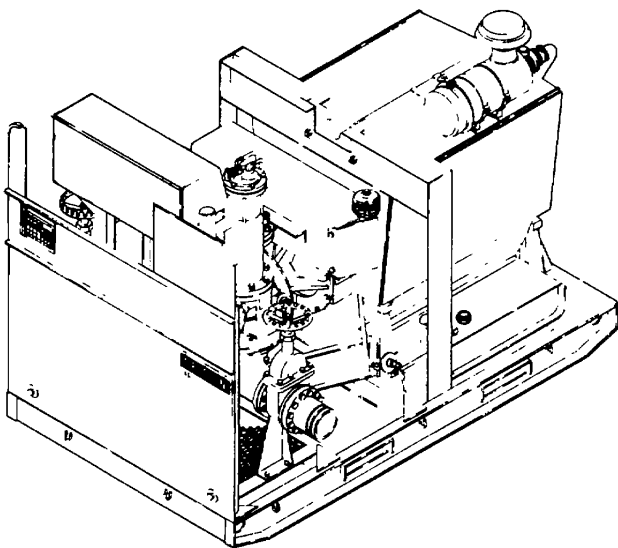


TECHNICAL MANUAL

**ORGANIZATIONAL,
DIRECT SUPPORT AND GENERAL SUPPORT
MAINTENANCE MANUAL**



This copy is a reprint which includes current pages from Changes I through 2.

**PUMP UNIT, CENTRIFUGAL,
FLOOD AND TRANSFER,
DIESEL-ENGINE-DRIVEN,
1250 GPM AT 180 FTH
MODEL US612ACD
NSN 4320-01-194-5601**

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DIRECT SUPPORT MAINTENANCE INSTRUCTIONS	3-1
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MAINTENANCE ALLOCATION CHART	5-1
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WARNING**DEATH OR SERIOUS INJURY**

could occur if unauthorized or unnecessary personnel are in the hoisting area. Permit only personnel actually engaged in the hoisting operation to be near the unit and hoisting equipment. All instructions for the hoisting operations must come from one authorized person.

DEATH OR SERIOUS INJURY

to personnel or damage to equipment could occur from improper hoisting. Hoist the load slowly to avoid tearing out lifting bail assembly, slipping slings, or load shift. Do not jerk the load or swing it from side-to-side when hoisting. This places additional stress on hoisting components which can cause failure and loss of load. Be sure hoisting equipment is on solid footing and is suitable for the size of the load. Watch boom angle and overhead clearance when hoisting.

SERIOUS INJURY

could occur from the careless handling of storage batteries or battery electrolyte (acid). If acid is splashed on the skin, wash the affected area immediately with plenty of clean water. If acid is splashed in the eyes, wash immediately with plenty of clean water and get medical attention.

DEATH OR SERIOUS INJURY

Leave filler caps installed while battery is being charged. Charge battery in a well-ventilated area. Do not smoke or use open flame or spark-producing equipment in the vicinity of charging battery.

DEATH OR SERIOUS INJURY

could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Engines must be turned off and cool before refueling. Use proper refueling procedures and equipment to avoid spillage. Do not run engines near open fuel containers. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

WARNING

SERIOUS INJURY

Be sure engine is shut down and control panel is closed to prevent accidental starting while rear panel is removed. If necessary to run engine without rear panel, be sure that area around V-belts is clear of personnel and tooling.

SERIOUS INJURY

Do not remove the air inlet and exhaust elbows while the engine is running. Touching a moving impeller could cause serious injury.

SERIOUS INJURY

Objects entering the turbine and compressor chambers could seriously damage the turbocharger, and fragments ejected from the chambers could cause serious eye injuries.

SEVERE BURNS

can be caused by turbocharger and exhaust system heated during operation of the engine. If the engine has been running, do not touch the turbocharger or exhaust system components until they have cooled.

SERIOUS INJURY

Do not allow engine side panel or battery box top to come in contact with electrical connections.

DEATH OR SERIOUS INJURY

Avoid making contact across the battery terminals. This can result in severe arcing which could cause an explosion resulting in bodily injury.

SERIOUS INJURY

Connect positive battery cables to battery first to prevent shocks and damage to other electrical system components.

WARNING**HEALTH AND SAFETY HAZARD**

Dry cleaning solvent P-D-680 (safety or Stoddard's Solvent) is potentially dangerous. Avoid repeated and prolonged breathing of vapors and skin contact with the liquid. Do not use near open flame, arcing equipment, or other ignition source. Always wear eye protection and protective clothing. The flash point of P-D-680 is 1000 to 138°F (380 to 590°C).

DEATH OR SERIOUS INJURY

could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

EXPLOSION HAZARD

Ether is highly flammable. Do not use near sparks or open flame. Do not inhale fumes. Do not operate valve for more than three seconds. Overloading the engine air housing with this highly flammable fluid (ether) could result in an explosion.

SEVERE INJURY

may result from contact with rotating engine parts, V-belts, or fan. Shut off the engine when it is necessary to inspect, service, or perform maintenance on any moving parts. Close control panel to prevent accidental starting. If it is necessary to run engine with rotating parts exposed, be sure the area around the moving parts is clear of personnel and tools.

SEVERE BURNS

Handling hot exhaust system can cause severe burns. Allow unit to cool before handling.

WARNING

CARBON MONOXIDE (EXHAUST GAS) CAN KILL YOU

Exposure to exhaust gases produces symptoms of headache, dizziness, loss of muscular control, drowsiness, or coma. Brain damage or death can result from severe exposure.

Fumes from engines become concentrated with poor ventilation. Operate engine in a ventilated area only.

While running engine, be alert for fumes. If someone is overcome, expose to fresh air; keep warm and still; give artificial respiration if needed. Seek medical attention. Administer oxygen, if available.

GOOD VENTILATION IS THE BEST DEFENSE AGAINST EXHAUST POISONING.

HEALTH AND SAFETY HAZARD

Operate acetylene torches properly and be alert for leaks on any part of the equipment. Inhalation of acetylene produces headache, dizziness, nausea, and possible loss of consciousness. If acetylene is inhaled, seek fresh air immediately.

SERIOUS INJURY

If the brush assembly has not been removed, it will spring out when rear housing is separated from the front housing. Flying parts may cause serious injury.

EXPLOSION HAZARD

Before application of heat, such as open flame, torch, or arc welding, be sure that all traces of cleaning solvent or flammable fluids or vapors are absent from the repair area.

CHANGE
NO. 2

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D. C, 10 October 1990

**Organizational, Direct Support and General Support Maintenance Manual
PUMP UNIT, CENTRIFUGAL, FLOOD AND TRANSFER,
DIESEL ENGINE DRIVEN, 1250 GPM AT 180 FTH
MODEL US61 2ACD, NSN 4320-01-194-5601**

Approved for public release; distribution is unlimited

TM 54320-306-24, 30 June 1987 is changed as follows:

1. Remove and insert pages as indicated below. New or changed text material is indicated by a vertical bar in the margin An illustration change is indicated by a miniature pointing hand.

Remove pages

Insert pages

- 2-7 and 2-8
- 2-13 and 2-14
- 2-35 and 2-36
- C-1 and C-2

- 2-7 and 2-8
- 2-13 and 2-14
- 2-35 and 2-36
- C-1 and C-2

2. Retain this sheet in front of manual for reference purposes

By Order of the Secretary of the Army:

CARL E. VUONO
General, United States Army
Chief of Staff

Official:

THOMAS F. SIKORA
Brigadier General, United States Army
The Adjutant General

DISTRIBUTION.

To be distributed in accordance with DA Form 12-25E, (qty rqr block no 2462)

CHANGE

No.1

Organizational, Direct Support and General Support Maintenance Manual

**PUMP UNIT, CENTRIFUGAL, FLOOD AND TRANSFER,
DIESEL-ENGINE-DRIVEN, 1250 GPM AT 180 FTH
MODEL US612ACD NSN 4320-01-194-5601**

TM 5-4320-306-24, 30 June 1987, is changed as follows:

1. Remove and insert pages as indicated below. New or changed text material is indicated by a vertical bar in the margin. An illustration change is indicated by a miniature pointing hand.

Remove pages

i and ii
2-65 and 2-66
2-147 and 2-148
3-25 and 3-26
3-27 and 3-28
3-29 and 3-30
3-31 through 3-34

Index 1 through Index 3/Index 4

Insert pages

i and ii
2-65 and 2-66
2-147 and 2-148
3-25 and 3-26
3-27/3-28
3-29 blank/3-30
3-31 through 3-34
E-1/E-2
Index 1 through Index 3/Index 4
FP-1//FP-2

2. Retain this sheet in front of manual for reference purposes.

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Chief of Staff

Official

R. L. DILWORTH
Brigadier General, United States Army
The Adjutant General

DISTRIBUTION:

To be distributed in accordance with DA Form 12-25A, Unit, Direct Support and General Support Maintenance requirements for Pumping Assembly, 1250 GPM.

Organizational, Direct Support and General Support Maintenance Manual

**PUMP UNIT, CENTRIFUGAL, FLOOD AND TRANSFER,
DIESEL-ENGINE-DRIVEN, 1250 GPM AT 180 FTH
MODEL US612ACD NSN 4320-01-194-5601**

Approved for public release. Distribution is unlimited.

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

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 directly to: Commander, U. S. Army Troop Support Command, ATTN: AMSTR-MCTS, 4300 Goodfellow Boulevard, St. Louis, MO 63120-1798. A reply will be furnished directly to you.

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**CHAPTER 1
INTRODUCTION**

Section 1. GENERAL INFORMATION

1-1. SCOPE

Type of Manual: Organizational, Direct Support, and General Support Maintenance

Model Number and Equipment Name: Pump Unit, Centrifugal, Flood and Transfer, 1250 gpm, Diesel-Engine-Driven, Model US612ACD

Purpose of Equipment: Pumps fuel or potable water

1-2. MAINTENANCE FORMS, RECORDS, AND REPORTS

Department of the Army forms and procedures used for equipment maintenance will be those prescribed by DA PAM 738-750, The Army Maintenance Management System (TAMMS).

1-3. DESTRUCTION OF ARMY MATERIEL TO PREVENT ENEMY USE

Refer to TM 750-24-3 for instructions.

1-4. PREPARATION FOR STORAGE AND SHIPMENT

Instructions for preparation for storage and shipment are in Chapter 2.

1-5. REPORTING EQUIPMENT IMPROVEMENT RECOMMENDATIONS (EIR'S)

If your centrifugal pump Unit needs improvement, let us know. Send us an EIR. You, the user, are the only one who can tell us what you do not like about your equipment. Let us know why you do not like the design or performance. Put it on an SF 368 (Quality Deficiency Report). Mail it to us at: U. S. Army Troop Support Command, ATTN: AMSTR-QX, 4300 Goodfellow Blvd. , St. Louis, MO 63120-1798. We will send you a reply.

1-6. NOMENCLATURE CROSS-REFERENCE

For precise identification, simplified nomenclature has been established for clarity and is shown in the nomenclature cross-reference list.

NOMENCLATURE CROSS-REFERENCE LIST

This listing includes nomenclature cross-references used in this manual

<u>Common Name</u>	<u>Official Nomenclature</u>
Centrifugal Pump Unit	Pump Unit, Centrifugal, Flood and Transfer, Diesel-Engine-Driven, 1250 gpm at 180 feet total head
Engine	Diesel Engine
Pump	Centrifugal Pump
Starter	Starter Motor

Section II. EQUIPMENT DESCRIPTION AND DATA

1-7. EQUIPMENT CHARACTERISTICS, CAPABILITIES, AND FEATURES

- Pumping rate of 1250 gpm at 180 feet total head
- Automatic shutdown for high temperature, low oil pressure, and overspeed
- Operates in surrounding temperature between +155° and -65°F (+68.3° and -53.9°C)
- Operates at altitudes between sea level and 9000 feet above sea level
- Continuous operation during periods of blowing sand
- Operator station protected by noise shield
- Ether start kit (cold weather starting aid)
- Skid mounted for transport

1-8. LOCATION AND DESCRIPTION OF EXTERNAL COMPONENTS

CONTROL PANEL AND ELECTRICAL SYSTEM (1). Used to operate and control the centrifugal pump unit. The control panel assembly is located at the front of the unit. It is supported by the suction assembly and noise shield. The control panel assembly contains the operating and instrument panels. The electrical system contains the wiring and hardware connecting the control panel components with the engine and pumping controls and sensors.

ETHER START KIT (2) Used when engine will not start normally in cold weather. Injects a mist of liquid ether into the engine air intake system to aid ignition. The starting aid components are the ether cylinder, control nozzle, and the hose between the nozzle and the air intake.

DISCHARGE MANIFOLD ASSEMBLY (3) Controls the liquid pumped out of the pump body discharge port. The manifold is attached to the discharge port flange at the top of the pump body. It is supported by this connection and support brackets on the skid frame. The assembly consists of a gate valve, a check valve, an air valve, connective piping, and a victaulic coupling flange.

FUEL TANK (4). Contains a 20-gallon supply of diesel fuel for the engine. The tank is mounted to the rear third of the skid frame, just below the engine. The tank includes a filler cap, fuel gage, and various fittings for fuel lines.

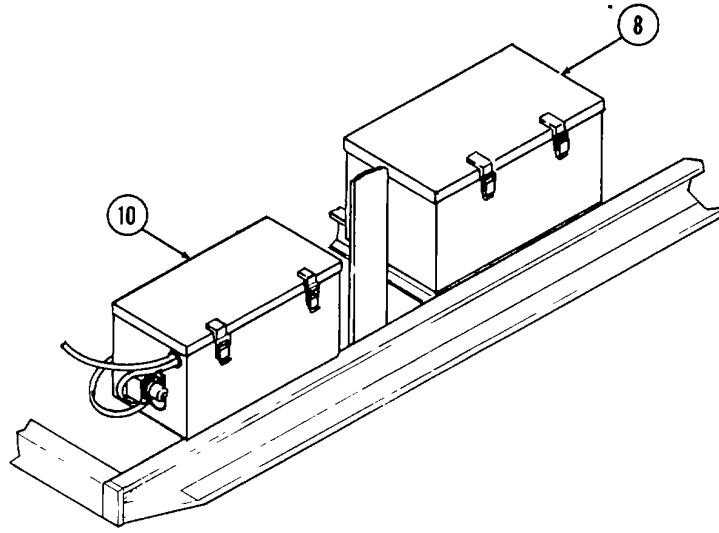
NOISE SHIELD (5). Reduces pump and engine noise at the operator's position in front of the control panel. In addition, the shield reduces vibration of the control panel and supports the front portion of the fabric cover. The base of the shield is mounted to the front of the skid frame, and to the supports of the control panel.

SUCTION ASSEMBLY (6). This assembly controls the liquid supply to the pump body suction port. The assembly is secured to the suction port mounting studs at the front of the pump body. It is supported by this connection and support brackets on the skid frame. The suction assembly consists of a gate valve, a strainer assembly, connective piping, and a victaulic coupling flange.

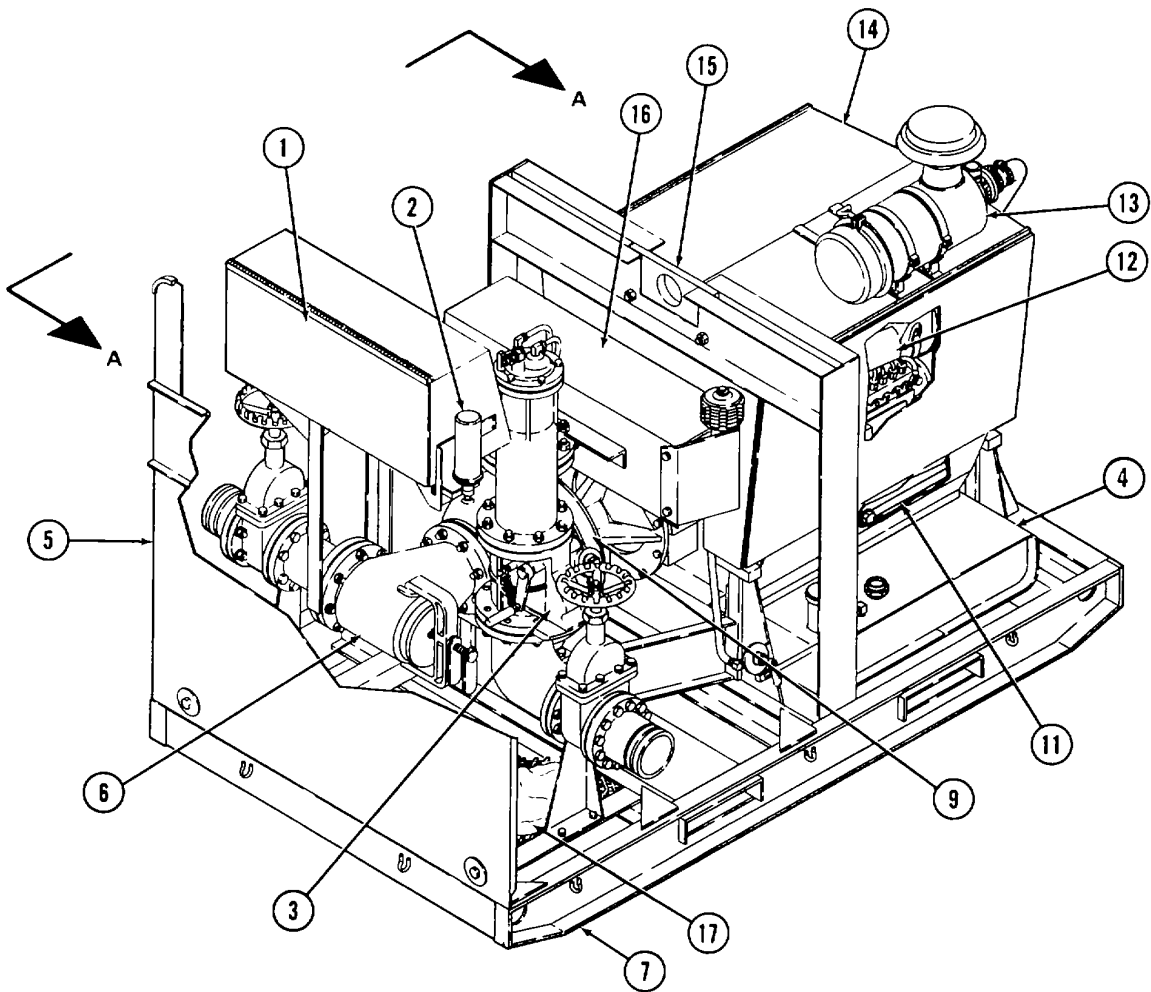
SKID ASSEMBLY (7). The skid assembly is a movable mounting platform for the major components of the centrifugal pump unit. The skid is a welded frame with provisions for mounting the components, runners which incorporate enclosed forklift pockets, battery and tool boxes, and a 20-gallon engine fuel tank.

TOOL BOX (8). Centrifugal pump unit accessories are stored in the tool box. It is attached to left side of the skid frame, in front of the battery box.

1-8. LOCATION AND DESCRIPTION OF EXTERNAL COMPONENTS (Continued)



VIEW A-A



1-8. LOCATION AND DESCRIPTION OF EXTERNAL COMPONENTS (Continued)

PUMP ASSEMBLY (9). The pump assembly uses the turning force of the engine to pump liquid from the suction port to the discharge port of the pump body. The pump assembly is a single-stage, centrifugal pump which is self priming after initial filling. The pump body portion of the assembly is mounted to the front portion of the skid frame. The bearing housing portion of the assembly attaches to the engine bell housing and flywheel.

BATTERY SYSTEM (10). The battery system components supply dc power to the starting motor, control panel, and electrical system. The components include a battery box, two 12-volt batteries, a charging receptacle, and connecting cables and wires.

OIL DRAIN ASSEMBLY (11). The oil drain assembly is an extension of the engine oil drain It makes draining the engine oil easier. The drain assembly is located below the engine and projects from the rear of the pump assembly.

ENGINE (12). The engine provides turning force to the pump rotor. The engine is a turbocharged, six-cylinder, in-line, diesel engine. It has a standard, continuous output rating of 102 hp at 2400 rpm. The engine is mounted to the rear portion of the skid frame. The engine flywheel is directly connected to the pump with a dry-type flexible coupling.

AIR INLET COMPONENTS (13). Supply filtered air to the inlet of the engine through the turbocharger. The components include a dry-type air cleaner and air hoses between the air cleaner and turbocharger.

ENGINE COVER ASSEMBLY (14). Encloses and protects the engine from environmental conditions during operation. The cover consists of a metal frame; and side, top, and end panels. The frame is attached to the skid assembly. The cover panels are attached to the frame with hand-operated fasteners. The rear panel includes an air intake duct and filter that provide filtered cooling air to the engine.

LIFTING BAIL (15). Provides a secure point of attachment for lifting the centrifugal pump unit. The bail is secured to the skid frame at the centrifugal pump unit center of gravity.

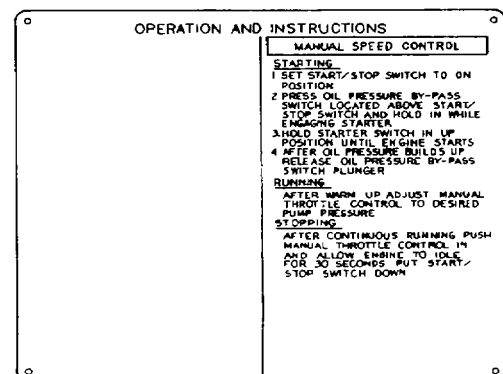
EXHAUST SYSTEM (16). Vents engine exhaust gases from the exhaust side of the turbocharger. The components include a spark arrestor, muffler, and the exhaust pipes between the muffler and turbocharger.

FABRIC COVER (17) Fits over the centrifugal pump unit It protects the components from environmental conditions when the unit is not in operation. The cover is made of a flame-resistant, vinyl-coated nylon material with rubber tiedowns that hold it in place.

1-9. LOCATION AND DESCRIPTION OF INSTRUCTION AND WARNING PLATES

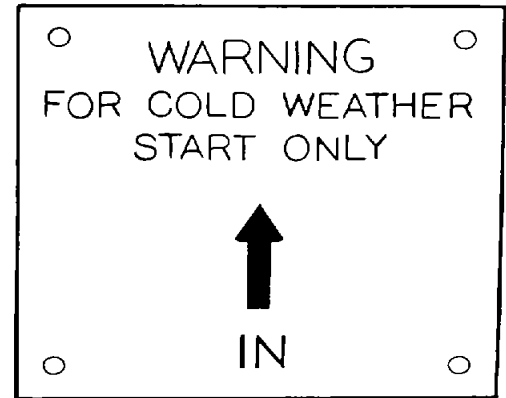
The centrifugal pump unit has the following identification, instruction, and warning plates.

a. *Instruction plate.* Mounted on the throttle panel on the control panel assembly. It displays operating instructions for starting, running, and stopping the centrifugal pump unit.

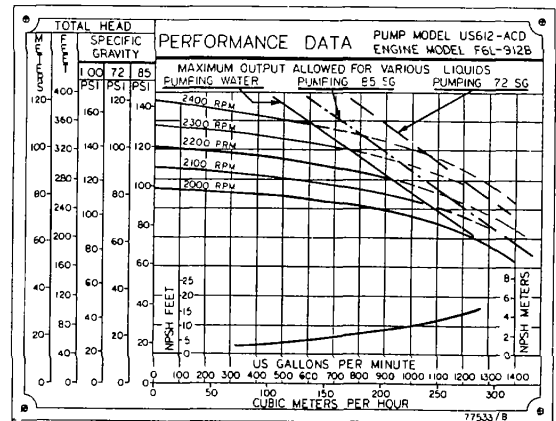


1-9. LOCATION AND DESCRIPTION OF EXTERNAL COMPONENTS (Continued)

b. *Cold start warning plate.* Located on the side of the control panel assembly next to the ether cylinder. Warns operator that ether release control knob is used only for starting engine in cold weather



c. *Performance data information plate.* Located on the front face of the noise shield. It provides the performance range curve based on total head, revolutions per minute, and US gallons per minute. It also lists the psi for liquids with the specific gravities of 1.00, 0.72, and 0.85.

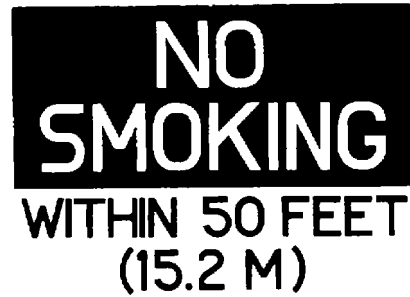


d. *Ear protection warning plates.* Warning plates visible from both sides of the centrifugal pump unit. They warn of engine operating noise hazard.

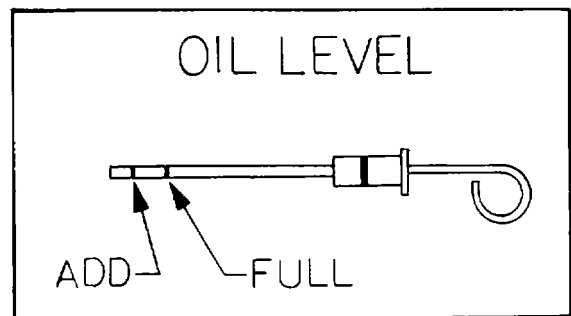


1-9. LOCATION AND DESCRIPTION OF EXTERNAL COMPONENTS (Continued)

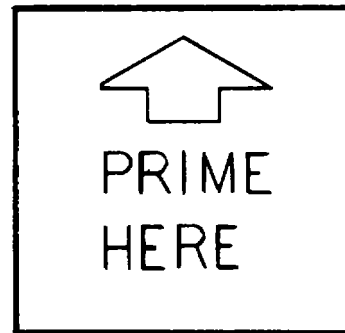
e. *No smoking warning plates.* Located on the engine housing.



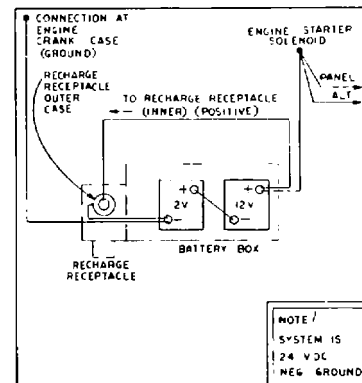
f. *Oil level plate.* Located on the engine. Illustrates the oil dipstick markings ADD and FULL..



g. *Prime plate.* Located on pump body. Arrow points to priming port.



h. *Battery circuit plate.* Located inside the battery box. Shows battery circuit flow and connections.

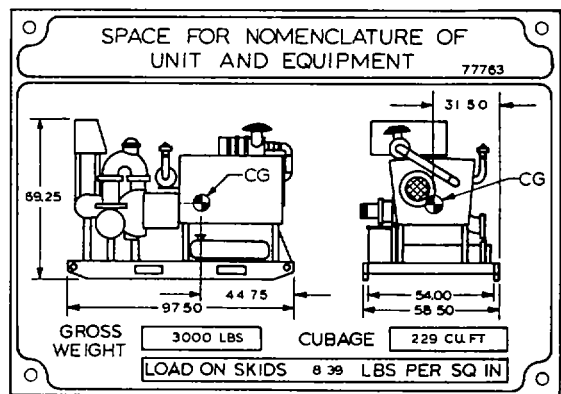


1-9. LOCATION AND DESCRIPTION OF EXTERNAL COMPONENTS (Continued)

i. *Pump identification plate.* Located on the front left side of the skid. It provides the pump and engine identification numbers, pump dimensions, weight, and shipping information.

US			
MODEL	CONTRNR		
SER NR	CAPACITY		
REG NR	GVW LB	LG	IN
FSN	DATE MFG	HGT	IN
ENG SER	SHIP WT LB	W	IN
WARRANTY	MO	MI	CU FT
DATE SHIPPED	DATE INSP		INSP STAMP
BARNES PUMP			
MFD BY PEABODY BARNES INC MANSFIELD OHIO USA			

j. *Transportation plate* Located on the front right side of the skid. It provides shipping information gross weight, loading cubic feet; overall width, length, and height, and the load on skids It includes a diagram of the centrifugal pump unit that shows the overall dimensions and center of gravity.



1-10. DIFFERENCES BETWEEN MODELS

This technical manual covers only Centrifugal Pump Unit, Peabody Barnes Model US612ACD, part number 77000CA. No known differences exist for this model number

1-11. EQUIPMENT DATA

a. *Pump.*

Manufacturer.....	Peabody Barnes, Inc.
Model number.....	US612ACD
Part number.....	, 77000CA
Type.....	Self-priming centrifugal
Primary service.....	Potable water
Secondary service.....	Fuel
Output	
Primary service.....	600gpm (2271 L/min)
Secondary service.....	1250 gpm (4730 L/min)
Rated driven speed.....	2400 rpm
Suction port (intake).....	6-inch NPT
Discharge port.....	6-inch NPT
Priming port.....	1-1/2-inch NPT
Priming method.....	Self priming
Drain port.....	2-inch NPT
Rotation.....	Counterclockwise (facing pump inlet)

1-11. EQUIPMENT DATA (Continued)

b. *Engine.*

Manufacturer Klockner-Humbolt-Deutz AG
 Model F6L 912B
 Type Four-stroke-cycle diesel
 Number of cylinders 6
 Bore 3.93 in (100 mm)
 Stroke 4.72 in. (120 mm)
 Total displacement 344.84 cu in. (5652 cm³)
 Compression ratio (nominal) 15.5-1
 Direction of rotation (facing flywheel) Counterclockwise
 Firing order 1-5-3-6-2-4
 Coolant Air

c. *Engine accessories.*

Starter Motor
 Manufacturer Bosch
 Part number 0 001 368 01
 Voltage 24

Alternator
 Manufacturer Motorola
 Part number 8AR3080F
 Voltage 24

Air Cleaner
 Manufacturer Donaldson
 Type Dry
 Element numbers
 Primary P 18-2064
 Secondary P 18-1064

Ether Start Kit
 Manufacturer KBI Dieselstart
 Model 20-652

d. *Capacities.*

Engine oil capacity 15 qt (14.2 liters)
 Fuel tank capacity 20 gal. (75.7 liters)

e. *Dimensions and weight.*

Overall length 97.50 in. (2.48 meters)
 Overall width 58.50 in (1.49 meters)
 Overall height 69.25 in. (1.76 meters)
 Gross weight 3000 lb (1360 kg)
 Shipping volume 229 cu ft (6.5 m³)

1-12. SAFETY, CARE, AND HANDLING

a. *Before operation.* Do not operate the unit in an enclosed area unless the exhaust is piped to the outside. The exhaust contains carbon monoxide, a colorless, odorless, deadly poisonous gas. Do not smoke or use hydrogen, a highly explosive gas. When filling the fuel tank, always maintain a metal-to-metal contact between the filling apparatus and the fuel tank to prevent a static spark from igniting the diesel oil fumes.

b. *During operation.* Do not fill the fuel tank while the engine is operating, nor attempt to perform maintenance on the centrifugal pump unit while it is in operation.

c. *After operation.* Exercise extreme caution when performing any maintenance while the engine is hot. This may result in serious burns to personnel. When filling the fuel tank, always maintain metal-to-metal contact between the filling apparatus and the fuel tank to prevent a static spark from igniting diesel oil fumes.

CHAPTER 2 ORGANIZATIONAL MAINTENANCE INSTRUCTIONS

INTRODUCTION

This chapter contains the following frequently used maintenance information

- a. Lubrication.
- b. Information on repair parts; special tools; test, measurement, and diagnostic equipment (TMDE), and support equipment.
- c. Instructions for service upon receipt of equipment
- d. Preventive maintenance checks and services (PMCS)
- e. Troubleshooting
- f. Maintenance procedures
- g. Preparation for storage or shipment.

Section 1. LUBRICATION INSTRUCTIONS

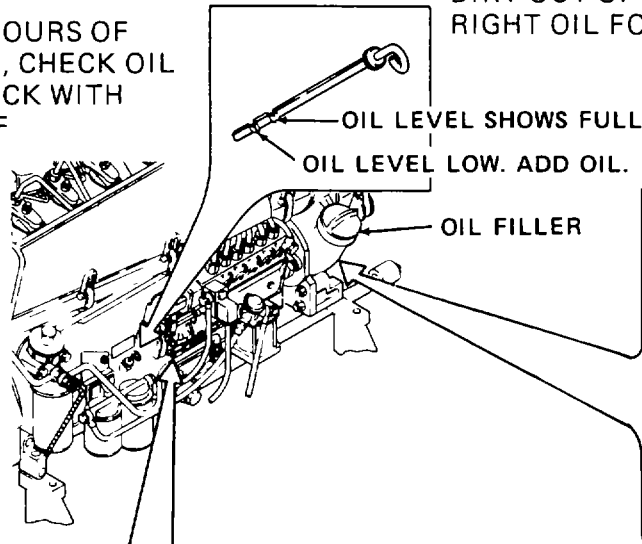
2-1. LUBRICATION INSTRUCTIONS

NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

NOTE: THESE LUBRICATION INSTRUCTIONS ARE MANDATORY.

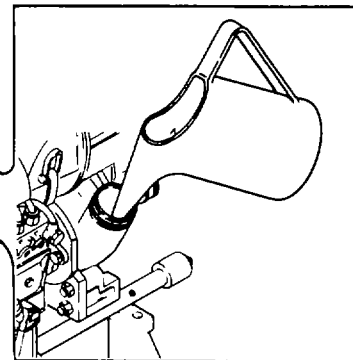
CHECK IT!

- 1 EVERY 10 HOURS OF OPERATION, CHECK OIL LEVEL CHECK WITH ENGINE OFF



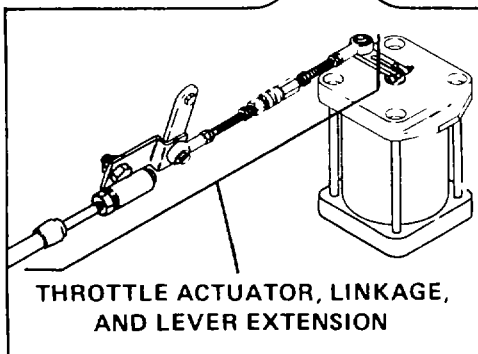
DON'T FORGET KEEP OIL CLEAN, KEEP DIRT OUT OF ENGINE, AND SELECT THE RIGHT OIL FOR EXPECTED TEMPERATURES

ADD IT!



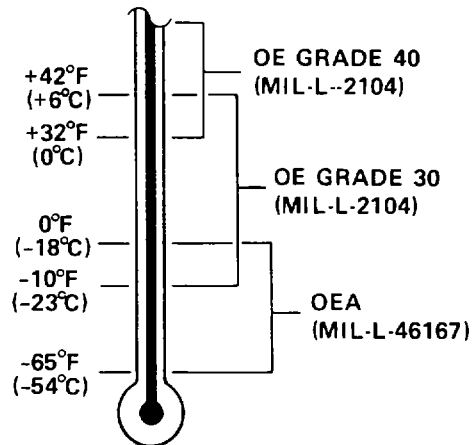
- 2 REMOVE OIL FILLER ADD OIL AS NEEDED TO RAISE OIL LEVEL TO FULL MARK ON DIPSTICK REPLACE OIL FILLER

LUBE IT!



- 3 EVERY 200 HOURS OF OPERATION, WIPE OFF ALL PIVOT POINTS AND ADJUSTING THREADS, THEN APPLY A LIGHT COAT OF ENGINE OIL

THE TEMPERATURE WILL DETERMINE WHICH OIL TO USE.

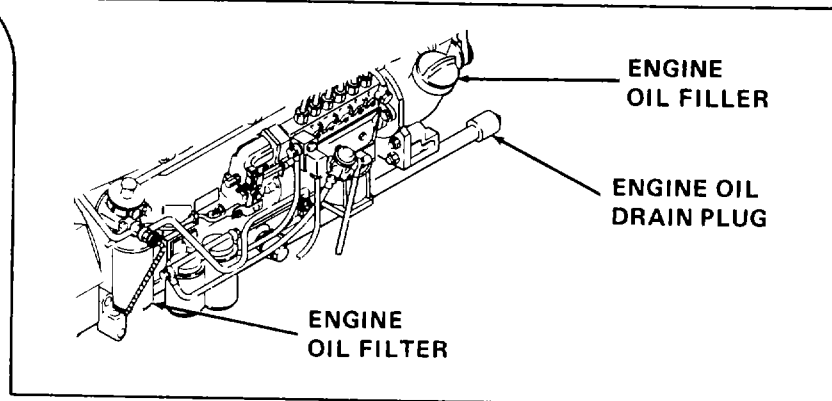
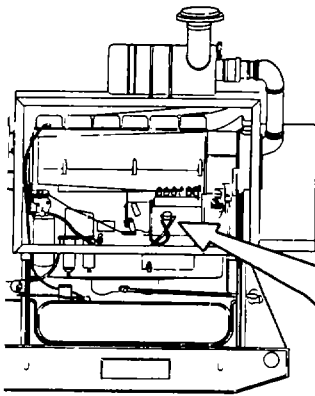


NOTE FOR ARCTIC OPERATION REFER TO TM 9-207

2-1. LUBRICATION INSTRUCTIONS (Continued)

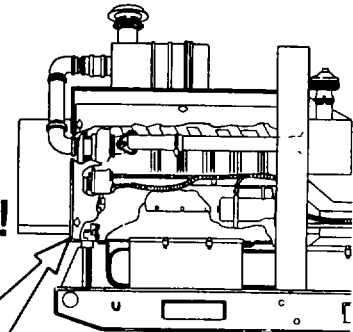
REPLACE IT!

DON'T FORGET: KEEP OIL CLEAN, KEEP DIRT OUT OF ENGINE, AND SELECT THE RIGHT OIL FOR EXPECTED TEMPERATURES.

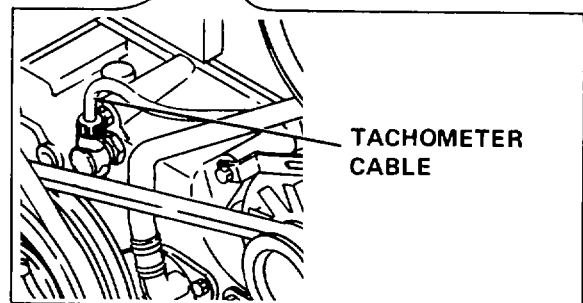


- 4 EVERY 100 HOURS OF OPERATION, REPLACE THE ENGINE OIL AND ENGINE OIL FILTER. DRAIN OIL WHILE ENGINE IS HOT. REMOVE ENGINE OIL DRAIN PLUG AND ALLOW OIL TO DRAIN. REINSTALL DRAIN PLUG AFTER OIL HAS DRAINED COMPLETELY AND WIPE OFF PLUG AND IMMEDIATE AREA OF OIL DRAIN ASSEMBLY WITH A RAG. USE A STRAP OR HAND WRENCH TO REMOVE ENGINE OIL FILTER. DISCARD FILTER. LUBRICATE GASKET OF NEW OIL FILTER WITH ENGINE OIL AND INSTALL HAND TIGHT ONLY. FILL CRANKCASE WITH CORRECT GRADE OF OIL. CAPACITY IS 15 QUARTS (14 LITERS). TIGHTEN ENGINE OIL DRAIN PLUG IF LEAKS APPEAR.

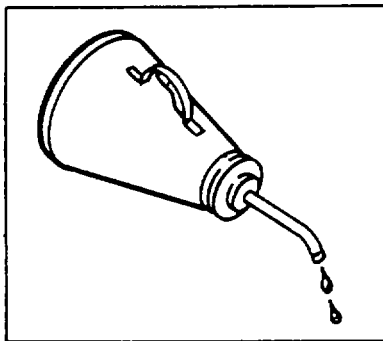
LUBE IT!



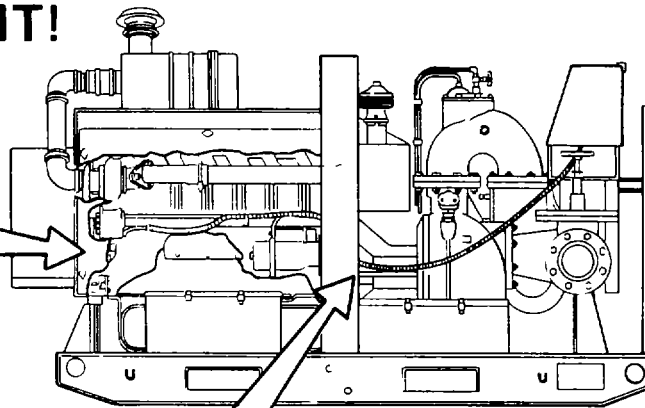
- 5 EVERY 500 HOURS OF OPERATION, LUBRICATE TACHOMETER CABLE UN-THREAD NUT AND REMOVE TACHOMETER CABLE FROM CAMSHAFT DRIVE. LUBRICATE CABLE END AND CAMSHAFT DRIVE WITH GAA GREASE (MIL-G-10924). REPLACE CABLE AND TIGHTEN NUT.



2-1. LUBRICATION INSTRUCTIONS (Continued)

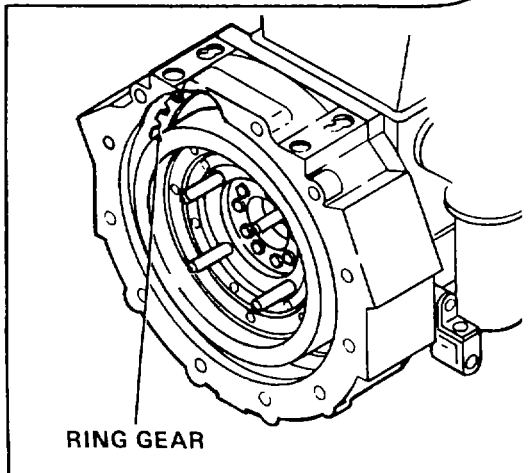


LUBE IT!



6. EVERY 500 HOURS OF OPERATION, CLEAN AND LIGHTLY COAT WITH ENGINE OIL ALL PIVOT POINTS, LINKAGES, CLEVIS PINS, WING NUTS, AND ADJUSTING THREADS.

LUBE IT!



7 IF FOR ANY REASON, THE CENTRIFUGAL PUMP UNIT MUST BE OPERATED AT TEMPERATURES BELOW -4°F (-20°C), THE RING GEAR OF THE FLYWHEEL SHALL BE LUBRICATED. REMOVE STARTER TO ALLOW ACCESS TO TEETH OF FLYWHEEL RING GEAR LUBRICATE STARTER DRIVE GEAR WHILE STARTER IS REMOVED ONLY A LIGHT COATING OF GREASE SHALL BE APPLIED.

NOTE

Pump bearings and cooling air blower bearings are lubricated by the manufacturer at assembly and require no subsequent lubrication.

Section II. REPAIR PARTS, SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT

2-2. COMMON TOOLS AND EQUIPMENT

For authorized common tools and equipment, refer to the Modified Table of Organization and Equipment (MTOE) applicable to your unit

2-3. SPECIAL TOOLS, TMDE, AND SUPPORT EQUIPMENT

The special tooling required to service the engine and pump assemblies is listed and illustrated in detail in TM 5-4320-306-24P, Repair Parts and Special Tools List (RPSTL)

2-4. REPAIR PARTS

Repair parts are listed and illustrated in TM 5-4320-306-24P.

Section III. SERVICE UPON RECEIPT OF EQUIPMENT

2-5. UNLOADING EQUIPMENT

- a. Before attempting to unload the Model US612ACD Centrifugal Pump Unit, make sure that the unloading facility is capable of handling 3000 pounds (1361 kg).
- b. Remove shipping tiedowns.

WARNING

Death or serious injury could occur if unauthorized or unnecessary personnel are in the hoisting area. Permit only personnel actually engaged in the hoisting operation to be near the unit and hoisting equipment. All instructions for the hoisting operations must come from one authorized person.

Injury to personnel or damage to equipment could occur from improper hoisting. Hoist the load slowly to avoid tearing out lifting bail assembly, slipping slings, or load shift. Do not jerk the load or swing it from side-to-side when hoisting. This places additional stress on hoisting components which can cause failure and loss of load. Be sure hoisting equipment is on solid footing and is suitable for the size of the load. Watch boom angle and overhead clearance when hoisting.

- c. Unload the centrifugal pump unit by lifting with a crane secured to lifting bail.

2-6. SETUP INSTRUCTIONS

The centrifugal pump unit is shipped completely assembled except for the exhaust muffler and spark arrestor. Refer to Operator's Manual, TM 5-4320-306-10, for setup and operating instructions.

2-7. INSPECTING AND SERVICING EQUIPMENT

- a. Inspect centrifugal pump unit for any damage that may have occurred during shipping.
- b. Inspect unit for loose mounting hardware.
- c. Inspect unit for missing components.
- d. Refer to paragraph 2-1 for lubrication instructions.
- e. Refer to table 2-1 and perform preventive maintenance checks and services.

2-8. INSPECTING AND SERVICING BATTERIES

- a. The centrifugal pump unit battery box (1) contains two waterproof, lead acid storage batteries (2).

CAUTION

Disconnect battery cable from negative battery post before disconnecting any other leads from engine components. This precaution will prevent short circuits which could damage the alternator, voltage regulator, or other electrical components.

When removing battery cable, use battery terminal puller to remove loosened terminal lugs. Forcing battery terminal lugs off without using puller may damage the battery posts.

Never disconnect battery while alternator is operating.

Never attempt to polarize the alternator.

- b. Open battery box top (3). Remove battery cables and batteries (2) from battery box (1) and inspect for damage.
- c. Clean positive terminals (4) and negative terminals (5)

2-8. INSPECTING AND SERVICING BATTERIES (Continued)

WARNING

Serious Injury could occur from the careless handling of storage batteries or battery electrolyte (acid). If acid is splashed on the skin, wash the affected area immediately with plenty of clean water. If acid is splashed in the eyes, wash immediately with plenty of clean water and get medical attention.

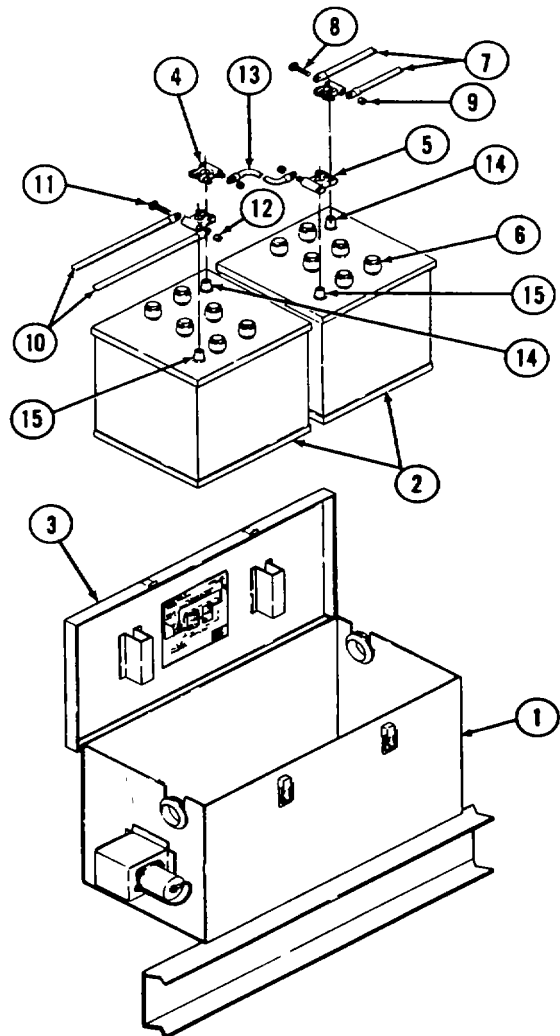
Leave filler caps installed while battery is being charged. Charge battery in a well-ventilated area. Do not smoke or use open flame or spark-producing equipment in the vicinity of charging battery.

- d. Remove filler caps (6) to check electrolyte level

NOTE

Use only an electrolyte with a specific gravity of 1.280. Do not use a tropical electrolyte which will reduce battery reserve capacity.

- e. If batteries (2) are dry, add electrolyte to each cell. Fill until level is above battery plates and reaches split ring in filler neck.
- f. Install filler caps (6)
- g. Charge batteries (2) fully
- h. Check that interior of battery box (1) is clean. Be sure drain holes are open and not painted closed
- i. Place batteries (2) into battery box (1). Orient terminals (4 and 5) as shown
- j. Clean terminals (4 and 5)



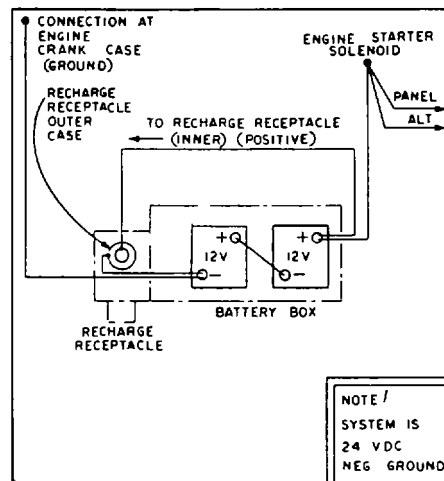
2-8. INSPECTING AND SERVICING BATTERIES (Continued)

CAUTION

Be sure that during installation the batteries are installed and connected in parallel. If batteries are not connected in parallel, damage to starter and controls may occur.

NOTE

Refer to battery circuit plate mounted on inside top of battery box when connecting battery cable assemblies.



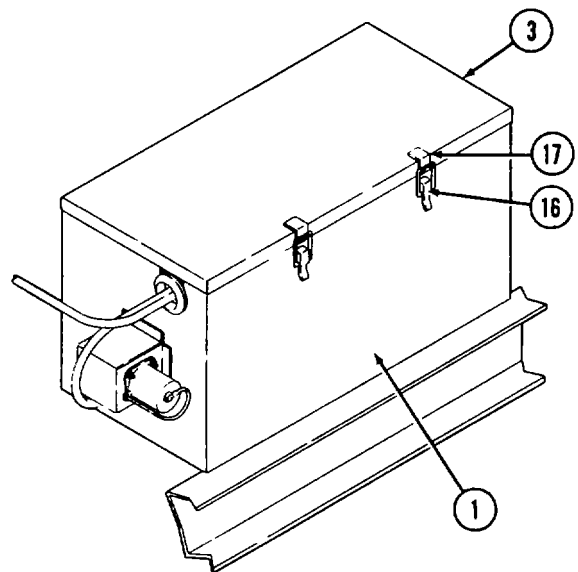
k. Connect positive battery cable assembly (7) to positive (+) terminal lug (4). Tighten screw (8) and nut (9) securely.

l. Connect negative battery cable assembly (10) to negative (-) terminal lug (5). Tighten screw (11) and nut (12) securely.

m. Connect cable jumper (13) to positive and negative terminals (4 and 5) as shown.

n. Lightly coat battery posts (14 and 15) and terminals (4 and 5) with MIL-G-10924 grease.

o. After placing batteries (2) into battery box (1), close battery box top (3). Be sure catches (16) are securely fastened over strikes (17).



Section IV. PREVENTIVE MAINTENANCE CHECKS AND SERVICES

2-9. PREVENTIVE MAINTENANCE CHECKS AND SERVICES

Table 2-1 lists the preventive maintenance checks and services which shall be performed at specified intervals by organizational maintenance personnel. It expands upon the preventive maintenance services performed by operator/crew maintenance and includes additional services which are allocated to organizational maintenance. The columns, codes, and location designations used in the table are as follows:

a. Item numbers are assigned to each check or service task. These numbers are to be used as a source of item numbers for the TM Number column on DA form 2404, Equipment Inspection and Maintenance Worksheet, in recording results of PMCS.

b. The service intervals are divided into four categories: W - Weekly, M - Monthly, Q - Quarterly, and S - Semiannually. A dot (.) is placed in the interval column for each check or service. If the same check or service is made in two or more intervals, a dot is placed in each applicable column.

c. The Item To Be Inspected column lists the item to be checked or serviced.

d. The Procedures column describes the procedure by which the check or service is to be performed. Illustrations are included to assist in locating that part of the equipment requiring the check or service.

e. The Equipment is Not Ready/Available If column contains the basis for classifying the equipment as not ready/available because it is unable to perform its primary mission. An entry in this column will:

- (1) Identify conditions that make the equipment not ready/available for readiness reporting purposes.
- (2) Deny use of the equipment until corrective maintenance has been performed.

f. The designations left, right, front, and rear as used in PMCS indicate the side or end of the centrifugal pump as viewed when facing the control panel.

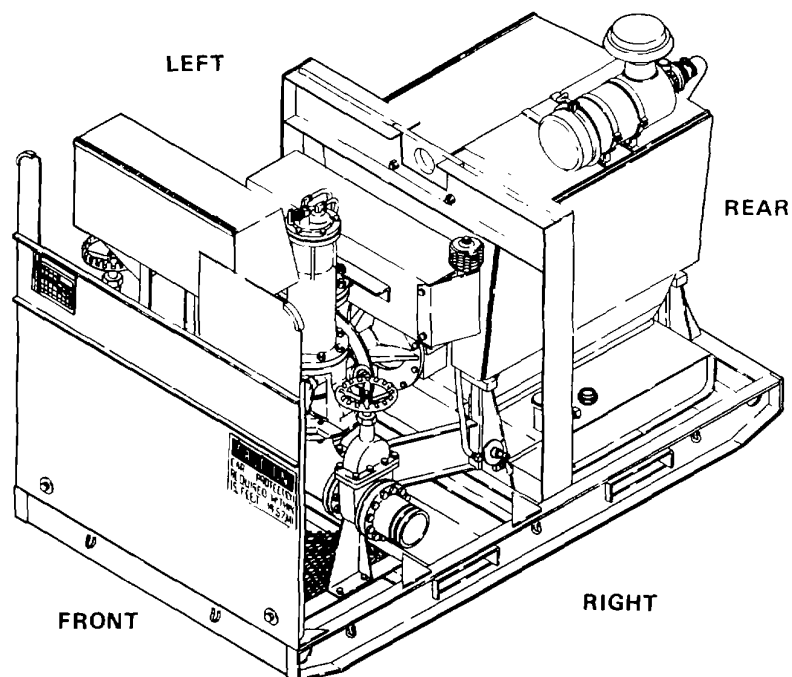


Table 2-1. Organizational Preventive Maintenance Checks and Services

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
						<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;">CAUTION</div> <p>During PMCS it is necessary to run the engine to be sure that the work has been accomplished satisfactorily. Since the pump is directly coupled to the engine, the pump will run when the engine runs. Do not run the pump without water in the volute. This will destroy the mechanical seal, causing pump failure. When necessary to run the pump for longer than a few seconds, make sure that suction and discharge hoses are installed and a source of water to be pumped is available. Start engine, prime and operate pump to duplicate normal operation and to prevent pump from overheating.</p> <p style="text-align: center;">NOTE</p> <p>Instructions for starting, running, and stopping the engine are located on the control panel assembly.</p> <div style="border: 1px solid black; padding: 10px; margin: 10px auto; width: 80%;"> <p style="text-align: center;">OPERATION AND INSTRUCTIONS</p> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;">MANUAL SPEED CONTROL</div> <p>STARTING:</p> <ol style="list-style-type: none"> 1 SET START/STOP SWITCH TO ON POSITION 2 PRESS OIL PRESSURE BY-PASS SWITCH LOCATED ABOVE START/STOP SWITCH AND HOLD IN WHILE ENGAGING STARTER 3 HOLD STARTER SWITCH IN UP POSITION UNTIL ENGINE STARTS 4 AFTER OIL PRESSURE BUILDS UP RELEASE OIL PRESSURE BY-PASS SWITCH PLUNGER <p>RUNNING:</p> <p>AFTER WARM UP ADJUST MANUAL THROTTLE CONTROL TO DESIRED PUMP PRESSURE</p> <p>STOPPING:</p> <p>AFTER CONTINUOUS RUNNING PUSH MANUAL THROTTLE CONTROL IN AND ALLOW ENGINE TO IDLE FOR 30 SECONDS PUT START/STOP SWITCH DOWN</p> </div>

Table 2-1. Organizational Preventive Maintenance Checks and Services - Continued

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
1	•				Control Panel Assembly	<p>Check fuse (1) and fuse holder for signs of damage or corrosion</p> <p>Check all control panel wiring for tight connections.</p> <p>Check hoses (2) for cracks</p> <p>Check hose connections for tightness.</p>

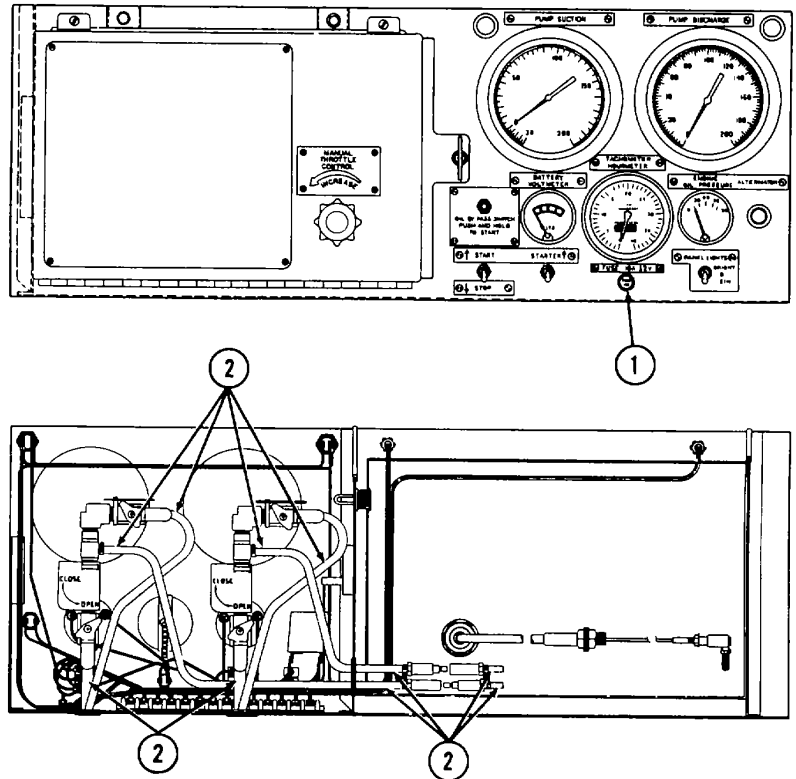


Table 2-1. Organizational Preventive Maintenance Checks and Services - Continued

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

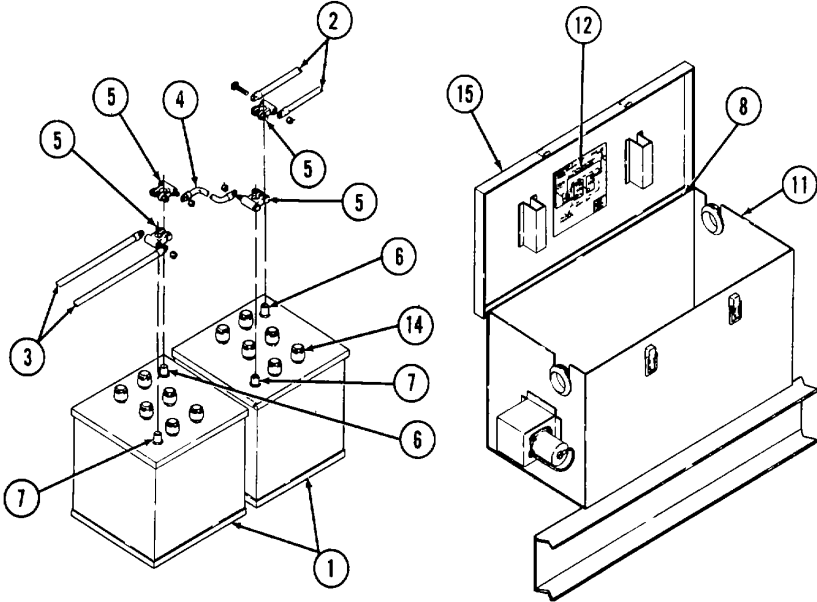
Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
2			•		Batteries, Battery Cables, and Battery Box	<p>WARNING</p> <p>Serious injury could occur from the careless handling of storage batteries or battery electrolyte (acid). If acid is splashed on the skin, wash the affected area immediately with plenty of clean water. If acid is splashed in the eyes, wash immediately with plenty of clean water and get medical attention.</p> <p>Remove batteries (1)</p> <p>Check positive battery cable assembly (2), negative battery cable assembly (3), and jumper battery cable assembly (4) for any signs of damage, corrosion, or looseness of terminal lugs (5).</p> 

Table 2-1. Organizational Preventive Maintenance Checks and Services - Continued

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

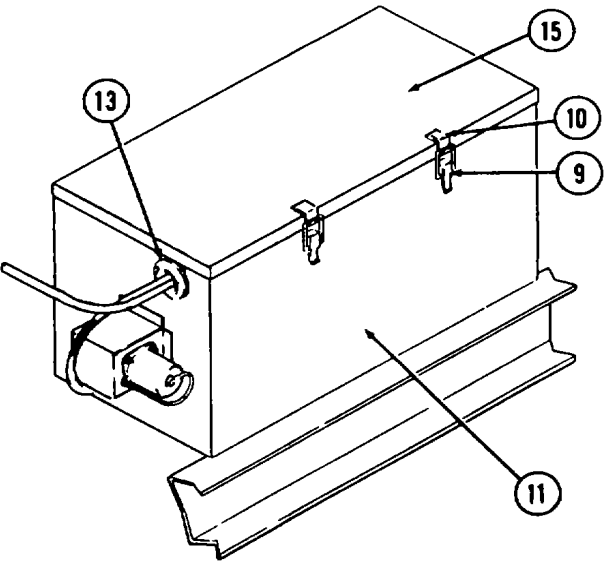
Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
2			•		Batteries, Battery Cables, and BatteryBox - Continued	<p>Check lugs (5) for damage or distortion that would prevent reliable contact with the battery posts (6 and 7).</p> <p>Check battery box hinge (8), catches (9), and strikes (10) for damage, corrosion, or looseness.</p> <p>Check that battery box (11) drains are open and no corrosion is detected in interior of box Check that schematic connection diagram (12) is mounted to the underside of battery box cover (15)</p> <p>Check grommets(13)for damage that would fray cable insulation Inspect batteries (1) for cracks, loose posts (6 and 7), leakage, and other damage</p> <p>Using a hydrometer, check each cell's charge</p> <p style="text-align: center;">NOTE Use distilled water or a good grade drinking water (excluding mineral water).</p> <p>Remove filler caps (14) and fill battery with distilled water as needed</p> 

Table 2-1. Organizational Preventive Maintenance Checks and Services - Continued

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

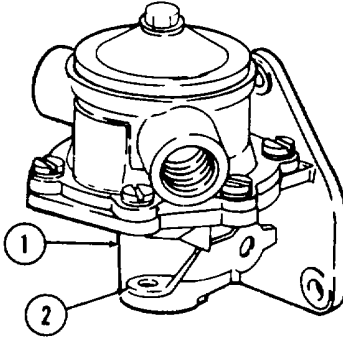
Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
3					Fuel Filter	<div style="border: 1px solid black; padding: 2px; width: fit-content; margin-bottom: 10px;">WARNING</div> <p>Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.</p> <ul style="list-style-type: none"> • • <p>Replace fuel filter cartridge.</p> <p>Start engine and observe fuel filter for leaks.</p>
4					Fuel Feed Pump	<div style="border: 1px solid black; padding: 2px; width: fit-content; margin-bottom: 10px;">WARNING</div> <p>Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.</p> <ul style="list-style-type: none"> • • • <p>Check fuel feed pump (1) for leaks.</p> <p>Check operation of fuel feed pump.</p> <p>Press fuel feed pump primer lever (2) and check for proper operation. Replace fuel feed pump if not operating properly.</p> <div style="text-align: center; margin-top: 20px;">  </div>

Table 2-1. Organizational Preventive Maintenance Checks and Services - Continued

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

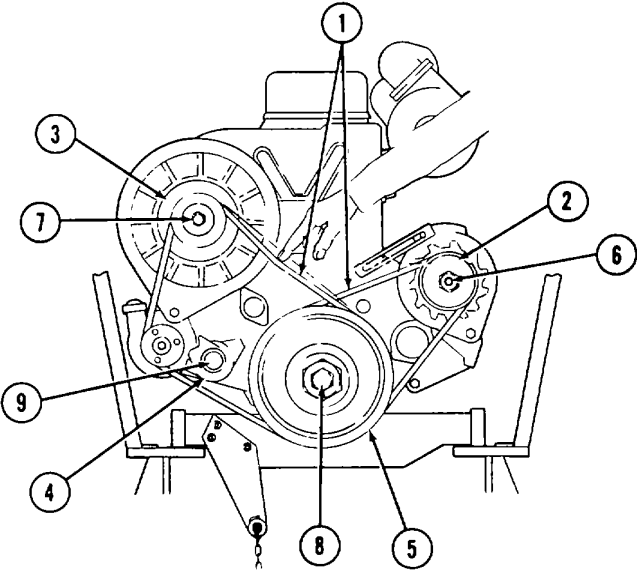
Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
5					Tachometer Cable	<p>Visually check cable for damage, corrosion, dirt, and wear</p> <p>Check that cable and adapter are secure.</p>
6					V-Belts, V-Belt Pulleys, Alternator Fan, and Air Guide Ring	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin-bottom: 10px;"> <p>WARNING</p> </div> <p>Be sure engine is shut down and control panel is closed to prevent accidental starting while rear panel is removed. If necessary to run engine without rear panel, be sure that area around V-belts is clear of personnel and tooling. With the intake duct, rear bottom panel, and both side panels removed from the engine cover, perform the following checks-</p> <p>V-Belt Check Check V-belts (1) for glazing, wear, abrasions, cracks, or cuts</p> 

Table 2-1. Organizational Preventive Maintenance Checks and Services - Continued

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
6			•		V-Belts, V-Belt Pulleys, Alternator Fan, and Air Guide Ring-Continued	<p>Check V-belt tension. When V-belt is pressed with forefinger at the mid-point between pulleys, it should deflect 1/2-3/4 inch (12.7-19.0 mm). If V-belts are damaged, replace as a set.</p> <p>Determine whether detected V-belt damage has been caused by damaged or worn pulleys. Be sure damaged or worn pulleys are replaced prior to replacing V-belts.</p> <p>Pulley Check.</p> <p>Check alternator pulley (2), cooling blower pulley (3), idler pulley (4), and crankshaft pulley (5) for sharp edges, nicks, corrosion, or wear sufficient to form sharp edges on pulley outside diameters. Check all pulleys for looseness on shafts.</p> <p>Check nut and lockwasher (6), hex bolt and nut (7), waisted bolt and washer (8), and washer and hex nut (9) for tightness and corrosion.</p> <p>Alternator Fan, Blower Blades, and Guide Ring Check.</p> <p>Check alternator fan (1) for damaged blades which could interfere with rotation or damage the V-belt.</p> <p>Check blower blades (2) for damage which could interfere with rotation or damage the V-belt.</p>

Table 2-1. Organizational Preventive Maintenance Checks and Services - Continued

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

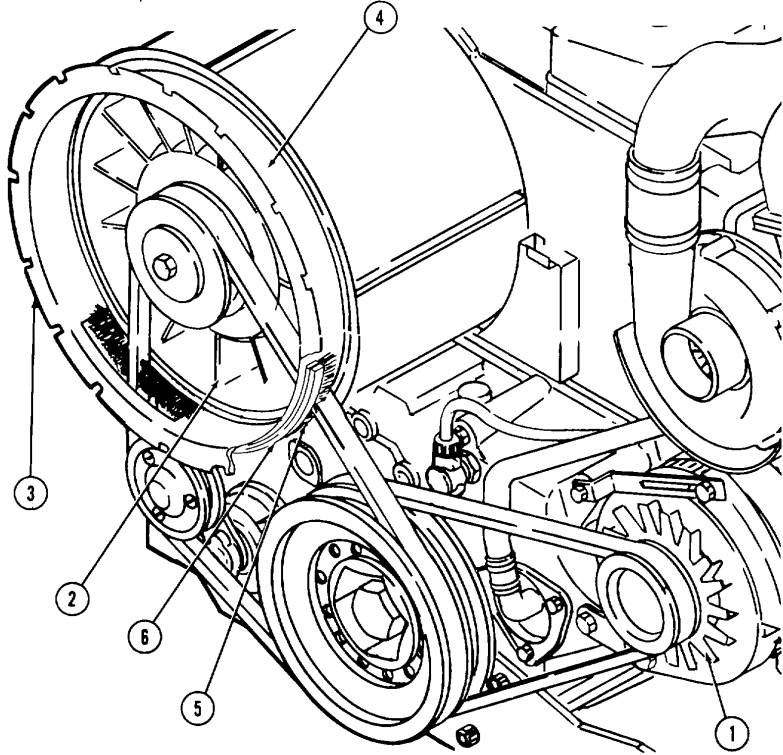
Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
6			•		V-Belts, V-Belt Pulleys, Alternator Fan, and Air Guide Ring - Continued	<p>Check air guide ring (3) components [air feed (4), sealing brush (5), and sealing section (6)] for damage or distortion that would interfere with blower rotation or damage the V-belt. Be sure sealing brush (5) and sealing section (6) are securely mounted and will not vibrate against the V-belt during engine operation.</p> <p>Check that the bristles of sealing brush (5) are in a condition to reduce cooling air loss along the V-belt.</p> 

Table 2-1. Organizational Preventive Maintenance Checks and Services - Continued

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

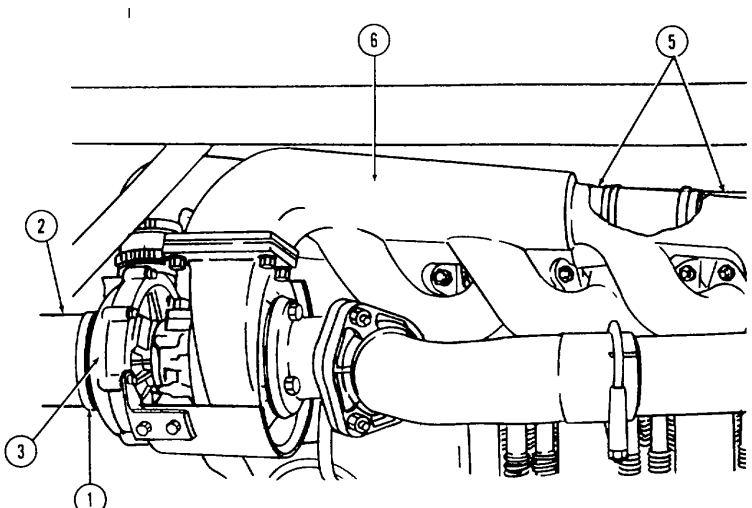
Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
7					Turbocharger	<div style="border: 1px solid black; padding: 2px; width: fit-content; margin-bottom: 10px;">WARNING</div> <p>Do not remove the air inlet and exhaust elbows while the engine is running. Touching a moving impeller could cause serious injury. Objects entering the turbine and compressor chambers could seriously damage the turbocharger, and fragments ejected from the chambers could cause serious eye injuries. Severe burns can be caused by turbocharger and exhaust system heated during operation of the engine. If the engine has been running, do not touch the turbocharger or exhaust system components until they have cooled. Loosen hose clamp (1) and pull air inlet (2) from turbocharger (3)</p> 

Table 2-1. Organizational Preventive Maintenance Checks and Services - Continued

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

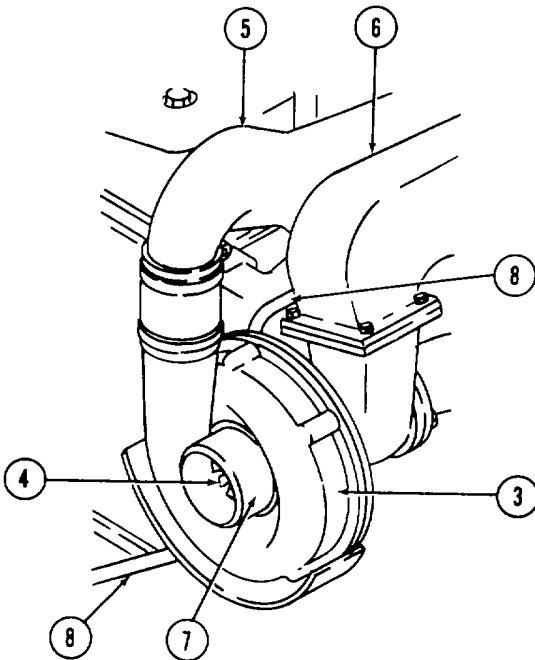
Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
7					Turbocharger - Continued	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin-bottom: 10px;">CAUTION</div> <p>Do not remove carbon or dirt buildup from the compressor or turbine impellers. The turbocharger must be disassembled to thoroughly clean the impellers. Even small deposits remaining on the blades unbalance the impeller and damage the turbocharger.</p> <p>Check for carbon or dirt buildup on impellers (4) and casing port. If buildup is present, the turbocharger must be cleaned Notify direct support</p> <p>Check for oil on the impeller (4) The presence of oil indicates seal leaks. Oil seal leaks are caused by blocked air intake ducts or damaged oil seals If the air filter and intake ducts are not blocked, the turbocharger oil seals must be replaced Notify direct support</p> 

Table 2-1. Organizational Preventive Maintenance Checks and Services - Continued

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
7			•		Turbocharger - Continued	<p>Turn impeller (4) by hand The impeller should turn freely. If the impeller scrapes the casing wall, or if the impeller shaft binds, the turbocharger must be replaced or repaired.</p> <p>Check the turbocharger connections to suction pipe (5) and exhaust manifold (6) for loose or missing hardware, signs of leaks, cracks, or other damage</p> <p>Check that exhaust manifold (6) and suction pipe (5) assemblies are securely mounted to the engine block. The turbocharger is mounted on these assemblies If they are loose, vibration will damage the turbocharger.</p> <p>Position air inlet (2) on the turbocharger (3) and tighten hose clamp (1) Be sure air inlet seats squarely on inlet flange (7) and there are no air leaks after the clamp is tightened</p> <p>Inspect oil lines (8) for loops or kinks that would restrict oil flow.</p> <p>While the engine is operating, inspect turbocharger oil lines (8) for leaks, and listen to the turbocharger for noise. Observe exhaust for discoloration</p>
8		•			Lube Oil Filter (Cartridge)	Inspect for leaks or damage.

Table 2-1. Organizational Preventive Maintenance Checks and Services - Continued

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

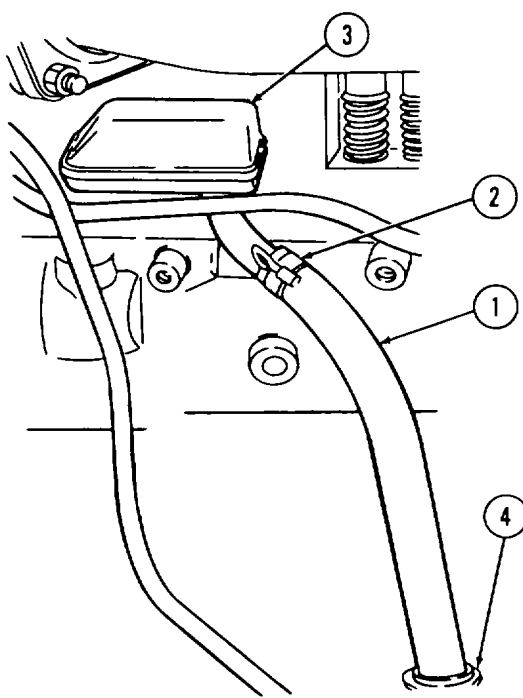
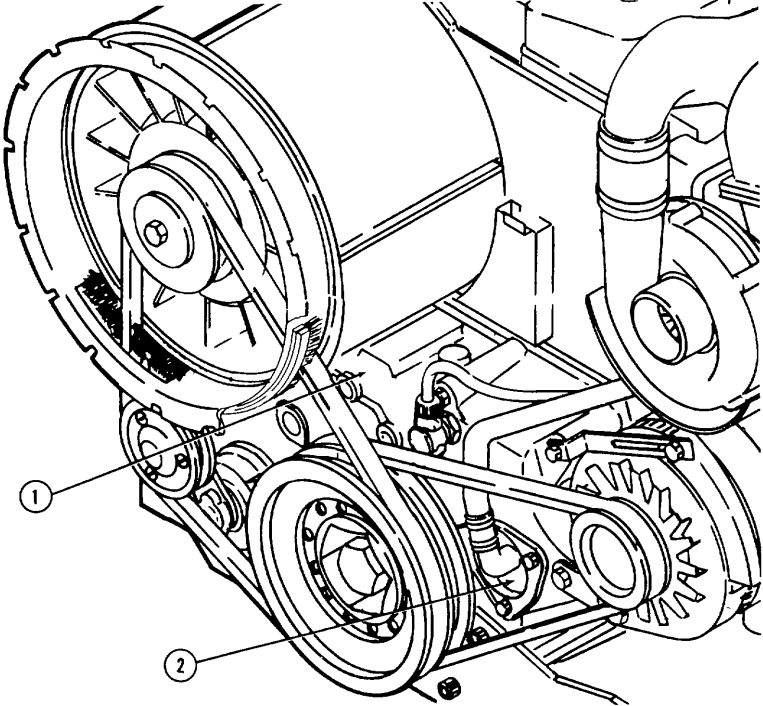
Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
9			•		Crankcase Breather	<p>Check hose (1) for cracks</p> <p>Check that hose strap (2) is tight and hose (1) and breather (3) are firmly attached</p> <p>Check that hose (1) is retained by retaining plate (4)</p> <p>Check for leaks</p> 

Table 2-1. Organizational Preventive Maintenance Checks and Services - Continued

W - Weekly
M - Monthly

Q - Quarterly
S - Semiannually

Item No.	Interval				Item To Be Inspected	Procedures
	W	M	Q	H		
10				•	Front Cover	<p>Check that front cover (1) is in place and not damaged</p> <p>Check for oil leak at joint between front cover (1) and crankcase.</p> <p>Check for oil leak at joint between front cover (1) and oil pump plate (2)</p> 

Section V. TROUBLESHOOTING

2-10. TROUBLESHOOTING

a. Table 2-2 contains troubleshooting information for locating and correcting most of the operating troubles which are the responsibility of organizational maintenance. Each malfunction for an individual component, unit, or system is followed by a list of tests or inspections which will help you to determine probable causes and corrective actions to take. Perform the tests/inspections and corrective actions in the order listed

b. This manual cannot list all malfunctions that may occur, nor all tests or inspections and corrective actions. If a malfunction is not listed or cannot be corrected by listed corrective actions, notify your supervisor

c. Only those functions within the scope of organizational maintenance are listed. For troubleshooting procedures within the scope of operator/crew maintenance, refer to TM 5-4320-306-10.

2-11. SYMPTOM INDEX

Refer to the Symptom Index below. Locate the malfunction which is the same, or most nearly the same, as the trouble you are having with the centrifugal pump unit. The Symptom Index lists the first page of troubleshooting information for that malfunction. Follow the steps one by one, and perform the corrective actions listed

Malfunction Number	Description	Page
1	Engine fails to crank or cranks very slowly	2-24
2	Engine cranks but fails to start	2-25
3	Engine runs unsteadily and power output is low	2-26
4	Engine starts but pump suction gage or pump discharge gage does not function	2-27
5	Dense exhaust smoke after warmup	2-27
6	Engine overheats	2-27
7	Low engine oil pressure	2-28
8	Charging indicator lamp (ALTERNATOR) lights when engine is running	2-28
9	Pump makes excessive noise	2-28
10	Pump output low	2-29

Table 2-2. Organizational Maintenance Troubleshooting

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
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CAUTION

During some troubleshooting procedures it may be necessary to run the engine. Since the pump is directly coupled to the engine, the pump will run when the engine runs. Do not run the pump without water in the volute. This will destroy the mechanical seal, causing pump failure. When necessary to run the pump for longer than a few seconds, make sure that suction and discharge hoses are installed and a source of water to be pumped is available. Start engine, prime and operate pump to duplicate normal operation and to prevent pump from overheating.

1. ENGINE FAILS TO CRANK OR CRANKS VERY SLOWLY

Step 1. Check fuse for corrosion or damage

Replace fuse (para 2-16).

Step 2. Check for weak batteries or dirty, corroded, or loose battery cable connections

Add distilled water as needed Recharge batteries or replace if defective (para 2-13)

Step 3. Check for dirty, corroded, or loose cable connections on starter and alternator (para 2-15).

Clean and tighten starter and/or alternator connections if necessary

Step 4. Check V-belts for breaks or cracks Check belt tension

Tighten or replace V-belts as necessary (para 2-25)

Step 5. Remove and check starter

Replace defective starter (para 2-34)

Step 6. If engine still will not crank or cranks slowly, the engine may be frozen or bound.

Notify direct support.

Table 2-2. Organizational Maintenance Troubleshooting

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
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2. ENGINE CRANKS BUT FAILS TO START

Step 1 Check that OIL BY-PASS switch has been depressed prior to starting

Press OIL BY-PASS switch and attempt to start engine (para 2-40)

Step 2 Check air cleaner intake restriction indicator for red band indicating blocked air cleaner elements

If red band appears in air cleaner restriction indicator and rain cap is not blocked and no damage to system components is found, replace primary and secondary elements (para 2-26).

Step 3. Be sure that fuel tank fill cap vent is in open position. A closed vent will cause a vacuum in the fuel tank and not allow fuel to flow freely to the fuel feed pump

If vent is in closed position, rotate cap vent to open position

Step 4. Check alinement of 3-way selector valve

Aline 3-way selector valve to open position (para 2-41).

Step 5 Check for empty fuel tank.

If fuel tank is empty, fill with diesel fuel oil and bleed air from fuel system

Step 6 Check fuel supply to injectors

If there is no fuel flow, replace fuel filter and clean fuel feed pump strainer as described in paragraphs 2-30 and 2-32

Step 7. Check air inlet and turbocharger for obstructions, carbon or dirt buildup on turbocharger impellers, or oil leaks.

Notify direct support.

Step 8. Check quick release link and lever extension for dirt, corrosion, damage, or loose nuts, washers, bolts, screws, and quick disconnect fittings

Clean, tighten hardware and quick disconnect fittings. Replace if severely damaged (para 2-24).

Step 9. Remove and check throttle actuator

Replace defective throttle actuator (para 2-24)

Table 2-2. Organizational Maintenance Troubleshooting

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
3. ENGINE RUNS UNSTEADILY AND POWER OUTPUT IS LOW		
Step 1	Check air cleaner intake restriction indicator for red band indicating blocked air cleaner elements	If red band appears in air cleaner restriction indicator and rain cap is not blocked and no damage to system components is found, replace primary and secondary elements (para 2-26)
Step 2	Be sure that fuel tank fill cap vent is in open position. A closed vent will cause a vacuum in the fuel tank and not allow fuel to flow freely to the fuel feed pump	If vent is in closed position, rotate cap vent to open position
Step 3	Check fuel supply to injectors	If there is no fuel flow, replace fuel filter and clean fuel feed pump strainer as described in paragraphs 2-30 and 2-32
Step 4	Check air inlet and turbocharger for obstructions, carbon or dirt buildup on turbocharger impellers, or oil leaks	Notify direct support
Step 5	a. Check quick release link and lever extension for dirt, corrosion, damage, or loose nuts, washers, bolts, screws, and quick disconnect fittings	Clean, tighten hardware and quick disconnect fittings Replace if severely damaged (para 2-24)
	b. Remove and check throttle actuator	Replace defective throttle actuator (para 2-24)
Step 6	Check magnetic pickup wiring for continuity, breaks, burrs, or fraying. Check for loose or damaged connectors.	Replace wires or connectors if broken or damaged (para 2-15 and 2-16)
Step 7.	Notify direct support	

Table 2-2. Organizational Maintenance Troubleshooting

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
4. ENGINE STARTS BUT PUMP SUCTION GAGE OR PUMP DISCHARGE GAGE DOES NOT FUNCTION		
Step 1 Check that valves are In open position.	Open valves	
Step 2. Gage IS damaged.	Replace gage (para 2-1 6)	
5. DENSE EXHAUST SMOKE AFTER WARMUP		
Step 1. Shut down engine. With engine level, check oil		
Step 2. Check air cleaner Intake restriction indicator for red band indicating blocked air cleaner elements	If red band appears In air cleaner restriction indicator and rain cap is not blocked and no damage to system components IS found, replace primary and secondary elements (para 2-26).	
Step 3. Check air intake piping for damage or obstructions	Remove obstructions, repair or replace (para 2-26).	
Step 4 Check turbocharger for leaking oil seals.	If the air filter and Intake ducts are not blocked, the turbocharger oil seals must be replaced Notify direct support.	
6. ENGINE OVERHEATS		
Step 1. Check cooling air ducting for damage and dirt	Notify direct support	
Step 2. Check V-belts for breaks or cracks Check belt tension	Tighten or replace V-belts (para 2-25)	
Step 3 Check exhaust system for an obstruction or damage.	Remove obstruction or replace damaged exhaust system components (para 2-28, 2-33, and 2-36).	
Step 4 Notify direct support.		

Table 2-2. Organizational Maintenance Troubleshooting

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
7. LOW ENGINE OIL PRESSURE		
Step 1.	Shut down engine and check oil system for leaks Check for damaged and leaking oil lines and fittings. Check inside control panel cover assembly for evidence of leakage from oil pressure indicator or oil pressure line hose. Check lube oil cooler for leaks. Examine area of crankcase directly below lube oil cooler. Notify direct support if lube oil cooler leaks. If leaks cannot be easily detected and engine can be run without damage, clean the engine as described below After engine is clean, start the engine and observe lubrication system for leaks	
	a. Remove accumulated dust and dirt with compressed air	
	b. Tighten loose components. Replace leaking components (para 2-16) If cover, front cover, or associated surfaces, other than fittings or fasteners, are leaking, notify direct support.	
8. CHARGING INDICATOR LAMP (ALTERNATOR) LIGHTS WHEN ENGINE IS RUNNING		
Step 1.	Check for weak batteries or dirty, corroded, or loose battery cable connections	
	Add distilled water as needed Recharge batteries or replace if defective (para 2-13)	
Step 2.	Check V-belts for breaks or damage. Check belt tension Check for damaged or frozen pulleys (table 2-1, item 6).	
	Tighten or replace V-belts as necessary (para 2-25) Replace alternator V-belt pulley (para 2-35)	
Step 3.	Check alternator.	
	Remove and test/inspect alternator (para 2-35) Replace alternator as required (para 2-35).	
9. PUMP MAKES EXCESSIVE NOISE		
Step 1.	Check that suction hose is immersed in liquid being pumped or properly connected to container from which liquid is being pumped Liquid level in container shall be above suction hose connection.	
	Relocate suction hose connection below surface of liquid Keep suction intake off of bottom when pumping (para 2-18)	
Step 2.	Check suction hoses, connections, or parting surface of suction flange for leaks	

Table 2-2. Organizational Maintenance Troubleshooting

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
	Step 3. Check for clogged strainer	Remove and clean strainer (para 2-18)
	Step 4. Inspect suction assembly strainer body and flanges for cracks or leaks	Repair or replace damaged suction assembly components (para 2-18)
	Step 5. Inspect discharge check valve assembly for proper operation. Check that extension spring and attaching hardware are tight and free of corrosion Inspect check valve assembly for evidence of leakage and seal damage. When in closed position, check valve disc must make an airtight seal. Be sure valve gasket disc is free to open with pump flow.	Repair or replace damaged discharge check valve (para 2-19 and 2-21)
	Step 6. Check pump body for foreign material	a. Remove suction assembly (para 2 18) and discharge manifold assembly (para 2-19) b. Inspect pump body for any foreign material or obstruction
10. PUMP OUTPUT LOW		
	Step 1. Be sure engine is primed	
	Step 2. Check that engine speed is properly adjusted for desired flow and conditions	Adjust engine speed
	Step 3. In order, perform steps 1 through 6 of Malfunction 8.	

Section VI. MAINTENANCE PROCEDURES

INDEX

	Para		Para
Air cleaner	2-26	Exhaust system	2-28
Air intake piping	2-26	Fuel feed pump	2-32
Air valve cover assembly	2-20	Fuel filter cartridges	2-30
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Battery cable assemblies	2-13	Muffler and exhaust pipe	2-28
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Data and warning plates	2-37	Strainer assembly	2-18
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Discharge elbow	2-19	Three-way selector valve	2-40
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Electrical system assembly	2-15	Tool box (and components)	2-38
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Ether start kit	2-23	V-belts	2-25
Exhaust manifold and suction pipe	2-36	V-belt pulley, alternator	2-35
Exhaust (turbine) elbow	2-33	Wiring harness (control panel)	2-17

2-12 GENERAL INSTRUCTIONS

Most maintenance instructions in this section will list resources required, personnel required, and equipment condition for the start of the procedure. Note the following:

- Resources required are not listed unless they apply to the procedure.
- Personnel required are listed only if the task requires more than one. If PERSONNEL is not listed, it means one person can do the task.
- The normal standard equipment condition to start a maintenance task is engine stopped and START/STOP switch set at STOP. EQUIPMENT CONDITION is not listed unless some other condition is required besides the power being off.
- Refer to Appendix D to determine torque requirements when tightening threaded fasteners, unless a specific torque value is given in the procedure. Standard torque values given in Appendix D are determined by thread size.

2-13. TEST/REPLACE/REPAIR BATTERY CABLE ASSEMBLIES, BATTERIES, AND CHARGING RECEPTACLE

This task covers:

- | | | |
|-----------------|---------------------------|-----------------|
| a. Removal | c. Inspection/Test/Repair | e. Installation |
| b. Dissassembly | d. Assembly | |

INITIAL SETUP:

Tools

Shop equipment, automotive maintenance and repair, common no. 1

Tool kit, general mechanics automotive

Voltmeter

Materials/Parts

Baking soda (Item 3, Appendix C)

Electrolyte (Item 5, Appendix C)

Grease (Item 7, Appendix C)

General Safety Instructions

Well-ventilated area.

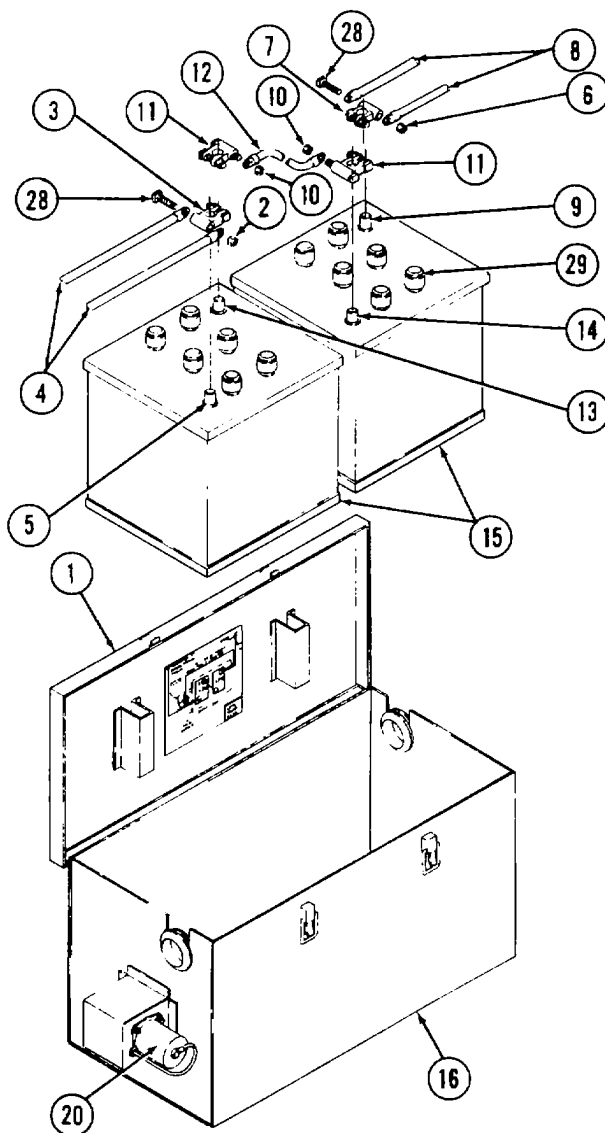
REMOVAL

WARNING

Serious injury could occur from the careless handling of storage batteries or battery electrolyte (acid). If acid is splashed on the skin, wash the affected area immediately with plenty of clean water. If acid is splashed in the eyes, wash immediately with plenty of clean water and get medical attention.

Do not allow engine side panel or battery box top to come in contact with electrical connections.

1. Remove engine side panel and open battery box top (1).



2-13. TEST/REPLACE/REPAIR BATTERY CABLE ASSEMBLIES, BATTERIES, AND CHARGING RECEPTACLE (Continued)

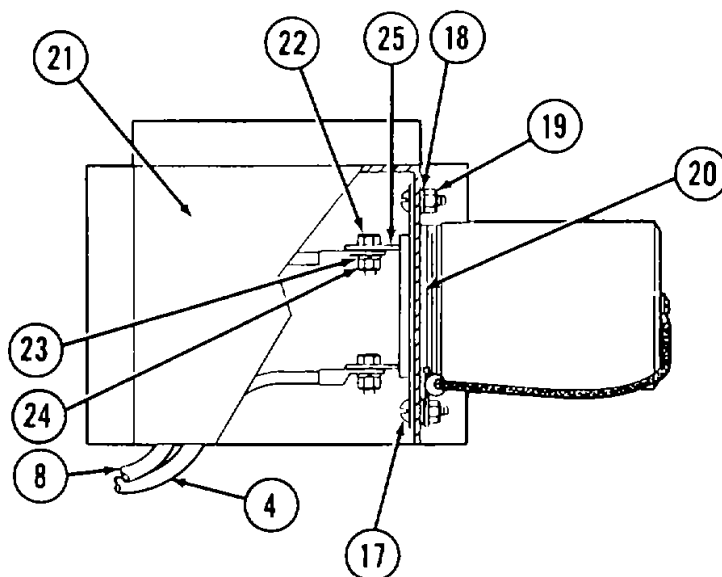
WARNING

Avoid making contact across the battery terminals. This can result in severe arcing which could cause an explosion resulting in bodily injury.

CAUTION

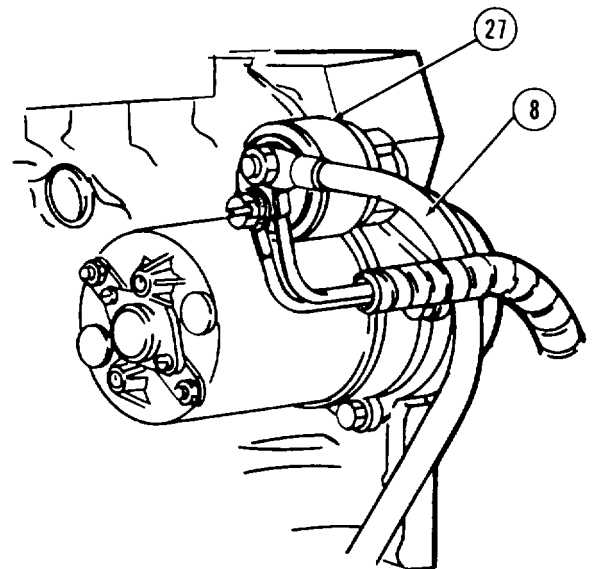
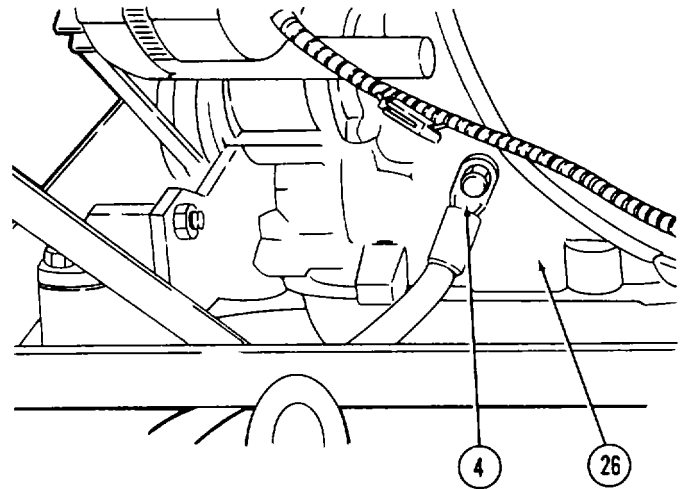
Disconnect battery cable from negative battery post before disconnecting any other leads from engine components. This precaution will prevent short circuits which could damage the alternator, voltage regulator, or other electrical components. When removing battery cable, use battery terminal puller to remove loosened terminal lugs. Forcing battery terminal lugs off without using puller may damage the battery posts. Never disconnect battery while alternator is operating. Never attempt to polarize the alternator.

- 2 Loosen nut (2) on terminal lug (3) Remove negative battery cable assembly (4) from negative battery post (5) using battery terminal puller.
- 3 Loosen nut (6) on terminal lug (7) Remove positive battery cable assembly (8) from positive battery post (9) using battery terminal puller
- 4 Loosen nuts (10) on terminal lugs (11) Remove jumper battery cable assembly (12) from positive battery post (13) and negative battery post (14) using battery terminal puller
- 5 Lift and remove batteries (15) from battery box (16)
- 6 Remove screws (17), lockwashers (18), and nuts (19) that secure charging receptacle (20) in bracket (21).
- 7 Push receptacle (20) inside bracket (21) and remove it through the bottom of the bracket
- 8 Remove screws (22), lockwashers (23), and nuts (24) that secure positive and negative battery cables (8 and 4) to receptacle terminals(25)



**2-13. TEST/REPLACE/REPAIR BATTERY CABLE ASSEMBLIES, BATTERIES, AND CHARGING RECEPTACLE
(Continued)**

9. Remove negative battery cable assembly (4) from engine (26)
10. Remove positive battery cable assembly (8) from starter relay (27)



**2-13. TEST/REPLACE/REPAIR BATTERY CABLE ASSEMBLIES, BATTERIES, AND CHARGING RECEPTACLE
(Continued)**

DISASSEMBLY

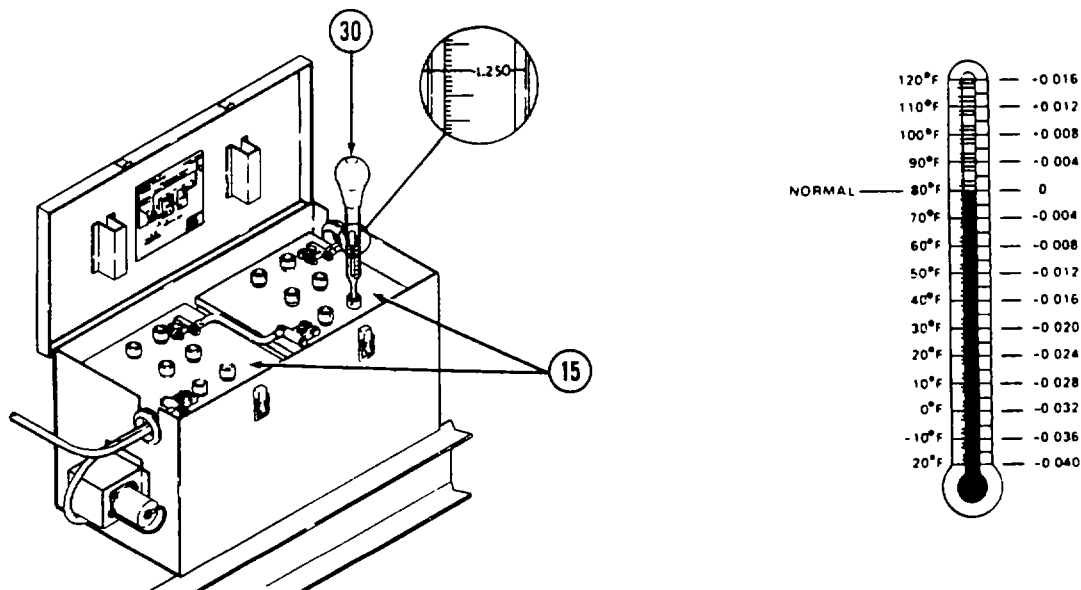
Disassemble screws (28), nuts (2, 6, and 10), and terminal lugs (3, 7, and 11) from positive battery cable assembly (8), negative battery cable assembly (4), and jumper battery cable assembly (12)

INSPECTION/TEST/REPAIR**WARNING**

Serious injury could occur from the careless handling of storage batteries or battery electrolyte (acid). If acid is splashed on the skin, wash the affected area immediately with plenty of clean water. If acid is splashed in the eyes, wash immediately with plenty of clean water and get medical attention.

1. Inspect battery posts (5, 9, 13, and 14) for corrosion. If corroded, clean with a solution of baking soda and water. Take care not to get baking soda solution in the battery cells.
2. Inspect battery (15) for cracks, loose posts, leakage, and other damage.

2-13. TEST/REPLACE/REPAIR BATTERY CABLE ASSEMBLIES, BATTERIES, AND CHARGING RECEPTACLE (Continued)



3. Remove filler cap (29) Using a hydrometer (30) check the specific gravity of the electrolyte. The specific gravity of a fully charged battery must be 1.250 minimum at 80°F (26°C). Measure the temperature of the battery electrolyte with an accurate thermometer. Compare the electrolyte temperature and the hydrometer specific gravity reading to the battery condition chart. Add or subtract (from your specific gravity reading) the decimal next to the temperature in degrees F that closely approximates the obtained electrolyte temperature. If the temperature corrected reading is below 1.250, charge the battery.

WARNING

Leave filler caps installed while battery is being charged. Charge battery in a well-ventilated area. Do not smoke or use open flame or spark-producing equipment in the vicinity of charging battery.

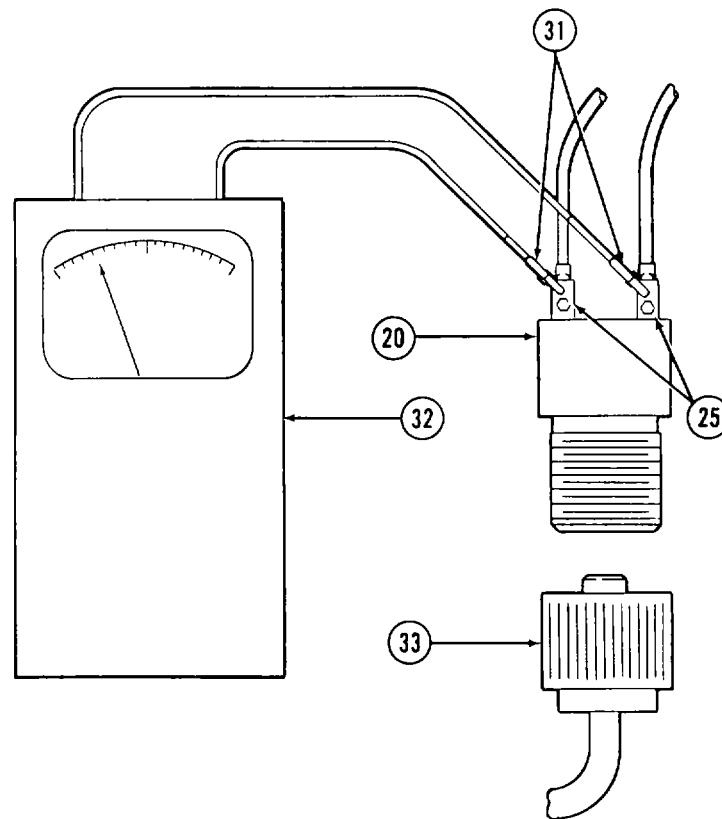
NOTE

The 6TN and 6TL batteries can be mixed or matched. However, maintenance-free batteries cannot be mixed or matched with military batteries. Use an electrolyte with a specific gravity of 1.280.

4. If battery will not hold the charge, discard and replace with new battery. Add electrolyte to new battery and charge before installation.
5. Inspect terminal lugs (3, 7, and 11), screws (28), and nuts (2, 6, and 10) for corrosion. If corroded, clean with a solution of baking soda and water. Inspect screws and nuts for damaged threads. Replace if damaged.
6. Inspect ends of cables (4, 8, and 12) for corrosion. If corroded, clean with a solution of baking soda and water.

2-13. TEST/REPLACE/REPAIR BATTERY CABLE ASSEMBLIES, BATTERIES, AND CHARGING RECEPTACLE
(Continued)

7. Test cables for electrical continuity between cable ends Replace cables that do not have continuity.
8. Inspect cable ends for damage and cable insulation for breaks Replace damaged cables



9. Test charging receptacle as follows
 - a. Connect positive and negative leads (31) of voltmeter (32) to positive and negative terminals (25) of charging receptacle (20)
 - b. Connect recharging cable (33) to receptacle (20) and apply recharging power
 - c. The voltmeter (32) reading should equal the recharging voltage applied (approximately 24 volts). If the reading is below the required voltage, replace charging receptacle (20)

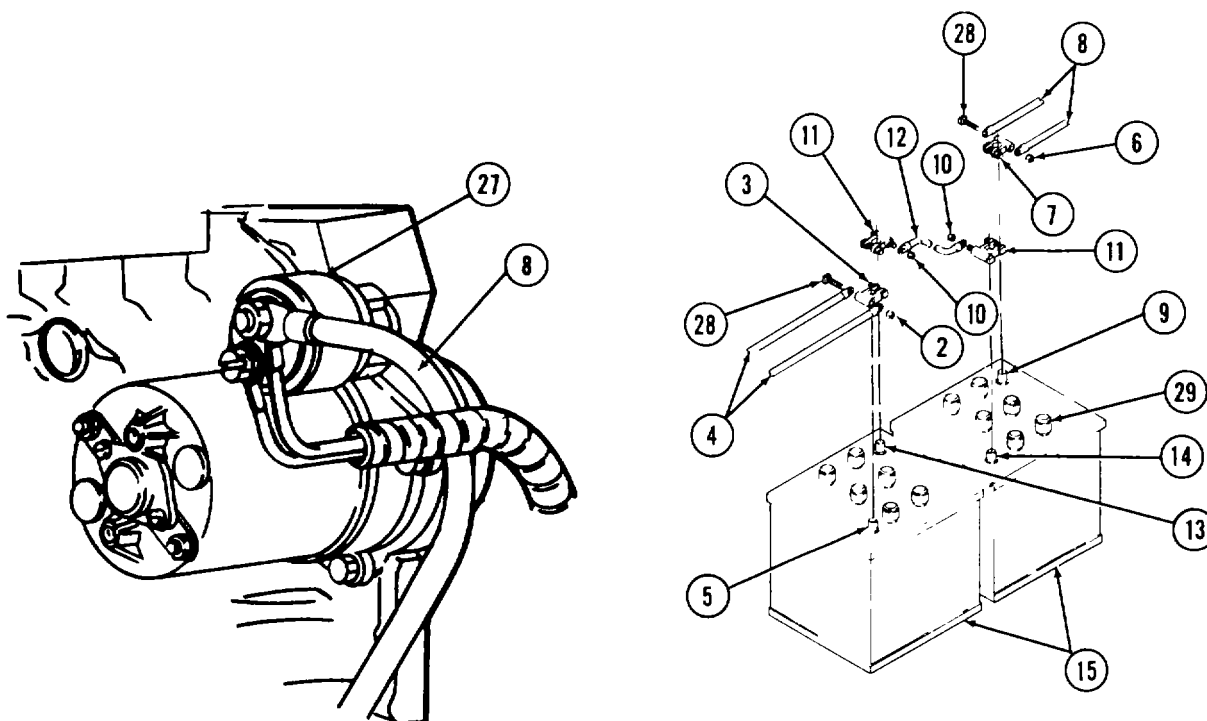
**2-13. TEST/REPLACE/REPAIR BATTERY CABLE ASSEMBLIES, BATTERIES, AND CHARGING RECEPTACLE
(Continued)**

ASSEMBLY/TEST

1. Assemble screws (28), nuts (2, 6, and 10), and terminal lugs (3, 7, and 11) onto positive battery cables (8), negative battery cables (4), and jumper battery cable (12).
2. Test positive battery cable assembly and negative battery cable assembly for electrical continuity between terminal lugs (3 and 7) and opposite end of cables
3. Test jumper battery cable assembly for electrical continuity between the two terminal lugs (11)
4. Inspect cables that do not have continuity for good electrical connection between cable ends and terminal lugs If connections are good, inspect cable according to INSPECTION/ TEST/REPAIR steps 6, 7, and 8

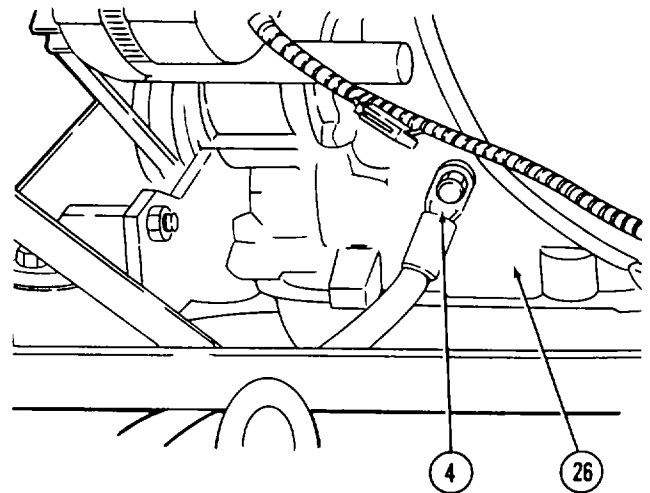
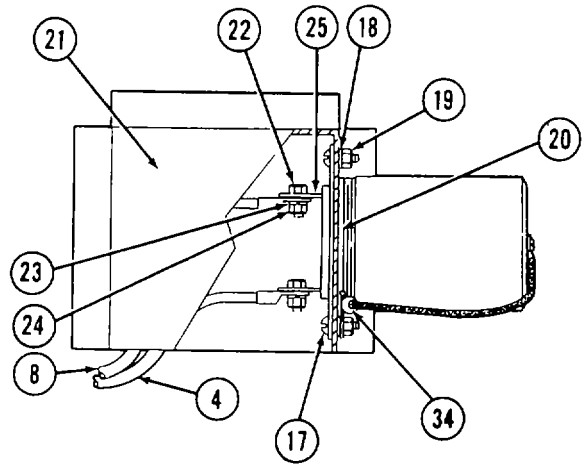
INSTALLATION

1. Reconnect positive battery cable (8) to starter relay (27).



2-13. TEST/REPLACE/REPAIR BATTERY CABLE ASSEMBLIES, BATTERIES, AND CHARGING RECEPTACLE (Continued)

- 2 Using screws (22), lockwashers (23), and nuts (24), secure battery cables (4 and 8) to receptacle terminals (25)
- 3 From the bottom of bracket (21), install receptacle (20) through the mounting hole at the front of bracket (21)
- 4 Using screws (17), lockwashers (18), and nuts (19), secure receptacle (20) in bracket (21).
- 5 Be sure lanyard eyelet (34) is secured to one of the screws (17) when installing mounting nuts (19) and lockwashers (18).
- 6 Reconnect negative battery cable assembly (4) to engine (26)

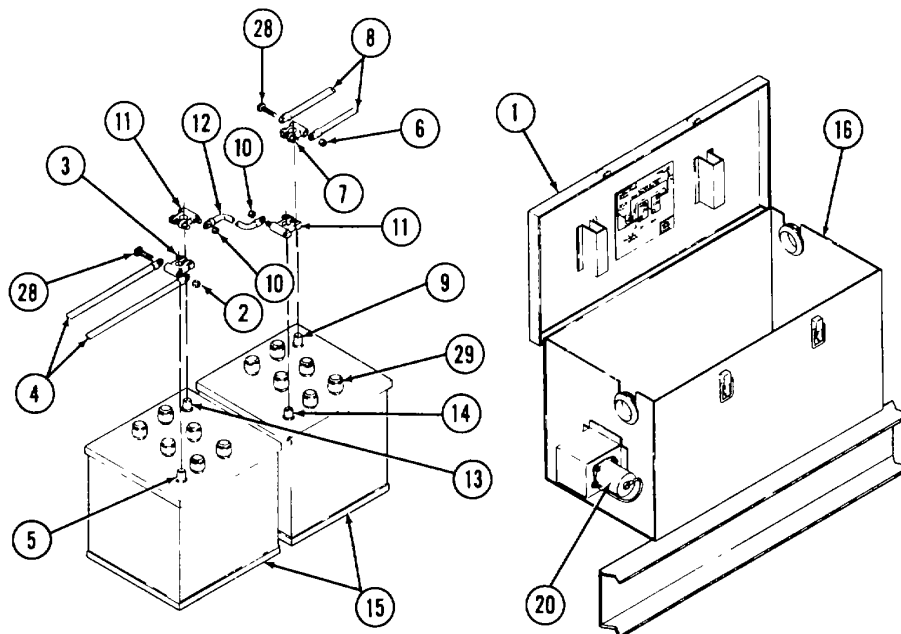


2-13. TEST/REPLACE/REPAIR BATTERY CABLE ASSEMBLIES, BATTERIES, AND CHARGING RECEPTACLE (Continued)

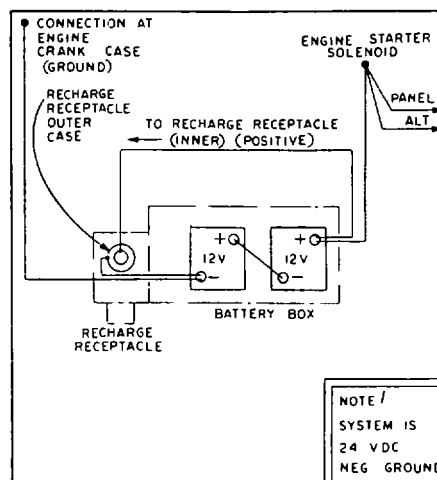
- 7 Place batteries (15) in battery box (16)

WARNING

Connect positive battery cables to battery first to prevent shocks and damage to other electrical system components.



- 8 Make sure posts (5, 9, 13, and 14) and terminal lugs (3, 7, and 11) are clean. Install positive battery cable assembly (8) to positive battery post (9) as shown on battery circuit plate. Tighten nut (6) securely. Cover terminals and posts with grease
- 9 Install negative battery cable assembly (4) to negative battery post (5) as shown on battery circuit plate. Tighten nut (2) securely. Cover terminals and posts with grease.
- 10 Install jumper battery cable assembly (12) to negative battery post (14) and positive battery post (13) as shown on battery circuit plate. Tighten nuts (10) securely. Cover terminals and posts with grease.
- 11 Close battery box top (1). Be sure catches are securely fastened over strikes.



2-14. REPLACE/REPAIR BATTERY BOX ASSEMBLY

This task covers a. Removal c. Installation
 b. Inspection/Repair

INITIAL SETUP

Tools

Shop equipment, automotive maintenance and repair, common no. 1

Tool kit, general mechanics automotive

Equipment Condition Para

2-13

Condition Description

Battery cables and batteries removed

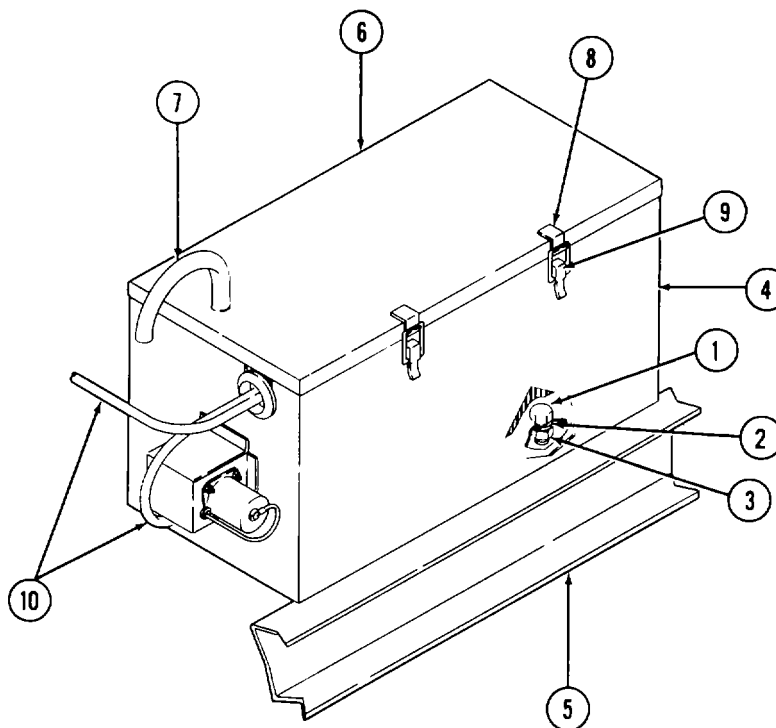
REMOVAL:

WARNING

Serious injury could occur from the careless handling of battery electrolyte (acid). If acid is splashed on the skin, wash the affected area immediately with plenty of clean water. If acid is splashed in the eyes, wash immediately with plenty of clean water and get medical attention.

Do not smoke or use open flame or spark-producing equipment.

- 1 Remove mounting screws (1), washers (2), and nuts (3)
- 2 Remove battery box (4) from skid (5)



2-14. REPLACE/REPAIR BATTERY BOX ASSEMBLY (Continued)

INSPECTION/REPAIR:

- 1 Inspect battery box (4) and battery box top (6) for minor dents, rust, acid corrosion, or other damage. Repair minor dents, rust, or corrosion. If damage is major or acid has corroded the battery box (4) extensively, replace it. If there are holes in box (4) and/or top (6), replace as required.

NOTE

If weld nuts in skid frame are stripped, notify direct support.

- 2 Inspect vent tube (7) for blockage, corrosion, or damage. Replace if blockage cannot be cleared.
- 3 Inspect hinge, strikes (8), and catches (9) for damage, rust, acid corrosion, or malfunction. If hinge, strikes, or catches do not function properly, notify direct support.

INSTALLATION:

- 1 Position battery box (4) over mounting holes on skid (5).
 - 2 Install screws (1), washers (2), and nuts (3). Tighten securely.
-

2-15. TEST/REPLACE/REPAIR ELECTRICAL SYSTEM ASSEMBLY

This task covers- a. Removal c. Installation
 b. Testing/Inspection

INITIAL SETUP

Tools

Shop equipment, automotive maintenance and repair, common no 1
 Tool kit, general mechanics automotive

Equipment Condition

Para
 2-13

Condition Description

Negative battery cable disconnected
 Positive battery cable disconnected from starter relay

Materials/Parts

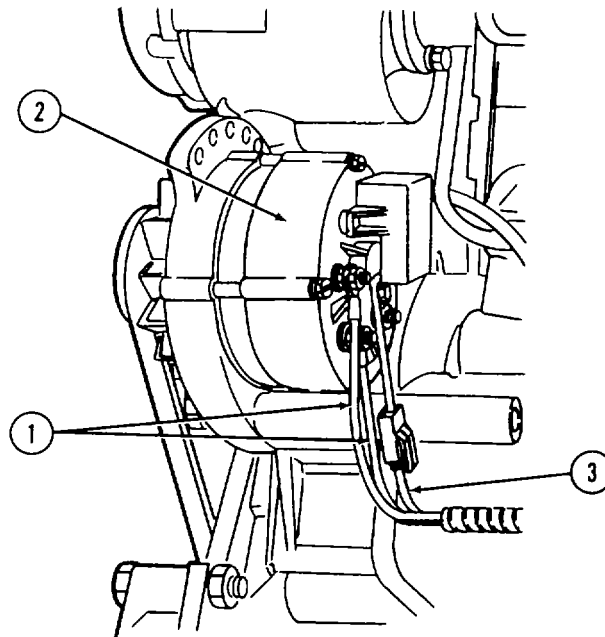
Insulation tape (Item 20, Appendix C)

REMOVAL:

CAUTION

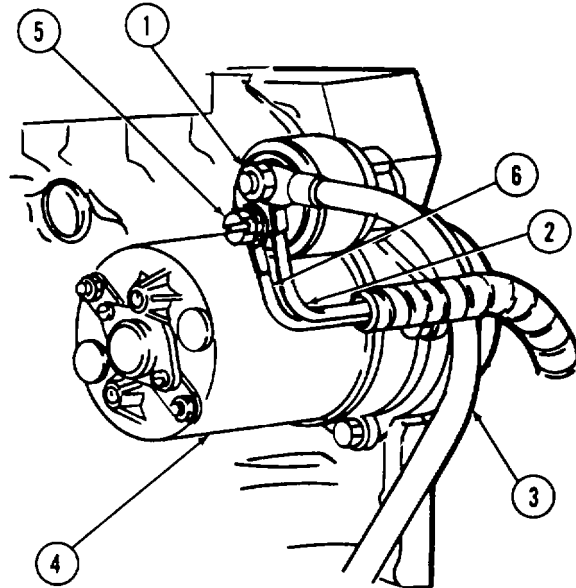
Disconnect negative battery cable before attempting repairs on electrical system.

- 1 Tag and remove two wires (1) from alternator (2).
- 2 Tag and disconnect wire (3) from alternator.

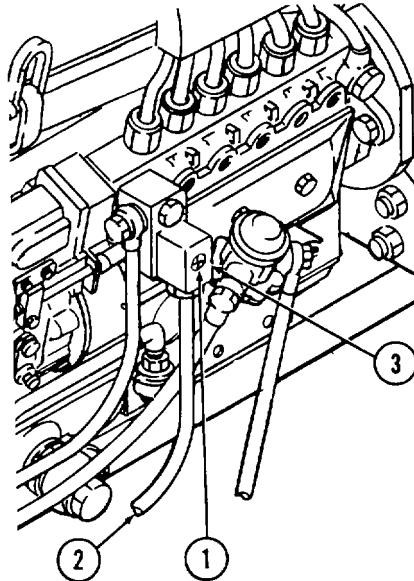


2-15. TEST/REPLACE/REPAIR ELECTRICAL SYSTEM ASSEMBLY (Continued)

- 3 Remove nut (1). Tag and remove wire (2) and cable (3) from starter (4).
- 4 Remove screw (5). Tag and remove wire (6).

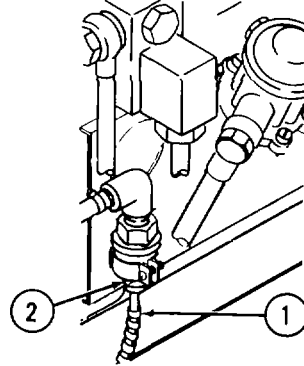


- 5 Loosen screw (1). Tag wire cable (2) and unplug cover (3) from engine solenoid valve (shutdown).

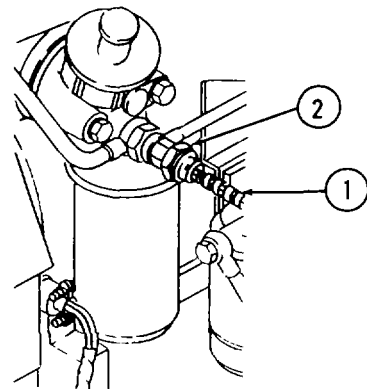


2-15. TEST/REPLACE/REPAIR ELECTRICAL SYSTEM ASSEMBLY (Continued)

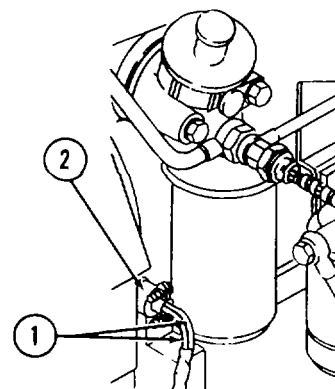
- 6 Tag and unplug wire cable (1) from oil pressure switch (2).



- 7 Tag wire cable (1) and remove from oil pressure sending unit (2) (high/low oil pressure sending unit).

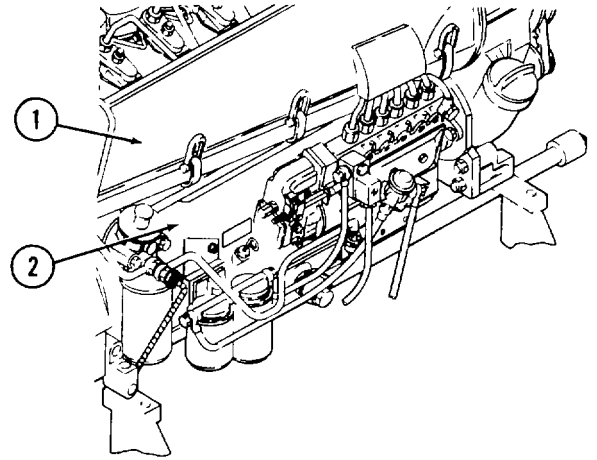


- 8 Tag wires (1) and unscrew connector from magnetic pickup (2).



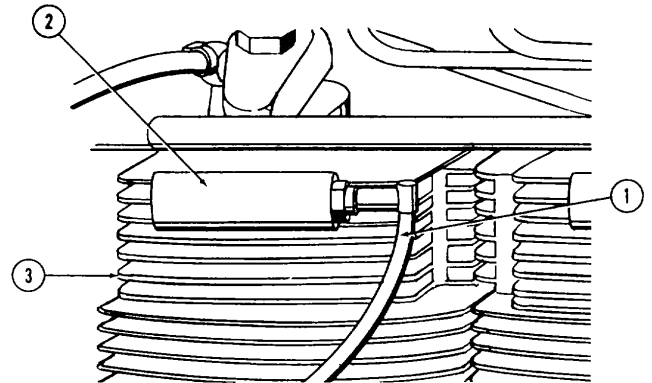
2-15. TEST/REPLACE/REPAIR ELECTRICAL SYSTEM ASSEMBLY (Continued)

9 Remove air cowling (1) from engine (2).

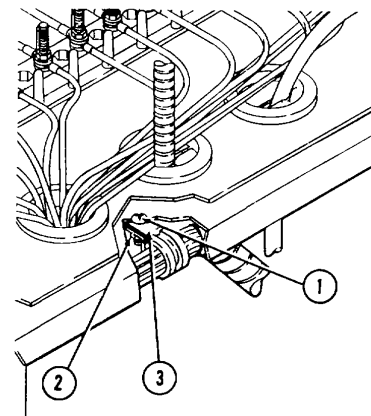


10 Tag and remove wire (1) from thermoswitch (2) on cylinder head (3).

11 Remove ground wire from pump.

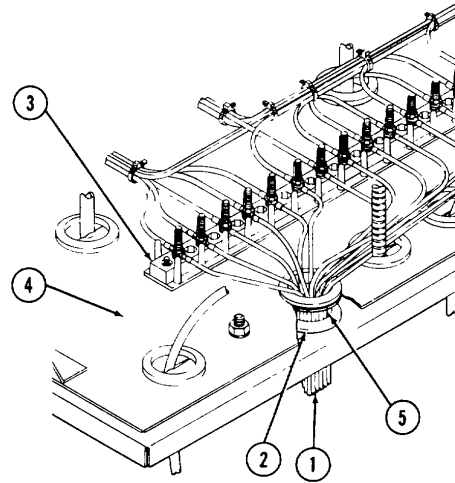


12 Remove screw (1), nut (2), and clamp (3).



2-15. TEST/REPLACE/REPAIR ELECTRICAL SYSTEM ASSEMBLY (Continued)

- 13 Tag wires (1) below bottom grommet (2) to aid in removal Disconnect wires from terminal block (3) on control panel back (4).
- 14 Remove wires (1) through bottom hole (5) on control panel back (4).

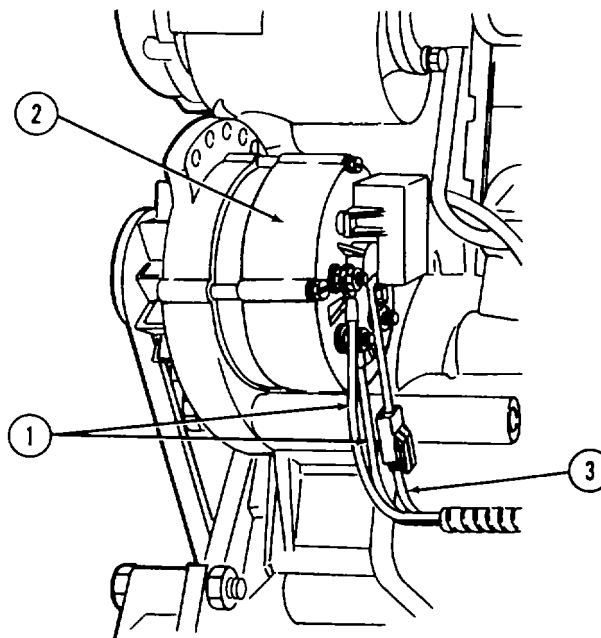


TESTING/INSPECTION:

Test wires and cables for continuity and inspect for broken, burred, damaged, or frayed wiring. Check for loose or damaged connectors on wires and cables.

INSTALLATION:

- 1 Replace wires, cables, and connectors if broken or damaged.
- 2 Connect wires (1 and 3) to alternator (2).

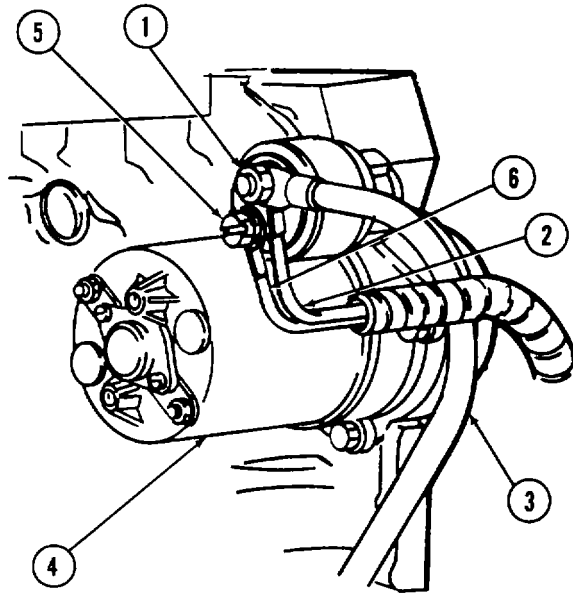


NOTE

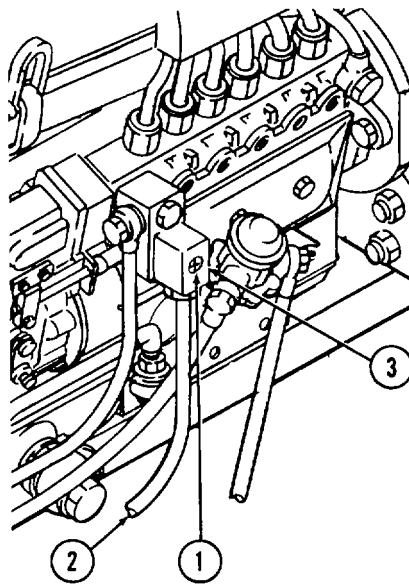
If wires could not be removed but are damaged, replace associated component and wiring.

2-15. TEST/REPLACE/REPAIR ELECTRICAL SYSTEM ASSEMBLY (Continued)

- 3 Connect wire (6). Secure with screw (5).
- 4 Connect wire (2) and cable (3) to starter (4). Secure with nut (1).

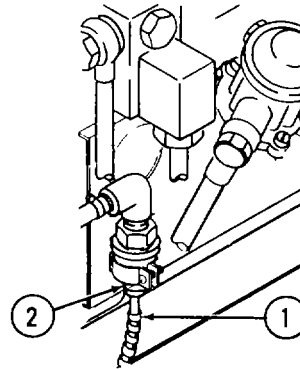


- 5 Connect wire cable (2) and plug cover (3) into engine solenoid valve (shutdown) Tighten screw (1).

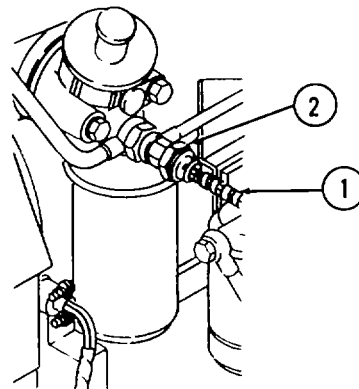


2-15. TEST/REPLACE/REPAIR ELECTRICAL SYSTEM ASSEMBLY (Continued)

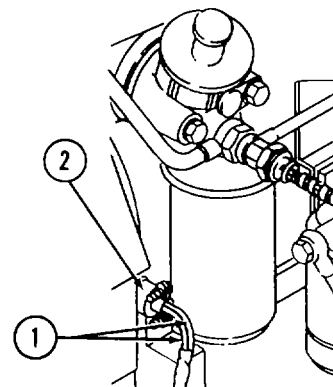
- 6 Connect wire cable (1) to oil pressure switch (2).



- 7 Connect wire cable (1) to oil pressure sending unit (2).

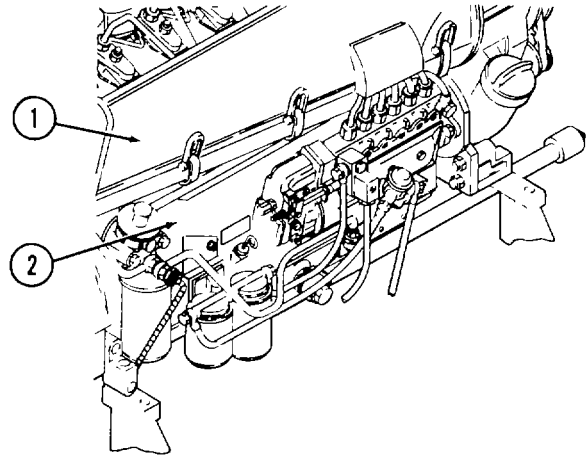


- 8 Connect wires (1) to magnetic pickup (2).

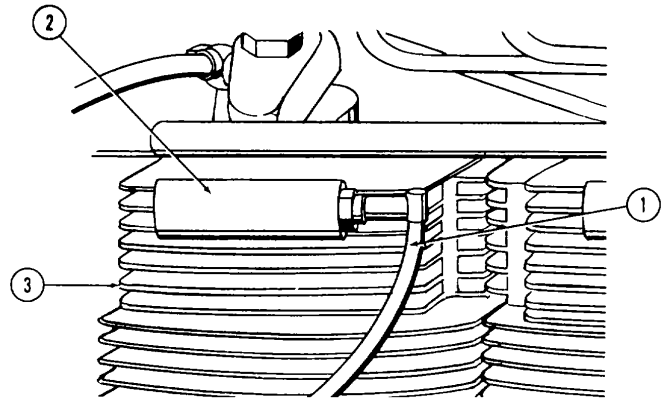


2-15. TEST/REPLACE/REPAIR ELECTRICAL SYSTEM ASSEMBLY (Continued)

9 Install air cowling (1) on engine (2).

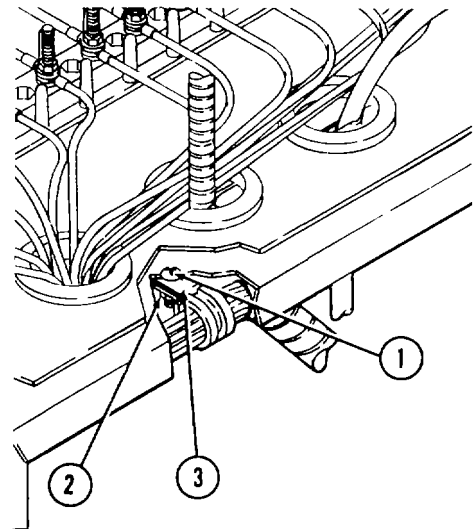


10 Connect wire (1) to thermoswitch (2) on cylinder head (3)

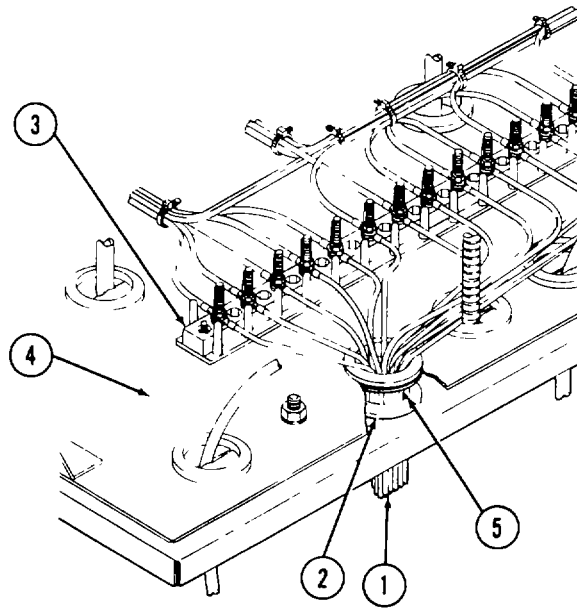


11 Attach ground wire to pump.

12 Install clamp (3), screw (1), and nut (2).



2-15. TEST/REPLACE/REPAIR ELECTRICAL SYSTEM ASSEMBLY (Continued)



13 Insert wires (1) through bottom hole (5) at bottom of control panel back (4).

14 Connect wires (1) to terminal block (3) at control panel back (4).

2-16. REPLACE/REPAIR CONTROL PANEL ASSEMBLY

This task covers **a. Removal** **c Repair**
 b. Testing/Inspection **d. Installation**

INITIAL SETUP

Tools

Shop equipment, automotive maintenance and repair, common no. 1

Tool kit, general mechanics automotive

Equipment Condition

Para

Condition Description

- Engine shut down and cool
- 2-13 Negative battery cable disconnected.
- 2-15 Electrical system assembly removed.

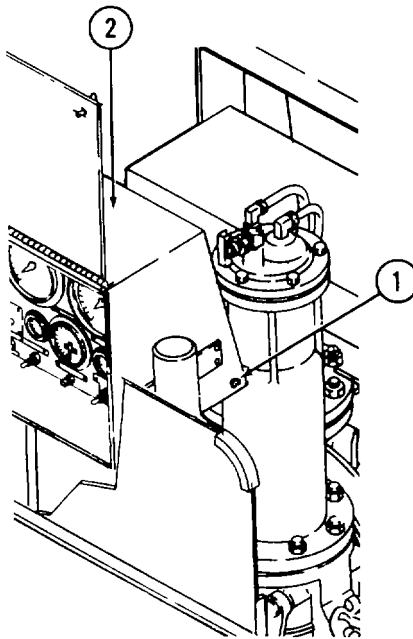
REMOVAL:

CAUTION

Control panel assembly must be removed carefully in order not to damage cables or instruments.

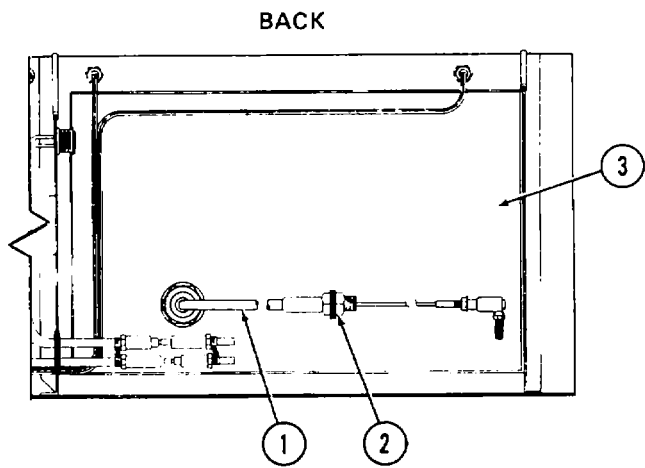
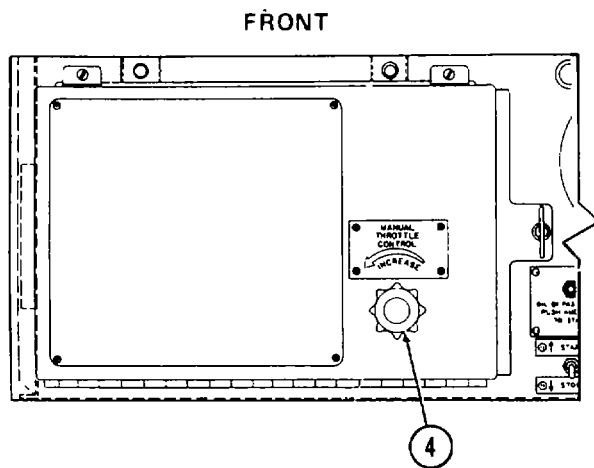
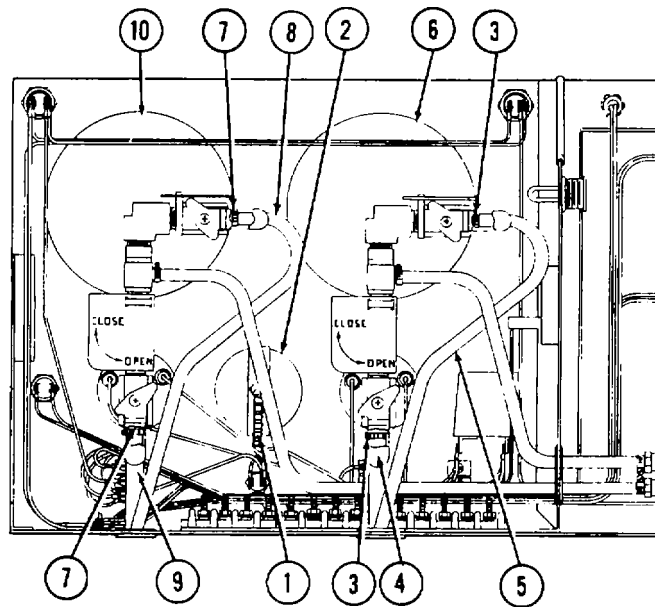
For ease of reassembly, tag all wires and mounting hardware when removed.

- 1 Release wing head studs (1) and lift off control panel cover assembly (2).



2-16. REPLACE/REPAIR CONTROL PANEL ASSEMBLY (Continued)

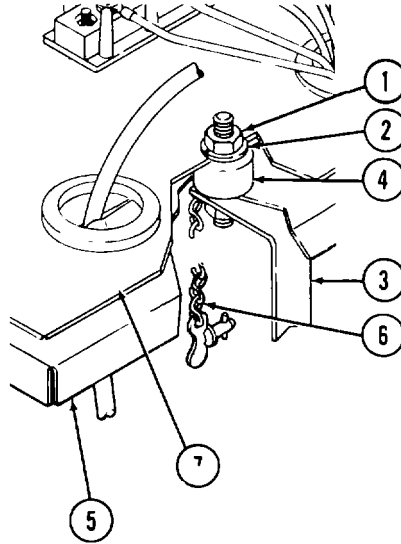
- 2 Tag, disconnect, and remove tachometer cable (1) from back of tachometer (2).
- 3 Tag, loosen clamps (3), and remove suction pressure hoses (4 and 5) from back of pump suction pressure gage (6).
- 4 Tag, loosen clamps (7), and remove discharge pressure hoses (8 and 9) from back of pump discharge pressure gage (10).



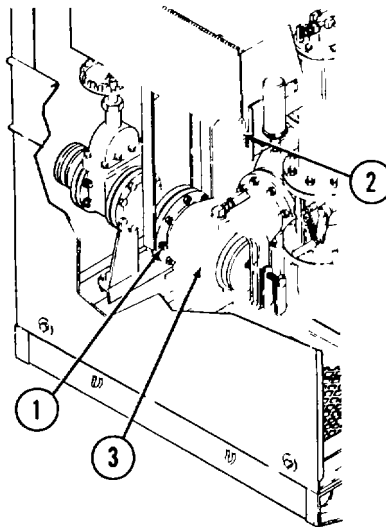
- 5 Disconnect throttle control cable (1) at quick release (2) on back of throttle panel assembly (3)
- 6 Remove throttle control knob and vernier (4) through front of throttle panel assembly (3)

2-16. REPLACE/REPAIR CONTROL PANEL ASSEMBLY (Continued)

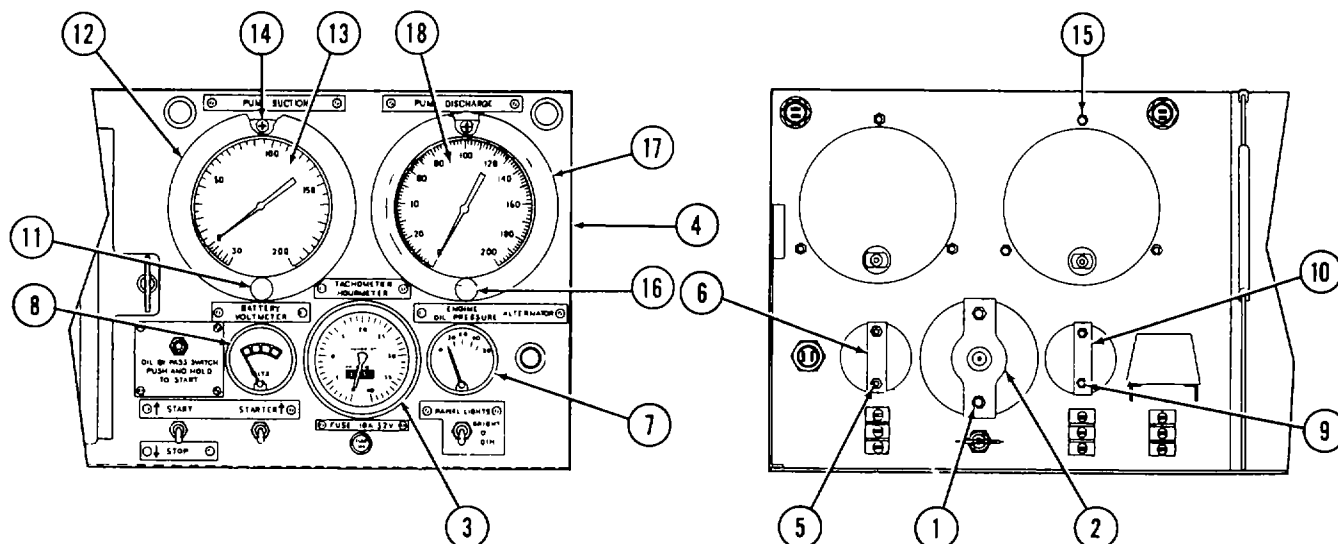
- 7 Remove nuts (1), lockwashers (2), and bracket (3) from shock mounts (4) under control panel base plate assembly (5). Remove chains (6) from shock mounts.
- 8 Carefully lift and remove control panel assembly (7).



- 9 Remove four nuts and lockwashers (1) that attach control panel base plate assembly (2) to strainer (3) on suction assembly
- 10 Remove control panel base plate assembly (2).

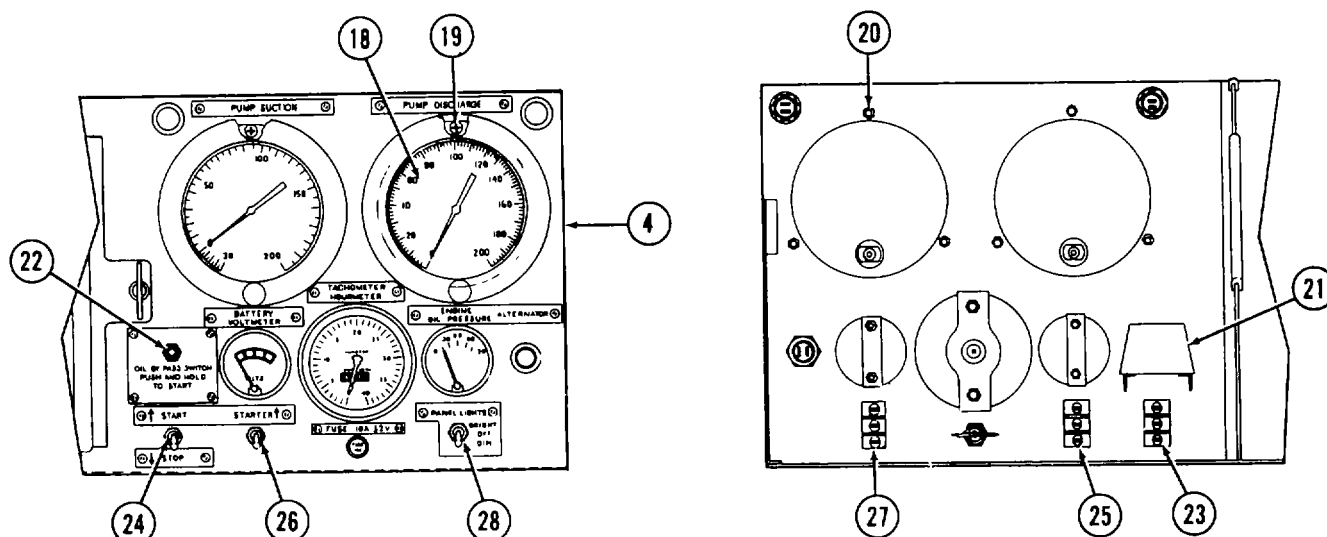


2-16. REPLACE/REPAIR CONTROL PANEL ASSEMBLY (Continued)



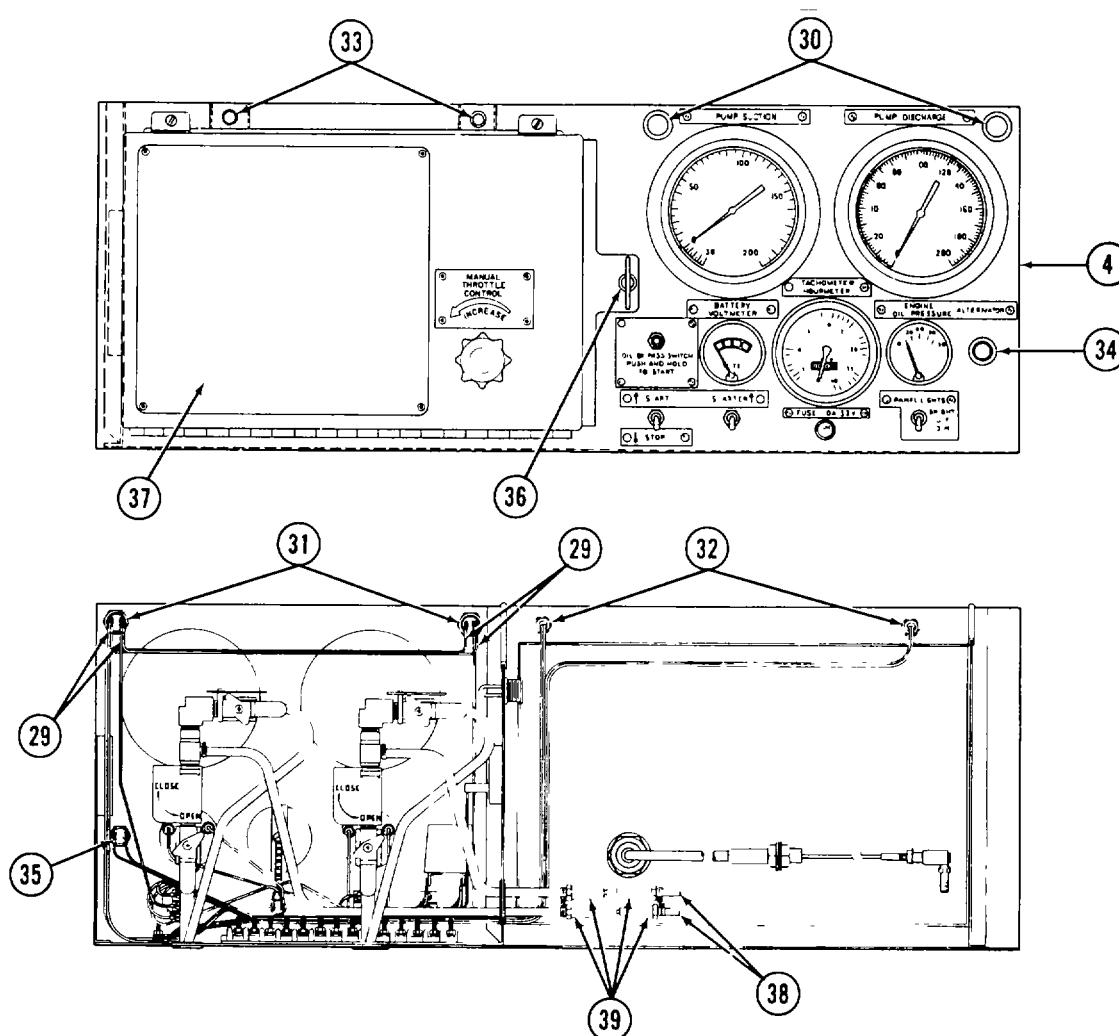
- 11 Remove nuts and lockwashers (1) from back of tachometer/hourmeter mounting bracket (2).
- 12 Remove mounting bracket (2).
- 13 Carefully slide TACHOMETER/HOURMETER (3) out through front of control panel (4).
- 14 Remove nuts and lockwashers (5) from back of oil pressure indicator mounting bracket (6).
- 15 Remove oil pressure indicator mounting bracket (6).
- 16 Tag and remove wires from ENGINE OIL PRESSURE indicator (7).
- 17 Carefully slide indicator out through front of control panel (4).
- 18 Tag and remove wires from BATTERY VOLTMETER (8).
- 19 Remove nuts and lockwashers (9) from battery voltmeter mounting bracket (10).
- 20 Remove mounting bracket (10).
- 21 Carefully remove BATTERY VOLTMETER (8) through front of control panel (4).
- 22 Remove thumbscrew (11) and bezel (12) securing compound gage (PUMP SUCTION) (13) to front of control panel (4).
- 23 Remove screws (14) and nuts and lockwashers (15).
- 24 Carefully remove compound gage (13) through front of control panel (4).
- 25 Remove thumbscrew (16) securing pressure gage (PUMP DISCHARGE) (18) and bezel (17) to front of control panel (4).

2-16. REPLACE/REPAIR CONTROL PANEL ASSEMBLY (Continued)



- 26 Remove screws (19) and nuts and lockwashers (20).
- 27 Carefully remove pressure gage (18) through front of control panel (4).
- 28 Tag and remove wires from OIL BY-PASS SWITCH (21).
- 29 Remove nut and washer (22) from OIL BY-PASS SWITCH (21).
- 30 Remove switch from back of control panel (4).
- 31 Tag three wires on START/STOP switch (23). Remove two screws and three wires from switch.
- 32 Remove nut and spring lockwasher (24) from START/STOP switch (23).
- 33 Remove switch from back of control panel (4).
- 34 Tag three wires on STARTER switch (25). Remove two screws and three wires from switch.
- 35 Remove nut and spring lockwasher (26) from STARTER switch (25).
- 36 Remove switch from back of control panel (4).
- 37 Tag six wires on PANEL LIGHTS switch (27). Remove three screws and six wires from switch.
- 38 Remove nut and spring lockwasher (28) from PANEL LIGHTS switch (27).
- 39 Remove switch from back of control panel (4).

2-16. REPLACE/REPAIR CONTROL PANEL ASSEMBLY (Continued)



- 40 Tag seven wires (29) on panel lights (30). Remove four screws and seven wires (29) from panel lights (30).
- 41 Remove knurled nut (31) from back of light fixtures.
- 42 Remove panel lights (30) from front of control panel (4).
- 43 Tag and remove four wires (32) from panel lights (33).
- 44 Pull panel lights (33) from front of control panel (4).
- 45 Tag and remove two wires from charging indicator lamp (ALTERNATOR) (34)
- 46 Remove nut (35) from back of indicator lamp (34).
- 47 Remove charging indicator lamp (34) through front of control panel (4).
- 48 With extreme care, release wing nut (36) on right side of throttle panel (37). Hinge out throttle panel 60 degrees toward front of unit.
- 49 Disconnect two fluid hoses (38) at quick disconnects (39).
- 50 Remove throttle panel (37) from front of control panel (4).

2-16. REPLACE/REPAIR CONTROL PANEL ASSEMBLY (Continued)

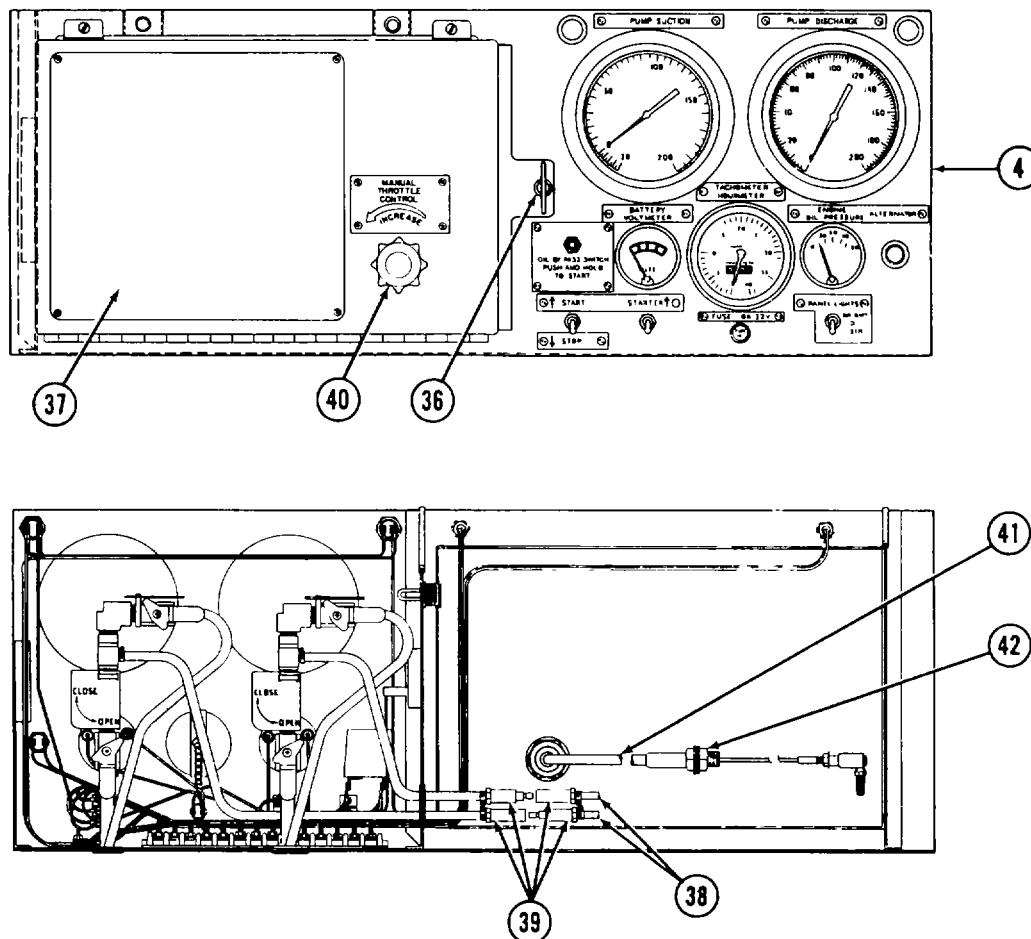
TESTING/INSPECTION

- 1 Test for continuity wires located in throttle panel for following items ENGINE OIL PRESSURE indicator, BATTERY VOLTMETER, OIL BY-PASS SWITCH, START/STOP switch, STARTER switch, PANEL LIGHTS switch, and panel lights. Test for continuity from the gage/instrument/switch wire end to the wire end connected to terminal strip. Inspect for broken, burred, damaged, or frayed wiring. Replace damaged or defective wires.
- 2 Inspect control panel, control panel cover assembly, throttle panel, and control panel base plate assembly for cracks, rust, corrosion, and for damaged or stripped threads. Check that identification and performance data plates are in place and readable.

REPAIR:

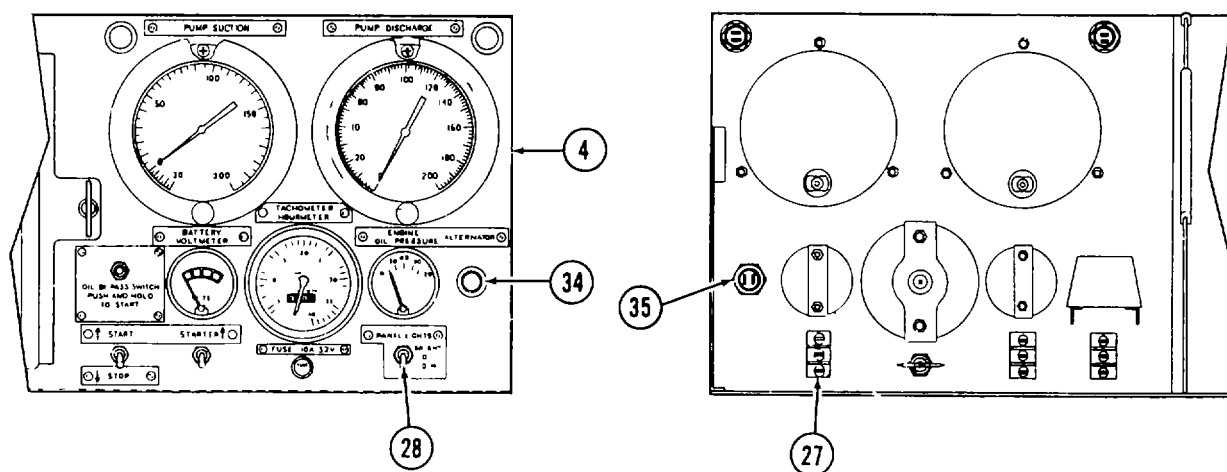
- 1 Repair minor dents, rust, or corrosion on control panel, control panel cover assembly, throttle panel, and control panel base plate assembly. If severely damaged, dented, rusted, or corroded, replace.
- 2 Replace identification and performance data plates as necessary.

INSTALLATION :



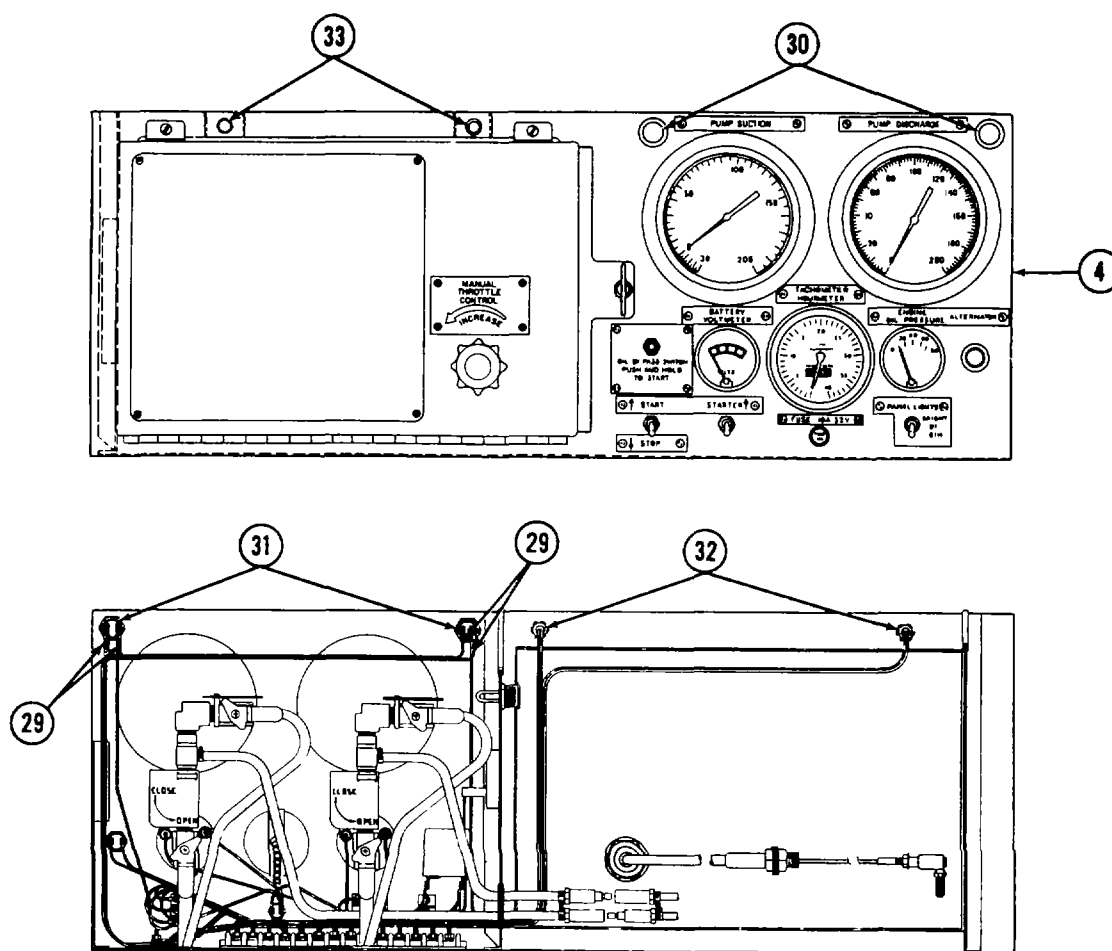
2-16. REPLACE/REPAIR CONTROL PANEL ASSEMBLY (Continued)

- 1 Place left side of throttle panel (37) in left opening of control panel (4) with right side of throttle panel angled out 60 degrees toward front of unit.
- 2 Connect two fluid hoses (38) at quick disconnects (39).
- 3 Position the right side of the throttle panel (37) in control panel (4) and fasten wing nut (36) on right side of throttle panel.
- 4 Install throttle knob and vernier (40) through front of throttle panel (37).
- 5 Connect and lock throttle control cable (41) at quick release (42) on back of throttle panel.



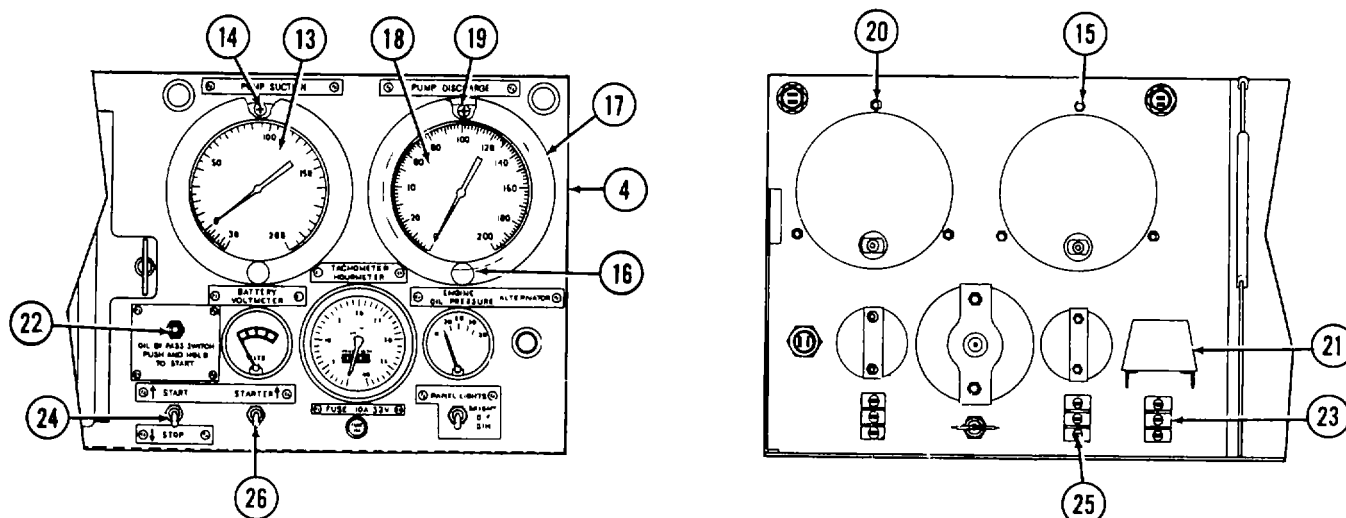
- 6 Install charging indicator lamp (ALTERNATOR) (34) through front of control panel (4).
- 7 Install nut (35) at back of indicator lamp (34).
- 8 Attach two tagged wires.
- 9 Install PANEL LIGHTS switch (27) through back of control panel (4).
- 10 Install nut and spring lockwasher (28) on PANEL LIGHTS switch (27).
- 11 Attach six tagged wires to PANEL LIGHTS switch (27) with three screws.

2-16. REPLACE CONTROL PANEL ASSEMBLY (Continued)



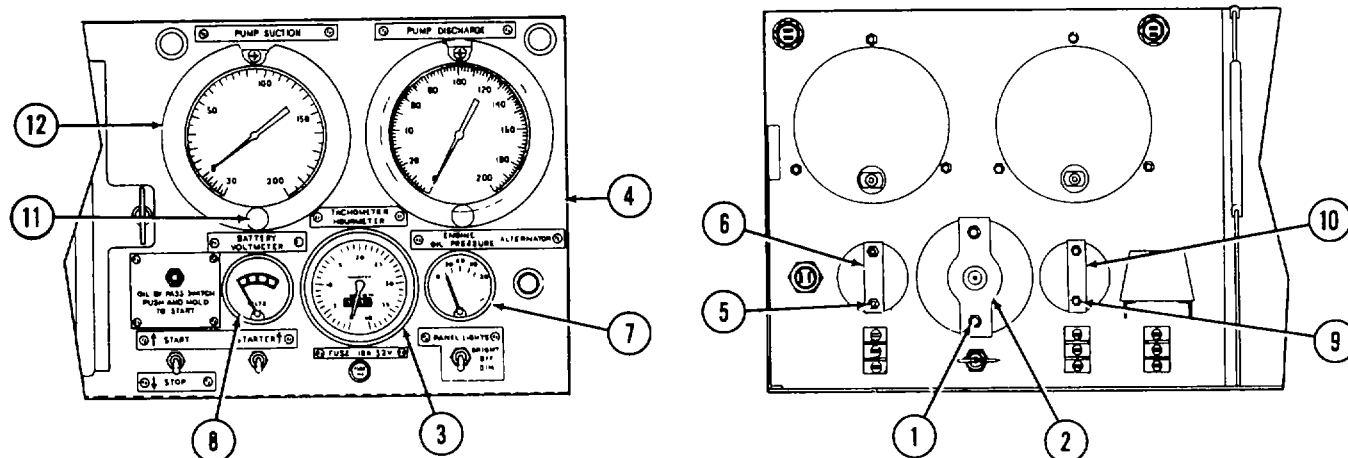
- 12 Install panel lights (30) through front of control panel (4).
- 13 Install knurled nut (31) on back of light fixtures.
- 14 Attach seven tagged wires (29) with four screws.
- 15 Insert panel lights (33) through front of control panel (4).
- 16 Attach four tagged wires (32).

2-16. REPLACE/REPAIR CONTROL PANEL ASSEMBLY (Continued)



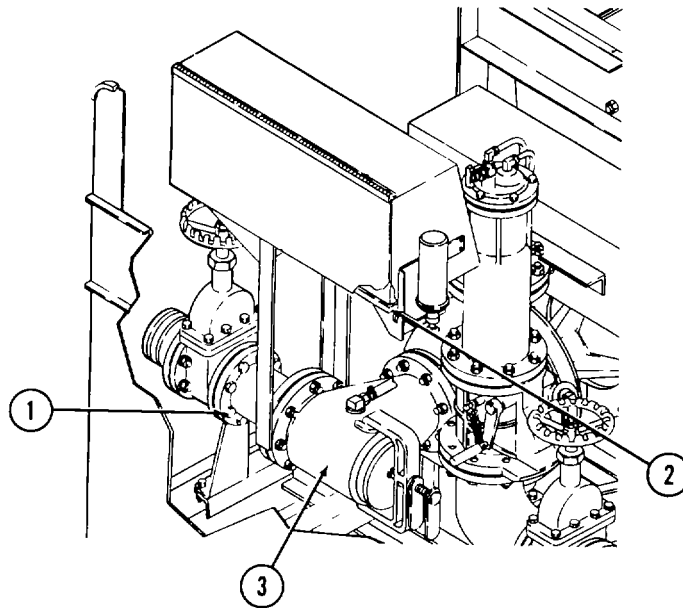
- 17 Install STARTER switch (25) through back of control panel (4).
- 18 Install nut and spring lockwasher (26) on STARTER switch (25).
- 19 Attach three tagged wires to STARTER switch (25) with two screws.
- 20 Install START/STOP switch (23) through back of control panel (4).
- 21 Install nut and spring lockwasher (24) on START/STOP switch (23).
- 22 Attach three tagged wires to START/STOP switch (23) with two screws.
- 23 Install OIL BY-PASS SWITCH (21) through back of control panel (4).
- 24 Install nut and washer (22) on OIL BY-PASS SWITCH (21).
- 25 Attach tagged wires to OIL BY-PASS SWITCH (21).
- 26 Carefully install pressure gage (PUMP DISCHARGE) (18) through front of control panel (4).
- 27 Install screws (19) and nuts and lockwashers (20).
- 28 Install bezel (17) and thumbscrew (16) on front of control panel (4).
- 29 Carefully install compound gage (PUMP SUCTION) (13) through front of control panel (4).
- 30 Install screws (14) and nuts and lockwashers (15).

2-16. REPLACE/REPAIR CONTROL PANEL ASSEMBLY (Continued)

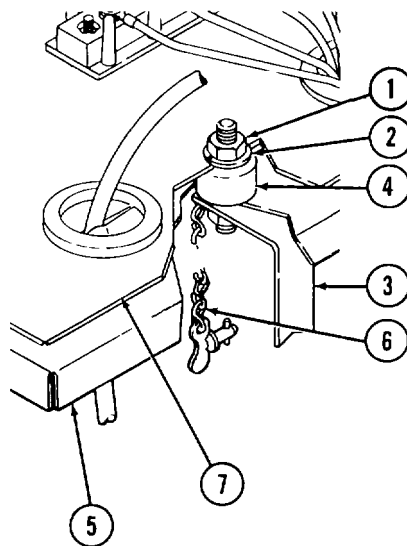


- 31 Install bezel (12) and thumbscrew (11) on front of control panel (4).
- 32 Carefully install BATTERY VOLTMETER (8) through front of control panel (4).
- 33 Install mounting bracket (10).
- 34 Install nuts and lockwashers (9) on battery voltmeter mounting bracket (10).
- 35 Attach tagged wires to BATTERY VOLTMETER (8).
- 36 Carefully install ENGINE OIL PRESSURE indicator (7) through front of control panel (4).
- 37 Install oil pressure indicator mounting bracket (6).
- 38 Install lockwashers and nuts (5) on back of oil pressure indicator mounting bracket (6).
- 39 Attach tagged wires to ENGINE OIL PRESSURE indicator (7).
- 40 Carefully install TACHOMETER/HOURMETER (3) through front of control panel (4).
- 41 Install tachometer/hourmeter mounting bracket (2).
- 42 Install nuts and lockwashers (1) to back of tachometer/hourmeter mounting bracket (2).
- 43 Attach tachometer cable to back of TACHOMETER/HOURMETER (3).

2-16. REPLACE/REPAIR CONTROL PANEL ASSEMBLY (Continued)

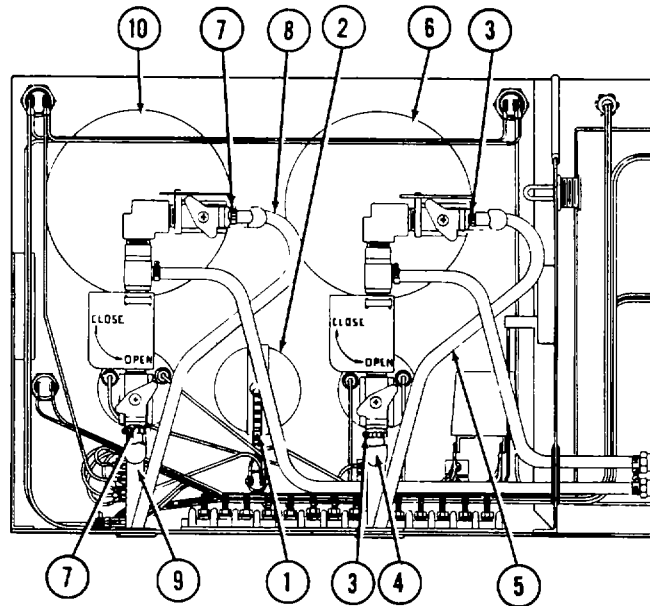


- 44 Position control panel base plate assembly (2) on strainer (3) on suction assembly.
- 45 Install four nuts and lockwashers (1) that secure base plate assembly (2) to strainer (3)
- 46 Attach chains (6) to shock mounts (4).
- 47 Carefully position control panel (7) on control panel base plate assembly (5) Install nuts (1), lockwashers (2), and bracket (3) on shock mounts (4). Tighten securely.

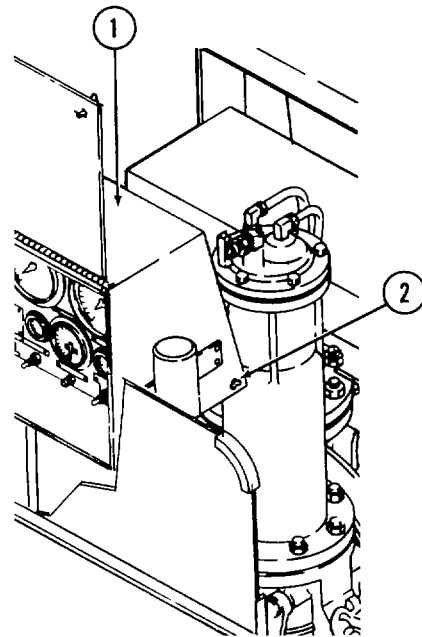


2-16. REPLACE/REPAIR CONTROL PANEL ASSEMBLY (Continued)

- 48 Install discharge pressure hoses (8 and 9) on back of pump discharge pressure gage (10). Tighten clamps (7).
- 49 Install suction pressure hoses (4 and 5) on back of pump suction pressure gage (6). Tighten clamps (3).



- 50 Install control panel cover assembly (1). Tighten wing head studs(2).



2-17. TEST/REPLACE/REPAIR WIRING HARNESS (CONTROL PANEL)

This task covers:

- | | | |
|-----------------|-----------------------|-----------|
| a. Removal | b. Testing/Inspection | c. Repair |
| d. Installation | | |
-

INITIAL SETUP:**Tools**

Shop equipment, automotive maintenance and repair, common no. 1

Tool kit, general mechanics automotive

Equipment Condition**Para**

2-13

Condition Description

Engine shut down and cool.

Negative battery cable removed from batteries.

Materials/Parts

2-16

Control panel cover assembly removed

Insulation tape (Item 20, Appendix C)

REMOVAL:

Remove wires and connectors and tag.

TESTING/INSPECTION:

Test wires and connectors for continuity. Inspect for broken, damaged, burned, frayed, or abraded wires or connectors.

REPAIR:

Replace any wires or connectors that are frayed, damaged, burned, or broken. Replace entire wiring harness if necessary. Refer to Wiring Harness Schematics, Appendix E.

INSTALLATION:

Install replaced wiring (as tagged) onto appropriate instruments and controls on control panel. Tighten mounting hardware securely. Install wiring (as tagged) on terminal block.

2-18. REPLACE/REPAIR SUCTION ASSEMBLY, STRAINER ASSEMBLY, AND GATE VALVE

This task covers:

- | | | |
|-------------|-----------------|-------------------------------|
| a. Removal | b. Disassembly | c. Cleaning/Inspection/Repair |
| d. Assembly | e. Installation | |
-

INITIAL SETUP

Tools

Shop equipment, automotive maintenance and repair, common no. 1

Tool kit, general mechanics automotive

Equipment Condition

Para

Condition Description

2-16

Control panel cover assembly, control panel assembly, and control panel base plate removed.

Materials/Parts

Crocus abrasive cloth (Item 1, Appendix C)

Dry cleaning solvent (Item 17, Appendix C)

Special Environmental Conditions

Well-ventilated area required for cleaning.

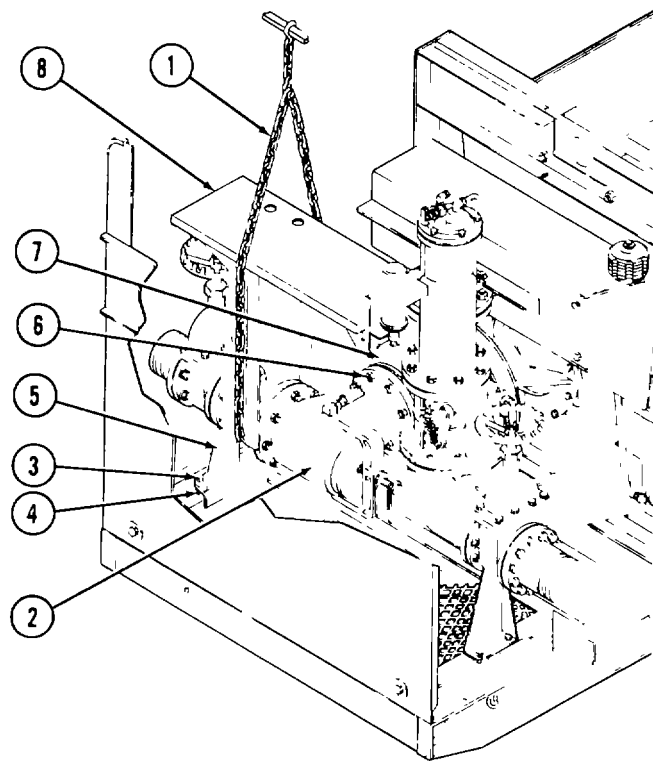
REMOVAL:

WARNING

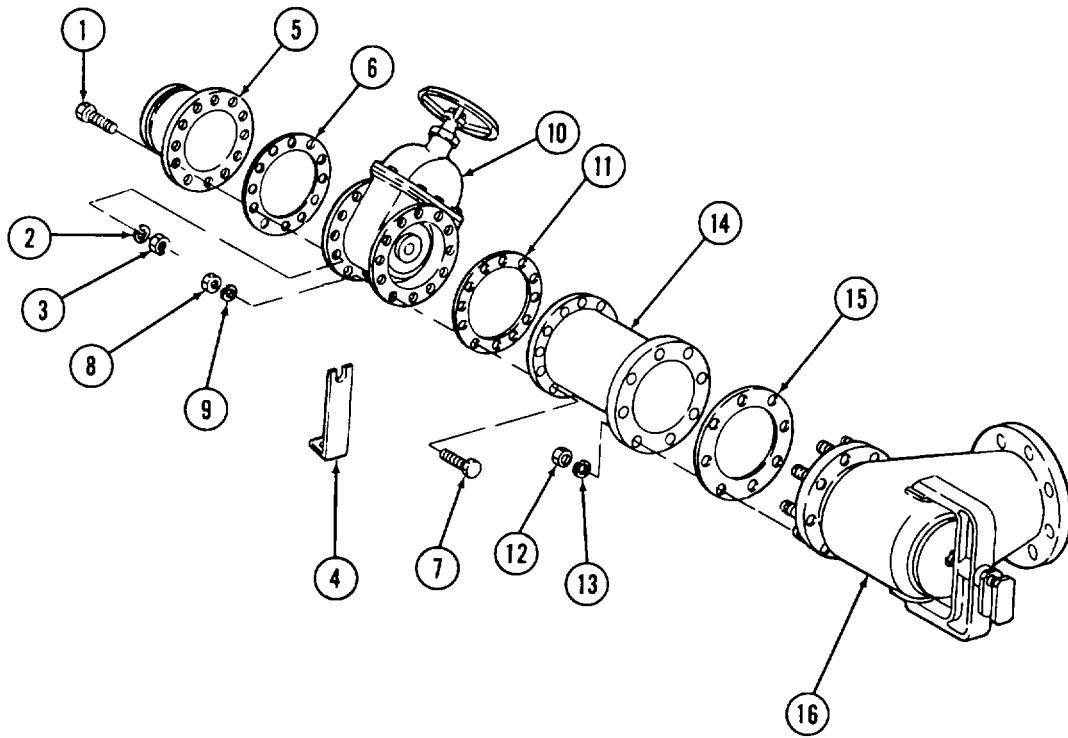
Death or serious injury could occur if unauthorized or unnecessary personnel are in the hoisting area. Permit only personnel actually engaged in the hoisting operation to be near the unit and hoisting equipment. All instructions for the hoisting operations must come from one authorized person.

Injury to personnel or damage to equipment could occur from improper hoisting. Hoist the load slowly to avoid tearing out lifting bail assembly, slipping slings, or load shift. Do not jerk the load or swing it from side-to-side when hoisting. This places additional stress on hoisting components which can cause failure and loss of load. Be sure hoisting equipment is on solid footing and is suitable for the size of the load. Watch boom angle and overhead clearance when hoisting.

- 1 Position a suitable lifting device (1) equipped with a spreader bar and slings over suction assembly (2).
- 2 Attach slings around assembly and put tension on slings. Make sure assembly is properly supported. Spread slings on spreader bar so that slings hang vertically when attached to assembly.

2-18. REPLACE/REPAIR SUCTION ASSEMBLY, STRAINER ASSEMBLY, AND GATE VALVE (Continued)

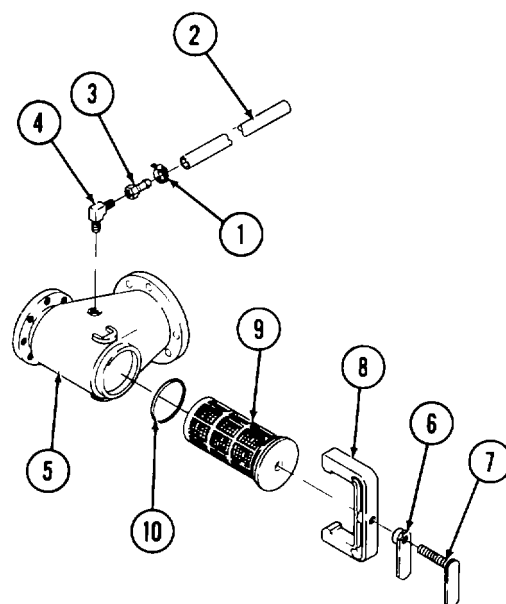
- 3 Remove bolts (3) and nuts and lockwashers (4) that secure support bracket (5) to skid.
- 4 Remove eight nuts and eight lockwashers (6) from suction assembly (2) and pump body (7)
- 5 Lift and remove suction assembly (2), support bracket (5), and control panel base plate assembly (8) from skid and pump body Lower onto blocks on a stable, level work platform

2-18. REPLACE/REPAIR SUCTION ASSEMBLY, STRAINER ASSEMBLY, AND GATE VALVE (Continued)**DISASSEMBLY:**

- 1 Remove 12 cap screws (1), lockwashers (2), and nuts (3). Remove support bracket (4).
- 2 Remove flange (5) and gasket (6). Discard gasket.
- 3 Remove cap screws (7), nuts (8), and lockwashers (9).
- 4 Remove gate valve (10) and gasket (11). Discard gasket.
- 5 Remove remaining four nuts (12) and four lockwashers (13).
- 6 Remove spool flange (14) and gasket (15) from strainer body (16). Discard gasket.

2-18. REPLACE/REPAIR SUCTION ASSEMBLY, STRAINER ASSEMBLY, AND GATE VALVE (Continued)

- 7 Loosen hose clamp (1) and remove suction pressure hose (2) from reducer (3)
- 8 Remove elbow (4) and reducer (3) from strainer body (5).
- 9 Unlock locking lever (6) and remove lever bolt (7)
- 10 Remove strainer clamp (8) from strainer body (5).
- 11 Remove strainer (9) and preformed packing (10). Discard preformed packing.

**CLEANING/INSPECTION/REPAIR:**

- 1 Inspect flanges, gate valve, strainer body, and strainer clamp for cracks, rust, corrosion, and for damaged or stripped threads. Inspect mounting surfaces. Make sure they are smooth and flat with no nicks or burrs.
- 2 Repair minor nicks or burrs and/or smooth out mounting surfaces with crocus abrasive cloth. Clean interior or mounting surfaces. Clean and refinish outside surfaces. Remove only a minimal amount of surface material, replace parts if necessary.
- 3 Inspect suction pressure hose (2). Replace if brittle, cracked, or deteriorated. Inspect hose clamp (1), reducer (3), and 90-degree elbow (4) for damage, rust, or corrosion. Replace parts if severely damaged or rusted.

WARNING

Dry cleaning solvent P-D-680 (safety or Stoddard's Solvent) is potentially dangerous. Avoid repeated and prolonged breathing of vapors and skin contact with the liquid. Do not use near open flame, arcing equipment, or other ignition source. Always wear eye protection and protective clothing. The flash point of P-D-680 is 100° to 138°F (38° to 59°C).

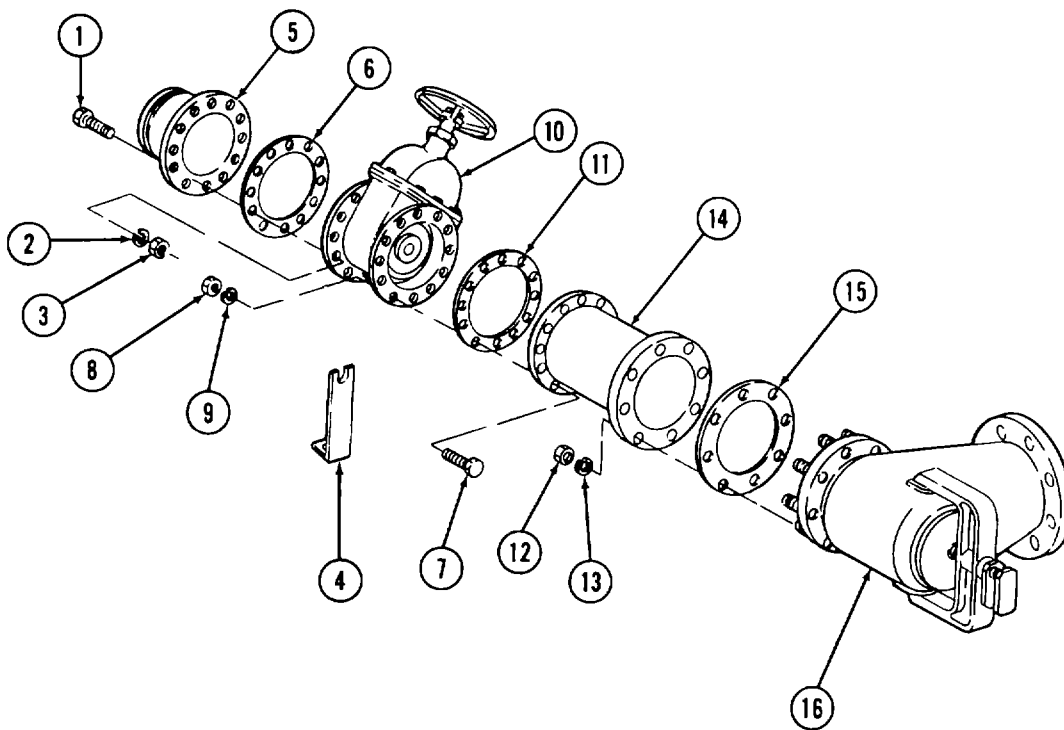
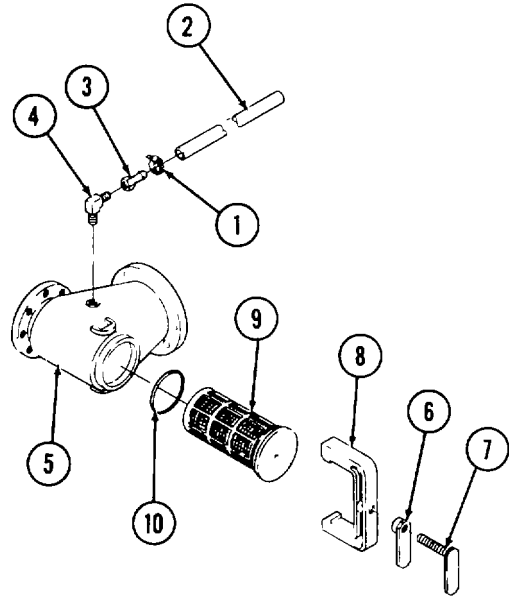
Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 4 Clean strainer with dry cleaning solvent. Dry with compressed air.
- 5 Inspect strainer for damage. Replace if severely damaged.

2-18. REPLACE/REPAIR SUCTION ASSEMBLY, STRAINER ASSEMBLY, AND GATE VALVE (Continued)

ASSEMBLY:

- 1 Install preformed packing (10) and strainer (9) in strainer body (5)
- 2 Install strainer clamp (8) on strainer body (5) with locking lever (6) and lever bolt (7).
- 3 Tighten lever bolt (7) and lock locking lever (6).
- 4 Install 90-degree elbow (4) and reducer (3) on strainer body (5).
- 5 Install suction pressure hose (2). Tighten hose clamp (1) securely.



- 6 Install new gasket (15) and spool flange (14) on strainer body (16) studs with nuts (12) and lockwashers (13). Tighten nuts.
- 7 Install new gasket (11) and gate valve (10) on spool flange (14) with cap screws (7), lockwashers (9), and nuts (8). Tighten cap screws.
- 8 Install new gasket (6) and flange (5) on gate valve (10) with cap screws (1), lockwashers (2), and hex nuts (3). Tighten cap screws (1).

2-18. REPLACE/REPAIR SUCTION ASSEMBLY, STRAINER ASSEMBLY, AND GATE VALVE (Continued)

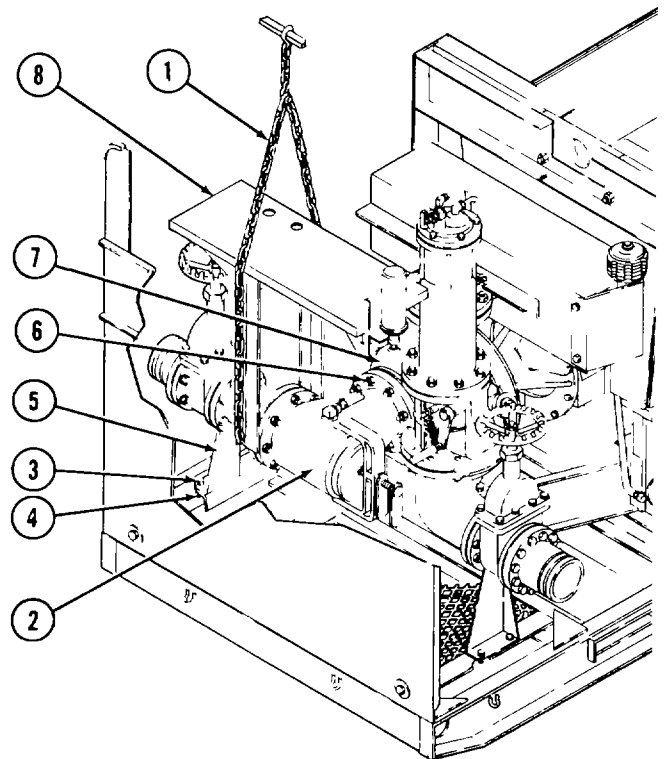
INSTALLATION:

WARNING

Death or serious injury could occur if unauthorized or unnecessary personnel are in the hoisting area. Permit only personnel actually engaged in the hoisting operation to be near the unit and hoisting equipment. All instructions for the hoisting operations must come from one authorized person.

Injury to personnel or damage to equipment could occur from improper hoisting. Hoist the load slowly to avoid tearing out lifting bail assembly, slipping slings, or load shift. Do not jerk the load or swing it from side-to-side when hoisting. This places additional stress on hoisting components which can cause failure and loss of load. Be sure hoisting equipment is on solid footing and is suitable for the size of the load. Watch boom angle and overhead clearance when hoisting.

- 1 Position a suitable lifting device (1) equipped with a spreader bar and slings over suction assembly (2)
- 2 Attach slings around assembly and put tension on slings. Make sure assembly is properly supported. Spread slings on spreader bar so that slings hang vertically when attached to assembly
- 3 Lift suction assembly (2) and remove from blocks on work platform. Lower carefully so that suction assembly (2) aligns with pump body (7). Align holes in strainer body with studs on pump body. When these holes and studs are aligned, slide suction assembly (2) toward pump body (7) so that flanges mate and engage properly
- 4 Install nuts and lockwashers (6) on pump body studs. Do not tighten nuts
- 5 Install bolts (3) and nuts and lockwashers (4) that secure support bracket (5) to skid. Do not tighten bolts. 6 Tighten nuts (6) alternately until secure. Tighten bolts (3) securely in a cross pattern



2-19. REPLACE/REPAIR DISCHARGE MANIFOLD ASSEMBLY AND DISCHARGE ELBOW

This task covers:

- | | | |
|----------------|-----------------------------------|-----------------|
| a. Removal | c. Cleaning/Inspection/
Repair | d. Assembly |
| b. Disassembly | | e. Installation |

INITIAL SETUP:**Tools**

Shop equipment, automotive maintenance and repair, common no. 1
Tool kit, general mechanics automotive

**Equipment
Condition****Para****Condition Description**

2-16

Control panel cover assembly, control panel assembly, and control panel base plate removed.

Materials/Parts

Crocus abrasive cloth (Item 1, Appendix C)

2-28

Muffler guard removed.

REMOVAL:**WARNING**

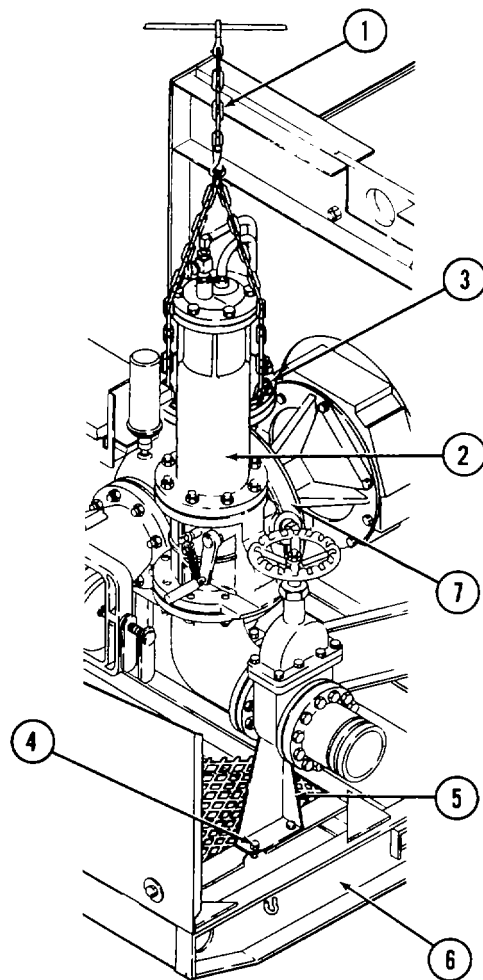
Death or serious injury could occur if unauthorized or unnecessary personnel are in the hoisting area. Permit only personnel actually engaged in the hoisting operation to be near the unit and hoisting equipment. All instructions for the hoisting operations must come from one authorized person.

Injury to personnel or damage to equipment could occur from improper hoisting. Hoist the load slowly to avoid tearing out lifting bail assembly, slipping slings, or load shift. Do not jerk the load or swing it from side-to-side when hoisting. This places additional stress on hoisting components which can cause failure and loss of load. Be sure hoisting equipment is on solid footing and is suitable for the size of the load. Watch boom angle and overhead clearance when hoisting.

- 1 Position a suitable lifting device (1) equipped with a spreader bar and slings over discharge manifold assembly (2).
- 2 Attach slings around assembly and put tension on slings. Make sure assembly is properly supported. Spread slings on spreader bar so that slings hang vertically when attached to assembly.
- 3 Remove remaining six nuts and six lockwashers (3).

NOTE

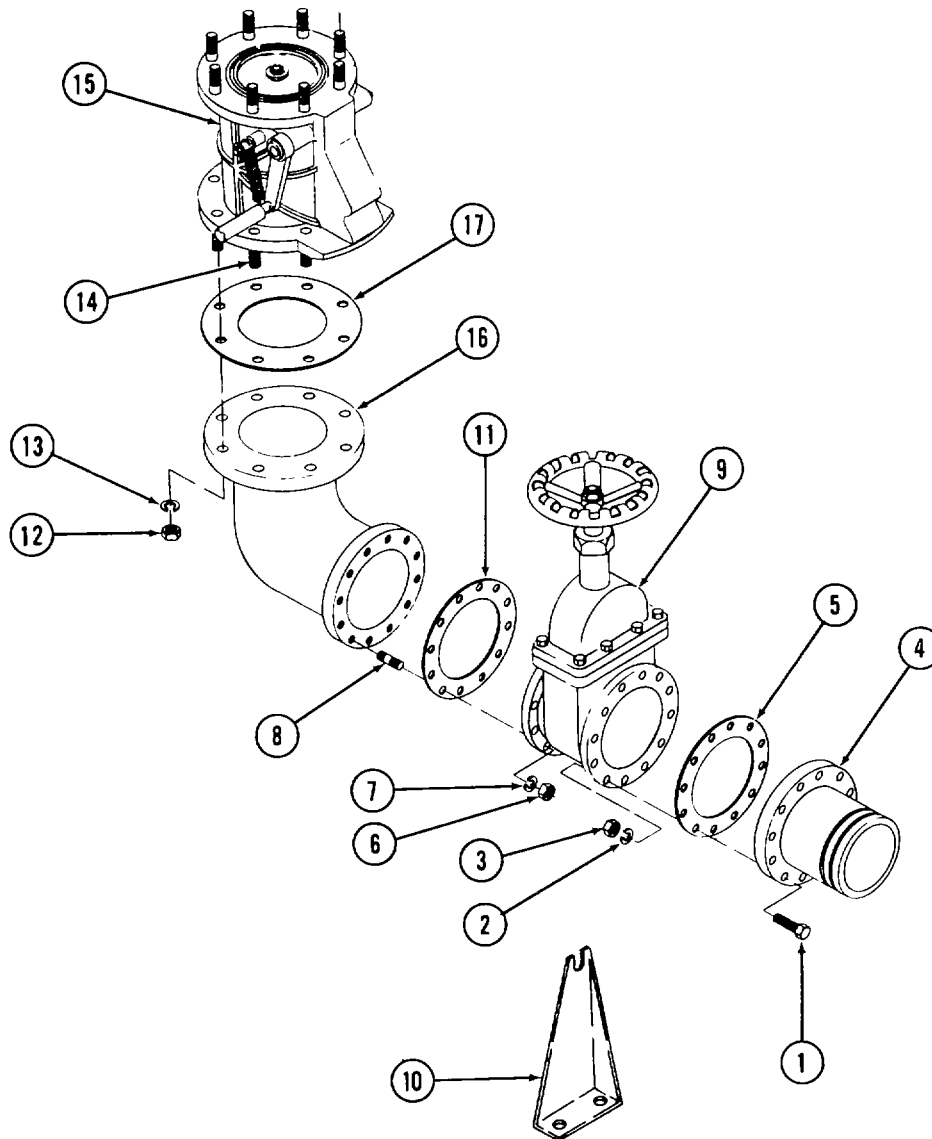
Two nuts and two lockwashers were removed when the muffler guard was removed for access.

2-19. REPLACE/REPAIR DISCHARGE MANIFOLD ASSEMBLY AND DISCHARGE ELBOW (Continued)

- 4 Remove bolts, nuts, and lockwashers (4) that secure support bracket (5) to skid (6).
- 5 Lift and remove discharge manifold assembly (2) and support bracket (5) from skid (6) and pump body (7). Lower onto blocks on a stable, level work platform.

2-19. REPLACE/REPAIR DISCHARGE MANIFOLD ASSEMBLY AND DISCHARGE ELBOW (Continued)

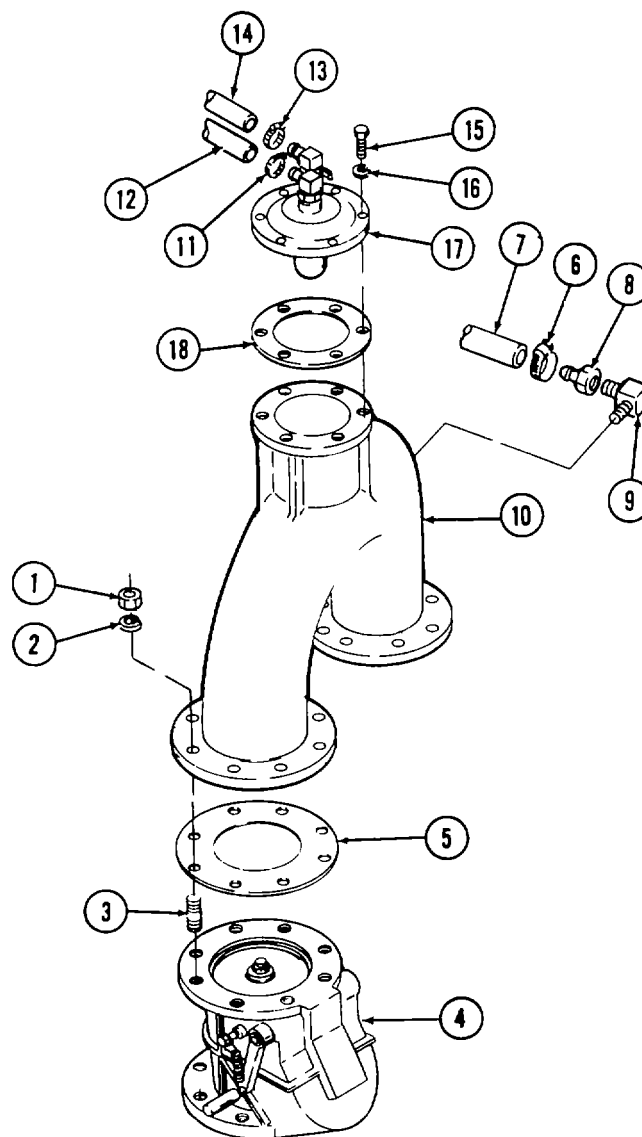
DISASSEMBLY:



- 1 Remove 12 cap screws (1), 12 lockwashers (2), and 12 nuts (3).
- 2 Remove flange (4) and gasket (5). Discard gasket.
- 3 Remove two nuts (6) and two lockwashers (7) from studs (8) on discharge elbow (16).
- 4 Remove gate valve (9), support bracket (10), and gasket (11). Discard gasket
- 5 Remove remaining 10 nuts (12) and 10 lockwashers (13) from studs (14) on check valve assembly (15).
- 6 Remove discharge elbow (16) and gasket (17). Discard gasket.

2-19. REPLACE/REPAIR DISCHARGE MANIFOLD ASSEMBLY AND DISCHARGE ELBOW (Continued)

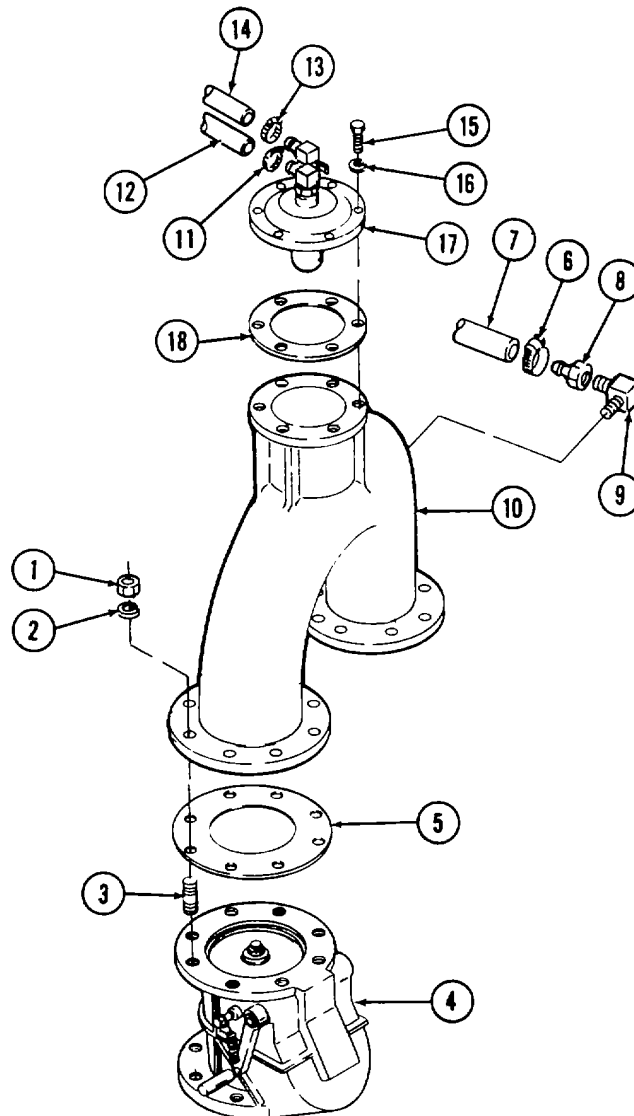
- 7 Remove eight nuts (1) and eight lockwashers (2) from studs (3)
- 8 Remove check valve assembly (4) and gasket (5). Discard gasket.
- 9 Loosen hose clamp (6) and remove discharge pressure hose (7) from reducer (8)
- 10 Remove reducer (8) and 90-degree elbow (9) from 180-degree elbow (10).
- 11 Remove hose clamp (11) and shutoff valve vent hose (12).
- 12 Remove hose clamp (13) and air release valve vent hose (14)
- 13 Remove six cap screws (15) and six lockwashers (16).
- 14 Remove air valve cover assembly (17) and gasket (18) Discard gasket

**CLEANING/INSPECTION/REPAIR:**

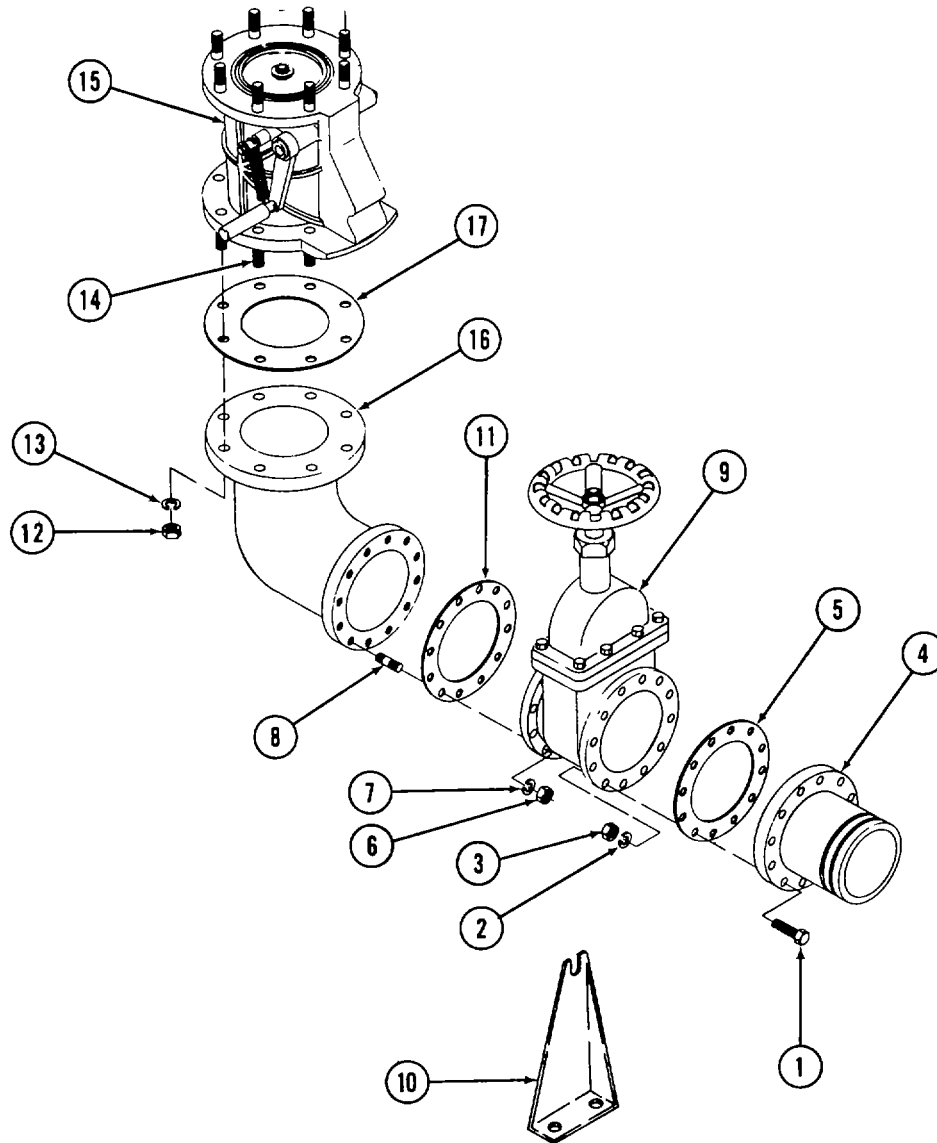
- 1 Inspect flanges and gate valve for cracks, rust, corrosion, and for damaged or stripped threads. Inspect mounting surfaces Make sure they are smooth and flat with no nicks or burrs.
- 2 Repair minor nicks or burrs and/or smooth out mounting surfaces with crocus abrasive cloth.
- 3 Clean and treat interior or mounting surfaces Clean and refinish outside surfaces. Remove only a minimal amount of surface material, replace parts if necessary.
- 4 Inspect discharge pressure hose, shutoff valve vent hose, and air release valve vent hose
- 5 Inspect hose clamps, reducer, and 90-degree elbow for damage, rust, or corrosion. Replace parts if severely damaged or rusted.

2-19. REPLACE/REPAIR DISCHARGE MANIFOLD ASSEMBLY AND DISCHARGE ELBOW (Continued)

ASSEMBLY:



- 1 Install air valve cover assembly (17) and new gaskets (18) on 180-degree elbow (10).
- 2 Install six lockwashers (16) and six cap screws (15). Tighten cap screws.
- 3 Install air release valve vent hose (14) and hose clamp (13).
- 4 Install shutoff valve vent hose (12) and hose clamp (11).
- 5 Install 90-degree elbow (9) and reducer (8) on 180-degree elbow (10).
- 6 Install discharge pressure hose (7). Tighten hose clamp (6) securely.
- 7 Install check valve assembly (4) and new gasket (5) on 180-degree elbow.
- 8 Install eight lockwashers (2) and nuts (1) on studs (3).

2-19. REPLACE/REPAIR DISCHARGE MANIFOLD ASSEMBLY AND DISCHARGE ELBOW (Continued)

- 9 Install discharge elbow (16) and new gasket (17) on check valve assembly studs (14).
- 10 Install 10 nuts (12) and 10 lockwashers (13). Tighten nuts.
- 11 Install gasket (11), support bracket (10), and gate valve (9) on discharge elbow studs (8).
- 12 Install two lockwashers (7) and two nuts (6) on studs (8). Tighten nuts.
- 13 Install new gasket (5) and flange (4) on gate valve (9).
- 14 Install 12 cap screws (1), 12 lockwashers (2), and 12 nuts (3). Tighten screws (1).

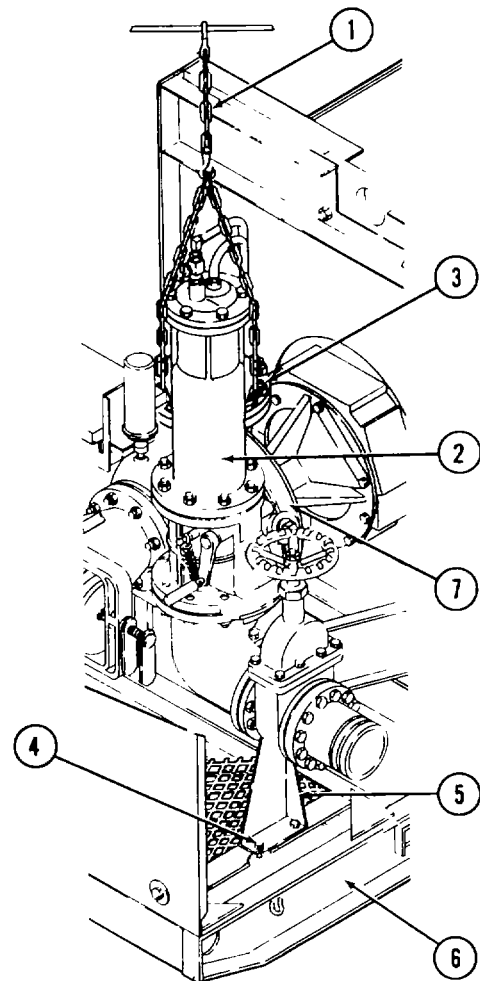
2-19. REPLACE/REPAIR DISCHARGE MANIFOLD ASSEMBLY AND DISCHARGE ELBOW (Continued)

INSTALLATION:

WARNING

Death or serious injury could occur if unauthorized or unnecessary personnel are in the hoisting area. Permit only personnel actually engaged in the hoisting operation to be near the unit and hoisting equipment. All instructions for the hoisting operations must come from one authorized person.

Injury to personnel or damage to equipment could occur from improper hoisting. Hoist the load slowly to avoid tearing out lifting bail assembly, slipping slings, or load shift. Do not jerk the load or swing it from side-to-side when hoisting. This places additional stress on hoisting components which can cause failure and loss of load. Be sure hoisting equipment is on solid footing and is suitable for the size of the load. Watch boom angle and overhead clearance when hoisting.



- 1 Position a suitable lifting device (1) equipped with a spreader bar and slings over discharge manifold assembly (2)
- 2 Attach slings around assembly and put tension on slings. Make sure assembly is properly supported. Spread slings on spreader bar so that slings hang vertically when attached to assembly.
- 3 Lift discharge manifold assembly and remove from blocks on work platform. Lower carefully so that discharge manifold assembly (2) aligns with pump body (3). Align holes in 180-degree elbow with studs on pump body so that flanges mate and engage properly.
- 4 Install nuts and lockwashers (3) on pump body studs. Do not tighten nuts.
- 5 Install support bracket (5), bolts, nuts, and lockwashers (4) on skid (6). Do not tighten bolts.
- 6 Tighten nuts (3) alternately until secure.
- 7 Tighten bolts (4) securely.

2-20. REPLACE/REPAIR AIR VALVE COVER ASSEMBLY

This task covers:

- | | |
|------------------------|-------------|
| a. Disassembly | c. Repair |
| b. Cleaning/Inspection | d. Assembly |

INITIAL SETUP:**Tools**

Shop equipment, automotive maintenance and repair, common no 1
 Tool kit, general mechanics automotive

Equipment Condition**Para**

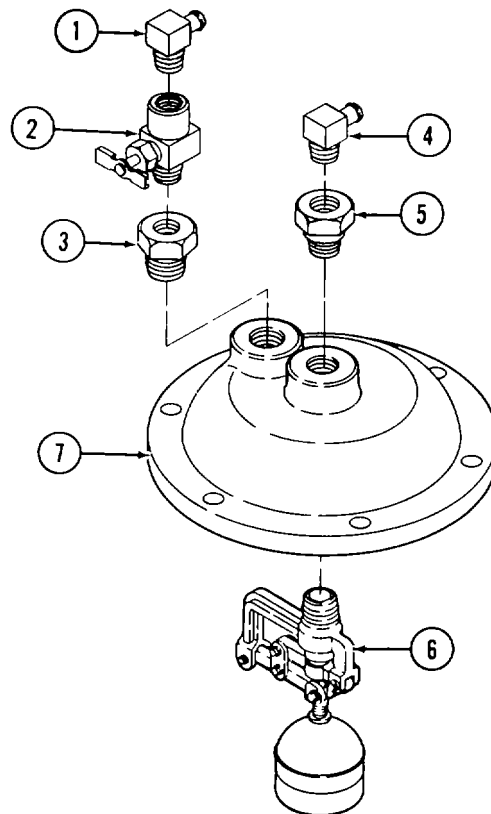
2-19

Condition Description

Air valve cover assembly removed from discharge manifold assembly

Materials/Parts

Crocus abrasive cloth (Item 1, Appendix C)
 Dry cleaning solvent (Item 17, Appendix C)
 Sealing compound (Item 15, Appendix C)

DISASSEMBLY:

- 1 Remove 90-degree elbow (1).
- 2 Remove shutoff valve (2) and bushing (3).
- 3 Remove 90-degree elbow (4) and bushing (5).
- 4 Remove air release valve (6) from bottom of air cover (7).

2-20. REPLACE/REPAIR AIR VALVE COVER ASSEMBLY (Continued)

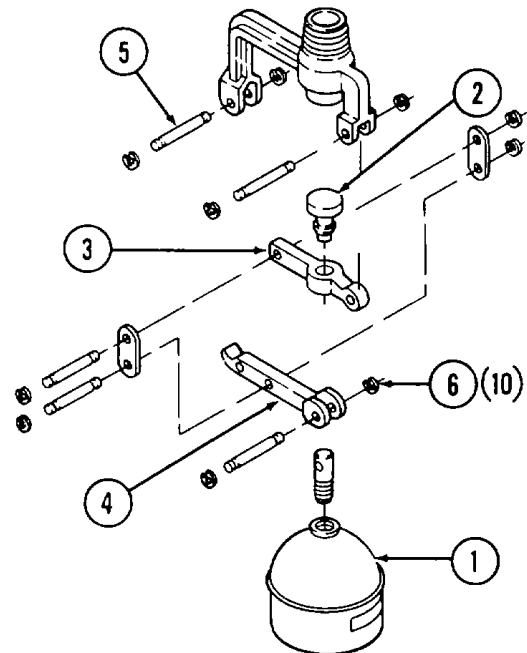
CLEANING/INSPECTION:

WARNING

Dry cleaning solvent P-D-680 (safety or Stoddard's Solvent) is potentially dangerous. Avoid repeated and prolonged breathing of vapors and skin contact with the liquid. Do not use near open flame, arcing equipment, or other ignition source. Always wear eye protection and protective clothing. The flash point of P-D-680 is 100° to 138OF (380 to 590C).

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 1 Clean all parts with dry cleaning solvent Dry with compressed air.
- 2 Inspect shutoff valve (2), bushings (3 and 5), and 90-degree elbows (1 and 4) for cracks, rust, corrosion, and for damaged or stripped threads. Replace parts if severely damaged or rusted.
- 3 Inspect air valve cover (7) for cracks, rust, or corrosion, and for damaged or stripped threads. Inspect mounting surface Make sure it is smooth and flat with no nicks or burrs.
- 4 Inspect air release valve for rust or corrosion Inspect float (1) for holes and cracks Inspect needle (2) and seat for wear, grooves, or ridges Check all threads for damage. Check levers (3 and 4) and lever pins (5) for straightness Check that lever pins (5) and retaining rings (6) are secure Check that all parts move freely Replace air release valve if any parts are severely damaged.

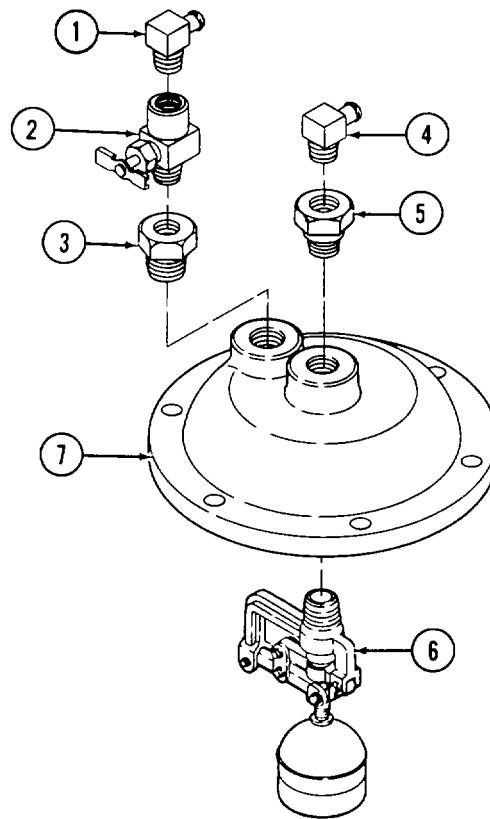


REPAIR:

- 1 Repair minor nicks or burrs on air valve cover (7) and/or smooth out mounting surface with crocus abrasive cloth Clean interior or mounting surface. Clean and refinish outside surface Remove only a minimal amount of surface material, replace if necessary.

2-20. REPLACE/REPAIR AIR VALVE COVER ASSEMBLY (Continued)

ASSEMBLY:

**NOTE**

Apply sealing compound to all threads during assembly.

- 1 Install air release valve (6) in bottom of air cover (7).
- 2 Install bushing (5) in air cover (7).
- 3 Install 90-degree elbow (4) in air release valve bushing (5).
- 4 Install bushing (3) in air cover (7).
- 5 Install shutoff valve (2) in bushing (3).
- 6 Install 90-degree elbow (1) in shutoff valve (2).

2-21. REPLACE/REPAIR DISCHARGE CHECK VALVE ASSEMBLY

This task covers:

- a. Disassembly
- b. Cleaning/Inspection/ Repair
- c. Assembly

INITIAL SETUP:

Tools

Shop equipment, automotive maintenance and repair, common no. 1
 Tool kit, general mechanics automotive

Equipment Condition

Para

2-19

Condition Description

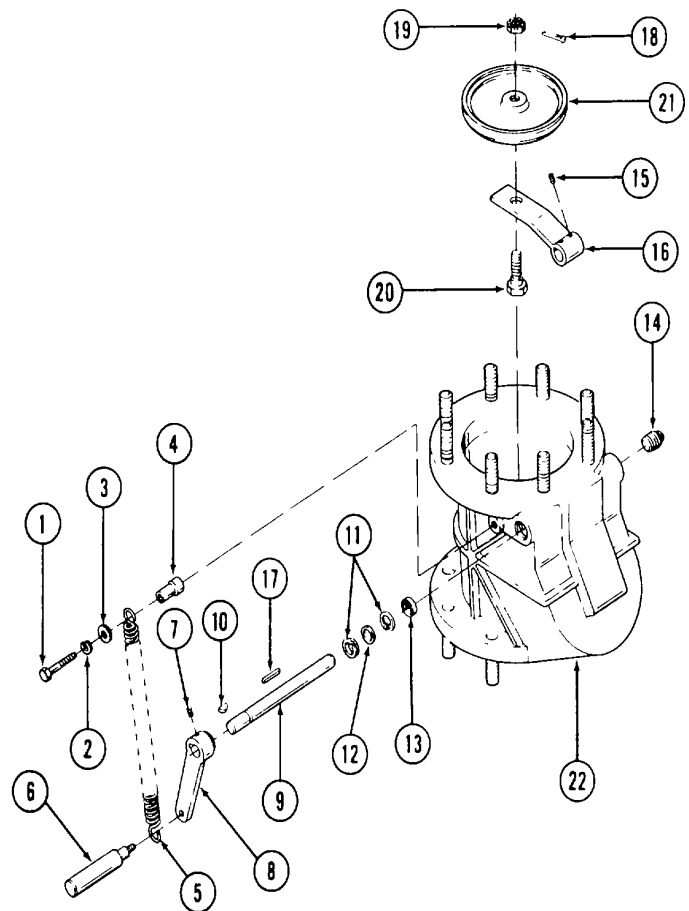
Discharge check valve assembly removed from discharge manifold assembly

Materials/Parts

Crocus abrasive cloth (Item 1, Appendix C)
 Sealing compound (Item 15, Appendix C)

DISASSEMBLY:

- 1 Remove cap screw (1), lockwasher (2), washer (3), and spacer sleeve (4).
- 2 Disconnect extension spring (5) from spacer sleeve (4).
- 3 Unscrew extension handle (6) and remove extension spring (5).
- 4 Loosen setscrew (7) and slide handle lever (8) from shaft (9).
- 5 Remove woodruff key (10).
- 6 Remove retaining rings (11), friction ring (12), and shaft seal (13). Discard friction ring (12) and shaft seal (13).
- 7 Remove pipe plug (14).
- 8 Loosen setscrews (15) in valve arm (16) and pull out shaft (9).
- 9 Remove key (17).
- 10 Remove cotter pin (18) from nut (19).
- 11 Remove nut (19) and shoulder bolt (20).
- 12 Remove valve seal disc (21) and valve arm (16).



2-21. REPLACE/REPAIR DISCHARGE CHECK VALVE ASSEMBLY (Continued)

CLEANING/INSPECTION/REPAIR:

- 1 Inspect valve body (22), handle lever (8), valve arm (16), and valve seal disc (21) for cracks, rust, corrosion, and for damaged or stripped threads Inspect mounting surfaces Make sure they are smooth and flat with no nicks or burrs.
- 2 Repair minor nicks or burrs and/or smooth out mounting surfaces with crocus abrasive cloth.
- 3 Clean interior or mounting surface Clean and refinish outside surface Remove only a minimal amount of surface material, replace if necessary.
- 4 Check shaft (9) for wear and damage Replace if severely damaged.
- 5 Replace extension spring (5) if damaged or if fatigue is evident.

ASSEMBLY:

- 1 Install valve seal disc (21) and valve arm (16) Secure with nut (19) and shoulder bolt (20).
 - 2 Install cotter pin (18) in nut (19).
 - 3 Insert setscrews (15) loosely in valve arm (16).
 - 4 Position key (17) in slot within shaft (9) and slide shaft into valve body (22) through valve arm (16).
 - 5 Position valve arm (16) on shaft (9) and tighten setscrews (15).
 - 6 Install pipe plug (14) on shaft (9).
 - 7 Install retaining rings (11), new friction ring (12), and new shaft seal (13) on shaft (9).
 - 8 Insert woodruff key (10) in shaft (9) and slide handle lever (8) onto shaft.
 - 9 Insert and tighten setscrew (7).
 - 10 Secure one end of extension spring (5) to lower end of handle lever (8) by screwing extension handle (6) into handle lever (8).
 - 11 Apply sealing compound to cap screw (1) threads.
 - 12 Install cap screw (1), lockwasher (2), washer (3), other end of extension spring (5), and spacer sleeve (4) on discharge check valve (22).
-

2-22. REPLACE/REPAIR ENGINE COVER, REPLACE INTAKE DUCT ASSEMBLY

This task covers:

- | | | |
|------------------------|----------------|----------------|
| a. Removal | c. Disassembly | e. Replacement |
| b. Cleaning/Inspection | d. Repair | |

INITIAL SETUP:

Tools

Shop equipment, automotive maintenance and repair, common no 1

Tool kit, general mechanics automotive

Materials/Parts

Dry cleaning solvent (Item 17, Appendix C)

Lubricating oil (Item 10, Appendix C)

Equipment Condition

Para

Condition Description

2-26

Air cleaner, air inlet hose, and elbows removed

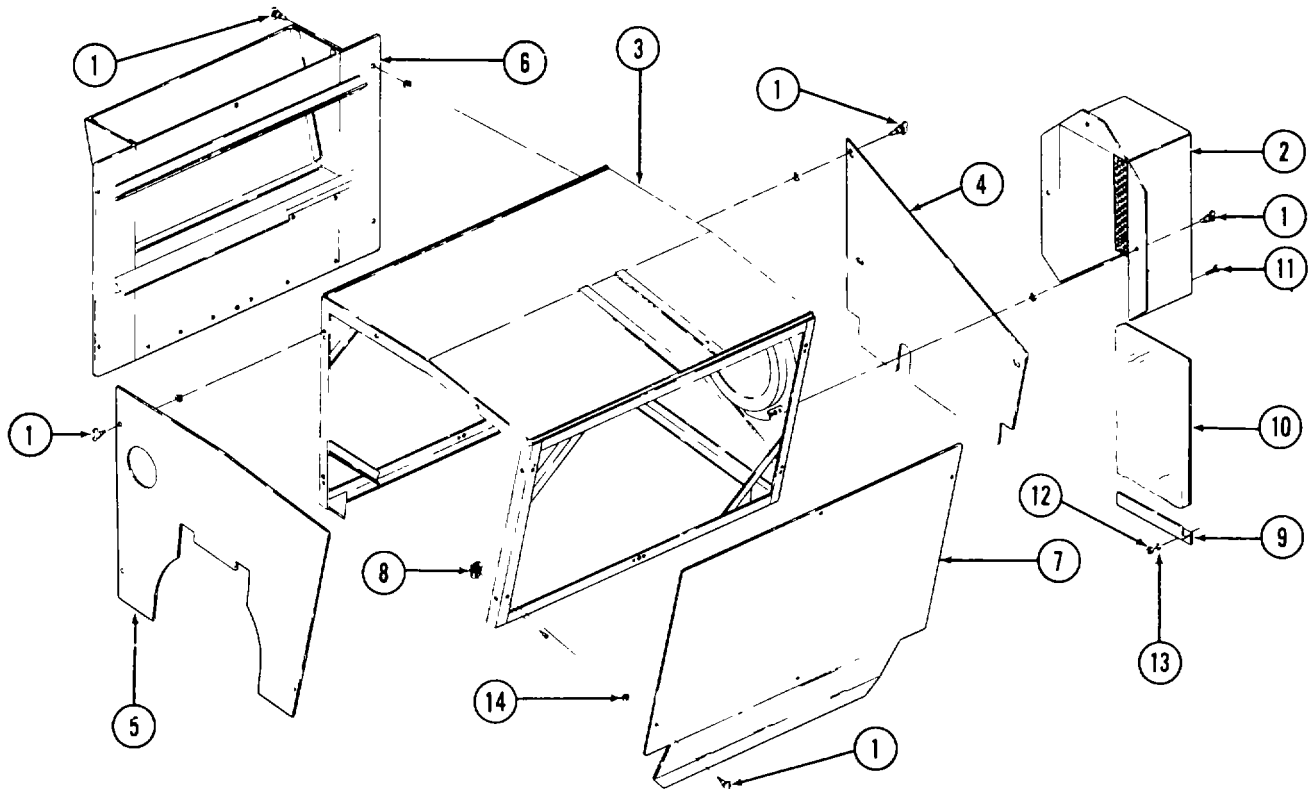
2-28

Exhaust piping and elbows removed

General Safety Instructions

Well-ventilated area

REMOVAL:



- 1 Loosen wing head studs (1) that secure intake duct (2) to frame (3) and rear bottom panel (4). Remove intake duct (2).
- 2 Remove front panel (5), left side panel (6), right side panel (7), and rear bottom panel (4) by loosening wing head studs (1) that secure each panel to frame (3).

2-22. REPLACE/REPAIR ENGINE COVER; REPLACE INTAKE DUCT ASSEMBLY (Continued)

WARNING

Death or serious injury could occur if unauthorized or unnecessary personnel are in the hoisting area. Permit only personnel actually engaged in the hoisting operation to be near the unit and hoisting equipment. All instructions for the hoisting operations must come from one authorized person.

Injury to personnel or damage to equipment could occur from improper hoisting. Hoist the load slowly to avoid tearing out lifting bail assembly, slipping slings, or load shift. Do not jerk the load or swing it from side-to-side when hoisting. This places additional stress on hoisting components which can cause failure and loss of load. Be sure hoisting equipment is on solid footing and is suitable for the size of the load. Watch boom angle and overhead clearance when hoisting.

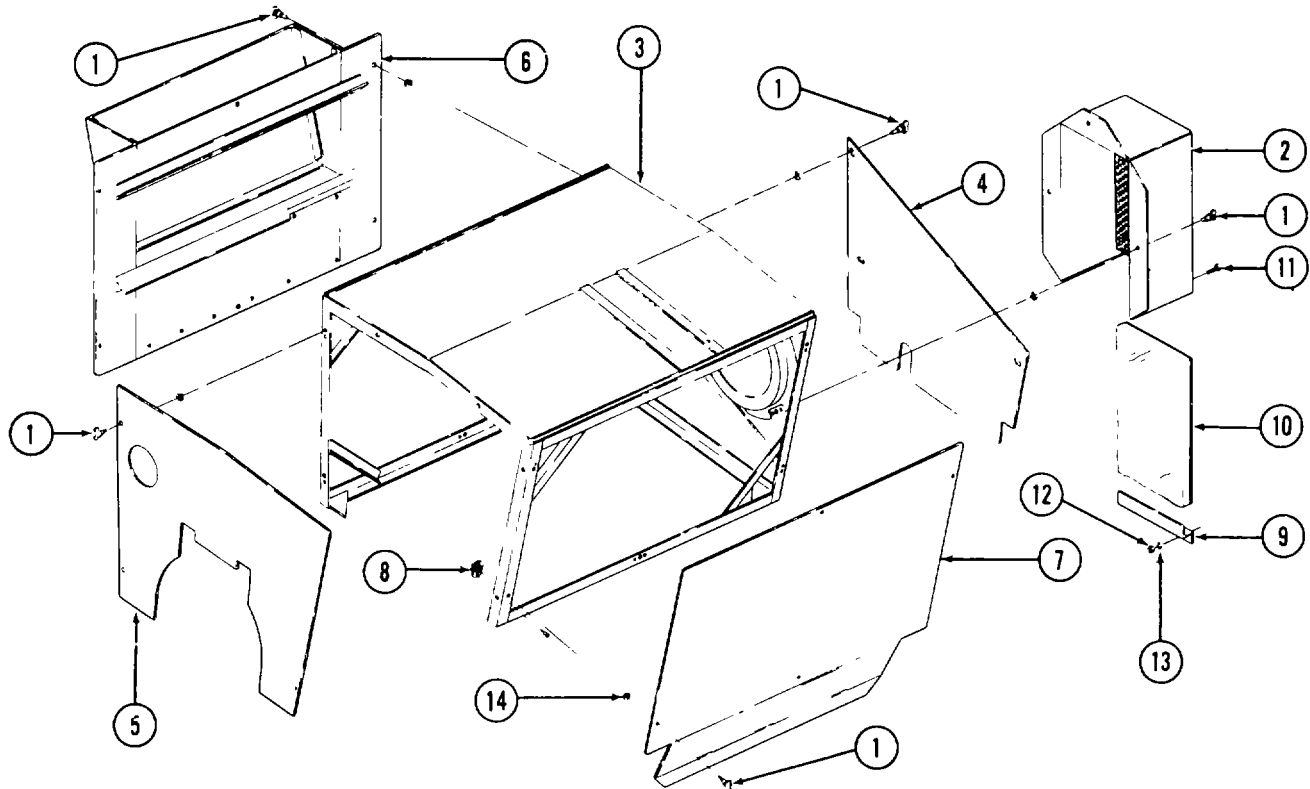
- 3 Secure sling to the four upper corners of frame (3) Secure hoist to the sling above the center of the frame.
- 4 Remove the bolts, washers, and nuts which secure the frame to the skid.
- 5 Lift frame (3) carefully from the skid, making sure it does not catch on or damage engine or pump components.
- 6 Place the removed frame on blocks, leveled to prevent distortion of the frame.

CLEANING/INSPECTION:**WARNING**

Dry cleaning solvent P-D-680 (safety or Stoddard's Solvent) is potentially dangerous. Avoid repeated and prolonged breathing of vapors and skin contact with the liquid. Do not use near open flame, arcing equipment, or other ignition source. Always wear eye protection and protective clothing. The flash point of P-D-680 is 100° to 138°F (38° to 59°C).

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 1 Clean all parts with dry cleaning solvent to remove all traces of grease and oil.
- 2 Dry all parts with compressed air.
- 3 Inspect all mating surfaces and mounting holes for distortion and tears.
- 4 Check wing head studs (1) and receptacles (8) for sufficient tension to hold panels securely.

2-22. REPLACE/REPAIR ENGINE COVER; REPLACE INTAKE DUCT ASSEMBLY (Continued)

- 5 Check that clip (9) holds acoustical panel (10) securely in intake duct (2).
- 6 Check that acoustical panel (10) is not cracked or broken and that it fills the back surface of intake duct (2) The acoustical panel should not be water or oil soaked.
- 7 Check frame (3) for cracked welds, missing braces, and damaged sheet metal If welding is required, notify direct support.

DISASSEMBLY:

- 1 Remove two screws (11), two nuts (12), and two lockwashers (13) that secure acoustical panel (10) in intake duct (2) Remove the panel from the intake duct.
- 2 Remove retainers (14) that secure wing head studs (1) in the panels Remove wing head studs from the panels.

REPAIR:

- 1 Replace missing wing head studs (1) or receptacles or those that do not provide sufficient tension to hold the panels in place.
- 2 Replace missing or damaged acoustical panel (10).
- 3 Replace damaged or missing screws (11), nuts (12), lockwashers (13), or clip (9) that does not hold acoustical panel (10) in place.

2-22. REPLACE/REPAIR ENGINE COVER; REPLACE INTAKE DUCT ASSEMBLY (Continued)

- 4 Reshape dented or distorted panels (4, 5, 6, or 7) or intake duct (2) When reshaping the mating surfaces, components must match with no more than a 1/8 inch (3 18 mm) separation, and overall configuration within 1/4 inch (6.35 mm) of original shape.

ASSEMBLY:

- 1 Use retainers (14) to secure the wing head studs (1) in panels (4, 5, 6, and 7) and intake duct (2).
- 2 Secure acoustical panel (10) in intake duct (2) by securing clip (9) with two mounting screws (11), two nuts (12), and two lockwashers (13).

INSTALLATION:**WARNING**

Death or serious injury could occur if unauthorized or unnecessary personnel are in the hoisting area. Permit only personnel actually engaged in the hoisting operation to be near the unit and hoisting equipment. All instructions for the hoisting operations must come from one authorized person.

Injury to personnel or damage to equipment could occur from improper hoisting. Hoist the load slowly to avoid tearing out lifting bail assembly, slipping slings, or load shift. Do not jerk the load or swing it from side-to-side when hoisting. This places additional stress on hoisting components which can cause failure and loss of load. Be sure hoisting equipment is on solid footing and is suitable for the size of the load. Watch boom angle and overhead clearance when hoisting.

- 1 Secure sling to the four upper corners of frame (3). Secure hoist to the sling above the center of the frame.
 - 2 Lift the engine frame (3) and carefully lower it onto the skid, making sure it does not catch on or damage engine or pump components.
 - 3 Using hex head bolts, washers, and nuts, secure the frame to the skid. Remove the lifting sling.
 - 4 Place a small drop of lubricating oil in each receptacle (8) before inserting wing head stud (1).
 - 5 Hold each panel (4, 5, 6, and 7) in place on frame (3) and turn wing head studs (1) until each panel is secured to the frame.
 - 6 Hold intake duct (2) in place against frame (3) and rear bottom panel (4) Turn wing head studs (1) until panel is secured to the frame.
-

2-23. REPLACE ETHER START KIT

This task covers:

- a. Test
- b. Removal
- c. Inspection
- d. Installation

INITIAL SETUP:

Tools

Shop equipment, automotive maintenance and repair, common no 1

Tool kit, general mechanics automotive

Equipment Condition

Para

2-16

Condition Description

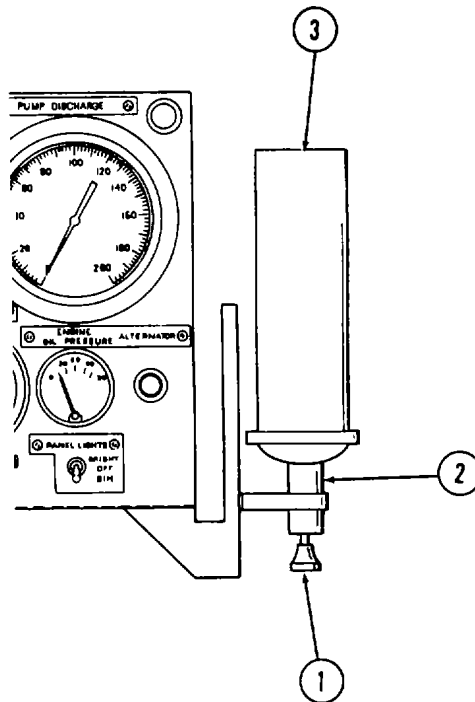
Control panel cover assembly removed.

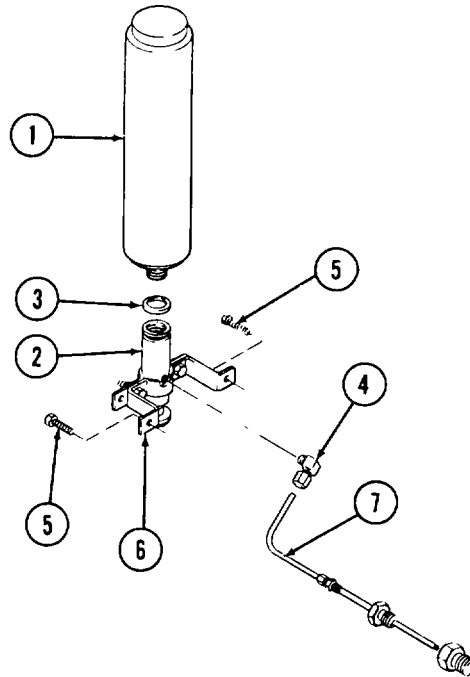
WARNING

Ether is highly flammable. Do not use near sparks or open flame. Do not inhale fumes. Do not operate valve for more than three seconds. Overloading the engine air housing with this highly flammable fluid (ether) could result in an explosion.

TEST:

Pull knob (1) for 3 seconds or less to test operation. If valve (2) operates but no ether is released, then replace cylinder (3) and test valve (2) again. If still no ether is released, replace valve (2).



2-23. REPLACE ETHER START KIT (Continued)**REMOVAL:**

- 1 Remove cylinder (1) by unscrewing from valve (2) Remove gasket (3).
- 2 Unscrew adapter (4) from air intake.
- 3 Remove two screws (5) Remove bracket (6) and valve (2).
- 4 Unscrew hose (7) from adapter (4) and valve (2).

INSPECTION:

- 1 Inspect hose (7) for cracks. Replace if damaged.
- 2 Inspect valve (2), cylinder (1), and adapter (4) for heavy corrosion, dents, or damaged threads Replace if damaged.

INSTALLATION:

- 1 Install hose (7) by screwing into adapter (4) and into valve (2).
- 2 Install valve (2) and bracket (6) using two screws (5).
- 3 Install gasket (3) and screw cylinder (1) onto valve (2) hand tight Do not tighten the cylinder (1) more than hand tight.
- 4 Install adapter (4) into air intake.

2-24. REPLACE THROTTLE CONTROL VERNIER

This task covers:

- | | |
|------------------------|-----------------|
| a. Removal | c. Installation |
| b. Cleaning/Inspection | |

INITIAL SETUP:**Tools**

Shop equipment, automotive maintenance and repair, common no. 1
 and repair, common no. 1
 Tool kit, general mechanics automotive

Materials/Parts

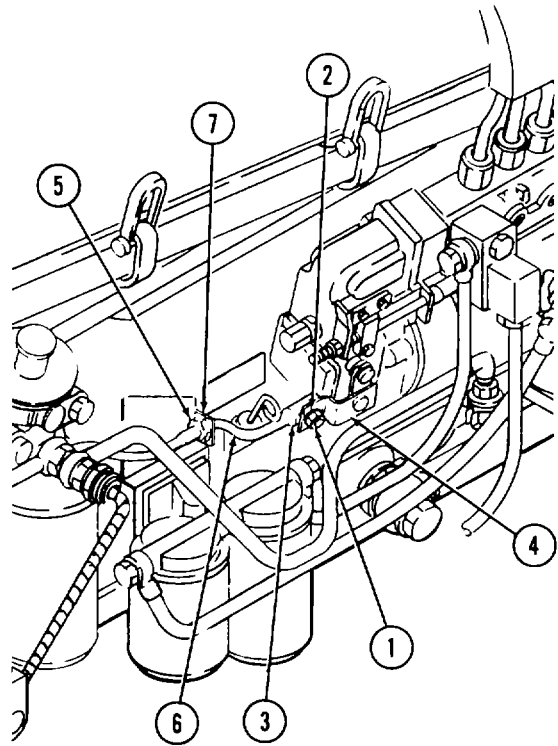
Diesel fuel oil (Item 6, Appendix C)

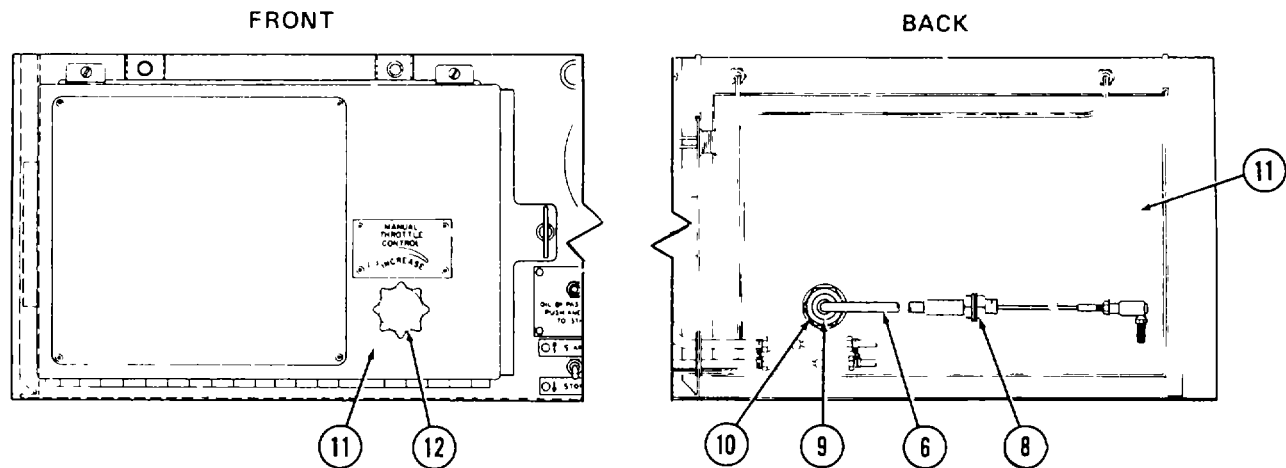
Special Environmental Conditions

Well-ventilated area required during cleaning.

REMOVAL:

- 1 Remove nut (1) and lockwasher (2)
- 2 Remove adapter (3) from lever extension (4).
- 3 Remove nut (5).
- 4 Slide throttle cable (6) out of throttle bracket (7).
- 5 Disconnect throttle cable (6) at quick release (8) at throttle bracket (7).



2-24. REPLACE THROTTLE CONTROL VERNIER (Continued)

- 6 Loosen nut (9) and washer (10) on back of throttle panel (11).
- 7 Remove throttle control knob and vernier (12) through front of throttle panel (11).

CLEANING/INSPECTION:**WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

- 1 Check that inner throttle cable moves freely within the outer sheath. Inspect for rust, corrosion, or stripped or damaged threads.
- 2 Clean throttle control lever extension, fittings, and hardware with diesel fuel oil.
- 3 Replace any severely damaged parts.

INSTALLATION:

- 1 Install throttle control knob and vernier (12) through front of throttle panel (11).
- 2 Connect one end of throttle cable (6) at quick release (8) at back of throttle panel (11)
- 3 Slide other end of throttle cable (6) into slot on throttle bracket (7).
- 4 Tighten nut (5).
- 5 Insert threaded segment of adapter (3) into lever extension (4).
- 6 Install lockwasher (2) and nut (1). Tighten nut.

2-25. ADJUST/REPLACE V-BELTS

This task covers:

- a. Removal/Inspection c. Adjustment
b. Installation

INITIAL SETUP:**Tools**

Shop equipment, automotive maintenance and repair, common no. 1
Tool kit, general mechanics automotive

Equipment Condition**Para**

2-22

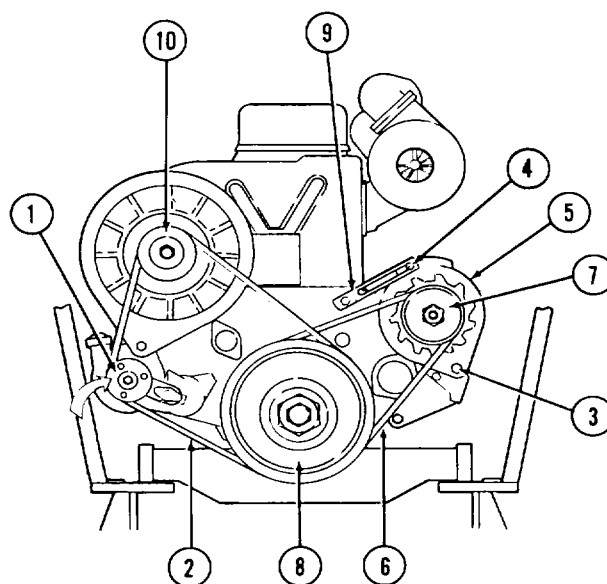
Condition Description

Engine shut down and cool.
Intake duct, right and left side panels, and rear bottom panel removed

REMOVAL/INSPECTION:**WARNING**

Severe injury may result from contact with rotating engine parts, V-belts, or fan. Shut off the engine when it is necessary to inspect, service, or perform maintenance on any moving parts. Close control panel to prevent accidental starting.

- 1 Carefully push idler pulley (1) toward engine centerline until slack in cooling air blower V-belt (2) is sufficient to allow V-belt removal.
- 2 Inspect cooling air blower V-belt (2) for worn or frayed edges and for brittle, cracked, or broken rubber. Replace worn or damaged belt.
- 3 Loosen bolts (3 and 4). Carefully push alternator (5) toward engine centerline until slack in alternator V-belt (6) is sufficient to allow V-belt removal.
- 4 Inspect alternator V-belt (6) for worn or frayed edges and for brittle, cracked, or broken rubber. Replace worn or damaged belt.

**NOTE**

If either V-belt is damaged, both must be replaced as a set.

2-25. ADJUST/REPLACE V-BELTS (Continued)

INSTALLATION:

- 1 Install alternator V-belt (6) over alternator pulley (7) and crankshaft pulley (8).
- 2 Carefully push alternator (5) away from engine centerline far enough to take up slack in V-belt (6).
- 3 Securely tighten bolt (4) in clamping plate (9) Tighten bolt (3).
- 4 Install cooling air blower V-belt (2) over blower pulley (10) and crankshaft pulley (8).
- 5 Carefully push idler pulley (1) toward engine centerline and place V-belt (2) in pulley trough.
- 6 Check that V-belt is in trough of blower pulley (10), crankshaft pulley (8), and idler pulley (1), then carefully release the idler pulley (1).
- 7 Check tension on V-belts (2 and 6) after tightening When V-belt is pressed with forefinger at midpoint between pulleys, it should deflect 1/2-3/4 inch (12. 7-19 0 mm) Run engine for 10 minutes and recheck tension of belts. Readjust as needed.

ADJUSTMENT:

- 1 Cooling air blower V-belt (2) tension can be adjusted only by replacing the torsion spring of the V-belt tensioner
Notify direct support
- 2 To adjust alternator V-belt (6) tension, loosen bolts (3 and 4) Carefully push alternator (5) away from engine centerline far enough to take up slack in V-belt
- 3 Tighten bolts (3 and 4) securely

2-26. REPLACE/REPAIR AIR CLEANER AND AIR INTAKE PIPING

This task covers:

- | | | |
|---------------|-----------------|----------------------|
| a. Removal | c. Repair | e. Operational Check |
| b. Inspection | d. Installation | |

INITIAL SETUP:

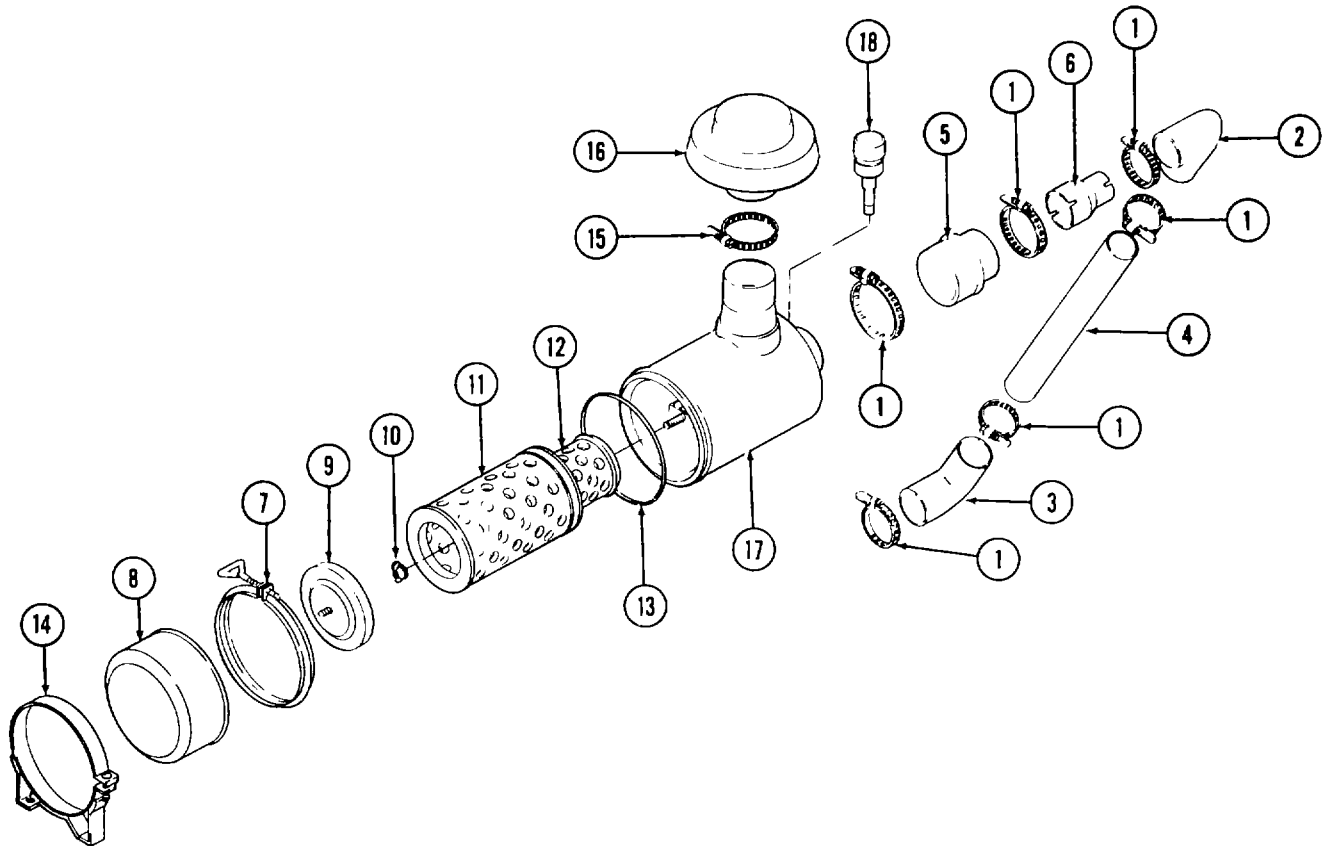
Tools

Shop equipment, automotive maintenance and repair, common no. 1
 Tool kit, general mechanics automotive

Special Environmental Conditions

Well-ventilated area required for cleaning and testing.

REMOVAL:



- 1 Loosen hose clamps (1) and remove elbows (2 and 3), air intake pipe (4), reducer (5), and adapter (6).
- 2 Loosen cup assembly clamp (7). Remove clamp, cup assembly (8), and baffle assembly (9).
- 3 Remove nut assembly (10), primary and secondary elements (11 and 12), and preformed packing (13) Discard preformed packing.
- 4 Loosen two air cleaner clamps (14) and clamp (15) under rain cap (16) Remove air cleaner body (17) and rain cap (16).
- 5 Thread restriction indicator (18) from the air cleaner outlet.

2-26. REPLACE/REPAIR AIR CLEANER AND AIR INTAKE PIPING (Continued)

INSPECTION:**NOTE**

Replace air filter elements if air cleaner restriction indicator signal indicates replacement.

- 1 Inspect air cleaner body assembly, cup assembly, baffle assembly, rain cap, restriction indicator, and clamps for damage, dents, holes, rust, or corrosion. Replace if severely damaged or rusted.
- 2 Inspect rubber elbows, reducer, and adapter. Replace if brittle, cracked, or deteriorated. Inspect pipe and clamps for damage, dents, rust, or corrosion. Replace if severely damaged or rusted.
- 3 Check that the restriction indicator, set under vacuum, is readable and can be reset. Replace if damaged or if it does not function.

REPAIR:

- 1 Clean elements (11 and 12) or replace if they cannot be cleaned properly.
- 2 Repair minor dents, abraded areas, rust, or corrosion on air cleaner body (17), rain cap (16), or clamps.
- 3 Repair or replace severely worn, damaged, or rusted components.
- 4 Do not attempt to repair brittle, cracked, or deteriorated rubber elbows (2 and 3), reducer (5), and adapter (6). Replace as necessary.
- 5 Repair rust or corrosion on air intake pipe (4). If damaged severely, replace.
- 6 Replace restriction indicator (18) if it is damaged.

INSTALLATION:

- 1 Thread restriction indicator (18) into threaded hole in the air cleaner outlet.
- 2 Install air cleaner body (17) on trailer-mounted air cleaner clamps (14) with inlet stack up. Tighten clamps securely. Install rain cap (16) on stack and tighten clamp (15) under rain cap (16).
- 3 Install new preformed packing (13), secondary element (12), primary element (11), and nut assembly (10).
- 4 Install cup assembly (8) and clamp (7) on air cleaner body (17). Tighten cup assembly clamp (7) securely.
- 5 Install reducer (5), adapter (6), and hose clamps (1) on air cleaner outlet. Tighten hose clamps securely.
- 6 Install upper elbow (2) on adapter (6), and tighten clamp (1) only enough to hold the elbow in place.
- 7 Assemble air intake pipe (4) and lower elbow (3) and tighten clamp (1) only enough to hold them together.
- 8 Insert air intake pipe (4) end into upper elbow (2) on adapter (6), and install lower elbow (3) onto turbocharger inlet flange. Adjust the positioning of the elbows and pipe, and tighten all clamps (1) securely.

2-26. REPLACE/REPAIR AIR CLEANER AND AIR INTAKE PIPING (Continued)

OPERATIONAL CHECK:

WARNING

Touching exhaust system during test can cause severe burns.

CARBON MONOXIDE (EXHAUST GAS) CAN KILL YOU

Exposure to exhaust gases produces symptoms of headache, dizziness, loss of muscular control, drowsiness, or coma. Brain damage or death can result from severe exposure.

Fumes from engines become concentrated with poor ventilation. Operate engine in a ventilated area only.

While running engine, be alert for fumes. If someone is overcome, expose to fresh air; keep warm and still; give artificial respiration if needed. Seek medical attention. Administer oxygen, if available.

GOOD VENTILATION IS THE BEST DEFENSE AGAINST EXHAUST POISONING .

- 1 Start engine and observe installed components for looseness, rattles, or leaks. Tighten.
 - 2 If red band is visible in window of restriction indicator, shut down engine. Recheck installation and element(s). Reset indicator Restart engine. If red band is still visible, replace indicator. Restart engine and check indicator. If indicator still shows red band, refer to direct support.
-

2-27. REPLACE/REPAIR CRANKCASE BREATHER

This task covers:

- | | |
|------------------------------------|------------------------|
| <p>a. Removal</p> <p>b. Repair</p> | <p>c. Installation</p> |
|------------------------------------|------------------------|

INITIAL SETUP:**Tools**

Shop equipment, automotive maintenance and repair, common no. 1
Tool kit, general mechanics automotive

**Equipment
Condition
Para**

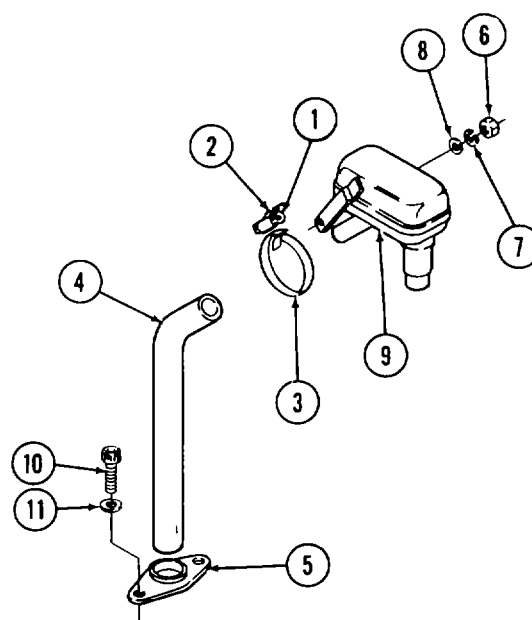
Condition Description
Engine shut down and cool.

References

Para 2-22 Replace/Repair Engine Cover;
Replace Intake Duct Assembly

REMOVAL:

- 1 Remove engine side panel.
- 2 Unscrew cotter pin (1) by turning clockwise.
- 3 Remove hose fastener (2) and hose strap (3)
Pull hose (4) from retaining plate (5).
- 4 Remove bolt (6), spring lockwasher (7), and washer (8) that secure breather (9) to the engine
Remove breather from crankcase.
- 5 Remove screw (10) and washer (11) that secure retaining plate (5) to the oil pan
Remove the retaining plate.

**REPAIR:**

- 1 If breather (9) is blocked, remove debris.
Replace if damaged.
- 2 If hose (4) is damaged, replace.

INSTALLATION:

- 1 Assemble hose (4), hose strap (3), and hose fastener (2) on breather (9).
- 2 Insert cotter pin (1) in hose fastener and tighten snugly but not too tight Overtightening hose fastener will crimp or damage hose (4).
- 3 Install retaining plate (5) using screw (10) and washer (11) Make sure retaining plate is securely fastened to crankcase
- 4 Slide hose (4) into the retaining plate (5).
- 5 Secure breather (9) on crankcase and shield, using bolt (6), spring lockwasher (7), and washer (8)
- 6 Attach side panel.

2-28. REPLACE/REPAIR EXHAUST SYSTEM

This task covers:

- | | | |
|------------------------|-----------------|----------------------|
| a. Removal | c. Repair | e. Operational Check |
| b. Cleaning/Inspection | d. Installation | |

INITIAL SETUP:**Tools**

Shop equipment, automotive maintenance and repair, common no. 1

Tool kit, general mechanics automotive

Materials/Parts

Diesel fuel oil (Item 6, Appendix E)

General Safety Instructions

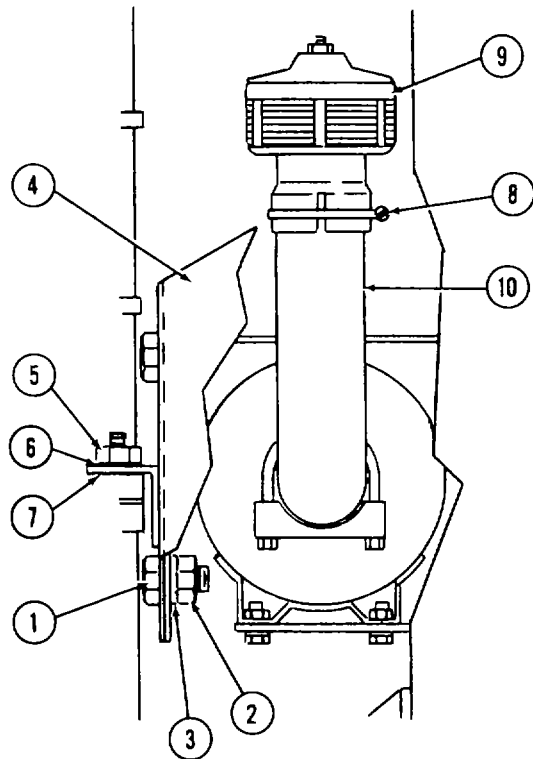
Unit cool

Well-ventilated area required

REMOVAL:**WARNING**

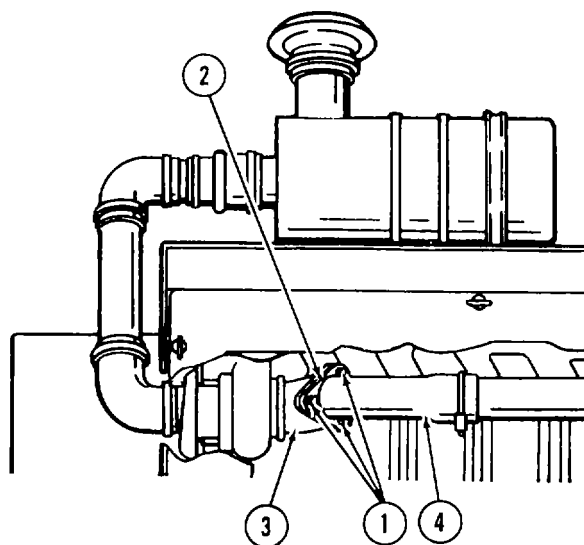
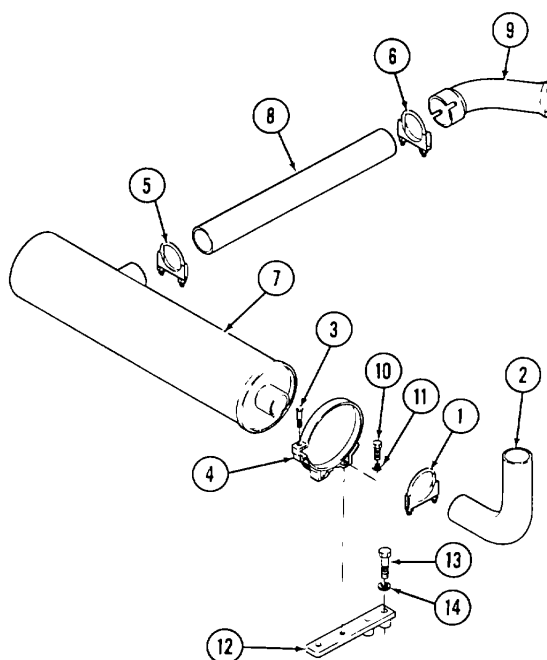
Handling hot exhaust system can cause severe burns Allow unit to cool before handling.

- 1 Remove two screws (1), two nuts (2), two washers (3), and remove exhaust guard (4).
- 2 Remove two nuts (5), two washers (6), and remove muffler guard (7).
- 3 Loosen clamp (8) and slide clamp (8) and spark arrestor (9) from exhaust elbow (10).



2-28. REPLACE/REPAIR EXHAUST SYSTEM (Continued)

4. Loosen nuts and remove clamp (1) and exhaust elbow (2) from muffler outlet
5. Loosen screws (3) on two mounting bands (4)
6. Loosen nuts on two clamps (5 and 6) Slide clamp (5) away from muffler (7) along exhaust pipe (8)
7. Separate exhaust pipe (8) from muffler (7) intake flange
8. Slide muffler (7) from mounting bands (4) Remove muffler (7)
9. Remove clamps (5 and 6) and pull exhaust pipe (8) from exhaust elbow (9)
10. Remove mounting bands (4) by removing screws (10) and washers (11)
11. Remove muffler bracket (12) by removing bolts (13) and lockwashers (14)
12. Remove bolts and nuts (1) (three sets) that secure exhaust elbow flange (2) to turbine elbow (3)
13. Remove exhaust elbow (4), flange washers, and gaskets. Discard gaskets as necessary



2-28. REPLACE/REPAIR EXHAUST SYSTEM (Continued)**CLEANING/INSPECTION****WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

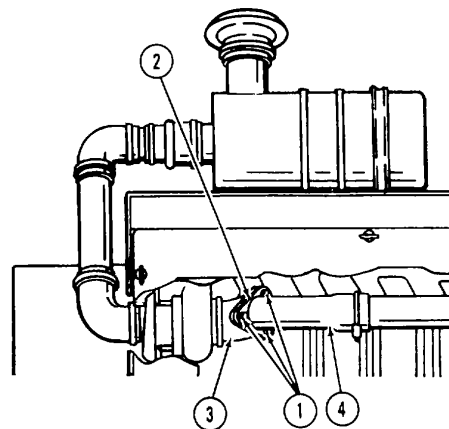
- 1 Clean exhaust guard, muffler guard, spark arrestor, exhaust elbow, mounting bands, exhaust pipe, muffler bracket, and exhaust elbow flange with diesel fuel oil and dry with compressed air. Inspect for minor rust, corrosion, or other damage. Replace if severely rusted or damaged.
- 2 Inspect spark arrestor fins for damage or erosion that would prevent gas flow or allow sparks to escape. Replace if fins are severely damaged or eroded.

REPAIR

- 1 Repair minor dents, rust, or corrosion on exhaust guard, muffler guard, spark arrestor, exhaust elbow, exhaust pipe, or exhaust elbow flange. If exhaust elbow flange is cracked or bent it must be replaced.
- 2 Straighten or replace bent clamps, mounting bands, or muffler bracket
- 3 Replace muffler if holes or tears are present or if severely dented or corroded

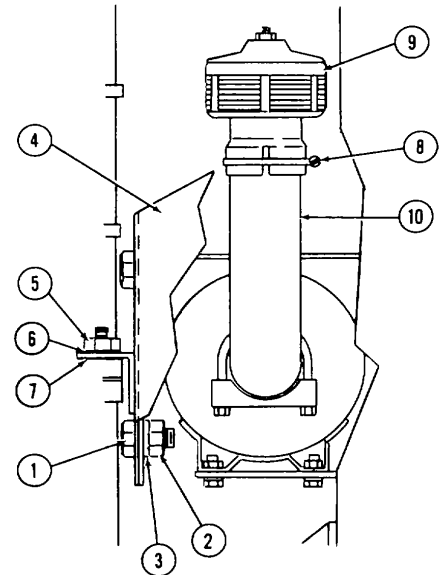
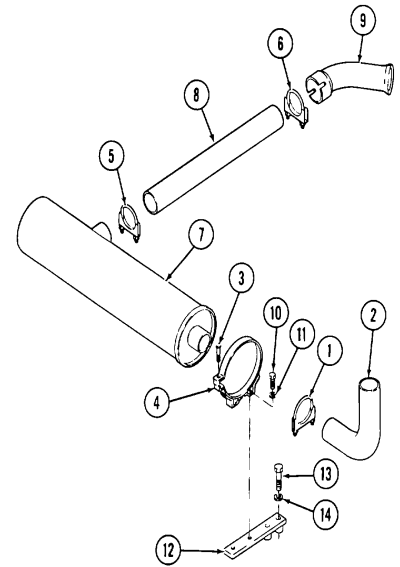
INSTALLATION

- 1 Install exhaust elbow flange (2) on exhaust elbow (4)
- 2 Install gaskets and washers on turbine elbow (3)
- 3 Install bolts and nuts (1) (three sets) to secure exhaust elbow (4) and exhaust elbow flange (2) to turbine elbow (3). Only tighten bolts and nuts (1) enough to hold parts in position.



2-28. REPLACE/REPAIR EXHAUST SYSTEM (Continued)

- 4 Install muffler bracket (12) and secure with bolts (13) and lockwashers (14).
- 5 Install mounting bands (4) and secure with screws (10) and lockwashers (11)
- 6 Install exhaust pipe (8) with clamps (5 and 6) on exhaust elbow (9). Do not tighten clamps (5 and 6)
- 7 Slide muffler (7) through mounting bands (4) Do not tighten screws (3) on mounting bands (4).
- 8 Attach exhaust pipe (8) to muffler (7) Tighten clamps (5 and 6).
- 9 Tighten screws (3) on mounting bands (4)
- 10 Install clamp (1) on exhaust elbow (2). Place exhaust elbow (2) in a vertical position and tighten clamp (1).
- 11 Place clamp (8) on spark arrestor (9) and install on exhaust elbow (10) Tighten clamp securely.
- 12 Install muffler guard (7) and secure with two nuts (5) and two washers (6).
- 13 Install exhaust guard (4) on muffler guard (7) and secure with two screws (1), two washers (3), and two nuts (2).



2-28. REPLACE/REPAIR EXHAUST SYSTEM (Continued)

OPERATIONAL CHECK**WARNING**

Touching exhaust system during test can cause severe burns.

CARBON MONOXIDE (EXHAUST GAS) CAN KILL YOU

Exposure to exhaust gases produces symptoms of headache, dizziness, loss of muscular control, drowsiness, or coma. Brain damage or death can result from severe exposure.

Fumes from engines become concentrated with poor ventilation. Operate engine in a ventilated area only.

While running engine, be alert for fumes. If someone is overcome, expose to fresh air, keep warm and still, give artificial respiration if needed. Seek medical attention. Administer oxygen, if available.

GOOD VENTILATION IS THE BEST DEFENSE AGAINST EXHAUST POISONING.

Start engine and observe exhaust elbow, spark arrestor, exhaust pipe, muffler, exhaust elbow flange, and turbine elbow for leaks and/or looseness or rattles. Tighten screws, clamps, and bands as necessary.

2-29. REPLACE/REPAIR OIL DRAIN ASSEMBLY

This task covers:

- a. Removal
- b. Cleaning/Inspection
- c. Repair
- d. Installation

INITIAL SETUP:

Tools

Shop equipment, automotive maintenance and repair, common no 1

Tool kit, general mechanics automotive

Equipment Condition

Para

Condition Description

Engine oil drained

2-22

Right and left side panels, air duct, and bottom rear panel removed from engine cover frame

Materials/Parts

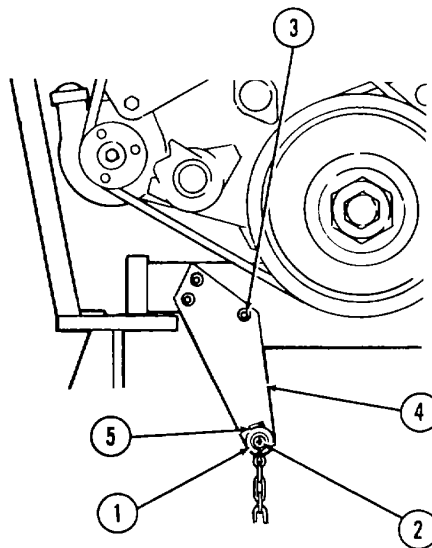
Diesel fuel oil (Item 6, Appendix C)
 Plywood board 1/8 x 19 x 48 inches
 (3 2 x 482 6 x 1219 2 mm)

Special Environmental Conditions

Well-ventilated area required for cleaning

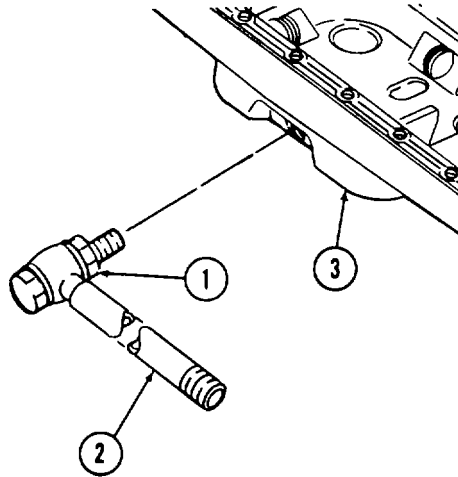
REMOVAL

- 1 Remove pipe coupling (1) from oil drain (2) Do not disassemble the chain and coupling from the engine unless replacement is required
- 2 From the rear end of the skid, slide a plywood board, approximately 1/8 x 19 x 48 inches (3 2 x 482 6 x 1219.2 mm) between the oil pan and the fuel tank Be sure the board does not rest on, crimp, or damage any fuel lines or fittings Place the board on top of the fuel tank to protect it from damage during removal of the oil drain assembly
- 3 Remove cap screws, washers, and lockwashers (3) from oil drain support bracket (4). With the bracket still attached to the oil drain pipe, rest the bracket on the plywood board.
- 4 Loosen hose clamp (5), and remove support bracket (4) and hose clamp from the oil drain pipe



2-29. REPLACE/REPAIR OIL DRAIN ASSEMBLY (Continued)

- 5 Loosen adapter (1) and unscrew the oil drain assembly (2) from the oil pan (3) Remove oil drain assembly from under the engine

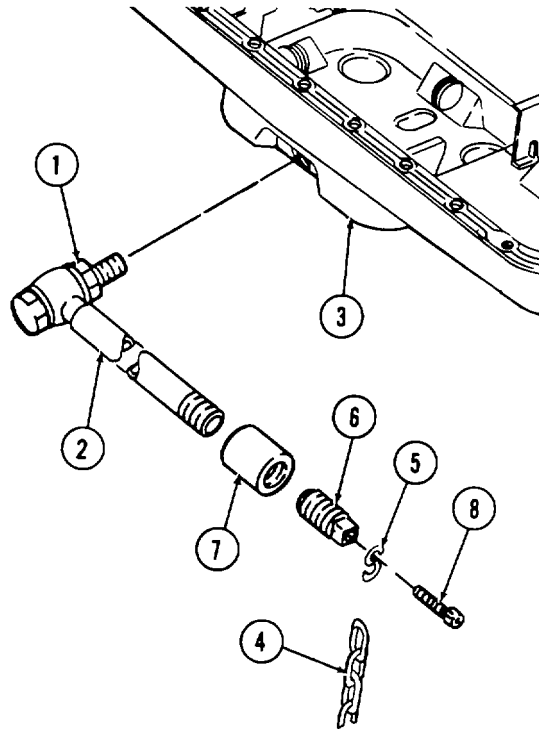
**CLEANING/INSPECTION****WARNING**

Severe burns, illness, or death could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. DO NOT SMOKE.

- 1 Clean support bracket with diesel fuel oil Inspect for rust, corrosion, dents, or distortion.
- 2 Inspect threads in oil drain assembly and coupling. Repair minor thread damage Replace components with stripped or damaged threads.
- 3 Inspect the chain for secure mounting to the skid and to the oil drain assembly
- 4 Clean oil drain assembly with diesel fuel oil Inspect for rust, corrosion, dents, or distortion

2-29. REPLACE/REPAIR OIL DRAIN ASSEMBLY (Continued)**REPAIR**

- 1 Repair minor damage to support bracket. File nicks or burrs Remove rust with sandpaper, then clean



2 Straighten minor bends in oil drain assembly (2) Replace if damage that restricts oil flow or causes leaks at connections cannot be repaired. Replace damaged or bent pipes, or pipes that cannot be cleaned.

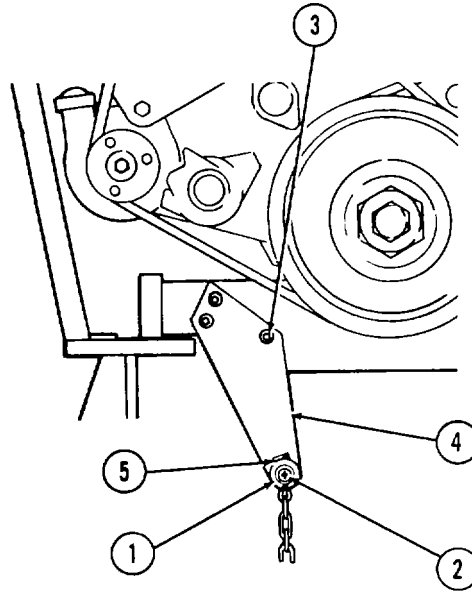
3 Repair threads by running tap or die along threads to remove burrs Replace the component if more than 25% of the thread is lost due to damage or during repair

- 4 Replace damaged chain (4), S-hook (5), plug (6), coupling (7), or screw (8)

INSTALLATION:

- 1 If chain (4), S-hooks (5), plug (6), coupling (7), or screw (8) have been repaired or replaced, attach S-hooks (5) to each end of chain (4) and crimp; assemble coupling (7) and plug (6) and secure one S-hook (5) to plug (6) with screw (8) Attach the other S-hook to the skid and crimp.
- 2 Secure oil drain assembly (2) to oil pan (3) and tighten adapter (1).

2-29. REPLACE/REPAIR OIL DRAIN ASSEMBLY (Continued)



3. Using cap screws, washers, and lockwashers (3), secure support bracket (4) to the rear crossmember of the engine suspension.
 4. Secure oil drain assembly to the support bracket lip with hose clamp (5) Tighten the hose clamp.
 5. Place coupling (1) on the end of the oil drain assembly and tighten
-

2-30. REPLACE FUEL FILTER CARTRIDGES

This task covers:**a. Removal****b. Installation**

INITIAL SETUP**Tools**

Shop equipment, automotive maintenance and repair, common no. 1

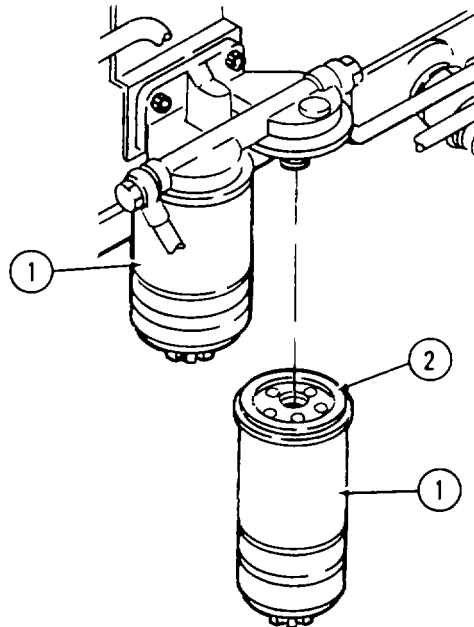
Tool kit, general mechanics automotive

Materials/Parts

Diesel fuel oil (Item 6, Appendix C)

REMOVAL

Remove fuel filter cartridges (1). Rotate counter-clockwise to remove. Discard cartridges

**INSTALLATION****WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

Fill each new fuel filter cartridge (1) 2/3 full with diesel fuel oil and coat top ring (2) Install by rotating fuel filter cartridge (1) clockwise Tighten hand tight.

2-31. TEST/REPLACE SOLENOID VALVE

This task covers:

- | | |
|--------------------|----------------------|
| a. Removal | c. Installation |
| b. Test/Inspection | d. Operational Check |

INITIAL SETUP:**Tools**

Shop equipment, automotive maintenance and repair, Lommon no 1
Tool kit, general mechanics automotive

References

Para 2-15 Electrical System Assembly
Para 2-16 Control Panel Assembly
Para 2-39 Fuel Tank Lines and Fittings

Materials/Parts

Diesel fuel oil (Item 6, Appendix C)

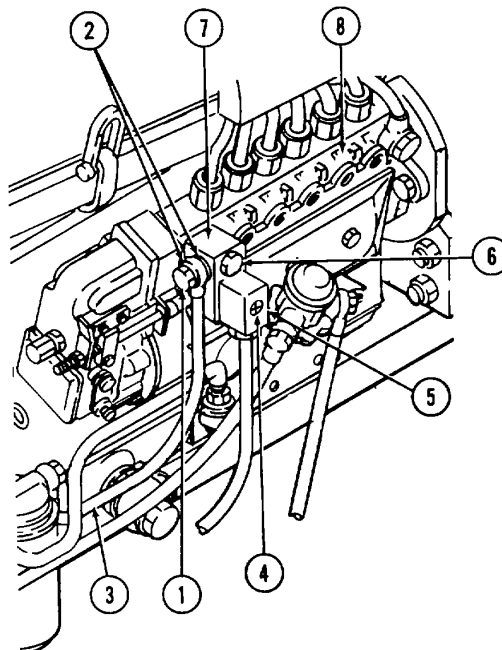
General Safety Instructions

Unit cool.
Well-ventilated area.

REMOVAL**WARNING**

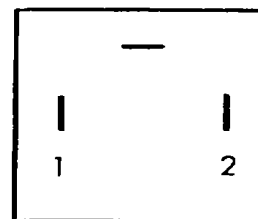
Severe burns, illness, or death could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Be certain that fuel lines and connections are secure. Always store fuel in proper, marked containers. DO NOT SMOKE.

- 1 Remove bolt (1) and washers (2).
- 2 Remove filter-to-injection pump hose (3).
- 3 Remove screw (4) from electrical connector (5) and attached wiring (to control panel) from solenoid valve (7)
- 4 Loosen screw and pull off three-prong connector
- 5 Remove bolt and washers (6) and solenoid valve (7) from fuel injection pump (8). Discard washers



2-31. TEST/REPLACE SOLENOID VALVE (Continued)**TEST/INSPECTION**

- 1 Electrically test operation of solenoid valve. Connect pin (P2) to ground. Intermittently apply +12 vdc to pin 1 (P1) The valve should normally be open with +12 volts applied to pin 1 (P1) but should close when no voltage is applied to pin 1 (P1). These signals simulate the engine fault sensitive control signals from the control panel. Test valve is open when an electrical signal (+12 vdc) is applied to the valve solenoid pin 1 (P1), simulating the reset signal. If either malfunctions, replace solenoid valve



- 2 Inspect solenoid valve and bolt for damage, rust, corrosion, or restrictions in fuel flow If damaged, severely rusted, or corroded, replace valve and/or bolt.
- 3 Inspect electrical contacts on both ends of electrical connectors at solenoid valve Inspect wiring to and from control panel For connections at control panel, follow procedures in paragraphs 2-15 and 2-16 If any electrical problems or malfunctions exist, replace wiring and/or connectors as necessary.

INSTALLATION

- 1 Install solenoid valve (7) using bolt and new washers (6) Rotate clockwise and tighten securely.

CAUTION

Do not force electrical connector onto solenoid valve. Be careful to match slots in connector to plug prongs on solenoid valve.

- 2 Install three-slot square electrical connector (5) onto three-prong plug on solenoid valve (17)
- 3 Install screw (4)
- 4 Install fuel filter-to-injection pump hose (3) with bolt (1) and new washers (2) Tighten bolt securely.
- 5 Bleed air from fuel lines in accordance with paragraph 2-39

2-31. TEST/REPLACE SOLENOID VALVE (Continued)

OPERATIONAL CHECK**WARNING**

Touching exhaust system during test can cause severe burns

CARBON MONOXIDE (EXHAUST GAS) CAN KILL YOU

Exposure to exhaust gases produces symptoms of headache, dizziness, loss of muscular control, drowsiness, or coma. Brain damage or death can result from severe exposure.

Fumes from engines become concentrated with poor ventilation. Operate engine in a ventilated area only.

While running engine, be alert for fumes. If someone is overcome, expose to fresh air; keep warm and still; give artificial respiration if needed. Seek medical attention Administer oxygen, if available.

GOOD VENTILATION IS THE BEST DEFENSE AGAINST EXHAUST POISONING.

- 1 Test engine shutdown capability and fuel flow when solenoid valve is normally open and closed. Try to start engine without pushing in OIL BY-PASS SWITCH Engine should not start Do not crank engine for more than 30 seconds. This procedure will test the valve's shutdown (closed) capability
 - 2 Start engine with OIL BY-PASS SWITCH pushed in. If engine starts and oil pressure reaches at least 25 psi (172 kPa), release button. Engine should continue to run Some adjustment of the valve may be necessary.
 - 3 Start engine. If engine malfunctions, refer to troubleshooting guide
-

2-32. REPLACE FUEL FEED PUMP

This task covers:

- a. Removal
- b. Inspection
- c. Installation

INITIAL SETUP

Tools

Shop equipment, automotive maintenance and repair, common no 1

Tool kit, general mechanics automotive

Equipment Condition

Para 2-39

Condition Description

Fuel feed pump-to-fuel filter fuel line and 3-way selector valve-to-fuel feed pump fuel line disconnected

Materials/Parts

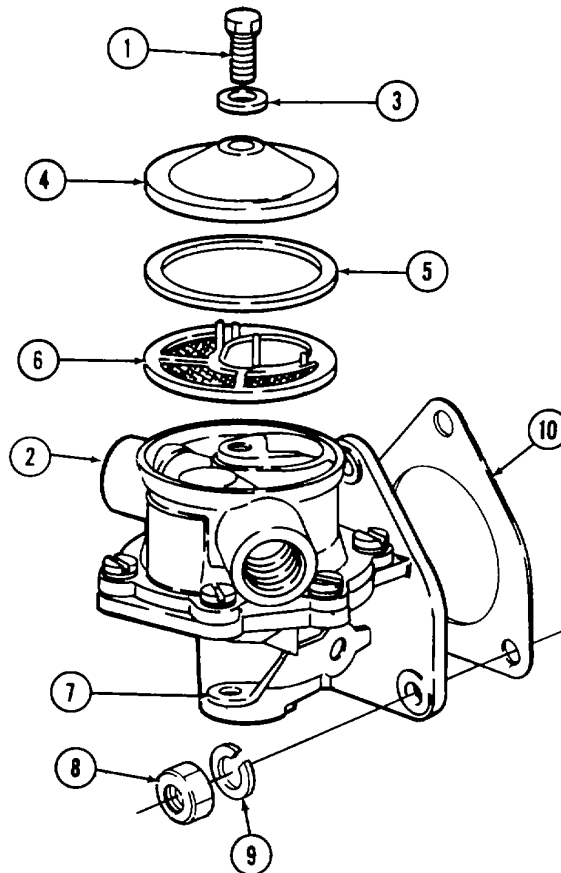
Diesel fuel oil (Item 6, Appendix C)

General Safety Instructions

Unit cool
Well-ventilated area.

INSPECTION:

- 1 Unthread bolt (1) from fuel feed pump (2). Remove bolt (1), washer (3), and cover (4)
- 2 Remove gasket (5) and strainer (6) If damaged, discard gasket (5) and washer (3)



2-32. REPLACE FUEL FEED PUMP (Continued)

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg.cm.) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 3 Using diesel fuel oil and a soft-bristled brush, clean strainer (6), cover (4), and bolt (2) Dry with low pressure compressed air
- 4 If deposits in strainer cannot be removed, discard strainer
- 5 Press feed pump primer lever (7) and check operation of feed pump diaphragm. Check diaphragm for leaks
- 6 If diaphragm leaks, replace fuel feed pump (2)

REMOVAL

- 1 Remove nuts (8) and lockwashers (9).
- 2 Remove and discard gasket (10).
- 3 Remove fuel feed pump.

INSTALLATION

- 1 Install new gasket (10) and fuel feed pump (2)
 - 2 Install nuts (8) and lockwashers (9). Tighten nuts securely.
 - 3 Install strainer (6) onto fuel feed pump (2)
 - 4 Place gasket (5) onto sealing surface of pump
 - 5 Install bolt (1) through washer (3) and cover (4)
 - 6 Place cover over gasket (5) and strainer (6).
 - 7 Mate cover to fuel feed pump (2) Thread bolt into pump
 - 8 Start engine and observe fuel feed pump for leaks
-

2-33. REPLACE TURBOCHARGER AND EXHAUST (TURBINE) ELBOW

This task covers:

- a. Removal
- b. Inspection
- c. Installation

INITIAL SETUP

Tools

Shop equipment, automotive maintenance and repair, common no. 1
 Tool kit, general mechanics automotive

Equipment Condition

Para	Condition Description
2-26	Air intake elbow removed
2-28	Exhaust (pipe) elbow removed

Materials/Parts

Lubricating oil (Item 10, Appendix C)

General Safety Instructions

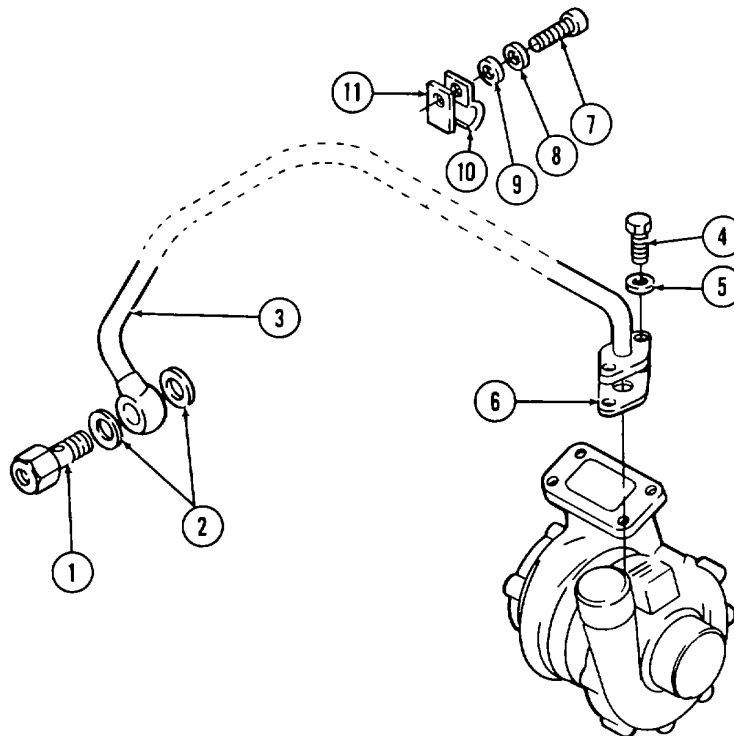
Unit cool

REMOVAL

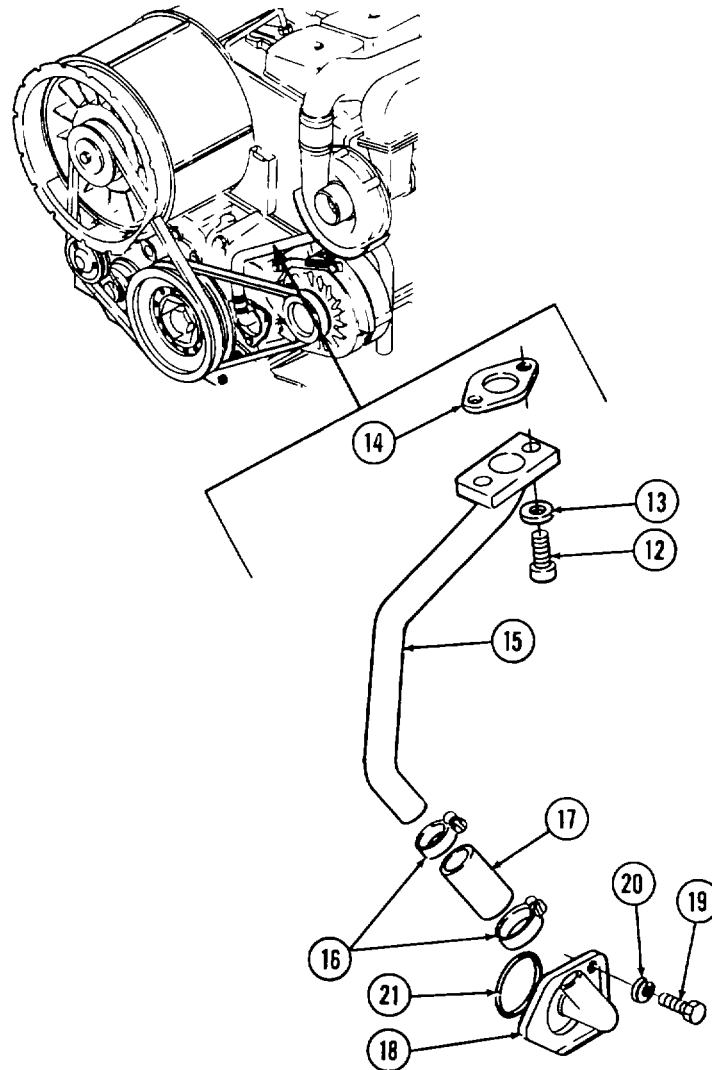
WARNING

Handling hot exhaust system can cause severe burns. Allow unit to cool before handling.

- 1 Unthread bolt (1) and remove two washers (2) and the bolt end of the turbocharger-to-filter lube oil pipe (3).
- 2 Remove two bolts (4), two washers (5), and gasket (6) from the turbocharger end of the pipe (3). Discard gasket
- 3 Remove three screws (7), three washers (8), three rings (9), three pipe clips (10), and three end plates (11) to remove pipe (3) from the engine



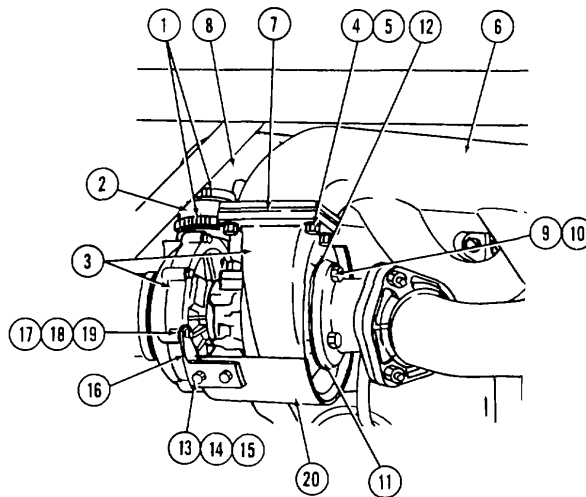
2-33. REPLACE TURBOCHARGER AND EXHAUST (TURBINE) ELBOW (Continued)



- 4 Remove two screws (12), two washers (13), and gasket (14) from the turbocharger end of oil return pipe (15)
- 5 Loosen clip (16) at each end of rubber sleeve (17). Pull the sleeve and oil return pipe (15) from the tube on cover (18).
- 6 Remove three bolts (19) and three washers (20) Remove cover (18) and preformed packing (21). Discard packing.

2-33. REPLACE TURBOCHARGER AND EXHAUST (TURBINE) ELBOW (Continued)

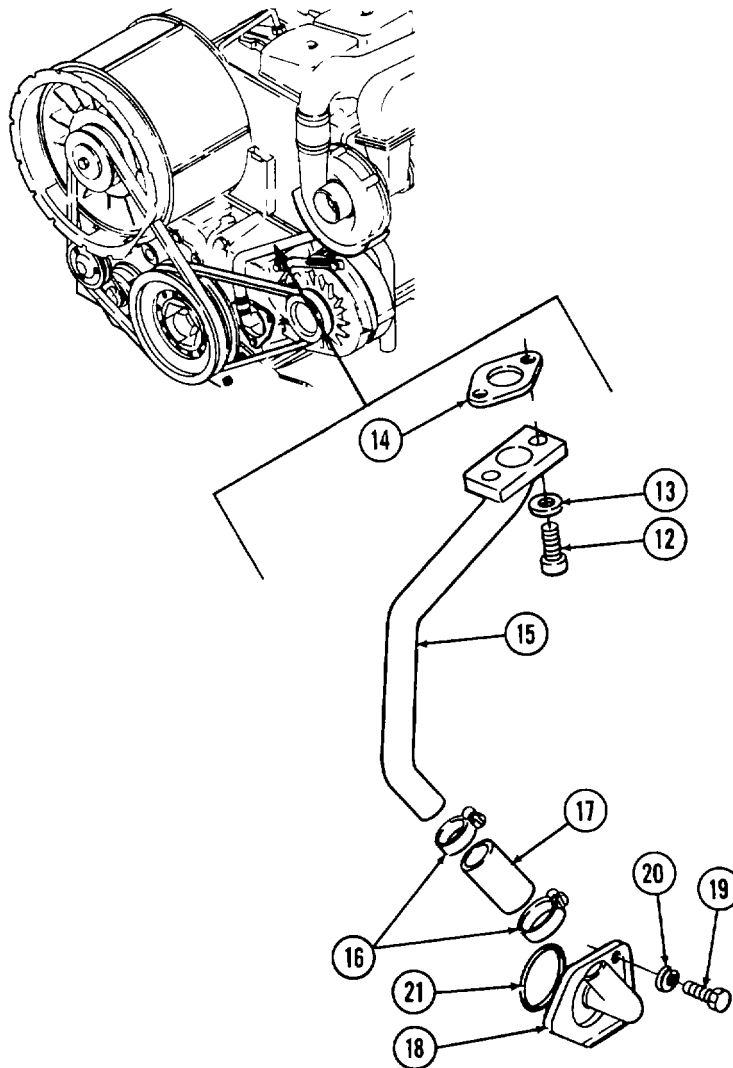
- 7 Loosen hose clamps (1) and slide them to the bottom of rubber sleeve (2) Do not attempt to remove the sleeve until turbocharger (3) has been removed
- 8 Remove four bolts (4) and washers (5) that secure turbocharger (3) to exhaust manifold (6)
- 9 Remove turbocharger (3) and gasket (7) from exhaust manifold (6) Discard gasket (7)
- 10 Pull compressor housing outlet and hose clamps (1) from rubber sleeve (2) Remove the rubber sleeve from the suction pipe (8)
- 11 Remove four bolts (9) and four toothed washers (10) that secure exhaust elbow (11) to the turbine housing Remove exhaust elbow (11) and gasket (12) Discard gasket (12)
- 12 Remove four bolts (13), four nuts (14), and four washers (15) to remove brackets (16) from turbocharger
- 13 Remove four bolts (17), four washers (18), and four lockwashers (19) that secure shield (20) to brackets (16)

**INSTALLATION**

- 1 Using four bolts (17), four washers (18), and four lockwashers (19), secure shield (20) to brackets (16)
- 2 Using four bolts (13), four nuts (14), and four washers (15), assemble brackets (16) on turbocharger (3)
- 3 Install new gasket (12) on the turbine housing outlet
- 4 Using four bolts (9) and four toothed washers (10), secure exhaust elbow (11) to the turbine housing
- 5 Install rubber sleeve (2) on compressor housing outlet and slide two hose clamps (1) over the sleeve Do not tighten the hose clamps
- 6 Pour clean lube oil into the turbocharger bearing housing
- 7 Slide rubber sleeve (2) over end of suction pipe (8). Adjust sleeve so it covers suction pipe (8) and compressor housing outlet equally.
- 8 Using four bolts (4), four washers (5), and a new gasket (7), secure turbocharger (3) to exhaust manifold (6)
- 9 Tighten hose clamps (1)

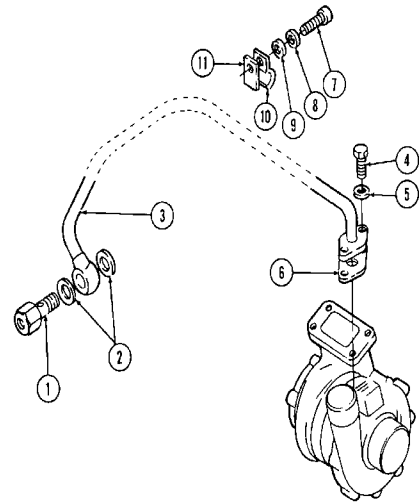
2-33. REPLACE TURBOCHARGER AND EXHAUST (TURBINE) ELBOW (Continued)

- 10 Install new preformed packing (21) in the front cover oil port. Secure cover (18) in place with three bolts (19) and three washers (20).
- 11 Install sleeve (17) and one pipe clip (16) on the tube of cover (18). Do not tighten pipe clip.
- 12 Install new gasket (14) on the turbocharger oil outlet port.
- 13 Using two screws (12) and washers (13), secure the turbocharger end of oil return pipe (15) to the turbocharger oil outlet.
- 14 Slide second pipe clip (16) and the free end of sleeve (17) onto oil return pipe (15). Position the sleeve equally on the pipe and tube ends. Tighten both pipe clips (16) securely.



2-33. REPLACE TURBOCHARGER AND EXHAUST (TURBINE) ELBOW (Continued)

- 15 Position turbocharger-to-filter lube oil pipe (3) between the oil filter and the turbocharger intake. Install three pipe clips (10) and three end plates (11) with screws (7), three washers (8), and three rings (9). Tighten screws only hand tight
- 16 Install new gasket (6) on the turbocharger oil inlet port.
- 17 Using two bolts (4) and two washers (5), secure lube oil pipe (3) to the turbocharger oil inlet.
- 18 Secure the bolt end of lube oil pipe (3) with bolt (1) and two washers (2).
- 19 Tighten screws (7) on pipe clips (10) to hold the lube oil pipe (3) securely in position without vibration.

**OPERATIONAL CHECK****WARNING**

Touching exhaust system during test can cause severe burns.

CARBON MONOXIDE (EXHAUST GAS) CAN KILL YOU

Exposure to exhaust gases produces symptoms of headache, dizziness, loss of muscular control, drowsiness, or coma.

Brain damage or death can result from severe exposure. Fumes from engines become concentrated with poor ventilation. Operate engine in a ventilated area only.

While running engine, be alert for fumes. If someone is overcome, expose to fresh air, keep warm and still; give artificial respiration if needed. Seek medical attention. Administer oxygen, if available.

GOOD VENTILATION IS THE BEST DEFENSE AGAINST EXHAUST POISONING.

- 1 Start engine and check for loose, rattling components. Tighten as necessary to prevent rattles
- 2 Check for oil leaks around lube oil line connections to the turbocharger, at the oil filter, and at the front cap of the return line. Tighten connections and reseal gaskets as necessary.

2-33. REPLACE TURBOCHARGER AND EXHAUST (TURBINE) ELBOW (Continued)

- 3 While the engine is running, listen to the turbocharger for noisy operation
 - 4 Observe the engine exhaust for discoloration.
 - 5 Shut down engine
-

2-34 TEST/REPLACE STARTER MOTOR

This task covers:

- | | |
|--------------------|----------------------|
| a. Removal | c. Installation |
| b. Test/Inspection | d. Operational Check |

INITIAL SETUP**Tools**

Shop equipment, automotive maintenance and repair, common no 1
Tool kit, general mechanics automotive

Equipment Condition

Para	Condition Description
	Engine shut down and cool.
2-13	Battery cables removed.
2-15	Starter electrical system wiring removed

REMOVAL

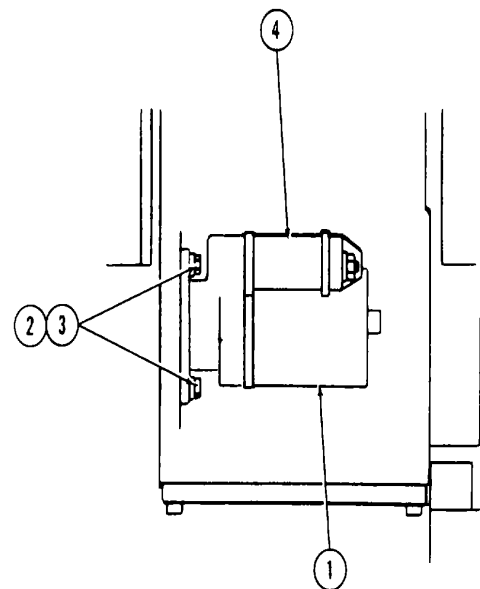
- Support starter (1) and remove three bolts (2) and three washers (3)
- Remove starter (1) with relay (4) attached

TEST/INSPECTION

Remove relay and starter Test and inspect relay If relay does not activate when excited with ground and +24 vdc from 24 vdc power supply, the unit is not operating properly Test starter with ground and +24 vdc. Replace starter motor if necessary

INSTALLATION

- Support starter (1) and relay (4) and install three bolts (2) and three washers (3) Tighten bolts (2) securely
- Install tagged electrical system wires and positive battery cable in accordance with paragraphs 2-15 and 2-13. Tighten lug nuts securely.
- Install negative battery cable Tighten lug nuts securely.



2-34. TEST/REPLACE STARTER MOTOR (Continued)

SYSTEM TEST**WARNING**

Touching exhaust system during test can cause severe burns

CARBON MONOXIDE (EXHAUST GAS) CAN KILL YOU

Exposure to exhaust gases produces symptoms of headache, dizziness, loss of muscular control, drowsiness, or coma. Brain damage or death can result from severe exposure.

Fumes from engines become concentrated with poor ventilation. Operate engine in a ventilated area only.

While running engine, be alert for fumes. If someone is overcome, expose to fresh air; keep warm and still; give artificial respiration if needed. Seek medical attention. Administer oxygen, if available.

GOOD VENTILATION IS THE BEST DEFENSE AGAINST EXHAUST POISONING.

- 1 Move START/STOP switch on control panel to START, press in and hold OIL BY-PASS switch, and move STARTER switch to UP position until engine starts. Engine should start within 10 seconds

NOTE

Starter transmission must be correctly aligned with flywheel ring gear.

- 2 If engine does not start, check starter, electrical system, and batteries. If engine still will not start, refer to troubleshooting guide.
 - 3 If systems are working properly and engine still will not start and does not crank, notify direct support maintenance, and replace starter
-

2-35. TEST/REPLACE ALTERNATOR, ALTERNATOR V-BELT PULLEY, AND FAN

This task covers:

- | | |
|--------------------|----------------------|
| a. Removal | c. Installation |
| b. Test/Inspection | d. Operational Check |

INITIAL SETUP**Tools**

Shop equipment, automotive maintenance and repair, common no 1
Tool kit, general mechanics automotive

References

Para 2-16 Control Panel Assembly

Equipment Condition

Para	Condition Description
2-13	Battery cables removed
2-15	Alternator wires disconnected
2-25	Alternator V-belt removed

General Safety Instructions

Well-ventilated area required.

REMOVAL :**WARNING**

Severe injury may result from contact with rotating engine parts, V-belts, or fan. Shut off the engine when it is necessary to inspect, service, or perform maintenance on any moving parts. Close control panel to prevent accidental starting. If it is necessary to run engine with rotating parts exposed, be sure the area around the moving parts is clear of personnel and tools.

CAUTION

Damage to the alternator could occur if the following precautions are not observed:

Do not reverse connecting polarity when connecting electrical leads and cables to the alternator

Do not operate the alternator in an open circuit with the rotor winding energized

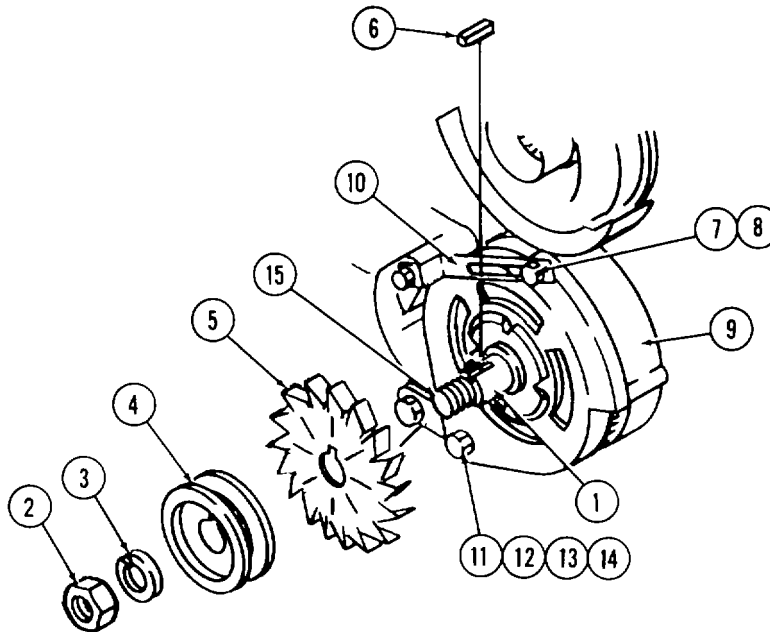
Do not ground the alternator output circuit or field terminal.

Do not disconnect leads from alternator or other electrical components before disconnecting the negative (-) terminal from the battery

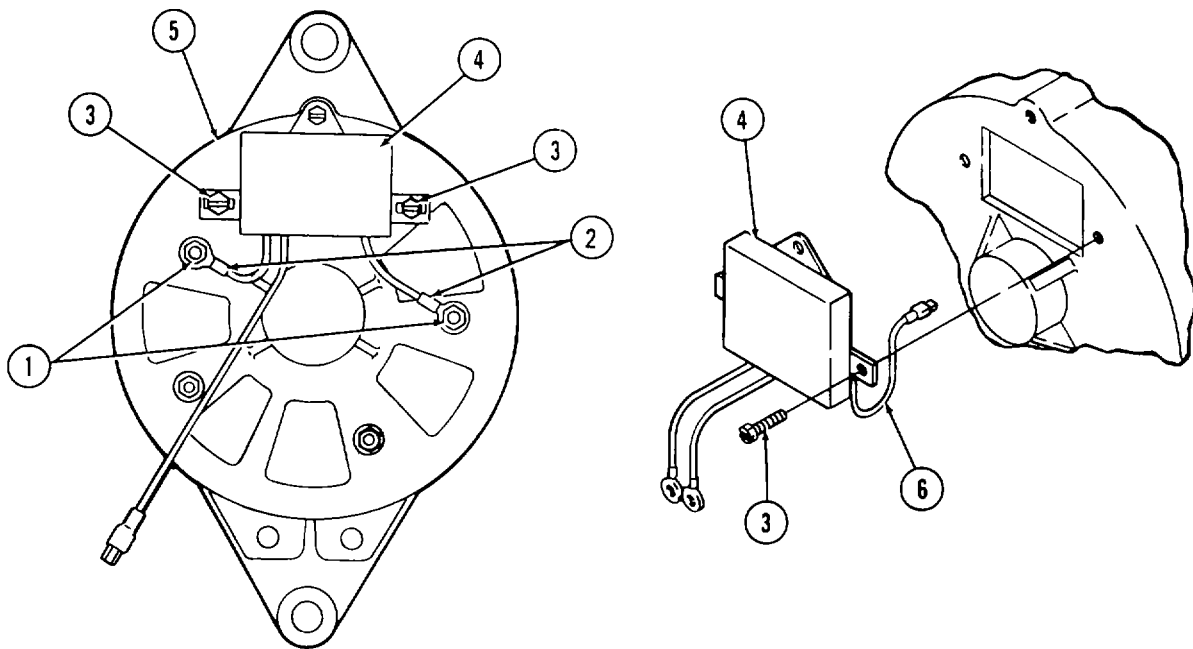
Do not disconnect the battery while the alternator is operating.

Do not reverse battery cable connections

- 1 Hold shaft (1) securely Remove nut (2) and lockwasher (3)
- 2 Remove alternator V-belt pulley (4)

2-35 TEST/REPLACE ALTERNATOR, ALTERNATOR V-BELT PULLEY, AND FAN (Continued)

- 3 Remove fan (5)
- 4 Remove key (6) from shaft (1)
- 5 Remove clamping plate screw (7) and washer (8) from alternator (9) and clamping plate (10)
- 6 Support alternator (9) and remove bolt (11), damping bushes (12), washers (13), and nut (14) from alternator mounting bracket (15).
- 7 Remove mounting bracket (15) and clamping plate (10) from alternator (9).

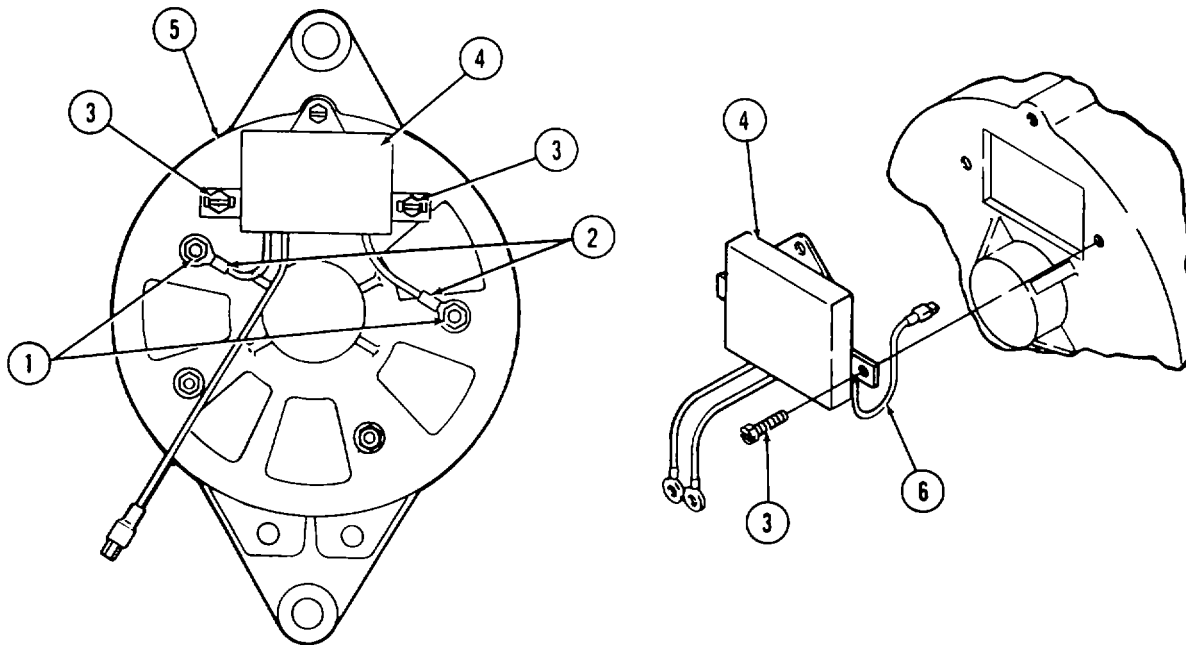
2-35 TEST/REPLACE ALTERNATOR, ALTERNATOR V-BELT PULLEY, AND FAN (Continued)

- 8 Remove two nuts (1). Tag and disconnect two wire leads (2)
- 9 Remove three screws (3). Remove voltage regulator (4) far enough from alternator (5) so that hidden wire lead can be accessed
- 10 Tag and disconnect wire lead (6). Remove voltage regulator (4).

INSPECTION

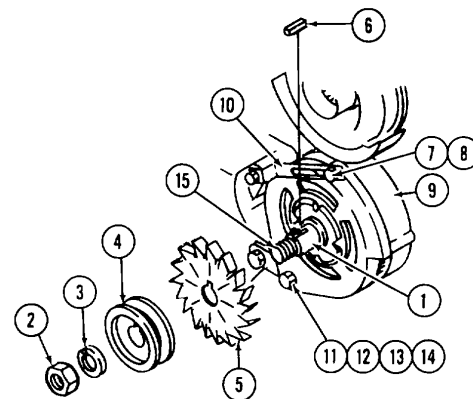
- 1 Inspect alternator V-belt pulley for cracks, groove wear, or damage to keyway. Replace if damaged.
- 2 Inspect fan for bent or missing fins Inspect mounting hole for wear. Replace fan if damaged.
- 3 Inspect voltage regulator for cracks and for loose or damaged terminals and leads Replace if damaged.
- 4 Inspect alternator for physical damage. Inspect shaft for stripped threads or worn keyway slot Inspect shaft for free rotation Replace alternator if damaged

2-35. TEST/REPLACE ALTERNATOR, ALTERNATOR V-BELT PULLEY, AND FAN (Continued)



INSTALLATION:

- 1 Connect wire lead (6) which has a push-on connector Install voltage regulator (4) onto alternator (5) using three screws (3)
- 2 Connect two wire leads (2) to alternator (5) as tagged during removal. Install two nuts (1).
- 3 Aline alternator (9) with front cover mounting hole. Support alternator and secure with hex head bolt (11), damping bushes (12), Washers (13), and nut (14) to alternator mounting bracket (15) Tighten nut only hand tight
- 4 Install clamping plate (10) on alternator (9) with clamping plate screw (7) and washer (8) Tighten only hand tight.
- 5 Install key (6) in shaft (1).
- 6 Install fan (5) onto shaft (1) over key (6) with fan blades toward alternator (9)
- 7 Install alternator V-belt pulley (4) onto shaft (1) over key (6)
- 8 Install nut (2) and lockwasher (3) Tighten securely



2-35. TEST/REPLACE ALTERNATOR, ALTERNATOR V-BELT PULLEY, AND FAN (Continued)

- 9 Check shaft (1) for free rotation
- 10 Install alternator V-belt and adjust in accordance with paragraph 2-25
- 11 Install V-belts and adjust V-belt tension in accordance with paragraph 2-25
- 12 Connect alternator wires in accordance with paragraph 2-15

OPERATIONAL CHECK:

WARNING

Touching exhaust system during test can cause severe burns.

CARBON MONOXIDE (EXHAUST GAS) CAN KILL YOU

Exposure to exhaust gases produces symptoms of headache, dizziness, loss of muscular control, drowsiness, or coma Brain damage or death can result from severe exposure.

Fumes from engines become concentrated with poor ventilation. Operate engine in a ventilated area only.

While running engine, be alert for fumes. If someone is overcome, expose to fresh air, keep warm and still; give artificial respiration if needed. Seek medical attention. Administer oxygen, if available.

GOOD VENTILATION IS THE BEST DEFENSE AGAINST EXHAUST POISONING.

- 1 Start engine Charging indicator light on control panel should light briefly, then go off indicating zero or a positive current flow
 - 2 If charging indicator light stays on, a negative current flow is indicated, check batteries and electrical system (paragraphs 2-13 and 2-15)
 - 3 If battery and electrical systems are operating properly, replace alternator.
 - 4 If condition still exists, recheck batteries and electrical system, then replace charging indicator light in accordance with paragraph 2-16
-

2-36. REPLACE EXHAUST MANIFOLD AND SUCTION PIPE

This task covers:

- a. Removal
- b. Test/Inspection
- c. Installation
- d. Operational Check

INITIAL SETUP

Tools

Shop equipment, automotive maintenance and repair, common no 1

Tool kit, general mechanics automotive

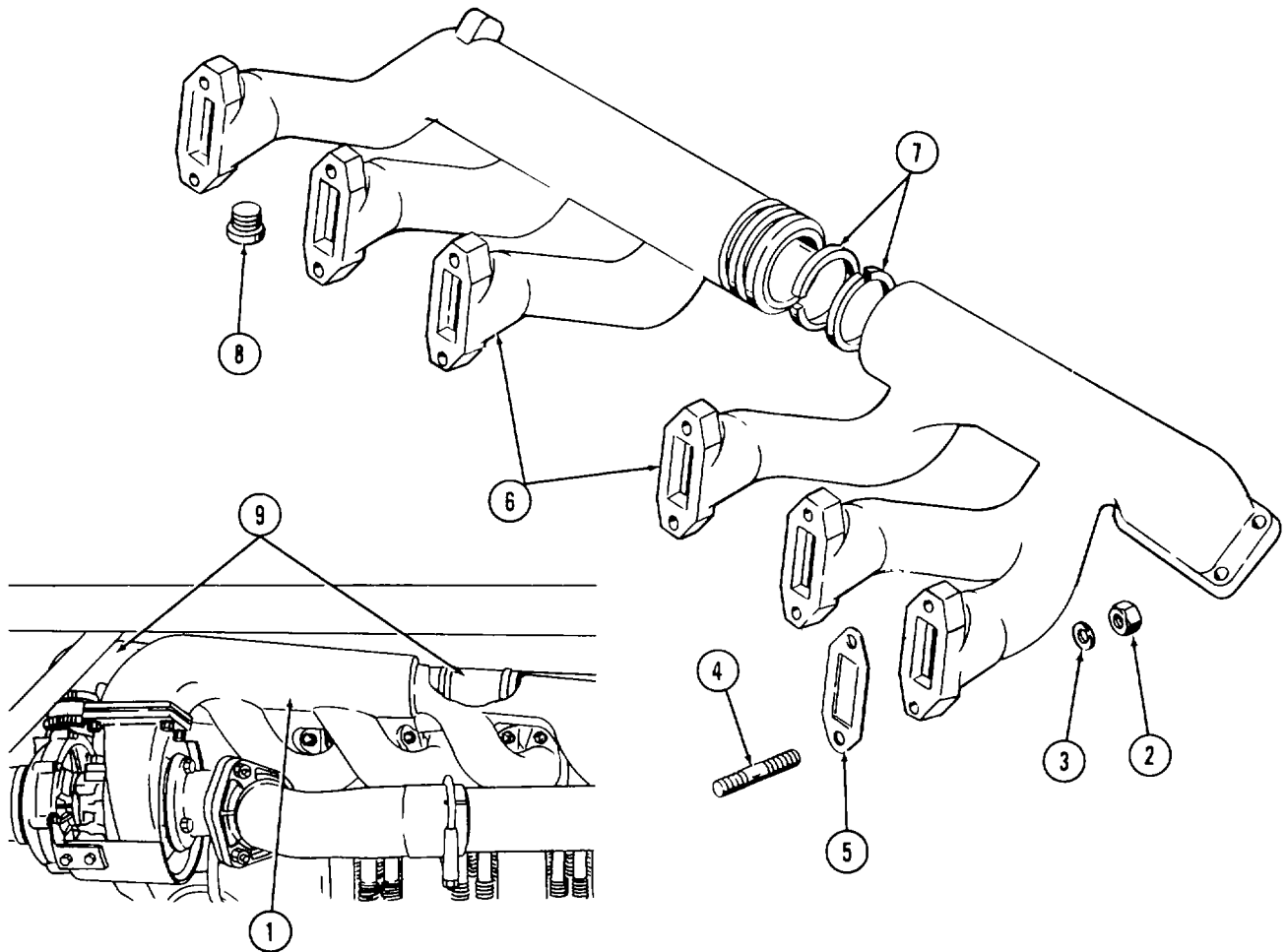
Materials/Parts

Dry cleaning solvent (Item 17, Appendix C)

Equipment Condition

Para	Condition Description
2-28	Exhaust pipe and exhaust elbow removed .
2-33	Turbocharger removed,
	Special Environmental Conditions
	Well-ventilated area required during operational check
	General Safety Instructions
	Unit cool.

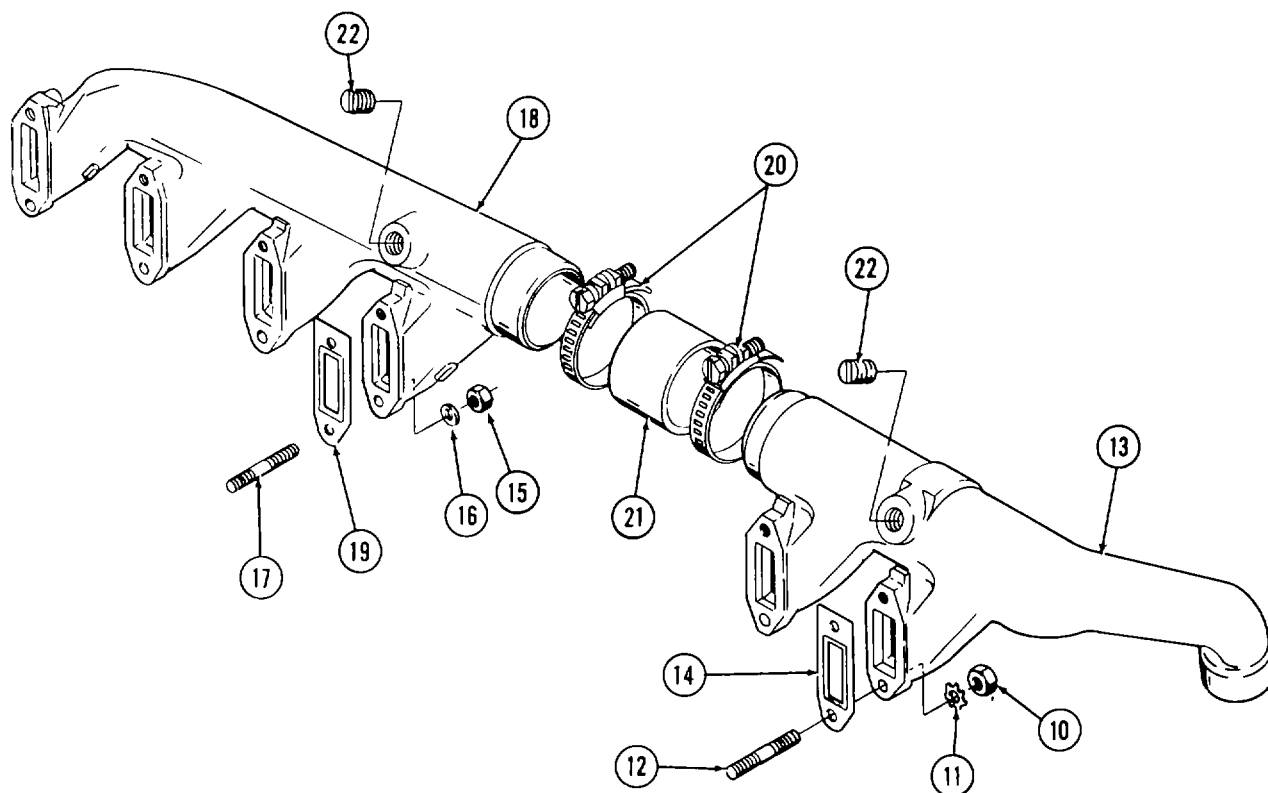
REMOVAL:



2-36. REPLACE EXHAUST MANIFOLD AND SUCTION PIPE (Continued)**WARNING**

Handling hot exhaust system can cause severe burns. Allow unit to cool before handling.

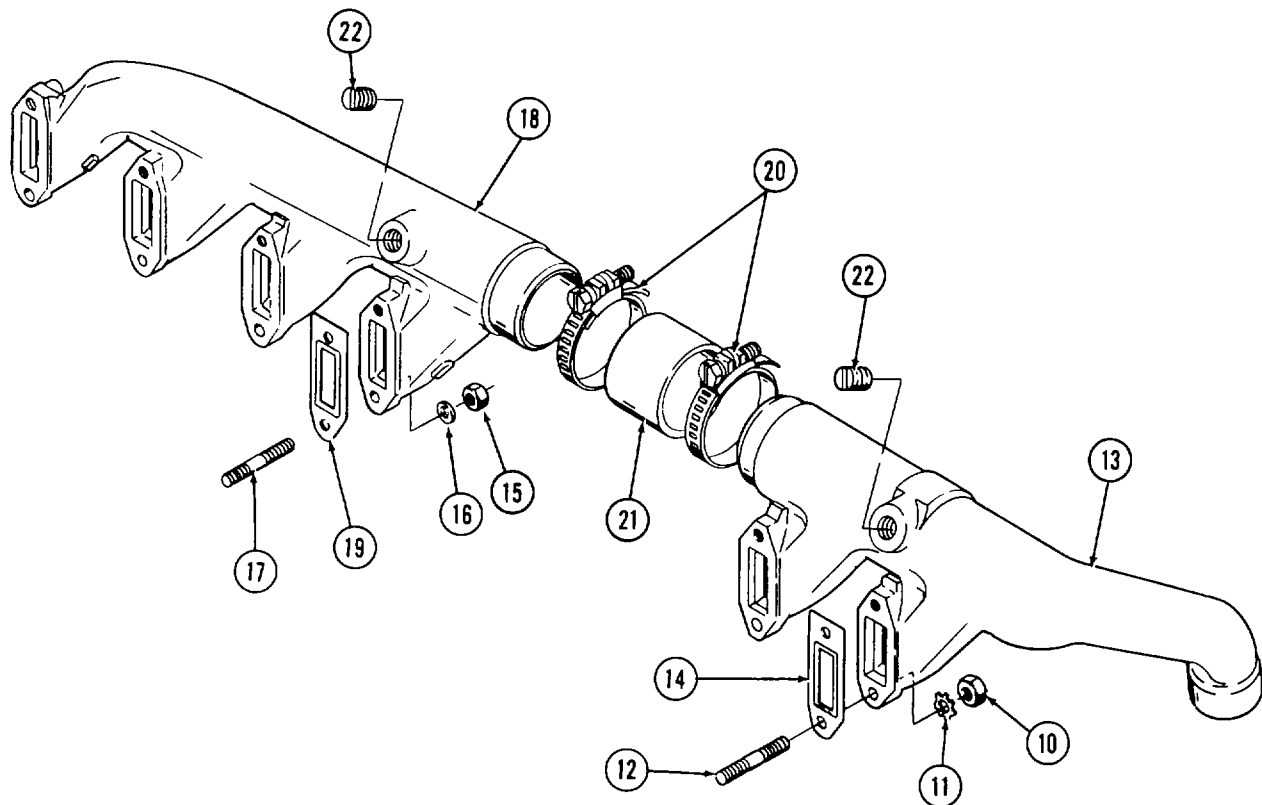
- 1 To remove exhaust manifold (1), remove nuts (2) and washers (3) from studs (4)
- 2 Remove and discard gaskets (5).
- 3 Remove only damaged studs (4) from the engine block
- 4 Separate exhaust manifold sections (6) and remove compression rings (7)
- 5 Remove ether line from suction pipe (9).



- 6 Remove twelve nuts (10) and twelve toothed washers (11) from studs (12) at charge air pipe (13) end of suction pipe (9).
- 7 Remove and discard gaskets (14)
- 8 Remove nuts (15) and washers (16) from studs (17) at intake manifold (18) end of suction pipe (9).
- 9 Remove and discard gaskets (19)
- 10 Remove suction pipe (9).
- 11 Remove only damaged studs (12) from the engine block
- 12 Loosen hose clips (20) and separate charge air pipe (13) and intake manifold (18) by removing rubber sleeve (21)

2-36. REPLACE EXHAUST MANIFOLD AND SUCTION PIPE (Continued)**CLEANING/INSPECTION**

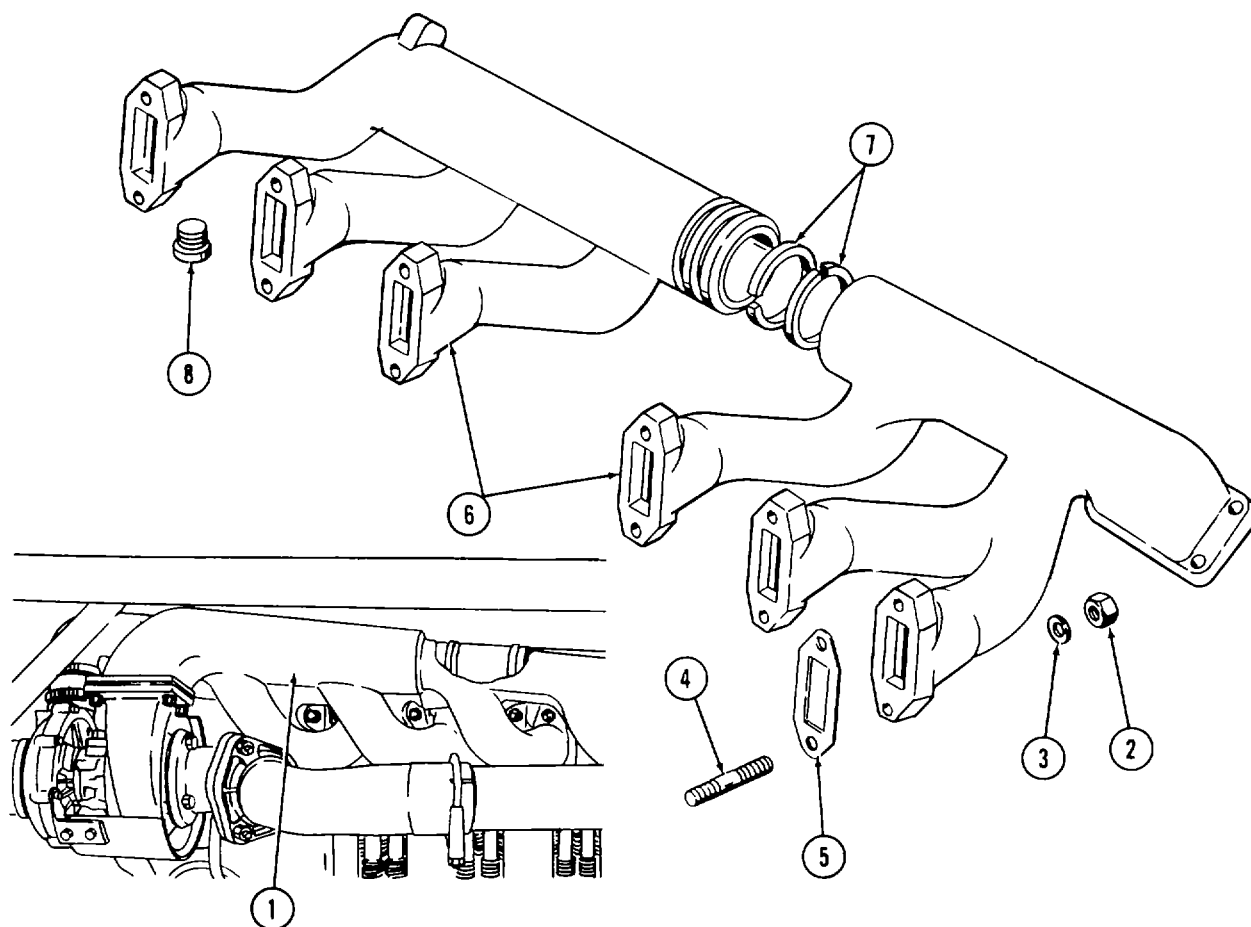
- 1 Inspect flanges for cracks, breaks, or damage that would prevent secure mounting
- 2 Inspect that screw plug (8) and slotted plugs (22) are in place. Replace missing plugs
- 3 Inspect for damage that would cause leaking of air or exhaust gases.
- 4 Inspect studs (4, 12, and 17), nuts (2, 10, and 15), and washers (3, 11, and 16) for rust or corrosion and for thread damage that would prevent secure mounting Replace as required
- 5 Inspect for loose or missing studs. Tighten or replace as required
- 6 Inspect compression rings (7) for rust or corrosion and loss of temper Replace as required.
- 7 Inspect rubber sleeve (21) for brittleness, tears, or leaks Replace worn or leaking sleeve

INSTALLATION

- 1 Install new mounting studs (12) in the engine block as required.
- 2 Place new gaskets (14) and the charge air pipe (13) on studs (12), and secure with nuts (10) and toothed washers (11)
- 3 Slide rubber sleeve (21) onto the charge air pipe (13) end and slide two hose clips (20) over sleeve (21). Do not tighten hose clips (20).
- 4 Place new gaskets (19) on studs (17).

2-36. REPLACE EXHAUST MANIFOLD AND SUCTION PIPE (Continued)

- 5 Slide intake manifold (18) end into rubber sleeve (21), and place intake manifold (18) on studs (17). Secure intake manifold (18) with nuts (15) and washers (16).
- 6 Position rubber sleeve (21) so it is on each pipe end equally. Securely tighten hose clips (20) at each end of sleeve (21).
- 7 Connect ether line to suction pipe (9).



- 8 Install compression rings (7) and assemble two exhaust pipes (13 and 18).
- 9 Install new mounting studs (12 and 17) in the engine block as required.
- 10 Place new gaskets (14 and 19) and the exhaust manifold (1) on studs (12 and 17), secure with nuts (10 and 15) and washers (11 and 16).
- 11 Install exhaust pipe and exhaust elbow in accordance with paragraph 2-28.
- 12 Install turbocharger in accordance with paragraph 2-33.

2-36. REPLACE EXHAUST MANIFOLD AND SUCTION PIPE (Continued)

OPERATIONAL CHECK:

WARNING

Touching exhaust system during test can cause severe burns.

CARBON MONOXIDE (EXHAUST GAS) CAN KILL YOU

Exposure to exhaust gases produces symptoms of headache, dizziness, loss of muscular control, drowsiness, or coma. Brain damage or death can result from severe exposure

Fumes from engines become concentrated with poor ventilation. Operate engine in a ventilated area only.

While running engine, be alert for fumes. If someone is overcome, expose to fresh air, keep warm and still; give artificial respiration if needed. Seek medical attention. Administer oxygen, if available.

GOOD VENTILATION IS THE BEST DEFENSE AGAINST EXHAUST POISONING.

- 1 Start engine and check for loose, rattling components. Tighten as necessary to prevent rattles.
- 2 Check for leaks around the flanges and at the pipe connections. Tighten connections and reseal gaskets as necessary
- 3 Shut down engine.

2-37. REPLACE DATA AND WARNING PLATES

This task covers: a. Removal b. Installation**INITIAL SETUP:****Tools**

Shop equipment, automotive maintenance and repair, common no. 1

Tool kit, general mechanics automotive

Materials/PartsDiesel fuel oil (Item 6, Appendix C)
Sealing compound (Item 15, Appendix C)**Special Environmental Conditions**Well-ventilated area required for cleaning.

REMOVAL:

- 1 To remove data and warning plates mounted with rivets, tap out rivets and remove plate.
- 2 To remove data and warning plates mounted with sealing compound, pry off plate with a broad-blade putty knife.
- 3 To remove data and warning plates mounted with screws, lockwashers, and nuts, remove mounting hardware and plate.

INSTALLATION:

- 1 To install data and warning plates mounted with rivets, install new plate with new rivets.

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

- 2 To install data and warning plates mounted with sealing compound, clean mounting surface with diesel fuel oil, then install new plate with sealing compound..
 - 3 To install data and warning plates mounted with screws, lockwashers, and nuts, replace any rusted or corroded mounting hardware Install new plate with screws, lockwashers, and nuts.
-

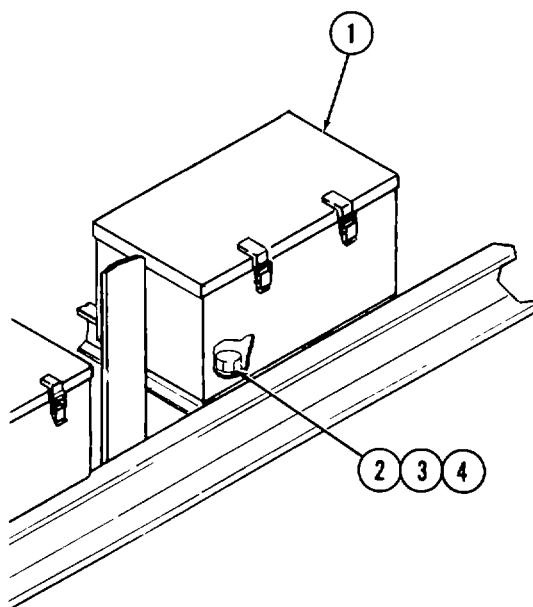
2-38. REPLACE/REPAIR TOOL BOX (AND COMPONENTS)

This task covers: a. Removal c. Installation
 b. Inspection/Repair

INITIAL SETUP:**Tools**

Shop equipment, automotive maintenance and repair, common no. 1

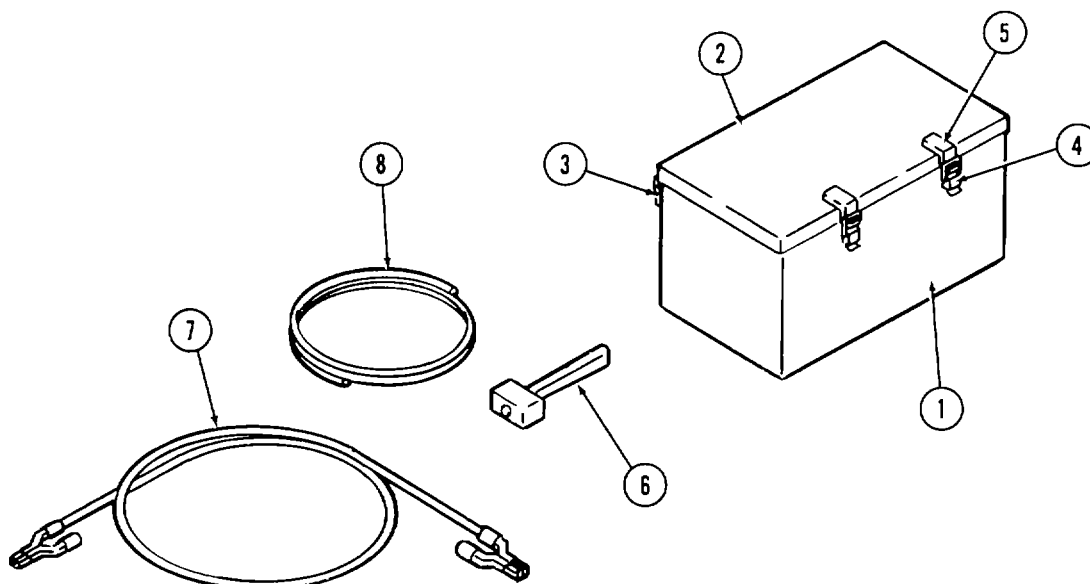
Tool kit, general mechanics automotive

REMOVAL:

- 1 Remove contents of tool box (1). The tool box contains one ground cable assembly, a brass mallet, and a 10-inch length of hose, when these items are not in use.
- 2 Remove four mounting screws (2), four washers (3), and four nuts (4).
- 3 Remove tool box (1) from skid.

2-38. REPLACE/REPAIR TOOL BOX (AND COMPONENTS) (Continued)

INSPECTION/REPAIR:

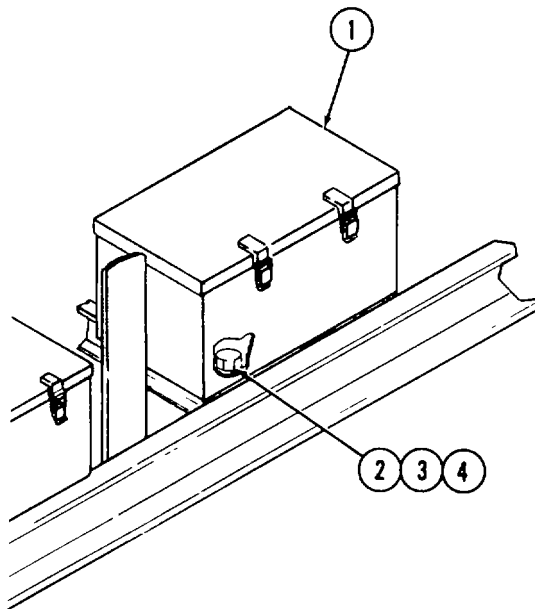


- 1 Inspect tool box (1) and top (2) for minor dents, rust, corrosion, or other damage. Repair minor dents. If severely damaged, replace tool box. If there are holes in box (1) and/or top (2), replace as required.
- 2 Inspect hinge (3), strikes (4), and catches (5) for damage or rust. If parts do not function properly, replace tool box.
- 3 Check that mallet (6) and ground cable (7) are present, either in use or stowed. Obtain replacements if any parts are missing.
- 4 Test ground cable (7) for electrical continuity. If cables and/or connectors are stripped or broken, replace them. Do not try to repair broken cable.
- 5 Inspect hose (8). Replace if brittle, cracked, or deteriorated.

2-38. REPLACE/REPAIR TOOL BOX (AND COMPONENTS) (Continued)

INSTALLATION:

- 1 Position tool box (1) over mounting holes on skid
- 2 Install screws (2), washers (3), and nuts (4). Tighten securely.
- 3 Stow ground cable, brass mallet, and hose, if not in use, in tool box (1).
- 4 Close tool box top, be sure catches are securely fastened over strikes



2-39. REPLACE FUEL TANK LINES AND FITTINGS

This task covers:

a. Removal	d. Bleeding Fuel System
b. Inspection	
c. Installation	

INITIAL SETUP:**Tools**

Shop equipment, automotive maintenance and repair, common no. 1

Tool kit, general mechanics automotive

General Safety Instructions

Engine cool.

Well-ventilated area.

Personnel Required

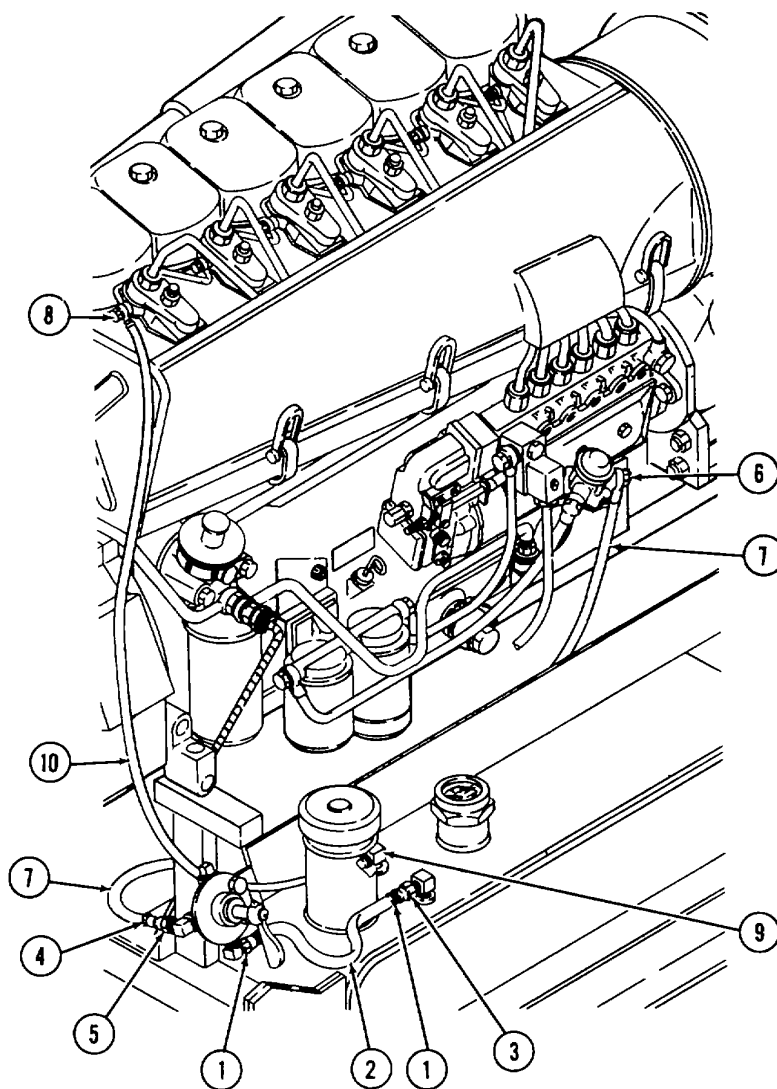
Mechanic 44B20 (2)

REMOVAL:**WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

- 1 Remove engine side panel.
- 2 Loosen two hose clamps (1).
- 3 Tag and remove fuel line (fuel tank-to-3-way selector valve) (2).
- 4 Loosen and remove male connectors (3).
- 5 Loosen hose clamps (4).
- 6 Loosen and remove male connector (5) and-banjo bolt (6).
- 7 Tag and remove fuel line (3-way selector valve to fuel feed pump) (7).

2-39. REPLACE FUEL TANK LINES AND FITTINGS (Continued)



- 8 Loosen and remove banjo bolt (8).
- 9 Loosen hose clamp (9).
- 10 Tag and remove fuel return line (10).
- 11 Tape over exposed fuel ports and lines so that contaminants do not enter the fuel system.

INSPECTION:

- 1 Inspect fittings and hose clamps for damage, rust, and corrosion.
- 2 Inspect fuel lines and fuel return line for cracking or brittleness. Check lines for leakage. Repair only minor rust or corrosion.
- 3 Replace damaged or leaking fuel lines, fuel return line, fittings, and hose clamps.

2-39. REPLACE FUEL TANK LINES AND FITTINGS (Continued)

INSTALLATION:

Install fuel lines (2 and 7) and fuel return line (10). Tighten male connectors (5), banjo bolts (6 and 8), and hose fittings

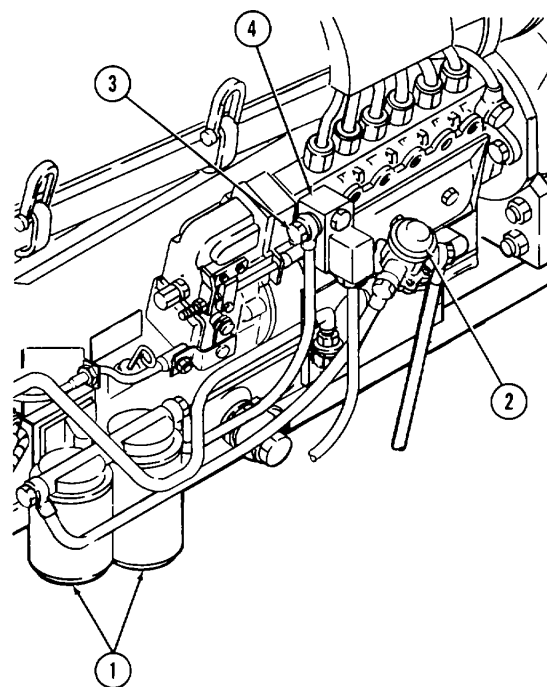
BLEEDING FUEL SYSTEM:**WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

- 1 Loosen vent screw on top of fuel filter cartridges (1) four complete turns.
- 2 Pump primer lever on fuel feed pump (2) until all air is removed from fuel filter (1) and fuel flows freely.

NOTE

The fuel feed pump is cam driven. If high point of camshaft cam is in contact with fuel feed pump cam lever, fuel system cannot be primed nor air bled from fuel system using fuel feed pump. Crank engine until pressure can be felt on fuel feed pump primer lever.



- 3 Tighten vent screw on top of fuel filter cartridges (1).
- 4 Loosen breather plug (3) on solenoid valve (4), four complete turns.
- 5 Place START/STOP switch in START position.
- 6 Press and hold in the OIL BY-PASS switch.
- 7 Pump primer lever on fuel feed pump (2) until all air is removed from fuel filter (1) and fuel flows freely. Release OIL BY-PASS switch after fuel flows freely.
- 8 Tighten breather plug (3) on top of solenoid valve (4).

2-39. REPLACE FUEL TANK LINES AND FITTINGS (Continued)

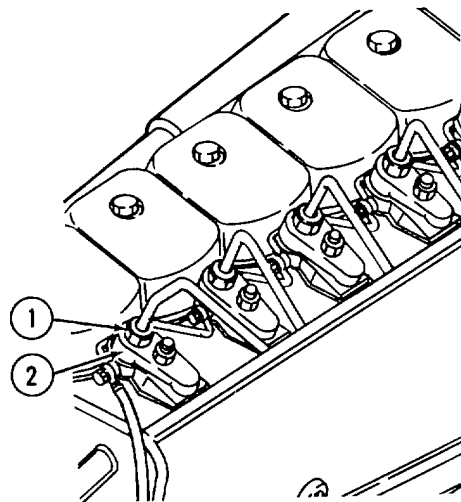
- 9 Loosen line nuts (1) on injectors (2) one full turn.
- 10 Hold a lint-free cloth below injectors (6) to collect leakage.

CAUTION

To prevent starter from overheating, do not crank engine with starter for more than 10 seconds.

Battery life will be lengthened if 60 seconds is allowed to elapse between starting attempts.

Under any condition, if engine does not start on initial attempt, allow engine rotation to stop completely before again engaging starter.



- 11 Set MANUAL THROTTLE CONTROL to maximum engine speed.
 - 12 Press and hold in the OIL BY-PASS switch, set START/STOP switch to START, push up STARTER switch and observe fuel flow from injector fittings until air is cleared from lines Release OIL BY-PASS switch.
 - 13 Tighten line nuts (1) on injectors (2)
 - 14 Start engine
-

2-40. REPLACE 3-WAY SELECTOR VALVE

This task covers: a. Removal b. Inspection c. Installation

INITIAL SETUP:

Tools

Shop equipment, automotive maintenance and repair, common no. 1

Tool kit, general mechanics automotive

Equipment Condition

Para

2-42

Condition Description

Fuel tank hoses and fittings removed.

Materials/Parts

Diesel fuel oil (Item 6, Appendix C)

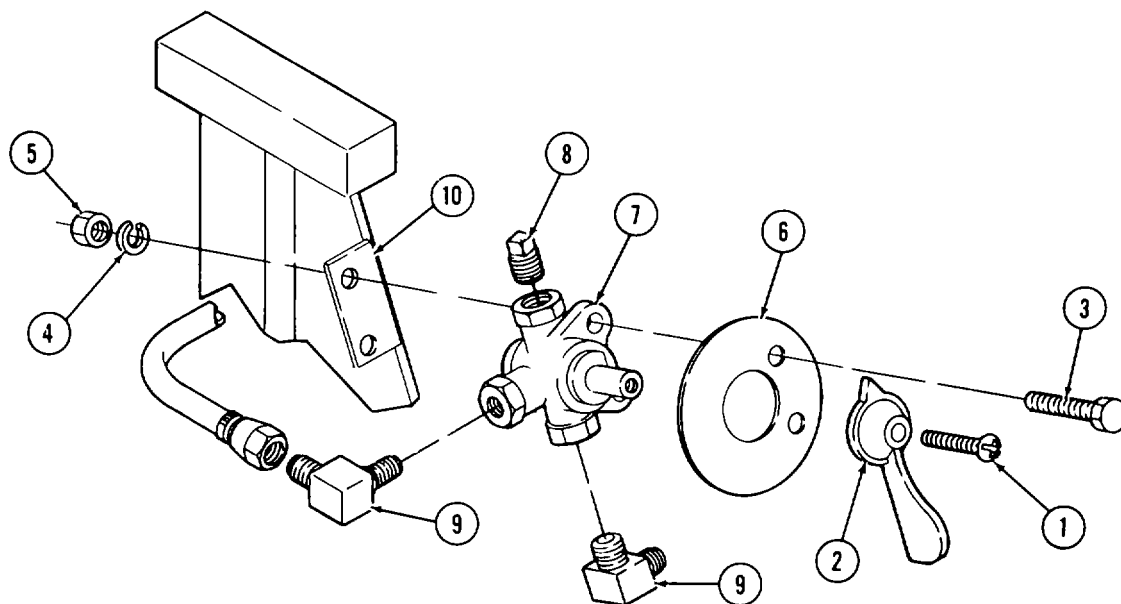
General Safety Instructions

Engine cool.
Well-ventilated area required.

REMOVAL:

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.



- 1 Remove screw (1) and valve handle (2).
- 2 Remove cap screws (3), lockwashers (4), and nuts (5)

2-40. REPLACE 3-WAY SELECTOR VALVE (Continued)

- 3 Remove fuel line plate (6) and 3-way selector valve (7).
- 4 Remove cap plug (8) and elbows (9).

INSPECTION:

Inspect 3-way selector valve and elbows for damage or damaged threads. Replace components as necessary. Inspect for rust, corrosion, or for frozen or sticking valve. If valve is severely damaged or is frozen, replace valve.

INSTALLATION:

- 1 Install cap plug (8).
- 2 Position 3-way selector valve (7) on trailer frame (10) and fuel line plate (6) on 3-way selector valve.
- 3 Install cap screws (3), lockwashers (4), and nuts (5). Tighten nuts securely.
- 4 Install valve handle (2) with screw (1). Tighten screw.
- 5 Install elbows (9) on 3-way selector valve (7) and tighten securely.

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Engines must be turned off and cool before refueling. Use proper refueling procedures and equipment to avoid spillage. Do not run engines near open fuel containers. Always store fuel in proper, marked containers DO NOT SMOKE.

- 6 Fill fuel tank with diesel fuel oil.
 - 7 Bleed fuel system in accordance with paragraph 2-38.
-

2-41. REPLACE/REPAIR FUEL TANK ASSEMBLY

This task covers: a. Removal c. Inspection/Repair e. Installation
 b. Disassembly d. Assembly

INITIAL SETUP:

Tools

Tool kit, general mechanics automotive
 Shop equipment, automotive maintenance
 and repair, common no. 1

**Equipment
 Condition**

Para
 2-22

Condition Description

Engine cover panels and frame re-
 moved from engine.

Materials/Parts

Diesel fuel oil (Item 6, Appendix C)

2-40
 2-39

3-way selector valve removed
 Fuel tank lines and fittings removed

Personnel Required

Mechanic 44B20 (2)

General Safety Instructions

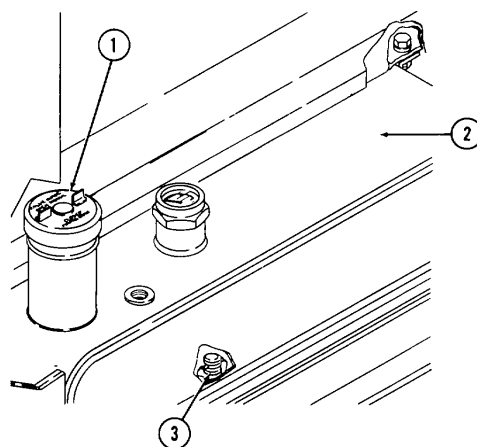
Well-ventilated area.

REMOVAL:

WARNING

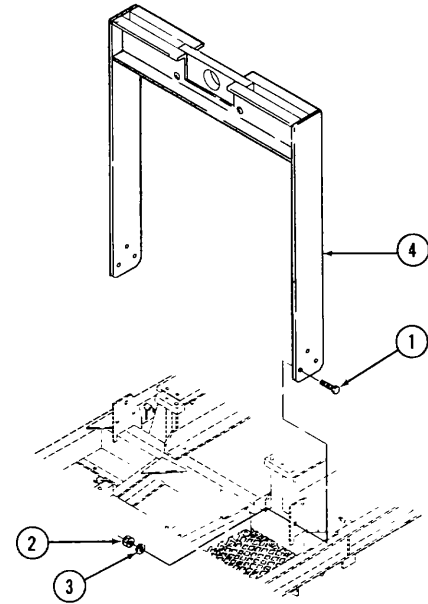
Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

- 1 Loosen cap (1) on fuel tank (2).
- 2 Remove plug (3).
- 3 Drain fuel into suitable container.
- 4 Install plug (3).
- 5 Tighten cap (1).

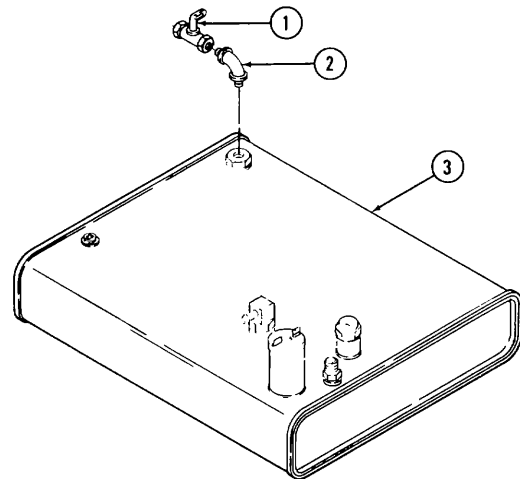


2-41. REPLACE/REPAIR FUEL TANK ASSEMBLY (Continued)

- 6 Remove four bolts (1), four nuts (2), and four lockwashers (3) Using lifting equipment, remove lifting bail (4) away from engine.



- 7 Remove drain cock (1) and street elbow (2) from fuel tank (3).



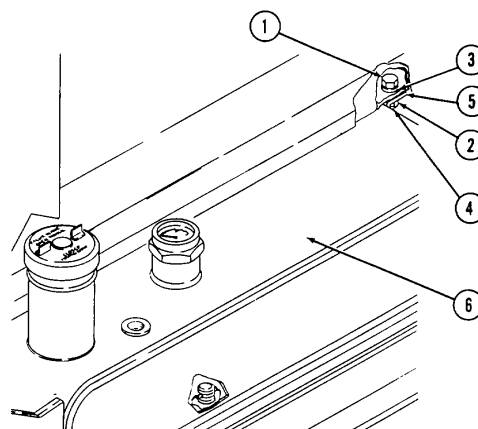
2-41. REPLACE/REPAIR FUEL TANK ASSEMBLY (Continued)

- 8 Remove cap screws (1), lockwashers (2), flat washers (3), and nuts (4) on both sides of fuel tank mounting brackets (5).

CAUTION

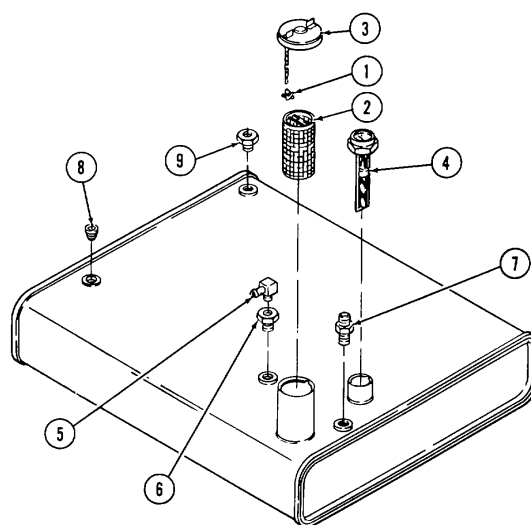
Do not allow fuel tank to drop after removing mounting brackets

- 9 Remove fuel tank mounting brackets (5).
- 10 Slide out fuel tank assembly (6) from right side of engine.



DISASSEMBLY:

- 1 Remove assembled fuel filler screen and fuel tank cap. Disengage connector clip (1) from fuel filler screen (2) to separate fuel tank cap (3).
- 2 Unscrew and remove fuel gage (4).
- 3 Unscrew and remove 90-degree elbow (5) and bushing (6).
- 4 Unscrew and remove male connector (7).
- 5 Unscrew and remove plug (8).
- 6 Unscrew and remove bushing (9).



2-41 REPLACE/REPAIR FUEL TANK ASSEMBLY (Continued)

INSPECTION/REPAIR:

WARNING

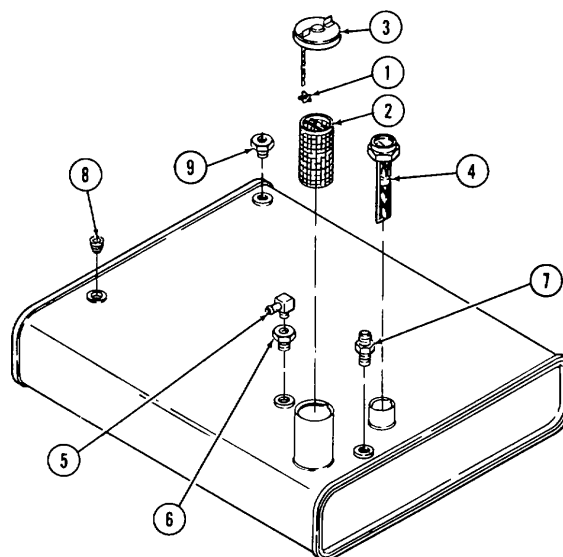
Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 1 Clean fuel mounting brackets and cushion mounts with diesel fuel oil and dry with compressed air. Inspect for minor rust, corrosion, or other damage. Replace mounting brackets if severely rusted or damaged. Inspect for worn or missing cushion mounts. Replace cushion mounts if damaged or missing.
- 2 Clean outside of fuel tank assembly and remove sediment with diesel fuel oil. Dry with compressed air. Inspect for minor rust, corrosion, or broken welds. Replace if damaged.
- 3 Clean fuel tank cap and fuel filler screen with diesel fuel oil and dry with compressed air. Inspect for minor rust or corrosion. Make sure fuel tank cap vent is open. Replace if damaged.
- 4 Check fuel gage for damage. Replace if damaged.
- 5 Check pipe plug, 90-degree elbow, male connector, and bushings for rust, corrosion, stripped threads, or other damage. Replace any damaged fittings.

ASSEMBLY:

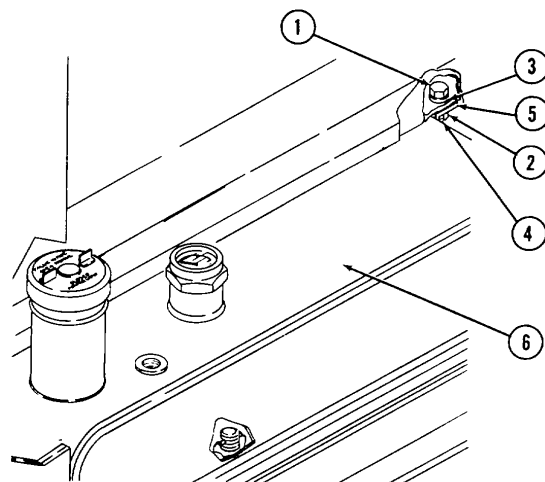
- 1 Install bushing (9).
- 2 Install plug (8).
- 3 Install male connector (7).
- 4 Install 90-degree elbow (5) and bushing (6).
- 5 Install fuel gage (4).
- 6 Engage connector clip (1) into fuel filler screen (2) and install. Be sure fuel tank cap vent is in open position.



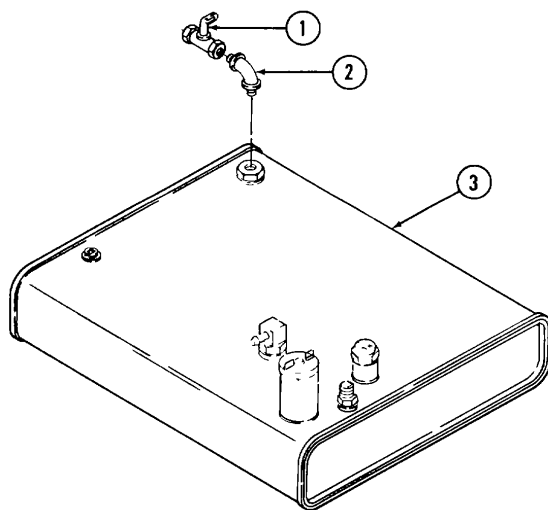
2-41. REPLACE/REPAIR FUEL TANK ASSEMBLY (Continued)

INSTALLATION:

- 1 Slide fuel tank assembly (6) into place from the right side of the engine.
- 2 Install mounting brackets (5). Install cap screws (1), lockwashers (2), flat washers (3), and nuts (4) on both sides of fuel tank mounting brackets (5).

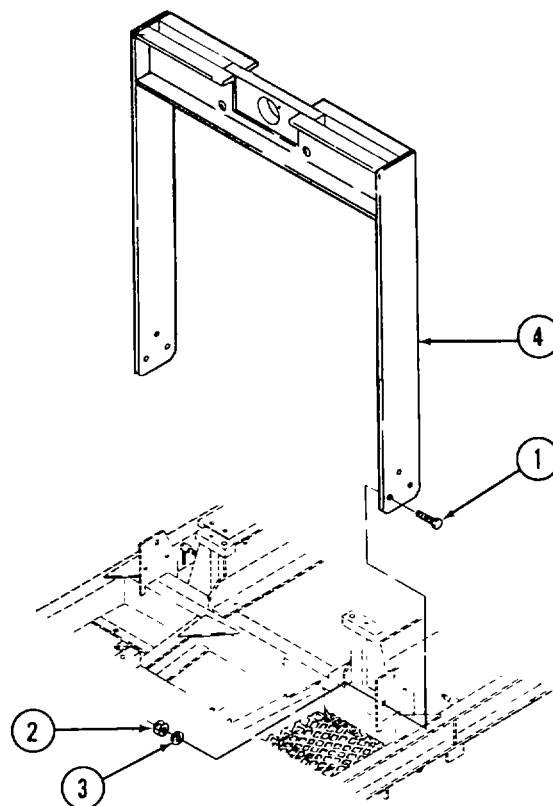


- 3 Install drain cock (1) and street elbow (2) onto fuel tank assembly (3).



2-41. REPLACE/REPAIR FUEL TANK ASSEMBLY (Continued)

- 4 Place lifting bail (4) into place using lifting equipment. Install lifting bail using four bolts (1), four nuts (2), and four lockwashers (3).



- 5 Install 3-way selector valve in accordance with paragraph 2-40.
- 6 Install fuel tank lines and fittings in accordance with paragraph 2-39.

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Engines must be turned off and cool before refueling. Use proper refueling procedures and equipment to avoid spillage. Do not run engines near open fuel containers. Always store fuel in proper, marked containers DO NOT SMOKE.

- 7 Fill fuel tank with diesel fuel oil.
- 8 Bleed fuel system in accordance with paragraph 2-39.
-

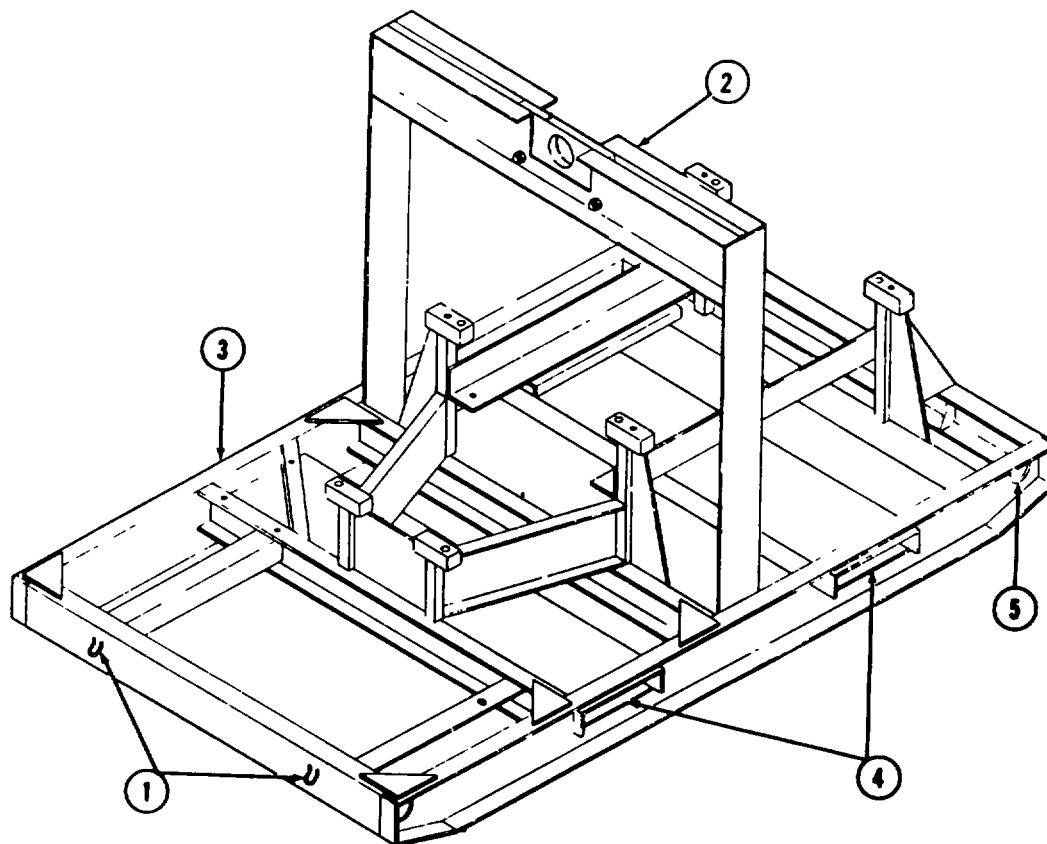
2-42. REPAIR SKID

This task covers: a. Inspection b. Repair

INITIAL SETUP:**Tools**

Shop equipment, automotive maintenance
and repair, common no. 1

Tool kit, general mechanics automotive

INSPECTION:

- 1 Inspect chain supports (1) and lifting bail (2) for cracks, rust, or deterioration.
- 2 Inspect skid (3) for dents, rust, corrosion, structural damage, broken welds, or warpage.
- 3 Check that forklift channels (4) and sling openings (5) are not rusted through or blocked.

REPAIR:

Straighten minor dents in skid assembly (3) and lifting bail (2). Remove rust or corrosion with sandpaper. Repair cracked weldments using arc welding methods.

Section VII. PREPARATION FOR STORAGE OR SHIPMENT

2-43. GENERAL

This section provides instructions for preparing the centrifugal pump unit for short term and intermediate storage or shipment.

2-44. ADMINISTRATIVE STORAGE

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) evaluation 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 containers may be used.

2-45. SHORT TERM STORAGE (30 days or less)

The following instructions apply when the centrifugal pump unit is to be placed in storage for a period of not more than 30 days. Additional or supplementary measures may be directed to meet current or anticipated conditions such as extremes of temperature; exposure to dust, sand, or debris, or salt air such as in a beachhead location. These instructions do not apply to temporary shutdowns to relocate the centrifugal pump unit.

NOTE

When centrifugal pump unit is taken out of service, take special precautions to protect the interior and exterior of the unit from rust accumulation and corrosion.

WARNING

Severe burns, illness, or death could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Be certain that fuel lines and connections are secure. Do not inhale vapor. Do not overfill fuel tank. Engines must be turned off and cooled before refueling. Use proper refueling procedures and equipment to avoid spillage. Do not run engines near open fuel containers. DO NOT SMOKE.

a. Fill fuel tank (1) with W-F-800 diesel fuel oil. Connect centrifugal pump unit to a water supply. Operate the engine for 2 minutes at idle and no load.

NOTE

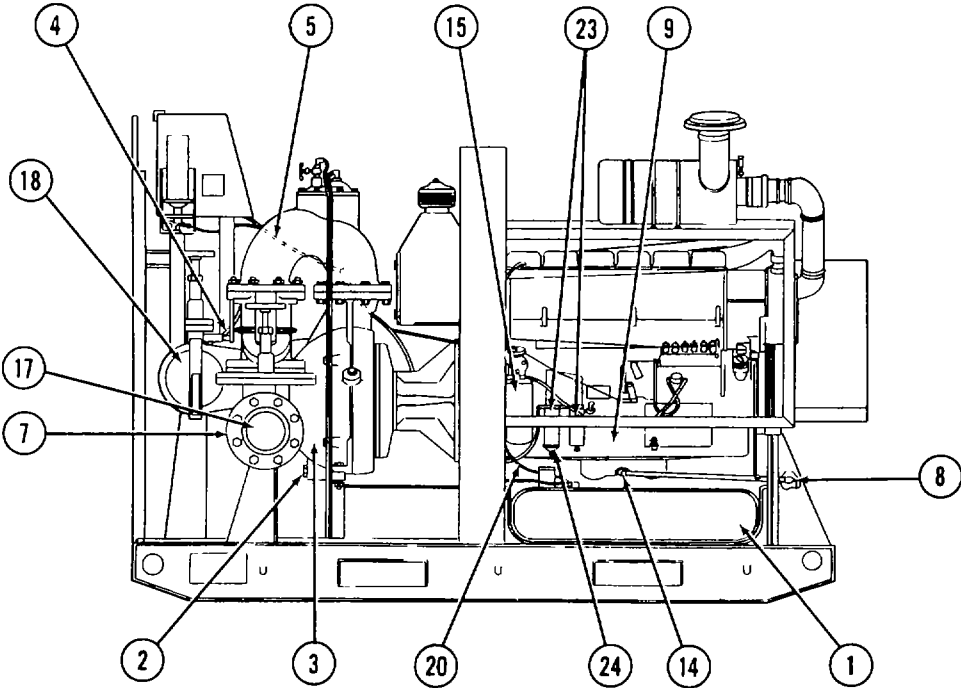
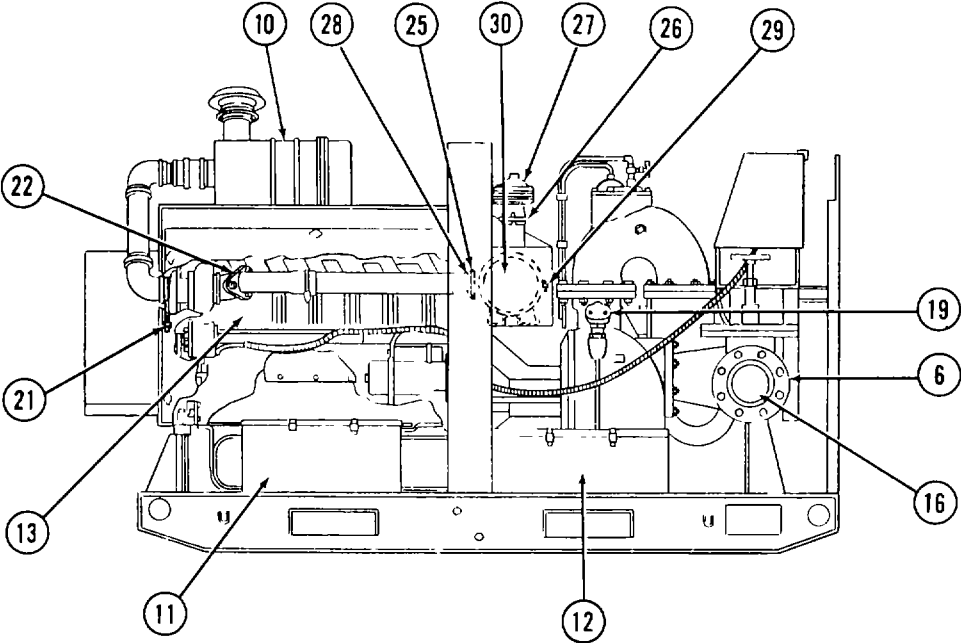
Do not drain the fuel system after the 2-minute run. Remove water supply after this run.

b. Remove plug (2) from bottom of pump assembly and drain pump body (3). Install plug (2).

c. Disconnect and drain suction and discharge pressure hoses (4 and 5). Reconnect hoses.

d. Remove hoses from suction assembly (intake) and discharge manifold assembly (discharge) flanges (6 and 7).

2-45. SHORT TERM STORAGE (30 days or less) (Continued)



2-45. SHORT TERM STORAGE (30 days or less) (Continued)

- e. Clean all accessible interior surfaces using a wet cloth.
- f. Install protective plugs in the suction assembly flange (6) (intake) and discharge manifold assembly flange (7).
- g. Remove oil drain plug (8) and completely drain oil from crankcase (9) Install oil drain plug (8).

CAUTION

Do not overfill crankcase. Oil will be blown out through the crankcase breather.

h. Fill crankcase (9) to the proper level with the recommended viscosity and grade of oil in accordance with lubrication instructions in paragraph 2-1

i. Clean air cleaner assembly (10) in accordance with paragraph 2-26.

j. Seal all engine openings with moisture proof, vapor proof tape, strong enough to resist puncture and damage from the expansion of entrapped air.

k. Stow ground rods and ground cable assembly.

l. Ensure that battery box assembly (11) and tool box (12) are closed securely.

m. For indoor and outdoor storage, cover entire unit with weather cover supplied with unit, tied or weighted to prevent movement.

2-46. INTERMEDIATE TERM STORAGE (More than 30 days)

The following instructions apply when the centrifugal pump unit is to be placed in storage for a period greater than 30 days. Additional or supplementary measures may be directed to meet current or anticipated conditions such as extremes of temperature; exposure to dust, sand, or debris, or salt air such as in a beachhead location. These instructions do not apply to temporary shutdowns to relocate the centrifugal pump unit.

NOTE

Procedure a., below, must be done with the assistance of direct support maintenance personnel.

a. *Injectors.* Contact direct support maintenance personnel to remove, check, and recondition the injectors, if necessary, to ensure operation when the engine is restored to service.

b. *Internal Surfaces.*

(1) Start engine (13) and allow to operate at idle for 10 to 12 minutes or until normal operating temperature is reached.

(2) Shut down engine.

2-46. INTERMEDIATE TERM STORAGE (More than 30 days) (Continued)

- (3) Remove drain tube pipe coupling (14) and completely drain oil from crankcase (9). Install drain tube pipe coupling and install new oil cartridge (15).

CAUTION

Do not overfill crankcase. Oil will be blown out through the crankcase breather.

- (4) Fill crankcase to the proper level with SAE Grade 30 preservative lubricating oil, conforming to MIL-L-21260.
- (5) Remove hoses from suction assembly (intake) port (16) and discharge manifold assembly (discharge) port (17). Coat all accessible interior surfaces with preservative oil MI L-L-21260, Grade 30. Install protective plugs in suction (intake) and discharge ports.
- (6) Remove, clean, and inspect strainer (18) in accordance with paragraph 2-18. Coat interior of strainer body and strainer with MI L-L-21260 preservative oil, Grade 30. Install strainer.
- (7) Remove pump assembly priming port cap (19) and pour approximately one quart of MIL-L-21260 preservative oil, Grade 30, into pump volute. Install and tighten priming port cap.

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers DO NOT SMOKE.

- (8) Drain the engine fuel tank (1), collect the fuel in an approved safety can.
- (9) Preserve fuel system, combustion chambers, and valves with P-10 preservative oil conforming to MIL-L-21260, Grade 10, as follows.
- (a) Hook up a pressure feed pump to fuel intake system.
 - (b) Disconnect fuel return line (20) from fuel tank (1) and place end of fuel return line in an approved container. (Do not reuse returned preservative oil.)
 - (c) Cap off turbine (21) with a blank plastic cap so engine cannot receive any air.
 - (d) Remove metal plug closest to turbine on intake manifold (22).
 - (e) Start and run feed pump until preservative oil flows from fuel return line (20).

2-46. INTERMEDIATE TERM STORAGE (More than 30 days) (Continued)**CAUTION**

Preservative oil must flow from fuel return line before engine is cranked.

Do not exceed 10 seconds of cranking at one interval.

- (f) Crank engine through six 10-second intervals at 150 rpm. While cranking engine, shoot preservative oil in through opening on intake manifold (step (d), above). Do not exceed 10 seconds of cranking at one interval. Stop for short periods of time and proceed again, if necessary. White smoke will come out of exhaust when engine preservation is complete.

- (10) Drain fuel filter (23) and fuel strainer (24), and discard and replace used elements.
- (11) Affix a waterproof tag to the engine (13), bearing the information: "Engine contains preservative oil. Drain and replace with required engine lubricant before operation."
- (12) Service air cleaner (10) in accordance with paragraph 2-26.
- (13) Drain engine crankcase (9).
- (14) Remove plug (2) from bottom of pump body (3) and drain preservative oil. This will leave a protective coating of preservative oil on interior surface of pump. Install and tighten plug.
- (15) Disconnect suction and discharge pressure hoses (4 and 5) at pump, and drain any excess preservative oil. Reconnect hoses.
- (16) Remove exhaust pipe clamp (25) and hose clamp (26) from spark arrestor (27) and muffler intake sleeve (28). Remove spark arrestor. Loosen mounting bands (29) of muffler bracket assembly and remove muffler (30) and muffler bracket assembly. Reinstall mounting hardware of muffler bracket assembly and tighten sufficiently to hold in place. Reinstall clamps and mounting bands on muffler, tighten sufficiently to hold in place.
- (17) Seal exhaust pipe opening and muffler intake opening with a moisture proof, vapor proof tape.
- (18) Remove air cleaner (10) in accordance with paragraph 2-26.
- (19) Openings that will permit direct entry of water shall be sealed with moisture proof, vapor proof tape. Large openings shall be bridged with waterproof barrier material, and the edges of the barrier material secured to adjacent surfaces with tape specified herein.

c. *Batteries.* Remove and clean batteries in accordance with table 2-1, item 2. Store batteries separately from pump unit in a cool, dry location at temperature no lower than 32° F (0°C).

d. *V-belt Adjustment.* Relieve V-belt tension in accordance with table 2-1, item 6. Insert slips of heavy kraft paper between pulleys and V-belt to prevent sticking. Adjust V-belt tension sufficiently to hold slips of paper in place.

e. *Storage.*

- (1) Cushion contents of the tool box with sufficient dunnage to prevent damage when the centrifugal pump unit is moved.

2-46. INTERMEDIATE TERM STORAGE (More than 30 days) (Continued)

- (2) Secure air cleaner assembly (10) and muffler assembly (30) to skid using soft annealed wire or strapping conforming to QQ-S-781, Class 1, Type I or IV.
- (3) Ensure that battery box assembly (11) and tool box (12) are closed securely.
- (4) For indoor or outdoor storage, cover entire unit with weather cover supplied with unit, tied or weighted to prevent movement.

f. Inspection.

- (1) Visually inspect the centrifugal pump unit monthly for evidence of rust, security of seals, and any evidence of deterioration of nonmetallic components.
- (2) When in outdoor storage, visually inspect as above immediately following heavy rains, snowfall, or high winds.

2-47. PREPARATION FOR SHIPMENT

- a. Prepare the centrifugal pump unit for intermediate storage in accordance with paragraph 2-46.
- b. Secure the batteries in battery box assembly (11) and tape the battery cables to the battery box to prevent grounding.

WARNING

Death or serious injury could occur if unauthorized or unnecessary personnel are in the hoisting area. Permit only personnel actually engaged in the hoisting operation to be near the unit and hoisting equipment. All instructions for the hoisting operations must come from one authorized person.

Injury to personnel or damage to equipment could occur from improper hoisting. Hoist the load slowly to avoid tearing out lifting bail assembly, slipping slings, or load shift. Do not jerk the load or swing it from side-to-side when hoisting. This places additional stress on hoisting components which can cause failure and loss of load. Be sure hoisting equipment is on solid footing and is suitable for the size of the load. Watch boom angle and overhead clearance when hoisting.

c. Use equipment such as a crane, forklift, or other cargo-lifting equipment to load the pump unit without any damage. When using cables for lifting, spreader bars of adequate length must be used to prevent cables from closing in and crushing the centrifugal pump unit. Cables should be connected to the centrifugal pump unit's multipurpose lifting and tiedown provisions, with the apex not exceeding a height of 24 feet (7.3 meters) above the lowest extremity of the unit and with each cable leg at a 45 degree true angle. The sling legs should converge over the center of gravity of the pump unit as shown on the transportation plate.

d. Secure centrifugal pump unit to a railway or highway transporter by using the chain supports on the skid. Cover the pump unit with a good weather-resistant tarpaulin or other cover.

**CHAPTER 3
DIRECT SUPPORT MAINTENANCE INSTRUCTIONS**

INTRODUCTION

This chapter contains the following frequently used maintenance information

- a. Troubleshooting
- b. Maintenance procedures

The symptom index on page 3-2 is a guide to the troubleshooting information. There is also an index to the maintenance procedures on page 3-6.

Section	Title	Page
I	Troubleshooting	3-1
II	Maintenance Procedures.....	3-6

Section I. TROUBLESHOOTING

3-1. TROUBLESHOOTING

a. Table 3-1 contains troubleshooting information for locating and correcting most of the operating troubles which are the responsibility of direct support maintenance. Each malfunction for an individual component, unit, or system is followed by a list of tests or inspections which will help you to determine probable causes and corrective actions to take. Perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests or inspections or corrective actions. If a malfunction is not listed or cannot be corrected by listed corrective actions, notify your supervisor.

c. Only those functions within the scope of direct support maintenance are listed. For troubleshooting procedures within the scope of operator/crew maintenance, refer to TM 3-4320-306-10. For troubleshooting procedures within the scope of organizational maintenance, refer to table 2-2.

3-2. SYMPTOM INDEX

Refer to the symptom index below. Locate the malfunction which is the same, or most nearly the same, as the trouble you are having with the centrifugal pump unit. The Symptom Index lists the first page of troubleshooting information for that malfunction. Follow the steps one by one, and perform the corrective actions listed.

Malfunction Number	Description	Page
1	Engine fails to crank or cranks at low speed	3-3
2	Engine cranks but fails to start	3-3
3	Engine starts but runs unevenly, stalls, or surges	3-3
4	Engine stops running or produces black, white, or grey smoke	3-4
5	Engine consumes excessive lube oil	3-4
6	Engine oil pressure is low	3-5
7	Pump does not discharge or has low discharge pressure	3-5
8	Pump makes excessive noise	3-5

Table 3-1. Direct Support Troubleshooting

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1. ENGINE FAILS TO CRANK OR CRANKS AT LOW SPEED		
	Step 1. Check for faulty starter motor.	Test and repair faulty starter motor (para 3-17).
	Step 2. Check for restricted impeller.	Remove pump body (para 3-4) and remove foreign objects restricting impeller.
2. ENGINE CRANKS BUT FAILS TO START		
	Step 1 Check for loose cylinder head waisted bolts.	If loose, tighten in a crosswise manner with socket spanner No 120040/120050 to 29.50 ft-lb (40 N•m). Using torque gage No. 101900 tighten each bolt, crosswise, three additional 45 degree increments; then, maintaining crosswise pattern, tighten each bolt an additional 30 degrees (para 3-19).
3. ENGINE STARTS BUT RUNS UNEVENLY, STALLS, OR SURGES		
	Step 1. Check adjustment of injection pump.	Adjust injection pump (para 3-13).
	Step 2. Check for faulty injectors. Remove and test injectors.	Repair or replace faulty injectors (para 3-15).
	Step 3. Check for malfunctioning fuel injection pump.	Replace fuel injection pump (para 3-13).
	Step 4. Check for air in the fuel system.	Service fuel feed pump (para 2-32).
	Step 5. Check for faulty magnetic pickup.	Replace faulty magnetic pickup (para 3-23).

Table 3-1. Direct Support Troubleshooting-Continued

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
4. ENGINE STOPS RUNNING OR PRODUCES BLACK, WHITE, OR GREY SMOKE		
Step 1. Check adjustment of injection pump.	Adjust injection pump (para 3-13).	
Step 2. Check for faulty injectors. Remove and test injectors.	Repair or replace faulty injectors (para 3-15).	
Step 3. Check for malfunctioning fuel injection pump.	Replace fuel injection pump (para 3-13).	
Step 4. Check for air in the fuel system.	Service fuel feed pump (para 2-32).	
Step 5. Check for faulty fuel feed pump.	Repair or replace fuel feed pump (para 3-14).	
5. ENGINE CONSUMES EXCESSIVE LUBE OIL (MAY PRODUCE BLUE SMOKE)		
Step 1. Check for leaking oil pan.	If oil pan is leaking, remove from crankcase, seal and install (para 3-10).	
	If oil pan continues to leak, replace it (para 3-10).	
Step 2. Check for lube oil cooler core leaks. Clean lube oil cooler and check for core leaks (para 3-8).	If leakage is evident, replace lube oil cooler (para 3-8).	
Step 3. Check turbocharger for leaking oil seals. Check for oil on the impellers and walls of the compression and turbine chambers. The presence of oil indicates seal leaks. Oil seal leaks are caused by blocked air intake ducts or damaged oil seals.	If the air filter and intake ducts are not blocked, the turbocharger oil seals must be replaced (para 3-16).	

MALFUNCTION
TEST OR INSPECTION
CORRECTIVE ACTION

6. ENGINE OIL PRESSURE IS LOW

Step 1 Check for clogged lube oil cooler inspect lube oil cooler (para 3-8).

Replace a clogged or otherwise faulty lube oil cooler (para 3-8).

Step 2. Check for partially clogged oil suction pipe inlet screen inspect oil suction pipe inlet screen.

Replace an oil suction pipe that is damaged or cannot be cleaned adequately (para 3-11).

Step 3. Check for air leak in oil suction pipe. Inspect oil suction pipe.

Replace a faulty oil suction pipe (para 3-11).

Step 4. Check for worn or damaged lube oil pump inspect lube oil pump.

Repair or replace a faulty lube oil pump (para 3-11).

7. PUMP DOES NOT DISCHARGE OR HAS LOW DISCHARGE PRESSURE

Step 1. Check for broken impeller Disassemble pump (para 3-4) inspect impeller.

Replace impeller if necessary (para 3-4).

8. PUMP MAKES EXCESSIVE NOISE

Step 1. Check for foreign matter in pump. Disassemble pump (para 3-4) Inspect for foreign matter.

Remove foreign matter.

Section II. MAINTENANCE PROCEDURES

		INDEX	
Para		Para	
Adapter housing	3-23	Fuel injection pump	3-13
Alternator, V-belt pulley, and fan	3-18	Fuel injectors	3-15
Bearing housing assembly	3-5	Fuel system lines and fittings	3-12
Cooling air blower	3-9	Idler pulley assembly	3-21
Cooling air ducting	3-9	Lube oil cooler	3-8
Crankshaft V-belt pulley	3-24	Lube oil filter	3-8
Cylinder head assembly, rocker arms, pushrods, and tappets	3-19	Oil pan assembly	3-10
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Fan	3-18	Pump assembly	3-4
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Front cover	3-22	Starter motor	3-17
Fuel feed pump	3-14	Tachometer drive	3-20
		Turbocharger	3-16

3-3. GENERAL INSTRUCTIONS

Most maintenance instructions in this section will list resources required, personnel required, and equipment condition for the start of the procedure. Note the following.

- Resources required are not listed unless they apply to the procedure.
- Personnel required are listed only if the task requires more than one. If PERSONNEL is not listed, it means one person can do the task.
- The normal standard equipment condition to start a maintenance task is engine stopped and START/STOP switch set at STOP EQUIPMENT CONDITION is not listed unless some other condition is required besides the power being off.
- Refer to Appendix D to determine torque requirements when tightening threaded fasteners, unless a specific torque value is given in the procedure. Standard torque values given in Appendix D are determined by thread size.
- If fuel tank has broken welds, dry it thoroughly before reworking cracked welds.

3-4. REPLACE/REPAIR PUMP ASSEMBLY

This task covers a. Removal c. Inspection e. Assembly
 b. Disassembly d. Repair f. Installation

INITIAL SETUP:

Tools

Shop set, automotive repair, field maintenance, basic
 Tool kit, master mechanics

Materials/Parts

Crocus abrasive cloth (Item 1, Appendix C)
 Grease (Item 7, Appendix C)

Equipment Condition Para

Condition Description

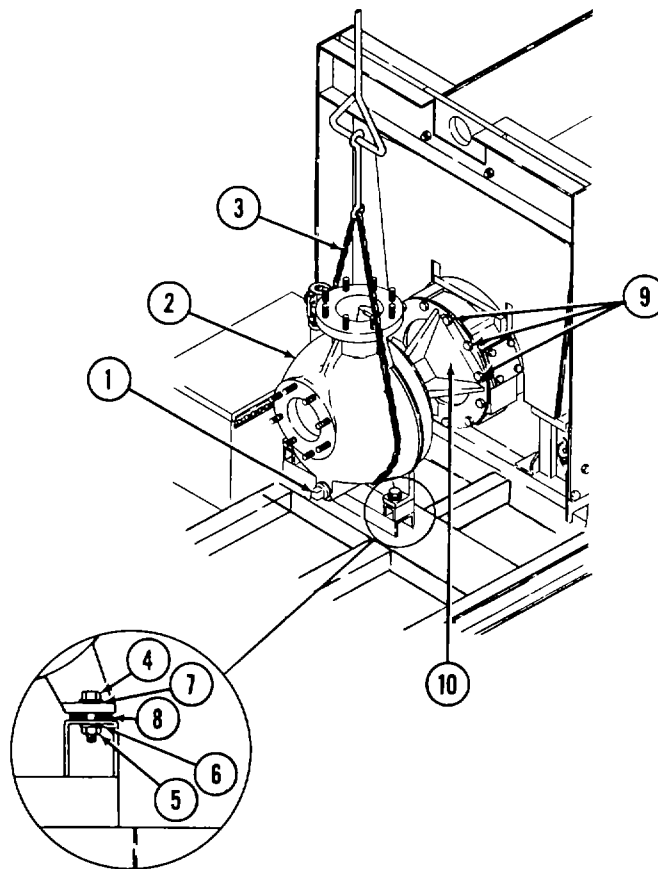
2-18

Suction assembly removed

2-19

Discharge manifold assembly removed

REMOVAL



1. Remove pipe plug (1) and drain pump assembly (2).

3-4. REPLACE/REPAIR PUMP ASSEMBLY (Continued)

WARNING

Death or serious injury could occur if unauthorized or unnecessary personnel are in the hoisting area. Permit only personnel actually engaged in the hoisting operation to be near the unit and hoisting equipment. All instructions for the hoisting operations must come from one authorized person.

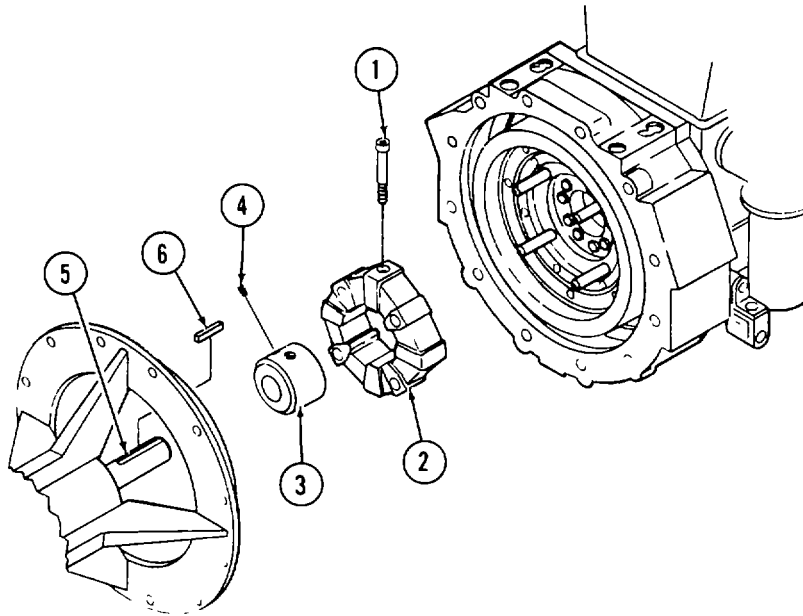
Injury to personnel or damage to equipment could occur from improper hoisting. Hoist the load slowly to avoid tearing out lifting bail assembly, slipping slings, or load shift. Do not jerk the load or swing it from side-to-side when hoisting. This places additional stress on hoisting components which can cause failure and loss of load. Be sure hoisting equipment is on solid footing and is suitable for the size of the load. Watch boom angle and overhead clearance when hoisting.

2. Position a suitable lifting device equipped with a spreader bar and slings over pump assembly (2). Attach slings (3) around assembly and put tension on slings. Make sure pump assembly is properly supported. Spread slings on spreader bar so that slings hang vertically when attached to assembly.
3. Remove screws (4), nuts (5), lockwashers (6), flat washers (7), and shims (8).

NOTE

Flywheel guards are mounted to bearing housing with screws that mount bearing housing to flywheel housing.

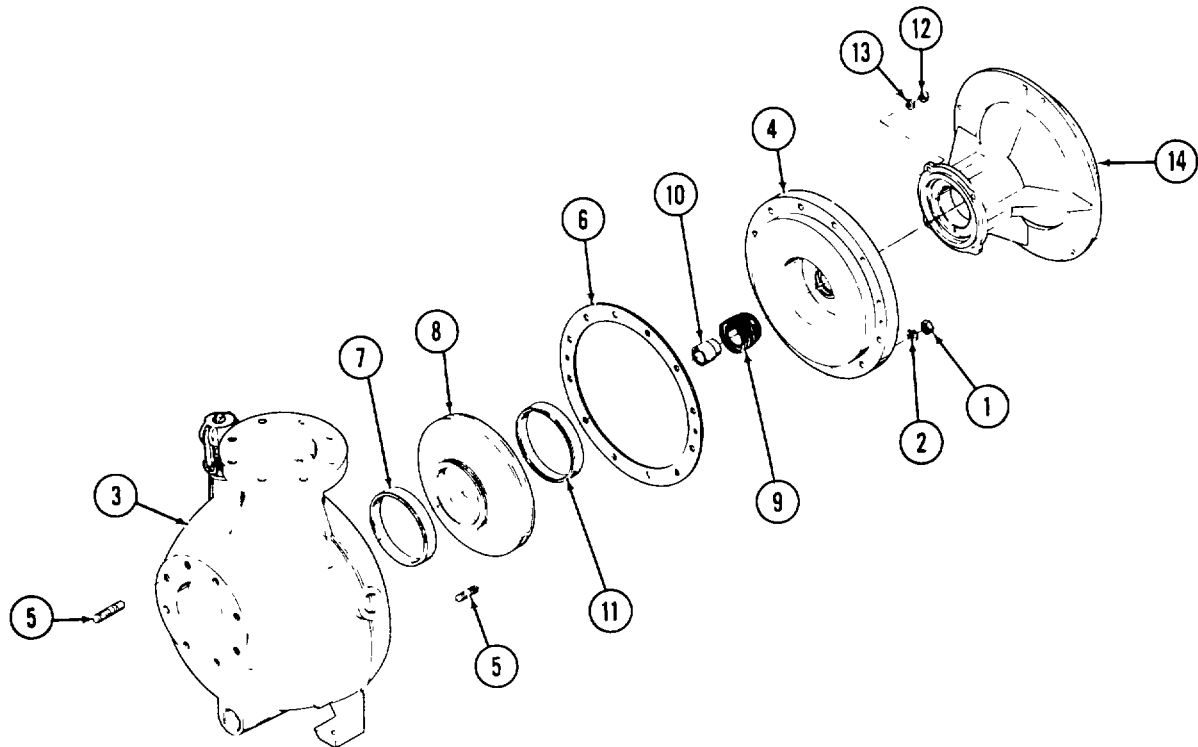
4. Remove screws and lockwashers (9).
5. Remove flywheel guards (10).
6. Lift and remove pump assembly (2) from skid and engine assembly, and lower onto blocks on a stable, level work platform.

3-4. REPLACE/REPAIR PUMP ASSEMBLY (Continued)

7. Remove bolts (1).
8. Remove coupling collar (2) from coupling hub (3).
9. Loosen setscrew (4) until coupling hub (3) moves freely on bearing housing shaft (5).
10. Remove coupling hub (3) from bearing housing shaft (5).
11. Remove key (6).

3-4. REPLACE/REPAIR PUMP ASSEMBLY (Continued)

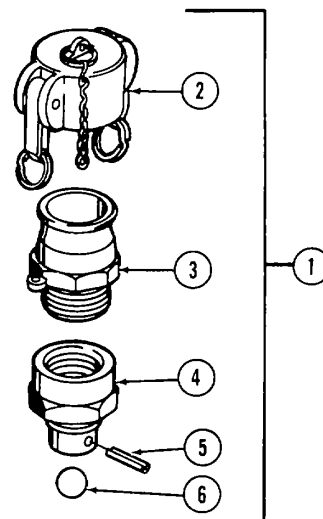
DISASSEMBLY



1. Remove nuts (1) and lockwashers (2)
2. Matchmark pump body (3) and seal housing (4) to aid in assembly. Remove pump body (3) with studs (5).
3. Remove and discard gasket (6).
4. Remove wear ring (7) from pump body (3) and discard.
5. Remove impeller (8).
6. Remove shaft seal (9) spring and rotating seal half and discard Remove stationary seal half from seal housing and discard.
7. Remove shaft sleeve (10).
8. Remove wear ring (11) from seal housing (4) and discard.
9. Remove nuts (12) and lockwashers (13).
10. Remove seal housing (4).
11. Set bearing housing assembly (14) aside.

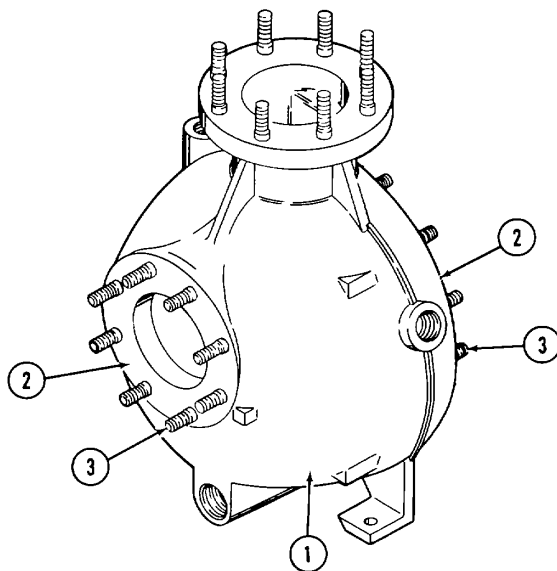
3-4. REPLACE/REPAIR PUMP ASSEMBLY (Continued)

- 12. Remove priming valve (1) from pump body.
- 13. Remove cap and chain (2) from coupling half (3)
- 14. Remove coupling half (3) from check valve (4).
- 15. Remove spring pin (5) and check valve ball (6) from check valve (4).



INSPECTION

- 1. Inspect pump body (1) for cracks, rust, corrosion, or other damage. Inspect mounting surfaces (2). Make sure they are smooth and flat with no nicks or burrs.
- 2. Inspect mounted studs (3). Make sure they are not cracked, bent, rusted, or corroded. Inspect for damaged or stripped threads. If severely damaged or cracked, replace pump body (1). Replace any studs (3) that are damaged, rusted, or corroded.

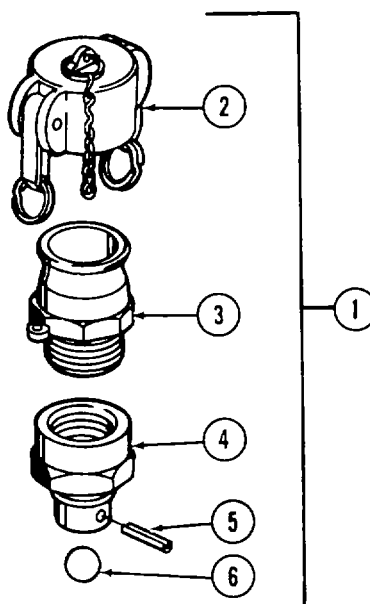


3-4. REPLACE/REPAIR PUMP ASSEMBLY (Continued)

3. Inspect impeller for cracks, rust, corrosion, or excessive wear. If severely damaged, cracked, or worn, replace impeller.
4. Inspect seal housing, shaft sleeve, and flexible coupling for cracks, rust, corrosion, or other damage. Inspect mounting surfaces. Make sure they are smooth and flat. Inspect for excessive wear where shaft sleeve contacts seal plate. Replace damaged, cracked, or excessively worn parts.
5. Inspect priming valve parts for cracks, rust, corrosion, stripped threads, or excessive wear. Be sure check valve ball seats properly in check valve. Check that chain is securely attached to cap and coupling half. Replace priming valve parts that are severely damaged, cracked, or worn.

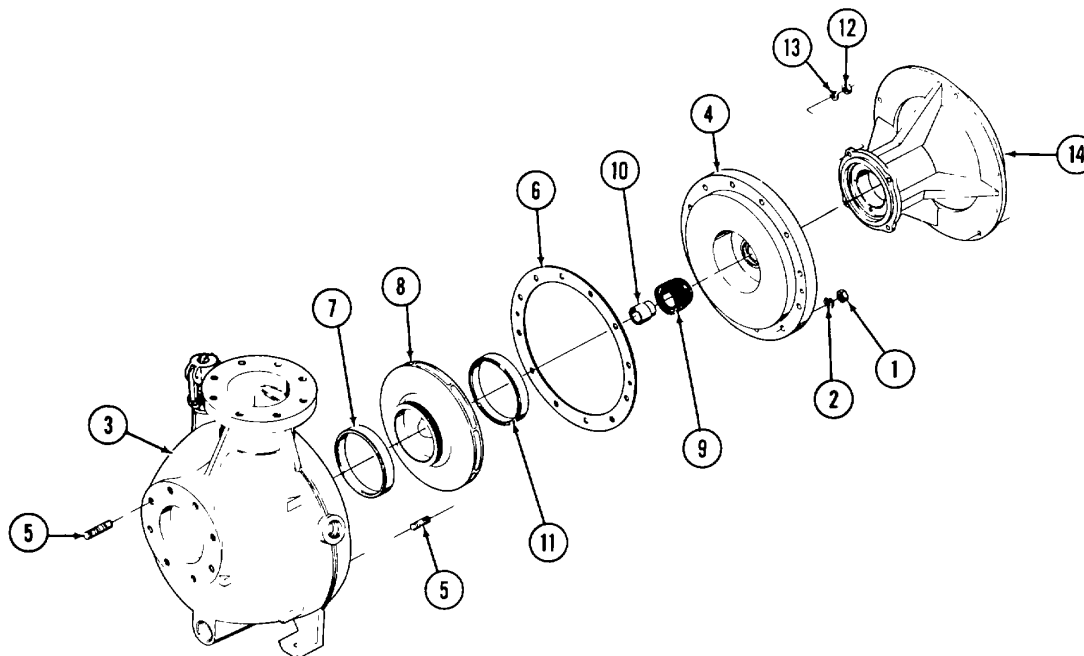
REPAIR:

Repair minor nicks or burrs on pump body or seal housing and/or smooth out mounting surfaces with crocus abrasive cloth. Clean interior or mounting surfaces. Clean and refinish outside surfaces. Remove only a minimal amount of surface material, replace parts if necessary.

ASSEMBLY:

1. Assemble priming valve (1).
 - a. Install check valve ball (6) in check valve (4) with spring pin (5).
 - b. Install coupling half (3) in check valve (4).
 - c. Clamp dust cap and chain (2) securely onto coupling half (3).
2. Install assembled priming valve (1) in pump body.

3-4. REPLACE/REPAIR PUMP ASSEMBLY (Continued)



3. Assemble and install new shaft seal (9)

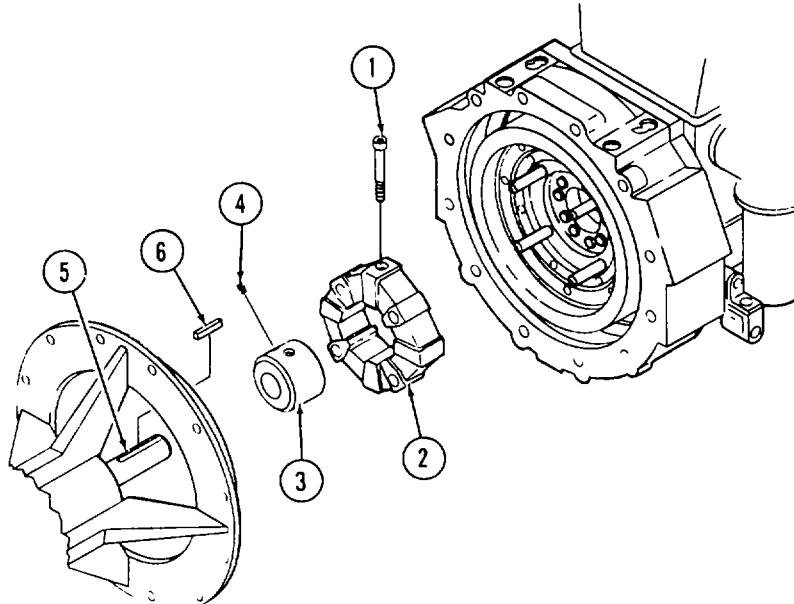
CAUTION

Be sure all seal surfaces are free of fingerprints and grease

- a. Install stationary seal half in seal housing (4), polished surface out.
 - b. Lubricate inside bore of new rotating seal half with grease. Install rotating seal half over shaft, carbon side in.
 - c. Install new seal spring.
4. Install seal housing (4) on bearing housing (14) with nuts (12) and lockwashers (13) Tighten nuts (12) in an alternating pattern
 5. Install new wear ring (11) in seal housing (4).
 6. Install shaft sleeve (10) over shaft, larger outside diameter out.
 7. Hold shaft securely and install impeller (8). Tighten securely on shaft.
 8. Install new gasket (6) on seal housing (4).
 9. Install new wear ring (7) into pump body (3).

3-4. REPLACE/REPAIR PUMP ASSEMBLY (Continued)

10. Aline pump body (3) and seal housing (4) matchmarks. Aline studs (5) with mounting holes on seal housing (4).
11. Install pump body hex nuts (1) and lockwashers (2). Tighten hex nuts (3) securely in an alternating pattern.
12. Rotate shaft by hand Be sure that assembly does not bind.

INSTALLATION:

1. Insert key (6) in bearing housing shaft (5).
2. Install coupling hub (3) on shaft, alining keyway in hub with key (6) on shaft.
3. Tighten setscrew (4).
4. Install coupling collar (2) over shaft and onto coupling hub (3).
5. Install bolts (1).

3-4. REPLACE/REPAIR PUMP ASSEMBLY (Continued)

WARNING

Death or serious injury could occur if unauthorized or unnecessary personnel are in the hoisting area. Permit only personnel actually engaged in the hoisting operation to be near the unit and hoisting equipment. All instructions for the hoisting operations must come from one authorized person.

Injury to personnel or damage to equipment could occur from improper hoisting. Hoist the load slowly to avoid tearing out lifting bail assembly, slipping slings, or load shift. Do not jerk the load or swing it from side-to-side when hoisting. This places additional stress on hoisting components which can cause failure and loss of load. Be sure hoisting equipment is on solid footing and is suitable for the size of the load. Watch boom angle and overhead clearance when hoisting.

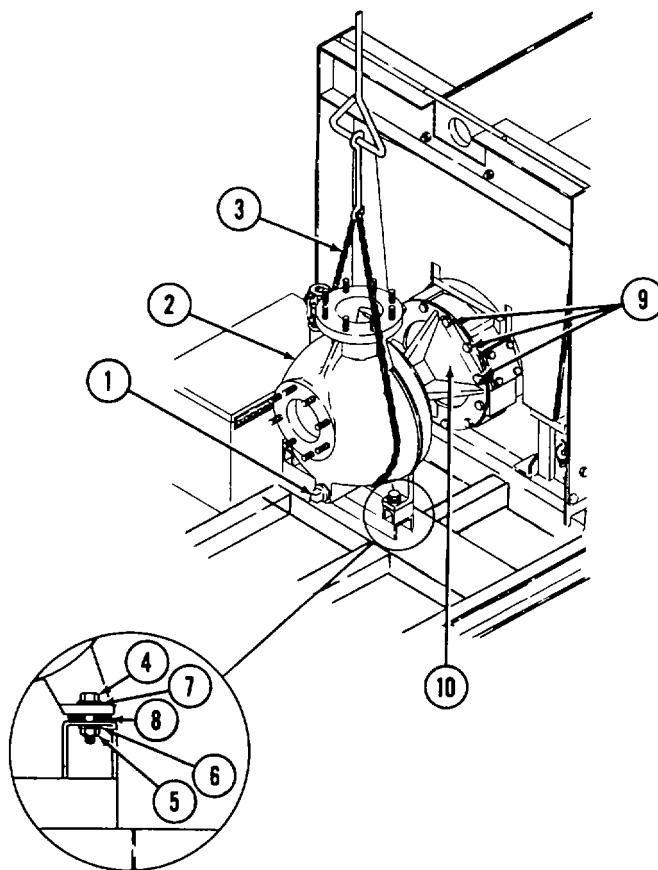
6. Position a suitable lifting device equipped with a spreader bar and slings over pump assembly. Attach slings around assembly and put tension on slings. Make sure pump assembly is properly supported. Spread slings on spreader bar so that slings hang vertically when attached to assembly.

7. Lift and remove pump assembly from blocks on work platform. Lower carefully so that bearing housing assembly aligns with flywheel housing. Aline holes in coupling collar with drive pins on flywheel, and pump body mounting holes with holes in pump mount beam. When these holes and pins are alined, slide pump and bearing housing assembly toward engine so that flexible coupling mates and engages properly.

NOTE

Alinement of the flexible coupling and flywheel may be checked and corrected by viewing through bearing housing.

3-4. REPLACE/REPAIR PUMP ASSEMBLY (Continued)



8. Position flywheel guards (10) on bearing housing (2).
9. Install screws and lockwashers (9). Do not tighten.
10. Install screws (4), nuts (5), lockwashers (6), flat washers (7), and shims (8) Do not tighten.
11. Tighten screws (9) securely in a cross pattern.
12. Tighten screws (4) in a cross pattern.
13. Remove lifting device (3).
14. Install pipe plug (1) on pump assembly (2). Tighten securely.
15. Fill the engine crankcase with oil in accordance with paragraph 2-1.
16. Install discharge manifold assembly in accordance with paragraph 2-19.
17. Install suction assembly in accordance with paragraph 2-18.

3-5. REPLACE/REPAIR BEARING HOUSING ASSEMBLY

This task covers a. Disassembly b. Cleaning/Inspection c. Assembly

INITIAL SETUP:

Tools

Shop set, automotive repair, field maintenance, basic
 Tool kit, master mechanics

Materials/Parts

Dry cleaning solvent (Item 17, Appendix C)
 Grease (Item 7, Appendix C)
 Thread compound (Item 21, Appendix C)

Equipment Condition Para

3-4

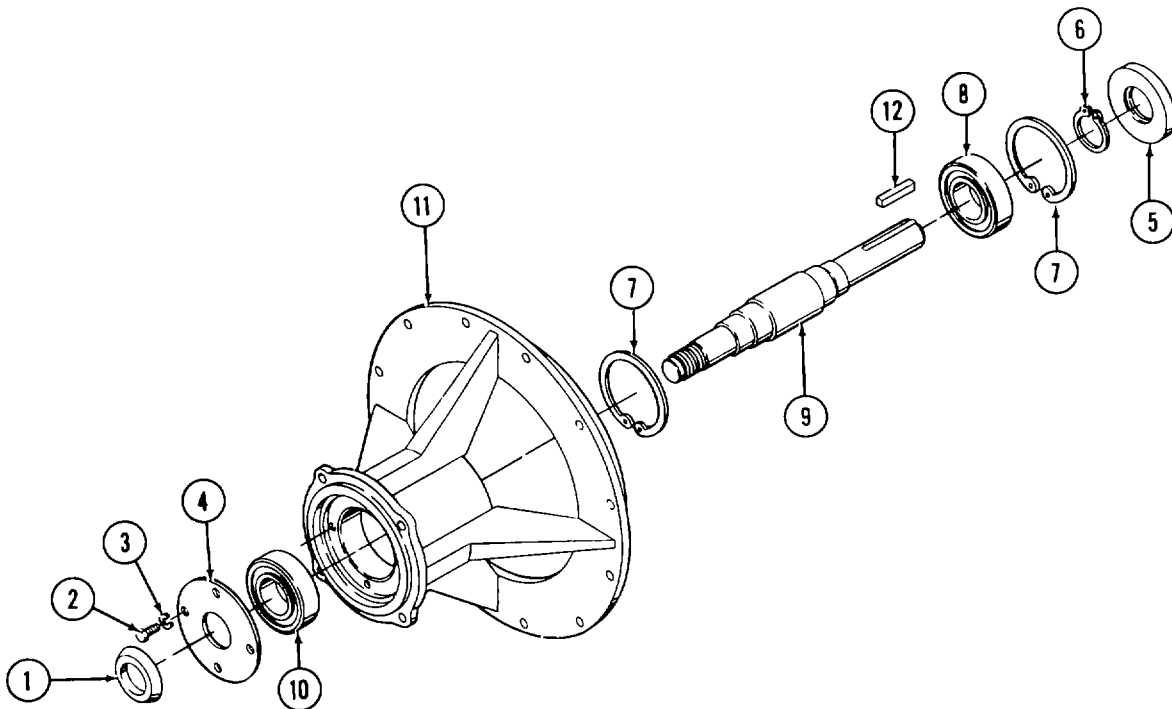
Condition Description

Pump assembly removed from unit Pump components removed from pump assembly

Special Environmental Conditions

Well- ventilated area required during cleaning

DISASSEMBLY:



1. Remove lip seal (1) and discard.
2. Remove screws (2) and lockwashers (3).
3. Remove retaining ring (4).

3-5. REPLACE/REPAIR BEARING HOUSING ASSEMBLY (Continued)

4. Remove seal (5) and discard.
5. Remove retaining ring (6).
6. Remove retaining rings (7) and bearing (8).
7. Remove shaft (9).
8. Pull out bearing (10) through pump end with bearing puller.

CLEANING/INSPECTION'**WARNING**

Dry cleaning solvent P-D-680 (safety or Stoddard's Solvent) is potentially dangerous. Avoid repeated and prolonged breathing of vapors and skin contact with the liquid. Do not use near open flame, arcing equipment, or other ignition sources. Always wear eye protection and protective clothing. The flash point of P-D-680 is 100° to 138°F (38°to 59°C).

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

1. Clean bearing housing assembly metal components with P-D-680 dry cleaning solvent and dry with compressed air.
2. Inspect bearing housing for cracks, rust, corrosion, or other damage. Inspect both engine and pump end mounting surfaces. Make sure they are smooth and flat. Inspect for excessive wear around mounting holes and main bore. Clean interior cr mounting surfaces. Clean and refinish outside surface. If unit is severely damaged, cracked, or worn, replace unit.
3. Inspect retaining rings for excessive wear, rust, corrosion, or other damage. Replace if worn or damaged.

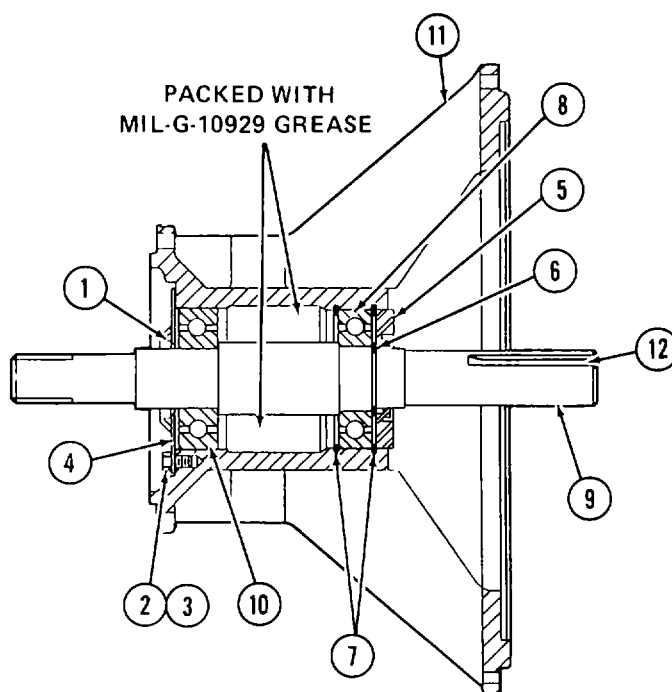
CAUTION

Do not rotate bearings with compressed air.

4. Inspect bearings for rough or tight spots. Replace bearings if rough or tight. Inspect bearing exterior for rust, corrosion, or other damage Replace bearings if damaged.
5. Inspect shaft for excessive wear, rust, corrosion, or other damage. Replace shaft if damaged.

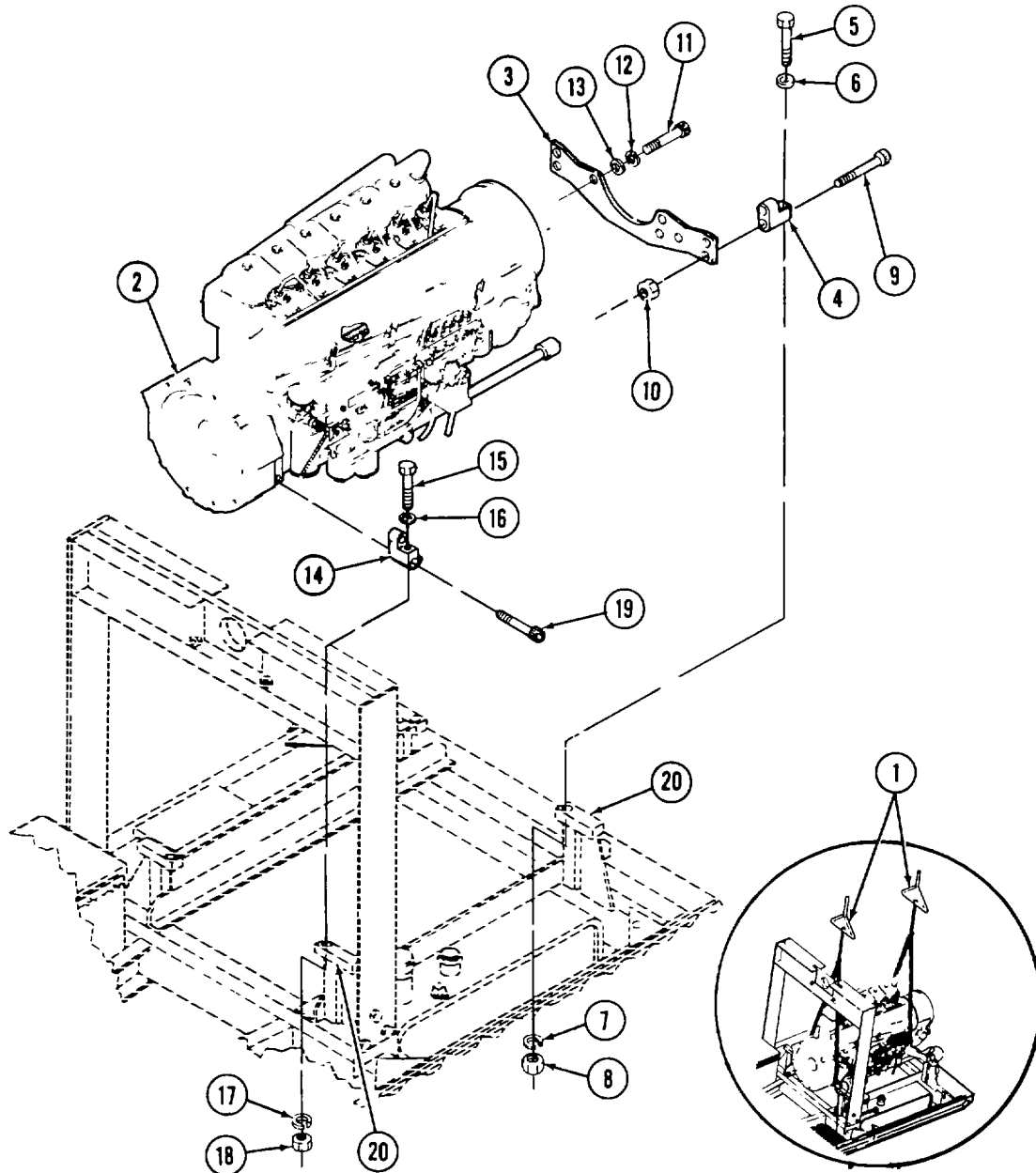
3-5. REPLACE/REPAIR BEARING HOUSING ASSEMBLY (Continued)

ASSEMBLY:



1. Pack pump end bearing (10) about 1/3 full of grease. Rotate bearing to distribute grease.
2. With loading notch toward engine end of bearing housing (11), press bearing (10) into bearing housing from pump end.
3. From engine end, install shaft (9) in ball bearing (10). Be sure keyway slot (12) is oriented toward engine end.
4. Install one retaining ring (7) into ring groove in bearing housing (11).
5. Pack grease into space in bearing housing between the bearing and the retaining ring.
6. Pack engine end bearing (8) about 1/3 full of grease. Rotate bearing to distribute grease. Apply coating of thread compound to inside diameter of bearing. Press bearing onto shaft (9).
7. Install second retaining ring (7) into ring groove in bearing housing (11).
8. Install retaining ring (6) into ring groove on shaft (9).
9. Install a new seal (5) into bearing housing assembly (11). Install with lip toward engine end.
10. Install retaining ring (4) on bearing housing (11) with screws (2) and lockwashers (3).
11. Install a new lip seal (1) on bearing retaining ring (4) Install with lip toward pump end.
12. Turn shaft (9) by hand to make sure that shaft moves freely in bearing housing assembly.

3-6. REPLACE ENGINE ASSEMBLY (Continued)



2. Place sling under crankcase at blower end of engine assembly.
3. Put tension on sling and position spreader bar so that sling hangs vertically and does not crush components mounted on engine. Make sure engine is properly supported.
4. Apply only enough lifting force to remove pressure from support bracket (3) and rear engine supports (4).
5. Remove bolts (5), washers (6), lockwashers (7), nuts (8), bolts (9), and nuts (10) from engine supports (4). Remove engine supports from support bracket (3) and from the skid.

3-6. REPLACE ENGINE ASSEMBLY (Continued)

6. Remove screws (11), lockwashers (12), and washers (13) that secure support bracket (3) to the front cover. Remove the support bracket.
7. Position another suitable lifting device (1) equipped with a spreader bar and sling over flywheel end of engine assembly.
8. Place sling under crankcase at flywheel end of engine assembly.
9. Put tension on sling and position spreader bar so that sling hangs vertically and does not crush components mounted on engine. Make sure engine is properly supported.
10. Apply only enough lifting force to remove pressure from front engine supports (14).
11. Remove bolts (15), washers (16), lockwashers (17), nuts (18), and screws (19) from front engine supports (14). Remove the engine supports from skid and engine.
12. With both slings attached, remove engine.

CLEANING/INSPECTION/REPAIR OF ENGINE SUSPENSION PARTS**WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2 11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

1. Clean support bracket and the front and rear engine supports with diesel fuel oil and dry with low pressure compressed air. Inspect all components for cracks, distortion, and elongated mounting holes. Replace components with visible damage.
2. Repair any minor damage, nicks, burrs, rust, or corrosion on support bracket or engine supports.
3. Inspect area around each mounting hole for minute cracks using MIL-L-6868 magnetic particle inspection. If any cracks are found, replace support bracket or engine support(s).

3-6. REPLACE ENGINE ASSEMBLY (Continued)

INSTALLATION:

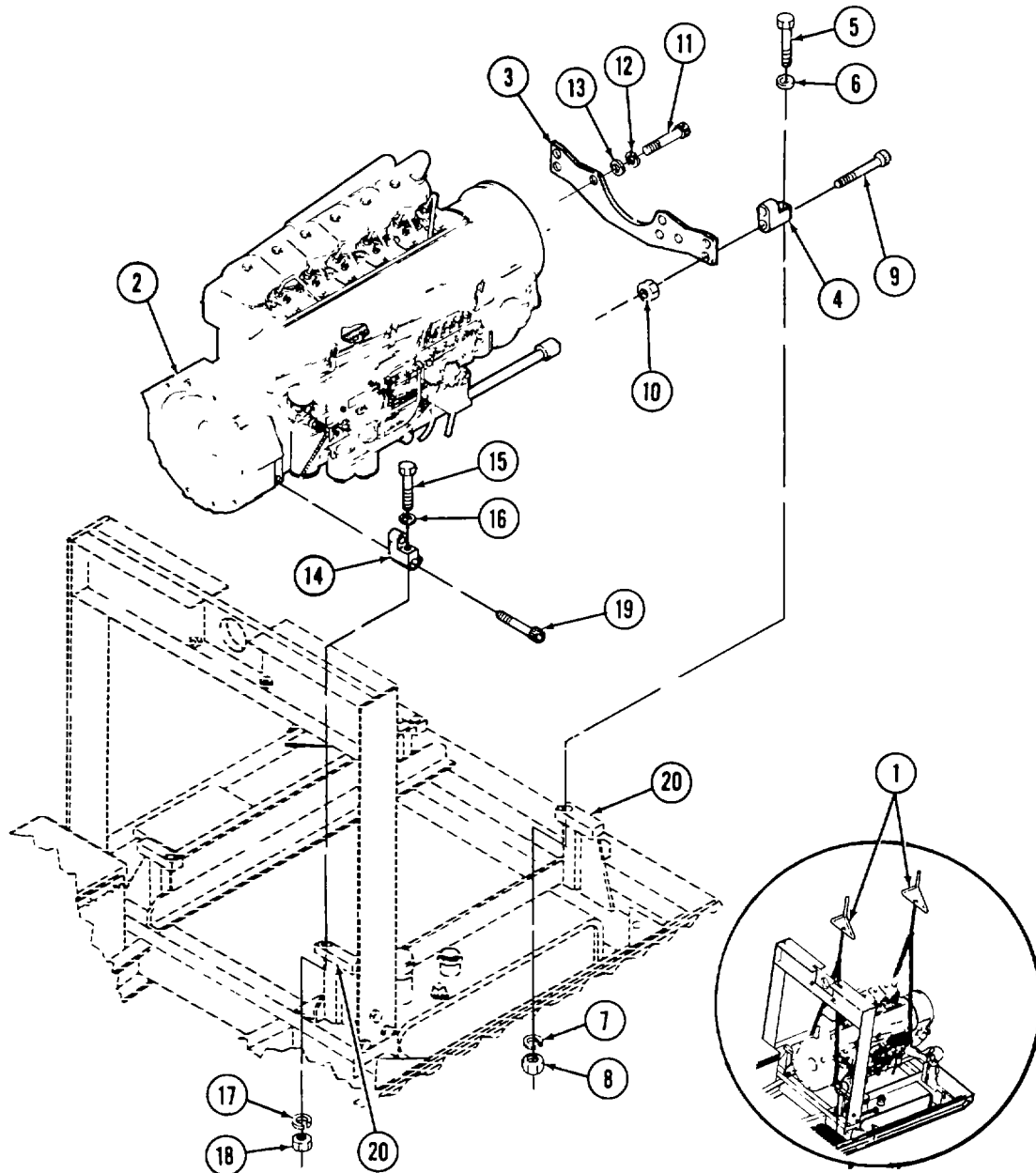
WARNING

Death or serious injury could occur if unauthorized or unnecessary personnel are in the hoisting area. Permit only personnel actually engaged in the hoisting operation to be near the unit and hoisting equipment. All instructions for the hoisting operations must come from one authorized person.

Injury to personnel or damage to equipment could occur from improper hoisting. Hoist the load slowly to avoid tearing out lifting bail assembly, slipping slings, or load shift. Do not jerk the load or swing it from side-to-side when hoisting. This places additional stress on hoisting components which can cause failure and loss of load. Be sure hoisting equipment is on solid footing and is suitable for the size of the load. Watch boom angle and overhead clearance when hoisting.

1. Position a suitable lifting device (1) equipped with a spreader bar and sling over flywheel end of new engine assembly (2).
2. Place sling under crankcase at flywheel end of engine assembly.
3. Put tension on sling and position spreader bar so that sling hangs vertically and does not crush components mounted on engine. Make sure engine is properly supported.
4. Only lift the engine high enough to install front engine supports (14) on the engine crankcase.
5. Using screws (19), secure front engine supports (14) to the engine crankcase.
6. Position another suitable lifting device (1) equipped with a spreader bar and sling over blower end of engine assembly (2).
7. Place sling under crankcase at blower end of engine assembly.
8. Put tension on sling and position spreader bar so that sling hangs vertically and does not crush components mounted on engine. Make sure engine is properly supported.
9. Only lift the engine high enough to install engine support (3) on the engine front cover.
10. Using screws (11), lockwashers (12), and washers (13), secure engine support (3) to the front cover.

3-6. REPLACE ENGINE ASSEMBLY (Continued)



11. Using bolts (9) and nuts (10) secure rear engine supports (4) to support bracket (3).
12. Carefully lower the engine onto skid engine mounts (20).
13. Using bolts (15), washers (16), lockwashers (17), and nuts (18), secure front engine supports (14) to skid. Tighten securely.
14. Using bolts (5), washers (6), lockwashers (7), and nuts (8), secure rear engine supports (4) to skid. Tighten securely

3-6. REPLACE ENGINE ASSEMBLY (Continued)

NOTE

Adjustment (timing) can be accomplished with engine in position (mounted on pump and trailer) or engine removed.

ADJUSTMENT:**WARNING**

Severe injury may result from contact with rotating engine parts, V-belts, or fan. Shut off the engine when it is necessary to inspect, service, or perform maintenance on any moving parts.

CAUTION

During the following timing procedures the engine V-belt pulley and crankshaft will be rotated clockwise and/or counterclockwise. Carefully read the timing Instructions.

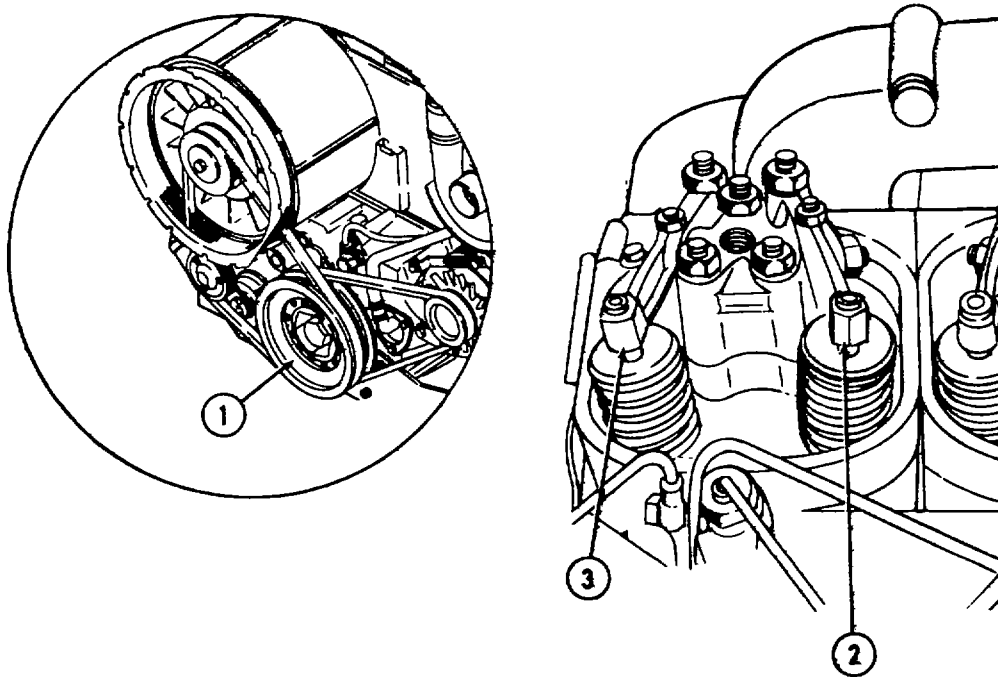
NOTE

Use the following procedure to determine TDC (top dead center).

Normal running direction of engine, flywheel, and crankshaft is clockwise when facing the V-belt pulley end of the engine.

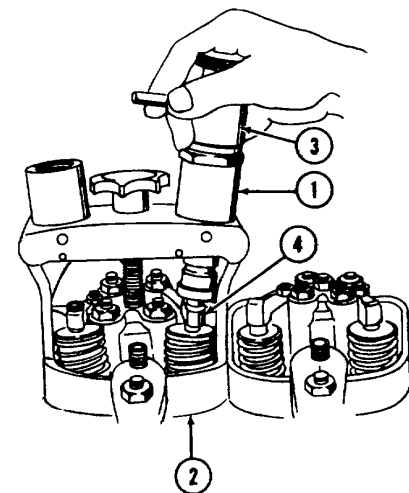
The cylinders are numbered one through six, starting with the cylinder at the flywheel end of the engine. Cylinder firing order is 1-5-3-6-2-4.

1 Remove rocker chamber covers from cylinders number one and two. |

3-6. REPLACEMENT ENGINE ASSEMBLY (Continued)

2. Rotate crankshaft by rotating crankshaft V-belt pulley (1) clockwise until valves are in overlap position on cylinder number one. The exhaust valve (2) should be closing and its valve stem rising. The inlet valve (3) should be opening and its valve stem going down. Rotate crankshaft another one-half revolution or 180 degrees of clockwise rotation of the V-belt pulley.

3. Mount adjusting device No.100640 (1) on cylinder head assembly (2). Locate pressure screw (3) over exhaust valve, and turn pressure screw counterclockwise until contacting valve end of rocker arm. Continue rotating six more revolutions to compress valve spring (4) the necessary 5.0 mm to 6.0 mm.



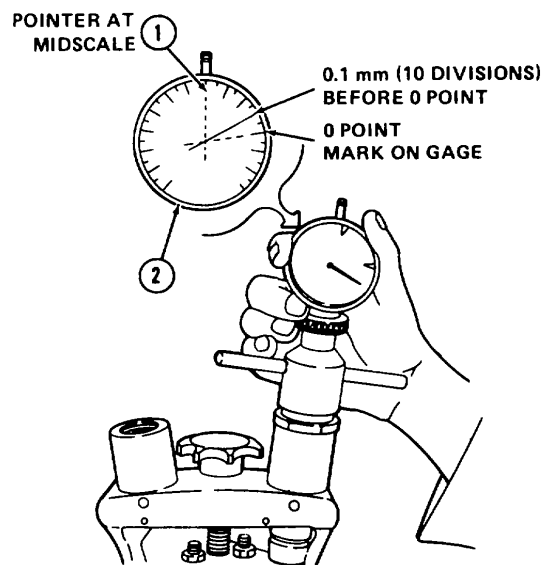
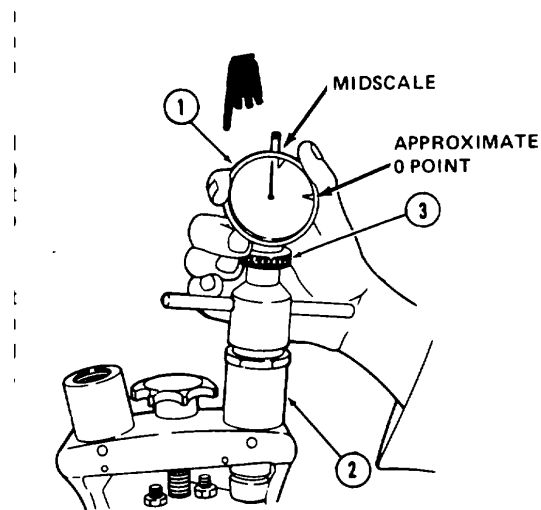
3-26 Change 1

36. REPLACE ENGINE ASSEMBLY (Continued)

4. Install dial gauge No.100400 (1). Pre-tension gauge to midscale (approximately 5.0 mm) or adjusting device No 100640 (2). Secure in place using knurled nut (3).

5. Slowly rotate V-belt pulley clockwise until piston starts to push valve up. Gauge pointer (1) will move clockwise. Continue to rotate V-bell pulley until gauge pointer stops. This is Top Dead Center (TDC).

6. Stop rotation at TDC, and mark V-belt pulley at this location. Location should align with roll pin in front cover above pulley. Remove adjusting device No 100640. Repeat steps 2 through 6, if necessary.



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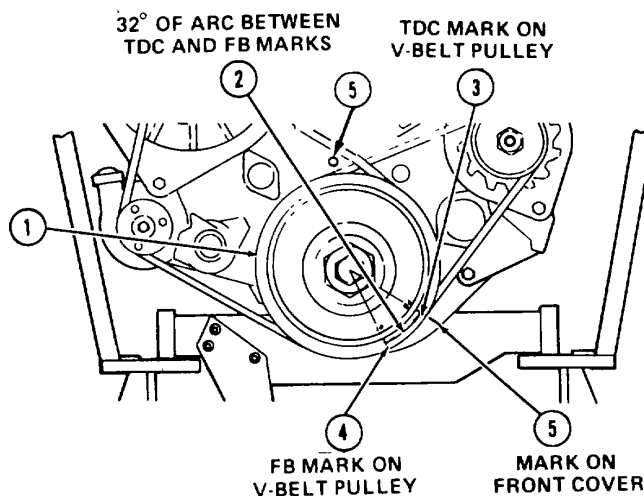
Change 1 3-27

3-6. REPLACE ENGINE ASSEMBLY (Continued)

NOTE

RUN/STOP lever must be in full run position (toward cooling blower).

7. Measure on the V-belt pulley (1) circumference 32 degrees (2.700 inches or 68 mm) of arc (2) clockwise from TDC mark (3) and point on the V-belt pulley (4). This is the Fuel Beginning (FB) or commencement of injection flow point and, when aligned with the roll pin above the V-belt pulley, indicates that the fuel injection pump is just starting to feed fuel to the injectors.



WARNING

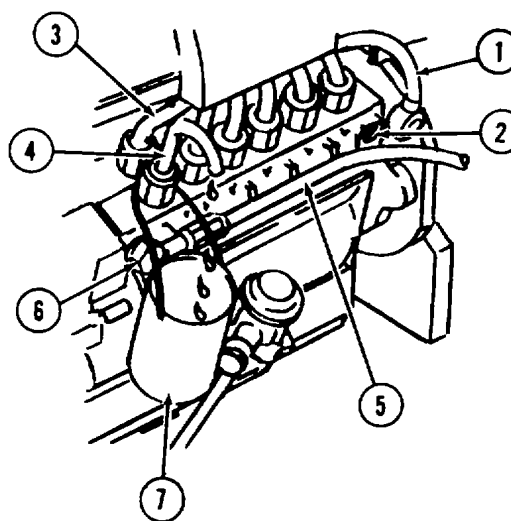
Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

8. Disconnect overflow line (1) from the injection pump and plug overflow port (2).

9. Disconnect the cylinder one injection line (3) from the injection pump. Connect stub pipe (4) to the cylinder one output connector of the injection pump.

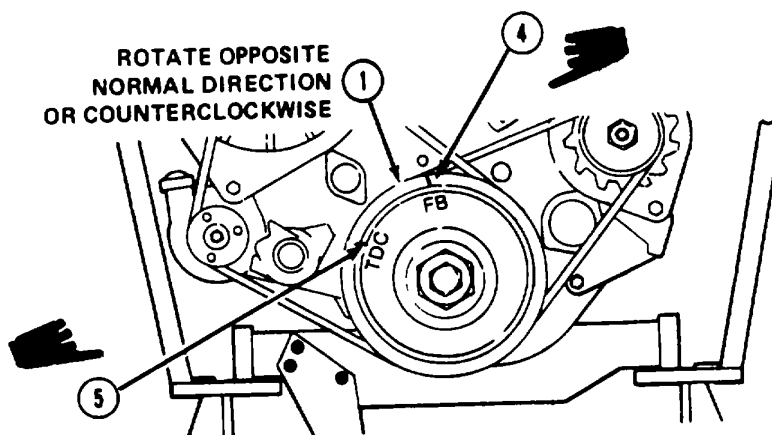
10. Connect the delivery pipe of high pressure timing device No. 003-0714 (5) to fuel inlet port (6) of the fuel injection pump.

11. Connect suction pipe of high pressure timing device No.003-0714 (5) to fuel line from fuel tank.



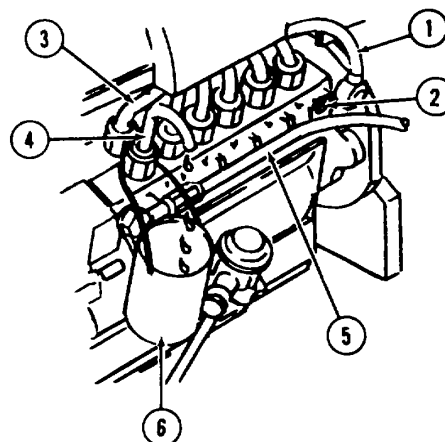
3-6. REPLACE ENGINE ASSEMBLY (Continued)

12. Position fuel reservoir No 003-0777 (7) under stub pipe (4) so that fuel runs into reservoir during injection timing test and adjustment.



13. Rotate V-belt pulley (1) counterclockwise until the FB mark (4) is approximately 90 degrees before engine TDC (5).

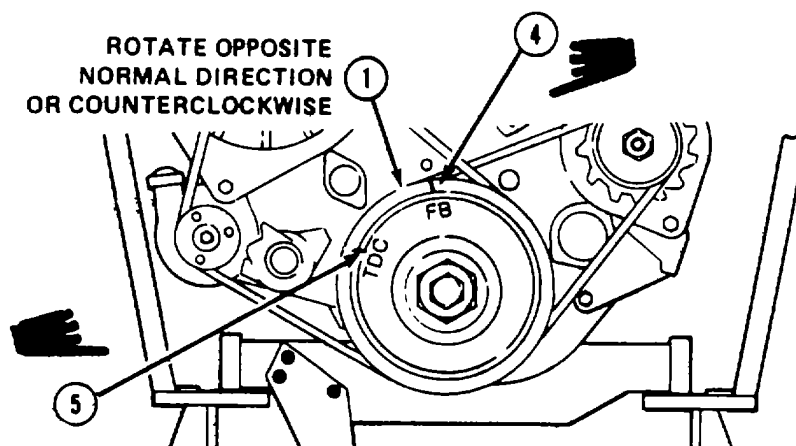
14. Pump hand pump handle of high pressure timing device No. 003-0714 (5) until fuel flows out of stub pipe (4) into reservoir (6)



15. Rotate V-belt pulley clockwise (in normal running direction) slowly and continue to pump hand pump handle until fuel flow decreases to a drip. When the interval between droplets is 5 to 8 seconds, the fuel injection rate is correct. Stop rotation of crankshaft.

16. Make sure mark FB lines up with marking on front cover. If so, the fuel injection timing is adjusted correctly and there is no need for further adjustment. If not, proceed with the following steps to adjust fuel injection timing.

3-6. REPLACE ENGINE ASSEMBLY (Continued)



17 Rotate V-belt pulley (1) counterclockwise until the FB mark (4) is approximately 90 degrees before engine TDC (5).

18 Rotate V-belt pulley (1) clockwise until the FB mark (4) aligns with the timing pin on the cover above the pulley. The crankshaft, gearing, and valves are in position for beginning of fuel delivery. Hold the crankshaft V-belt pulley in this position until the injection pump is adjusted. Paragraph 3-21 gives instructions for removal of idler pulley assembly for access to the injection pump adjustment.

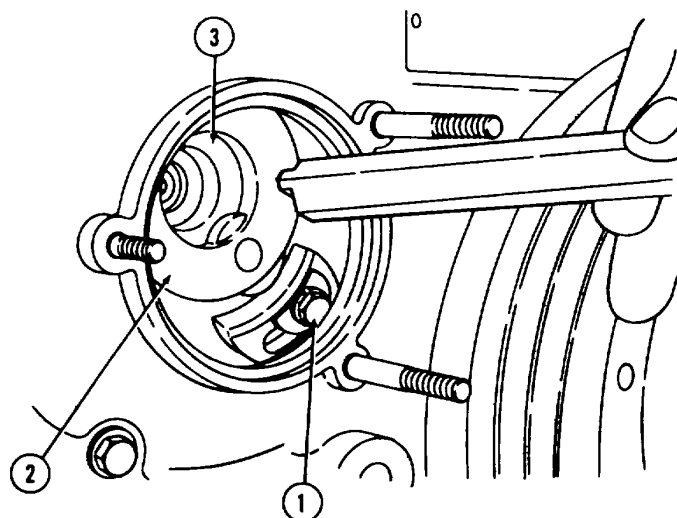
NOTE

Parts or tools should be protected from dropping into the front cover using a shop cloth.

19. Loosen hex bolts (1) but do not remove them from injection pump gear (2) and hub (3). The drive hub cap can now be turned without gear movement.

20. Slowly rotate injection pump hub (3) and shaft clockwise until the injection pump starts to deliver fuel. If necessary, rotate injection pump hub fully counterclockwise, and repeat this step.

21. Pump high pressure timing device No. 0030714 until fuel comes out of stub pipe at 5 to 8 second intervals. When it does, the injection pump is adjusted for beginning of fuel delivery.

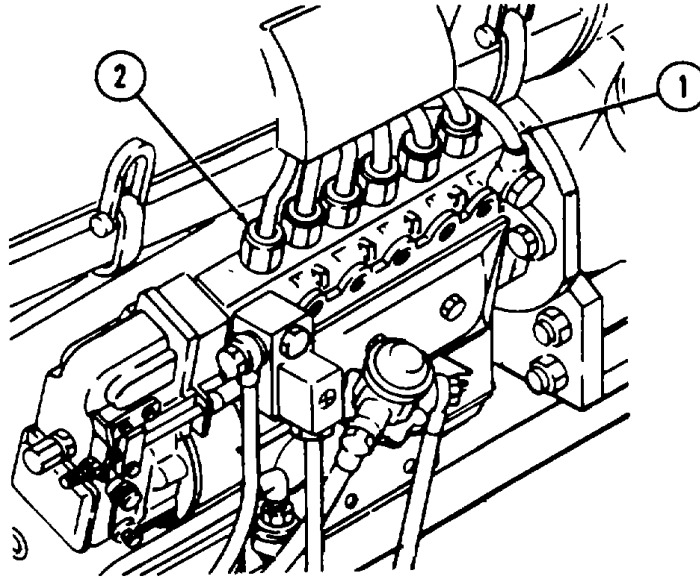


22. Without changing the position of injection pump gears (2) or hub (3), tighten the hex bolts (1) that secure the injection pump hub to the injection pump gear.

23. Recheck fuel injection timing and adjust if necessary. To readjust, repeat procedure starting with step 12. If no adjustment is necessary, fuel injection timing is now correct.

3-6. REPLACE ENGINE ASSEMBLY (Continued)

24. Remove delivery and suction pipes of timing device No. 003-0714, fuel reservoir No. 0030777, and stub pipe from injection pump. Replace washers on banjo bolts when reinstalling fuel lines.



25. Connect the overflow line (1) to the injection pump overflow port.

26. Connect the cylinder one injection line (2) to the injection pump port.

3-7. REPLACE/REPAIR FLYWHEEL

This task covers a. Removal c. Repair
 b. Cleaning/inspection d. Installation

INITIAL SETUP:

Tools

Shop set, automotive repair, field maintenance, basic

Tool kit, master mechanics

Torque gage No.101910

Equipment Condition Para

Condition Description

Engine shut down and cool

3-4

Pump assembly removed from engine.

3-23

Adapter housing removed.

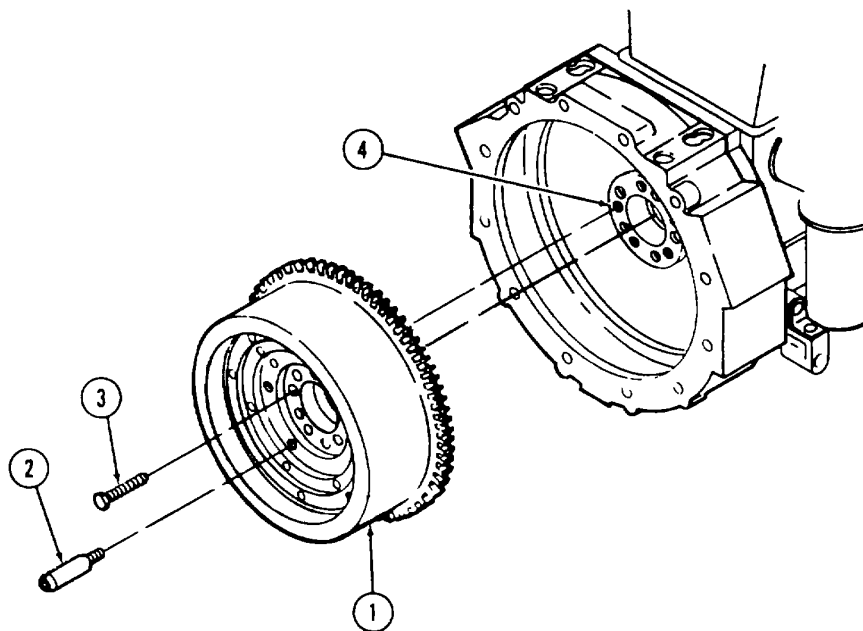
Materials/Parts

Diesel fuel oil (Item 6, Appendix C)

Special Environmental Conditions

Well-ventilated area required for cleaning.

REMOVAL:



1. Restrain flywheel (1) and remove drive pins (2) from flywheel.
2. Restrain flywheel (1) and remove bolts (3).
3. Remove flywheel (1) from crankshaft (4).

3-7. REPLACE/REPAIR FLYWHEEL (Continued)

CLEANING/INSPECTION:**WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 1 Clean flywheel thoroughly with diesel fuel oil. Use wire brush if necessary. Dry with compressed air.
- 2 Inspect flywheel for cracks, rust, corrosion, or other damage. Check for damaged, chipped, or broken teeth on flywheel ring gear. Check for unusual or uneven wear of ring gear. If units are severely damaged, cracked, or worn, replace flywheel.

REPAIR:**WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 1 Smooth out nicks or burrs on flywheel-to-crankshaft mounting surface. Remove rust or corrosion, then clean with diesel fuel oil. Dry with compressed air.

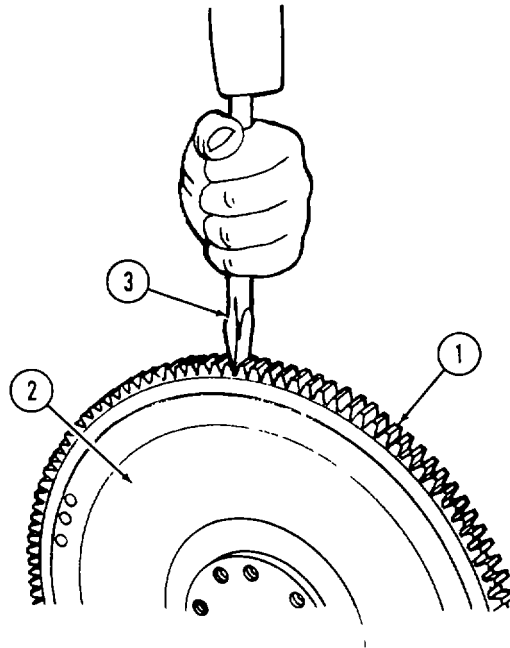
3-7. REPLACE/REPAIR FLYWHEEL (Continued)

CAUTION

Starter transmission damage may occur if chamfered side of replacement ring gear is not facing same direction as chamfer on replaced gear. Note chamfered side of gear before replacement.

NOTE

Only remove a ring gear if it is to be replaced.



- 2 To remove ring gear (1) from flywheel (2), support flywheel on a solid flat surface in an upright position. Cut through the ring gear with a hard chisel (3) and remove the gear from the flywheel.
Support flywheel crankshaft side down after cutting the gear.

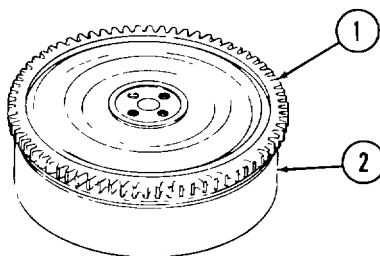
3-7. REPLACE/REPAIR FLYWHEEL (Continued)

WARNING

Operate acetylene torches properly and be alert for leaks on any part of the equipment. Inhalation of acetylene produces headache, dizziness, nausea, and possible loss of consciousness. If acetylene is inhaled, seek fresh air immediately.

CAUTION

Ring gear damage may occur if gear is overheated. Do not heat gear over 400°F (204°C). Use minimum amount of heat required to fit ring gear on flywheel. Keep flame moving at all times.



- 3 Install replacement ring gear (1) on flywheel (2) as follows
 - a. Support flywheel (2) (ring gear side up) on a solid flat surface.
 - b. Rest ring gear (1) on a flat metal surface

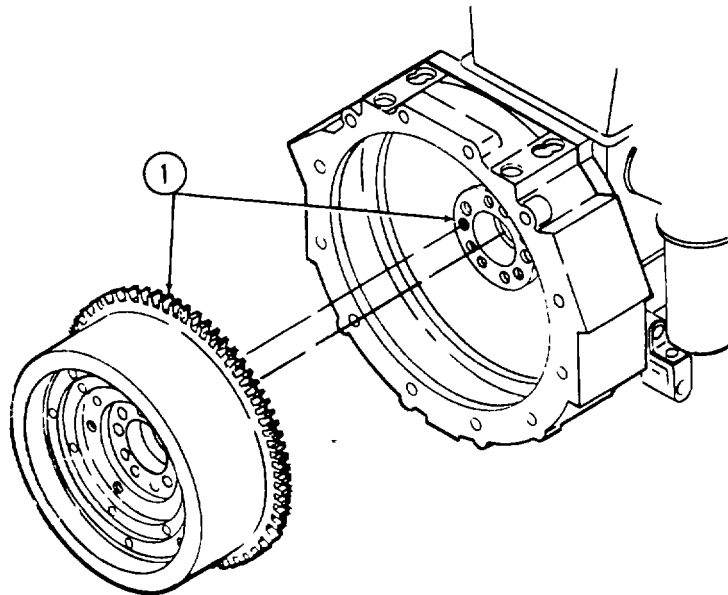
NOTE

Heat-indicating crayons, which are placed on the ring gear and melt at a predetermined temperature, may be obtained from most vendors. Use of crayons will guard against overheating the gear

- c. Heat ring gear (1) evenly with an acetylene torch to 400° F (204°C) Keep moving flame rapidly over surface of gear.
- d. Use tongs to position replacement gear in identical position to old gear.
- e. Tap gear in place against shoulder. If gear will not seat flatly on shoulder, remove it and carefully repeat the heating operation

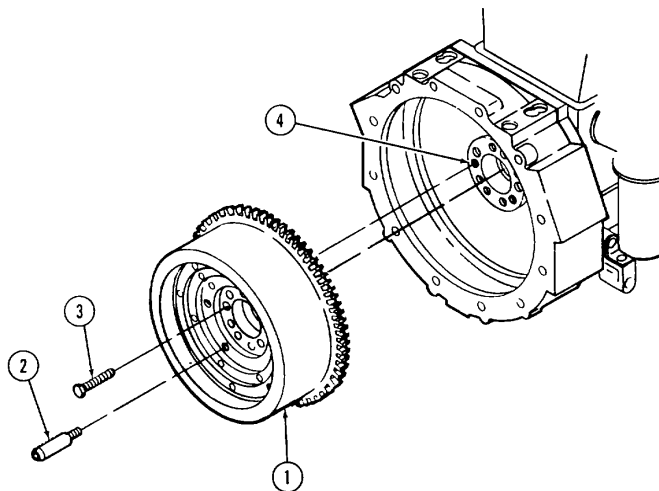
3-7. REPLACE/REPAIR FLYWHEEL (Continued)

- 4 Inspect crankshaft and flywheel mounting surfaces (1). Lightly stone to remove any fretting or brinnelling. Remove dirt and debris.



INSTALLATION:

- 1 Aline flywheel (1) mounting holes with mounting holes on crankshaft (4). Insert bolts (3) and tighten hand tight.



- 2 Restrain flywheel (1) and tighten bolts (3) alternately and evenly across flywheel (1) to 22.13 ft-lb (30 N•m) torque using socket wrench. Using socket wrench and torque gage No. 101910, tighten bolts alternately and evenly an additional 30 degrees, then another 60 degrees.
- 3 Restrain flywheel (1) Install drive pins (2). Take restraint off flywheel Make sure flywheel turns freely with no hitches or tight spots.

3-8. REPLACE LUBE OIL COOLER/REPLACE LUBE OIL FILTER

This task covers: a. Removal c. Installation
 b. Inspection d. Operational Check

INITIAL SETUP

Tools

Shop equipment, automotive maintenance and repair, common no. 1
 Tool kit, general mechanics automotive

**Equipment
 Condition
 Para**

Condition Description

Engine shut down and cool.

Materials/Parts

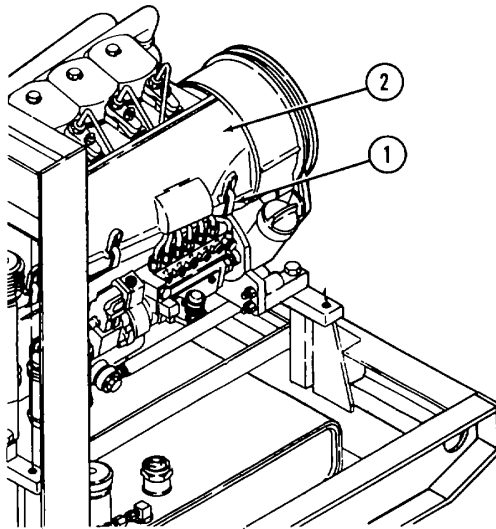
3-12

Engine oil drained.
 Fuel injection and return
 removed.

lines

Lubricating oil (Item 10, Appendix C)

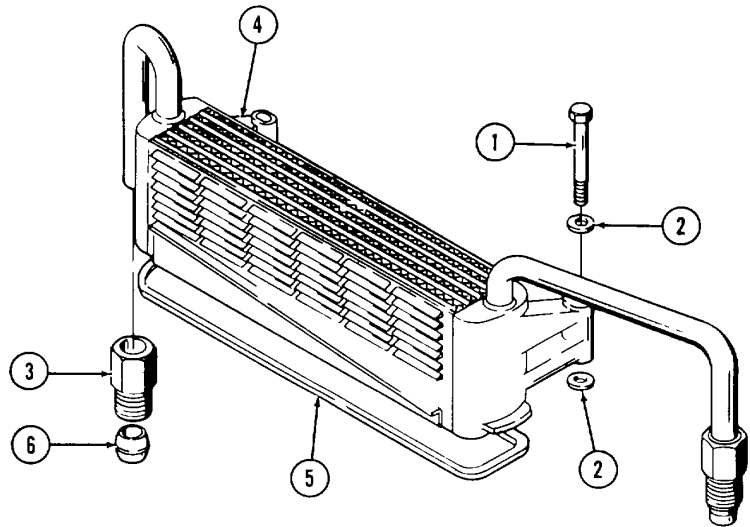
REMOVAL:



- 1 Loosen three fasteners (1) and remove air cowling top (2).

3-8. REPLACE LUBE OIL COOLER/REPLACE LUBE OIL FILTER (Continued)

- 2 Remove bolts (1) and washers (2).
- 3 Thread cap screw/nut (3) out of the engine and remove oil cooler (4).
- 4 Remove gasket (5) and duplex ring (

**INSPECTION:**

Replace lube oil cooler if damaged.

INSTALLATION:

- 1 Install gasket (5) and duplex ring (6).
- 2 Secure oil cooler (4) in place with bolts (1) and washers (2) hand tight.
- 3 Aline oil cooler pipes, and apply hand pressure to compress duplex ring (6).
- 4 Tighten cap screw/nut (3).
- 5 Tighten bolts (1) and washers (2).
- 6 Install and secure banjo bolts and washers at both ends of injection-to-crankcase hose.
- 7 Install fuel injection and return lines in accordance with paragraph 3-12.
- 8 Fill the engine crankcase with oil in accordance with paragraph 2-1.
- 9 Install air cowling top and secure with three fasteners.

3-8. REPLACE LUBE OIL COOLER/REPLACE LUBE OIL FILTER (Continued)

OPERATIONAL CHECK:

WARNING

Touching exhaust system during test can cause severe burns.

CARBON MONOXIDE (EXHAUST GAS) CAN KILL YOU

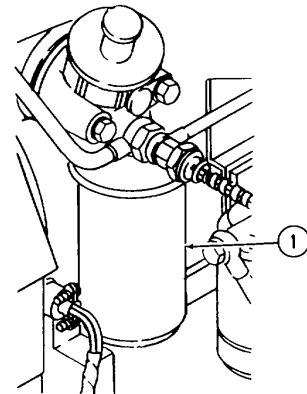
Exposure to exhaust gases produces symptoms of headache, dizziness, loss of muscular control, drowsiness, or coma. Brain damage or death can result from severe exposure.

Fumes from engines become concentrated with poor ventilation. Operate engine in a ventilated area only.

While running engine, be alert for fumes. If someone is overcome, expose to fresh air, keep warm and still, give artificial respiration if needed. Seek medical attention Administer oxygen, if available.

GOOD VENTILATION IS THE BEST DEFENSE AGAINST EXHAUST POISONING.

Start engine and check for oil leaks around lube oil cooler and lube hose clamps, hose clips, and mounting hardware as necessary. Check for and fuel lines. Tighten connections as necessary.



volts,
lines

LUBE OIL FILTER SERVICE:

- 1 Rotate lube oil filter (cartridge) (1) counterclockwise to remove. Discard filter.
- 2 Coat gasket of new filter with clean lubricating oil.
- 3 Rotate lube oil filter (cartridge) (1) clockwise to install.
- 4 Tighten hand tight.

3-9. REPLACE/REPAIR COOLING AIR BLOWER AND COOLING AIR DUCTING

This task covers	a. Removal	c. Cleaning/Inspection/Repair	e. Installation
	b. Disassembly	d. Assembly	f. Operational Check

INITIAL SETUP

Tools

Shop equipment, automotive maintenance and repair, common no 1
 Tool kit, general mechanics automotive
 Shop set, automotive repair, field maintenance, basic

Materials/Parts

Crocus abrasive cloth (Item 1, Appendix C)
 Diesel fuel oil (Item 6, Appendix C)
 Emery abrasive cloth (Item 2, Appendix C)
 Grease (Item 8, Appendix C)

Equipment Condition Para

Equipment Condition Para	Condition Description
	Engine shut down and cool.
2-22	Air duct and right side panel removed.
2-25	Blower V-belt removed.
2-27	Crankcase breather removed.
3-8	Lube oil cooler removed.
3-12	Fuel injection and return lines removed

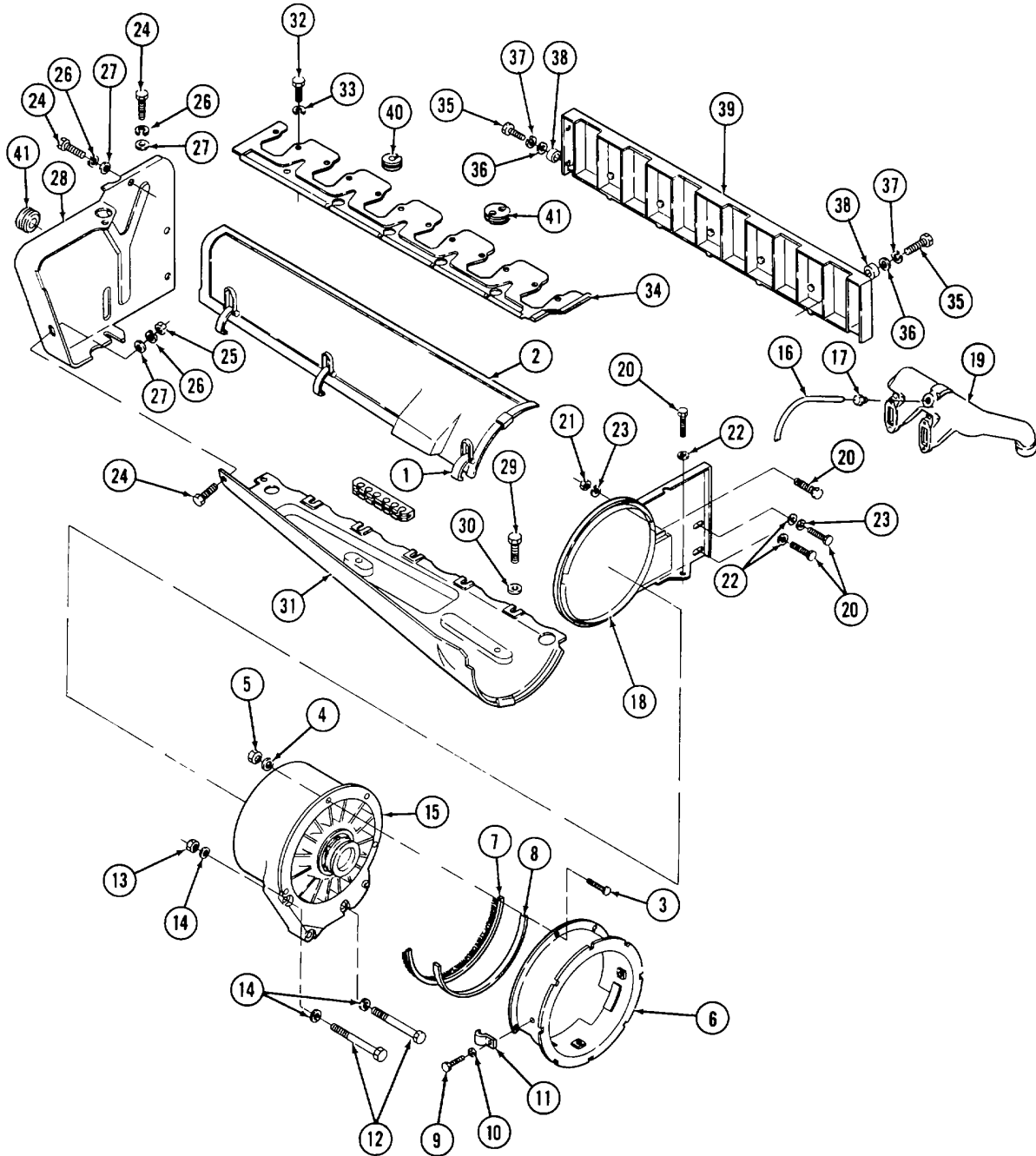
General Safety Instructions

Well-ventilated area

REMOVAL:

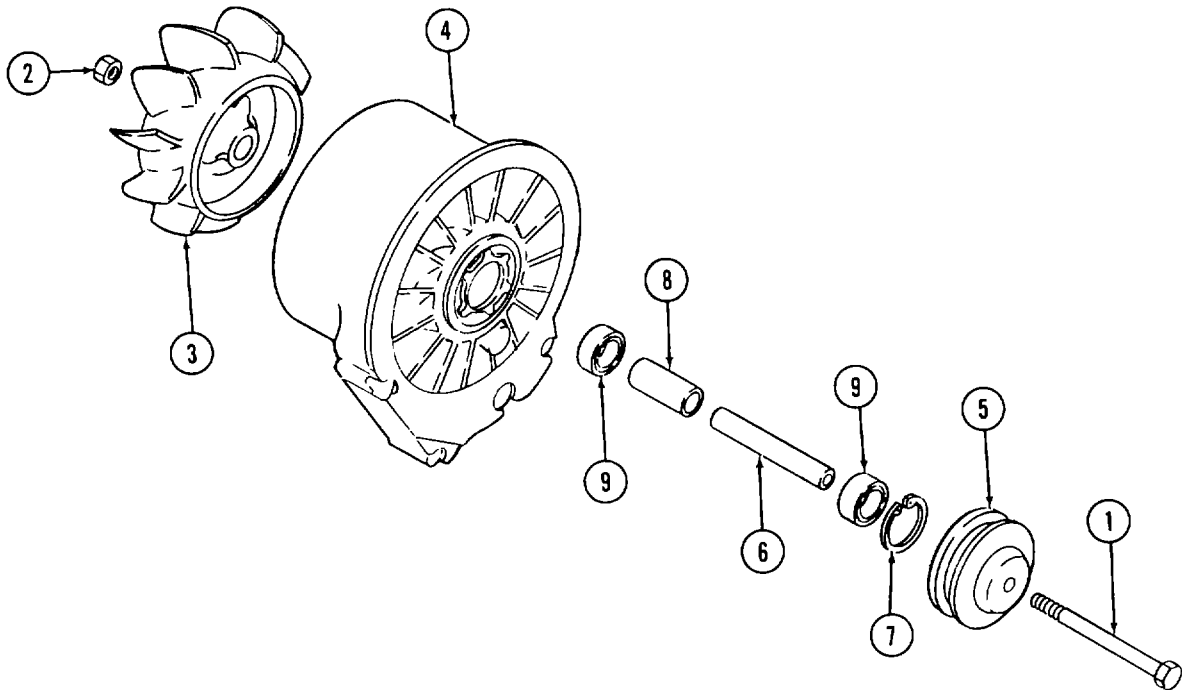
- 1 Loosen three fasteners (1) and remove air cowling top (2).
- 2 Remove four bolts (3), four washers (4), and four nuts (5) that secure air guide ring (6) to blower jacket. Remove air guide ring and assembled sealing brush (7) and sealing section (8).
- 3 Disassemble sealing brush (7) and sealing section (8) from air guide ring (6) by removing bolts (9), washers (10), and pipe clips (11).
- 4 Remove four bolts (12), one nut (13), and four washers (14) from cooling air blower (15).
- 5 Remove cooling air blower (15) from inside cooling air ducting.
- 6 Cut ether line (16) close to fitting (17). Remove ether line from front stay plate (18). Remove fitting from suction pipe (19).
- 7 Remove four bolts (20), one nut (21), five washers (22), and five lockwashers (23) that secure front stay plate (18) to engine. Remove stay plate.
- 8 Remove seven bolts (24), one nut (25), seven spring lockwashers (26), and seven washers (27) that secure rear stay plate (28) to engine. Remove rear stay plate.
- 9 Remove three bolts (29) and three washers (30) that secure air cowling base (31) to engine. Remove base.
- 10 Remove eleven bolts (32) and eleven lockwashers (33) that secure baffle mounting plate (34), and remove plate.

3-9. REPLACE/REPAIR COOLING AIR BLOWER AND COOLING AIR DUCTING (Continued)



3-9 REPLACE/REPAIR COOLING AIR BLOWER AND COOLING AIR DUCTING (Continued)

- 11 Remove five bolts (35), five washers (36), five spring lockwashers (37), and two spacers (38).
- 12 Remove air shield (39).
- 13 Do not remove grommets (40 and 41) unless they are damaged.

DISASSEMBLY:

- 1 Restrain bolt (1). Remove nut (2).
- 2 Remove bolt (1).
- 3 Lift bottom roller (3) up and out of blower jacket (4).
- 4 Pull V-belt pulley (5) from quill shaft (6).
- 5 Compress circip (7) and remove from groove in blower jacket (4).

CAUTION

Use care to avoid damage to quill shaft and blower jacket during following step.

- 6 Press assembled quill shaft (6), bushing (8), and ball bearings (9) out of blower jacket (4). Press from bottom roller (3) side of blower jacket.
- 7 Press ball bearings (9) from quill shaft (6). Discard ball bearings.

NOTE

Leave bushing on quill shaft.

3-9. REPLACE/REPAIR COOLING AIR BLOWER AND COOLING AIR DUCTING (Continued)

CLEANING/INSPECTION/REPAIR:

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers DO NOT SMOKE.

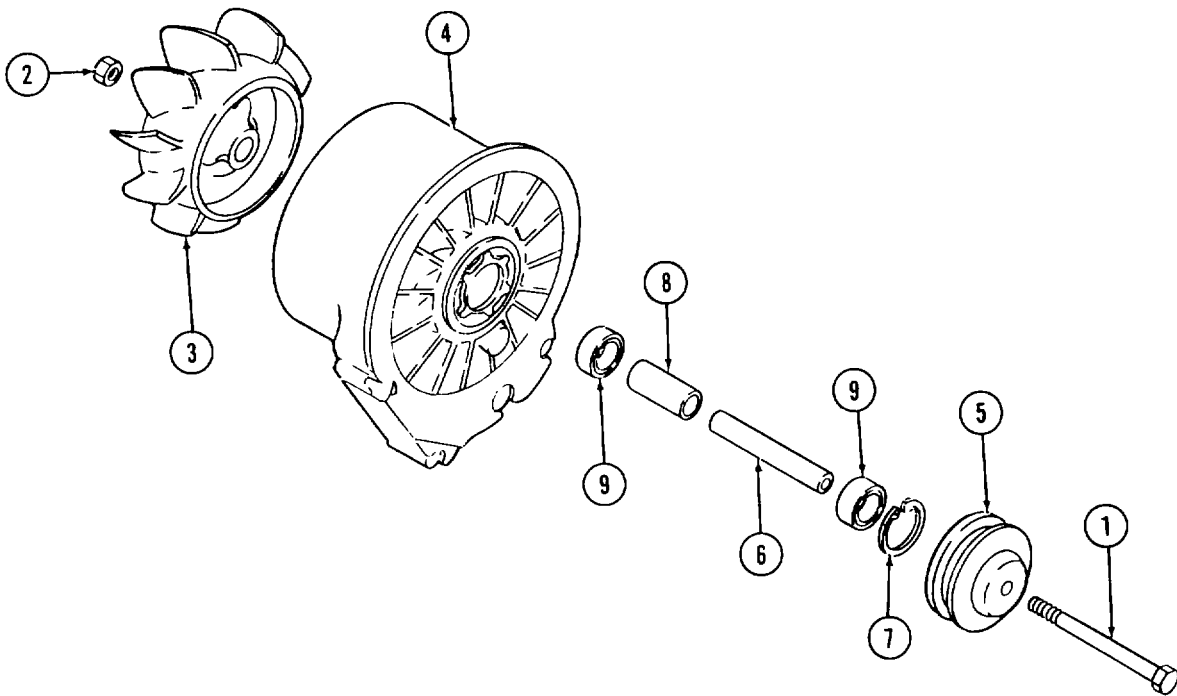
Death or serious injury could occur if compressed air is directed against the skin Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 1 Use a lint-free cloth dampened with diesel fuel oil to clean the cooling air ducting (air cowling top and base, stay plates, baffle mounting plate, and air shield). Remove all traces of grease and dirt. Dry ducting with compressed air. Inspect for dents, rust, corrosion, or other damage. Straighten dents. Remove rust or corrosion. Replace if severely rusted or damaged.
- 2 Check rubber grommets for deterioration or hardening. If the grommets are missing or damaged so they cannot protect the injector lines or fuel hose from vibration against the plates, the grommets must be replaced.
- 3 Inspect sealing brush for loss of bristles and other damage that would prevent sealing of cooling air. Replace damaged brush.
- 4 Wash cooling air blower components with clean diesel fuel oil. If necessary, scrub with a soft-bristled brush. Allow parts to air dry.
- 5 Inspect assembled quill shaft and bushing for evidence of corrosion on mating surfaces. If corrosion is evident, mark location of bushing on quill shaft, and press quill shaft out of bushing. Inspect inside diameter of bushing and outside diameter of quill shaft for corrosion and/or damage that would prevent reuse of parts. Remove corrosion using emery cloth or crocus cloth. If no corrosion is evident at mating surfaces of bushing and quill shaft, inspect all exposed surfaces for corrosion and/or physical damage that would prevent reuse. Remove surface damage and blend in damaged areas of components using emery cloth or crocus cloth. Remove sharp edges caused by wear or repair effort. Be sure quill shaft is straight. Replace bent quill shaft.
- 6 Check threads of V-belt pulley bolt and nut for cross threading, damage, and/or corrosion that would prevent reuse. Replace damaged bolt or nut.
- 7 Check V-belt pulley sheaves for sharp edges and/or corrosion or damage that could damage V-belts during operation. Remove corrosion using emery cloth or crocus cloth. Replace damaged V-belt pulley.

3-9. REPLACE/REPAIR COOLING AIR BLOWER AND COOLING AIR DUCTING (Continued)

- 8 Check blades of bottom roller for indications that roller has been rubbing on blower jacket. Physical damage to roller blades could indicate damaged blower jacket or bent quill shaft. Check surface of roller and inside diameter of the bore into which the quill shaft is installed for corrosion or damage. Remove corrosion using emery cloth or crocus cloth. Replace damaged bottom roller.
- 9 Check area of blower jacket into which the bottom roller is installed for physical damage or corrosion that would indicate roller is rubbing jacket during operation.
- 10 Check inside diameter of blower jacket for corrosion or damage that would prevent reuse. Check inside diameter for discoloration caused by overheated bearings. Check circlip groove for damage that would prevent proper seating of circlip during installation. Replace damaged blower jacket.

ASSEMBLY:

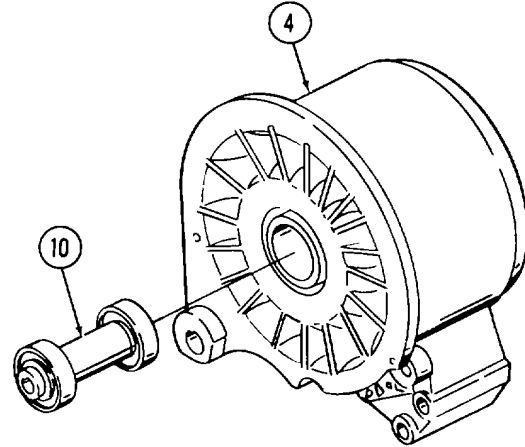


- 1 If bushing (8) was removed from quill shaft (6), press quill shaft into bushing.
- 2 Pack ball bearings (9) with grease. Press onto quill shaft (6) Seat against bushing (8).

3-9. REPLACE/REPAIR COOLING AIR BLOWER AND COOLING AIR DUCTING (Continued)**CAUTION**

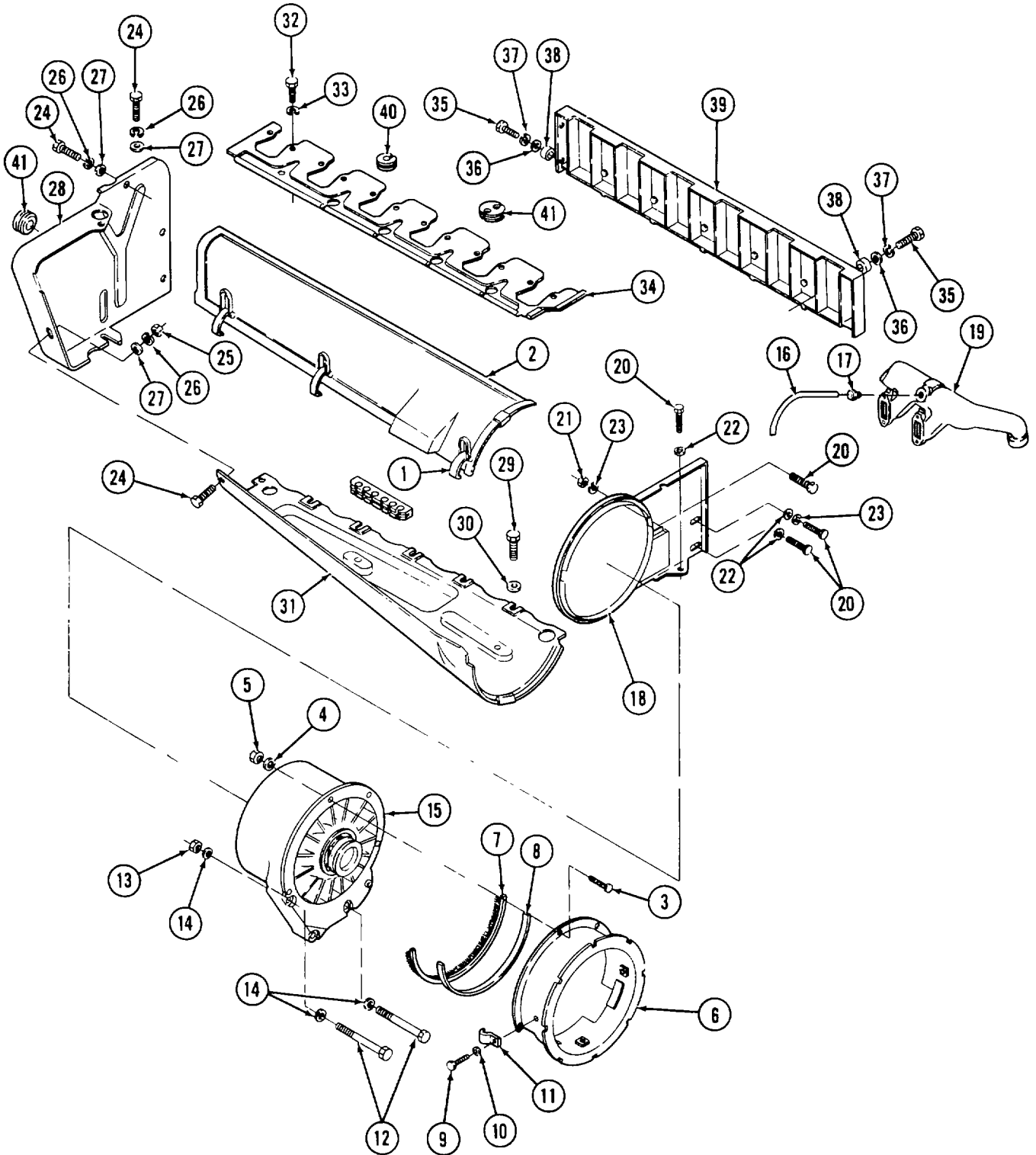
Use care to avoid damage to quill shaft and blower jacket during following step.

- 3 Press assembled quill shaft, bushing, and ball bearings (10) into blower jacket (4). Press from V-belt pulley side of blower jacket.
- 4 Compress circlip (7) and install into groove in blower jacket (4). Be sure circlip expands fully into groove.
- 5 Install V-belt pulley (5) onto quill shaft (6).
- 6 Install bottom roller (3) into blower jacket (4).
- 7 Install bolt (1) through V-belt pulley (5), quill shaft (6), and bottom roller (3).
- 8 Thread nut (2) onto bolt (1). Tighten securely.
- 9 Slowly rotate bottom roller (3). Check for rubbing, binding, or excessive resistance to rotation. Check that V-belt pulley (5) runs true relative to blower jacket (4). Slowly rotate V-belt pulley. Check that bottom roller runs true relative to blower jacket.

**INSTALLATION:**

- 1 Install air shield (39) using bolts (35), washers (36), spring lockwashers (37), and spacers (38). Tighten securely.
- 2 Install baffle mounting plate (34) using bolts (32) and lockwashers (33). Tighten securely.
- 3 Install grommets (40 and 41) (if removed).
- 4 Install rear stay plate (28) using bolts (24), nuts (25), lockwashers (26), and washers (27). Tighten securely.
- 5 Install front stay plate (18) using bolts (20), nuts (21), lockwashers (23), and washers (22). Tighten securely.
- 6 Install air cowling base (31) using bolts (29) and washers (30). Tighten securely.
- 7 Install cooling air blower (15) using bolts (12), nuts (13), and washers (14). Tighten securely.
- 8 Install sealing brush (7) and sealing section (8) on air guide ring (6) using bolts (9), washers (10), and pipe clips (11).

3-9. REPLACE/REPAIR COOLING AIR BLOWER AND COOLING AIR DUCTING (Continued)



3-9. REPLACE/REPAIR COOLING AIR BLOWER AND COOLING AIR DUCTING (Continued)

- 9 From outside the rear panel of the engine cover, install assembled guide ring (6), sealing brush (7), and sealing section (8) on cooling air blower (15). Secure in position using bolts (3), washers (4), and nuts (5).
- 10 Install air cowling top (2) Clamp fasteners (1).
- 11 Install air duct and right side panel in accordance with paragraph 2-22.
- 12 Install blower V-belt in accordance with paragraph 2-25.
- 13 Install crankcase breather in accordance with paragraph 2-27.
- 14 Install lube oil cooler in accordance with paragraph 3-8.
- 15 Install fuel injection and return lines in accordance with paragraph 3-12.

OPERATIONAL CHECK:

WARNING

Touching exhaust system during test can cause severe burns.

CARBON MONOXIDE (EXHAUST GAS) CAN KILL YOU

Exposure to exhaust gases produces symptoms of headache, dizziness, loss of muscular control, drowsiness, or coma. Brain damage or death can result from severe exposure.

Fumes from engines become concentrated with poor ventilation. Operate engine in a ventilated area only.

While running engine, be alert for fumes. If someone is overcome, expose to fresh air; keep warm and still, give artificial respiration if needed. Seek medical attention. Administer oxygen, if available.

GOOD VENTILATION IS THE BEST DEFENSE AGAINST EXHAUST POISONING.

- 1 Start engine and check for loose, rattling components. Tighten as necessary to prevent rattles.
 - 2 Check for fuel leaks around injection lines and fuel vent. Tighten connections as necessary. Shut down engine.
-

3-10. REPLACE/REPAIR OIL PAN ASSEMBLY

This task covers a. Removal c. Repair
 b. Cleaning/inspection d. Installation

INITIAL SETUP

Tools

Shop set, automotive repair, field maintenance, basic

Materials/Parts

Diesel fuel oil (Item 6, Appendix C)
 Sealing compound (Item 15, Appendix C)

Equipment Condition

Para 2-29

Condition Description

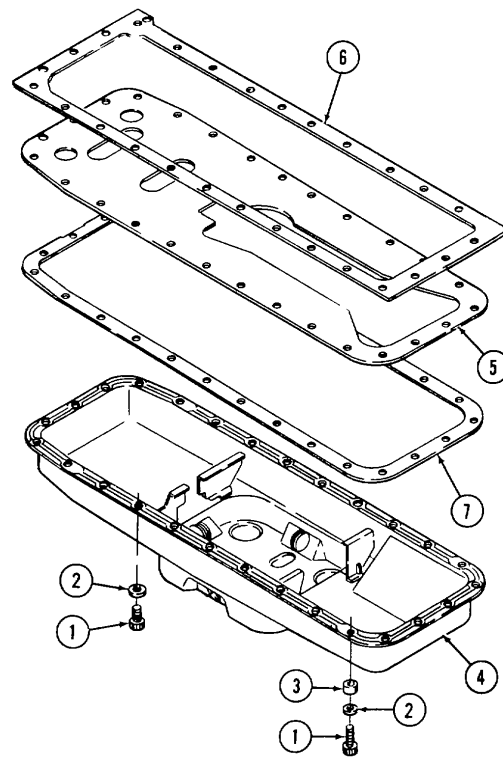
Oil drain assembly removed from oil pan Plywood board in place.

Special Environmental Conditions

Well-ventilated area required for cleaning

REMOVAL

- 1 From the rear of the skid, slide a plywood board (3.2 x 482.6 x 1219.2 mm) between the oil pan and on, crimp, or damage any fuel lines or fittings, protect it from damage.
- 2 Remove screws (1), washers (2), and bushings (3) from the oil pan (4) and lower the assembled oil pan onto the plywood board.
- 3 Remove intermediate bottom (5) and upper gasket (6) from the engine crankcase.
- 4 Slide oil pan (4) from under the engine. Remove lower gasket (7) from oil pan (4).



(3.2 x 482.6 x 1219.2 mm) plywood board to be used as a rest for the oil pan to prevent damage to the crankcase.

3-10. REPLACE/REPAIR OIL PAN ASSEMBLY (Continued)

CLEANING/INSPECTION:

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

- 1 Clean oil pan and intermediate bottom with diesel fuel oil. Inspect for rust, corrosion, dents, or distortion
- 2 Scrape all traces of the gaskets and sealing compound from the sealing surfaces of the oil pan, intermediate bottom, and engine crankcase.
- 3 Inspect the oil pan and intermediate bottom for dents, distortion, and torn or elongated mounting holes that would prevent proper sealing.
- 4 Inspect threads in oil drain port in oil pan.

REPAIR:

- 1 Repair minor oil pan damage. File nicks or burrs. Remove rust with sandpaper, then clean.
- 2 Reshape oil pan (4) and intermediate bottom (6) as required. Replace if torn or punctured during reshaping.
- 3 Replace oil pan if, after repair, the sealing flange does not rest evenly when inverted on a flat surface.
- 4 Repair minor thread damage in oil pan oil drain port by running tap or die along threads to remove burrs. Replace the oil pan if more than 25% of the thread is lost due to damage or during repair.

INSTALLATION:

- 1 Slide oil pan (4) under the engine.
 - 2 Apply sealing compound to the sealing surface of the oil pan flange, and install the lower gasket (7).
 - 3 Apply sealing compound to the lower sealing surface of intermediate bottom (5) and place the bottom on lower gasket (7).
 - 4 Apply sealing compound to the upper sealing surface of intermediate bottom (5) and place upper gasket (6) on top of the intermediate bottom.
 - 5 Apply sealing compound to the sealing surface of the crankcase bottom flange.
 - 6 Using screws (1) and washers (2), secure bushings (3) and oil pan (4) with assembled gaskets to the bottom flange of the crankcase. Tighten screws (1) alternately, until oil pan is secured to the crankcase.
 - 7 Wipe excess sealing compound from the oil pan and crankcase.
-

3-11. REPLACE/REPAIR OIL PUMP ASSEMBLY

This task covers: a Removal c Cleaning/Inspection e. Assembly
 b Disassembly d Repair f. Installation

INITIAL SETUP

Tools

Shop set, automotive repair, field maintenance, basic

Materials/Parts

Crocus abrasive cloth (Item 1, Appendix C)
 Diesel fuel oil (Item 6, Appendix C)
 Emery abrasive cloth (Item 2, Appendix C)

Condition

Para

3-10

3-22

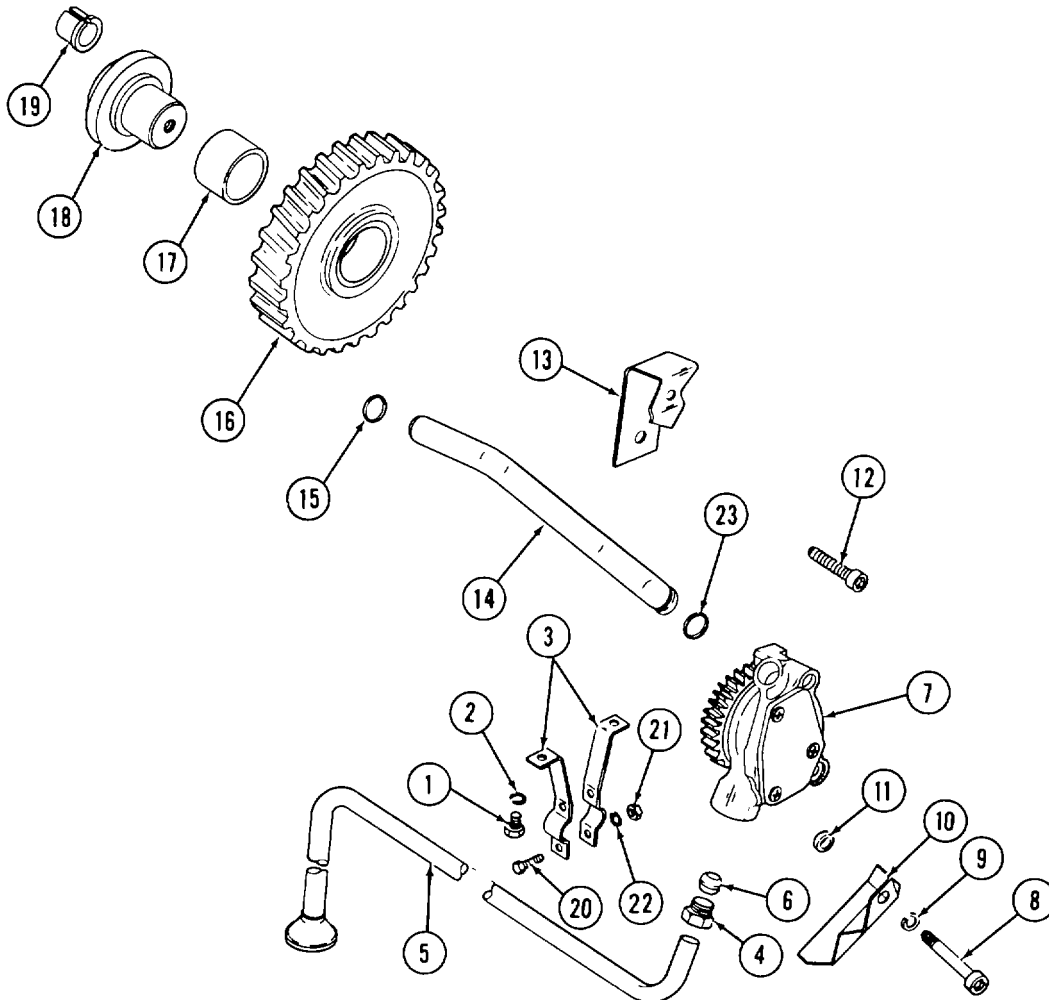
Equipment

Condition Description

Oil pan removed from engine.
 Front cover removed from engine.

Special Environmental Conditions

Well-ventilated area required for cleaning



1 Remove bolts (1) and lockwashers (2) that secure pipe clips (3) to the lower bearing cap.

3-11. REPLACE/REPAIR OIL PUMP ASSEMBLY (Continued)

- 2 Loosen cap screw/nut (4) and remove suction pipe (5) and duplex ring (6) from oil pump (7) Discard the duplex ring.
- 3 Remove screw (8) and spring lockwasher (9), to remove shield (10) and washer (11) from oil pump (7).
- 4 Remove screw (12) that secures yoke spring (13), and remove the assembled yoke spring, lube oil pump (7), and hydraulic pipe (14).
- 5 Remove preformed packing (15) from hydraulic pipe (14) Discard the preformed packing .
- 6 Check the reference marks on idler gear (16) Turn the gears until the reference marks aline between each set of gears Notice the combination of marks between each set of gears.
- 7 Remove the assembled idler gear (16) and bushing (17). 8Remove journal (18) from crankcase. Remove bushing (19) from crankcase.

DISASSEMBLY:

- 1 Remove bolt (20), nut (21), and toothed washer (22). Remove pipe clips (3) from suction pipe (5).
- 2 Pull assembled yoke spring (13) and hydraulic pipe (14) from oil pump (7). Remove and discard preformed packing (23).
- 3 If either hydraulic pipe (14) or yoke spring (13) require replacement, remove the spring from the pipe. Otherwise, leave the pipe and spring assembled.

CLEANING/INSPECTION**WARNING**

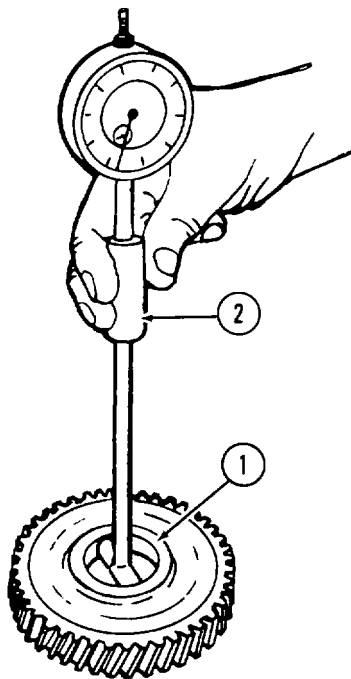
Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 1 Clean oil pump (7), idler gear (16), journal (18), suction pipe (5), hydraulic pipe (14), yoke spring (13), shield (10), and pipe clips (3) with diesel fuel oil. Dry with compressed air and/or soft clean cloth. Inspect components for excessive wear, rust, damage, and/or warpage. Replace if worn or damaged.
- 2 Inspect yoke spring (13), shield (10), and pipe clips (3) for wear, distortion, or damage that would prevent the secure fastening of components or interfere with the operation of the gears or pump Repair or replace damaged components.

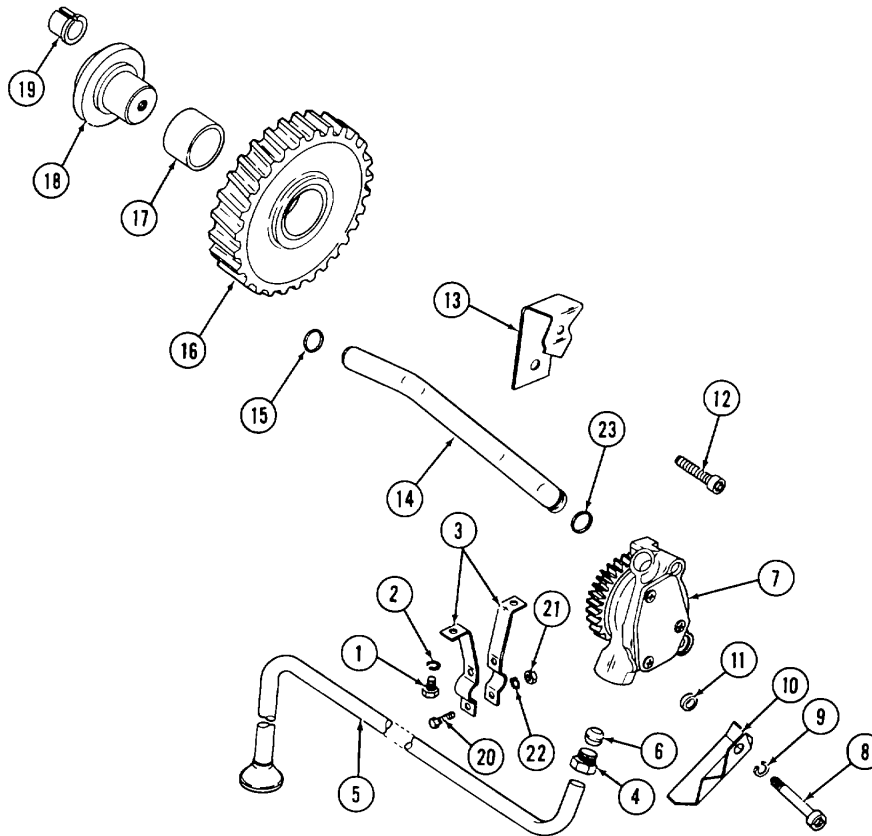
3-11. REPLACE/REPAIR OIL PUMP ASSEMBLY (Continued)

- 3 Inspect suction pipe (5) and hydraulic pipe (14) for holes, clogs, or crimps that would restrict oil flow or cause leaks at connections. Replace damaged or bent pipes or pipes that cannot be cleaned.
- 4 Inspect suction pipe (5) with screen for clogs or holes in screen. Clean screen by soaking in solvent and brushing lightly with scrub brush. If the screen is torn or cannot be cleaned, replace suction pipe.
- 5 Inspect cap screw/nut (4) for stripped or worn threads. Replace if stripped or worn.
- 6 Inspect journal (18) bearing surface for wear or pitting. If the surface is damaged or pitted, the journal must be repaired or replaced.
- 7 Inspect bushing (19) and the bushing contacting hole of the journal for wear, chips, or signs of shearing. Replace damaged components.
- 8 Inspect idler gear (16) teeth for worn, chipped, or pitted teeth or contact surfaces. If gear is damaged or pitted, it must be repaired or replaced.
- 9 Measure the bushing bore (1) of the idler gear with a dial indicator (2). The vertical clearance must not exceed 1.576 inches (40.030 mm). If clearance exceeds this limit, replace the bushing.

**REPAIR:**

- 1 Do not attempt repairs on interior of oil pump. Replace oil pump.
- 2 Remove any rust or corrosion from oil pump outer gear.
- 3 Repair only minor nicks or burrs on outer gear with crocus cloth. If gear is severely damaged, replace oil pump.
- 4 Replace any stripped or damaged hardware.

3-11. REPLACE/REPAIR OIL PUMP ASSEMBLY (Continued)



- 5 If yoke spring (13), shield (10), or pipe clips (3) are bent, reshape to approximate the original functional shape. If the component cannot be restored to a functional configuration, or if the mounting holes are elongated or torn, replace the component.
- 6 Buff a scratched or pitted journal (18) surface with emery cloth. If the pitting or scratches are too deep to remove with fine emery cloth, the journal must be replaced.
- 7 Smooth chips or burrs from the bushing contacting hole of the journal with a fine file. If the chips or burrs cannot be smoothed with a fine file, replace the journal.
- 8 A sheared or damaged bushing cannot be repaired; replace with new bushing.
- 9 Minor chips or pitting of idler gear (16) teeth can be smoothed with a fine file and crocus cloth. If the chips or pitting cannot be smoothed, the gear must be replaced.
- 10 If the vertical clearance of the gear bushing exceeds 1.576 inches (40.030 mm), press the damaged bushing from the gear and press in a new bushing.

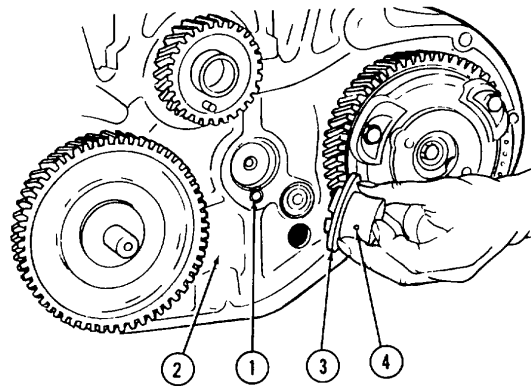
3-11. REPLACE/REPAIR OIL PUMP ASSEMBLY (Continued)

ASSEMBLY

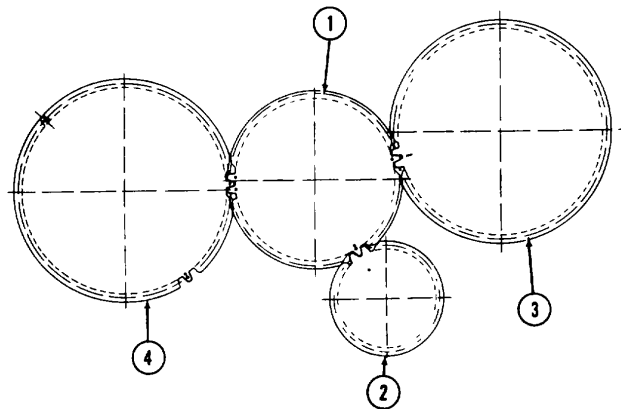
- 1 Using bolt (20), nut (21), and toothed washer (22), secure pipe clips (3) to suction pipe (5). Tighten the nut and bolt only tight enough to hold the clips on the pipe.
- 2 If either hydraulic pipe (14) or yoke spring (13) have been replaced, assemble the spring and pipe by sliding the pipe into the clamping portion of the spring.
- 3 Place a new preformed packing (23) on the end of hydraulic pipe (14) and slide the long end of the pipe into the outlet (upper, unthreaded) port of the pump. Be sure the preformed packing seats properly to provide a seal.

INSTALLATION:

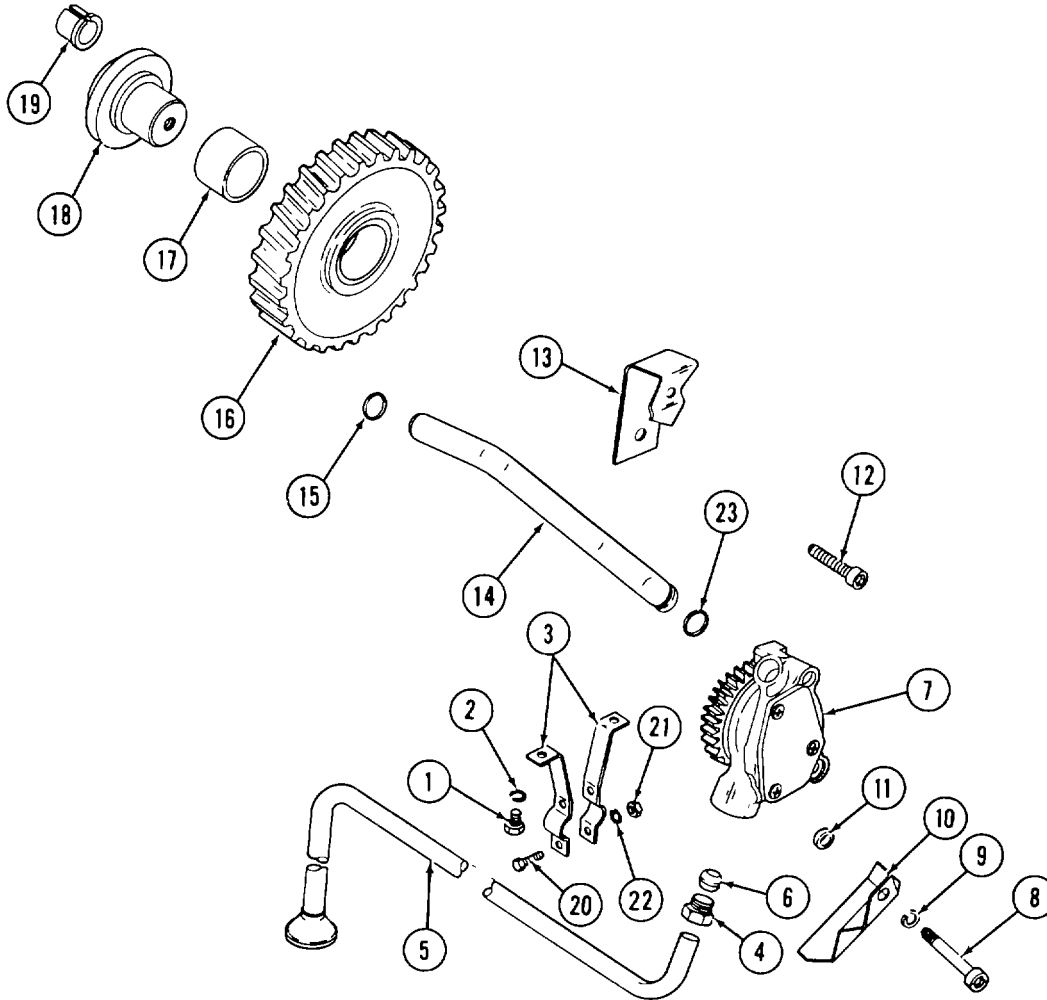
- 1 Insert bushing (1) into crankcase (2).
- 2 Install journal (3) into crankcase bore. Be sure to align bushing hole in the journal with the bushing.



- 3 Check the reference marks on idler gear (1), crankshaft gear (2), camshaft gear (3), and injection pump gear (4).
- 4 Align the idler gear marks with those of the crankshaft, camshaft, and injection pump gears, as noted during disassembly.
- 5 Place the idler gear on the journal. The teeth of the other gears may hold the idler gear and journal in place. If they do not, hold the idler gear in place by hand until the yoke spring can be installed to secure the idler gear.



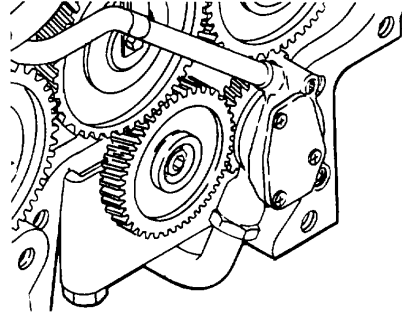
3-11. REPLACE/REPAIR OIL PUMP ASSEMBLY (Continued)



- 6 Place new preformed packing (15) on the end of hydraulic pipe (14) and slide pipe with assembled oil pump into the lube oil inlet port of the crankcase. Be sure the preformed packing seats properly to provide a seal.
- 7 Using screw (12) secure the assembled yoke spring (13), oil pump (7), and hydraulic pipe (14) to the crankcase. Do not tighten screw.
- 8 Using screw (8) and spring lockwasher (9), secure shield (10) and washer (11) to oil pump (7), and the pump to the crankcase. Do not tighten screw.

3-11. REPLACE/REPAIR OIL PUMP ASSEMBLY (Continued)

- 9 Oil pump gear-to-crankshaft gear backlash should be 0.039 to 0.078 inch (1 to 2 mm). Adjust backlash by sliding oil pump in toward crankcase to decrease backlash. Increase backlash by sliding oil pump away from crankcase. Tighten screws to 25 ft-lb (35 N•m)



- 10 Using bolts (1) and lockwashers (2), secure assembled pipe clips (3) and suction pipe (5) to the lower bearing cap.
- 11 Move suction pipe (5) in pipe clips (3) as required to install a new duplex ring (6) and the suction pipe end into the intake (lower, threaded) port of oil pump (7).
- 12 Tighten cap screw/nut (4) to secure the suction pipe (5) and duplex ring (6) in oil pump (7).
- 13 Make sure reference markings on idler, crankshaft, camshaft, and injection pump gears are aligned properly. Secure idler gear by tightening the screw (12) to 22.13 ft-lb (30 N•m) torque. Then tighten screw an additional 60 degrees.
- 14 Tighten bolts (1) and screws (8) to a torque of 25.81 ft-lb (35 N•m)
-

3-12. REPLACE FUEL SYSTEM LINES AND FITTINGS

This task covers a. Removal b. Installation

INITIAL SETUP

Tools

Shop equipment, automotive maintenance and repair, common no 1
Tool kit, general mechanics automotive`

Equipment Condition

Para

Condition Description

Engine shut down and cool.

2-42

Fuel lines and fuel return line removed.

Materials/Parts

Diesel fuel oil (Item 6, Appendix C)

General Safety Instructions

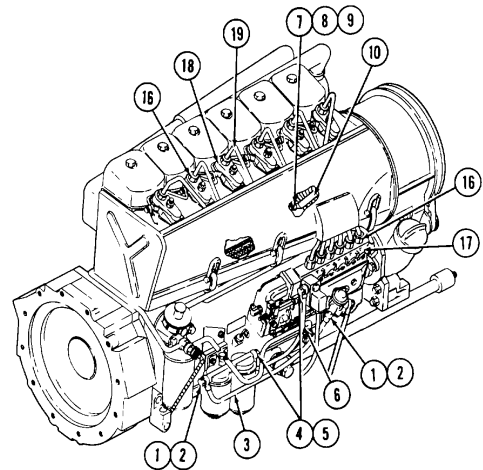
Unit cool
Well-ventilated area.

REMOVAL:

WARNING

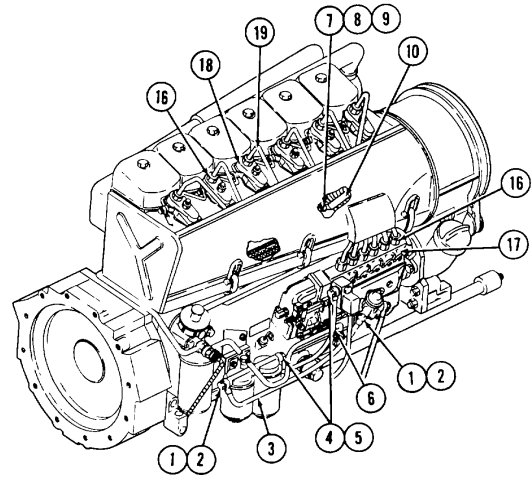
Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE

- 1 Remove bolts (1) and washers (2).
- 2 Remove fuel feed pump-to-fuel filter hose (3).
- 3 Tape or plug fittings and ports.
- 4 Remove bolts (4) and washers (5).
- 5 Remove fuel filter-to-fuel injection pump hose (6).
- 6 Tape or plug fittings and ports.

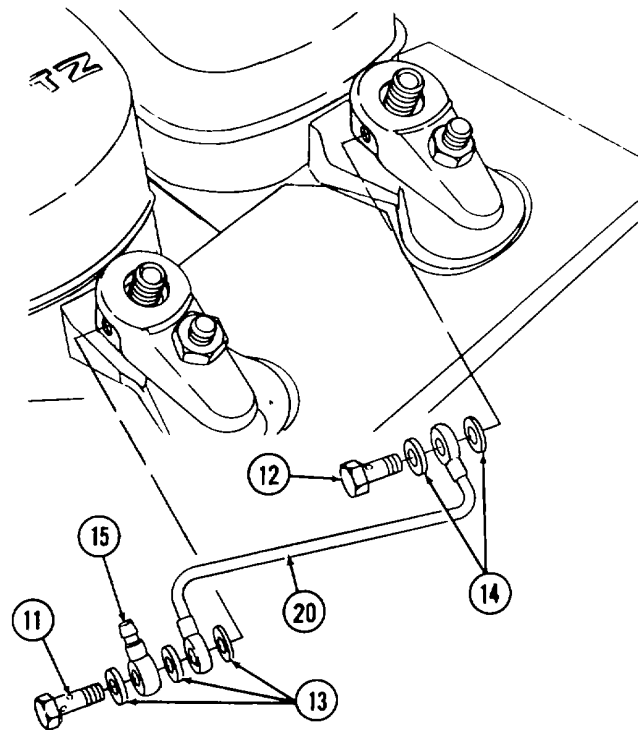


3-12. REPLACE FUEL SYSTEM LINES AND FITTINGS (Continued)

- 7 Remove bolt (7), washer (8), and nut (9).
- 8 Remove pipe clip and end plate (10).



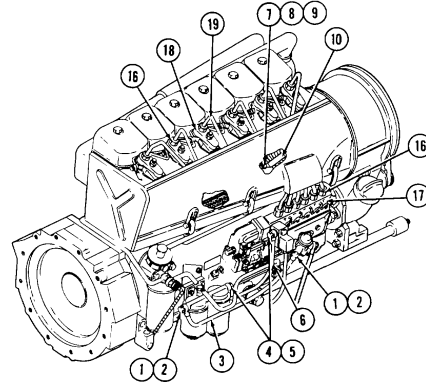
- 9 Remove bolts (11 and 12), washers (13 and 14), and hose fitting (15).
- 10 Remove fuel injection pipe connectors (16), fuel injection pump (17) and injectors (18). move grommets.
- 11 Remove fuel injection pipes (19) with connectors (16) and backleakage lines (20) attached.



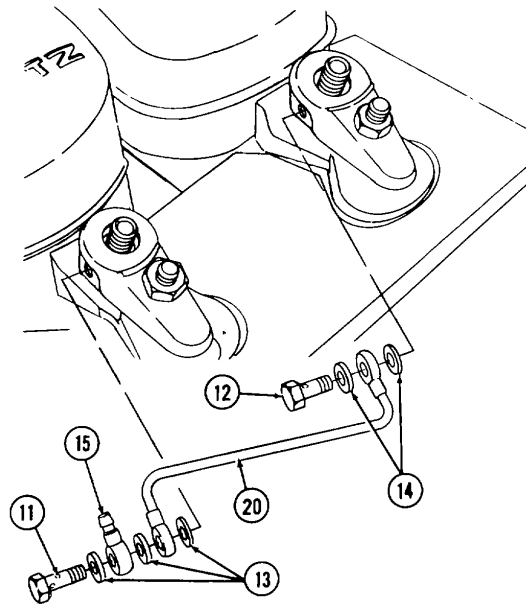
3-12. REPLACE FUEL SYSTEM LINES AND FITTINGS (Continued)

INSTALLATION

- 1 Install backleakage lines (20).
- 2 Install fuel injection pipes (19) with connectors (16). Tighten connectors on fuel injection pump (17) and injectors (18).



- 3 Install bolts (11 and 12), washers (13 and 14), and hose fittings (16) that secure backleakage lines (20) to injectors (18).
- 4 Install end plate (10) and pipe clip. Secure with bolt (7), washer (8), and nut (9). Tighten bolt securely.
- 5 Install fuel filter-to-fuel injection pump hose (6). Secure with bolt; (4) and new washers (5).
- 6 Install fuel feed pump-to-fuel filter hose (3) with bolts (1) and new washers (2). Tighten bolts securely.
- 7 Install fuel lines and fuel return line in accordance with paragraph 2-42.
- 8 Bleed air from fuel system in accordance with paragraph 2-42.



3-13. REPLACE FUEL INJECTION PUMP

This task covers a. Removal c. Adjustment
 b. Installation

INITIAL SETUP

Tools

Shop set, automotive repair, field maintenance, basic

Tool kit, master mechanics

Condition Para

2-24

2-32

2-33

Equipment

Condition Description
 Engine shut down and cool.

Actuator linkage removed from fuel injection pump.

Fuel feed pump and fuel lines removed from fuel injection pump

Lube oil line removed from fuel injection pump.

Materials/Parts

Grease (Item 8, Appendix C)

Lubricating oil (Item 10, Appendix C)

References

3-6 Adjust fuel injection pump.

3-21

V-belt idler pulley assembly removed from front cover

General Safety Instructions

Well-ventilated area required.

REMOVAL:

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers DO NOT SMOKE.

- 1 Hold crankshaft V-belt pulley in position.

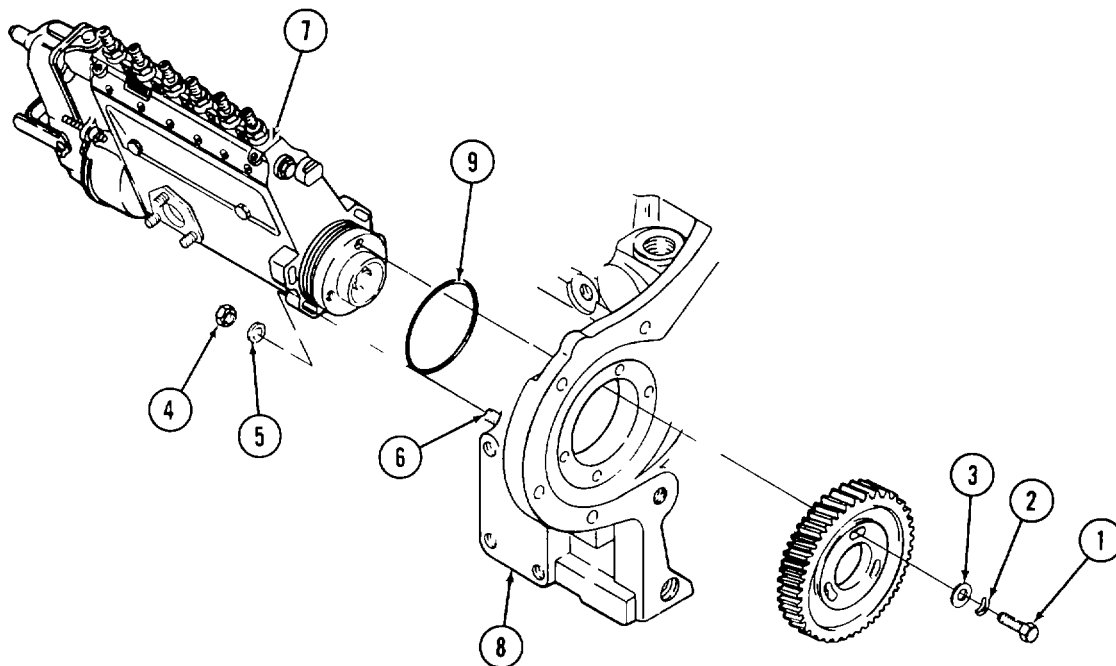
CAUTION

Be sure to pull the washers away from the drive gear with the bolt. Do not drop the gear mounting hardware into the crankcase.

Do not move the gear train after the injection pump drive gear mounting hardware has been removed. The gears could be damaged by movement while the injection pump drive gear is loose inside the crankcase.

- 2 Remove three bolts (1), three lockwashers (2), and three washers (3).
- 3 Remove four nuts (4) and four washers (5) from mounting studs (6).

3-13. REPLACE FUEL INJECTION PUMP (Continued)



4 Remove fuel injection pump (7) from crankcase (8).

5 Remove and discard preformed packing (9).

INSTALLATION:

1 Install new preformed packing (9) into crankcase (8).

2 Lubricate packing (9) with a light coat of lubricating oil.

3 Place fuel injection pump (7) over mounting studs (6). Make sure that preformed packing (9) seats properly in crankcase (8).

4 Install four nuts (4) and four washers (5).

5 Place three washers (3) and three lockwashers (2) over three bolts (1). Place a light coat of grease on these parts to hold them together during installation.

3-13. REPLACE FUEL INJECTION PUMP (Continued)

CAUTION

Do not drop the gear mounting hardware into the crankcase.

6 Install one bolt (1), lockwasher (2), and washer (3).

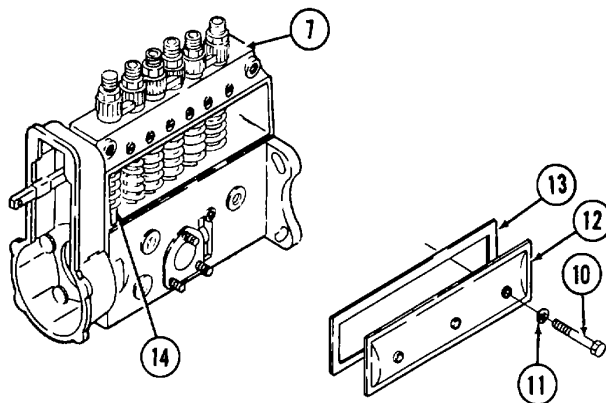
7 Remove two screws (10) and two washers (11).

8 Remove cover (12) and gasket (13) from fuel injection pump (7).

9 Rotate crankshaft pulley until plunger for cylinder number one (14) is at TDC. Secure crankshaft pulley to hold in this position.

10 Place gasket (13) and cover (12) onto fuel injection pump (7).

11 Install two screws (10) and two washers (11).



CAUTION

Do not drop the gear mounting hardware into the crankcase.

12 Remove bolt (1), lockwasher (2), and washer (3)

13 Rotate crankshaft until cylinder number one is at TDC Secure crankshaft to hold in this position

CAUTION

Do not drop the gear mounting hardware into the crankcase.

14 Install three bolts (1), three lockwashers (2), and three washers (3).

15 Release the crankshaft V-belt pulley.

ADJUSTMENT:

Adjust the fuel injection pump in accordance with paragraph 3-6.

3-14. REPAIR FUEL FEED PUMP

This task covers:

- a. Disassembly b. Inspection/Repair c. Assembly

INITIAL SETUP

Tools

Shop set, automotive repair, field maintenance, basic

Materials/Parts

- Crocus abrasive cloth (Item 1, Appendix C)
- Diesel fuel oil (Item 6, Appendix C)
- Emery abrasive cloth (Item 2, Appendix C)
- Lubricating oil (Item 10, Appendix C)

Equipment

Condition

Para.

2-32

Condition Description

Fuel feed pump removed from engine.

General Safety Instructions

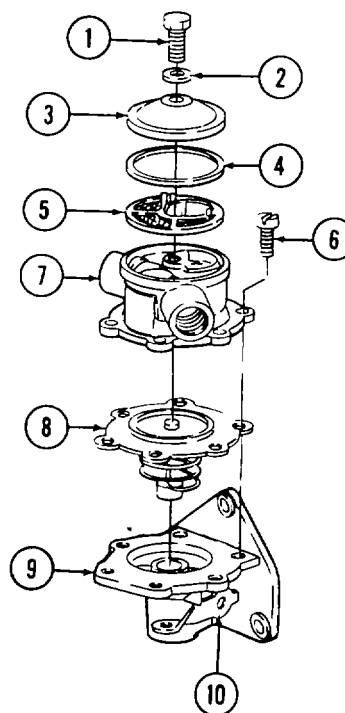
Well-ventilated area,

DISASSEMBLY:

CAUTION

Do not scratch or mar mating surfaces of cover, upper pump chamber, or pump body. The pump may leak or otherwise malfunction after assembly.

- 1 Remove bolt (1), washer (2), and cover (3).
- 2 Remove gasket (4) and discard.
- 3 Remove strainer (5).
- 4 Remove screws (6).
- 5 Remove pump top (7).
- 6 Remove diaphragm assembly (8) from pump body (9).



3-14. REPAIR FUEL FEED PUMP (Continued)**INSPECTION/REPAIR:****WARNING**

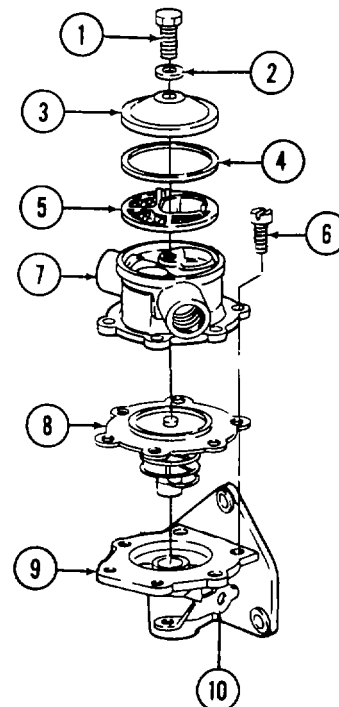
Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 1 Clean all parts except gasket in clean diesel fuel oil and dry with low pressure compressed air.
- 2 Inspect mating surfaces of cover and pump body parts for roughness or other damage. Scratches or other damage may result in pressure leaks. Also check for wear at contact areas. Replace pump body or cover if necessary
- 3 All parts must be free from score marks and burrs and must fit together tightly. If scored or burred, clean with emery cloth or crocus cloth. If parts are not repairable, replace.

ASSEMBLY:

- 1 Install diaphragm assembly (8) on pump body (9).
- 2 Install pump top (7) on diaphragm assembly (8).
- 3 Install screws (6) hand tight. Move cam lever (10) to compress diaphragm spring
- 4 Tighten screws (6).
- 5 Install strainer (5).
- 6 Lubricate gasket (4) with a very thin coat of lubricating oil, and install
- 7 Install bolt (1), washer (2), and cover (3).



3-15. TEST/REPLACE FUEL INJECTORS

This task covers:

- a. Removal b. Inspection/Test c. Installation

INITIAL SETUP

Test Equipment

Bosch pump outfit No. 003-3345

Tools

- Injector extractor No. 110030
- Injector extractor No. 150800
- Injector gasket remover No. 120630

Materials/Parts

- Diesel fuel oil (Item 6, Appendix C)
- Grease (Item 7, Appendix C)

Equipment

Condition

- | | |
|--------------|------------------------------|
| Para. | Condition Description |
| 3-12 | Fuel injector lines removed |

General Safety Instructions

Well-ventilated area required

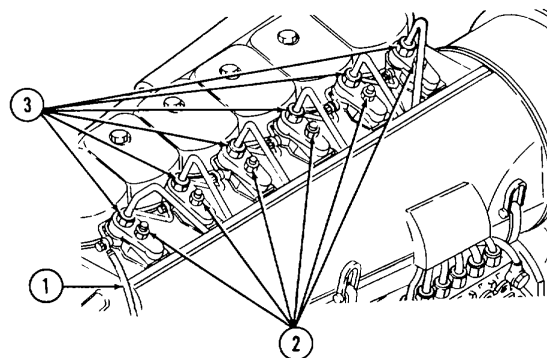
REMOVAL:

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

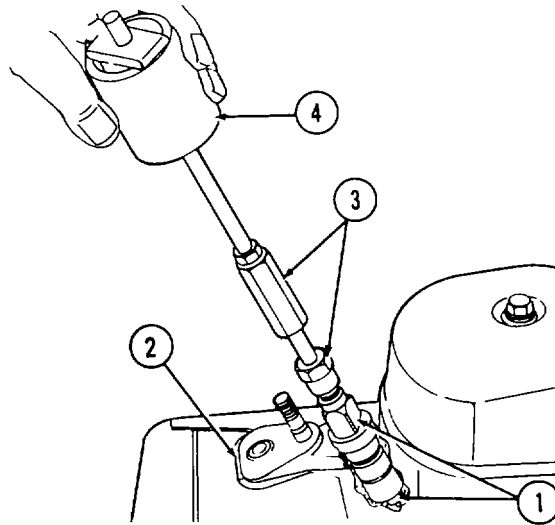
CAUTION

The fuel injection system is extremely intricate and complex. All possible care should be taken in the removal, inspection, testing, and assembly of these components. While handling the fuel injector, be extremely careful not to touch the nozzle or the pin assembly on the nozzle end.

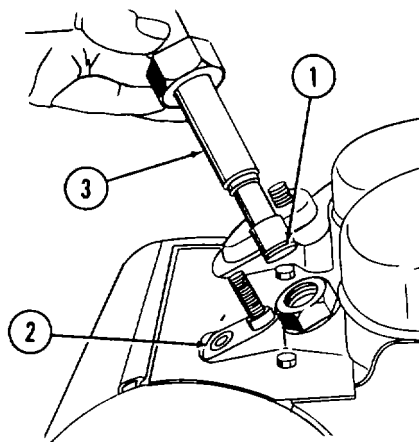


- 1 Remove fuel return line (1).
- 2 Remove nuts (2) and retainers (3).

3-15. TEST/REPLACE FUEL INJECTORS (Continued)



- 3 Remove fuel injectors (1) from cylinder heads (2) using injector extractors No. 110030 (3) and 150800 (4).



- 4 Remove washer (1) from cylinder head (2) using injector gasket remover No. 120630 (3). Discard washer (1).

INSPECTION/TEST:

- 1 Visually Inspect fuel injectors for damage, scoring, or burning. Inspect to see if units are bent, cracked, or damaged. If repairable, contact general support maintenance for repair, and replace injectors.

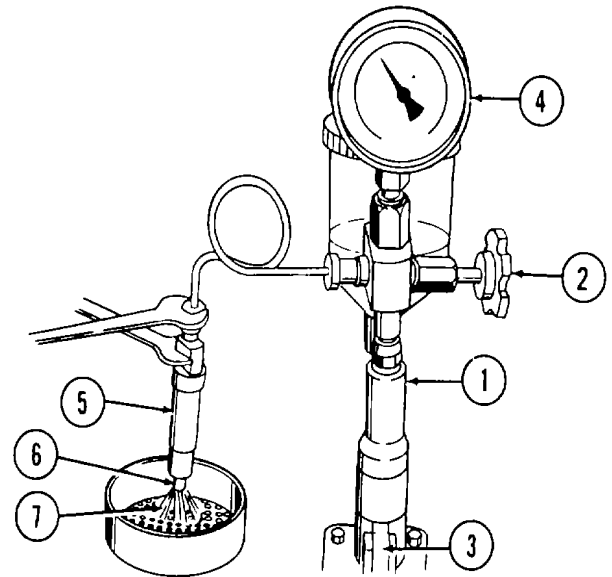
3-15. TEST/REPLACE FUEL INJECTORS (Continued)**WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

- 2 Connect Bosch pump outfit No 003-3345. (1)
- 3 Fill Bosch pump fuel container 3/4 full with diesel fuel oil. Do not overfill.

- 4 Make sure pressure valve (2) is turned all the way clockwise and closed. Pump up air pressure in unit by pumping the pump hand lever (3) up and down several times.

- 5 Slowly turn pressure valve (2) counterclockwise. As the valve starts to open, read fuel injection pressure on gage (4). Continue to open valve to increase fuel injection pressure to injector (5) until fuel sprays out of nozzle (6). Read and record injection pressure. Injection pressure should be 2611 to 2727 psi (18000 to 18 800 kPa) for a new injector, or 2538 to 2654 psi (17 500 to 18 300 kPa) for an injector in operation and being tested. Injection pressure may be adjusted if it does not fall within the limits above. Refer injector to general support for adjustment or repair, and replace injector.

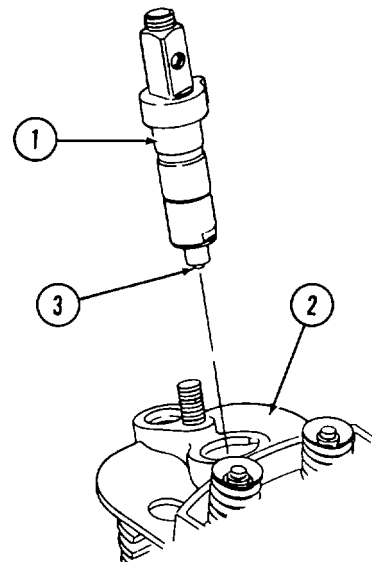
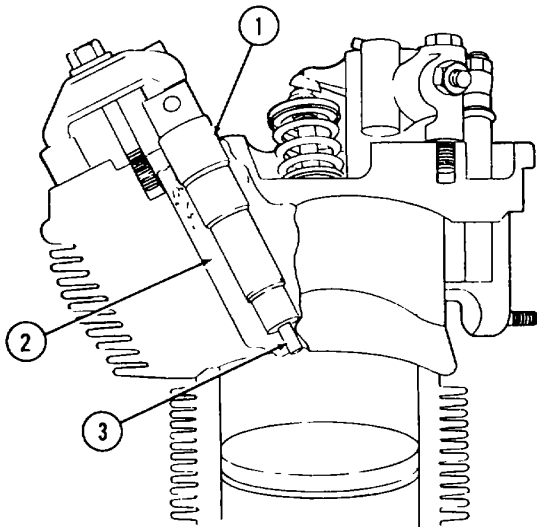
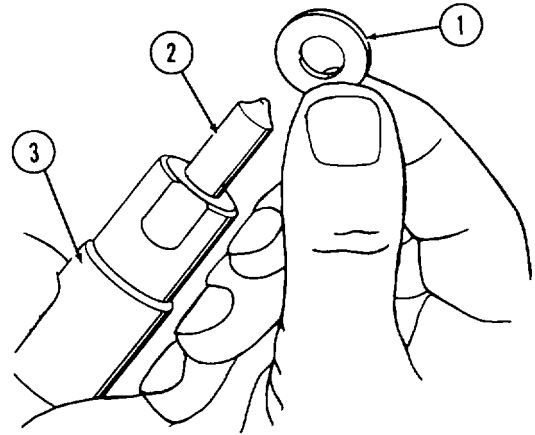


- 6 Check fuel spray (7) pattern from injector nozzle (6). Fuel should spray out in several evenly spaced jets of equal thickness and with no mist surrounding the jets. If spray pattern does not conform to above, refer injector (3) to general support maintenance for repair, and replace injector. If injector nozzle drips fuel at approximately 2100 to 2360 psi (14 500 to 16 300 kPa) before it has reached recommended injection pressure, refer injector to general support maintenance for repair, and replace injector. If nozzle drips fuel after injection pressure test, refer injector to general support for repair, and replace injector.

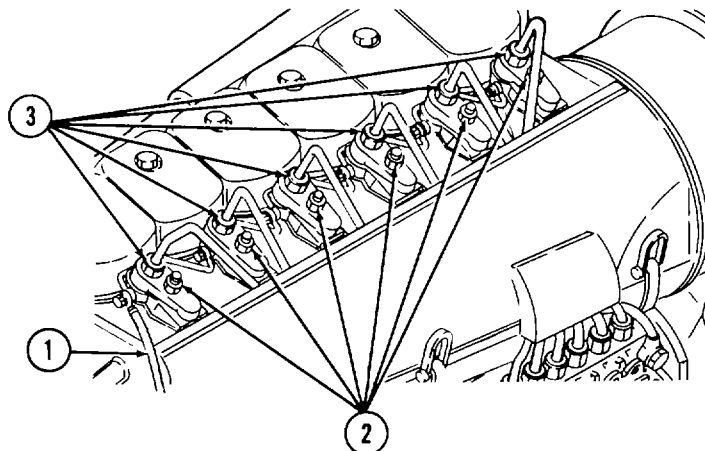
3-15. TEST/REPLACE FUEL INJECTORS (Continued)**INSTALLATION:****CAUTION**

Use care when cleaning injector seat in cylinder head to prevent scratches. Scratches will cause a carbon track.

- 1 Lightly coat graphited side of washer (1) with grease and install on injector nozzle (2). Make sure graphited side of washer points toward injector (3). Be certain injector seat in cylinder head is clean. Make sure washer sticks to nozzle during installation of fuel injector in cylinder head.
- 2 Carefully insert fuel injector (1) into injector bore in cylinder head (2). Make sure not to damage nozzle needle (3). Insert injector until it seats properly at bottom of bore in cylinder head.



3-15. TEST/REPLACE FUEL INJECTORS (Continued)



- 3 Install retainer (3) and hex nut (2). Tighten securely.
- 4 Connect fuel return line (1).
-

3-16. REPAIR TURBOCHARGER

This task covers:

- | | | |
|---------------|----------------|-------------|
| a. Cleaning | c. Disassembly | e. Assembly |
| b. Inspection | d. Repair | |

INITIAL SETUP

Tools

Shop set, automotive repair, field maintenance, basic

Materials/Parts

- Crocus cloth (Item 1, Appendix C)
- Dry cleaning solvent (Item 17, Appendix C)
- Emery cloth (Item 2, Appendix C)
- Lubricating oil (Item 10, Appendix C)
- Sealing compound (Item 15, Appendix C)

Equipment Condition

Para.	Condition Description
2-33	Turbocharger removed.

General Safety Instructions

Engine off and cool

CLEANING:

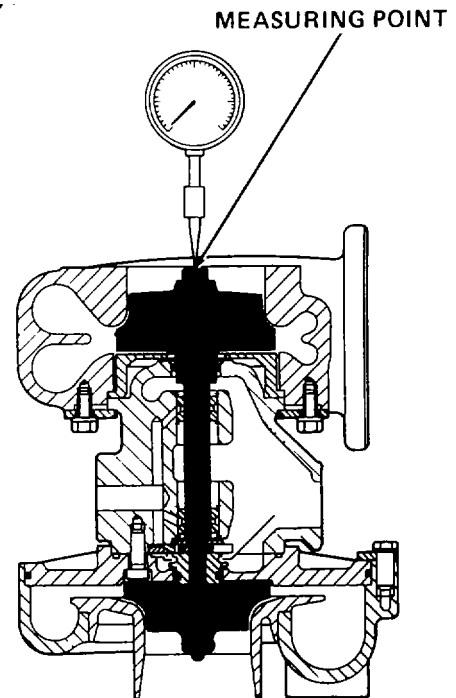
WARNING

Dry cleaning solvent P-D-680 (safety or Stoddard's Solvent) is potentially dangerous. Avoid repeated and prolonged breathing of vapors and skin contact with the liquid. Do not use near open flame, arcing equipment, or other ignition sources. Always wear eye protection and protective clothing. The flash point of P-D-680 is 100° to 138 ° F (38° to 59°C).

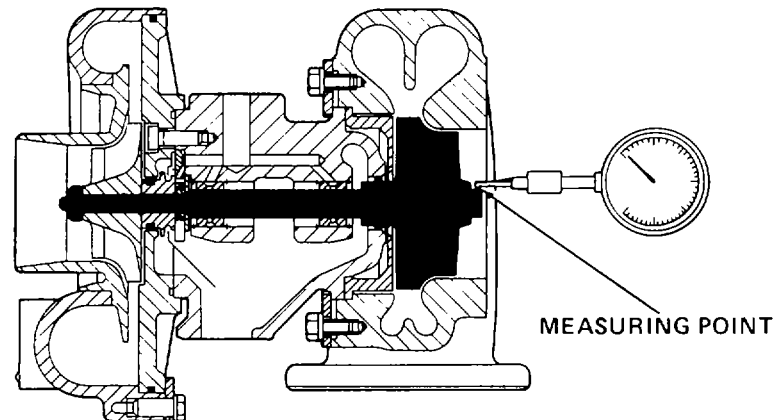
Clean exterior of turbocharger with dry cleaning solvent. Wipe dry.

INSPECTION:

- 1 Check axial clearance.
 - a. Fasten dial gage to turbine casing.
 - b. Position dial gage on end of rotor shaft.
 - c. Push shaft against gage and record reading.
 - d. Push shaft in opposite direction and record reading.
 - e. The difference between readings is the axial clearance. Maximum clearance allowable is 0.0059 inch (0.15 mm).



3-16. REPAIR TURBOCHARGER (Continued)

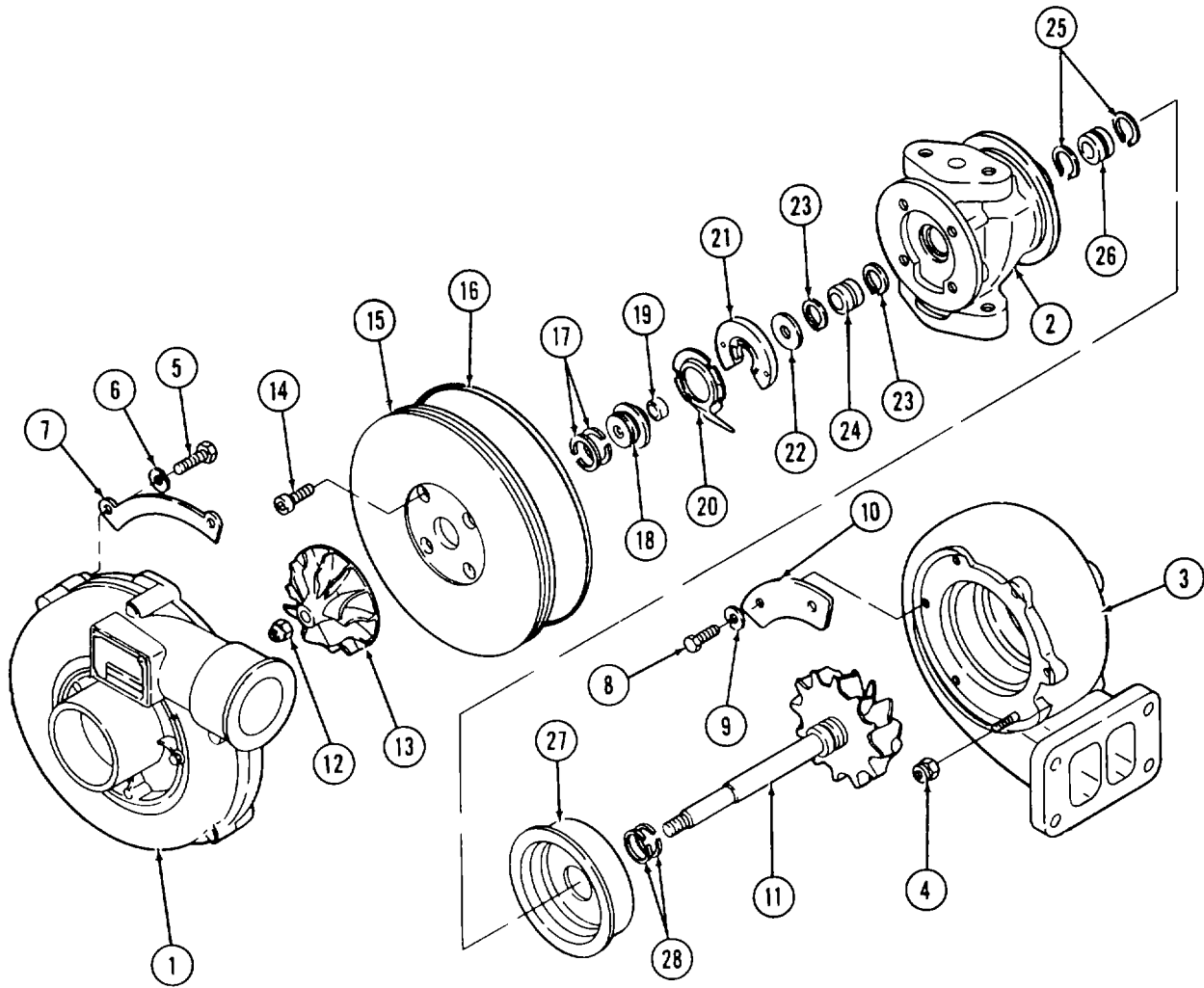
**2 Check radial clearance.**

- a. Fasten dial gage to turbine casing.
- b. Position dial gage on side of rotor shaft as close to end as possible.
- c. Push shaft down and record reading.
- d. Push shaft up and record reading.
- e. The difference between readings is the radial clearance. Maximum clearance allowable is 0.0255 inch (0.65 mm).

DISASSEMBLY:

- 1 Matchmark positions of compressor housing (1), bearing housing (2), and turbine housing (3) with a punch or scribe to aid assembly.
- 2 Remove nut (4), bolts (5 and 8), lockwashers (6 and 9), and clamp plates (7 and 10).

3-16. REPAIR TURBOCHARGER (Continued)



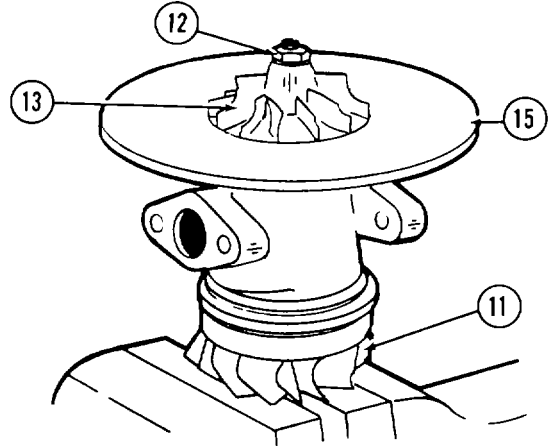
CAUTION

Do not rest or drop housings on the compressor wheel and turbine wheel during disassembly. Impeller and rotor could be damaged.

- 3 Remove compressor housing (1) and turbine housing (3). Tap with rubber mallet if necessary.

3-16. REPAIR TURBOCHARGER (Continued)**CAUTION****Do not bend the rotor shaft.**

- 4 Position shaft and turbine wheel assembly (11) in a holding fixture.
- 5 Using a double universal socket and tee handle, remove locknut (12).



- 6 Remove compressor wheel (13).
- 7 Remove screws (14).
- 8 Remove compressor backplate (15) and preformed packing (16).
- 9 Press flinger sleeve (18) and spacer sleeve (19) out of compressor backplate (15).
- 10 Remove and discard piston rings (17).
- 11 Remove oil deflector (20), thrust bearing (21), thrust ring (22), snap rings (23), and bearing (24).
- 12 Remove bearing housing (2), snap rings (25), bearing (26), and heat shield (27).
- 13 Remove and discard piston rings (28).
- 14 Remove shaft and turbine wheel (11).

CLEANING:

- 1 Before cleaning turbocharger components, inspect all parts for signs of burning, rubbing, or other damage which might not be evident after cleaning.

3-16. REPAIR TURBOCHARGER (Continued)

WARNING

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Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 2 Soak all parts in dry cleaning solvent.
- 3 After soaking, use a stiff-bristle brush and remove all dirt particles.
- 4 Thoroughly clean deposits from compressor wheel and turbine wheel blades.
- 5 Dry all parts thoroughly with compressed air.
- 6 Clean bearing housing internal cavities and oil passages with compressed air. Be sure oil lines are thoroughly clean according to paragraph 2-33.

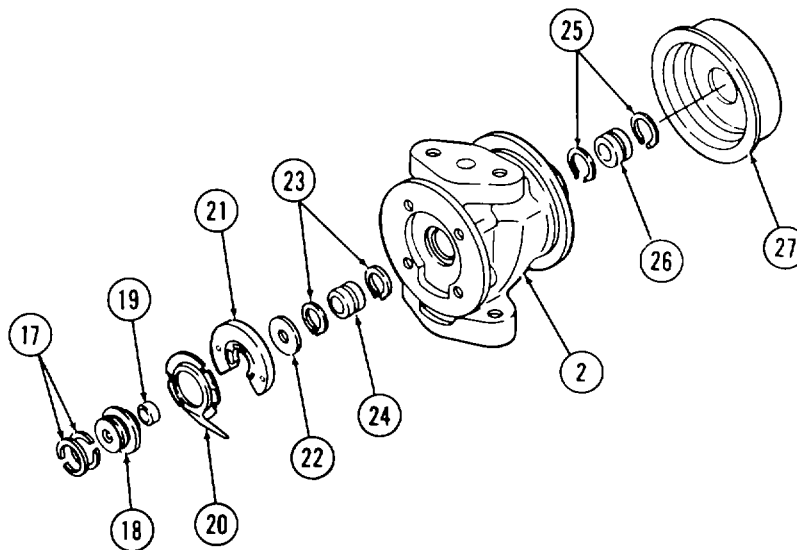
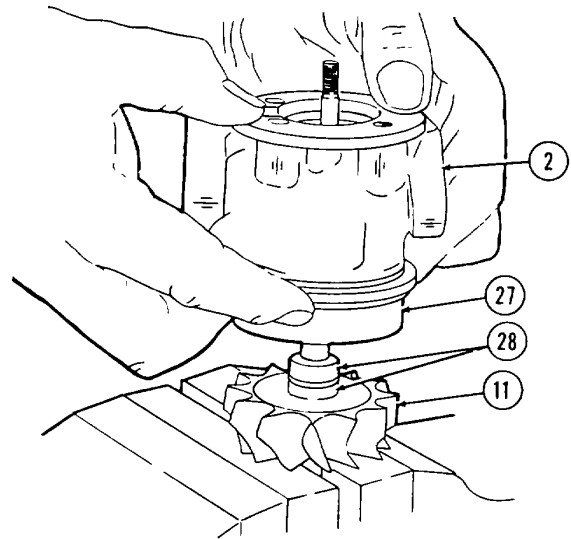
INSPECTION/REPAIR:

- 1 Inspect all parts for corrosion, deterioration, signs of rubbing, and damage. Check for nicked, crossed, or stripped threads. Inspect casings for cracks, foreign particles, and scoring. Burnish minor surface damage with crocus cloth or emery cloth. Remove sharp edges caused by wear. Replace any severely damaged components.
- 2 Check turbine housing, shaft and turbine wheel assembly, and compressor wheel for damage from rubbing or foreign material. Check that turbine wheel blades are not warped or defective. Check that compressor wheel bore is not galled. Replace severely damaged components.
- 3 Inspect shaft of shaft and turbine wheel assembly for scoring, scratches, or bearing seizure. Check shaft for true run. The maximum tolerance as measured 0.7874 inch (20 mm) from threaded end is 0.00028 inch (0.007 mm). Replace severely damaged shaft and turbine wheel assembly.

3-16. REPAIR TURBOCHARGER (Continued)

ASSEMBLY:

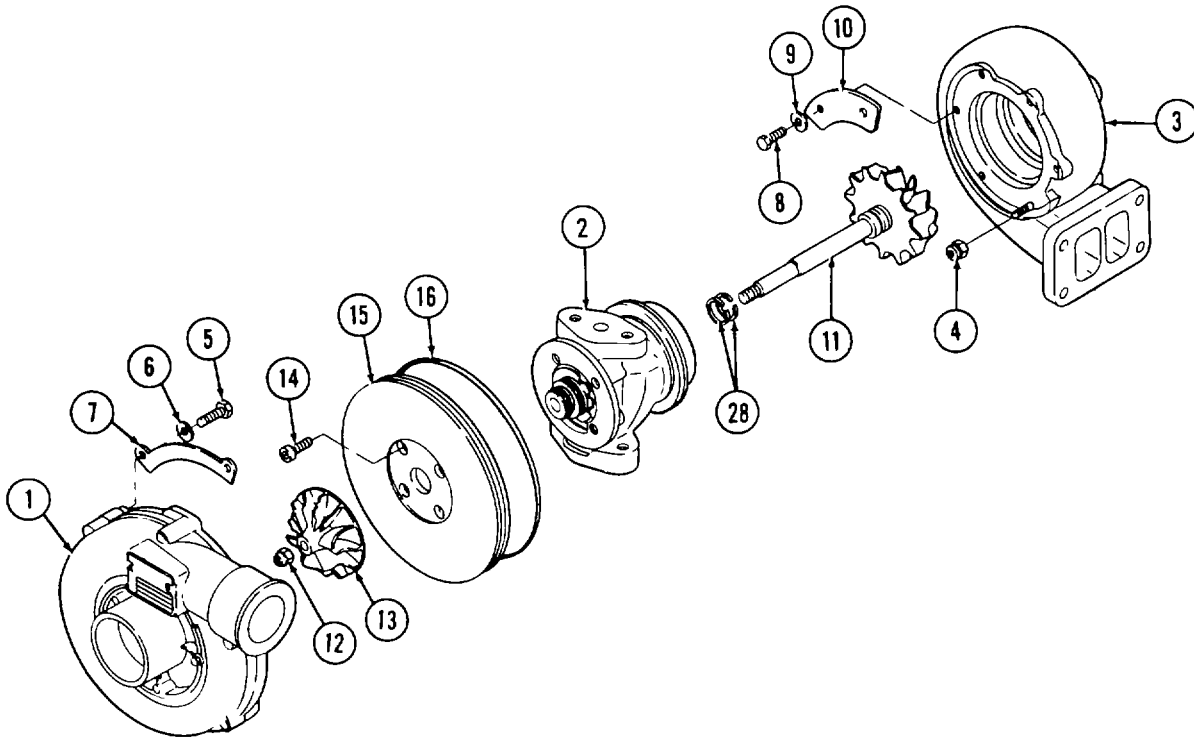
- 1 Lubricate bearings (24 and 26) and shaft of shaft and turbine wheel assembly (11) with lubricating oil.
- 2 Clamp down shaft and turbine wheel assembly (11) at hub.
- 3 Install piston rings (28) in groove. Install with gaps offset through 90 degrees toward oil inlet.



- 4 Install new snap rings (25) and bearing (26) in bearing housing (2).
- 5 Install heat shield (27) on bearing housing (2).
- 6 Install bearing (24) and new snap rings (23) in bearing housing (2).
- 7 Install bearing housing (2) carefully over shaft.
- 8 Install thrust ring (22), thrust bearing (21), and oil deflector (20) in bearing housing (2).
- 9 Install spacer sleeve (19), flinger sleeve (18), and piston rings (17).

3-16. REPAIR TURBOCHARGER (Continued)

- 10 Check that piston rings (17) are not pressed out of grooves. Be sure piston ring gaps are offset through 90 degrees toward oil inlet.



- 11 Install preformed packing (16) on backplate (15).
- 12 Apply sealing compound to backplate (15) sealing face and to screw (14) threads.
- 13 Install backplate (15).
- 14 Tighten screws (14) to 20.65 ft-lb. (28 N•m) torque.

3-16. REPAIR TURBOCHARGER (Continued)

WARNING

Severe burns could result from handling heated parts. Use proper equipment to handle heated parts.

CAUTION

Do not use open flame to heat compressor wheel. Uneven heat may cause distortion.

- 15 Preheat compressor wheel (13) to 266°F (130°C) and install.
- 16 Install locknut (12) and tighten to 29.50 ft-lb (40 N•m) above the drag torque required to bottom the locknut.
- 17 Allow compressor wheel (13) to cool to 86° F (30° C).
- 18 Loosen locknut (12) and apply seating compound to thread of shaft and retighten to torque in step 16.

CAUTION

Do not bend or strain the rotor shaft.

Do not cant components.

- 19 Mount compressor housing (1) and clamp plate (7) with bolts (5) and lockwashers (6). Be sure preformed packing (16) is properly seated.
- 0 Torque bolts (5) to 11.06 ft-lb (15 N•m).

CAUTION

Do not cant components.

- 21 Install turbine housing (3) and clamp plate (10) with bolts (8), lockwashers (9), and nut (4).
 - 22 Torque bolts to 29 50 ft-lb (40 N•m).
-

3-17. TEST/REPAIR STARTER MOTOR

This task covers:

- | | | |
|----------------|-------------------------|----------------------|
| a. Test | c. Cleaning/Inspection/ | e. Assembly |
| b. Disassembly | d. Repair | f. Operational Check |

INITIAL SETUP:

Test Equipment

Batteries (12 volt) (2 required)
 Starter switch w/leads

Tools

Shop set, automotive repair, field maintenance, basic

Materials/Parts

Dry cleaning solvent (Item 17, Appendix C)
 Rosin flux core solder (Item 16, Appendix C)

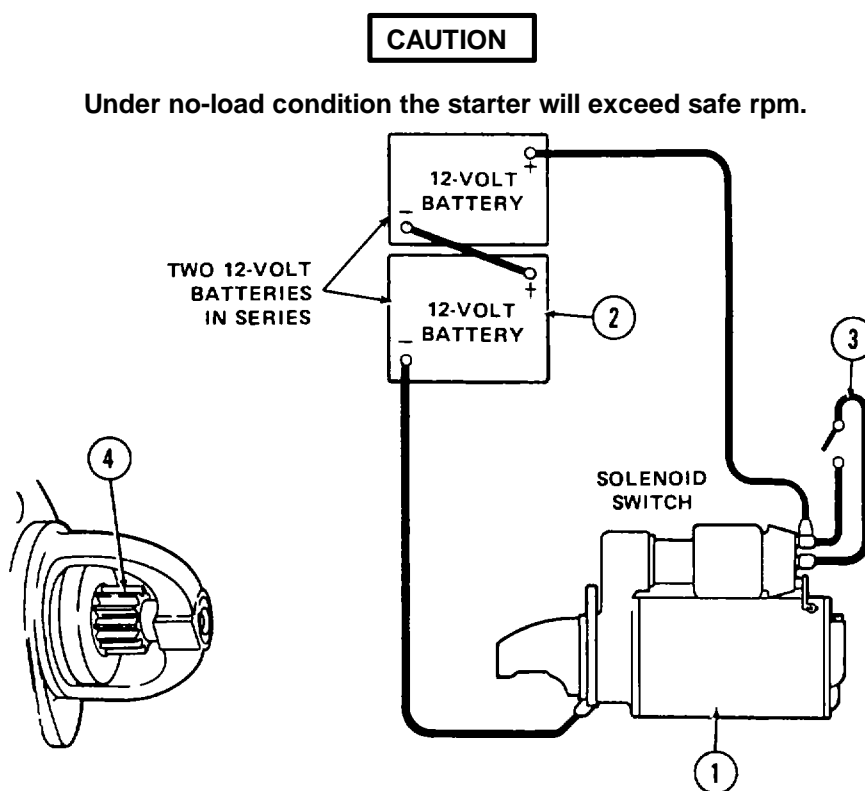
Equipment Condition

Para 2-34

Condition Description

Starter motor removed from engine.

TEST:



Connect starter motor (1) in series with two fully charged 12-volt batteries (2) and connect a remote starting switch (3) as shown. Energize starter by momentarily depressing switch; observe whether overrunning clutch drive (4) moves forward and begins rotating at a high rate of speed. If it does not, consult the following symptom chart.

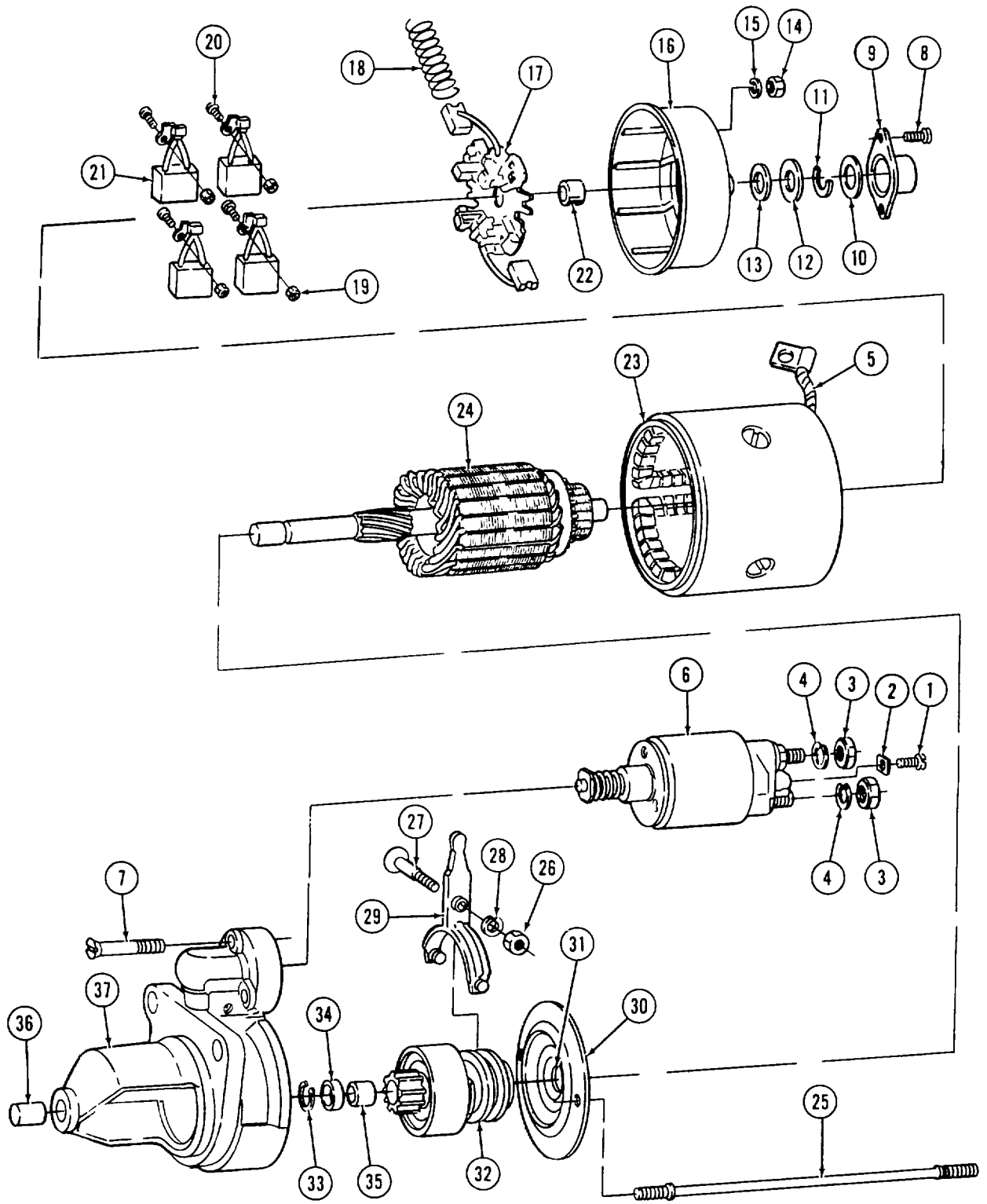
3-17. TEST/REPAIR STARTER MOTOR (Continued)

SYMPTOM	REASON
Overrunning clutch drive rotates slowly	Damaged bearings, poor connections, dirty or damaged commutator, damaged leads.
Overrunning clutch drive does not rotate	Frozen bearings, poor contact between brushes and commutator, field terminal shorted out to starter frame.

DISASSEMBLY:

- 1 Remove screw (1) and clamping saddle (2).
- 2 Remove nuts (3) and lockwashers (4).
- 3 Remove wire (5) (solenoid switch to excitation winding) from solenoid switch (6).
- 4 Remove screws (7).
- 5 Remove solenoid switch (6).
- 6 Remove screws (8).
- 7 Remove closure cap (9).
- 8 Remove seal ring (10), locking washer (11), and shims (12 and 13).
- 9 Remove nuts (14) and washers (15).
- 10 Remove commutator end shield (16).
- 11 Remove brush holder (17) and compression springs (18).
- 12 Remove nuts (19) and screws (20).
- 13 Remove carbon brushes (21) from brush holder (17).
- 14 If necessary, remove bushing (22) from commutator end shield (16).
- 15 Remove excitation winding (23) and studs (25).
- 16 Remove nut (26), screw (27), and spring washer (28).
- 17 Remove fork lever (29).
- 18 Remove armature (24), intermediate bearing (30), overrunning clutch drive (32), retainer (33), stop ring (34), and bushings (35) as an assembly.

3-17. TEST/REPAIR STARTER MOTOR (Continued)



3-17. TEST/REPAIR STARTER MOTOR (Continued)

- 19 Remove retainer (33) from armature (24). Remove stop ring (34), bushings (35), overrunning clutch drive (32), and intermediate bearing (30) from armature (24).
- 20 Remove bushing (31) from intermediate bearing (30).
- 21 Remove bushing (36) from drive end shield (37).

CLEANING/INSPECTION/REPAIR:

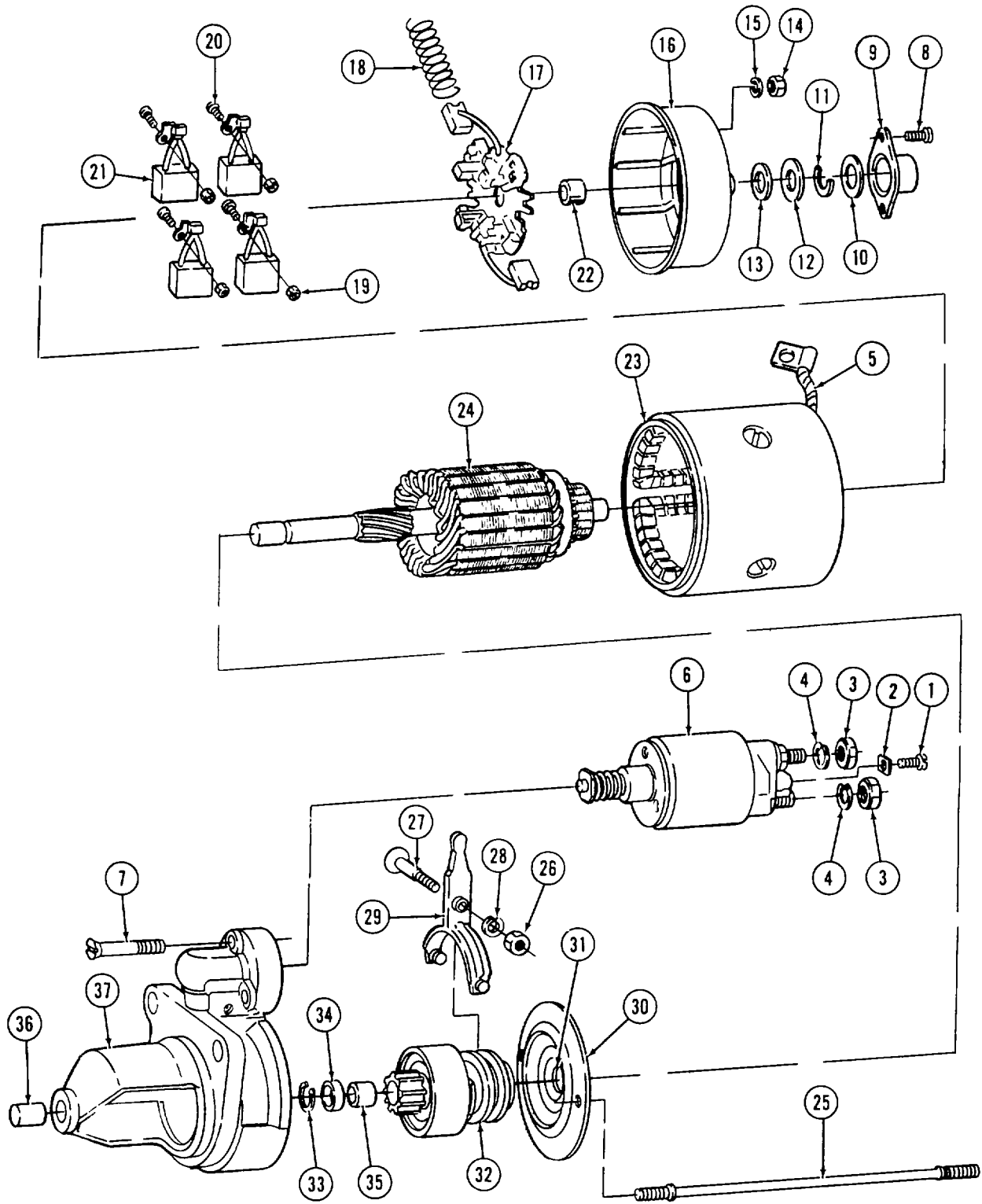
WARNING

Dry cleaning solvent P-D-680 (safety or Stoddard's Solvent) is potentially dangerous. Avoid repeated and prolonged breathing of vapors and skin contact with the liquid. Do not use near open flame, arcing equipment, or other ignition sources. Always wear eye protection and protective clothing. The flash point of P-D-680 is 100° to 138 °F (38° to 59°C).

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 1 Clean starter components with P-D-680 solvent and dry with compressed air. When cleaning armature, excitation winding, and solenoid switch, use soft cloth wet with solvent. Do not soak these components in solvent. Dry with soft cloth or compressed air.
- 2 Clean accumulated dirt, carbon, or other foreign material from brush holder, carbon brushes, and other brush components with P-D-680 solvent. Dry with soft cloth or low pressure compressed air. Inspect for excessive wear or damage. Inspect commutator end of brushes for dirt, glaze, or other material preventing good electrical contact with commutator. Replace glazed brushes or brush components that are excessively worn or damaged. Replace brushes and leads if leads are frayed or broken.
- 3 Remove dirt and carbon from between commutator bars. Inspect armature and its commutator for excessive wear, missing bars, or broken solder connections. Replace armature if commutator is excessively worn or has missing commutator bars. Repair any loose or frayed solder connections at commutator.
- 4 Rotate armature shaft in bushings to determine if bushings are frozen or excessively worn. Worn bushing will permit the shaft to be moved sideways. Replace bushings if excessively worn or frozen.
- 5 Inspect excitation winding and wire to solenoid switch for loose, burned, frayed, or shorted wires.
- 6 Repair loose connections on excitation winding or solenoid switch if necessary. Replace excitation winding if frayed, shorted, or damaged.
- 7 Inspect all other starter components for excessive wear or damage. Replace any worn, damaged, cracked, or broken components.

3-17. TEST/REPAIR STARTER MOTOR (Continued)



3-17. TEST/REPAIR STARTER MOTOR (Continued)

ASSEMBLY:

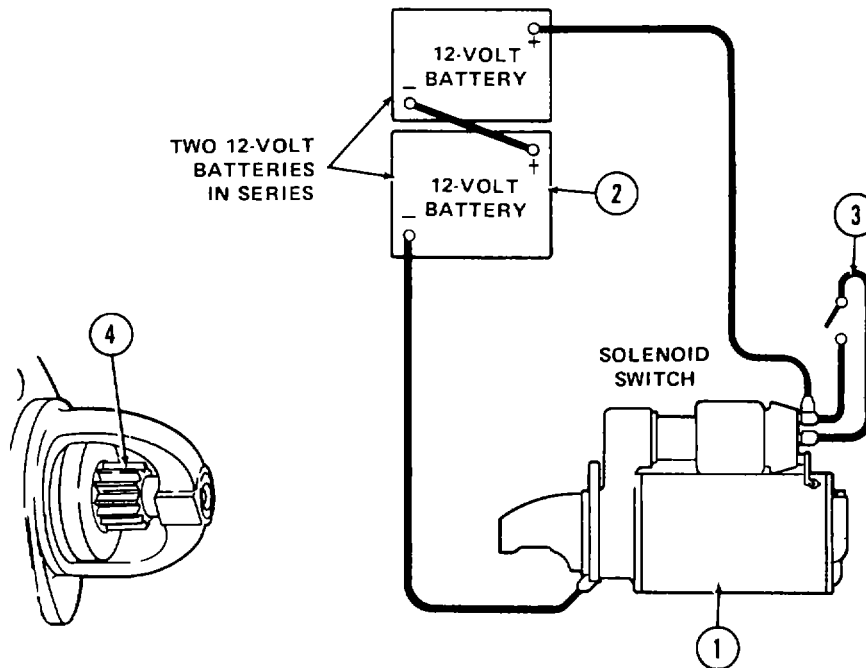
- 1 Install bushing (36) into drive end shield (37).
- 2 Install bushing (31) into intermediate bearing (30).
- 3 Install intermediate bearing (30), overrunning clutch drive (32), bushings (35), stop ring (34), and retainer (33) on armature (24). Install this assembly into drive end shield (37).
- 4 Install fork lever (29) and secure with screw (27), spring washer (28), and nut (26).
- 5 Install studs (25).
- 6 Install excitation winding (23).
- 7 Install bushing (22) into commutator end shield (16).
- 8 Install carbon brushes (21) into brush holder (17) and secure with screws (20) and nuts (19).
- 9 Install brush holder (17) with compression springs (18).
- 10 Install commutator end shield (16) and secure with washers (15) and nuts (14).
- 11 Install shims (12 and 13), locking washer (11), and seal ring (10) on armature shaft.
- 12 Install closure cap (9) and secure with screws (8).
- 13 Install solenoid switch (6) into drive end shield (37) and secure with screws (7).
- 14 Attach wire (5) (solenoid switch to excitation winding) to solenoid switch (6).
- 15 Install lockwashers (4) and nuts (3).
- 16 Install clamping saddle (2) and screw (1).

3-17. TEST/REPAIR STARTER MOTOR (Continued)

OPERATIONAL CHECK:

CAUTION

Under no-load conditions the starter will exceed safe rpm.



Retest assembled starter as in TEST procedure. Connect starter (1) in series with two fully charged 12-volt batteries (2) and connect a remote starting switch (3) as shown. Energize starter by momentarily depressing switch; observe whether overrunning clutch drive (4) moves forward and begins rotating at a high rate of speed. If it does not, consult the symptom chart in TEST and proceed accordingly.

INSERT SUBTITLE HERE!**This task covers:**

- | | | |
|-------------------------------|-------------|----------------|
| a. Disassembly | c. Test | e. Operational |
| b. Cleaning/Inspection/Repair | d. Assembly | |

INITIAL SETUP:**Test Equipment**

Multimeter

Tools

Shop set, automotive repair, field maintenance, basic
 Arbor press
 Bearing extractor
 Electronic soldering iron, 25-watt

Equipment Condition

Para 2-35

Condition Description

Alternator, V-belt pulley, and fan removed from engine.

Voltage regulator removed from alternator.

Materials/Parts

Crocus abrasive cloth (Item 1, Appendix C)
 Dry cleaning solvent (Item 17, Appendix C)
 Rosin flux solder (Item 16, Appendix C)

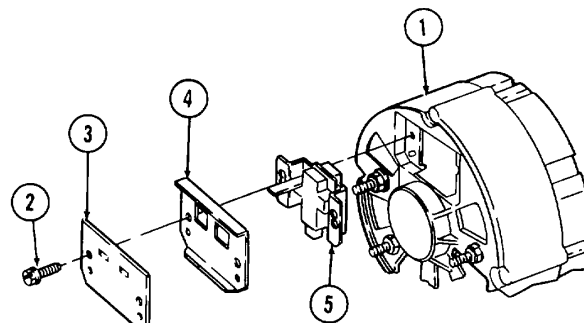
Special Environmental Conditions

Well-ventilated area required for cleaning.

DISASSEMBLY:**CAUTION**

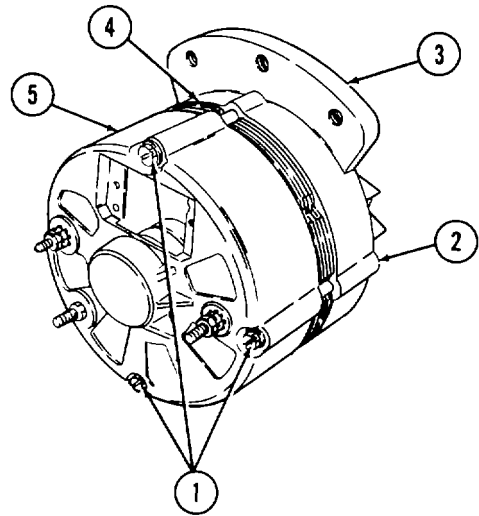
- Damage to the alternator could occur if the following precautions are not observed.
- Do not reverse connection polarity when connecting electrical leads and cables to the alternator.
- Do not operate the alternator in an open circuit with the rotor winding energized.
- Do not ground the alternator output circuit or field terminal.
- Do not disconnect leads from alternator or other electrical components before disconnecting the negative (-) terminal from the battery.
- Do not disconnect the battery while the alternator is operating.
- Do not reverse battery cable connections.

- 1 Place alternator (1) in a vise. Remove two screws (2). Remove brush cover (3), dust shield (4), and brush assembly (5) from alternator (1).



3-18. REPAIR ALTERNATOR, V-BELT PULLEY, AND FAN (Continued)

- 2 Remove four through bolts (1) and four nuts (2).
- 3 Remove alternator (3) from vise.

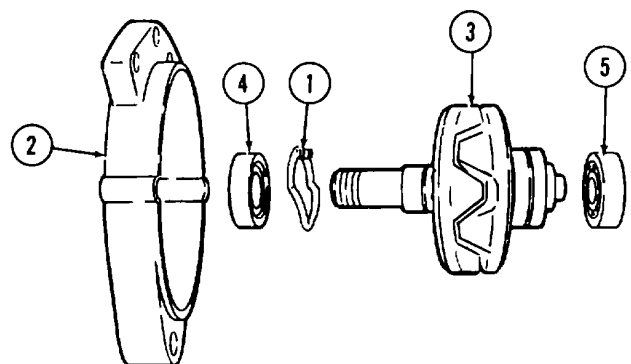
**WARNING**

If the brush assembly has not been removed, it will spring out when rear housing is separated from the front housing. Flying parts may cause serious injury.

CAUTION

Do not insert screwdriver more than 1/16 inch (1.6 mm) deep between the two housings to avoid damage to stator.

- 4 Insert two small-bladed screwdrivers between front housing (4) and rear housing (5) and carefully pry apart. Separate the two housings. Rear bearing retainer may remain in rear housing.
- 5 Remove front bearing retainer (1) from recess in front housing (2) by using a long-nose pliers to compress the ears of front bearing retainer; lift bearing retainer out of housing.
- 6 Use a wooden block to tap on the shaft of rotor (3) to free it from front housing (2).

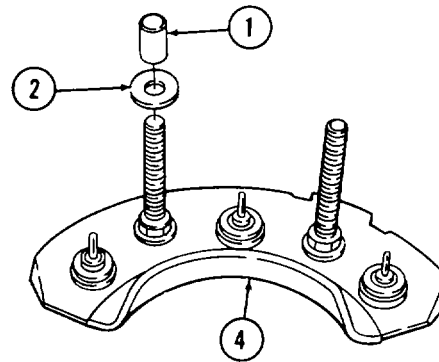
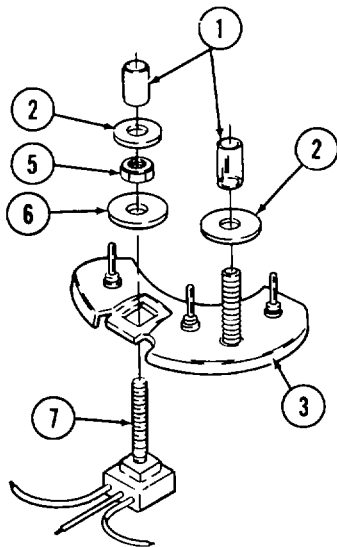
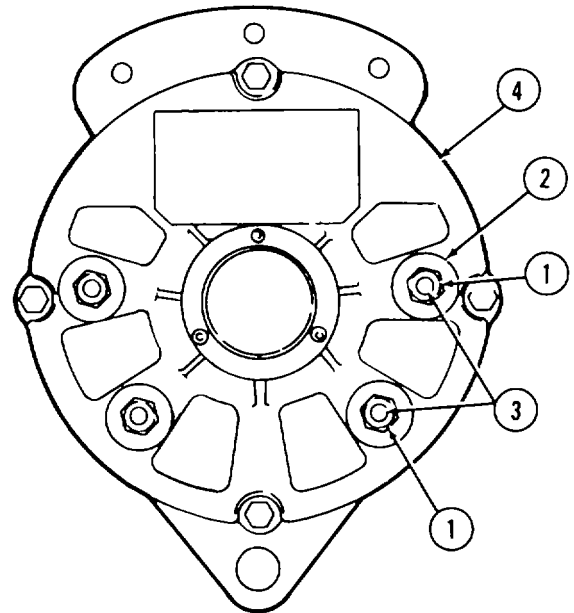
**CAUTION**

Do not press on inner race of bearing during removal. Excessive pressure on the inner race may damage the bearing.

- 7 Remove front bearing (4) and rear bearing (5) from rotor (3) by using a bearing puller.

3-18. REPAIR ALTERNATOR, V-BELT PULLEY, AND FAN (Continued)

- 8 Remove four locknuts (1) and three insulating washers (2) from diode terminal studs (3). Carefully and evenly tap diode terminal studs (3) from rear housing (4).



- 9 Remove three insulating sleeves (1) and three insulating washers (2) from positive diode assembly (3) and negative diode assembly (4). Remove nut (5) and insulator (6). Remove trio diode (7) from positive diode assembly (3).

3-18. REPAIR ALTERNATOR, V-BELT PULLEY, AND FAN (Continued)**CAUTION**

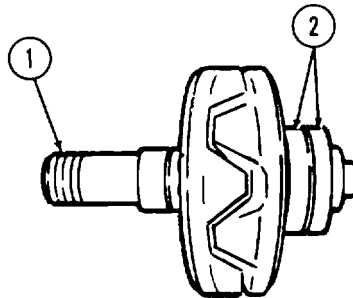
Protect diodes from heat when desoldering. Grasp the diode lead with a needle nose pliers to give better heat dissipation. Heating the diode may damage it.

- 10 Tag and desolder positive diode leads, negative diode leads, trio diode leads, and stator leads. Desolder and disconnect common stator leads.

CLEANING/INSPECTION/REPAIR**WARNING**

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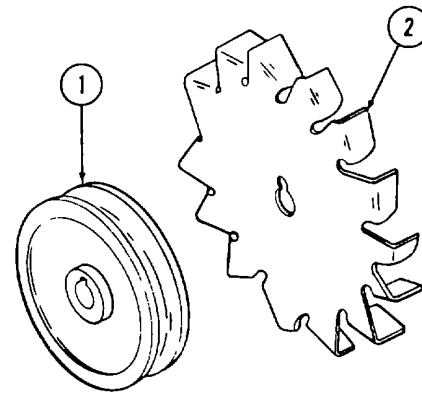
- 1 Clean with dry cleaning solvent. Inspect front housing and rear housing for cracks, corrosion, and stripped threads. Inspect bearing bores for wear. Replace a damaged housing.
- 2 Wipe bearings clean with a cloth, taking care not to disturb bearing seals. Inspect front and rear bearings for smooth rotation and for cracked or broken seals. Replace if damaged.
- 3 Clean stator with dry cleaning solvent. Inspect stator for gouged or discolored windings. Inspect leads for frayed or damaged wires or damaged insulation. Replace if damaged or discolored.
- 4 Inspect rotor shaft (1) for damaged threads or worn key slot. Wipe slip rings (2) with crocus cloth, then remove all residue with clean cloth. Inspect slip rings for cracks or wear grooves. Replace if damaged



- 5 Inspect leads of positive diode assembly, negative diode assembly, and trio diode for wear or fraying. Clean with dry cleaning solvent. Inspect all diodes for discoloration. Replace if damaged.
- 6 Clean insulator and insulating washers with dry cleaning solvent. Inspect for cracks. Replace if damaged.
- 7 Clean brush assembly with dry cleaning solvent. Inspect for cracks or oil soaking. Replace if damaged. Replace if length of brushes is less than 3/16 inch (4.8 mm).

3-18. REPAIR ALTERNATOR, V-BELT PULLEY, AND FAN (Continued)

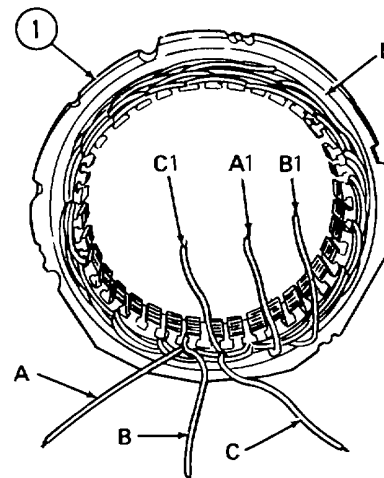
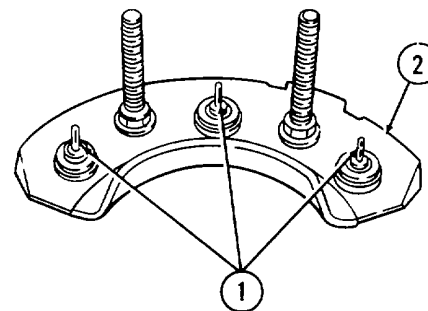
- 8 Inspect alternator V-belt pulley (1) and fan (2) for nicks, dents, rust, corrosion, or other damage.
- 9 File burrs on V-belt pulley (1). Remove rust and clean.
- 10 Straighten and align fan (2) blades. Remove rust and clean.



TEST:

- 1 Test diodes using diode tester.
 - a. For the positive diode assembly and negative diode assembly, test points are diode stems (1) and heat sink (2). Current should flow in one direction only. Replace entire assembly if one diode tests faulty.
 - b. For the trio diode, test points are the three wire leads.
- 2 Test stator (1) using a multimeter set on ohms.
 - a. Connect the multimeter test probes to each of the following pairs of test points.

- Point A-to Point B
- Point A to Point C
- Point B to Point C
- Point A to Point D
- Point B to Point D
- Point C to Point D



- b. The test should indicate an infinite resistance between each of the above test points. If any one test fails, replace stator.

3-18. REPAIR ALTERNATOR, V-BELT PULLEY, AND FAN (Continued)

- c. Connect the multimeter test probes to each of the following pairs of test points.

Point A to Point A
 Point B to Point B
 Point C to Point C

- d. The test should indicate a resistance of 1.0 ohm between each of the three pairs of test points. If any one test fails, replace the stator.

- 3 Test brush assembly (1) using a multimeter set to ohms.

- a. Connect the multimeter between each of the following pairs of points.

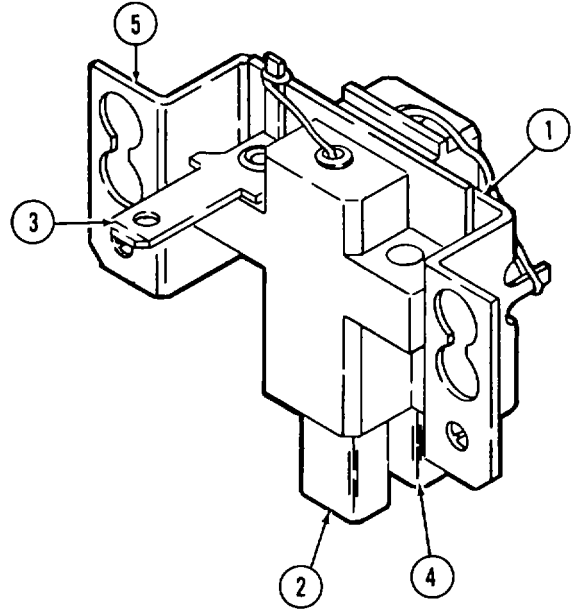
Brush (2) and terminal (3)
 Brush (4) and holder (5)

- b. There should be continuity between both pairs of points.

- c. Connect the multimeter between each of the following pairs of points.

Brush (2) and holder (5)
 Terminal (3) and holder (5)

- d. There should be infinite resistance between both pairs of points. If any one test fails, replace brush assembly.



- 4 Test rotor using a multimeter set to ohms.

- a. Place test leads across the slip rings. Resistance should read between 11 to 14 ohms.
 b. Place one test lead to a slip ring and the other to the rotor body. Resistance should read infinite.
 c. Place one test lead on other slip ring and second test lead to rotor body. Resistance should read infinite.
 d. If any one test fails, replace rotor.

3-18. REPAIR ALTERNATOR, V-BELT PULLEY, AND FAN (Continued)

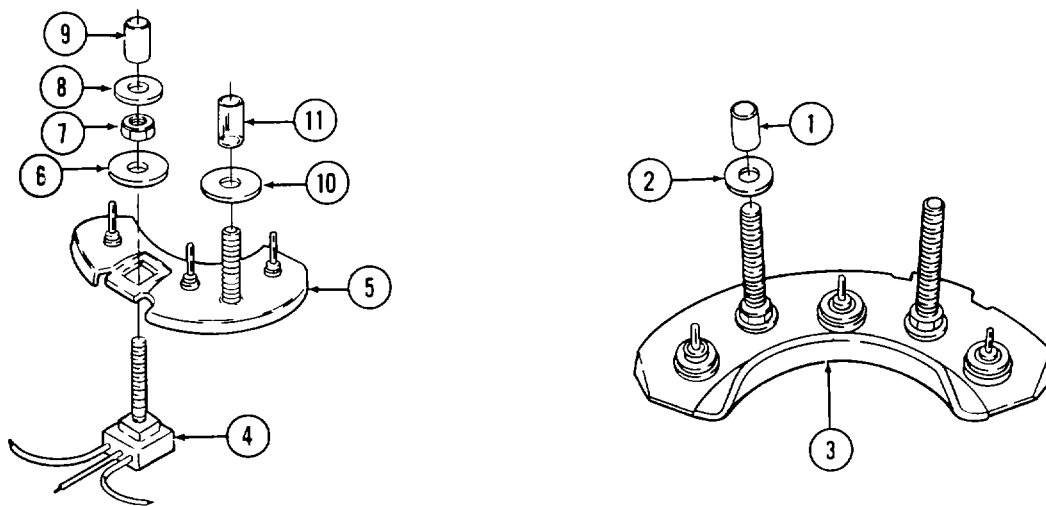
ASSEMBLY:

CAUTION

Use only rosin core solder to solder leads. The use of acid core solder will corrode connections, resulting in an open circuit and damage to components.

Protect diodes from heat when soldering by grasping the diode stem with a needle nose pliers. This will give better heat dissipation. Heating the diode can damage the diode.

- 1 Solder common leads of stator. Match up leads of positive diode assembly, negative diode assembly, trio diode, and stator as tagged during disassembly. Solder matched leads.

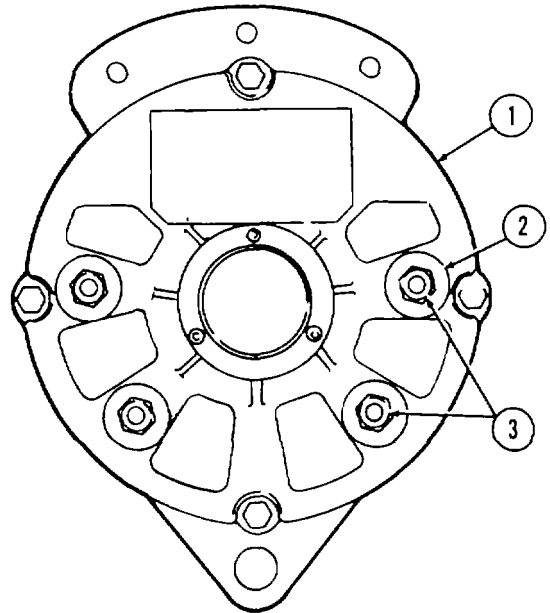


- 2 Assemble positive diode assembly, negative diode assembly, and trio diode.

- a. Place insulating sleeve (1) and insulating washer (2) onto negative diode assembly (3).
- b. Assemble trio diode (4) and positive diode assembly (5) using insulator (6) and nut (7). Hand tighten the nut.
- c. Place insulating washer (8) and insulating sleeve (9) onto trio diode (4).
- d. Place insulating washer (10) and insulating sleeve (11) onto positive diode assembly (5).

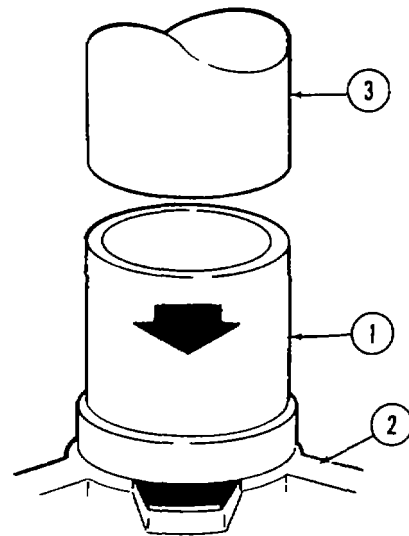
3-18. REPAIR ALTERNATOR, V-BELT PULLEY, AND FAN (Continued)

- 3 Place stator and diodes into rear housing (1)
Assemble using three insulating washers (2) and
four locknuts (3) as shown.

**CAUTION**

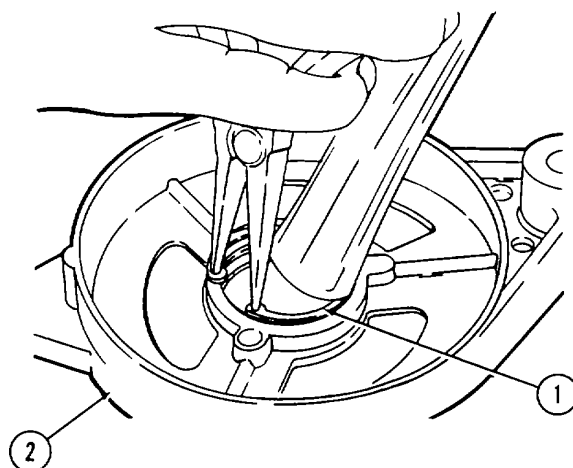
Do not press on inner race when installing front bearing. Pressure on inner race may damage bearing

- 4 Press front bearing (1) into front housing (2)
using driving tool (3) that exerts pressure on
outer race only.



3-18. REPAIR ALTERNATOR, V-BELT PULLEY, AND FAN (Continued)

- Place front bearing retainer (1) into recess of front housing (2). Align ears of front bearing retainer with opening in front housing using a long nose pliers. Exert pressure on front bearing retainer using a wooden dowel, and lock edge of retainer in recess.

**CAUTION**

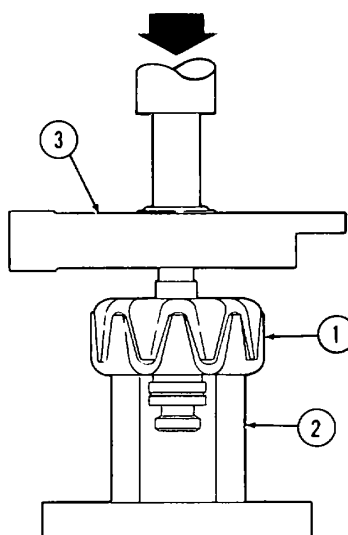
Do not press on outer race when installing rear bearing. Excessive pressure on outer race may damage bearing.

- Support pulley end of rotor on arbor press. Place rear bearing on end of shaft. Press rear bearing using a tool that contacts only the inner race. Press rear bearing until inner race contacts shoulder of shaft.

CAUTION

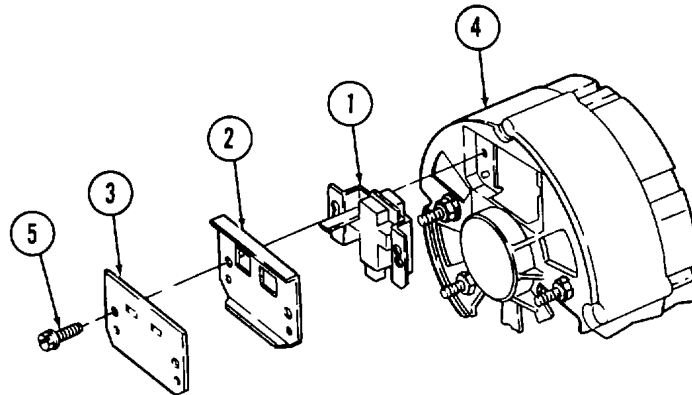
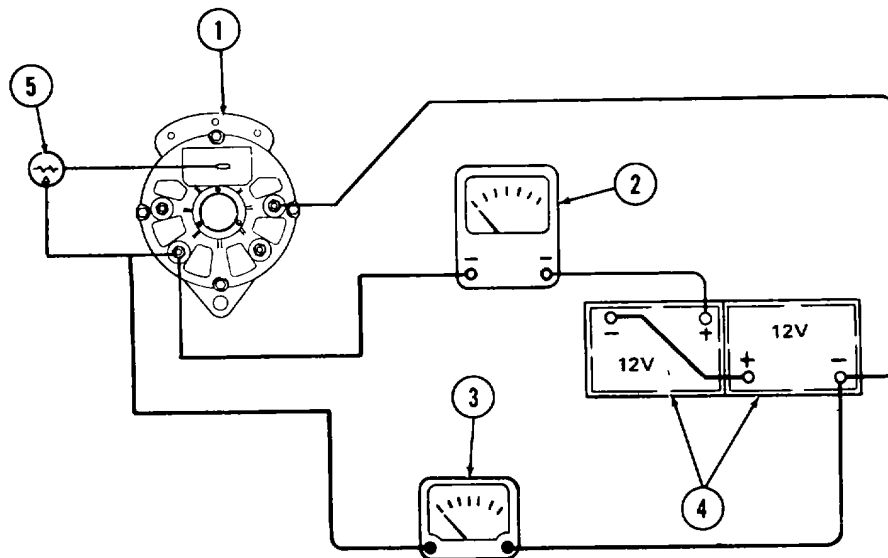
Do not press on outer race when installing rotor to front housing. Excessive pressure on outer race may damage front bearing.

- Place rotor (1) on bed of arbor press, using two steel blocks (2) for support. Place front housing (3) over shaft. Using a driving tool that contacts only the inner race of the front bearing, press front housing onto shaft until inner race of front bearing contacts shoulder of shaft.



3-18. REPAIR ALTERNATOR, V-BELT PULLEY AND FAN (Continued)

8. If rear bearing retainer was removed, install into recess in the rear housing.
9. Aline bolt holes of front housing and rear housing. Make certain that internal wiring is properly placed to avoid contact with spinning rotor. Hand press housings together. Install four through bolts and four square nuts. Tighten bolts to 50 to 60 in-lb (0.58 to 0.69 kg-m) torque.
10. Install brush assembly (1), dust shield (2), and brush cover (3) on- to alternator (4) using two screws (5).

**OPERATIONAL CHECK:**

1. Mount alternator (1) in a test fixture capable of providing 4000 rpm.
2. Connect ammeter (2), voltmeter (3), batteries (4), and 50-ohm field rheostat (5) to alternator (1) as shown
3. Place field rheostat (5) in maximum resistance position.

3-18. REPAIR ALTERNATOR, V-BELT PULLEY, AND FAN (Continued)

CAUTION

Do not operate alternator for more than a few minutes with field rheostat in other than maximum resistance position. Failure to do this may damage alternator or test equipment.

4. Turn drive motor on, and adjust to obtain 3000 to 4000 rpm. Slowly reduce field rheostat (5) resistance until ammeter (2) reads 26 amperes. Voltmeter (3) should read a minimum of 24 volts.
5. Turn off drive motor and disconnect test equipment
6. Remove alternator from test stand.

3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS

This task covers:

- | | | |
|------------------------|-------------|-------------------------------|
| a. Removal | d. Repair | g. Adjustment |
| b. Disassembly | e. Assembly | h. Installation |
| c. Cleaning/Inspection | f. Test | i. Valve Clearance Adjustment |

INITIAL SETUP:

Tools

Shop set, automotive repair, field maintenance, basic
 Tool kit, master mechanics

Pushrod tube compressor No. 125300

Socket spanner No 120040/120050
 Torque gage No 101900

Equipment Condition

Para

Condition Description

- | | |
|-------|---|
| 2-26. | Air cleaner and air intake piping removed |
| 2-28. | Muffler and exhaust pipe removed. |
| 3-9. | Cooling air blower and cooling air ducting removed. |
| 3-15. | Fuel injectors removed. |

Materials/Parts

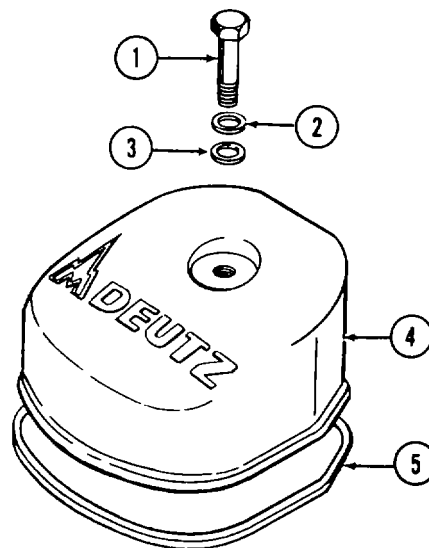
Diesel fuel oil (Item 6, Appendix C)
 Grease (Item 7, Appendix C)
 Sealing compound (Item 15, Appendix C)

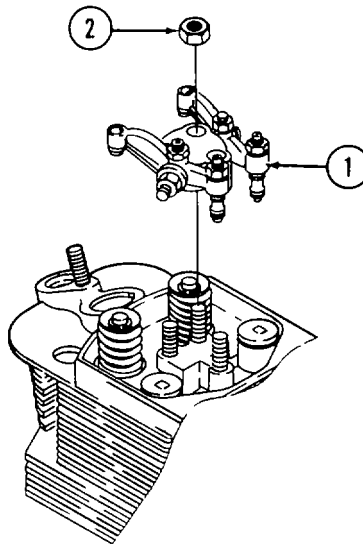
Special Environmental Conditions

Well-ventilated area required for cleaning.

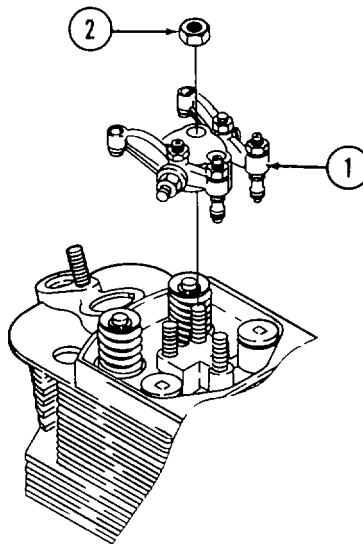
REMOVAL:

1. Remove bolt (1), washer (2), and neoprene washer (3).
2. Remove cover (4).
3. Remove and discard gasket (5).



3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)

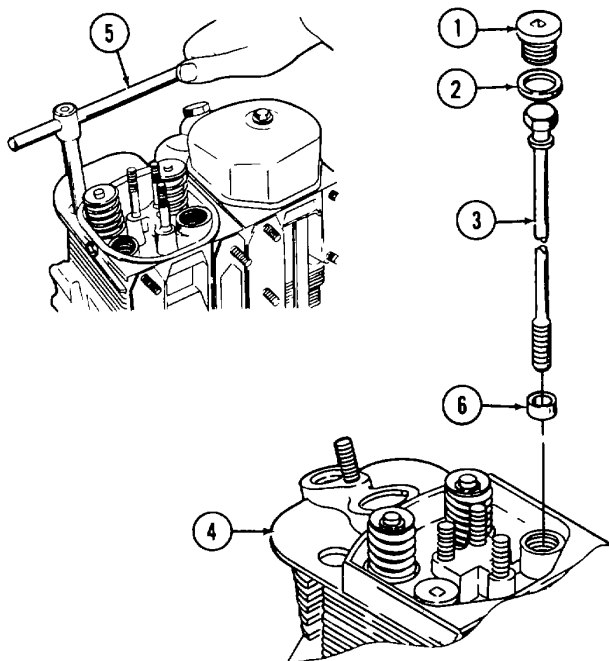
4. Remove hex nuts (1).
5. Remove rocker bracket and rocker arms with attached parts (2)



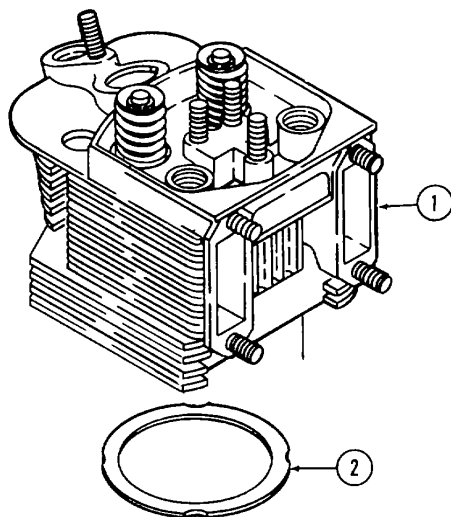
6. Remove pushrods (1) from cylinder head.

3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)

7. Remove brass screw plugs (1).
8. Remove and discard washers (2)
9. Loosen waisted bolts (3) alternately and evenly across cylinder head (4) with socket spanner No 120040/120050 (5) and remove
10. Remove washers (6).

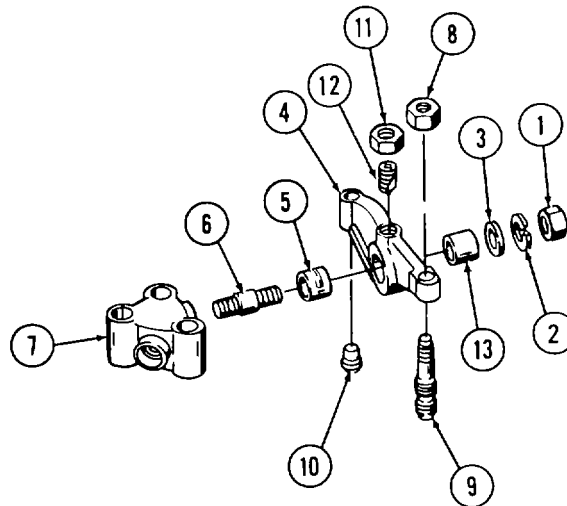
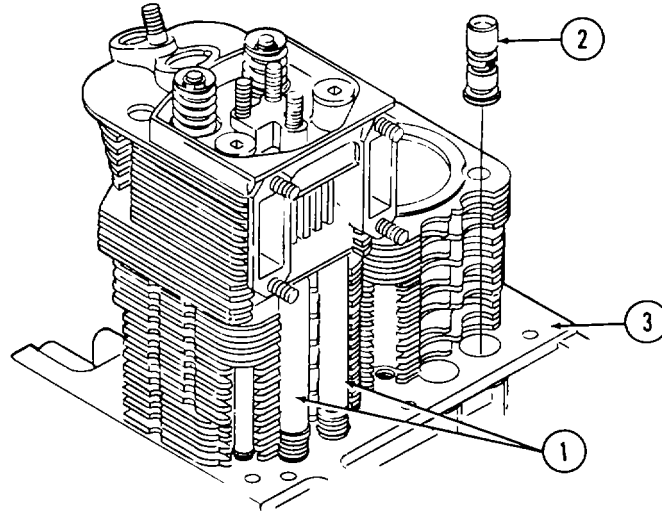


11. Remove cylinder head (1) and intermediate ring (2) from cylinder Matchmark cylinder head and cylinder to facilitate installation. Discard intermediate ring.



3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)

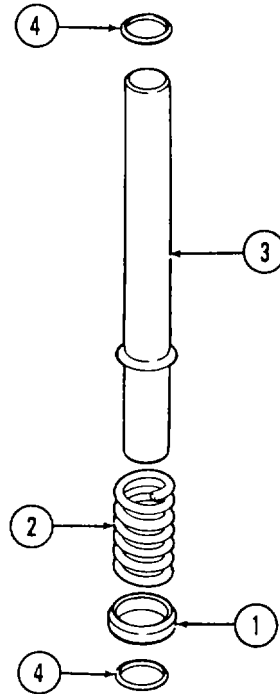
12. Remove cover tubes (1).
13. Remove tappets (2) from crankcase (3)

**DISASSEMBLY:**

1. Remove nut (1), lockwasher (2), and washer (3)
2. Remove rocker arm (4) and fulcrum (5).
3. Remove stud (6) from rocker bracket (7)
4. Remove nut (8) and adjusting screw (9) from rocker arm (4). Notice location of chamfer on adjusting screw. It should point toward thrust pad (10).
5. Remove nut (11) and oil nozzle (12) from rocker arm (4)
6. Remove thrust pad (10)
7. Press out bearing bushing (13).

3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)

8. Remove cap (1) and compression spring (2) from cover tube (3)
9. Remove washers (4)

**CLEANING/INSPECTION:****WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment

1. Clean cylinder head, intermediate ring, cover, rocker arms, pushrods, cover tubes, tappets, and associated parts with a clean cloth dampened with diesel fuel oil. Use wire brush where necessary. Dry with compressed air. Inspect for cracks, rust, corrosion, and excessive heat damage. Inspect cylinder head for carbon buildup near injector area.
2. Inspect bolt holes for chipped or cracked edges. Check that cylinder head seat is smooth and flat. Replace cylinder head assembly if it is excessively worn or damaged and refer unit to general support for repair.

3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)

3. Inspect all other components for excessive wear, alinement, dents, rust, corrosion, stripped threads, or other damage. Replace any damaged or excessively worn components Refer replaced rocker arms and tappets to general support for repair. Inspect waisted bolts If a waisted bolt is strained past the length limit of 8 366 inches (212 5 mm), replace it.

REPAIR:

1. Refer cylinder head, rocker arms, and tappets to general support for repair as necessary.

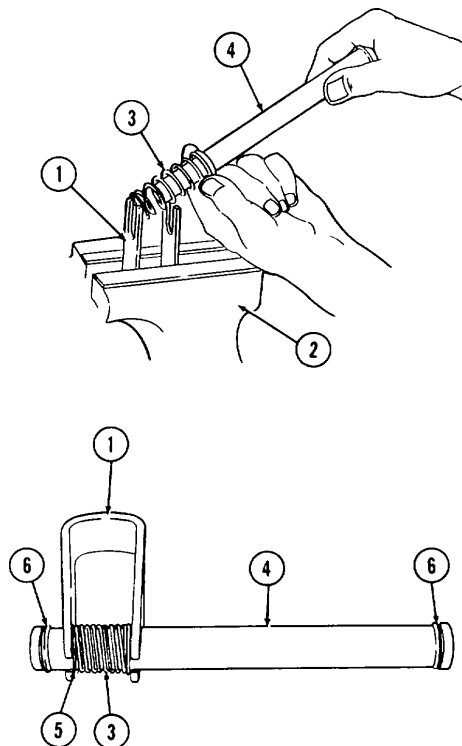
WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

2. Open oil holes in pushrods with small wire. If necessary, soak pushrods in diesel fuel oil to loosen deposits in oil holes, then open with wire. If pushrods or cover tubes are damaged, replace.

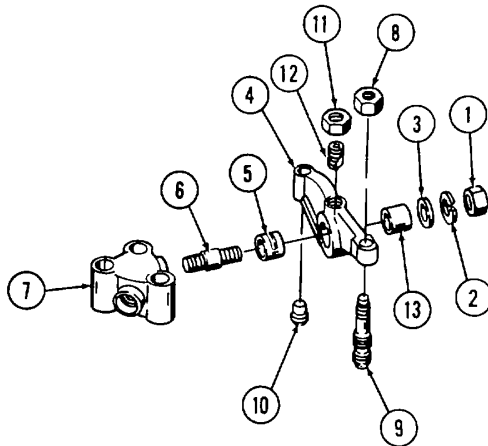
ASSEMBLY:

1. Mount pushrod tube compressor No. 125300 (1) in vise (2).
2. Fit compression spring (3) onto cover tube (4) Compress with pushrod tube compressor No. 125300 (1) mounted in vise (2).
3. Install cap (5) and one washer (6) on spring end of cover tube (4). Install second washer (6) on other end.



3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)

4. Press bearing bushing (13) into rocker arm (4). Make sure oil hole is aligned with rocker arm oil hole.
5. Install thrust pad (10).
6. Install oil nozzle (12) and nut (11) in rocker arm (4) so that chamfered edge of oil nozzle points toward thrust pad (10). Make sure that one thread turn of the oil nozzle projects out from nut when nut has been tightened securely.
7. Install adjusting screw (9) in rocker arm (4) with chamfer on adjusting screw pointing toward thrust pad (10). Install nut (8) and tighten securely.
8. Install stud (6) in rocker bracket (7).
9. Install rocker fulcrum (5) and rocker arm (4) on stud (6).
10. Install washer (3), lockwasher (2), and nut (1). Tighten nut securely

**NOTE**

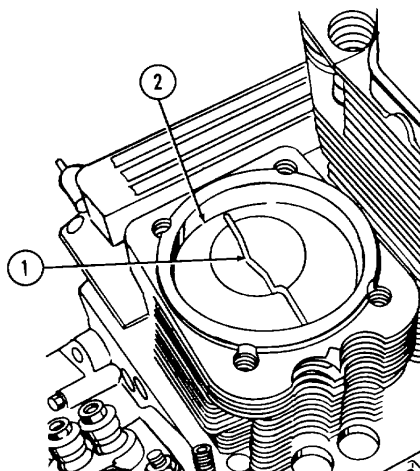
Before installing repaired or new cylinder head, piston top clearance should be measured and checked. Use the following procedure.

TEST:

NOTE

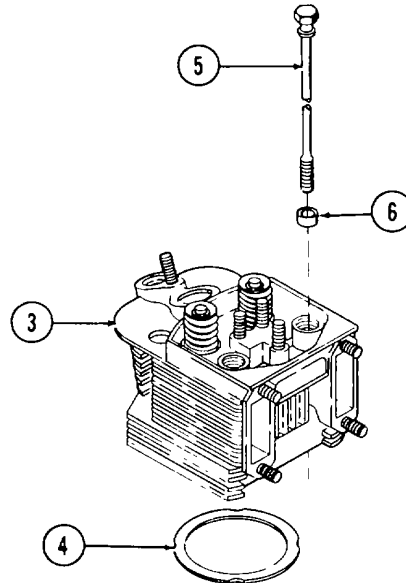
Make sure piston is below top dead center (TDC) position Refer to paragraph 3-6 to determine TDC position.

1. Apply coating of grease to approximately 4.0 inches (102 mm) of 00787 inch (2 mm) lead wire (1) and mold wire to top of piston (2). Grease will allow wire to adhere to piston. Trim off wire that overlaps top of piston

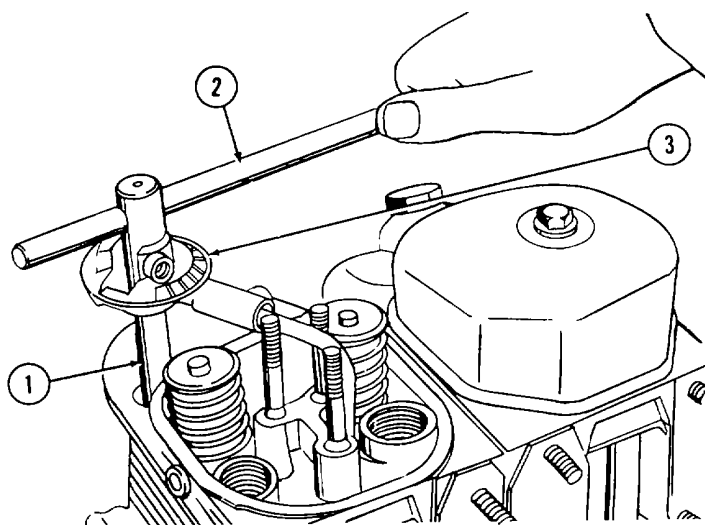


3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)

2. Mount cylinder head (3) and intermediate ring (4) on cylinder
3. Insert waisted bolts (5) and washers (6) in cylinder head (3).

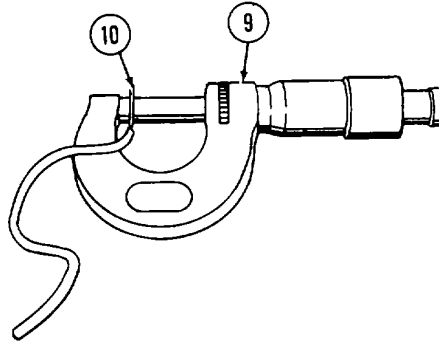


4. Pretighten waisted bolts (5) alternately and evenly across cylinder head (3) with socket spanner No 120040/120050 (7) to 29.50 ft-lb (40 N.m) torque Using torque gage No. 101900 (8), tighten each bolt (5), crosswise, three additional 45 degree increments, then, maintaining crosswise pattern, tighten each bolt an additional 30 degrees.
5. Rotate crankshaft two complete revolutions of 360 degrees.
6. Remove waisted bolts (5) and washers (6). Mark and remove cylinder head(s) (3) and intermediate rings (4)

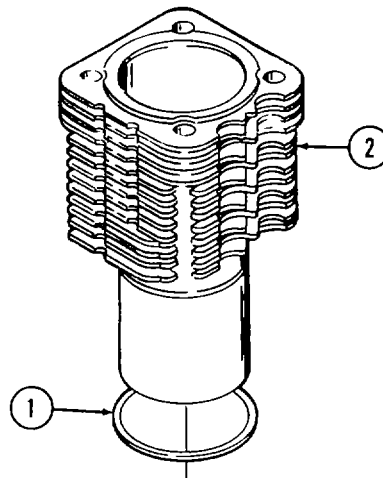


3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)

7. Remove lead wire (1) and measure thickness with micrometer (9) at thinnest point (10). Thickness should be 0.0394 to 0.0472 inch (1.0 to 1.2 mm). The measured thickness or piston top clearance should be compared to the specified limits. If measurement is outside limits, piston top clearance may be adjusted using the following procedure. If measurement is within limits, proceed to INSTALLATION.

**ADJUSTMENT:**

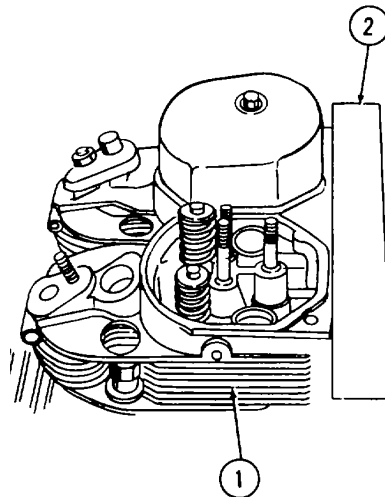
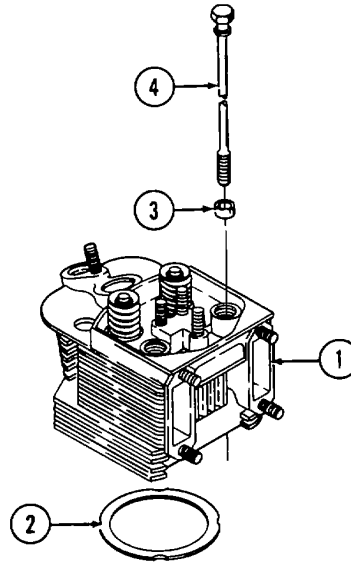
1. Piston top clearance may be increased or decreased by adding or removing shims (1). Shims are available in two thicknesses 0.0079 inch (0.2 mm) or 0.0197 inch (0.5 mm).
2. If piston top clearance is below 0.0394 inch (1.0 mm), remove cylinder (2) and add appropriate number of shims (1). Use thicker shims rather than thinner shims whenever possible.
3. If piston top clearance is greater than 0.0472 inch (1.2 mm), lift cylinder (2) up and remove appropriate number of shims (1) with side-cutting pliers.



3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)

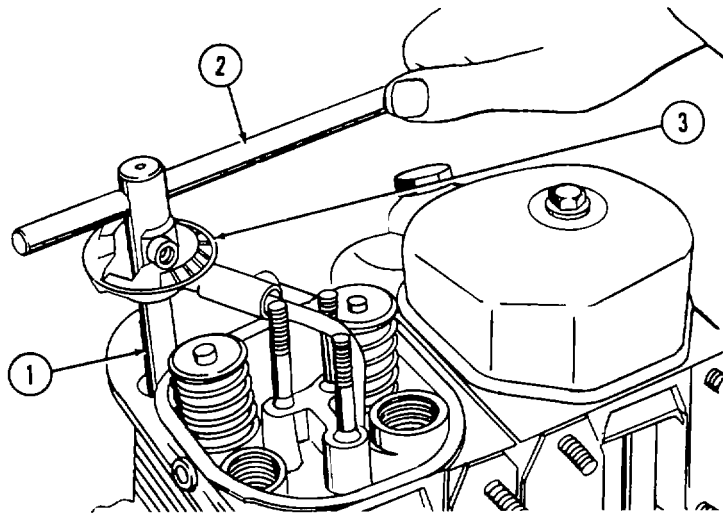
INSTALLATION:

1. Position cylinder head (1) and new intermediate ring (2) or cylinder, aligning matchmarks made during removal
2. Install washers (3) and waisted bolts (4) loosely.

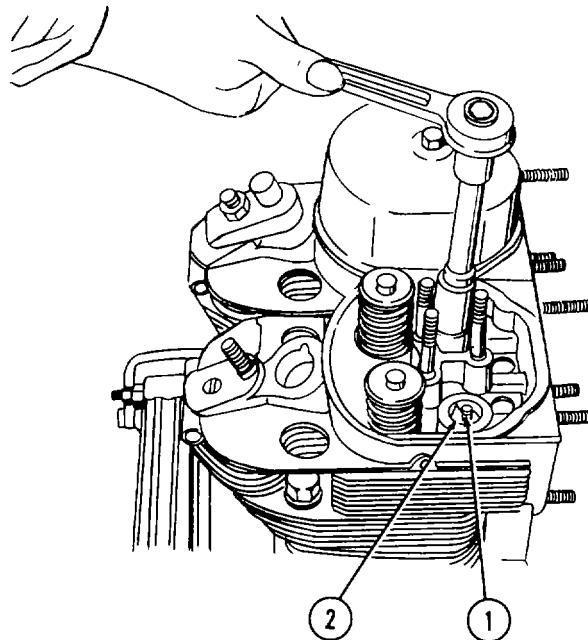


3. Check and align cylinder head (1) with flat straightedge (2).

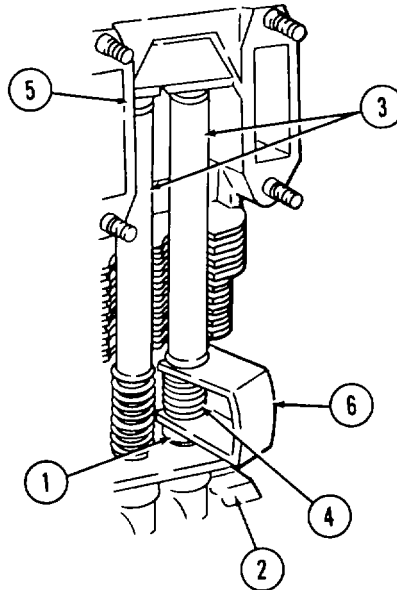
3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)



4. Tighten waisted bolts (1) in a crosswise manner with socket spanner No. 120040/120050 (2) to 29 50 ft-lb (40 N.m) torque. Using torque gage No. 101900 (3), tighten each bolt, crosswise, three additional 45 degree increments. Then, maintaining crosswise pattern, tighten each bolt an additional 30 degrees.



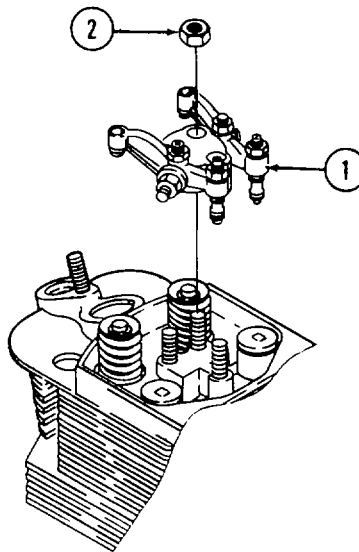
5. Install new screw plug washers (1). Install screw plugs (2) and tighten securely. If screw plugs have been replaced, make sure replacements are brass

3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)

6. Install tappets (1) in tappet holes in crankcase (2)
7. Install spring end of cover tube (3), with spring (4) compressed, into tappet hole in crankcase. Install opposite end into hole in cylinder head (5)
8. Remove pushrod tube compressor No. 125300 (6)
9. Install pushrods (1).

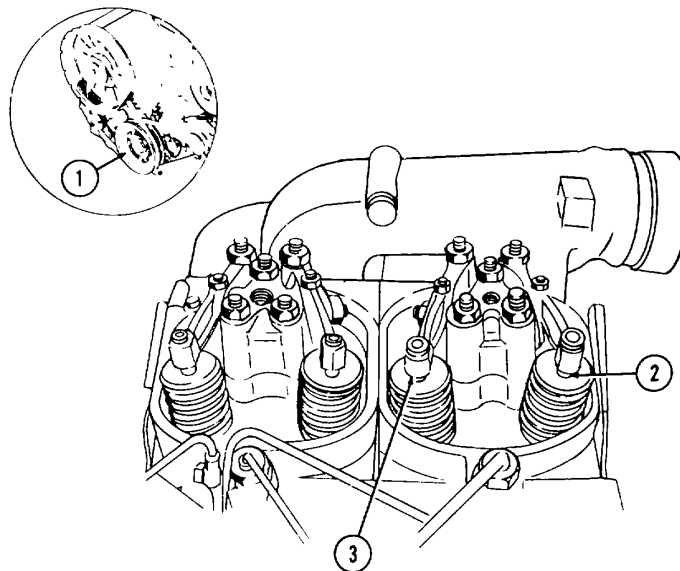
3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)

10. Install assembled rocker bracket and rocker arms (1) and nuts (2) Tighten nuts to 20.65 ft-lb (28 N m)

**VALVE CLEARANCE ADJUSTMENT:****NOTE**

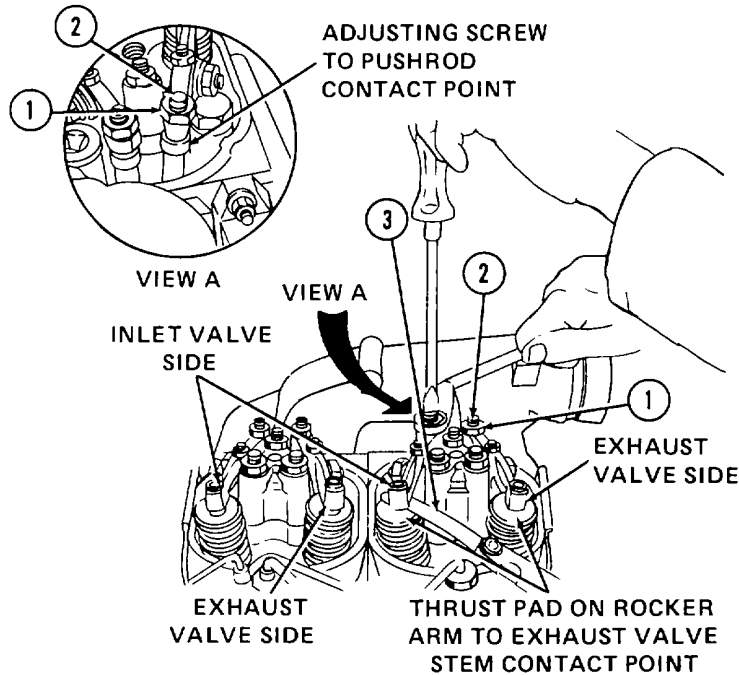
Adjust valve clearance only when engine is cold.

1. Rotate crankshaft by rotating flywheel or crankshaft V-belt pulley (1) clockwise until valve stems and rocker arms overlap. The exhaust valve (2) should be closing and its valve stem rising. The inlet valve (3) should be opening and its valve stem going down. Both valve stems (2 and 3) should be at the same height. Rotate crankshaft pulley (1) another complete revolution, or 360 degrees of travel of the flywheel or pulley. The piston should be at the top of its compression stroke and the valve clearance can be checked and adjusted.

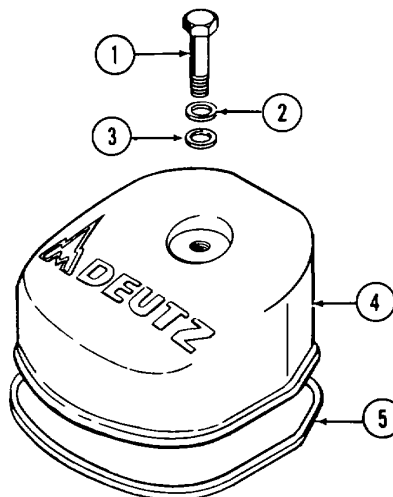


3-19. REPLACE CYLINDER HEAD ASSEMBLY, ROCKER ARMS, PUSHRODS, AND TAPPETS (Continued)

- Loosen nuts (1) on adjusting screws (2) on inlet and exhaust valve rocker arms. Insert a feeler gage (3) of 0.0059 inch (0.15 mm) thickness between valve stem and thrust pad of each rocker arm. Turn slotted adjusting screws (2) until they are in contact with their respective pushrods and exerting approximately the same contact pressure against pushrods as thrust pads are against the feeler gage and valve stems. Retighten hex nuts securely.



- Rotate crankshaft in running direction several complete revolutions.
- Recheck valve clearance. Make sure that feeler gage distance and contact pressures are the same as adjusted previously in step 2 above.
- Install new gasket (5) with sealing compound. Install cover (4), washers (2 and 3), and hex bolt (1). Tighten hex bolt to 20.65 ft-lb (28 N m).



3-20. SERVICE/REPLACE TACHOMETER DRIVE

This task covers:

a. Removal**b. Cleaning/Inspection****c. Installation****INITIAL SETUP:****Tools**

Shop set, automotive repair, field maintenance, basic

Equipment Condition

Para

Condition Description

2-16.

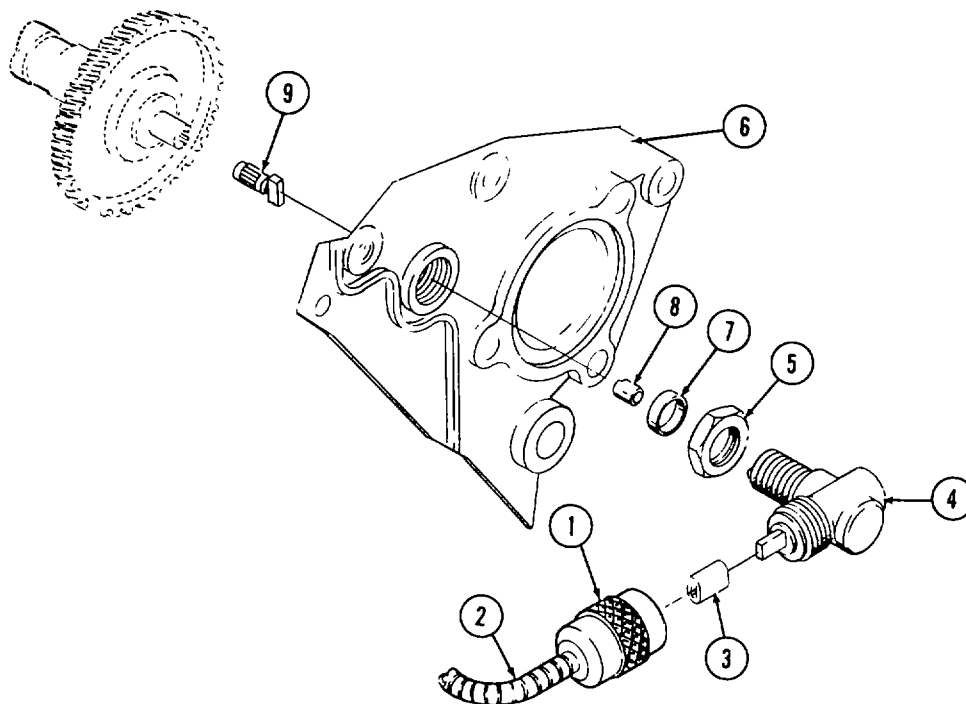
Tachometer cable removed from control panel.

Materials/Parts

Diesel fuel oil (item 6, Appendix C)

Lubricating oil (Item 10, Appendix C)

Sealing compound (Item 15, Appendix C)

REMOVAL:

1. Loosen threaded collar (1) on tachometer cable (2). Remove cable and sleeve (3) from angle drive (4)
2. Loosen nut (5).
3. Remove angle drive (4) from front cover (6).
4. Remove and discard ring (7).
5. Remove driver actuator (8) from spigot pin (9) of camshaft

3-20. SERVICE/REPLACE TACHOMETER DRIVE (Continued)

CLEANING/INSPECTION:

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

1. Clean angle drive (4), nut (5), driver actuator (8), sleeve (3), and tachometer cable (2) with diesel fuel oil and dry with compressed air. Inspect components for damage, rust, wear, or malfunctions Remove rust or corrosion with fine sandpaper.
2. Check that the tachometer inner cable turns freely within the outer sheath
3. Clean dirt from inside the tachometer cable sheath by flushing drops of diesel fuel oil through the cable while turning the inner cable by hand or with an electric drill
4. Inspect angle drive (4), nut (5), and tachometer cable (2) for stripped or damaged threads Replace component with stripped or damaged threads. If angle drive or tachometer cable is sticking or frozen, soak in diesel fuel oil and work free. Dry with compressed air Lubricate with lubricating oil
5. Inspect driver actuator (8) and sleeve (3) for wear or other damage to the internal bore that would prevent secure fit of the mating components.

INSTALLATION:

1. Install new ring (7) in front cover (6) bore.
 2. Install driver actuator (8) on spigot pin (9) of camshaft
 3. Thread nut (5) onto angle drive (4) and apply sealing compound to the threads of angle drive.
 4. Aline drive tab of angle drive (4) with driver actuator (8) and thread angle into front cover (6).
 5. Aline and connect the drive tab of angle drive (4) and the drive tab of tachometer cable (2) with sleeve (3). Tighten threaded collar (1)
-

3-21. REPLACE/REPAIR IDLER PULLEY ASSEMBLY

This task covers:

- | | | |
|----------------|--------------------------------|-----------------|
| a. Removal | c. Cleaning/Inspection/ Repair | e. Installation |
| b. Disassembly | d. Assembly | f. Adjustment |

INITIAL SETUP:

Tools

Shop set, automotive repair, field maintenance, basic

Equipment Condition

Para	Condition Description
-------------	------------------------------

2-25.	Blower V-belt removed
-------	-----------------------

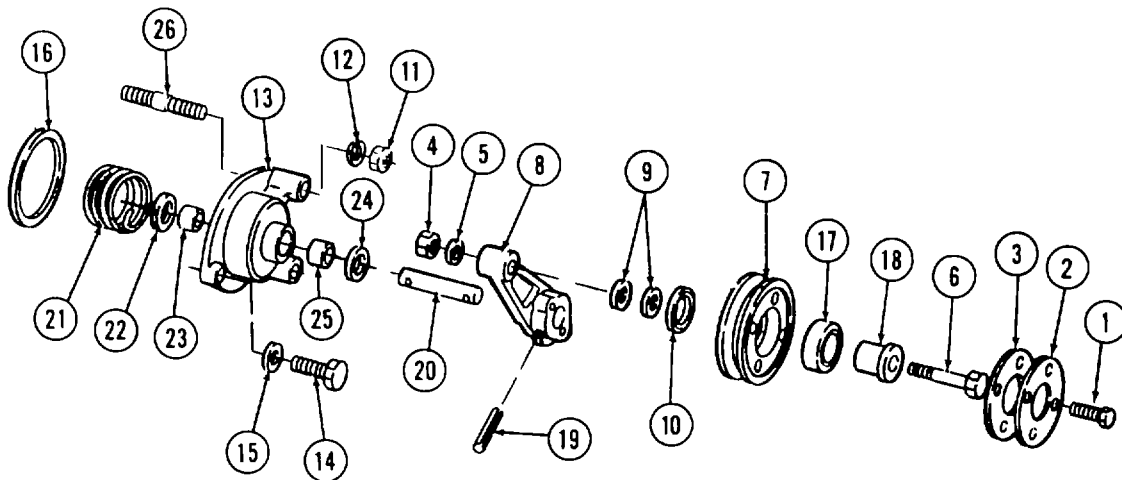
Materials/Parts

- Crocus abrasive cloth (Item 1, Appendix C)
- Diesel fuel oil (Item 6, Appendix C)
- Emery abrasive cloth (Item 2, Appendix C)
- Lubricating oil (Item 10, Appendix C)

Special Environmental Conditions

Well-ventilated area required for cleaning

REMOVAL:



1. Remove bolts (1) and pull cover (2) and gasket (3) from the assembled V-belt pulley. Discard the gasket only if it is obviously damaged
2. Remove nut (4), washer (5), and bolt (6) that secure pulley (7) to pulley lever (8).
3. Remove pulley (7), washers (9), and ring (10) from pulley lever (8).
4. Remove nuts (11) and washers (12) that secure the assembled idler pulley cover (13) to the engine front cover.
5. Remove bolt (14) and washer (15) that secure the assembled idler pulley cover (13) to the engine front cover. Remove the assembled idler pulley cover
6. Remove seal (16) from the cover and discard it

3-21. REPLACE/REPAIR IDLER PULLEY ASSEMBLY (Continued)

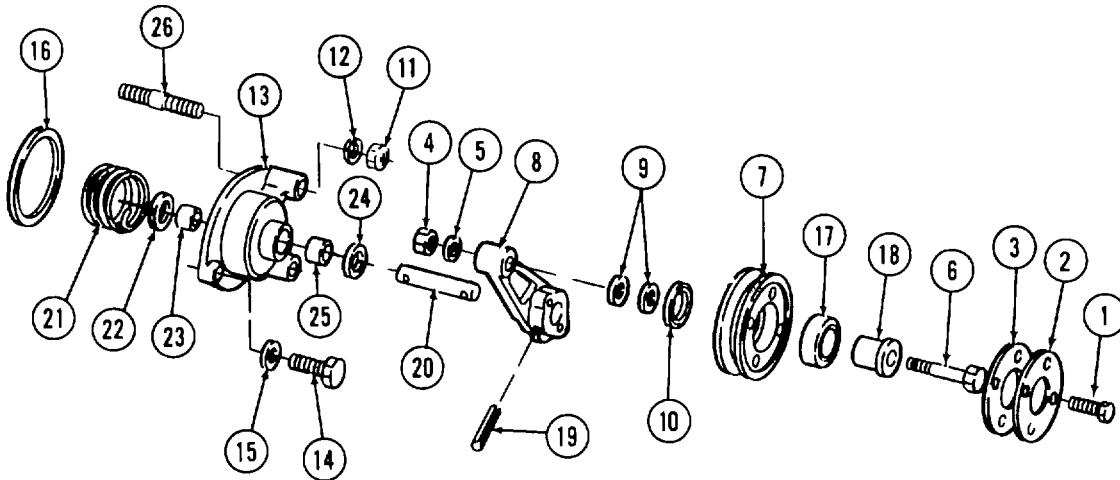
DISASSEMBLY:

1. Press ball bearing (17) and bushing (18) from pulley (7)
2. Press dowel pin (19) from pulley lever (8) and remove the pulley lever from shaft (20)
3. Remove yoke spring (21), washer (22), and bushing (23) from the engine side of idler pulley cover (13).
4. Remove seal (24) and bushing (25) from idler pulley cover (13). Discard the seal.
5. Do not remove studs (26) from front cover unless studs are damaged.

CLEANING/INSPECTION/REPAIR:**WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat Always store fuel in proper, marked containers. DO NOT SMOKE.

1. Clean all components with diesel fuel oil Inspect for rust, corrosion, wear, or other obvious damage.
2. Inspect idler pulley cover and pulley lever for cracks at shaft and bushing bores, mounting flanges, and mounting hardware bores. Discard components with cracks.
3. Inspect shaft, pin, and bolt (6) for wear or signs of shearing fatigue.
4. If the cylindrical surface of the shaft is worn significantly at any point, replace the shaft and the bushing that mates with that surface.
5. Rotate ball bearing by hand, inspecting for rough or tight spots. Replace bearing if rough or tight.
6. Inspect ball bearing exterior for rust, corrosion, or other damage Replace damaged bearing.
7. Inspect exterior surfaces of bushings for wear or scoring. Replace a worn or scored bushing.
8. Inspect interior diameter of bushings for excessive wear or elongation. Replace a worn or elongated bushing.
9. Inspect yoke spring for rust or corrosion, and loss of temper. Replace the spring if it is rusted or corroded
Replace spring if it was not providing proper belt tension during operation.
10. Inspect the idler pulley groove for roughness, gouges, or burrs that will damage the belt. Remove burrs and smooth gouges with a fine file. Smooth the pulley groove with crocus or emery cloth If more than 25% of the pulley groove requires repair, replace pulley.
11. Inspect diameter of pulley bore for distortion and elongation. Replace pulley if the internal bore is distorted.
12. Inspect stud for damaged or stripped threads. Make sure stud is not cracked, bent, or corroded. Replace damaged stud

3-21. REPLACE/REPAIR IDLER PULLEY ASSEMBLY (Continued)**ASSEMBLY:**

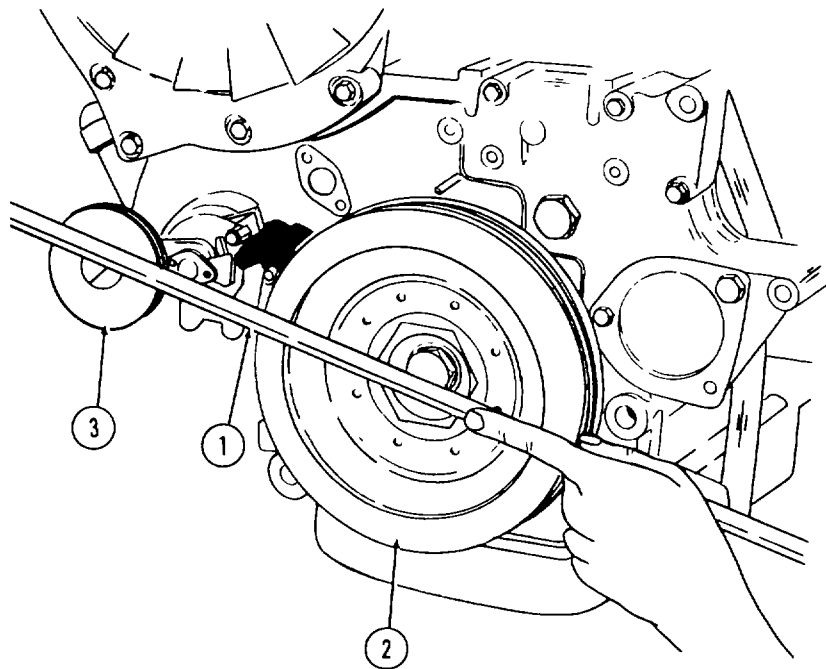
1. Press ball bearing (17) and bushing (18) into idler pulley (7).
2. Press bushing (23) into idler pulley cover (13) until it is flush with engine side.
3. Press bushing (25) into idler pulley cover (13) from lever side. Measure the height of seal (24) and press the bushing deeper into the cover by this amount
4. Press new seal (24) into cover (13) until it is flush with lever side of the cover.
5. Insert the long end of yoke spring (21) into shaft (20) and position washer (22) on shaft
6. Lubricate the end of shaft (20) and the inner lip of seal (24) with lubricating oil.
7. Insert assembled shaft (20), spring (21), and washer (22) into cover (13) from the engine side Do not push seal (24) out of the cover when inserting the shaft.
8. Position the short end of yoke spring (21) against the spring catch boss inside idler pulley cover (13)
9. Push pulley lever (8) onto shaft (20) so the bores coincide and the long end of the spring points downward.
10. Press pin (19) into pulley lever (8).

INSTALLATION:

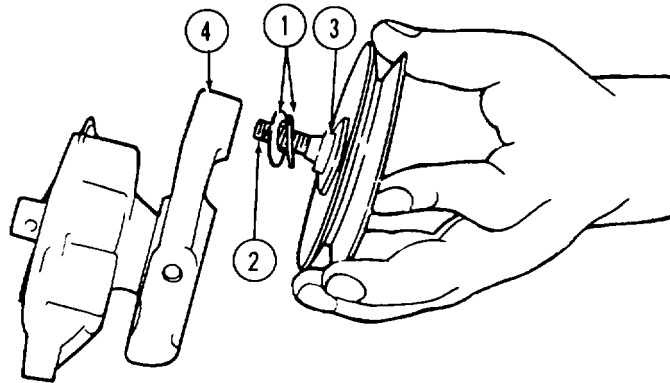
1. Install new seal (16) in flange of cover (13) that mates with engine front cover.
2. Install cover (13) into the bore of the front cover. Be sure seal (16) seats properly
3. Insert bolt (14) with washer (15) in smallest cover flange. Place the other two flanges over studs (26) in the front cover.
4. Using bolt (14) and washer (15), hold assembled idler pulley cover to the engine front cover.

3-21. REPLACE/REPAIR IDLER PULLEY ASSEMBLY (Continued)

5. Using nut (11) and washer (12), secure assembled idler pulley cover to studs (26) in the engine front cover. Tighten nuts.
6. Install bolt (6), bushing (18), spacing washers (9), and ring (10) on pulley (7), and using bolt (6), washer (5), and nut (4), secure pulley (7) to pulley lever (8).
7. Check the adjustment of the pulley according to ADJUSTMENT below Readjust pulley as required
8. Once the pulley is adjusted, use bolts (1) to secure cover (2) and gasket (3) to V-belt pulley (7) Use a new gasket only if the old gasket was damaged and discarded

ADJUSTMENT:

1. With a metal straightedge (1) held firmly across the face of crankshaft pulley (2), check the alignment of idler pulley (3) The pulleys are aligned if the straightedge continues across the face of the idler pulley without moving the edge from the face of the crankshaft pulley
2. Idler pulley is out of fore-and-aft alignment if the pulley face is in front of or in back of the straight-edge (1) held across the face of crankshaft pulley

3-21. REPLACE/REPAIR IDLER PULLEY ASSEMBLY (Continued)

3. Fore-and-aft misalignment can be corrected by increasing or decreasing the number of washers (1) on bolt (2) between ring (3) and pulley lever (4). The thickness of the washers can also be changed to accomplish alignment.
 4. Idler pulley is out of vertical alignment if the part of the pulley face is in front of or in back of the straightedge held across the face of the crankshaft pulley.
 5. Vertical misalignment is caused by damaged or improperly assembled components. It can be corrected by disassembling the idler pulley, replacing damaged components, and assembling the components properly.
-

3-22. REPLACE/REPAIR Front Cover

This task covers:

- | | |
|------------------------|-----------------|
| a. Removal | c. Repair |
| b. Cleaning/Inspection | d. Installation |

INITIAL SETUP:

Tools

Shop set, automotive repair, field maintenance, basic
Crankshaft seal assembly tool No 142520 2-35.

Materials/Parts

Diesel fuel oil (Item 6, Appendix C)
Emery cloth (Item 2, Appendix C)
Lubricating oil (Item 10, Appendix C)
Sealing compound (Item 13 or 15, Appendix C)

Equipment

Condition

Para	Condition Description
2-22.	Skid level. Engine cover panels and frame removed from engine.

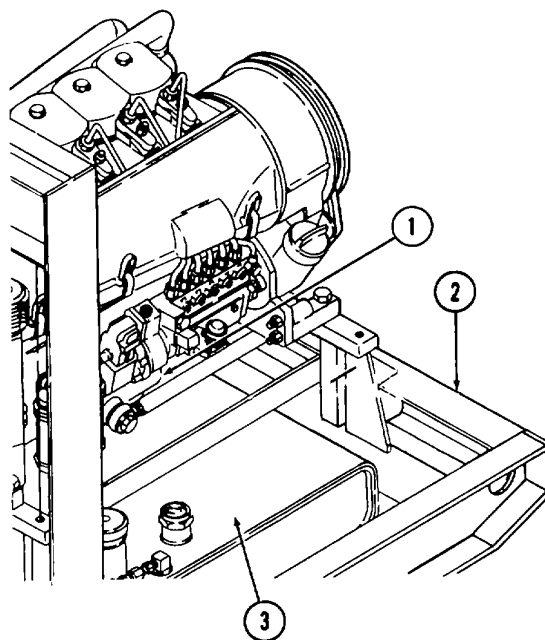
- 2-33. Turbocharger lube oil return line and cover removed from front cover.
Alternator mounting brackets removed from engine
- 3-9. Cooling air blower removed from engine
- 3-10. Oil pan removed from engine.
- 3-20. Tachometer drive removed from front cover.
- 3-21. Idler pulley assembly removed from front cover.
- 3-24. Crankshaft V-belt pulley removed from engine.

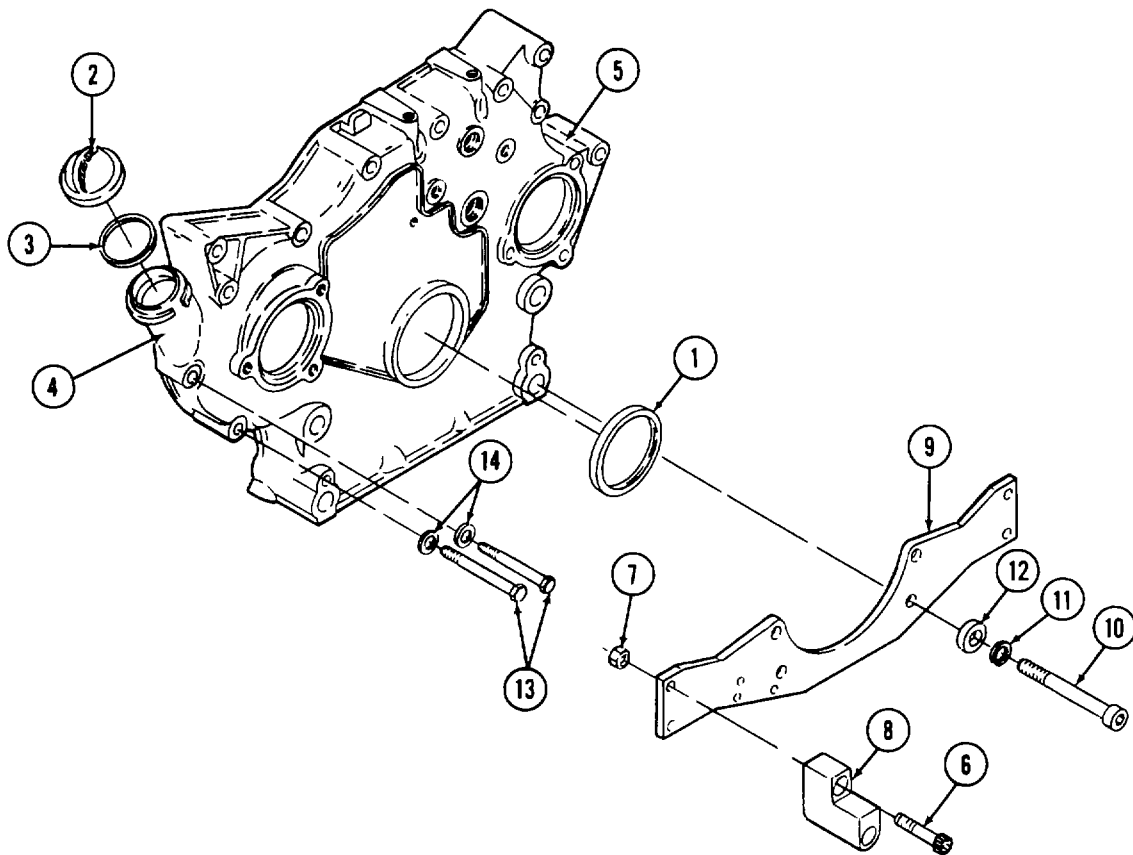
Special Environmental Conditions

Well-ventilated area required for cleaning.

REMOVAL:

- Place blocking between the bottom of the engine crankcase (1) and the skid (2) The blocking should be strong enough to support the weight of the engine Do not allow the blocking to press on the fuel tank (3), front cover, or oil suction pipe



3-22. REPLACE/REPAIR FRONT COVER (Continued)

2. Work shaft seal (1) loose, remove and discard
3. Remove the oil filler cap (2) and washer (3) from the oil filler neck (4) of the front cover (5).
4. Remove bolts (6) and nuts (7) that secure rear engine supports (8) to support bracket (9)
5. Remove screws (10), lockwashers (11), and washers (12) that secure support bracket (9) to front cover (5). Remove support bracket.
6. Remove bolts (13) and washers (14), and remove front cover (5) from engine

3-22. REPLACE/REPAIR FRONT COVER (Continued)

CLEANING/INSPECTION:**WARNING**

Death or serious Injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

Death or serious Injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment

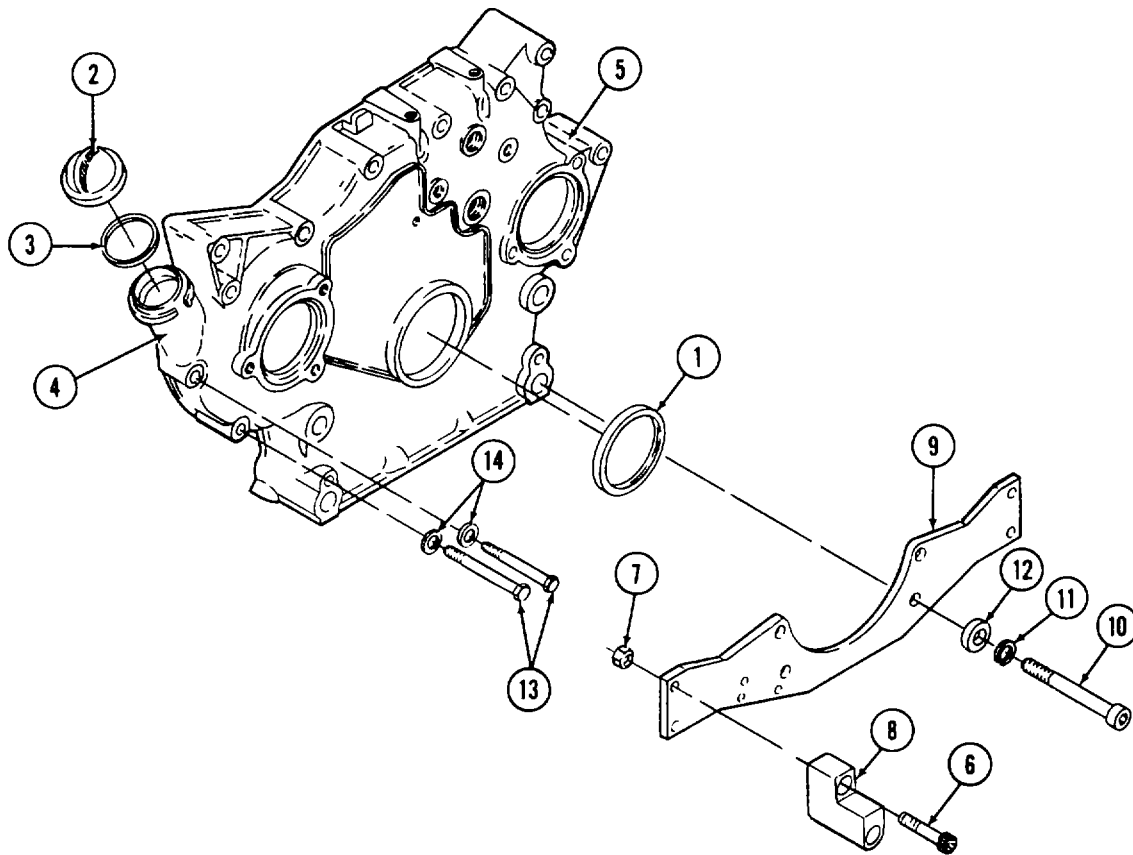
1. Clean front cover, support bracket, and oil filler cap with diesel fuel oil and dry with low pressure compressed air. Inspect all components for cracks, distortion, and other damage.
2. Inspect front cover
 - a. Remove all traces of sealing compound from crankcase mating surface
 - b. Inspect crankcase mating surface for cracks, gouges, or other damage that would prevent proper seating or sealing of the front cover. Replace a cracked front cover.
 - c. Inspect the front cover for warpage by placing it mating flange down on a flat surface. Replace a warped front cover.
 - d. Inspect shaft seal bore for gouges, wear, or other damage that would prevent proper seating of the seal.
 - e. Inspect idler pulley bore and oil return cover bore for gouges, wear, or other damage that would prevent proper seating of the preformed packings.
3. Check that the clamping tabs on oil filler cap are not bent or broken. Replace the cap if the tabs are broken.
4. Inspect the oil filler cap washer in place, for hardening, cracks, and missing segments. Replace a hardened, cracked, or broken washer.

REPAIR:

1. Clean up minor burrs and gouges of the shaft seal and preformed packing seats in the front cover with emery cloth. If defects cannot be removed, replace the front cover.
2. Repair any minor damage, nicks, burrs, rust, or corrosion on the front cover.
3. Carefully reshape bent clamping tabs on oil filler cap. Replace the cap if the tabs cannot be reshaped to hold the neck securely.
4. Scrape all traces of damaged washer from the oil filler cap. Replace with new washer.
5. Repair damaged support bracket in accordance with paragraph 3-6.

3-22. REPLACE/REPAIR FRONT COVER (Continued)

INSTALLATION:



1. Coat sealing surface of the front cover (5) and crankcase with sealing compound.
2. Position front cover (5) on crankcase so mounting holes align with mating holes in crankcase.
3. Install bolts (13) and washers (14). Tighten alternately and evenly until all are tightened securely.
4. Wipe excess sealant from crankcase and front cover.
5. Secure support bracket (9) to front cover (5) using screws (10), lockwashers (11), and washers (12).
6. Secure engine supports (8) to support bracket (9) using bolts (6) and nuts (7).
7. Apply lubricating oil to lip of new shaft seal (1).
8. Place shaft seal (1) in seat of crankshaft bore, and install crankshaft seal assembly tool No. 142520 (12).
9. Press shaft seal (1) into front cover (5).
10. Install assembled oil filler cap (2) and washer (3) onto oil filler neck (4) of front cover (5).
11. Remove blocking from the skid. Do not allow the blocking to damage unit components during removal.

3-23. REPLACE/REPAIR ADAPTER HOUSING

This task covers:

- | | |
|------------------------|-----------------|
| a. Removal | c. Repair |
| b. Cleaning/Inspection | d. Installation |

INITIAL SETUP:

Tools

Shop set, automotive repair, field maintenance, basic

Equipment Condition

Para

Condition Description

Engine shut down and cool.

Materials/Parts

Crocus cloth (Item 1, Appendix C)
 Diesel fuel oil (Item 6, Appendix C)

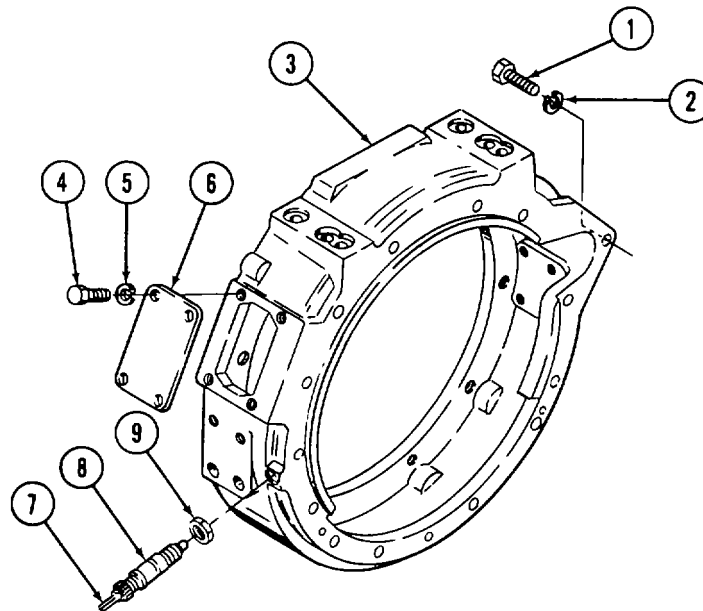
3-4.

Pump assembly removed from engine

Special Environmental Conditions

well-ventilated area required for cleaning.

REMOVAL:



1. Remove bolts (1) and lockwashers (2).
2. Remove adapter housing (3) from engine.
3. Remove bolts (4) and lockwashers (5).
4. Remove cover (6) from adapter housing (3).
5. Tag and disconnect wire leads (7) from magnetic pickup (8).
6. Loosen locking nut (9).
7. Unscrew magnetic pickup (8) from adapter housing (3).

3-23. REPLACE/REPAIR ADAPTER HOUSING (Continued)

CLEANING/INSPECTION:

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

1. Clean adapter housing and cover with diesel fuel oil. Dry with compressed air
2. Inspect adapter housing for cracks, rust, corrosion, warpage, worn mounting holes, or other damage. Inspect bolts for stripped threads.

REPAIR:

1. Replace adapter housing (3) or cover (6) if cracked, worn, damaged, or if minor hairline cracks are present. Do not attempt repairs by welding or brazing.
2. If adapter housing is nicked or burned on mounting surfaces, grind smooth or smooth out with crocus cloth. Be careful not to remove any more material than is absolutely necessary.
3. If adapter housing is rusted or corroded, remove rust or corrosion from exterior surfaces
4. Remove rust, corrosion, or dirt from the sensor and terminals of the magnetic pickup. Replace pickup if insulation is cracked, if sensor head is damaged, or if threads along the body are stripped.

INSTALLATION:

1. Screw magnetic pickup (8) into adapter housing (3). Tighten locking nut (9). Connect wire leads (7) as tagged during removal.
 2. Using bolts (4) and lockwashers (5) install cover (6) on adapter housing (3). Using bolts (1) and lockwashers (2) install adapter housing (3) on engine
-

3-24. REPLACE/REPAIR CRANKSHAFT V-BELT PULLEY

This task covers:

- | | |
|---------------|-----------------|
| a. Removal | c. Repair |
| b. Inspection | d. Installation |

INITIAL SETUP

Tools

Shop set, automotive repair, field maintenance, basic

Equipment Condition

Para 2-25

Condition Description

Alternator and cooling air blower V-belts removed

General Safety Instructions

Well-ventilated area required

REMOVAL

WARNING

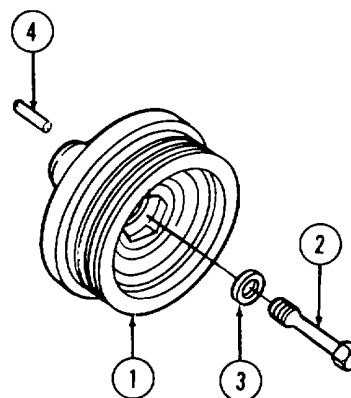
Severe injury may result from contact with rotating engine parts, V-belts, or fan. Shut off the engine when it is necessary to inspect, service, or perform maintenance on any moving parts. Close control panel to prevent accidental starting. If it is necessary to run engine with rotating parts exposed, be sure the area around the moving parts is clear of personnel and tools.

- 1 Restrain crankshaft V-belt pulley (1)
- 2 Remove wasted bolt (2) and washer (3)

NOTE

The wasted bolt is left-hand threaded. Turn clockwise to loosen.

- 3 Pull crankshaft V-belt pulley (1) from crankshaft
- 4 Remove parallel pin (4).



INSPECTION:

- 1 Inspect crankshaft V-belt pulley for nicks, dents, rust, or other damage
- 2 Inspect pulley trough for sharp or jagged edges and the parallel pin bore for wear or elongation. Replace pulley if damaged.
- 3 Inspect parallel pin for wear, bends, or signs of shearing. If pin is damaged, it must be replaced, and the crankshaft must be inspected by general support maintenance.

3-24. REPLACE/REPAIR CRANKSHAFT V-BELT PULLEY (Continued)

REPAIR:

File off burrs from crankshaft V-belt pulley Remove rust and clean. Replace if otherwise damaged

INSTALLATION

- 1 Install parallel pin in crankshaft.
- 2 Install crankshaft V-belt pulley (1) onto crankshaft, alining hole in pulley with parallel pin in crankshaft
- 3 Restrain pulley
- 4 Install washer (3) and wasted bolts (2). Tighten securely

NOTE

The wasted bolt (2) is left-hand threaded Turn counterclockwise to tighten.

3-25. REPLACE/REPAIR SKID

This task covers:

- a. Inspection b. Repair
-

INITIAL SETUP:

Tools

Tool kit, general mechanics automotive
 Shop equipment, automotive maintenance
 and repair, common no. 1
 Shop set, automotive repair, field
 maintenance, basic
 Tool kit, master mechanics

**Equipment
 Condition**

Para
 2-14
 2-38
 2-41
 3-4
 3-6

Condition Description

Battery box removed.
 Tool box removed.
 Fuel tank removed.
 Pump and bearing housing removed.
 Engine removed.

Special Environmental Conditions

Well-ventilated area required.

INSPECTION:

Inspect skid for rust, corrosion, flaking paint, cracked weldments, cracks, stress lines, or structural fatigue. Replace skid if cracks, stress lines, or structural fatigue are found.

REPAIR

- 1 Straighten minor bends.

WARNING

Before application of heat, such as open flame, torch, or arc welding, be sure that all traces of cleaning solvent or flammable fluids or vapors are absent from the repair area.

- 2 Reweld cracked weldment. Thoroughly wire brush area to be repaired. Grind weld bead down to parent metal for the length of the defect plus 0.25 inch (6.35 mm) on each side. Blend repair weld into original weld bead.
- 3 Clean and refinish welded areas.

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**CHAPTER 4
GENERAL SUPPORT MAINTENANCE INSTRUCTIONS**

INTRODUCTION

This chapter contains the following frequently used maintenance information

- a. Troubleshooting
- b. Maintenance procedures

The symptom index on page 4-2 is a guide to the troubleshooting information. There is also an index to the maintenance procedures on page 4-4.

Section	Title	Page
I	Troubleshooting	4-1
II	Maintenance Procedures.....	4-4

Section I. TROUBLESHOOTING

4-1. TROUBLESHOOTING

a. Table 4-1 contains troubleshooting information for locating and correcting most of the operating troubles which are the responsibility of general support maintenance. Each malfunction for an individual component, unit, or system is followed by a list of tests or inspections which will help you to determine probable causes and corrective actions to take. Perform the tests/inspections and corrective actions in the order listed.

b. This manual cannot list all malfunctions that may occur, nor all tests or inspections or corrective actions. If a malfunction is not listed or cannot be corrected by listed corrective actions, notify your supervisor.

c. Only those functions within the scope of general support maintenance are listed. For troubleshooting procedures within the scope of operator/crew maintenance, refer to TM 3-4320-306-10. For troubleshooting procedures within the scope of organizational maintenance, refer to table 2-2. For troubleshooting procedures within the scope of direct support maintenance, refer to table 3-1.

4-2. SYMPTOM INDEX

Refer to the symptom index below. Locate the malfunction which is the same, or most nearly the same, as the trouble you are having with the centrifugal pump unit. The Symptom Index lists the first page of troubleshooting information for that malfunction. Follow the steps one by one, and perform the corrective actions listed.

Malfunction Number	Description	Page
1	Engine is hard to start	4-3
2	Engine consumes excessive lube oil (may produce blue smoke)	4-3
3	Engine produces excessive crankcase pressure	4-3
4	Engine has low oil pressure	4-3

Table 4-1. General Support Maintenance Troubleshooting

MALFUNCTION	TEST OR INSPECTION	CORRECTIVE ACTION
1. ENGINE IS HARD TO START		
	Step 1. Check for sticking or burned exhaust valves. Inspect valves.	Repair or replace faulty valves (para 4-7).
	Step 2. Check for broken or worn piston rings. Inspect pistons and rings. Inspect cylinder head assembly.	Repair or replace pistons (para 4-10) and cylinder head assembly (para 4-6 or 3-19). Replace piston rings (para 4-10).
	Step 3. Check for improper exhaust valve clearance. Check and adjust exhaust valve clearance (para 4-7).	
2. ENGINE CONSUMES EXCESSIVE LUBE OIL (MAY PRODUCE BLUE SMOKE)		
	Step 1. Check for worn or broken double-chamfered rings. Inspect pistons and rings. Inspect cylinder head assembly.	Repair or replace faulty pistons (para 4-10) and cylinder head assembly (para 4-6 or 3-19). Replace piston rings (para 4-10).
	Step 2. Check for scored cylinders or pistons. Inspect cylinders and pistons.	Repair or replace faulty cylinder head assembly (para 4-6 or 3-19) and piston (para 4-10).
	Step 3. Check for loose piston pin circlips. Inspect piston pin circlips.	Replace a loose piston pin circlip (para 4-10).
	Step 4. Check for piston and connecting rod alignment. Inspect pistons and connecting rods. Check crankshaft thrust surfaces for wear or grooving.	Replace a faulty piston (para 4-10) or connecting rod (para 4-11). If necessary, replace crankshaft (4-12).
3. ENGINE PRODUCES EXCESSIVE CRANKCASE PRESSURE		
	Step 1. Check for worn piston rings, a hole or crack in a piston crown, or excessive exhaust back pressure.	Replace worn or damaged parts (para 4-10).
4. ENGINE HAS LOW OIL PRESSURE		
	Step 1. Check for excessive wear on crankshaft bearing journals or main bearings. Inspect crankshaft and main bearings.	Replace faulty crankshaft or main bearings, if necessary (para 4-12 and 4-13).

Section II. MAINTENANCE PROCEDURES

INDEX

	Para		Para
Camshaft	4-8	Cylinder head assembly and rocker arms	4-6
Connecting rod assembly	4-11	Fuel injectors	4-5
Crankcase assembly	4-13	Injection pump	4-4
Crankshaft assembly	4-12	Piston assembly	4-10
Cylinder assembly	4-9	Valves, valve guides, and valve seats	4-7
INDEX			

4-3. GENERAL INSTRUCTIONS

Most maintenance instructions in this section will list resources required, personnel required, and equipment condition for the start of the procedure. Note the following.

- * Resources required are not listed unless they apply to the procedure.
- * Personnel required are listed only if the task requires more than one. If PERSONNEL is not listed, it means one person can do the task.
- * The normal standard equipment condition to start a maintenance task is engine stopped and START/STOP switch set at STOP. EQUIPMENT CONDITION is not listed unless some other condition is required besides the power being off.
- * Refer to Appendix D to determine torque requirements when tightening threaded fasteners, unless a specific torque value is given in the procedure. Standard torque values given in Appendix D are determined by thread size.

4-4. REPAIR INJECTION PUMP

This task covers:

- a. Disassembly b. Repair c. Assembly
-

INITIAL SETUP:

Tools

- Shop set, automotive repair, field maintenance, basic
- Tool kit, master mechanics
- Tool kit, automotive electrical system
- Barrel seat cutter KDEP 2995
- Breast wrench KDEP 2887
- Bushing reamer KDEP 2999
- Connector, air source, 1/4-28
- Delivery valve puller KDEP 2892
- End play gage KDEP 2890
- Flyweight extractor EF 8449
- Flyweight pin wrench EFEP 187A
- Pipe plug, 1/4-28
- Plug tool, KDEP 2993
- Plunger pliers KDEP 2915
- Protective sleeve KDEP 2874
- Ring wrench KDEP 2961
- Tappet holder KDEP 2912
- Tappet tongs KDEP 2941
- Torque capsule wrench KDEP 2968

Materials/Parts

- Antiseize thread compound (Item 21, Appendix C)
- Crocus cloth (Item 1, Appendix C)
- Grease (Item 7, Appendix C)
- Lubricating oil (Item 10, Appendix C)
- Sealing compound (Item 15, Appendix C)

Equipment

Condition

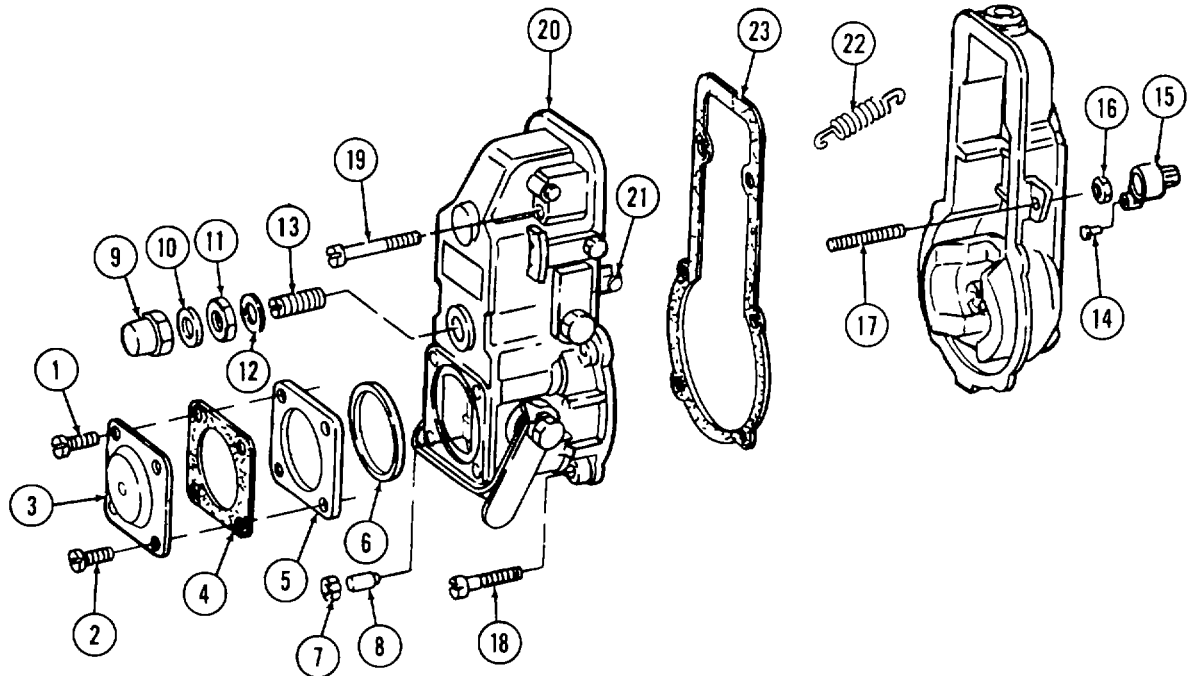
Para	Equipment Description
3-13	Injection pump removed from engine.

General Safety Instructions

Well-ventilated area required.

4-4. REPAIR INJECTION PUMP (Continued)

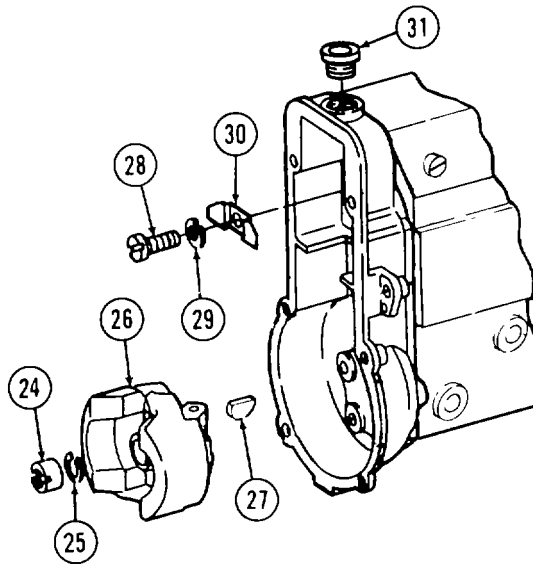
DISASSEMBLY



- 1 Mount fuel injection pump in vise.
- 2 Place an oil drain container under governor housing
- 3 Remove two bolts (1) and two bolts (2)
- 4 Remove cover (3) and drain oil into container.
- 5 Remove sealing plate (4), intermediate plate (5), and gasket (6).
- 6 Remove nut (7)
- 7 Remove torque capsule (8) using torque capsule wrench KDEP 2968
- 8 Remove cap nut (9) and washer (10).
- 9 Remove nut (11) and washer (12)
- 10 Remove setscrew (13).
- 11 Remove lead seal (14) and cap (15).
- 12 Remove nut (16) and adjusting screw (17)
- 13 Remove four screws (18) and two bolts (19).
- 14 Loosen governor cover (20) from governor housing using a rubber mallet. Swing open but do not remove governor cover.

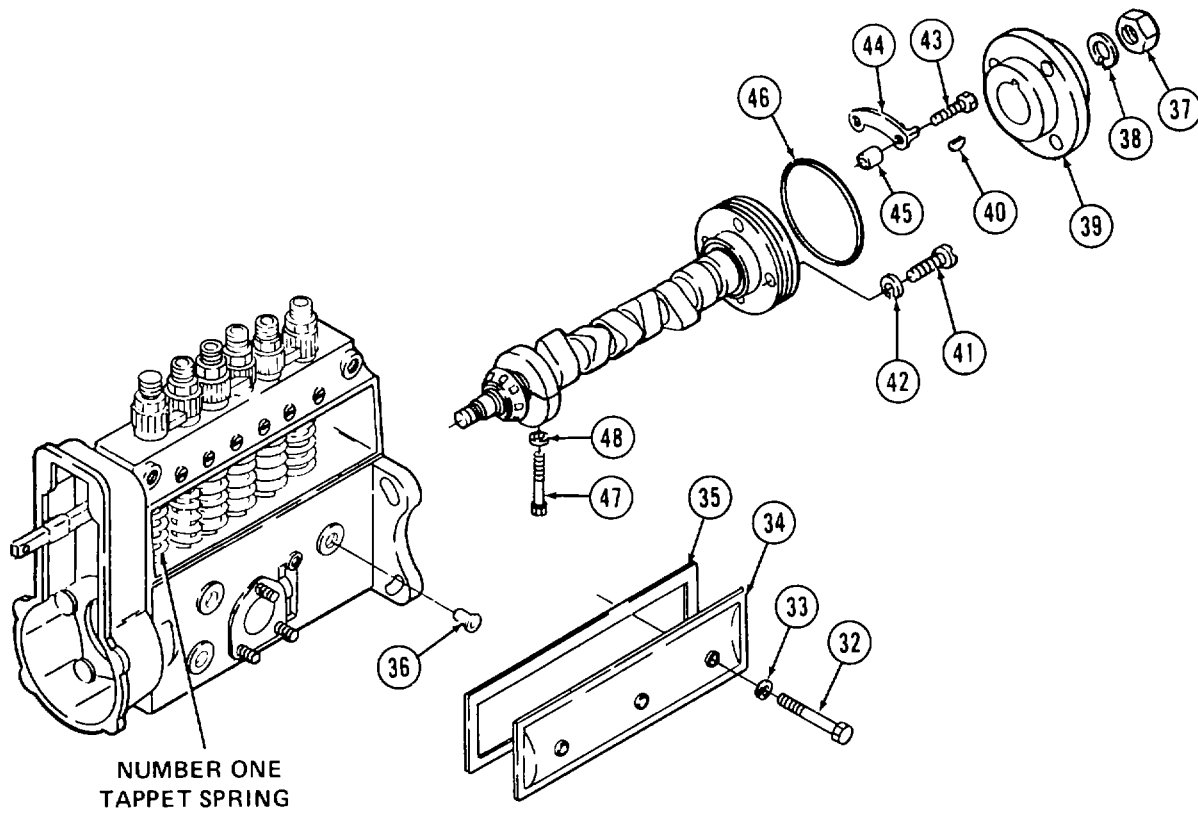
4-4. REPAIR INJECTION PUMP (Continued)

- 15 Disconnect rack link (21) from injection pump by spreading end of rack link.
- 16 Remove draw spring (22) using needle-nose pliers
- 17 Remove governor cover (20).
- 18 Remove and discard gasket (23).



- 19 Hold camshaft steady by using a wrench on hub nut Remove annular nut (24) using flyweight pin wrench EFEP 187A
- 20 Remove lockwasher (25).
- 21 Remove flyweight (26) using flyweight extractor EF 8449
- 22 Remove woodruff key (27) from injection pump camshaft.
- 23 Remove screw (28) and lockwasher (29).
- 24 Remove retaining plate (30)
- 25 Remove screw plug (31)

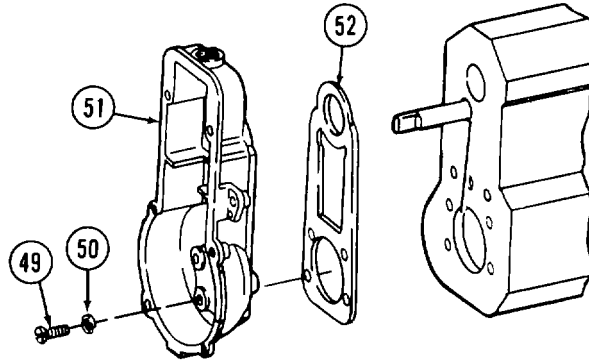
4-4. REPAIR INJECTION PUMP (Continued)



- 26 Remove two bolts (32) and two sealing rings (33)
- 27 Remove cover (34)
- 28 Remove and discard gasket (35).
- 29 Remove cap (36)
- 30 Lift and hold roller tappets away from camshaft lobes
 - a. Rotate hub until number one tappet spring is fully compressed.
 - b. Install tappet holder KDEP 2912 so that nose of bottom pawl ties between tappet capscrew and nut
 - c. Press lever on tappet holder KDEP 2912 and guide tappet holder top pawl into housing recess.
 - d. Repeat steps a through c above to lift remaining five tappets from camshaft lobes
- 31 Remove nut (37), lockwasher (38), and hub (39) from camshaft.
- 32 Remove and discard woodruff key (40)
- 33 Remove two bolts (41) and two lockwashers (42)
- 34 Remove two screws (43), timing indicator (44), and two spacers (45)

4-4. REPAIR INJECTION PUMP (Continued)

- 35 Remove and discard preformed packing (46).
- 36 Remove two screws (47) and two sealing rings (48) from housing
- 37 Loosen bearing cap, camshaft, and bearing assembly by tapping governor end of camshaft with a rubber mallet
Remove bearing cap, camshaft, and bearings as an assembly
- 38 Remove six screws (49) and six washers (50).

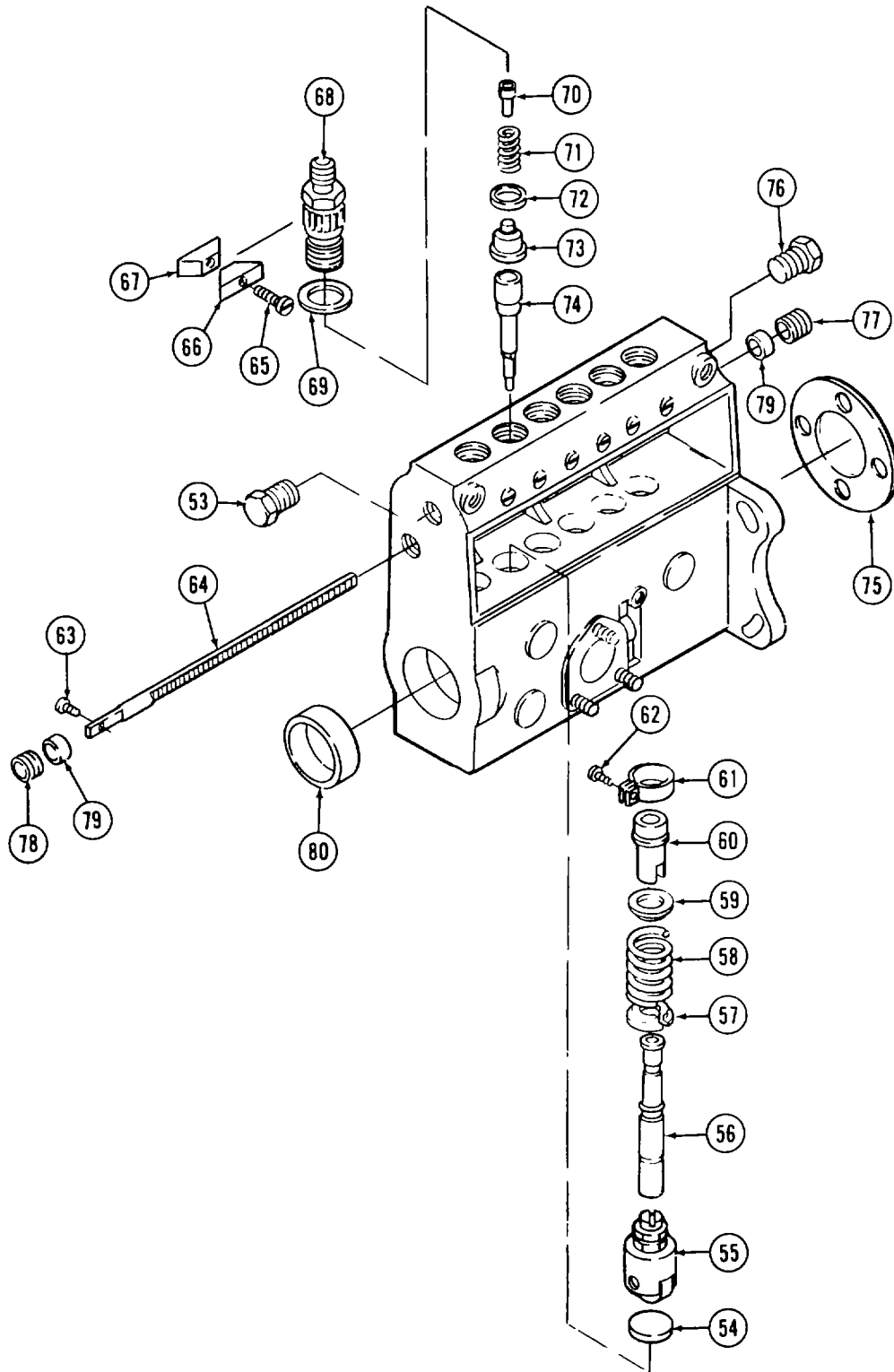


CAUTION

In the following step, tap housing straight back from fuel injection pump. The camshaft bearing support may break off if housing is twisted while being removed.

39. Carefully remove housing (51) from injection pump by tapping with rubber mallet
40. Remove and discard gasket (52)
41. Remove screw plug (53).
42. Remove six lock fasteners (54) using breast wrench KDEP 2887.
43. Remove roller tappet assembly (55).
 - a. Push against one roller tappet assembly (55) using tappet tongs KDEP 2941 to relieve spring force on tappet holder
 - b. Remove tappet holder
 - c. Pull roller tappet assembly (55) through housing bore from bottom of housing using a second tappet tongs
 - d. Remove roller tappet assembly (55) from tappet tongs
 - e. Tag roller tappet assembly (55) to indicate the bore from which the assembly was removed.

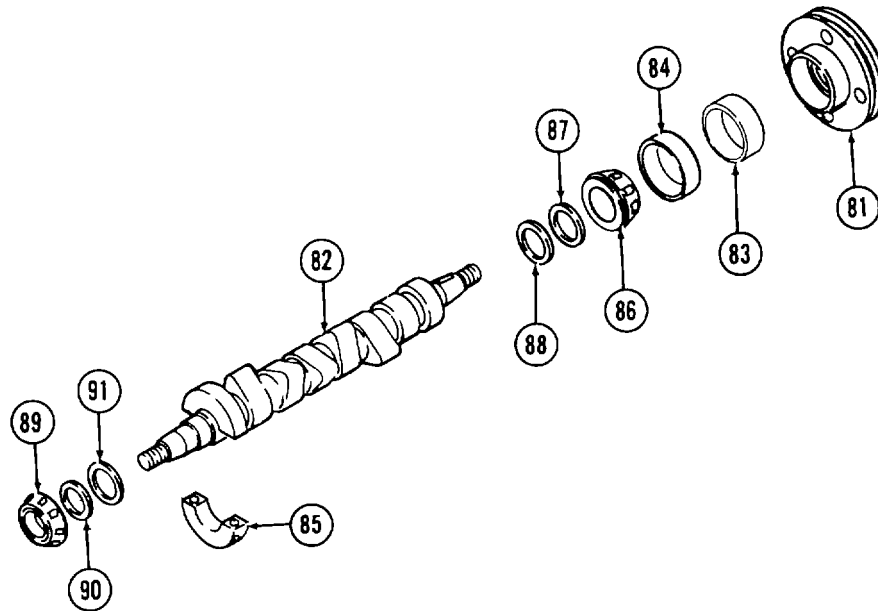
4-4. REPAIR INJECTION PUMP (Continued)



4-4 REPAIR INJECTION PUMP (Continued)

- f. Repeat steps a through e for other five tappet assemblies.
- 44 Remove the following parts from bore number one
- a. Remove piston (56) and lower spring cap (57) using plunger pliers KDEP 2915.
 - b. Remove piston spring (58).
 - c. Remove upper spring cap (59)
 - d. Scribe control sleeve (60) and gear ring (61).
 - e. Remove clamping screw (62).
 - f. Remove control sleeve (60) and gear ring (61)
 - g. Tag those parts removed in steps a through f to indicate the bore from which the parts were removed. Keep mating parts together.
 - h. Repeat steps a through g for other five bores.
- 45 Remove screw (63)
- 46 Remove rod (64) from housing
- 47 Remove three screws (65), three jaws (66), and three jaws (67)
- 48 Remove the following parts from bore number one
- a. Remove pipe connection (68) using socket wrench
 - b. Remove and discard sealing ring (69).
 - c. Remove filler (70)
 - d. Remove spring (71).
 - e. Remove and discard sealing washer (72)
 - f. Remove delivery valve (73) using delivery valve puller KDEP 2892. Screw valve puller into delivery valve. Use a wrench to turn the valve puller clockwise to remove delivery valve.
 - g. Remove plunger (74)
 - h. Tag items removed in steps a, c, d, f, and g to indicate from which bore the parts were removed.
 - i. Repeat steps a through h for remaining five bores
- 49 Remove and discard gasket (75)
- 50 Remove screw plug (76) using plug tool KDEP 2993.
- 51 Remove guide bushing (77) using bushing puller
- 52 Remove threaded ring (78) using allen wrench.
- 53 Remove and discard two rings (79).
- 54 Remove bearing cup (80) from housing using bearing puller

44. REPAIR INJECTION PUMP (Continued)

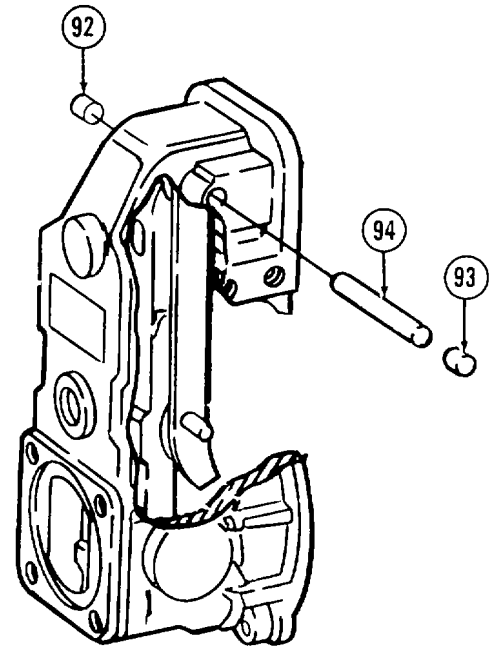


- 55 Install protective sleeve KDEP 2874 on bearing cap (81)
- 56 Press bearing cap (81) from camshaft (82) using mechanical puller. Remove protective sleeve KDEP 2874.
- 57 Remove oil seal (83) from bearing cap (81). Discard oil seal.
- 58 Remove bearing cup (84) from end plate using bearing puller.
- 59 Remove bearing support (85) from camshaft.
- 60 Press bearing cone (86) from camshaft using mechanical puller.
- 61 Remove shims (87) and wire together to prevent loss. Remove intermediate ring (88)
- 62 Press bearing cone (89) from camshaft using mechanical puller.
- 63 Remove shims (90) and wire together to prevent loss. Remove intermediate ring (91).

4-4. REPAIR INJECTION PUMP (Continued)

64 Drive out plug (92) by using a hammer and punch on plug (93) on opposite side

65 Insert punch through hole where plug (92) was removed. Use a hammer on punch to drive out plug (93) and axle (94).



66 Remove C-clip (95) using screwdriver Remove connecting plate (96).

67 Remove lever arms (97 and 98), bearing support (99), and shims (100) as an assembly by sliding assembly down and out from under lever (145).

68 Remove C-clip (101) using screwdriver. Remove lever arm (98) from lever arm (97)

69 Press bearing support (99) and shims (100) from lever arm (97).

70 Remove spring (102) using long-nosed pliers to unhook ends.

71 Remove lever arm (103) by sliding up and out from behind lever (145)

72 Remove screw (104) and lockwasher (105).

73 Remove screw plug (106) and washer (107)

74 Remove shutdown lever (108).

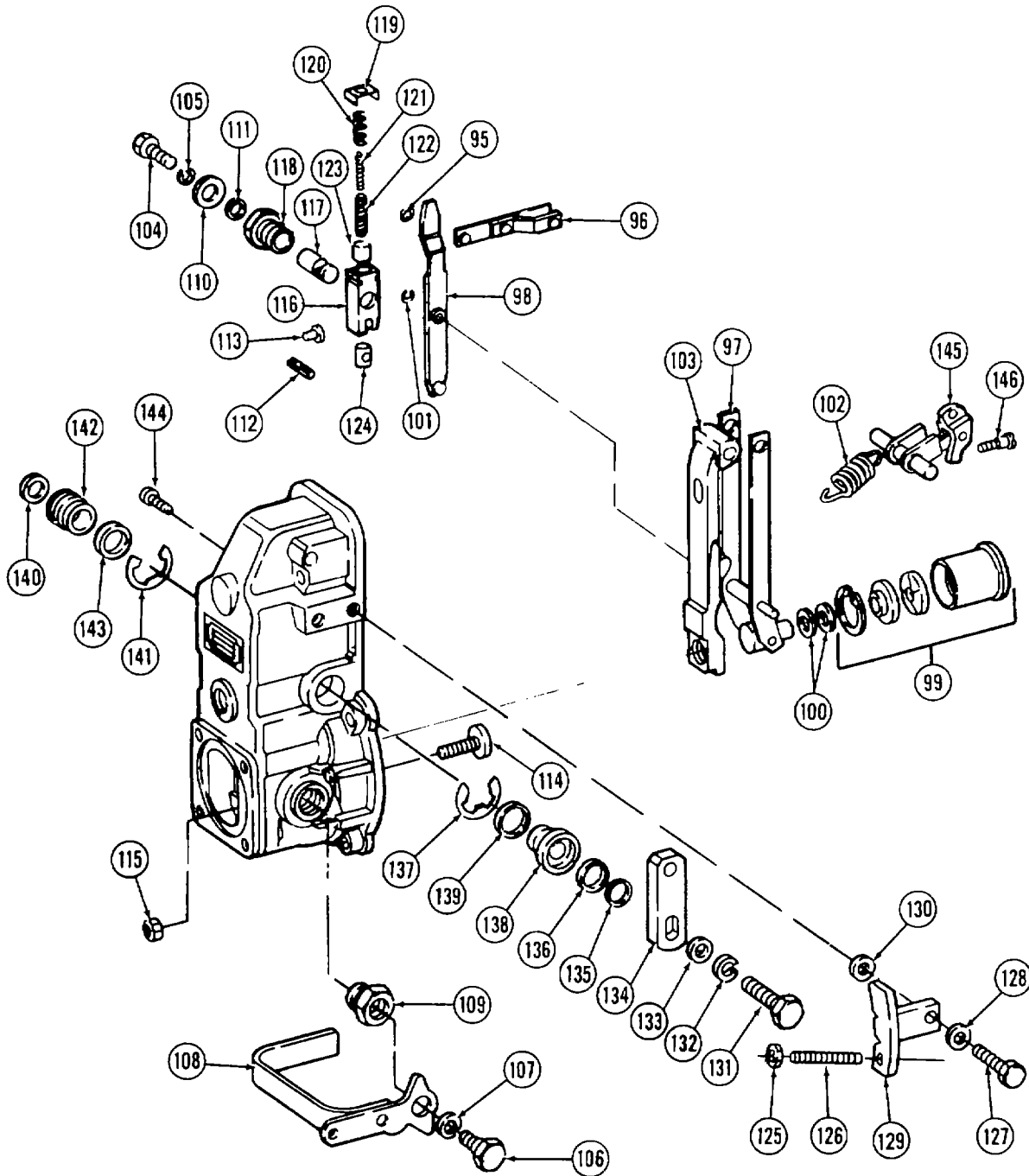
75 Remove threaded bushing (109).

76 Remove shim (110) and washer (111).

77 Remove parallel pin (112) and studpin (113)

78 Use a wrench and screwdriver to remove banjo bolt (114) and nut (115).

4-4. REPAIR INJECTION PUMP (Continued)

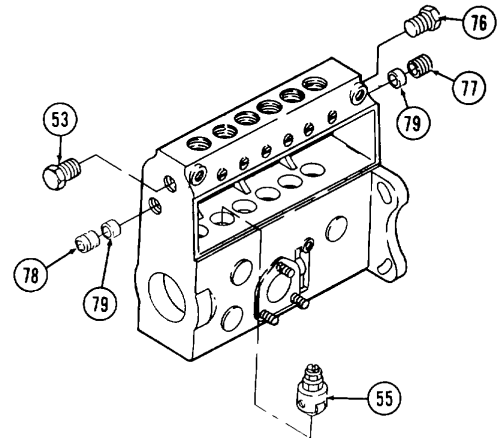


4-4. REPAIR INJECTION PUMP (Continued)

- 79 Remove clevis (116) and shaft (117) as an assembly
- 80 Remove threaded bushing (118).
- 81 Disassemble clevis (116) by removing spring-loaded retainer (119), compression springs (120, 121, and 122), and spring capsule (123)
- 82 Slide shaft (117) from clevis (116)
- 83 Remove sliding pad (124) from clevis (116)
- 84 Remove nut (125) and threaded pin (126).
- 85 Remove two bolts (127) and two washers (128)
- 86 Remove bracket (129) and two washers (130)
- 87 Remove bolt (131)
- 88 Remove lockwasher (132) and washer (133).
- 89 Remove control lever (134)
- 90 Remove washers (135 and 136)
- 91 Remove C-clip (137) Remove bearing bushing (138) and washer (139).
- 92 Remove capsule (140)
- 93 Remove C-clip (141). Remove bearing bushing (142) and washer (143).
- 94 Remove screw plug (144).
- 95 Remove lever (145) Remove screw (146) from lever

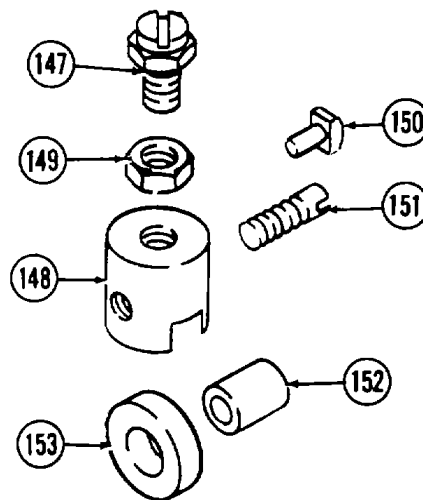
REPAIR:

- 1 Inspect injection pump housing for cracks, distortion, or thread damage Clean up rough barrel seats in housing using light cuts with barrel seat cutter KDEP 2995 If other defects are found, replace housing along with screw plug (53), screw plug (76), guide bushing (77), threaded ring (78), and two rings (79) as an assembly.
- 2 Inspect six roller tappet assemblies (55) by rotating roller and checking that it turns smoothly without wobble. Also check for flat spots, pitting, scratches, or cracks If defects are found, repair as follows.



4-4. REPAIR INJECTION PUMP (Continued)

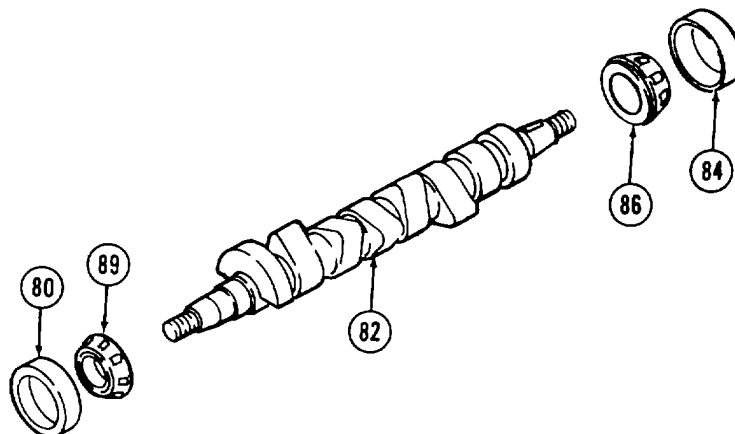
- a. Measure and record height of screw (147) above tappet (148).
- b. Loosen nut (149), and remove screw (147) and nut. Remove guide pin (150).
- c. Press stud (151) from bushing (152) and tappet (148). Remove bushing from roller (153).
- d. Inspect screw (147) for thread damage and for worn or crushed end. Replace if damaged.
- e. Inspect tappet (148) for pressure marks or scoring. Remove light marks and scoring using crocus cloth.
- f. Inspect stud (151) for grooving. Replace if grooved or bent.
- g. Inspect nut (149), guide pin (150), bushing (152), and roller (153) for heavy wear. Replace damaged parts.



- h. Press bushing (152) into roller (153), and position roller in tappet (148).
- i. Press stud (151) through tappet (148) and into bushing (152). Install guide pin (150), nut (149), and screw (147). Turn screw to height above tappet body as recorded in step a above.
- j. Install guide pin (150), nut (149), and screw (147). Turn screw to height above tappet body as recorded in step a above.
- k. Tighten nut (149) to secure screw (147).

3. Inspect camshaft (82) for cracks or distortion. Inspect threads for damage. Inspect cam lobes for chipping, scoring, grooving, or cracks. If damaged, replace camshaft.

4. Inspect bearing cups (80 and 84) and bearing cones (86 and 89) for flat areas, pitting, cracks, or chipping. Inspect bearing cones for cracked races. Replace mating bearing cups and bearing cones as a pair if either is damaged.



4-4. REPAIR INJECTION PUMP (Continued)

5 Inspect six pistons (56) and six plungers (74) for scratches, nicks, and grooves. Dip each mating plunger and barrel in clean calibrating fluid. Place piston in plunger. Hold parts vertically and position about 3/4 of plunger length in piston. Release plunger into barrel. Plunger must slide smoothly into barrel until it reaches the stop. If part fails inspection, replace mating barrel and plunger as an assembly.

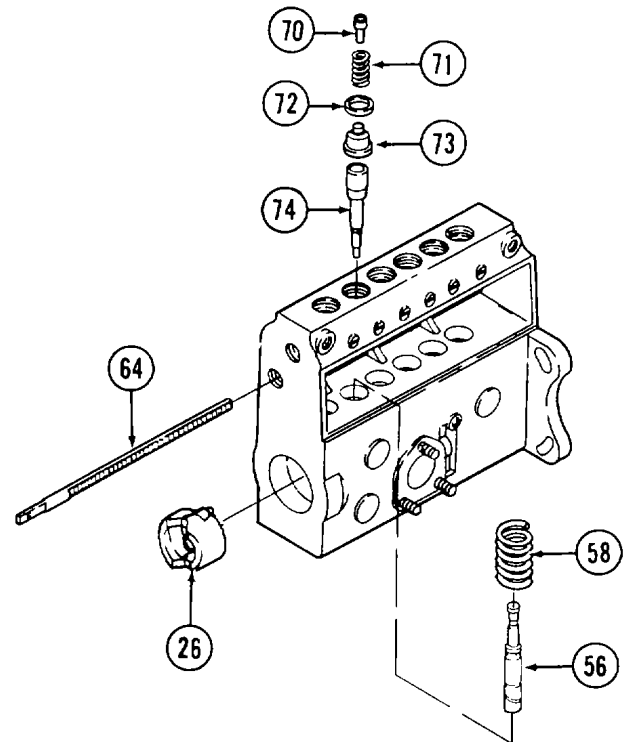
6 Inspect six delivery valves (73) and six fillers (70) for cracks or grooving. Inspect delivery valve for crushed or unevenly worn seats. Insert each filler into mating delivery valve and inspect for freedom of movement. If either part is damaged, replace both filler and its mating delivery valve.

7 Inspect six piston springs (58) for damage to protective coating, cracks, or permanent set. Replace damaged spring.

8 Inspect rod (64) for chipping, cracks, or worn gear teeth. Remove slight grooving using crocus cloth. If otherwise damaged, replace rod.

9 Inspect flyweight (26) for damaged or worn rollers, pivot pins, and weights. If damaged, replace flyweight as an assembly.

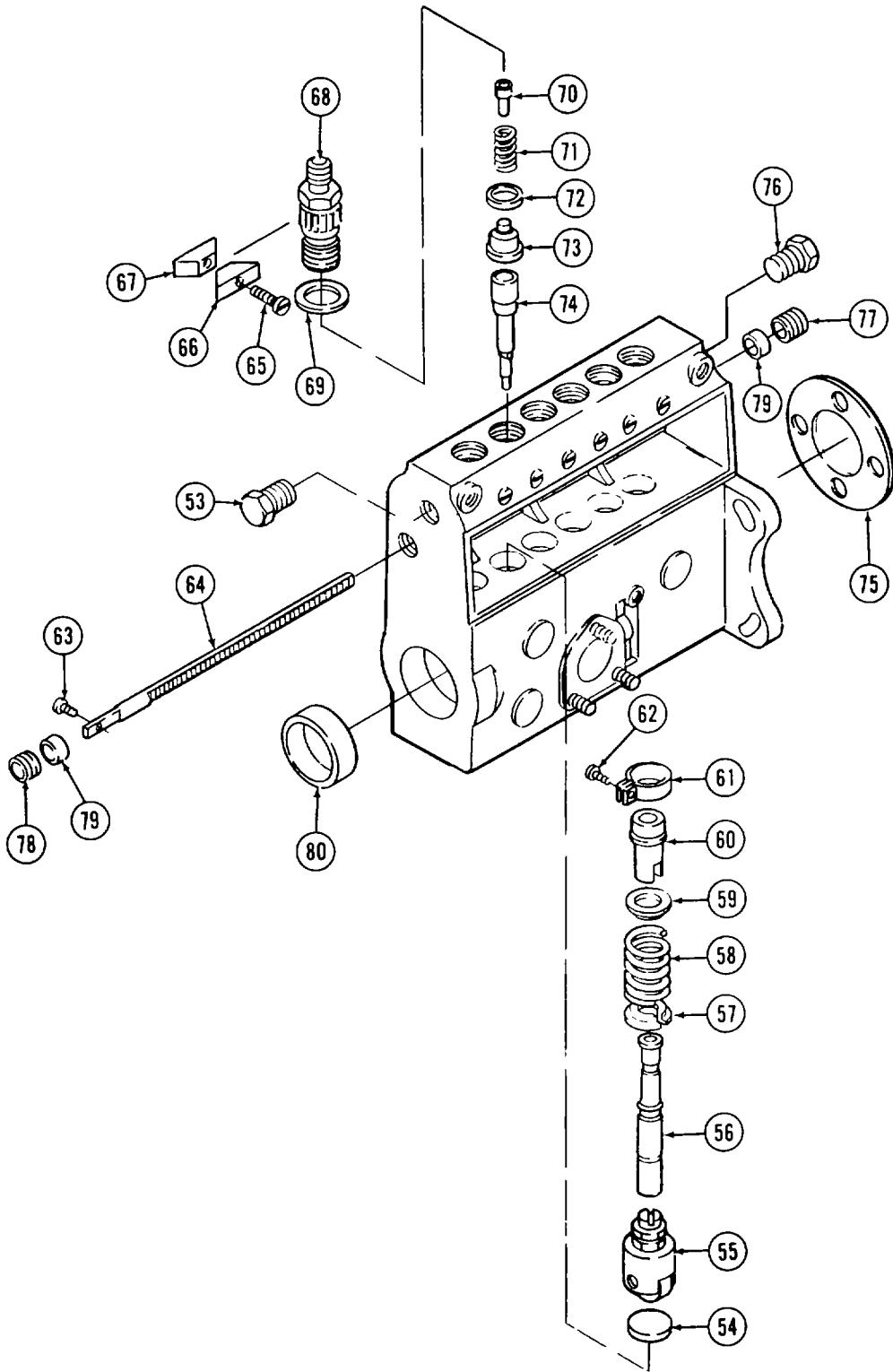
10 Inspect all other parts for cracks, distortion, uneven wear, or heavy grooving. Inspect all threaded parts for damage to threads. Replace damaged part.



ASSEMBLY:

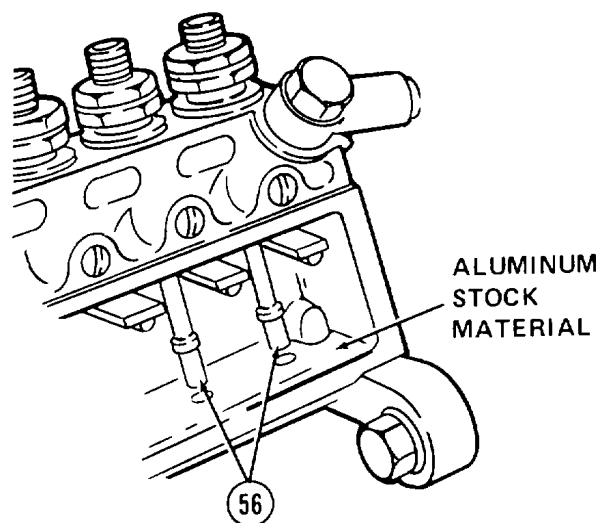
- 1 Install two rings (79) into housing.
- 2 Install threaded ring (78).
- 3 Install guide bushing (77) using ring wrench KDEP 2961.
- 4 If new rings (79) were installed, ream rings using bushing reamer KDEP 2999. Remove all chips created by reaming operation.
- 5 Place together the following parts tagged as belonging to bore number one during disassembly: pipe connection (68), filler (70), spring (71), delivery valve (73), and plunger (74). Install parts as follows:
 - a. Lower plunger (74) into housing bore number one. Align groove in plunger with pin in housing.
 - b. Install delivery valve (73) into bore and onto plunger.
 - c. Install a new sealing washer (72).

4-4. REPAIR INJECTION PUMP (Continued)



4-4. REPAIR INJECTION PUMP (Continued)

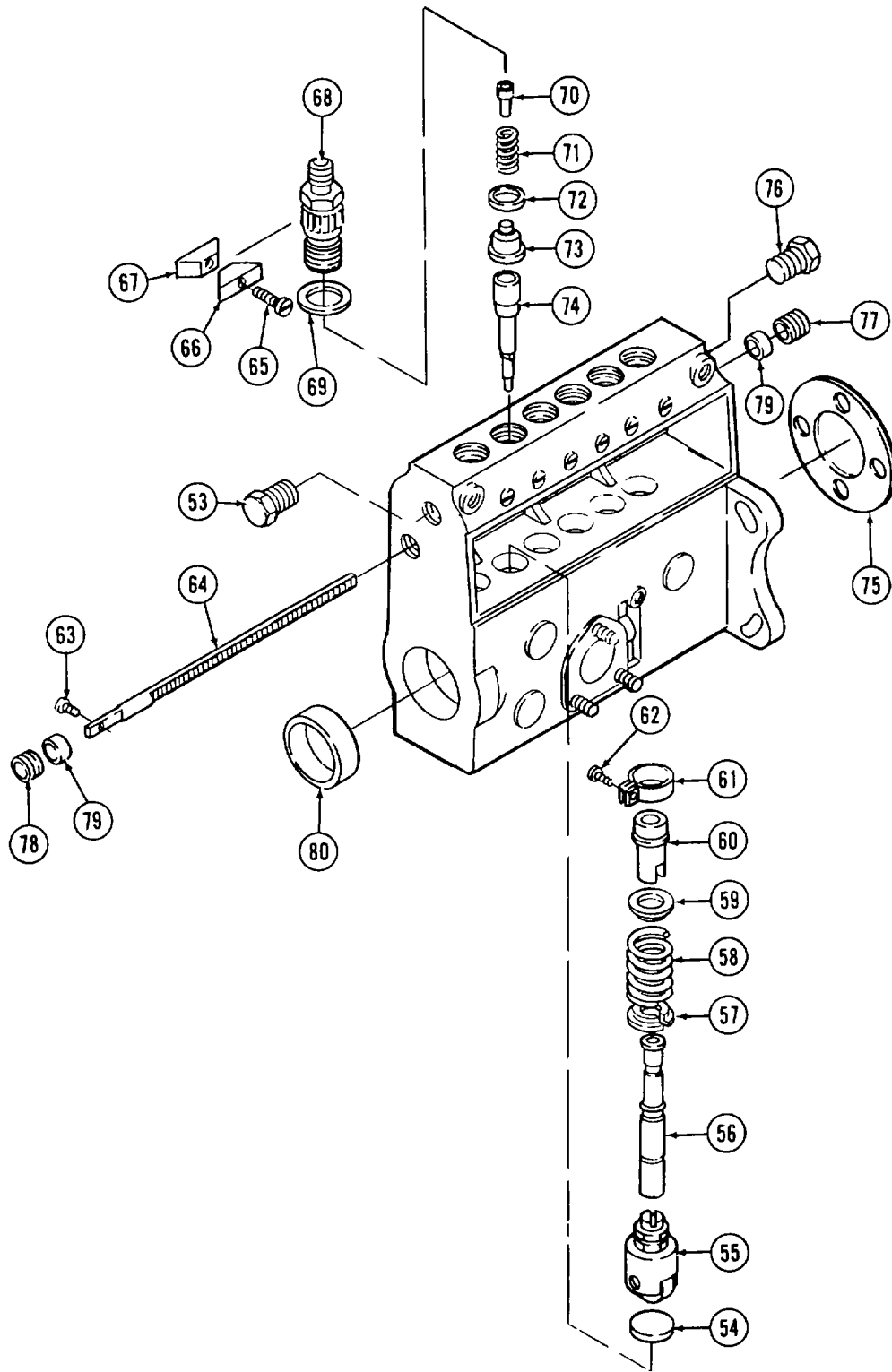
- d. Install spring (71) and filler (70)
 - e. Install a new sealing ring (69)
 - f. Install pipe connection (68) using torque wrench Torque to 32 to 33 ft-lb (43.4 to 44.8 N•m).
 - g. Repeat steps a through f for remaining five bores.
- 6 Apply thread compound to threads of screw plug (76). Install screw plug into housing.
 - 7 Apply thread compound to screw plug (53). Install screw plug into housing using plug tool KDEP 2993 and torque wrench Torque to 44 to 50 ft-lb (59.7 to 67.8 N•m).
 - 8 Place pistons (56) into bores as tagged during disassembly. Using plunger pliers KDEP 2915, install the piston over plunger (74) so that markings on piston face outward
 - 9 Cut a piece of aluminum stock to size to fit ledge of housing. Place the cut aluminum stock on ledge to hold piston in position as shown.

**WARNING**

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

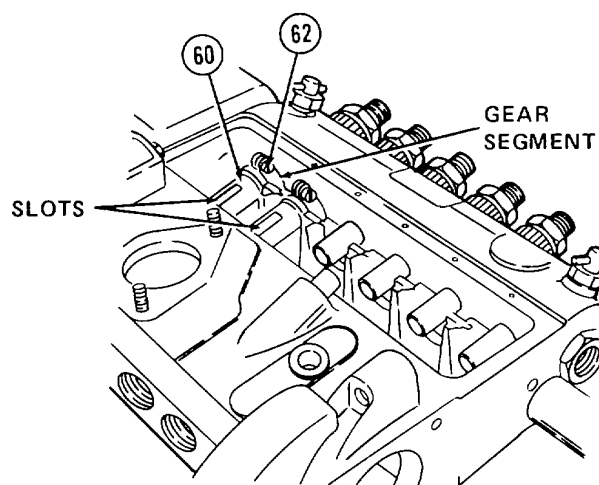
- 10 Install a 1/4-28 pipe plug into threaded port near drive end of housing. Connect a source of compressed air to the threaded port near the governor end of the housing using a 1/4-28 connector.
- 11 Immerse the housing into a vat of clean calibrating fluid. Apply 40 psi (2.81 kg/cm²) air pressure to the housing. Inspect for defects as follows:
 - a. Check for air bubbles from screw plugs (76 and 53). Air bubbles indicate defective parts.
 - b. Check for air bubbles from around delivery valve (73) and barrel seats of housing. A steady stream of air bubbles indicates a defective sealing ring (69) or sealing washer (72). An intermittent stream of air bubbles is permissible.

4-4. REPAIR INJECTION PUMP (Continued)



4-4. REPAIR INJECTION PUMP (Continued)

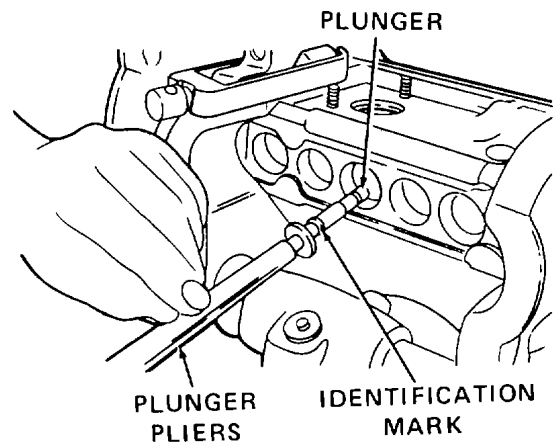
- c. Remove housing from vat.
 - d. Relieve air pressure Disconnect air pressure source and remove 1/4-28 connector from port. Remove 1/4-28 pipe plug from other port.
 - e. Remove aluminum stock from ledge.
 - f. Remove six pistons (56) using plunger pliers KDEP 2915.
 - g. If any defects were indicated in steps a or b, remove and discard defective parts. Install new parts and repeat steps 8 through 11 to inspect for defects.
 - h. If no defects were indicated in steps a or b, continue to step 12 below
- 12 Install three jaws (67), three jaws (66), and three screws (65)
- 13 Install rod (64) into housing.
- 14 Position rod (64) at center of travel. Install screw (63) using torque wrench Torque screw to 44 to 52 in-lb (59.7 to 70.5 N•m).
- 15 Place together the following parts tagged during disassembly as belonging to bore number one gear ring (61), control sleeve (60), and screw (62).
- a. Install screw (62) onto gear ring (61) but do not tighten
 - b. Place gear ring (61) onto control sleeve (60)
 - c. Position gear ring so that adjusting slot of control sleeve faces out and screw is on the right hand side.
 - d. Slide control sleeve (60) onto plunger (74) of appropriate bore.
 - e. Mesh gear teeth of gear ring (61) onto gear teeth of rod (64)
 - f. Rotate control sleeve (60) to face outward as shown. If control sleeve and gear ring are the original parts, aline scribe marks made during disassembly
 - g Tighten screw (62) to 26 to 28 in-lb (2.9 to 3.2 N•m)



4-4. REPAIR INJECTION PUMP (Continued)

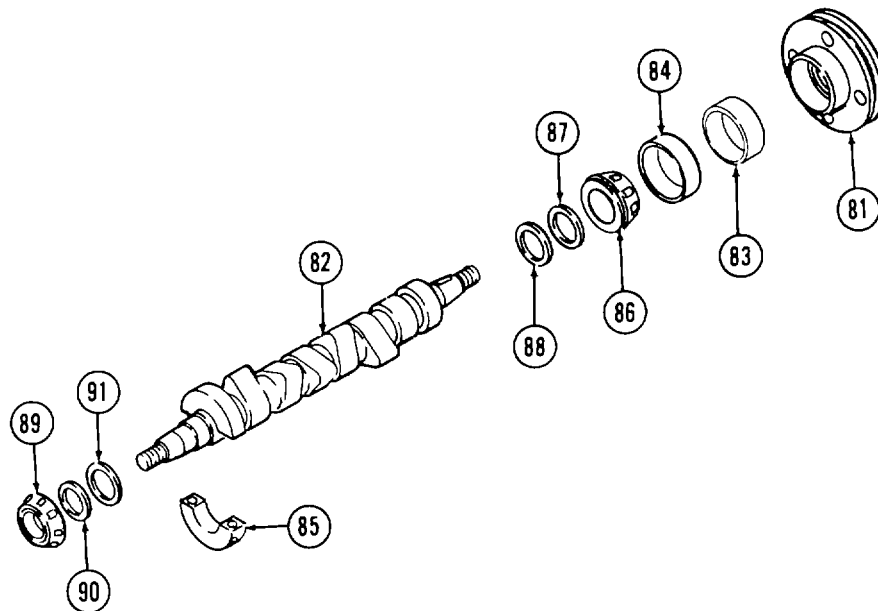
- h. Check that rod (64) and gear ring (61) move freely. Check that gear ring moves through its full range of travel. If necessary, reposition gear ring on rod according to step f.
 - i. Repeat steps a through h for remaining five bores
- 16 Place together the following parts tagged during disassembly as belonging to bore number one roller tappet assembly (55), piston (56), lower spring cap (57), piston spring (58), and upper spring cap (59). Install these parts in bore number one as follows.

- a. Install upper spring cap (59)
- b. Install piston spring (58).
- c. Install piston (56) and lower spring cap (57) using plunger pliers KDEP 2915. Position identification mark on piston as shown.



- d. Grasp roller tappet assembly (55) using tappet tongs KDEP 2941. Insert tappet assembly (55) through housing bore.
 - e. Reach through housing bottom bore using second tappet tongs KDEP 2941. Grasp roller tappet assembly (55) and align tappet pin with guide groove of housing bore.
 - f. Place bottom pawl of tappet holder KDEP 2912 between tappet screw and nut.
 - g. Press lever of tappet holder KDEP 2912 and guide top pawl of tappet holder into housing recess.
 - h. Repeat steps a through g for remaining five bores.
- 17 Install bearing cup (80) into housing.

4-4. REPAIR INJECTION PUMP (Continued)



- 18 Press new oil seal (83) into bearing cap (81)
- 19 Press bearing cup (84) into bearing cap (81)
- 20 Place intermediate ring (91) and shims (90) onto governor end of camshaft (82)

CAUTION

Press only on the inner race of bearing cone during installation to prevent damage to bearing.

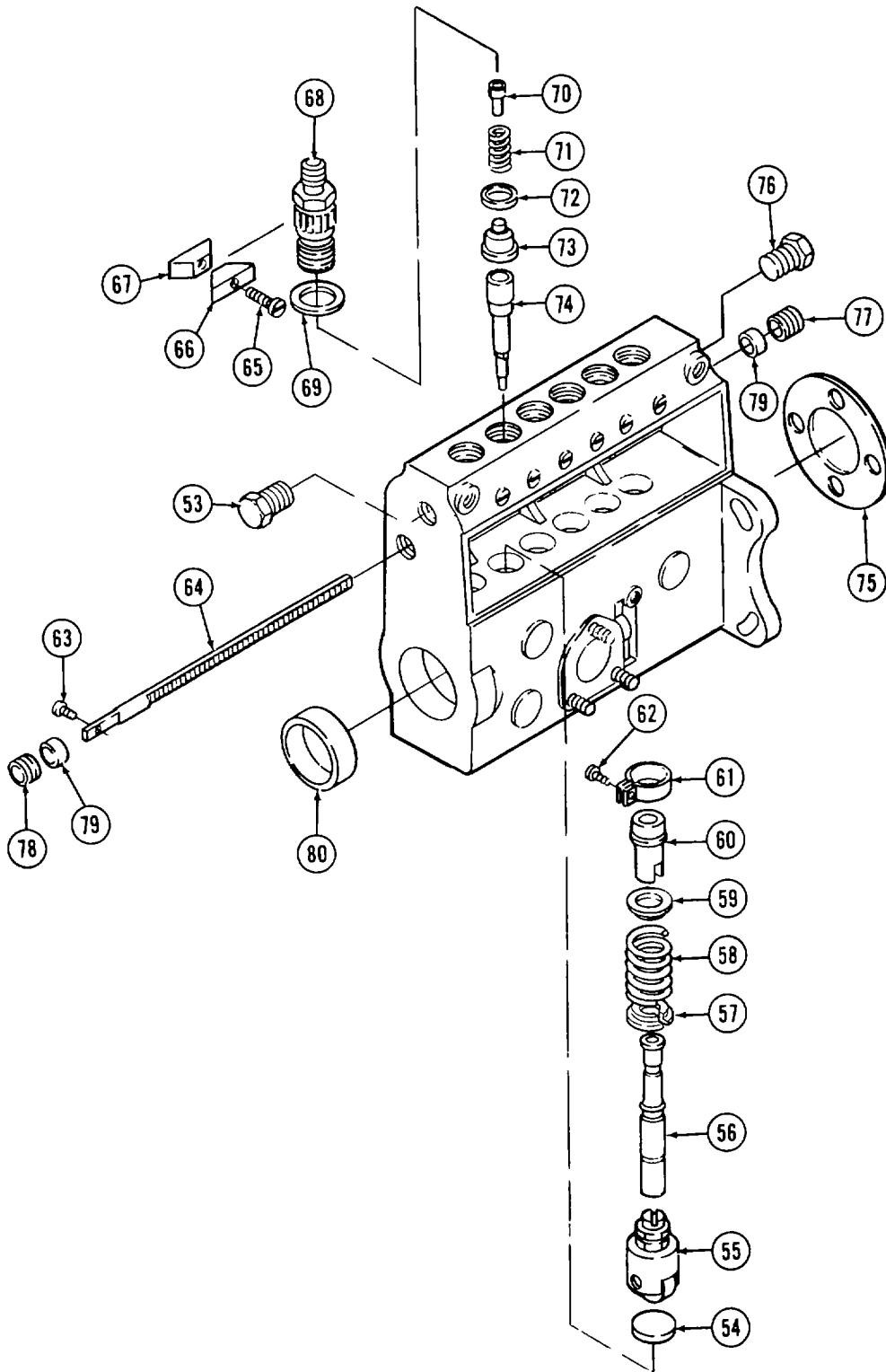
- 21 Press bearing cone (89) onto camshaft (82)
- 22 Place intermediate ring (88) and shims (87) onto drive end of camshaft (82)

CAUTION

Press only on inner race of bearing cone during installation to prevent damage to bearing.

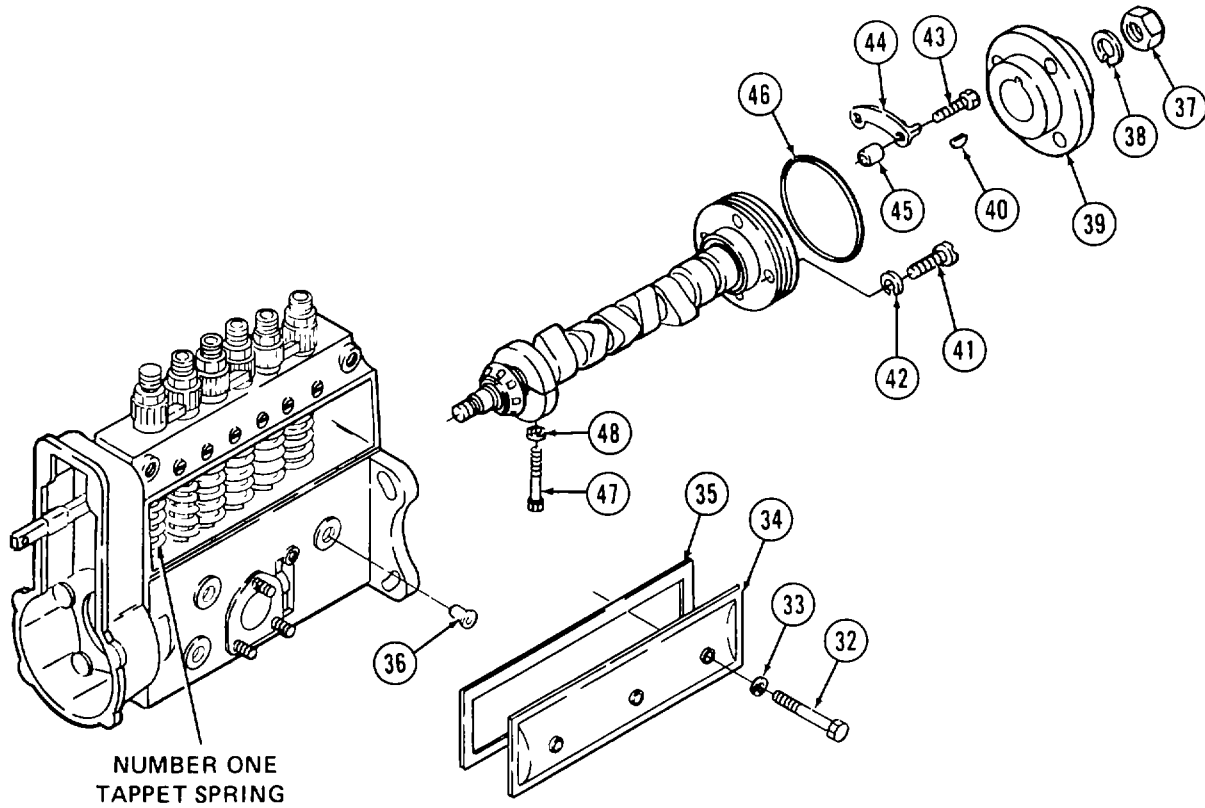
- 23 Press bearing cone (86) onto camshaft (82)
- 24 Apply a thin film of MolyKote paste to surface of bearing support (85) Install bearing support onto camshaft (82)
- 25 Press bearing cap (81) onto camshaft (82).

4-4. REPAIR INJECTION PUMP (Continued)



4-4. REPAIR INJECTION PUMP (Continued)

26 Install new gasket (75) into housing.



27 Install assembled bearing cap (81) and camshaft (82) into housing

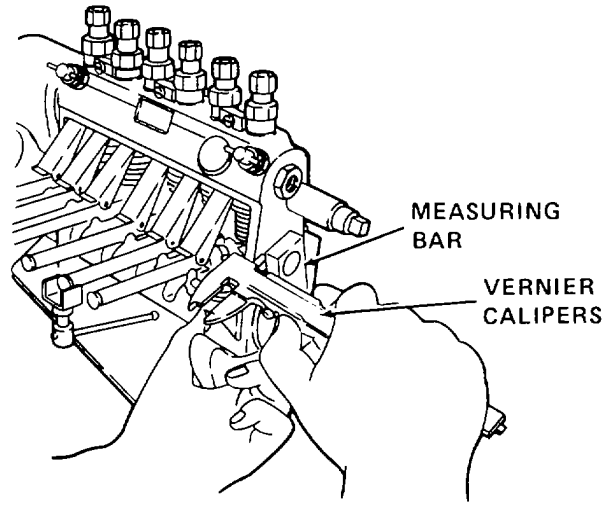
28 Install two screws (41) and two lockwashers (42) Torque screws to 61 to 78 in-lb (6.9 to 8.8 N•m).

29 Install two spacers (45), timing indicator (44), and two screws (43). Torque screws to 61 to 78 in-lb (6.9 to 8.8 N•m).

4-4. REPAIR INJECTION PUMP (Continued)

30 Check camshaft projection as follows.

- a. Place measuring bar over shaft of camshaft drive end. Keep firm pressure on measuring bar.
- b. Measure and record distance from housing face to measuring bar using vernier caliper as shown.
- c. If distance measured is between 0.36 to 0.39 inch (9.1 to 9.9 mm), skip steps d through m and proceed with step 31.
- d. If distance measured is not between 0.36 to 0.39 inch (9.1 to 9.9 mm), remove two screws (43), timing indicator (44), two spacers (45), two screws (41), and two lockwashers (42)
- e. Tap governor end of camshaft using rubber mallet. Remove bearing cap and camshaft as an assembly
- f. Install protective sleeve KDEP 2874 onto bearing cap (81) Press bearing cap from camshaft using mechanical puller Remove protective sleeve KDEP 2874.
- g. Remove and discard oil seal (83) Remove bearing cone (89) from governor end of camshaft using mechanical puller



4-4. REPAIR INJECTION PUMP (Continued)

- h. If measurement recorded in step a is less than 0.36 inch (9.1 mm), add shim (90). If measurement recorded in step a is more than 0.39 inch (9.9 mm), remove a shim (90).
- i. Press new oil seal (83) into bearing cap (81).

CAUTION

Press only on inner race of bearing cone during installation to prevent damage to bearing.

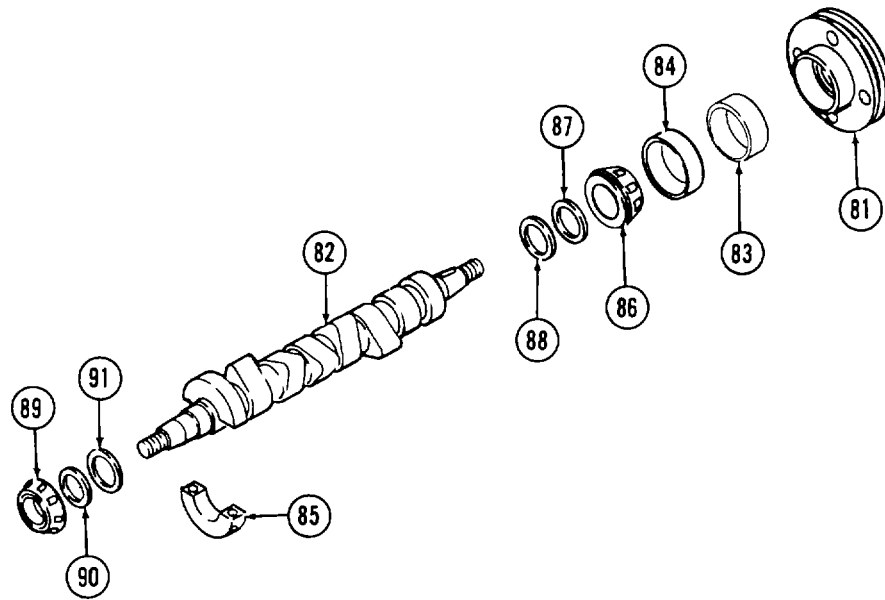
- j. Press bearing cone (89) onto camshaft (82). Press bearing cap (81) onto camshaft.
 - k. Install assembled bearing cap (81) and camshaft (82) into housing.
 - l. Install two screws (41) and two lockwashers (42). Torque screws to 61 to 78 in-lb (6.9 to 8.8 N m).
 - m. Install two spacers (45), timing indicator (44), and two screws (43). Torque screws to 61 to 78 in-lb (6.9 to 8.8 Nm).
 - n. Repeat steps a through m to recheck camshaft projection.
- 31 Check camshaft end play as follows
- a. Place a wood block into feed pump bore to prevent camshaft rotation. Screw end play gage KDEP 2890 onto drive end of camshaft. Remove wood block.
 - b. Install dial indicator on end play gage.

NOTE

Exert steady pressure along camshaft centerline in the following two steps. Side pressure will give incorrect measurements.

- c. Steadily pull and swivel end play gage. Set dial indicator to zero.
- d. Press firmly and squarely on end play gage while swiveling the gage. Record dial indicator reading.
- e. Remove dial indicator from end play gage. Install a wooden block into housing bore to prevent camshaft rotation. Remove end play gage. Remove wooden block.
- f. If dial indicator reading for end play is between 0.0008 to 0.0024 inch (0.020 to 0.061 mm), skip steps g through q and proceed with step 32.
- g. If dial indicator reading is not between 0.0008 and 0.0024 inch (0.024 to 0.061 mm), remove two screws (43), timing indicator (44), two spacers (45), two screws (41), and two lockwashers (42).
- h. Tap governor end of camshaft using rubber mallet. Remove bearing cap and camshaft as an assembly.

4-4. REPAIR INJECTION PUMP (Continued)



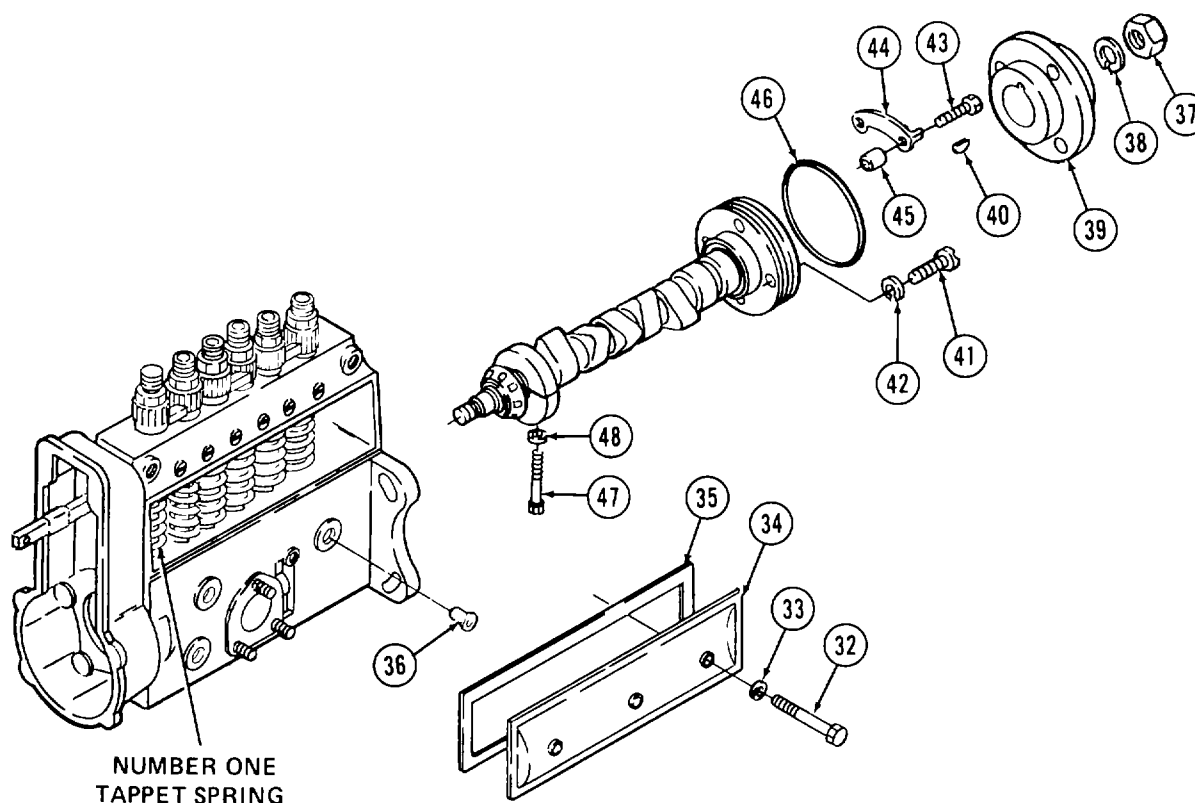
- i. Install protective sleeve KDEP 2874 onto bearing cap (81). Press bearing cap from camshaft (82) using mechanical puller. Remove protective sleeve.
- j. Remove and discard oil seal (83). Remove bearing cone (86) from drive end of camshaft using mechanical puller.
- k. If reading recorded in step d is less than 0.0008 inch (0.020 mm), remove shim (87). If end play is more than 0.0024 inch (0.061 mm), add a shim.
- l. Press new oil seal (83) into bearing cap (81).

CAUTION

Press only on inner race of bearing cone during installation to prevent damage to bearing.

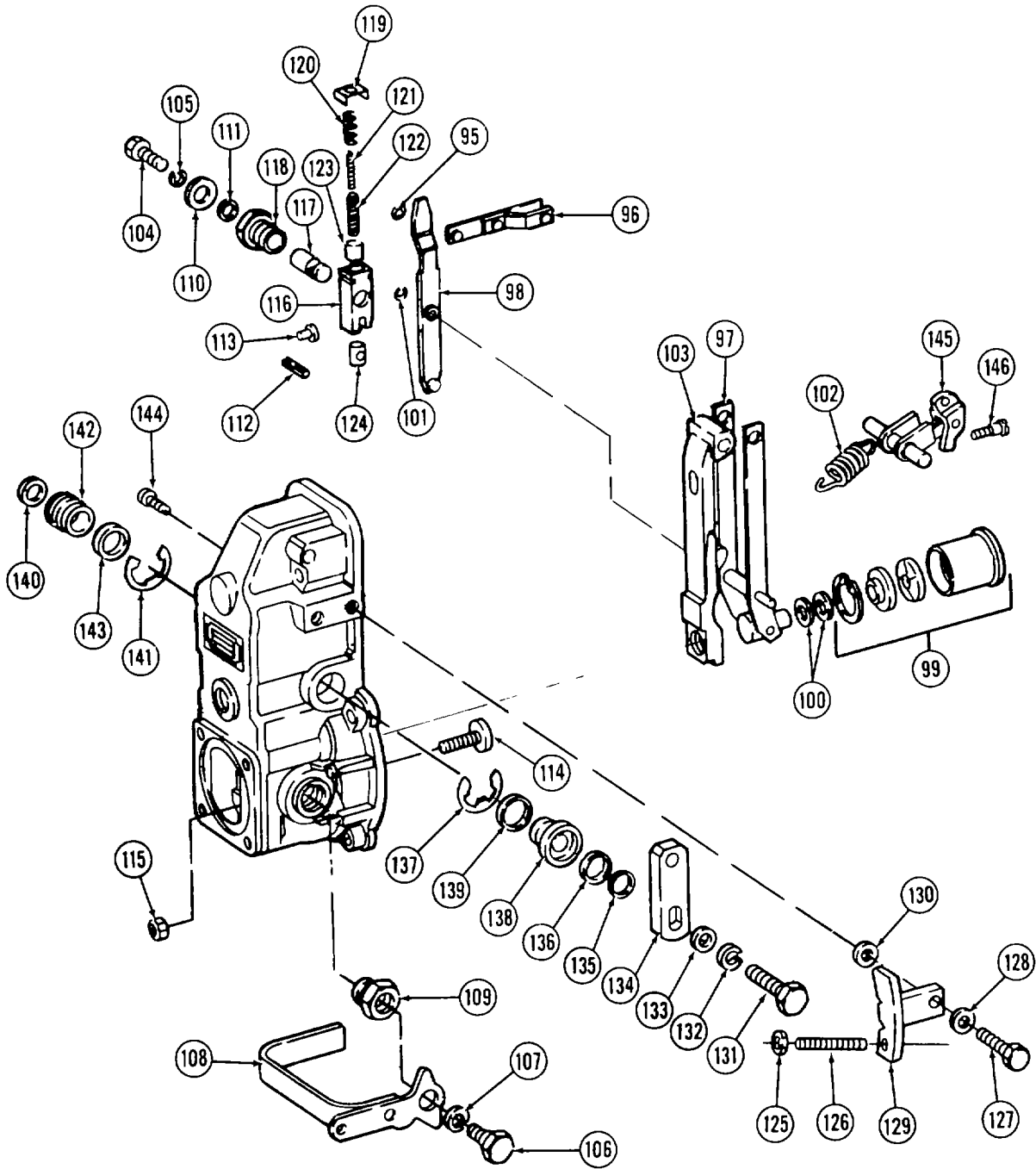
- m. Press bearing cone (86) onto camshaft. Press bearing cap (81) onto camshaft.
- n. Install assembled bearing cap and camshaft into housing.
- o. Install two screws (41) and two lockwashers (42). Torque screws to 61 to 78 in-lb (6.9 to 8.8 N-m).
- p. Install two spacers (45), timing indicator (44), and two screws (43). Torque screws to 61 to 78 in-lb (6.9 to 8.8 N-m).
- q. Repeat steps a through p to recheck camshaft end play.

4-4. REPAIR INJECTION PUMP (Continued)



- 32 Aline bearing support (85) with holes in housing.
- 33 Install two sealing rings (48) and two screws (47).
- 34 Install new preformed packing (46)
- 35 Place hub (39) onto camshaft.
- 36 Install woodruff key (40).
- 37 Install lockwasher (38) and nut (37). Torque nut to 47 to 51 ft-lb (63.7 to 69.2 N-m)
- 38 Install six new lock fasteners (54) into housing using breast wrench KDEP 2887
- 39 Install cap (36)
- 40 Turn camshaft until lobe for bore number one is at top dead center (TDC) Remove tappet holder. Repeat step to remove remaining five tappet holders
- 41 Rotate camshaft a full turn Check for proper movement of tappets, springs, and plungers in the firing order 1-5-3-6-2-4 Check that rod (64) moves freely If any signs of improper operation are found, disassemble components according to the disassembly procedure and repair defective components as necessary.
- 42 Install new gasket (35) and cover (34). Install two sealing rings (33) and two bolts (32)

4-4. REPAIR INJECTION PUMP (Continued)

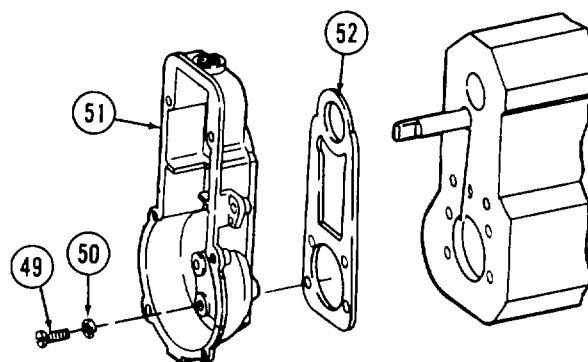


4-4. REPAIR INJECTION PUMP (Continued)

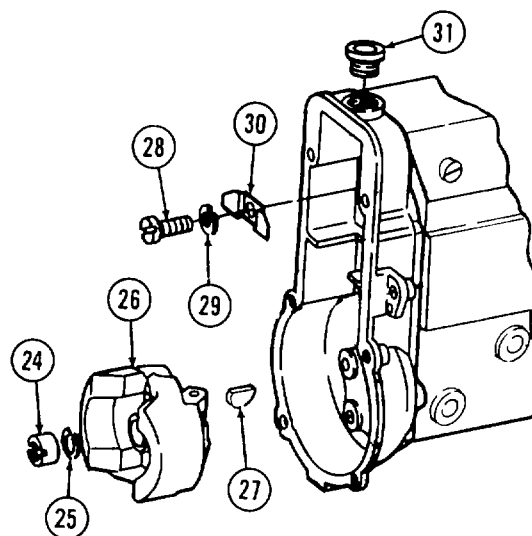
- 43 Install screw (146) into lever (145)
- 44 Place lever (145) in position inside governor cover (20)
- 45 Install washer (143) and bearing bushing (142) into governor cover (20)
- 46 Install washer (139) and bearing bushing (138) while guiding lever (145) into bearing bushings (138 and 142)
- 47 Install two C-clips (137 and 141)
- 48 Install capsule (140).
- 49 Install screw plug (144)
- 50 Install two washers (135 and 136)
- 51 Install control lever (134) onto lever (145)
- 52 Install washer (133), lockwasher (132), and bolt (131)
- 53 Install two washers (130) and bracket (129)
- 54 Install two washers (128) and two bolts (127)
- 55 Install threaded pin (126) and nut (125).
- 56 Place sliding pad (124) onto clevis (116)
- 57 Slide shaft (117) onto clevis (116)
- 58 Install the following parts into bore of clevis (116) spring capsule (123) and compression springs (122, 121, and 120). Install spring-loaded retainer (119) onto clevis (116)
- 59 Install threaded bushing (118) into governor cover (20)
- 60 Install shaft (117) and clevis (116) assembly into threaded bushing (118).
- 61 Use wrench and screwdriver to install banjo bolt (114) and nut (115) into governor cover (20)
- 62 Install studpin (113) and parallel pin (112)
- 63 Install threaded bushing (109)
- 64 Install washer (111) and shim (110), and place shutdown lever (108) into position.
- 65 Install lockwasher (105) and screw (104)
- 66 Install washer (107) and screw plug (106)
- 67 Mount injection pump body in vise.

4-4. REPAIR INJECTION PUMP (Continued)

- 68 Apply a thin coat of sealing compound to new gasket (52).
- 69 Position housing (51) onto injection pump.
- 70 Install six lockwashers (50) and six screws (49).
Torque screws to 52 to 69 in-lb (5.9 to 7.8 N-m)

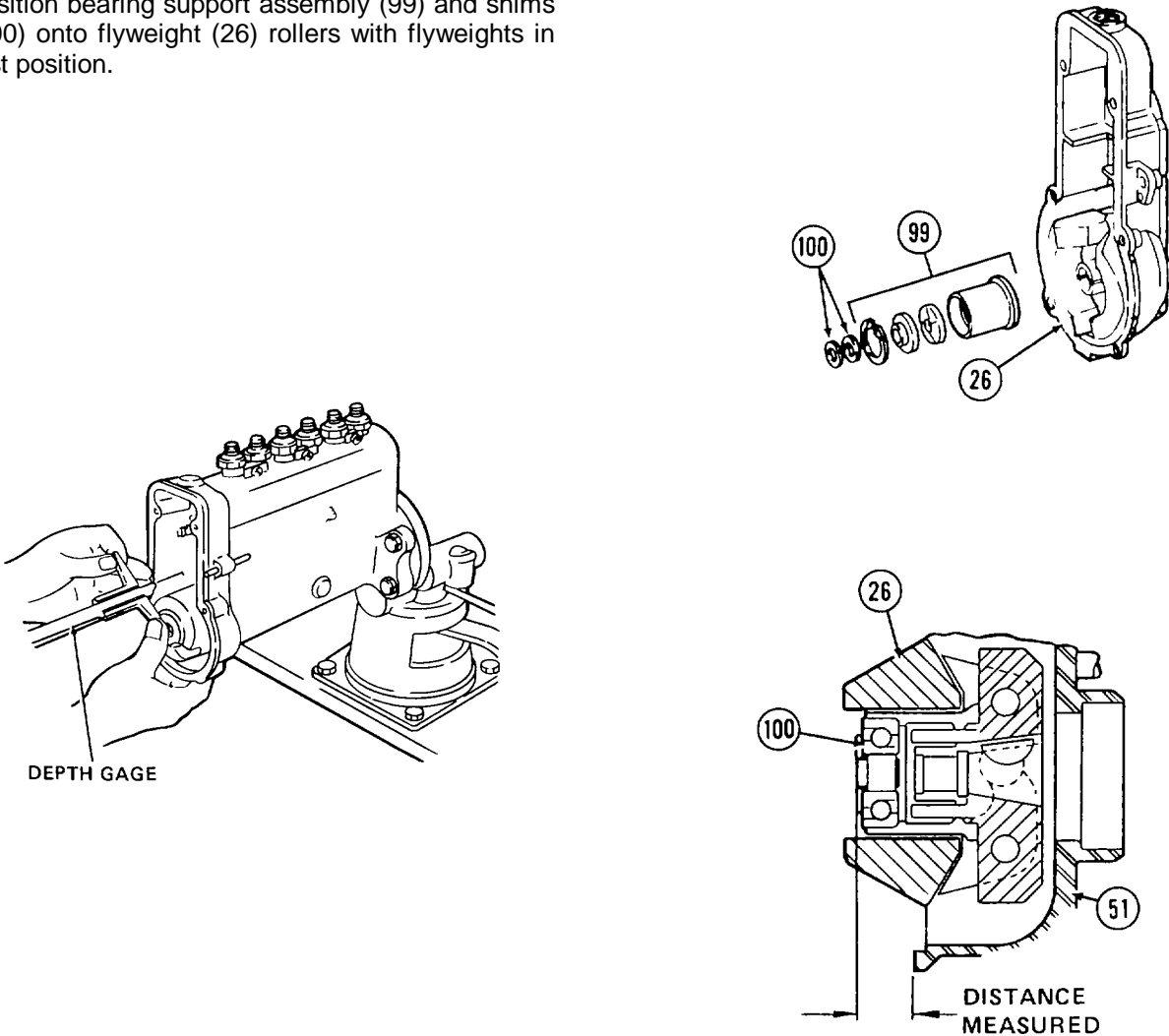


- 71 Place woodruff key (27) in camshaft.
- 72 Push flyweight (26) firmly onto taper of camshaft.
- 73 Install lockwasher (25) and annular nut (24) onto camshaft. Torque annular nut to 36 to 43 ft-lb (48.8 to 58.3 N-m) using flyweight pin wrench EFEP 187A and torque wrench.
- 74 Install retaining plate (30), lockwasher (29), and screw (28).



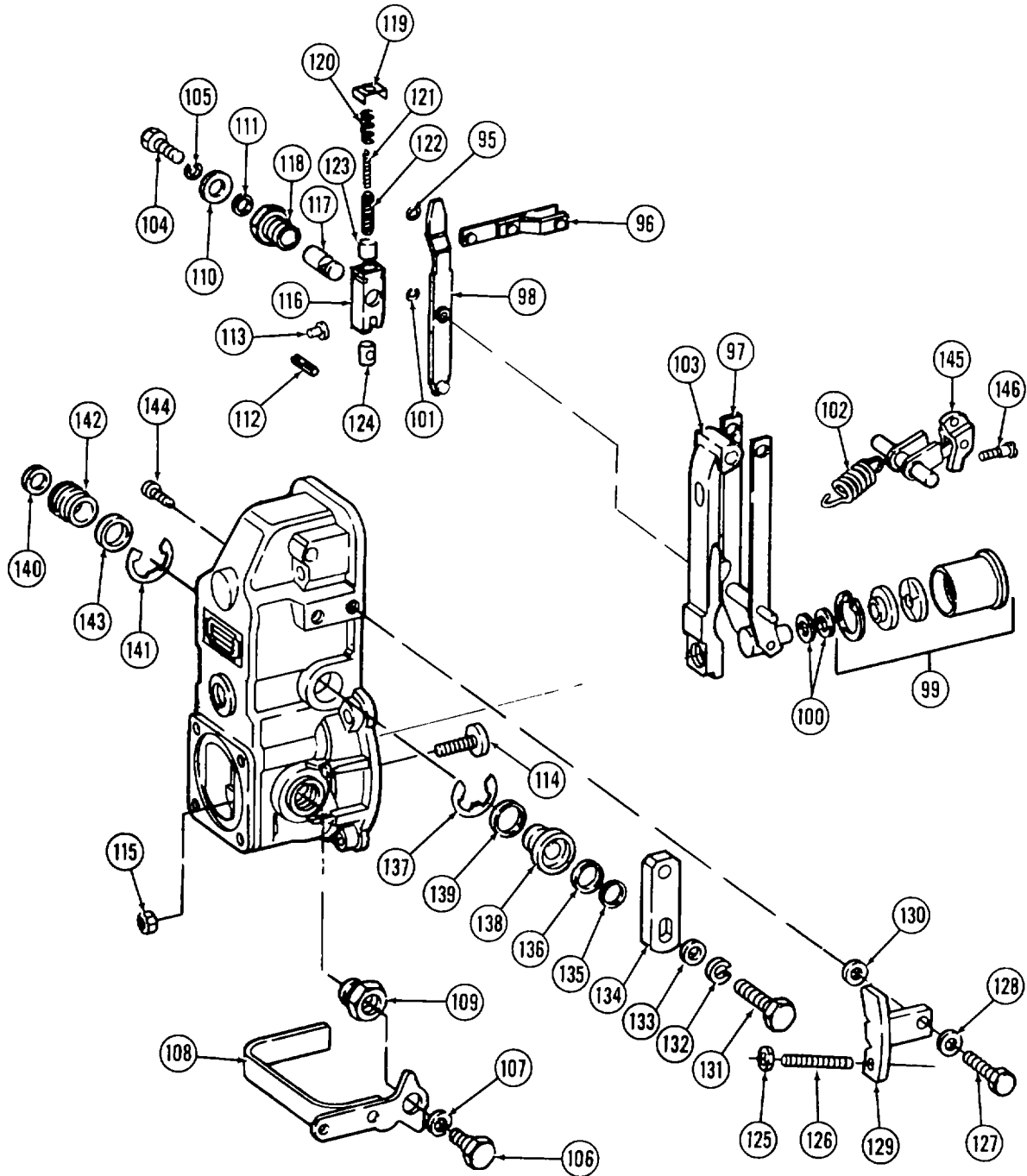
4-4. REPAIR INJECTION PUMP (Continued)

- 75 Position bearing support assembly (99) and shims (100) onto flyweight (26) rollers with flyweights in rest position.



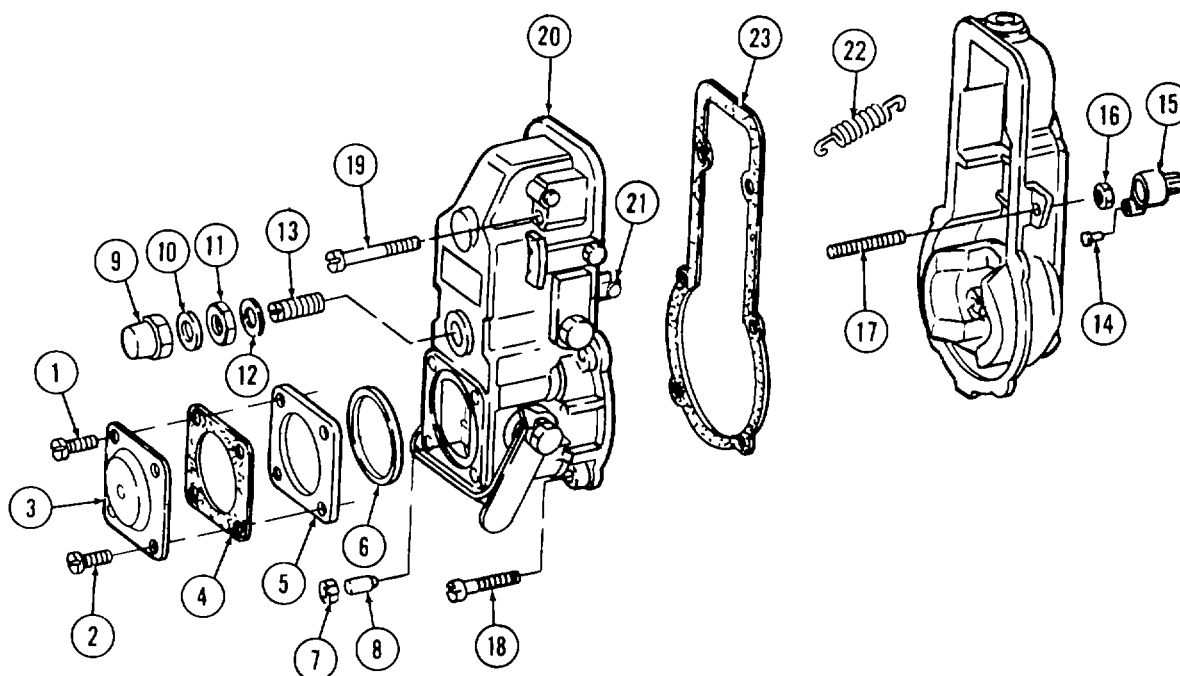
- 76 Using depth gage, measure and record distance between outermost shim (100) installed and the gasket surface of housing (51).
- 77 Using depth measured in step 76 is not between 0.740 to 0.755 inch (18.8 to 19.2 mm), adjust the number of shims (100) used. Add a shim if the distance is less than 0.740 inch (18.8 mm). Remove a shim if the distance is greater than 0.755 inch (19.2 mm). Repeat steps 75 and 76 until required dimension is met.

4-4. REPAIR INJECTION PUMP (Continued)



4-4. REPAIR INJECTION PUMP (Continued)

- 78 Position the number of shims selected in step 77 onto lever arm (97)
- 79 Press bearing support (99) onto lever arm (97) using arbor press.
- 80 Slide lever arm (103) behind lever (145) working from the top of governor cover (20)
- 81 Install spring (102) onto lever arm (103) and lever (145) using a long-nosed pliers.
- 82 Place lever arm (98) onto lever arm (97) and install C-clip (101).
- 83 Slide assembled lever arms (98 and 97) under lever (145), working from the bottom of governor cover (20)
- 84 Place connecting plate (96) onto lever arm (98) and install C-clip (95).
- 85 Using a punch and hammer, drive axle (94) through governor cover (20) and lever arms (97 and 103).
- 86 Using hammer and punch, install two plugs (92 and 93)



- 87 Install adjusting screw (17) and nut (16).
- 88 Install cap (15) and lead seal (14).
- 89 Install spring (22) onto retaining plate (30).
- 90 Apply thin coat of sealing compound to gasket (23) and place on housing (51)
- 91 Position governor cover (20) near housing (51).
- 92 Connect rack link (21) to injection pump rod (64) and squeeze together ends of rack link to secure connections

4-4. REPAIR INJECTION PUMP (Continued)

- 93 Hook free end of spring (22) onto lever arm (98)
 - 94 Place governor cover (20) against housing (51) Install two bolts (19) and four screws (18) Torque the screws to 43 to 61 in-lb (4.9 to 6.9 N•m)
 - 95 Install torque capsule (8) using torque capsule wrench KDEP 2968.
 - 96 Install nut (7) onto torque capsule (8).
 - 97 Install setscrew (13).
 - 98 Install washer (12) and nut (11).
 - 99 Install washer (10) and cap nut (9).
 - 100 Install new gasket (6)
 - 101 Install intermediate plate (5) and sealing plate (4)
 - 102 Install cover (3).
 - 103 Install two bolts (2) and two bolts (1).
 - 104 Fill governor with clean engine oil through port at top of governor
 - 105 Install screw plug (31) in housing (51).
 - 106 Install injection pump on engine in accordance with paragraph 3-13
 - 107 Bleed air from fuel system in accordance with paragraph 2-38.
 - 108 Adjust the injection pump in accordance with paragraph 3-6.
-

4-5. REPAIR/TEST FUEL INJECTORS

This task covers:	a. Disassembly	c. Inspection/Repair	e. Test
	b. Cleaning	d. Assembly	

INITIAL SETUP:

Materials/Parts

Diesel fuel oil (Item 6, Appendix C)

Special Environmental Conditions

Well-ventilated area required

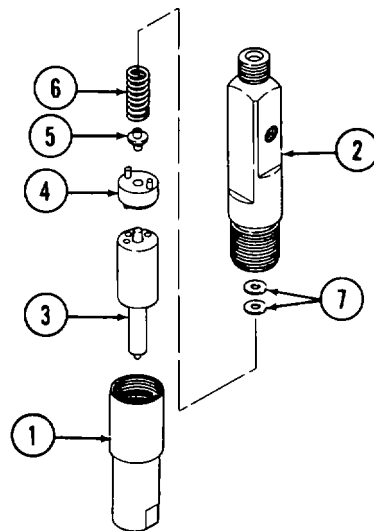
Equipment Condition

Para
3-15
3-15
and
4-4

Condition Description

Fuel injectors removed from engine
Install fuel injectors in engine as
needed for adjustment and
testing.

DISASSEMBLY:



- 1 Unscrew nozzle cap (1) from nozzle holder (2).
- 2 Remove nozzle needle (3), intermediate piece (4), plunger (5), pressure spring (6), and shims (7).

4-5. REPAIR/TEST FUEL INJECTORS (Continued)

CLEANING:**WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

Wash all components in clean diesel fuel oil and blow out with compressed air

INSPECTION/REPAIR**CAUTION**

The nozzle needle and nozzle body are lapped together and should not be mixed up or replaced separately. Do not touch the nozzle needle seating surface.

- 1 Holding the nozzle vertically, the nozzle needle must be allowed to slide slowly and smoothly on its seating under its own weight. If nozzle needle does not slide smoothly, wash with fuel again and replace if necessary.
- 2 Check seating surfaces and centering pins on intermediate piece for wear and be sure that pins seat properly.

ASSEMBLY:

- 1 Insert existing shims (7) into nozzle holder (2)

NOTE

Spraying pressure is increased by adding shims and reduced by removing them

- 2 Insert pressure spring (6) in nozzle holder (2).
- 3 Insert plunger (5) with spigot facing pressure spring (6)
- 4 Insert intermediate piece (4) guide pins into holes in nozzle holder (2)
- 5 Align nozzle on intermediate piece (4) and tighten nozzle cap (1) to nozzle holder (2)

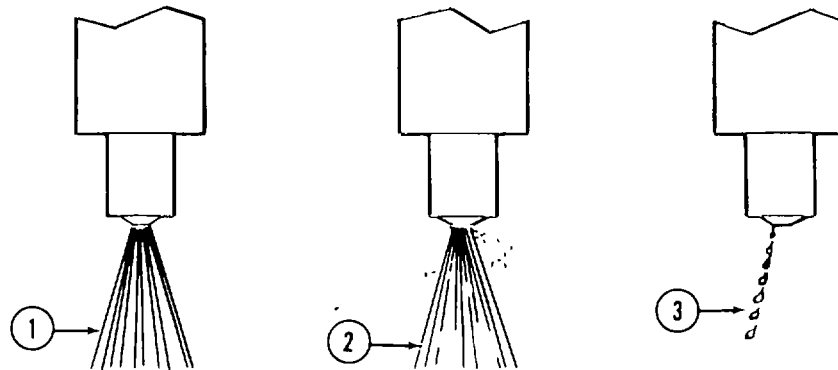
4-5. REPAIR/TEST FUEL INJECTORS (Continued)

TEST:

- 1 Adjust nozzle spraying pressure by adding or removing shims (7) below the spring (6)

NOTE

Spraying pressure is increased by adding shims and reduced by removing them.



- 2 Test and check spray pattern. Jet(s) should be solid (1) without surrounding mist (2).
 - 3 Check that there is no after-dribble (3) If nozzle is defective, replace it
-

4-6. REPAIR CYLINDER HEAD ASSEMBLY AND ROCKER ARMS

This task covers a. Cleaning/inspection b. Repair

INITIAL SETUP:

Tools

Shop set, automotive repair, field maintenance, basic
 Tool kit, master mechanics
 Clamping plate No 120910
 Cylinder head clamping stand No 120900
 Cylinder head lathe fixture No 125500
 Cylinder head sealing surface cutter No 124480
 Socket spanner No. 120040/120050
 Torque gage No 101900

Equipment Condition

Para	Condition Description
3-19	Cylinder head assembly removed from engine Rocker arms and pushrods removed from cylinder head assembly. Tappets removed from crankcase.
4-7	Valves, valve guides, and valve seats removed from cylinder head.

Materials/Parts

Copper or lead wire - 12.0 inches (305 mm) long and 0.0787 inch (2.0 mm) in diameter
 Diesel fuel oil (Item 6, Appendix C)
 Grease (Item 7, Appendix C)
 Lapping and grinding compound, 600 grit (Item 9, Appendix C)

Special Environmental Conditions

Well-ventilated area required for cleaning.

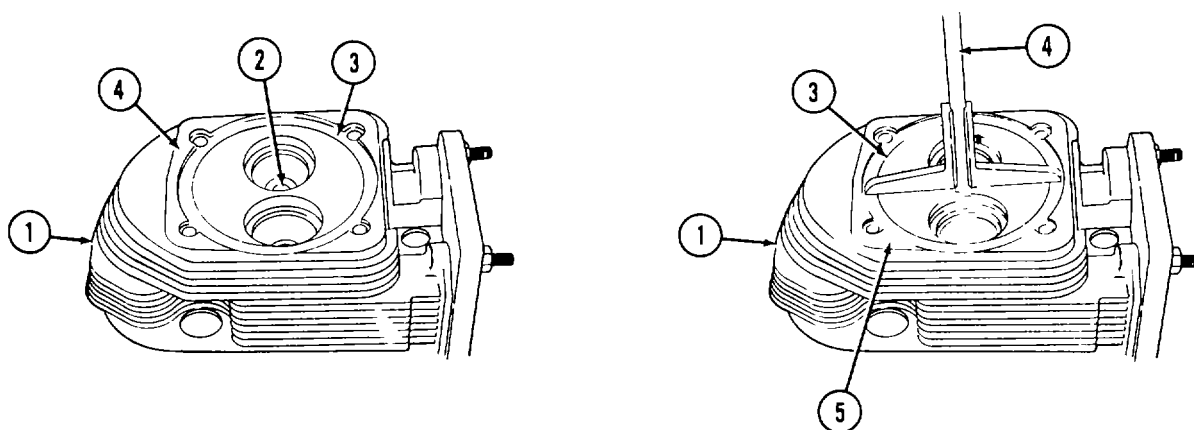
4-6. REPAIR CYLINDER HEAD ASSEMBLY AND ROCKER ARMS (Continued)

CLEANING/INSPECTION:

WARNING

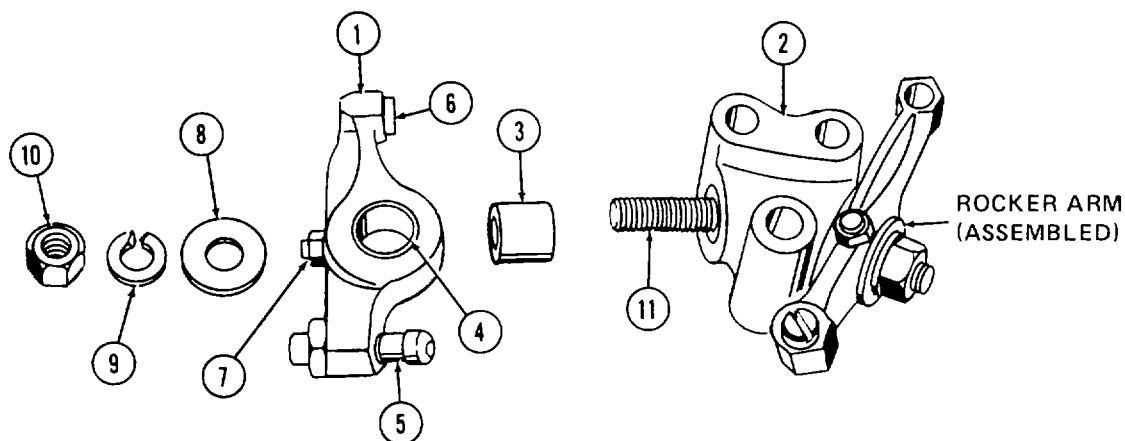
Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

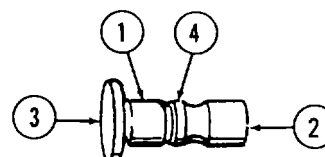


- 1 Mount cylinder head (1) on cylinder head clamping stand No. 120900 and clamping plate No. 120910 Clean with a clean cloth dampened with diesel fuel oil. Use wire brush where necessary Dry with compressed air.
- 2 Inspect cylinder head (1) for cracks, rust, corrosion, and excessive heat damage. Inspect for accumulated carbon around injector spray tips (2). Replace cylinder head if it is damaged
- 3 Check that cylinder head seat (3) is smooth and flat If not, use a depth gage (4) to measure distance from the cylinder head bottom (5) to cylinder head seat (3) or sealing surface. If the cylinder head bottom-to-cylinder head seat distance is between 0.2283 inch (5.8 mm) and 0.2480 inch (6.3 mm), the cylinder head seat can be smoothed and flattened by remachining. If distance is not within the specified limits, replace cylinder head (1).

4-6. REPAIR CYLINDER HEAD ASSEMBLY AND ROCKER ARMS (Continued)



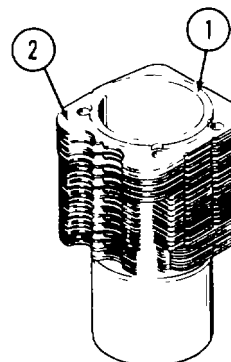
- 4 Clean rocker arm (1), rocker bracket (2), rocker fulcrum (3), bearing bushing (4), adjusting screw (5), thrust pad (6), nut and oil nozzle (7), washer (8), lockwasher (9), and nut (10) with diesel fuel oil
- 5 Use a small wire to clean drilled oil passages in rocker arms (1), oil nozzle (7), and bearing bushing (4). Dry parts with low pressure compressed air.
- 6 Inspect rocker bracket (2) and stud (11) for excessive wear or other damage. Inspect rocker arm (1), rocker fulcrum (3), and bearing bushing (4) bores for wear.
- 7 Inspect shaft-to-bushing clearance for excessive wear
- 8 Inspect bearing bushing (4) exterior surface and oil nozzle (7) for excessive wear.
- 9 Inspect rocker arms (1), adjusting screw (5) (pushrod contact surface), and thrust pads (6) (valve contact surfaces) for excessive wear
- 10 Clean tappets (1), tappet head (2), tappet seat (3), and oil hole (4) thoroughly with diesel fuel oil and dry with low pressure compressed air. Inspect for damage, wear, or clogged oil hole.



4-6. REPAIR CYLINDER HEAD ASSEMBLY AND ROCKER ARMS (Continued)

REPAIR:

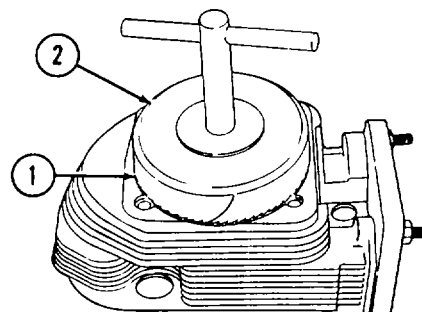
- 1 Smooth and flatten head of cylinder (1) with 600 grit grinding compound to compensate for minor surface defects on cylinder head seat (2)



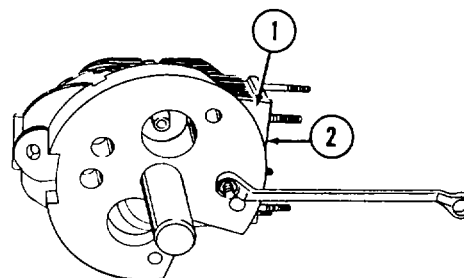
CAUTION

Do not remove any more material from cylinder head seat surface than is absolutely necessary to smooth and flatten seat.

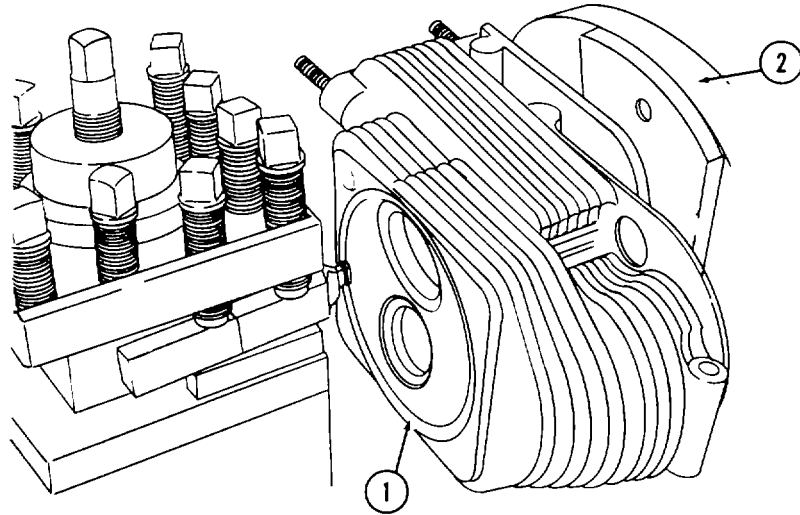
- 2 Smooth out and/or flatten major damage to cylinder head seat (1) with cylinder head sealing surface cutter No 124480(2)



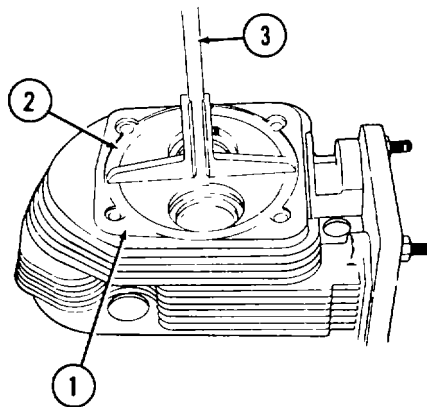
- 3 Bolt cylinder head (1) to cylinder head lathe fixture No 125500 (2).



4-6. REPAIR CYLINDER HEAD ASSEMBLY AND ROCKER ARMS (Continued)

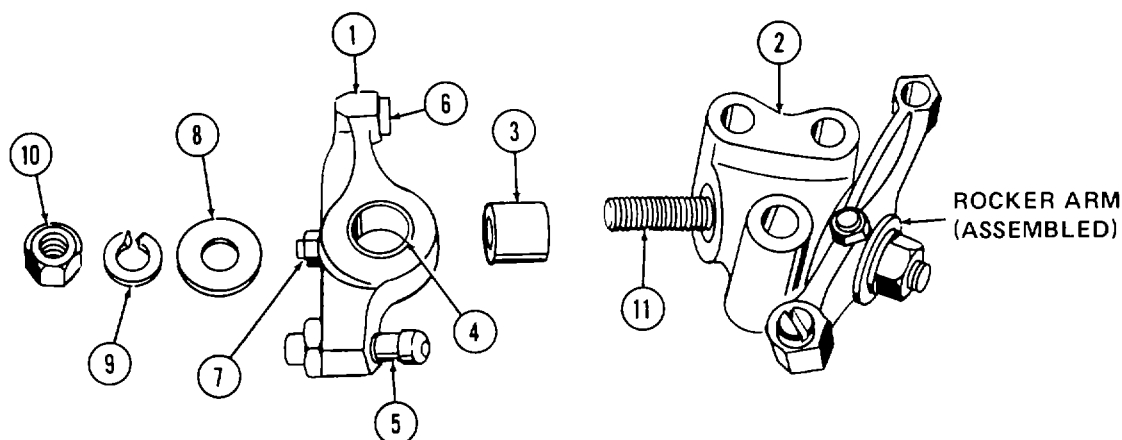


- 4 Turn on lathe (2) until cylinder head seat (1) is smooth and flat.

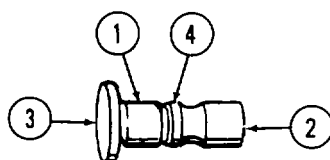


- 5 Measure cylinder head bottom (1) to cylinder head seat (2) clearance using depth gage (3) Make sure distance does not exceed 0.248 inch (6.3 mm). If it does cylinder head must be replaced.

4-6. REPAIR CYLINDER HEAD ASSEMBLY AND ROCKER ARMS (Continued)



- 6 Replace bearing bushings (4), rocker arms (1), or rocker brackets (2) if extremely worn or damaged
- 7 Replace rocker arms (1) or bushings (4) if clearance to rocker fulcrum (3) is too great
- 8 Replace thrust pads (6) if they are galled or worn.
- 9 Replace rocker arms (1), oil nozzle (7), or bearing bushing (4) if oil passage is permanently blocked



- 10 Open clogged oil hole (4) in tappet (1) with small wire. Repair only minor nicks or burrs in tappet head (2) or seat (3) if possible. Major damage such as dents or warpage, excessive wear, or permanently restricted oil hole will require replacement. Replace as necessary.

NOTE

Before installing repaired or new cylinder head, piston top clearance should be measured and checked. Use the test and adjustment procedures described in paragraph 3-19.

4-7. REPLACE/REPAIR VALVES, VALVE GUIDES, AND VALVE SEATS

This task cover:

- a. Removal**
 - b. Cleaning/Inspection**
 - c. Repair**
 - d Installation**
-

INITIAL SETUP:

Tools

Shop set, automotive repair, field maintenance, basic
 Tool kit, master mechanics
 Calipers
 Clamping plate No. 120910
 Cylinder head clamping stand No 120900

Depth gage
 Drill fixture No 122460

Hard metal milling cutter No
 Pilot pin for drill fixture No

Valve guide mandrel, 8 mm, No. 122305
 Valve guide mandrel, 8 mm, No. 123310
 Valve guide mandrel handles, No. 122306
 Valve guide reamer, 8 mm, No. 123510
 Valve holder No. 122304

Valve seat ring cutter No. 122302
 Valve seat ring mandrel No. 122450
 Valve seat ring mandrel No. 123950
 Valve seat ring mandrel No 123960
 Valve spring compressor No 121120

Materials/Parts

Crocus abrasive cloth (Item 1, Appendix C)

Diesel fuel oil (Item 6, Appendix C)

122463 Lubricating oil (Item 10, Appendix C)

122461 **Equipment**

Condition

Para	Condition Description
3-19	Cylinder head assembly removed from engine

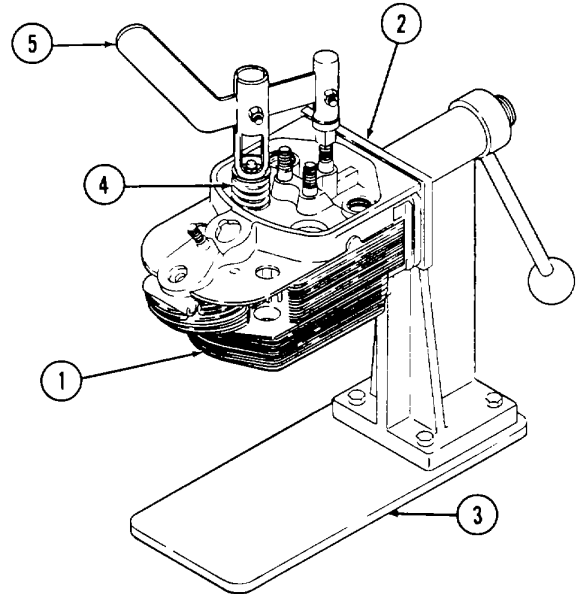
Special Environmental Conditions

Well-ventilated area required for cleaning

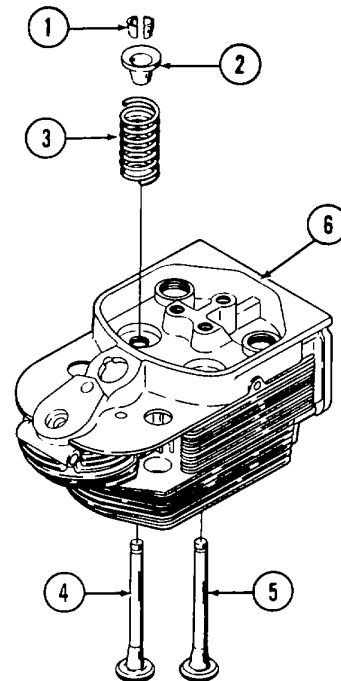
4-7. REPLACE/REPAIR VALVES, VALVE GUIDES, AND VALVE SEATS (Continued)

REMOVAL:

- 1 Mount cylinder head (1) on cylinder head clamping stand No. 120900 (2) with clamping plate No 120910 (3)
- 2 Compress spring (4) with valve spring compressor No 121120 (5)



- 3 Remove valve cones (1), spring caps (2), compression springs (3), inlet valve (4), and exhaust valve (5) from cylinder head (6).



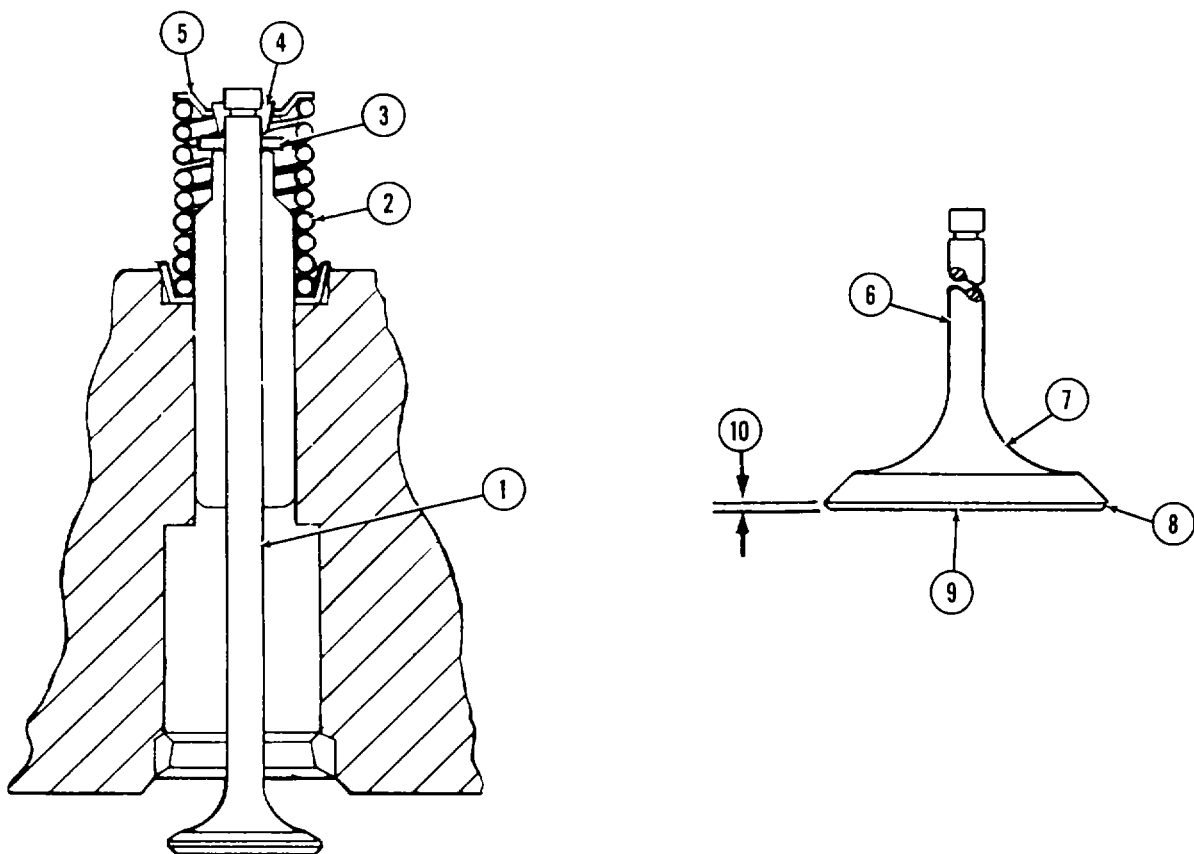
4-7. REPLACE/REPAIR VALVES, VALVE GUIDES, AND VALVE SEATS (Continued)

CLEANING/INSPECTION:

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

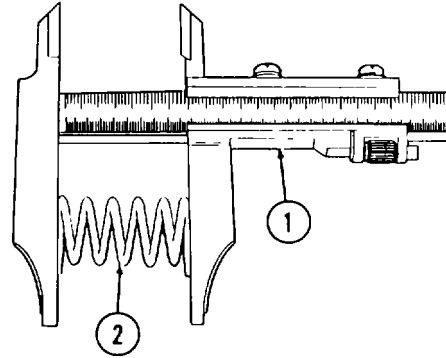
Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.



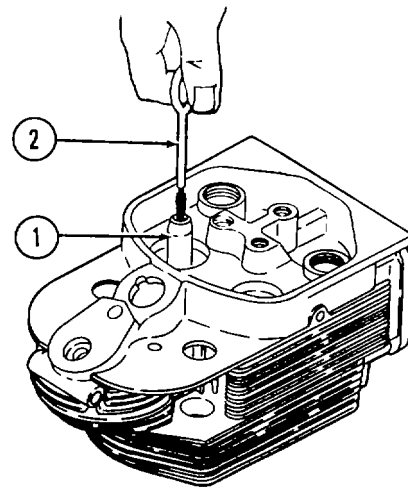
- 1 Clean valves (1), compression springs (2), snap rings (3), valve cones (4), and spring caps (5) with diesel fuel oil and dry with low pressure compressed air. Inspect for valve warpage, burning, or other damage.
- 2 Inspect valve stems (6) for scratches, scuff marks, or other damage.

4-7. REPLACE/REPAIR VALVES, VALVE GUIDES, AND VALVE SEATS (Continued)

- 3 Inspect valve tulips (7), faces (8), and heads (9) for pitting, ridges, or cracks
- 4 Check that valve joint face thickness (10) is no less than 0.0197 inch (0.5 mm)
- 5 Inspect snap rings (3), valve cones (4), and spring caps (5) for pitting, fractures, excessive wear, or other damage
- 6 Using calipers (1), inspect compression spring (2) for proper length. Fatigued (unloaded) length shall be not less than 2.2047 inches (56 mm). Normal (replacement) length (unloaded) is 2.2480 to 2.3976 inches (57.1 to 60.9 mm)

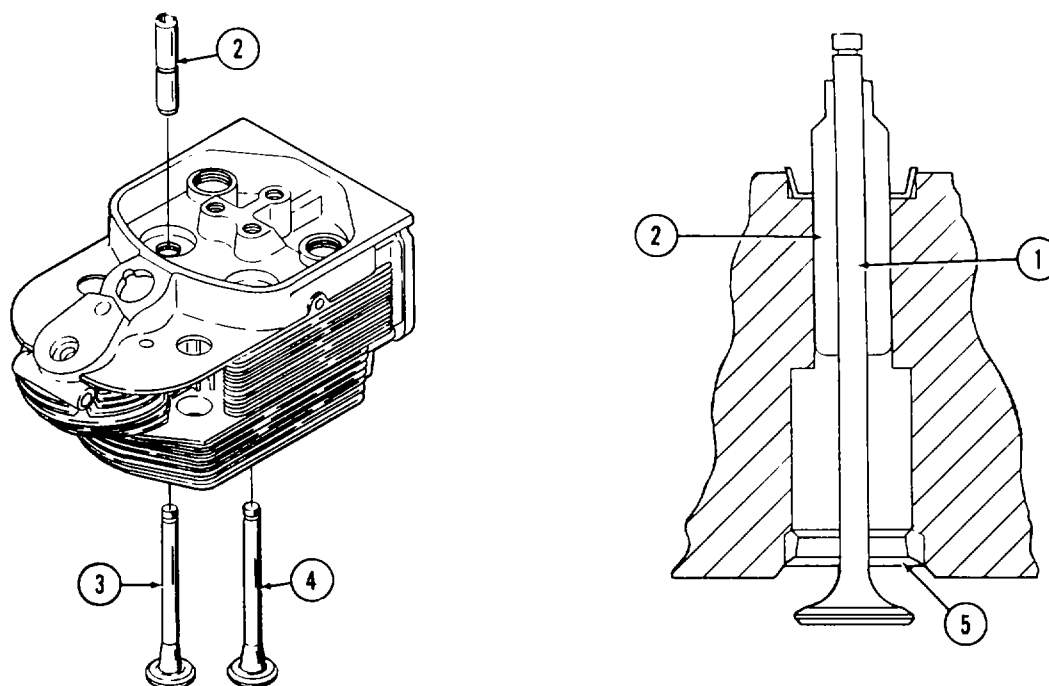


- 7 Clean the inside of valve guides (1) using brush (2) and diesel fuel oil. Dry with low pressure compressed air. Inspect valve guides for fractures, chipping, scoring, or excessive wear.

**NOTE**

Valve guides can be inspected and cleaned without being removed from the cylinder head.

4-7. REPLACE/REPAIR VALVES, VALVE GUIDES, AND VALVE SEATS (Continued)



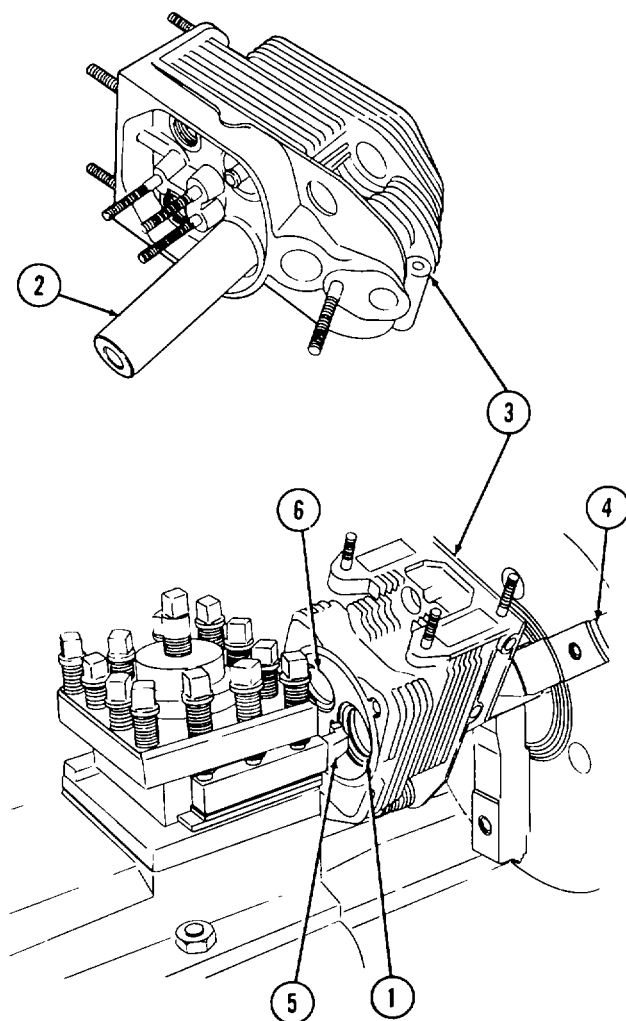
- 8 Measure valve stem (1)/valve guide (2) clearance on inlet valve (3) and exhaust valve (4) with micro feeler gage. The inlet valve stem/valve guide clearance limit is 0.0118 inch (0.3 mm). The exhaust valve stem/guide clearance limit is 0.0197 inch (0.5 mm).
- 9 Clean valve seat insert rings (5) with small wire bristle brush and diesel fuel oil and dry with low pressure compressed air. Inspect and replace for excessive wear, pitting, cracking, or improper valve seat insert ring angle (greater or less than 45 degrees).

NOTE

Valve seat insert rings can be inspected and cleaned without being removed from the cylinder head. Always use NEW valve in making valve seat insert ring measurements.

- 10 Measure distance between installed valve head center (1) and cylinder head seat (2) with depth gage. Distance should be between 0.2283 and 0.2520 inch (5.8 and 6.4 mm).

4-7. REPLACE/REPAIR VALVES, VALVE GUIDES, AND VALVE SEATS (Continued)

REPAIR:

- 1 Repair valve seat insert rings (1)

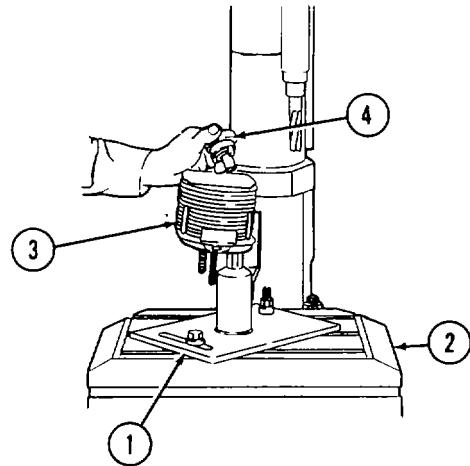
CAUTION

Do not damage cylinder head.

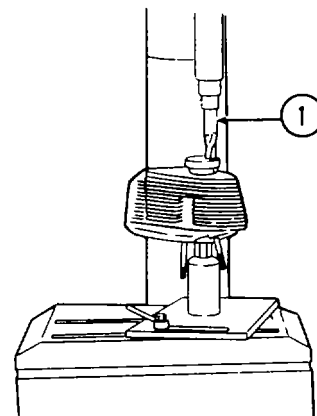
- a. Insert valve seat ring mandrel No. 122450 (2) into cylinder head (3) Clamp down valve seat ring mandrel and cylinder head into milling lathe (4) and bore out valve seat insert rings with milling cutter No. 122463 (5) Take care not to bore into cylinder head counterbore (6)

4-7. REPLACE/REPAIR VALVES, VALVE GUIDES, AND VALVE SEATS (Continued)

- b. An alternate method to remove valve seat insert rings is by using a drill press Position drill fixture No. 122460 (1) on a drill press (2). Place cylinder head (3) on drill fixture. Insert pilot pin with drilling bushings No. 122461 (4) on cylinder head (3)



Drill out the valve seat insert rings using hard metal milling cutter No. 122463 (1)

**WARNING**

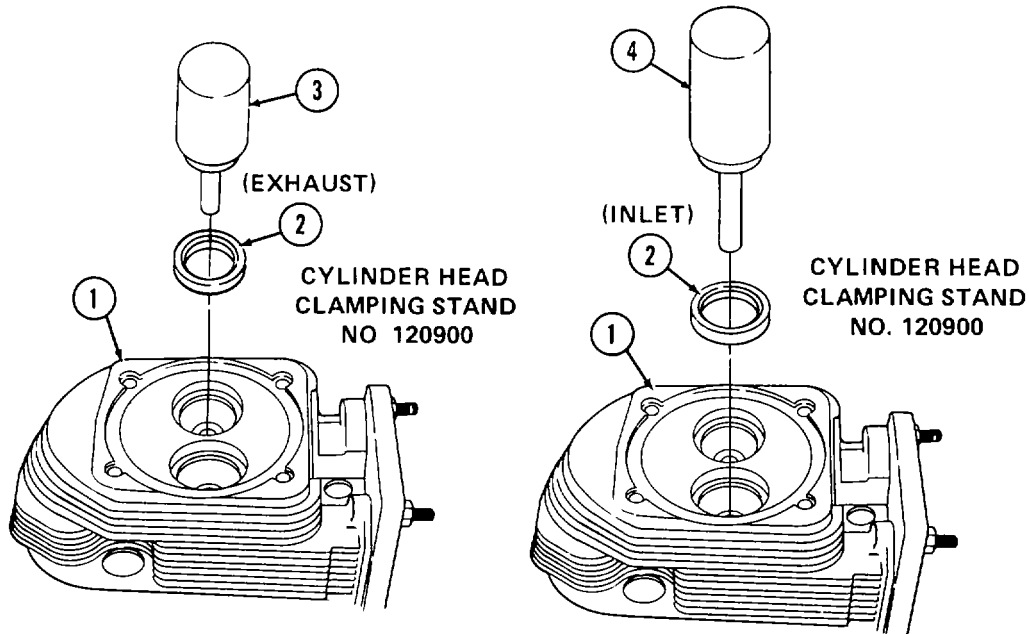
Use care when handling heated parts.

NOTE

Valve seat insert rings are inserted and seated from bottom of cylinder head which has been heated to 428° F (220°C).

- c. Heat cylinder head to 4280 F (2200C) in furnace

4-7. REPLACE/REPAIR VALVES, VALVE GUIDES, AND VALVE SEATS (Continued)



- d. Insert and evenly seat in bottom of cylinder head (1) new valve seat insert rings (2) with valve seat ring mandrel No. 123950 (3) or 123960 (4).

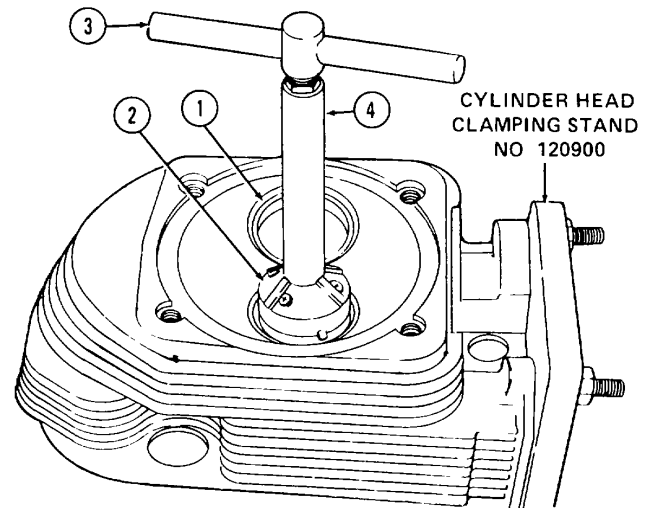
NOTE

If both valve seat inserts and valve guides need to be repaired, valve guides should be repaired at the same time as the valve seat inserts as long as the cylinder head is heated to 428°F (220°C).

- e. If valve guides are to be repaired, repair them now according to REPAIR procedure 2 before continuing with valve seat insert repair.
- f. Allow cylinder head to cool to room temperature, 75° F (23.9° C).

4-7. REPLACE/REPAIR VALVES, VALVE GUIDES, AND VALVE SEATS (Continued)

- g. Inspect installed valve seat insert rings (1) for nicks, burrs, or other minor damage to valve mating surfaces. Very carefully smooth out any nicks, burrs, or other minor damage with valve seat ring cutter No 122305, valve seat ring cutter No. 122302 (2), mandrel handle 122306 (3), and holder No 122304 (4).



- h. Check valve head/cylinder head seat clearance with NEW valve in accordance with procedure in CLEANING/INSPECTION step 10.
- Maximum clearance is 0.2520 inch (6.4 mm)
- Minimum clearance is 0.2283 inch (5.8 mm)
- i. If maximum clearance is exceeded, replace valve seat insert rings again. Follow procedure described in step d. If clearance is below minimum, remachine valve seat insert rings with valve seat ring cutter No. 122302 and holder No 122304. Reconfirm that clearance falls within limits after remachining.

NOTE

If remachining will cause either limit to be exceeded, replace valve seat insert rings or valves, respectively.

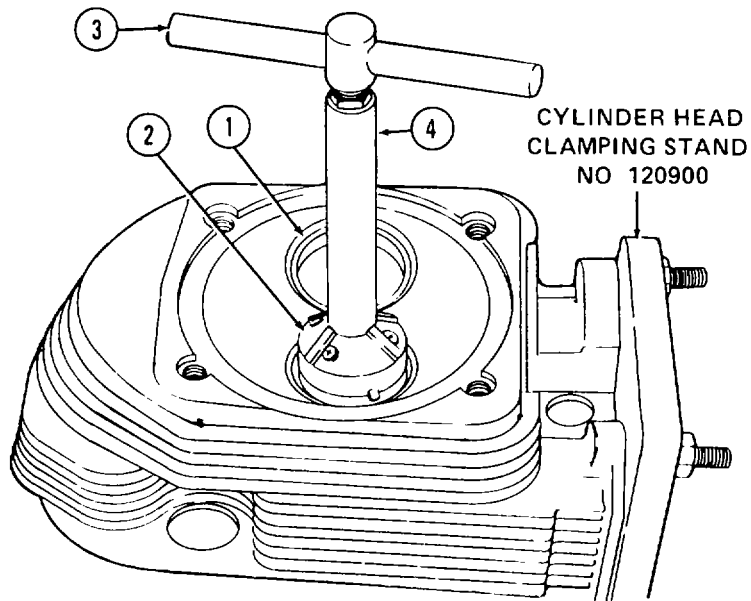
WARNING

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Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- j. Clean valve seat insert rings with diesel fuel oil and dry with low pressure compressed air

4-7. REPLACE/REPAIR VALVES, VALVE GUIDES, AND VALVE SEATS (Continued)

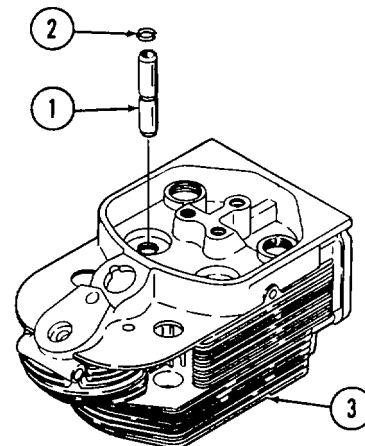


2 Repair valve guides (1)

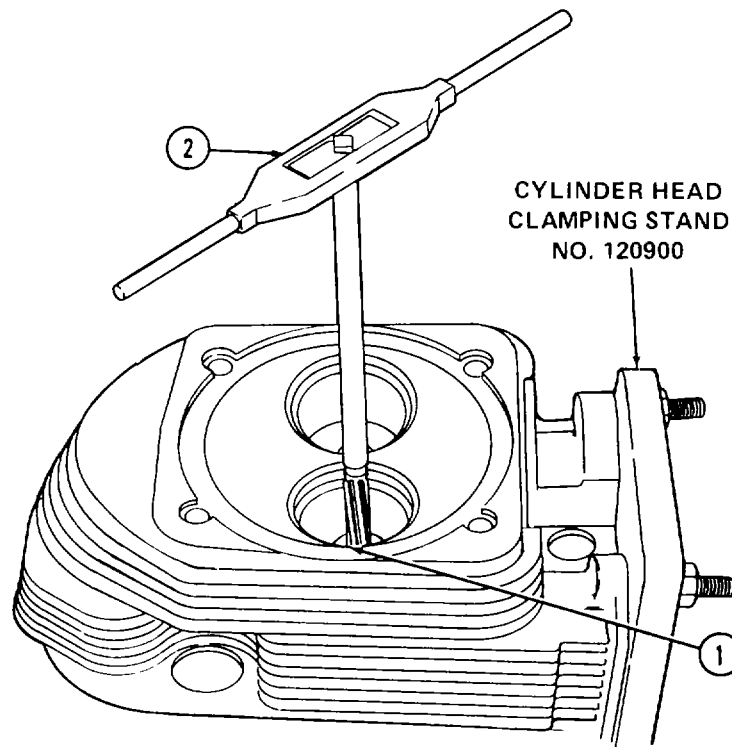
WARNING

Use care when handling heated parts.

- a. Heat cylinder head (2) to 428° F (220°C) in furnace
- b. Press out old guides (1) with valve guide mandrel, 8 mm, No 123310 (3) and mallet or hammer (4).
- c. Install new valve guides (1) with snap rings (2) installed Lightly press into heated cylinder heads (3) with chamfered ends toward top of cylinder head.
- d. Allow cylinder head to cool to room temperature, 75° F (23.9° C)



4-7. REPLACE/REPAIR VALVES, VALVE GUIDES, AND VALVE SEATS (Continued)



- e. Inspect valve guides (1) and ream with valve guide reamer, 8 mm, No. 123510 (2).

WARNING

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Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- f. Clean valve guides with brush and diesel fuel oil Dry with low pressure compressed air.
- 3 Replace any valves that show head warping, burning, or other damage. Replace valves that have seriously scratched or scuffed stems; or pitted, ridged, or cracked tulips, faces, or heads. Replace valves that have a valve joint face thickness less than 0.0197 inch (0.5 mm) for inlet or exhaust valve. Remove slight scratches or scuff marks with crocus cloth

4-7. REPLACE/REPAIR VALVES, VALVE GUIDES, AND VALVE SEATS (Continued)

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

Clean valves with brush and diesel fuel oil. Dry with low pressure compressed air.

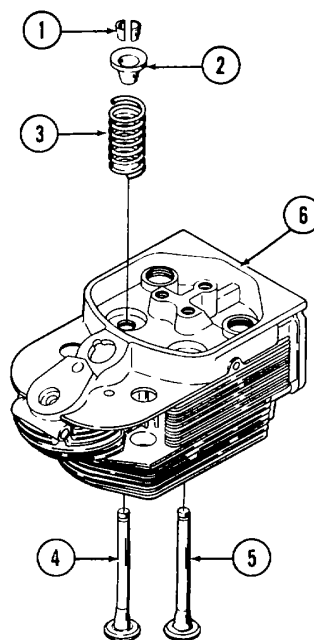
- 4 Replace compression springs that are pitted, fractured, excessively worn, or damaged Replace any compression spring that has an unloaded fatigue length of less than 2.2047 inches (56 mm).
- 5 Replace valve cones and caps that are fractured, excessively worn, or damaged.
- 6 Replace snap rings.

INSTALLATION :

- 1 Install compression springs (3) and spring caps (2) in cylinder head (6).
- 2 Apply lubricating oil to stems of valves (4 and 5) and insert valves in cylinder head (6)
- 3 Compress springs (3) and insert valve cones (1).

NOTE

Be sure valve cones are properly and firmly seated.



4-8. REPLACE/REPAIR CAMSHAFT

This task covers:

- a. Removal
- b. Cleaning/Inspection
- c. Repair
- d. Installation

INITIAL SETUP

Tools

- Shop set, automotive repair, field maintenance, basic
- Tool kit, master mechanics
- Camshaft plug installer No. 143610

Materials/Parts

- Crocus abrasive cloth (Item 1, Appendix C)
- Diesel fuel oil (Item 6, Appendix C)
- Lubricating oil (Item 10, Appendix C)
- Surfacing stone (Item 18, Appendix C)

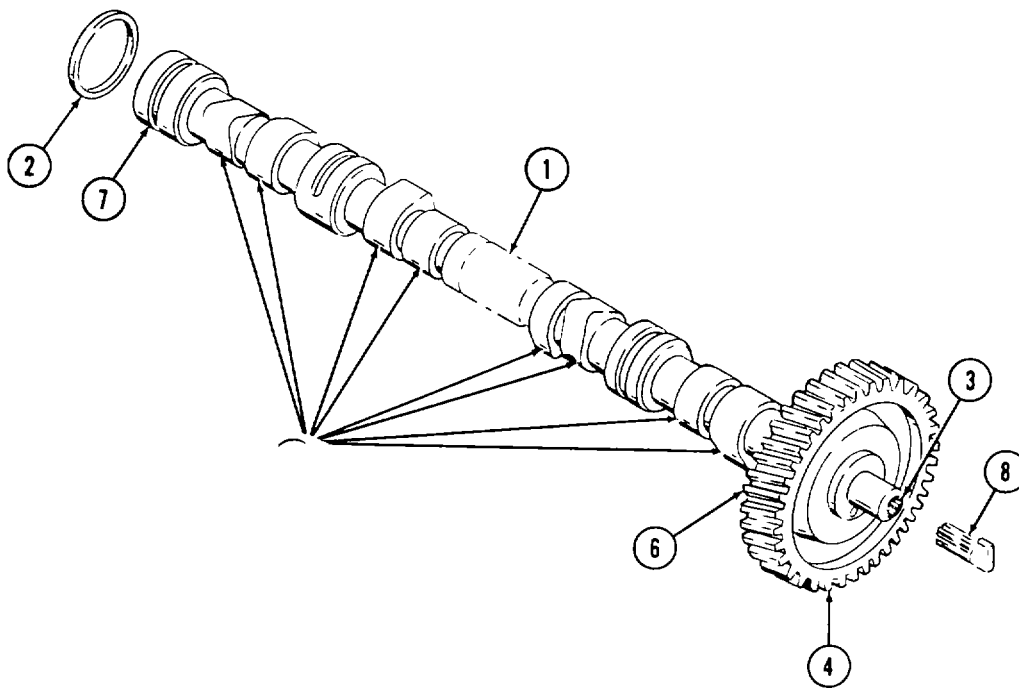
Special Environmental Conditions

Well-ventilated area required during cleaning and repair

REMOVAL:

CAUTION

Do not lay camshaft on its side. Stand it on end to prevent warpage.



Remove camshaft (1) and washer (2)

4-8. REPLACE/REPAIR CAMSHAFT (Continued)

CLEANING/INSPECTION :**WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

Live steam used for cleaning shall not exceed 100 psi (690 kPa). Use goggles or a face shield for eye protection.

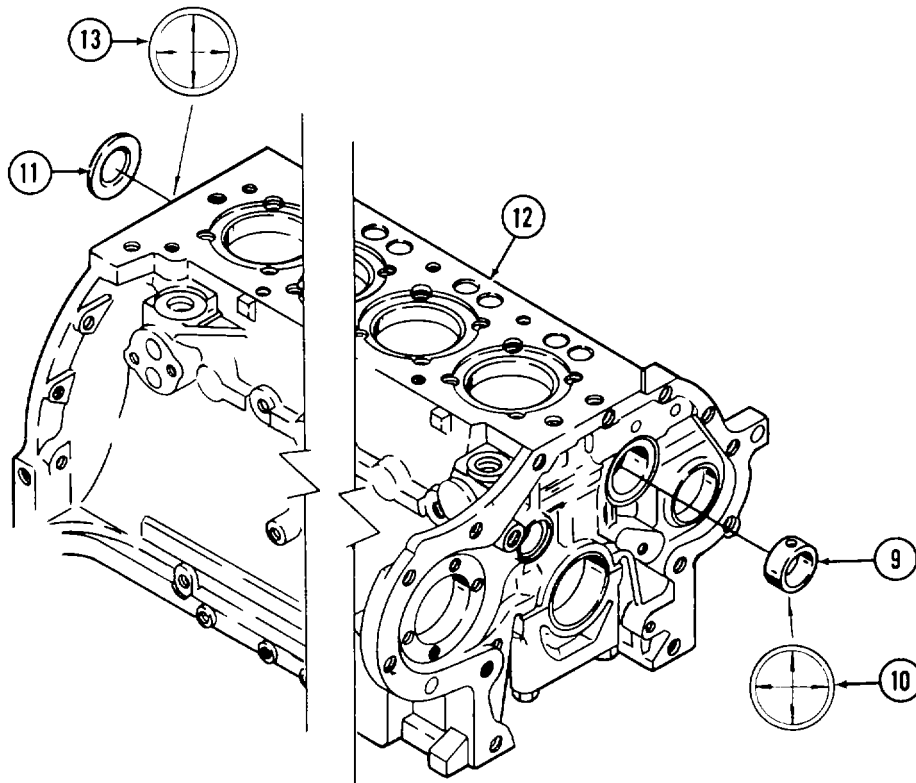
- 1 Soak camshaft (1) in clean diesel fuel oil Then run a wire brush through the camshaft oil passage (3) to remove any foreign material or sludge.
- 2 Clean exterior of camshaft and blow through the oil passage with compressed air.
- 3 Clean gear (4), cams (5), and washer (2) with diesel fuel oil and dry with compressed air.
- 4 Inspect washer (2) and replace if damaged or worn.

NOTE

If a new camshaft is to be installed, steam clean it to remove the rust preventive. Blow out the oil passages with compressed air.

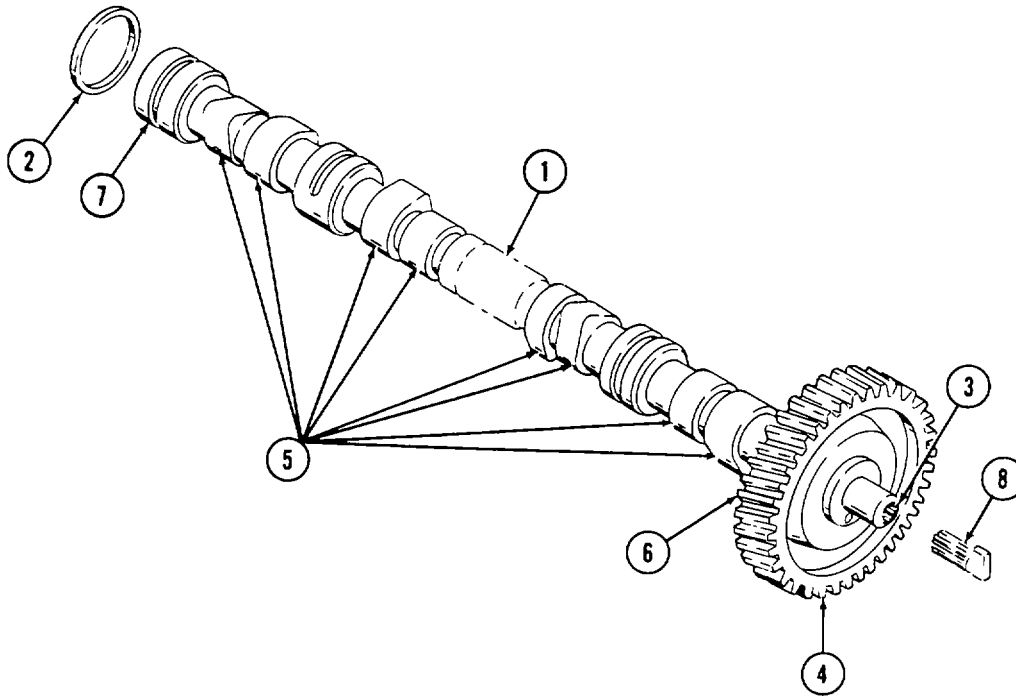
- 5 Inspect cams (5) and bearing journal (6) for wear and scoring. If cams are scored, inspect tappets in accordance with paragraph 4-6. Replace camshaft (1) if journals or cams are excessively worn or scored.
- 6 Replace camshaft (1) if bent or damaged.
- 7 Examine all contact surfaces. If surfaces are scratched but not severely scored, they may be smoothed down with a surfacing stone If the score marks are too deep to be removed, replace camshaft.
- 8 Inspect camshaft gear (4) for cracking, excessive wear, cracked or broken teeth, rust, corrosion, or other damage. If gear is excessively worn or damaged, replace camshaft (1). Minor nicks, burrs, or wear may be smoothed out with crocus cloth.
- 9 Inspect spigot pin (8). Replace if damaged or worn.

4-8. REPLACE/REPAIR CAMSHAFT (Continued)

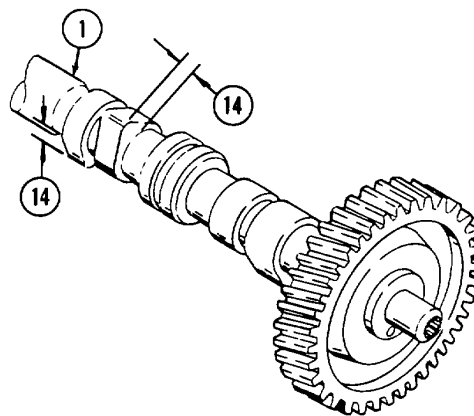


- 10 Measure inside diameter of bushing (9) with a precision bore gage at 90 degree axes (10) as shown. Diameter should be 1.8890 to 1.8911 inches (47.981 to 48.034 mm). If diameter is outside specified limits, replace bushing in accordance with paragraph 4-13.
- 11 Measure outside diameter of bearing journal (6). Diameter should be 1.8902 to 1.8950 inches (48.011 to 48.133 mm). If diameter is outside specified limits, replace camshaft (1).
- 12 The radial clearance (difference between above measurements) for new camshaft bushing (9) should be 0.0012 to 0.0039 inch (0.031 to 0.099 mm) or for worn parts a maximum of 0.0079 inch (0.200 mm). Replace bearing journal or bushing as needed to restore tolerance.
- 13 Remove dished plug (11) from crankcase (12) and discard. Measure rear camshaft bore in crankcase (13). Record measurement.
- 14 Measure diameter of rear journal (7). Record measurement.

4-8. REPLACE/REPAIR CAMSHAFT (Continued)

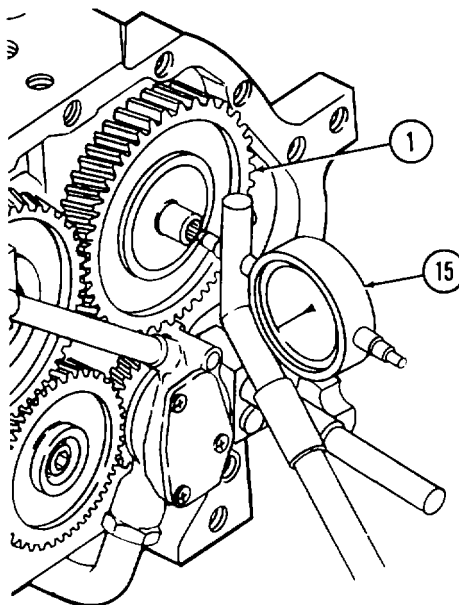


- 15 Under normal conditions, the radial clearance (difference between above measurements) should be 0.0028 to 0.0047 inch (0.07 to 0.12 mm). If clearance is greater than 0.0079 inch (0.200 mm), the camshaft (1) and/or crankcase (12) must be replaced. If camshaft rear journal (7) diameter is within its specified limits, replace the crankcase in accordance with paragraph 4-13. If camshaft rear journal is worn and outside its specified limits, replace the camshaft. Measure bore, journal, and radial clearance again to check that the clearance is within specified limits. Install new dished plug (11) with camshaft plug installer No. 143610.
- 16 Measure height of cam lobe (14) from shaft to top of lobe. Height should be 0.3110 to 0.3189 inch (7.90 to 8.10 mm). If cam lobes are damaged or worn, and do not measure within the specified limits, replace camshaft (1). Minor nicks, burrs, or wear may be smoothed out with a surfacing stone or crocus cloth. Reclean camshaft as described in steps 1 and 2.



4-8. REPLACE/REPAIR CAMSHAFT (Continued)

- 17 Install camshaft (1) and measure axial clearance using dial gage (15) mounted on crankshaft with a magnetic adapter. Clearance should be 0.0098 to 0.0236 inch (0.250 to 0.600 mm). If clearance is not within specified limits, recheck bushing. Make sure bushing bore is within specified limits and bushing is seated properly in crankcase. Replace in accordance with paragraph 4-13 if necessary.
- 18 Recheck bearing journal on camshaft for wear. Replace if worn close to camshaft gear. Recheck washer and camshaft gear for wear. Recheck axial clearance to see that it is within specified limits.

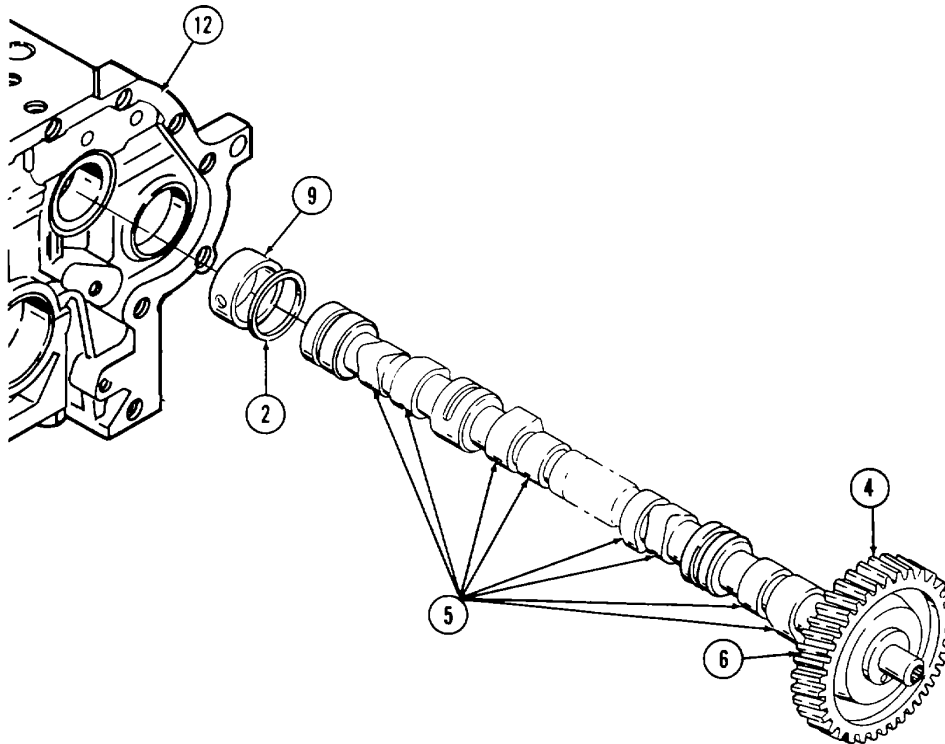
**REPAIR:****WARNING**

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. **DO NOT SMOKE.**

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 1 If contact surfaces are severely scratched, worn, or scored, replace camshaft (1). Repair minor nicks, burrs, or wear with surfacing stone. Clean with diesel fuel oil and dry with compressed air.
- 2 Use crocus cloth to repair minor nicks, burrs, or wear on camshaft gear (4). Clean with diesel fuel oil and dry with compressed air. Replace camshaft (1) if there is severe cracking or damage to gear (2).
- 3 Replace bushing (9) in accordance with paragraph 4-13 if bore is outside specified limits. Do not repair bushing.
- 4 Replace bearing journal (6) if diameter is outside specified limits. Do not repair bearing journal.

4-8. REPLACE/REPAIR CAMSHAFT (Continued)



- 5 Replace bushing (9) or camshaft (1) if radial clearance is outside specified limits. Replace bushing in accordance with paragraph 4-13.
- 6 Replace camshaft (1) or crankcase assembly (12) if radial clearance at rear camshaft bore (13) is outside specified limits. Replace crankcase in accordance with paragraph 4-13.
- 7 Replace camshaft (1) if any inlet or exhaust valve cam lobe height (14) is outside specified limits. Repair only minor nicks, burrs, or worn spots with surfacing stone or crocus cloth. Repair only if repairs will not cause tolerance limits to be exceeded.
- 8 Replace washer (2) if excessively worn, bent, cracked, or otherwise damaged. Do not repair.

INSTALLATION :

Lubricate camshaft (1), washer (2), and bushing (9) with lubricating oil and install in crankcase (12). If tappets are already installed in crankcase, make sure they are in top dead center position.

4-9. REPLACE/REPAIR CYLINDER ASSEMBLY

This task covers:

- | | | |
|---------------|------------------------|-----------|
| a. Removal | b. Cleaning/Inspection | c. Repair |
| d. Adjustment | e. Installation | |

INITIAL SETUP :

Tools

Shop set, automotive repair, field maintenance, basic
 Tool kit, master mechanics
 Hone with 120-grit stones
 Piston ring compressor, 100 mm, No. 130530

Equipment Condition
Para

3-19

Condition Description

Cylinder head removed from engine.

Special Environmental Conditions

Well-ventilated area required for cleaning.

Materials/Parts

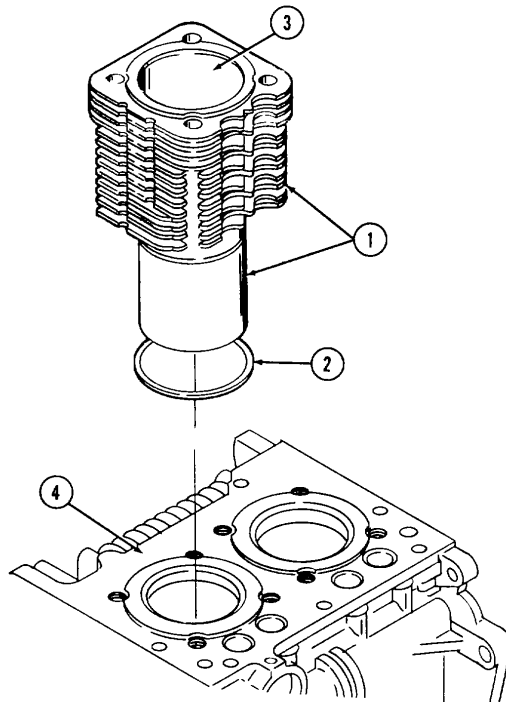
Dry cleaning solvent (Item 17, Appendix C)
 Grease (Item 7, Appendix C)
 Lubricating oil (Item 10, Appendix C)

REMOVAL:

CAUTION

When removing cylinder and shims, make sure piston or connecting rods do not knock against crankcase. This could result in serious damage to piston or connecting rod.

Remove cylinder (1), shims (2), and piston (3) from top of crankcase (4). Match-mark each cylinder and corresponding piston

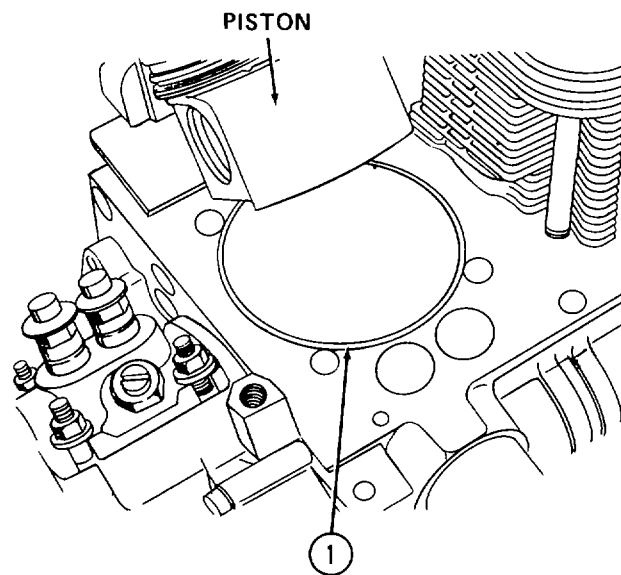


4-9. REPLACE/REPAIR CYLINDER ASSEMBLY (Continued)

CLEANING/INSPECTION :**WARNING**

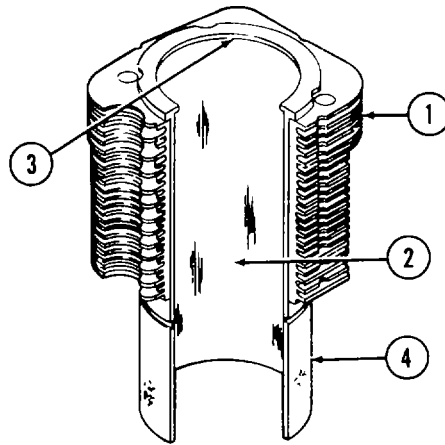
Dry cleaning solvent P-D-680 (safety or Stoddard's Solvent) is potentially dangerous. Avoid repeated and prolonged breathing of vapors and skin contact with the liquid. Do not use near open flame, arcing equipment, or other ignition sources. Always wear eye protection and protective clothing. The flash point of P-D-680 is 100° to 138°F (38° to 59°C).

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

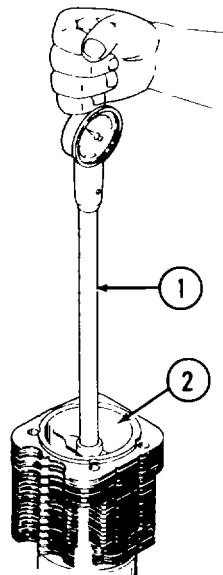


- 1 Clean cylinder seats (1) with dry cleaning solvent and dry with compressed air. Check that cylinder seats in crankcase are smooth and flat (90 degrees). If not, refer to paragraph 4-13 for remachining procedure:

4-9. REPLACE/REPAIR CYLINDER ASSEMBLY (Continued)



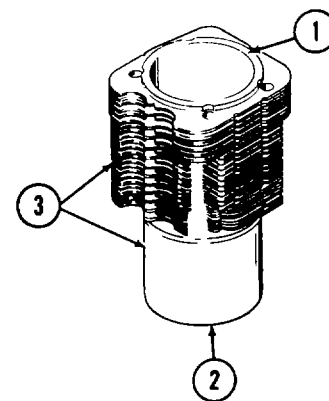
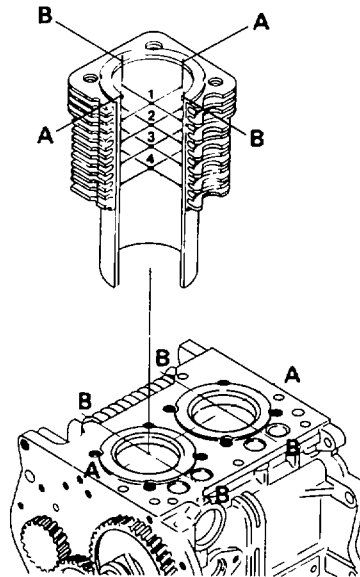
- 2 Clean cylinder (1) thoroughly with dry cleaning solvent. Dry with compressed air. Inspect for damage, warpage, rust, or corrosion. If severely damaged or warped, replace complete with new piston as necessary.
- 3 Inspect cylinder for cracks, scoring, glazing (2), a ridge (3) on the upper portion of inner surface, or adhering metal particles (fretting) (4) on outer surface.



- 4 Set precision bore gage (1) in cylinder bore (2), and measure bore diameter should be 3.9370 to 3.9457 inches (100.0 to 100.22 mm).

4-9. REPLACE/REPAIR CYLINDER ASSEMBLY (Continued)

- 5 Measure cylinder bore at levels 1 to 4 of engine centerline axis A and crossline axis B. Cylinder bore should be 3.9370 to 3.9457 inches (100.0 to 100.22 mm). If 3.9488 to 3.9575 inches (100.3 to 100.52 mm) wear limits have been reached or exceeded, replace cylinder and/or piston.
- 6 If measurements on axis A and axis B are different, cylinder is out-of-round or has high spots. Replace cylinder and/or piston as necessary.
- 7 Check that top joint face (1) and bottom joint face (2) are smooth and flat. If severely damaged, replace cylinder (3) and/or piston. If joint faces have only minor nicks or burrs or minor high spots, repair.
- 8 Replace a cylinder and/or piston if:
 - a. It is cracked, severely scored, or has a high ridge at the top of its inner surface as described in step 3.
 - b. Out-of-round exceeds the limits described in step 4.
 - c. Cylinder bore exceeds the limits described in step 4.



4-9. REPLACE/REPAIR CYLINDER ASSEMBLY (Continued)

REPAIR:

- 1 Remove slight ridges, score marks, and glaze on cylinder bore with a hone equipped with 120-grit stones. Work hone up and down rapidly the full length of the cylinder bore several times in a criss-cross pattern.

NOTE

Criss-cross pattern produces hone marks on a 45 degree axis, which aids piston movement and helps prevent formation of ridges.

WARNING

Dry cleaning solvent P-D-680 (safety or Stoddard's Solvent) is potentially dangerous. Avoid repeated and prolonged breathing of vapors and skin contact with the liquid. Do not use near open flame, arcing equipment, or other ignition sources. Always wear eye protection and protective clothing. The flash point of P-D-680 is 100° to 138°F (38° to 59°C).

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 2 Reclean each repaired cylinder with dry cleaning solvent and dry with compressed air. Remove any burrs

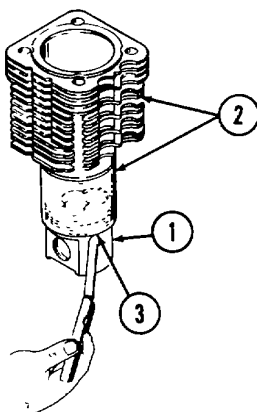
ADJUSTMENT:

- 1 Recheck cylinder bore and out-of-round on repaired cylinder as described in CLEANING/INSPECTION step 4. Replace if necessary.

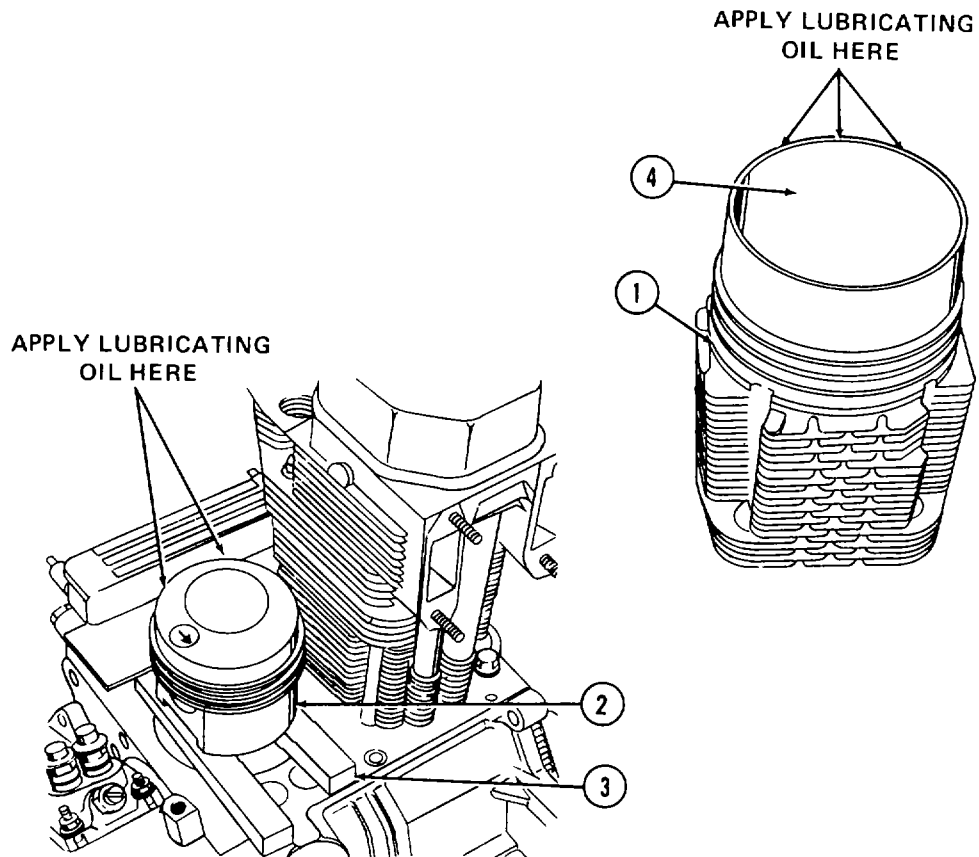
CAUTION

Piston and cylinder damage may result if pistons are not returned to their original cylinders. Observe matchmarks so that mixups do not occur.

- 2 Insert each piston (1) in its respective cylinder (2) or replacement and measure the piston skirt-to-cylinder clearance (3) with a feeler gage. If clearance is not within 0.0032 to 0.0166 inch (0.081 to 0.422 mm), replace piston.
- 3 Install cylinder (new or replacement) in proper bore of crankcase and measure cylinder bore and out-of-round with a bore gage at the locations described in CLEANING/INSPECTION step 5. Rehone or replace as needed.

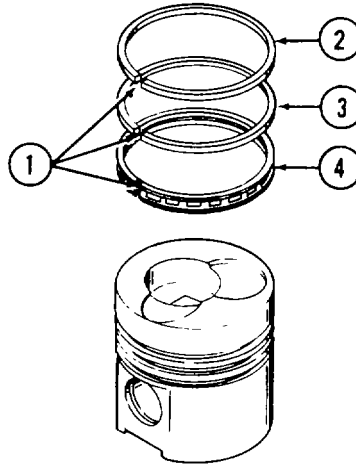


4-9. REPLACE/REPAIR CYLINDER ASSEMBLY (Continued)

INSTALLATION:

- 1 Apply grease to shims (1). Install cylinder base.
- 2 Place piston (2) on flat wooden blocks (3). Apply lubricating oil to inside running surface of cylinder (4) and to piston.

4-9. REPLACE/REPAIR CYLINDER ASSEMBLY (Continued)



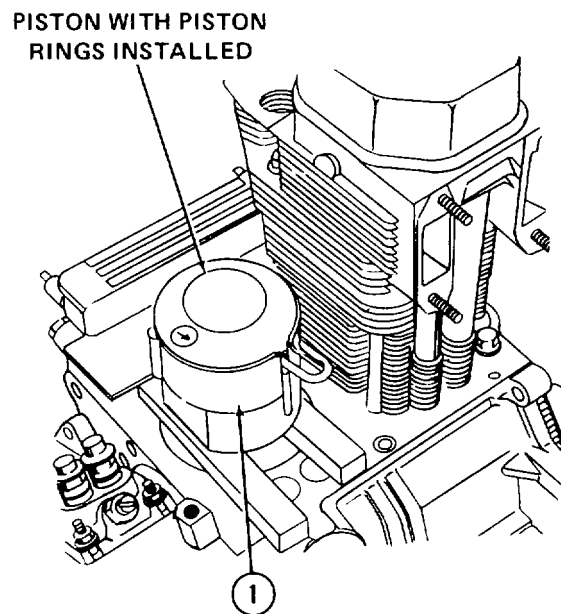
3 Install piston rings.

a. Check that piston ring gaps are offset by 120 degrees (1). The piston ring set contains three rings:

No. 1 - Trapezoidal ring (2)

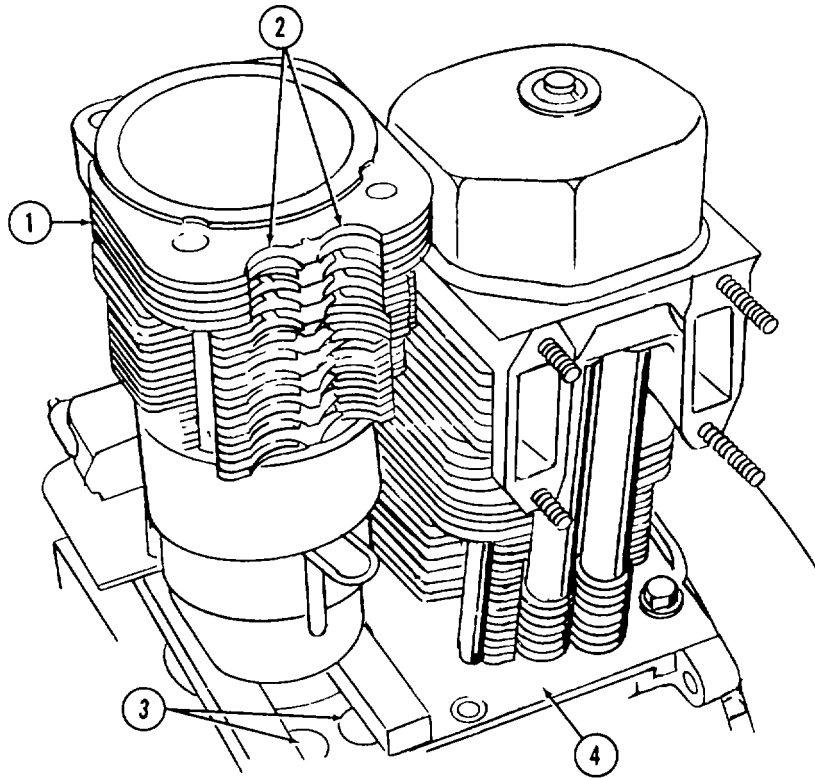
No. 2 -Taper ring (3)

No. 3 - Oil control ring (4)



b. Compress rings with piston ring compressor No. 130530 (1)

4-9. REPLACE/REPAIR CYLINDER ASSEMBLY (Continued)



- 4 Install cylinder (1) with recesses (2) facing pushrod cover tube bores (3) in crankcase (4) and aline cylinder properly.
-

4-10. REPLACE/REPAIR PISTON ASSEMBLY

This task covers:

- a. Removal
- b. Cleaning/Inspection
- c. Repair
- d. Installation

INITIAL SETUP

Tools

Shop set, automotive repair, field maintenance, basic
 Tool kit, master mechanics
 Piston heating unit No. 139000
 Piston ring groove gage No. 130360
 Piston ring pliers No. 130300

Equipment Condition

Para

Condition Description

3-10	Oil pan assembly removed from engine.
3-19	Cylinder head assembly removed from engine.
4-9	Cylinder removed from engine and piston up on wooden blocks.

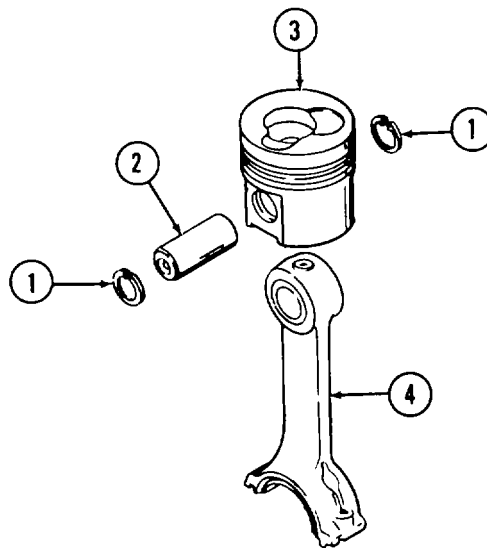
Materials/Parts

Crocus abrasive cloth (Item 1, Appendix C)
 Dry cleaning solvent (Item 17, Appendix C)

Special Environmental Conditions

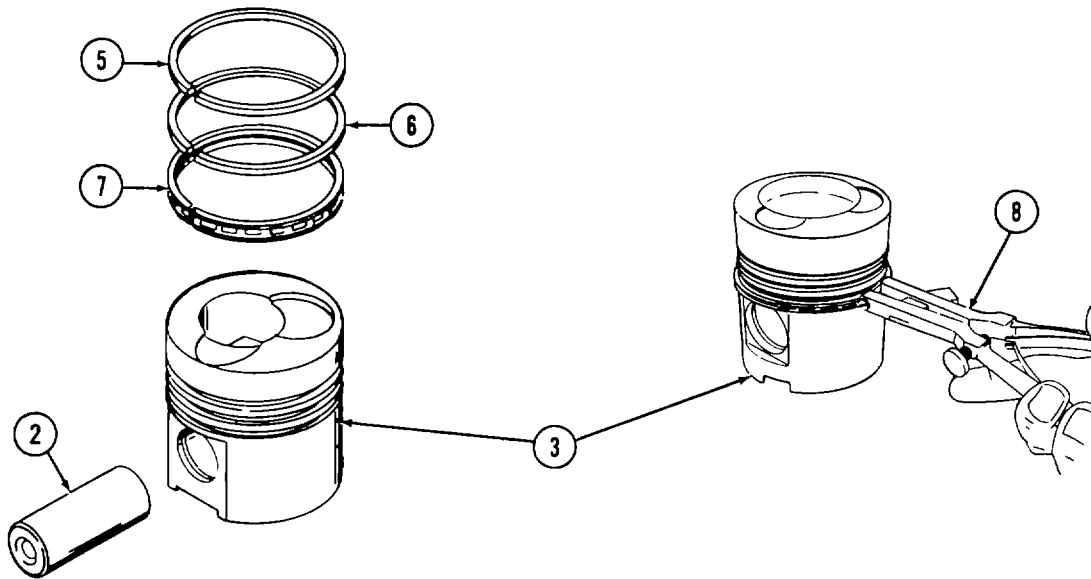
Well-ventilated area required for cleaning.

REMOVAL:



- 1 Remove and discard circlips (1).
- 2 Press piston pin (2) out far enough to remove piston pin and piston (3) from connecting rod (4). If piston pin has seized, heat piston with piston heating unit No 139000 and press out pin.

4-10. REPLACE/REPAIR PISTON ASSEMBLY (Continued)



- 3 Remove piston pin (2) from piston (3).
- 4 Remove piston rings (5, 6, and 7) from piston (3) with piston ring pliers No. 130300 (8). Discard piston rings.

CLEANING/INSPECTION :**WARNING**

Dry cleaning solvent P-D-680 (safety or Stoddard's Solvent) is potentially dangerous. Avoid repeated and prolonged breathing of vapors and skin contact with the liquid. Do not use near open flame, arcing equipment, or other ignition sources. Always wear eye protection and protective clothing. The flash point of P-D-680 is 100° to 138°F (38° to 59°C).

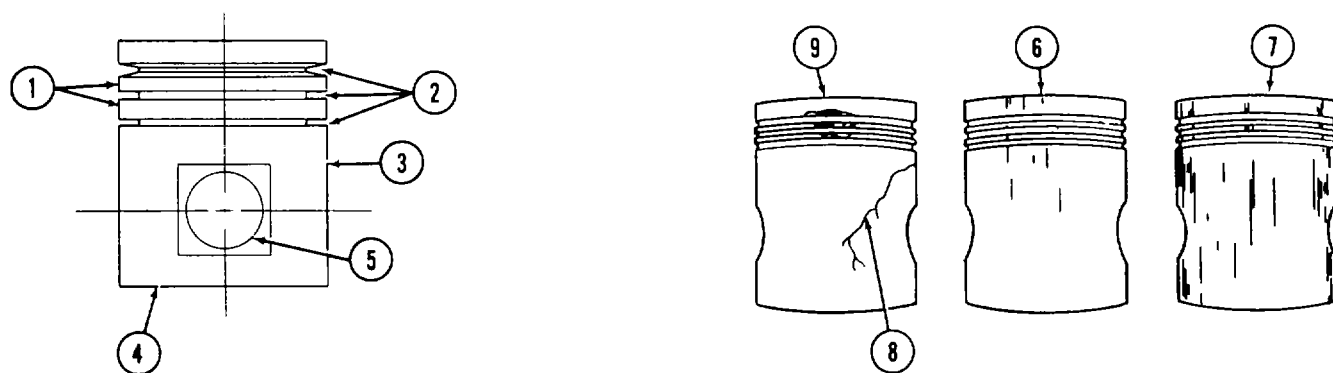
Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 1 Clean piston, piston pin, and piston rings with dry cleaning solvent and dry with compressed air. Remove carbon from piston ring lands (1) and grooves (2) with a wire brush. Clean inside surface of piston (3) and piston skirt (4). Clean piston pin bore (5) with small wire brush.

NOTE

Excessively worn pistons, rings, or cylinders may be an indication of abnormal maintenance practices or operating conditions. Check for and correct any abnormalities.

4-10. REPLACE/REPAIR PISTON ASSEMBLY (Continued)

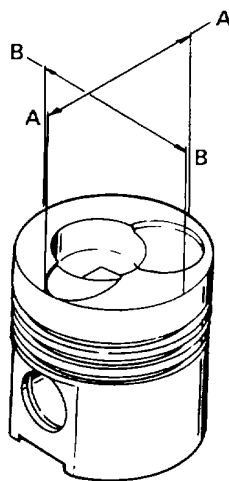


- 2 Inspect piston (3), piston skirt (4), and all grooves (2) for excessive wear (6) and damage. Examine piston for slight scoring (6), heavy scoring (17), fretting, pitting, cracks (8) (especially on the interior surfaces), damaged ring grooves or lands, or indications of overheating (9) Slight scoring may be cleaned with crocus cloth. Follow procedure described under repair.
- 3 If piston is badly worn or damaged, check cylinder for excessive out-of-round, high spots, or other damage in accordance with paragraph 4-9.

CAUTION

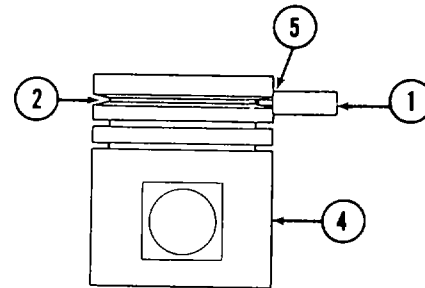
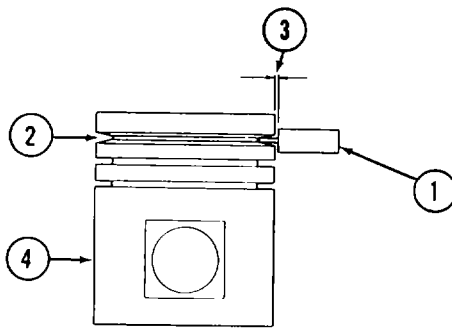
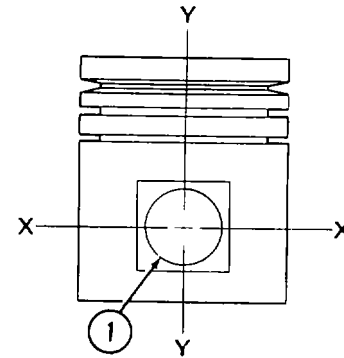
Pistons, piston rings, and cylinders must always be matched to the same size. Failure to match all three in size could cause serious damage to the engine.

- 4 Replace piston (3) if tin plate or ring grooves (2) are excessively worn or damaged, ring lands (1) are damaged; piston is heavily scored or cracked, or shows signs of excessive overheating.
- 5 Measure piston diameter along axis A and B. Piston diameter should be 3.9331 to 3.9338 inches (99.901 to 99.919 mm). If piston is out-of-round, replace piston.
- 6 If cylinder has been replaced, piston must also be replaced. Refer to paragraph 4-9 for more detail on cylinder replacement.



4-10. REPLACE/REPAIR PISTON ASSEMBLY (Continued)

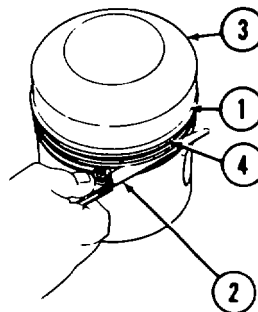
7 Measure piston pin bore (1) on X and Y axis with precision bore gage. Measurement should be 1.3780 to 1.3782 inches (35.00 to 35.006 mm). If bore measurement is larger than 1.3782 inches (35.006 mm) or is out-of-round, replace piston. This is also an indication of unusual wear. Check cylinder in accordance with paragraph 4-9 and also connecting rod in accordance with paragraph 4-11.



8 Measure axial clearance of trapezoidal ring groove with piston ring groove gage No. 130360 (1). Insert gage into ring groove (2). If a gap (3) exists between the inserted gage and piston (4), the axial ring clearance is 0.1096 to 0.1104 inch (2.784 to 2.804 mm) and the piston is still usable. Do not replace piston. If the gage contacts the side of the piston with no gap (5), the axial ring clearance is too great and the piston must be replaced.

9 Measure axial ring clearance of taper ring groove (1) with standard clearance gage (2). Measurement should be 0.102 to 0.1028 inch (2.59 to 2.61 mm). If measurement is greater than 0.1028 inch (2.61 mm), replace piston (3).

10 Measure axial ring clearance of oil control ring groove (4) with standard clearance gage (2). Measurement should be 0.1980 to 0.1988 inch (5.03 to 5.05 mm). If measurement is greater than 0.1988 inch (5.05 mm), replace piston (3).



4-10. REPLACE/REPAIR PISTON ASSEMBLY (Continued)**WARNING**

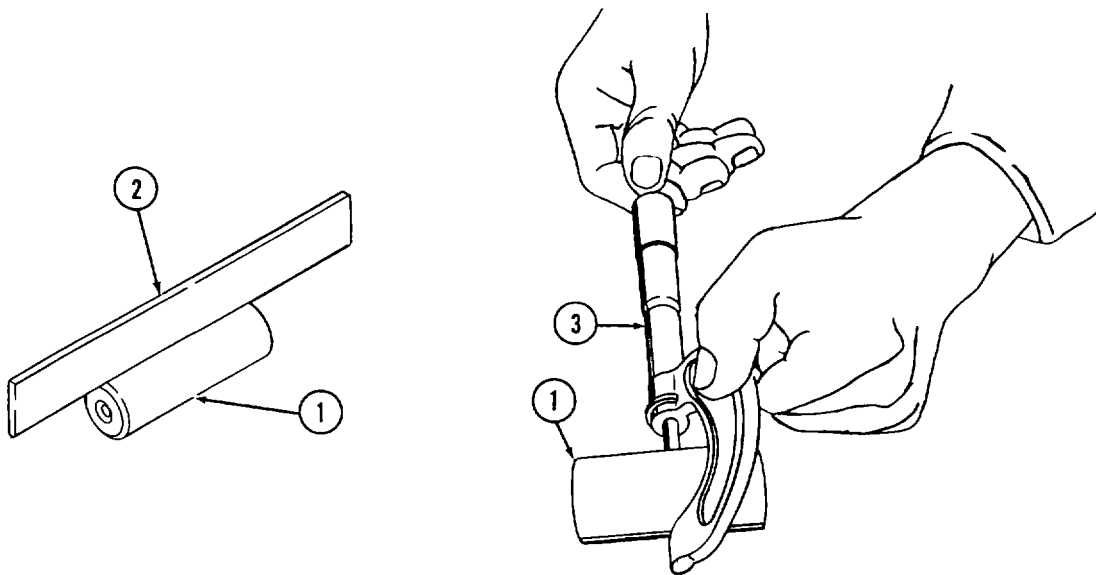
Dry cleaning solvent P-D-680 (safety or Stoddard's Solvent) is potentially dangerous. Avoid repeated and prolonged breathing of vapors and skin contact with the liquid. Do not use near open flame, arcing equipment, or other ignition sources. Always wear eye protection and protective clothing. The flash point of P-D-680 is 100° to 138°F (38° to 59°C).

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 11 If any axial ring clearance measurements are smaller than the minimum values given above, piston ring grooves may be clogged with carbon deposits. Reclean piston with dry cleaning solvent and wire brush. Dry with compressed air. Take measurements again. If still smaller than minimum values, piston is damaged or defective. Replace piston.

CAUTION

Small-end bushing in connecting rod may be damaged if piston pin is refinished. Do not refinish highly polished or lapped piston pin surface.



- 12 Inspect piston pin (1) for scoring, fretting, pitting, or indications of overheating. If damaged, replace piston pin.
- 13 Measure piston pin (1) for wear and check alinement. Measure alinement with beveled steel straightedge (2). This measurement will also indicate relative wear along the piston pin. Measure diameter of piston.

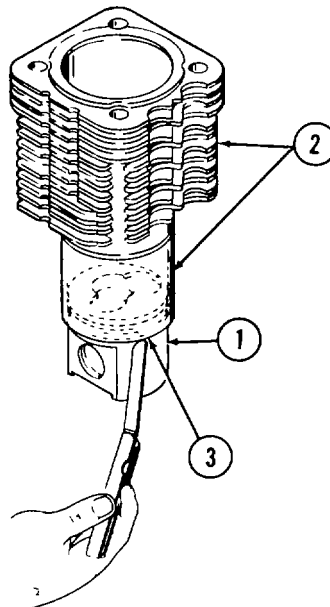
4-10. REPLACE/REPAIR PISTON ASSEMBLY (Continued)

pin with micrometer (3) at several points along the length of the pin. The diameter should be 1.3777 to 1.3780 inches (34.994 to 35.0 mm). The diameter should not be greater than 1.3780 inches (35.0 mm) under normal conditions. However, if it is, replace piston pin and recheck piston bore measurements. Replace piston if necessary. If piston pin is worn and any diameter measurements are less than 1.3777 inches (34.994 mm), replace piston pin.

CAUTION

Piston and cylinder damage may result if pistons are not returned to their original cylinders. Observe matchmarks so that mixups do not occur.

- 14 Insert each piston (1) in its respective cylinder (2) or replacement, and measure the piston skirt-to-cylinder clearance with feeler gage (3). If clearance is not within 0.0032 to 0.0166 inch (0.081 to 0.421 mm), inspect pistons and replace if necessary.



NOTE

Each piston is fitted with three rings: two compression rings and a double-chamfered oil control ring. The top compression or trapezoidal ring can be identified by the bright chrome plating. The second compression or taper ring can be identified by its cast iron construction. A double-chamfered oil control ring is used in the oil ring groove. All new piston rings must be installed whenever a piston is removed or replaced, or when a new cylinder is installed.

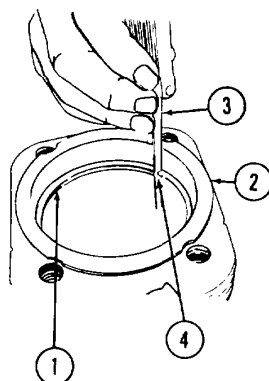
4-10. REPLACE/REPAIR PISTON ASSEMBLY (Continued)

15 Measure piston ring gap.

- a. Use piston to push piston rings (1), one at a time, down into cylinder (2). With feeler gage (3), measure ring gap (4) according to the following chart.

NOTE

Push ring in far enough to be in the normal area of ring travel, about 1.18 to 1.57 inches (30 to 40 mm).

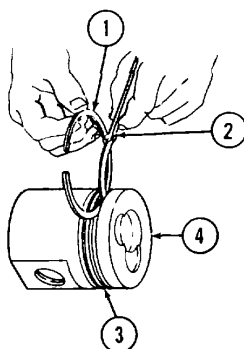


PISTON RING	NORMAL RING GAP inches (millimeters)	RING GAP WEAR LIMIT inches (millimeters)
Compression rings	0.0138 to 0.0217 (0.35 to 0.55)	0.1575 (4.00)
Oil control ring	0.0008 to 0.0157 (0.25 to 0.40)	0.0984 (2.50)

- b. If compression ring gap (4) measurements are less than 0.0138 inch (0.35 mm), the gap may be widened by very carefully filing or stoning. See REPAIR step 2 for details.
- c. If the double-chamfered oil control ring gap measurement is less than 0.0098 inch (0.25 mm), replace the double-chamfered ring.
- d. If any ring gap measurement is greater than 0.1575 inch (4.0 mm), replace the piston ring set.

16 Measure piston ring side clearance.

- a. Measure piston ring (1) side clearance with new piston rings only. Measure side clearance of each piston ring with feeler gage (2) in its corresponding piston ring groove (3) in accordance with the following chart.



4-10. REPLACE/REPAIR PISTON ASSEMBLY (Continued)

PISTON RING	NORMAL SIDE CLEARANCE inches (millimeters)	SIDE CLEARANCE WEAR LIMIT inches (millimeters)
First or trapezoidal rings	0.0031 to 0.0047 (0.079 to 0.119)	0.0197 (0.5)
Second or taper ring	0.0039 to 0.0052 (0.10 to 0.132)	0.0118 (0.3)
Third or oil control ring	0.0016 to 0.0028 (0.041 to 0.071)	0.0059 (0.15)

- b. If piston ring (1) side clearance for any piston ring is less than normal lower limit value given in chart, replace piston ring and measure side clearance again. If condition still exists, replace piston (4). If side clearance for any piston ring exceeds wear limit in chart, replace piston. Also replace cylinder, if necessary.

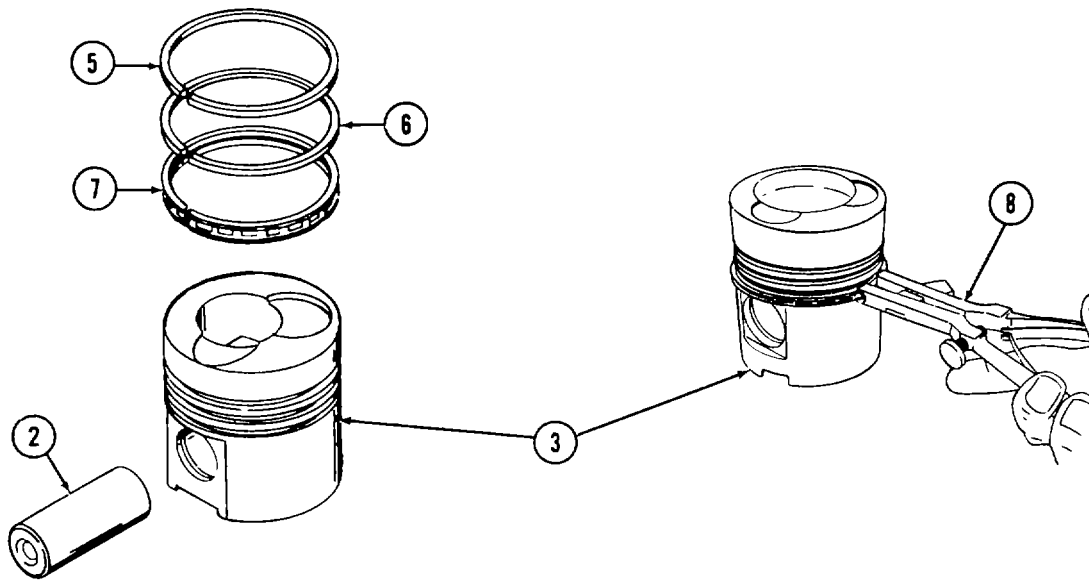
REPAIR:

- 1 Remove slight scoring or fretting on piston with crocus cloth. Reclean and repeat procedure if necessary.
- 2 If gap on new compression ring is insufficient, it may be increased by filing or stoning the ends of the ring. File or stone both ends of ring so cutting action is from outer surface to inner surface. This will prevent any chipping or peeling of chrome plate on ring. The ends of the ring must remain square with chamfer on outer edge.
- 3 If cylinder is worn or damaged, repair or replace in accordance with paragraph 4-9.

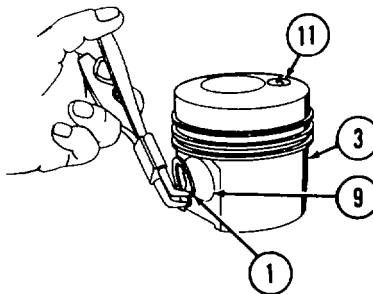
4-10. REPLACE/REPAIR PISTON ASSEMBLY (Continued)

INSTALLATION:**CAUTION**

Piston ring breakage may occur if rings are opened more than necessary when removing or installing them. Do not strain rings.

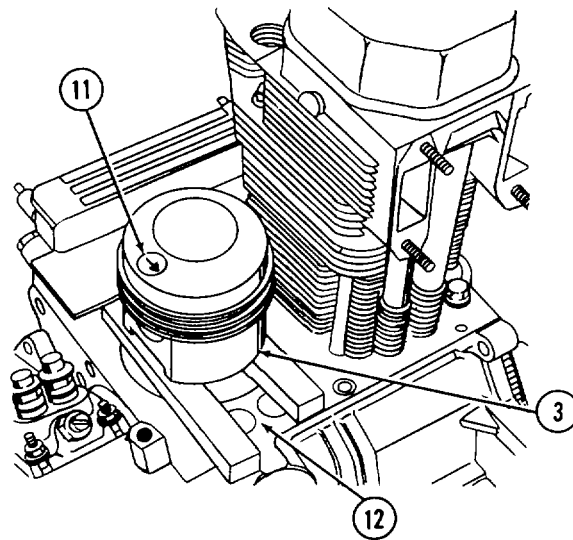
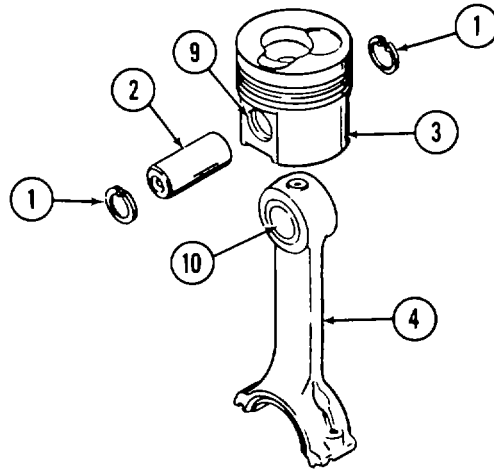


- 1 Install new piston rings (7, 6, and 5) with piston ring pliers No. 130300 (8). Install rings in the order listed, starting with the oil control ring (7). Be careful not to strain rings by opening them too wide during installation. Make sure that the piston ring gaps are equally spaced around the piston 120 degrees from each other.
- 2 Install new circlip (1) in lip groove of piston pin bore (9) opposite arrow (11) marked on the top of the piston (3), and pointing to the left as circlip is installed.



4-10. REPLACE/REPAIR PISTON ASSEMBLY (Continued)

- 3 Insert connecting rod (4) into bottom of piston (3), and place piston on two flat wooden blocks.



- 4 Insert piston pin (2) into piston pin bore (9) and through small-end bushing (10) of connecting rod. Push pin in until it contacts installed circlip (1) and stops. Make sure arrow (11) on top of piston (3) points toward pushrod cover tube bores (12) (inlet and exhaust side).
- 5 Install second new circlip (1).
-

4-11. REPLACE/REPAIR CONNECTING ROD ASSEMBLY

This task covers:

- a. Removal
- b. Cleaning/Inspection
- c. Repair
- d. Installation

INITIAL SETUP

Tools

Tool kit, master mechanics
 Piston pin bush inserter No 131310

References

MIL-I-6868 Magnetic Particle Inspection

Materials/Parts

Dry cleaning solvent (Item 17, Appendix C)
 Lubricating oil (Item 10, Appendix C)

Equipment Condition

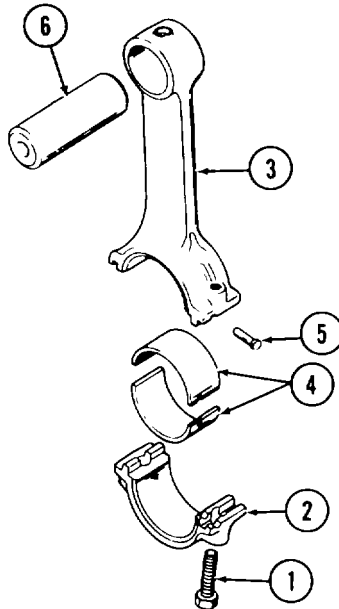
Para	Condition Description
4-10	Piston assembly removed from connecting rod.

Special Environmental Conditions

Well-ventilated area required for cleaning.

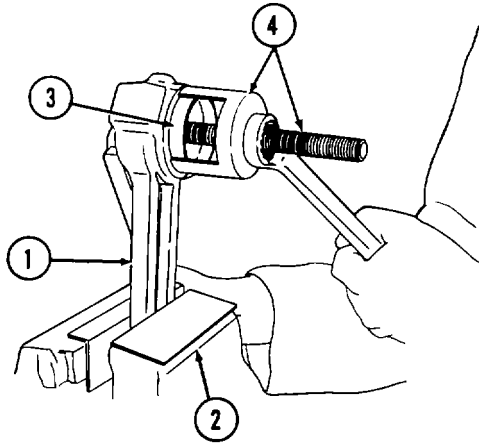
REMOVAL:

- 1 Remove big-end bolts (1) from bearing cap (2) and connecting rod (3).
- 2 Remove bearing cap (2) and one-half of bearing shell (4) from bottom of crankcase. Remove dowel pin (5).
- 3 Remove connecting rod (3) and one-half of bearing shell (4) from top of crankcase.
- 4 Remove piston pin (6) from connecting rod (3).



4-11. REPLACE/REPAIR CONNECTING ROD ASSEMBLY (Continued)

- 5 Clamp connecting rod (1) in a padded vise (2) and remove small-end bushing (3) with piston pin bush inserter No. 131310 (4).

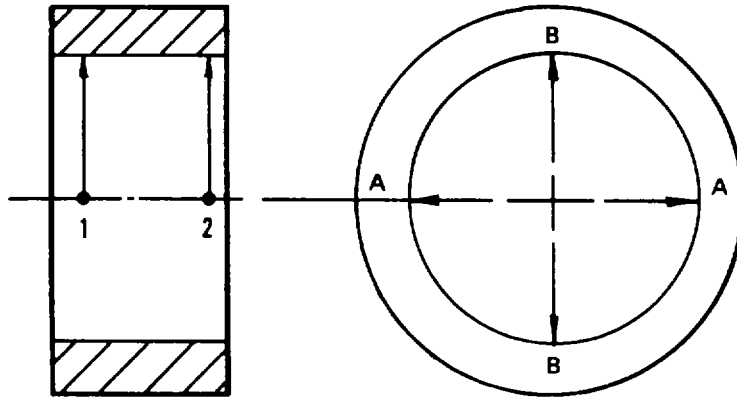
**CLEANING/INSPECTION:****WARNING**

Dry cleaning solvent P-D-680 (safety or Stoddard's Solvent) is potentially dangerous. Avoid repeated and prolonged breathing of vapors and skin contact with the liquid. Do not use near open flame, arcing equipment, or other ignition sources. Always wear eye protection and protective clothing. The flash point of P-D-680 is 100° to 138°F (38° to 59°C).

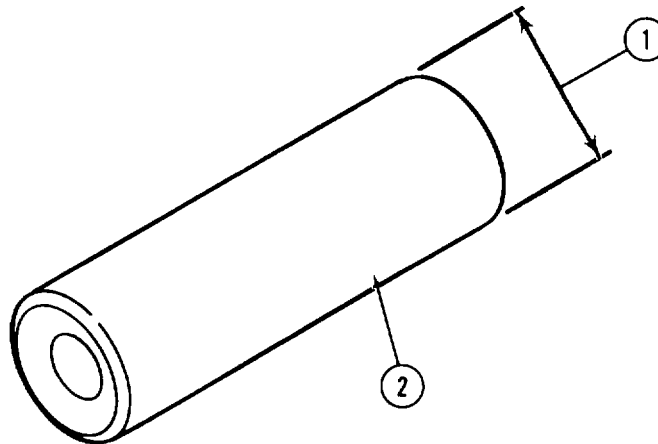
Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kgcm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- 1 Clean connecting rod components (1 through 7) with dry cleaning solvent and dry with compressed air. Remove any carbon deposits with a wire brush.
- 2 Clean inside surface of small-end bushing, connecting rod, and bearing shells.
- 3 Blow compressed air through the drilled oil passage in connecting rod, so that air flows freely through oil holes in connecting rod and bushing to clean them out.

4-11. REPLACE/REPAIR CONNECTING ROD ASSEMBLY (Continued)



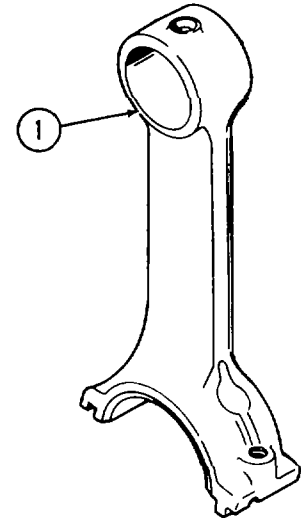
- 4 Inspect small-end bushing.
 - a. Adjust inside micrometer to 1.5748 inches (40.0 mm).
 - b. Measure and record small-end bushing bore or inside diameter. Measure at points 1 and 2 along axes A and B. Measurements should be 1.5763 to 1.5781 inches (40.038 to 40.084 mm). If any measurement is outside these limits, replace small-end bushing.
 - c. Inspect for scoring, overheating, or other damage. Replace as necessary. Measure outside diameter of bushing with outside micrometer. Measurement should be 1.6949 to 1.6961 inches (43.05 to 43.08 mm). If measurement is outside specified limits, replace small-end bushing.
- 5 Measure and record diameter (1) of corresponding piston pin (2) with micrometer at several points along the length of the pin. The diameter should be 1.5746 to 1.5748 inches (39.995 to 40.0 mm). If measurement is outside these limits, replace piston pin.



- 6 Check piston pin clearance in small-end bushing.
 - a. Subtract piston pin diameter measured in step 5 from small-end bushing bore measurement recorded in step 4. Clearance should be 0.0015 to 0.0035 inch (0.038 to 0.089 mm) under normal conditions.
 - b. If clearance is greater than 0.0098 inch (0.25 mm), piston pin and small-end bushing should be remeasured and clearance redetermined.
 - c. If clearance is still greater than 0.0098 inch (0.25 mm), replace piston pin or small-end bushing, or both. Be sure to recheck measurements and clearances to see that they fall within their respective tolerance limits.

4-11. REPLACE/REPAIR CONNECTING ROD ASSEMBLY (Continued)

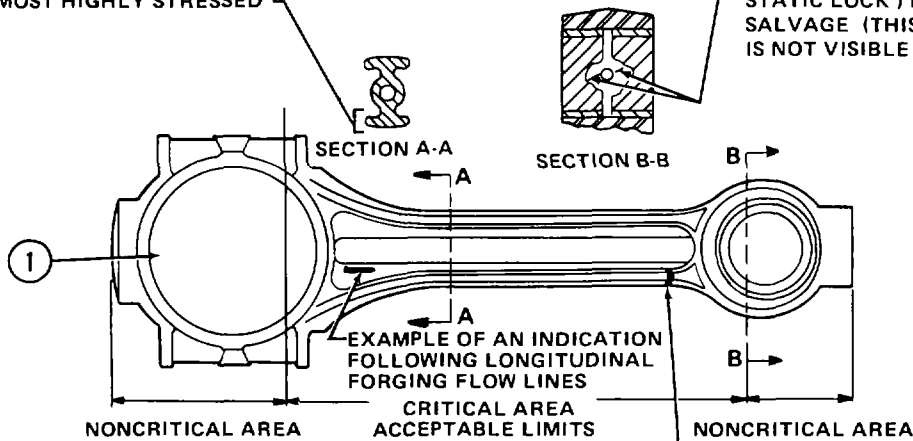
- 7 Measure connecting rod bore (1) with inside micrometer. Bore (1) should measure 1.6929 to 1.6935 inches (43.0 to 43.015 mm) If measurement is outside specified limits, replace connecting rod.



TRANSVERSE INDICATIONS (ACROSS FLOW LINES), HAVING A MAXIMUM LENGTH OF 1/2 INCH (12.7 mm) WHICH CAN BE REMOVED BY GRINDING NO DEEPER THAN 1/64 INCH (0.3969 mm) ARE ACCEPTABLE AFTER THEIR COMPLETE REMOVAL. AN EXCEPTION TO THIS IS A ROD HAVING AN INDICATION WHICH EXTENDS OVER THE EDGE OF H SECTION AND IS PRESENT ON BOTH SIDES OF THE FLANGE IN THIS CASE MAXIMUM ALLOWABLE DEPTH IS 0.005 (SEE SECTION A-A)

DO NOT USE OR ATTEMPT TO SALVAGE RODS WITH INDICATIONS OVER 0.005 INCH (0.127 mm) DEEP EXTENDING OVER EDGES OF H SECTION ON BOTH SIDES OF FLANGE. SHADED AREAS ARE MOST HIGHLY STRESSED

START OF FATIGUE CRACK RESULTING FROM OVERLOADING (DUE TO HYDROSTATIC LOCK) DO NOT ATTEMPT TO SALVAGE (THIS TYPE OF INDICATION IS NOT VISIBLE WITH BUSHING IN PLACE)



INDICATIONS IN NONCRITICAL AREAS ARE ACCEPTABLE UNLESS THEY CAN BE OBSERVED AS OBVIOUS CRACKS WITHOUT MAGNETIC INSPECTIONS.

EXAMPLE OF A TRANSVERSE INDICATION THAT DOES NOT FOLLOW LONGITUDINAL FORGING FLOW LINES CAN BE EITHER A FORGING LAP, HEAT TREAT CRACK, OR START OF A FATIGUE CRACK

LONGITUDINAL INDICATIONS FOLLOWING FORGED FLOW LINES ARE USUALLY SEAMS AND ARE NOT CONSIDERED HARMFUL IF LESS THAN 1/32 INCH (0.7938 mm) DEEP. DEPTH CAN BE DETERMINED BY GRINDING A SMALL AREA NEAR THE CENTER OF THE INDICATION

**GRINDING NOTES
CARE SHOULD BE TAKEN IN GRINDING OUT INDICATIONS TO ASSURE PROPER BLENDING OF GROUND AREA INTO UNGROUND SURFACE SO AS TO FORM A SMOOTH CONTOUR.**



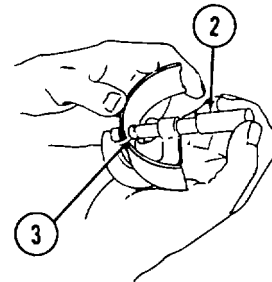
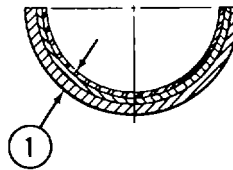
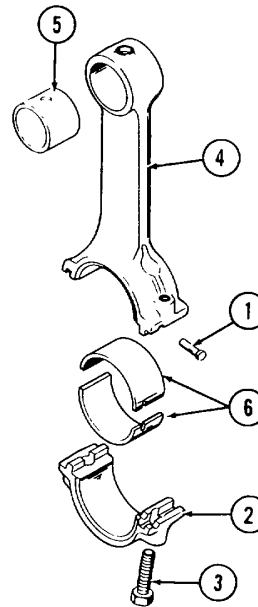
- 8 Visually inspect connecting rod for bending, warping, cracking, rust, or other damage. Check for cracks using MIL-I-6868 magnetic particle inspection. Replace if twisted or bent. Grind or replace if indications of cracks are revealed by magnetic particle inspection. Stamp the cylinder number on a replacement connecting rod and bearing cap.

4-11. REPLACE/REPAIR CONNECTING ROD ASSEMBLY (Continued)

NOTE

Clean rust preventive from replacement connecting rod. Also make sure the bearing cap is thoroughly cleaned to prevent trapped contaminants from adversely affecting the bearing shells.

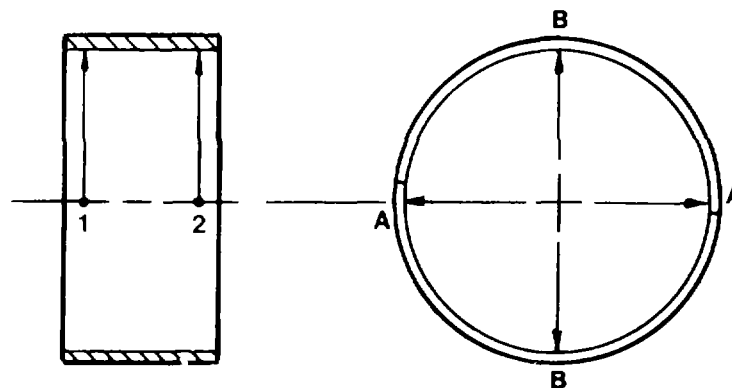
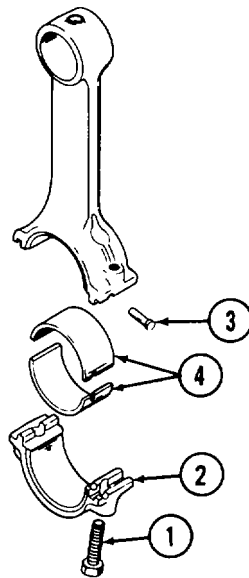
- 9 Temporarily reassemble dowel pin (1) and bearing cap (2) with big-end bolts (3) onto match-marked connecting rod (4). Tighten bolts to 22.13 ft-lb (30 N•m) torque. Using a torque gage, retighten bolts an additional 60 degrees, then an additional 30 degrees.
- 10 Measure width of connecting rod (4) with micrometer. Measurement should be 1.3960 to 1.3984 inches (35.46 to 35.52 mm). If measurement is outside specified limits, replace connecting rod.
- 11 Measure connecting rod bore with inside micrometer. Measurement should be 2.6771 to 2.6779 inches (68.0 to 68.019 mm). If measurement is outside specified limits, replace connecting rod (4) including bearing cap (2), small-end bushing (5), bearing shells (6), and big-end bolts (3).



- 12 Inspect bearing shells.
 - a. Inspect upper and lower bearing shells for excessive wear, scoring, pitting, flaking, etching, and signs of overheating.
 - b. Inspect bearing shell backs for bright spots (bearing moving in bearing shells).
 - c. Measure bearing shell width. Measurement should be 1.0157 to 1.0236 inches (25.8 to 26.0 mm). If measurement is outside specified limits, replace bearing shells.
 - d. Measure bearing shell wall thickness (1) with a micrometer (2) and ball attachment (3). The minimum thickness of a worn standard bearing shell is 0.0778 inch (1.976 mm). If measurement is below specified limit, replace bearing shells.

4-11 REPLACE/REPAIR CONNECTING ROD ASSEMBLY (Continued)

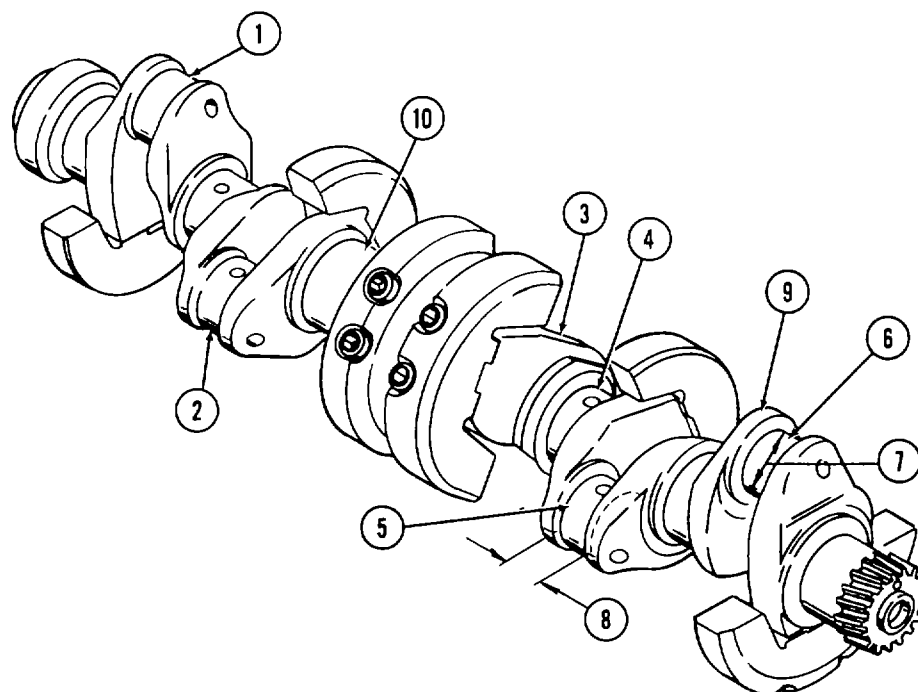
- 13 Remove big-end bolts (1), bearing cap (2), and dowel pin (3), and carefully insert bearing shells (4) Reinsert pin and tighten big-end bolts following procedure described in step 9 above.



- 14 Check bearing shell bore

- a Measure with inside micrometer at points 1 and 2 and along axes A and B. Measurement should be 2.5209 to 2.5224 inches (64.031 to 64.069 mm).
- b. If any measurement is outside the tolerance limits, replace the bearing shells.
- c Make sure that measurements at points 1 and 2 are not different nor outside the tolerance limits indicating that bearing shell is wearing in a conical shape.
- d Make sure measurements along axes A and B are not different nor outside the tolerance limits indicating bearing shell is wearing in an oval shape.
- e If bearing shell is wearing out-of-round, replace it and check the crankpin on the crankshaft. Follow procedure described in paragraph 4-12 Also check pistons and cylinders for unusual wear. Follow procedures described in paragraphs 4-9 and 4-10.

4-11. REPLACE/REPAIR CONNECTING ROD ASSEMBLY (Continued)



- 15 Measure diameter and width of all six crankpins (1 through 6) and record measurements. Make sure measurements are identified as cylinder No. 1, cylinder No. 2, and so on. Cylinder No. 1 is closest to the flywheel end of the engine; cylinder No. 6 is closest to the blower end.

NOTE

When determining bearing shell radial and side clearance, make sure connecting rods and bearing shells are properly matched and also properly matched to the corresponding crankpin.

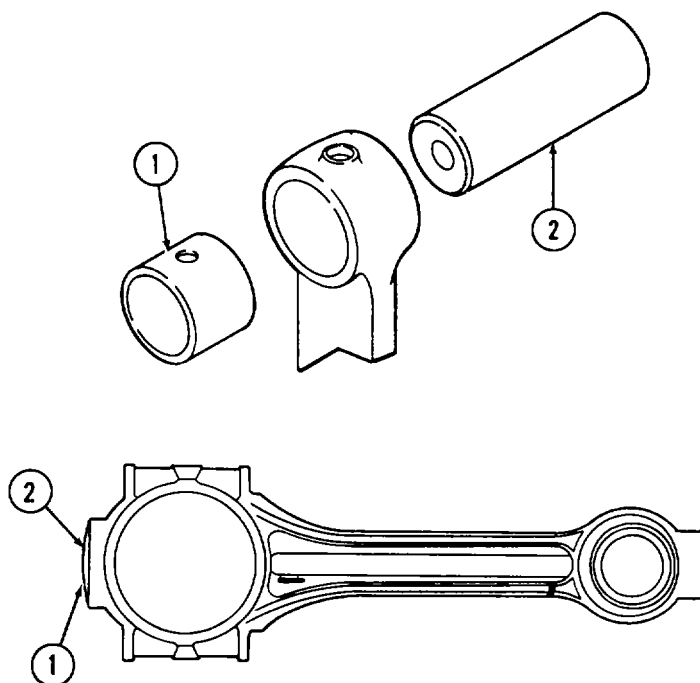
- 16 Check bearing shell radial clearance.
- Take the smallest measurement of the bearing shell bore that is still within the tolerance limits, measured in step 14, and subtract largest crankpin diameter (7) measurement measured in step 15. The difference between these two measurements is the bearing shell radial clearance. It should be 0.0016 to 0.0039 inch (0.04 to 0.099 mm) under normal conditions.
 - Radial clearance upper limit value is 0.0118 inch (0.3 mm). If radial clearance is less than 0.0016 inch (0.04 mm), replace bearing shells.
- 17 Check bearing shell side clearance.
- Measure crankpin width (8) and record the measurement. Subtract connecting rod width measured in step 10. The difference is bearing shell side clearance and it should be 0.0189 to 0.0229 inch (0.48 to 0.582 mm) under normal conditions.
 - The side clearance upper limit value is 0.0315 inch (0.8 mm). If the side clearance is less than 0.0189 inch (0.48 mm), the connecting rod should be rechecked and remeasured. Replace the connecting rod if necessary.

4-11. REPLACE/REPAIR CONNECTING ROD ASSEMBLY (Continued)

- c If the side clearance is greater than 0.0315 inch (0.8 mm), either the connecting rod or crankpin fillets (9) on the crankshaft (10) are worn. Recheck and remeasure connecting rod. Replace connecting rod if width is below tolerance limits. If not, recheck crankpin width (8) on crankshaft (10). Crankpin width should be 1.4173 to 1.4189 inches (36.0 to 36.04 mm). If crankpin width is greater than 1.4189 inches (36.04 mm), replace crankshaft. Connecting rods and big-end support bearings may also have to be replaced.

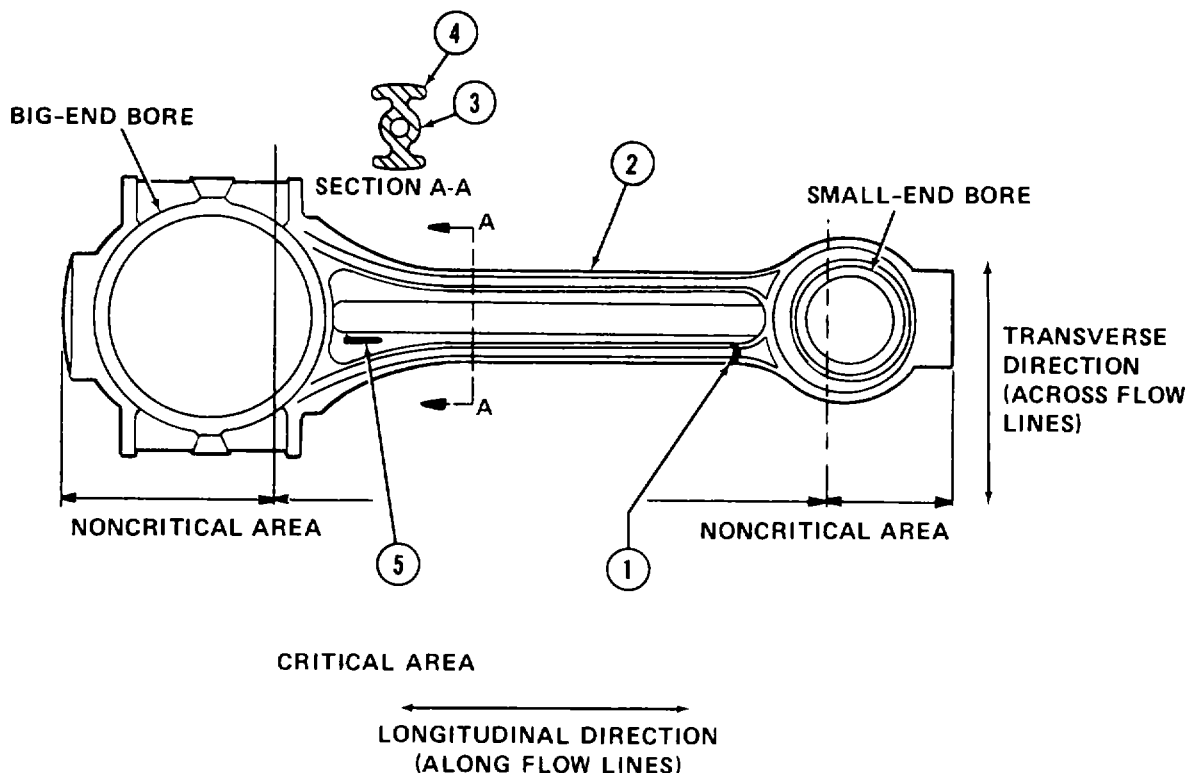
REPAIR:

- 1 Replace small-end bushing (1) if scored, overheated, out-of-round, or damaged. Replace if inside diameter (pressed in) or outside diameter is beyond the tolerance limits. Replace bushing if piston pin (2) (new or acceptable) clearance is outside the tolerance limits.
- 2 Replace piston pin (2) if clearance in new or acceptable small-end bushing is outside the tolerance limits.



- 3 Replace connecting rod if bent, warped, cracked, or damaged. Replace if bore for small-end bushing is outside tolerance limits. Replace if bearing shell bore or side clearance is outside tolerance limits. When replacing connecting rods, make sure color code (1) on bottom of bearing cap (2) is the same as the replaced rod, indicating the same weight class. The connecting rods within any weight class should not differ more than 1.058 ounce (30 grams).

4-11. REPLACE/REPAIR CONNECTING ROD ASSEMBLY (Continued)



- 4 Repair minor cracking in the transverse direction (1) (across flow lines) of the connecting rod (2) as long as the cracks are no longer than 0.50 inch (12.70 mm) and can be completely removed by grinding no deeper than 0.0156 inch (0.3962 mm). If the cracking extends over the edge of the H section (3) or on both sides of the connecting rod flange (4), the crack must be completely removable, by grinding no deeper than 0.0050 inch (0.1270 mm). Otherwise, replace connecting rod (2) in either case. Minor cracking in the longitudinal direction (5) (along flow lines) may be removed by grinding no deeper than 0.0313 inch (0.7950 mm). If crack is deeper, replace connecting rod. Remove rust. Do not finish connecting rod.

NOTE

When grinding out minor nicks, abrasions, or cracks on connecting rod, make sure ground areas form smooth contours with adjacent unground areas.

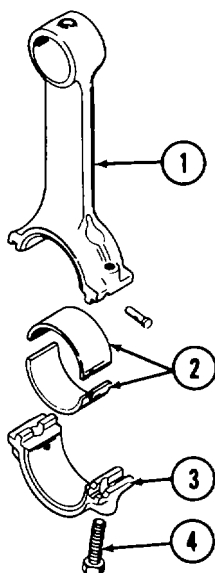
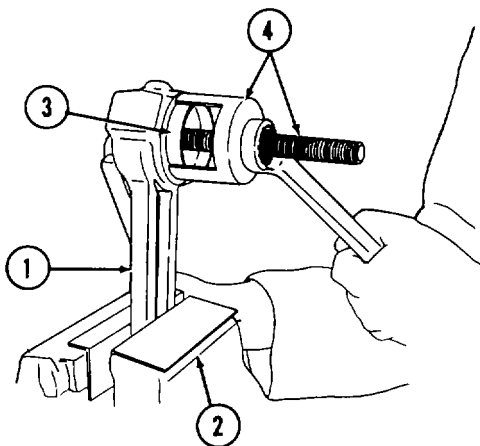
- 5 Repair bearing shells.
- Replace bearing shells if they are excessively worn, out-of-tolerance, out-of-round, or show any scoring, pitting, flaking, etching, or signs of overheating. Replace bearing shells if they show any bright spots on the back or outside surfaces.
 - Install new bearing shells in connecting rod only if necessary. Follow procedure described in step 13. Tighten and retighten big-end bolts in accordance with procedure described in step 9.

4-11. REPLACE/REPAIR CONNECTING ROD ASSEMBLY (Continued)

- c. Remeasure bearing shell bore in accordance with step 14. The bearing shell bore, for example, should be 2.5209 to 2.5224 inches (64.03 to 64.069 mm). However, if the bore measures an additional 0.0008 inch (0.020 mm) on either side of tolerance limits, the connecting rod and bearing shells would still be acceptable for reinstallation. The tolerance limits would then become 2.5217 to 2.5232 inches (64.05 to 64.089 mm) and the connecting rod and bearing shells would be acceptable for further use
- d. If bearing shell bore measurements are still outside the extended tolerance limits, the connecting rod must be replaced. This would include replacement of small-end bushing, bearing shells, bearing cap, dowel pin, and big-end bolts

INSTALLATION

- 1 If connecting rod (1) has been replaced, clamp new connecting rod into padded vise (2) and pull in small-end bushing (3) with piston pin bush inserter No. 131310 (4)



- 2 If connecting rod (1) and/or bearing shells (2) have been replaced, matchmark connecting rod, bearing shells, and bearing cap (3) for each cylinder. Always use new big-end bolts (4) for installation of connecting rod and bearing shells onto crankpin on crankshaft. Tighten bolts (2) to 22.13 ft-lb (30 N-m) torque. Using a torque gage, retighten bolts an additional 60 degrees, then an additional 30 degrees.

4-12. REPLACE/REPAIR CRANKSHAFT ASSEMBLY

This task covers: **a. Removal** **c. Inspection** **e. Installation**
 b. Cleaning **d. Repair**

INITIAL SETUP:**Tools**

Shop set, automotive repair, field maintenance, basic
 Tool kit, master mechanics

Crankshaft seal puller No. 142700

Oil seal assembly tool No. 142510

Torque gage No. 101910

References

MIL- 1-6868 Magnetic Particle Inspection

Equipment Condition**Para****Condition Description**

3-11 Oil pump removed from engine

3-23 Adapter housing removed from engine

4-11 Connecting rods removed from engine.

Materials/Parts

Crocus abrasive cloth (Item 1, Appendix C)

Diesel fuel oil (Item 6, Appendix C)

Emery abrasive cloth (Item 2, Appendix C)

Grease (Item 7, Appendix C)

Lubricating oil (Item 10, Appendix C)

Surfacing stone (Item 18, Appendix C)

Special Environmental Conditions

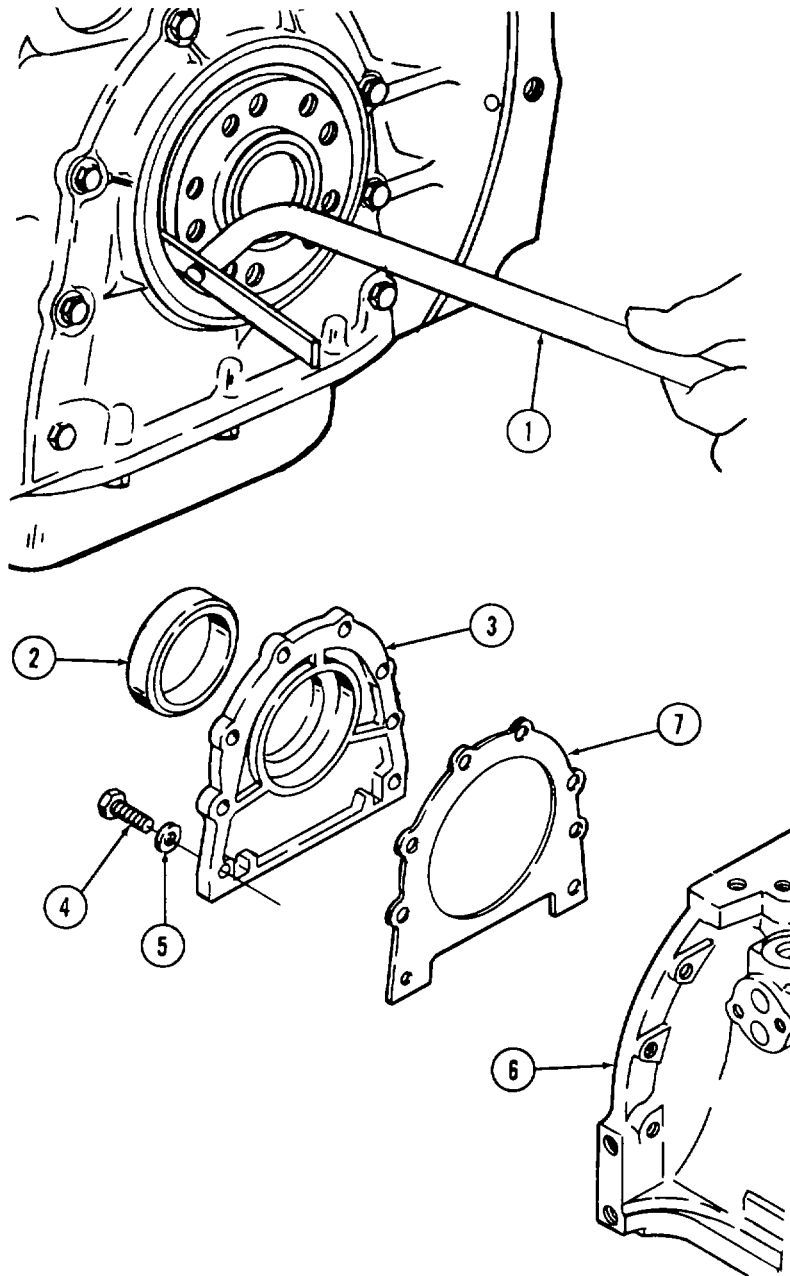
Well-ventilated area required during cleaning and repair.

4-12 REPLACE/REPAIR CRANKSHAFT ASSEMBLY (Continued)

REMOVAL**CAUTION**

Do not lay crankshaft on its side. Stand it on end to prevent warpage.

- 1 Using crankshaft seal puller No. 142700 (1), remove shaft seal (2) from rear-end cover (3). Discard the seal
- 2 Remove bolts (4) and washers (5) that secure rear-end cover (3) to engine crankcase (6) and pull the cover and gasket (7) from the crankcase.



4-12. REPLACE/REPAIR CRANKSHAFT ASSEMBLY (Continued)

3 Passing 3/4 inch (19.05 mm) rope or fabric lifting slings through cylinder bores 1 and 6, secure the crankshaft so it will not fall from the crankcase when the bearing caps are removed.

4 Check that each bearing cap (1) is marked with a corresponding matchmark on the crankcase (2). The matchmarks must indicate direction of match as well as location.

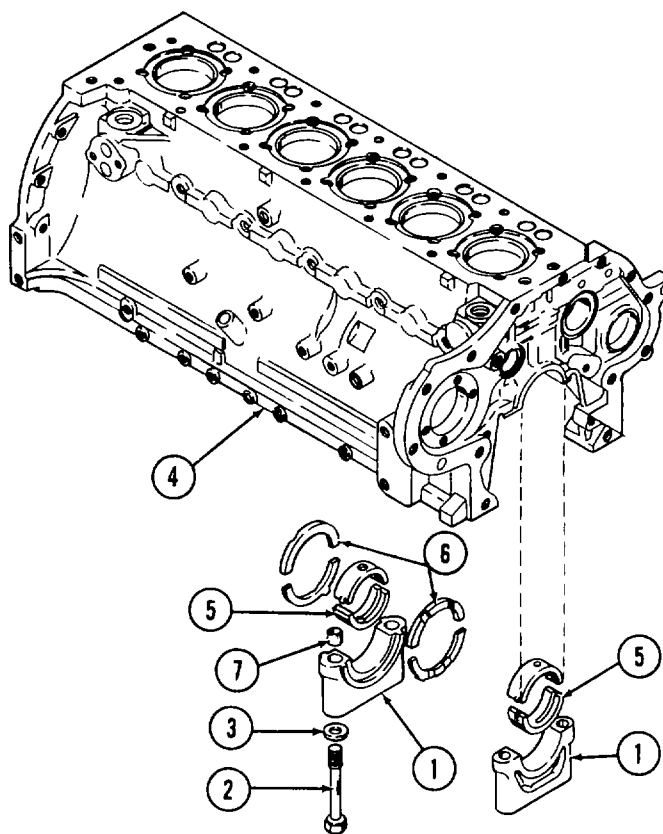
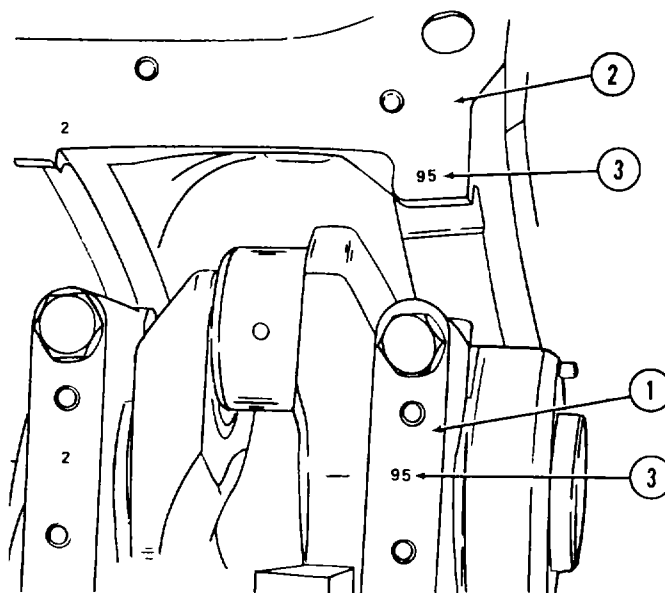
5 If there are no existing matchmarks, mark each bearing cap (1) and its corresponding position with an identification number (3). The number and direction of the number should be the same for each cap and crankcase position.

6 Starting with the front and rear bearing caps (1), and working toward the center bearing caps, remove the bolts (2) and washers (3) that secure each bearing cap to the crankcase (4).

7 Remove bearing caps (1), main bearings (5), and stop rings (6). Be sure to note location of the two stop rings to aid in installation. Remove dowel bushings (7) that align each bearing cap to crankcase.

8 Follow procedure described in paragraph 4-13 for inspection, repair, or replacement of bearing cap, bracket, and main bearing.

9 Release the slings holding the crankshaft in position and remove it from the crankcase.



4-12. REPLACE/REPAIR CRANKSHAFT ASSEMBLY (Continued)

CLEANING.

WARNING

Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

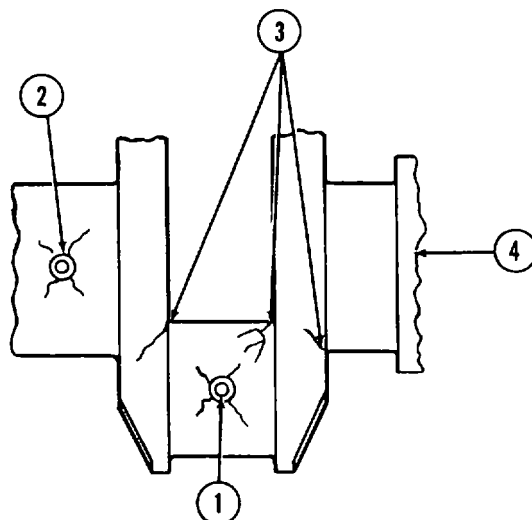
- 1 Clean crankshaft oil passages with a stiff wire brush. Clean crankshaft, rear-end cover, bearing caps, stop rings, and dowel bushing with diesel fuel oil and dry with compressed air.
- 2 Remove all traces of old gasket and sealant from the mating surfaces of the crankshaft and rear-end cover.

INSPECTION:

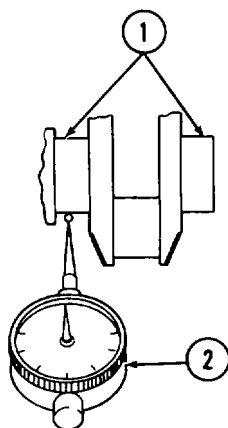
- 1 Inspect rear-end cover
 - a. Inspect crankcase mating surface for cracks, gouges, or other damage that would prevent proper seating or sealing of rear-end cover. Replace a cracked cover.
 - b. Inspect rear-end cover for warpage by placing it mating flange down on a flat surface. Replace a warped rear-end cover.
 - c. Inspect shaft seal bore for gouges, wear, or other damage that would prevent proper seating of the seal.
- 2 Inspect crankshaft gear for cracking, excessive wear, cracked or broken gear teeth, rust, corrosion, or other damage. If gear is damaged or excessively worn, replace it. Inspect dowel sleeve keyhole. Make sure it has not been worn out of its square shape or that dowel sleeve has not been broken off in dowel sleeve keyhole. If keyhole is worn and/or part of dowel sleeve is lodged in keyhole, replace gear.
- 3 Inspect dowel sleeve for excessive wear. Replace if worn or damaged.

4-12. REPLACE/REPAIR CRANKSHAFT ASSEMBLY (Continued)

- 4 Visually inspect crankshaft journals and crankpins for overheating, cracking, excessive wear, or other damage. Visually inspect for cracks which start at a crankpin or journal oil hole (1 or 2) and follow the journal or crankpin surface at an angle of 45 degrees to the axis. Inspect for cracks in critical fillet areas (3). Replace crankshaft (4) if cracks are visible. Inspect for minute cracks using MIL-I-6868 Magnetic Particle Inspection. Replace crankshaft if any cracks are found or if it has been overheated.



- 5 Check alinement at adjacent center and main bearing journals (1) with a dial indicator (2). Maximum allowable runout is 0.002 inch (0.0508 mm). Replace crankshaft, if necessary.

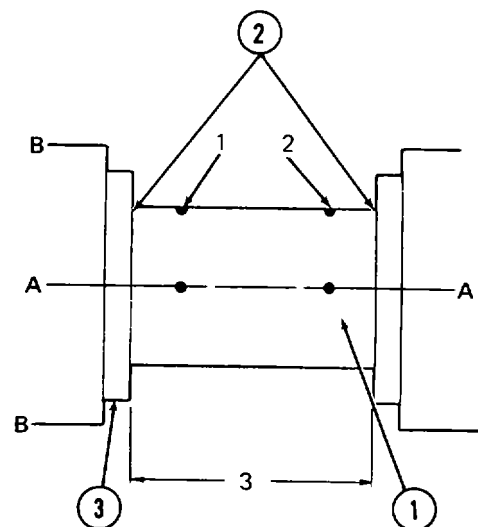


- 6 Inspect crankpins.

- a. Measure diameter of each crankpin (1) at points 1 and 2 and along axes A and B with micrometer. Measure width of crankpin at point 3. Measure radius of fillets (2) between crankpin and crank cheek (3).
- b. Diameter should be 2.5185 to 2.5193 inches (63.971 to 63.99 mm). If any measurement is outside the specified limits, crankshaft must be replaced.

4-12. REPLACE/REPAIR CRANKSHAFT ASSEMBLY (Continued)

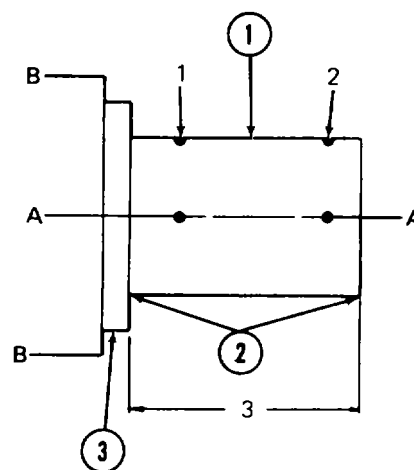
- c. However, if the crankpins are evenly worn, not out-of-round, and the crankshaft journal diameters are within specified limits, the condition may be rectified by replacing connecting rod bearing shells. Replace in accordance with paragraph 4-11. Check the radial clearance of the bearing shells. If it exceeds the tolerance limits of 0.0016 to 0.0118 inch (0.04 to 0.3 mm), the crankshaft must be replaced.
- d. If the measurements at points 1 and 2 differ by more than 0.0028 inch (0.07 mm) and/or any one set is outside the tolerance limits, the crankpin is worn into a conical shape and the crankshaft must be replaced. If the measurements along axes A and B differ by more than 0.0028 inch (0.07 mm) and/or one set is outside the tolerance limits, the crankpin is worn into an oval shape and the crankshaft must be replaced. For both these out-of-round conditions, also check connecting rods, pistons, and cylinders for unusual wear.



- e. The crankpin width at point 3 should be 1.4173 to 1.4189 inches (36.0 to 36.039 mm). The fillet radius measurement should be 0.1693 to 0.1772 inch (4.30 to 4.50 mm). If either measurement is outside the specified limits, the crankshaft must be replaced.

7 Inspect crankshaft main bearing journals.

- a. Measure diameter of each crankshaft main bearing journal (1) at points 1 and 2 and along axes A and B with micrometer. Measure width of journal at point 3. Measure radius of fillets (2) between main bearing journal and crank cheek (3).
- b. Normal main bearing journal diameter should be 2.8728 to 2.8736 inches (72.97 to 72.99 mm). If any measurement is outside the specified limits, the crankshaft must be replaced. However, if journals are evenly worn, not out-of-round, and crankpin diameters are within specified limits, only main bearing bushings need be replaced.
- c. Replace bearing bushings in accordance with paragraph 4-13. Make sure that main bearing bushing radial clearance does not exceed 0.0020 to 0.0118 inch (0.052 to 0.3 mm). If specified limits are exceeded, the crankshaft must be replaced.



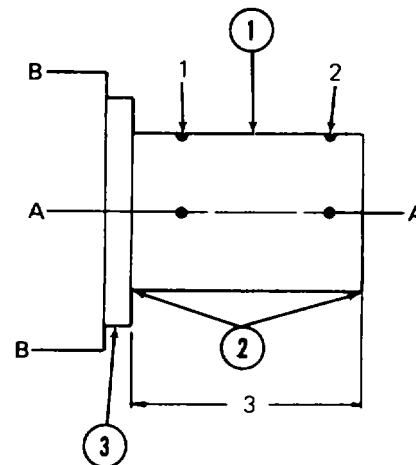
- d. If measurements at points 1 and 2 differ by more than 0.0028 inch (0.07 mm) and/or one set is outside the specified limits, the journal is worn into a conical shape and crankshaft must be replaced. If measurements along axes A and B differ by more than 0.0028 inch (0.07 mm) and/or one set is outside the specified limits, the journal is worn into an oval shape and crankshaft must be replaced.

4-12. REPLACE/REPAIR CRANKSHAFT ASSEMBLY (Continued)

For both of these out-of-round conditions, also check connecting rods, pistons, cylinder, and main bearing bushings for unusual wear. Journal width measured at point 3 should be 1.4173 to 1.4189 inches (36.0 to 36.039 mm). Fillet radius measurement should be 0.1693 to 0.1772 inch (4.30 to 4.50 mm). If either measurement is outside specified limits, the crankshaft must be replaced.

8 Inspect crankshaft center bearing journal

- a. Measure diameter of crankshaft center bearing journal (1) at points 1 and 2 and along axes A and B with micrometer. Measure width of journal at point 3. Measure radius of fillets (2) between center bearing journal and crank cheeks (3).
- b. Nominal center bearing journal diameter should be 2.8728 to 2.8736 inches (72.97 to 72.99 mm). If any measurement is outside the specified limits, the crankshaft must be replaced. However, if journal is evenly worn, not out-of-round, and main bearing journal and crankpin diameters are within their specified limits, only center main bearings need be replaced.
- c. Replace main bearings in accordance with paragraph 4-13. Make sure that main bearing radial clearance does not exceed 0.0020 to 0.0118 inch (0.052 to 0.3 mm). If specified limits are exceeded, the crankshaft must be replaced.
- d. If measurements at points 1 and 2 differ by more than 0.0028 inch (0.07 mm) and/or one set is outside the specified limits, the journal is worn into a conical shape and crankshaft must be replaced. If measurements along axes A and B differ by more than 0.0028 inch (0.07 mm) and/or one set is outside the specified limits, the journal is worn into an oval shape and crankshaft must be replaced. For both these out-of-round conditions, also check connecting rods, pistons, cylinders, main bearing bushes, and main bearings for unusual wear. Journal width measured at point 3 should be 1.4576 to 1.4577 inches (37.0 to 37.025 mm). Fillet radius measurement should be 0.1693 to 0.1772 inch (4.30 to 4.50 mm). If either measurement is outside specified limits, the crankshaft must be replaced.

**REPAIR:**

- 1 Inspect crankshaft drive end (to flywheel) contact surface. Lightly stone surface with surfacing stone to remove any fretting or brinnelling. Remove dirt and debris from contact surface.

WARNING

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- 2 If crankpins and bearing journals are only slightly outside specified limits because of nicks, burrs, or high spots, remove these slight imperfections with crocus cloth wet with diesel fuel oil. Work wet crocus.

4-12. REPLACE/REPAIR CRANKSHAFT ASSEMBLY (Continued)

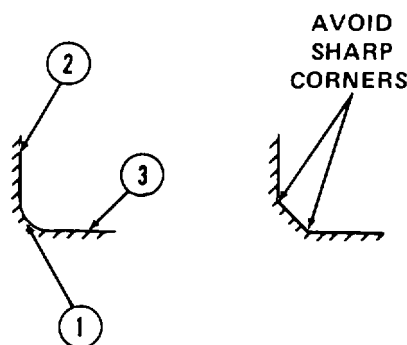
cloth evenly around circumference of crankpin or journal until surface is polished smooth. If wet crocus cloth is not effective, use emery cloth, 120 grit for removing imperfections and 240 grit for finishing. Polish smooth with wet crocus cloth. Use of a piece of rawhide or other suitable rope wrapped around the emery cloth or crocus cloth and drawn back and forth will minimize the possibility of an out-of-round condition developing (keep the strands of rawhide apart to avoid bind). If rawhide or rope is not used, the crankshaft should be rotated at intervals. If the above procedure is not effective or imperfections are too great, the crankshaft must be replaced.

- 3 All crankpin and journal fillets must have a 0.1693 to 0.1772 inch (4.30 to 4.50 mm) radius between crank cheek and crankpin or journal and must not have any sharp grind marks. Fillet must blend smoothly into crankpin or journal and crank cheek, and must be free of scratches. Check radius with a fillet gage and polish smooth any slight imperfections with crocus cloth wet with diesel fuel oil. If radius is too far outside specified limits, the crankshaft must be replaced.
- 4 Stone edges of all oil holes in crankpin and journal surfaces with surfacing stone to provide a smooth radius.

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- 5 Polish ground surfaces to an 8 to 12 RMS finish with crocus cloth wet with diesel fuel oil.
- 6 Inspect crankshaft thrust surfaces. If slightly worn or grooved, smooth out and polish surfaces with wet crocus cloth. Make sure to leave a 0.1693 to 0.1772 inch (4.30 to 4.50 mm) radius (1) on crankshaft between each thrust surface (2) and bearing journal (3) or crankpin.
- 7 Clean up minor burrs and gouges of the shaft seal and preformed packing seats with emery cloth. Repair any minor damage, nicks, burrs, rust, or corrosion. If defects cannot be removed, replace the rear-end cover.



4-12. REPLACE/REPAIR CRANKSHAFT ASSEMBLY (Continued)

CLEANING AFTER REPAIR

WARNING

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Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

Live steam used for cleaning shall not exceed 100 psi (690 kPa). Use goggles or face shield for eye protection. Do not direct live steam against skin.

Clean crankshaft and oil passages with diesel fuel oil and dry with compressed air.

NOTE

If a new crankshaft is to be installed, steam-clean it to remove the rust preventive. Blow through oil passages with compressed air.

INSTALLATION

CAUTION

Equipment damage could occur if bearing caps or bearings are not returned to their original positions. Follow matchmarks made during disassembly.

NOTE

When a new or reground crankshaft is installed, ALL new main and center bearings and bearing shells (upper and lower) must also be installed.

- 1 Passing a 3/4 inch (19.05 mm) rope or a fabric lifting sling through cylinder bores 1 and 6, secure the crankshaft in approximate position for installation of bearings and bearing caps.

4-12. REPLACE/REPAIR CRANKSHAFT ASSEMBLY (Cont inued)

2 Check the matchmark (1) on each bearing cap (2) and match it with the corresponding matchmark (1) on the crankcase (3). The matchmarks indicate direction of installation as well as location. The number and direction of the matchmark on each bearing cap shall be the same as the matchmark at each crankcase position.

3 In each bearing cap (1), install bolts (2), washers (3) and dowel bushings (4).

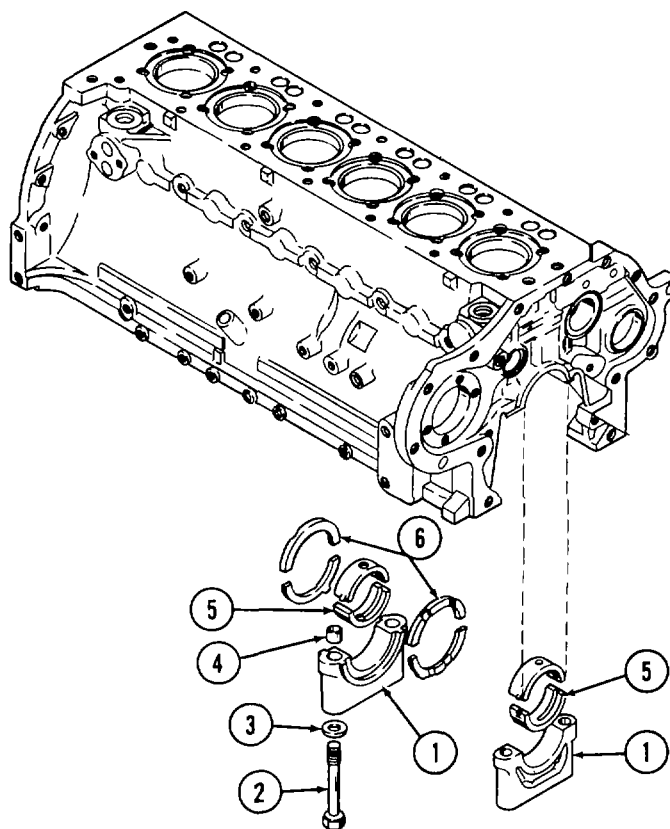
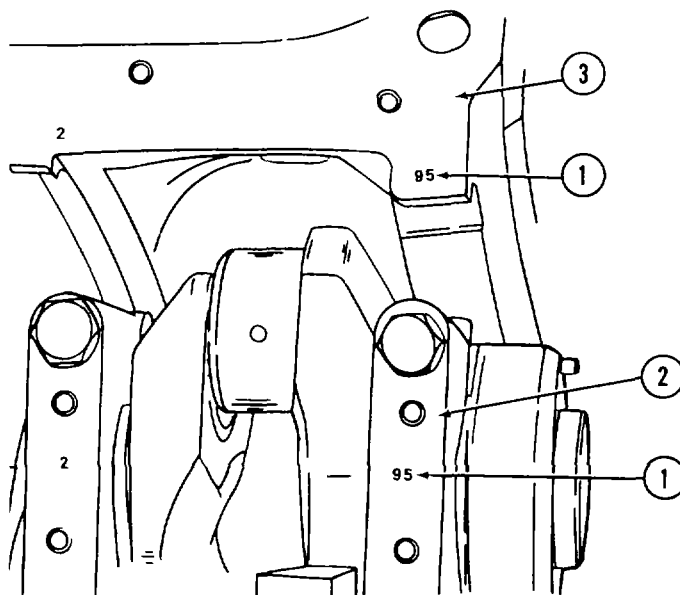
4 Coat main bearings (5) with lubricating oil.

5 Coat stop rings (6) with grease and position on bearing caps so that each stop ring lines up with groove on stop ring face of bearing cap. Be sure to install the two stop rings on the bearing caps from which they were removed.

6 Starting with the center locating bearing and working toward the front and rear bearings, install correctly matched main bearings (5), bearing caps (1), and stop rings (6) in the corresponding bearing brackets of the crankcase.

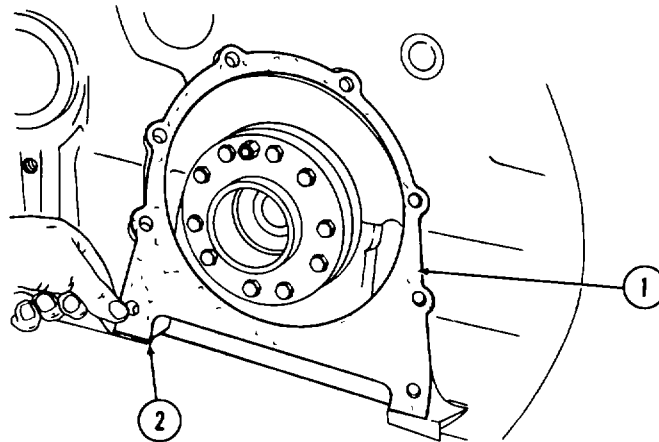
7 Make sure main bearing half (5) with oil groove is installed in the crankcase, and that each bearing cap (1) is properly alined by dowel bushings (4).

8 Tighten bolts (2) alternately and evenly to 22.13 ft-lb (30 N.m) torque with socket wrench. Using torque gage No. 101910, tighten bolts an additional 60 degrees. Following the same pattern, tighten bolts again an additional 45 degrees.

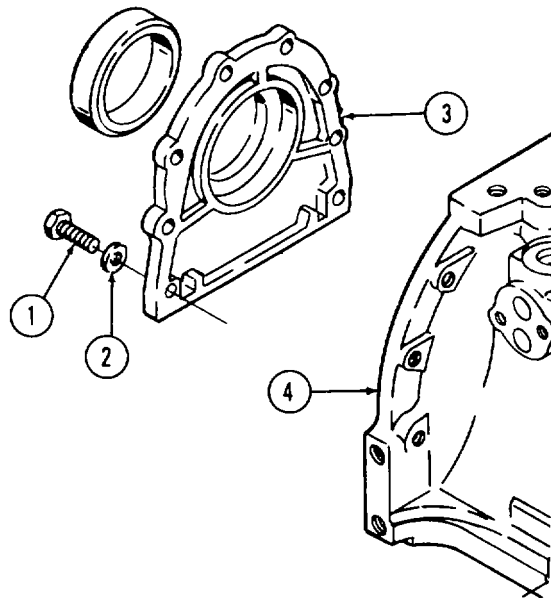


4-12. REPLACE/REPAIR CRANKSHAFT ASSEMBLY (Continued)

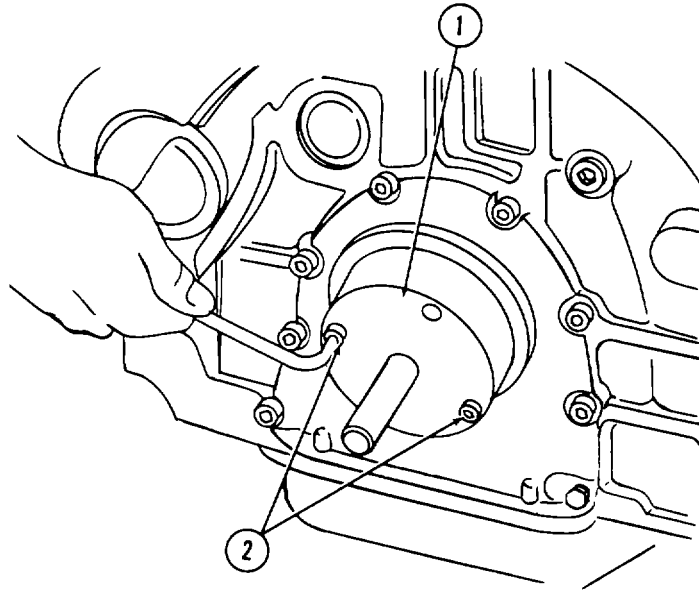
- 9 Remove the slings from the crankcase and crankshaft.



- 10 Install new gaskets (1) on crankcase mounting surface, and trim away any gasket material below the bottom edge of crankcase (2).
- 11 Using bolts (1) and washers (2), secure rear-end cover (3) to engine crankcase (4).



4-12. REPLACE/REPAIR CRANKSHAFT ASSEMBLY (Continued)



- 12 Install oil seal assembly tool No. 142510 (1) on crankshaft and tighten two bolts (2).
 - 13 Lubricate packing washer side of new shaft seal with lubricating oil and install on oil seal assembly tool with packing washer side toward crankshaft.
 - 14 Press shaft seal into bearing housing and crankshaft until seal is flush with bearing housing.
-

4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY

This task covers: **a. Removal** **c. Inspection** **e. Assembly**
 b. Disassembly **d. Repair** **f. Installation**

INITIAL SETUP:

Tools

Shop set, automotive repair, field maintenance, basic

Tool kit, master mechanics

Camshaft bearing tool No. 143630

Camshaft plug installer No. 143610

Crankcase cylinder seat refacing tool No. 150020

Torque gage No. 101910

Materials/Parts

Crocus abrasive cloth (Item 1, Appendix C)

Diesel fuel oil (Item 6, Appendix C)

Lubricating oil (Item 10, Appendix C)

References

MIL-1-6868 Magnetic Particle Inspection

EQUIPMENT CONDITION

Para	Condition Description
------	-----------------------

2-24	Throttle control vernier removed from engine.
------	---

2-27	Crankcase breather removed.
------	-----------------------------

2-34	Starter motor removed.
------	------------------------

3-6	Engine removed from skid and from pump assembly.
-----	--

3-8	Lube oil filter, lines, and fittings removed.
-----	---

3-10	Oil pan assembly removed from engine
------	--------------------------------------

3-11	Oil pump removed from engine.
------	-------------------------------

3-12	Fuel system lines and fittings removed.
------	---

3-23	Adapter housing removed from engine.
------	--------------------------------------

4-4	Injection pump removed from engine.
-----	-------------------------------------

4-8	Camshaft removed from crankcase
-----	---------------------------------

4-11	Connecting rods removed from engine.
------	--------------------------------------

4-12	Crankshaft removed from crankcase.
------	------------------------------------

Special Environmental Conditions

Well-ventilated area required for cleaning.

REMOVAL:

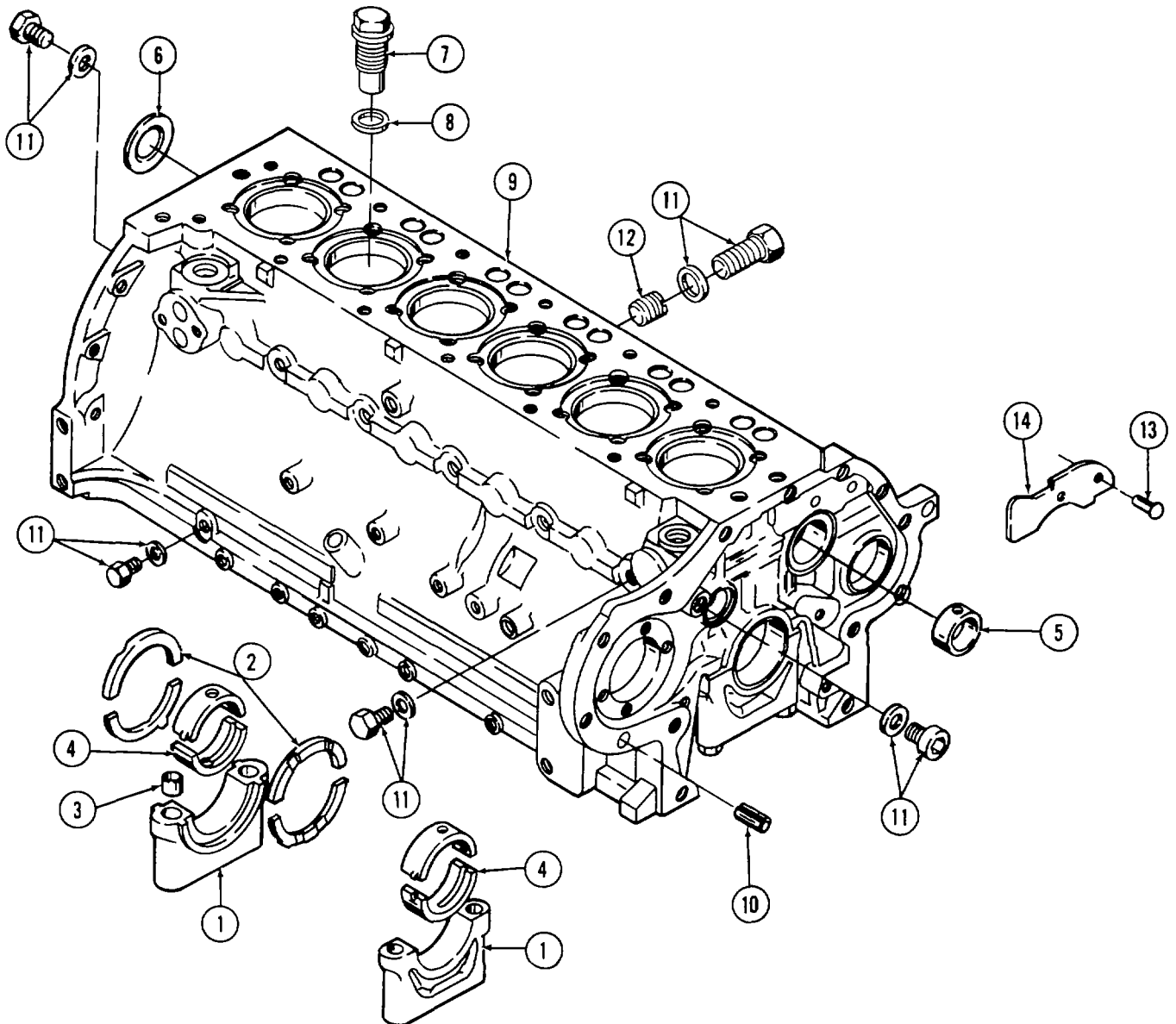
Remove as described in Equipment Condition

DISASSEMBLY:

1 Remove bearing cap (1), stop rings (2), dowel bushings (3), and main bearings (4) in accordance with paragraph 4-12.

2 Do not remove camshaft bushing (5) and dished plug (6) unless replacement is required. If bushing and/or plug must be removed, they are not reusable and must be discarded. If required, remove and discard in accordance with paragraph 4-8.

4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)



- 3 Remove spray nozzle (7) and lockwasher (8) from crankcase (9).
- 4 Remove clamping bushing (10).
- 5 Remove and discard all screw plug and washer sets (11).
- 6 Remove slotted plug (12).
- 7 Remove and discard notched nail (13) that secures deflector plate (14) to crankcase (9) Remove the deflector plate.

4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)

CLEANING/INSPECTION

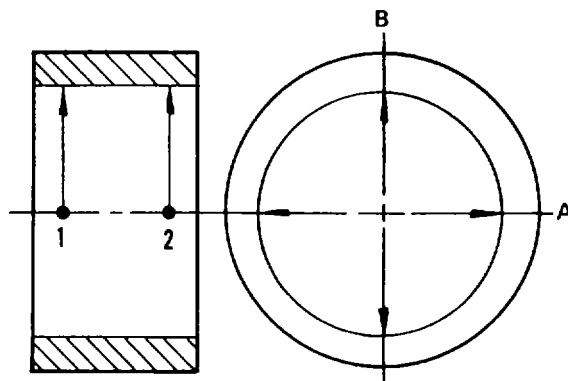
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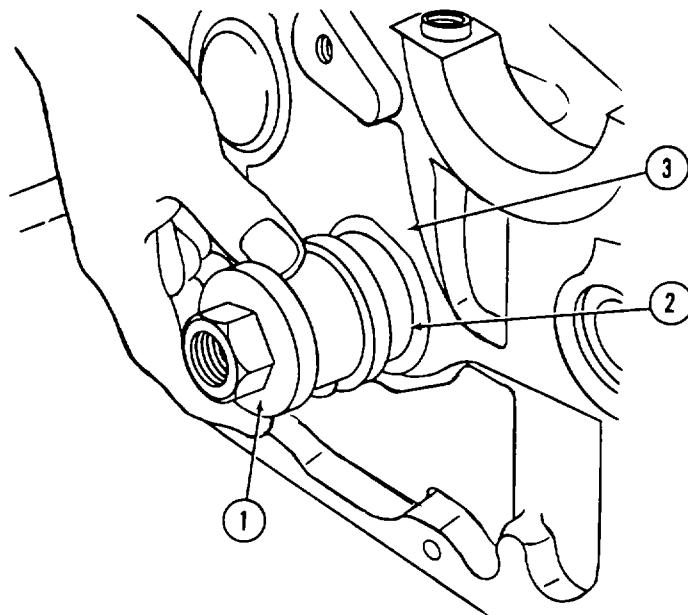
- 1 Clean crankcase thoroughly with live steam. Clean all exterior and interior openings and surfaces. Be especially careful to clean all oil passages to make sure they are open. Use a small and/or large wire bristle brush where necessary to remove carbon or other deposits from openings and surfaces. Use diesel fuel oil as necessary to soften and remove carbon or hardened oil deposits. Dry with compressed air.
- 2 Thoroughly inspect crankcase for any cracks, discoloration, distortion, rust, corrosion, or other damage. Use MIL-1-6868 magnetic particle inspection to detect cracks. If crankcase is cracked, distorted, overheated, seriously rusted or corroded on machined surfaces, or exhibits other serious damage, replace crankcase.



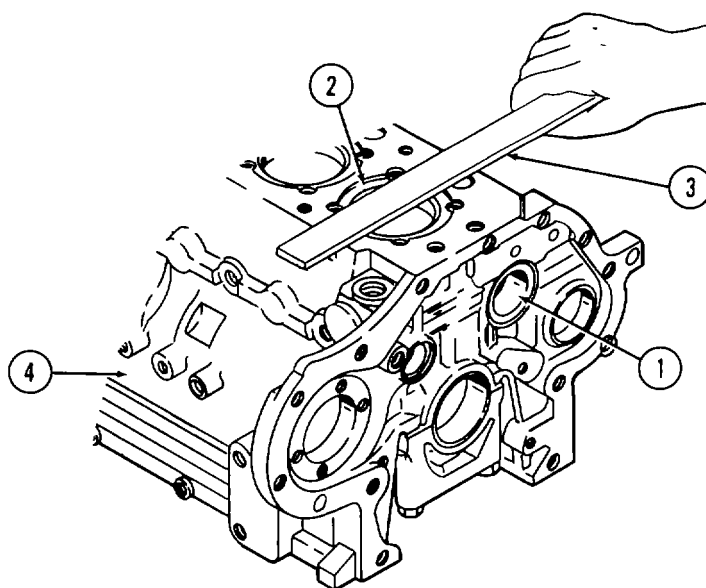
- 3 Make sure camshaft bushing (1) is seated properly in crankcase. Inspect for damage or excessive wear. Measure bushing bore with micrometer at points 1 and 2 and along axes A and B. Bore measurement should be 1.889 to 1.8911 inches (47.98 to 48.034 mm). If measurement is outside these tolerance limits, replace bushing.

4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)

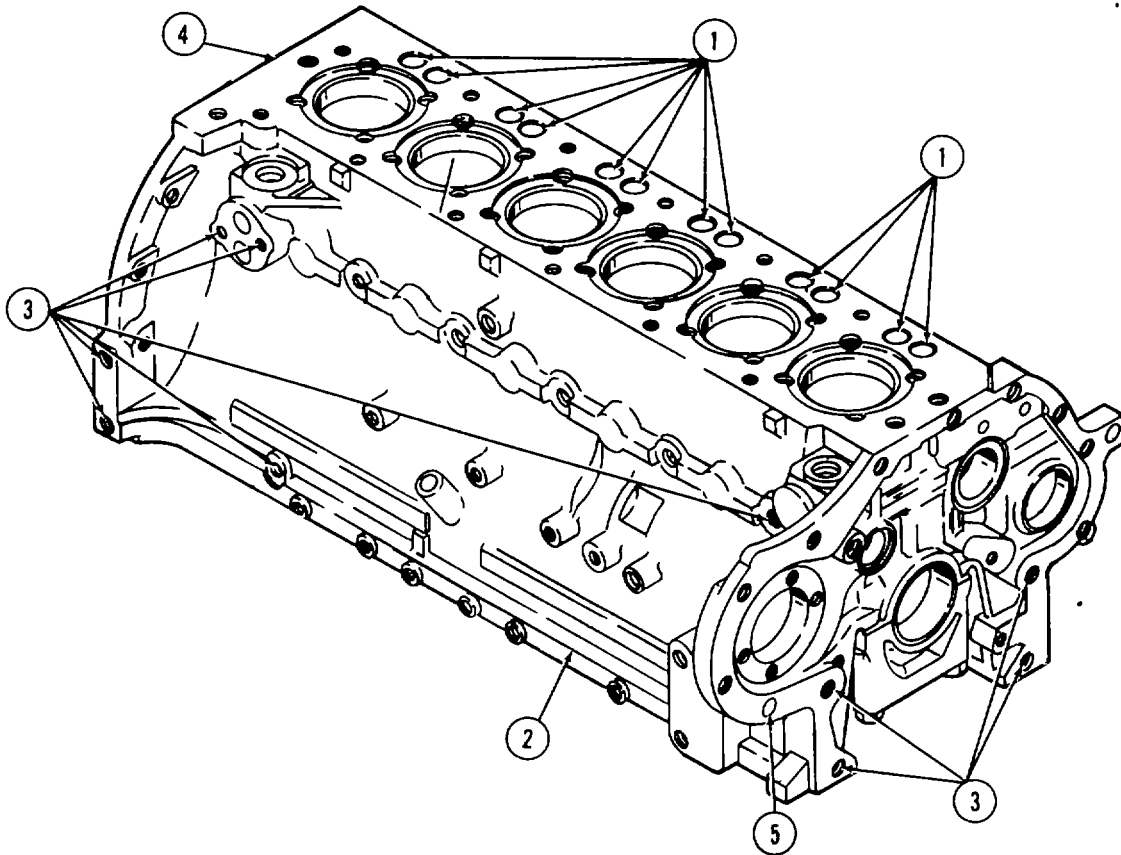
- 4 Measure camshaft bearing journal diameter and determine radial clearance in accordance with paragraph 4-8. If radial clearance is not within tolerance limits, replace bushing or camshaft to bring radial clearance within tolerance limits



- 5 Install camshaft bearing tool No 143630 (1) and remove camshaft bushing (2) from crankcase (3).
- 6 Measure camshaft bushing bore (1) in crankcase with micrometer. Measurement should be 2.0461 to 2.0484 inches (51.97 to 52.030 mm). If measurement is not within these tolerance limits, crankcase must be replaced.
- 7 Inspect cylinder seats (2). Make sure they are smooth and flat. Use a steel straightedge (3) to check flatness. If seats are damaged beyond repair, replace crankcase (4). If seats can be ground smooth or have minor nicks or burrs, repair in accordance with REPAIR instructions.

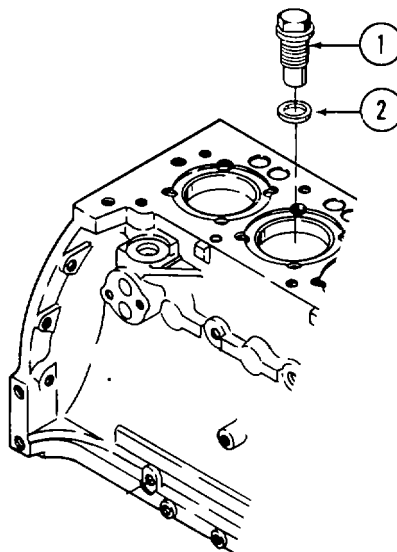


4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)



- 8 Inspect tappet bores (1) for excessive wear or damage. If repairable, follow REPAIR instructions. If severely worn, cracked, or damaged, replace crankcase (2).
- 9 Inspect all tappet holes (3). Make sure they are clean. If necessary, retap in accordance with REPAIR instructions.
- 10 Inspect dished plug (4). Make sure plug is tightly seated in crankcase (2). If not, replace plug.
- 11 Inspect all parallel pin and plug holes for wear or damage. If excessively worn or damaged but repairable, retap holes. If not repairable, replace crankcase.

4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)



- 12 Inspect spray nozzle (1) for blockage and excessive wear, stripped threads. Replace if worn, clogged, or cracked, or if mounting threads are stripped. Replace lockwasher (2) if worn, distorted, or damaged.

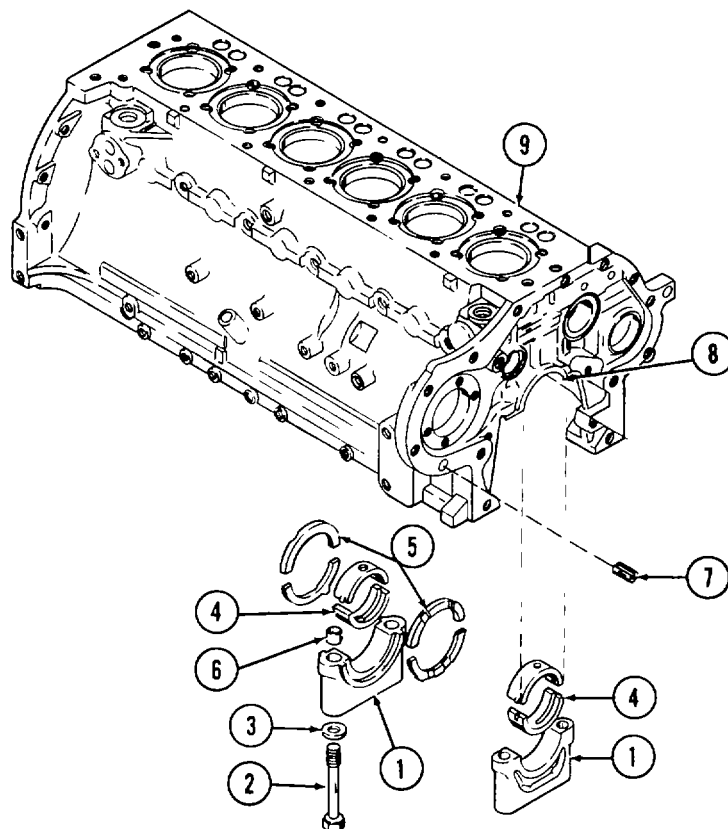
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- 13 Clean bearing caps (1), bolts (2), washers (3), main bearings (4), stop rings (5), and dowel bushings (6) thoroughly with diesel fuel oil. Dry with compressed air. Make sure oil passages are clean and free of any deposits or restrictions.
- 14 Inspect bolts (2) and washers (3). Replace if stripped, worn, bent, or damaged. Replace clamping bushings (7) if worn, overheated, cracked, or damaged.

4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)



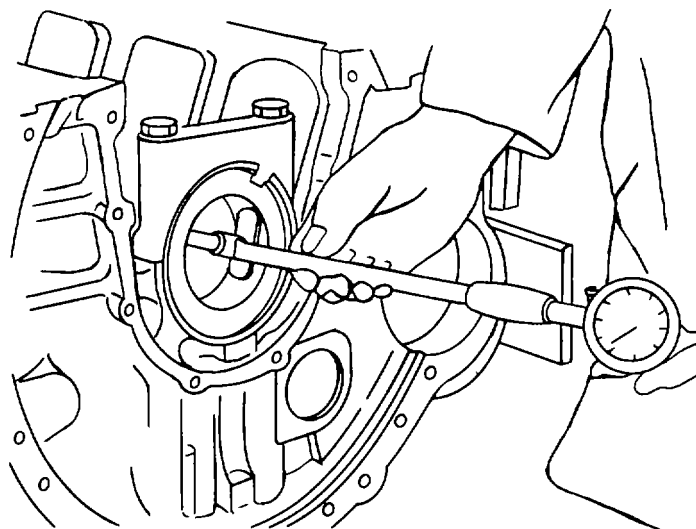
- 15 Check and match-mark the main bearings and caps according to paragraph 4-12.
- 16 Inspect crankcase bearing caps (8). If stripped, worn, cracked, or damaged, replace crankcase (9).

NOTE

The upper bearing cap is an integral part of the crankcase. If an upper bearing cap is damaged, the crankcase must be replaced.

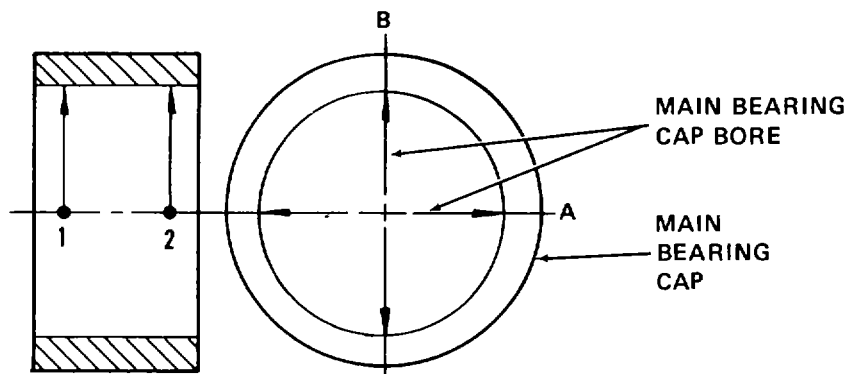
- 17 Inspect bearing caps (1), and replace for excessive wear, overheating, distortion, cracking, high spots, or other damage.
- 18 Inspect main bearings (4) for excessive wear, overheating, distortion, cracking, or other damage. Replace worn or damaged bearings.
- 19 Measure main bearing (4) wall thickness. The normal wall thickness should be between 0.0876 to 0.0878 inch (2.224 to 2.229 mm) If measurement is outside of tolerance limit, replace bearing.

4-13 REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)



20 Check main bearing cap bore

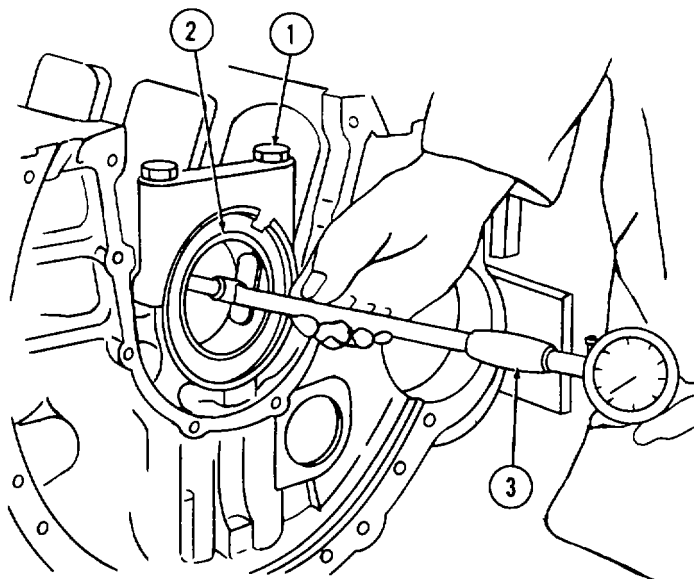
- a. Assemble upper and lower bearing caps, dowel bushings, washers, and bolts to crankcase. Make sure matchmarks line up properly. Make sure threads and seat areas are clean. Lightly lubricate them with lubricating oil
- b. Tighten bolts alternately and evenly, in small increments, to 22.13 ft-lb (30 N-m) torque. Using torque gage No. 101910, tighten bolts an additional 60 degrees. Again tighten all screws 30 degrees.



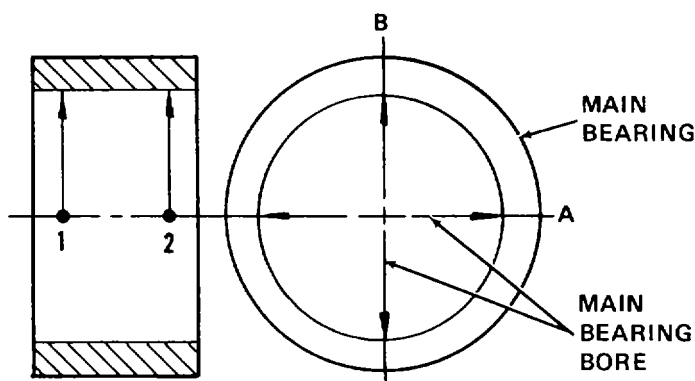
- c. Measure bore with a micrometer at points 1 and 2 and along axes A and B. Bore should measure 3.0512 to 3.0519 inches (77.50 to 77.519 mm). If all measurements are not within these tolerance limits, it may be necessary to replace the bearing caps and crankcase. The crankcase and caps may be usable if the cap bore is only slightly out of tolerance, but the bearing bore is within tolerance. Install new main bearings and measure internal bearing bore. If the bearing bore is within tolerance, the caps and crankcase can be used with these bearings, otherwise replace the crankcase and caps.

4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)**21 Check main bearing bore**

- a. If a main bearing cap bore is within or just slightly outside tolerance limits or if a new main bearing cap is being used, loosen bolts (1) alternately and evenly far enough to be able to install main bearings (2). Make sure matchmarks are correctly aligned if new bearings are not being installed. Make sure oil passage is installed in upper bearing cap. If new caps or bearings are being installed, match-mark them. Tighten and retighten bolts as in step 20b.
- b. Measure main bearing bore with micrometer (3) at points 1 and 2 and along axes A and B. Bore should measure 2.8757 to 2.8772 inches (73.042 to 73.081 mm). If measurement is not within these tolerance limits, main bearing must be replaced.



- c. If measurements were taken with new main bearings and a main bearing cap that was only slightly outside tolerance limits, the acceptable main bearing tolerance limits may be increased to 2.8749 to 2.878 inches (73.022 to 73.101 mm). If measurements are still not within these extended tolerance limits, the main bearing caps and crankcase must be replaced.

**22 Check radial clearance.**

- a. Replacement of main bearings depends on the diameter of the crankshaft center bearing journal. Measure diameter and determine radial clearance by subtracting journal diameter from bearing bore. Clearance should be 0.0020 to 0.0043 inch (0.052 to 0.110 mm). Maximum allowable clearance is 0.0118 inch (0.3 mm),
- b. If radial clearance is not within these tolerance limits, recheck main bearings, main bearing cap, and/or crankshaft. Replace components in that order until clearance is within tolerance limits.

23 Check side clearance.

- a. Measure width of crankshaft center bearing journal. Measure width of main bearing cap at bearing bore. Determine side clearance by subtracting bearing cap width from bearing journal width. Side clearance should be 0.0059 to 0.0124 inch (0.150 to 0.314 mm) Maximum allowable clearance is 0.0157 inch (0.4 mm).
- b. If side clearance is not within these tolerance limits, recheck main bearing cap and crankshaft center bearing journal. Replace in that order until side clearance is within tolerance limits

4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)

- 24 Inspect and replace stop rings for excessive wear, cracks, warpage, rust, corrosion, or other damage. Measure thickness, which should be 0.1156 to 0.1175 inch (2.935 to 2.985 mm). If measurement is not within tolerance limits, replace stop ring.
- 25 Inspect dowel bushings and screw plugs and replace if excessively worn, warped, rusted, corroded, or otherwise damaged.

REPAIR.

- 1 Replace crankcase if:
 - a. Crankcase is cracked, overheated, distorted, or seriously damaged.
 - b. Crankcase machined surfaces are severely rusted or corroded.
 - c. New main bearing bushing or camshaft bushing will not seat properly in crankcase.
 - d. Crankcase bore for main bearing bushing or camshaft bushing is outside tolerance limits.
 - e. Cylinder seats are worn, not flat, or damaged beyond repair.
 - f. Tapholes, tappet bores, dished plug bore, parallel pin, or screw plug holes are excessively worn, cracked, or damaged beyond repair.
- 2 Repair minor rust, corrosion, nicks, or burrs on crankcase. Use crocus cloth to smooth out surfaces if necessary. Clean and refinish nonmachined surfaces. Allow finish to dry. Do not finish machined surfaces. Rebore tappet bores if necessary. Retap tapholes if necessary.
- 3 Do not attempt to rebore or otherwise repair any crankcase bearing bores. If bushings or ball bearings do not fit tightly into bore, replace crankcase.
- 4 Repair minor nicks, burrs, rust, or corrosion on cylinder seats with crocus cloth. Do not refinish. If seats need to be refaced smooth or flat, use crankcase cylinder seat refacing tool No 150020.

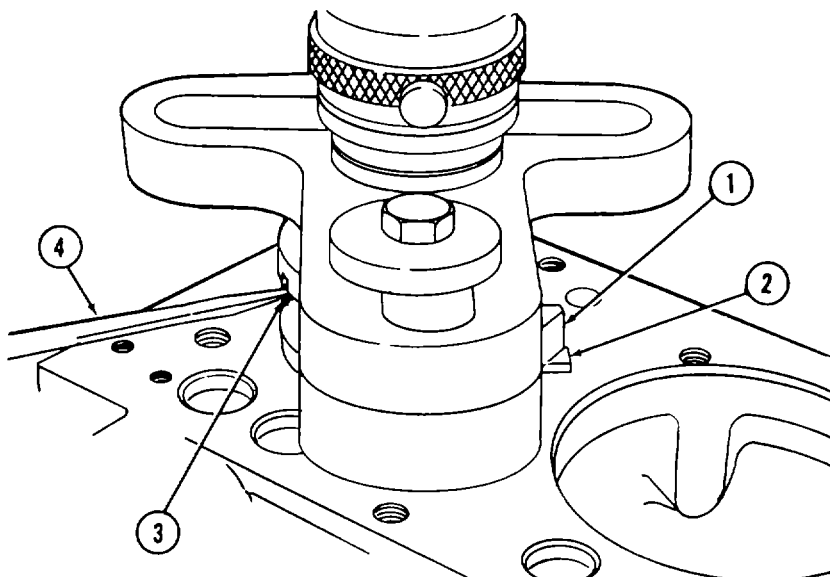
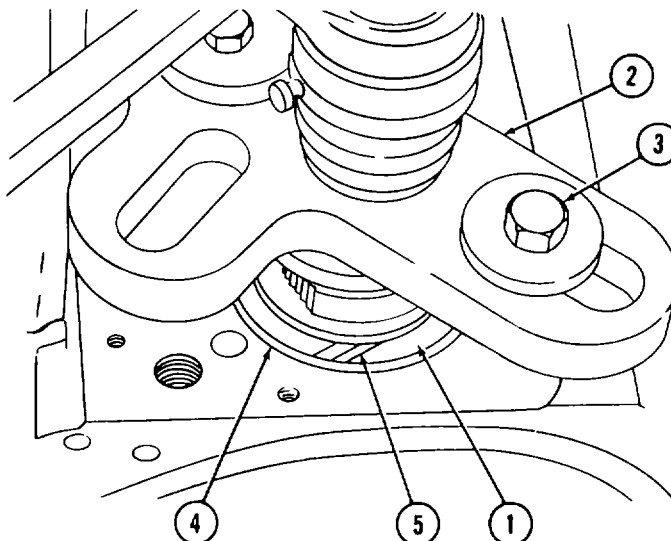
4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)

WARNING

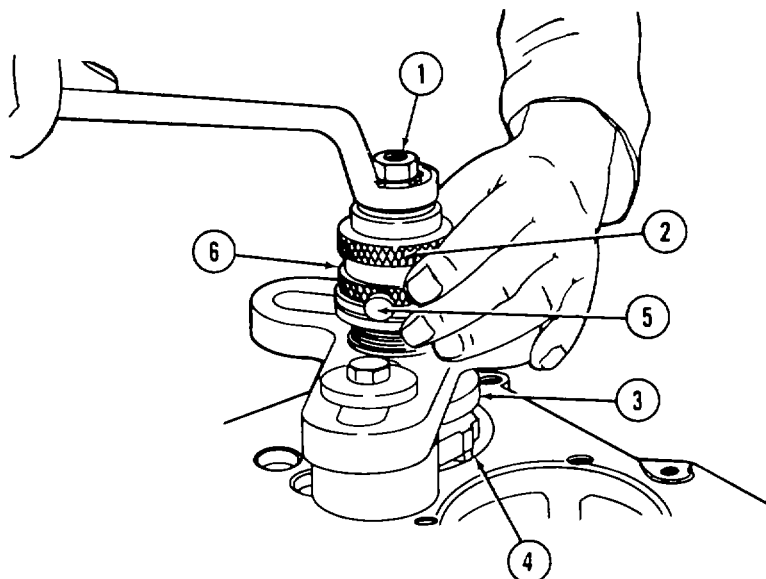
Death or serious injury could occur if diesel fuel oil is not handled carefully. Use in a well-ventilated area away from open flame, arcing equipment, ignition sources, heaters, or excessive heat. Always store fuel in proper, marked containers. DO NOT SMOKE.

Death or serious injury could occur if compressed air is directed against the skin. Do not use compressed air for cleaning or drying unless the pressure is/has been reduced to 30 psi (2.11 kg/cm²) or less. When working with compressed air always use chip guards, eye protection, and other personal protective equipment.

- a. Clean cylinder seats (1) thoroughly with diesel fuel oil and dry with compressed air. Mount crankcase cylinder seat refacing tool No 150020 (2) with supports onto cylinder seat. Install bolts (3) but do not tighten. Make sure tool is still movable.
- b. Center refacing tool (1) on inside lip of cylinder bore (4) with centering fingers (5). Tighten bolts (3) securely.
- c. Withdraw centering fingers and position seat cutter holder (1) over inside lip of cylinder seat (2) with positioning screw (3) and small slot-head screwdriver (4).



4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)



- d Turn spindle (1) and knurled nut (2) clockwise (viewing unit from top) until seat cutter and holder (3) just contact cylinder seat (4) Lock knurled nut in place with setscrew (5).

CAUTION

Do not turn spindle counterclockwise. This will damage the cylinder seat and may damage the crankcase bore. Turn only in clockwise direction as shown.

- 5 Turn spindle (1) clockwise to smooth, flatten, and reface cylinder seat (4) as necessary. Do not remove more material than absolutely necessary.
- 6 After refacing cylinder seat (4), loosen setscrew (5), and turn knurled nut (2) counterclockwise to back seat cutter and holder (3) away from cylinder seat (4). Withdraw seat cutter holder with positioning screw and remove refacing tool (6).
- 7 If other cylinder seat also needs to be refaced, smoothed, and or flattened, repeat above process starting with step 4.

NOTE

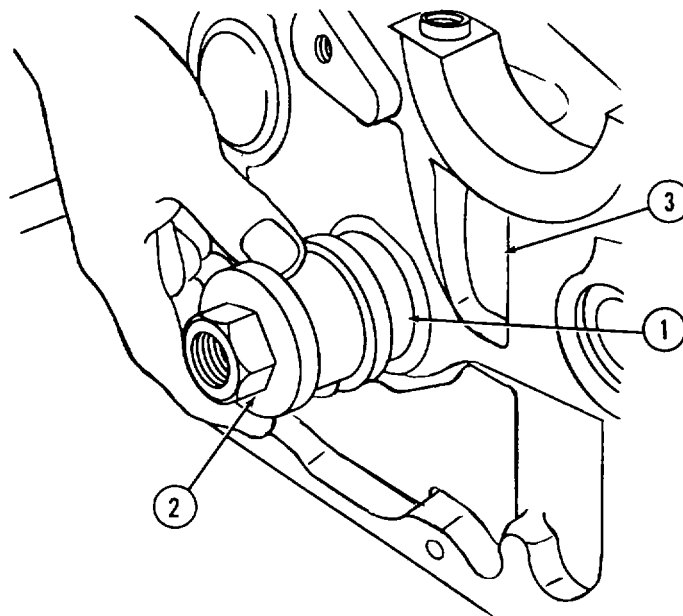
If cylinder seats are refaced, check piston top clearance when cylinder and cylinder head are installed. If too much of the cylinder seat has not been removed, the difference in height can be corrected with additional shims when the cylinder is installed. Follow procedure in paragraph 4-9.

4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)

- 8 Do not attempt repairs on dished plug, parallel pins, screw plugs, and washers. Replace if worn, cracked, or damaged.
- 9 Do not attempt repairs on spray nozzle or lockwasher. Replace if worn, distorted, or damaged.
- 10 Do not attempt repairs on bearing caps. Replace if excessively worn, out-of-tolerance, overheated, distorted, cracked, or damaged in any way. Replace bearing cap and main bearings as necessary to maintain correct bore clearances and radial clearances with crankshaft.
- 11 Do not attempt repairs on stop rings. Replace if worn, cracked, warped, rusted, corroded, or damaged.

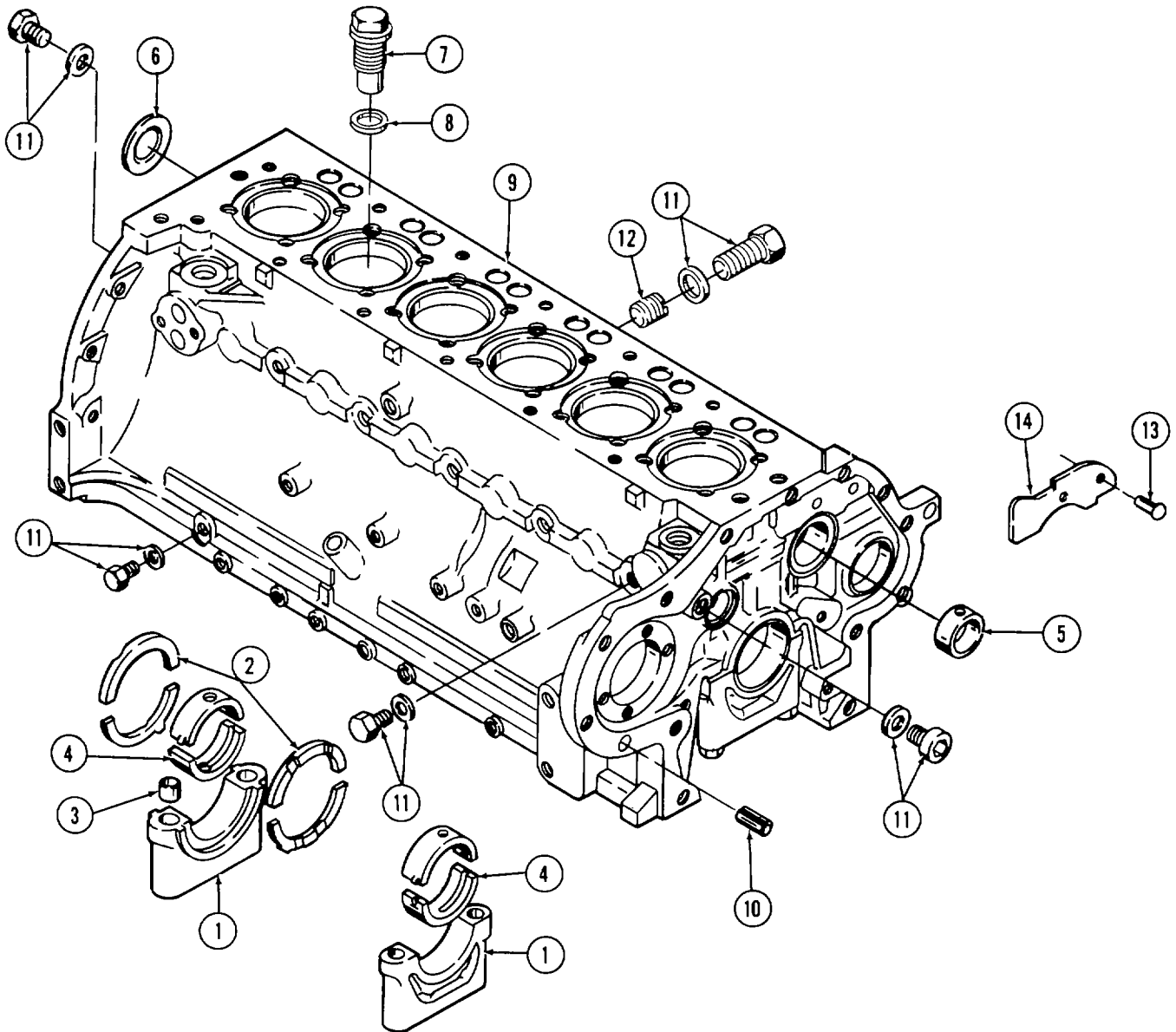
REASSEMBLY.

- 1 Install camshaft bushing (1) with camshaft bearing tool No. 143630 (2). Make sure oil passages are aligned correctly and bearing bush is seated flush with the outside surface of the crankcase (3).



- 2 Install clamping bushings (10) and slotted plug (12) and seat properly.
- 3 Install all screw plug and washer sets (11) in crankcase (9) and seat properly.
- 4 If dished plug (6) was removed, install new plug in crankcase (9) using camshaft plug installer No 143610.
- 5 Install spray nozzle (7) and lockwasher (8). Tighten nozzle securely.

4-13. REPLACE/REPAIR CRANKCASE ASSEMBLY (Continued)



- 6 Install main bearings (4), bearing caps (1), dowel bushings (3) and stop rings (2) in accordance with paragraph 4-12. Make sure sizes of main bearings and crankshaft center bearing journal are directly compatible and that the radial clearance is within tolerance limits.
- 7 Position deflector plate (14) on crankcase (9). Using new notched nail (13), secure the deflector plate to the crankshaft.

INSTALLATION:

Install in accordance with Equipment Condition.

APPENDIX A REFERENCES

A-1. PUBLICATIONS INDEX

The following index should be consulted frequently for latest changes or revisions of references given in this appendix and for new publications relating to material covered in this manual.

Index of Administrative Publications..... DA PAM 310-1

A-2. FORMS AND RECORDS

Recommended Changes to Publications and Blank Forms..... DA 2028-2
 Equipment Inspection and Maintenance Worksheet DA Form 2404
 Equipment Control Record DA Form 2408-9
 Packaging Improvement Report DD Form 6
 Quality Deficiency Report..... SF 368

A-3. FIELD MANUALS

Operation and Maintenance of Ordnance Materiel in Cold Weather (0° to -65°F) FM 9-207

A-4. TECHNICAL MANUALS

The Army Maintenance Management System (TAMMS) DA PAM 738-750
 Hand Portable Fire Extinguishers for Army Users..... TB 5-4200-200-10
 Operator's Manual, Pump Unit,
 Centrifugal, Flood and Transfer, 1250 GPM
 DED, Model US612ACD..... TM 5-4320-306-10
 Organizational, Direct Support and General Support
 Maintenance Repair Parts and Special Tools List,
 Pump Unit, Centrifugal, Flood and Transfer, 1250 GPM,
 DED, Model US612ACD..... TM 5-4320-306-24P

A-5. OTHER PUBLICATIONS

Administrative Storage.....AR 750-1

A-6. MILITARY SPECIFICATIONS

Treatment and Painting of Materiel MIL-T-704

APPENDIX B MAINTENANCE ALLOCATION CHART

Section I. INTRODUCTION

B-1. GENERAL

a. This section provides a general explanation of all maintenance and repair functions authorized at various maintenance categories.

b. The Maintenance Allocation Chart (MAC) in Section II designates overall authority and responsibility for the performance of maintenance functions on the identified end item or component. The application of the maintenance functions to the end item or component will be consistent with the capacities and capabilities of the designated maintenance levels

c. Section III lists the tools and test equipment (both special tools and common tool sets) required for each maintenance function as referenced from Section II.

d. Section IV contains supplemental instructions and explanatory notes for a particular maintenance function.

B-2. MAINTENANCE FUNCTIONS

Maintenance functions will be limited to and defined as follows:

a. *Inspect.* To determine the serviceability of an item by comparing its physical, mechanical, and/or electrical characteristics with established standards through examination (e.g , by sight, sound, or feel).

b. *Test.* To verify serviceability by measuring the mechanical, pneumatic, hydraulic, or electrical characteristics of an item and comparing those characteristics with prescribed standards.

c. *Service.* Operations required periodically to keep an item in proper operating condition, i e , to clean (includes decontaminate, when required), to preserve, to drain, to paint, or to replenish fuel, lubricants, chemical fluids, or gases

d. *Adjust.* To maintain or regulate, within prescribed limits, by bringing into proper or exact position, or by setting the operating characteristics to specified parameters.

e. *Aline.* To adjust specified variable elements of an item to bring about optimum or desired performance.

f. *Calibrate.* To determine and cause corrections to be made or to be adjusted on instruments or test, measuring, and diagnostic equipments used in precision measurement. Consists of comparisons of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared.

g. *Remove/Install.* To remove and install the same item when required to perform service or other maintenance functions. Install may be the act of emplacing, seating, or fixing into position a spare, repair part, or module (component or assembly) in a manner to allow the proper functioning of an equipment or system

B-2. MAINTENANCE FUNCTIONS (Continued)

h. *Replace*. To remove an unserviceable item and install a serviceable counterpart in its place. "Replace" is authorized by the MAC and is shown as the 3d position code of the SMR code.

i. *Repair*. The application of maintenance services, including fault location/troubleshooting, removal/ installation, and disassembly/assembly procedures, and maintenance actions to identify troubles and restore serviceability to an item by correcting specific damage, fault, malfunctions, or failure in a part, subassembly, module (component or assembly), end item, or system.

j. *Overhaul*. That maintenance effort (service/action) prescribed to restore an item to a completely serviceable/operational condition as required by maintenance standards in appropriate technical publications (i.e., DMWR). Overhaul is normally the highest degree of maintenance performed by the Army Overhaul does not normally return an item to like new condition.

k. *Rebuild*. Consists of those services/actions necessary for the restoration of unserviceable equipment to a like new condition in accordance with original manufacturing standards Rebuild is the highest degree of materiel maintenance applied to Army equipment. The rebuild operation includes the act of returning to zero those age measurements (hours/miles, etc.) considered in classifying Army equipment/components.

B-3. EXPLANATION OF COLUMNS IN THE MAC, SECTION II

a. *Column (1) Group Number*. Column 1 lists functional group code numbers, the purpose of which is to identify maintenance significant components, assemblies, subassemblies, and modules with the next higher assembly. End item group number shall be 00

b. *Column (2) Component/Assembly*. Column 2 contains the names of components, assemblies, subassemblies, and modules for which maintenance is authorized.

c. *Column (3) Maintenance Function*. Column 3 lists the functions to be performed on the item listed in Column 2. (For detailed explanation of these functions, see paragraph B-2.)

d. *Column (4) Maintenance Level*. Column 4 specifies, by the listing of a work time figure in the appropriate subcolumn(s), the level of maintenance authorized to perform the function listed in Column 3. This figure represents the active time required to perform that maintenance function at the indicated level of maintenance. If the number or complexity of the tasks within the listed maintenance function vary at different maintenance levels, appropriate work time figures will be shown for each level The work time figure represents the average time required to restore an item (assembly, subassembly, component, module, end item, or system) to a serviceable condition under typical field operating conditions This time includes preparation time (including any necessary disassembly/assembly time), troubleshooting/fault location time, and quality assurance/quality control time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the maintenance allocation chart. The symbol designations for the various maintenance levels are as follows

- C Operator or crew
- O Organizational maintenance
- F Direct support maintenance
- H General support maintenance
- D Depot maintenance

e. *Column (5) Tools and Equipment*. Column 5 specifies, by code, those common tool sets (not individual tools) and special tools, TMDE, and support equipment required to perform the designated function.

f. *Column (6) Remarks*. This column shall, when applicable, contain a letter code, in alphabetical order, which shall be keyed to the remarks contained in Section IV

B-4. EXPLANATION OF COLUMNS IN TOOL AND TEST EQUIPMENT REQUIREMENTS, SECTION III

a. *Column (7) Reference Code.* The tool and test equipment reference code correlates with a code used in the MAC, Section II, Column 5.

b. *Column (2) Maintenance Category.* The lowest category of maintenance authorized to use the tool or test equipment.

c. *Column (3) Nomenclature.* Name or identification of the tool or test equipment.

d. *Column (4) National Stock Number.* The National stock number of the tool or test equipment.

e. *Column (5) Tool Number.* The manufacturer's part number.

B-5. EXPLANATION OF COLUMNS IN REMARKS, SECTION IV

a. *Column (1) Reference Code.* The code recorded in column 6, Section II.

b. *Column (2) Remarks.* This column lists information pertinent to the maintenance function being performed as indicated in the MAC, Section II.

Section II. MAINTENANCE ALLOCATION CHART

PUMP UNIT, CENTRIFUGAL, FLOOD AND TRANSFER, 1250 GPM, DED

(1) GROUP NUMBER	(2) COMPONENT/ ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE CATEGORY					(5) TOOLS AND EQUIPMENT	(6) REMARKS
			C	O	F	H	D		
00	Pump and Skid Assembly								
01	Battery System								
	Battery Cables and Charging Receptacle	Inspect Service Test Replace Repair	0.1 0.5	0.5 1.0 1.5				1,2 A	
	Battery	Inspect Service Test Replace	0.1 0.5 0.8 1.0					1, 2 B	
	Battery Box Assembly	Inspect Service Replace Repair	0.1 0.5	2.0 2.0				1, 2 C	
02	Electrical System								
	Electrical System Assembly	Inspect Test Replace Repair	0.5	1.0 2.0 2.5				1, 2, 3 D, E	
	Control Panel Assembly	Inspect Replace Repair	0.1 2.0 2.5		1, 2, 3 C				
	Wiring (Control Panel)	Inspect Test Replace Repair	0.2	1.0 2.0 2.5				1, 2, 3 D, E	

Pump Unit, Centrifugal, Flood and Transfer, 1250 GPM, DED

(1) GROUP NUMBER	(2) COMPONENT/ ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE CATEGORY					(5) TOOLS AND EQUIPMENT	(6) REMARKS
			C	O	F	H	D		
03	Pump Suction Assembly								
	Suction Assembly	Inspect Replace Repair	0.2	1.0 1.5				1,2	C
	Strainer Assembly	Inspect Service Replace	0.2	0.5 1.0				1, 2	
04	Gate Valve, 6 Inch	Inspect Replace Repair	0.1	1.0 1.5				1,2	
	Pump Discharge Assembly								
	Discharge Manifold Assembly	Inspect Replace Repair	0.2	1.0 1.5				1, 2	
	Air Valve Cover Assembly	Inspect Replace Repair	0.2	0.5 1.0				1, 2	
	Discharge Check Valve Assembly	Inspect Replace Repair		0.2 0.5 1.5				1, 2	
	Discharge Elbow Assembly	Inspect Replace Repair		0.2 0.5 1.0				1, 2	C
	Gate Valve	Inspect Replace Repair		0.2 1.0 2.0				1,2	C
05	Pump Assembly								
	Check Valve	Inspect Replace Repair		0.2 1.0 1.0				3,4	C

Pump Unit, Centrifugal, Flood and Transfer, 1250 GPM, DED

(1) GROUP NUMBER	(2) COMPONENT/ ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE CATEGORY					(5) TOOLS AND EQUIPMENT	(6) REMARKS	
			C	O	F	H	D			
05 (cont)	Pump Assembly									
	Seal	Inspect Replace		0.2 0.2				3,4		
	Shaft Lip Seal	Inspect Replace		0.5 1.0				3,4		
	Shaft Seal	Inspect Replace		0.5 1.0				3, 4		
	Wear Rings	Inspect Replace		0.5 2.0				3, 4		
	Impeller	Inspect Replace		0.5 1.0				3, 4		
	Shaft	Inspect Replace			1.0 1.5			3, 4		
	Pump Body	Inspect Replace Repair			0.5 2.0 1.0			3, 4		
	Bearing Housing Assembly	Inspect Replace Repair			0.2 1.0 2.0			3,4		
	06	Engine Cover	Inspect		0.2				1,2	C
			Replace		0.5					
			Repair		0.5					
	06	Intake Duct Assembly	Inspect	0.5				1, 2, 3	C	
			Replace		1.0					
Repair				1.0						
07	Engine Assembly	Inspect		0.4			1, 2, 3, 4, 5, 6			
		Service		1.5						
		Replace			8.0					
		Repair		4.0	4.0					
		Overhaul				60.0				

Pump Unit, Centrifugal, Flood and Transfer, 1250 GPM, DED

(1) GROUP NUMBER	(2) COMPONENT/ ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE CATEGORY					(5) TOOLS AND EQUIPMENT	(6) REMARKS
			C	O	F	H	D		
07 (cont)	Engine Assembly								
	V-Belts	Inspect Adjust Replace	0.1	0.2 1.0					I
	Air Cleaner Assembly	Inspect Service Replace Repair	0.2 0.5	1.0 1.0				1	G, H
	Flywheel	Inspect Replace Repair	0.2	1.0 1.5				8	C
	Lube Oil Cooler	Inspect Replace		0.2	1.0			1, 2, 3	J
	Cooling Air Blower and Ducting	Inspect Replace Repair		0.2	4.0 6.0			1, 2, 3	C
	Exhaust System	Inspect Replace Repair	0.1	1.0 1.0				1, 2	C
	Oil Pan	Inspect Replace Repair	0.2	1.0 1.5				3	C
	Oil Drain Assembly	Inspect Replace Repair	0.1	0.5 1.0				1, 2	C
	Oil Pump Assembly	Inspect Replace Repair			0.2 1.5 2.0			3	
	Fuel Filter Cartridges	Inspect Replace	0.1	0.5				1	G
	Fuel System Lines and Fittings	Inspect Replace	0.2		1.0			1, 2	

Pump Unit, Centrifugal, Flood and Transfer, 1250 GPM, DED

(1) GROUP NUMBER	(2) COMPONENT/ ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE CATEGORY					(5) TOOLS AND EQUIPMENT	(6) REMARKS
			C	O	F	H	D		
07 (cont)	Engine Assembly								
	Injection Pump	Inspect Adjust Replace Repair	0.2		1.0 2.0		6.0	49 thru 62	F, K
	Solenoid Valve	Inspect Test Replace	0.1	0.5 1.0				1,2	A
	Fuel Feed Pump	Inspect Service Replace Repair	0.1	0.2 1.0		2.0		1, 2,3	C
	Fuel Injectors	Inspect Test Replace Repair	0.2		1.5 2.0	1.5 2.0		9, 12, 44, 45, 46, 47	L
	Turbocharger	Inspect Replace Repair	0.2	1.5		2.0		1, 2	C
	Starter Assembly	Inspect Test Replace Repair	0.1	0.5 1.0	1.0 2.0			1, 2, 3	A, M, N
	Alternator	Inspect Test Replace Repair	0.1	0.5 1.0	1.0 3.0			1, 2,3	A,D,0
	Cylinder Head Assembly	Inspect Service Replace Repair			0.2 0.5 3.0		3.0	7, 10, 11, 13, 14, 28, 30, 39	P
	Rocker Arms	Inspect Replace Repair			1.0 2.0		1.0	3,4	

Pump Unit, Centrifugal, Flood and Transfer, 1250 GPM, DED

(1) GROUP NUMBER	(2) COMPONENT/ ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE CATEGORY					(5) TOOLS AND EQUIPMENT	(6) REMARKS
			C	O	F	H	D		
07 (cont)	Engine Assembly								
	Pushrods	Inspect Replace Repair			1.0 2.5 0.5			29	
	Tappets	Inspect Replace			1.0 2.5			3, 4	
	Valves	Inspect Replace Repair				1.0 2.0 3.0		15, 17	
	Valve Guides	Inspect Replace Repair				1.0 3.0 3.0		18, 19, 24, 25	
	Valve Seats	Inspect Replace Repair				1.0 3.0 3.0		16, 20, 21, 22, 23, 26, 27	
	Tachometer Drive	Inspect Service Replace			0.2 0.5 1.0			1, 2, 3	
	Front Cover	Inspect Replace Repair		0.1				39	
	Camshaft	Inspect Replace Repair				2.0 6.0 6.0		41, 42	Q
	Piston Assembly	Inspect Replace Repair				1.0 6.0 6.0		31, 32, 33, 34, 37	R
	Connecting Rod Assembly	Inspect Replace Repair				1.0 6.0 6.0		4	C, S
	Crankshaft Assembly	Inspect Replace Repair				2.0 6.0 6.0		38, 39, 40	T
		B-9							

Pump Unit, Centrifugal, Flood and Transfer, 1250 GPM, DED

(1) GROUP NUMBER	(2) COMPONENT/ ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE CATEGORY					(5) TOOLS AND EQUIPMENT	(6) REMARKS
			C	O	F	H	D		
07 (cont)	Engine Assembly Crankcase	Inspect				4.0		8, 35, 36 38, 43	C, T
		Replace				8.0			
		Repair				8.0			
08	Fuel System Data Plates	Inspect	0.1					1, 2	
		Replace		0.5					
		Inspect	0.1						
		Replace		0.5					
08	Fuel System Fuel Tank Lines and Fittings	Inspect	0.1					1, 2	
		Replace		0.5					
		Inspect	0.1						
		Replace		0.5					
08	Fuel System 3-Way Selector Valve	Inspect	0.1					1, 2	
		Replace		0.5					
		Inspect	0.2						
08	Fuel System Fuel Tank Assembly	Service	0.2					1, 2	
		Replace	0.2						
		Repair		1.0 1.5					
09	Skid	Inspect	0.2					1, 2, 3, 4	U
		Replace				8.0			
		Repair				1.5			

SECTION III. TOOL AND TEST EQUIPMENT REQUIREMENTS

(1) TOOL OR TEST EQUIPMENT REF CODE	(2) MAINTENANCE CATEGORY	(3) NOMENCLATURE	(4) NATIONAL/ NATO STOCK NUMBER	(5) TOOL NUMBER
1	0	Tool Kit, General Mechanics Automotive	5180-00-177-7033	
2	0	Shop Equipment, Automotive Maintenance and Repair, Common No 1	4910-00-754-0654	
3	F, H	Shop Set, Automotive Repair Field Maintenance, Basic	4910-00-754-0705	
4	F, H	Tool Kit, Master Mechanics	5180-00-699-5273	
5	F	Dial Gage 0 01 mm		100400
6	F	Adjusting Device for TDC		100640
7	F, H	Torque Gage for Cylinder Head Bolts		101900
8	F, H	Torque Gage for Main Bear- ing and Flywheel Bolts		101910
9	F, H	Injector Extractor		110030
10	F, H	Socket Spanner for Cylinder		120040
11	F, H	Socket Spanner for Cylinder Head Bolts		120050
12	F, H	Injector Gasket Remover		120630
13	F, H	Cylinder Head Clamping Stand		120900
14	F, H	Clamping Plate for Cylinder Head Clamping Stand		120910
15	F, H	Valve Spring Compressor		121120
16	F, H	Valve Seat Ring Cutter		122302
17	F, H	Valve Holder		122304
18	H	Valve Guide Mandrel, 8 mm		122305

SECTION III. TOOL AND TEST EQUIPMENT REQUIREMENTS

(1) TOOL OR TEST EQUIPMENT REF CODE	(2) MAINTENANCE CATEGORY	(3) NOMENCLATURE	(4) NATIONAL/ NATO STOCK NUMBER	(5) TOOL NUMBER
19	H	Valve Guide Mandrel Handles		122306
20	H	Valve Seat Ring Mandrel		122450
21	H	Drill Fixture for Cutting Out Valve Seat Insert Rings		122460
22	H	Pilot Pin for Drill Fixture		122461
23	H	Hard Metal Milling Cutter		122463
24	H	Valve Guide Mandrel, 8 mm		123310
25	H	Valve Guide Reamer, 8 mm		123510
26	H	Valve Seat Ring Mandrel		123950
27	H	Valve Seat Ring Mandrel, Intake		123960
28	H	Cylinder Head Sealing Surface Cutter		124480
29	F	Pushrod Tube Compressor		125300
30	H	Cylinder Head Lathe Fixture		125500
31	H	Piston Ring Pliers		130300
32	H	Piston Ring Groove Gage		130360
33	H	Piston Ring Compressor, 100 mm		130530
34	H	Gudgeon Pin Bush Inserter		131310
35	H	Main Bearing Bolt Socket Spanner		131500
36	H	Bearing Bolt Socket Spanner		131540
37	H	Piston Heater		139000
38	H	Oil Seal Assembly Tool		142510
39	F	Crankshaft Seal Assembly Tool		142520

SECTION III. TOOL AND TEST EQUIPMENT REQUIREMENTS

(1) TOOL OR TEST EQUIPMENT REF CODE	(2) MAINTENANCE CATEGORY	(3) NOMENCLATURE	(4) NATIONAL/ NATO STOCK NUMBER	(5) TOOL NUMBER
40	H	Crankshaft Gasket Ring		142700
41	H	Camshaft Plug Installer		143610
42	H	Camshaft Bearing Tool		143630
43	H	Crankcase Cylinder Seat Refacing Tool		150020
44	F. H	Injector Extractor		150800
45	H	High Pressure Timing Device		003-0714
46	H	Fuel Reservoir		003-0777
47	F	Bosch Pump Outfit		003-3345
48	H	Flyweight Extractor		EF 8449
49	H	Flyweight Pin Wrench		EFEP 187A
50	H	Protective Sleeve		KDEP 2874
51	H	Breast Wrench		KDEP 2887
52	H	End Play Gage		KDEP 2890
53	H	Delivery Valve Puller		KDEP 2892
54	H	Tappet Holder		KDEP 2912
55	H	Plunger Pliers		KDEP 2915
56	H	Tappet Tongs		KDEP 2941
57	H	Ring Wrench		KDEP 2961
58	H	Torque Capsule Wrench		KDEP 2968
59	H	Plug Tool		KDEP 2993
60	H	Barrel Seat Cutter		KDEP 2995
61	H	Bushing Reamer		KDEP 2999

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(1) Reference Code	(2) Remarks
A	Continuity Test
B	Check Specific Gravity
C	Repair by Replacing Defective Components
D	Insulation Breakdown and Continuity Test
E	Repair by Replacing Defective Wire
F	Adjust to Specification
G	Replace Element
H	Service by Cleaning Filter
I	Adjust Belt Tension
J	Test for Leakage
K	Bleed Air From Fuel System
L	Test Timing and Pressure Output
M	Operational Test
N	Test for Opens, Grounds, and Shorts
O	Test for Known Voltage
P	Includes Replacing Valve Seats and Guides
Q	Includes Camshaft Grinding
R	Includes Replacing Rings
S	Includes Replacing Rod Bearings
T	Includes Replacing Main Bearings
U	Weld

APPENDIX C
EXPENDABLE SUPPLIES AND MATERIALS LIST

Section I. INTRODUCTION

C-1. SCOPE

This appendix lists expendable supplies and materials you will need to operate and maintain the centrifugal pump unit. These items are authorized to you by CTA 50-970, Expendable Items (Except Medical, Class V, Repair Parts, and Heraldic Items).

C-2. EXPLANATION OF COLUMNS

a. *Column (1) - Item Number.* This number is assigned to the entry in the listing and is referenced in the narrative instructions to identify the material (e.g., Dry Cleaning Solvent, Item 17, Appendix C).

b. *Column (2) - Level.* This column identifies the lowest level of maintenance that requires the listed item.

C - Operator/Crew
O - Organizational Maintenance
F - Direct Support Maintenance
H - General Support Maintenance

c. *Column (3) - National Stock Number.* This is the National stock number assigned to the item; use it to request or requisition the item.

d. *Column (4) - Description.* Indicates the Federal item name and, if required, a description to identify the item. The last line for each item indicates the part number followed by Federal Supply Code for Manufacturer (FSCM) in parentheses.

e. *Column (5) - Unit of Measure (U/M).* Indicates the measure used in performing the actual maintenance function. This measure is expressed by two-character alphabetical abbreviations (e.g., ea, in., pr). If the unit of measure differs from the unit of issue, requisition the lowest unit of issue that will satisfy your requirements.

(1) ITEM NUMBER	(2) LEVEL	(3) NATIONAL STOCK NUMBER	(4) DESCRIPTION	(5) U/M
1	O, F, H		Abrasive Cloth, Crocus, P-C-458	ea
2	F, H		Abrasive Cloth, Emery, P-C-1673	ea
3	O		Baking Soda, EE-B-86	oz
4	O		Brake Fluid, Automotive, VV-B-680	gl
5	O I	6810-00-249-9354 6810-00-843-1640	Electrolyte	gl
6	C, O, F, H		Fuel Oil, Diesel, VV-F-800	gl
7	O, F, H	9150-00-190-0907	Grease, Automotive and Artillery, MIL-G-10924	gl
8	F, H	9150-00-754-2595	Grease, Ball and Roller Bearing, MIL-G-18709	lb
9	H		Lapping and Grinding Compound (Valve), 600 grit, A-A-1 203	gl
10	O, F, H	9150-00-186-6681	Oil, Lubricating, Internal Combustion Engine, MIL-L-2104	qt
11	O		Oil, Lubricating, Preservative, MIL-L-21260	qt
12	O		Oil, Preservative, Corrosion-inhibited MIL-L-46002	qt
13	H		Sealant, Deutz DW47	gl
14	H		Sealant, Deutz DW 60	gl
15	O, F, H		Sealing Compound, MIL-S-45180	oz
16	F		Solder, Rosin Flux Core, ASTM B284-79	lb
17	OF H	6850-00-274-5421	Solvent, Dry Cleaning, P-D-680	gl
18	F, H		Stone, Commutator Surfacing, MIL-S-17243	ea
19	O		Strapping, Steel, QQ-5-781, Class 1 Type I or IV	rl
20	O		Tape, Electrician's Insulating, MIL-T-50886	rl
21	F		Thread Compound, Antiseize, MIL-T-22361	oz

**APPENDIX D
TORQUE LIMITS**

Self-Locking Nut Breakaway Torque Values

Thread Size	Minimum Breakaway Torque (In Lbs)	Thread Size	Minimum Breakaway Torque (In. Lbs)
10-32	2.0	5/8-18	32.0
1/4-28	3.5	3/4-16	50.0
5/16-24	6.5	7/8-14	70.0
3/8-24	9.5	1-12	90.0
7/16-20	14.0	1-1/8-12	117.0
1/2-20	18.0	1-1/4-12	143.0
9/16-18	24.0		

NOTE

To determine breakaway torque, thread nut onto screw or bolt until at least two threads stick out. Nut shall not make contact with a mating part. Stop the nut. Torque necessary to begin turning nut again is the breakaway torque. Do not reuse self-locking nuts that do not meet minimum breakaway torque.

APPENDIX E

WIRING HARNESS SCHEMATICS

**For Wiring Harness Schematic refer to Foldout on
page FP-1/(FP-2 blank)**

Change 1 E-1/(E-2 blank)

GLOSSARY

Section I. ABBREVIATIONS

A	Amperes
BDC	Bottom dead center
°CC	Degree Celsius
cm	Centimeter
cm ³	Cubic centimeter
cu ft.....	Cubic feet
cu in.....	Cubic inch
cu m.....	Cubic meter
dc.....	Direct current
DED	Diesel-Engine-Driven
EIR	Equipment Improvement Recommendations
° F.....	Degree Fahrenheit
FBB	Commencement of injection flow
ft	Foot, feet
ft-lb	Foot-pound
gal	Gallon
gpm	Gallons per minute
hp	Horsepower
in	Inch
kg	Kilogram
kgcm ³	Kilograms per cubic centimeter
kPa	Kilopascal
L/min.....	Liters per minute
lb	Pound
m	Meter
m ³	Cubic meter
mm	Millimeter
N-m	Newton-meter
No.....	Number
NPT	National pipe thread
para	Paragraph
PMCS	Preventive maintenance checks and services
psi.....	Pounds per square inch
qt	Quart
rpm	Revolutions per minute
TDC	Top dead center
TMDE	Test, measurement, and diagnostic equipment
V	Volts

Section II. DEFINITION OF UNUSUAL TERMS**A**

Abrasion A - scraped or scuffed area. A hose may become abraded if an unshielded portion of it rubs against a piece of bracket or another hose.

Acoustical - Sound deadening.

Actuate - To cause an action. When electric power is applied to a solenoid, it actuates a valve, causing a part in the valve to move.

Aline - To arrange in a line vertically and/or horizontally.

Allocation - Assignment of duties or materials according to plan

Approved - Permitted to be used for a specific purpose by the person or group who is authorized to grant approval.

Assembly - A combination of parts that may be taken apart without destruction, which has no application or use of its own but is needed for the completeness of a more complex item with which it is combined, or to which it is attached.

C

Capacity - The volume, amount, or quantity that can be held or contained.

Carbon monoxide - A poisonous gas that is made while a fuel is burning, especially if there is not quite enough air. The gas is colorless, odorless, and tasteless, but it can cause illness or death. See the warnings on the Warning page at front of manual.

Cavitation - Condition caused when engine speed is increased beyond point of maximum suction vacuum. Cavitation is indicated by loud cracking noise in pump housing and is harmful to the pump unit.

Combustion - A chemical change, especially oxidation, accompanied by the production of heat and light. A combustion engine functions by burning fuel to produce heat, i.e., energy.

Component - A part or a combination of parts which together accomplish a function.

Compressed air - Air that is under pressure. When the compressed air in a hose or pipe is allowed to escape (such as when you use an air gun), the air moves very fast and is used to blow away dirt and chips for cleaning.

Condensation - A liquid formed from a vapor. Moisture carried in warm air will condense when it reaches a cold area, such as the surface of a fuel tank in subzero weather.

Corrosion - A gradual wearing away caused by chemical action. Metals exposed to salt water are likely to corrode.

D

Deteriorate - A worsening of condition usually as a result of age or hostile environment, as opposed to mechanical damage.

Distortion - The bending, twisting, or any other dynamic change of a surface

Dunnage - Padding or loose material placed in a shipping container to prevent damage to contents.

E

Exhaust - The gases that leave the engine through the tailpipe while the engine is running.

Expendable - An item that is not repairable and is discarded if damaged

Exposure - Being in the presence of something, or in contact with something Skin is exposed to cleaning solvent when the solvent contacts the skin during cleaning operations.

F

Filter - A device which removes dirt from the air or a fluid.

Flash point - The lowest temperature at which the vapors of a solvent will ignite and burn

Fluid - A substance that can flow; that is, either a gas or a liquid.

Frayed - Something which has been worn away or unravelled, usually by rubbing.

G

Gasket - A seal or packing used between matched machine parts or around pipe joints to prevent the escape of gas or fluid.

Goggles - A device used to protect the eyes from dust, dirt, flying chips, etc

Gudgeon - pin A pivot pin.

Immerse - To completely cover by fluid.

Inhalation - The act of breathing in. The breathing in or inhalation of carbon monoxide can cause illness or death.

Initial - The first or starting condition.

L

Legible - Capable of being read. A legible nameplate can be read, an illegible plate cannot

M

Malfunction - Occurs when a unit fails to operate normally.

Manufacturer - The company which makes an item or piece of equipment for sale.

Materiel - Equipment, apparatus, and supplies of an organization such as an army.

O

Obstruction - An obstacle

P

Pivot - A short rod or shaft about which a related part rotates, the act of turning on or as if on a pivot.

Port - A threaded hole through which fluid may pass, or pressure may be measured. Ports on the pump are used to connect hoses, and to measure pressure.

Prime - The act of introducing a liquid into a pump to increase the pump's ability to overcome negative head pressure

R

Race - grooved part of a component, such as a bearing, in which a moving part slides or rolls.

Recommendations - Suggestions for change; advice given usually to make an improvement.

Require - To demand or need.

Respiration - The process of breathing, inhaling and exhaling.

S

Scope - extent of an activity or concept; the amount of information covered as in a book.

Solvent - A liquid that can dissolve another substance

Specific gravity - Ratio of the weight of a liquid to the weight of an equal volume of water. Specific gravity of water is 1

Symptom - The external sign or indication of a condition.

T

Tiedown - Strap or fastening device used to hold an object in position

Torque - Force around an axis. It produces a rotary or twisting motion, and is measured in foot-pounds (ft-lb) or newton-meters (N•m)

V

Valve - A device used to control the flow of a fluid.

Vapor - The gaseous form of any substance which is usually a liquid; vapors are present in the air around the substance.

Ventilate - To provide with a source of fresh or uncontaminated air.

Visual - Visible; detected by the unaided eye.

Volute - Housing into which impeller discharges water

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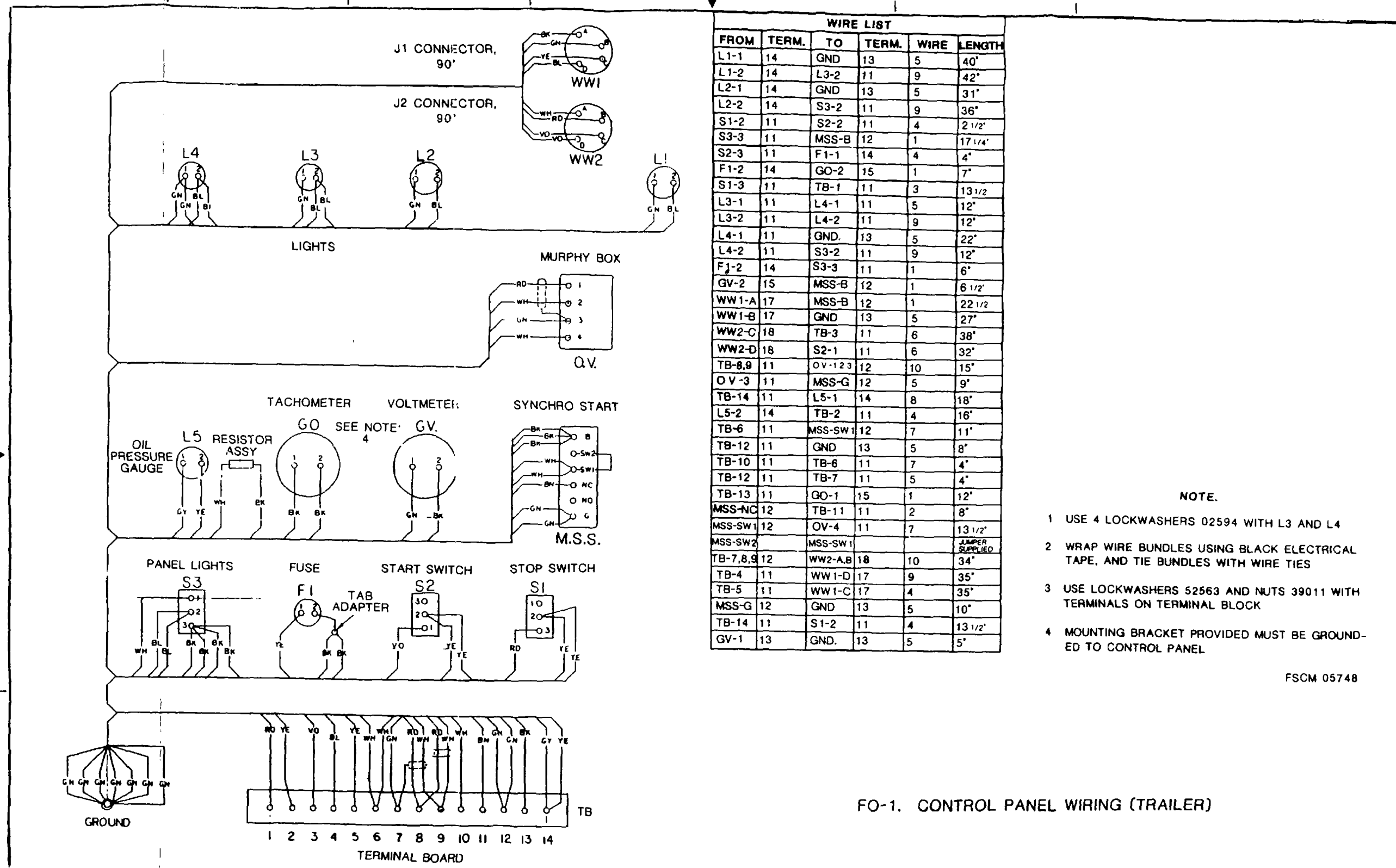
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FO-1. CONTROL PANEL WIRING (TRAILER)

FO-1. CONTROL PANEL WIRING (TRAILER)

Change 1 FP-1/(FP-2 blank)

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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 = 3,280.8 feet

Weights

1 centigram = 10 milligrams = .15 grain
 1 decigram = 10 centigrams = 1.54 grains
 1 gram = 10 decigrams = .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	To change	To	Multiply by
inches	centimeters	2.540	ounce inches	newton-meters	.0070062
feet	meters	.305	centimeters	inches	.394
yards	meters	.914	meters	feet	3.280
miles	kilometers	1.609	meters	yards	1.094
sq. inches	sq. centimeters	6.451	kilometers	miles	.621
sq. feet	sq. meters	.093	sq. centimeters	sq. inches	.155
sq. yards	sq. meters	.836	sq. meters	sq. yards	10.764
sq. miles	sq. kilometers	2.590	sq. kilometers	sq. miles	1.196
acres	sq. hectometers	.405	sq. hectometers	acres	2.471
cubic feet	cubic meters	.028	cubic meters	cubic feet	35.315
cubic yards	cubic meters	.765	milliliters	fluid ounces	.034
fluid ounces	milliliters	29.573	liters	pints	2.113
pints	liters	.472	liters	quarts	1.057
quarts	liters	.946	grams	ounces	.035
gallons	liters	3.785	kilograms	pounds	2.205
ounces	grams	28.349	metric tons	short tons	1.102
pounds	kilograms	.454	pound-feet	newton-meters	1.356
short tons	metric tons	.907			
pound inches	newton-meters	.11296			

Temperature (Exact)

°F Fahrenheit temperature

5/9 (after subtracting 32)

Celsius Temperature °C

