2. Check the cover for cracks, leaks or other damage; repair as necessary.

Note: Crank seal, water pump seal, accessory drive seal are to be installed after the cover has been assembled to the engine.

Drive Bore Bushings

- a. Measure the bore of alternator and accessory (fuel pump and compressor) drive. If worn larger than 1.571" (39.90 mm), replace.

- b. If either shaft is worn enough to use on oversize bore bushing (minimum clearance of 0.003" (0.08 mm) between shaft and bushing, use bushings as listed in Table 1-1 (16).
- c. Install the new bushing. (Use ST-598 Mandrel).
- d. Measure the bore of the hydraulic pump drive bushings; if worn larger than 1.506" (38.25 mm), replace.

Idler Gear and Shafts

1. Measure the bushing bore of the cam shaft and water pump idler gears; IF the bushing is worn larger than 1.8785" (47.714 mm), replace.

Note: All idler gear bushing must be precision bored after installation in gears. The gear and bushing must be concentric. See Table 1-1 (17).

2. Measure the camshaft and water pump idler gear shafts; replace if worn smaller than 1.872" (47.55 mm).
3. The camshaft and water pump idler gear thrust must be less than 0.018" (0.46 mm).
4. Replace the hydraulic pump idler shaft if worn smaller than 1.747" (44.37 mm).
5. Measure the hydraulic pump gear bushing. Replace if worn larger than 1.7535" (44.539 mm).
6. The hydraulic pump gear end thrust, when mounted on the engine, must be less than 0.022" (0.56 mm). Select oversize thrust bearings to bring gear end clearance between 0.009" to 0.018" (0.23 to 0.46 mm).
7. New idler gear thrust washers are 0.092" to 0.095" (2.34 to 2.41 mm). See the parts catalog for part numbers of oversize thrust washers. Discard the standard washers if worn thinner than 0.088" (2.23 mm).
8. Backlash on each gear of the front gear train is 0.003" to 0.013". Replace the gear if the backlash exceeds 0.020" (0.50 mm).

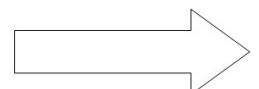
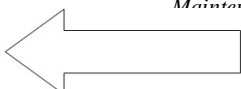
Service Tool Instructions

ST – 1252 Concentricity Gauge

Check the common centers of the cylinder liner counter bore to lower bore as follows:

1. Put the gauge flat on the top surface of the cylinder block with the pins against the counter bore inside diameter.
2. Raise or lower the shaft to the position indicator in the area of the lower bore to be checked.
3. Holding the gauge pins firmly against the counter bore inside diameter, turn the indicator to zero.
4. Release the pressure. Position the gauge again to check the indicator reading. Turn the indicator to zero if necessary.
5. Turn the gauge 180 degrees from the original setting position. Hold the pin against the counter bore inside diameter and record the indicator reading.
6. Move the gauge 90 degrees and repeat the procedure.

Note: indicator readings recorded are two times the actual shift of the bore. (Example: Indicator reading – 0.002" (0.05 mm). Actual shift from center of bore -0.001" (0.03 mm))



ST-1177 Main Bearing Boring Tool

The tool is designed for both the boring and checking functions. Before the boring operation, the tool and block are stabilized to room temperature.

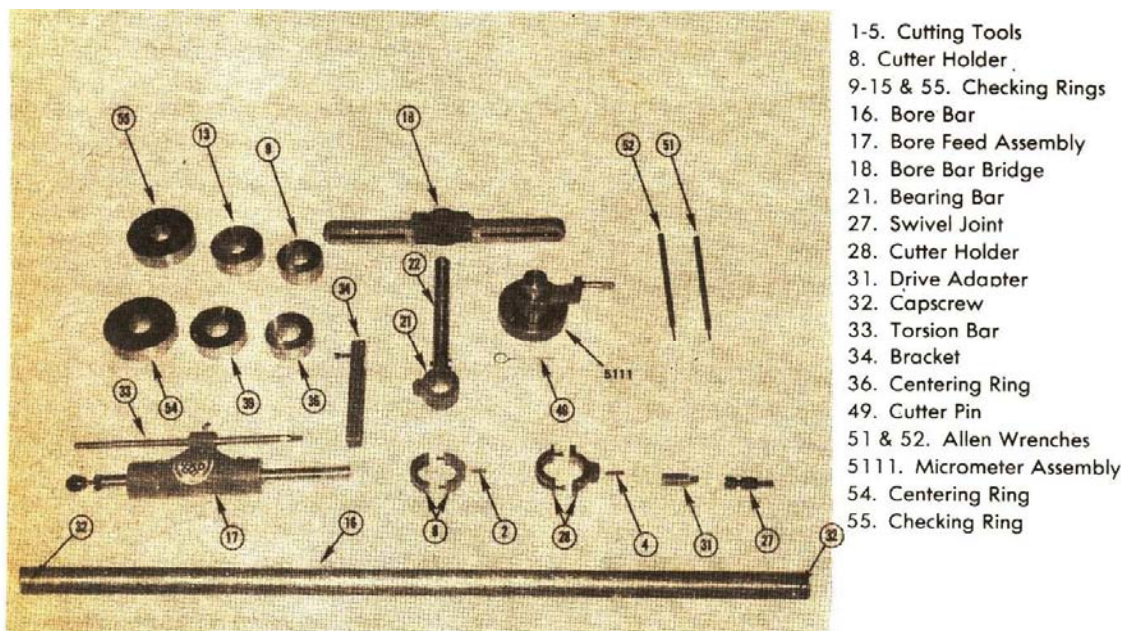


Fig. 1-44. Exploded view of the ST-1177 Boring Tool

Assembly to Block

- Remove two main bearing caps which are as close as possible to the end of the block and have not been damaged.
- Install the proper centering rings into two bores and strike the top of the centering ring with a plastic hammer in order to correctly position.
- Install the main bearing caps and tighten to the specification following the steps in table 1-1.

Note: If the centering ring must be installed in the journals which have had the caps replaced by semi-finished caps, limit the torque to 10 ft-lbs (14 N-m).

- Oil the centering ring bores and boring bar (ST – 1177 – 16 Fig. 1-44) through the centering rings rotating the bar slowly. The boring bar should spin free. Slide the boring bar out one end until the checking ring (ST-1177 -55) can be installed in the bar. Oil the outside diameter of the checking ring.
 - Use finger pressure against the checking ring on both sides of the boring bar to push the checking ring through each bore. The bar must be turned during this check.
- Check the bore for the sharp edges if the checking ring will not pass through the bore.
 - A 0.003" (0.08 mm) feeler gauge (not over ½" (12.70 mm) wide) can be used in detecting problems in the bore.
 - Attempt to insert a feeler gauge between the bore and slip ring. Run the gauge completely around the slip ring on each side of the bore. Evaluate as follows;
 - The gauge does not enter at any point, the boring bar rotates freely standard bore.
 - The gauge enter on one side and not on the opposite side – slight misalignment. No problem if the boring bar rotates freely.

3. The gauge is loose - oversize bore.
4. The gauge enters on the front and on the rear of the bore tapered bore.
- f. Mark the bores to be salvaged.

Assembling Micrometer Tool Bit Setting gauge and tool Bit

1. Install the micrometer base shaft (ST – 1177 – 46) through the bore of the micrometer bracket (ST-1177-45) and thread into the micrometer base (ST-1177-44) and tighten.
2. Tighten the socket head screw (ST – 1177 – 29) in the micrometer bracket until the bracket is tight on the micrometer base shaft. The micrometer hole in the micrometer bracket must be in alignment with the cutting tool hole in the micrometer base shaft.
3. Install the centering ring (ST-1177-54) over the micrometer base shaft and micrometer (ST-1177-5111):
 1. Adjust the micrometer thimble to the value stamped on the centering ring.
 2. Hold the micrometer spindle against the centering ring and tighten the socket head screw in the micrometer bracket. Check to see that the micrometer spindle turns freely.
4. Remove the centering ring and install the cutter holder over the micrometer shaft.
5. Align the tool bit hole in the cutter holder with the hole through the micrometer base shaft and tighten the cutter holder socket head screws. Scribed lines are used on the base shaft and cutter holder for this purpose. Keep even gaps between the two halves of the cutter holder.
6. Insert the cutting bit in the tool holder. The tool must be short enough so that it does not extend in to the bore of the tool holder. When adjusting the micrometer or tool cutter \, be careful with the tool to prevent damage.
7. with the cutter (ST – 1177 – 49), adjust the tool bit against the micrometer spindle and tighten the tool bit retaining screw in the cutter holder. Back of the micrometer and check the tool bit setting.

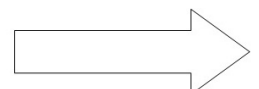
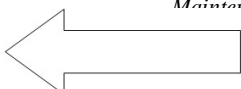
Note: Do not tighten the micrometer spindle against the tool bit point or carbide may be chipped. Do not sweep the micrometer spindle across the carbide cutter since it will chip the cutting edge.

8. Back of the micrometer and remove the cutter holder from the micrometer base shaft.

Cutting Bores

Note: Review the use of bridges before boring.

- a. Install the bore feed assembly (ST-1177-17) in one end of the boring bar and tighten the socket head screw.
- b. Install the torsion bar (ST-1177-33), threaded end first, through the bore feed assembly (ST-1177-17). Start the threads into the end hole of the torsion bracket (ST-1177-34). The float on the abr can be used to secure it to the bracket.
- c. Locate the tapped hole in the end of the block and secure the torsion bracket to the block with a suitable cap screw and washer.
- d. Pull out the plastic knob of the feed assembly until the pin is free of the slot and turn one fourth turn, then pull the complete feed assembly back all the way to the



- knob and tighten the wing set screw in the feed assembly to secure on the torsion bar.
- e. Install the square head set bolt in the second threaded hole of the torsion bracket end and tighten against the cylinder block to hold the torsion assembly.
 - f. Turn the plastic knob on drive assembly one fourth (1/4) turn until the pin seats in the groove.
 - g. Install the adaptor (ST-1177-31) in the other end of the boring bar with the ½ inch square drive out. Lock with the socket head set screw.
 - h. Lock the swivel joint (ST-1177-27) in a one half inch drill chuck. These instructions assume use of a right hand rotation drill.
 - i. Install the tool bit holder on the boring bar, next to the journal to be cut. When operating, the boring bar will feed towards the feed assembly. Make sure the tool bit cutting edge is turned in the direction of the drill rotation.
 - j. With the swivel joint on the boring bar adaptor, but the main bore. Keep the boring bar lubricated during all boring operation.

Caution: Do not use a drill of less than ten amperes or over 450 rpm.

- k. TO cut the next main bore:
 - (A) Remove the cutter holder from the boring bar.
 - (B) Pull out the plastic knob on the feed assembly and turn a one-fourth turn.
 - (C) Push in the feed shaft (the knob) until it stops against the feed assembly.
 - (D) Turn the plastic knob one-fourth turn, until the pin seats in the slot.
 - (E) Repeat Steps 9 and 10.
- l. Clean the block and measure the size of the bore with a dial bore gauge and alignment with the checking ring.

Use of the Bridges

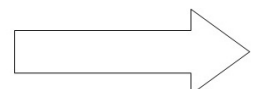
The bridges and borings are intended for additional support of the boring bar and are designed to compensate for any distortion of the block oil pan surface. It is not necessary to use bridges if the centering rings areequally apart.

For example : If Number One, Three, Four, Five or Seven main bores are to be bored and the centering rings are in Number Two and Six main bores, bridges are not necessary.

1. Assemble the bearing bar (ST-1166-22) on the boring bridges (ST-1177-21) with the hexagon head capscrew (ST-1177-23) finger tight.
2. Install the bearing over the boring bar at the point where the support is needed. Allow room for the cutter holder, if it is next to the bore being cut.
3. Lower the liner bore bridge (ST-1177-18) over the bearing bar and secure to the oil pan rails.
4. Tighten the socket head screw (ST-1177-25) in the bearing until the bearing is tight on the boring bar, do not over tighten.
5. Tighten the hexagon head capscrew (ST-1177-25) in bearing bar and socket head capscrew (ST-1177-19) in bridge.
6. Turn the boring bar to see that it is free.

Liner Counter bore Conversion Kits

The 3375820 liner counter bore conversion kit is for machining the KT/ KTA -1150 series engine cylinder liner counter bores to accept oversize service liners, Fig. 1-45.



This kit has been specifically design for use with the ST-1168 liner counter bore boring tool. Fig. 1-46.

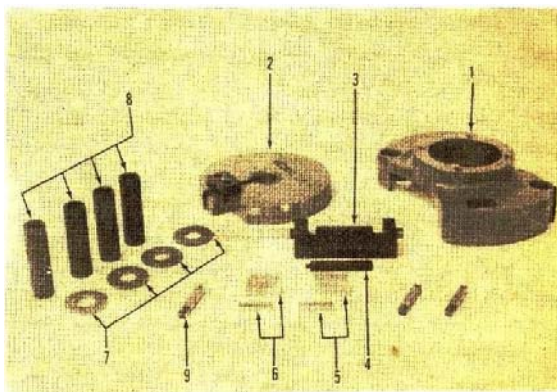
Machining the Counter bores

Determine the vintage of the block before an machining operation. Reference the engine serial number and/ or block part number included in Table 1-1.

Reference the service instructions that come with the 3375820 liner counter bore conversion kit and the ST-1168 boring tool for step by step instruction for their proper use. A quick tool reference has been included for each block and liner configuration listed in Table 1-1.

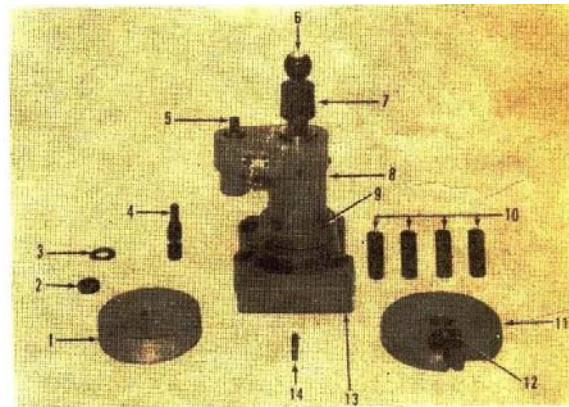
When machining the block for oversize liners, there is a possibility of contamination critical areas within the engine with cast iron cuttings. Keep this contamination to a minimum. Make sure every drilling, cavity and possibly journal surface is adequately protected before any machining takes place.

Before installing liners in the block, apply a 3/64 inch to 1/16 inch bead of Cummins sealant part No. 3801048 or its equivalent to the liner flange surface that comes in contact with the counter bore seat.



- | | |
|--|-----------------------|
| 1. Base Plate | 5. Depth Spacer Block |
| 2. Cutter Head (0.10 inch [0.75 mm] O/S Liner) | 6. Depth Spacer Block |
| 3. Tool Bit Setting Tool | 7. Spacer Pipes |
| 4. Master Set Block | 8. Washers |
| | 9. Tool Bits |

Fig. 1-45. 3375442 Liner Counterbore Conversion Kit



- | | |
|----------------------------|-----------------------|
| 1. Bushing Device | 8. Main Housing Assy. |
| 2. Jam Nut | 9. Capscrews |
| 3. Cutoff Washer | 10. Stud Adapters |
| 4. Universal Drive Adapter | 11. Cutter Plate |
| 5. Drive Shaft | 12. Capscrews |
| 6. Knob | 13. Base Plate |
| 7. Depth Collar | 14. Tool Bit |

Fig. 1-46. ST-1168 Liner Counterbore Boring Tool

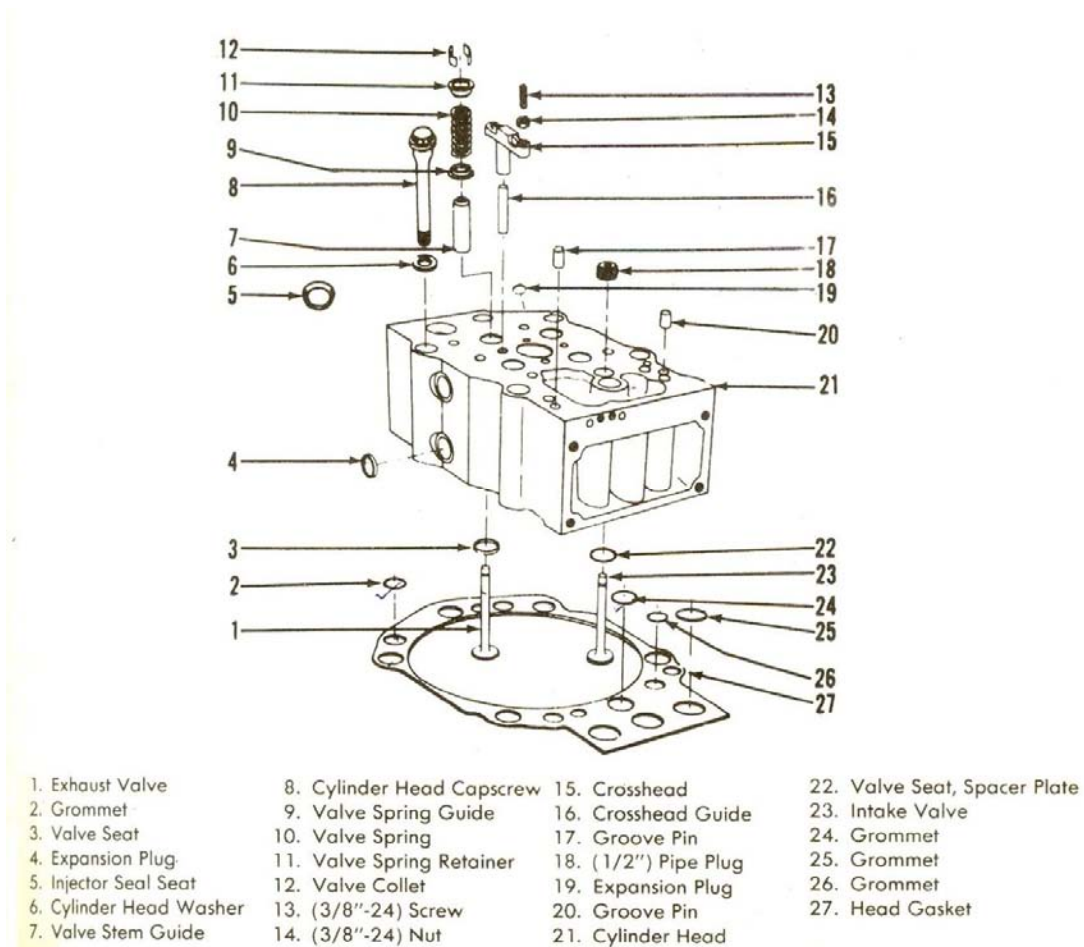
(C) Cylinder Head

This chapter covers inspection, repair and assembly of the cylinder head, valves and guides, crossheads and guides, valve seat inserts, spacer plates, injector seal seats and valve springs.

The following service tools or tools of comparable quality are necessary to repair or rebuild the cylinder heads as described in this section.

SNo.	Tool Name	Tool Number
Essential Service Tools		
1	Valve Seat Tool	ST-257
2	Valve Vacuum Tester	ST-1257-A or D
3	Valve Seat Insert Cutter Set	ST- 1310
4	Valve Guide Arbor Set	3375946
5	Valve Facing Machine	3376256
6	Valve Seat Grinding Machine	ST-685
7	Hydrostatic Tester	ST-1012
8	Hydrostatic Tester Base Plate	3375070
9	Dowel Pin Extractor	ST-1134
10	Valve Guide Driver (Tapered Top)	ST- 1265
11	Cup Plug Driver 0.7 60 Plug I.D	ST -1282
12	Cup Plug Driver 1.485 Plug I.D.	ST -1315
13	Valve Guide Driver (Flat Top) Valve Spring Tester	3375182
Desirable Service Tools		
1	Valve Spring Compressor Plate	3375043
2	Valve Spring Compressor	ST-448
3	Inj. Protrusion Gauge Block	ST- 547
4	Head Holding ,Fixture	ST- 583
5	Crosshead Guide Spacer	ST- 1264
6	Fuel Passage Cleaning Brush	ST- 876
7	Staking Tool Driver	ST-1122
8	Valve Seat Insert Staking Tool	ST-1288
9	Valve Seat Extractor	ST-1323
10	Magnetic Crack Detector	ST-1166
11	Injector Protrusion Comparator	3375155
12	Injector Seat Cutter Valve	3375369
13	Head Checking Tool (Exhaust)	3375939
14	Valve Head Checking Tool (In take)	3375940
Standard Tools		
1	0- 1 Micrometers	

2	Small Bore Gauge	
3	Vernier Depth Gauge	



Cylinder Head Disassembly and Testing

1. Use the ST-4481-6 (1, Fig. 2-2), 3375043 valve spring compressor to compress the valve springs. Remove the half collets (2), retainers springs, valve spring guides and valves. Fig. 2-3.

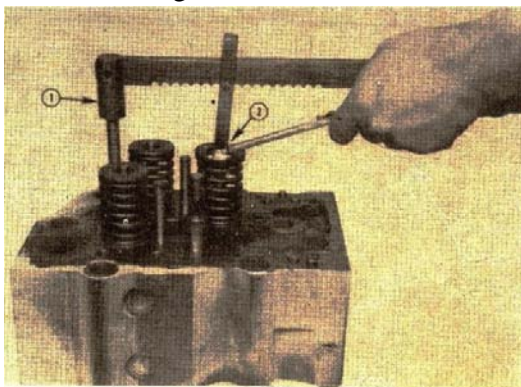


Fig. 2-2, Remove the valve springs

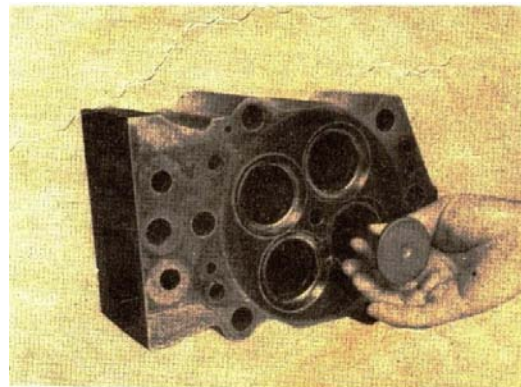


Fig. 2-3, Remove the valves

Note: A small magnet may be used as an aid in removing the half collets (2, Fig. 2-2).

2. Put the valves on a numbered valve rack for inspection.

Pressure Testing

1. Put the cylinder head in the ST-1012 Hydrostatic Tester and 3375070 Adapter Plate (Fig. 2-4).

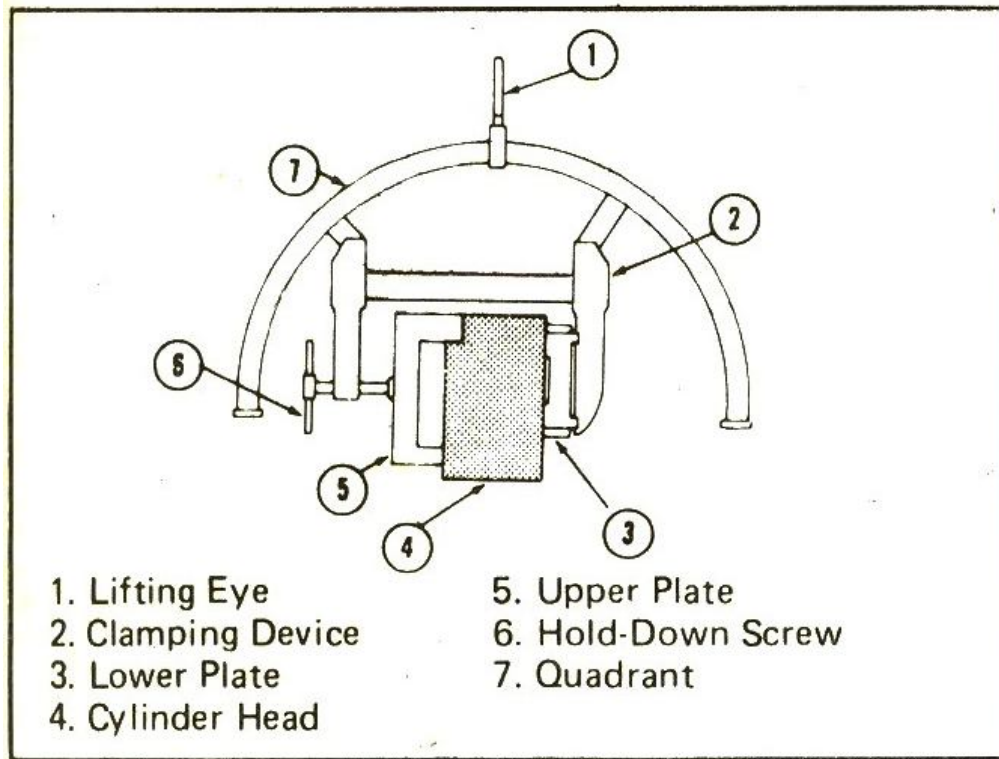


Fig. 2-4, Cylinder head installed in the ST-1012 Hydrostatic Tester

Air Test

- a. Use a hoist or another suitable lifting device to position the head and testing device over the water tank.
- b. Connect an air line with a coupler.
- c. Apply 30 to 40 psi [2.11 to 2.81 kg/sq cm] air pressure.
- d. Set the head in water deep enough to cover the head.
- e. Check carefully around the expansion plugs, valve seats and injector seal seat area for cracks.
- f. Discard the head if it is cracked.

Water Test

1. Test the cylinder head for leaks at 35 to 85 psi [2.46 to 5.98 kg/sq cm] water pressure with the water temperature at 180 to 200°F [82 to 93°C] if possible. Check

carefully around the valve seats and the injector seal seat area for cracks even when such cracks do not show water leakage. Discard the head if it is cracked.

2. Open the water outlet of test fixture. Check for free water flow through the cylinder head. If it is restricted, remove all the expansion plugs and pipe plugs. Clean the water jackets of deposits with alkaline or solvent type cleaners. To remove heavy deposits of lime, use acid-type cleaner.

Warning: The use of acid is dangerous to you personally and damaging to machinery. Always make available a tank of strong soda water as a neutralizing agent.

3. Clean the fuel passage with the ST-876 Brush. Flush the passages with the solvent to remove the deposits.

Magnetic Crack Detection

Use the ST - 1166 Magnetic Crack Detector to inspect the cylinder head for cracks in the valve and injector areas. Discard the head if cracked.

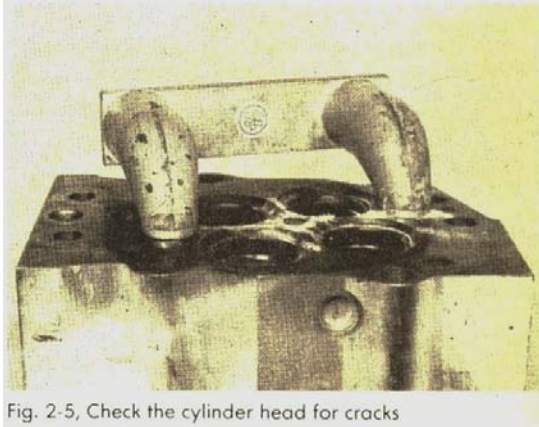


Fig. 2-5, Check the cylinder head for cracks

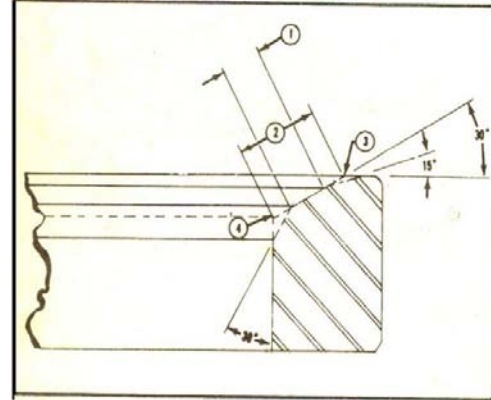


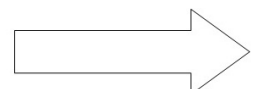
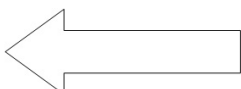
Fig. 2-6, Valve seat cross-section

Inspection Valve Seats

1. Inspect for loose valve seats in the cylinder head by striking, lightly with a hammer near the valve seat. If the valve seat is loose enough to bounce, mark for valve seat replacement. Use a soft nose hammer to check this loose valve seat.
2. If the seat area width exceeds 0.100 inch [2.54 mm] at any point and cannot be narrowed sufficiently (1) during regrinding, the valve should be marked for replacement.
3. The valve must not have a negative protrusion of more than - 0.020 inch [- 0.51 mm]. If it does mark valve seat for replacement.

Injector Sealing Ring

Inspect for cracks, scratches and indentation caused from injector hold down clamp torque and other damage. Discard unserviceable parts.



Injector Tip Protrusion

Cylinder heads that have passed the above tests must further be checked for injector tip protrusion (seat depth) and seating pattern.

1. Lightly cover the injector cup with bluing compound. Install the injector assembly and seal seat into injector hole. Tighten to 11 to 13 ft- lbs (15 to 18N-m) torque. Remove and check the seat pattern. The bluing band must be 0.060 inch (1.52 mm) minimum in width.
2. Measure the tip protrusion with the ST - 547 Dial indicator. The tip protrusion must be 0.090 to 0.110 inch (2.29 to 2.79 mm). Injector sealing rings are available std. in 0.010, 0.020 and 0.030 widths to correct protrusion.

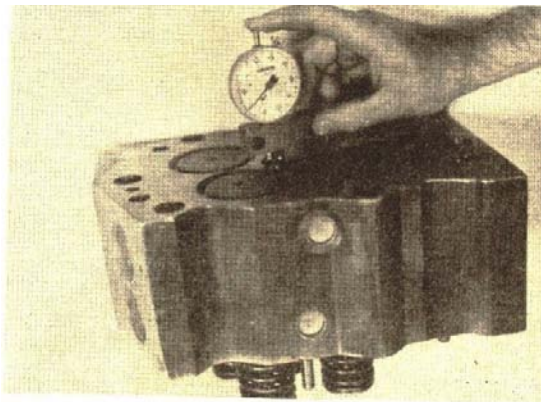


Fig. 2-7, Measure the injector tip protrusion

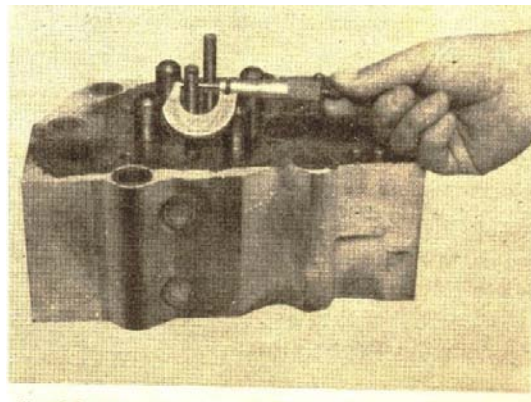


Fig. 2-8, Measure the crosshead guide outside diameter

Valve Crosshead Guides and Crossheads

1. Measure the guide outside diameter with micrometers. See Table 2-1 (10) for worn limits.
2. Measure the guide for straightness, which is to be at right angles with milled surface of head. Mark the guides for replacement if not straight or worn beyond limits.

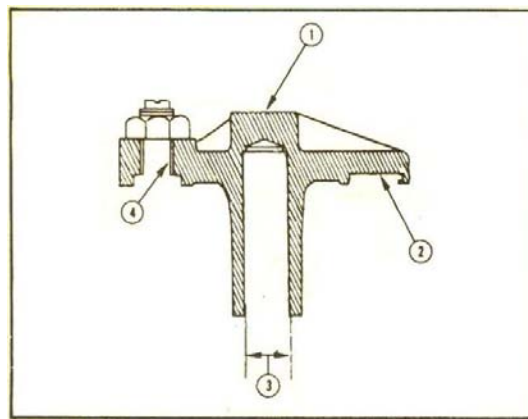


Fig. 2-9, Crosshead wear points

3. Inspect the crossheads for cracks by the Magnaflux process.
4. Measure the stem inside diameter (3, Fig. 2-9). Use a small bore gauge set at 0.4402 inch [11.181 mm]. The gauge should not fit into the bore at this setting.
5. Measure for out-of-round holes. Set the gauge at several points 90 degrees apart.
6. Visually check for wear on the rocker lever (1) and valve stem contact surface (2). Check the adjusting screw and crosshead threads (4) for wear or distortion.

Valve Guides

- a. Measure the guide inside diameter. Use a small bore gauge set at 0.4989 inch [12.672 mm]. The gauge should not enter the bore at this setting. Table 2-1 (3).
- b. Measure for out-of-round holes. Set the gauge at several points of the head. Fig. 2-10. Visually check the valve guides for chips, cracks or sharp edges. Mark guides which show extra amounts of wear or damage for replacement.

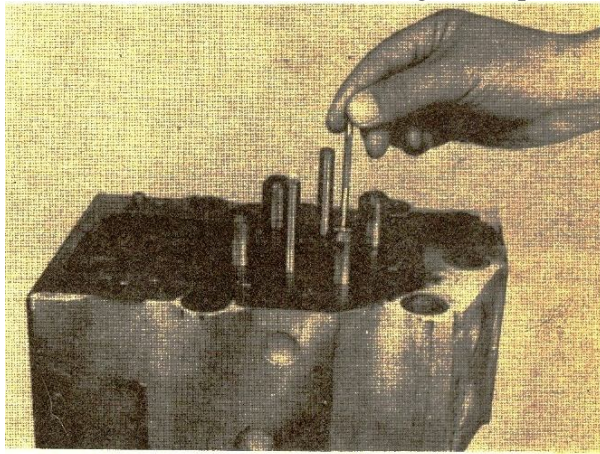


Fig. 2-10, Check the valve guide for out-of-round

Valves Inspection

Clean the valves and polish with crocus cloth. Inspect and then discard if:

The heads are bent, cracked, or worn too thin to grind to within limits. Measure the valve head rim thickness (1, Fig. 2-11), which is to be a minimum of 0.105 inch [2.67 mm]. The stems (Fig. 2-12) are worn beyond worn limit as listed in Table 2-1 (1). The collet groove is worn so that new collets will not fit securely.

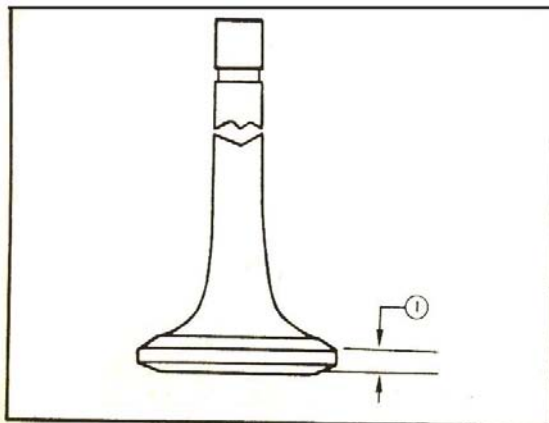


Fig. 2-11, Minimum valve head rim thickness

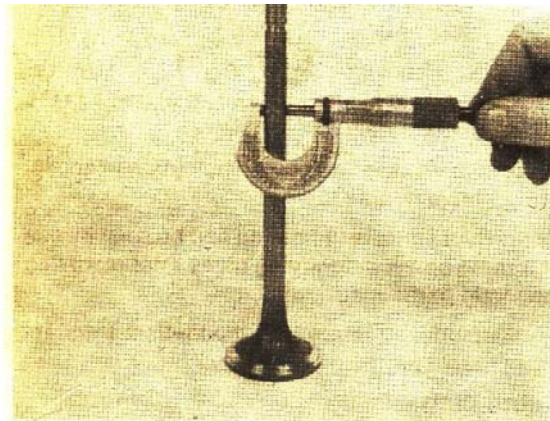
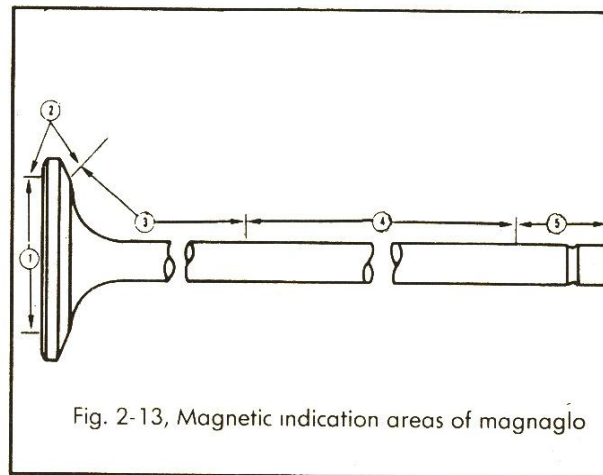


Fig. 2-12, Measure valve stem

Magnetic Method

1. The surface to be inspected must be cleaned to remove all foreign material which will give negative indications. Vapor cleaning is recommended with a penetrant or developer.
2. Welded valves which have two types of metal, may be Magnaflux inspected. Because of the change of metal at weld, there will be magnetic leakage at this point. This will be indicated by a broad fuzzy pattern of magnetic particles. These valves should be magnetized in the coil at low amperage, (100 to 200 amps) and then inspected residually with Magnaflux. A crack at, or near, the weld would show as a sharp bright fluorescent line.
3. Valves with only one type of metal can be inspected in normal way. Magnetize and inspect in two directions. For coil magnetization, use 100 to 300 amps. Inspect with residual Magnaflux. Defects found after this magnetization will be in a transverse direction. Follow by headshot magnetization, 500 to 700 amps, use residual Magnaflux. Defects by this magnetizing method will be radial.
4. Magnetic indications can be as follow: Reference Fig. 2-13.



- a) No magnetic indication over 1/2 in [12.70 mm] in length or more than five indications spaced closer than 1/8 in, [3.18 mm] will be acceptable in area (1)
- b) No visual or magnetic indication is acceptable in area (2).
- c) No visual or magnetic indications are acceptable in areas (3) and (4), if they run the circumference of the valve.
- d) No visual or magnetic indication is acceptable in area (5).

Note: Visual means indication can be seen by use of a three power magnifying glass after removing magnetic particle suspension.

5. Magnetically remove all magnetism from acceptable parts

Rebuilding of Cylinder Head

If the cylinder head has been scratched, etched or is uneven at the point of contact in the gasket sealing area, the head may be milled or surface ground.

1. Use the ST-1323 Valve Seat Extractor to remove all the valve seat inserts and intake seat spacer plates.
2. After machining, use a micrometer or a Vernier depth gauge to measure the head height.
3. Machine the valve seat counter bore and remove the amount of material equal to that removed during head surfacing.
4. Sand the surface of the cylinder head with a sander. Fig. 2-16. Do not use a disc sander.
5. Clean area thoroughly.
6. Install injector sealing rings to correct for amount of material removed during head machining.

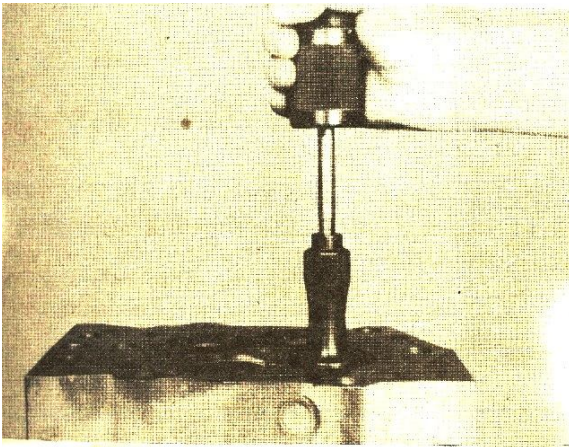


Fig. 2-14, Remove the valve seat insert

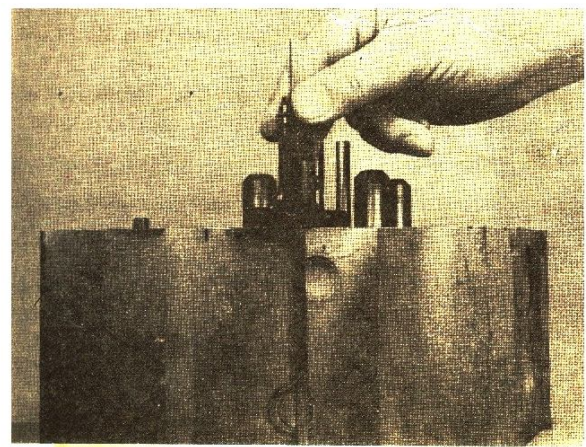


Fig. 2-15, Measure the cylinder head height.

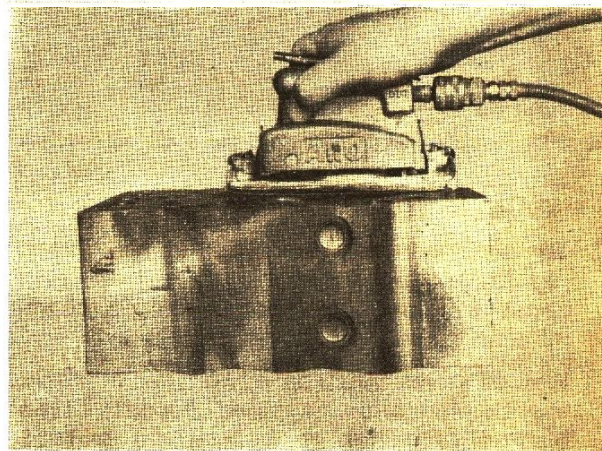


Fig. 2-16, Sand the cylinder head

Replace Valve Guides

1. Drive out the guides marked for replacement from the valve head side of the cylinder head. Install the new valve guide with the ST-1265 Valve Guide Driver.
2. If the proper valve guide driver is not available, press guide into head. See Table 2-1 (4) for valve guide assembled height.

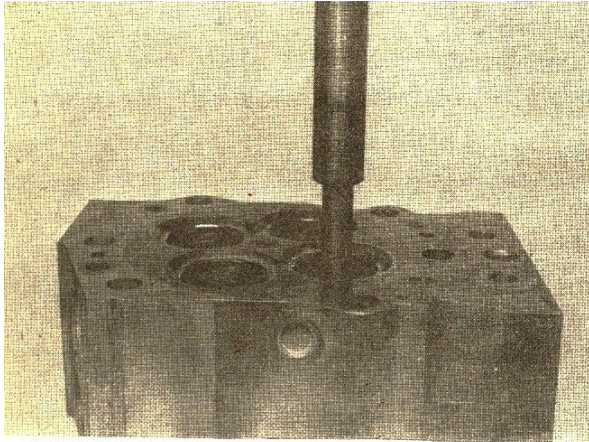


Fig. 2-17, Remove the valve guides

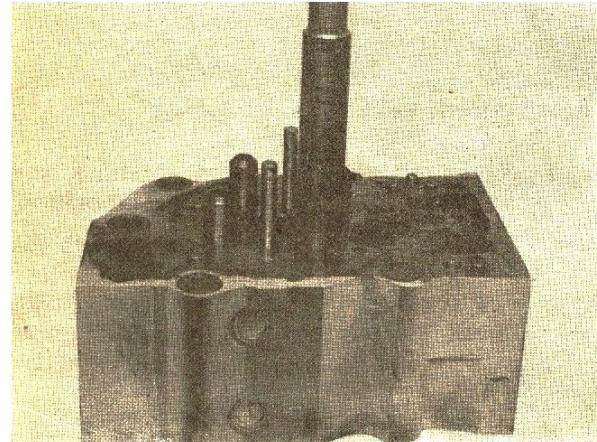


Fig. 2-18, Install the valve guides

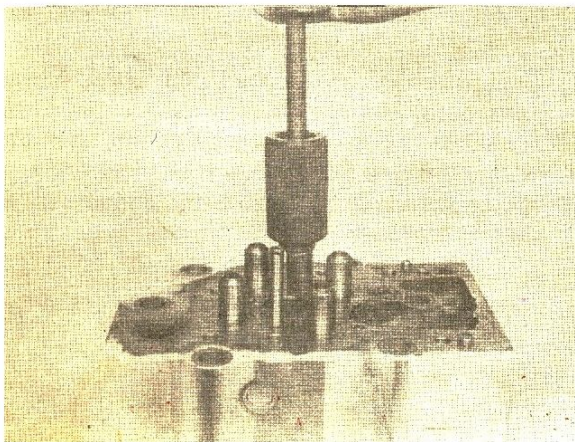


Fig. 2-19, Remove the crosshead guides

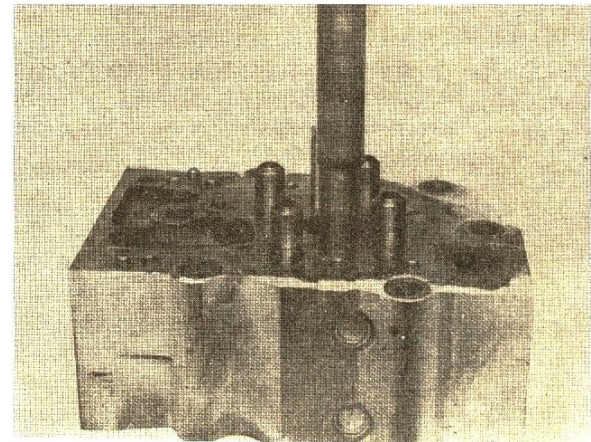


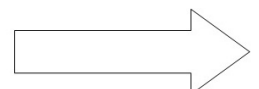
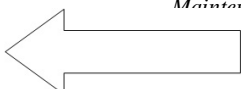
Fig. 2-20, Install the crosshead guides

Replace Crosshead Guides

1. Use the ST-667 or ST-1134 Dowel Puller to remove the crosshead guides marked for replacement.
2. Use the ST - 1 264 Crosshead Guide Driver to press the new guides into the cylinder head. If the new driver is not available press the new guides into the head to obtain the assembled height as listed in Table 2- 1(11).

Replace Valve Seat

Use the ST -1323 Valve Seat Extractor to remove the valve seats and the (intake) swirl plates that are marked for replacement, if this has not been done already.



- a. Machine the counter bore to the next available oversize. The valve seats are available as listed in the Master Part Book Filmcard.
- b. Use the 3375946 Valve Guide Arbor and ST - 257 Valve Seat Tool Driver to hold and drive the ST -1310 Valve Seat Cutter when cutting the valve seat insert counter bore.
- c. Machine the counter bore 0.006 to 0.010 inch [0.15 to 0.25 mm] deeper than the seat thickness to permit swaging or peening of the head to hold to seat. Allow the cutter to dwell upon reaching the proper depth to insure a flat seating surface.
- d. Install the valve seat and swirl plate (when used) and stake the seat into head using the 5T -1122 Tool Driver over the shaft of ST1288 Valve Seat Swaging Tool. A 1/4 inch [6.35 mm] diameter round point punch may be used if the swaging tool is not available.

Caution: Over swaging around the insert may crock the cylinder head.

Valve Seats Grind

1. Use the ST-685 Valve Seat Grinder to correct the arbor from the 3375946 Valve Guide Arbor Set.
2. Grind the valve seats to assure negative valve protrusion in the cylinder head. Rough grind and finish with the correct stones from the ST-685. The rough grinder stone must be cut to 30 degrees before the grinding operation. Check the valve seat width. It should be 0.060 to 0.100 inch [1.52 to 2.54 mm]. See 1, Fig. 2-6. If the seating area (1) is wider than 0.100 inch [2.54 mm] maximum, stock can be removed from the points (3) and (4) with specially cut stones. Narrowing is not to extend beyond the chamfer on" the valve seat. The chamfer provides metal for staking or peening.
3. Check the valve seat with a valve seat indicator. Total out-of-round is not to exceed the value listed in Table 2-1 (7).

Valve Grinding

1. Use a new valve and an indicator gauge to check the valve grinder setting.

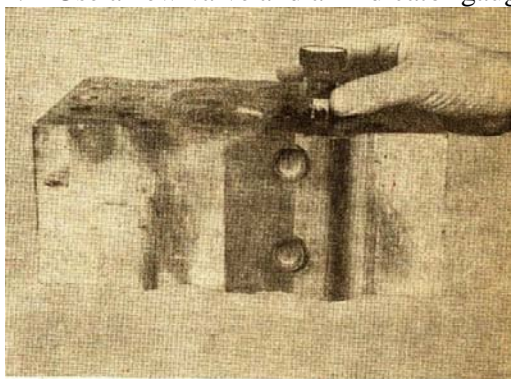


Fig. 2-21, Check the valve seat common centers

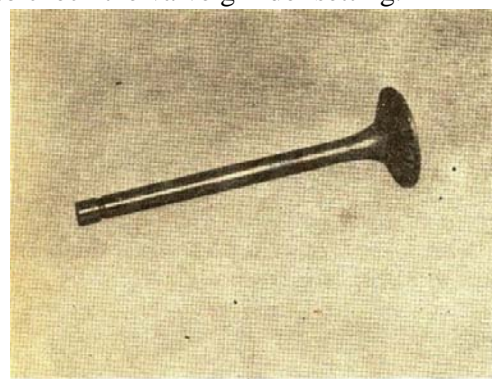


Fig. 2-22, Pencil marks on the valves

- a. Put the valve in the chuck of the valve grinder on the guide area-of the stem. Relieved portions on both ends of guide area are not necessarily parallel to guide area of stem.
 - b. Indicate on the face of valve.
 - c. Turn the valve and mark the high area on the head of the valve.
 - d. Again put a valve in grinder chuck and center 180 degrees from first position.
 - e. Repeat (b) and (c). If high areas are the same for both (a) and (d) position the valve is bent. If the high areas occur in different positions, the chuck is out of alignment. Out-of round is not to exceed 0.001 inch [0.03 mm].
2. Wet-grind the valves to an exact 30 degree angle from vertical. Check the rim thickness as shown in Fig: 2-11. If the rim is less than 0.105 inch [2.67 mm], do not use valve.
3. Mark with lead the valve face as shown in Fig. 2-22. Put the valve guide against a newly ground valve seat and rotate the valve 10 degrees. A good seat will be indicated if all lead marks are broken. If lead marks are not broken, the grinder wheel needs cutting or grinder has not been properly adjusted. The final check should be made with a vacuum tester.

Valve Springs

Weak valve springs may cause valve float which will result in excessive wear on both the valve and seat. The valve float interferes with valve timing and may cause the valve to strike the top of the piston.

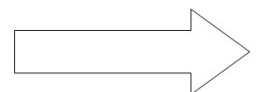
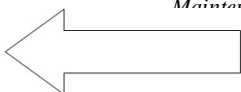
1. Use the valve spring tester, Part No. 3375182 to test the valve springs. Apply the required load for length as listed in Table 2-1 (9). If the valve springs compress to the dimensions shown at less than the load indicated under "worn-limit", discard the valve spring.
2. Spacers are to be used under the valve spring when the seat and valve have been ground more than a total of 0.030 inch [0.76 mm]. A maximum of two spacers may be used under each valve spring.

Assembly

1. Use sealant, the ST – 1280 and the ST- 1282 Expansion Plug Drivers to install the expansion plugs.
2. Install pipe plugs and use sealant or Teflon tape the tighten the to the torque listed in Table 2-1
3. Insert the valve stems into clean engine lubricating oil. Put them into the valve guide. Place the cylinder head face down on a wood bench or protective surface to prevent marking on the finish surface.
4. Install the lower valve spring guides over the valve guides.
5. Assemble the spring, spring seats, and spring spacers as required. Install the upper valve spring retainer over springs. Compress with the ST-448-6 Valve Spring Compressor. Install new half collets.

Valve and Seat Vacuum Test

Use the ST-1257 Vacuum Tester with ST-125738 Cup to check the valves and seats for leakage.



Caution: Never vacuum test a cylinder head with the injectors installed. Installation of injectors while the head is removed from block will cause out of alignment of the valves in the valve seat area and result in leakage during testing which will not normally occur during engine operation,

1. Operate the vacuum pump until the hand on vacuum gauge (1, Fig. 2-23) reaches 18 to 125 inches [457 to 635 mm] vacuum. Close the shutoff valve (2). Keep the motor running while checking the vacuum.

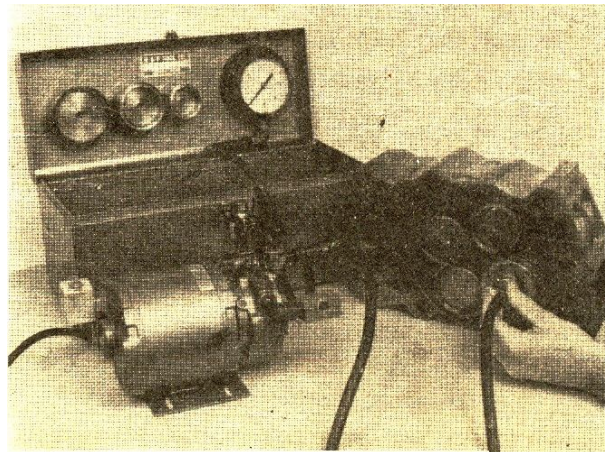


Fig. 2-23, Vacuum test the valves for leaks

2. Time the fall of the gauge hand as follows:
 - a. Begin timing as soon as the hand reaches "18" on the gauge.
 - b. Stop the timing when the gauge reaches "8"
 - c. If the time elapsed is less than ten seconds, the valve seat is not satisfactory.
3. Hit the stem end of the valve with a soft faced mallet and test again. If valve seat is not satisfactory:
 - a. Check for leakage at the connections in the tester. Operate the vacuum pump against a clean glass or a smooth flat surface, the fall of the gauge indicates a loose connection.
 - b. Check tile valve and seat face area to be sure that they are free of dirt particles.
4. Grind the seat and face valve again if necessary; however, it is possible to mistake leakage around the valve seat for valve seat leakage. If this type leakage is suspected, apply grease around the outside edge of valve seat to make a seal.
5. Again vacuum test and inspect the seal for a break indicating air leakage between the wall of the counter bore and the valve seat. If a leak around the valve seat is found:
 - a. Swike or peen valve seat, vacuum test.
 - b. Remove the valve seat, counter bore for, the next oversize. See "Replace Valve Seat Insert".

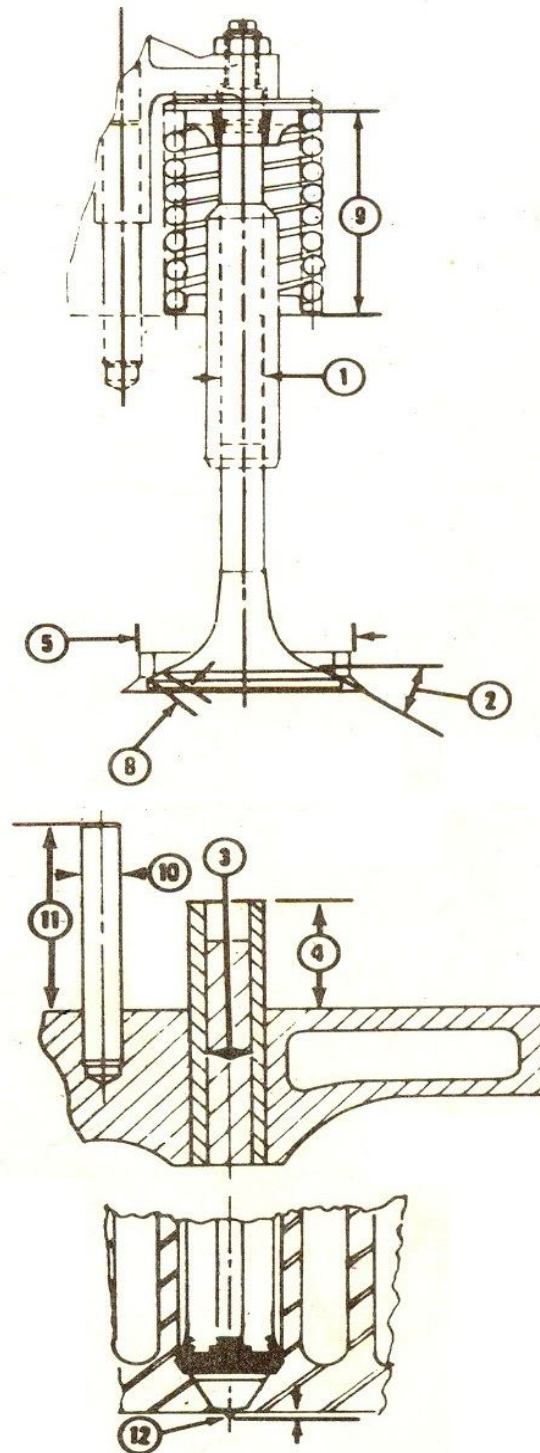


Fig. For Table 2-1: Specifications

Table 2-1: Specifications-Inch [mm]

S. No.		Worn Limit	New Minimum	New Maximum
	Measurement Cylinder Head Valve Guide Bore		0.8435 [21.415]	0.8445 [21.450]
	Crosshead Guide Bore		0.4314 [10.960]	0.4325 [10.9B6]
1.	Valve Stem Outside Diameter	0.4935 [12.535]	0.4945 [12.560]	0.4955 [12.586]
2.	Valve Guide Face Angle		30 deg	30 deg.
3.	Valve Guide Inside Diameter (Installed)	0.4987 [12.668]	0.4961 [1 2.60 1]	0.4971 [12.626]
4.	Valve Guide Outside Diameter	0.8441 [21.440]	0.8456 [21.478]	0.8461 [21.491]
5.	Assembled Height		1.375 [34.93]	1.390 [35.31]
6.	Valve Seat Outside Diameter		2.3805 [60.465]	2.3815 [60.490]
7.	Counter bore Inside Diameter		2.377 (60.38]	2.378 [60.40]
8.	Counter bore Depth Intake		0.512 [13.00]	0.517 [13.13]
9.	Counter bore Depth Exhaust		0.492 [12.50]	0.497 [12.62]
10.	Run Out In 360 Deg.	0.002 [0.05]		
11.	Faced Seat Width		0.060 [1.52]	0.100 [2.54]
12.	Valve Spring Assembled Height			2.470 [62.74]
13.	Crosshead Guide Outside Diameter	0.432 [10.97]	0.433 [11.00]	0.4335 [11.011]
14.	Assembled Height		2.350 [59.69]	2.370 [60.20]
15.	Injector Tip Protrusion		0.090 [2.29]	0.110 [2.79]
16.	Sealing Ring Thickness (Std.)		0.0135 [0.343]	0.0165 [0.419]

Table 2-1: Specifications-Inch [mm] (Reference Fig. 2-1)

Valve Seat Part No.	Over size diameter	Over size depth
205981	0.010 [0.25]	Std.
205982	0.020 [0.50]	0.005 [0.13]
205983	0.030 [0.076]	0.010 [0.25]
205984	0.040 [1.02]	0.015 [0.38]

Be sure to measure valve seat before machining head or installing in head.

Cylinder Head Pipe Plug Torque-ft-lbs [N-m]

Plug Size	Minimum	Maximum
1/8 Inch	5 [7]	10[14]
3/8 Inch	3[47]	45 [61]
1/2 Inch	60 [81]	70 [95]
3/4 Inch	65 [88]	75 [102]
1 inch	135[186]	145 [197]

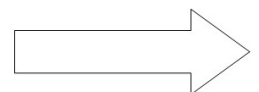
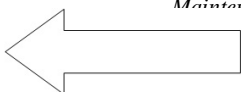
Valve Spring Data

Valve Spring Part No.	Approximate Free Length Inch [mm]	No. Coils	Wire Diameter Inch [mm]	Length Inch [mm]	Required Load for Length		New Maxi Lb [kg]
					Worn Limit Lb [kg]	New Mini Lb [kg]	
205208	3.349 [8.06]	7.8	0.234 [5.94]	1.908 [48.46]	253 [14.8]	266 [20.7]	294 [133.4]

Injector Sealing Rings

Part No.	Wall Thickness	Change in Tip Protrusion (Into Head)
207244	0.0135 -0 .0165 [0.343] [0.419]	Std.
3001658	0.0185 -0 .0215 [0.470] [0.546]	0.010 [0.254]
3001659	0.0235 -0 .0265 [0.597] [0.673]	0.020 [0.508]
3001660	0.0285 -0 .0315 [0.724] [0.800]	0.030 [0.762]

Thicker rings may be required when cylinder head is resurfaced in order to maintain proper injector protrusion.

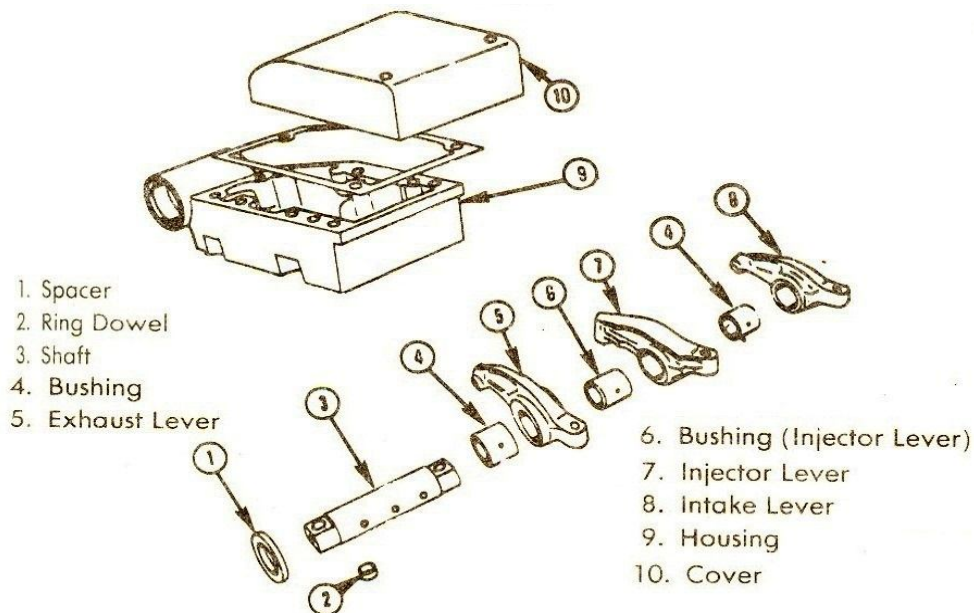


(D) Rocker Levers

This chapter covers rocker levers, rocker lever shafts, covers and housing & Rocker lever housings.

The following service tools or tools of comparable quality are necessary to repair or rebuild the cylinder heads as described in this section.

SNo.	Tool Name	Tool Number
Service Tools		
1	Bushing Drivers	ST-1284
Standard Tools		
1	Small Bore gauge	
2	Micrometers	



Rocker Levers

Rocker levers and shafts are removed from the housings during engine disassembly.

Disassembly and Inspection

1. Remove the lever and spacer (when used) from the shaft Fig. 3-2.
2. Mark the rocker levers for position as removed from the shaft.
3. Remove the adjusting screws and nuts.
4. Inspect for surface defects by magnetic inspection. Apply coil amperage at 300 to 500 with residual Magnaflux. See Fig. 3-3 for most likely areas. Magnetically remove all magnetism from acceptable parts.
5. Use a 1/4 inch (6.35 mm) radius gauge to measure the ball end of the rocker lever adjusting screws. Fig. 3-4. The ball end and socket of the push rod should "blue in" 80 percent of the seat area.

6. Check the thread condition on all screws and levers. Screws must turn freely through the levers.
7. Inspect the injector lever sockets for fit to the injector links. Remove the damaged or badly worn sockets by drilling a small hole in the lever above sockets, drive the socket out with a punch. After the socket is removed, weld the hold closed or install and swage a plug in the hole.

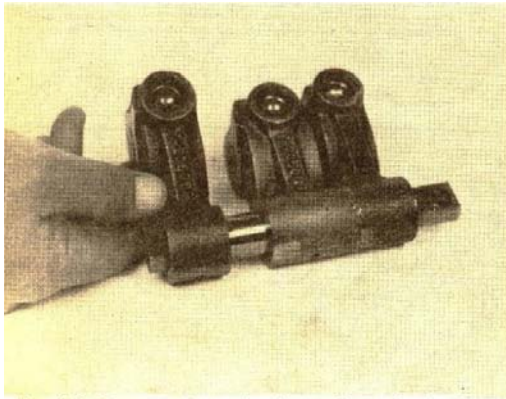


Fig. 3-2. Remove the rocker levers from the shaft

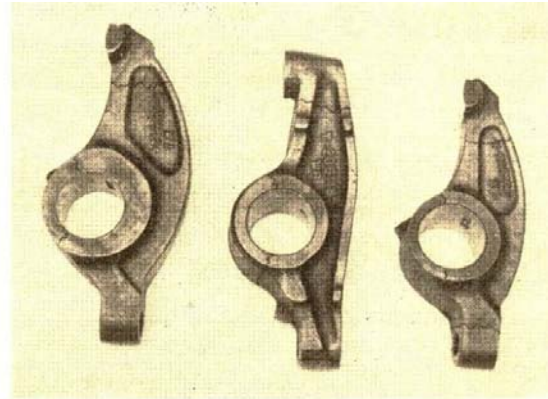


Fig. 3.3. Magnetic inspection crack indication

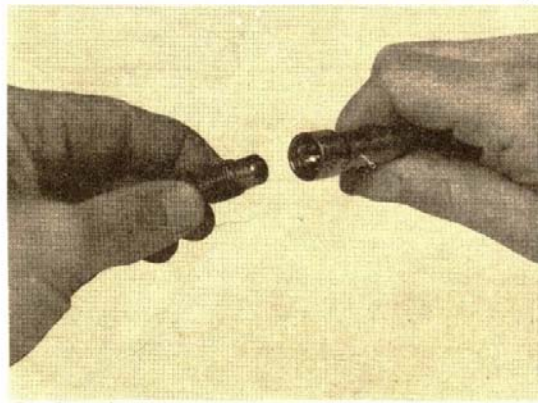


Fig. 3-4. Check the rocker lever adjusting screw ball end

Note: New injector lever sockets must be installed against the bottom of the socket bore when replaced.

8. Visually inspect the rocker lever bushings for scratches, pitting or scoring. Use inside micrometers or a small bore gauge to measure bushing inside diameter. Fig. 3-5. If the bushing is worn larger than 1.3776 inch (34.991 mm) Use ST—1824 Bushing Driver to remove it Fig. 3-6
9. Clean the rocker levers in an approved solvent. Be sure oil drillings are open. Install new bushings as follows:
 - a. Cut the bushing so that oil holes in the bushing and lever are aligned.
 - b. Use the ST-1284 Bushing driver and an arbor press to press the bushing into the lever until flush, or 0.020 inch (0.51 mm) below the machined surface of the rocker lever. Fig. 3-7.
10. Inspect visually the intake and exhaust rocker lever-to-crosshead contact surfaces. If worn or damaged, replace with the new rocker lever.
11. Measure the rocker lever shaft for wear. Fig. 3-8. If the shaft is worn smaller than 1.371 inch (34.82 mm), replace with a new shaft.

12. Flush the shaft bore with an approved cleaning solvent. Dry with compressed air. Replace the cup plug if removed.



Fig. 3-5. Check the rocker lever bushing for wear

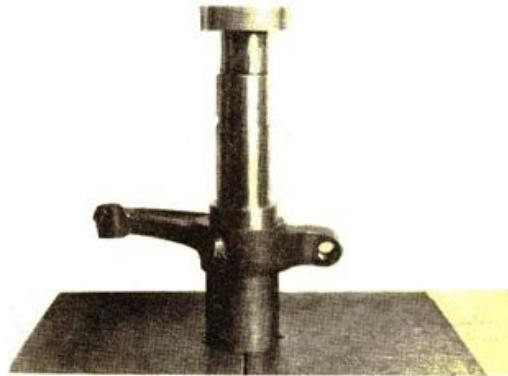


Fig. 3-7. Install the rocker lever bushing

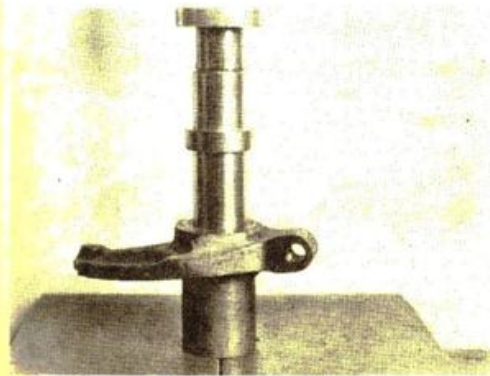


Fig. 3-6. Remove the rocker lever bushing

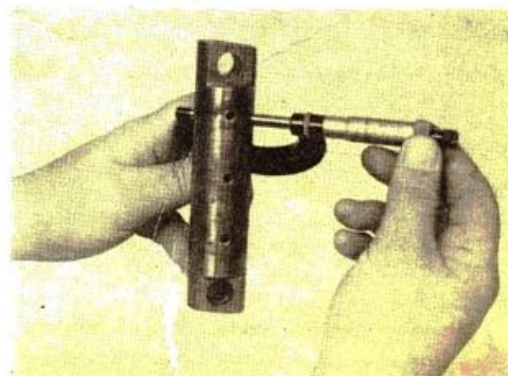


Fig. 3-8. Measure the rocker lever shaft

Assembly

Rocker levers are not attached to the housings until after the housings are installed on the cylinder head.

1. Install the adjusting screws and locknuts in the rocker levers. Do not tighten the locknuts.
2. Cover the rocker lever shaft with clean lubricating oil.
3. Install the rocker levers on the shaft in the following order: intake (1, Fig.3-9), injector (2), exhaust (3) and spacer (4) (when used).

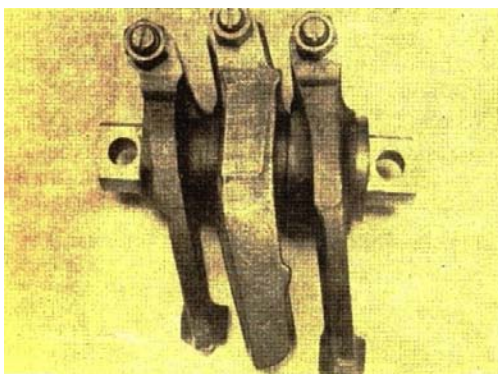


Fig. 3-9. Rocker lever assembly

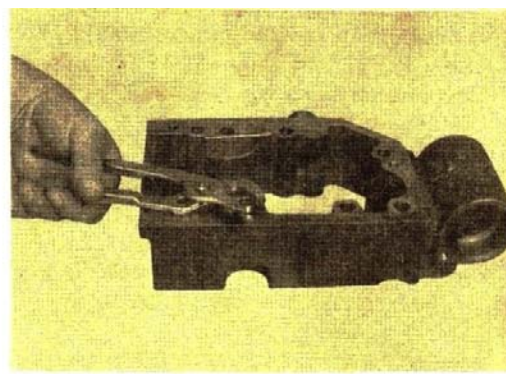
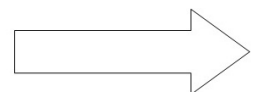
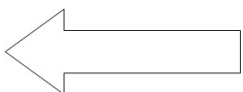


Fig. 3-10. Remove the ring dowel



Rocker Lever Housing

The rocker lever housings have a water passage that makes up a part of the water manifold.

Inspection

- Remove the groove pin in the rear housing, attaching the water transfer plug, if not previously removed.
- Remove the water transfer plug. Discard the O-ring.
- Inspect the housing for cracks, or other damage in the gasket and the O-ring sealing areas. Discard parts which can not be repaired.
- Replace the ring dowel (Fig. 3-10) defective.

Assembly

The rocker lever housing to be used on the rear cylinder head requires a water transfer plug and O-ring, secured with a groove pin or cover plate with expansion or pipe plug. These parts may be installed after the housings are installed on the engine, if so desired.

Rocker Housing Cover

Inspection and Repair

- Visually check the cover for cracks or other damage that may effect the gasket sealing area.
- Repair small cracks by welding. If the gasket surface must be welded through, use a large flat smooth cut file to return the surface to the original smoothness.

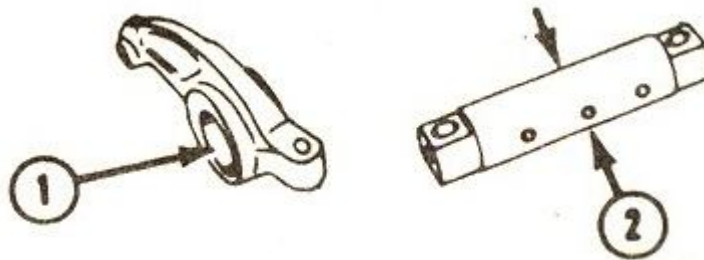


Table 3-1: Specifications- Inch [mm] Ref.: Fig. Above

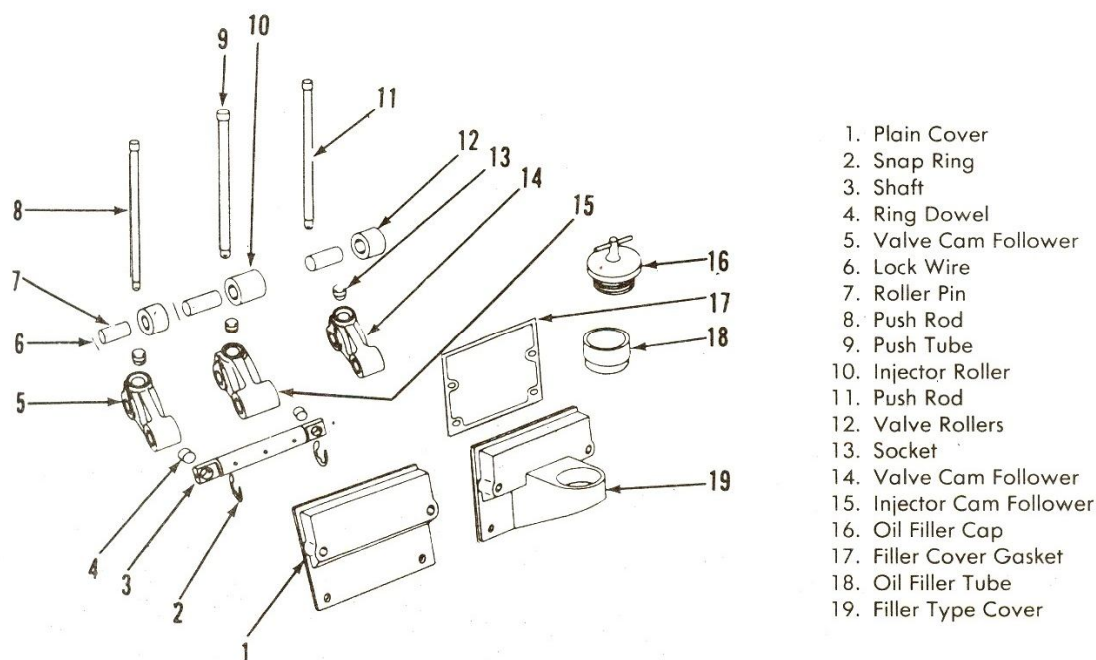
Ref. No.	Measurement	Worn Limit	New Min.	New Max.
1.	Bushing Inside Diameter	1.3776" [34.99 mm]	1.3735" [34.887 mm]	1.3765" [34.963 mm]
2.	Shaft Outside Diameter	1.371" [34.82 mm]	1.372" [34.85 mm]	1.3725" [34.86 mm]

(E) Cam Followers

This chapter covers Cam Followers shafts, ring Dowel, Injector Push rods, valve push tubes, oil filler cap, crank case breather and cam follower covers.

The following service tools or tools of comparable quality are necessary to repair or rebuild the cylinder heads as described in this section.

SNo.	Tool Name	Tool Number
Service Tools		
1	Cam Follower roller pin block	ST-1283
Standard Tools		
1	Small Bore gauge	
2	Micrometers 0-1", 0-2"	
3.	Snap ring pliers	
4	Filler Gauge	



Cam Followers

Cam followers are mounted to the cylinder block and receive lubrication during operation through special slotted mounting cap screw. See "Engine Assembly and Testing" Group (M).

Disassembly and Inspection

1. Remove the retaining rings holding the spacers and followers on the shaft. Fig. 4-2.

2. Remove the spacers and cam follower levers from the shaft. Clean the parts in solvent.
3. Measure the outside diameter of the shaft with micrometers Fig.4-3. If worn smaller than 0.873 inch (22.17 mm) or is damaged, mark for replacement.
4. Check the inside diameter of the cam follower for damage. Measure the inside diameter with a small bore gauge. Fig. 4-4. If worn larger than 0.8777 inch (22.28 mm), mark for replacement.

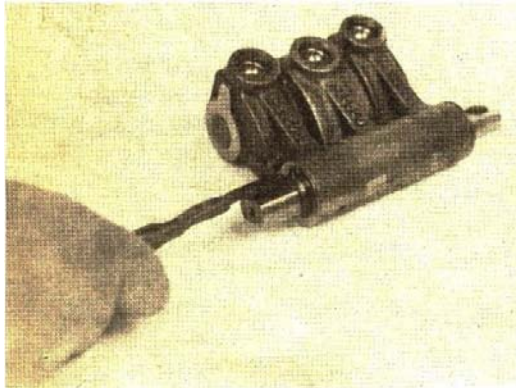


Fig. 4-2. Remove the cam follower retaining ring

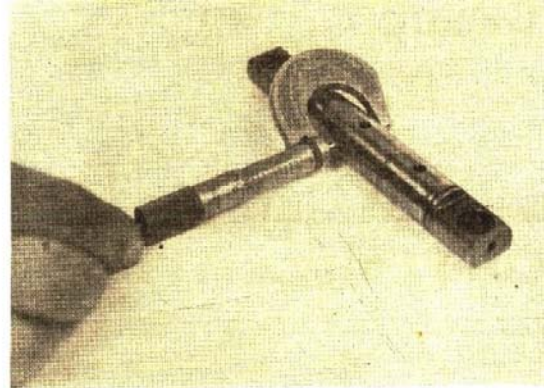


Fig. 4-3. Measure the cam follower shaft

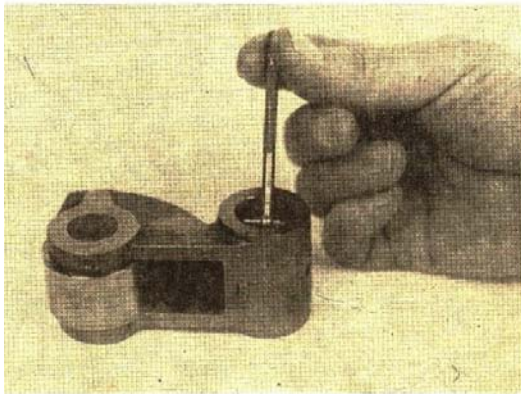


Fig. 4-4. Measure the cam follower inside diameter

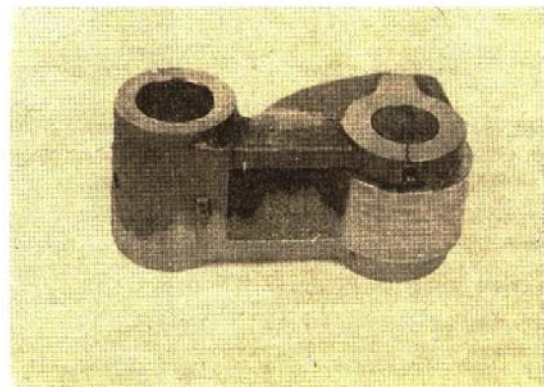


Fig. 4-5. Magnetic crack detection check

5. Check for surface cracks by magnetic inspection. Apply coil amperage at 300 to 500 with residual magnaglo. See Fig. 4-5 for most likely areas. Magnetically remove the magnetism from all serviceable parts.

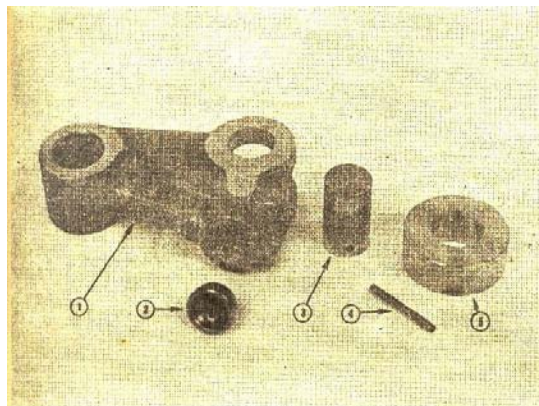


Fig. 4-6. Cam follower — exploded view



Fig. 4-9. Check the cam roller inside diameter

6. Cam follower levers have a removable socket (2, Fig 4-6). These must be replaced if scored or worn. Check with a new push rod ball with bluing compound. This area must show a continuous blue pattern over 80 percent of radius area or the socket must be replaced. Fig. 4-7.
7. Remove the roll pins (1, Fig. 4-8) and cam roller pins (2). Remove the rollers from the cam followers.
8. Use a small bore gauge to measure the cam roller inside diameter as in Fig. 4-9. Discard the roller if worn larger than values given in the Table 4-1 (3) at the end of this section, or if the bore is found to be out-of-round.
9. Use the micrometers to measure the outside diameter of the rollers. Fig. 4-10 if worn smaller than 1.622 inch (41.20 mm) or otherwise damaged, mark for replacement.

Note: The cam roller inside diameter must be parallel with the outside diameter within 0.002 inch (0.05 mm). Sides must be square to the bore and parallel to each other within 0.004 inch (0.10 mm).

10. Check the cam roller pins for scratch, or other damage. Measure the outside diameter with the micrometers. Fig. 4-11. If worn smaller than 0.748 inch (19.00 mm), where the roller rides or at least a 0.002 inch (.005 mm) press fit no longer exists between the pin and pin bore in the follower, mark for replacement.

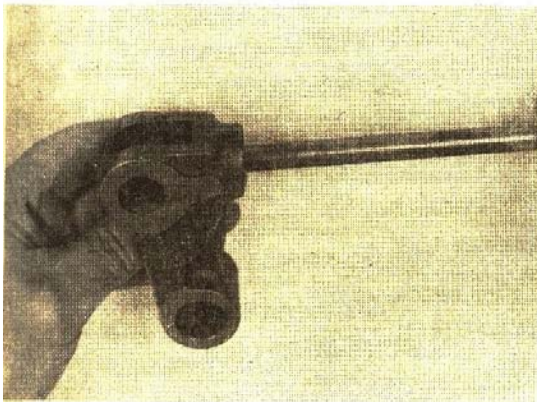


Fig. 4-7. Check the cam follower socket with the push tube

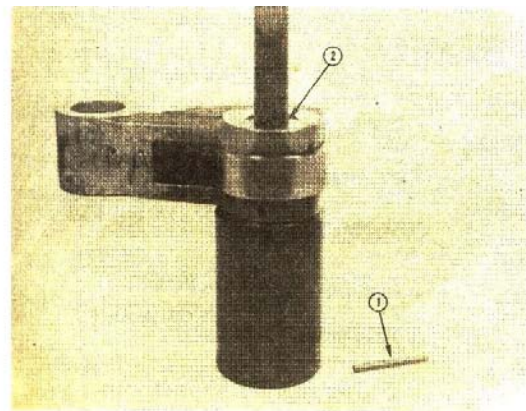


Fig. 4-8. Remove the cam roller pin

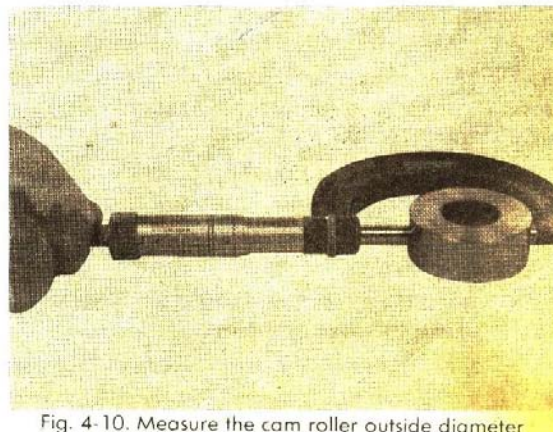


Fig. 4-10. Measure the cam roller outside diameter



Fig. 4-11. Measure the cam roller pin

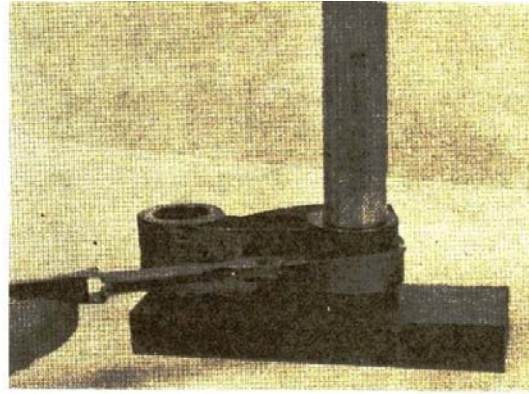


Fig. 4-12. Install the cam follower roller pin

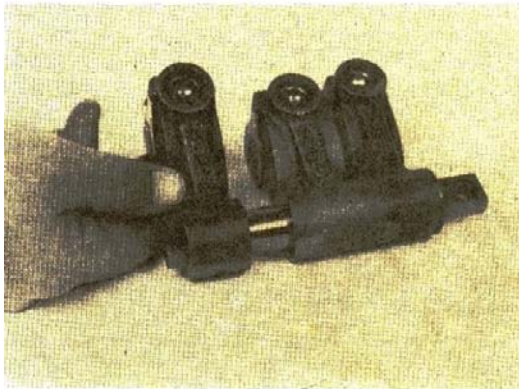


Fig. 4-13. Install the cam followers



Fig. 4-14. Install the retainer snap ring on the shaft

Assembly

Note: Lubricate the lever assembly with clean 20W or 30W engine lubricating oil and check for free rotation of roller before installation.

If removed, press in a new lever socket (2, Fig. 4-6). Align the oil drillings, make sure the socket is securely seated.

Note: If a new injector socket is installed, a new injector push rod is to be used.

Use an arbor press and the ST-1283 Mandrel to assemble the rollers and pin as follows:

Position the roller, pin and follower in the press.

Align the oil passage and roll the pin holes in the follower and roller pin.

Select the correct thickness feeler gauge, and position it between the roller and lever as a support while pressing the pin in to the lever.

Note: The roller to cam follower side clearance must be 0.009 to 0.024 inch (0.23 to 0.61 mm) after the pin is pressed into position.

Press the roller pin into the follower and roller until it is flush. Fig. 4-12.

Remove the feeler gauge and again measure the side clearance. See Note above.

Use a soft hammer to drive the roll pin into position.

Assemble the cam followers (Fig. 4-13) and spacers (Fig. 4-14) on to the shaft. Install the retaining rings.

Note: The injector followers are in the center position on each shaft.

Push Rods**Inspection**

1. Check the injector push rod and valve push rod ball ends for wear with blue compound applied on a new cam follower socket. See “Cam Followers, Disassembly and Inspection”, Step 6.

Note: The push rods with worn ball ends are not to be installed in new cam follower sockets.

2. Check the socket of the push rod with the ball end of a new rocker lever adjusting screw or with a 1/2 inch (12.7 mm) check ball. Contact should show in 80 percent of seat area. Fig. 4-15.
3. Check the push rods to see if they are bent. Push rods that are bent have normally had the adjusting screw over tightened or tightened out of sequence.

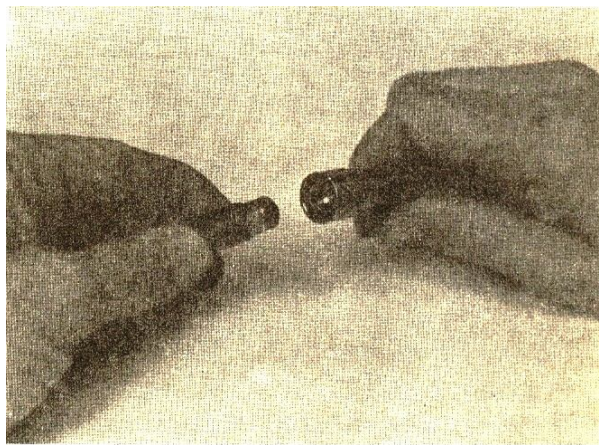


Fig. 4-15. Check the push rod socket

Note: Support the push rods at the ends. Place the dial indicator midway between ends. Rotate the shaft 360 degrees. Run out must not exceed 0.025 inch (0.64 mm) total indicator reading.

Cam Follower Covers

Two types of cam follower covers are used: plain and breather, and/ or oil filter tube type. Fig. 4-16.

Inspection:

Inspect the cover for cracks, or other damage in gasket sealing area. Inspect the breather / filler type covers for cracks in the area where the breather or filler tube presses in. Discard all unserviceable parts.

Crankcase Breather**Disassembly and Inspection**

- a. Remove the cover (4, Fig. 4-17) and lift out the top screen (6), mesh element (7) and bottom screen (8). Clean in approved cleaning solvent.
- b. Inspect the rubber gasket (5), body (9) and cover (4) for cracks or other damage. Discard and replace damaged parts.

Assembly

1. Install the bottom screen (8), new or cleaned element (7) and top screen (6) into the breather body (9).
2. Place the rubber gasket (5) into the cover (4). Position the cover assembly to body (9).
3. Position the rubber washer (3) and flat washer (2) over the shaft of the body (9). Hold in place with a wing nut (1).

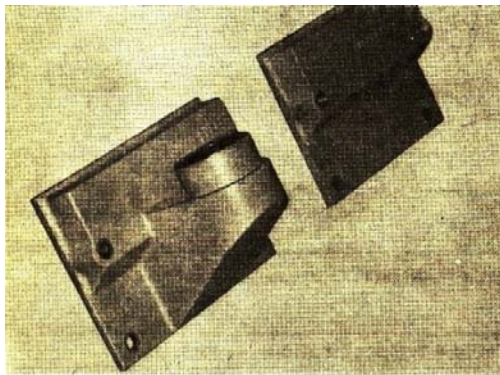
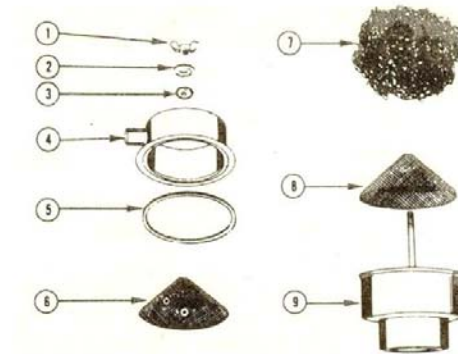


Fig. 4-16. Cam follower covers

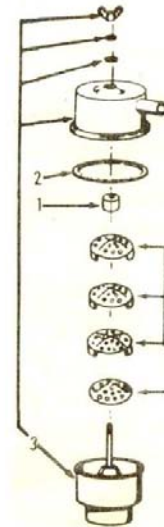


Fig. 4-17. Crankcase breather

(F) Lubricating System

This chapter covers Oil pump, oil pan, pan adapter, dipstick, filters, by- pass filter, lines and oil coolers.

The following service tools or tools of comparable quality are necessary to repair or rebuild the cylinder heads as described in this section.

SNo.	Tool Name	Tool Number
Service Tools		
1	Lube oil pump boring Tool	3375206
2	Dowel pin Extractor	ST-1134

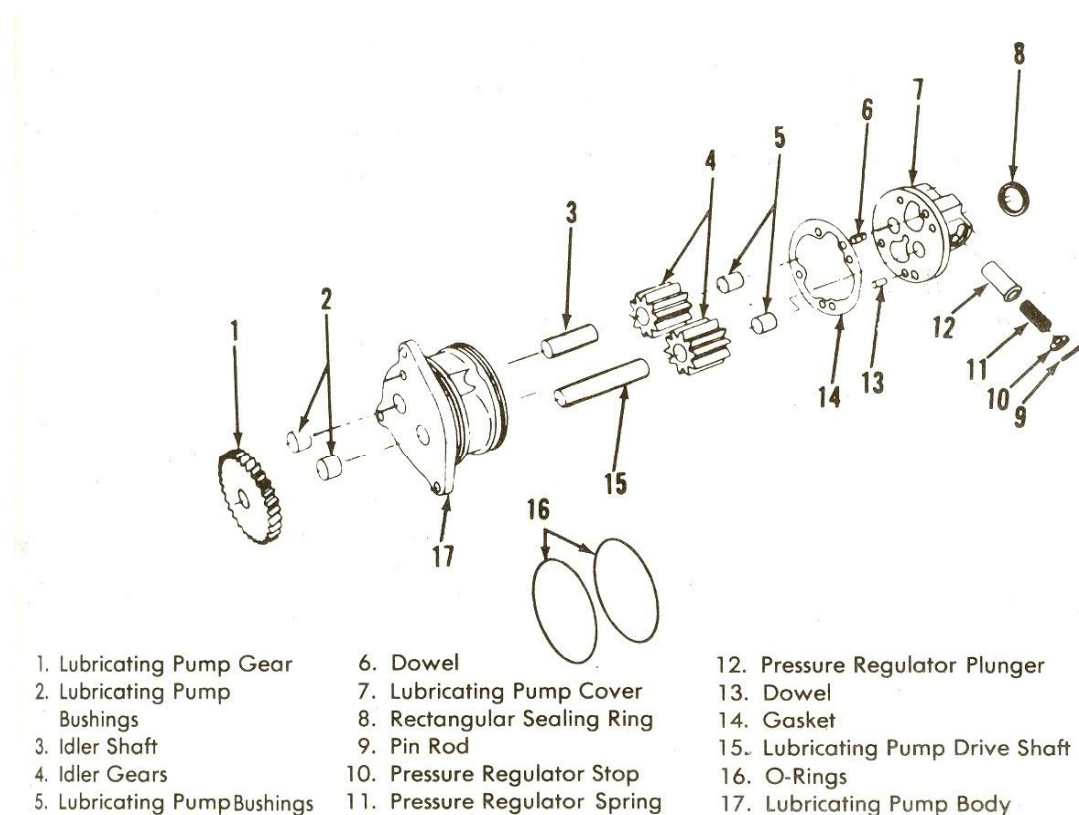


Fig. 7-1. Lubricating Oil Pump

Lubricating Oil Pump Disassembly

1. Remove the cover (7, Fig. 7-1) from the pump body, (17). Use a soft hammer to loosen from the dowels (6 and 13).
2. Remove the idler gears (4) and the shafts (3 and 15) from the pump body (17).
3. Use a puller to pull the pump gear (1) from the shaft and body.

4. Remove the roll pin (9), stop (10), spring (11) and pressure regulator (12) from cover (7).
5. Clean all parts in an approved cleaning solvent. Dry with compressed air.

Note: Old style regulators use a snap ring that may be removed with Service Tool 3375055 without removing the pump from the engine. The new style regulators have either a roll pin and plug or a solid dowel that can not be removed with the pump in the engine.

Inspection

1. Inspect the drive shaft (93) and idler shaft (15). Mark for replacement if badly scratched or worn smaller than 0.874 inch (22.20 mm). See Table 7-1 (2).
2. Inspect the idler gears (4). Mark for replacement if the teeth are chipped, cracked, badly scratched or show excessive wear.
3. Measure the bushings in the body (17) and cover (7). Mark for replacement if worn larger than 0.8785 inch (22.314 mm). See Table 7-1 (1).
4. Check the pressure regulator valve for free movement in the pump cover.

Repair

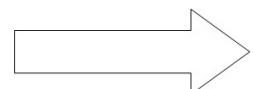
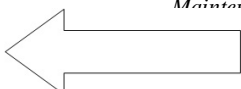
1. If the bushings in the body or the cover were marked for replacement, remove and press the new bushings flush to 0.020 inch (0.51 mm) below surface of the body or cover with the ST-0000 Bushing Mandrel.

Note: Use the 3375206 Bushing Boring Tool to machine the bushing in the body and cover to 0.8765 to 0.8775 inch (22.263 to 22.289 mm) after the bushings are installed.

2. If the drive shaft or driven gear were marked for replacement, press the gear from the shaft. When assembling replacement parts, press the drive shaft through the driven gear to 1.665 to 1.685 inch (42.29 to 42.80 mm) shaft protrusion from the end of the gear.
3. If the idler shaft or idler gear were marked for replacement, press the gear from the shaft. When assembling the replacement parts, press the idler shaft through the idler gear to 1.085 to 1.105 inch (27.56 to 28.07 mm) shaft protrusion from the end of the gear.

Assembly

1. Put the drive shaft (3) and the idler gear (4, Fig. 7-1) through the bushing in the pump body (17).
2. Put the assembly on the end of the drive shaft and then press the pump gear (1) onto the shaft with a 0.130 to 0.150 inch (3.30 to 3.81 mm) clearance between the gear and pump body. See Table 7-1 (3). After the pump gear is pressed into position, the drive shaft is to have 1.030 to 1.050 inch (26.16 to 26.67 mm) protrusion above the cover surface of the pump body. See Table 7-1 (4).
3. Put the other idler gear (4) and the idler shaft (15) into the pump body and bushing.
4. Install the cover (7) to the pump body (17). Tighten the cap screws to 30 to 35 ft-lbs (41 to 47 Nm) torque.
5. Install the pressure regulator valve (12) spring (11) and stop (10) and secure with the snap ring (old style). New style regulators that use a roll pin instead of a snap ring must have the sport plug pressed in flush with the pump cover gasket surface.



New style pumps that use a long solid dowel instead of the roll pin do not need the short plug. It is important that the roll pin or solid dowel be seated in the spring retainer slot.

6. Rotate the shaft. Check for movement. Measure the drive shaft end clearance. See Table 7-1 (5).

Lubricating Oil Pan and Adapter

The extreme angular operating at which a vehicle is to be operated must be known and a lubrication system provided that is suitable for the maximum angle of operation. Engines for automotive vehicle should be protected to at least 10 degrees vehicles angularity of operation and engines for construction equipment must be equipped with the necessary components to permit at least 30 degrees vehicle angularity of operation.

Inspection

1. Visually check the oil pan and adapter and cover for cracks or, if a leak is suspected, use a dye penetrant to inspect it.
 - a. Spray the area with dye penetrant. Allow the penetrant to dry for fifteen minutes.
 - b. Spray the area with a dye developer and check for crack indications.
2. Check the thread inserts. If damaged, replace. Check all the threaded holes for damaged threads.

Repair

1. Replace the damaged thread insert. Use an insert extractor tool to remove the damaged inserts. Condition hole and install a new insert.
2. Repair the small cracks in the pan b welding. Do not weld finished surfaces.

Lubricating Oil Dipstick

Finished dipsticks are no longer available for purchase. Unmarked dipsticks are available and will require fabrication by measuring and marking.

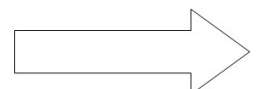
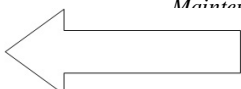
Make the finished dipstick high and low oil level marking according to the instruction sheet contained in the service assembly dipstick package. Reference bulletin number 3379134. Also see service parts topic 78t 7-8.

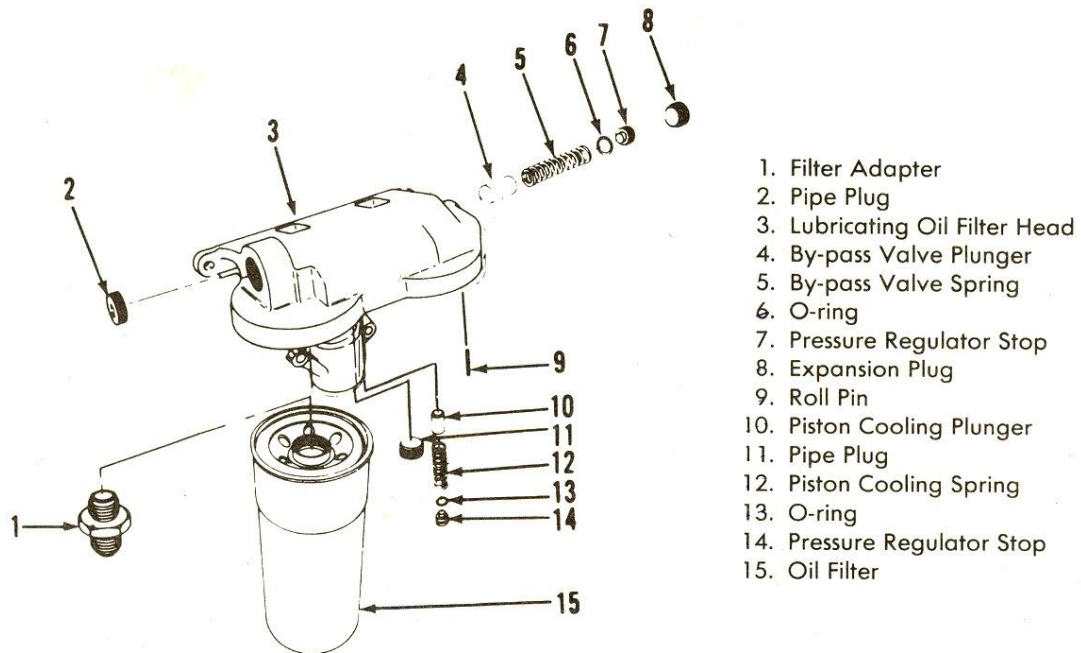
For the proper marking identification, etch with an electrical pencil to a depth of 0.005 to 0.010 inch (0.13 to 0.25 mm).

Lubricating Oil Filter Head Full Flow

Disassembly and Inspection

- a. Inspect the filter head for damage to the sealing ring area. Replace all parts which are not serviceable.
- b. The filter by-pass and pressure control valves normally require no servicing. Check to see that the valves open and close freely. If the valves do not open and close freely.
1. Remove the pipe plug (2, 8 and 11, Fig. 7-2), pressure regulator stops (7 and 14), springs 5 and 12) and plunger (4 and 10) from filter head (3). Discard the O-rings (6 and 13).
2. Clean all the parts in approved cleaning solvent and dry with compressed air. Vent hole in the piston cooling plunger must be open. Inspect for wear or distortion. Discard and replace all parts which are not serviceable.





Assembly

1. Lubricate the plungers, springs, pressure regulator stops and O-rings with clean engine lubricating oil; position the O-rings on the regulator stops.
2. Put the by-pass valve plunger (4, Fig. 7-2) into the bore of the filter head (3). Install the spring (5) and the pressure regulator stop (7).
3. Put the piston cooling valve plunger (10) into the bore of the filter head (3).
4. Coat the pipe plugs (2, 8 and 11) with sealing tape or lead sealer. Install in the filter head. Tighten to 50 to 55 ft-lbs torque (68-75N-m).

By-Pass Filter

A by-pass filter can be used with a full-flow filter. Never use a by-pass filter instead of a full-flow filter.

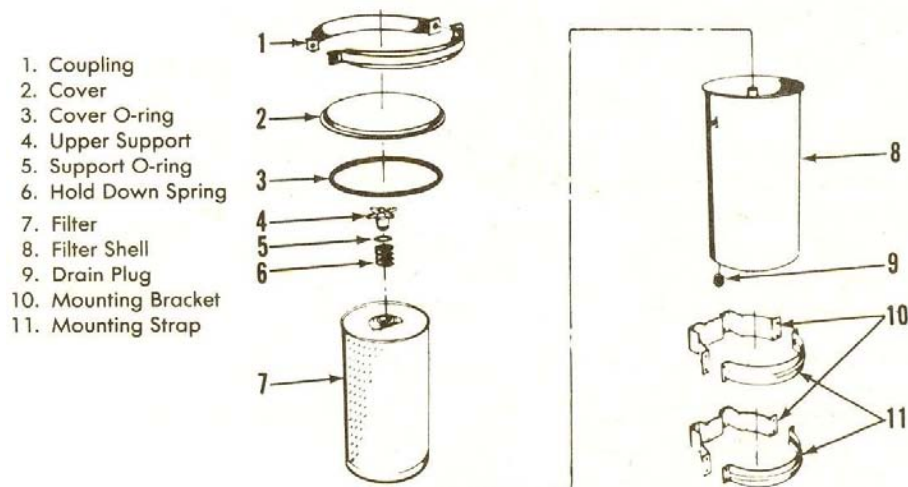


Fig. 7-3. Lubricating Oil By-pass Filter

Disassembly

7. Remove the coupling half (1) and lift off the cover (2) and O-ring (3).
8. Remove the upper support assembly (4, 5, 6). Lift out the filter (7).

Inspection

1. Inspect the upper support assembly and seal drain plug connections and filter cover. Replace if damaged.
2. Clean the orifice in the standpipe. The orifice controls the amount of oil flow through the by-pass filter and so must be kept clean.

Assembly

1. Install the new filter (7).
2. Install the spring (6) and the O-ring (5).
3. Replace upper support hold-down (4) on the filter and tighten to stop.
4. Position the O-ring (3) on the cover (2).
5. Install the cover (2) and coupling (1). Tighten the cap screws until the clamps come together.

Inverted Mounting**Flow Characteristics And Specifications**

With a 180°F (82°C) oil temperature and with engine at high idle, oil flow through the by-pass filters is to be a minimum of 1-1/2 to 3 gallon (5.7 to 11.4 lit) per minute, to be sure maximum filtration and adequate oil pressures are available.

Hose Size

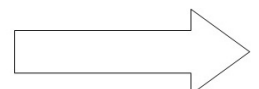
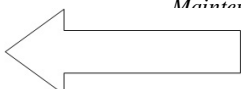
- a. The supply and drain hoses are Number 6 (5/16 inch (7.9 mm) inside diameter) flexible hose up to 10 ft (3 m), use Number 8 (13/32 inch (10.3 mm) inside diameter). All fittings in the by-pass circuit should be no less than 1/4 inch (6.4 mm) pipe size.
- b. The drain hose should discharge below the oil level in the oil pan to prevent foaming.
- c. Supply hose should be connected to the oil circuit between the oil pump and full-flow filter.

Fuel and Lubricating Oil Hoses**Hose Specification**

The hose must be either Teflon lined strengthened with corrosion resistant wire braid or a multiple ply construction consisting of a steam less Buna N synthetic rubber inner tube reinforced with one fabric or synthetic rubber and at least one wire braid layer, with an oil resistant cover of impregnated fabric braid.

The particular size hose must be noted by the manufacturer as suitable for a temperature range at least -40°F to + 275°F and a working or operating pressure of a minimum of 250 psi.

In addition, it must be certified by the manufacturer to have the following minimum burst pressure.

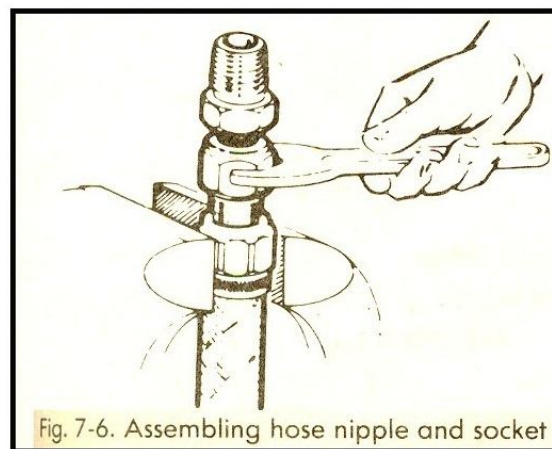
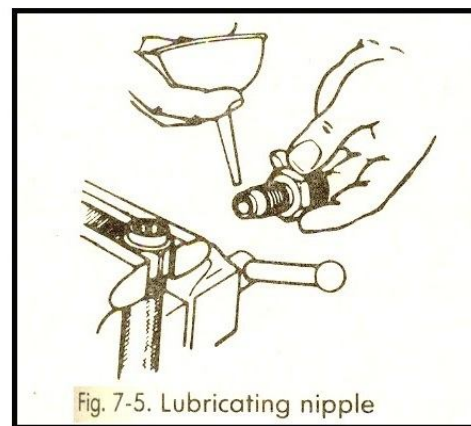
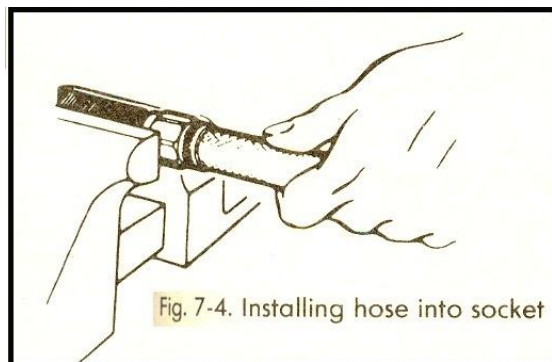


Hose Size	Min I.D. In. (Ref.)	Min. Burst Press. PSI
-6	5/16	1000
-8	13/32	1000
-10	1/2	1000
-12	5/8	1000
-16	7/8	1000
-20	1-1/8	1000
24	1-3/8	750

Assembly

Replace the hose and worn or cracked connections with new parts. The average life of flexible oil hose is 100,000 to 200,000 miles (160,900 to 321,000 km) or 3200 to 6400 hours. Time depends on the amount of bend and temperature to which the hose is subjected. Shops which make up new hose from bulk hose follow the steps below to ensure proper fitting installation.

- Use a hacksaw to cut the hose to length. The cut is to be square within 5 degrees and smooth so that the inner liner will not be damaged.
- Position the socket in the jaws of a vise. Check all fittings to make sure of fit.
- Hold the hose so that it enters the socket straight. Fig. 7-4. Rotate the hose counter clockwise while pushing it into the socket.



- d. Turn the hose into the socket until it bottoms. Check to be sure that it does not collapse in on the inside from being pushed it too far.
- e. Put the socket and hose assembly in the jaws of a vise. (clamp on the socket). Apply lubrication on the nipple (Fig. 7-5) and the inside of the hose for assembly.
- f. Hand assembly tools are available for assembling the nipple assemblies into the hose and socket assembly. The ST-1160 Assembly Tool Kit, includes an assembly mandrel for each hose Size 4,5,6,8, 10,12 and 16. In an emergency, a brass fitting can be tightened enough in the swivel nut to enable turning the flare seat (nipple) into the hose and socket. Fig. 7-6.
- g. After assembly, always look carefully inside the fittings and hose for possible hose damage. A cut in the inside diameter of the hose lining can plug the hose bore when the flow of fluid goes through the hose.

Lubricating Oil Cooler Disassembly

2. Ream out the cap screw from the oil cooler cover (6) and housing (3). Fig. 7-7.
3. Remove capscrews attaching the element (9) to the cooler housing (3). Remove elements.
4. Discard gaskets (2, 5, and 10) and O-rings (7 and 11).

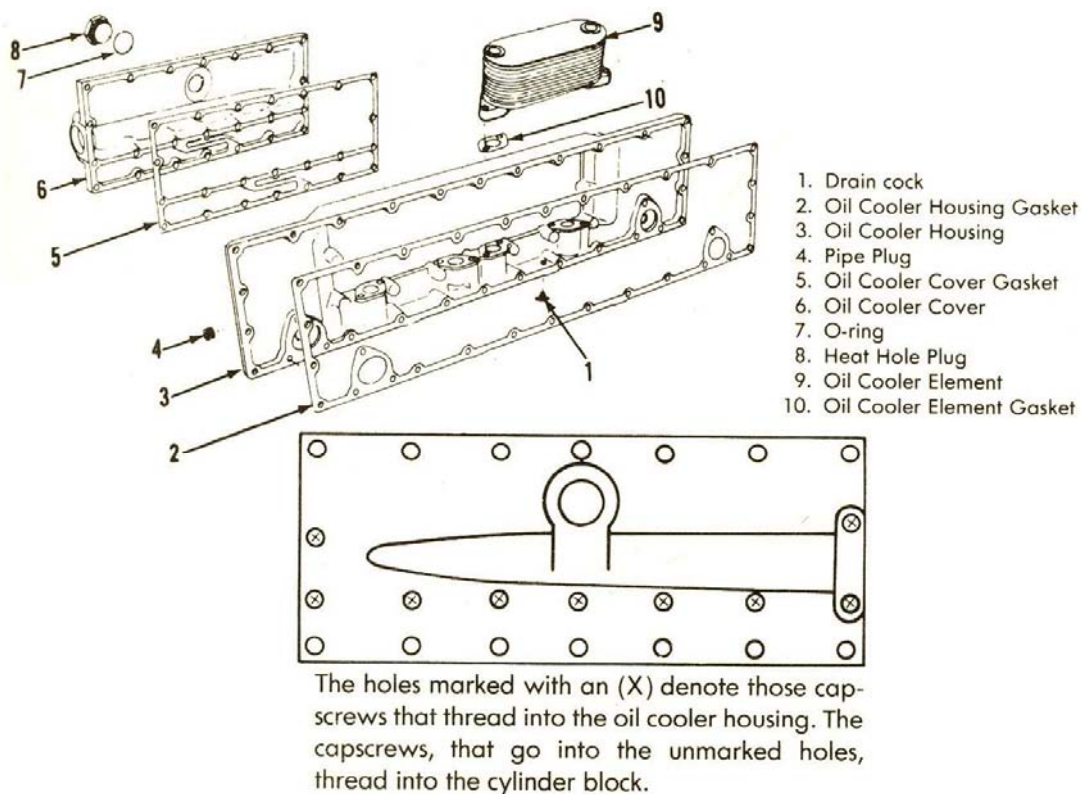


Fig. 7-7. Lubricating oil cooler

Cleaning

- a) To prevent hardening and drying of foreign material, clean the elements immediately with an approved cleaning solvent. Make sure solvent will not harm copper.

Inspection

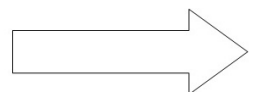
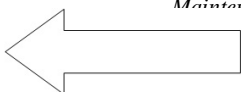
1. Inspect the housing (3) and the cover (6) for cracks or damage.
2. Use adaptors to plug the openings in the elements. Test the elements in the water tank.
3. Apply 60 p.s.i. (4.2 kg/sq cm) of air pressure to the element.
4. Inspect for air leaks. Replace defective parts.

Assembly

- a. Use new gaskets (2, 5 and 10, Fig. 7-7) and the O-rings (7 and 11). Lubricate the O-rings with clean engine lubricating oil. Install the elements (9) in the housing (3).

Note: If the retainer hold-down clamps are used, hand tighten capscrews at this time. Tighten capscrews to 30 to 35 ft-lbs (41 to 47 N-m) torque.

- b. Install the plug (8) with an O-ring (7) into the housing and cover. Tighten to 50 to 55 ft-lb (95 to 108 N-m) torque.
- c. Install the cover with nine capscrews and washers as shown in fig. 7-8. Install the drain cock (1) in the bottom of the housing. Tighten to 5 to 10 ft-lbs (7 to 14 N-m) torque.



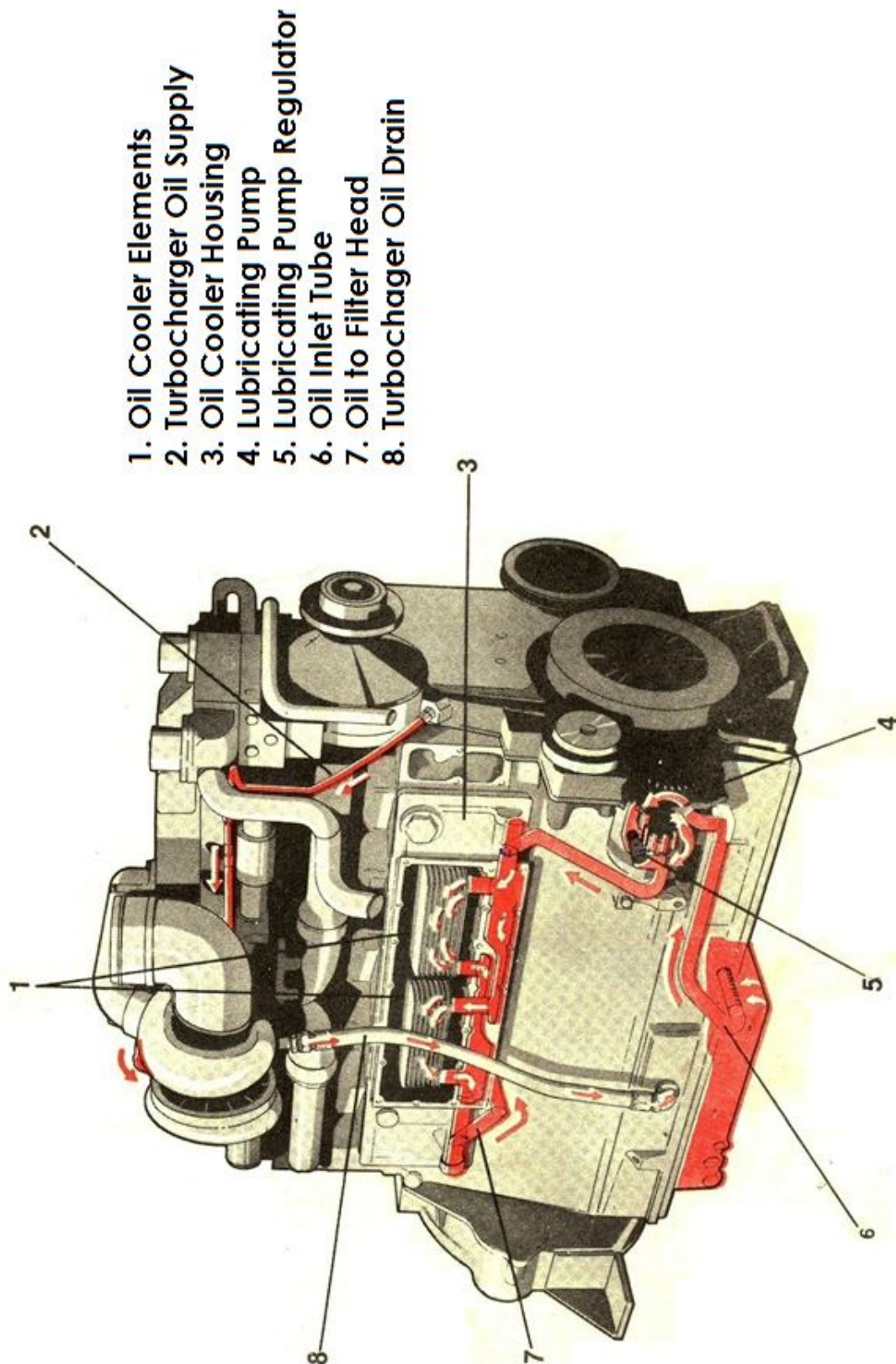


FIG. Lubricating System- 1

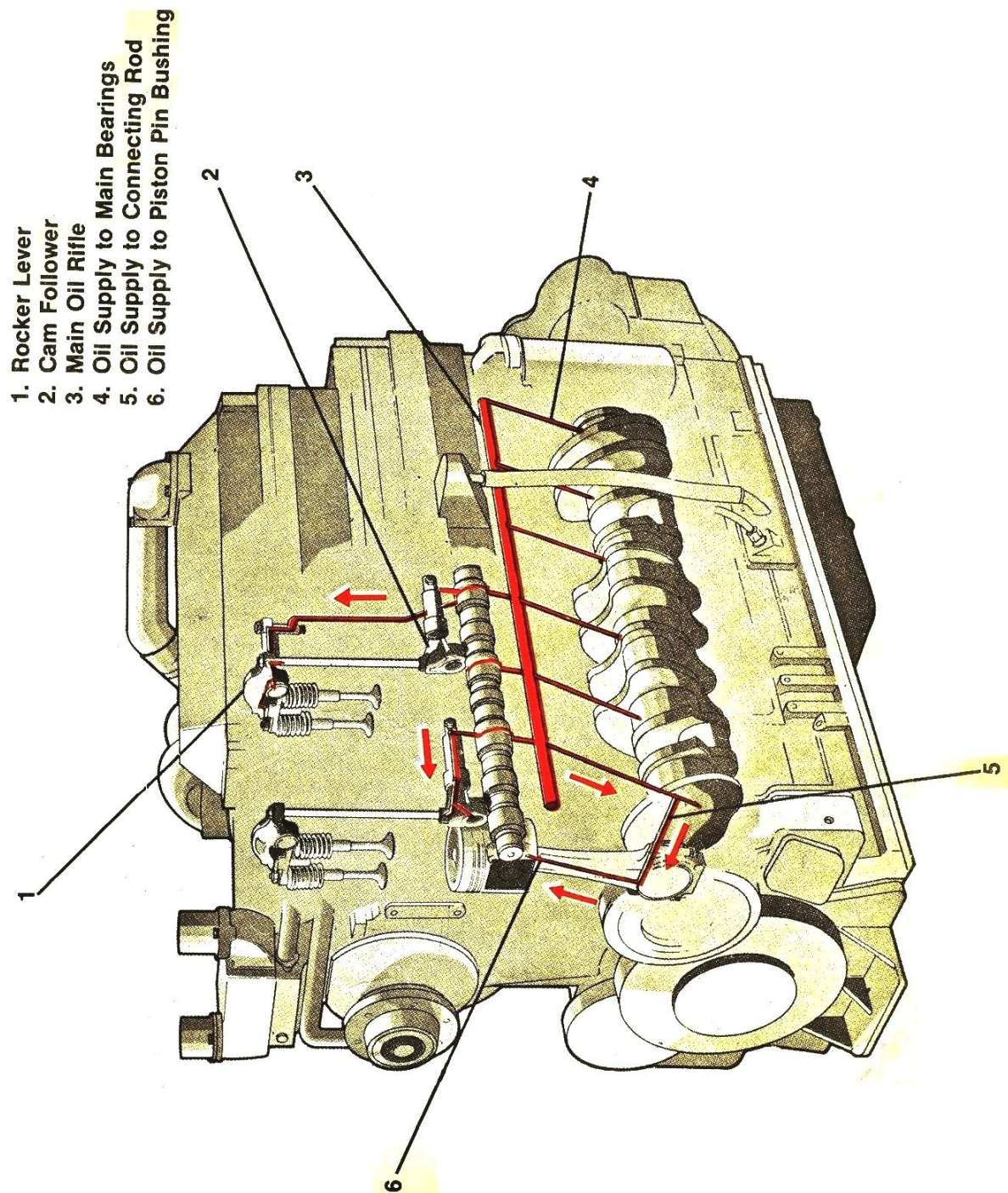


FIG. Lubricating System- 2

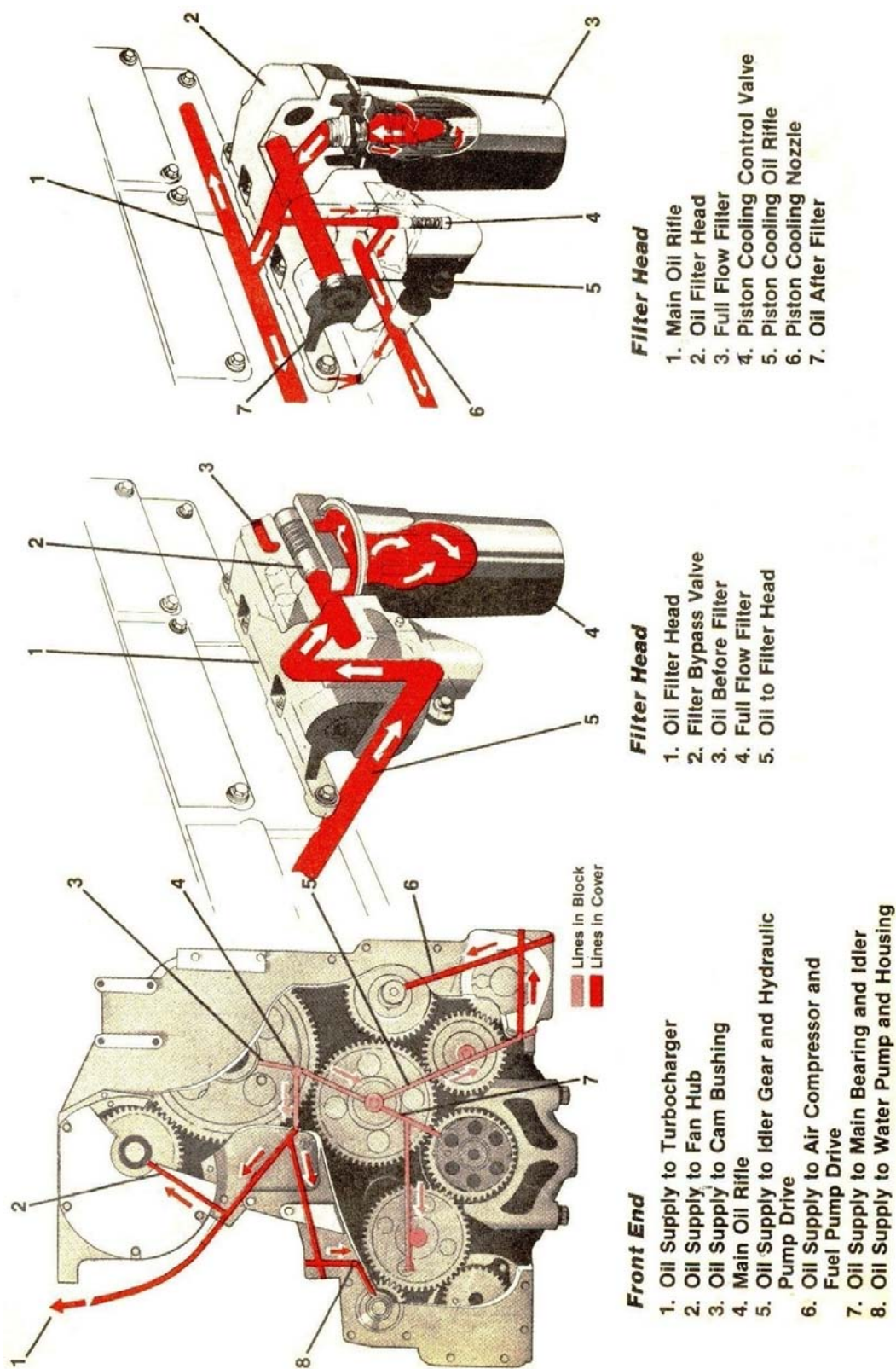


FIG. Lubricating System- 3

(G) Cooling System

This chapter covers engine water pump, fan hub and thermostats

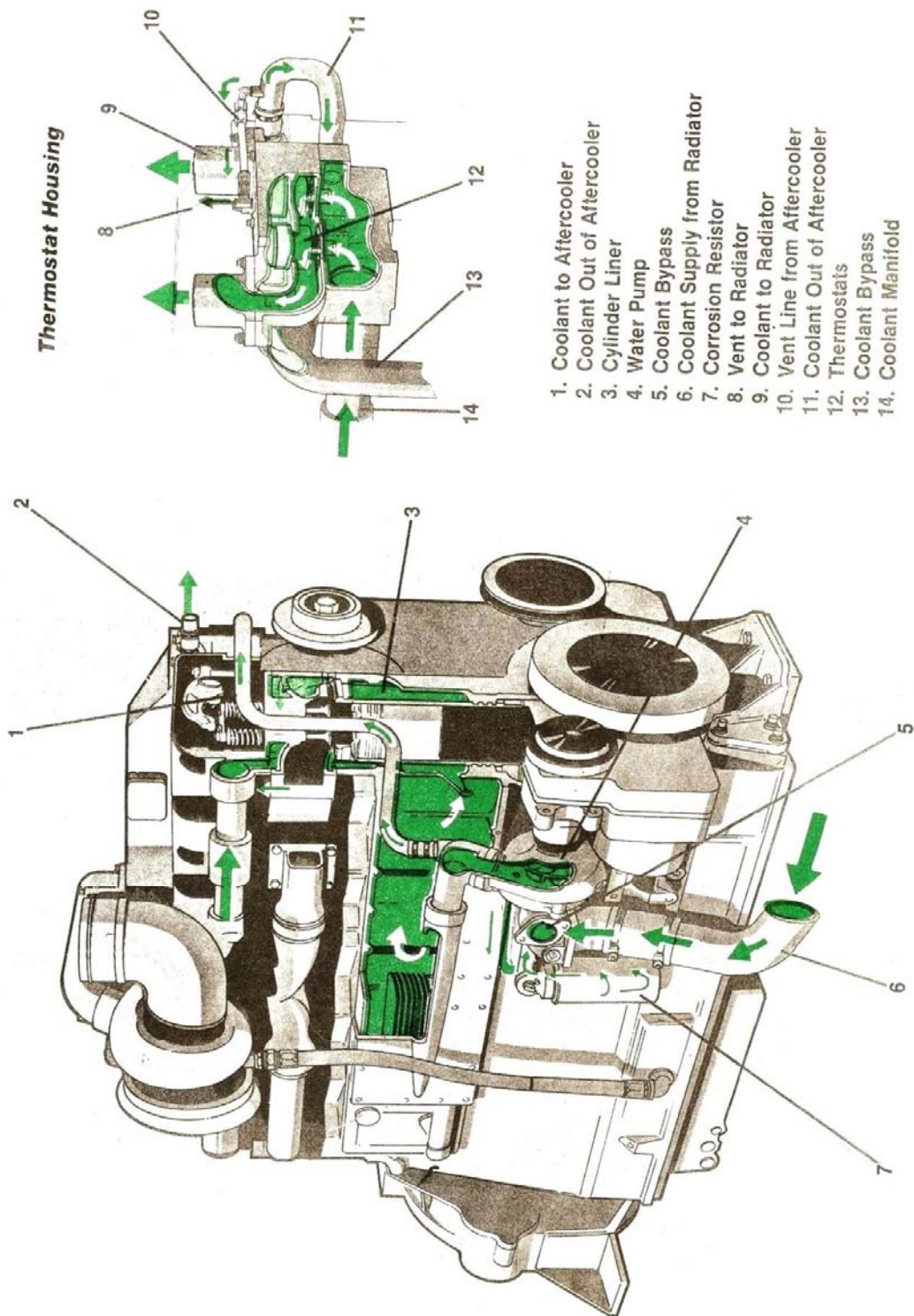


FIG. Cooling System of Engine

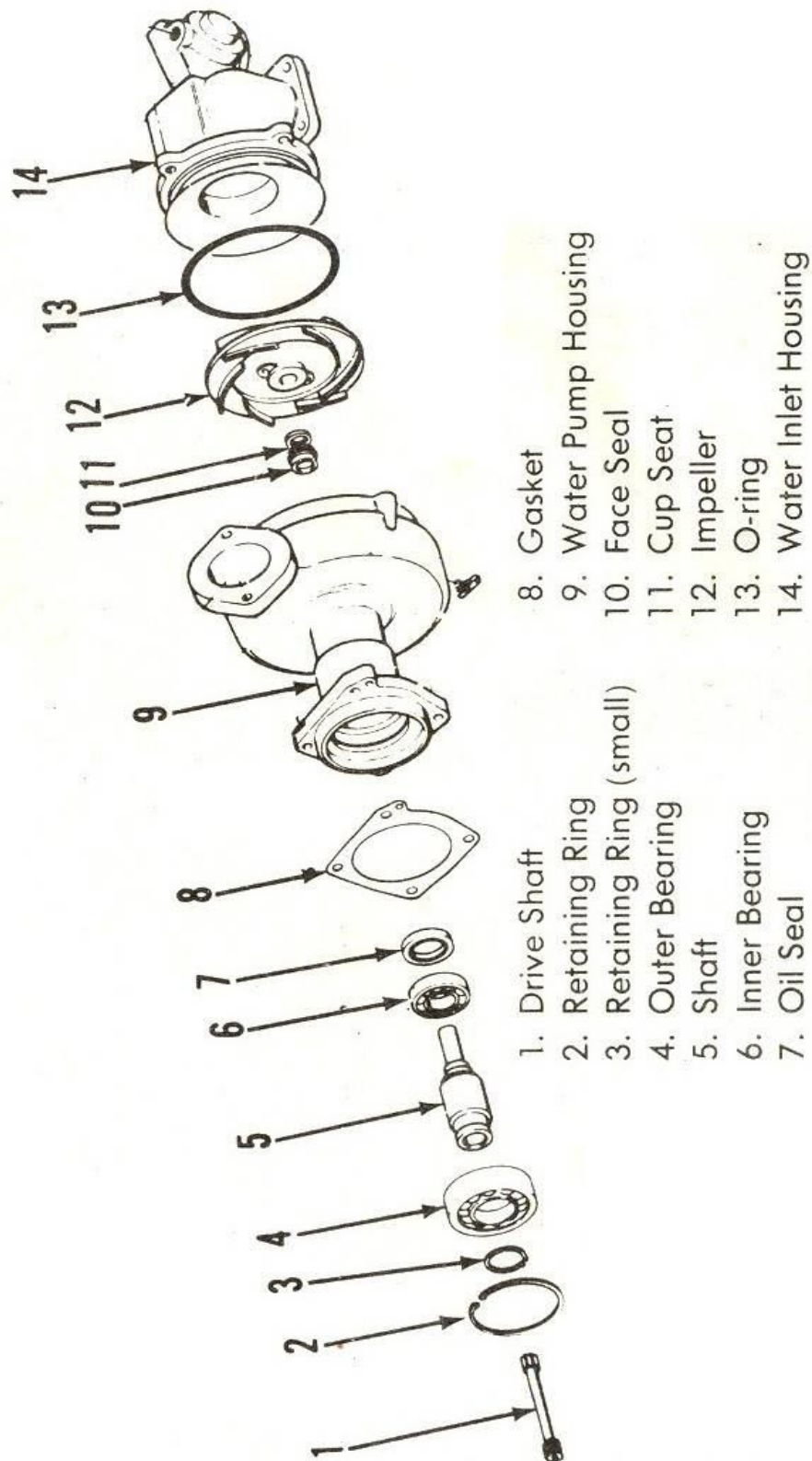


FIG. VIEW OF WATER PUMP

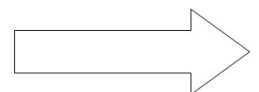
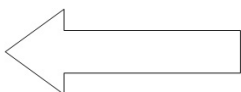
The following service tools or tools of comparable quality are necessary to repair or rebuild the Water pump as described in this section.

SNo.	Tool Name	Tool Number
Service Tools		
1	Puller	ST- 647
2	Bearing Mandrel	ST- 657
3	Pulley Impeller Puller	3375256
4	Seal Driver	3375320
5	Bearing Separator	3375326
6	Seal and Seal Mandrel	3375448
7	Spring Compressor Plate	3375705
8	Drive Bushing Mandrel	ST- 1314
9	Thermostat Seal Driver	3375411
10	Oil Seal Driver Mandrel	3375692
11	Seal and Pulley assembly Tool	3375707
12	Bearing Race Driver	3375693
13	Bearing Race Driver	3375694
14	Bearing Driver	3375695
15	Bearing Race Driver	3375704
	Wear Sleeve Driver	3375697
Standard Tools		
1	Snap ring pliers (Large and Small)	
2	Arbor Press	
3.	Grease Gun	
4	Bearing Packer	
5	Taps	
6	Filler Gauge set	
7		

Water Pump

Disassembly

- Remove the capscrews and lock washers securing the water inlet housing (14) to the water pump housing (9). Discard the O-rings.
- Use a 3375265 Puller to remove the water pump impeller (12) from the shaft (5), Fig. 8-2.
- Remove the retaining ring (2) holding the bearing and the shaft assembly (4, 5, 6) in the water pump housing.
- Support the water pump housing at the drive end. Press the shaft and bearing assembly from the housing by applying pressure to the impeller end of the shaft, Fig. 8-3.
- Remove the seat (11), drive the oil seal (7) and the face seal (100) from the housing. Discard the seat and seal.



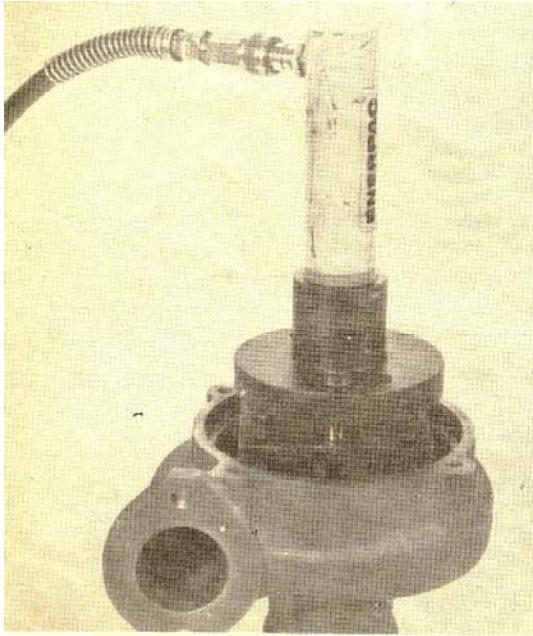


Fig. 8-2, Remove the Impeller

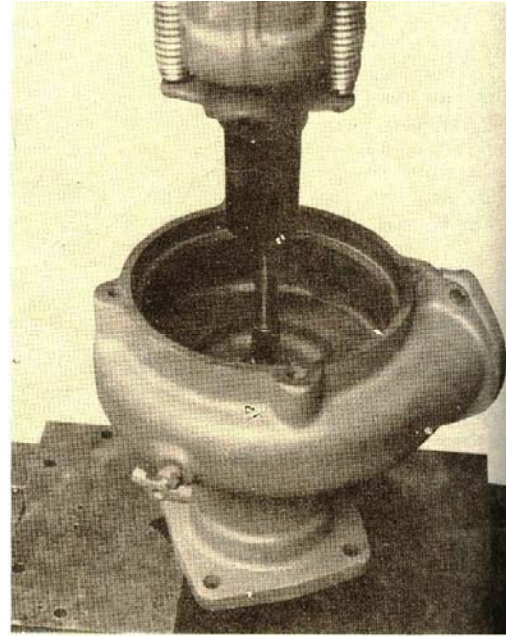


Fig. 8-3, Press the shaft assembly from the housing

- f. Remove the retaining ring (3) retaining the outer bearing (4) from the shaft, Fig. 8-4. Support the outer bearing with a 3375326 Bearing Separator and press the shaft (5) from the bearing.
- g. Use a 3375326 Bearing Separator supporting the inner bearing (6) to press the shaft from the inner bearing.

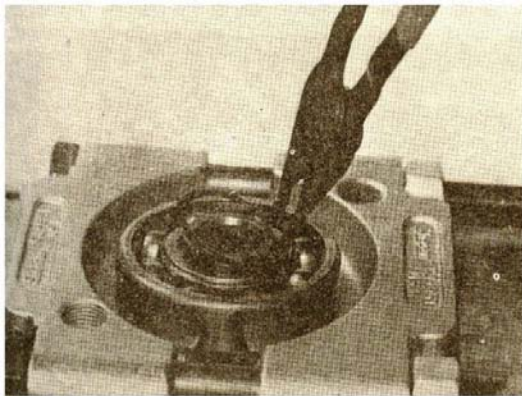


Fig. 8-4, Remove the retaining ring

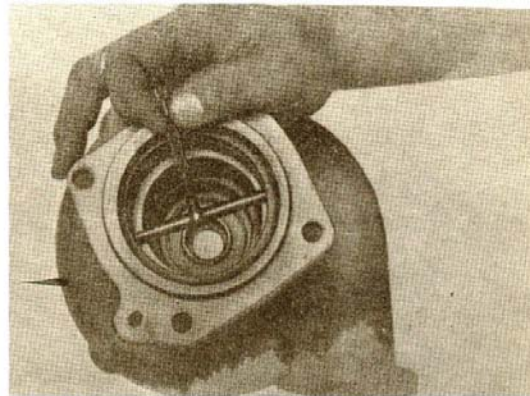
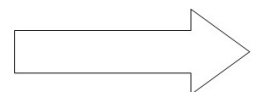
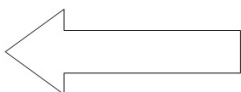


Fig. 8-5, Measure the housing bore

Inspection

1. Inspect the water pump bearings. Rough or worn races indicate possible damage to the shafts outside diameter and the pump housing bore. **Discard the bearings.**
2. Visually inspect the water pump housing, and inlet housing for cracks, corrosion and excessive wear. Measure the water pump housing bore (Fig. 8-5); if larger than maximum specifications, replace the housing. See Table 8-3.
3. Inspect the water pump impeller for cracks or erosion to the extent that it will retard coolant circulation.



4. Measure the impeller bore and the shaft diameter. There should be a minimum of 0.001 inch (0.03 mm) press fit between the bore and the shaft mating surface. See table 8-3.
5. Inspect the shaft for straightness and gelling on the diameter surfaces that are press fit.
6. Inspect the water pump drive shaft for wear or distortion.
7. Clean all the parts in an approved cleaning solvent and dry with moisture free compressed air. Discard all the parts that do not meet inspection criteria.

Assembly

1. Lubricate the shaft bearing surface with a thin coat of clean lubricating oil. Use a ST-657 Bearing Mandrel to support the inner bearing (6), to press the impeller end of the shaft (5) through the inner bearing until the shaft shoulder seats tightly against the bearing inner race, Fig. 8-6.

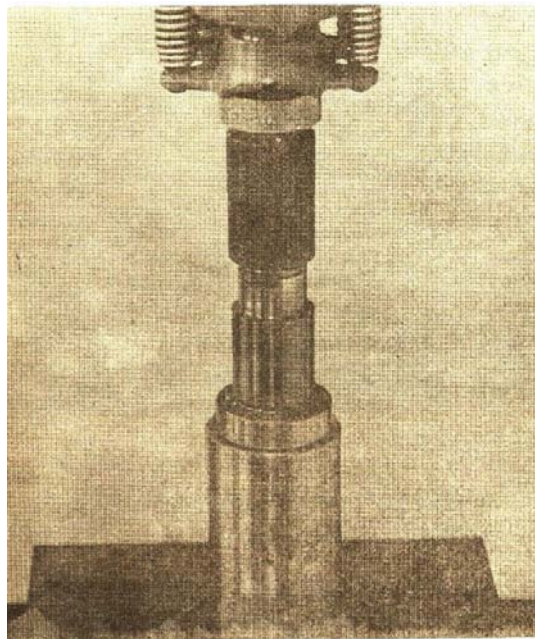
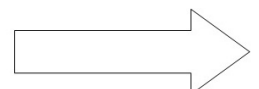
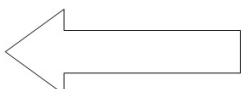


Fig. 8-6, (K10811). Press the shaft into the small bearing

2. Use a 3375318 Bearing Mandrel to support the outer bearing (4) and press. Press the drive end of the shaft (5) through the outer bearing until the shaft shoulders seat against the bearing inner race. Secure the outer bearing with a retaining ring (3), beveled side away from the bearing. Fig. 5-8.
3. Support the water pump housing (9) at the impeller end. Use the 3375320 Seal Driver to press the oil seal (7) into the bore. Seal the lip up toward the bearing, until it is even with the shoulder of the inner bearing surface.
4. Apply a thin coat of Loctite 601 to the bearing(s) outer race only, Fig. 8-8. Lubricate the shaft seal mating surface. Position the bearing and the shaft assembly (3, 4, 5, 6) into the water pump bore and press it into the housing until the outer bearing (4) seats. Use a 3375318 Bearing Mandrel to support the bearing outer race.

Caution: Take care not to damage the oil seal.



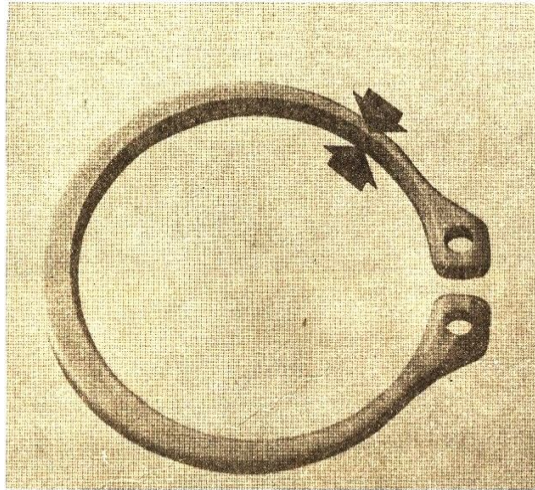


Fig. 8-7, Beveled edge of the retaining ring

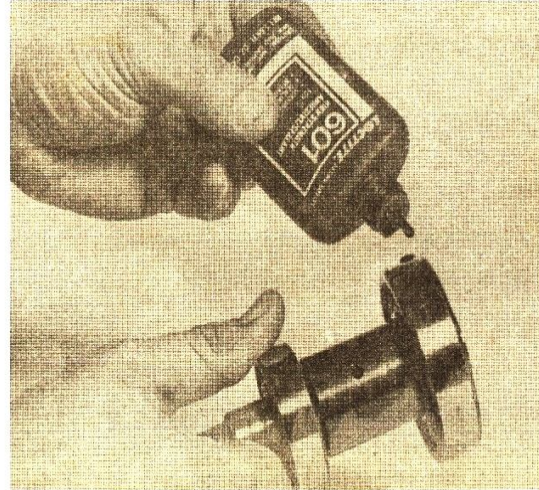
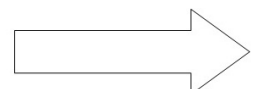
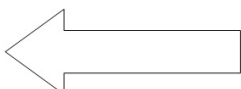


Fig. 8-8, Apply Loctite to the bearings

5. Install the large retaining ring (2) to hold the bearing assembly in place.
 6. Apply a thin coat of Loctite 3375066 to the brass case on the face seal (10), Fig. 8-9. Use a 3375448 Mandrel to support the water pump on the drive end of the housing – not on the shaft – and press the face seal into the housing until it seats, Fig. 8-10.
 7. Use a 3375448 Mandrel to press the new cup seat (11) into place on the shaft. A 3375448 Mandrel is designed to put the cup seat to an exact location against the face seal. Fig. 8-11.
 8. Apply one drop of Loctite 290 to the cup seat at the shaft, Fig. 8-12.
- Caution:** If an excess amount is applied, the face seal and could become locked together.
9. Apply a thin coat of Loctite 601 to the impeller bore and press on the shaft maintaining 0.013 to 0.020 inch (0.33 to 0.51) clearance between the impeller and the housing. Use a feeler gauge through the water discharge port in the housing to check the clearance, Fig. 8-13.
 10. Apply a thin coat of clean lubricating oil to the O-ring (13) and put it in the groove on the inlet housing.
 11. Put the inlet housing to the water pump housing in the correct position. Secure the water inlet housing to the water pump housing with capscrews and lock washers.



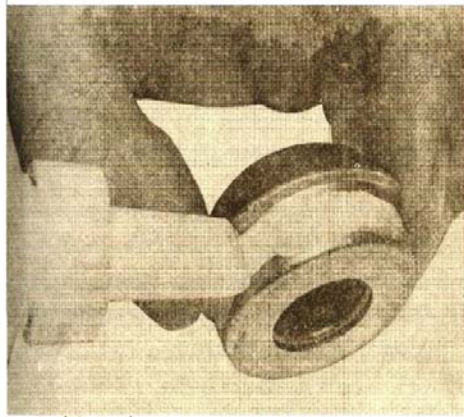


Fig-8-9, Apply pipe sealant to the seal



Fig. 8-10, Press the carbon face seal in the housing



Fig. 8-11, Install the cup seat



Fig. 8-12, Apply Loctite to the shaft behind the seat

Fan and Fan Hub (Gear Driven)

Check the fan blades for bends, cracks or other damage. Clean the disassembled parts as described in group O, Engine Disassembly.

Disassembly

1. Remove the locknut (1, Fig. 8-14) clamp washer (2) from fan hub shaft (12).
2. Support the fan hub (4) on arbor press. Press the shaft and support assembly (6, 8, 9, 11, 12 and 13) from the hub. Inspect the water sleeve (5). If the wear grooves are visible, replace the wear sleeve.
3. Remove the shaft (12), spacer, inner bearing and gear (12) from the support (9), remove the spacer and bearing from shaft.
4. Using a suitable puller, remove the oil seal (6), lift the outer bearing from the support (9). Discard the oil seal.

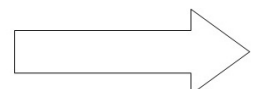
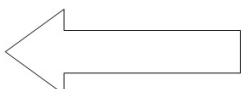
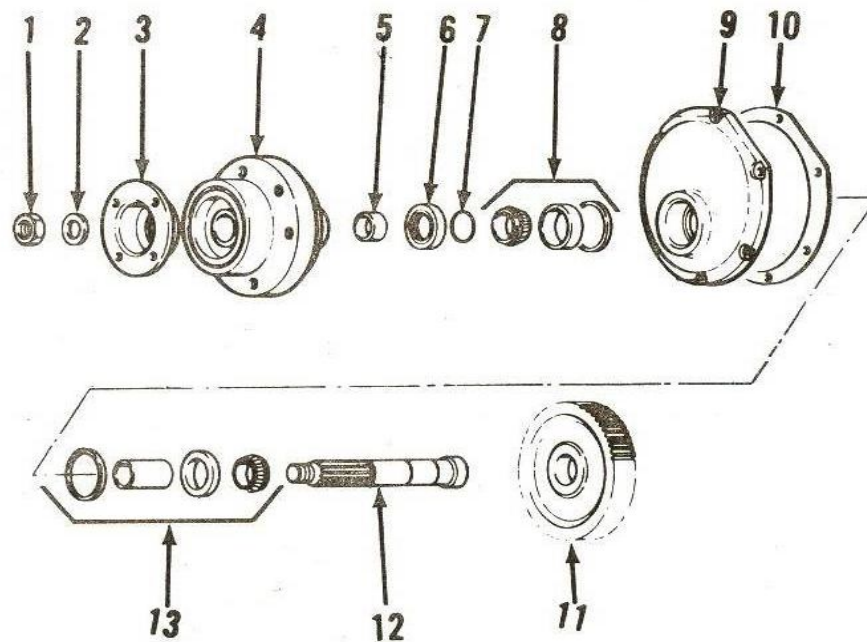




Fig. 8-13, Check the impeller clearance

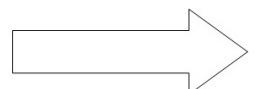
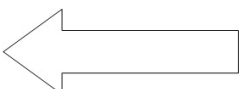


- | | | |
|-----------------|--------------------|---------------------|
| 1. Slotted Nut | 6. Oil Seal | 10. Gasket |
| 2. Clamp Washer | 7. O-ring | 11. Fan Gear |
| 3. Retainer | 8. Roller Bearing | 12. Shaft |
| 4. Fan Hub | 9. Fan Hub Support | 13. Roller Bearings |
| 5. Wear Sleeve | | |

Fig. 8-14, Gear driven fan hub assembly

Inspection

1. Inspect the bearings, races and shaft for rough condition and wear. Bearing races may be removed, with a flat punch by hitting, from the back side, first from one side and then the other.



Note: The bearings, spacers and lock rings (8) must be replaced as an assembly. See the parts Catalog. Do not remove lock rings from the support unless the bearings are to be replaced.

2. Inspect the drive gear (11) for damaged teeth and large areas of water. Do not remove the gear from the shaft unless it is defective.

Assembly

Lubricate the bearings, races, lock rings, and seal with clean lubricating oil during assembly.

Note: Steps 1 and 2 apply only if a part of the bearing assembly is defective, and the bearing assembly must be replaced.

1. If the lock rings were removed, install new lock rings into the lock ring grooves in the fan hub support (9).
2. With the cupped area facing away from the lock rings; press the bearing races into the bore of the fan hub support (9) until seated squarely against the lock rings.

Note: This step applies only if step one was used.

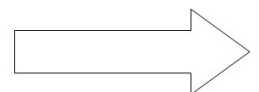
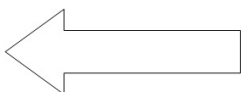
3. Press the gear (11) onto the shaft (12). Maintain flush to 0.010 inch (0.25 mm) from the gear face to the shaft. Loctite No. 601 or an equivalent sealer must be used in the press fit area of the gear and shaft.
4. Position the inner bearing and spacer onto the shaft (12); insert the shaft and the bearing through the fan hub support (9) seating the bearing in the bearing race.
5. Place the outer bearing and spacer onto the shaft (12); insert the shaft and the bearing through the fan hub support (9).
6. Press these components onto the shaft at the same time until the inner bearing seats against the shoulder on the gear end of the shaft. Recheck the press fit of the gear to the shaft to insure it is flush to 0.010 inch (0.25 mm) from the gear face to the shoulder on the shaft as specified in Step 3.
7. Place O-ring (7) over the shaft and slide down to seat against the outer bearing.
8. Place the oil seal (6) on the shaft and press into the fan hub support (9) until flush.
9. Using a press (or mallet) with a piece of metal plate, insert retainer (5) into the groove of the fan.

Fan Drive Clutch Disassembly

1. Removal from Engine.
2. Remove all the parts that would prevent the fan drive assembly from being removed from the engine. Remove the six hex head capscrews holding the fan blade to the fan hub. Remove the six hex head capscrews from the face of the fan drive cover assembly.

Note: Do not remove the two flat socket head screws (A) from the face of the fan drive assembly.

Use a soft hammer to tap around the outside of the fan drive assembly to loosen the fan drive assembly from the adapter plate.



Caution: Do not drive or wedge tool between the mounting flanges to loosen fan drive assembly.

Disassembly of the Fan Clutch Assembly

1. Place the fan clutch assembly on a work bench and drive the gear (1) down.
2. Remove the two flat head socket screws from the face of the front cover assembly.

Note: The fan drive assembly is two sections consisting of:

- a. Front Cover assembly (front section)
 - b. Fan drive housing assembly (rear section)
3. Lift the fan front cover assembly up and out of the fan drive housing assembly and place on a bench with the fan drive hub down.
 4. Remove the gasket from the front cover assembly.

Fan Drive Housing Disassembly

Note: Bend the lock tabs of the lock plate (47) away from the capscrews (3).

1. Remove the two 5/16 hex head capscrews (3) from the drive gear (1) and washer (4). Two 5/16-18 hex head screws are thin head and six point socket should be used to remove and replace the capscrews.
2. Remove the lock plate (47), retainer washer (4) and the shims (46).
3. Place the fan drive housing assembly in a press with the drive gear (1) down. Using six inch blocks placed between the rear flange of the drive housing (5) and the press table, press the shaft and the gear (1) out of the clutch drum hub (6) and fan drive housing (5). The inward bearing cone and rollers (7) will be pressed from the shaft at this time.

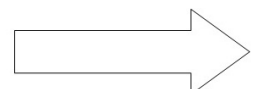
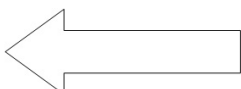
Caution: When pulling the bearing cups (11 and 12) from the fan drive housing, pull the cups straight and even to prevent bore damages as the housing is Aluminum. One cup must be removed each way.

4. Remove the bearing cone spacer (8) from the shaft and pull the bearing (9) from the shaft. Do not remove the bearing cup spacer (10) from the fan drive housing at this time.
5. Remove the bearing cups (11 and 12) from the fan drive housing (5), one from each end of the fan drive housing.

Disassembly of the Front Cover Assembly

Apply air pressure through the fitting of the front over to release pressure on the Belleville springs.

1. Remove the two 5/16 X18 flat head socket screws (13) from the fan hub (14) and the retainer washer (15). Discard the two flat head socket screws (13) and replace.
2. Remove the retaining washer (15) and the shims (16) from the fan hub.
3. To remove the splined hub (17) and the drive plates (18 and 19), place two screwdrivers 180 degrees apart under the face of the pressure plate (20) and over the edge of the piston housing (21). Pry up with equal pressure to loosen the splined hub (17) from the fan hub (14) and hold the pressure plate (20) toward the back plate (22) to prevent the plates from coming off the splined hub assembly (17).
4. Remove the shims (16) which are next to bearing (23).



5. Remove the needle thrust bearing (24) from the thrust washer (36). Remove the air supply from the fitting on the front cover.
6. Remove the external retaining ring (26), retaining the piston housing (21) to the front cover (27).
7. Remove the piston housing (21) from the front cover (27).
8. Place the front cover assembly (27) in a press, fan mounting hub (14) down. Using six inch blocks, block the front cover assembly between the pres plate and front cover (27).
9. Press the fan hub (14) down and out of the front cover (27). The inward bearing (23) will be pressed from the shaft also.
10. Remove the shims (28) and the bearing spacer (29) from the fan hub (14).
11. Remove the seal (30) from the front cover (27).
12. Remove the two bearing cup spacers (31 and 32), one from each end of the front cover.
13. Pull or press the bearing (33) from the fan hub(14).
14. Remove the two O-rings (34 and 35) from the front cover.
15. To disassemble the clutch piston assembly, put in a press with the thrust washer(36) and retaining ring (37) up.
16. Put a flat plate on the thrust washer (36).

Note: The plate diameter must be large enough to allow good contact on the thrust washer, but small enough at the outside diameter to allow the removal of the retaining ring. The plate diameter at the outside diameter should be 4.562 inch (11.87 mm).

17. Press down the flat plate and thrust washer (36) to compress the Belleville springs (38) so that the retaining ring (37) can be removed.
18. Release the press force and remove the thrust washer (36) and Belleville springs (38).

Note: The direction of the Belleville springs, as they must be installed in the same direction when reassembled. Belleville springs are a matched set and must be secure together and maintained as a matched set.

19. Remove the clutch body (25) from the piston housing (21).
20. Remove and discard the O-ring (39) from the clutch body (25).

Cleaning:

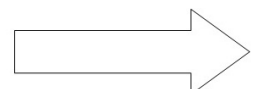
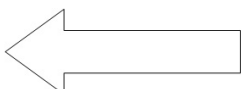
Thoroughly clean all the parts using a good grade solvent. Special attention should be given to the oil and air passage when cleaning. Visually inspect the parts after cleaning. Discard and replace all the parts that are worn and / or damaged.

Inspection of Fan Drive Components

Fan Drive Housing Assembly

The housing bearing bore sizes and input drive gear shaft diameter size are shown in Table 8-1.

1. Inspect the housing for cracks and damage. Mounting surfaces must be flat and free from nicks and burrs.
2. Inspect the bearing for wear and spalling.
3. Inspect the drum hub for wear in the drive slots. The drum hub must be replaced if the indentations from the drive plates exceed 0.015 inch (0.38 mm) in the drive



surfaces of the slots. Check the drive splines of drum hub for fretting and wear on the splines. Replace unserviceable parts.

Note: Heat the drum hub assembly (6) to 350°F (177°C). Place the drum hub assembly (6) on the spline of the input drive gear (1) with the matching splines aligned, and press the drum hub assembly (6) shoulder seated tight against bearing (7).

4. Inspect the input drive gear. Teeth of the gear must be smooth with no visible scoring or pitting. Drive splines must be free of fretting and without wear.

Front Cover Assembly

1. Check the bearing bore size of the front cover. Refer to Table 8-1.
2. Check the fan mounting hub shaft bearing diameters. Refer to Table 8-1.

Note: Due to the different shaft and housing diameters, care must be taken to install the proper size bearings.

3. Inspect the seal wear sleeve of the fan mounting hub shaft for wear from the seal. Replace the wear sleeve in accordance with wear replacement procedures.
4. Inspect the disc pack which includes internal and external clutch plates. If the disc pack (7 internal and 6 external plates) is less than 0.778 inch (19.76 mm) total thickness, the internal plates must be replaced. Inspect the plate for fitness and burning. Discard all the plates that are warped or burnt. Check the drive tangs of the external drive plates. The drive edge must be square and not indented. Check the drive spline of the internal drive plates for excessive wear.
5. Inspect the splined hub internal and external spline for excessive wear.
6. Inspect the back plate and pressure plate for flatness and burning. Check the splines for excessive wear.
7. Inspect the fan mounting hub shaft for excessive wear. Check the fan mounting bolts holes for stripped threads.

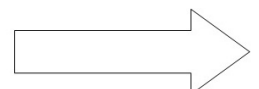
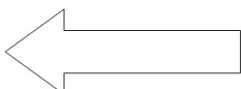
Note: All the seals, O-rings, gaskets and shims should be replaced when overhauling the Rockford drive assembly.

Table 8-1: Shaft & Housing Specifications

Location	Shaft OD in Inch [mm]	Housing ID in Inch [mm]
Gear opposite & adjacent	1.7822 [45.2768]	3.0585 [77.6859]
	1.7827 [45.2805]	3.0595 [77.7113]
Housing opposite	1.4966 [38.0136]	2.4763 [62.8980]
	1.4971 [38.0263]	2.4775 [62.9285]
Housing adjacent	1.5010 [38.1254]	2.5590 [64.9936]
	1.5015 [38.1381]	2.5606 [65.0392]

Assembly of Front Cover Assembly

1. If the oil seal (30) was removed, the wear sleeve (40) must be replaced at this time.
2. Put the bearing (33) on the fan hub shaft (14) with the large end of the cone toward the seal sleeve (40) and the shaft shoulder.
3. Put the fan hub shaft (14) and the bearing in a press and press the bearing (..) light against the shoulder on the shaft.
4. Place the bearing spacer (29) on the fan hub shaft (14).



5. Install the bearing spacer (29) on the fan hub shaft (14) tight against the bearing (33).
6. Install the bearing cup spacer (31 and 32) in the front cover (27). Bearing cup spacers (31 and 32) are installed with the large end of the cup in press each cup in tight against the bearing shoulder in the front cover (27).

Note: Do not install the front cover seal at this time.

7. Install the fan drive hub (14) into the front cover (27) with shaft end of the hub entering the seal and of the front cover (27) first.
8. Put the front cover (27) and fan hub (14) in a press, fan hub down.
9. Place 0.030 inch (0.76 mm) shims (28) on the fan hub shaft (14) against bearing spacer (29). Install the bearing (23) on the fan hub shaft small end of the cone towards the spacer (29) and the shims (28). Press the bearing (23) into the place tight against the shims (28).
10. Remove the front cover assembly from the press area and place on the flat work table. Mount a dial indicator so as to read the relative movement between the fan hub shaft (14) and the front cover (27). Bearings should be rolled into obtain the correct bearing setting. Shims are available in 0.020, 0.010, 0.005 and 0.002 inch (0.50, 0.25, 0.13 and 0.05 mm) thickness.

Example : (A) Shim Stack

Total movement with 0.030 inch [0.76 mm] shim equals 0.013 inch [0.33 mm] movement
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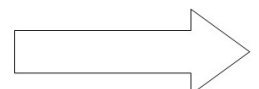
Example : (A) Shim Stack cont.		
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	inch	[mm]
Preload required	0.002	[0.05]
Total shims removed	0.015	[0.38]
Shims used	0.015	[0.38]

11. Place the front cover assembly in a press. Press the fan hub shaft (14) out of the fan cover (27). Follow example (A) Table 8-2 to obtain the proper shim thickness and bearing preload. Remove the shims required to obtain preload.
12. Coat the outside diameter of the oil seal (30) in the front cover (27). Install the oil seal (30) with a sealant. Install the oil seal (30) in the front cover (27). Install the seal so that the outer face of the seal is flush with face of the front cover. The lip must be in.
13. Using a number of shims (28) as determined by step 10 , put the shim (28) on the fan hub shaft (14) and repeat Step 8 and 9.

Assembly of Clutch Piston

14. Put the piston housing (21) in a press with the retaining ring (37) groove up.
 - a. Install the O-ring (39) in the groove at the outside diameter of the clutch body (25).
 - b. Coat the O-ring with a light film of clean engine oil. Install the clutch body (25) and the O-ring (39) into the piston housing (21) with the flat side of the clutch body (25) down.
 - c. Place the two Belleville springs (38) on the clutch body (25) with the inside diameter of the spring down , outside the diameter of the spring up.

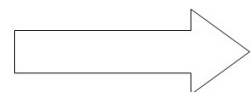
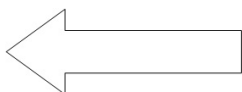


Caution: Both springs must be installed in the same direction.

- d. Install the thrust washer (36) with the chamfered edge down against the Belleville springs (38).
- e. Put the retaining ring (37), in the assembly before pressing. Slide the complete assembly under the press ram. Use the flat plate as described in the disassembly procedure to press the thrust washer (36) and the Belleville spring (38) just for enough to install the retainer ring (37) in the piston

Assembly of Splined Hub Assembly

15. Place the splined hub (17) on the work table with the external retaining ring (41) groove up.
 - a. Align the mating splines of the back plate (22) with the splined hub (17) and install the back plate (22) with the flat side down.
 - b. Install the external retaining ring (41).
 - c. Turn the splined hub (17) and the back plate (22) over so as to rest on the back plate end of the hub.
 - d. Install the internal and external splined clutch plates (18) against the back plate (22). The next plate will be external splined (19), then internal, external, et. Until pack is complete. (7 internal, 6 external).
 - e. Install the internal retaining ring (42) into the groove of the splined hub (17). This retaining ring acts as an oil dam for lubrication to plates. It must be installed.
 - f. Align the splines of the pressure plate (20) with the splines of splined hub (17).
 16. Put the front cover assembly on the work table with the fan hub down.
 17. Install the two O-rings (34 and 35) in the front cover (27).
 18. If the roll pin (43) was removed from the front cover (27), install the new roll pin (43) at this time.
 19. Coat the O-rings (34 and 35) with small amount of clean engine, oil, slide clutch piston assembly onto the front cover (27). Line up the hole in the clutch body (25) with the roll pin (43) and push the clutch piston assembly down tight against the shoulder on front cover (27).
 20. Install the external retaining ring (26) onto the front cover (27) to hold the clutch piston assembly in place.
- Caution: Check to make sure that external retaining ring (26) is properly seated in position. Apply air pressure to the fitting of the front cover and check for air leaks. The shim stack (16) between bearing cone (23) and front of the splined hub is 0.029 inch (0.74 mm).
21. Install the shim stack (.16) of 0.029 inch (0.74 mm).
 22. Place the needle thrust bearing (24) on the thrust washer (36).
 23. Apply air pressure to the clutch piston minimum 100 psi , maximum 120 psi required.
 24. Hold the pressure plate (20) and splined hub assembly (17) together. Align the splines of fan hub drive (14) and splined hub (17), and push the splined hub (17) into place against the shims (16).
 25. Hold the splined hub assembly (17) tight against the shims (16). Measure the distance from the end of the shaft (14) to flat surface of splined hub (16). Add shim



- stack equal to this measurement plus additional 0.003 to 0.005 inch (0.08 to 0.13 mm) shims.
26. Install the total shims (16) to include the 0.003 to 0.005 inch (0.08 to 0.13 mm).
 27. Install the retaining washer (15).
 28. Install two new 5/16 X18 flat socket head screws (13) and tighten to 30 ft-lbs (27 N-m) torque.
 29. Place the drum assembly (6) over the external clutch plate (19) to align the drive tags.

Special Note: The test of the Belleville spring must be done with fan drive assembled. Clamp the fan drive input gear in a vise. Adopt the torque wrench to the fan drive hub. Apply air pressure through the regulator to the air fitting of the fan drive. Start with the regulator at 0 and then open to 50 psi. Rotate the fan hub.

The hub should rotate at 120 to 140 ft-lbs (163 to 191 N-m) torque. Increase the regulator to 100 psi. The fan hub should rotate with 6 to 20 in-lbs (0.68 to 2.26 N-m) torque.

30. Remove the air pressure from the front cover assembly.
31. With the air pressure removed, the drive plates will be locked in place for complete unit assembly. Remove the drum assembly (6) from the drive plates.

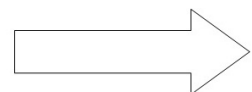
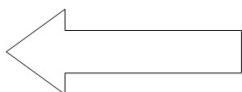
Assembly of Fan Drive Housing

Before assembling, make sure that all the parts are clean and can be used the bearing set for the fan drive housing assembly is a matched set with spacers included and must be used as a matched set. The bearing cup spacer (10) was not removed from the fan drive housing. Measure the cup spacer in the fan drive housing (5) and record the reading. Measure the new cup spacer in this bearing set. If the spacers are dimensionally within 0.001 inch (0.02 mm), discard the new cup spacer and use the cup spacer in fan drive housing. If the new cup spacer is used, the slot in the cup spacer must be aligned with the oil hole in the fan drive housing.

1. Press both bearing cups (11 and 12) into the fan drive housing (5) –one from each end, larger end of cup to spacer. The inner bearing cup (12) should be pressed in first. Pressing the inner bearing first makes sure that the tolerance stack of the bearings and spacers is correct.
2. Put the input drive gear (1) in a press, gear end down.
3. Put one bearing (9) on the shaft (1) with the large end of the bearing toward the gear.
4. Install the input drive gear (1) into the fan drive housing (5) splined end first.
5. Install the bearing cone spacer (8) on to the shaft against bearing (9).
6. Put the fan drive housing (5) and input drive gear (1) in the press. Install the bearing (7) on the drive gear shaft (1) with the small end of the bearing toward cone spacer (8).
7. Press the bearing (7) into position against the bearing cone spacer (8).

Note: Heat the drum assembly (6) to 350°F (177°C)

8. Put the drum hub assembly (6) on the spline of the input drive gear (1) with matching splines aligned, and press the drum hub assembly (6) shoulder seated tight against bearing (7).
9. Use a depth micrometer to measure the gap from the flat of the drum hub (6) to the end of input drive gear shaft (1).
10. Put the required shims (46) on the end of the input drive gear shaft.



11. Put the washer (4) and lock plate (47) on the drum hub assembly (6) and input drive gear (1).
12. Install the two 5/16X18 hex head screws (3) through the lock plate (47) and washer (4) into the end of the input drive gear (1) and tighten 20 to 25 ft-lbs (27 to 34 N-m) torque.
13. Bend the lock plate (47) up to the cap screws (3).
14. Hold the drum and rotate the housing. There should be a light bearing drag when the housing is rotated.

Unit Assembly

1. Put the fan housing assembly on a work table with the gear end down
2. Install the gasket (2) on the face of the fan drive housing (5) assembly.
Caution: The holes of the gasket must be lined up with the holes of the cover assembly. Install two 5/6X3 dowel bolts in the housing.
3. Line up the bolt holes between the fan drive housing assembly and front cover assembly. Rotate the fan mounting hub so that the clutch plates line up with the slot of the drum hub. Push the front cover down against the gasket and fan drive housing. Remove the two 5/16X3 dowel bolts.
4. Install two flat head socket screws in the front cover assembly and tighten. These two screws are with nylon patch.

The fan drive lubrication flow through the adapter plate should be check prior to installation of a new or rebuilt fan drive assembly. The lubricating oil flow through the adapter plate should be 1 to 1-1/4 GPM @ 1000 rpm.

Start the engine. Use a clean container to catch the oil that comes out of the adapter plate lubricating hole in one minutes time. If the amount of oil is less than 1 to 1-1/4 gallons, remove the adapter plate from the engine and check the orifice in the engine side of the adapter plate. Refer to previous installation instructions to complete the assembly.

Thermostat And Housing

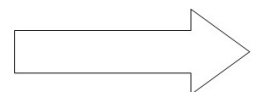
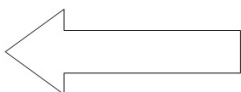
Thermostats can not be repaired, but are to be checked to ensure they are opening and closing at the correct temperatures.

Disassembly

Remove the thermostat housing (7). Remove the seal (5) and the thermostat (4) from the housing support (3). Fig. 8-17.

Inspection

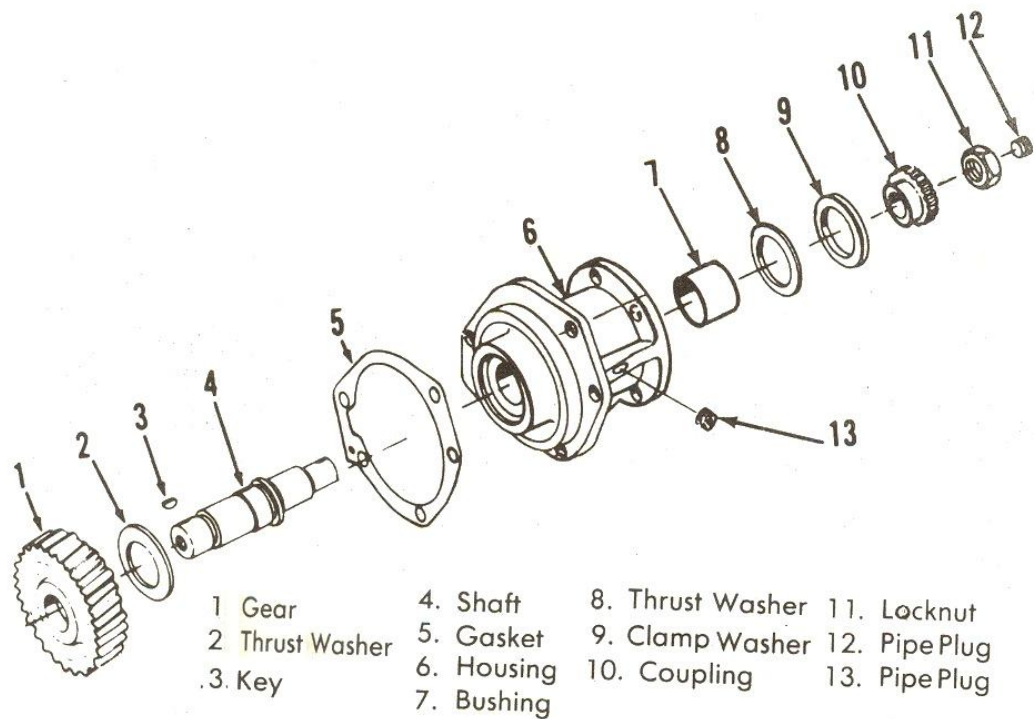
1. Check the thermostats for opening and closing at the correct temperature.
1. Put the thermostats and thermometer in water.
2. Heat the water to the thermostat operating temperature, which is normally marked on the thermostat.
3. Compare the thermostat operation with the thermometer.



(H) Drive Unit

INTRODUCTION

The drive units are used to transfer power from engine crankshaft, through camshaft gear to drive a compressor, fuel pump, water pump and other assemblies. Replacement of oil seals, bearings or bushings is the only normal service required.



Essential Service Tools (Or Equivalent)	
Service Tool Number	Tool Name
ST - 1249	Puller

Oil Seals

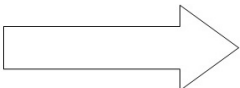
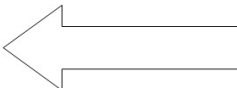
Always check the pulley sleeve surface for wear and replace the sleeve if necessary before installing the new seal. Before installing oil seals, always lubricate with clean lubricating oil.

Bores in Housing

If the bushing have turned in the bore ad damaged the housing, the housing must be discarded. The bore of the housing must be clean before pressing the bearing in position.

Thrust Washers.

In the installation of thrush washers on necessary drives, the thrush side of the washers is installed away from the housing. The thrust side contains grooves. Wrong installation of



these washers will result in an excessive wear and increased end play, which causes early failure of the accessory drive assembly.

Fuel Pump or Compressor Drive

Disassembly

Remove the drive shaft locknut (11, Fig. 9-1). Use the ST – 1249 Coupling Puller to pull the coupling (10-) from the shaft (4). Press the shaft and gear assembly from the housing (6). Press the shaft (4) from the gear (1), and remove the key (3) from the shaft (4).

Note: A splined coupling is used on the air compressor drive. A spider coupling is used on the fuel pump drive.

Inspection

Inspect the bushing (7) in the drive housing. Replace it if worn beyond specifications as shown in Table 9-1 (3). Replace the thrust washer (2 and 8) if worn or damaged.

Inspect the shaft (4) for wear, chips or sharp edges. Discard the shaft if it is worn smaller than worn limits as shown in Table 9-1 (1 and 2).

Assembly

- ❖ Install the shaft (4) through the housing (6) and bushing (7). Install the thrust washer (2) with the face up.
- ❖ Install the key (3) and press it on the drive gear (1).
- ❖ Turn the assembly over. Install the thrust washer (8) (face up) and clamp washer. Install the coupling key, if used.
- ❖ Press on the coupling (10), hub end down. Hold in place with the locknut (11). Install the pipe plug (12), if removed.
- ❖ Rotate the assembly in the housing to check for movement.
- ❖ Check the end clearance which is to be 0.002 to 0.012 inch (0.05 to 0.30mm) with the unit assembled.

Note: Oil slinger, if used, is installed on the shaft after the unit is installed to the gear housing and cover. See Group 14.

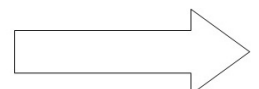
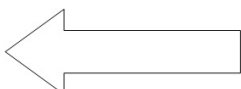
Inspection and Repair of Drive Pulleys:

Check for cracks and other damaged in the hub, web and groove areas and for wear in the grooves and oil seal sleeve. If wear on the sleeve can be seen, remove the worn oil sleeve by cutting with a chisel. Do not damage the pulley hub.

Press the new sleeve with mandrel until it is even to 0.015 inch (0.38mm) below the face of hub. See the latest Parts Catalog for the correct pulley/sleeve combination.

Disassembly of Barring Device

- ❖ Remove the retaining ring (2) from the barring device shaft (1).



- ❖ Remove the barring device Shaft (1) by pulling out on the shaft. This will remove the spring (5) and the worm gear (4).
- ❖ Remove the barring shaft guide assembly.

Inspection of Barring Device

Examine the shaft bore for burrs, sharp edges, or dirt in the shaft bore. Clean or repair as required.

Assembly of Barring Device

- ❖ With the gear cover remove, compress the guide assembly bushing (6) for installation into the front cover.
- ❖ Put the slotted end of the barring device shaft (1) over the roll pin (7) in the guide assembly and tap into position, Fig 9-2.

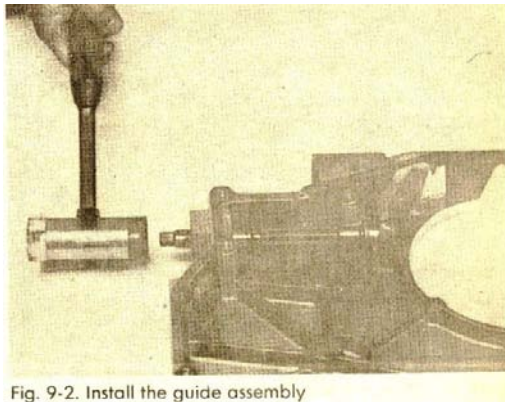


Fig. 9-2. Install the guide assembly

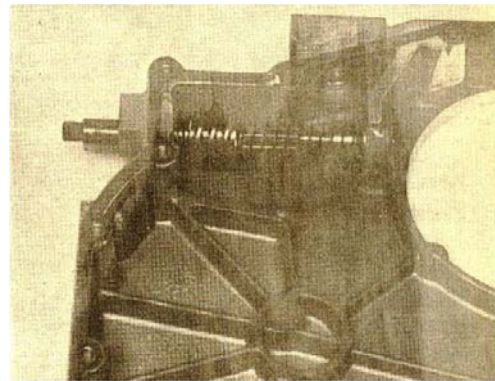
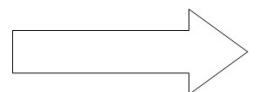
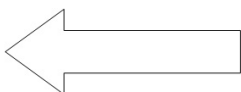


Fig. 9-3. Barring device installed

- ❖ Remove the barring device shaft (1) and install the O-ring (3) Fig. 9-4, in the proper location on the shaft.
- ❖ Insert the barring shaft (1) into the shaft bore for enough to expose the splined end of the shaft, Install the worm gear (4) and the spring into position on the shaft.
- ❖ Continue to insert the barring shaft (1) for enough to expose the retaining ring groove and install the retaining ring (2), Fig. 9-4.
- ❖ Refer to Fig. 9-3 for a view of the barring device installed in the front cover.

Engagement of the Barring Device Worm Gear:

While turning the barring device shaft counterclockwise, slowly push the shaft into the gear cover. The shaft is in the correct position when the step near the hex portion of the shaft is flush with the front cover.



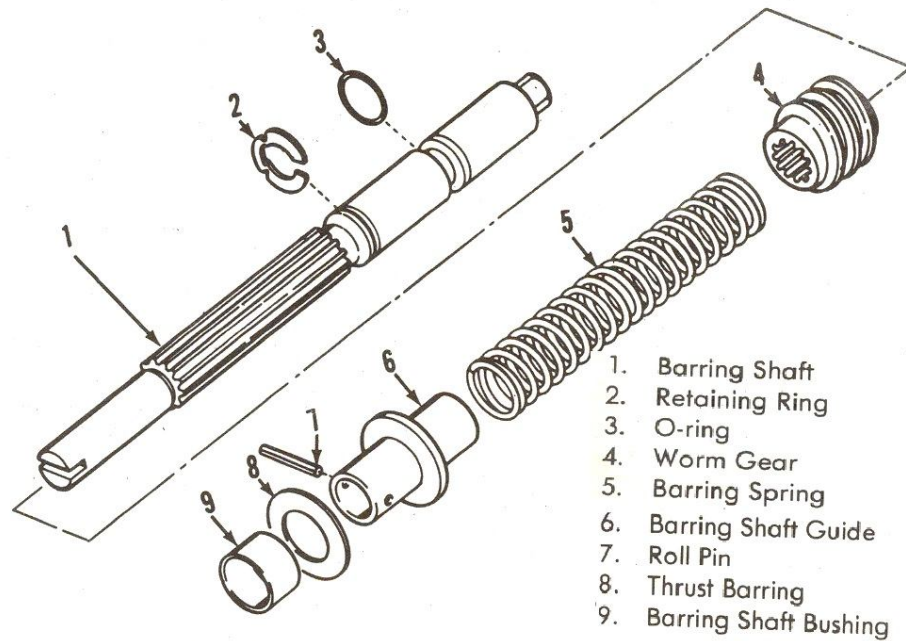


Fig. 9-4. Barring device

Several additional turns of the barring device shaft will be required to completely engage the worm gear and the camshaft gear. It is important that no force is used to engage the gears. Repeat steps 1 and 2 if the gears do not engage easily.

Approximately 50 ft-lb (68 Nm) torque is required to bar the engine to the desired “set point” positions.

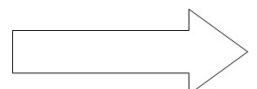
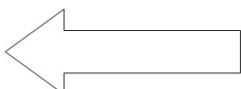
To disengage the barring device shaft, rotate the shaft clockwise until the worm gear is free of the camshaft gear.

Caution: Do not use an impact wrench on the barring device to rotate the engine. Also do not rotate the engine in a counterclockwise direction when the barring device is engaged.

Hydraulic Pump Drive Disassembly and Inspection:

- ❖ Remove the retaining ring, clamping washer and thrust washer.
- ❖ Remove the shaft and gear assembly and the second thrust washer from the support. Discard the thrust washers.
- ❖ Inspect the support for cracks and replace if necessary. Press the bushing from housing if worn larger than 2.0015 inch (50.838mm). See Table 9-1.
- ❖ Inspect the gear for wear and broken teeth. Replace as necessary.
- ❖ Inspect the shaft for wear, or other damage. Replace if worn smaller than 1.9975 inch (50.737mm) in the large bushing area or smaller than 1.4975 inch (38.037mm) in the small bushing area.

Water Pump Drive Disassembly and inspection:



Use a mandrel to press the new bushing into the support, if remove. Bushings must be even or below the thrust bearing surface of support. The oil hole must be in alignment with the housing oil hole.

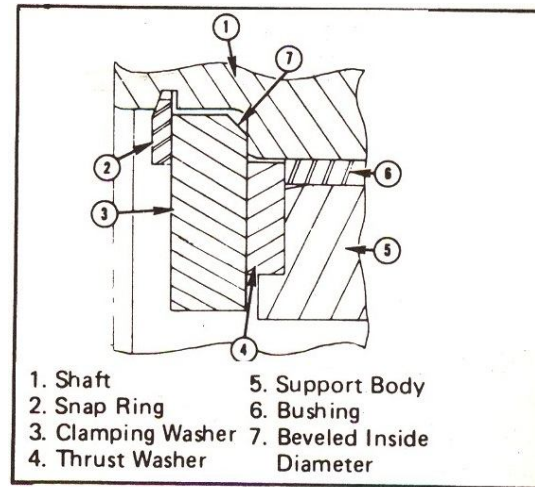


Fig. 9-5. Water pump drive clamping washer installation

Press the gear on the shaft, if removed, until the gear bottoms on the shaft stop.

Put the thrust washer over the shaft to the gear. Install the shaft and gear assembly into the support.

Install the thrust washer and clamping washer over the shaft. Hold in place with a retaining ring. The beveled side of the retaining ring must be out during the installation. The chamfer on the clamping washer must be toward the shaft stop as in (7, Fig. 9-4)

Note: The water pump pulley is installed after the pump drive is installed to the gear housing and cover. This pulley is used to drive the alternator.

Measurement – Inch (mm)		Useable limit		New Minimum		New Maximum	
Barring Mechanism							
Barring Mechanism for Two Piece Gear Cover.							
Ref. No.							
1	Bushing Inside Diameter	0.755	19.18	0.751	19.08	0.754	19.15
2	Shaft Outside Diameter	0.748	19.99	0.7485	19.012	0.749	19.02
3	Shaft Protrusion			0.880	22.35	0.900	22.86
4	Clearance between Gear and Housing.			0.007	0.17	0.015	0.38
Barring Mechanism for One Piece Gear Cover							
1	Bushing Inside Diameter	0.626	15.900	0.624	15.849	0.625	15.875
2	Barring Shaft Guide Outside Diameter	0.6210	15.773	0.6215	15.786	0.6220	15.80
3	Shaft Outside Diameter in Guide Area			0.498	12.65	0.501	12.72
4	Shaft Outside Diameter			0.7451	18.925	0.7471	18.975

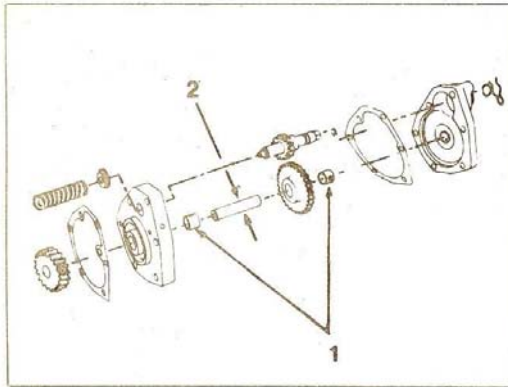


Fig. 9-6. Barring mechanism dimension for two-piece gear cover

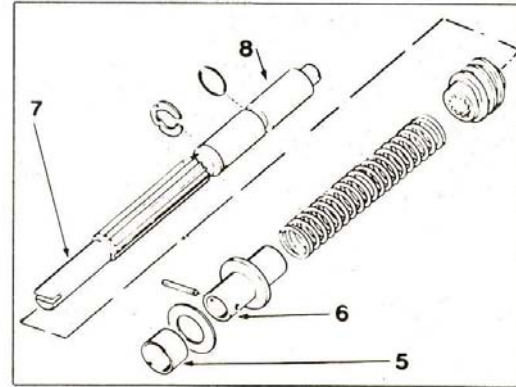


Fig. 9-8. Barring mechanism for one-piece gear cover

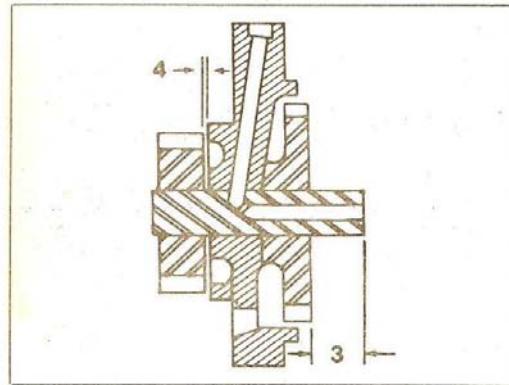


Fig. 9-7. Barring mechanism dimensions

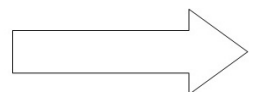
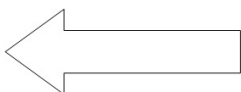
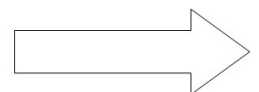
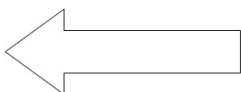


Table 9-1: Drive Unit Specifications – Inch (mm)

Ref. No	Measurement	Useable limit	New Minimum	New Maximum
	Fuel Pump/Compressor Drive			
1	Shaft Guide Outside Diameter		1.3765	1.377
	At Pulley Location		34.963	34.98
2	Shaft Guide Outside Diameter	1.810	1.3115	1.312
	Bushing Wear Area.	33.27	33.312	33.32
3	Bushing Inside	1.320	1.316	1.319
	Diameter	33.53	33.43	33.50
	End clearance		0.002	0.012
	Assembled		0.05	0.30
	Water Pump Alternator Drive			
	Bushing inside	1.755	1.751	1.754
	Diameter	44.58	44.48	44.55
	Shaft Outside Diameter	1.748	1.7485	1.749
	Bushing Wear Area.	44.40	44.412	44.42
	End clearance		0.007 0.178	0.015 0.571
	Barring Mechanism (Old Style)			
	Bushing inside	0.755	0.751	0.754
	Diameter	19.18	19.08	19.02
	Shaft Outside	0.748	0.7485	0.749
	Diameter	19.00	19.012	19.02
	Barring Mechanism (New Style)			
	Bushing inside	0.626	0.624	0.625
	Diameter	15.900	15.849	15.875
	Shaft Outside	.6210	.6215	.6220
	Diameter	15.773	15.786	15.80
	Hydraulic Pump Drive			
	Bushing	2.0015	1.9990	2.0005
	Inside Diameter	50.838	50.775	50.813
	Shaft Outside Diameter			
	Large End	1.9975	1.9985	1.9990
		50.737	50.762	50.775
	Small End	1.4975	1.4985	1.4990
		38.037	38.062	38.075



(I) Air Intake System

The intake air system group contains the intake manifolds, connections, air cleaners piping and turbochargers. The Turbochargers are covered in separate manuals.

Intake Manifolds and Connections

Cleaning and Inspection.

1. Clean the intake manifolds, air crossover connections and tubes with steam.
2. Inspect for chips, cracks, distortions and damaged threads. Discard all parts which are not useable.
3. Damage threads are to be repaired by installing Heli-coils.

Air Cleaners (Composite Dry Type)

Before disassembly, clean the dirt from the cover and upper area of the air cleaner.

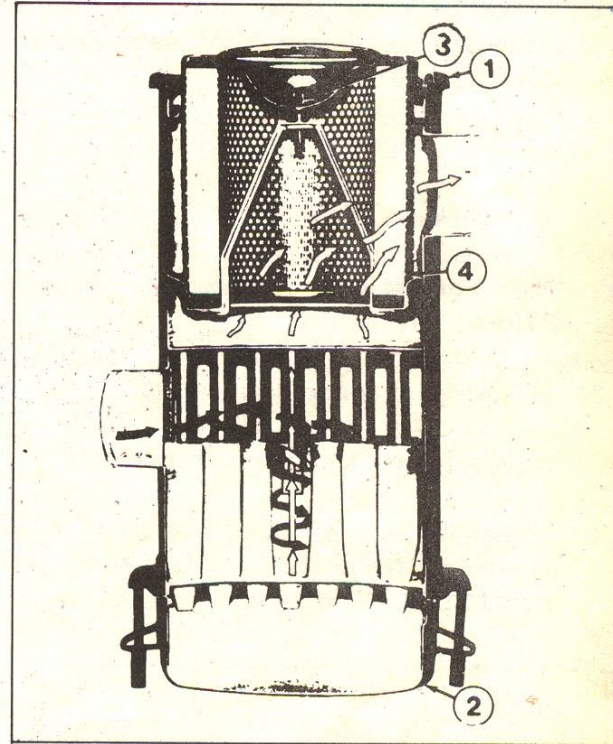
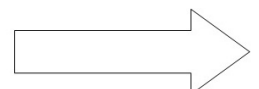
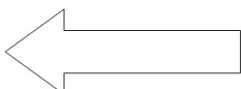


Fig. 10-1. Composite dry type air cleaner.

1. Loosen the clamps and remove the top cover (1), Fig. 10-1.
2. Remove the dust cup (2) from the bottom of the cleaner.
3. Remove the wing nut bolt (3) holding the element in position. Remove the element carefully so that the loose dirt does not fall back into the chamber.

Cleaning and inspection

1. Empty the dust cup.
2. Use compressed air to clean out the element from the clean air side.



Caution: The air pressure is not to be more than 30 psi to keep from damaging the element. Do not hold the air pressure in one area.

- 3 Wash the element with detergent and warm water (120 to 140°F (49 to 46°C)). Wash away with a maximum of 40 psi (2.8 Kg/sq cm) water pressure until the drain water is clean. Dry with compressed air. Inspect for holes in the filter paper. Replace it if necessary.
- 4 With the filter element and dust cup removed, inspect the tubes. Dust deposits can be removed with a fiber brush.
- 5 Inspect the cover gasket and gasket washer under the wing nut bolt for wear. Replace them if necessary.

Assembly

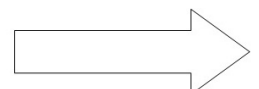
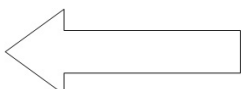
- Put the element (4) in position.
- Put the gasket washer under the wing nut (3) before tightening.
- Install the cover and dust cup (2).

Cartridge-type Air Cleaner Element.

1. Loosen the nuts (4, Fig. 10-2 or 10-3) on the air cleaner housing (5) to remove the pre-cleaner panel with the dust collector (1). To remove the pre-cleaner panel (2) equipped with an exhaust aspirator, loosen the U-bolt clamp attaching the pre-cleaner to the aspirator tubing.
2. To remove a dirty Pamic cartridge (3), insert your fingers in the cartridge opening. Loosen all four corners of the cartridge, one at a time. By pulling straight out. It will be necessary to break the seal along the edges of the cartridge. After the seal has been broken, pull the cartridge straight out and up so the cartridge will clear the sealing frame and the edges of the air cleaner housing.

Cleaning and inspection.

1. Clean the pre-cleaner openings (2) of all dirt, thin coating of oil and any other material that will restrict the openings.
 - a. Remove any dust or dirt that is in the lower area of the pre-cleaner and aspirator tubing. Inspect the inside of the air cleaner housing to be sure there are no foreign materials.
 - b. Pre-cleaners with an accumulator valve in the dust collector automatically remove dust and water while the engine is running. During engine operation the dust collector is under a vacuum using the engines pulsing action to open and close the accumulator valve. The accumulator valve also removes dirt and water when the engine is not running.
2. Inspect the dirty cartridge for carbon or oil. If there is carbon inside the Pamic tubes, check for leaks in the engine exhaust system and exhaust blowing back into the intake and exhaust from other equipment. When the cartridge contains oil, check for fumes entering from the crankcase breather. Excessive amounts of vapor



shorten the life of any dry type cartridge. Troubleshooting before a new cartridge is placed in the air cleaner can lengthen the cartridge life.

3. Do not clean a cartridge.
4. Inspect the clamps and flexible hose or tubing to be sure all the fittings are air tight on cleaners with exhaust aspirators.
5. The pre-cleaner dust bin is self-cleaning.

Assembly

1. Inspect a new filter cartridge for shipment damage before installing it.
2. To install a new cartridge, hold the cartridge (3, Fig. 10-2 and 10-3) in same manner as when removing it from the housing (5). Always inspect the inside of the air cleaner housing, keeping it free of all foreign material. Insert the clean cartridge into the housing. Do not hit the cartridge tubes against the sealing flange on the edges of the air cleaner housing.
3. The cleaner uses no separate gaskets. Take care when inserting the cartridge to be sure that cartridge fits properly within the air cleaner housing. Press all the edges and corners of the cartridge with your fingers so that there is a positive air seal against the sealing flange of the housing.

Note: Do not pound cartridge as sealing area will be damaged.

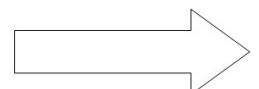
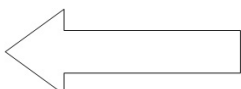
4. Replace the pre-cleaner panel (2) and tighten the wing nuts (4) by hand. Then turn 1-1/2 to two turns with a small adjustable wrench. If hexagon nuts are used, tighten them to 70 in-lb (8 Nm) torque. Assemble the exhaust aspirator tube to the pre-cleaner panel and tighten the "U" bolt, if use.

Caution: Cartridge elements or tube damage will result from over tightening the wing nuts or by using a hammer when installing the cartridge.

5. Care is to be taken to keep restrictions from the air cleaner intake. Restrictions can result in a reverse exhaust flow through the bleed line and cause damage to the cartridge.

Cleaner Restriction Indicator:

1. The best method to indicate change periods for any dry type air cleaner is by the use of a restriction indicator as shown in Fig. 10-4.
2. The restriction indicator signals when to change the cartridges. The red disc (1, Fig. 10-4) in the loads with dirt. Do not change the cartridge unit the disc reaches the top and locks in position. When it is locked, the disc will remain up after the engine is not running. Change the cartridge when the disc locks of the top. After changing the cartridge, reset the indicator by pushing the reset button (2). Push the button all the way in and then release.
3. Another method is to use a vacuum gauge and warning light that has the same function as described in step 1 and 2. Components for the vacuum gauge include an electrical supply (1, Fig. 10-5) air piping (2), Vacuum switch (3) and red warning light (4).

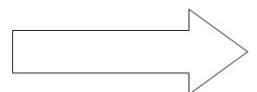
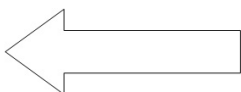


Turbochargers

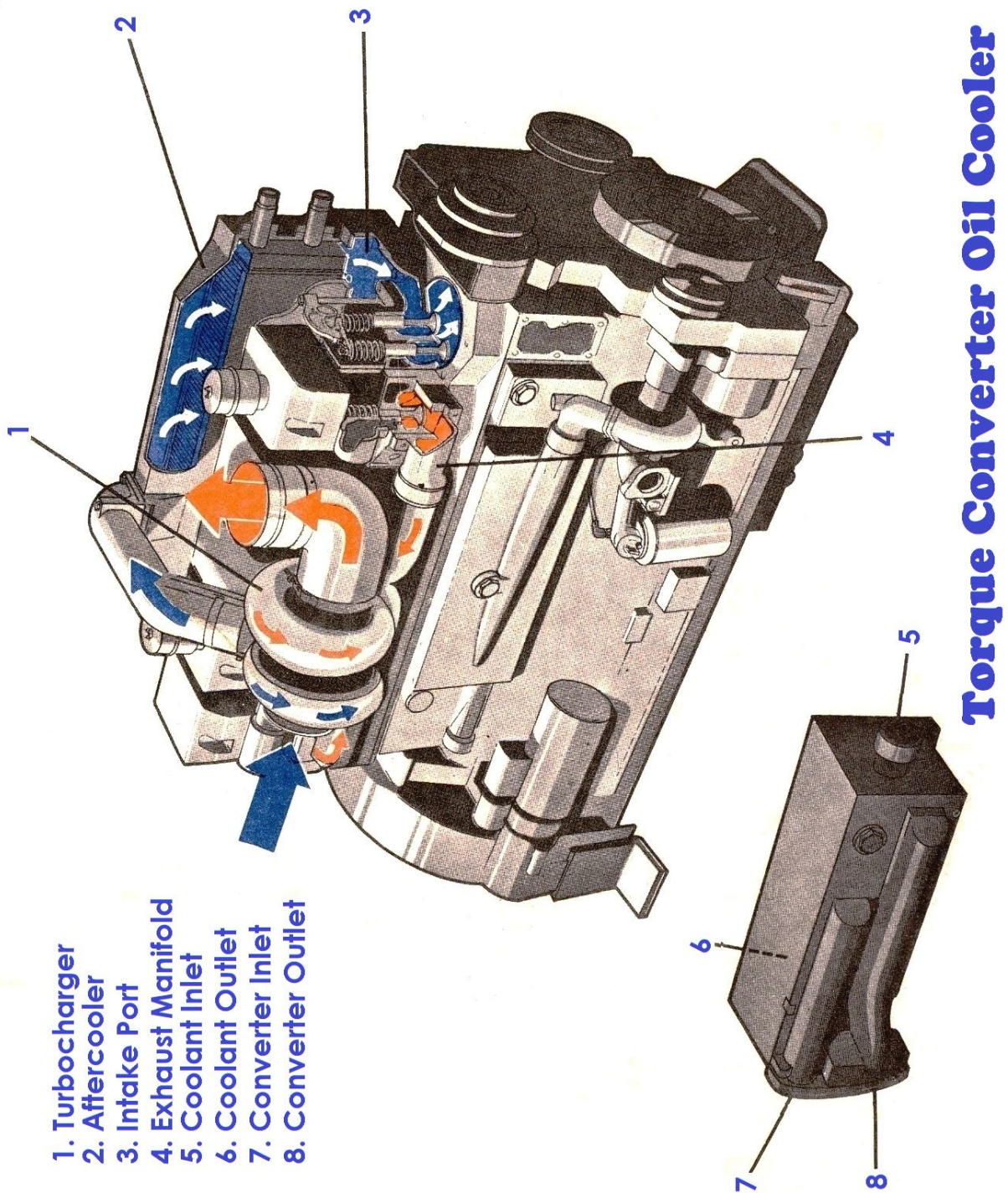
T-18A Turbochargers are covered by Bulletin No. 3379091. They can be identified by the model on the nameplate.

DRY TYPE (HORIZONTAL) AIR CLEANER

Ref. No.	Part No.	Part Name	No. Req'd.
1	3225660	Dust cap	1
2	3230039	Hood air cleaner	1
3	3228522	Assembly, shell air cleaner.	1
4	3226018	Element outer	1
5	3226019	Element inner.	1
6	3231652	'O' Ring	1
7	3231642	Gasket.	1
	3232387	Cleaner air (17'5" dia)	1
8	3232389	Element	1
9	3232390	Gasket	1
10	3232388	Shell air cleaner	1



KTA 1150L Air Intake System



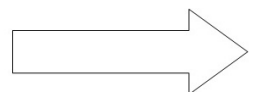
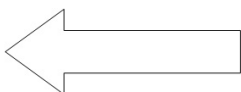
(J) EXHAUST SYSTEM

The exhaust system group contains the exhaust manifolds, piping and mufflers.

Exhaust Manifold

Inspection

Inspect the exhaust manifold for cracks and Distortions; discard the defective parts.



(K) Air Equipment

The air equipment group contains Cummins air compressors, check valve, vacuum pump and piping; also included: The air starting motor, which is used on some Cummins engines

Air Compressor

Cummins air compressors are used on all models of Cummins Engines and service information is given in Bulletin No. 3379056

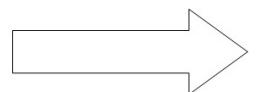
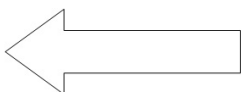
Optional units are contained in publications available from the manufacturer or authorized Service stations.

Vacuum Pump

The Cummins vacuum pump is a conversion of the compact Cummins air compressor and is contained in Bulletin No. 3379066

Air Starting Motor

Contact Kirloskar Cummins Limited for air starting motor servicing and relative information



(L) Electrical Equipment

The primary function of the Electrical system on Cummins engines is that of starting and operating electrical accessories as required by the unit being powered.

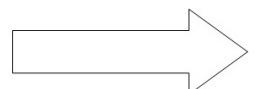
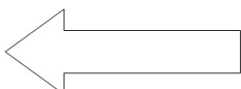
Electrical Equipment.

Wiring Diagrams

A Complete set of wiring diagrams, as applied to all Cummins Engines, is contained in Bulletin No. SPT – 3242438.00; SPT 3242445 & SPT 3242451. The Bulletin may be obtained from a local distributor.

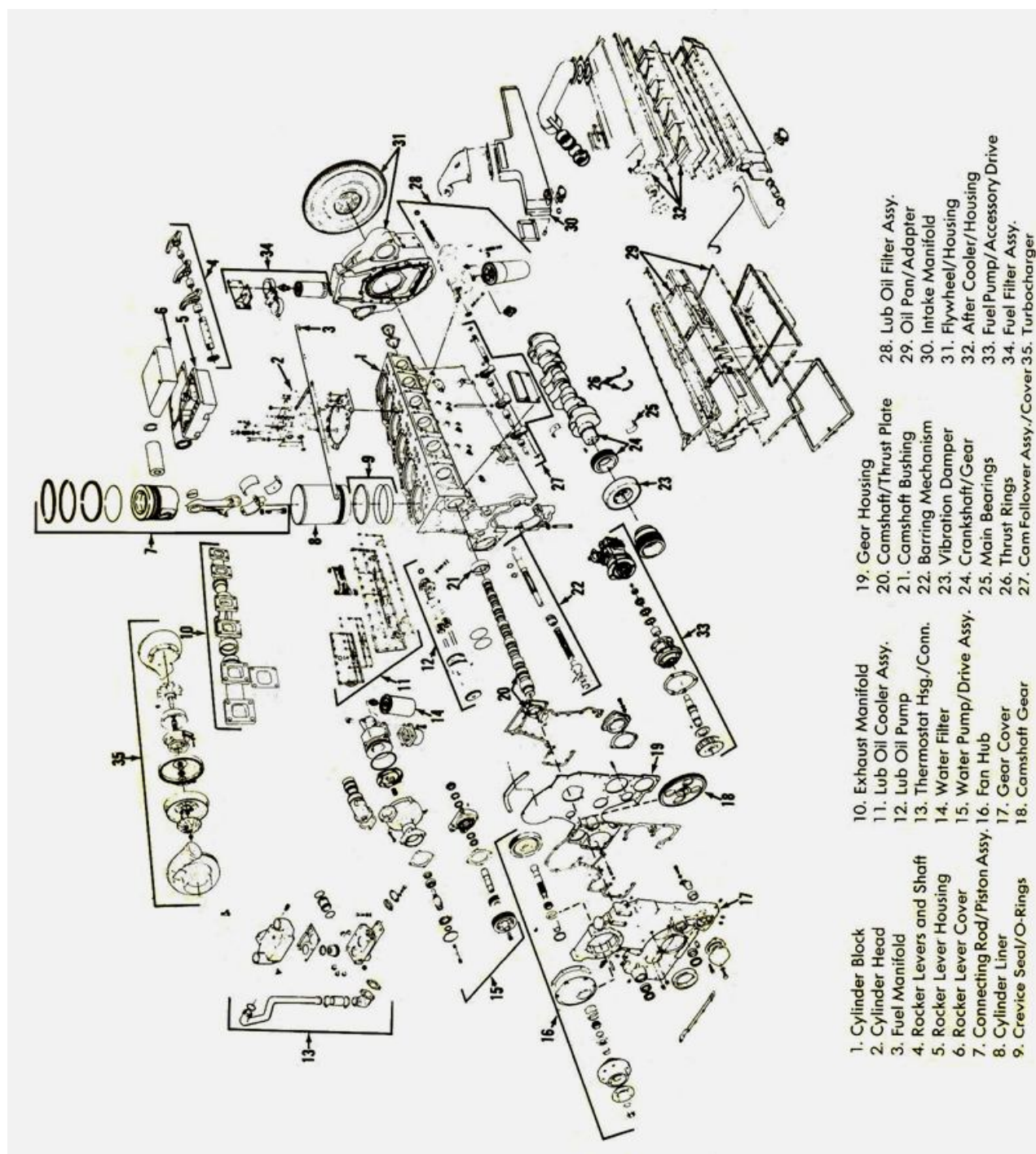
Electrical Components

Complete instructions for testing, repairing and adjusting alternators, generators, voltage regulators, starting motors, batteries, electric cable and connections are available from your area electrical equipment service distributor.



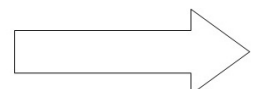
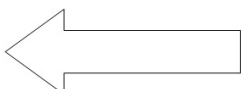
(M) Engine Assembly and Testing

The engine assembly and testing section covers assembly of all units and subassemblies to the cylinder block. Adjustments before and during engine test and break-in, in and out of equipment, are also covered.



EXPLODED VIEW OF ENGINE

Essential Service Tools (Or Equivalent).	
Service Tool Number	Tool Name
3376030	Dial Indicator and sleeve Assembly
3375155	Injector Tip Protrusion Comparator
3376085	Pulley Assembly Tool
ST-1313	Camshaft Pilot
ST-1325	Dial Gauge Attachment
3375932	Pressure Gauge
3375150	Blow-By checking Tool
ST - 547	Gauge Block
3375522	Timing Fixture
3375422	Liner Drive
3375342	Piston Ring Compressor Sleeve
3375004	Injector Indicator Kt.
Desirable Service Tools (Or Equivalent).	
ST-1319	Tube Driver
ST-1307	Engine Adapter Plate
3375193	Engine Rebuild Stand
ST-386	Pulley Assembly Tool
ST-669	Torque Wrench Adapter
3375855	Template Indicator, Level and Angle.
ST-1190	Fuel Consumption Measuring Device.
ST - 1232	Drill Reamer Fixture
ST-1133	Drill Reamer Bushing.
ST - 1258	Engine Lifting Fixture
ST-1167	Cylinder Liner Hold-Down Tool
ST - 1269	Piston Ring Expander
ST-1293	Belt Gauge
3375098	Connecting Rod Guide Pins
ST-1311	Front Crankshaft Seal Installation Tool
ST - 1286	Engine Lifting Hook (2 Required)
3375496	Drill Pilot
3375292	Heavy Duty Socket Set
3375707	Seal and Pulley Assembly Tool
Standard Tools – obtain Locally	
0-150 Inch-pound Torque Wrench	
0-250 Foot-pound Torque Wrench	
0-600 Foot-pound Torque Wrench	
Dial Indicator (starret No. 196A)	
Dial Indicator sleeve (starret No. 196)	
Manometer (Mercury or Water)	
0-1 Micrometer	
Impact Wrench	
Engine and /or Chassis Dynamometer	
Hoist (Power or chain)	
Straight Edge	
Feeler Gauge	



Engine Assembly

Engine assembly as described in this Group, is with the assumption that all units have been rebuilt to specification or are new and ready to be installed. New gaskets, O-rings and lock plates, where used, should be installed as the engine is assembled. Torque values and procedures must be used where specified when tightening cap screws. If the cap screw torque is not specified, refer to specifications and Wear Limits.

Mount Cylinder Block To Rebuild Stand:

1. Secure the ST-1307 Engine stand Adapter to the 3375193 Engine Rebuild stand.
2. Use a suitable block lifting fixture and hoist to put the block to the adapter plate. Secure it with cap screws and lock washers.

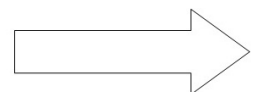
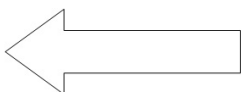
Crank shaft And Main Bearing:

Before installation, check the crankshaft front and rear counterweights for main and thrust bearing sizes. See Crankshaft, Group 1.

1. Be sure that mating surfaces and the main bearing bore are clean.

Note: As a precautionary measure, clean the main bearing cap screw holes out with compressed air.

2. Put the upper main bearing shells in the block. Hold in position with a tang. The ends of the bearing shells must be flush with the parting face of the block. Fig. 14-2.



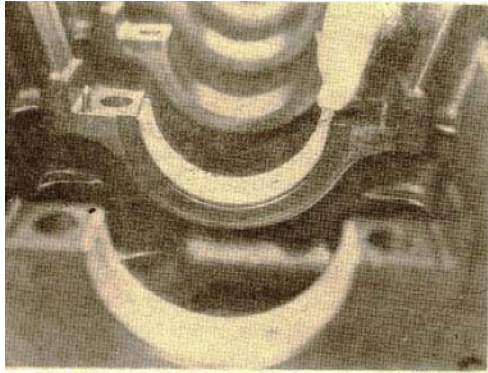


Fig. 14-2, Install the upper main bearing shells

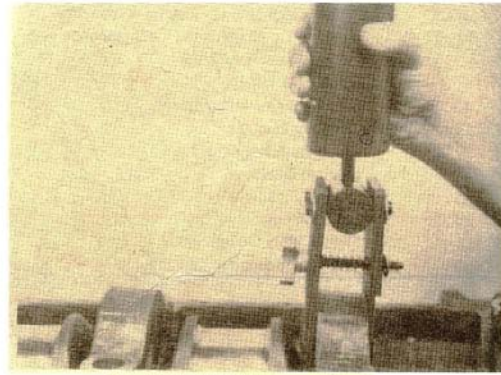


Fig. 14-3, Install the crankshaft

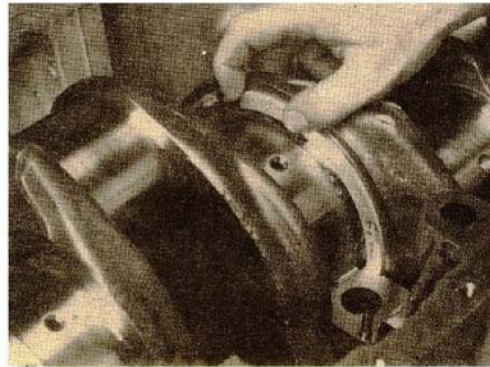


Fig. 14-4, Install the upper thrust bearings

Note: The upper main bearing shells are grooved and drilled for lubrication. No's 2,3,4,5 & 6 are interchangeable and No's. 1 and 7 are interchangeable.

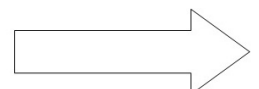
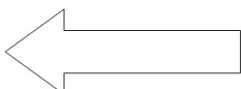
3. Lubricate the crankshaft journals and upper main bearing shells with a coat of clean engine lubricating oil.
4. Use a hoist and lifting hooks protected with rubber hose or a lifting strap to lower the crankshaft carefully into position. Fig. 14-3.

Caution: Avoid cocking the crankshaft during installation. Damage to bearing shells may result. If the crankshaft cocks, remove and inspect the condition and position of the bearing shells.

5. Lubricate the upper thrust bearing halves and slide into position around the no. 6 main bearing journal. Fig. 14-4.

Note: The grooved face of the thrust bearing must be installed toward the crankshaft flange. The ends of the thrust bearing must be even with the mounting face of the main bearing.

6. Put the lower half of the main bearing shells into the caps. Lubricate the bearing surfaces with a clean engine lubricating oil.
7. Install the main bearing caps as follows:



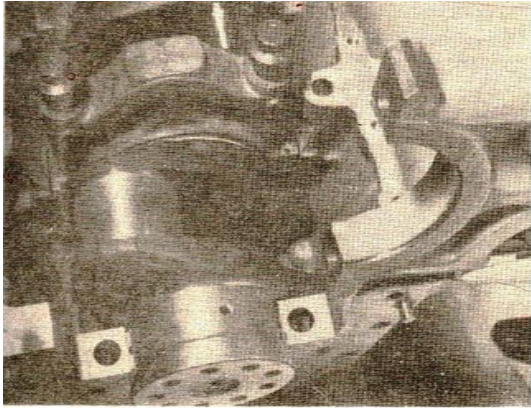


Fig. 14-5, Install the main bearing caps

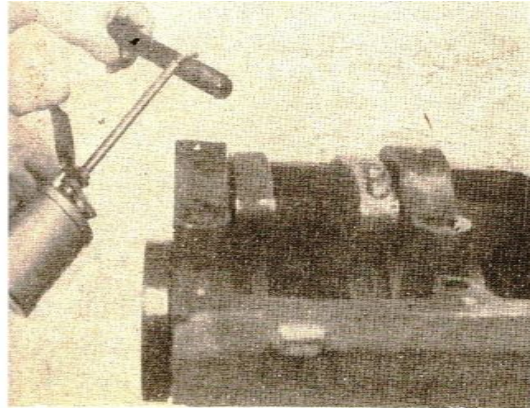
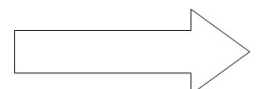
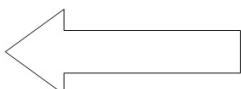


Fig. 14-6, Lubricate the main bearing cap screw threads

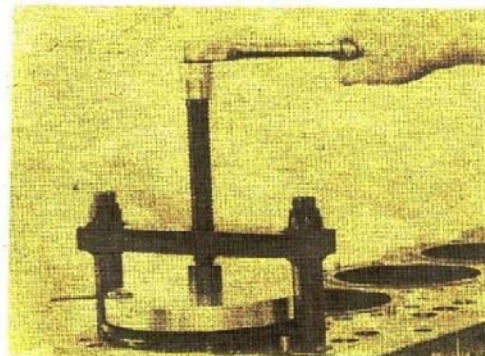
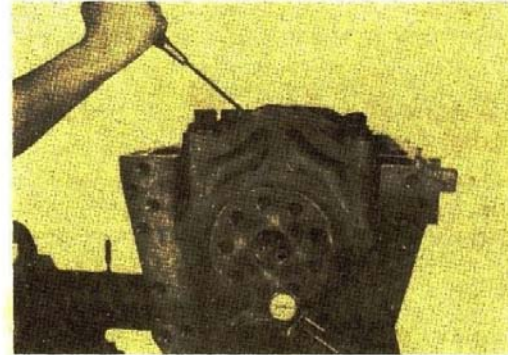
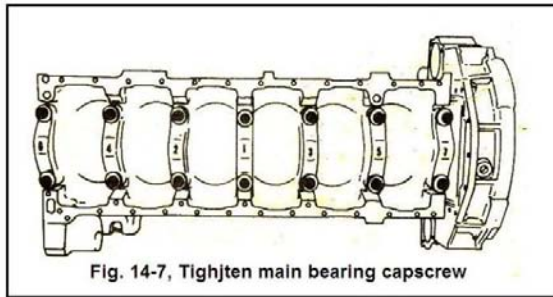
- a. Place caps Nos. 1 through 5 and 7 carefully into their correct position as shown by the number on the cap and the block. The number is stamped on the block on the bottom of the lubricating pump boss. **EXAMPLE 5B14.** The caps are stamped 5B141, 5B142, 5B143 etc. with the last digit being the cap position from the front of the block. **ALL THE NUMBERS SHOULD FACE THE SAME DIRECTION. DO NOT ATTEMPT TO PUSH THE CAPS DOWN AT THIS POINT.**
 - b. Install the lower thrust bearings on the No. 6 main cap. The grooves across the bearing go toward the crankshaft thrust face.
 - c. Lubricate the main bearing cap screw threads and the bottom of the cap screw heads with clean SAE 140W lubricant. **LET THE EXCESS OIL RUN OFF BEFORE INSTALLING THE CAPSCREWS IN THE BLOCK. EXCESS OIL IN THE BOTTOM OF THE HOLE CAN CRACK THE BLOCK WHEN THE CAPSCREW IS TIGHTENED.**
 - d. Carefully place the cap screws in the holes in the main cap and turn the cap screws for two or three revolutions **BY HAND.** **IF THE CAPSCREWS WILL NOT TURN BY HAND, CORRECTLY ALIGN THE CAP. DO NOT USE A WRENCH.**
 - e. As soon as all cap screws have been correctly started, strike the center of the cap with a large plastic or dead-below hammer until the cap is seated in the block. When the cap seats, there will be a sharp, distinctive sound. If the sound is not heard or the cap feels spongy when struck, remove the cap and check for a displaced bearing shell. Be particularly careful to start the No.6 cap on the dowels and the thrust bearings do not fall off.
 - f. Tighten the cap screws as shown in Table on Page 11 Group 18 (Specification & Torque Valve).
8. Attach a dial indicator gauge securely to the rear of the cylinder block with the contact point of gauge resting on the crankshaft flange end-face. Fig. 14-8.
 9. Pry the crankshaft toward the front of the engine. Remove the pry bar and see the gauge at "0".
 10. Pry the crankshaft toward the rear of the engine. Remove the pry bar. The gauge should indicate 0.004 to 0.016 inch (0.10 to 0.41mm) end clearance for an engine with a new crankshaft and new thrust bearing.
 11. If the end clearance is less than 0.004 inch (0.10mm), loosen the cap screws slightly and shift the crankshaft toward the front of the engine and then to the rear of the engine. Tighten the crankshaft as described in Step 8. Check the end clearance.



Note: When an engine is being rebuilt, it may be necessary to bring the crankshaft end clearance to specifications by using a reconditioned crankshaft and oversize thrust bearing as described in Group.1

Cylinder Liners:

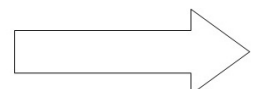
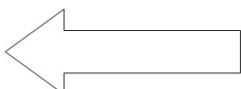
Before installing cylinder liners, check the liner protrusion. If necessary, install the counter bore shims around liners to maintain 0.003 to 0.006 inch (0.08 to 0.15mm) liner protrusion as described in Group 1.



1. Lubricate the crevice seal and the O-rings with a light coat of clean engine lubricating oil, just prior to installing the liner into block.

Note: Check for twisted O-rings. Use the mold mark on the o-ring as a guide to straighten as required. Do not stretch the O-rings more than required during installation.

2. Put the crevice seal into position on the liner.
3. Roll (Black) top O-ring into the groove on the liner.
4. Roll the (red) bottom O-ring into the bottom groove on the liner.
5. Lubricate the machined portions of the block on which the O-rings will seat with a light coat of clean engine lubricating oil.
6. Put the liner into the block by hand, being careful to avoid dislodging the o-rings and crevice seal. Drive the liner into position. Use the 3375855 Liner Drive to drive the liner securely into the block. Fig. 14-9.



7. Install the ST-1267 Liner Hold-Down Clamps. Tighten to 50 ft-lbs (68 Nom). Use the ST-547 Gauge Block (at four equidistant points) to determine if the liner protrusion is uniform and 0.003 to 0.006 inch (0.08 to 0.15mm). Fig. 14-10.

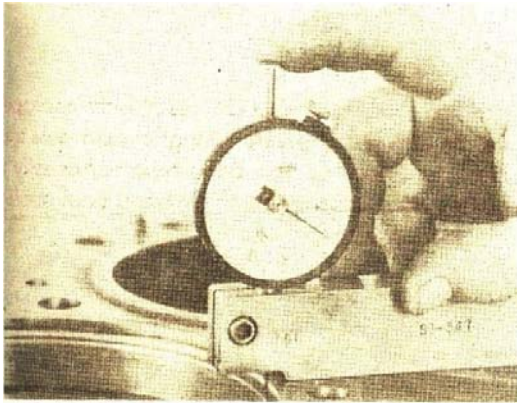


Fig. 14-10, Check the liner protrusion with a ST- 547

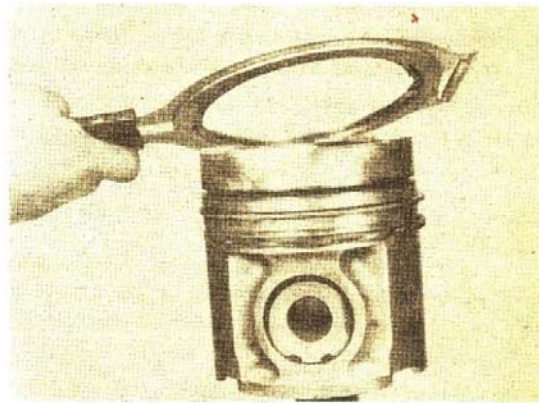


Fig. 14-11, Install the piston rings

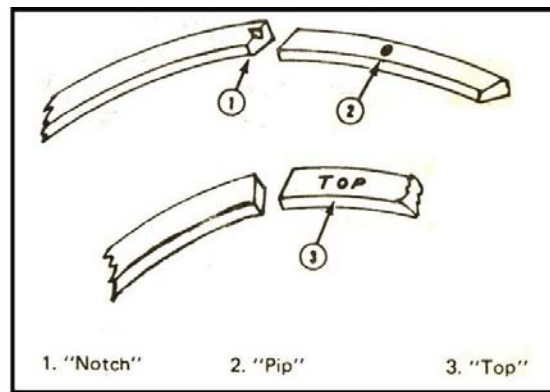


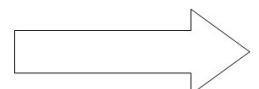
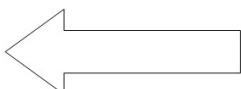
Fig. 14-12, Piston ring marking

8. Check the line bore with a precision dial bore gauge for roundness at several points within the range of piston travel, Fig. 1-6. If the liner is more than 0.002 inch (0.05mm) out-or-round in the packing ring area, remove the liner and check the cause of distortion. It is permissible to have 0.003 inch (0.08mm) out-or-round at the top 1 inch (25.4mm) of the liner bore.
9. Check the liner to block clearance as described in "Cylinder Liner Lower4 Bore". Group 1.

Connecting Rods and Pistons:

1. Use the ST-1269 Piston Ring Expander to install the rings on the piston with the "Top Marking" toward the top of the piston, Fig. 14-11.
2. Over-expanding a piston ring during installation on the piston can cause distortion which will result in damage leading to ring failure. A ring should be expanded only enough to allow it to pass over the piston. The measured gap should not be expanded more than eight (8) times the nominal radial wall thickness of the ring.

Note: The top surface of a piston ring is identified either with the work "Top" a "Notch" in the ring gap or a "Pip" in the top ring surface. See Fig. 14-12.



3. Stagger the ring gaps so they are not in line with each other or the piston pin. Lubricate the piston and rings with a clean engine lubricating oil.
4. Remove the connecting rod caps and put the bearing shells into the rods and caps. Make sure that the tang on the shell is in the proper position in the milled recess of the rod and cap. Install the rod guide pins to protect the crank journal.

Note: Connecting rod caps are not interchangeable and must be kept with the matching rod. Keep the same part number pistons in all cylinders.

5. Apply a film of clean engine lubricating oil to the bearing shells and cylinder liner walls.
6. Starting with any cylinder, rotate the crankshaft to the top center position.
7. Use the ST-1268 or 3375342 Ring Compressor to insert the piston and rod assembly into the cylinder liner with the numbered side of the rod toward the camshaft side of the block. Do not allow the rod to damage the liner wall.
8. Push the piston and rod assembly through the ring compressor into the liner until the top bearing shell is seated on the crankshaft. Fig. 14-13.

Caution: Ring damage can result from improper use of a ring compressor. Rings should pass into the liner smoothly. If a band-type compressor is used, make sure that the inner band does not slip and bind the piston.

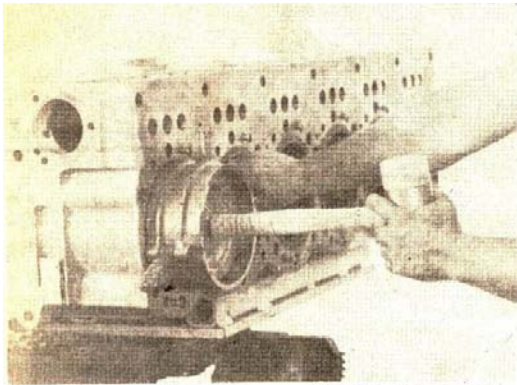


Fig. 14-13, Install the piston assembly using a 3375342

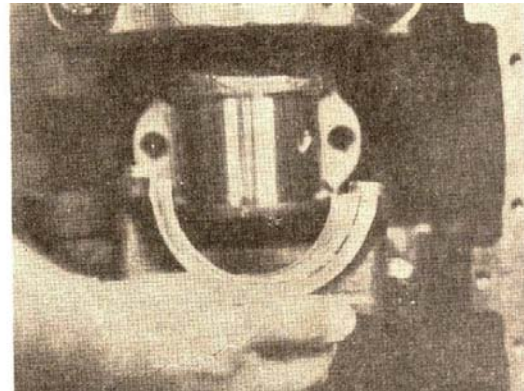
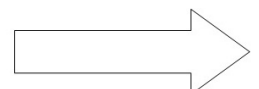
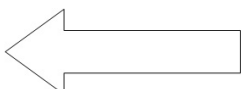


Fig. 14-14, Position the connecting rod cap to the rod

9. Rotate the crankshaft to the bottom center position while holding the rod and bearing shell against the bearing journal.
10. Install the rod cap.
 - a. Match the number on the cap with the number on the rod.
 - b. Put the cap over the journal, starting it on ring dowels in the rod mating surface. Fig. 14-14.
 - c. Lubricate the rod bolt threads and hardened washers with SAE 140W lubricant.
 - d. Pull the cap and rod together by tightening the bolts alternately and evenly. Do not tighten the bolts to the final torque until all rods and caps are in position.
11. Proceed with the remaining cylinders. Repeat steps 6 through 10 for each cylinder.



12. Tighten the connecting rod bolts (Fig. 14-15) in sequence 3-4, 1-6 and 2-5 alternately and evenly. See Table 14-2.
13. Check the connecting rod to crankshaft side clearance. Fig. 14-16. The tightened rod should be free to move sideways on the crankshaft journal. The side clearance is 0.008 to 0.014 inch (0.20 to 0.36mm). If the rod does not move freely, remove the cap and check for improper bearing size, burrs, dirt, etc.

Table 14-2 Connecting Rod Bolt Tightening Ft-lb (Nom)		
	Step	Torque Reading
1	Tighten to	70 to 80 FT-lb (95 to 108 Nom)
2	Advance to	140 to 150 FT-lb (190 to 281 Nom)
3	Advance to	210 to 220 FT-lb (285 to 295 Nom)
4	Loosen bolts	remove all tension.
5	Tighten to	70 to 80 FT-lb (95 to 108 Nom)
6	Advance to	140 to 150 FT-lb (190 to 281 Nom)
7	Advance to	210 to 220 FT-lb (285 to 2951 Nom)

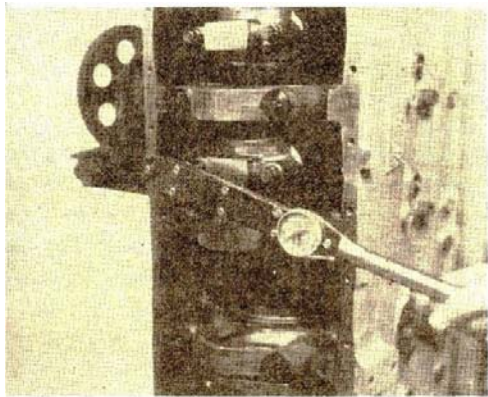


Fig. 14-15, Tighten the connecting rod



Fig. 14-16, Checking the connecting rod side clearance.

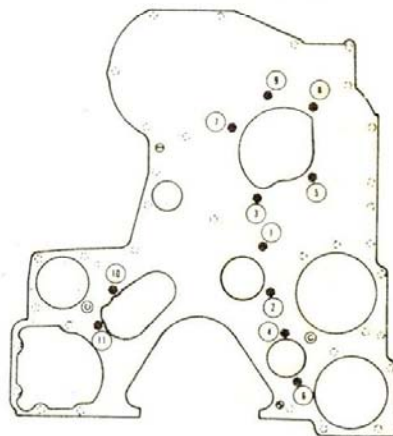
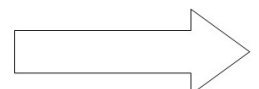


Fig. 14-17. Dowel and mounting capscrew locations

Steel Plate Installation with the Pan Adapter Removed:

1. Use a suitable gasket adhesive to install the housing gasket to the block.



2. Install the diamond dowel in the front of the cylinder block. The flats on the diamond dowel must be turned 90° from the master dowel. Make sure the dowel is fully seated to the bottom of the dowel hole. See Fig. 14-17 for the dowel location.
3. Use the eleven cap screws installed in the locations shown in Fig. 14-17 to install the steel plate to the cylinder block.
4. Tighten the two bottom retaining cap screws to 10 in-lb (1 Nom) torque.
5. Put the steel plate so that the bottom side of the plate is flush to ± 0.002 inch (0.5mm) with pan rail surface of the cylinder block. Use service tool gauge block, ST-547 to measure the distance. Fig. 14-18.
6. Tighten the eleven cap screws to 30 to 35 ft.lb (41 to 47 Nom) torque in the sequence shown in Fig. 14-17.

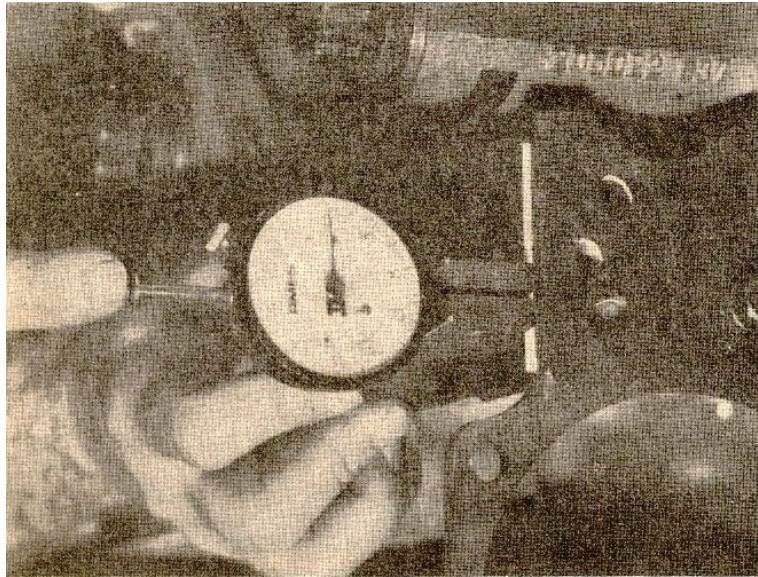


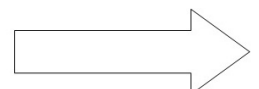
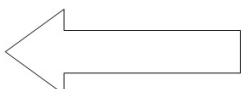
Fig. 14-18, Position the steel plate

Steel Plate Installation with The Pan Adapter Installed:

1. Install the diamond dowel in the front of the cylinder block, but do not install the master dowel at this time. Ref. Fig. 14-17.
2. Starting at the front of the cylinder block, remove the portion of the pan adapter gasket that was under the front cover and the steel plate. Clean the exposed gasket mounting surface of the pan adapter.

Note: This gasket is marked and can be cut for use when the front cover is the only thing removed.

3. Apply sealant to the area where the cylinder block and oil pan adapter meet and install the complete service gasket on the pan adapter.
4. Install the steel plate on the cylinder block. Trim the gasket to fit even with the pan adapter gasket. Apply sealant to the area where the steel plate contacts the oil pan adapter.
5. Tighten the eleven cap screws in sequence to 30 to 35 ft.lb (41 to 47 Nom) torque. Ref. Fig. 14-17.



Idler Gears:

1. Rotate the crankshaft to put the No. 1 cylinder in the top center position.
2. Put the idler gear on the shaft with the timing marks on the camshaft idler gear (2) out. Align the “o” on the crankshaft gear (4) with the “O” on the camshaft idler gear (2) Fig. 14-19.
3. Mount only the accessory drive gasket and housing into position on the mounting stud.
4. With the crankshaft gear in position, align the timing marks “A” on the camshaft idler gear (2) and “A” on the accessory drive gear (3) Fig. 14-19.

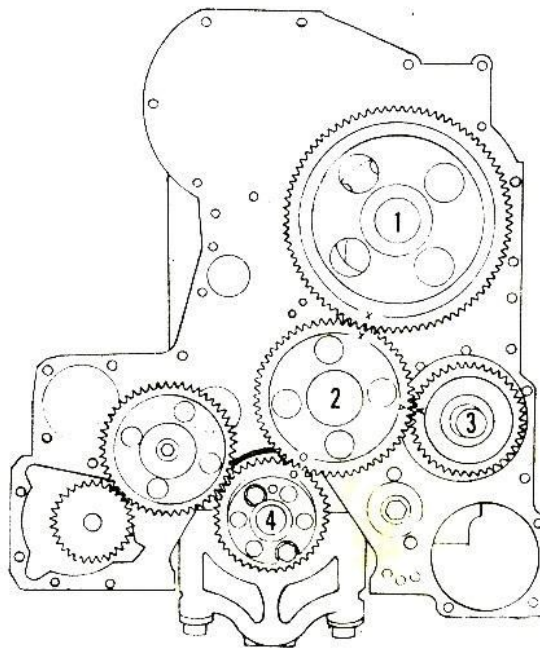


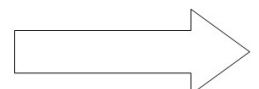
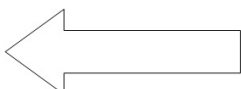
Fig. 14-19. Align the timing marks

Note: Tighten the accessory drive retaining nut finger tight only.

- 5a Tighten the idler gear retaining cap screw to 175 to 185 ft.lb (237 to 251 Nom) torque on blocks with the bolt in idler shaft, present configuration.
- 5b Tighten the idler gear retaining cap screw to 30 to 35 ft.lb (41 to 47 Nom) torque on blocks with pressed in idlers, old style.
6. Use a dial indicator or feeler gauge to check the end clearance of the idler gears. See “Idler Gears”, Group 1 for end clearance.

Note: Because of excess weight, the air compressor and fuel pump should not be installed at this time.

Caution: Do not bar engine until camshaft and accessory drive have been installed as misalignment of timing marks will result.



Accessory Drive to Gear Train Timing with Gear Cover Installed:

If the accessory drive is removed without the gear train in position (Fig. 14-19) or the engine is barred after accessory drive is remove, time the accessory drive as follows:

1. Remove the pipe plugs (1 and 2, Fig. 14-38) from the gear case cover. Reference Page 14-14.
2. Bar the engine in the direction of rotation until the timing mark "X" on the camshaft gear can be seen through the upper pipe plug hole (1)
3. Install the accessory drive assembly with the timing mark "A" visible through the lower pipe plug hole (2).

Camshaft and Gear:

1. Install the ST-1313 Camshaft pilot for the rear of the camshaft.
2. Lubricate the camshaft lobes and thrush plate with a high pressure lubricant.
3. Install the camshaft in the block. Use the pilot as guide to rotate and lift the camshaft slightly, Fig. 14-21. Take care not to distort the camshaft lobes or journals.

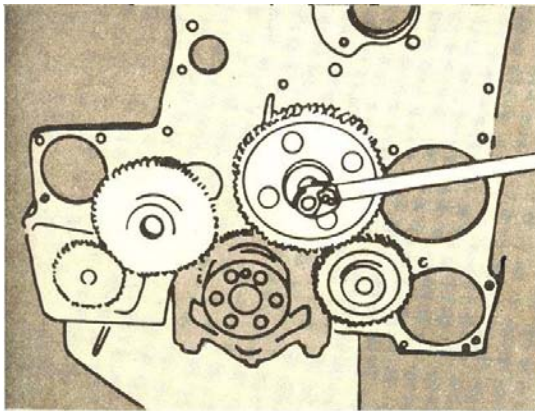


Fig. 14-20, Tighten the idler gear retainer cap screws.

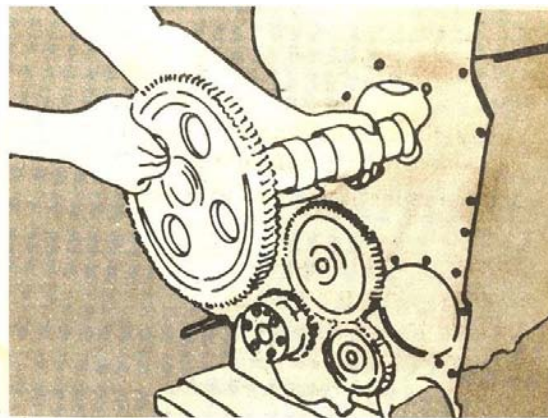
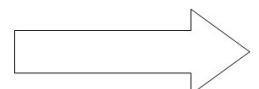
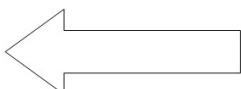


Fig. 14-21, Install the camshaft

Note: Due to weight and length of the camshaft and pilot, two men may be required during camshaft installation.

4. Align the "X" marks on the camshaft and idler gear to make sure the timing is correct. Ref. Fig. 14-19.
5. Secure the camshaft thrust plate to the block. Tighten the cap screws to 30 to 35 Ft.lbs (41 to 47 Nom) torque. Fig. 14-22 Bend lock plates.
6. Remove the camshaft pilot from the rear of the camshaft. Install the camshaft rear cover.
7. Attach the dial Indicator gauge to the housing and check the camshaft end clearance. Fig. 14-23. It must be 0.006 to 0.013 inch (0.15 to 0.33mm). If the end clearance is not within limits, remove the camshaft and change the thrust plate as outlined in Group 1.



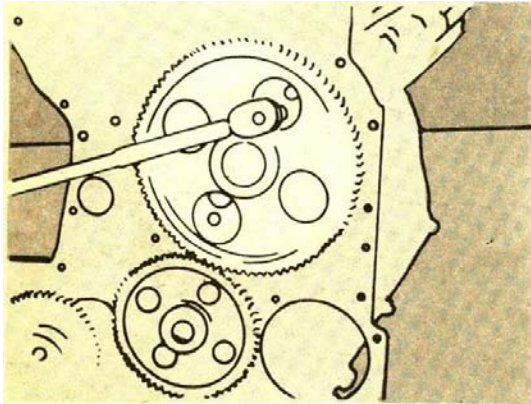


Fig. 14-22, Tighten the camshaft thrust plate

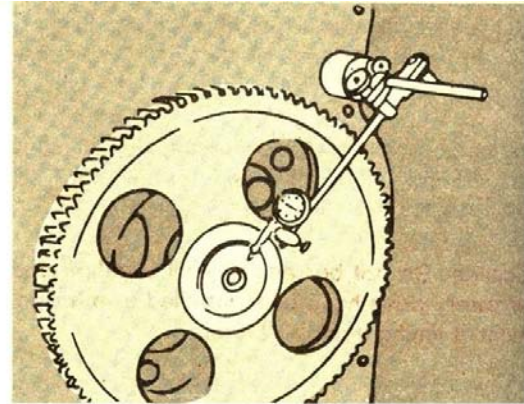


Fig. 14-23, Check the camshaft end clearance

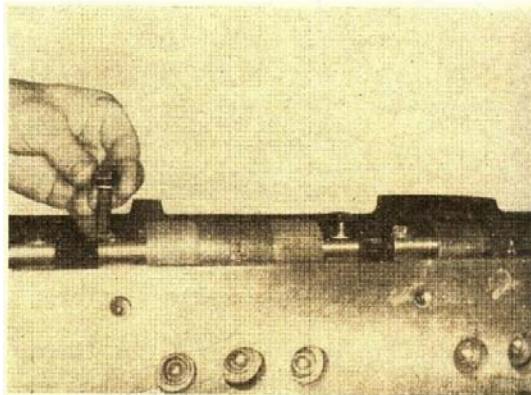


Fig. 14-24, Install the slotted capscrew

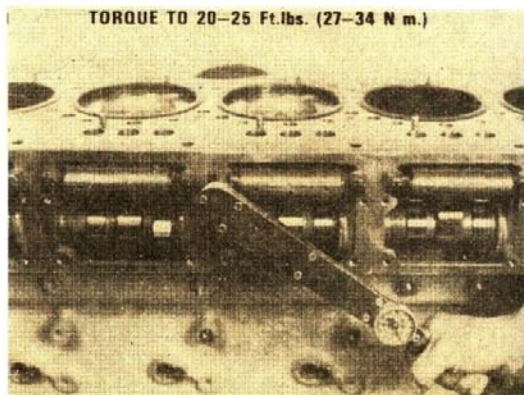


Fig. 14-25, Tighten the cam follower shaft capscrews

Cam Followers:

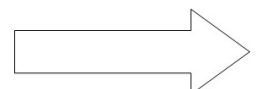
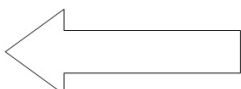
1. Put the cam follower assemblies over the ring dowels to the cylinder block.
2. Install the special drilled capscrews. Fig. 14-24.

Note: Visually inspect the cross drilled hole in the capscrew shank for evidence of over tightening. Compare the capscrews with the new capscrews. If the drilled holes are out-of-round, replace the capscrews.

3. Tighten the capscrews alternately and evenly to 29 to 31 ft.lbs (39 to 42 Nom)

Cylinder Heads:

1. Put the cylinder Head gaskets over the dowels in the block. The work "TOP" on gasket must be visible after the gasket is installed. Fig. 14-26.
2. Put the water, oil and push rod-grommets into position in each cylinder head gasket. Fig. 14-27. One capscrew hole in each gasket, on the camshaft side of the engine, requires a grommet.
3. Use a hoist or suitable lifting device to put the cylinder heads over the dowels in block Fig. 14-28.



Note: Exercise care when inserting the rubber water grommets into the head gasket so the rubber bonded to the steel washer does not roll and become pinched when head is finally installed.

4. Lubricate the threads of the cylinder head capscrew with a rust preservative lubricant. Lubricate under the capscrew head and hardened washer with SAE 140W lubricant.

Note: Washers must be placed on capscrews with the rounded edges toward the washer surface under the capscrew head.

5. Start the capscrews through the cylinder heads to the block by hand, engaging two (2) or more threads.
6. Tighten the cylinder head capscrews in sequence as shown in Fig. 14-29 to the torque values as listed in Table 14-3.

Setting of Engine Timing:

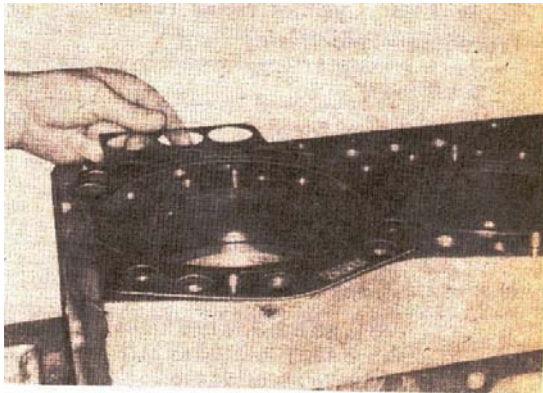


Fig. 14-26, Install the cylinder head gasket

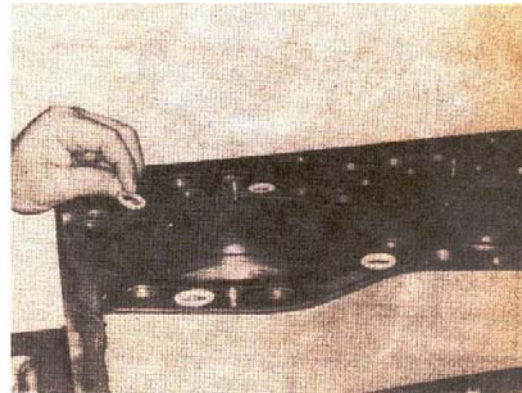


Fig. 14-27, Install the cylinder head grommets

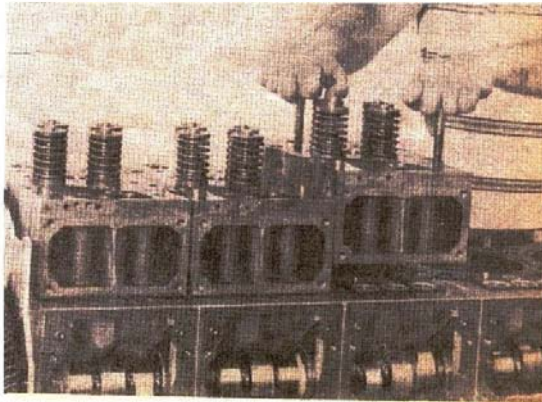
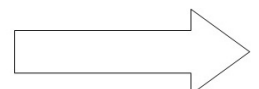
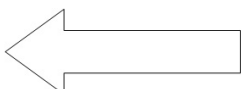


Fig. 14-28, Install the cylinder heads

Use the ST-593 Timing Fixture and the ST 593-40 Support Bock to obtain the precise timing of the push rod and piston travel. Adjustments to the timing are mode by changing the camshaft keys. Timing one cylinder will complete engine timing.

1. Position the ST 593 Timing Fixture in the injector “Well”. Engage the push rod indicator in the injector push rod socket. Secure with knurled hold downs, tighten evenly by hand.

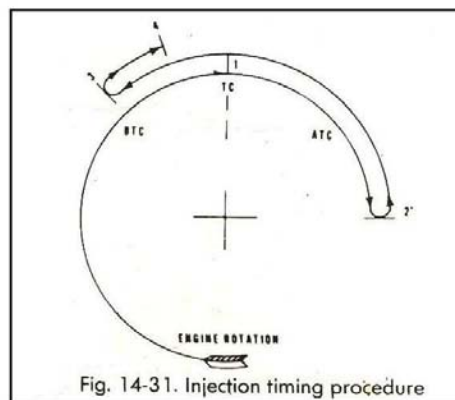
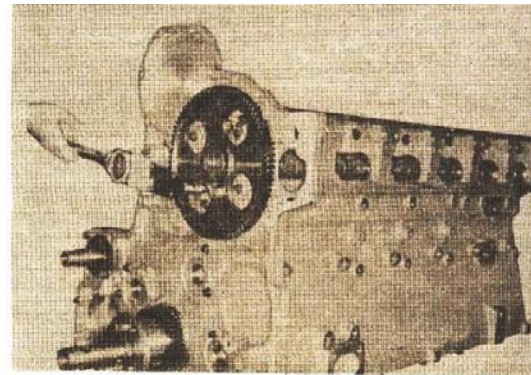
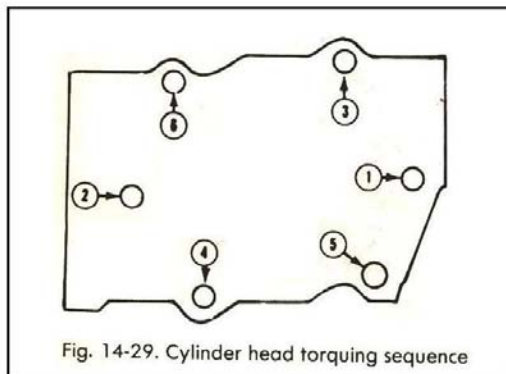


Note: If the adapter block as shown in Fig. 14-30, is used, attach the block to the housing and then secure the push rod indicator to the block. Tools must be mounted straight in the cylinder and over the injector push rod. Loosen the indicators in their support to prevent damage when barring the engine.

Table 14-3: Cylinder Head Torquing Procedure – Ft.lbs (Nm)	
Torque Reading	
Step	Cadium plated
1	40 to 60 Ft-lbs (54 to 81 Nom)
2	110 to 130 Ft-lbs (149 to 176 Nom)
3	180 to 190 Ft-lbs (244 to 258 Nom)
4	250 to 260 Ft-lbs (339 to 353 Nom)
Step	Lubrited
1	40 to 60 Ft-lbs (54 to 81 Nom)
2	140 to 160 Ft-lbs (190 to 217 Nom)
3	240 to 260 Ft-lbs (244 to 353 Nom)
4	350 to 370 Ft-lbs (475 to 502 Nom)

2. Use the crankshaft to bar the engine in the direction of rotation. Bring the piston on the cylinder being checked to the top center firing position.

Caution: The crankshaft must be used when barring the engine to check timing. If the regular barring mechanism is used on error in the indicator readings will occur and result in incorrect timing.



3. Put the piston indicator to the compress stem within 0.010 inch of inner travel stop. Secure the indicator.
4. Check the piston to be at exactly top center (1, Fig. 14-31). Turn the indicator dial to zero at this point.
5. Bar the crankshaft in the direction of rotation (2) to 90 degrees after top center. At this point, put the push rod indicator on the push rod follower to 0.020 inch from its inner travel stop. Secure the indicator. Turn the indicator dial to zero.
6. Bar the crankshaft in the opposite direction of rotation to a position 45 degrees before top center (3).
7. Rotate the crankshaft the direction of the rotation (4) until a reading of 0.2032 inch before top center is reached on the piston travel indicator. The exact reading in ten thousandths must be estimated. Exercise care in bringing the piston travel indicator to this reading.

Table 14-4: Injection Timing		
Timing Code	Piston Travel (Inches)	Push Road Travel (Inches)
AE Non-Aftercooled	0.2032	0.108 \pm 0.002
AM Aftercooled	0.2032	0.118 \pm 0.002

8. Read the push road travel indicator. If should read the push rod travel as indicated in Table 14-4.
9. If the timing is not within these limits, refer to “Camshaft”. Group 1 for instructions in changing the key to adjust the timing.
10. Remove the timing fixture.

Accessory Drive (Fuel Pump, Air Compressor):

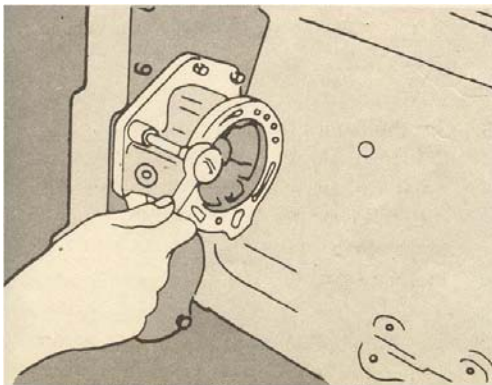


Fig. 14-32, Install the accessory drive

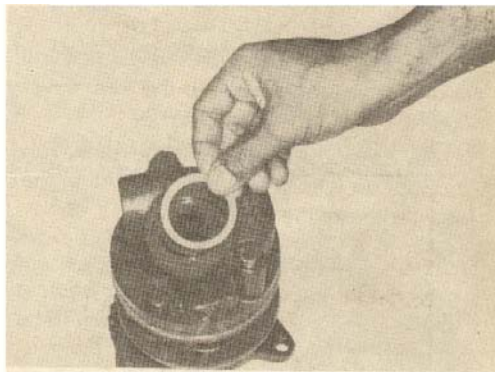


Fig. 14.33, Install the sealing ring

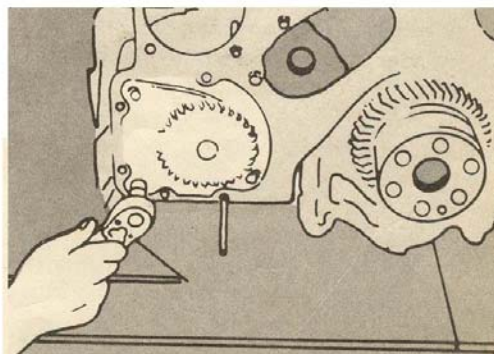
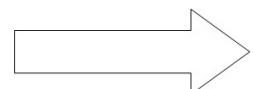
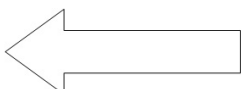


Fig. 14.34, Tighten the lubricating oil pump capscrew



1. Install the accessory drive over the stud to the housing. Align the “A’ S” on the accessory drive gear and idler gear.
2. The Accessory drive capscrews are installed offer the front housing cover installation. Fig. 14-32.

Lubricating Oil Pump:

1. Lubricate the o-rings with clean engine lubricating oil. Put on the pump body.
2. Coat both sides of the sealing ring with a lubriplate and put on the rear (block end) of the pump. Fig. 14-33.

Note: The sealing ring must stay in position on the pump body during installation.

3. Lubricate the pump bore in the block with a clean engine lubricating oil.
4. Install the pump into the bore. Tighten the capscrews to 30 to 35 Ft-lbs (41 to 47 Nom) torque. Fig. 14-34.
5. Check the gear backlash. The backlash must be 0.003 to 0.012 (0.08 to 0.30mm) Backlash can be adjusted by loosening the capscrews and rotating the lubricating pump.
6. Visually check the sealing ring through the pump cavity (between No.1 rod and No.2 main bearing journals) to make sure that the ring is properly seated.

Water Pump Drive:

The water pump drive and water pump assembly with a water filter may be installed as a complete assembly after the front cover installation.

1. Use a suitable gasket adhesive to position the drive assembly gasket to the front cover housing.
2. Put the drive assembly over the stud. Tap into position with a soft hammer. Align the drive gear the idler gear.

Checking of Gear Train Backlash:

1. Attach a dial indicator to the gear housing with the plunger on a tooth of the gear to be checked. Fig. 14-35.
2. Lock the mating gear in position. Rotate the gear to be checked as far as it will move to take up the backlash. Turn the indicator to zero.
3. Rotate the gear in the opposite direction. Read the gear backlash travel on the indicator gauge. Backlash travel should be 0.003" to 0.012 inch (0.08 to 0.30 mm) on all gears.
4. Move the dial indicator to the next gear and repeat the procedure.

Installation of Front Cover:

Make sure all bushing, seals and pipe plugs are installed before installation.

1. Use a suitable gasket adhesive, place the front cover gasket to the steel plate.
2. Lubricate the seal inside diameters and shaft outside diameters. Crankshaft and fuel pump/compressor, water pump drives (if installed), with a clean lubricating oil.

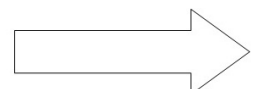
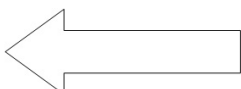




Fig. 14-35, Check the gear backlash

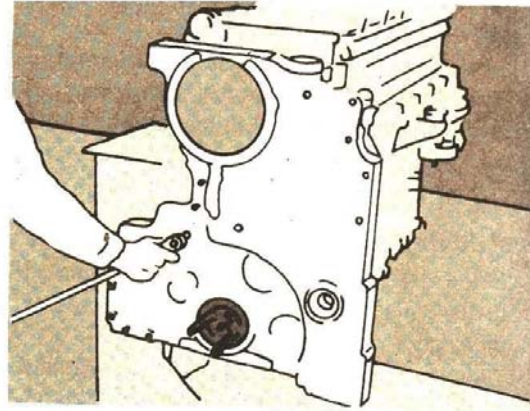


Fig. 14-36, Install the front cover

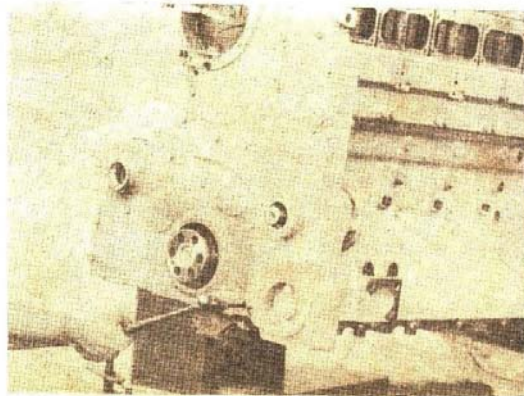


Fig. 14-37, Install the master dowel

3. Align the cover over the shafts and dowels in the housing and tap into position using a soft hammer. Fig. 14-36.

Note: Install the master dowel in the cylinder block at this time if the steel plate and front cover were installed with the pan adapted already installed. Fig. 14-37.

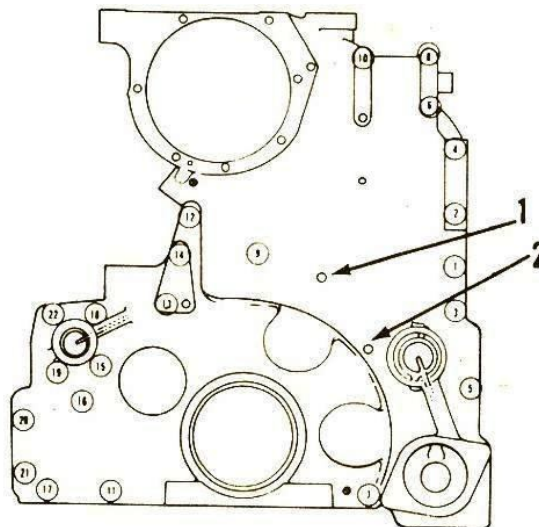
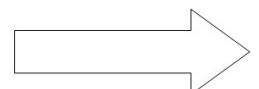
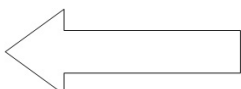


Fig. 14-38, Front cover mounting capscrew tightening sequence



4. Install and tighten the front cover mounting capscrews in the sequence shown in Fig. 14-38 to 30 to 35 ft.lb (41 to 47 Nm)
5. Trim the excess gasket material from the front cover gasket and the steel plate gasket so that only 0.010 inch (0.25mm) gasket material protrudes from the lower side of the block. Fig. 14-39.

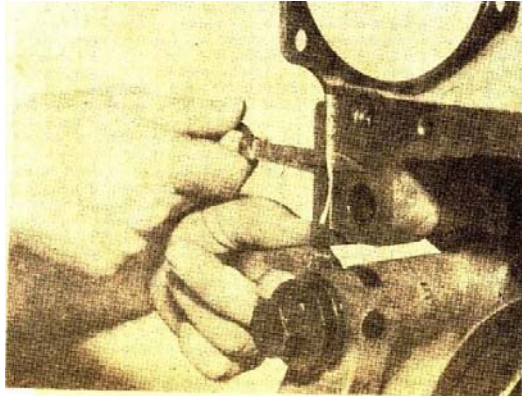


Fig. 14-39, Trim the excess gasket material

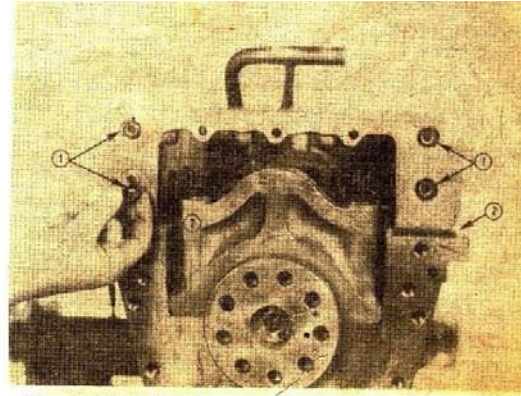


Fig. 14-40, Install the pan adapter to the flywheel housing seats

Installation of Oil Pan Adapter:

Before installing the pan adapter to the block, secure the lubricating oil pump suction tube assembly to the adapter, if not previously installed. Install the oil pan rear baffle, if used.

1. Rotate the engine on the rebuild stand until the pan adapter rail is at the top and horizontal.
2. Install the four (4) guide studs (two on each side spaced evenly) into the capscrew holes in the rail.
3. Install the gasket to the pan rail over the guide studs.
4. Put the adapter over the studs. Start several capscrews by hand to align the adapter to the block. Do not tighten the capscrews. Remove the guide studs.

Note: Capscrew installation is to be completed after the flywheel housing is installed.

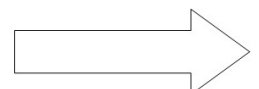
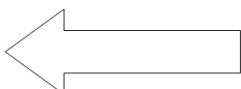
5. Use a suitable gasket adhesive. Install four (4) bolt seals (1, Fig. 14-40) and to (2) rectangular sealing strips (2) to the pan adapter (flywheel end).

Note: The adhesive must hold these seals in position during the flywheel housing installation.

Flywheel Housing:

1. Inspect the flywheel housing dowels. If looseness or evidence of wear is found, remove the dowels from the block.

Note: If a new flywheel housing is being installed, the old dowels must be removed and oversize dowels installed. See "Custom Dowels Flywheel Housing" following.



2. Install two (2) guide studs into the rear of the block to guide and support flywheel housing.
3. Use a suitable gasket adhesive to install a rectangular sealing strip into the groove of flywheel housing. The butt joint should be at the top of the housing.

Note: If a wet-type flywheel housing is being used, the sealing ring must be installed in the counter bores around the capscrew and dowel holes.

4. Lift the housing into position over the guide studs and use a soft hammer to tap in o position over the dowels.
5. Start the capscrews and tighten them finger light (Fig. 14-41). Remove the guide studs. Install and tighten all the capscrews.

Checking of Flywheel Housing Bore with Indicator:

The flywheel housing face and seal bores are checked in a similar manner. Both bores should be checked in a similar manner. Both bores should be checked and corrected to meet specifications in Table 14-5, if necessary.

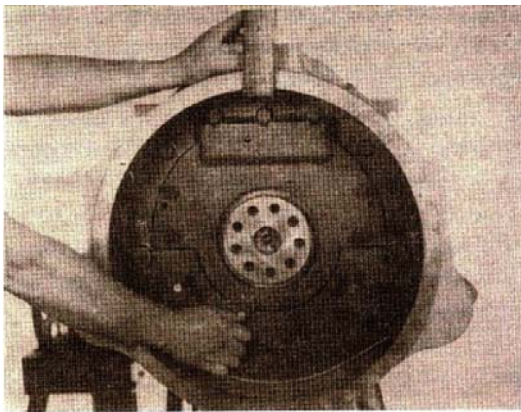


Fig. 14-41, Install the flywheel housing capscrews

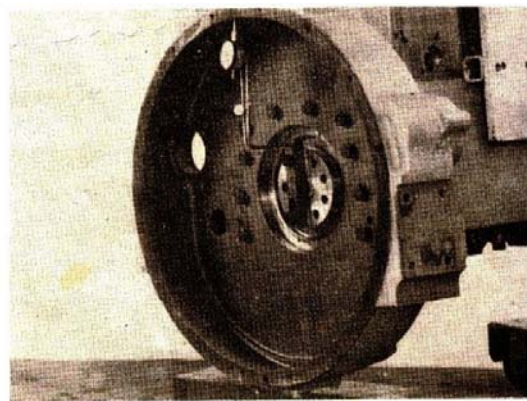
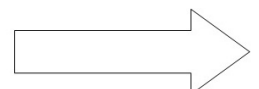
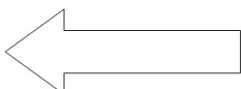


Fig. 14-42, Use the indicator to check the flywheel housing bore

1. Install the ST-1325 Dial Gauge or a suitable fixture to the crankshaft flange. Fig. 14-42. Turn the indicator to zero on the surface to be checked.
2. Draw chalk marks on the flywheel housing at 12, 3, 6 and 9 o'clock.
3. Check the readings at 9 and 3 o'clock. If the total indicator reading exceeds the specifications, move the housing one-half the distance of the total indicator reading to center the housing horizontally.
4. Check the readings at 12 and 6 o'clock. If the total runout exceeds the specifications, move the housing up or down, whichever is necessary, one half the distance of the total indicator reading to center the housing vertically.

Checking of Flywheel Housing Face with Indicator:

1. Move the dial gauge to the face of the housing as shown in Fig. 14-43.
2. Push the crankshaft forward to take up end clearance. Turn the crankshaft to obtain readings on the housing face.
3. The total flywheel housing face run-out must not exceed the specifications in Table 14-5.



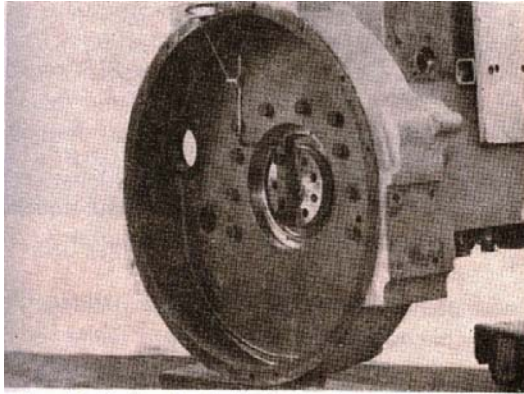


Fig. 14-43, Use the indicator to check the flywheel housing face

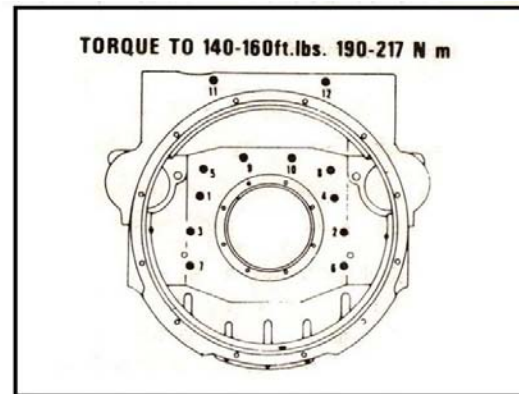


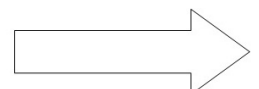
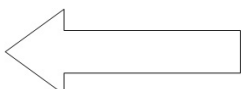
Fig. 14-44, Tighten the flywheel housing

4. To correct housing face run-out, remove the housing and check the sealing strip alignment. Remove any burrs and clean the mating surfaces. Install and align the housing.
5. If the readings are within the limits and the dowels were not removed, tighten the capscrews to 140 to 160 Ft-lbs (190 to 217 Nom) torque. Fig. 14-44.
6. Install the remaining capscrews in the oil pan adapter. Check the capscrews for proper size and length.
7. Tighten two (2) end capscrews (flywheel housing end) to hold the pan adapter to the block rail.
8. Starting with the side capscrews securing the buttress end of the adapter to the flywheel housing, tighten the capscrews (Fig. 14-45) alternately and evenly to the values listen in step 11 following. See "B", Fig. 14-45.
9. Loosen the capscrews tightened in Step 7.
10. Tighten the pan adapter to block capscrews in the sequence shown in "A", Fig. 14-45.
11. The pan adapter capscrews torque values are:
 - a. 3/8-16 30 to 35 Ft-lbs (41 to 47 Nom)
 - b. 7/16-14 40 to 45 Ft-lbs (54 to 61 Nom)
 - c. 9/16-12 60 to 70 Ft-lbs (81 to 91 Nom)

Table 14-5: Flywheel Housing Specifications-Inch (mm)							
SAE No.	Bore Diameter	Clutch Bore Tolerance Faced Run-out Tolerance Seal Bore Tolerance					
00	31.00 to 31.91 (787 to 787.7)	0.012	0.30	0.012	0.30	0.008	0.20
0	25.50 to 25.51 (647.7 to 648)	0.010	0.25	0.010	0.25	0.008	0.20
½	23.00 to 23.008 (584.0 to 584.20)	0.010	0.25	0.010	0.25	0.008	0.20
1	20.125 to 20.130 (534.27 to 534.40)	0.008	0.20	0.008	0.20	0.008	0.20

Custom Dowel Flywheel Housing:

If a new flywheel housing is being used or if the dowels were removed from the block, install oversize dowels as follows:



1. After the dowels are removed from block, install undersize, internally drilled, dummy dowels.
2. Install the housing to block. Tighten the capscrews. The capscrews must be tight enough to hold the housing in position. Remove the dummy dowels.
3. Use the indicator to check the flywheel housing bores and face as described under "Flywheel Housing".
4. After the flywheel housing is in the correct position tighten all the capscrews to 140 to 160 ft-lbs (190 to 217 Nom) torque.
5. Use the ST-1232 Dial and Ream Fixture and ST-1233 Bushing Set to drill and ream the dowel holes to the smallest permissible oversize.

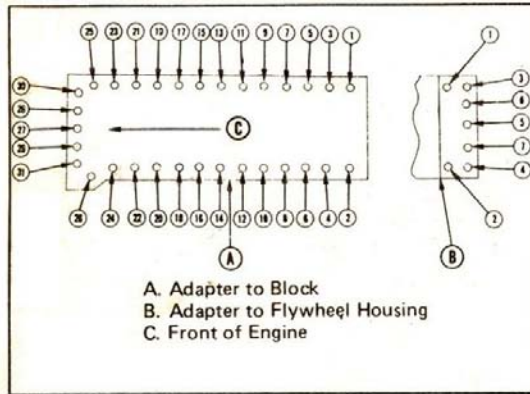


Fig. 14-45, Oil pan adaptor tightening sequence

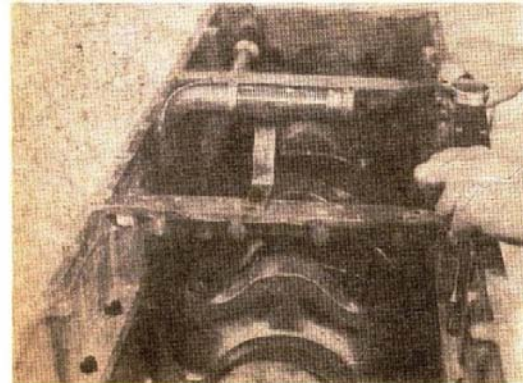


Fig. 14-46, Tighten the pan adaptor to the block

Note: The crankshaft must be held stationary during the drilling and reaming operation.

6. Remove the drill and ream fixtures. Clean the holes thoroughly.
7. Install the oversize dowels. The dowels must be even or below the surface of the flywheel housing.

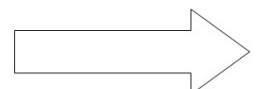
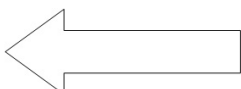
Rear Crankshaft Oil Seal:

1. Lubricate the oil seal O-ring with a clean engine lubricating oil. Put the seal over the crankshaft into the bore in the flywheel housing.
2. Put the seal housing over the crankshaft. Align the capscrew holes. Make sure the housing trunnion enters the O-ring evenly.
3. Install the locking (self-sealing) capscrews. Tighten alternately and evenly to 7 to 9 ft-lbs (9 to 12 Nm) torque.

Note: Do not apply oil to LAY DOWN LIP type seal.

Flywheel:

1. Install the two (2) guide studs in the crankshaft flange to guide and support the flywheel.
2. Use a suitable lifting device to put the flywheel over the guide studs and against the crankshaft flange. Fig. 14-17.



3. Lubricate the place bolt threads with a clean engine lubricating oil. Lubricate the hardened washer faces with SAE 140W lubricant.
4. Install the seven (7) place bolts and tighten by hand 1 to 1-1/2 turns.
5. Remove the guide studs. Install and tighten the remaining place bolts 1 to 1-1/2 turns by hand.
6. Tighten all the place bolts in sequence as shown in Fig. 14-48 to 100 to 120 ft-lbs (136 to 163 Nm) torque.
7. Repeat the tightening sequence. Tighten to a final torque of 200 to 220 ft-lbs (271 to 292 Nm).

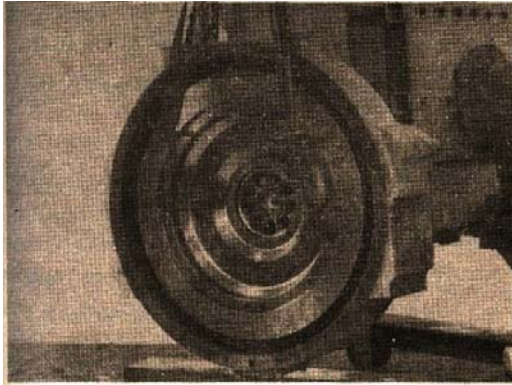


Fig. 14-47, Install the flywheel

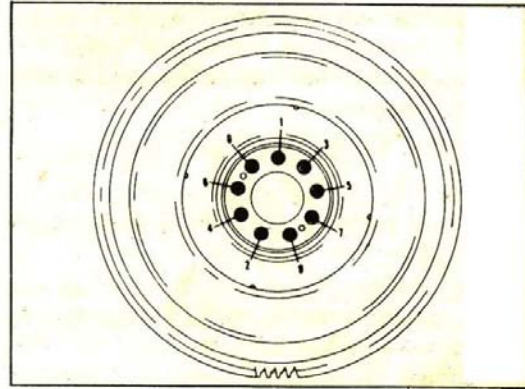


Fig. 14-48, Flywheel to crankshaft tightening sequence

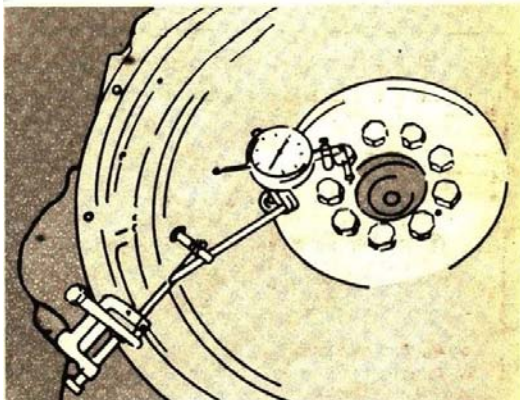


Fig. 14-49, Check the flywheel bearing bore with the indicator

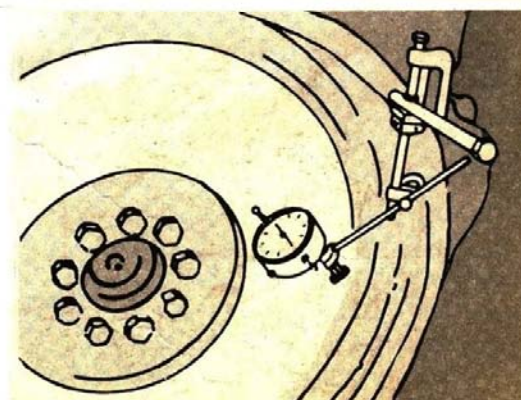
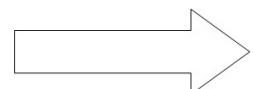
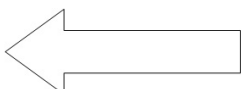


Fig. 14-50, Check the flywheel clutch force with the indicator

8. Check the clutch pilot bearing bore with an indicator.
 - a. Attach the indicator gauge to the flywheel housing. Put the point of the indicator into the bore inside diameter.
 - b. Rotate the flywheel. The total indicator reading must not exceed 0.005 inch (0.13mm) in one complete revolution. Fig. 14-49
9. Check the flywheel clutch face with the indicator.
 - a. Move the gauge to the clutch face of the flywheel. Fig. 14-50.
 - b. Put the crankshaft to the front or rear limit of the thrust clearance. Turn the gauge to zero.



- c. Rotate the flywheel. To total indicator reading must not exceed 0.0005 inch (0.013mm) per inch of the diameter of the outer 1/3 of the clutch face radius.

Note: IF the total indicator reading exceeds the limits listed in 8b and 9c preceding, remove the flywheel. Clean the flywheel and crankshaft flange faces and install the flywheel. Repeat checks.

10. If any place bolts are removed or loosened after final tightening, loosen and tighten all the place bolts and repeat steps 6 through 9.

Oil Pan And Adapter Cover:

1. Use guide studs to put the gasket to pan adapter in the correct position.
2. Put the sump of the oil pan in the proper position. Put the pan and adapter cover over the guide studs. Start several capscrews Hand tighten and remove the guide studs.
3. Install the remaining capscrews. Starting at center and alternating from side to side of the oil pan or adapter, tighten the capscrews evenly to 30 to 35 ft-lbs (41 to 47 Nm) torque Fig. 14-51.

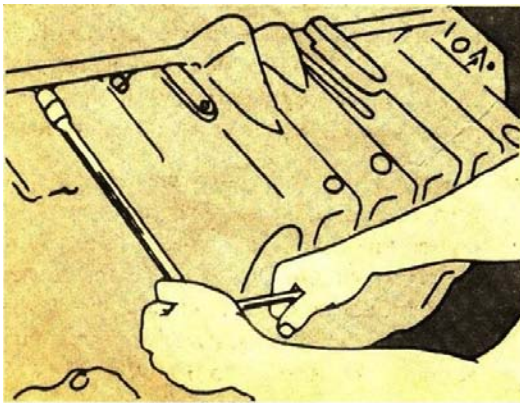


Fig. 14-51, Tighten the oil

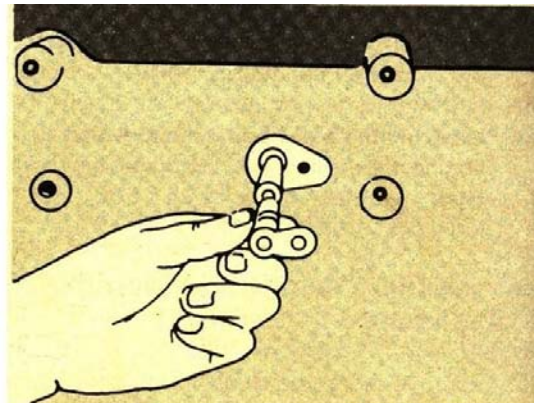


Fig. 14-52, Install the piston cooling nozzle

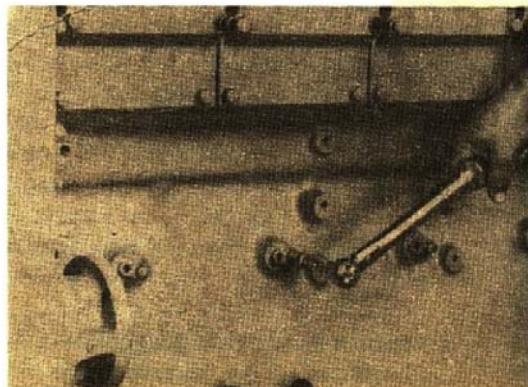
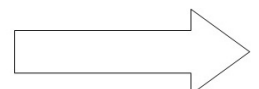
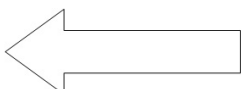


Fig. 14-51, Tighten the piston cooling nozzle screw

Piston Cooling Nozzles:

1. Lubricate the O-ring with a clean engine lubricating oil; position on the nozzle. Be sure the O-rings are not twisted in groove.



2. Insert the nozzles in the block (Fig. 14-52) and align the notch in the nozzle with the threaded hole in the block.
3. Tighten the nozzle screws to 8 to 10 ft-lbs (11 to 14 Nom) torque. Fig. 14-53.

Rocker Housing /water Manifold:

The water manifolds and rocker housing are installed to the cylinder heads at the same time. Passages cast into the housing and transfer tubes sealed with O-rings make up the water manifold.

1. Put the gaskets over the dowels in the cylinder heads.
2. Lubricate the 'O-rings with a clean engine lubricating oil and put on the water transfer tubes and rear housing plug.
3. Install the front rocker housing to the cylinder head. Put the water transfer tube into the rear of the water passage. Make sure the retaining ring groove is to the front of the engine. Push the tube into the passage until it reaches bottom.
4. Install the second rocking housing. Use the ST-1319 to move the water transfer tube from the water passage in the front housing into position in the passage of the housing being installed. Secure with a retaining ring.
5. Repeat steps 3 and 4 for the remaining rocker housing. Fig. 14-54.
6. Starting in the center tighten the capscrews alternately and evenly to 60 to 73 Ft-lbs (81 to 95 Nom) torque. Fig. 14-53.
7. Put the plug in the rear of the rear rocker housing and secure it with groove pin.

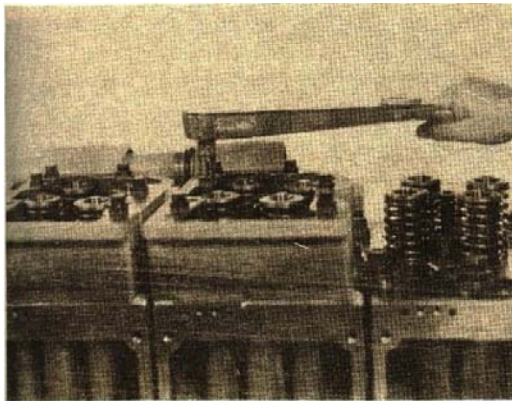


Fig.14-54, Tighten the rocker housing capscrews

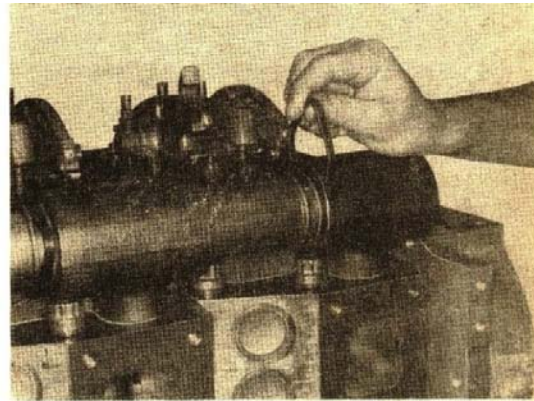
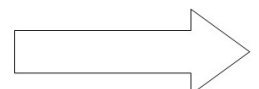


Fig. 14-55, Install the water transfer tube retaining ring

Valve Crosshead Adjustment:

1. Put the crossheads over the guides with the adjusting screws toward the water passage in the rocker housing.
2. Loosen the adjusting screw locknuts and back the adjusting screws off one (1) turn, if not previously done.
3. Use light finger pressure at rocker lever contact surface to hold the crosshead in contact with the valve stem nearest the push rod. Turn the adjusting screw down until it contacts its mating valve stem. Fig. 14-56.
4. Use the ST-669 Torque Wrench Adapter to hold the adjusting screw in position. Then tighten the locknut to 22 to 26 Ft-lbs (30 to 35 Nom) torque. Fig. 14-57. If



the torque wrench adapter is not used, hold the adjusting screw with a screwdriver and then tighten locknuts to 25 to 30 ft-lbs (36 to 41 Nm) torque.

5. Check the clearance between the crosshead and the valve spring retainer (Fig. 14-58) with a wire gauge. There should be a minimum of 0.025 inch (0.64mm) clearance at this point.

Note: When installing a Jacobs Brake cross head, use a 3375008 Adapter to tighten to 30 to 32 ft-lbs (41 to 43 Nm) torque.

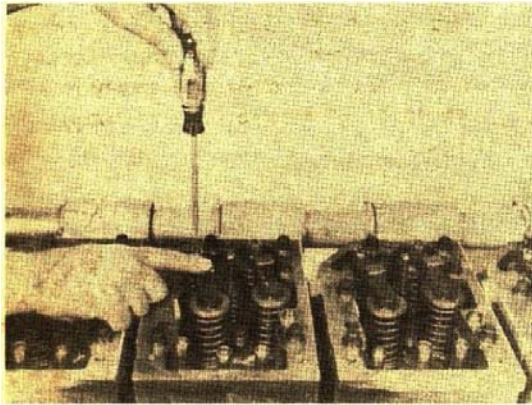


Fig. 14-56 Adjust the valve crosshead

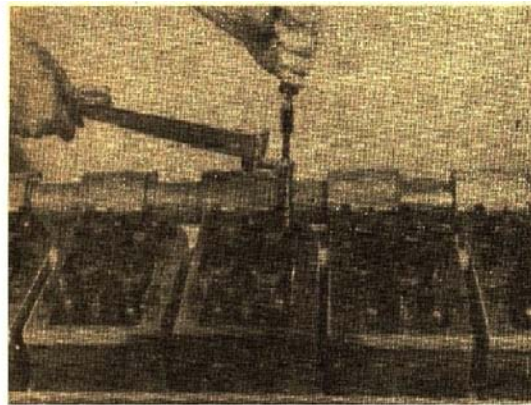


Fig. 14-57 Tighten the valve crosshead and torque it

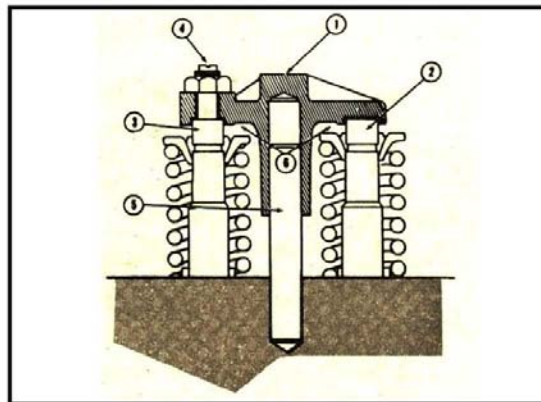


Fig. 14-58 Valve crosshead

Push Rods:

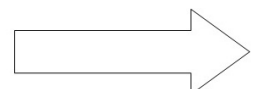
The injector push rod has a larger outside diameter than the valve push rods. The injector push rod fits in the middle socket. Lubricate the ball ends with clean engine lubricating oil. Seat push rods firmly in the cam follower sockets.

Injectors:

1. Lubricate the injector “wells” with clean engine lubricating oil. Install the injector seal seats onto the injector.

Note: Only one (1) valve seat is to be installed in each injector “Well”.

2. Lubricate the injector body O-rings with a light coat of clean engine lubricating oil. Check after installation on injectors for twisted O-rings. Straighten as required.



3. Start the injector into the bore by hand. Then use the ST-1297 to push the injector into position.

Note: Remove the injector and inspect the O-rings and valve seat if the injector fails to go into position.

4. Put the hold down plate over the injector body. Start the hold-down capscrews. Do not tighten.
5. Carefully insert the injector plunger link. Fig. 14-59. Tighten the hold down capscrews alternately and evenly to 11 to 13 ft-lbs (15 to 18 Nom) torque. Fig. 14-60.

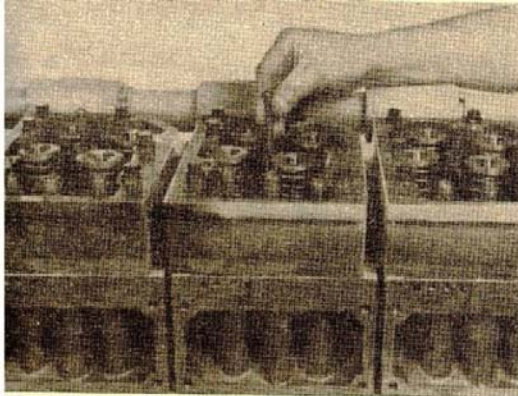


Fig. 14-59, Install the injector plunger link

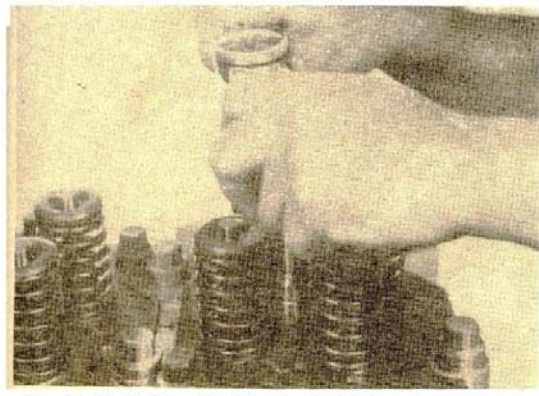


Fig. 14-60, Tighten the injector hold down capscrews

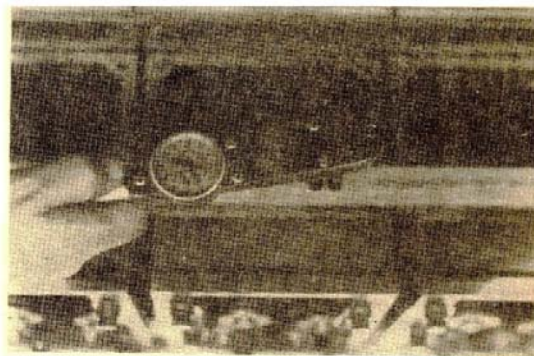


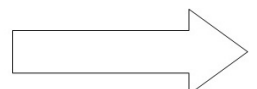
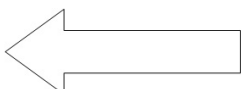
Fig. 14-61, Tighten the fuel manifold screws

Fuel Manifold:

1. Coat the O-ring with lubriplate and put them into the counter bores on the block side of the fuel manifold.
2. Note: O-rings must stay in position in the manifold counter bores during installation.
3. Carefully put the manifold to the cylinder heads. Align the o-rings with the fuel drilling. Secure with Allen-head countersunk screws.

Note: Coat the mating surface of the screw head with anti-seize compound to aid in removal.

4. Use on Apex adapter and inch-pound torque wrench to tighten screws starting in the center, alternately and evenly to 40 to 45 in-lbs (4.5 to 5.1 Nom) torque. Fig. 14-61.



Rocker Lever Assemblies:

1. Loosen the locknuts and back off the rocker lever adjusting screws two (2) or three (3) turns, if not previously done.
2. Lubricate the push rod sockets and adjusting screws with clean engine lubricating oil.
3. Put the rocker lever assembly to the housing with the bail ends of adjusting screws fitting into their respective push rod sockets.
4. Install the capscrews and washers. The longer capscrew goes through the rear of the housing into the cylinder head. Tighten the capscrews alternately and evenly to 60 to 70 ft-lbs (81 to 95 Nm) torque. Fig. 14-62.

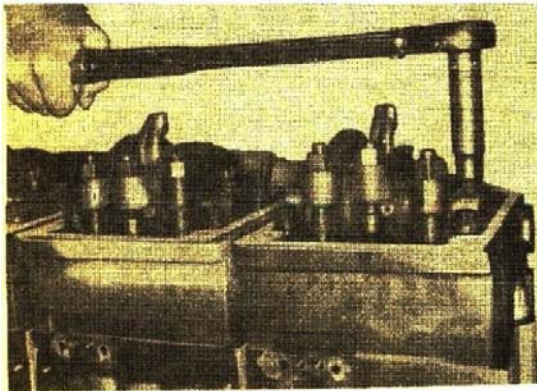


Fig. 14-62, Tighten the rocker lever assembly capscrews

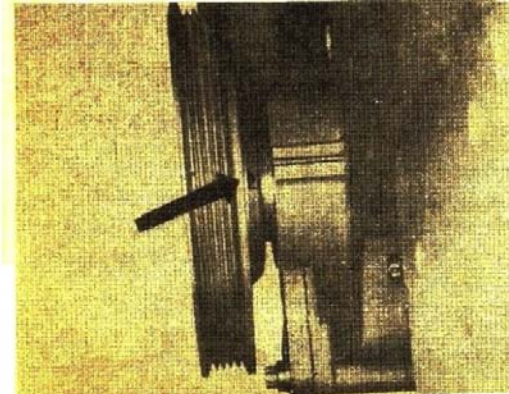


Fig. 14-63, Valve set marks

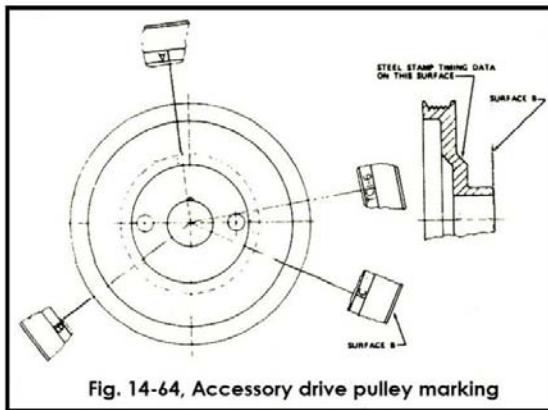


Fig. 14-64, Accessory drive pulley marking

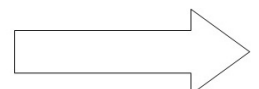
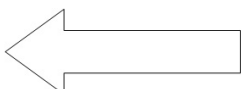


Fig. 14-65, Actuate the rocker lever to set the dial indicator

Injector and Valve Adjustment:

Bar the engine in the direction of rotation until the “A” valve set mark on the pulley is aligned with the pointer on the gear housing cover, Fig’s 14-63 and 14-64. In this position the injector plunger for the No. 3 or No.4 cylinder will be at the top of its travel an rocker levers for No.5 or No.2 cylinder will be free (valves closed).

Note: The injector and valves or any one (1) cylinder cannot be set at the same time. Example: If the rocker levers on No.2 cylinder are free (valves close), the injector plunger travel on No.4 cylinder is to be adjusted. Then adjust the valves on No.2 cylinder, See Table 14-6.



Injector Plunger Travel Adjustment, with 3375004 Kit:

1. Set up the 3375007 Indicator Support with on existing on the injector plunger top at the No.4 cylinder. Make sure the indicator extension is secure in the indicator stem and not against the rocker.
2. Use the 3375010 Rocker Lever Actuator (Fig. 14-65) to depress the injector plunger until the plunger is at the bottom in the cup to squeeze oil film from the cup.

Table 14-6: Injector And valve set Position			
Bar in Direction	Pulley Position	Set Injector	Cylinder Valves
Star	A	3	5
Adv. To	B	6	3
Adv. To	C	2	6
Adv. To	A	4	2
Adv. To	B	1	4
Adv. To	C	5	1
Firing Order 1 – 5 -3 -6 -2 -4			

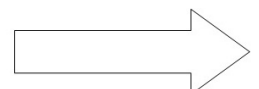
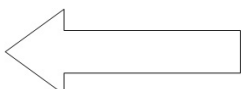
3. Allow the injector plunger to rise and reach the bottom again. Set the dial indicator at zero (0) with the injector plunger at bottom. Fig. 14-65. At this point, check the extension contact with the plunger top.
4. Allow the plunger to rise. Then go to the bottom again to check the zero (o) dial indicator setting.
5. Remove the rocker lever actuator and turn the adjusting screw until the adjustment valve, Table 14-7, is obtained on the dial indicator. Fig. 14-66.
6. Use the rocker lever actuator bottom plunger again to release the lever. The indicator must show the injector plunger travel to be within the travel range as shown in Table 14-7.
7. Use the ST-669 Torque Wrench Adapter on the adjusting screw to tighten the locknut to 30 to 35 ft-lbs (41 to 47 Nom) torque. Fig. 14-67. If the torque wrench adapter is not used, hold the adjusting screw with a screwdriver and tighten the locknuts to 40 to 45 ft-lbs (54 to 61 Nom) torque.
8. Actuate the injector plunger several times as a check of adjustment. Adjust again if necessary.

Table 14-7: Uniform Plunger Travel Adjustment Limits		
Injector Plunger Travel inch (mm)	Valve Clearance inch (mm)	
Adj. Valve	Intake	Exhaust
0.304 ± 0.001 (7.72)	0.014 (0.36)	0.027 (0.69)

Valve Adjustment:

Before adjusting the valves on cylinder No.2, ensure that the crossheads are in proper adjustment.

1. Insert the correct thickness feeler gauge between the rocker lever and crosshead for the valves being adjusted. See Table 14-7 for valve clearance.



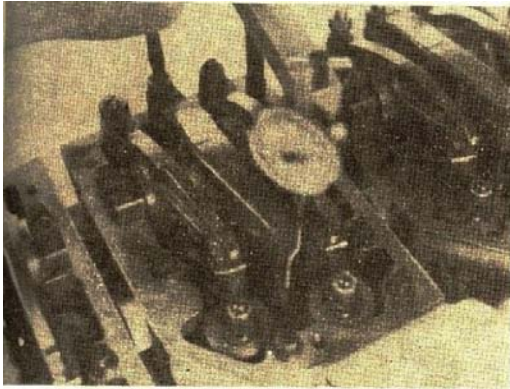


Fig. 14-66, Adjust the injector plunger travel

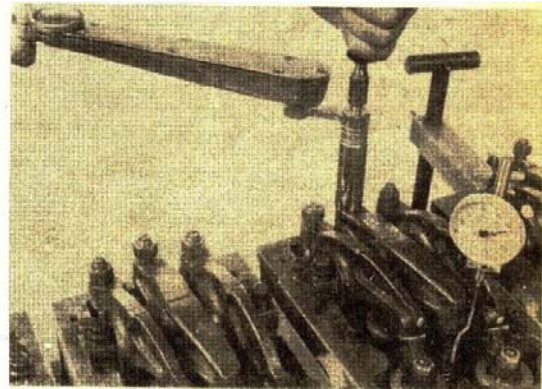


Fig. 14-67, Tighten the locknut with a ST-669 Adapter

Note: The exhaust valves are toward the front of each cylinder head.

2. Turn the adjusting screw down until the rocker lever just touches the feeler gauge (Fig. 14-68). In this position, tighten the locknut to the same value as the injector locknuts.

After completing the injector and valve adjustments at the “A” valve set position, bar the engine in the direction of rotation until the next valve set mark on the accessory drive pulley is lined up with the mark on the gear housing cover. Repeat “Injector Plunger Travel” and “Valve Adjustment” procedure as described in Table 14-6 for each cylinder until all rocker levers are properly adjusted.

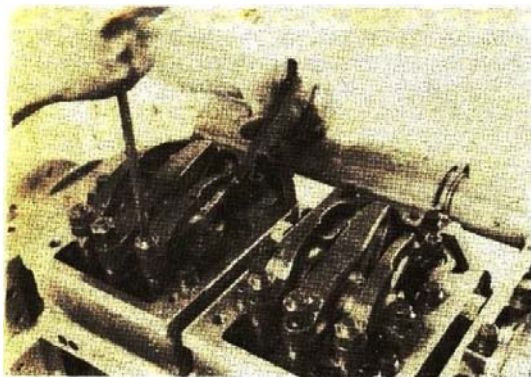


Fig. 14-68, Adjust the valves

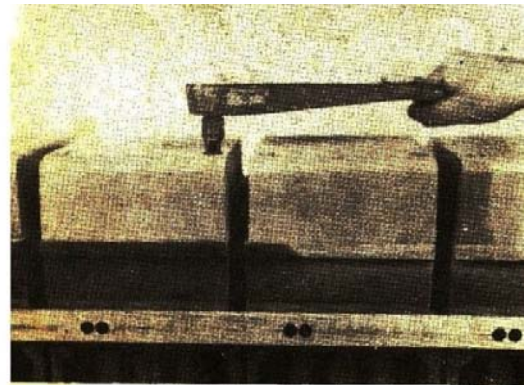


Fig. 14-69, Tighten the valve covers

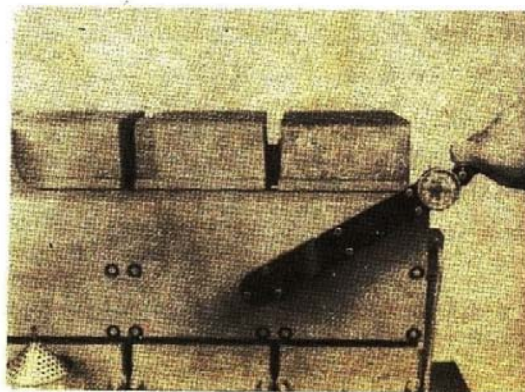
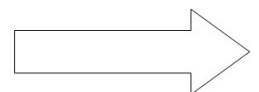
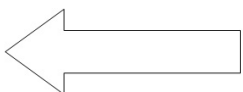


Fig. 14-70, Tighten the intake manifold



Valve Covers:

Put the valve covers and gaskets to rocker housings. Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 Nom) torque. Fig. 14-69.

Intake Manifold:

1. Put the intake manifold to the cylinder heads. Use several guide studs to hold the gasket in position.

Note: Be sure the guide studs are long enough to protrude through the intake manifold after installation.

2. Put the intake manifold over the guide studs. Be sure the gasket is not misaligned. Tighten several capscrews finger tight to hold the gasket in position before removing the guide studs.
3. Lubricate the O-ring on the air compressor supply tube (if used) with clean engine lubricating oil. Put the tube into the bore in front of the intake manifold.
4. Install the remaining capscrews. Starting in the center, tighten the capscrews alternately and evenly to 30 to 35 lbs (41 to 47 Nom) torque. Fig. 14-70.

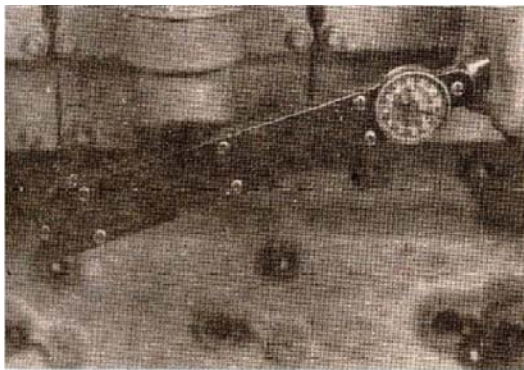
Installation of Cam Follower Covers:

Fig. 14-71, Tighten the cam follower covers

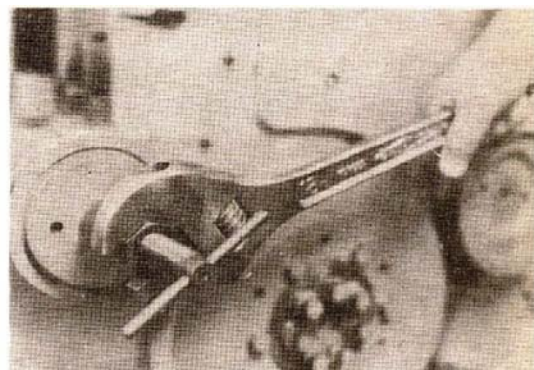


Fig. 14-72, Install the alternator drive pulley

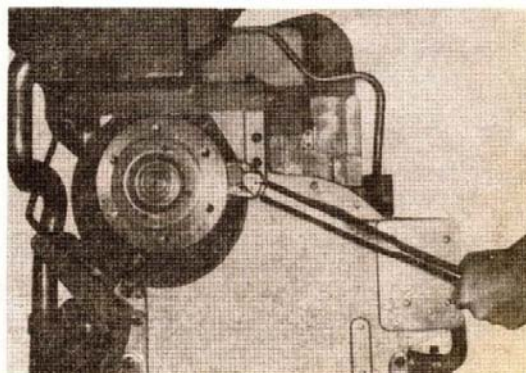
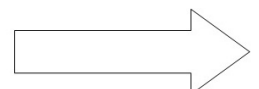
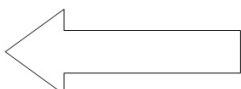


Fig. 14-73, Tighten the fan hub mounting capscrews

1. Install the cam follower covers. Put the covers with the filler tube and breather over cam followers as noted during removal.



2. Tighten the capscrews to 15 to 20 ft lbs (920 to 27 Nom) torque. Fig. 14-71.

Installation of Accessory Drive and Alternator Pulleys:

The accessory drive and alternator pulleys are installed in a similar manner.

1. Put the oil slinger over the shaft (accessory drive shaft). Install the key and keyway seal, if used. Lubricate the shaft and pulley bore with clean engine lubricating oil.
2. Start the pulley on shaft and key (Accessory drive shaft), use the ST-386 Pulley Assembly Tool to press into position. Fig. 14-72.
3. Remove the pulley assembly tool, install the shaft plug (alternator drive pulley) and tighten to 65 to 75 ft-lbs (88 to 102 Nom) torque.

Fan Hub (Gear Driven):

1. Align the fan hub gear with the camshaft gear. Put the fan hub to the gear housing front cover.
2. Check the mounting capscrews for proper length (as noted during removal). Install the capscrews. Tighten alternately and evenly to 30 to 35 ft-lbs (41 to 47 Nom) torque Fig. 14-73).
3. If the fan hub shaft nut was loosened or remove, tighten to 150 ft-lbs (203 Nom) torque. Fig. 14-74. Replace the cotter pin.
4. Attach the dial indicator gauge to the front cover, or remove and install a longer capscrews as illustrated in Fig. 14-75, and check the fan hub end clearance. The end clearance on a new or newly or newly rebuilt for hub should be 0.003 to 0.012 inch (0.08 to 0.25mm). See "Fan Hub", Group 8.
5. Move the fan hub shaft by hand. A small amount of the gear backlash should be felt.

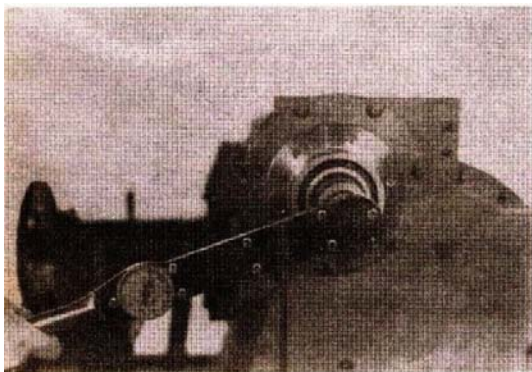


Fig. 14-74, Tighten the fan hub shaft nut

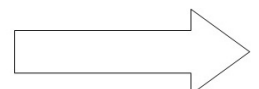
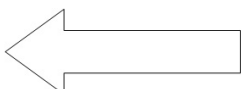


Fig. 14-75, Check the fan hub end clearance

Installation of Fan Drive:

Clean the old gasket material from the front of the engine.

1. Place the gasket on the adapter plate so as to have all the holes of the gasket aligned with the holes of the adapter plate.
2. Place the adapter plate on the front of the engine.
3. Install the marked bolts in the correct position around the adapter plate to engine.



4. Tighten all the bolts to the recommended torque specifications.
5. Place the (2) 3/8-4x 16" dowel guide bolts in the adapter plate.
6. Place the fan drive housing gasket on the (2) dowel bolts with the holes of the gasket aligned with the holes in the adapter plate.
7. Install the fan drive assembly on the engine using the dowel bolts as guides. Slide the fan drive back contacting the gasket. Rotate the fan mounting hub to mate the input drive gear with the engine drive gear.
 - a. To install the 0.84:1 fan drive assembly to the adapter plate, the flat spot or name plate must be at the bottom. Start the input drive gear into the adapter plate by coking the fan drive sideways. After the input drive gear has entered the adapter plate, push the fan drive toward the engine and rotate the fan drive assembly 180 degrees or until the flat spot is at the top. Push the fan drive tight against the adapter state and install the mounting bolts.
8. Install the (6) hex head capscrews marked (D) and tighten to 30 ft-lbs (41 Nom) torque.
9. Place for blade (and spacer if required) on the fan mounting hub.
10. Place the (6) hex head bolts that retain the fan blade to the fan mounting hub and tighten.

Caution: Fan mounting bolts must not extend through the fan mounting hub and make contact with the front cover.

Installation of Vibration Damper and Crankshaft Adapter:

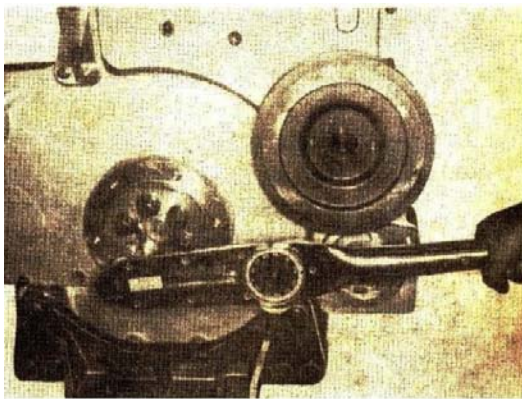


Fig. 14-76, Tighten the crankshaft adapter

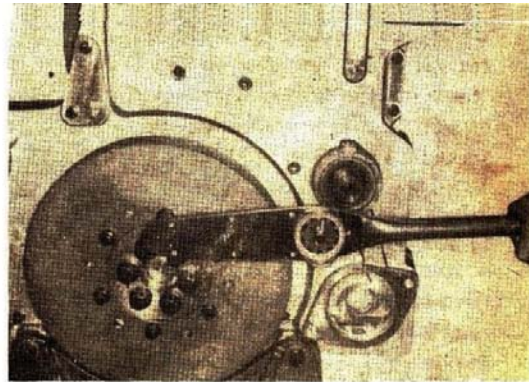


Fig. 14-77, Tighten the vibration damper to crankshaft adapter

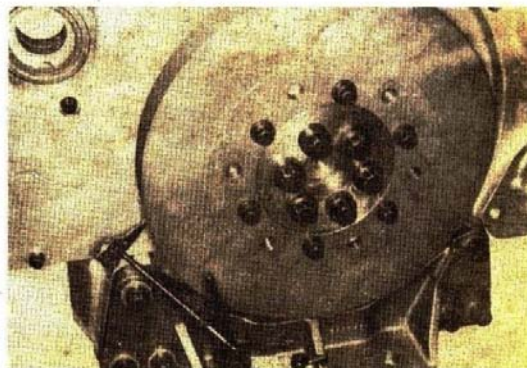
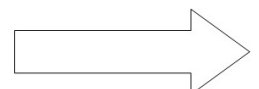
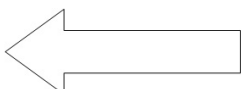


Fig. 14-78, Check the vibration damper common centers



1. Wipe the crankshaft and adapter mating surfaces with a clean, dry cloth. Align the capscrews holes. Put the adapter to the crankshaft.
2. Lubricate the washer faces and capscrew threads with a clean engine lubricating oil. Tighten the capscrews to 160 to 180 ft-lbs (217 to 244 Nom) torque. Repeat the Torquing sequence. Tighten the capscrews to a final torque of 320 to 340 ft lbs (434 to 461 Nm)
3. Wipe the mating surfaces of the damper and adapter with a clean dry cloth. Align the capscrew holes. Put the damper to the adapter.
4. Lubricate the washer faces and capscrew threads with a clean engine lubricating oil. Tighten the capscrews alternately and evenly to 65 to 75 ft-lbs (88 to 102 Nm) torque. Fig. 14-77.
5. Check the vibration damper for common centers and wobble as follows:
 - a. Mount the dial indicator gauge to the oil pan adapter. Turn the indicator to zero on the vibration damper as shown in Fig. 14-78.
 - b. Rotate the engine 360 degrees. The common centers must be within 0.030 inch (0.76mm).
 - c. Move the dial indicator gauge to the face of the vibration damper. Put the crankshaft at either the front or rear limit of the thrust clearance. Turn the indicator to zero. Fig. 14-79.
 - d. Rotate the engine 360 degrees; wobble must not exceed 0.030 inch (0.76mm)

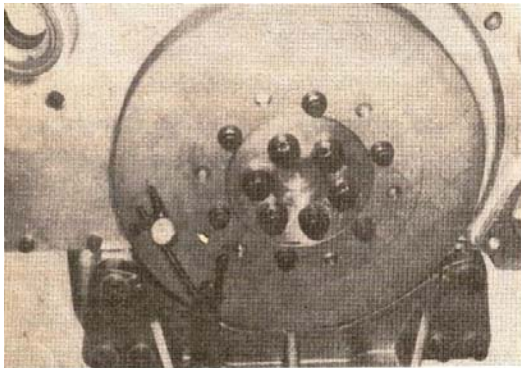


Fig. 14-79, Check the vibration damper wobble

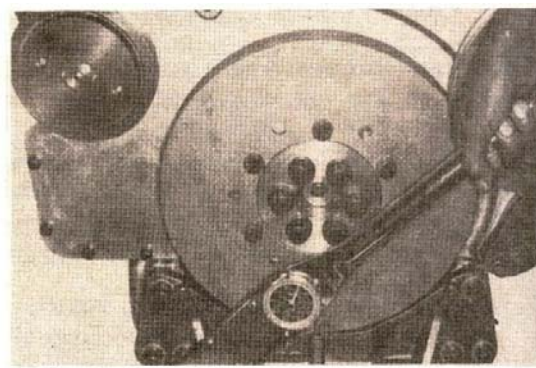


Fig. 14-80, Tighten the front engine support

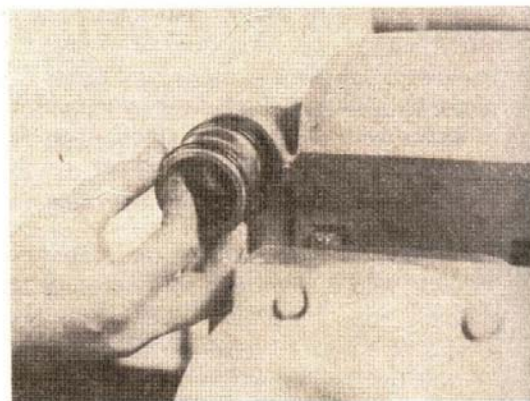
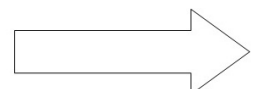
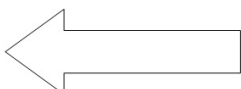


Fig. 14-81, Install the water transfer tube

Note: The crankshaft must be kept at either front or rear limit of the thrust clearance while checking the vibration damper for wobble.



Front Engine Support:

Before adjusting the valves on cylinder No.2, sure that the crossheads are in proper adjustment.

Thermostat Housing:

1. Lubricate the O-rings. Put the water transfer tube into the water passage of the rocker lever housing. Fig. 14-81.
2. Put the thermostat housing over the water transfer tube and secure to the gear housing front cover.

Note: The thermostat housing is secured to the gear housing front cover with two (2) capscrews from the top and two (2) capscrews through the front cover into a bracket mounted to the rear of the thermostat housing. See Fig. 14-82.

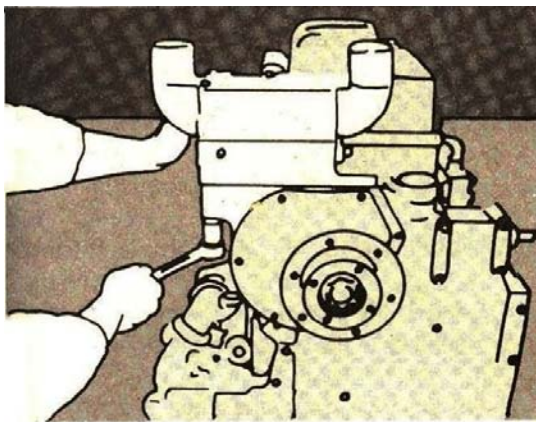


Fig. 14-82, Install the thermostat housing

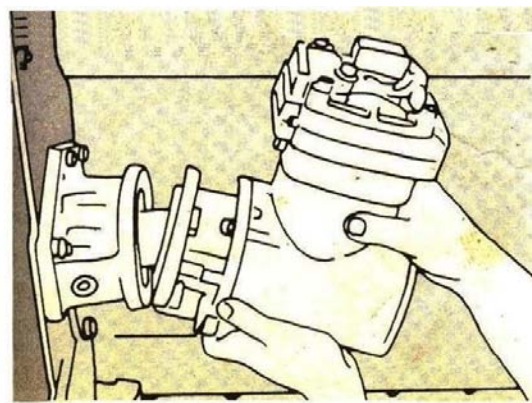


Fig. 14-83, Install the air compressor

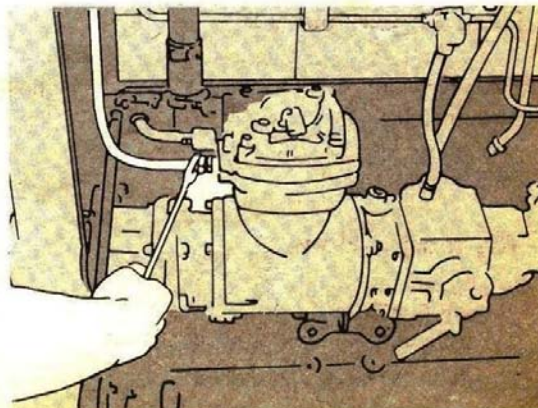
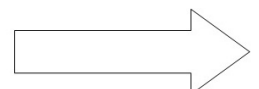
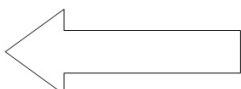


Fig. 14-84, Install the air compressor piping

Air compressor/ Fuel pump:

The air compressor (if sued) and fuel pump may be installed as an assembly, if so desired.

1. Put the splined coupling on the accessory drive gear.
2. With a new gasket in position, align the air compressor gear with the splined coupling. Tighten the capscrews. Fig. 14-83.
3. Install the air compressor support bracket to the compressor and cylinder block.
4. Put the fuel pump to the accessory drive of the air compressor with a new gasket and buffer or splined drive in position.



5. Tighten the capscrews to the following torque values:

Note: Use a flat washer between the front support and the lock-washer when assembling the compressor crankcase to the front support.

- a. The air compressor to support 40 to 45 ft-lbs (54 to 61 Nm).
 - b. Mounting bracket to block and air compressor 30 to 35 ft-lbs (41 to 47 Nm).
 - c. Fuel pump to air compressor support 30 to 35ft-lbs (41 to 47 Nm).
6. Install the fuel filter (if fuel pump is mounted). Coat the seal with a clean engine lubricating oil. Tighten by hand until the seal touches the filter head. Tighten an additional one-half to three-fourths turn.

Caution: Mechanical tightening will distort or crack filter head.

7. Install the water inlet and outlet tubes from the air compressor to the thermostat housing and block. Install the air supply connection to the supply tube (installed in intake manifold). Secure them with hose clamps and capscrews. Fig. 14-84.
8. Use new O-rings. Install the fuel connection to the rear of the fuel manifold, if removed.
9. Put the fuel supply tube from the solenoid on the fuel pump to the upper opening and fuel return tube assembly from the gear pump to the lower opening in the fuel connection starting tube nuts by hand. Secure with lips and tube nuts as illustrated in Fig. 14-85.

Note: When installing the fuel tubes to the connection, be sure the sealing sleeves are in position and the tubing is at the bottom in the connection before the tube nuts are tightened.

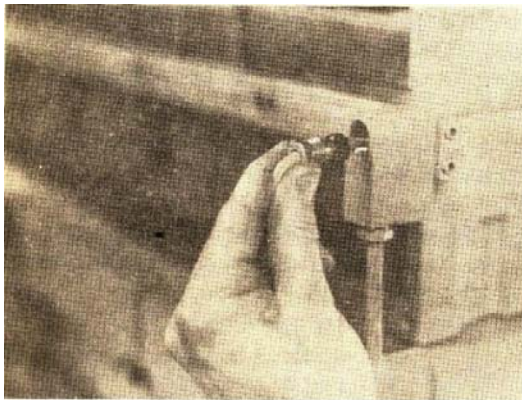


Fig. 14-85, Install the fuel tubing

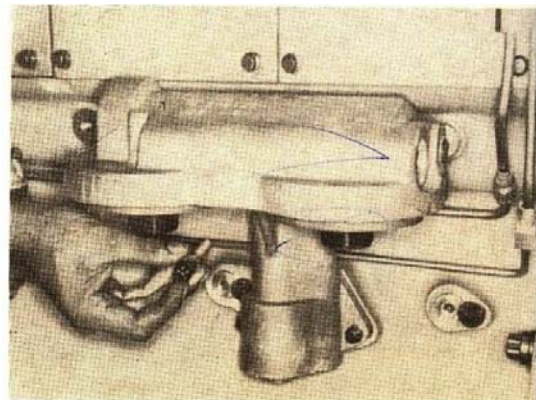
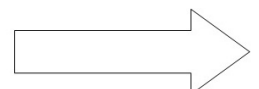
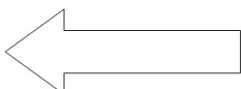


Fig. 14-86, Install the lube oil filter head

Lubricating Oil Filters:

1. Install the capscrews through the filter head. Put the gasket over the capscrews.
2. Put the filter head to the block and fingers tighten all the capscrews.



3. Starting with the inside center capscrews (Fig. 14-86) Tighten the capscrews alternately and evenly to 30 to 35 ft-lbs (41 to 47 Nm) torque.
4. Install the throw-away type filter elements (Fig. 14-87). Coat the seal with clean engine lubricating oil Tighten by hand until the seal touches the filter head and then tighten an additional one-half to three-fourths turn.

Fuel Filter Engine or Remove Mounted:

The fuel filter bracket may be mounted to the intake manifold, block, lubricating oil pan adapter or fuel pump.

1. Install the filter mounting bracket in the desired position. Secure the filter head to the mounting bracket.
2. Coat the seal with a clean engine lubricating oil. Install the element to the filter head. Tighten by hand until the seal touches the filter head, and then tighten on additional one-half to three-fourths turn.
3. Connect the fuel line between the fuel pump and fitting marked "OUT" on the fuel filter head. Secure with hose clamps.

Remove Engine From Rebuild Stand:

1. Attach the lifting arrangement and remove the engine from the rebuild stand.
2. Mount the front and rear supports to the engine remove the lifting arrangement.

Oil Gauge Bracket and Hand Hole Cover:

Install the oil gauge mounting bracket and hand hole covers-to the oil pan adapter (if remove). Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 Nm) torque. Fig. 14-88.

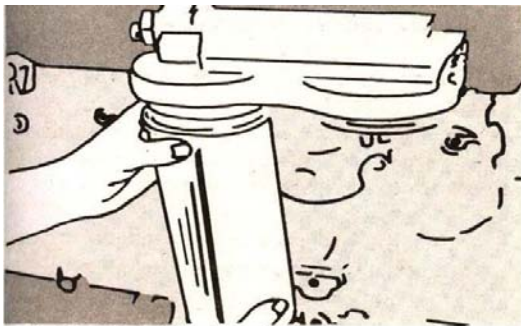


Fig. 14-87, Install the lube oil filter

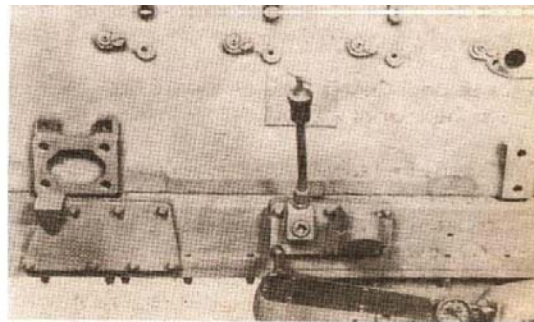


Fig. 14-88, Install the hand hole cover

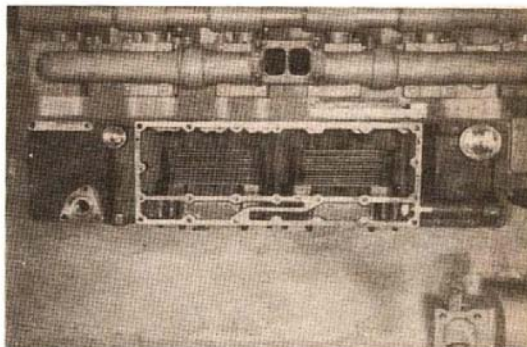
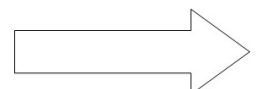
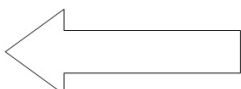


Fig. 14-89, Install the lubricating oil cooler housing



Power Steering Pump or Cover:

1. Install the power steering pump drive assembly (if used) to the rear of the gear housing. Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 Nom) torque.

Note: If a scavenger lubricating oil pump is used, the power steering pump must be mounted to and driven from front of the gear housing.

2. Install the power steering pump to the gear housing (as noted during removal). Tighten the capscrews to 65 to 75 ft-lbs (88 to 102 Nom) torque.
3. If the power steering pump is not used, install the covers as follows:
 - a. Lubricate the O-ring with a clean engine lubricating oil. Put on the rear cover. Install the rear cover and gasket to the housing. Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 Nom) torque.
 - b. Install the front cover and gasket to the gear cover. Tighten the capscrews to 65 to 75 ft-lbs (88 to 102 Nom) torque.

Scavenger Lubricating Oil pump:

The scavenger lubricating oil pump, when used, mounts to the scavenger pump opening in the oil pan adapter and is driven by the gear train through the rear of the gear housing. Tighten the capscrews securing the cooler housing to the cylinder block to 30 to 35 ft-lbs (41 to 47 Nom) torque. Fig. 14-91. See Fig. 14-90 for tightening sequence.

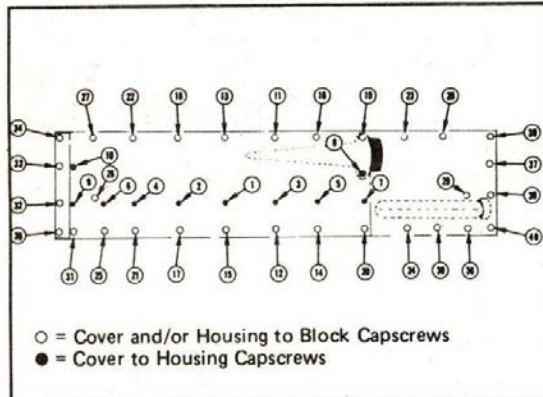


Fig. 14-90. Lubricating oil cooler and the housing torquing sequence

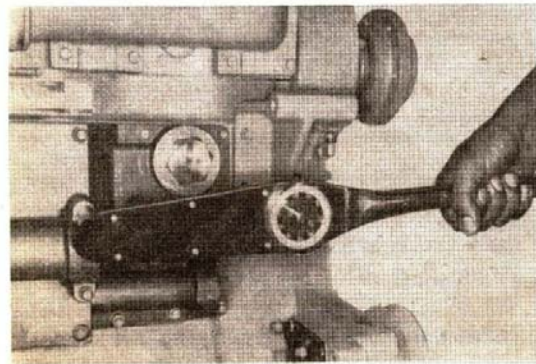


Fig. 14-91. Tighten the lubricating oil cooler to the cylinder block

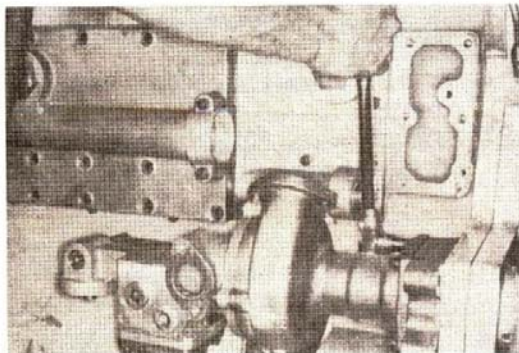


Fig. 14-92. Tighten the water pump capscrews

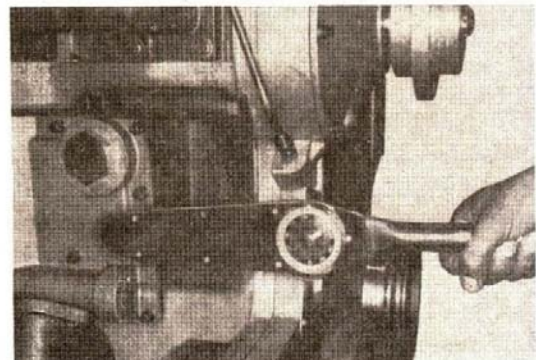


Fig. 14-93. Tighten the alternator bracket

Water Pump/Water Filter:

1. Put the water pump drive shaft into the water pump drive support.
2. Put the water pump assembly with the gasket over the drive shaft and the stud in the water pump support.
3. Install and tighten the capscrews and stud nut alternately and evenly to 30 to 35 ft-lbs (41 to 47 Nom) torque. Fig. 14-92.
4. Install the alternator mounting bracket to the block. Make sure that the tapped hole is toward the front of the engine. Tighten the capscrews to 30 to 35 ft-lbs (41 to 47 Nom) torque. Fig. 14-93.

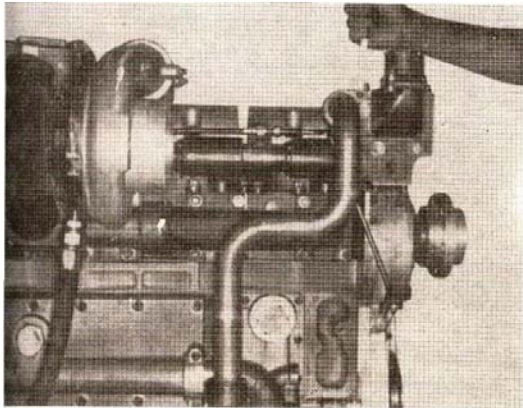


Fig. 14-94. Install the by-pass tube assembly

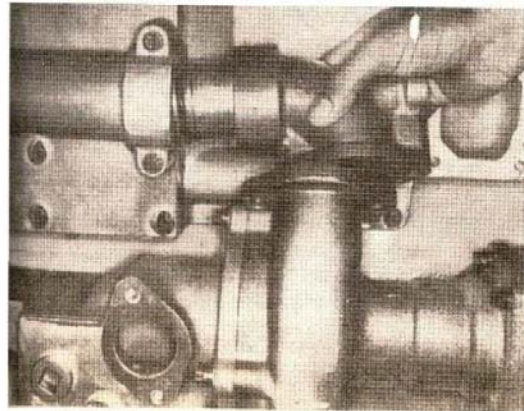


Fig. 14-95. Install the water transfer tube

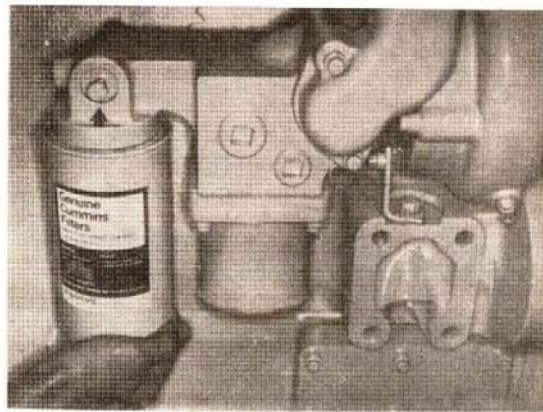
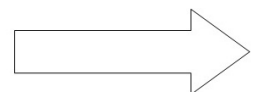
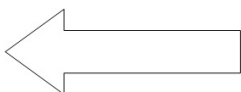


Fig. 14-96. Install the pre-charge DCA water filter

5. Use a new gasket, hose and O-ring lubricated with clean engine lubricating oil. Put the water by-pass tube to the thermostat housing and the water pump as shown in Fig. 14-94.
6. Install the capscrews. Tighten the flange to the water pump capscrews to 20 to 25 ft-lbs (27 to 34 Nom) torque. Tighten the support to the alternator mounting bracket capscrews to 30 to 35 ft. lbs (41 to 47 Nom) torque. Tighten the hose clamps.
7. Lubricate the O-rings with clean engine lubricating oil. Assemble the water transfer tube into the connector. Do not tighten the capscrew. Put the tube assembly and gasket to the lubricating oil cooler cover and water pump as shown in Fig. 14-95.
8. Tighten the capscrews to 30 to 35 ft.lbs (41 to 47 Nom) torque.



9. Install the water filter on the gear of the water pump assembly. Fig. 14-96. Coat the seal with a clean engine lubricating oil. Tighten by hand until the seal touches the sealing surface. Tighten on additional one half to three fourths turn.
10. Turn the shut-off valve on the water pump to the "ON" position.

Exhaust Manifold:

Exhaust manifold sections may be installed separately or assembled and installed as a unit.

1. Install the gaskets to the cylinder block. Use guide studs to hold the gaskets in position. The side of the gasket marked "OUT" must be installed toward the manifold.
2. Put the exhaust manifold over the guide studs. Install and tighten the capscrews in the holes not used for guide studs.
3. Remove the guide studs. Install the remaining capscrews. Tighten all capscrews alternately and evenly to 40 to 45 ft.lbs (54 to 61 Nom) torque. Fig. 14-9.

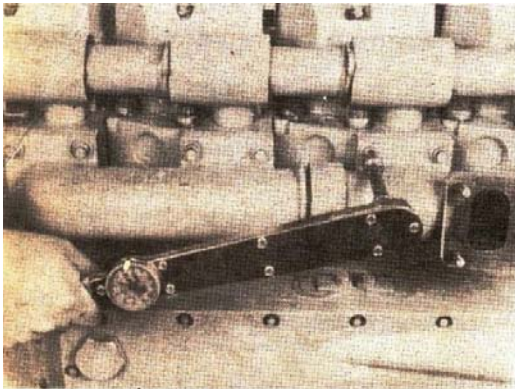


Fig. 14-97, Tighten the exhaust manifold capscrews

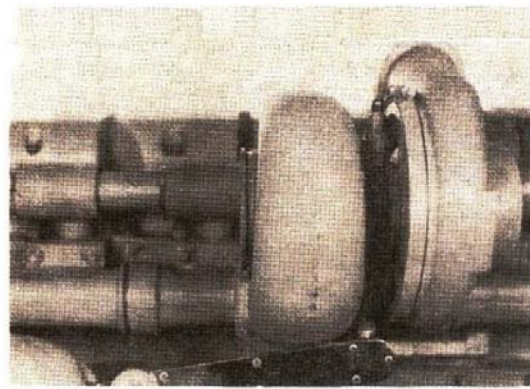


Fig. 14-99, Tighten the turbocharger locknuts

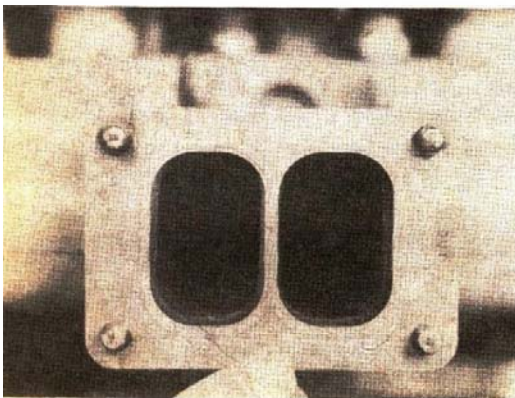


Fig. 14-98, Install the turbocharger mounting gasket

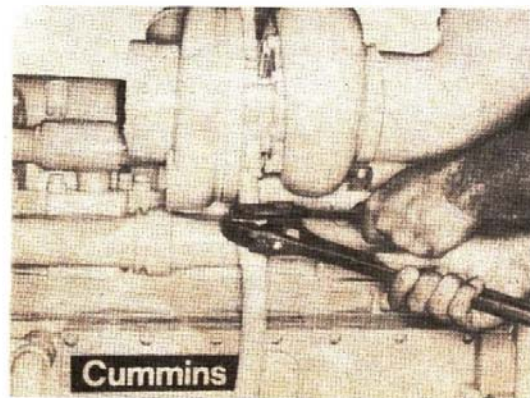
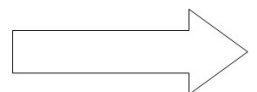
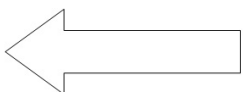


Fig. 14-100, Install the turbocharger oil drain line

Turbocharger and Air Crossover:

1. Install the turbocharger mounting studs, if removed as follows:
 - a. Coat the threads with high temperature "Thread Guard" or the equivalent.



- b. Use a stud drive or two (2) nuts and locked together to install the studs at 20 to 25 ft.lbs (27 to 34 Nom) torque until no more than one thread is showing above the gasket mating surface of the exhaust manifold.

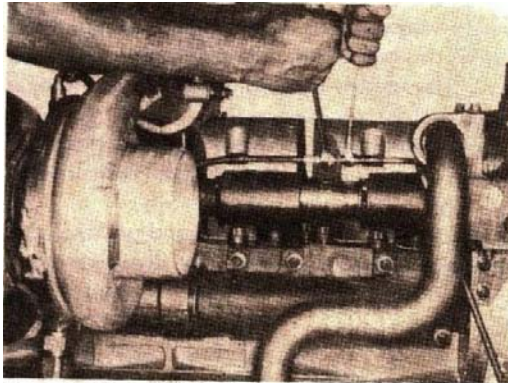


Fig. 14-101, Install the turbocharger supply line

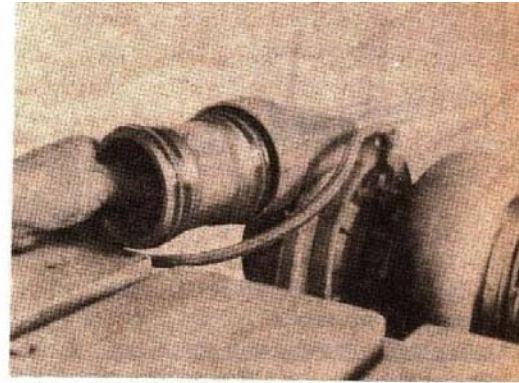


Fig. 14-102, Install the air crossover tube

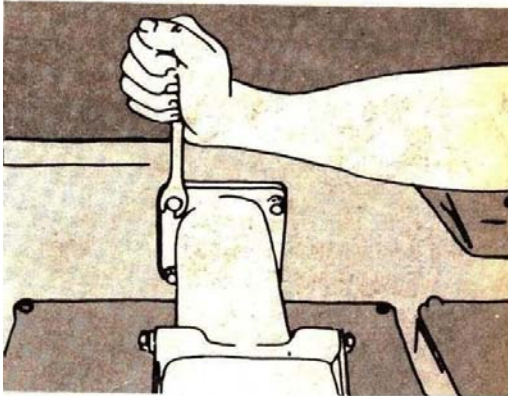


Fig. 14-103, Tighten the air crossover connection capscrews

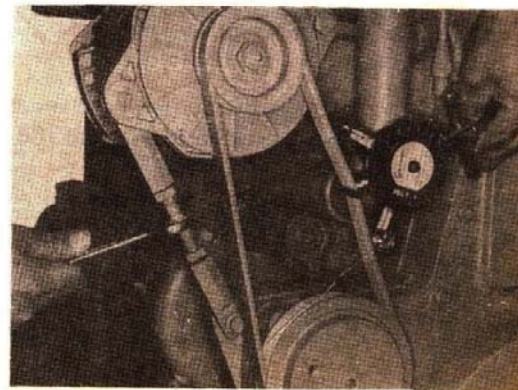


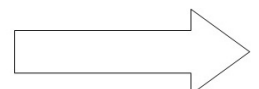
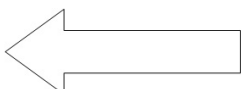
Fig. 14-104, Adjust the belt tension

2. Install the gasket over the studs. The side of the gasket marked "OUT" must be installed toward the turbocharger. Fig. 14-98.
3. Coat the stud threads with high temperature "Thread Guard" or the equivalent. "Put the turbocharger over the studs, being careful not to damage the stud threads.
4. Install the locknuts. Tighten alternately and evenly to 22 to 28 ft.lbs (30 to 38 Nom) torque. Fig. 14-99.

Note: The round part of the locknut must be toward the turbocharger flange.

5. Install the turbocharger oil drain line. The drain line must be in vertical or down position or within 30 degrees of that position. Fig. 14-100.
6. Note: The round part of the locknut must be toward the turbocharger flange.
7. Install the turbocharger oil drain line. The drain line must be in a vertical or down position or within 30 degrees of that position.

Note: If the turbocharger must be loosened to align the oil drain line, tighten the V-band nut to 40 to 60 ft.lbs (4.5 to 6.8 Nm) Tighten the turbine housing capscrews to 100 to 110 ft.lbs (11.3 to 12.4 Nm) torque.



8. Install the turbocharger supply line. Secure it with tube clips and tube nuts . Fig. 14-101.
9. Lubricate the O-rings with a clean engine lubricating oil. Put the air crossover tube into the inlet opening or turbocharger compressor housing. Fig. 14-102
10. Put the air crossover connection with the gasket over the crossover tube. Tighten the capscrews to 30 to 35 ft.lbs (41 to 47 Nom) torque. Fig. 14-103

Caution: The improper use of gaskets. (Fig. 14-98) could result in damage to the turbocharger or cause exhaust leakage.

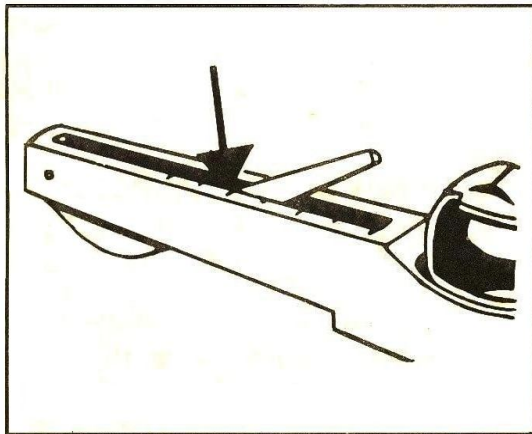


Fig. 14-105, ST- 1274 "Krikitt" Indicator reading point

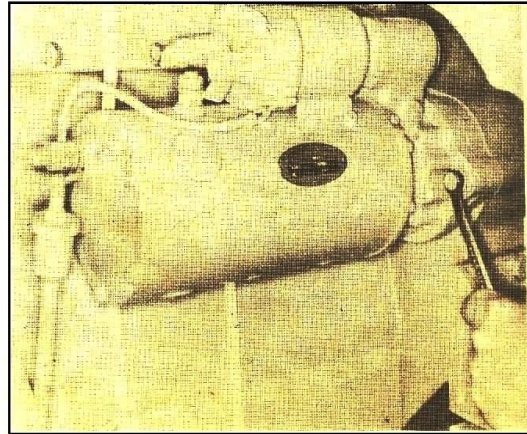
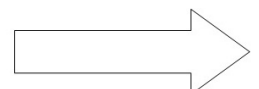
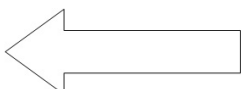


Fig. 14-106, Install the cranking motor

Alternator:

1. Put the alternator to the mounting bracket. Loosely assemble the capscrew, hardened washers and spacers, as used, through the alternator lugs and mounting bracket. Do not tighten capscrews nut.
2. Put the belt over the pulleys. Tighten the adjusting link to the alternator and water pump support.
3. Put the ST-1293 Belt Tension Gauge on the belt as shown in Fig. 14.104. Adjust the belt tension by turning in center section in the alternator adjusting link until a reading of 100 to 110 lbs is obtained on the gauge.
4. Tighten the adjusting link locknuts to 50 to 55 ft.lbs (68 to 75Nom) torque.
5. Tighten the capscrew nut on the alternator mountain bracket to 65 to 75 ft.lbs (88 to 102 Nom) torque.
6. Tighten the adjusting link to the alternator mountain bracket to 65 to 75 ft.lbs (88 to 102 Nom) and the adjusting link to the water pump support capscrew to 40 to 45 ft.lbs (54 to 61 Nom) torque. Remove the belt tension gauge

Note: When using the "Krikitt" gauge the correct belt tension reading for the belt tested must be read at the point where the top of the black indicator arm crosses the bottom numbered scale as shown in Fig. 14-105. Put the gauge in the center of the belt between two pulleys. The flange at the side of the gauge should be flat.



Cranking Motor:

1. Check the cranking motor. See that it is the same type as removed. Cranking motors are designed with different type drives and must be used with a matching flywheel ring gear.
2. If a spacer is used, put it and the gasket, if required, into the bore of the flywheel housing.
3. Put the cranking motor and gasket, if required, into the spacer or flywheel housing bore. Tighten the capscrew to 150 to 170 ft.lbs (203 to 231 Nom) torque. Fig. 14-106

Electrical Connections:

Secure the electrical connections to the mounted equipment. See "Engine Wiring Diagram" Bulletin No. 3379099..

Fan Installation:

When installing the fan to the fan hub, 3/8" (9.5mm) capscrews must have 9/16" (14.3mm) thread engagement. Fans using 1/2" (12.7mm) capscrews must have 3/4" (19.1mm) thread engagement. Check the decal on fan hub for proper capscrew length. The fan may be installed before or after dynamometer testing.

Engine Testing:

Engine break-in and testing are accomplished simultaneously. Break-in on a new or rebuilt engine is necessary because it provides an operating period during which the moving parts acquire their final finish and mating surfaces reach a full seat. Engine testing helps for adjustments as the engine breaks in and establishes a period for final adjustments for the best engine performance.

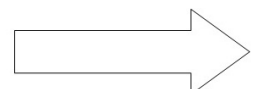
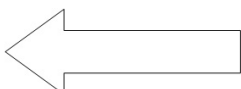
Priming the Fuel System:

1. Fill the fuel tanks and filter with clean No.2 diesel fuel oil meeting the specifications in Group 18.
2. If the injector and valve or other adjustments have been disturbed, be sure they have been properly adjusted before starting the engine.

Priming the Lubricating System:

1. Fill the crankcase to the "L" (low) mark on the dipstick. See "Lubricating Oil Specification" Group 18. Fill the by-pass filter, if used.
2. Remove the oil inlet line from the turbocharger and pre-lubricate the bearing by adding 2 to 3 oz. (60cc) of clean lubricating oil. Reconnect the oil inlet line.
3. Remove the aneroid fill plug. Fill the aneroid with clean engine lubricating oil. Replace the fill plug.

Note: A dipstick oil gauge fill plug. Fill the aneroid with clean engine lubricating oil. Replace the fill plug.



4. Remove the plug from the lubricating oil cooler housing to the prime system. Fig. 14-107.

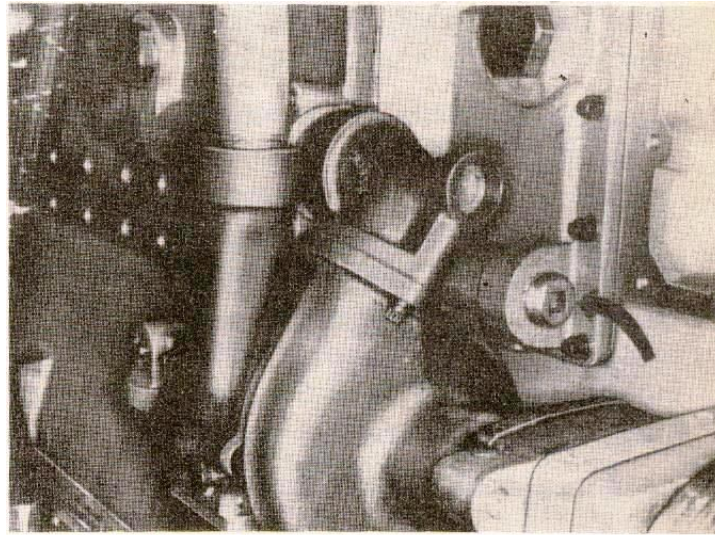


Fig. 14-107, Lubricating system priming point

Caution: Do not prime the engine lubricating system from the by-pass filter.

5. Connect a hand or motor driven priming pump line from the source of clean lubricating oil to plug the boss in the housing. Prime until a 30 psi (2.1 Kg/sqcm) (maximum pressure is obtained).
6. Crank the engine at least 15 seconds (With the fuel shut-off valve closed or disconnect to prevent starting) while maintaining external oil pressure at a minimum of 15 psi (1.1 Kg/sq cm).
7. Remove the external oil supply line and replace the plug.

Warning: Clean the area of any lubricating oil spilled while priming or filling the crankshaft.

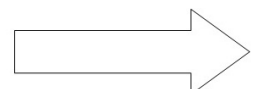
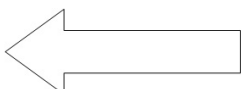
8. Finish filling the crankcase to the "H" (high) mark on the dipstick.

Fill Hydraulic Governor:

Many engines used in stationary power applications are equipped with hydraulic-governed fuel pumps. This governor uses lubricating oil (of the same weight as used in the engine) as an energy medium. The oil level in the governor sump must be at the dull mark on the dipstick, or the half way level on the inspection glass.

Fuel Pump Throttle Travel:

The most sensitive adjustment on units using a hydraulic governor is the fuel pump throttle travel. DO NOT change the idle throttle stop screw setting (front). Use a protractor or the tool shown in Fig. 14-108 or ST-1162 to set the fuel pump lever idle. Position the centerline at 55 degrees from vertical on the centerline of the fuel pump throttle shaft.



Lock the throttle lever screw. Set the centerline of the fuel pump lever in the maximum position 27 degrees from vertical, Lock the adjusting screw. Check the throttle lever centerline travel. It must be 28 degrees between idle and full throttle.

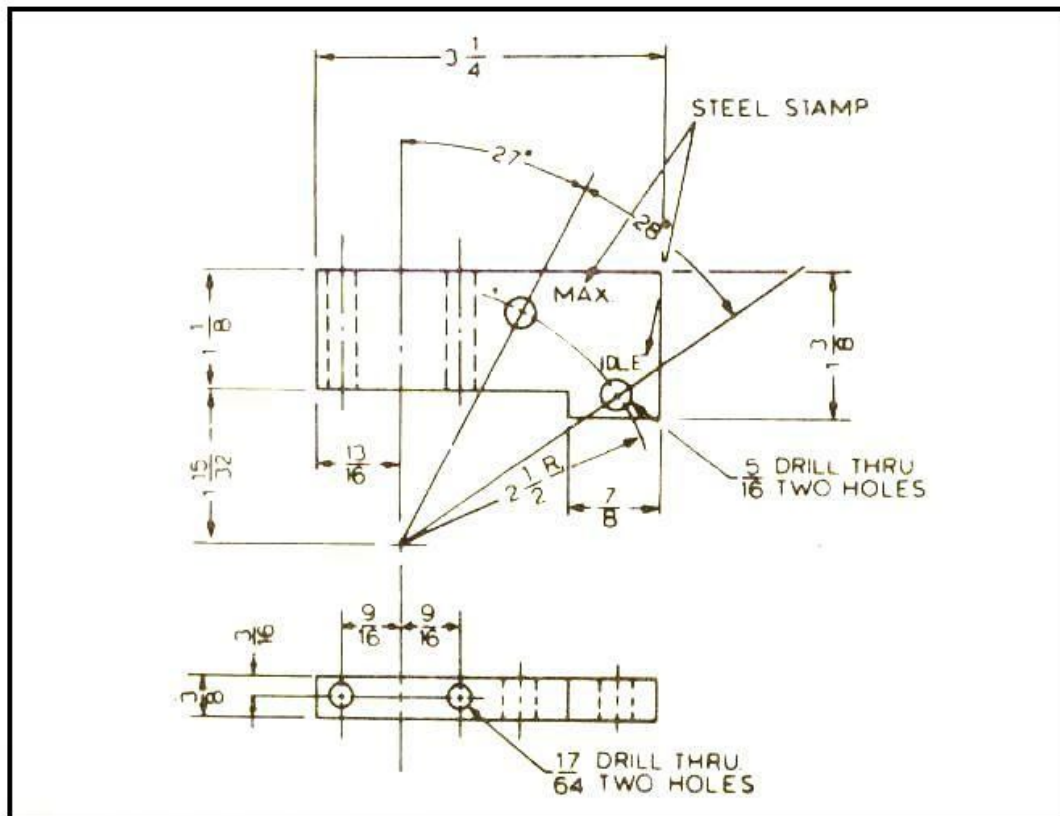


Fig. 14-108, Fuel pump throttle adjustment template

For the PT Fuel pump calibration and speed setting refer the "PT Fuel Pump Manual", Bulletin No. 3379068.

Governor Shaft and Linkage Adjustment:

1. The Governor-to-fuel-pump linkage must be connected with both the fuel pump throttle and governor terminal shaft levers in the fuel shut-off or idle position. The fuel pump throttle lever will be all the way down against the stop (full clockwise). The governor terminal shaft away from the engine will be in the extreme clockwise position.
2. Adjust the control linkage to a length (9-3/4 to 10 inches (247.65 to 254mm) which will permit the installation of unibals in the levers without any movement of levers.

Caution: For correct operation of the fuel pump, make sure linkage and levers are not binding.

3. Start the engine.
4. Adjust the low-speed stop screw (on top of governor head) for the desired idling speed, normal maximum 600 rpm.

Speed Droop Adjustment:

1. Remove the top cover from the governor to expose the speed droop mechanism and adjustments.
2. The speed droop bracket is clamped to the terminal lever by the slotted hexagonal head screw. When loosened, it can be moved to the front or rear. Moving the bracket to the rear produces more speed droop.
3. This speed droop lever movement thus produces a speed setting which is a function of the terminal shaft position with speed decreasing as the fuel flow increases. This is speed droop.
4. Speed droop is increased by moving the bracket to the rear and is reduced to approximately zero when the pivot pin is all the way forward. Since there is no calibration for the droop adjustment, the zero droop position may be precisely set only by trial and error on the engine or by use of a dial indicator on the speed droop lever during manual rotation of the terminal shaft.
5. Speed droop is required when using the SG Woodward Governors. It must be set by operation on the engine. The speed droop bracket is adjusted to obtain the desired speed droop between full load and no load.

Engine Dynamometer:

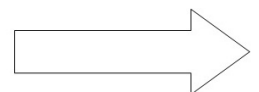
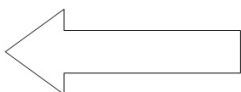
Check dynamometer capacity, make sure the capacity is sufficient to allow testing at 96 to 100 percent maximum engine horsepower. If the capacity is insufficient, testing procedures must be modified to prevent damage to dynamometer.

Installation of Engine:

1. Place the engine on the dynamometer test stand. Secure the engine mounting pads to the engine support risers.
2. Put the dynamometer drive shaft flange to the engine flywheel. Follow the manufacturer's instructions for proper alignment.
3. Connect the water supply and return the hose to the water cooling arrangement.
4. Attach the ST-1190 Fuel Consumption Measuring Device to the engine.
5. Disconnect the aneroid control fuel pressure and return lines. Plug the openings. The aneroid is reconnected just after the "power check" is made.
6. Connect the throttle linkage instruments, exhaust piping and air intake piping to the engine.
7. Install the 3375150 Blow-By checking Tool in the crankcase breather opening. Use the water manometer and fill to "O" mark at the middle of the scale. Close all openings that would allow blow-by pressure to escape.
8. Start the engine: see "Starting Procedure" Open the coolant supply to the engine water connection. Introduce the water to the dynamometer following the manufacturer's instructions. Check the tubing, hose, lines, fittings and plugs for leaks. Correct as necessary. See "Check Turbocharger Oil Flow" following.
9. For the engine run-in, see "Test Procedure".

Check Turbocharger Oil Flow:

1. Disconnect the turbocharger oil drain line.
2. Start the engine and maintain rpm at low idle.



3. Observe the oil drain, Oil should flow in 10 to 15 seconds. If no oil flows in 30 seconds, shut the engine off and correct the fault.
4. Connect the oil drain line when the flow is established.

Normal Starting Procedure without Cold-Starting Aid:

- ❖ Set the throttle for idle speed. Open the manual fuel shutoff valve, if used. Electric fuel shutoff valves operate automatically.

Note: The manual override knob provided on the forward end of the electric shutoff valve allows the valve to be opened in case of electric power failure or if power is not available during testing. To use, open by turning clockwise.

- ❖ Press the starter button or turn the switch key to the “Start” position.

Caution: Do not crank the engine continuously for more than 30 seconds. If the engine does not fire, wait two to five minutes before repeating to avoid cranking motor damage.

Test Procedure for Horsepower Ratings:

1. The maximum horsepower ratings at rpm shown in Table 14-8, “Dynamometer Test Chart”, are for engines operating at No.1 Curve or intermittent-duty applications at sea level, 60°F (16°C) intake air temperature and 29.92 inch (760.0mm) Hg (Mercury) barometric pressure.
2. Where it is necessary to derate because of high altitude operation, the derating may be done by reducing maximum governed rpm or maximum fuel rate.
3. Turbocharged engines do not require fuel derating below maximum altitudes shown in the “Dynamometer Test Chart”. Above maximum altitudes, derate at 4 percent from each 1000 ft (304.8m) additional altitude.
4. New or newly rebuilt engines during dynamometer tests are not required to deliver more than 96 percent of maximum horsepower at power checks.

Break in Run Initial Starting:

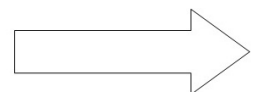
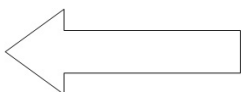
Start the engine and idle at approximately 800 rpm no load for five to ten minutes. Check the oil pressure and water circulation; look for leaks..

At Each Phase:

1. Apply dynamometer load to (+ 10%) horsepower at (+ 5%) speed shown in Table 14-8, “Dynamometer Chart”.
2. Check the crankcase pressure (b low-by) with 3375150. IF the pressure continues to drop, reduce run-in time by half; otherwise, run the engine for the time period shown in the dynamometer chart.

At Phase 1:

1. Run the engine until normal oil operating temperature has been obtained.
2. Add the lubricating oil to bring level up to “H” mark on dipstick; allow the oil temperature to stabilize.



At Phase 2:

Set the engine idle governed speed and fuel rate. Refer to Bulletin No. 3379068.

At Phase 3:

At the blow-by rises, reduce load to preceding phase and run for 30 minutes; then return to original phase specifications.

At Phase 4:

1. Run at speed and horsepower indicated.
2. Check for leaks and tighten all exposed capscrews.
3. Recheck valves and injectors. Use "Hot Setting". Refer to Tables 14-6 and 14-7.

Note: Readjustment after 1 hour operation is necessary to assure lowest smoke potential and avoid excessive injector train loads.

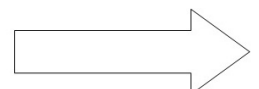
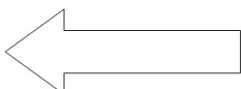
Power Check:

1. Run the engine at rated speed for 5 minutes. It should develop 96 percent of rated horsepower at standard fuel rate. Check the crankcase pressure (blow-by). If the pressure exceeds value shown in Table 14-8, reduce the engine speed and load to preceding phase; run engine 30 to 45 minutes.
2. Repeat the procedure described above until the engine develops 96 percent rated horsepower at standard fuel rate within permissible crankcase pressure limit.
3. Reconnect aneroid after the power check is completed.

Table 14-8:Dynamometer Test Chart							
Engine Model	HP @ RPM	Rated HP @ RPM 500 ft. Altitude	Fuel Rate Lb./Hr.	Air manifold Pressure In./Hg.	Altitude Max. HP Alt.	Turbo	Crankcase Pressure with 3375150
KT-1150	450@2100	450@2100	160/167	32/38	12,000	T-18A	12
Phase 1 To Temperature HP @ RPM		Phase 2 15 Min HP @ RPM	Phase 3 15Min HP @ RPM	Phase 4 15 Min HP @ RPM	Power Check5 Min HP @ RPM	Torqu e Ft./Lb . See level	Torque Ft./Lb. 500 Ft. Altitude
225 @ 1575		338@2100	338@2100	405@2100	432 @2100	1300	1300

Notes:

1. Turbocharged engines do not require fuel derating below altitude shown in column entitled "Rating @ Altitude Maximum". Above maximum altitude, derate at each 1000 Ft (304.8m) additional altitude by 4%.
2. Crankcase pressure with 3375150 is given in inches of water.
3. See Bulletin No. 3379068for Rated HP @ RPM and fuel rate for derated engines not listed above.



Check during Run-in Test:

During the period of engine run-in, the following checks should be made frequently.

Lubricating Oil

1. Lubricating oil pressure should remain at or near a constant figure at constant engine speed and load (Use Table 14-9) after normal operating temperature has been reached. Abnormally high pressure may indicate blocked lubricating oil lines. Abnormally low pressures indicate on insufficient supply of lubricating oil clearances which may be due to bearing failure.
2. If the oil temperature rises sharply above 225°F (107°C), shut down the engine and correct as necessary.
3. Now lubricating oil filter elements will absorb oil, therefore, engine must be shut down after five or ten minutes of operation add additional oil added to bring oil level to "H" mark on dipstick. Check oil level every phase during run-in test.

Table 14-9: Normal Lubricating Oil Pressure

Idle PSI (Kg/sq.cm)	Rated speed PSI (Kg/sq cm)
15(1.1)	45/70 (3.2/4.9)

Note: Individual engines may vary from above pressures.

Engine Coolant:

After the engine is started, add coolant as necessary to completely fill cooling system and replace entrapped air. Coolant should not exceed 200°F (93°C) or drop below 160°F (71°C) during engine operation. Do not turn the engine off immediately after a load run. Heat stores in the iron masses will boil coolant in the jackets if air and coolant circulation is immediately stopped while engine is hot. Allow the engine to idle for a few minutes before shutting down.

Fuel Pressures:

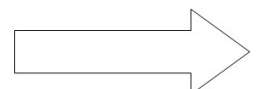
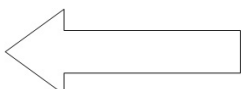
For Fuel pressure reading and adjustment, refer to Bulletin No. 3379068 and 3379182.

Over-speed Stop:

Over speed stops, when used are set to trip and shut off fuel supply when engine exceeds maximum rated speed by approximately 15 percent. After determining and correcting the cause of over speed stop trip, reset in the running position.

Blow-by Readings:

1. Manometer reading must be taken frequently during run-in test so mechanic will not any blow by increase at given speed any road. If there is any indication of blow by increase, engine speed must be reduced for a few minutes and then brought back to the original settings.
2. During each power check, keep a constant check on the manometer; if pressure rises, more run-in is required. Representative pressure limits for engine running at



governed speed and pulling 96 to 100 percent of rated horsepower are given in Table 14-8.

3. If a pressure is greater than values listed at end of testing period, operate 30 minutes extra at 96 to 100 percent rated load and rpm. If there is no rapid change in excess of 2 inches (50.8mm) of water and reading does not exceed 100 percent of representative pressure, blow-by acceptable.

Note: Manometer readings not exceeding 0.3 inch (7.62mm) surge are desirable.

Chassis Dynamometer Tests:

If the engine is installed in equipment, it may be tested on a chassis dynamometer as follows:

1. Check instruments; follow manufacturer's instructions.
2. Perform all phases of engine dynamometer break-in-run. See Table 14-8.

Maintenance of Dynamometer:

Follow manufacturer's maintenance instructions to service the dynamometer.

Calibrating Instruments:

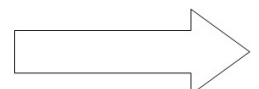
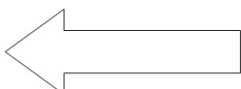
Keep beam or spring scales properly calibrated. Follow manufacturer's recommendation when recalibrating or instrument adjusting is necessary.

In-Chassis Run-in:

In chassis repaired engines should receive run in equivalent to that on an engine dynamometer.

Follow procedure given below after an in-chassis repair or rebuild.

1. Start the engine. Idle at 800 to 100 rpm, no load, for 5 to 10 minutes. Check the oil pressure and the water circulation. Correct any leaks.
2. Operate at 1/4 to 1/2 throttle for first 5 to 10 hours.
3. Operate at 1/2 to 2/3 throttle for first 45 to 50 hours.
4. After 50 hours of operation, do not operate engine at full load and speed in excess of 5 minutes continuously at any time. After 5 minutes full power run, drop back to 3/4 throttle.
5. During the first 100 hours service:
 - a. Do not idle engine for long periods.
 - b. Watch instruments closely. Decrease engine rpm if oil temperature reaches 250°F (121°C) or if the coolant temperature exceeds 190°F (88°C).
 - c. Operate with a power requirement low enough to allow the acceleration to governed speed under any condition.
6. Check the exhaust restrictions (Back pressure) as follow:



- a. Using a mercury or water manometer, take reading when engine is developing maximum horsepower at maximum engine speed.
- b. Maximum permissible back-pressure is 3.0 inch (76.2mm) Hg 40.74 inches (103.48cm) of water.

Engine Painting:

1. Prior to painting, clean the surface for maximum paint adherence. Dry with compressed air.
2. Cover all openings, pulley grooves, instrument faces and belts. Cover all data plates. Exposed threads, wire terminals, hose fittings and pipe openings with water proof paper or tape.
3. Cover the clutch contact surface on the flywheel with anti-rust compound, if the engine is not going into immediate service.
4. Spray the outside surface of the castings and corrodible parts with a primer coat of lacquer to serve as a base for the second coat of engine enamel.

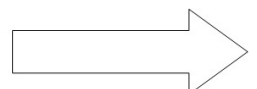
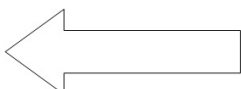
Storage of Engine:

On any engine not in service, the unpainted machined surfaces are subject to rust and corrosion. The rate of corrosion varies with climatic conditions. An engine stores in a climate with a high amount of moisture in the air will corrode more rapidly than an engine stores in a dry climate.

Temporary Storage:

If an engine remains out of service for three or four weeks (maximum Six months) special precautions should be taken to prevent rust. The operations listed below are required to minimize or prevent damage to temporarily stored engines.

1. The engine must be started and operated until thoroughly warm. Disconnect the fuel lines to the engine fuel filter and injector drain line. Fill two containers, one with diesel fuel and a second with preservative oil.
2. Start the engine with fuel line to the filter using diesel fuel. The injector drain can flow into the container with diesel fuel. After the engine is running smoothly, switch the fuel line to the container with preservative oil. Stop the engine and reconnect at the fuel lines.
3. Drain the oil sump, fuel filters and fuel tank and reinstall the drain plugs. The sump may remain empty until the engine is ready for use. Tag the engine with a warning tag.
4. Disconnect the electrical wiring and turn the fuel pump manual shutoff valve fully counterclockwise to "Off". Spray lubricating oil into the intake manifold and air compressor while cranking the engine slowly.
5. Cover all openings with tap to prevent the entrance of dirt and moisture.
6. Drain the coolant from the cooling system unless it is permanent type antifreeze with a rust inhibitor added.
7. Store the engine in a dry and uniform temperature area.
8. Bar the engine crankshaft two or three revolutions each three to four weeks.

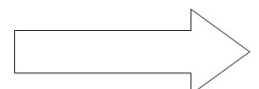
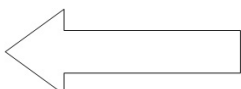


Long Term Storage:

1. When the engine is to be stored six months or more, the lubricating system, cooling system, fuel system, crankcase and external parts must be protected against rust and corrosion.
2. Start the engine and operate at fast idle until the engine is thoroughly warm. Stop the engine and drain the oil.
3. Fill the crankcase to full mark on bayonet gauge or dipstick with preservative oil, U.S. Military specification MIL-L-21260, Type P-10, Grade 2SAE 30. This specification may be obtained as shell-brand Code 66202, or equivalent.
4. Disconnect the fuel lines to the engine fuel filter and injector drain line. Fill two containers, one with diesel fuel and a second with preservative oil U.S. Military Specification MIL-L-644 Type P9. Preservative oil to this specification is Daubert Chemical Co., Nox-Rust No. 518 or equivalent. The Daubert Chemical address is 2000 Spring Road, Oakville, Illinois.
5. Start the engine with the fuel line to the filter using diesel fuel. The injector drain line can flow into the container with diesel fuel. After the engine is running smoothly, switch the fuel line to container with the preservative oil. Operate five to ten minutes on the preservative oil. Stop the engine and reconnect the fuel lines.
6. Drain the oil sumps of pumps, compressors, coolers, filters and crankcase, etc. Replace oil plugs after draining.
7. Remove the intake and exhaust manifolds. Spray all intake and exhaust ports, including air compressor intake port, with preservative oil. Replace the intake and exhaust manifolds.
8. Inspect the cooling system. If the coolant is contaminated, drain and flush. Fill with rust preventive compound.
9. If an air starter is used, remove the exhaust plate. Spray with preservative oil and replace the plate. Loosen the belt tension.
10. Brush or spray a film of rust preventative compound on all exposed, unpainted surface of the engine. Use a rust preventive conforming to Type P-2, Grade 1 or 2, U.S. Military Specification MIL-C-16173C. Remove the cylinder head covers and spray the rocker levers, valve stems, springs, guides, crossheads and push rods. Replace the cover.
11. Cover all engine openings with heavy paper and tape. Tag the engine to indicate that it has been treated with preservatives and crankshaft should not be barred over. The tag should show the coolant has been removed, the date of the treatment and that engine is not ready to run.
12. Store the engine in an area where the air is dry and the temperature is uniform.

Note: Engines in storage more than 24 months should be flushed out with a suitable solvent or light, hot oil and then be reprocessed with rust preventative materials. Periodically inspect engines for rust or corrosion. Take corrective action if necessary.

13. Although the preservative materials may be added to and used for the same purpose repeatedly, they must be kept clean. The accumulated deposits should be removed after being allowed to settle.



Preparing a Stored Engine for Service:

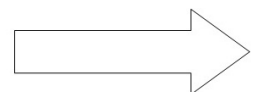
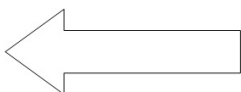
When an engine is removed from storage and put into service, the following operations should be performed.

Clean The Engine:

- ❖ Clean the accumulated dirt from the exterior of the engine. Remove covers, tape and wrappings.
- ❖ Use a suitable cleaner to remove the rust preventive compound from unpainted surfaces.
- ❖ Refill the crankcase with clean lubricating oil. Flush and fill the cooling system.

Inspection:

1. When an engine has been stored for six months or less, it is necessary to adjust the injectors, valves and belt, tighten the cylinder head capscrews and connections, replace the filters and check the air filter and screens.
2. When an engine has been stored for six months or more, the following procedure should be followed:
 - a. Flush the fuel system with clean fuel oil until all preservative oil is removed.
 - b. Remove the plug from oil gallery and force hot, light mineral oil through the oil passages to flush away all preservative oil. Bar over the engine crankshaft three or four revolutions during the flushing operation.
 - c. Replace oil filters and clean all screens before the engine is started.
 - d. After inspecting the engine and parts, make sure that all preservative oil and gummed oil has been flushed away. Start the engine as described in "Engine Testing".



(N) Instruments and Controls

Instruments and gauges show at all times how to get the most satisfactory service from an engine. Safety controls are used on Cummins Engines to shut down the engine because of high coolant temperature, low or loss of lubricating oil pressure and engine speeds above rated rpm.

Tachometer:

Rated engine speed is the rpm attained at full load. Governed engine speed is the highest rpm a properly adjusted governor will allow the engine to turn at no load. Governed engine speed must never be exceeded on down grades or any other condition in which the load drives the engine.

Operate at partial throttle in continuous-duty situations to give required torque with the tachometer showing rpm approximately 15 percent below governed speed.

Oil Temperature Gauge:

The oil temperature gauge normally should read between 180°F (82°C) for best lubrication. Any sudden increase in oil temperature which is not caused by load increase is a warning of possible mechanical failure and should be investigated at once.

Water Temperature Gauge:

A water temperature of 165° to 190° (74° to 88°C) is the best assurance that cylinder liners are heated to the proper temperature to support good combustion and that the working parts of the engine have expanded evenly to the most favorable oil clearances.

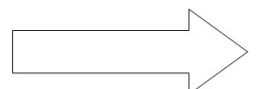
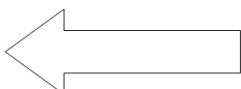
Overheating problems require mechanical correction. It may be caused by a clogged cooling system or heat exchanger, or insufficient radiator capacity. 200°F (93°C) maximum engine coolant temperature should not be exceeded coolant safety (High water temp. trip) range 92°C to 94.5°C.

Oil Pressure Gauge:

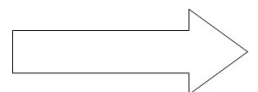
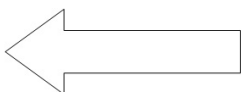
The oil pressure gauge indicates any drop in lubricating oil supply or mechanical malfunction in the lubricating oil system. Individual engines may vary from normal pressures. Observe and record pressures when engine is new to serve as a guide for indication of progressive engine condition.

Safety Controls:

The safety control system provides protection from low lubricating oil pressure and excessively high coolant temperature of preset values. When either is exceeded, the controls disrupt the electrical circuit to the fuel solenoid shutoff valve and shuts off the engine. The oil pressure valve and shuts off the engine. The oil pressure safety controls is mounted directly in the main oil gallery. The temperature safety control mounts directly into the water manifold.



During the cranking of engine, a permissive start switch is used to bypass the low lubricating oil pressure safety control. Actual cranking is accomplished by use of a push button starting switch wired into the cranking circuit See. "Wiring Diagram" Bulletin No. SPT 3242338-00 & SPT 3242445.00.



(O) Mounting Adaptations

The mounting adaptations group consists of the flywheel and flywheel housing.

Flywheel and Ring Gear

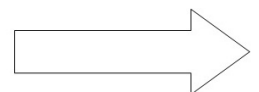
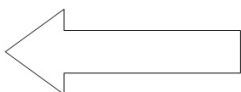
Replacement of Flywheel Ring Gears

Inspection and Removal

1. Inspect the ring gear for broken or cracked teeth.
2. If replacement is necessary, drive the gear from the flywheel with a blunt chisel.

Replacement of Flywheel Ring Gears

1. If an over with a heat control is not available heat the gear with a heating torch not a cutting torch-from the inside diameter so that the heat travels outward to the teeth.
2. Use a 600°F (316°C) Tempilstick crayon or equivalent to determine the amount of heat applied. Stroke the gear several times while applying heat. The crayon will leave a chalk mark until temperature is reached and then will leave a liquid smear. Overheating will soften the gear.
3. Place the ring gear on the flywheel and quickly drive on unit it is firmly seated.
4. No attempt should be made to re-machine flywheels in a shop that is not equipped to maintain factory standards both as to dimensions and static balance. The static balance tolerance of flywheels is 2 inch oz. (144 g cm) maximum. Never reface the flywheel beyond the point where clutch face is less than 5/8 inch (15.88mm) thick.



(P) Wear Limits, Specifications and Torque.

Worn limits as stated in this manual indicate that the part may be reused if it is at the worn limit. Discard only if it exceeds the worn limit. All engine models are the same unless otherwise stated. Limits are given in U.S. and Metric measurements. All Metric units are enclosed in brackets [].

Measurement - Inch [mm]	Useable Limit		New Minimum		New Maximum	
Cylinder Block						
Camshaft Bushing Bore in Cylinder Block			3.2535	[82.639]	3.2545	[82.664]
Camshaft Bushing Inside Diameter (Installed)	3.0035	[76.289]	3.000	[76.200]	3.002	[76.251]
Camshaft Thrust Bearing Thickness (Standard)	0.359	[9.119]	0.368	[9.437]	0.372	[9.449]
Camshaft End Clearance			0.006	[0.153]	0.013	[0.330]
Main Bearing Bore	5.8465	[148.501]	5.845	[148.463]	5.846	[148.488]
Main Bearing Cap Press Fit in Cylinder Block	0.000	[0.000]	+0.002	[0.051]	+0.005	[0.127]
Cylinder Block Height						
From Main Bearing Centerline	18.994	[482.448]	18.994	[482.448]	19.006	[482.753]
From Top of Main Bearing Bore	16.071	[408.203]	16.081	[408.457]	16.084	[408.534]

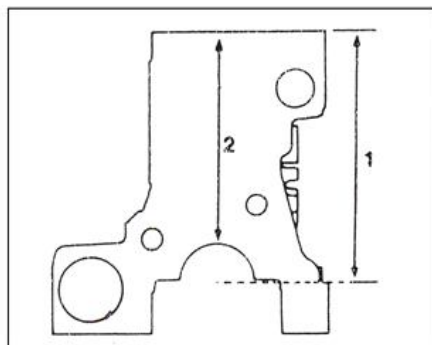


Fig. 1, Cylinder Block Height

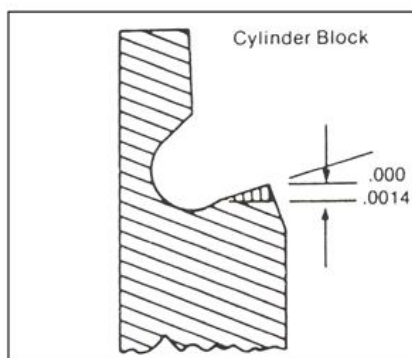
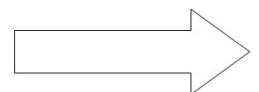
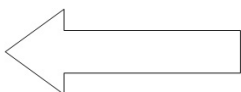


Fig. 2, Upper Counterbore Ledge Cupping

Measurement - Inch [mm]	Useable Limit		New Minimum		New Maximum	
Cylinder Block (Cont'd.)						
Cylinder Block Resurfacing Limits						
W/Standard Cylinder Head Gasket						
From Centerline of Bore	18.984	[482.194]	18.994	[482.448]	18.996	[482.498]
From Top of Bore	16.061	[407.949]	16.071	[408.203]	16.074	[408.280]
W/Oversize Cylinder Head Gasket						
From Centerline of Bore	18.964	[481.686]	18.974	[481.940]	18.976	[481.990]
From Top of Bore	16.041	[407.441]	16.051	[407.695]	16.054	[407.772]
Cylinder Block Deck Surface						
Finish Micro-Inch [Micro-m]					125	[3.2]
Note : The cylinder block deck flatness must be within 0.002 in. [0.05 mm] over the length of the block.						
Surface waviness—Must not exceed 0.0007 in. [0.018 mm] depth. The distance between the high and low points of the waves must not be closer than 1.000 in. [254 mm].						
Cylinder Block Lower Bore Diameter			7.090	[180.08]	7.092	[180.14]
(Packing Ring Bore)						
Upper Counterbore to Lower					0.005	[0.127]
Bore Concentricity						
(Total Indicator Reading)						
Upper Counterbore Diametrical Run Out					0.001	[0.254]
Upper Counterbore Ledge Cupping	0.0014	[0.0356]				

Measurement - Inch [mm]	Useable Limit		New Minimum		New Maximum	
Cylinder Block (Cont'd.)						
Cylinder Liner Protrusion			0.003	[0.76]	0.006	[0.152]
Cylinder Liner Press Fit						
Upper Counterbore			—0.001	[—0.025]	0.003	[0.076]
Lower Counterbore (See Fig. 3)			0.001	[0.025]	0.004	[0.102]
Cylinder Liner Inside Diameter (Installed)	6.255	[158.877]	6.2495	[158.737]	6.251	[158.775]
Note : New cylinder liners dimensions at 60 to 70°F [16 to 21°C]; may be 0.0002 to 0.0006 in. [0.005 to 0.015 mm] smaller than indicated due to lubrite coating.						
Cylinder Liner Out of Round						
Top One Inch of Bore					0.003	[0.076]
Lower Packing Area					0.002	[0.050]
(Total Indicator Reading)						
Cylinder Liner to Block Clearance (In Packing Area) W/O Seals			0.002	[0.05]	0.006	[0.15]
Cylinder Liner Shim Thickness & Part Number						
3014226	0.007	[0.178]				
3014227	0.008	[0.203]				
3014228	0.009	[0.229]				
3014229	0.020	[0.508]				
3014230	0.031	[0.787]				



Cylinder Liner Counterbore

The following Tables show the progression of cylinder blocks and cylinder liners. Check the serial number of your cylinder block against the Tables to find the correct cylinder block and liner combination. The tables also give instructions for machining the cylinder block for oversize cylinder liners.

Use the Part No. ST-1168 Liner Counterbore Tool and the Part No. 3375820 Liner Counterbore Salvage Tool to machine the cylinder block for oversize cylinder liners. Use the following parts from the 3375820 Tool :

3376189 Depth Spacer
3375821 Cutter Plate
3375822 Cutter

Cylinder Block with Thick Flange Cylinder Liners

Liner shim part numbers and thickness in. [mm]

Engine serial number range	3014226	0.007 [0.18]
31121670 to present	3014227	0.008 [0.20]
	3014228	0.009 [0.23]
Cylinder Block Part No. 3028130	3014229	0.020 [0.51]
Service Block Part No. 3028439	3014230	0.031 [0.79]

Dimensions—Inch [mm]

A	Cylinder Block Upper Counterbore Inside Diameter	Std	7.408 to 7.410 [188.163 to 188.214]
		0.020 [0.51] OS	7.428 to 7.430 [188.671 to 188.722]
		0.040 [1.01] OS	7.448 to 7.450 [189.179 to 189.23]
		0.060 [1.52] OS	7.468 to 7.470 [189.687 to 189.738]
		0.083 [2.10] OS	7.491 to 7.493 [190.271 to 190.322]
		0.095 [2.42] OS	7.503 to 7.505 [190.576 to 190.627]

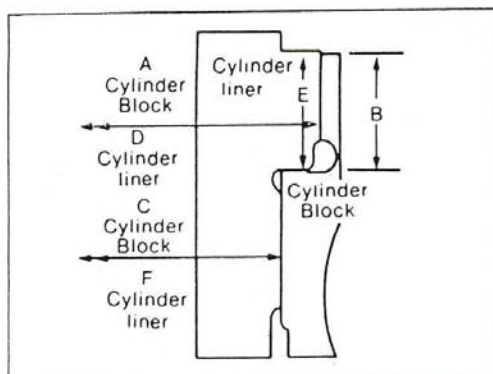


Fig. 3, Cross section of production cylinder block and liner-thick flange

Dimensions—Inch [mm] (Cont'd.)		
B	Cylinder Block Upper Counterbore Depth	0.521 to 0.523 [13.233 to 13.284]
C	Cylinder Block Lower Counterbore Inside Diameter	7.090 to 7.092 [180.086 to 180.136]
D	Cylinder Liner Flange Outside Diameter	Std. 7.409 to 7.411 [188.188 to 188.239]
		0.020 [0.51] OS 7.429 to 7.431 [188.696 to 188.747]
		0.040 [1.01] OS 7.449 to 7.451 [180.204 to 189.255]
		0.060 [1.52] OS 7.469 to 7.471 [189.713 to 189.763]
		0.083 [2.10] OS 7.492 to 7.494 [190.296 to 190.347]
		0.095 [2.41] OS 7.504 to 7.506 [190.601 to 190.652]
E	Cylinder Liner Flange Thickness	0.526 to 0.527 [13.360 to 13.385]
F	Cylinder Liner Lower Outside Diameter	7.093 to 7.095 [180.162 to 180.213]

Service upfit of cylinder blocks for thin flange cylinder liners to use thick flange cylinder liners.

Engine serial number range 31103629 to 31121669

Cylinder block Part Nos. 3005860 or 3001700

Note : These part numbers are now obsolete.

Service block, Part No. 3011409 (Obsolete).

Use the Part No. ST-1168 Liner Counterbore Tool and the Part No. 3375820 Liner Counterbore Salvage Tool to machine the cylinder block for oversize cylinder liners. Use the following parts from the 3375820 tool :

3375821 Cutter Plate
3376187 Cutter
3376189 Depth Spacer

Liner shim part numbers and thickness in. [mm]

3014226 0.007 [0.18]
3014227 0.008 [0.20]
3014228 0.009 [0.23]
3014229 0.020 [0.51]
3014230 0.031 [0.79]

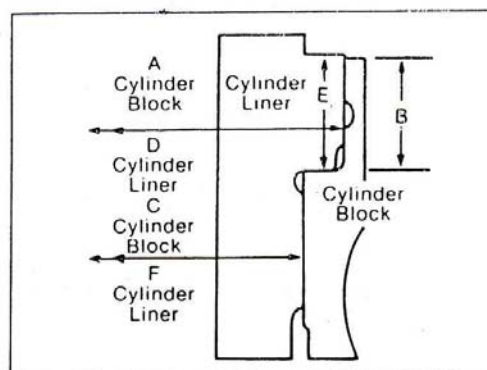


Fig. 4, Cross section of service cylinder block and liner-flange

Dimensions—Inch [mm] (Cont'd.)			
A	Cylinder Block Upper Counterbore Inside Diameter	0.069 [1.75] OS	7.468 to 7.470 [189.687 to 189.738]
		0.092 [2.34] OS	7.491 to 7.493 [190.271 to 190.322]
		0.104 [2.64] OS	7.503 to 7.505 [190.576 to 190.627]
B	Cylinder Block Upper Counterbore Depth		0.521 to 0.523 [13.233 to 13.289]
C	Cylinder Block Counterbore Inside Diameter		7.090 to 7.092 [180.086 to 180.136]
D	Cylinder Liner Flange Outside Diameter	0.069 [1.75] OS	7.469 to 7.471 [189.713 to 189.763]
		0.092 [2.34] OS	7.492 to 7.494 [190.296 to 190.347]
		0.104 [2.64] OS	7.504 to 7.506 [190.601 to 190.652]
E	Cylinder Liner Flange Thickness		0.526 to 0.527 [13.360 to 13.385]
F	Cylinder Liner Lower Outside Diameter		7.093 to 7.095 [180.162 to 180.213]

Thin Flange Cylinder Block and Liner

Engine serial number range 31103629 to 31121669

Cylinder block, Part No. 3005860, obsolete and superseded by 3001700 (also obsolete). Refer to Service/Parts Topic No. 79T 1-24.

Service block assembly, Part No. 3011409 (Obsolete).

Refer to the preceding cylinder liner configuration for Service Tool information.

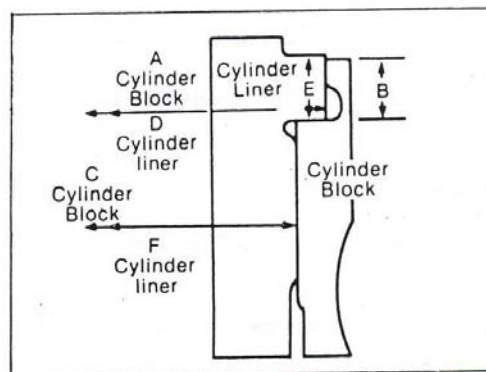


Fig. 5, Cross section of cylinder block and liner-thin flange

Liner shim part numbers and thickness in. [mm]

3014226	0.007 [0.18]
3014227	0.008 [0.20]
3014228	0.009 [0.23]
3014229	0.020 [0.51]
3014230	0.031 [0.79]

Note : The thick flange liner was released for this configuration in Service - 0.010 in. [0.25 mm] and 0.020 in. [0.51 mm] oversize thin flange liners are no longer a recommended fix.

Dimensions—Inch [mm] (Cont'd.)			
A	Cylinder Block Upper Counterbore Inside Diameter	Std.	7.399 to 7.401 [187.934 to 187.985]
		0.010 [0.25] OS	7.409 to 7.411 [188.188 to 188.239]
		0.020 [0.51] OS	7.419 to 7.421 [188.442 to 188.493]
B	Cylinder Block Upper Counterbore Depth	Std.	0.300 to 0.302 [7.62 to 7.67]
		0.010 [0.25] OS	0.310 to 0.312 [7.87 to 7.92]
		0.020 [0.51] OS	0.320 to 0.322 [8.13 to 8.18]
C	Cylinder Block Lower Counterbore Inside Diameter		7.090 to 7.092 [180.086 to 180.136]
D	Cylinder Liner Flange Outside Diameter	Std.	7.400 to 7.402 [187.960 to 188.010]
		0.010 [0.25] OS	7.410 to 7.412 [188.214 to 188.264]
		0.020 [0.51] OS	7.420 to 7.422 [188.468 to 188.518]
E	Cylinder Liner Flange Thickness	Std.	0.305 to 0.306 [7.747 to 7.772]
		0.010 [0.25] OS	0.315 to 0.316 [8.001 to 8.026]
		0.020 [0.51] OS	0.325 to 0.326 [8.255 to 8.280]
F	Cylinder Liner Lower Outside Diameter		7.093 to 7.095 [180.162 to 180.213]

Charleston Fix Thick Flange Cylinder Block and Liner

Engine serial number range 31101150 to 31103628

Cylinder block Part Nos. 205006, 3006200, 3006201, 3008563

Note : These part numbers are now obsolete.

Use the Part No. ST-1168 Liner Counterbore Tool and the Part No. 3375820 Liner Counterbore Salvage Tool to machine the cylinder block for oversize cylinder liners. Use the following parts from the 3375820 tool :

- 3375443 Cutter
- 3375821 Cutter Plate
- 3375824 Depth Spacer (0.010 and 0.020 O.S.)
- 3375831 Depth Spacer (0.030 and 0.040 O.S.)

Liner shim part numbers and thickness in. [mm]

205741	0.007 [0.18]
205742	0.008 [0.20]
205743	0.009 [0.23]
205744	0.020 [0.51]
205745	0.031 [0.79]

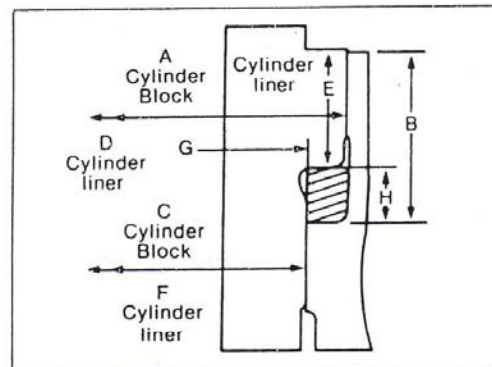
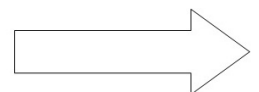
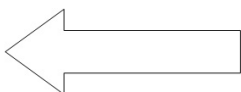


Fig. 6, Cross section of cylinder block and liner-thick flange (Charleston Fix)

Dimensions—Inch [mm] (Cont d.)		
A	Cylinder Block Upper Counterbore Inside Diameter	Std. 7.4915 to 7.4935 [190.284 to 190.335]
		0.010 [0.25] OS 7.5015 to 7.5035 [190.538 to 190.589]
		0.020 [0.51] OS 7.5115 to 7.5135 [190.792 to 190.843]
		0.030 [0.76] OS 7.5215 to 7.5235 [191.046 to 191.097]
		0.040 [1.02] OS 7.5315 to 7.5335 [191.300 to 191.351]
B	Cylinder Block Upper Counterbore Depth	Std. 0.721 to 0.723 [18.313 to 18.364]
		0.010 [0.25] OS 0.731 to 0.733 [18.567 to 18.618]
		0.020 [0.51] OS 0.741 to 0.743 [18.821 to 18.872]
		0.030 [0.76] OS 0.751 to 0.753 [19.075 to 19.126]
		0.040 [1.02] OS 0.761 to 0.763 [19.329 to 19.380]
C	Cylinder Block Lower Counterbore Inside Diameter	7.155 to 7.157 [181.737 to 181.788]
D	Cylinder Liner Flange Outside Diameter	Std. 7.4925 to 7.4945 [190.309 to 190.360]
		0.010 [0.25] OS 7.5025 to 7.5045 [190.563 to 190.614]
		0.020 [0.51] OS 7.5125 to 7.5145 [190.817 to 190.868]
		0.030 [0.76] OS 7.5225 to 7.5245 [191.071 to 191.125]
		0.040 [1.02] OS 7.5325 to 7.5345 [191.325 to 191.376]
E	Cylinder Liner Flange Thickness	Std. 0.526 to 0.527 [13.360 to 13.386]
		0.010 [0.25] OS 0.536 to 0.537 [13.614 to 13.639]
		0.020 [0.51] OS 0.546 to 0.547 [13.868 to 13.893]
		0.030 [0.76] OS 0.556 to 0.557 [14.122 to 14.147]
		0.040 [1.02] OS 0.566 to 0.567 [14.376 to 14.401]
F	Cylinder Liner Lower Outside Diameter	7.158 to 7.160 [181.813 to 182.041]
G	Counterbore Ring Inside Diameter	7.162 to 7.167 [181.914 to 182.041]
H	Counterbore Ring Thickness	Std. 0.1990 to 0.1995 [5.054 to 5.067]
		0.002 [0.05] OS 0.2010 to 0.2015 [5.105 to 5.118]
		0.004 [0.10] OS 0.2030 to 0.2035 [5.156 to 5.169]

Note: Cylinder liner shims and thicker than standard counterbore rings can be used to get the correct cylinder liner protrusion after the cylinder blocks have been machined for oversized liners. More than one cylinder liner shim can be used if necessary and must only be placed between the flange of the cylinder liner and the counterbore ring.



Measurement - Inch [mm]	Useable Limit		New Minimum		New Maximum	
Crankshaft						
Ref. No.						
1. Connecting Rod Journal Outside Diameter	3.997	[101.524]	3.9985	[101.562]	4.0000	[101.600]
2. Main Bearing Journal Outside Diameter	5.4975	[139.636]	5.4985	[139.662]	5.5000	[139.700]
Thrust Bearing Surface Between Counterweights (No. 6 Main Bearing)	2.379	[60.43]	2.374	[60.30]	2.376	[60.35]
Main and Rod Journals Out-of-round T.I.R.**	0.002	[0.05]	0.0000	[0.0000]	0.0004	[0.010]
Main and Rod Journal Taper (Width of Journal)	0.0005	[0.013]				
Fillet Radius			0.240	[6.096]	0.263	[6.680]
**T.I.R. Total Indicated Runout						

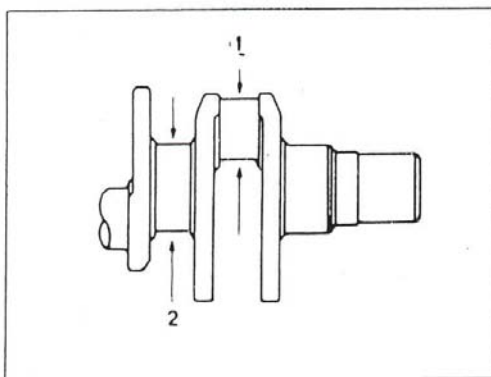


Fig. 7, Measure the crankshaft journals

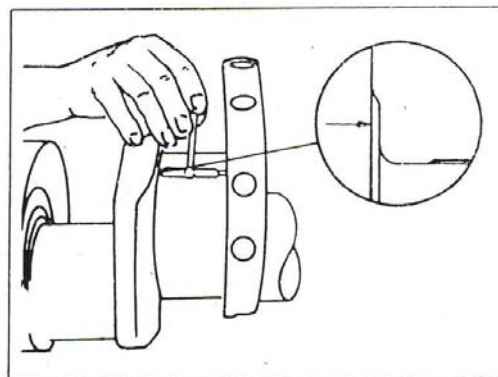
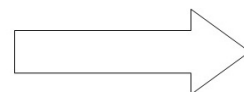
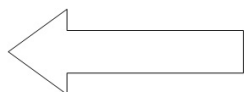


Fig. 8, Measure the thrust bearing surface between counter-weights



Measurement - Inch [mm]	Useable Limit		New Minimum		New Maximum	
Bearings						
Thickness (Standard Size)						
Main Bearing	0.1690	[4.29]	0.1705	[4.331]	0.1712	[4.348]
Connecting Rods	0.123	[3.12]	0.1245	[3.162]	0.125	[3.18]
Journal to Bearing Clearance						
Main	0.0085	[0.216]	0.0026	[0.066]	0.0065	[0.165]
Connecting Rods			0.002	[0.05]	0.005	[0.13]
Connecting Rod Side Clearance			0.008	[0.20]	0.014	[0.35]
Crankshaft Thrust Ring Thickness			0.1505	[6.22]	0.1535	[6.27]
*Use Crankshaft End Clearance.						
Crankshaft End Clearance	0.021	[0.53]	0.004	[0.10]	0.016	[0.41]

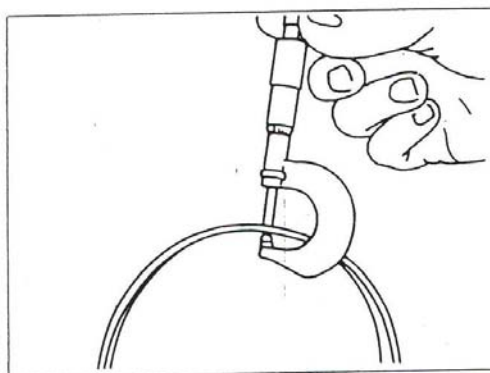


Fig. 9, Measure the bearing shell

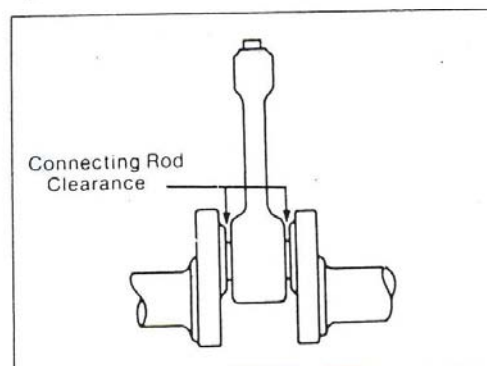


Fig. 10, Connecting rod side clearance

Measurement - Inch [mm]	Useable Limit		New Minimum		New Maximum	
Bearings (Cqnt'd.)						
Main Bearing Tightening Sequence and Torque Value ft-lb [N•m]						
1. Tighten to			190	[258]	200	[272]
2. Advance to			440	[597]	450	[610]
3. Loosen			All		All	
4. Tighten to			190	[258]	200	[271]
5. Advance to (Final Torque)			440	[595]	450	[610]

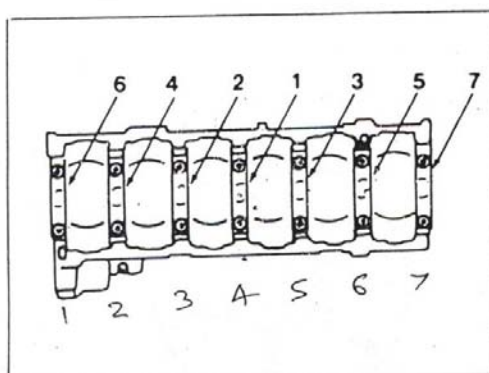


Fig. 1.1, Main bearing tightening sequence

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Vibration Damper & Adapter			
Vibration Damper Alignment Mark (Rubber) $\pm 1/16''$			
Vibration Damper (Rubber) to Crankshaft Torque Value ft-lb [N•m]		160 [217]	180 [244]
Vibration Damper Adapter to Crankshaft Torque Value ft-lb [N•m]		160 [217] 320 [434]	180 [244] 340 [461]
Vibration Damper to Adapter Torque Value ft-lb [N•m]		65 [88]	75 [102]

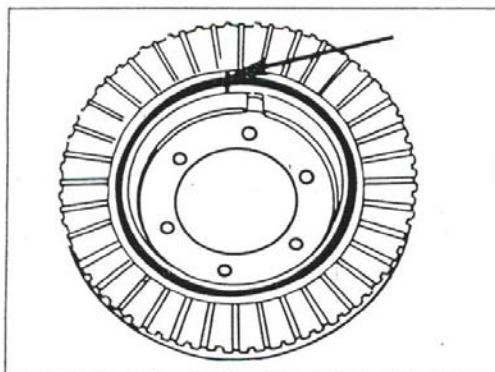


Fig. 12, Vibration damper alignment marks

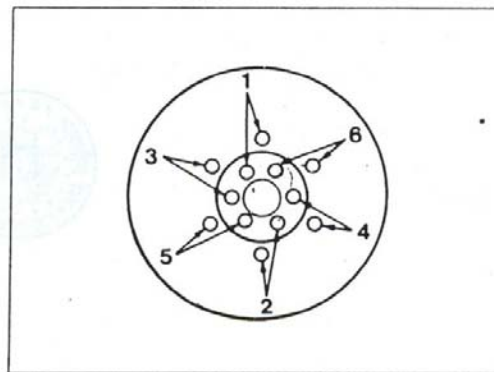


Fig. 13, Vibration damper and adapter tightening sequence

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Vibration Damper & Adapter (Cont'd.)			
Vibration Damper Wobble			
(Rubber) 0.005 in. [0.127 mm] per in. Radius (At Point of Measurement)			
(Viscous) 0.004 in. [0.102 mm] per in. Radius (At Point of Measurement)			
Eccentricity			
(Rubber) 0.003 in. [0.076 mm] per in. [25.4 mm] Damper dia.			
(Viscous) 0.001 in. [0.025 mm] per in. [25.4 mm] Damper dia.			
Variation of Vibration Damper Thickness (Viscous)		0.000	0.010 [0.25]
Runout of Mounting Flange			0.030 [0.76]

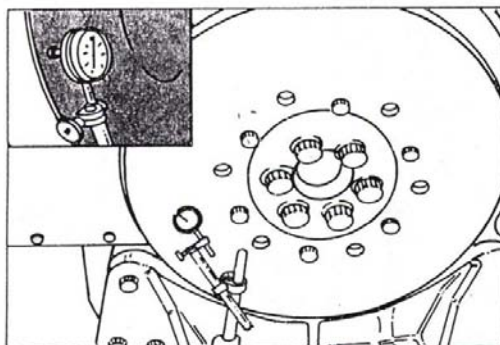


Fig. 14, Check vibration damper wobble

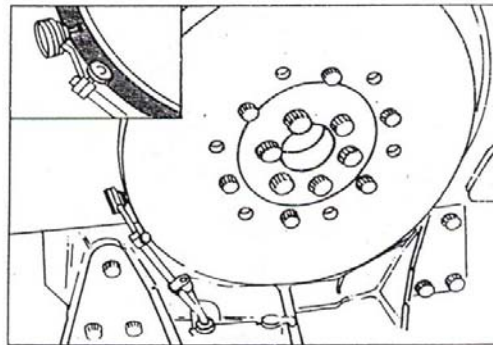


Fig. 15, Check vibration damper eccentricity

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Flywheel & Flywheel Housing			
Flywheel Mounting Torque Value ft-lb [N•m]			
Tighten to		100 [136]	120 [163]
Advance to		200 [271]	220 [298]
Flywheel Housing Mounting Torque Value ft-lb [N•m]			
Tighten to		70 [95]	80 [108]
Advance to		140 [190]	160 [217]
Flywheel Clutch Face Run Out			
0.001 in. [0.025 mm] per in. [25.4 mm] distance from flywheel center to indicator			
Flywheel & Ring Gear Assembly Static Balance			
2 Ounce-inch (Minimum)			
Flywheel Pilot Bore Run Out			
0.005 in. [0.127 mm] T.I.R.			

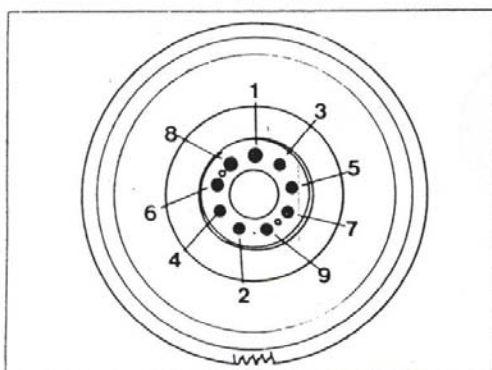


Fig. 16, Flywheel tightening sequence

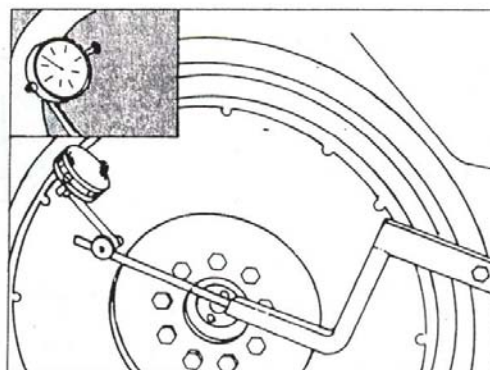


Fig. 18, Measure the flywheel clutch face runout

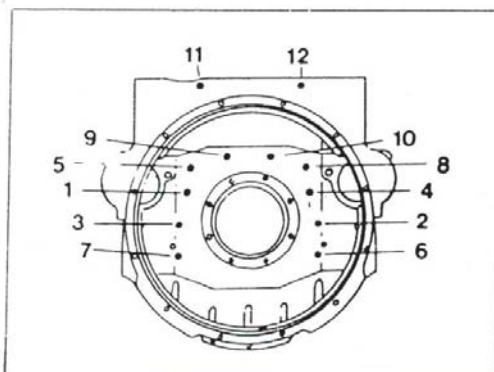


Fig. 17, Flywheel housing tightening sequence

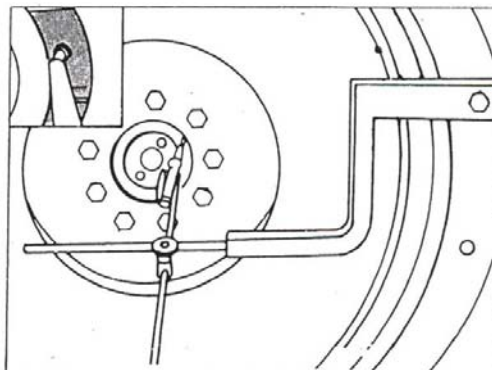


Fig. 19, Measure the flywheel pilot bore runout

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Flywheel & Flywheel Housing (Cont'd.)			
Resurface of Flywheel Clutch Face 0.625 in [15.875 mm] (Minimum Thickness)			

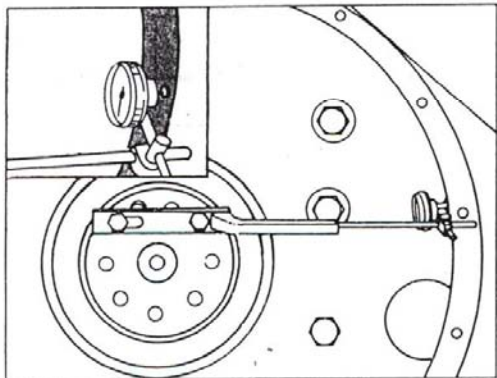


Fig. 20, Measure the clutch bore runout

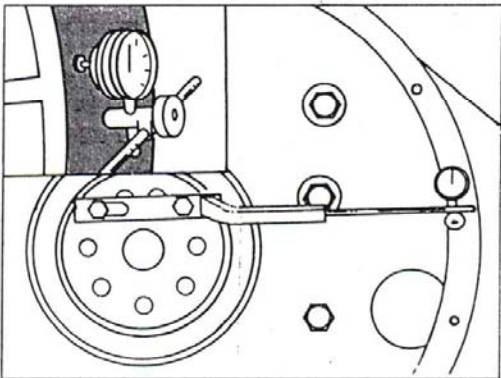
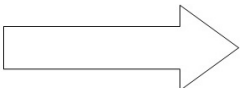
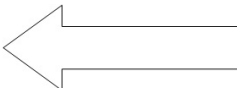


Fig. 21, Measure the face runout



Flywheel Housing Specifications—Inch [mm]

SAE No.	Bore Diameter (for Reference only)	Clutch Bore Tolerance	Face Run-Out Tolerance	Seal Bore Tolerance
00	31.00 to 31.91 [787 to 787.7]	0.012 [0.30]	0.012 [0.30]	0.008 [0.20]
0	25.50 to 25.51 [647.7 to 648.0]	0.010 [0.25]	0.010 [0.25]	0.008 [0.20]
1/2	23.00 to 23.008 [584.0 to 584.20]	0.010 [0.25]	0.010 [0.25]	0.008 [0.20]
1	20.125 to 20.130 [534.27 to 534.40]	0.008 [0.20]	0.008 [0.20]	0.008 [0.20]

Rear Crankshaft Oil Seal

Housing Mounting Torque Value ft-lb [N•m]	7 [9]	9 [12]
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Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Connecting Rods			
Crankpin Bore		4.2518 [107.996]	4.2522 [108.006]
Piston Pin Bore in Rod		2.6495 [67.297]	2.6505 [67.322]
Piston Pin Bushing (Installed)	2.402 [61.011]	2.4010 [60.985]	2.4015 [60.998]
Center to Center Length		11.405 [289.687]	11.407 [289.738]

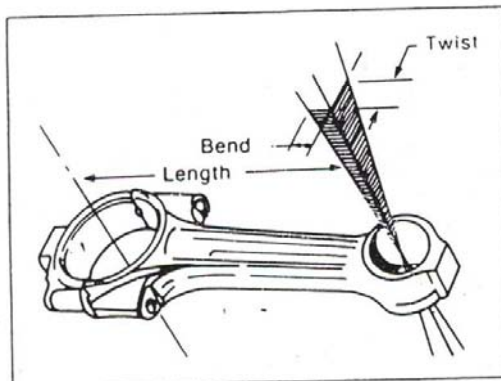


Fig. 22. Connecting rod length, alignment and twist

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Connecting Rods (Cont'd.)			
Connecting Rod Alignment			
Bend			
Without Bushing	0.008	[0.20]	
With Bushing	0.004	[0.10]	
Twist			
Without Bushing	0.020	[0.51]	
With Bushing	0.010	[0.25]	
Connecting Rod Dowels (Ring Type)			
Rod Dowel Pilot Bore		0.8137	[20.668]
Cap Dowel Pilot Bore		0.8140	[20.676]
Connecting Rod Bolt			
Outside Diameter (A)		0.683	[17.35]
Outside Diameter (B)	0.600	[15.24]	0.601
			[15.27]
			0.687
			[17.45]
			0.605
			[15.37]

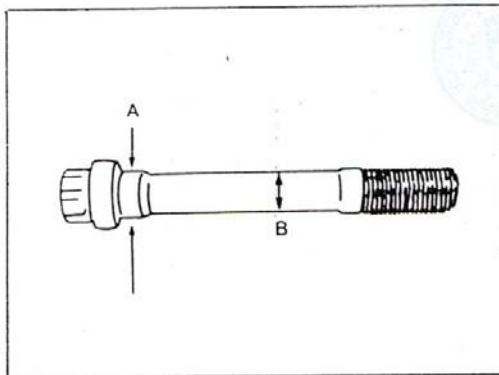


Fig. 23, Connecting rod bolt outside diameter

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Connecting Rod Dowels (Ring Type) (Cont'd.)			
Ring Dowel			
Outside Diameter		0.8147 [20.693]	0.8152 [20.751]
Inside Diameter		0.698 [17.73]	0.708 [17.89]
Connecting Rod Dowels (Solid Type)			
Diameter		0.2501 [6.35]	0.2503 [6.36]
Quantity per Rod		4	
Pilot Diameter in Rod		0.2485 [6.31]	0.249 [6.32]
Pilot Diameter in Cap		0.249 [6.32]	0.2501 [6.351]
Bearing to Journal Clearance		0.002 [0.05]	0.005 [0.13]
Bearing Shel Thickness (Standard Size)	0.1230 [3.12]	0.1245 [3.16]	0.1250 [3.18]
Connecting Rod Tightening Sequence and Torque Value			
Bolt Tightening ft-lb [N•m]			
1. Tighten to		70 [95]	80 [108]
2. Advance to		140 [190]	150 [203]
3. Advance to		210 [285]	220 [298]
4. Loosen		All	All
5. Tighten to		70 [95]	80 [108]
6. Advance to		140 [190]	150 [203]
7. Advance to (Final Torque)		210 [285]	220 [298]

Measurement - Inch [mm]	Useable Limit		New Minimum		New Maximum	
Pistons						
Piston Skirt Outside Diameter (A)						
Measure the diameter when the temperature of the piston is at 70° F [21° C]. Measure 90 degrees from the pin bore and bore 0.11 to 0.25 in. up from the bottom of the piston.	6.237	[158.42]	6.240	[158.50]	6.242	[158.55]
Piston Pin Bore Inside Diameter (B)						
Measure the diameter when the temperature of the piston is at 70° F [21° C].	2.3990	[60.935]	2.3985	[60.922]	2.3989	[60.932]

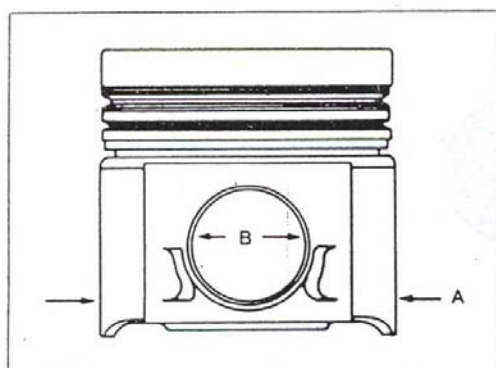


Fig. 24, Piston dimensions

Measurement - Inch [mm]	Useable Limit		New Minimum		New Maximum	
Piston Pin						
Outside Diameter	2.398	[60.91]	2.3988	[60.929]	2.399	[60.94]
Piston Ring Gap						
Top Ring	**		0.025	[0.64]	0.040	[1.02]
Center Ring	**		0.025	[0.64]	0.040	[1.02]
Oil Ring	**		0.015	[0.38]	0.030	[0.76]
Piston Pin Press Fit (In to Piston)			+0.0001		-0.0005	
Temperature for Piston-Pin-Rod Assembly			120° F for 30 minutes [49° C] for 30 minutes			
Piston Ring Groove Width						
	For Top & Center Ring Grooves Use Service Tool ST-560					
Oil Ring			0.1885	[4.788]	0.1895	[4.813]

* * Add 0.003 in. [0.08 mm] ring gap to new maximum limit for each 0.001 in. [0.03 mm] wear in cylinder liner wall.

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Crankshaft			
Bearing Journal Diameter	2.995 [76.57]	2.996 [76.09]	2.997 [76.12]
Thrust Plate Thickness (Std)	0.359 [9.12]	0.368 [9.34]	0.372 [9.44]
End Clearance		0.006 [0.15]	0.013 [0.33]
Gear Lash	0.020 [0.50]	0.003 [0.07]	0.012 [0.30]
Gear Installation Temperature (Hold for 1 hour minimum) Do not exceed 24 hours		375° F [191° C]	440° F [227° C]
Thrust Plate Capscrews Torque Value ft-lb [N•m]		30 [41]	35 [47]

Camshaft Offset Keys

Key Part No.	Amount of Offset	Change in Push Tube Travel	Angle of Offset
200711	0.0070 [0.179]	0.0033 [0.084]	0° 20'
200709	0.0150 [0.381]	0.0070 [0.178]	0° 42'
200704	0.0197 [0.500]	0.0095 [0.241]	0° 56'
200708	0.0230 [0.584]	0.0110 [0.279]	1° 5'
200706	0.0328 [0.833]	0.0155 [0.394]	1° 33'
200714	0.0390 [0.991]	0.0185 [0.470]	1° 50'
216782	0.0110 [0.279]	0.0055 [0.140]	0° 31'
216294	0.0035 [0.089]	0.0017 [0.043]	0° 10'
3000491	0.0270 [0.686]	0.0135 [0.343]	1° 16'
3000492	0.0360 [0.914]	0.0180 [0.457]	1° 42'
3000493	0.0430 [1.092]	0.0215 [0.546]	2° 1'
3000494	0.0470 [1.194]	0.0235 [0.597]	2° 12'
3000495	0.0510 [1.295]	0.0256 [0.650]	2° 24'
S-302 (Straight Key) 0			0°

Measurement - Inch [mm]	Useable Limit		New Minimum		New Maximum	
Gear Cover						
Hyd. Drive Bushing (Installed)	1.506	[38.25]	1.501	[38.13]	1.504	[38.20]
Camshaft & Water Pump Idler Shaft Diameter	1.8720	[47.55]	1.8735	[47.59]	1.8740	[47.60]
End Thrust for Camshaft & Water Pump Idler	0.018	[0.46]	0.004	[0.10]	0.014	[0.36]
End Thrust for Hyd. Drive Camshaft & Water Pump Idler	0.022	[0.56]	0.009	[0.23]	0.018	[0.46]
Thrust Washer Thickness			0.096	[2.44]	0.100	[2.54]
Accessory & Alt. Drive Shaft Bushing I.D. (Installed)	1.571	[39.90]	1.565	[39.75]	1.569	[39.85]
Wear Sleeve Position on Acc. Drive Pulley Hub			Flush	[0.381]	-0.015	
Gear to Gear Backlash (All Gears)	0.020	[0.51]	0.003	[0.08]	0.012	[0.30]
Front Gear Cover Plate Edge Position From Oil Pan Rail			-0.002	[-0.05]	+0.002	[0.05]
Front Cover Gasket Protrusion (You must manually trim the gasket)					+0.010	[0.25]
Front Gear Cover Plate Capscrew Torque Value ft-lb [N*m]			30	[41]	35	[47]

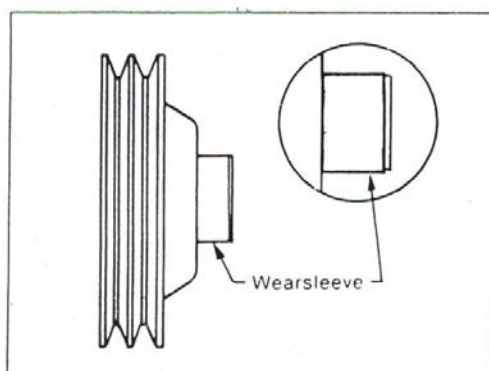


Fig. 25, Cross section of accessory drive pulley and sleeve

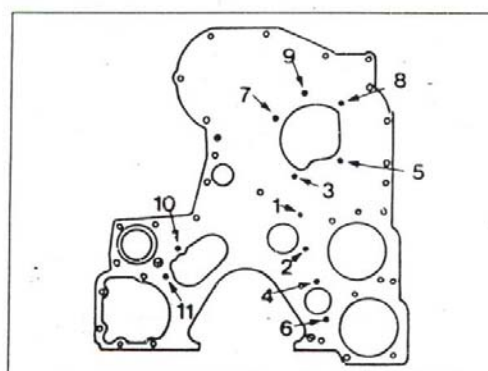
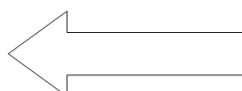


Fig. 26, Tightening sequence of the front gear cover plate



Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Gear Cover (Cont'd.)			
Idler Gear Retaining Capscrew			
Torque Value ft-lb [N•m]		175	[237]
New Style (Bolt in Shaft)		30	[41]
Old Style (Pressed in Idler)			35 [47]
Front Gear Cover Capscrew			
Torque Value ft-lb [N•m]		30	[41]
			35 [47]

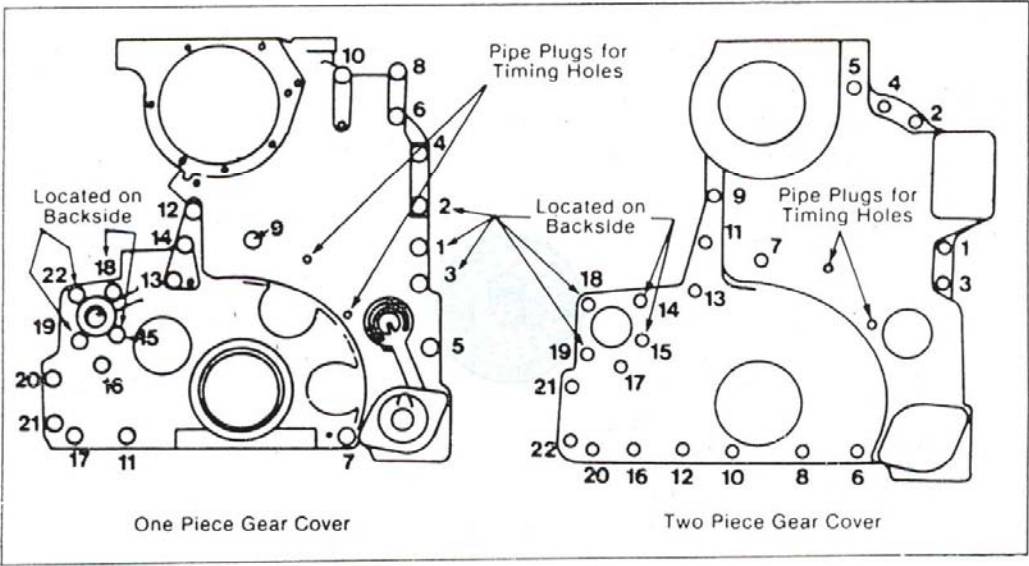


Fig. 27, Tightening sequence of front gear cover

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Cylinder Head			
Ref. No.			
1. Height from combustion face to rocker housing mounting surface	4.715 [119.76]	4.745 [120.52]	4.755 [120.78]
Surface finish requirements micro-inch [micro-m]			125 [3.2]
Combustion Face			
Surface Waviness - Must not exceed 0.0007 in. [0.018 mm] depth. The distance between the high and low points must not be closer than 1.000 in. [254 mm].			
Combustion Face			
Surface Flatness - Must not deviate from a true plane more than 0.003 in. [0.08 mm].			

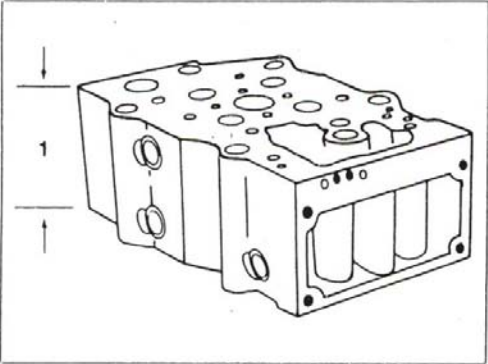
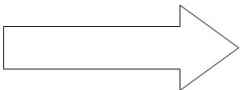
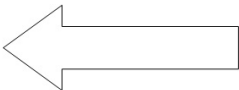


Fig. 28, Height of the cylinder head



Cylinder Head Capscrew Torque Value

Step No. Cadmium Plated Capscrews (Silver or Gold Colour)

1	40 to 60 ft-lbs [54 to 81 N•m]
2	110 to 130 ft-lbs [149 to 176 N•m]
3	180 to 190 ft-lbs [244 to 258 N•m]
4	250 to 260 ft-lbs [339 to 353 N•m]

Step No. Lubrited Capscrews (Black)

1	40 to 60 ft-lbs [54 to 81 N•m]
2	140 to 160 ft-lbs [190 to 217 N•m]
3	240 to 260 ft-lbs [244 to 353 N•m]
4	350 to 370 ft-lbs [475 to 502 N•m]

Cylinder Head Pipe Plug
Torque Value - ft-lbs [N•m]

Plug Size	Minimum	Maximum
1/8 Inch	5 [7]	10 [14]
3/8 Inch	35 [47]	45 [61]
1/2 Inch	60 [81]	70 [95]
3/4 Inch	65 [88]	75 [102]
1 Inch	135 [186]	145 [197]

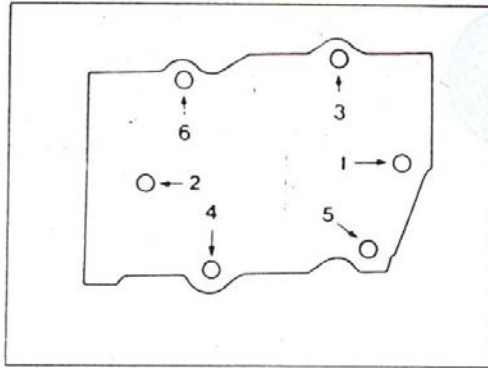


Fig. 29, Tightening sequence of the cylinder head

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Crosshead*			
Ref. No.			
1. Valve Stem Pocket Depth	0.440 [11.17]	0.110 [2.79]	0.150 [3.81]
2. Crosshead Stem Inside Diameter		0.434 [11.02]	0.436 [11.07]
3. Crosshead Guide Outside Diameter		0.433 [10.99]	0.4335 [11.01]
4. Installed Height of Guide		2.350 [59.70]	2.370 [60.20]
5 & 6. Clearance between X-head and Valve Spring Retainer	0.4402 [11.181]	0.025 [0.63]	
Guide Bore in Cylinder Head		0.4314 [10.957]	0.4325 [10.985]
Adjusting Locknut Torque Value ft-lb [N•m]		25 [34]	30 [41]
Adjusting Locknut Torque Value (Jacobs Brake Type)		42 [57]	44 [60]

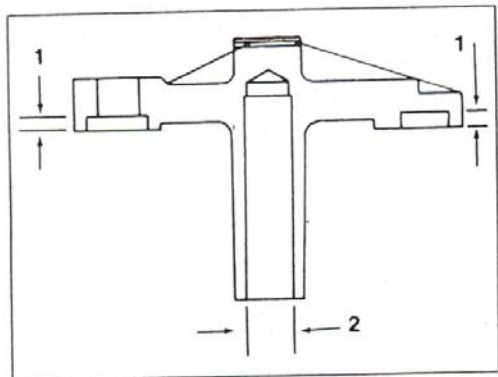


Fig. 30, Crosshead Dimensions

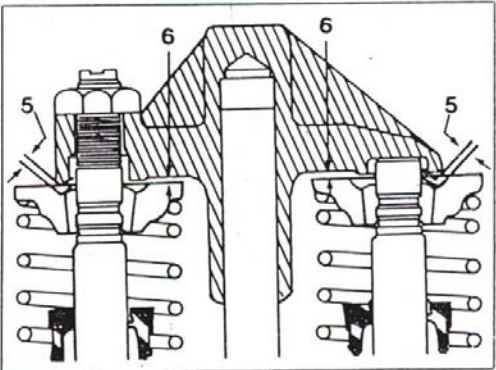


Fig. 32, Clearance between crosshead and valve spring retainer

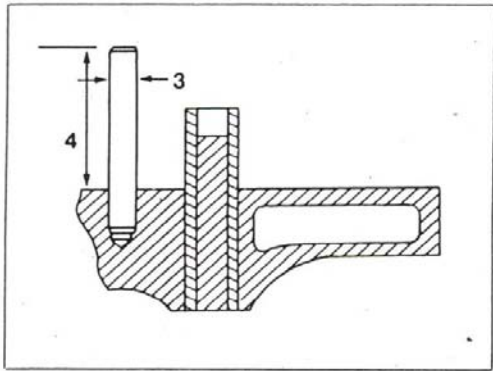


Fig. 31, Crosshead guide dimensions

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Valves			
Ref. No.			
Valve Stem Straightness, Run Out		0.0005 [0.013]	0.001 [0.025]
1. Outside Diameter	0.4935 [12.53]	0.4945 [12.56]	0.4955 [12.59]
2. Thickness of Valve Face at Gauge Diameter	0.105 [2.67]	0.165 [4.19]	0.175 [4.45]
Valve Protrusion from Combustion Face of Cylinder Head		-0.020 Max 0.000	
3. Seat Angle (degrees)		30	30

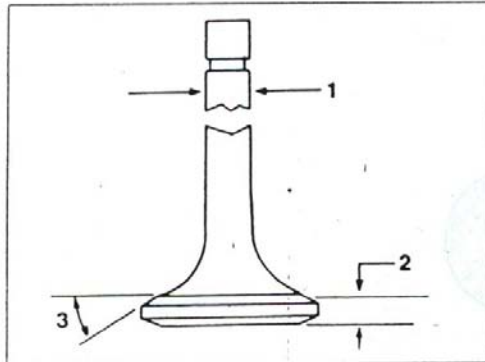


Fig. 33, Valve dimensions

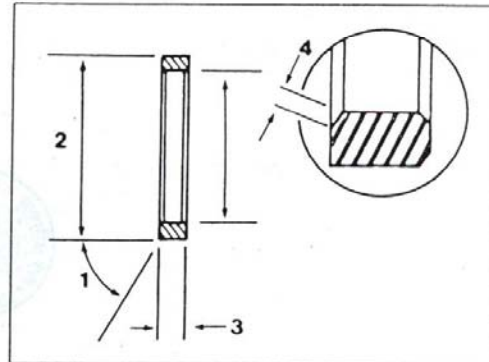
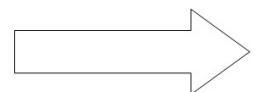
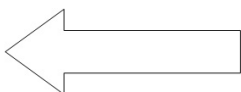


Fig. 34, Valve seat dimensions



Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Valve Seat			
Ref. No.			
1. Seat Angle (degrees)		30	30
2. Outside Diameter		2.3805 [60.464]	2.3815 [60.490]
3. Overall Height			
Intake		0.320 [8.13]	0.325 [8.26]
Exhaust		0.316 [8.03]	0.322 [8.18]
Press Fit Requirements		0.0035 [.09]	
4. Seat Width			
Exhaust		0.060 [1.52]	0.100 [2.54]
Intake		0.100 [2.54]	0.140 [3.56]
Runout 360 (degrees)	0.002 T.I.R.		
Overall Specifications			
+0.010 Oversize	Std. Depth		
+0.020 Oversize	+0.005 Depth		
+0.030 Oversize	+0.010 Depth		
+0.040 Oversize	+0.015 Depth		
Valve Vacuum Test in-Hg [mm-Hg]		18 [457]	25 [635]
Valve Guide			
Inside Diameter (Installed)	0.4987 [12.666]	0.4961 [12.601]	0.4971 [12.626]
Outside Diameter	0.8441 [21.440]	0.8456 [21.478]	0.8461 [21.491]
Bore in Cylinder Head for Valve Guide		0.8435 [21.424]	0.8445 [21.450]
Valve Springs			
Number of Coils		7.8	
Wire Diameter		0.234 [5.94]	
Assembled Height			2.470 [62.74]
Free Length		3.349 [85.06]	
Load to Overcome Spring (To Installed Length)		170.8 lb 77.5 Kg.	294 lb 133.4 Kg.
Injector Tip Protrusion (Nominal)		0.090 [2.28]	0.110 [2.79]

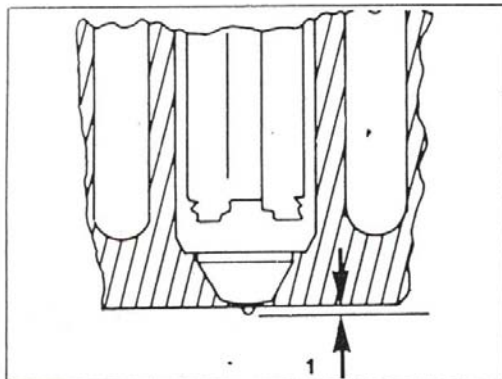


Fig. 35. Injector tip protrusion

Injector Sealing Rings—inch [mm]	
Wall Thickness	Protrusion Change (Into Cylinder Head)
0.135/0.165 [3.43/4.19]	0.000 [0.000]
0.185/0.215 [4.70/5.46]	0.010 [0.254]
0.235/0.266 [5.97/6.73]	0.020 [0.508]
0.285/0.315 [7.24/8.00]	0.030 [0.762]

Measurement—Inch [mm]	Useable Limit	New Minimum	New Maximum
Injector Cup Seating	Blueing Band 0.060 in. [1.52 mm] (minimum) Full Circumference		
Injector Hold Down Capscrew Torque Value ft-lb [N•m]		11 [15]	13 [18]
Fuel Manifold Torque Value in-lb [N•m]		80 [9]	90 [10]

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Push Rods			
Injector Push Rod			
Ball End Radius		0.623 [15.82]	0.625 [15.88]
Socket End Inside Spherical Diameter		0.505 [12.83]	0.520 [13.21]
Contact in Socket	80% blueing w/1/2" Diameter Check Ball		
Straightness	0.010 T.I.R. [0.254]		
Valve Push Rod			
Ball End Spherical Diameter		0.623 [15.82]	0.625 [15.88]
Socket End Inside Spherical Diameter		0.505 [12.83]	0.520 [13.21]
Contact in socket	80% blueing w/1/2" Diameter Check Ball		
Straightness	0.010 T.I.R. [0.254]		

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Rocker Levers			
Ref. No.			
1. Bushing Location from Edge of Lever		Flush	-0.020 below [-0.508]
2. Bushing Inside Diameter (Installed)	1.3776 [34.99]	1.3735 [34.89]	1.3765 [34.96]
Shaft Outside Diameter	1.371 [34.82]	1.372 [34.85]	1.3725 [34.86]
Pad Surface Finish		32 [0.8]	63 [1.6]
Micro-inch [Micro-m]			
Adjusting Screws			
Must be able to thread full length by hand			
Ball Diameter		0.505 [12.83]	0.520 [13.21]
60 [81]			70 [95]
Rocker Lever Shaft Mounting			
Torque Value ft-lb [N•m]			
Rocker Lever Housing Torque Value		60 [81]	70 [95]
ft-lb [N•m]			

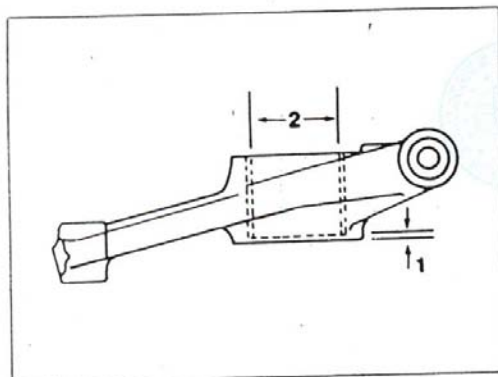


Fig. 36, Rocker lever dimensions

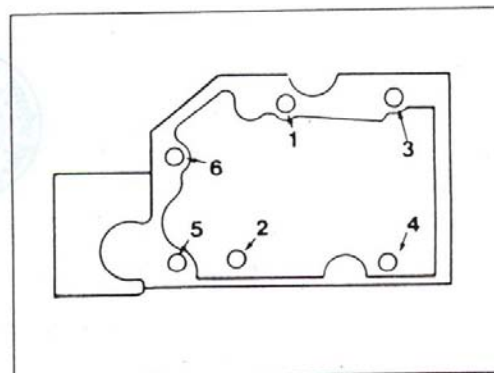


Fig. 37, Tightening sequence for the rocker lever housing

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Rocker Levers (Cont'd.)			
Rocker Lever Cover Torque Value ft-lb [N•m]		30 [41]	35 [47]
Rocker Lever Locknut Torque Value ft-lb [N•m]		30 [41]	40 [54]

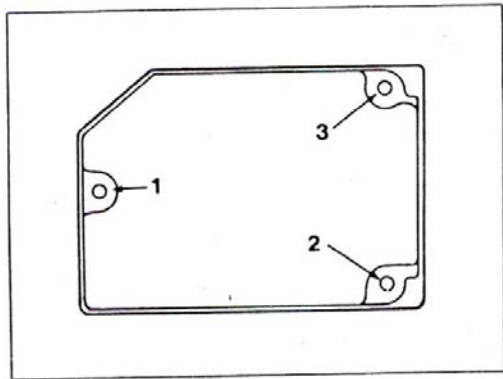
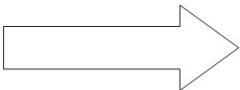
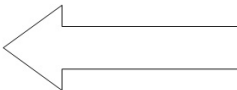


Fig. 38, Tightening sequence for the rocker housing cover



Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Cam Followers			
Ref. No. *			
1. Shaft			
Outside Diameter	0.873 [22.17]	0.8735 [22.187]	0.874 [22.20]
Cam Follower Lever Inside Diameter			
2. Shaft Bore	0.877 [22.28]	0.875 [22.23]	0.876 [22.25]
3. Pin Bore	0.7503 [19.057]	0.7495 [19.037]	0.7502 [19.055]
Cam Rollers			
4. Inside Diameter	0.756 [19.20]	0.754 [19.15]	0.755 [19.18]
5. Outside Diameter	1.622 [41.20]	1.624 [41.25]	1.625 [41.28]
Cam Roller Pin			
6. Outside Diameter	0.748 [19.00]	0.7505 [19.06]	0.751 [19.08]
Roller to Pin Clearance		0.003 [0.08]	0.0045 [0.11]
Roller to Follower Side Clearance		0.009 [0.23]	0.024 [0.61]
Side Squareness to Bore	0.004 [0.102]		
Side Parallelism	0.004 [0.102]		
Roller Inside Diameter to Outside Diameter Parallelism	0.002 [0.51]		
Press Fit in Pin Bore		0.0002 [0.005]	0.0015 [0.0038]
Socket Spherical Inside Diameter		.505 [12.83]	.520 [13.21]
Cam Follower Shaft Torque Value ft-lb [N•m]		29 [39]	31 [42]
Cam Follower Cover Torque Value ft-lb [N•m]		30 [41]	35 [47]

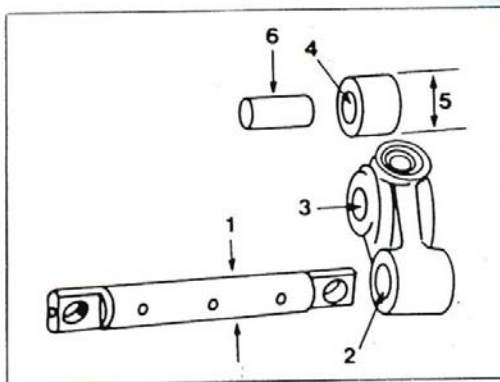


Fig. 39, Cam follower dimensions

Measurement - Inch [mm]	Useable Limit		New Minimum		New Maximum	
Lubrication Oil Pump						
Ref. No.						
1. Inside Diameter	0.8785	[22.324]	0.8765	[22.263]	0.8775	[22.289]
2. Bushing to Body Position			Flush		-0.020	[-0.508]
3. Idler and Drive Shaft Outside Diameter	0.8740	[22.20]	0.8745	[22.212]	0.8750	[22.225]
4. Drive Gear to Body Clearance			0.130	[3.30]	0.150	[3.81]
5. Shaft Protrusion Above Cover Mounting Surface			1.030	[26.16]	1.050	[26.67]
6. Drive Shaft End Clearance			0.0025	[0.064]	0.0065	[0.165]

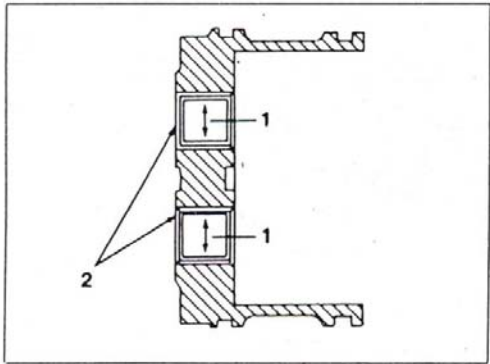


Fig. 40, Lubricating oil pump body dimensions

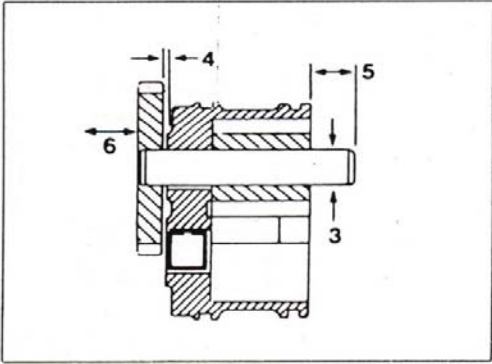


Fig. 41, Lubricating oil pump dimensions

Measurement - Inch [mm]	Useable Limit	New	
		Minimum	Maximum
Lubricating Oil Pump (Cont'd.)			
Driven Gear Position from End of Shaft		1.665 [42.29]	1.685 [42.80]
Idler Gear Position from End of Shaft		1.085 [27.56]	1.105 [28.07]
Gear Backlash from Idler Gear to Drive Gear		0.003 [0.08]	0.012 [0.30]
Lubricating Oil Pump Capscrew Torque Value ft-lb [N•m]		30 [40]	35 [48]
Oil Cooler Housing & Cover Mounting Torque Value ft-lb [N•m]		30 [41]	35 [48]

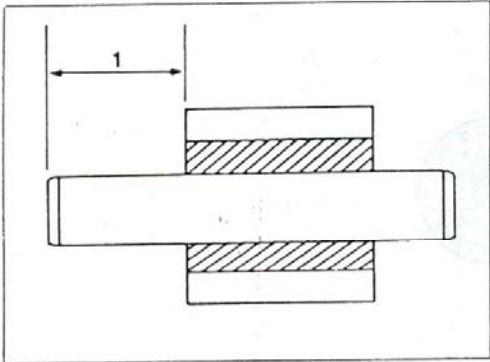


Fig. 42, Driven gear and shaft

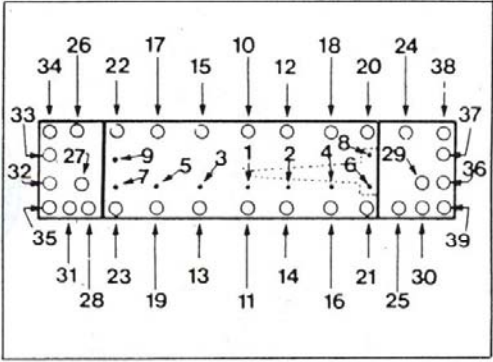


Fig. 44, Oil cooler housing and cover tightening sequence

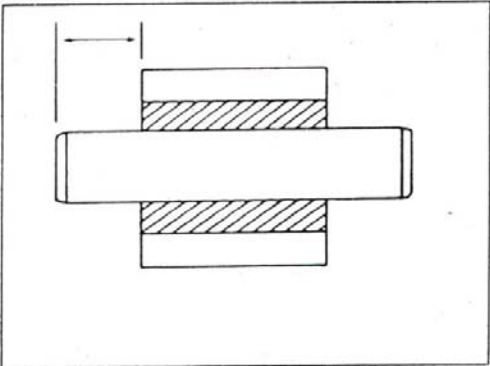
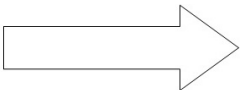
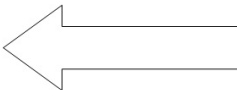


Fig. 43, Idler gear and shaft



Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Lubricating Oil Pump (Cont'd.)			
Lubricating Oil Cooler Heater Plug Torque Value ft-lb [N•m]		70 [95]	80 [108]
Piston Cooling Nozzle Torque Value ft-lb [N•m]		10 [14]	15 [20]
Filter Mounting Head Torque Value ft-lb [N•m]		30 [41]	35 [48]
Oil Gauge Bracket Mounting Torque Value ft-lb [N•m]		30 [41]	35 [48]
Oil Cooler Element to Block Clearance	0.000 [0.000]	0.030 [0.76]	
Oil Flow Thru Bypass Filter at 190°F (GPM)		1 1/2	3
Supply and Drain Hose Size for Systems Less than 10 ft.		#6	
For Systems Greater than 10 ft.		#8	

Hose Number and Size	Min ID	Min Burst in PSI
6	5/16	[7.94]
8	13/32	[10.32]
10	1/2	[12.7]
12	5/8	[15.88]
16	7/8	[22.23]
20	1 1/8	[28.58]
24	1 3/8	[34.93]

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Lubricating Oil Pump (Cont'd.)			
Bypass Circuit Size (Pipe Size)		1/4"	
Oil Cooler Element Torque Value ft-lb [N•m]		30 [41]	35 [48]
Oil Cooler Housing Plug Torque Value ft-lb [N•m]		50 [68]	55 [75]
Drain Cock Installation Torque Value ft-lb [N•m]		5 [7]	10 [13.56]
Lubricating Oil Pan Adapter Capscrew Mounting Torque Value ft-lb [N•m]			
3/8-16 Threads		30 [41]	35 [47]
7/16-14 Threads		45 [61]	50 [68]
9/16-12 Threads		100 [136]	110 [149]
Lubricating Oil Pan Drain Plug Torque Value ft-lb [N•m]		60 [81]	70 [95]

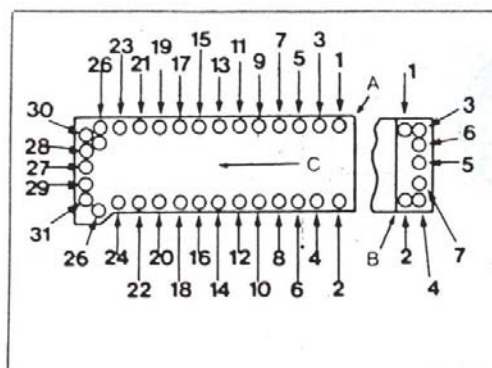


Fig. 45, Oil pan adapter tightening sequence

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Water Pump			
Ref. No.			
1. Housing Bore (Outer Bearing)	2.8431 [72.215]	2.8345 [71.996]	2.8351 [72.012]
2. Housing Bore (Inner Bearing)	2.0557 [52.215]	2.0471 [51.996]	2.0477 [52.012]
3. Housing Bore (Oil Seal)		1.749 [44.43]	1.751 [44.48]
4. Housing Bore (Carbon Face Seal)		1.435 [36.45]	1.436 [36.47]
5. Shaft Diameter (Impeller End and Seat Location)		0.6262 [15.905]	0.6267 [15.918]
6. Shaft Diameter (Oil Seal Location)		0.872 [22.15]	0.878 [22.30]
7. Shaft Diameter (Inner Bearing Location)		0.9842 [24.999]	0.9846 [25.009]
8. Shaft Diameter (Outer Bearing Location)		1.1810 [29.997]	1.1814 [30.008]

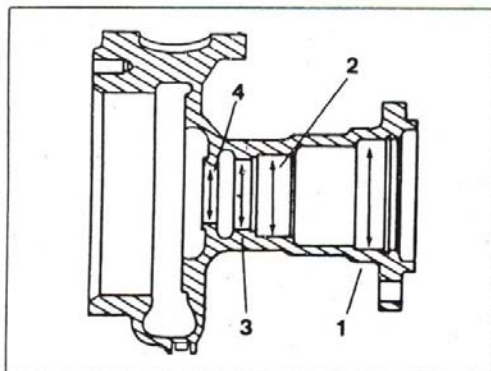


Fig. 46, Water pump housing dimension

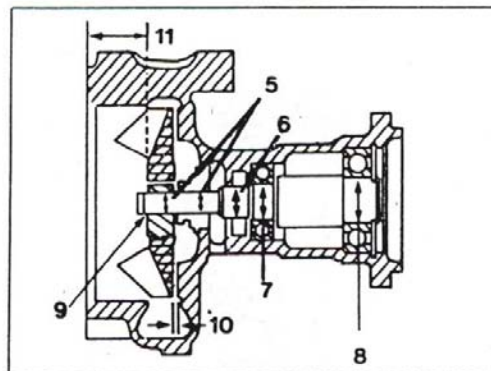


Fig. 47, Water pump shaft and impeller

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Water Pump (Cont'd.)			
9. Impeller Bore		0.624 [15.85]	0.625 [15.86]
10. Impeller to Body Clearance		0.013 [0.33]	0.020 [0.51]
11. Impeller Depth in Body		1.200 [30.48]	1.205 [30.60]
Minimum Press-Fit Between Shaft and Impeller		0.001 [0.03]	
Water Transfer Connection Mounting Torque Value ft-lb [N•m]		30 [41]	35 [48]
Water Pump Mounting Torque Value ft-lb [N•m]		25 [34]	30 [41]
Corrosion Resistor Tightening 1/2 to 3/4 Turn After Seal Touches Filter Head			
Water Bypass to Thermostat Tube Retainer Capscrew Torque Value ft-lb [N•m]		20 [27]	25 [34]

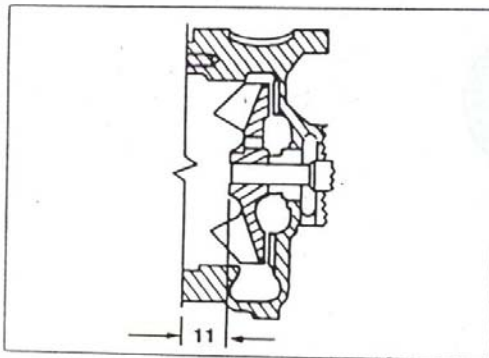


Fig. 48, Impeller depth in water pump body

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Water Pump (Cont'd.)			
Ref. No.			
1. Bushing Inside Diameter	1.755 [44.58]	1.751 [44.48]	1.754 [44.55]
2. Shaft Outside Diameter at Bushing Water Area	1.748 [44.40]	1.7485 [44.41]	1.749 [44.42]
3. Shaft Outside Diameter at Gear Location		1.5666 [39.791]	1.5670 [39.801]
4. Shaft Outside Diameter at Pulley Location		1.3776 [34.991]	1.3780 [35.001]

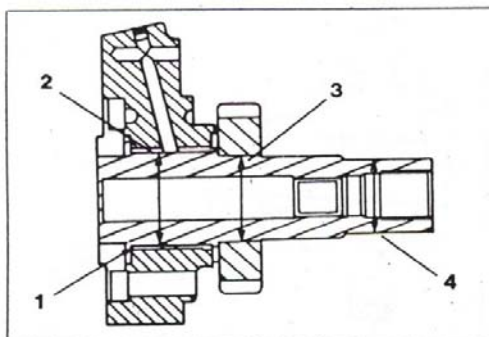


Fig. 49, Alternator drive dimensions

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Fan Drive			
Ref. No.			
Fan Support			
1. Oil Seal Bore		2.8735 [72.986]	2.8765 [73.063]
2. Bearing Bore		2.559 [64.998]	2.560 [65.024]
3. Retaining Ring Bore		2.653 [67.386]	2.659 [67.538]
Fan Hub			
4. Wear Sleeve Position on Hub		Flush	-0.020 [-0.51]

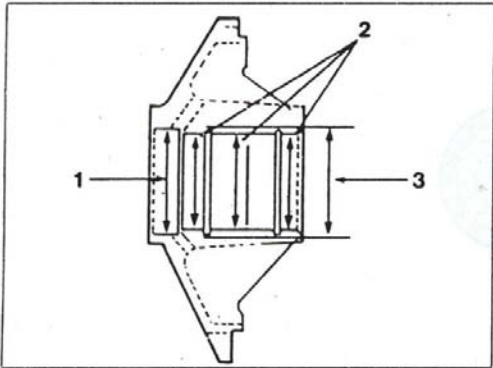


Fig. 50, Fan support dimensions

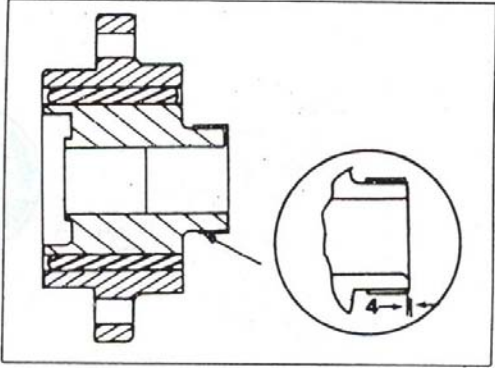
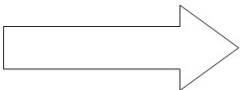
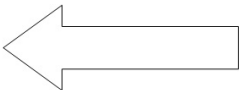


Fig. 51, Fan hub dimensions



Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Fan Drive (Cont'd.)			
Gear and Shaft			
5. Gear Position on Shaft		Flush -0.010	[-0.25]
Fan Hub Assembly			
6. Fan Hub End Clearance		0.003 [0.08]	0.010 [0.25]
7. Fan Hub Member to Retainer Clearance		0.100 [2.54]	
8. Fan Hub Nut Torque Value ft-lb [N•m]		145 [197]	155 [210]
Fan Hub Mounting Capscrew Torque Value ft-lb [N•m]		30 [41]	35 [47]
Fan to Fan Hub Mounting Torque Value ft-lb [N•m]		90 [122]	100 [136]
3/8" Capscrews must have at least 9/16 inch thread engagement			
1/2" Capscrews must have at least 3/4 inch thread engagement			

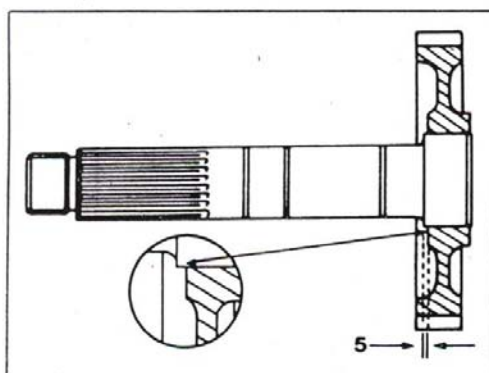


Fig. 52, Gear and shaft dimensions

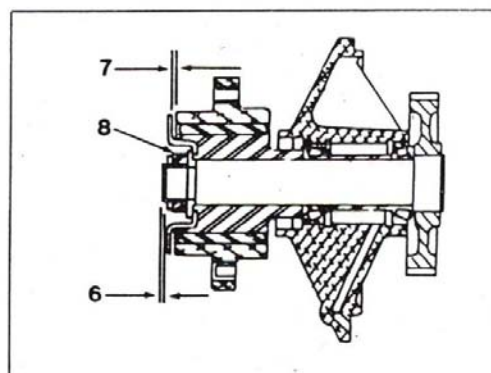


Fig. 53, Fan hub assembly

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Turbocharger			
Model •		T18A	
Mounting Stud Torque Value ft-lb [N•m] (Coated w/high Temperature Thread Guard)		28 [38]	30 [41]
Mounting Locknut Torque Value ft-lb [N•m]		22 [30]	28 [38]
Drain Line must not vary more than 30 of verticle			
V-Band Torque Value in-lbs [N•m]		40 [4.5]	60 [6.8]
Turbine Housing Capscrew Torque Value in-lbs [N•m]		100 [11.5]	110 [12.5]
Air Crossover Mounting Torque Value ft-lb [N•m]		30 [41]	35 [47]
Prelubricate inlet with lubricating oil (oz:)		2	3

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Intake Manifold			
Aftercooler Housing to Cylinder Head Capscrew Torque Value ft-lb [N•m]		24 [33]	28 [37]
Aftercooler Cover to Housing Capscrew Torque Value ft-lb [N•m]		30 [41]	35 [47]

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Accessory Drive			
Alternator Pulley Mounting Torque Value ft-lb [N•m]		70 [95]	80 [108]
Ref. No.			
1. Accessory Drive Shaft Outside Diameter (Pulley Location)		1.3765 [34.96]	1.3770 [34.98]
2. Shaft Diameter at Bushing Wear Area	1.310 [33.27]	1.3115 [33.31]	1.312 [33.32]
3. Shaft Diameter		1.5615 [39.66]	1.5620 [39.67]
4. Shaft Diameter		1.5665 [39.78]	1.5670 [39.80]
5. Bushing Inside Diameter Installed in Housing	1.320 [33.53]	1.316 [33.43]	1.319 [33.50]
6. Location of Bushing in Housing Assembled End Clearance		Flush 0.002 [0.05]	-0.020 [-0.5] 0.012 [0.30]

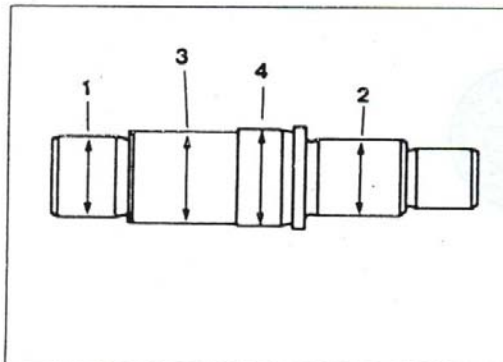


Fig. 54, Accessory drive shaft dimensions

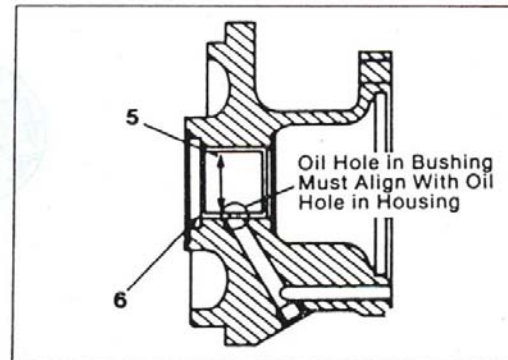


Fig. 55, Housing dimensions

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Accessory Drive (Cont'd.)			
Air Compressor Mounting			
Air Compressor to Support Mounting Torque Value ft-lb [N•m]		30 [41]	35 [47]
Mounting Bracket to Cylinder Block Torque Value ft-lb [N•m]		40 [54]	45 [61]
Fuel Pump to Air Compressor Mounting Torque Value ft-lb [N•m]		30 [41]	35 [47]
Assembled End Clearance		0.002 [0.05]	0.012 [0.30]
Assembled End Clearance Between Fuel Pump & Compressor Drive		0.002 [0.05]	0.012 [0.30]

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Barring Mechanism			
Barring Mechanism for Two Piece Gear Cover			
Ref. No.			
1. Bushing Inside Diameter	0.755 [19.18]	0.751 [19.08]	0.754 [19.15]
2. Shaft Outside Diameter	0.748 [19.99]	0.7485 [19.012]	0.749 [19.02]
3. Shaft Protrusion		0.880 [22.35]	0.900 [22.86]
4. Clearance Between Gear and Housing		0.007 [0.17]	0.015 [0.38]
Barring Mechanism for One Piece Gear Cover			
5. Bushing Inside Diameter	0.626 [15.900]	0.624 [15.849]	0.625 [15.875]
6. Barring Shaft Guide Outside Diameter	0.6210 [15.773]	0.6215 [15.786]	0.6220 [15.80]
7. Shaft Outside Diameter in Guide Area		0.498 [12.65]	0.501 [12.72]
8. Shaft Outside Diameter		0.7451 [18.925]	0.7471 [18.975]

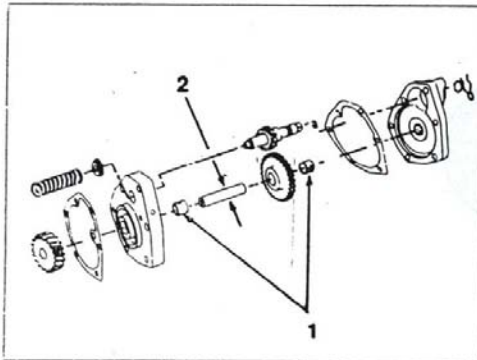


Fig. 56, Barring mechanism dimension for two-piece gear cover

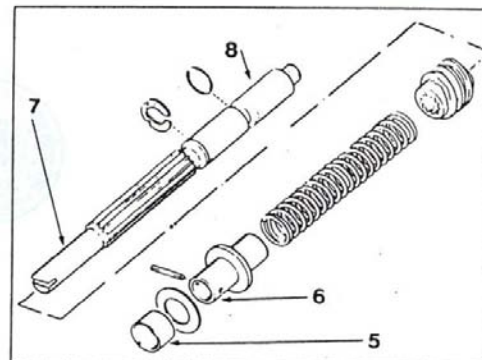


Fig. 58, Barring mechanism for one-piece gear cover

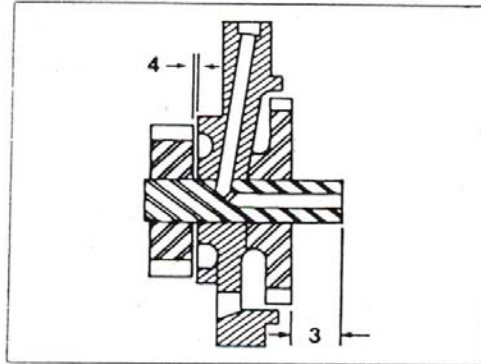


Fig. 57, Barring mechanism dimensions

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Hydraulic Pump Drive			
Thrust Washer Thickness	0.088 [2.24]		
End Thrust	0.022 [0.55]	0.009 [0.23]	0.018 [0.45]
Support Housing Bushing Inside Diameter	2.0015 [50.838]		
Bushing Installed Diameter	1.7535 [44.539]		
Shaft Outside Diameter			
At Large Bushing Area	1.9975 [50.736]		
At Intermediate Bushing Area	1.747 [44.37]		
At Small Bushing Area	1.4975 [38.036]		
Gear Backlash	0.020 [0.50]	0.003 [0.07]	0.013 [0.33]

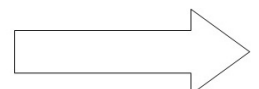
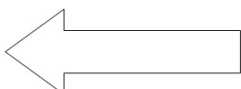
Engine Firing Order

1-5-3-6-2-4

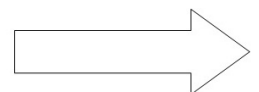
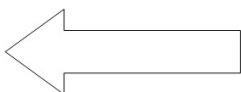
Injection Timing

Timing Code	Engine Model	Piston Travel (Inches)	Push Rod Travel (Inches)
AJ	KTA-1150	-0.2032	0.126 ± 0.002
AE	KT-1150	-0.2032	0.108 ± 0.002
AM	KTA-1150	-0.2032	0.118 ± 0.002
CI	KT-1150	-0.2032	0.114 ± 0.002
CU	KTA-1150	-0.2032	0.128 ± 0.002
CL	KTA-1150-C (700 HP)	-0.2032	0.144 ± 0.002

Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Valve Adjustments			
Intake (Clearance) inch [mm]		0.014 [0.36]	
Exhaust (Clearance) inch [mm]		0.027 [0.69]	
Injector Adjustment			
Plunger Travel inch [mm]		0.304 [7.72]	± 0.0005 [± 0.03]
Lubricating Oil Temperature			
Normal Oil Temp		180° F [82° C]	220° F [104° C]
Normal Oil Pressure at Idle		15 psi [103 kPa]	20 psi [138 kPa]
Normal Oil Pressure at Rated RPM		45 psi [310 kPa]	70 psi [483 kPa]
Normal Oil Operating Temperature		160° F [71° C]	190° F [88° C]
Thermostats			
Thermostat Operating Range		170° F [77° C]	185° F [85° C]



Measurement - Inch [mm]	Useable Limit	New Minimum	New Maximum
Miscellaneous Mounting Torque Values			
Front Engine Mount		140 [190]	150 [203]
Power Steering Pump			
Power Steering Pump Rear Cover		30 [41]	35 [47]
Power Steering Pump Mounting		60 [88]	75 [102]
Alternator			
Adjusting Link Locknut		50 [68]	55 [75]
Mounting Bracket			
Tighten to		30 [41]	35 [47]
Advance to		65 [88]	75 [102]
Adjusting Link to Alternator		40 [54]	45 [61]
Adjusting Link to Water Pump		40 [54]	45 [61]
Cranking Motor Mounting			
Cast Iron Flywheel Housing		150 [203]	170 [231]
Aluminum Flywheel Housing		140 [190]	150 [203]



Lubricating Oil

The use of quality oil, combined with the appropriate oil drain and filter change intervals, is an important factor in extending the life of the engine. Kirloskar Cummins Limited does not recommend any specific brand of oil. The responsibility for meeting the specifications, quality and performance of lubricating oils must rest with the oil supplier.

Following are brief descriptions of the specifications must commonly used for commercial oils:

API classification CC is the current American Petroleum Institute classification for oils for moderate duty service. This classification is equal to the military specification MIL-L-2104B. Oils meeting this specification are designed to protect the engine from sludge deposits and rusting (aggravated by stop-and-go operation) and to provide protection from high temperature operation, ring sticks and piston deposits.

API classification CD is the current American Petroleum Institute classification for service duty for lubricating oils to be used in highly rated diesel engines operating with high loads. Oils which meet this specification have a high detergent content and will provide added protection against piston deposits and ring sticking during high temperature operation. The military equivalent of this classification is MIL-L-45199B.

API classification SC] SC and SE were established for the Automobile Manufacturers association. They require a sequence of tests for approval. The primary advantage of oils in these categories is low temperature operation protection against sludge, rust combustion chamber deposits and bearing corrosion. The test procedure for these specifications are published by the American Society for Test and Materials as STP – 315.

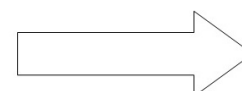
Do not use oils with the classification CB in Cummins Engines.

Table 18-1 : SAE Viscosity Numbers for Lubricating Oils.			
SAE Viscosity	Millipascal-second, mPa*s (Centipoise, cP) @ 0* (-18°C)	Viscosity Ranges milimetre 2/second, mm2/s (centistake, cSt) @ 212°F (100°C)	
Grade	maximum	minimum	maximum
5W	1250	3.8	-
10W	2500	4.1	-
15W	5000	5.6	-
20W	10000	5.6	-
20	-	5.6	Less than 9.3
30	-	9.3	Less than 12.5
40	-	12.5	Less than 16.3
50	-	16.3	Less than 21.9

1. SAE Recommended Practice J 300d.
2. 1 mPa*s = 1 cP
3. 1mm2/s = cSt

Break in Oil

The use of quality oil, combined with the appropriate oil drain and filter change intervals, is an important factor in extending the life of the engine. Kirloskar Cummins Limited does



not recommend any specific brand of oil. The responsibility for meeting the specifications, quality and performance of lubricating oils must rest with the oil supplier.

Viscosity Recommendations.

The viscosity on an oil is a measure of its resistance to flow. The society of Automotive Engineers has classified engine oils in viscosity grades; Table 18-1 shown the viscosity range for these grades. Oils that meet the low temperature (0°F (-18°C)) requirement carry a grade designation with a “W” suffix. Oils that meet both the low and high temperature requirements are referred to as multigrade or multi viscosity grade oils.

Multigraded oils are generally produced by adding viscosity index improver additives to retard the thinning effects a low viscosity base oil will experience at engine operating temperatures. Multigraded oil that meet the requirements of the API classification, are recommended for use in Cummins engines.

Kirloskar Cummins recommends the use of multigraded lubricating oil with the viscosity grades shown in Table 18-2. Table 18-2 shown Cummins viscosity grade recommendations at various ambient temperatures. The only viscosity grades recommended are those shown in this table.

Kirloskar Cummins has found that the use of multigraded lubricating oil improves oil consumption control, improves engine cranking in cold conditions while maintaining lubrication at high operating temperatures and can contribute to improved fuel consumption.

Caution: When single grade oil is used, be sure that the oil will be operating within the temperature ranges shown in Table 18-3.

The primary criterion for selecting an oil viscosity grade is the lowest temperature the oil will experience while in the engine oil sump. Bearing problems can be caused by the lack of lubrication during the cranking and start up of a cold engine when the oil being used is too viscous to flow properly. Change to a lower viscosity grade of oil as the temperature of the oil in the engine oil sump reaches the lower end of the ranges shown in Table 18-2.

Table 18-2 : Kirloskar Cummins Recommendations for Viscosity Grade v/s Ambient Temperatures.	
SAE Viscosity Grade*	Ambient Temperature**
Recommended	
10W-30	-10°F to 14°F (-23°C to -10°C)
15W-40 or	14°F and above (-10°C and above)
20W-40	

* SAE 5WQ mineral oils should not be used.

** For temperatures consistently below 10°F (-23°C)
See Table 18-4.

Exception to Table 18-2.

For standby and emergency engine applications such as electric generators and fire pumps where the engine is located in a heated room or enclosure use an SAE 10W-30. For unheated stand by and emergency applications, consult your Cummins service representative for advice.

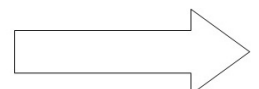
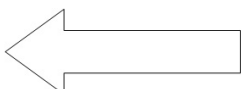


Table 18-3 : Alternate Oil Grades.	
SAE Viscosity Grade*	Ambient Temperature**
10W	13°F to 32°F (-25°C to 0°C)
20W	23°F to 68°F (-5°C to 20°C)
20W-20*	23°F to 68°F (-5°C to 20°C)
20	23°F to 68°F (-5°C to 20°C)
30	39°F and above (4°C and above)
40	50°F and above (10°C and above)

* 20W-20 is not considered a multigrade even through it meets two grades.

Synthetic Lubricating Oil

Synthetic oils for use in diesel engines are primarily blended from synthesized hydrocarbons and esters. These base oils are manufactured by chemicals to produce a lubricant that has planned predictable properties.

Synthetic oil was developed for use in an extreme environment where the ambient temperature may be as low as -50°F (-45°C) and extremely high engine temperatures at up to 400°F (205°C). Under these extreme conditions petroleum base stock lubricants (mineral oil) do not perform satisfactorily.

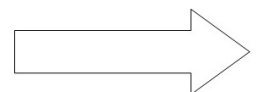
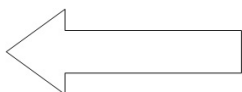
Kirloskar Cummins Ltd. Recommends synthetic lubricating oil for use in Cummins engines operating in areas where the ambient temperature is consistently lower than -10°F (-23°C). Synthetic lubricating oils may be used at higher ambient temperatures provided they meet the approximate API Service categories and viscosity grades.

Kirloskar Cummins Ltd. recommends the same oil change interval be followed for synthetic lubricating oil as that for petroleum based lubricating oil.

Arctic Operations.

For engine operating in areas where the ambient temperature is consistently below -10°F (-23°C) and where there is no provision to keep the engine warm when it is not operating, the lubricating oil should meet the requirements in the following table. Oil meeting these requirements usually have synthetic base stocks. SAE 5W viscosity grade synthetic oils may be used provided they meet the minimum viscosity requirement at 212°F (100°C).

Table 18-4 : Arctic Oil Recommendations.	
Parameter (Test Method)	Specification
Performance	API Classification CC/SC.
Quality level	API Classification CC/CD.
Viscosity	10,000 mPa*s Max. at 31°F (-35°C) 4.1 mm/s Min. at 212°F (100°C)
Pour Point (ASTM-D-97)	Min. of 9°F (5°C) Below the Lowest Expected Ambient Temperature
Sulfated Ash Content (ASTM-D-874)	1.85% by Weight Maximum



Grease :

Kirloskar Cummins Ltd. recommends use of grease meeting the specifications of MIL-G 3545, excluding those of sodium or soda soap thickeners. Contract lubricant supplier for grease meeting these specifications.

Table 18-5 : Recommended Fuel Oil Properties.	
Viscosity (ASTM-D-445)	Centistokes per second -1.3 to 5.8 (1.3 to 5.8mm) per Second. at 104°F (40°C)
Cetane Number (ASTM-D-613)	40 minimus except in cold weather or in service with prolonged idle, a higher cetane number is desirable.
Suffer Content (ASTM-D-129 or 1552)	Not to exceed 1 percent by weight.
Water and Sediment (ASTM-D-1976)	Not to exceed 0.1 percent by volume.
Carbon Residue (Ramsbottom, ASTM D-524 or Conrodson ASTM D-189)	Not to exceed 0.25 percent by weight on 10 percent volume residue.
Flash Point (ASTM-D-93)	At least 125°F (52°C) or legal temperature if higher than 125°F (52°C)
Density (ASTM-D-287)	30 to 42 A.P.I. gravity at 60°F (0.816 to 0.876 g/cc at 15°C)
Cloud Point (ASTM-D-97)	10°F (6°C) Below lowest ambient temperature of which the fuel is expected to operate.
Active Sulfur	Copper strip Corrosion Not to exceed No.2 rating after 3 hours at 122°F (49°C)
Ash (ASTM-D-482) Distillation (ASTM-D-86)	Not to exceed 0.02 percent by weight. The distillation curve must be smooth and continuous. At least 90 percent of the fuel must evaporate at less than 680°F (360°C). All of the fuel must evaporate at less than 725°F.

Caution: Do not mix brands of grease as damage to bearings can result. Excessive lubrication is harmful as inadequate lubrication. After lubrication the fan hub, replace both pipe plugs. Use of fittings will allow lubricant to be thrown out, due to rotative speed.

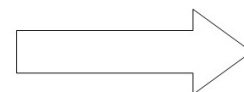
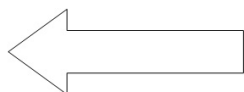
Fuel Oil:

Cummins Diesel Engines have been developed to take advantage of the high energy content and generally lower cost of No.2 Diesel fuels. Cummins diesel engines will also operate satisfactorily on No.1 fuels or other fuels within the following specifications:

Alternate Fuels

Note: Kirloskar Cummins Limited is not responsible and cannot warrant the emissions or performance of their engines when using other than the recommended fuels shown in Table 18-5.

During periods when the supply of No.2-D diesel fuel is limited, alternate fuels, whose properties are within those defined in Table 18-6 can be used.



The following fuel specifications generally define alternate fuels within the prescribed limits:

Table 18-6 : Alternate Fuels.	
1	ASTM – D 975 (grades No. 1 D and No.3 D diesel fuel)
2	ASTM – D 396 (grades No. 2 fuel oil)- heating oil.
3	ASTM – D 1655 (grades Jet A and Jet A-1 aviation turbine fuel)- commercial jet fuel
4	ASTM – D 2880 (grades No. 1 GT and No.2GT non-aviation gas turbine fuel)
5	ASTM – D 36995 (grades No. 1 K and No.2K -Kerosine)
6	VV-F-800 (grades DFA, FF-1 and DF-2) military diesel fuel.
7	VV-F-815 (grades FS-1, and FS-2) military heating fuel.
8	MIL-F-16884 (grade DFM) military marine diesel fuel.
9	MIL-T-5626(grade JP-5) military jet fuel.
10	MIL-J-25656 (grade JP-6) military jet fuel.
11	MIL-T-83133 (grade JP-6) military jet fuel.
12	VV-K-211 (Kerosine) military Kerosine.

Coolant

Water must be clean and free of any corrosive chemical such as chloride, sulphates and acids. It must be kept slightly alkaline with a pH value in the range of 8.0 to 9.5. Any Water which is suitable for drinking can be treated as described in the following paragraphs for use in an engine.

Maintain the Fleetguard DCA Water Filter on the engine. The filter by-passes a small amount of coolant from the system via a filtering and treating element which must be replaced periodically.

- In summer, with no antifreeze, fill the system with water.
- In winter select an antifreeze, except those with anti-leak compounds. Mix the anti freeze with water as required by temperature.
- Install or replace DCA Water Filter Element as follows and as recommended in Cummins Engine Operation and Maintenance Manuals.

Caution: Although anti-leak antifreezes are chemically compatible with the DA water treatment, the anti-leak compound can clog the coolant filters. Therefore “anti-leak antifreeze cannot be used in Cummins Engines

Engines Equipped with DCA Water Filters

- New engines shipped from the factory are equipped with water filters containing a “DCA precharge” element. See Table 18-7. This element is compatible with plain water or all permanent-type antifreeze except anti leak antifreeze.

Note: The corrosion resistor cartridge part numbers listed in Table 18-7 are recommended for service replacement use on engines using the chart Method to determine the “B” Maintenance Check. Refer to the Operation and Maintenance Manual (S) for details on using the Chart Method for extending the “B” Maintenance Checks. Refer to

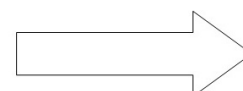
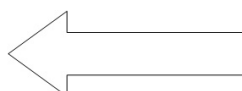


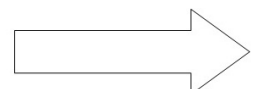
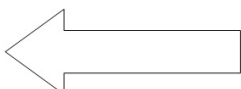
Table 18-8 for liquid DCA part numbers and to the parts Status Table for a listing of old and new part numbers.

In order to obtain the number of DCA units required to precharge the cooling system multiply the number of U.S. gallons by 1.0, the number of Imperial gallons by 1.2 (one unit of DCA will treat one gallon of coolant). Use a corrosion resistor cartridge (s) from Table 18-7. (which contains that chemical charge) or use the regular service cartridge and add enough DCA liquid to reach the required protective level. See Table 18-8.

2. At the first “B” check (oil change period) the DCA precharge element must be changed to the DCA Service Element.
3. Replace the DCA Service Element at each succeeding “B” Check except under the following conditions.
 - i. If make-up coolant must be added between element changes, use coolant from a pretreated supply, as stated in “Make-up Coolant Specification”, in Group 2 of Operation and Maintenance Manual.
 - ii. Each time the system is drained, go back to the precharge element.
4. To make sure of adequate protection, have to coolant checked at each third element change or more often.

Table 18-7 : Corrosion Resistor Cartridges for Extended Maintenance intervals – Miles (Kilometers).

Cooling System Capacity			Corrosion Resistor Part No's	DCA Units	Corrosion Resistor Part No's	DCA Units	Corrosion Resistor Part No's	DCA Units
U.S. Gallons	Imperial Gallons	Liters						
			10,000-14,000(16,000-22,500)		15,000-19,000(24,000-30,500)		20,000-25,000(32,000-40,500)	
0-10	0-8	0-38	3305366 (WF-2050)	2	3305366 (WF-2050)	2	3305367 (WF-2051)	2
11-20	9-17	42-76	3305367 (WF-2051)	4	3305367 (WF-2051)	4	3305368 (WF-2052)	6
21-30	17-25	79-114	3305367 (WF-2051)	4	3305368 (WF-2051)	6	3305369 (WF-2053)	8
31-50	26-42	117-379	3305369 (WF-2053) or 3305367 (WF-2051)	8 4 each	3305370 (WF-2054) or 3305368 (WF-2052)	15 6 each	3305371 (WF-2055) or 3305370 (WF-2054)	23 15 each
51-100	42-83	193-379	3305370 (WF-2054) or	15	3305371 (WF-2055) or	23	3305370 (WF-2054)	23



			3305368 (WF-2052) or 3305367 (WF-2051)	6 each 4 each	3305370 (WF-2054) or 3305368 (WF-2052)	15 each 6 each	or 3305368 (WF- 2052) or 3305367 (WF- 2051)	15 each 6 each
101- 150	84-125	382- 568	3305371 (WF-2055) or 3305370 (WF-2054) or 3305369 (WF-2053)	23 15 each 8 each	3305371 (WF-2055) or 3305370 (WF-2054) or 3305369 (WF-2053)	23 15 each	3305371 (WF- 2055) or 3305370 (WF- 2054) or 3305369 (WF- 2053)	23 15 each

Table 18-8 : Liquid DCA Products.

Part No.	DCA Units	Part Name
3305372 (DCA-30L)	4 (1 pint)	Liquid DCA
3305373 (DCA-35L)	16 (1/2 Gallon)	Liquid DCA
3305374 (DCA-40L)	32 (1 Gallon)	Liquid DCA
3305375 (DCA-45L)	160 (5 Gallon)	Liquid DCA
3305377 (DCA-50L)	1760 (155 Gallon)	Liquid DCA

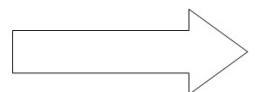
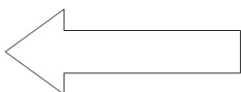


Table 18-9 : Capscrew Torque Values.		
SAE Grade Number Capscrew Body Size (Inches)- (Thread)		8 Torque ft-lb(Nm)
1/4	20	12(16)
	28	14(19)
5/16	18	24(33)
	24	24(37)
3/8	16	44(60)
	24	49(66)
7/16	14	70(95)
	20	78(106)
1/2	13	105(142)
	20	120(163)
9/16	12	155(210)
	18	170(231)
5/8	11	210(285)
	18	240(325)
3/4	10	375(509)
	16	420(570)
7/8	9	605(820)
	14	675(915)
1	8	910(1234)
	14	990(1342)

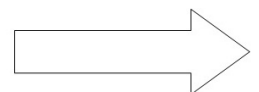
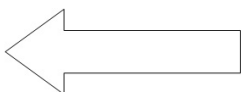
Note:

1. Always use the torque values listed above when specific torque values are not available.
2. Do not use above values in place of those specified in other sections of this manual.
3. The above is based on use of clean dry threads.
4. Reduce torque by 10% when engine oil is used as a lubricant.
5. Capscrew threaded into aluminum may require reductions in torque of 30% or more, unless insert are used.

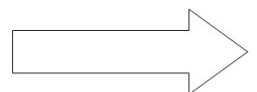
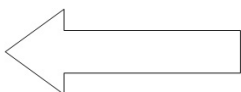
Capscrew Lubrication

A Capscrew carrying residual oil of manufacture may require 10 percent more torque to bring it to the proper tightness value than a capscrew lubricated with lubricating oil. In addition, the oil adds extra protection against rust and corrosion which would weaken the capscrew. Normally, the use of straight lubricating oil (the same as used in the crankcase) is recommended for use on capscrews for Cummins engines.

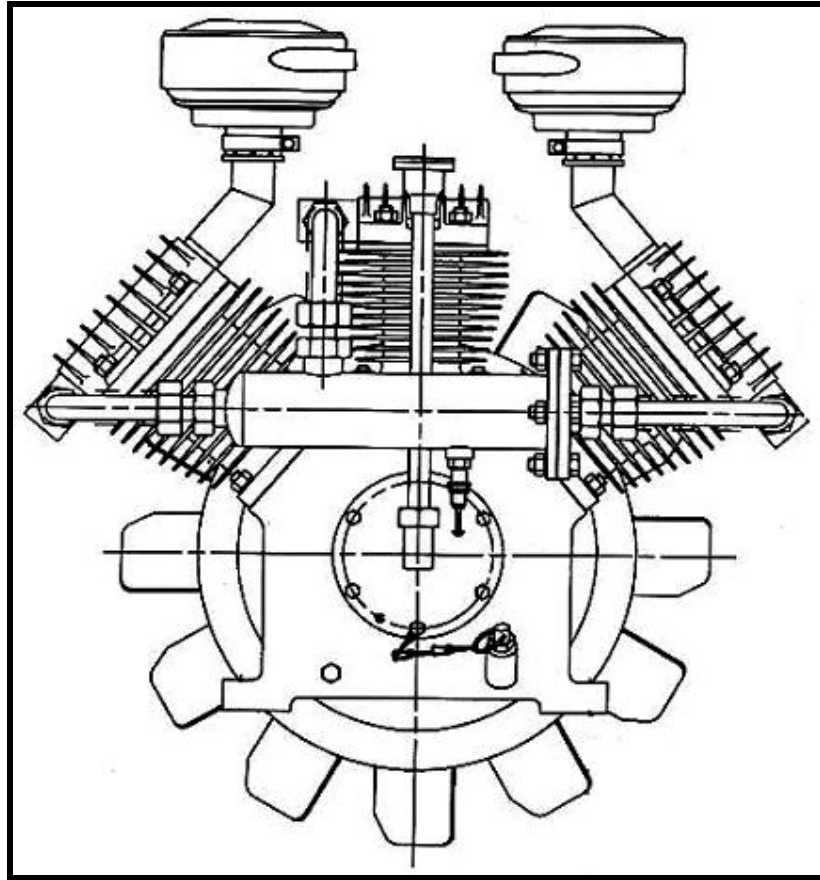
During lubrication, check the capscrew face and mating surface, lock plate, or washer to make sure all are free of burrs, unbent and otherwise in good condition to obtain uniform tightening.

Torque Wrenches:

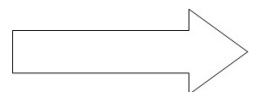
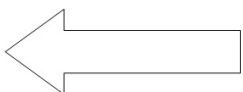
Most torque wrenches are sturdy tools because of the loads they must withstand; however, they are also precision in nature and must be handled with care. The most frequent problem encountered with torque wrenches that will not show on the surface is incorrect calibration. Wrenches that have been dropped or otherwise damaged may appear to be in calibration; however, a regular check should be made.



Chapter- 3



RECIPROCATING AIR COMPRESSOR (TRC 1000)

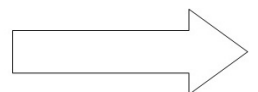
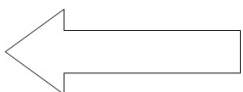


CONTENTS

Chapter-3

AIR COMPRESSOR TRC 1000 B

No.	Description	Page No
3.0	Introduction & Main parts	1
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3.2	Connecting Rod and Crankshaft	1
3.3	Piston Assembly	1
3.4	Cylinder and Cylinder heads	2
3.5	Suction Air filter	2
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3.7	Technical Specification	6
3.8	Air compressor System	6



RECIPROCATING AIR COMPRESSOR

INTRODUCTION & MAIN PARTS

A reciprocating air compressor model TRC 1000 B is a two stage, three cylinder compressor. The compressor has splash type lubricating oil system and its cooling is done by air. The compressor consists of three cylinders arranged in a 'W' form on a crankcase, with the low pressure (LP) cylinder at the both sides and the high pressure (HP) cylinder in the middle of the crankcase. The low pressure (LP) cylinder heads are provided with oil bath air filters at their suction sides. The discharge sides of the low pressure (LP) cylinder heads are connected to an inter cooler pipe. Another similar design pipe connects the intercooler with the suction side of the high pressure (HP) cylinder head. The outlet of the high pressure (HP) cylinder head is provided with an ermeto to facilitate a take-off connection. At one end of the crankshaft is fitted a flywheel cum pulley with a fan for cooling the cylinders and cylinder heads.

CRANKCASE

The crankcase houses the crankshaft assembly. It acts as the sump for the lubricating oil and is provided with a dipstick, a drain plug and a breather valve.

CONNECTING ROD AND CRANKSHAFT

The connecting rod and crankshaft assembly are dynamically balanced. The combined crankshaft with web is forged out of carbon steel, hardened and precision ground. The crankshaft is provided with single row ball bearing at both ends. The main connecting rod big end is provided with steel bearing rollers and small ends are provided with needle roller bearings.

PISTON ASSEMBLY

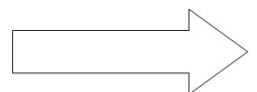
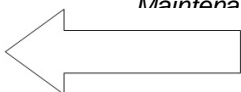
The pistons fitted to the connecting rods are of automotive type. The pistons are provided with plain, stepped compression and slotted oil control rings. The rings are designed for controlling wear and oil consumption to a great extent. The gudgeon pins are hardened and precision ground.

CYLINDERS AND CYLINDER HEADS

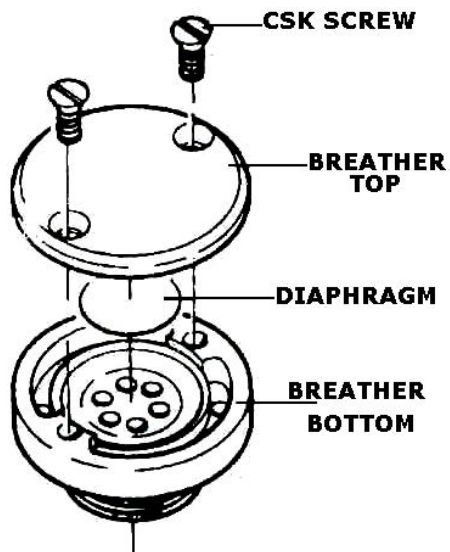
The cylinders and cylinder heads have deep fins for effective cooling and are wear resistance. The cylinders bores are precision honed.

SUCTION AIR FILTER

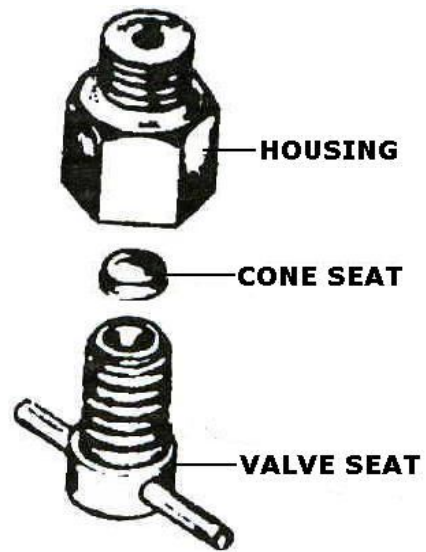
Air passes through the oil bath and the wire mesh. While passing through the oil bath all dust particles in the air will be absorbed by the oil wire mesh. So, the suction air will



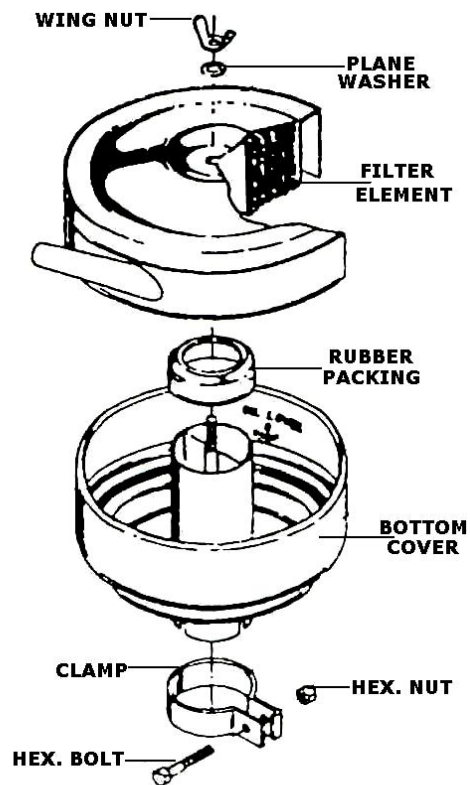
be dust free.



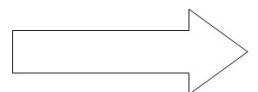
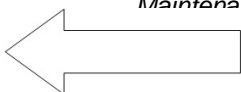
BREATHER VALVE

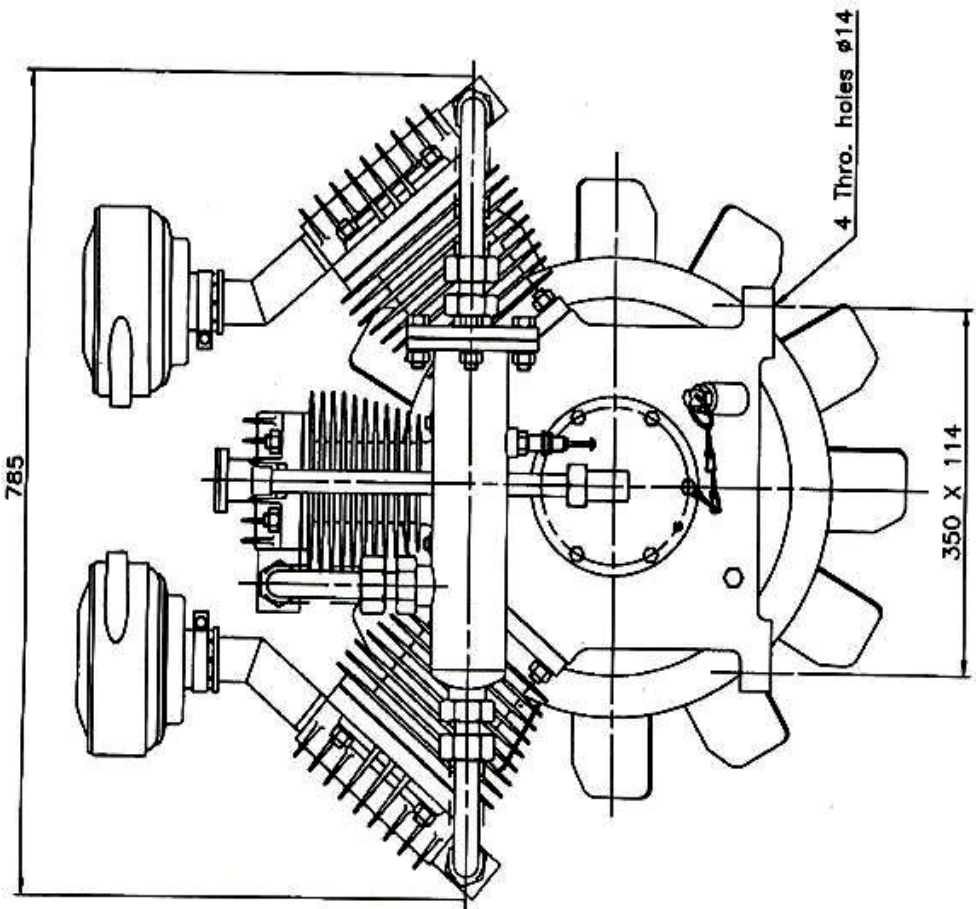
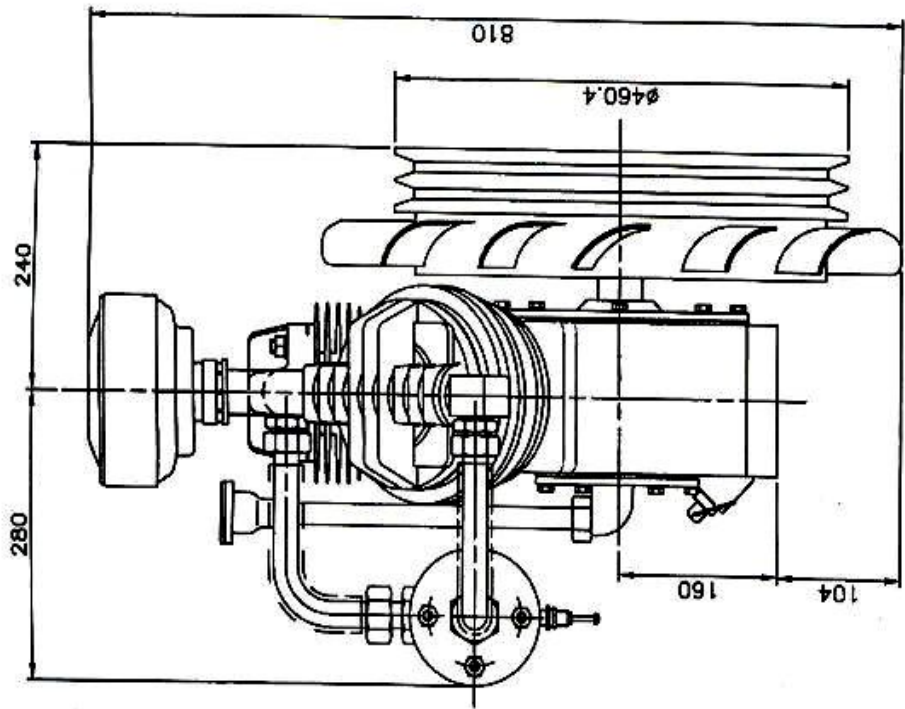


DRAIN VALVE ASSEMBLY

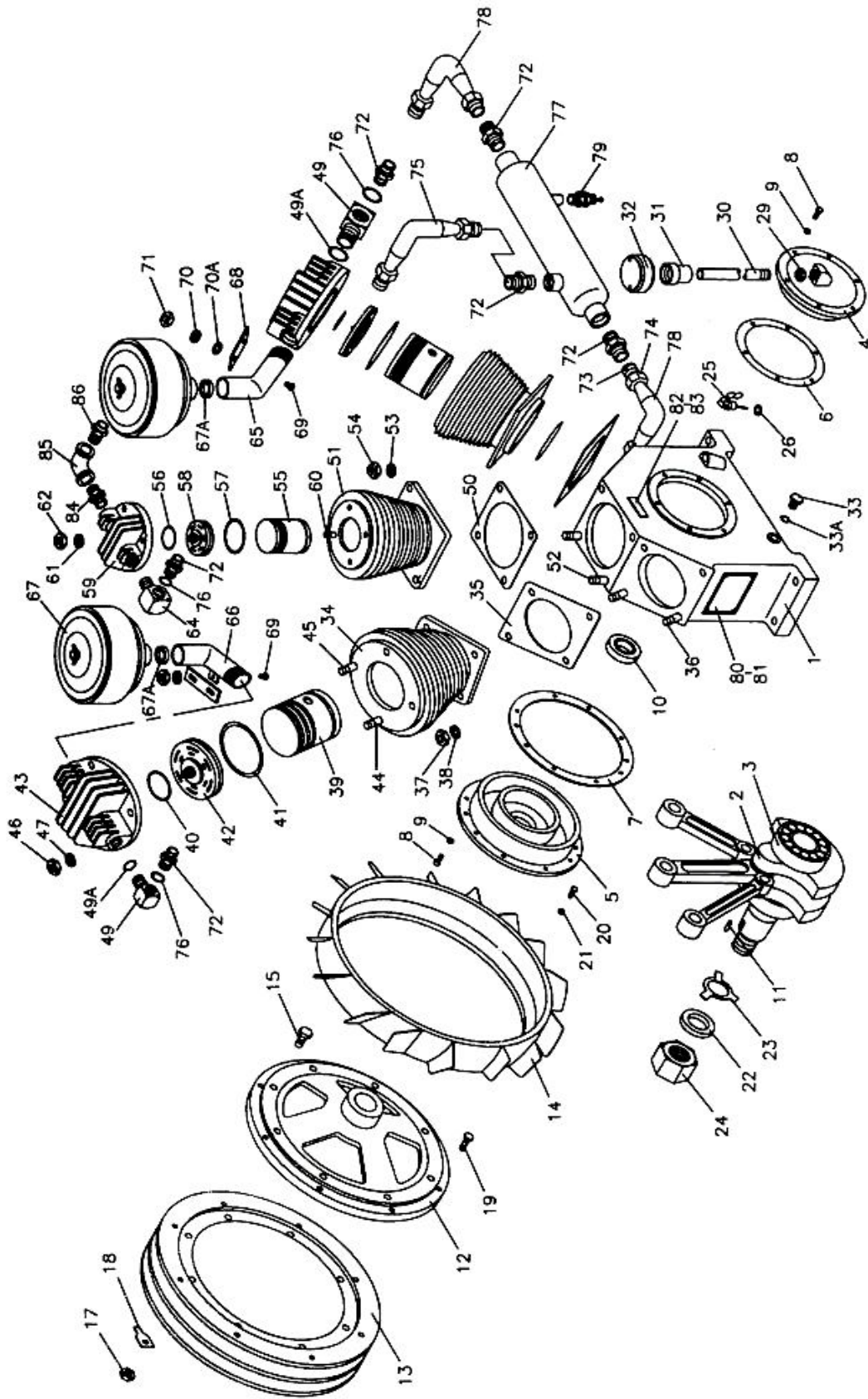


OIL BATH AIR INLET FILTER





FRONT AND SIDE VIEW OF THE COMPRESSOR



EXPLODED VIEW OF THE COMPRESSOR ASSEMBLY

NOMENCLATURE

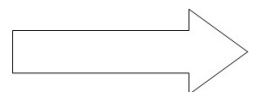
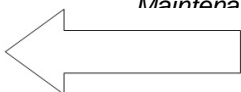
No.	Description	No.	Description
1	Crankcase	46	Hexagonal Nut
2	Con. rod & crank shaft assembly	47	Spring washer
3	Ball bearing	48	Small end conn. rod bush
4	Free end cover	49	Connecting housing
5	Fly end cover	50	Gasket, crankcase to HP cyl.
6	Gasket, free end cover	51	Cylinder liner HP
7	Gasket, fly end cover	52	Stud
8	Hexagonal bolt	53	Spring washer
9	Spring washer	54	Hexagonal Nut
10	Oil seal	55	HP piston assembly
11	Woodruff key	56	Small gasket, HP valve disc
12	Cooling fan flange	57	Big gasket, HP valve disc
13	Compressor pulley	58	Disc valve for HP cylinder
14	Cooling fan	59	Cylinder head for HP
15	Hexagonal bolt	60	Stud
17	Hexagonal Nut	61	Spring washer
18	Locking plate	62	Hexagonal Nut
19	Guide, Hexagonal bolt	63	Conn. rod bush HP
20	Hexagonal bolt	64	Connecting housing
21	Spring washer	65	Pipe bend RH for Air filter
22	Lock plate washer	66	Pipe bend LH for Air filter
23	Lock plate	67	Oil bath filter assembly
24	Hexagonal Nut	68	Flat support for bend pipe
25	Dip stick with chain	69	Hexagonal bolt
26	Packing ring for dipstick	70	Spring washer
29	Lock Nut	71	Hexagonal Nut
30	Breather valve pipe	72	Ermeto
31	Reducer	73	Connection for ermeto
32	Breather valve assembly	74	Nut for ermeto
33	Drain plug assembly	75	Connecting pipe assembly
34	Cylinder liner	76	Packing ring for ermeto
35	Gasket, crankcase to cylinder	77	Inter cooler pipe
36	Stud	78	Connection for pipe assly
37	Hexagonal Nut	79	Safety valve
38	Spring washer	80	Name plate
39	Piston assembly	81	Rivet
40	Small gasket for valve	82	Direction indicator plate
41	Big gasket for valve	83	Rivet
42	Disc valve assembly	84	Nipple
43	Cylinder head LP	85	Elbow
44	Stud	86	Ermeto
45	Stud		

TECHNICAL SPECIFICATION

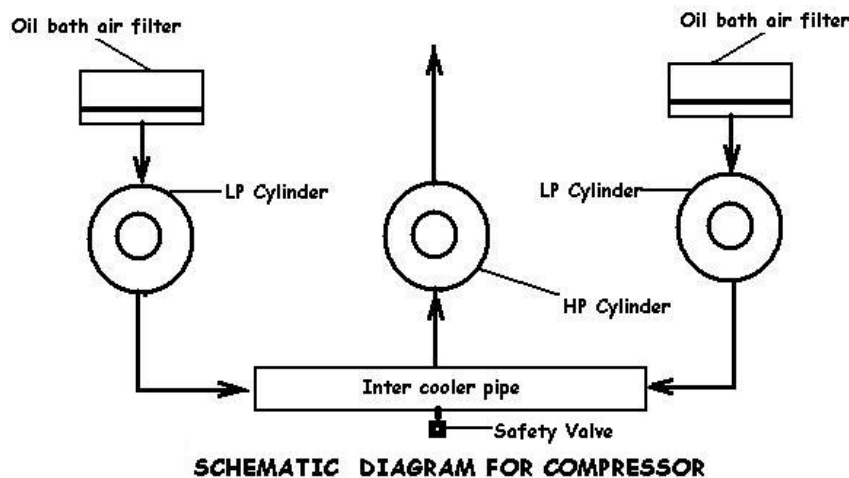
MODEL	TRC 1000 B	
Type	Reciprocating, Air cooled, Splash lubricated	
Displacement	1309 lpm (46.25 cfm)	
Free air delivery	1000. lpm (35.32 cfm)	
Working pressure	8 Kgf/cm ²	
Type of configuration	W	
Compression stage	2 stage	
Cylinders	3 No.	
Cylinder size & stroke	100 x 60 x 100 x 85 mm	
Type of piston rings	Dia 100 mm	Dia 60 mm
a) Plain compression	2 Nos.	01 No.
b) Stepped compression	0 1 No.	01 No.
c) Slotted oil control	2 Nos.	02 Nos.
Type of valve (Suction & Delivery)	Disc valves LP & HP	
Volumetric Efficiency	79%	
Compressor speed	1000 rpm	
Type of lubrication	Splash	
Type of cooling	Air cooled	
Type of fan	Forced draught	
Oil fill capacity	Max. 1350 ml. Min 770 ml	
Grade of oil	Servo Press 150	
Direction of rotation	Clockwise - viewed from non driving end	
Safety valve set pressure	5 kgf/cm ²	
Overall dimensions L x B x H	740 mm x 460 mm x 810 mm	
Net Weight	125 kg	
Mounting hole	350 x 114	
No. of holes	4 holes. Dia 14 mm	
Drive		
a) Type of drive	V belt	
b) Type of groove & Qty.	"C" groove & 2 Nos.	
c) Compressor pulley	OD 460.4 mm, PCD 49 mm	

AIR COMPRESSION SYSTEM

When the piston of LP cylinders starts moving downwards, the combined action of discharge valve return spring and the pressure differential existing between the discharge pipe and the LP cylinders closes the discharged valves. At the same time, inlet valve open due to the pressure differential existing between inside and outside



the LP cylinders. The atmospheric air is then sucked into the cylinders through an oil bath intake strainer. In the upwards stroke of the piston, the combined action of inlet valve spring and pressure differential existing between inside and outside the low pressure cylinders closes the inlet valves. The air available in the cylinder above the piston is then compressed.



Toward the end of the upward stroke, the compressed air opens the discharge valve due to the pressure differential existing between the discharged manifold and the cylinders. Thus the compressed air reaches the inter cooler pipe through discharge valves and the manifold pipe.

The inter cooler which is of aluminium pipe type, cools the low-pressure compressed air before compression in the high-pressure cylinder. The compressed air from low-pressure cylinder manifolds enters both sides of the inter cooler pipe and passes through the inter cooler. This cooled compressed air then enters into the high pressure cylinder, where it is further compressed to attain the specified pressure. The discharge side of the high-pressure cylinder head provides air to the main air reservoir.

DRIVE SYSTEM

The drive system transmits the power required to drive the compressor from the engine. The drive system comprises of a drive pulley mounted on the engine shaft and a driven pulley mounted on the crankshaft of the compressor unit. The motion is transmitted between the pulleys through 'V' belts.

The dynamically balanced driven pulley, fitted on the crankshaft, acts as a flywheel which imparts vibration-free dynamic rotation of the crankshaft. The fan fitted on the

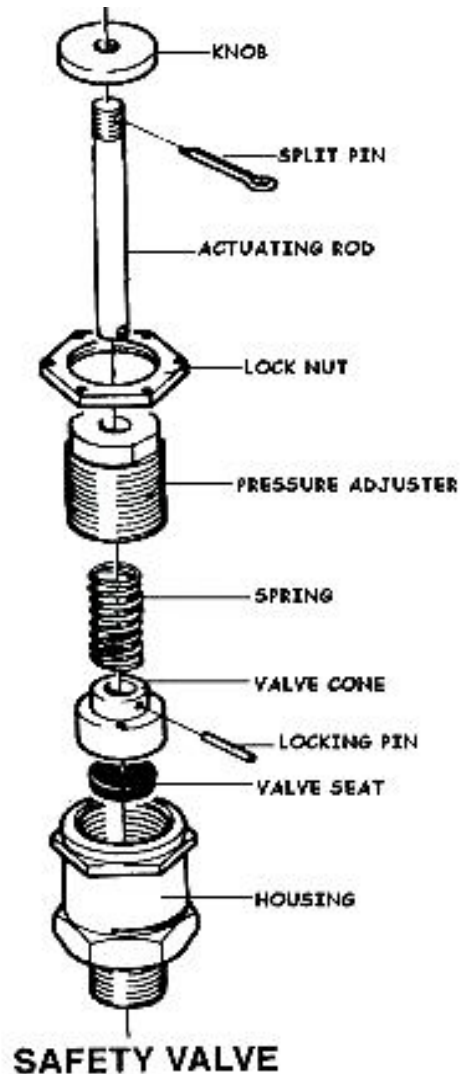
driven pulley forces the air on the cylinders, cylinder heads and inter cooler pipe which cools down the temperature of whole unit.

LUBRICATION SYSTEM

When the crankshaft is move the connecting rod assemblies splash the sump lubricating oil in the crankcase and lubricate all moving parts. A lip type oil seal is provided on the flywheel side to close the crankcase for maintaining the partial vacuum in the sump.

SAFETY VALVE OF INTER COOLER PIPE

A safety valve is fitted to the inter cooler for protection of the inter cooler and low-pressure cylinder. Valve vents excess air pressure in the intercooler when the pressure inside inter cooler rises above 130% of intermediate pressure.



STANDARD AND SPECIAL TOOLS

Standard Tools

1. 10-11 Double end spanner
2. 13 Box spanner
3. 18-19 Double end spanner
4. 19 Box spanner
5. 20-22 Double end spanner
6. 25-28 Double end spanner
7. 38-41 Double end spanner
8. 12 mm stud tightening spanner
9. Circlip plier
10. Pipe wrench 9"
11. Screw driver 6"

Special Tools

1. Oil bath bearing puller
2. Puller assembly for fan flange
3. Piston rings inserting tool, dia 60
4. Piston rings inserting tool dia 100
5. Piston rings expander dia 100
6. Piston rings expander dia 60

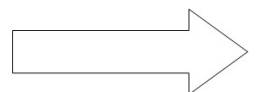
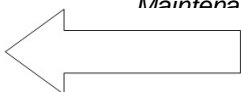
MAINTENANCE SCHEDULES

The following maintenance schedules are carried out in the Diesel sheds and workshops (During POH).

TRIP SCHEDULE

In every trip schedule the following checks should be done-

- Ensure proper belt tension. Too much tension and loose belt will induce an excessive load jerks on engine shaft and compressor bearings. Correctly adjusted belts should have a play of 10 mm about their mean position
- Check whether the compressor is running smoothly and the running sound is normal.
- Check the compressor crankcase and delivery pipe shall be hand-felt to ensure that their temperatures are within touchable limits through out the duration of



operation of compressor.

- Observe for air leaks at the joints of the pipes and if noticed, stop the compressor and rectify the defects.
- Clean the compressor thoroughly.
- Check the oil level in the crankcase. Replenish with the correct grade of oil if required.

MONTHLY SCHEDULE

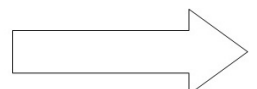
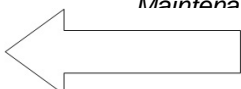
Check the compressor for satisfactory operation which include.

- Clean the compressor thoroughly.
- Check operational noise and vibration.
- Check tightness of mounting bolts and other fasteners.
- Check air leaks at the pipe joints and safety valve.
- Clean the suction filters thoroughly and renew the oil to the correct level.
- Check the suction and discharge operations and general performance of the compressor.
- Change the compressor sump oil, for this-
 - The compressor should be run for a short while to warm the oil.
 - Remove the oil drain plug and drain the oil.
 - Refit the drain plug
 - Fill the lubricating oil into the crankcase through breather hole after removing the breather from the end cover.

NOTE: Do not use any cleaning agents to clean the interior, when changing oil.

RECOMMENDED OIL

Ambient temp. °C	ISO VG No	Bharat Petroleum	Indian Oil	Chemoleums	Bharat Shell
25 to 80	ISO150	Bharat Compressor Oil 50	Servo Press 150	Erato 150 HDC	Shell Corena P150



QUARTERLY SCHEDULE

- All check points indicated under IA schedule to be carried out.
- Breather valve should be dismantled, cleaned and checked for perfect seating of the valve.
- Check the safety valve setting.

HALF YEARLY SCHEDULE

- All check points indicated under Monthly and Quarterly schedule to be carried out.
- Remove the entire disc valve by removing the cylinder heads and replaced with readily available spare valves assemble it to the cylinder with new packings.
- Fit the cylinder heads to the cylinder
- All the pipelines should be checked for leaks at joints and packings renewed as necessary.

YEARLY SCHEDULE AND ABOVE SCHEDULE

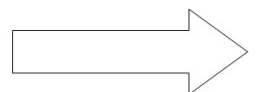
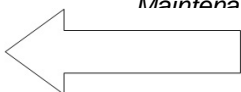
A complete overhauling should be done in the Yearly schedule in Diesel Shed. The compressor should be completely stripped in this schedule. All parts should be thoroughly cleaned, examined and repaired in a clean surrounding.

Removal of compressor from Engine

- Loose the belt tension and take off the V belts.
- Remove the foundation mounting bolts.
- Remove the both side oil bath air maize filter assembly by loosening the clamp and drain the oil from air filter.
- Take out the compressor unit from the Engine.

Dismantling of compressor

- Drain the lube oil from the compressor sump.
- Loosen both side ermeto nuts and remove the suction pipe line.
- Remove the Intercooler pipe safety valve and drain valve.
- Remove the intercooler pipe by opening the ermeto nuts.
- Remove the both side LP cylinder head hex. nuts and take out the cylinder head.
- Remove the HP cylinder head hex. nuts and take out the HP cylinder head.
- Loosen the four hex. nuts provided at the both side LP cylinder liner.



- Gently lift the cylinder liner and remove the cylinder liner from the crank case housing.
- Now loosen the four hex. nuts of the HP cylinder liner provided of the bottom of the cylinder and gently take out the HP cylinder liner.
- Remove the circlip of the LP and HP pistons by using the circlip plier.
- Gently knock out the wrist pin (gudgeon pin) and take the piston out from the connecting rod small ends.
- Now remove the piston ring from the piston by using piston ring expander tools.
- Open hex. nut of the flywheel and fan assembly holding at the crankshaft.
- Remove the flywheel and the fan assembly by using puller.
- Remove the breather valve assembly from free end side cover.
- Open the six hex. bolt of free end cover and remove the cover.
- Open the flywheel and fan end side cover by loosening the six hex. bolts.
- Jack the flywheel end side cover and take out crankshaft and connecting rod assembly.
- Gently hammer the cover and remove the cover from crankshaft.
- Remove the oil seal from the crankshaft.
- Remove disc valves assembly from the cylinder heads.
- Remove the split pin from disc valve nut and open the nut
- Dismantle all valves.

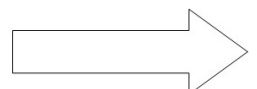
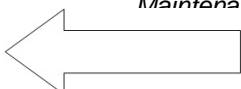
Cleaning of parts

- Clean cylinder heads, cylinder liners, crank case housing, piston, parts of the disc valve and both side covers etc. are clean with diesel oil/kerosene oil and water then blow with compressed air. Ensure complete removal of carbon from piston ring grooves.
- Clean crankshaft and connecting rod assembly by petrol/kerosene oil and blow out with compressed air.
- Clean all nuts and bolts, air filter assembly, flywheel cum fan assembly and other small parts by using diesel oil/kerosene and water.

Inspection and repairs

Crank shaft and connecting rod assembly:

- Inspect the crankshaft and connecting rod assembly for any repair.
- If connecting rod needle bearings size worn out replace the bearings.



- Check both side main bearing of the crankshaft for excessive play. If play found replace the main bearing.

For replacing the main bearing following procedures may be adopted.

- Immerse the crankshaft assembly in the hot oil at the 100 °C.
- Take a small steel wedge and gently hammer it keeping it in the between the crank wed and the bearing. Then use a suitable bearing puller and take out the bearing.

For fitting of the bearing on the crankshaft assembly the following procedure may be adopted.

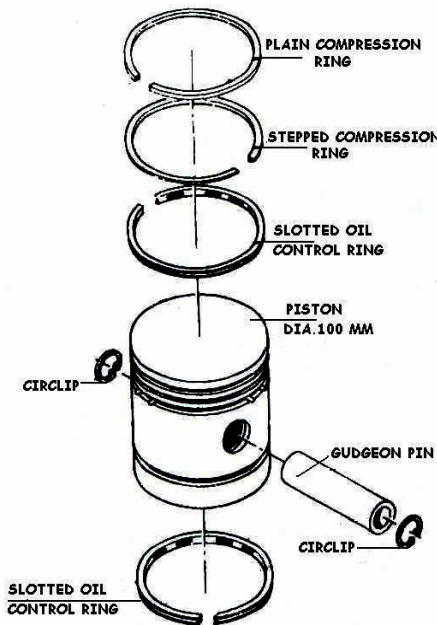
- Heat the main bearing by immersing then in the hot oil at the 100 °C.
- Take the hot bearing from the oil and insert the bearing on the shaft, so that it will slide and fit tightly on the shaft when cooled.

Piston assembly

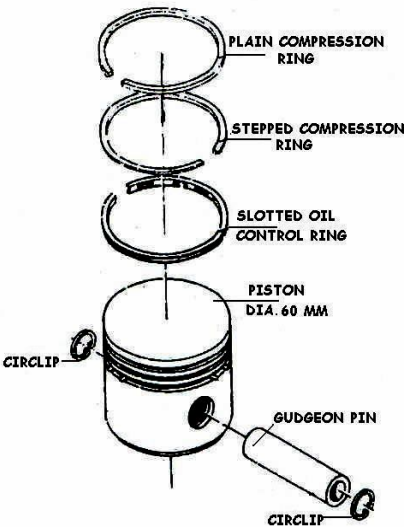
- Check the piston diameter and piston pin boss diameter as per specified in the table. If these sizes are found beyond limit change the piston.
- Check gudgeon pin diameter and surface for any scratches or slackness in the gudgeon pin boss replace the gudgeon pin if found loose.
- Check the piston pin side clearance in the piston groove.
- Check the piston ring butt clearance and maintain the clearance as specified in the parameter table.

PARAMETERS TABLE

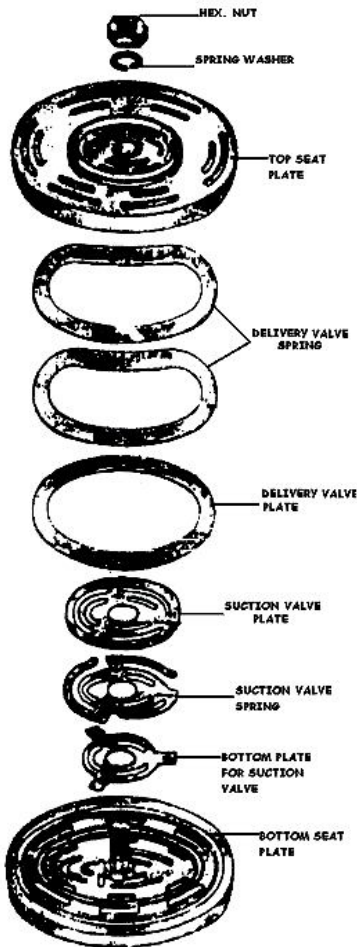
DESCRIPTION	IN	LP	HP
Cylinder bore diameter	mm	100 $\begin{smallmatrix} +0.01 \\ - 0.01 \end{smallmatrix}$	60 $\begin{smallmatrix} +0.01 \\ - 0.01 \end{smallmatrix}$
Piston diameter	mm	99.85 ± 0.005	59.92
Gudgeon size	mm	20 $\begin{smallmatrix} +0.000 \\ - 0.005 \end{smallmatrix}$	18 $\begin{smallmatrix} +0.000 \\ - 0.005 \end{smallmatrix}$
Cylinder to piston clearance	Normal Max.	mm mm	0.15 to 0.16 0.25
Piston ring butt clearance	Normal Max.	mm mm	0.018 to 0.18 0.40
Piston ring side clearance in groove	Normal Max.	mm mm	0.04 to 0.08 0.06 to 0.069
Connecting rod small end needle roller bearing internal diameter	mm	20	18
Piston crown and disc valve clearance	mm	1.4 to 1.6	1.4 to 1.6
Wear limit in cylinder liner	mm	0.127 max. for std. rings	



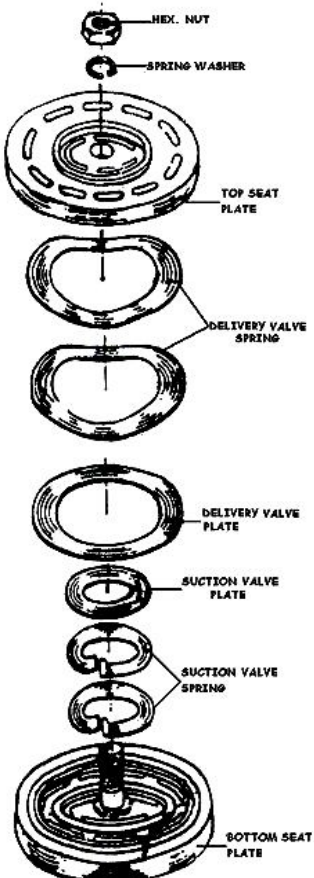
PISTON ASSEMBLY DIA 100



PISTON ASSEMBLY DIA 60



DISC VALVE ASSEMBLY DIA. 100



DISC VALVE ASSEMBLY DIA. 60

Disc Valve

- Check disc valve top and bottom seat plate. There should not be any scratches or damage in the seating area of the valve plate. If there is any damage found, it should be lapped by grinding paste.
- Check all springs for any damage if the spring are damaged, they should be replaced.
- Check all delivery and suction valve plate for any scratches or dent. Lap the valve plate by fine grinding plate. Damage valve plate should be replaced by new one.

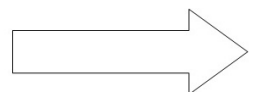
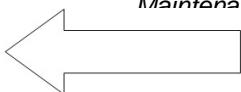
Cylinder Liner & Cylinder head

- Check & maintain the LP cylinder liners bore diameter as given in the table above.
- Check & maintain the HP cylinder liner bore diameter as given in the table above.
- Visually check all cylinder heads for any crack. If crack is found in any head replace the cylinder head.

Assembly of Compressor

Take all checked and repaired parts, assemble the compressor as per following:

- Place the crankshaft with connecting rod assembly in the crank case housing.
- Put the flywheel side cover and tight with six hex. bolts (M8x20) with all spring washers.
- Gently tapped the cover and torque the bolts. Check the free movement of the crankshaft. The crankshaft should be moved freely in the housing.
- Place the free end cover with gasket and tight with bolts. Gently tapped this cover also and again check the movement of crankshaft by hand and ensure there is no friction for the connecting rods to rotate.
- Torque the free end cover bolts.
- Now fit the oil seal on the flywheel side. Ensure that the oil seal should not be damage.
- Place the piston assembly with the rings on the connecting rod small and fix with gudgeon pin and circlips.
- Now set the rings butt joints at 120° with respect to each other rings.
- Take the liner and lubricate inside with light lubricant oil.



- Put the liner with bottom gasket on the piston and tight with four hex. nuts.
- Assemble the disc valve as per given in figure and tight with nut and torque the nut and secure with split pin.
- Take cylinder head and place disc valve with upper and lower gasket and fit on the liner.
- Tight the cylinder head assembly with four hex. nuts and torque them.
- Fit the breather valve assembly on the free end cover.
- Fit suction pipe, delivery pipe and damping pipe (intercooler pipe).
- Fit the intercooler safety valve in the damping pipe.
- Fit the drain valve.
- Fit the air suction oil bath filter assembly and tight its clamp. Fill the oil in the filters at the required correct level.
- Fill the fresh lube oil (1.35 liters SP 150 or equivalent) in the crankcase.
- Place the flywheel cum fan assembly with key on the crankshaft and tighten with lock plate and nut. Torque the nut with torque wrench.

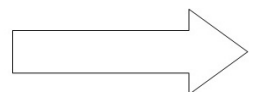
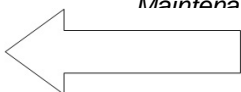
TORQUE VALUE CHART

S.No	Location	Thread size	Tightening Torque
1.	Unit (Foundation bolts)	1/2" BSW or M12	5.0 kg-m
2.	Cylinder	M12 x 1.75mm	5.0 kg-m
3.	Cylinder head	M12 x 1.75mm	5.0 kg-m
4.	End cover, (Free end)	M8 x 1 .25mm	2.5 kg-m
5.	End cover, (Fly end)	M8 x 1 .25mm	3.0 kg-m
6.	Disc valve dia.1 00	M10 x 1.5mm	2.5 kg-m
7.	Disc valve dia. 60	M8 x 1.25mm	1.75 kg-m
8.	Drain plug	3/8" BSP	3.0 kg-m

Fitment of Compressor in the Engine

- Place the compressor on its foundation.
- Fit all foundation bolts.
- Place the 'V' belts between drive and driven pulley.
- Tighten the 'V' belts and ensure the proper belt tension. The belts should have the play of 10 mm about their mean position.

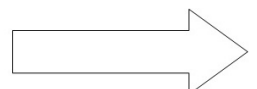
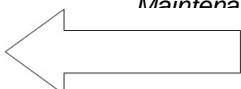
Start the engine and check the compressor working as follows:



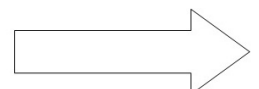
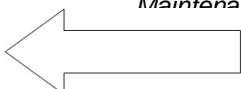
- Check whether the compressor is running smoothly and running sound is normal.
- Check the compressor crankcase and delivery pipes shall be hand felt to ensure that their temperature are within touchable limit through out the operation time of compressor.
- Observe the air leakage at the pipe joints. If any leakage is found, stop the compressor and rectify the defect.
- Check the air pressure in the pressure gauge at various loads and unload condition.
- Check the working of the breather valve for maintains partial vacuum inside the crankcase.
- Stop the compressor and check the oil level in the crankcase by dipstick.

TROUBLE SHOOTING CHART

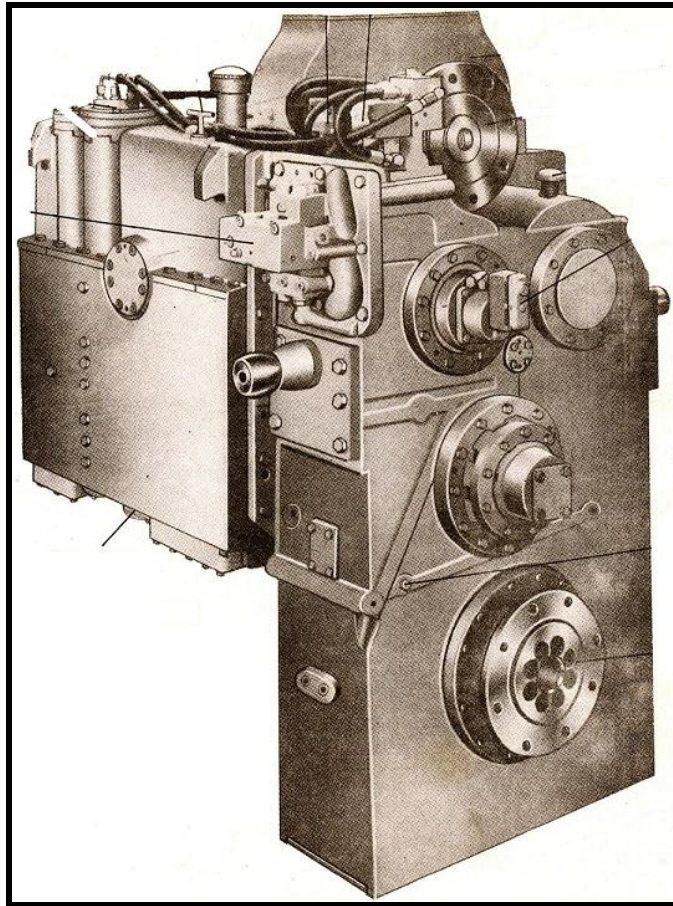
DEFECT	LIKELY CAUSES	REMEDIES
Compressor over heats	<ul style="list-style-type: none"> • Dirty oil • Oil level low • Cylinder and inter cooler pipe fins dirty • Breather valve not working • Wrong direction of rotation 	<ul style="list-style-type: none"> • Change oil. • Fill correct grade of oil up to maximum level in the dipstick. • Blow with compressed air or clean manually. • Open, clean and refit after checking. • Interchange correct direction
Oil carryover in Compressed air	<ul style="list-style-type: none"> • Chocked air filter. • Oil level high • Oil viscosity too low • Breather not working • Piston rings stuck in grooves or broken. • Piston to cylinder clearance excessive 	<ul style="list-style-type: none"> • Clean or renew the air filter element. • Drain to correct level • Change to recommended grade • Open, clean and refit after checking • Loosen the piston rings, if broken, change the rings as a set. Check all related parts for wear before fitting. • Check and change as required
Unusual wear of cylinder, piston and piston ring	<ul style="list-style-type: none"> • Inadequate air filter maintenance • Oil change frequency insufficient • Incorrect grade of oil 	<ul style="list-style-type: none"> • Increase frequency of cleaning • Increase frequency with more periodic check of oil • Change to correct grade as given in recommended lubricants chart.



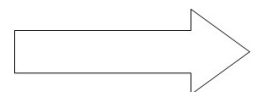
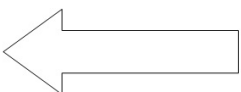
Water or rust formation in crankcase	<ul style="list-style-type: none"> Faulty breather valve. 	<ul style="list-style-type: none"> Check and replace the breather valve if necessary.
Oil leak through breather valve	<ul style="list-style-type: none"> Breather valve is not working. Piston rings stuck in Grooves or broken. Piston to cylinder clearance excessive. 	<ul style="list-style-type: none"> Open and refit the breather. Loosen the piston rings. If broken. Change the rings as a set. Check all related parts for wear before fitting. Check and change as required.
Abnormal noise and Compressor Knocking	<ul style="list-style-type: none"> Loose compressor pulley and key. Worn out piston, cylinder, crankshaft and connecting rod bearings. 	<ul style="list-style-type: none"> Remove pulley and examine keyway and key for wear, Change the key / pulley as required Overhaul compressor unit. Replace the related components.
Pressure built up time excessive	<ul style="list-style-type: none"> Chocked air filter. Loosen belts. Leak joints in pressure lines. Defective seating of inlet and delivery valve plates. Worn out piston rings. 	<ul style="list-style-type: none"> Renew new one. Adjuster or replace, if elongated. Open and re-tighten with teflon tape or jute and shellac. Open, clean and refit after careful check. Replace after checking the related components.
Excessive belt wear	<ul style="list-style-type: none"> Incorrect engine and compressor pulley alignment. Incorrect belt tension 	<ul style="list-style-type: none"> Check and adjuster using a straight edge or string across the diameter of bolt the pulleys. Check belt adjustments frequently.
Compressor package vibration	<ul style="list-style-type: none"> Uneven surface level. Mounting bolts and nuts loose. 	<ul style="list-style-type: none"> Check the surface with spirit level and correct the surface level. Tighten bolts and nuts.



Chapter- 4



FORWARD REVERSE TURBO TRANSMISSION (Kirloskar)

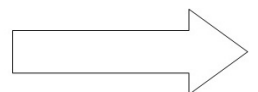
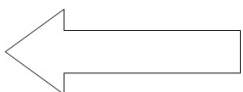


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CHAPTER -4

FORWARD REVERSE TURBO TRANSMISSION (Kirloskar)

1.0 INTRODUCTION

KIRLOSKAR – VOITH Turbo Reversing Transmissions – Model: L4r2U2 and L4r2U are essentially meant for use on diesel hydraulic locomotives. The special feature of this transmission is that the reversing is done by use of filling and emptying the oil in respective torque converters.

The change-over from forward to reverse or vice versa is accompanied by hydrodynamic braking effect by filling the torque converter in opposite direction. The two models are similar in construction except that L4r2U2 has two output flanges suitable for connection to axle drives and L4r2U has one output end (predominantly meant for jackshaft gear boxes with side rod drives).

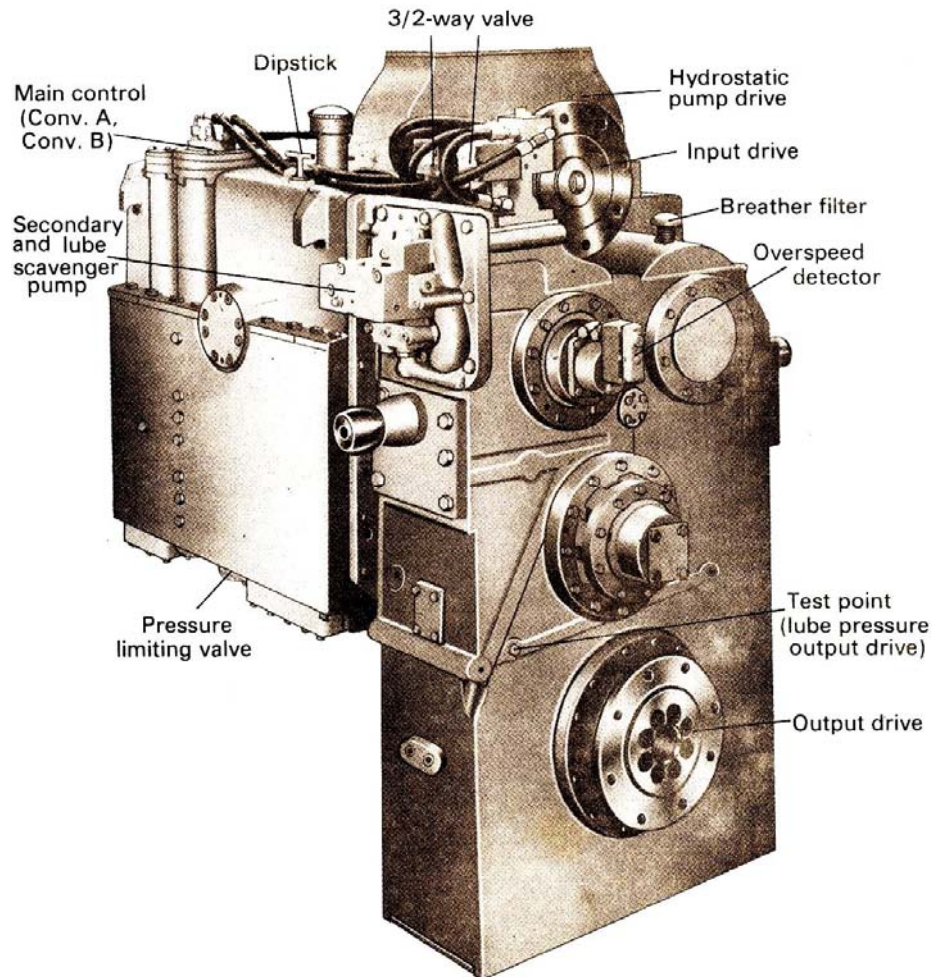
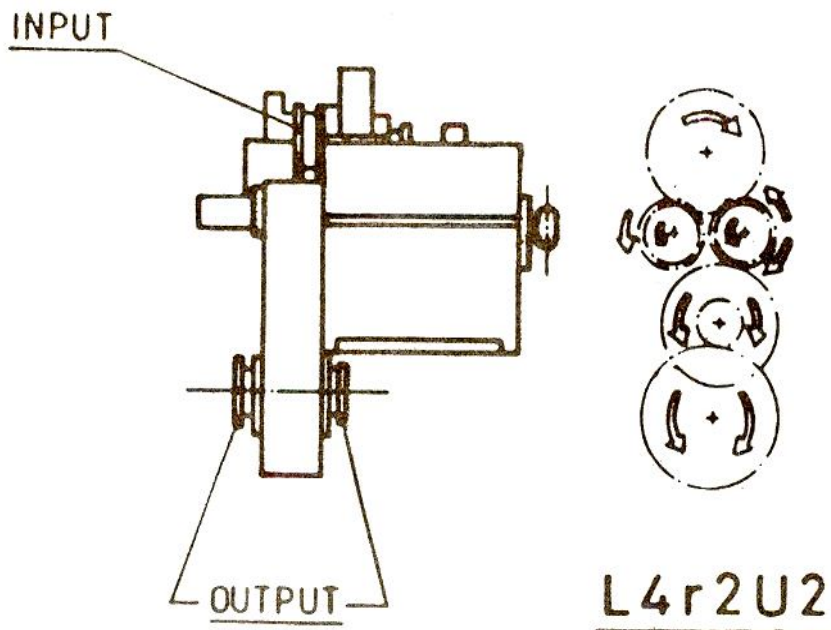


FIG: FRONT VIEW OF TRANSMISSION (L4r2U2)

SBM No.	Loco Model Narrow Gauge	Axle drive
741.100	ZDM 4A	2 Nos. Countershaft Axle Drive SBM 730.100 2 Nos. final Axle Drive SBM 728.000
	Special Narrow Gauge	
741.600	NDM 5	2 Nos. Counter Axle Shaft Drive SBM 734.100
	ZDM 5	2 Nos. final Shaft Axle Drive SBM 731.100



1.1 GENERAL DESCRIPTION:

The primary components of the transmissions are two hydrodynamic torque converters with which the transmission of power is effected by means of inertia forces of the operating medium.

The hydrodynamic torque converters each consist of one pump impeller, one turbine wheel, and one fixed reaction member or guide wheel. In the power absorbing section, i.e. the pump impeller, the mechanical energy delivered by the diesel engine is converted into fluid-kinetic energy. In the adjacent turbine wheel. The mechanical energy is re-obtained by deceleration and deflection of the flow of operating oil. Torque developed in the turbine wheel is dependent upon the degree of deflection of the operating oil. The deflection, and thus torque is at its greatest with turbine wheel arrested; with increasing turbine speed, it decreases. As the third primary component of a Hydrodynamic torque converter, the guide wheel has the task of maintaining constant direction of flow to the pump impeller, independent of outflow direction from the turbine wheel, so that the power absorption of the pump impeller is not influenced by the prevailing turbine wheel speed. In this way, the guide wheel enables a multiplication of torque to be effected, and takes up the reaction torque between pump impeller and turbine wheel.

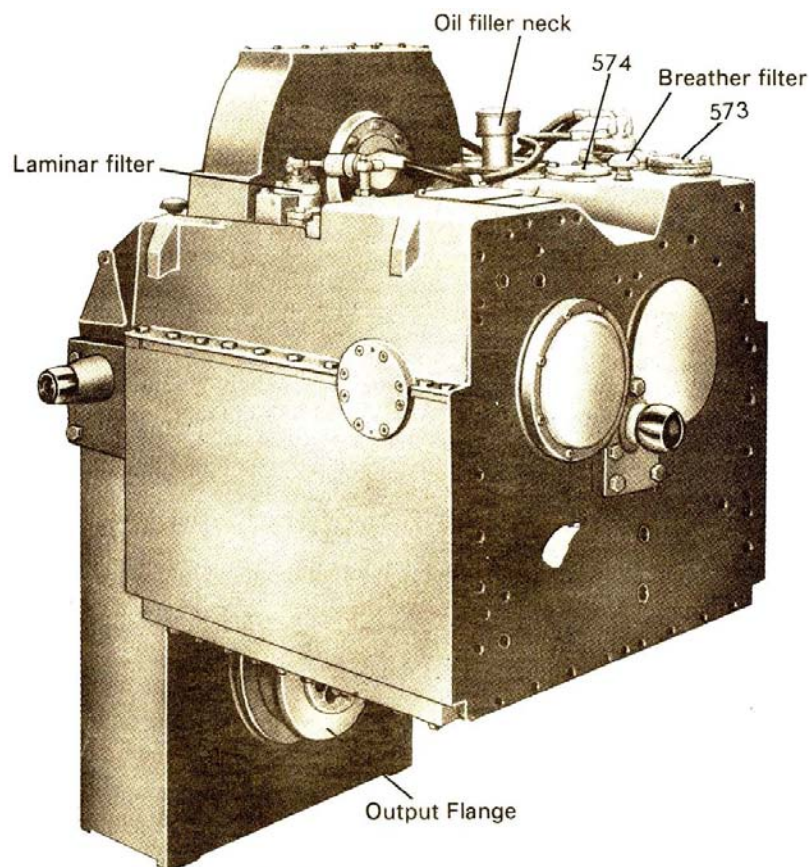


Fig. 2 — Rear View (L4r2U2)

- 573 Connection to heat exchanger (temperature monitoring device to be provided in pipeline)
- 574 Connection from heat exchanger

Due to their ability to multiply torque and to automatically adapt turbine speed, i.e. rail speed, to prevailing load conditions, torque converters are suitable both for starting and for operation at medium and high speed. The torque converter is engaged by filling it with oil and disengaged by draining it. The hydraulic circuits are filled by a centrifugal pump driven from the primary side of the transmission. This pump is known as the filling pump.

Each of the two torque converters is allocated a direction of travel. (As the relationship between rotational direction of output shaft and locomotive direction of travel can differ, the terms "Rotor A" and B" or " Converter direction "A" and "Converter B" are employed in the following text. Rotational direction "A" refers to a situation where input and output shafts in the same direction, and rotational direction "B" where these two shafts rotate in opposite direction). Locomotives take off or a shafing from one converter to another by respective filling and draining is effected smoothly. All gearwheel remain constantly in mesh. This purely hydraulic transmission dispenses with mechanical selector components subject to wear and ensures a maximum in operational reliability and freedom from maintenance.

A great advantage of the forward-reverse turbo transmission is that the reverse torque converter can be engaged while still traveling in a forward direction. As soon as the opposite direction of travel has been selection on the master controller, the reverse torque converter automatically retards the locomotive. The degree of braking effort is governed by the setting of the master controller.

1.1 MECHANICAL DESIGN

Input shaft, directly driven by the engine, drives primary shafts via gearwheel. Mounted on the primary shafts are pump impeller of converter A and pump impeller of converter B.

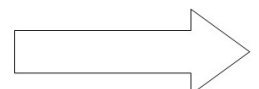
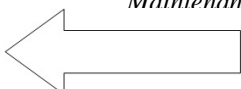
1.2 CONTROL SYSTEM

1.2.1 Transmission in neutral (Ref. Schematic Control Circuit diagrams)

Primary shaft driven by the step-up gear drives the filling pump via gears. At engine idling speed, this draws oil from the transmission sump and delivers it to the heat exchanger along line and to the main control valve along line. The oil flows back to the sump via the neutral outlet in the main control piston. The valve is a pressure-limiting valve. Oil is supplied to lubricating points and converter jets via the non-return valve. See cooling 1.4 and Lubrication 1.5.

1.2.2 Transmission engagement – traction – transmission disengagement (direction of rotation A or B) (Ref. Control Schematic Control Circuit diagrams)

The positioning piston or main control piston is moved up or down pneumatically via lines according to the direction of travel selected by the master controller. The neutral outlet in control piston is closed when this takes place. According to the position of control piston oil is passed either from line 574 via line 115 to converter A or via line 125 to converter A or 126for converter B is closed as the case may be. In this way, a closed circuit is obtained between converter, main control, heat exchanger, main control, and converter.



When the master controller is placed in its neutral position, line 301 or 302 is unloaded. The main control piston 602 is pushed into mid-position by spring pressure, the supply and drain lines 115+116 of converter A or 125+126 of converter B are opened to the oil sump, the respective converter is drained, and the transmission is disengaged.

1.2.3 Braking operation A (from direction of travel converter B) (Ref. Schematic Control Circuit diagrams)

To effect a hydrodynamic braking operation with the transmission, the master controller is placed in the position for the opposite direction of travel.

The compressed air line 302 is unloaded via the vehicle controls and converter B is drained. Simultaneously, the pilot piston 301 of main control 60 is loaded and converter A for the opposite direction of travel is filled. Braking torque can be regulated with the master controller via the engine speed.

By the oil pressure from secondary lube pump 54 in line 543, the control piston 311, in three-way valve 31, is held against spring tension, in end position up until approx. 3% of V max & maintains air line 303 for engine speed limitation unloaded until close to stationary state when a braking command is given.

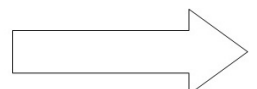
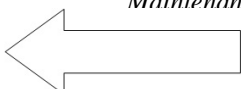
When braking with transmission, engine speed must be limit to 60% of maximum to avoid the possibility of skidding and inadmissibly high oil temperatures. Close to stationary state of the vehicle, the spring tension in three-way valve 31 is greater than the secondary control pressure in line 543. The spring pushes the control piston 311 into and position and lets air under pressure pass from line 301 to 303. This means that the air in line 303 is switched as follows: "loaded during traction." "Unloaded during braking or control common opposite direction of travel". Without bringing the master control into the neutral position, the vehicle takes off immediately in the opposite direction of travel.

1.3 COOLING

With the transmission in neutral and the engine running, a specific flow of oil is conveyed by filling pump 51 to the heat exchanger 57 where it is cooled and passed through the outlet in main control piston 602 into the oil sump. (Circuit not closed). Simultaneously, oil is passed to the converter spray jets 545 via non-return valve 563/564 and line 562. When the locomotive is coasting or on Towing, oil is supplied by the secondary lubricating pump 54 to the converter spray jets 545 via the non-return valve 546.

The oil subjected by the converter jets dissipates the heat developed by air circulation in the empty converter.

During traction and braking, the oil circulates in a closed circuit from converter A or B to the main control 60, line 573 to the heat exchanger 57 where it is cooled, and



from there to the main control 60 via line 574, and then to respective, engaged converter.

Oil cooling is so designed that, under normal operating conditions, the oil temperature will remain within permissible limits. Long-term operation under full load below the minimum permissible continuous rail speed or sustained braking with the transmission at high engine speed, cause excessive oil temperatures and thus premature ageing of the oil. Excessive oil temperature by decreasing the engine speed.

For the monitoring of transmission oil temperature, provision must be made in the locomotive control system for an appropriate device.

The normal operating temperature for the Transmission oil is between 70°C to 100°C. However, transmission oil temperature upto 120°C is permissible for very short duration. Frequent or prolonged operation of transmission under such temperatures are harmful to service life of oil and consequently might affect the performance. Oil which has reached 130°C must be checked in Laboratory for serviceability.

Temperatures as mentioned above are to be measured before oil enters the Heat Exchanger.

1.4 LUBRICATION

All ball and roller bearings of the Kirloskar Voith Turbo-reversing transmission are lubricated with filtered oil. From engine idling speed, the filling pump 51 supplies the oil. During operation, this is supported by the secondary lubricating pump 54. During towing operations, the secondary lubricating pump takes over the task of oil supply irrespective of direction of rotation.

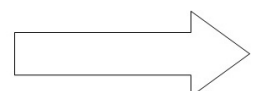
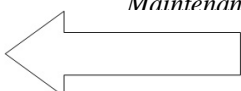
Lubricating oil supplied by the filling pump 51 is branched off after the heat exchanger 57. From here it is passed to filter 56 via the non-return valve 553 and line 561, and from there to the lubricating point 58 via line 581.

The oil supplied by the secondary lubricating pump 54 during normal operation and during towing flows through the non-return valves 546 and 564 and line 562 / 561 to the filter 56, and via line 581 to the lubricating points 58.

In stationary state, and with the locomotive moving slowly, the non-return valve 564 (with restrictor bore) allows an adequate of oil for the converter spray jets.

1.5 SCAVENGER PUMPS:

Lubricating oil collecting in the output drive housing is returned to the transmission sump by the primary scavenger pump 53 along lines 532 and 534 any by the secondary scavenger pump 55 along lines 552 and 554.



At low rail speed with the engine running, the supply capacity of the primary scavenger pump 53 predominates; during towing operations, i.e. with engine switched off and secondary components rotating, the suction of lubricating oil collecting is under taken by the secondary scavenger pump 55.

1.6 OVERSPEED DETECTOR

The over speed detector is mounted on the secondary shaft 22 for L4r2U2 and 23 for L4r2U which is comprised of the centrifugal governor 70 with electrical/Pneumatic contractor 68.

This instrument has the task of protecting the secondary components of the transmission from getting damaged by excessive rotational speeds (due to excessive rail speed). Response is approx. 50% above V_{max} .

When centrifugal governor 70 responds, an electrical/ Pneumatic contact is made which initiates an emergency braking through the vehicle control system. The emergency braking is released again when rail speed has fallen below maximum ($V_{max}+50\%$)

The transmission must also be protected against over speeding when the vehicle is towed, meaning that the function of the over speed detector and emergency braking must be maintained during this mode of operation too.

2. OPERATION:

2.1 PRE-OPERATIONAL PROCEDURE:

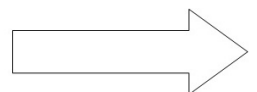
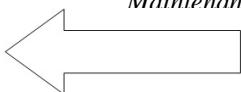
1. Check the oil level (with a new transmission fill with oil as per 3.1)
- 2 Start the engine with master controller in the neutral position.
- 3 If the engine speed is to be increased to pump air faster, the transmission filling inhibitor should be engaged.

2.2 STARTING:

Place the master controller in the desired direction of travel to "Transmission fill" Converter A or Converter B as the case may be is then filled, and a higher power stage can be selected. Avoid wheel slip. In the event of wheel slip, do not sand, but notch down the master controller.

2.3 MAIN LINE OPERATION:

If the master controller is placed in neutral position while on the move, the engine will revert to idling speed and the engaged torque converter will drain. This enables a perfect free wheeling of the transmission. If the transmission is re-engaged by the master controller. The appropriate converter will fill.



The maximum rail speed indicated on the operating and instruction plate must under no circumstances be exceeded under full power or when idling, e.g. on a down-gradient.

2.4 CHANGING THE DIRECTION OF TRAVEL:

When the master controller has been placed in “forward” or “reverse” a change in direction of travel is initiated and the torque converter corresponding to the selected direction will be filled. The transmission can be re-engaged in the same direction or engaged in the opposite direction of travel at any time while the vehicle is moving.

2.5 BRAKING WITH THE TRANSMISSION”

To brake hydro dynamically, the master controller in the vehicle must be moved into the braking position. This causes the converter of the prevailing direction of travel to drain and the other converter to fill. The vehicle is retarded. The control command braking-traction can be initiated at any speed.

With regard to heat dissipation from the transmission oil and danger of skidding, the engine speed during braking is to be limited to 60% of its maximum. When the vehicle reaches stationary state and the master controller is not placed back in the neutral position, the vehicle will take off immediately in the opposite direction of travel.

2.6 TOWING:

The transmission is equipped with a secondary lubricating pump, allowing the vehicle to be towed with the engine switched off. The secondary components rotating during a towing operation are lubricated by the secondary lubricating pump 54. An adequate oil filling is to be ensured.

Because only one converter is employed for the entire speed range, the vehicle can be towed at 50% over maximum operating speed.

If damage to the secondary parts of the transmission is suspected, the universal joint shafts between transmission and axle drives must be uncoupled.

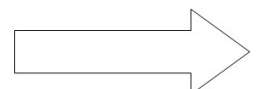
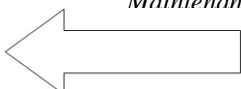
3. MAINTENANCE:

3.1 FILLING THE TRANSMISSION WITH OIL:

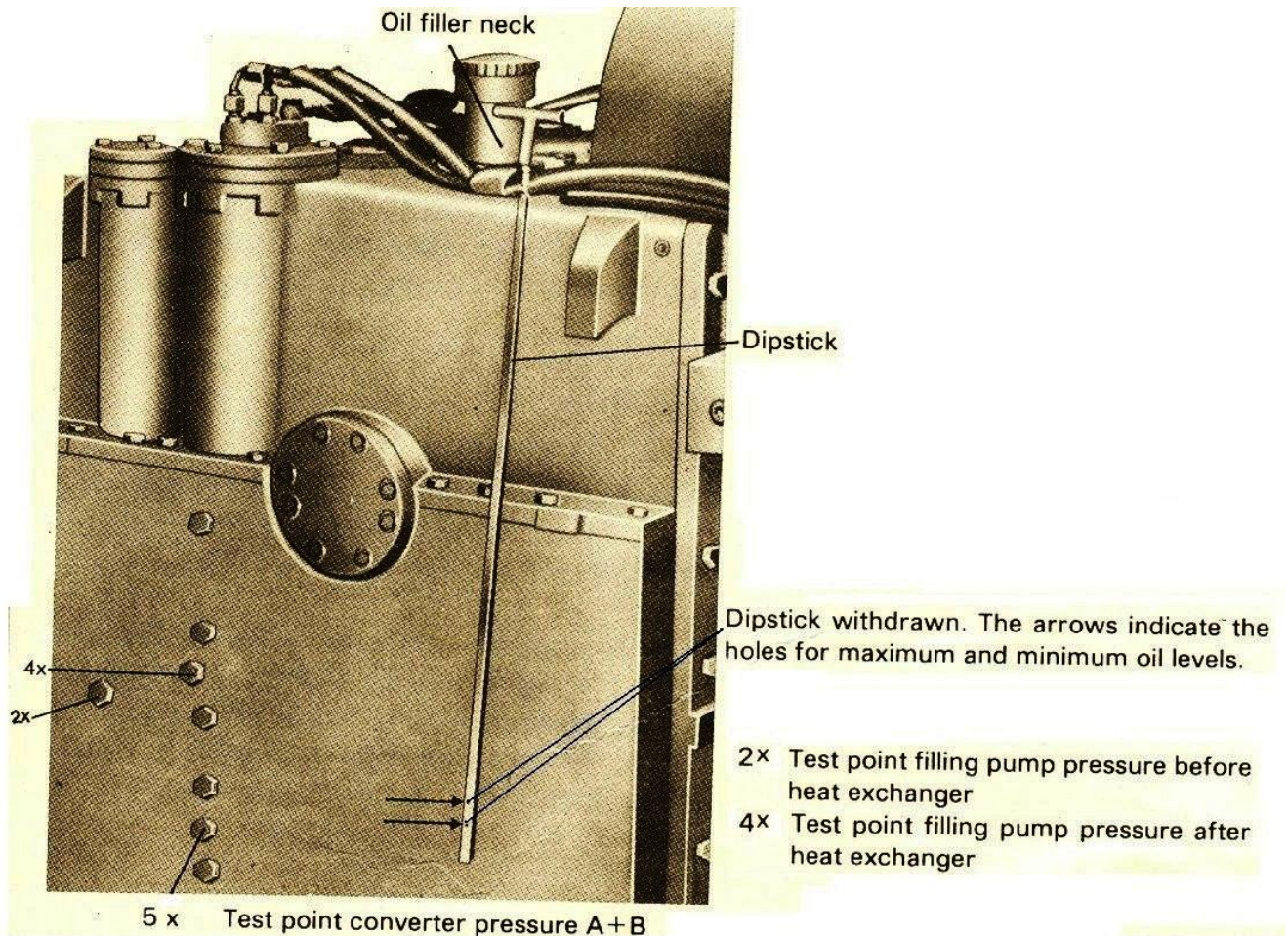
The transmission must be filled prior to starting the engine.

This is undertaken as follows:

1. Unscrew the cover from the oil filler neck 803 and withdraw the dipstick. See fig. 3.



2. Pour in oil. The transmission required approx. 130 Liters of oil not counting the contents of the heat exchanger.
3. Run the engine for several minutes at idling speed and then switch off.
4. Check the oil level (fig.3) and top up as necessary until the oil level is between the two holes in the dipstick.
5. If a large amount of oil is required to top up, repeat 3 and 4.
6. Close the oil filter neck and replace the dipstick.



3.1.1 Any mineral oil selected from our list of recommended oils may be employed (see appendix). Other oils specified as "Equivalent" and mixtures of fouled oils must under no circumstances be used; these can cause foaming and may often not possess the required lubricating properties. Before another types of oil is used, which is not listed in the attached list, it must be approved by Kirloskar Pneumatic, otherwise the rights under the transmission guarantee may be forfeited.

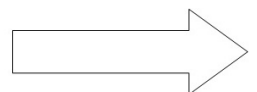
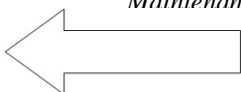
3.2 MAINTENANCE SCHEDULE:

50 Hrs./3 Days after first commissioning or after major overhaul.

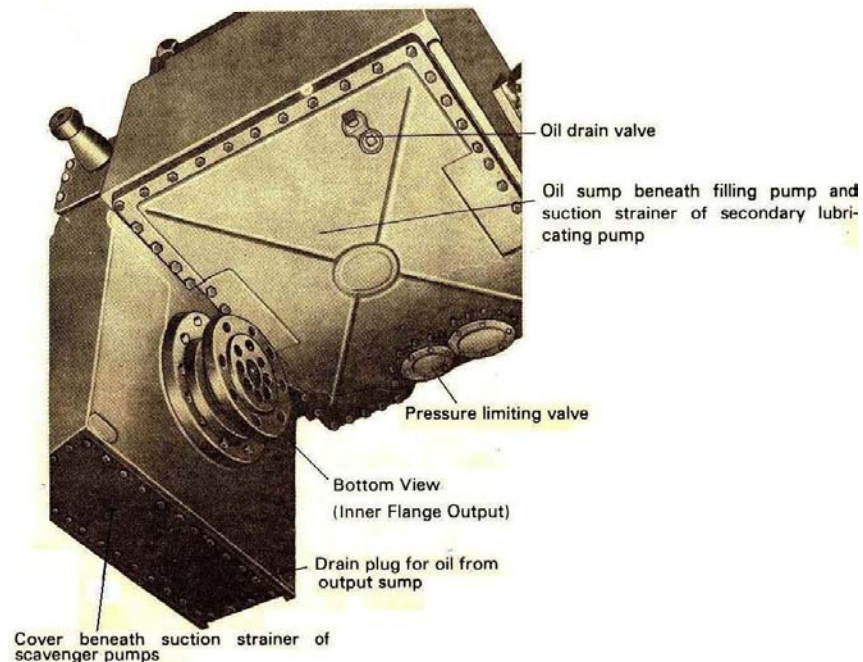
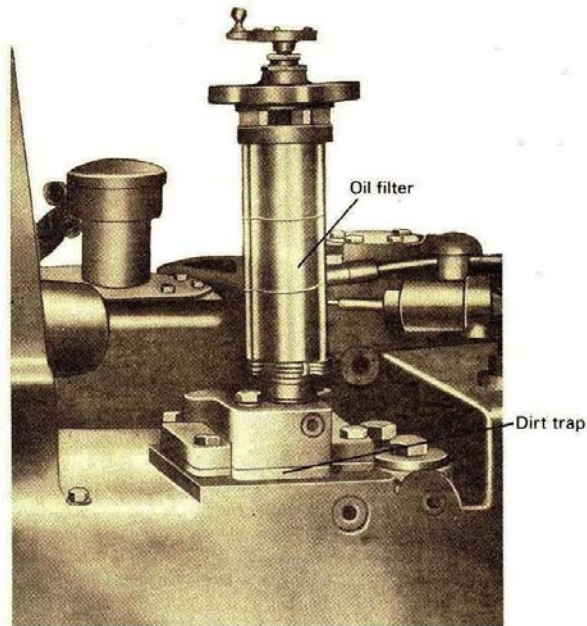
a) Drain off from sump completely and filter it (See Figure 5).

- b) Clean
- 1) Laminate Filter Element.
 - 2) Strainer of Secondary Lube and Scavenging Pump.
 - 3) Strainer of Primary Scavenging Pump.
 - 4) Strainer of Filter Pump.
 - 5) Bottom Covers of Main housing and Final Drive housing.

	Period	Work to be done.
1	Daily	A) Check for Oil Leakage.
		B) Check Oil level Top up if necessary.
		C) If automatic facility is not available, rotate oil filter handle manually
2	Every 300 Hours or 10 days which ever is earlier.	Repeat procedure A, B & C Above.
		D) Remove and clean laminar element and its dirt trap.
		E) Drain Moisture separator in Pneumatic circuit of Trans. Follow instruction as per OEM Manual.
3	Every 1000 Hours or 3 months which ever is earlier.	Repeat procedure A,B,C,D & E above.
		F) Drain oil from sump completely and filter it.
		G) Analyse oil sample from sump for contamination of Foreign particles, Water or change of viscosity. Reuse if it is in good condition otherwise change.
		H Clean:
		i) Laminar filter element.
		ii) Strainer of Secondary lube and scavenger Pump.
		iii) Strainer of Primary scavenger Pump.
		iv) Strainer of Filler Pump.
		l) Clean bottom cover of main housing And final drive housing.
4	Every 5000 Hrs. 15 Months.	j) All the Non-Return valves to be cleaned (Two Nos. Near the Laminar Filter and one No. on Secondary Lube Pump) Because of similar construction and appearance this work should be done on one valve at a time basis. This will avoid mix-up of location.
		Repeat procedure A to J above.
		K) Disassemble Relief Valve Assembly. (See drawing No. 741.1.33.00.50) Clean, reassemble and refit on transmission.
		L) Remove Bottom cover of Main Control. 741.1.32.28.50 (Ref. Drawing No. 741.1.32.00.50) of main control Assembly. Clean bottom area and refit.
		M) Check Laminar element. Replace if necessary.
		N) Replace both breathers.
		O) Replace all sealing rings of controls of transmission.
		P) Check both pumps and replace if necessary.
		Q) Check all strainers, Replace if necessary.
		R) Replace Direction Control valve if necessary.



5	Every 30000 Hrs.	Major Overhaul.	
		a	Replace all Antifriction Ball and roller bearings.
		b	Replace all rubber parts.
		c	Replace all Labyrinths.
		d	Replace felt seals.
		e	Replace both pumps.
		f	Replace all Pneumatic and hydraulic valves.
		g	Replace hoses check for wear on gears and shafts, Replace if necessary.

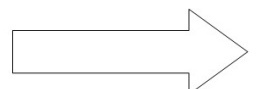
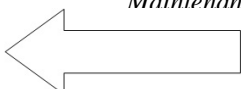


4. TROUBLE SHOOTING:

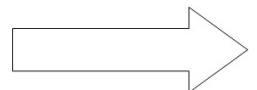
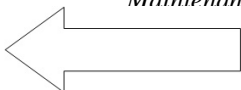
4.1 DETECT AND ELIMINATION OF FAULTS:

If any fault is noticed first check the oil, see 4.1 a to d below:

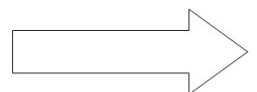
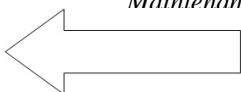
	Observation	Possible cause	Remedy
4.1.1	Vehicles fails to move with master control in "Transmission fill" position & brakes released.	Master controller of Loco malfunctioning. Air pressure at Main control of Trans. Too low.	
		a) Too little oil in the transmission.	Check oil level (See figure 3) and top up as necessary with the same brand of oil.
		b) Oil is too cold (Guaranteed tractive effort is not attained until oil has reached a temperature of 70°C) at outlet of Heat Exchanger.	Apply Vehicle brake place Master controller in "Transmission fill" position until normal oil temperature is obtained. While doing so, occasionally switch to neutral to allow Converter to drain and thus not to overheat.
		C) Incorrect or dirty oil.	c) Change oil (See 3.1)
		d) Water in the oil (if oil is cooled in a heat exchanger.	d) Check heat exchange for leakage and repair as necessary change oil (See 3.1).
		e) Position piston 601 and main control piston 602 remain in idling position.	e) Check control air pressure. Minimum pressure at Main control should be 5.0 Bar. If not check master controller Valve in Loco control circuit.
		f) Main control piston (602) or positioning piston 601 sticky.	f) Remove Main control and free the piston see fig. 6.
		g) Sealing ring on positioning piston 601 damaged.	g) Remove main control and replace sealing ring.
		h) Filling Pump pressure too low though oil level is	h) Check the pressure at test point



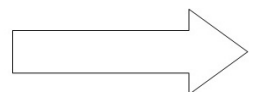
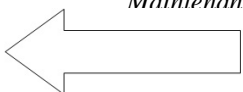
		correct.	2X (fig.3) engage filling inhibitor and bring engine up to upper idling speed. If no pressure is in evidence remove cover (511 take out the filling pump and examine (See ifg.5) Replace pump if required.
		i) Loco service brake not physically released.	i) Check & correct the brake system.
		j) Pressure limiting valve (61) stuck in open position.	j) Remove valve 61 and examine (Fig.5) replace if required.
		k) Air in direction control valve leaking (item 741.1.50.12.50)	k) Replace direction control valve.
		l) Poor sealing effect of piston rubber (item 741.1.50.10.50)	l) Replace the piston and clean stationary flanges. (item 741.1.50.07.50)
4.1.2	Poor tractive effort.	a) See 4.1.1 'a' to 'j'.	a) See 4.1.1 'a' to 'j'.
		b) Engine does not reach its full speed under load.	b) Check air supply line pressure by unscrewing control air line 303 (union 3) on flange 30. It should be min. 5.0 bar. If air pressure is OK, check piston in 3/2 way valve 31/32, may be sticking or spring broken Double check if valve 304 does not seal properly (fig.7). Repair or replace 3/2 way valve and double check valve if necessary.
4.1.3	Transmission oil gets too hot.	a) Heat exchanger capacity of cooling unit too low (Shutters closed' tubes blocked).	a) Repair heat exchanger or cooling units as necessary.
		b) Operation below the minimum continuous speed	b) Decrease the trailing load or work at

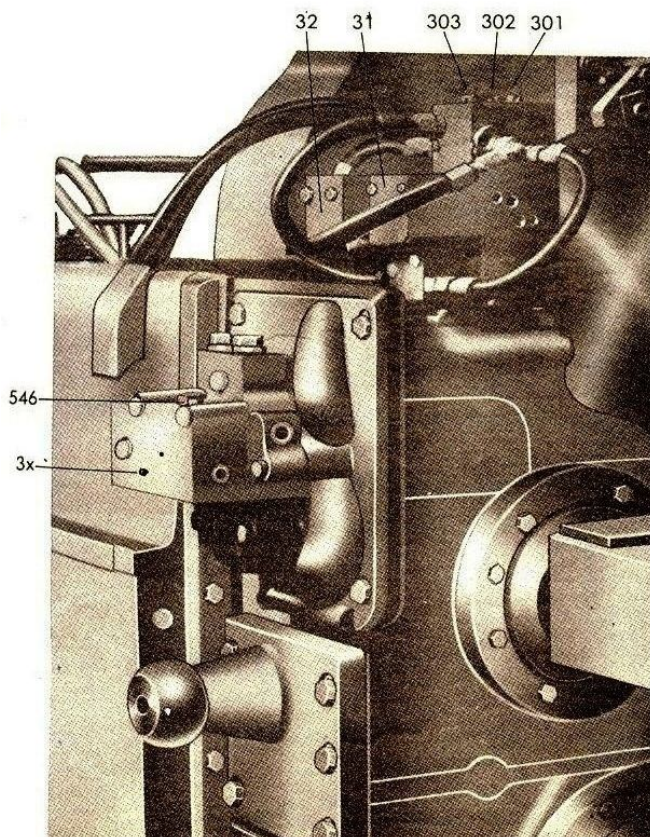
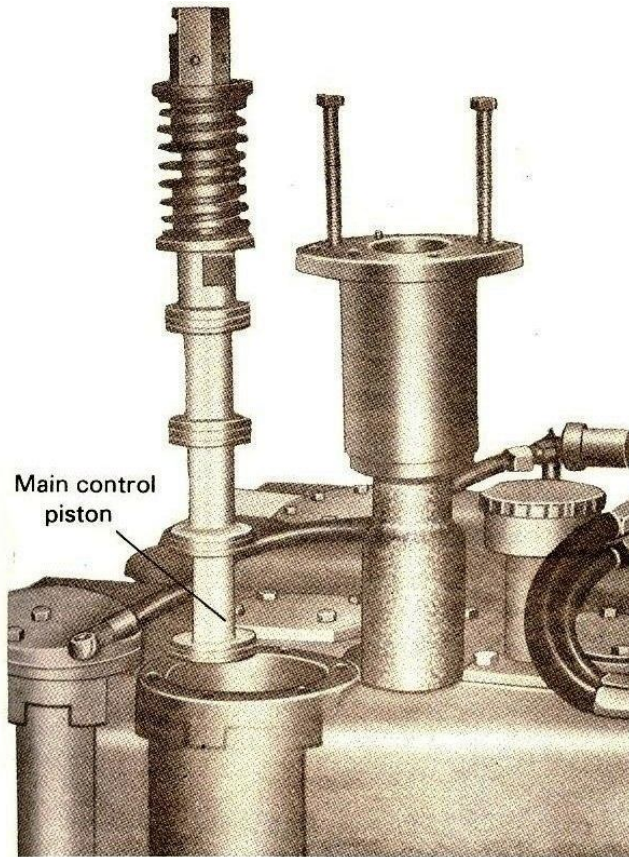


		under full engine power.	high Loco speed.
		C) When braking hydro dynamically. Engine runs at full speed 3/2way valve (31 or 32) not operating, piston sticking.	C) Remove 3/2way valve (31 or 32) inspect and renew seals as necessary (Fig. 7).
		d) See (4.13c) by pass line 543 or 544.	d) Check Control pressure of sec. Lube Pump 54 at check point 3x (fig.7) when vehicle is stationary this will not indicate any pressure and when vehicle is on move this will show pressure while vehicle is on move, remove sec. lub oil pump 54 and inspect (Fig. 8).
		e) Water in oil.	e) Check heat exchanger for leakage and repair. Drain oil from Heat exchanger & clean. Use new oil.
4.1.4	Master Control in Neutral position & tractive effort observed.	a) Main control piston (602) or positioning piston (601) Sticky.	a) See 4.1.1.f.
		b) Compressor air escaping via Master controller at Driver's cabin.	b) Rectify the fault in the vehicle control system using instructions recommended by supplier for master controller.
4.1.5	Too little or no braking effort.	a) See 4.1.1 a to 4.1.1.g.	a) See 4.1.1 a to 4.1.1.g.
		b) Engine does not come up to its specified speed during braking.	b) Eliminate the fault in the vehicle control system or engine regulation to achieve the engine speed as recommended (Ref. 2.5 and Loco Manual for relevant Instruction).

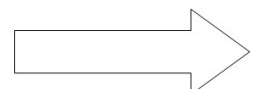
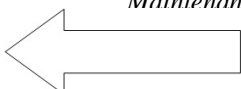


4.1.6	Braking effort too great.	a) See 4.1.3c to 4.1.3.d	a) See 4.1.3c to 4.1.3.d
4.1.7	Oil Leakage at out put drive.	a) Strainer for primary & secondary pump clogged.	a) Drain oil from output drive housing screw 806 remove cover 805 and clean strainers (Fig.5).
		b) Secondary scavenger Pump defective.	b) Remove pump (54/55) & examine replace if required.
		C) Primary scavenger pump 53 defective.	C) Remove oil sump 511 beneath the filling pump (Fig.5) Remove & inspect filling pump(51) with Primary scavenger pump (53) Replace if required.
		d) Drive to pump broken down.	d) Replace drive components.
4.1.8	Emergency braking initiated.	a) Spring in centrifugal Governor 70 possibly broken.	a) Remove over speed drive 68/70 and examine (Fig. 9)Replace damaged/broken parts..
4.1.9	Abnormal noise in neutral & during operation.	a) Lube pumps defective check pressure at check point 1x(fig 10) and 6x (Fig. 12) minimum pressure at test point 6x=0.3 bar with vehicle moving.	a) See 4.1.1 h and 4.1.3d.
		b) Damage to rotary component or bearings.	b) Check Lamina filter 56 for metal particle. If metal particle is traced drain sump and inspect from bottom opening. Replace damaged/broken parts.
		C) Elastic rubber in flexible coupling between engine & trans. Becomes too hard, carrying torsional vibrations in pumps and pump drives.	C) Check & replace rubber element and damaged/broken parts in trans.





- 31 3-way valve direction of rotation A
- 32 3-way valve direction of rotation B
- 301 Air union direction of rotation A
- 302 Air union direction of rotation B
- 303 Air union for engine speed regulation
- 546 Non-return valve secondary lube pressure
- 3 x Test point secondary lube pressure



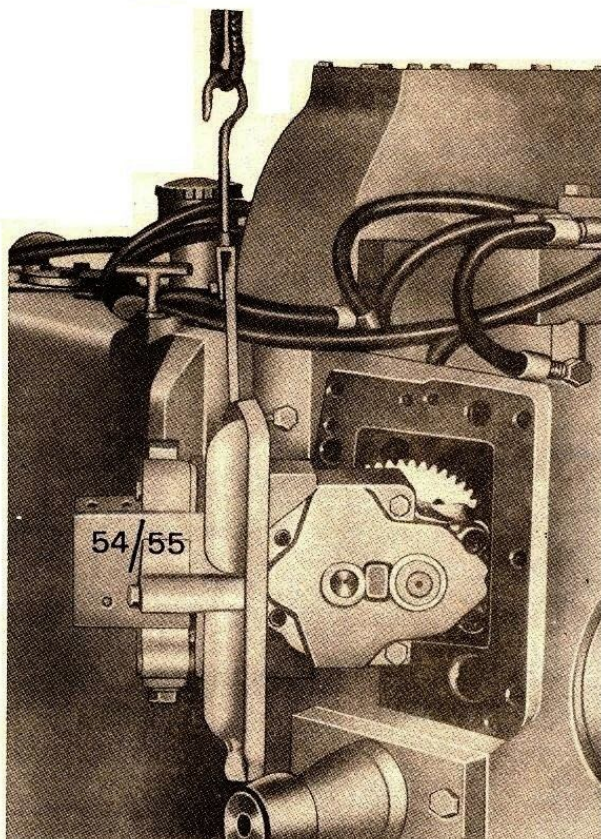
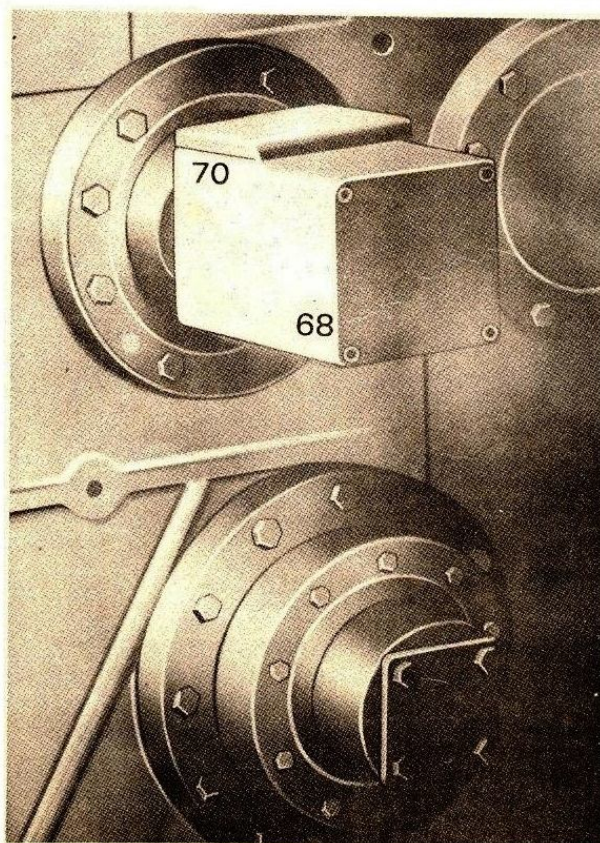
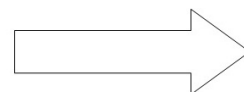
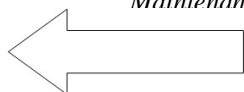


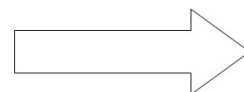
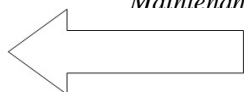
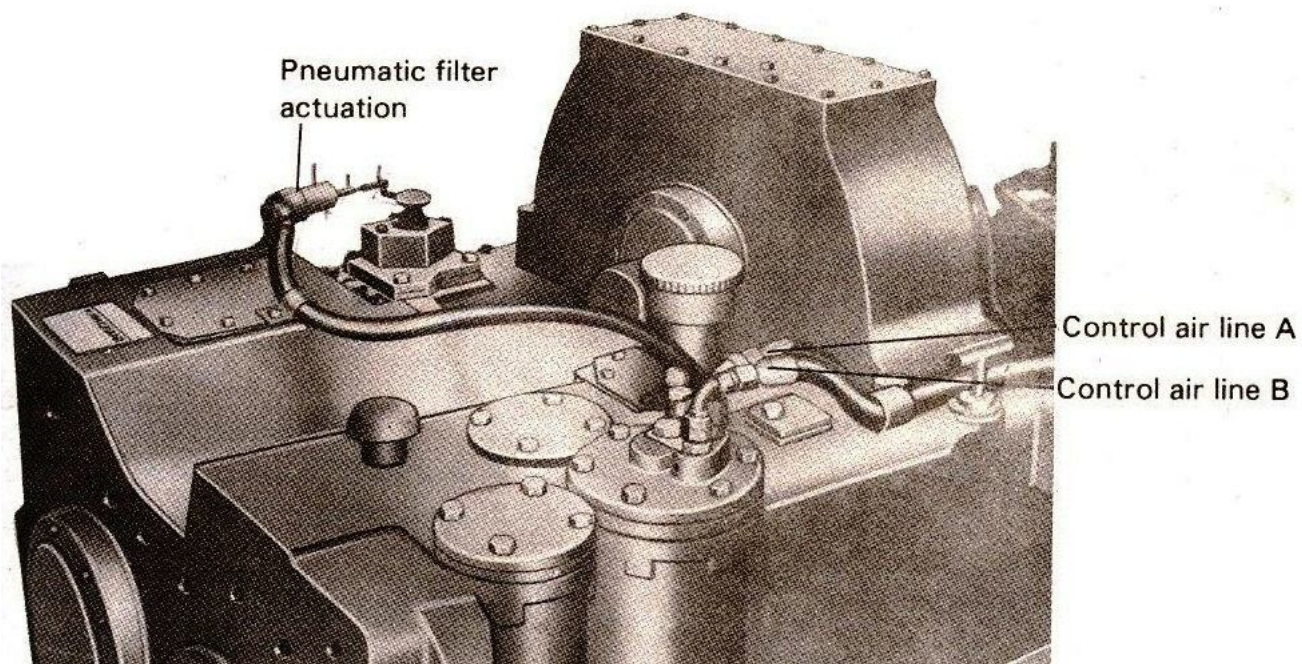
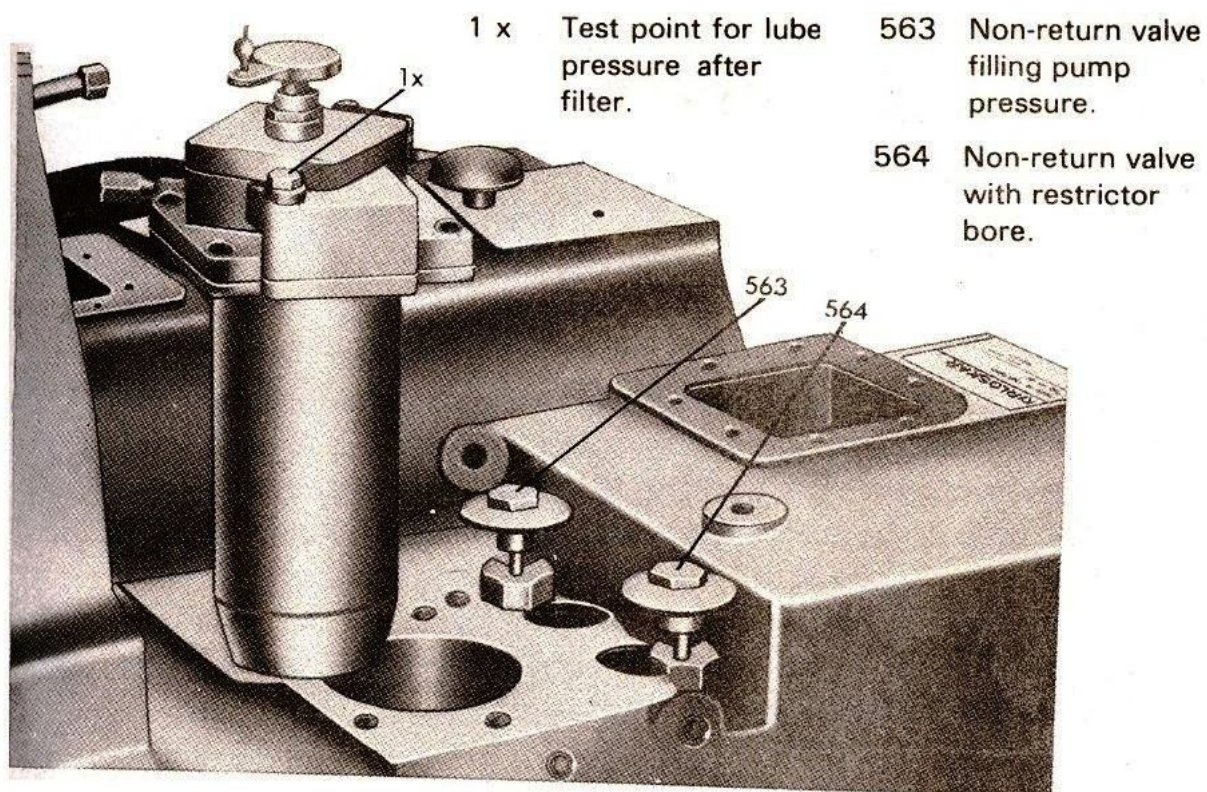
Fig. 8

- 54 Secondary lube pump
- 55 Secondary scavenger pump



- Overspeed valve, comprising:
- 68 Electrical contactor
 - 70 Centrifugal governor





4.2 TRANSMISSION TOOL KIT TO BE KEPT IN THE LOCOMOTIVE:

For use in maintenance work, removing some of the transmission components and repairing minor faults, a transmission tool kit is available, which should be kept in Locomotive.

4.3 ACTION TO BE TAKEN PRIOR TO THE REMOVAL OF A DAMAGED TRANSMISSION.

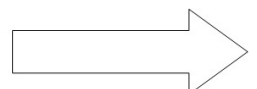
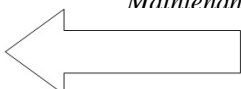
If an unusual noise noticed while in operation or some shining metallic particles noticed in oil filter Assly. Which indicates the possible damage in the transmission. First it should be check the location of defect whether on the primary side or secondary side components by feeling the resistance on rotating.

- a) Cardan shaft between engine and transmission Input should be disconnected and input shaft should be rotated.
- b) The Secondary side is checked simply by towing the locomotive.

Additionally, inspection is Possible through the openings in the transmission after removal of pumps and covers.

4.4 WORK PERMISSIBLE DURING THE PERIOD OF GUARANTEE:

Only minor repairs as listed under 4.1 may be carried out during the period of guarantee. Major repairs during this period are undertaken at the risk of forfeiting the rights of guarantee.



APPENDIX
KEY TO COMPONENT NUMBERS
(Shown in photographs)

1. Primary parts, Circuits.

10. Input drive Shaft.

- 101 Input drive gear.
- 102 Pinion and primary shaft (rotor A)
- 103 Pinion and primary shaft (rotor B)

11. Converter A.

- 111 Pump impeller.
- 112 Turbine wheel.
- 113 Guide wheel.
- 115 Supply line.
- 116 Drain line.

12. Converter B.

- 121 Pump impeller.
- 122 Turbine wheel.
- 123 Guide wheel.
- 125 Supply line.
- 126 Drain line.

13. Secondary parts.

- 20 Output drive shaft.
- 201 Output drive gear.

14. Countershaft.

- 211 Gear on Countershaft.
- 212 Gear on Countershaft.

22 Secondary shaft rotor B.

- 221 Output gear rotor B
- 222 Input Gear for 54/55.

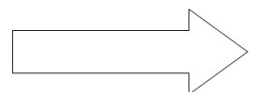
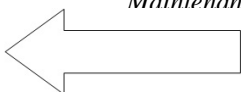
23 Secondary shaft rotor A.

- 231 Output gear rotor A.

2. Control arts reversing traction breaking.

30 Connection flange for control air lines.

- 301 Control air line to 31 and 60 (traction, direction or rotation A)
- 302 Control air line to 32 and 60 (traction, direction or rotation B)
- 303 Control air line after 31 + 32 (for engine speed regulation with out pressure when braking)



304 Double check valve in line 303.

31 3/2 way valve A.

311 Control piston in 31.

312 Relief restrictor before 31.

32 3/2 way valve B.

321 Control piston in 32.

332 Relief restrictor before 32.

5. Pumps, filter, Cooler.

51 Filling pump.

511 Oil sump under filling pump.

512 Pressure line.

516 Spur gear for

517 Filling pump drive.

518 Bevel Gear for.

519 Filling pump drive.

53 Primary scavenger pump.

532 Suction line.

534 Return line.

54 Secondary control and lube pump.

541 Drive Gear for 54.

542 Suction line.

543 Bypass line for 31

544 Bypass line for 32

545 Feed to converter spray jets.

546 Non-return valve.

547 Restrictor in line 543.

548 Restrictor in line 544.

549 Double check valve between lines 543/544.

55 Secondary scavenger pump.

552 Suction line.

554 Return line.

56 Oil filter.

561 Supply line from 51.

562 Supply line from 54.

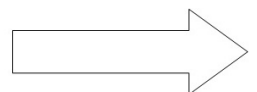
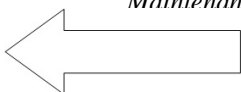
563 Non-return valve.

564 Non-return valve with restrictor office.

568 Drip trap.

57 Heat Exchanger.

573 Supply line to heat exchanger.



573/1 Restrictor in line 573 (injector)
574 Return line from heat exchanger.

58 Lubricating points.

581 Supply line.

6. Control parts.

60 Main control valve.

601 Positioning piston.

602 Control piston.

603 Neutral Outlet

61 Pressure limiting valve.

611 Supply line.

68 Electric contractor.

681 Lever.

682 Valve piston.

683 Thrust pin.

684 Manual release.

685 Control air line from brake relay valve.

686 Breather.

70 Centrifugal switch.

8. Miscellaneous.

801 Dipstick.

802 Breather filter.

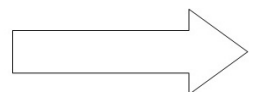
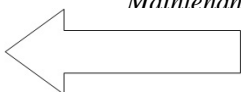
803 Oil filter neck.

804 Oil drain valve.

805 Cover below suction strainers.

806 Oil drain plug on output drive.

807 Pneumatic filter.



TEST POINTS.

Test Point No.	Connection Thread	Test Point Designation
1x	M 14 x 1.5	Lube pressure after filter
2x	M 14 x 1.5	Filling pump pressure before heat exchanger.
3x	M 14 x 1.5	Secondary lube pump pressure.
4x	M 14 x 1.5	Pressure after heat exchanger.
5x	M 14 x 1.5	Converter pressure.
6x	M 14 x 1.5	Lube pressure for output drive.

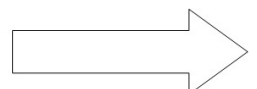
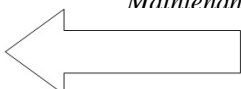
RECOMMENDED OILS

Supplier	Designation
Castrol	Hyspin VT2.
Indian Oil Corp. Ltd.	Servo Torque 10
Bharat Petroleum	Bharat Automatic Transmission Fluid 'D'
Veedol.	VeedolTF 32.

5. DISASSEMBLY & ASSEMBLY INSTRUCTIONS.**GENERAL REMARKS ON DISASSEMBLY AND ASSEMBLY OF KIRLOSKAR – TURBO REVERSE TRANSMISSION.**

The Manual is based on current mechanical design of the transmission. The KIRLOSKAR Company reserves the right to undertake the modifications of design as and when necessary.

1. The instructions for dismantling and assembly are prepared based on following two versions.
 - a. Instructions for removal and replacement of subgroups.
 - b. Instructions for disassembly and reassembly of subgroups.



Removal of subgroups is further subdivided into :-

- i. Removal of subgroups without dismantling the transmission from the Locomotive.
- ii. Removal of subgroups after dismantling the transmission from the Locomotive.

The design of Locomotive should be made in such a way that subgroup assemblies should be easily accessible and removed without taking out the transmission from the locomotive.

In all these above cases, this manual describes the correct sequence of dismantling in the assembly procedure. The assembly instructions are usually in the reverse fashion of those mentioned in the dismantling instructions.

While making the general overhauling some special equipments, such as Oil injection assembly, dismantling tools are necessary.

Special care must be taken while removing the transmission from the locomotive.

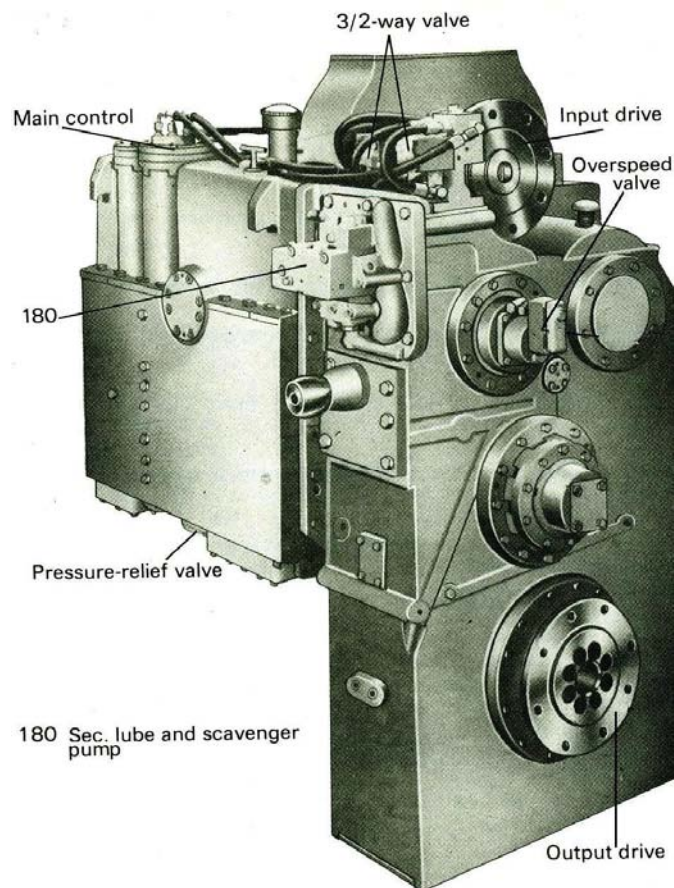


Fig. 1—Front view (L4r2U2)

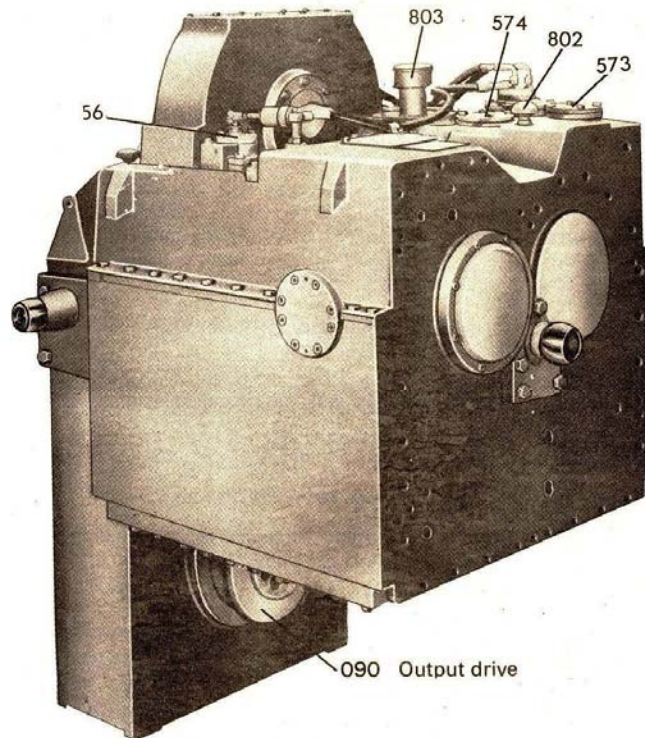


Fig. 2—Rear view (L4r2U2)

5.1 SUBASSEMBLY GROUPS WHICH CAN BE REMOVED AND REINSTALLED WITHOUT DISMANTLING OF THE TRANSMISSION FROM THE LOCOMOTIVE.

5.1.1 COMPRESSED AIR LINES (Ref. Drg. No. 741.1.47.00.50)

Disconnect compressed air lines on the 3/2 way valves, main control, and drive for laminar filter.

5.1.2 3/2 way valve (Ref. Drg. No. 741.1.50.00.50)

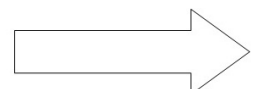
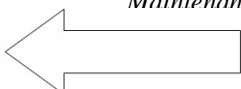
Unscrew hex head bolts 19 and remove 3/2 way valves. Unscrew socket head screws 15 and take off flange stationary 1. Unscrew socket head screws 11 and take off flange stationary 13. White Assembling gasket cement or loctite should be applied to the seating surface of flange stationary 13 and attention to be paid to sealing washers 18 and 10.

5.1.3 MAIN CONTROL (Ref. Drg. No. 741.1.32.00.50)

Unscrew Hex Head Bolts 20 and take off cover 21. Withdraw housing 17 and fitted main control piston 15 with the help of 2 eye bolts M 10 x 180.

Unscrew Hex. Head bolt 3 remove the cover 1 and withdraw the control bush with suitable clamp.

5.1.4 SAVET VALVE (Ref. Drg. No. 741.1.33.00.50)



Drain off oil before removing the safety valve. Unscrew Hex Head Bolts 11 & 12 and remove the drain valve completely.

5.1.5 OVERSPEED VALVE (Ref. Drg. No. 741.1.45.00.50)

Unscrew Hex Head Bolts 4 and remove the over speed valve with Ring support 2 by using M 10 puller bolts. Remove Sleeve spring and separate washer Disc 7. Unscrew nut Hex 5 and separate Ring support 2.

5.1.6 SEC. LUBE AND SCAVENGR PUMP GROUP 180 (Ref. Fig.1)

5.2 SUBASSEMBLY GROUPS WHICH CAN BE REMOVED AND REINSTALLED AFTER DISMANTLING OF THE TRANSMISSION FROM THE LOCOMOTIVE.

5.2.1 Separation of final drive Housing assembly from Main Housing Assembly.

5.2.1.1 Set the transmission in such a way that the final drive housing will be in top position.

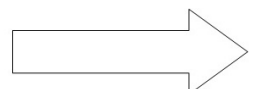
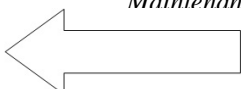
Unscrew hex head bolts 82 (Ref. Drg. No. 741.1.21.00.50) and remove the cover 30 by using puller screws of M x 1.5

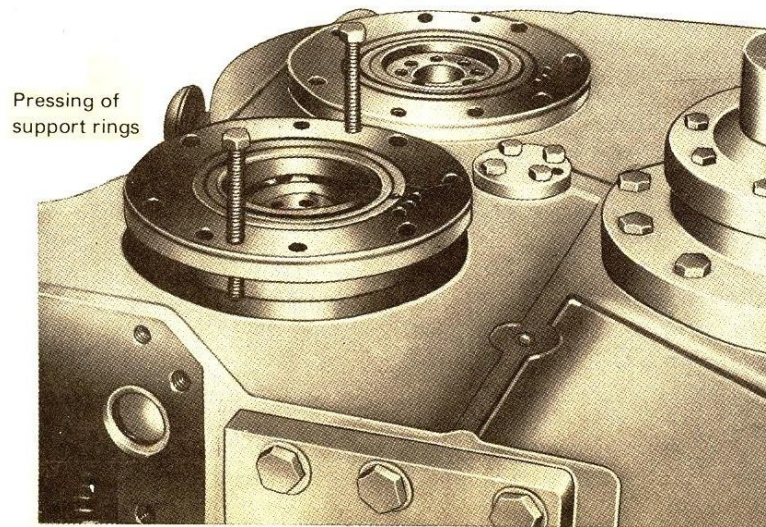
Unscrew socket Head Screw 79 (Ref. Drg. No. 741.1.21.00.50) and 68 (Ref. Drg. No. 741.1.20.00.50). Remove Ring retaining 78 (Ref. Drg. No. 741.1.21.00.50) and 57 (Ref. Drg. No. 741.1.20.00.50) by using M 6 puller screws.

Removing carrier Bearing 74 (Ref. Drg. No. 741.1.21.00.50) and 65 (Ref. Drg. No. 741.1.20.00.50) by using M 10 x 1.5 x 100 puller screws. In doing so, the four point contact bearing 73 (Ref. Drg. No. 741.1.21.00.50) and 64 (Ref. Drg. No. 741.1.20.00.50) and 63 (Ref. Drg. No. 741.1.20.00.50) are also removed from the housing.

Remove inner races of cylindrical roller bearing from both shaft along with retainer 71 & 62 in both rotor assembly.

Remove helical gear 58 (Ref. Pt. 60105) by using puller screws M 8 x 100.

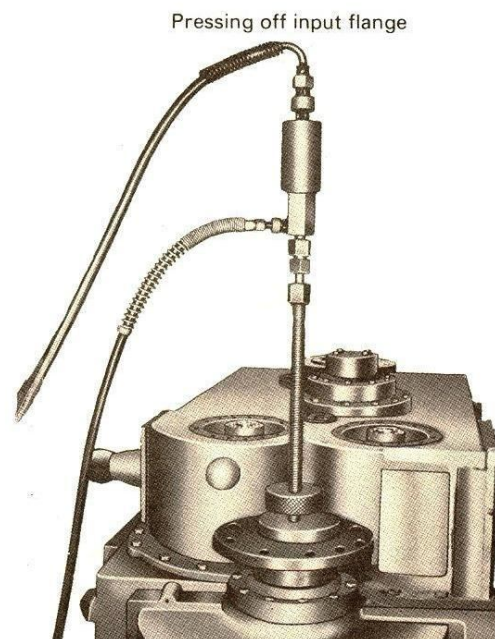
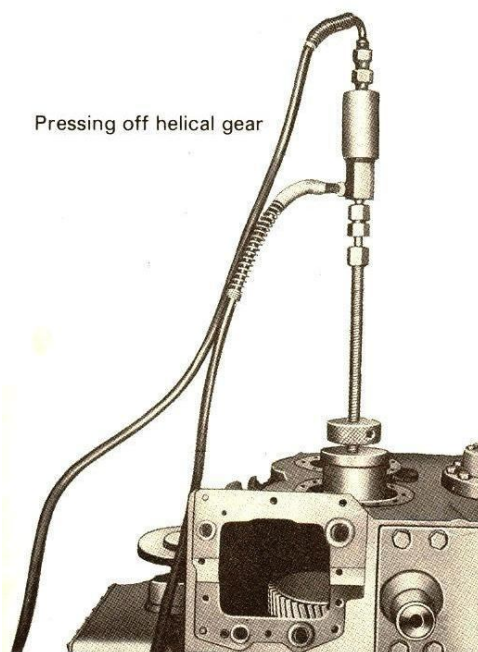




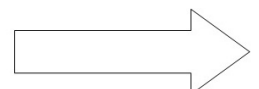
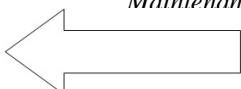
5.2.1.2 Remove gear 57 (Ref. Drg. No. 741.1.20.00.50) by oil injection method.

5.2.1.3 Remove input flange 23 (Ref. Drg. No. 741.1.36.00.50) by oil injection method.

5.2.2 Unscrew Hex Bolts 59, 60, 61, 62 (Ref. Drg. No. 741.1.10.00.50). Remove cover with gasket 57, 58 (Ref. Drg. No. 741.1.10.00.50). Discard gasket. Use new gasket while reassembling.



5.2.3 Remove transmission suspensions sub-assembly. (Ref. Drg. No. 741.1.46.00.50)



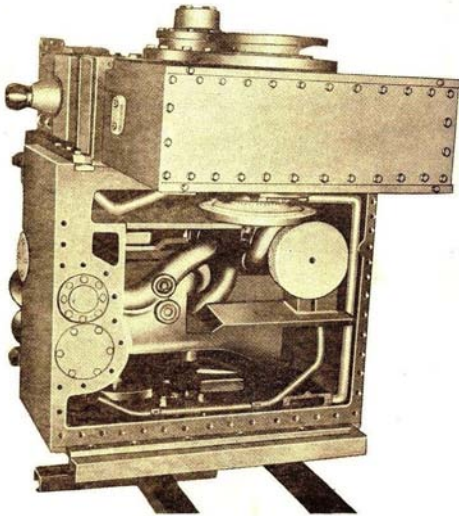


Fig. 6
Cover underneath filling pump
removed.

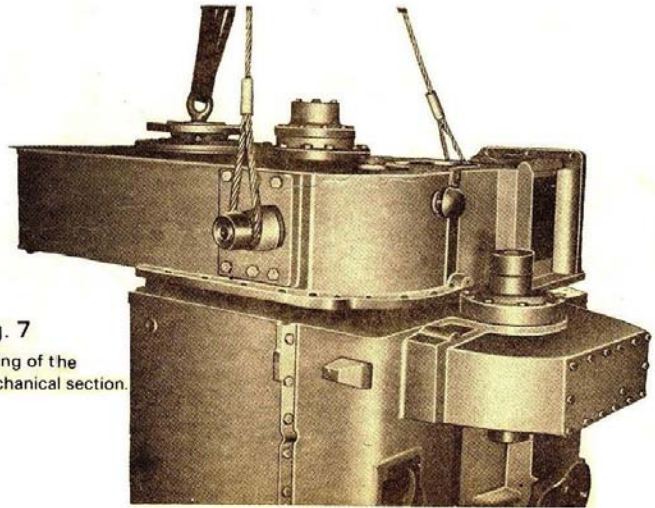


Fig. 7
Lifting of the
mechanical section.

Unscrew Hex bolts 4 (Ref. Drg. No. 741.1.30.00.50). Lift the final drive housing with the aid of two transmission suspensions sub assembly mounted on final housing and eye bolt fitted to output flange.

5.3 REMOVAL OF FILLING PUMP.

Unscrew the socket head screw 45 (Ref. Drg. No. 741.1.31.00.50) and remove the filling pump from Housing lower section. Take care of sealing rings 43 (Ref. Drg. No. 741.1.31.00.50)

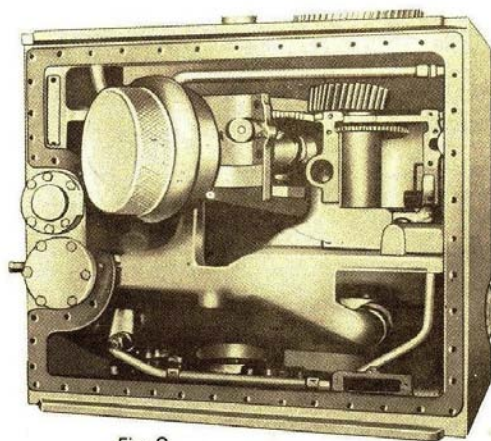
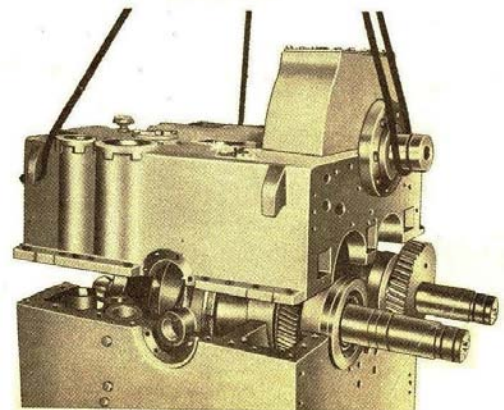


Fig. 8
Filling pump removed

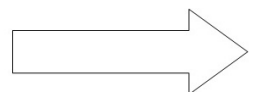
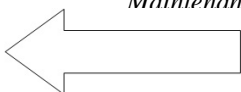
Fig. 9
Lifting off the housing
upper section



5.4 REMOVAL OF HOUSING UPPER SECTION WITH INPUT DRIVE.

5.4.1 Lift transmission and rest on platform so that the housing upper section is on top side. Unscrew Hex. Head bolts 76 and remove cover gasket 69, 70 (Ref. Drg. No.

- 741.1.20.00.50). Unscrew socket head screws 84, cover 93.2 (Ref. Drg. No. 741.1.21.00.50) Discard the gasket and use new gasket while reassembling.
- 5.4.2 Unscrew socket head screws 74 and remove torque arm 73.1 (Ref. Drg. No. 741.1.20.00.50)
- 5.4.3 Unscrew socket head screws 87 and remove torque arm 86 (Ref. Drg. No. 741.1.21.00.50)
- 5.4.4 Remove bolts 3, 4, 5, 6 Unscrew socket head screws 74 and remove torque arm 73.1 (Ref. Drg. No. 741.1.10.00.50). Lift the housing upper section with input drive complete. Due care must be taken for sealing ring 7, 8, 9, 10 Unscrew socket head screws 74 and remove torque arm 73.1 (Ref. Drg. No. 741.1.10.00.50)
- 5.5 REMOVAL OF ROTOR ASSEMBLY.**
- 5.5.1 Use suitable eye bolts (M 24 & M 20 size) and lift out the rotor assembly (Both)



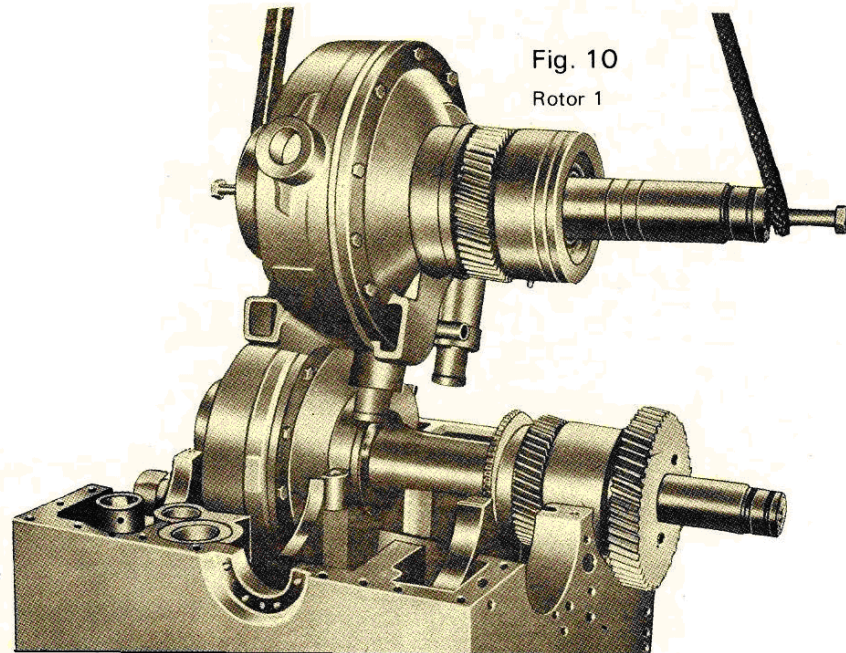


Fig. 10

Rotor 1

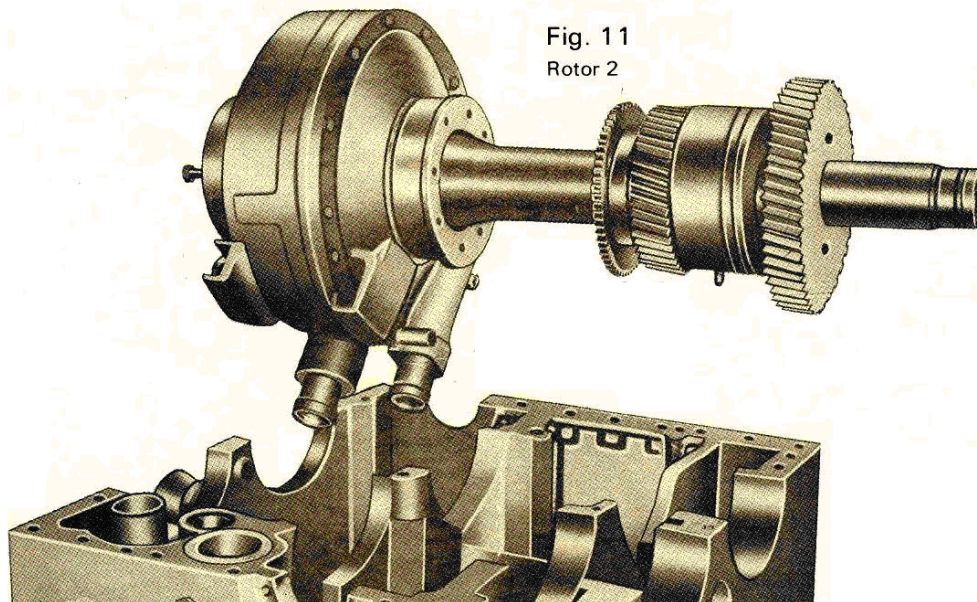


Fig. 11

Rotor 2

5.6 INPUT DRIVE GROUP (Drg. No. 741.1.36.00.50)

- 5.6.1 Set the top housing in such a way that the input flange faces down wards.
- 5.6.2 Unscrew Hex Bolts 17 and remove cover 15 take care of sealing ring 16. Remove circlips. Remove the outer race of cylindrical roller Bearing 3.
- 5.6.3 Remove Hydro Static fan pump 18 cover & gasket 19, 21.
- 5.6.4 Place the top housing so that the input flange faces upwards.

Unscrew bolts 14 remove labyrinth Cover 10, unscrew bolts, 20, 21, 22, 23, 76 and remove cover, gasket 19, 75 Unscrew socket head screws 74 and remove torque arm 73.1 (Ref. Drg. No. 741.1.10.00.50) Discard Gasket and unscrew gasket while reassembling. Place packing between gear and housing (opposite to input flange) so that when bearing bush is removed the gear will not hit on the housing wall. Remove bearing bush 6 along with four point contact bearing B, cylindrical roller bearing 9 and labyrinth ring 11 with the help of puller bolts. Press off the gear 24 from shaft 1 and remove shaft input, with bearing bush and bearing, separate the labyrinth ring, cyl. Roller bearing inner race from shaft. Remove the four point contact bearing from the bearing bush and input shaft.

Assembly can be made in the reverse fashion of disassembly. While doing the assembly care should be taken for dowel pin 7. Use the gasket cement for jointing surfaces. Care also should be taken for all sealing rings.

5.7 DISMANTLING OF ROTOR ASSEMBLY (Drg. No. 741.1.20.00.50)

- 5.7.1.1 Remove circlips 35, 36. Unscrew socket Head Screws 53, 54 Pull the converter Housing 46 along with bearing cylindrical roller 38, using proper tooling. Unscrew socket head screw 44, press off the flange 45 with oil injection kit. Separate the flange from turbine wheel 26.

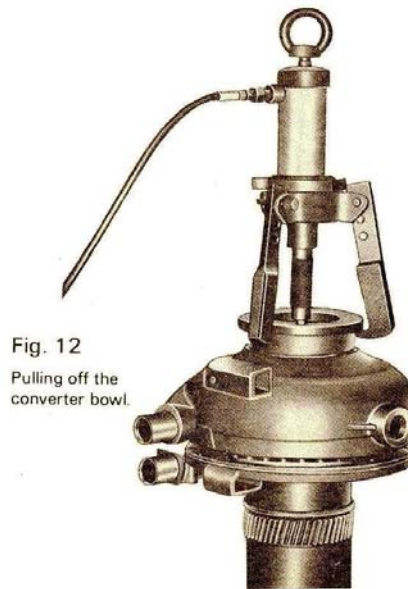
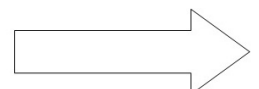
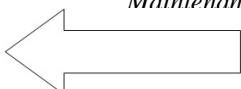


Fig. 12
Pulling off the
converter bowl.

- 5.7.1.2 Remove the circlip 37, separate the cylindrical roller brg. Outer race. Remove socket head screws 50, 51 and separate labyrinth ring 49 with the help of M 6 puller screws.
- 5.7.1.3 Unscrew socket head screws 29 and press off ring 28 from turbine wheel 26 with the help of M8 puller screws. Remove Guide wheel flange 22 complete with the help of M 12 puller screw. Unscrew socket head screws 21 and remove ring 18 with aid of M8 puller screws. Use M 12 eye bolts and lift cover converter 10 with cylindrical roller bearing 8, angular contact bearing 7, ring 5 and primary shaft 75.



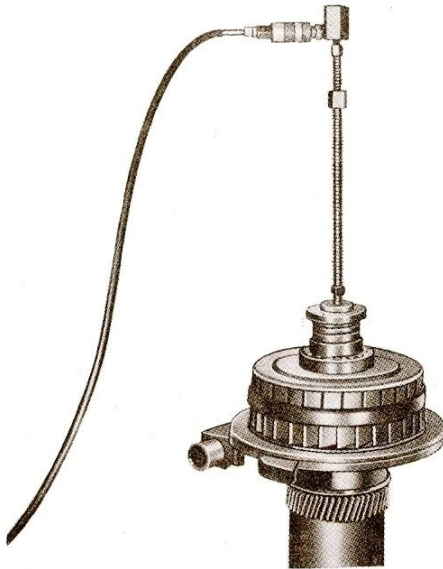


Fig. 13 Pressing off flange

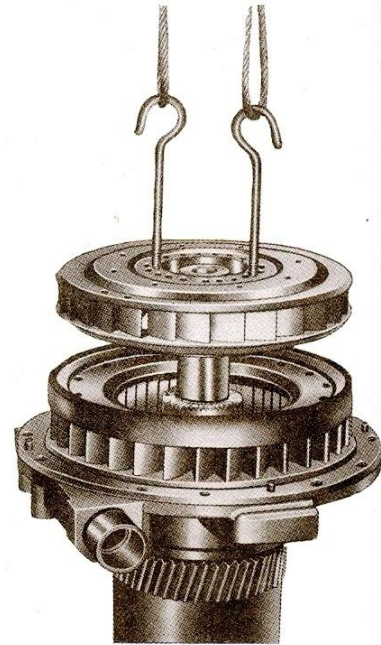


Fig. 14 Lifting off the turbine wheel with impeller

5.7.1.4 Unscrew Socket Head screws 40, 41 and remove Labyrinth ring 39.

Unscrew socket head screw 33, 34 and remove Labyrinth ring 32, with the help of M6 puller screw. Unscrew socket head screws 31 suspend turbine wheel 26 with the help of eye bolts of M 12 x 1.5 and lift complete assembly with impeller 27 give due care to ring 30.

5.7.1.5 Remove Lock nut 17 and tab washer 16. Locknut has lefthand threading. Unscrew socket head screws 15 and remove converter cover 10, using M12 eye bolts. Remove Ring 5 Ring 9 bearing inner race 8 and bearing from primary shaft 75. Unscrews socket head screws 4 and remove ring 3 and remove inner race of bearing 1.

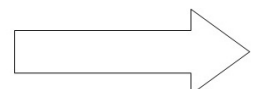
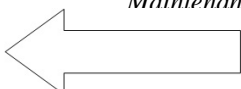
Remove circlip2, 56 and press out outer race of bearing 1 and 55 from bearing bush 60, remove the inner ring of bearing 55 from shaft 59.

5.7.2 Dismantling of Rotor II Assly. (Ref. Drg. No. 741.1.21.00.50) Set the Assembly on gear wheel 68.

Dismantling is done in the same fashion as indicated in section '7.1' refer equivalent illustration number with Unscrew socket head screws 74 and remove torque arm 73.1 Drg. No. 741.1.20.00.50)

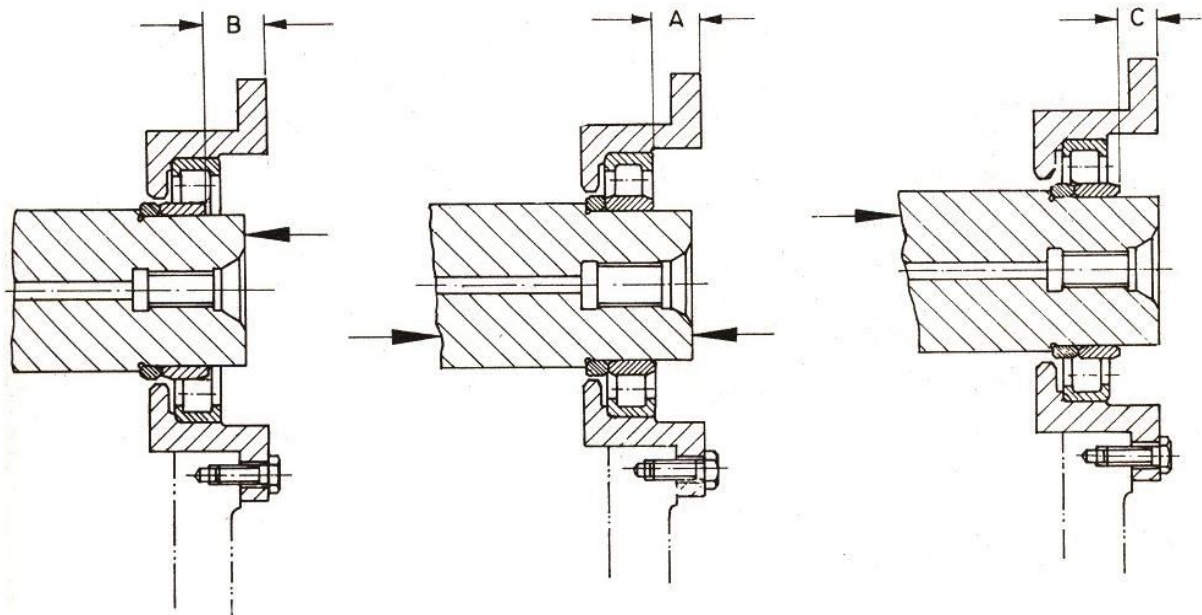
5.7.3 Assembly of Rotor Assembly I & II.

Generally assembly can be made in the reverse fashion of disassembly. While doing care should be taken for following points:

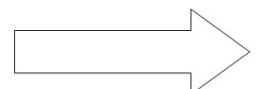
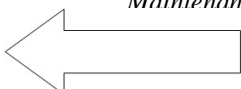


- A) While making assembly the wheel impeller 27 (in Rotor I) 35 (in Rotor II) with Primary shaft 75 (in Rotor I) & 88 (in Rotor II) the 'X' marks made on Hirth teeth are to be matched.
- B) Ref. Drg. No. 741.1.20.00.50. Do not press on gear 57 & 58 (oil injection for 57). Gear 57 must be inserted in the Final drive housing 1 (Ref. Drg. No. 741.1.30.00.50) Gear 58 can not be fitted until the assembly of final drive housing on the Main housing is made and then the gear 57 is "press on" fitted. (Oil injection).
- C) All sealing rings & all gaskets to be discarded and new one to be used.

MEASUREMENT OF AXLE FLOAT / CLEARANCES OF SECONDARY SHAFT IN ROTOR ASSEMBLY FOR VOITH TRANSMISSION.



1. Fit the Rotor Assembly Complete except, Angular Contact Bearing (64) / (73) & retainer (67) / (78) & cover (80) in Housing Top and Bottom with Housing Final Drive Clamped. Support Ring Assy. (65) / (74) to be bolted to Housing Final Drive.
2. Measure the distances as shown :-
 - a) DIMENSION 'A'
(When inner & outer races of Cylindrical Roller Brg. (63)/ (72) are inline)
 - b) DIMENSION 'B'
(Inner most position of Secondary Shaft Assly)
DIMENSION 'B' = $A + 3.0\text{mm}$ to $A + 1.0\text{ mm}$.
 - c) DIMENSION 'C'
(Outer most position of Secondary Shaft Assly)
DIMENSION 'C' = $A - 1.8\text{ mm}$ to $A + - 3.0\text{ mm}$.



- 3.i. If obtained actual values of 'B' & 'C' are not within the limits check first for fouling of bolt heads and radii of adjacent members and correct to Drg. Limits.
- 3.ii If after correction at 3 (i) dimension 'B' & 'C' do not fall within the limits then all stacked components should be re-inspected and deviations to be corrected.

5.8 FILLING PUMP (Drg. No. 741.1.31.00.50) (See OEM Manual)

5.8.1 DISMANTLING OF FILLER PUMP:

- 5.8.1.1 Unscrew socket head screws 4, 5 and remove bearing caps 2,3. Remove complete shaft assy. Remove circlip 35 and inner race of Bearing 21. Remove Locknut 39 and tab washer 40 Remove carrier bearing 37 Spacer 41 and ball bearing 36 and circlip.
- 5.8.1.2 Bevel gear 31, gear 32 need not be removed from shaft 33 unless the replacement is necessary.
- 5.8.1.3 Remove Socket head screw 23 strainer 30 and socket head screw 19 Press off intake guide wheel 29, ring 28 and labyrinth cover 27 with the help of M8 Puller screws.
- 5.8.1.4 Press off pump impeller 25 from shaft 6. The pump impeller seat is cylindrical and hence the disassembly will be gradual and will not springing off with force. Remove socket head screws 11. Set the pump so that pump impeller side is facing upwards. Press out the shaft 6 along with angular contact bearing 7 and bearing seat 10. While doing some the inner race of cylindrical roller bearing 21 will also come off. Remove Locknut 13 and tab washer 14, press off angular contact bearing 7 from shaft 6. Remove socket head screws 23 and remove spiral housing 22. Press off the bearing outer race 21. Remove socket head screws 19, 20 and separate the cover 18. Press out housing 15 with the help of M 10 x 100 puller screws.

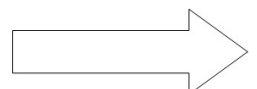
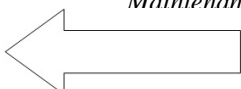
5.8.2 ASSEMBLY OF FILLER PUMP:

Assembly is done in the reverse manner as is done in dismantling procedure. Back lash in the bevel pair should be of $0.15 + 0.1$ mm, Also ensure that the gap between guide wheel 29 and pump impeller 25 should be 1.2-0.2mm (Min.)

5.9 MAIN CONTROL GOUP.

5.9.1 DISMANTLING OF MAIN CONTROL (Ref. Drg. No. 741.1.32.00.50) See OEM Manual

- 5.9.1.1 Press out spring sleeve 10 and slightly loosen nut 11. Press the spring 9 with nut 11 pointing down wards and loosen nut 11 completely. Remove piston 15, remove the sealing rings and discard.



5.9.2 Assembly is done in the reverse sequence.

5.10 PRESSURE-RELIEF VALVE GOUP (Ref. Drg. No. 741.1.33.00.50) See OE Manual

5.10.1 PRESSURE-RELIEF VALVE.

5.10.1.1 Remove socket head screws 2 and hex head bolts 11 and remove valve covers 1 and 10. Press spring plate 7 against piston 3 and remove washer lock 3 from valve housing 4.

5.10.2 Assembly is done in the reverse sequence.

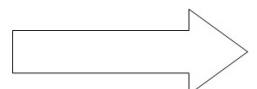
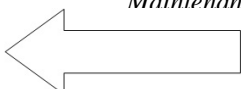
5.11 OUTPUT DRIVE GROUP

5.11.1 DISMANTLING OF OUTPUT DRIVE (Ref. Drg. No. 741.1.38.00.50 for L4r2U2)

5.11.1.1 Set the Housing final drive with axes of output shaft and intermediate shaft vertical. Remove socket head screws 22 from both sides and remove flanges 24. Remove locknut and 12 tab washer 13. Remove socket head screws 20, 21 and cover 15. Take care of sealing ring 17. Remove ring 4 with puller screws of M 10.

5.11.1.2 Press out bearing carrier 15 by using puller screws M 12 x 100. Remove inner Race of bearing 2 from shaft 1.

5.11.1.3 Reverse the housing. Remove screws with washer 18, 19, 20. Remove the ring support 5 alongwith Cyl. Roller bearing 2, angular contact bearing 3, plate 7 and shaft 1 from housing with the help of M 12 x 100 Puller screws. Remove bolt 9, 10. Press off the Ring support 5 alongwith cyl. Roller bearing 2 angular contact brg. 3 and ring 4. Separate the outer race of bearing From support rings. Remove Gear 23. (by oil injection method)



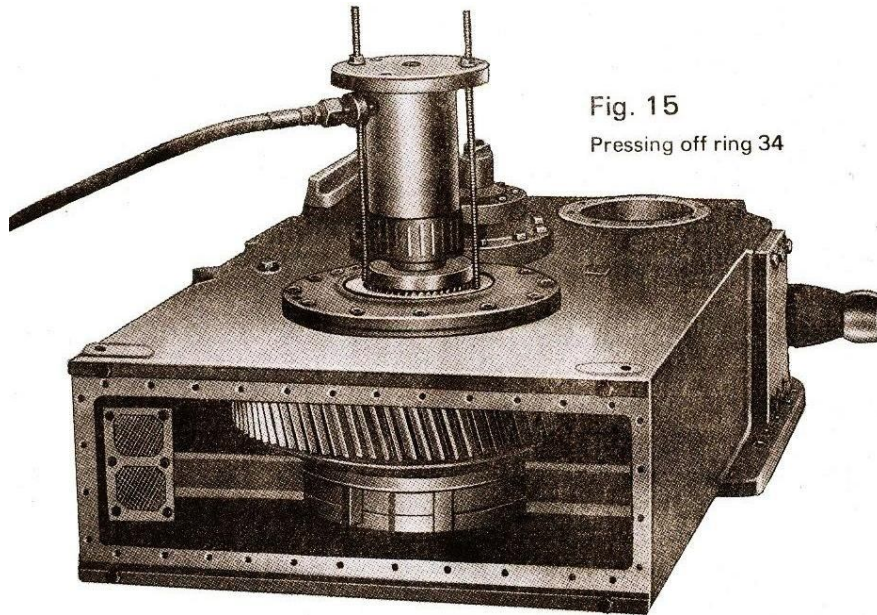


Fig. 15

Pressing off ring 34

5.11.2 DISMANTLING OF OUTPUT DRIVE.

(For L4r2U See Assembly. Drg. 742.1.38.00.50) See OEM Manual

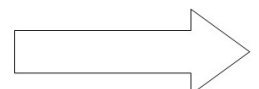
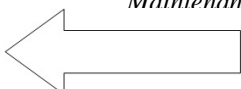
- 5.11.2.1 Set the Housing final drive with axis of output vertical and output coupling facing upwards. Oil inject out coupling (24). Remove sling Labyrinth by using puller screws & dismantle Cover Labyrinth (21) by removing socket head screws (22). Remove Ring Labyrinth (20) by using Puller holes.
- 5.11.2.2 Press out Ring support (12) along with Bearing Ball angular contact (10) Cylindrical roller (Bearing (3), washer retaining (14) from output shaft by using puller bolts.
- 5.11.2.3 Remove cover (7) by removing bolts (9), Press out output gear (2) from output shaft (1). Take care the gear will not lift the housing final drive.
- 5.11.2.4 Remove ring retaining (5) and bearing cylindrical roller (3). Separate the cylindrical roller bearing (3), & Angular contact bearing (10) from Ring support (12) if necessary.

5.11.2.5 ASSEMBLY OF OUTPUT SHAFT:

Assembly is under taken in the reverse sequence. While doing assembly apply cement gasket for jointing surface. Discard all ring sealing and replace with new ones.

5.12 ASSEMBLY & DISASSEMBLY OF INTERMEDIATE SHAFT (For only L4r2U2)

5.12.1 DISASSEMBLY OF INTERMEDIATE SHAFT (Ref. Drg. No. 741.1.40.00.50) See OEM Manual



- 5.12.1.1 Set the Final drive housing so that speedo-drive arrangement faces upwards. This side disassembly can be carried out while doing the disassembly of output group.
- 5.12.1.2 Remove Hex 20, cover 19. Remove socket head screws 16 and support ring 15 using M6 puller screws. Press out angular contact bearing 14 for supporting ring 15. Unscrew hex screw 13 and press off support ring 12 using M 12 puller screws. Remove snap ring 5 and press out outer race of Cylindrical roller bearing 4 from housing. Remove ring 11 keep packing in the housing for gears to rest.
- 5.12.1.3 Turn the housing upside down. Remove socket head screws 10 and cover 9 using M8 puller screws. Remove snap ring 5 and press out outer race of cylindrical roller bearing 4 from housing, remove screw socket head 7 and plate, press out gear 3 from shaft 1 by oil injection method. Similarly press off gear 2 from shaft 1 by oil injection method. Take care so that the shaft does not fall, suspend it with M30 eye bolt and put packing below. Take out shaft 1 and remove packing. Remove bearing inner races from shaft. Remove gears 2 and 3 and gear of rotor assembly from final drive housing.

5.12.2 **ASSEMBLY OF INTERMEDIATE SHAFT:**

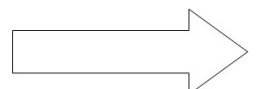
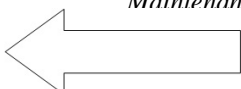
- 5.12.2.1 Assembly is under taken in the reverse sequences. While doing

Apply is under taken in the reverse sequences. While doing assembly apply cement gasket for jointing surfaces. Discard all rings, sealing and replace with new ones. Take care of pin mounted on cover 19 which enters the slot provided in outer race of angular contact bearing 14.

5.13 **SECONDARY LUBOIL ANDSCANVENER PUMP.**

5.13.1 **DISASSEMBLY** (Ref. Drg. No. 741.1.41.00.50)

- 5.13.1.1 Remove socket head screws 27, 28 and take out valve housing 22. Remove socket head screw 21 and lift the housing 1 complete. Remove plug 23, both side and piston 25.
- 5.13.1.2 Remove circlip 8 and shaft 3 along with gear driving 29. Remove Nuts and bolts 13, 14, 15 and socket head screws 16. Remove cover 2 shaft 11 and gears 4, 9 Bushes 5, 6, 10 are to be removed only if replacement is required. Discard all sealing rings.



5.13.2 ASSEMBLY

Assembly is under taken in the reverse sequence. Renew all sealing rings. Apply cement gasket for jointing faces.

Note: While using cement gasket for jointing faces use loctite compound No. 574.

5.14 TORQUE TIGHTENING VALVES FOR SCREWS (SPECIAL TYPE)

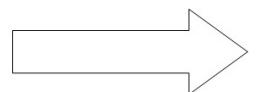
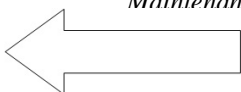
Sl. No.	Part No	Description	Torque KGM.
1	741.1.20.57.50	Screw Socket Hear M12	13.2
2	741.1.20.47.50	Screw Socket Hear M10	6.9
3	741.1.20.84.50	Screw Socket Hear M10	6.9
4	741.1.20.33.50	Screw Socket Hear M 8	3.4
5	741.1.20.28.50	Screw Socket Hear M 8	3.4
6	741.1.20.34.50	Screw Socket Hear M6	1.5
7	741.1.20.06.50	Screw Socket Hear M6	1.5
8	741.1.20.22.50	Lock Nut	300.0
9	741.1.20.12.50	Screw Socket Hear M 8	3.4
10	741.1.20.17.50	Screw Socket Hear M12	15.0
11	741.1.20.29.50	Screw Socket Hear M20	49.0
12	9992110950	Lock Nut	550.0

TORQUE TIGHTENING VALVES FOR STANDARD SCREWS

Sl. No.	Part No	Threading	Torque KGM.
1	741.1.20.57.50	M 6	1.0
2	741.1.20.47.50	M 8	2.6
3	741.1.20.84.50	M 10	5.2
4	741.1.20.33.50	M 12	8.9
5	741.1.20.28.50	M 12 x 1.5	9.3
6	741.1.20.34.50	M 14	14.3
7	741.1.20.06.50	M 16	21.4
8	741.1.20.22.50	M 20	21.8

Note:- 1) The above figures are for dry type threads.

2) When tightening with "Loctite" (Compound No. 270) the torque value to be increased by 20%.



RECOMMENDED SPARE PARTS STOCKING FOR KIRLOSKAR TURBY TRANSMISSION TYPE – L4R2U2 AND L4R2U.

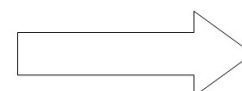
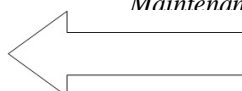
The spare parts listed below should be ordered in advance before major overhauling is planned. Delivery periods of up to 1 year are to be anticipated.

Wearing Parts Groups	Details
A	Breather Filter, Laminar, Filter Element, Over speed Detector, Pneumatic Hoses.
B	'O' Rings, Piston Rings, Felt Strip, Seals.
C	Ball Bearings, Roller Bearings.
E	Control Components, Pumps.
F	Labryinths, Pistons, Guide Bushes.
G	Screws, Spring washers, Circlips, Lock Washers, Tab Washers.
J	Complete Stand by Transmission.

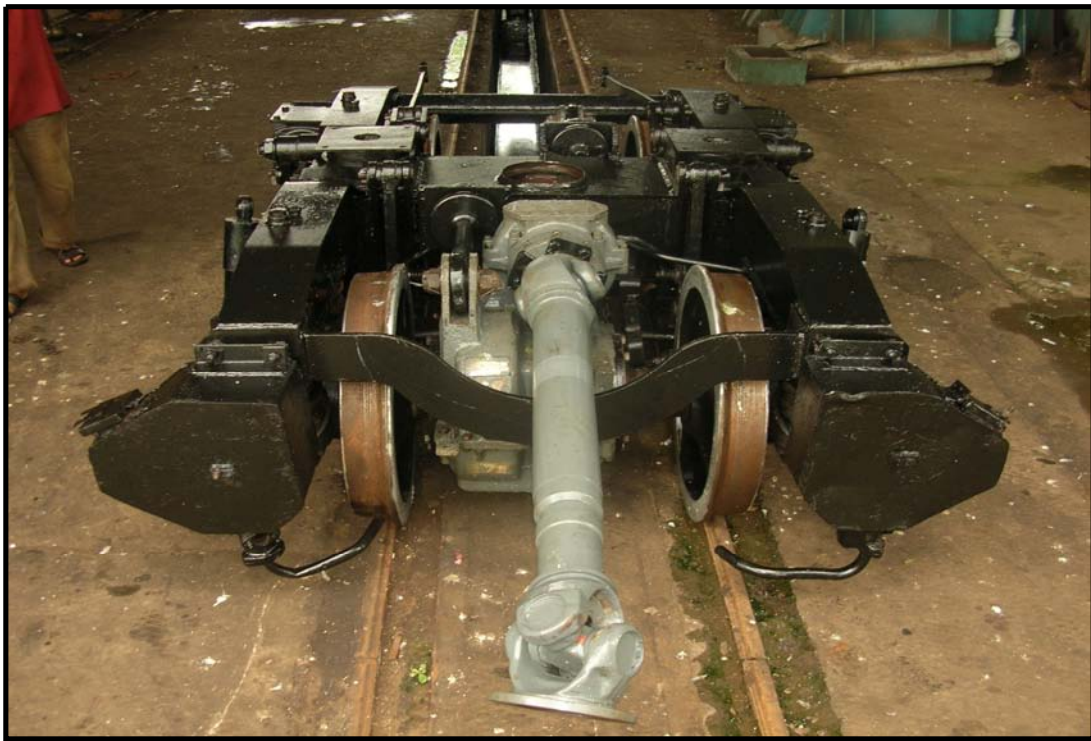
No. of Trans.	2 Yrs. or 10,000 Operating Hrs.	5 Yrs. Or 25000 Operating Hrs. Incl. 1 st Major over haul	10 Yrs. Or 50,000 Operating Hrs. Incl. 2 nd Major overhaul
** Service Location : Indian **			
5	-	1A + 5B + 5C + 5E + 1G	1A + 5B + 5C + 5E + 1F + 1G
10	1J	1A + 10B + 10C + 10E + 1F + 2G	2A + 10B + 10C + 10E + 2F + 2G
25	2J	2A + 25B + 25C + 25E + 2F + 5G	3A + 25B + 25C + 25E + 3F + 5G
50	3J	4A + 50B + 50C + 50E + 4F + 10G	4A + 50B + 50C + 50E + 4F + 10G

** Service Location - Overseas **			
5	1A + 1B + 1C + 1E	1A + 5B + 5C + 5E + 1G + 1J	1A + 5B + 5C + 5E + 1F + 1G
10	1A + 1B + 1C + 1E + 1J	1A + 10B + 10C + 10E + 1F + 2G	2A + 10B + 10C + 10E + 2F + 2G
25	1A + 2B + 2C + 1E + 2J	2A + 25B + 25C + 25E + 2F + 5G	2A + 25B + 25C + 25E + 3F + 5G
50	2A + 2B + 2C + 2E + 3J	4A + 50B + 50C + 50E + 4F + 10G	4A + 50B + 50C + 50E + 5F + 10G

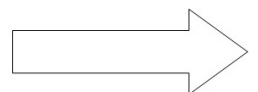
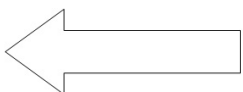
The periods of time between overhauls as quoted above are recommended by us and are dependent upon operating conditions to which the transmissions are subjected. Whichever figure is attained first, i.e. number of yrs. Or operating Hrs. is decisive.



Chapter -5



BOGIE

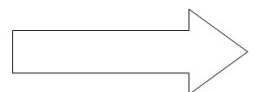
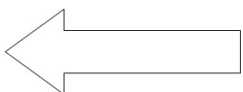


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Chapter- 5

BOGIE OF ZDM 5/NDM 5 LOCOMOTIVES

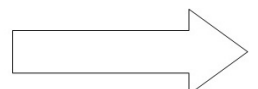
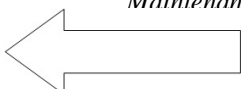
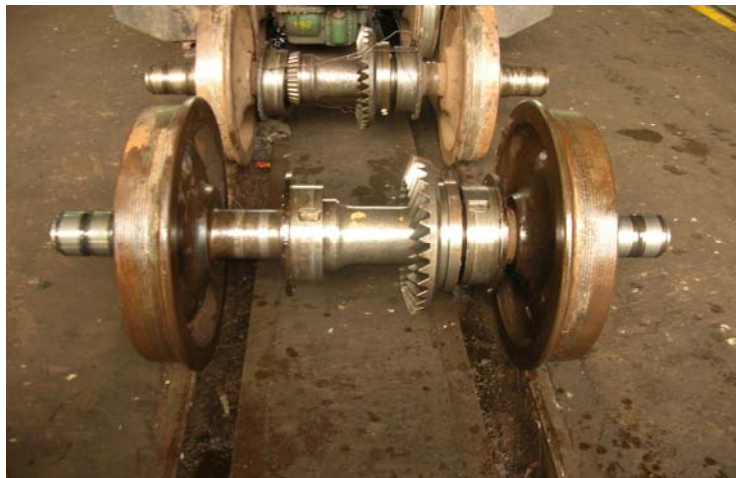
DISMANTLING OF BOGIE FROM LOCOMOTIVE

- Dismantle 8 Nos. linkages, 4 Nos. shock absorber bottom pin, both big TRM jointing cardan shaft, 16 Nos. magie jointing nut-bolts
- Check bogie for any obstruction.
- Lift Loco on electric jack's equally on all four sides.
- Run out the bogie from the locomotive.
- Drain both center pivot and gear box 1 to 4 oil and send to Lab. for testing.
- Check the both center pivot pin for any crack / breakage. Check center pivot foundation plate welding.
- Check center pivot pin size Max. 90 mm. dia.

DISMANTLING OF BOGIE

- Dismantle bogie frame with brake hanger and torque arm assembly and axle drive gear box.
- Dismantle 02 Nos. big and small carden shaft from bogie.
- Dismantle axle drive gear box housing and pinions and axle box from axle journal for overhauling.

AXLES



Axle journal should be thoroughly cleaned for inspection to detect flaws pitting, ovality, taper, ridges etc. Each axle should also be ultrasonically tested for detecting internal flaws and defects. Axles found flawed, badly pitted, tapered or worn, oval beyond limit should be replaced.

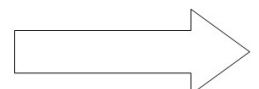
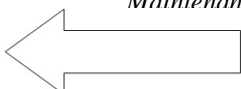


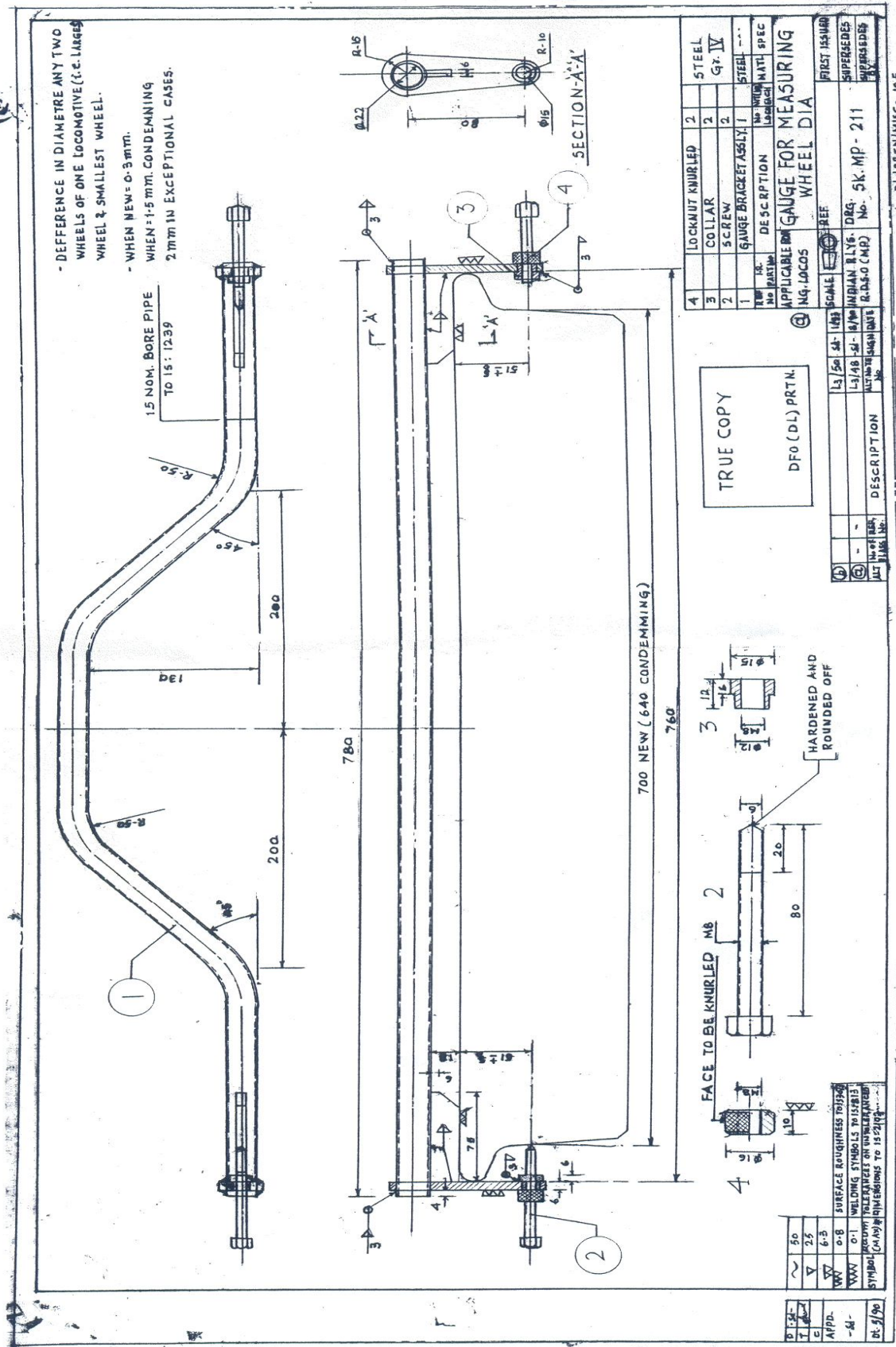
As per OSD/Sr. CMT (C&M) Ajmer Letter No. C&M/NDT/O/P Dt. 20/06/1991 " Axles of all N.G. Locomotives viz ZDM 3 ZDM 4A ZDM 5 and other will be tested Ultrasonically once in three months.

WHEELS

The wheel should be turned and the following measurement to be recorded.

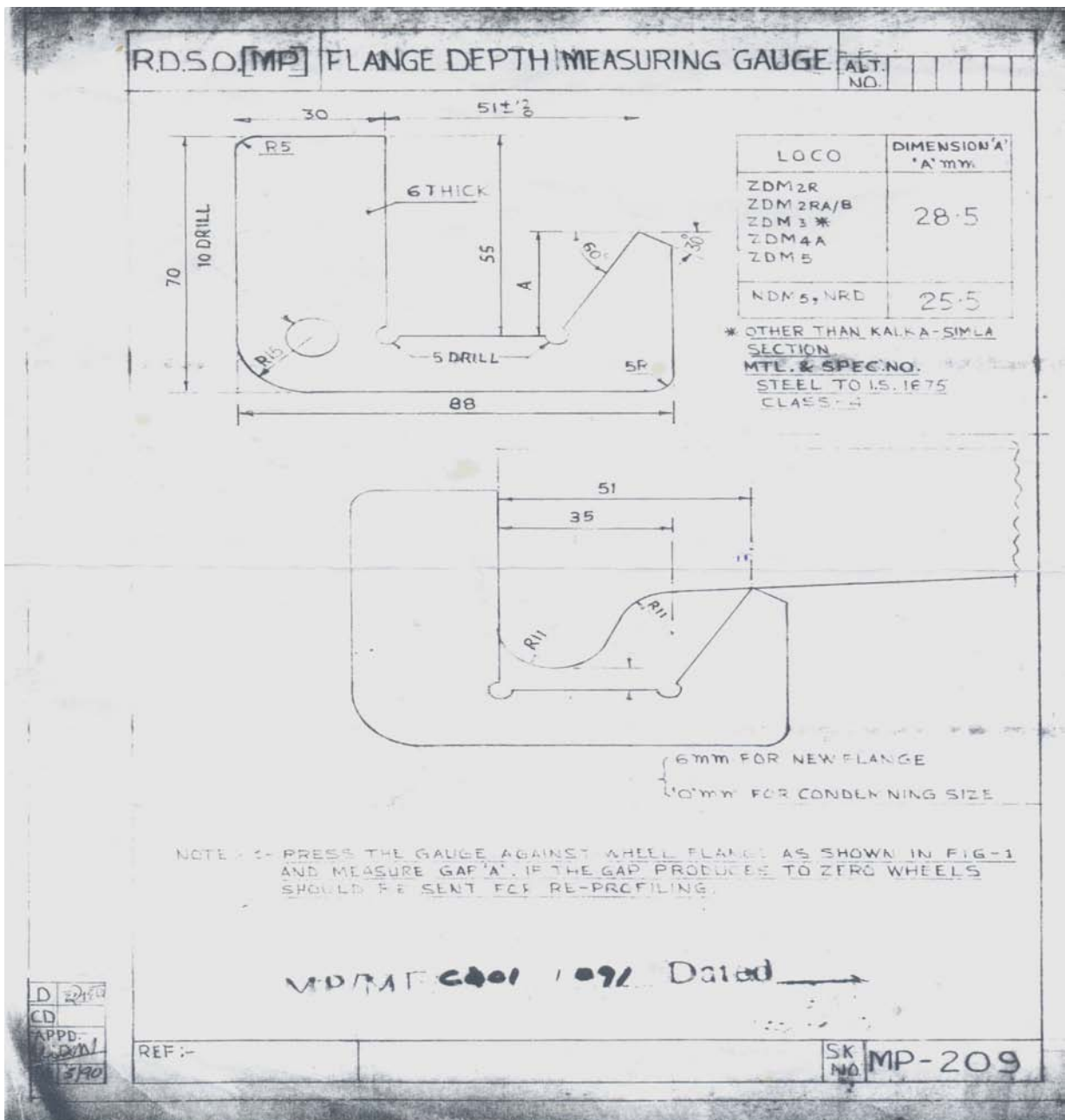
- 1) Tread Dia.
Normal dia. (New wheel) 700 mm.
Service limit 640 mm.
(Ref.: RDSO Drg. No. SKMP-211.)





- 2) Check and examine wheel flange for wear and record.
- a) Flange depth/Tread Wear
For N/ZDM5 Loco
Max. 6 mm.
Min. Nil.

(Ref.: RDSO Drg.No. SKMP-209 & SK. DL 4260)



b) Flange thickness/ Flange Wear for ZDM5

Max. 24.0 mm.

Min. 13.0 mm.

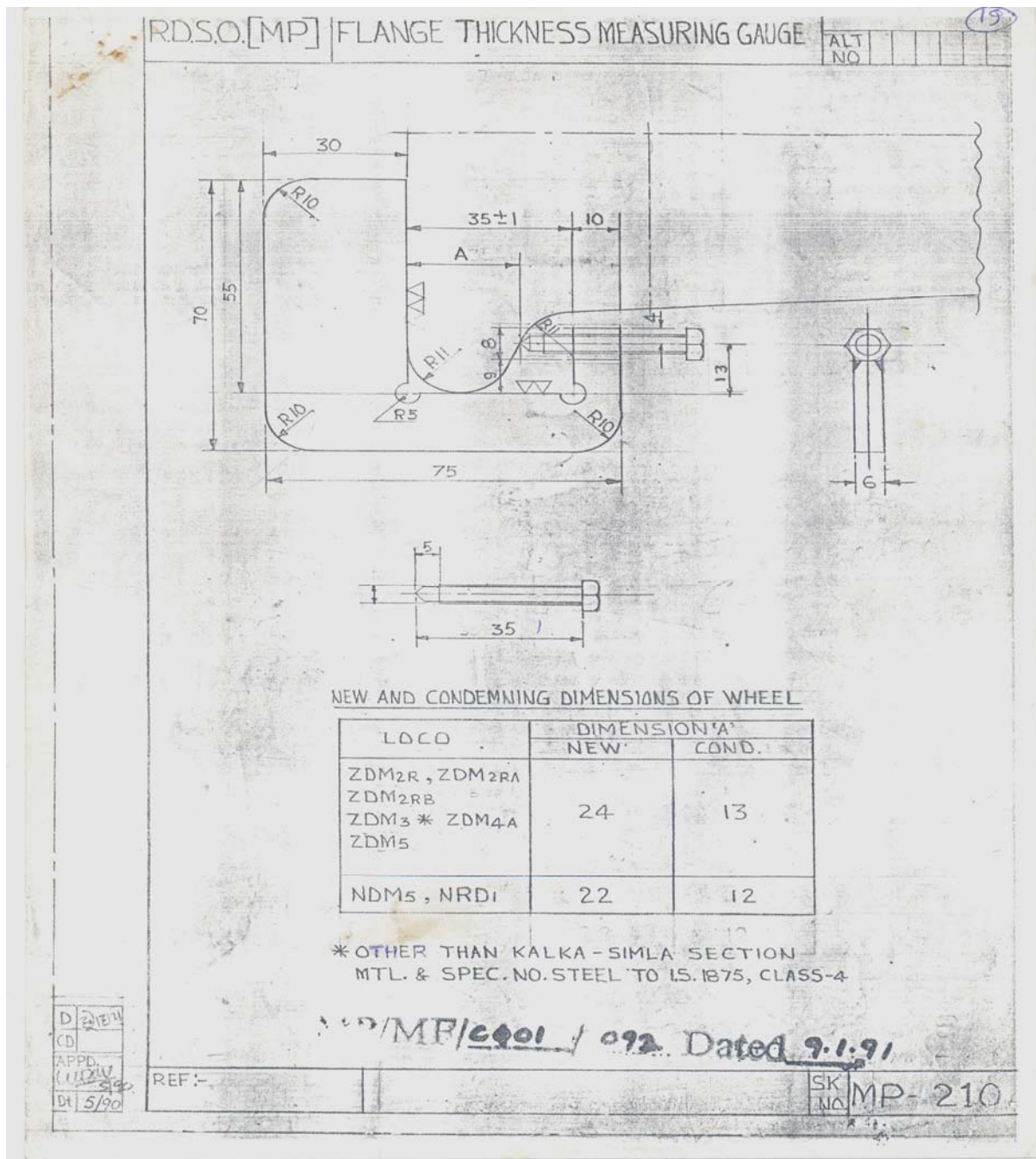
Flange thickness for NDM5

Max. 22.0 mm.

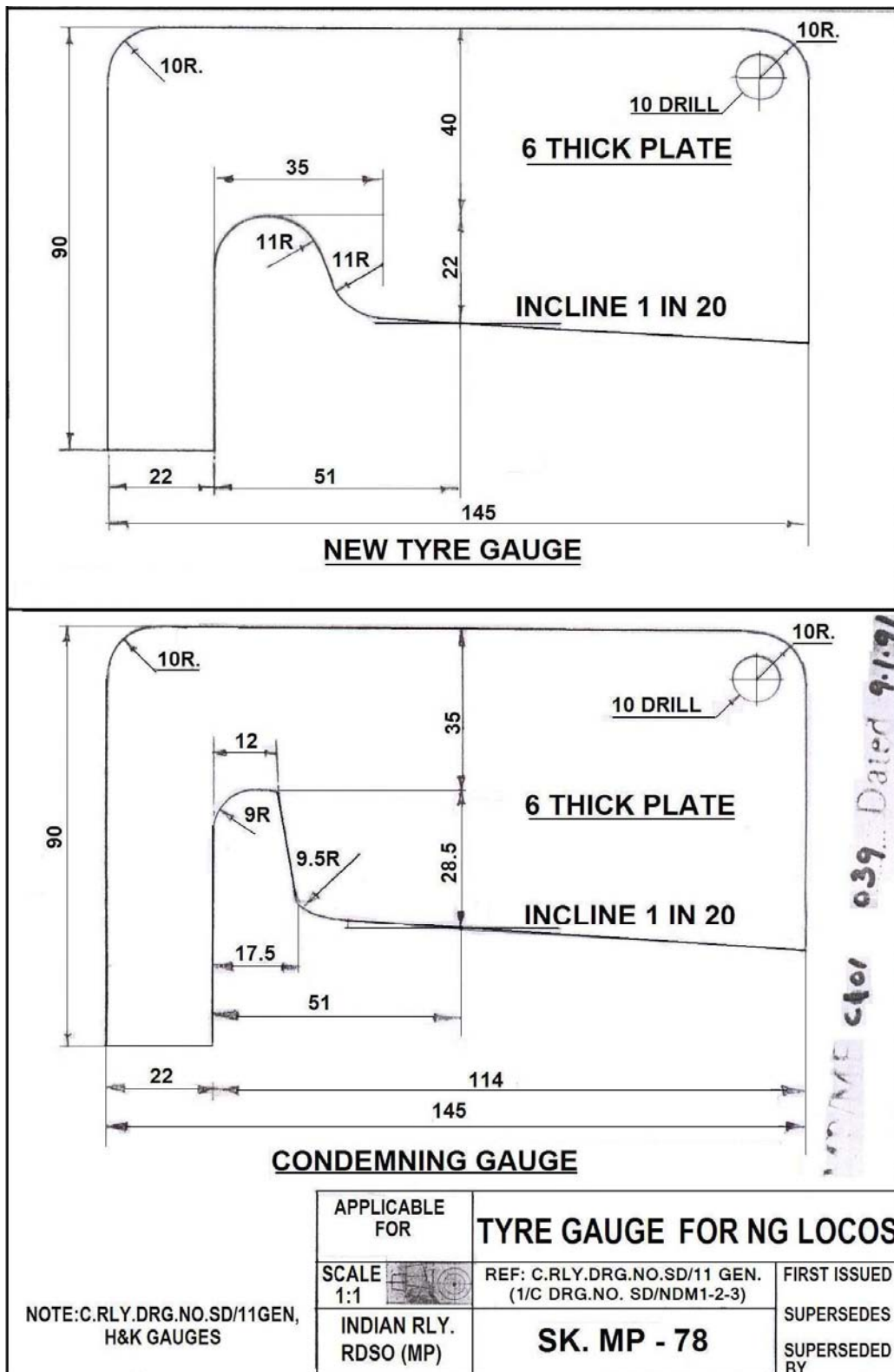
Min. 12.0 mm.

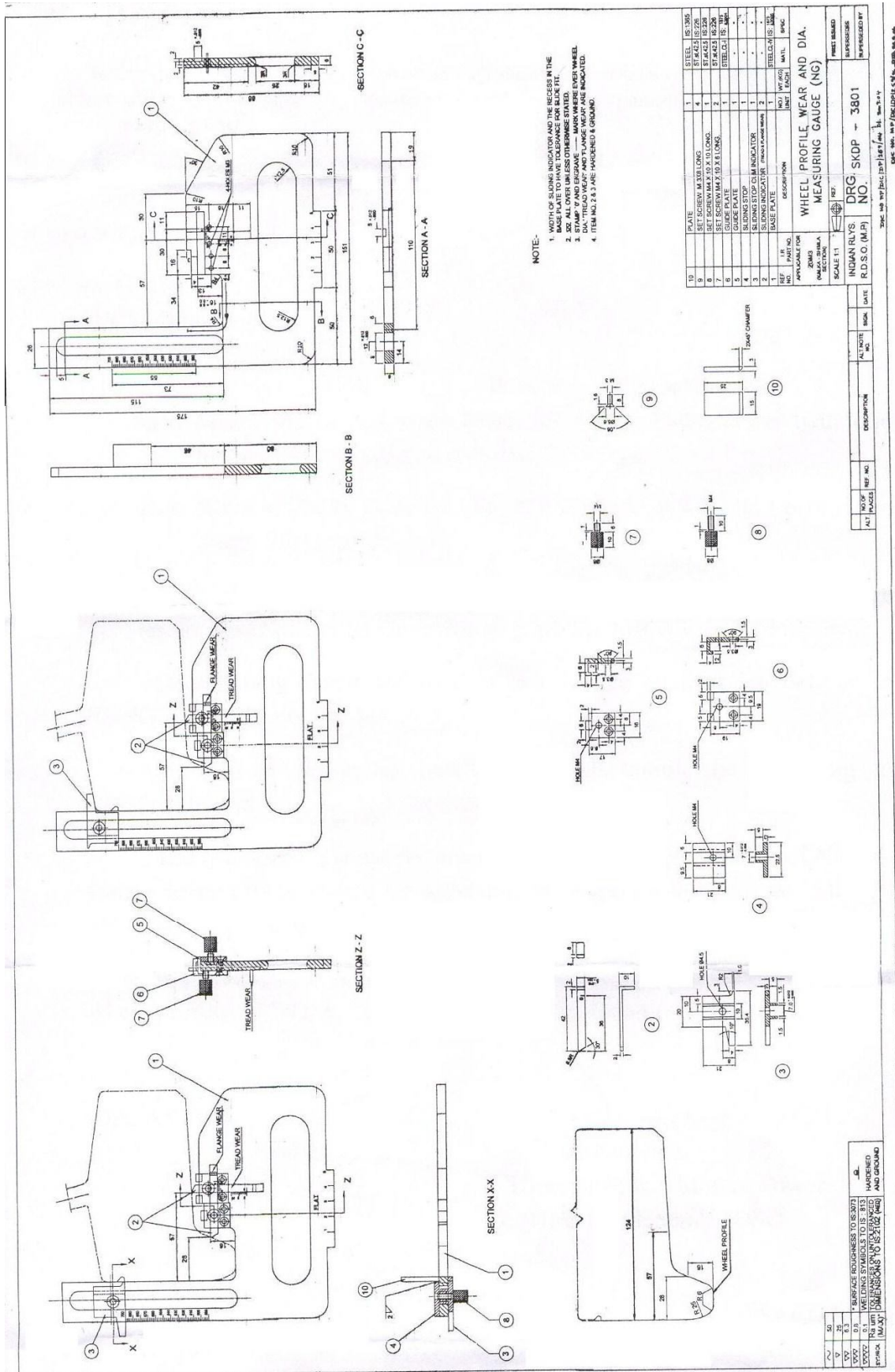


(Ref.: RDSO Drg.No. SKMP-210 & SK. DL 4260)



- C) **Root Wear for NDM5/ZDM5 locos:** Root wear should be checked as per RDSO Drg.No. SK. MP – 78 (Given Below)





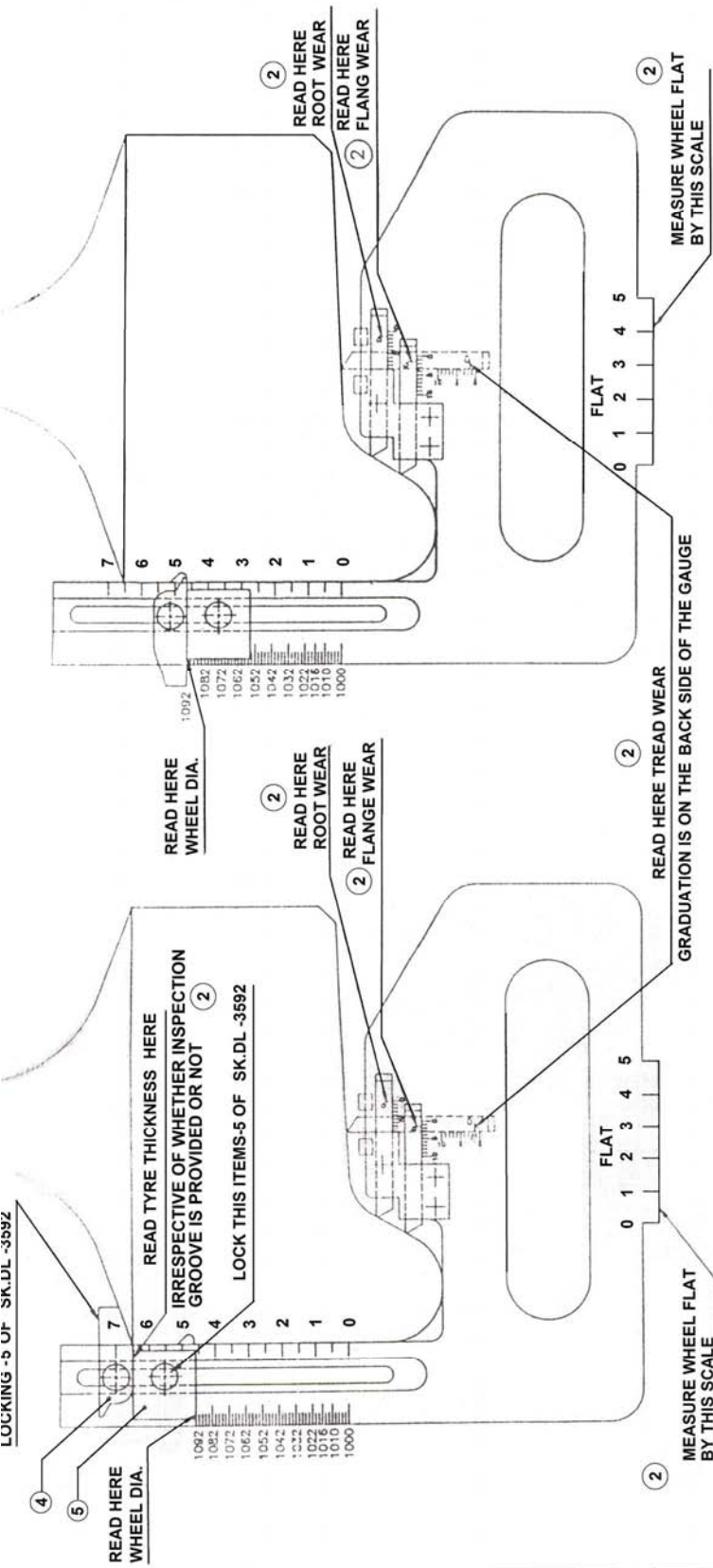


FIG. - A

MEASUREMENT OF WHEEL DIA. WHEN INSPECTION GROOVE IS NOT PROVIDED

FIG. - B

1. MEASUREMENT OF WHEEL DIA. WHERE INSPECTION GROOVE 1000 mm WHEEL DIA. IS PROVIDED. (AS SHOWN IN FIG. - B)

NOTE:-

ACTUAL DIA. OF WHEEL = DIA. MEASURED BY GAUGE - TWICE OF TREAD WEAR

27.9.99	(2)	L-2/764	POSITION OF GAUGE READING SHOWN IN THE DRAWING.		
16.4.99	(1)	L-2/752	DRG. REVISED AND NOTE ADDED		
DATE	ALT.NO.	AUTH.	DESCRIPTION	SIGN	

METHOD OF MEASUREMENT OF WHEEL DIA, TYRE THICKNESS, FLANGE WEAR, ROOT WEAR, TREAD WEAR, AND WHEEL FLAT WITH WHEEL GAUGE TO DRG. NO. SKDL-3592

INDIAN RLYS R.D.S.O.(MP) SK.DL.-4260

- 3) Record difference in tread dia. of wheels on the same axles, same bogie and same locomotive.

Permissible limit with new 0.3 mm.

Service limit 2.0 mm.

(Ref.: RDSO Drg. No. SKMP-211.)

- 4) Check and record distance between the inside gauge face of the wheels on same axle whether the axle is bent or not..

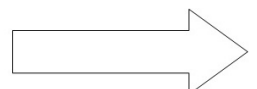
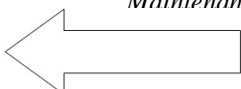
Permissible variation N.G. 698.5 ± 0.5 mm.

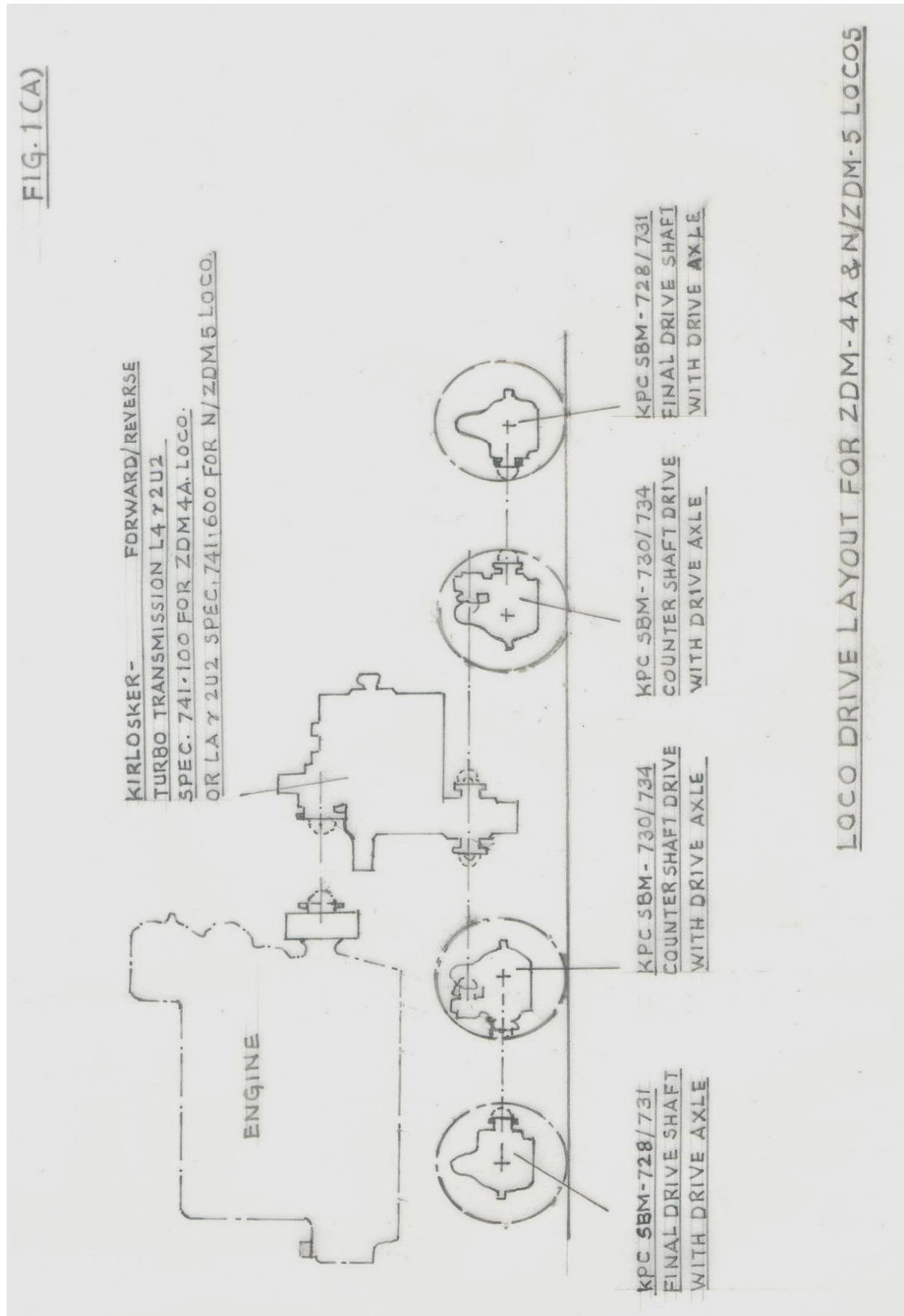
(Ref.: CLW Drg.No. 1D/28A-05-101)

(Average of four measurement at equal spacing on the periphery of the wheels is to be recorded)

Examine wheels visually for the following:

- a) Thermal crack
- b) Broken flange
- c) Cracked hub
- d) Loose wheels
- e) Wheels which have over heated.





AXLE DRIVE GEAR BOX OVERHAULING

Both the axle drives are housed in high quality cast steel housing having horizontal splits for ease of assembly and dis-assembly. The gears and shafts are made from superior quality alloy steels. Ball and roller bearings used are of adequate capacity for giving long trouble free service. The lubricants is of splash oil and is collected in troughs and led through passage to the points of lubrication. The gearbox gets drive from Transmission through cardan shafts. Torque reaction arm bolted to top housing of gearbox is anchored to bogie frame through rubber elements.

1.1 DISASSEMBLY OF COUNTER SHAFT AXLE DRIVE :

(Ref. SBM: 729) (Fig No. 1)

- 1.1.1 Un-screw screw plug (49), drain out the oil and entirely remove the sludge from the unit. Place the gearbox in horizontal position over two wooden supports. Unscrew socket head screw (17) connecting bearing cover (35) to housing and socket head screws (65 & 66) connecting top part of housing (21) to middle part of housing (6). Lift the top part of housing (21). Lift the counter shaft assembly.

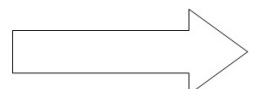
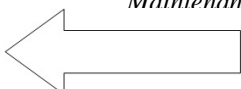
Unscrew hex screw (8), socket head screw (64) connecting middle part of housing (6) to lower part of housing (1), hex screws (51) which connect bearing covers (56) to housing and socket head screw (46) connecting bush (39) to the housing (39) to the housing (39). Remove middle housing (6). Lift the traction drive assemble. Pull out outer race of bearing (12) from the housing by means of proper tool. Remove pinion shaft assembly by pulling it in suitable inclined position.

1.1.2 DISASSEMBLY OF PINION SHAFT COMPLETE.

Press-off the coupling (40) by injecting high pressure hydraulic oil (2100kg/cm^2) through the tapping at the end of the shaft (42), using the suitable fixture and a high pressure oil injecting pump. Slide out bush (39), spacer ring (37) and ring (41). Pull out bush assembly (38) along with bearing (19), the outer race and the left hand half of the inner race of the bearing (44). Remove the right hand half o the inner race of the bearing (44) and ring (45). Press-off the gear wheel (48) by injecting high pressure hydraulic oil (2600kg/cm^2) through tapping provided at the end of opposite coupling (40). Remove the outer race and extract the inner race of bearing (13).

1.1.3 DISASSEMBLY OF DRIVE AXLE ASSLY.

Slide out bearing covers (56) along with the outer races of bearings



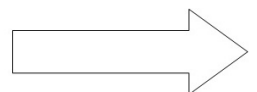
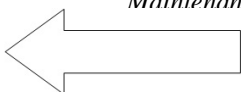
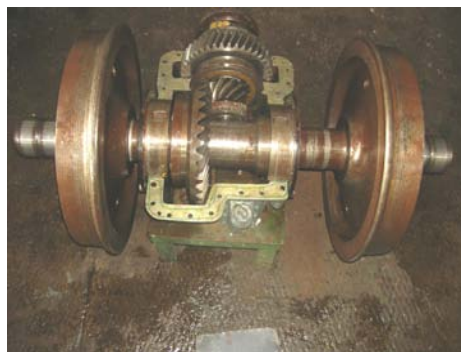
(55). Pull out bushes (60, 62) along with labyrinth rings (54) and inner races of bearings (55). Unscrew hex nut (58) and knock out fitted screws (61). Press out Bevel Gear (50).

1.1.4 DISASSEMBLY OF COUNTER SHAFT COMPLETE

Press-off coupling (40) injecting high pressure hydraulic oil (21000kg/cm^2) through tapping provided for the purpose. Slide out bush (16) and bearing cover (35). Unscrew socket head screws (17) and remove cover (33). Pull out ring (20) along with outer race of bearing (19) on the coupling side and ten ring (20), outer race of bearing (19), bearing (34) and spacer ring (28) on the outer side. Remove inner races of bearing (19) and spacer ring (27). Press-off gear wheel (25) by injecting high pressure hydraulic oil (27000kg/cm^2) through the tapping high pressure hydraulic oil (27000kg/cm^2) through the tapping provided for the purpose.

1.1.5 After the disassembly, all parts must be checked thoroughly. The races of the bearings must be inspected. If grooving or pitting is found, the bearing must be replaced. It is not necessary to replace a gearwheel if small cracks are found at the top of the teeth, but the gearbox must then be inspected at shorter intervals if cracks are found at the root of the teeth, the gearwheel must be replaced. Grooves can be smoothed away, eventually with grinding compound.

1.2 ASSEMBLY OF COUNTER SHAFT AXLE DRIVE : (Ref. SBM 729).



Maximum pressure = 2200 kg/cm²

1.2.11 Pinion (48)

Press on way = 11 to 15 mm.

Press-off pressure = 2600 kg/cm²

Maximum pressure = 3500 kg/cm²

1.3 DISASSEMBLY OF FINAL SHAFT AXLE DRIVE :

(Ref. SBM : 728) (Fig No. 2)

- 1.3.1 Unscrew drain plug (45) and drain out the oil and entirely remove the sludge from the unit. Remove the wheel set. Place the gearbox in a horizontal position over two wooden supports. Unscrew socket head screws (6) connecting bearing cover (5) to the housing, socket head screw (47) connecting two halves of housing (25 & 24), hex screws (30) connecting bearing covers (35) to the housing and hex screws (26) connecting two halves of housing (25 & 24). Remove the top housing (24), pull out the pinion shaft assembly complete along with inner race of bearing (19). Lift drive axle assembly off the bottom housing (25).

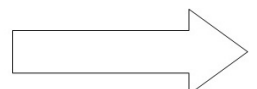
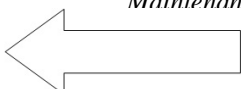


1.3.2 DISASSEMBLY OF PINION SHAFT COMPLETE

Press-off the coupling (2) by injecting high pressure hydraulic oil (2100kg/cm²) through the tapping at the end of shaft (1) using suitable fixtures and high pressure oil injecting pump. Slip out bearing cover (5) and ring (3). Pull out bush (9) using suitable puller along with bearing (8), ring (17) and outer race of bearing (13). Pull out inner race of bearing (13) and ring (17). Unscrew hex screws (16) and remove sheet (14). Pull out inner race of bearing (19).

1.3.3 DISASSEMBLY OF DRIVE AXLE ASSEMBLY

Slide out bearing covers (35) along with the outer race of the bearing (34). Pull out bushes (37) & 44) with labyrinth rings (32) and (37 & 44)



inner races of bearing (34). Unscrew hex nut (42) and knock out fitted screws (39). Then press out bevel gear (40).

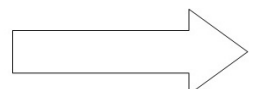
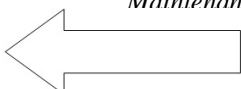
- 1.3.4 After the disassembly, all parts must be checked thoroughly. The races of the bearing must be inspected. If grooving or pitting is found, the bearings must be replaced. It is not necessary to replace a gear wheel if small cracks are found at the tip of the teeth, but the gearbox must then be inspected at short intervals. If cracks are found at the root of the teeth, the gearwheel must be replaced. Grooves can be smoothed away, eventually with grinding compound.

1.4 ASSEMBLY OF FINAL SHAFT AXLE DRIVE :

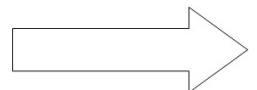
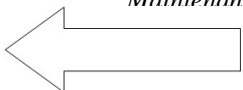


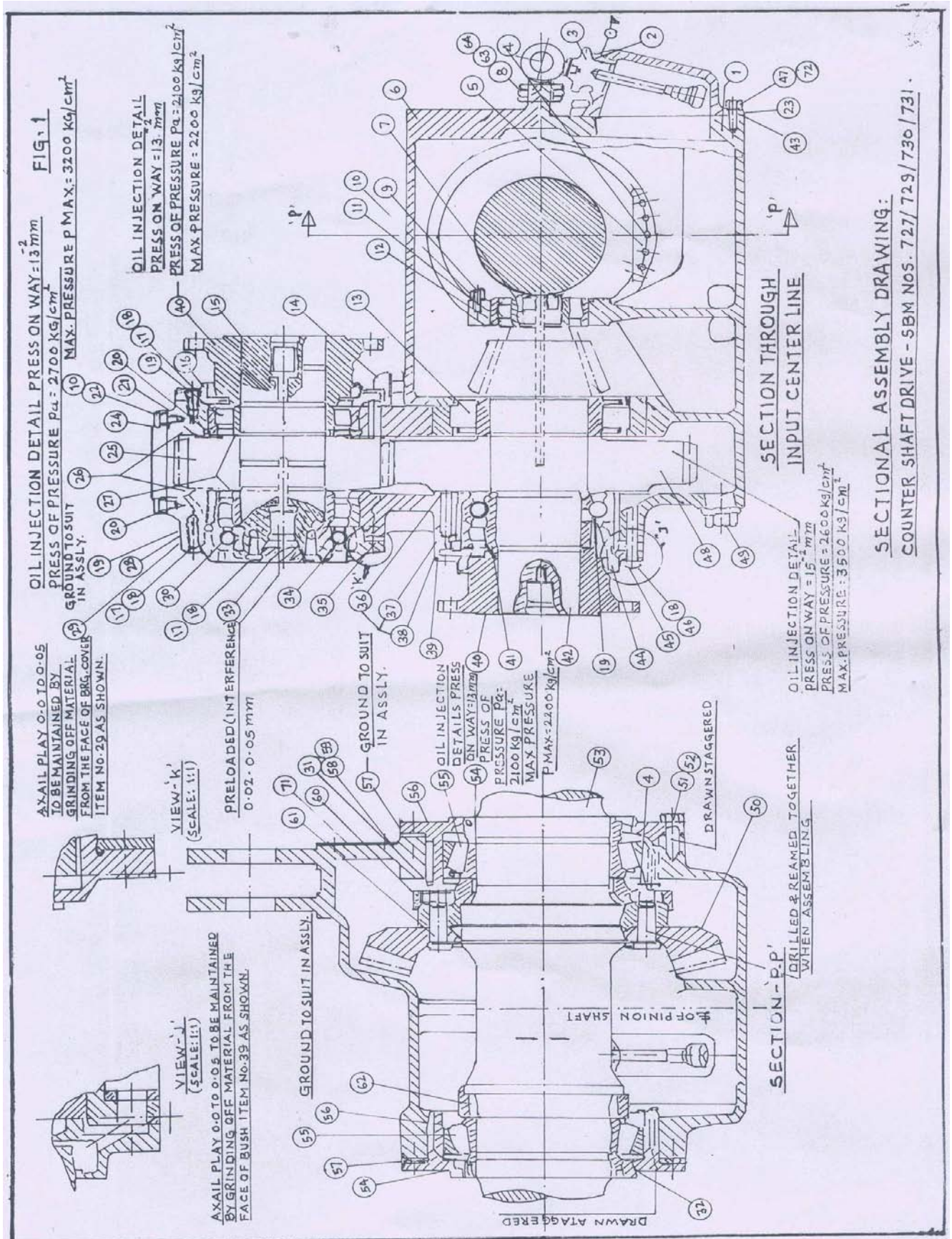
When all parts are checked for damage, they must be cleaned with Carbon Tetrachloride or similar cleaning agent. Before assembly, all sets of bearings, spacer rings etc. must be cleaned of oil and grease. Change all damaged components. All locking washers must be renewed and not to be used again. Assembly, in general, should be done in the reverse order of disassembly. However, the following points should be noted while carrying out the assembly.

- 1.4.1 Apply gasket compound (loctite) between mating faces of housing external spacers and any joint where there is possibility of leakages.
- 1.4.2 The anti-friction bearings have an interference fit on the shafts. Before mounting, they must be heated upto 80° to 100° C in an oil bath.
- 1.4.3 The ring (17) must be re-finished so that the axle clearance of the outer race of the bearing (13) is 0.0 to 0.05 mm.
- 1.4.4 Check the tooth contact of bevel gear pair and adjust them, if necessary, correct the tooth markings by means of spacer ring (33) on the bevel gear side of the axle and spacer ring (10) on pinion shaft, Backlash = 0.3 to 0.4 mm.



- 1.4.5 Measure the distance between the bearing cover (35) and the gear box housing. Regrind the spacer ring (33) so that an axle play of 0.05 to 0.08 mm is obtained.
- 1.4.6 Check freedom of rotation.
- 1.4.7 Pump grease in labyrinth rings and fill in oil upto the upper mark on dip rod before commissioning.
- 1.4.8 Assemble coupling (10) by oil injection method. Press-on-way = 11 to 13 mm. Press-off pressure 2100 kg/cm^2 , Maximum pressure = 2200 kg/cm^2 .

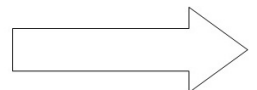
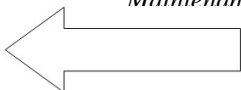


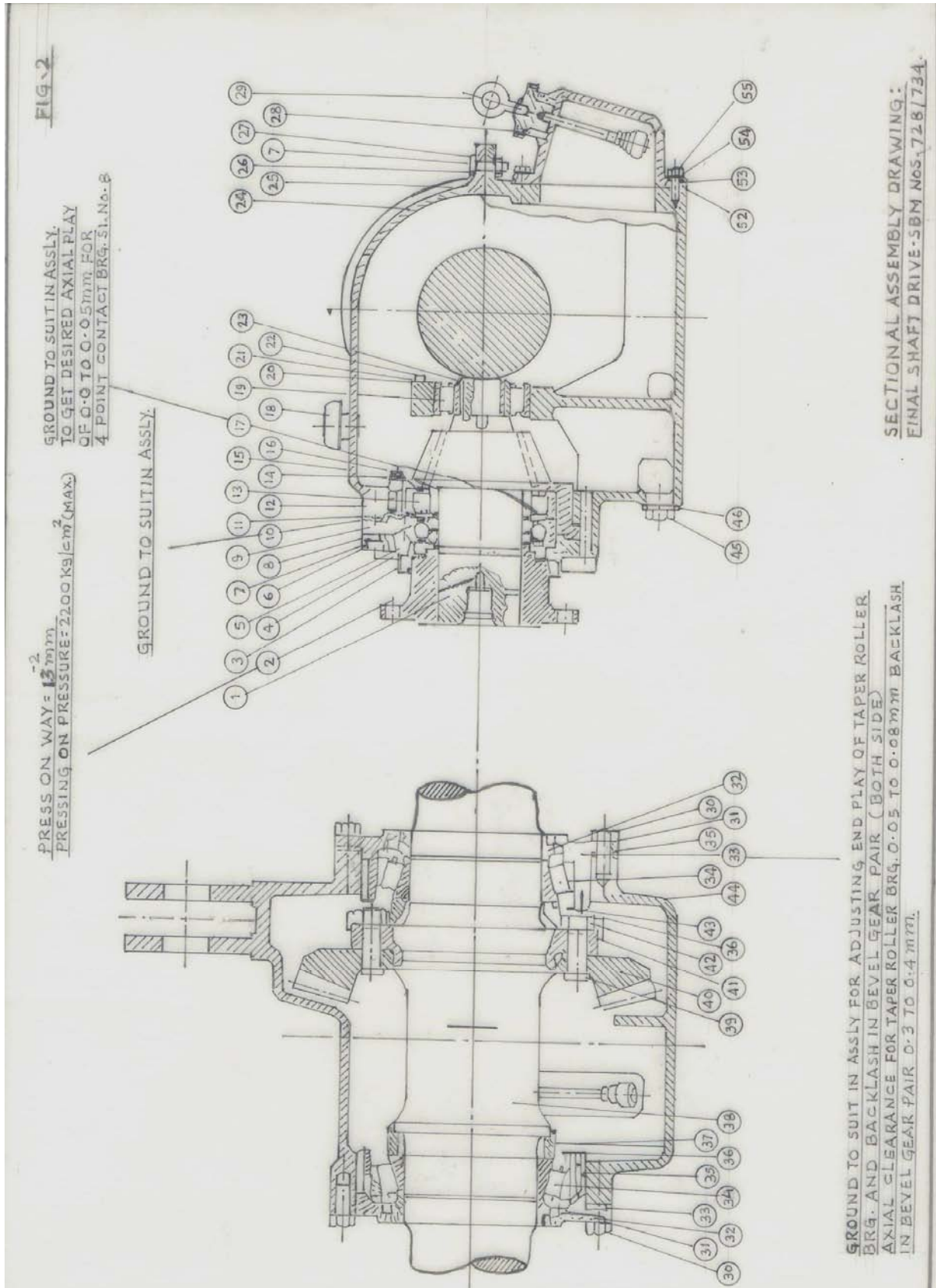


PART LIST OF COUNTER SHAFT AXLE DRIVE

No.	PART No.	DESCRIPTION	No. off
01	729.04.0.03.50	Housing, Lower	1
02	727.00.0.05.50	Socket	1
03	727.00.0.01.50	Dip Rod complete	1
04	727.03.0.08.50	Sheet	2
05	999.30.105.50	Counter Sunk Screw	8
06	727.04.0.02.50	HSG Middle	1
07	999.13.6.02.50	Circlip Ext.	1
08	999.01.6.70.50	Screw Hex. Hd.	15
09	999.01.6.19.50	Screw Hex. HD	3
10	999.11.2.62.50	Washer Spring	11
11	727.02.0.10.50	Sheet	1
12	727.02.0.13.50	Brg. Cyl. Roller with Snap Ring FAG No. – 2310 MENR-MIA C-50/SKF NU-2310 ENR MA-6 C with circlip SP-110.	1
13	727.02.0.11.50	Brg. Cyl. Roller with Snap Ring., FAG-NU-322 ENR MPA-C F-59 SKF NU 322. ENR MP 6 C –Complete with circlip Sp 240.	1
14	727.00.0.04.50	Vent Socket	1
15	727.01.0.01.50	Counter Shaft	1
16	727.01.0.05.50	Bush	1
17	999.0.26.64.50	Screw HEx Sock. Hd. Cap	18
18	999.11.2.74.50	Washer Spring	60
19	727.01.0.12.50	Brg. Cyl. Roller FAG NU 219E-NIA-C3-50/SKF NU 219 E MA6 C3	3
20	727.01.0.11.50	Ring	2
21	727.04.0.01.50	Housing Top	1
22	999.02.6.20.50	Screw Hex. Sock Hd. Cap	8
23	727.0.04.01.50	Dipstick Boss	1
24	727.00.1.00.50	Cover	1
25	729.01.0.01.50	Gear Wheel	1
26	727.04.0.04.50	Oil Guard	2
27	727.01.0.07.50	Spacer Ring	2
28	727.01.0.09.50	Spacer Ring	1
29	727.01.0.08.50	Spacer Ring (2 Pieces)	1
30	727.01.0.10.50	Spacer Ring	1
32	700.99.705.00	Felt Packing	2
33	727.01.0.06.50	Cover	1
34	727.01.0.13.50	Bearing four Pint Contact FAG QJ-218-NI MPA-C3.50/SKF QJ-218-N2 M-C3	1
35	727.01.3.00.50	Brg. Cover	1
36	727.04.1.00.50	Oil Guard Complete	2

37	727.02.0.09.50	Spacer Ring	1
38	727.02.4.00.50	Bush Assly.	1
39	727.02.0.05.50	Bush	1
40	727.01.0.03.50	Coupling	2
41	727.02.0.06.50	Ring	1
42	727.02.2.00.50	Pinion Shaft Assly.	1
43	727.0.04.02.50	Gasket	1
44	727.02.0.14.50	Bearing Four Pint Contact FAG-QJ-219 NI-MPA-C3.50 SKF-QJ-219 NZM C3.	1
45	727.02.0.07.50	Ring	1
46	999.02.6.70.50	Screw HEx. Sock Hd. Cap	8
47	999.01.6.38.50	Screw HEx. Hd.	9
48	729.02.0.01.50	Gearwheel	--
49	700.99.0.20.50	Screw Plug	1
50	727.03.0.01.50	Bevel Gear	1
51	999.01.6.91.50	Screw Hex. Hd.	16
52	999.11.2.86.50	Washer Spring	16
53	727.0.00.12.50	Axle Shaft	1
54	727.03.0.03.50	Ring Labyrinth	2
55	727.03.0.09.50	Brg. Taper Roller 320 30 X	2
56	727.03.0.02.50	Brg. Cover	2
57	727.03.0.05.50	Spacer Ring (2 Pieces)	2
58	999.0.67.25.50	Nut Hex.	10
59	999.11.2.98.50	Washer Spring	10
60	727.03.0.07.50	Bush	1
61	727.03.0.06.50	Screw Fitted	10
62	727.03.0.04.50	Bush	1
63	999.0.66.50.50	Nut Hex	15
64	999.0.27.17.50	Screw Hex. Sock. Hd. Cap	6
65	999.0.27.16.50	Screw Hex. Sock Hd. Cap	4
66	999.0.26.73.50	Screw Hex. Sock. Hd. Cap	4
68	700.6.19.03.50	Pin Taper	2
69	727.04.0.05.50	Pin Taper	2
70	999.18.4.61.50	Washer Sealing	1
72	999.11.2.68.50	Washer Spring	9

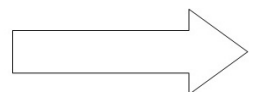
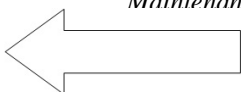




PART LIST OF FINAL SHAFT AXLE DRIVE

No.	PART No.	DESCRIPTION	Qty.
01	728.01.2.00.50	Pinion Shaft Assly	1
02	727.01.0.03.50	Coupling	1
03	728.01.0.04.50	Ring	1
04	727.01.3.03.50	Pin	1
05	728.01.1.00.50	Brg. Cover Complete	1
06	999.02.6.71.50	Screw, Sock. Hd.	8
07	999.11.2.74.50	Washer, Spring	17
08	727.02.0.14.50	Four Point Contact Brg. GAG-QJ 219 NI MPA C3-50 SKF QJ-219 MZM C3	1
09	728.01.0.01.50	Bush	1
10	728.01.0.02.50	Spacer Ring (2 pieces)	1
11	999.0.28.72.50	Grub Screw	1
12	728.01.0.05.50	Ring	1
13	727.01.0.12.50	Cyl. Roller Brg. FAG NU 219E NIA-C3-50/ SKF-NU 219E-MA6-C3	1
14	728.01.0.06.50	Sheet	1
15	999.1.12.50.50	Washer, Spring	2
16	999.01.6.06.50	Screw Hex. Hd.	2
17	728.01.0.03.50	Ring	1
18	727.00.0.04.50	Vent Socket	1
19	727.02.0.13.50	Cyl. Roller Brg. (with snap ring) FAG NU-2310M-ENR-MIA-C3-50/SKF NU 2310 ENR MA6-C3 with circlip SP 110	1
20	727.02.0.10.50	Sheet	1
21	999.11.2.62.50	Washer Spring	3
22	999.01.6.19.50	Screw Hex. Hd.	3
23	999.13.6.02.50	Circlip Ext.	1
24	728.02.0.02.50	Housing Top Part	1
25	728.02.0.01.50	Housing Lower Part	1
26	999.01.6.70.50	Screw Hex. Hd.	9
27	999.06.6.50.50	Nut Hex.	9
28	727.00.0.02.50	Socket	1
29	727.00.0.01.50	Dip Rod Complete	1
30	999.01.6.91.50	Screw Hex. Hd	16
31	999.11.2.86.50	Washer Spring	16
32	727.03.0.03.50	Labyrinth Ring	2
33	727.03.0.05.50	Spacer Ring (2 pieces)	2
34	727.03.0.09.50	Taper Roller Brg. 320 30 X	2
35	727.03.0.02.50	Brg. Cover	2
36	727.03.0.08.50	Sheet	2

37	727.03.0.04.50	Bush	1
38	728.0.00.03.50	Axle Shaft	1
39	727.03.0.06.50	Screw Fitted	10
40	727.03.0.01.50	Bevel Gear	1
41	999.11.2.98.50	Washer Spring	10
42	999.06.7.25.50	Nut Hex	10
43	999.30.1.05.50	Screw Slotted C' sunk Hd.	8
44	727.03.0.07.50	Bush	1
45	700.99.0.20.50	Screw, Plug	1
46	999.18.4.61.50	Washer Sealing	1
47	999.02.7.17.50	Screw Socket Hd. Cap	6
48	999.11.2.86.50	Washer, spring	6
49	700.61.9.03.50	Pin, Taper	2
52	727.0.04.02.50	Gasket	1
53	728.0.03.01.50	Dip Stick Boss	1
54	999.11.2.68.50	Washer Spring	9
55	999.01.6.38.50	Screw Hex. Hd.	9



AXLE BOX OVERHAULING
(Ref.: CLW Drg.No.1D/26A.05.112)

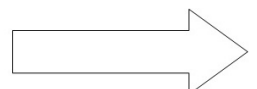
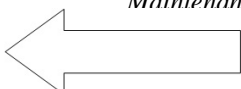
2. Clean axle box externally from dust & dirt.
3. Degrease bearings of Axle boxes.
4. Remove Roller Bear from Axle boxes on the puller.
5. Clean Axle Box Housing, Cover and its parts free from grease, dust and water.
6. Clean Roller Bearings thoroughly. It should be free from Grease, Dirt, Dust and Water.
7. Check the condition and defect of Roller Inner Race/Roller Bearings visually as listed below.
 - a) Rust & Corrosion
 - b) Seizure
 - c) Crackness
 - d) Cage damage
 - e) Wear
 - f) Chipping
 - g) Colour change
 - h) Ovality of sizes



8. Check the condition and crackness of followings.
 - a) Axle Box Housing
 - b) Axle Box Cover.
 - c) Axle Box Cover Bolts.
 - d) Axle Box Bearing Locking Bolts.
 - e) Axle Box Bearing Locking Retaining Ring.
 - f) Axle Box Bearing Locking Plate.
9. Check the condition of Axle Box eye hole for crack and weariness. Repair, if required.
10. Check the condition of Axle Box all tapping thread hole. Re-tape, if required.
11. Check the ovality of Axle Box Housing and record in register.

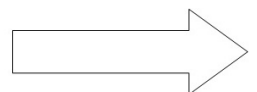
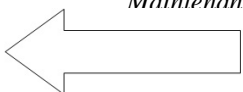


12. Paint the Axle Box Housing and cover with black enamel color.
13. Check the condition of Axle Box felt and change if required.
14. Grease the Roller Bearing with specified grease with specified quantity.





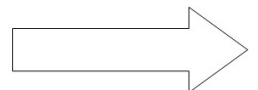
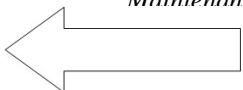
15. Fit the Roller Bearings in Axle Box.
16. Cover the Axle Box Housing both side to avoid entrance of foreign particles in Axle Box Bearing.
17. Fit the Axle Box properly related axle after taking bearing clearances.



MAINTENANCE OF BOGIE CARDEN SHAFTS

- | | | | |
|----|---|---|---------|
| 1. | Carden Shaft (Total length 710 mm – 785 mm.) | - | 02 Nos. |
| 2. | Carden Shaft (Total length 1300 mm -1375 mm.) | - | 01 No. |
| 3. | Carden Shaft (Total length 1375 mm – 1450 mm) | - | 01 No. |

Inspect both side universal of Carden Shaft for crack, tear & wear. Properly check all side of circlip fitment of both side of universals of carden shafts. Check all three greasing nipple fitment and replace as necessary and properly grease through these greasing points.



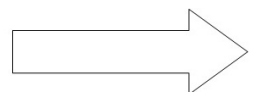
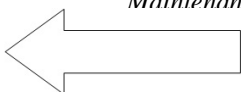
DOUBLE ACTING HYDRAULIC SHOCK ABSORBER

Double acting hydraulic shock absorber Qty. – 04 Nos. fitted in ZDM-5 loco between loco and bogie for preventing excessive vibration of loco during motion. These shock absorbers are as CLW Drg.No.2D/26A-07-101 with following specifications.

Compressed length	-	345 \pm 5 mm.
Extended length	-	475 \pm 5 mm.
Tension	-	1200 Kg. \pm 10%.
Compression	-	1200 Kg. \pm 10%.
Piston Speed	-	10 Cm./Second.

Maintenance:

1. Remove top pin from loco and bottom pin from bogie frame of each shock absorber.
2. Dismantle top & bottom of each shock absorber.
3. Clean & check pin, ball, cover plate and bush for ovality and rubber gasket and replace if necessary.
4. Reassemble top & bottom with proper greasing and assemble with loco with pin & locking screw.



CATTLE GUARD

(Ref. : CLW Drg.No.1D/28.03.102)

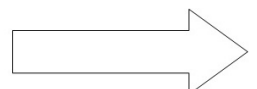
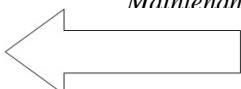
1. Check 10 Nut-bolt fitment of cattle guard each side.
2. Check cattle guard for damaged or bent. It should be heated at appropriate places & straightened.
3. Crack should be welded.
4. Paint the cattle guard with black enamel.
5. Maintain the clearance of cattle guard from rail level Max. 86 mm., Min. 76mm.



SUSPENSION SPRINGS

(Ref.: CLW Drg.No.3D/12.07.101)

1. Clean all 16 Nos. Coil Springs with wire brush (Do not scrap).
2. Visually examine the springs for any cracks or breakages.
3. Cracked springs should not be continued in service under any circumstances.
4. Check and match free height of the spring and record free height 220 mm.
5. Apply protective coating of anti-corrosive paint (Black Enamel based).



OVERHAULING OF BOGIE FRAME WITH BRAKE RIGGING ARRANGEMENT & TORQUE ARM ASSEMBLY PARTS

BOGIE FRAME OVERHAULING

The bogie frame of ZDM-5 loco is Bo Bo type (Fabricated). The frame should be checked for cracks especially at corners. It should also be checked for damage, bending, warping and distortion. In case found damaged or distorted, it should be heated at appropriate places & straightened. Crack should be welded and patched if necessary.

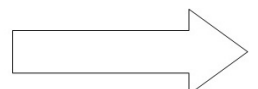
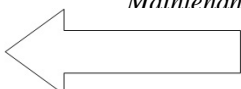
1. Rinse the bogie frame with cleaning agent for sufficient time to ensure removal of dust & rust. Blow out with compressed air to remove moisture and loose scale.
- i. Check evidence of cracks by carrying out magna flux check at critical stress area and repair any defect.
3. Check the frame, serration block, threads of all 16 Nos. holes and retape if necessary.
4. Check bogie center pivot for bronze bush condition, self aligning bearing free movement and circlip fitment. Bronze bush ID 90 mm. + 0.035 mm. (Ref.: CLW Drg.No.4D/12.04.179).
5. Paint the bogie frame with black enamel paint.



BRAKE RIGGING ARRANGEMENT & TORQUE ARM ASSEMBLY PARTS OVERHAULING

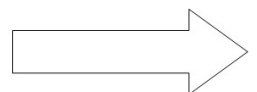
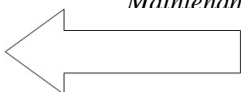
Properly clean and check the following brake hanger and torque arm parts for bush ovality and pin fitment and reassemble with proper greasing.

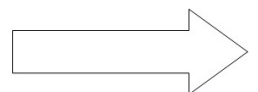
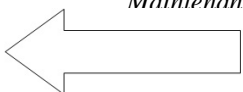
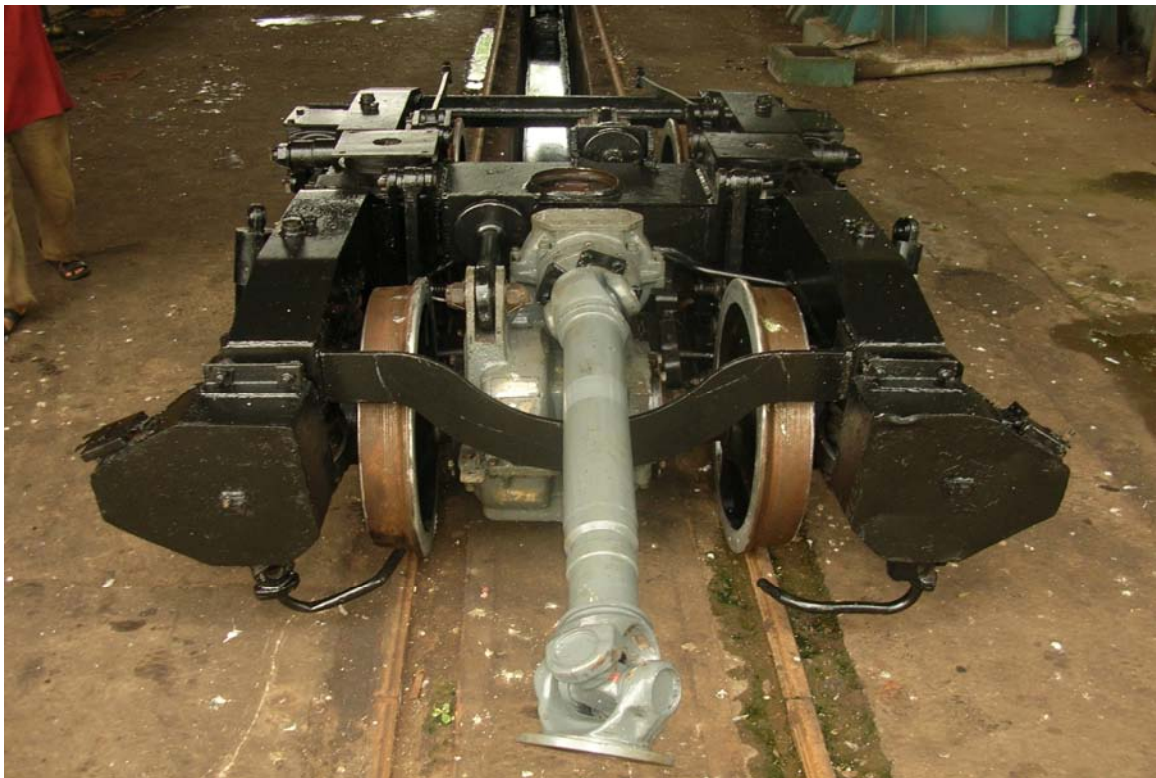
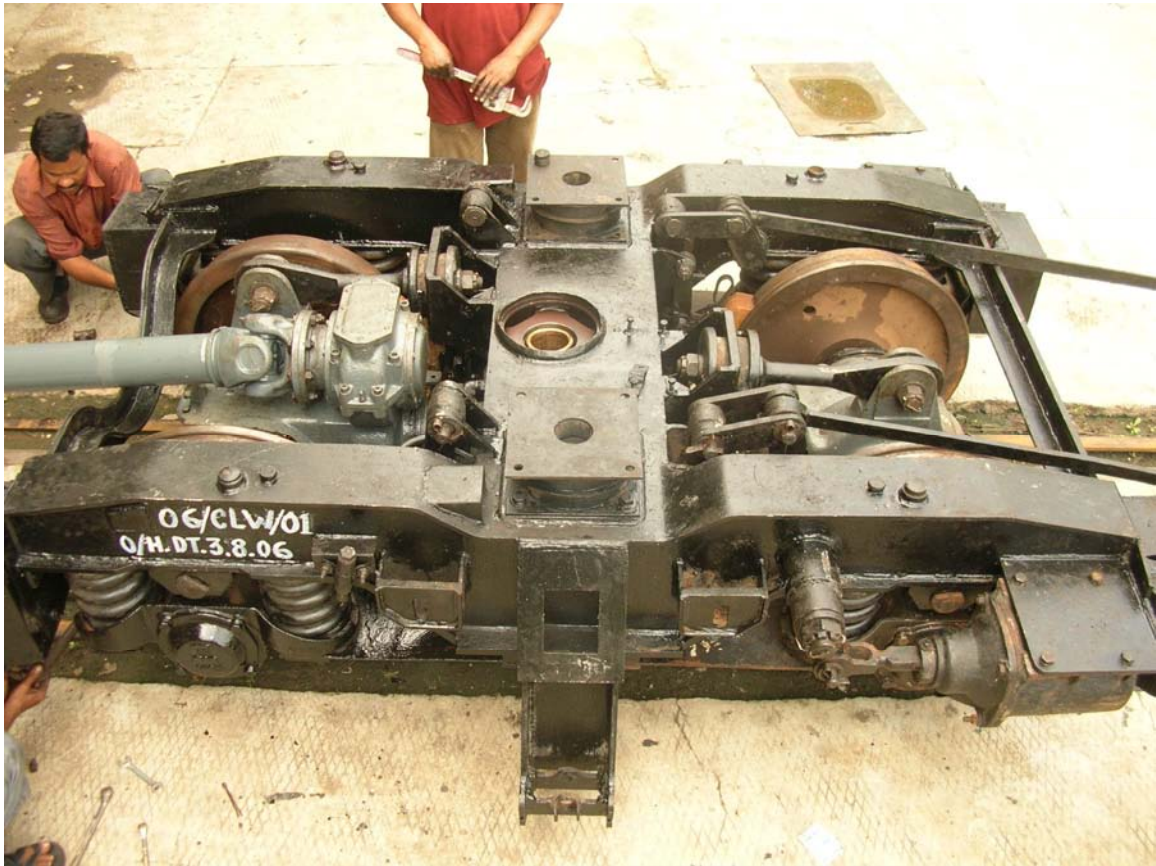
- a) 04 set of brake rigging lever.
- b) 04 set of brake hanger with link.
- c) 04 set of fork (LH) & (RH).
- d) Free both side fork on screw with proper lubrication.
- e) 04 Nos. brake rigging lever/ boss with brake supporting arm.
- f) Overhaul 04 Nos. brake cylinder. Bushes and rubber bucket to be changed if required. Check on test stand for proper working.
- g) 04 Nos. torque reaction arm assembly with self aligning bearing. Change spring rubber disk if required.
- h) 02 Nos. hand brake rigging lever.
- i) 04 Nos. brake rigging arm supporting rod.
- j) 08 Nos. brake shoe.
- k) Both center pivot oil filling pipeline.



ASSEMBLING OF BOGIE

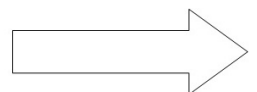
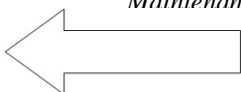
1. Assemble bogie frame with brake gearing parts with proper greasing of pins and new split pin, cotter pin.
2. Assemble torque arm assembly with bogie frame.
3. Adjust axle drive gear box – wheel unit and maintain suspension spring height 220mm with adding liner if necessary and fit bogie with proper alignment.
4. Assemble axle drive gearbox with torque arm assembly with alignment. Check self aligning bearing, inner-outer pair, pressure disc and torque arm pin for crack & wear and change if necessary.
5. Assemble 4 Nos. axle guide pin of proper size with each bogie with split pin.
6. Assemble 16 Nos. horn-stay plate bolt with locking plate. Join horn-stay plate with serration block of each bogie frame with proper alignment. To check matching of serration block teeth with leaf spring teeth.
7. Check axle box center to center distance (wheel base) 1590mm. (Ref.: CLW Drg.No.1D/28A.01.101)
8. Assemble small carden shaft with both gear boxes flange with nut-bolts with locking plate i.e. primary axle drive gear box to secondary axle drive gear box.
9. Assemble 4 Nos. safety bracket / chain between bogie frame and cross over rod for safety of small carden shaft.
10. Assemble "U" shape bracket with each bogie frame for safety of small carden shaft.
11. Assemble 02 Nos. overhauled brake cylinders after checking bushes for ovality with each bogie frame and connect with brake supporting arm with proper cotter pin.
12. Assemble 4 Nos. new brake block with proper fitment of brake key.
13. Assemble 4 Nos. sand box with pipe arrangement with bogie. Keep minimum height of sand box pipe from rail level 55mm. (Ref.: CLW Drg.No.1D/28.04.101).
14. Check magie side bearer condition and change if required.
15. Assemble big carden shaft with primary axle drive gearbox Input flange with nut-bolts and locking plates.





ASSEMBLING OF BOGIE WITH LOCOMOTIVE

1. Lift loco on electric jack equally on all four sides.
2. Check 4 Nos. magie side bearers with frame. Check condition & free height and replace if necessary.
3. Run in both overhauled bogie with alignment of center pivot pin into the bronze bush with self aligning bush of bogie.
4. Lower loco and assemble center pivot pin 1 & 2 into the bush and check clearance between center pivot pin and bush. Fit bottom plate of center pivot with new gasket and fill oil upto HIGH mark.
5. Adjust frame stop clearance Max. 22mm. with adding shim if necessary and fit & tight 16 Nos. bolt with nut.
6. Assemble both big carden shaft with Transmission output flange with lockbolt with locking plate.
7. Lock all 32 Nos. horn-stay bolts. Assemble 2 Nos. hand brake lever with shaft with proper greasing.
8. Check and clean hand brake assembly parts, small & big sproket, long screw, chain, levers & pins with cotter pin and replace if required. Proper greasing in chain, sprockets and other moving parts.
9. Assemble additional "U" shape bracket for safety of big carden shaft jointing to TRM.
10. Carry out final general inspection of complete bogie.



**OVERHAULING OF THE DRAW AND BUFFING GEAR
(NG Coupler ABC Yoke End With Lifting Gear)
(Ref.: HQ.Drg.No. CA/BD/2/H)**

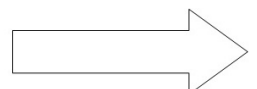
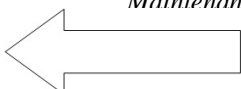
1. Dismantle the Coupler Assembly for inspection and overhauling.
2. Clean properly all dismantled parts with cleaning agent.
3. Check the draw bar for shank wear, bent, thread damaged, hole oblong and repair or replace if necessary.
4. Check the helical spring for free camber, crack and replace if necessary.
5. Check the coupling block, link and coupling yoke for wear, crack, hole oblong and repair or replace as necessary.
6. Check the pivot pin, yoke pin and the link pin for wear, bent and replace if necessary.
7. Check the coupling yoke nut for worn thread, crack and replace as necessary.
8. Check the hook head and yoke head for face worn, crack, damage and repair or replace if necessary.
9. Check all dismantled buffer assembly parts with magnaflux test.
10. Assemble all parts with proper greasing and new cotter pins.
11. Maintain distance between buffer and rail level. Maximum 540 mm Min 495 mm



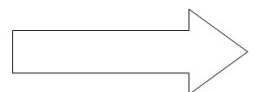
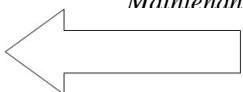
NDM-5/ZDM-5 BOGIE IMPORTANT MEASUREMENT

Description	New	Condemn	Ref. Drg.No.
Wheel Dia	700 mm.	640 mm.	RDSO Drg.No.SKMP.211
Wheel Flange Depth	6.0 mm.	0.00 mm.	RDSO Drg.No.SKMP.209
Wheel Flange Thickness/ Flange Wear ZDM5	24 mm.	13 mm.	RDSO Drg.No.SKMP.210
Wheel Flange Thickness/ Flange Wear NDM5	22 mm.	12 mm.	RDSO Drg.No.SKMP.210
Distance between inside gauge face of wheel on same axle (Wheel gauge)	698.5 \pm 0.5 mm.		CLW Drg.No.1D/28A.05.101
In Wheel Dia Permissible difference in same axle wheels or same locomotive wheels	2.00 mm.		RDSO Drg.No.SKMP.211

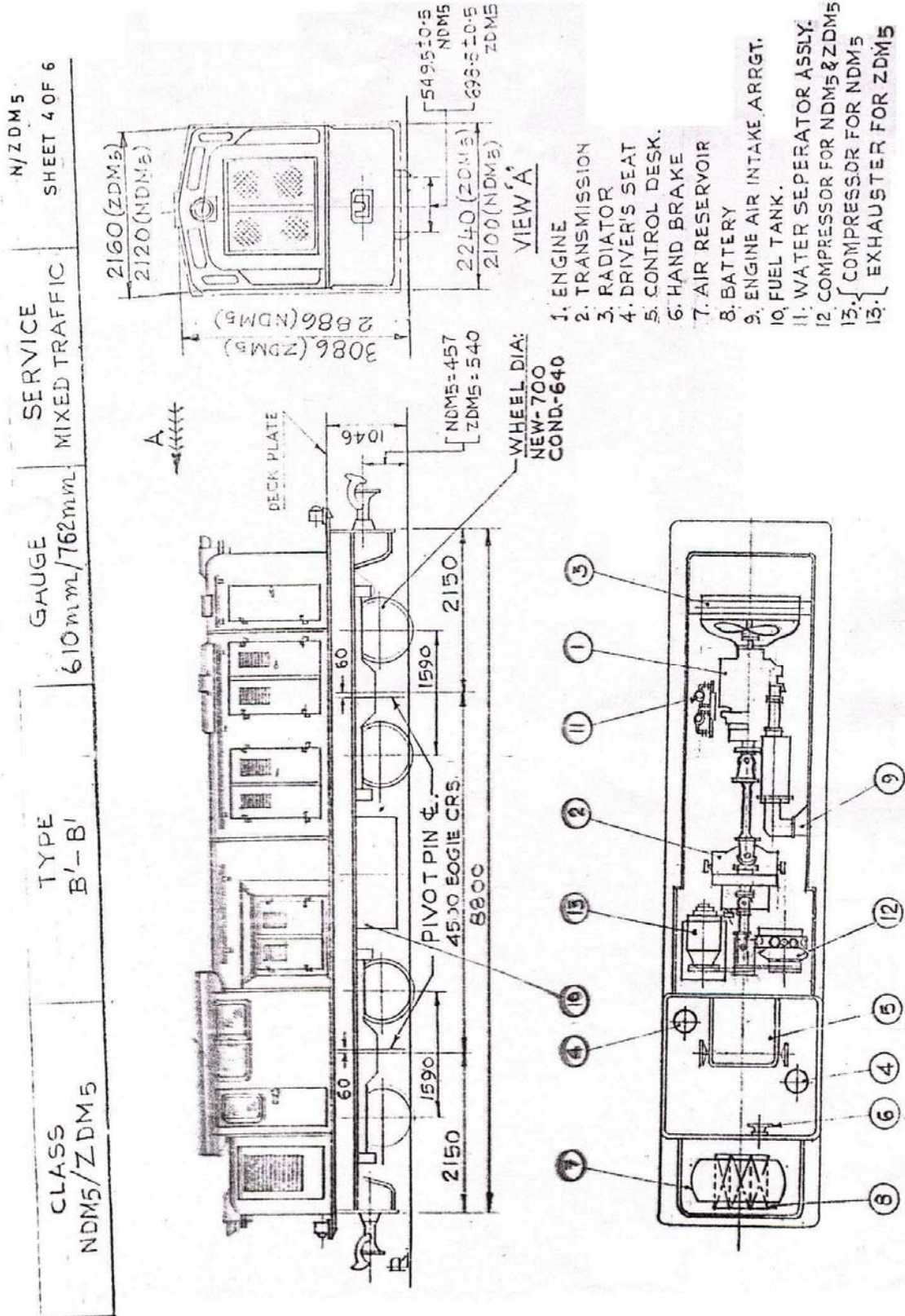
Description	Normal	Max	Min.	Ref. Drg.No.
Bogie Stop Clearance over axle box (BSC)	15mm.	20mm.	15mm.	CLW Drg.No.1D/12A.07.119
Frame Stop Clearance (FSC)	20mm.	22mm.	15mm.	CLW Drg.No.1D/12A.07.119
Height of Deck Frame to Rail (Foot Race)	1046mm.	1046mm.	1041mm.	CLW Drg.No.1D/12A.07.119
Distance of Shock Absorber Pin to Pin	375mm.	378mm.	369mm.	CLW Drg.No.1D/12A.07.119
Buffer Height from Rail	520mm.	540mm.	595mm.	CLW Drg.No.1D/28A.01.101 WM/PRTN Sketch No. 356. RDSO Let.No.SD/DEV ZDM5.1 dt. 15.07.05
Clearance between Cattleguard and Rail	85mm.	86mm.	76mm.	RDSO Drg.No.1D/28A.03.102
Safety Linkage clearance		35mm.		CLW Drg.No.1D/12A.07.119
Distance between two axle box center to center on difference axle (Wheel base)	1590mm.			CLW Drg.No.1D/28A.01.101
Free height of Coil Spring	219.2 \pm 3.5 mm.			CLW Drg.No.3D/12.07.101
Axle box housing size	ϕ 200 + 0.046 mm.			CLW Drg.No.1D/26A.05.112

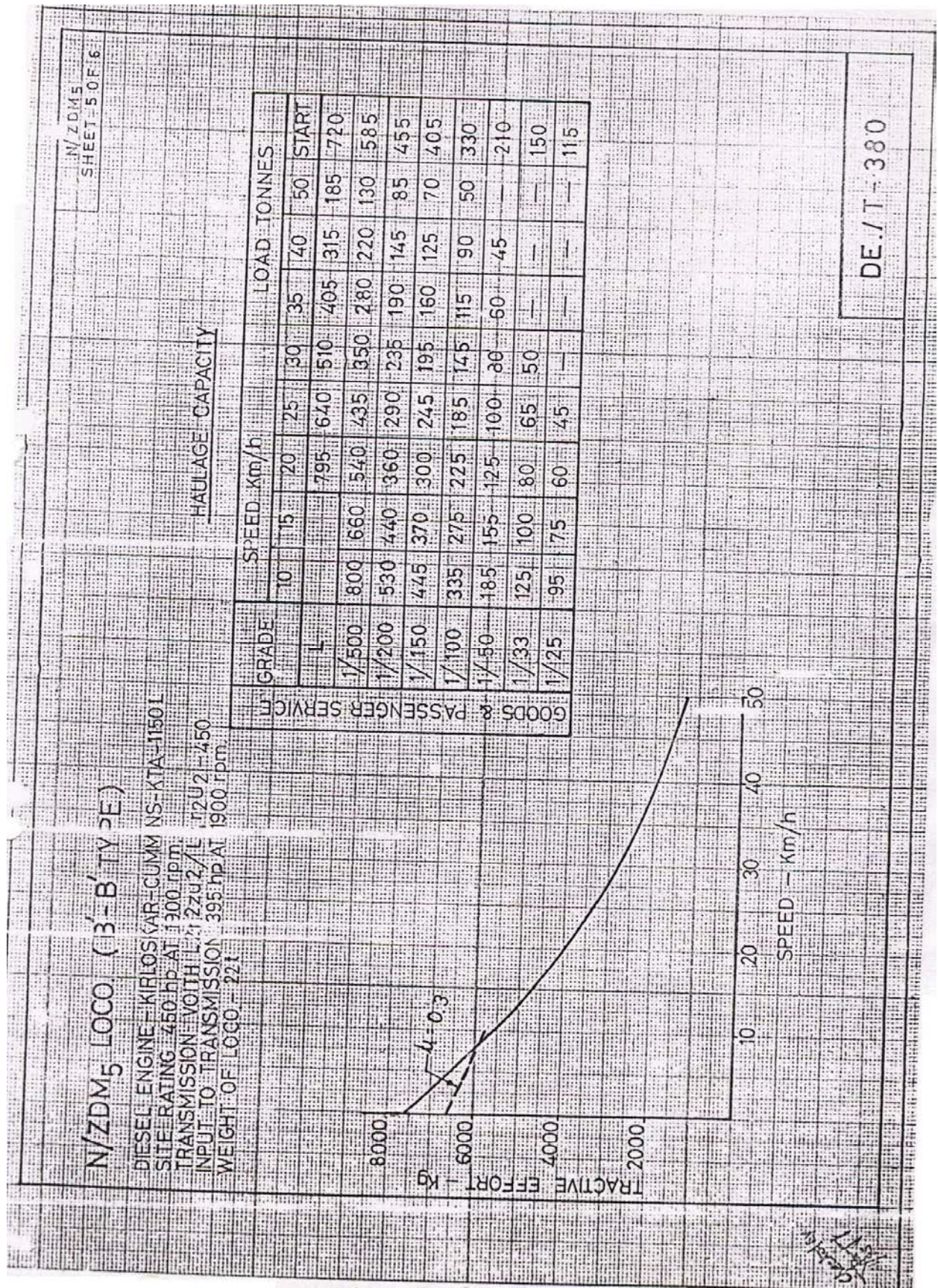


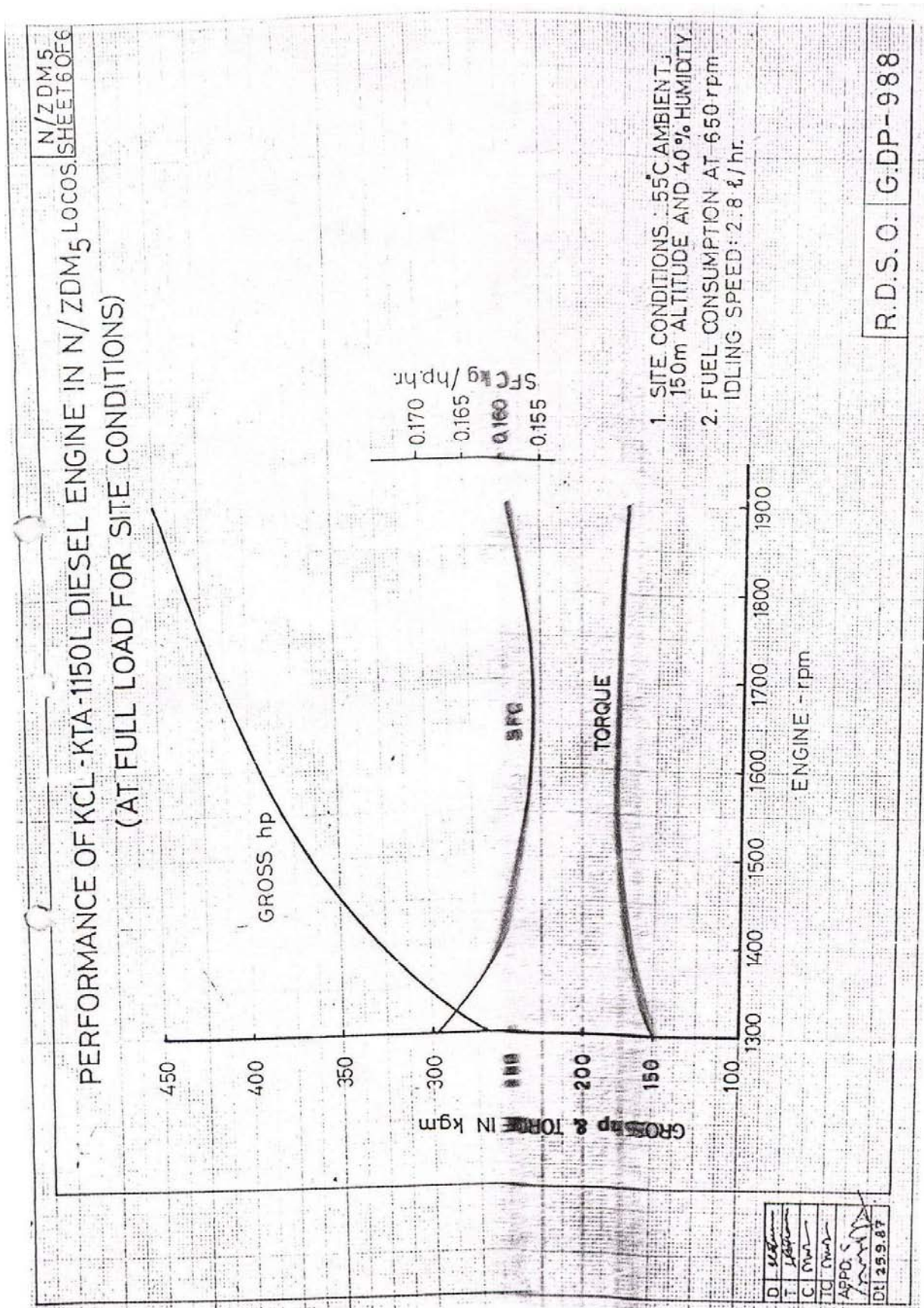
IMPORTANT PARAMETERS AND DRAWINGS

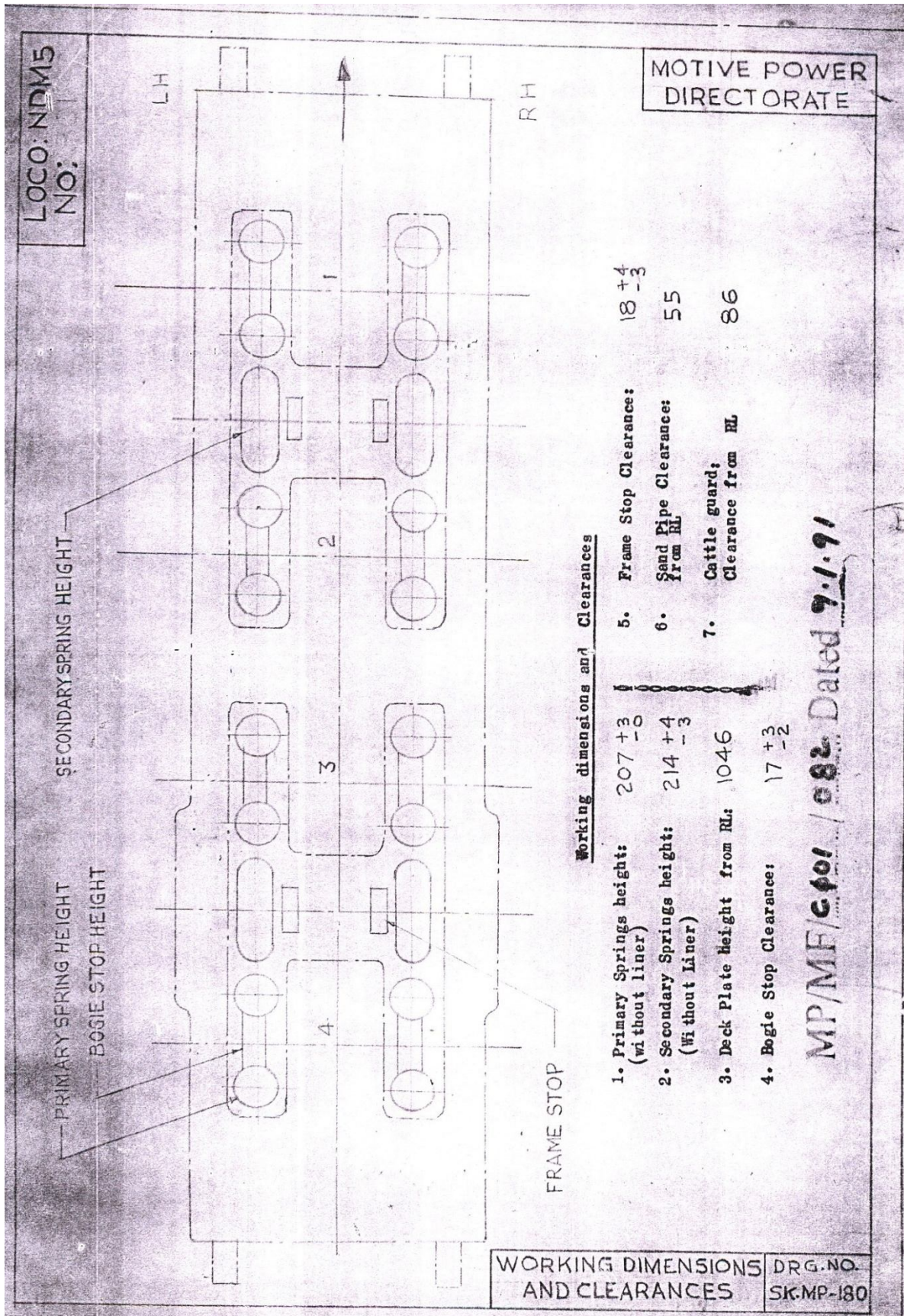


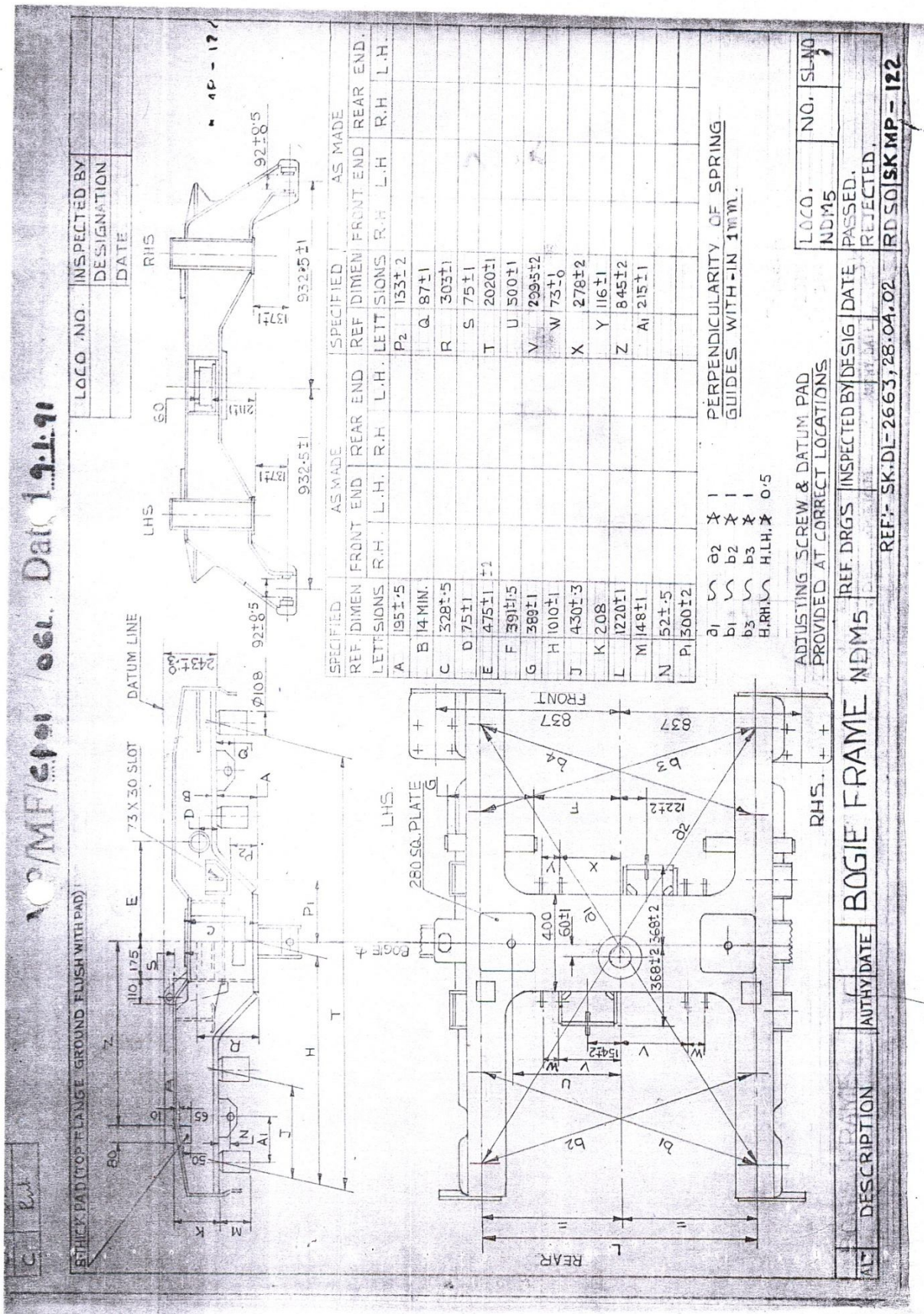
ANNEXURE

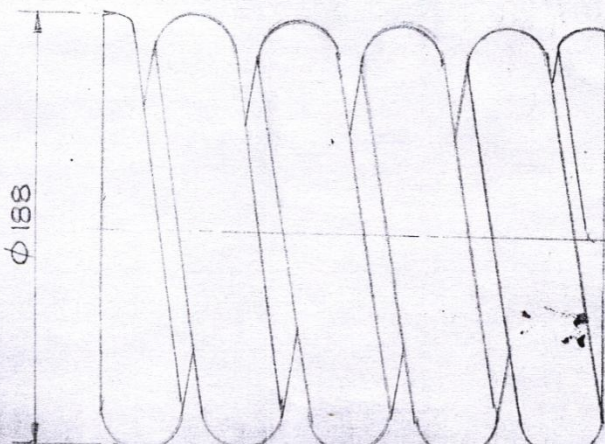











INDIAN RLYS		APPLICABLE FOR		BOGIE SUSPENSION SPRINGS	
RD 50 (MP)		ZDM2R, ZDM3 ZDM4A, N/ZDM5			
					
MP/MP/6001 /056. Dated 9.1.91					
MATL: & SPEC Gr: 50 Cr4 V2, IS: 3195 NO./LOCQ:- 16					
SPRING DATA					
1	DIAMETER OF WIRE - mm	34			
2	FREE HEIGHT - mm	219.2			
3	SOLID HEIGHT - mm	170			
4	TOTAL NO. OF TURNS	5.5			
5	SPRING WORKING LOAD - Kg	1936			
6	SOLID CAPACITY - Kg	4585			
7	SPRING RATE - Kg/mm	93.2			
8	WORKING HEIGHT - mm	198.5			
DIMENSIONAL TOLERANCES					
1	VARIATION IN WIRE DIA. - mm	± 0.17			
2	VARIATION OF OUT SIDE DIA. - mm	± 1.8			
3	VARIATION IN FREE HEIGHT - mm	± 2.5			
4	VARIATION IN LOADED HEIGHT WITH WORKING LOAD - mm	± 1.5			
5	OUT OF SQUARE OF SPRING MAX.	57° (2.2 mm)			
6	PARALLELISM OF THE GROUND ENDS TO BE WITHIN	9° (2.8 mm)			
7	VARIATION IN SPRING RATE	± 5%			
PAIRING OF SPRINGS					
GROUP	COMPRESSED HEIGHT MEASURED AT 1936 Kg LOAD	FROM	TO	COLOUR TO BE PAINTED	
A	197	198		WHITE	
B	198.5	199.5		RED	
NOTE:- FOR MANUFACTURE, INSPECTION AND TESTING OF HOT COILED HELICAL COMPRESSION SPRINGS REFER TO TECHNICAL SPECIFICATION NO. MP-0-4700-01.					

ALT.	NO. OF PLACES	REF. NO.	DESCRIPTION	ALT. NOTE NO.	SIGN.	DATE	FIRST ISSUED	SUPERSEDES SK. DL-	SUPERSEDED BY
1/86									

SCALE:-	REF. SK. MP-
	DRG. No. SK.MP-113

RD 50
MOTIVE POWER
DIRECTORATE

MAINTENANCE INSTRUCTION FOR
FRICTION DAMPING ARRGT. - NDM5

ALT.

MP/MF/c401/080 Dated 9.1.91

AXLE NO.	ACTION	LHS			RHS			DATE
		DIMENSION			DIMENSION			
		A	B ₁	B ₂	A	B ₁	B ₂	
1	RECORDED							
	ADJUSTED TO							
2	RECORDED							
	ADJUSTED TO							
3	RECORDED							
	ADJUSTED TO							
4	RECORDED							
	ADJUSTED TO							

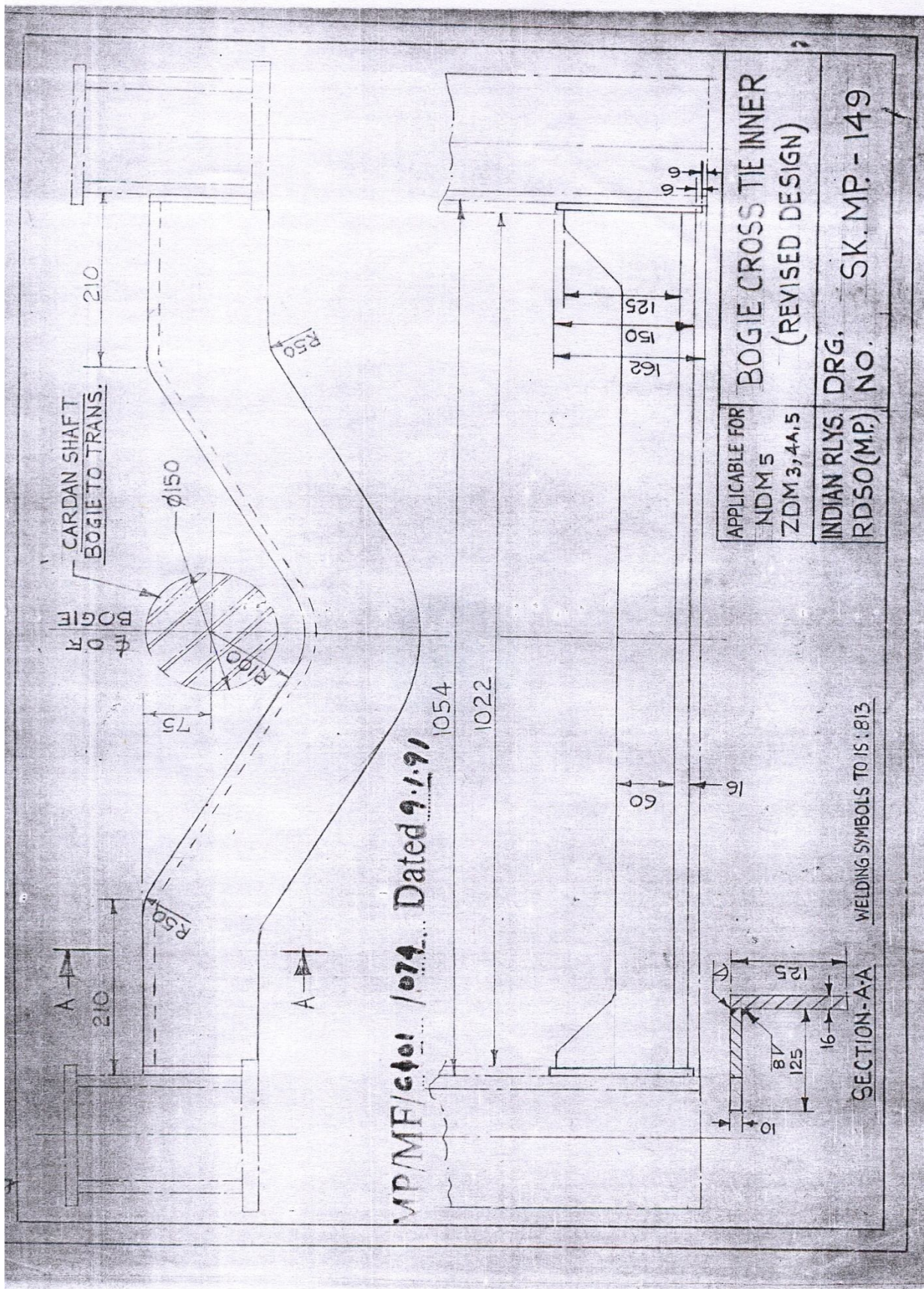
NOTE :-

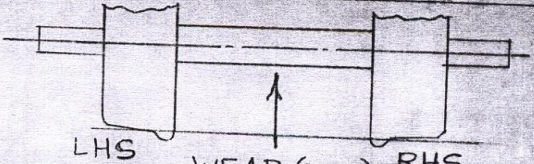
1. WHEN DIMENSION 'A' OF SPRING BECOMES 33 mm DUE TO WEAR OF FRICTION LINERS, REF. NO. (2), ADJUST IT TO 30 ± 0 mm BY TIGHTENING NUT, REF. NO. (1)
2. CONDEMN THE LINERS, REF. NO. (2), WHEN CLEARANCE B₁ OR B₂ IS REDUCED TO 3 mm.

REF:- SK.MP-160 & 161 ALT. @

MAINTENANCE INSTRUCTION SK.MP - 188

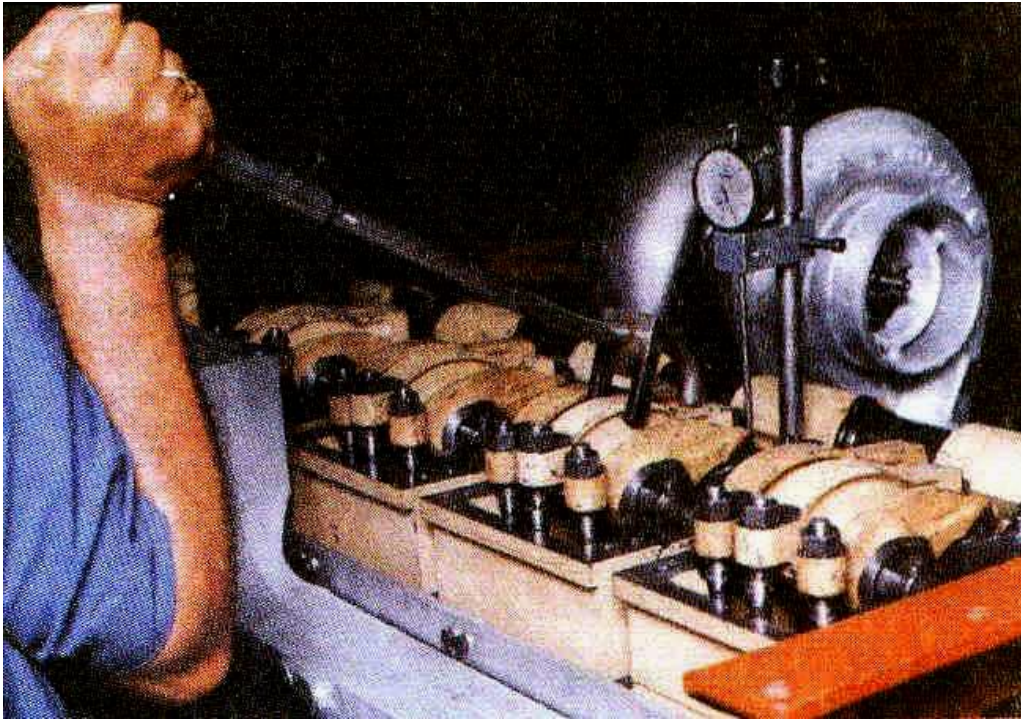
D 24/10/91
C
T
TC
APPD.
WUDAV
06/6/89



WHEEL WEAR DATA OF NDM5 LOCOS											
(Collected from GWO Sheet on)											
LOCO NO.	Date of Commission	Km. Earned	On Date	Date of Last Wheel turning	AXLE NO.	Tread Wear	Root Wear	Flange Wear	Flange Wear	Root Wear	Tread Wear
801											
802											
803											
804											
805											
806											
807											
808											
809											
810											
811											

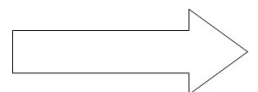
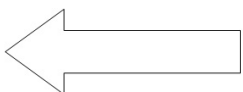
SK MP-187

Chapter- 6



SCHEDULE OF STANDARD EXAMINATION

(NDM-5/ZDM-5 NG LOCO)



Chapter- 6

SCHEDULE OF STANDARD EXAMINATION OF NDM-5/ZDM-5 NG LOCOMOTIVE

1. Introduction:

- 1.1 The schedule for examination and maintenance of NDM-5/ZDM-5 NG Locomotive has been prepared taking into account the recommendation of OEM and suitably modified based on feedback received from users of Locomotive.
- 1.2 The service periods of NDM-5/ZDM-5 NG Locomotive specified in this schedule for maintenance attention are the maximum allowable periods between successive examinations. Variations in operating conditions in different regions may make it necessary to carry out examination more frequently, or introduce examinations not scheduled herein. In such cases, the matter should be brought to the notice of the appropriate Sr. DME/DME, who alone is authorised to introduce any change in the standard examination detailed herein. The Sr. DME/DME in all such cases, will bring to the notice of the Motive Power Directorate of RDSO, for any modification to the schedules, giving full details.

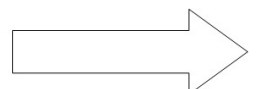
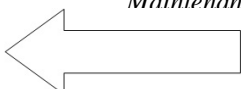
2. References:

The following documents are also required to be referred for further information.

- 1) Operation and Maintenance Manual, Bulletin No. 3243773-05 (Latest issue), Cummins India Limited.
- 2) Shop Manual, Cummins KT(A)-1150 Diesel Engines, Bulletin No. 3243673-00 (Latest issue), Cummins India Limited.
- 3) PT injectors Calibration Instructions, Bulletin No. 3243607-01 (Latest issue), Cummins India Limited.
- 4) Cummins PT injectors component shop Manual, Bulletin No. 3379071-06 (Latest issue), Cummins India Limited..
- 5) Operating, Maintenance Manual for Reciprocating Air Compressor, ELGI Equipments Limited.
- 6) Operating Instructions and Maintenance Manual for Kirloskar Forward Reverse Turbo Transmission Model – L4r2U & L4r2U2, Kirloskar Pneumatic Company Limited.

3. Periodicity of maintenance of CIL engine, Compressor, Forward Reverse Turbo Transmission, Bogie, Turbo supercharger, Electrical equipments, Brake equipments etc.:

- i) Trip Schedule.
- ii) fortnightly Schedule
- ii) Monthly Schedule.



- iii) Quarterly Schedule.
 - iv) Half yearly Schedule
 - v) Yearly Schedule
4. Based on the recommendations of OEM, the periodicity of change of filters and oil in various systems of NDM-5/ZDM-5 NG Locomotive, their specification and source of supply are summarised below for information.

4.1 Recommended Lubricants for Engine lube oil:

S.No	Name of Manufacturer	Brand name
1.	Indian Oil Corporation	SERVO-PREMIUM CF45W40
2.	Hindustan Petroleum corporation	Hylube Milcy Power
3	Bharat Petroleum Corporation	MAKCF4-15W40
4.	Valvoline Cummins Limited	Valvoline Power Supreme 15 W40

4.2 Recommended Hydraulic oil for cooling system of CIL engine.

IOC - Servo System – 68

HP - Enklo – 68

BP - Hydrol – 68

4.3 Cleaning of Hydraulic oil :

The hydraulic oil is required to be periodically cleaned by Centrifuge Cleaning arrangement. During oil change and also during top-up, oil should be added through Centrifuge Cleaning arrangement so that cleanliness of oil is maintained.

4.4 High speed Diesel:

The high speed diesel oil shall be to IS 1460: 1995 read with Amendment 2 (February'1999)

5. General Instructions :

- 5.1 The intensive utilisation of the NDM-5/ZDM-5 NG Locomotive necessitates properly laid down maintenance schedules to be followed. A well organised inspection is essential to ensure reliability and freedom from failure in service.
- 5.2 There are certain fundamental requirements that are important to any successful maintenance programme. These are:-

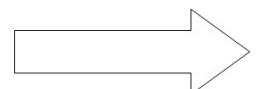
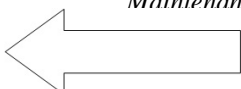
Adequate provision of well trained supervisors and skilled workmen.

Adequate provision of proper maintenance facilities and tools.

Adequate time for scheduled maintenance work to be completed properly before a NDM-5/ZDM-5 NG Locomotive is released for its next trip.

Provision of lubricating oil, water treatment etc. required to ensure satisfactory engine performance.

A well scheduled maintenance programme including an adequate system of maintenance of records.



While carrying out the work of the schedule, all missing nuts, bolts, set-screws, cotters, split pins etc. must be REPLACED as and when found defective. Split pins and cotters once removed should not be used again and new ones must be fitted.

All loose nuts, set screws etc. must be tightened. Wherever cotters or split pins are fitted, they must be of the correct size and so fitted that they bear against the nut or washer properly. Examine and ensure that all locking devices, wherever provided, are properly secured.

All measuring devices such as torque wrenches, electric meters, lubricant dispensers etc. which require calibration should be checked quarterly or sooner, if required, for accuracy.

All tools and parts should be accounted for and removed from the NDM-5/ZDM-5 NG Locomotive after any maintenance work has been performed.

All work done including methods and tools used must be in accordance with the manufacturers instructions, maintenance manual or any technical orders issued.

Do not mix different brands of greases. Excessive lubrication is as harmful as inadequate lubrication.

Use of waste cotton on NDM-5/ZDM-5 NG Locomotive is prohibited.

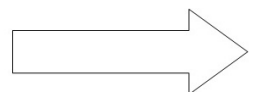
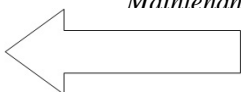
Use lint less rags or wiping towels. Exterior of NDM-5/ZDM-5 NG Locomotive is to be washed after each trip.

The underframe and top surface of fuel tanks should be cleaned to remove dirt and oil.

Spraying of water directly on electrical equipment should be avoided. Interior of cab, all windows, head/light and warning light lenses etc., must be thoroughly cleaned.

The fire extinguishers should be refilled and maintained as per the schedule. Under no circumstances should any NDM-5/ZDM-5 NG Locomotive be allowed to leave the shed without requisite number of fire extinguishers in working order.

During any schedule examination, all the items of the lower schedules should also be carried out.

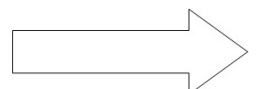
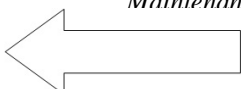


GENERAL INSPECTION (MECHANICAL)

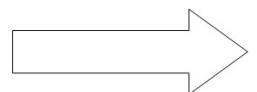
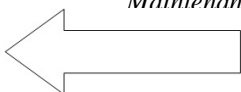
LOCO NO.:

DATE:.....

	Work to be done	Work done by
1	Check Driver's booking and attend.	
	Diesel Engine in Running Condition	
2.	Feel Temperature of all Axle Boxes.	
3.	Check abnormal sound of the following: a) Engine b) Turbo charger c) Transmission d) Exhauster e) Compressor f) Radiator fan	
4.	Check leakages from the following: a) Lube Oil System b) Fuel System c) Transmission d) Air & Vac. System e) Axle Drive Gear Box f) Cooling Water System g) All Pressure to check & adjust.	
5.	<u>Vacuum Exhauster:</u> Ensure lubrication at the following points. a) Floating Ring - 18 drops/Min. b) Bearing - 9 drops/Min.	
6.	<u>Engine Lube Oil Pressure & Water Temperature:</u> Check the Lube Oil Pressure & Water Temperature at engine idling & record.	
7.	<u>Driver Cab.:</u> Check the following for proper working: Wiper Horns Driver Main Control Valve. Brake Cyl. Pressure(not less than 3 kg/cm ² Vacuum on dummy/Test plate 45/43 cm ² M.R. Pressure build up time 0 to 8.0 kg/cm ² .	
	<u>Diesel Engine Stopped Condition:</u>	
8.	Check Oil level in the following and top up if necessary. a) Engine Crank Case b) Transmission c) Air Compressor d) Center pivot pin e) Axle Drive Gearbox f) Exhauster	
9.	Check water level, top up radiator with treated water if required	



10.	Record GI repairs and action taken.	
11	Drain M.R. Tanks.	
12	<p>Examine visually, the bogies to detect loose, defective or missing parts of sub-assly. & Assly.</p> <p>Apply the air brake of the loco and check if all the brake cylinder piston are operating freely & travel of piston should be adjusted to 50mm.</p> <p>Inspect wheels & Axle box for visual defects such as flat spots, skidding, crack etc.</p> <p>Check following for any defects:</p> <p>1) Cattle guard 2) Axle box on arrival</p> <p>Buffer couplers 4) All brake gearing</p> <p>Hand brake for proper working.</p> <p>Torque arm nuts & pins.</p> <p>Check the condition & tension of all belts.</p>	
13.	<p>Fire extinguishers:</p> <p>Check for broken & missing seals.</p>	
14.	Loco cleaning.	
<p>Signature : ----- Signature : -----</p> <p>Name of D/Mech.: ----- Name of Supervisor: -----</p>		



GENERAL INSPECTION (ELECTRICAL)

LOCO NO.:

DATE:.....

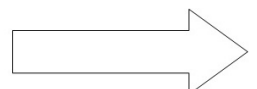
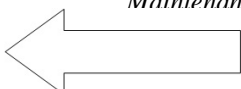
	Work to be done	Work done by
1	Check Driver's booking and attend.	
	DIESEL ENGINE IN RUNNING CONDITION	
1.	Check Earth Check Alternator and Battery Voltage Check All Lightings Check All Gauges Check OPS and EP Valve Check Leakage in OPS & TOT Switch Check Loco shut down by –ve Circuit Braker	
	DIESEL ENGINE STOPPED CONDITION	
2.	Check Electrolyte level in all battery and its condition. Check Alternator belt condition. Check +ve earth in all Circuit. Check All indication by pressing Test Push Button. Check All electrical wiring pipe fittings. Visually inspect axle generator of Medha Speedometer. Visually inspect all junction boxes and wirings. Visually inspect all safety devices, wiring and its connections.	

Signature :

Signature :

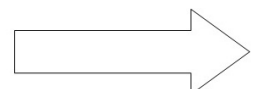
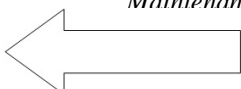
Name of EL/Fitter . :

Name of Supervisor :



TRIP SCHEDULE (MECHANICAL)**LOCO NO.:****DATE:**

	Work to be done	Work done
	Diesel Engine in Running Condition	
1.	General Inspection of loco and check abnormal sound of following: a) Engine b) Turbo charger c) Transmission d) Exhauster e) Compressor f) Radiator fan	
2.	Check the leakage from the following: a) Lube Oil System b) Fuel System c) Transmission d) Air & Vac. System e) Axle Drive Gear Box f) Cooling Water System g) All Pressure to check & adjust.	
3.	Check Oil level in the following and top up if necessary. Engine Crank Case b) Transmission c) Air Compressor d) Center pivot pin e) Axle Drive Gearbox f) Exhauster	
4.	<u>Vacuum Exhauster:</u> Ensure lubrication at the following points. a) Floating Ring - 18 drops/Min. b) Bearing - 9 drops/Min.	
5.	<u>Engine Lube Oil Pressure & Water Temperature:</u> Check the Lube Oil Pressure & Water Temperature at engine idling & record.	
6.	<u>Driver Cab.:</u> Check the following for proper working: Wiper Horns Driver Main Control Valve. Brake Cyl. Pressure (not less than 3 kg/cm ² Vacuum on dummy/Test plate 45/43 cm of Hg. M.R. Pressure 7.0 to 8.0 kg/cm ²	
	Diesel Engine Stopped Condition:	
7.	Send sample of Cooling water & L.Oil.	
8.	Clean & refit the Air & Vac.Filter & Carbody filter.	
9.	Check water level, top up radiator with treated water if required.	
10.	Grease Radiator fan bearing & Center Drive Pulley. (Check Alenkey of radiator fan bearing for tightness. Check both nuts & locks of center drive pulley)	
11.	Drain Exhauster Silencer Oil.	
12.	Drain M.R.Tanks.	
13.	Check M.R., NRV for leakage.	



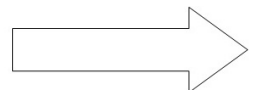
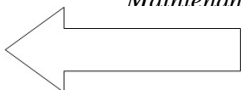
14.	General lubrication: Lubricate the following with grease & Check crackness. Brake Cylinder Piston Belt tension adjusting pulley All Carden Shafts on Upper truck and carden shafts visible on undertruck.	
15.	Examine visually, the bogies to detect loose, defective or missing parts of subassly. & Assly. Apply the air brake of the loco and check if all the brake cylinder piston are operating freely & travel of piston should be adjusted to 50mm. Inspect wheels & Axle box for visual defects such as flat spots, skidding, crack etc. Check following for any defects: 1) Cattle guard 2) Axle box on arrival Buffer couplers 4) All brake gearing Hand brake for proper working. Torque arm nuts & pins. Check the condition & tension of all belts with tensometer.	
16.	Fire extinguishers: Check for broken & missing seals.	
17.	Loco cleaning.	
18.	<u>Driver's booking:</u>	

1) Signature : -----

2) Signature : -----

Name of D/Mech.: -----

Name of Supervisor: -----



TRIP SCHEDULE (ELECTRICAL)

LOCO NO.:

DATE:.....

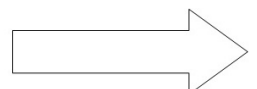
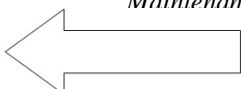
LOCO NO.:		DATE:	
	Work to be done	Work done	
1.	IN COMING: Earth Alternator Battery Voltage Blow out Alternator belt condition		
2.	CONTROL EQUIPMENTS: Speedometer Graph Wiper Motor Washing E.P.Valve Operation		
3.	LIGHTING CHECK: Headlight Focus Marker Light with Assly. or not Cab Light		
4.	<u>BATTERY:</u> Lug Dt Make	B1 C.V <u>SPG</u> B2	C.V B3 C.V
5.	<u>Driver BOOKING:</u>		

1) Signature :

2) Signature :

Name of ELF. :

Name of Supervisor :

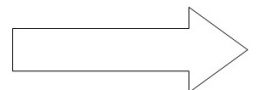
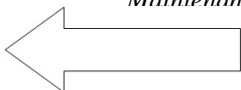


FORTNIGHTLY SCHEDULE (Mechanical & Electrical)

Loco No.....

Date:.....

SNo.	Details of work to be carried out	Work done by	Sign. of D/Mech.
A.	Condition – Diesel Engine stopped		
1.	Fuel Oil Check fuel oil sample for water contamination		
2.	Fuel oil filters: Clean and inspect: change element if necessary-		
3.	Aneroid in fuel system: Check oil level. Top up if required with engine oil		
4.	Fuel tank breather: Clean and Inspect		
5.	Throttle linkage: Check and adjust if required		
6.	Fuel injectors and valves clearance: Check and adjust		
7.	Lubricating oil full flow filter: Clean and inspect: change filter element if necessary		
8.	Lubricating oil by-pass filter: Clean and inspect: change filter element if necessary		
9.	Engine crankcase breather: Clean and inspect. Change if necessary		
10.	Air compressor breather element: Clean and inspect, change if required.		
11.	Radiators: Clean the radiators by blowing compressed air in the direction opposite to normal air flow.		
12.	Cardan shafts: Lubricate the universal joints & splained yokes with specified grease		
13.	Axle drive gear box: i. Clean the outside of axle drive gear box ii. Check the shaft seals for leaks iii. Clean magnetic plug iv. Clean and refit breather v. Test sample of oil for impurities if a large amount of metal particles are noticed, the loco must be taken out of service and damages detected and repaired. In case of water contamination, change oil and investigate the reasons.		



14.	Electric circuit and wiring: Check insulation resistance of reversible protected type plugs and ensure for earthing.		
15.	Electric control equipment: Check the condition and ensure the proper working of all relays, pressure and tumbler switches, rectifiers, micro switches and contractors etc. Adjust if required. For details consult electrical wiring diagram.		
16.	Engine starting press keys: Clean and inspect contacts		
17.	Transmission oil filters: Remove and clean laminar element and dirt trap.		
18.	Moisture separator: Drain moisture separator in pneumatic circuit of transmission		
19.	Wheels: Examine for fracture, flat spot etc. and any abnormality.		
20.	Bogies: Make a careful detailed examination of frames, links, pins, springs, brake gears etc. Lubricate as necessary		
B.	Condition – Diesel engine running		
1.	Fuel system: Check fuel oil leakages in fuel system		
2	Lube oil system: Check lube oil leakages in lube oil system		
3.	Attend Driver's Booking if any.		

Signature:

Name D/Mech:

Signature:

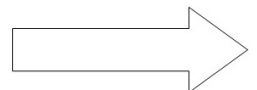
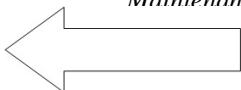
Name Supervisor(Mech.):

Signature:

Name of ELF:

Signature:

Name Supervisor(Elect.):



MONTHLY SCHEDULE (Mechanical)

LOCO NO.:

DATE:.....

Work to be done			Work carried out			
Carried out Trip & Fortnightly Sch. Items						
<u>CONDITION:DIESELENGINE RUNNING</u>			<u>Standard</u>		<u>Actual</u>	
1.						
a)	Charging time main reservoir from 0 to 8 kg/cm2.		11 Minute			
b)	MR cut out pressure.		8+0.1 kg/cm2			
c)	MR cut in pressure.		7+0.1 kg/cm2			
d)	Setting of pressure limiting		2.8 kg/cm2			
e)	Control Pressure		6.0 kg/cm2			
f)	Throttle Pressure		5.0 kg/cm2			
2.	a) Vacuum on Dummy & Test Plate1/8” through hole.		45cms/40cms			
	b) LOP on Idle & Full Throttle.					
3.	General Check: Check tightness of foundation holdown bolts of engine, TRM, Auxiliary pulley, drive arrgt., heat exchanger, radiator, torque arm, compressor & exhaustor.					
4.	Axle Drive Gearbox: Tighten all external fasteners including cardon shaft bolts, torque reaction arm bolts.					
5.	Check all door hinges.					
6.	Air Intake Filter to clean.					
7.	Air Compressor: Change HP Valve.					
8.	Automatic & Independent Brake Valve Cams: Lubricate with soft grease.					
9.	<u>Air reservoir</u> : Drain residues.					
10.	Air and Vacuum Hose Couplings: Check the condition of rubber sealing rings and replace if necessary.					
11.	<u>Slack Adjustors</u> : Lubricate with oil.					
12.	Check working of Hand brake, lubricate if necessary.					
Wheel No.	Wheel Dia.		Flange Depth/Tread Wear		Flange Thickness/ Flange Wear	
	R	L	R	L	R	L
1.						
2.						
3.						
4.						

1) Signature : -----
 Name of D/Mech.: -----

2) Signature : -----
 Name of Supervisor: -----

MONTHLY SCHEDULE (Electrical)

LOCO NO.:

DATE:.....

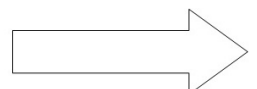
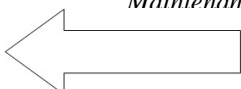
	LOCO NO.:	DATE:
	Work to be done	Work done
	Carried out Trip & Fortnightly Sch. Items	
1.	INCOMING: Earth Alternator Output Battery Voltage Blow out	
2.	Misc. Equipments to check: Starter Oiling (Attend in Qtly. Sch.) Alternator belt condition Low Water Sander length & Condition Speed Recorder Memory & Graph Wiper Motor working	
3.	CONTROL EQUIPMENTS TO CHECK: T.B.Connection tightness Panel Board connection tightness Key board connection tightness Control Pressure for E.P.ValveKg/cm2 Safety device connection tightness All J.B. connection tightness	
4.	LIGHTING CHECK: 1) Head Light Focus 2) Marker Light 3) Cab Light	
5.	BATTERY: Lug Dt Make Bat.Voltage Electrolyte level <div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> B1 C.V </div> <div style="text-align: center;"> B2 <u>SPG</u> C.V </div> <div style="text-align: center;"> B3 C.V </div> </div>	
6.	<u>DRIVER'S BOOKING</u>	

1) Signature :

2) Signature :

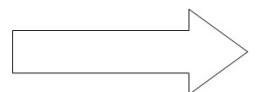
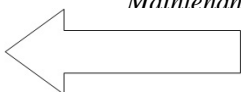
Name of ELF. :

Name of Supervisor :

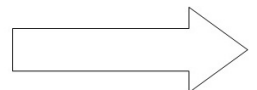
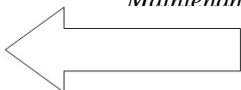


QTLY. SCHEDULE (Mechanical)**Loco No.:****Date:**

Work to be done	Attended by	Sign. of D/Mech.
Diesel Engine Running Condition: General inspection of engine & check abnormal sound of following. a) Engine Block b) Turbo Charger c) Radiator Fan d) Carden Shaft (Engine to TRM)		
Check the leakages from the following: a) Lub.Oil System b) Fuelling System c) Cooling Water System		
Check Lub.Oil Pressure and Water Temperature at engine idling and record.		
Fuel System: a) Change Fuel filter Elements and Rubber Rings. b) Change Fuel line Gaskets. c) Clean PT Pump screen filters. d) Check tightness of Fuel suction & discharge connection. Lub.Oil System: Change Lub.Oil Filters, Bypass filters with new rubber rings & gaskets.		
Diesel Engine Stopped Condition: a) Send sample of cooling water and Lube Oil. b) Check engine mountings. c) Clean Radiator Fan. d) Clean Air filters, Car body filters, Dust pan. e) Check Water level, top up radiator with treated water if requires. f) Grease radiator fan bearing. g) Tighten Turbocharger mounting nuts. h) Check exhaust & inlet manifold nuts & Cap screw for tightness. i) Check vibration dampers for leakages. j) Fill grease in Idler Pulley housing. k) Check Idler Pulley & Drive Pulley foundation bolts for tightness. l) Check Fan hub for tightness of bolts. m) Lubricate and check sound test for crackness Carden Shaft (Engine to TRM). n) Check 'V' Belt tension of Radiator fan with T/meter & condition, replace if required. o) Attend Driver's booking.		



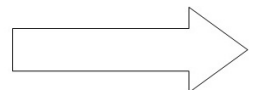
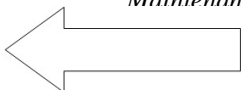
<p>a) Examine sliding surface of Cam and Rollers.</p> <p>b) Check & adjust fuel injectors and valve's clearance (Inlet valve clearance – 0.014", Exhaust valve clearance – 0.027", Injector lift 7.72mm)</p> <p>c) Clean & refit breather strainer.</p> <p>d) Check the tightness of Rocker Lever Shaft holding bolts.</p> <p>Loco Start Condition:</p> <p>a) Check water pump, fuel pump for leakage.</p> <p>b) Check turbo charger for oil leakages after the engine has attained full speed.</p> <p>c) Attend Lub.Oil Leakages.</p> <p>d) Record Lub.Oil Pressure at Idle and Full RPM.</p>		
Clean Engine Block.		
<p>Water System:</p> <p>a) Change Hoses & End fitting if required.</p> <p>b) Check Water Pump foundation bolts for tightness.</p> <p>c) Fill DM Water and leakage to attend.</p> <p>Fuel Tank Glow Rod:</p> <p>Remove, clean and refit with new gasket.</p> <p>Check the Condition of Air Suction line hose & leather bellow, change if necessary.</p>		
BOGIE SECTION		
<p>Carry out general inspection of bogie. Check Axle box for temperature.</p> <p>General cleaning of Gear box and bogie.</p>		
<p>Bogie Pivot Pin (Both bogie) :</p> <p>Check the Center Pivot Pin for crack if any and check bush for crack.</p> <p>Send Oil sample for laboratory test.</p> <p>Inspect all items of Bogie Pivot Pin and refit.</p> <p>Check the foundation bolt tightness of Center Pivot Pin Plate.</p> <p>Top up oil after laboratory test.</p> <p>Check Center Pivot pin dipstick.</p>		
<p>Gear Box (04 Nos.) :</p> <p>a) Check the Gear box Oil Dipstick for condition, change if required.</p> <p>b) Clean the Gear box housing internally after draining oil.</p> <p>c) Check the condition of Bevel Gear Teeth and Pinion Teeth.</p> <p>d) Check the tightness of Gear box all bolts & nuts.</p> <p>e) Check Gear box externally.</p> <p>f) Send sample of Gear box oil for testing.</p> <p>g) Top up oil after laboratory test.</p>		
<p>I General lubrication:</p> <p>a) Brake Cylinder Piston</p> <p>b) Hand Brake Shaft</p>		



	c) Buffer Coupling Screw d) Slack adjuster e) Carden Shaft. Check sound test for crackness.														
II	Attend all GI Repairs/Driver's booking.														
III	Check the condition of Brake block, change if necessary.														
IV	Check the tightness of all Gearing, Pins, Cutters, Nut, bolts														
V	and Split Pins. Examine the bogie visually to detect loose, defective or missing parts and attend.														
I	Check & examine Wheels tyres for wear and record. <table><tr><td></td><td><u>Minimum</u></td><td><u>Actual</u></td></tr><tr><td>a) Flange thickness</td><td>13mm.</td><td></td></tr><tr><td>b) Flange depth</td><td>Nil</td><td></td></tr><tr><td>c) Wheel dia.</td><td>640mm</td><td></td></tr></table>		<u>Minimum</u>	<u>Actual</u>	a) Flange thickness	13mm.		b) Flange depth	Nil		c) Wheel dia.	640mm			
	<u>Minimum</u>	<u>Actual</u>													
a) Flange thickness	13mm.														
b) Flange depth	Nil														
c) Wheel dia.	640mm														
II	Examine Wheels visually for the following: a) Thermal Crack b) Broken flange c) Cracked hub d) Loose Wheels														
III	e) Wheels which have overheated														
IV	Check & adjust Cattle Guard height. Check the clearances of Axle box and Magie & record.														
	Axle Box Min. 14mm., Maxi. 20mm														
V	Magie Min. 15mm, Maxi. 22mm Check following for any defects: a) Axle box b) Buffer coupler c) Hand brake for proper working														

COMPRESSOR & EXHAUSTER

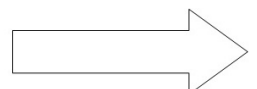
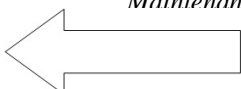
	Work to be done	Attended by	Sign. of D/Mech.
I	Diesel Engine Running Condition: General inspection of loco and check abnormal sound of following. a) Compressor b) Exhauster		
	Diesel Engine Stopped Condition: Exhauster: a) Check Exhauster No. _____ b) Send sample of Exhauster Oil for Lab. Testing c) Clean & refit the Vacuum filter. d) Drain Exhauster Silencer Oil. e) Clean & refit Oil Drop Counter.		



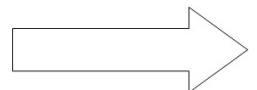
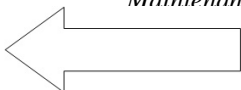
	f) Clean Suction Strainer and IVO Pump & thoroughly examine IVO Pump suction & discharge pipe for crackness. g) Remove extension pulley, check play in pulley and shaft hub & shaft, there should be no play. h) Check rubber bushes of fan, replace if necessary. i) Check the tightness of all bolts of exhauster. j) Clean exhauster externally. k) Top up oil (old) after testing if suitable. l) Check the condition & Tension of Exhauster belt with T/meter, change if necessary.		
	Compressor: a) Check Compressor No. _____ b) Send oil sample for laboratory test. c) Clean oil intake filter. d) Check all foundation bolts for tightness. e) Overhaul breather valve and intercooler safety valve. f) Overhauled LP & HP valves to fit. g) Clean Compressor externally. h) Check "V" belts of compressor for tightness with Tensometer & condition, change if necessary. i) Clean & inspect breather element, change if necessary. j) Top up oil (old) after testing if suitable.		
	Compressor Valve LP & HP O/H by :		
II	General inspection of Compressor & Exhauster in running condition. Ensure lubrication of Exhauster at following points at idle speed and adjust a) Floating Ring - 18 Drops/Minute b) Bearing - 09 Drops/Minute		
III	Check MR Pressure build up 0 to 8 KG/Cm ² - ____ min. Check Vacuum on Dummy ____ cms & test plate ____ cms at ____ Idle RPM.		
	Final Checking.		

TRANSMISSION SECTION

	Work to be done	Attended by	Sign. of D/Mech.
	Diesel Engine Running Condition: General inspection of loco and check abnormal sound of following. a) Transmission b) CD Pulley c) Idler Pulley d) Carden Shafts		



I	<p>DIESEL ENGINE STOPPED CONDITON:</p> <p>Transmission:</p> <ul style="list-style-type: none"> a) Drain TRM Oil, send sample for test. Remove bottom plates and inspect internal parts of TRM. b) Clean all Strainers. c) Check Filler Pump, Gear backlash and record. Standard Bevel Gear : 0.15 to 0.25 mm Spur Gear : 0.11 to 0.15 mm d) Check Filler pump foundation bolts for tightness. e) Refit bottom plates of TRM and tighten the foundation bolts of TRM plate. <p>II Center Drive Pulley:</p> <ul style="list-style-type: none"> a) Remove and clean CD Pulley. b) Inspect all loose & missing parts. c) Fit the missing parts and check the tightness of all bolts, nuts and locking plates. d) Check the end play and adjust if required. e) Grease the pulley, refit the pulley in loco and tighten the foundation bolts. f) Clean Transmission hood & Transmission externally. 		
	<p>Transmission:</p> <ul style="list-style-type: none"> a) Clean Laminar filter. b) Clean both NRV & Breather Valve. c) Clean Pneumatic Drives and inspect all parts. d) Fill TRM Oil after testing. e) Check the TRM Oil Seal for leakage. f) Check the oil leakage from TRM and attend. g) Check the proper working of TRM. 		
	<p>Idler Pulley:</p> <ul style="list-style-type: none"> a) Remove, clean and inspect Idler Pulley, b) Change parts of Idler Pulley if required. c) Grease & refit the Idler Pulley in loco. <p>Cardan Shaft:</p> <ul style="list-style-type: none"> a) Clean Carden Shaft and check sound test for crackness. b) Inspect universal cross joints. c) Check the condition of Carden shaft for proper working, change if required. d) Grease Carden Shaft's all cross joints & greasing points. e) Check the bendness of locking plate bolts. f) Check the proper tightness of Carden shaft jointing bolts. g) Check the Center Drive Pulley working. h) Attend Driver's booking. 		



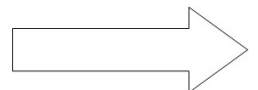
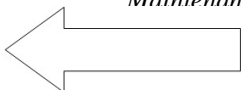
BRAKE SYSTEM

	Work to be done	Attended by	Sign. of D/Mech.
I	Diesel Engine Running Condition: Check the leakages from the followings: a) Air Line Joints. b) Vacuum Line Joints.		
II	Check the Pressure & Vacuum for repair.		
III	Diesel Engine Stopped Condition: a) Drain MR tank. b) Check MR, NRV for leakages.		
	Brake Valves: Remove the following brake valves, refit after overhauling & testing on test stand. a) Engine Control Valve b) TRM Control Valve c) Two Way Stop Valve d) Horn Bell e) Reducing Valve (02 Nos.) f) RV-3 & RV-5 Valve (02 Nos.) g) Limiting Valves h) MR Safety Valves		
I	Check the following for proper working. a) Wiper b) Horn c) Driver Main Control Valve d) Brake Cylinder Pressure (not less than 3.0 Kg/cm ²) e) Vacuum on dummy/test plate 1/8" hole (45/40 Cms.) f) MR Pressure 0.0 Kg/cm ² to 8.0 kg/cm ² time taken in Minute and record		
II	Diesel Engine Running Condition: All pressure to check, adjust and record as under.		
1.	<u>Main Air System:</u> Check and record. a) Time for charging the main reservoir from 0 to 8 kg/cm ² . Time taken for charging from 7.0 kg/cm ² to 8.0 kg/cm ² . b) Compressor Safety valve Blows off at Closes at c) a) Main Reservoir (MR) Safety Valve start blowing off at Closes at b) Setting of Pressure Limiting Valve. d) <u>Air leakage tests:</u>	Standard 11 Min. 75 Sec. 10.5 \pm 0.1 Kg/cm ² 9.5 to 9.8 Kg/cm ²	<u>Actual</u>

2.	a) With engine shut time for fall of MR Pressure from 8 to 7 Kg/cm ² with brake off. b) Apply independent Air brakes and note the rate of drop in pressure in brake cylinder from maximum value with driver application brake valve in lap position. c) Vacuum on Dummy & Test Plate 1/8" hole.	8.5 \pm 0.1 Kg/cm ² 7.5 to 7.8 Kg/cm ² 2.8 Kg/cm ² 20 Min. 1.1 Kg/cm ² /05 Sec. 45 cm./40 cm.	
3	Attend Driver's Booking if any.		

Signature of Supervisor :

Name of Supervisor :

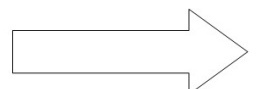
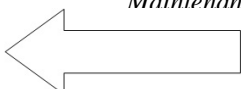


QUARTERLY & HALF YEARLY SCHEDULE (ELECTRICAL)

LOCO NO.:

DATE:.....

LOCO NO.:		DATE:
	Work to be done	Work done by
1.	INCOMING: i) Earth & IR ii) Alternator Voltage iii) Battery Voltage iv) Blow out	
2.	Misc. Equipments to check: i) Alternator belt condition ii) Low Water Sander length i) Speed Recorder ii) Wiper Motor iii) Low Water Sw. (In M-9)	
3.	LIGHTING: i) Head Light Focus ii) Head Light Reflector iii) Marker Light iv) Cab Light	
4.	BATTERY: Check the SPG, Cell, Electrolyte, Vent plugs, note, clean & connection tightness. i) Lug Dt ii) Make iii) Electrolyte level iv) Conn.tightness	<div style="text-align: center;"><u>SPG</u></div> <div style="display: flex; justify-content: space-around;"> B1 C.V B2 C.V B3 C.V </div>
5.	Complete Overhaul in M-9 Sch. & GI in Qtly.Sch. i) Starter ii) Alternator iii) E.P.Valve	
6.	CONTROL EQUIPMENTS TO CHECK: i) T.B.Connection tightness ii) Panel Board connection tightness iii) Key board connection tightness iv) Control Pressure for E.P.ValveKg/cm2 v) Push Button Overhaul & Test vi) All Junction Box connection tightness	



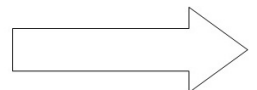
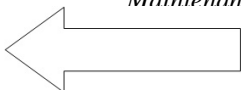
	vii) Fuel shut down valve / magnetic coil. Overhaul Starting Key & test.	
7.	ENGINE SIDE i) All Safety item's connection tightness ii) Starter provide iii) Alternator provide iv) Engine Room's all J.B. Connection tightness	
8.	DRIVER'S BOOKING:	

1) Signature : -----

2) Signature : -----

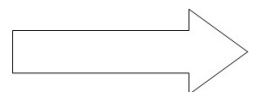
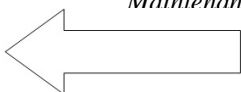
Name of ELF. : -----

Name of Supervisor : -----

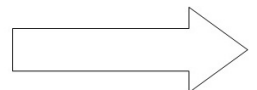
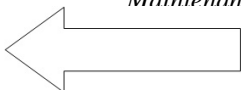


HALF YEARLY SCHEDULE (MECHANICAL)**Loco No.:****Date:**

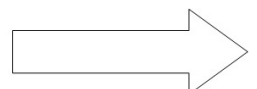
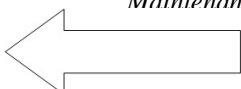
Work to be done	Attended by	Signature of D/Mech.
Diesel Engine Running Condition: General inspection of engine & check abnormal sound of following. a) Engine Block b) Turbo Charger c) Radiator Fan d) Carden Shaft (Engine to TRM)		
Check the leakages from the following: Lube Oil System Fuelling System Cooling Water System		
Check Lube Oil Pressure and Water Temperature at engine idling and record. Fuel System: a) Change Fuel filter Elements and Rubber Rings. b) Change Fuel line Gaskets. c) Clean PT Pump screen filters. d) Check tightness of Fuel suction & discharge connection. Lube Oil System: Change Lube Oil Filters, Bypass filters with new rubber rings & gaskets.		
Diesel Engine Stopped Condition: a) Send sample of cooling water and Lube Oil. b) Check engine mountings. c) Clean Radiator Fan. d) Clean Air filters, Car body filters, Dust pan. e) Tighten Turbocharger mounting nuts. f) Check the tightness of Carden shaft bolts & locking plates. g) Check the condition of "V" belt, replace if required. h) Check exhaust & inlet manifold nuts & Cap screw for tightness. i) Check Idler Pulley & Drive Pulley foundation bolts for tightness. j) Check the tightness Radiator fan shaft bearing. k) Check Fan hub for tightness of bolts. l) Fill grease in Idler Pulley housing. m) Grease radiator fan bearing. n) Grease Carden shafts check sound test for crackness with soft grease.		



<p>a) Check the Lifter Shaft and Arm's roller for any damage, replace if required.</p> <p>b) Check the rocker lever shaft, lever's yokes, foundation bolts, push rods for any damage, replace it if required.</p> <p>c) Check the Cam shaft end play and record.</p> <p>d) Examine sliding surface of Cam and Rollers.</p> <p>e) Clean and refit breather strainer.</p> <p>f) Check the oil passages of rocker arm and lifter assembly items for proper working.</p> <p>g) Refit Rocker arms and Lifter assembly items.</p> <p>Water System:</p> <p>a) Change Hoses & End fitting if required.</p> <p>b) Check Water Pump foundation bolts for tightness.</p> <p>Drain Radiator Water.</p>		
<p>Change Thermostat valve seat if required.</p> <p>Check opening of thermostat valve in hot water.</p> <p>a) Start opening at 77 D.C.</p> <p>b) Full opening at 85 D.C.</p> <p>c) Refit thermostat valve & housing .</p> <p>d) Fit water pipeline and fittings.</p> <p>e) Fill Radiator water & leakage to attend.</p>		
<p>Clean Engine Block.</p> <p>Fuel Tank Glow Rod:</p> <p>a) Remove, clean and refit with new gasket.</p> <p>b) Check the Condition of Air Suction line hose & leather bellow, change if necessary.</p> <p>c) Check the tightness of Fuel tank crossover pipe.</p> <p>d) Change fuel suction line gasket.</p> <p>e) Clean PT Pump filter screen, change if required.</p> <p>f) Attend Driver booking.</p>		
<p>Adjust fuel injectors and valve's clearance (Inlet valve clearance – 0.014", Exhaust valve clearance – 0.027", Injector lift 7.72mm)</p> <p>Loco Start Condition:</p> <p>a) Check water pump, fuel pump for leakage.</p> <p>b) Check turbo charger for oil leakages after the engine has attained full speed.</p> <p>c) Attend Lub.oil Leakages.</p> <p>d) Record Lub.oil Pressure at Idle and Full RPM.</p>		
BOGIE		
<p>I Carry out general inspection of bogie. Check Axle box for temperature.</p> <p>General cleaning of Gear box and bogie.</p>		



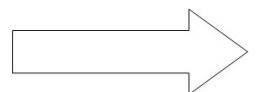
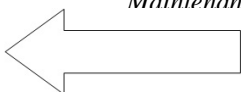
	<p>Bogie Pivot Pin (Both bogie) :</p> <p>a) Check the Center Pivot Pin for crack if any and check bush for crack.</p> <p>b) Send Oil sample for laboratory test.</p> <p>c) Inspect all items of Bogie Pivot Pin and refit.</p> <p>d) Check the foundation bolt tightness of Center Pivot Pin Plate.</p> <p>e) Top up oil after laboratory test.</p> <p>f) Check Center Pivot pin dipstick.</p>														
	<p>Gear Box (04 Nos.) :</p> <p>a) Check the Gear box Oil Dipstick for condition, change if required.</p> <p>b) Clean the Gear box housing internally after draining oil.</p> <p>c) Check the condition of Bevel Gear Teeth and Pinion Teeth.</p> <p>d) Check the tightness of Gear box all bolts & nuts.</p> <p>e) Check Gear box externally.</p> <p>f) Send sample of Gear box oil for testing.</p> <p>g) Top up oil after laboratory test.</p> <p>h) Check the leakage Oil in Gear box.</p>														
I	Examine the bogie visually to detect loose, defective or missing parts and attend.														
II	Inspect Wheels & Axle box for visual defects such as Flat-spots, skidding, cracks etc.														
III	Check following for any defects: a) Cattle guard b) Axle box c) Buffer coupler d) Hand brake for proper working e) All brake gearing														
I	General lubrication: a) Brake Cylinder Piston b) Hand Brake Shaft c) Buffer Coupling Screw d) Slack adjuster e) Carden Shaft. Check sound test for crackness.														
II	Attend all GI Repairs/Driver's booking.														
III	Check the condition of Brake block, change if necessary.														
IV	Check the tightness of all Gearing, Pins, Cutters, Nut, bolts and Split Pins.														
I	Check & examine Wheels tyres for wear and record. <table><tr><td></td><td><u>Minimum</u></td><td><u>Actual</u></td></tr><tr><td>a) Flange thickness</td><td>13mm.</td><td></td></tr><tr><td>b) Flange depth</td><td>Nil</td><td></td></tr><tr><td>c) Wheel dia.</td><td>640mm</td><td></td></tr></table>		<u>Minimum</u>	<u>Actual</u>	a) Flange thickness	13mm.		b) Flange depth	Nil		c) Wheel dia.	640mm			
	<u>Minimum</u>	<u>Actual</u>													
a) Flange thickness	13mm.														
b) Flange depth	Nil														
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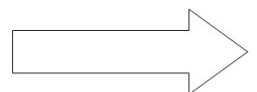
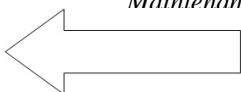
II	Check & record wheel to wheel distance at four quadrant of the wheel to check whether the axle is bent or not.		
III	(Wheel to Wheel distance $698.5 \pm 0.5\text{mm}$)		
IV	Check & adjust Cattle Guard height. Examine Wheels visually for the following: a) Thermal Crack b) Broken flange c) Cracked hub d) Loose Wheels e) Wheels which have overheated Check the clearances of Axle box and Magie & record. a) Axle Box Min. 14mm., Maxi. 20mm b) Magie Min. 15mm, Maxi. 22mm		
	Shock absorbers: Remove and clean Shock absorbers, refit after greasing and repairs.		
	Draw & Buffer Gear: a) Remove & inspect carefully for wear, strain and cracks. Repair as necessary and refit on loco. b) Check and record the buffer height of the loco both end. c) Lubricate the Draw & Buffer gear.		

BRAKE SYSTEM

	Work to be done	Attended by	Sign. of D/Mech.
I	Diesel Engine Running Condition: Check the leakages from the followings: a) Air Line Joints. b) Vacuum Line Joints. Check the Pressure & Vacuum for repair.		
II	Diesel Engine Stopped Condition:		
III	a) Drain MR tank. b) Check MR, NRV for leakages. Air / Vacuum Gauges:		
IV	Check all Air & Vacuum Gauges, replace if defective.		
	Brake Valves: Remove the following brake valves, refit after overhauling & testing on test stand. a) Engine Control Valve b) TRM Control Valve c) Two Way Stop Valve d) Horn Bell		



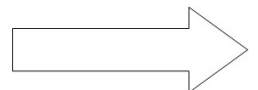
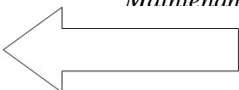
	e) Reducing Valve (02 Nos.) f) RV-3 & RV-5 Valve (02 Nos.) g) Limiting Valves h) MR Safety Valves		
I	Air & Vacuum Brake Valves: Remove the following Brake Valves, refit after overhauling & testing. a) Air Proportionate Valve b) Vacuum Relief Valve c) Two Nos. Brake Double Check Valve		
II	Driver's Main Control Valves: Inspect component for serviceability & repair if required.		
II	Check the following for proper working. a) Wiper b) Horn c) Driver Main Control Valve d) Brake Cylinder Pressure (not less than 3.0 Kg/cm ²) e) Vacuum on dummy/test plate 1/8" hole (45/40 Cm.) f) MR Pressure 0.0 Kg/cm ² to 8.0 kg/cm ² time taken in Minute and record		
III	Diesel Engine Running Condition: All pressure to check, adjust and record as under. <u>Main Air System:</u> Check and record. Time for charging the main reservoir from 0 to 8 kg/cm ² . Time taken for charging from 7.0 kg/cm ² to 8.0 kg/cm ² . Compressor Safety valve Blows off at Closes at a) Main Reservoir (MR) Safety Valve start blowing off at Closes at b) Setting of Pressure Limiting Valve. <u>Air leakage tests:</u> a) With engine shut time for fall of MR Pressure from 8	<u>Standard</u> 11 Min. 75 Sec. 10.5 ± 0.1 Kg/cm² 9.5 to 9.8 Kg/cm² 8.5 ± 0.1 Kg/cm² 7.5 to 7.8 Kg/cm² 2.8 Kg/cm² 20 Min.	<u>Actual</u>



	to 7 Kg/cm ² with brake off. b) Apply independent Air brakes and note the rate of drop in pressure in brake cylinder from maximum value with driver application brake valve in lap position. c) Vacuum on Dummy & Test Plate 1/8" hole.	1.2 Kg/cm²/ 05 Sec. 45 cm./40 cm.	
	Attend Driver's Booking if any.		

Signature of Supervisor :

Name of Supervisor :



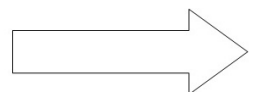
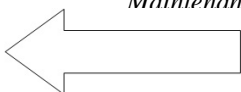
**YEARLY & ABOVE SCHEDULE
(Bogie Section)**

LOCO NO.:

DATE:.....

Loco No.:		Date:		
		Work to be done	Work attended by	Remarks
1		Attend up to Half Yly.Sch. items.		
2		<u>Bogie:</u> Run out the bogie from the locomotive, dismantle Wheel and axle Assy., Gearbox, Axle boxes, Pinion's Assy. Clean and wash them thoroughly to remove clogged oil, dirt, grease etc.		
3	i ii iii	Check the both Centre Pivot Pin for any crack/breakage. Check Centre Pivot Pin size Max.: 90 mm. Check Self aligning bearing & Bogie Pivot bearing. Inside dia.: 90.0 + 0.035mm.		
4	i ii iii iv v vi	<u>Wheel and Axle:</u> The wheels should be turned and the following measurements recorded.(These measurements should also be recorded during reprofiling or wheel changing in service). Thread Diameter: (N.G.) Normal dia. : 700mm. Service limit : 640mm. Record difference in tread dia. Of wheels on the same axle: Permissible limit when new : 0.3mm Max. Service limit : 2.0mm Max. Record difference in tread dia. Of the wheels on the same locomotive: Permissible limit when new : 0.3mm. Service limit : 2.0mm. Record difference in tread dia. Of wheels on the same bogie : 2.0mm Max. Record distance between the inside gauge face of the wheels on same axle: Permissible variation(NG): 698.5 ± 0.5mm. (Average of 4 measurement at equal spacing on the periphery of wheel is to be recorded). <u>Ultrasonic Test:</u> Test the Axle in site with Ultrasonic Crack Detection Equipment.		

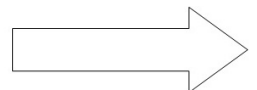
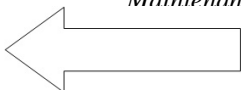
5	i	<u>Bogie:</u> Dismantle bogie frame completely. Rinse in water for sufficient time to ensure removal of foreign materials and cleaning agent. Air to blown out to remove moisture and loose scale.		
	ii	Check for evidence of cracks, magnaflux critical stress area and repair any defects.		
	iii	Check the frame, serration block, hole thread etc. and re-tap if necessary.		
	iv	Paint the Bogie frame.		
6	i	<u>Axle Boxes:</u> Dissemble, remove bearings, clean grease and paint axle boxes.		
	ii	Do visual inspection of Roller Brgs. And refitting with new grease.		
7	i	<u>Gear Boxes:</u> Remove, strip and inspect the Axle drive gear boxes and re-assemble.		
	ii	Drain the Oil, remove the sludge. The gear box should then be cleaned.		
	iii	Check the tooth contact of bevel gear pair and adjust them if necessary. Adjust back lash 0.3 to 0.4mm.		
		Adjust Axial play of Gear box 0.05 to 0.08mm.		
8		<u>Pinion Assembly:</u> Dissemble the pinion shaft assembly if required.		
		Inspect the parts and reassemble.		
9		<u>Carden shafts:</u> Remove all Carden shafts, clean and Magnaflux test carryout and record, examine the condition of universal coupling, replace the same if required, re-grease the carden shaft.		
10	i	<u>Suspension springs:</u> Clean the springs with wire brush (do not scrap), visually examine the springs for any cracks or breakage. Cracked springs should not be continued in service under any circumstance.		
	ii	Check and match the working height of the springs and record.		
	iii	Check and match free height of the spring and record Free height 220mm.		
	iv	Apply protective coating of anti-corrosive		



		paint (Black enamel based).		
11		<u>Re-assembly of Bogie:</u> Reassemble bogie after inspection to see if all the necessary parts are intact giving special attention for missing parts such as cotter pins, safety brackets, washer etc.		
12		Maintain the axles parallel to each other and at right angles. The centre distances between 2 axles 1590mm both side to check & record.		
13		Check buffer height at short hood & long hood end of the locomotive. Max. : 540mm. Min. : 495mm.		
14	i ii iii	Couple the bogie in loco & check and adjust the megie clearance. Maximum : 22mm. Minimum : 15mm. Normal : 20mm. Check bogie stop clearance: Maximum : 20mm. Minimum : 14mm. Normal : 15mm. Check & adjust clearance between Cattle guard & Rail. Maximum : 85mm.		
15	i ii	Check the free height of Megie spring and record. Check the condition of Megie spring and Torque reaction arm disc. And change if required.		

Signature : _____

Name of Supervisor: _____

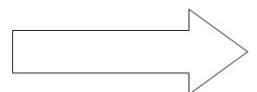
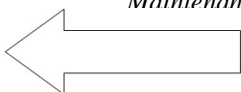


**YEARLY & ABOVE SCHEDULE
(Engine Section)**

Loco No.:

Date:

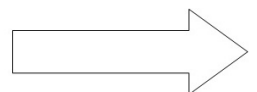
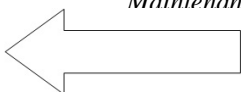
	Work to be done	Work attended by	Sign. of D/M	Remarks
1.	Attend up to Half yearly Schedule items.			
2.	<u>Fuel Injectors:</u> Remove, clean and check for leakage in leakage tester, change if necessary.			
3.	<u>Fuel Pump:</u> Replace fuel pump filter screen and magnet if necessary.			
4.	<u>Turbo Charger:</u> Clean Turbo Charger compressor wheel and diffuser, check end float and record Maximum : 0.005".			
5.	<u>Air and Exhaust Manifolds:</u> a) Check leakages of Air and Exhaust gas line, repair if necessary. b) Remove the exhaust manifold and cleaned exhaust manifold and refit. c) Tighten manifold nuts/cap screw in Air and Exhaust manifold.			
6.	<u>Crank Shaft:</u> Check end clearance and record Maximum - 0.016".			
7.	<u>Fan Hub and Drive Pulley:</u> Check fan hub and drive pulley for normal working.			
8.	<u>Fuel Pump and Water Pump Drive Unit:</u> Check the end thrust of fuel pump and water pump drive unit and record. Replace thrust washer if necessary. Maximum end play - 0.45mm.			
9.	<u>L.Oil Filter/Super bypass/Fuel filter Housing:</u> Remove and refit the filter housings, clean housing. Examine its parts, change if necessary.			
10.	<u>Fuel Oil and Lubricating Oil Hoses:</u> Hydraulically check flexible hoses to 100 PSI, change if required.			
11.	<u>Water Hoses:</u> Examine and renew if necessary.			



	ENGINE LUBRICATING OIL SYSTEM:			
12.	Pressure Regulating and Relief Valves: Remove, clean and change 'O' rings.			
13.	Pulleys: a) Check pulley grooves for wear, change if required. b) Ensure that the pulleys are tight on the shaft. c) Ensure that the running pulleys are in alignment to ensure straight belt operation.			
14.	Vulcon Elastic Couplings: Examine the rubber tyre for crack in assembled position. Change if required.			
15.	Rocker Arm Assy./Lifter Assy. Disassemble all the parts, check for crack of parts (Zyglo test), change if required.			
16.	P.T.Pump: a) Check fuel pump for proper working, calibrate to repair if required. b) Replace fuel pump filter screen and magnet if required.			
17.	Carden Shaft: a) Remove all Carden shafts, clean and Megnaflux test carryout and record, examine visually from outside bearing's universal couplings (Cross pieces) etc. for crack. Replace parts or whole if required. b) Check the proper locking of carden shaft bolts.			
18.	Cam Shaft: Check the condition of cam shaft profile for damage.			
19.	Radiator Fan 'V' Belt: Check the condition of fan 'V' Belt, change if required.			
20.	Engine/Radiator Compartment: Change the hood profile if required.			

Signature : _____

Name of Supervisor: _____

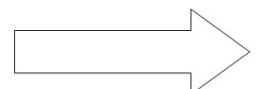
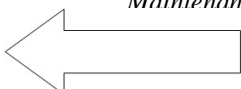
YEARLY & ABOVE SCHEDULE

(Engine Section)

Loco No.:

Date:

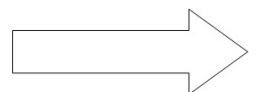
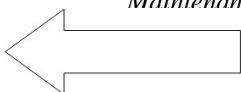
	Work to be done	Work attended by	Sign. of D/M	Remarks
1.	Attend up to Half yearly Schedule items.			
2.	Charge Air Cooler: Dismantle, clean and assemble with new gasket & seal.			
3.	Heat Exchanger: Check heat exchanger element for leakages and refit with new gasket and 'O' rings if required.			
4.	Water Pump: a) Check water pump impeller for play and refit with new 'O' ring & gasket. b) Change Water Pump Oil and water seal if required.			
5.	Injectors: Calibrate injectors, Repair if required.			
6.	Fuel Tank: Clean and check for leakages.			
7.	Engine Oil Sump: Clean the sump and refit covers with new gasket.			
8.	Cylinder Head Assly.: a) Disassemble the cylinder head. Inspect parts for Damage/Crack, refit the head Sub.Assy. after valve & seat lapping. b) Check the spring tension and record in register. c) Check the vacuum leakage in valve and seat from vacuum testing machine and record in cylinder head O/H register. d) Fit the head assy. With block and record in register torque valve for tighten.			
9.	Connecting Rods: Check the connecting rod big end bearing cap holdown bolts for tightness and record value.			
10.	Check the sizes of Rocker Lever Shaft, Arm/Roller Arm Holding shaft. Change if required.			
11.	Check sizes of bushes of rocker lever			



	arm. Or Roller Arm. Change if required.			
12.	Radiator Fan Shaft and Bearings: Check the condition of fan shaft and bearings. Change if required.			
13.	Piston Nozzle Cooling: Check the tightness of foundation of piston nozzle cooling.			

Signature : _____

Name of Supervisor:_____



**YEARLY & ABOVE SCHEDULE
(Engine Section)**

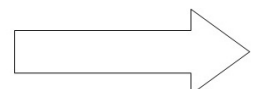
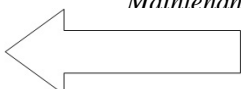
Loco No.:

Date:

		Work to be done	Work attended by	Sign. of D/M	Remarks
1.		Attend up to Half yearly Schedule items.			
2.		Vulcon Coupling Assy.: Disassemble Vulcon Coupling. Check its parts for wear/crack. Change if necessary.			
3.	i. ii. iii.	Gear Case Assy.: Check the end play of Cam shaft, and idler gears. Change thrust washer if required. Max.: 0.014". Change the oil seal of Crank shaft, P.T. Pump Drives, Water Pump Drive. Change the gears of Cam Shaft and Idler Shaft if required. Record the back lash of Gear teeth.			
4.		Flywheel Housing: Change the Oil seal of Crank Shaft rear end if required.			
5.	i. ii.	Cylinder liners: Clean the Cylinder liners. Check the bore of Cylinder liners and change liners if required with new 'O' Rings. Record the sizes in register.			
6.	i. ii. iii.	Pistons/Connecting rods: Clean the Piston Crown. Change the Piston Rings if liners changed or piston rings wear found. Check the connecting rod big end bearing's for wear. Change if required.			
7.		Piston Nozzle Cooling: Change the 'O' ring of Piston Nozzle Cooling.			
8.	i. ii. iii.	Radiator Fan Assy.: Change the Radiator fan bearing if required. Change the fan shaft if required. Clean the Radiator with solvent flushing.			

Signature : _____

Name of Supervisor.: _____

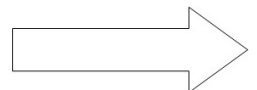
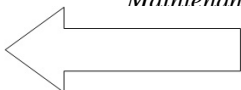


YEARLY & ABOVE SCHEDULE (TRANSMISSION)

Loco No.:		Date:		
	Work to be done	Attended by	Sign. of D/Mech.	Remarks
I	TRANSMISSION: 1. Attend up to M9 Sch. Items. 2. Overhaul filler pump and adjust back lash (Qtly.). 3. Remove Secondary Scavenger Pump & refit after overhauling. 4. Change heat exchanger flange joint gasket. 5. Remove, check & refit master control piston. Change all 'O' rings. 6. Remove bottom cover of Main Control Valve, carry out internal inspection and fit cover with new gasket. 7. Remove 3/2 Way valve, direction valve and refit after overhauling. 8. Remove relief valve, overhaul and refit.			
II	IDLER PULLY Remove & refit after overhauling.			
III	C.D. PULLY Remove & refit after overhauling.			
IV	CARDEN SHAFT Remove and Megnaflux test and carryout on record & refit after overhauling.			

Signature : _____

Name of Supervisor: _____



YEARLY & ABOVE SCHEDULE (Air Brake Section)

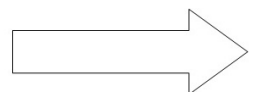
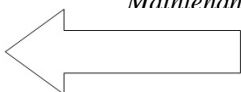
Loco No.:

Date:

	Work to be done	Attended by	Sign. of D/Mech.	Remarks
I	Attend up to Half yearly Sch. Item.			
II	Brake valves: Remove the following brake valves & refit after overhauling & testing on Test Stand. 1.Brake valve up to H.Yly. Schedules. 2.Brake Driver Control Valve. 3.Throttle Valve. 4.Engine Control Device. 5.M.R.Safety Valves.			
III	Remove, clean & refit the M.R.Tank after hydraulic test.			
IV	Change all Air Joint Gasket.			
V	Change all Vacuum Joint Gasket.			
VI	Brake Cylinder: Disassemble, clean, check bucket, repair/replace parts if necessary. Grease, couple & test on test stand.			

Signature : _____

Name of Supervisor:_____



**YEARLY & ABOVE SCHEDULE
(Compressor & Exhauster)**

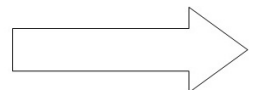
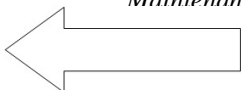
LOCO NO.:

DATE:.....

Loco No.:			Date:	
	Work to be done	Work attended by	Sign. of D/Mech	Remarks
I	Attend up to M9 Sch. Iteam.			
II	Compressor: a) Remove & refit after complete overhauling. b) Fit new "V" belts. c) Compressor No. _____			
III	Exhauster: a) Remove & refit after complete overhauling. b) Fit new "V" belts c) Exhauster No. _____			
	Compressor Valve LP & HP O/H by :			

Signature : _____

Name of Supervisor. _____



**YEARLY & ABOVE SCHEDULE
(Electrical Section)**

LOCO NO.:

DATE:.....

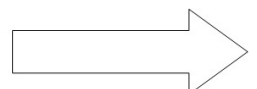
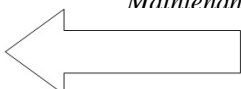
LOCO NO.:		DATE:
	Work to be done	Work done
1.	Attend up to M-9 Schedule items.	
2.	TEMP. GAUGES & METERS OVERHAUL & TEST: i) Transmission Oil Temp. Gauge ii) Lube Oil Temp. Gauge iii) Water Temp. Gauge iv) Ampere Meter v) Speed Recorder vi) RPM Indicators	
3.	CHECK, CLEAN & TEST: i) Fuel Stop Valve Coil Resistance ii) Starter Safety Switch Coil resistance iii) All Warning Lamp iv) Circuit Breaker 10A Tripping Time v) Circuit Breaker 15A Tripping Time vi) Water Temperature Switch a) Pick up b) Drop out vii) Oil Pressure Switch a) Pick up Kg/cm2 b) Drop out Kg/cm2 viii) T.O.T. Switch check, set on 105 & 115 Degree centigrade. ix) Lub.Oil & Water Temperature Sensor x) Low Water Level Switch xi) M.P. Relays overhaul and test iix) All Pipe fitting	
4.	WIRING & CABLE CHECK: i) Starter's Cable with Lug ii) Head Light wiring change from T.B. to Holder. iii) All wiring & Lug condition. Battery Knife Switch remove and clean (in M54 Sch.)	
5.	<u>Driver BOOKING:</u>	

Signature :

Signature :

Name of ELF. :

Name of Supervisor :



OUR OBJECTIVE

To upgrade maintenance technologies and methodologies and achieve improvement in productivity and performance of all Railway assets and man power which inter-alia would cover reliability, availability, utilisation and efficiency.

If you have any suggestions and any specific comments, please write to us.

Contact person : *Director/Mech*

Postal address : *Indian Railways,
Centre for Advanced
Maintenance Technology,
Maharajpur, Gwalior.
Pin code - 474 005*

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