TECHNICAL MANUAL

OPERATOR, ORGANIZATIONAL, DIRECT SUPPORT AND GENERAL SUPPORT MAINTENANCE MANUAL FOR

WATER PURIFICATION BARGES (NSN 4610-01-234-2165)

WINCH, DOUBLE DRUM, DIESEL ENGINE DRIVEN, 40,000 LB CAPACITY, CONMACO MODEL 270

i This technical manual is an authentication of the manufacturer's commercial literature and does not conform with the format and the content requirements normally associated with Army technical manuals. This technical manual does, however, contain all essential information required to operate and maintain the equipment.

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4 JUNE 1991

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OPERATOR, UNIT,
DIRECT SUPPORT AND GENERAL SUPPORT
MAINTENANCE MANUAL
FOR

WATER PURIFICATION BARGES
(NSN 1930-01-234-2165)

Volume 21
WINCH, DOUBLE DRUM,DIESEL ENGINE DRIVEN
40,000 LB CAPACITY, CONMACO MODEL 270

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WARNINGS AND SAFETY NOTICES

WARNING

**DANGEROUS VOLTAGES AND HAZARDOUS MATERIALS
ARE USED IN THIS EQUIPMENT.
DO NOT TAKE CHANCES!**

GENERAL WARNINGS

- Always redtag electrical equipment, controls, circuits, and switches before beginning repairs.
- Do not service or adjust high voltage electrical equipment when alone.
- Do not overload circuits.
- Always use authorized, insulated tools and test equipment when working on electrical equipment.
- Remove all jewelry before working on or around electrical equipment with exposed current-carrying areas.
- Do not wear clothing with exposed metal fasteners when working on electrical equipment.
- Always use approved breathing apparatus when working with chemicals.
- Avoid chemical contact with eyes, skin, and clothing.
- Always wear safety glasses, gloves, and rubber aprons when handling chemicals.
- Wear protective clothing and safety glasses as required when working on barge equipment.
- Always wear approved ear protection in noise hazard areas.

SPECIFIC WARNINGS

- Do not connect any new circuit to an existing circuit.
- Do not energize circuits if water condensation is present.
- If any sparks are seen, stop operation immediately. Determine cause and take corrective action.
- Never touch radio antennas of fixed-base radio transmitters. When transmitting, antennas contain high voltage'
- Always use approved breathing apparatus when handling material in multimedia filters and chlorination unit descaling acid crystals. Do not breathe dust from these materials.
- Avoid breathing vapors from coagulant aid chemicals. Use in a well-ventilated area. In case of chemical contact with skin, wash with water. For eyes, immediately flush at eyewash station and obtain medical help as soon as possible.
- Always wear work gloves and shirts with full-length, buttoned sleeves when handling fuel oil and gasoline.
- Smoking or open flames while handling fuel oil or gases is prohibited. Only minimum number of personnel required to conduct fueling operation is permitted in the fueling area.

- Before starting any repairs on compressed air system, always release pressure from air receiver and compressor and open and red tag circuit breakers.
- On air compressor, do not adjust automatic regulator switch (pressure switch) and pilot valve settings.
- To avoid flying particles lodging in eyes, do not use compressed air to "dust- off" clothing or workspace.
- Stay clear of anchor cables when operating anchor winches.
- Always wear safety glasses or face shield when using power tools.
- Always wear lifevests when on weatherdeck and throughout the barge during storm conditions.
- Lifevests are to be worn at all times aboard workboat.
- Only qualified persons will operate and maintain arc and fuel gas welders.
- When welding, always make sure those working with or near the welder wear proper clothing: heavy, hole-free gloves, heavy shirt, cuffless trousers, high shoes, and cap. Keep clothing dry and free of oil and other flammable substances.
- Use dry, heavy canvas drop cloth to cover work area and adjacent deck when arc welding.
- Before welding on bulkheads, deck plating and similar surfaces, always check carefully to make sure that the other side of the surface does not hide fuel, compressed materials, electrical equipment or wiring. Station a watch with fire extinguisher on the other side of the bulkheads and deck plating prior to welding.
- When welding, keep your head out of the fumes and make sure area is well ventilated.
- Before welding on surfaces which have been cleaned with cleaning solutions containing chlorinated hydrocarbons, always wash with water, dry, gas-free, and ventilate area thoroughly.
- Use shield with proper filter lens when welding. Do not allow others near welding operations to assist or observe without proper eye protection. This must include side shields during sag chipping operations.
- Warm personnel in area during welding operations not to look at arc or expose themselves to hot spatter or metal.
- Before welding on fuel oil or sludge tanks, make sure the tank is gas-free by:
  - Removing all liquid from tank.
  - Cleaning tank thoroughly.
  - Ensuring tank is thoroughly dry.
  - Testing to ensure tank is gas-free.
  - Forcing ventilation of tank.
- Connect arc welding work cable as close to welding area as possible. Work cables connected to barge framework or other locations far from welding site increase the possibility of the welding current passing through lifting chains, crane cables, or other possible circuit paths. This can create fire hazards or weaken lifting chains or crane cables until they break or fall.
- Always weld with all doors, portholes, and hatches propped open and necessary ventilation systems operating.

- Take frequent breaks away from the area where you are welding.
- Do not take oxygen and acetylene tanks into confined area when welding.
- Always use a friction lighter to start oxyacetylene torch.
- Always maintain all welding equipment in proper working condition. If you have any doubts about the safety of any welding equipment, do not use the welder.

ELECTRICAL SHOCK SAFETY STEPS

Five safety steps to follow if someone is the victim of electrical shock.

a. Do not try to pull or grab individual.
b. Turn off electrical power when possible.
c. If you can not turn off electrical power, pull, push, or lift person to safety using a wooden pole, rope, or some other insulating material.
d. Get medical help as soon as possible.
e. After injured person is free of contact with source of electrical shock, move person a short distance away and, if needed, start CPR immediately.

INTRODUCTION TO

TM 55-1930-209-14&P-21

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in the back of this manual direct to: Commander, US Army Troop Support Command, ATTN: AMSTR-MMTS, 4300 Goodfellow Blvd., St. Louis, MO 63120-1798. A reply will be furnished directly to you.

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1. SCOPE

TM 55-1930-209-14&P covers the Reverse Osmosis Water Purification Barges, Models 300-WPB-1, 300-WPB-2 and 300WPB-3, NSN 1930-01-234-2165. This manual consists of twenty-one volumes.

2. REVERSE OSMOSIS WATER PURIFICATION BARGES

The Reverse Osmosis Water Purification Barges provide up to 300,000 gallons of drinking water per 24 hour period. The drinking water, converted from seawater or brackish water, is for use by a Rapid Deployment Force in a forward area. When needed, the drinking water can be pumped to a shore facility or to another vessel. This manual provides operation and maintenance procedures for all the component systems on the barges.

3. VOLUME 1 -- NORMAL OPERATIONS

This volume provides information and procedures on normal Reverse Osmosis Water Purification Barge operations, including barge movement and deployment, communications and electrical power systems, drinking water production, shutdown, and required operational maintenance. Emergency shutdown procedures are also provided.

4. VOLUME 2 -- SEAWATER SYSTEM

This volume describes operation and maintenance of the seawater system which supplies seawater to the Reverse Osmosis Water Purification Units (ROWPUs) for processing to the air conditioning unit for cooling to the ballast tank for barge trimming to the chlorination unit for priming and cooling, and to the diesel generators for cooling.

5. VOLUME 3 -- REVERSE OSMOSIS WATER PURIFICATION UNIT (ROWPU) SYSTEM

Volume 3 provides operation and maintenance procedures for the ROWPU System which processes seawater or brackish water to produce drinking water. Normally, this system processes seawater supplied by the seawater system (TM 55-1930-209-14&P-2) to create product water. Chlorine is then added to this product water by the chlorination system (TM 55-1930-209-14&P-4). The resultant drinking water is discharged into four storage tanks that are part of the drinking water system (TM 55-1930-209-14&P-5).

6. VOLUME 4 -- CHLORINATION SYSTEM

Operation and maintenance procedures for the chlorination system onboard the Water Purification Barges are contained in this volume. This system produces chlorine in a sodium hypochlorite solution, upon demand, to water processed by the ROWPU system just before the water enters the four drinking water storage tanks.

7. VOLUME 5 -- DRINKING WATER SYSTEM

The drinking water system provides storage for water produced by the ROWPUs and includes pumps and valves to move this water from onboard storage tanks to the shore discharge system, to another vessel, or overboard. The drinking water system also provides a pressurized water supply for drinking and washing onboard the barges.

8 VOLUME 6 -- SHORE DISCHARGE SYSTEM

This volume provides operation and maintenance procedures for the shore discharge system which transfers drinking water from barge storage tanks to holding/storage facilities ashore.

9. VOLUME 7 -- COMPRESSED AIR SYSTEM

Volume 7 describes the operation and maintenance of the compressed air system which provides compressed air to five air stations in the ROWPU space, one in the workshop, and one on stern weatherdeck. This system also provides compressed air to two air stations for blowdown of seachests in void 2 starboard and void 4 port. Compressed air is used on the barges to operate air-powered impact tools, to propel air through the shore discharge hose, to blowdown seachest, and for general cleaning blowdown.

10. VOLUME 8 -- FUEL OIL SYSTEM

This volume provides operation and maintenance procedures for the fuel oil system which functions as a centralized receiving storage and distribution system for diesel fuel used for barge operations. This onboard fuel system provides fuel for two 155 kW diesel ship service generators, a 20 kW ship auxiliary generator, two ROWPU high-pressure pump diesel engines, and a fueling station for the barge workboat.

11. VOLUME 9 -- ELECTRICAL POWER SYSTEMS

Operation and maintenance procedures for the two electrical power systems installed aboard the Water Purification Barges are contained in Volume 9. The normal electrical power system generates, controls and distributes all electrical power for operating the water purification system and its auxiliary systems. The emergency electrical system supplies 24 Vdc from a battery bank to 24 Vdc equipment and converts to 24 Vdc through an inverter to 120 Vac to power emergency lighting and equipment.

12. VOLUME 10 -- LIGHTING SYSTEM

Volume 10 contains operation and maintenance procedures for the onboard lighting systems for the Water Purification Barges. This system supplies interior and exterior lighting. Normal and emergency interior lighting is provided in the deckhouse ROWPU space, dayroom, workshop, and voids. Exterior lighting consists of searchlights and floodlights for use at night or during reduced visibility. Lights on the weatherdecks and standard navigation and status lights are for use during operation and towing.

13. VOLUME 11 -- EQUIPMENT MONITORING SYSTEM

This volume provides operation and maintenance procedures for the equipment monitoring system which monitors the operation of several equipment components onboard the Water Purification Barges. This system monitors operating conditions such as amount of drinking water in storage tanks and temperature of diesel engine cooling water. Sensors detect unacceptable operating conditions, the main processor flashes at double intensity and remote alarms (horns, strobe lights and buzzer alert crewmembers that corrective action is necessary.

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14. VOLUME 12--COMMUNICATIONS SYSTEM

Operation and maintenance procedures for the communications system are provided in Volume 12. This system consists of three separate communications methods, radio communications, foghorn and intercom telephones.

15. VOLUME 13 - HANDLING EQUIPMENT

This volume contains operation and maintenance procedures for handling equipment used for lifting, transporting and repositioning equipment and materials onboard the barges. The system includes a bridge crane, bow crane and a void 4 trolley hoist.

16. VOLUME 14 - ANCHOR, MOORING, AND TOWING EQUIPMENT

Volume 14 describes the operation and maintenance procedures for the anchor mooring, and towing equipment on the Water Purification Barges. This equipment provides a method to hold (anchor) the barges in a fixed position offshore, at dockside, or next to another vessel and a method to move the barges from one location to another.

17. VOLUME 15 - MISCELLANEOUS EQUIPMENT (DAYROOM, WORKSHOP, ACCESSES, AND SANITATION SYSTEMS)

Volume 15 addresses operation and maintenance procedures for miscellaneous equipment installed on the Water Purification Barges. This equipment includes the dayroom on the forward starboard side of deckhouse, the workshop on the forward portside of deckhouse, accesses such as deckhouse doors and portholes and various accesses to and from the voids, and two separate sanitation systems (toilets and bilge). Additional equipment addressed in this volume includes: guard rails, rubber fendering, removable floor mats, eyewash stations, component labels, caution, warning and danger signs, and storage areas.

18. VOLUME 16 - VENTILATION, HEATING, AND AIR CONDITIONING SYSTEMS

This volume contains operation and maintenance procedures for the deckhouse and voids ventilation systems and the heating and air conditioning (HAC) system installed on the Water Purificaiton Barges. The ventilation system provides fresh air circulation in the deckhouse and voids with 17 hatches and 10 ventilation fans. The HAC controls the temperature in the dayroom and deckhouse.

19. VOLUME 17 - WORKBOAT, LIFESAVING, AND FIREFIGHTING EQUIPMENT

Volume 17 includes procedures for the operation and maintenance of:

a. Workboat - provides water transportation for crew members and visitors, small cargo items, transportation of the messenger line for the shore discharge hose and similar work-related tasks associated with operating the Water Purification Barges.

b. Lifesaving Equipment - installed on the barges and consisting of 2 liferafts, 15 Type II and 24 Type V lifevests and 4 lifesaving rings.

c. Firefighting Equipment - installed on the barges and consisting of Halon 1301 system, 2 CO2 hose reel units, a smoke detector system, 17 portable CO2 fire extinguishers, 5 dry chemical fire extinguishers, 5 self-contained breathing apparatuses, and a portable, engine driven firefighting pump. The workboat also has a 1 O0-pound, portable, dry chemical fire extinguisher.

20. VOLUME 18 - SUPPORTING APPENDICES FOR VOLUMES 1-17

Volume 18 contains the Maintenance Allocation Chart, Components of End Item List, Tools and Test Equipment List, Expendable/Durable Supplies and Materials List and the Repair Parts and Special Tools List.

All of the information contained in this volume is common to volumes 1-17 and does not appear in each individual , volume.

Appendix A in volumes 1-17 provides information unique to each volume. Appendix B in volumes 1-17 provides manufacturers manuals and instructions unique to the system described in each volume. Appendixes C-G are located in Volume 18.

21. VOLUME 19 - PREVENTIVE MAINTENANCE CHECKS AND SERVICES (PMCS)

Volume 19 contains PMCS pertinent to all onboard systems for the Reverse Osmosis Water Purification Barges.

22. VOLUME 20-- SUPPLEMENTAL DATA

Volume 20 contains the Basic Issue Items Ust, and Additional Authorization Ust for all onboard systems for the Reverse Osmosis Water Purification Barges.

23. VOLUME 21 - This volume contains operation and maintenance procedures for the 20-ton double drum diesel engine winch used on the Water Purification Barges.

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The following appendices, common to all TM's in this series, are in TM 55-1930-209-14&P-18.

MAINTENANCE ALLOCATION CHART (MAC)
TOOLS AND TEST EQUIPMENT (TTEL)
EXPENDABLE/DURABLE SUPPLIES AND MATERIALS LIST
REPAIR PARTS AND SPECIAL TOOLS LIST (RPSTL)

NOTE

The following appendices, common to all TM's in this series, are in TM 55-1930-209-14&P-20.

COMPONENTS OF END ITEM LIST (COEIL)
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The following appendices, Common to all TM's in this series, are in TM 55-1930-209-14&P-20.

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The following appendices, common to all TM's in this series, are in TM 55-1930-209-14&P-20.

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CHAPTER 1 INTRODUCTION

Section I. General

1-1 Purpose. This technical manual (TM) describes the operation and maintenance of the 20-ton double drum, diesel engine winch on Reverse Osmosis Water Purification Barges. Differences between Barge 1 and other barges are noted in appropriate paragraphs and figures. Otherwise, information pertains to all barges. Information on other installed systems is in TM 55-1930-209-14&P-1 thru P-1 7. TM 55-1930-209-14&P-18 and TM 55-1930-209-14&P-20 contains appendices common to all TM's. Location of major barge components is shown in Figure 1-1. TM 55-1930-209-14&P-19 contains Preventive Maintenance Checks and Services for all systems on the Barges.

1-2 Scope. The winch, double drum, diesel engine driven, 40,000 lb capacity, CONMACO Model 270 is used on Water Purification Barges 1, 2, and 3 to deploy and return hoses. This manual contains operation and maintenance procedures for the winch power unit and the winch mechanism mounted on a skid base.

1-3 Maintenance forms and records. Required maintenance forms and records are explained in DA PAM 738-750, The Army Maintenance Management System (TAMMS).

1-4 Destruction of Army materiel to prevent enemy use. This shall be as directed in TM 750-244-3.

1-5 Administrative storage of equipment

a. Placement of equipment in administrative storage should be for short periods of time when a shortage of maintenance effort exists. Items should be in mission readiness within 24 hours or within the time factors as determined by the directing authority. During the storage period, appropriate maintenance records will be kept.

b. Before placing equipment in administrative storage, current maintenance services and equipment serviceable criteria (ESC) evaluations should be completed. Shortcomings and deficiencies should be corrected and all modification work orders (MWO's) should be applied.

c. Storage site selection. Inside storage is preferred for items selected for administrative storage. If inside storage is not available, trucks, vans, conex containers and other storage may be used.

1-6 Equipment Serviceability Criteria. This equipment is not covered by an equipment serviceability criteria.

1-7 Calibration. There is no equipment calibration required.

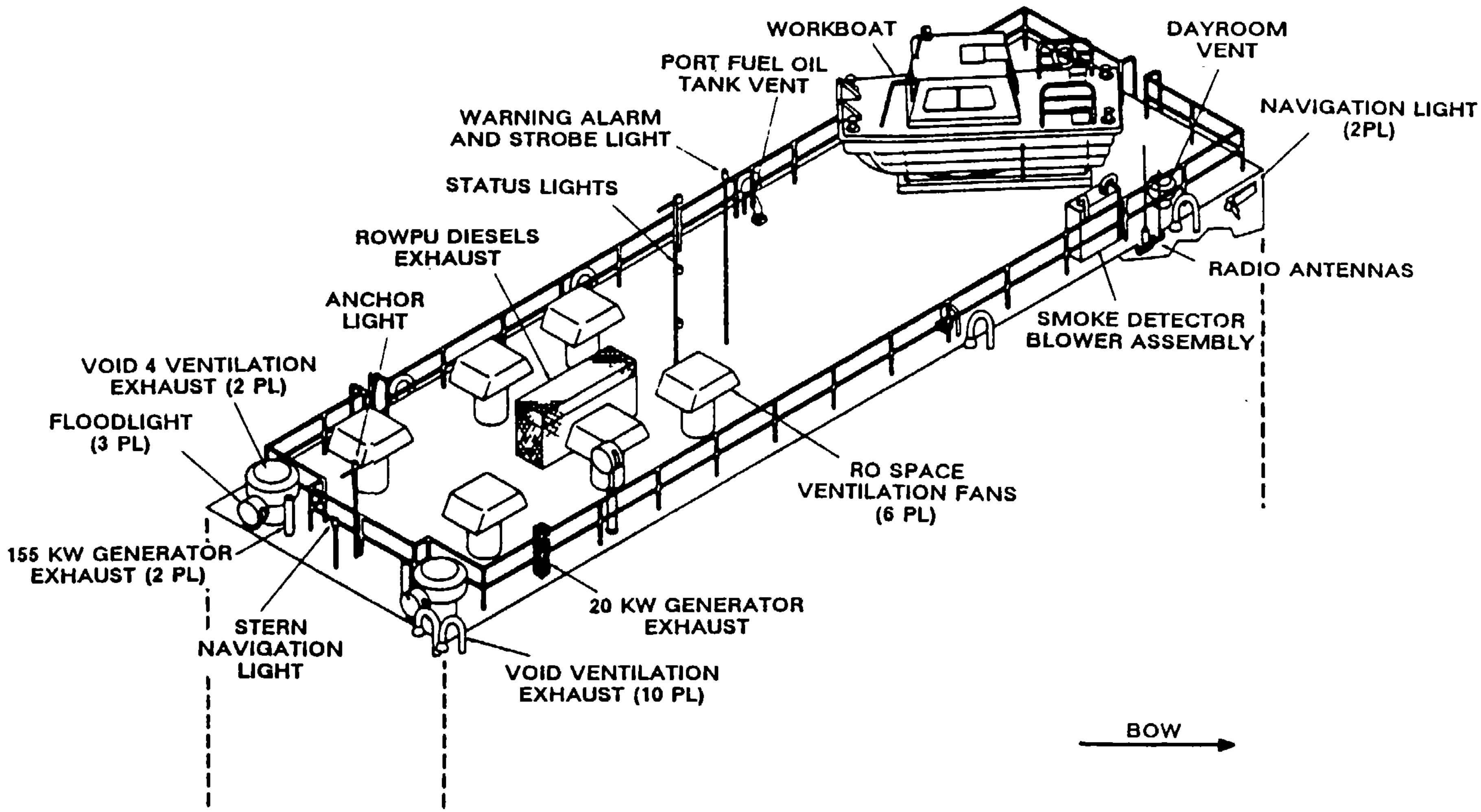


Figure 1-1. Major Components of ROWPU Barge Systems and Equipment - Deckhouse Roof
(Sheet 1 of 3)

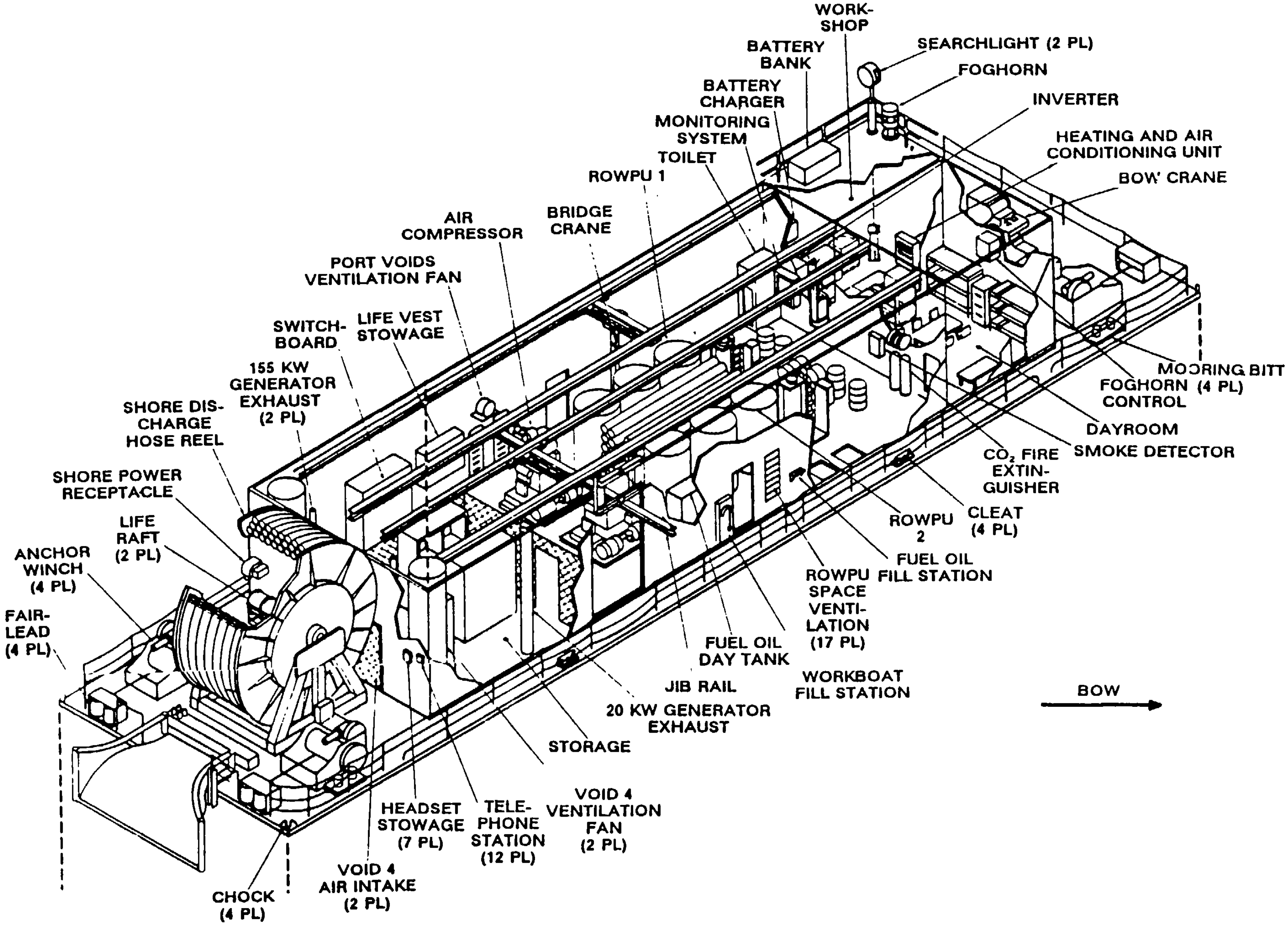


Figure 1-1. Major Components of ROWPU Barge Systems and Equipment - Deckhouse
Sheet 2 of 3)

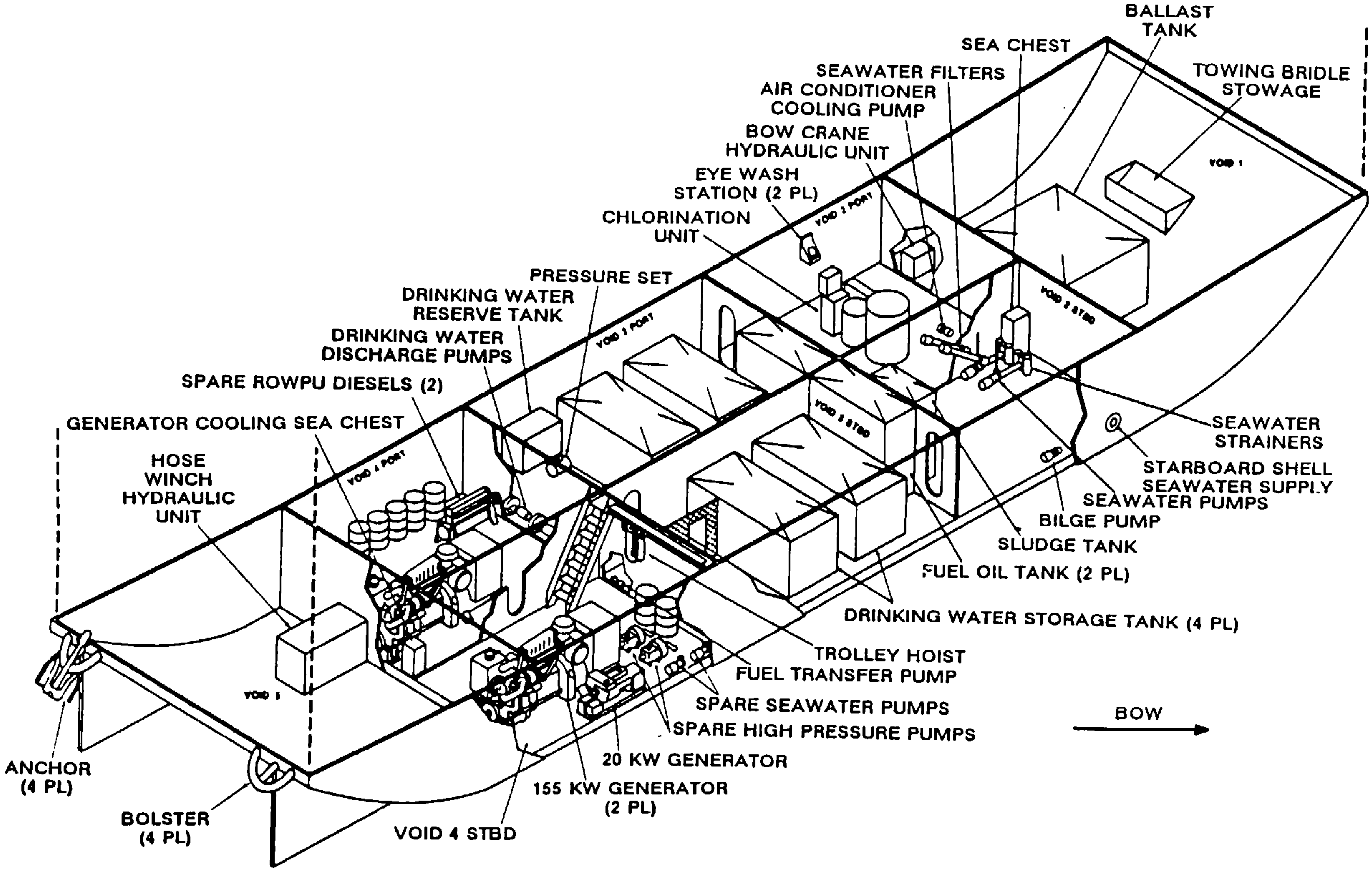


Figure 1-1. Major Components of ROWPU Barge Systems and Equipment - Voids (Sheet 3 of 3)

Section II. Description and data

1-8 Description

a. General

(1) The CONMACO Model 270 Winch (Fig. 1-2 and 1-3) is a 20-ton double drum diesel engine driven with winchhead drums. It consists of a winch power unit and the winch mechanism mounted on a skid base.

(2) The winch mechanism is driven by the diesel engine through a torque converter and multiple strand chain.

b. Engine. The winch is equipped with a Detroit Diesel, 4-71N series, Model 1043-7000, water cooled diesel engine that develops 152 rated HP at 2100 RPM.

c. Winch Assembly

(1) The winch assembly is constructed of steel with cast steel drums. The main drive shaft and two drum shafts run on tapered roller bearings.

(2) The two drums are engaged by an air actuated clutch and are equipped with air operated brakes.

1-9 Identification and tabulated data

a. Identification. The double drum winch has three major identification plates. The information contained on these plates is listed below.

(1) End Item Identification Plate. Located on the left hand side of the winch below the front drum axle.

(2) Engine Identification plate. Attached to the engine rocker arm cover. It specifies engine model number, engine serial number, and other optional equipment installed on the engine. The engine model number is also stamped on the right hand side of the cylinder block on the upper rear corner.

(3) Torque Converter Identification Plate. Located on the top of the torque converter. It specifies the manufacturer, model number, serial number, and part number.

b. Tabulated Data. ("Type No." refers to Detroit Diesel Engine data plate numbers.)

(1) End Item.

Manufacturer	CONMACO
Model	270

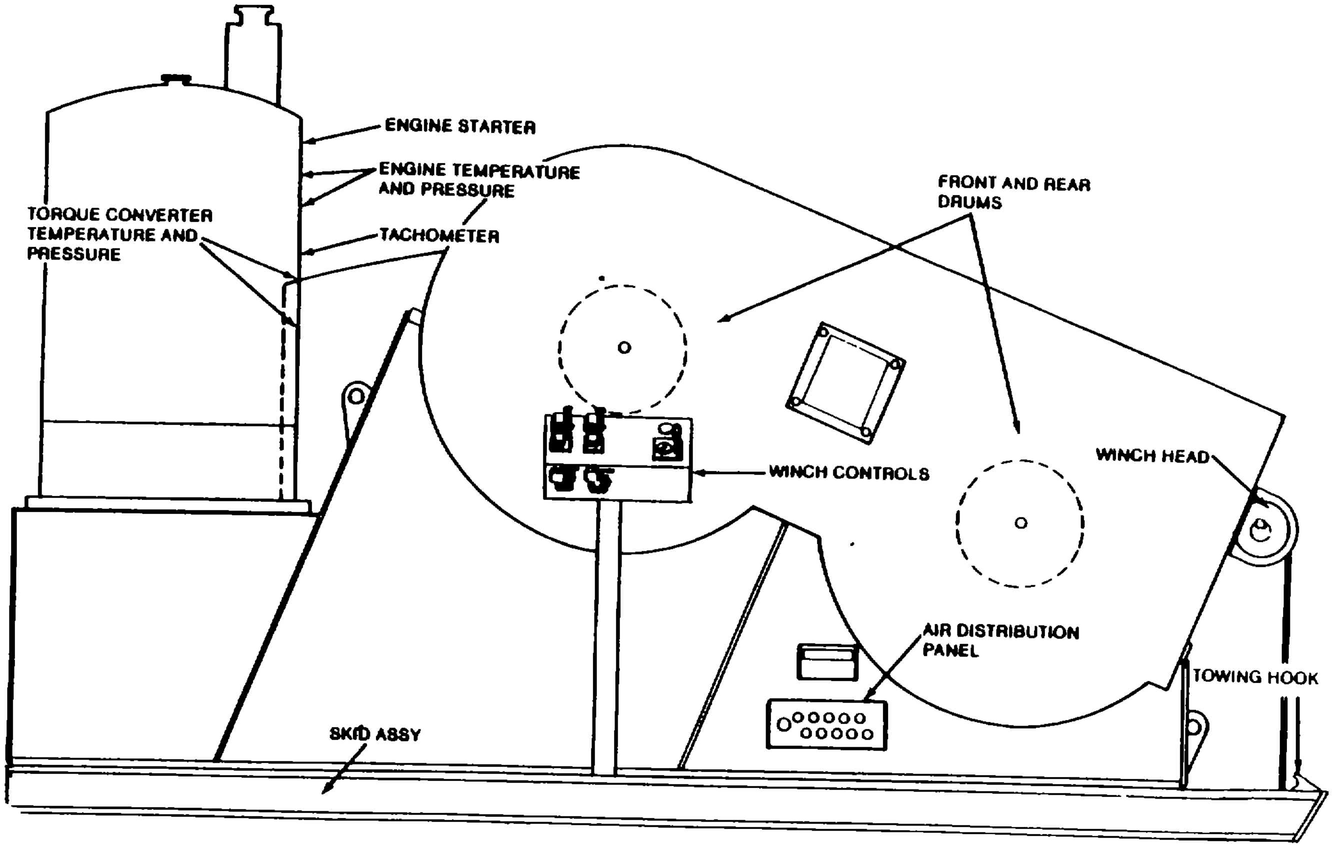
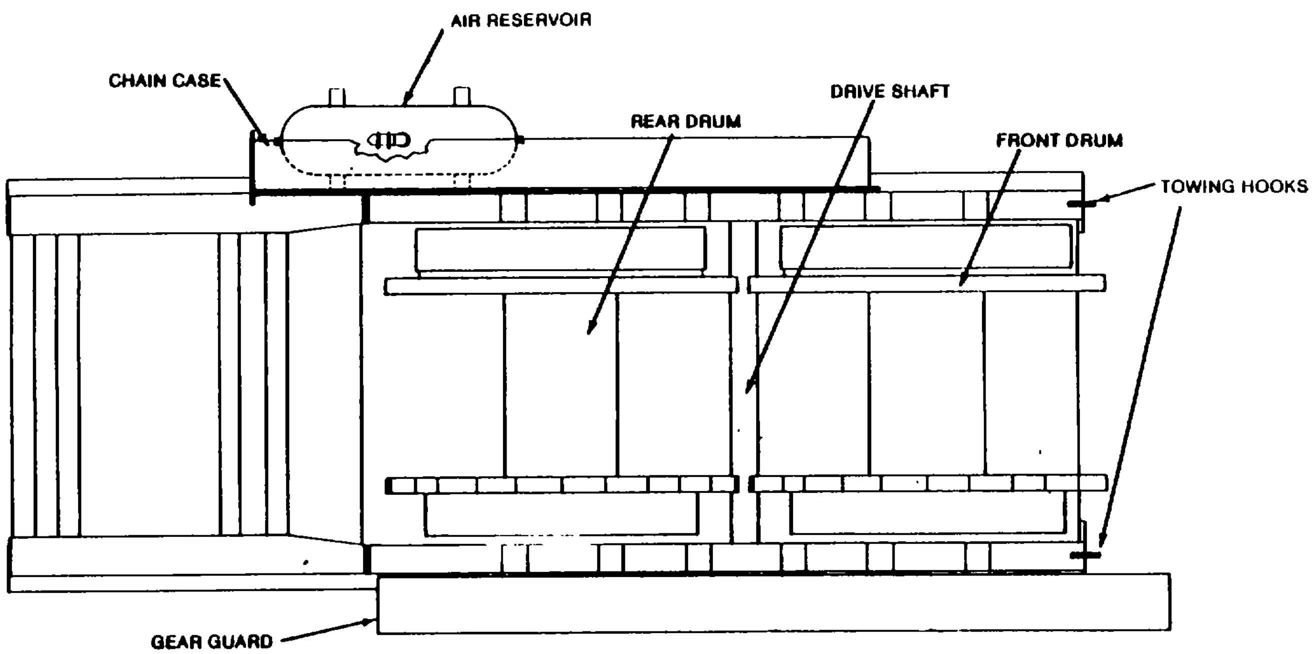


Figure 1-2. Winch Assembly Right Side View.



NOTE: ENGINE AND WINCH HEADS NOT SHOWN

Figure 1-3. Winch Assembly Top View.

(2) Engine.

Manufacturer	Detroit Diesel
Type	4-71N
Model	1043-7000
Max RPM (no load)	1940 RPM
Rated HP (horsepower)	152 at 2100 RPM
Number of cylinders	4
Firing order	1-3-4-2
Bore	4 1/4 in
Stroke	5 in
Compression ratio	18.7 to 1
Total displacement	284 cubic in
Number of main bearings	5

(3) Torque Converter Assembly.

Manufacturer	Twin Disc
Model	CF-1 0032-TC1
Type	B (Heavy Duty Chain Drive

(4) Engine Accessories.

(a) Starting Motor.

Manufacturer	Delco Remy
Voltage	12 volts
Type Number	16

(b) Alternator.

Manufacturer	Delco Remy
Voltage	12 volts
Amperes	42
Continuous operating RPM	1,850-4000
RPM range	8,000
Type Number	1963

(c) Voltage Regulator. (Built into the Alternator)

Manufacturer	Delco Remy
Voltage	12 volts
Amperes	42 amps
Type ground	Negative
Type	Transistorized

(d) Fuel Filter.

Manufacturer	AC Spark Plug
Type number	122

(e) Fuel Strainer.

Manufacturer	AC Spark Plug
Type number	44

(f) Oil Filter.

Manufacturer	AC Spark Plug
Part number	12-132 W

(g) Governor Assembly.

Manufacturer	Detroit Diesel
Operating RPM	1200-2100 RPM
Type number	85

(h) Air System.

Manufacturer	AMCON
Operating pressure	105-125 psi
Operating controls	Side mounted panel

(i) Air Compressor.

Manufacturer	Bendix
Capacity	12 SCFM
Drive	Accessory, from engine balance shaft
Mounting	Engine-Mounted
Type number	893

(5) Adjustment Data.

Exhaust valves (cold)	.011 in
Exhaust valves (hot)	.008 in
Governor gap	.006 in

(6) Capacities.

Fuel tank	30 gal
Engine crankcase	13 qt
Torque converter	9 qt
Cooling system	26 qt

(7) Batteries.

Quantity used	one
Voltage	12 volts DC
Polarity	Negative ground

c. Direct or General Support Data Items. Data items which receive Direct Support (F) or General Support (H) maintenance (and repair (1)) are:

DATA ITEM	DIRECT SUPPORT (F)	GENERAL SUPPORT (H)
Diesel Engine	1	1
Starting Motor	1	1
Alternator	1	1
Voltage Regulator	1	
Fuel Filter	1	
Fuel Strainer	1	
Oil Filter	1	
Governor Assembly	1	1
Torque Converter & Clutch Assembly	1	1
Air System	1	1

1-10 Differences in models. No differences in models are identified within the text pertinent to each major system on board the Water Purification Barges.

1-11 Repair and replacement standards. Table 1-1 lists the manufacturer's sizes, tolerances, desired clearance, and maximum allowable wear limits.

1-12 Spring specifications. Table 1-2 lists the diesel engine spring specifications.

1-13 Torque data

a. Table 1-3 lists the standard and specific torque data for the diesel engine.

b. Table 1-4 lists the standard and special pipe plug torque data.

Table 1-1. Specifications, New Clearances and Wear Limits

ENGINE PARTS (Standard Size, New, in inches)	MINIMUM	MAXIMUM	LIMITS
Cylinder Block			
Block bore:			
Diameter	4.6260	4.6270	
Out-of-round		.0010	.0020
Taper		.0010	.0020
Cylinder liner counterbore:			
Diameter	5.0460	5.0485	
Depth	.4770	.4795	
Depth	.2460	.2480	
Main bearing bore:			
Inside diameter (vertical axis)	3.8120	3.8130	
Top surface of block:			
Centerline of main bearing bore to top of block	16.1840	16.1890	16.176 min
Flatness, transverse (3, 4, and 6 cyl)			.0030
Flatness, longitudinal (4 cyl)			.0070
Depth of counterbores (top surface):			
Cylinder head seal strip groove	.0920	.1070	
Large water holes (between cylinders)	.1090	.1200	
Small water holes (at ends)	.0870	.0980	
Combination water and oil holes	.0870	.0980	
Cylinder Liner			
Outside diameter	4.6250	4.6260	
Inside diameter	4.2495	4.2511	
Clearance, liner-to-block	.0000	.0020	.0025
Out-of-round, inside diameter		.0020	.0025
Taper, inside diameter		.0010	.0020
Variation in depth between adjacent liners		.0020	.0020
Insert thickness	.1795	.1800	
71N Engines			
Piston:			
Height (centerline of bushing to top)	3.5430	3.5480	
Diameter (above compression rings)	4.2225	4.2255	
Diameter (at skirt)	4.2428	4.2450	
Clearance, piston skirt-to-liner	.0045	.0083	.0120
Out-of-round		.0005	
Taper		.0005	
Compression rings:			
Gap (top-fire ring)	.0230	.0380	.0600
Gap (No. 2, 3, and 4)	.0180	.0430	.0600
Clearance, ring-to-groove:			
No. 1 (top-fire ring)	.0230	.0380	.0600
No. 2	.0100	.0130	.0220
No. 3 and 4	.0040	.0070	.0130
Oil control rings:			
Gap	.0080	.0230	.0430
Clearance	.0015	.0055	.0080

Table 1-1. Specifications, New Clearances and Wear Limits - Continued

ENGINE PARTS (Standard Size, New, in inches)	MINIMUM	MAXIMUM	LIMITS
71T Engines			
Piston Pins (Trunk Pistons)			
Length	3.6050	3.6200	
Diameter	1.4996	1.5000@	1.4980
Clearance, pin to piston bushing	.0025	.0034	.0100
Clearance, pin to conn. rod bushing	.0025	.0034	.0100
Clearance, end (pin-to-retainer-retainer with lock ring)	.0160	.0640	.0640
Piston bushing, inside diameter	1.5025	1.5030	1.5050
Connecting Rod			
Length center-to-center of upper and lower bores	10.1240	10.1260	
Inside diameter (upper bushing)	1.5025	1.5030	1.5080
Normal side clearance	.0060	.0120	
Cross-Head Pistons and Rings 71N and 71T Engines			
Piston crown:			
Saddle-to-crown distance:			
N piston (18. 7:1 prsn ratio)	2.7030	2.7100	
Diameter:			
At top	4.2226	4.2256	
Below both compression rings	4.2391	4.2421	
Above and below seal ring groove	3.8850	3.8950	
Above and below bearing saddle	3.2360	3.2370	
Compression rings:			
Gap (top-fire ring)	.0230	.0380	.0600
Gap (No. 2 and 3)	.0180	.0430	.0600
Clearance, ring-to-groove:			
*Top (Keystone fire ring)	.0010	.0050	.0070
No. 2 (rectangular section)	.0100	.0130	.0220
No. 3 (rectangular section)	.0040	.0070	.0130
Seal ring:			
Gap (in skirt counterbore)	.0020	.0210	.0270
Clearance	.0005	.0030	.0130
Piston skirt:			
Diameter	4.2428	4.2450	
Clearance, skirt-to-liner	.0045	.0083	.0120
Seal ring bore	3.9200	3.9240	
Piston pin bore	1.500	1.5030	1.5040
Oil control rings:			
Gap (two rings in lower groove) (71N engine)	.0080	.0230	.0430
Gap (one ring in upper groove) (71N engine)	.0080	.0230	.0430
Clearance (two rings in lower groove)	.0015	.0055	.0080
Clearance (one ring in upper groove)	.0010	.0035	.0060

*Measured with Keystone fire ring flush with outside diameter of piston crown.
Diameter above and below the piston pin may be 4.2414 in.

Table 1-1. Specifications, New Clearances and Wear Limits - Continued

ENGINE PARTS (Standard Size, New, in inches)	MINIMUM	MAXIMUM	LIMITS
Connecting Rod (cross-head)			
Length center-to-center of upper and lower bore	10.1230	10.1260	
Piston Pins (Cross-Head Piston)			
Length	3.6250	3.6250	
Diameter	1.4996	1.5000	1.4980
Slipper bearing (bushing):			
Thickness at center	.0870	.0880	.0860
Clearance (edge of bushing to groove in piston)	.0005	.0105	
Crankshaft			
Journal diameter - main bearing	3.4990	3.500	
Journal diameter - conn. rod bearing	2.7490	2.7500	
Journal out-of-round		.00025	.0010
Journal taper		.0005	.0015
**Runout on journals - total indicator reading:			
4 cylinder (mounted on No. 1 and No. 5 journals):			
At No. 2 and No. 4 journals		.0020	
At No. 3 journal		.0040	
Thrust washer thickness	.1205	.1220	
End play (end thrust clearance)	.0040	.0140	.0180
Connecting Rod Bearings			
Inside diameter (vertical axis)	2.7514	2.7534	
Bearing-to-journal clearance	.0014	.0044	.0060
Bearing thickness 90° from parting line	.1548	.1553	.153 min
Main Bearings			
Inside diameter (vertical axis)	3.5014	3.5034	
Bearing-to-journal clearance	.0014	.0044	.0060
Bearing thickness 90° from parting line	.1548	.1553	.153 min
Camshaft			
Diameter (at bearing journals):			
Front and rear	1.4970	1.4975	
Center and intermediate	1.4980	1.4985	
Runout at center bearing (when mounted on end bearings)		.0020	
Shaft diameter at gear	1.1875	1.1880	

**Runout tolerance given for guidance when regrinding crankshaft. When the runout on adjacent journals is in the opposite direction, the sum must not exceed .003 inches total indicator reading. When the runout on adjacent journals is in the same direction, the difference must not exceed .003 inches total indicator reading. When high spots of the runout on adjacent journals are at right angles to each other, the sum must not exceed .004 inches total indicator reading or .002 inches on each journal.

Table 1-1. Specifications, New Clearances and Wear Limits - Continued

ENGINE PARTS (Standard Size, New, in inches)	MINIMUM	MAXIMUM	LIMITS
Balance Shaft			
Shaft diameter at bearings	1.4970	1.4975	
Shaft diameter at gear	1.1875	1.1880	
Length, thrust bearing end journal	2.8740	2.8760	
End thrust	.0040	.0120	.0180
Camshaft and Balance Shaft Bearings			
Inside diameter:			
Front and rear	1.5000	1.5010	
Center and intermediate	1.5010	1.5030	
Clearance, bearing-to-shaft:			
Front and rear	.0025	.0040	
Center and intermediate	.0025	.0050	
Outside diameter:			
Front and rear	2.1880	2.1885	
Center and intermediate	2.1840	2.1860	
Diameter of cylinder block bore	2.1875	2.1885	
Clearance, bearings-to-block:			
Front and rear	.001 prft	.0005 loose fit	
Intermediate (extruded)	.0015	.0065	
Intermediate (die cast)	.0015	.0105	
Camshaft and Balance Shaft Gears			
Inside diameter	1.1865	1.1875	
Clearance, gear-to-shaft	.0015 prft	.0000	
Backlash	.0030	.0080	.0100
Idler Gear			
Backlash	.0030	.0080	. 0100
Pre-load, Variation on pull 2 lbs 11 oz	1/2 lb	6 3/4 lb	1/2-6 3/4 lb
Crankshaft Timing Gear			
Backlash	.0030	.0080	.0100
Gear-to-hub fit	.0005 prft	.001 loose fit	
Support-to-end plate	.0005 prft	.0025 loose fit	
Blower Drive Gear			
Backlash	.0030	.0080	.0100
Gear-to-hub fit	.0005 prft	.001 loose fit	
Support-to-end plate	.0005 prft	.0025 loose fit	
Inside diameter (support bushing)	1.6260	1.6265	
Hub diameter (at bearing)	1.6240	1.6250	
Hub-to-support bushing clearance	.0010	.0025	.0050
Hub-to-cam clearance	.0020	.0070	
End thrust (current bearing)	.0060	.9140	
End thrust (former flanged bearing)	.0050	.0080	.0100

Table 1-1. Specifications, New Clearances and Wear Limits - Continued

ENGINE PARTS (Standard Size, New, in inches)	MINIMUM	MAXIMUM	LIMITS
Cylinder Head			
Flatness - transverse (3, 4, and 6 cyl)			.0040
Flatness - longitudinal (4 cyl)			.0080
Distance between top deck and fire deck	3.5560	3.5680	3.5360
Water nozzles	.0312 recess	flush	
Cam follower bores	1.0620	1.0630	1.0650
Exhaust Valve Seat Inserts			
Seat width - 30° (4 valve)	.0468	.0937	.0937
Valve seat runout		.0020	.0020
Exhaust Valves			
Stem diameter (4-valve)	.3100	.3105	.3090
Valve head-to-cylinder head:			
30° (current 2-valve and 4-valve)	.023 recess	.006 protruding	
Valve Guides			
Height above cylinder head:			
4-valve (machined guide)	.6900	.6900	
Diameter - inside (4-valve)	.3125	.3135	.3140
Clearance - valve-to-guide (4 valve)	.0020	.0035	.0050
Valve Bridge Guides			
Height above cylinder head (4-valve)	2.0400	2.0400	
Rocker Arms and Shafts			
Diameter - rocker shaft	.8735	.8740	
Diameter - inside (rocker arm bushing)	.8750	.8760	
Clearance - shaft-to-bushing	.0010	.0025	.0040
Cam Followers			
Diameter	1.0600	1.0610	
Clearance - follower-to-head	.0010	.0030	.0060
Rollers and pins:			
Clearance - pin-to-bushing	.0013	.0021	.010 horiz
Side clearance - roller-to-follower	.0150	.0230	.0230

Table 1-2. Diesel Engine Spring Specifications

Spring	No. Coils	Wire Diameter	Approx. Free Length	Replace When Load is Less Than
Cam Follower	11	.177	2 5/8	172 lbs at 2 1/8 in
Cam Follower	11 1/2	.162	2 21/32	133 lbs at 2 7/64 in
Exhaust Valve	8 3/4	.177	2 3/8	135 lbs at 1 49/64 in

Table 1-3. Torque Data

Standard Torque Values (lb-ft)					
Size	Torque	Size	Torque	Size	Torque
1/4-20	7-9	7/16-20	57-61	3/4-10	240-250
1/4-28	8-10	12-13	71-75	3/4-16	290-300
5/16-18	13-17	1/2-20	93-03	7/8-9	410-420
5/16-24	15-19	9/16-12	90-100	7/8-14	475-485
3/8-16	30-35	9/16-18	107-117	1-8	580-590
3/8-24	35-39	5/8-11	137-147	1-14	685-695
7/16-14	46-50	5/8-18	168-178		

Specific Torque Values		
Application	Size Nut or Bolt	Torque (lb-ft)
Cylinder head stud (high block)	4 3/4	
Cylinder head stud (low block)	4 7/16	
Main bearing stud	4	35-75
Injector clamp stud		10-25
Water manifold stud		10-25
Exhaust manifold stud		25-40
Cam follower guide bolt	1/4-20	12-15
Injector control shaft bracket bolt	1/4-20	10-12
Oil pan bolts	5/16-18	10-12
Exhaust valve bridge adj. screw lock nut	5/16-24	20-25
Blower drive coupling to gear hub bolt	5/16-24	20-25
Idler gear bearing retainer bolt	5/16-24	24-29
Injector clamp bolt	3/8-16	20-25
Hand hole cover	3/8-16	10-15
Flywheel housing bolts	3/8-16	25-30
*Idler gear hub and spacer	3/8-16	40-45
**Idler gear hub and spacer	3/8-16	25-40
Cam and balance shaft end bearing bolt	3/8-16	35-40
Balance weight cover bolt	3/8-16-24	25-30
Flywheel housing bolts	3/8-24	25-30
Crankshaft front cover	3/8-24	25-30

Table 1-3. Torque Data (Continued)

Specific Torque Values – continued

Application	Size Nut or Bolt	Torque (lb-ft)
Camshaft intermediate bearing lock screw	3/8-24	15-20
Balance weight to hub bolt	3/8-24	25-30
Blower drive gear hub bearing support bolts and nuts	3/8-24	25-30
Balance weight to timing gear bolt	3/8-24	25-30
Accessory drive to gear bolt (steel disc)	3/8-24	45-50
Accessory drive to gear bolt (fiber disc)	3/8-24	35-39
Injector clamp nut	3/8-24	20-25
Exhaust manifold outlet flange nuts (brass)	3/8-24	20-25
Water manifold nut	3/8-24	25-30
Fuel pipe nut	3/8-24	12-15
Lifter bracket bolt	7/16-14	55-60
+ Threaded exhaust valve bridge guide (nylon insert)	7/16-14	46-50
Air compressor adjusting support pivot bolt (280M)G	7/16-14	72-77
Generator drive bearing retaining bolt	7/16-14	30-35
Generator drive oil seal retaining bolt	7/16-14	30-35
Tachometer drive cover bolt	7/16-14	30-35
Connecting rod nut (Lubrite)	7/16-20	60-70
Connecting rod nut (Castellated)	7/16-20	65-75
Exhaust manifold nuts	7/16-20	30-35
Fuel manifold connectors (steel washer)	7/16-20	40-45
+ Fuel manifold connectors (nylon insert)	7/16-20	30-35
Fuel manifold connector nuts	7/16-20	30-35
Crankshaft front cover bolts	1/2-13	80-90
Flywheel housing bolts	1/2-13	90-100
+ Rocker shaft bolts	1/2-13	90-100
Generator drive bearing retaining bolt	1/2-13	30-35
Generator drive oil seal retaining bolt	1/2-13	30-35
Tachometer drive cover bolt	1/2-13	30-35
Rocker shaft bolt	1/2-13	90-100
Idler gear and dummy hub bolt	1/2-13	80-90
Blower rotor gear retaining nut	1/2-20	55-65
***Main bearing bolts (assy)	5/8-11	180-190
***Cylinder head bolts	5/8-11	175-185
***Main bearing nuts (assy)	5/8-18	155-185
***Cylinder head nuts	5/8-18	175-185
***Flywheel bolts	9/16-18	150-160
Crankshaft end bolt	1-14	290-310
Camshaft and balancer shaft nut	1 1/8-18	300-325
Blower drive gear nub nut	1 1/2-16	50-60

+ 75-85 lb-ft torque on the two bolts attaching load limit screw bracket (if used) to the rocker arm shaft.
+ Lubricate before assembling to cylinder head.
*Self locking only.
**Wired head only.
***Lubricate at assembly with International Compound No. 2 or equivalent.

Table 1-4. Pipe Plug Torque Data

Standard Pipe Plugs	
Plug Size (in)	**Torque (lb-ft)**
1/8	10-12
1/4	14-16
3/8	18-22
1/2	23-27
3/4	33-37
1	75-85
1 1/4	95-105
1 1/2	110-130

Special Pipe Plugs		
Application	**Plug Size**	**Assembly**
Oil gallery plug	3/8	Assemble with max. 1/16 in. protrusion from surface.
Cylinder head (side)	3/8-16	Assemble flush to 1/16 in. protrusion from surface.
Cylinder head (top)	1/2	Flush to 1/8 in. recessed.
Cylinder head (end)	3/4	Flush to 1/8 in. recessed.
Water plug	1	Assemble 2 to 2 1/4 in. below machined surface.
Core hole plug	1 3/4	180 lb-ft torque.
Oil drain plug with nylon washer	18 mm	25-35 lb-ft torque.

CHAPTER 2 OPERATING INSTRUCTIONS
Section I. Operation Under Usual Conditions

2-1 General. This section provides operating procedures for crew members utilizing the 20-ton double drum winch on board the Water Purification Barges. Controls and instruments are described and illustrated, providing all information necessary to operate the winch.

Crew members must be familiar with every procedure required to operate the double drum winch. Paragraphs 2-5 through 2-7 contain instructions for starting, stopping, and operating the double drum winch and coordinating basic motions required to perform specific tasks using the winch. The operator may have to vary certain procedures to fit individual tasks.

WARNING

For the safety of personnel, cargo, and equipment, operators using this equipment must be thoroughly familiar with its operation before putting the winch into service.

WARNING

While operating the winch, never allow attention to be diverted from the load or from other personnel in the work area. Make sure all persons are clear of the load before operations begin.

2-2 Controls and Instruments

a. The engine instruments are illustrated in figure 2-1.

b. The winch controls are illustrated in figure 2-2.

2-3 Preparation for operation

a. Perform BEFORE Preventive Maintenance Checks and Services (TM 55-1930-209-14&P-19, Chapter 18).

b. Make a visual inspection of the equipment to make sure all components are secured in their proper position.

2-4 Starting the diesel engine

a. Disengage torque converter clutch.

b. Set automatic shutdown system in the OPEN position.

c. Set speed control lever at part throttle.

d. Make sure that stop lever on governor is in RUN position.

e. Press start button on the engine cow firmly and hold down.

CAUTION

To prevent damage to starting motor or flywheel, do not re-engage the starter with starter or engine still turning.

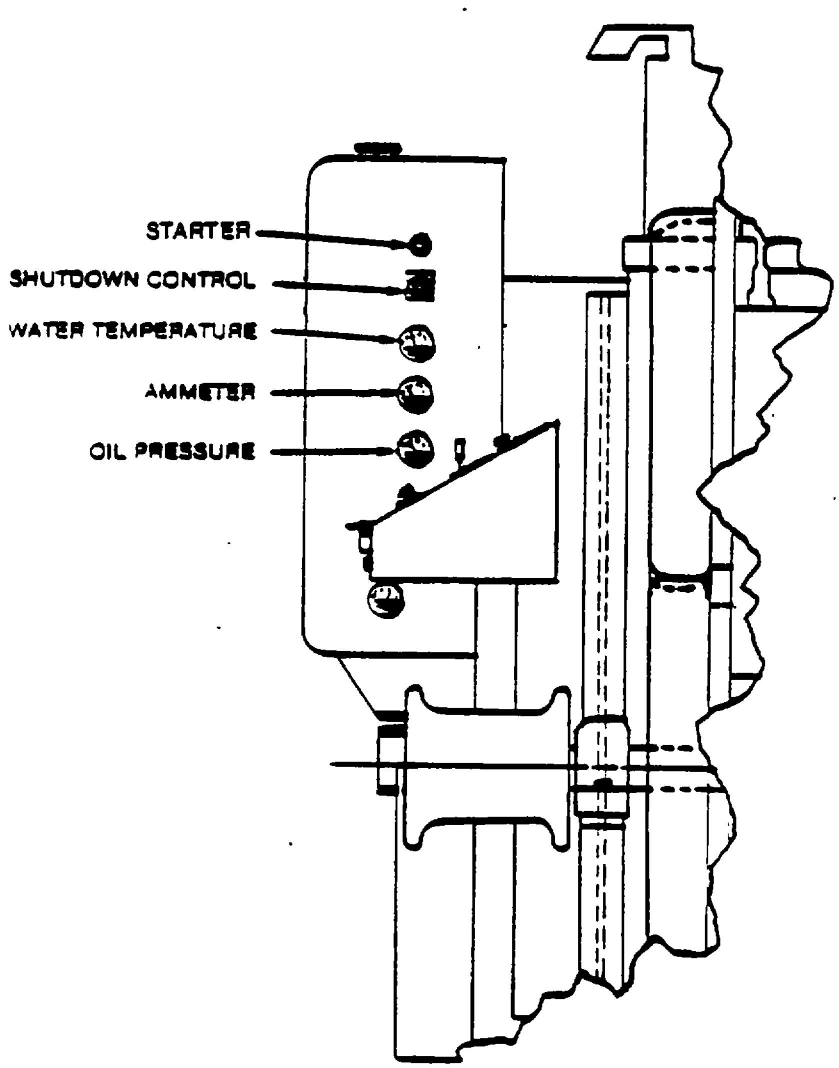


Figure 2-1. Engine Instruments.

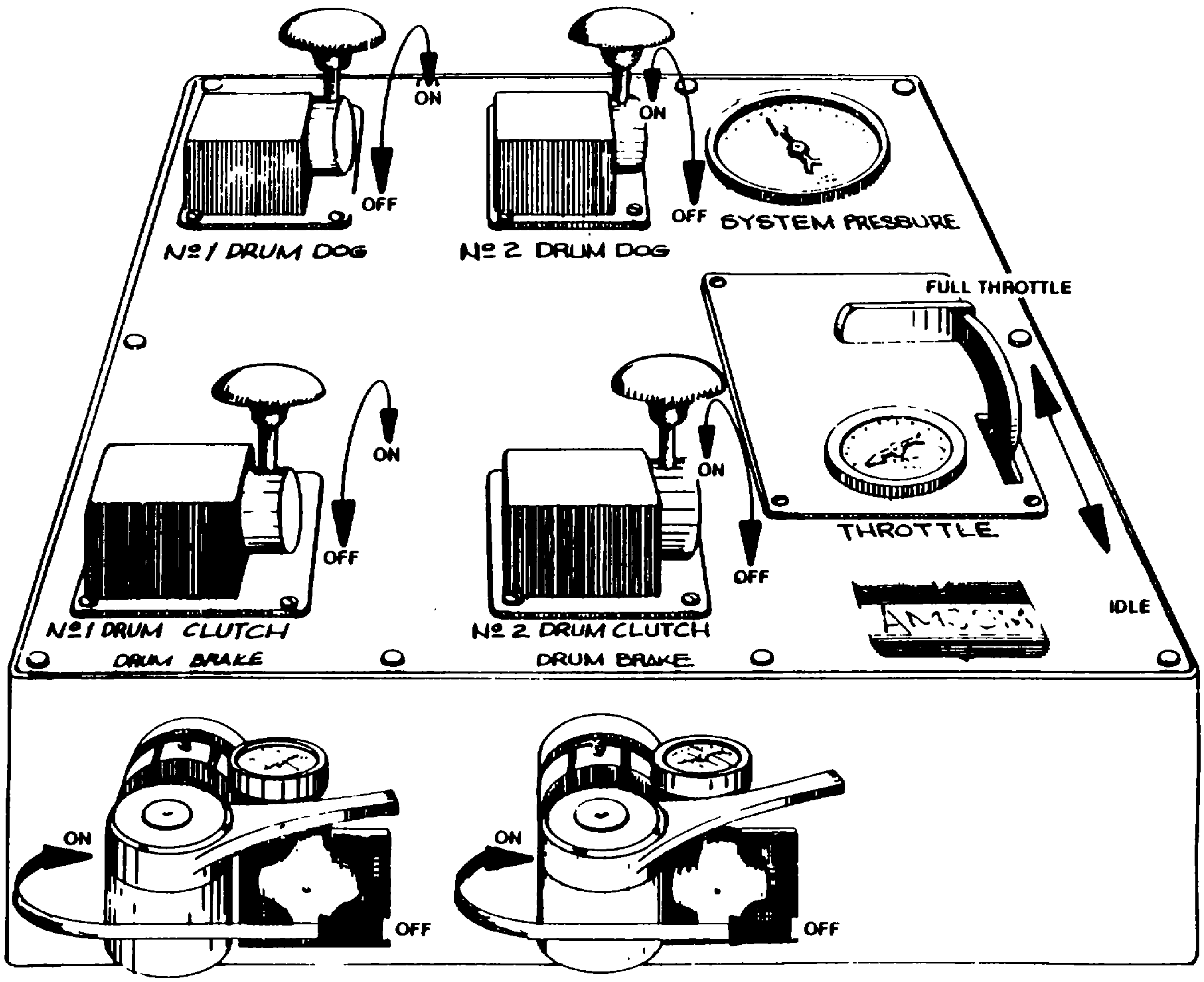


Figure 2-2. Winch Controls.

f. If engine fails to start within thirty seconds, release start button. Allow starter to cool for several minutes.

g. If engine will not start after three attempts, discontinue, start, and refer to troubleshooting procedures in Table 3-2.

h. After engine has started, reset throttle control to desired no-load rpm and allow engine to warm up.

i. When engine is sufficiently warmed up, ensure drum brakes are set and drum clutches are disengaged. Ensure that winch heads are clear.

j. Engage torque converter clutch.

k. All winch operations can now be conducted from winch operator's console.

2-5 Stopping the diesel engine.

CAUTION

Do not utilize the "emergency stop" unless there is an emergency. "Emergency stop" can cause oil to be sucked through the blower seals, damaging the seals.

a Disengage winchdrum clutches and set drum parking brakes.

b Reduce engine rpm to less than 1000.

c Disengage torque converter clutch.

d Run engine at less than half speed for four or five minutes.

e Move stoplever to stop position.

2-6 Operation of the winch

a. Starting the Winch

(1) Engage hand operated clutch on torque converter assembly.

(2) Engage rear winch drum to haul, payout, brake, hold, and lock a load.

CAUTION

- **DO NOT prolong engaging the drum clutch. This causes unnecessary wear on friction blocks.**
- **DO NOT hold a load with clutch partially engaged.**
- **DO NOT apply or release the drum brakes suddenly. Sudden release may put the load out of control. Sudden application causes dangerous stress on the load cable and machinery.**
- **Always keep the drum firmly braked while engaging the dog and DO NOT engage a dog while drum is running out.**

(3) Engage drum clutch slowly enough to achieve a gradual start.

(4) Release and apply drum brakes gradually and evenly.

(5) With the drum firmly braked, engage the dog then release brake slowly until dog locks firmly into ratchet without slippage or shock.

(6) To keep the load under control, engage the drum clutch enough so the dog can be readily disengaged.

(7) Release the dog, then release the clutch and instantly apply the brake.

WARNING

Do not use throttle control as a direct accelerator to supply extra power for momentary loads. This causes power surges and excessive machinery speed which is dangerous and difficult to control. Always set throttle control at most advantageous operating speed, and let governor compensate for variations in load.

b. Operating Speed. Adjust speed of winch with throttle lever (Fig. 2-2) which is connected through an air line and mechanical linkage to engine governor. Thereafter, the speed selected is maintained by engine governor.

c. Fleet Angle

(1) -On installations where wire rope passes over lead sheave and on to drum, lead sheave must be located a sufficient distance from drum to maintain a small fleet angle at all times. The fleet angle is the side angle at which cable approaches drum from the sheave (See fig. 2-3).

(2) For best cable service, maximum fleet angle should not be more than 1-1/2 degrees.

(3) Maximum fleet angle is measured between center line of sheave and rope when it is at end of traverse travel on drum. Fleet angles of 1-1/2 degrees are equivalent to approximately 38 feet of lead for each foot of cable traverse either side of center line of sheave. A smooth drum on this winch requires a distance of not less than 42 feet between lead sheave and drum.

d. Winding First Layer on Drum

(1) Insure that only right lay wire rope is used on this winch.

(2) If necessary, use a 2" x 4" or similar piece of wood to keep the coils tight when winding the first layer. If the wire rope spreads, check that the rope is not left lay.

e. Coiling Wire Rope. When hand coiling wire rope, on the floor or bench, always coil it in the direction that will take twist out of the rope. Rope coiled in the wrong direction causes twists and bends which result in fraying and weakening of rope. Always coil right lay wire rope in a clockwise direction.

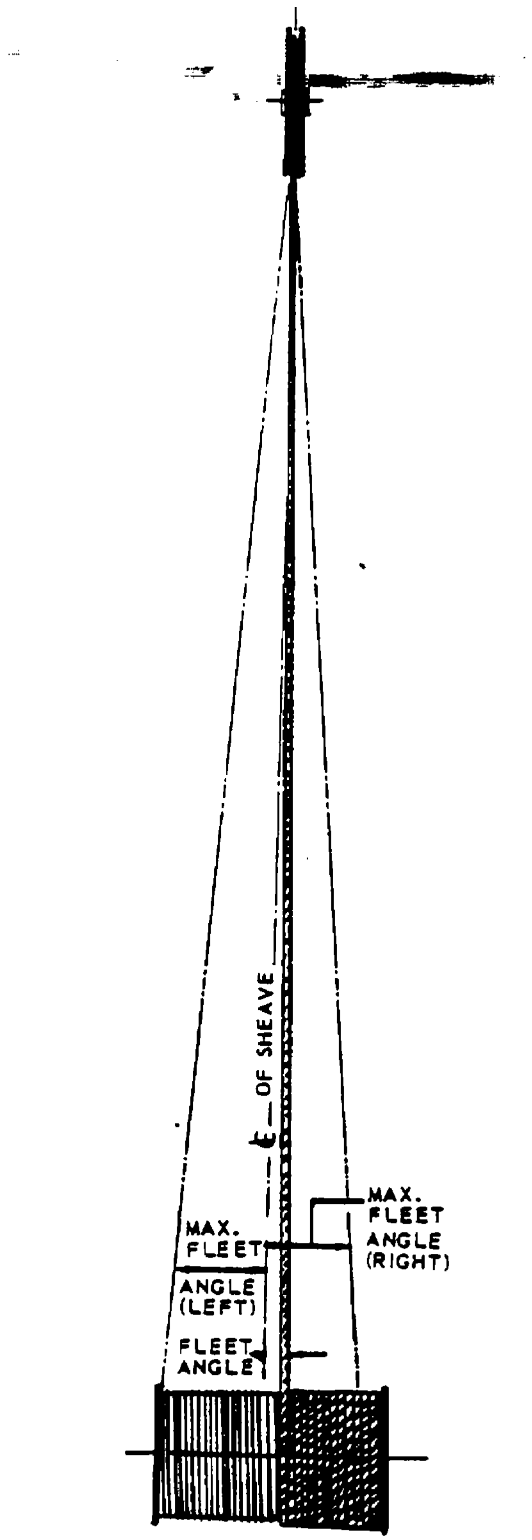


Figure 2-3. Fleet Angle.

Section II. Operation Under Unusual Conditions

2-7 Operation in extreme cold (below O°F)

a. General. At extremely low temperatures, lubricants used for normal temperatures stiffen and lose much of their lubricating effect. Metals become more brittle and lose some of their ability to withstand shock. Engine coolant requires special attention. Batteries and wiring are also adversely affected by extreme cold.

b. Lubrication. Refer to the lubrication chart (Fig. 3-1) and lubricate. Change the lubricants as indicated for specific temperature ranges shown in Fig. 3-1, 4 of 4.

c. Operational Precautions. Avoid all unnecessary shock loads when operating winch. Take up all cable slack and increase tension on cables gradually to avoid sudden stress.

d. Engine Coolant

(1) Refer to Table 2-1 and add necessary anti-freeze mixture to engine cooling system.

(2) Check coolant frequently to make sure there is sufficient anti-freeze.

e. Fuel Tank. Keep fuel tank as full as possible at all times to prevent condensation of moisture in tank. Be sure to use proper grade of fuel.

f. Electrical Wiring. Disturb electrical wiring as little as possible to keep it from becoming brittle.

g. Battery

(1) Inspect cables and battery for damage. Clean battery and cables as necessary and make sure battery terminals are clean and tight.

(2) Make sure battery filler cap vent holes are open. Keep electrolyte level 3/8 in. above battery plates.

(3) To prevent battery from freezing, keep fully charged.

2-8 Operation in extreme heat

a. Cooling System

(1) Inspect engine coolant level frequently and maintain proper level. Avoid using water that contains substances likely to cause rust or scale.

(2) Make sure all "V" belts are properly adjusted.

b. Lubrication. Refer to lubrication chart (Fig. 3-1) and lubricate unit more frequently. Clean any oil or foreign matter from exterior of engine and winch.

Table 2-1. Anti-freeze Mixture

Lowest Air Temperature °F	Quarts Anti-freeze	Water to fill system
20 to 30	1	8
15 to 20	2	7
0 to 15	3	6
-25 to 0	4	5
-50 to -25	5	4
Cooling System Capacity = 9 Quarts		

c. Battery. Inspect electrolyte level in battery daily, and add water as necessary.

2-9 Operation at high altitudes. With the Water Purification Barges, high altitude operation will not be a factor.

2-10 Operation in dusty or sandy areas

a. Fuel System

(1) Service fuel filter and strainer at more frequent intervals.

(2) Take extra precautions to keep dirt and grit out of fuel.

b. Cooling System

(1) Inspect cooling system frequently for leaks or other damage.

(2) Keep cooling system properly filled and radiator cap tightened at all times.

(3) Make sure all V-belts are properly adjusted.

c. Lubrication

(1) Service engine oil filter more frequently.

(2) Refer to lubrication chart (Fig. 3-1), and lubricate unit more frequently. Clean all lubrication points before applying lubricant.

(3) Clean area around engine and torque converter, oil filler caps, and oil level gage thoroughly before checking or adding oil.

(4) Wet down area around winch to reduce dust.

(5) Drive gears are particularly susceptible to collecting sand and dirt during windy and dry weather conditions. Clean and lubricate drum drive gears often when operating in dusty or sandy areas.

2-11 Operation in rainy or humid conditions

a. Keep fuel tank full at all times to prevent condensation buildup in tank.

b. Inspect unit closely for corrosion. Clean and paint chipped areas.

c. Lubricate more frequently when operating under wet conditions, and always lubricate after operation to force all water from bearing surfaces.

2-12 Operation in salt water areas

a. Pay special attention to general maintenance instructions to prevent corrosion and rusting of metal parts.

b. Keep all components as clean and free of moisture as possible. Apply a thin coat of oil on all exposed machined surfaces.

c. Clean and repaint all painted surfaces as required.

d. If winch has been exposed to excessive salt water spray, wash all exposed areas with clean, fresh water as soon as possible.

CHAPTER 3 OPERATOR/CREW MAINTENANCE INSTRUCTIONS

Section I. Lubrication Instructions

3-1 Detailed lubrication information

a. General. Lubrication of winch assembly is covered in lubrication chart (Fig. 3-1). Keep all lubricants in closed containers and stored in a clean, dry place away from external heat. Allow no dust, dirt, or other foreign material to mix with lubricants. Keep all lubrication equipment clean and ready for use. See Chapter 2 for operation under unusual conditions, and modify lubrication frequency accordingly.

b. Cleaning. Keep all external parts not requiring lubrication clean of lubricants. Before lubricating equipment, wipe all lubrication points free of dirt and grease. Clean all lubrication points after lubricating to prevent accumulation of foreign matter.

3-2 Points of lubrication

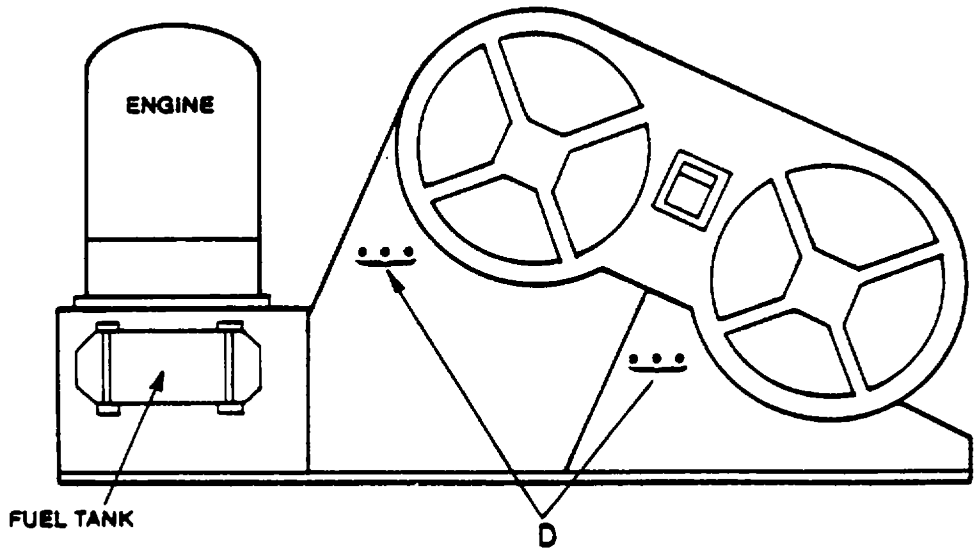
a. Service lubrication points at proper intervals as illustrated in figure 3- 1.

b. The engine crankcase oil level must be checked frequently, as oil consumption may increase.

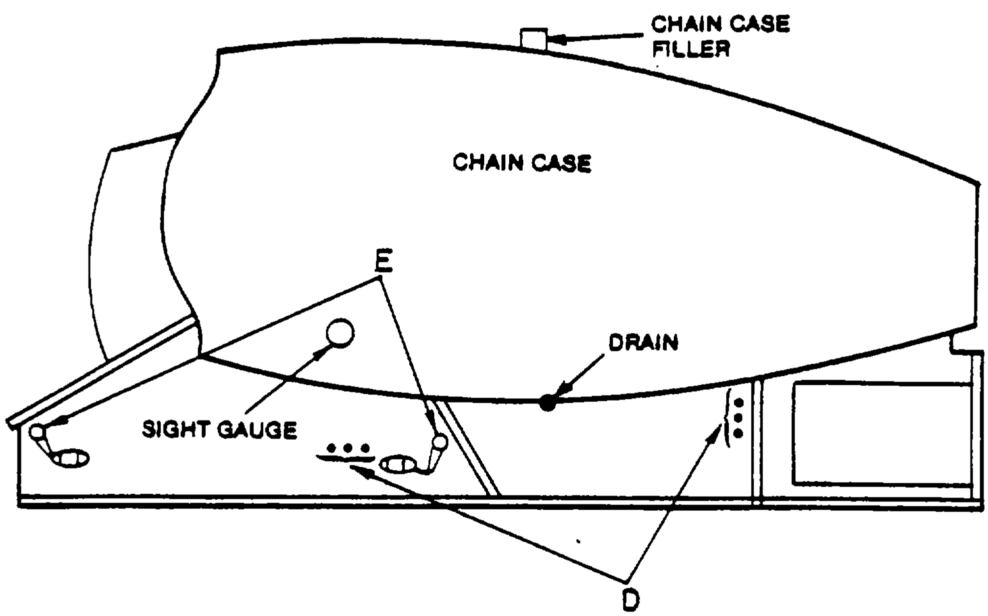
c. The engine and transmission oil may require changing more frequently than usual because contamination by dilution and sludge formation will increase under cold weather operating conditions.

Section II. Preventive Maintenance Checks and Services

3-3 General. To insure that the winch is ready for operation at all times, it must be inspected systematically so that defects may be discovered and corrected before they result in serious damage or failure. The necessary preventive maintenance checks and services to be performed are listed in TM 551930-209-14&P-19, Chapter 18.



GREASE FITTINGS–RIGHT SIDE



GREASE FITTINGS–LEFT SIDE

Figure 3-1. Lubrication Chart (Sheet 1 of 4).

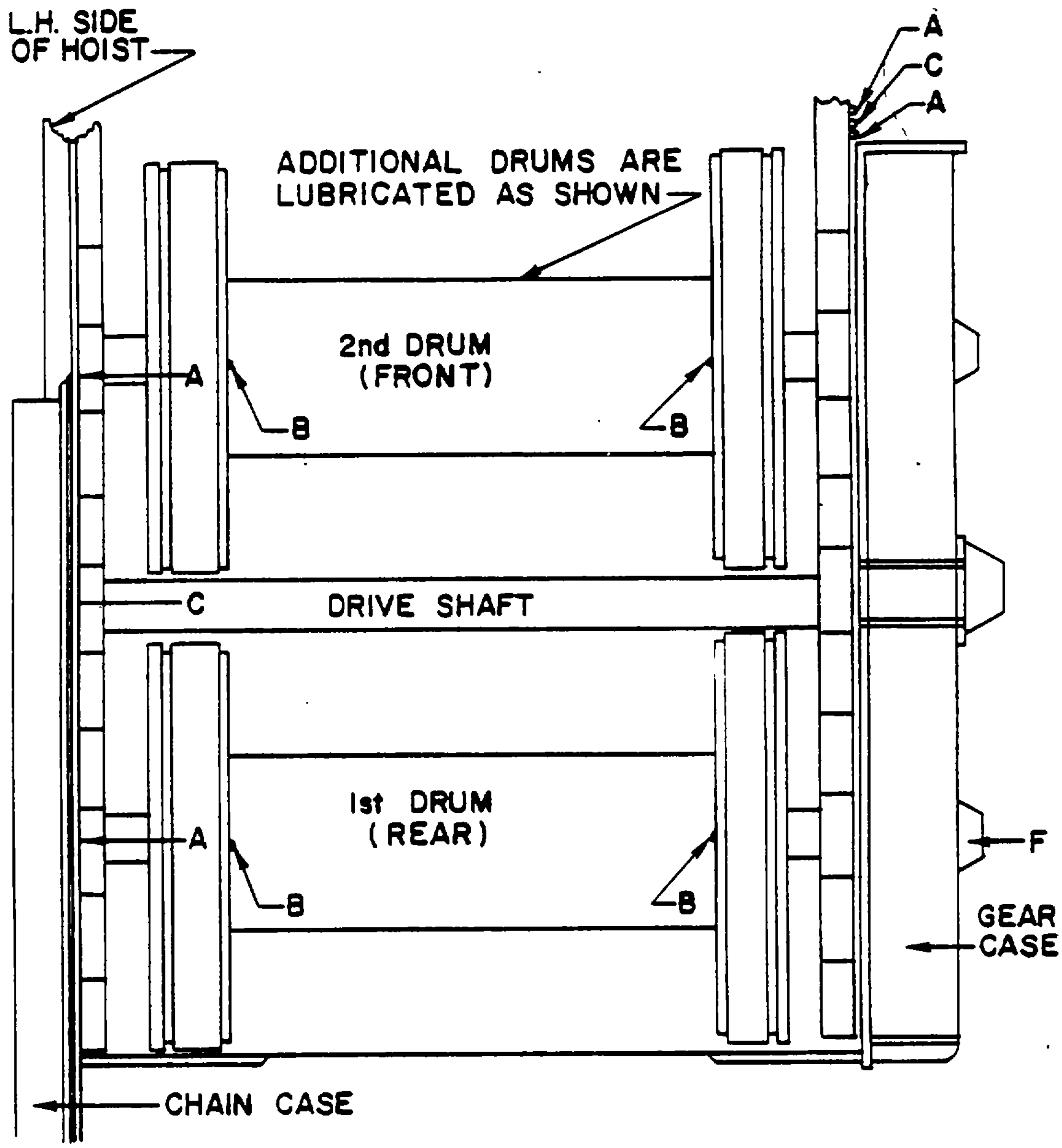


Figure 3-1. Lubrication Chart (Sheet 2 of 4).

PARTS LUBRICATED	LUBE POINT	LUBE TYPE	QUANTITY OF LUBE	INTERVAL IN HRS OF OPERATION	COMMENTS
DRUM SHAFT PILLOW BLOCKS	A	1	REPLENISH SUPPLY	480 HOURS	
DRUM SHAFT DRUM BEARINGS	B	1	REPLENISH SUPPLY	480 HOURS	
DRIVE SHAFT PILLOW BLOCKS	C	1	2-4 SHOTS	40 HOURS	
BRAKE SHAFT BEARING	D	1	2-4 SHOTS	160 HOURS	
BRAKE CRANK BEARING	E	1	REPACK	960 HOURS	
DRUM GEARS AND PINION	F	2	-	8 HOURS	BRUSH OR APPLY HEATED LUBE WITH A PADDLE TO MAINTAIN A FILM ON THE TEETH.
CHAIN CASE	CHAIN CASE FILLER	3	12 GALLONS (45. 42 LITERS)	960 HOURS (DRAIN AND REFILL)	MAINTAIN OIL LEVEL AT CHAIN PIN. SEE THROUGH THE PLASTIC WINDOWS.
CLUTCH, BRAKE AND DOG PINS AND BUSHINGS	-	4	A FEW DROPS	160 HOURS	LUBRICATE WITH MOLYCOTE GREASE OR OTHER SUITABLE RUST-PREVENTIVE LUBRICANT.

Figure 3-1. Lubrication Chart (Sheet 3 of 4).

LUBE TYPE	APPLICATIONS	BRANDS USED* SUMMER		BRANDS USED* WINTER
1	— PLAIN, BALL OR ROLLER BEARINGS — SLIDES AND GUIDES	BP ENERGREASE LS-EP2 STANDARD OIL CO. RYKON GREASE NO. EP SHELL OIL CO. SUPER DUTY GREASE		(SAME AS SUMMER)
2	— OPEN GEARS — WIRE ROPE	BP ENERGREASE GG BP ENERGOL GR STANDARD OIL CO. AMOVIS LUBE NO. 10-x SHELL OIL CO. OMALA OIL 96		STANDARD OIL CO. AMOVIS LUBE NO. 5-X SHELL OIL CO. OMALA OIL 96
		ABOVE 100°F (ABOVE 38°C)	40°F-100°F (40°C-38°C)	20°F-40°F (-7°C-4°C)
3	— ROLLER CHAIN BATHS	BP ENERGOL HD 50 STANDARD OIL CO. SAE 50	BP ENERGOL HD 50 STANDARD OIL CO. SAE 30	BP ENERGOL HD 20W STANDARD OIL CO. SAE 20
		SHELL OIL CO. ROTELLA OIL SAE 50	SHELL OIL CO. ROTELLA OIL SAE 30	SHELL OIL CO. ROTELLA OIL 20 - 20W
4	— ROLLER PATH AND AXLES — OIL GROOVES — SWIVEL JOINTS	SUMMER	WINTER	
		BP ENERGOL HLP 150 STANDARD OIL CO. PERMA-LUBE MOTOR OIL #30		BP ENERGOL HLP 80 STANDARD OIL CO. PERMA-LUBE MOTOR OIL #20

* THE PRESENCE OR OMISSION OF A BRAND NAME IS NOT A GUARANTEE OF ANY PETROLEUM PRODUCT BY AMCON OR CONMACO INC., AND OTHER BRANDS WITH THE SAME PROPERTIES MAY BE CROSS REFERENCED AND USED.

Figure 3-1. Lubrication Chart (Sheet 4 of 4).

Section III. Operator/Crew Troubleshooting

3-4. General. This section provides information necessary to diagnose and correct unsatisfactory operation or failure of the winch and its components. Malfunctions are listed in Table 3-2. Each malfunction is followed by a list of probable causes of the trouble. The recommended corrective action is described below the probable cause.

3-5. Troubleshooting table. Table 3-2 lists operator and crew troubleshooting malfunctions, probable causes and the recommended corrective action.

Table 3-2. Operator/Crew Troubleshooting

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

1. Engine Hard to Start or Fails to Start

Step 1. Check battery leads for loose or corroded terminals.

Clean and tighten terminal leads.

Step 2. Check for empty fuel tank.

Add fuel as necessary.

Step 3. Check for water or dirt in fuel system.

Service the fuel filters (Para 3-8).

Step 4. Check for closed fuel control valve.

Open fuel control valve.

Step 5. Check for clogged air cleaner.

Service the air cleaner (Para 3-7).

Step 6. Other causes.

Notify higher maintenance.

2. Engine Misses or Runs Erratically

Step 1. Check for cold engine.

Reduce load and allow engine to warm up.

Step 2. Check for water in fuel system.

Drain fuel system and refill with clean fuel.

Step 3. Check for air in fuel system.

Bleed the fuel system.

Step 4. Other causes.

Notify higher maintenance.

Table 3-2. Operator/Crew Troubleshooting - Continued

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

3. Engine Lacks Power

Step 1. Check for clogged fuel filter.

Service the fuel filters (Para 3-8).

Step 2. Check for clogged air cleaner.

Service the air cleaner (Para 3-7).

Step 3. Check for air in fuel system.

Bleed the fuel system.

Step 4. Other causes.

Notify higher maintenance.

4. Engine Knocks, Develops Excessive Noise or Vibration

Step 1. Check for low oil level in crankcase.

Refer to lubrication chart (Fig. 3-1) and service engine crankcase.

Step 2. Check for improper fuel grade.

Drain fuel tank and fill with proper fuel.

Step 3. Other causes.

Notify higher maintenance.

5. Engine Stops Suddenly

Step 1. Check for empty fuel tank.

Fill fuel tank with proper fuel.

Step 2. Check for clogged fuel filter.

Service fuel filters (Para 3-8).

Step 3. Check for water in fuel.

Drain fuel tank and fill with clean fuel. Service the fuel filter (Para 3-8).

Step 4. Check for overheated engine.

Inspect coolant level and add coolant as necessary. Inspect radiator and grill for obstructions.

Step 5. Check for low oil pressure.

Refer to lubrication chart (Fig. 3-1), and service engine crankcase.

Table 3-2. Operator/Crew Troubleshooting - Continued

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

Step 6. Check for air in fuel system.

Bleed the fuel system. Tighten all fuel line connections.

Step 7. Other causes.

Notify higher maintenance.

6. Engine Has Low or No Oil Pressure

Step 1. Check for low oil supply in crankcase.

Refer to lubrication chart (Fig. 3-1), and service engine crankcase.

Step 2. Check for clogged oil filter.

Service the oil filter (Para 3-9).

Step 3. Check for dirty oil filter.

Service oil filter (Para 3-9).

Step 4. Other causes.

Notify higher maintenance.

7. Engine Overheats

Step 1. Check for low coolant level.

Inspect cooling system for leaks. Add coolant as necessary.

Step 2. Check for low engine oil level.

Refer to lubrication chart (Fig. 3-1), and service engine crankcase.

Step 3. Check for slipping or broken fan drive belt.

Adjust fan drive belts (Para 3-10).

Step 4. Check for loose water pump drive belts.

Adjust water pump drive belts.

Step 5. Other causes.

Notify higher maintenance.

8. Engine Exhaust is Smoky

Step 1. Check for improper grade of fuel.

Drain fuel tank and fill with proper grade of fuel.

Table 3-2. Operator/Crew Troubleshooting - Continued

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

Step 2. Check for excessive oil in crankcase.

Refer to lubrication chart (Fig. 3-1), and drain and refill engine crankcase.

Step 3. Check for clogged air cleaner.

Service the air cleaner (Para 3-7).

Step 4. Other causes.

Notify higher maintenance.

9. Engine Oil Consumption is Too High

Step 1. Check for leaking oil line connection.

Inspect exterior oil lines and tighten connections.

Step 2. Check for restricted air intake at blower.

Service the air cleaner (Para 3-7).

Step 3. Other causes.

Notify higher maintenance.

10. Engine Generator Output is Too Low

Step 1. Check for slipping alternator drive belt.

Adjust alternator drive belt tension.

Step 2. Other causes.

Notify higher maintenance.

11. Ammeter Does Not Register

Step 1. Check for loose alternator drive belt.

Adjust alternator drive belt.

Step 2. Other causes.

Notify higher maintenance.

12. Winch Brake Slips

Step 1. Check brake for adjustment.

Adjust brake (Para 3-11).

Step 2. Check for binding band.

Adjust brake drum linkage (Para 3-11).

Step 3. Other causes.

Notify higher maintenance.

Table 3-2. Operator/Crew Troubleshooting - Continued

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

13. Winch Drum Clutch Slips or Drags.

Step 1. Check for proper clutch adjustment.

Adjust clutch (Para 3-12).

Step 2. Other causes.

Notify higher maintenance.

14. Clutches or Brakes Overheat

Step 1. Check for brake slippage.

Adjust brakes (Para 3-11).

Step 2. Check for clutch slippage.

Adjust clutch (Para 3-12).

Step 3. Check system air pressure between 105-125 psi.

Notify higher maintenance.

Step 4. Check for proper clutch air actuator operation.

Notify higher maintenance.

Step 5. Other causes.

Notify higher maintenance.

15. Winch Drum Clutch Releases Slow

Step 1. Check for clutch air actuator failure.

Notify higher maintenance.

Step 2. Other causes.

Notify higher maintenance.

16. Cables Twist During Operation

Step 1. Check for improperly installed cable.

Rewind cable.

Step 2. Other causes.

Notify higher maintenance.

17. Winch Not Pulling Normal Load

Step 1. Check torque converter clutch engagement.

Re-engage clutch.

Step 2. Check torque converter fluid level.

Change fuel filter element.

Step 3. Other causes.

Refer to higher maintenance.

Section IV. Maintenance Procedures

3-6. General. The instructions contained in this section are for the operator's information and guidance in maintenance of the winch unit diesel engine and the winch.

3-7. Air cleaner. Service diesel engine air cleaner, figure 3-2.

a Remove coverbolt and bolt gasket.

b Remove body and element.

c Wash all parts with cleaning solvent and dry thoroughly.

d Discard and replace bolt gasket.

e Install body and element and secure with cover bolt.

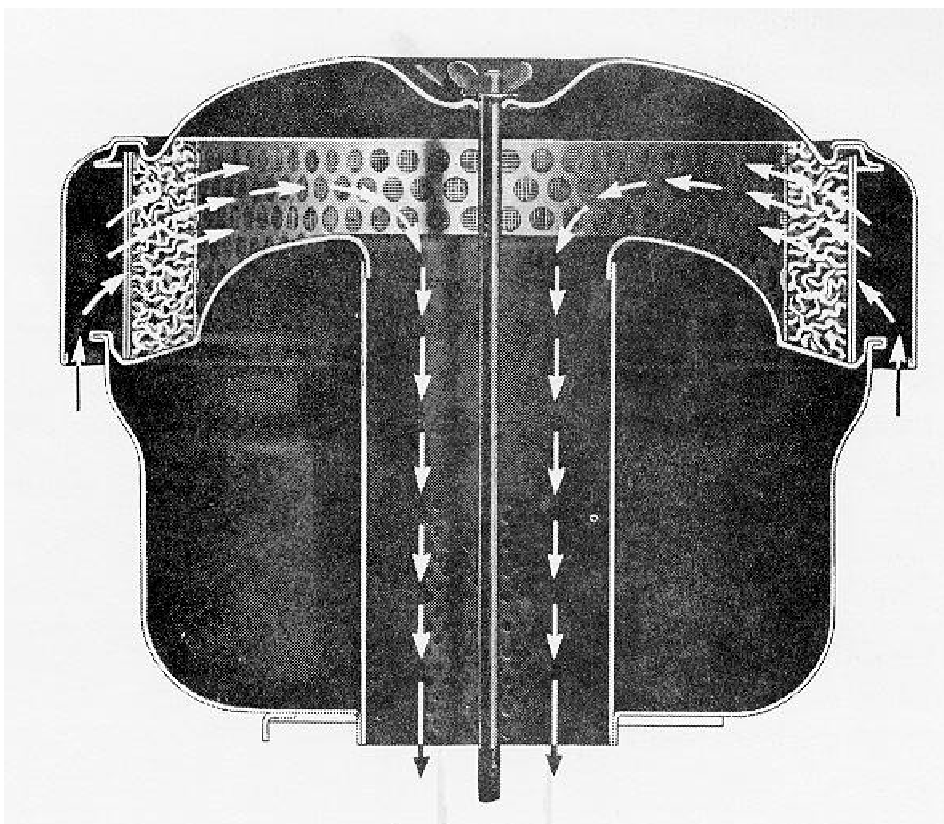


Figure 3-2. Engine Air Cleaner Service.

3-8. Fuel Filter. Service the fuel filter, figure 3-3.

a. Loosen fuel filter draincock.

b. Loosen fuel filter retaining bolt.

c. Allow fuel to drain into a suitable container.

d. Remove fuel filter retaining bolt while holding filter housing.

e. Remove filter assembly and gasket.

f. Remove filter element.

g. Clean filter shell as necessary to remove sludge and other foreign material.

h. Close filter draincock and fill shell approximately two thirds full with clean fuel oil.

i. Insert new filter and gasket and reinstall filter on the engine.

j. Start engine and check for leaks.

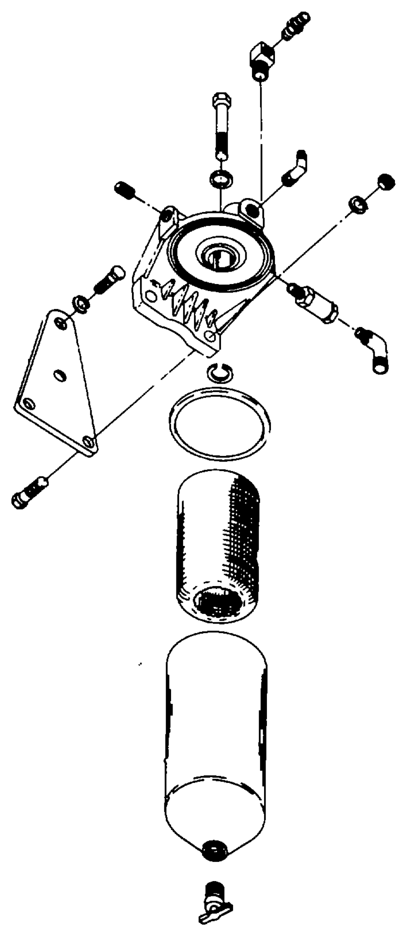


Figure 3-3. Fuel Filter and Fuel Strainer Inspect.

3-9. Oil Filter Service. Service the diesel engine oil filter, located on lower left side of engine, figure 3-4.

a. Start and run engine until normal operating temperatures are reached.

b. Remove shell drain plug and oil filter assembly center stud.

c. Remove oil filter shell and gasket.

d. Remove and replace filter element and gasket.

e. Reinstall shell drain plug when oil has stopped.

f. Reinstall oil filter assembly.

g. Start engine and check for leaks.

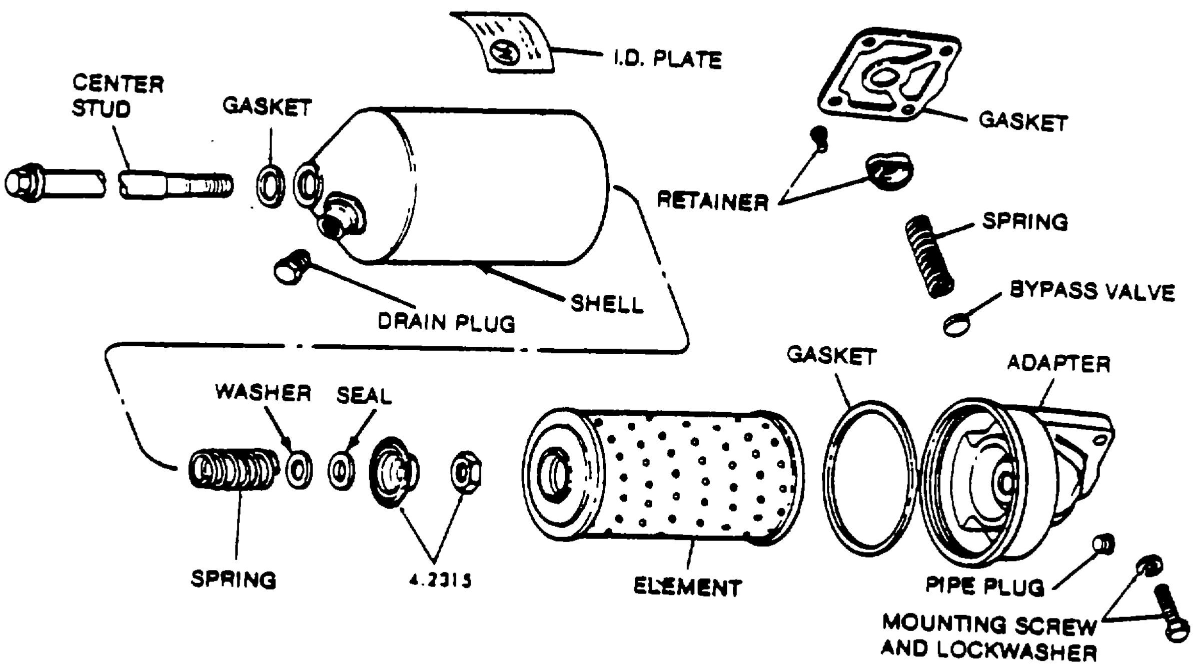


Figure 3-4. Engine Oil Filter Service.

3-10. Fan drive belt. Adjust the diesel engine fan drive belts, figure 3- 5.

a. Loosen bolts in fan support bracket.

b. Loosen adjusting bolt.

c. Adjust fan support bracket to obtain 3/8 to 1/2 in. deflection midway between fan pulley hub and crankshaft pulley.

d. Tighten fan support bracket bolts and adjusting bolt.

NOTE
Always replace fan belts as a set.

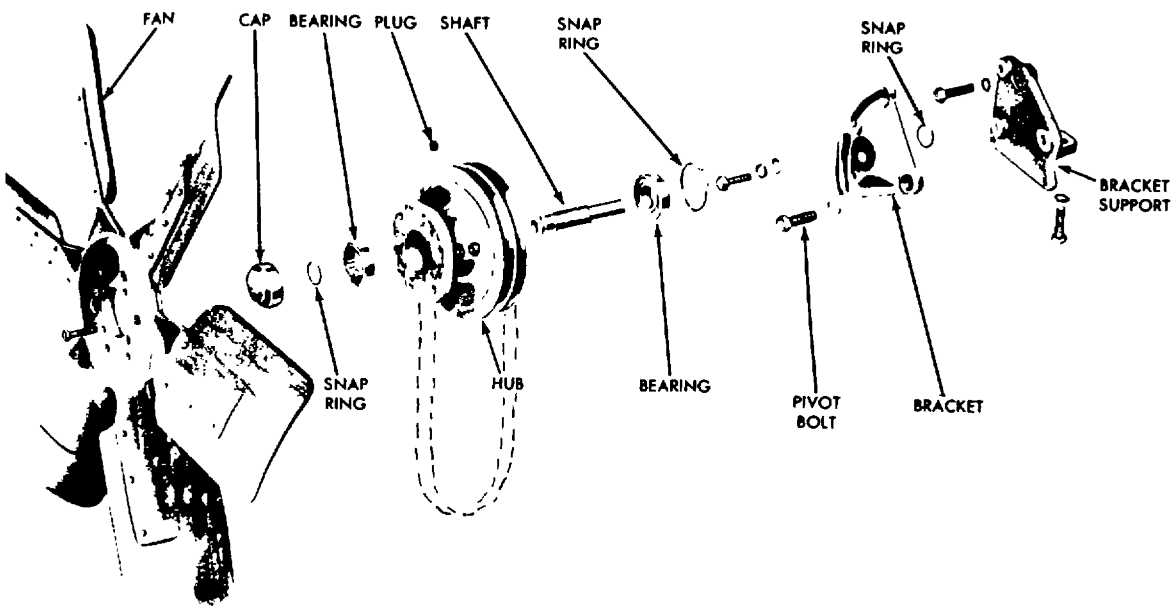


Figure 3-5. Fan Drive Belt Adjustment.

3-11. Front and rear winch drum brake adjustment

a. General. The front and rear winch drums are equipped with band brakes, controlled by air pressure from operator's console. The leading dead end of band is connected to hoist bed and lagging end is connected to brake actuating arm. Each brake band is set for parking by a spring inside the air chamber connected to brake arm. Air pressure is required to compress spring and release parking brake. Parking brake is set even if air pressure is lost. The second part of the chamber uses air pressure to operate the same piston to move actuating arm and apply brake. This arrangement allows for smooth brake applications during winching operations.

b. Adjustment.

(1) Open front and rear drum brake band covers as illustrated in figure 3-6.

(2) Inspect brake bands for out-of-round condition, uneven pad wear, and contact over at least 85% of drum surface. If brake band fails this visual inspection, refer problem to your supervisor as brake repair may be required.

(3) Refer to figure 3-7; apply and release brakes and measure crank travel from released to set position. If crank travel approaches 2 inches, brake requires adjustment.

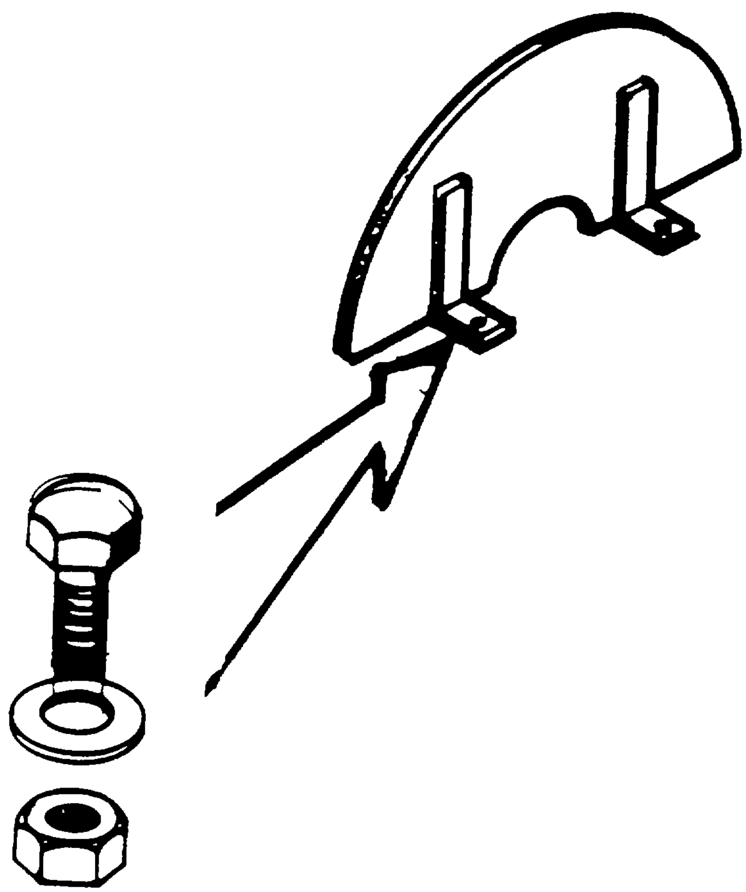


Figure 3-6. Front and Rear Brake Drum Covers.

(4) Apply air pressure and release parking brake.

(5) Loosen adjusting nuts where the brake bands are joined.

NOTE

After two adjustments of removing all four 1/8 inch shims, a 1/2 inch shim may be removed and replaced with four 1/8 inch shims. This can be continued until all three 1/2 inch shims have been removed.

(6) Remove two 1/8 inch shims and retighten adjusting nuts to 121 Ib-ft torque.

(7) Apply parking brake and set band stop screws and cam roller to clearances shown in figure 3-7. Reset the jam nuts as necessary.

(8) Apply and release the service brake and measure crank travel. Adjusted travel should not be less than one inch.

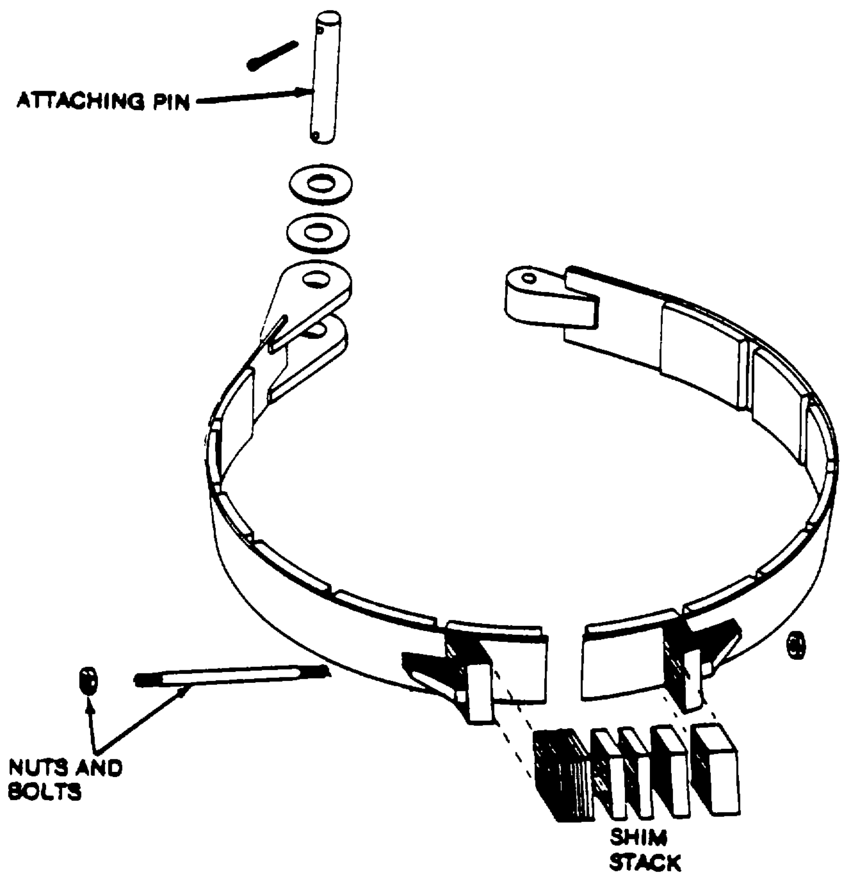


Figure 3-7. Front and Rear Brake Drum Adjustment.

3-12. Drum clutch adjustment

a. General. As clutch friction blocks wear, adjust five clutch adjusting screws (Fig. 3-8) so that just enough clearance is maintained to clear blocks from drum.

b. Adjustment

CAUTION

If proper clearance is not maintained, heat and scoring of clutch drum may occur.

(1) Apply air pressure of at least 90 psi to air chamber.

(2) Rotate clutch drum so that adjusting screw #1 in Fig. 3-8 is at position "x" and adjust to .020 in.

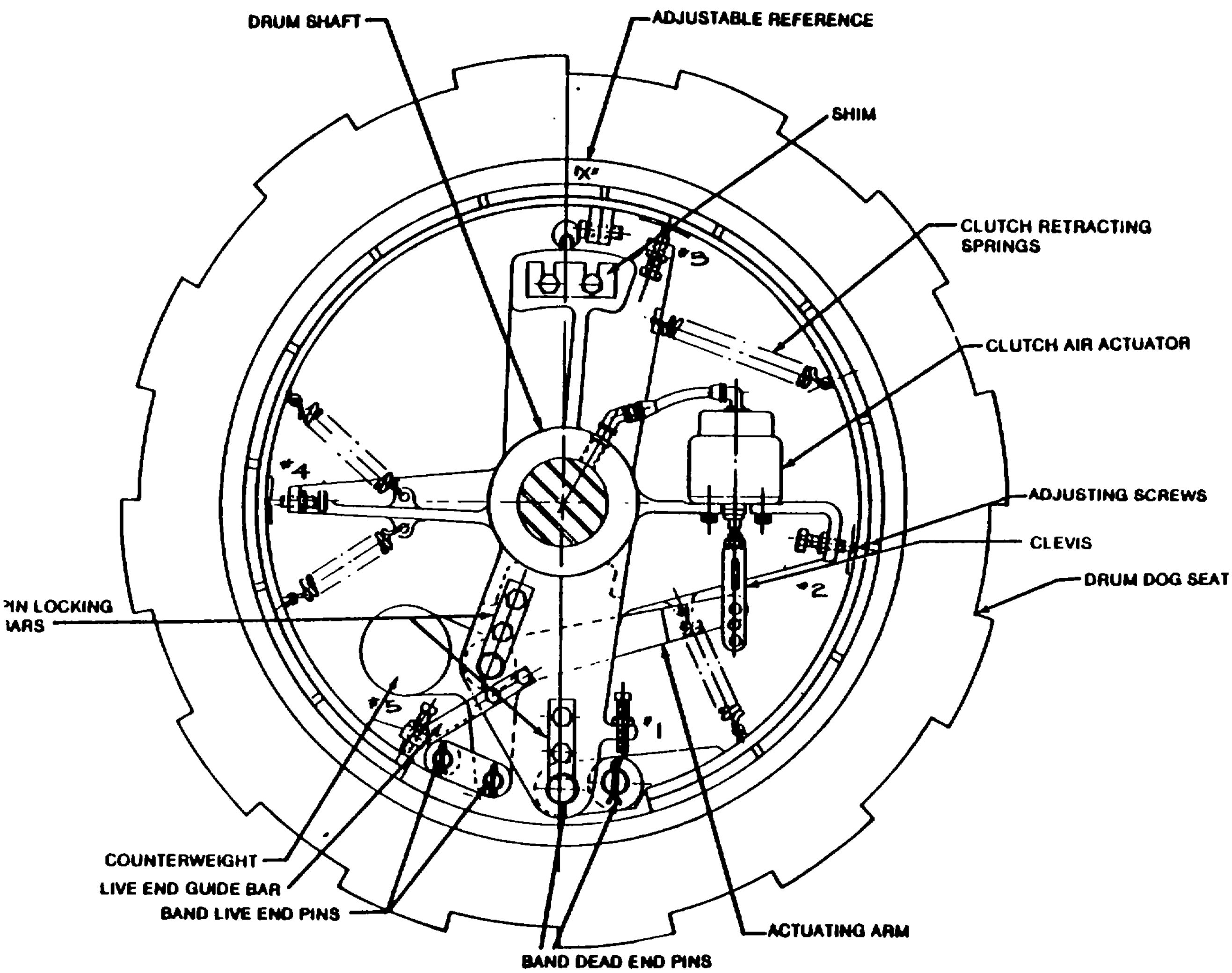


Figure 3-8. Drum Clutch Adjustments.

(3) Rotate clutch so that adjusting screw #2 is at position "x" and adjust to . 030 in. Continue by rotating drum to position set screws with set screw #3 adjusted to . 040 in. , set screw #4 adjusted to . 050 in. , and set screw #5 adjusted to . 060 in. clearance.

(4) Release air pressure on air chamber. Use adjustment nut to set chamber clevis. Adjust distance from bottom surface of air chamber to sight pin in clevis to 4.25 in., as shown in Fig. 3-8.

CHAPTER 4 ORGANIZATIONAL MAINTENANCE INSTRUCTIONS
Section I. SERVICE UPON RECEIPT OF EQUIPMENT

4-1. Inspection and Servicing Equipment

a. Inspection.

(1) Make a complete visual inspection of equipment, checking for loss or damage which may have occurred during shipment.

(2) Inspect engine accessories to make sure they are securely mounted and in good working condition.

(3) Inspect all winch controls to see that they are intact and working properly.

(4) Inspect engine instrument panel for missing parts or damage.

(5) With torque converter disengaged, use a crowbar to turn drum gears enough to insure that gears will turn freely.

b. Servicing.

(1) Refer to lubrication chart (Fig. 3-1) and service the winch assembly.

(2) Perform organizational maintenance preventive maintenance checks and services TM 55-1930-209-14 & P-19, Chapter 18.

4-2. Installation and Setting Up Instructions

a. General

WARNINGS

- **Winch must be anchored laterally to prevent slippage sideways under a heavy load.**
-
- **Always stand behind the winch during operation. Only the operator should be forward of the diesel engine.**

Provide adequate space on all sides of the winch for access to operate and service.

Provide suitable rigid foundation.

b. Installation

(1) Refer to figure 4-1 for mounting winch assembly on skid or barge deck.

(2) Use a suitable hoist with at least 20,000 pounds capacity to lift and lower unit onto suitable blocking approximately 9-12 inches high. Slip aluminum skids under sides of winch frame and install the nuts, bolts and lockwashers. It is not necessary to torque these bolts.

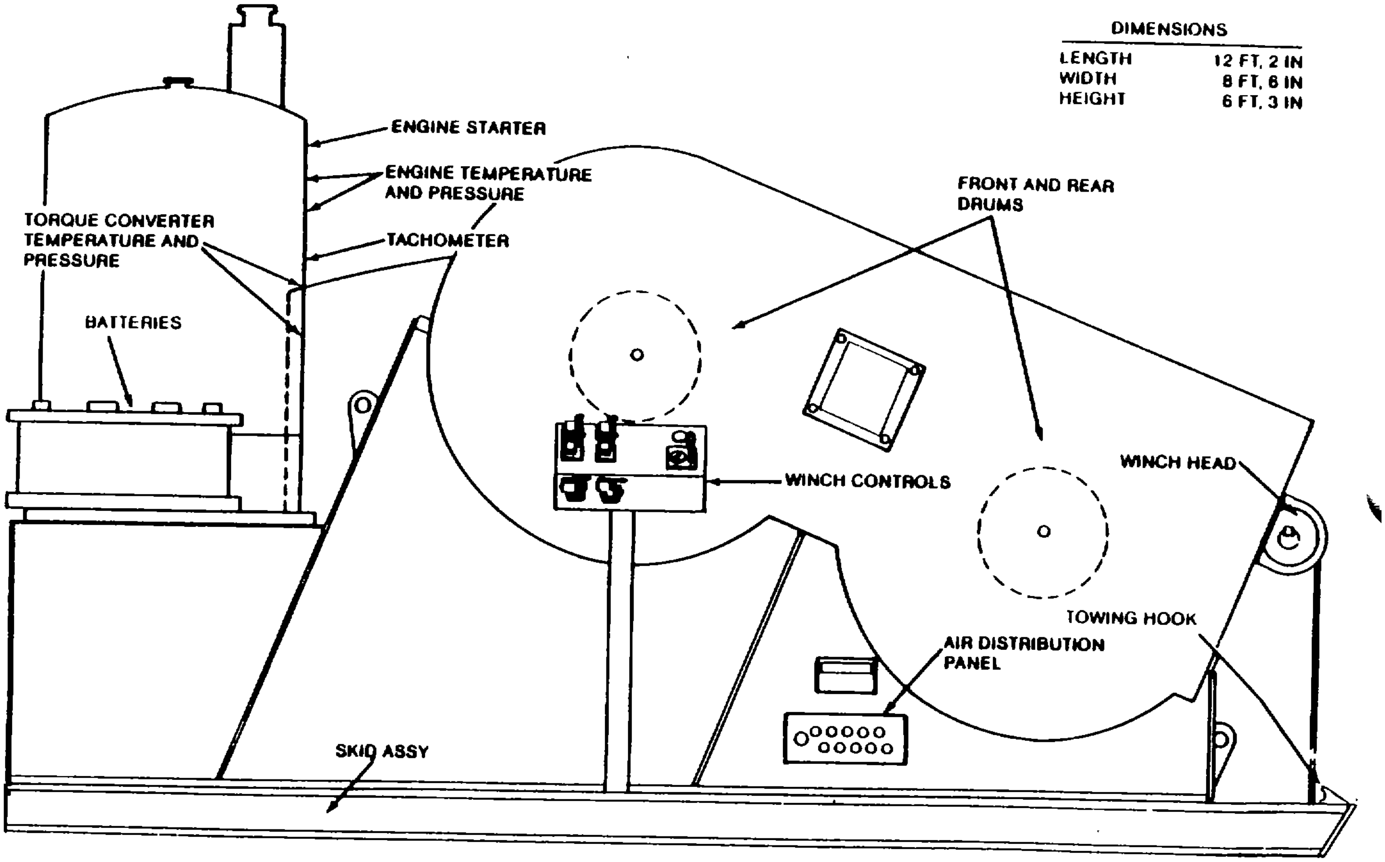


Figure 4-1. Mounting Dimensions - Winch to Skid.

c. Battery. Install winch battery as shown in Figure 4-2.

(1) Be sure battery carrier is clean and that battery rests level when installed.

CAUTION

Do not overtighten or damage to battery case will result.

(2) Tighten hold-down clamps evenly until snug.

(3) Attach cable clamps after making sure cables and terminal clamps are clean and in good condition. Place a felt washer at base of each terminal beneath cable clamps to make cable connections as corrosion resistant as possible. Coat entire connection with general purpose grease. Be sure ground cable is clean and tight at engine block or frame.

(4) Check polarity to be sure battery is not reversed with respect to generating system.

WARNINGS

ELECTRICAL HIGH VOLTAGE CAN KILL YOU.

Electrical high voltage cannot be seen but it can kill you. Electricity is unlike most other dangerous things you can come in contact with because it gives no warning and no symptoms to be wary of. Its effect is immediate. It can kill you, render you unconscious, or severely burn you. To ensure your safety and that of other maintenance personnel, always observe the following precautions:

ALWAYS make sure the unit is properly grounded.

(5) Connect grounded terminal of battery last to avoid short, circuits which will damage battery.

WARNING

Always gage the length of the cable so that at least five turns remain on drums and the last full layer. Less than five turns on drum with cable under load will overload clamps that attach the cable to drum. If clamp fails under load, cable will whip in a large arc posing extreme danger to personnel and equipment.

d. Winch Cable.

(1) Wire rope cable is overwound on front and rear drums. Cable leadoff will be from top of drum and toward front of winch.

(2) Front and rear drums are driven by same drive shaft and rotate together when both drum clutches are engaged. In order that winch drum may haul in one line and pay out the other at the same time, drum with in-haul line must have its clutch engaged, and drum with out-haul line must have its clutch disengaged.

(3) Install end of cable in rear drum assembly in rope wedge slot and install rope wedge.

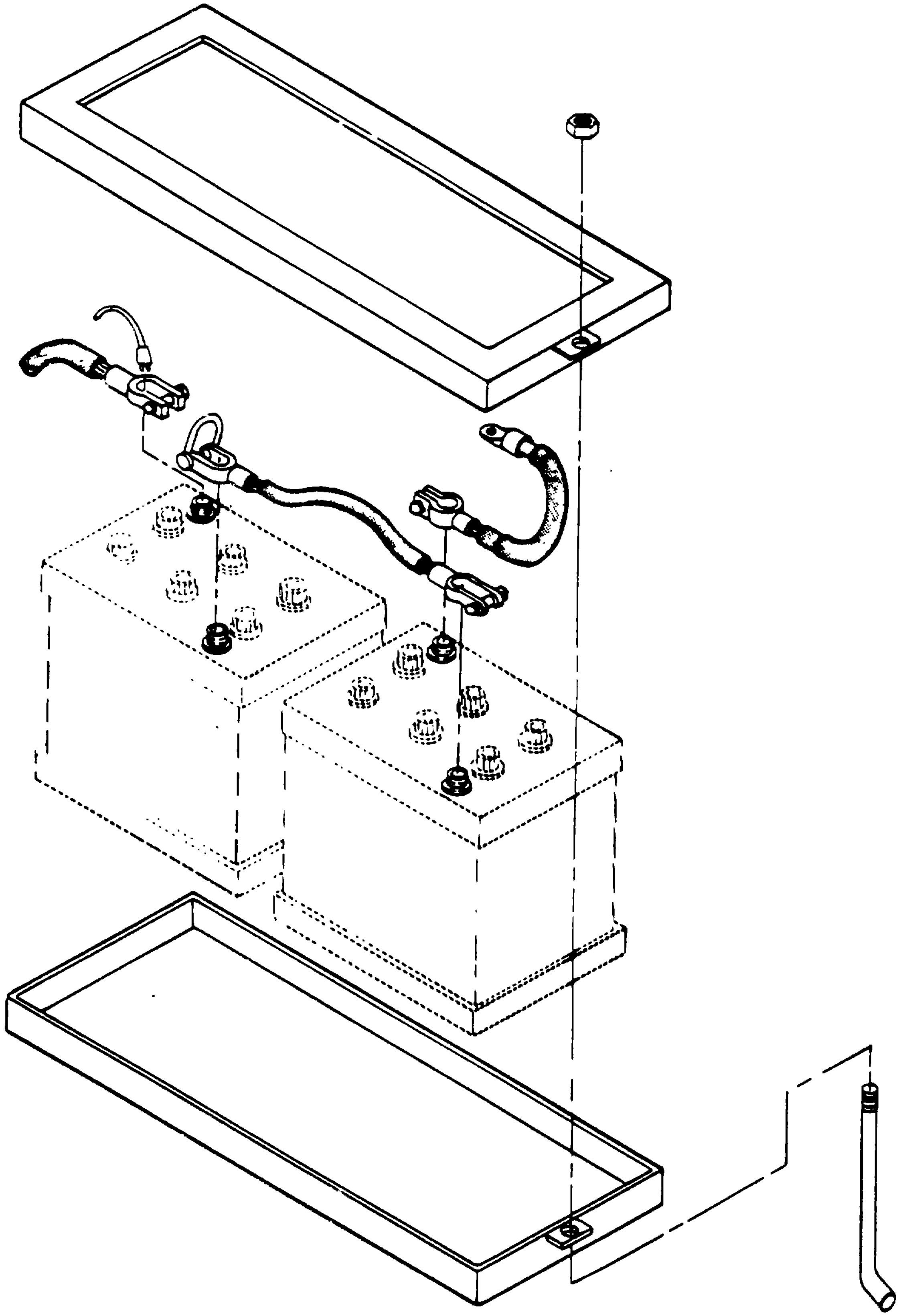


Figure 4-2. Battery Installation.

(4) Start the diesel engine.

CAUTION

If it is necessary to force cable closer together during winding, do so with a 2" x 4" piece of wood. Never strike cable with a hammer or other metal tools.

(5) Slowly and carefully wind full length of cable on drum. For first winding, turn drum slowly and guide cable so that coils are side by side, with each coil firmly against preceding coil. Use a two by four piece of wood to drive coils tightly together. Good coiling is dependent on proper wrap and minimum fleet angle.

Section II. MOVEMENT TO A NEW WORKSITE

4-3. Dismantling for Movement

a. Short Distance Movement. To move the winch assembly a short distance, attach towing vehicle to two front towing rings, and tow unit to worksite. Loop a bridle around front piece at front of aluminum skid base. Connect crawler tractor close to front so front of winch is lifted up during tow. This prevents sand from getting into the winch drums.

b. Preparation for Long Distance Movement.

(1) Stow all tools and equipment securely in their proper positions.

(2) Drain diesel engine fuel tank.

(3) Remove battery.

(4) Stow all steel stakes, connecting plates and turnbuckles.

(5) Roll up all winch cable on reels.

(6) Attach suitable lifting device of at least 20,000 pounds capacity to lifting eyes as illustrated in figure 4-3 and lift winch assembly on carrier bed.

(7) Secure winch assembly, stakes and equipment to carrier bed with steel strapping or chain and move the equipment to new worksite.

4-4. installation after Movement

a. Remove tie down straps or chains securing winch assembly on carrier bed.

b. Remove stakes, chains and other equipment from carrier bed.

c. Refer to paragraph 4-2 and prepare winch assembly for operation.

Section III. Preventive Maintenance Checks And Services

4-5. Organizational Preventive Maintenance Checks and Services are detailed in TM 55-1930-209-14/P-19, Chapter 18.

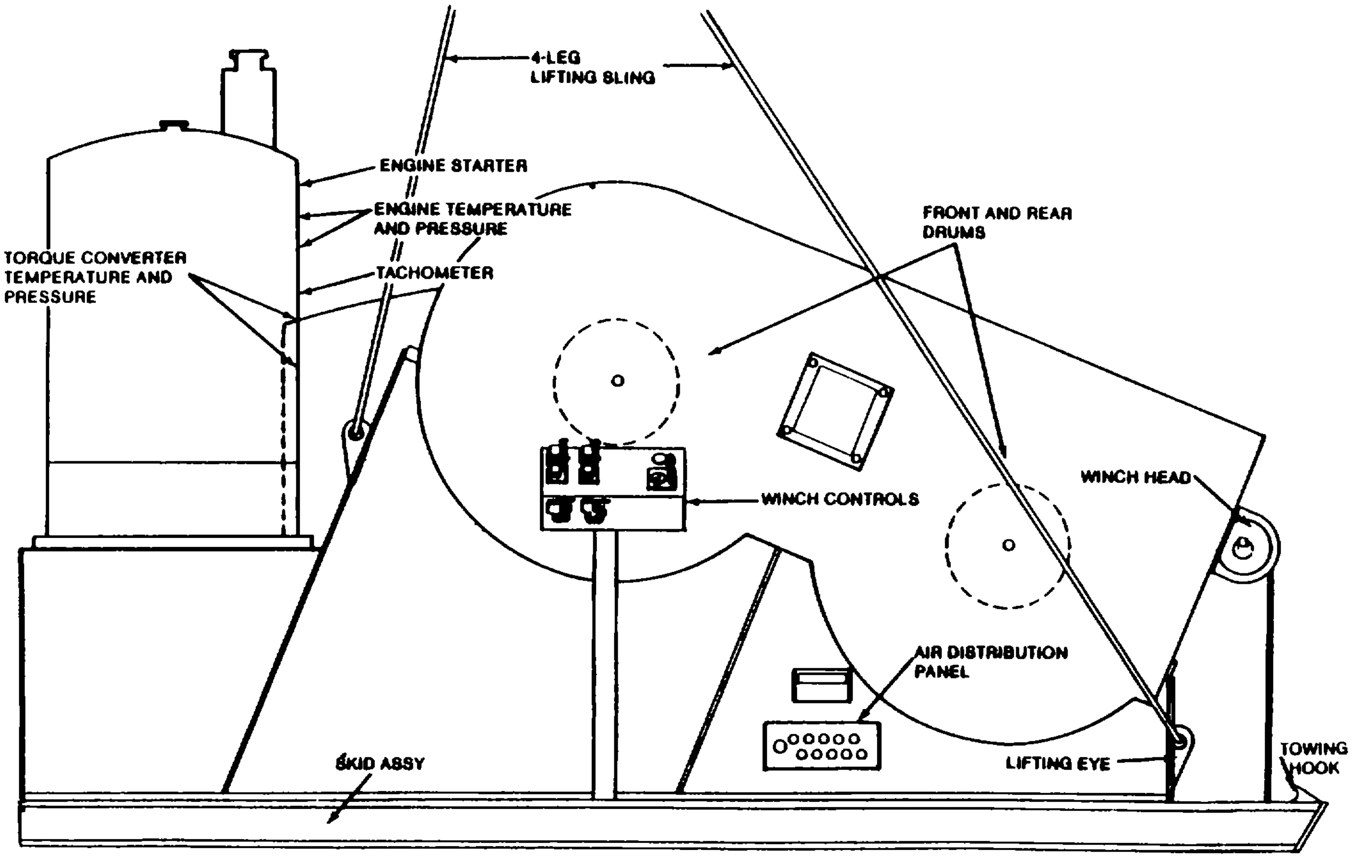


Figure 4-3. Hoisting Sling.

Section IV. Organizational Maintenance Troubleshooting

4-6. Organizational Maintenance Troubleshooting Chart. Table 4-1 lists the organizational maintenance troubleshooting malfunctions, probable causes and recommend corrective action.

Table 4-1. Organizational Maintenance Troubleshooting

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

1. Engine Fails to Start

Step 1. Check for clogged fuel filters.

Service fuel filters (Para 3-8).

Step 2. Check for defective battery.

Recharge or replace battery (Para 4-2). Clean and tighten battery connections.

Step 3. Other causes.

Notify higher maintenance.

2. Engine Misses

Step 1. Check for clogged fuel filter.

Service fuel filters (Para 3-8).

Step 2. Check for water in the fuel filter and strainer.

Drain the filter and strainer.

Step 3. Check for water and sediment in the fuel tank.

Drain and refill the fuel tank as necessary.

Step 4. Other causes.

Notify higher maintenance.

3. Engine Loses Power

Step 1. Check for binding governor linkage.

Inspect, repair and lubricate governor linkage.

Step 2. Check for system air pressure between 105-125 psi.

Clean compressor inlet port.

Step 3. Check for air system leaks between the throttle control and actuator.

Replace defective air lines.

Table 4-1. Organizational Maintenance Troubleshooting -Continued

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

Step 4. Check proper operation of the throttle air actuator.

Replace defective actuator.

Step 5. Check for dirty fuel filter.

Service fuel filter (Para 3-8).

Step 6. Other causes.

Notify higher maintenance.

4. Engine Consumes Excessive Fuel

Step 1. Check for fuel leak.

Inspect and repair fuel lines as required.

Step 2. Check for cold engine operation.

Remove, test and replace thermostat (Para 4-8).

Step 3. Other causes.

Notify higher maintenance.

5. Engine Surges at Governed RPM

Step 1. Check for air leaks in fuel lines.

Tighten fuel line connections.

Step 2. Check for clogged fuel filter.

Service the fuel filter (Para 3-8).

Step 3. Check air system for proper operation.

Correct air system defects.

Step 4. Other causes.

Notify higher maintenance.

6. Engine Fails to Reach Governed RPM

Step 1. Check for restricted fuel flow.

Service fuel filter and strainer (Para 3-8).

Step 2. Other causes.

Notify higher maintenance.

Table 4-1. Organizational Maintenance Troubleshooting -Continued

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

7. Engine Oil Consumption is Too High

Step 1. Check for external oil leaks.

Tighten connections or replace oil line.

Step 2. Other causes.

Notify higher maintenance.

8. Engine Oil Pressure is Low

Step 1. Check for broken oil line.

Replace oil line.

Step 2. Other causes.

Notify higher maintenance.

9. Engine Temperature is Too High

Step 1. Check for defective thermostat.

Test and/or replace thermostat (Para 4-8).

Step 2. Check for clogged cooling system.

Flush cooling system and clean exterior portion of radiator core.

Step 3. Check for broken fan belt.

Adjust or replace fan belts (Para 4-10).

Step 4. Other causes.

Notify higher maintenance.

10. Engine Temperature is Too Low

Step 1. Check for defective thermostat.

Test and/or replace thermostat (Para 4-8).

Step 2. Other causes.

Notify higher maintenance.

11. Starter Will Not Turn

Step 1. Check for loose or dirty connections at battery (Para 4-2).

Clean and replace battery cables (Para 4-2).

Table 4-1. Organizational Maintenance Troubleshooting -Continued

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

Step 2. Check for defective battery.

Recharge or replace battery.

Step 3. Other causes.

Notify higher maintenance.

12. Ammeter Does Not Register Charge

Step 1. Check for loose electrical connection.

Tighten connections or replace wire.

Step 2. Check for loose or broken alternator drive belt.

Adjust belt tension or replace belt (Para 4-10).

Step 3. Test ammeter for proper functioning.

Replace a malfunctioning ammeter.

13. Winch Drum Brake Slips

Step 1. Check for defective brake band adjustment.

Adjust drum brake bands (Para 3-11).

Step 2. Check for defective brake linkage adjustments.

Adjust brake linkage (Para 3-11).

Step 3. Other causes.

Notify higher maintenance.

14. Winch Drum Clutch Slips

Step 1. Check air system pressure.

Correct air system defects.

Step 2. Check adjustment.

Adjust clutch (Para 3-12).

Step 3. Other causes.

Notify higher maintenance.

Table 4-1. Organizational Maintenance Troubleshooting -Continued

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

15. Clutches or Brakes Overheat

Step 1. Check for slippage.

Adjust brakes (Para 3-11).

Adjust clutches (Para 3-12).

Step 2. Other causes.

Notify higher maintenance.

16. Winch Not Pulling Normal Load

Step 1. Check torque converter for proper clutch engagement.

Adjust clutch as required.

Step 2. Check torque converter fluid level.

Clean and replace fuel filter and aspirator valve.

Step 3. Other causes.

Refer to higher maintenance.

Section V. Maintenance Of The Diesel Engine

4-7. General. The double drum winch is driven by a four cylinder, in-line diesel engine through a clutch, torque converter and a multiple strand drive chain. This section covers engine maintenance authorized at organizational level of maintenance.

4-8. Thermostat

a. Removal

(1) Remove the thermostat, illustrated in figure 4-4, as follows:

(2) Open drain cock at bottom of water pump and drain engine coolant to necessary level.

(3) Remove bolts that secure outlet elbow and thermostat housing to water manifold.

(4) Remove thermostat from thermostat housing.

(5) Clean all gasket material from mating surfaces.

b. Test

(1) Immerse thermostat in a container of hot water.

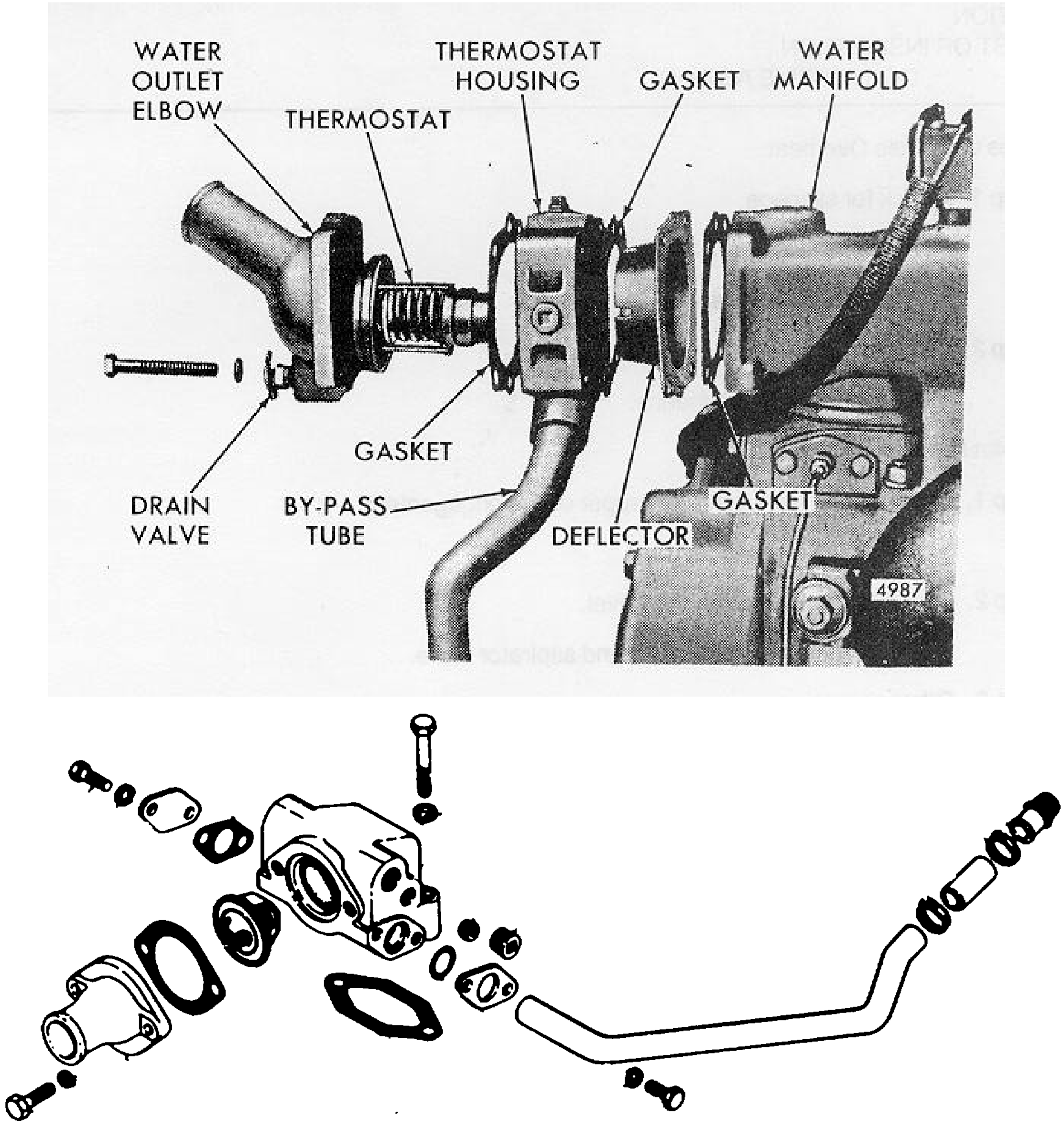


Figure 4-4. Thermostat Removal and Installation.

(2) Place thermometer in container but do not allow it to touch bottom.

(3) Heat and agitate water to maintain an even temperature throughout container. As the water is heated, thermostat valve should begin to open when temperature is 167° to 172°F. Thermostat valve should be fully open at 190° to 192°F.

(4) Discard and replace a defective thermostat.

c. Installation

(1) Check to make sure bleed hole in thermostat housing is open.

(2) Use a new housing gasket and install thermostat in reverse of disassembly sequence.

(3) Service cooling system.

4-9. Engine Fan Guard

a. Removal. Remove fan guard by removing bolts and lockwashers that mate fan guard to radiator shell.

b. Cleaning, Inspection and Repair.

(1) Clean fan guard with cleaning solvent and dry thoroughly.

(2) Inspect fan guard for cracks, breaks, or other damage.

(3) Inspect mounting hardware for damaged threads.

(4) Repair by replacement of defective parts.

c. Installation. Install engine fan guard in reverse of disassembly sequence.

4-10. Alternator Fan Drive Belts

a. Removal

(1) Remove engine fan guard (Para 4-9).

(2) Loosen fan adjusting bolts (Fig. 3-5) and remove two fan drive belts.

(3) Loosen alternator adjusting screw.

b. Installation

NOTE

Always replace alternator fan drive belts in complete sets when one is worn. Single belts of similar size must not be used as a substitute for a matched belt set.

(1) With adjusting bolts loose, install the set of matched fan drive belts.

(2) Adjust drive belts.

(3) Install engine fan guard, (Para 4-9).

4-11. Battery. Remove and replace as required, (Para 4-2).

4-12. Engine Oil Pressure Switch. Engine oil pressure switch is just above oil filter. Removal and installation of engine low oil pressure switch is accomplished by removing electric leads and unscrewing sensor.

4-13. Engine Cooling Water Overheat Switch. The cooling water overheat switch is located on water manifold adjacent to thermostat.

a. Removal

(1) Remove electrical leads.

(2) Unscrew and remove the switch.

b. Installation

(1) Secure switch with screws.

(2) Connect electrical leads.

Section VI. Maintenance Of Winch

4-14. General. The winch assembly is equipped with a drive chain case, brake drum covers, and winch gear guards. Access covers are provided on the gear guard for lubrication of gears.

4-15. Winch Gear and Brake Drum Guard

a. Removal. Remove winch gear guard as illustrated in figure 4-5.

b. Cleaning, Inspection and Repair.

(1) Remove gear lubrication covers.

(2) Wash all remaining parts with cleaning solvent and dry thoroughly.

(3) Inspect guards for cracks or breaks.

(4) Inspect mounting hardware for damaged threads.

(5) Repair guards by straightening and/or welding. Replace defective parts.

c. Installation

(1) Install winch gear and brake drum covers as illustrated in figure 4-5.

(2) Open gear lubrication cover and lubricate gears.

(3) Replace gear lubrication access covers.

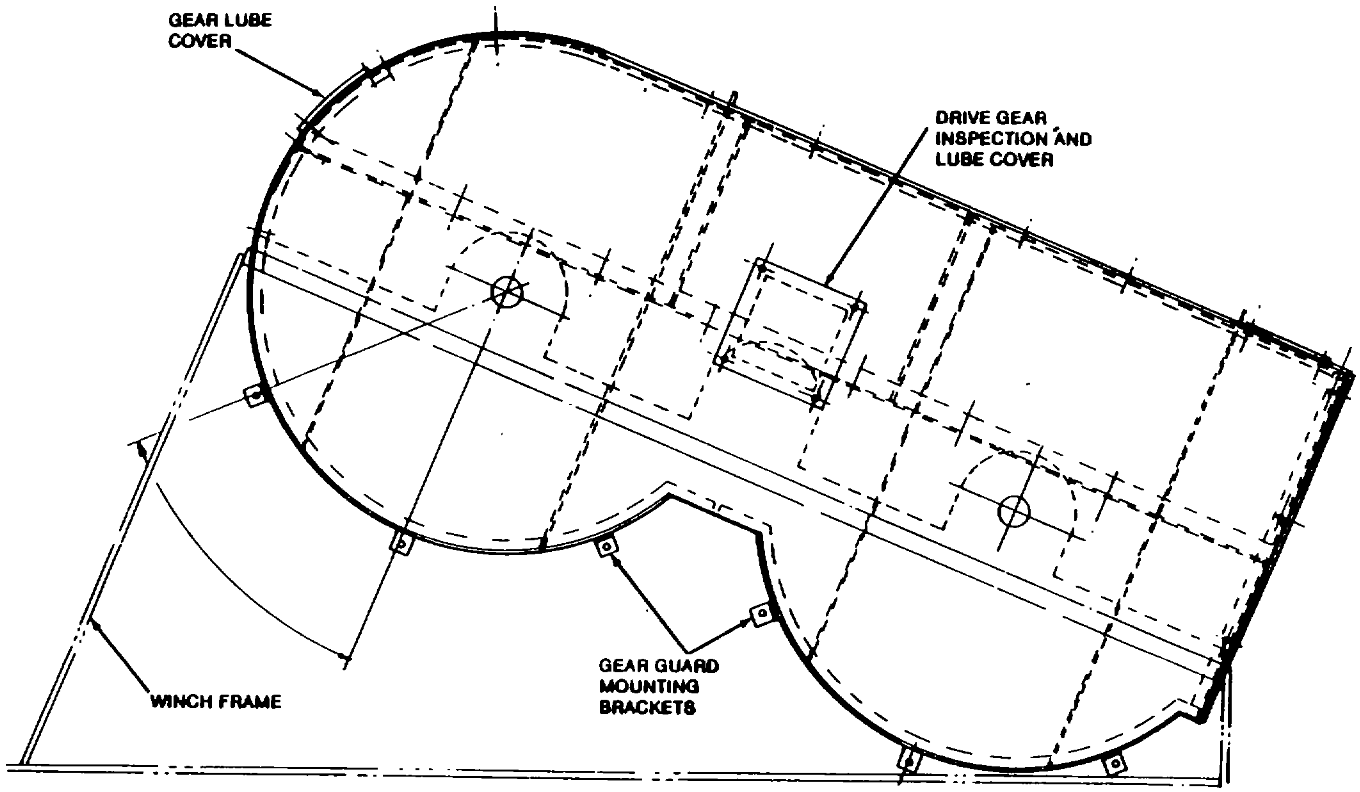


Figure 4-5. Gear Guard Removal and Installation.

4-16. Drive Chain Case

a. Removal. Remove winch drive chain case as illustrated in figure 4-6.

(1) Drain lubricating oil from chain case.

(2) Disconnect bellows where it joins chain case by removing nuts, bolts and washers.

(3) Remove nuts, bolts and washers that mate chain case to backing plate.

(4) Carefully remove fiber glass chain case to avoid damaging foam gasket.

NOTE

If gasket is damaged, replace damaged portion with foam tape of same thickness. Insure that mating surfaces are cut at a 45° angle or more.

b. Cleaning, Inspection and Repair.

(1) Wash all parts with cleaning solvent and dry thoroughly.

(2) Inspect all hardware for damaged threads.

(3) Repair by replacement of defective parts..

c. Installation. Install drive chain case as illustrated in figure 4-6.

4-17. Drive Chain Adjustment

a. Remove drive chain case (Para 4-16).

b. Lay a straight edge along faces of the drive and driven sprockets to check for proper alignment. Also check for excessive chain sag.

c. If there is misalignment, refer to higher maintenance. Excessive sag indicates a worn chain or sprockets.

d. Install drive chain case (Para 4-16).

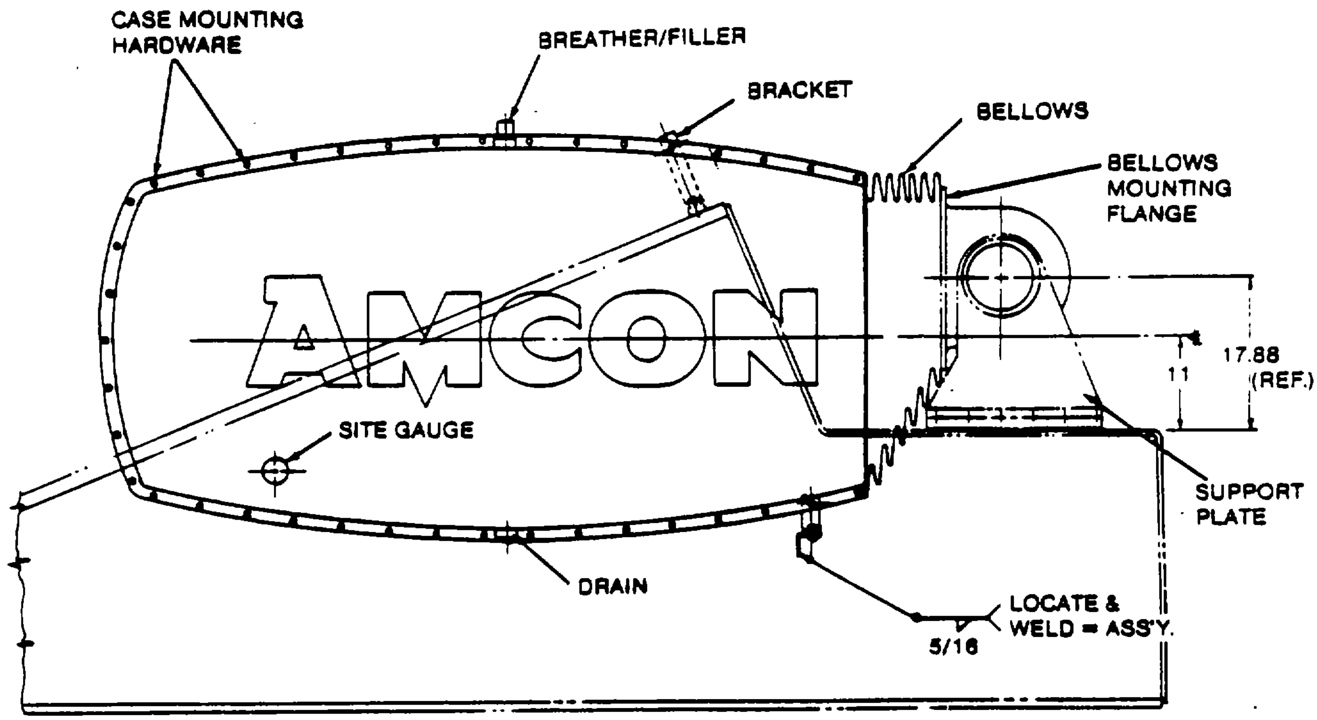


Figure 4-6. Drive Chain Case Removal and Installation (1 of 2).

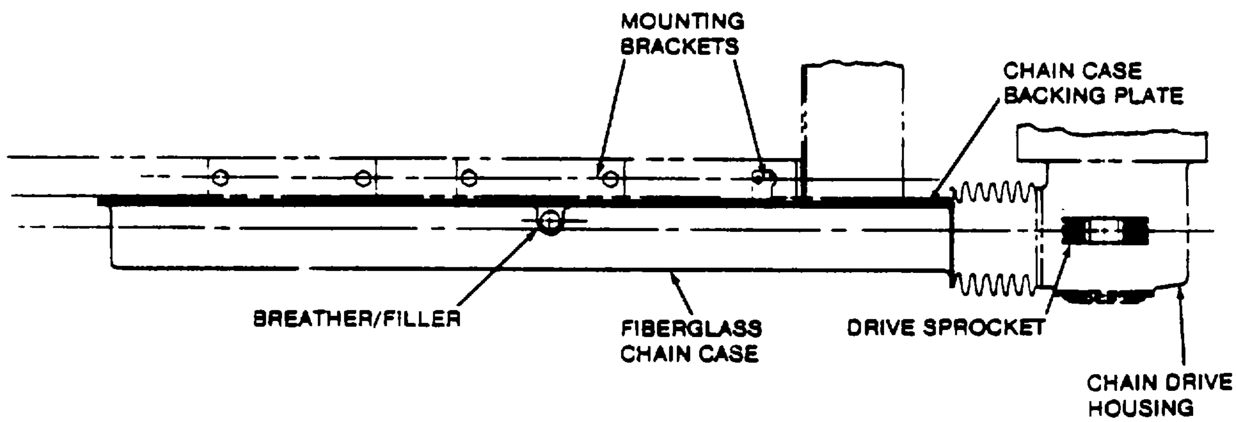


Figure 4-6. Drive Chain Case Removal and Installation (2 of 2).

Section VII. Maintenance Of Brake

4-18. Brake System

a. Brake band retainer fitting and brake actuating air chambers are located behind and below axis of drum shaft on rear drum. Brake band retainer and brake actuating air chamber on front drum are level with and behind axis of drum shaft. All other front brake band adjusting screws and related hardware are located approximately 20° clockwise facing chain case side of winch.

b. All drum brake components, except brake band attaching hardware are interchangeable. Refer to figure 4-7.

CAUTION

DO NOT interchange hardware from one drum to another. Wear patterns established after extended use dictate that brake bands remain matched to their respective drums.

c. All brake adjustment settings and adjustment screw settings are the same for front and rear drums.

NOTE

Remember that adjustment screws are rotated approximately 20° clockwise on front drum.

d. Brake band actuating air chambers are dual direction air chambers. A large spring in mounting end of chamber drives actuating piston outward to set parking brake. When air pressure is applied it counteracts spring and releases parking brake. When air pressure is applied at end of chamber it forces piston forward against air pressure in parking brake chamber and acts as service (working) brake. If air is shut off, pressure will bleed off both chambers and spring will actuate parking brake side of air chamber and set parking brake.

4-19. Brake Assembly Removal

a. Remove brake drum dust cover.

WARNING

Wear eye protection when using compressed air to avoid serious eye injury from blowing dust and dirt.

b. Use compressed air to blow all dust and dirt out of brake mechanism.

c. Perform a preliminary inspection of the brake assembly.

(1) Insure that parking brake is set.

(2) Examine brake drum and brake band to insure that both drum and bands are round.

(3) Examine brake band friction pads for evidence of uneven wear.

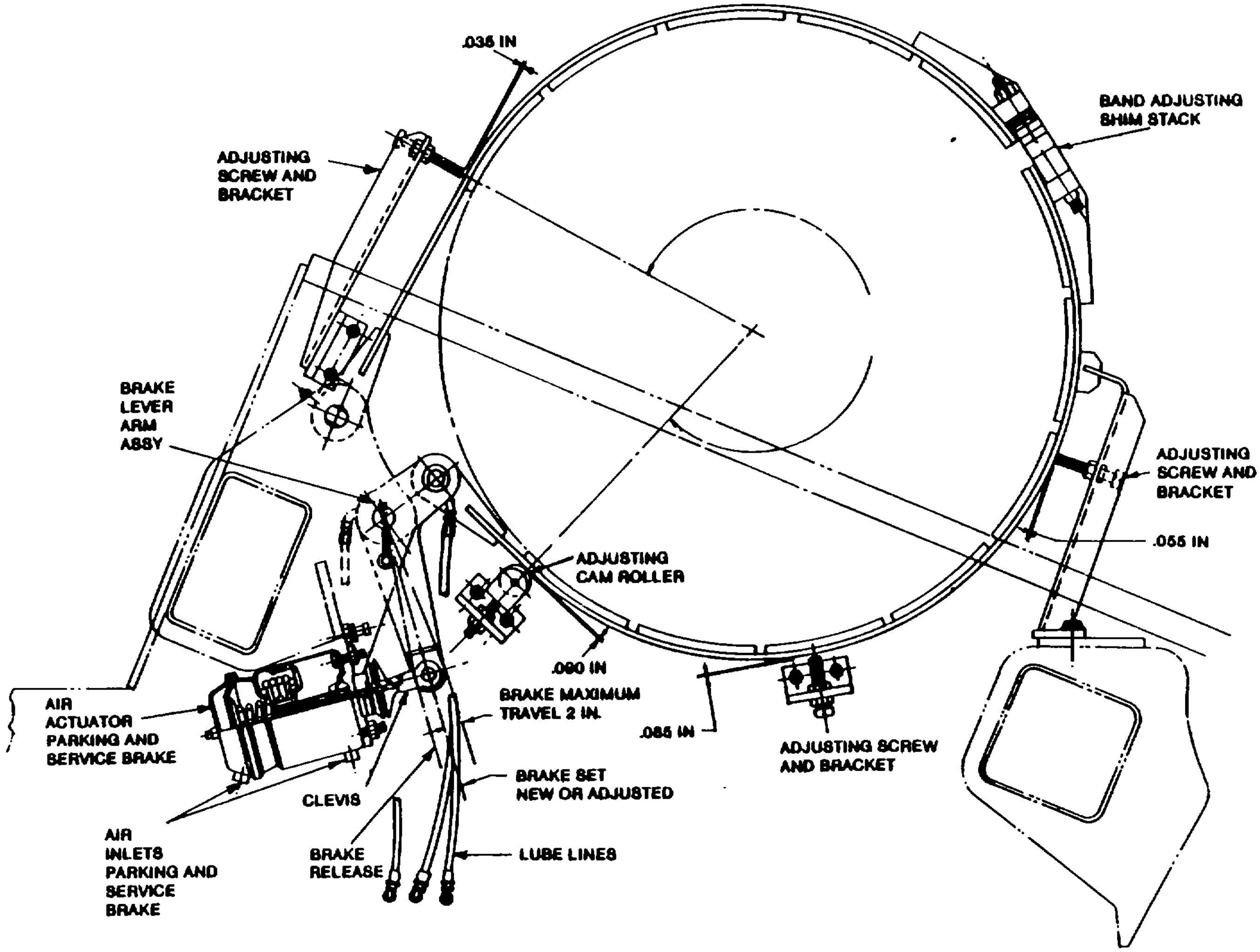


Figure 4-7. Drum Brake Assembly.

NOTE

Minor variations in thickness of pads are possible. More than an 1/8 inch variation indicates that drum or bands are out of round or that brake band set screws have been improperly adjusted.

(4) Examine remaining hardware for discrepancies. Pay particular attention to brake band retaining pins and brake arm pins. Clean excess grease and dirt off pins.

(5) Inspect pin lube lines for signs of damage.

d. If inspection indicates no discrepancies, do not perform any more maintenance except to adjust brakes as required. Refer to paragraph 3-11.

4-20. Drum Brake Installation

a. Install drum brake bands in reverse of removal sequence.

b. Adjust brake bands as in para 3-11.

c. Install the brake drum dust cover.

CHAPTER 5 DIRECT SUPPORT MAINTENANCE INSTRUCTIONS

Section I. Special Tools and Equipment

5-1. Special tools and equipment. No special tools or equipment are required by Direct Support maintenance personnel for performing maintenance on the winch assembly.

Section II. Direct Support Troubleshooting

5-2 General. For a general description and purpose of the troubleshooting table, refer to paragraph 3-5.

5-3 Direct support maintenance troubleshooting. Table 5-1 lists the winch assembly troubleshooting malfunctions for direct support maintenance personnel.

Table 5-1. Direct Support Maintenance Troubleshooting

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

1. Engine Fails to Start

Step 1. Check for defective fuel pump.

Repair or replace fuel pump (paras 5-37 thru 5-39).

Step 2. Check for defective fuel injector.

Repair or replace fuel injector (paras 5-33 thru 5-35.

Step 3. Check for poor compression.

Repair or replace valves (paras 5-66 thru 5-67).

2. Engine Misses

Step 1. Check for defective fuel injector.

Test fuel injector (para 5-33). Repair or replace fuel injector (paras 5-33 thru 5-35).

Step 2. Check for defective fuel pump.

Repair or replace fuel pump (paras 5-37 thru 5-39).

Step 3. Check for burned or sticking valves.

Grind or replace valves (paras 5-66 thru 5-67).

3. Engine Produces Excessive Smoke at Idle Speed

Step 1. Check for dirty or damaged fuel injector.

Repair or replace fuel injector (paras 5-33 thru 5-35).

Table 5-1. Direct Support Maintenance Troubleshooting - Continued

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

Step 2. Check for defective fuel pump.

Repair or replace fuel pump (paras 5-37 thru 5-39).

4. Engine Produces Excessive Smoke Under Load

Step 1. Check for defective fuel injectors.

Repair or replace fuel injectors (paras 5-33 thru 5-35).

5. Engine Lacks Power

Step 1. Check for defective fuel pump.

Repair or replace fuel pump (paras 5-37 thru 5-39).

Step 2. Check for defective valves.

Repair or replace valves (paras 5-66 thru 5-67).

6. Engine Consumes an Excessive Amount of Fuel

Step 1. Check for fuel leaks.

Inspect fuel lines for leaks and repair as necessary.

Step 2. Check for defective fuel injectors.

Repair or replace fuel injectors (paras 5-33 thru 5-35).

Step 3. Check for faulty injector seals.

Replace injector seal (paras 5-33 thru 5-35).

7. Engine Does Not Receive a Sufficient Amount of Fuel

Step 1. Check for defective fuel pump.

Repair or replace fuel pump (paras 5-37 thru 5-39).

Step 2. Check for defective fuel injector.

Repair or replace fuel injector (paras 5-33 thru 5-35).

8. Engine Runs Hot

Step 1. Check for defective water pump.

Repair or replace water pump (paras 5-47 thru 5-49).

Step 2. Check for clogged cooling system.

Flush cooling system.

Table 5-1. Direct Support Maintenance Troubleshooting - Continued

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

Step 3. Check for clogged oil cooler.

Clean or replace oil cooler (paras 5-53 thru 5-56).

9. Starting Motor Will Not Spin

Step 1. Check for defective starter drive.

Repair or replace starter drive (paras 5-28 thru 5-30).

Step 2. Defective starter solenoid.

Repair or replace solenoid (paras 5-28 thru 5-30).

Step 3. Defective starter.

Repair starter (paras 5-28 thru 5-30).

10. Winch Brake Slips

Step 1. Check for defective lining.

Replace brake lining (paras 5-91 thru 5-93).

Step 2. Repair linkage (paras 5-91 thru 5-93) or adjust linkage.

11. Winch Drum Clutch Slips

Step 1. Check for defective clutch actuator.

Replace clutch actuator (paras 5-92 and 5-93).

Step 2. Check for glazed, greasy or worn friction pads.

Replace friction pads (para 5-91).

12. Winch Drum Releases Slowly or Drags

Step 1. Check for low clutch spring tension.

Replace clutch springs as necessary (para 5-84 and 5-85)

Step 2. Check for slipping torque converter clutch.

Adjust the torque converter clutch (paras 5-84 thru 5-85).

Step 3. Check for defective drum bearings.

Replace drum bearings.

Section III. General Maintenance Instructions

5-4. General

a. This section provides general cleaning, inspection and repair instructions that are common to components of the winch assembly.

b. Special cleaning, inspection and repair instructions applicable to any individual component are covered with that component in the applicable sections of this manual.

5-5. General cleaning instructions.

a. Metal Parts

(1) Prior to removal or disassembly of major components, clean off excess oil or dirt with a cleaning solvent or steam clean.

(2) Use a cleaning solvent to clean parts such as gears, housings and hand packed bearings.

WARNING

Cleaning solvents are dangerous to your health. Long term effects from solvents such as Fed. Spec. P-D-680 can include cancer. Short term effects, especially when used in poorly ventilated areas, include unconsciousness and death. Some solvents, such as Methyl Ethyl Ketone Peroxide (also used as a fiberglass catalyst) can be more hazardous to eyesight than battery acid. Limit exposure to solvents and use eye protection. Always insure that ventilation is adequate.

CAUTION

Do not immerse oil impregnated bearings or sealed bearings in cleaning solvent; clean with a solvent moistened cloth.

(3) Use brushes to clean irregular shaped surfaces; use wooden pegs to clean ports and orifices. Use a lint free cloth to wipe parts clean.

(4) Exercise care when handling machined and polished surfaces to avoid nicks and other damage. Do not immerse more than one metal machined part in solvent at same time unless such parts are separated or protected from contacting each other.

b. Electrical Components

CAUTION

Do not immerse any electrical component or device in cleaning solvent.

(1) Prior to removal or disassembly of electrical components, clean exterior by scraping off excess oil and dirt. Wipe clean with a lint-free cloth dampened with cleaning solvent.

WARNING

Safety glasses must be used when cleaning parts with compressed air.

(2) Clean armatures, coils and solenoids with compressed air and wipe clean with a lint-free cloth dampened in cleaning solvent.

(3) Wipe electrical terminals clean with a lint-free cloth dampened with cleaning solvent. Use a soldering iron to clean solder from terminals and connectors.

c. Gaskets, Seals and O-Rings

(1) Clean all old gasket particles from mating surfaces.

(2) Discard and replace all gaskets, seals, O-rings and felt washers.

5-6. General inspection instructions

a. General. Perform an inspection of all parts as soon as possible after cleaning.

b. Visual Inspection

(1) Visually inspect all machined and polished areas. Use a strong light to shine across polished surfaces to inspect for scoring, cracks, breaks or excessive wear.

(2) Visually inspect all gears for evidence of metal to metal abrasion, pitting, cracks, breaks, chipped teeth or excessive wear.

c. Electrical Parts

(1) Visually inspect wiring harness and wiring for frayed edges or damaged insulation.

(2) Inspect all electrical parts, such as solenoids, with power applied to observe actual operation.

d. Dimensional Inspection. Refer to Table 1-1 for minimum, maximum and allowable clearances and perform a dimensional inspection. Central dimensional inspections must be performed during reassembly of components.

5-7. General repair instructions

a. Thread Repair. Use the proper size tapping tool to repair tapped holes. Discard and replace all hardware that has defective threads.

CAUTION

Do not press on the outer race of bearings when installing on shafts. Do not press on inner race of bearing when installing in housing.

b. Press Fit Parts

(1) Removal and installation of gears and bearings may require the use of a pneumatic or hand operated arbor press.

(2) Preheat all press-fit parts before reassembly if specified. Use a lubricant if necessary to reduce friction.

Section IV. Removal and Installation of Major Components and Assemblies

5-8. General

a. This section contains instructions for removal and installation of major components of the winch assembly to facilitate repair and overhaul procedures. Complete repair and overhaul instructions are covered in the following sections of this manual.

b. The engine and torque converter are mounted on the same sub frame which is then mounted on the winch frame. Normally, maintenance requiring disassembly of either of these major components will be accomplished by removing the complete assembly from the winch frame. Remove and move the engine and torque converter assembly mounted on the engine sub frame to the maintenance shelter prior to further disassembly.

CAUTION

Cap or cover all disconnected air and fluid lines and the open end of the chain case on the winch to prevent accumulation of dirt, sand and water in the lines and drive chain case. Cap or cover all engine and torque ports, lines and the chain drive sprocket until the engine assembly is moved to a maintenance shelter.

NOTE

The torque converter can be removed from engine assembly sub frame and engine for repair without removing engine assembly.

5-9. Engine assembly removal and installation

a. Removal

(1) Refer to lubrication chart (Figure 3-1) and drain engine crankcase and torque converter.

(2) Drain engine cooling system.

(3) Refer to Figure 4-6. Disconnect chain case bellows and drive chain.

(4) Disconnect and cap air and fluid lines and ports between engine and winch frame. Cover open end of chain case and drive sprocket.

(5) Remove engine assembly sub frame bolts.

(6) Remove engine assembly from winch.

b. Installation

(1) Install engine assembly in reverse order of that described in paragraph 5- 9a.

(2) Insure that all caps and covers are removed from lines, plugs and openings before reconnecting.

(3) Service equipment in accordance with paragraph 4-1.

(4) Start engine and adjust throttle linkage for proper idle rpm.

CAUTION

Do not attempt engine or torque converter disassembly at the beach work site unless appropriate maintenance shelters are available. Disassembly at the beach site allows excess dirt and sand to enter bearings and stick to machined surfaces and results in rapid wear that can cause major equipment failure.

5-10. Torque converter removal

a. Refer to figure 5-1 and remove torque converter mounting bolts from engine sub frame support plate.

b. Remove bolts that mate torque converter to engine drive shaft flywheel housing.

NOTE

The clutch assembly will remain attached to the engine flywheel. During removal, move the clutch handle as necessary to allow the forks to slip off the sliding sleeve pins.

c. Remove torque converter from engine and sub frame.

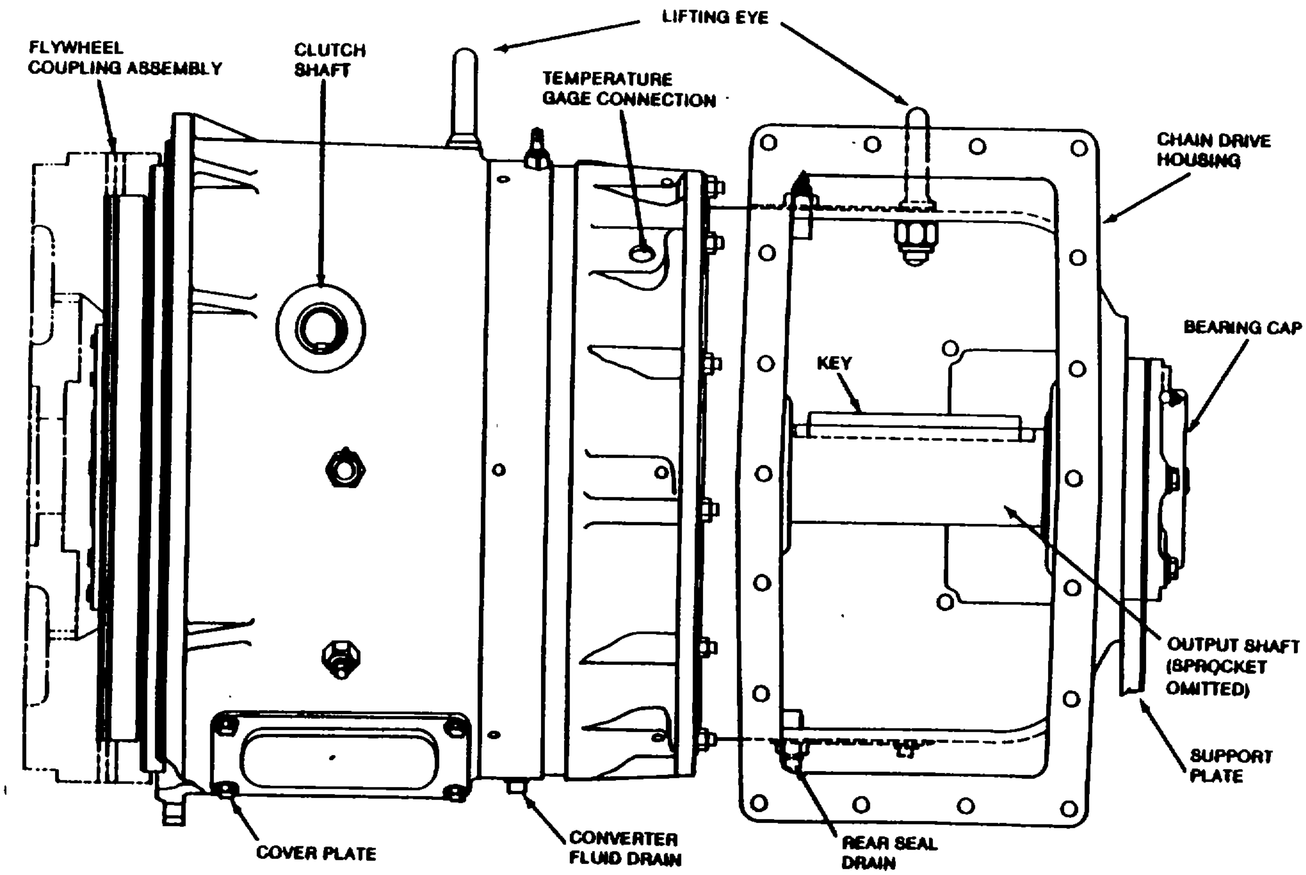


Figure 5-1. Torque Converter Removal and Installation.

5-11. Torque converter installation

a. Install torque converter in reverse order of paragraph 5-10.

NOTE

Move clutch operating handle as necessary to align forks with pins on sliding sleeve during assembly.

CAUTION

Insure that torque converter is properly aligned with engine drive shaft and tighten converter to engine bolts. Do not attempt to tighten torque converter to sub frame until converter is properly attached to engine. Reversing this sequence can result in a misaligned drive shaft which can damage engine and torque converter.

b. Service torque converter.

5-12. Engine removal

a. Remove all engine and torque converter mounting bolts from the sub frame.

NOTE

If the anticipated engine maintenance can be accomplished with the torque converter mounted to the engine, the torque converter may remain attached to the engine. As a general rule, if the engine must be removed from the sub frame, the torque converter must be removed from the engine. For example, maintenance on the cylinder head, rockers, fuel injectors and front of the engine can normally be accomplished with the engine and torque converter mounted on the sub frame; in this case step a. above may be omitted. Maintenance on the drive end of the engine, the crankshaft, connecting rods, etc., will require torque converter removal.

CAUTION

Always remove torque converter and engine as a unit from sub frame or remove torque converter first. Never attempt to remove engine with torque converter attached to sub frame. The engine drive shaft or torque converter can be damaged due to size, weight and handling problems associated with engine.

b. Remove torque converter from the engine.

5-13. Engine installation

WARNING

Insure that all mounting bolts are properly installed. Loose or missing mounting hardware could cause the engine assembly to be ripped from the sub frame at peak winch loads causing death or serious injury to personnel and major damage to the equipment.

CAUTION

If proper alignment of the engine assembly and sub frame mounting points cannot be achieved check the sub frame for misalignment and insure that the torque converter is properly aligned with the engine. Realign the frame as necessary. Do not misalign the torque converter and engine to achieve mount- ing alignment since this can damage the drive system.

a. Install torque converter on engine as necessary.

b. Install engine and torque converter on sub frame as a unit.

c. Insure that all engine and torque converter sub frame mounting points are properly aligned and install all mounting bolts.

Section V. Removal, Repair and Installation of Chain Drive Components

5-14. Chain drive housing removal

a. Chain drive housing may be removed without removing torque converter.

b. Clean assembly with a suitable cleaning solvent and dry thoroughly.

c. Support torque converter assembly with suitable blocking.

d. Drain chain case (para 4-17).

e. Disconnect bellows between chain drive and drive housings (Figure 4-6).

f. Remove chain drive support plate from chain drive housing.

g. Remove nuts and lockwashers mating the chain drive housing to converter housing.

h. Using three tapped holes, insert and tighten bolts evenly to force housings apart.

5-15. Chain drive assembly repair

a. Refer to Figure 5-2 and disassemble chain drive mechanism.

b. Wash all components in a suitable cleaning solvent and dry thoroughly.

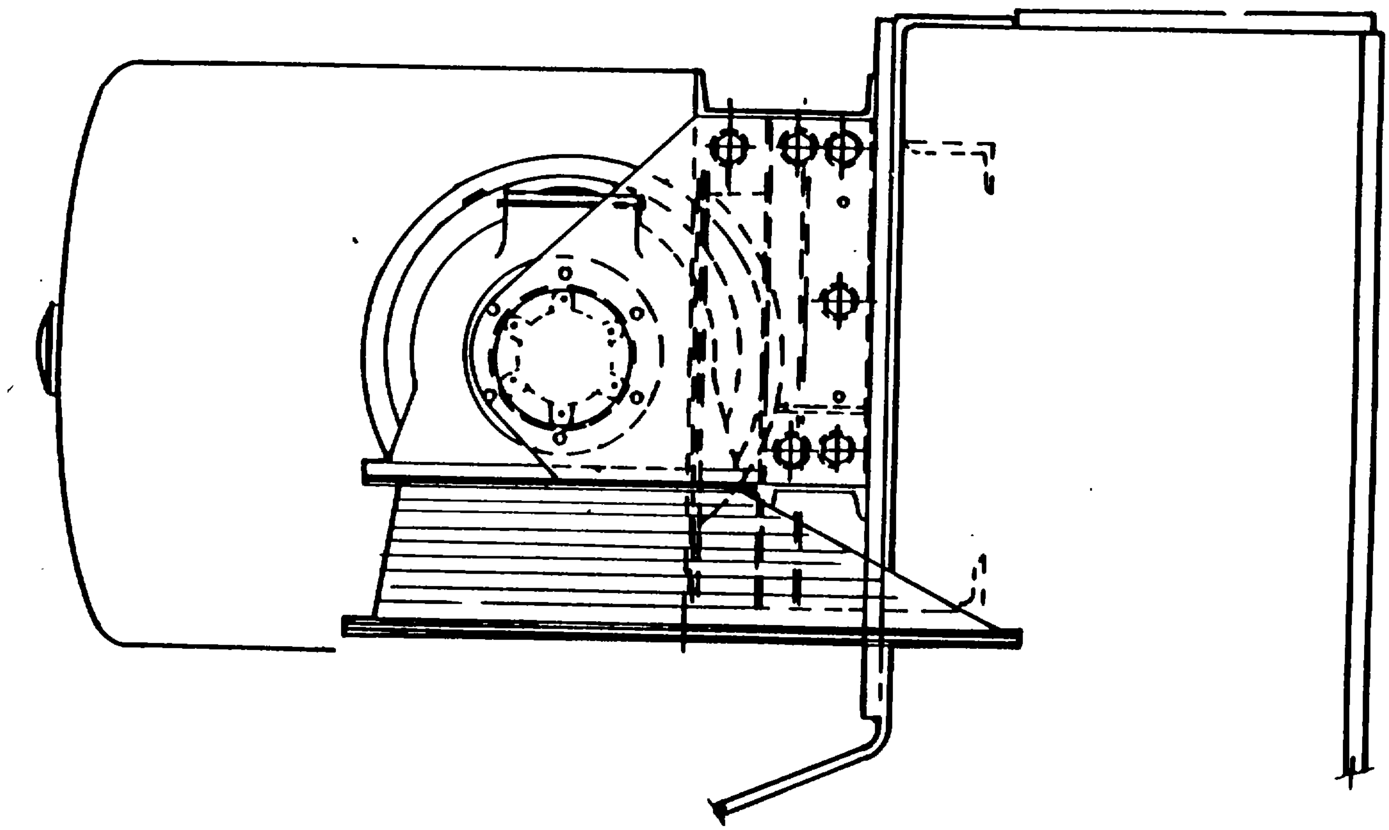


Figure 5-2. Chain Drive Mechanism.

CAUTION

If the chain drive sprocket is damaged, examine the chain to insure that it has not been damaged during winch operation. A damaged chain and drive sprocket will be an indication that the winch sprocket is also damaged. Refer to paragraph 5-21 for inspection and Repair of the winch sprocket. Failure to inspect the winch sprocket can result in a repeat failure and more serious damage to the winch.

c. Examine bearings, splines, shaft and sprocket for scoring, excessive wear or other damage.

d. Light scoring and similar minor damage can be repaired with a fine emery cloth.

e. Repair other defective parts by replacement with new items.

5-16 Chain drive assembly installation

a. Install chain drive assembly in reverse disassembly sequence.

b. Install chain drive support plate.

NOTE

Check for movement of the converter during disassembly, and any apparent misalignment. Also check alignment during support plate installation.

c. Install drive chain to chain case bellows.

d. Service torque converter and chain case as necessary.

Section VI. Winch Shafts Removal and Installation

5-17 General

a. The winch shafts described in this section include both winch drum assemblies, the drive shaft and the winch head shaft. Shaft removal requires removal of the gear guard.

b. Removal of drum shaft assemblies requires removal of gear guard, brake bands and clutch air lines.

c. Drive shaft removal requires removal of chain case, and gear guard.

d. Winch head shaft can be removed by removing winch head gear guard only.

5-18 Winch drive shaft removal

a. Drain all lubricating oil from chain case.

b. Remove chain case and chain (para 4-17).

c. Refer to figure 5-3 and remove sprocket nut and lockwasher.

d. Remove sprocket.

NOTE

A gear puller may be required to remove sprocket from drive shaft spline.

e. Remove chain case mounting plate from winch.

f. Remove gear guard.

g. Remove bolts that mount drive shaft pillow blocks to winch frame.

h. Slide drive shaft, with pillow blocks attached, out of winch drum gears and remove drive shaft assembly.

5-19 Winch drive shaft installation

a. Install drive shaft in reverse of removal sequence.

b. Lubricate pillow block bolts and torque to 820-825 lb ft.

c. Lubricate chain sprocket splines and drive shaft splines with high pressure grease lube prior to installing the sprocket.

5-20 Winch drum and drum shaft removal and installation

a. The winch drum assemblies are similar. The only differences are in the location of items such as the air lines and air actuating chambers.

WARNING

Insure sufficient tension on the lifting device so it cannot slip on the winch frame. The angle of the winch frame and the weight of the assembly could damage the winch or cause serious injury if it moves suddenly.

b. Removal of winch drum assembly will require use of an overhead lifting device of at least 1 ton capacity.

5-21 Winch drum assembly removal

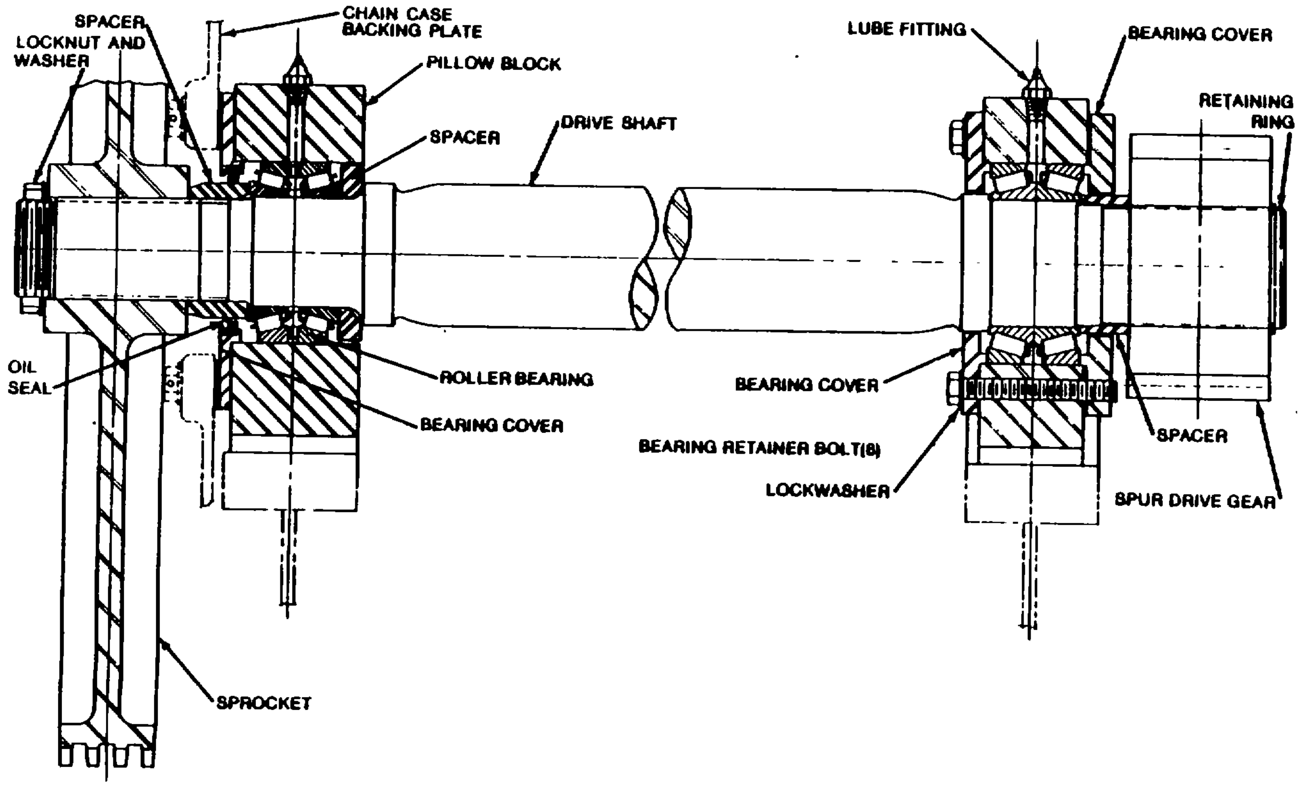
a. Remove gear guard.

b. Remove air line fittings from drum gear end of shaft

c. Remove brake bands.

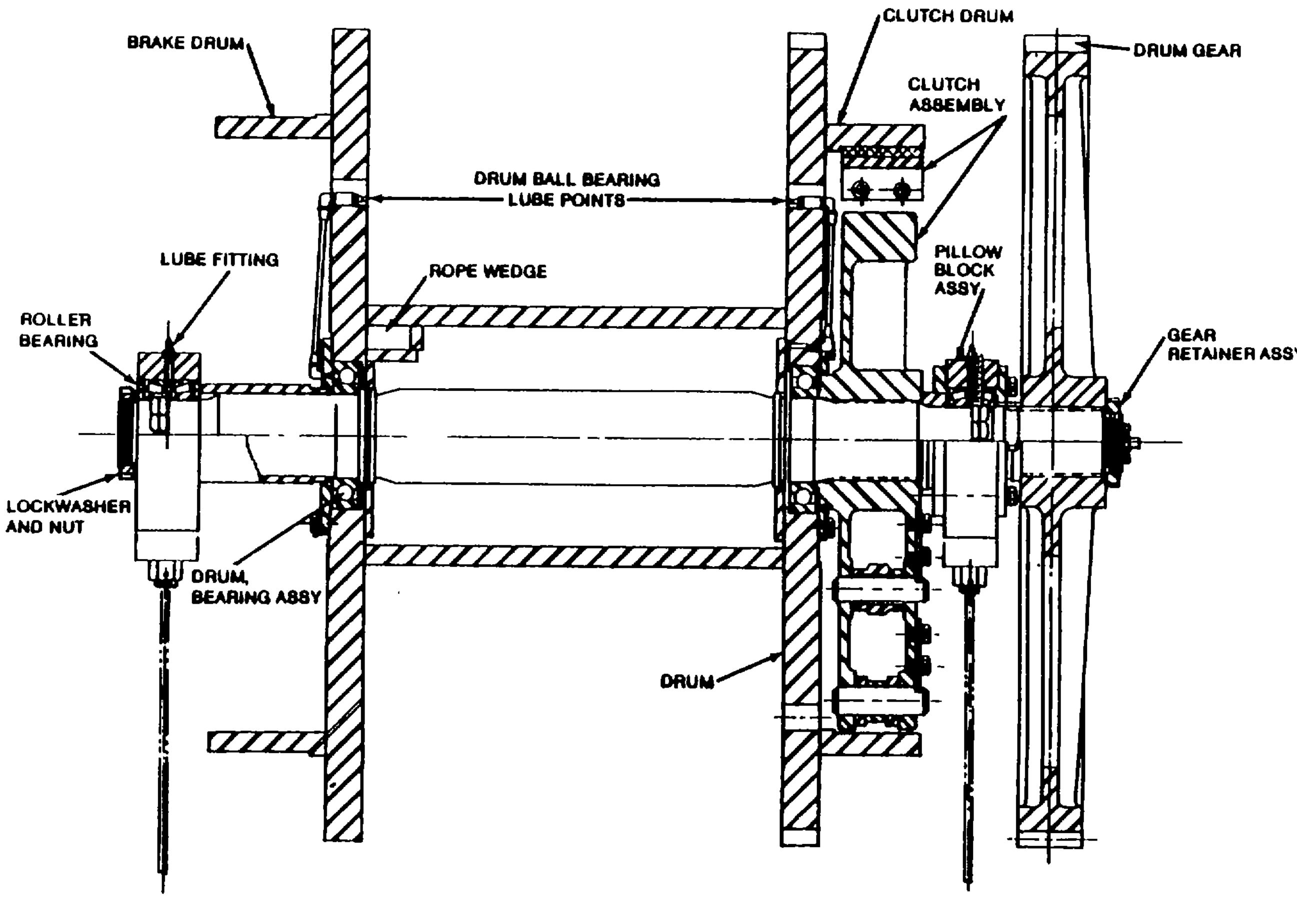
d. Remove drum gear retaining nut and washer.

e. Use a suitable gear puller and pull drum gear off shaft (Figure 5-4).



NOTE: VIEW FROM ENGINE FORWARD

Figure 5-3. Winch Drive Shaft.



NOTE: VIEW FROM ENGINE FORWARD

Figure 5-4. Winch Drum Assembly.

f. Remove nuts from pillow block bolts, attach lifting device to winch drum assembly and apply light tension.

g. Tap pillow blocks with a soft hammer and remove one pillow block bolt at a time.

h. Carefully remove two remaining pillow block bolts.

i. Remove drum assembly to a suitable work area.

5-22 Drum and drum shaft installation

a. Install drum assembly in reverse of removal sequence.

b. Torque pillow block bolts to 820-825 lb ft (lubricated).

c. Use a high pressure oil or grease lube on pillow block bolts and drum gear spline prior to assembly.

d. Reinstall brake bands and adjust as necessary.

e. Reinstall air lines, gear guard and chain case.

f. Service chain case.

5-23 Winch head shaft removal

a. Remove winch head gear guard from winch gear guard and frame.

b. Remove pillow block bolts from winch head pillow blocks.

c. Remove winch head shaft.

5-24 Winch head shaft installation

a. Place winch head shaft on frame.

b. Align and install pillow block bolts.

c. Torque pillow block bolts to standard values as listed in Table 1-3.

d. Lubricate bolts with a high pressure lube and torque to values listed in Table 1-3.

e. Install winch head gear guard.

Section VII. Alternator and Voltage Regulator

5-25 General

a. Alternator

(1) The alternator assembly is hinge-mounted on left side of diesel engine. It is belt-driven from an accessory pulley driven from balance shaft. See figure 5-5.

(2) The alternator is a Delco "Delcotron" heavy-duty unit. The shaft rotates in a roller bearing at slip ring end and a ball bearing at driving pulley end. Bearing grease reservoirs contain enough lubricant to eliminate need for periodic lubrication. Two brushes carry current through two slip rings to field coil mounted on rotor.

(3) No periodic adjustment or maintenance is required on alternator assembly.

b. Stator. The stator windings are assembled on inside of a laminated core that forms part of alternator frame. Rectifier bridge is connected to stator windings contains six diodes, and electrically changes stator ac voltages to a dc voltage which appears at alternator output terminal. Alternator field current is supplies through a diode trio which also is connected to stator windings. Condenser, mounted in end frame, protects rectifier bridge and diode trio from high voltages and suppresses radio noise. Wiring diagram is shown in Figure 5- 6.

c. Voltage Regulator

(1) Voltage regulator is mounted inside alternator slip ring and frame.

(2) Voltage regulator is a sealed solid-state unit and is not repairable. Replace when necessary.

(3) Regulator voltage setting never needs adjusting, and no provision for adjustment is provided.

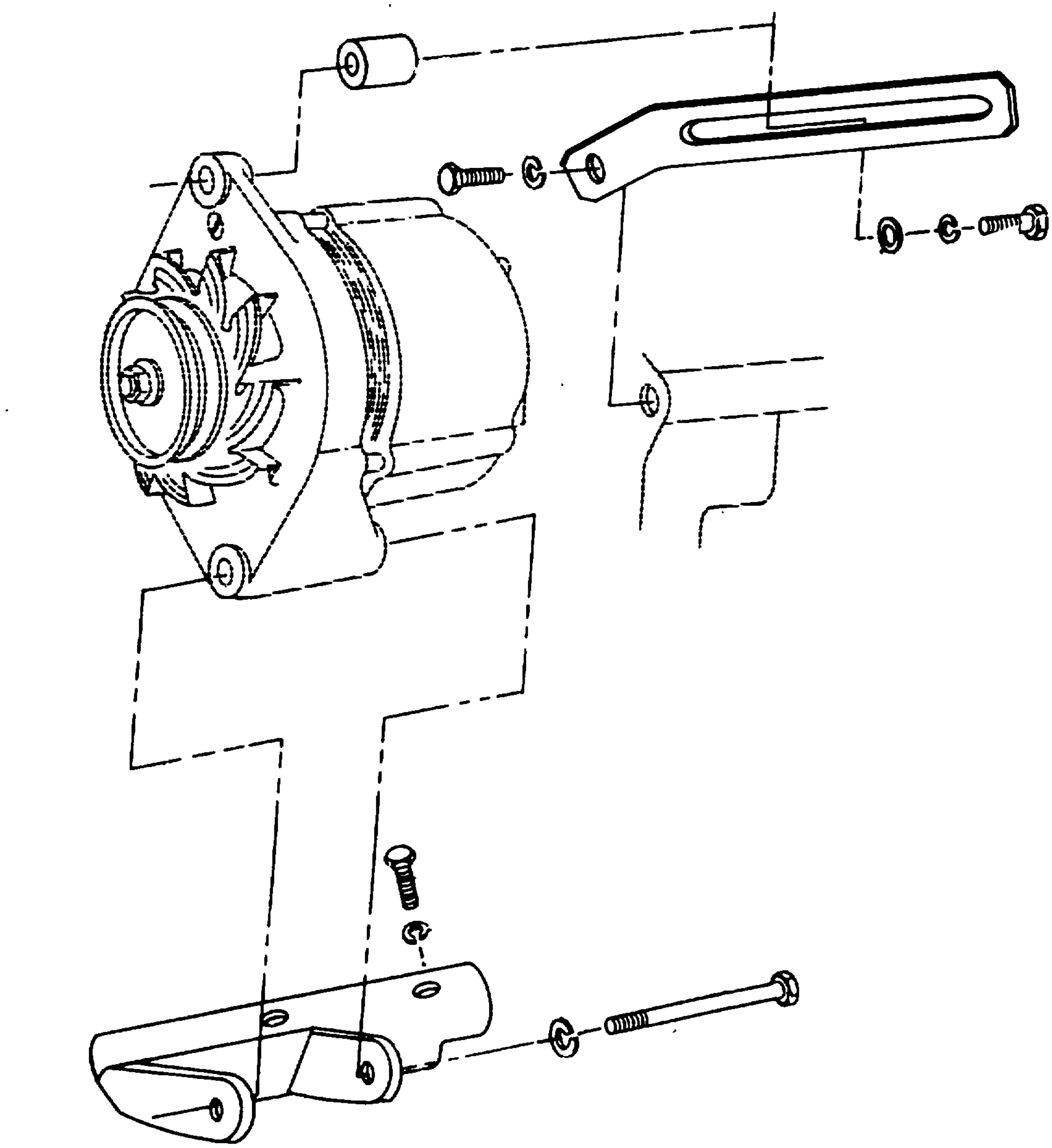


Figure 5-5. Delcotron Alternator Cross Section (2 of 2).

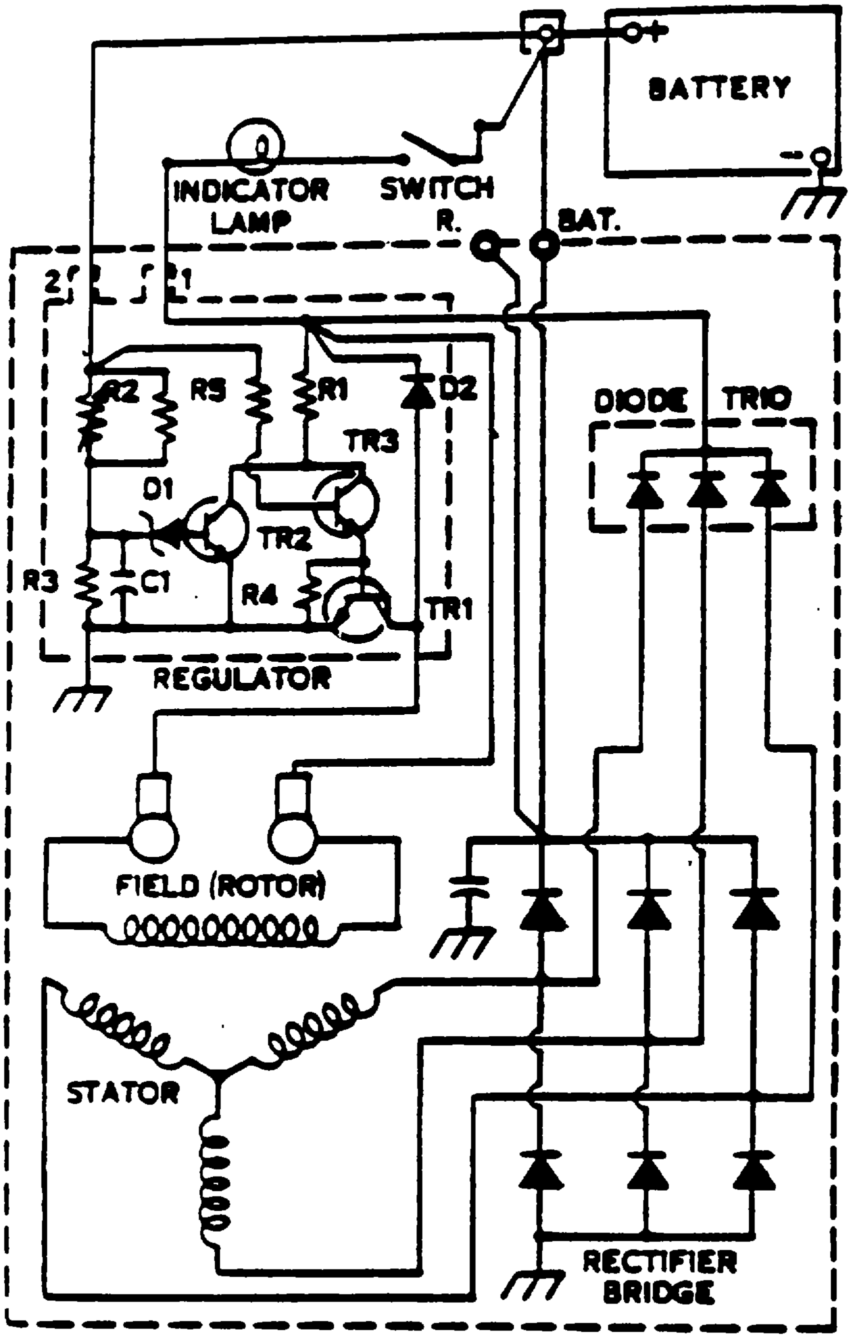


Figure 5-6. Delcotron Alternator Internal Wiring Diagram.

d. Disassembly. Disassemble alternator assembly (Figure 5-7) as follows:

(1) Take out four thru-bolts and separate drive end frame and rotor assembly from stator frame assembly.

(2) Make scribe marks across junction of two frame sections to make reassembly easier.

(3) Pry two sections apart by using a screwdriver at stator slot.

CAUTION

Use pressure sensitive tape to perform following steps. Use of friction tape leaves a gummy deposit, particularly on shaft.

(4) Place piece of tape over slip ring and bearing to prevent entry of dirt and other foreign material.

(5) Place piece of tape over rotor shaft on slip ring end.

(6) Clean brushes with soft, dry cloth if they are to be re-used.

CAUTION

Do not over tighten vise to keep rotor from turning in next step.

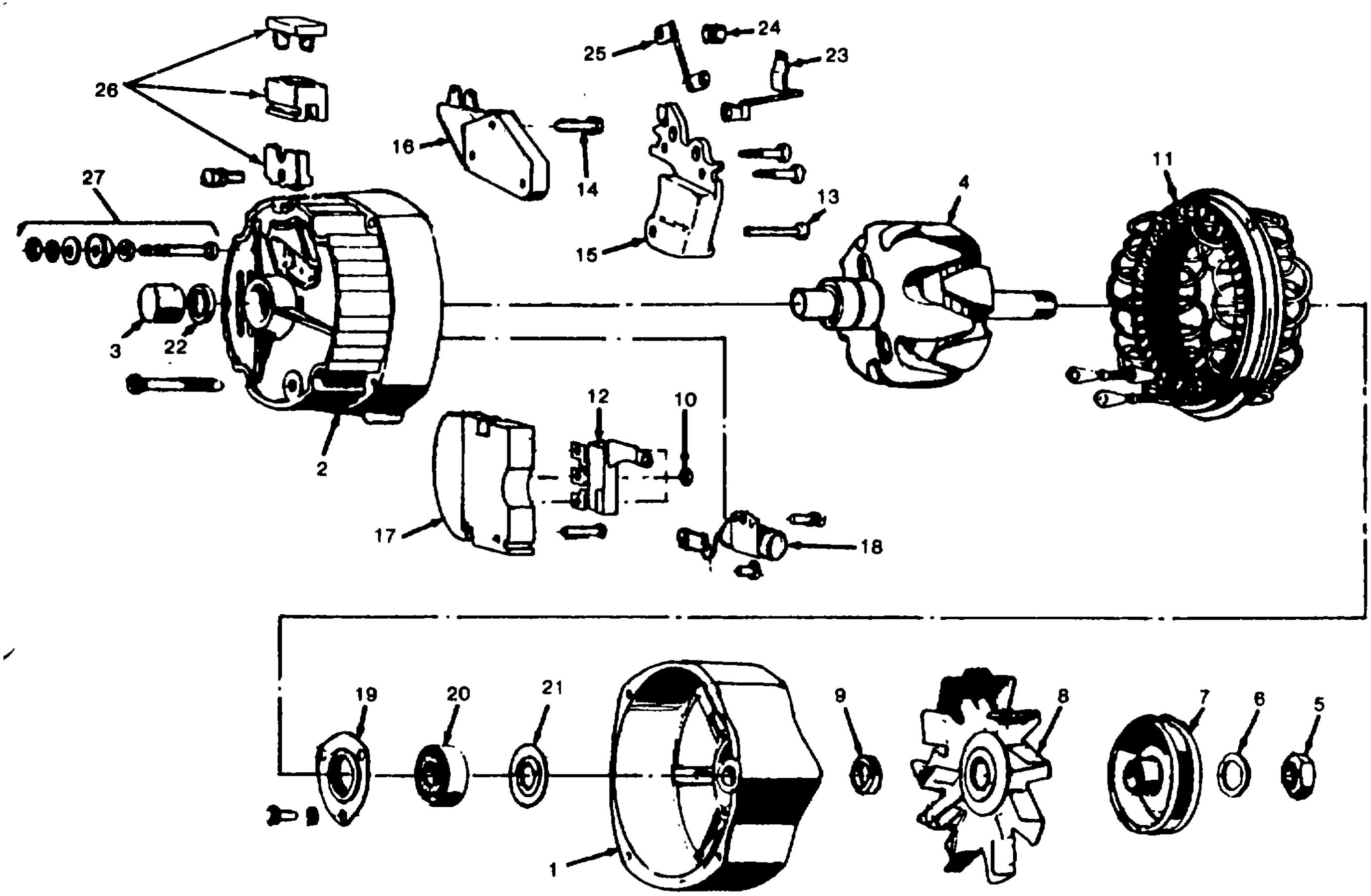
(7) Place rotor in vise; remove shaft nut, lockwasher, pulley, fan, and outside collar.

(8) Work drive end frame off end of rotor shaft.

NOTE

Do not perform steps 9 through 13 unless necessary to perform tests or replace items.

(9) Remove three attaching nuts and attaching screw, remove stator assembly and diode trio. Insulating washer on screw is assembled over top of diode trio connector.



1. End Frame
2. End Frame
3. Bearing
4. Rotor
5. Nut
6. Lockwasher
7. Pulley
8. Fan
9. Collar (Outside)
10. Nut (Rectifier Bridge)
11. Stator
12. Diode Trio
13. Brush Holder Screw (Pivot)
    a. Screws, Brush Holder (insulated)
14. Regulator Screw and Lockwasher (Attach)
15. Brush Holder Assembly
16. Regulator
17. Rectifier Bridge
18. Capacitor
19. Bearing Retainer
20. Bearing Set
21. Slinger
22. Seal
23. Relay Terminal
24. Terminal Stud Nut
25. Lead
26. Voltage Adjust Assembly
27. BatteryTerminal Connector

Figure 5-7. Delcotron Alternator Illustrated Parts.

(10) Remove two remaining screws and remove brush holder and regulator.

WARNING

Notice two insulators located over top of brush clips. These two screws have special insulating sleeves over screw body above threads. Third mounting screw may or may not have an insulating sleeve. If not, this screw must NOT be interchanged with either one of other two screws. A ground may result. This would cause no output or uncontrolled alternator output. Regulators may vary in appearance, but are interchangeable in these alternators.

(11) Remove rectifier and capacitor as necessary.

(12) Remove three retainer plate screws and lockwashers and ball bearing retainer plate from driven end frame. Press ball bearing grease slinger from driven end frame.

(13) Press slip ring end grease cup and bearing and lip grease seal out of frame, from the outside inward.

5-26 Alternator and voltage regulator inspection and repair

a. Rotor Field Winding. Check for open circuit by connecting an ohmmeter between slip rings. Infinite resistance requires replacement of rotor. Use ohmmeter to check for grounded winding by connecting between slip rings and shaft. Check for high-or-low-resistance of winding (burnout or shorted turns) by noting resistance reading, and compare it with specification values in this manual.

b. Diode Trio. Connect a 1 1/2-volt ohmmeter, set on lowest range, between single connector and one of three other connectors. Note reading, then reverse ohmmeter connections and again note reading. If both readings are same, replace diode. Repeat this step for each of other two connectors of trio, using same criteria.

NOTE

The rectifier bridge has a grounded heat sink and an insulated heat sink connected to output terminal.

c. Rectifier Bridge. Connect a low-voltage ohmmeter between ungrounded heat sink and one of three terminals. Perform same tests to same criteria as in preceding (diode trio) check.

d. Stator. Connect a low-voltage ohmmeter successively between pairs of stator leads. If any of three readings are high, windings are open. Then take reading between any stator lead and frame; a low reading means winding is grounded.

e. Voltage Regulator. Special test equipment must be used to determine if a regulator is defective.

5-27 Alternator reassembly and reinstallation

a. General. Reassembly is the reverse of disassembly procedure.

b. Specific instructions.

(1) Assembling pulley to shaft. Secure rotor in a vise only tight enough to permit tightening shaft nut to 40-60 lb ft.

(2) Installing drive end frame with rotor into slip ring end frame. Remove tape over bearing and shaft, make sure shaft is perfectly clean. Insert a pin through holes to hold brushes up. Install slip ring end very carefully to avoid damage to seal. Tighten through bolts. Remove brush retaining pins to let brushes contact slip rings.

Section VIII. Starting Motor and Solenoid

5-28 General

a. The starting motor is a heavy duty, 12 volt, submersion, fungus and corrosion resistant, solenoid operated, enclosed shift type engine starter with eight (or four) brushes retained by four brush holders. Figure 5-8 is a typical unit used on this winch; minor variations such as the number of brushes may be noticed on disassembly.

b. The drive clutch is a Sprag overrunning type. The overrunning clutch prevents overspeeding of starter during intermittent engine firing by allowing pinion to turn faster than armature.

c. The principal components of starter are frame, field coils, armature, commutator, brush assembly, drive housing, shift lever, and solenoid plunger.

NOTE

Refer to Figures 5-4 and 5-5 for the following steps.

(1) Disconnect field coil connector from solenoid motor terminal and remove solenoid mounting screws.

(2) Remove end frame cap screws.

CAUTION

While removing field frame, do not drop the armature out of field frame or allow it to fall from lever housing.

(3) Remove end frame from field frame.

(4) Remove capscrews between field frame and lever housing.

(5) Remove field frame.

(6) Remove nose housing attaching bolts and separate nose housing, from lever housing.

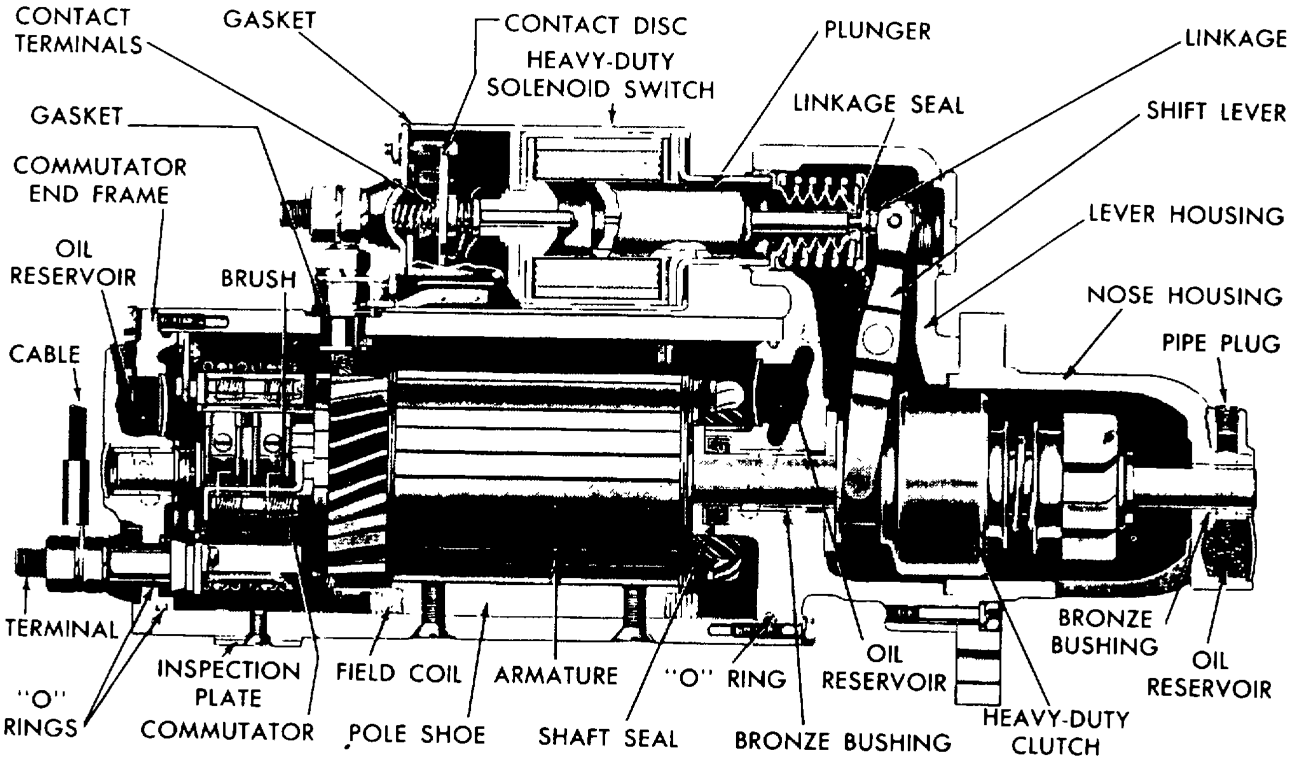


Figure 5-8. Starting Motor

(7) Remove clutch assembly from lever housing.

(8) Refer to Figure 5-9 if disassembly of field frames, clutch assembly, lever mechanism, etc. Is required.

(9) Remove pipe plugs and oil wicks from end frame, lever housing and drive housing.

5-29 Starting motor cleaning, inspection and repair

a. Cleaning

(1) Clean all metal nonelectrical parts in cleaning solvent and dry thoroughly.

WARNING

Wear safety goggles whenever using compressed air.

(2) Clean field coils thoroughly with clean cloth dampened with cleaning solvent. Be careful not to damage insulation coating. Dry thoroughly with compressed air.

(3) Remove dust from armature with compressed air, wipe with a clean cloth dampened in cleaning solvent and dry thoroughly. Clean armature commutator lightly with No. 00 sandpaper, and remove all traces of copper dust with low- pressure compressed air.

(4) Clean solenoid insulation plates and nonmetallic washers with a clean cloth dampened with cleaning solvent and dry thoroughly.

b. Inspection and Repair

(1) Discard and replace brushes.

(2) Inspect housing and frames for cracks, breaks or other damage. Inspect threads in tapped holes for damage.

(3) Inspect sleeve bearings for wear, gouges, and grooves. Check for loose fits in housing. If bearing is loose in bore, replace housing or end cover.

(4) Discard and replace oil wicks.

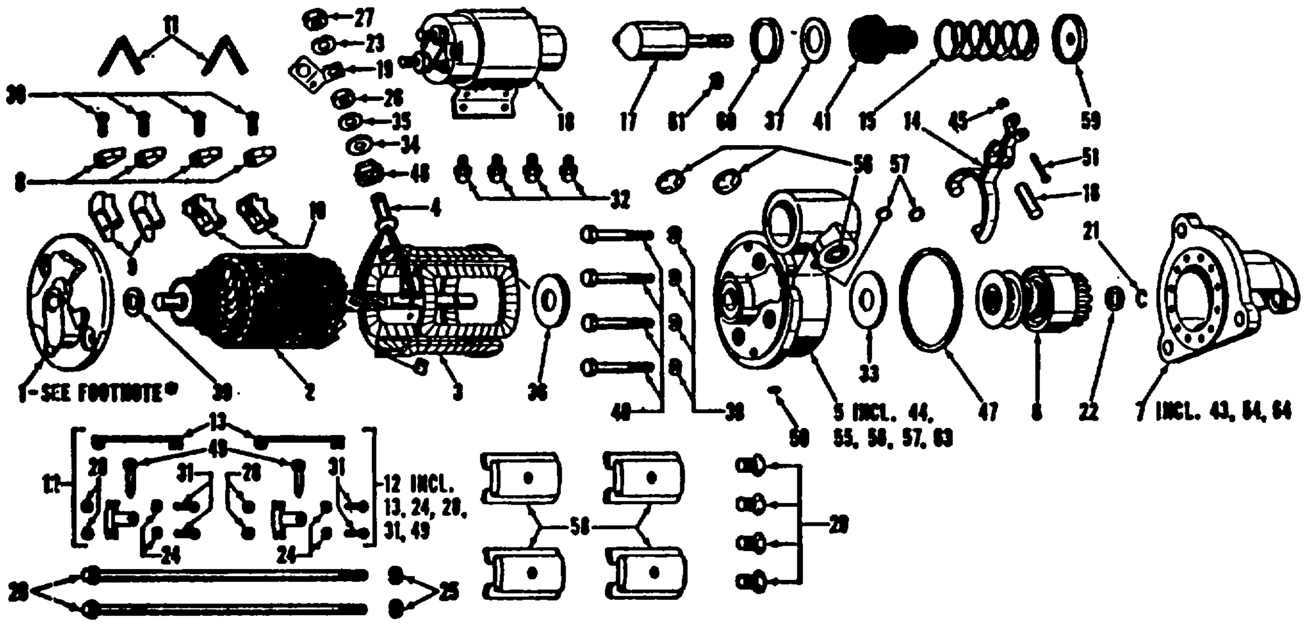
(5) Inspect armature for grounds, shorts, and open circuits, and replace if damaged.

(6) Use an ohmmeter to inspect field windings in frame for insulation breakdown. Attach one probe of ohmmeter to frame and other one to field winding terminals. Reading should not be less than one megohm. Replace defective coils.

(7) Inspect drive pinion for broken or badly worn teeth. Inspect clutch splines for wear or damage. Replace defective drive pinion.

(8) Inspect shift lever, shaft, and solenoid plunger for cracks or distortion.

(9) Repair by replacement of defective parts.



1. FRAME
2. ARMATURE
3. FIELD COILS
4. TERMINAL STUD
5. LEVER HOUSING
6. DRIVE ASSEMBLY
7. DRIVE ASSEMBLY
8. BRUSH
9. BRUSH HOLDER (GROUND)
10. BRUSH HOLDER (INSULATED)
11. BRUSH SPRING
12. BRUSH SUPPORTS
13. GROUND LEAD
14. SHIFT LEVER
15. RETURN SPRING
16. LEVER SHAFT
17. PLUNGER
18. SWITCH
19. CONNECTOR SWITCH
20. THRU BOLT
21. RETAINER RING
22. STOP COLLAR

NOTE: REFER TO -24P/9 FOR MINOR PARTS

Figure 5-9. Starting Motor Illustrated Parts.

5-30 Starting motor reassembly and installation

a. Reassembly

(1) Refer to Figure 5-9 and reassemble starter end cover and brush holder in reverse of disassembly sequence (para 5-28).

(2) Refer to Figure 5-9 and reassemble remaining components of starter assembly in reverse of disassembly sequence (para 5-28).

(3) Install and saturate new wicks with engine oil.

(4) Apply sealer to expansion plugs and holes.

(5) If sleeve bearings were removed, press new bearings into housings.

(6) If field windings were removed, coat threads of pole shoe screws with a suitable thread sealer before installation. Varnish inside of frame and field windings. Leave 0.38 inch from each end of frame free of varnish.

(7) Adjust drive clutch as follows:

(a) Remove plug.

(b) With starter pinion in engaged position, press clutch assembly inward toward lever to take up slack.

(c) Adjust hex nut until clearance between outer face of clutch pinion and inner face of drive housing is 23/64 inch, + 1/32 inch.

Section IX. Fuel Injectors

5-31 General

a. The fuel injector (Figure 5-10) is a lightweight compact unit which enables quick easy starting directly on diesel fuel and permits use of a simple open type combustion chamber. The simplicity of design and operation provides for simplified controls and easy adjustment.

b. The fuel injector performs four functions:

(1) Creates high fuel pressure required for efficient operation.

(2) Meters and injects fuel to exact amount required to handle load.

(3) Atomizes fuel for mixing with air in the combustion chamber.

(4) Permits continuous fuel flow.

c. Combustion required for satisfactory engine operation is obtained by injecting a small quantity of accurately metered and finely atomized fuel oil into the cylinder under pressure.

d. Metering of fuel is accomplished by an upper and lower helix machined in lower end of injector plunger.

e. The continuous fuel flow through injector prevents air pockets in the fuel system, and serves as a coolant for those injector parts subjected to high combustion temperatures.

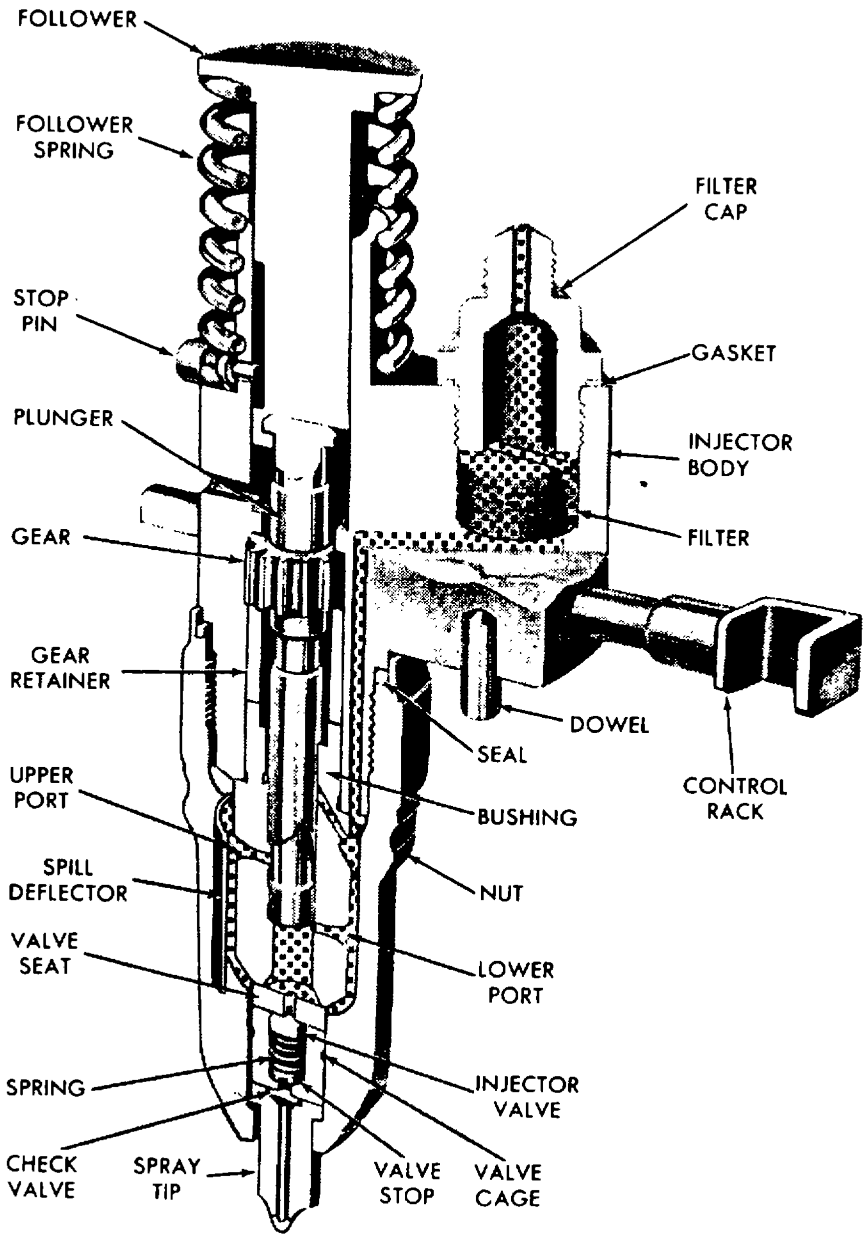
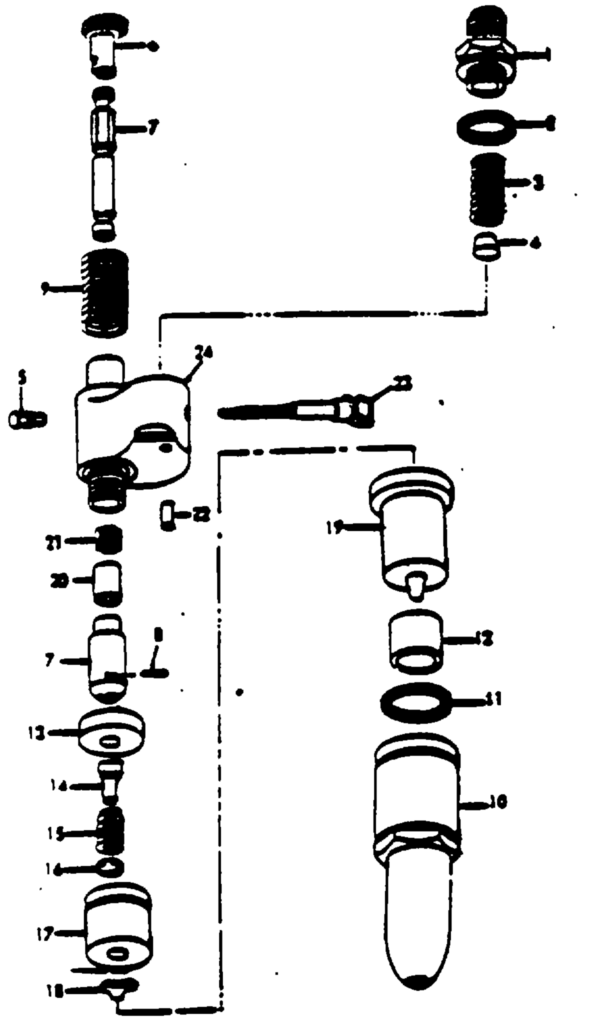


Figure 5-10. Fuel Injector (Sheet 1 of 2).



1. FILTER CAP
2. PREFORMED PACKING
3. COMPRESSION SPRING
4. FILTER ELEMENT
5. STOP PIN
6. FOLLOWER GUIDE
7. PLUNGER AND BUSHING
8. PIN, HEADLESS
9. COMPRESSION SPRING
10. NUT
11. SPACER
12. DEFLECTOR
13. VALVE SEAT
14. INJECTOR VALVE
15. SPRING
16. SPRAY TIP STOP
17. INJECTOR VALVE CAGE
18. INJECTOR CHECK VALVE
19. INJECTOR TIP
20. SLEEVE SPACER
21. SPUR GEAR
22. PIN, HEADLESS
23. INJECTOR CONTROL GEAR
24. INJECTOR BODY

Figure 5-10. Fuel injector (Sheet 2 of 2).

f. To vary engine power output, use injectors having different fuel output capacities. The fuel output for various injectors is governed by helix angle of the plunger and type of spray tip used. Refer to Figure 5-6 for identification of injectors and their respective plungers and spray tips.

CAUTION

The helix angle of plunger determines output and operating characteristics of a particular type of injector. It is imperative that correct injectors are used for engine application. If injectors of different types are mixed, erratic operation will result and may cause serious damage to engine or to equipment which it powers.

g. Each fuel injector control rack (Figure 5-10), is actuated by a lever on injector control tube which, in turn, is connected to governor by means of a fuel rod. These levers can be adjusted independently on control tube, thus permitting a uniform setting of all injector racks.

5-32 Fuel injector timing

a Remove rocker arm cover.

b. Each fuel injector has a circular disc pressed into a recess in front side of injector body for identification purposes as illustrated in Figure 5-10. The identification tag indicates nominal output of injector in cubic millimeters. A horizontal bar on injector identification tag between "GM" and injector size indicates current needle valve injector. Use a timing gage with a dimension of 1.484 inches when timing injector.

c. Time fuel injectors as illustrated in Figure 5-11.

d. Install rocker arm cover.

5-33 Fuel Injector removal, test and disassembly

a. Removal

(1) Remove rocker arm cover.

(2) Remove two fuel tubes (Figure 5-12).

CAUTION

Immediately after removal of fuel pipes from injectors, cover filter caps with shipping caps to prevent dirt from entering injector. Also, cover fuel pipes and connectors to prevent entry of dirt or foreign material.

(3) Crank engine with starting motor to bring push rod ends, outer ends of injector, and valve rocker arms in line horizontally.

(4) Remove rocker arm shaft bracket bolts and fuel injector as illustrated in Figure 5-12.

CAUTION

When using a wrench on the crankshaft bolt at the front of the engine, do not turn the crankshaft in a left-hand direction of rotation, as the bolt will be loosened.

1. PLACE THE THROTTLE CONTROL LEVER IN THE NO-FUEL POSITION.

2. ROTATE THE CRANKSHAFT UNTIL THE EXHAUST VALVES ARE FULLY DEPRESSED ON THE PARTICULAR CYLINDER TO BE TIMED.

3. PLACE THE SMALL END OF THE INJECTOR TIMING GAGE IN THE HOLE PROVIDED IN THE TOP OF THE INJECTOR BODY,WITH THE FLAT OF THE GAGE TOWARD THE INJECTOR FOLLOWER.

4. TURN THE PUSH ROD AND ADJUST THE INJECTOR ROCKER ARM NTIL THE EXTENDED PART OF THE GAGE WILL PASS OVER THE TOP OF THE INJECTOR FOLLOWER.

5. HOLD THE PUSH ROD AND TIGHTEN THE LOCK NUT. CHECK THE ADJUSTMENT AND, IF NECESSARY, RE-ADJUST THE PUSH ROD.

6. TIME THE REMAINING INJECTORS IN THE SAME MANNER AS OUTLINED IN ITEMS 1 THROUGH 6.

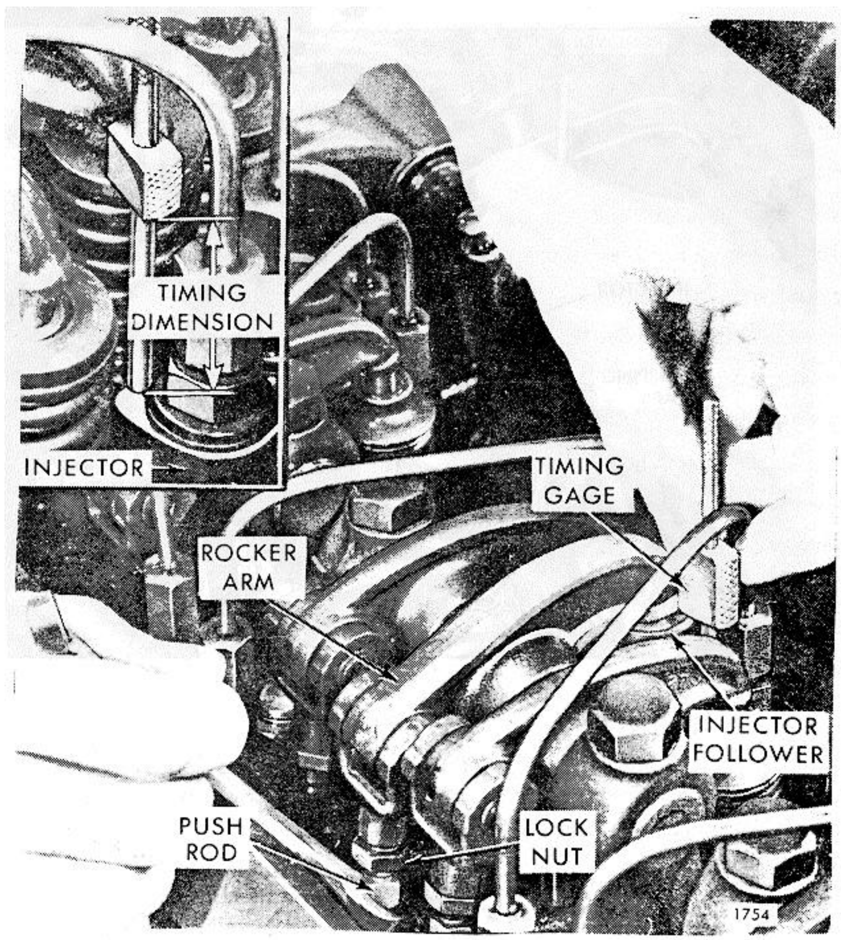


Figure 5-11. Fuel Injector Timing.

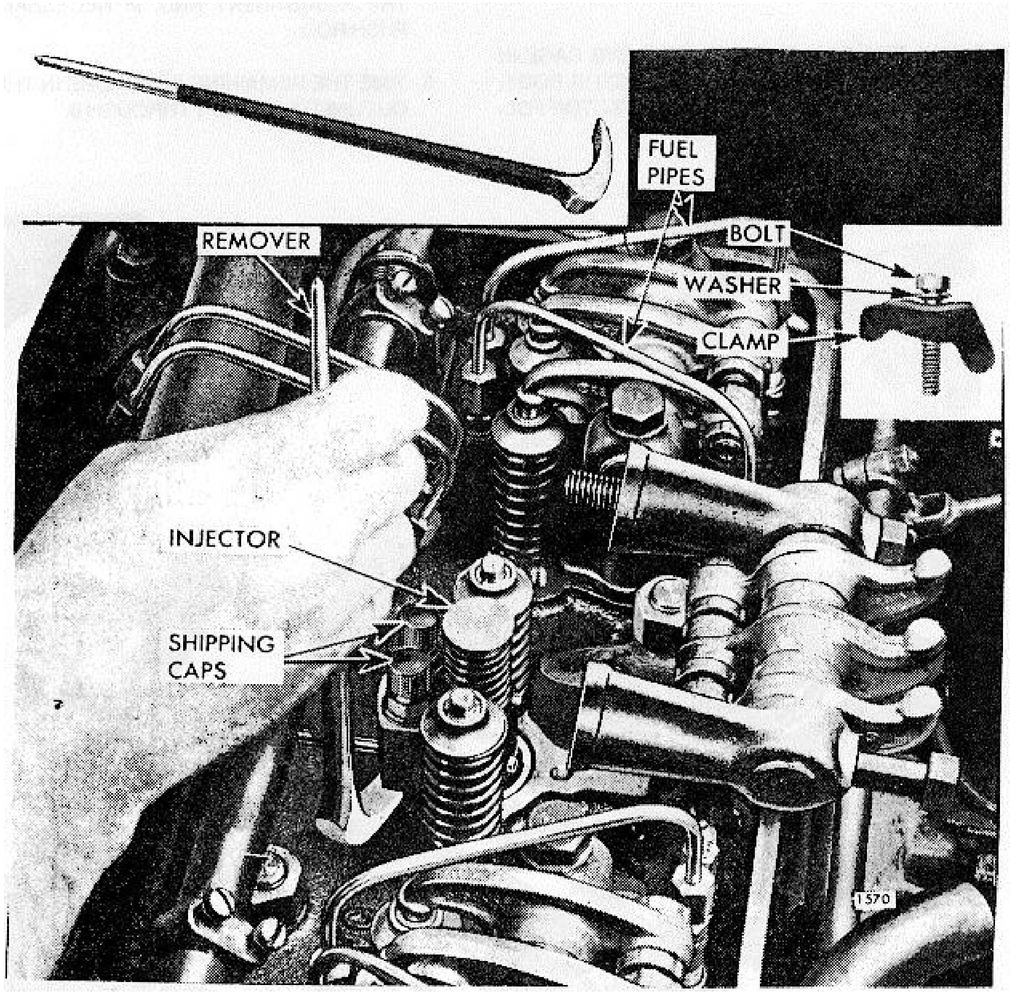


Figure 5-12. Fuel Injector Removal and Installation.

b. Test. If inspection does not reveal any external damage, make a series of tests to determine condition of injector to avoid unnecessary repair. An injector that passes all tests outlined below is considered satisfactory for service. Test fuel injector as follows:

(1) Control Rack and Plunger Movement Test

(a) Place injector in injector fixture and rack freeness tester. Then, place handle on top of injector follower.

(b) If necessary, adjust contact screw in handle to insure contact screw is at center of follower when follower spring is compressed.

(c) With injector control rack held in NO FUEL position, push handle down and depress follower to bottom of its stroke. Then, very slowly release pressure on handle while moving control rack up and down, until follower reaches top of its travel. If rack does not fall freely, loosen injector nut, turn tip, then retighten nut. Loosen and retighten nut several times if necessary. If rack isn't free, change injector nut. Generally, this will free rack. In some cases it may be necessary to disassemble injector to eliminate cause of misaligned parts.

(2) Valve Opening Pressure Test. The purpose of this test is to determine relative pressure at which injector valve opens and fuel injection begins. The test is performed in injector test fixture. Place injector in tester as shown in Figure 5-13 (1 of 3). Locate adaptor plate on top of support bracket by positioning the 3/8 inch diameter hole at far right of adaptor plate onto 3/8 inch diameter dowel pin. Mount injector through large hole and insert injector pin in proper locating pinhole.

WARNING

Always place injector in proper position in relation to spray deflector before it is tested, in order to prevent fuel spray from penetrating skin. Fuel oil which enters blood can cause serious infection.

(a) Refer to Figure 5-13 (2 of 3). Purge air from tester and injector system by moving lever 4 down and operating pump lever 1 until bubbles no longer appear in clear discharge tubing.

CAUTION

Do not overtighten nut or nut on seal will be damaged.

(b) Close thru-flow valve to allow pressure to build in gage 1.

(c) With fuel rack in FULL FUEL position, operate pump lever 1 rapidly until valve opening pressure of 450 to 850 psi is reached and spray tip holes are open by pattern of spray produced. If valve opening pressure is not within 450 to 850 psi range when spray pattern occurs, see troubleshooting chart, Table 5-1.

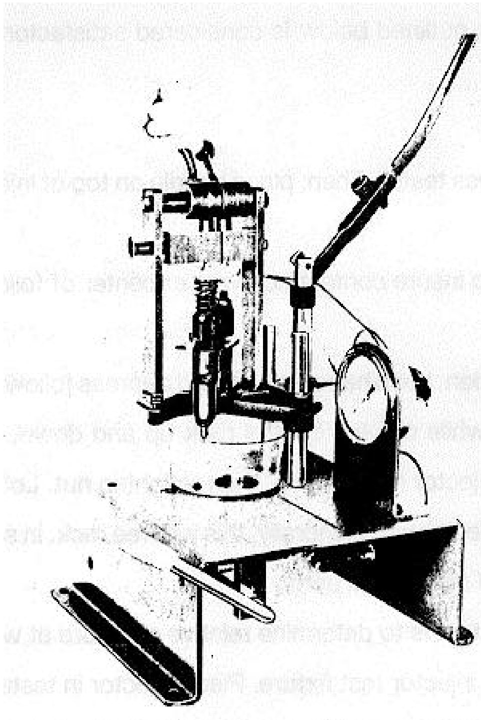


Figure 5-13. Injector Installed in Tester (1 of 3)

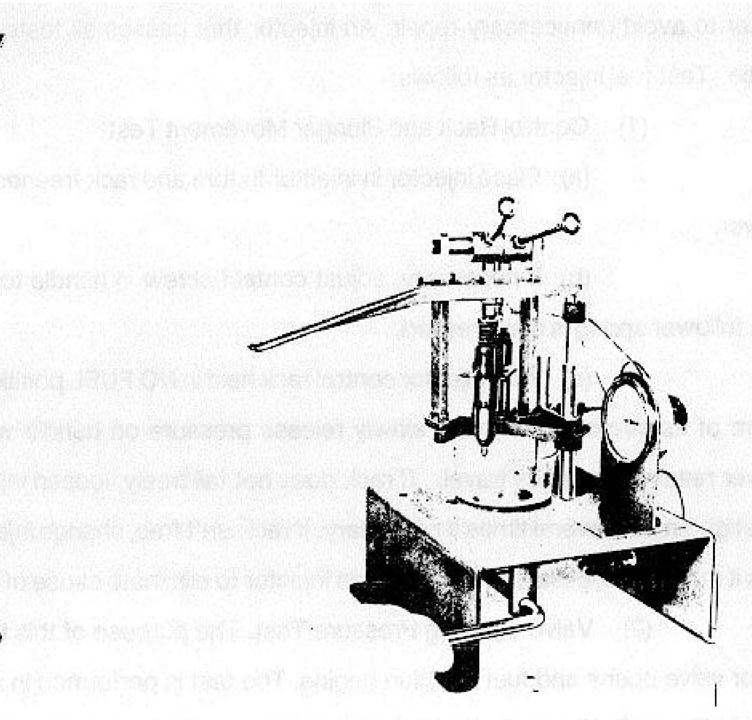


Figure 5-13. Fuel injector for High Pressure Tests. (2 of 3)

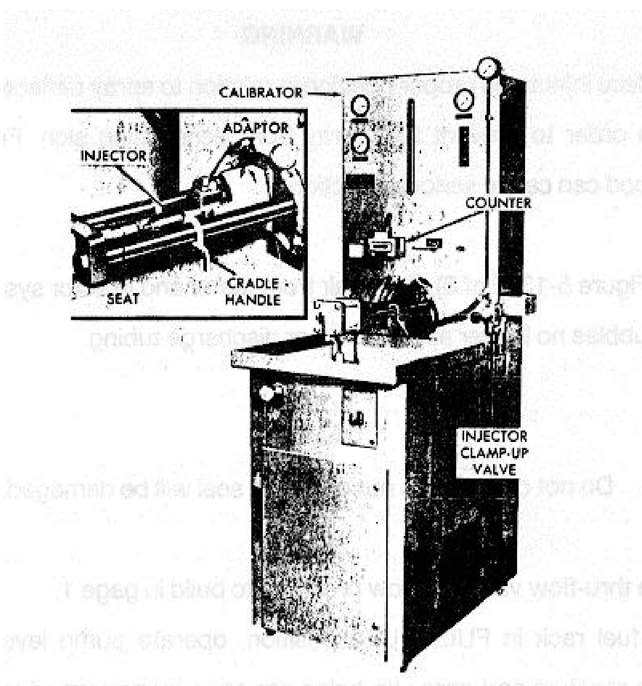


Figure 5-13. Injector in Calibrator (3 or 3).

(3) Valve Holding Pressure Test. This test determines if body-to-bushing mating surfaces in injector are sealing properly and indicates proper plunger- to-bushing fit.

(a) Clamp injector properly and purge air from system.

(b) Close thru-flow valve, but do not overtighten.

(c) Move lever 2 to rear, horizontal position.

(d) Operate pump lever 1 until gage 1 reads approximately 500 psi.

(e) Move lever 4 to UP position.

(f) Time pressure drop between 450 to 250 psi. If pressure drop occurs In less than 15 seconds, leakage is excessive.

(4) High Pressure Test. This test checks for leaks at Injector filter cap gaskets, body plugs, and nut seal ring.

(a) Clamp injector properly and purge air from system.

(b) Close thru-flow valve, but do not overtighten.

CAUTION

Be sure lever 4 is down position before operating pump lever 1.

(c) Move lever 2 to forward, horizontal position.

(d) Operate pump lever 1 to build up to 1600-2000 psi on gage 1 and check for leakage at filter cap gaskets, body plugs, and nut seal ring.

(5) Spray Pattern Test. This test determines spray pattern uniformity and relative pressure at which injector valve opens and fuel injection begins.

(a) Clamp injector properly and purge air from system.

(b) Close thru-flow valve to allow pressure to build In gage 1.

CAUTION

Do not overtighten or nut on seal will be damaged.

(c) With fuel rack in FULL FUEL position, operate pump lever 1 rapidly until valve opening pressure of 450 to 850 psi is reached and spray pattern occurs.

(6) Visual Inspection of Plunger. An injector which passes test must have plunger checked visually, under a magnifying glass, for excessive wear or for a possible chip in bottom helix. There is a small area on bottom helix and lower portion of upper helix that, If chipped, will not be indicated in any of tests.

(7) Fuel Output Test

(a) When injectors are removed from an engine for output testing, and If satisfactory, reinstalled without disassembly, extreme care must be taken to avoid reversing fuel flow. When fuel flow is reversed, dirt trapped by filter is back-flushed Into Injector components.

(b) Before removing an injector from engine, note direction of fuel flow. To avoid reversing fuel flow when checking injector fuel output on calibrator (Figure 5-13) (3 of 3), use appropriate adaptor. The position of braided fuel inlet tube and plastic fuel outlet tube on calibrator depends on adapter being used and direction of fuel flow through injector.

NOTE

Fuel passages in some adapters are drilled straight through adapters while others are cross drilled.

(c) Operate injector in calibrator, and check fuel output as follows:

1 Place injector adaptor between tie rods and engage it with fuel block locating pin, Then slide adaptor forward and up against fuel block face.

NOTE

Make sure counter on comparator is preset to 1,000 strokes. If for any reason this setting has been altered, reset counter to 1,000 strokes by twisting cover release button to left and holding reset lever in full up position while setting numbered wheels. Close cover. Refer to calibrator instruction book for further information.

2 Pull injector rack out to the NO FUEL position.

3 Start calibrator by turning switch to the ON position.

4 After calibrator has started, push injector rack in FULL FUEL position and allow injector to operate for approximately 30 seconds to purge air that may be in system.

5 After 30 seconds, press fuel flow start button (red). This will start flow of fuel into vial. Calibrator will automatically stop flow of fuel after 1,000 strokes.

6 Shut calibrator off.

7 Observe reading on vial and refer to Table 5-2 and determine whether injector fuel output falls within specified limits.

(d) Calibrator may be used to check and select a set of injectors which will inject same amount of fuel in each cylinder at a given throttle setting, thus resulting in a smooth running engine.

(e) An injector which passes all tests can be put back into service. However, an injector which fails to pass one or more test must be repaired or replaced.

c. Disassembly

(1) Support injector upright in injector assembly fixture or in injector vise jaws. Disassemble injector filter as illustrated in Figure 5-10.

(2) Refer to Figure 5-10 and remove follower stop pin.

Table 5-2. Fuel Check Chart

Calibrator Fuel Output

Injector	Minimum	Maximum
N65	64	68

NOTE

Whenever a fuel injector is disassembled, discard filters and gaskets and replace them.

(3) Disassemble injector follower, spring, and plunger as illustrated in Figure 5-10.

(4) Reverse fuel injector in fixture and disassemble remaining injector components as illustrated in figure 5-10.

(5) Lift injector straight up, being careful not to dislodge the spray tip and valve parts. Place all parts in a clean receptacle.

(6) When an injector has been in service for some time, the spray tip, even though clean on the outside, may not be pushed readily from nut with the fingers. If necessary, support nut on a wood block and tap tip through nut. Use care not to damage spray tip. A section of brass rod or tube should be used to tap on spray tip.

5-34 Fuel injector cleaning, inspection and repair

a. Cleaning

WARNING

Cleaning solvents are dangerous and can be toxic. Use only in well-ventilated areas. Observe all precautions stated on the container, and never put solvents in unmarked containers.

(1) Carbon on inside of spray tip may be loosened for easy removal by soaking about 15 minutes in a suitable solution prior to external cleaning and buffing. (Methyel Etheyl Ketone solution TT-M-261 D is recommended.)

CAUTION

Care must be exercised when inserting reamer in spray tip to avoid contacting needle valve seat in tip.

WARNING

Wear safety goggles when using compressed air.

(2) Clean spray tip with a reamer. Turn reamer in a clockwise direction to remove carbon deposits. Wash spray tip and dry with compressed air.

(3) Clean spray tip orifices with a pin vise and proper size spray tip cleaning wire. Before using a wire, hone the end of wire until it is smooth and free of burrs using a fine stone. Allow wire to extend 1/8 in from the tool.

(4) Clean exterior surface of spray tip using a brass wire buffing wheel. Place tip over drill end of spray tip cleaner tool and hold body of tip against buffing wheel. In this way, spray tip is rotating while being buffed.

(5) When body of spray tip is clean, lightly buff tip end in a similar manner. This cleans spray tip orifice area and will not plug orifice.

(6) Wash spray tip in clean fuel oil, use safety goggles and dry with moisture free compressed air.

(7) Clean and brush passages in injector body, using a fuel hole cleaning brush and rack hole cleaning brush. Use safety goggles and blow out passages; dry them with compressed air.

(8) Carefully insert reamer in injector body. Turn the reamer in a clockwise direction a few turns; then remove reamer and check face of ring for reamer contact. If reamer does not make contact over entire face of ring, repeat reaming procedure until reamer makes contact with entire face of ring. Clean opposite side of ring in a similar manner.

(9) Carefully insert reaming tool in injector nut. Turn reaming tool in a clockwise direction to remove carbon deposits. Use care In reaming to prevent removal of metal or setting up burrs on spray tip seat.

(10) Wash injector nut in clean fuel oil and dry with compressed air. Carbon deposits on spray tip seating surfaces of injector nut will result in poor sealing and consequent fuel leakage around spray tip.

(11) Carefully insert a . 375 in. diameter straight fluted reamer inside ring bore in injector body. Turn reamer in a clockwise direction and remove any burrs inside ring bore. Then, wash injector body in clean fuel oil and dry with compressed air.

(12) When handling Injector plunger, do not touch finished plunger surfaces with your fingers. Wash plunger and bushing with dean fuel oil and dry with compressed air. Be sure high pressure bleed hole inside of bushing is not plugged. If this hole is plugged, fuel leakage will occur at upper end of bushing where it will drain out of injector body vent and rack holes during engine operation, causing a serious oil dilution problem.

(13) After washing, submerge parts in a clean receptacle containing clean fuel oil. Keep parts of each injector assembly together.

b. Inspection

(1) Inspect teeth on control rack and control rack gear (Figure 5-10) for excessive wear or damage. Also, check for excessive wear in bore of gear, replace damaged or worn parts.

(2) Inspect injector follower for wear. Inspect both ends of spill deflector for sharp edges or burrs which could create burrs on injector body or injector nut and cause particles of metal to be introduced into spray tip and valve parts. Remove burrs with a 500 grit stone.

(3) Inspect follower spring for defects and check spring with a spring tester and a torque wrench. Injector follower spring (0. 142-inch diameter wire) has a free length of approximately 1. 504 inches and must be replaced when a load of less than 70 pounds will compress to 1.028 inches.

CAUTION

A faulty sealing surface will result in high fuel consumption and contamination of lubricating oil.

(4) Check seal ring area on injector body for burrs or scratches. Also check surface which contacts injector bushing for scratches, scuff marks, or other damage. If necessary, lap this surface.

(5) Replace any loose injector body plugs or a loose dowel pin. Install proper number tag on a replacement injector.

(6) Inspect injector plunger and bushing for scoring, erosion, chipping, or wear. Check for sharp edges on that portion of plunger which rides in gear. Remove sharp edges with a 500 grit stone. Wash plunger after stoning it. Use injector bushing 'Inspectalite" to check plunger bushing for cracks or chipping. Check locating pin in bushing. If pin is damaged or sheared off, it must be replaced. Slip plunger in bushing and check for free movement. Badly worn, chipped or scored plungers or bushings must be replaced. Plungers and bushings are mated parts and must be replaced as an assembly.

CAUTION

Injector plungers cannot be reworked to change the output. Grinding will destroy hardened case at the helix and result in chipping and seizure or scoring of plunger.

(7) Examine the spray tip seating surface of injector nut for nicks or burrs. Reseat surface or replace nut if it is severely damaged.

(8) Inspect sealing surfaces of injector parts with a magnifying glass. The slightest imperfections will prevent the Injector from operating properly. Check for burrs, nicks, erosion, cracks, chipping and excessive wear. Check for enlarged orifices in spray tip. Replace damaged or excessively worn parts.

5-35 Fuel injector reassembly and installation

a. Reassembly

(1) Filter Assembly

(a) Use new filters and gaskets and reassemble filter assembly in reverse of disassembly.

(b) Lubricate filter cap threads and torque cap to 65 to 75 lb ft. Install shipping caps on all openings to prevent any dirt particles from entering injector.

(c) Purge filters after installation by directing compressed air or fuel through filter caps.

(d) Install clean shipping caps on filters to prevent dirt from entering injector.

(2) Rack and Gear Assembly

(a) Refer to Figure 5-10 and note rack and gear assembly; then, proceed as follows:

(b) Hold injector body, bottom end up, and slide the rack through hole in body. Look into bore for gear. Then move rack so that drill marks can be observed; hold rack in this position.

(c) Slide the gear into injector body so that marked tooth is engaged between two marked teeth on rack as shown in insert (Figure 5-10).

(d) Place gear retainer on top of gear. Next, align locating pin in bushing with the slot in injector body; then slide the end of bushing into place.

(3) Injector Valve and Related Parts. After having lapped and cleaned injector valve and its related parts, refer to figure 5-6 and reassemble as follows:

(a) Support injector body, bottom end up in injector fixture or in injector vise jaws.

(b) Place a new seal on shoulder of injector body. Then, slide spill deflector over barrel of the bushing.

(c) Place valve seat on end of the bushing. Then, insert stem of valve in one end of valve spring and valve stop in other end. Lower valve and cage over this assembly so that valve stop seats in cage. Place valve cage assembly on valve seat.

(d) Locate check valve centrally on the cage and place spray tip over check valve and against valve cage.

(e) Lubricate threads in injector nut and carefully thread nut on injector body by hand with an oil-resistant type grease (MIL-G-6032). Rotate spray tip between your thumb and first finger while threading nut on injector body. As nut is being tightened by hand, spray tip should be increasingly difficult to turn. When nut is turned down as far as possible by hand, spray tip should then be too tight to turn with your fingers.

(f) Use a socket and torque wrench and tighten injector nut to 55-65 lb ft torque.

CAUTION

Do not exceed specified torque. Nut may be stretched and result in improper sealing of the lapped surfaces in injector.

(4) Plunger and Follower

(a) Invert injector assembly in fixture (filter cap end up), and push rack in all way. Then place follower spring on injector body.

(b) Refer to Figure 5-10 and place stop pin on the injector body so that tighter wound end of follower spring rests on narrow flange of stop pin. This end of follower spring has been cut so that end point is to outside. Then, align slot in follower with stop pin hole in injector body. Next, align flat side of plunger with slot in follower. Then, insert free end of plunger in injector body. Press down on follower and at same time press stop pin into position. When in place, spring will hold the stop pin in position.

(5) Check Spray Tip Concentricity. To ensure correct alignment, check concentricity of the spray tip as follows:

(a) Place injector in concentricity gage as illustrated in Figure 5-14 and adjust dial indicator to zero.

(b) Rotate injector to 360° and note total runout as indicated on dial.

(c) If total runout exceeds 0.008 in. remove injector from gage. Loosen injector nut, recenter spray tip, tighten nut to 55-65 lb ft torque and recheck concentricity.

(d) If after several attempts spray tip cannot be positioned satisfactorily, replace injector nut.

(6) Test Reconditioned Injector

(a) Before placing a reconditioned injector in service, perform all tests except visual inspection of plunger.

(b) The injector is satisfactory if it passes these tests. Failure to pass any one of tests indicates that defective or dirty parts have been assembled.

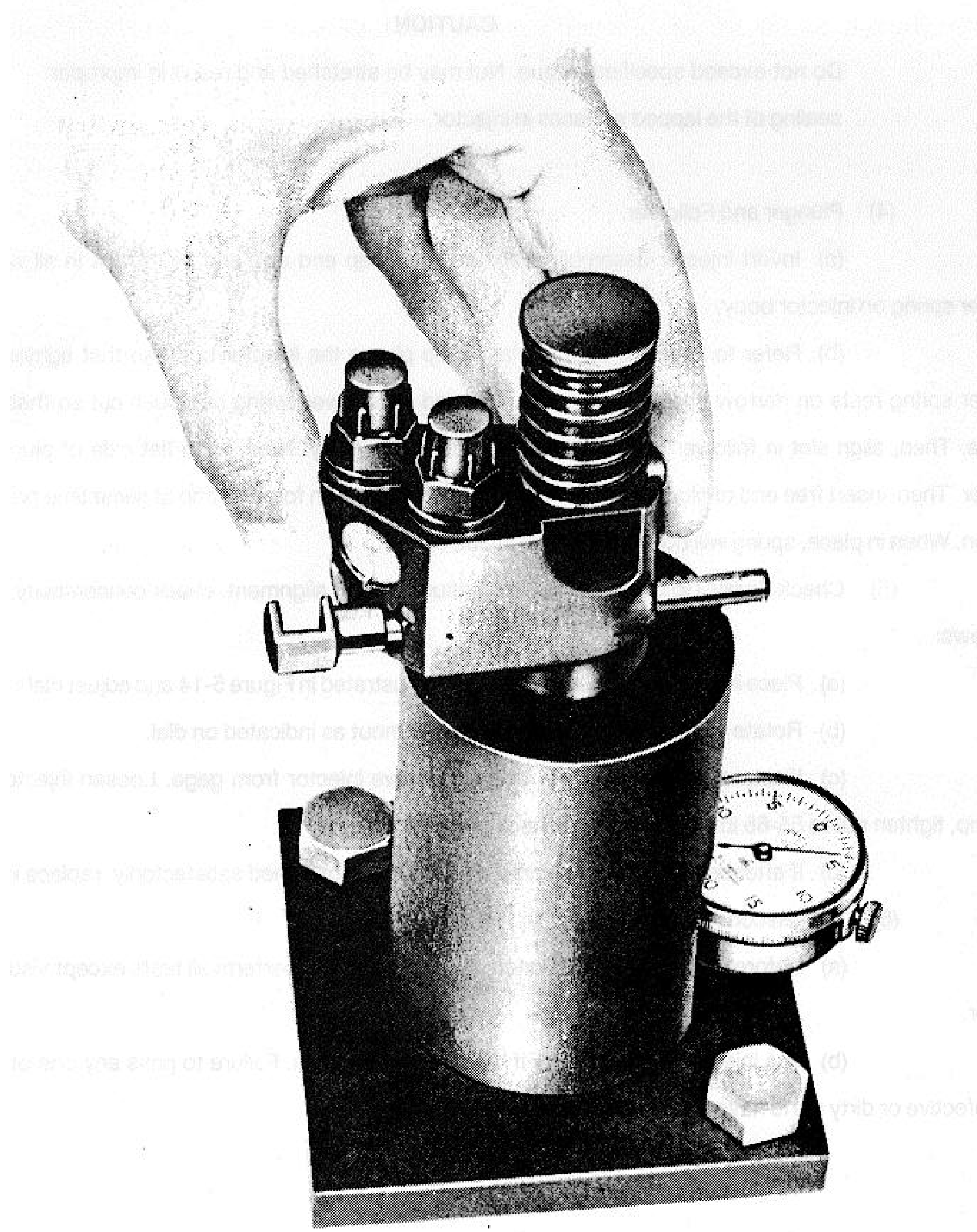


Figure 5-14. Checking Injector Spray Tip Concentricity.

b. Installation

(1) Before installing an injector in an engine, remove carbon deposits from beveled seat of injector tube in cylinder head. This will assure correct alignment of injector tube and prevent any undue stresses from being exerted against spray tip.

(2) Remove carbon deposits from beveled seat of injector tube in cylinder head. Exercise care to remove only the carbon so that proper clearance between injector body and cylinder head is maintained.

(3) Fill injector with clean fuel oil. If necessary, add clean fuel oil at inlet filter cap until it runs out outlet filter cap.

(4) Refer to Figure 5-12 and install fuel injector.

(a) Make sure dowel in injector body is aligned with dowel hole in cylinder head.

(b) Place injector clamp in place and install special washer. Install bolts and tighten to 20-25 lb ft torque. Make sure that clamp does not interfere with exhaust valve or injector springs.

NOTE

Check injector rack for free movement. Excess torque can cause injector control rack to stick or bind.

(c) Move rocker arm into position and secure rocker arm brackets to cylinder head by tightening bolts to 50-55 lb ft.

(d) Tighten fuel pipe connections to 12-15 lb ft torque.

(e) Adjust valve clearance.

(f) Time fuel injectors.

(g) Install rocker arm cover.

Section X. Fuel Pump and Fuel Filters

5-36 General

a. The fuel pump (Figure 5-15) is a positive displacement gear type. The pump circulates or transfers fuel from fuel tank to fuel injectors. The pump circulates excess supply of fuel through fuel injectors and through an aspirator valve to supply fluid for torque converter. The unused fuel returns to fuel tank.

b. The fuel pump body and cover are positioned by means of two dowels. The dowels aid in maintaining gear shaft alignment. The mating surfaces of pump body and cover are ground perfectly flat. No-gasket is used between cover and body since pump clearances are set up on a metal-to-metal contact basis. A very thin coating of sealant provides a seal against any irregularities in mating surfaces.

c. A spring-loaded relief valve incorporated in pump body normally remains in closed position, operating only when pressure on outlet side (to fuel filter) reaches approximately 65 psi.

d. The fuel pump draws fuel from fuel tank through strainer, and forces it under pressure through fuel filter. From filter, fuel is forced through fuel inlet passage in cylinder head and fuel lines into fuel injectors.

e. Fuel passes through a filter element within fuel injector to a chamber where it is metered, displaced, and atomized through spray tip into the combustion chamber.

f. Heat, generated during high compression of the air, ignites fine fuel spray and combustion continues until fuel is burned.

g. Fuel in excess of that required for engine operation is circulated through injectors by fuel pump and serves as a coolant. In addition to serving as a coolant, circulation of surplus fuel bleeds any air or vapor in system back to fuel tank where it is vented to atmosphere. Surplus fuel leaving injectors flows through outlet fuel line to fuel return passage and then through a restricted fitting and a tube back to fuel tank.

5-37 Fuel pump removal and disassembly

a. Removal. Remove fuel pump assembly as illustrated in Figure 5-15.

b. Disassembly

(1) Disassemble fuel pump in numerical sequence as illustrated in Figure 5-16.

(2) Remove drive shaft, drive gear, and retaining ball as an assembly.

(3) Press drive shaft through gear far enough to remove ball. Then invert shaft and gear assembly and press the shaft from gear. Do not press square end of shaft through gear.

(4) If oil seals need replacing, remove them as illustrated in Figure 5-17. Clamp pump body in a bench vise and screw threaded end of removal tool shaft into outer oil seal (seal nearest bolt flange). Tap pilot end of tool and remove seal. Repeat this operation on inner seal.

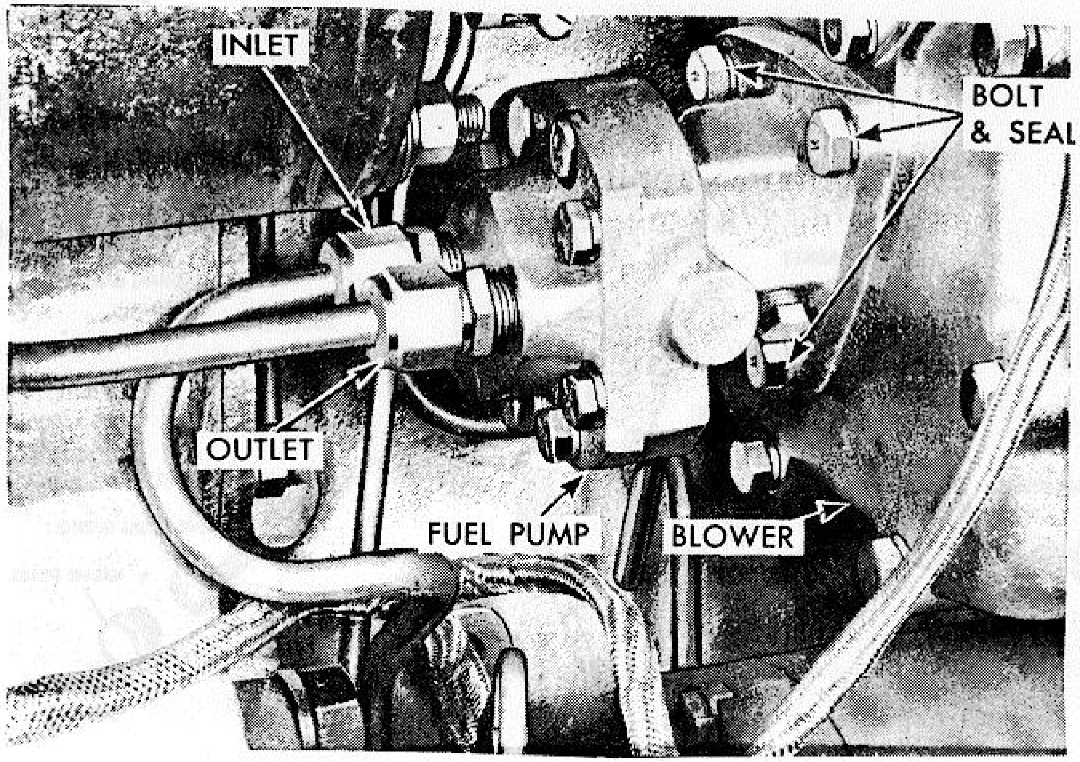


Figure 5-15. Fuel Pump Removal and Installation.

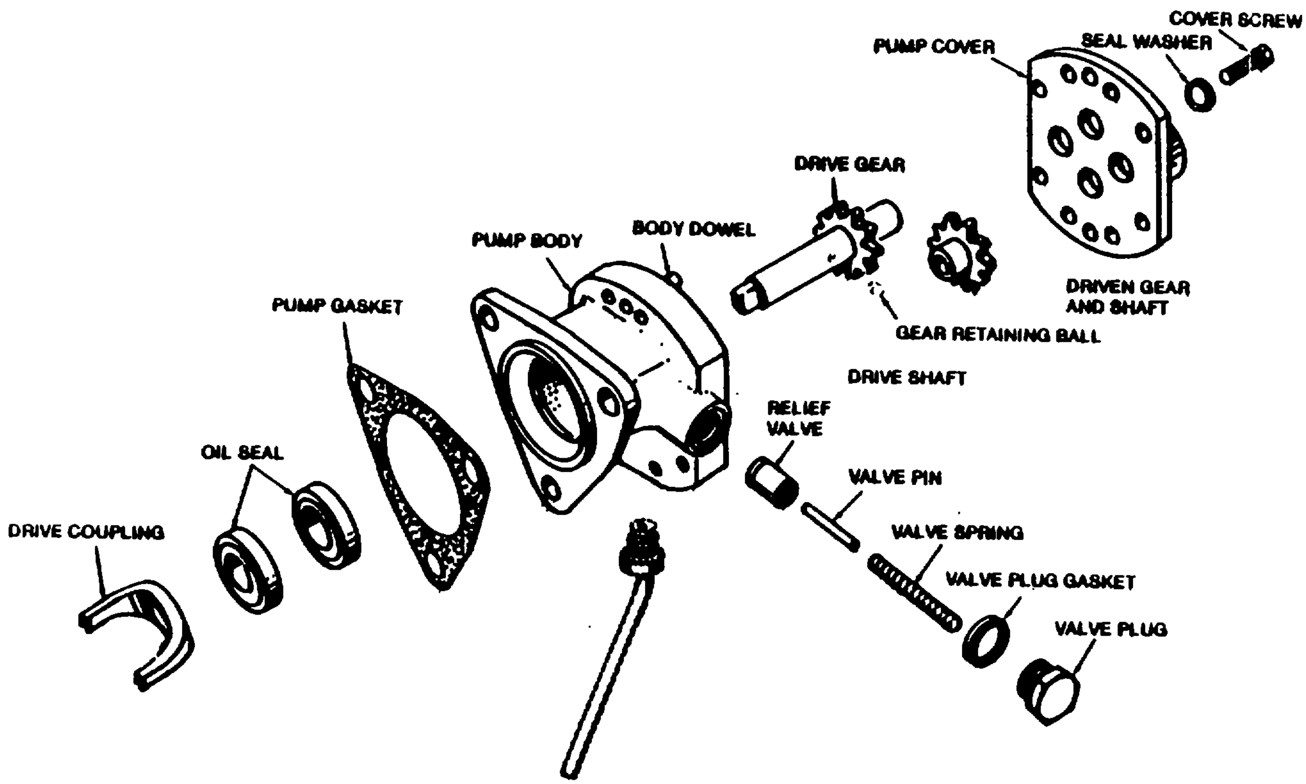


Figure 5-16. Fuel Pump Disassembly and Reassembly.

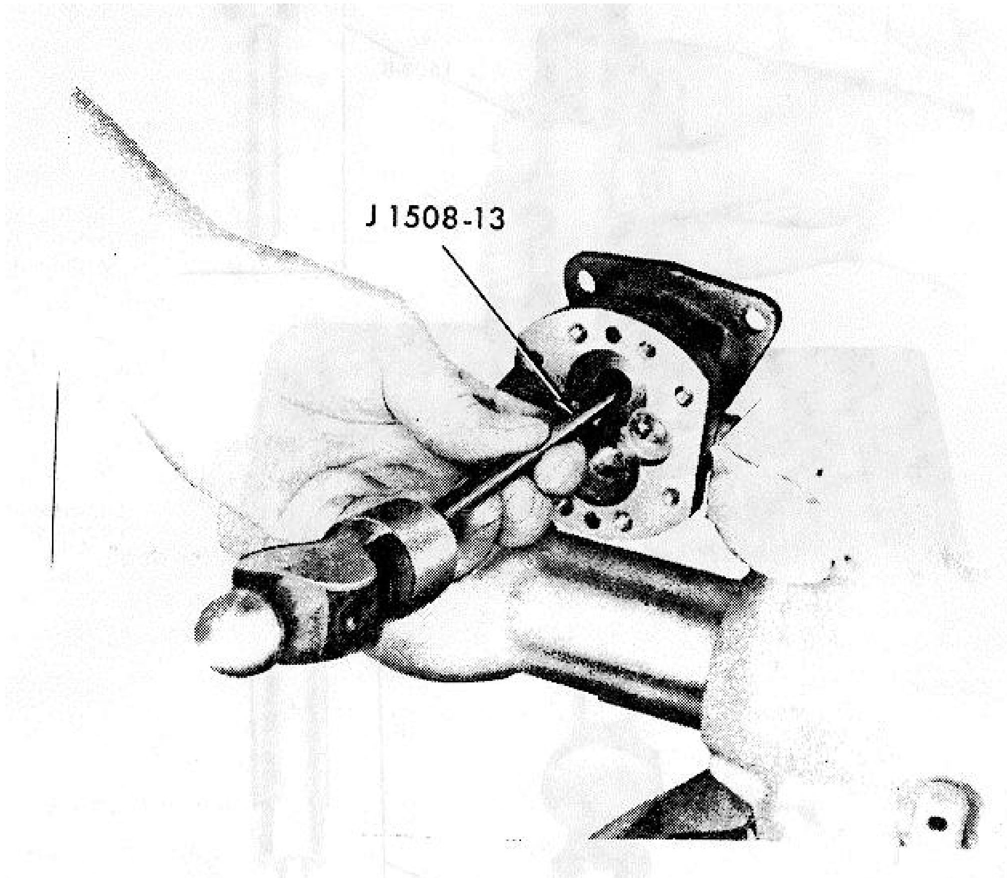


Figure 5-17. Fuel Pump Seal Removal (Sheet 1 of 2).

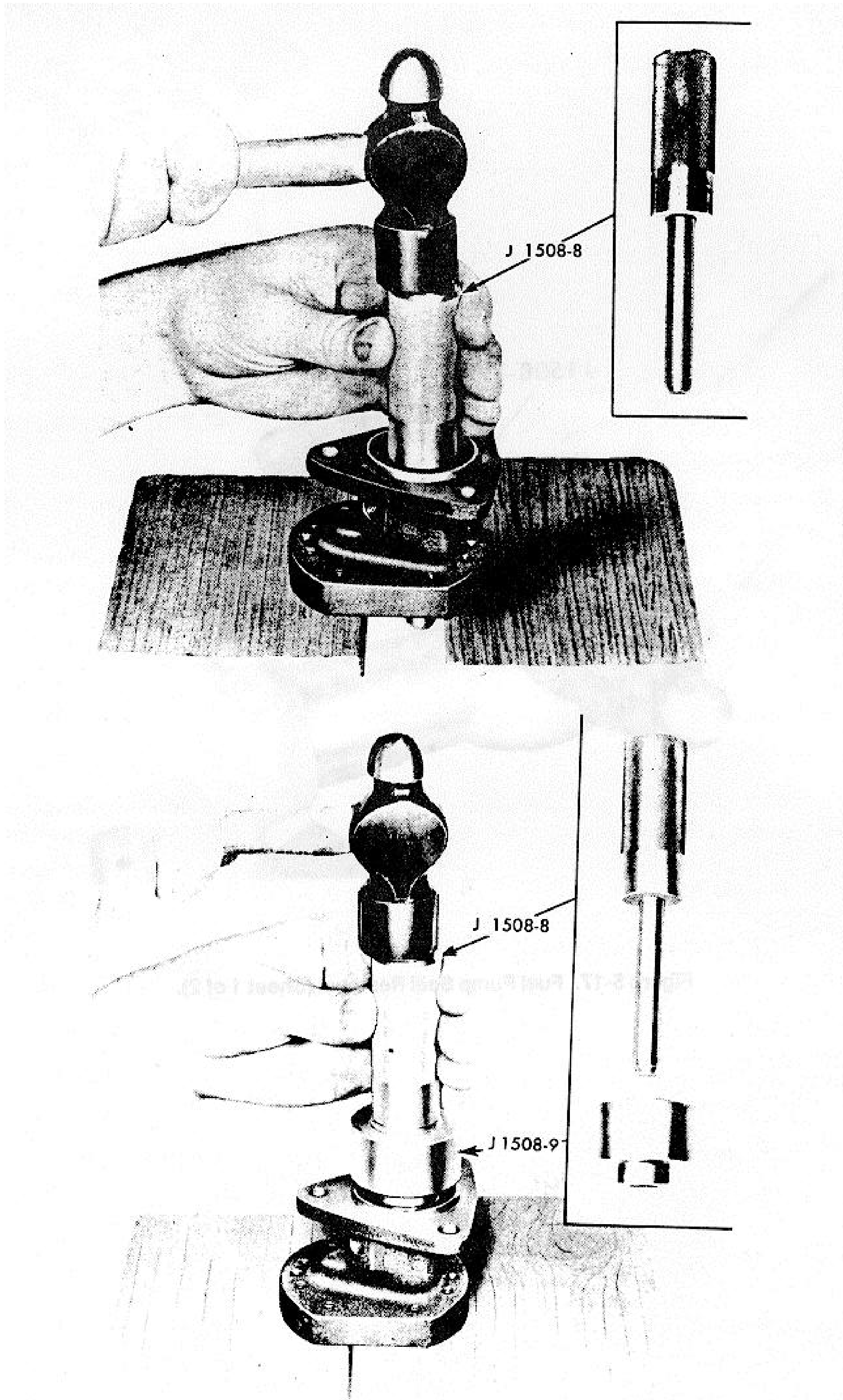


Figure 5-17. Fuel Pump Seal Installation (Sheet 2 or 2).

5-38 Fuel pump cleaning, inspection and repair

a. Wash all parts in cleaning solvent and dry thoroughly.

b. Discard and replace mounting gaskets. Discard and replace oil seals if removed from pump body.

c. Inspect pump gear teeth for scoring or chipping.

d. Inspect mating surfaces of pump body and cover. The surface must be flat and smooth and free from nicks.

e. Inspect relief valve to make sure it is free from score marks.

f. Repair minor nicks and burrs with a fine crocus cloth. Replace all defective parts.

5-39 Fuel pump reassembly and installation

a. Reassembly

(1) Reassemble fuel pump in reverse sequence illustrated in Figure 5-16.

(2) Install inner oil seal, with lip of oil seal facing toward shoulder of tool. Drive seal in until it bottoms in body counterbore.

(3) Support pump body on wood blocks and install outer oil seal. Install lip of seal facing the adapter, then insert pilot of installer into pump so seal starts straight into pump flange. Drive seal into the pump body until shoulder of adapter contacts body.

(4) Lubricate outside diameter of relief valve (Figure 5-15), and install the valve, pin, spring, gasket, and plug.

(5) Press drive gear on the shaft beyond retaining ball hole in drive shaft. Then, place retaining ball in hole, and press gear back until ends of slot contacts ball.

(6) Lubricate shaft and gears with clean engine oil. Install drive shaft and driven gear shaft, and gear assembly into the pump body.

(7) Apply a thin coat of sealer on face of pump cover outside gear pocket area. Install pump cover and secure with eight cover screws.

(8) After assembly rotate pump shaft by hand to make certain parts rotate freely.

b. Installation. Install fuel pump in reverse sequence of removal procedure.

Section XI. Variable Speed Governor

5-40 General

a. The variable speed mechanical governor is designed to control engine idle speed, limit maximum no load speed, and hold engine at any constant speed between idle and maximum as desired by operator.

b. The governor is a double-weight speed limiting governor and is mounted on right front side of the engine. It is driven by a shaft that extends through end plate and keys to balance shaft gear.

c. Two manual controls are provided on governor: a stop lever and a speed control lever. In its normal position, stop lever holds fuel injector rack near full-fuel position. When engine is started, governor moves injector racks toward idle speed position. The engine speed is then controlled by movement of speed control lever.

d. The governor is lubricated by oil splashed from engine gear train. The oil passes through governor weight housing to shaft and weight assembly. The revolving weights distribute oil to various moving parts of governor. The surplus oil drains back to engine crankcase through holes in governor bearing retainer.

5-41 Governor operation check

a. Governor deficiencies are usually indicated by speed variations to engine; however, it does not necessarily mean that all such speed fluctuations are caused by governor. Therefore, when improper speed variations appear, engine must be checked as follows before removal and disassembly of governor:

(1) Make sure governor speed changes are not result of excessive load fluctuations.

(2) Make sure that all cylinders are firing properly. The deficiency could be in fuel injectors.

(3) Check for binding in governor operating mechanism or in linkage between governor and injector control tubes.

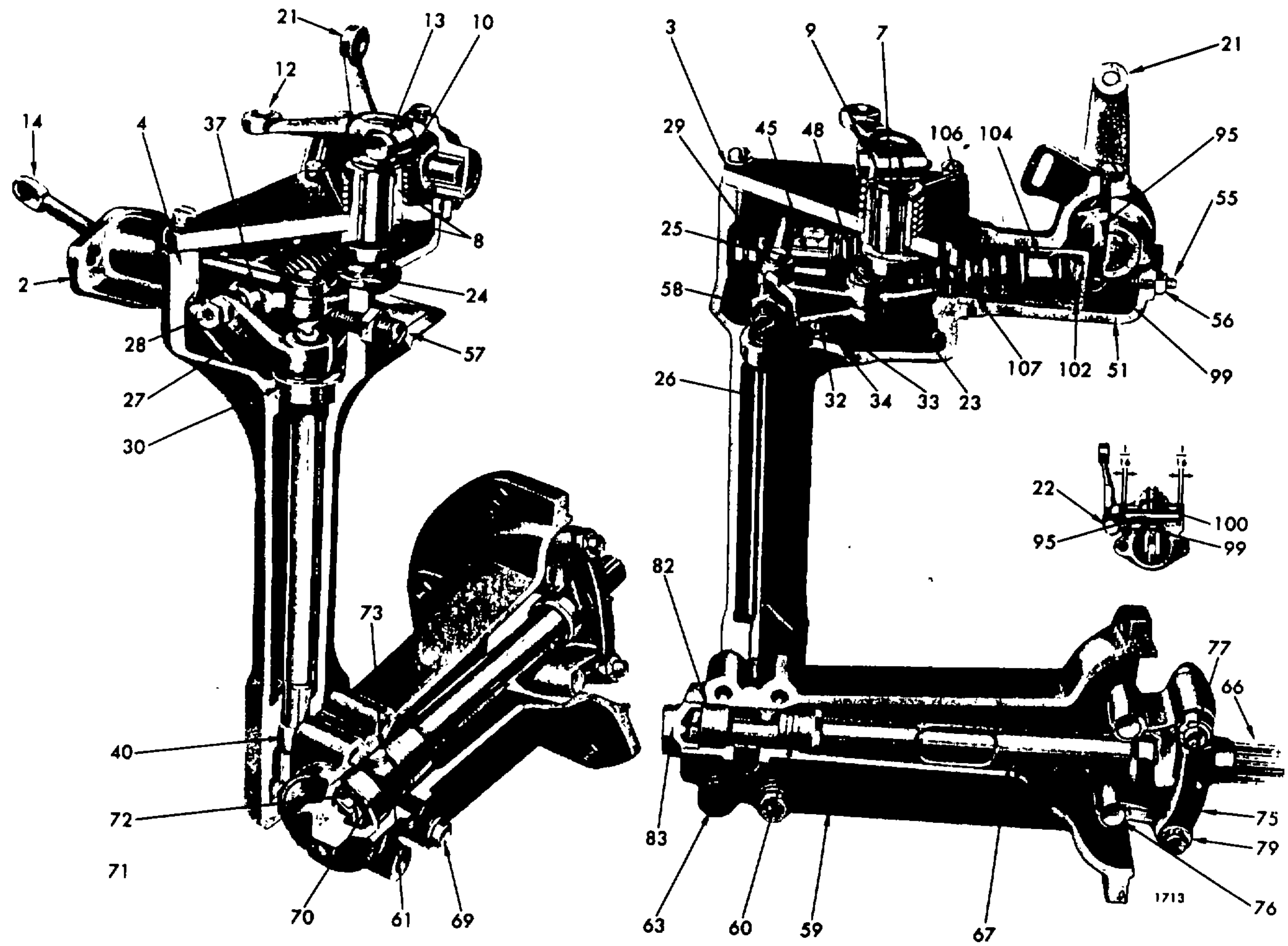
b. With fuel rod connected to fuel injector control tube lever, mechanism must be free from binding throughout the entire travel of fuel injector racks. If friction exists in mechanism, it can be located and corrected as follows:

(1) If injector rack sticks or moves too hard, the injector hold-down clamp maybe too tight or improperly positioned. To correct condition, loosen injector clamp, reposition and tighten to 20-25 lb ft torque.

(2) A binding injector may be caused by internal dirt accumulation, defective plunger and bushing, or a bent injector rack. The injector must then be removed, reconditioned and tested.

(3) An injector rack may bind as a result of an improperly positioned rack control lever. Loosen control rack adjusting screw. If this relieves bind, relocate lever or control tube and reposition rack as outlined in (4) below.

(4) The injector control tube may bind in its support brackets, thus preventing free movement of injector racks to their no-fuel position due to tension on return spring. This condition may be corrected by loosening and realigning control tube support brackets. If control tube support brackets were loosened, realigned and tightened, then injector racks must be repositioned as outlined in (3) above.



2. Housing-Governor Control
3. Cover--Governor
4. Gasket
7. Shaft--Control Lever
8. Bearing--Shaft
9. Ring--Seal.
10. Retainer--Seal Ring
12. Lever--Stop
13. Bolt
14. Rod--Fuel
21. Lever—Speed Control
22. Bolt
23. Lever—Differential
24. Washer--Lever Pin
25. Retainer—Spring
26. Shaft—Operating
27. Lever—Operating Shaft
28. Screw--Gap Adjusting
29. Lock Nut
30. Bearing--Operating Shaft
32. Screw
33. Washer--Flat
34. Lock Washer
37. Guide--Plunger
40. Bushing--Operating Shaft
45. Plunger--Variable Speed Spring
48. Spring--Variable Speed
51. Housing--Variable Speed Spring
55. Screw--Idle Speed Adjusting
56. Lock Nut
57. Screw--Buffer
58. Lock Nut
59. Housing--Weight
60. Bearing--Thrust
66. Shaft Assy.—Weight
67. Riser—Governor
68. Lock Washer
69. Bolt
70. Bearing--Shaft End
71. Bolt--Retaining
72. Lock Washer
73. Fork--Operating Shaft
75. Carrier--Weight
76. Weight Assy.--Governor
77. Pin--Weight
79. Lock Ring
82. Gasket
83. Plug--Weight Housing
95. Shaft--Speed Control Lever
99. Lever--Variable Speed Spring
100. Screw--Set
102. Shim
104. Plunger--Variable
106. Stop
107. Stop

Figure 5-18. Variable Speed Mechanical Governor. (1 of 2)

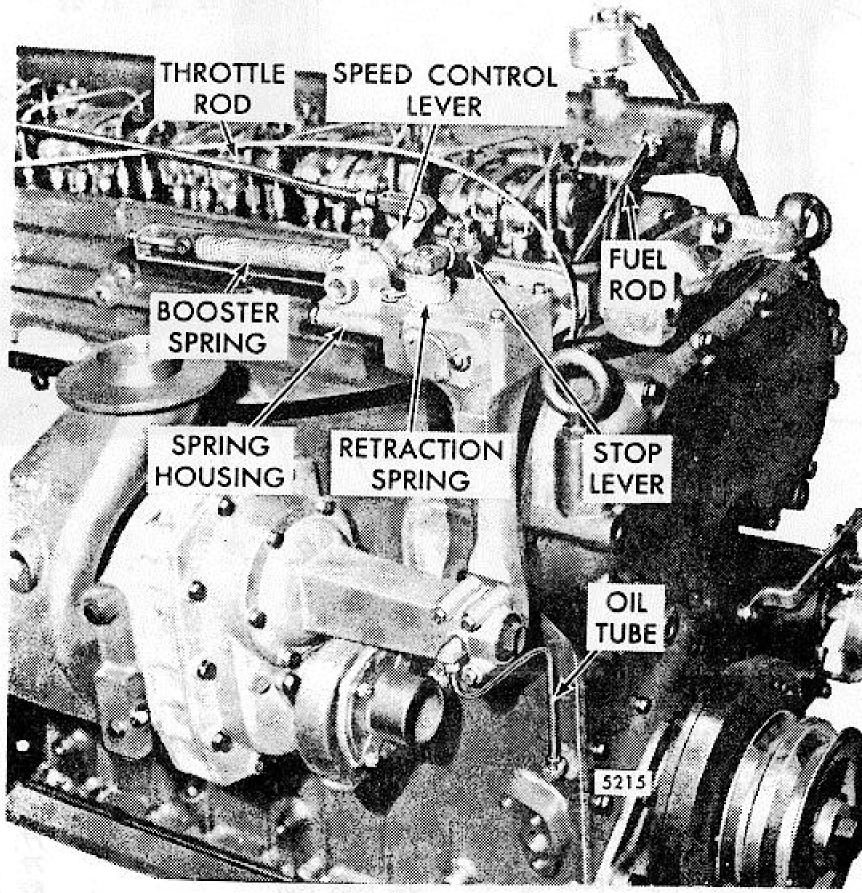


Figure 5-18. Variable Speed Governor Mount. (2 of 2)

(5) A bent injector control tube return spring may cause friction in operation of injector control tube. If spring has been bent or damaged, install a new spring.

(6) Check for binding at pin which connects fuel rod to injector control tube lever. Replace pin if necessary.

c. After making preceding checks, if governor fails to control engine properly, governor must be removed and reconditioned.

5-42 Governor adjustment

NOTE

Governor adjustments must be made simultaneously with adjustment of valves, injectors and control rod assembly. Do not adjust governor unless a complete tune-up is accomplished.

a. Air Gap Adjustment

(1) Disconnect governor control linkage and remove governor top cover as illustrated in Figure 5-19.

(2) Adjust governor air gap to 0. 0016 inch.

b. Positioning Injector Control Levers

(1) The position of fuel injector control rack must be set in relation to governor. Their position determines amount of fuel injected into each cylinder and ensures equal distribution of load. Properly positioned injector rack control levers with engine in full load will result in following:

(a) Speed control lever at maximum position.

(b) Governor low-speed gap closed.

(c) Stop lever in run position.

(d) High speed spring plunger on seat in governor control housing.

(e) Injector fuel control rack in FULL FUEL position.

(2) Adjust number 1 injector control rack lever first to establish a guide for adjusting remaining injector rack control levers.

(3) Adjust fuel injector control levers.

c. Maximum No-Load Speed Adjustment. Maximum no-load speed on engines equipped with variable speed governors must not be less than 125 rpm or more than 150 rpm above recommended load speed. Using a hand tachometer, determine maximum no-load speed of engine. If required, make following adjustments:

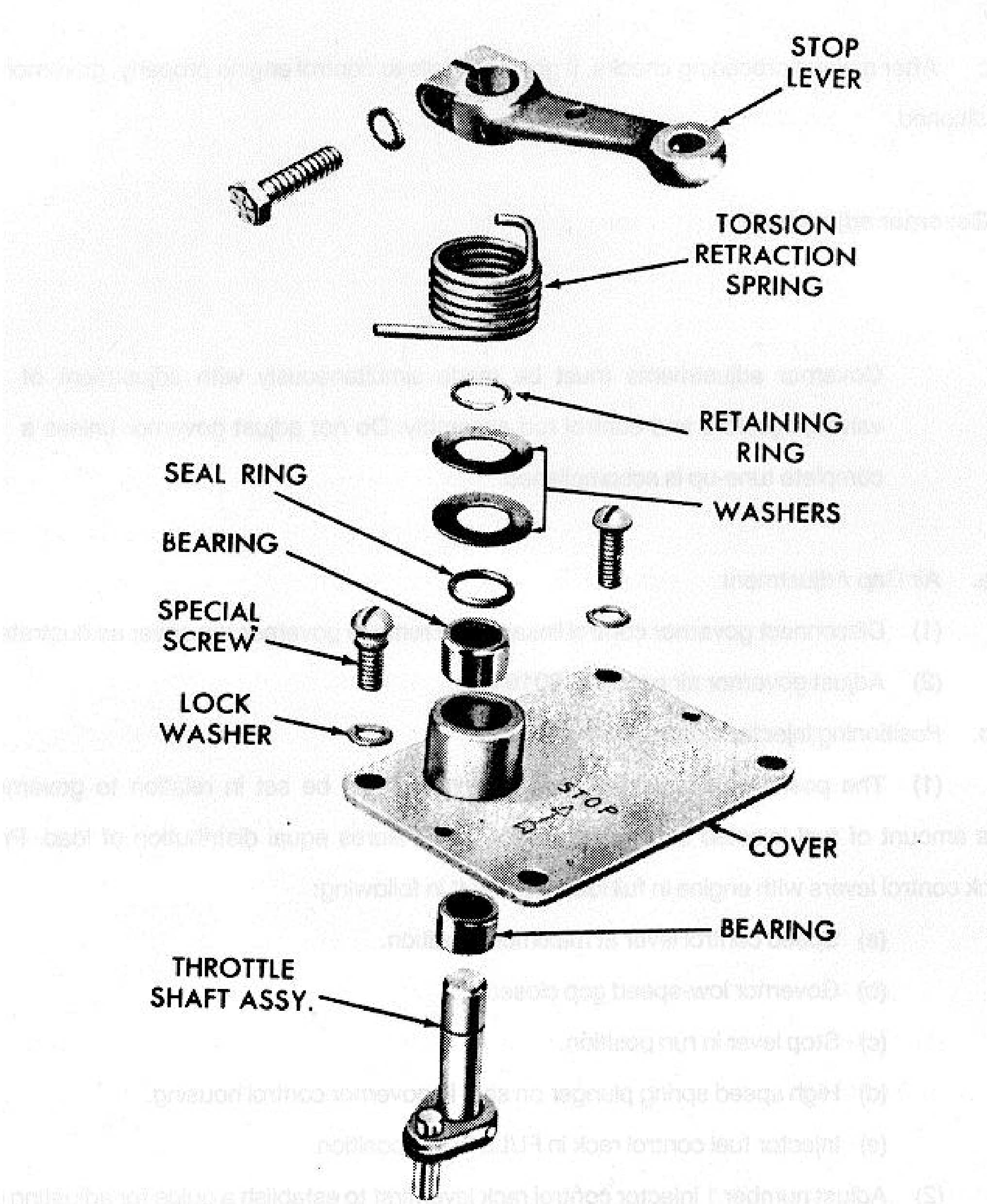


Figure 5-19. Governor Cover Details.

(1) With engine running, move speed control lever to maximum speed position. Use an accurate tachometer to determine no-load speed of engine.

NOTE

Do not overspeed the engine.

(2) Loosen locknut and adjust maximum speed adjusting screw until required no-load speed is obtained.

(3) Hold adjusting screw and tighten locknut.

NOTE

If maximum no-load speed is raised or lowered more than 50 rpm by installation or removal of governor shims, governor gap must be readjusted.

(4) Hold high-speed spring retainer and tighten locknut.

d. Idle Speed Adjustment. After maximum no-load speed has been set, adjust the idle speed as follows:

(1) Place stop lever in RUN position and speed control lever in IDLE position.

(2) Start engine and allow to warm up to normal operating temperature.

(3) Back out buffer screw to avoid contact with the differential lever.

(4) Loosen buffer screw locknut and turn idle speed adjusting screw until engine is operating at approximately 15 rpm below the recommended idle speed.

NOTE

The recommended idle speed is 500 to 600 rpm.

e. Buffer Screw Adjustment.

(1) After adjusting idle speed to 15 rpm below recommended speed, loosen buffer-screw locknut and turn buffer screw in until it just comes in contact with differential lever while still eliminating engine roll.

NOTE

Do not increase engine idle speed more than 15 rpm with buffer screw.

(2) Recheck maximum no-load speed. If it has increased more than 25 rpm from maximum speed attained in para c, back off buffer screw until increase is less than 25 rpm.

(3) Hold buffer screw and tighten buffer screw locknut.

5-43 Governor removal and disassembly

a. Removal

(1) Disconnect throttle rod and booster spring from speed control lever.

(2) Disconnect retaining spring from stop lever. Also disconnect any linkage attached to stop lever.

(3) Remove four screws from cover, lever retaining spring, governor cover and gasket from governor housing.

(4) Refer to figure 5-18 and disconnect rods from the stop lever and speed control lever.

(5) Disconnect oil tube at governor weight housing, or cover, if used.

(6) Remove two governor-to-cylinder head bolts.

(7) Remove control housing from cylinder head and weight housing.

(8) Remove six governor weight housing-to-blower bolts; then withdraw housing from blower.

(9) Disconnect fuel lines from fuel pump. Remove fuel pump from governor weight housing.

(10) Disconnect lubricating oil tube from control housing and governor weight housing.

(11) Withdraw five bolts from weight housing and two bolts from control housing. Remove governor and gaskets from engine.

(12) Remove fuel rod from differential lever.

b. Install Governor

(1) Affix a new governor-to-blower gasket to governor weight housing. Refer to Figure 6-15 and start splined end of weight shaft into upper blower rotor and position housing against blower end plate.

(2) Place a new copper gasket on each weight housing-to-blower bolt and thread bolts into blower end plate; finger tighten only.

(3) Place a new gasket over dowels and against side of weight housing facing engine.

(4) Move thrust bearing assembly and riser toward weight end of shaft.

(5) Refer to Figure 5-18 and position the lower end of control housing over dowel pins of weight housing.

NOTE

The finished surface of operating fork must be placed against outer side of thrust bearing.

(6) Use new gasket and attach governor control housing to cylinder head with two bolts (Figure 5-18). Tighten bolts.

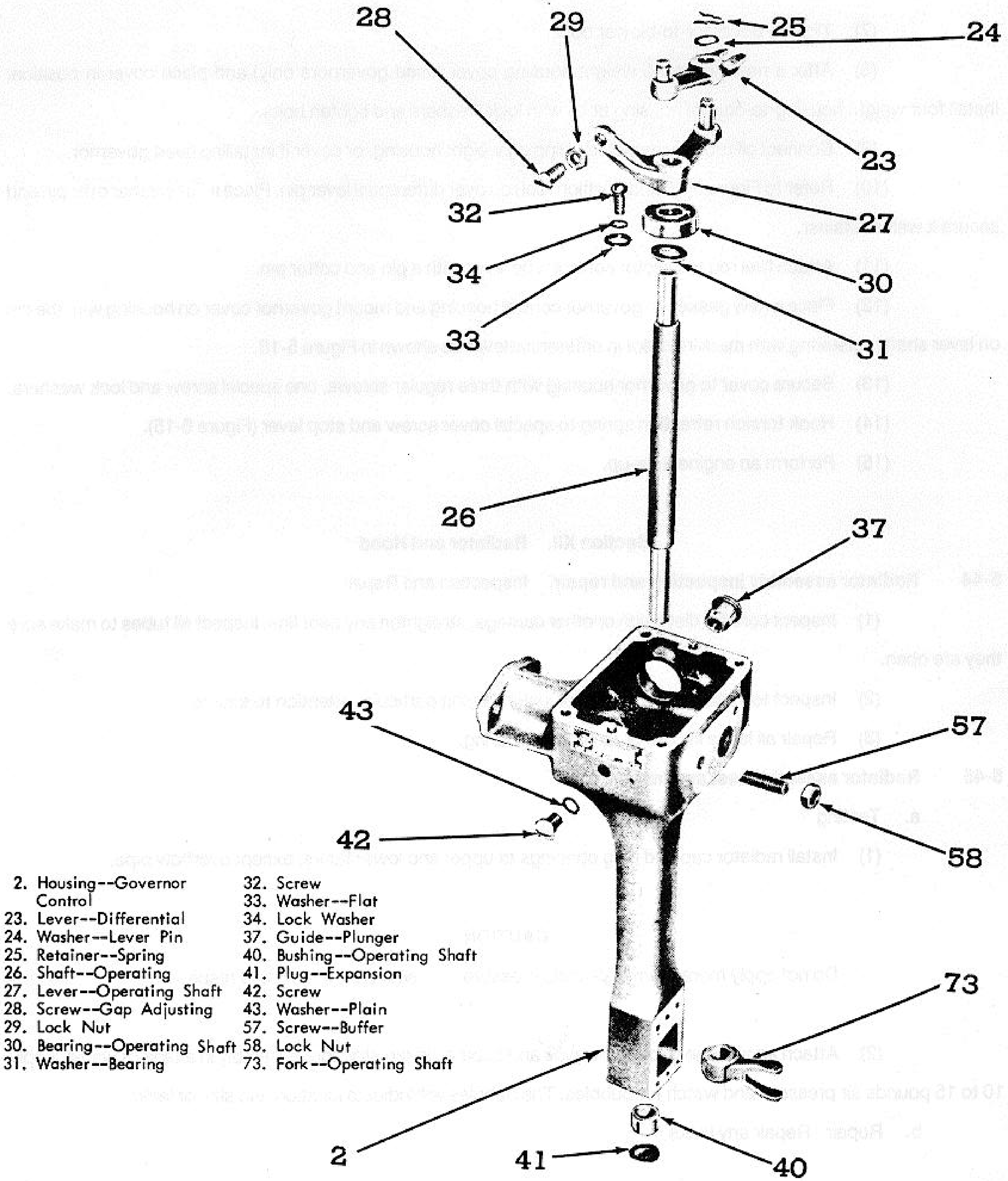


Figure 5-20. Governor Control Housing.

(7) Tighten governor-to-blower bolts.

(8) Affix a new gasket to weight housing cover (used governors only) and place cover in position. Install four weight housing-to-control housing bolts with lock washers and tighten bolts.

(9) Connect oil tube to restricted fitting on weight housing, or cover if installing used governor.

(10) Refer to Figure 5-18 and position fuel rod over differential lever pin. Place a flat washer over pin and secure it with a retainer.

(11) Attach fuel rod to injector control tube lever with a pin and cotter pin.

(12) Place a new gasket on governor control housing and mount governor cover on housing with the pin on lever shaft registering with machined slot in differential lever as shown in Figure 5-18.

(13) Secure cover to governor housing with three regular screws, one special screw and lock washers.

(14) Hook torsion retraction spring to special cover screw and stop lever (Figure 6-15).

(15) Perform an engine tune-up.

Section XII. Radiator and Hood

5-44 Radiator assembly inspection and repair. Inspection and Repair.

(1) Inspect core for distortion or other damage; straighten any bent fins. Inspect all tubes to make sure they are open.

(2) Inspect top and bottom tanks for leaks, paying particular attention to seams.

(3) Repair all leaks in core or tanks by soldering.

5-45 Radiator assembly test and installation

a. Testing

(1) Install radiator cap and plug openings at upper and lower tanks, except overflow pipe.

CAUTION

Do not apply more than 15 pounds pressure, as serious damage could result.

(2) Attach an air hose to overflow pipe and submerge radiator core assembly in a tank of water. Apply 10 to 15 pounds air pressure and watch for bubbles. The bubbles will indicate location and size of leaks.

b. Repair. Repair any leaks.

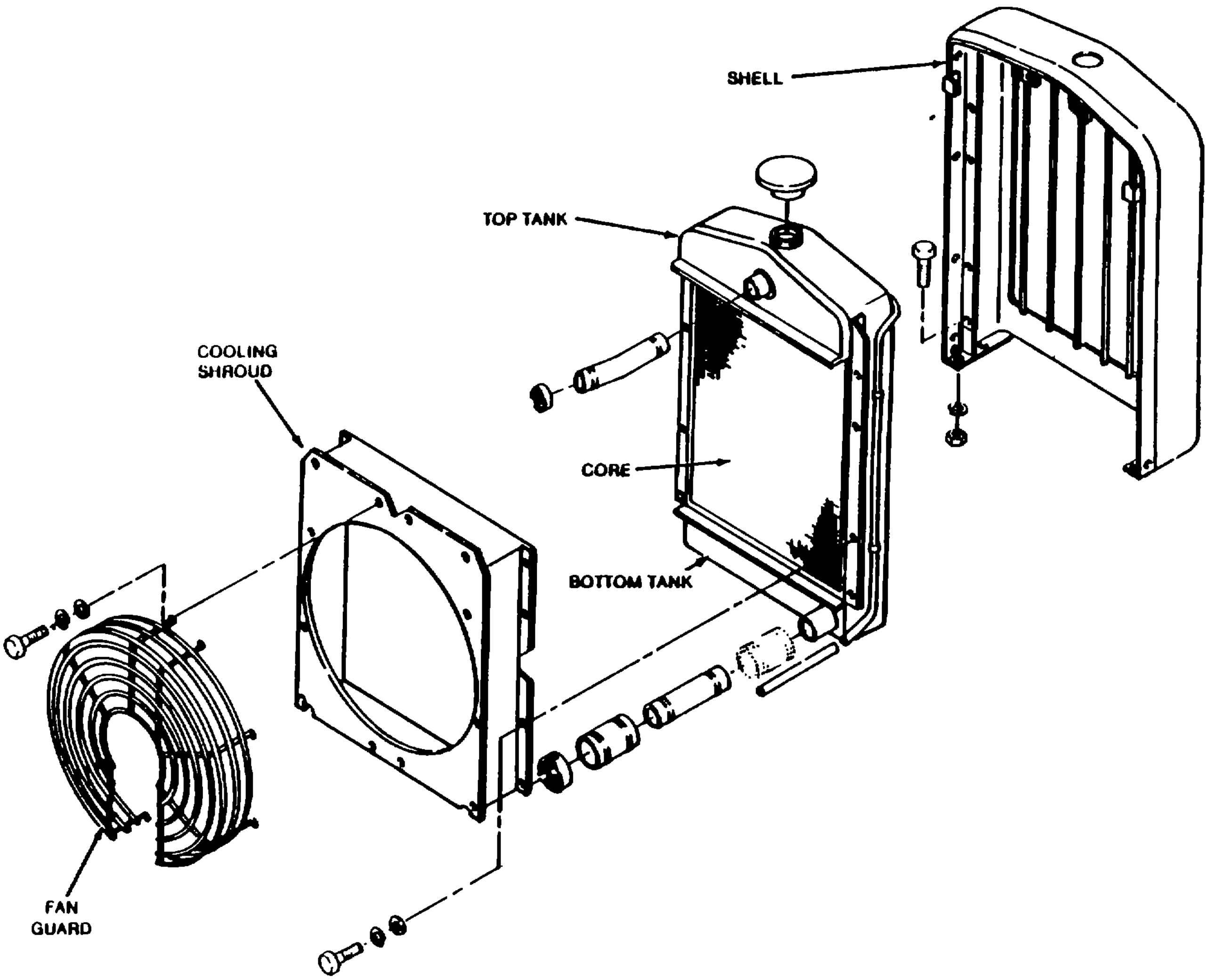


Figure 5-21. Radiator Disassembly and Reassembly.

Section XIII. Water Pump and Fan

5-46 General

a. Water Pump. The water pump assembly is mounted on oil cooler and is driven by camshaft pulley. It is a centrifugal type and circulates coolant through cylinder block, cylinder head, radiator heat exchanger and oil cooler. The drive end of pump shaft is supported by a sealed double-row combination radial and thrust ball bearing. The pump shaft serves as an inner race for bearing.

b. Fan Assembly. The fan assembly, used for cooling engine, is driven by belts directly from crankshaft. The fan is heavy duty five blade type.

5-47 Water pump disassembly

NOTE

Clean the corrosion from around impeller and shaft before separating shaft and bearing assembly from impeller, seal and water pump body.

a. Note position of pulley on shaft so that it can be assembled in same position.

b. Use a suitable puller and remove pulley.

c. Refer to Figure 5-22 and remove pump cover and gasket. Discard gasket.

d. Press shaft and bearing assembly, seal, and impeller out of pump body as an assembly, by applying pressure on bearing outer race with a remove.

CAUTION

The bearing will be damaged if pump is disassembled by pressing on end of pump shaft.

e. Press end of shaft out of impeller placing shaft long end down in an arbor press. Use a drift and press shaft out of impeller.

f. Remove seal assembly from pump shaft and discard.

5-48 Water pump cleaning, inspection and repair

WARNING

Cleaning solvents are dangerous and can be toxic. Use only in well-ventilated areas. Observe all precautions stated on the container, and never put solvents in unmarked containers.

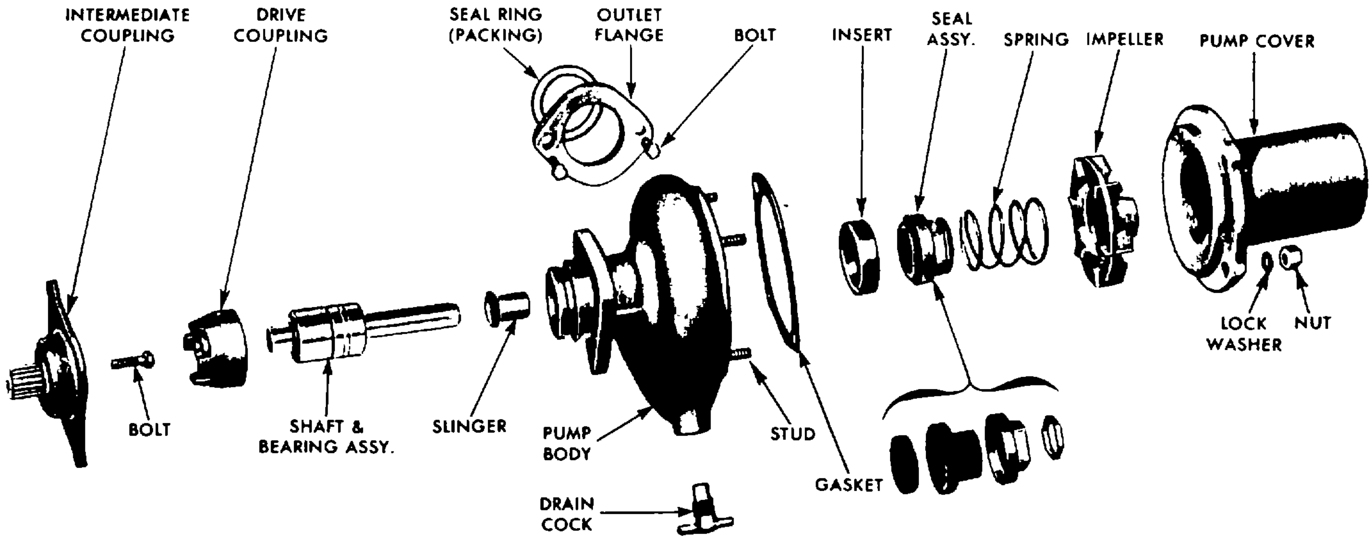


Figure 5-22. Water Pump Disassembly and Reassembly.

a. Cleaning. Clean all parts except shaft and bearing assembly with cleaning solvent and dry thoroughly.

b. Inspection and Repair

(1) Inspect pump shaft and bearing for rough spots or excessive wear. If worn, replace shaft and bearing assembly.

(2) Inspect impeller for cracks, breaks or excessive wear.

(3) Inspect all hardware and threaded areas for damage.

(4) Repair by replacement of defective parts.

5-49 Water pump reassembly and installation

a. Reassembly

(1) Reassemble water pump assembly in the reverse sequence of disassembly procedure.

(2) Before installing a new seal insert make sure counterbore in body is clean.

(3) Press shaft and bearing assembly into pump body. Press against outer race of shaft and bearing assembly until outer race of bearing is flush with pump body.

(4) Lightly coat outside diameter of new seal with sealing compound (MIL-5- 45180). With face of the body and bearing outer race supported install seal by pressing on outer flange.

(5) Support pulley end of shaft in an arbor press and press impeller on shaft. End of shaft must be flush with impeller hub.

(6) Place pulley on bed of an arbor press. Apply ram to impeller end of shaft until pulley is seated in its original position.

(7) Install a new gasket and pump cover.

5-50 Fan assembly, disassembly

a. Measure and record distance between fan pulley and adjusting bracket. This measurement will be utilized for reassembly.

b. Remove fan pulley from shaft with a puller.

c. Place bracket assembly in an arbor press and, using a suitable sleeve to press on bearing outer race, press bearing and sleeve out of bracket.

5-51 Fan assembly, cleaning, inspection and repair

WARNING

Cleaning solvents are dangerous and can be toxic. Use only in well-ventilated areas. Observe all precautions stated on the container, and never put solvents in unmarked containers.

a. Cleaning. Clean all parts except bearings and seals with cleaning solvent and dry thoroughly.

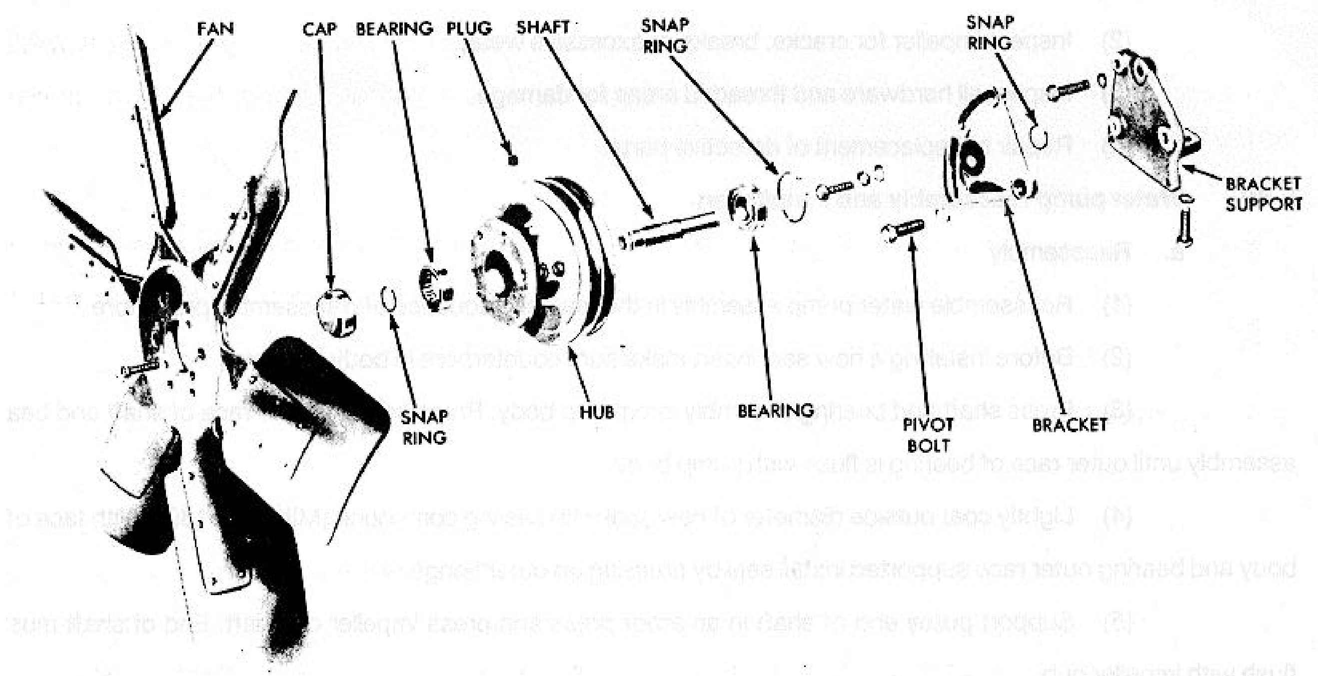


Figure 5-23. Fan Disassembly and Reassembly.

b. Inspection and Repair

(1) Inspect bearings for excessive wear or rough spots.

(2) Inspect fan blade assembly for cracks, bends or breaks.

(3) Remove any rust or rough spots from grooves of fan pulley and crankshaft pulley.

(4) Discard and replace all seals.

(5) Repair by replacement of defective parts.

5-52 Fan assembly, reassembly and installation. Reassemble fan assembly in reverse sequence of disassembly procedure.

Section XIV. Oil Cooler and Oil Filter

5-53 General

a. Oil Cooler

(1) Engine oil cooler is mounted on lower right front side of engine block in front of oil filter.

(2) Cooling water circulated through oil cooler completely surrounds oil cooler core. Oil cooler housing is attached to an oil cooler adaptor, which in turn is attached to cylinder block. Flow of oil is from oil pump through a passage in oil cooler adaptor to full flow oil filter, (which is also mounted on adaptor) and then through oil cooler core and cylinder block galleries.

(3) If oil cooler should become plugged, a bypass valve located near top of lower engine front cover, bypasses oil from oil pump discharge port directly to oil galleries in cylinder block. Bypass valve opens at approximately 52 psi.

b. Oil Filter

(1) Engine oil filter is mounted on lower right front of engine just behind oil cooler and below blower.

(2) Full flow oil filter consists of a replaceable element enclosed within a shell. A bypass valve, which opens at 18 to 21 psi, is located in adaptor to ensure engine lubrication should filter become clogged.

5-54 Oil cooler, removal and disassembly

a. Removal

(1) Drain cooling system.

(2) Loosen and slide clamps and hose back on water inlet elbow on cylinder block.

(3) Loosen and slide clamps and hose back on tube leading from thermostat to water pump.

(4) Remove bolts and lock washers which attach the water pump to the oil cooler housing.

(5) Remove the oil filter assembly.

(6) Matchmark end of oil cooler housing, cooler core and adaptor with a punch or file so they can be reinstalled in same position.

(7) Refer to Figure 5-24 and remove bolts and lockwashers which attach oil cooler housing to adaptor.

CAUTION

When removing the housing and core do not drop the core. Damage to the core could cause oil to leak into the cooling system during engine operation. Core damage could also allow water to leak into the oil when the engine is shut down. Either problem has the potential of ruining the engine.

(8) Remove housing and core as an assembly.

(9) Remove oil cooler adaptor as required.

(10) Remove all gasket material from mating surfaces.

b. Disassembly. Disassemble oil cooler as illustrated in Figure 5-24.

5-55 Oil cooler cleaning, test, inspection, and repair

WARNING

This operation must be performed in open air or in a well ventilated room when trichloroethylene or other toxic chemicals are used for cleaning.

a. Cleaning

(1) Clean oil side of cooler by circulating a solution of trichloroethylene through core passages with a force pump to remove carbon and sludge.

(2) Clean core before sludge hardens. If oil passages are badly clogged, circulate an alkaline solution through core and flush thoroughly with clean hot water.

(3) Clean water side of oil cooler core as follows:

WARNING

Wear eye protection when using strong chemicals.

(a) Add 1/2 pound of oxalic acid to each 2 1/2 gallons of solution composed of 1/3 muriatic acid and 2/3 water.

(b) Immerse cooler core in solution.

(c) Cleaning action is indicated by a bubbling and foaming action.

(d) Watch solution. When bubbling stops (30 to 60 seconds), remove core from solution and flush thoroughly with clean hot water.

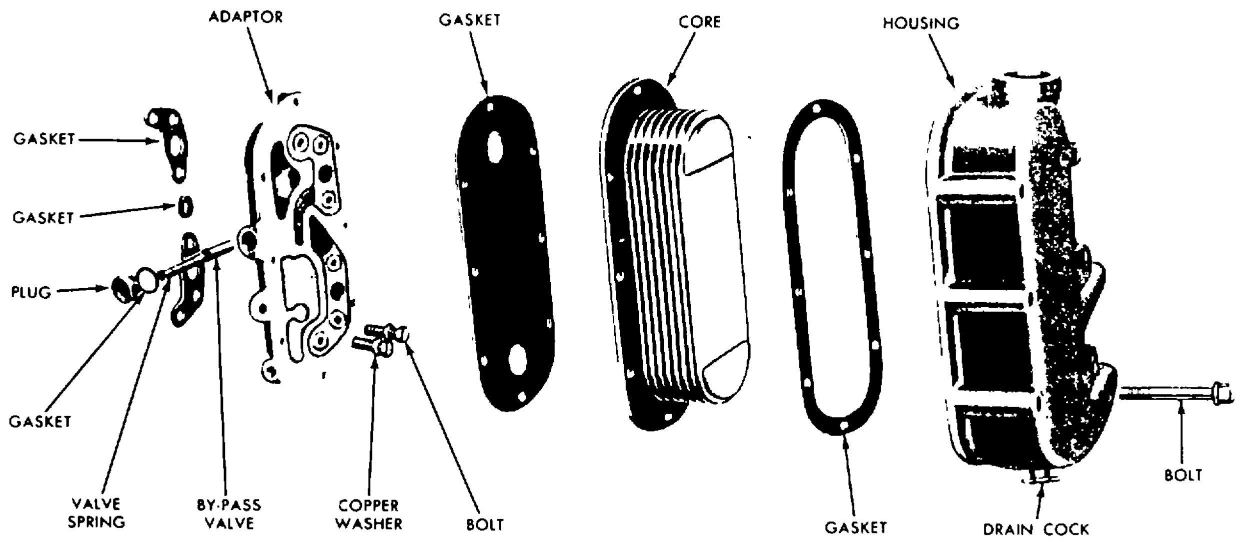


Figure 5-24. Oil Cooler Disassembly and Reassembly.

(e) After cleaning, dip core in a light weight engine oil.

NOTE

Do not attempt to clean the oil cooler core after an engine failure occurs in which metal particles from worn or broken parts are released into the lubricating oil. Replace the oil cooler core.

b. Test. After oil cooler has been cleaned, test it for leaks as follows:

NOTE

Before testing inspect all parts for cracks, breaks or other damage. Do not test an oil cooler that requires repair or replacement.

WARNING

When making the pressure test, be sure that all personnel are adequately protected against leak or rupture of a fitting, hose, or the oil cooler core. Eye protection is required. Leaks will be evident before reaching test pressure. If there are core leaks terminate the test and replace the oil cooler core. If the core ruptures at test pressure serious injury could occur.

(1) Make a suitable test plate and attach it to flanged side of cooler core. Use a gasket made from rubber to assure a tight seal. Drill and tap test plate to permit installation of an air hose fitting at inlet side of core.

(2) Attach an air hose and apply 75-125 psi, and submerge cooler core and test plate in a container of water. Any leaks will be indicated by air bubbles. If leaks are indicated, replace core.

WARNING

Safety glasses must be used when cleaning parts with compressed air.

(3) After pressure check is completed, remove plate and air hose from cooler core. Dry core with compressed air.

c. Inspection and Repair

(1) Reinspect all parts for cracks, breaks or other damage.

(2) Inspect hardware and threaded holes for damaged threads.

(3) Discard and replace all gaskets.

(4) Repair damaged threads if possible. Replace all defective parts.

5-56 Oil cooler reassembly and installation

a. Reassembly. Reassemble oil cooler assembly in reverse sequence of disassembly procedure.

b. Installation. Install oil cooler assembly in reverse sequence of removal procedure.

Section XV. Air Shutdown Housing and Blower

5-57 General

a. Air Shutdown Housing. Air shutdown housing is mounted on right side of engine on blower, and serves as a mounting for air cleaner. Air shutdown housing contains an air shutdown valve that shuts off air supply and stops engine whenever abnormal operating conditions require an emergency shutdown.

b. Blower

(1) Blower assembly, mounted on right rear side of engine block, supplies fresh air required for combustion and scavenging. Two hollow double-lobe rotors revolve in rotor housing. Revolving motion of rotors provides a continuous and uniform displacement of air.

(2) Gears located at splined ends of rotor shafts assist in spacing rotor lobes. Normal gear wear will have some effect on rotor-to-rotor clearance. A combination of gear and rotor shaft bearing surface wear will result in a decrease of rotor to housing clearance.

(3) Oil seals, consisting of a fiber washer, O-ring, retainer and seal spring are Incorporated in each end of the blower rotors.

5-58 Blower Inspection (blower Installed)

WARNING

When Inspecting blower on an engine with engine running, keep fingers and clothing away from moving parts of blower and run engine at low speed only. Equipment damage and severe personal injury can occur if clothing or fingers enter moving rotors.

a. Blower, with a removable air inlet housing can be inspected without being removed from engine, (Fig. 5-25).

b. Remove air shutdown housing and screen and inspect the blower as follows:

(1) Inspect rotors for scratches, chips or other abrasions. If burrs cause interference between rotors or between rotors and housing blower must be removed and repaired or replaced.

(2) Start engine and check for leaking oil seals. Leaky oil seals are indicated by presence of oil on blower rotors or inside the surfaces of housing. Run the engine at low speed and direct a light Into the rotor compartment at end plates and oil seals. A thin film of oil radiating away from seal Indicates an oil leak is present.

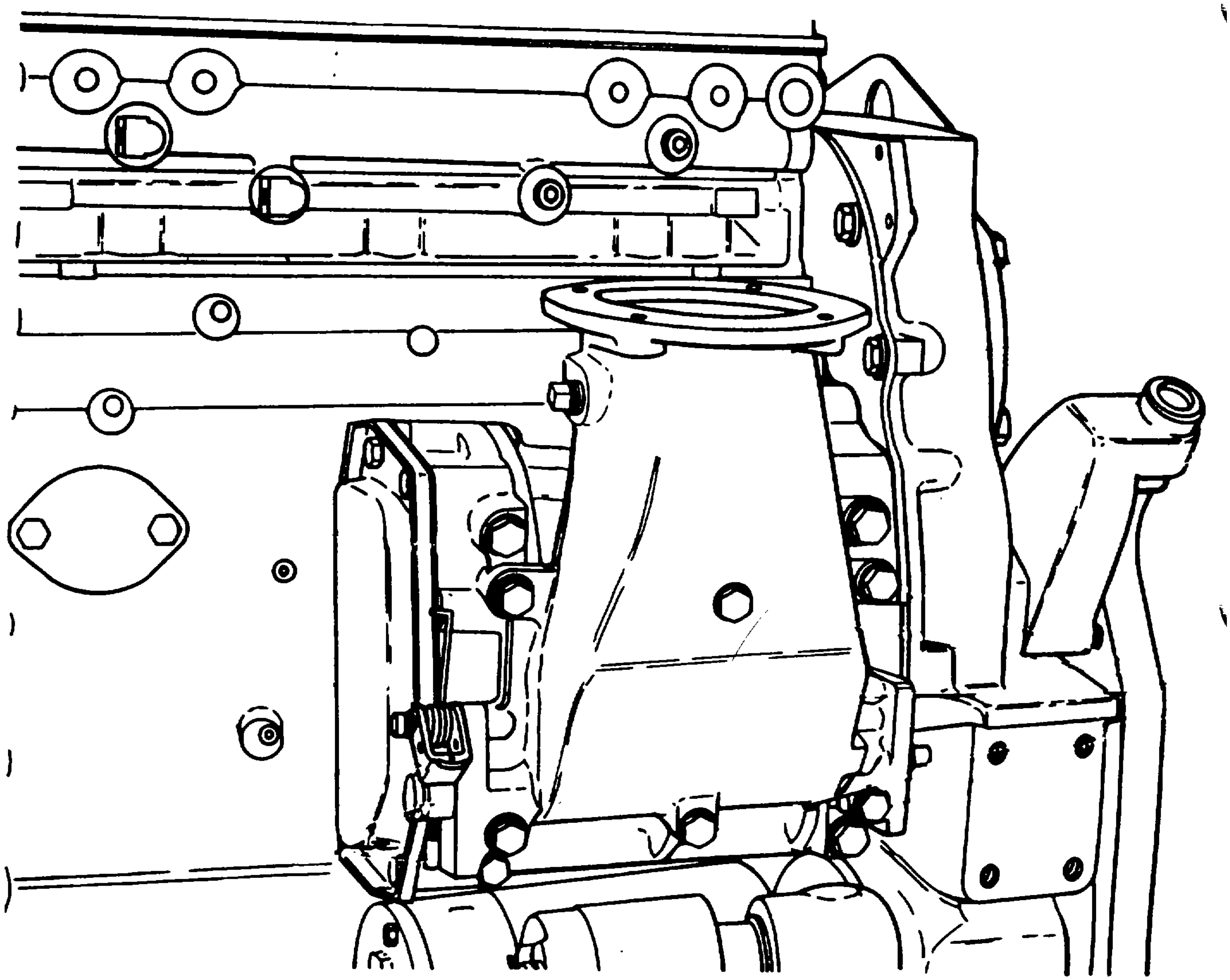


Figure 5-25. Blower Installation.

(3) With engine running, check blower drive. A worn blower drive, resulting in a loose, rattling sound within blower can be detected with engine operating at idle 500 rpm.

(4) Inspect rotor for loose rotor shafts or worn rotor bearings. Defective bearings will result in contact between the rotor lobes, rotors and end plates or rotor and housing.

(5) Inspect blower lobes for excessive backlash. Excessive backlash between blower timing gears will result in rotor lobes rubbing along their entire length.

c. Install air shutdown housing.

5-59 Blower removal and disassembly

NOTE

Whenever possible remove the blower, together with the governor drive, fresh water pump, fuel oil pump, and the blower drive shaft cover. For removal of this assembly proceed as follows:

a. Removal

(1) Drain cooling system.

(2) Remove governor control housing assembly.

(3) Disconnect fuel lines at fuel pump.

(4) Loosen water pump connections at pump cover (inlet) and cylinder block.

(5) Disconnect control wire from air shutdown valve shaft lever. Then remove bolt securing control wire clip to air shutdown housing.

(6) Remove air cleaner; then remove air inlet housing, gasket, striker plate and air inlet screen from blower.

(7) Remove blower drive shaft.

(8) Loosen blower drive shaft cover seal clamp at blower drive gear hub support.

(9) Remove bolts and plain washers securing blower to cylinder block. Slide blower slightly forward, withdraw blower drive shaft cover from seal, then lift blower away from cylinder block.

b. Removal of Accessories from the Blower

(1) Remove three bolts and seal washer assemblies securing fuel pump to the blower rear end plate cover, then remove fuel pump, gasket and drive coupling fork.

(2) On current blower, loosen seal clamp securing blower drive shaft cover to blower end plate cover, then remove cover, seal and clamp from the end plate cover.

(3) Remove three bolts and seal washer assemblies securing fresh water pump to blower front end plate cover, then remove water pump and gasket. If necessary, tap pump with a plastic hammer to loosen it.

5-60 Blower drive coupling, removal and disassembly

a. Removal

(1) Remove blower assembly.

(2) Withdraw blower drive shaft from drive support.

(3) Disconnect oil tube.

(4) Remove drive support attaching bolts.

(5) Tap drive support to loosen it.

(6) Carefully withdraw support from end plate so blower drive gear teeth will not be damaged.

b. Disassembly. Disassemble blower drive coupling.

5-61 Blower drive coupling, cleaning, inspection and repair

a. Cleaning. Clean all parts with cleaning solvent or diesel fuel and dry thoroughly. Ensure that oil grooves and other passages are free of dirt.

b. Inspection and Repair. Inspect inside diameter and thrust surfaces of blower drive gear support hub for scoring and wear. The clearance between shaft and support should be between .0010 to .0025 inch with new parts. A maximum of . 0050 inch is allowed with used parts. Replace worn or scored bearings.

c. Inspect drive shaft for signs of excessive wear, scoring and worn gear teeth. Replace a defective shaft.

d. Inspect blower drive coupling support, cam spring seats, and spring packs. Replace worn or damaged parts.

e. Examine blower drive support thrust washer for scoring and wear. Replace thrust washer which is .093 to .103 inch.

5-62 Blower drive coupling, reassembly and Installation

a. Reassembly. Reassemble blower drive support components in reverse of disassembly.

b. Installation

(1) Install blower drive coupling.

(2) Install blower assembly.

Section XVI. Rocker Arms and Cylinder Head

5-83 General

a. Rocker Arms

(1) Three rocker arms are provided for each of four cylinders; two outer arms operate exhaust valves and center arm operate fuel injector.

(2) Each set of three rocker arm assemblies pivots on a separate shaft supported by two brackets. A single bolt secures each bracket to top of cylinder.

(3) Rocker arms are operated by camshaft through cam followers and short push rods extending through cylinder head (Figure 5-26).

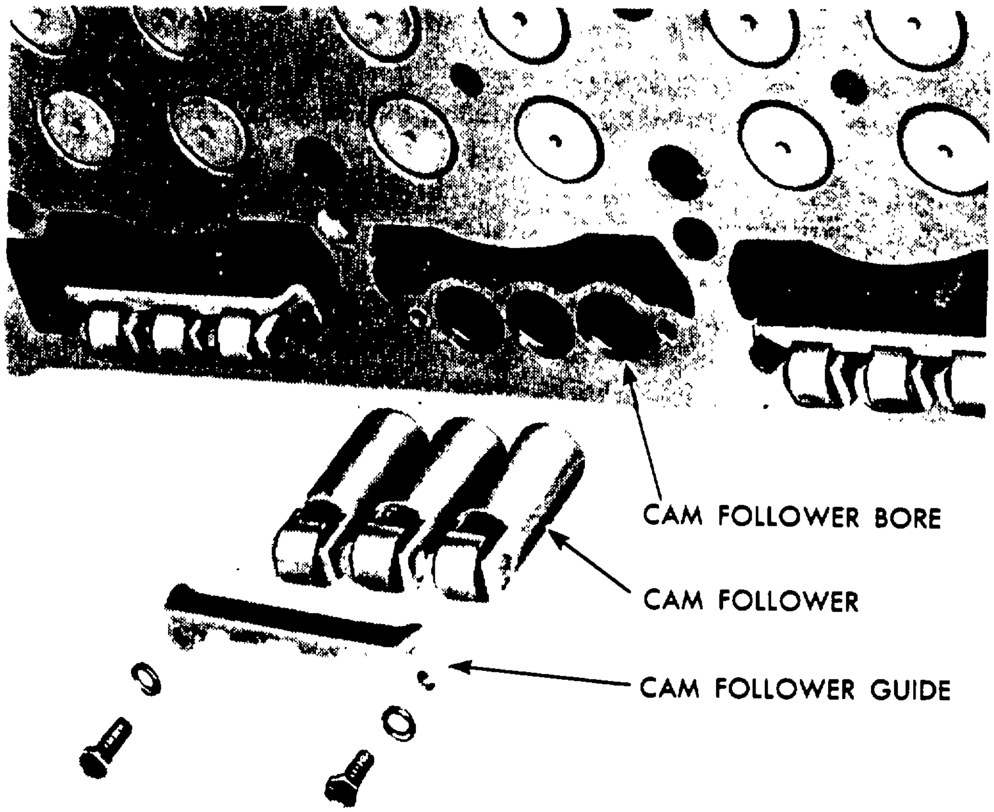


Figure 5-26. Cam Followers and Cylinder Head.

(4) Valve and injector mechanism is lubricated by oil from a longitudinal oil passage on camshaft side of cylinder head, which connects with oil passages in cylinder block. Oil from this passage enters drilled rocker arm shafts through lower end of drilled rocker shaft bracket bolts.

b. Cylinder Head. Cylinder head is a one piece casting. It can be removed from cylinder block as an assembly consisting of cam followers, cam follower guides, rocker arms, exhaust valves and fuel injectors.

5-64 Rocker arm and cam follower removal and disassembly

a. General. Cam followers may be removed from either top or bottom of cylinder head. When followers are removed from bottom, cylinder head must be removed. When followers are removed from top, cylinder head removal is not necessary.

b. Rocker Arm Removal

(1) Remove rocker arm cover.

(2) Remove fuel pipes from injector and fuel connectors.

NOTE

Place shipping caps on injector openings immediately after removing lines to prevent dirt and other foreign material from entering system.

(3) Turn crankshaft or crank starting motor to bring injector and valve rocker arms in line horizontally.

NOTE

Do not bar crankshaft in a left hand direction of rotation with a wrench or barring tool on the crankshaft bolt, or the bolt may be loosened.

(4) Remove two bolts (Figure 5-27) which secure rocker arm shaft brackets to the cylinder head. Remove brackets and shaft.

NOTE

When removing rocker arm shaft, fold three rocker arms back just enough to allow removal of shaft.

(5) Loosen lock nuts on upper ends of push rods, next to clevises, and unscrew the rocker arms from the push rods.

NOTE

If rocker arms and shafts from two or more cylinders are removed, tag them so they can be re-installed in their original positions.

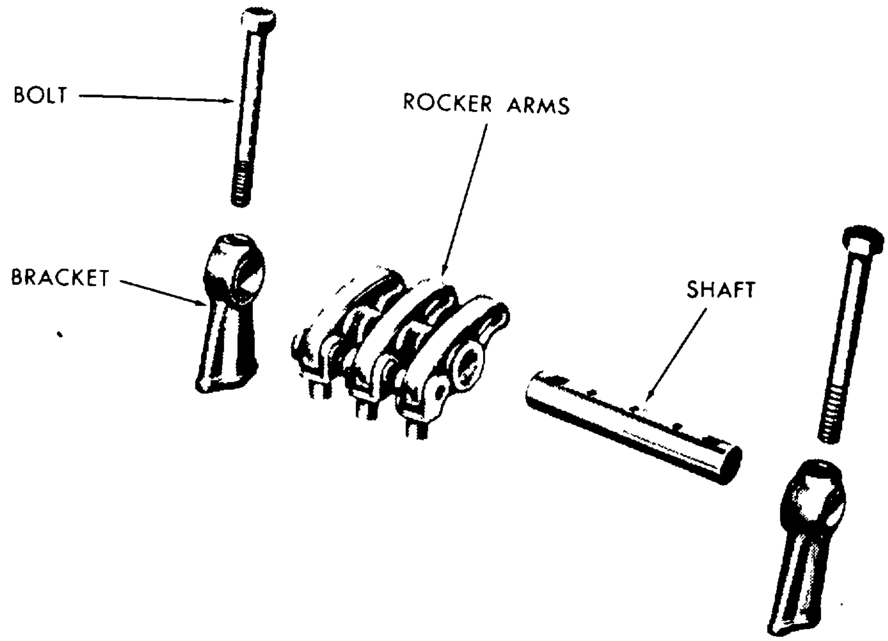


Figure 5-27. Rocker Arm Shaft Bracket.

c. Cam Follower Removal (Cylinder Head Installed)

(1) For removal of push rod, push rod spring, spring seats and cam followers a push rod removal tool must be used.

(2) Loosen push rod locknut at upper end of push rod, next to clevis, and unscrew rocker arm from push rod to be removed. Remove locknut from the push rod.

(3) Install removal tool and flat washer on push rod. Screw nut down on end of push rod, to compress push rod spring.

(4) Remove spring retainer from cylinder head with a screwdriver.

(5) Unscrew nut at outer end of push rod, thus reteasing push rod spring.

(6) Pull push rod (Figure 5-28), upper spring seat, spring, lower spring seat and cam follower out of cylinder head.

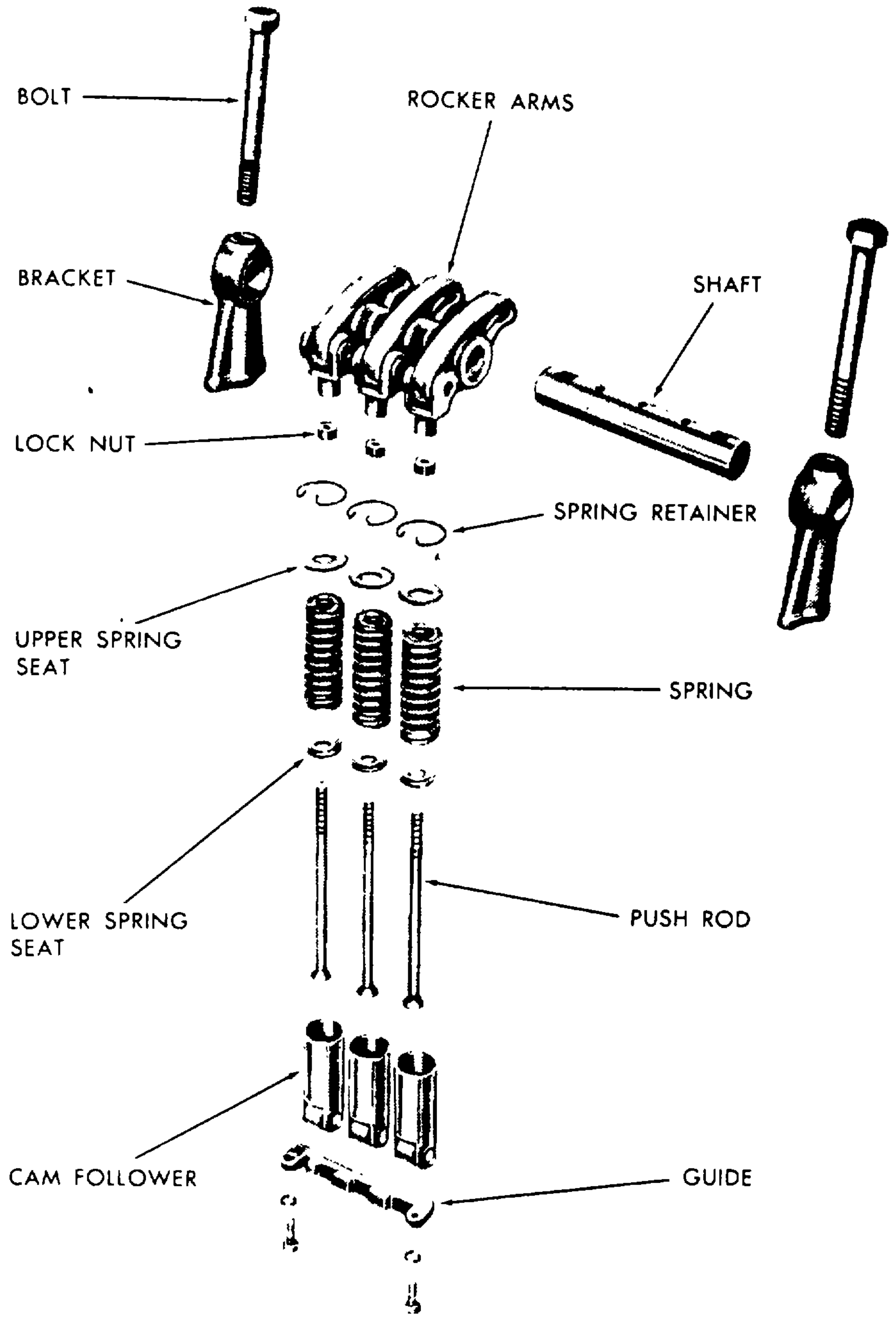


Figure 5-28. Cam Follower Disassembly and Reassembly.

5-65 Rocker arm and cam follower cleaning, Inspection, and repair

a. Rocker Arms

(1) Wash all parts thoroughly with cleaning solvent and dry thoroughly. Make sure oil passages In rocker arms, rocker arm shafts, and bracket bolts are open and clean.

(2) Inspect all parts for excessive wear or other damage.

(3) Measure clearance between rocker arm shaft and Injector rocker arm bushing. Measure clearance between the rocker arm shaft and exhaust rocker arm (which has no bushing). The maximum clearance Is 0.004 inch with used parts and .0025 Inch for new parts.

(4) Inspect each rocker arm pallet at contact face for excessive wear or galling. Inspect contact surfaces of exhaust valve bridge.

b. Cam Followers and Push Rods

(1) Proper cam follower inspection and service are necessary for continued efficient engine performance. When any appreciable change In Injector timing or exhaust valve clearance occurs during engine operation, cam followers and their related parts must be removed and inspected for wear. This change during engine operation can usually be detected by excessive noise at idle speed.

(2) Wash all cam followers and related parts with cleaning solvent and dry thoroughly.

(3) Examine cam follower rollers (Figure 5-28), for scoring, pitting or flat spots. Rollers must turn freely on their pins. Measure total diametric clearance and side clearance. Install a new roller and pin If clearances exceed those specified.

NOTE

Cam follower assemblies stamped with letter "S" on the pin, roller and follower body are equipped with an oversized pin and roller. The same clearances apply to both standard and large cam follower assembly.

(4) Use a suitable light and examine camshaft lobes for scoring, pitting or flat spots. Bar engine over so that all cam surfaces can be observed.

(5) Measure cam follower bores In cylinder head with a telescope gage and micrometer and record readings. Measure cam followers with a micrometer and record data. Determine follower to bore clearances and compare them to those specified In Table 1-1.

(6) Inspect push rods and spring seats for wear.

(7) Examine cam follower springs for wear and damage and check spring load.

(8) Use a spring tester to check the spring load. Replace spring when a load of less than 250 pounds will compress it to a length of 2.1406 inch.

(9) Remove and install cam follower roller and pin as follows:

(a) Clamp cam follower fixture in a vise and place cam follower in groove in the top of fixture, with follower pin resting on top of corresponding plunger in fixture.

(b) Use a suitable drift and drive pin from roller. Exercise caution in removing cam follower body and roller from fixture as follower pin is seated on top of a spring loaded plunger in fixture body.

(c) Prior to installing a new pin, remove any burrs on surface of cam follower at pin holes.

(d) Position follower body in groove of the fixture with proper size fixture plunger extending through roller pin hole in one of legs of follower body.

(e) Coat new roller bushing and pin with lightweight engine oil.

(f) Position roller in cam follower body. The small plunger in fixture will align roller with pin holes in follower body.

(g) Align pin with hole in follower body and carefully drive pin into body until ends of pin are centered in legs of body.

(h) Check side clearance.

5-66 Rocker arm and cam follower reassembly and installation

a. Cam Follower Installation (Cylinder Head Installed)

(1) Immerse cam follower assemblies in a screen type basket and place basket in a container of lightweight engine oil (heated to 100° to 125° F) for at least 1 hour before installation. Rotate cam follower roller during soaking period to aid in purging any air from bushing-roller area.

(2) Note the oil hole in bottom of cam follower. With this hole pointing away from the exhaust valves, slide the cam follower assembly into position.

(3) Install a serrated lower spring seat and upper spring seat on each push rod.

(4) Install assembled push rod into proper cam follower.

(5) Install flatwasher and nut on push rod, then place removal tool on push rod between washer and upper spring seat. Tighten nut on push rod until spring is compressed far enough and install push rod spring retainer.

(6) Remove nut and tool from push rod; reinstall locknut on push rod. Then, screw rocker arm clevis down on push rod until end of push rod is flush with inner side of clevis.

b. Rocker Arm Installation

NOTE

Note that injector rocker arm (center rocker arm) is slightly different from exhaust rocker arms. Boss for shaft on valve rocker arms is longer on one side of the arm than the other. The extended boss on valve rocker arms must face injector rocker arm.

CAUTION

When a push rod has been disconnected from rocker arm clevis, push rod must be threaded into clevis until end of rod is flush with, or above inner side of clevis yoke at time of reassembly, before valve clearance is adjusted. If this is not accomplished, valve may strike piston (due to the small clearance between valve head and piston head when piston is at top dead center) and cause serious damage.

(1) Apply clean engine oil to rocker arm shafts.

(2) Install rocker arm and shaft assemblies as illustrated in Figure 5-27.

(3) Tighten rocker arm shaft bracket bolts to 50-55 lb ft torque. After tightening bolts, check for some side clearance to prevent binding between rocker arms.

(4) Align fuel pipes and connect them. Tighten pipe nuts to 12-15 lb ft torque.

CAUTION

Do not bend fuel pipes and do not exceed specified torque. Excessive tightening will twist or fracture ends of fuel pipes and result in leaks.

(5) Fill cooling system.

(6) Adjust exhaust valve clearance.

(7) Adjust rocker arms.

(8) Time fuel injectors.

(9) Install rocker arm cover.

5-67 Rocker arm and valve adjustment

a. General. Operate engine until water temperature reaches 160° to 180°F before adjusting valve clearance. Stop engine to make adjustment. Since adjustments are made with engine stopped, it may be necessary to run engine between valve adjustments to prevent it from cooling off. All valve clearances can be adjusted in sequence of firing order during one full revolution of crankshaft.

b. Adjustment

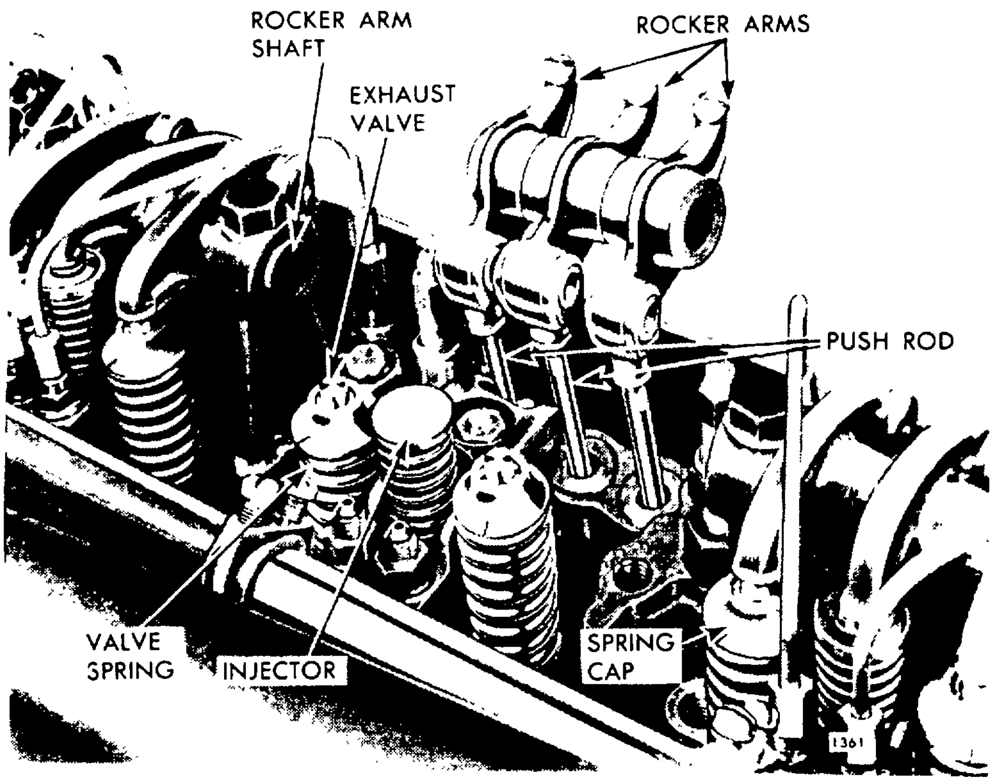
(1) Remove rocker arm cover.

(2) Adjust rocker arms as illustrated in Figure 5-29.

1. PLACE GOVERNOR CONTROL LEVEL IN THE NO FUEL POSITION.

2. ROTATE CRANKSHAFT UNTIL THE INJECTOR FOLLOWER IS FULLY DEPRESSED ON THE CYLINDER BEING ADJUSTED.

3. LOOSEN THE PUSH ROD LOCKNUTS ON THE VALVE PUSH RODS. PLACE A 0.009 INCH FEELER GAGE BETWEEN THE VALVE STEM AND ROCKER ARM. ADJUST THE PUSH ROD TO OBTAIN A SMOOTH PULL ON THE FEELER GAGE.



4. REMOVE: FEELER GAGE AND TIGHTEN LOCKNUT. RECHECK CLEARANCE, READJUST AS REQUIRED.

5. ADJUST REMAINING VALVES IN THE SAME MANNER.

Figure 5-29. Valve Adjustment.

5-68 Cylinder head, removal and disassembly

a. Removal

(1) Open the drain cock at bottom of oil cooler and drain cooling system.

(2) Drain engine oil.

(3) Remove exhaust manifold.

(4) Remove air cleaner or silencer and cover air Inlet housing.

(5) Disconnect fuel lines at cylinder head.

(6) Remove thermostat housing and thermostat assembly.

(7) Clean and remove valve rocker cover and governor cover.

(8) Remove fuel control rod.

(9) Remove two screws securing top of governor housing to cylinder head.

(10) If cylinder head Is to be disassembled for reconditioning of exhaust valves and valve seat Inserts or for a complete overhaul, remove fuel pipes and Injectors at this time.

(11) Check torque on cylinder head bolts before removing head. Then remove bolts and lift cylinder head from cylinder block.

NOTE

When placing cylinder head assembly on a bench, protect cam followers and injector spray tips, if they have not been removed, by straddling the cylinder head, valve side down, on 3 inch thick wood blocks.

(12) Remove and discard cylinder head compression gaskets, oil seals and water seals.

5-69 Cylinder head installation

a. Check to make sure tops of pistons are clean and free from foreign material.

b. Check to make sure that each push rod Is threaded Into clevis until end of push rod projects through clevis.

c. To avoid damage to water and oil seals, check to make sure that grooves and counterbores in top of cylinder block are clean and smooth.

d. Refer to Figure 5-30 and install new seal rings In counterbores of water and oil holes and a new seal In milled groove near outer edge of area covered by cylinder head.

e. Install two guide studs in each end of cylinder block holes to keep from disturbing gaskets and seals during cylinder head installation.

f. Wipe bottom of cylinder head clean. Use a suitable lifting device and install cylinder head.

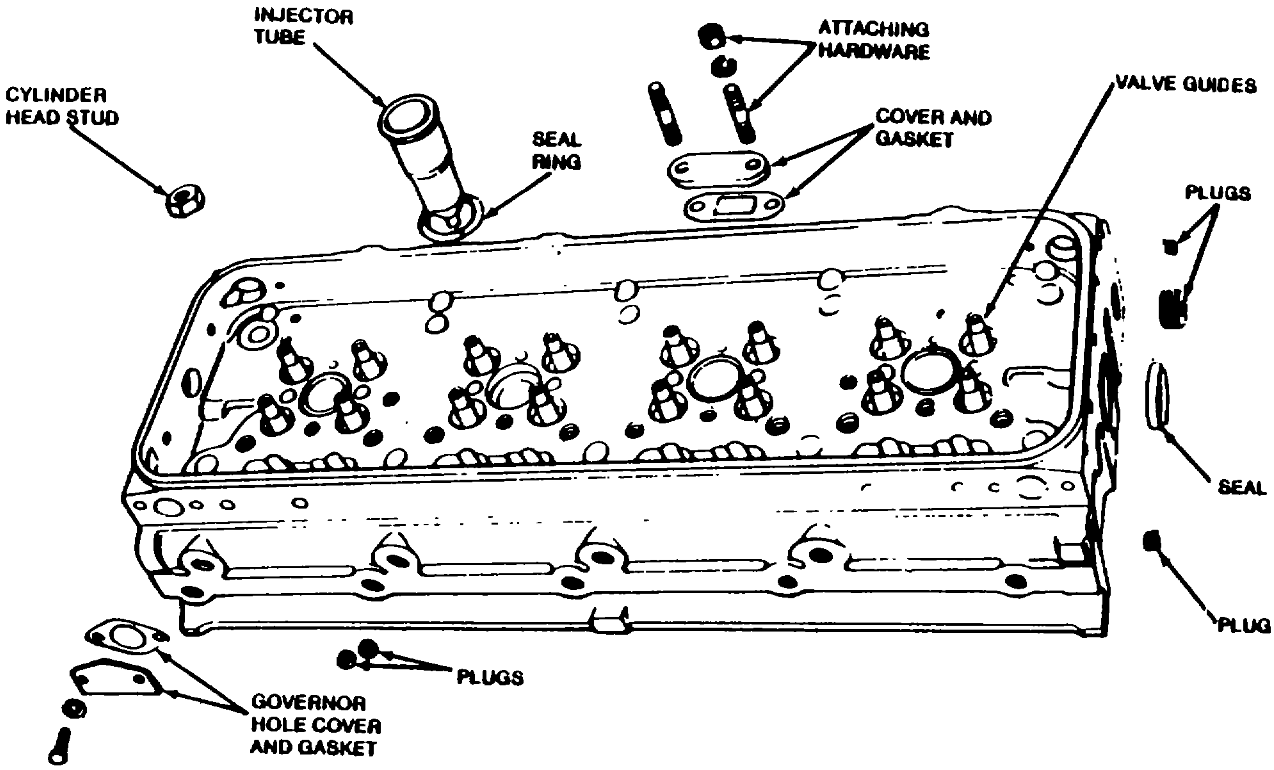


Figure 5-30. Cylinder Head Plugs and Studs.

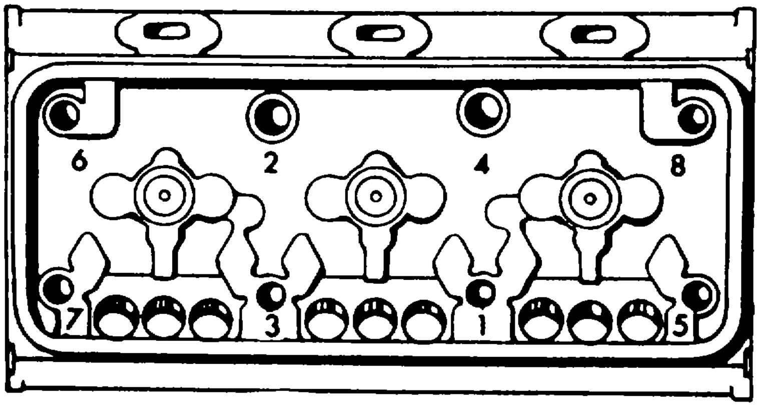


Figure 5-31. Cylinder Head Bolt Tightening Sequence.

g. Lubricate head bolt threads and under side of each bolt head with a good sealing compound and tighten cylinder head bolts in numerical sequence as illustrated in Figure 5-27. Tighten bolts to 170-180 lb ft torque.

h. Install fuel filter.

i. Install two screws securing top of governor housing to cylinder head.

j. Refer to figure 5-32 and install fuel control rod.

k. Refer to figure 5-19 and install governor top cover.

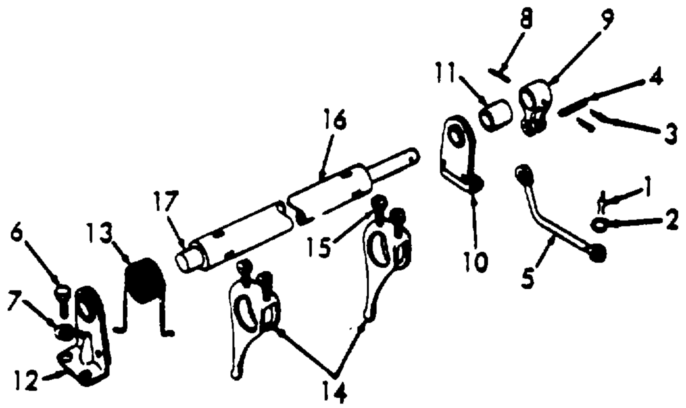
l. Install exhaust manifold.

m. Install breather.

n. Service cooling system and crankcase. Start the engine and check for leaks.

o. Operate engine until it reaches normal operating temperature. Stop engine and retorque cylinder head bolts.

p. Install rocker arm cover.



1. COTTER PIN
2. SHAFT SPACER
3. COTTER PIN
4. CONTROL ROD SHAFT
5. FUEL CONTROL ROD
6. MACHINE BOLT
7. LOCKWASHER
8. GROOVE PIN
9. CONTROL TUBE LEVER
10. CONTROL TUBE BRACKET
11. SPACER
12. CONTROL TUBE BRACKET
13. CONTROL TUBE SPRING
14. CONTROL LEVER
15. ADJUSTING SCREW
16. CONTROL TUBE ASSEMBLY
17. CONTROL TUBE PIN

Figure 5-32. Fuel Injector Control Tube Removal.

Section XVII. Oil Pan

5-70 General

a. Oil Pan. Oil pan is shallow type, steel construction used as a reservoir for engine lubricating oil.

5-71 Oil pan removal

NOTE

Oil pan can be removed without removing engine. If major repair work is required, remove engine assembly.

a. Refer to lubrication chart, Figure 3-1, and drain engine crankcase.

b. Remove oil pan assembly by removing 20 mounting screws and washers.

5-72 Oil pan cleaning, inspection and repair

a. Scrape all old gasket particles from oil pan and cylinder block.

b. Wash all parts with cleaning solvent and dry thoroughly.

c. Discard and replace oil pan gasket.

d. Check for dents or cracks in oil pan.

e. Check for misaligned flanges or raised surfaces surrounding bolt holes by placing pan on a large flat surface.

f. Minor dents and misalignment of bolt holes can normally be pounded out.

g. Repair by replacement of defective parts.

5-73 Oil pan installation

a. Install oil pan starting with center bolt on either side and work around.

b. Install engine assembly.

c. Refer to lubrication chart, Figure 3-1, and service engine crankcase.

Section XVIII. Flywheel and Flywheel Housing

5-74 General

a. Flywheel

(1) The flywheel is bolted securely to crankshaft with six self-locking bolts.

(2) The flywheel is machined to provide true alignment of clutch.

(3) A steel ring gear, which meshes with starting motor pinion, is shrunk onto the rim of flywheel.

b. Flywheel Housing

(1) Flywheel housing is a one piece casting mounted against engine rear end plat which is attached to cylinder block, thus providing a cover for gear train and flywheel.

(2) Flywheel housing is counterbored for a lip type oil seal at crankshaft rear end.

5-75 Flywheel removal and disassembly

a. Removal

(1) Remove torque converter assembly.

CAUTION

When removing or installing attaching bolts, hold flywheel firmly against crankshaft. Flywheel is NOT doweled to crankshaft.

(2) Refer to Figure 5-33 and remove flywheel attaching bolts and scuff plate. (Reinstall one bolt.)

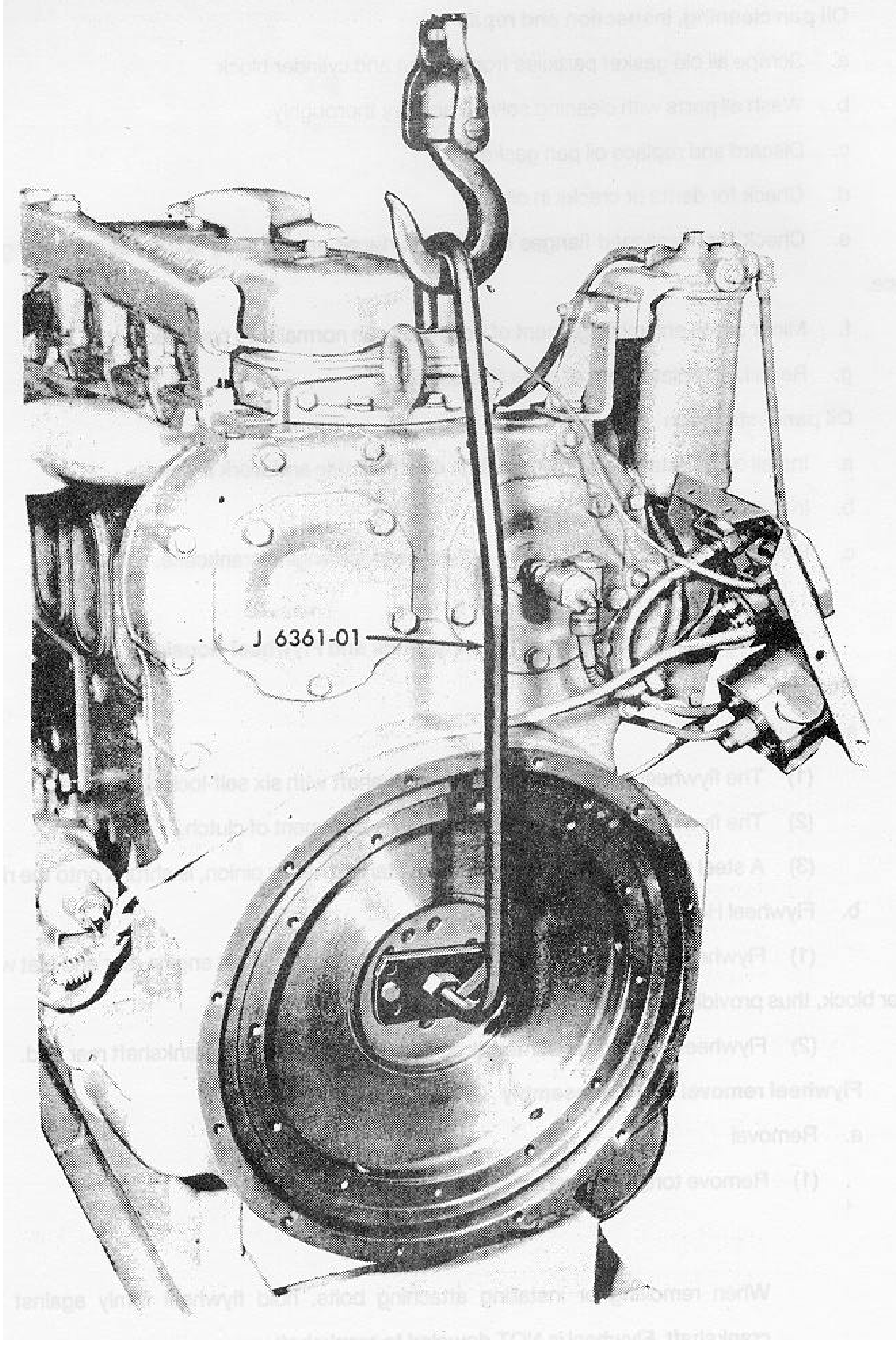


Figure 5-33. Flywheel Removal and Installation.

(3) Attach flywheel lifting tool to flywheel with two 3/8 inch bolts of suitable length.

(4) Attach a chain hoist to tool, remove remaining bolt, and withdraw flywheel from housing.

NOTE

Loosen flywheel by moving upper end of tool in and out.

(5) Remove oil seal ring.

b. Disassembly

NOTE

Note whether or not ring gear teeth are chamfered. Replacement gear must be installed so that chamfer on teeth faces in same direction as one removed. Do not remove ring gear unless there is evidence of damage or excessive wear.

(1) Support flywheel crankshaft side down, on a solid flat surface which is slightly smaller than diameter of ring gear.

(2) Drive ring gear off flywheel with a suitable drift and hammer. Work around circumference of ring gear to avoid binding on flywheel.

5-76 Flywheel cleaning, inspection, and repair

a. Cleaning. Wash all parts with a cleaning solvent and dry thoroughly.

b. Inspection and Repair

(1) Inspect friction surface on clutch disc side of flywheel for scratches or other damage.

(2) Inspect mounting hardware for damaged threads.

(3) Inspect ring gear for excessive wear.

(4) Repair by replacement of defective parts.

5-77 Flywheel reassembly and installation

a. Reassembly

(1) Support flywheel, ring gear side up, on a fiat surface.

CAUTION

Do not under any circumstances, heat gear over 400°F; excessive heating may destroy original heat treatment.

(2) Rest ring gear on a flat surface and heat gear uniformly with an acetylene torch, keeping torch moving around gear to avoid hot spots.

(3) Use a pair of tongs and place gear on flywheel, with chamfer facing same direction as gear just removed.

(4) Tap ring gear into place against shoulder on flywheel.

b. Installation

(1) Install flywheel assembly in reverse sequence of disassembly procedure.

(2) Re-Install torque converter assembly.

5-78 Flywheel housing, removal and disassembly

a. Removal

(1) Remove engine assembly.

(2) Remove flywheel assembly.

(3) Refer to Figure 5-34 and remove flywheel housing.

b. Disassembly. Disassemble flywheel housing as illustrated in Figure 5-34.

5-79 Flywheel housing cleaning, Inspection and repair

a. Cleaning. Wash all parts with cleaning solvent and dry thoroughly.

b. Inspection and Repair

(1) Inspect flywheel housing for cracks, breaks or other damage.

(2) Inspect all hardware and threaded areas for damaged threads. Retap threaded holes and replace defective hardware as necessary.

(3) Discard and replace all gaskets.

NOTE

Make sure that all gasket material is removed from flywheel housing and the end plate.

(4) Repair by replacement of defective parts.

5-80 Flywheel housing, reassembly and installation

a. Reassembly. Reassemble flywheel housing in reverse sequence of disassembly procedure.

b. Installation (1) Lubricate gear train teeth with clean engine oil before installing flywheel housing.

(2) Affix a new flywheel housing gasket to rear face of cylinder block rear end plate.

(3) If flywheel housing has an integral cast hub, install a flywheel housing to-end plate shim (.015 inch thick). Use grease to hold shim to cylinder block rear end plate.

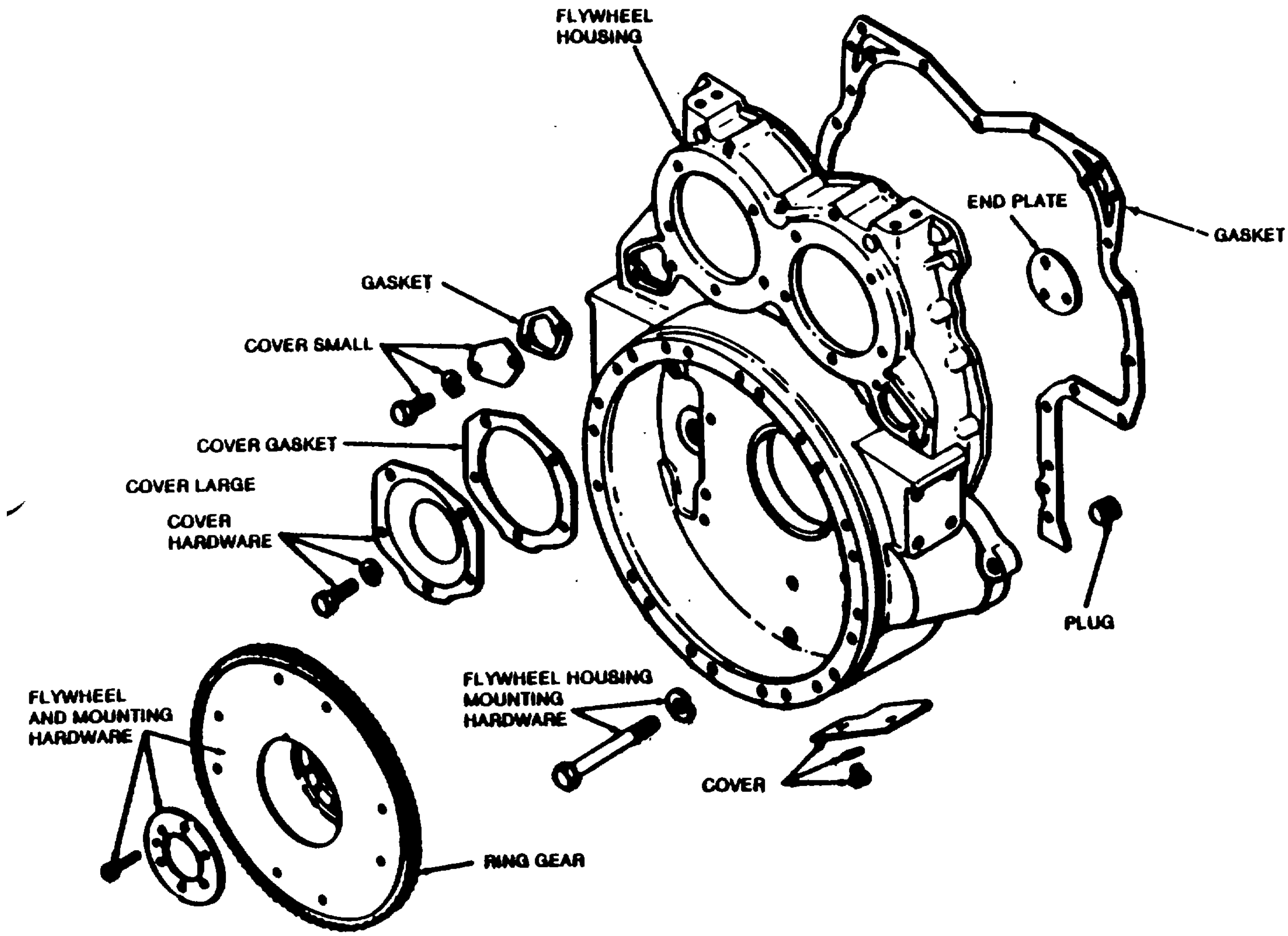


Figure 5-34. Flywheel housing removal and installation.

(4) Coat the lip of crankshaft oil seal lightly with engine oil.

(5) Thread two pilot studs into cylinder block to guide housing in place (Figure 5-34). To pilot oil seal on crankshaft use an oil seal expander.

(6) With housing suitably supported, position it over crankshaft and up against cylinder block rear end plate and gasket. Remove oil seal expander.

(7) Install all of flywheel housing bolts, lock washers, flat washers, and copper washers in their proper location, finger tight. Remove pilot studs.

NOTE

Rotate crank shaft often during bolt tightening sequence to insure there is no binding of shaft or gear train.

(8) Tighten bolts up to 10-15 lb ft less than specified torque as shown in Figure 5-35.

(9) Refer to Figure 5-35, and tighten bolts in order to torques shown below.

(a) Nos. 1-6 to 90-100 lb ft torque.

(b) Nos. 7-12 and 21-22 to 40-45 lb ft torque.

(c) All other 3/8 16 bolts to 25-30 lb ft torque.

(10) Install flywheel.

(11) Check flywheel housing concentricity and bolting flange face with a suitable dial indicator as follows:

(a) Thread base post tightly into one of tapped holes in flywheel. Then assemble dial indicators on base post.

(b) Position dial indicators straight and square with flywheel housing bell face and inside bore of bell. Make sure each indicator has adequate travel in each direction.

NOTE

If flywheel extends beyond housing bell, bore and face must be checked separately. Use special adapter in tool set to check bore.

(c) Tap front end of crankshaft with a soft hammer or pry it toward one end of block to ensure end play is only in one direction.

(d) Adjust each dial indicator to read zero at 12 o'clock position. Then rotate crankshaft one full revolution, taking face and bore readings every 45 . Stop and remove wrench or cranking bar at each interval to ensure reading accuracy. The maximum indicator reading must not be more than .013 inch for either bore or face.

(e) If runout exceeds .013 inch, remove flywheel housing and check for dirt or foreign materials (i.e. old gasket material) between flywheel housing and cylinder block and plate.

(f) Reinstall flywheel housing, and flywheel and retighten bolts as described in steps (7) thru (10) above. Then recheck runout. If necessary, replace flywheel housing.

(12) Install torque converter assembly.

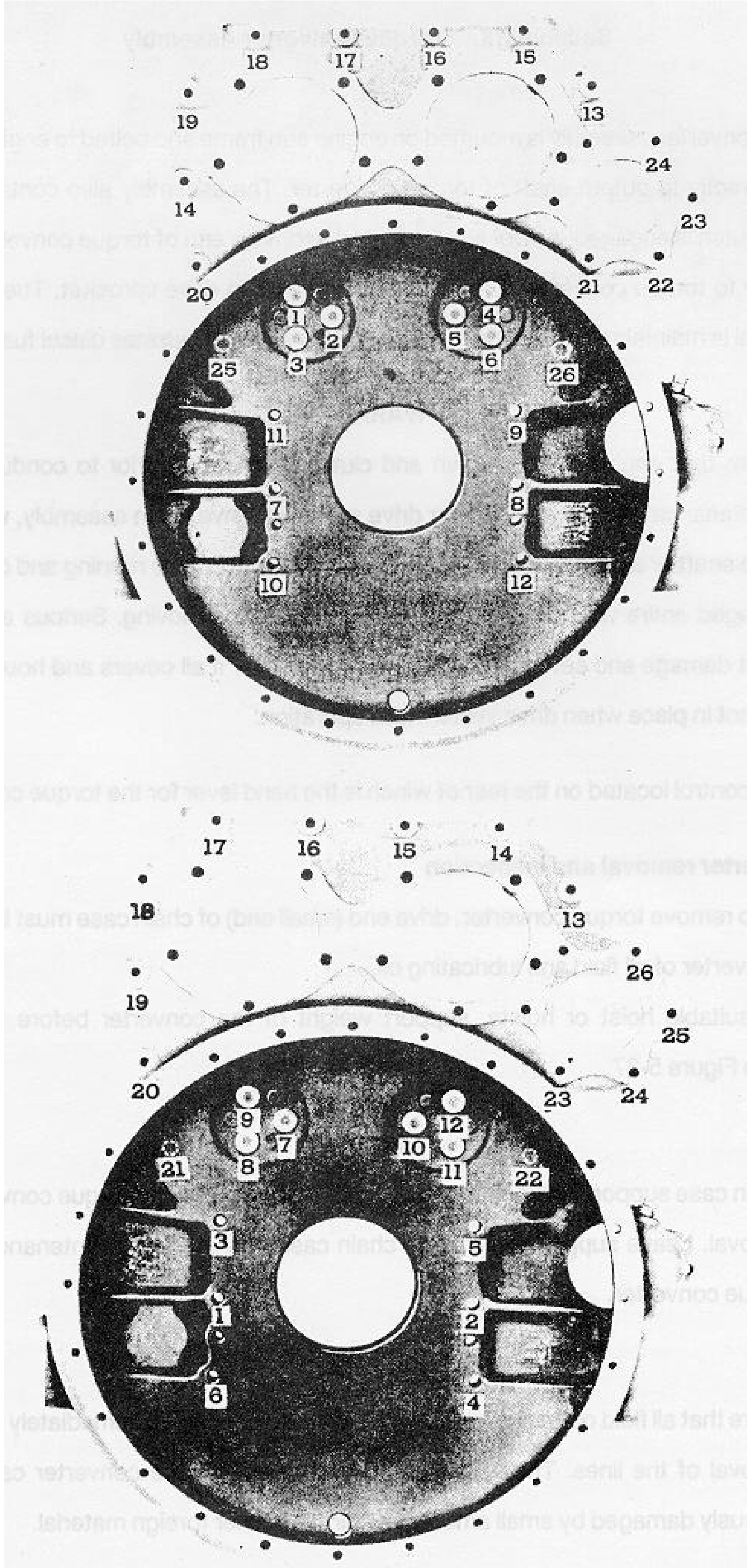


Figure 5-35. Flywheel Housing Bolt Tightening Sequence.

Section XIX. Torque Converter Assembly

5-81 General

a. Torque converter assembly is mounted on engine sub frame and bolted to engine. The winch chain drive sprocket is attached directly to output shaft of torque converter. The assembly also contains a clutch with a hand operated lever. When clutch is engaged, power is transmitted to driving end of torque converter where converter fluid transmits engine power to torque converter turbine disc, then to chain drive sprocket. The torque converter fluid is diesel fuel, and fluid level is maintained by engine fuel pump. Figure 5-36 illustrates diesel fuel piping system.

WARNING

Insure that engine is shut down and clutch disengaged prior to conducting maintenance on torque converter drive sprocket, drive chain assembly, winch drive shaft or any part of winch gear assembly. With engine running and clutch engaged entire winch drum drive mechanism will be moving. Serious equipment damage and severe personal injury can occur if all covers and housings are not in place when drive system is in operation.

b. The only control located on the rear of winch is the hand lever for the torque converter clutch.

5-82 Torque converter removal and inspection

a In order to remove torque converter, drive end (small end) of chain case must be disconnected.

b. Drain converter of all fluid and lubricating oil.

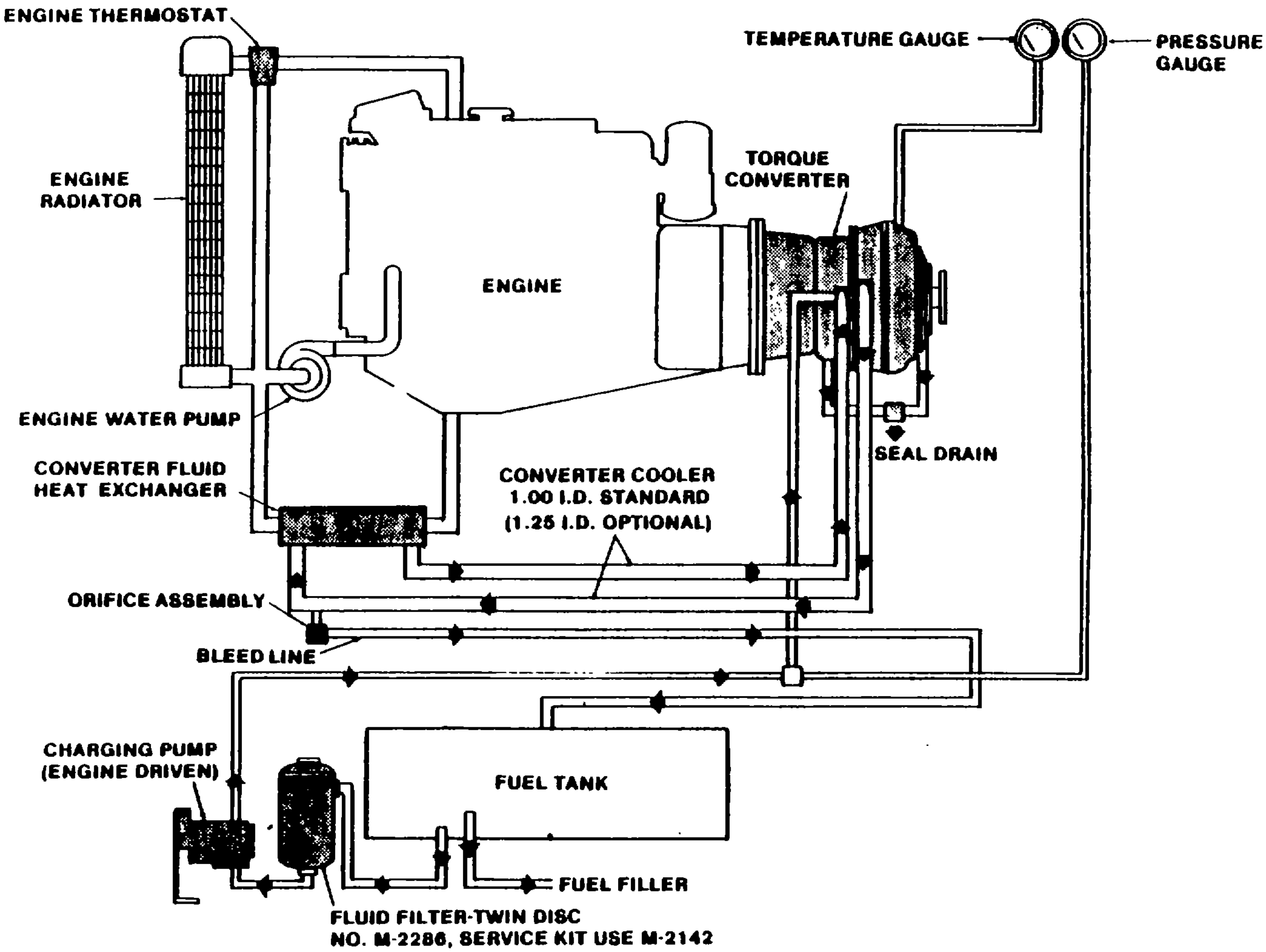
c. Using a suitable hoist or hoists, support weight of the converter before removing any converter mounting bolts. Refer to Figure 5-37.

NOTE

Chain case support is unbolted from engine sub frame during torque converter removal. Leave support in place on chain case until starting maintenance on torque converter.

CAUTION

Insure that all fluid openings and lines are capped or plugged immediately upon removal of the lines. The very close tolerances of torque converter can be seriously damaged by small amounts of dirt and other foreign material.



NOTE:
CONVERTER SEAL DRAINS
OPEN TO GROUND.

Figure 5-36. Diesel Fuel Piping System.

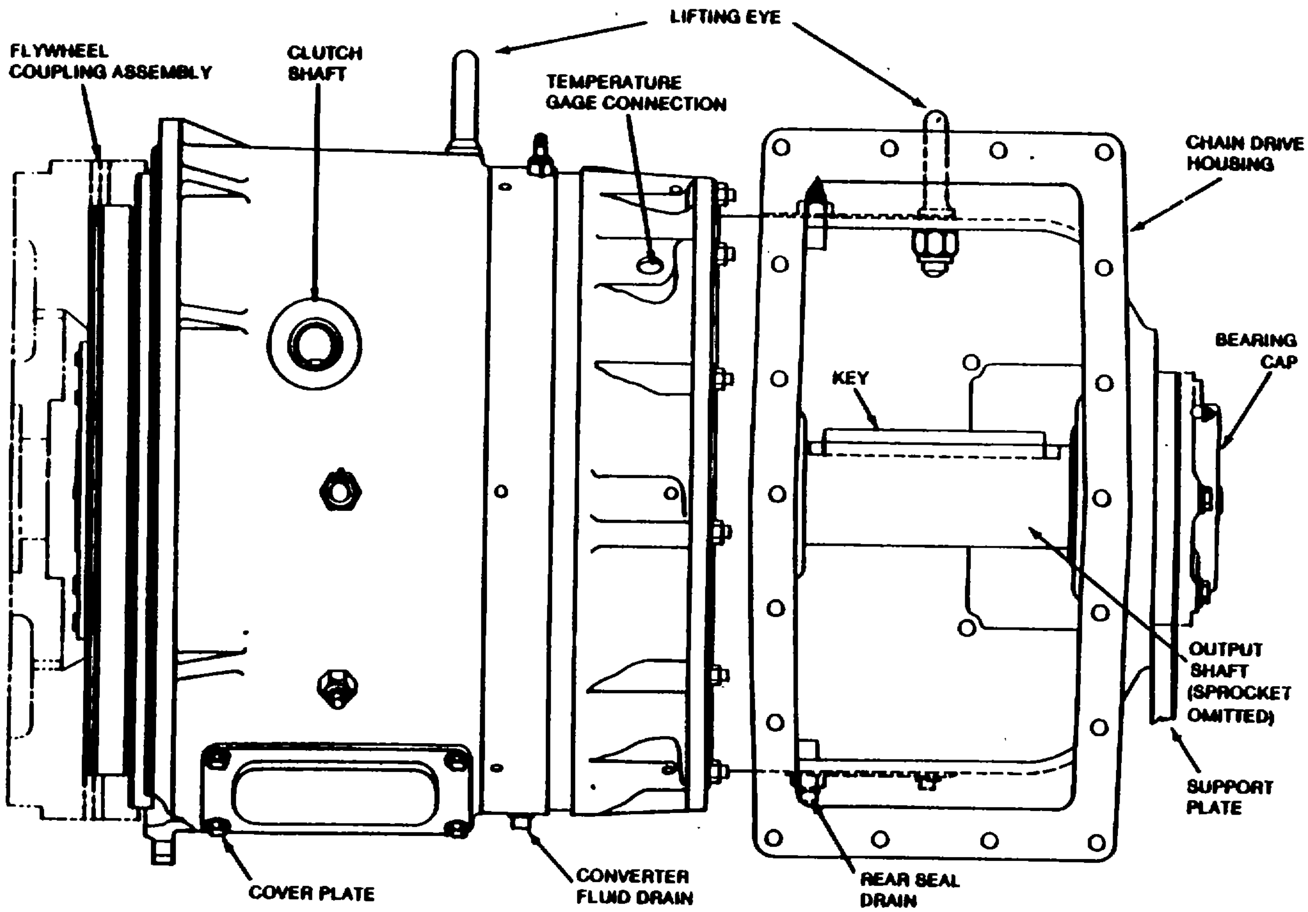


Figure 5-37. Torque Converter Assembly.

d. Disconnect fluid lines, temperature and pressure gage probes, and linkage to clutch operating shaft.

e. Remove 12 capscrews mating converter to engine flywheel housing.

f. Remove six bolts, nuts and lockwashers from chain drive support plate.

g. The converter may now be moved to rear until converter input shaft will clear clutch sliding sleeve.

h. Remove converter from engine.

NOTE

The clutch mechanism will still be attached to flywheel. If maintenance is to be performed on the clutch or flywheel remove clutch at this time (para 5-84).

i. Clean the exterior of torque converter with a suitable solvent.

NOTE

If torque converter does not require maintenance, do not disassemble. See paragraph 5-84 for partial disassembly for clutch repair.

5-83 Torque converter installation

a. Using a dial indicator, take readings on flywheel and flywheel housings.

CAUTION

Corrective steps must be taken if these readings are not within tolerances listed in Table 1-1.

b. Attach a dial indicator to engine block. Arrange indicator so its anvil rests on engine flywheel housing. You will then be able to measure amount of sag in housing after attaching converter.

c. Attach rear support plate to converter before mounting converter to engine.

d. Using a suitable hoist, move converter to engine flywheel housing, guiding input shaft into clutch plate hub.

e. After bolting converter to flywheel housing, place a jack under converter housing and raise until indicator at engine flywheel housing again reads zero. A zero indication will show that there is no longer any deflection in housing.

f. With hydraulic jack still supporting converter, install bolts that mate support plate and engine subframe. Torque these bolts to standard values from Table 1-3.

g. Connect clutch linkage to clutch shaft.

h. Refer to Figure 5-38 and install fluid cooling lines as follows:

(1) Check for burrs and nicks on fluid couplings and remove prior to installation of the lines.

(2) Install 1 inch ID fluid outlet on side of converter 90° from top center.

NOTE

There are two ports on the side of the converter. The rearward port is 90° from top center and is the outlet port. The forward port is 60° from top center and is the inlet port.

(3) Install 1 inch ID fluid inlet line in torque converter in forward port located 60° from top center.

i. Install converter pressure lines between fluid cooler, reservoir and converter as follows:

NOTE

The converter pressure lines are 3/8 inch OD.

(1) Install line from fluid reservoir to filter on suction side of charging pump.

(2) Install line from suction filter to charging pump.

(3) Install line from main fluid filter to converter. This line enters converter at inlet provided next to fluid inlet from cooler.

(4) Install a second line from outlet side of main fluid filter to converter fluid pressure gage.

(5) Install line from highest point of fluid system to orifice assembly.

5-84 Clutch assembly removal and inspection

a. After removal of torque converter assembly, paragraph 5-57, place torque converter on firm blocking with clutch housing up.

b. Remove 24 nuts and lockwashers that mate clutch housing to converter housing.

c. Using jack screws in three tapped holes provided separate clutch housing from converter housing.

WARNING

Safety glasses must be worn when using high pressure air or serious eye damage can occur.

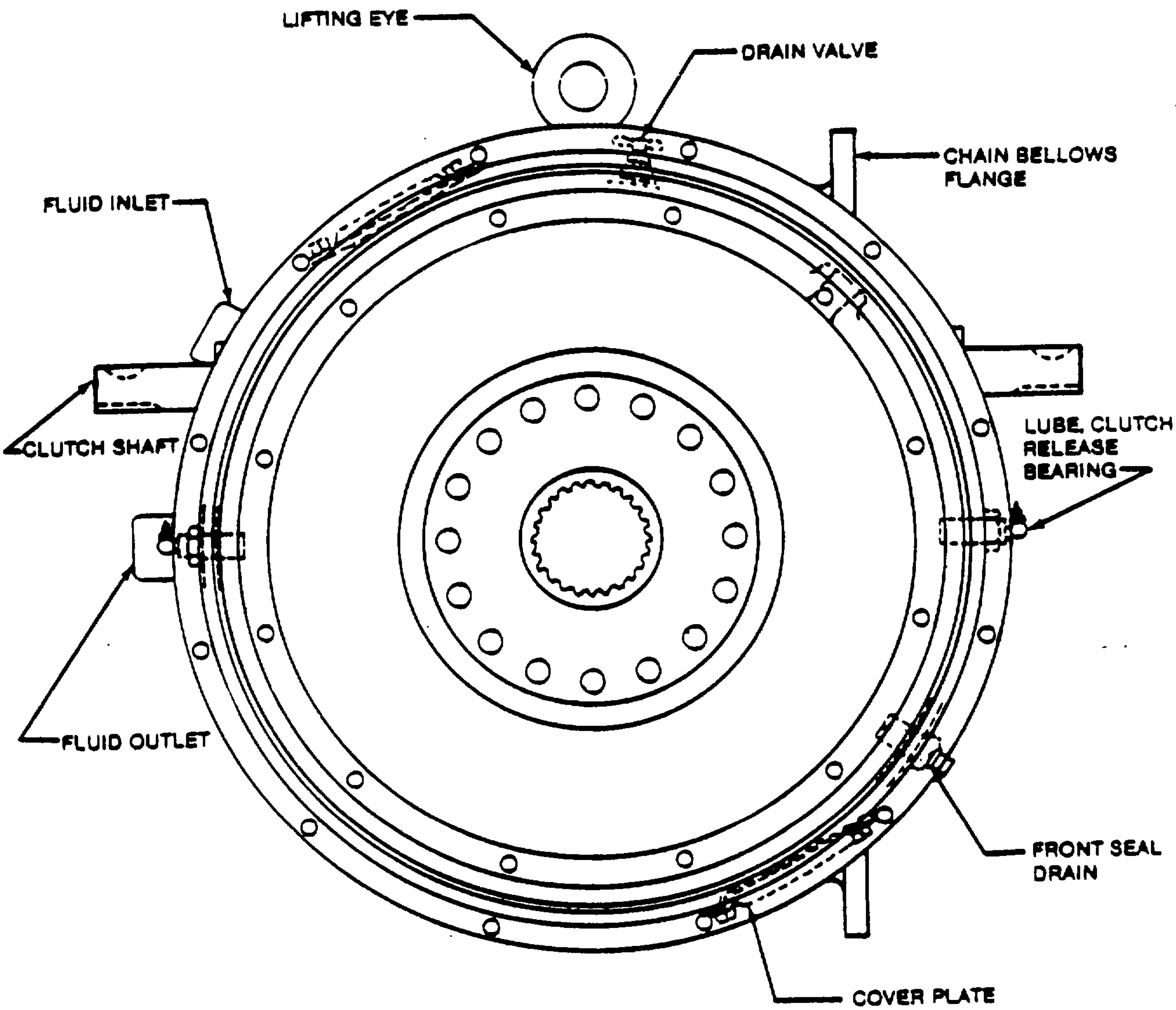


Figure 5-38. Fluid Line Installation.

d. Using high pressure air, blow all dust and dirt out of clutch housing.

e. Using a strong light, inspect interior of clutch housing for defects. Inspect clutch friction plate ensuring even wear and adequate thickness. Check lube lines for damage.

f. Check operation of clutch lever mechanism.

g. Using a dial gage, check shaft runout for evidence of excessive play between bearings and shaft.

NOTE

If above inspections reveal no discrepancies and there is no prior evidence of clutch malfunction, assembly should not be further disassembled.

h. If clutch assembly failed any previous inspection or was removed for a malfunction such as an inability to adjust clutch, proceed with disassembly as follows:

(1) Remove operating shaft and throwout fork from housing (Figures 5-39 and 540).

(2) Remove the six capscrews retaining sliding sleeve carrier. Using jack screws in two tapped holes provided, separate carrier from clutch housing and remove carrier with input shaft.

(3) Press input shaft and input shaft bearing out of sliding sleeve carrier.

(4) Remove impeller lock nut, lock washer and spacer and press impeller out of impeller bearing.

(5) Remove six socket head capscrews retaining seal carrier to end plate and remove seal assembly.

(6) Remove impeller bearing.

(7) Refer to Figure 5-41 and disassemble the remainder of clutch.

5-85 Clutch assembly Inspection and repair

a. Wash all metal parts in a suitable cleaning solvent and dry thoroughly.

b. Inspect shaft splines for excessive wear or damage. Using a fine grit emery cloth remove any light scoring marks and burrs. Replace shaft if scoring marks cannot be removed by above procedure.

NOTE

The shaft should be turned frequently when using emery cloth to avoid flat spots.

c. Inspect clutch driving plate splines for excessive wear, chipped splines and other damage. Replace driving plate if splines are damaged.

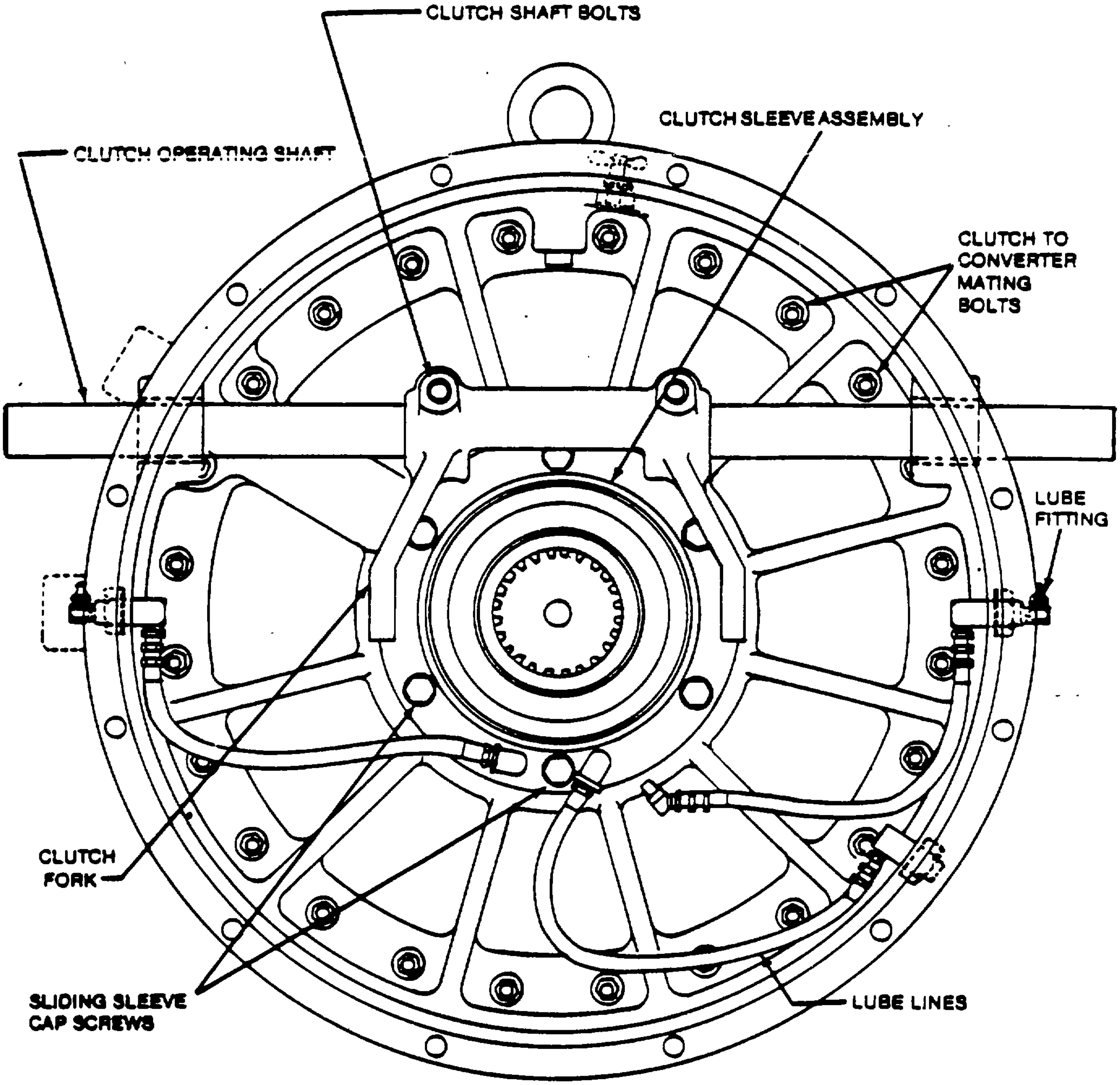


Figure 5-39. Clutch Assembly Removal.

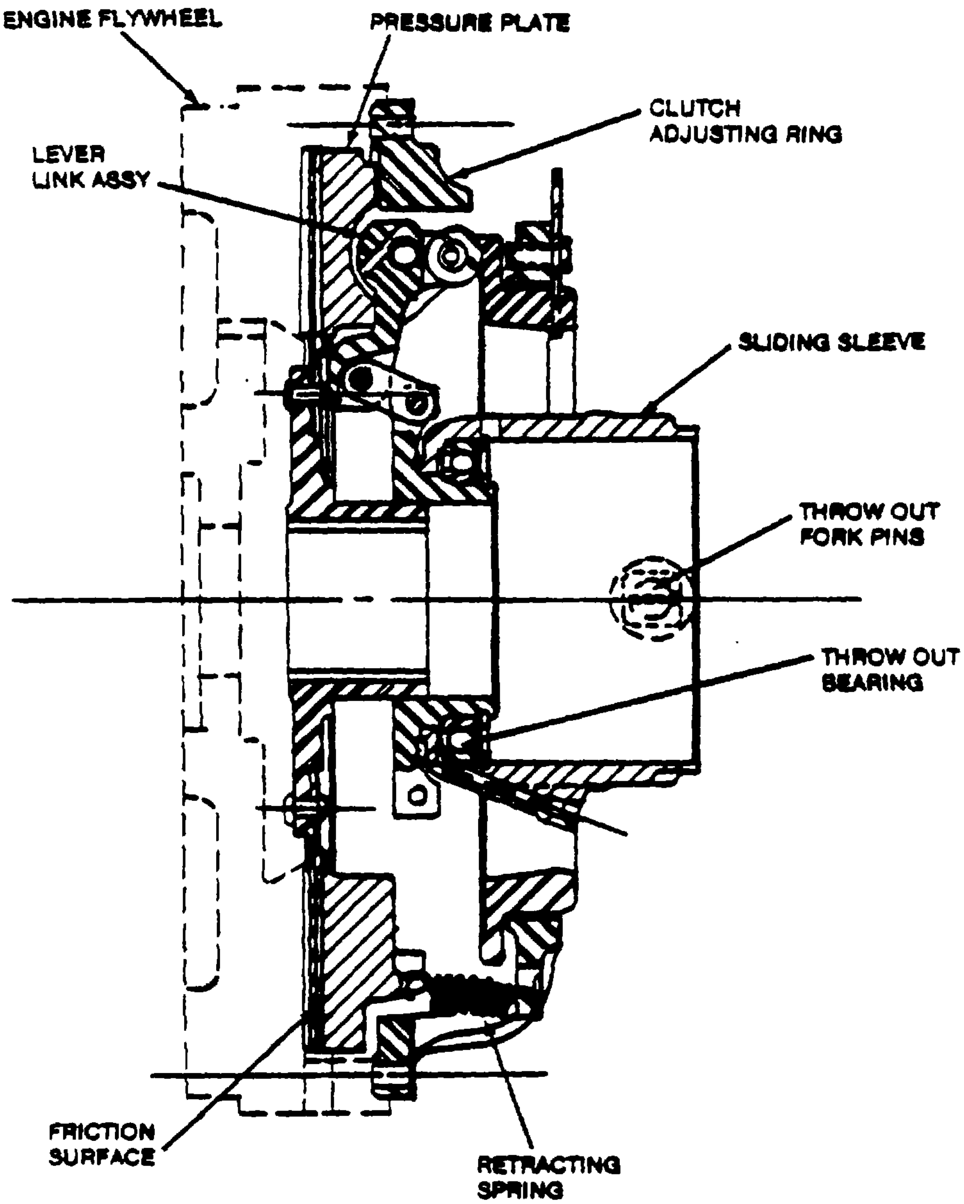
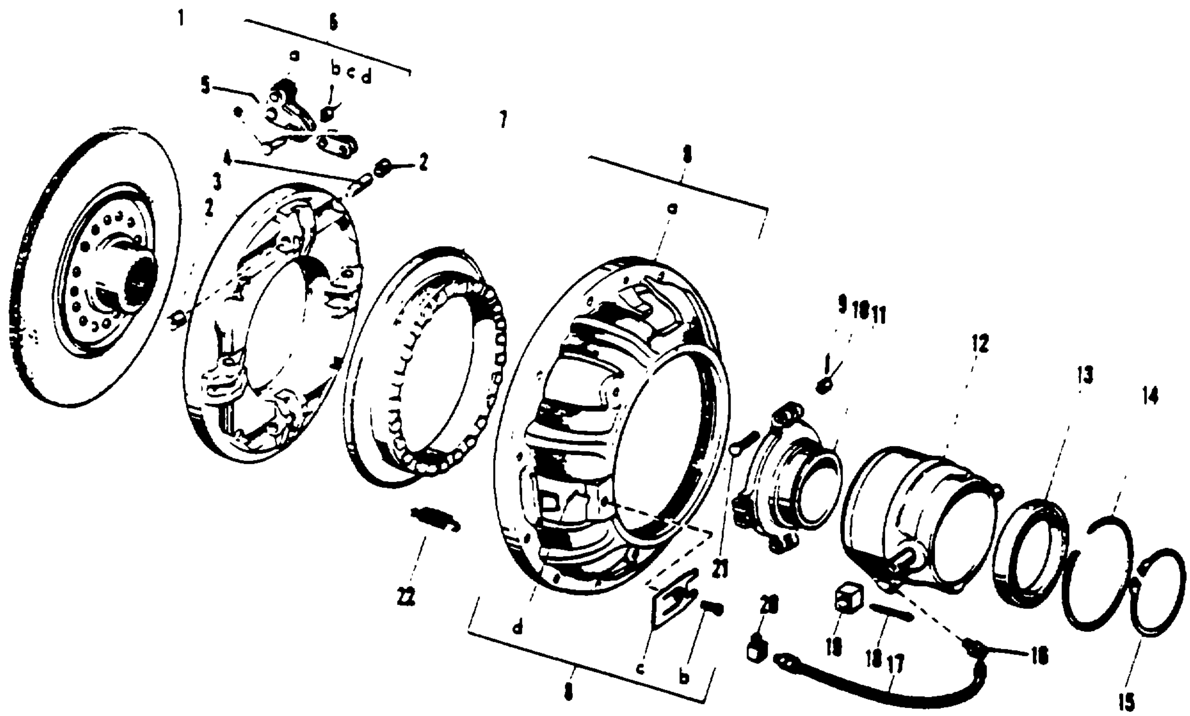


Figure 5-40. Clutch Assembly.



Item	Description	Quantity
1	PLATE, driving, assembly	1
2	NEEDLE BEARING, closed-end	8
3	PLATE, pressure	1
4	PIN, lever	4
5	PIN, dowel, grooved	4
6	LEVER, link, plate and, pressure, assembly	4
a	LEVER, plate, pressure, assembly	1
b	PIN, roll, 1/8-inch	1
c	COLLAR, pin, headed	1
d	LINK	2
e	PIN, headed, 1.59-inch	1
7	RING, adjusting	1
8	PLATE, cover, clutch, assembly	1
a	PLATE, cover, clutch	1
b	SCREW, cap, hex-head	1

Item	Description	Quantity
c	LOCK, ring, adjusting	1
d	PIN, roll, 3/32-inch	1
9	PIN, roll, 1/8-inch	4
10	COLLAR, pin, headed	4
11	COLLAR, bearing, release	1
12	SLEEVE, sliding	1
13	BALL BEARING, throwout, clutch	1
14	RING, snap, internal	1
15	RING, snap, external	1
16	FITTING, hose, 45-degree	1
17	HOSE, flexible	1
18	PIN, cotter	2
19	BLOCK, shifter	2
20	FITTING, hose, 90-degree	1
21	PIN, headed, 1.91-inch	4
22	SPRING, release	4

Figure 5-41. Clutch Assembly Disassembly and Reassembly.

d. Inspect bearings and lube lines for evidence of excessive wear or damage. Replace unsatisfactory bearings and lube lines.

e. Inspect remaining metal parts for chips, scoring and other damage. Pay particular attention to any scoring of pressure plate. Light scoring should be smoothed out with a fine grade of emery cloth. Replace a pressure plate that cannot be easily resurfaced.

f. Inspect remaining metal parts for excessive wear or damage and replace as necessary.

g. Inspect clutch operating shaft and bushings for excessive wear and scoring. Replace bushings if worn excessively.

5-86 Clutch assembly reassembly

a. Reassemble clutch in reverse sequence of removal procedure.

b. Use new seals during reassembly and use care not to damage seal during mating.

c. Lubricate clutch assembly through grease fittings to insure there are no blockages in lube lines and fittings.

d. Actuate clutch operating shaft, by temporarily attaching handle, and insure proper clutch action. Preliminary clutch adjustment may be made at this time.

e. If no discrepancies are noted, install clutch assembly on torque converter and engine flywheel.

f. Install torque converter on winch.

Section XX. Winch Drive Shaft and Drum Assemblies Repair Instructions

5-87 Heavy components

a. General

(1) Maintenance of winch components will normally require use of a suitable lifting device. Utilization of a standard electric shop hoist with both lateral and vertical movement and high and low speed controls is recommended.

WARNING

Do not attempt to remove winch drums with a hoist of less than 2000 lb capacity. If the drum jams during removal it could cause lifting device failure and winch damage. Due to the slant of the winch frame and the weight of the drums, personal injury is probable if a drum is dropped.

(2) Drums can be removed from winch with wire rope on drum. However, extra weight will increase difficulty of handling drum. Remove wire rope from drum prior to maintenance that requires complete drum disassembly such as winch overhaul.

(3) Instructions in this chapter assume complete disassembly of each component addressed. It is unnecessary to disassemble all parts of a drum to replace a single part such as a bearing. Disassemble components only as far as is necessary to effect repair.

b. Preparation. Drum and drive shaft maintenance requiring removal of the shafts will require removal of the chain case, gear guard and brake bands.

(1) Remove chain case.

(2) Remove brake bands.

c. Cleaning. Clean all components prior to disassembly and as required during disassembly. Use a suitable solvent to clean grease and oil from metal parts.

Section XXI. Drive Shafts and Drums

5-88 Winch drive shaft removal

NOTE

If the gears are binding, ensure that the torque converter clutch is disengaged and release one drum parking brake. Then bar the drum gear so that the drive gear assembly rides up the other drum gear (parking brake applied) until the drive gear is free.

b. Disassembly

(1) Refer to Figure 5-42 and start at drive gear end of shaft. Remove six hex head screws from roller bearing retainer, and retainer.

(2) Remove lube fitting from roller bearing pillow block and pull pillow block off bearing.

(3) Use a suitable gear puller and pull roller bearing, spacer and drive gear off shaft. Remove second spacer at ball bearing shoulder of shaft.

(4) Remove bearing cover, seal and spacer from sprocket end of shaft.

(5) Pull pillow block off ball bearing. Use a suitable bearing puller and pull bearing and bearing retainer off shaft.

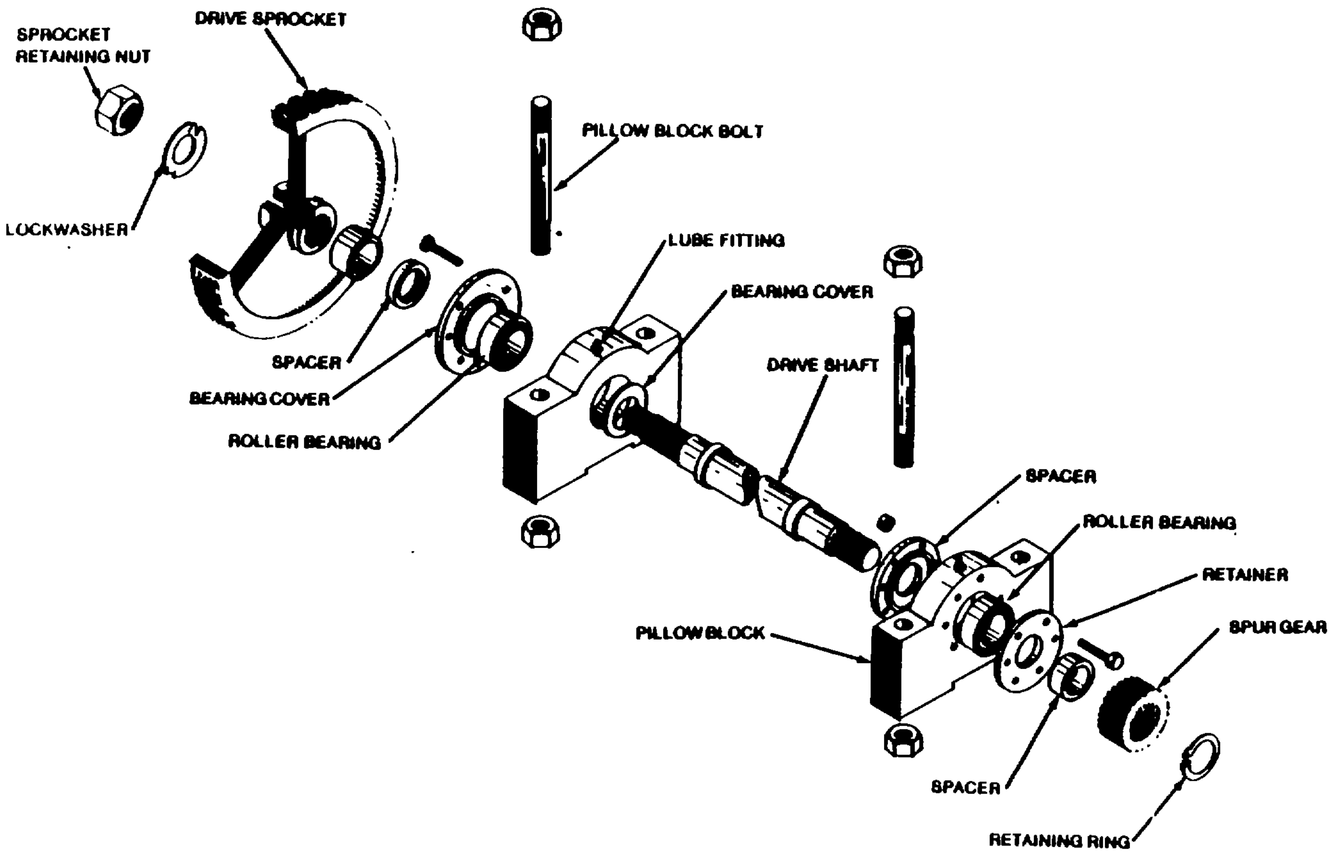


Figure 5-42. Drive Shaft Disassembly and Reassembly.

5-89 Drive shaft inspection and repair

a. Cleaning. Thoroughly clean all parts in a suitable solvent and dry thoroughly. Do not immerse parts in solvent since bearing surfaces and other highly machined parts could be damaged if they are banged together.

b. Inspection. Inspect all parts for signs of excessive wear as follows:

(1) Inspect male and female splined surfaces for wear, chipped teeth and other damage.

(2) Inspect sprocket and gear teeth for excessive wear, chipped teeth and other damage.

(3) Inspect shaft and pillow blocks for signs of scoring.

(4) Inspect bearings, bearing retainers and seal for signs of damage.

c. Drive Shaft Repair

(1) Light scoring of shaft bearing surfaces and pillow block surfaces can be polished out with 400 grit or finer emery cloth.

(2) Repair other defective parts by replacement.

5-90 Winch drive shaft reassembly and installation

NOTE

During reassembly lubricate bearing and splined surfaces to reduce friction. Hand pack bearings with lubricant before installation. Bearings may be heated to a maximum of 225°F in an oil bath or oven to ease installation. (Ensure bearings are not in contact with a heated surface such as the bottom of the pan.) After installation of the lube fittings lubricate the bearings before installing final seals and retainers.

a. Install inner ball bearing retainer on shaft.

b. Press ball bearing on shaft from sprocket end until it is seated against shoulder and bearing retainer.

c. Push pillow block over bearing and install spacer.

d. Install bearing retainer, lube fitting and seal.

e. Turn shaft around and install spacer and drive gear. Drive gear can be tapped with a soft hammer if necessary. Tap all around gear to insure it remains square with shaft.

f. Install roller bearing spacer and press roller bearing on shaft.

g. Complete assembly in reverse sequence of removal procedure.

h. Reinstall winch drive shaft assembly.

5-91 Winch drum removal

a. Shaft and Bearings Disassembly

(1) Remove drum shaft and drum assembly.

(2) Gear end disassembly is performed as follows:

CAUTION

Support the winch drum assembly in a suitable stand so that the drum drive gear teeth are not supporting any of the weight of the assembly.

(a) Refer to Figure 5-43 and remove bolts attaching airline end plate and air coupling to shaft.

(b) Remove lock nut and lock washer from end of shaft bolts attaching end plate to shaft.

(c) Pull drive gear off shaft using a suitable puller.

(d) Pull pillow block off roller bearing.

(e) Use a suitable puller and pull inner roller bearing retainer and roller bearing off the shaft.

(f) Pull clutch mechanism out of clutch drum.

(g) Remove drum bearing lube line, elbow and bearing retainer.

(3) Disassemble other end of drum as follows:

(a) Remove lock nut and washer from end of shaft.

(b) Pull pillow block off shaft.

(c) Use a suitable puller, if necessary, and pull roller bearing off shaft.

NOTE

The bearings on the end of the shaft away from the drive gear are floating bearings and are installed with a push fit or light press fit. A puller may not be required to remove these bearings.

(d) Remove spacer and drum bearing lube line and elbow.

(e) Remove bearing retainer.

(4) Push shaft, from drive gear end, through drum far enough to attach a puller to drum bearing. Remove drum bearing.

(5) Push shaft toward drive gear end until other drum bearing can be removed. Use a puller as necessary.

(6) Remove drum shaft.

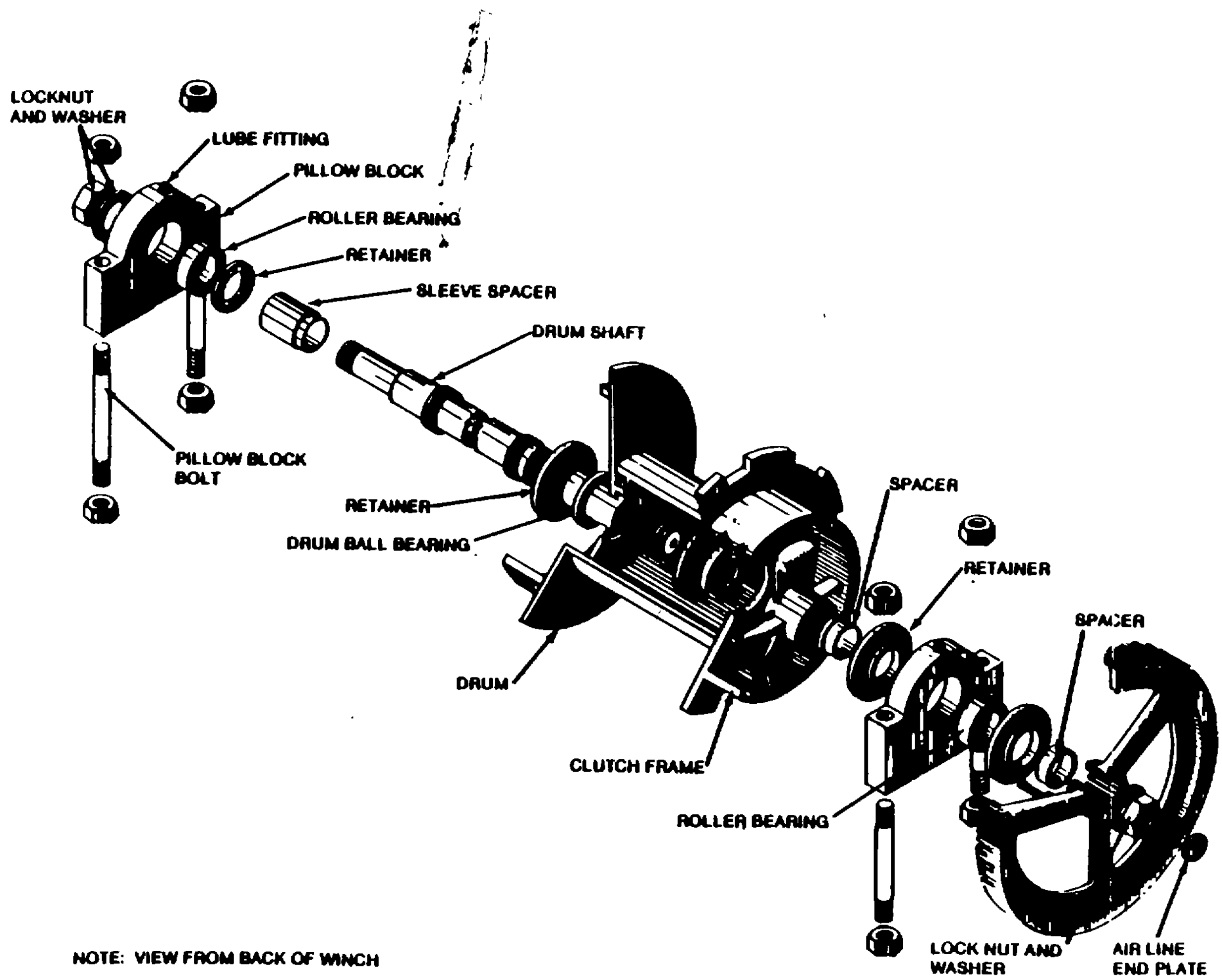


Figure 5-43. Winch Drum Disassembly and Reassembly.

b. Shaft and bearings inspection and repair

CAUTION

Do not immerse parts in solvent since bearing surfaces and other highly machined parts could be damaged if they are banged together.

(1) Cleaning. Thoroughly clean all parts in a suitable solvent and dry thoroughly.

(2) Inspection. Inspect all parts for signs of excessive wear as follows:

(a) Inspect male and female splined surfaces for wear, chipped teeth and other damage.

(b) Inspect gear teeth for excessive wear, chipped teeth and other damage.

(c) Inspect shaft and pillow blocks for signs of scoring.

(d) Inspect bearings and bearing retainers for signs of damage.

(3) Drum Drive Shaft Repair.

(a) Light scoring of shaft bearing surfaces and pillow block surfaces can be polished out with 400 grit or finer emery cloth.

(b) Repair other defective parts by replacement.

c. Shaft and bearings reassembly and installation

NOTE

During reassembly, lubricate bearings and splined surfaces to reduce friction. Hand pack bearings with lubricant before installation. Bearings may be heated to a maximum of 225°F in an oil bath or oven to ease installation. (Ensure bearings are not in contact with a heated surface such as the bottom of the pan.) After installation of the lube fittings lubricate the bearings before installing final seals and retainers.

(1) Assemble and install drum drive assembly in reverse sequence of disassembly procedure.

(2) Lubricate threads of pillow block bolts and torque to 110-115 lb ft during installation.

Section XXII. Drum Brakes

5-92 Drum brake assemblies

a. General. The Conmaco Model 270 two drum winch has a brake attached to each drum mechanism. The brakes are band type that are applied around the exterior surface of the cylindrical brake drum welded to the cable drum flange. Figure 5-44 is a schematic of the right side of the cable drum showing the location and size of the brake drum flange.

b. Drum Brake Assembly Removal

(1) Front and rear drum brake assemblies are identical except that certain brake band hardware is located differently.

NOTE

Maintenance procedures will be performed facing the engine end of the winch toward the drums.

(2) Removal, inspection, repair and installation instructions in this section will apply to either drum brake. Where procedure is different for front drum, it will be addressed as a note.

c. Brake Band Removal

(1) Ensure that area around winch brakes is clean and remove brake drum dust cover.

WARNING

Wear eye protection when using compressed air or serious eye injury could result.

(2) Use compressed air and blow loose brake dust out of brake and clutch drums.

(3) Inspect brake bands and brake drum for an out of round condition. Check individual pads for excessive wear. Note any discrepancies.

CAUTION

If normal air pressure is not available from the winch air tank ensure that the source air pressure is between 90-125 psi. Air pressure below 90 psi may not release the brake; excess pressure could damage the air actuator.

(4) Apply air pressure to release parking brake.

(5) Loosen and remove adjusting bolts and shims between live and dead brake bands (Figure 5-45).

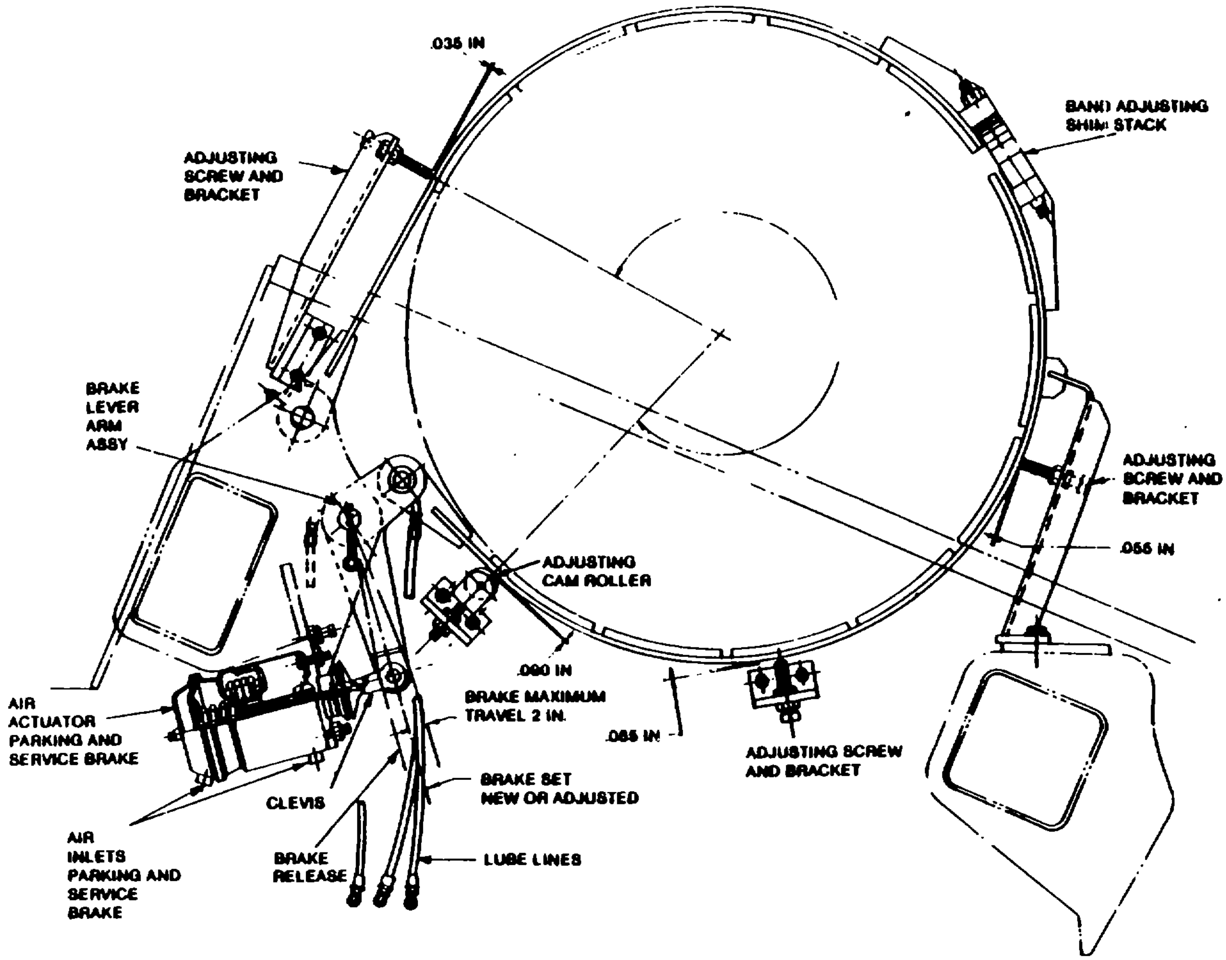


Figure 5-44. Drum Brake Assembly.

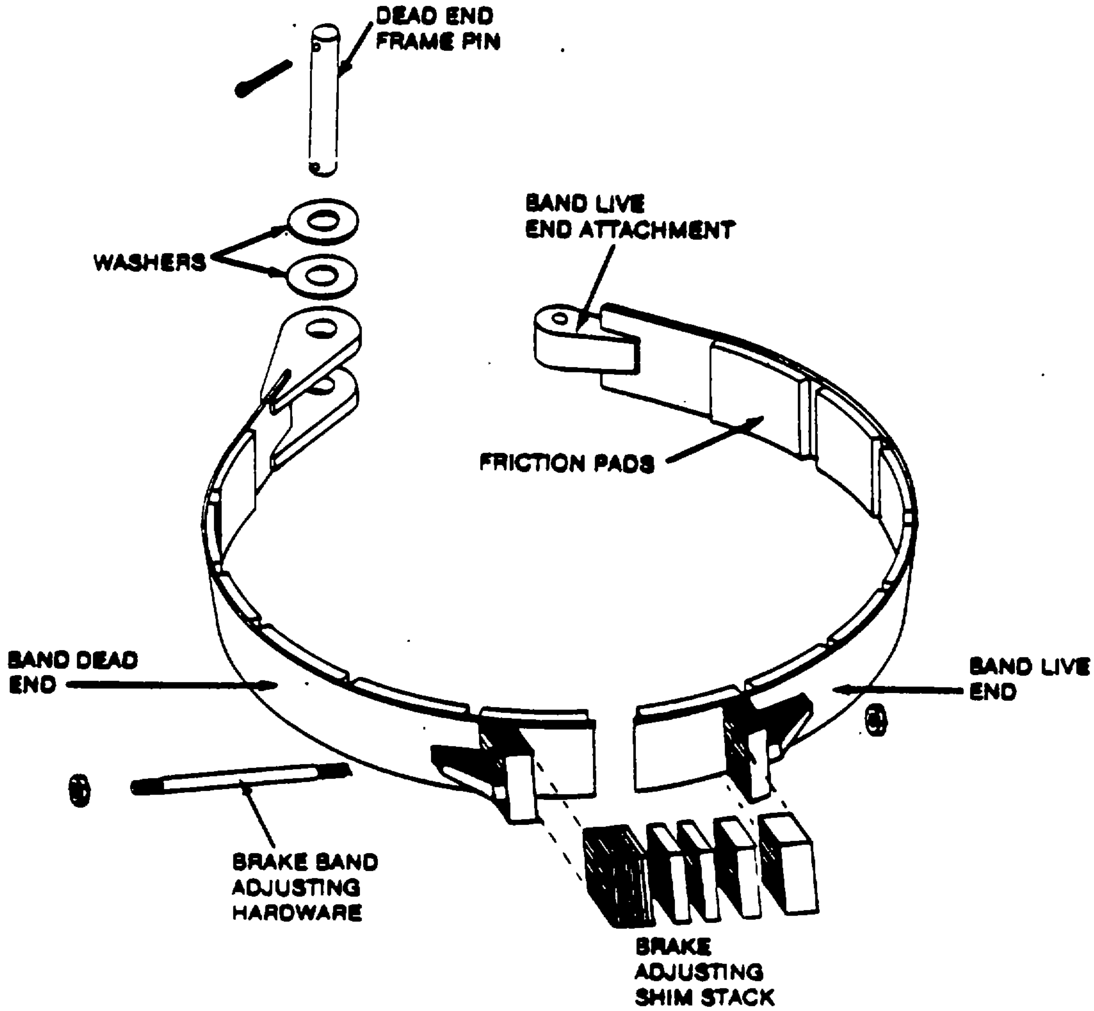


Figure 5-45. Brake Band Assembly.

(6) Loosen brake band guide bolts and cam roller(s) enough to remove brake bands.

(7) Slowly release air pressure on parking brake air chamber. Then remove pin attaching live end of brake band to brake actuating arm.

(8) Remove dead end of band in a similar manner.

(9) Remove pin from brake actuating chamber clevis.

(10) Refer to Figure 5-46 and remove four hex bolts, clip washers and nuts that mount brake actuating arm to winch frame. Remove swivel lube line to live end brake band pin. Remove brake arm.

(11) Remove hex nuts and lock washers that mate brake air chamber to winch frame.

(12) Remove air line to brake chamber.

(13) Loosen jam nuts on brake connecting rod and disconnect hex sleeve while removing air chamber.

(14) Remove hex nuts and lockwashers that mount parking brake air chamber. Remove chamber.

d. Brake band inspection and repair

(1) Inspect cam roller(s) and brake band guide bolts. Remove and replace with new parts if these items are damaged.

(2) Clean all remaining parts with cleaning solvent and dry thoroughly. Do not immerse the air chamber in solvent.

(3) Inspect brake actuating arm and shaft. Pay particular attention to end of shaft that enters bushing in winch frame. If either bushing or shaft show signs of excessive wear or other damage proceed as follows:

(a) Remove hex head retaining bolt, washer, and lockwasher from winch frame.

(b) Remove retaining ring and knock bushing out of frame using a suitable drift.

(c) Reinstall a new bushing in reverse sequence of removal procedure.

NOTE

Use a soft hammer as necessary to seat the new bushing.

(d) Use a 400 grit or finer emery cloth to polish light scoring from end of shaft that is seated in bushing. If scoring cannot be polished out replace brake actuating arm assembly.

(4) Inspect brake arm assembly as follows:

(a) Inspect connecting pin holes for signs of excessive wear. Look for signs of elongation of holes.

(b) Rotate arm around bearing and check for signs of binding, loose bearings or other damage.

(c) If damage is noted proceed as follows, and remove hex screw and nut holding each of brake arms on shaft and remove the arms.

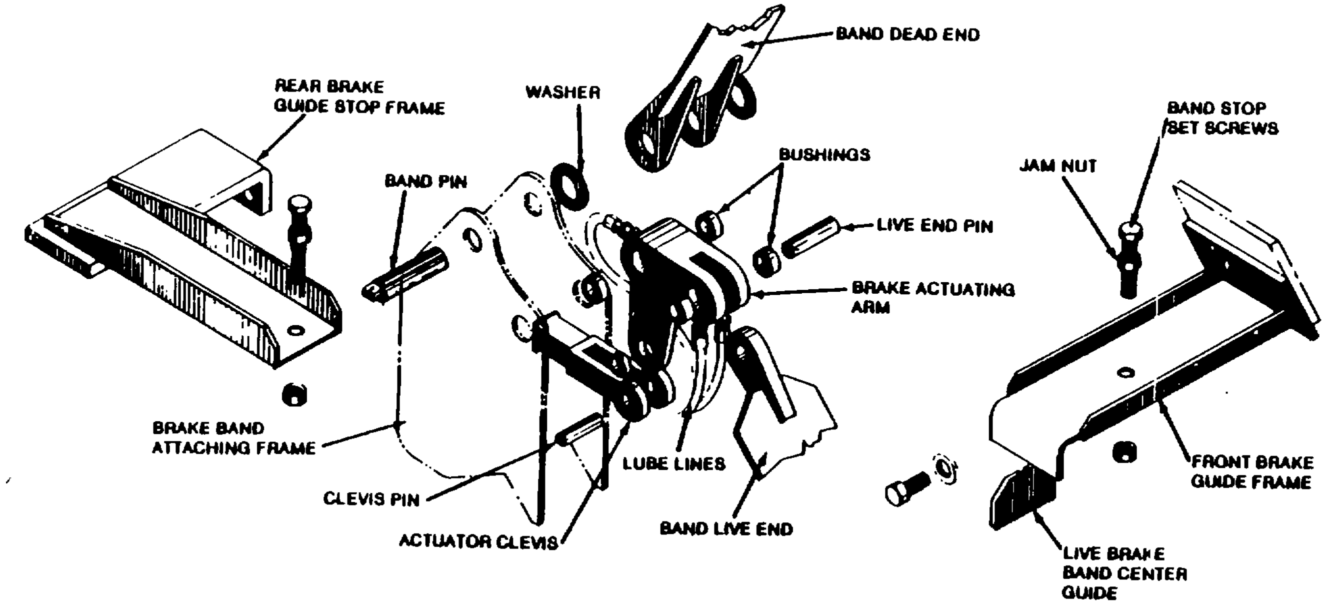


Figure 5-46. Brake Acutating Arm Assembly and Disassembly.

(d) Use a suitable press and push bearing and shaft out of brake arm mounting sleeve.

(e) Repair by replacement of defective parts.

(f) Rebuild brake arm assembly.

NOTE

Coat shaft and bearing surfaces of the housing with light weight engine oil to reduce friction during reassembly.

(g) Lubricate bearing and rotate shaft several times to check binding.

(5) Inspect brake bands and pads for excessive wear or damage.

(6) If any pads are badly worn or damaged replace all pads on both bands.

NOTE

In some circumstances it may not be necessary to replace all the pads. If there is any doubt contact your supervisor for guidance.

e. Brake band installation

(1) Reassemble in reverse of disassembly sequence.

NOTE

Connect the air line to the parking brake air chamber and release the parking brake prior to installation. This will retract the piston so that it can more easily be mated to the brake arm. With the brake still released mount and connect the brake air chamber.

(2) Adjust the brakes.

Section XXIII. Clutches

5-93 Clutch assemblies

a. General. The clutch assemblies are integral with the drum drive mechanism. The air swivel joint on the end of the drive shaft is the only connection to the static portions of the winch and control system.

b. Previous Steps. Procedures in this Section assume that steps 5-91.a. thru 5-91.a.(2Xg), removal of the clutch assembly, have been completed.

c. Clutch disassembly

(1) Refer to Figure 5-47 and loosen the five jam nuts and band screws.

(2) Remove cotter keys from band live and dead end line pins.

(3) Remove link pins.

(4) Remove four clutch band retaining springs.

(5) Remove clutch band.

NOTE

Do not disassemble the clutch mechanism further unless there is evidence of excessive wear of the actuating arm pin holes, bearing or air actuator failure. The flexible air line and elbows may be replaced without removal of the air actuator, clevis or actuating arm.

(6) Remove nuts, bolts and washers that hold actuating arm pin and band dead end frame pin.

(7) Disconnect clevis from air actuator and actuating arm. Actuating arm and pin, and dead end link and frame pin can now be removed.

(8) Remove live end guide bar.

(9) Disconnect flexible air line.

(10) Remove bolts and lock washer mounting air chamber.

(11) Remove air chamber.

d. Clutch assembly inspection and repair

(1) Clean all parts except the clutch band with a suitable solvent and dry thoroughly.

(2) Wipe clutch band pads with a solvent dampened cloth.

(3) Inspect all parts for signs of excessive wear or other damage. Pay particular attention to actuating arm and link pin holes for sings of elongation.

(4) Inspect all mounting hardware for damaged threads. Retap holes as necessary and replace damaged bolts.

(5) The four retracting springs are all same length when new. Spring attached nearest set screw #3 is stretched most and may elongate after extended use. Replace all springs if they are not the same length.

(6) Repair all other components by replacement of defective parts.

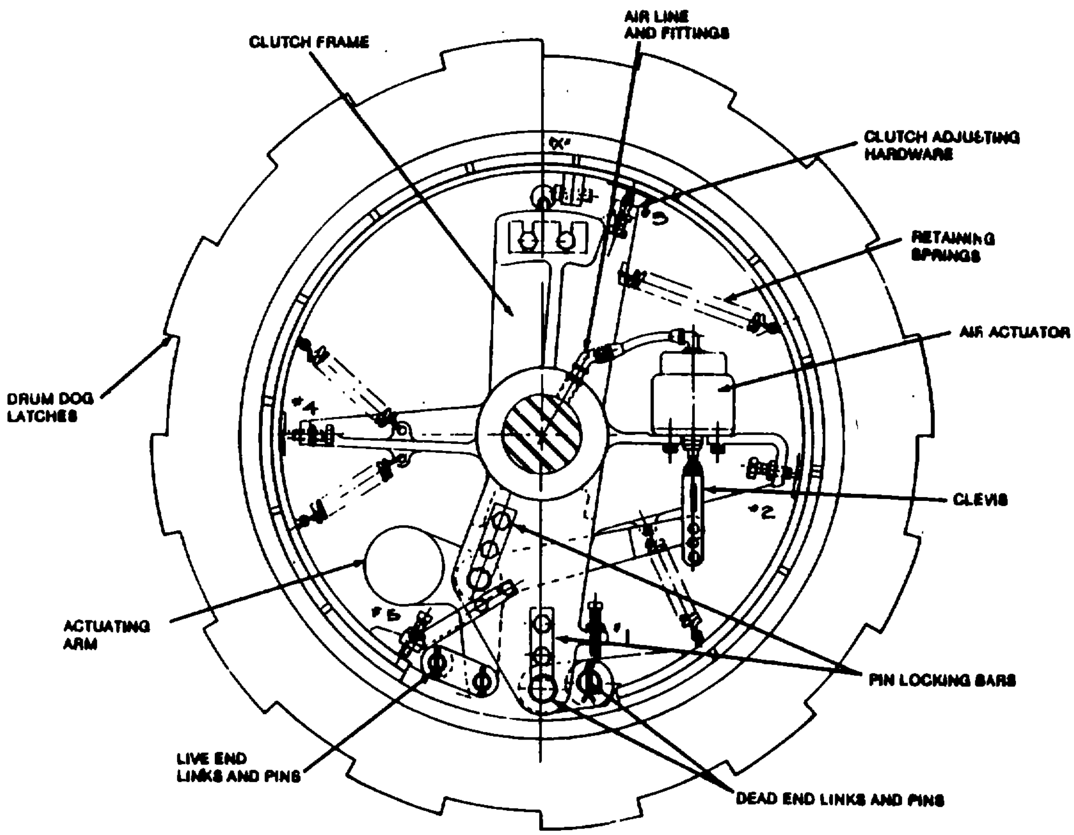


Figure 5-47. Drum Clutch.

(7) Inspect friction pads for uneven wear and other damage. Repair by replacing all friction pads as a set.

(8) Inspect clutch drum face for signs of overheating and scoring. Normally deep scoring and out of round condition require wire drum replacement.

e. Clutch assembly reassembly

(1) Reassemble clutch assembly in reverse of disassembly sequence.

(2) Leave five band jet screws retracted until clutch is installed on drum shaft.

5-94 Drum reassembly and installation

a. Reassemble drum in reverse sequence of disassembly procedure. Hand pack bearings with grease prior to installation.

b. Lubricate both inner and outer clutch splines with a high pressure grease to ease assembly.

CAUTION

When installing the clutch on the shaft insure that the air hole in the clutch frame aligns with the hole in the shaft.

c. When installing pillow block roller bearings press them on shaft first. Then push pillow blocks on to bearings.

NOTE

The pillow block roller bearings are a light press fit on the shaft and a push fit in the pillow blocks. The bearings may be heated to a maximum of 225°F in an oil bath or temperature controlled over to ease installation on the shaft. Do not allow bearings to come in contact with the container surface during heating. Hot spots can damage the bearing surface hardness.

d. Reinstall tube fittings and lubricate all bearings to insure clear tube lines. Rotate drum shaft and pillow blocks to spread lube in bearings.

e. Install drum assembly on winch frame.

f. Lubricate Drum Drive gear splines in same manner as clutch splines and install drive gear and air fitting.

g. Test clutch for proper operation and adjust clutch band set screws.

h. Install brake bands, guards and dust covers.

Section XXIV. Winch Head Drive and Guide Removal, Inspection, Repair and Installation

5-95 General. The winch head drive assembly can be removed, repaired and replaced independently from the rest of the winch drive mechanism.

5-96 Winch head assembly removal

a. Refer to Figure 5-48 and remove winch head gear guard.

b. Remove winch head shaft pillow block mounting bolts and lock washers.

c. Lift winch head shaft with the pillow blocks attached from winch frame. Move assembly to a suitable maintenance area before further disassembly.

CAUTION

Do not attempt disassembly of the pillow blocks at the work site. Dust and dirt can enter the bearings which will cause excessive wear and premature bearing failure.

5-97 Winch head disassembly inspection and repair

a. Mark pillow blocks and bearings by location on shaft.

b. Remove Gib keys inside winch heads.

NOTE

If Gib keys cannot be removed by pulling on the tab at end of the key, use a drift and tap them loose from inside. Use care to avoid damaging winch head and shaft key ways.

c. Pull winch heads off shaft.

d. Remove drive gear locking collar and pull gear off the shaft. Remove inner gear locking collar.

e. Remove bearing retainers from each pillow block.

f. Pull pillow blocks off the bearings.

g. Remove bearings with a suitable puller.

h. Wash all parts in a suitable cleaning solvent and dry thoroughly.

i. Inspect shaft for signs of scoring, excessive wear and chipped spline teeth.

j. Inspect bearing faces of pillow blocks for signs of scoring.

CAUTION

If either the shaft or pillow block bearing surfaces show evidence of scoring, replace the associated bearing. Scoring of the bearing face indicates actual or impending bearing failure. Bearing failure under operational loads can seriously damage winch components.

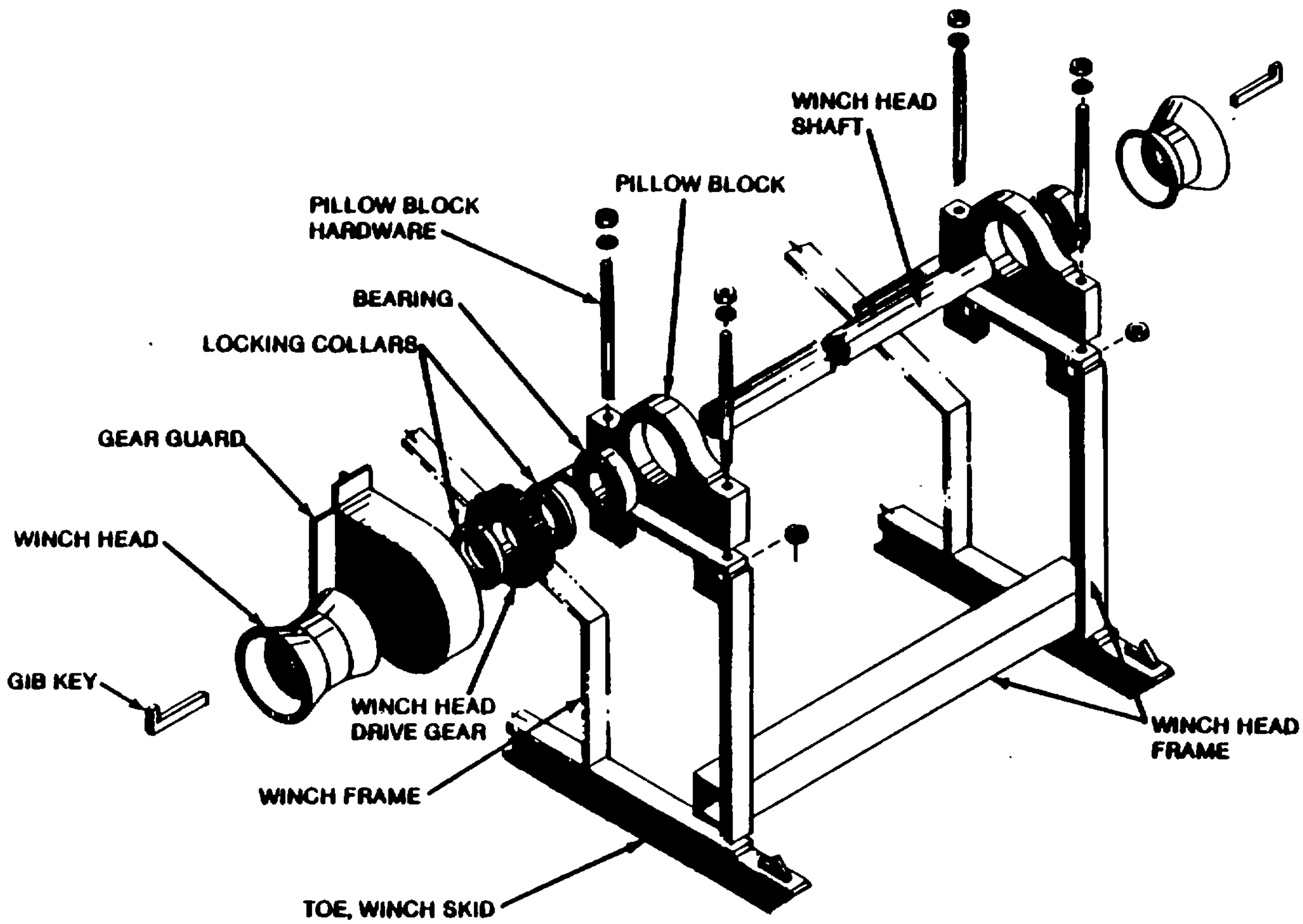


Figure 5-48. Winch Head Disassembly and Reassembly.

k. Light scoring marks on shaft or bearing faces of pillow blocks can be polished out with a fine grade emery cloth. Use care when polishing these surfaces to avoid flat spots.

l. Inspect winch shaft drive gear for signs of excessive wear and chipped teeth. Inspect female spline area for excessive wear or other damage.

m. Apply a lube gun to pillow block lube fittings and insure that lubricant flows freely through fitting.

n. Repair by replacement of defective or non-repairable parts.

5-98 Winch head shaft assembly Installation

a. Lubricate shaft bearing surfaces with 30-weight or similar engine oil and press the roller bearings on the shaft.

CAUTION

Insure that bearings are reinstalled In original location. Bearings are not identical and reversed installation could cause premature bearing failure and additional equipment damage.

b. Push pillow blocks on roller bearings.

c. Lubricate roller bearings and rotate pillow blocks around shaft several times. This will spread lubricant and provide a way to check that bearings are properly installed.

d. Install bearing retainers.

e. Lubricate inner and outer splines of winch head drive gear and after Installing Inner locking collar, press gear on shaft.

f. Complete assembly and installation In reverse of disassembly sequence.

NOTE

Use a light weight oil to lubricate the winch heads and Gib keys. Tap the Gib keys with a hammer to insure that they are firmly seated in the key way.

5-99 Winch head guide

a. General. The winch head guides are unpowered rollers mounted on winch frame so that roller is vertical. This roller is used to redirect polypropylene line from winch head to reeling machine.

CAUTION

Do not allow the polypropylene line to become slack and fall off the rollers. Also, do not allow the reeling machine to take up line faster than it is being delivered from the winch head. Slack line could be pinched and damaged between the roller and frame. Excess tension could damage the reeling machine clutch or the roller guide bushing.

b. Construction. Winch head guides are of steel construction mounted on steel frames that are bolted to winch frame. Rollers have a bronze bushing that is lubricated through a grease fitting in top of the shaft.

5-100 Winch head guide removal, repair and reassembly

a. Remove four bolts and lockwashers that hold drum retainer to shaft and remove retainer.

b. Pull drum off winch head guide shaft.

c. If guide frame requires repair, remove six nuts, lockwashers and bolts that mount guide frame to winch frame.

d. Clean all parts with a suitable solvent and dry thoroughly.

e. Repair winch head guide components as follows:

(1) Use a torch and hammer to straighten frame components.

(2) Press bronze bushing out of roller if it is scored. Install new bushing by heating roller and pressing bushing in with a suitable press.

(3) If shaft is scored replace shaft.

(4) Replace damaged hardware such as nuts and bolts.

f. Install winch head guide roller in reverse sequence of disassembly procedure.

g. Lubricate roller guide prior to operation.

CHAPTER 6 GENERAL SUPPORT MAINTENANCE INSTRUCTIONS

Section I. Repair Parts, Special Tools and Equipment

6-1 Special tools and equipment. No special tools or equipment are required by General Support maintenance personnel for performing maintenance on the winch assembly.

Section II. General Support Troubleshooting

6-2 General. For a general description and purpose of the troubleshooting table, refer to paragraph 3-5.

6-3 General support maintenance troubleshooting. Table 6-1 lists the winch assembly troubleshooting malfunctions for direct and general support maintenance personnel.

Section III. General Maintenance Instructions

6-4 General

a. This section provides general cleaning, inspection and repair instructions that are common to components of the winch assembly.

b. Special cleaning, inspection and repair instructions applicable to any individual component are covered with that component in the applicable sections of this manual.

6-5 General cleaning instructions

a. Metal Parts

WARNING

Cleaning solvents are dangerous to your health. Long term effects from solvents such as Fed. Spec. P-D-680 can include cancer. Short term effects, especially when used in poorly ventilated areas, include unconsciousness and death.

(1) Prior to removal or disassembly of major components, clean excess oil or dirt with a cleaning solvent or steam clean.

(2) Use a cleaning solvent to clean parts such as gears, housings and hand packed bearings.

Table 6-1. General Support Maintenance Troubleshooting

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

1. Engine Fails to Start

   Check for poor compression.

   Replace piston rings (paras 6-31 thru 6-33).

   Repair or replace valves.

2. Engine Produces Excessive Smoke at Idle Speed

   Step 1. Check for worn valve guides.

   Replace valve guides (paras 6-69 thru 6-71).

   Step 2. Check for worn or broken piston rings.

   Replace piston rings (paras 6-31 thru 6-33).

   Step 3. Check for scored or defective cylinder liners.

   Replace piston rings (paras 6-31 thru 6-32) and cylinder liners (paras 6-34 thru 6-36).

3. Engine Produces Excessive Smoke Under Load

   Check for worn or broken piston rings.

   Replace piston rings (paras 6-31 thru 6-33).

4. Engine Lacks Power

   Step 1. Check for broken or worn piston rings.

   Replace piston rings (paras 6-31 thru 6-33).

   Step 2. Check for scored or worn pistons and liners.

   Replace pistons and rings (paras 6-31 thru 6-33) or liners (paras 6-34 thru 6- 33).

5. Engine Consumes an Excessive Amount of Fuel

   Check for worn or sticking valves.

   Repair or replace valves.

6. Engine Consumes an Excessive Amount of Oil

   Step 1. Check for worn or broken piston rings.

   Replace piston rings (paras 6-31 thru 6-33).

   Step 2. Check for worn valve guides.

   Replace valve guides.

Table 6-1. General Support Maintenance Troubleshooting - Continued

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

Step 3. Check for defective main bearings.

Replace main bearings (paras 6-37 thru 6-39).

Step 4. Check for scored pistons or piston liners.

Replace pistons (paras 6-31 thru 6-33) and liners (paras 6-34 thru 6-33).

7. Engine Oil Pressure is Low

Step 1. Check for restricted oil pump suction line.

Clean oil pump screen.

Step 2. Check for defective oil pump.

Repair or replace oil pump (Para 6-18).

Step 3. Check for worn connecting rod bearings.

Replace connecting rod bearings (paras 6-31 thru 6-33).

Step 4. Check for worn main bearings.

Replace main bearings (paras 6-37 thru 6-39).

Step 5. Check for defective oil pressure regulator.

Repair or replace oil pressure regulator (Para 6-18).

Step 6. Check for defective crankshaft.

Replace crankshaft (paras 6-37 thru 6-39).

8. Winch Drum Releases Slowly or Drags

Check for torque converter failure.

Repair or replace the torque converter (paras 6-45 thru 6-47).

Section IV. Variable Speed Governor

6-6 General

a. The variable speed mechanical governor is designed to control engine idle speed, limit maximum no load speed, and hold engine at any constant speed between idle and maximum as desired by operator.

b. The governor is a double-weight speed limiting governor and is mounted on right front side of engine. It is driven by a shaft that extends through end plate and keys to balance shaft gear.

c. There are two manual controls on governor: a stop lever and a speed control lever. In its normal position, stop lever holds fuel injector rack near fullfuel position. When engine is started, governor moves injector racks toward idle speed position. Engine speed is then controlled by movement of speed control lever.

d. Governor is lubricated by oil splashed from engine gear train. Oil passes through governor weight housing to shaft and weight assembly. Revolving weights distribute oil to various moving parts of governor. Surplus oil drains back to engine crankcase through holes in governor bearing retainer.

6-7 Govemor disassembly

a. Remove four special cap screws from cover and remove cover assembly.

b. Disassemble governor cover assembly as follows (Figure 6-1):

(1) Loosen clamping bolt and remove stop lever from shaft.

(2) Remove torsion retraction spring.

(3) Remove throttle shaft, lock washer, and retaining ring. Withdraw control shaft from cover.

(4) Remove seal ring from governor cover.

(5) Wash cover assembly (on former engines cover assembly contained two needle bearings, however on current engines, cover assembly contains a bushing which is not serviced. When replacement is necessary, use needle bearings) thoroughly in clean fuel oil and inspect needle bearings or bushing for wear or damage.

(6) If needle bearing or bushing removal is necessary, place inner face of cover over the opening in bed of an arbor press. Place remover on top of bearing or bushing and under ram of press, then press both bearings or bushing out of cover.

c. Place control housing (Figure 6-2) in soft jaws of a vise.

d. Remove two bolts and lock washers and withdraw variable speed spring housing, spring plunger, and spring as an assembly. Withdraw spring plunger from plunger guide.

e. Remove spring retainer and washer. Lift differential lever off pin of operating shaft lever.

f. Refer to Figure 6-3 and remove variable speed spring plunger guide. Remove bearing retaining screw, flat washer and lock washer.

g. Remove expansion plug out of lower end of control housing.

h. Loosen operating fork setscrew, if used.

i. Support control housing bottom side up on the bed of the press. Use a brass rod and press operating shaft from operating fork (Figure 6-2). Withdraw operating shaft, operating lever and bearing as an assembly from control housing.

j. Support operating shaft and lever on bed of press. Use brass rod and press shaft from operating lever and bearing.

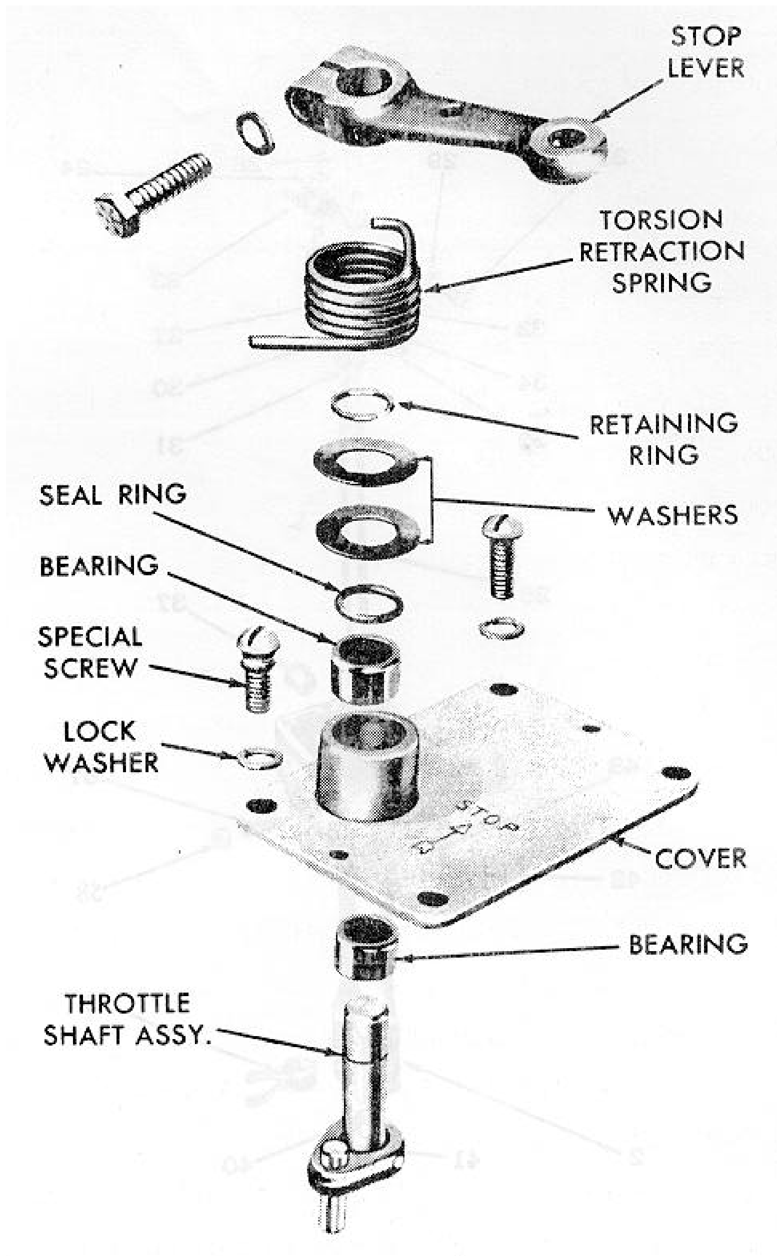
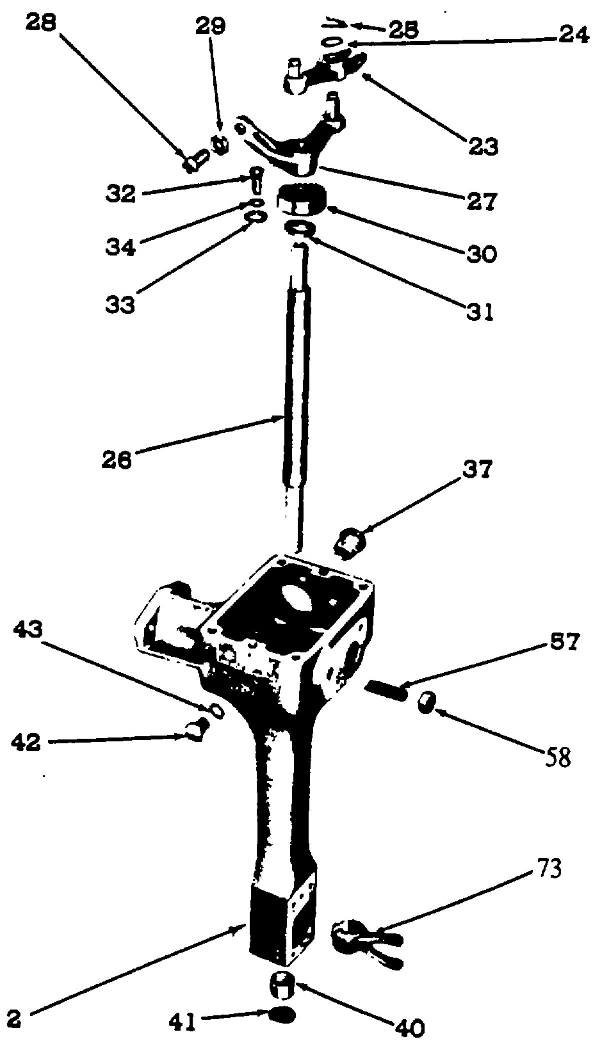
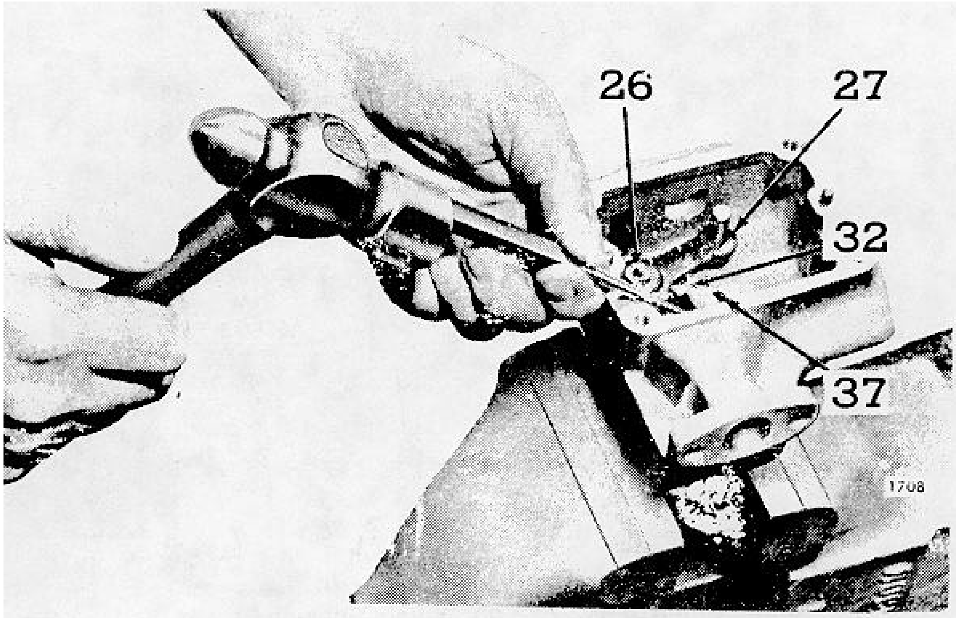


Figure 6-1. Governor Cover Details.



2. Housing--Governor Control
23. Lever--Differential
24. Washer--Lever Pin
25. Retainer--Spring
26. Shaft--Operating
27. Lever--Operating Shaft
28. Screw--Gap Adjusting
29. Lock Nut
30. Bearing--Operating Shaft
31. Washer--Bearing
32. Screw
33. Washer--Flat
34. Lock Washer
37. Guide--Plunger
40. Bushing--Operating Shaft
41. Plug--Expansion
42. Screw
43. Washer--Plain
57. Screw--Buffer
58. Lock Nut
73. Fork--Operating Shaft

Figure 6-2. Governor Control Housing.



26. Shaft -Operating	32. Screw
27. Lever - Operating Shaft	37. Guide -Plunger

Figure 6-3. Removing Variable Speed Spring Plunger Guide.

k. Disassemble governor weight housing as follows:

(1) Place weight housing (Figure 6-4) in soft jaws of a vise. Remove end plug and gasket.

(2) Straighten tang of lockwasher and remove bearing retaining bolt.

(3) Thread a 5/16in-24 x 3in bolt into tapped end of weight shaft. Support weight housing on bed of press as shown in Figure 6-5, then press shaft from bearing.

(4) Slide riser thrust bearing and governor riser from shaft. This bearing is specially designed to absorb thrust load; therefore, looseness between mating parts does not indicate excessive wear.

(5) Remove bearing from weight housing.

(6) Use a removal tool and remove one lockring from each weight pin. Withdraw pins, flatwashers and governor weights.

(7) If required, weight carrier (Figure 6-4) may be pressed from governor weight shaft and a new carrier installed.

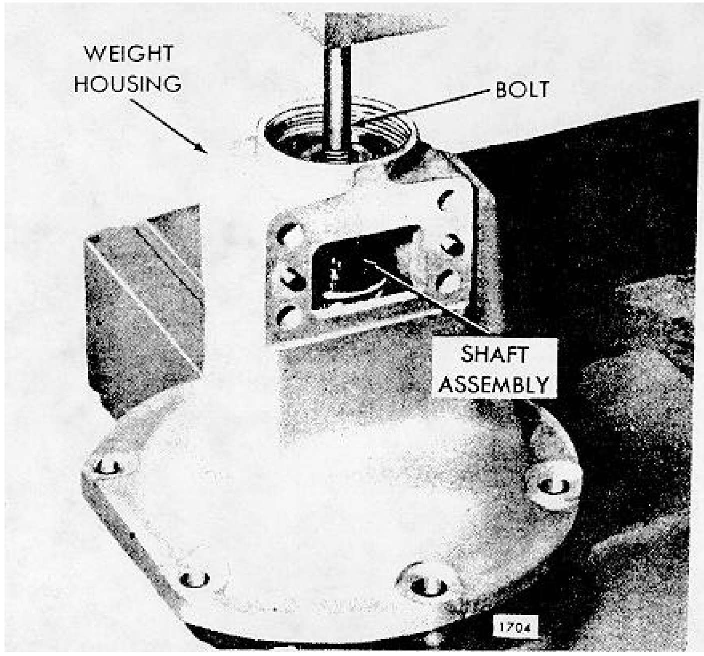
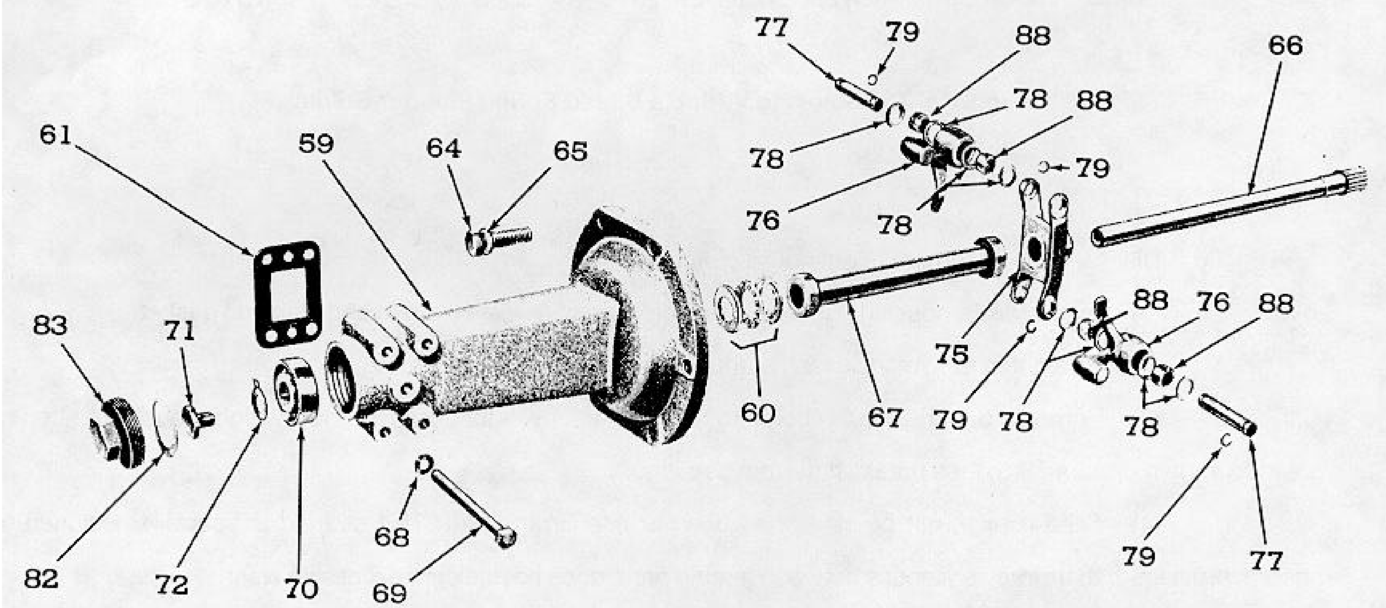


Figure 6-4. Governor Weight Housing Details.



59. Housing--Weight
60. Bearing--Thrust
61. Gasket
64. Bolt
65. Lock Washer
66. Shaft Assy.--Weight
67. Riser--Governor
68. Lock Washer
69. Bolt
70. Bearing--Shaft End
71. Bolt--Retaining
72. Lock Washer
75. Carrier--Weight
76. Weight--Governor
77. Pin--Weight
78. Washer--Plain
79. Lock Ring
82. Gasket
83. Plug--Weight Housing
88. Bearing--Weight

Figure 6-5. Remove Governor Weight and Shaft Assembly.

m. Disassemble governor variable speed spring housing as follows:

(1) Refer to Figure 6-6 and withdraw variable speed spring, stops, spring plunger and shims from spring housing.

(2) Loosen bolt and withdraw speed control lever (Figure 6-6) from speed control lever shaft. Remove Woodruff key from shaft.

(3) Remove plain washer and seal from shaft.

(4) On former spring housing, remove pipe plug in top of spring housing. On current spring housing, remove one screw and lockwasher and remove spring housing cover and gasket. Then remove the setscrew from the spring lever.

(5) Support the spring housing on the bed of the press with the shaft up. Use a brass rod and press the shaft, plug, and bearing from the housing. Remove the bearing from shaft and spring lever from the housing (Figure 6-6).

(6) If required, second bearing may be pressed from housing (Figure 6-7).

6-8 Governor cleaning, inspection and repair

a. Cleaning. Clean governor components.

b. Inspection and repair

(1) Inspect bearings.

(a) Examine bearings for any signs of corrosion or pitting.

(b) Lubricate each bearing with light engine oil.

(c) While holding inner race stationary, revolve outer race slowly, by hand. If any sticking or roughness is felt, replace bearing.

(2) Inspect riser assembly.

(a) Inspect riser thrust bearing for flat spots, corrosion, or excessive wear. If any of these conditions exist, replace entire riser and bearing assembly.

(b) Inspect weight carrier pins for wear and replace when necessary.

(3) Inspect weight carrier, weights and retaining pins for wear.

(4) Inspect drive end of weight shaft. Replace shaft if worn or rounded.

(5) Inspect bushings in weight housing for excessive wear or corrosion.

(6) Inspect spring seats, plungers, adjusting screws, locknuts and other parts of the control housing for defects.

(7) Replace all worn or defective parts.

(8) Replace all gaskets and seals.

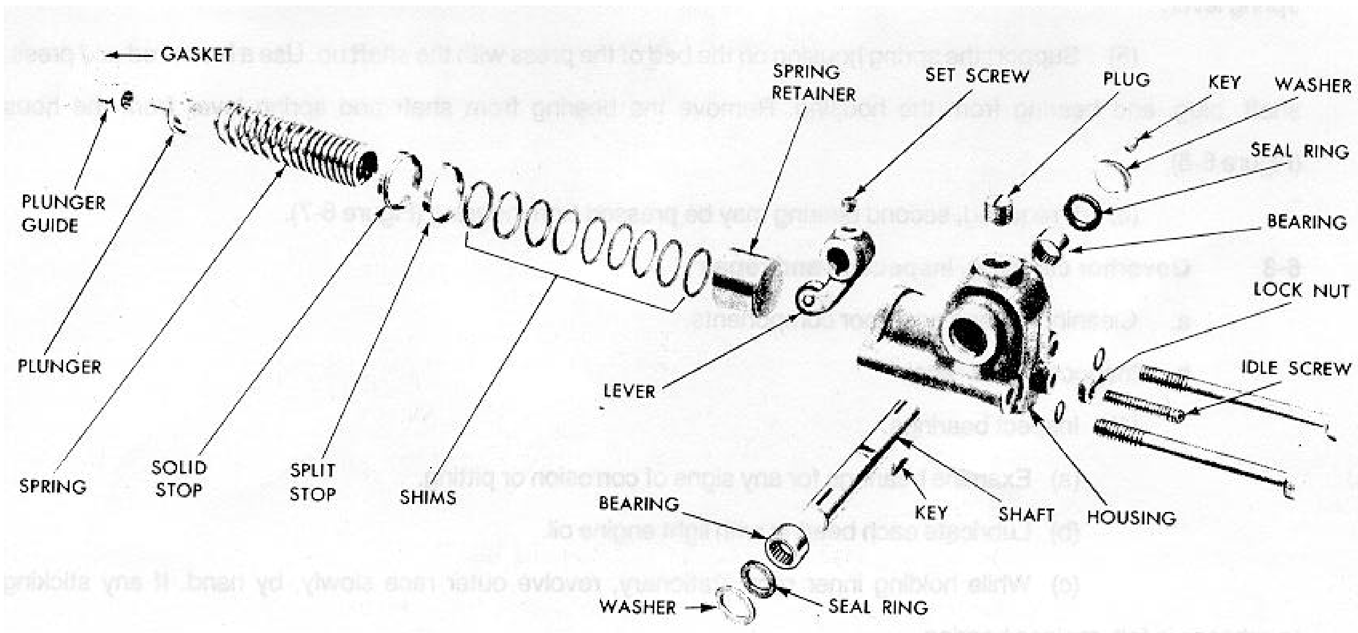


Figure 6-6. Variable Speed Spring Housing and Shaft Details. (1 of 2)

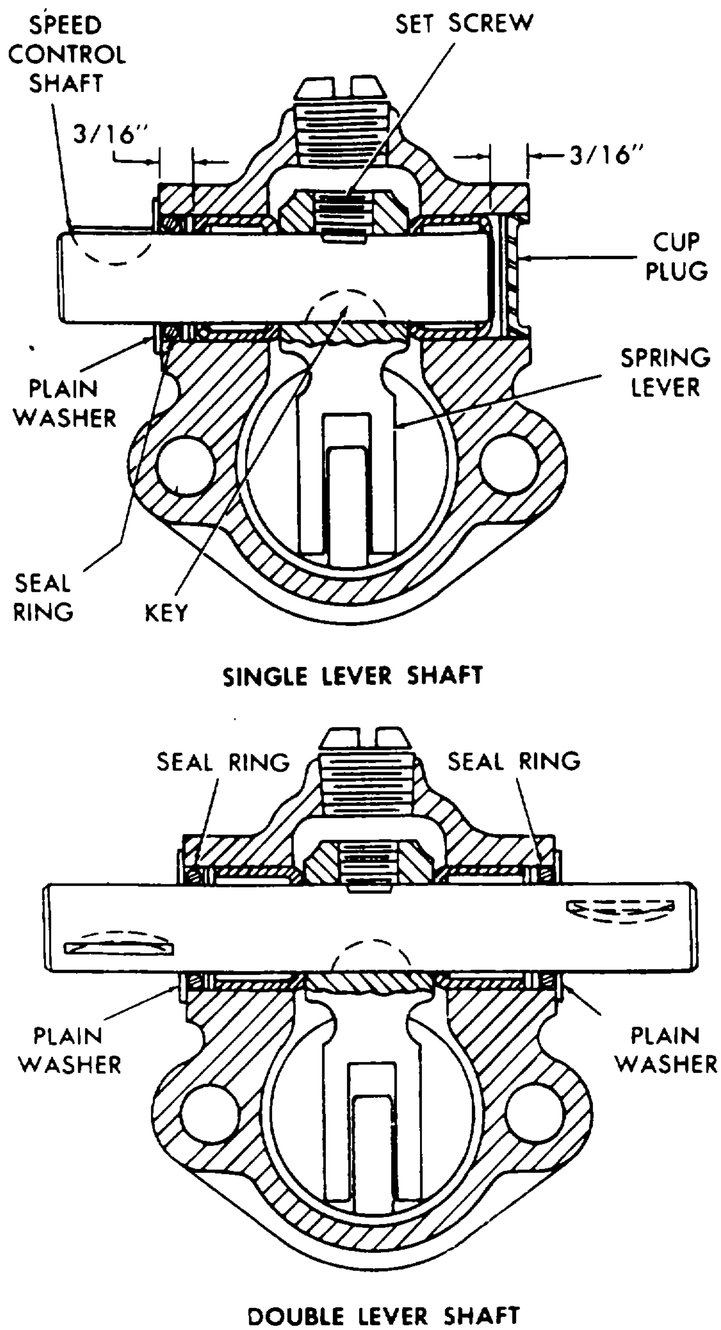


Figure 6-6. Cross Section of Governor Variable Speed Spring Housings. (2 of 2)

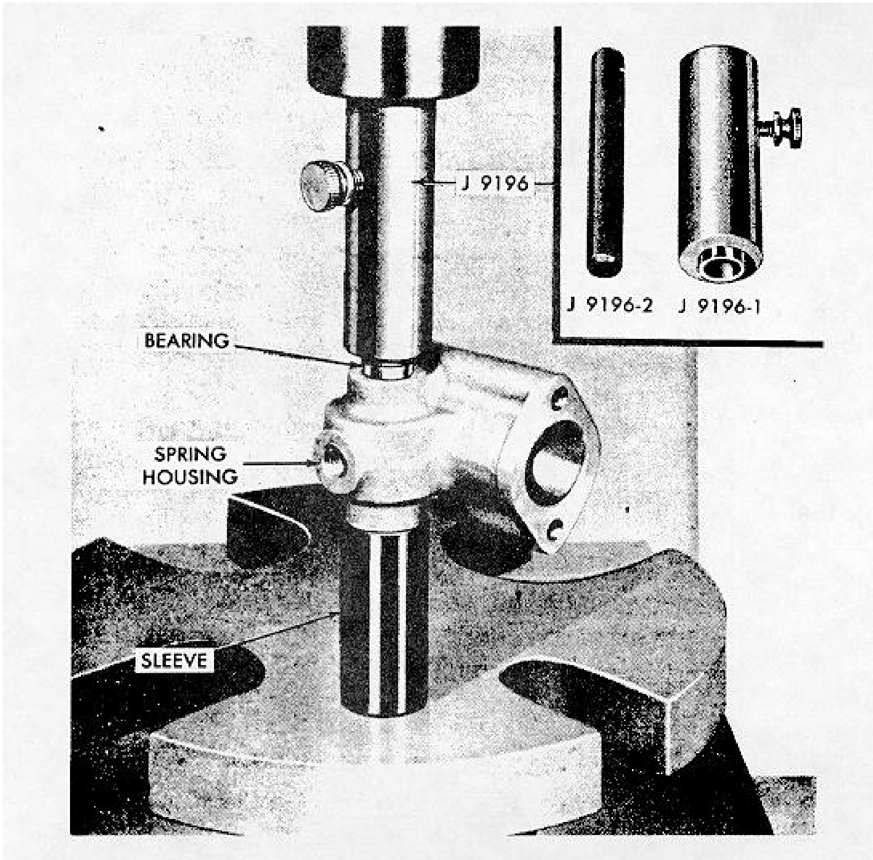


Figure 6-7. Installing Speed Control Shaft Bearings in Spring Housing.

6-9 Governor reassembly and installation

a. Governor cover reassembly

(1) If new needle bearings are to be installed in governor cover, place governor cover on bed of an arbor press with inner face of cover down. Start a new needle bearing straight into the bearing bore of the cover with bearing number up. Then insert bearing installer in bearing and press bearing in until shoulder on tool contacts cover.

(2) Reverse governor cover on bed of press (inner face of cover up). Start second bearing straight into bore of cover with bearing number up. Press bearing in flush with cover.

NOTE
Do not use impact tools to install needle bearings.

(3) Pack needle bearings with grease. If cover contained a bushing which was not removed, lubricate it with clean engine oil. Insert throttle shaft through bearing or bushing.

(4) Insert a sealring over throttle shaft and into counterbore against upper bearing. Place retainer over shaft and against sealring.

(5) Locate lock ring in groove of throttle shaft.

(6) Place torsion retraction spring over cover hub with hooked end up. Then place stop lever on shaft and tighten clamping bolt.

b. Governor control housing reassembly

(1) Place bearing washer (Figure 6-2) over short, finished end of operating shaft. Start bearing over end of shaft. Support opposite end of shaft on bed of the press. Using a sleeve having same diameter as bearing inner race, press bearing on shaft tight against washer.

(2) With pivot pin in operating lever up, start lever over end of shaft with flat on shaft registering with flat surface in lever. Press lever on shaft tight against bearing.

(3) Lubricate bearing and operating shaft bushing in housing with clean engine oil. Insert lever and operating shaft assembly in control housing.

(4) Position operating fork over lower end of operating shaft so finished side of fork fingers will rest against thrust bearing.

(5) Support operating shaft and control housing on bed of an arbor press with upper end of shaft resting on a steel block. Align flat in operating fork with flat on shaft, then place sleeve over end of shaft and rest it on fork. Press fork straight down tightly against shoulder on shaft.

(6) Tighten fork setscrew (if used).

(7) Place differential lever over pivot pin of operating lever. Install plain washer and spring retainer.

(8) Place lockwasher and flatwasher over the bearing retaining screw. Thread the screw in the control housing tight to secure the bearing.

(9) Refer to figure 6-3 and insert variable speed spring plunger guide in control housing.

(10) Apply a good quality sealant around outer periphery of expansion plug and tap plug into lower end of control housing.

c. Governor Weight Housing Reassembly.

(1) Install lockring (Figure 6-4) in groove of weight pin. Place flatwasher over pin and against lockring.

(2) Start pin through opening in weight carrier. Place second washer over pin and against projecting arm of weight carrier.

(3) Position governor weight between projecting arms of weight carrier. Push pin through governor weight. Place third flatwasher over pin and against weight.

(4) Push pin completely through weight carrier and place fourth flatwasher over pin and against projecting arm of weight carrier. Install second lock ring in groove of weight carrier pin.

(5) Install second governor weight as outlined in steps (1) through (4).

(6) Slide riser over shaft and against finished surfaces of governor weights.

(7) Assemble riser thrust bearing on weight shaft with bearing race having smaller inside diameter against thrust riser. Incorrect installation of bearing will result in erratic operation of governor.

(8) Insert weight carrier and shaft assembly in weight housing.

(9) Support splined end of shaft on bed of an arbor press. Start shaft end bearing in housing and over end of shaft with the numbered side of bearing facing away from shaft. Press bearing in place with a sleeve that bears against inner race.

(10) Place a washer (Figure 6-4) over bearing retaining bolt. Thread bolt into tapped end of shaft and tighten it. Bend tang of washer against head of bolt.

(11) Place gasket in housing and against bearing. Apply a Loctite sealant, grade HV, or equivalent, to full 360° circumference of end plug and thread plug into tapped end of governor weight housing. Tighten plug to 45 Ib-ft torque with either flat or point of head on a horizontal line.

d. Variable speed spring housing reassembly

(1) Lubricate speed control lever shaft needle bearings with Shell Alvania No. 2 grease, or equivalent. Then start one of bearings, numbered end up, straight in bearing bore in right-hand side of spring housing.

(2) Install needle bearing pilot rod in installer body and secure it in place with retaining screw.

(3) Place pilot rod end of bearing installer assembly in bearing. Support spring housing, bearing, and installer on a short sleeve on the bed of an arbor press as shown in Figure 6-7, then press bearing in housing until shoulder on installer contacts the housing.

NOTE

When the shoulder on installer body contacts housing, bearing will be properly positioned in housing.

(4) If removed, install spring lever Woodruff key in center keyway in speed control lever shaft.

(5) Place spring lever assembly between bearing bores inside spring housing with arm (roller end) of lever facing out.

(6) Insert correct end of single or double lever type, speed control lever shaft (Figure 6-6) through bearing bore in side of spring housing, opposite bearing previously installed. Align key in shaft with keyway in spring lever, and push shaft through lever and in bearing until flat on top of shaft is centered under setscrew hole in lever.

(7) Thread setscrew into spring lever, making sure point of screw is seated in the flat on shaft.

(8) Place second speed control lever shaft needle bearing, numbered end up, over protruding end of shaft and start it straight in bore of housing.

(9) Remove bearing pilot rod from installer body and place installer body over end of shaft and against the bearing. Support spring housing, bearings, and installer on a short sleeve on bed of an arbor press as shown in Figure 6-7, then press bearing in housing until shoulder on installer contacts housing.

(10) If a single lever shaft was installed in spring housing, apply a thin coat of sealing compound to outside diameter of cup plug. Start cup plug straight in bearing bore in housing, then support spring housing, bearings, and shaft assembly on a sleeve on bed of an arbor press, and press cup plug in flush with outside face of housing (Figure 6-6).

(11) Clamp spring housing assembly in a bench vise equipped with soft jaws. Then tighten spring lever retaining setscrew to 5-7 lb-ft torque.

(12) Stake edge of spring lever setscrew hole with a small center punch and hammer to retain setscrew in lever. Then, install plug in former spring housing.

(13) On a single lever shaft, place a sealring over the end of shaft and push it into bearing bore and against bearing. Place plain washer over shaft and against housing, then install Woodruff key in keyway in shaft.

(14) On a double lever shaft, place a sealring over each end of shaft and push them into bearing bores and against bearings. Place a plain washer over each end of shaft and against housing, then install a Woodruff key in keyway at each end of shaft.

(15) Place speed control lever(s) on shaft in its original position. Align keyway in lever with key in shaft and push lever in against plain washer and secure it in place with retaining bolt and lockwasher.

(16) If removed, thread locknut on idle speed adjusting screw. Then, thread idle speed adjusting screw into spring housing cover approximately 1.00 in.

e. Variable speed spring housing to control housing reassembly

(1) Insert small end of spring plunger in plunger guide. Insert solid stop in governor control housing.

(2) Place spring retainer in spring housing, with closed end of the retainer against spring lever. If shims were used, place them inside of spring retainer. Insert split stop in spring housing and against spring retainer.

NOTE

Be sure to use shims with an .344 in. inside diameter. Either spring retainer may be used with shims which have a .750 in. I.D. However, do not use the .344 in. I.D. shims with a spring retainer which has only one air bleed hole.

(3) Insert variable speed spring in spring plunger with tightly wound end of spring against shims.

(4) Insert bolts through spring housing. Place a new gasket over bolts and against housing.

(5) Place spring housing in position against control housing with spring plunger engaged in end of variable speed spring. Thread bolts in control housing and tighten them securely.

Section V. Air Shutdown Housing and Blower

6-10 General

a. Air Shutdown Housing. The air shutdown housing is mounted on right side of engine on blower, and serves as a mounting for air cleaner. The air shutdown housing contains an air shutdown valve that shuts off air supply and stops engine whenever abnormal operating conditions require an emergency shutdown.

b. Blower

(1) The blower assembly, mounted on right rear side of engine block, supplies fresh air required for combustion and scavenging. Two hollow double-lobe rotors revolve in rotor housing. The revolving motion of rotors provides a continuous and uniform displacement of air.

(2) Gears located at splined ends of rotor shafts assist in spacing rotor lobes. Normal gear wear will have some effect on rotor-to-rotor clearance. A combination of gear and rotor shaft bearing surface wear will result in a decrease of rotor-to-housing clearance.

(3) Oil seals, consisting of a fiber washer, O-ring, retainer, and seal spring are incorporated in each end of blower rotors.

6-11 Air shutdown housing disassembly

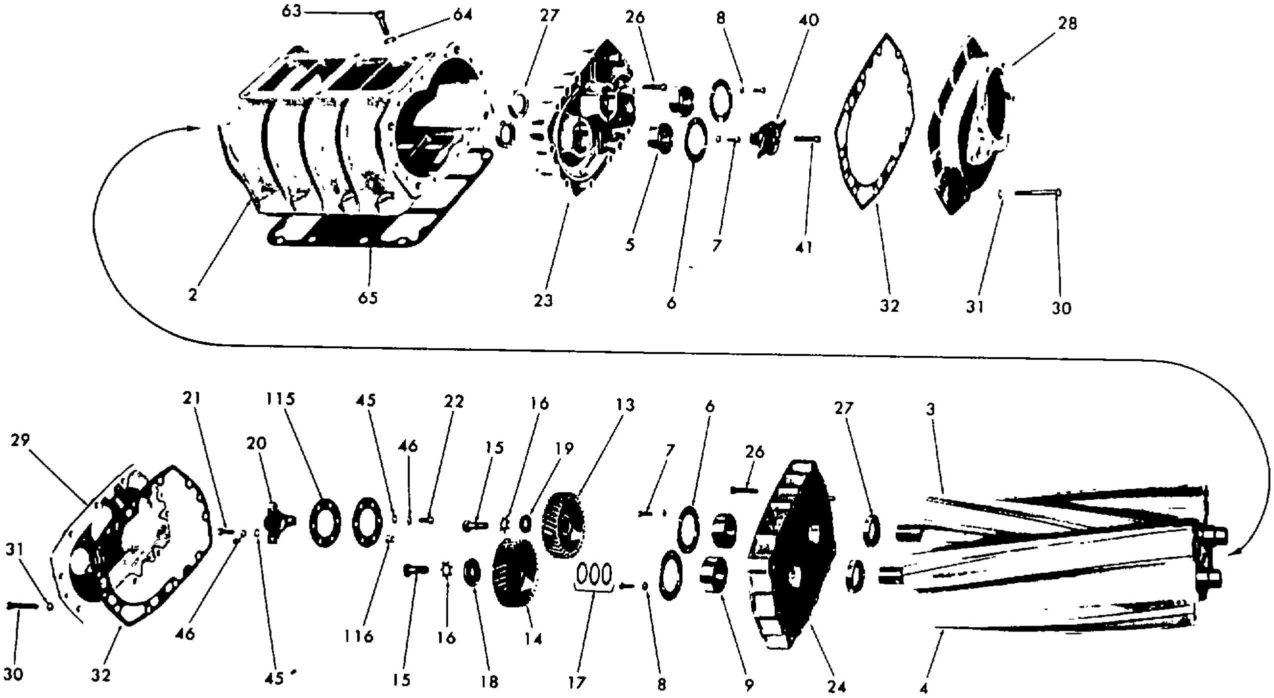
a. Refer to Figure 6-8 and disassemble blower as follows:

(1) Remove 10 bolts and lockwashers securing the end plate covers to blower front and rear end plates. Tap ends of end plate covers with a plastic hammer to loosen covers from gaskets and dowel pins in end plates. Then, remove covers and gaskets from endplates.

(2) Place a clean folded shop towel between rotors and a towel between rotor and housing to prevent rotors from turning. Then, remove the bolt securing water pump drive coupling to blower rotor shaft.

(3) Thread an adapter (1/2 inch-20 threads) or adapter (9/16 inch-18) into water pump drive coupling, then attach slide hammer and shaft to adapter and pull drive coupling from blower rotor shaft.

(4) Remove bolts, lockwashers, and plain washers securing blower rotor drive hub and drive hub plates to blower rotor timing gear or drive gear, then remove drive hub plates and spacers from gear. If necessary, remove three bolts, lockwashers, and plain washers securing drive plates to drive hub.



2. Housing--Blower
3. Rotor--Blower--Upper--R.H. Helix
4. Rotor--Blower--Lower--L.H. Helix
5. Bearing (Roller)--Front
6. Retainer--Bearing
7. Bolt--Bearing--Retainer
8. Lock Washer
9. Bearing (Ball)--Rear Double Row Thrust
13. Gear--Rotor--Upper--R.H. Helix
14. Gear--Rotor--Lower--L.H. Helix
15. Bolt--Rotor Gear
16. Lock Washer--Bolt to Rotor Gear
17. Shim--Gear to Bearing (For Timing Rotors)
18. Disc--Fuel Pump Coupling
19. Washer--Rotor Gear Retaining
20. Hub--Rotor Drive
21. Bolt--Plate to Gear
22. Bolt--Plate to Hub
23. End Plate--Front
24. End Plate--Rear
25. Pin (Dowel)--Housing to End Plate
26. Bolt--End Plate
27. Oil Seal--End Plate
28. Cover--End Plate--Front
29. Cover--End Plate Rear
30. Bolt--End Plate Cover
31. Lock Washer
32. Gasket--End Plate Cover
40. Coupling Assy.--Water Pump Drive
41. Bolt--Allen Head
45. Plain Washer
46. Lock Washer
63. Bolt--Blower Mounting
64. Plain Washer--Blower Mounting
65. Gasket--Blower Housing
115. Plate--Blower Rotor Drive Hub
116. Spacer--Plate to Gear

Figure 6-8. Blower Assembly and Disassembly.

(5) Remove blower rotor timing gears as follows:

(a) Remove bolt, lockwasher, and retainer securing timing gear to right-hand helix rotor shaft. Then remove bolt, lockwasher, and fuel pump coupling disc securing other timing gear to left-hand helix rotor shaft.

(b) Back out center screw of both gear pullers and secure pullers to gears with 5/16 inch-24 x 1 1/2 inch bolts.

NOTE
Both gears must be pulled from the rotor shafts at the same time.

(c) With shop towels between blower rotors and housing to prevent from turning, turn puller screws uniformly clockwise and pull gears from rotor shafts.

(d) Remove shims from rotor shafts or inner face of gears, and note number and thickness of shims used with each gear.

(6) Remove bolts and lockwashers securing rotor shaft bearing retainers to both front and rear end plates. Remove retainers.

(7) Remove blower rear end plate and bearing assembly from blower housing and rotors with two pullers as follows:

(a) Remove two fillisterhead screws securing rear end plate to blower housing, and loosen two fillisterhead screws securing front end plate to housing approximately three turns.

(b) Back out center screws of pullers far enough to permit flange of each puller to lay flat on face of end plate.

(c) Secure pullers to end plate with six 1/4 inch-20 x 1 1/4 inch bolts.

NOTE

Be sure that the 1/4 inch-20 bolts are threaded all the way into the tapped holes in the end plate to eliminate possible damage to the end plate.

(d) Turn two puller screws uniformly clockwise and withdraw end plate and bearings from blower housing and rotors.

(8) Remove blower front end plate in same manner as described above.

(9) Withdraw blower rotors from housing.

6-12 Blower cleaning, Inspection and repair

CAUTION

Do not use a wire brush or emery cloth for cleaning the blower parts. Handle blower parts carefully; aluminum parts are easily dented and burred.

a. Cleaning. Clean all parts with cleaning solvent and dry thoroughly.

b. Inspection and Repair

(1) Inspect inside of the blower housing and all finished surfaces for smoothness. Inspect housing for cracks, breaks, and distortion. Remove all rough spots or burrs with a fine mill file or scraper. Replace a housing that is badly scored, warped, or cracked.

(2) Inspect rotor lobes for smoothness. Inspect rotor shaft serrations and bearing surfaces for wear or burrs. Remove all high spots and burrs from rotors with a fine mill file or scraper. Replace defective rotor assemblies.

(3) When washed clean and lubricated with light oil, all bearings should roll smoothly. Replace loose, rough, or overheated bearings.

(4) The seal lip must be smooth, pliable, and leakproof. Replace all oil seals that have been removed from housing plates or that are brittle, thin, or cut.

(5) Inspect housing end plates for cracks, breaks, distortion, and other damage. Inspect finished surfaces of housing plates to see that they are true, smooth, and unscored. Inspect counterbores for bearing and bearing bosses to see that they are not worn excessively or scored. The bearings must fit the counterbore with a slight push or tap fit. Remove all burrs or minor local score marks by filing or scraping carefully. Replace housing plates that are cracked, badly scored or distorted, or have worn bearing counterbores.

(6) Inspect gears for worn splines and for cracked, broken, or worn teeth. Replace damaged or defective gears. The maximum allowable backlash for gears is 0.0035 inch and the minimum is 0.0005 inch.

(7) Clean all gasket material from mating surfaces. Reassemble the blower with all new gaskets.

6-13 Blower reassembly and installation

CAUTION

The lobes on the upper blower rotor and the teeth on its gear form a right-hand twist. The lower rotor and its gear twist to the left. Insure that the gear and rotor twists match or the blower assembly will be damaged during reassembly.

a. Reassembly of the Blower

(1) Install lip type oil seals as follows:

(a) Support blower end plate, finished surface facing up, on wood blocks on the bed of an arbor press.

(b) Start the oil seal straight into bore in end plate with sealing edge facing down (toward bearing bore).

(c) Place short end of oil seal remover and installer in the oil seal and under ram of press. Then, press oil seal into end plate until shoulder on installer contacts end plate.

NOTE

A step under the shoulder of the installer will position the oil seal approximately .005 inch below the finished face of the end plate. This is within the .002 to .008 inch specified.

(d) Install remaining oil seals In end plates in same manner.

(2) Install ring type oil seal, carriers, and collars on rotor shafts and in end plates as follows:

(a) Support one of rotor assemblies on wood blocks on bed of an arbor press as shown in figure 6-9.

(b) Lubricate inside diameter of oil sealring carrier with engine oil; then start carrier straight over end of rotor shaft with chamfered inside diameter end facing rotor.

(c) Place oil sealring carrier installer over end of rotor shaft and against carrier with end of installer under ram of press. Then, press carrier down tight against rotor.

(d) Install remaining oil sealring carriers on rotor shafts in same manner.

(e) Install an oil sealring in ring groove of each carrier with a pair of snapring pliers in same manner.

CAUTION

To avoid breaking the oil sealrings, do not spread them any more than necessary to place them over the end of the carrier.

(f) Support one of blower end plates, inner face up, on wood blocks on the bed of an arbor press.

(g) Lubricate outside diameter of a sealring collar with engine oil; then start chamfered outside diameter end of collar straight into bore in end plate.

(h) Place oil sealring collar installer on top of sealring collar and under ram of press in same manner. Then, press collar into end plate until shoulder on installer contacts end plate.

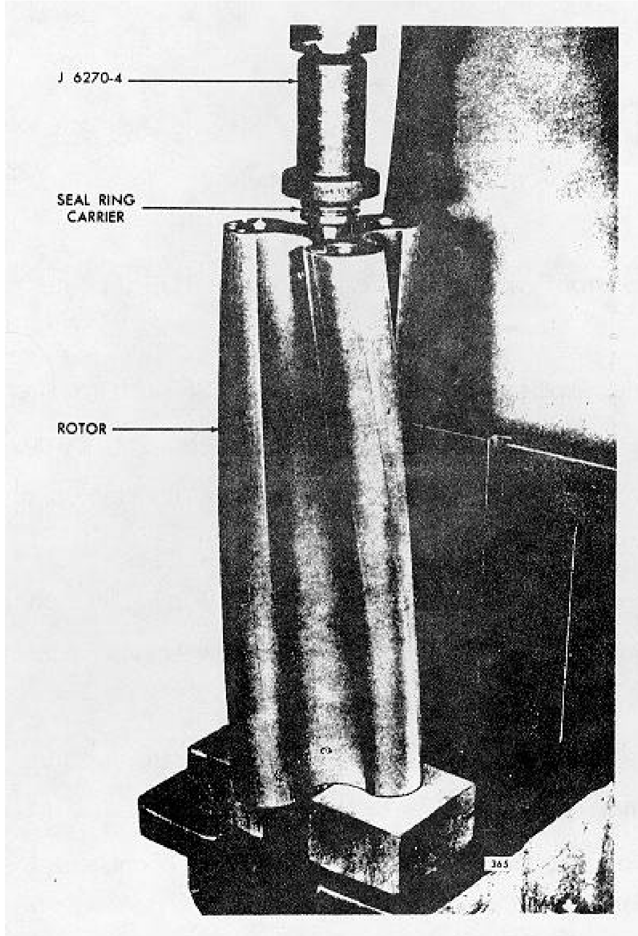


Figure 6-9. Installing Oil Sealring Carrier On Rotor.

NOTE

A step under shoulder of installer will position collar approximately .005 inch below finished face of end plate. This is within .002 to .008 inch specified.

(i) Install remaining oil sealring collars in end plates in same manner.

b. Assemble rotors and endplates

NOTE

No gaskets are used between endplates and housing, therefore mating surfaces must be perfectly flat and smooth.

(1) Apply a rubber base sealant as required to avoid leakage between endplates and blower housing.

NOTE

Be sure no sealant protrudes into blower housing. Also, sealant must not prevent endplates from laying against the housing.

(2) Install blower front endplate, making sure mark TOP on outer ribbed side is at top of blower housing.

(a) Check dowel pins. Dowel pins must project .380 inch from flat inner face, and .270 inch from outer face of front endplate to assure proper alignment of endplate to housing and cover to endplate.

(b) Place blower housing on a bench with top of housing up, and front end of housing facing outside of bench.

(c) Position endplate in front of blower housing with flat finished face of endplate facing housing and end marked TOP facing flanged side of housing. Then, start dowel pins straight into dowel pin holes in housing. Push or tap endplate against housing.

(d) Insert two fillister head screws through endplate and thread them into housing. Tighten screws to 5-10 Ib-ft torque. Do not use lock washers on these screws.

(3) Assemble blower rotors in blower housing and front endplate as follows:

CAUTION

Rotors must be assembled in blower housing with omitted serrations in rotor shafts aligned.

(a) Place an oilseal pilot on short (non-splined) end of each rotor shaft. Then, place rotors in mesh with omitted serrations in shafts in alignment as shown in Figure 6-8.

(b) Insert blower rotors with oilseal pilots straight into blower housing with right-hand helix rotor at top, flange side of housing. Then, push rotor shafts and oilseal pilots on through oilseal in front endplate as shown in Figure 6-8.

(c) Remove oilseal pilots from rotor shafts.

(4) Attach blower rear endplate to blower housing as follows:

(a) Reverse blower housing on bench (rear end of housing facing outside of bench).

(b) Place an oilseal pilot on serrated end of each rotor shaft.

(c) Check dowel pins. Dowel pins must project .380 inch from flat inner face, and .270 inch from outer face of rear endplate to assure proper alignment of endplate to housing and cover to endplate.

(d) Place rear endplate in position in front of oilseal pilots with flat finished face of endplate facing blower housing and mark TOP on endplate at top flange side of housing.

(e) Place rear endplate over oilseal pilots and start dowel pins straight into dowel pin holes in housing. Push or tap endplate against housing.

(f) Insert two fillisterhead screws through endplate and thread them into housing. Tighten screws to 5-10 lb-ft torque. Do not use lockwashers on these screws.

(g) Remove oilseal pilots from rotor shafts.

c. Install blower rotor shaft bearings and gears

(1) With blower housing, rotors, and endplates supported in a vertical position on two wood blocks, install roller bearings on rotor shafts and in front endplate as follows:

(a) Lubricate one of roller bearings with engine oil. Start bearing, numbered end up, straight on one of rotor shafts.

(b) Place installer on top of bearing and tap bearing on shaft and into front endplate.

(c) Install second roller bearing on remaining rotor shaft in same manner.

(d) Place bearing retainers on top of bearings and endplate; then, install retainer bolts and lockwashers. Tighten bolts to 7-9 Ib-ft torque.

(2) Start end of water pump drive coupling straight into left-hand helix rotor shaft. Then, place a clean shop towel between blower rotors to prevent them from turning. Install drive coupling retaining bolt and draw coupling and slinger tight against end of shaft, then tighten bolt to 18 Ib-ft torque.

(3) Affix a new gasket to blower front endplate cover.

(4) Position endplate cover over endplate dowel pins, with large hole in cover toward top of endplate, then push cover against endplate. Install ten bolts and lockwashers. Tighten bolts to 13-17 Ib-ft torque.

(5) Install ball bearings on rotor shafts and in rear endplate as follows:

(a) Reverse position of blower housing on two wood blocks.

(b) On a blower with ring type oilseals, insert two fillisterhead screws through rear endplate and thread them into the housing. Tighten screws to 5-10 lb-ft torque. Do not use lockwashers on these screws.

(c) Lubricate one of ball bearings with engine oil. Start bearing numbered end up, straight on one of rotor shafts.

(d) Place installer on top of bearing and tap bearing straight on shaft and into rear endplate.

(e) Install second ball bearing on remaining rotor shaft in same manner.

(f) Place bearing retainers on top of bearing and endplate; then, install retainer bolts and lockwashers. Tighten bolts to 7-9 lb-ft torque.

(6) Make a preliminary check of rotor-to-end plate and rotor-to-housing clearances at this time with a feeler gage. Refer to figure 6-10 for minimum blower clearances.

(7) Install blower rotor timing gears on a standard blower or a smaller diameter rotor blower as follows: one serration is omitted on drive end of each blower rotor shaft and a corresponding serration is omitted in each gear. Assemble gears on rotor shafts with serrations in alignment.

(a) Place blower housing and rotor assembly on bench with air inlet side of housing facing up and rear end (serrated end of rotor shafts) of the blower facing outside of bench.

(b) Rotate rotors to bring omitted serrations on shafts in alignment and facing top of blower housing.

(c) Install same number and thickness of shims on rotor shafts that were removed at time of disassembly.

(d) Lubricate serrations of rotor shafts with engine oil.

(e) Place teeth of rotor gears in mesh so that omitted serrations inside gears are in alignment and facing same direction as serrations on shafts.

NOTE

A center punch mark placed in end of each rotor shaft at omitted serrations will assist in aligning gears on the shafts.

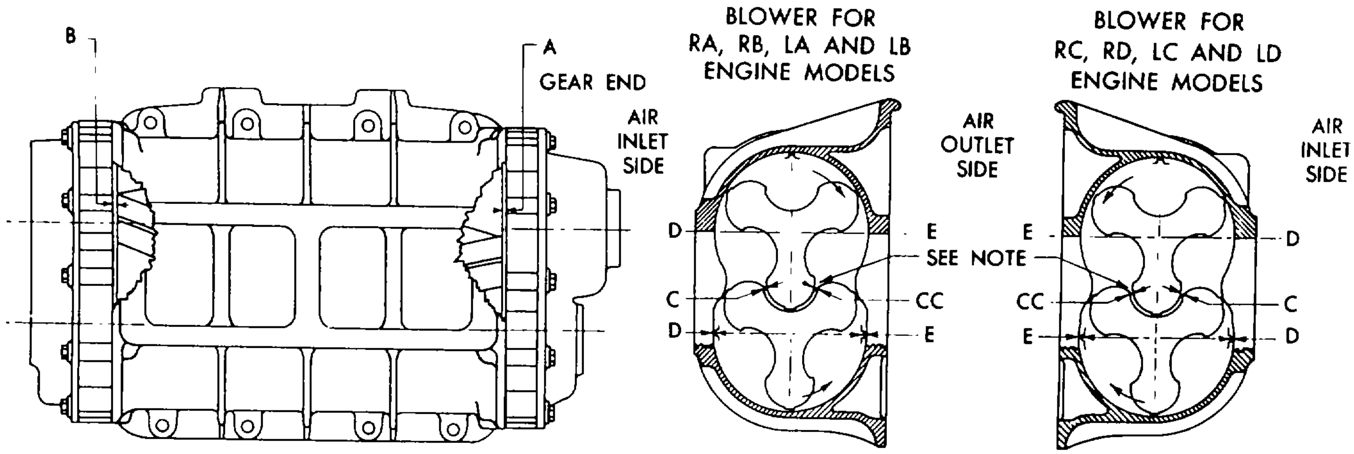
(f) Start both rotor gears straight on rotor shafts with right-hand helix gear on right-hand helix rotor and left-hand helix gear on left-hand helix rotor, and omitted serrations in gears in line with omitted serrations on rotor shafts.

(g) Thread an installer screw in end of each rotor shaft until it bottoms. Place gear installer over installer screw and against right-hand helix gear, and gear installer over installer screw and against left-hand helix gear; then, thread a nut on each installer screw.

(h) Place a clean shop towel between rotors, and another one between rotor and housing to prevent rotors from turning. Then, turn nuts on installer screws clockwise and force gears into position tight against shims and bearing inner races.

NOTE

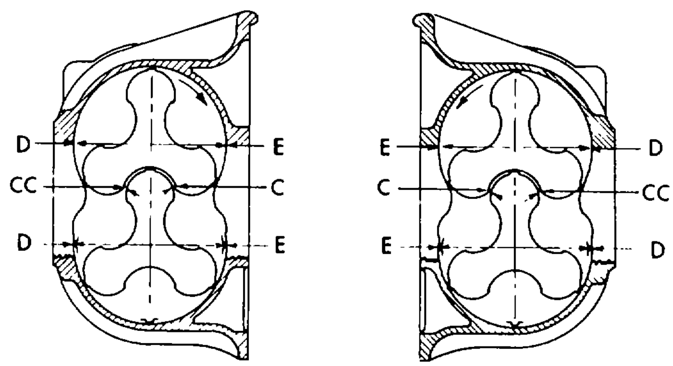
Both gears must be pressed on rotor shafts at same time.



		A	B	C	CC	D	E
3-71	MIN.	.007	.007	.012	.002	.015	.004
	MAX.				.006		
4-71	MIN.	.007	.009	.012	.002	.015	.004
	MAX.				.006		
6-71	MIN.	.007	.014	.012	.002	.015	.004
	MAX.				.006		
6-71P	MIN.	.012	.019	.014	.002	.030	.004
	MAX.				.006		

TIME ROTORS TO DIMENSIONS ABOVE

NOTE: TIME ROTORS TO DIMENSION ON CHART FOR CLEARANCE BETWEEN TRAILING SIDE OF UPPER ROTOR AND LEADING SIDE OF LOWER ROTOR (CC) FROM BOTH OUTLET AND INLET SIDE OF BLOWER



ALL VIEWS FROM REAR OF ENGINE

Figure 6-10. Blower Rotor Clearances.

(i) Remove rotor timing gear installers from rotor shafts.

(j) Place a lockwasher and gear retaining washer on one of gear retaining bolts. Thread bolt into right-hand helix rotor shaft, and guide lugs on retaining washer in slots in gear hub, then bend one of the tangs on lockwasher over into slot of retaining washer. Tighten gear retaining bolt to 55-65 lb-ft torque.

(k) Place a lockwasher and fuel pump drive coupling disc on remaining gear retaining bolt. Thread bolt into left-hand helix rotor shaft and guide lugs on disc in slots in gear hub, then bend one of tangs on lockwasher over into slot in disc. Tighten gear retaining bolt to 55-65 lb-ft torque.

(l) Bend one of tangs of each lockwasher over against head of gear retaining bolt. Remove cloth from blower rotors.

(8) Timing Blower Rotors.

(a) After blower rotors and timing gears have been installed, rotors must be timed. When properly positioned, blower rotors run with a slight clearance between two rotor lobes and between lobes and housing wall.

(b) Clearance between rotor lobes may be established by moving one helical gear in or out on shaft relative to other gear by adding or removing shims between gear hub and rotor spacers.

d. Installation

(1) Affix a new blower to block gasket to cylinder block with a rubber base sealer.

(2) Install a new drive shaft cover seal and seal clamp over end of drive shaft cover.

(3) Place water pump outlet packing flange, flat face toward pump body, and slide a new packing ring over pump outlet. Then, place a new water pump cover seal and clamp on top of oil cooler housing outlet opening.

(4) Place blower assembly into position against cylinder block, being careful not to dislodge blower gasket.

(5) Install eight blower to cylinder block bolts and plain washers, and tighten bolts to 55-60 Ib-ft torque.

(6) Slide blower drive shaft cover seal into position against blower drive gear hub support and tighten seal clamp.

(7) Install blower drive shaft by pushing plain end, without squared hole, of shaft through blower drive coupling from rear of engine, then into blower drive gear hub. If necessary, rotate blower rotors slightly to align splines of drive shaft with those in gear hub. Then, install lockring in blower drive cam.

(8) Install flywheel housing small hole cover.

(9) Connect water pump outlet packing flange to cylinder block. Also, tighten seal clamp connecting water pump cover to oil cooler housing.

(10) Place blower air shutdown housing, together with striker plate gasket, striker plate (if used), and screen and gasket assembly against blower, screen side of gasket assembly toward blower, and secure them in place with bolts and lockwashers. Tighten bolts to 16-20 Ib-ft torque.

(11) If engine is equipped with a manual shutdown assembly, connect control wire to air shutdown valve shaft lever and attach control wire clip under head of the air inlet housing attaching bolt.

(12) Install governor (para 6-9).

(13) Install breathers.

(14) Service engine cooling system.

Section VI. Rocker Arms and Cylinder Head

6-14 General

a. Rocker arms

(1) Three rocker arms are provided for each of four cylinders; two outer arms operate exhaust valves and center arm operates fuel injector.

(2) Each set of three rocker arm assemblies pivots on a separate shaft supported by two brackets. A single bolt secures each bracket to top of cylinder.

(3) The rocker arms are operated by camshaft through cam followers and short push rods extending through cylinder head as illustrated in Figure 6-11.

(4) The valve and Injector mechanism Is lubricated by oil from a longitudinal oil passage on camshaft side of cylinder head, which connects with oil passages in cylinder block. Oil from this passage enters drilled rocker arm shafts through lower end of drilled rocker shaft bracket bolts.

b. Cylinder Head. Cylinder head is a one piece casting. It can be removed from cylinder block as an assembly consisting of cam followers, cam follower guides, rocker arms, exhaust valves, and fuel Injectors.

6-15 Cylinder head maintenance

a. Disassembly of cylinder head

NOTE

When removing cam followers and associated parts, tag them so they may be reinstalled In their original location.

(1) Rest cylinder head on its side and remove cam follower guide.

(2) Pull cam follower out of cylinder head.

(3) Loosen push rod locknut and unscrew push rod from rocker arm clevis.

(4) Pull push rod and spring assembly from bottom of cylinder head.

(5) Remove push rod locknut, spring, and spring seats from pushrod.

(6) Remove rocker arms and pushrods.

(7) Remove fuel injectors if they have not already been removed.

(8) Disassemble fuel Injector control tube in numerical sequence as illustrated In Figure 6-12.

(9) Remove exhaust valve guides as illustrated In Figure 6-13.

(10) Support cylinder head, bottom side up, on wooden blocks which are at least three Inches thick. Remove exhaust valve guides using a removal tool and drive guides out of head.

(11) Place cylinder head on Its side and remove exhaust valve seat Insert as Illustrated in Figure 6-14.

(12) Place Injector tube removal tool in injector tube; then thread pilot Into end of removal tool and remove injector tube.

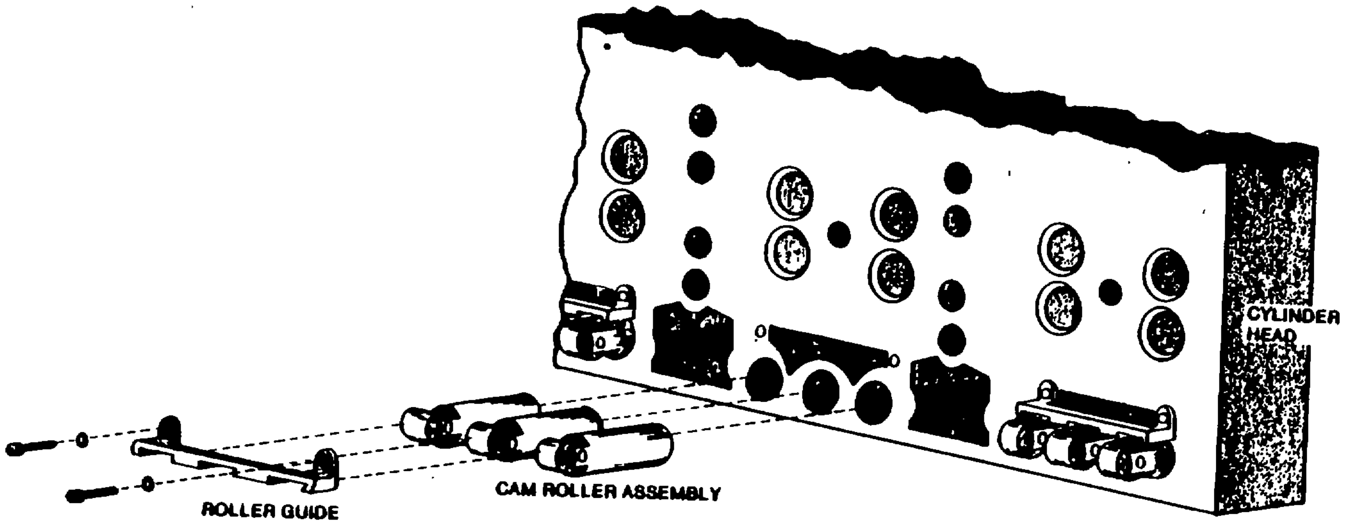
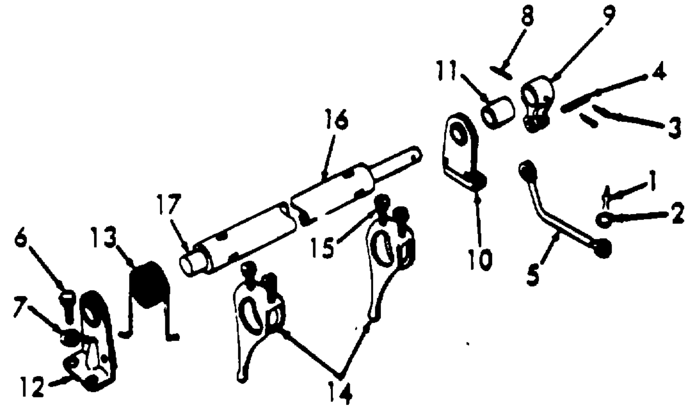


Figure 6-11. Cam Followers and Cylinder Head.



1. COTTER PIN
2. SHAFT SPACER
3. COTTER PIN
4. CONTROL ROD SHAFT
5. FUEL CONTROL ROD
6. MACHINE BOLT
7. LOCKWASHER
8. GROOVE PIN
9. CONTROL TUBE LEVER
10. CONTROL TUBE BRACKET
11. SPACER
12. CONTROL TUBE BRACKET
13. CONTROL TUBE SPRING
14. CONTROL LEVER
15. ADJUSTING SCREW
16. CONTROL TUBE ASSEMBLY
17. CONTROL TUBE PIN

Figure 6-12. Fuel Injector Control Tube Removal.

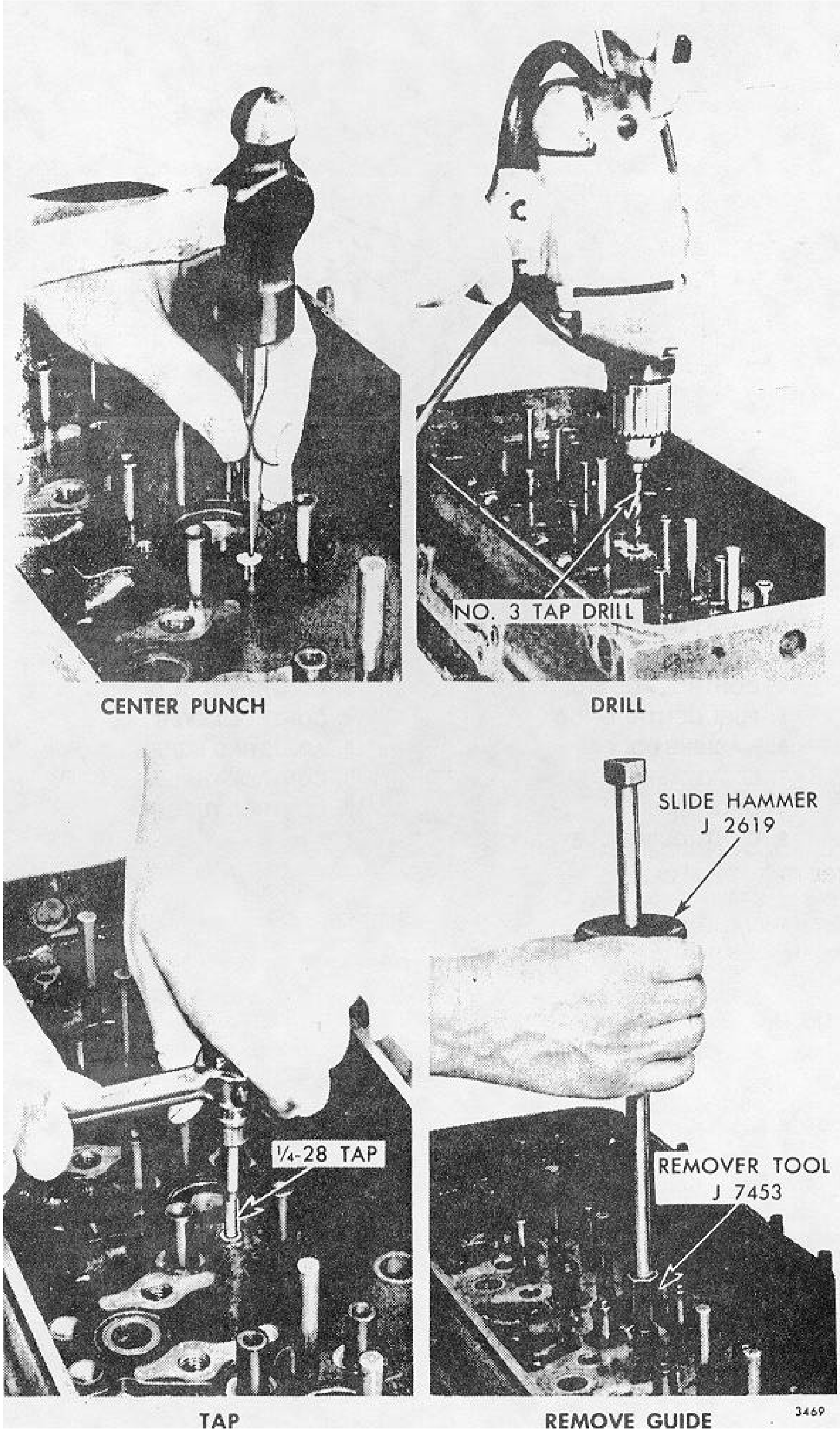


Figure 6-13. Exhaust Valve Guide Removal.

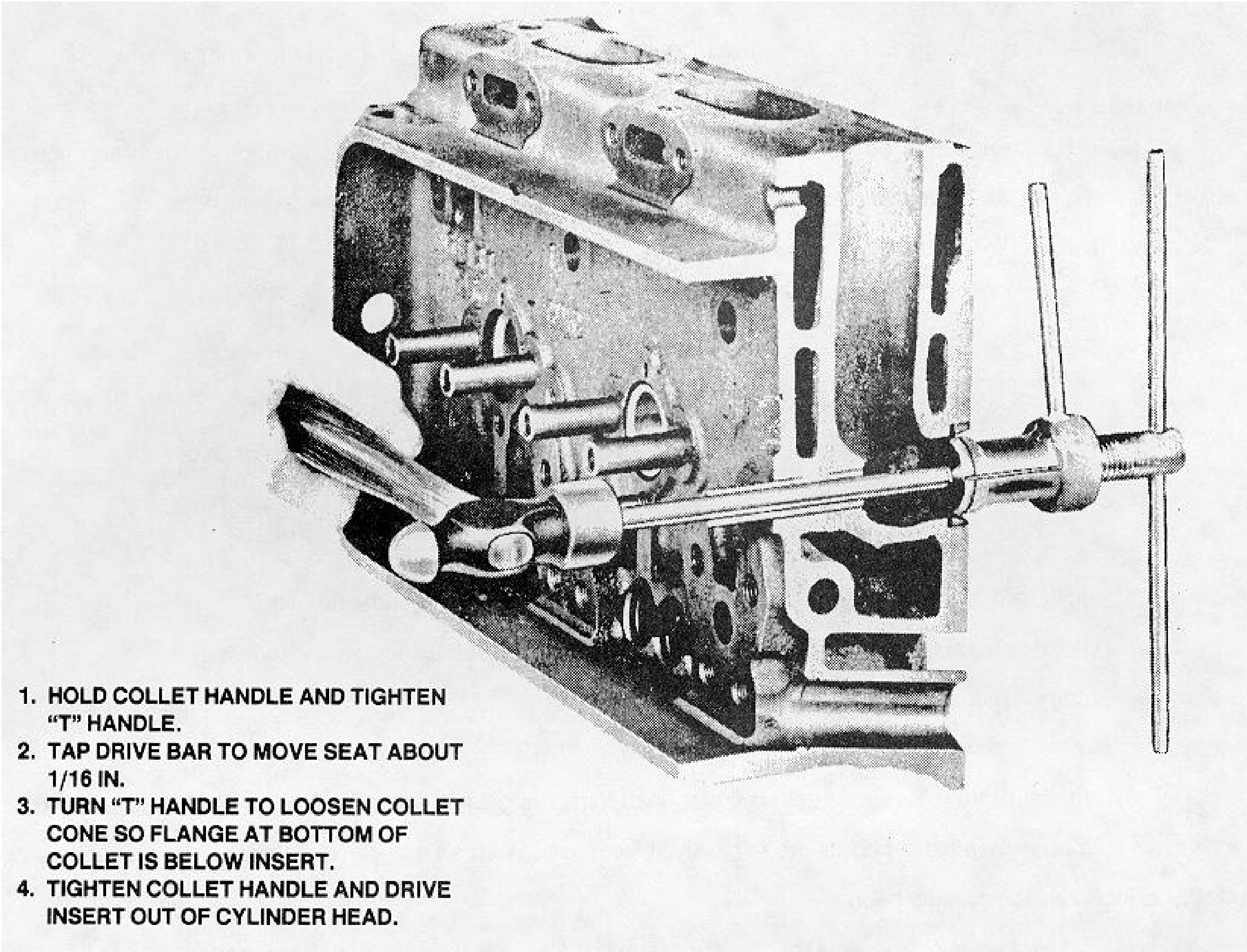


Figure 6-14. Exhaust Valve Seat Removal.

6-16 Cylinder head cleaning test, inspection and repair

a. Cleaning. Wash cylinder head with cleaning solvent and dry with compressed air.

b. Test, Inspection and Repair

(1) After cylinder head has been disassembled, remove oil gallery plugs and thoroughly steam clean cylinder head.

(2) Use an accurate straight edge and feeler gage to check transverse warpage at each end and between all cylinders. Also, check longitudinal warpage in six places. Maximum allowable transverse warpage is 0.004 inch and maximum allowable longitudinal warpage is. 006 inch.

CAUTION

Do not remove over 0.020 inch metal when refacing cylinder head. Distance from top to bottom (fire deck) of cylinder head must not be less than 4.376 inches.

NOTE

Injector tubes must be removed prior to refacing head. After cylinder head has been refaced, stamp amount of stock removed, on face of fire deck, away from combustion or sealing areas.

(3) Inspect cam follower bores in cylinder head for scoring. Light score marks can be cleaned up with crocus cloth dampened with fuel oil. If bores are excessively scored or worn so that cam follower-to-head clearance exceeds 0.006 inch, replace cylinder head.

(4) Inspect valve seat inserts for cracks or burning. Also, check valve guides for scoring.

(5) Inspect water nozzles to make sure they are not too loose in cylinder head.

(6) Prepare cylinder head for a leak test by sealing all water holes in head with steel plates and rubber gaskets.

(a) Install dummy or scrap injectors and tighten injector clamp bolts to 2025 lb-ft torque.

(b) Drill and tap one steel plates for an air hose connection and apply 40 psi air pressure to water jacket.

(c) Immerse head in a tank of water previously heated 180° to 200°F for 20 minutes. Observe water in tank for bubbles, which will indicate a crack or leak.

(d) Release air pressure and remove cylinder from tank. Remove plates and dummy injectors.

(e) Dry head with compressed air.

(7) If necessary, replace cylinder head water nozzles as follows:

(a) Make sure water inlet ports in bottom of water holes at each end of head can be cleaned with 5/8 inch drill, and all other water holes can be cleaned with 13/16 inch drill. Break edges of holes slightly.

(b) Make sure nozzles fit tight in cylinder head. If water holes in head have been enlarged by corrosion, use a wooden plug or other suitable tool to expand nozzles, so that they will remain tight after installation.

(c) Press nozzles into place with nozzle openings parallel to longitudinal center line. Install 1/2-inch diameter nozzles at ends of cylinder head with their openings toward center of engine.

6-17 Cylinder head reassembly and installation

a. Reassembly

(1) Cylinder Head Plugs and Studs.

(a) Install all cylinder plugs (Figure 6-15) and studs. Install gaskets and covers over water holes and secure with bolts and washers.

(b) When installing plugs in fuel manifold, apply a small amount of sealant as a "dual purpose sealer" to threads of plugs only. Work sealant into threads and wipe off excess sealant with a clean lint-free cloth so that sealant will not be washed into fuel system and result in serious damage to fuel injectors.

(2) Exhaust Valve Seats

(a) Clean valve seat insert counterbores in cylinder head and valve seat inserts with cleaning solvent and dry thoroughly.

(b) Inspect counterbores for cleanliness, concentricity, flatness and cracks. Refer to Table 1-1 for counterbore dimensions.

(c) Immerse cylinder head for at least 3 minutes in water heated from 180°F to 200°F.

(d) Rest cylinder head, bottom side up, on a work bench and locate insert squarely in counterbore seating, face up. Install insert in cylinder while head is still hot and insert is at room temperature. Drive insert into place with installing tool.

(3) Exhaust Valve Guide. Turn cylinder head right side up and install exhaust valve guides as follows:

(a) Install threaded end of valve guide in proper guide installation tool.

(b) Position valve guide squarely in bore of cylinder head and tap installation tool gently and drive guide into cylinder head. Refer to Figure 6-16 for proper valve guide position.

CAUTION

Do not use valve guides as a means of turning cylinder head over or handling the cylinder head.

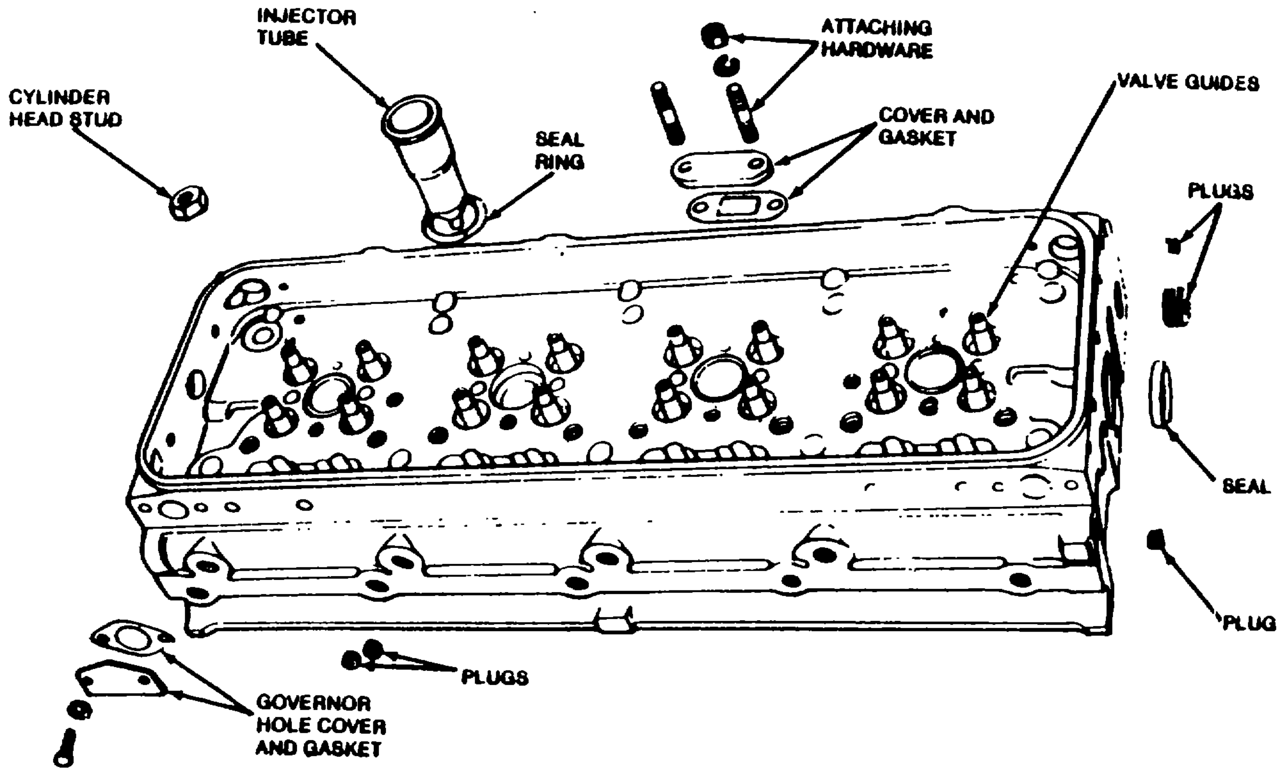


Figure 6-15. Cylinder Head Plugs and Studs.

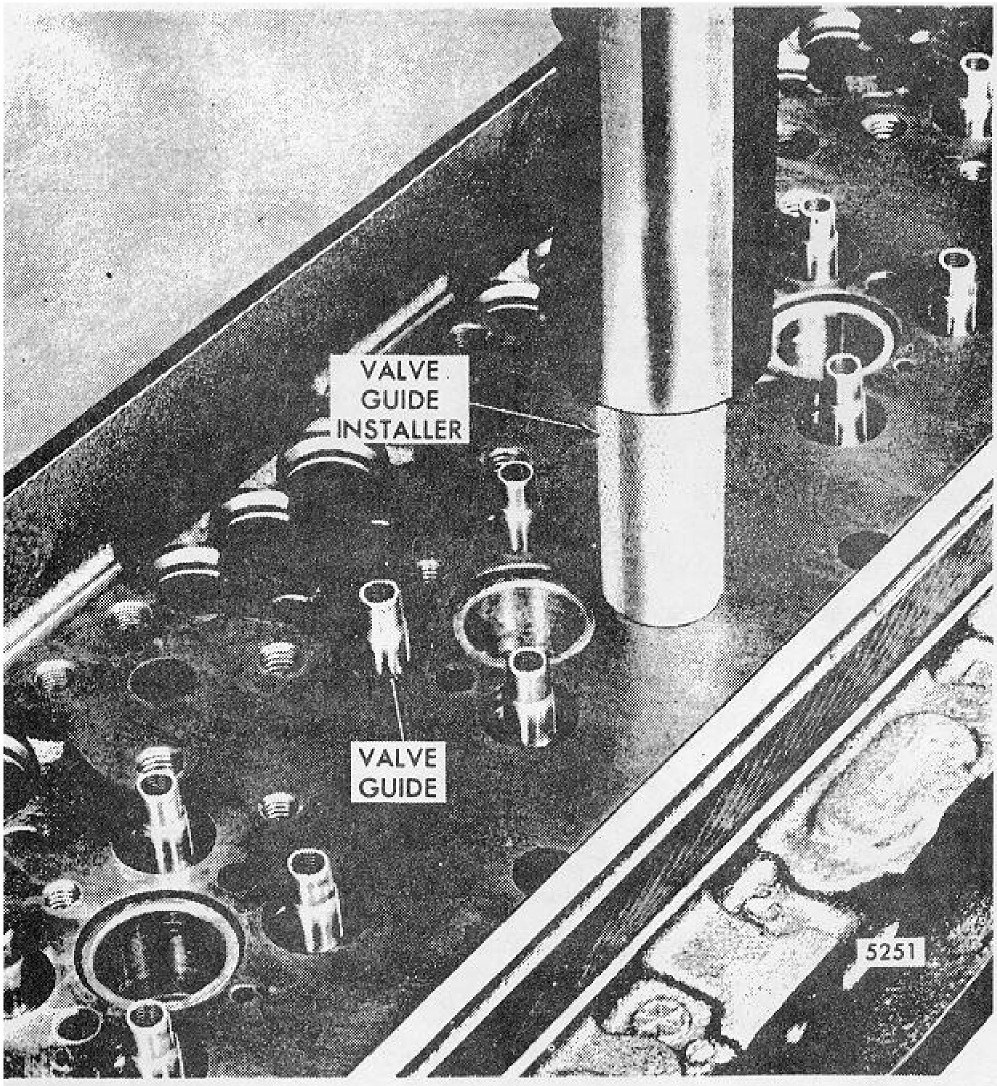


Figure 6-16. Valve Guide Installation.

(4) Exhaust Valves

(a) An exhaust valve which is to be reused may be refaced, if necessary. To provide sufficient valve strength and spring tension, edge of valve must not be less than 1/32 inch thick.

(b) Before either a new or used valve is installed, inspect valve seat in cylinder head for proper valve seating. The proper angle for the seating face of the valve is 30°, valve seat insert should be 31 °.

(c) When a new valve seat insert is installed or an old insert is reconditioned, valve inserts must be ground.

(d) Refer to Figure 6-17 for exhaust valve seat insert grinding specifications.

CAUTION

Do not allow grinding wheel to touch cylinder head when grinding inserts.

(e) Grinding will reduce thickness of valve seat insert and cause valve to recede into cylinder head. If, after several grinding operations, valve recedes beyond limits shown in Figure 6-17, replace valve seat insert.

(f) After grinding has been completed, clean valve seat thoroughly with cleaning solvent and dry. Set a dial indicator in position and rotate dial indicator to check concentricity of each valve seat relative to valve guide. If runout is excessive, check for a bent valve guide before regrinding insert.

(g) After a valve seat insert runout is obtained that is within desired limits, determine position of contact area between valve and valve seat insert. Apply a light coat of Prussian Blue, or similar paste to valve seat insert. Next, lower stem of valve in valve guide and bounce, but do not rotate valve on insert. This procedure will indicate area of contact on valve face. The most desirable area of contact is center of valve face.

(h) After valve seat inserts have been ground and checked, thoroughly clean cylinder head before installing valves.

(i) Apply a light coat of engine oil on valve stems and install valves in cylinder head. If reconditioned valves are used, install in same port from which they were removed.

(j) Hold valves in place with masking tape and turn cylinder head right side up on work bench. Place a board under head to support valves.

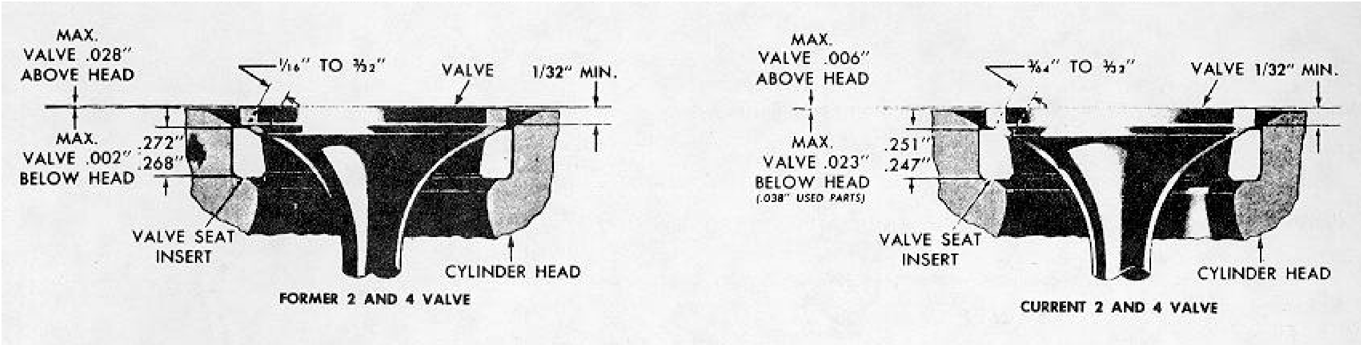


Figure 6-17. Valve Seat Grinding Specifications.

(k) Install valve spring seat (Figure 6-18), valve spring, and spring cap. Use a valve spring compressor and depress tool and secure each valve in position with two spring locks. Release tool and install remaining exhaust valves in a similar manner.

(l) Refer to Figure 6-17 and check position of exhaust valves after installation.

(5) Fuel Injector Tubes

(a) Thoroughly clean injector tube hole in cylinder head; remove all dirt, burrs, or foreign material that may prevent tube from seating at lower end or sealing at upper end.

(b) Install a new injector tube sealing ring in injector tube counterbore. Use injector tube installation tool and install injector tube in cylinder head.

(c) With injector tube properly positioned in cylinder head, flare lower end of tube as follows:

1 Turn cylinder head bottom side up. Remove pilot tool and thread upsetting die into tapped end of installer tool.

2 Use a socket and torque wrench and apply approximately 30 lb-ft torque on upsetting die.

3 Remove tool and ream injector tube.

(d) After injector tube has been installed in cylinder head, it must be finished in three operations as follows:

1 Place a few drops of light cutting oil on reamer flutes.

2 Carefully position reamer in tube and turn in a clockwise direction.

3 Continue reaming, with frequent stops to remove chips, until lower shoulder of reamer contacts injector tube.

4 Clean out any remaining chips.

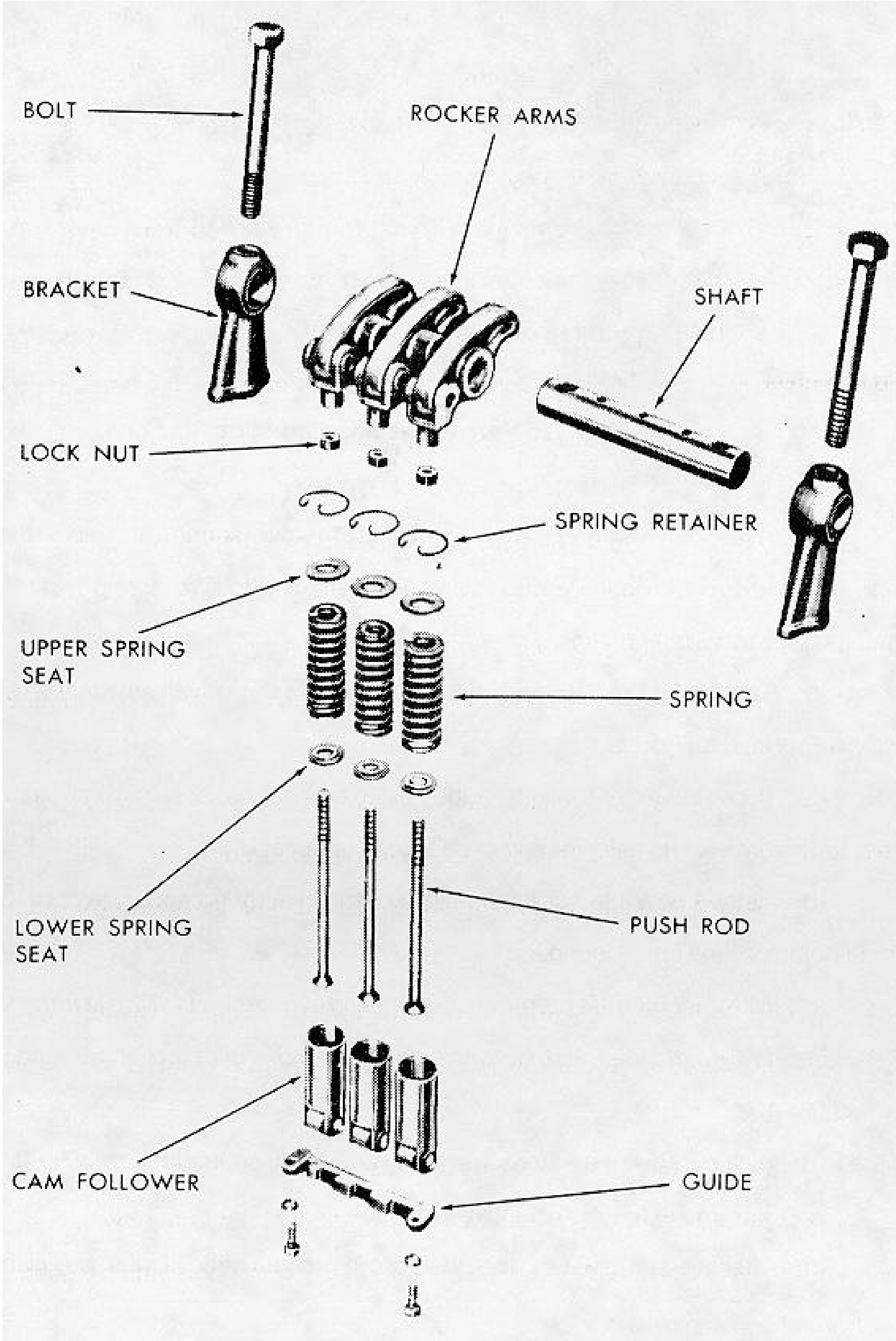


Figure 6-18. Cam Follower Disassembly and Reassembly.

5 Turn cylinder head bottom side up.

6 Lubricate small end of reamer into injector tube.

7 Use a speed handle and remove excess stock at bottom end of tube. Ream until small end of tube is flush to .005 inch below finished surface of cylinder head.

(e) Ream bevel seat in injector tube as follows:

1 To determine amount of metal to be removed from bevel seat, place injector gage into injector tube. Zero dial indicator to fire deck. Dial injector should be flush, i .014 inch with fire deck (Figure 6-19).

2 Install injector in tube and note relationship between surface of spray tip and fire deck of cylinder head as shown in Figure 6-19. This will determine amount of stock that must be reamed from bevel seat in tube.

CAUTION

Wear safety goggles when using compressed air.

3 Wash interior of injector tube with fuel oil and dry thoroughly with compressed air.

4 Place a few drops of cutting oil on bevel seat of injector tube. Carefully lower reamer into tube until it contacts bevel seat.

5 Without applying any downward force, make a trial cut by turning reamer steadily. Remove reamer, blow out chips and note what portion of bevel seat has been cut.

6 Proceed carefully with reaming operation, withdrawing the reamer occasionally to observe progress.

7 Remove chips from injector tube and using an injector for a gage, continue reaming operation until shoulder of spray tip is either flush or extends a maximum of 0.015 inch below fire deck or cylinder head as illustrated in figure 6-19.

(6) Push Rods and Cam Followers (Cylinder Head Removed)

(a) Install pushrod spring retainers (Figure 6-18) in cylinder head.

(b) Install lower spring seat, spring, and upper spring seat on pushrod. Then, install assembled pushrod into cylinder head in proper bore.

(c) Screw pushrod locknut on each pushrod as far as possible; then, screw the pushrod into rocket arm clevis until end of rod is flush with or above inner side of clevis.

(d) Immerse cam followers in a screen type basket and place basket in a container of lightweight engine oil (heated to 100° to 125°F) for at least 1 hour before installation. Rotate cam follower rollers during soaking period to aid in purging any air from bushing roller area.

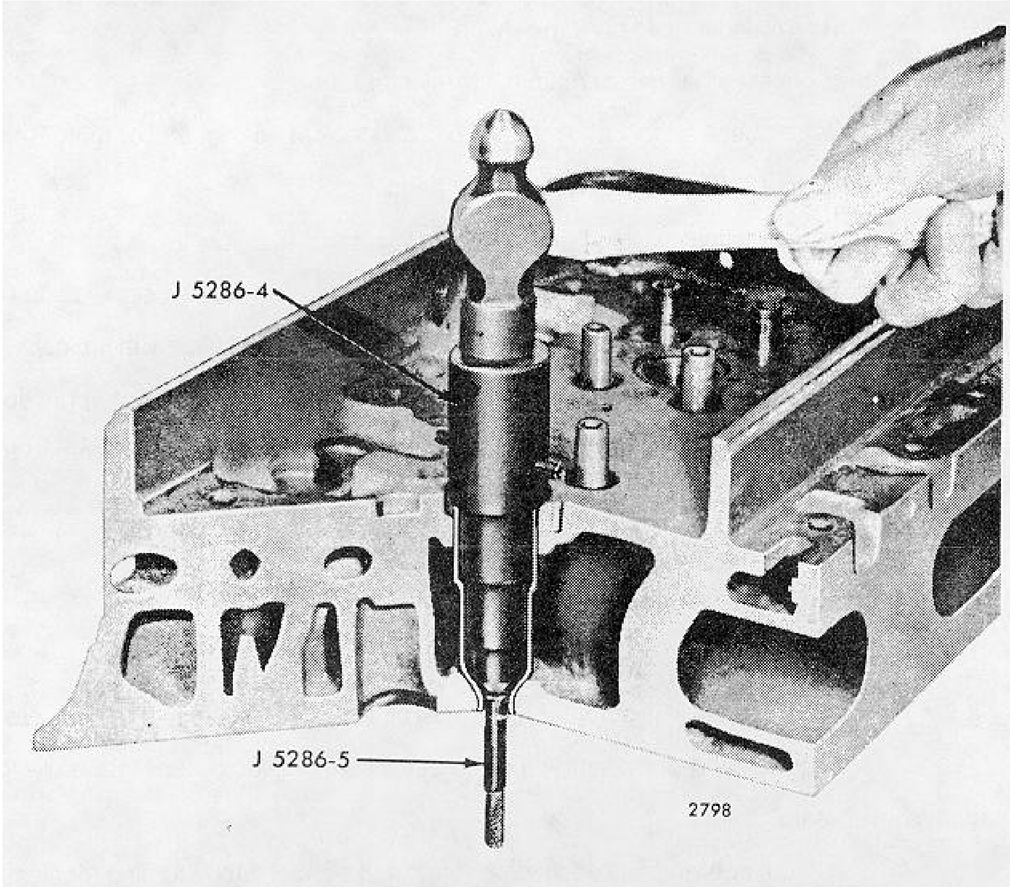


Figure 6-19. Injector Tube Clearance/Reaming.

(e) Note 1/8 inch oil hole in bottom of cam follower. With this hole pointing away from exhaust valves and injectors so that hole is not covered by cam follower guide, slide cam follower into position from bottom of cylinder head.

(f) Install cam follower guide as illustrated in Figure 6-11. Tighten cam follower bolts to 12-15 Ib-ft torque.

(g) Check to make sure there is at least 0.005 inch clearance between cam follower legs and follower guide.

(h) If clearance is insufficient, loosen guide bolts slightly and tap each comer of guide with a brass rod. Then, retighten bolts and recheck clearance.

(i) Install fuel injectors (para 6-14).

j) Install rocker arms.

(k) Reassemble injector control tube in reverse of disassembly sequence. Refer to Figure 6-12 for parts location and identification.

Section VII. Oil Pan and Oil Pump

6-18 General

a. Oil Pan. The oil pan is the shallow type, steel construction used as a reservoir for engine lubricating oil.

b. Oil Pump

(1) The gear driven oil pump is mounted on first and second main bearing caps and is gear driven from front end of crankshaft.

(2) The oil pump helical gears rotate inside a housing. Drive gear is keyed to drive shaft which is supported inside housing on two bushings with a driven gear keyed to outer end of shaft. Driven gear is supported on driven gear shaft which is pressed into pump body.

(3) An integral plunger-type relief valve by-passes excess oil to inlet side of the pump when pressure in oil line exceeds 105 psi.

(4) An inlet pipe attached to inlet opening in pump body leads to inlet screen which is mounted with brackets to main bearing cap.

6-19 Oil pump removal and disassembly

a. Removal

(1) Remove the oil pan as in para 6-73.

(2) Refer to Figure 6-21 and remove bolts and lockwashers securing oil pump, regulator body, oil outlet tube, oil inlet tube support, and main bearing cap, from cylinder block.

NOTE

If shims have been used between oil pump mounting feet and bearing caps, remove and save these shims for reuse during assembly.

b. Disassembly

(1) Observe carefully position of oil inlet and outlet pipes during disassembly to facilitate reassembly in same position.

(2) Remove scavenging pump inlet pipe together with inlet screen, if so equipped, from scavenging pump body.

(3) Remove oil pump inlet pipe with screen cover and mounting bracket.

(4) Remove oil pressure regulator and oil pump outlet pipe, as an assembly, from pump body.

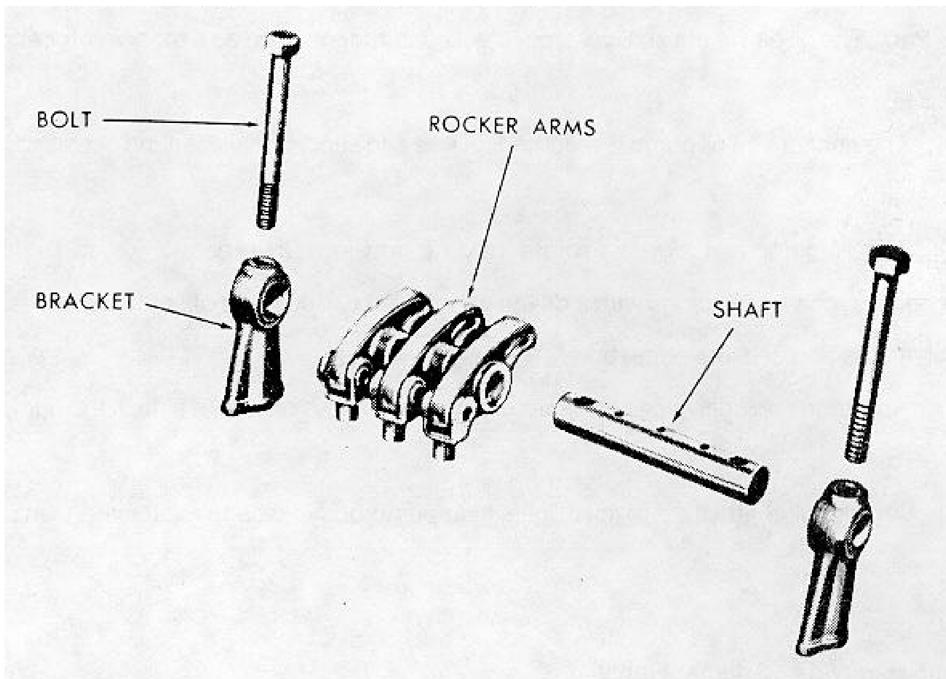
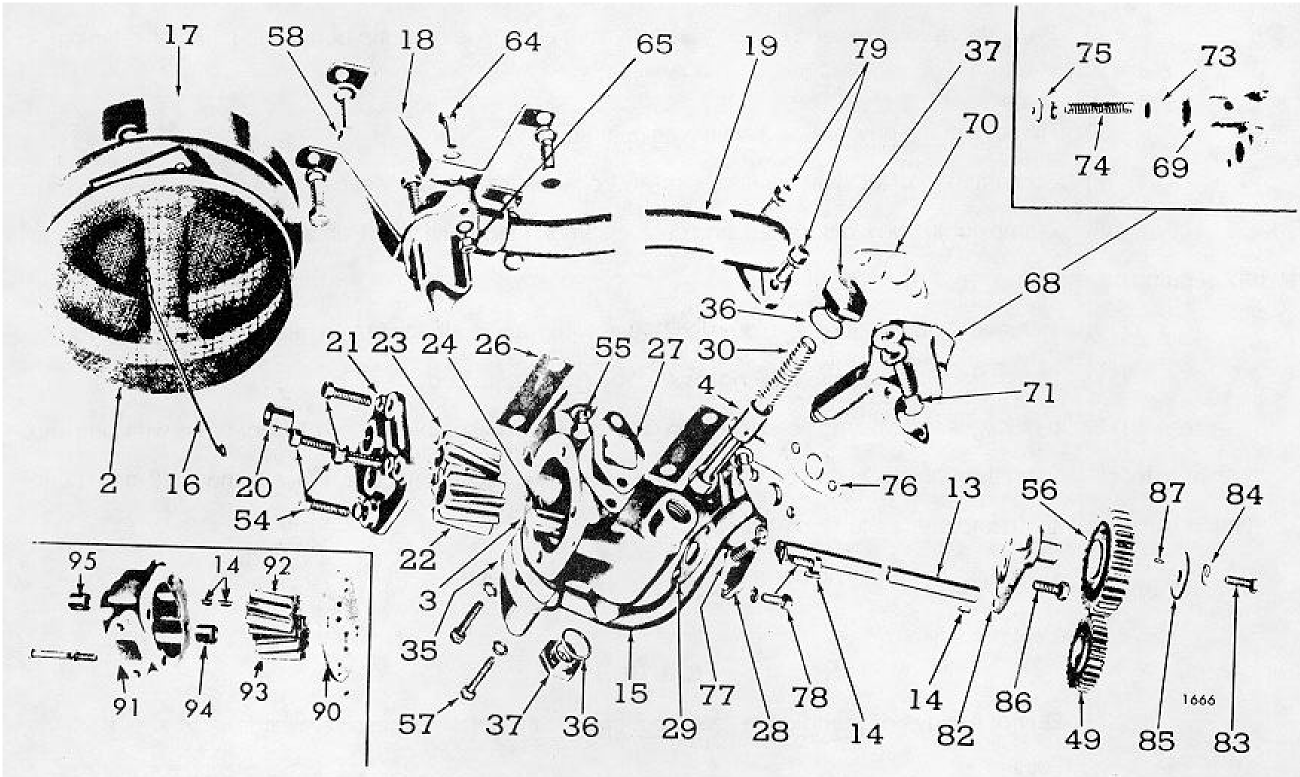


Figure 6-20. Rocker Arm Shaft Bracket.



2. Screen--Pump
3. Body-Oil Pump
4. Valve--Oil Pressure Relief
13. Shaft-Drive
14. Woodruff Key
15. Pipe--Pump Outlet
16. Retainer--Screen
17. Cover--Screen
18. Bracket--Screen
19. Pipe--Pump Inlet
20. Bushing--Drive Shaft (Short)
21. Cover--Pump
22. Gear-Driven
23. Gear-Drive-
24. Shaft--Driven Gear
26. Shim
27. Gasket--Inlet Pipe to Pump
28. Cover--Pump Inlet Pod
29. Gasket--Pod Cover
30. Spring--Relief Valve
35. Gasket--Outlet Pipe to Pump
36. Gasket--Copper
37. Plug--Relief Valve
49. Gear--Drive-Driven
54. Bolt--Pump Cover
55. Bolt--Pump to Bearing Cap
56. Gear--Idler
57. Bolt--Outlet Pipe to Pump
58. Bolt--Screen Bracket to Bearing Cap
64. Bolt--Inlet Pipe and Cover to Bracket
65. Nut
68. Regulator Assy.--Oil Pressure
69. Regulator Body
70. Gasket--Regulator to Cylinder Block
71. Bolt--Regulator to Cylinder Block
73. Valve--Regulator
74. Spring--Regulator
75. Plug--Regulator
76. Gasket--Outlet Pipe to Pressure Regulator
77. Bolt--Outlet Pipe to Pressure Regulator
78. Bolt--Inlet Pad Cover
79. Bolt--Inlet Pipe to Pump
82. Support--Idler Gear
83. Bolt--Idler Gear to Support
84. Lock Washer-Idler Gear-to-Support

Bolt Pump Body

85. Washer--Idler Gear-to-Support Bolt
86. Bolt--Idler Gear Support-to-Pump
87. Locating Pin--Idler Gear Washer
88. Dowel--Idler Gear Support
90. Spacer--Pump Body
91. Body--Scavenging Pump
92. Gear--Scavenging Drive
93. Gear--Scavenging Driven
94. Bushing--Scavenging Driven Gear
95. Bushing--Scavenging Pump Body
96. Bolt--Scavenging

Figure 6-21. Engine Oil Pump Disassembly and Reassembly.

(5) Remove four bolts and lockwashers securing cover to oil pump body.

(6) Remove valve plugs and copper gaskets from each side of pump body, and jar relief valve parts from body.

(7) Remove pump driven gear from driven gear shaft.

(8) Straighten lip of lockwasher and unscrew bolt thus freeing idler gear.

(9) Clamp pump body, drive shaft, and gear assembly in a bench vise. Pull drive-driven gear from outer end of pump drive shaft.

(10) Remove Woodruff key from drive shaft and withdraw shaft and driven gear from pump body.

(11) Unscrew bolt and remove idler gear support from pump body.

(12) If drive gear is to be replaced, position gear and shaft assembly on bed of arbor press with long end of shaft extending down through slot in bed plate and with face of gear resting on plate. Place a short 1/2 inch round steel rod on end of shaft, and press shaft from gear.

(13) Disassemble remaining parts as necessary to effect repair.

CAUTION

Do not remove oil pump drive gear from crankshaft unless excessive wear is evident.

(14) To remove pump gear from drive shaft, engine lower front cover (Figure 6- 22) must be removed.

(15) Thread crankshaft pulley retaining bolt into crankshaft. Attach a suitable puller behind gear and locate puller screw in center of pulley retaining bolt.

(16) Pull drive gear off crankshaft.

6-20 Oil pump cleaning, inspection and repair

a. Cleaning. Wash all parts with cleaning solvent and dry thoroughly.

b. Inspection and Repair

(1) Inspect pump rotor lobes for excessive wear. Remove any scratches or score marks with an emery paper or stone.

(2) Measure clearance between inner and outer rotors at each lobe. It should be between .004 and .011 inch. Clearance between face of pump body and faces of rotors should also be measured. Proper clearance is between .001 and .0035 inch.

(3) Inspect pump gears for chipped teeth or excessive wear.

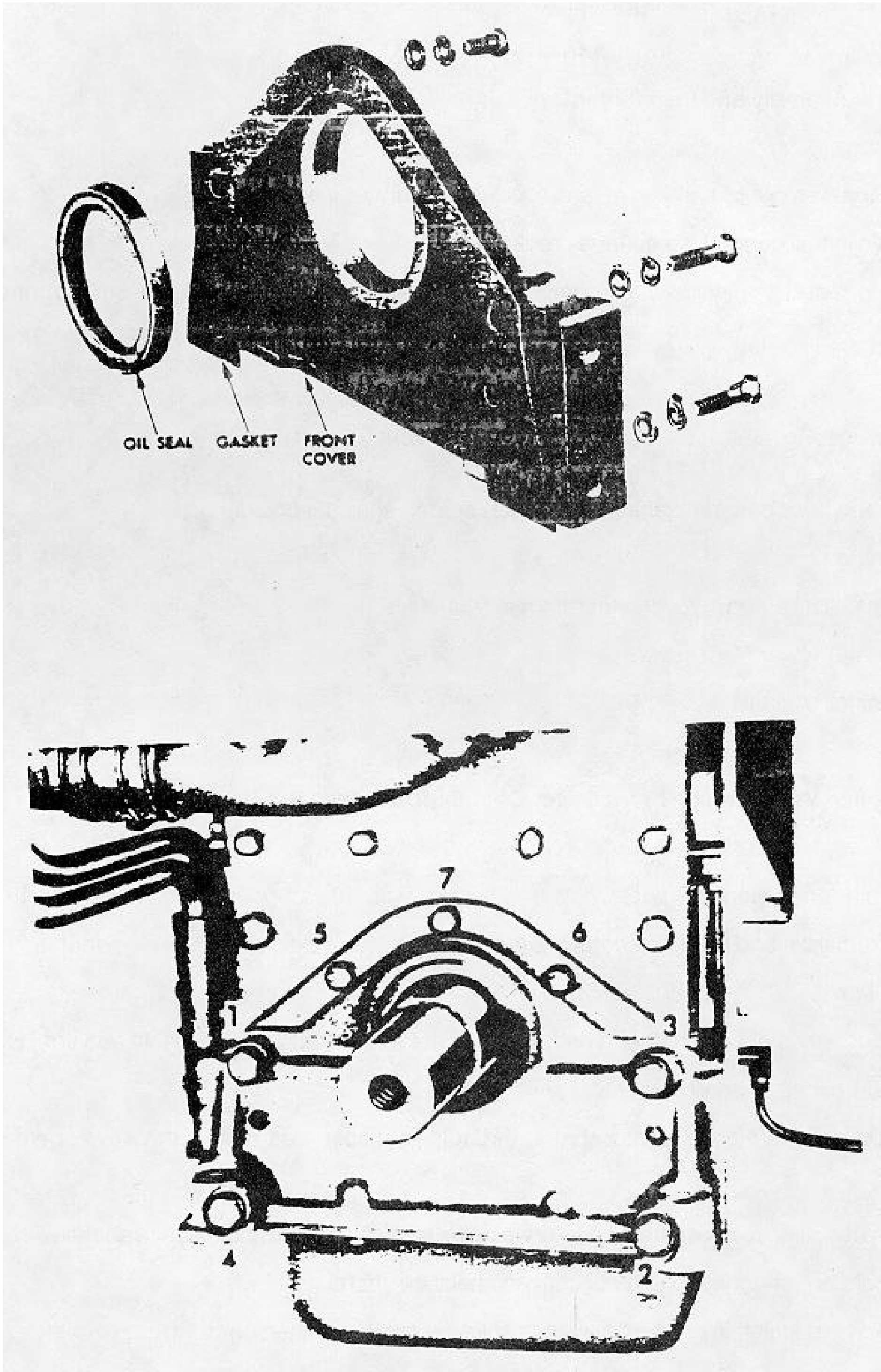


Figure 6-22. Engine Front Cover Installation.

(4) Inspect pressure relief valve and its seat in oil pump body.

(5) Discard and replace all gaskets and seals.

(6) Repair by replacement of defective parts.

6-21 Oil pump reassembly and installation

a. Reassembly

(1) Reassemble oil pump in reverse of disassembly sequence.

(2) To install pump drive gear on crankshaft with lower front cover removed:

(a) Lubricate inside of oil pump gear with engine oil. Then start gear straight onto shaft, chamfered edge first.

NOTE

Reinstallation of a used gear on crankshaft is not recommended.

(b) Press gear on crankshaft until it is seated against shoulder.

b. Installation.

(1) Install oil pump in reverse of removal sequence.

(2) Install lower front cover.

(3) Install oil pan.

Section VIII. Engine Front Cover, Camshaft, Balance Shaft, and Timing Gears

6-22 General

a. Camshaft and Balance Shaft

(1) Camshaft and balance shafts are located near top of cylinder block. Camshaft actuates valve and fuel injector mechanisms.

(2) Both ends of camshaft and balance shaft are supported by bearings. In addition, two intermediate bearings and a center bearing support camshaft.

(3) On both cam and balance shafts, thrust load is absorbed by two thrust washers on each end of rear end shaft bearings.

(4) A helical drive gear with a counterweight is secured to cam and balance shafts with a Woodruff key and hexnut. Drive gears are attached to ends of cam and balance shafts.

(5) To help maintain engine balance, a solid weight is attached on front end of shaft.

b. Gear Train

(1) A completely enclosed train of five helical gears (Figure 6-23) is located at rear of engine. A gear bolted to crankshaft flange drives camshaft and balance shaft gears, as well as blower drive gear, through an idler gear mounted between crankshaft and balance shaft gears.

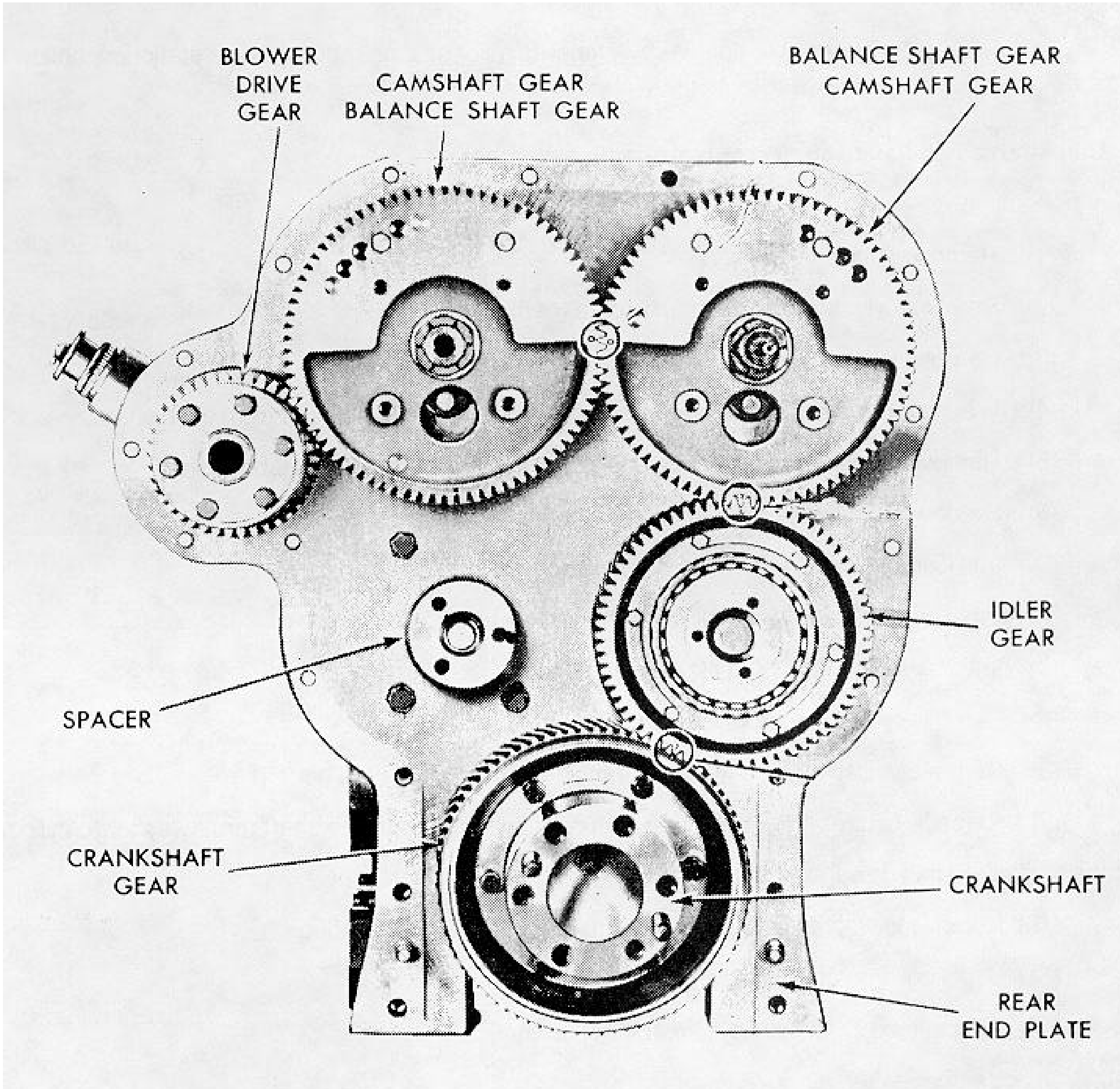


Figure 6-23. Gear Train.

(2) Camshaft and balance shaft gears mesh with each other and run at same speed as crankshaft gear. Since these two gears must be in time with each other, and two as a unit in time with crankshaft gear, letter O" is stamped on one tooth of one of gears (Figure 6-23) with a corresponding mark on root of mating teeth of other gear.

(3) Camshaft and balance shaft gears are keyed to their respective shafts and held securely against shoulder on shaft by a nut.

(4) Idler gear rotates on a double-row, tapered roller bearing mounted on a stationary hollow hub.

6-23 Camshaft and balance shaft removal and disassembly

a. Removal

(1) Remove engine assembly.

(2) Remove cylinder head assembly (para 6-15).

(3) Remove flywheel housing.

(4) Wedge a clean rag between gears and remove gear retaining nut from each shaft.

(5) Remove camshaft and balance shaft balance pulleys using a suitable puller.

(6) Remove front balance weight cover (Figure 6-24) as follows:

(a) Remove cover to cylinder block attaching bolts.

(b) Tap cover and dowel pin assembly away from cylinder block.

(c) Remove all traces of old gasket material.

(7) Remove front balance weights.

(8) Remove thrustwasher between bearing and balance weight hubs.

(9) Remove two retaining bolts that secure camshaft or balance shaft thrustwasher to cylinder block by inserting a socket wrench through a hole in web of gear.

(10) Remove lockscrews that secure camshaft intermediate bearings.

(11) Use a puller to pull camshaft from cylinder block.

(12) Pull balance shaft from cylinder block.

b. Disassembly

(1) Remove either shaft gear using a suitable puller.

(2) Remove end plugs from camshaft to facilitate removal of foreign objects.

(a) Clamp camshaft in a vise equipped with soft jaws, being careful not to damage lobes or machined surfaces of shaft.

(b) Make an indentation in center of end plug with a 31/64 inch drill (carboloy tip).

(c) Punch a hole as deeply as possible with a center punch to aid in breaking through plug.

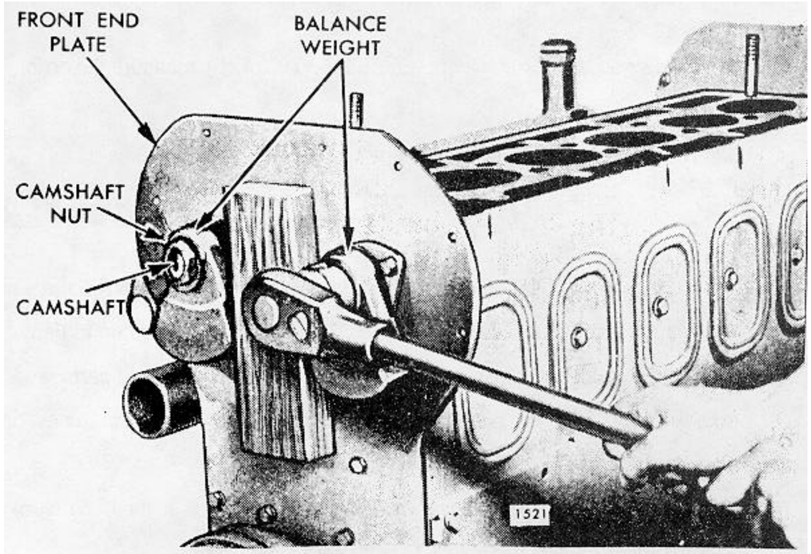


Figure 6-24. Loosening Nut on Camshaft or Balance Shaft.

(d) Then drill a hole straight through center of plug with a 1/4 inch drill (carboloy tip).

(e) Redrill with a 5/16 inch drill (carboloy tip), using existing hole as a guide.

(f) Tap hole with a 3/8 inch 16 tap.

(g) Thread a 3/8 inch 16 adaptor into plug. Then attach a slide hammer to adaptor and remove plug by striking weight against handle.

(h) Insert a length of 3/8 inch steel rod in camshaft and drive out other plug.

6-24 Camshaft and balance shaft cleaning, inspection and repair

a. Cleaning

(1) Wash all parts with cleaning solvent and dry thoroughly with compressed air.

(2) Make sure hollow camshaft is thoroughly clean and free from sludge. All sludge accumulations, which might restrict oil flow must be removed.

b. Inspection and Repair

(1) Inspect cam lobes and cam bearing journals for scoring, scratches, or nicks. If cam lobes are scored, the cam followers must also be inspected. Replace a defective camshaft.

(2) Check camshaft lobe wear.

(a) Place a piece of square, hard material across lobe, parallel to shaft.

NOTE

The material must touch both edges of the lobe.

(b) With a tapered leaf set of feeler gages (.0015-.0100 inch), measure flat on injector rise side of cam lobes.

(c) If flats measure less than .003 inch, lobe is satisfactory in that respect.

(d) A slightly worn lobe may be stoned and smoothed over with a fine crocus cloth as long as wear is within limit.

(3) Inspect both faces of thrustwashers. If either face is scored or if thrustwashers are worn excessively, replace washers. New thrustwashers are .208 to .210 inch thick. Clearance between thrustwasher and thrust shoulder of shafts is .004 to .012 inch with new parts, or a maximum of.01 8 inch with used parts.

(4) Also, examine surfaces which thrustwashers contact. If they are scratched but not severely scored, smooth them down with an oil stone.

(5) Inspect shaft bearings for excessive wear. Replace bearings if they are worn excessively or bushings have been turned with bearing. Refer to Table 1-1 for bearing dimensions.

(6) Clearance between new shafts and new bearings is .0045 to .006 inch or a maximum of .008 inch with worn parts.

NOTE

Excessive clearance between shafts and their bearings will cause low oil pressure and excessive backlash between gears.

NOTE

Oversize bearings and oversize shafts are available for use if bearing bores or bearings must be ground.

(7) Inspect camshaft and balance shaft timing gears for chipped teeth or other damage.

(8) Repair by replacement of defective parts.

6-25 Camshaft and balance shaft bearing removal and repair

NOTE

Camshaft end bearings must be removed before intermediate bearings. Balance shaft does not have intermediate or center bearings.

NOTE

When removing bearings be sure to note position of bearings in bore with respect to their notches. Replacement bearings must be installed in same positions.

a. Remove bearing lockscrews. Then insert small diameter end of pilot into end bearing.

b. With unthreaded end of shaft started through pilot, push shaft through block bore until end of shaft snaps into remover.

c. Drive bearing out of bore.

d. Next, remove nearest intermediate bearing and center bearing.

e. Remove tool and pilot. Insert pilot's larger diameter end into bore on opposite side.

f. Drive out remaining two bearings, end bearing first.

g. Remove balance shaft bearings as in step b above.

h. Repair by replacement of defective parts.

6-26 Camshaft and balance shaft bearing installation

a. Intermediate and center bearing installation. (camshaft only)

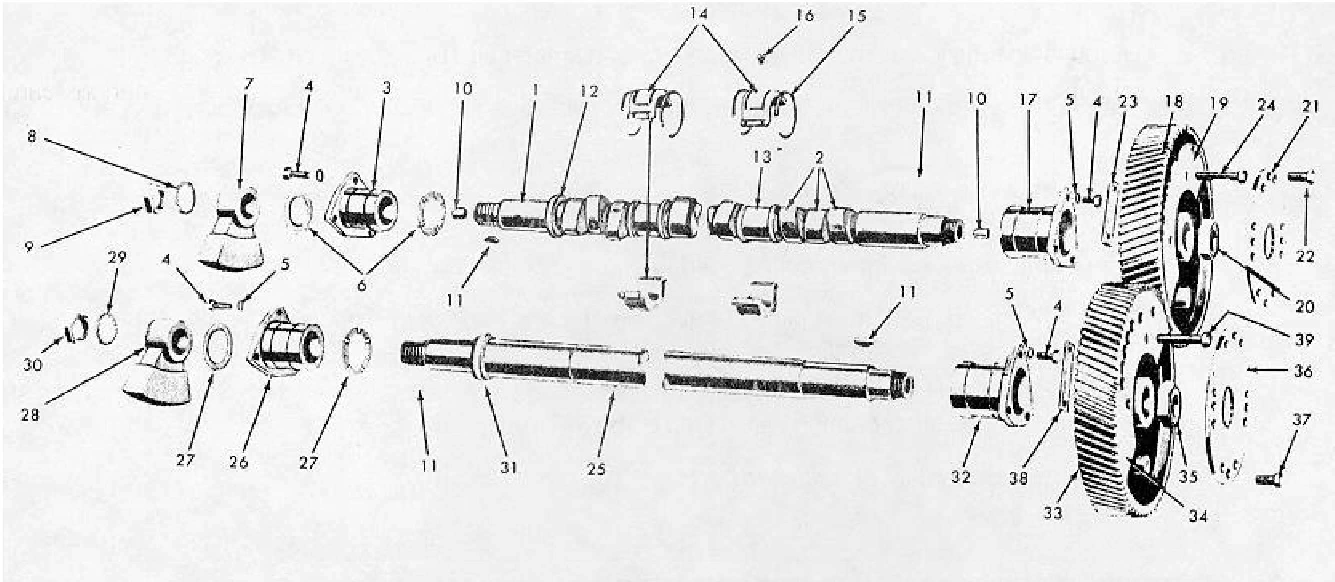
NOTES

- **Center and intermediate bearings must be installed before end bearings.**
- **Current bearings incorporate lubrication grooves on inner surface.**
- **To help facilitate assembly, the bearings are color coded on the side and/or end.**

(1) Refer to figure 6-25 for location of notch in relation to bore centerline.

(2) Insert pilot of bearing tool in bore of block.

(3) Insert a new center bearing into correct bore and position it correctly. Install center bearing first.



1. Camshaft
2. Cam
3. Bearing--Camshaft Front
4. Bolt--Bearing Retainer
5. Lock Washer
6. Washer-Camshaft Thrust
7. Balance Weight Assy.--Camshaft Front
8. Lock Washer
9. Nut--Camshaft Front
10. Plug.-Camshaft
11. Key
12. Thrust Shoulder--Camshaft
13. Journal--Camshaft Intermediate
14. Bearing—Camshaft Intermediate
15. Lock Ring--Intermediate Bearing
16. Set Screw--Intermediate Bearing
17. Bearing-Camshaft Rear
18. Gear--Camshaft L.H Helix
19. Weight-Camshaft Integral Balance
20. Nut-.Camshaft Rear
21. Retainer--Camshaft Gear Nut Front
22. Bolt--Gear Nut Retainer
23. Balance Weight--Camshaft Rear
24. Bolt--Weight Retaining
25. Balance Shaft
26. Bearing--Balance Shaft Front
27. Washer -Balance Shaft Thrust
28. Balance Weight Assy -Balance Shaft Front
29. Lock Washer Balance Shaft Nut
30. Nut.-Balance Shaft
39. Bolt--Weight Retaining
31. Thrust Shoulder--Balance Shaft
32. Bearing--Balance Shaft Rear
33. Gear-.Balance Shaft R.H Helix
34. Weight Balance Shaft Integral Balance
35. Nut--Balance Shaft Rear
36 Retainer.-Balance Shaft Gear Nut
37. Bolt-Gear Nut Retainer
38. Balance Weight--Balance Shaft Rear

Figure 6-25. Camshaft and Balance Shaft Assembly.

(4) Using installer, set bearing in its seat and align it so that bearing lockscrew can be installed.

(5) Install bearing lockscrew.

CAUTION

Bearing must have slight movement in block bore after lockscrew is seated.

(6) Install remaining intermediate bearings in a similar manner. Then two rear-end bearings can be installed.

b. End bearing installation

(1) Insert pilot in bore of block.

(2) Insert support in bore in opposite end of block; then, with unthreaded end of shaft started through pilot, push shaft through block and support.

(3) Place a new end bearing on installer and align notch in bearing with pin on installer. Then slide installer and bearing on shaft. Position bearing correctly with groove in camshaft bore.

(4) Place the "C" washer in end notch in shaft; pull shaft back until washer butts against bearing.

(5) Next, place a spacer thrustwasher, plain washer and hexnut over threaded end of shaft and, using a suitable wrench on hexnut, draw bearing into place until shoulder of installer prevents further shaft movement.

(6) Follow steps (1) thru (5) above for remaining end bearings.

6-27 Camshaft and balance shaft reassembly and installation

a. Install new end plugs in camshaft. Press plugs in to a depth of 1.940 to 2.060 inches.

b. Install cam and balance shafts as follows:

(1) Reinstall gears on cam and balance shafts in reverse of disassembly sequence.

(2) Insert front end of camshaft into opening on blower side of cylinder block. Push camshaft through block until camshaft gear teeth almost engage idler gear.

(3) Align timing marks and push camshaft into place.

(4) Secure camshaft rear-end bearing to block with three bolts and lockwashers. Tighten bolts to 35-40 lb-ft torque.

(5) Install balance shaft in a similar manner.

(6) Apply grease to steel face of cam and balance shaft thrustwashers.

(7) Slide bearing on shaft with greased face of inner thrustwasher against bearing. Push bearing and thrustwasher into place in block.

(8) Install outer thrustwasher and three bearing retainer bolts and lockwashers.

(9) Reinstall balance weights on shafts using new internal tooth lockwashers.

(10) Install cam and balance shaft gear nut retainers with bolts and lockwasher. Tighten bolts to 35-39 lb.-ft torque.

(11) Check clearance between thrustwasher and thrust shoulder of both shafts. Clearance specified is .004 to .012 inch with new parts. (Maximum .018 inch with used parts.)

(12) Check backlash between mating gears between .013 to .008 inch. (Maximum of .010 inch with used parts.)

(13) Reinstall remaining items in reverse of disassembly.

(14) Service cooling and lubrication system as necessary.

6-28 Gear train removal and disassembly

a. Remove engine assembly.

b. Remove flywheel housing.

c. Use a suitable gear puller and remove camshaft and balance shaft timing gears (para 6-22).

NOTE

Shafts do not have to be removed from block to repair or replace a gear.

d. Refer to Figure 6-26 and remove idler gear as follows:

(1) Remove idler gear outer thrust washer from hub.

(2) Slide idler gear straight off hub.

(3) Remove bolt which secures idler gear hub to block.

(4) Remove idler gear hub and inner thrust washer as an assembly.

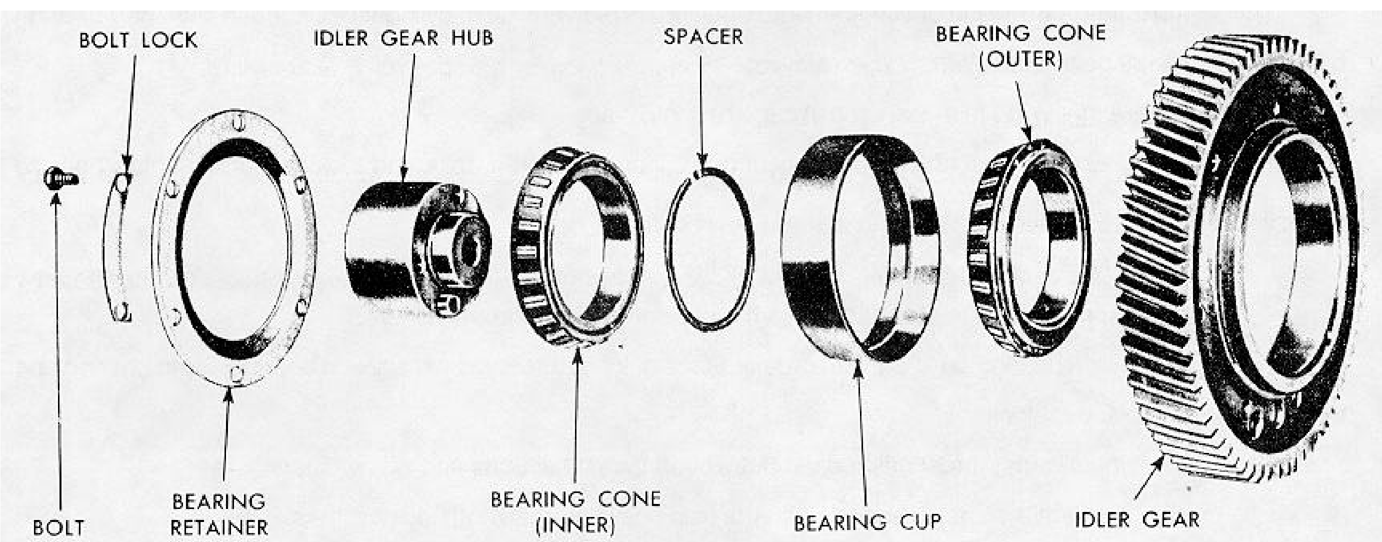


Figure 6-26. Idler Gear Assembly.

NOTE

Before disassembling idler gear assembly, check gear, hub, and bearing assembly for any perceptible wobble or shake when pressure is applied by firmly grasping rim of gear with both hands and rocking. If gear is satisfactory, it will only be necessary to check pre-load before installation.

Component parts of idler gear bearing are mated; therefore, match-mark parts during disassembly so they can be reassembled in their original position.

e. Remove crankshaft timing gear as follows:

NOTE

Crankshaft gear can be inspected on crankshaft and should not be removed unless replacement is required or complete engine overhaul/crankshaft replacement is in progress.

(1) Remove retaining nut and rear oil seal sleeve if one is installed.

(2) Use a three prong gear puller that can be aligned with holes in gear and pull crankshaft gear off shaft.

6-29 Gear train cleaning, inspection and repair

a. Cleaning. Wash all parts with cleaning solvent and dry thoroughly.

b. Inspection and Repair

(1) Inspect bearings for excessive wear, pitting, scoring, or flat spots on roller or races.

(2) Inspect idler gear.

(a) Examine gear teeth and bearing for scoring, pitting, or wear. If gear teeth are worn or bearing is excessively damaged, replace assembly or install a new bearing in gear.

(b) Test pre-load (or axial load) of bushing after installation. It must sustain a 2000 lb load without pushing out of gear.

NOTE

Bushing must not protrude beyond gear face.

(3) Repair by replacement of defective parts.

6-30 Gear train reassembly and installation

a. Install crankshaft gear as follows:

(1) Install key if it was removed from crankshaft.

(2) Start timing gear on shaft with timing marks out and slot aligned with key.

(3) Use installer and drive gear on until it seats against crankshaft shoulder.

b. Reassemble and install cam and balance shafts and gears in reverse of disassembly sequence (para 6-22).

c. Refer to Figure 6-23 and align cam and balance shaft timing marks. Rotate crankshaft to obtain preliminary timing alignment.

d. Reassemble idler gear assembly as follows:

(1) Place inner thrust washer on forward end of idler gear hub with flat of inner diameter over flat on hub, and with oil grooves on washer facing hub.

(2) Place small protruding end of idler gear hub through end plate and into counterbore in cylinder block.

(3) Insert two 3/8 inch-16 bolts through idler gear hub and thread them into cylinder block.

(4) Insert 3/8 inch-16 x 1-3/4 inch special bolt through center of idler gear hub and thread it into cylinder block. Tighten bolt to 40-45 Ib-ft torque. Then remove two pilot bolts.

(5) Lubricate idler gear hub and idler gear bearing with clean engine oil.

(6) Install cam and balance shaft gears (para 6-25).

(7) Position gears so that their timing marks (circle) will align with those on idler gear. Refer to Figure 6-23.

e. Install idler gear.

f. Apply a thin film of cup grease to grooved face of outer thrust washer and place washer on gear hub.

g. Check backlash between mating gears. It should be between .003 and .005 inch between new gears and not more than .007 inch between used gears.

h. Install flywheel housing.

i. Install engine assembly.

Section IX. Pistons, Connecting Rod and Cylinder Liners

6-31 General

a. Pistons and piston rings

(1) The trunk type malleable iron piston (Figure 6-27) is plated with a protective coating of tin which permits close fitting, reduces scuffing and prolongs piston life. Top of piston forms combustion chamber bowl and is designed to compress air into close proximity to fuel spray.

(2) Piston is cooled by a spray of lubricating oil directed at underside of piston head from a nozzle in top of connecting rod, by fresh air from blower to top of piston, and indirectly by water jacket around cylinder.

(3) Two bushings with helical grooved oil passages are pressed into piston to provide a bearing for hardened, floating piston pin. Each end of piston pin is sealed with a piston pin retainer.

(4) Each piston is fitted with six piston rings. Four compression rings are installed above piston pin and two, three piece oil control rings are installed below piston pin, eight equally spaced holes are drilled just below each oil control ring to permit excess oil to return to crankcase.

b. Connecting rods

(1) Each connecting rod is made of forged steel. The rod is drilled to provide lubrication to piston at upper end and is equipped with an oil spray nozzle for cooling piston.

(2) Connecting rod bearing shells are different and not interchangeable.

(3) A helically-grooved bushing is pressed into each side of connecting rod at upper end. A cavity of approximately 1/8 inch between inner ends of bushings, registering with the drilled oil passage in rod, forms a duct around piston pin for lubrication.

(4) Connecting rod bearings are prevented from movement by a tang at parting line of each shell. Each connecting rod cap is numbered.

c. Cylinder liners

(1) Cylinder liners are of replaceable wet type, made of hardened alloy cast iron, and are a slip fit in cylinder block. They are installed in cylinder bores from top. A flange on each liner rests on a counterbore in top of block.

(2) A synthetic rubber cylinder liner seal ring recessed in cylinder block bore between liner and block prevents water leakage.

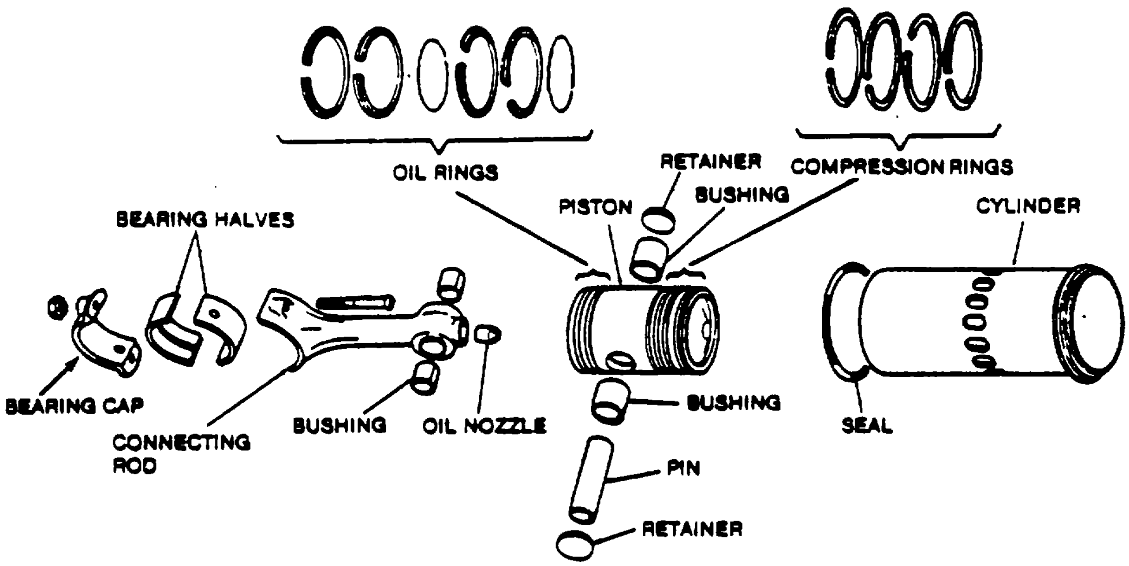


Figure 6-27. Piston Assembly.

(3) Upper portion of liner is directly cooled by water surrounding liner. Center portion of liner is cooled by scavenging air which enters cylinder through 18 equally spaced ports.

6-32 Piston and connecting rod removal and disassembly

NOTE

If a complete overhaul is to be accomplished, do not commence reassembly until cylinder liner inspection and repair and crankshaft repair has been accomplished.

a. Removal

(1) Remove engine assembly.

(2) Remove cylinder head assembly, (para 6-15).

(3) Remove oil pan.

(4) Remove oil pump.

(5) Use a suitable ridge reamer and remove carbon from upper inner surface of cylinder liners.

NOTE

Move piston to bottom of its travel and place a cloth on top of piston to collect cuttings. After reaming is completed, turn crankshaft until piston is at its top of stroke and carefully remove cloth with cuttings.

(6) Remove four piston and connecting rod assemblies as follows:

(a) Remove bearing cap and lower bearing shell from connecting rod.

(b) Push piston and rod assembly out through top of cylinder block.

b. Disassembly

(1) Secure connecting rod in a vise equipped with soft jaws and remove rings using a ring expander.

(2) Punch a hole through center of one of pin retainers with a narrow chisel or punch and pry retainer from piston being careful not to damage piston or bushings.

(3) Withdraw piston pin from piston, then remove connecting rod.

(4) Drive remaining piston pin retainer out from inside with a brass rod or other suitable tool.

6-33 Piston and connecting rod cleaning, inspection and repair

a. Cleaning

WARNING

Cleaning solvents are toxic and additional hazard is posed when compressed air is used to dry off parts cleaned with solvents. This type of maintenance requires the use of safety goggles and a well-ventilated work area. Observe all precautions stated on the container, and never put solvents in unmarked containers.

(1) Clean all parts with cleaning solvent and dry thoroughly with compressed air.

(2) Clean carbon from top of piston using a wire brush.

(3) Use diesel oil or kerosene to clean carbon from piston ring grooves.

(4) Use a twist drill of a diameter corresponding to holes to clean carbon from eight oil control holes in bottom of piston oil ring grooves.

b. Inspection and repair

(1) Inspect pistons for scoring, overheating, cracks, or damaged ring grooves. A piston with light score marks can be cleaned up and reused.

(2) Refer to Table 1-1 and inspect and measure piston pins and pin bushings.

(3) Replace piston bushings as follows:

(a) Place piston in a holding fixture and drive bushings from piston.

(b) Place fixture spacer in counterbore of holding fixture, small end up. Place piston on holding fixture so that spacer protrudes into piston pin bushing bore.

(c) Locate joint in bushing toward bottom of piston, insert installer handle, and drive bushing in until it bottoms on spacer.

(d) Install opposite pin bushing in a similar manner.

NOTE

The bushings must withstand an end load of 1800 pounds without moving after installation.

(4) Refer to Table 1-1 and ream piston pin bushings as necessary.

(5) Fit pistons in cylinder liners as follows:

(a) Refer to Table 1-1 and measure the piston skirt diameter and cylinder liner bores. Take these measurements with piston and liner at normal room temperature (70°F). Measure lengthwise and crosswise to piston pin bore. Out-of-round diameter must not exceed .0005 inch.

(b) Refer to Table 1-1 and check piston to liner clearance. Check this in four places, 90* apart while holding piston upside down in cylinder liner.

(c) Insert appropriate feeler gage between piston skirt and cylinder liner. Attach spring scale to feeler gage and slowly pull gage from between piston and liner.

NOTE

Watch spring scale reading while pulling feeler gage out. A reading of six pounds indicates that clearance is thickness of feeler gage plus .001 inch. Feeler gage must be flat and free of nicks and bends. Piston skirt to cylinder clearance must be greater than .003 inch and less than .010 inch.

(6) Fit piston rings as follows:

NOTE

Use new piston rings whenever a piston is removed for inspection or replacement.

(a) Refer to Table 1-1 and measure gap between ends of piston rings before placing rings on piston.

(b) Insert piston rings into cylinder liner, far enough in bore to be on normal wiping area of ring. Measure ring gap with a feeler gage. Gap must be between .020 and .046 inch for compression rings and .010 to .025 inch for oil rings. Make sure ring is parallel to top of liner.

(c) If piston ring gap is below clearance specified in Table 1-1, file or stone end of piston ring. File or stone ring in such a direction that file or stone will cut from outside (chrome plated) surface of ring toward inside surface. This will prevent chipping or peeling of chrome plate. Ends of ring must remain square and chamfer must be approximately 0.0015 inch on outer edge.

(7) Check ring side clearance in piston groove. Clearances are contained in Table 1-1.

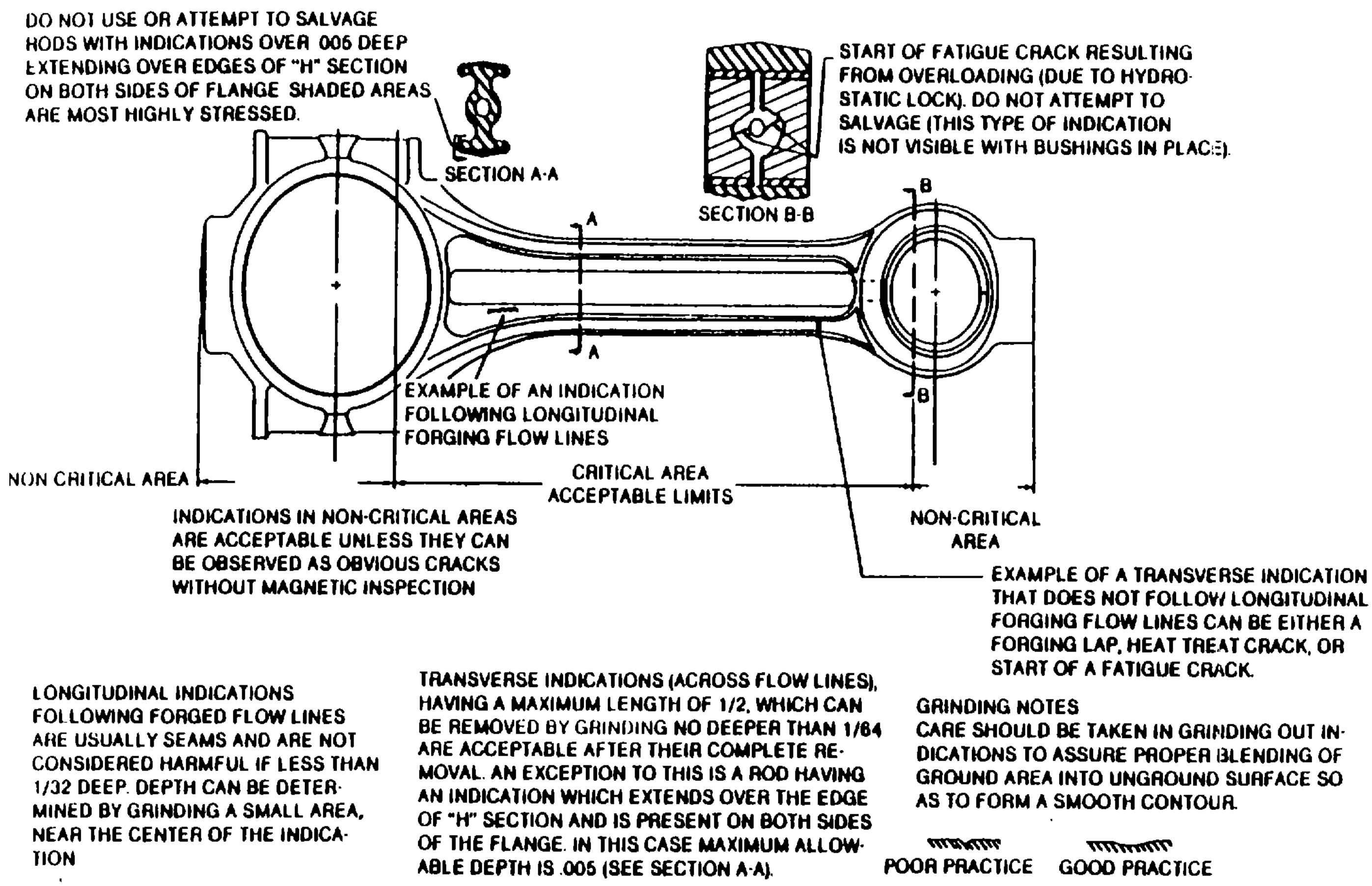


Figure 6-28. Connecting Rod Magnetic Particle Inspection Lines.

(8) Inspect and open holes in spray nozzle. Blow dry compressed air through drilled oil passages in rod and nozzle to make sure all passages are open.

(9) Refer to Figure 6-28 for connecting rod magnetic particle inspection limits.

(10) Refer to Table 1-1 and inspect connecting rod bushings for scoring, indications of overheating, or other damage. Bushings that have overheated may become loose and creep together, thus blocking off lubricating oil to piston pin bushing and spray nozzle.

(11) Replace piston pin bushing and spray nozzle as follows:

(a) Remove piston pin bushing by driving bushing out with a suitably sized remover.

(b) Remove spray nozzle from connecting rod by placing nozzle remover tool inside connecting rod and suspend both over a slotted support. Use a short hollow drift placed over nozzle and drive connecting rod down on tool. Nozzle will be pushed out top of connecting rod.

NOTE

Orifice in lower end of drilled passage in connecting rod is not serviced separately, and it is not necessary to remove it when replacing spray nozzle.

(c) Install new oil spray nozzle with holes positioned straight into counterbore in top of connecting rod. Support connecting rod in an arbor press. Then, place a short 3/8 inch ID sleeve on top of spray nozzle and press spray nozzle in connecting rod.

(d) Clamp upper end of connecting rod in holder so that bore of bushing is aligned with hole in base of installation tool.

(e) Drive bushing into connecting rod bore with joint at top of rod.

(f) Turn connecting rod over in holder and install opposite bushing in same manner.

NOTE

Bushings must withstand an end load of 2000 pounds after being installed.

(12) Refer to Table 1-1 for dimensions and ream piston pin bushing as follows:

(a) Clamp reaming fixture in a bench vise.

(b) Place crankshaft end of connecting rod on arbor of fixture. Tighten nuts on 3/8 inch-24 bolts to 40-45 Ib-ft torque.

(c) Slide front guide bushing (pin end facing out) in fixture.

(d) Install a spacer in fixture.

(e) Align upper end of connecting rod with hole in reaming fixture.

(f) Install rear guide bushing on reamer, then slide reamer and bushing into fixture.

(g) Turn reamer in a clockwise direction only, when reaming or withdrawing reamer. For best results, use only moderate pressure on reamer.

(h) Remove reamer and connecting rod from fixture, blow out chips and measure inside diameter of bushings. Inside diameter of bushings must be 1.3760 to 1.3765 inch. Pin to bushing clearance should be .0010 to .0019 inch. Piston pin diameter will be 1.3745 to 1.3750 inch.

(13) Refer to Table 1-1 for dimensions and measure connecting rod bearings for excessive wear. Visually inspect bearings for excessive wear to determine if used bearings are satisfactory for further service. Upper bearings, which carry load will normally show signs of distress before lower bearings do.

(14) Refer to Table 1-1 for dimensions and measure thickness of bearing 90° from parting line using a micrometer with a ball attachment.

6-34 Piston and connecting rod, reassembly and installation

a. Reassembly

(1) Apply clean engine oil to piston pin and bushing and rest piston in a fixture.

CAUTION

Do not drive too hard on pin retainer or pin bushing may be moved inward and result in reduced pin clearance.

(2) Install one piston pin retainer in piston. Strike installation tool just hard enough to deflect retainer and seat it evenly.

(3) Slide piston pin into piston and connecting rod and install second piston pin retainer as in step (2) above.

NOTE

Piston pin will slip readily into position without force and must float freely after installation.

(4) Check piston pin retainers for proper sealing as follows:

(a) Place suction cup of leak detector over retainer.

(b) Hand pump fixture until gage reads 10 inches.

(c) A drop in gage reading indicates air leakage.

(5) Install oil control rings by hand with the scraping edge of each ring down.

(6) Install expander in upper oil ring groove being careful not to overlap ends.

CAUTION

Oil ring expander must be completely seated in oil ring groove. If ends of expander should overlap, oil ring will protrude slightly and be broken when piston ring compressor is installed over piston, or when piston and rod assembly is installed in cylinder liner.

(7) Install top oil ring, with gap 180° from ends of expander. Install bottom oil ring with gap 45° from top oil ring gap. Recheck to make sure ends of expanders are not overlapped.

CAUTION

Do not at any time, cut off or grind ends of oil ring expander to prevent ends from overlapping. This will decrease the tension on oil control rings and result in high oil consumption.

(8) Install second set of oil rings in a similar manner.

(9) Install four compression rings on piston using a ring expander. Stagger ring gaps around piston with gap of each succeeding ring at least 45° and not more than 90° from preceding ring gap. Proceed either clockwise or counterclockwise with ring gaps.

NOTE

When installing top compression (fire) ring with tapered face, be sure and install ring with oxide (rust) colored side facing toward top of piston.

b. Installation

(1) Rotate crankshaft until connecting rod journal is at bottom of its travel. Wipe journal clean and lubricate it with clean engine oil.

(2) Install two connecting rod bolts and upper bearing half in assembled connecting rod.

(3) Use a suitable ring compressor and apply clean engine oil to piston rings and inside of ring compressor.

(4) Position piston and connecting rod assembly so that identification number on rod is facing serial number side of engine block.

(5) Start skirt of piston into cylinder block and lightly tap top of piston into block with wooden handle of a hammer until it clears ring compressor. Pull piston and rod assembly down until upper bearing half seats firmly on crankshaft journal.

(6) Place lower bearing half in connecting rod cap and lubricate bearing with clean engine oil.

(7) Note identification marks on bearing cap and rod, and assemble cap to rod on same cylinder and rod as disassembly.

(8) Install oil pump (para 6-20).

(9) Install oil pan.

(10) Install cylinder head (para 6-17).

(11) Install engine assembly.

6-35 Cylinder liner removal

a. Remove engine assembly and mount engine on a suitable overhaul stand.

b. Remove pistons and connecting rods (para 6-32).

NOTE

Before removing cylinder liner, perform dimension inspection and hone as necessary as outlined in para 6-36.

c. Use liner removal tool and remove cylinder liner.

(1) Slip lower puller clamp up puller rod and off its tapered seat. Cock clamp so it slides down through liner. Clamp will drop back into its seat in horizontal position after it clears bottom of liner.

(2) Slide upper puller clamp down against top edge of liner.

(3) With tool in place, strike upset head on upper end of puller rod a sharp blow with puller weight, thus releasing liner.

(4) Remove cylinder liner and remove liner seal ring from groove in block bore.

d. If removal tool is not available, tap liner out with a hardwood block and hammer.

6-36 Cylinder liner cleaning, inspection and repair

a. Cleaning. Wash cylinder liner with cleaning solvent and dry thoroughly.

b. Inspection and Repair

(1) Thoroughly inspect cylinder liner for out of round condition, taper, cracks, scoring, flange irregularities, and erosion.

(2) Refer to Table 1-1 for liner dimensions and measure the liner at points shown in Figure 6-29. To check these dimensions, use a bore gage which has a dial indicator calibrated in 0.001 inch increments.

(3) If taper is out of round and does not exceed limits listed in Table 1-1, hone liner to remove any step or ridge at top of ring travel and to remove glaze caused by rubbing action of piston rings.

WARNING

Cleaning solvents are toxic and additional hazard is posed when compressed air is used to dry off parts cleaned with solvents. This type of maintenance requires the use of safety goggles and a well-ventilated work area. Observe all precautions stated on the container, and never put solvents in unmarked containers.

(4) After liner has been honed, clean liner and cylinder block thoroughly with cleaning solvent and dry with compressed air.

(5) After honing, liner must conform to same limits on taper and out-of-round as a new liner, and piston-to-liner clearance must be within specified limits listed in Table 1-1.

(6) Discard and replace seal ring. Replace a defective liner.

(7) Wipe inside and outside of cylinder liner clean. Make sure block bore and counterbore are clean so liner flange will seat properly.

(8) Slide liner into block until flange on liner rests on bottom of counterbore in block.

CAUTION

Do not drop or slam cylinder liner flange against counterbore in block.

(9) Tap liner lightly with a soft hammer to make sure liner seats in bottom of counterbore.

(10) Clamp cylinder liner in place using a liner clamp. Refer to Table 1-1 and measure distance from top of liner flange to top of block with a dial indicator.

(11) Matchmark liner and block with chalk, felt tip, or white paint, so liner may be reinstalled in same position and in same bore. Place matchmark on outer edge of engine serial number side.

(12) Remove hold-down clamp and cylinder liner from block.

6-37 Cylinder liner installation

a. With piston assembled to connecting rod and piston rings in place (para 6-34), apply a clean coat of engine oil to piston, rings, and inside of piston ring compressor tool.

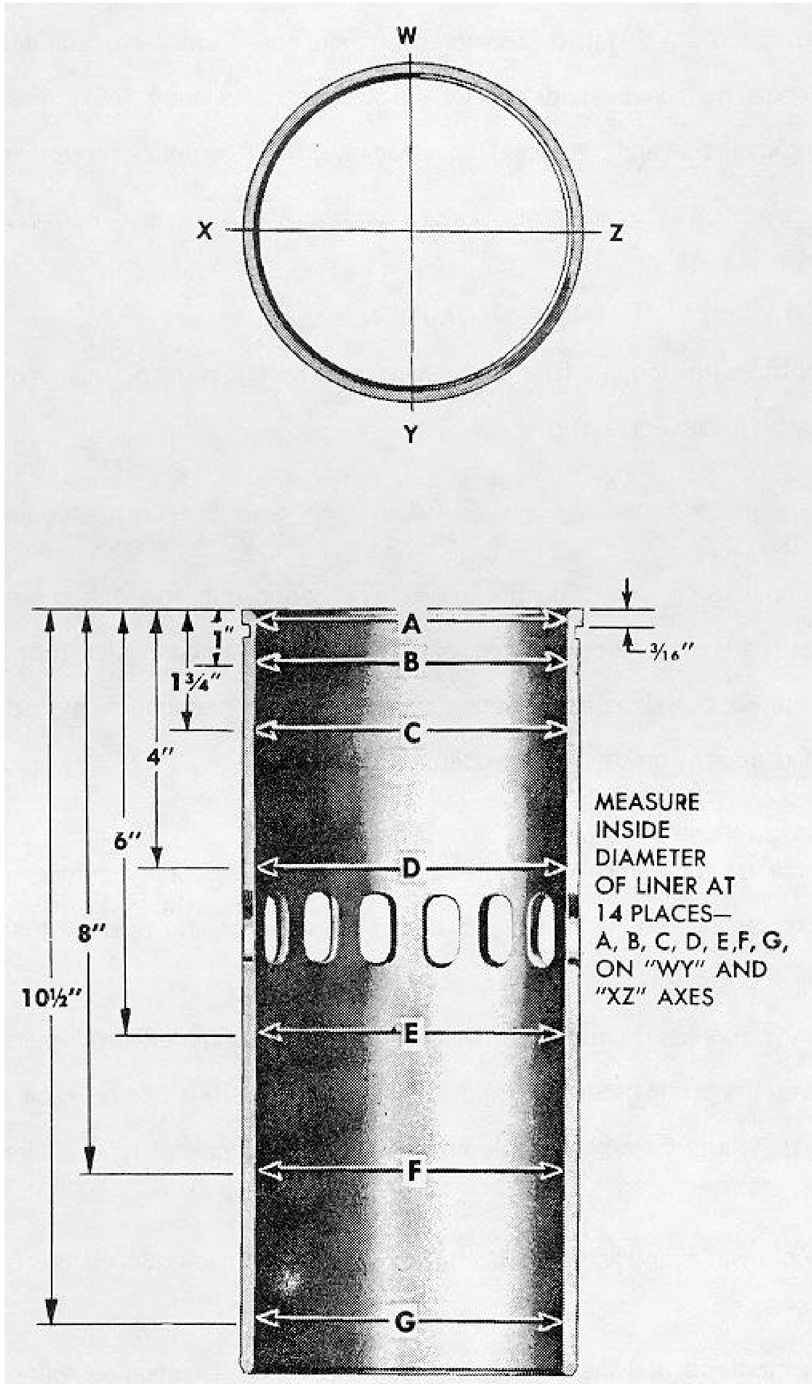


Figure 6-29. Cylinder Liner Dimensional Inspection.

b. Place ring compressor on a wood block, tapered end up.

c. Stagger piston ring gaps and make sure oil control ring expanders are not overlapped (para 6-34).

d. Start top of piston straight into ring compressor; then, push piston down until it contacts wood block.

e. Note position of matchmark made on liner and place liner on a wood block.

f. Place ring compressor and piston and rod assembly on liner, so number on rod and cap are aligned with matchmark on liner.

CAUTION

Do not force piston into liner. Extra care must be taken during this loading operation to prevent ring breakage.

NOTE

The numbers on side of connecting rod and cap identify rod with cap and indicate particular cylinder on which they are used. If a new connecting rod is to be installed, the same identification number must be stamped or etched in same location as on connecting rod that was replaced.

g. Push piston and rod assembly down into liner until piston is out of ring compressor.

h. Remove connecting rod bearing cap and ring compressor and push piston down into liner until compression rings pass liner ports.

i. After piston and connecting rod assembly have been installed in liner, install entire assembly as follows:

(1) Make sure seal ring groove in cylinder block is clean. then install a new seal ring.

(2) Apply a hydrogenated vegetable shortening or a permanent type antifreeze solution to inner surface of seal ring.

(3) If any of pistons and liners are already in engine, use hold-down clamps to retain liners in place when crankshaft is rotated.

(4) Hold piston, rod, and liner in line with block bore so identification number on rod is facing engine serial number side. Also, align matchmarks on liner and block. Slide entire assembly into block bore and seal ring, being careful not to damage seal ring.

(5) Install bearing shells and connecting rod caps as outlined in para 6-38.

(6) Remove liner hold-down clamps.

j. Complete installation of pistons and connecting rods (para 6-34).

k. Remove engine from overhaul stand. Install engine assembly.

Section X. Crankshaft and Main Bearings

6-38 General

a. Crankshaft

(1) Crankshaft one piece of steel forging, heat-treated to ensure strength and durability. All main bearings and connecting rod bearing journal surfaces and oil seal surfaces are induction hardened.

(2) Complete static and dynamic balance of crankshaft is achieved by counterweights incorporated in crankshaft.

(3) Crankshaft thrust is taken through two-piece washers on each side of rear main bearing. Full pressure lubrication to all connecting rod and main bearings is provided by drilled passages within crankshaft and cylinder block.

b. Main Bearings

(1) Engine is equipped with a front and rear main bearing and three intermediate main bearings.

(2) Main bearing shells are precision type and are readily replaceable without machining. Upper main bearing half is seated in cylinder block support and lower bearing half is seated in main bearing cap. Bearing shells are prevented from movement by a tang at parting end of each shell. Each bearing cap is numbered 1, 2, 3, and 4 and when removed, must always be reinstalled in their original position.

(3) Rear main bearing thrust washers absorb crankshaft thrust at each side of rear main bearing. Each washer is made of two halves; lower halves are doweled to bearing cap; upper halves are not doweled.

6-39 Crankshaft and main bearing removal and disassembly

a. Removal

WARNING

Be absolutely sure engine is securely attached to stand before releasing lifting sling. Severe injury to personnel and destruction of engine parts will result if engine breaks away from stand.

(1) Remove engine assembly and install it on a suitable overhaul stand.

(2) Remove cylinder head (para 6-16).

(3) Remove oil pump inlet pipe and screen.

(4) Remove flywheel and flywheel housing.

(5) Remove crankshaft pulley as follows:

(a) Remove special bolt and washer that secure pulley to crankshaft.

(b) Use a suitable two jaw puller and pull pulley off crankshaft.

(c) Remove key from keyway in crankshaft.

(6) Remove front engine support.

(7) Remove engine lower front cover and oil pump assembly.

(8) Remove connecting rod bearing caps.

(9) Remove main bearing caps.

(10) Refer to Figure 6-30 and remove thrust washers from each side of rear main bearing.

(11) Remove pistons and connecting rods. Remove liners if necessary.

(12) Remove crankshaft, including timing gear.

b. Disassembly.

(1) Disassemble remaining components of crankshaft using Figure 6-30 as a reference.

(2) Use a suitable puller to remove oil pump drive gear.

NOTE

Do not remove oil pump drive gear unless it shows excessive wear or damage.

6-40 Crankshaft and main bearing cleaning, inspection and repair

a. Cleaning

WARNING

Wear eye protection when using compressed air.

(1) Remove crankshaft plugs and thoroughly clean oil passages with a stiff wire brush and blow out passages with compressed air.

(2) Wash crankshaft in cleaning solvent and dry with compressed air. Reinstall plugs.

b. Inspection and repair

(1) Support crankshaft on its front and rear journals on V-blocks or in a lathe, and check alignment at adjacent and intermediate journals using a dial indicator.

(2) Refer to Table 1-1 for maximum allowable wear limits. If runo0t limits are greater than that given in Table 1-1, replace crankshaft.

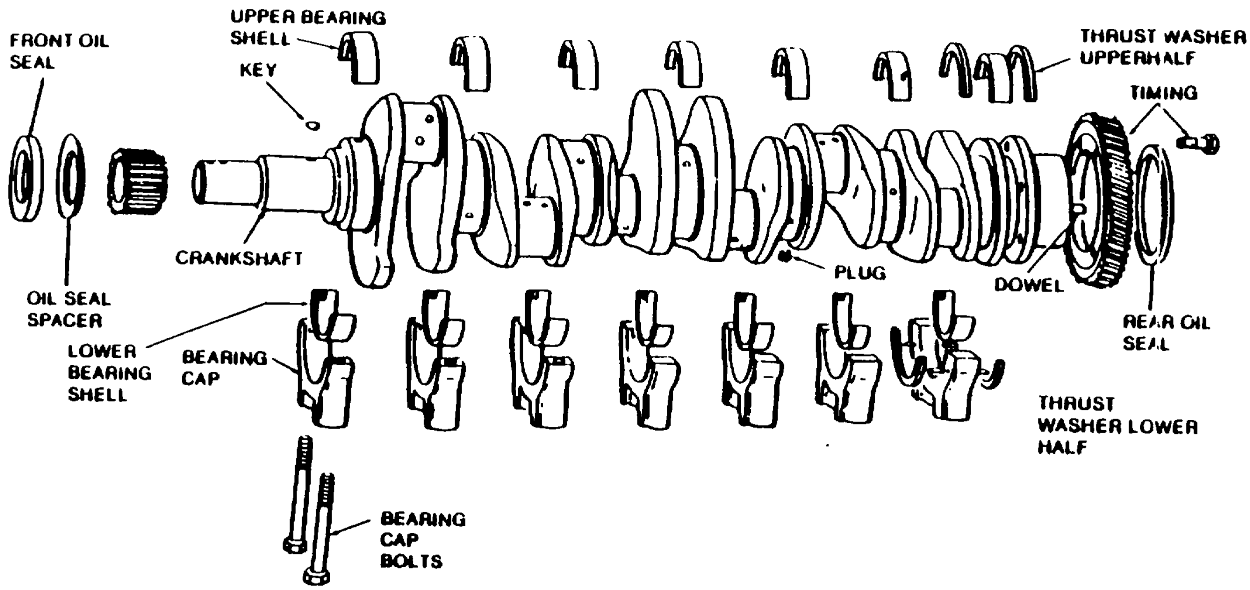


Figure 6-30. Crankshaft Assembly.

(3) Refer to Table 1-1 and measure all connecting rod journals at several different places on circumference in order to determine smallest diameter.

NOTE

If runout is out of limits on main or connecting rod journals, replace crankshaft.

(4) Used crankshafts sometimes show a certain amount of ridging caused by a groove in upper main bearing shell. Remove ridges before new bearing shells are installed. Slight ridges may be cleaned up with 120 grit emery cloth, followed by 240 grit emery cloth. Rotate crankshaft at intervals to avoid polishing in flat spots. Finally, polish surface with a fine crocus cloth with fuel oil. If grooves cannot be removed in this manner, crankshaft must be reground or replaced.

(5) Inspect surface of crankshaft for evidence of cracks. To be effective, this inspection should be performed using magnetic particle, fluorescent dye penetrant or a similar inspection technique. Demagnetize crankshaft following use of magnetic particle inspections. Inspection must be performed if engine has experienced catastrophic failure such as piston or connecting rod failure. Inspection should also be performed in course of engine overhaul. Replace a crankshaft that is cracked.

(6) Inspect crankshaft for excessive binding or twisting. Certain areas are critical and sustain most of load. These areas are indicated by arrows in Figure 6-31.

(7) Inspect crankshafts for circumferential fillet cracks. Check all fillets for smoothness. Journal fillets should have a 0. 130 to 0. 160 inch radius.

(8) Inspect crankshaft keyway for evidence of cracks or worn condition.

(9) Inspect crankshaft in area at front and rear oil seal contact surfaces for evidence of roughness or grooving. Slight ridges of more than 0. 0002 inch must be removed. Use crocus cloth, dampened with fuel oil. Ridges of more than .0005 inch must be removed with 120 grit emery cloth and finished with 240 grit emery cloth followed by wet crocus cloth.

(10) Excessive wear or grooving on front and rear crankshaft oil seal area may require use of an oil seal sleeve. This sleeve can be pressed on crankshaft. This sleeve provides a replaceable wear surface for lip type oil seal. However, an oversize oil seal must be used with this sleeve.

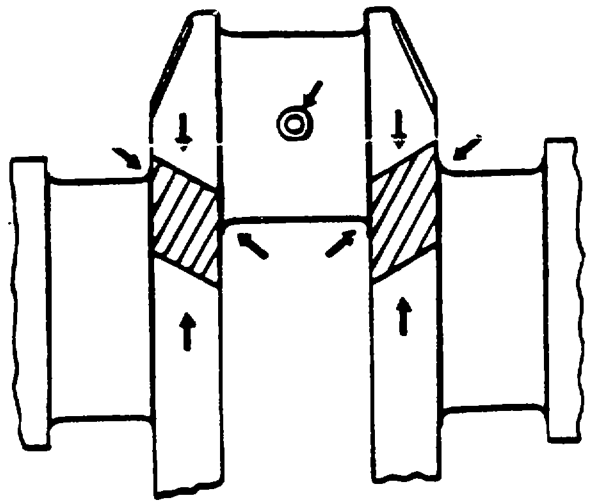


Figure 6-31. Crankshaft Critical Loading Zones.

(11) Install rear oil seal sleeve as follows:

(a) Stone high spots from oil seal contact surface of crankshaft.

(b) Coat area of shaft, where sleeve will be positioned, with shellac or an equivalent sealant.

(c) Press sleeve squarely on shaft with crankshaft oil seal installation tool.

(d) Wipe off all excess sealant.

(12) Inspect oil pump drive gear and crankshaft timing gear for worn or chipped teeth.

(13) Refer to Table 1-1 for dimensions and measure the main bearing inserts for excessive wear. Visually inspect bearings for wear to determine if used bearings are satisfactory for further service. Lower main bearings, which carry load will normally show signs of distress before upper shells do.

(14) Refer to Table 1-1 for dimensions and measure thickness of bearing shell 90° from the parting line, using a micrometer with a ball attachment.

6-41 Crankshaft and main bearing reassembly and installation

a. Reassembly

(1) Install oil pump gear on the crankshaft if it was removed.

(2) Install Woodruff key in keyway on crankshaft.

(3) Install timing gear on crankshaft (with timing marks facing out).

(4) Install six bolts and lockwashers. Start screws through gear into crankshaft. Then draw gear up tight against shoulder on crankshaft. Tighten bolts to 35-49 lb ft torque.

b. Installation

(1) Install upper grooved bearing shells in cylinder block.

(2) Apply clean engine oil to crankshaft journals. Attach a rope or strap sling to a suitable hoist and lower crankshaft into position. Make sure timing marks on crankshaft gear match idler gear timing marks.

(3) Check backlash with mating gear. Backlash must be . 003 to . 008 inch and a maximum of . 007 inch on used gears.

(4) Install upper bearing thrust washer halves on each side of rear bearing shell. Install lower doweled thrust washer halves in each side of rear main bearing cap.

(5) Install lower shells in caps. Install caps in their original position on crankshaft. Lubricate the cap bolt threads and head contact areas with a suitable compound before installation. Draw bolt up snug. Then, tap bearing caps lightly with a soft hammer to seat properly. Tighten cap bolts, starting with the center bolts and working alternately towards both ends of block.

(6) Rotate crankshaft to make sure it rotates freely.

(7) Check crankshaft end play as illustrated in Figure 6-32. Move crankshaft toward gage and keep constant pressure on tool. Set dial indicator to zero. Then, remove and insert screwdriver on other side of bearing cap. Force screwdriver in opposite direction and note amount of end play on dial. The clearance must be 0. 004 to 0. 011 inch with new parts and a maximum of 0. 018 inch with used parts.

(8) Install pistons and connecting rods (para 6-34).

(9) Install crankshaft from cover and pulley in reverse of disassembly sequence.

(10) Install flywheel housing.

(11) Install oil pump inlet assembly and pan (para 6-21).

(12) Install cylinder head (para 6-17).

(13) Install engine assembly.

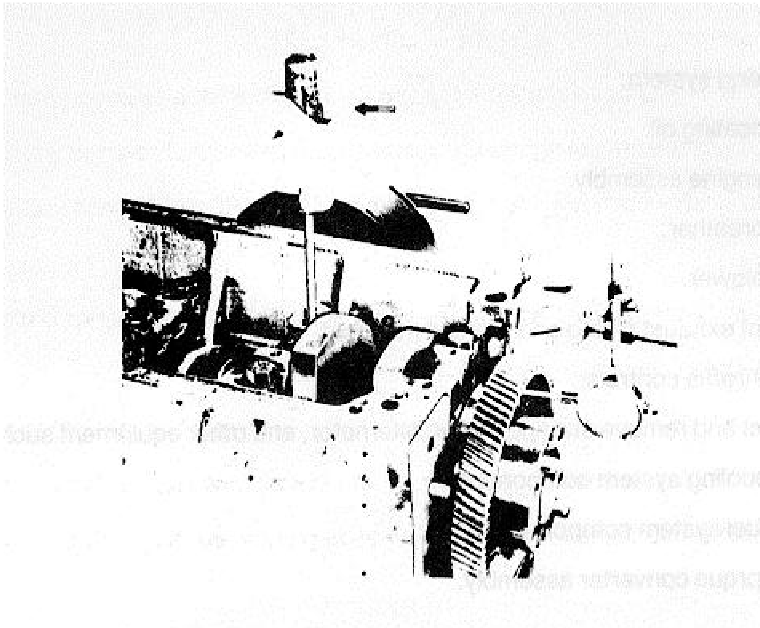


Figure 6-32. Crankshaft End Play.

Section XI. Cylinder Block and Engine End Plates

6-42 General

a. Cylinder block

(1) Cylinder block Is a one piece casting which forms main structural part of engine. Transverse webs provide rigidity and strength and ensure alignment of block bores and bearings under load.

(2) Block Is bored to receive replaceable wet-type cylinder liners. A water jacket surround upper half of each cylinder liner. Water Jacket and air boxes are sealed off by a seal ring compressed between liner and a groove In block.

(3) Camshaft and balance shaft bores are located on opposite sides, near top of engine block.

(4) Upper half of main bearing supports are cast Integral with block. Drilled passages in block carry lubricating oil to all moving parts in engine.

b. Endplate. A flat steel plate Is bolted to rear ends of cylinder block to provide a means for attaching flywheel housing, timing gears and balance weight covers.

6-43 Cylinder block and end plates removal and disassembly

a. Removal

(1) Drain cooling system.

(2) Drain lubricating oil.

(3) Remove engine assembly.

(4) Remove breather.

(5) Remove blower.

(6) Disconnect exhaust piping and remove manifold.

(7) Remove throttle controls.

(8) Disconnect and remove starting motor, alternator, and other equipment such as air compressor.

(9) Remove cooling system components.

(10) Remove fuel system components.

(11) Remove torque converter assembly.

b. Disassembly

WARNING

Be sure the engine is securely mounted to the overhaul stand. Severe injury to personnel and destruction of engine parts will result if the engine breaks away from the stand.

(1) Lift engine using a suitable hoist and place on an overhaul stand using an adaptor plate.

(2) Align bolt holes in adapter plate with those in cylinder block. Then install 3/18 inch-16 and 5/16 inch-1i 8 bolts with a flatwasher under head of each bolt and tighten securely.

(3) Remove all remaining subassemblies and parts from the cylinder block.

6-44 Cylinder block and endplates, cleaning, inspection and repair

a. Cleaning

(1) Refer to Figure 6-32 and remove all plugs and scrape all old gasket material from the block.

CAUTION

Wear safety goggles when using compressed air or serious eye injury can occur.

(2) Steam clean entire block and dry thoroughly with compressed air.

(3) Make sure all oil galleries, and air box drain openings are open and thoroughly cleaned.

b Inspection and repair

(1) Check top of the block for flatness with an accurate straight edge and a feeler gage. Top surface must not vary more than 0. 003 inch transversely and not over 0. 007 inch longitudinally.

(2) Make sure liner seal ring grooves are clean. Then, inspect ring grooves and lands for evidence of pitting and erosion. If grooves are eroded to extent that sealing is affected, block must be replaced.

(3) Check main bearing bores as follows:

(a) Reinstall main bearing caps in their original position. Lubricate bolt threads and underside of each bolt head with engine oil and tighten bolts to high side of torque specified in Table 1-1.

CAUTION

It is imperative that main bearing caps are reinstalled in their original position to maintain bearing bore alignment.

(b) Measure main bearing bores. Bearing bores must be 3. 251 to 3. 252 inches. If bores do not fall within these limits, replace block.

(c) Check bearing bores for alignment. Bearing bores are aligned with one another if a crankshaft with standard size journals can be rotated freely by hand, after new standard size main bearing shells have been installed and lubricated as in step (a) above.

(4) Pressure test cylinder block.

(a) Make a 1/2 inch thick steel plate to seal top surface of cylinder block.

(b) Make sure seal ring grooves in cylinder bores are clean, then install new rings in grooves (para 6-17).

(c) Apply a light coating of hydrogenated vegetable shortening or permanent anti-freeze to seal rings.

(d) Install cylinder liners (para 6-37).

(e) Install new compression gaskets, and water hole seal rings.

(f) Secure steel plate with 5/8 inch-i 1 bolts and flat washers.

(g) Install water hole cover plates and gaskets on side of block.

NOTE

One cover plate should be drilled and tapped for an air line connection.

(h) Immerse cylinder block for 20 minutes in a tank of water heated to 180-200°F.

(i) Attach an air line to water hole cover plate and apply 40 psi air pressure. Observe water for bubbles which indicate cracks or leaks. Replace a cracked cylinder block.

(j) Remove block from water tank. Remove plates, seals and gaskets.

(k) Remove cylinder liners from block. Dry them with compressed air and coat them with oil to prevent rust.

(5) Make sure all cylinder liner counterbores in block are clean and free from dirt. Then, refer to Table 1-1 and measure counterbores. Counterbored surfaces must be smooth and square with cylinder bore within 0. 001 inch total indicator reading.

(6) Inspect all machined surfaces and threaded holes in block for damaged threads. Remove nicks and burrs from machined surfaces with a fine stone. Clean up damaged threads in tapped holes with a tap or install threaded inserts.

(7) Replace loose or damaged dowels.

(8) Check surface of rear endplate for nicks, dents, scratches or score marks. Remove all nicks, dents or scratches with a fine stone.

(9) Check endplate for flatness.

(10) Replace all defective parts.

(11) Discard and replace all gaskets and seals.

6-45 Cylinder block and endplates reassembly and installation

a. Reassembly

(1) Apply thin coat of non-hardening gasket cement to both sides of endplate gaskets (Figure 6-33).

(2), Use a good grade of sealing compound on threads of all plugs before installation.

(3) Install gaskets and plugs.

(4) Install all interior sub-assemblies.

(5) Install endplates.

(6) Remove engine from overhaul stand with suitable hoist.

b. Installation

(1) Install torque converter assembly.

(2) Install cooling system.

(3) Install electrical system, starting motor, air compressor, etc.

(4) Install throttle controls and exhaust system.

(5) Install blower.

(6) Install air cleaner.

(7) Recharge cooling system and lubricating system.

(8) Install engine assembly.

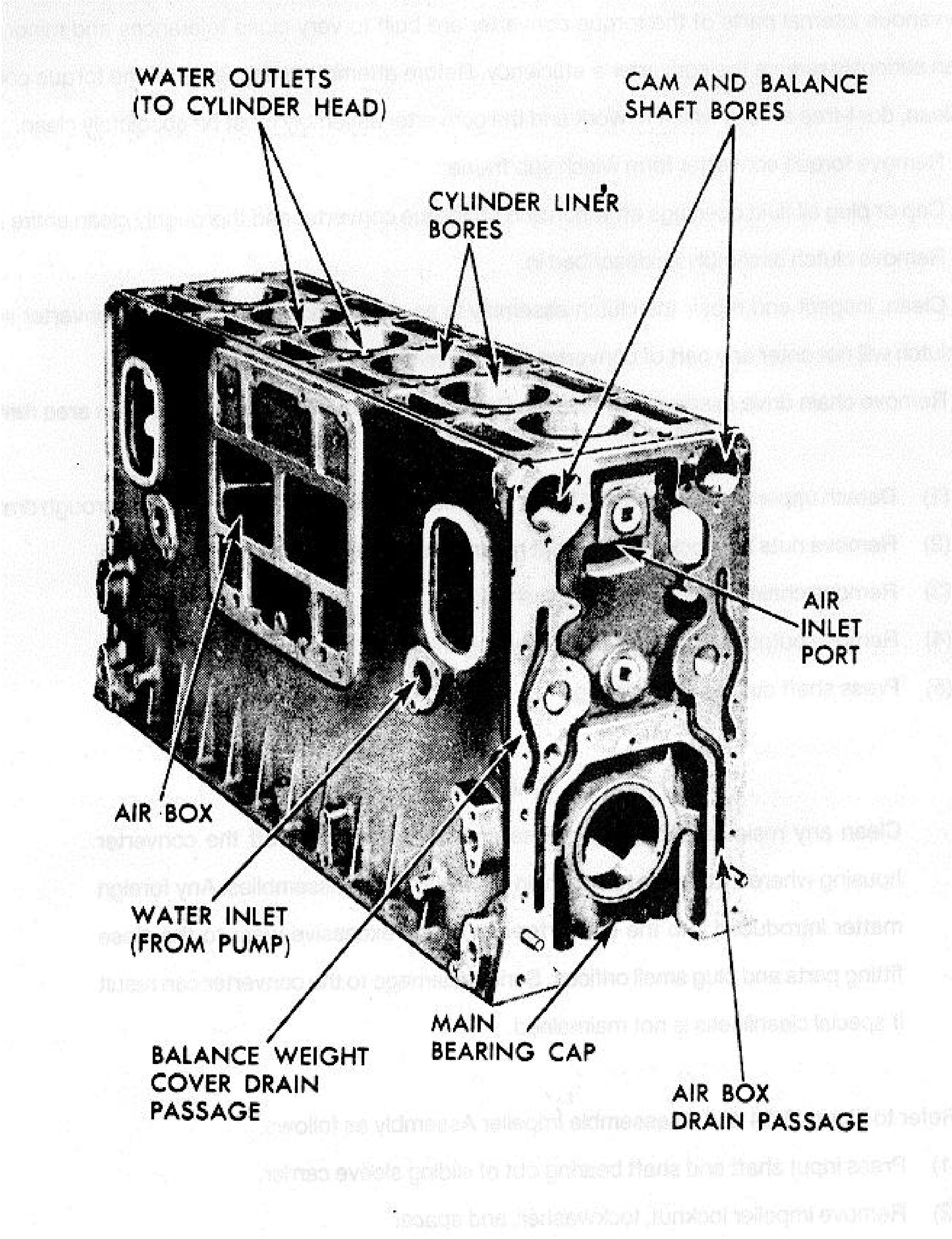


Figure 6-33. Cylinder Block and End Plates.

Section XII. Torque Converter Disassembly, Inspection and Repair

6-4 Torque converter disassembly

a. General. The torque converter is a highly reliable and relatively simple power transmission device. However, the various internal parts of the torque converter are built to very close tolerances and minor damage to these parts can seriously reduce the converter's efficiency. Before attempting any repair of the torque converter you must have a clean, dust-free area in which to work and the converter assembly must be absolutely clean.

b. Remove torque converter form winch sub frame.

c. Cap or plug all fluid openings on winch and on torque converter and thoroughly clean entire assembly.

d. Remove clutch assembly as described in.

e. Clean, inspect and repair the clutch assembly in an area removed from torque converter so that soot and dirt from clutch will not enter any part of converter during maintenance.

f. Remove chain drive assembly as follows: Perform any required maintenance in an area removed from the converter.

(1) Detach upper grease hose and lower rear seal drain line at ends which pass through drain housing.

(2) Remove nuts and lockwashers that retain chain housing to converter housing.

(3) Remove chain housing with output shaft.

(4) Remove output shaft by removing bearing retainer, shaft lock nut and washer.

(5) Press shaft out of shaft bearing.

CAUTION

Clean any residual soot, dirt, grease and foreign material off the converter housing where it attaches to the chain drive and clutch assemblies. Any foreign matter introduced into the converter can cause excessive wear to the close fitting parts and plug small orifices. Serious damage to the converter can result if special cleanliness is not maintained.

g. Refer to Figure 6-34 and disassemble Impeller Assembly as follows:

(1) Press input shaft and shaft bearing out of sliding sleeve carrier.

(2) Remove impeller locknut, lockwasher, and spacer.

(3) Press impeller out of impeller bearing

(4) Remove six socket head capscrews retaining seal carrier to endplate and remove seal assembly.

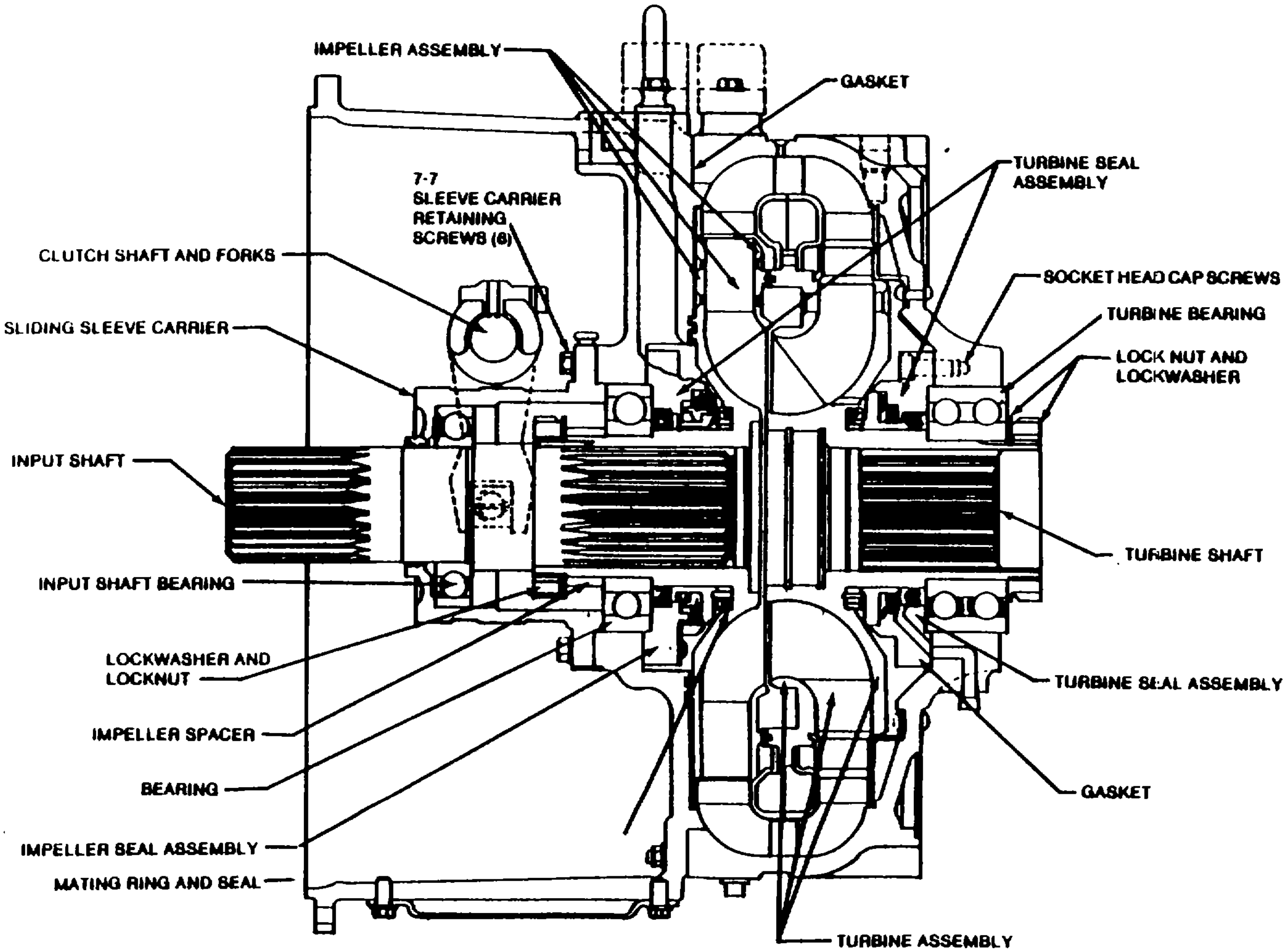


Figure 6-34. Torque Converter Assembly.

h. Remove turbine wheel from converter housing as follows:

(1) Remove turbine wheel bearing retainer and remove turbine wheel lock nut and lock washer.

(2) Press turbine wheel and shaft out of converter housing through turbine wheel bearing.

(3) Remove six socket head capscrews retaining seal carrier (Figure 6-35) to converter housing and remove seal assembly. Seal carrier may be removed from converter housing by tapping on the opposite side of turbine wheel bearing outer race.

(4) Remove turbine wheel bearing.

NOTE

If converter is being disassembled for reasons other than seal repair, and it is intended to reassemble converter using same seal assemblies and carbon mating rings, extreme care must be taken to keep sealing surfaces of steel nose piece and carbon mating ring free from all dirt and scratches.

i. Refer to Figure 6-35 and disassemble fluid seal assemblies as follows:

(1) Remove two screws and clips retaining steel nose piece to seal carrier and remove nose piece.

(2) Remove eight coil springs and retaining washer and rubber element with garter spring.

(3) Remove lip-type grease and oil seal.

CAUTION

If seals or carbon rings show excessive wear or have been damaged during disassembly replace during reassembly. Close tolerances of converter require near perfect sealing surfaces.

(4) Remove carbon mating rings and rubber washers from pump and turbine wheels.

6-47 Torque converter inspection

a. Wash all parts in a suitable cleaning solvent and dry thoroughly.

b. Carefully inspect all parts for excessive wear, scoring and other damage.

c. Using 400 grit or finer emery cloth soaked in diesel fuel carefully polish out all minor nicks and burrs in the impeller wheel and turbine wheel.

d. Inspect male and female splines on impeller disk, turbine disk and output shaft for chipped splines and excess wear.

e. Replace defective parts.

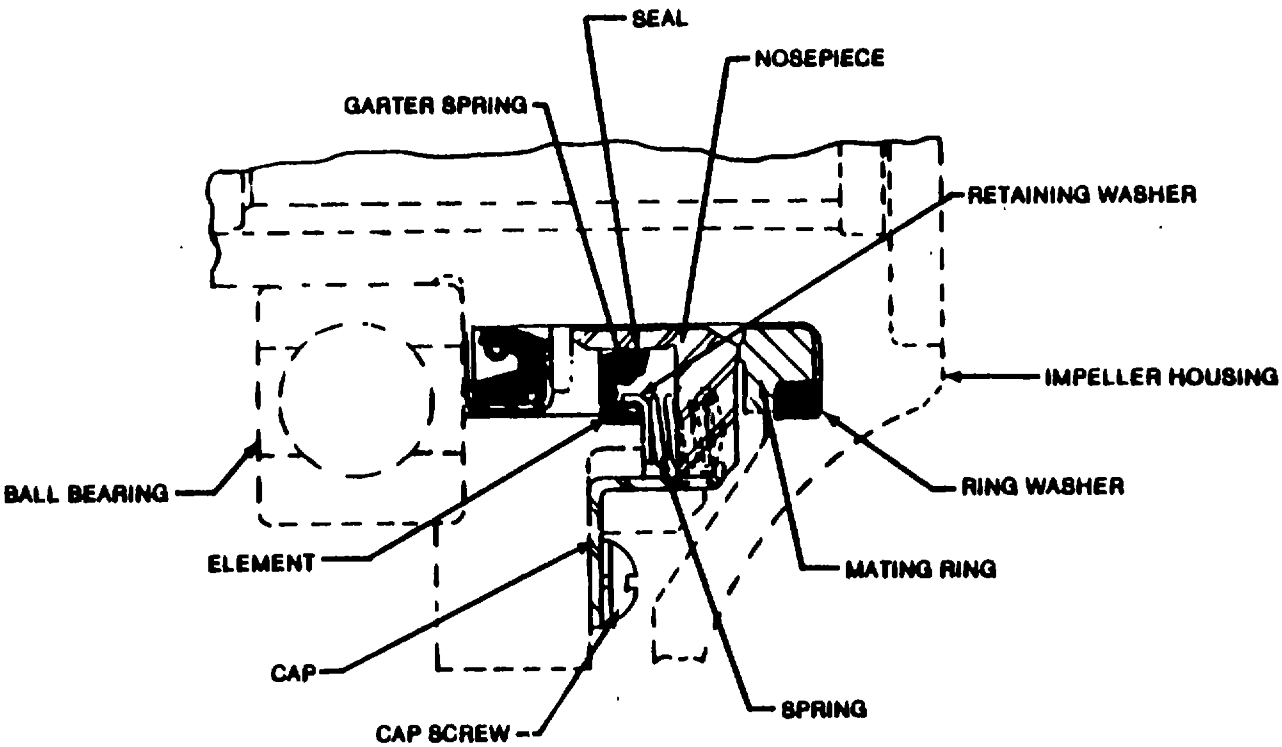


Figure 6-35. Seal Carrier Assembly.

6-48 Torque converter reassembly

a. General. Reassembly of torque converter requires a clean, dust free location. Insure that work bench and all converter parts are thoroughly clean and dry. During reassembly some parts will be soaked or coated with diesel fuel (torque converter fluid); DO NOT use more fluid than required and wipe up any spills.

CAUTION

Do not attempt to repair parts in work area where you are assembling torque converter. Sanding or polishing nicks and burrs will leave fine metal dust and grit in work area which will require recleaning all parts and work area. Small amounts of this type of foreign material can seriously damage converter.

b. During reassembly reinspect each part for burrs, nicks or similar damage. Refer to paragraph 6-35 for repair or replacement of damaged parts.

c. Refer to Figure 6-35 and assembly fluid seal assemblies as follows:

NOTE

During this assembly, be sure rubber elements and washers are properly seated. Apply a film of motor oil to sealing surfaces of steel nose piece and carbon mating ring for lubrication and protection during reassembly of converter.

(1) Start at drive end and install lip type oil seal in its bore on bearing side of seal carrier. Lip of this seal will face bearing.

(2) Lay seal carrier on a clean surface, oil seal side down.

(3) Place garter spring in rubber element and install rubber element in its bore in seal carrier, garter spring side up. Lubricate this side of rubber element with clean oil.

(4) Install retaining washer, or spring carrier, shoulder side down in mating bore of rubber element.

(5) Fill spring counterbores in nose piece with grease. Place compression springs in grease filled counterbores. Lubricate the skirt of nose piece into lip of rubber element. Line up clip slots in nose piece with clip slots in seal carrier.

(6) Invert nose piece and install it in seal carrier. Exercise care in entering skirt of nose piece into lip of rubber element. Line up clip slots in nose piece with clip slots in seal carrier.

(7) Compress nose piece to carrier and install two clips and screws retaining nose piece to seal carrier. Check for free movement of steel nose piece.

(8) Place a new gasket with seal assembly and bolt the assembly to housing with socket head capscrews.

NOTE

Soak this gasket briefly in clean converter fluid before installing. Make sure holes line up properly with grease and seal drain passages.

(9) Place rubber carbon mating ring washer on carbon mating ring. Flat side of washer bears against shoulder of mating ring.

(10) Lubricate bore of pump wheel or turbine wheel, which will receive carbon mating ring and washer, with a film of clean oil. Hand press mating ring and washer in this bore. Make sure they are properly seated.

(11) Make sure the sealing surfaces of nose piece and mating ring are clean and smooth. Lubricate sealing surfaces with clean oil.

CAUTION

Extreme care must be exercised in assembly to make certain that the lapped surfaces of the carbon mating ring and steel nose piece are free from all particles of dust or grit as this will result in scratches on the lapped surfaces and cause fluid leakage. These surfaces are originally lapped smooth within twelve millionths of an inch.

d. Install turbine wheel and output shaft in housing as follows:

(1) Place seal gasket in converter housing and install the seal assembly. Soak this gasket briefly in clean converter fluid before installing. Be sure holes line up properly with seal drain passage in seal carrier and turbine housing.

(2) Install turbine wheel bearing. Hand pack turbine wheel bearing with grease before installing.

(3) Check for proper position of carbon mating ring and washer in turbine wheel.

(4) Press turbine wheel and shaft into converter housing through turbine wheel bearing.

(5) Install turbine wheel lockwasher and locknut. Tighten locknut securely and lock in place.

(6) Install bearing retainer gasket and install bearing retainer.

(7) Install output assembly with output shaft as follows:

(a) Press shaft into shaft bearing.

(b) Install chain housing complete with output shaft.

(c) Install lockwashers and nuts that mate chain housing and converter housing.

(d) Reinstall upper grease hose and lower rear seal drain line at ends which pass through chain housing.

(8) Install a new corprene ring gasket on pilot flange to converter housing.

e. Install impeller and input shaft in clutch housing as follows:

(1) Install impeller bearing in clutch housing.

(2) Refer to Figure 6-35 and build up impeller seal assembly in same manner as turbine seal assembly.

(3) Place seal gasket in end plate and install seal assembly. Soak this gasket briefly in clean converter fluid (diesel fuel) before installing. Be sure holes line up properly with seal drain passage in seal carrier and end plate.

(4) Check for proper position of carbon mating ring and washer in impeller.

(5) Press impeller into clutch housing through impeller bearing. Install impeller spacer, lockwasher and locknut. Tighten locknut securely and lock in place.

(6) Install input shaft bearing in sliding sleeve carrier.

(7) Press input shaft into input shaft bearing.

(8) Install carrier gasket and install sliding sleeve carrier with input shaft.

f. Assemble clutch housing to converter housing as follows:

(1) Place converter housing on firm blocking, open end up.

(2) Install corprene ring gasket on converter housing pilot flange of clutch housing.

(3) Install clutch housing.

(4) Install 24 lockwashers and nuts.

(5) Add a small amount of grease to operating shaft needle bearings.

(6) Install operating shaft and throwout fork. Install fork to shaft lockwashers and two fork retaining bolts and lockwashers.

NOTE

Be sure to install fork retaining bolts from rear, that is, with bolt heads on converter side of the fork.

(7) Check all drain plugs and fittings to be sure they are tight.

g. Install torque converter to engine as in paragraph 6-36.

h. Service torque converter with clean filtered converter fluid (diesel fuel).

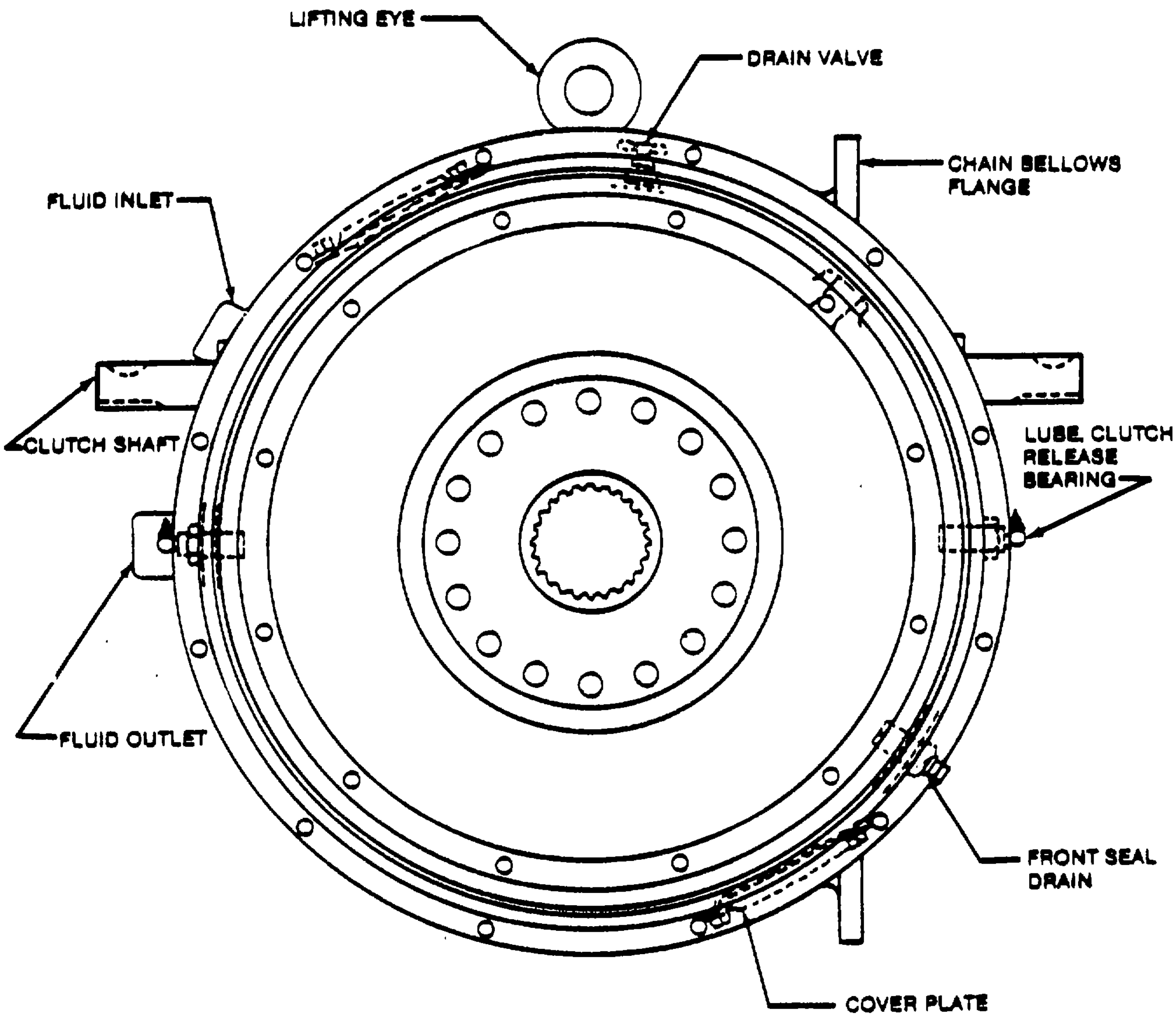


Figure 6-36. Fluid Line Installation.

Section XIII. Winch Frame

6-49 General

a. The Connaco 40,000 lb 2-drum Waterfall Winch is a heavy-duty unit designed for such tasks as anchor handling and specialized pulling/hoisting operations. The frame components are steel weldments, to transfer the pulling stresses of up to nearly 20 tons to the ground anchor points without misalignment of the frame or hoisting mechanisms.

b. The machinery bed is a rigid steel weldment with machined surfaces for bolt-on steel pillow blocks. The bed, or winch frame, also provides convenient locations for mounting the control mechanisms, piping, and auxiliary equipment such as the air and hydraulic fluid storage tanks.

c. The pillow blocks are held in alignment on their machined surfaces by large body fit alloy steel bolts designed to take the tension and shear loadings imposed.

d. The fixed end of each brake band is connected to the hoist bed through a 1 1/4 inch pivot pin, held by a pair of heavy padeyes welded to the winch bed.

e. The drum dog pivot pins transfer the drum moment load to the bed when engaged. They are mounted in heavy padeyes welded to a heavy footplate, which in turn is welded to the winch bed.

f. The winch frame, as a whole, is bolted to fabricated skids for shipping and as a ground mounting when anchored in place ready to operate.

6-50 Winch frame disassembly, inspection and repair

a. Disassembly. The winch frame is normally not disassembled. Components such as pillow blocks are unbolted only when replacement or shop repair is needed.

b. Inspection. Make the periodic inspections with the winch frame fully assembled. Check for corrosion protection integrity, and for obvious frame member distortion such as might be caused by overloads, misaligned loads, or improper use of tractor to move/align the unit.

c. Repair. Repairs to winch frame components will normally be required only for broken or distorted members. Repair procedures consist of straightening using hydraulic presses, and of heavy structural cutting and welding. Realignment and re-machining of bolting pads may be required.

6-51 Winch frame reassembly. Reassembly is in the reverse order of disassembly.

Section XIV. Air System

6-52 General. Operation of the winch is controlled by air pressure. The air pressure is applied to the various drum clutches, brakes and dogs as directed by the operator at a control console. It is supplied at 6 cfm or more from an engine-mounted compressor. The compressor keeps the air reservoir at a pressure of 105 to 125 psi. Filtered air is then supplied to the control stand, and from there directed to the hoist air terminal. The various operating elements receive controlled air from the air terminal via flexible hoses. System air pressure is required to release the drum parking brakes, set the drum dogs, engage the drum clutches, and set the drum service brakes.

6-53 Air compressor

a. Type and Mounting. The air compressor is bolted with five bolts to the engine flywheel cover at the right rear. It is driven at camshaft speed by an accessory drive bolted to the balance shaft gear (Figure 6-37). It receives its lubricating oil and cooling water through hoses from the engine.

b. Operation

(1) The air compressor runs continuously while the engine is running. While the compressor is running, actual compression of air is controlled by the compressor governor which acts in conjunction with the unloading mechanism in the compressor cylinder block. The governor starts and stops the compression of air by loading or unloading the compressor when the air pressure in the system reaches the desired minimum or maximum pressure.

(2) During the downstroke of each piston, a partial vacuum is created above the piston which unseats the inlet valve and then allows air drawn from the air box in the engine cylinder block or through an intake strainer to enter the cylinder above the piston. As the piston starts the upward stroke, the air pressure on top of the inlet valves, plus the inlet valve return spring force, closes the inlet valve. The air above the piston is further compressed until the pressure lifts the discharge valve and the compressed air is discharged through the discharge line into the reservoir.

(3) As each piston starts its downstroke, the discharge valve above it returns to its seat, preventing the compressed air from returning to the cylinder, and the same cycle is repeated.

(4) When the air pressure in the reservoir reaches the maximum setting of the governor, compressed air from the reservoir passes through the governor into the cavity below the unloading pistons in the compressor cylinder block. The air pressure lifts the unloading pistons, which in turn lifts the inlet valves off their seats.

(5) With the inlet valves held off their seats, the air during each upstroke of the piston is merely passed back through the air inlet cavity and to the other cylinder where the piston is on the downstroke. When the air pressure in the reservoir drops to the minimum setting of the governor, the governor releases the air pressure beneath the unloading pistons. The unloading piston return spring then forces the piston down and the inlet valve springs return the inlet valves to their seats and compression is resumed.

c. Maintenance. The accessory drive should be inspected for tooth wear and bolt tightness whenever abnormal noise or other sign of malfunction is noticed. The same items should be checked whenever the flywheel cover is removed for any reason. Repair the compressor itself, if necessary, by replacement of the unit.

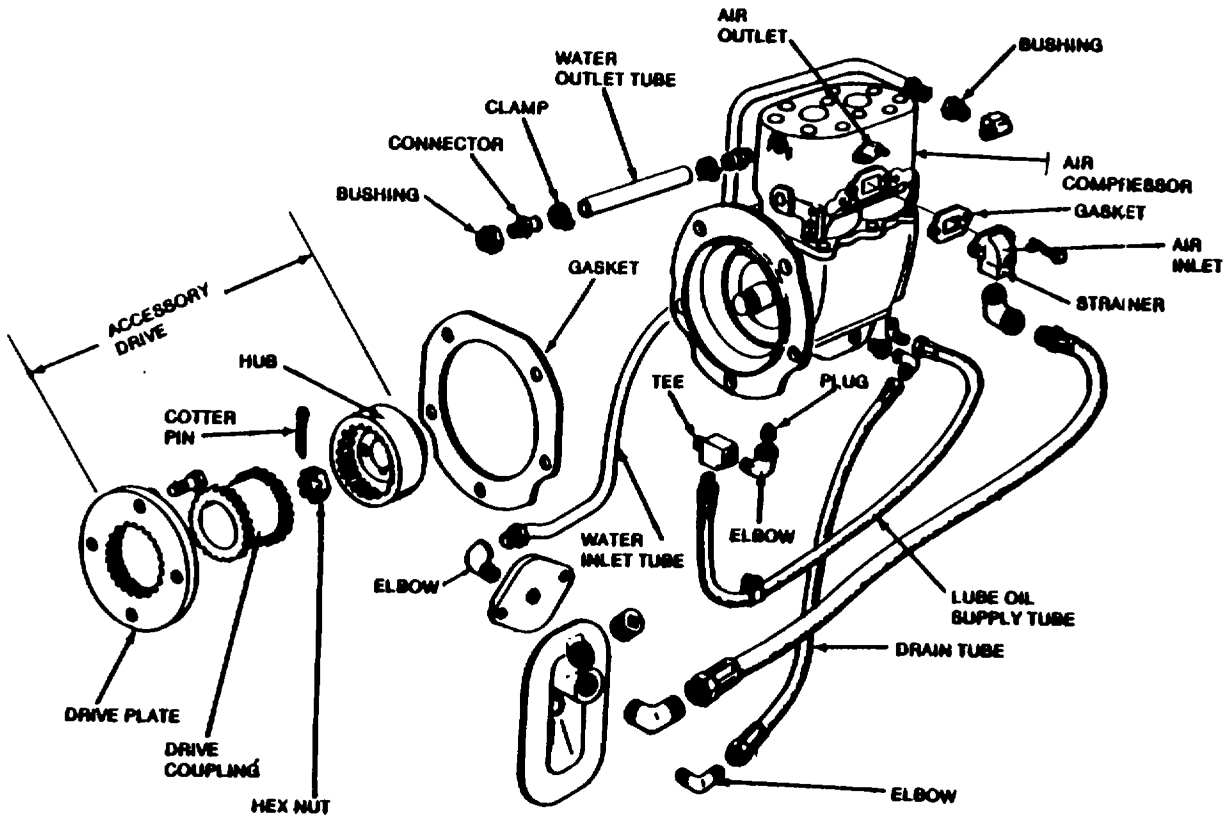


Figure 6-37. Air Compressor Disassembly and Reassembly.

6-54 Air distribution

a. Compression and Storage. Figure 6-38 shows the items needed to receive the compressed air from the compressor, control the pressure, store the air and ensure delivery of clean, dry air to the control console.

b. System Elements

(1) Air from the compressor is carried by 5/8 inch Teflon hose and suitable fittings, through a check valve to the air reservoir.

(2) Pressure-sensing air is transmitted from a fitting at the top of the air reservoir through 1/4-inch "push-on" hose to the "reservoir" port of the compressor governor.

(3) Control air passes from the reservoir through an air line filter to remove any entrained dirt or moisture to the control console.

(4) Clean, dry control air is received at the control console manifold. The winch operating valves and throttle control then direct control air through the hoist air terminal and from there through 5/8 inch pneumatic hoses to:

(a) the air/hydraulic actuator assemblies for drum clutch no. 1, drum clutch no. 2, or both;

(b) the service brake actuator assemblies at drum no. 1 brake, drum no. 2 brake, or both;

(c) the parking brake release inlet at the brake actuators for drum no. 1 brake, drum no. 2 brake, or both;

(d) the drum dog set actuator at drum no. 1, drum no. 2, or both;

(e) (through 3/8-inch black Nylo-Seal tubing to) the throttle slave cylinder at the engine.

6-55 Controls. All winch operating controls with the engine throttle are grouped at the winch operating console is mounted on a bracket bolted to the winch frame on the right side (the side opposite to the chain case). The winch control valves described above are so mounted in the console that the operating handles for each are convenient to the operator (Figure 6-39). An air pressure gage is mounted at each drum brake operating handle, and a manifold air pressure gage is mounted at the top right of the console. An engine speed indicator (tachometer) is mounted by the throttle control handle on the console.

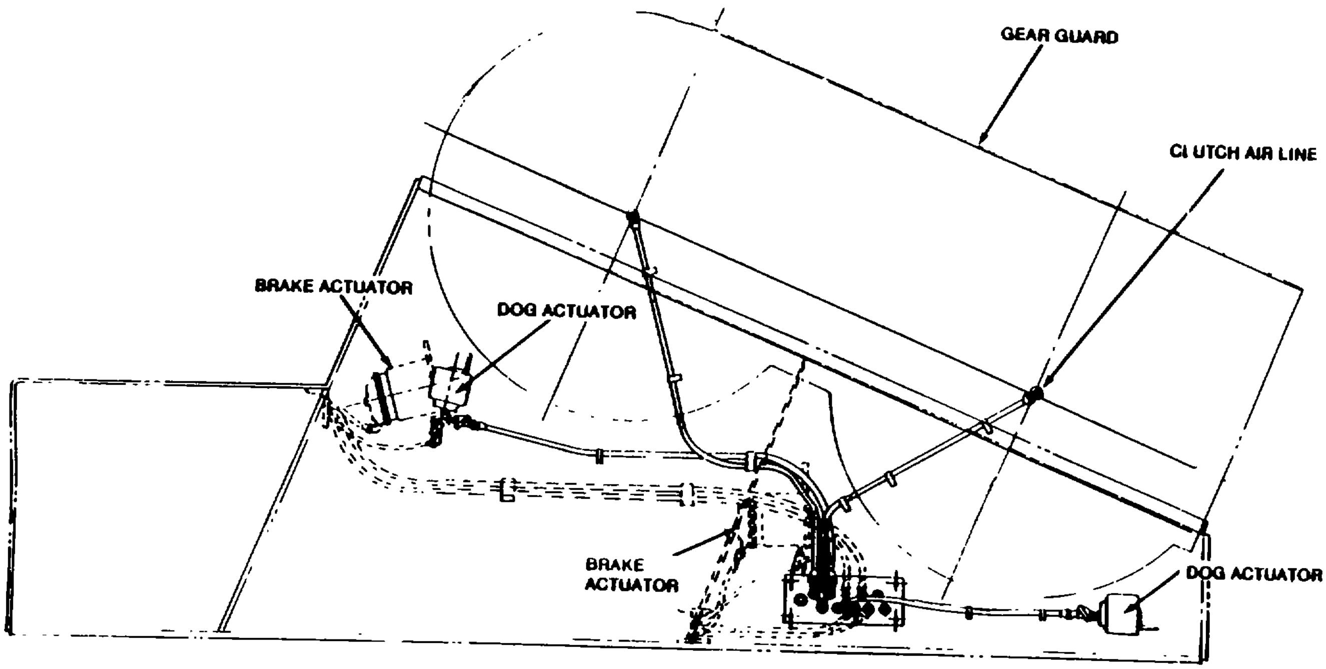


Figure 6-38. Air Distribution Compression and Storage.

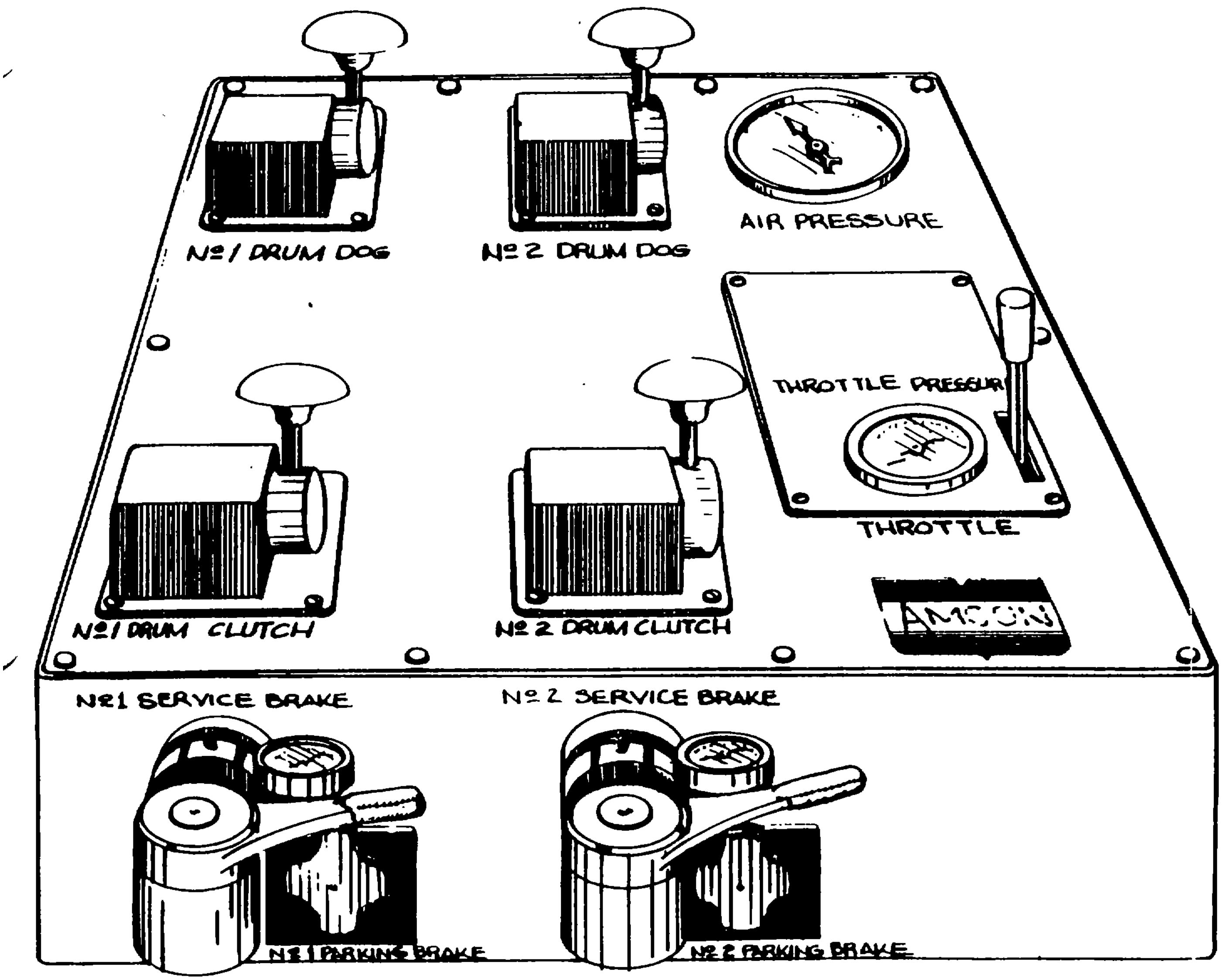


Figure 6-39. Winch Control Panel.

By Order of the Secretary of the Army:

CARL E. VUONO
General, United States Army
Chief of Staff

Official:

PATRICIA P. HICKERSON
Colonel, United States Army
The Adjutant General

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THE METRIC SYSTEM AND EQUIVALENTS

Linear Measure

1 centimeter = 10 millimeters = .39 inch
1 decimeter = 10 centimeters = 3.94 inches
1 meter = 10 decimeters = 39.37 inches
1 dekameter = 10 meters = 32.8 feet
1 hectometer = 10 dekameters = 328.08 feet
1 kilometer = 10 hectometers = 3.2808.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
1 decigram = 10 centigrams = 1.54 grains
1 gram = 10 decigram = .035 ounce
1 dekagram = 10 grams = .35 ounce
1 hectogram = 10 dekagrams = 3.52 ounces
1 kilogram = 10 hectograms = 2.2 pounds
1 quintal = 100 kilograms = 220.46 pounds
1 metric ton = 10 quintals = 1.1 short tons

Cubic Measure

1 cu. centimeter = 1000 cu. millimeters = .06 cu. inch
1 cu. decimeter = 1000 cu. centimeters = 61.02 cu in.
1 cu. meter = 1000 cu. decimeters = 35.31 cu. feet

Square measure

1 sq. centimeter = 100 sq. millimeters =.155 sq. in.
1 sq. decimeter = 100 sq. centimeters = 15.5 inches
1 sq. meter (centare) = 100 sq. decimeters = 10.76 feet
1 sq. dekameter (are) = 100 sq. meters = 1.076.4 sq. ft.
1 sq. hectometer (hectare) = 100 sq. dekameters = 2.47 acres
1 sq. kilometer = 100 hectometers = .386 sq. miles

Liquid Measure

1 dekaliter = 10 liters = 2.64 gallons
1 hectoliter = 10 dekaliters = 26.42 gallons
1 kiloliter = 10 hectoliters = 264.18 gallons
1 liter = 10 deciliters = 33.81 fl. ounces
1 centiliter = 10 milliliters = .34 fl. ounce
1 deciliter = 10 centiliters = 3 38 fl. ounces
1 metric ton = 10 quintals = 1.1 short tons

Approximate Conversion Factors

To change	To	Multiply by
inches	centimeters	2.540
feet	meters	.305
yards	meters	.914
miles	kilometers	1.609
sq. inches	sq. centimeters	6.451
sq. feet	sq. meters	.093
sq. yards	sq. meters	.836
sq. miles	sq. kilometers	2.590
acres	sq. hectometers	.405
cubic feet	cubic meters	.028
cubic yards	cubic meters	.765
fluid ounces	milliliters	29.573
pints	liters	.472
quarts	liters	.946
gallons	liters	3.785
ounces	grams	28.349
pounds	kilograms	.454
short tons	metric tons	.907
pound inches	newton-meters	.11296

To change	To	Multiply by
ounce inches	newton-meters	.0070062
centimeters	inches	.394
meters	feet	3.280
meters	yards	1.094
kilometers	miles	.621
sq. centimeters	sq. inches	.155
sq. meters	sq. yards	10.764
sq. kilometers	sq. miles	1.196
sq. hectometers	acres	2.471
cubic meters	cubic feet	35.315
milliliters	fluid ounces	.034
liters	pints	2.113
liters	quarts	1.057
grams	ounces	.035
kilograms	pounds	2.205
metric tons	short tons	1.102
pound-feet	newton-meters	1.356

Temperature (Exact)

°F Fahrenheit temperature	5/9 (after subtracting 32)	Celsius Temperature °C

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