10000
11000
11000 MK II
685T
ENGINES

service manual

Form 70645121 English

⚠ WARNING

STUDY THE OPERATION AND MAINTENANCE INSTRUCTION MANUAL THROUGH BEFORE STARTING, OPERATING, MAINTAINING, FUELING OR SERVICING THIS MACHINE.

⚠ The Operation and Maintenance Instruction Manual provides the instructions and procedures for starting, operating, maintaining, fueling, shutdown and servicing that are necessary for properly conducting the procedures for overhaul of the related components outlined in this Service Manual.

⚠ This symbol is your safety alert sign. It MEANS ATTENTION! BECOME ALERT! YOUR SAFETY IS INVOLVED.

⚠ Read and heed all safety instructions carrying the signal words WARNING and DANGER.

⚠ Machine mounted safety signs have been color coded yellow with black borders and lettering for warning and red with white borders and lettering for danger points.

SAFETY RULES

GENERAL

Study the Operation and Maintenance Instruction Manual before starting, operating, maintaining, fueling, or servicing machine.

Read and heed all machine-mounted safety signs before starting, operating, maintaining, fueling or servicing machine.

Machine-mounted safety signs have been color coded yellow with black borders and lettering for warning and red with white borders and lettering for danger points.

Do not allow unauthorized personnel to service or maintain this machine. Do not perform any work on equipment that is not authorized. Follow the Maintenance and Service procedures. Study the Operation and Maintenance Instruction Manual before starting, operating, maintaining, fueling or servicing this machine.

Always wear safety glasses with side shields.

Do not wear rings, wrist watches, jewelry, or loose or hanging apparel, such as ties, torn clothing, scarves, unbuttoned, or unzipped jackets that can catch on moving parts. Wear proper safety equipment as authorized for the job. Examples: hard hats, safety shoes, heavy gloves, ear protectors, safety glasses or goggles, reflector vests, or respirators. Consult your employer for specific safety equipment requirements.

Do not use controls or hoses as handholds when climbing on or off machine. Hoses and controls are movable and do not provide a solid support. Controls may also be inadvertently moved causing accidental machine or equipment movement.

Do not jump on or off machine. Keep two hands and one foot, or two feet and one hand, in contact with steps and grab-rails and handles at all times.

Machine should not be serviced with anyone in the operator's seat unless they are qualified to operate the machine and are assisting in the servicing.

Keep operator's compartment, stepping points, grab-rails and handles clean of foreign objects, oil, grease, mud or snow accumulation to minimize the danger of slipping or stumbling. Clean mud or grease from shoes before attempting to mount or operate the machine.

Never attempt to operate the machine or its tools from any other position than seated in the operator's seat.

Keep operator's compartment clear of loose objects.

If movement of an attachment by means of the machine's hydraulic system is required for service or maintenance, do not raise or lower attachments from any position other than when seated in the operator's seat. Before starting machine or moving attachment or tool, make sure to set brakes, sound horn and call for an all clear. Raise attachment slowly.

Always block with external support any linkage or part on machine that requires work under the raised linkage, parts, or machine per OSHA requirements. Never allow anyone to walk under or be near unblocked raised equipment. Avoid working or walking under raised blocked equipment unless you are assured of your safety.

Never place head, body, limbs, fingers, feet or hands into an exposed portion between uncontrolled or unguarded scissor points of machine without first providing secure blocking.

Never lubricate, service or adjust a machine with the engine running, except as called for in the Operation and Maintenance Instruction Manuals. Do not wear loose clothing or jewelry near moving parts.

When servicing or maintenance requires access to areas that cannot be reached from the ground, use a ladder or step platform that meets OSHA requirements to reach the service point. If such ladders or platforms are not available, use the machine handholds and steps as provided. Perform all service or maintenance carefully.

Shop or field service platforms and ladders used to maintain or service machinery should be constructed and maintained according to local or national requirements.

Disconnect batteries and TAG all controls according to OSHA requirements to warn that work is in progress. Block the machine and all attachments that must be raised per OSHA requirements.

Never check or fill fuel tanks, storage batteries or use starter fluid near lighted smoking materials or open flame due to the presence of flammable fluid.

Brakes are inoperative when manually released for servicing. Provision must be made to maintain control of the machine by blocking or other means.

Always place the fuel nozzle against the side of the filler opening before starting and during fuel flow. To reduce the chance of a static electricity spark, keep contact until after fuel flow is shut off.

Use only designated towing or pulling attachment points. Use care in making attachment. Be sure pins and locks as provided are secure before pulling. Stay clear of drawbars, cables or chains under load.

To move a disabled machine, use a trailer or low boy truck if available. If towing is necessary, provide warning signals as required by local rules and regulations and follow operation and maintenance instruction manual recommendations. Load and unload on a level area that gives full support to the trailer wheels. Use ramps of adequate strength, low angle and proper height. Keep trailer bed clean of clay, oil and all materials that become slippery. Tie machine down securely to truck or trailer bed and block tracks (or wheels) as required by the carrier.

Never align holes with fingers or hands. Use the proper aligning tool.

Remove sharp edges and burrs from reworked parts.

Use only grounded auxiliary power source for heaters, chargers, pumps and similar equipment to reduce the hazards of electrical shock.

Lift and handle all heavy parts with a lifting device of proper capacity. Be sure parts are supported by proper slings and hooks. Use lifting eyes if provided. Watch out for people in the vicinity.

Never place gasoline or diesel fuel in an open pan.

Never use gasoline or solvent or other flammable fluid to clean parts. Use authorized commercial, non-flammable, non-toxic solvents.

When using compressed air for cleaning parts use safety

GENERAL (Continued)

glasses with side shields or goggles. Limit the pressure to 30 psi according to local or national requirements.

Do not smoke or permit any open flame or spark near when refueling, or handling highly flammable materials.

Do not use an open flame as a light source to look for leaks or for inspection anywhere on the machine.

Be sure all mechanic's tools are in good condition. DO NOT use tools with mushroomed heads. Always wear safety glasses with side shields.

Move carefully when under, in or near machine or implements. Wear required protective equipment, such as hard hat, safety glasses, safety shoes, ear protectors.

When making equipment checks that require running of the engine, have an operator in the operator seat at all times with the mechanic in sight. Place the transmission in neutral and set the brakes and lock. Keep hands and clothing away from moving parts. Shut off engine and disengage the Power Take-Off lever before attempting adjustments or service.

Never use the bucket as a man lift.

The articulation point between frames will not clear a person. Stay clear when engine is running. Support, using device provided when servicing. Return support to carry position and secure before moving machine after servicing. See Operation and Maintenance Instruction Manual.

For field service, move machine to level ground if possible and block machine. If work is absolutely necessary on an incline, block machine and its attachments securely. Move the machine to level ground as soon as possible.

Guard against kinking chains or cables. Do not lift or pull through a kinked chain or cable. Always wear heavy gloves when handling chain or cable.

Be sure cables are anchored and the anchor point is strong enough to handle the expected load. Keep exposed personnel clear of anchor point and cable or chain. DO NOT PULL OR TOW UNLESS OPERATOR'S COMPARTMENTS OF MACHINES INVOLVED ARE PROPERLY GUARDED against accidental cable or chain backlash.

Keep maintenance area CLEAN and DRY. Remove water or oil slicks immediately.

DO NOT pile oily, greasy rags — they are a fire hazard. Store in a closed metal container.

Before starting machine or moving attachment check and adjust and lock operator's seat. Be sure all personnel in the area are clear before starting or moving machine and any of its attachments. Sound horn.

Rust inhibitors are volatile and flammable. Prepare parts in well-ventilated place. Keep open flame away — DO NOT SMOKE. Store container in a cool well-ventilated place secured against unauthorized personnel.

Do not carry loose objects in pockets that might fall unnoticed into open compartments.

Keep clutches and brakes on machine and attachments such as Power Control Units, winches and master clutches adjusted according to Operation and Maintenance Instruction Manuals of the manufacturer at all times. DO NOT adjust machine with engine running except as specified.

Wear proper protective equipment such as safety goggles or safety glasses with side shields, hard hat, safety shoes, heavy gloves when metal or other particles are apt to fly or fall.

Wear welder's protective equipment such as dark safety glasses, helmets, protective clothing, gloves and safety shoes when welding. Wear dark safety glasses near welding. DO NOT LOOK AT ARC WITHOUT PROPER EYE PROTECTION.

Know your jacking equipment and its capacity. Be sure the jacking point used on the machine is appropriate for the load to be applied. Be sure the support for the jack at the machine and under the jack is appropriate and stable. Any equipment up on a jack is dangerous. Transfer load to appropriate blocking as a safety measure before proceeding with service or maintenance work according to local or national requirements.

Wire rope develops steel slivers. Use authorized protective equipment such as heavy gloves, safety glasses when handling.

Handle all parts with extreme care. Keep hands and fingers from between parts. Wear authorized protective equipment such as safety glasses, heavy gloves, safety shoes.

Inspect your seat belt at least twice a year for signs of fraying, wear, or other weakness that could lead to failure.

Where it is necessary to use diesel fuel as a lubricant make sure all smoking material and open flames are extinguished or that no sparks are near. Place all parts in a closed container of clear diesel fuel for use as needed.

To minimize dangers of fire and explosion, it is recommended that before any welding is done on a fuel tank, the tank be completely drained of fuel, fuel lines disconnected and the ends closed to protect them, and the tank be steam cleaned. All traces of fuel must be removed before welding is started. Flood the tank with carbon dioxide (CO_2) before and during welding. Caps must be removed and vents and other openings left open during welding.

Dry ice (solid carbon dioxide) is extremely cold and will freeze flesh on contact. Use care to prevent contact with skin, eyes, or other parts of the body to avoid personal injury.

When work is required under or between components, block with an external support capable of holding the components in place according to local or national requirements.

START UP

Do not run the engine of this machine in closed areas without proper ventilation to remove deadly exhaust gases.

Do not place head, body, limbs, feet, fingers, or hands near a rotating fan or belts. Be especially alert around a pusher fan.

STARTING FLUID IS FLAMMABLE. Follow the recommendations as outlined in the Operation and Maintenance Instruction Manual and as marked on the containers. Store containers in cool, well-ventilated place secure from unauthorized personnel. DO NOT PUNCTURE OR BURN CONTAINERS. Follow the recommendation of the manufacturer for storage and disposal.

Safety Rules

ENGINE

Turn radiator cap slowly to relieve pressure before removing. Add coolant only with engine stopped or idling if hot. See Operation and Maintenance Instruction Manual.

Do not run engine when refueling and use care if engine is hot due to the increased possibility of a fire if fuel is spilled.

Never attempt to check or adjust fan belts when engine is running.

Do not adjust engine fuel pump when the machine is in motion.

Never lubricate a machine with the engine running.

Avoid running engine with open unprotected air inlets. If such running is unavoidable for service reasons, place protective screen over all inlet openings before servicing engine.

ELECTRICAL

Be sure to connect the booster cables to the proper terminals (+ to +) and (- to -) at both ends. Avoid shorting clamps. Follow the Operation and Maintenance Instruction Manual procedure.

Always turn the master switch (key switch if so equipped) to the off position when maintaining or servicing machine.

BATTERY GAS IS HIGHLY FLAMMABLE. Leave battery box open to improve ventilation when charging batteries. Never check charge by placing metal objects across the posts. Keep sparks or open flame away from batteries. Do not smoke near battery to guard against the possibility of an accidental explosion.

Check for fuel or battery electrolyte leaks before starting service or maintenance work. Eliminate leaks before proceeding.

Do not charge batteries in a closed area. Provide proper ventilation to guard against an accidental explosion from an accumulation of explosive gases given off in the charging process.

Disconnect batteries before working on electrical system or repair work of any kind.

HYDRAULIC

Fluid escaping under pressure from a very small hole can almost be invisible and can have sufficient force to penetrate the skin. Use a piece of cardboard or wood to search for suspected pressure leaks. DO NOT USE HANDS. If injured by escaping fluid, see a doctor at once. Serious infection or reaction can develop if proper medical treatment is not administered immediately.

Shut off engine and be sure all pressure in system has been relieved before removing panels, housings, covers, and caps. See Operation and Maintenance Instruction Manual.

When making pressure checks use the correct gage for expected pressure. See Operation and Maintenance Instruction Manual or Service Manual for Guidance.

ATTACHMENTS

Keep head, body, limbs, feet, hands and fingers away from blade, bucket or ripper when in raised position. Use authorized blocking as a safety measure before proceeding with service or maintenance per OSHA requirements.

If movement of an attachment by means of the machine's hydraulic system is required for service or maintenance do not raise or lower attachments from any position other than when seated in the operator's seat. Before starting machine or moving attachments or tools, make sure to set brakes, sound horn and call for an all clear. Raise attachment slowly.

Do not use machine to carry loose objects by means other than attachments for carrying such objects.

Never use any gas other than dry nitrogen to charge accumulators. See Operation and Maintenance Instruction Manual.

Keep clutches and brakes on machine and attachments such as power control units, winches and master clutches adjusted according to Operation and Maintenance Instruction Manuals of the manufacturer at all times. DO NOT adjust machine with engine running except as specified.

TIRES (APPLICABLE MACHINES)

Be sure tires are properly inflated to the manufacturer's specified pressure. Inspect for damage periodically.

Stand to one side when changing inflation of tires.

Check tires only when the machine is empty and tires are cool to avoid overinflation. Do not use reworked wheel parts. Improper welding, heating or brazing weakens them and can cause failure.

Never cut or weld on the rim of an inflated tire. Inflate a spare tire only enough to keep rim parts in place — a fully inflated tire might fly apart when it is not installed on a machine.

Use care if you must transport (haul) a fully inflated tire.

When servicing tires block the machine in front and back of all wheels. After jacking up, place blocking under machine to protect from falling per OSHA requirements.

Deflate tires before removing objects from the tread.

Never inflate tires with flammable gases. Explosion and personal injury could result.

FIAT-ALLIS

SUPPLEMENT NO. 5

SERVICE MANUAL FORM 70645121

10000, 11000, 11000 MK II ENGINES

(4-79)

ATTENTION: Insert this sheet in the front of publication as record of receipt. Replace or add pages in the publication according to instructions below.

Additional copies of this supplement are available. Please direct your request to:
Fiat-Allis Construction Machinery, Inc., Publications Services Dept.,
3000 South 6th Street, Springfield, Illinois 62710 U. S. A.

Write in the following changes:

Section 4, Pg. 7

NOTICE
THESE CHANGES ARE INCLUDED IN THIS COPY

C. FUEL INJECTION NOZZLE-HOLDER SERVICE

The fuel injection nozzle-holder assemblies should be removed after approximately every 2000 hours of operation, tested and adjusted if necessary. The nozzle-holder assembly when properly adjusted should require an opening pressure of (refer to FUEL INJ. NOZZLE ASSEMBLIES S.M. 70682797). When adjusting "popping" pressure of a new nozzle-holder or a rebuilt nozzle-holder in which a new

Section 4, Pg. 8

1. Using a nozzle tester similar to the one shown in Fig. 10, operate tester handle a few quick strokes and observe "popping" pressure of fuel injection nozzle-holder as indicated by pressure gauge of the nozzle tester. For specified pressure, refer to FUEL INJ. NOZZLE ASSEMBLIES S.M. 70682797.

NOTE

Reason: Fuel injection nozzle pressure changes.

FIAT-ALLIS

SUPPLEMENT NO. 4

SERVICE MANUAL FORM 70645121

10000, 11000, 11000 MKII ENGINES

(5-78)

ATTENTION: Insert this sheet in the front of publication as record of receipt. Replace or add pages in the publication according to instructions below.

Additional copies of this supplement are available. Please direct your request to:
Fiat-Allis Construction Machinery, Inc., Publications Service Dept.,
3000 South 6th Street, Springfield, Illinois 62710 U. S. A.

Reason: This supplement updates manual to cover the 11000 MKII engine.

Replace or add the following like pages:

1-1	(No change)	5-1	(Revised)	5-15	(Added)	11-6E	(Added)
1-2	(Revised)	5-2	(Revised)	5-16	(Added)		
2-2A	(Added)	5-4A	(Added)	[illegible]1	(Revised)	13-1	(Revised)
					(Revised)	13-2	(No change)
2-23	(Revised)	5-7	(Revised)	11-6A	(Added)	15-3	(Revised)
2-24	(Revised)	5-8	(No change)	11-6B	(Added)	15-4	(No change)
2-25	(Revised)	5-13	(Revised)	11-6C	(Added)	Section 18: Entire section revised.	
2-26	(Revised)	5-14		11-6D	(Added)		
2-27	(Revised)					20-1	(Revised)
2-28	(Revised)					20-2	(Revised)

NOTICE
THESE CHANGES ARE INCLUDED IN THIS COPY

Write in the following changes (changes are underlined):

Page 2-2	TOPIC 1	Add new sentence before first paragraph: Refer to FIG. 1A.
4-12	Paragraph H. 2	Add new first sentence to paragraph: Coat nozzle- holder threads with anti-seize compound.
4-12	Paragraph H. 2	Change "Position a new rubber dust shield ..." to "Position two new rubber dust shields..."

(continued)

8-3	Legend for FIG. 1	Add to item 8: (One piece gasket effective with engine serial number 11-25689). Add to item 16 ... or rotator. Add to item 32: (Used prior to engine serial number 11-25689).
8-5	Paragraph A. 6 NOTE	Change "cams" to "arms."
8-6	Paragraph B. 2	Change " ... 19-22 lbs. ft." to "... 10-35 lb-ft (1.4-4.8 kg-m) for stud nuts and 14-45 lb-ft (1.9-6.2 kg-m) for place bolts."
8-8	Paragraph B. 5	Change first sentence to read: Tighten 1/2 in. nuts to 100 lb-ft (13.8 kg-m), 1/2 in. capscrews to 115 lb-ft (15.9 kg-m) and 5/8 in. nuts or capscrews to 185 lb-ft (25.6 kg-m).
8-9	Legend for FIG. 10	Add to item 4: (Not necessary with one piece gasket).
10-4	Paragraph C. 3	Change "45-50 lb-ft" to "70 lb-ft (9.7 kg-m).
10-4A	Paragraph i.	Add: If flywheel is fastened by socket head capscrews, tighten to 135 lb-ft (18.7 kg-m).
11-3	Legend for FIG. 2 (cont.)	Omit: Legend for FIG. 2 (continued), items 25 through 28.
11-5	FIG. 5, Title	Add: Used prior to engine serial number 11-24134.
11-10	Paragraph B. 6	Change next to last sentence to read: " ... tighten nut to 125-135 lb-ft (17.3 - 18.7 kg-m)."
12-4	Paragraph 9	Add new sentence and change first sentence: Apply sealant to camshaft bore plug. Install a new plug in camshaft hole ... ".
13-3	Paragraph E. 1	Replace piston ring end gap dimensions with the following new data: Top Ring: First Type Pistons 0.013-0.033 in (0.33-0.84 mm) Second Type Pistons 0.013-0.028 in (0.33-0.71 mm) 2nd and 3rd rings 0.013-0.33 in (0.33-0.84 mm) 4th ring 0.008-0.028 in (0.20 0.71 mm)

(continued)

13-4	Paragraph E. 2	Replace piston ring-to-groove clearance dimensions with the following new data: Top ring 0.004-0.007 in (0.10-0.18 mm) 2nd and 3rd rings 0.003-0.005 in (0.08-0.13 mm) 4th ring 0.0015-0.004 in (0.04-0.10 mm)
13-6	TOPIC 2	Add to paragraph 4: On current engines with twelve-point capscrews instead of nuts, tighten capscrews to 160 lb-ft (22.1 kg-m) (217 Nm).
14-3	Legend FIG. 1	Add to item 3: (Used prior to engine serial number 11-19386).
14-4	Paragraph 6	Add: On current engines with twelve-point capscrews instead of nuts, tighten capscrews to 160 lb-ft (22.1 kg-m) (217 Nm).
15-5	Section 4, right-hand column, third paragraph.	Change second sentence to read: If this lubricant is not available, use liquid edible vegetable oil. Delete sub-paragraphs a. and b.

SUPPLEMENT NO.3

SERVICE MANUAL FORM 0645121-5 (7-66)

10000 -11000 ENGINES

CONSTRUCTION MACHINERY DIVISION

(10-71)

ATTENTION: Insert this sheet into the front of publication as record of receipt. Replace or add pages in the publication according to instructions below.

NOTICE
THESE CHANGES ARE INCLUDED IN THIS COPY

Replace the following like pages:

Index Pg. 3 (Revised)

Sect. 1 Pg. 1 (No change)
Sect. 1 Pg. 2 (Revised)

Sect. 2 Pg. 1 (Revised)
Sect. 2 Pg. 2 (No change)

Sect. 2 Pg. 11 (No change)
Sect. 2 Pg. 12 (Revised)

Sect. 2 Pg. 27 (Revised)
Sect. 2 Pg. 28 (Revised)

Sect. 3 Pg. 1 (Revised)
Sect. 3 Pg. 2 (No change)

Sect. 3 Pg. 3 (No change)
Sect. 3 Pg. 4 (Revised)

Sect. 3 Pg. 4a (Added)

Sect. 5A Pg. 1 (Added)
Sect. 5A Pg. 2 (Added)

Sect. 5A Pg. 3 (Added)
Sect. 5A Pg. 4 (Added)

Sect. 5A Pg. 5 (Added)
Sect. 5A Pg. 6 (Added)

Sect. 5A Pg. 7 (Added)
Sect. 5A Pg. 8 (Added)

Sect. 5A Pg. 9 (Added)
Sect. 5A Pg. 10 (Added)

Sect. 8 Pg. 11 (No change)
Sect. 8 Pg. 12 (Revised)

Sect. 8 Pg. 13 (Revised)
Sect. 8 Pg. 14 (Revised)

Sect. 10 Pg. 3 (Revised)
Sect. 10 Pg. 4 (Revised)

Sect. 10 Pg. 4a (Added)

Sect. 13 Pg. 1 (Revised)
Sect. 13 Pg. 2 (Revised)

Sect. 13 Pg. 3 (Revised)
Sect. 13 Pg. 4 (Revised)

Sect. 13 Pg. 5 (Revised)
Sect. 13 Pg. 6 (Revised)

Sect. 13 Pg. 7 (Added)

Sect. 15 Pg. 5 (Revised)
Sect. 15 Pg. 6 (Revised)

Reason: This supplement adds the Bosch (Germany) injection pump data and other miscellaneous changes.

Printed in U.S.A.

NOTICE
THESE CHANGES ARE INCLUDED IN THIS COPY

NOTICE OF CHANGE

TO

SERVICE MANUAL 645121 (7-66)

10000 11000

ENGINES

CONSTRUCTION MACHINERY DIVISION

Write in the following changes:

Section 2, Page 16 — Legend for Fig. 11c — Add: 33. Spider Kit

Replace the following like pages:

Section 1 Pg. 1 (No change)
Section 1 Pg. 2 (Revised)

Section 2 Pg. 3 (No change)
Section 2 Pg. 4 (Revised)

Section 2 Pg. 13 (Revised)
Section 2 Pg. 14 (Revised)

Section 2 Pg. 21 (Revised)
Section 2 Pg. 22 (No change)

Section 2 Pg. 23 (Revised)
Section 2 Pg. 24 (Revised)

Section 2 Pg. 25 (Revised)
Section 2 Pg. 26 (Revised)

Section 3 Pg. 1 (Revised)
Section 3 Pg. 2 (No change)

Section 4 Pg. 7 (Revised)
Section 4 Pg. 8 (Revised)

Section 5 Pg. 7 (No change)
Section 5 Pg. 8 (Revised)

Section 8 Pg. 3 (No change)
Section 8 Pg. 4 (Revised)

Section 8 Pg. 5 (Revised)
Section 8 Pg. 6 (No change)

Section 8 Pg. 13 (No change)
Section 8 Pg. 14 (Revised)

Section 8 Pg. 15 (No change)
Section 8 Pg. 16 (Revised)

Section 9 Pg. 1 (Revised)
Section 9 Pg. 2 (No change)

Section 10 Pg. 3 (Revised)
Section 10 Pg. 4 (No change)

Section 14 Pg. 1 (No change)
Section 14 Pg. 2 (Revised)

Section 14 Pg. 7 (Revised)
Section 14 Pg. 8 (No change)

Section 15 Pg. 5 (Revised)
Section 15 Pg. 6 (No change)

Section 18 Pg. 5 (Revised)
Section 18 Pg. 6 (Revised)

Section 18 Pg. 7 (Revised)
Section 18 Pg. 8 (Revised)

Reason: This mailing provides latest information on 10000 & 11000 engines.

INSERT THIS SHEET INTO THE FRONT OF MANUAL 0645121 (7-66) TO INDICATE RECEIPT OF THIS MAILING.

Additional copies of this mailing are available. Please direct your order to the Technical Publications Department, Springfield Plant.

Printed in U.S.A.

MAILING NO. 2
Issued 3-70

NOTICE
THESE CHANGES ARE INCLUDED IN THIS COPY

REPLACEMENT PAGES FOR

645121 (7-66)

SERVICE MANUAL

Mailing No. 1

10000 11000

ENGINES

CONSTRUCTION MACHINERY DIVISION

The following replace like pages:

Sect. 1 Pg. 1 (Revised)
Sect. 1 Pg. 2 (Revised)

Sect. 2 Pg. 1 (Revised)
Sect. 2 Pg. 2 (Revised)

Sect. 2 Pg. 3 (Revised)
Sect. 2 Pg. 4 (Revised)

Sect. 2 Pg. 5 (Revised)
Sect. 2 Pg. 6 (Revised)

Sect. 2 Pg. 7 (Revised)
Sect. 2 Pg. 8 (Revised)

Sect. 2 Pg. 9 (Revised)
Sect. 2 Pg. 10 (Revised)

Sect. 2 Pg. 11 (Revised)
Sect. 2 Pg. 12 (Revised)

Sect. 2 Pg. 13 (Revised)
Sect. 2 Pg. 14 (Revised)

Sect. 2 Pg. 15 (Revised)
Sect. 2 Pg. 16 (Revised)

Sect. 2 Pg. 17 (Revised)
Sect. 2 Pg. 18 (Revised)

Sect. 2 Pg. 19 (Revised)
Sect. 2 Pg. 20 (Revised)

Sect. 2 Pg. 21 (Revised)
Sect. 2 Pg. 22 (Revised)

Sect. 2 Pg. 23 (Added)
Sect. 2 Pg. 24 (Added)

Sect. 2 Pg. 25 (Added)
Sect. 2 Pg. 26 (Added)

Sect. 2 Pg. 27 (Added)
Sect. 2 Pg. 28 (Added)

Sect. 5 Pg. 1 (Revised)
Sect. 5 Pg. 2 (No change)

Sect. 5 Pg. 5 (No change)
Sect. 5 Pg. 6 (Revised)

Sect. 5 Pg. 7 (Revised)
Sect. 5 Pg. 8 (Revised)

Sect. 5 Pg. 9 (Revised)
Sect. 5 Pg. 10 (Revised)

Sect. 5 Pg. 11 (Added)
Sect. 5 Pg. 12 (Added)

Sect. 8 Pg. 1 (No change)
Sect. 8 Pg. 2 (Revised)

Sect. 11 Pg. 1 (No change)
Sect. 11 Pg. 2 (Revised)

INSERT THIS SHEET INTO THE FRONT OF MANUAL 645121 (7-66) TO INDICATE RECEIPT OF THIS MAILING. Additional copies of this mailing are available. Please direct your order to Parts Order Department.

This mailing incorporates recent engine changes.

Litho in U.S.A.

Issued 4-67

FOREWORD

This manual covers the Model 10000, 11000, 11000 MKII, and 685T engines as used in Fiat-Allis Construction Machinery. For the purpose of this manual, the engine is considered to consist of the basic engine extending from the radiator to the flywheel and flywheel housing inclusive. The 10000, 11000, and 685T engines are covered in this one manual because the repair and overhaul procedures are similar. In cases where the procedures differ, they are clearly indicated. Capacities of the crankcase, cooling system, etc. which vary, depending upon the unit in which the engine is used, may be found in the Operation and Maintenance Instruction Manual furnished with the unit.

This manual has been prepared to provide maintenance personnel with information and instructions for repairing and overhauling these engines. In order to become familiar with the various parts of the engines, it is urged that the maintenance personnel study the instructions and illustrations in the manual and use it as reference when performing repair or overhaul operations.

All information, illustrations, and specifications in this manual are based on information available at the time of publication. FIAT-ALLIS reserves the right to make changes at any time without notice.

The terms "front", "rear", "left", and "right" as used in this manual are defined as follows:

"front" - Fan end of engine.
"rear" - Flywheel end of engine.
"left" - Fuel injection pump side of engine.
"right" - Water pump side of engine.

Many owners of FIAT-ALLIS equipment employ the Dealers Service Department for all work other than routine care and adjustments. This practice is encouraged as our Dealers are kept well informed by the factory regarding advanced methods of servicing FIAT-ALLIS products and are equipped to render satisfactory service.

To assure the best results and maintain the original quality built into the engine it is important that FIAT-ALLIS parts be used when new parts are required.

IMPORTANT

Always furnish unit and engine serial numbers when ordering parts.

SUBJECT INDEX

SUBJECT	SECTION
DESCRIPTION AND SPECIFICATIONS	1
COOLING SYSTEM	2
ELECTRICAL SYSTEM	3
FUEL SYSTEM (With American Bosch Fuel Injection Pump)	4
FUEL SYSTEM (With Roosa Master Fuel Injection Pump)	5
FUEL SYSTEM (With Bosch (Germany) Fuel Injection Pump)	5a
AIR CLEANER AND INTAKE MANIFOLD	6
EXHAUST MANIFOLD AND TURBOCHARGER	7
VALVES, VALVE OPERATING MECHANISM, AND CYLINDER HEADS	8
FRONT END AND GEAR TRAIN	9
FLYWHEEL AND RING GEAR; FLYWHEEL HOUSING AND CRANKSHAFT REAR OIL SEAL	10
LUBRICATING SYSTEM	11
CAMSHAFT AND CAMSHAFT BEARINGS	12
PISTONS, PISTON RINGS, CONNECTING RODS, AND CONNECTING ROD BEARINGS	13
CRANKSHAFT AND CRANKSHAFT GEAR, MAIN BEARINGS AND MAIN BEARING CAPS	14
CYLINDER BLOCK AND CYLINDER SLEEVES	15
ENGINE REMOVAL AND INSTALLATION	16
ENGINE DISASSEMBLY AND ASSEMBLY	17
FITS AND TOLERANCES AND TORQUE SPECIFICATIONS	18
TROUBLE SHOOTING	19
SERVICE TOOLS	20

SECTION 1 - DESCRIPTION AND SPECIFICATIONS

TOPIC NO.	TITLE	PAGE
1.	DESCRIPTION	
	A. General	1-1
	B. Principles of Operation	1-1
2.	SPECIFICATIONS	
	A. Engine Data and Characteristics	1-2
	B. Fuel Injection (American Bosch (PSB) Fuel Injection Pump)	1-2
	C. Fuel Injection (Roosa Master Fuel Injection Pump without Automatic Timing Advance)	1-2
	D. Fuel Injection (Roosa Master Fuel Injection Pump with Automatic Timing Advance)	1-2
	E. Valve Timing	1-2
	F. Lubrication	1-2
	G. Engine Speeds	1-2

TOPIC 1 - DESCRIPTION

A. GENERAL

The Model 10000, 11000, 11000 MKII, and 685T engines covered in this manual are both six cylinder, vertical in-line, four cycle, water cooled, open combustion chamber, direct injection, full diesel engines. The main difference between the models is that the 10000 engine is naturally aspirated, and the 11000, 11000 MKII, and 685T are turbo-charged.

Fuel is supplied to the cylinders by a fuel injection pump. The pump delivers accurately metered quantities of fuel, under high pressure, through fuel injection nozzles, into the cylinders at a definite timing in relation to the engine firing cycle. The fuel is ignited by heat generated by compression of the air in the cylinders.

A combustion chamber is located in the head of each piston and the fuel injection nozzles are mounted in the cylinder head. The orifices in the tip of the nozzle are drilled at a slight angle so that the fuel is sprayed directly into the combustion chamber which is slightly offset toward the camshaft side of the engine. The shape of the combustion chamber, angle of fuel injection, and the shrouded intake valves, causes extreme turbulence of the air within the cylinders and results in the fuel and air being thoroughly mixed for complete combustion.

The engines are full pressure lubricated by a gear type oil pump driven by the crankshaft gear. Engine cooling is accomplished by coolant, forced through the engine cooling and radiator system by a centrifugal type water pump. The water pump is belt driven.

B. PRINCIPLES OF OPERATION

In a four cycle diesel engine, a power stroke is made by each piston for every two complete revolutions of the crankshaft. The sequence of the strokes is as follows: Intake, compression, power, and exhaust.

1. INTAKE STROKE

As the piston moves downward on the first, or intake stroke, air enters the cylinder through the air intake manifold, and the intake valve which starts to open a few degrees before the piston reaches top dead center. The intake charge consists of air only, with no fuel mixture.

2. COMPRESSION STROKE

Shortly after the piston starts to move upward on the second, or compression stroke, the intake valve closes. The air is compressed in the cylinder and compression of the air raises the temperature in the cylinder to approximately 1000°F. At the proper moment during the compression stroke, a metered quantity of fuel is injected into the combustion chamber under extremely high pressure. The finely atomized fuel is ignited by heat of the compressed air and starts to burn immediately.

3. POWER STROKE

Expansion of the burning gases forces the piston downward on its third, or power stroke. Near the bottom of the power stroke, the exhaust valve starts to open.

4. EXHAUST STROKE

As the piston moves upward on the fourth, or exhaust stroke, the exhaust valve is open and burned gases are forced out of the cylinder by the upward travel of the piston. A few degrees before the piston reaches top dead center, the intake valve starts to open to admit a fresh charge of air to the cylinder. A few degrees after top dead center, the exhaust valve completely closes and the cycle is repeated.

TOPIC 2 - SPECIFICATIONS

A. ENGINE DATA AND CHARACTERISTICS

Number of Cylinders 6
Bore . . . . . 4.4375 in (112.71 mm)
Stroke . . . . . 5.5625 in (141.29 mm)
Total Displacement . . . . . 516 in ^{3} (8.4 lit)
Crankshaft Rotation (Viewed from Fan End) . . . . . Clockwise
Number of Main Bearings 7
Compression Ratio (Nominal) 16.2:1
Compression Pressure (Minimum) at Sea Level 600 rpm hot . . . . . 445 psi (31.3 kg/cm^2)
Firing Order 1-5-3-6-2-4
Minimum Stabilized Water Temp: 170 °F. (76.7 °C)
Maximum Air Intake Restriction: 30 in (762 mm) H_2O
Maximum Permissible Exhaust Restriction
Naturally Aspirated . . . . . 3 in Hg (10.2 kPa)
Turbocharged . . . . . 1 in Hg (3.4 kPa)

B. FUEL INJECTION PUMP (AMERICAN BOSCH (PSB)

Nozzle Opening Pressure: 3800-3850 psi (267.2-270.7 kg/cm^2)
Fuel Injection Timing:
Track-Type Tractors without Torque Converter and Motor Graders . . . . . 30°
Track-Type Tractors with Torque Converter . . . . . 32°
Tractor Loaders and Tractor Dozers
TL20D . . . . . 32°
D30 . . . . . 33°
TL30D . . . . . 34°
Fuel Injection Pump Speed (Ratio to Crankshaft) 1:1

C. FUEL INJECTION PUMP (ROOSA MASTER WITHOUT AUTOMATIC TIMING ADVANCE)

Nozzle Opening Pressure . . 2825 psi (198.6 kg/cm^2)
Fuel Injection Timing:
Naturally Aspirated Engines (10000) . . . . . 30°
Turbocharged Engines (11000) . . . . . 36°
Fuel Injection Pump Speed (Ratio to Crankshaft) 1:2

D. FUEL INJECTION PUMP (ROOSA MASTER WITH AUTOMATIC TIMING ADVANCE)

Nozzle Opening Pressure (First type) . . 2800-2850 psi (196.9-100.4 kg/cm^2)
Nozzle Opening Pressure . . . . . (Second Type) 3800-3850 psi (267.2-270.7 kg/cm^2)
Fuel Injection Pump Timing:
11000 24° BTDC (Static), 36° BTDC (Running)
11000 MKII (DB, DC): 18°BTDC (Static) 36°BTDC (Running)
11000 MKII (DM): 14° BTDC (Static), 36° BTDC (Running)
Fuel Injection Pump Speed (Ratio to Crankshaft) 1:2

E. FUEL INJECTION PUMP (BOSCH-GERMANY)

Nozzle Opening Pressure . . . . . 3800-3850 psi . . . (267.2-270.7 kg/cm^2)
Fuel Injection Timing BTDC
HD-11, 11-B Crawler Tractor . . . . . 32°
12G , 12G-B Crawler Loader . . . . . 34°
100-C, 150-C, 200-C Motor Graders . . . . . 32°
745, 745H, 745B, 745H-B Wheel Loaders . . . . . 34°
Fuel Injection Pump Speed (Ratio to Crankshaft) 1:2

F. VALVE TIMING

NOTE

Early model engines used camshaft part no. 4336274 and later model engines use camshaft part no. 4337723. The part no. is stamped on the camshaft near the front end. The valve timing for each camshaft is as follows:

	Camshaft no. 4337723 With Tappets Set at 0.024 in (0.61mm)	Camshaft no. 4336274 With Tappets Set at 0.018 in (0.46 mm)
Intake Valve Opens BTDC	21°	40°
Intake Valve Closes ABDC	55°	70°
Duration	256°	290°
Exhaust Valve Opens BBDC	53°	70°
Exhaust Valve Closes ATDC	23°	40°
Duration	256°	290°
Overlap	44°	80°
Running Clearance for Valve Tappets (Intake and Exhaust)	0.018 in (0.46 mm) HOT 0.020 in (0.51 mm) COLD	

G. LUBRICATION

Type . . . . . Full Pressure
Lubricating Oil Filter . . . . . Full Flow
Lubricating Oil Specifications . . . . CD, MIL-L-45199B or MIL-L-2104C
Oil Pump Speed Ratio to Crankshaft 0.682:1

H. ENGINE SPEEDS

For specified high and low idle engine speeds, which vary depending upon the unit in which the engine is used, refer to the OPERATION AND MAINTENANCE INSTRUCTION MANUAL furnished with the unit.

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

SECTION 2 - COOLING SYSTEM

TOPIC NO.	TITLE	PAGE NO.
1.	GENERAL	2-2
2.	RADIATOR (EXCEPT 12G CRAWLER LOADER)	
	A. General	2-2
	B. Radiator Removal and Installation	2-2
	C. Radiator Inspection	2-4
3.	RADIATOR (12G CRAWLER LOADER)	
	A. General	2-4
	B. Radiator Removal and Installation	2-4
	C. Radiator Inspection	2-4
4.	FAN, FAN BELTS, FAN HUB, FAN BELT TIGHTENER, AND FAN DRIVE (EXCEPT 12G CRAWLER LOADER)	
	A. Description	2-4
	B. Fan Belt Adjustment	2-4
	C. Fan Removal, Inspection, and Installation	2-6
	D. Fan Belt Removal, Inspection, and Installation	2-6
	E. Fan Hub Removal, Disassembly, and Inspection	2-6
	F. Fan Hub Assembly and Installation	2-6
	G. Fan Belt Tightener Removal, Disassembly, and Inspection	2-9
	H. Fan Belt Tightener Assembly and Installation	2-10
	I. Fan Drive Removal, Disassembly, and Inspection (Track-Type Tractor Engines w/American Bosch Fuel Injection Pump)	2-10
	J. Fan Drive Assembly and Installation (Track-Type Tractor Engines w/American Bosch Fuel Injection Pump)	2-11
	K. Fan Drive Removal, Disassembly, and Inspection (Crawler Tractor Engines w/Roosa Master or Bosch (Germany) Fuel Injection Pump)	2-12
	L. Fan Drive Assembly and Installation (Crawler Tractor Engines w/Roosa Master or Bosch (Germany) Fuel Injection Pump)	2-12
5.	FAN, FAN BELTS, AND FAN DRIVE (12G CRAWLER LOADER)	
	A. Description	2-13
	B. Fan Belt Adjustment	2-13
	C. Fan Removal, Inspection, and Installation	2-13
	D. Fan Belt Removal, Inspection, and Installation	2-13
	E. Fan Hub Removal, Disassembly, Inspection, Assembly, and Installation	2-15
	F. Fan Drive Removal, Disassembly, Inspection, Assembly, and Installation	2-15
6.	THERMOSTATS	
	A. General	2-17
	B. Thermostat Removal, Testing, and Installation	2-18
7.	OIL COOLERS	
	A. General	2-18
	B. Oil Cooler Removal	2-18
	C. Oil Cooler Cleaning	2-20
	D. Oil Cooler Testing	2-23
	E. Oil Cooler Installation	2-23
8.	WATER PUMP	
	A. Description	2-24
	B. Water Pump Removal	2-24
	C. Water Pump Disassembly, Inspection, and Assembly	2-25
	D. Water Pump Installation	2-27
9.	COOLANT FILTER	
	A. General	2-27
	B. Coolant Filter Service	2-28
	C. Coolant Filter Removal and Installation	2-28

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

TOPIC 1 - GENERAL

Refer to FIG. 1A. The engine cooling system includes radiator, water pump, oil cooler, water inlet and water outlet manifolds, thermostats, coolant temperature gauge, and water passages in cylinder block and cylinder head.

All units, using engines covered in this manual, with the exception of early model motor graders, have a pressurized cooling system. A double acting pressure relief valve is provided in the radiator filler cap. The valve is set to open at approximately 7 psi. Early model motor graders have an open type vented cooling system.

The water pump draws water from the bottom of the radiator and forces it through the oil cooler and the cored water passages in the engine. The coolant is discharged from the cylinder head into the water outlet manifold, through the thermostat and upper radiator hose and into the upper part of the radiator. The coolant dissipates its heat as it passes from the top to the bottom of the radiator through the cooling cores. The fan helps dissipate the heat as it forces air through the radiator. The thermostats, located in the thermostat housing at the front end of the water outlet manifold, operate automatically to maintain a minimum coolant temperature of 170°F.

TOPIC 2 - RADIATOR (EXCEPT 12G CRAWLER LOADER)

A. GENERAL

The radiator used on motor graders, tractor loaders, and tractor dozers is a one piece welded assembly. The radiator used on track-type tractors consists of a top and bottom tank, core, and side members bolted together and serviced separately.

On track-type tractors, the radiator is mounted on a radiator support, Fig. 1, which is bolted to the tractor main frame.

On motor graders, the radiator is bolted to the radiator grill, Fig. 2, which is bolted to the grader main frame.

On tractor loaders, and tractor dozers the radiator is bolted to the radiator support, Fig. 3, which is bolted to the loader main frame.

B. RADIATOR REMOVAL AND INSTALLATION

1. TRACK-TYPE TRACTORS (Fig. 1)

   a. Drain cooling system.

   b. Remove or tilt radiator guard forward.

   c. Disconnect radiator inlet and outlet hoses. Disconnect any wires which may be attached to radiator.

   d. The radiator (1) and radiator support (2) may now be removed as an assembly by removing fan guard (if so equipped), support mounting capscrews (9), and capscrews (6); or the radiator may be removed from the support by removing capscrews (13) and lockwashers.

   e. If Radiator support was removed from tractor, install by direct reversal of removal procedure.

   f. Install radiator on radiator support and secure with capscrews (13) and lockwashers.

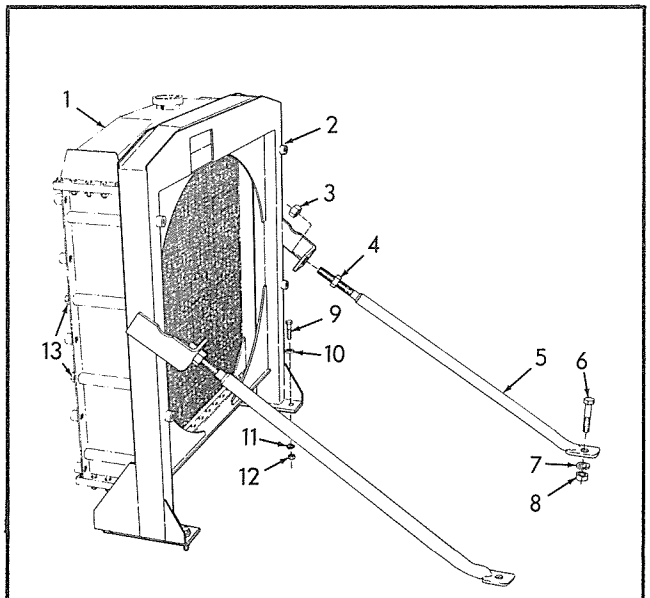


Fig. 1—Typical Radiator Mounting (Track-Type Tractors) (T-16315)

1. Radiator Assembly
2. Radiator Support
3. Nut
4. Lock Nut
5. Brace
6. Capscrew
7. Lockwasher
8. Nut
9. Capscrew
10. Plain Washer
11. Lockwasher
12. Nut
13. Capscrews

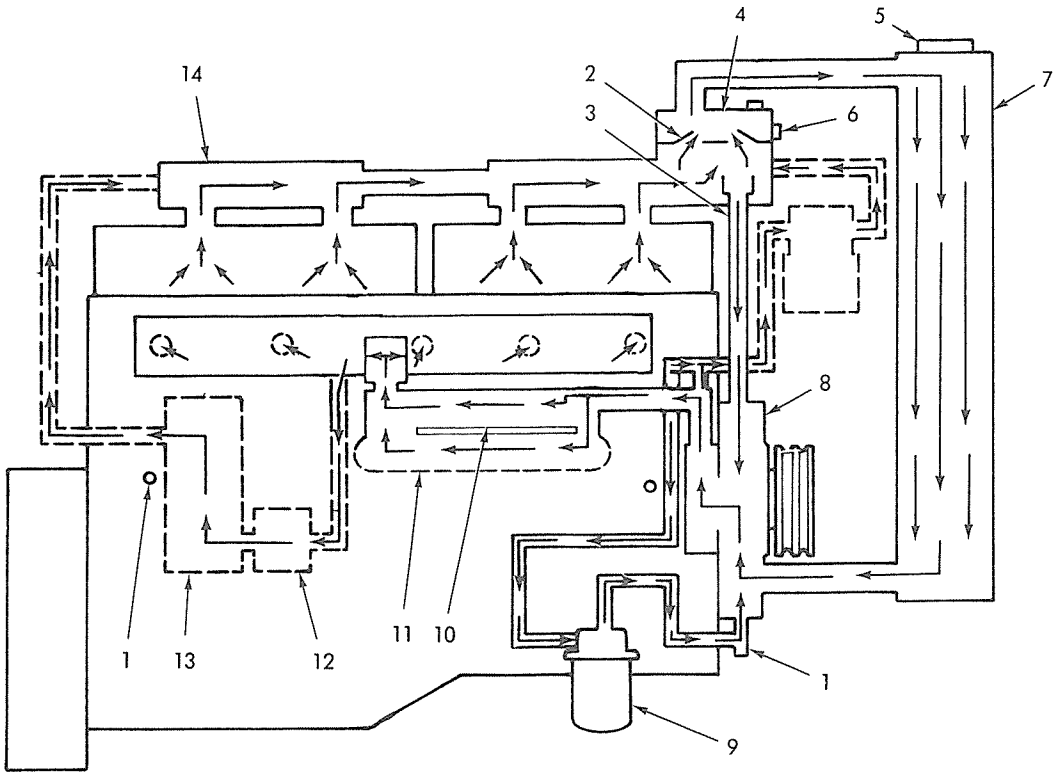


FIG. 1A COOLANT FLOW SCHEMATIC

1. Drain cock
2. Thermostat
3. Bypass pipe
4. Thermostat housing cover
5. Pressure cap (7 psi) (0.49 kg/cm^2)
6. Vent cocks
7. Radiator
8. Water pump
9. Coolant filter
10. Engine oil cooler
11. Torque converter fluid cooler
12. Immersion heater thermostat } Optional
13. Immersion heater } Optional
14. Water outlet manifold

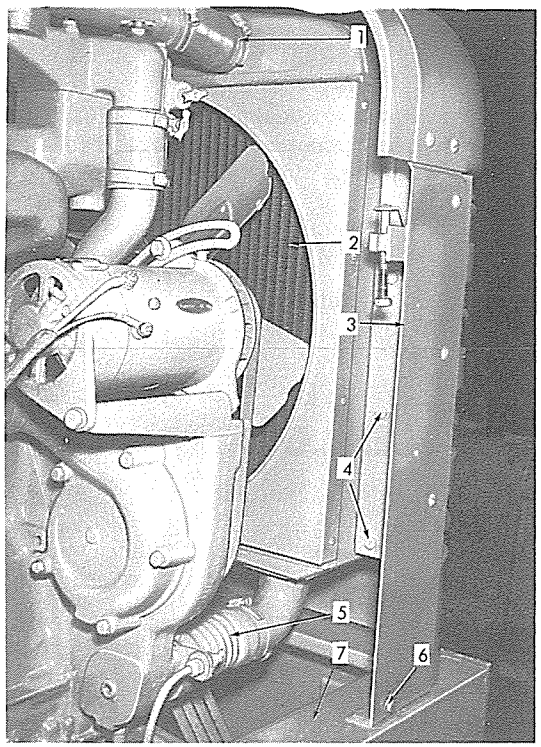


Fig. 2–Typical Radiator Mounting
(Motor Graders)
(T-71403)

1. Radiator Inlet Hose
2. Radiator
3. Radiator Grill
4. Capscrews
5. Radiator Outlet Hose
6. Capscrew
7. Main Frame

g. Complete installation of radiator and fill cooling system.

2. MOTOR GRADERS (Fig. 2)

a. Drain cooling system.

b. Remove engine hood.

c. Disconnect radiator inlet (1) and outlet (5) hoses.

d. Remove capscrews (6) attaching radiator grill (3) to grader main frame (7) and remove radiator and radiator grill as an assembly.

e. Remove capscrews (4) and plain washers attaching radiator (2) to radiator grill (3) and remove radiator.

f. Install radiator in radiator grill and install radiator grill and radiator on grader, as an assembly, by direct reversal of removal procedure.

g. Fill cooling system.

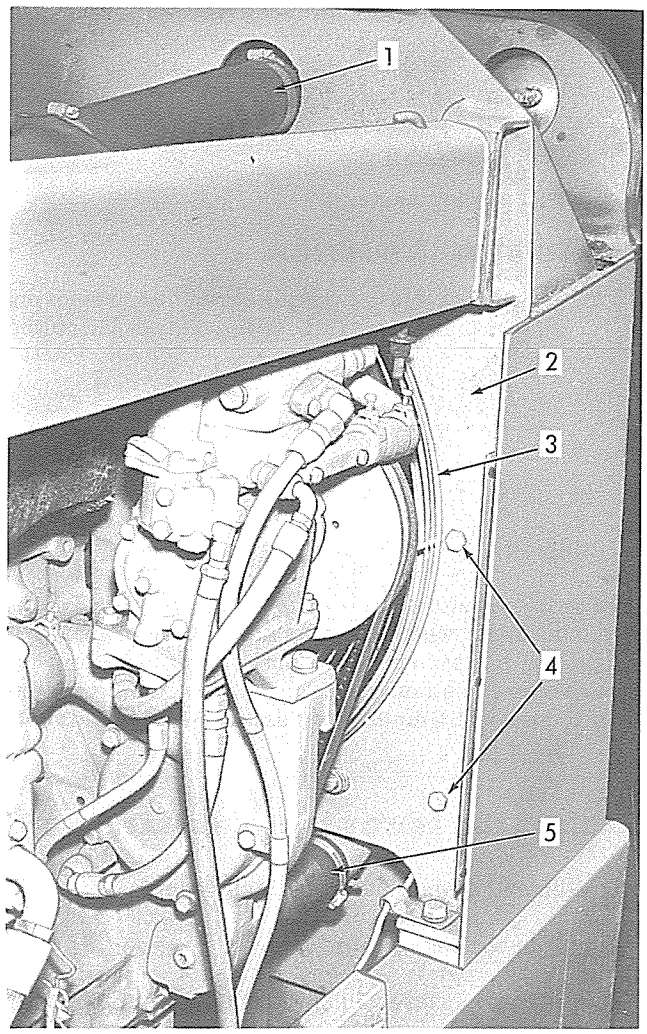


Fig. 3–Typical Radiator Mounting
(Tractor Loaders and Tractor Dozers)
(T-71404)

1. Radiator Inlet Hose
2. Radiator Support
3. Fan Guard
4. Capscrews
5. Radiator Outlet Hose

3. TRACTOR LOADERS AND TRACTOR DOZERS (Fig. 3)

a. Drain cooling system.

b. Remove the engine hood and side plates.

c. Disconnect radiator inlet (1) and outlet (5) hoses.

d. Remove fan guard (3).

e. Remove capscrews (4), nuts, plain washers, and rubber washers attaching radiator to radiator support (2).

f. Using a suitable hoist, remove the radiator.

g. Install radiator by a direct reversal of removal procedure. When installing the radiator attaching capscrews, place one rubber washer between the radiator and radiator support. Place the other rubber washer under the plain washer and then install the nut.

h. Fill cooling system.

C. RADIATOR INSPECTION

1. Thoroughly clean exterior of radiator, removing all foreign material from between cooling cores and fins. Be careful not to bend fins; straighten any that are bent.

2. Test radiator for leaks. Cover inlet and outlet opening and immerse in water. Test using no more than 10 psi internal air pressure.

IMPORTANT

Do not paint radiator core as this decreases cooling efficiency.

TOPIC 3 - RADIATOR (12G CRAWLER LOADER)

A. GENERAL

The twin radiators used on the 12G Crawler Loader are one piece welded assemblies. Each radiator is supported by two rubber snubbers at the bottom and a rubber enclosed mount at the top. The cooling system is filled through a mutual expansion tank mounted above the radiators.

B. RADIATOR REMOVAL AND INSTALLATION

1. Remove radiator grill and top cover.

2. Drain cooling system.

3. Remove capscrews holding radiators into rubber snubbers.

4. Unbolt lower radiator elbows from radiators.

5. Disconnect upper radiator hoses.

6. Remove two capscrews attaching each upper radiator mounting bracket to radiator support. Remove radiators.

7. Install by direct reversal of removal procedure.

CAUTION

Make certain correct length capscrews are used to prevent interference between radiator and guard.

C. RADIATOR INSPECTION

1. Thoroughly clean exterior of radiator, removing all foreign material from between cooling cores and fins. Be careful not to bend fins; straighten any that are bent.

2. Test radiator for leaks. Cover inlet and outlet openings and immerse in water. Test using no more than 10 psi internal air pressure.

IMPORTANT

Do not paint radiator core as this decreases cooling efficiency.

TOPIC 4 - FAN, FAN BELTS, FAN HUB, FAN BELT TIGHTENER, AND FAN DRIVE (EXCEPT 12G CRAWLER LOADER)

A. DESCRIPTION

The engine may be equipped with either a pusher type or suction type fan depending upon the engine application.

NOTE

(A reversible fan is available as special equipment for most models.)

The fan pushes or pulls air through the radiator and helps cool the engine coolant as it passes through the radiator core. The fan is bolted to the fan hub which is mounted on a bracket bolted to the front end of the engine. The fan hub on track type tractors is driven from the fan drive pulley by V-belts. The fan hub on motor graders, tractor loaders, and tractor dozers is driven from the crankshaft pulley by V-belts.

B. FAN BELT ADJUSTMENT

1. TRACK-TYPE TRACTORS (Fig. 4)

The fan belts (6) are properly adjusted when they can be pressed inward by hand approximately 3/8" to 1/2" at a point half way between the fan hub (2) and fan drive pulley (4). To adjust belts, loosen jam nut

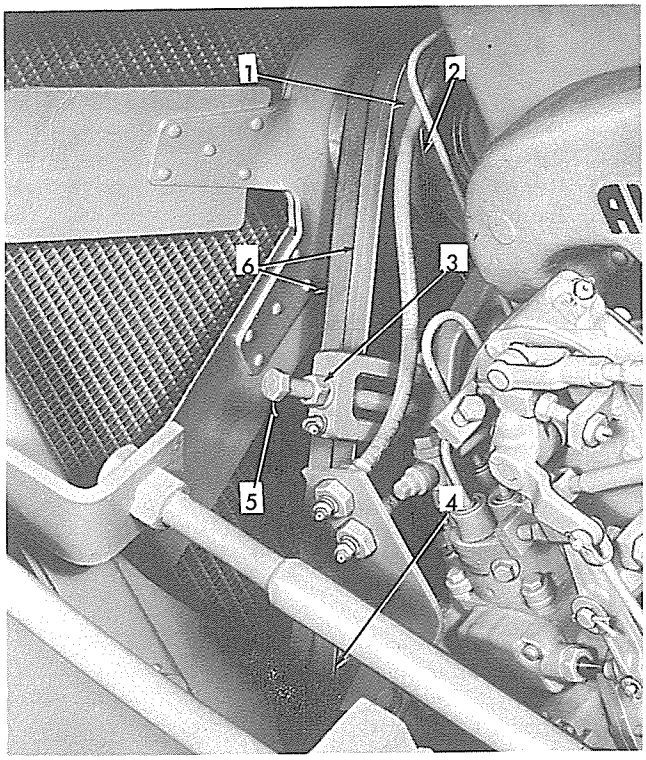


Fig. 4—Fan Belt Adjustment Location
(Track-Type Tractors)
(T-28898)

1. Water Pump and Generator Drive Belt
2. Fan Hub
3. Jam Nut
4. Fan Drive Pulley
5. Fan Belt Adjustment Screw
6. Fan Drive Belts

(3) and turn adjustment screw (5) in or out as necessary to obtain proper tension on the belts, then tighten jam nut (3).

2. MOTOR GRADERS (Fig. 5)

The fan belts (6) are properly adjusted when the straight side of the belts can be pressed inward by hand approximately 3/4" at a point halfway between the fan hub (1) and the crankshaft pulley. To adjust belts, loosen locking clamp capscrew (5) and jam nut (3). Turn adjustment screw (2) in or out as necessary to obtain proper tension on the belts, then tighten jam nut (3) and capscrew (5).

3. TRACTOR LOADERS AND TRACTOR DOZERS (Fig. 6)

The fan belts are properly adjusted when they can be pressed inward by hand approximately 1/2" to 3/4" at a point halfway between the fan hub and the crankshaft pulley. To adjust belts, loosen fan spindle locknut (2). Turn adjustment screw (1) in or out as necessary to obtain proper tension on the belts, then tighten locknut (2).

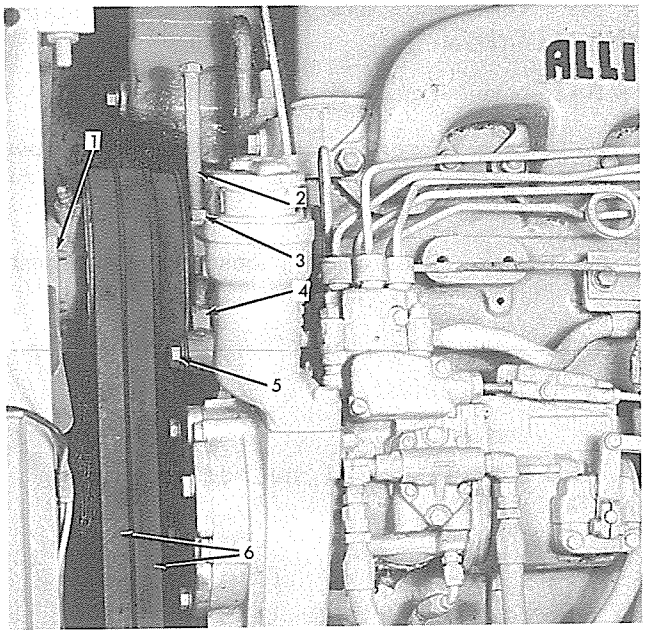


Fig. 5—Fan Belt Adjustment Location
(Motor Graders)
(T-36914)

1. Fan Hub
2. Fan Belt Adjustment Screw
3. Jam Nut
4. Fan Belt Tightener
5. Locking Clamp Capscrew
6. Fan Drive Belts

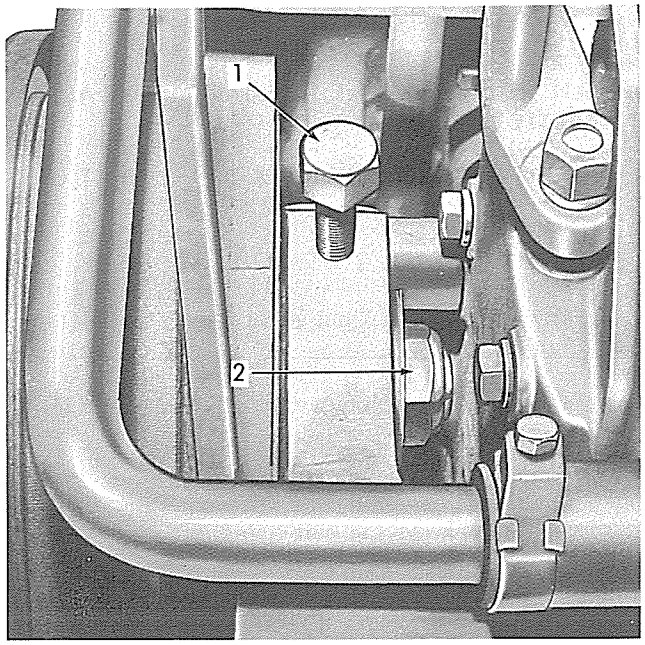


Fig. 6—Fan Belt Adjustment Location
(Tractor Loaders and Tractor Dozers)
(T-28855)

1. Fan Belt Adjustment Screw
2. Fan Spindle Locknut

C. FAN REMOVAL, INSPECTION, AND INSTALLATION

1. Remove fan guard if so equipped.

2. Remove capscrews attaching fan to fan hub and remove fan. Remove fan spacer if so equipped.

3. Inspect fan for cracks, loose rivets, or bent blades. Repair or replace if necessary.

4. Install fan by direct reversal of removal procedure.

D. FAN BELT REMOVAL, INSPECTION, AND INSTALLATION

1. Remove fan.

2. Relieve tension on fan belts until belts can be slipped off of pulleys. Remove fan belts.

3. Inspect fan belts for excessive slickness, oil-soak, wear, tears, cracks and overstretching. The fan belts are a matched pair. If only one belt replacement is required, both belts must be replaced to assure satisfactory belt performance.

4. Install fan belts by slipping belts into proper grooves in pulley and adjusting belts to proper tension.

5. Install fan.

E. FAN HUB REMOVAL, DISASSEMBLY, AND INSPECTION

1. FAN HUB REMOVAL (TRACK-TYPE TRACTORS) Fig. 7

   a. Remove fan (1).

   b. Remove fan belts and generator drive belt from fan hub.

   c. Disconnect and remove lubricating hose (24).

   d. Remove nut and lockwasher attaching fan belt tightener assembly to fan mounting bracket (3) and remove fan belt tightener.

   e. Remove capscrews attaching fan mounting bracket (3) to cylinder block and remove bracket and fan hub assembly (8) as a unit.

   f. Remove roll pin (6), slotted nut (7), and washer (5). Remove pipe nipple (4).

   g. Pull fan hub assembly (8) from mounting bracket (3).

2. FAN HUB REMOVAL (MOTOR GRADERS, TRACTOR LOADERS, AND TRACTOR DOZERS) Fig. 8

   a. Remove fan (1) and fan spacer (2) if so equipped.

   b. Remove fan belts and generator drive belt from fan hub.

   c. Remove roll pin (6), slotted nut (7), and washer (5).

   NOTE

   On later model engines a flanged nut is used in place of the slotted nut (7) and the roll pin (6) is not used.

   d. Remove adjustment screw (4) and pull fan hub assembly (8) from bracket (3). Remove washer (24) from spindle (23).

3. FAN HUB DISASSEMBLY AND INSPECTION (Fig. 7 or 8)

The internal parts of the fan hub assemblies, Figs. 7 and 8, are identical and the following disassembly procedure applies to both:

   a. Remove snap ring (9) and hub cap (10).

   b. Remove lockwire (22) and turn retainer (21) out of fan hub (11). Remove sealing washer (20), retaining washer (19), and gasket (18) from fan hub.

   c. Place fan hub assembly in a press, fan end up. Press on fan end of spindle (23) and remove spindle and bearings (14) (17) from hub (11).

   d. Remove cotter pin (13) and nut (12) and press spindle (23) from bearings (14) (17).

   e. Wash all parts thoroughly in clean solvent or fuel and inspect parts for wear or damage. Rotate ball bearings by hand and check for looseness, roughness, and binding. Inspect spindle and make certain it is not bent or worn and that the threads are not damaged. Inspect fan hub for wear and make certain that pulley grooves are smooth and that pulley is not chipped or cracked. Discard sealing washer (20) and retaining washer gasket (18). Inspect generator drive belt and fan drive belts. Replace if they are worn or frayed.

F. FAN HUB ASSEMBLY AND INSTALLATION

1. FAN HUB ASSEMBLY (Fig. 7 or 8)

The internal parts of the fan hub assemblies, Figs. 7

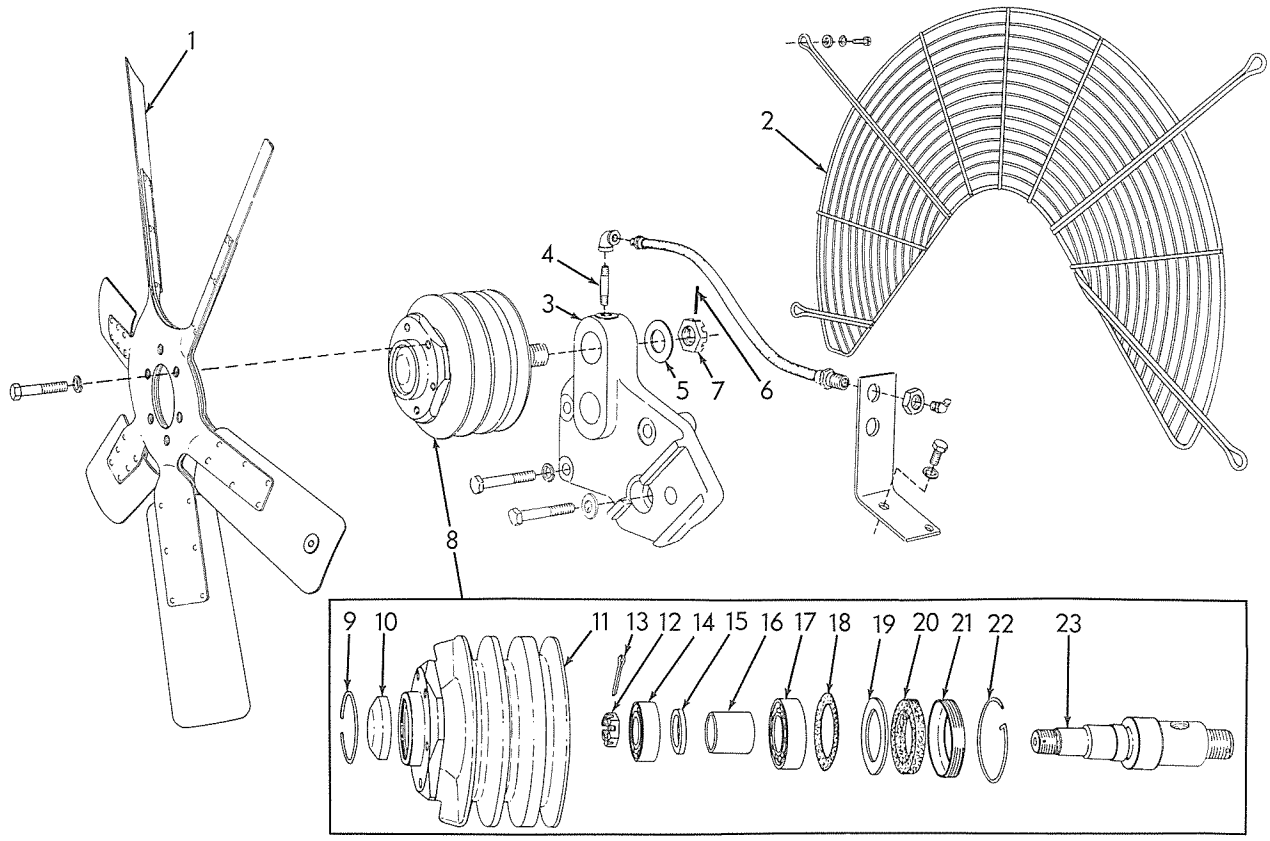


Fig. 7—Fan Hub Details (Track-Type Tractors)
(T-41843)

1. Fan
2. Fan Guard (Special Equipment Some Models)
3. Fan Mounting Bracket
4. Pipe Nipple
5. Plain Washer
6. Roll Pin
7. Slotted Nut
8. Fan Hub Assembly
9. Snap Ring
10. Hub Cap
11. Fan Hub
12. Spindle Nut
13. Cotter Pin
14. Front Ball Bearing
15. Spacing Washer
16. Bearing Spacer
17. Rear Ball Bearing
18. Retaining Washer Gasket
19. Bearing Retaining Washer
20. Spindle Sealing Washer (Cork)
21. Sealing Washer Retainer
22. Fan Hub Lockwire
23. Spindle
24. Lubricating Hose

and 8, are identical and the following assembly procedure applies to both:

a. Press rear ball bearing (17) onto spindle (23). Place bearing spacer (16) and washer (15) in position and press front ball bearing (21) onto spindle.

b. Install spindle nut (12), tighten securely, and install cotter pin (13).

c. Place fan hub (11) in a press, fan end down. Start spindle (23), with bearings, into position in fan hub. Pack area between bearings half full with clean ball and roller bearing lubricant. Press spindle into position in fan hub.

d. Install a new gasket (18) and washer (19) on spindle. Install a new sealing washer (20) in retainer (21) and turn retainer into fan hub (11) until hole in retainer is aligned with hole in fan hub, then install lockwire (22).

e. Install hub cap (10) so that cap is flush to 1/32" below fan hub surface, then install snap ring (9).

2. FAN HUB INSTALLATION (TRACK-TYPE TRACTORS) Fig. 7

a. Place fan hub assembly (8) in position in bracket (3). Install pipe nipple (4) in tapped hole in fan spindle (23).

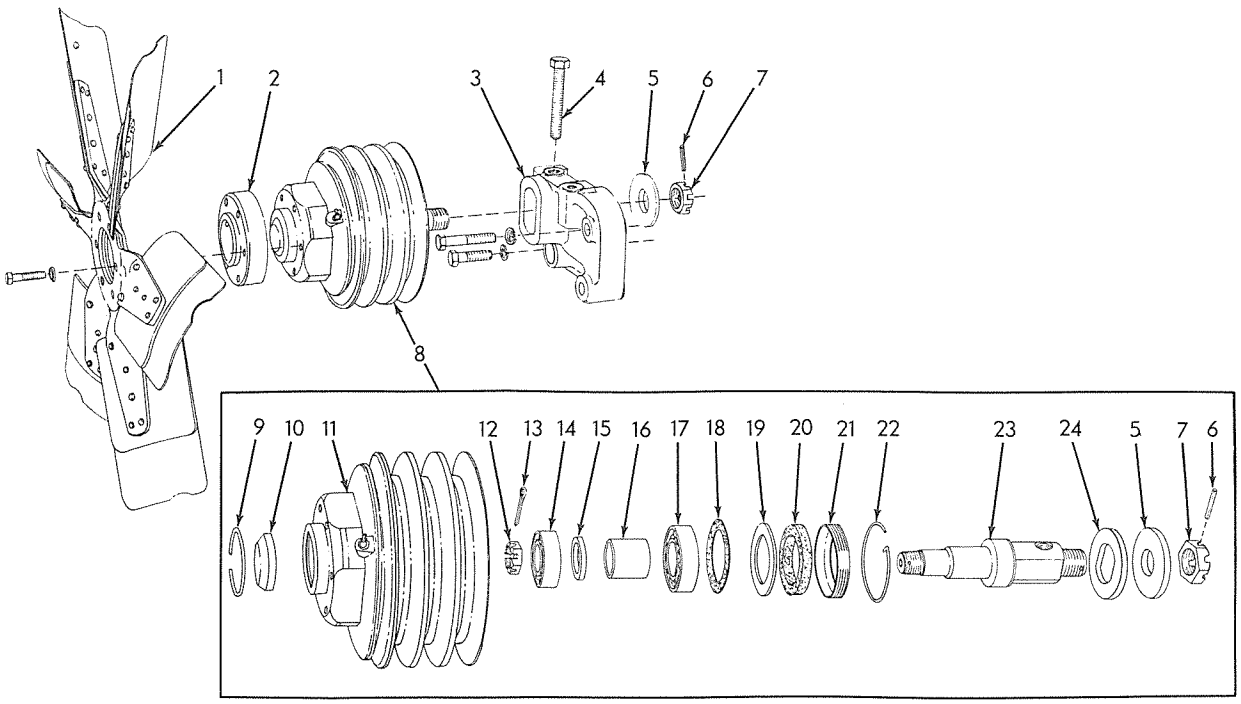


Fig. 8—Fan Hub Details (Motor Graders, Tractor Loaders, and Tractor Dozers)
(T-14061)

1. Fan
2. Fan Spacer (For Use With Suction Fan Only)
3. Fan Mounting Bracket
4. Adjustment Screw
5. Plain Washer
6. Roll Pin
7. Slotted Nut
8. Fan Hub Assembly
9. Snap Ring
10. Hub Cap
11. Fan Hub
12. Spindle Nut
13. Cotter Pin
14. Front Ball Bearing
15. Spacing Washer
16. Bearing Spacer
17. Rear Ball Bearing
18. Retaining Washer Gasket
19. Bearing Retainer Washer
20. Spindle Sealing Washer (Cork)
21. Sealing Washer Retainer
22. Fan Hub Lockwire
23. Spindle
24. Front Spindle Washer

b. Install plain washer (5) and nut (7) on spindle (23). Tighten nut securely and install roll pin (6).

c. Install fan mounting bracket (3) in position on cylinder block and secure with capscrews and lockwashers.

d. Install fan belt tightener assembly on fan mounting bracket.

e. Install and adjust fan belts and generator drive belt.

f. Install and connect lubricating hose (24).

g. Install fan (1).

h. Lubricate fan hub and fan belt tightener at lube fittings.

3. FAN HUB INSTALLATION (MOTOR GRADERS, TRACTOR LOADERS, AND TRACTOR DOZERS) Fig. 8

a. Place washer (24) on spindle (23) and install fan hub assembly (8) in position in bracket (3).

b. Install adjustment screw (4), washer (5), and slotted nut (7), but do not tighten nut at this time.

c. Install and adjust fan belts and generator drive belt, then tighten slotted nut (7) securely and lock with roll pin (6).

NOTE

On later model engines a flanged nut is used in place of the slotted nut (7) and the roll pin (6) is not used.

d. Install fan (1) and fan spacer (2) if so equipped.

G. FAN BELT TIGHTENER REMOVAL, DISASSEMBLY, AND INSPECTION

1. FAN BELT TIGHTENER REMOVAL, DISASSEMBLY, AND INSPECTION (TRACK-TYPE TRACTORS) Fig. 9

   a. Loosen tension on fan belts.

   b. Remove nut (15) and lockwasher (14) from slide clamping bolt (10) and remove fan belt tightener from fan mounting bracket.

   c. Remove pulley cover (3) and gasket (4).

   d. Remove front snap ring (6).

   e. Place tightener assembly in a press, pulley side up, and press fan belt tightener slide (16) from pulley (5).

   f. Remove oil seal (9) and rear snap ring (8) and drive or press ball bearing (7) from pulley (5).

   g. Wash all parts thoroughly in clean solvent or fuel and inspect parts for wear or damage. Rotate ball bearing by hand and check for looseness, roughness, and binding. Replace if necessary. The bearing must fit snugly in pulley and on slide shaft. Inspect the fan belt slide tightener and make certain it is in good condition and that the grease passage is clean. Make certain that grooves in pulley are smooth and that pulley is not chipped or cracked. Replace fan drive belts if they are worn or frayed.

2. FAN BELT TIGHTENER REMOVAL, DISASSEMBLY, AND INSPECTION (MOTOR GRADERS) Fig. 10

   a. Remove the fan hub.

   b. Remove locking clamp capscrew (17), lockwasher (16), and locking clamp (15).

   c. Pull fan belt tightener assembly from fan mounting bracket (12).

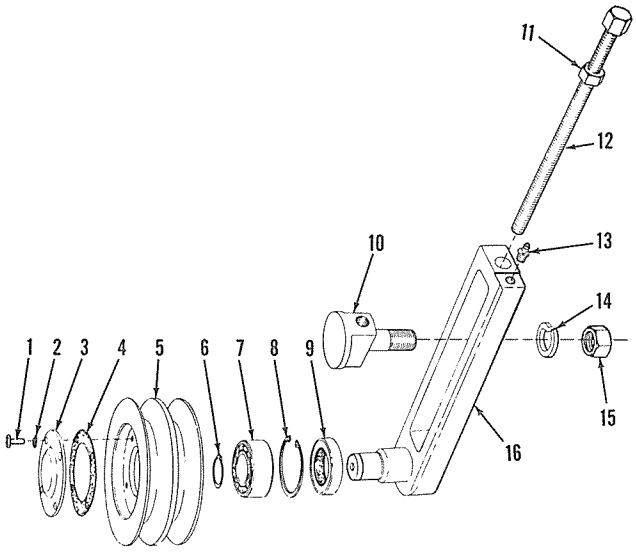


Fig. 9—Fan Belt Tightener Details
(Track-Type Tractors)
(T-70421)

1. Capscrew
2. Lockwasher
3. Pulley Cover
4. Gasket
5. Pulley
6. Front Snap Ring
7. Ball Bearing
8. Rear Snap Ring
9. Oil Seal
10. Slide Clamp Bolt
11. Jam Nut
12. Fan Belt Adjustment Screw
13. Lubricating Fitting
14. Lockwasher
15. Nut
16. Fan Belt Tightener Slide

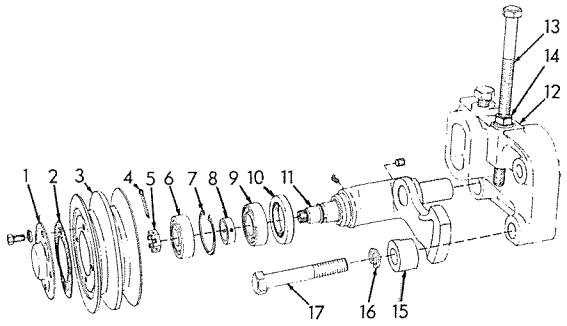


Fig. 10 — Fan Belt Tightener Details
(Motor Graders)
(T-14062)

1. Pulley Cover
2. Gasket
3. Pulley
4. Cotter Pin
5. Slotted Nut
6. Front Ball Bearing
7. Snap Ring
8. Bearing Spacer
9. Rear Ball Bearing
10. Oil Seal
11. Lever Assembly
12. Fan Mounting Bracket
13. Fan Belt Adjustment Screw
14. Jam Nut
15. Locking Clamp
16. Lockwasher
17. Locking Clamp Capscrew

d. Remove pulley cover (1) and gasket (2).

e. Place tightener assembly in a press, pulley end up. Press on front end of lever assembly (11) and press lever out of pulley (3).

f. Drive or press front ball bearing (6) from pulley (3). Remove snap ring (7) and bearing spacer (8).

g. Drive or press rear ball bearing (9) and oil seal (10) from pulley (3).

h. Wash all parts thoroughly in clean solvent or fuel and inspect parts for wear or damage. Rotate ball bearings by hand and check for looseness, roughness, and binding. Replace if necessary. The bearings must fit snugly in pulley and on lever assembly. Inspect the lever assembly and make certain it is in good condition and that the grease passage is clean. Make certain that grooves in pulley are smooth and that pulley is not chipped or cracked. Replace fan drive belts if they are worn or frayed.

H. FAN BELT TIGHTENER ASSEMBLY AND INSTALLATION

1. FAN BELT TIGHTENER ASSEMBLY AND INSTALLATION (TRACK-TYPE TRACTORS) Fig. 9

a. Press ball bearing (7) into pulley (5) so that it is tight against counterbore in pulley.

b. Install rear snap ring (8) and oil seal (9) with sealing lip of seal directed toward rear of pulley.

c. Drive or press tightener slide shaft into position in pulley. Install front snap ring (6).

d. Install gasket (4) and pulley cover (3).

e. Install fan belt tightener on fan mounting bracket. Install and adjust fan belts.

f. Lubricate fan belt tightener, through lubricating fitting (13), using clean ball and roller bearing lubricant.

2. FAN BELT TIGHTENER ASSEMBLY AND INSTALLATION (MOTOR GRADERS) Fig. 10

a. Install snap ring (7) in pulley (3).

b. Press rear ball bearing (9) into pulley (3) until rear face of bearing is below counterbore for oil seal.

c. Press oil seal (10) into pulley (3) with sealing lip of seal directed toward rear of pulley.

d. Place pulley (3) in a press, front end up. Center bearing spacer (8) on inner race of rear ball bearing (9) and press front ball bearing (6) into position in pulley.

e. Turn pulley assembly over and place a suitable sleeve between inner race of front ball bearing (6) and bed plate of the press, then press lever assembly (11) into position in pulley assembly.

f. Install slotted nut (5) and tighten securely, then install cotter pin (4).

g. Install cover gasket (2) and pulley cover (1). Fill tightener with clean ball and roller bearing lubricant through lubricating fitting.

h. Install fan belt tightener on fan mounting bracket, install fan hub and adjust fan and generator drive belts.

I. FAN DRIVE REMOVAL, DISASSEMBLY AND INSPECTION (TRACK-TYPE TRACTOR ENGINES W/AMERICAN BOSCH FUEL INJECTION PUMP)

1. FAN DRIVE REMOVAL (Fig. 11)

IMPORTANT

Before attempting to remove the fan drive, remove the timing window cover from the fuel injection pump and turn the engine by hand until the marked tooth on the plunger drive gear is aligned with the timing mark.

a. Loosen tension on fan belts and remove them from fan drive pulley Fig. 4 (4).

b. Remove capscrews, Fig. 11 (17) and lockwashers (16) and remove pulley (2) from mounting flange (3).

c. Remove capscrews (15) and lockwashers (14) and remove fan drive assembly from timing gear housing cover.

2. FAN DRIVE DISASSEMBLY AND INSPECTION (Fig. 11)

a. Remove retaining nut (1) and drive timing shaft (13) from fan drive gear (11).

b. Using suitable puller tools, remove pulley mounting flange (3). Remove woodruff key (10).

c. Remove flange (5) from bearing retainer (8).

d. Press fan drive gear (11) from bearing retainer (8).

e. Drive or press roller bearing (7) from bearing retainer (8).

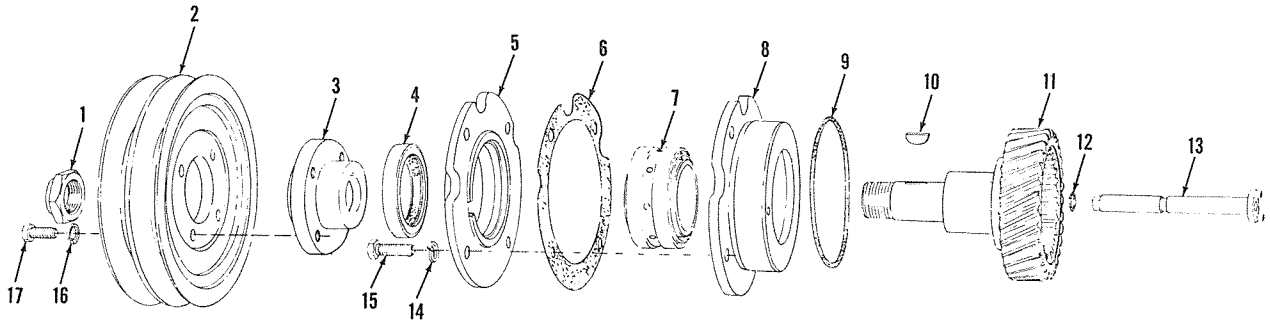


Fig. 11 — Fan Drive Details (Track-Type Tractor Engines w/American Bosch Fuel Injection Pump) (T-70422)

1. Flange Retaining Nut
2. Fan Drive Pulley
3. Pulley Mounting Flange
4. Oil Seal
5. Seal Retaining Flange
6. Gasket
7. Roller Bearing
8. Bearing Retainer
9. O-Ring
10. Woodruff Key
11. Fan Drive Gear
12. O-Ring
13. Fuel Injection Pump Timing Shaft
14. Lockwasher
15. Capscrew
16. Lockwasher
17. Capscrew

f. Remove oil seal (4) from seal retaining flange (5).

g. Wash all parts in clean solvent or fuel and inspect for wear or damage. Rotate bearing by hand and check for looseness, roughness, and binding. Inspect interior and exterior teeth of fan drive gear for cracks or wear. Inspect bore in bearing retainer for signs of wear. Replace any worn or damaged parts.

J. FAN DRIVE ASSEMBLY AND INSTALLATION (TRACK-TYPE TRACTOR ENGINES W/AMERICAN BOSCH FUEL INJECTION PUMP)

1. FAN DRIVE ASSEMBLY (Fig. 11)

a. Press roller bearing (7) into bearing retainer (8) until it bottoms in counterbore.

b. Lubricate bearing, and press fan drive gear (11) into position in bearing.

c. Install a new oil seal (4) in seal retaining flange (5), with coil spring side of seal facing bearing.

d. Using a new gasket (6), place flange (5) in position on bearing retainer (8).

e. Install woodruff key (10) and pulley mounting flange (3). Install retaining nut (1), tighten securely, and lock nut in position by staking.

2. FAN DRIVE INSTALLATION (Fig. 11)

a. Install a new O-ring (12) on timing shaft (13) and drive shaft into position in fan drive gear (11). Install coil spring in end of timing shaft.

b. Install a new O-ring (9) on bearing retainer (8).

c. Remove timing access cover from timing gear housing.

d. Start fan drive gear into mesh with camshaft gear. Just before fuel injection pump drive gear enters internal teeth of fan drive gear, align marked tooth in fuel injection pump with timing mark, using a wrench on one of the pump drive gear attaching capscrews and working through the timing access hole. Hold the pump in this position and push fan drive into position on timing gear housing cover.

NOTE

Due to the helical teeth of the fan drive gear, the fan drive will rotate slightly to the left as it is installed. This may cause the marked tooth in fuel injection pump to move off the timing mark. In this case, remove the fan drive and reinstall with the fan drive gear moved one tooth to the right. This is a trial and error method and must be repeated until the marked tooth is aligned with the timing pointer when the fan drive is installed.

e. Secure the fan drive to the timing gear housing cover with capscrews (15) and lockwashers (14).

f. Install pulley (2) on fan mounting flange (3) with capscrews (17) and lockwashers (16).

g. Install and adjust fan belts.

h. Check timing of fuel injection pump (refer to "FUEL SYSTEM" Section). Install timing window cover on fuel injection pump. Install timing access cover on timing gear housing.

K. FAN DRIVE REMOVAL, DISASSEMBLY AND INSPECTION (CRAWLER TRACTOR ENGINES w/ROOSA MASTER OR BOSCH (GERMANY) FUEL INJECTION PUMP)

1. FAN DRIVE REMOVAL (Fig. 11A)

   a. Loosen tension on fan belts and remove them from fan drive pulley.

   b. Remove capscrews (1) and lockwashers attaching pulley (2) to pulley mounting flange (3) and remove pulley.

   c. Remove capscrews (4) and lockwashers attaching fan drive bearing retainer (5) to timing gear housing cover and remove bearing retainer and O-ring (8).

2. FAN DRIVE DISASSEMBLY AND INSPECTION (Fig. 11A)

   a. Remove retaining nut (16).

   b. Using suitable puller tools, remove pulley mounting flange (3). Remove woodruff key (10).

   c. Press fan drive gear (9) from retainer (5). Bearing cone (11) and spacer (7) will be removed with the drive gear.

   d. Remove oil seal (15) and bearing cone (14) from retainer (5).

   e. If necessary, bearing cups (12) and (13) can be removed with suitable puller tools. The bearing is serviced only as a unit and if a new bearing is to be installed the old bearing spacer snap ring (6) must be removed and the new one (furnished with the bearing) installed in its place.

   f. Wash all parts in clean solvent or fuel and inspect for wear or damage. Rotate bearings by hand and check for looseness, roughness, and binding. Inspect teeth of fan drive gear for cracks or wear. Inspect bores in bearing retainer for signs of wear and make certain oil passages are open and clean. Replace any worn or damaged parts.

CAUTION

The bearing is serviced only as a unit and must be installed as such. Never intermix parts of a new bearing with parts from an old one.

L. FAN DRIVE ASSEMBLY AND INSTALLATION (CRAWLER TRACTOR ENGINES w/ROOSA MASTER OR BOSCH (GERMANY) FUEL INJECTION PUMP)

1. FAN DRIVE ASSEMBLY (Fig. 11A)

   a. Install bearing spacer snap ring (6) in groove in bore of bearing retainer (5).

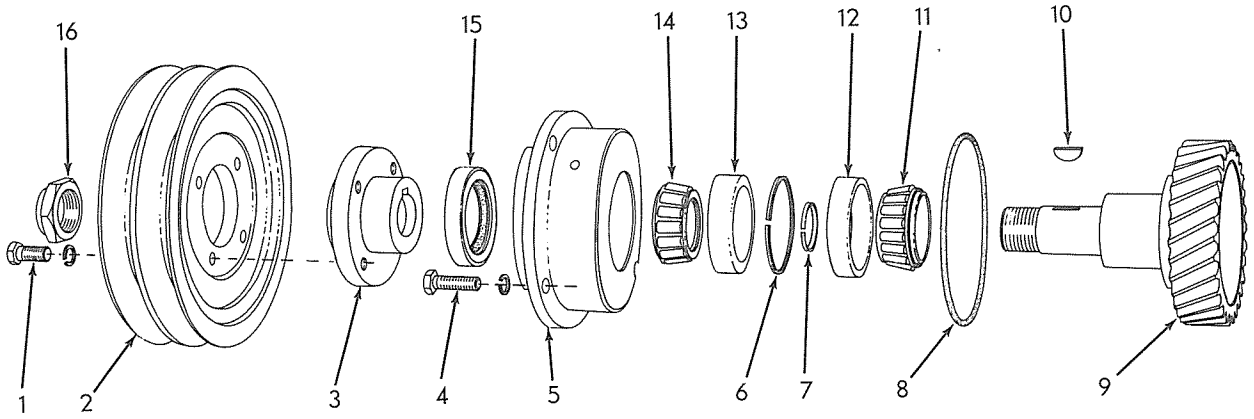


Fig. 11-A–Fan Drive Details (Crawler Tractor Engines w/Roosa Master or Bosch (Germany) Fuel Injection Pump) (T-72379)

1. Capscrew
2. Fan Drive Pulley
3. Pulley Mounting Flange
4. Capscrew
5. Bearing Retainer
6. Bearing Spacer Snap Ring
7. Bearing Spacer
8. O-Ring
9. Fan Drive Gear
10. Woodruff Key
11. Bearing Cone
12. Bearing Cup
13. Bearing Cup
14. Bearing Cone
15. Oil Seal
16. Flange Retaining Nut

b. Press bearing cups (12) and (13) into retainer (5) until they are tight against snap ring (6).

c. Press bearing cone (11) onto fan drive gear (9) until it is tight against shoulder on shaft.

d. Install bearing spacer (7) on shaft next to bearing cone (11).

e. Install fan drive gear (9) in bearing retainer (5).

f. Press bearing cone (14) onto shaft until it is tight against spacer (7).

g. Lubricate bearings and install a new oil seal (15).

h. Install woodruff key (10) and pulley mounting flange (3) on shaft.

i. Install flange retaining nut and tighten to a torque of 200 - 220 lbs. ft. Lock nut by peening.

2. FAN DRIVE INSTALLATION (Fig. 11A)

a. Install O-ring (8) on bearing retainer and place fan drive assembly in position on timing gear housing cover. Secure with capscrews and lockwashers.

b. Place fan drive pulley (2) in position on mounting flange (3) and secure with capscrews and lockwashers.

c. Install fan drive belts on pulley and adjust to proper tension (refer to "FAN BELT ADJUSTMENT" in this Section).

TOPIC 5 - FAN, FAN BELTS, AND FAN DRIVE (12G CRAWLER LOADER)

A. DESCRIPTION

The 12G Crawler Loader is equipped with twin pusher fans mounted at the rear of the tractor. (A reversible fan is available as special equipment). Each fan has its own fan hub and mounting bracket. The fans are driven by a single fan drive using a single set of 3 V-belts. The fan drive is driven by a drive shaft assembly which is driven by a special power take-off incorporated in the torque converter.

B. FAN BELT ADJUSTMENT

Belts are properly adjusted when they can be depressed 3/4" to 1" halfway between the fan drive assembly and left side fan pulley. Adjust fan drive belts as follows:

1. Remove seat assembly.

2. Remove cotter pin from drive assembly pivot capscrews; loosen slotted nut.

3. Loosen strap attaching capscrew and adjustment capscrew.

4. Pry or push fan drive assembly down to obtain proper tension.

5. Hold fan drive assembly in this position and tighten adjustment capscrew, strap attaching capscrew, and slotted nut on pivot capscrew. Secure slotted nut with cotter pin.

C. FAN REMOVAL, INSPECTION, AND INSTALLATION

1. Remove radiators (refer to "RADIATOR REMOVAL AND INSTALLATION" in this Section).

2. Remove capscrews attaching fan to fan hub and remove fan.

3. Inspect fan for cracks, loose rivets, or bent blades. Repair or replace if necessary.

4. Install fan by direct reversal of removal procedure.

D. FAN BELT REMOVAL, INSPECTION, AND INSTALLATION

1. Remove left radiator (refer to "RADIATOR REMOVAL AND INSTALLATION" in this Section).

2. Remove cotter pin from drive assembly pivot capscrew; loosen slotted nut.

3. Loosen strap attaching capscrew and adjustment capscrew.

4. Relieve tension on fan belts until belts can be slipped off of drive pulley. Remove fan belts.

5. Inspect fan belts for excessive slickness, oil-soak, wear, tears, cracks, and overstretching. The fan belts are a matched set. If only one or

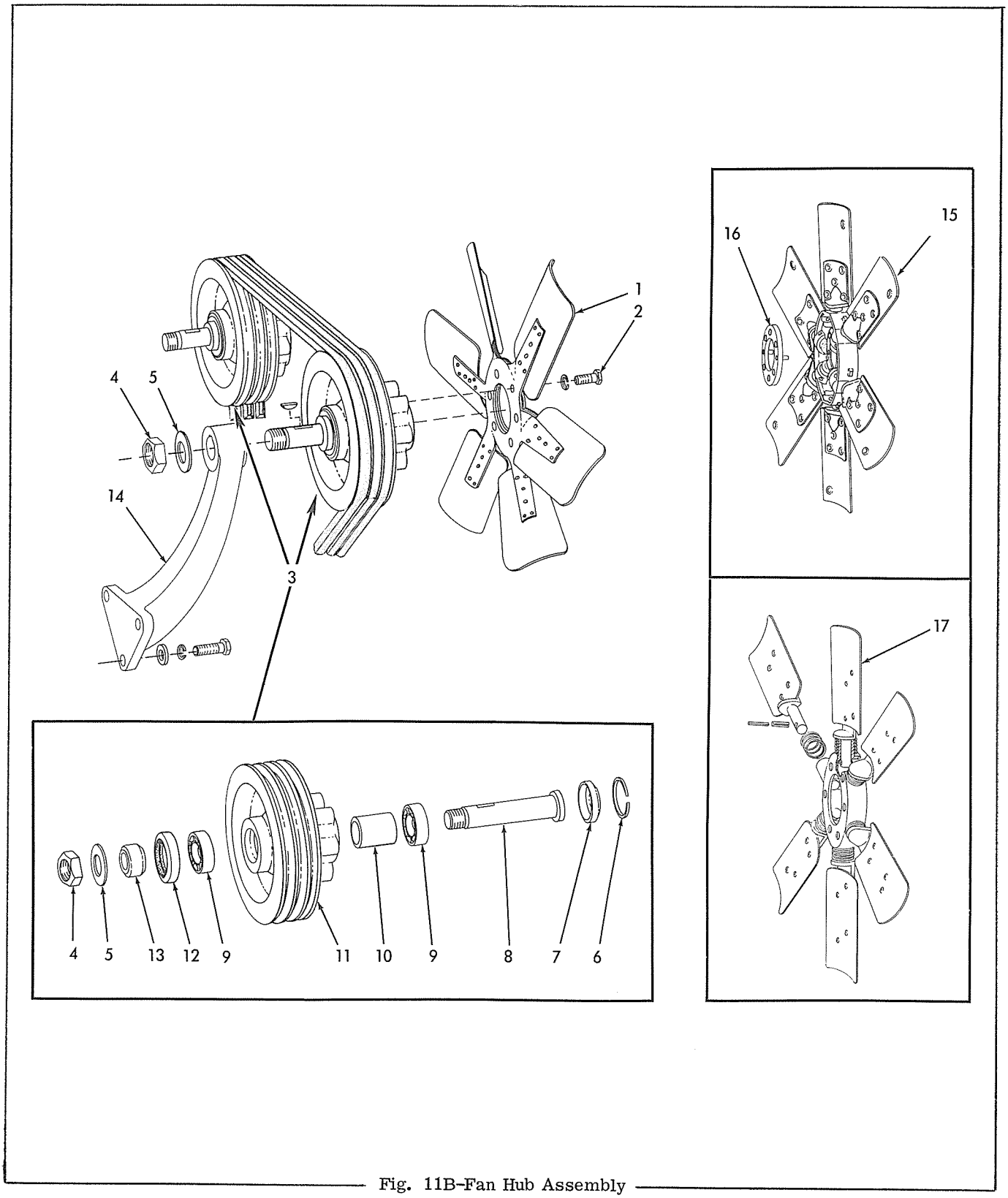


Fig. 11B–Fan Hub Assembly
(T-72824)

1. Fan
2. Capscrew
3. Fan Hub Assembly
4. Self Locking Nut
5. Plain Washer
6. Snap Ring
7. Pulley Cap
8. Shaft
9. Ball Bearing
10. Bearing Spacer
11. Pulley
12. Oil Seal
13. Mounting Spacer
14. Mounting Bracket
15. Reversible Fan (First Type)
16. Spacer (For First Type Rev. Fan)
17. Reversible Fan (Second Type)

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

two belts need replacing, all three must be replaced to assure satisfactory belt performance.

6. Install fan belts by slipping belts over the fans and into their proper pulley grooves.

7. Adjust fan belts to proper tension.

8. Install radiator (refer to "RADIATOR REMOVAL AND INSTALLATION" in this Section).

E. FAN HUB REMOVAL, DISASSEMBLY, INSPECTION, ASSEMBLY, AND INSTALLATION

1. Remove radiators (refer to "RADIATOR REMOVAL AND INSTALLATION" in this Section).

2. Remove capscrews attaching fan to fan hub and remove fan, Fig. 11B (1).

3. Relieve tension on fan belts until belts can be slipped off pulleys.

4. Remove self-locking nut (4) and washer (5).

5. Pull fan hub (3) from mounting bracket (14).

6. Remove woodruff key and mounting spacer (13) from shaft.

7. Remove snap ring (6) and pulley cap (7).

8. Place fan hub assembly in a press, fan end down. Press on threaded end of shaft (8) and remove fan end bearing (9) bearing spacer (10) and shaft.

9. Turn fan hub over and push out remaining bearing (9) and seal (12).

10. Remove bearing and bearing spacer from shaft.

11. Wash all parts thoroughly in clean solvent or fuel oil and inspect parts for wear or damage. Rotate ball bearings by hand and check for looseness, roughness and binding. Inspect shaft and make certain it is not bent or worn. Inspect fan pulley for wear and make certain that pulley grooves are smooth and that pulley is not chipped or cracked.

12. Press ball bearing (9) into pulley end of fan hub.

13. Press bearing (9) onto shaft.

14. Fill cavity inside fan hub 1/3 full with ball bearing lubricant. Press shaft, with spacer (10) in place, into fan hub.

15. Install oil seal (12) and spacer (13).

16. Install cap (7) so that cap is flush to 1/32" below fan hub surface, then install snap ring (6).

17. Place fan hub assembly into place in fan bracket (14) with woodruff key in keyway. Install plain washer (5) and nut (4). Torque nut to 250 - 280 lbs. ft.

18. Install fan belts and adjust to proper tension.

19. Attach fan to fan hub assembly.

20. Install radiators (refer to "RADIATOR REMOVAL AND INSTALLATION" in this Section).

F. FAN DRIVE REMOVAL, DISASSEMBLY, INSPECTION, ASSEMBLY, AND INSTALLATION (FIG. 11C)

1. Remove left radiator (refer to "RADIATOR REMOVAL AND INSTALLATION" in this Section).

2. Remove left fan from fan hub.

3. Loosen capscrew (15) and remove capscrew (16).

4. Remove cotter key (17) nut (18) and capscrew (2).

5. Lift fan drive assembly (1) off bracket and fan belts.

6. To remove fan drive shaft assembly (19), remove restricting angle (31) and left front floor plate.

7. Unbolt front end yoke (20) from coupling flange (27). Remove shaft assembly (19) rearward from tractor.

8. Remove nut (13) washer (12) and pulley (11) from shaft (3). Remove woodruff key and pulley spacer (10).

9. Place assembly, with threaded end of shaft up, in suitable press. Press out the shaft (3), seal (4) and spacer (6).

10. Remove bearing (5) from shaft (3).

11. Remove bearing (8) and seal (9) from housing (7).

12. Wash all parts in clean solvent or fuel oil and inspect for wear or damage. Rotate bearings by hand and check for looseness, roughness, and binding.

13. To reassemble fan drive assembly press bearing (5) onto shaft (3) until it bottoms against shoulder. Install shaft and bearing into housing (7) slip bearing spacer onto shaft and press bearing (8) into housing and onto shaft.

14. Install seals (4) (9) into housing so they are flush with ends of housing.

15. Install spacer (10), key, pulley, washer and nut. Torque nut to 250-280 lbs. ft.

16. Install fan drive and fan drive shaft assembly by a direct reversal of removal procedure.

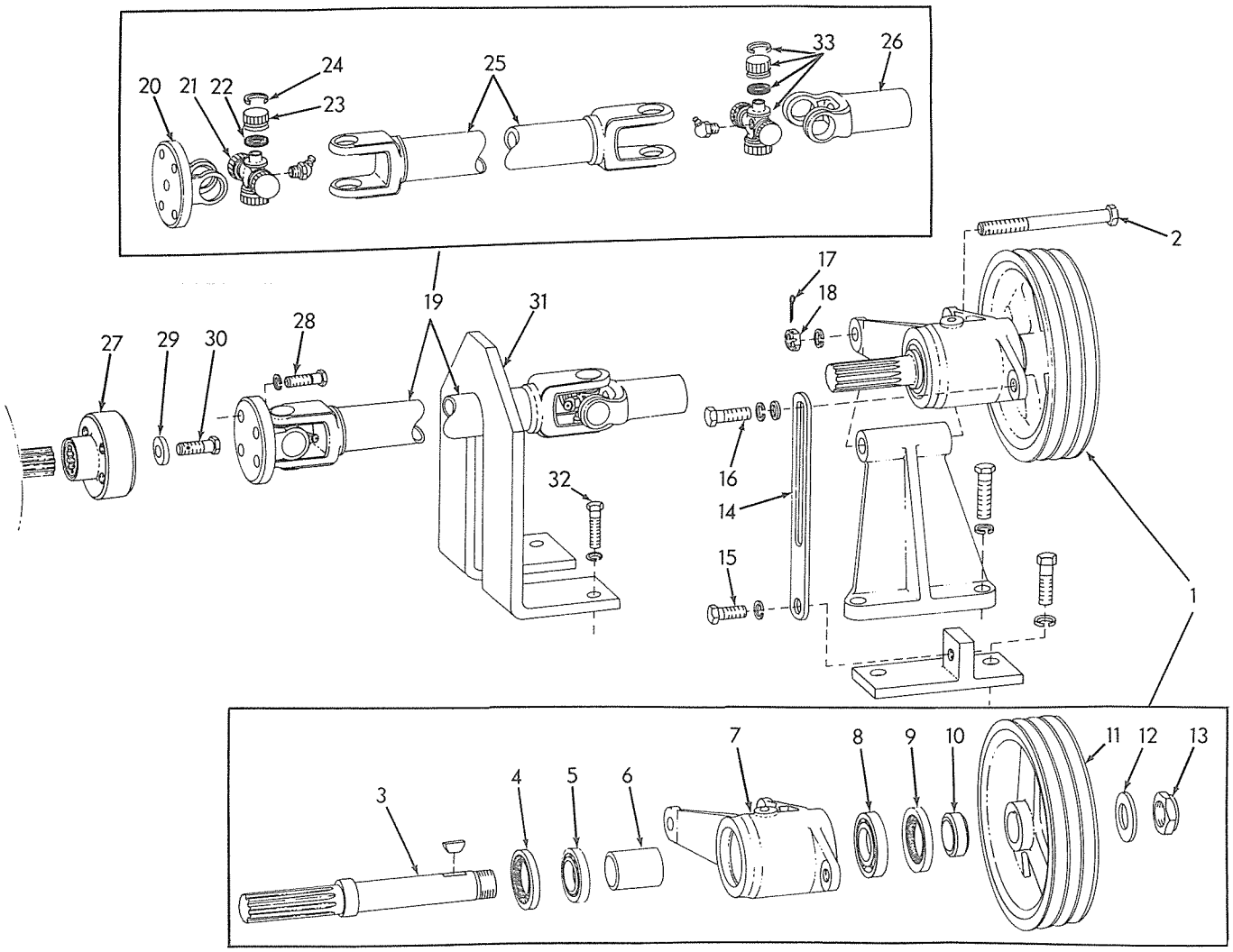


Fig. 11C—Fan Drive
(T-72823)

1. Drive Assembly
2. Capscrew
3. Shaft
4. Oil Seal
5. Ball Bearing
6. Bearing Spacer
7. Housing
8. Ball Bearing
9. Oil Seal
10. Pulley Spacer
11. Pulley
12. Plain Washer
13. Self-locking Nut
14. Strap
15. Capscrew
16. Capscrew
17. Cotter Pin
18. Slotted Nut
19. Shaft Assembly
20. Yoke
21. Spider
22. Sealing Washer
23. Needle Bearing
24. Snap Ring
25. Tube
26. Yoke
27. Coupling Flange
28. Capscrew
29. Washer
30. Nylok Capscrew
31. Restricting Angle
32. Capscrew
33. Spider Kit

TOPIC 6 - THERMOSTATS

A. GENERAL

The two thermostats, located at the front of the water outlet manifold, are so positioned that when they are closed, the flow of coolant from the engine water outlet manifold to the radiator is completely shut off. The flow of coolant is then directed from the water outlet manifold through the water bypass tube and back to the inlet side of the water pump.

Before the thermostats open, the coolant circulates through the engine circulating system only. When the thermostats open, the coolant circulates through the radiator and the engine circulating system.

The thermostats are of the by-pass type. Both thermostats have an opening temperature rate of 180°F. It does not make any difference in their operation which thermostat is placed in the front or rear openings in the water outlet manifold. The thermostats are designed to start opening at 180°F. and to be fully opened at 195°F.

Replacement of the thermostats is necessary when the thermostats become corroded, sticking in the open or closed position. If the engine overheats or does not reach and maintain a minimum temperature of 180°F., the thermostats should be removed and tested as a possible cause of trouble.

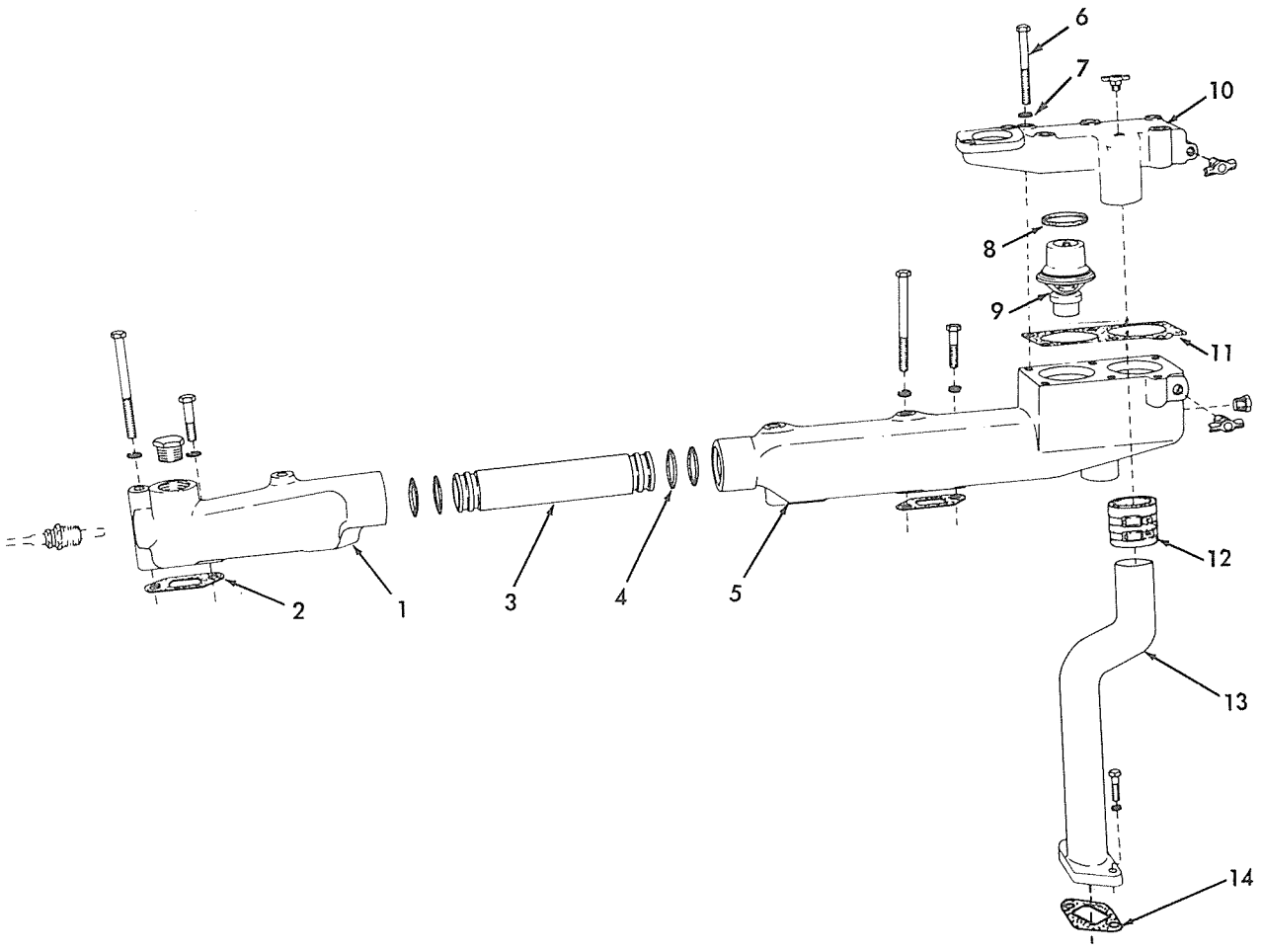


Fig. 12—Water Outlet Manifold Details
(T-38101)

1. Water Outlet Rear Manifold
2. Gasket
3. Connecting Tube
4. O-Ring
5. Water Outlet Front Manifold
6. Capscrew
7. Lockwasher
8. Thermostat Seal
9. Thermostat
10. Thermostat Housing
11. Thermostat Housing Gasket
12. Hose
13. Water By-Pass Tube
14. Gasket

B. THERMOSTAT REMOVAL, TESTING, AND INSTALLATION

1. THERMOSTAT REMOVAL (Fig. 12)

   a. Drain cooling system.

   b. Remove two capscrews securing radiator inlet elbow to thermostat housing and remove gasket.

   c. Remove capscrews (6) and lockwashers (7). Remove housing (10) and gasket (11). Remove thermostats (9).

   d. Clean and inspect housing (10) and examine gasket (11) and seals (8); replace gasket or seals if necessary.

NOTE

To remove seals (8), pry them from their seats in thermostat housing. Install new seals in the inserts using a suitable driver. The open side of the seal must be positioned toward top of thermostat housing.

2. THERMOSTAT TESTING

   a. Suspend thermostats in a pan of clean water so that the thermostats are completely immersed.

   b. Gradually heat the water and use an accurate thermometer to check the temperature of the water.

NOTE

Stir water during this procedure so that heat is evenly distributed in the volume of water.

   c. Observe the thermostats as temperature of the water reaches 180°F. If thermostats are functioning properly, thermostats should begin to open at 180°F. and be fully open at 195°F. plus or minus 5° (for either rate).

NOTE

The thermostats are not adjustable and if they do not open or close within the above limits, they must be replaced.

3. THERMOSTAT INSTALLATION (Fig. 12)

   a. Place gasket (11) in position and install thermostats (9).

   b. Position housing (10) in position on manifold (5) and secure with capscrews (6) and lockwashers (7).

   c. Place radiator inlet elbow and gasket in position on thermostat housing and secure with capscrews and lockwashers.

   d. Fill cooling system.

TOPIC 7 - OIL COOLERS

A. GENERAL

All engines covered in this manual are equipped with an engine oil cooler except the engine used in the TL20D Tractor Loader.

In addition to the engine oil cooler most of the engines are equipped with an engine clutch oil cooler, torque converter oil cooler, and/or a transmission oil cooler depending upon the engine application. Each oil cooler consists of a cooling core and a tank. The coolant flows through the tubes of the core and the oil circulates through the tank.

B. OIL COOLER REMOVAL

1. ENGINE OIL COOLER REMOVAL (TRACK-TYPE TRACTORS) Fig. 13

   a. Drain cooling system.

   b. Remove oil filter body and filter element.

   c. Remove capscrews (5) and lockwashers (4) attaching engine oil cooler (3) to head assembly (1).

   d. Remove capscrews (15) and lockwashers (14) attaching adapter (13) to torque converter and/or transmission oil cooler. Remove capscrews (10) and lockwashers (9) attaching oil cooler (3) to cylinder block.

   e. Remove engine oil cooler (3) and gaskets (2) (6) and (12) from engine.

   f. Remove capscrews (7) and lockwashers (8) and remove adapter (13) and gasket (11) from engine oil cooler (3).

2. ENGINE OIL COOLER REMOVAL (MOTOR GRADERS) Fig. 14

   a. Drain cooling system.

   b. Disconnect engine lubricating oil inlet and outlet lines from the oil cooler (4).

   c. Remove capscrews (13) and lockwashers (12)

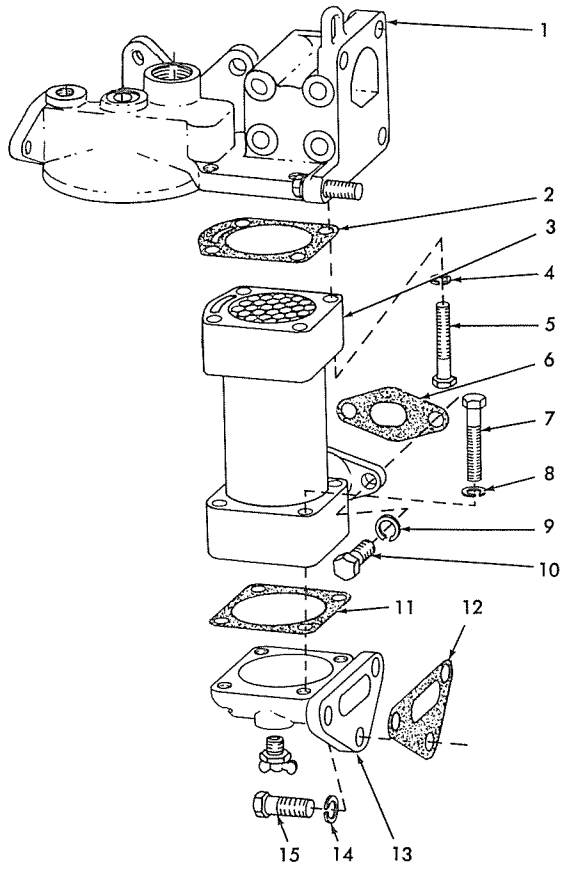


Fig. 13—Engine Oil Cooler Details
(Track-Type Tractors)
(T-41946)

1. Oil Filter Head Assembly
2. Gasket
3. Engine Oil Cooler
4. Lockwasher
5. Capscrew
6. Gasket
7. Capscrew
8. Lockwasher
9. Lockwasher
10. Capscrew
11. Gasket
12. Gasket
13. Adapter
14. Lockwasher
15. Capscrew

attaching oil cooler (4) to water inlet connection (6).

d. Remove capscrews (17) (18) and lockwasher (16) (19) and remove engine oil cooler (4) and water outlet connection (1) from the engine as an assembly. Remove gaskets (2) and (5).

e. Remove capscrews (14) and lockwashers (15) and remove outlet connection (1) and gasket (3) from oil cooler (4).

3. ENGINE OIL COOLER REMOVAL (TRACTOR LOADERS)

Refer to "TORQUE CONVERTER OIL COOLER REMOVAL (TRACTOR LOADERS)" in this Topic.

4. TRANSMISSION, TORQUE CONVERTER, AND/OR ENGINE CLUTCH OIL COOLER REMOVAL (TRACK-TYPE TRACTORS) Fig. 15

The front and rear covers (10) (1) are the same on all engines used in track-type tractors, however, the type of oil cooler used depends upon the engine application. The various oil coolers used are illustrated in Fig. 15 and the following removal procedure applies to all.

a. Drain cooling system.

b. Disconnect hose (15).

c. Disconnect all external hoses from the transmission, torque converter and/or engine clutch oil cooler.

d. Remove capscrews and lockwashers attaching front cover (10) to oil cooler(s).

e. Remove nuts, capscrew and lockwashers attaching front cover (10) to cylinder block and remove front cover spacing washer (14), and gaskets (13) and (11) or (7).

f. Remove capscrews and lockwashers attaching oil cooler(s) to rear cover (1) and remove oil cooler(s).

5. TORQUE CONVERTER OIL COOLER REMOVAL (TRACTOR LOADERS) Fig. 16

a. Drain cooling system.

b. Disconnect all external hoses from the oil cooler(s).

c. Remove capscrews and lockwashers attaching water outlet connection (1) to oil cooler(s) and cylinder block and remove water outlet connection and gasket (2).

d. Remove capscrews and lockwashers attaching oil cooler(s) to water inlet connection (4) and remove oil cooler(s).

6. TRANSMISSION, TORQUE CONVERTER, AND ENGINE OIL COOLER (12G CRAWLER LOADER AND 745 WHEEL LOADER) Fig. 16A

a. Drain cooling system.

b. Disconnect all external hoses and tubes from oil coolers.

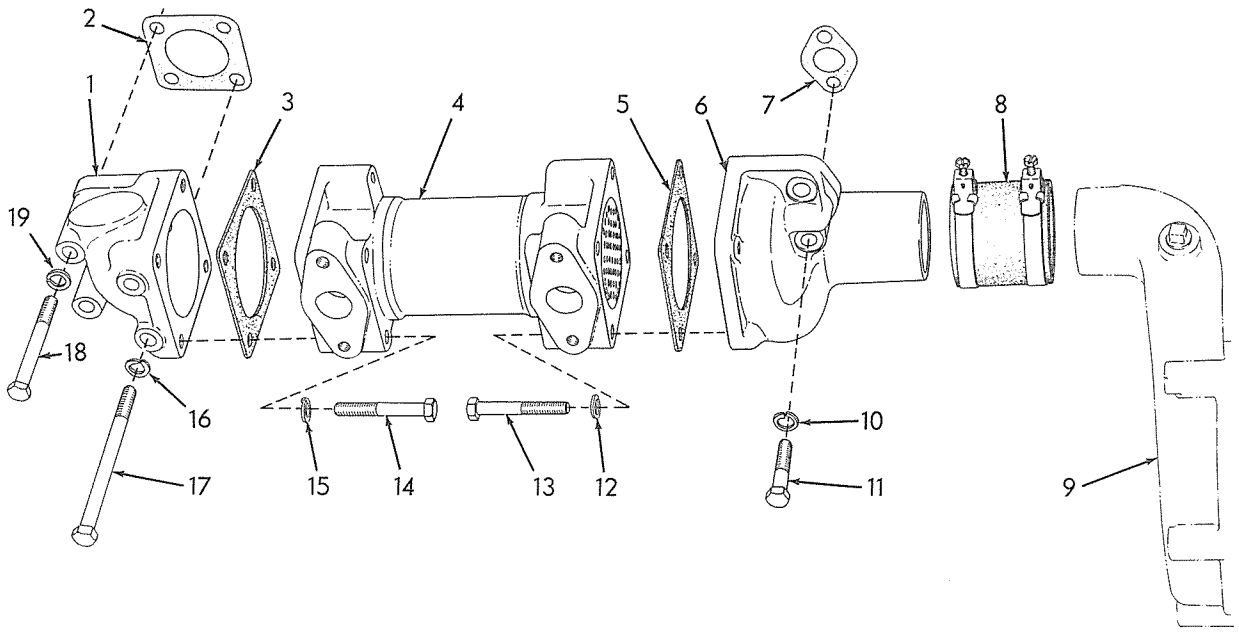


Fig. 14—Engine Oil Cooler Details (Motor Graders)
(T-13161)

1. Water Outlet Connection
2. Gasket
3. Gasket
4. Engine Oil Cooler
5. Gasket
6. Water Inlet Connection
7. Gasket
8. Hose
9. Water Pump
10. Lockwasher
11. Capscrew
12. Lockwasher
13. Capscrew
14. Capscrew
15. Lockwasher
16. Lockwasher
17. Capscrew
18. Capscrew
19. Lockwasher

c. Loosen hose clamps on hose (7).

d. Remove capscrews attaching oil coolers (3) and (4) to rear cover (1). Remove capscrew and nuts attaching front cover (6) to cylinder block and remove cover and coolers as an assembly.

e. Remove capscrews attaching oil coolers to cover (6).

C. OIL COOLER CLEANING

To function efficiently the oil cooler tank and core must be kept as clean as possible. Scale and sludge deposits reduce the cooling capacity of the oil cooler. Whenever an oil cooler is removed from the engine or if the efficiency of the cooler is impaired due to an accumulation of sludge or scale the oil cooler should be cleaned.

In many repair shops and service departments, caustic compounds are used to clean grease, dirt, paint, gasket remnants, etc., off parts. These compounds are very effective and very useful when used properly, but can cause considerable damage to certain materials.

Materials such as aluminum, rubber, fiber, sintered bronze and bonding agents are particularly sensitive to all highly concentrated caustic cleaners. There are many of these cleaning compounds on the market, under various trade names, but the majority of them are based on the same active agent — sodium hydroxide. Steam "jenny" compounds also generally contain this agent.

Some current oil coolers and radiators are being manufactured with aluminum fins. A few cleaning solutions have been found to react with aluminum to the extent of dissolving the metal.

We recommend that Trichlorethylene solvent or equivalent be used for both internal and external cleaning of oil coolers and radiators used in Fiat-Allis units since there is no reaction between the aluminum and the solvent.

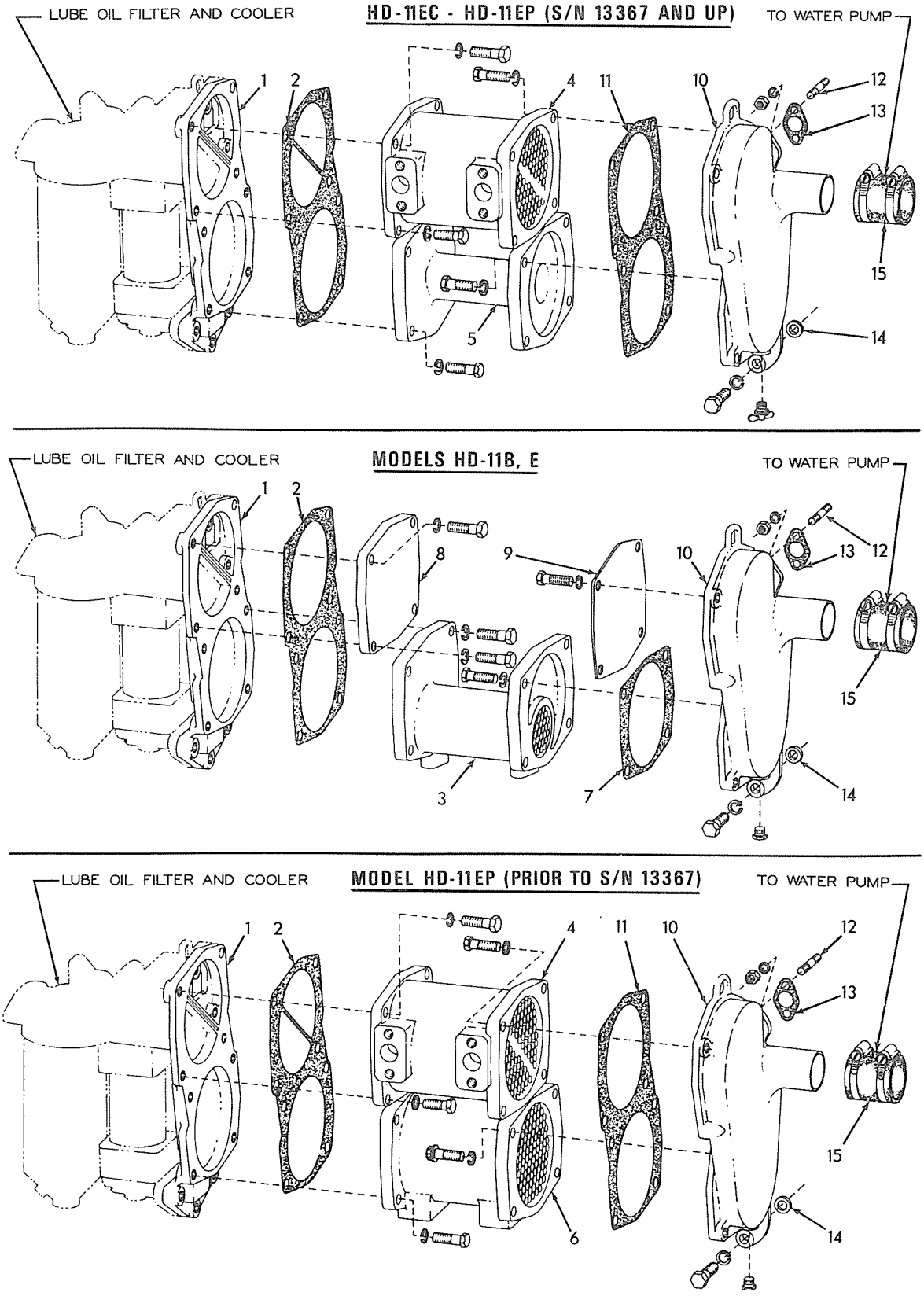


Fig. 15 — Transmission, Torque Converter, and/or Engine Clutch Oil Cooler Details (Track-Type Tractors) (T-41945)

1. Rear Cover
2. Rear Cover Gasket
3. Engine Clutch Oil Cooler
4. Torque Converter Oil Cooler
5. Connecting Tube
6. Transmission Oil Cooler
7. Front Cover Gasket
8. Water Passage Rear Cover
9. Water Passage Front Cover
10. Front Cover
11. Front Cover Gasket
12. Stud
13. Front Cover-to-Block Gasket
14. Front Cover Spacing Washer
15. Hose

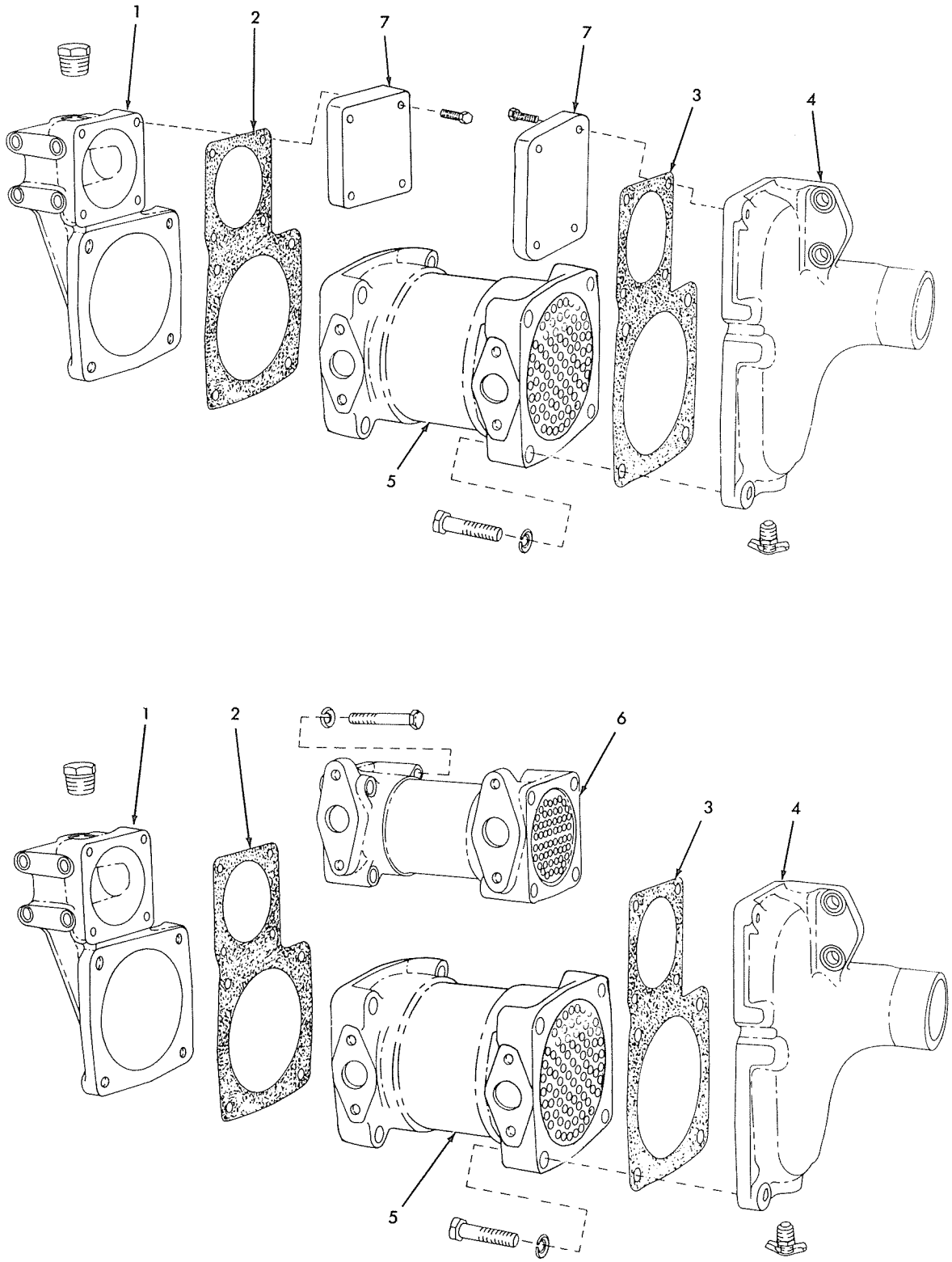
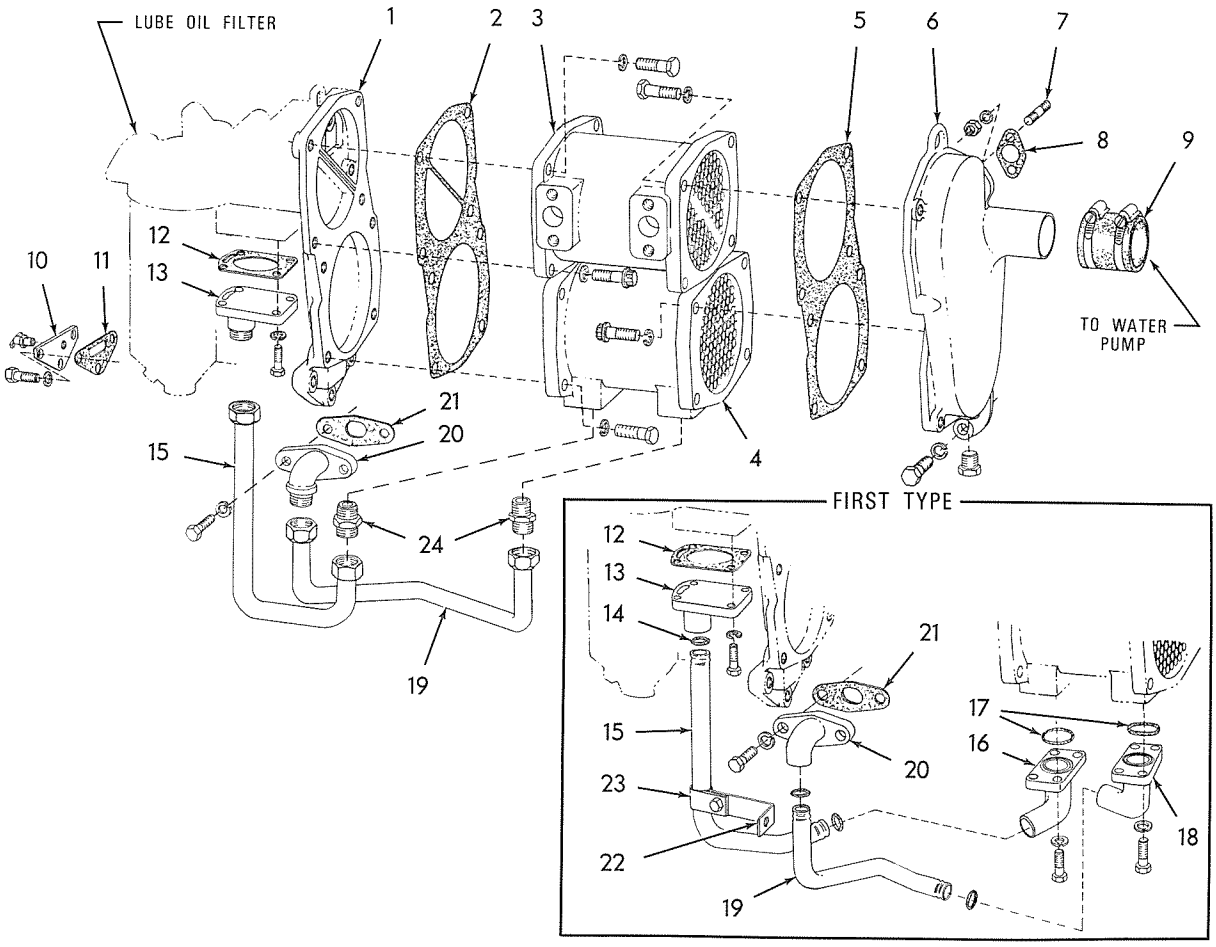


Fig. 16 — Torque Converter Oil Cooler Details (Tractor Loaders)
(T-34386 and T-29456)

1. Water Outlet Connection
2. Gasket
3. Gasket
4. Water Inlet Connection
5. Torque Converter Oil Cooler
6. Engine Oil Cooler
7. Cover Plates



T-80457

FIG. 17 HEAT EXCHANGER

FIRST TYPE: Used prior to engine serial number 11-21925.
SECOND TYPE: Effective with engine serial number 11-21925.

1. Cover
2. Gasket
3. Exchanger
4. Exchanger
5. Gasket
6. Cover
7. Stud
8. Gasket
9. Hose
10. Cover
11. Gasket
12. Gasket
13. Flange
14. O-ring
15. Tube
16. Elbow
17. O-Ring
18. Elbow
19. Tube
20. Elbow
21. Gasket
22. Bracket
23. Clamp
24. Connector

WARNING

Trichlorethylene solvent is toxic and very volatile. Use only in a well ventilated room or area. Do not inhale the fumes. Do not allow it to come in contact with the skin.

In all cleaning operations care must be taken in the selection of cleaning materials. When any doubt exists as to whether or not caustic compounds would damage the materials to be cleaned, the use of such compounds must be avoided.

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

D. OIL COOLER TESTING

1. Using an improvised seal, such as a metal plate and rubber gasket, seal either the fluid inlet or outlet opening in the oil cooler tank and attach an air pressure hose to the other opening.

2. Submerge the oil cooler in water heated to approximately 180 ^{o} F. (82 ^{o} C.) and allow sufficient time for oil cooler to warm up, then test for leaks using air under pressure of 100 psi (7.0 kg/ cm ^{2}) or as near that pressure as possible.

3. Air bubbles observed at either open end of the oil cooler indicate that a cooling core tube may have a puncture or be defective in another way. If cooling core is faulty, the oil cooler must be replaced. If repair of oil cooler tank is necessary, the repair must be made by a reputable radiator repair shop.

E. OIL COOLER INSTALLATION

1. Refer to Fig.'s 13 thru 17 and install oil cooler (s) by direct reversal of removal procedure. Use new gaskets where gaskets are required.

   On late model engines, only one (1) O-ring is used on each end of oil tubes, Fig. 17 (15, 19). O-ring must be isntalled in end groove of each tube.

2. Fill cooling system.

3. Operate engine and check for oil or water leaks at oil cooler connections. Correct any leaks found. Check coolant level in the radiator and add coolant if necessary. Check the oil level of any related components such as the crankcase, engine clutch (if oil-type), torque converter, and/or transmission. Fill to the proper level with the specified oil.

TOPIC 8 - WATER PUMP

A. DESCRIPTION

A centrifual type water pump is provided for circulating coolant through the engine and radiator. The water pump is flange mounted on the front of the engine timing gear housing and is belt driven at 1.26 times crankshaft speed.

The pump shaft is supported in the pump body by two ball bearings. The impeller is retained on the pump shaft by a nut and cotter pin (first type) or by a press fit (second type). A spring loaded seal assembly and a water flinger are provided at the front of the impeller to prevent coolant from entering the bearing compartment side of the pump body. The pump shaft and bearings are retained in the pump body by a sealing washer retainer threaded into the front of the pump body; the retainer is locked in position in the pump body by a lockwire.

The construction of the water pump is conducive to long life with minimum attention providing only clean water is added to the cooling system. Water containing excessive alkali or acid is especially harmful to the components of the water pump as they cause corrosion.

B. WATER PUMP REMOVAL (Fig. 18)

1. Drain cooling system. Remove radiator.

2. Disconnect the water pump lubricating hose if so equipped.

3. Loosen generator adjusting arm capscrew, move generator down, and slip belt off water pump pulley.

4. Remove capscrews and lockwashers securing water pump pulley (15) to pulley flange and remove the pulley.

5. Remove capscrews and lockwashers securing water pump assembly (1) to timing gear housing (21). Remove the water pump assembly.

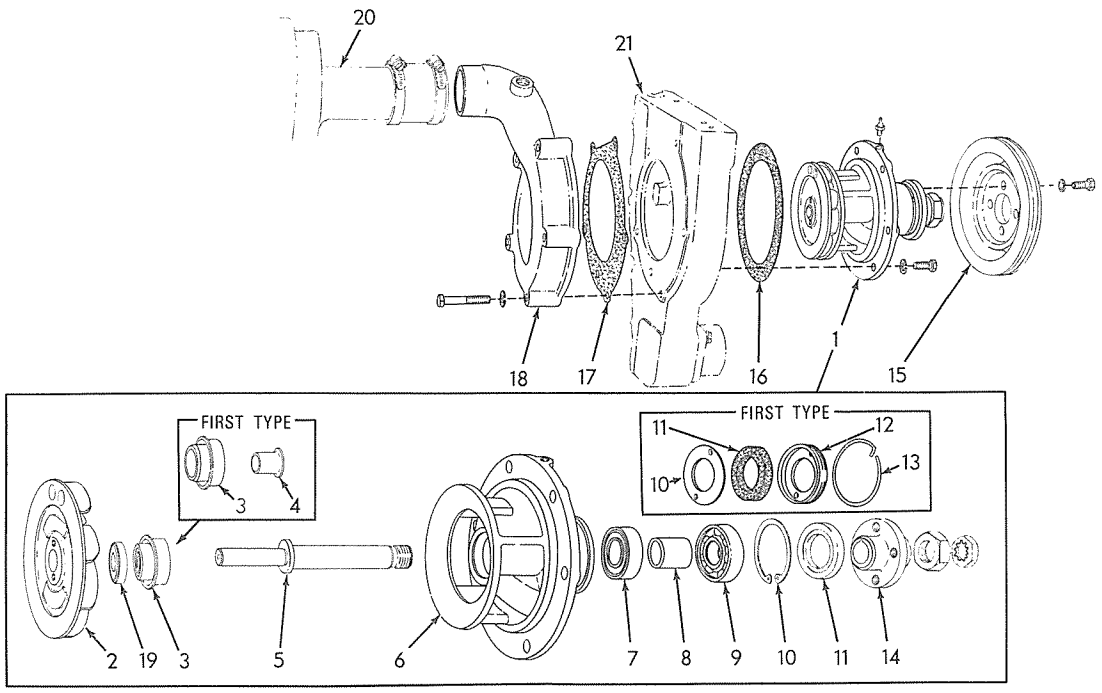
C. WATER PUMP DISASSEMBLY INSPECTION, AND ASSEMBLY

1. WATER PUMP DISASSEMBLY (Fig. 18)

   a. On first type remove cotter pin and impeller retaining nut from pump shaft (5). The tapped holes are provided in the impeller (2) for use of a puller to remove impeller from shaft.

   b. Using a suitable bar type puller, pull impeller from shaft.

      The seal assembly (3 or 19) is now accessible. If a seal assembly replacement only is to be made, it will not be necessary to remove shaft (5) from pump.



T-80417

FIG. 18 WATER PUMP

FIRST TYPE: Used prior to engine serial number 11-27556.
SECOND TYPE: Effective with engine serial number 11-27556.

1. Pump assy.
2. Impeller assy.
3. Seal assy.
4. Flinger
5. Shaft assy.
6. Body
7. Bearing
8. Spacer
9. Bearing
10. Ring washer
11. Seal washer
12. Retainer
13. Lockwire
14. Flange
15. Pulley
16. Gasket
17. Gasket
18. Volute
19. Ceramic seal
20. Cover
21. Housing

c. Remove locking nut and retaining nut from pump shaft (5). Remove body (6).

d. Remove retainer lockwire (13) and turn sealing washer retainer (12) from pump body (6). Remove sealing washer (11) and ring washer (10) from pump body.

e. Place pump body (6) in postion in a press, with impeller end of shaft up. Press on impeller end of shaft and remove shaft (5) bearing spacer (8), and bearings (7) and (9) from the pump body.

f. Press shaft (5) from bearings.

2. WATER PUMP INSPECTION (Fig. 18)

Repair of water pump will consist of replacement of any worn or damaged parts.

a. If ceramic insert, bonded to impeller (2), is scored or rough, a new impeller must be installed. If sealing face of seal assembly (3) is scored or rough, drive seal assembly from pump body.

b. Clean and inspect bearings (7) and (9) for looseness, roughness, and binding; replace if necessary.

c. Thoroughly clean pump body (6) and check condition of bearing bore in pump body. Replace pump body if necessary.

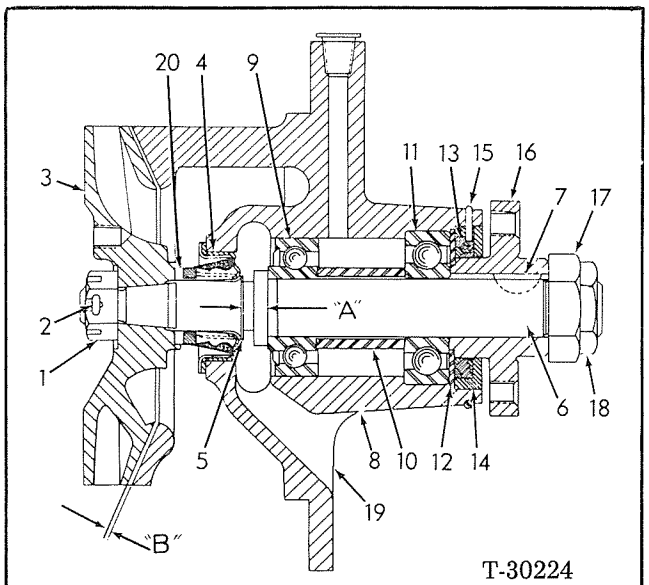


FIG. 19 WATER PUMP - SECTIONAL VIEW (FIRST TYPE)

* 1. Impeller Retaining Nut
* 2. Cotter Pin
3. Impeller
4. Seal Assembly
5. Water Flinger
6. Pump Shaft
* 7. Woodruff Key
8. Water Pump Body
9. Rear Ball Bearing
10. Bearing Spacer
11. Front Ball Bearing
12. Retaining Washer
13. Sealing Washer
14. Sealing Washer Retainer
15. Retainer Lockwire
16. Pulley Flange
17. Flange Retaining Nut
18. Locking Nut
19. Cored Opening (Seal Drain Passage)
20. Ceramic Insert - Bonded-to-Impeller
"A" 0.3125 in (7.94 mm)
"B" .018 - .049 in (0.46-1.24 mm) First Type
.015 - .072 in (0.38-1.83 mm) Second Type

*Items not used on second type

d. Inspect condition of pump shaft (5) and water flinger (4); replace if necessary.

3. WATER PUMP ASSEMBLY (Figs. 18 and 19)

a. Install water flinger (4) on pump shaft (5) so that flanged end is located 0.3125 in (7.94 mm) from front face of shaft shoulder (refer to dimension "A" Fig. 19).

b. Press rear ball bearing (11) onto shaft (5) making certain that shielded side of bearing is towards impeller end of shaft. Place bearing spacer (8) in position on shaft. Press bearing (7) onto shaft, making certain that shielded side of bearing is towards pulley end of shaft.

c. Place pump body (6) in position on a press, with impeller side of body down. Start shaft (with bearings) into position to pump body. Pressing on inner race of front ball bearing, press shaft (with bearings) into position in pump body. While pressing shaft into pump body, hand pack area between bearings half full with clean ball and roller bearing lubricant.

d. Install retaining washer (10) in pump body. Insert a new sealing washer (11) in sealing washer retainer (12) and turn retainer into pump body until hole in the retainer is aligned with hole in body for the retainer lockwire. Install retainer lockwire (13).

e. Install seal assembly (3) in position on impeller end of pump shaft and into position in the pump body, using care to prevent damage to seal assembly. Make certain carbon washer surface is wiped clean with an absorbent paper on lint-free cloth. If thorough cleaning cannot be accomplished this way, us a non-toxic, non-flammable cleaning solution and then wipe clean DO NOT APPLY OIL FOR GREASE TO THE CARBON WASHER SURFACE.

f. First type
Place impeller (2) in position on pump shaft and start impeller retaining nut. Tighten retaining nut to a torque of 3-36 lb-ft (4.1-5.0 kg/m). This must press impeller onto shaft so that a clearance of .018 -.049 in (0.46-1.24 mm) is provided between impeller and rear face of body (refer to dimension "B", Fig. 19).

Second type
Place support under threaded end of shaft and press on impeller. Face of impeller must be from .010 in (0.03 mm) above to flush with end of shaft. This should maintain the specified clearance of .015 - -.072 in (0.38-1.83 mm) between impeller and rear face of body (refer to dimension "B", Fig. 19). If a new impeller is used, and if it has a protective wax-like coating covering ceramic sealing ring, the coating must be removed before assembling impeller to shaft.

g. On first type install Woodruff key in position in pump shaft and start pulley flange (15) onto shaft Install flange retaining nut and tighten securely, then lock retaining nut by installing locking nut.

D. WATER PUMP INSTALLATION
(Fig. 18)

1. Place water pump assembly (1) in position in timing gear housing, making certain that gasket (16) is in good condition and that drilled passage for lubricating hose is at the top. Secure water pump to timing gear housing with capscrews and lockwashers.

2. Install water pump pulley (15) in position on pulley flange and secure with capscrews and lockwashers.

3. Install lubricating hose (if so equipped) first making certain that hose is in good condition.

4. Install and adjust the water pump and generator drive belt.

5. Install the radiator and fill cooling system.

TOPIC 9 — COOLANT FILTER

A. GENERAL

Most late model engines covered in this manual are equipped with a coolant filter, Fig. 20 or Fig. 20A. Most filters are mounted on a bracket attached to the engine. When the filter is not mounted directly on the engine, it is grounded to the engine with a ground wire.

The inlet and outlet valves must both be open before coolant can circulate through the filter. Coolant enters the bottom of the filter and circulates upward through the corrosion resistor plate, filter element, and upper plate. Coolant leaves the top of the filter and is returned to the cooling system.

Both types of filter contain chemically active resins which perform the following functions:

1. Eliminates harmful sludge and abrasive dirt suspended in the coolant.

2. Prevents the formation of scale on metal surfaces within the cooling system by removing, through an ion-exchange resin contained in the coolant, "hard water" deposits from the coolant.

3. Reduces rust formation and corrosion, effecting the most desirable acid-alkali level.

4. Provides a protective film on cooling system surfaces through a combination of rust inhibitors contained in the filter element.

5. Prevents pitting of metal tubes and walls within the cooling system by controlling electrolytic action through the electro-chemical corrosion resistor plate.

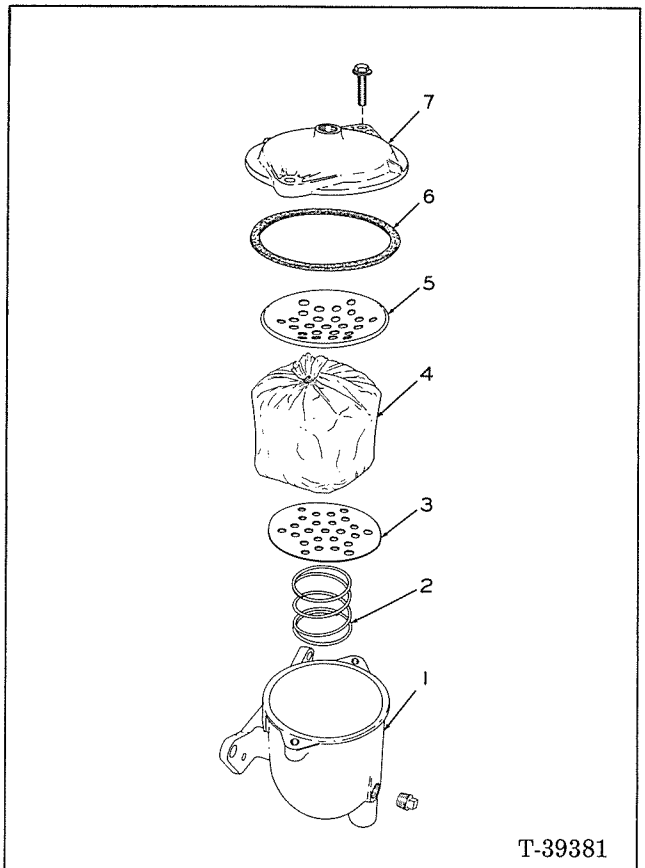


FIG. 20 COOLANT FILTER DETAILS
(Used prior to engine serial number 11-22075)

1. Filter body
2. Spring
3. Corrosion resistor plate
4. Filter element
5. Upper plate
6. Gasket
7. Cover

B. COOLANT FILTER SERVICE

The coolant filter element must be changed after each 500 hours of operation, or more often depending upon amount of coolant added to cooling system during this operating period.

For detailed instructions on filter element replacement, refer to the OPERATION AND MAINTENANCE MANUAL furnished with the unit.

C. COOLANT FILTER REMOVAL AND INSTALLATION

If for any reason the coolant filter must be removed from engine, close inlet and outlet shutoff valves.

Disconnect inlet and outlet lines and either remove filter from its mounting bracket, or remove filter and mounting bracket as an assembly. Install the filter by reversing the removal procedure.

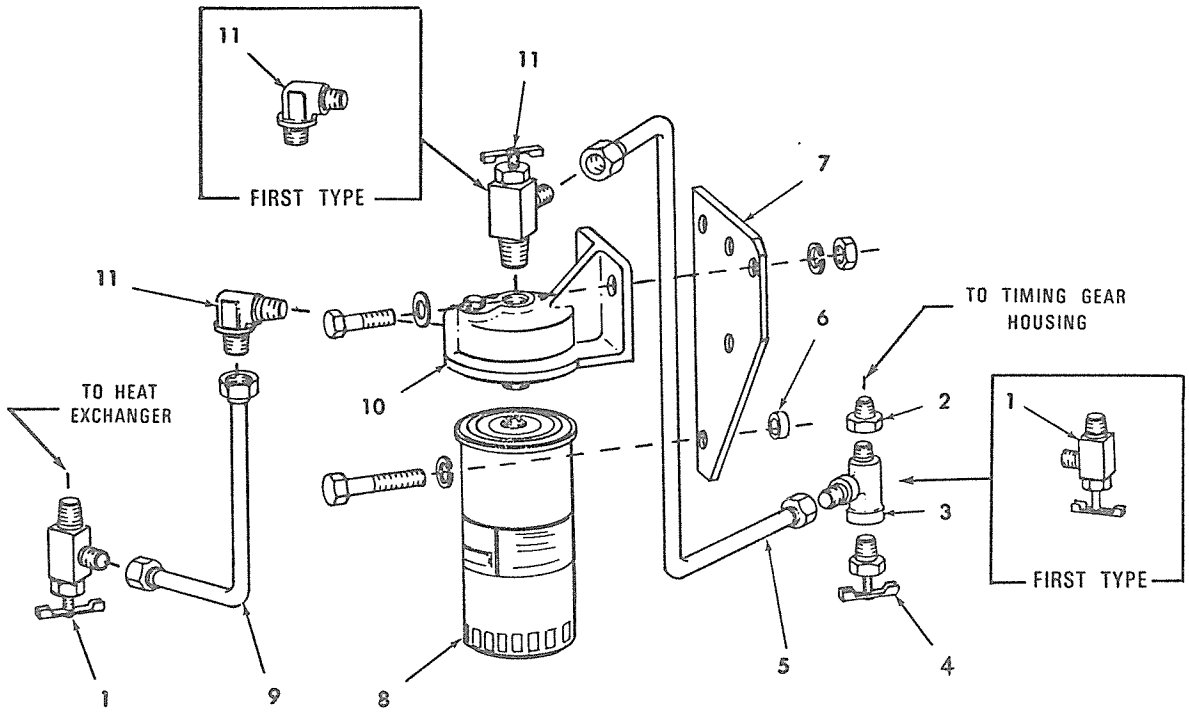


FIG. 20A COOLANT FILTER AND LINES

USAGE: Effective with engine s/n 11-22075

1. Valve
2. Bushing
3. Tee
4. Drain cock
5. Tube
6. Spacer
7. Bracket
8. Filter
9. Tube
10. Base assy.
11. Elbow (First type)
    Valve (Second type)

SECTION 3 - ELECTRICAL SYSTEM

TOPIC NO.	TITLE	PAGE NO.
1.	GENERAL	
	A. Charging Circuit	3-1
	B. Cranking Circuit	3-1
	C. Accessory Circuit	3-1
2.	WARRANTY AND ADJUSTMENT	3-2
3.	WIRING SYSTEM	3-2
4.	GENERATOR	
	A. Description	3-2
	B. Generator Maintenance	3-2
5.	GENERATOR REGULATOR	
	A. Description	3-3
	B. Generator Regulator Removal and Installation	3-3
6.	STARTER	
	A. Description	3-3
	B. Starter Service	3-3
	C. Starter Removal and Installation	3-4
7.	ALTERNATOR	
	A. Description	3-4
	B. Operation	3-4
8.	ALTERNATOR REGULATOR	
	A. Description	3-4a
	B. Operation	3-4a

TOPIC 1 - GENERAL

The electrical system, which includes the starter, generator (or alternator), generator regulator (or alternator regulator), batteries, and ammeter, is a 24 volt system throughout. Current is supplied by wet cell storage batteries. Three circuits work together to supply the needed electrical energy.

A. CHARGING CIRCUIT

The basic units of the charging circuit are the batteries, generator, and generator regulator. The batteries are the storage plant for electrical energy and must be kept fully charged while using a minimum amount of water. Refer to the "Operator's Manual", furnished with the unit, for battery testing information.

Electrical energy, drained from the batteries, is replaced by the generator. Too much generator output will usually burn out the generator or damage the batteries so they will not hold a charge. To prevent this, a generator regulator is connected into the circuit.

B. CRANKING CIRCUIT

The basic units of the cranking circuit are the batteries, starter, solenoid switch, and a remote control switch. The remote control switch completes the circuit between the batteries and solenoid switch. As current flows through the solenoid, the drive pinion of the starter is shifted into mesh with the flywheel ring gear, the main contacts in the solenoid close, connecting the batteries directly to the starter which turns the engine. When the engine starts and the remote control switch (starter button or ignition key) is released, the solenoid contacts open and the drive pinion is automatically disengaged. To prevent overheating and damage, never operate the starter for more than 30 seconds at a time.

C. ACCESSORY CIRCUIT

The accessory circuit is composed entirely of current-consuming devices such as lights, horn, heaters, etc. In this circuit, good connections at junction points, fuses, switches, and circuit breakers, are important to prevent voltage losses which will reduce the efficiency of operation.

TOPIC 2 - WARRANTY AND ADJUSTMENT

Manufacturers of the batteries, starter, generator, and generator regulator, used on the unit, are responsible for this equipment during the warranty period. Any claim for replacement or repair of any of these units must be presented to the manufacturer, not to Fiat-Allis Construction Machinery, Inc. Suppliers of such equipment are represented by distributors or dealers in nearly all cities; they are authorized to make reasonable adjustments or replacements for their respective companies. Always give the serial number of the unit and the date the unit was delivered when presenting a claim of this nature.

TOPIC 3 - WIRING SYSTEM

Heavy cables connect batteries and starter. All cables are color coded for identification purposes. Inspect wiring frequently to detect any loose connections or frayed insulation; make sure all grommets and cable protecting boots are in good condition and properly installed. Tighten connections and wrap any frayed insulation with friction tape to prevent short circuits. Check all cable clips and make certain they are properly installed and secured.

CAUTION

To prevent possibility of bodily injury, always turn electrical system master switch handle to the "OFF" position or disconnect battery-to-ground cable before cleaning, repairing, disconnecting or connecting any of the heavy electrical cables.

TOPIC 4 - GENERATOR

A. DESCRIPTION

The generator is a direct current (DC) unit. The generator pole pieces and the field winding are stationary and the field leads are insulated from the housing. High output current, from the armature windings (coils) is picked up by the brushes when the armature revolves.

B. GENERATOR MAINTENANCE

Inspection of generator brushes, commutator, drive belt, and terminal connections should be made periodically.

1. BRUSHES AND COMMUTATOR

Brush spring tension must not be less, or exceed, that specified by the manufacturer. Excessive tension will cause rapid wear of brushes and commutator; low tension will cause arcing and reduced generator output.

If the brushes are worn down to less than half their normal size, they should be replaced. New brushes should be seated with a brush seating stone. Do not use emery cloth. Blow out dust. If the commutator is out of round or rough, it must be trued in a lathe or replaced. After truing commutator, the mica between the segments must be undercut 1/32".

2. GENERATOR DRIVE BELT ADJUSTMENT

Keep drive belt properly adjusted. When the generator drive belt can be pressed inward, by hand, 3/8" to 1/2" at a point half-way between pulley and fan hub, the belt is properly adjusted. To adjust drive belt, loosen generator adjusting capscrews, move generator up or down to obtain proper tension, and tighten the capscrews.

3. GENERATOR REMOVAL AND INSTALLATION

a. Disconnect wiring harness from generator; identify cables to simplify installation.

b. Remove capscrews and lockwashers attaching generator to the generator mounting bracket and remove generator.

c. Install generator by a reversal of the above procedure.

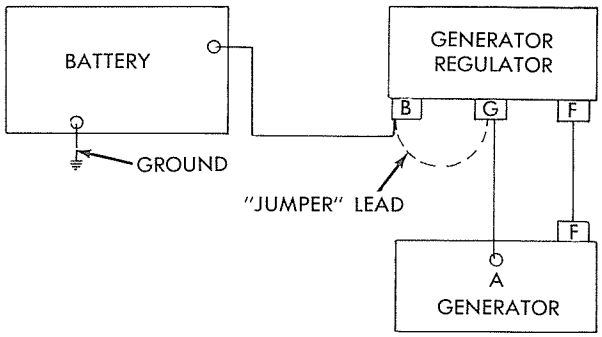


Fig. 1 — Polarizing Circuit Diagram (T-18731)

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

IMPORTANT

Whenever generator has been removed or disconnected, it must be polarized.

4. POLARIZING GENERATOR

   a. If generator is equipped with a cover band, insulate generator brushes from the armature by using a piece of cardboard between the brushes and commutator. If generator is the sealed type and the brushes are not accessible without removing the commutator end frame, loosen the tension on the generator drive belt and slip it off of generator drive pulley.

   b. Using a short "jumper" lead, momentarily touch "jumper" lead to "BAT" (Battery) and to "GEN" (Generator) terminals of the generator regulator.

   c. Remove cardboard from under the generator brushes and install cover band or install and adjust generator drive belt.

CAUTION

Do not run or test the generator on an open circuit.

If it should become necessary to operate the generator without it being connected to batteries, it should be short circuited. This can be done by disconnecting the lead connected to "GEN" terminal of the regulator and connecting the end of lead to a convenient ground.

TOPIC 5 - GENERATOR REGULATOR

A. DESCRIPTION

The generator regulator, used to limit the generator output, consists of three units; the cut-out relay to prevent battery current drain when the generator slows down or stops; the voltage regulator to prevent system voltage from exceeding a specified maximum, thus protecting the battery and other voltage sensitive equipment; the current regulator to limit the current output and prevent the generator from burning out.

B. GENERATOR REGULATOR REMOVAL AND INSTALLATION

Removal of the regulator may be accomplished by disconnecting the wires, and removing the attaching capscrews, nuts, and lockwashers. Be certain to identify the wires so they can be reinstalled in the correct location.

NOTE

After installation of the regulator always polarize the system.

TOPIC 6 - STARTER

A. DESCRIPTION

The starter, mounted on the engine flywheel housing, is an 8-brush, 4-pole, 24-volt heavy duty unit. The armature is supported by bushings at drive end, center, and commutator end. A sprag type overrunning clutch is used to mesh drive pinion of starter with the flywheel ring gear.

B. STARTER SERVICE

Field service on starter will be limited to cleaning of starter, cleaning of commutator, replacement of brushes, brush springs, or starter switch. All other adjustments or repairs require use of special equipment. For this reason, it will be necessary to remove starter and take it to a dependable electrical repair shop, when repair or adjustment is necessary. With fully charged batteries the starter will engage promptly and crank engine at an adequate cranking speed. However, in cold weather, "drag" caused by cold oil between pistons and cylinder walls, and in the bearings of the engine, causes engine to crank harder and cranking speed will naturally be decreased.

IMPORTANT

The starter must never be used for more than 30 seconds at any one time without a pause to allow it to cool.

The starter must NEVER be used to move the vehicle. Failure to observe these rules may result in failure of starter.

1. If starter fails to operate properly, remove and inspect commutator and brush connections. The commutator should be clean, not out of round or excessively worn, and without high mica or burned bars. A glazed or blued commutator does not indicate a condition requiring service, as this is a normal and satisfactory condition on a used unit. All electrical connections should be kept clean and tight, brush spring tension should be 35 ounces, and brushes must not be worn shorter than half

their original length. The brush spring tension can be tested by attaching a small spring scale to each brush, directly under head of screw that holds brush in arm.

2. A dirty commutator should be cleaned with #00 sandpaper.

IMPORTANT

Never use emery cloth.

If dust and dirt have accumulated in starter, it should be cleaned with compressed air as such accumulations are likely to interfere with operation of both starter and starter drive assembly.

3. Continued cranking of starter, after starter switch button has been released, indicates shorted turns in the solenoid switch windings, or that the solenoid switch is mounted out-of-line causing binding of the solenoid plunger. Chattering of the solenoid switch indicates shorted turns in windings or run-down batteries. It is recommended that the solenoid switches be taken to a dependable electrical repair shop when repair or adjustment is necessary.

C. REMOVAL AND INSTALLATION OF STARTER

1. Turn electrical system master switch to the off position or disconnect battery-to-ground cable.

2. Disconnect starter-to-ground strap from starter. Disconnect wiring harness from solenoid switch.

3. Remove capscrews and lockwashers attaching starter to flywheel housing and remove starter and starter adapter.

4. Install starter by a direct reversal of removal procedure.

TOPIC 7 — ALTERNATOR

A. DESCRIPTION

The alternator is a continuous output, diode rectified, alternating current (AC) generator. It normally will require very little maintenance. The bearings are provided with a self-contained grease supply thus eliminating the need for periodic lubrication. Two brushes are used to carry current through the two slip rings to the field coil mounted on the rotor. Since the brushes carry only the small field current and are extra long they will require little attention. The stator windings of the generator are assembled on the inside of a laminated core that forms part of the generator frame. Six rectifier diodes are mounted in the slip ring end frame and are connected to the stator windings.

B. OPERATION

The diodes are a unique feature of the alternator. They function as electrical check valves allowing current to pass in one direction only according to their polarity. Three negative diodes are mounted in the end frame. Three positive diodes are mounted in a "heat sink" which is insulated from the end frame.

By their unique ability to permit current to pass in one direction only, the diodes are able to convert the pulsating alternating current from the stator windings to direct current at the generator output terminal. The ability of the diodes to permit current to pass freely that is of opposite polarity of the diodes requires special precautions to preclude reversing the polarity of the battery or of charging or boosting aids that may be connected to the circuit. The following precautions must be observed:

1. When installing a battery, always make sure the ground polarity of the battery and the alternator are the same. If the battery polarity is reversed, the battery will be directly shorted through the diodes. Burned wiring harness and burned "open" diodes will probably result.

2. When connecting a booster battery, make certain the negative battery terminals are connected together and the positive terminals are connected together.

3. When connecting a charger to the battery, connect the charger positive lead to the battery positive terminal and the charger negative lead to the battery negative terminal.

4. Never operate the alternator on open circuit. Make certain all connections in the circuit are tight and clean.

5. Do not short across or ground any of the terminals of the alternator or regulator.

6. Do not attempt to polarize the alternator.

7. Prior to disconnecting or removing parts of the electrical system, turn electrical system master switch handle to the "OFF" position or disconnect battery-to-ground cable.

TOPIC 8 — ALTERNATOR REGULATOR

I DELCO-REMY

A. DESCRIPTION

A double contact regulator is used with the alternator. The terminals of the regulator are of the slip-connection type and a special connector body on the loader wiring harness is keyed to mating slots in the regulator base to insure proper connections. A projection on the connector body serves to latch the assembly together to prevent accidental disconnection. The regulator assembly consists of a double contact voltage regulator unit and a field relay unit. The voltage regulator unit limits the alternator output voltage to a pre-set value whereas the field relay connects the alternator field winding directly to the battery.

B. OPERATION

When the starter switch is activated, the field relay winding in the regulator is connected directly to the battery causing the contacts to close. This connects the alternator field winding directly to the battery, allowing field current to flow from the battery to the regulator No. 3 terminal, through the field relay contacts and then through the voltage regulator (or series) contacts. Current continues to flow to the regulator "F" terminal and then through the alternator field winding to ground. When the alternator begins to operate, AC voltages are generated in the stator windings. These voltages are then changed to DC voltages at the output terminal.

II MOTOROLA

A. DESCRIPTION

The regulator is a fully transistorized unit that has two basic circuits, the load circuit and the control circuit. It is factory adjusted and sealed and cannot be adjusted in the field.

B. OPERATION

The regulator is an electronic switching device which senses the voltage at the vehicle key switch and supplies the necessary field current to maintain system voltage at the alternator output terminal.

SECTION 4 - FUEL SYSTEM (WITH AMERICAN BOSCH FUEL INJECTION PUMP)

TOPIC NO.	TITLE	PAGE
1.	GENERAL DESCRIPTION	4-1
2.	CHECKING OF FUEL SYSTEM	
	A. General	4-2
	B. Air in System	4-2
	C. Clogged Fuel Filters or Collapsed Fuel Lines	4-3
	D. Inoperative Fuel Pressure Relief Valve or Fuel Transfer Pump	4-3
	E. Malfunctioning Fuel Injection Nozzle-Holder Assemblies	4-4
	F. Malfunctioning Fuel Injection Pump	4-4
3.	FUEL FILTERS AND FUEL FILTER HEAD	
	A. Fuel Filters	4-4
	B. Fuel Filter Head	4-5
4.	FUEL INJECTION NOZZLE-HOLDER ASSEMBLIES	
	A. General	4-6
	B. Fuel Injection Nozzle-Holder Operation	4-6
	C. Fuel Injection Nozzle-Holder Service	4-7
	D. Fuel Injection Nozzle-Holder Removal	4-7
	E. Testing and Adjusting Fuel Injection Nozzle-Holders	4-8
	F. Nozzle Spray Pattern	4-9
	G. Cleaning and Inspection of Fuel Injection Nozzle-Holder	4-9
	H. Fuel Injection Nozzle-Holder Installation	4-12
5.	FUEL INJECTION NOZZLE-HOLDER SLEEVES	
	A. Description	4-12
	B. Fuel Injection Nozzle-Holder Sleeve Removal	4-12
	C. Fuel Injection Nozzle-Holder Sleeve Installation	4-13
6.	FUEL INJECTION PUMP AND GOVERNOR	
	A. Description	4-13
	B. Fuel Injection Pump Operation	4-13
	C. Fuel Injection Pump Service	4-15
	D. Fuel Injection Pump Removal	4-16
	E. Fuel Injection Pump Installation and Timing	4-17
	F. Governor Adjustment	4-20
7.	VENTING OF FUEL SYSTEM	
	A. Venting of Low Pressure Fuel System	4-21
	B. Venting of High Pressure Fuel System	4-21
8.	FUEL TRANSFER PUMP	
	A. General	4-21
	B. Fuel Transfer Pump Service	4-21
	C. Fuel Transfer Pump Removal and Installation	4-21

TOPIC 1 - GENERAL DESCRIPTION

The engine fuel system consists of two fuel pressure systems, the low pressure system and the high pressure system.

In the low pressure system, fuel is drawn from the fuel tank through the first stage filter, Fig. 1 (6), by the fuel transfer pump (9). The fuel is then forced through the second stage filter (7) to the fuel injection pump (11). Once the injection pump sump is full, the excess fuel builds up pressure, opens the fuel pressure relief valve (10), flows to the filter head (8) and returns to the fuel tank.

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

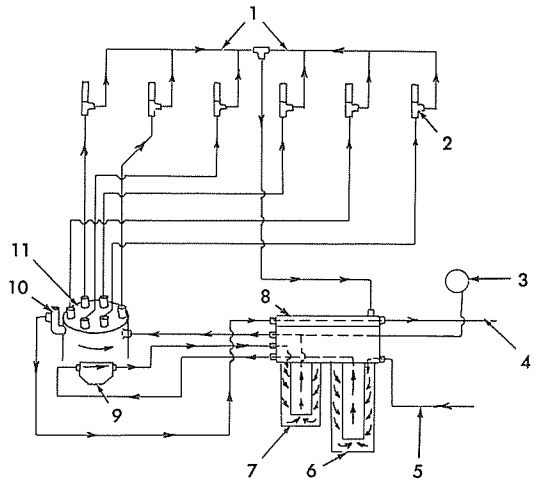


Fig. 1 — Fuel Flow Schematic
(T-71407)

1. Fuel Return Manifolds
2. Fuel Injection Nozzle-Holder
3. Fuel Pressure Gauge
4. Fuel Return Line (To Fuel Tank)
5. Fuel Supply Line (From Fuel Tank)
6. First Stage Fuel Filter
7. Second Stage Fuel Filter
8. Fuel Filter Head
9. Fuel Transfer Pump
10. Fuel Pressure Relief Valve
11. Fuel Injection Pump

In the high pressure system the fuel injection pump picks up fuel from the low pressure sump, meters and forces the fuel, under extremely high pressure,

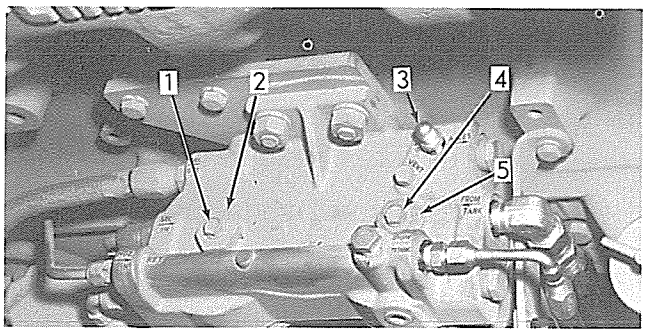


Fig. 2 — Location of Low Pressure Fuel System Vent Screws
(T-71005)

1. Second Stage Fuel Filter Vent Screw
2. Second Stage Fuel Filter Shell Retaining Nut
3. Fitting for Fuel Pressure Gauge Line
4. First Stage Fuel Filter Vent Screw
5. First Stage Fuel Filter Shell Retaining Nut

to the fuel injection nozzles. The nozzles spray the fuel into the engine combustion chambers. The fuel injection lines are seamless steel tubing and each line is the same length. These lines being of equal length assures proper timing and the proper amount of fuel to each injection nozzle.

There is a certain amount of fuel seepage between the lapped surfaces of each fuel injection nozzle valve and its body, which is necessary for lubrication. This leakage of fuel accumulates around the spindle and in the spring compartment of each fuel injection nozzle-holder and is returned through the fuel return manifold to the fuel return line. The excess fuel delivered to the fuel injection pump by the fuel transfer pump flows to the filter head and returns to the fuel tank.

TOPIC 2 - CHECKING OF FUEL SYSTEM

A. GENERAL

"Missing" or uneven running of the engine, excessive vibration, stalling when idling, and loss of power are indications of insufficient fuel supply to the engine. Before performing any of the following checks, make certain there is an ample supply of clean fuel in the fuel tank and that the fuel tank shut-off valve (if so equipped) is open.

B. AIR IN SYSTEM (Fig. 2)

Loosen the vent screw (1) in top of second stage fuel filter retaining nut (2). Crank engine with starter. If fuel containing bubbles flows from around the vent screw, air being drawn into the system on the suction side of the fuel transfer pump is indicated. Correct this condition by tightening any loose low pressure fuel line connections, first stage fuel filter

connections, and the first stage fuel filter shell retaining nut (5).

C. CLOGGED FUEL FILTERS OR COLLAPSED FUEL LINES (Fig. 2)

Loosen the vent screw (1) in top of second stage fuel filter shell retaining nut (2). Crank engine with starter. If a full flow of fuel is not obtained from around the loosened vent screw, a clogged or collapsed fuel line or a clogged first stage fuel filter element, Fig. 5 (6), is indicated. If this condition exists, remove and replace first stage fuel filter element or clean or replace the necessary fuel line.

D. INOPERATIVE FUEL PRESSURE RELIEF VALVE OR FUEL TRANSFER PUMP (Fig. 3)

The fuel transfer pump (2) should deliver more fuel to the fuel sump of the fuel injection pump than is required for engine operation. The fuel pressure relief valve (1) connected into the fuel return passage of the fuel injection pump, controls maximum fuel pressure within the fuel sump of the injection pump. The relief valve is set to open between 8 and 30 psi. When fuel pressure within the fuel sump

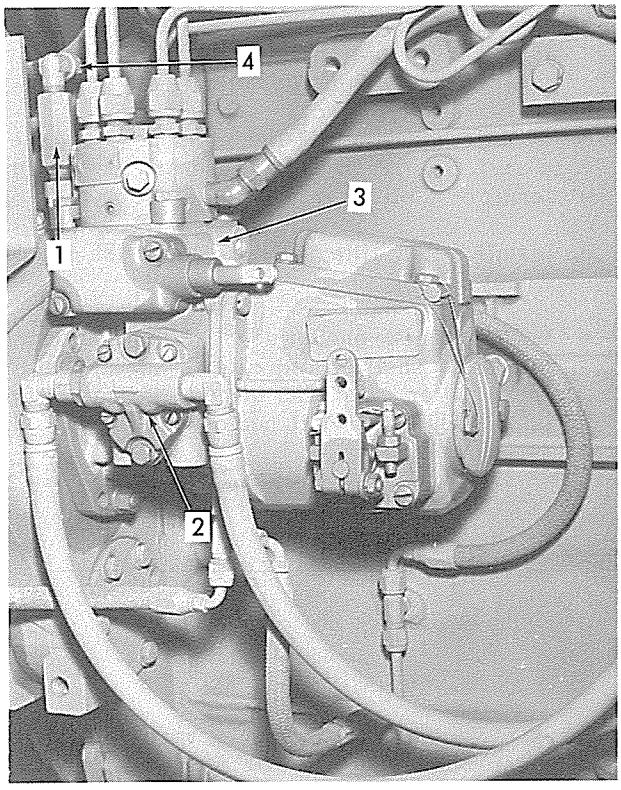


Fig. 3 — Typical Fuel Injection Pump Installation (T-71409)

1. Fuel Pressure Relief Valve
2. Fuel Transfer Pump
3. Fuel Injection Pump
4. Relief Valve-to-Filter Head Fuel Return Line

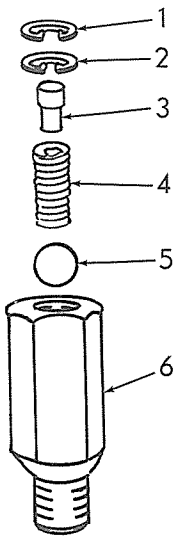


Fig. 4 — Fuel Pressure Relief Valve Details (T-71529)

1. Snap Ring
2. E-Ring Relief Valve Stop
3. Relief Valve Stop
4. Spring
5. Ball
6. Relief Valve Body

of the injection pump exceeds relief valve setting, the pressure relief valve opens and allows excess fuel to return to the fuel tank through the fuel filter head and fuel return line.

Check for an inoperative fuel pressure relief valve (1) or an inoperative fuel transfer pump (2) as follows:

1. Start engine and operate at approximately one-half throttle. Observe the fuel pressure gauge. Gauge should indicate a pressure of 8 to 30 psi. If gauge indicates a pressure below specified minimum, stop engine and disconnect the relief valve-to-filter head fuel return line (4).
2. Start engine and operate at approximately one-half throttle. If gauge indicates a pressure below the specified minimum, and a full flow of fuel is observed from disconnected return line, this indicates that the pressure relief valve (1) is stuck in the open position and the valve must be replaced as a unit. However, if gauge indicates a pressure below specified minimum and little or no fuel is observed from disconnected return line, an inoperative fuel transfer pump (2) is indicated, and the transfer pump must be removed, inspected, and replaced as a unit if necessary.
3. If a pressure above 30 psi is indicated by the gauge, the fuel pressure relief valve (1) is inoperative and must be replaced as a unit.

4. Stop engine and connect fuel return line (4).

E. MALFUNCTIONING FUEL INJECTION NOZZLE-HOLDER ASSEMBLIES

"Missing" or uneven running of the engine and loss of power indicates a malfunctioning fuel injection nozzle-holder or holders. Locate malfunctioning fuel injection nozzle-holder assemblies as follows:

Run engine at low idle speed and "cut-out" each fuel injection nozzle-holder in turn by loosening the fuel injection line nut attaching the fuel injection line to its corresponding fuel injection nozzle-holder.

CAUTION

Keep hands away from loosened nuts while performing this test.

A decrease in engine speed with injection line nut loosened, indicates that the fuel injection nozzle-holder for that cylinder is functioning properly. If engine speed does not decrease, the fuel injection nozzle-holder is malfunctioning and must be removed, tested, adjusted and cleaned (refer to "FUEL INJECTION NOZZLE-HOLDER ASSEMBLIES" in this Section).

F. MALFUNCTIONING FUEL INJECTION PUMP

Do not replace the fuel injection pump before making a compression test (refer to "TROUBLE SHOOTING" Section).

The compression test will indicate whether or not burned or stuck valves, worn or scored pistons and sleeves, worn or stuck rings, etc., are causing the improper engine operation.

If all causes for insufficient fuel supply have been eliminated, and the engine still runs unevenly and normal engine performance is not obtained, the fuel injection pump will be considered at fault and should be repaired or replaced. The faulty fuel injection pump (with governor) should be taken to your nearest Fiat-Allis Construction Machinery Dealer for repairs and testing.

TOPIC 3 - FUEL FILTERS AND FUEL FILTER HEAD

A. FUEL FILTERS (Fig. 5)

The first stage and second stage fuel filter each contain a replaceable element (6) (15). Dirt and sediment are collected by the first stage fuel filter (6) and prevented from entering the fuel transfer pump. Any dirt or sediment passing through the first stage fuel filter and the fuel transfer pump is collected by the second stage fuel filter (15) and prevented from entering the fuel injection pump. A drain cock (9) is provided in the bottom of each fuel filter shell (8) (10) for draining any water or sediment.

1. SERVICE (Fig. 5)

Open the drain cock (9) in the bottom of each fuel filter shell (8) (10) daily, before the start of the day's operation in warm weather or shortly after the end of the day's operation in freezing weather, and allow any water or sediment to drain.

2. FIRST STAGE FUEL FILTER ELEMENT REPLACEMENT (Fig. 5)

   a. Clean all dirt from around filter head (17) and shell (8). Loosen vent screw (1) and drain cock (9) and allow the filter shell to drain.

NOTE

Close the fuel tank shut-off valve.

   b. Loosen retaining nut (3) in the filter head until it is free from shell centerbolt and remove filter shell (8) from the filter head.

   c. Remove and discard filter element (6) and shell gasket (7). Thoroughly wash and dry the interior of shell.

   d. Install a new filter element and push it down firmly.

   e. Install a new shell gasket (7) in position in lip of the shell. Hold filter shell in position under filter head and engage threads of retaining nut with shell centerbolt. Tighten the nut securely.

CAUTION

Do not overtighten retaining nut (3).

   f. Close drain cock (9).

NOTE

After replacing filter elements, vent fuel system (refer to "VENTING OF FUEL SYSTEM" in this Section).

3. SECOND STAGE FUEL FILTER ELEMENT REPLACEMENT (Fig. 5)

   a. Clean all dirt from around filter head (17) and shell (10). Loosen vent screw (1) and drain cock (9) and allow filter shell to drain.

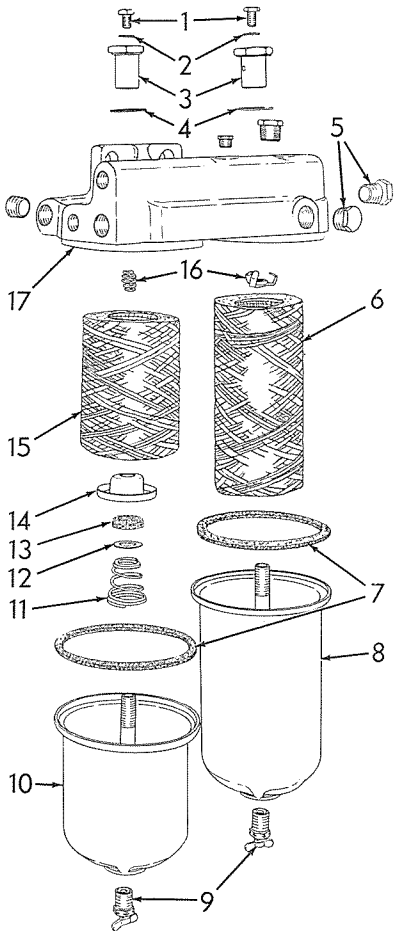


Fig. 5 — Fuel Filter Details
(T-22578)

1. Vent Screws
2. Copper Washers
3. Shell Retaining Nuts
4. Gaskets
5. Hex-Head Pipe Plugs
6. First Stage Fuel Filter Element
7. Filter Shell Gaskets
8. First Stage Fuel Filter Shell
9. Drain Cocks
10. Second Stage Fuel Filter Shell
11. Element Spring
12. Metal Washer
13. Element Seating Plate Gasket
14. Element Seating Plate
15. Second Stage Fuel Filter Element
16. Element Centering Guides
17. Filter Head

NOTE

Close the fuel tank shut-off valve.

b. Loosen retaining nut (3), in the filter head, until it is free from shell centerbolt and remove shell from filter head.

c. Remove and discard filter element (15). Remove centering guide (16), element seating plate (14), seating plate gasket (13), and metal washer (12) from the shell centerbolt. Discard seating plate gasket (13), metal washer (12), and shell gasket (7).

d. Thoroughly wash and dry interior of filter shell. Close and tighten drain cock (9).

e. Place element spring (11), large end downward, in position on shell centerbolt and install a new metal washer (12) over the shell centerbolt and down onto element spring.

f. Install a new seating plate gasket (13) in position in element seating plate (14) then install element seating plate in position on shell centerbolt.

NOTE

When installing element seating plate and gasket on shell centerbolt, install seating plate so that the gasket contacts the metal washer.

g. Install centering guide (16) in position near the top of shell centerbolt and install a new filter element (15) in position in the filter shell. Install a new shell gasket (7) in position in lip of filter shell.

h. Fill filter shell with CLEAN fuel. Hold filter shell in position under filter head, and install retaining nut (3) and gasket (4). Tighten the nut securely.

NOTE

After replacing filter elements, vent fuel system (refer to "VENTING OF FUEL SYSTEM" in this Section).

B. FUEL FILTER HEAD (Fig. 5)

The fuel filter head (17) is a manifold to collect and distribute fuel and also serves as a holder for the filter elements and filter shells.

To remove fuel filter head from the engine, when dismantling of filters or element replacement is not required, use the following procedure:

1. Clean the area around filter head and shells. Loosen vent screws (1) in the top of the filter head, and drain cocks (9) in the bottom of the shells, allowing the filter shells to drain completely.

NOTE

Close fuel tank shut-off valve.

2. Disconnect all hoses necessary to permit re-

moval of the filter head. Remove capscrews, lockwashers, and nuts securing the filter head to the mounting bracket and remove the assembly.

3. Install fuel filter head using a reversal of the removal procedure. Vent the fuel system (refer to "VENTING OF FUEL SYSTEM" in this Section).

TOPIC 4 - FUEL INJECTION NOZZLE-HOLDER ASSEMBLIES

A. GENERAL (Fig. 6)

Each cylinder of the engine is provided with a multi-hole, differential needle, hydraulically-lifted fuel injection nozzle-holder assembly. The function of each fuel injection nozzle-holder is to direct the metered quantity of fuel, received from the fuel injection pump, into the corresponding combustion chamber of the engine in a highly atomized, predetermined spray pattern and in such a manner as to produce the most efficient engine performance.

Each fuel injection nozzle-holder consists of two assemblies; the holder assembly and nozzle assembly. The holder assembly is used to hold the nozzle in its correct position in the cylinder head and to provide a means of conducting fuel, received from the fuel injection pump, to the nozzle. The holder assembly consists of a holder body (7), spindle (8), spindle spring (5), pressure adjusting screw (2), adjusting screw locknut (3), protection cap (1), and a nozzle retaining nut (11).

The nozzle consists of a nozzle valve (16), and a nozzle valve body (17) in which is located four equally spaced spray orifices.

The nozzle is positioned on the holder body by two dowels, Fig. 7 (3), so positioned that the four spray orifices are on a plane parallel to the top of the piston and the fuel duct in the nozzle is registered with the fuel duct in the holder.

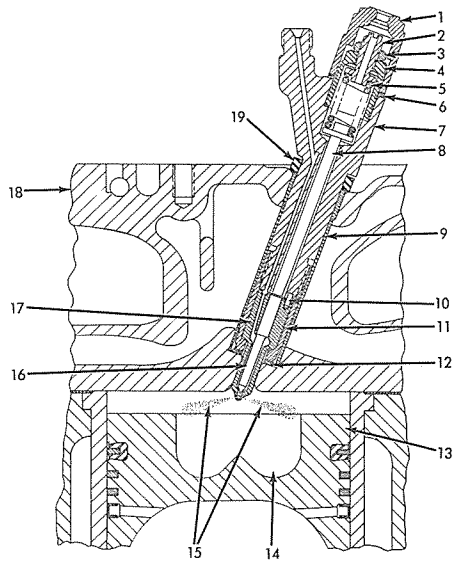


Fig. 6 — Fuel Injection Nozzle-Holder — Installed (T-35178)

1. Protection Cap
2. Pressure Adjusting Screw
3. Adjusting Screw Lock Nut
4. Spring Retaining Nut
5. Spindle Spring
6. Gasket
7. Holder Body
8. Spindle
9. Nozzle Sleeve
10. Dowel
11. Nozzle Retaining Nut
12. Nozzle-Holder Gasket
13. Piston
14. Combustion Chamber
15. Spray Pattern
16. Nozzle Valve
17. Nozzle Valve Body
18. Cylinder Head
19. Dirt Shield

B. FUEL INJECTION NOZZLE-HOLDER OPERATION

The metered quantity of fuel under pressure, delivered by the fuel injection pump, enters the fuel inlet passage of the nozzle-holder, passes through the holder fuel duct into the nozzle fuel duct, and then into the pressure chamber above the nozzle valve seat. At the instant the pressure of the fuel in the pressure chamber exceeds the pressure exerted on the spindle and the nozzle valve by the spindle spring, the nozzle valve is lifted off its seat and the fuel is forced through the orifices in the end of the valve body and into the corresponding combustion chamber of the engine. The nozzle valve is returned to its seat by the pressure exerted by the spindle spring as soon as the fuel injection pump has ceased to deliver fuel to the nozzle-holder.

There is a certain amount of fuel seepage in the nozzle between the lapped surfaces of each nozzle valve and valve body, which is necessary for lubrication. This leakage of fuel accumulates around the spindle and in the spring compartment of the nozzle-holder, and is returned through the fuel return manifold and fuel return lines to the fuel tank.

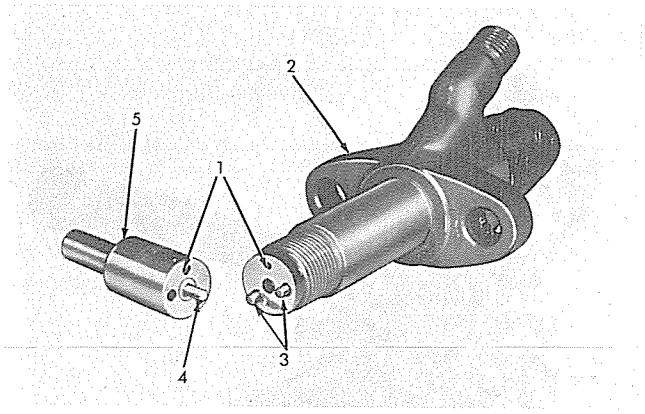


Fig. 7 — Fuel Injection Nozzle-Holder Dowel Location (T-27650)

1. Fuel Ducts
2. Holder Body
3. Dowels
4. Nozzle Valve
5. Nozzle Valve Body

C. FUEL INJECTION NOZZLE-HOLDER SERVICE

The fuel injection nozzle-holder assemblies should be removed after approximately every 2000 hours of operation, tested and adjusted if necessary. The nozzle-holder assembly when properly adjusted should require an opening pressure of (refer to FUEL INJECTION NOZZLE ASSEMBLIES S.M. 70682797). When adjusting "popping" pressure of a new nozzle-holder or a rebuilt nozzle-holder in which a new spindle spring has been installed, the initial "popping" pressure should be set 25 psi higher than specified pressure. This will compensate for the initial set of a new nozzle spindle spring. The opening pressure ("popping" pressure) is adjusted by means of the pressure adjusting screw. Turning the adjusting screw counterclockwise decreases the opening pressure; turning the adjusting screw clockwise increases the opening pressure. A nozzle tester, similar to the one shown in Fig. 10, must be used to observe the opening pressure, spray pattern, and general function of the nozzle.

NOTE

A kit is available, designed to test the operating pressure of the fuel injection nozzles as well as other fuel injection equipment without removing the components from the engine. For further information contact your Fiat-Allis Construction Machinery Dealer.

D. FUEL INJECTION NOZZLE-HOLDER REMOVAL

1. Thoroughly clean the fuel injection nozzle-holders and surrounding area before removing them from cylinder head.

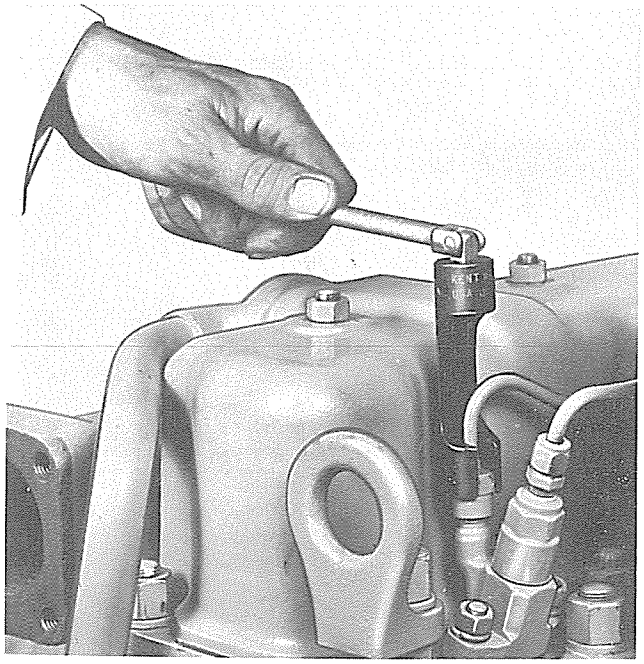


Fig. 8 — Disconnecting Fuel Injection Line from Fuel Injection Nozzle-Holder (T-27628)

2. Loosen the fuel injection line brackets, disconnect the fuel return manifold and fuel injection line from the nozzle-holder, Fig. 8.

CAUTION

Do not bend line when disconnecting. Cover the end of disconnected line to prevent entrance of dirt.

3. Remove the two nuts and lockwashers securing the nozzle-holder assembly to cylinder head. Withdraw the assembly, exercising care not to strike tip of nozzle on any sharp, hard surfaces.

4. If for any reason the nozzle-holder assembly is stuck in the cylinder head, a nozzle-holder puller adapter and slide hammer puller, Fig. 9, can be used to pull the fuel injection nozzle-holder assemblies as follows:

   a. Remove the protection cap, Fig. 12 (1) from holder and turn puller adapter onto holder as shown in Fig. 9. Make certain that puller adapter is turned onto holder as far as possible, then tighten with a wrench.

   b. Turn the end of slide hammer into puller adapter as shown. Before pulling nozzle-holder from cylinder head, bump inward (lightly) on holder with the slide hammer to loosen the nozzle-holder, then pull the nozzle-holder assembly from cylinder head.

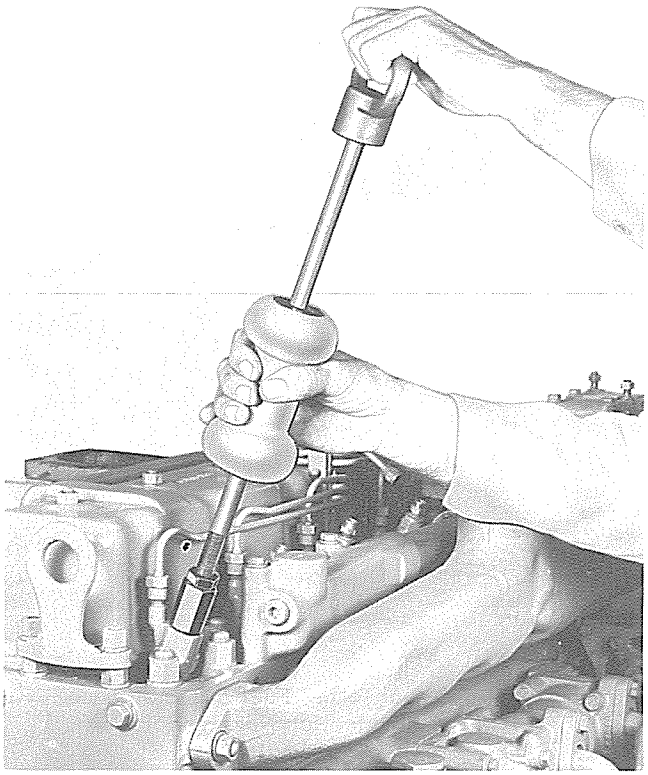


Fig. 9 — Removing Fuel Injection Nozzle-Holder (T-27638)

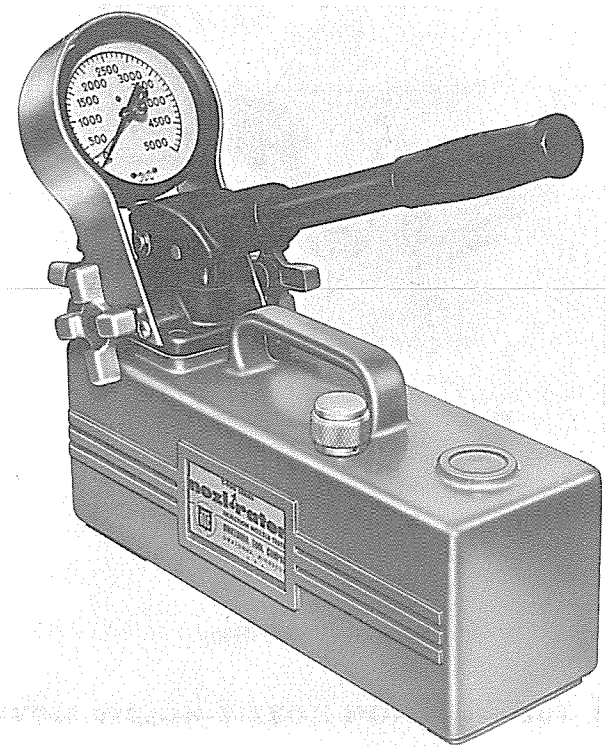


Fig. 10 Fuel Injection Nozzle-Holder Tester (T-72082)

c. Remove the slide hammer puller and nozzle-holder puller adapter. Reinstall protection cap in position on holder.

E. TESTING AND ADJUSTING FUEL INJECTION NOZZLE-HOLDERS

WARNING

Keep hands away from nozzle tip when "popping" a nozzle. The finely atomized fuel is ejected with such force that it may penetrate the skin and cause blood poisoning.

Test and adjust each nozzle-holder as follows:

1. Using a nozzle tester similar to the one shown in Fig. 10, operate tester handle a few quick strokes and observe "popping" pressure of fuel injection nozzle-holder as indicated by pressure gauge of the nozzle tester. For specified pressure, refer to FUEL INJ. NOZZLE ASSEMBLIES S. M. 70682797.

NOTE

When adjusting "popping" pressure of a new nozzle-holder or a rebuilt nozzle-holder in which a new spindle spring has been installed, the initial "popping" pressure should be set 25 psi higher than specified pressure. This will compensate for the initial set of a new nozzle spindle spring. If specified "popping" pressure is not obtained, adjust nozzle-holder as follows:

a. Remove nozzle-holder protection cap Fig. 12 (1), and loosen the adjusting screw lock nut (3).

b. While operating tester handle, turn the pressure adjusting screw (4) IN to increase or OUT to decrease the pressure as necessary to obtain specified "popping" pressure. When specified "popping" pressure is obtained, hold the adjusting screw with a screwdriver and tighten the adjusting screw lock nut. Install and tighten the nozzle-holder protection cap (1) and gasket (2).

2. After adjusting the fuel injection nozzle-holder for specified "popping" pressure, test the nozzle as follows:

a. Wipe tip of the nozzle dry and watch it for about a minute, keeping pressure about 200 pounds below "popping" pressure and observing tip of the nozzle for fuel leakage.

If no leakage is observed, the valve is seating properly on seat in valve body. If any fuel leakage is observed at tip, valve is not seating properly in valve body and the nozzle assembly MUST be removed for cleaning and inspection.

b. If the fuel injection nozzle proved satisfactory when subjected to leakage test above, operate tester handle at a speed of approximately 100 strokes per minute and observe the nozzle spray pattern.

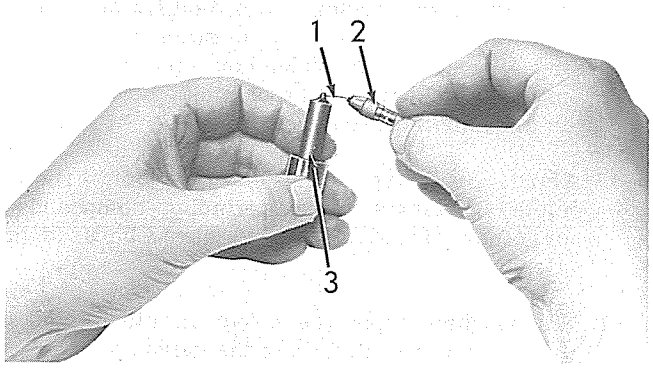


Fig. 11 — Cleaning Holes in Nozzle Valve Body (T-23244)

1. Wire
2. Chuck
3. Valve Body

F. NOZZLE SPRAY PATTERN

The nozzle tip has four equally spaced holes. Nozzles used with American Bosch fuel injection pump have .32 mm (.0126") holes and nozzles used with Roosa Master fuel injection pump have a .375 mm (.0148") holes. The size and spacing of these holes determines the spray pattern and, if fuel is being discharged evenly through all four holes in the nozzle tip at the specified "popping" pressure, the spray pattern is considered satisfactory. If fuel is not being discharged evenly from all four holes in the nozzle tip, a plugged hole or holes is indicated, and the nozzle must be removed and the holes cleaned, Fig. 11, using a wire of the proper diameter.

G. CLEANING AND INSPECTION OF FUEL INJECTION NOZZLE-HOLDER

Before starting the disassembly of a fuel injection nozzle-holder, it is of the utmost importance to have a clean work bench, clean washing fluid containers, clean tools, and clean hands. Cleanliness is emphasized because injection nozzle service troubles are, in most instances, due to dirt entering the nozzles. Use clean paper on the work bench and as the nozzle-holder is disassembled, place the components in a container of clean diesel fuel as a protection against dirt and corrosion.

When more than one fuel injection nozzle-holder is disassembled, keep parts of each separate. Complete disassembly of the fuel injection nozzle-holder is seldom necessary. In most cases only disassembly and cleaning of the nozzle assembly, Fig. 12 (10) (11) is required to place the nozzle-holder in good operational condition. The nozzle valve and nozzle valve body are mated parts, and must be kept together; if replacement of either part is necessary, both parts must be replaced as matched sets. Remove, clean, and inspect the nozzle assembly as follows;

1. NOZZLE VALVE BODY AND VALVE REMOVAL, CLEANING AND INSTALLATION (Fig. 12)

   a. Before disassembly, thoroughly clean the injection nozzle-holder assembly.

   b. Clamp nozzle-holder body (8) in a vise having copper jaws or similar protective material.

   c. Remove protection cap (1) and gasket (2) from upper end of nozzle-holder. Loosen adjusting screw locknut (3) and turn pressure adjusting screw (4) out sufficiently to release spring tension on spindle spring (6).

   d. Using a suitable socket or box wrench, loosen and remove the nozzle retaining nut (12). Remove the nozzle valve body (11) and nozzle valve (10) from the retaining nut (12). Start the nut back onto the holder body to protect the lapped end of the holder body.

   e. Withdraw the valve from the valve body and place them in Allis-Chalmers carbon and rust remover solution for cleaning. Normally, the valve can easily be withdrawn from the valve body, however, in some cases it may be necessary to soak the valve body (11) and valve (10) in the carbon and rust remover solution before the valve can be withdrawn.

WARNING

Do not allow the solution to get on the hands or body; use tweezers or the basket method to handle the parts.

For faster and better cleaning results, the carbon and rust remover solution should be heated to approximately 200°F. The parts generally can be separated in two or three minutes; however, for stubborn cases they can be left in the solution longer.

After removing the parts from the solution,

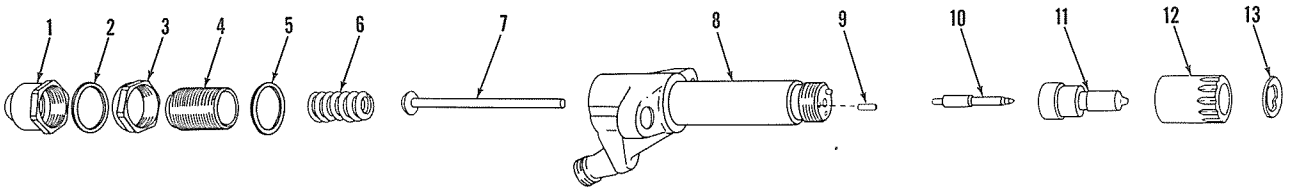


Fig. 12 — Fuel Injection Nozzle-Holder Details
(T-71003)

1. Protection Cap
2. Gasket
3. Adjusting Screw Locknut
4. Pressure Adjusting Screw
5. Gasket
6. Spindle Spring
7. Spindle
8. Holder Body
9. Dowel
10. Nozzle Valve
11. Nozzle Valve Body
12. Nozzle Retaining Nut
13. Nozzle-holder Gasket

immediately place them in clean diesel fuel for neutralizing. Always handle the parts carefully to protect the lapped surfaces.

f. The valve seat and the seat in the valve body are originally ground to slightly different angles to provide a line contact seat between the two parts. Practically all the wear occurs in the seat in the valve body. The valve should never be lapped to the seat in the valve body.

g. Using a magnifying glass, inspect condition of seat in the valve body. If the seat is damaged or worn in any way to prevent proper seating of the valve, the nozzle assembly must be replaced. Examine the lapped bore in valve body for any signs of scoring. If scoring is apparent, the nozzle assembly must be replaced.

h. The outer surfaces of the valve body may be cleaned with a brass wire brush. Do not scrape carbon from the surface around the orifices in tip of valve body with any hard object as damage may result.

i. Using proper size wire, clean the four orifices in the valve body tip.

j. Visually inspect the condition of the valve, preferably with aid of a magnifying glass. The lapped surface (large O.D.) of the valve must be smooth and free of signs of scoring. Also, the valve must not show any wear or damage at seat location. If the valve is damaged in any way, the nozzle assembly must be replaced.

k. Thoroughly rinse the valve and valve body in clean diesel fuel or calibrating oil. The valve must fit freely in the valve body. To check this fit, lift valve about one third of its length out of the body. The valve should slide down to its seat without aid when assembly is held at a 45° angle.

If the fit of the valve in the valve body is unsatisfactory, the valve may be cleaned and polished with Allis-Chalmers 1000G lapping compound and castor oil used on tissue paper. The valve may be held by its stem in a revolving chuck for this cleaning operation. An orange stick or round toothpick will be helpful in cleaning the valve.

Hard, or sharp tools, emery cloth, crocus cloth, jeweler's rouge, grinding compounds, or other abrasives should never be used in cleaning.

l. Thoroughly rinse the valve in clean diesel fuel before installing it in the valve body.

m. Examine the flat sealing surface of the valve body (surface which contacts lower end of the holder body) and make certain surface is clean and free of scratches. This surface may be lapped, if necessary, using Allis-Chalmers lapping compound, castor oil, and a lapping block as shown in Fig. 13. After lapping, remove all traces of lapping compound with clean diesel fuel.

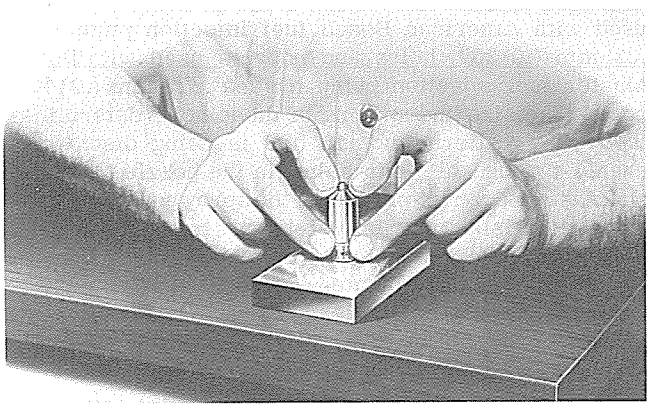


Fig. 13 — Lapping Fuel Injection Nozzle Valve Body
(T-20655)

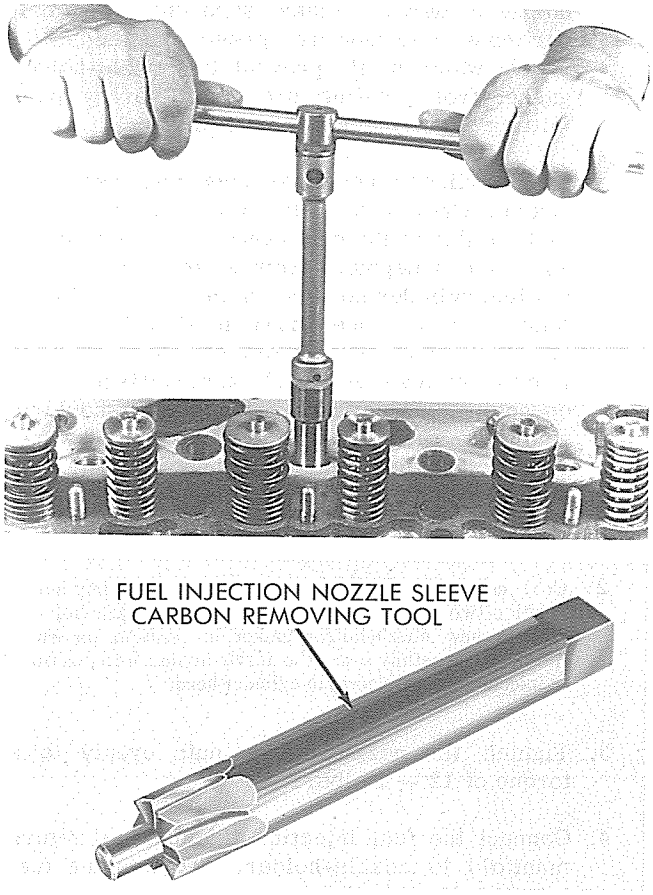


Fig. 14 — Cleaning Carbon from Fuel Injection Nozzle Sleeve (T-29500 & T-23031)

n. Make certain that the bottom flat sealing surface of the nozzle-holder body is clean and in good condition. Rinse the valve and valve body in clean diesel fuel, then insert valve into position in valve body. Place the nozzle in position on the two dowels of the nozzle-holder body. Lower the nozzle retaining nut Fig. 12 (12) into position over the valve body. Tighten nut to a torque of 40 — 60 lbs. ft.

NOTE

Pressure adjusting screw must be completely backed out prior to this assembly, otherwise dowels may damage nozzle seal face.

o. Adjust and test the fuel injection nozzle (refer to "TESTING AND ADJUSTING FUEL INJECTION NOZZLE-HOLDERS" in this Topic).

2. NOZZLE-HOLDER DISASSEMBLY, CLEANING AND ASSEMBLY

If malfunctioning of the fuel injection nozzle-holder was not corrected by removal and cleaning of the nozzle valve body and valve, disassemble and clean the nozzle-holder as follows:

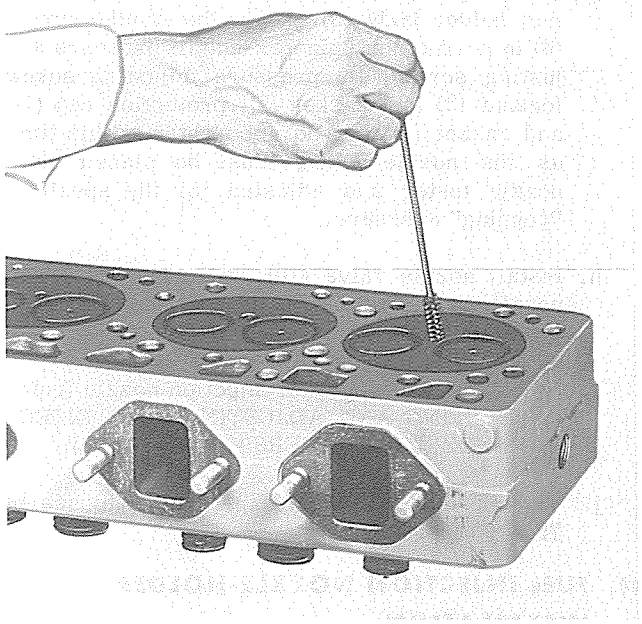


Fig. 15 — Cleaning Fuel Injection Nozzle Tip Hole in Cylinder Head (T-29501)

a. Clamp nozzle-holder assembly in a copper jawed vise and remove the protection cap, Fig. 12 (1) and gasket (2) from upper end of nozzle-holder. Loosen and remove the adjusting screw locknut (3) and gasket (5).

b. Remove pressure adjusting screw (4), spindle spring (6) and spindle (7).

c. Remove nozzle retaining nut (12), nozzle valve body (11) and nozzle valve (10).

d. Place all parts in clean diesel fuel. Using filtered compressed air, blow out the fuel passages in the holder body (8).

e. Visually inspect the parts for damage or wear and replace the necessary parts. Examine the flat sealing surface of holder body (surface which contacts upper end of valve body) and make certain the surface is clean and free from scratches. This surface should be lapped if necessary, using Allis-Chalmers 1000G lapping compound, castor oil, and a lapping block. When lapping, use care to keep the nozzle holder body square with the lapping block to assure contact with the entire area being re-surfaced. After lapping remove all traces of the lapping compound with clean diesel fuel and dry with filtered compressed air.

f. Examine the spindle spring. If the spring is scratched or pitted, it must be replaced. Also the spring must be replaced if the ends have

worn. Always replace questionable springs.

g. Rinse spindle (7) in clean fuel and insert it into holder body (8). Place the spindle spring (6) in position on spindle. Install pressure adjusting screw (4), pressure adjusting screw locknut (3) and gasket (5), protection cap (1), and gasket (2), but do not tighten at this time as the nozzle-holder must be placed on a nozzle tester and adjusted for the specified "popping" pressure.

h. Install nozzle valve (10), valve body (11), and nozzle retaining nut (12). Tighten nut to a torque of 40 — 60 lbs. ft.

i. Adjust and test the fuel injection nozzle (refer to "TESTING AND ADJUSTING FUEL INJECTION NOZZLE-HOLDERS" in this Topic).

j. Tighten the protection cap (1) to a torque of 75 — 90 lbs. ft.

H. FUEL INJECTION NOZZLE-HOLDER INSTALLATION

1. Thoroughly clean the inside of the nozzle-holder sleeves before installing the nozzle-holders. When cleaning the nozzle sleeves, make certain that the old nozzle-holder gaskets are removed from the sleeve as new gaskets, Fig. 12 (13), must be used when installing the nozzle-holders. Make sure that no small particles of carbon are present in the nozzle sleeve which would prevent the nozzle-holder gasket from seating properly, thereby permitting "blow-by" from the cylinder.

   When cylinder head has been removed from engine, it is advisable to use a carbon removing tool similar to the one shown in Fig. 14 to clean any carbon deposits from sleeves before installing cylinder head on engine. A wire brush similar to the one shown in Fig. 15 may be used to clean carbon from the nozzle tip hole in cylinder head before cylinder head is installed on engine. Under no circumstances should an engine be operated with a leaky or "blowing-by" nozzle-holder, this will cause a localization of heat which will distort the nozzle-holder, resulting in serious damage.

2. Coat nozzle-holder threads with anti-seize compound. Position two new rubber dust shields on the nozzle-holder. Place a new nozzle-holder gasket in position on each nozzle and carefully insert the nozzle-holders into position in injection nozzle sleeves in cylinder head.

3. Tighten the nozzle-holder nuts evenly to a torque of 12 — 15 lbs. ft.

4. Connect the fuel injection line and fuel return manifold to nozzle-holder. Tighten the fuel injection line brackets.

TOPIC 5 - FUEL INJECTION NOZZLE-HOLDER SLEEVES

A. DESCRIPTION

The bore in the cylinder head for each fuel injection nozzle-holder extends directly through the cylinder head water jacket. To prevent engine coolant from contacting the fuel injection nozzle-holder, a stainless steel sleeve is pressed into the cylinder head at each fuel injection nozzle bore. The sleeve forms a water tight receptacle for the fuel injection nozzle-holder. The coolant in the cylinder head flows around the stainless steel sleeve and helps to cool the fuel injection nozzle-holder.

B. FUEL INJECTION NOZZLE-HOLDER SLEEVE REMOVAL

Whenever the cylinder head is removed from the engine, the nozzle-holder sleeve and tip hole in cylinder head should be thoroughly cleaned, Figs. 14, 15 and inspected. If condition of the sleeve is such that replacement is necessary, the sleeve may be removed as follows:

1. Using tools similar to the ones shown in Fig. 16, screw the 7/8" tap down into fuel injection nozzle-holder sleeve as shown in Fig. 17.

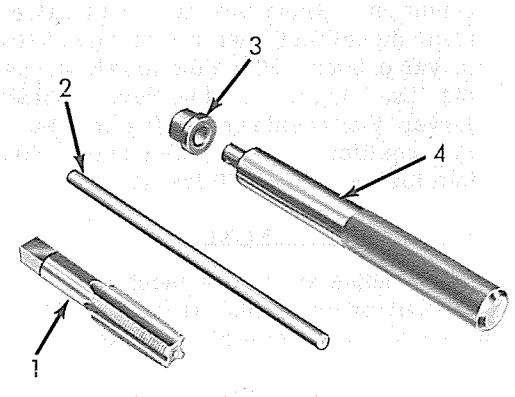


Fig. 16 — Fuel Injection Nozzle-Holder Sleeve Removing and Installing Tool Details (T-22342)

1. 7/8" Tap
2. Driving Rod
3. Sleeve Installing Tool
4. Handle

2. Insert driving rod, Fig. 16 (2), through the nozzle tip hole in bottom of the cylinder head,

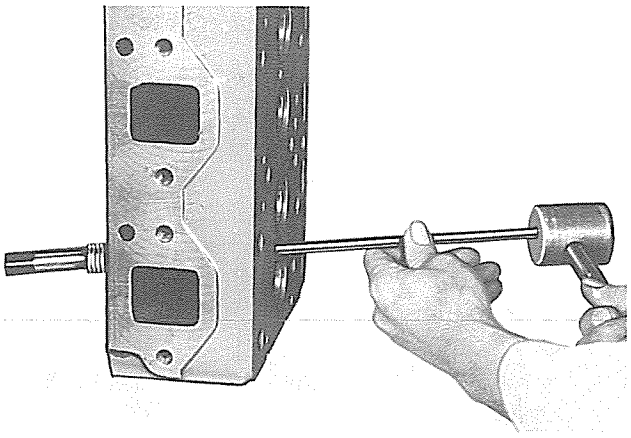


Fig. 17 — Removing Fuel Injection Nozzle-Holder Sleeve (T-27647)

and using a hammer, drive sleeve out of the cylinder head.

C. FUEL INJECTION NOZZLE-HOLDER SLEEVE INSTALLATION

1. Thoroughly clean the bore in the cylinder head for injection nozzle-holder sleeve.

2. Clean new nozzle-holder sleeve with a solvent and dry. Apply sealant to the sleeve at the top and bottom outside surfaces which contact the head. Use grade A "Loctite Sealant" or equivalent.

3. Install sleeve in position in cylinder head, with the end of sleeve having the large O.D. toward the top. Using tools similar to the ones shown in Fig. 18, drive sleeve into position in cylinder head until it bottoms solidly in the bore.

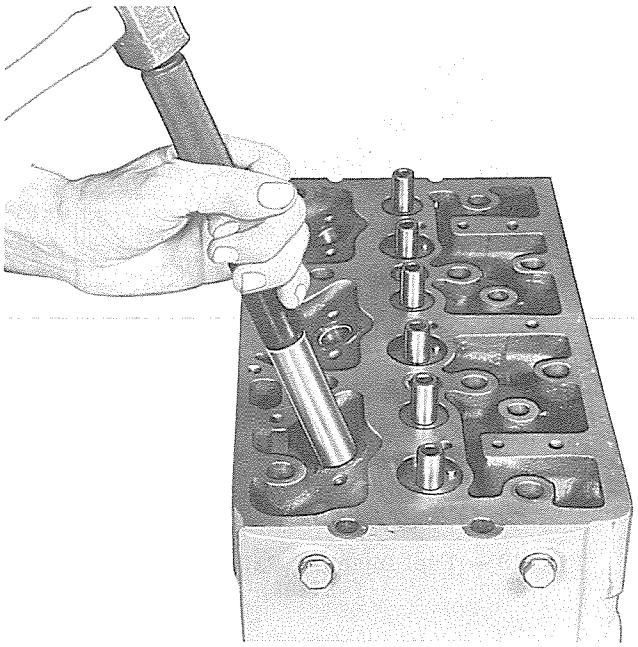


Fig. 18 — Installing Fuel Injection Nozzle-Holder Sleeve (T-27620)

4. Install cylinder head on engine (refer to "VALVES, VALVE OPERATING MECHANISM, AND CYLINDER HEAD" Section).

TOPIC 6 - FUEL INJECTION PUMP AND GOVERNOR

A. DESCRIPTION

The engine is equipped with an "American Bosch" (Type PSB) heavy-duty fuel injection pump having a mechanical-centrifugal type internal spring governor. The fuel pump is of the constant stroke, multi-outlet, single and distributing-plunger, sleeve control type, the plunger being actuated by a cam and tappet arrangement which also carries the gearing for the distribution function. The fuel injection pump incorporates a "low volume" hydraulic head. The delivery valve is located in a horizontal position in the side of the hydraulic head. The purpose of the pump is to meter fuel accurately and deliver it precisely at a definite moment in the engine cycle and under high pressure to the fuel injection nozzles. The fuel injection pump is driven at crankshaft speed by the pump drive gear in mesh with the engine camshaft gear. The pump receives lubrication from the engine lubricating system.

The engine governor is of the mechanical-certrifugal type and is attached to the rear of the fuel injection pump as an integral unit. The governor is driven directly from the end of the fuel injection pump camshaft. The purpose of the governor is to serve as a means for pre-setting and maintaining within close regulation any desired engine speed within nominal idling and nominal maximum speed range.

NOTE

The two types of fuel injection pumps illustrated in Figs. 19 and 20, are basically similar and the information contained in this section pertains to both.

B. FUEL INJECTION PUMP OPERATION

1. PUMPING

Fuel enters the hydraulic head at the fuel supply intake, Fig. 21 (8) and fills the cavity at the top of plunger (5) when the plunger is at the bottom of its

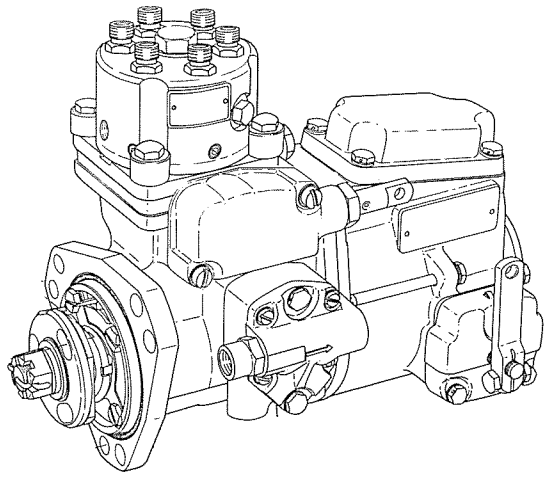


Fig. 19 — Fuel Injection Pump (Early Model)
(T-24203)

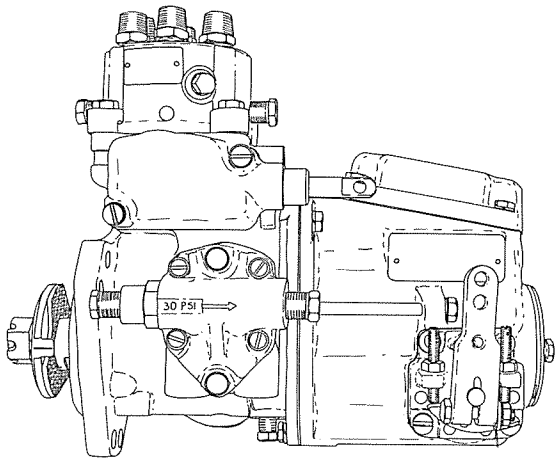


Fig. 20 — Fuel Injection Pump (Late Model)
(T-71408)

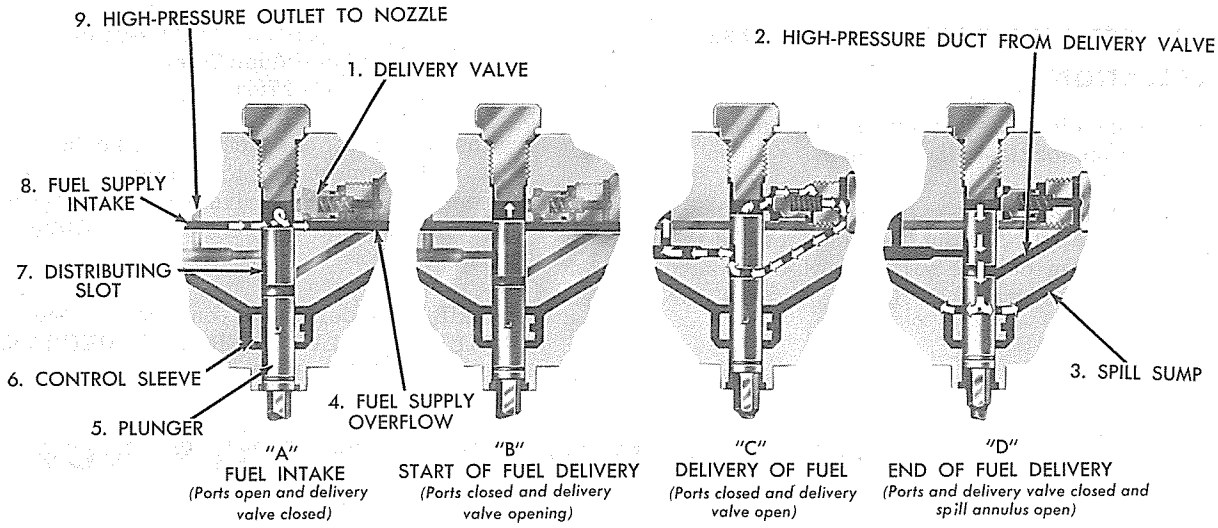


Fig. 21 — Fuel Injection Pump Pumping Cycles
(T-29548)

stroke. As the rotating plunger moves upward in its stroke it passes and closes the intake ports, trapping and compressing the fuel, and the fuel under pressure opens the spring-loaded delivery valve (1). As the plunger continues its upward stroke, the fuel which is forced through the delivery valve, is conveyed through the communicating ducts to the annulus in the plunger and then through the vertical distributing slot (7) on the plunger to the outlet duct with which the distributing slot is then registering as the plunger rotates, "B" and "C". After sufficient upward movement of the plunger, its lower annulus passes the edge of the control sleeve (6) and the fuel under pressure escapes down the vertical hole in the center of the plunger and into the sump of the control sleeve, which is at fuel supply pressure "D". With collapse of the pressure, the delivery valve closes and the piston portion of the valve blocks the passage before the valve reaches its function of reducing the residual pressure in the discharge system. This is the end of the pumping cycle.

2. METERING AND CONTROL

The quantity of fuel delivered per stroke is governed by variation of the position of the control sleeve, Fig. 22 (6) in relation to the fixed port closing position (the point at which the top of the plunger (9) covers

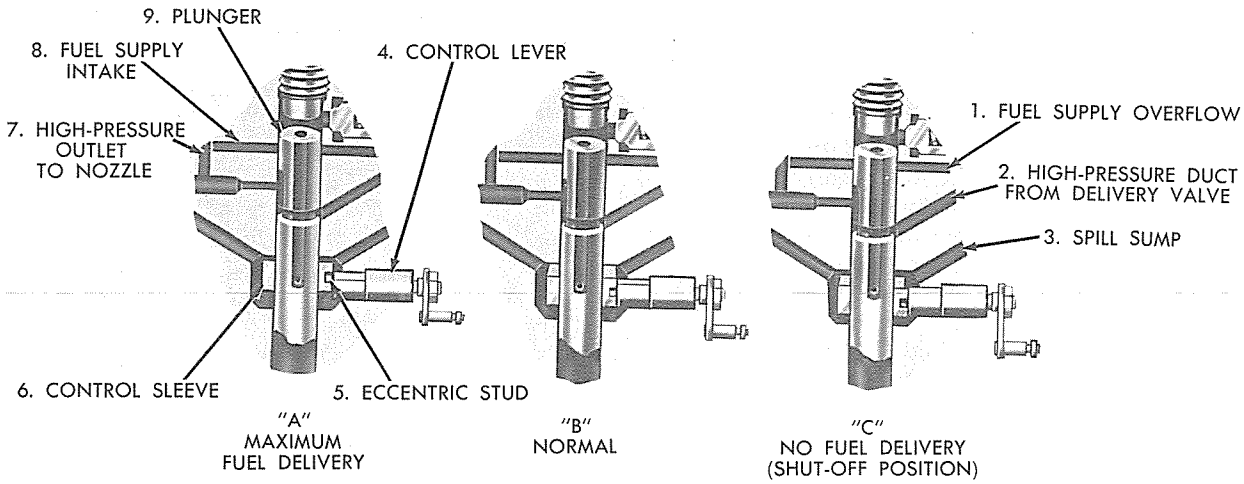


Fig. 22 — Fuel Injection Pump Control Sleeve Positions
(T-29549)

the intake ports), for as the spill annulus on the plunger breaks over the top edge of the control sleeve, pumping pressure is relieved down through the center hole of the plunger and out into the sump surrounding the control sleeve, and delivery terminates despite the continued upward movement of the plunger.

If the control sleeve position is raised, the spill annulus on the plunger remains covered by the sleeve until relatively late in the plunger stroke, hence the effective fuel delivery stroke of the plunger is longer and more fuel is delivered "A". If the control sleeve position is lowered, the spill annulus on the plunger is uncovered by the sleeve relatively sooner in the plunger stroke, hence the effective fuel delivery stroke of the plunger is shorter and less fuel is delivered, "B". The position of the control sleeve is controlled by governor movement transmitted by an internal control rod connecting the fulcrum lever of the governor to the sleeve control lever (4) of the fuel injection pump.

When the control sleeve is lowered to its extreme point, "C". The spill annulus on the plunger is uncovered by the top edge of the sleeve before the upper end of the plunger can cover the intake ports. Under this condition, no pressure can build up even after the ports are closed, hence no fuel can be delivered by the plunger. This is the fuel shut-off position.

C. FUEL INJECTION PUMP SERVICE

In most cases, malfunctioning of the fuel injection equipment is the direct result of dirty fuel. Dirt in the fuel causes rapid wear on the precision parts, particularly the plunger, hydraulic head, control sleeve, delivery valves and seats, and the fuel injection nozzle valves and valve bodies. Therefore, extreme care should be used in the storage and handling of fuel to prevent the entrance of dirt, water, and abrasive particles. Any water or sediment should be drained from the fuel filters daily.

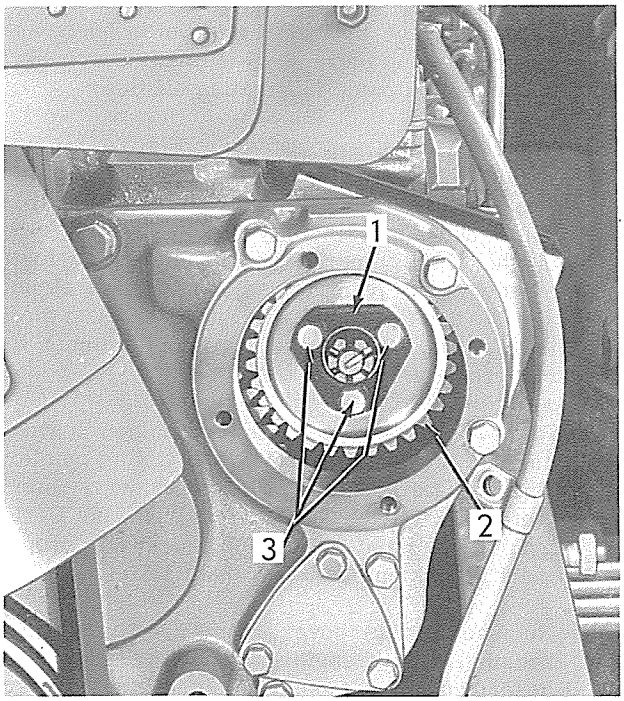


Fig. 23 — Fuel Injection Pump Drive Gear Installed (Engines Without Fan Drive Pulley)
(T-15281)

1. Serrated Plate
2. Fuel Injection Pump Drive Gear
3. Gear Attaching Capscrews

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

The fuel injection pump and governor assembly is lubricated by the engine lubricating system. No lubrication service on the injection pump and governor assembly is required.

Fiat-Allis Construction Machinery Dealers are equipped with Fuel Injection Pump Calibrating and Test Stands and the special tools required to test, adjust, and repair the fuel injection pump and governor assembly. Therefore, if at any time the fuel injection pump and governor assembly requires repairs or adjustment, the assembly should be removed and taken to your nearest Fiat-Allis Construction Machinery Dealer. It is important that the dealer be furnished with the injection pump serial number and the model and serial number of the unit so that the pump may be properly calibrated.

D. FUEL INJECTION PUMP REMOVAL

The fuel injection pump removal procedure for engines equipped with a fan drive pulley, Fig. 29 is slightly different than for engines equipped with a fan driven from the crankshaft pulley. The following removal procedure applies to both types unless otherwise stated.

1. Disconnect engine shut-off and throttle control linkage from the fuel injection pump.

2. Shut off fuel supply.

3. Disconnect the fuel inlet and outlet hoses and fuel return and fuel injection lines. Disconnect fuel injection pump lubricating oil line.

4. Remove timing window cover, Fig. 24 (7) and crank engine by hand until the marked tooth, Fig. 26 (2), of the plunger drive gear (4) is positioned approximately one tooth to the rear of the timing mark (1). The marked tooth beside being painted red, has a line etched across the tip of the tooth. With marked tooth in this position, #1 piston is near the top on its compression stroke.

5. Remove timing hole cover from engine flywheel housing and make certain that timing pointer, Fig. 25, is aligned with the proper degree mark (refer to "TIMING CHART" in following Paragraph). If pointer is not aligned with proper mark, crank engine by hand until it is.

6. Remove access cover from the timing gear housing. With engine flywheel positioned as described in preceding step, timing pointer, Fig. 30 (1), should be aligned with timing mark (2) on the pump drive gear hub.

   The engine is now in correct position for beginning of fuel injection into #1 cylinder and for removing or installing the fuel injection pump. If the timing marks on engine flywheel, plunger drive gear, and pump drive gear hub cannot be aligned as described above, the fuel injection pump is not properly timed to the engine (refer to "FUEL INJECTION PUMP INSTALLATION AND TIMING" in this Topic).

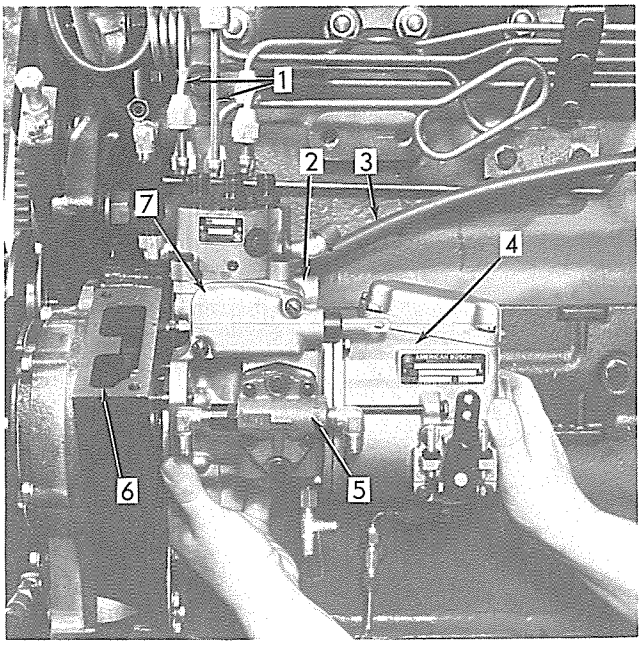


Fig. 24 — Removing Typical Fuel Injection Pump (T-71445)

1. Fuel Injection Lines
2. Fuel Injection Pump
3. Second Stage Fuel Filter-to-Pump Hose
4. Governor
5. Fuel Transfer Pump
6. Access Hole in Timing Gear Housing
7. Timing Window Cover

7. On engines equipped with a fan drive pulley, proceed as follows:

   a. Remove pump attaching stud nuts and lockwashers and remove fuel injection pump and governor as unit, Fig. 24.

CAUTION

When removing fuel injection pump, use care to prevent loss of coil spring located in end of pump timing shaft, Fig. 28.

   b. If for any reason the pump timing shaft, Fig. 28 (1), must be removed, it may now be pushed or driven, toward the rear, out of the fan drive gear hub.

8. On engines with a fan driven from the crankshaft pulley, proceed as follows:

   a. Remove fuel injection pump drive gear access cover from front side of timing gear housing.

   b. Remove capscrews Fig. 23 (3), serrated

plate (1), and drive gear (2) from drive gear hub.

c. Remove pump attaching stud nuts and lockwashers and remove fuel injection pump and governor as a unit, Fig. 24.

E. FUEL INJECTION PUMP INSTALLATION AND TIMING

The fuel injection pump installation and timing procedures for engines equipped with a fan drive pulley, Fig. 29, are slightly different than for engines equipped with a fan driven from the crankshaft pulley. The following procedures apply to both types unless otherwise stated.

1. Before installing the pump on the engine, make certain the #1 piston is on its compression stroke. This may be determined as follows:

   a. Remove the rocker arm rear cover so valve action can be observed.

   b. Crank engine by hand until #6 cylinder exhaust valve is nearly closed and #6 cylinder intake valve is just beginning to open. This will position #1 piston near the top on its compression stroke.

2. Continue rotating the flywheel until the timing pointer, Fig. 25, indicates the specified number of degrees B.T.D.C. on the flywheel (refer to following table).

TIMING CHART

UNITS	SET FLYWHEEL TIMING POINTER AT:
Track-Type Tractors and Motor Graders Without Torque Converter	30° B.T.D.C.
Track-Type Tractors with Torque Converter	32° B.T.D.C.
Tractor Loaders and Tractor Dozers:	
TL20D	32° B.T.D.C.
D30	33° B.T.D.C.
TL30D	34° B.T.D.C.

IMPORTANT

To be sure that all slack is out of the timing gears, back up the engine a few degrees and again come up to the timing mark in the direction of normal engine rotation (clockwise viewed from front). The engine is now in correct position for beginning of fuel injection into number one cylinder and for installing the fuel injection pump or for checking its timing.

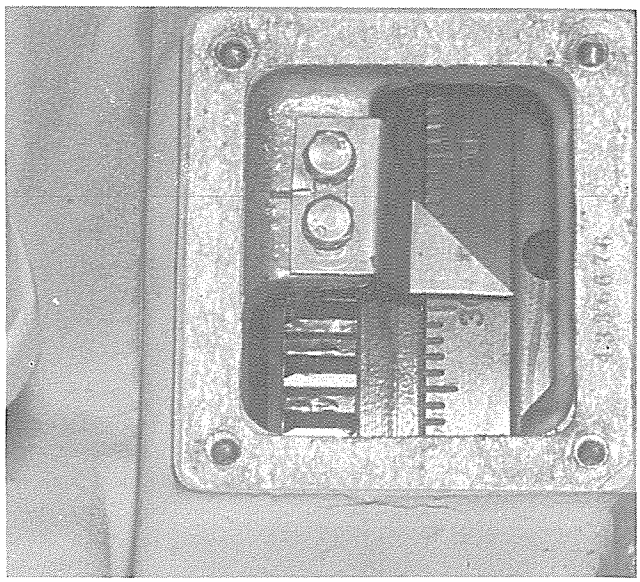


Fig. 25 — Timing Mark on Engine Flywheel Indicating 30°
(T-71410)

3. Remove timing window cover, Fig. 24 (7) from fuel injection pump. One tooth of the plunger drive gear is marked (painted red and etched) for timing fuel injection pump for injection of fuel into #1 cylinder. Turn the pump drive gear or hub until marked tooth of the plunger drive gear is positioned approximately one tooth to the rear of the timing mark, Fig. 26 (1), in pump housing, then hold drive hub stationary. While holding drive gear hub in the above position, timing mark on hub should be aligned with timing pointer as shown in Fig. 27 (1) (2). With timing mark on the plunger drive gear and timing mark on pump drive gear hub positioned as described above, the pump is properly timed for installation on engine.

NOTE

When the drive gear hub is released for installation of pump on engine, the hub will rotate slightly counterclockwise due to spring pressure on the cam.

4. On engines equipped with a fan drive pulley, install and time fuel injection pump as follows:

   a. Loosen capscrews attaching pump drive gear to drive gear hub. Install O-ring gasket in position on pump mounting flange. Center capscrews in slots in drive gear hub and tighten the upper-most capscrew.

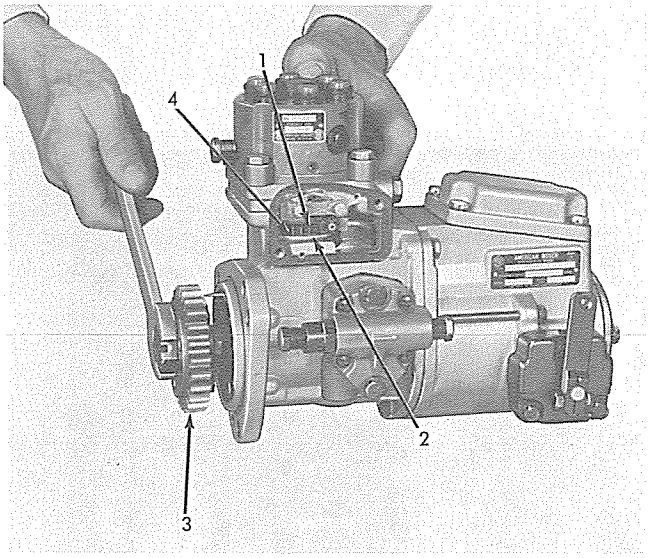


Fig. 26 — Plunger Drive Gear Positioned for Installation of Pump on Engine (T-27634)

1. Timing Mark
2. Marked Tooth Positioned Approximately One Tooth to Rear of Timing Mark
3. Pump Drive Gear
4. Plunger Drive Gear

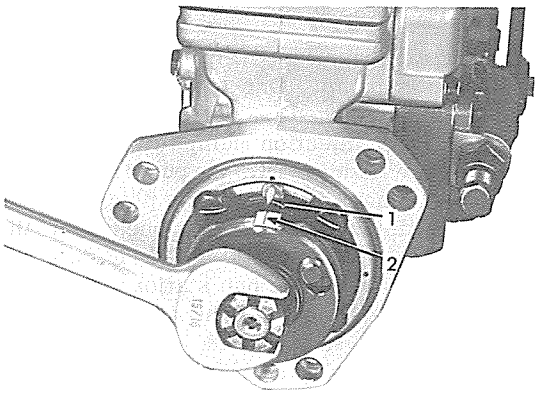


Fig. 27 — Timing Mark on Pump Drive Gear Hub Aligned With Timing Pointer (T-27635)

1. Timing Pointer
2. Timing Mark on Pump Drive Gear Hub

b. If pump timing shaft, Fig. 28 (1) was removed, install pump timing shaft using a new sealing ring. Insert coil spring (2) into position in end of the timing shaft.

c. Start fuel injection pump into position on studs in timing gear housing. Just before external teeth of pump drive gear enter internal teeth of fan drive gear, position marked tooth Fig. 26 (2), of plunger drive

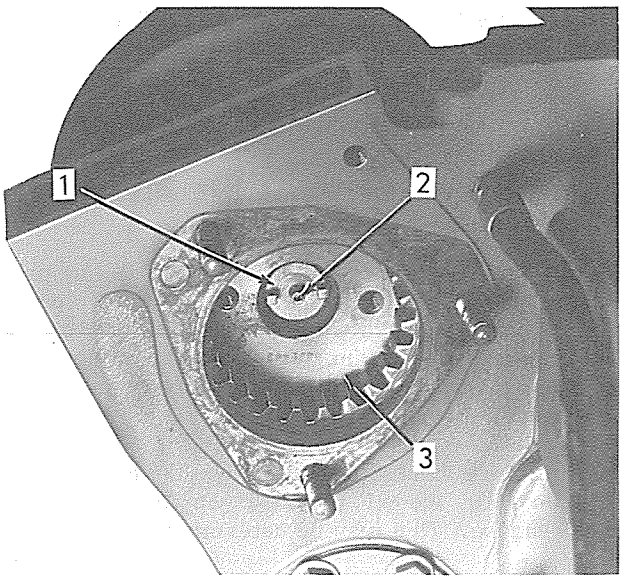


Fig. 28 — Pump Timing Shaft and Spring Installed (Used Only on Engines With Fan Drive Pulley) (T-29507)

1. Pump Timing Shaft
2. Coil Spring
3. Fan Drive Gear

gear and timing pointer, Fig. 30 (1), as described in preceding Step. This can be accomplished by using a screwdriver, or similar tool and working through access hole, Fig. 24 (6), in timing gear housing. With timing marks in this position, push pump forward so that external teeth of pump drive gear mesh with internal teeth of fan drive gear.

NOTE

If pump will not seat itself, continue to push pump forward while slowly turning pump timing shaft, Fig. 29. This will allow the tangs on the timing shaft to align with the slots in the hub retaining nut and allow the pump to seat.

d. Install and tighten pump attaching stud nuts and lockwashers.

e. Loosen the one pump drive attaching capscrew (tightened in Step a.) then using a wrench on the front end of pump timing shaft, Fig. 29, turn timing shaft as necessary to align timing mark on pump drive gear hub with timing pointer as shown in Fig. 30. Hold pump timing shaft in this position and securely tighten one of the capscrews attaching the pump drive gear to drive gear hub. Crank engine by hand, as necessary, and tighten remaining two capscrews.

5. On engines with a fan driven from the crank-

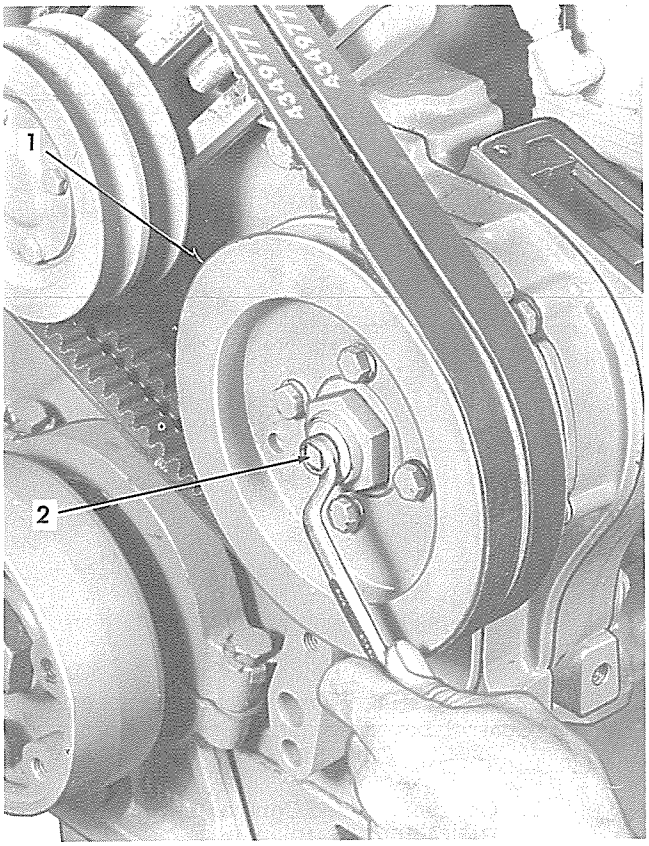


Fig. 29 — Aligning Timing Mark on Pump Drive Gear Hub With Timing Pointer (Engines With Fan Drive Pulley)
(T-29504)

1. Fan Drive Pulley
2. Pump Timing Shaft

shaft pulley, proceed as follows:

a. Install O-ring gasket in position on pump mounting flange and install pump into position on mounting studs. Secure pump with stud nuts and lockwashers.

b. Install pump drive gear, Fig. 23 (2) on drive gear hub. Install serrated plate (1) and start attaching capscrews (3) but do not tighten at this time.

NOTE

The elongated holes in the pump drive gear are provided so that the drive gear hub can be turned slightly to accurately align the timing pointer and timing mark, Fig. 30.

c. Using a wrench on the drive gear hub retaining nut, Fig. 31, turn the nut to align the timing mark on the drive gear hub with the timing pointer, Fig. 30. While holding the timing mark in alignment with the timing pointer, tighten the three pump drive gear attaching capscrews, Fig. 31.

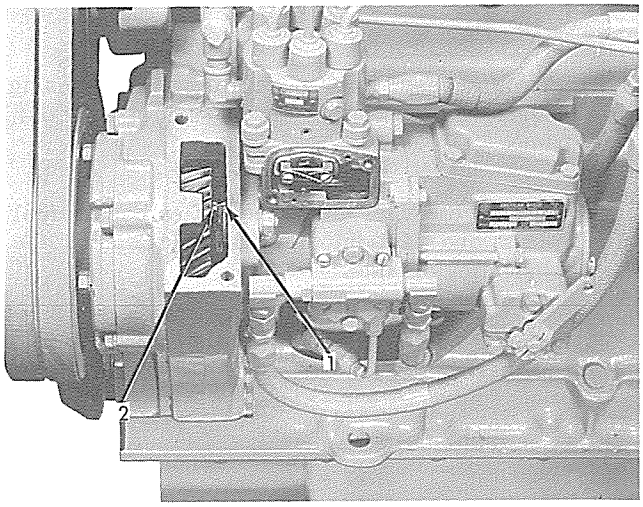


Fig. 30 — Typical Fuel Injection Pump Timing Pointer Location
(T-27630)

1. Timing Pointer
2. Timing Mark on Pump Drive Gear Hub

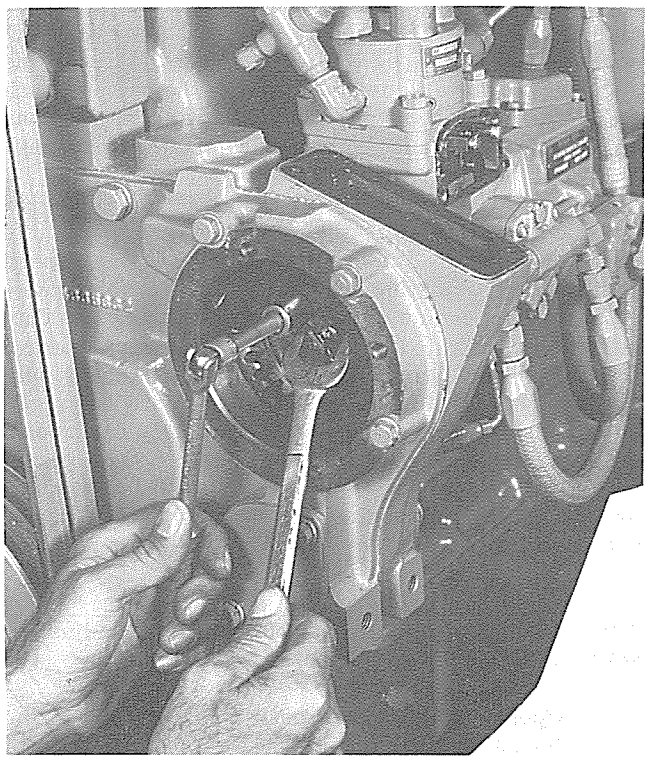


Fig. 31 — Aligning Timing Mark on Pump Drive Gear Hub With Timing Pointer and Tightening Gear Attaching Capscrews (Engines Without Fan Drive Pulley)
(T-29520)

d. Using a new gasket, install pump drive gear access cover on front side of timing gear housing.

6. Install timing hole cover on engine flywheel housing.

7. Install access cover on timing gear housing. Install timing window cover on fuel injection pump.

8. Connect the fuel inlet and outlet hoses, fuel return and fuel injection lines. Connect the lubricating oil line.

9. Connect engine shut-off and throttle control linkage.

10. Open fuel tank shut-off valve.

11. Vent the fuel system (refer to "VENTING OF FUEL SYSTEM" in this Section).

F. GOVERNOR ADJUSTMENT

With the exception of low and high idle engine speeds, all governor adjustments should be performed by an authorized serviceman with factory approved test equipment. For specified high and low idle engine speeds, which vary depending upon the unit in which the engine is used, refer to the Operating Instructions and Field Maintenance Manual furnished with the unit.

On rubber tired units the engine low and high idle speeds are controlled directly by the governor speed control lever adjusting screws, Fig. 32 (2) (5) Track-type tractor engines are equipped with heavy duty adjusting screws, located on the operating control bracket. When the engine is equipped with heavy duty adjusting screws, the governor speed control low idle adjusting screw, Fig. 32 (5) is set slightly lower than specifications and the high idle adjusting (2) screw is set slightly higher than specifications. This is done in order to make certain the heavy duty adjusting screws act as stop screws.

Adjust the governor speed control lever adjusting screws, Fig. 32 (2) (5), as follows:

1. Operate the engine until minimum operating temperature is obtained.
2. Disconnect throttle linkage from governor speed control lever (1) so the lever may be moved by hand.
3. On early model fuel injection pumps, Fig. 19, remove the speed adjusting screw access cover from governor.

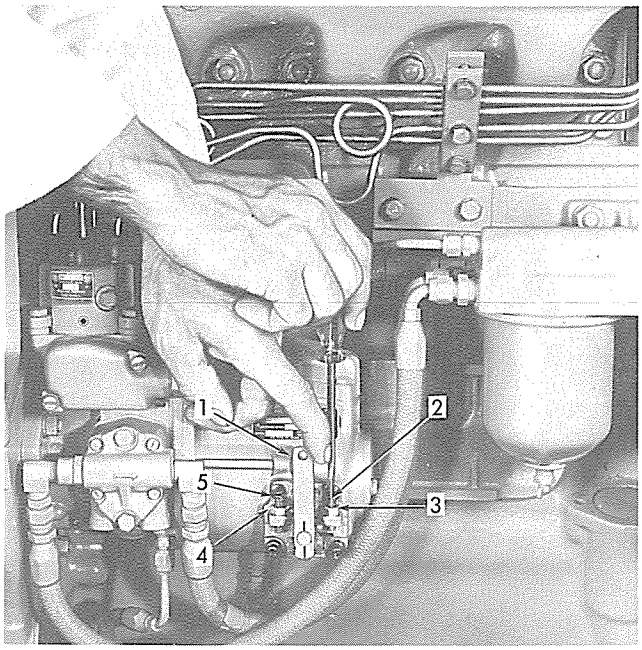


Fig. 32 — Adjusting Typical Governor Speed Control Lever Adjusting Screws (T-27642)

1. Governor Speed Control Lever
2. High Idle Adjusting Screw
3. Jam Nut
4. Jam Nut
5. Low Idle Adjusting Screw

4. With engine running, loosen jam nut (4) on low idle adjusting screw (5). Hold speed control lever (1) so control lever shaft stop plate is tight against the low idle adjusting screw (5). Turn adjusting screw as necessary to increase or decrease the low idle speed. When the specified low idle speed is obtained, hold the adjusting screw and tighten the jam nut (4).

5. Loosen jam nut (3) on high idle adjusting screw (2). Hold speed control lever (1) so control lever shaft stop plate is tight against high idle adjusting screw (2). Turn adjusting screw as necessary to increase or decrease the high idle speed. When the specified high idle speed is obtained, hold the adjusting screw and tighten the jam nut (3). Stop the engine.

6. On early model fuel injection pumps, Fig. 19, install the speed adjusting screw access cover.

7. Connect the throttle linkage to the governor speed control lever (1).

TOPIC 7 - VENTING OF FUEL SYSTEM

A. VENTING OF LOW PRESSURE FUEL SYSTEM

Vent first stage and second stage fuel filters and the low pressure fuel lines as follows:

1. Make certain level of fuel in fuel tank is above fuel filters, then loosen first stage fuel filter vent screw, Fig. 33 (4), and allow filter to fill with fuel by gravity. When fuel (free of bubbles) flows from around loosened vent screw, tighten vent screw securely.

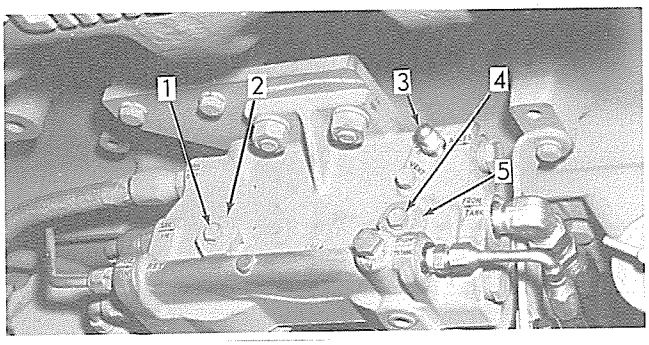


Fig. 33 — Location of Low Pressure Fuel System Vent Screws (T-71005)

1. Second Stage Fuel Filter Vent Screw
2. Second Stage Fuel Filter Shell Retaining Nut
3. Fitting for Fuel Pressure Gauge Line
4. First Stage Fuel Filter Vent Screw
5. First Stage Fuel Filter Shell Retaining Nut

2. Loosen second stage fuel filter vent screw (1) and crank engine with starter until fuel (free of bubbles) flows from around loosened vent screw, then tighten vent screw securely.

B. VENTING OF HIGH PRESSURE FUEL SYSTEM

The high pressure fuel system is usually self-venting due to the fact that any air trapped by the fuel injection pump is forced out through the fuel injection nozzles and into the engine combustion chambers. However, if the fuel lines have been removed, the engine has run out of fuel, or the unit has not been operated for some time, venting of the high pressure fuel system may be necessary to facilitate starting of the engine.

Vent the high pressure fuel system as follows:

1. Loosen fuel line connection nut attaching each fuel injection line to its corresponding fuel injection nozzle-holder.

2. Place engine throttle in high speed position and push engine shut-off knob to run position.

3. Crank engine with starter until fuel flows from the ends of all fuel injection lines. Connect fuel injection lines to fuel injection nozzle-holders and tighten fuel line connection nuts.

TOPIC 8 - FUEL TRANSFER PUMP

A. GENERAL

The fuel injection pump is equipped with a positive-displacement gear type fuel transfer pump. The transfer pump is mounted on a pad on the left side of the injection pump housing, and is driven by a gear which meshes with the injection pump integral camshaft gear.

B. FUEL TRANSFER PUMP SERVICE

If tests described in "CHECKING OF FUEL SYSTEM" in this Section, indicate that the fuel transfer pump is inoperative, the fuel transfer pump must be removed and replaced as a unit.

C. FUEL TRANSFER PUMP REMOVAL AND INSTALLATION

1. Close fuel tank shut-off valve.

2. Disconnect fuel inlet and outlet lines at fuel transfer pump. Remove two hex-head capscrews attaching fuel transfer pump to fuel injection pump and remove fuel transfer pump and drive gear as an assembly.

3. The fuel transfer pump may be installed by a direct reversal of the removal procedure.

SECTION 5 - FUEL SYSTEM (WITH ROOSA MASTER FUEL INJECTION PUMP)

TOPIC NO.	TITLE	PAGE
1	GENERAL	5-1
2	CHECKING FUEL SYSTEM	5-3
	A. Check for Admission of Air into System	5-3
	B. Check for Clogged Fuel Filters and Clogged or Collapsed Fuel Lines	5-3
	C. Check for Inoperative Fuel Transfer Pump	5-3
	D. Check for Inoperative Fuel Injection Nozzles	5-4
	E. Check for Inoperative Fuel Injection Pump	5-4
3	FUEL FILTER	5-4
	A. Description	5-4
	B. Service	5-4
	C. Replacement of Fuel Filter	5-4
4	VENTING FUEL SYSTEM	5-5
	A. Venting of Low Pressure Fuel System	5-5
	B. Venting of High Pressure Fuel System	5-5
5	FUEL INJECTION PUMP AND GOVERNOR	5-5
	A. General	5-5
	B. Fuel Injection Pump Removal	5-6
	C. Installation and Timing of Fuel Injection Pump	5-7
	D. Checking and Adjusting Automatic Timing Advance	5-8
	E. Speed Adjustments	5-10
	F. Fuel Pump Drive Gear, Drive Shaft, and Mounting Cover	5-10
	G. Governor	5-11
	H. Fuel Injection Pump and Governor Service	5-12
6	FUEL INJECTION NOZZLE HOLDER ASSEMBLIES	5-10
	A. General	5-10

TOPIC 1 - GENERAL

The fuel system consists of a fuel tank, two fuel filters, fuel injection pump, fuel injection nozzles, and fuel lines. There are two fuel pressure systems, low pressure and high pressure.

The low pressure system is comprised of the fuel tank, two fuel filters, fuel lines between the fuel tank and the fuel pump, and leakage return lines.

The high pressure system begins in the fuel injection pump where the fuel is forced by the action of cam-actuated plungers into the outlet ports and through the high pressure fuel lines connected to the fuel injection nozzles.

The fuel is drawn from the fuel tank through the combination primary and secondary fuel filters by the transfer pump located in the fuel injection pump. The fuel is then forced by the transfer pump to the cam-actuated plungers which force the fuel under high pressure thru the fuel lines to the fuel injection nozzles from which the fuel enters the combustion chambers in the form of four fine, cone shaped sprays.

The fuel transfer pump delivers more fuel to the fuel sump of the fuel injection pump than is required for engine operation. A line extending from the top of the fuel injection pump to the fuel tank conveys the surplus fuel back to the fuel tank.

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

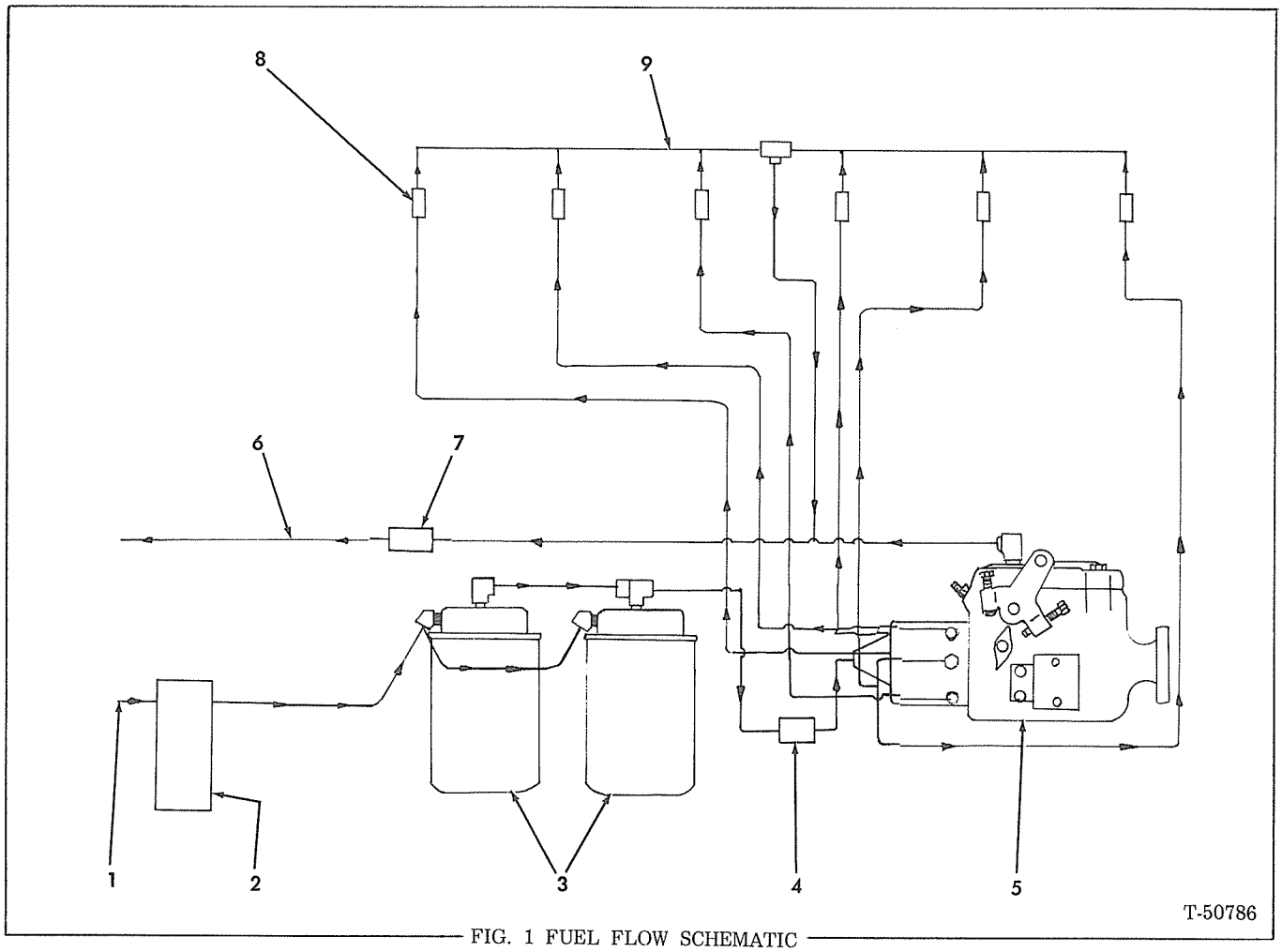


FIG. 1 FUEL FLOW SCHEMATIC

1. Fuel supply line (from fuel tank)
2. Water separator
3. Fuel filters
4. Hand primer pump
5. Fuel injection pump
6. Fuel return line (to tank)
7. Air starter lubricator
8. Nozzle injectors
9. Drip manifold

There is a certain amount of fuel seepage between the lapped surfaces of each fuel injection nozzle valve and its body, which is necessary for lubrication. This leakage of fuel accumulates around the spindle and in the spring compartment of each fuel injection nozzle holder and is returned through the fuel drip manifold to the fuel return line, extending to the fuel tank. The excess fuel delivered to the fuel injection pump by the fuel supply pump is also returned to the fuel tank through the fuel return line.

A regulating valve in the pump end plate allows a large percentage of the fuel to be bypassed back to the inlet side. The fuel bypassed increases in proportion to speed, and the regulating valve is designed so the transfer pump pressure also increases with speed.

If necessary precautions are not taken in the storage of fuel, the transfer of fuel to the fuel tank, and in keeping the fuel tank full to prevent condensation, it is possible for foreign material and water, which may damage the fuel injection pump, to enter the fuel system. The fuel filters are installed in the fuel injection system to clean the fuel before it enters the fuel injection pump.

It is essential that personnel responsible for the care and operation of the engine adhere to the following maintenance recommendations:

1. Use only fuel meeting specifications.

2. Store and handle fuel with utmost care to prevent water and foreign matter from entering the fuel system.

3. Properly maintain fuel oil filters.

4. Remove injection nozzle-holder assemblies at the prescribed intervals; adjust the opening pressure and check the spray pattern.

5. Daily, drain the water from the fuel tank.

6. Periodically check injection pump timing.

7. Keep all fuel line connections, filter, injection pump and injection nozzle assemblies tightened securely to the engine.

8. Before removing any part of the fuel injection system from the engine be sure to wash the part with cleaning solvent, also the surrounding area to prevent the entrance of abrasives into the system. COVER ALL OPENINGS IMMEDIATELY.

TOPIC 2 - CHECKING FUEL SYSTEM

"Missing" or uneven running of the engine, excessive vibration, stalling when idling, and loss of power are indications of insufficient fuel supply to the engine. Before performing any of the following checks, make certain there is an ample supply of the proper fuel in the fuel tank and the fuel tank shutoff valve is open.

A. CHECK FOR ADMISSION OF AIR INTO SYSTEM

Remove the fuel return line from the fitting in the injection pump cover. Insert a length of hose on the fitting. Place the other end of the hose in a container partially filled with fuel oil. Run engine at approximately 800 to 1000 RPM and observe the end of the hose in the container for bubbles. Occasional bubbles are permissible, however excessive bubbles or foaming indicates air is being drawn into the system. Correct this condition by tightening any loose low-pressure fuel line connections and filter connections.

B. CHECK FOR CLOGGED FUEL FILTERS AND CLOGGED OR COLLAPSED FUEL LINES

A clogged filter or restrictions in the fuel lines will cause low power, engine stall or erratic operation. A simple method of eliminating these troubles is to remove the fuel filters, blow out all low pressure fuel lines with filtered compressed air and install new filters. Another method is to install a vacuum gauge at the inlet and at the outlet of the fuel filters. A pressure drop across clean filters should not be more than 1-1/2" to 2-1/2" of mercury at full load speed. A pressure drop of 10" of mercury indicates filters are loaded and should be replaced. If a reading of 10" of mercury is still present with new filters, all low pressure lines should be inspected for clogging, crimping, etc., and cleaned or replaced.

To check the high pressure lines between the pump and fuel injection nozzles, start the engine and loosen the line nuts (one at a time) at the injectors. If no fuel is observed at the loosened line nut, the line may be clogged, crimped or cracked. In any case the line must be replaced.

Check the fuel strainer in the end-plate of the injection pump. Remove any foreign matter if the screen is clogged.

C. CHECK FOR INOPERATIVE FUEL TRANSFER PUMP

If the engine is still erratic after making the checks listed in Steps A and B, check the operation of the

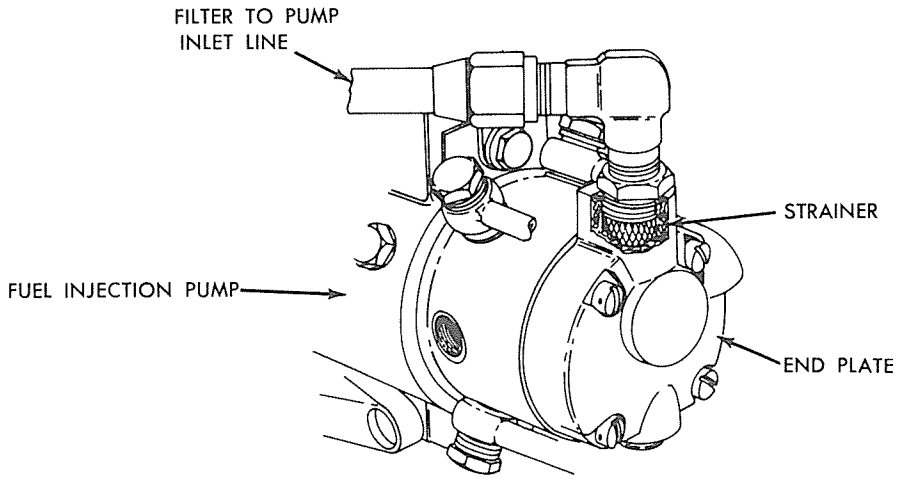


Fig. 2 Fuel Strainer Location
(T-33512)

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

fuel transfer pump and end plate pressure regulating valve. Operate the engine until normal operating temperature is reached; then shut off the engine. Remove plug marked OUT in bottom of end plate opposite the fuel inlet and install a pressure gauge. With the key switch in the OFF position and the throttle in the idle position, crank the engine with the starter. A minimum of 10 psi should register on the gauge. If it does not, check for malfunction in the end plate and transfer pump parts.

D. CHECK FOR INOPERATIVE FUEL INJECTION NOZZLES

"Missing" or uneven running of the engine and loss of power are also indicative of an inoperative fuel injection nozzle, or nozzles. To locate a faulty fuel nozzle, use the following procedure:

1. Run the engine at low idle speed and "cut-out" each fuel nozzle in turn by loosening the line nut attaching the high pressure line to its corresponding fuel nozzle.

2. A decrease in engine speed with the line nut loosened indicates that the fuel nozzle for that cylinder is functioning properly.

3. If the engine speed does not decrease, the fuel nozzle is inoperative and should be repaired or replaced.

E. CHECK FOR INOPERATIVE FUEL INJECTION PUMP

Do not replace the fuel injection pump before making a compression test. The compression test eliminates the possibility of burned or stuck valves, worn or scored pistons and sleeves, worn or stuck rings, etc., to be causing improper engine operation.

If all possible causes for insufficient fuel supply have been eliminated and the engine still runs uneven, and normal engine performance is not obtained, the fuel injection pump may be at fault and should be checked, repaired or replaced.

IMPORTANT

Do not replace the fuel pump until making certain that all other possible causes for improper engine operations have been eliminated.

TOPIC 3 - FUEL FILTER

A. DESCRIPTION

Refer to FIG. 2A. The water separator (4) and fuel filter elements (5) are disposable. The water separator is equipped with a drain cock to drain accumulated water.

B. SERVICE

Open drain cock, located at bottom of fuel tank, before engine is started at beginning of day's operation in warm weather, or shortly after end of day's operation in freezing weather, and allow any water and sediment to drain; close drain cock when clean fuel runs out.

C. REPLACEMENT OF FUEL FILTER

1. Close fuel tank shut-off valve.

2. Clean all dirt from around the filters and surrounding area.

3. Unscrew and remove filter and O-ring from filter head. Discard filter and O-ring.

4. Position new O-ring (from filter replacement kit) on threaded insert in filter head and screw new filter by hand into position until the gasket contacts the base of filter head. Using hand pressure, tighten filter one half to three quarters of a turn more.

CAUTION

Do not use any sealing compounds or lubricants. Do not use any tools to tighten fuel filter. Always use Fiat-Allis replacement filter.

5. Open the fuel tank shutoff valve and vent the low pressure system. Refer to the following Topic.

IMPORTANT

Keep filter parts clean when changing the fuel filter.

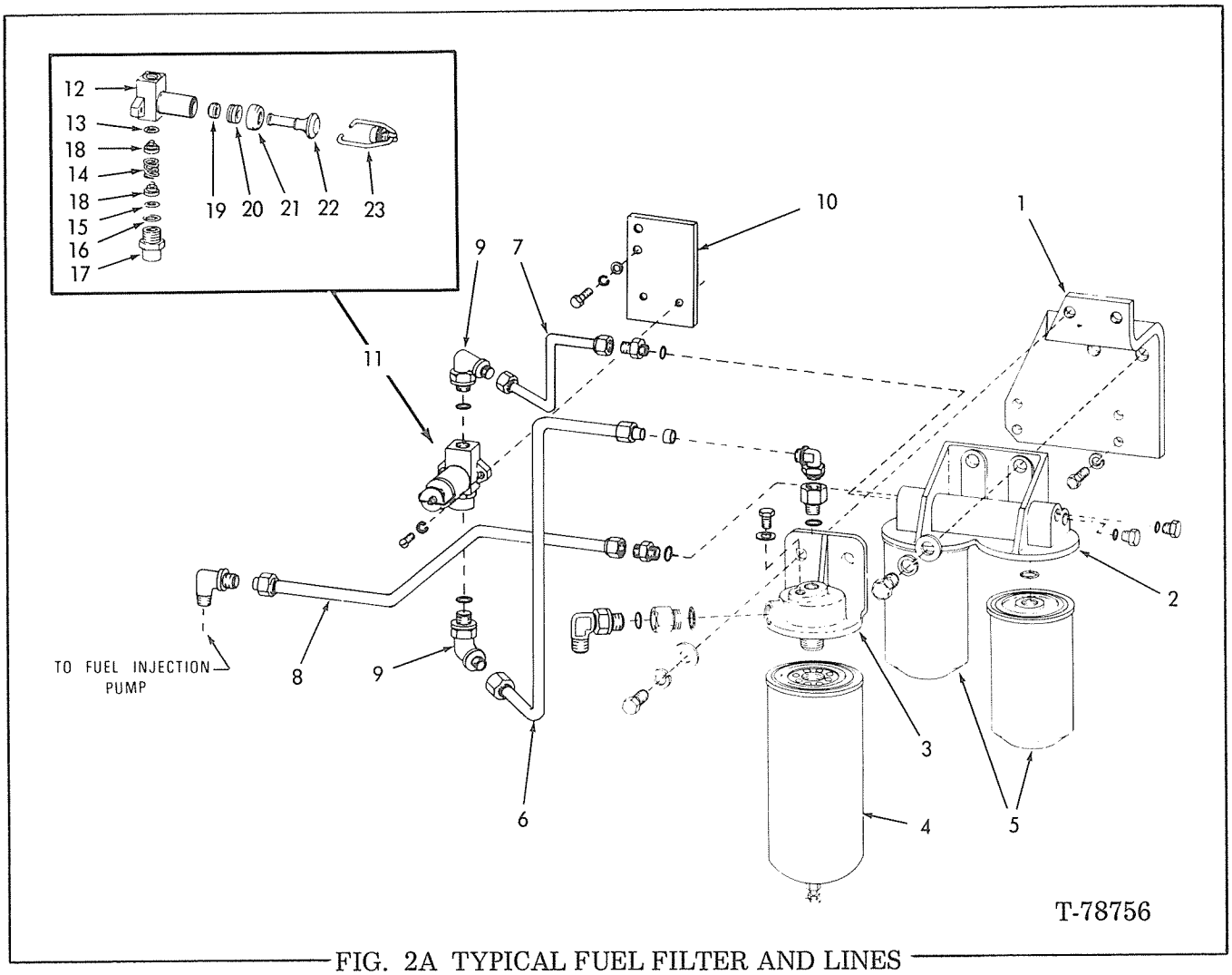


FIG. 2A TYPICAL FUEL FILTER AND LINES

1. Bracket
2. Filterhead
3. Base assy.
4. Element, water separator
5. Element, fuel filter
6. Tube
7. Tube
8. Tube assy.
9. Elbow
10. Bracket
11. Hand primer pump assy.
12. Body
14. Spring
15. Seal
16. Ring
17. Nut
18. Valve
19. Seal
20. Guide
21. Cap
22. Plunger
23. Clamp assy.

TOPIC 4 - VENTING FUEL SYSTEM

The engine fuel system consists of a fuel tank, water separator, two disposable fuel filters, fuel filters, fuel supply pump, fuel injection pump, fuel injection nozzle-holder assemblies, and the fuel lines. There are two fuel pressure systems; the low pressure system and the high pressure sytem.

The low pressure system consists of the fuel tank, water separator, two disposable fuel filters, fuel filters, fuel drain manifold, and the fuel return line leading from the fuel injection pump to the fuel tank .

The high pressure system consists of the fuel injection pump, fuel injection nozzle-holder assemblies, and fuel injection lines connecting the fuel injection pump to the fuel nozzle-holders.

A. VENTING OF LOW PRESSURE FUEL SYSTEM

Remove small pipe plugs from vent holes in filter head at top of each filter; open fuel tank shut-off valve and allow filter to fill by gravity. When fuel (free of bubbles) runs from both vent holes, install and tighten the small pipe plugs. Start engine and check for fuel leaks; correct any leaks found.

B. VENTING OF HIGH PRESSURE FUEL SYSTEM

The high pressure fuel system is usually self venting, due to the fact that any air trapped by the fuel injection pump is forced out through the fuel injection nozzles and into the combustion chambers. However, if the fuel lines have been removed, the engine has run out of fuel, or the unit has not been operated for sometime, venting of the high pressure system may be necessary to facilitate starting of the engine. Vent the high pressure fuel system as follows:

1. Loosen the fuel line connection nut attaching each fuel injection line to its corresponding fuel nozzle-holder.
2. Place the throttle in the high speed position.
3. Crank the engine with the starter until fuel flows from the ends of all high pressure fuel lines. Connect the fuel injection lines to the fuel nozzle-holders and tighten the fuel line connection nuts.

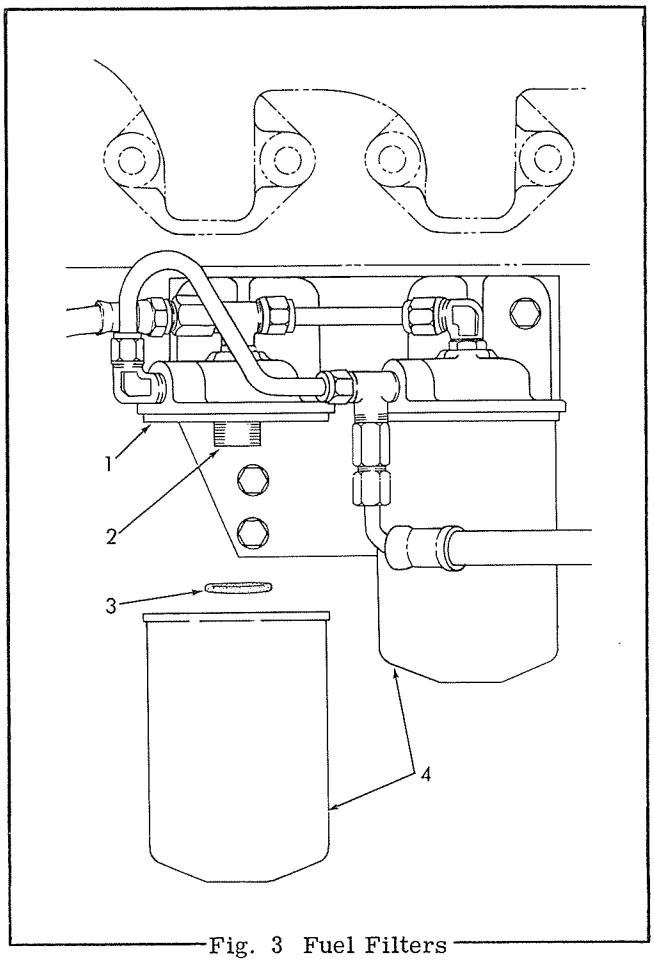


Fig. 3 Fuel Filters
(T-71994)

1. Filter Head
2. Threaded Insert
3. O-Ring
4. Fuel Filters

CAUTION

Do not operate the starting motor continuously for more than 30 seconds at a time without a pause of two minutes to permit the starter to cool.

TOPIC 5 - FUEL INJECTION PUMP AND GOVERNOR

A. GENERAL

The fuel injection pump is of the single cylinder, opposed plunger, inlet metering, distributor type. The plungers are operated by an internal cam ring. The purpose of the pump is to accurately deliver metered quantities of fuel under high pressure to the injection nozzles through which the fuel is introduced into the engine combustion chambers, at a definite timing in relation to the engine firing cycle, and within the required injection period.

An integral governor of the mechanical-centrifugal type controls fuel delivery and, therefore, engine speed. The governor is driven directly off of the pump drive shaft without gearing. The direction of rotation of the drive shaft is clockwise.

The transfer or supply pump, in the opposite end of the rotor from the pumping cylinder, is of the positive displacement, vane type and is covered by the end-plate.

The pump is designed for self-lubrication by the fuel oil supply.

The fuel injection pump contains its own mechanical or flyweight-type governor which controls the amount of fuel delivered to the engine. The movement of the flyweights against the governor thrust sleeve rotates the metering valve. The rotation varies the position of the metering valve slot with the passage to the rotor, controlling the flow of fuel. The governor is adjusted at the factory to provide for the proper horsepower at full-load governed speeds.

The governor seldom requires adjustment. If the engine speed is irregular, check the fuel system and all other engine adjustments before removing the fuel injection pump assembly for governor repair.

B. FUEL INJECTION PUMP REMOVAL

Clean the outer surfaces of the injection pump, including all fittings and line connections that are to be disconnected to eliminate any possibility of dirt from entering the system. Remove the pump as follows:

1. Remove timing window cover, Fig. 7 (1) and crank engine by hand until the fuel pump timing marks are aligned, Fig. 4 (2).

2. Remove timing window cover from side of fuel injection pump and observe timing marks through window, Fig. 4. If both timing marks do NOT appear, rotate engine one complete revolution and again bring timing mark on flywheel into alignment with pointer. Both timing marks, Fig. 4, should now appear in timing window and the engine is timed so that the No. 1 piston is near the top on its compression stroke and the fuel injection pump may be removed from the engine. The engine will not have to be repositioned when the pump is installed, providing the position of the engine crankshaft is not changed prior to reinstallation of fuel injection pump.

3. Shut off fuel supply at fuel tank.

4. Disconnect fuel pressure gauge hose, drip manifold return line, filter to pump hose, and all fuel injection lines from fuel injection pump. Due to rigidity of fuel injection line tubing it is necessary to loosen tube supporting bracket from side of engine.

5. Disconnect throttle control rod from fuel injection pump; remove two stud nuts and serrated washers. Remove pump by sliding to the rear off of drive shaft. Use care to prevent damaging the drive shaft seals, Fig. 6 (3).

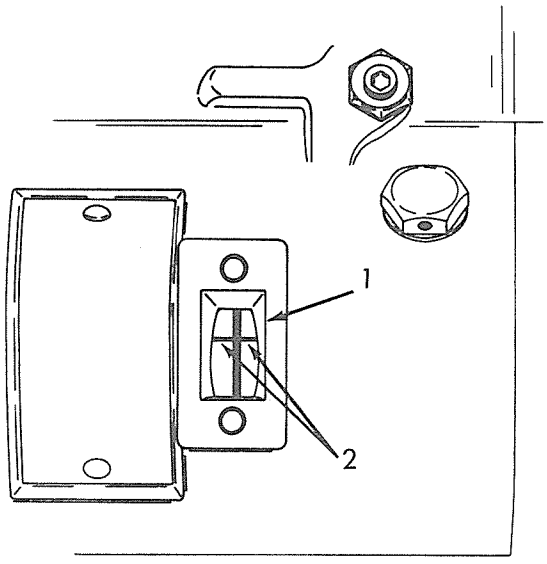


Fig. 4–Fuel Pump Timing Marks
(T-50586)

1. Timing Window 2. Timing Marks

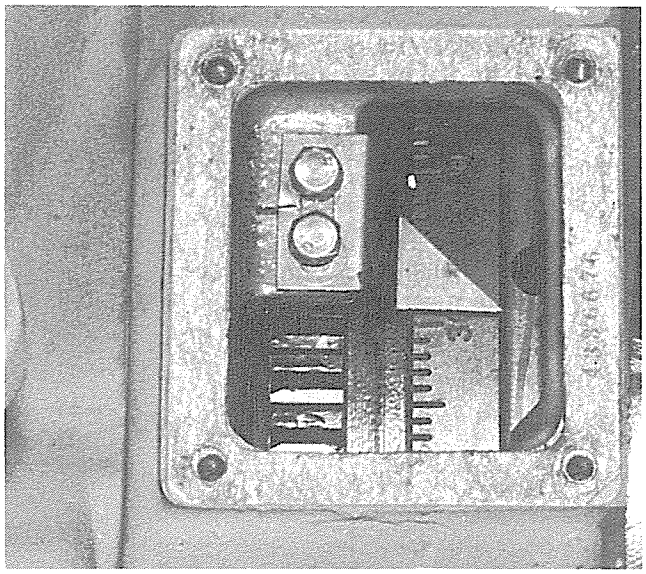


Fig. 5–Timing Mark on Engine Flywheel Indicating 30°
(T-71410)

NOTE

If removal of the pump shaft and/or pump drive gear is required, refer to "FUEL PUMP DRIVE GEAR, DRIVE SHAFT, AND MOUNTING COVER" in this Section.

C. INSTALLATION AND TIMING OF FUEL INJECTION PUMP

When the fuel injection pump has been serviced and is ready to be reinstalled, or if a new pump is to be installed on the engine, follow the procedure outlined below:

1. Remove the timing window cover from the fuel injection pump. There are two timing marks, Fig. 4, one on the governor weight retainer hub and one on the cam ring for timing the pump for injection of fuel into No. 1 cylinder. Using a screwdriver or suitable tool inserted into the drive shaft end of the pump, turn the distributor rotor until the timing marks are aligned.

2. Before installing the pump on the engine, make certain the #1 piston is on its compression stroke. This may be determined as follows:

   a. Remove the rocker arm rear cover so valve action can be observed.

   b. Crank engine by hand until #6 cylinder exhaust valve is nearly closed and #6 cylinder intake valve is just beginning to open. This will position #1 piston near the top on its compression stroke.

3. Continue rotating the flywheel until the timing pointer, Fig. 5, indicates the specified number of degrees B.T.D.C., refer to following table:

ENGINE	TIMING IN°BTDC	
	STATIC	RUNNING
10000	12	30
1100 (without automatic advance)	18	36
11000 (with automatic advance)	24	36
11000 MKII (DB, DC)	18	36
11000 MKII (DM)	14	36

4. Inspect the seals on the pump drive shaft, Fig. 6 (3), and replace them if necessary. Inspect the pump drive shaft and replace if worn or damaged. Refer to "FUEL PUMP DRIVE GEAR, DRIVE SHAFT, AND MOUNTING COVER ", in this Topic, for drive shaft removal.

NOTE

In order to prevent the installation of the fuel pump 180° out-of-time an internal groove is provided in the splined end of the pump drive shaft which must be engaged by an internal tang of the distributor rotor within the fuel injection pump, Fig. 6.

5. Lubricate the seals, Fig. 6 (3), with engine oil or grease. Slide the fuel injection pump assembly into position over the drive shaft, using care to prevent damage to the seals. Install the serrated washers and the pump-attaching stud nuts but do not tighten the nuts at this time.

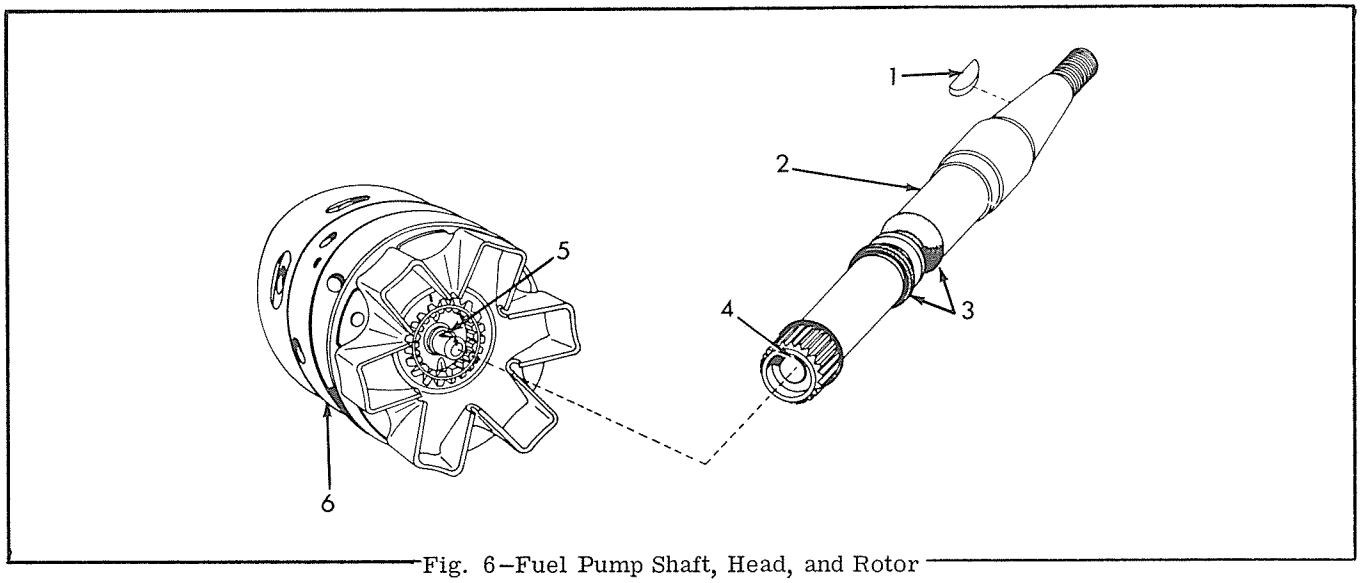


Fig. 6—Fuel Pump Shaft, Head, and Rotor
(T-50595)

1. Key
2. Pump Drive Shaft
3. Seals
4. Internal Groove
5. Internal Tang
6. Hydraulic Head and Rotor Assembly

6. The mounting holes in the pump housing are elongated so that the pump can be turned to align the timing marks. Turn the pump until the timing marks are aligned; tighten the pump-attaching stud nuts securely to a torque of 19 to 22 lbs. ft.

7. Install the timing window cover and gasket in position on the fuel injection pump.

8. Install and connect the fuel injection lines to their corresponding openings in the fuel injection pump and fuel injection nozzles. Make sure that a copper gasket is used on both sides of the injection line fitting at the fuel injection pump opening. Tighten the fuel injection line nuts and connecting screws securely.

9. Complete the installation by reversing the removal procedure.

10. Open the fuel supply shutoff valve and vent the fuel system.

WARNING

Never attempt to time pump to engine while engine is running. Loosening of pump attaching nuts might cause drive shaft to seize, resulting in damage to pump and possible personal injury.

D. CHECKING AND ADJUSTING AUTOMATIC TIMING ADVANCE

Some of the Roosa Master fuel injection pumps are equipped with an automatic timing advance, Fig. 7 (2). The function of the automatic advance, is to advance the timing automatically as the engine speed increases.

The specified static timing of the fuel injection pumps, equipped with the automatic advance, is 24° B.T.D.C.

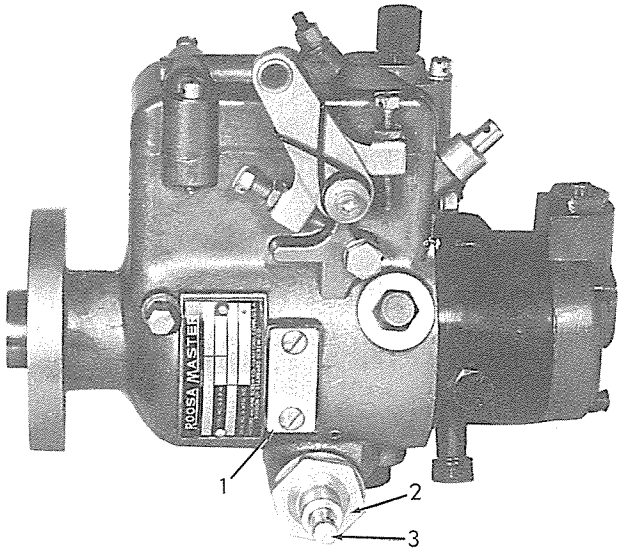


Fig. 7–Roosa Master Fuel Injection Pump With Automatic Timing Advance (T-73855)

1. Timing Window Cover
2. Automatic Timing Advance
3. Adjusting Screw Cover

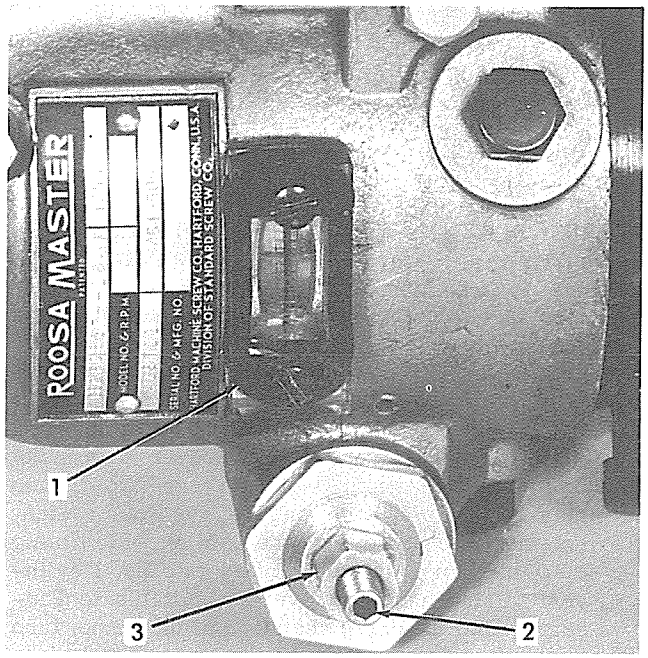


Fig. 8–Timing Window Installed On Fuel Injection Pump (T-73856)

1. Plastic Timing Window
2. Timing Advance Adjusting Screw
3. Lock Nut

The specified advance, as the engine speed increases, is 2° at 1000-1200 rpm and 12° at 1600-1800 rpm. A plastic timing window, Fig. 8 (1), Roosa Master tool number 13366, is required to test and adjust the automatic timing advance. Test and adjust as follows:

1. Make certain the fuel injection pump static timing (engine stopped) is set at the specified 24° B.T.D.C. Refer to "INSTALLATION AND TIMING OF FUEL INJECTION PUMP" in this Topic.

2. Remove timing window cover, Fig. 7 (1), and install plastic timing window, Fig. 8 (1).

3. Run engine until coolant reaches normal operating temperature.

4. Run engine at high idle, then reduce speed to 1000 - 1200 rpm and observe timing marks. The timing mark on the governor weight retainer assembly will not be visible because the assembly is rotating at one-half engine speed. The timing mark on the cam ring should have risen one-half (1/2) a graduation on the timing window, Fig. 9 ("B"), indicating a timing advance of 1° pump or 2° engine.

IMPORTANT

When setting or checking the automatic advance, it must always be done after reducing the engine speed from high idle to the specified RPM. Do not attempt to adjust static timing while engine is running.

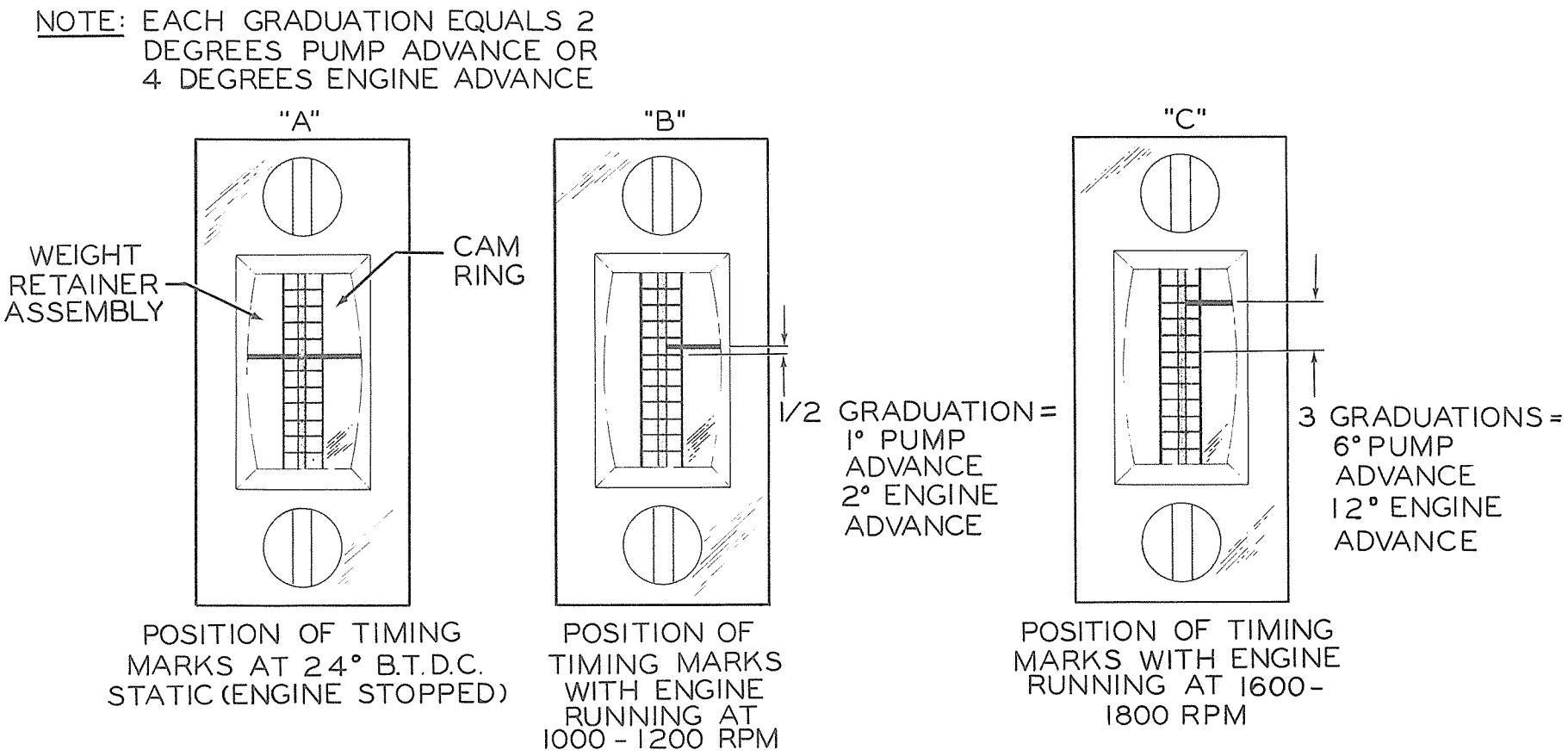


Fig. 9–Checking Timing Mark Advance
(T-73857)

5. Run engine at high idle, then reduce speed to 1600 - 1800 rpm and observe timing mark on cam ring. The timing mark should have risen three (3) graduations on the timing window, Fig. 9 ("C"), indicating a timing advance of 6° pump or 12° engine.

6. To adjust the timing advance mechanism, remove the adjusting screw cover, Fig. 7 (3), and loosen the lock nut Fig. 8 (3). Using a #4 (1/8") Allen wrench turn the adjusting screw, Fig. 8 (2), until the specified advance is attained. Turning the adjusting screw clockwise retards the timing; counter-clockwise advances the timing. Securely tighten the lock nut, Fig. 8 (3), after each adjustment.

E. SPEED ADJUSTMENTS

Refer to Paragraph F, GOVERNOR, for procedure to adjust the idle and full load speeds.

F. FUEL PUMP DRIVE GEAR, DRIVE SHAFT, AND MOUNTING COVER

1. GENERAL

The fuel pump drive gear is driven by a gear cast integral with the camshaft gear. The gear is keyed to the tapered pump drive shaft and secured with a nut and lockwasher.

2. FUEL PUMP DRIVE GEAR REMOVAL AND INSTALLATION

The fuel pump drive gear may be removed with the fuel injection pump mounted on the cover or the pump may be removed before the gear is removed; proceed as follows:

a. Remove the fuel injection pump (refer to "FUEL INJECTION PUMP REMOVAL" in this Topic).

b. Remove the capscrews and lockwashers attaching the pump mounting cover, Fig. 10 (5), to the timing gear housing.

c. Remove the pump timing gear (3), cover (5), and pump drive shaft from the timing gear housing as an assembly.

d. Remove thrust button, Fig. 11 (2), and spring from end of pump drive shaft.

e. Remove nut, Fig. 10 (1), and lockwasher (2) from end of shaft and pull or press gear (3) from shaft.

f. To install the pump drive gear, place the woodruff key, Fig. 10 (7), in position in the pump drive shaft, place gear in position on shaft, install lockwasher (2) and nut (1) on the shaft and tighten to a torque of 35 - 40 lbs. ft.

g. Inspect O-rings (4) and (6), if they are not dam-

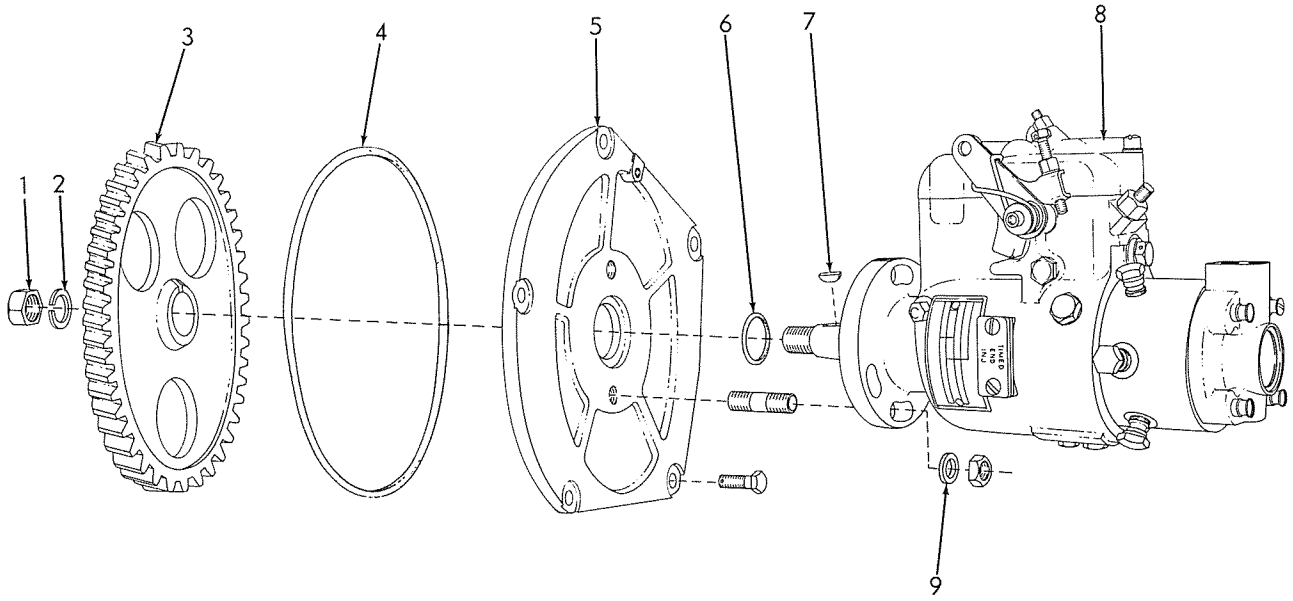


Fig. 10–Pump Drive Gear and Mounting Cover Details
(T-71999)

1. Nut
2. Lockwasher
3. Pump Drive Gear
4. O-Ring
5. Pump Mounting Cover
6. O-Ring
7. Woodruff Key
8. Fuel Injection Pump
9. Serrated Washer

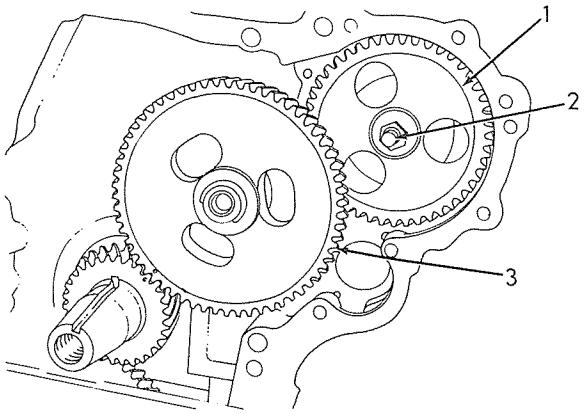


Fig. 11—Location of Fuel Pump Drive Gear (T-72703)

1. Fuel Pump Drive Gear
2. Thrust Button
3. Camshaft Gear

aged, place them in position in cover (5). If they are damaged, use new ones.

h. Place cover (5) in position on pump drive shaft. Install fuel injection pump on shaft and secure to cover with serrated washers (9) and nuts.

i. Position engine flywheel so that timing pointer, Fig. 5, indicates proper number of degrees B.T.D.C. for injection pump installation (refer to "INSTALLATION AND TIMING OF FUEL INJECTION PUMP" in this Topic).

j. Place spring and thrust button, Fig. 8, in position in end of pump shaft. Rotate the pump drive gear until the timing marks on the fuel injection pump are aligned, Fig. 4. Hold the gear in this position and carefully install the assembly on the timing gear housing so that pump drive gear meshes with the dual gear on the camshaft gear.

k. With cover, Fig. 7 (5), in position on timing gear housing, make certain pump timing marks are still aligned. Slight misalignment must be corrected by loosening the pump mounting stud nuts and rotating the pump, however, if misalignment is too great, remove the pump drive gear and reinstall it so that it meshes with the camshaft gear one tooth removed from the former position. Repeat until proper pump timing mark alignment is attained.

l. Install lockwashers and capscrews to secure pump mounting cover to timing gear housing. Tighten capscrews securely.

m. Install the timing window cover and gasket in position on the fuel injection pump.

n. Install and connect the fuel injection lines to their corresponding openings in the fuel injection pump and fuel injection nozzles.

o. Complete the installation by reversing the removal procedure.

p. Open the fuel supply shutoff valve and vent the fuel system.

G. GOVERNOR

1. GOVERNOR ADJUSTMENTS

Before changing the low idle or high idle speed settings, move the throttle control rod to its low and high speed positions and make certain that the throttle control rod moves the speed control lever of the pump through its full length of travel.

Refer to the OPERATING INSTRUCTIONS AND FIELD MAINTENANCE manual, furnished with the unit, for specified high and low idle engine speeds. Check the idle speed and the full-load speed. If it is necessary to adjust either, proceed as follows:

a. Operate engine until normal operating temperature is reached.

b. Disconnect the throttle-control from the speed control lever of the fuel injection pump so the lever can be moved by hand.

c. With the engine running, loosen the jam nut on the low-idle adjusting screw. Hold the speed-

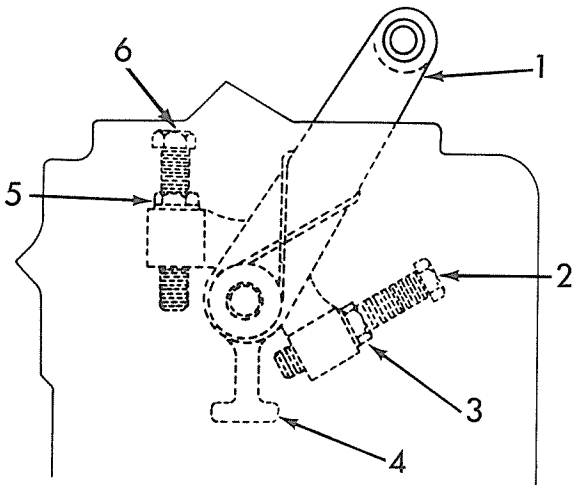


Fig. 12—Engine Speed Adjustment (T-50894)

1. Speed Control Lever (Spring Loaded)
2. Low Speed Adjustment Screw
3. Jam Nut
4. Lever Stop
5. Jam Nut
6. High Speed Adjustment Screw

control lever toward the front (fan end) of the engine so that the low-idle adjusting screw contacts the lever stop. Turn the low-idle adjusting screw "in" to increase or "out" to decrease the low-idle engine speed. When the specified low idle speed is obtained, hold the adjusting screw and tighten the jam nut.

d. With the engine running, loosen the jam nut on the high-idle adjusting screw. Hold the speed-control lever toward the rear (away from the fan end) of the engine so that the high-idle adjusting screw contacts the lever stop. Turn the high-idle adjusting screw "in" to decrease or "out" to increase the high idle engine speed. When the desired high idle speed is obtained, hold the adjusting screw and tighten the jam nut.

e. Connect the throttle-control ball joint to the speed-control lever. Make certain it is so positioned that when the throttle is not depressed, the control lever low-idle adjusting screw contacts the lever stop on the pump housing. Likewise, when the throttle is fully depressed, the high-speed adjusting screw also contacts the lever stop.

H. FUEL INJECTION PUMP AND GOVERNOR SERVICE

Generally, malfunctioning of the fuel injection equipment is the direct result of dirty fuel. Dirt in the fuel causes rapid wear on precision parts, particularly the plunger, control sleeve, delivery valves and seats, and the fuel injection nozzle valves and valve bodies. Therefore, extreme care should be used in the storage and handling of fuel to prevent the entrance of dirt, water, and abrasive particles. Any water or sediment should be drained from the fuel filter daily, and the fuel filter must be changed at the specified intervals or more often when conditions warrant.

The fuel injection pump is self-lubricated and no lubrication service on the injection pump and governor assembly is required.

Fiat-Allis dealers are equipped with fuel injection pump calibrating and test stands and the special tools required to test, adjust, and repair the fuel injection pump and governor assembly. Therefore, if at any time the fuel injection pump and governor assembly requires repairs or adjustment, the fuel pump should be removed and taken to your nearest Fiat-Allis dealer. It is important that the dealer be furnished with the injection pump serial number and the model and serial number of the unit so that the pump may be properly calibrated and the correct replacement pump or pump parts may be furnished.

TOPIC 6 - FUEL INJECTION NOZZLE HOLDER ASSEMBLIES

A. GENERAL

The fuel injection nozzle holders used with the Roosa Master fuel injection pump are almost identical to the ones used with the American Bosch fuel injection pump.

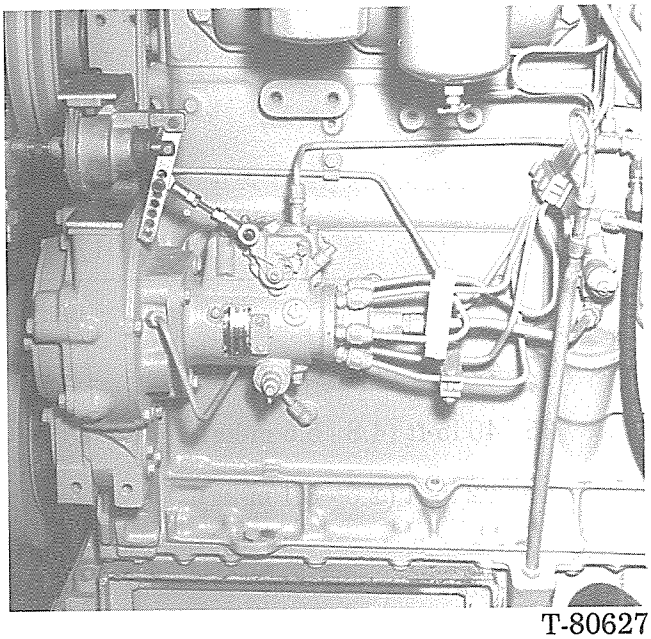
For fuel injection nozzle holder service, refer to "FUEL INJECTION NOZZLE HOLDER ASSEMBLIES" in Section 4.

⚠ DANGER

Extinguish all smoking materials and open flames before working around diesel fuel.

⚠ WARNING

Never use gasoline, solvent or other flammable fluids to clean parts.



T-80627

FIG. 13 FUEL INJECTION PUMP INSTALLATION

This procedure for removal of the pump from the engine should be followed in detail to assure ease of re-installation.

A. Clean and wash down the pump, fittings and all connections with non-flammable, non-toxic, commercial solvent to eliminate the possibility of contamination entering the system when lines are disconnected.

NOTE: Do not steam clean or wash down while the engine is operating. Severe damage to the pump may occur if its temperature is changed radically while running.

B. Shut off the fuel supply and disconnect inlet and return lines from their fittings. Loosen injection tubing nuts at the nozzles and pump.

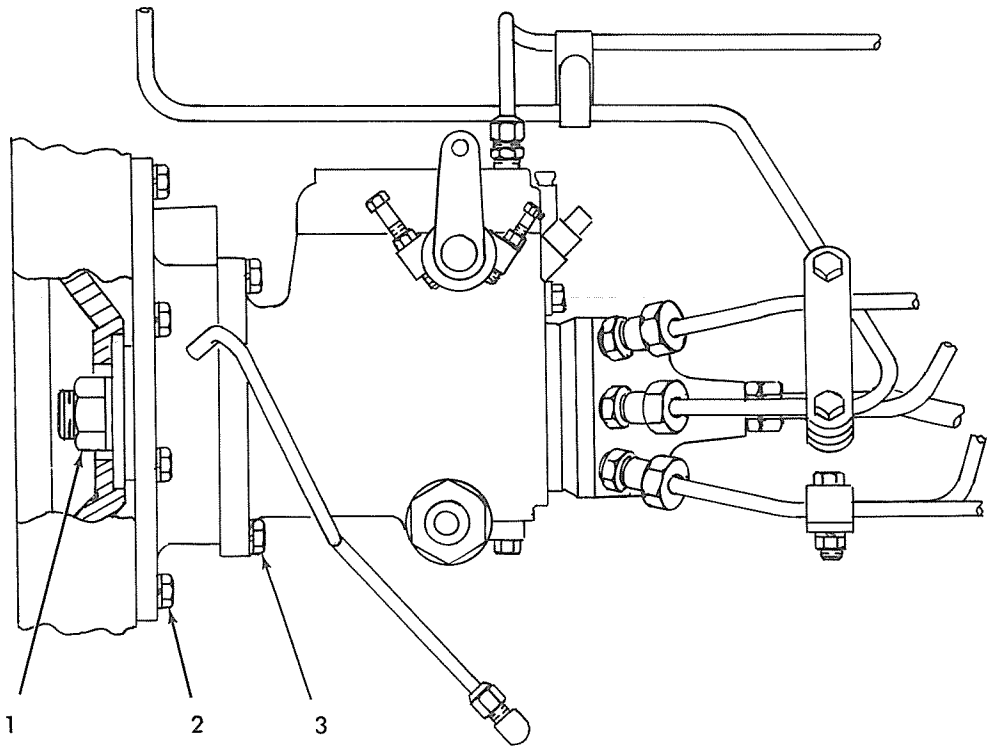
NOTE: In removing the injection tubing nut from the pump, hold the discharge fitting with a wrench to prevent loosening from the hydraulic head. Immediately after the lines are removed, all pump, nozzles and line openings should be capped or plugged.

C. Refer to FUEL INJECTION PUMP Service Manual for proper timing position of crankshaft. Bar the engine in correct direction of rotation until the engine timing mark is indexed and the No. 1 cylinder is at the end of the compression stroke. Remove the timing line cover from the outboard side of the pump. Timing line on the governor weight retainer hub should be directly opposite the line on the cam.

D. Disconnect throttle and shut-off linkage and electrical connections if used.

E. In most cases it will be necessary to remove the pump drive gear from the hub or drive shaft.

F. Support the pump with one hand and remove the mounting stud nuts and washers on the pump flange. Remove the pump from the engine.



T-80177

FIG. 14 FUEL INJECTION PUMP

1. Drive hub nut . . . . . 35 - 40 lb-ft (4.8 - 5.5 m-kg)
2. Cover attaching capscrews . . . . . 35 - 40 lb-ft (4.8 - 5.5 m-kg)
3. Pump attaching capscrews . . . . . 19 - 22 lb-ft (2.6 - 3.1 m-kg)

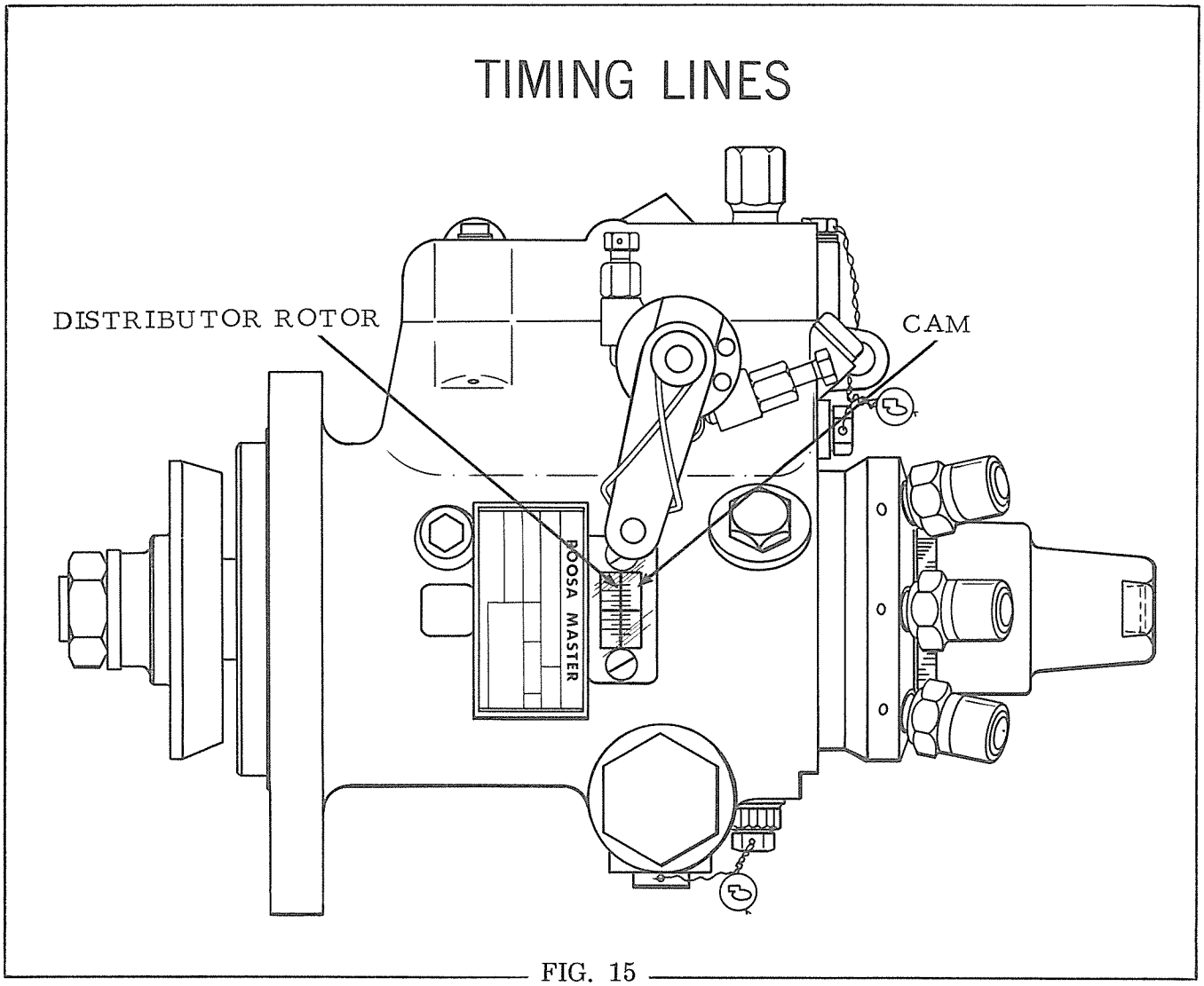


FIG. 15

DANGER

Extinguish all smoking materials and open flames before working around diesel fuel.

INSTALLING THE PUMP

A. Remove timing line cover.

B. Turn pump drive shaft in the direction of pump rotation until the timing line on the Distributor rotor registers with the line on the cam O. D. (Fig. 15).

C. Refer to FUEL INJECTION PUMP Service Manual for proper timing position of crankshaft.

D. Slide the pump into position over the mounting studs. Assemble washers and the mounting stud nuts and tighten.

E. Install the pump drive gear to the hub or drive shaft. Refer to the engine manual. Back off the engine at least 1/2 revolution and bar it in the direction of rotation to the proper timing mark. Recheck line marks in the pump and correct if necessary. Repeat procedure to insure proper timing. Install timing line cover.

F. Remove caps on high pressure lines. Connect the lines to their respective discharge fittings and tighten to specified torque. Connect throttle and shut-off linkage and electrical connections if used. Assemble and tighten fuel return line. Open bleed screw on secondary filter, and operate hand primer (if equipped and filter is after hand primer) or allow fuel to flow from tank until all air is dispelled from filter.

NOTE: Do not open filter bleed if hand primer is after filter. Close bleed screw. Continue hand priming until a quantity of fuel flows "air-free" at pump inlet line. Fasten the inlet to the pump. This procedure should also be followed without fail after every filter change. Refer to Operation and Maintenance Instruction Manual for starting instructions and observe all safety precautions before starting engine.

SECTION 5A — FUEL SYSTEM
(WITH BOSCH (GERMANY) FUEL INJECTION PUMP)

TOPIC NO.	TITLE	PAGE
1.	GENERAL DESCRIPTION.	5A-1
2.	CHECKING OF FUEL SYSTEM	
	A. General.	5A-1
	B. Air in System.	5A-1
	C. Clogged Fuel Filters or Collapsed Fuel Lines.	5A-2
	D. Inoperative Fuel Pressure Relief Valve or Fuel Transfer Pump.	5A-2
	E. Malfunctioning Fuel Injection Nozzle-Holder Assemblies.	5A-2
	F. Malfunctioning Fuel Injection Pump.	5A-2
3.	FUEL FILTERS.	5A-3
	A. Description.	5A-3
	B. Service.	5A-3
4.	FUEL TRANSFER (SUPPLY) PUMP.	5A-3
	A. General.	5A-3
	B. Fuel Transfer Pump Testing.	5A-4
5.	FUEL INJECTION NOZZLE-HOLDER ASSEMBLIES.	5A-4
6.	FUEL INJECTION NOZZLE-HOLDER SLEEVES.	5A-4
7.	FUEL INJECTION PUMP AND GOVERNOR-BOSCH (GERMANY).	5A-4
	A. Description.	5A-4
	B. Fuel Injection Pump and Governor Service.	5A-4
	C. Fuel Injection Pump Removal.	5A-5
	D. Fuel Injection Pump Installation and Timing.	5A-6
	E. Governor Adjustment.	5A-9
8.	VENTING OF FUEL SYSTEM.	5A-10
	A. Low Pressure System.	5A-10
	B. High Pressure System.	5A-10

TOPIC 1 — GENERAL DESCRIPTION

The engine fuel system consists of two fuel pressure systems, the low pressure system, and the high pressure system.

In the low pressure system, fuel is drawn from the fuel tank by the fuel transfer (supply) pump. The inlet side of the pump is equipped with a filter and a sediment bowl. Fuel from the outlet side of the transfer (supply) pump is forced through the fuel filters to the fuel injection pump. Once the injection pump sump is full, the excess fuel builds up pressure, opens the fuel pressure relief valve, and returns to the fuel tank.

In the high pressure system the fuel injection pump picks up fuel from the sump, meters and forces the fuel, under extremely high pressure, to the fuel injection nozzles. The nozzles spray the fuel into the engine combusion chambers. The fuel injection lines are seamless steel tubing and each line is the same length. These lines being of equal length assures proper timing and the proper amount of fuel to each injection nozzle.

TOPIC 2 —CHECKING OF FUEL SYSTEM

A. GENERAL

"Missing" or uneven running of the engine, excessive vibration, stalling when idling, and loss of power are indications of insufficient fuel supply to the engine. Before performing any of the following checks, make certain there is an ample supply of clean fuel in the fuel tank and that the fuel tank shut-off valve (if so equipped) is open.

B. AIR IN SYSTEM

Loosen vent screw, Fig 2 (3). Crank engine with starter. If fuel containing bubbles flows from around vent screw, air being drawn into system on suction side of transfer pump is indicated. Correct this condition by tightening any loose low pressure fuel line connections, fuel filter elements, and sediment bowl.

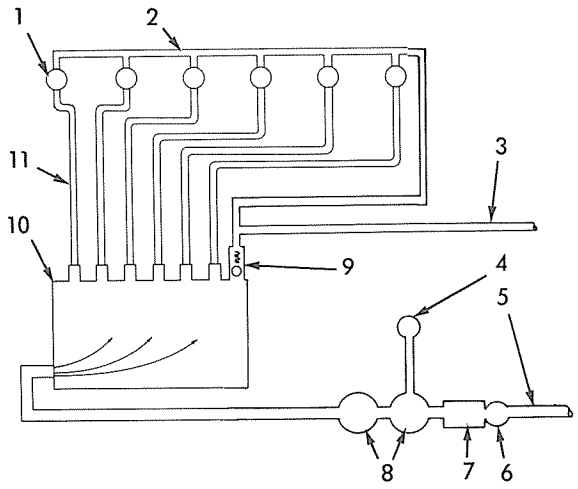


Fig. 1 Fuel Flow-Schematic Diagram (T-41358)

1. Fuel injection nozzle-holders
2. Fuel return manifolds and return line
3. Returns to fuel tank
4. Fuel pressure gauge
5. From fuel tank
6. Transfer pump fuel filter and sediment bowl
7. Fuel transfer (supply) pump
8. Fuel filters
9. Pressure relief valve
10. Fuel injection pump
11. Fuel injection lines

C. CLOGGED FUEL FILTERS OR COLLAPSED FUEL LINES

Loosen vent screw, Fig. 2 (3). Crank engine with starter. If a full flow of fuel is not obtained from around the vent screw, a clogged or collapsed fuel line or a clogged filter element is indicated. If this condition exists, replace clogged filter elements, or clean or replace fuel line.

D. INOPERATIVE FUEL PRESSURE RELIEF VALVE OR FUEL TRANSFER PUMP

The fuel transfer pump should deliver more fuel to the fuel sump of the fuel injection pump than is required for engine operation. The fuel pressure relief valve connected into the fuel return passage of the fuel injection pump, controls maximum fuel pressure within the fuel sump of the injection pump. The relief valve is set to open between 19 and 21 psi. When fuel pressure within the fuel sump of the injection pump exceeds relief valve setting, the pressure relief valve opens and allows excess fuel to return to the fuel tank through the fuel return line.

Check for an inoperative fuel pressure relief valve or an inoperative fuel transfer pump as follows:

1. Start engine and operate at approximately one-half throttle. Observe the fuel pressure gauge. Gauge should indicate a pressure of 19 to 21 psi. If gauge indicates a pressure below specified minimum, stop engine and disconnect the fuel return line from the fuel pressure relief valve.
2. Start engine and operate at approximately one-half throttle. If gauge indicates a pressure below the specified minimum, and a full flow of fuel is observed from disconnected return line, this indicates that the pressure relief valve is stuck in the open position and the valve must be replaced as a unit. However, if gauge indicates a pressure below specified minimum and little or no fuel is observed from disconnected return line, an inoperative fuel pump is indicated, and the pump must be removed, inspected and replaced as a unit if necessary.
3. If a pressure above 21 psi is indicated by the gauge, the fuel pressure relief valve is inoperative and must be replaced as a unit.
4. Stop engine and connect fuel return line to fuel pressure relief valve.

E. MALFUNCTIONING FUEL INJECTION NOZZLE-HOLDER ASSEMBLIES

"Missing" or uneven running of the engine and loss of power indicates a malfunctioning fuel injection nozzle-holder or holders. Locate malfunctioning fuel injection nozzle-holder assemblies as follows:

Run engine at low idle speed and "cut-out" each fuel injection nozzle-holder in turn by loosening the fuel injection line nut attaching the fuel injection line to the fuel injection pump.

CAUTION

Keep hands away from loosened nuts while performing this test.

A decrease in engine speed with injection line nut loosened, indicates that the fuel injection nozzle-holder for that cylinder is functioning properly. If engine speed does not decrease, the fuel injection nozzle-holder is malfunctioning and must be removed, tested, adjusted and cleaned.

F. MALFUNCTIONING FUEL INJECTION PUMP

Do not replace the fuel injection pump before making a compression test (refer to "TROUBLESHOOTING" Section).

The compression test will indicate whether or not burned or stuck valves, worn or scored pistons and sleeves, worn or stuck rings, etc., are causing the improper engine operation.

If all causes for insufficient fuel supply have been eliminated, and the engine still runs unevenly and normal engine performance is not obtained, the fuel injection pump will be considered at fault and should be repaired or replaced. The faulty fuel injection pump (with governor) should be taken to your nearest Fiat-Allis Construction Machinery Dealer for repairs and testing.

TOPIC 3 — FUEL FILTERS

A. DESCRIPTION

Three fuel filters are incorporated in the fuel system. A ceramic type filter and a sediment bowl, located on the suction side of the fuel transfer (supply) pump, filters dirt and removes any water from the fuel before it enters the transfer pump. Fuel leaving the transfer pump is forced through a pair of full flow filters with throw-away type elements. The filtered fuel then flows to the fuel injection pump.

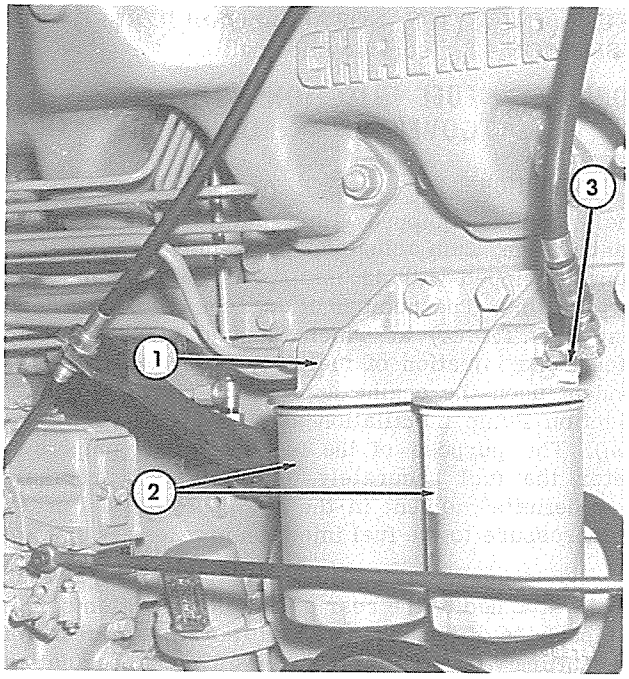


Fig. 2 Fuel Filters
(T-76364)

1. Filter head
2. Filter elements
3. Vent screw

B. SERVICE

1. The transfer pump filter, Fig. 3 (17) and sediment bowl (18) should be inspected after every 10 hours of operation; if sediment or water has collected in sediment bowl, remove sediment bowl and filter and clean. Filter should always be removed and cleaned after every 600 hours of operation or when fuel filters are replaced. Clean filter as follows:

   a. If fuel tank is located above fuel filter, close fuel tank shut-off valve.

   b. Loosen clamping nut (22), swing clip (21) to one side and remove sediment bowl and filter.

   c. Wash and clean sediment bowl and filter with solvent or clean diesel fuel.

   d. Inspect sediment bowl gasket and replace if necessary. Position spring (20) and filter (17) in sediment bowl.

   e. Install bowl with filter on transfer pump; be certain sediment bowl is properly seated against gasket. Move clip (21) into position and tighten clamping nut finger tight.

   f. Open fuel tank shut-off valve and let sediment bowl fill by gravity, or if so equipped operate hand primer pump until sediment bowl is filled. Observe sediment bowl for leaks and correct any leaks found.

2. Remove and discard fuel filters, Fig. 2, and install new filters after every 600 hours of operation (more often if conditions warrant) or when fuel filters become clogged and a pressure of less than 19 psi is indicated by fuel pressure gauge. Clogged filters are usually indicated by irregular engine performance. Replace filters as follows:

   a. Clean fuel filter head and surrounding area. If fuel tank is located above fuel filters, close fuel tank shut-off valve.

   b. Turn filters counterclockwise to remove; discard old filters.

   c. Fill each new filter with clean fuel oil. Install new O-rings at top of each filter. Turn filter onto filter head, until O-ring just touches head, then tighten an additional half turn; use hand pressure only!

   NOTE: Use only recommended filters available from Fiat-Allis Dealer.

   d. Open fuel tank shut-off valve and let sediment bowl fill by gravity, or if so equipped operate hand primer pump until sediment bowl is filled.

   e. Loosen pipe plug, Fig. 2 (3), in rear end of filter head; with engine shut-off in OFF position, crank engine with starter until a full stream of fuel (free of bubbles) flows from around pipe plug; tighten pipe plug while continuing to crank engine.

   f. Start engine, observe for fuel leaks; correct any leaks found.

TOPIC 4 — FUEL TRANSFER (SUPPLY) PUMP

A. GENERAL

The fuel transfer pump is mounted directly on the fuel injection pump. The purpose of the pump is to supply fuel under low pressure, to the fuel sump of the injection pump.

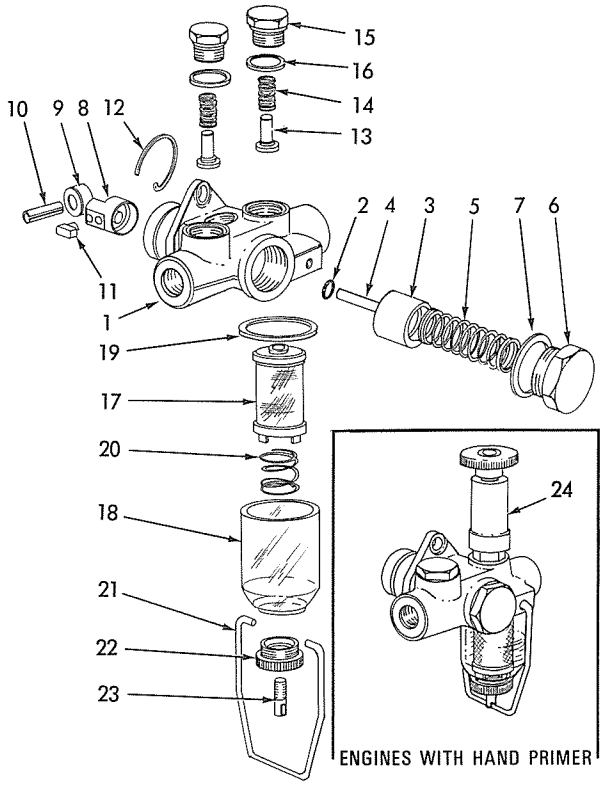


Fig. 3 Fuel Transfer (Supply) Pump (T-76149)

1. Pump housing
2. O-ring
3. Pump plunger
4. Pressure spindle
5. Spring
6. Retaining screw
7. Gasket
8. Roller tappet
9. Roller
10. Roller pin
11. Sliding block
12. Snap ring
13. Valve
14. Valve spring
15. Screw plug
16. Gasket
17. Filter
18. Sediment bowl
19. Gasket
20. Spring
21. Clip
22. Clamping nut
23. Stud
24. Hand primer

B. FUEL TRANSFER PUMP TESTING

Periodically the fuel transfer pump should be removed and inspected. Disconnect the fuel lines from the fuel transfer pump. Remove the nuts, lock-washers, and plain washers attaching the transfer pump to the fuel injection pump and remove the transfer pump and hand primer (if engine is so equipped) as an assembly. Connect a piece of tubing to the fitting on the inlet side of the pump and place the free end of the tubing in a container of clean diesel fuel.

Work the tappet assembly in and out, by hand, until fuel flows from outlet side of the transfer pump. If a solid flow of fuel does not emerge from the outlet opening, weak valve springs and/or worn or damaged valves or valve seats are indicated. Disassemble the transfer pump and inspect the various components. If the valve seats are damaged in any way the transfer pump must be replaced as a unit.

TOPIC 5 — FUEL INJECTION NOZZLE-HOLDER ASSEMBLIES

The fuel injection nozzle-holder assemblies used with the Bosch (Germany) fuel injection pump are the same as those used with the American Bosch pump. Refer to "FUEL INJECTION NOZZLE-HOLDER ASSEMBLIES" in SECTION 4 for service information.

TOPIC 6 — FUEL INJECTION NOZZLE-HOLDER SLEEVES

The fuel injection nozzle-holder sleeves, used with the Bosch (Germany) fuel injection pump are the same as those used with the American Bosch pump. Refer to "FUEL INJECTION NOZZLE-HOLDER SLEEVES" in SECTION 4 for service information.

TOPIC 7 — FUEL INJECTION PUMP AND GOVERNOR — BOSCH (GERMANY)

A. DESCRIPTION

The engine is equipped with a multiple-plunger, constant stroke, cam actuated, heavy-duty fuel injection pump, equipped with 11 mm. plungers and timed for port closing. The number of degrees before top dead center (B.T.D.C.) at which the fuel injection pump effects the injection of fuel into the cylinders is dependent upon the engine application (refer to "Fuel Injection Pump Installation and Timing" in this section). The purpose of the fuel injection pump is to meter the fuel accurately and deliver it precisely at a definite moment in the engine cycle and under high pressure to the fuel injection nozzles.

The governor is of the mechanical-centrifugal type and is attached to the rear of the fuel injection pump. The purpose of the governor is to serve as a means of pre-setting and maintaining within close regulation any desired engine speed within the nominal idling and maximum speed range, irrespective of engine load. The governor also controls the engine idling speed to prevent stalling and the maximum speed to prevent racing.

The fuel injection pump and governor are mounted on the left side of the engine. The pump is gear driven, at one-half engine speed, by a gear in mesh with a special gear cast integral with the camshaft gear.

B. FUEL INJECTION PUMP AND GOVERNOR SERVICE

Generally, malfunctioning of the fuel injection equipment is the direct result of dirty fuel. Dirt in the fuel causes rapid wear on precision parts, particularly the plunger, control sleeve, delivery valves and seats, and the fuel injection nozzle valves and valve bodies. Therefore, extreme care should be used in the storage and handling of fuel to prevent the entrance of dirt, water, and abrasive particles. Any water or sediment should be drained from the fuel filter daily, and the fuel filter elements must be changed at the specified intervals or more often when conditions warrant.

The fuel injection pump governor assembly is lubricated by the engine lubricating system. No lubrication service on the injection pump and governor assembly is required.

Fiat-Allis dealers are equipped with fuel injection pump calibrating and test stands and the special tools required to test, adjust, and repair the fuel injection pump and governor assembly. Therefore, if at any time the fuel injection pump and governor assembly requires repairs or adjustment, the assembly should be removed and taken to your nearest Fiat-Allis dealer. It is important that the dealer be furnished with the injection pump serial number and the model and serial number of the unit so that the pump may be properly calibrated and the correct replacement pump or pump parts may be furnished.

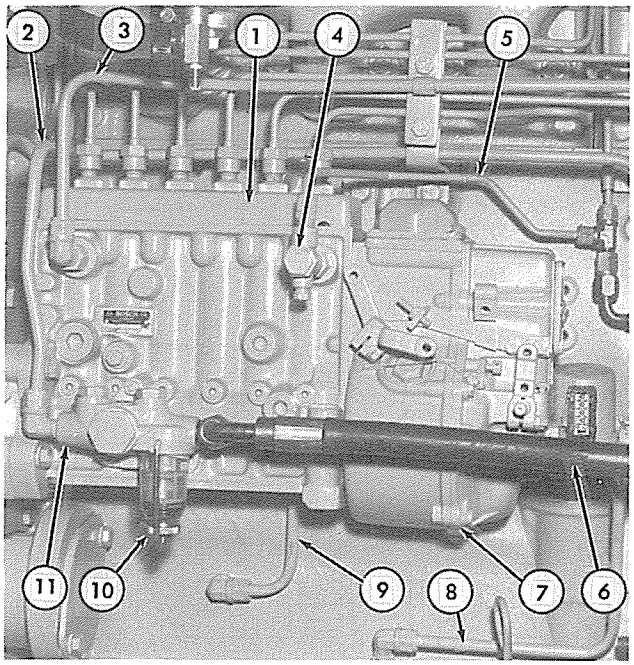


Fig. 4 Fuel Injection Pump and Governor–Bosch (Germany) (T-76387)

1. Fuel Injection Pump
2. Fuel Transfer Pump-to-Fuel Filter Line
3. Fuel Filter-to-Fuel Injection Pump Line
4. Pressure Relief Valve
5. Fuel Return Line
6. Fuel Supply Line
7. Governor
8. Lube Oil Return Line
9. Lube Oil Supply Line
10. Fuel Filter and Sediment Bowl
11. Fuel Transfer (Supply) Pump

C. FUEL INJECTION PUMP REMOVAL

1. Remove pipe plug, Fig. 5 (1). Rotate engine until timing marks on drive gear hub, Fig. 8 (3), and timing pointer are aligned (these marks are visible through the pipe plug hole). Aligning these marks will position the #1 piston on its compression stroke and facilitate pump installation.
2. If engine is so equipped, remove hydraulic pump located below fuel injection pump.
3. If engine is equipped with an hour meter located in the block at the rear of the injection pump, loosen the mounting screws and rotate it so the window is halfway between the injection pump and the rear tappet cover.
4. Shut off fuel supply and disconnect all low and high pressure fuel lines and lube oil supply and return lines. Remove capscrew securing line supporting bracket to cylinder block.
5. Disconnect throttle and stop control linkage from fuel injection pump.
6. Remove capscrew securing rear pump mounting bracket to cylinder block.
7. Remove capscrews securing pump mounting cover, Fig. 5 (4), to timing gear housing (5). Pull pump back and swing it away from the cylinder block just as the pump drive gear clears the timing gear housing. If removal of the pump at this point cannot be accomplished due to interference at the front valve lifter cover, remove cover to gain additional clearance.
8. If engine has a fan drive pully installed in front of injection pump extend timing mark from hub on to gear before loosening gear attaching capscrews. Remove gear from hub and pump from mounting cover.

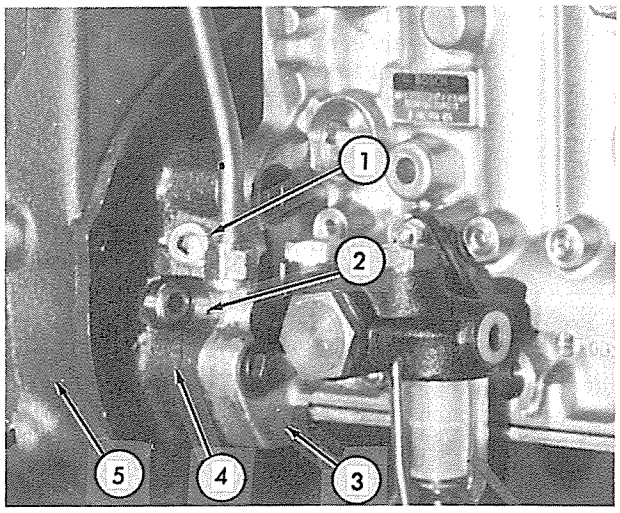


Fig. 5 Fuel Injection Pump Timing Window (T-76871)

1. Pipe Plug (Pump Timing Window)
2. Pipe Plug
3. Fuel Injection Pump
4. Pump Mounting Cover
5. Timing Gear Housing

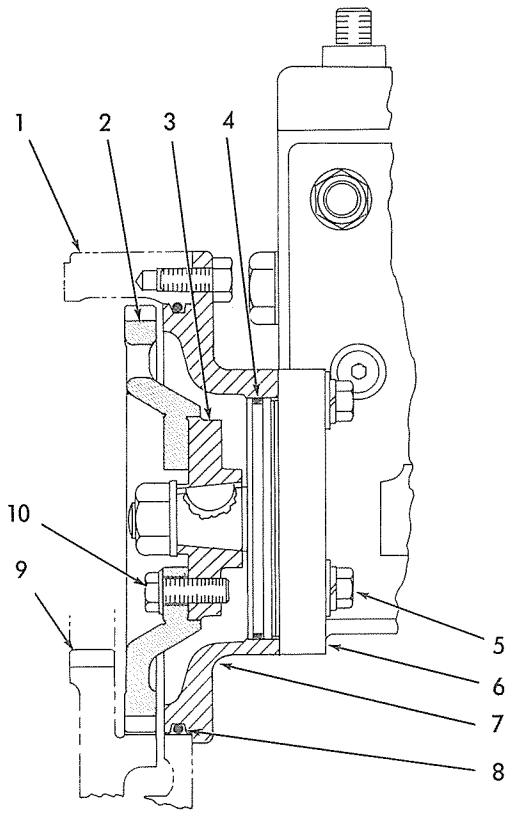


Fig. 6 Fuel Injection Pump Drive
(T-76304)

1. Timing Gear Housing
2. Pump Drive Gear
3. Drive Gear Hub
4. O-ring
5. Capscrew
6. Fuel Injection Pump
7. Pump Mounting Cover
8. O-ring
9. Camshaft Gear
10. Capscrew

D. FUEL INJECTION PUMP INSTALLATION AND TIMING

1. GENERAL

Before installing the pump on the engine, make certain the #1 piston is on its compression stroke and the flywheel is at the correct mark. This can be determined as follows:

a. Remove the rocker arm rear cover so valve action can be observed. Remove timing hole cover from engine flywheel housing.

b. Hand rotate the engine flywheel until the #6 cylinder exhaust valves are nearly closed and intake valves start to open. This will position the #1 piston on its compression stroke.

c. Continue rotating the flywheel until the timing pointer indicates the specified number of degrees B.T.D.C. on the flywheel timing marks (refer to following table and Fig. 7).

IMPORTANT

To be sure that all slack is out of the timing gears, back up the engine a few degrees and again come up to the timing mark in the direction of normal engine rotation (clockwise viewed from front). The engine is now in correct position for beginning of fuel injection into number one cylinder and for installing the fuel injection pump or for checking its timing.

TIMING CHART

UNITS	SET FLYWHEEL TIMING POINTER AT:
HD-11 Crawler Tractors	32°B.T.D.C.
12G Crawler Loaders	34° B.T.D.C.
745 & 745H Wheel Loaders	34° B.T.D.C.

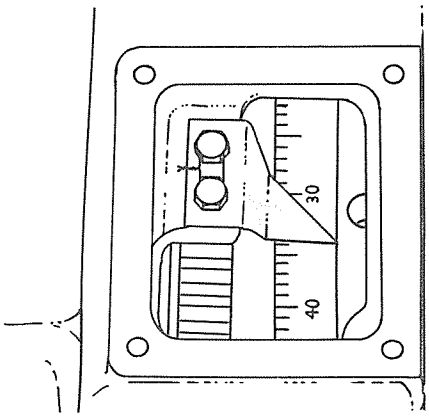


Fig. 7 Timing Mark on Engine Flywheel
Indicating 34°
(T-76872)

2. ENGINES WITH FAN DRIVE PULLEY INSTALLED IN FRONT OF INJECTION PUMP

a. Refer to Fig. 6 and install O-ring in groove of injection pump. Assemble mounting cover on injection pump using capscrews, lock-washer, and plain washer. Tighten capscrews securely. Install O-ring in groove of mounting cover.

b. Install the lube oil supply tube and elbow in the oil inlet opening located on the engine side of the injection pump body. Also attach the pump rear mounting bracket to pump.

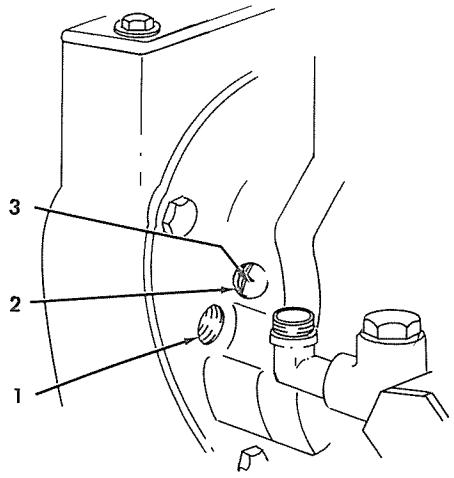


Fig. 8 Injection Pump Timing Marks
(T-76886)

1. Timing pin hole
2. Timing mark window
3. Timing mark (pump drive gear)
   Timing mark (pump drive gear hub)
   Timing pointer

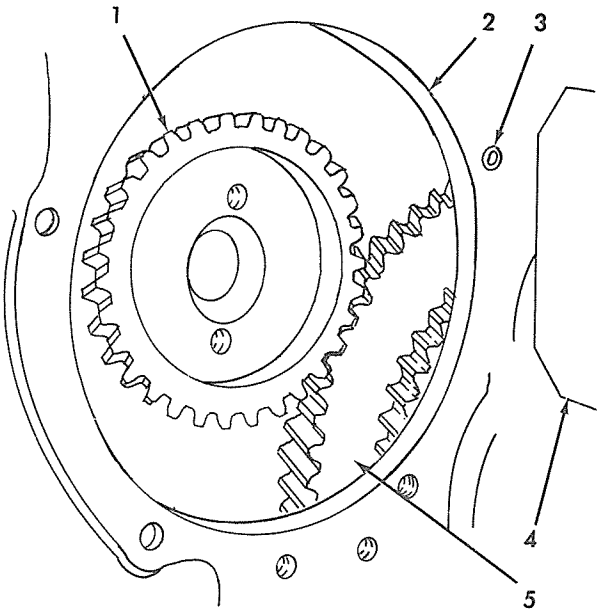


Fig. 10 Timing Gear Housing
(T-76888)

1. Fan drive gear (if so equipped)
2. Timing gear housing
3. Setscrew (nylon pellet type)
4. Front tappet cover
5. Camshaft gear

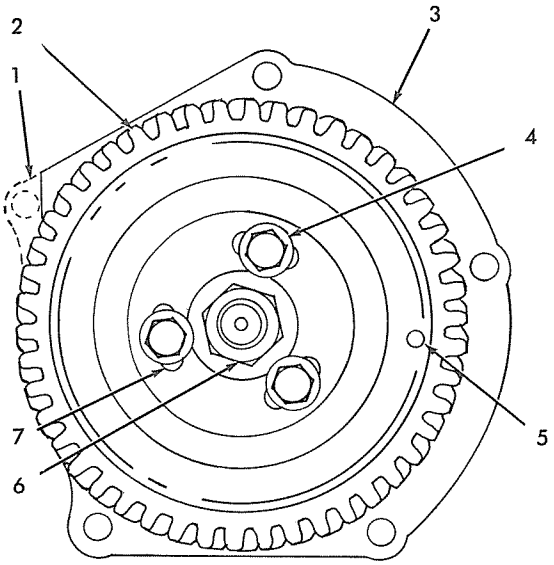


Fig. 9 Injection Pump Drive Gear
(T-76887)

1. First type mounting cover (5 hole)
2. Pump drive gear
3. Second type mounting cover (4 hole)
4. Gear attaching capscrews
5. Timing pin hole (units with fan drive pulley installed in front of injection pump
6. Drive gear hub retaining nut
7. Elongated holes in gear

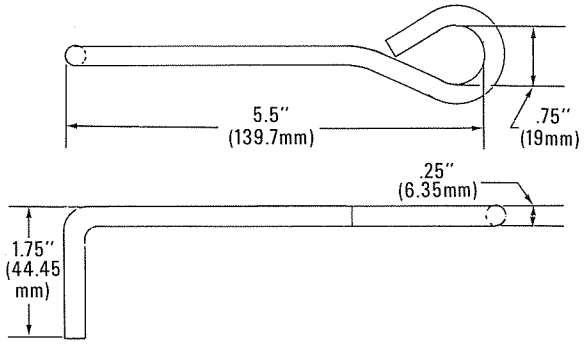


Fig. 11 Timing Pin
(T-76889)

c. The first type mounting cover has 5 holes for mounting the injection pump to the rear of the timing gear housing; the second type mounting cover has 4 holes. If the second type is used to replace the first type, it is necessary to install a countersunk hex head (nylon pellet type) set-screw (3/8" - 16 x 1/2") in the upper right hand tapped hole of the timing gear housing. This location is the place where the hole has been removed from the pump mounting cover, Fig. 9 and 10.

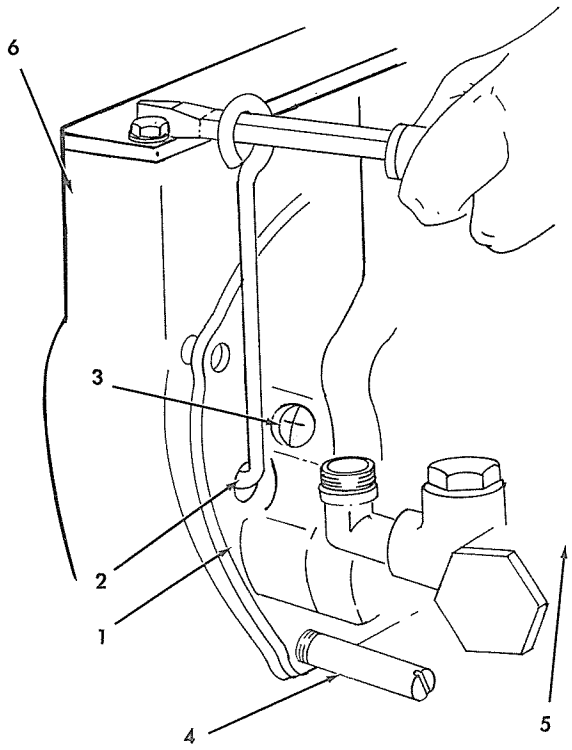


Fig. 12 Installing Injection Pump Using Timing Pin (T-76890)

1. Injection pump mounting flange
2. Timing pin
3. Timing marks
4. Guide stud
5. Injection pump
6. Timing gear housing

d. Rotate fuel injection pump camshaft until timing mark on the pump drive gear hub appears in or near the upper pipe plug hole (timing window) of the mounting cover.

e. Assemble the drive gear to gear hub of the injection pump with the timing mark aligned with the mark on the drive gear hub. Tighten securely the 3 self-locking capscrews which secure the gear to the hub.

f. Rotate injection pump gear until the timing marks on the gear and the hub appear in the upper timing window of the mounting cover.

g. On engines with second type mounting cover, install the timing pin through the lower window of the mounting cover and into the hole in the gear. This will lock the pump in position so that the proper pump drive gear tooth will mesh with the engine gear train. Make up timing pin according to dimensions in Fig. 11.

h. Position pump with its drive gear in the opening in the rear of the timing gear housing. With the pump held in this position, install a 3/8"-16x3" guide stud or capscrew through the lower left hand hole in the pump mounting cover and into the gear housing. This will serve to position the pump and act as a support to hold the pump in place.

i. Insert a pry bar or heavy duty screwdriver through the loop in the timing pin. Slowly pry upward with the left hand while pushing the pump forward with the right hand until the pump drive gear engages the camshaft gear.

NOTE

If difficulty is experienced in meshing the pump drive gear with the camshaft gear, slightly move the engine flywheel one way or the other until they do mesh.

j. With the injection pump cover held tightly against the timing gear housing, the mark on the gear and hub must align with the pointer on the front of the injection pump and the specified number of timing degrees on the flywheel must be aligned with the pointer in the flywheel housing.

If these timing marks do not line up, remove injection pump and repeat the installation procedure.

k. Secure the injection pump in position by installing the 3 nylon pellet type capscrews through the mounting cover and into the gear housing. Remove the guide stud and install the remaining capscrew. Tighten all capscrews securely.

l. Complete the installation by reversing the removal procedure. Open fuel shut-off cock and vent the system. See Topic 8.

3. ENGINES WITHOUT FAN DRIVE PULLEY INSTALLED IN FRONT OF INJECTION PUMP

a. Install O-ring in groove of injection pump. Assemble mounting cover on injection pump using capscrews, lock-washer, and plain washer. Tighten capscrews securely. Install O-ring in groove of mounting cover.

b. Install the lube oil supply tube and elbow in the oil inlet opening located on the engine side of the injection pump body. Also attach the pump rear mounting bracket to pump.

c. The first type mounting cover has 5 holes for mounting the injection pump to the rear of the timing gear housing; the second type mounting cover has 4 holes. If the second type is used to replace the first type, it is necessary to install a countersunk hex head (nylon pellet type) set screw (3/8" - 16 x 1/2") in the upper right hand tapped hole of the timing gear housing. This location is the place where the hole has been removed from the pump mounting cover, Fig. 9 and 10.

d. Assemble the drive gear to gear hub of the injection pump. Leave gear retaining capscrews loose enough so that hub can be turned after gear is meshed with camshaft gear.

e. Remove access cover from timing gear housing opposite the pump drive gear.

f. Position timing mark on drive gear hub with the pointer on front of the injection pump. Insert pump into opening of timing gear housing and mesh pump drive gear with camshaft gear. Secure pump mounting cover to timing gear housing with capscrews, lock-washers, and plain washers.

g. Place 1 1/16" socket and handle on drive gear hub retaining nut on end of pump camshaft. Turn pump camshaft to align timing mark on gear mounting hub with pointer on pump. Tighten securely the 3 self-locking capscrews retaining the gear to the hub.

h. Complete the installation by reversing the removal procedure. Open fuel shut-off cock and vent the system. See Topic 8.

E. GOVERNOR ADJUSTMENT

No lubrication nor regularly scheduled service, other than operational checks, on the governor assembly is required as it is engine lubricated and the governor very seldom gets out of working order. If the engine speed is irregular, check the fuel system and all other engine adjustments before changing the governor setting.

All governor adjustments should be performed by an authorized serviceman using factory approved test equipment. Refer to Operator's Manual furnished with unit for specified high and low idle engine speeds and for the method of checking the speeds.

Do not make any speed adjustments at the pump unless absolutely certain that engine control linkage on unit is adjusted and operating correctly.

1. LOW IDLE ADJUSTMENT

a. Refer to Fig. 13. With engine running, loosen the jam nut on the low idle adjusting screw. Hold governor speed control lever so control lever stop contacts the low idle adjusting screw. Turn the idle adjusting screw as necessary to increase or decrease low idle speed.

b. When specified low idle speed is obtained, hold the low idle adjusting screw and tighten the jam nut.

2. HIGH IDLE ADJUSTMENT

a. Remove the flat head screw seal, Fig. 13 (7) from the securing link of the high idle adjusting screw. Remove flat head screw securing the link and remove link in order to gain access to the high idle adjusting screw jam nut.

b. With engine running, loosen jam nut on the high idle adjusting screw. Hold governor speed control lever so control lever shaft stop contacts the high idle adjusting screw. Turn adjusting screw as necessary to increase or decrease the high idle speed. Tighten jam nut.

c. Place link Fig. 13 (3) in position and secure with flat head screw.

3. ENGINE SHUT-OFF ADJUSTMENT

a. Disconnect control linkage from shut-off lever, Fig. 13 (1). Loosen jam nut on stop screw (2) and turn stop screw out several turns.

b. Hold shut-off lever (1) in the extreme stop position. Turn the stop screw (2) until it contacts the shut-off lever, then turn the screw for one additional turn and lock with the jam nut.

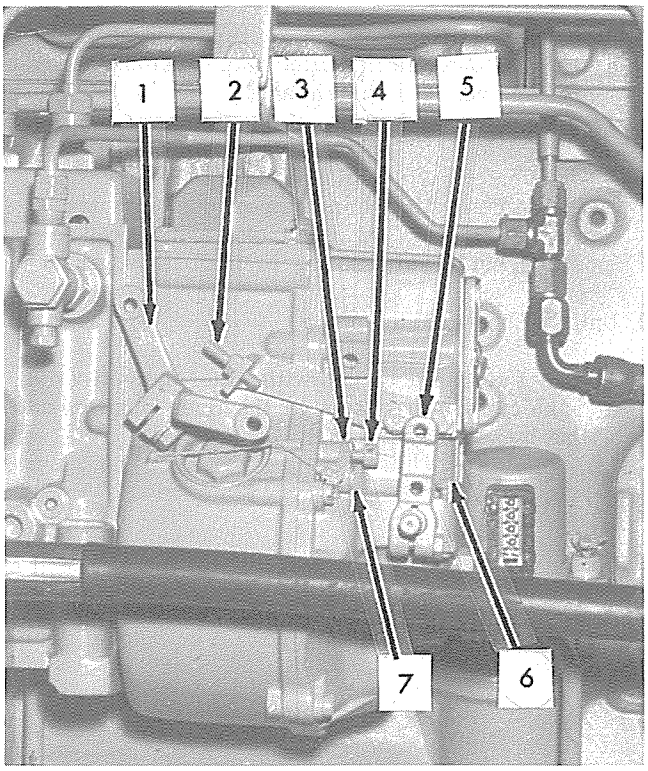


Fig. 13 Engine Speed and Shut-off Adjustment (T-76387)

1. Engine shut-off lever
2. Shut-off lever stop screw
3. Securing link
4. High idle adjusting screw
5. Governor speed control lever
6. Low idle adjusting screw
7. Seal (lead plug)

TOPIC 8 — VENTING OF FUEL SYSTEM

A. LOW PRESSURE SYSTEM

1. Units with primer pump

   a. If fuel tank is equipped with a fuel shut-off valve, make certain that it is in the open position and that tank has ample fuel.

   b. Loosen filter vent plug, Fig. 2 (3). Unlock the plunger of the primer pump by turning it counter-clockwise several turns. Move the primer pump plunger up and down in a pumping motion to fill the filters with fuel and to expel the air.

   c. When fuel free of air bubbles appears at the filter vent, tighten the vent screw securely, while continuing to operate hand primer plunger.

   d. Continue to operate the primer pump plunger to expel the air from the fuel gallery of the injection pump.

   e. If the low pressure system has been properly vented, the hand primer will have a "solid" feel. If the primer has a "spongy" feel, an air leak in the fuel lines on the suction side of the fuel transfer pump is indicated. Correct the malfunction and vent the system again.

CAUTION

Make certain the hand primer pump plunger is at the bottom of its stroke and locked in position before attempting to start the engine.

2. Units without primer pump

   a. If fuel tank is equipped with a fuel shut-off valve, make certain that it is in the open position and that tank has ample fuel.

   b. Loosen filter vent plug, Fig. 2 (3). With engine shut-off knob in OFF position crank engine until fuel free of air bubbles flows from vent. Tighten vent securely.

CAUTION

Do not use starting motor continuously for more than 30 seconds. After 30 seconds of use, pause two minutes to allow it to cool.

B. HIGH PRESSURE SYSTEM

The high pressure fuel system is usually self-venting due to the fact that any air trapped by the fuel injection pump plungers is forced out through the fuel injection nozzles and into the engine combusion chambers. However, in the event the fuel lines have been removed, the engine has run out of fuel, or the engine has not been operated for some time, venting of the high pressure system may be necessary to facilitate starting of the engine.

Vent the high pressure fuel system as follows:

1. Loosen connector nut attaching the upper end of each fuel injection line to its corresponding nozzle holder assembly.

2. Place engine throttle in high speed position. Place engine shut-off control in run position.

3. Crank engine with the starter until fuel flows from ends of all fuel injection lines. Tighten fuel line connector nuts.

CAUTION

Do not use starting motor continuously for more than 30 seconds. After 30 seconds of use, pause two minutes to allow it to cool.

SECTION 6 - AIR CLEANER AND INTAKE MANIFOLD

TOPIC NO.	TITLE	PAGE NO.
1.	GENERAL	6-1
2.	AIR CLEANER	
	A. General	6-1
	B. Air Cleaner Service	6-3
	C. Pressure Testing Air Intake System	6-3
3.	INTAKE MANIFOLD	
	A. Intake Manifold Removal	6-5
	B. Intake Manifold Inspection	6-5
	C. Intake Manifold Installation	6-5

TOPIC 1 - GENERAL

The air intake system consists of the air cleaner and intake manifold. If the engine is equipped with a turbocharger, the compressor side of the turbocharger is part of the intake system.

It is important to provide an ample supply of fresh air to the combustion chambers. Insufficient air will limit the amount of fuel the engine can burn and will lead to loss of power, excessive exhaust smoke, and high fuel comsumption. Contaminated and dirty air leads to worn engine parts, high oil consumption, and eventual engine failure.

Two types of intake manifolds, as shown in Fig. 4, are used with the various engine applications. The intake manifold is sealed to the cylinder heads with gaskets and secured in place with nuts and lockwashers.

TOPIC 2 - AIR CLEANER

A. GENERAL

The air cleaner is used to remove dust and other foreign matter from the air used by the engine. The life of the engine depends largely upon the efficiency of the air cleaner.

Four types of air cleaners, as shown in Fig. 1, 2, 3, and 4 are used with the various engine applications.

1. DESCRIPTION OF AIR CLEANER (TYPE 1) Fig. 1

Air for the engine is drawn into the air cleaner through openings in the air pre-cleaner panel. The air pre-cleaner imparts a rotary motion to the air, causing heavier particles of dirt and foreign material to drop to the bottom of pre-cleaner compartment. Heavier particles are then removed by a suction line and aspirator connected to the engine exhaust system. The pre-cleaned air is then drawn through the filter elements, removing the fine dust. The cleaned air then passes through air tight hoses and/or tubes into the turbocharger, if engine is so equipped, and then into the intake manifold which directs the air into the cylinders.

2. DESCRIPTION OF AIR CLEANER (TYPE II) Fig. 2

Air enters through a pipe that connects to the side of the air cleaner body. Due to the cylindrical shape of the air cleaner body and the directional control effected by the fins on the front end of the element, the incoming air takes on a highspeed rotary flow around the inside of the housing. This rotary flow throws off a majority of the dust particles in the air. These particles are collected in and ejected from, the flexible unloader in the bottom of the air cleaner.

Engine vacuum overcomes the rotary flow and draws the air through the paper element in the center of the air cleaner body. Dust particles still remaining in the air are then deposited on the outside of the element and only clean air is delivered to the engine.

3. DESCRIPTION OF AIR CLEANER (TYPE III) Fig. 3

Air enters through the air inlet tube and strikes an air baffle (5) which causes the heavy dust particles to fall into air cleaner dust cup (7).

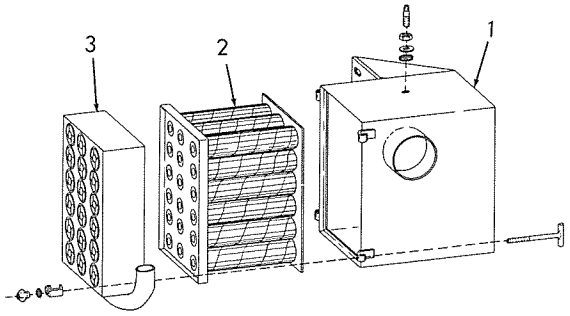


Fig. 1 — Air Cleaner (Type I)
(T-41845)

1. Housing Assembly
2. Cartridge
3. Pre-Cleaner

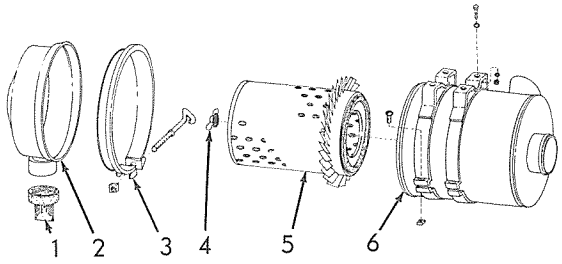


Fig. 2 — Air Cleaner (Type II)
(T-39704)

1. Dust Unloader
2. Cup
3. Clamp
4. Nut
5. Element
6. Body

The partially cleaned air is drawn through the filter element (3) which removes any dust particles still remaining in the air. The clean filtered air leaves the filter element through the air outlet opening and enters the intake manifold.

The dust cup must be removed and cleaned periodically, refer to the "Operating Instructions and Field Maintenance Manual" furnished with the unit.

4. DESCRIPTION OF AIR CLEANER (TYPE IV) Fig. 4

Air enters the Dyna-Panel pre-cleaner through an air intake adapter. The interior of the pre-cleaner consists of a series of louvres which separates the heavier

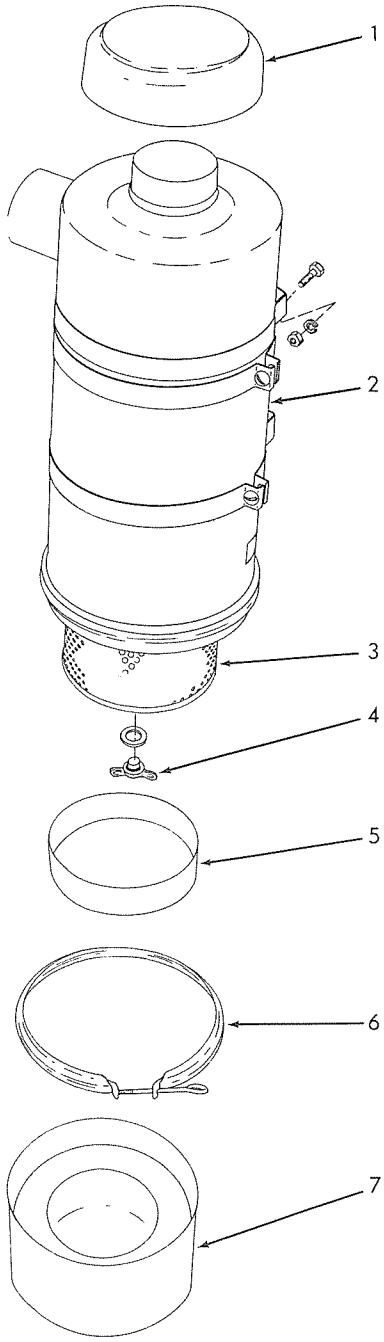


Fig. 3 — Air Cleaner (Type III)
(T-37278)

1. Rain Cap
2. Body
3. Element
4. Element Retaining Nut
5. Air Baffle
6. Dust Cup Clamp
7. Dust Cup

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

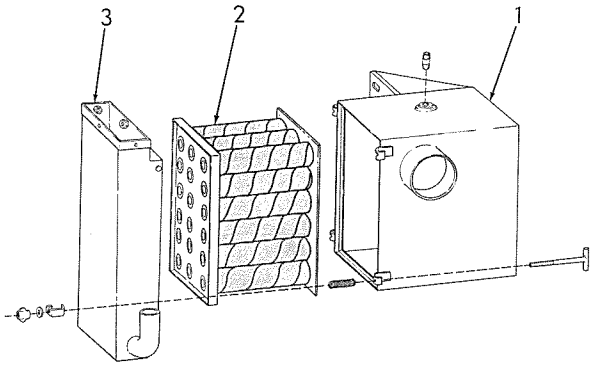


Fig. 4 — Air Cleaner (Type IV)
(T-72062)

1. Housing Assembly
2. Cartridge
3. Dyna-Panel Pre-Cleaner

particles of dirt which are then removed through a suction line and aspirator connected to the engine exhaust system. The pre-cleaned air is then drawn through the filter elements, removing the remaining dust. The cleaned air then passes through air tight hoses and/or tubes into the turbocharger and then into the intake manifold which directs the air into the cylinders.

B. AIR CLEANER SERVICE

Periodic inspection of air cleaner body for dents, cracks, etc. should be made frequently. Also check for damaged hoses, loose hose clamps, damaged gaskets or any kind of leak that allows air to enter engine cylinders without first passing through the air cleaner. If any of above conditions are found they MUST be corrected immediately.

A dirty air filter can greatly reduce the horsepower output of an engine. If unit is equipped with an air cleaner indicator, this will help to tell the condition of the air cleaner filter.

The detailed and correct procedure for replacing the air cleaner filter element can be found in the "Operating Instructions and Field Maintenance Manual" furnished with the unit.

C. PRESSURE TESTING AIR INTAKE SYSTEM FOR LEAKAGE

Whenever any work that involves partial or complete dismantling of the air intake system (such as removal of engine, turbocharger air cleaner, etc.) the air intake system should be pressure tested for leakage immediately after repair or replacement is completed. Also, if when the air filter cartridge is removed and any dust is found to be present in the inside of the filter housing, the system must be pressure tested immediately and the cause located and corrected.

1. The following equipment is required to pressure test the air intake system (refer to Fig. 5).

   a. Air tight rubberized or plastic material (3) to cover intake face of air cleaner or, on earlier model units, air cleaner intake pipe.

   b. Tire pump (1) or low pressure air supply (preferably equipped with a regulating valve).

   c. Pressure gauge (2) (that will read accurately at 5 psi).

   d. 1/4" pipe nipple (4).

   e. 1/4" pipe tee (5).

   f. Valve stem with 1/4" pipe plug (6) (not required if low pressure air supply with regulating valve is used).

   g. Adequate hose clamps if required.

2. Pressure test air intake system as follows:

   a. Position engine so that valves will not allow air to exhaust to atmosphere. On engines covered in this manual, this position is approximately 25° ATDC.

NOTE

Usually when the engine is cranked with the starter, the engine will stop at approximately 25° ATDC when the starter button is released.

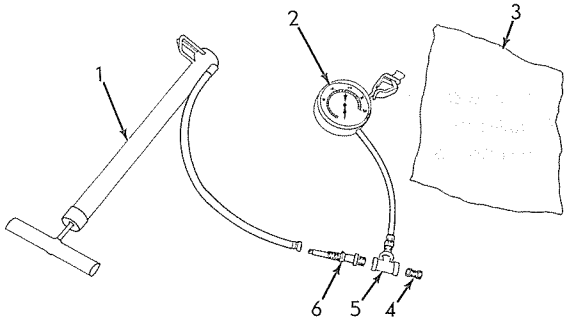


Fig. 5 — Equipment Required to Pressure Test Air Intake System
(T-71532)

1. Tire Pump
2. Pressure Gauge
3. Air Tight Rubberized or Plastic Material
4. 1/4" Pipe Nipple
5. 1/4" Pipe Tee
6. Valve Stem with 1/4" Pipe Plug

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

b. On units equipped with Type I (Fig. 1) or Type IV (Fig. 4) air cleaners, remove the pre-cleaner and cover the face of the filter cartridge with a piece of air tight rubberized or plastic material cut to the proper size, then install the pre-cleaner.

NOTE

On units equipped with Type IV (Fig. 4) pre-cleaner, a metal plate (18 or 20 gauge) cut to the size of the panel, will be required to support the rubberized or plastic material.

c. On units equipped with Type II (Fig. 2) air cleaner, disconnect the air inlet tube elbow from the air cleaner and remove the dust unloader (1). Cover both openings with air tight rubberized or plastic material and secure with hose clamps.

d. On units equipped with Type III (Fig. 3) air cleaner, remove the rain cap (1) and cover the opening in the air cleaner body with a piece of air tight rubberized or plastic material. Secure with a hose clamp.

e. Remove 1/4" pipe plug from air intake elbow and install the 1/4" pipe nipple (Fig. 5) (4) and tee (5) in the opening. Install pressure gauge (2) in one opening in the tee and the 1/4" pipe plug with valve stem (6) in the other opening.

f. Attach the tire pump, or low pressure air supply, to the valve and pump air into the system until the gauge registers 5 psi maximum.

CAUTION

Never exceed 7 psi pressure in the system. Pressure in excess of 7 psi will cause the hoses to expand allowing the stiffener rings to fall out.

g. Shut off air supply and observe the pressure gauge. If pressure drops slowly and evenly, the air intake system may be assumed to be in satisfactory condition. However, to locate possible small leaks, apply a soap and water solution to hose connections and at gasket locations while system is under pressure. Formation of bubbles indicates an air leak. Correct leak immediately.

If pressure drops back to zero almost immediately after air supply is shut off, a serious leak in the air intake system is indicated. Application of a soap and water solution will usually indicate where the leak is located. Correct all leaks immediately.

If a serious leak is indicated, and a thorough check of the hoses, hose clamps, gaskets, etc. does not indicate where the leak is located, the leak may be in a part of the air cleaner housing that is not visible, or readily accessible, and the air cleaner should be removed and tested as a unit.

NOTE

Before removing and testing the air cleaner, recheck the material covering the face of the filter cartridge to make certain it is not leaking air.

If the entire air intake system, including the air cleaner housing, proves to be free from air leaks but the specified air pressure cannot be obtained and/or drops off rapidly, a leaking valve or valves is indicated and the engine compression pressure should be checked to localize the trouble. For detailed instructions on checking compression pressure, refer to "ENGINE" in "TROUBLE SHOOTING" Section.

TOPIC 3 - INTAKE MANIFOLD

A. INTAKE MANIFOLD REMOVAL

1. Remove capscrews securing air inlet elbow to the intake manifold.
2. Loosen hose clamp securing air inlet elbow and remove elbow.
3. On track-type tractors equipped with hydraulic steering, remove capscrews holding steering filters to intake manifold.
4. Remove remaining nuts and washers which secure manifold to cylinder heads and remove intake manifold.

B. INTAKE MANIFOLD INSPECTION

1. Wash and clean the intake manifold with a cleaning solvent.
2. Check manifold for foreign deposits, clean and remove obstructions found within the manifold.
3. If manifold is cracked, repair or replace it.
4. If mounting surfaces of the manifold are warped enough so that they will not seal, all of the surfaces must be machined or the manifold must be replaced.
5. Inspect and clean surface on cylinder heads to make certain it is free of gasket particles or foreign matter.

C. INTAKE MANIFOLD INSTALLATION

The installation of the intake manifold to the engine is a direct reversal of the removal procedure.

Always use new gaskets when installing the intake manifold.

Torque the intake manifold nuts to 45 - 50 lbs. ft. After the engine is run and coolant temperature reaches operating range, again torque nuts to 45 - 50 lbs. ft.

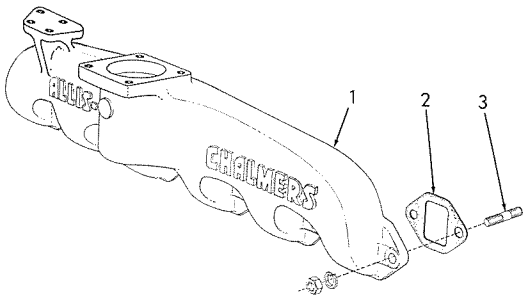


Fig. 6 — Intake Manifold
(T-13159)

1. Intake Manifold
2. Gasket
3. Stud

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

SECTION 7 - EXHAUST MANIFOLD AND TURBOCHARGER

TOPIC NO.	TITLE	PAGE NO.
1.	EXHAUST MANIFOLD	
	A. General	7-2
	B. Exhaust Manifold Removal	7-2
	C. Exhaust Manifold Inspection	7-2
	D. Exhaust Manifold Installation	7-2
2.	TURBOCHARGER	
	A. Turbocharger Removal	7-2
	B. Turbocharger Installation	7-2
	C. Turbocharger Service	7-3

TOPIC 1 - EXHAUST MANIFOLD

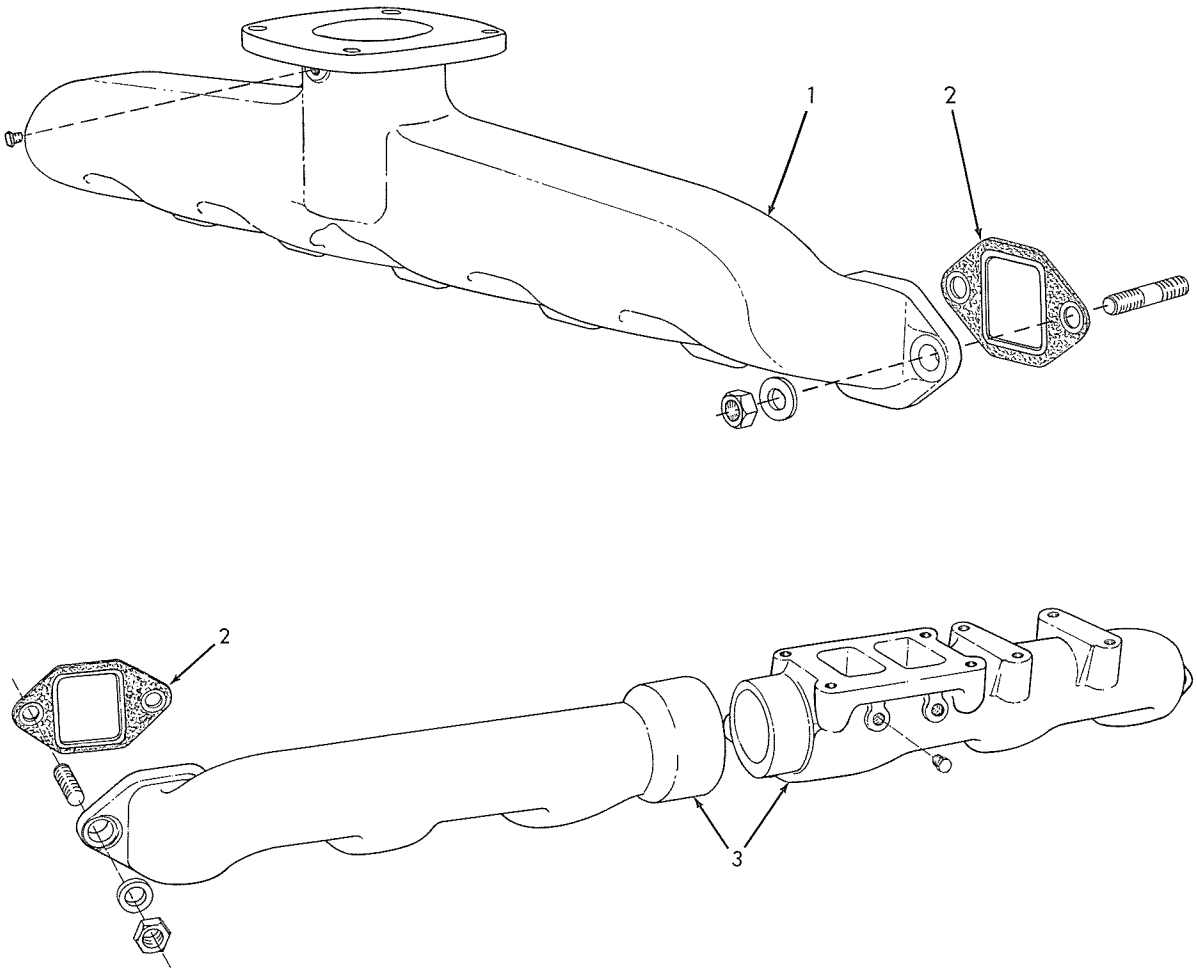


Fig. 1 — Exhaust Manifolds
(T-13158 & T-41856)

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

Legend for Fig. 1

1. Exhaust Manifold (Naturally Aspirated Engines)
2. Gasket
3. Exhaust Manifold (Turbocharged Engines)

A. GENERAL

The cast iron exhaust manifold assemblies are of two types, Fig. 1; one type is used on turbocharged engines and the other on naturally aspirated engines. The naturally aspirated engine exhaust manifold is a one piece casting. The turbocharged engine exhaust manifold is a two piece casting with a turbocharger mounting pad cast as part of the front section. The manifolds are sealed to the exhaust ports of the cylinder heads with steel asbestos gaskets and secured in place with nuts and plain washers.

B. EXHAUST MANIFOLD REMOVAL

1. EXHAUST MANIFOLD REMOVAL (Turbocharged Engines)

   a. Remove turbocharger (refer to "TURBOCHARGER" in this section).

   b. Remove nuts which secure exhaust manifold assembly to cylinder heads and remove exhaust manifold as an assembly.

   c. The manifold assembly should be treated as a single piece unless it is necessary to separate the two pieces.

2. EXHAUST MANIFOLD REMOVAL (Naturally Aspirated Engines)

   a. Remove nuts which secure exhaust manifold to cylinder heads and remove exhaust manifold.

C. EXHAUST MANIFOLD INSPECTION

1. Wash and clean exhaust manifold with a cleaning solvent.

2. Check manifold for carbon deposits, clean and remove obstructions found within the manifold ports.

3. If manifold is cracked, repair or replace it.

4. If mounting surfaces are warped enough so that they will not seal, the manifold must be replaced or machined.

5. Inspect and clean surface on cylinder head to make certain it is free of gasket particles or foreign matter.

D. EXHAUST MANIFOLD INSTALLATION

The installation of the exhaust manifold to the engine is a direct reversal of the removal procedure as outlined in the proceding paragraph.

Always use new gaskets when installing the exhaust manifold and mounting turbocharger (when so equipped).

Torque the exhaust manifold nuts to 45 - 50 lbs ft. After the engine is run and coolant temperature reaches operating range, again torque the nuts to 45 - 50 lbs. ft.

TOPIC 2 - TURBOCHARGER

A. TURBOCHARGER REMOVAL (Fig. 2)

1. Disconnect hose (8) from turbocharger (7).

2. On models equipped with an aspirator (13), disconnect aspirator hose (12) and remove aspirator (13) and/or exhaust pipe (14).

3. Remove capscrews (2) and lockwashers, and remove elbow (1) from manifold (3).

4. Loosen hose clamps (9) and free hose (10) from turbocharger.

5. Disconnect oil supply line (11) and drain line (5) from turbocharger.

6. Remove nuts (6) and plain washers and carefully remove turbocharger (7) and gasket (4) from manifold (3).

B. TURBOCHARGER INSTALLATION (Fig. 2)

1. Just prior to mounting the turbocharger on the engine, fill the oil reservoir of the turbocharger with new clean oil through the oil inlet. Turn rotating assembly by hand to coat bearings and internal parts with oil.

2. Using a new gasket (4), position turbocharger (7) on manifold (3).

3. Install plain washers and special nuts (6) and tighten to a torque of 18 - 21 lbs. ft.

4. Slide hose (10) into position on turbocharger and tighten hose clamps (9).

5. Connect hose (8) to turbocharger.

6. Install elbow (1) and secure with lockwashers and capscrews (2).

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

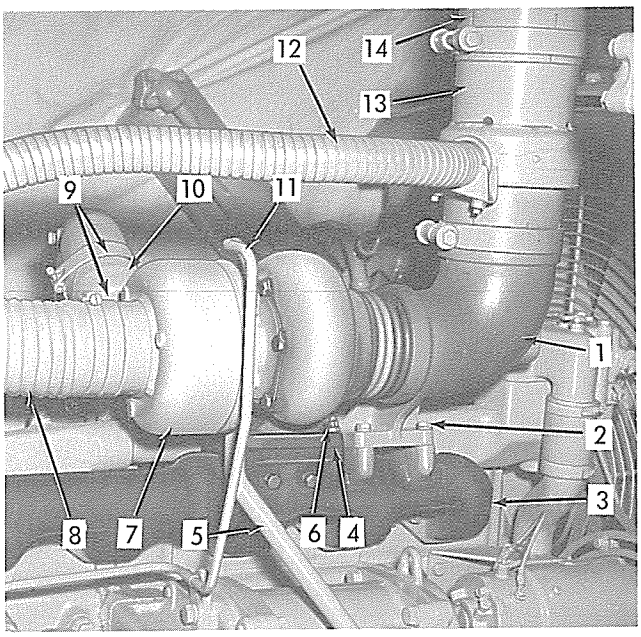


Fig. 2 — Turbocharger — Installed
(T-71405)

7. Install aspirator and/or exhaust pipe and if equipped with aspirator connect aspirator hose (12).

CAUTION

Do not connect oil inlet or drain line to turbocharger until it is definite that there is a free flow of oil to the turbocharger and through it.

Legend for Fig. 2

1. Exhaust Diffuser
2. Capscrew (Stainless Steel)
3. Manifold
4. Gasket
5. Oil Drain Line
6. Nut (Stainless Steel)
7. Turbocharger
8. Air Inlet Hose
9. Hose Clamps
10. Air Discharge Hose
11. Oil Supply Line
12. Aspirator Hose
13. Aspirator
14. Exhaust Pipe

8. Move engine shut-off control to the "STOP" position. Crank engine until there is a free flow of oil from upper end of oil supply line (11). Connect the inlet line. Continue to crank engine until oil flows from oil outlet, then connect the oil drain line (5).

C. TURBOCHARGER SERVICE

Complete instructions regarding the servicing of this unit are contained in Turbocharger Service Manual.

SECTION 8 - VALVES, VALVE OPERATING MECHANISM, AND CYLINDER HEADS

TOPIC NO.	TITLE	PAGE NO.
1.	GENERAL	
	A. Description	8-1
	B. Service of Valve Mechanism	8-3
2.	ROCKER ARMS, ROCKER ARM SHAFTS AND BRACKETS, PUSH RODS AND VALVE LIFTERS	
	A. Rocker Arms, Rocker Arm Shafts and Brackets Removal, Disassembly, and Inspection	8-5
	B. Rocker Arms, Rocker Arm Shafts and Brackets Assembly and Installation	8-5
	C. Push Rods and Valve Lifters Removal and Inspection	8-6
	D. Push Rods and Valve Lifters Installation	8-7
3.	CYLINDER HEADS	
	A. Cylinder Head Removal and Inspection	8-7
	B. Cylinder Head Installation	8-8
4.	VALVES	
	A. Valve Lash Adjustment	8-9
	B. Valve Springs and/or Intake Valve Indexing Locators Removal, Inspection, and Installation	8-11
	C. Valves, Valve Guides, and Valve Seat Insert Removal, Inspection, and Installation	8-12
	D. Valve Face and Valve Seat Grinding	8-14

TOPIC 1 - GENERAL

A. DESCRIPTION

The cylinder heads are a one-piece alloy iron casting with cored passages provided for the intake of air, expulsion of exhaust gases, and the circulation of coolant. To seal pressures and the coolant within the engine, cylinder head gaskets are positioned between the cylinder heads and the cylinder block. There are two types of cylinder head gaskets used. The early type is a one piece gasket and the late type consists of a cylinder head gasket with individual cylinder sleeve gaskets, Fig. 1 (8) (32).

Located in each cylinder head, above each cylinder, is one intake valve and valve guide, one exhaust valve and valve guide, a fuel injection nozzle, fuel injection nozzle-holder sleeve, and two rocker arms. One rocker arm actuates the intake valve and the other operates the exhaust valve.

The valve guides are pressed into the cylinder head and hold the valve heads in accurate alignment with the valve seats. The guides have a shallow spiral thread cut in the lower two-thirds of their bore. This thread collects and retains enough lubricating oil during engine operation to considerably reduce valve guide wear and increase valve guide life. It also permits less running clearance and a tighter initial fit between valve stems and guides. The guides are Parcolubricated to deter scuffing of valve stems during initial run-in period.

The intake and exhaust valves are made of hardened alloy steel. The valves are carefully heat-treated to develop the special properties required for service. Each valve stem is accurately ground to size and hardened.

The replaceable hardened valve seat inserts, installed in the cylinder heads, are accurately ground to very close limits and their freedom from warpage under ordinary working conditions reduces valve grinding to a minimum. Cylindrical valve springs (one on exhaust and two on intake) are held in place, on the upper end of the valve stems, by valve spring retainers. An indexing intake valve locator prevents each shrouded intake valve from rotating.

The rocker arm assemblies, consisting of two rocker arms for each cylinder, are mounted on two common shafts supported by rocker shaft brackets attached to the cylinder heads.

The push rods extend down through the cylinder heads

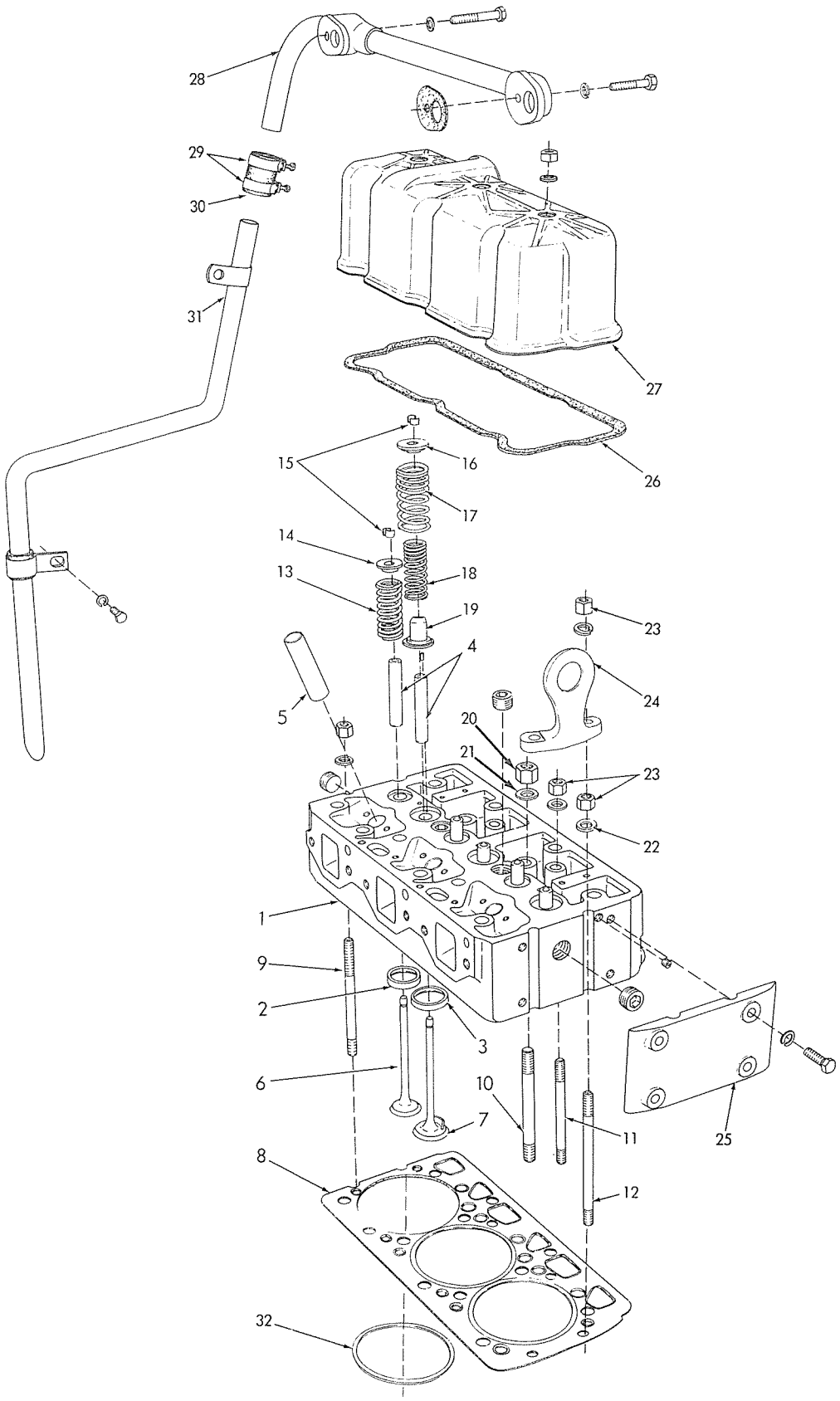


Fig. 1 — Cylinder Head Assembly Details
(T-24202)

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

Legend for Fig. 1

1. Head Assembly
2. Exhaust Valve Seat Insert
3. Intake Valve Seat Insert
4. Valve Guides
5. Fuel Injection Nozzle-Holder Sleeve
6. Exhaust Valve
7. Intake Valve
8. Cylinder Head Gasket (one pc. gasket eff. eng. s/n 11-25689)
9. Stud (1/2" x 7" and 1/2" x 8-5/8")
10. Stud (5/8" x 6-1/2")
11. Stud (1/2" x 6-1/8")
12. Stud (1/2" x 7-3/8")
13. Exhaust Valve Spring
14. Exhaust Valve Spring Retainer
15. Valve Spring Retainer Lock
16. Intake Valve Spring Retainer or Rotator
17. Intake Valve Outer Spring
18. Intake Valve Inner Spring
19. Intake Valve Indexing Locator
20. Nut (5/8" NF) - Nylock nuts for end studs only
21. Washer (For 5/8" stud)
22. Washer (For 1/2" stud)
23. Nut (1/2" NF)
24. Engine Lifting Eye
25. End Plate
26. Rocker Cover Gasket
27. Rocker Cover
28. Breather Tube
29. Hose Clamps
30. Hose
31. Breather Tube
32. Cylinder Sleeve Gasket (Used prior to eng. s/n 11-25689)

and cylinder block, and into the valve lifters which are held in valve lifter brackets. The valve lifters contact the lobes on the camshaft. The upper ends of the push rods are concave to receive the ends of the valve lash adjusting screws threaded into one end of the rocker arms. The other end of the rocker arm actuates the valve by the action of the push rod. When the push rod is forced upward by the camshaft lobe, the rocker arm is raised on one end and forces the other end down, opening the valve. The tension of the valve spring closes the valve when the push rod moves downward.

A horizontal and vertical oil passage through the center of the cylinder block extends from the main oil gallery to a cavity in the left side of the cylinder block. From this cavity there are two openings which align with an oil passage in each cylinder head, conveying the oil to a passage in the Nos. 3 and 4 rocker arm shaft brackets and to the hollow center of the rocker arm shafts which have oil holes at each rocker arm location.

NOTE

Engines prior to S/N 90846 have an oil restrictor located in the vertical oil passages in the cylinder block that restrict the flow of oil to the rocker arm shafts. Engines S/N 90846 and up do not have these restrictors and the Nos. 3 and 4 rocker arm shaft brackets have a restricted drilled oil passage leading to the rocker arm shafts.

The oil is forced out through the oil hole at each rocker arm location and into the drilled passage of each rocker arm providing lubrication for the rocker arm bushing. The oil spills down over the push rods and valve springs and drains back to the oil pan.

B. SERVICE OF VALVE MECHANISM

Service on some of the parts contained in the cylinder heads can be accomplished with the heads installed on the engine. For other service the heads must first be removed from the engine.

1. Operations which DO NOT require that the cylinder heads be removed are:
   a. Replacement of fuel injection nozzles.
   b. Adjustment of valves.
   c. Replacement of rocker arms or rocker arm shafts.
   d. Replacement of valve push rods.
   e. Replacement of valve lifters.
   f. Replacement of valve lifter brackets.
   g. Replacement of valve springs.
   h. Replacement of intake valve indexing locators.
2. Operations which DO require that the cylinder heads be removed are:
   a. Grinding, reseating, or replacement of valves.
   b. Replacement of valve guides.
   c. Replacement of valve seat inserts.
   d. Replacement of fuel injection nozzle sleeves.

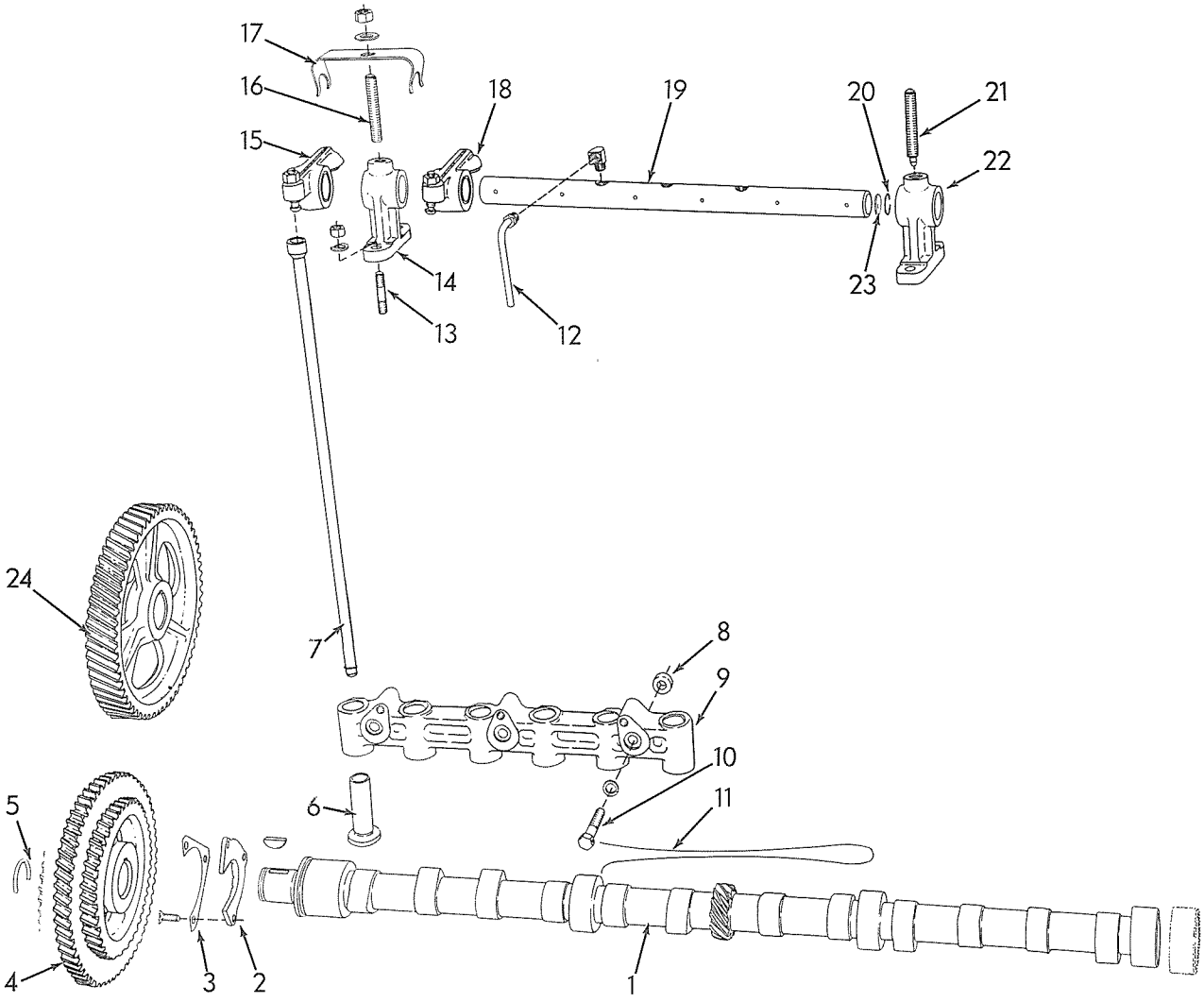


Fig. 2 — Valve Operating Mechanism Details
(T-27404)

1. Camshaft
2. Thrust Collar
3. Capscrew Locking Plate
4. Camshaft Gear (Used on Engines with Roosa Master Fuel Injection Pump)
5. Snap Ring
6. Valve Lifter
7. Push Rod
8. Hollow Dowel
9. Valve Lifter Bracket
10. Capscrew
11. Locking Wire
12. Rocker Arm Shaft Oil Overflow Tube
13. Stud (Bolts on late units)
14. Rocker Shaft End Bracket
15. Intake Valve Rocker Arm Assembly
16. Rocker Cover Stud
17. Rocker Arm Retaining Spring Clip
18. Exhaust Valve Rocker Arm Assembly
19. Rocker Arm Shaft Assembly
20. Snap Ring
21. Rocker Arm Shaft Retaining Screw
22. Rocker Shaft Center Bracket
23. Expansion Plug
24. Camshaft Gear (Used on Engines with American Bosch Fuel Injection Pump)

TOPIC 2 - ROCKER ARMS, ROCKER ARM SHAFTS AND BRACKETS, PUSH RODS AND VALVE LIFTERS

A. ROCKER ARMS, ROCKER ARM SHAFTS AND BRACKETS REMOVAL, DISASSEMBLY, AND INSPECTION

1. Thoroughly clean valve rocker covers, remove capscrews attaching breather tube to covers and remove covers.

2. Remove nuts and lockwashers attaching rocker shaft brackets Fig. 2 (14) (22) to cylinder head and remove rocker shaft brackets, shafts, and rocker arms as an assembly.

3. Remove rocker arm shaft oil over-flow tube (12) and elbow from each rocker arm shaft.

4. Remove nut and washer from rocker arm shaft retaining screw Fig. 7 (5) and remove screw. Remove nuts and washers from rocker cover studs, Fig. 2 (16).

5. Remove rocker arm retaining spring clips (17) and slide rocker arms (15) (18) and brackets (22) (14) from shafts (19).

6. Inspect bushings inside rocker arms for wear. Normal clearance between shaft and bushing is .001" - .0025" and must not exceed .005". If bushings are excessively worn, install new bushings, Fig. 5. After a new bushing is installed, a 1/8" oil hole must be drilled through the bushing, in line with oil hole in rocker arm. A burnishing tool, Fig. 6, must be pressed through bushing to obtain the specified I.D. of 1.001" - 1.0015"

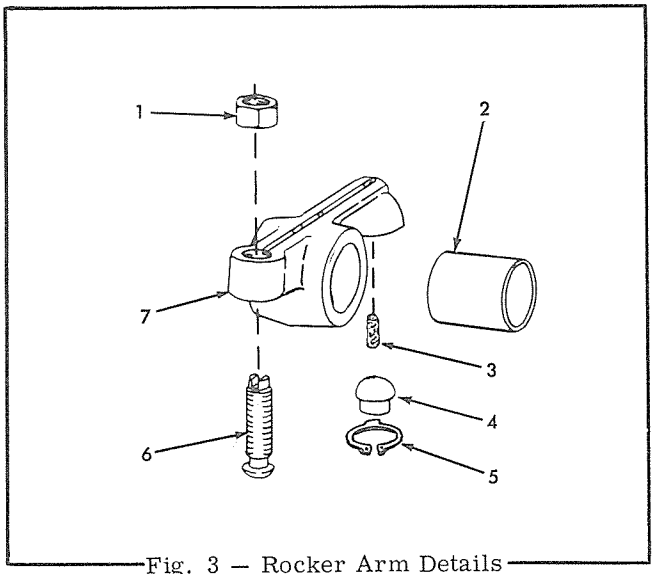


Fig. 3 — Rocker Arm Details
(T-71024)

1. Lock Nut
*2. Rocker Arm Bushing
*3. Rocker Arm Ball Oiling Wick
*4. Rocker Arm Ball
*5. Ball Retaining Snap Ring
6. Valve Lash Adjusting Screw
7. Rocker Arm

*Early units

NOTE

Bushing has been eliminated from late type rocker arms. If I.D. becomes worn to more than 1.007" arm should be replaced. Burnishing is not required since I.D. of arm is factory finished to 1.001" - 1.002".

7. Remove snap ring, Fig. 3 (5), and ball (4) from each rocker arm. Inspect ball (4) for wear and replace if necessary. Inspect oiling wick (3) and if wick has become hard, replace it.

8. Inspect rocker arm shaft for wear. The specified O.D. of a new shaft is .999"-1.000". Clean oil holes in rocker arms and rocker arm shaft with solvent, a small wire, and compressed air.

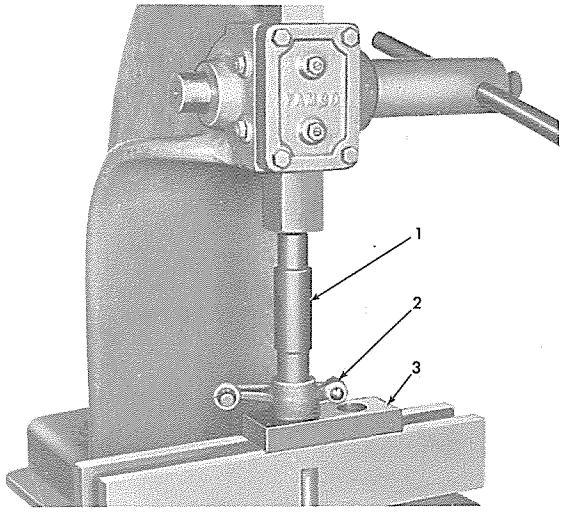


Fig. 4 – Removing Rocker Arm Bushing
(T-19047)

1. Bushing Installing and Removing Tool
2. Rocker Arm
3. Backing Plate

B. ROCKER ARMS, ROCKER ARM SHAFTS AND BRACKETS ASSEMBLY AND INSTALLATION

1. Lubricate rocker arm bushings and shafts with clean oil. Install rocker arms and rocker shaft brackets by reversing sequence of operations for removal.

IMPORTANT

When installing rocker arms and brackets, make sure exhaust valve rocker arms and intake valve rocker arms are installed in their proper positions as shown in Fig. 7. Make certain rocker arm shafts are positioned so that oil holes for rocker arm bushings are nearest

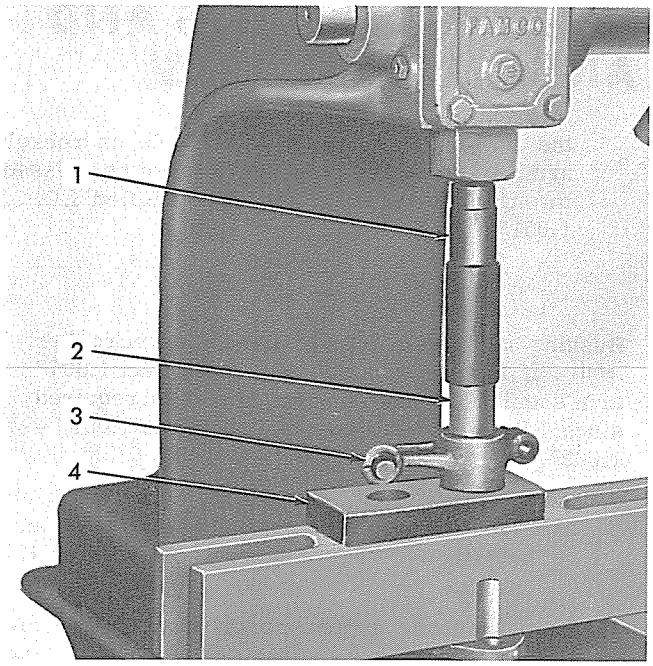


Fig. 5 — Installing Rocker Arm Bushing (T-19048)

1. Bushing Installing and Removing Tool
2. Bushing
3. Rocker Arm
4. Backing Plate

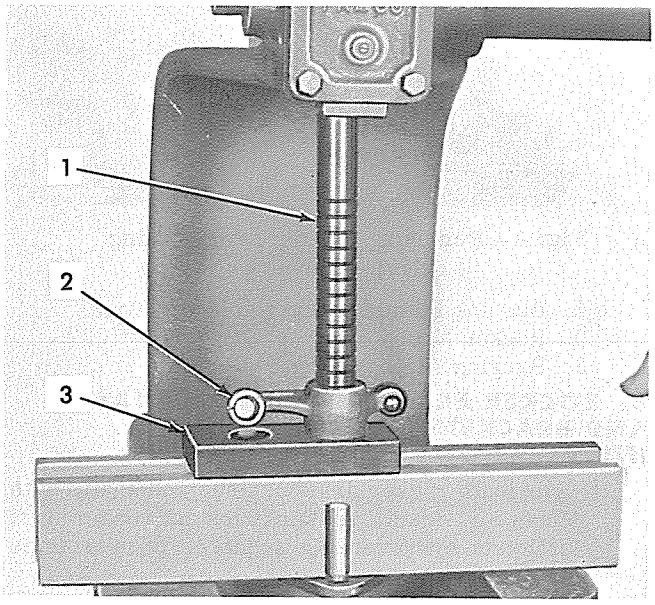


Fig. 6 — Burnishing Rocker Arm Bushing (T-19049)

1. Burnishing Tool
2. Rocker Arm
3. Backing Plate

adjusting screw end of rocker arms. This can be confirmed by observing arrow etched on shaft. The arrow must be on push rod side and point to front (fan end) of engine. The rocker arms, shaft, and bracket assemblies when assembled properly are identical and can be installed on either front or rear cylinder head.

2. Before installing assemblies on cylinder heads, loosen lock nut on each valve lash adjusting screw and turn adjusting screw up (counterclockwise) into rocker arm, several turns, to prevent possible damage to push rods or valves when engine is cranked. Place assemblies in position on cylinder heads with rocker shaft brackets in position over studs. Install lockwashers and rocker shaft bracket stud nuts and tighten to a torque of 10-35 lb-ft (1.4-4.8 kg-m) for stud nuts and 4-45 lb-ft (1.9-6.2 kg-m) for place bolts.

3. Install oil overflow tube elbows, Fig. 7 (4) in rocker arm shafts, and install oil overflow tubes (3).

4. Adjust valves (refer to "VALVE LASH ADJUSTMENT" in this Section).

5. Install valve rocker covers, making certain gaskets are in good condition and properly positioned. Install breather tube and gaskets.

C. PUSH RODS AND VALVE LIFTERS REMOVAL AND INSPECTION

1. Remove rocker arm assemblies (refer to "ROCKER ARMS, ROCKER ARM SHAFTS AND BRACKETS REMOVAL, DISASSEMBLY, AND INSPECTION" in this Topic).

2. Withdraw push rods, Fig. 2 (7). Inpsect ball and cup ends for signs of wear; polish out any nicks or scores. If push rods are bent, twisted, or damaged they must be replaced.

3. In order to remove valve lifter covers from left side of cylinder block, remove fuel injection pump and fuel filters (refer to "FUEL SYSTEM" Section). Remove front and rear valve lifter covers. Remove locking wires (11), capscrews (10), and lockwashers attaching valve lifter brackets (9) to cylinder block, and remove valve lifter brackets and valve lifters as shown in Fig. 8. When removing brackets and lifters, use care to prevent lifters (2) and hollow dowels, Fig. 2 (8) from falling

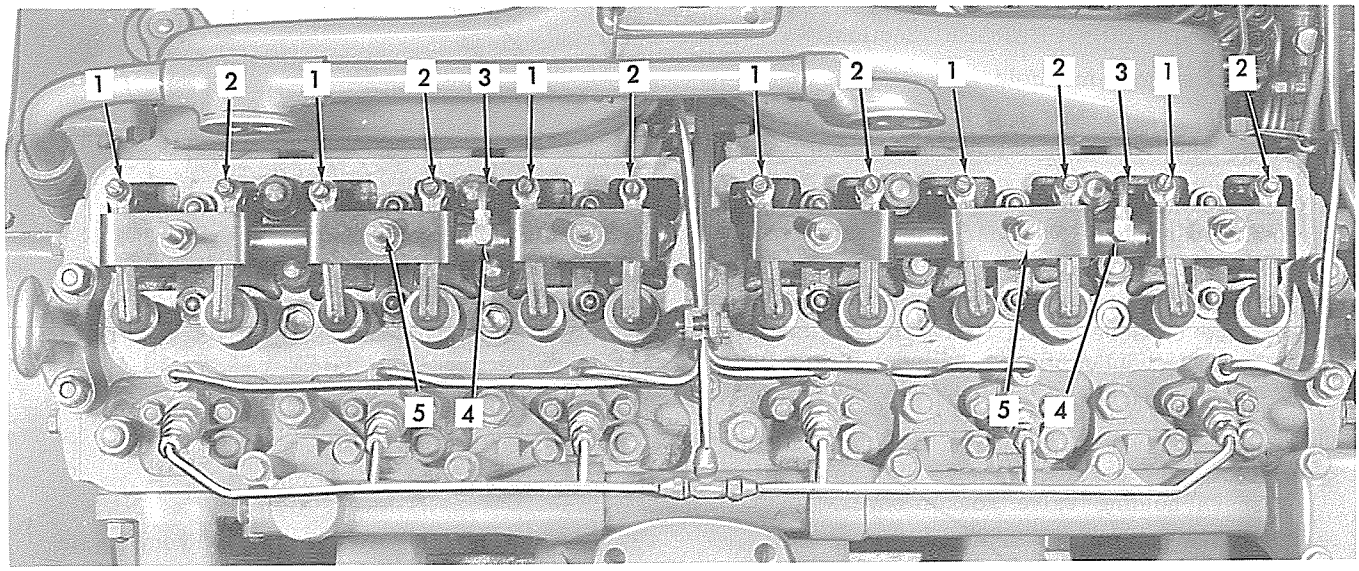


Fig. 7 — Rocker Arm Position and Valve Location
(T-27643)

1. Exhaust Valve Rocker Arm Assembly
2. Intake Valve Rocker Arm Assembly
3. Oil Overflow Tube
4. Oil Overflow Drain Tube Elbow
5. Rocker Arm Shaft Retaining Screw

into crankcase. Inspect contact surface of valve lifters. If scuffing or pitting has occurred, install new lifters. The O.D. of valve lifter stems is .8102" - .8107" and the I.D. of the lifter bore in the bracket is .8127" - .8137" giving an operating clearance of .002" - .0035".

D. PUSH RODS AND VALVE LIFTERS INSTALLATION

1. Lubricate valve lifters, Fig. 2 (6) with clean oil, make certain that hollow dowels (8) are in position, and install lifters and brackets by a direct reversal of the removal procedure.

2. Install push rods (7) with cup end toward top. Make certain that push rods are seated in the valve lifters.

3. Install rocker arm assemblies (refer to "ROCKER ARMS, ROCKER ARM SHAFTS AND BRACKETS ASSEMBLY AND INSTALLATION" in this Topic).

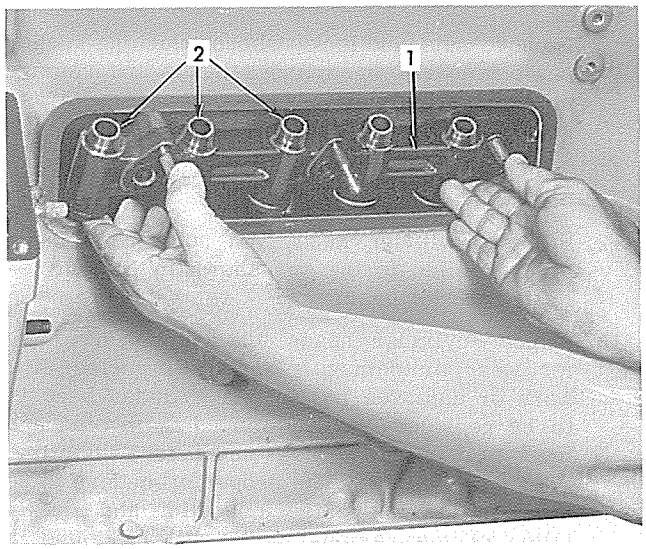


Fig. 8 — Removing Valve Lifters and Valve Lifter Bracket
(T-20214)

1. Valve Lifter Bracket
2. Valve Lifter

TOPIC 3 - CYLINDER HEADS

A. CYLINDER HEAD REMOVAL AND INSPECTION

1. Drain cooling system.

2. Depending upon engine application, remove or disconnect all components and/or assemblies necessary for access to the cylinder head, such as engine hood, air cleaner, etc.

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

3. If engine is equipped with a turbocharger, remove turbocharger (refer to "EXHAUST MANIFOLD AND TURBOCHARGER" Section).
4. Remove exhaust manifold.
5. Disconnect and remove engine temperature gauge tube from rear of water outlet manifold.
6. Remove nuts and lockwashers attaching air intake manifold to cylinder heads and remove manifold.
7. Disconnect and remove radiator upper hose. Remove capscrews and lockwashers attaching water outlet manifold to cylinder heads and remove manifold and thermostat housing.
8. Remove capscrews attaching breather tube to valve rocker covers. Remove nuts and sealing washers holding valve rocker covers to cylinder heads and remove covers.
9. Disconnect and remove fuel return manifold assembly from fuel injection nozzle holders. Disconnect fuel injection lines from fuel pump and nozzle holders and remove lines and supporting brackets as an assembly. Cover all fuel openings to prevent entrance of dirt. Remove fuel injection nozzle-holder assemblies from cylinder heads to prevent possible damage to nozzle tips after head is removed.
10. Remove nuts and lockwashers attaching rocker shaft brackets to cylinder heads and remove brackets, shaft, and rocker arms (as an assembly) from each cylinder head.
11. Withdraw push rods from cylinder heads and block.
12. Remove cylinder head stud nuts and using a sling similar to the one shown in Fig. 9, remove cylinder head.
13. Inspect cylinder heads and component parts for wear or damage. Repair or replace any worn or damaged parts. If a cylinder head is to be replaced, parts removed from old head must be thoroughly inspected before installing them in new head. The proper procedure to be followed in making the inspection and installation of the various parts will be found in pertinent Topics in this Section. Make certain that the cored water and air passages and drilled oil holes in the cylinder heads are clean.

B. CYLINDER HEAD INSTALLATION

Make certain that machined surfaces of cylinder block and cylinder heads are thoroughly clean. New cylinder head gaskets must be used when installing cylinder heads.

Install cylinder heads as follows:

1. Check cylinder sleeve standout above top deck of cylinder block. A standout of .002" - .005" is desirable with the late model gaskets having individual cylinder sleeve gaskets, Fig. 1 (32). Late model engines have this standout, however, the late model gaskets may be used, with satisfactory results, on earlier model engines having the old specified standout of .006" - .0095". It is important that no cylinder sleeves, under any one cylinder head, have more than .003" difference in standout.

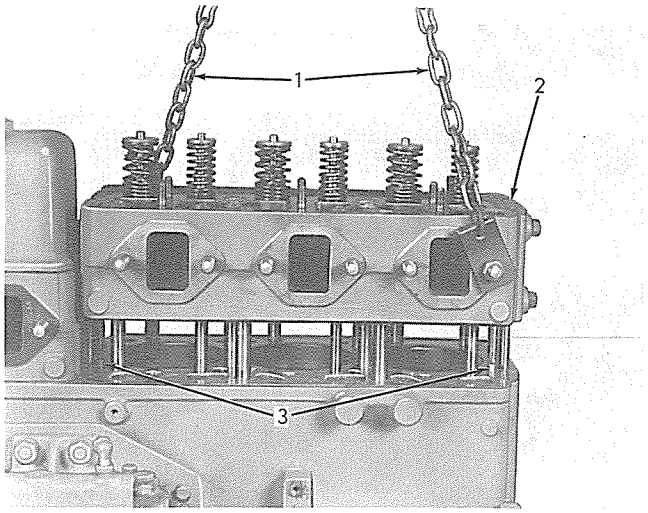


Fig. 9 — Removing Cylinder Head From Engine (T-27629)

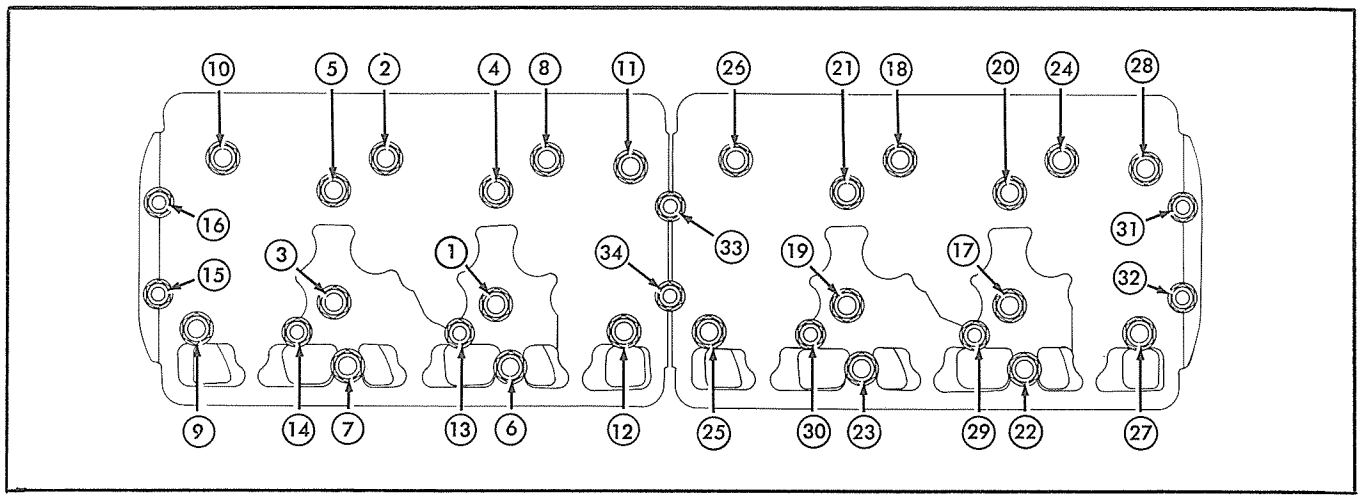
1. Sling
2. Cylinder Head
3. Cylinder Head Locating Dowels

2. Install the cylinder head gaskets in their correct front or rear position and with the indicated side down as stamped on the gasket. Install a cylinder sleeve gasket on each cylinder sleeve making sure the gaskets do not overlap.
3. Lower each cylinder head into position over studs and locating dowels.
4. Lubricate the cylinder head studs with clean oil and install washers and nuts. Install the nuts with the Nylok inserts in positions 9, 12, 25, and 27, Fig. 10.
5. Tighten 1/2 in. nuts to 100 lb-ft (13.8 kg-m), 1/2 inch capscrews to 115 lb-ft (15.9 kg-m) and 5/8 in. nuts or capscrews to 185 lb-ft (25.6 kg-m).

NOTE

When the later type cylinder head gaskets with individual cylinder sleeve gaskets are used, it is NOT necessary to retorque the stud nuts after the first 10 and 100 hours of operation as was required with the early type, one piece gaskets.

6. Install push rods, rocker arm assemblies, fuel injection nozzle-holders, fuel lines, etc. by



INSTRUCTIONS

1. Tighten stud nuts in numerical sequence to 1/2 final torque
2. Tighten stud nuts in numerical sequence to full recommended torque
3. Retighten stud nuts in numerical sequence to full recommended torque
4. Run engine until water temperature reaches minimum of 160°F., and retighten stud nuts in numerical sequence to full recommended torque (Not necessary with one-piece gasket)

Fig. 10 — Torque Sequence and Instructions (T-28930)

reversing the removal procedure.

7. Fill cooling system.
8. Adjust valves (refer to "VALVE LASH ADJUSTMENT" in this Section).

NOTE

Valve lash adjustment should be checked and reset, if necessary, after final torquing of the cylinder head stud nuts.

TOPIC 4 - VALVES

A. VALVE LASH ADJUSTMENT

The correct clearance (lash) between the end of intake valve stem, exhaust valve stem, and related rocker arm is very important in a diesel engine due to the high compression developed within the cylinders. Insufficient valve lash will cause loss of compression, misfiring, and will eventually cause burning of the valves and valve seats. Excessive valve lash will result in faulty engine operation, valve lifter noise, and cause rapid wear on the valve operating mechanism.

With engine at normal operating temperature (160°F. minimum) proper valve lash for both intake and exhaust valves is .018". After any mechanical work has been done which would disturb valve lash, valves may be set "cold" at .020" so that engine may be run and allowed to warm up to normal operating temperature. After engine has been "warmed up", valve lash should be checked for proper clearance.

CAUTION

After any mechanical work has been done which would disturb the valve adjustment, make certain that the adjusting screws in the rocker arms are turned upward (counterclockwise) in the rocker arms high enough so that the rocker arms and push rods will not open the valves too far and thus allow the pistons to strike the valves when the engine is cranked.

1. Remove valve rocker covers.
2. Use a .018" feeler gauge when checking lash of intake and exhaust valves. The feeler gauge should pass between rocker arm and corresponding valve stem with a slight drag when valve lash is properly adjusted.
3. To adjust each valve, loosen lock nut on adjusting screw and turn screw clockwise to decrease clearance or counterclockwise to increase clearance as necessary, Fig. 11. When proper clearance is obtained, tighten lock nut and recheck to make certain clearance did not change when lock nut was tightened.
4. The valves must be adjusted when piston is

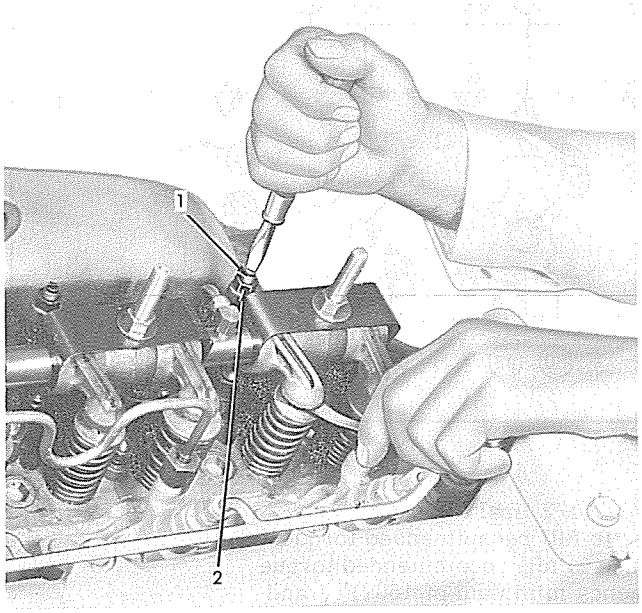


Fig. 11 — Checking and Adjusting Valve Lash (T-27644)

1. Adjusting Screw 2. Lock Nut

near top dead center on its compression stroke and both valves are closed. No. 1 and No. 6 pistons move up and down in their respective cylinders together and when one piston is on its compression stroke the other is on its exhaust stroke and vice versa. Observe valves of the No. 6 cylinder; when exhaust valve is nearly closed and intake valve starts to open, No. 6 piston is near top dead center on its exhaust stroke and No. 1 piston is in the same relative position on its compression stroke, therefore, both valves of No. 1 cylinder are fully closed and both valves may be adjusted. The same relationship exists between Nos. 2 and 5 pistons and Nos. 3 and 4 pistons. The firing order of the engine is 1-5-3-6-2-4 and if this sequence is followed in adjusting valves, all valves can be adjusted in two complete revolutions of the crankshaft. Starting with valves on No. 1 cylinder, adjust valves in the following sequence:

a. Crank engine by hand (or with starter) until No. 6 cylinder exhaust valve is nearly closed and intake valve starts to open, then adjust intake valve and exhaust valve of No. 1 cylinder.

b. Turn engine by hand (approximately 120°) until No. 2 cylinder exhaust valve is nearly closed and intake valve starts to open, then adjust intake valve and exhaust valve of No. 5 cylinder.

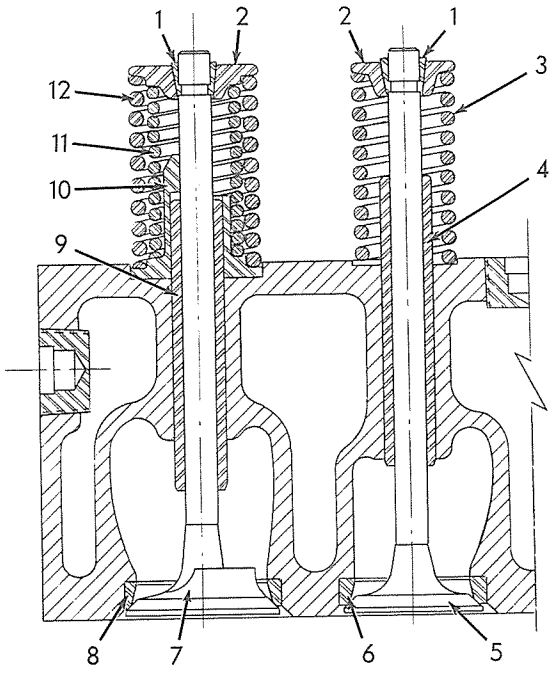


Fig. 12 — Valves Installed in Cylinder Head — Sectional View (T-27516)

1. Valve Spring Retainer Locks
2. Valve Spring Retainers
3. Exhaust Valve Spring
4. Exhaust Valve Guide
5. Exhaust Valve
6. Exhaust Valve Seat Insert
7. Shrouded Intake Valve
8. Intake Valve Seat Insert
9. Intake Valve Guide
10. Intake Valve Indexing Locator
11. Intake Valve Inner Spring
12. Intake Valve Outer Spring

c. Turn engine by hand (approximately 120°) until No. 4 cylinder exhaust valve is nearly closed and intake valve starts to open, then adjust intake valve and exhaust valve of No. 3 cylinder.

d. Turn engine by hand (approximately 120°) until No. 1 cylinder exhaust valve is nearly closed and intake valve starts to open, then adjust intake valve and exhaust valve of No. 6 cylinder.

e. Turn engine by hand (approximately 120°) until No. 5 cylinder exhaust valve is nearly closed and intake valve starts to open, then adjust intake valve and exhaust valve of No. 2 cylinder.

f. Turn engine by hand (approximately 120°) until No. 3 cylinder exhaust valve is nearly closed and intake valve starts to open, then adjust intake valve and exhaust valve of No. 4 cylinder.

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

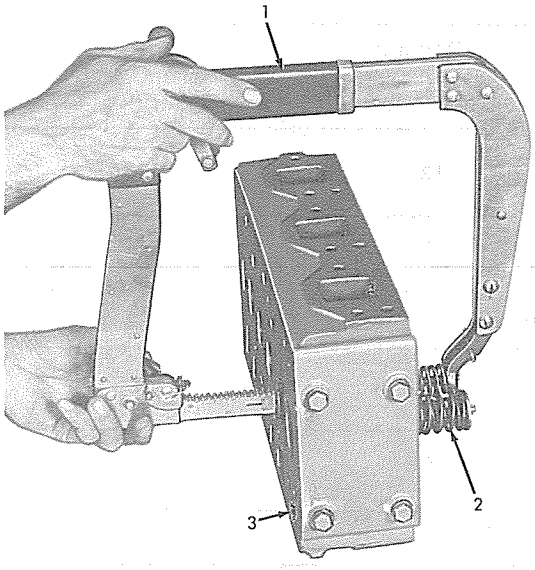


Fig. 13 — Removing Valve Springs
(T-27621)

1. Valve Spring Compressor
2. Valve Spring
3. Cylinder Head

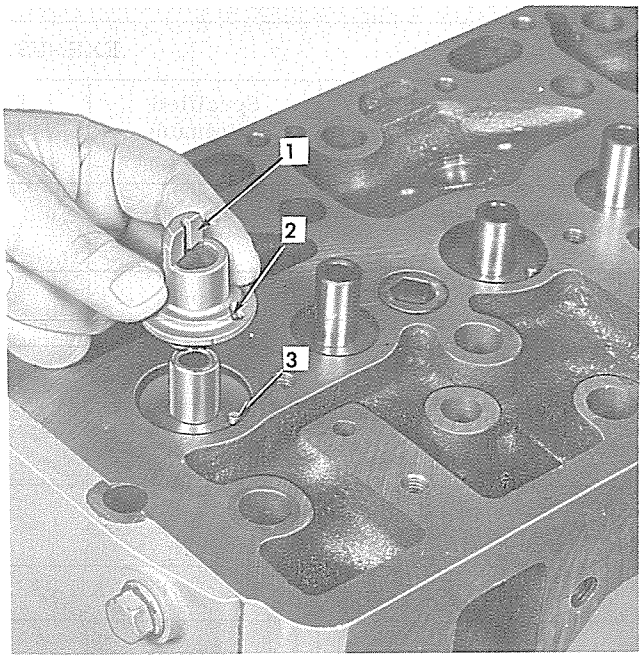


Fig. 14 — Removing Intake Valve Indexing Locator
(T-27619)

1. Intake Valve Indexing Locator
2. Dowel Hole
3. Locating Dowel Pin

5. After all valves are adjusted and checked, install the valve rocker covers.

B. VALVE SPRINGS AND/OR INTAKE VALVE INDEXING LOCATORS REMOVAL, INSPECTION, AND INSTALLATION

Intake and exhaust valve springs and intake valve indexing locators may be removed without removing cylinder heads from engine, or cylinder heads may be removed and valve springs removed with a tool similar to the one shown in Fig. 13. To remove valve springs without removing cylinder heads, proceed as follows:

1. Remove valve rocker cover. Remove rocker arm retaining spring clips. Disconnect and remove rocker shaft oil overflow tube, remove elbow from rocker arm shaft. Loosen adjusting screw in valve rocker arms sufficiently so that rocker arms may be moved to one side.

2. Make certain that piston, in cylinder from which valve springs are to be removed, is at top dead center. Using two suitable pry bars, and using the rocker arm shaft as a fulcrum, pry down on valve spring retainer, Fig. 12 (2) until valve spring retainer locks (1) can be removed. Remove valve spring retainer locks and carefully release tension on valve spring (s). Remove valve spring retainer and valve spring(s).

3. After inner (11) and outer (12) intake valve springs have been removed, the intake valve indexing locator (10) can be removed as shown in Fig. 14.

4. Inspect valve springs for nicks. Refer to following table for specified valve spring tension.

5. To install each intake valve indexing locator, start locator in position over valve stem, hold upward on valve stem and index the locator with valve stem. Lower locator into position on cylinder head, aligning hole in locator with locator dowel pin, Fig. 14.

6. Install valve springs by a direct reversal of the removal procedure (dampening coils to bottom).

NOTE

Close visual inspection will show "dampening coils" closer together.

VALVE SPRING TENSION GUIDE				
EXHAUST VALVE SPRING				
	Specified Minimum (lbs.)	Specified Maximum (lbs.)	Replace When Less Than (lbs.)	Replace When More Than (lbs.)
Spring Load at 1.832" Length	136	146	129	153
Spring Load at 2.312" Length	57	64	54	67
INTAKE VALVE INNER SPRING				
Spring Load at 1.578" Length	66	72	63	76
Spring Load at 2.062" Length	30	35	28	37
INTAKE VALVE OUTER SPRING				
Spring Load at 1.828" Length	88	97	84	102
Spring Load at 2.312" Length	40	45	38	47

C. VALVES, VALVE GUIDES, AND VALVE SEAT INSERT REMOVAL, INSPECTION, AND INSTALLATION

1. Remove cylinder heads (refer to "CYLINDER HEADS" in this Section).

2. Remove valve springs (refer to preceding Paragraph) Remove intake valve indexing locators and valves from cylinder head. Place valves and locators in a rack as they are removed from cylinder head so they can be identified and reinstalled in their original positions.

3. Clean carbon from valves, and valve seats. Clean carbon from valve guide bores with a nylon brush.

CAUTION

Do not use a metal type cleaning tool.

4. Replace valves if they are cracked, bent, or worn. Replace valve guides if they are worn. Specified dimensions for valves and guides are as shown in the table at bottom of page.

5. The valve guides may be removed by pressing them out through bottom of cylinder head using a valve guide removing tool similar to the one shown in Fig. 15.

6. The top of the guide is that portion which protrudes above top of cylinder head and has a smaller outside diameter, Fig. 17, than portion which forms press fit in cylinder head. When installing new guides it is important that upper end of guide is to top of cylinder head so that spiral thread cut into lower two thirds of the bore is to the bottom.

   The exhaust valve guides are installed with upper end 1-1/16" above bottom of counterbore in the head around the guide. The intake guide is installed with upper end 7/8" above bottom of counterbore in the head around the guide.

	Valve Guide I.D.	Valve Stem O.D.	Stem-to-Guide Clearance	Install new parts when clearance exceeds:
Intake	.3735" - .3742"	.3715" - .3720"	.0015" - .0027"	.0065"
Exhaust	.3742" - .3749"	.3715" - .3720"	.0022" - .0034"	.0075"

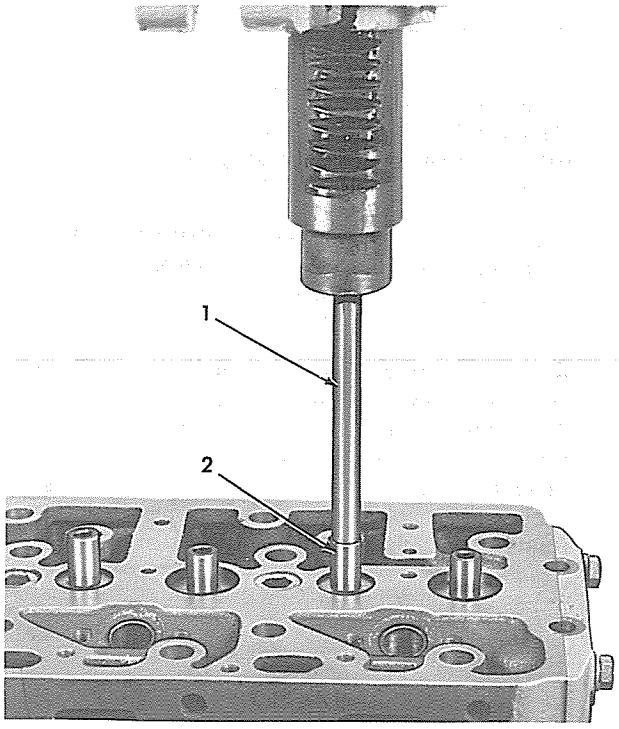


Fig. 15 — Removing Valve Guides
(T-27615)

1. Valve Guide Removing Tool
2. Valve Guide

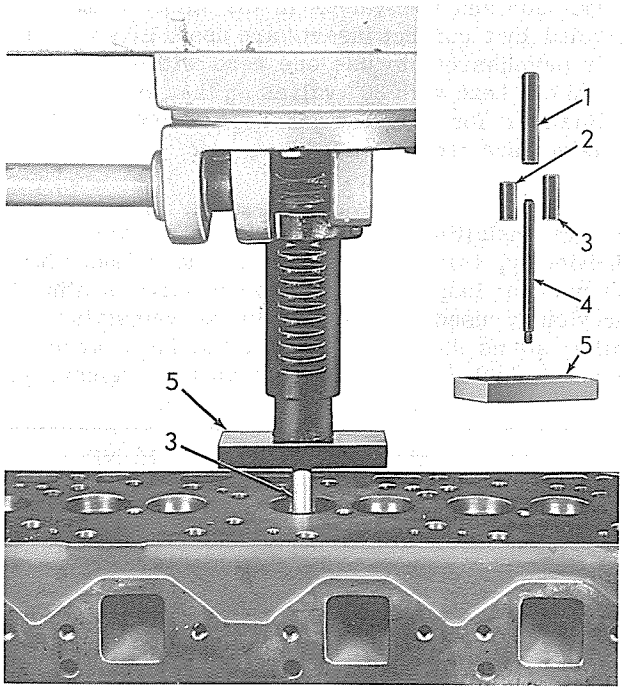


Fig. 16 — Installing Valve Guides
(T-29557 & T-29559)

1. Valve Guide
2. Valve Guide Adapter (Intake)
3. Valve Guide Adapter (Exhaust)
4. Guide Pilot
5. Plate

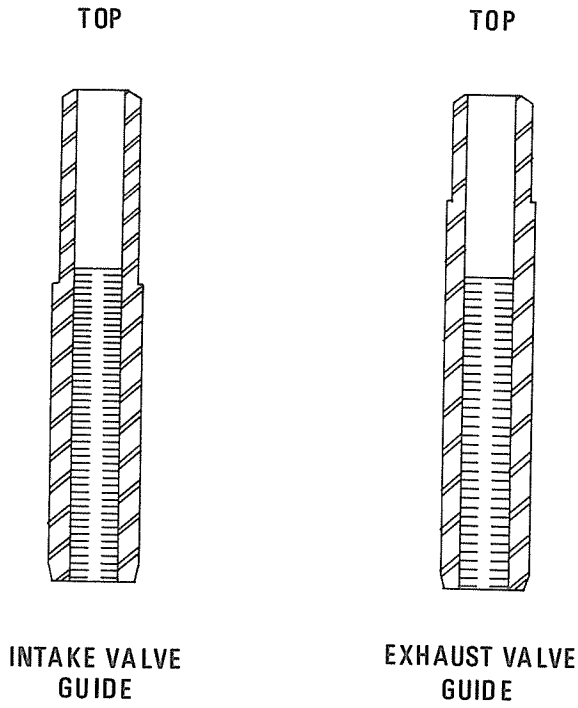


Fig. 17 – Valve Guides
(T-76812)

CAUTION

To eliminate possibility of scuffing the guide or the bore in the head, coat outside surface of guide with a 50/50 mixture of white lead and lubricating oil before pressing guide into position.

7. New valve guides are pressed into position from bottom of head with a guide installing tool, Fig. 16. The adapters (2) (3) establish proper protrusion of guides above the cylinder head. To use the tool, place cylinder head in a press with head gasket surface up. Assemble guide installing tool by screwing pilot (4) into plate (5). Insert the proper adapter, exhaust (3) or intake (2) on the pilot (4). Insert valve guide (1) on pilot with bottom end against the adapter.

   Insert installing tool, with guide, into guide bore in the head and press downward until plate rests on head gasket surface of head.

   The valve guides are prefinished and do not require reaming after they are pressed into the cylinder head.

8. Inspect valve seat inserts. If loose, cracked, or pitted, new ones must be installed. The inserts are a press fit in the cylinder head.

   Valve seat inserts may be removed by electric welding three small beads on inside on beveled portion. Allow insert to cool, then lift out.

CAUTION

Protect machined surfaces from splatter.

9. If it becomes necessary to replace valve seat inserts, it is imperative that the original press fit be maintained between new inserts and insert bores in the cylinder heads. If insert bores in cylinder heads are damaged or worn enough so that the recommended press fit cannot be attained when installing new standard size valve seat inserts, the bores must be machined .005" larger than their original I.D. and .005" oversize valve seat inserts installed.

NOTE

The thickness of both the intake and exhaust inserts was changed from 5/16" to 13/32" effective with engine serial nos. 10-11863 and 11-10327. At the same time the O.D. of the inserts and the bores in the cylinder heads were changed, refer to the following table for O.D. of valve seat inserts and I.D. of bores in cylinder heads:

Install valve seat inserts as follows:

a. Make certain valve seat counterbore in cylinder head are clean, free of burrs, and of the correct size. (refer to table.)

b. Immerse cylinder head for approximately 30 minutes in water heated to near boiling temperature, and/or thoroughly chill inserts in a cold box or with dry ice.

c. Place cylinder head, bottom side up, on a bench. Thoroughly clean the counterbores for inserts with compressed air and start an insert into the counterbore (valve seat side up).

d. Using a valve seat insert installing tool, similar to the one shown in Fig. 18, drive or press insert down tightly into counterbore. This operation must be done quickly while insert is cold.

e. After the inserts have been installed, the exhaust valve seat inserts must be staked to eliminate the possibility of the insert loosening in its bore. It is not necessary to stake the intake valve seat inserts. Using a center punch and hammer, stake each exhaust valve seat insert at 3 points approximately 120° apart. Do not use old staking points.

f. It will be necessary to refinish valve seat inserts with a grinder (refer to "VALVE FACE AND VALVE SEAT GRINDING", below).

D. VALVE FACE AND VALVE SEAT GRINDING

IMPORTANT

Some engines have 45° valves and inserts, others have 30°; both types are available as service items. It is permissible, but not advisable, to mix 30° and 45° valves in the same head, provided that correct inserts are used. Likewise, it is permissible to use one head with 45° valves and one head with 30° valves on the same engine. However for 12G and 745 applications, the 30° valves are recommended.

Before installing either new valves or valves used previously, valve seat inserts in the cylinder heads should be inspected for proper valve seating. If previously used valves are to be reinstalled, the valve stems should be cleaned and faces ground to correct angle. When refacing valves, remove just

	PRIOR TO ENGINE S/N's 10-11863 & 11-10327		EFFECTIVE WITH ENGINE S/N's 10-11863 & 11-10327	
VALVE SEAT INSERT	O.D. OF INSERT	BORE IN CYLINDER HEADS	O.D. OF INSERT	BORE IN CYLINDER HEADS
INTAKE- STANDARD SIZE	1.8745" / 1.8755"	1.871" / 1.872"	1.8645" / 1.8655"	1.8615" / 1.8625"
INTAKE - .005" OVERSIZE	1.8795" / 1.8805"	1.876" / 1.877"	1.8695" / 1.8705"	1.8665" / 1.8675"
EXHAUST - STANDARD SIZE	1.690" / 1.691"	1.6865" / 1.6875"	1.6445" / 1.6450"	1.6415" / 1.6425"
EXHAUST - .005" OVERSIZE	1.695" / 1.696"	1.6915" / 1.6925"	1.6495" / 1.6500"	1.6465" / 1.6475"

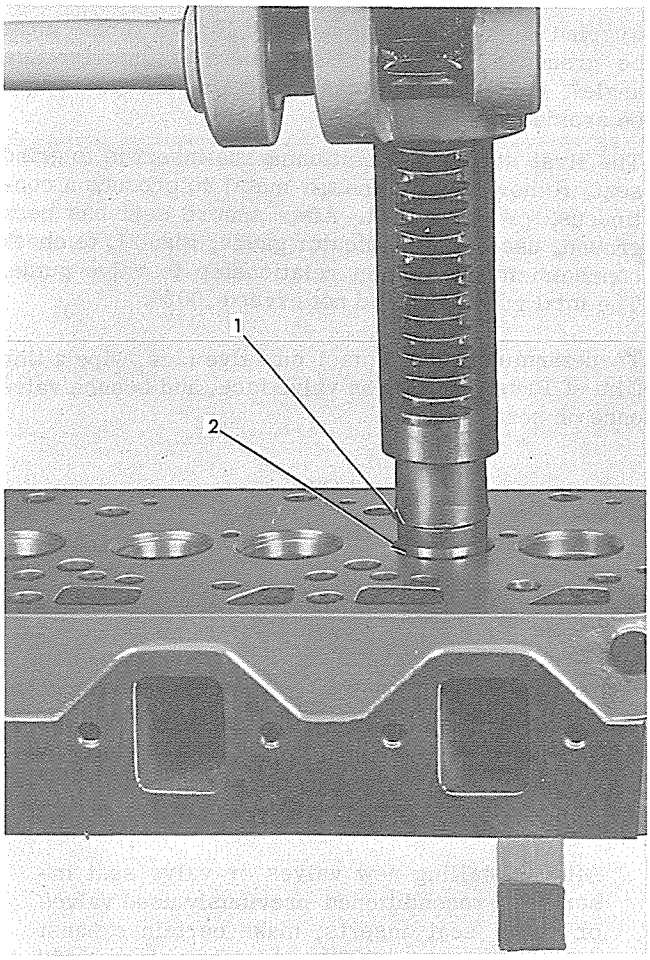


Fig. 18 — Installing Valve Seat Insert
(T-27614)

1. Valve Seat Insert Installing Tool
2. Valve Seat Insert

enough metal to clean up face, removing all evidence of pitting and grooving. If bore in valve guide, after cleaning with a nylon brush, is worn oblong, or if valve head is warped relative to valve stem, the necessary parts must be replaced.

When new valve seat inserts are installed, or previously used inserts faced, the facing work must be done with a valve seat grinder set similar to the one shown in Fig. 19.

Usual equipment furnished with the valve seat grinder set includes the following items:

1. Valve seat grinder
2. Dial gauge
3. Tool pilot
4. Three grinding wheels — 30^{o} - 45^{o} and 60^{o}

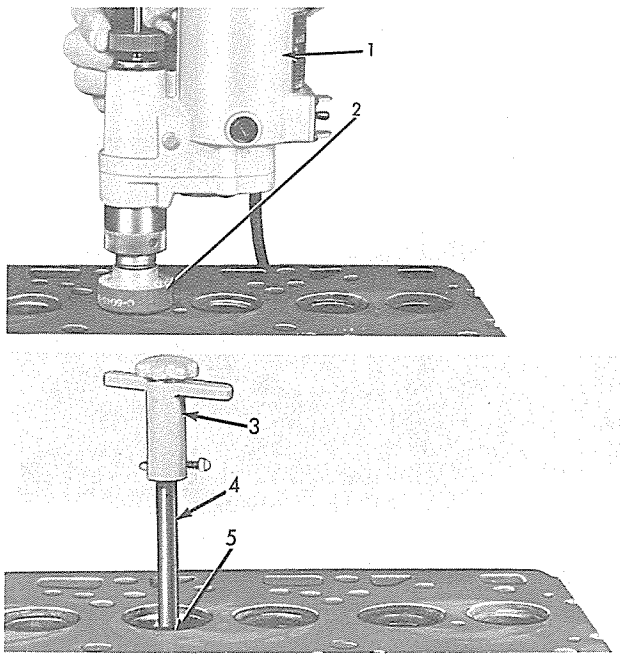


Fig. 19 — Grinding Valve Seats
(T-29530 & T-29531)

1. Valve Seat Grinding Set
2. Grinding Wheel
3. Pilot Installing Tool
4. Tool Pilot
5. Valve Guide

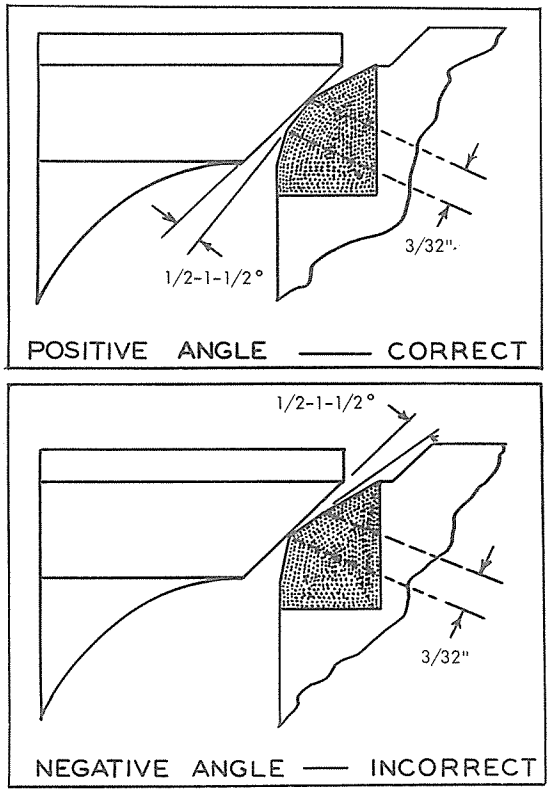


Fig. 20 — Interference Angle
(T-30192)

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

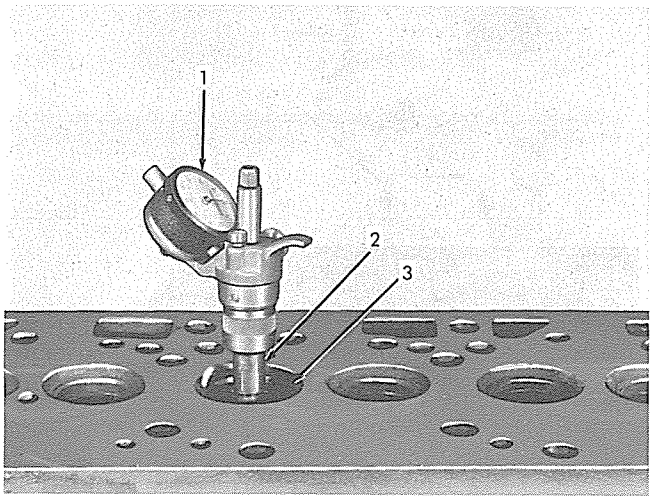


Fig. 21 — Checking Concentricity of Valve Seats (T-29532)

1. Indicator Tool
2. Pilot
3. Valve Seat

The cutting face of grinding wheel must be maintained at the correct angle and in proper condition by frequent dressing with a diamond wheel dresser. The frequency of dressing will be determined by condition of seats and amount of metal required to be removed during facing operation.

NOTE

It is very important that the valve grinder set be used in accordance with the manufacturer's directions.

By grinding valve face and insert seat at slightly different angles, a fine line contact of face and seat is obtained, eliminating the need to lap seating surfaces with grinding compound. The difference of angles is termed "interference angle", Fig. 20, and is usually between $1/2^{o}$ to $1\text{-}1/2^{o}$. The angle of the insert seat is made greater than that of valve face to assure contact at top of insert seat. Thus, for 45^{o} valve face angle, and a 1^{o} interference angle, the insert seat grinding wheel must be dressed to grind insert seat at an angle of 46^{o} (30^{o} angle must be ground to 31^{o}). This is a positive "interference angle". A negative angle as illustrated in Fig. 20 must be avoided.

The first step in reconditioning the insert is to grind seat, removing only enough metal to produce a continuous, pit free seat. After insert seat has been ground, use a dial indicator gauge, Fig. 21, to check concentricity of seat in relationship to valve guide. The total run out should not exceed .002".

To determine seat contact on valve face, wipe a thin film of Prussian Blue on valve face, and bounce valve once on seat.

NOTE

Do not revolve valve while checking seat.

A continuous pencil thin line must be evident on valve face, otherwise further grinding is required.

If insert seat is too wide after reconditioning, use the necessary grinding wheels to narrow seat to recommended width of 3/32".

IMPORTANT

After installing new valves or valve seat inserts or reconditioned previously used valves or valve seat inserts, make certain exhaust valves are set in .059" and intake valves .046" minimum below head gasket surface of cylinder head, otherwise, serious damage will result.

If head of valve is set in less than the specified minimums below head gasket surface of cylinder head, the valve head may be lowered by relocating (lowering) the face of the valve seat insert. Use the correct grinding wheel to remove metal from face of valve seat insert until head of valve is lowered to the specified minimum. Then use the necessary grinding wheels to narrow seat to the recommended width of 3/32", refer to Fig. 20.

Assemble and install cylinder heads (refer to "CYLINDER HEADS" in this Section).

SECTION 9 - FRONT END AND GEAR TRAIN

TOPIC NO.	TITLE	PAGE
1.	CRANKSHAFT PULLEY/VIBRATION DAMPER AND ENGINE FRONT MOUNTING BRACKET	
	A. General	9-1
	B. Crankshaft Pulley/Vibration Damper Removal and Installation	9-1
	C. Engine Front Mounting Bracket Removal and Installation	9-3
2.	TIMING GEAR HOUSING COVER AND CRANKSHAFT FRONT OIL SEAL	
	A. General	9-3
	B. Timing Gear Housing Cover Removal	9-3
	C. Crankshaft Front Oil Seal Removal and Installation	9-4
	D. Timing Gear Housing Cover Installation	9-5
3.	GEAR TRAIN AND TIMING GEAR HOUSING	
	A. General	9-5
	B. Camshaft Gear Removal and Installation	9-5
	C. Crankshaft Gear Removal and Installation	9-5
	D. Oil Pump Drive Gear Removal and Installation	9-5
	E. Fuel Injection Pump Drive Gear Removal and Installation	9-5
	F. Type I Hydraulic Pump Drive Removal, Disassembly, and Inspection	9-6
	G. Type I Hydraulic Pump Drive Assembly and Installation	9-7
	H. Type II Hydraulic Pump Drive Removal, Disassembly, and Inspection	9-7
	I. Type II Hydraulic Pump Drive Assembly and Installation	9-8
	J. Timing Gear Housing Removal and Installation	9-8

TOPIC 1 - CRANKSHAFT PULLEY VIBRATION DAMPER AND ENGINE FRONT MOUNTING BRACKET

A. GENERAL

Two types of engine front mounting brackets and four types of crankshaft pulley/vibration dampers are used on engines covered in this manual. The specific type used depends upon the engine application.

The Type I and Type II crankshaft pulley/vibration dampers, as shown in Fig. 1, consists of a cast iron hub and a cast iron damper which is an integral part of the hub but is separated from metal-to-metal contact by a layer of neoprene compound. The whole unit is accurately balanced. The Type I assembly is used on track-type tractors and the Type II on tractor loaders. The type III damper (Fig. 1) used on HD12G & 745 loaders has a metal ring enclosed in an outer housing and suspended in a viscous fluid. The floating ring absorbs the shock and vibrations. The damper is bolted to crankshaft pulley on 745 loader and the drive pulley on the 12G loader.

A one piece cast iron crankshaft pulley, Fig. 2, is used on motor graders.

An engine front mounting bracket, similar to the one shown in Fig. 3, is used on engines in track-type tractors and tractor loaders. The mounting bracket bolts to an engine support which bolts, in turn, to the tractor main frame.

An engine front mounting bracket, similar to the one shown in Fig. 4, is used on engines in motor graders and 12G. The mounting bracket bolts directly to the main frame.

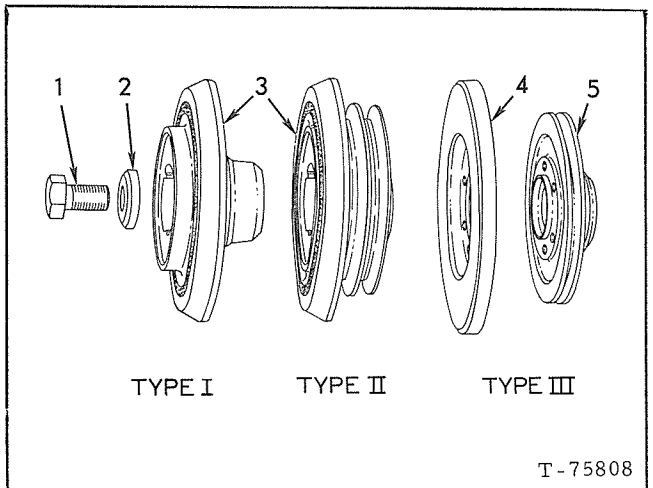


Fig. 1 — Crankshaft Pulley/Vibration Dampers

1. Retaining Capscrew
2. Washer
3. Crankshaft Hub
4. Damper (Fluid)
5. Drive Pulley

B. CRANKSHAFT PULLEY/VIBRATION DAMPER REMOVAL AND INSTALLATION

The procedure and tools, used for removing and installing the crankshaft pulley, Fig. 2, or crankshaft

pulley/vibration damper, Fig. 1, are the same. Proceed as follows:

1. If engine is installed in a unit, drain cooling system and remove the radiator.

2. If engine is equipped with a fan drive pulley, release tension on fan and hydraulic pump drive belts and remove belts from pulley.

3. Loosen retaining capscrew, Fig. 5 (1), and turn out 1/4" to 1/2".

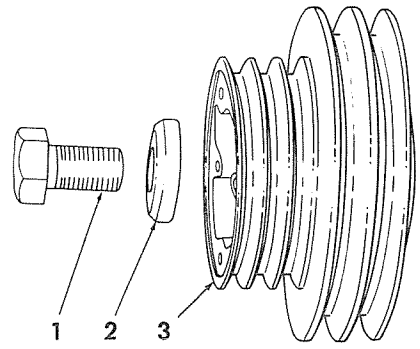


Fig. 2 — Crankshaft Pulley (Used on Motor Graders) (T-71016)

1. Retaining Capscrew
2. Washer
3. Crankshaft Pulley

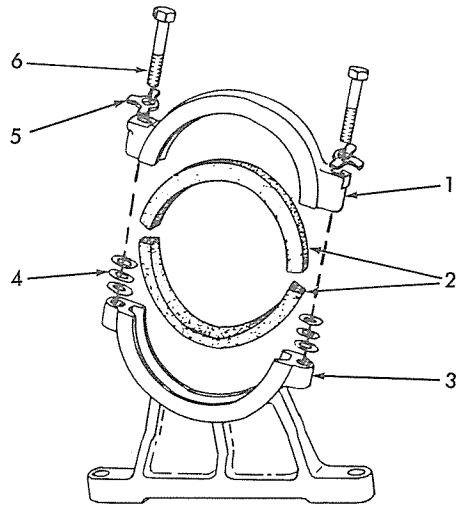


Fig. 3 — Engine Front Mounting Bracket (Used on Track-Type Tractors and Tractor Loaders) (T-71017)

1. Mounting Bracket Cap
2. Liners
3. Mounting Bracket
4. Shimming Washers
5. Lockwasher
6. Capscrew

4. Using puller tools similar to the ones shown in Fig. 5, break pulley loose from crankshaft.

5. Remove puller tools, retaining capscrew, Fig. 5 (1), washer (5), and pulley.

6. Inspect key and keyway for wear and replace key if necessary. Install key in crankshaft then install pulley, Figs. 1 or 2 (3), washer (2), and retaining capscrew (1). Tighten capscrew to a torque of 290 — 310 lbs. ft.

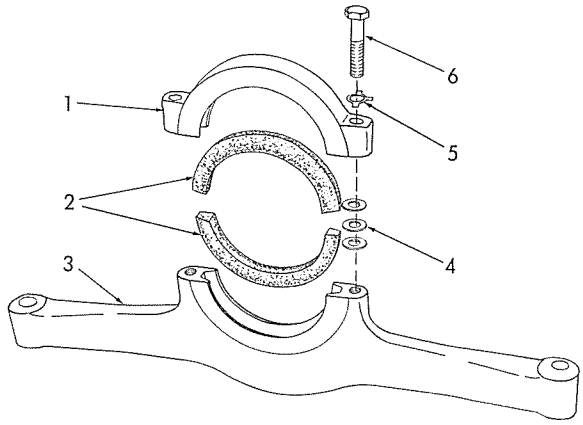


Fig. 4 — Engine Front Mounting Bracket (Used on Motor Graders) (T-71018)

1. Mounting Bracket Cap
2. Liners
3. Mounting Bracket
4. Shimming Washers
5. Lockwashers
6. Capscrew

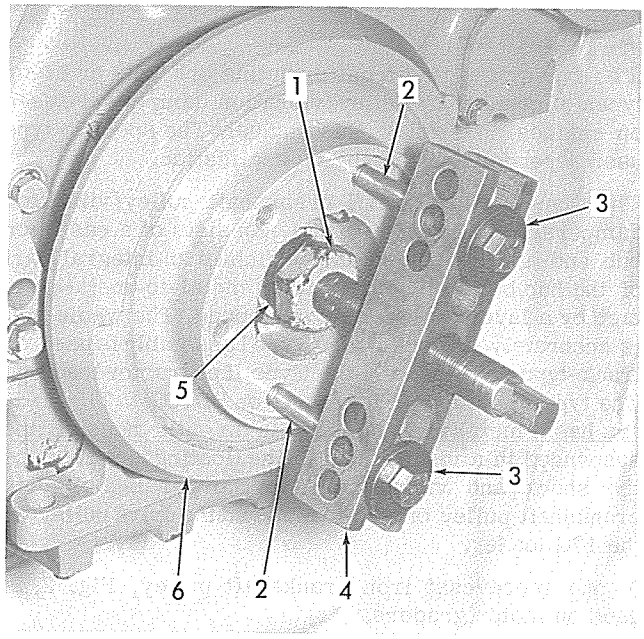


Fig. 5 — Removing Crankshaft Pulley/Vibration Damper (Crankshaft Pulley Removal Similar) (T-71007)

1. Retaining Capscrew
2. 1/2" NC Capscrew
3. Heavy Washer
4. Puller Tool
5. Washer
6. Crankshaft Pulley/ Vibration Damper

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

C. ENGINE FRONT MOUNTING BRACKET REMOVAL AND INSTALLATION

For the purpose of this manual, the engine front mounting bracket is considered to be the trunnion type bracket located at gear train (fan) end of the engine, irregardless of how engine is mounted in the unit.

1. ENGINE FRONT MOUNTING BRACKET REMOVAL

   a. Remove capscrews, Figs. 3 or 4 (6), and remove cap (1).

   b. If engine is installed in unit, raise fan end of engine slightly and block.

   c. Remove capscrews securing mounting bracket (3) to engine support or, on motor graders to main frame, and remove bracket.

   NOTE

   On some engine applications it is necessary to remove the engine support and mounting bracket as an assembly.

   d. If liners (2) have become hard or deteriorated, install new liners as follows:

      (1) Remove old liners (2) and carefully clean the grooves in bracket (3) and cap (1).

      (2) Install new liners making certain that the ends of liners are flush with the ends of grooves in bracket and cap.

2. ENGINE FRONT MOUNTING BRACKET INSTALLATION

   a. Install bracket, Figs. 3 or 4 (3) on engine support or, on motor graders on main frame, and secure with capscrews and nuts.

   b. Lower engine into position in bracket.

   c. To determine the necessary amount of shimming washers (4) proceed as follows:

      (1) Install cap (1), with liner, but do not install shimming washers (4) at this time.

      (2) Install capscrews (6) and tighten evenly to a torque of 50 lb-ft (6.9 kg-m).

      (3) Measure gap between bracket and cap.

      (4) Remove capscrews (6) and cap (1).

      (5) Reinstall cap (1), lockwashers (5), and capscrews (6), using enough shimming washers (4) to fill the gap measured in preceding steps. The shimming washers must be evenly distributed on each side of the bracket. Tighten capscrews (6) to a torque of 95 — 105 lbs. ft. and lock with lockwashers.

TOPIC 2 - TIMING GEAR HOUSING COVER AND CRANKSHAFT FRONT OIL SEAL

A. GENERAL

The timing gear housing cover encloses the timing gear housing and gear train.

The unitized crankshaft front oil seal is located in the timing gear housing cover. The construction of the unitized seal is completely different from the lip-type seal and is made up of an inner part which fits tight on the crankshaft, and the outer part which is tight in the front cover. Sealing is accomplished by an internal contact (spring loaded) of the inner and outer parts of the seal and the two parts are so constructed that they form a single assembly.

NOTE

Install a new oil seal each time the engine is disassembled.

B. TIMING GEAR HOUSING COVER REMOVAL

1. If engine is installed in unit, drain cooling system and remove radiator (refer to "COOLING SYSTEM" Section).

2. Release tension on all engine drive belts and remove belts.

3. Remove crankshaft pulley and engine front mounting bracket (refer to "CRANKSHAFT PULLEY/VIBRATION DAMPER AND ENGINE FRONT MOUNTING BRACKET" in this Section).

4. Remove fan and fan hub (refer to "COOLING SYSTEM" Section).

5. If engine is equipped with a fan drive pulley, remove fan drive pulley and fan drive. Remove fan belt tightener slide assembly. Refer to "COOLING SYSTEM" Section.

6. If engine is so equipped, disconnect lubricating oil line from steering pump drive gear and remove drive gear, refer to Fig. 9.

7. Remove one nut and capscrews and lockwashers securing timing gear housing cover, Fig. 6 (1) to timing gear housing (3). Remove capscrews securing cover to oil pan and remove cover (1) and gasket (2).

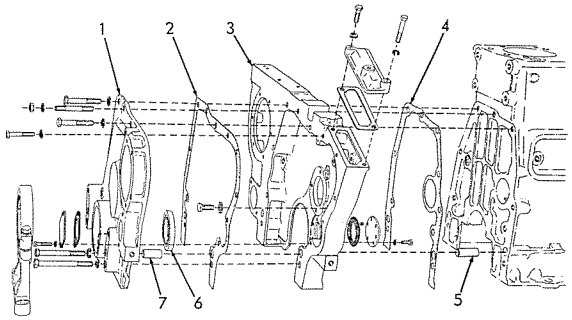


Fig. 6 — Typical Timing Gear Housing and Cover Details
(T-71019)

1. Timing Gear Housing Cover
2. Cover Gasket
3. Timing Gear Housing
4. Housing Gasket
5. Housing Dowel Pin
6. Crankshaft Front Oil Seal
7. Cover Dowel Pin

NOTE

It will probably be necessary to pry cover loose from dowel pins (7) and if oil pan is installed on engine, use care to prevent damage to front portion of oil pan gasket.

8. Before reinstalling cover, install a new crankshaft front oil seal (refer to following Paragraph).

C. CRANKSHAFT FRONT OIL SEAL REMOVAL AND INSTALLATION

1. CRANKSHAFT FRONT OIL SEAL REMOVAL

a. Remove timing gear housing cover (refer to preceding Paragraph).

b. Drive seal from cover.

c. Clean bore in cover to receive a new seal.

2. CRANKSHAFT FRONT OIL SEAL INSTALLATION

The O.D. of seal, Fig. 7 (2), has a layer of red-colored sealant which forms a seal between the O.D. of seal and the bore in the cover (3) eliminating the need of putting a sealing compound on O.D. of seal prior to pressing it into the cover. The I.D. of seal has a layer of rubber compound to prevent oil leakage between the seal and the crankshaft((1).

a. Place cover on a flat surface with the front side to the top, Fig. 8.

b. Position seal in cover with open side of seal facing down and positioned squarely in bore of cover.

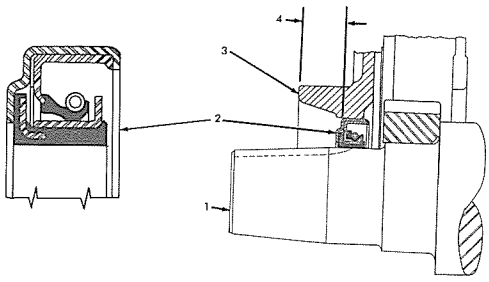


Fig. 7 — Crankshaft Front Oil Seal Location
(T-71020)

1. Crankshaft
2. Crankshaft Front Oil Seal
3. Timing Gear Housing Cover
4. 1-1/64" — 1-1/32"

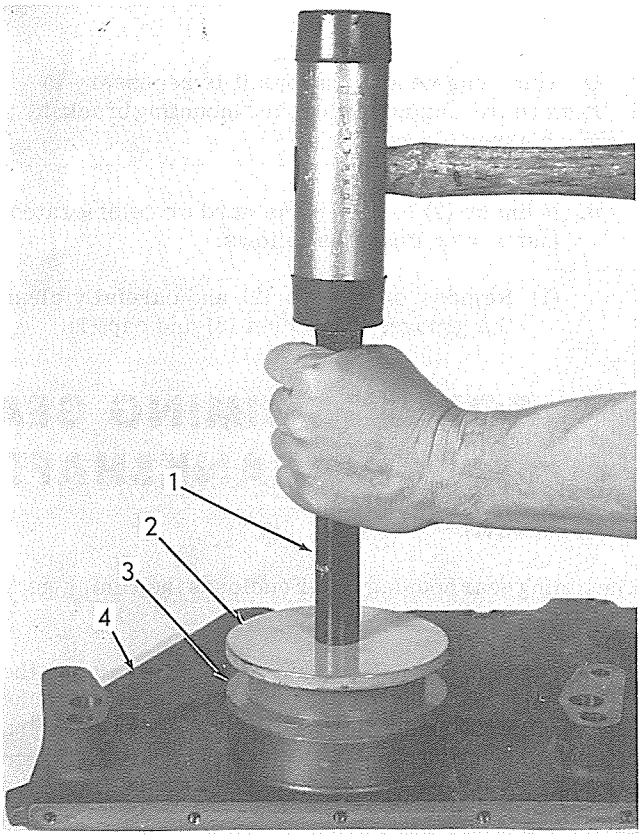


Fig. 8 — Installing Crankshaft Front Oil Seal
(T-71021)

1. Driver Handle
2. Installing Tool
3. Spacer
4. Timing Gear Housing

CAUTION

Make certain seal is not cocked in cover bore.

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

c. Drive or press seal into cover bore the specified distance of 1-1/64" — 1-1/32" as shown in Fig. 7 (4). Using the service tool shown in Fig. 8 will properly position the seal the correct distance in the cover bore, and will place the driving force on the outer edge of the seal.

CAUTION

Do not press on open face of seal or seal damage will occur.

d. After seal is positioned in cover, insert fingers into inner part of seal and check for rotation. If seal was installed properly, the inner part will turn with a firm feel to the fingers.

D. TIMING GEAR HOUSING COVER INSTALLATION

1. Remove burrs from keyway in crankshaft, using a finecut mill file or stone, to prevent damaging the layer of rubber in the I.D. of the crankshaft front oil seal.
2. Coat crankshaft lightly with lubricating oil.
3. Cement a new gasket, Fig. 6 (2), to the timing gear housing cover (1).
4. Using a reversal of the removal procedure, install the timing gear housing cover and components. Torque the 1/2" capscrews and nut to 45 — 50 lbs. ft., and the 3/8" capscrews to 18 — 21 lbs. ft.

TOPIC 3 - GEAR TRAIN AND TIMING GEAR HOUSING

A. GENERAL

Located in the timing gear housing, at the fan end of the engine, is a completely enclosed train of four helical gears as shown in Figs. 9, 10, and 11. The crankshaft gear (4) which is pressed and keyed to the crankshaft (5) drives the camshaft gear (2) and the engine oil pump drive gear (6). The fuel injection pump drive gear, Fig. 9 (1), is driven by internal teeth in the fan drive gear. The fuel injection pump drive gear, Fig. 9 (1), is driven directly by the camshaft gear. The fuel injection pump drive gear, Fig. 10 (1), is driven directly by the camshaft gear. The fuel injection pump drive gear, Fig. 11 (1) is driven by a gear integral with the camshaft gear. The fan drive, on all engines so equipped, is driven by the camshaft gear. On engines equipped with a hydraulic pump mounted on the rear of the timing gear housing, the camshaft gear also drives the pump drive gear, Figs. 12 or 13.

The gear train is splash lubricated by oil thrown by the gears. The specified backlash between any two mating gears is .003" - .007".

B. CAMSHAFT GEAR REMOVAL AND INSTALLATION

1. Remove camshaft from engine (refer to "CAMSHAFT AND CAMSHAFT BEARINGS" Section).
2. Remove gear retaining snap ring from end of camshaft and press gear from shaft.
3. Before installing gear examine the thrust collar for signs of wear and replace if necessary.
4. Install woodruff key in camshaft.

IMPORTANT

When installing the camshaft gear with integral fuel injection pump drive gear, place the thrust collar and locking plate in position on the camshaft before pressing the gear onto the shaft. Install thrust collar with oil groove side toward the gear.

5. Heat gear in oil to a temperature of approximately 280° F. Coat camshaft, at gear location, with a mixture of white lead and oil and drive or press gear onto camshaft.
6. Install gear retaining snap ring.
7. Check camshaft end play (.003" - .009") and install camshaft (refer to "CAMSHAFT AND CAMSHAFT BEARINGS" Section).

C. CRANKSHAFT GEAR REMOVAL AND INSTALLATION

Refer to "CRANKSHAFT AND CRANKSHAFT GEAR, MAIN BEARINGS, AND MAIN BEARING CAPS" Section.

D. OIL PUMP DRIVE GEAR REMOVAL AND INSTALLATION

Refer to "LUBRICATING SYSTEM" Section.

E. FUEL INJECTION PUMP DRIVE GEAR REMOVAL AND INSTALLATION

On engines with fuel injection pump drive gears similar to those illustrated in Figs. 9 or 11, it is not necessary to remove the gear in order to remove the timing gear housing. The gear is removed with the fuel injection pump (refer to "FUEL SYSTEM" Sections).

On engines with a fuel injection pump drive gear similar to the one illustrated in Fig. 10, proceed as follows:

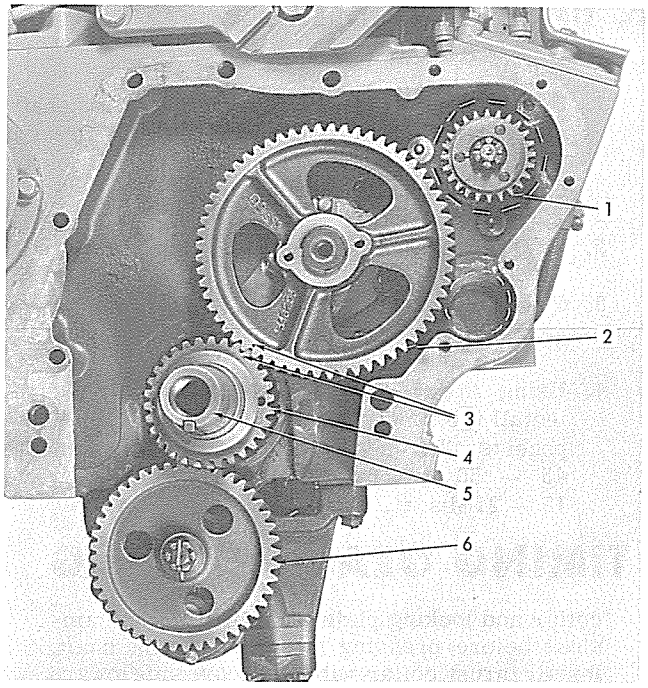


Fig. 9 — Typical Gear Train (Engines with American Bosch Fuel Injection Pump and Fan Drive Pulley) (T-27622)

1. Fuel Injection Pump Drive Gear
2. Camshaft Gear
3. Timing Marks
4. Crankshaft Gear
5. Crankshaft
6. Engine Oil Pump Drive Gear

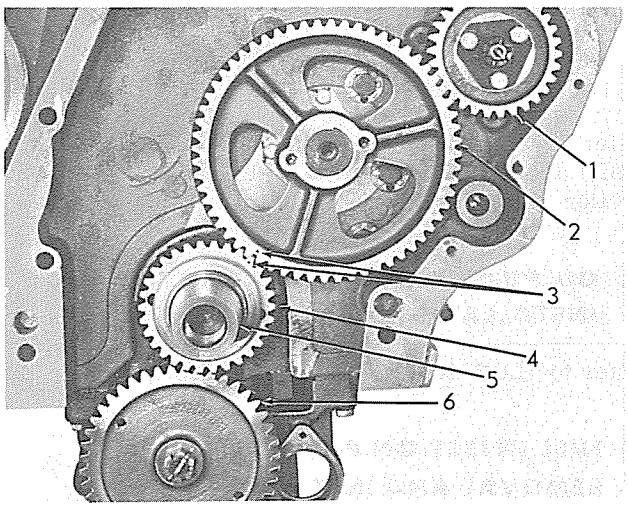


Fig. 10 — Typical Gear Train (Engines with American Bosch Fuel Injection Pump but without Fan Drive Pulley) (T-19297)

1. Fuel Injection Pump Drive Gear
2. Camshaft Gear
3. Timing Marks
4. Crankshaft Gear
5. Crankshaft
6. Engine Oil Pump Drive Gear

1. REMOVAL

Remove the three capscrews and serrated plate securing the fuel injection pump drive gear to the hub and remove the gear.

2. INSTALLATION

When installing the fuel injection pump drive gear, the fuel injection pump must be properly timed to the engine; for complete instructions refer to "FUEL SYSTEM" Section.

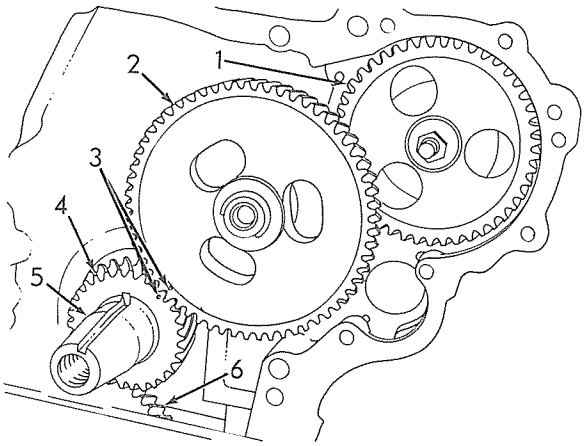


Fig. 11 — Typical Gear Train (All Engines with Roosa Master Fuel Injection Pump) (T-72703)

1. Fuel Injection Pump Drive Gear
2. Camshaft Gear
3. Timing Marks
4. Crankshaft Gear
5. Crankshaft
6. Engine Oil Pump Drive Gear

F. TYPE I HYDRAULIC PUMP DRIVE REMOVAL, DISASSEMBLY, AND INSPECTION (Fig. 12)

1. If engine is so equipped, loosen fan drive belts and remove from fan drive pulley. Remove fan drive pulley.

2. Remove hydraulic pump to prevent possibility of tang type coupling falling into timing gear housing.

3. Disconnect lubricating oil hose (10).

NOTE

On motor graders disconnect both hoses.

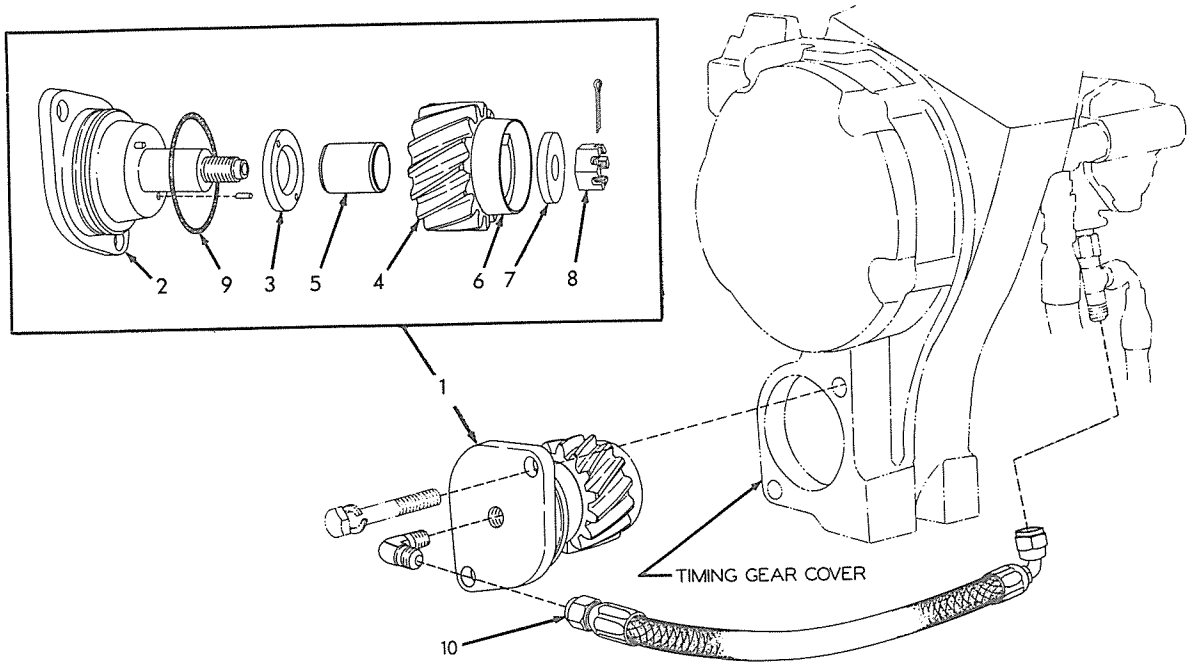


Fig. 12 — Type I Hydraulic Pump Drive
(T-24154)

1. Hydraulic Pump Drive
2. Shaft Assembly
3. Thrust Washer
4. Gear
5. Bushing
6. Sleeve
7. Gear Retaining Washer
8. Nut
9. O-Ring
10. Lubricating Oil Hose

4. Remove capscrews and lockwashers and pull drive gear assembly (1) from timing gear cover.

5. Remove cotter pin and nut (8) from shaft.

6. Remove washer (7) gear (4) and washer (3). Remove O-ring (9).

7. Inspect bushing in gear, the specified I.D. is .812" - .813" and the O.D. of the shaft, at the gear location, is .8095" - .8105". If bushing is worn, replace and burnish to the specified .812" - .813" I.D. If shaft is worn, replace.

G. TYPE I HYDRAULIC PUMP DRIVE ASSEMBLY AND INSTALLATION (Fig. 12)

1. Assemble drive gear by reversing the disassembly procedure. Install thrust washer (3) on dowel pins with oil grooves in washer facing the gear (4). Install retaining washer (7) with chamfered side facing the gear. After nut (8) is tightened, check end play between thrust washer (3) and gear (4). The specified end play is .002" - .007". If end play exceeds .010", replace thrust washer (3). The specified thickness of a new thrust washer is .186" - .188".

NOTE

When cotter pin is installed, spread ends tightly against nut (8) to prevent interference with tangs of pump drive coupling.

2. Using a new O-ring (9) install drive gear assembly on timing gear cover. Connect lubricating oil hose(s). Install hydraulic pump.

H. TYPE II HYDRAULIC PUMP DRIVE REMOVAL, DISASSEMBLY, AND INSPECTION (Fig. 13)

1. Remove hydraulic pump and adapter (8) from rear of timing gear housing.

2. Remove coupling (11) and coupling (12).

3. Remove bearing retainer (1).

4. Drive or press gear (16) and bearings (6) and (15) from timing gear housing.

5. Drive or press bearings (6) and (15) from gear (16).

6. Inspect bearings for roughness, looseness or signs of wear. Inspect gear for chipped or cracked teeth. Inspect gear O.D. at bearing locations for signs of wear; the specified O.D. at these locations is .9842" - .9846". Inspect the bearing bore in the timing gear housing and bearing retainer. The specified I.D. of the bores at these locations is 2.047" - 2.048". Replace any worn or damaged parts.

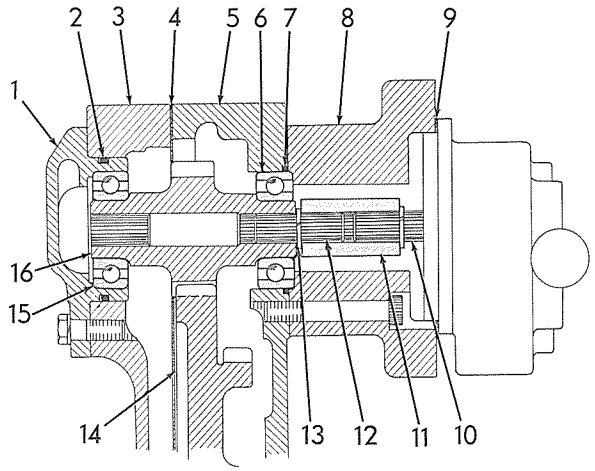


Fig. 13 — Type II Hydraulic Pump Drive (T-72729)

1. Bearing Retainer
2. O-Ring
3. Timing Gear Housing Cover
4. Gasket
5. Timing Gear Housing
6. Rear Ball Bearing
7. O-Ring
8. Pump Mounting Adapter
9. Gasket
10. Hydraulic Pump Drive Shaft
11. Internal Spline Coupling
12. External Spline Coupling
13. Snap Ring
14. Camshaft Gear
15. Front Ball Bearing
16. Hydraulic Pump Drive Gear

I. TYPE II HYDRAULIC PUMP DRIVE ASSEMBLY AND INSTALLATION (Fig. 13)

1. Press bearings (6) and (16) onto gear.
2. Install a new O-ring (2) in groove in bearing retainer (1) and install retainer in position in timing gear housing cover (3). Secure with capscrews and lockwashers.
3. Lubricate bearings, and drive gear and bearings assembly into position in bearing retainer and timing gear housing.
4. Place a new O-ring (7) in counterbore in housing (5).
5. Install coupling (12) and coupling (11).
6. Install adapter (8) and secure with 12 point nylok capscrews.
7. Install hydraulic pump and gasket.

J. TIMING GEAR HOUSING REMOVAL AND INSTALLATION

1. Disconnect and remove the water pump hoses.

NOTE

The water pump may or may not be removed, as desired.

2. Remove capscrews securing timing gear housing to cylinder block and remove housing.

NOTE

If oil pan was not removed be extremely careful not to damage oil pan gaskets.

3. Before reinstalling the housing, clean it in cleaning solvent, inspect it for cracks and other damage.
4. Cement a new gasket to the housing, coat dowels with white lead and install the housing. Install retaining capscrews and lockwashers and torque capscrews to 45 — 50 lbs. ft.

SECTION 10 - FLYWHEEL AND RING GEAR; FLYWHEEL HOUSING AND CRANKSHAFT REAR OIL SEAL

TOPIC NO.	TITLE	PAGE
1.	FLYWHEEL AND RING GEAR	
	A. General	10-1
	B. Flywheel Removal and Installation	10-1
	C. Flywheel Inspection	10-1
	D. Flywheel Ring Gear Inspection, Removal, and Installation	10-3
2.	FLYWHEEL HOUSING AND CRANKSHAFT REAR OIL SEAL	
	A. General	10-3
	B. Flywheel Housing Removal and Inspection	10-3
	C. Flywheel Housing Installation	10-4
	D. Crankshaft Rear Oil Seal Removal and Installation	10-4

TOPIC 1 - FLYWHEEL AND RING GEAR

A. GENERAL

The flywheel Fig. 1 (1) is bolted to a flange (13) on the rear end of the crankshaft and is doweled (11) in two places. One capscrew hole in the flywheel is offset and the flywheel can be attached to the crankshaft flange in only one position. A starter ring gear (2), made from heat treated steel, is shrunk onto the rim of the flywheel.

Two basic types of flywheels are used on engines covered in this manual. Track-type tractors and motor graders use a flywheel with internal teeth which drive clutch discs. Tractor loaders use a plain flywheel and a bolted on driving ring, with internal teeth which drive a torque converter. Tractor dozers use a plain flywheel and a bolted on flex plate which drives a torque converter.

On earlier model engines a plastic timing strip is fastened to the flywheel; on later model engines the timing marks are rolled directly into the flywheel.

B. FLYWHEEL REMOVAL AND INSTALLATION

Removal of flywheel in most units will not require removal of engine.

a. Remove engine clutch and/or torque converter.

b. Remove bolts, Fig. 1 (3); attaching flywheel (1) to crankshaft flange (13) and remove flywheel.

NOTE

It may be necessary to remove the flywheel timing hole cover (9) and pry flywheel loose with a suitable bar.

c. Thoroughly clean and inspect the flywheel.

d. Install flywheel by reversing the removal procedure, and on applications requiring a new O-ring, Fig. 1 (4), insert it between flywheel and crankshaft flange when assembling flywheel to engine.

e. After flywheel is assembled to crankshaft, tighten the flywheel bolts (3) to the specified torque of 95 — 105 lbs.ft.

f. Attach a dial indicator to the flywheel housing and check flywheel face for run-out, Fig. 2, using a suitable bar inserted into the timing hole, pry flywheel to the rear, eliminating crankshaft end play, otherwise dial indicator reading will not be accurate. Flywheel face run-out should not exceed .0005" maximum total indicator reading per inch of flywheel diameter.

Readjust indicator so that finger of indicator rides the bore of the flywheel housing, Fig. 3. The bore run-out should not exceed .005" total indicator reading.

C. FLYWHEEL INSPECTION

Check to see if flywheel surface is scored or heat-checked; flywheel should be machined smooth or replaced if either condition exists. It is very important that all burrs and nicks be removed from the surface of flywheel that fits against flange of the crankshaft. If this surface is not smooth and true, the flywheel may have a slight wobble which will result in improper clutch or converter operation and engine vibration.

If surface of the flywheel is scored or heat checked, it may be machined smooth; replace the flywheel if more than 1/16" stock must be removed.

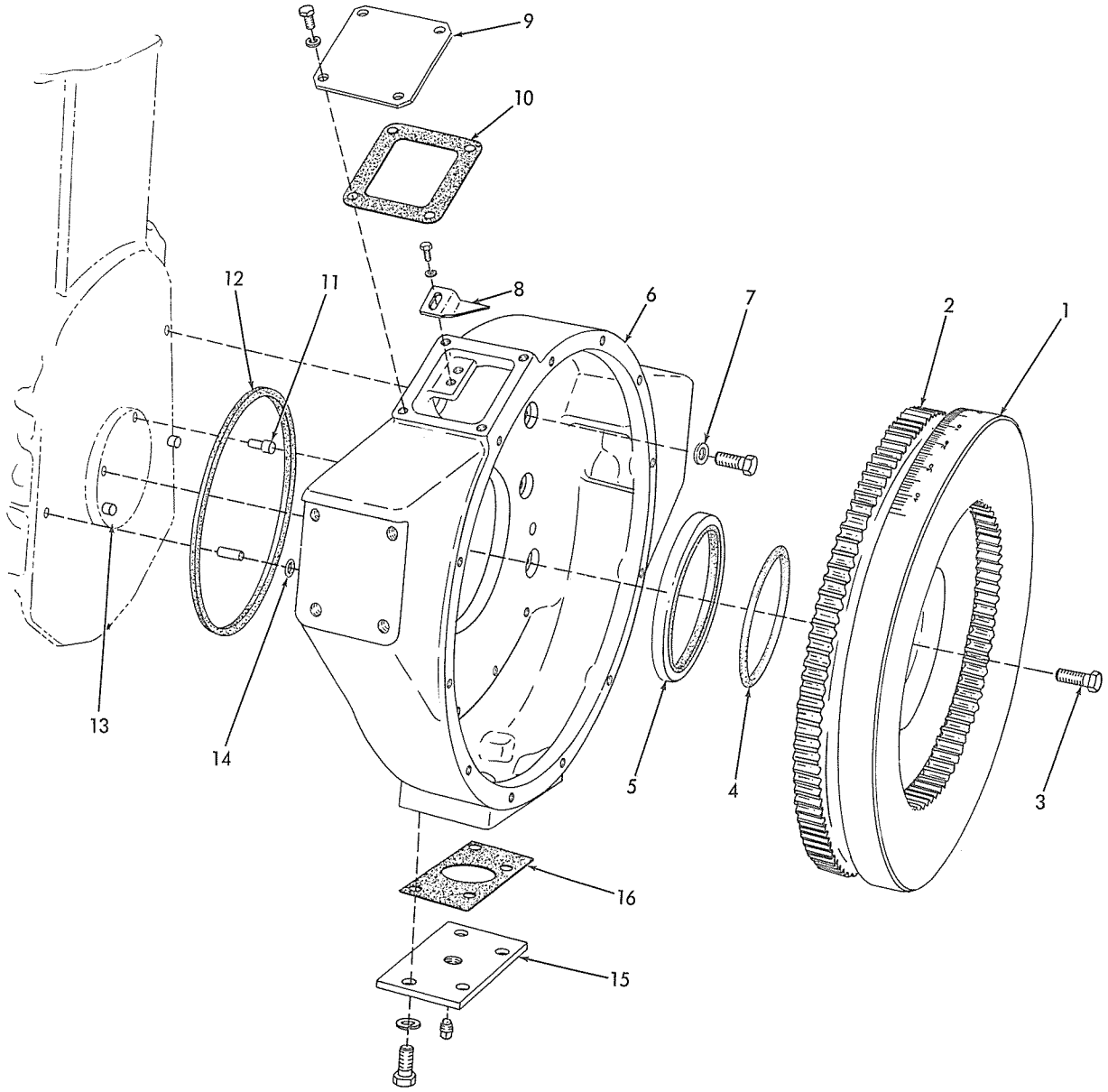


Fig. 1 — Typical Flywheel and Flywheel Housing
(T-41854)

1. Flywheel
2. Ring Gear
3. Flywheel Bolt
4. Flywheel-to-Crankshaft O-ring (Used only on track-type tractors with oil-type engine clutch and/or torque converter)
5. Crankshaft Rear Oil Seal
6. Flywheel Housing
7. Sealing Washer (Used only with oil-type engine clutch and/or torque converter)
8. Timing Pointer
9. Timing Hole Cover
10. Timing Hole Cover Gasket (Used only with oil-type engine clutch and/or torque converter)
11. Dowel Pin
12. Sealing Ring
13. Crankshaft Flange
14. O-Ring (Used only with oil-type engine clutch and/or torque converter)
15. Bottom Cover (Not used on some housings)
16. Bottom Cover Gasket (Not used on some housings)

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

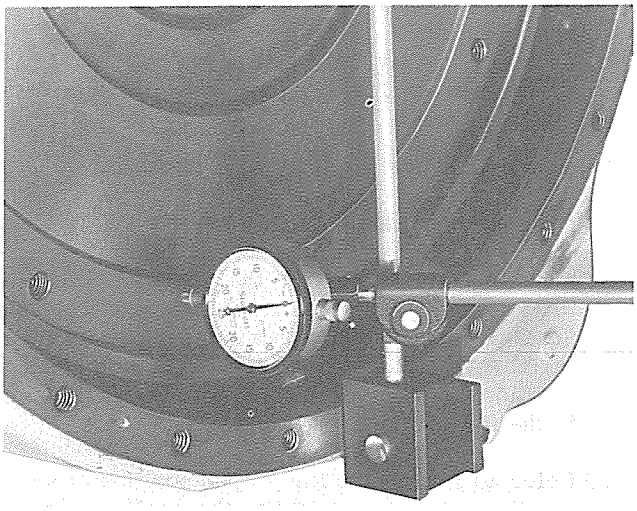


Fig. 2 — Measuring Run-Out of Flywheel Face (T-40271)

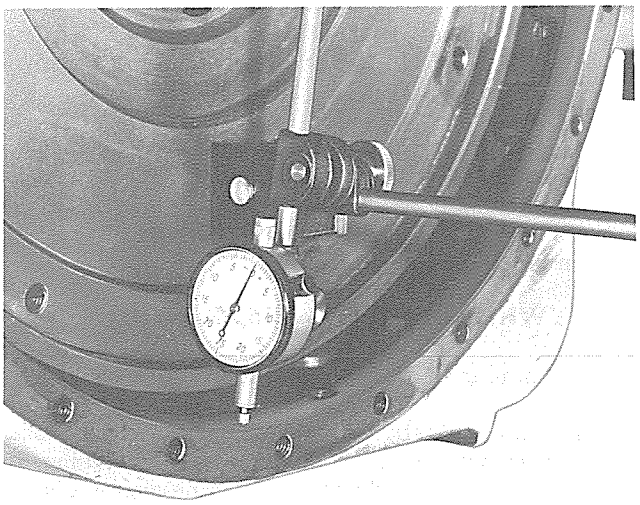


Fig. 3 — Measuring Run-Out of Flywheel Housing Bore (T-40272)

NOTE

In cases where it is necessary to machine the friction surface of the flywheel, the same amount of material must be machined from the surface of the flywheel on which the clutch bolts. The following dimensions are the distance between the friction surface and the clutch bolting surface of the flywheel.

HD11 Tractor with dry-type engine clutch	1.615"-1.625"
HD11 Tractor with oil-type engine clutch	3.158"-3.168"
M-100 Motor Grader with oil-type engine clutch	1.958"-1.968"

D. FLYWHEEL RING GEAR INSPECTION, REMOVAL, AND INSTALLATION

Inspect flywheel ring gear for general condition and wear. Replace ring gear if it is not in good condition. Remove ring gear from flywheel by grinding a notch through the ring gear at root of one of the teeth, then expand the ring and drive it from its position. Do not attempt to remove ring gear without first expanding it. To install a flywheel ring gear, proceed as follows:

1. Coat one side of the ring gear with a temperature indicating crayon (400°F. crayon); then uniformly heat the ring gear until the crayon just starts to liquify on the entire gear.

CAUTION

Do not heat beyond the flowing point of crayon as the heat treatment of the gear may be destroyed.

2. After heating, start ring gear on the flywheel so that when the flywheel is installed, chamfered ends of the teeth on the ring gear will face the cylinder block; these ends of the teeth engage with the pinion of the starter. Drive ring gear down tight against shoulder on the flywheel. Allow ring gear to cool slowly; do not cool with water.

TOPIC 2 - FLYWHEEL HOUSING AND CRANKSHAFT REAR OIL SEAL

A. GENERAL

The flywheel housings covered in this manual are all basically similar to the one illustrated in Fig. 1 (6).

In order to remove the flywheel housing from the engine, it is necessary to remove the engine from the unit. With the engine mounted on an engine stand or supported on blocks, remove the flywheel housing as follows:

B. FLYWHEEL HOUSING REMOVAL AND INSPECTION

1. Remove the engine.
2. Remove engine clutch and/or torque converter.
3. Remove flywheel from the engine.
4. Remove capscrews securing the oil pan to the flywheel housing.
5. Remove bolts securing flywheel housing to the cylinder block. Tap housing with a soft-headed hammer to break it loose from the housing dowels and remove the housing.

6. Thoroughly clean housing with a cleaning solvent. Remove flywheel housing-to-block sealing ring, Fig. 1 (12). Remove housing dowel O-rings (14) if so equipped.

   Inspect housing for cracks and other damage; replace or repair the housing if damaged.

7. Remove and discard crankshaft rear oil seal (5) and install a new seal.

C. FLYWHEEL HOUSING INSTALLATION

1. Clean rear of cylinder block.

2. Position a new flywheel housing-to-cylinder block sealing ring Fig. 1 (12) in groove in housing. If engine is equipped with an oil-type engine clutch and/or torque converter, make certain the housing dowel O-rings (14) are installed.

3. Assemble flywheel housing to the rear of the cylinder block by reversing the removal procedure. Tighten the housing attaching capscrews to a torque of 70 lb-ft (9.7 kg-m). Tighten the capscrews securing the rear of the oil pan to the flywheel housing to a torque of 28-33 lb−ft (3.9-4.6 kg-m).

4. Install the flywheel and check the flywheel run-out and flywheel housing bore run out (refer to "FLYWHEEL REMOVAL AND INSTALLATION" in this Section).

D. CRANKSHAFT REAR OIL SEAL REMOVAL AND INSTALLATION

The crankshaft rear oil seal is a single lip seal. One seal, Fig. 5, is used in dry clutch applications. Two seals, Fig. 4, are used in wet clutch applications to prevent transfer of oil from the clutch housing to the engine crankcase.

NOTE: Although the M-100 motor grader has a wet clutch, only one seal, as shown in Fig. 5, is necessary because engine crankcase oil is used in the clutch. A wear sleeve on the flywheel seal flange, as shown in Figs. 4 and 5, is required with the seal(s).

CAUTION

Double seal installations are suitable for operation only in engines with wet flywheel housings, such as oil clutch applications. The rear seal is dependent upon the clutch or transmission oil, or oil mist, for lubrication to prevent burning or excessive wear of the seal lips. If it is necessary to run the engine for more than a few minutes without the normal clutch or transmission oil lubricating the rear seal, such as would be required for a dynamometer break-in of a newly overhauled engine before re-installation in a vehicle, enough lubrication can be provided for an approximate four hour run if the seal is thoroughly lubricated and the cavity between the lips of the two seals is filled as much as possible with engine lubricating oil prior to installation of the flywheel.

1. CRANKSHAFT REAR OIL SEAL REMOVAL

   a. Remove the flywheel (refer to "FLYWHEEL REMOVAL AND INSTALLATION" in this Section).

   b. Remove old seal from flywheel housing.

2. CRANKSHAFT REAR OIL SEAL INSTALLATION

   a. Clean oil seal bore in the flywheel housing.

   b. Seals are precoated with a sealing compound on their O.D.'s. It is not necessary to apply any additional sealing compound when installing them in the flywheel housing.

   c. Refer to Fig. 4 or 5 for proper position of sealing lip and press or drive the seal(s), with an adequate seal installing tool, into the flywheel housing bore so it is seated against the seal stop in the bore on all 10000 and 11000 series engines equipped with flywheels having 1" long seal flanges.

      For early 10000 and 11000 engines equipped with flywheels having 15/16" long seal flanges, the seal should be positioned 1/32" away from the seal stop in the bore in the flywheel housing. This is important to ensure that the front seal lip does not ride on the leading chamfer of the wear sleeve. A spacer shim is available for correctly positioning the seal 1/32" away from its stop in the flywheel housing seal bore.

   d. Press wear sleeve on flywheel flange, as illustrated, with beveled outside edge away from flywheel. Do not use any lubricant or sealer between sleeve and flywheel flange. Metal to metal contact is required for adequate heat flow to prevent damage to seal(s). Do not heat sleeve prior to installation.

   e. Install three temporary installation guide studs approximately 120° apart in the crankshaft flange to act as guides for installing the flywheel.

   f. For double seal, wet flywheel housing applications, coat the crankshaft flange with a non-hardening type of gasket sealer to prevent any possibility of oil transferring between the flange and the flywheel. (On later flywheels using an O-ring seal between the flywheel and the crankshaft flange, this is not required.)

   g. Lubricate the seal lips, the flywheel wear sleeve, and the guide studs with engine lubricating oil to aid the entry of the flywheel into the seal. Do not use grease, white lead, soap, etc.

   h. The final installation of the flywheel into the seal is blind; therefore extreme precaution must be taken in making the installation to prevent damage to the tender Silicone material. Install the flywheel over the temporary installation pilot

studs as straight as possible being careful to not cut, crimp or double back the rear seal lip on double seal applications.

i. Install flywheel bolts and tighten to a torque of 95-105 lb-ft (13.1-15.9 kg-m). If socket head capscrews are used, tighten to 135 lb-ft (18.7 kg-m).

j. For double seal, wet flywheel housing applications, the crankshaft flange to flywheel positioning dowels must also be sealed to prevent oil transfer. This is accomplished with lead slugs, Fig. 4 (3). Insert them, pointed end towards the dowel, into the dowel hole of the flywheel, with the flywheel mounted on the crankshaft. Peen the slug to the inside of the dowel hole until the surface of the slug is flush with the flywheel.

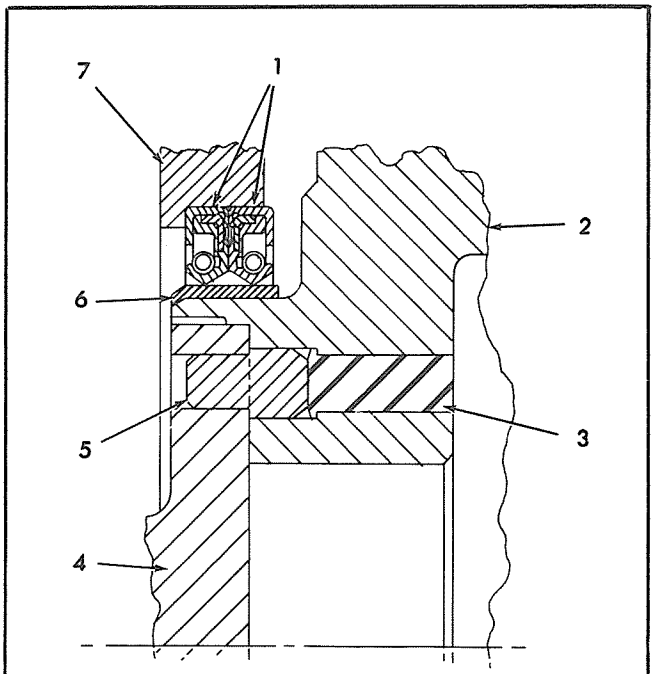


Fig. 4 – Crankshaft Rear Oil Seal – Wet Clutch Applications
T-76818

1. Oil Seals
2. Flywheel
3. Lead Slug
4. Crankshaft Flange
5. Dowel
6. Wear Sleeve
7. Flywheel Housing

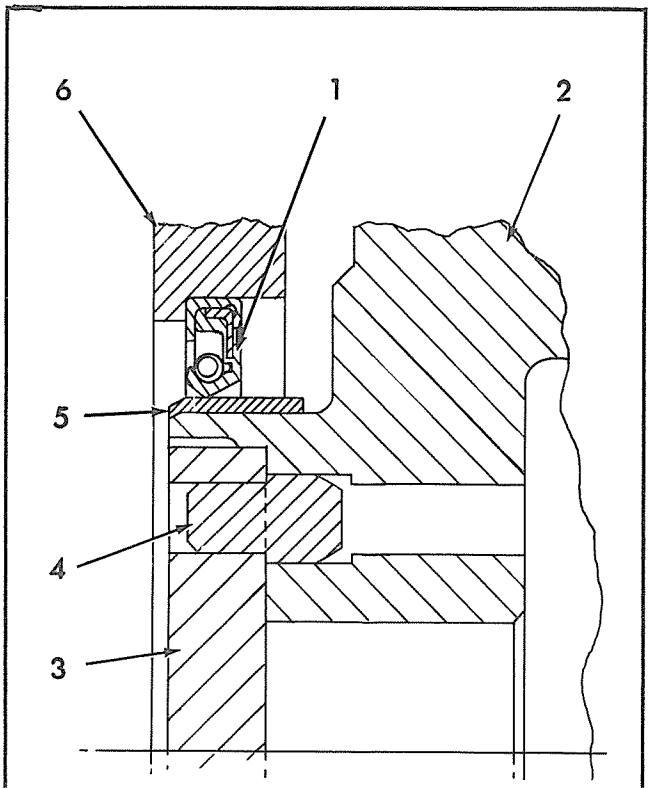


Fig. 5 – Crankshaft Rear Oil Seal – Dry Clutch Applications
T-76819

1. Oil Seal
2. Flywheel
3. Crankshaft Flange
4. Dowel
5. Wear Sleeve
6. Flywheel Housing

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

SECTION 11 - LUBRICATING SYSTEM

TOPIC NO.	TITLE	PAGE
1.	GENERAL	11-1
2.	OIL PAN	
	A. General	11-3
	B. Oil Pan Removal, Inspection, and Installation	11-3
3.	OIL PRESSURE PUMP	
3A	OIL PRESSURE PUMP AND LINES (SECOND TYPE)	11-6A
4.	OIL SCAVENGING PUMP	
	A. General	11-7
	B. Oil Scavenging Pump Removal, Disassembly, and Inspection	11-8
5.	OIL PRESSURE REGULATING VALVE	
	A. General	11-10
	B. Oil Pressure Regulating Valve Disassembly and Assembly	11-10
6.	LUBRICATING OIL FILTER AND BY-PASS VALVE	
	A. General	11-11
	B. Lubricating Oil Filter Removal, Disassembly, Assembly, and Installation	11-11
	C. By-Pass Valve Removal and Installation	11-13

TOPIC 1 - GENERAL

The lubricating system is designed so that the engines, referred to in this manual, can be operated at various degrees in any direction from horizontal as follows:

Track-Type Tractors w/10000 or 11000 Engines . . . . . 45°

Motor Graders w/10000 Engines. . . . . 25°

Tractor Loaders and Tractor Dozers (Wheel-Type) w/10000 or 11000 Engines. . . . 20°

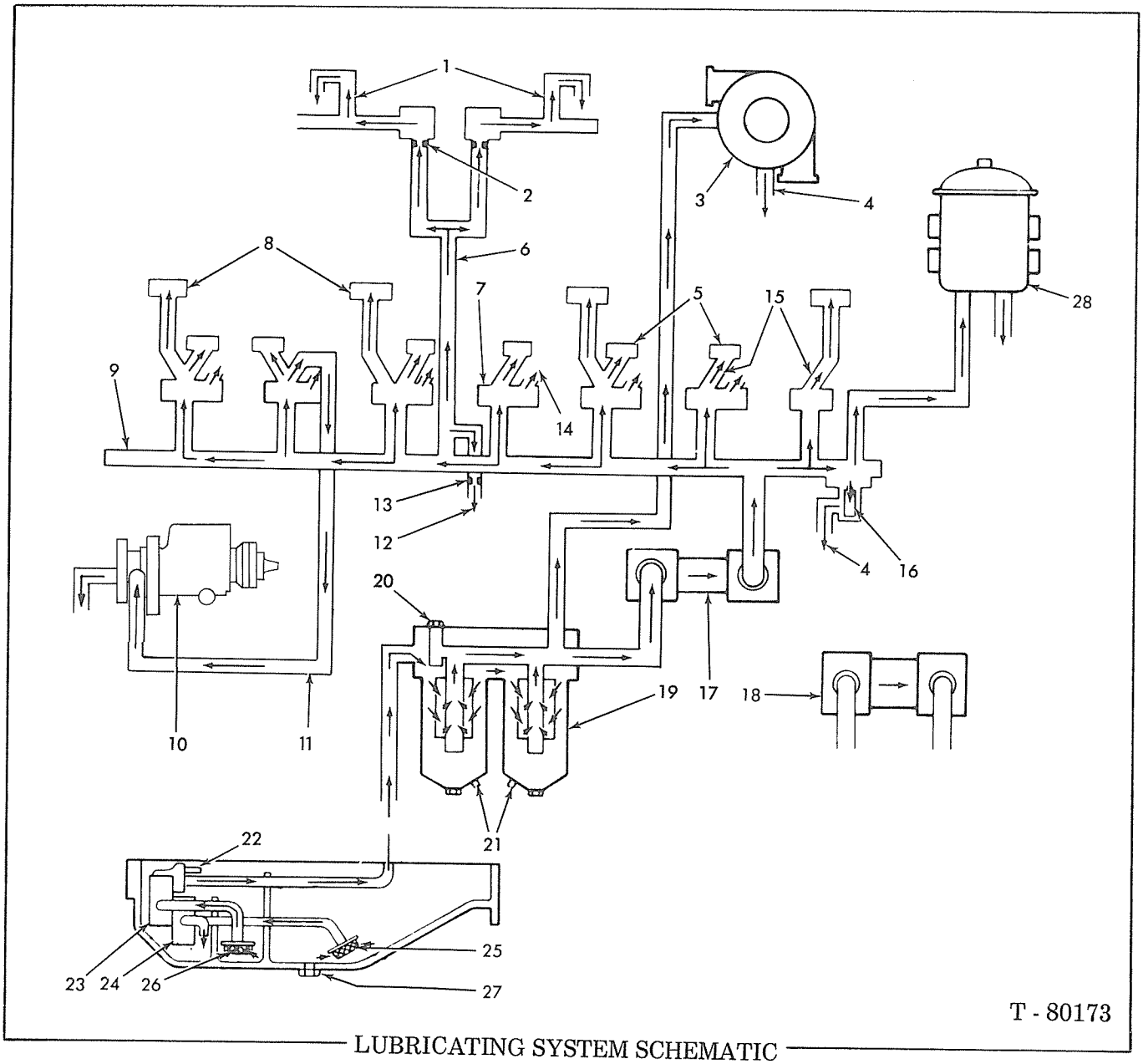
In applications where the unit is consistently working on a grade, the engine is equipped with an oil scavenging pump. The purpose of this pump is to keep a constant supply of oil to the oil pressure pump. Refer to Fig. 1, the engine is lubricated by a gear-type pump (23) driven by a gear on the front end of the crankshaft. An oil pump pressure relief valve (22) is set to relieve when pressure in the passages and lines exceeds 180 psi.

Oil pressure, at normal operating temperature, should be 30-55 psi at full throttle. Stabilized oil pressure is maintained within the engine by an oil pressure regulating valve (16) located in the main oil gallery at the right rear corner of the cylinder block. Excess oil, by-passed through this valve, returns to the oil pan.

The oil filter head contains an oil filter by-pass valve (20). If the oil filter cartridge becomes clogged, or if in cold weather the oil is too thick to circulate freely through the filter, the valve opens and the oil by-passes the filter and is forced directly into the main oil gallery.

The oil pressure pump draws oil through the suction screen (25) then circulates the oil, under pressure, through the oil filter (19) and oil cooler (17). The oil then flows into the main oil gallery (9). Oil passages convey the oil from the main oil gallery to the main bearings (7) camshaft bearings (8) connecting rod bearings (5) and through the rifle-drilled connecting rods to the piston pins.

A horizontal and vertical oil passage through the center of the cylinder block extends from the main oil gallery to a cavity in the left side of the cylinder block. Oil from this cavity is conveyed to the hollow rocker arm shafts through drilled passages in the cylinder heads, and through restricted passages in the rocker arm shaft brackets located at no. 3 and 4 cylinders. The rocker arm shafts have drilled openings at each rocker arm location.



LUBRICATING SYSTEM SCHEMATIC

1. Rocker arm shaft drain tubes (to oil pan)
2. Restricted rocker arm brackets (No. 3 and No. 4 cylinders)
3. Turbocharger
4. Retrun to oil pan
5. Connecting rod bearings and piston pins
6. To valve rocker arms
7. Main bearings
8. Camshaft bearings
9. Main oil gallery
10. Fuel injection pumps
11. Oil supply tube
12. Return to oil pan
13. Restrictor
14. Piston cooling jets (Eff. eng. s/n 11-24134)
15. Crankshaft oil passage
16. Oil pressure regulating valve
17. Engine oil cooler
18. Torque converter oil cooler
19. Full-flow type oil filter
20. Oil filter by-pass valve
21. Filter drain plugs
22. Lubricating oil pump pressure relief valve
23. Lubricating oil pressure pumps
24. Scavenging oil pumps
25. Scavenging oil pumps suction screen
26. Lubricating oil pressure pump suction screen
27. Oil drain plug
28. By-pass ty pe

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

A horizontal oil passage, extending from the main oil gallery to a fitting in the left side of the cylinder block, conveys oil to the fuel injection pump (20) through an external oil line. Excess oil from the fuel injection pump is dumped into the timing gear housing and returns to the oil pan.

If the engine is equipped with a turbocharger (3) and/or a fan drive gear oil is conveyed to and returned from these units through external oil lines.

On motor graders equipped with an oil-type engine clutch, oil to the clutch is supplied from a drilled passage at the rear main bearing and returns to the oil pan through an oil return line.

TOPIC 2 - OIL PAN

A. GENERAL

The oil pan is the reservoir for the engine lubricating oil. On some engine applications the oil pan is provided with a clean-out cover for ease of inspecting and cleaning the oil pump suction screen. The oil drain plug is located in the clean-out cover or bottom of pan.

B. OIL PAN REMOVAL, INSPECTION, AND INSTALLATION

1. In all units using engines covered in this manual, except tractor loaders, the oil pan may be removed with the engine mounted in the unit. To remove oil pan on tractor loaders the engine must be removed from the unit (refer to "ENGINE REMOVAL AND INSTALLATION" Section).
2. Remove engine crankcase guard if so equipped.
3. Remove oil drain plug and drain lubricating oil.
4. On motor graders, disconnect the oil return line elbow from the oil pan.
5. Remove capscrews and lockwashers or Nylok capscrews securing rear of oil pan to flywheel housing. Remove capscrews and lockwashers securing oil pan to cylinder block.
6. Jar oil pan loose from cylinder block and remove oil pan.
7. Remove clean-out cover, if so equipped, and thoroughly wash all parts in cleaning solvent.
8. Inspect clean-out cover, drain plug, and oil pan for cracks or other damage. Replace if necessary.
9. Using gasket cement, cement a new oil pan gasket set to bolting flange of oil pan.
10. Using care to prevent damage to seal ring in flywheel housing, place oil pan in position on cylinder block and insert a capscrew and lockwasher near each corner, but do not tighten capscrews to extent that oil pan cannot be shifted.
11. Install capscrews and lockwasher or Nylok capscrews which secure rear flange of oil pan to flywheel housing and tighten securely. Install remaining capscrews and lockwashers securing oil pan to cylinder block. Tighten 5/16" NC capscrews to a torque of 11 - 13 lbs. ft. Tighten 3/8" NC (grade 2) capscrews to 18 - 21 lbs. ft. and, if 3/8" NC (grade 5) capscrews are used on the rear flange, tighten to 28 - 33 lbs. ft.
12. If equipped with a clean out cover, use a new gasket, install cover and secure with capscrews and lockwashers.
13. Install drain plug and tighten securely.
14. Fill engine crankcase to the proper level with specified lubricant.

TOPIC 3 - OIL PRESSURE PUMP

A. OIL PRESSURE PUMP REMOVAL, DISASSEMBLY AND INSPECTION

1. OIL PRESSURE PUMP REMOVAL (Figs. 2, 3)
   a. Drain engine lubricating oil and remove oil pan.
   b. Remove oil pressure pump discharge pipe (2).
   c. Remove oil pressure pump suction pipe (4).
   d. Remove lockwire, capscrews, and lockwashers securing lubricating oil pump assembly (1) to cylinder block and remove oil pump assembly.

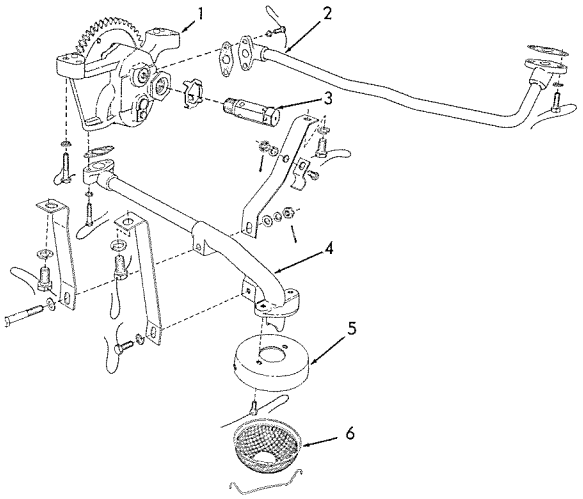


Fig. 2 — Tubing Arrangement (All Units Except Track-Type Tractors) (T-15138)

1. Lubricating Oil Pump Assembly
2. Discharge Pipe
3. Oil Pressure Relief Valve Assembly
4. Suction Pipe
5. Oil Screen Cover
6. Oil Screen

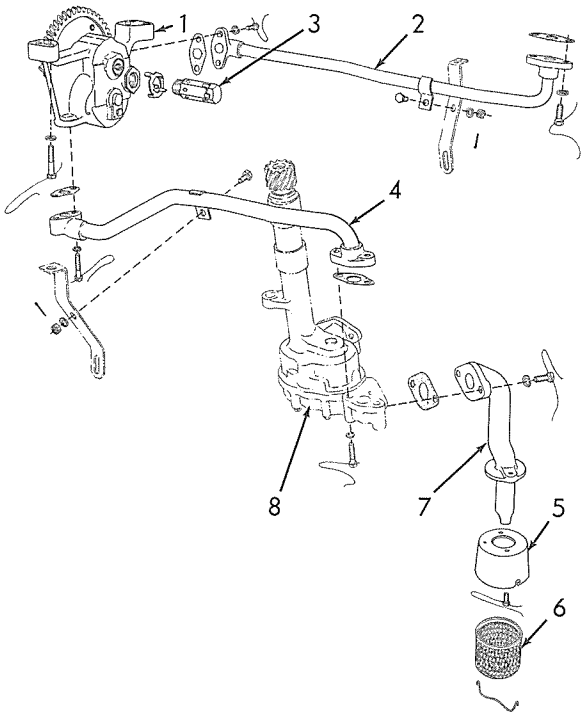


Fig. 3 — Tubing Arrangement (Track-Type Tractors Only) (T-13181)

1. Lubricating Oil Pump Assembly
2. Discharge Pipe
3. Oil Pressure Relief Valve Assembly
4. Suction Pipe
5. Oil Screen Cover
6. Oil Screen
7. Suction Pipe Rear Section
8. Oil Scavenging Pump

2. OIL PRESSURE PUMP DISASSEMBLY AND INSPECTION (Fig. 5)

a. Thoroughly wash pump assembly. Remove cotter pin (1) and nut (2). Using tools similar to the ones shown in Fig. 4, pull gear, Fig. 5 (3) from shaft (23). Remove Woodruff key (4). File off any burrs on shaft.

b. Remove locking wires (22), capscrews (21), and lockwashers (20). Tap cover (7) lightly to loosen it from dowel pin (12) and remove cover (7).

c. Remove shaft (23) with gear (8).

d. Slide gear (10) from shaft (9).

e. Unlock and remove pressure relief valve, Fig. 2 or 3 (3).

f. Remove lockwire (18), capscrew (17), lockwasher (16) and remove retainer (19) and shaft (9).

g. Wash all oil pump components in clean solvent and thoroughly inspect all parts before reassembling the pump.

The principle wearing parts of the oil pump are the upper (8) and lower (10) gears. If dirt and sludge have been allowed to accumulate in lubricating system, oil pump gears may show signs of wear in a short time. When oil has been kept clean and oil filter has been properly serviced, wear on these parts should be very slight.

h. Inspect pump gear teeth, inside of pump housing (13) and inner face of cover (7) for wear and scoring. Gear teeth, inside of pump housing, and inner face of cover must be smooth, with no scratches, score marks or rough spots.

Specified radial clearance between pump gears and pump housing is .00175" - .00275" and must not exceed .004" - .005". Specified end clearance of gears in pump is .002" - .004", and must not exceed .005" - .007". If radial or end clearance of gears is in excess of above limits, worn parts must be replaced. If replacement of oil pump gears is necessary, the upper gear (8) must be pressed from upper shaft (23). When installing upper gear on upper shaft,

install Woodruff key (4) in shaft and press shaft into gear (chamfered side of gear next to shoulder on shaft) until gear is tight against shoulder.

i. Inspect pump shafts and bushings for excessive wear or scoring and replace if necessary.

(1) Specified clearance between upper shaft (23) and bushing (15) in pump housing is .0015" - .0030". After installing a new bushing in pump housing, it must be reamed to .937" - .938".

(2) Specified clearance between upper shaft (23) and bushing (6) in pump cover is .0015" - .0035". After installing a new bushing in pump cover, it must be reamed to 1.2495" - 1.2505".

(3) Specified O.D. of upper shaft at housing location is .9350" - .9355" and at cover location is 1.247" - 1.248".

(4) Specified clearance between lower gear bushing (11) and lower shaft (9) is .0005"

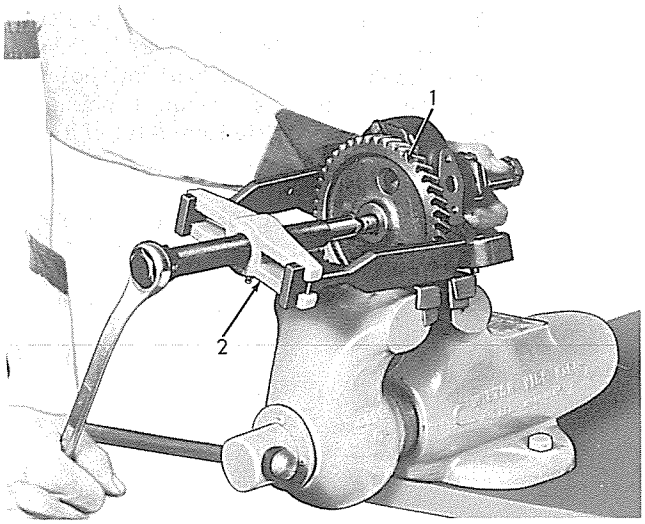


Fig. 4 — Removing Lubricating Oil Pump Driving Gear (T-29481)

1. Oil Pump Driving Gear
2. Puller

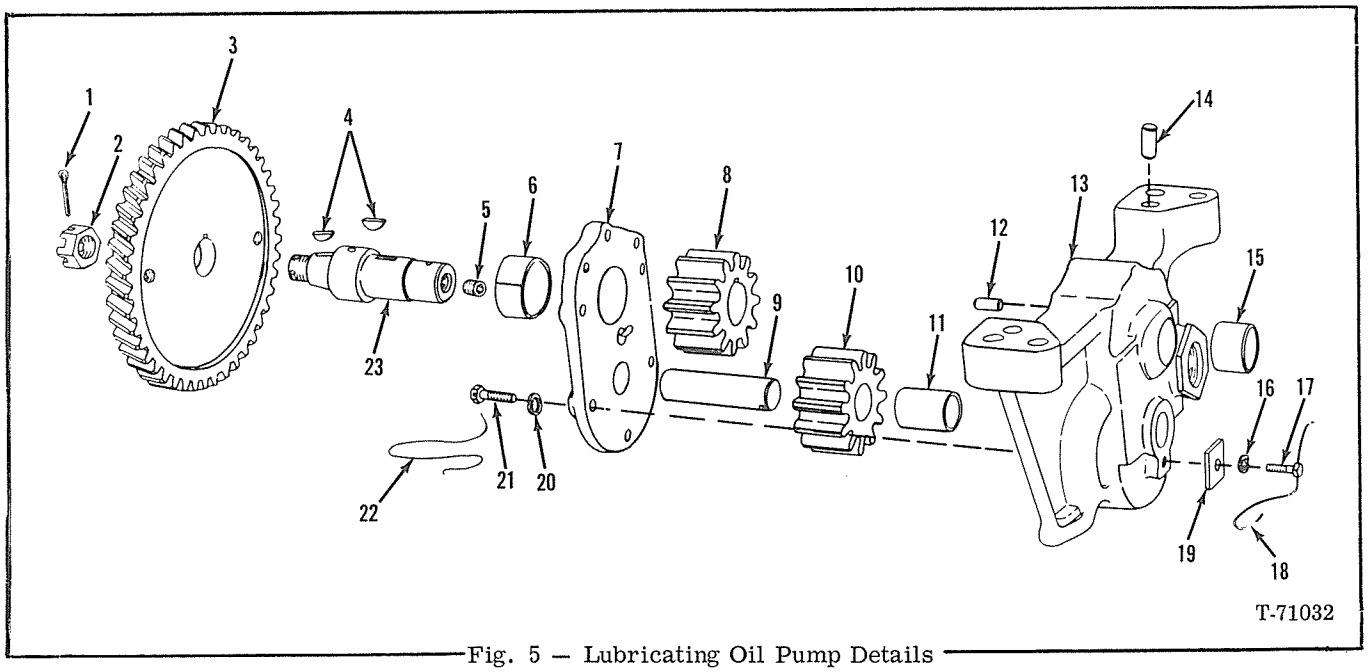


Fig. 5 — Lubricating Oil Pump Details
(Used prior to engine serial number 11-24134)

1. Cotter Pin
2. Slotted Nut
3. Pump Driving Gear
4. Woodruff Keys
5. Pipe Plug
6. Pump Cover Bushing
7. Pump Cover
8. Upper Gear
9. Lower Shaft
10. Lower Gear
11. Lower Gear Bushing
12. Dowel Pin
13. Pump Housing
14. Dowel Pin
15. Pump Housing Bushing
16. Lockwasher
17. Drilled Head Capscrew
18. Locking Wire
19. Lower Shaft Retainer
20. Lockwasher
21. Drilled Head Capscrew
22. Locking Wire
23. Upper Shaft

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

-.002". After pressing a new bushing into lower gear, drill a 1/8" oil hole through bushing (in line with oil hole in gear), then burnish or ream bushing to .7495" - .7505". Specified diameter of lower shaft is .7485" - .7490".

(5) Make certain that oil holes and passage in upper shaft and oil hole in each gear are open before reassembling the oil pump.

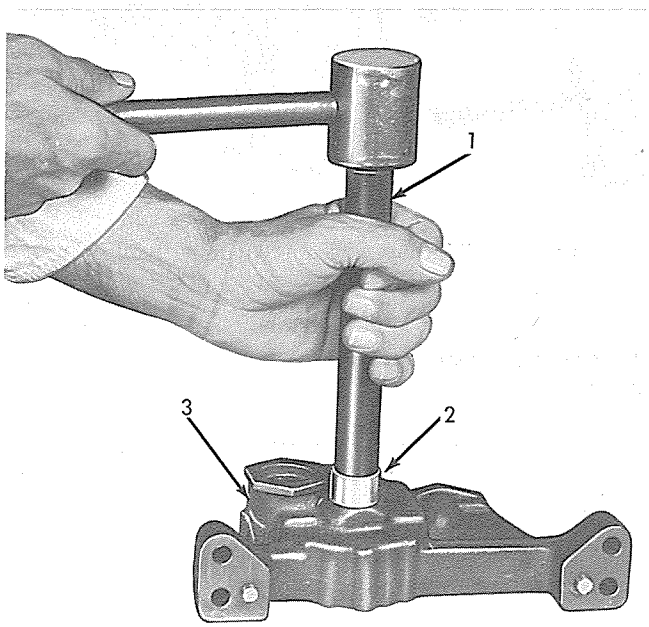


Fig. 6 — Installing Lubricating Oil Pump Housing Bushing (T-29545)

1. Bushing Installing Tool
2. Pump Housing Bushing
3. Pump Housing

j. Disassemble and inspect the pressure relief valve. Piston Fig. 7 (2) must slide smoothly in bore of valve body (1). When piston or bore of valve body show excessive wear or roughness, a new valve assembly must be installed.

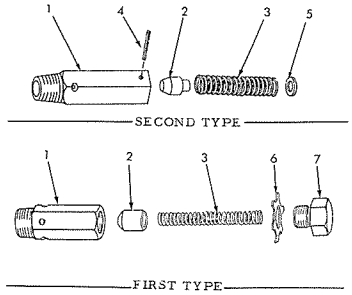


Fig. 7 — Oil Pressure Relief Valve Assembly (T-13181)

1. Body
2. Piston
3. Spring
4. Roll Pin
5. Washer
6. Locking Washer
7. Cap

k. Clean pressure relief valve parts, reassemble, and reinstall the valve on the pump housing. Lock in position with the lock.

l. Remove suction screen from suction pipe. Thoroughly clean screen and reinstall.

B. OIL PRESSURE PUMP ASSEMBLY AND INSTALLATION

1. OIL PRESSURE PUMP ASSEMBLY (Fig. 5)

a. Install lower shaft (9) in pump housing (13) and secure with retainer (19), lockwasher (16), and capscrew (17). Lock capscrew (17) with locking wire (18).

b. Install gear (10) in position on shaft (9).

c. Insert upper shaft (23) with gear (8) into housing (13).

d. Position cover (7) over dowel pin (12) and secure with capscrews (21), lockwashers (20), and locking wires (22).

e. Install Woodruff key (4) in shaft (23) and press driving gear (3) into shaft. Install nut (2), tighten to a torque of 75 - 85 lbs. ft. and install cotter pin (1).

f. Make certain assembled pump will turn without binding before installing it on the engine.

2. OIL PRESSURE PUMP INSTALLATION (Figs. 2, 3)

a. Install oil pump (1) on cylinder block, inserting dowel pins, Fig. 5 (14) into holes in cylinder block, and secure pump with capscrews, lockwashers, and locking wire.

NOTE

Specified backlash between oil pump driving gear and crankshaft gear is .003" - .007" and should not exceed .020".

b. Using a new gasket, install suction pipe, Figs. 2, 3 (4). Secure both ends of the pipe with capscrews, lockwashers, and locking wire.

c. Using new gaskets, install lubricating oil pump discharge pipe (2). Secure with capscrews, lockwashers, and locking wire.

d. Install the engine oil pan using a new oil pan gasket set. Fill engine crankcase to proper oil level with specified lubricant.

3A - OIL PRESSURE PUMP AND LINES (SECOND TYPE)

3A.1 REMOVAL

3A.1.1.
Drain the engine oil. Refer to Operation and Maintenance Instruction Manual.

3A.1.2
Remove oil pan. On wheel loader applications, first remove engine from unit before attempting to remove oil pan.

3A.1.3

> **WARNING**
>
> Do not work under or near unblocked or unsupported linkage, parts or machine.

Remove capscrews and lockwashers securing oil suction tube (17), FIG. 7A, to pump body (1) and remove tube and gasket.

3A.1.4
Remove U-bolt (13) from bucket on tube (11).

3A.1.5
Remove capscrews and lockwashers securing scavenge tube assembly (14) to pump body and remove tube assembly and gasket.

3A.1.6
Remove the capscrews securing tube (11) to cylinder block. Remove tube.

3A.1.7
Remove capscrews and lockwashers securing elbow (4) to pump body. Remove elbow and gasket.

3A.1.8
Remove capscrews and lockwashers fastening bracket (15) to engine block and withdraw bracket with pump body attached.

3A.1.9
Remove nuts securing pump body to bracket (15).

3A.1.10
Remove capscrews securing elbow (18) to pump body. Separate elbow from pump body and discard gasket.

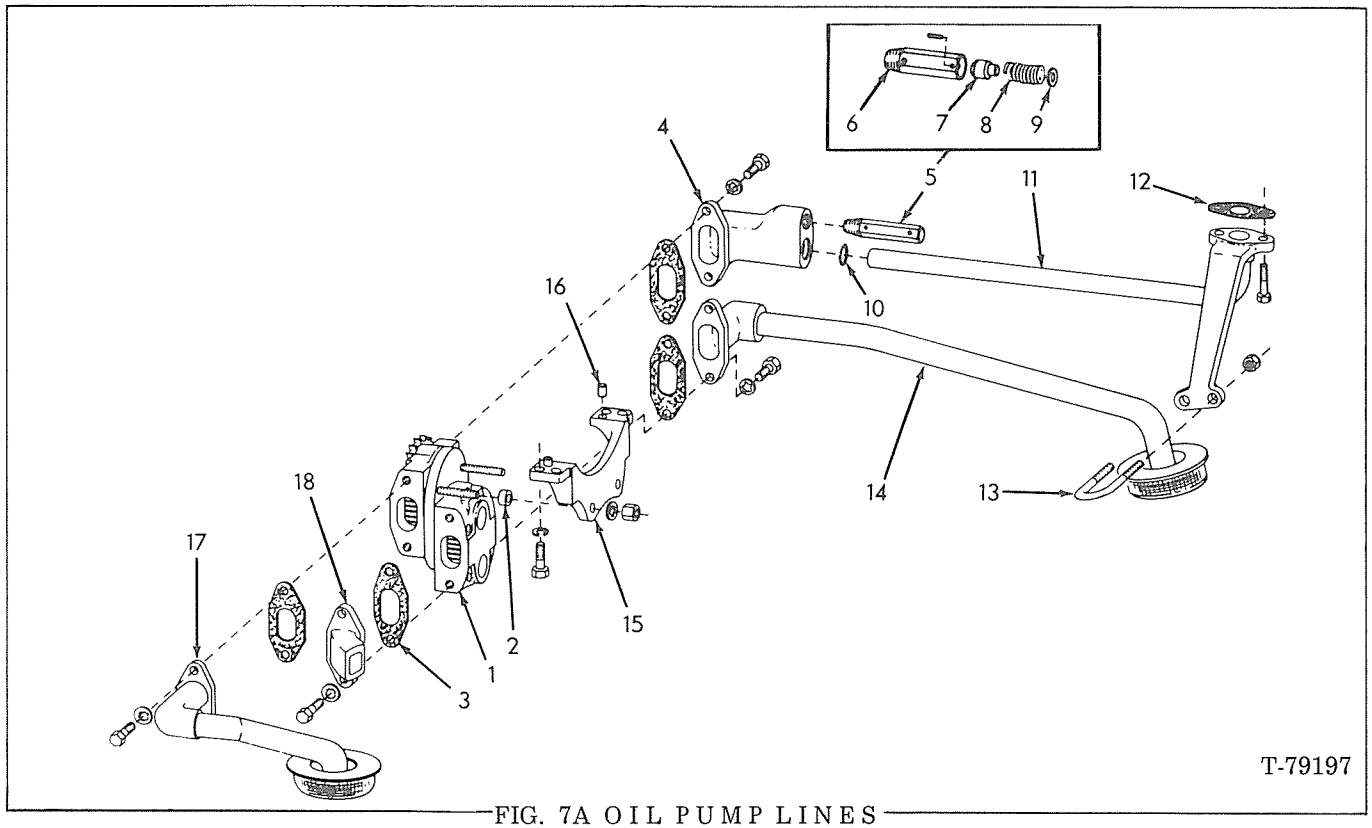


FIG. 7A OIL PUMP LINES

USAGE: Effective with engine serial no. 11-24134

1. Pump Assy.
2. Dowel
3. Gasket
4. Elbow
5. Relief valve assy.
6. Valve body
7. Piston
8. Spring
9. Washer
10. O-ring
11. Tube assy., pump to cylinder block
12. Gasket
13. U-bolt
14. Tube
15. Bracket
16. Dowel
17. Tube
18. Elbow

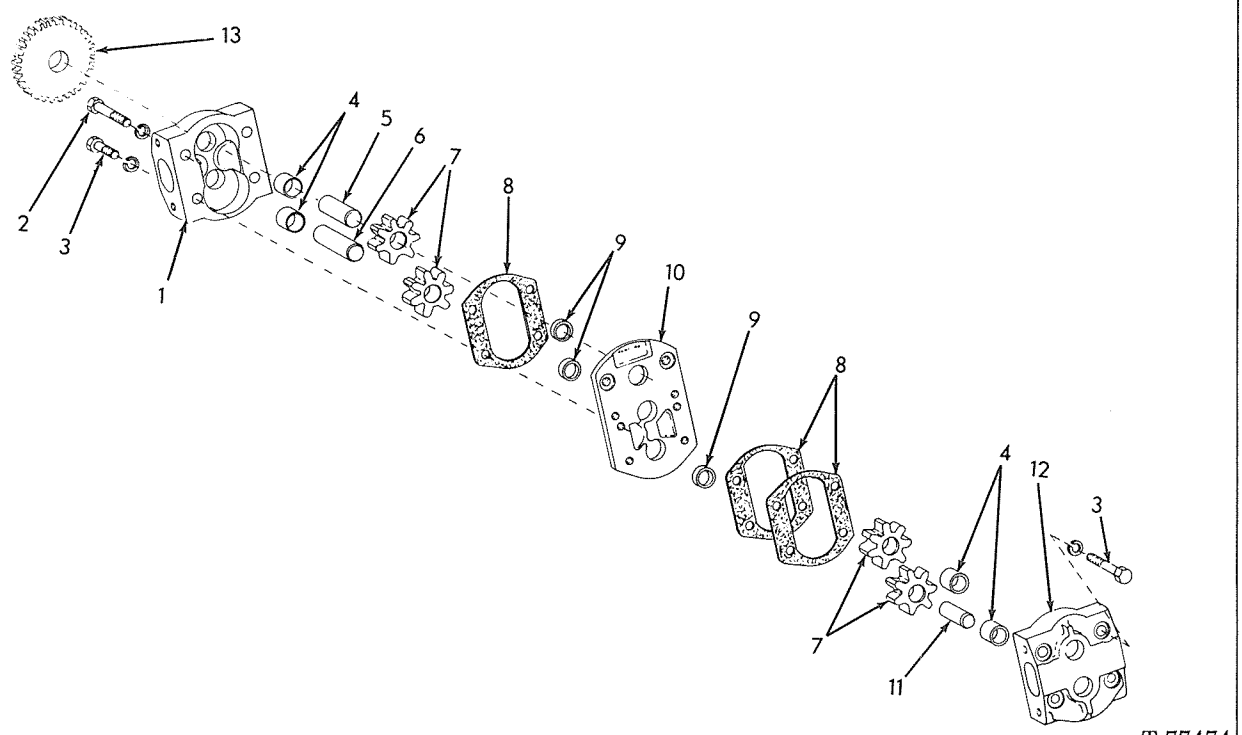


FIG. 7B OIL PUMP ASSEMBLY

1. Pressure side body half
2. Capscrew, 3.75 in (95.25 mm)
3. Capscrew, 2 in (50.8 mm)
4. Bushing
5. Driving shaft
6. Long driven shaft
7. Gear
8. Gasket
9. Bushing
10. Center plate
11. Short driven shaft
12. Scavenge side body half
13. Driving gear

3A. 2 DISASSEMBLY AND INSPECTION

3A.2.1

WARNING

Never use gasoline, solvent or other flammable fluids to clean parts. See Operation and Maintenance Instruction Manual.

Clean the oil pump assembly of dirt, sludge, and excess oil.

3A.2.2
Remove the six capscrews attaching the body assembly halves (1, 12) to the plate assembly (10).

3A.2.3
Remove the two long capscrews securing the pump to the mounting bracket, (18) FIG. 7A.

3A.2.4
Remove body half, (12), FIG. 7B. Remove two gaskets, (8), from scavenge side of center plate (10).

3A.2.5
Remove shaft and gear assembly (11).

3A.2.6
Press bushings (4) from body half (12).

3A.2.7
Press shaft (6) from two gears (7) and remove from center plate.

3A.2.8
Remove body half (1). Remove gear (7) and shaft (5) from body half.

3A.2.9
Press bushings (4) from body half (1). Remove gasket (8).

3A.2.10
Press drive gear (13) from shaft (5).

3A.2.11
Inspect the pump gear teeth (7), the inside of the pump body halves (1, 12), and the center plate (10) for wear or scoring. The gear teeth, the inside of the body halves, and the center plate must be smooth, having no scratches, score marks, or rough spots. Replace any parts which are defective or damaged. Gears may be pressed from shafts. See sub-topic 3A.3 for assembly of new shafts and gears.

3A.3 ASSEMBLY

3A.3.1
Support pump body halves (1,12) under area between shaft holes. Press new bushings (4) into body halves from chamfered side of shaft holes (outer sides of body halves.). Edges of bushings must be 0.04 in - 0.07 in (1.02 - 1.78 mm) below outer surface of each body half.

3A.3.2
Pressing from chamfered sides of holes in center plate (10), install three new bushings (9) so that edges of bushings are 0.03 in - 0.05 in (0.76 - 1.27 mm) below surface of same side of plate as chamfers on holes.

3A.3.3
Heat three gears (7) to 450°F. (232°C). Coat gears and shafts (5, 6, 11) with molybdenum disulfide extreme pressure lubricant. Press one gear onto each shaft until face of each gear is 0.550 in - 0.560 in (13.79-14.22 mm) from end of shaft. Be sure that shafts are free of scratch marks after installing gears.

3A.3.4
Lubricate shaft (6) and gear (7) with clean engine oil and install in body half (1).

3A.3.5
Lubricate shaft (5) and gear (7) with clean engine oil and install in body half (1). Turn shafts as necessary to mesh gears.

3A.3.6
Check radial clearance of gear teeth to pump body half. As gear (7), FIG. 7B, has an odd number of teeth, clearance cannot be checked by placing two feeler gauges opposed diametrically to one another. Three feeler gauges, spaced as evenly as possible around gear teeth, may be used in making a check of radial clearance. Clearance must be 0.002 in - 0.0045 in (0.05-0.11 mm). If clearance is too large, replace worn parts. Install gears and shafts temporarily in body half (12) and check radial clearance in a similar manner.

3A.3.7
Refer to FIG. 7B. Install one gasket (8) on body half (1) and install body half on center plate (10).

3A.3.8
Install two capscrews (2), two capscrews (3) and four lockwashers finger tight to hold body half (1) to center plate during gear assembly.

3A.3.9
Position the output side of the pump downward on a press. The body half must lie on a flat surface. Place a U-shaped 0.003 in (0.08 mm) shim around shaft (6).

3A.3.10
Heat remaining gear (7) to 450° ± 50°F. (232 ± 10°C.). Coat gear and shaft (6) with molybdenum disulfide extreme pressure lubricant.

3A.3.11
Press heated gear (7), chamfered side of hole first, onto the shaft (6) until gear contacts shim. Remove shim.

3A.3.12
Lubricate shaft (11) and gear (7) and install in center plate (10), turning shafts by hand as necessary to mesh gears.

3A.3.13
Install two gaskets (8) and body half (12) on center plate. Install four capscrews (3) and lockwashers finger tight.

3A.3.14
Make certain that all shafts and gears turn freely. Adjust positions of body halves accordingly if binding occurs.

3A.3.15
Tighten four capscrews (2,3) on pressure side of pump to a torque of 55-75 lb-ft (7.6-10.4 kg-m). Turn shafts by hand to make sure that gears are still free.

3A.3.16
Tighten four capscrews (3) on scavenge side of pump to a torque of 55-75 lb-ft (9.6-10.4 kg-m). Turn shafts by hand to make sure that gears are still free.

3A.3.17
Heat gear, (13), FIG. 12 to 400° + 25°F. (205 + 15°C.). Coat gear (13) and shaft (5) with molybdenum disulfide extreme pressure lubricant.

3A.3.18
Rest rear surface of center plate (10) flat on a press. Press gear onto shaft flush with end of shaft. Turn gear by hand to be sure all parts turn freely.

3A.4 INSTALLATION

3A.4.1
Pour clean engine oil into pump body and turn shafts by hand to thoroughly lubricate all parts.

3A.4.2
Install bracket (15) on long capscrews in pump body. Install two dowels (2) and nuts finger tight to hold bracket to pump body.

3A.4.3
Install capscrews and lockwashers finger tight to fasten bracket (15) to cylinder block, simultaneously engaging oi pump drive gear with crankshaft gear.

3A.4.4
Install oil pressure relief valve (5) in elbow (4).

3A.4.5
Assemble elbow (4) to tube (11), using new O-ring (10).

3A.4.6
Install tube assembly (11) to cylinder block and to oil pump. Use new gaskets (3) and (12). Install capscrews holding elbow and tube only finger tight.

3A.4.7
Install tube assembly (17) using new gasket. Do not tighten elbow capscrews at this point.

3A.4.8
Install U-bolt (13) to bracket of tube (11) but do not fasten nuts more than finger tight.

3A.4.9
Attach tube assembly (17) to oil pump using new gasket. Do not fully tighten capscrews.

3A.4.10
Attach elbow (18) to oil pump, using new gasket (3).

3A.4.11
Make sure that there are no interferences among the several tube assemblies, elbows, and brackets. If interferences are found, reposition parts to correct the condition.

3A.4.12
Tighten all fasteners to full torques as specified in Section 18, Topic 2.

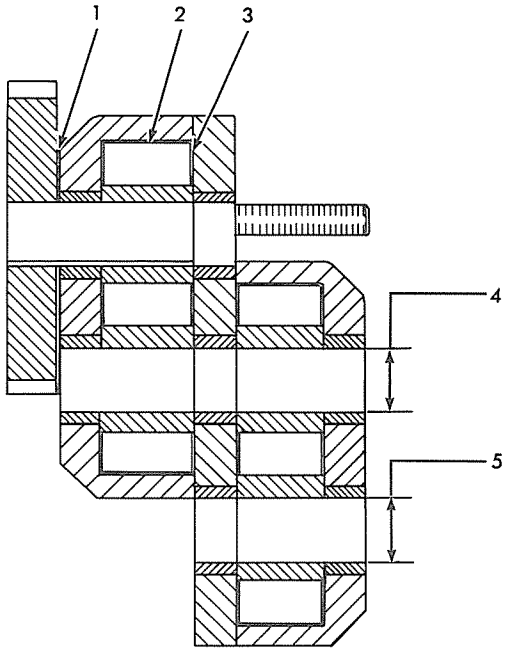
3A.4.13
Install oil pan. Refer to Topic 2 in this Section.

3A.4.14
Fill engine with specified type and quantity of oil. See Section 21.

3A.5 OIL PRESSURE RELIEF VALVE

3A.5.1
Remove, disassemble, and inspect the pressure relief valve. The piston must slide smoothly in the bore of the valve body. When the piston or bore of the valve body shows excessive wear or roughness, a new valve assembly must be installed.

3A.5.2
Clean valve parts, reassemble, and reinstall the valve in the pump discharge tube.



T-80161

FIG. 7C ENGINE OIL PUMP (SECOND TYPE) CROSS SECTION

1.	Clearance between pump driving gear and pump cover	.004 in - .061 in (0.10 - 1.55 mm)
2.	Gear to pump body radial clearance	.002 in - .0045 in (0.05 - 0.11 mm)
3.	Clearance between pump gears and center plate	.003 in (0.08 mm)
4.	I. D. of gear shaft bushings, installed	.873 in - .875 in (22.17 - 22.23 mm)
5.	O. D. of pump gear shafts	.8715 in - 8720 in (22.14 - 22.15 mm)
6.	Torque for all capscrews	55 - 75 lb-ft (7.6 - 10.4 kg-m)

TOPIC 4 - OIL SCAVENGING PUMP

A. GENERAL

The oil scavenging pump is used only on track-type tractors, it serves as a transfer pump, transferring oil from front oil sump of oil pan to main oil sump in rear of oil pan, keeping oil pressure pump suction screen submerged at all times. The scavenging oil pump is driven by a spiral gear in mesh with the

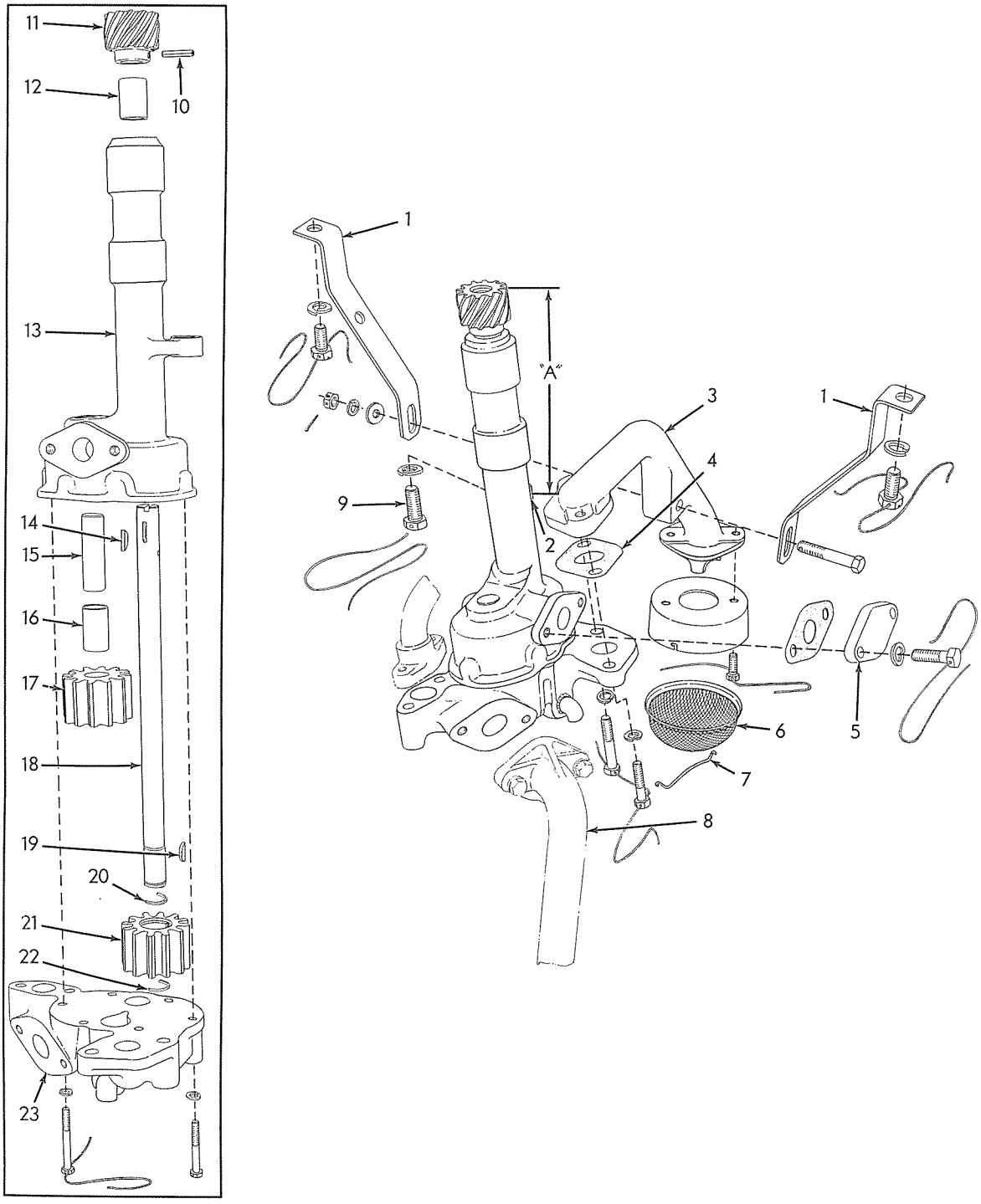


Fig. 8 — Scavenging Oil Pump Details
(T-13980)

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

Legend For Fig. 8

1. Suction Pipe Bracing Bracket
2. Mounting Boss
3. Suction Pipe
4. Gasket
5. Pump Body Side Cover
6. Oil Screen
7. Oil Screen Retainer
8. Oil Pressure Pump Suction Pipe
9. Pump Mounting Capscrew
10. Roll Pin
11. Pump Driving Gear
12. Pump Body Bushing
13. Body Assembly
14. Key
15. Stub Shaft
16. Pumping Gear Bushing
17. Pumping Gear (Driven)
18. Drive Shaft
19. Key
20. Drive Shaft Snap Ring (Upper)
21. Pumping Gear (Drive)
22. Drive Shaft Snap Ring (Lower)
23. Pump Body Cover

"A" 7-31/32"

spiral gear which is an integral part of the camshaft. The scavenging oil pump does not contain a pressure relief valve.

B. OIL SCAVENGING PUMP REMOVAL, DISASSEMBLY, AND INSPECTION

1. OIL SCAVENGING PUMP REMOVAL

   a. Drain engine oil.

   b. Remove oil pan.

   c. Remove capscrews attaching suction pipe Fig. 3 (4) to scavenging pump.

   d. Remove capscrew, washers, and nut securing suction pipe Fig. 8 (3) to supporting brackets (1).

   e. Remove locking wire, capscrew, and lockwasher securing scavenging oil pump to cylinder block. Remove scavenging oil pump and the two suction pipes (3) (8) as a unit.

2. OIL SCAVENGING PUMP DISASSEMBLY

   a. Remove capscrews and lockwashers securing the two suction pipes Fig. 8 (8) (3) to scavenging oil pump and remove both pipes.

   b. Remove roll pin securing pump driving gear to the drive shaft. Using a gear puller similar to one shown in Fig. 9, remove gear (2) from drive shaft. Remove key Fig. 8 (14) from shaft (18).

   c. Remove capscrews and lockwashers securing pump body cover, Fig. 8 (23), to body assembly (13) and remove cover (23).

   d. Remove pumping gear (21) and drive shaft (18) from body (13). Remove snap ring (22) from shaft (18) and pull gear (21) from shaft (18) using a puller similar to one shown in Fig. 9.

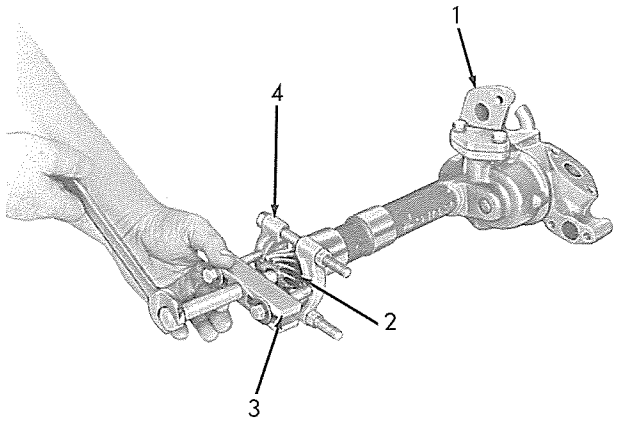


Fig. 9 — Removing Scavenging Pump Driving Gear
(T-20233)

1. Oil Scavenging Pump Assembly
2. Pump Driving Gear
3. Push-Puller
4. Pulling Attachment

   e. Remove gear (17) from shaft (15).

3. CLEANING AND INSPECTION OF OIL SCAVENGING PUMP PARTS

   a. Wash all oil pump components in clean solvent and thoroughly inspect all parts before reassembling oil pump. The principal wearing parts of the oil pump are driving gear (11) and pump gears (17) and (21).

   b. Inspect pump gear teeth (17) (21), inside of pump housing, and inner face of cover (23) for wear and scoring. All gear teeth, inside of housing, and inner face of cover must be smooth, with no scratches, score marks, or rough spots.

   Radial clearance between pump gears and pump housing should be .0035" - .0055". End clearance of the gears in the pump should be .002"

-.004". When these clearances are exceeded, it will be necessary to replace worn parts.

c. Inspect pump shafts and bushings for excessive wear or scoring and replace if necessary. The specified clearance between the drive shaft and pump body bushings is .0015" - .003". After installing new bushings in the pump body, bushings should be reamed to .7495" - .7505". The specified diameter of the drive shaft is .7475" - .7480".

d. The stub shaft is pressed into the body assembly and the bushing is pressed into the pump body driven gear. The specified clearance between stub shaft and bushing in the pump body driven gear is .0015" - .003". After pressing a new bushing into the pump body driven gear, drill a 1/8" oil hole through bushing (in line with the oil hole provided in the gear), then burnish or ream bushing to .7495" - .7505". The specified diameter of the stub shaft is .7475" - .7480".

e. Remove oil suction screen from scavenging pump suction pipe, thoroughly clean, and reinstall.

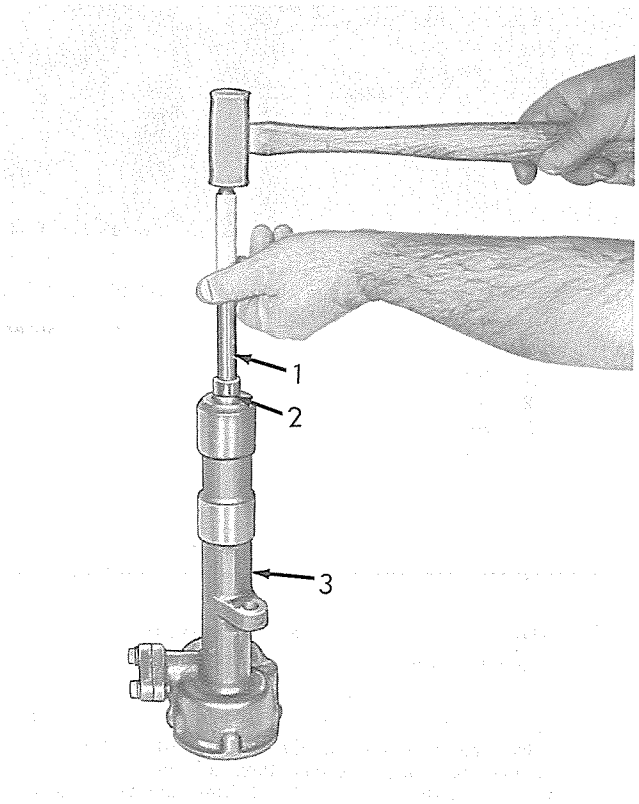


Fig. 10 — Installing Bushing in Oil Scavenging Pump Body (T-20232)

1. Bushing Installing Tool
2. Pump Body Bushing
3. Body Assembly

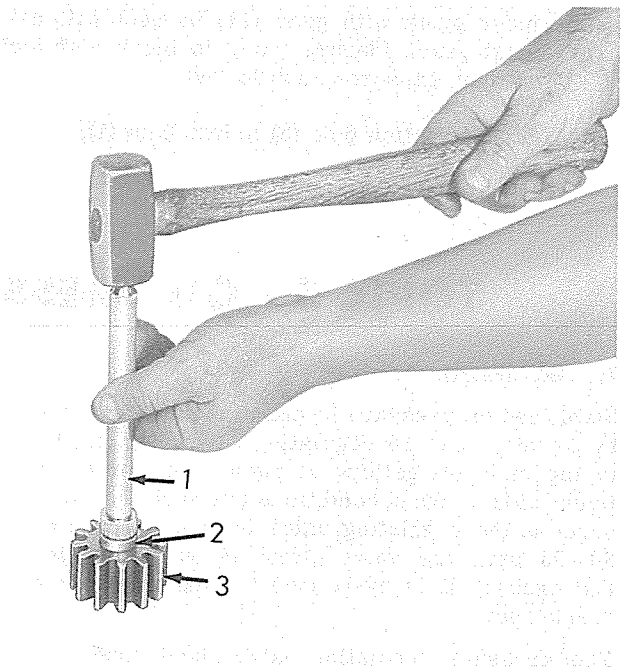


Fig. 11 — Installing Bushing in Oil Scavenging Pump Driven Gear (T-20236)

1. Bushing Installing Tool
2. Pumping Gear Bushing
3. Pumping Gear (Driven)

4. OIL SCAVENGING PUMP ASSEMBLY

a. Install snap ring Fig. 8 (20) and key (19) in position on the shaft (18). Using a press, install gear (21) on shaft (18) against snap ring (20). Install snap ring (22).

b. Insert drive shaft assembly into body assembly. Install key (14).

c. Using a press, install gear (11) on shaft (18) lining up the holes for roll pin (10). Install roll pin.

NOTE

If a new drive shaft is being used press gear (11) onto shaft (18) so that upper face of gear (11) is 7-31/32" from upper face of pump body mounting boss, Fig. 8 "A". Drill a .187" - .192" hole through the shaft (18) then install roll pin (10).

d. Install gear assembly (17) on stub shaft (15).

e. Install cover (23) in position on body and secure with capscrews and lockwashers.

f. Using new gaskets install suction pipes (8) (3).

5. OIL SCAVENGING PUMP INSTALLATION

a. Install oil scavenging pump in position on cyl-

inder block with gear (11) in mesh with camshaft gear. Secure pump to block with lockwasher, capscrew, and lockwire.

b. Secure suction pipe (3) to brackets (1).

c. Secure oil pressure pump suction pipe to oil scavenging pump using a new gasket.

d. Install oil pan and fill with proper amount of specified lubricant.

TOPIC 5 - OIL PRESSURE REGULATING VALVE

A. GENERAL

Stabilized oil pressure is maintained within the engine by an oil pressure regulating valve, Fig. 12, located in the main oil gallery at right rear corner of cylinder block. When conditions are such that oil pressure at the regulating valve exceeds approximately 30 - 55 psi., the valve piston is pushed off its seat and excess oil is by-passed through the valve to the crankcase.

The pressure regulating valve should require very little attention under normal conditions. If lubricating system is allowed to sludge, the valve may not work properly. If valve sticks in open position, a sharp drop in engine oil pressure will occur; if valve sticks in closed position, a sharp rise in engine oil pressure will occur. If oil pressure should rise or drop sharply, regulating valve must be disassembled and checked for damage or sludge.

Whenever oil pump or engine are disassembled, all components of oil pressure regulating valve assembly should also be removed, thoroughly cleaned, and inspected.

B. OIL PRESSURE REGULATING VALVE DISASSEMBLY AND ASSEMBLY (Fig. 12)

1. Loosen jam nut (2) and remove screw (1) noting the number of turns required for removal. Remove valve spring (3) and piston (4).

2. Wash all parts thoroughly and inspect. Replace any necessary parts.

3. Lubricate valve seat insert (5) and piston (4) with clean oil. Install piston and valve spring in position in cylinder block.

4. Install pressure regulating valve screw (1).

NOTE

Turn screw into cylinder block the same number of turns as required for removal.

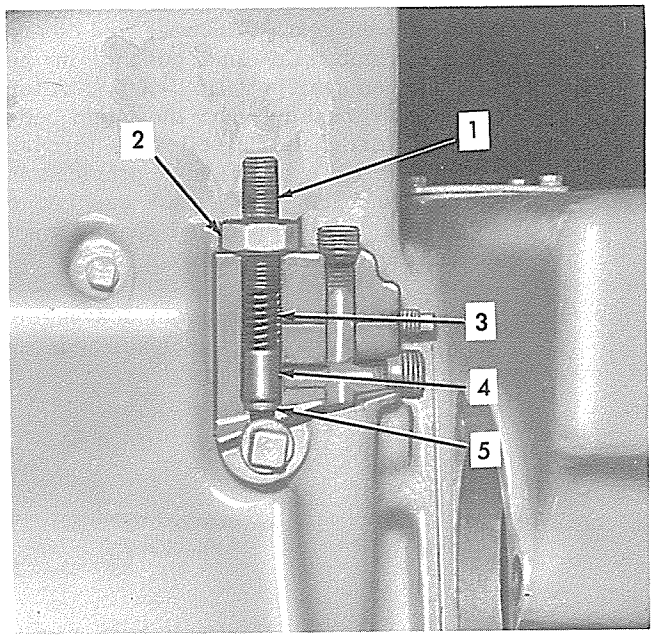


Fig. 12 — Oil Pressure Regulating Valve Cutaway View (T-18735)

1. Screw
2. Jam Nut
3. Spring
4. Piston
5. Seat Insert

5. Install jam nut (2) on screw (1) and snug up.

6. After engine has been reassembled and is running, operate engine until normal operating temperature is indicated by the engine temperature gauge. Adjust oil pressure regulating valve screw to obtain an oil pressure of 40 psi (2.8 kg/cm^2) at high idle engine speed, then tighten nut to 125-135 lb-ft (17.3-18.7 kg-m). No further adjustment is necessary.

TOPIC 6 - LUBRICATING OIL FILTER AND BY-PASS VALVE

A. GENERAL

The engine lubricating oil filter, located on the right side of the engine, is of the full-flow type and contains a replaceable type cartridge. A new cartridge must be installed each time the engine crankcase oil is changed, or more often if conditions warrant.

NOTE

Most engines covered in this manual are equipped with a dual type oil filter as shown in Fig. 13 or 14. Some engines, however, are equipped with a single filter as shown in Fig. 13. The following description and procedures apply to both types unless stated otherwise.

An oil by-pass valve, located in the oil filter head, permits oil to pass directly to the main oil gallery if the oil filter becomes clogged, or when the oil is too thick to flow freely through the filter. Under normal conditions, the by-pass valve should require very little attention. If the lubricating system has been allowed to sludge, the valve may not work freely. Whenever the engine is disassembled for repairs, the by-pass valve assembly should be removed, thoroughly cleaned in fuel oil, and inspected.

B. LUBRICATING OIL FILTER REMOVAL, DISASSEMBLY, ASSEMBLY, AND INSTALLATION

1. LUBRICATING OIL FILTER REMOVAL AND DISASSEMBLY (Fig. 13 or 14)

   a. Thoroughly clean filter head (1) filter body (17), and surrounding area. Remove oil drain

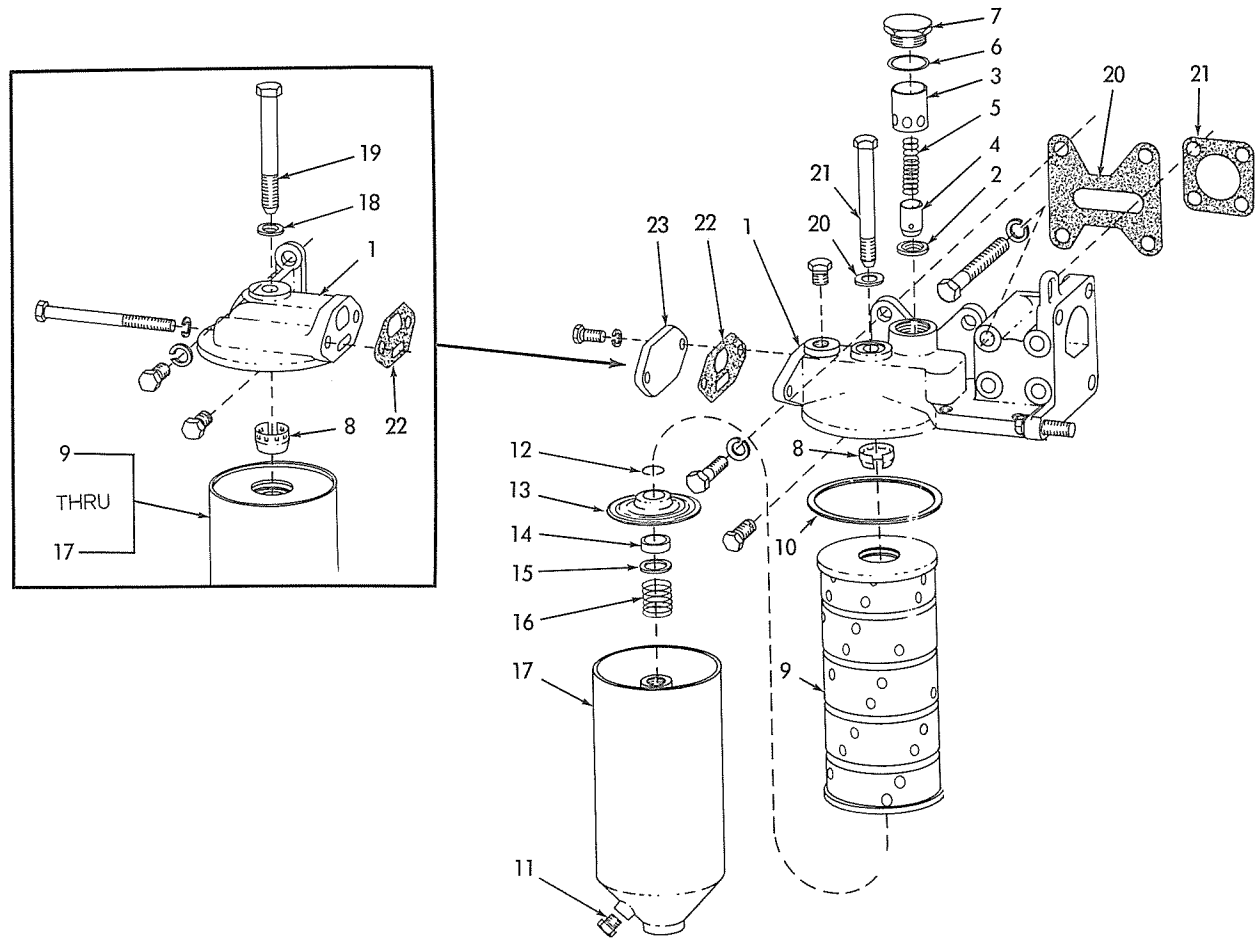


Fig. 13 — Lubricating Oil Filter Details (First Type) (T-41946)

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

Legend For Fig. 13

1. Head Assembly
2. By-pass Valve Seat
3. By-pass Valve Piston Sleeve
4. By-pass Valve Piston
5. By-pass Valve Spring
6. By-pass Valve Cap Gasket
7. By-pass Valve Cap
8. Cartridge Centering Adapter
9. Cartridge Assembly
10. Oil Filter Body Gasket
11. Oil Drain Plug
12. Adapter Retaining Snap Ring
13. Cartridge Centering Adapter
14. Cartridge Adapter Seal
15. Cartridge Adapter Seal Washer
16. Cartridge Retaining Spring
17. Oil Filter Body
18. Filter Body Capscrew Sealing Washer
19. Oil Filter Body Capscrew
20. Filter Head-to-Block Rear Gasket
21. Filter Head-to-Block Front Gasket
22. Filter Inter Connection or Cover Gasket (Not Used With Dual Filters)
23. Filter Head Cover (Not Used With Dual Filters)

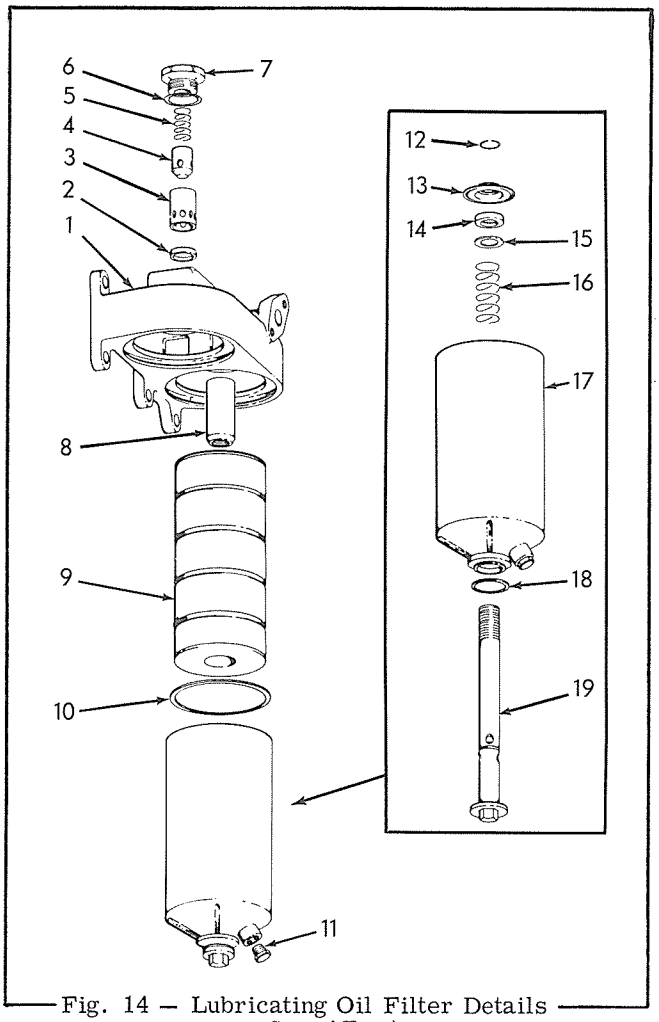


Fig. 14 — Lubricating Oil Filter Details
(Second Type)
(T-37197)

1. Head Assembly
2. By-pass Valve Seat
3. By-pass Valve Piston Sleeve
4. By-pass Valve Piston
5. By-pass Valve Spring
6. By-pass Valve Cap Gasket
7. By-pass Valve Cap
8. Center Bolt Adapter
9. Cartridge Assembly
10. Oil Filter Body Gasket
11. Oil Drain Plug
12. Filter Center Bolt Snap Ring
13. Cartridge Adapter
14. Cartridge Adapter Seal
15. Cartridge Adapter Seal Washer
16. Cartridge Retaining Spring
17. Oil Filter Body
18. Filter Center Bolt Gasket
19. Center Bolt

plug (11) and allow oil to drain.

b. Loosen and remove capscrew (19). Remove filter body (17) and filter cartridge (9) from filter head (1).

c. Remove filter cartridge (9) from body (17) and discard cartridge (9). Remove and discard gasket (10).

d. If it is necessary to remove the oil filter head (1) from the engine, it is recommended that the oil cooler and filter head be removed as an assembly (refer to "COOLING SYSTEM" Section).

e. Remove by-pass valve (refer to "BY-PASS VALVE REMOVAL AND INSTALLATION" in this Topic).

f. Clean all parts thoroughly with cleaning solvent. Remove all sludge deposits.

2. LUBRICATING OIL FILTER ASSEMBLY AND INSTALLATION (Fig. 13 or 14)

a. Install by-pass valve and cartridge guide (8) in filter head.

b. Install filter head on engine by a reversal of removal procedure.

c. Install spring (16), washer (15), seal (14), adapter (13), and snap ring (12) in body (17).

d. Install a new cartridge (9) in body (17).

e. Install filter body assembly in position on filter head (1) using new gasket (10). Install

sealing washer and retaining capscrew (19) tighten capscrew to 45 - 50 lbs. ft. torque. Install and tighten oil drain plug (11).

f. Fill engine crankcase to the proper level with the specified lubricant.

g. Crank engine with starter for 15 seconds to insure that lubricant has been pumped to engine components. Start engine and run for about 5 minutes.

h. Stop engine and allow a few minutes for oil to drain back to crankcase, then check oil level and add oil as necessary to raise level to uppermost mark on dipstick. Check oil filter for leaks and correct any leaks found.

C. BY-PASS VALVE REMOVAL AND INSTALLATION (Fig. 13 or 14)

1. Remove the by-pass valve cap (7) and gasket (6) from filter head (1).

2. Remove spring (5) and piston (4).

3. Remove sleeve (3) and seat (2).

4. Thoroughly wash all parts in fuel oil or solvent, inspect for wear or damage, and replace any necessary parts. If the piston (4) or seat (2) are damaged in any way, they must be replaced.

5. Assemble the oil by-pass valve by a direct reversal of the removal procedure.

SECTION 12 - CAMSHAFT AND CAMSHAFT BEARINGS

TOPIC NO.	TITLE	PAGE
1.	CAMSHAFT	
	A. Description	12-1
	B. Lubrication	12-1
	C. Camshaft Removal and Installation	12-1
2.	CAMSHAFT BEARINGS	
	A. General	12-3
	B. Camshaft Bearing Removal and Installation	12-3

TOPIC 1 - CAMSHAFT

A. DESCRIPTION

The one piece camshaft is drop forged, open-hearth steel, case hardened at the cams and journals, and is located in the lower half of the cylinder block on the left hand side of the engine. The camshaft is rigidly supported in the cylinder block by four precision type bearings. A smoothly ground, hardened steel, camshaft thrust collar is provided at the front (gear) end of the camshaft. The spiral gear, cast integral with the camshaft, drives the oil scavenging pump on engines so equipped.

B. LUBRICATION

Lubrication is supplied to the camshaft bearings from four oil passages drilled through the cylinder block from the front, intermediate, and rear main bearings.

C. CAMSHAFT REMOVAL AND INSTALLATION

1. CAMSHAFT REMOVAL

The camshaft may be removed without removing the engine, however, if the camshaft bearings require replacement, removal of the engine is necessary.

a. Remove the timing gear housing cover (refer to "FRONT END AND GEAR TRAIN" Section).

b. Remove the push rods and valve lifters (refer

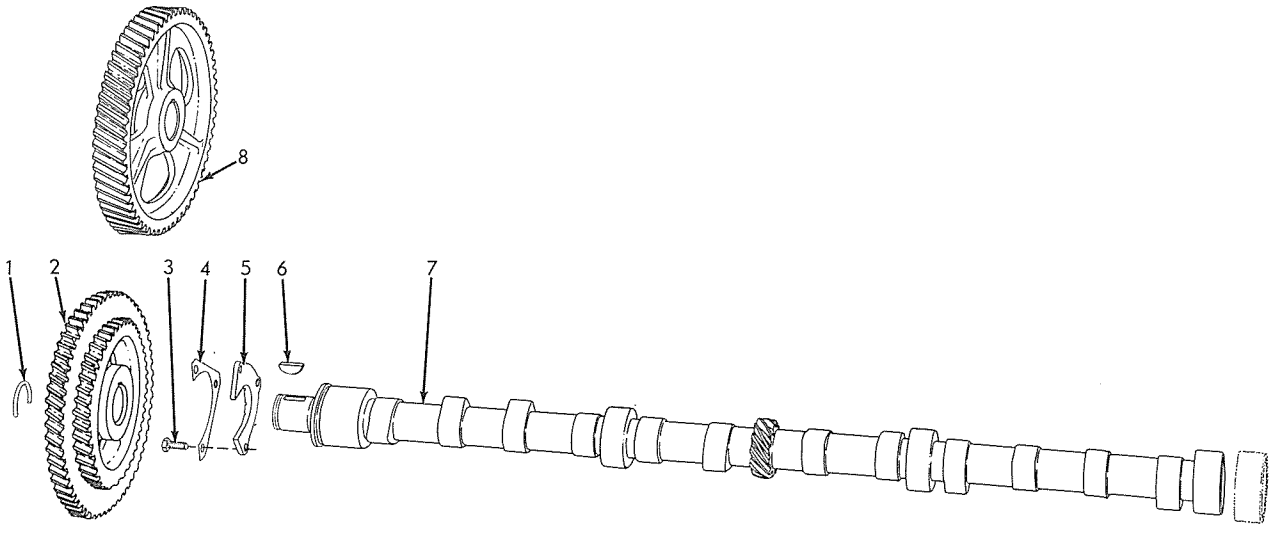


Fig. 1 — Camshaft and Camshaft Gear Details
(T-27404)

1. Gear Retaining Snap Ring
2. Camshaft Gear (Used with Roosa Master Fuel Injection Pump)
3. Capscrew
4. Capscrew Locking Plate
5. Camshaft Thrust Collar
6. Woodruff Key
7. Camshaft
8. Camshaft Gear (Used with American Bosch Fuel Injection Pump)

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

to "VALVES, VALVE OPERATING MECHANISM, AND CYLINDER HEAD" Section).

c. If engine is equipped with an oil scavenging pump, remove the pump.

d. Remove capscrews, Fig. 1 (3), and locking plate (4) attaching the camshaft thrust collar (5) to the cylinder block. Using care to prevent the cams from damaging the bearings, remove the camshaft and camshaft gear as an assembly.

NOTE

Before removing the camshaft and camshaft gear, rotate the crankshaft until the timing marks, Fig. 3, on the crankshaft gear and the camshaft gear are aligned.

e. Remove the gear retaining snap ring (1) from the end of the camshaft and press the shaft (7) from the camshaft gear (2) or (8).

f. Inspect the camshaft gear for nicked, scored, or broken teeth; inspect the camshaft lobes for wear.

g. To assemble the camshaft gear onto the camshaft, first place the woodruff key (6) in position on the camshaft. Heat the gear (2) or (8) in oil to a temperature of approximately 280°F. Coat camshaft at gear location, with a mixture of white lead and oil then press gear onto shaft. Install gear retaining snap ring (1).

IMPORTANT

When installing the camshaft gear with integral fuel injection pump drive gear (8), place the thrust collar (5) and locking plate (4) in position on the camshaft (7) before pressing the gear onto the shaft. Install thrust collar with oil groove side toward the gear.

2. CAMSHAFT INSTALLATION

After gear has been installed, place camshaft thrust collar, Fig. 1 (5), on camshaft and measure clearance between thrust collar and camshaft with a feeler gauge, Fig. 2. The clearance (end play) should be .003" — .009". The specified thickness of a new thrust collar is .205" — .206"; install a new thrust collar if necessary.

The camshaft may be installed by a direct reversal of removal procedure. When installing, make certain oil groove side of thrust collar is toward camshaft gear.

NOTE

Make sure timing marks, Fig. 3, on camshaft gear and crankshaft gear are aligned when camshaft is installed.

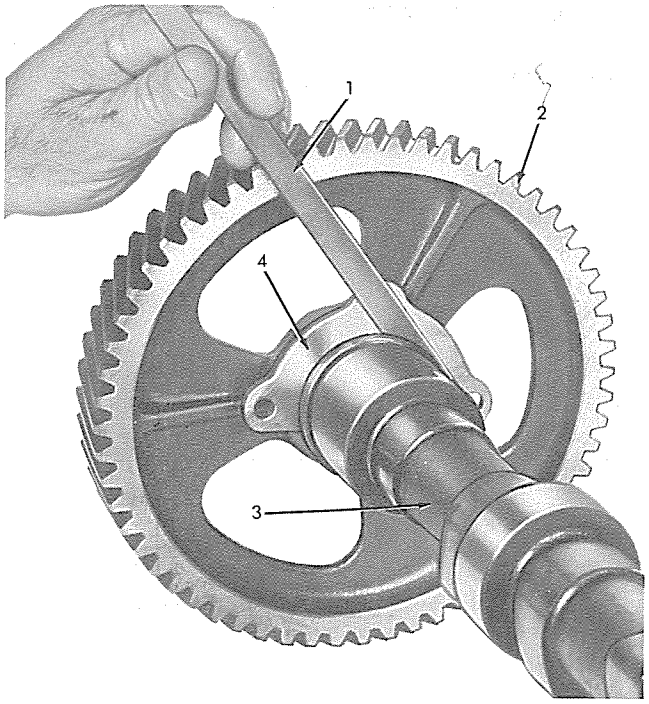


Fig. 2 — Checking Camshaft End Play
(T-19382)

1. Feeler Gauge
2. Camshaft Gear
3. Camshaft
4. Camshaft Thrust Collar

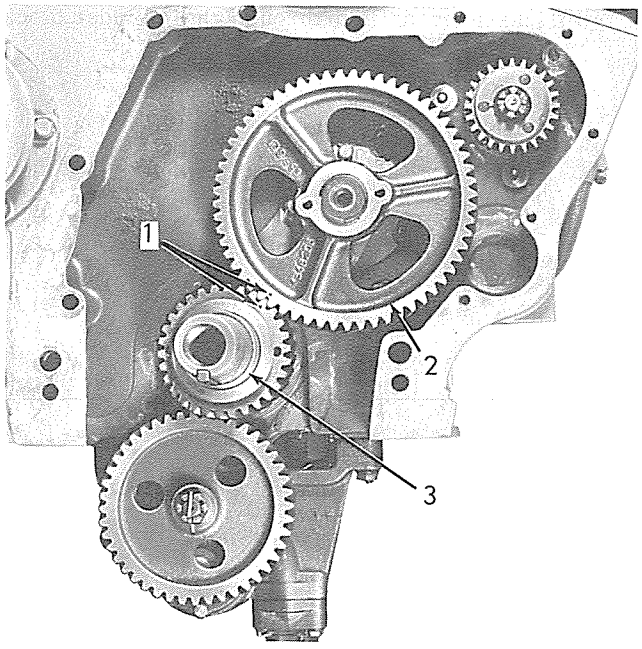


Fig. 3 — Camshaft Gear and Crankshaft Gear Timing Marks Aligned
(T-27622)

1. Timing Marks
2. Camshaft Gear
3. Crankshaft Gear

TOPIC 2 - CAMSHAFT BEARINGS

A. GENERAL

The specified clearance between camshaft bearings and journals is .0019" — .0055". If clearance is .0075" or more, new camshaft bearings must be installed. The specified diameter of camshaft bearing journals is 2.2465" — 2.2475" and inside diameter of new camshaft bearings when installed is 2.2494" — 2.2520". With camshaft removed, measure diameter of camshaft journals and inside diameter of camshaft bearings, with micrometers, to determine clearance.

NOTE

As a field expedient and when the proper micrometers are not available, the camshaft journal-to-bearing clearance may be measured with a feeler gauge as shown in Fig. 4. This is not an accurate or recommended method.

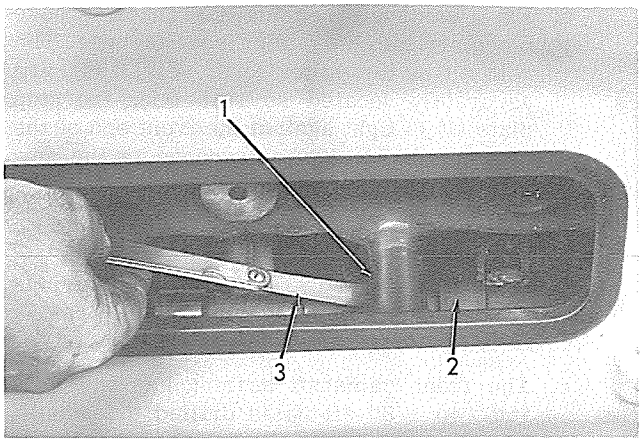


Fig. 4 — Checking Camshaft Bearing Clearance (T-20215)

1. Camshaft Bearing
2. Camshaft
3. Feeler Gauge

B. CAMSHAFT BEARING REMOVAL AND INSTALLATION

1. Remove the engine.
2. Remove camshaft (refer to "CAMSHAFT REMOVAL AND INSTALLATION" in this Section).
3. Remove timing gear housing (refer to "FRONT END AND GEAR TRAIN" Section).
4. Remove flywheel and flywheel housing (refer to "FLYWHEEL AND RING GEAR; FLYWHEEL HOUSING AND CRANKSHAFT REAR OIL SEAL" Section).
5. Using a slide hammer puller and a 1/4" x 20 NC adapter, pull camshaft hole plug and O-ring from rear end of cylinder block.
6. It is possible to remove and install camshaft bearings without removing the oil pan, however, to prevent dirt from falling into crankcase and to facilitate bearing removal and installation, it is advisable to drain engine oil and remove oil pan.
7. Using a camshaft bearing removing and installing set similar to the one shown in Fig. 5, proceed as shown in Fig. 6 to remove the old and install new camshaft bearings.

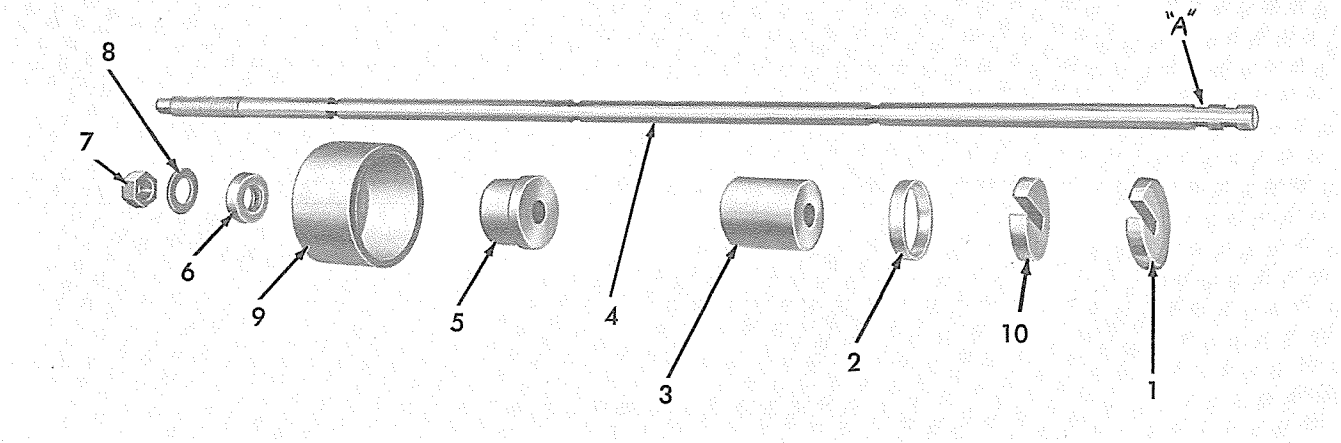


Fig. 5 — Camshaft Bearing Removing and Installing Tool Set (T-20252)

1. Stop Plate
2. Spacer
3. Installing Pilot
4. Puller Shaft
5. Puller Shaft Pilot
6. Thrust Bearing
7. Hex Nut
8. Flat Washer
9. Collar
10. "C" Washer

"A" Notch to be used for all 10000 and 11000 engines

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

8. When installing new camshaft bearings, observe the following:

   a. Each camshaft bearing has an oil groove machined into the outer circumference. The notches in the puller shaft, Fig. 6 (4), are accurately located so that when the stop plate (1) is tight against the front end of the cylinder block the oil groove in the new bearing is automatically aligned with the oil supply hole in the cylinder block.

   b. The front camshaft bearing is 1.560" — 1.564" long, the two intermediate bearings are .935" — .939" long, and the rear bearing is 1.000" long.

   c. The front camshaft bearing has one 3/8" and two 1/8" oil holes drilled through it. When bearing is installed, the 3/8" hole must be aligned with the oil supply hole in the cylinder block.

   d. The rear and intermediate main bearings have three 1/8" oil holes. When bearings are installed, one of these holes must be aligned with the oil supply hole in the cylinder block.

   e. All four camshaft bearings have one end beveled. Bearings must be installed with beveled end facing rear (flywheel end) of cylinder block.

   f. The camshaft bearings are precision type and do not require reaming after installation.

9. Install a new O-ring in camshaft hole plug and drive plug into position in cylinder block. The threaded hole is for removing the plug and must face the rear (flywheel end) of cylinder block when the plug is installed.

10. Install camshaft by direct reversal of removal procedure.

11. Before attempting to start engine, check fuel injection pump timing (refer to "FUEL SYSTEM" Section).

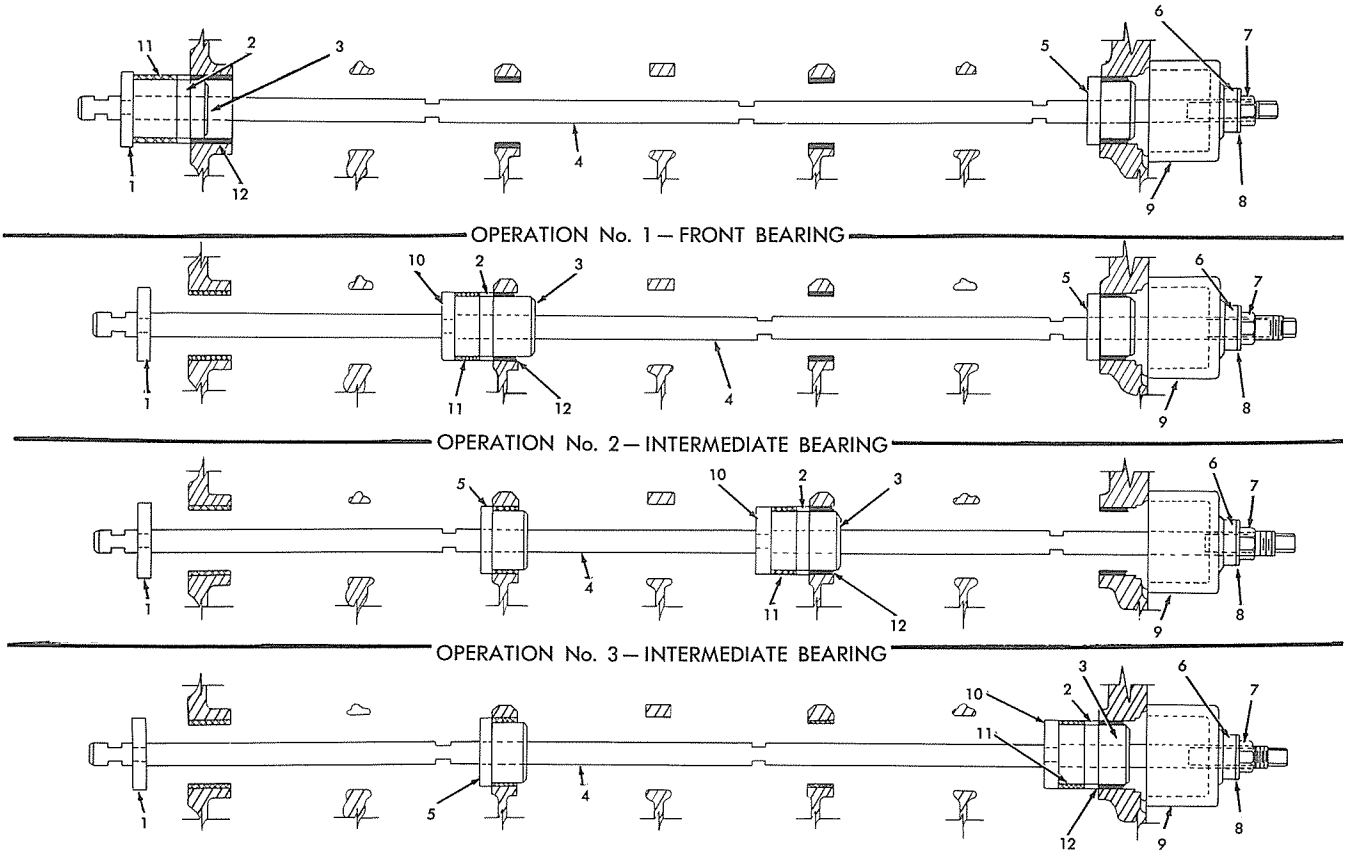


Fig. 6 — Sequence of Operations for Removing and Installing Camshaft Bearings (T-20267)

1. Stop
2. Spacer
3. Installing Pilot
4. Puller Shaft
5. Puller Shaft Pilot
6. Thrust Bearing
7. Hex Nut
8. Flat Washer
9. Collar
10. "C" Washer
11. New Camshaft Bearing
12. Old Camshaft Bearing

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

SECTION 13 - PISTONS, PISTON RINGS, CONNECTING RODS, AND CONNECTING ROD BEARINGS

TOPIC NO.	TITLE	PAGE
1.	GENERAL	13 - 1
2.	PISTONS AND PISTON RINGS	13 - 1
3.	CONNECTING RODS AND CONNECTING ROD BEARINGS	13 - 6

TOPIC 1 - GENERAL

Refer to FIG. 2A. Two types of pistons are used in the engines covered by this manual. The first type has an off-center, deep combustion chamber. The second type has a centered, shallow combustion chamber of greater area. The effective engine serial numbers of this change are:

Wheel loaders and crawler loaders: 11-18404
Motor graders and crawler tractors: 11-18999

The different types of pistons must never be mixed in the same engine and one type must not be substituted for the other because a different fuel injection nozzle is used with each type. The combustion chamber is located in the head of the piston. In the first type piston, the top of the piston is stamped "CAMSHAFT SIDE". The piston must be installed with this side facing camshaft side of the engine. The second type piston may be installed either way.

The pistons are cast aluminum alloy, precision machined, cam ground, balanced, and tin plated. Each piston is fitted with three compression rings and one oil control ring, located above the piston pin.

The connecting rods are made of drop-forged, heat-treated steel, rifle-drilled for pressure lubrication of the piston pin and are statically and electronically balanced.

The connecting rod bearings are precision type, replaceable without machining.

The upper end of each connecting rod contains a bushing with an oil hole and a radial groove to allow the oil, pumped through the connecting rod, to lubricate the piston pin.

TOPIC 2 - PISTONS AND PISTON RINGS

A. PISTON CONNECTING ROD, AND CONNECTING ROD BEARING REMOVAL

Replacement of connecting rod bearings may be accomplished without removing pistons and connecting rods from the engine. If only removal of connecting rod bearings is required, follow steps 2 and 4.

1. Remove the cylinder heads (refer to "VALVES, VALVE OPERATING MECHANISM' AND CYLINDER HEADS" Section).
2. Drain oil from oil pan and remove oil pan, oil pump and associated tubing (refer to "LUBRICATING SYSTEM" Section).
3. Remove the piston ring travel ridge from the cylinder sleeves (refer to "CYLINDER BLOCK AND CYLINDER SLEEVES" Section).
4. Remove nuts from connecting rod bearing caps.

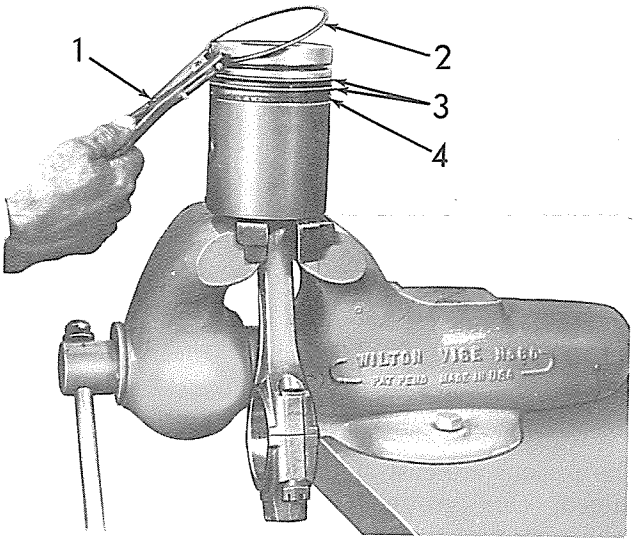


Fig. 1 — Removing Piston Rings from Piston (T-27632)

1. Ring Remover and Installer Tool
2. Top Compression Ring (Chrome)
3. 2nd & 3rd Compression Rings
4. Oil Control Ring Assembly

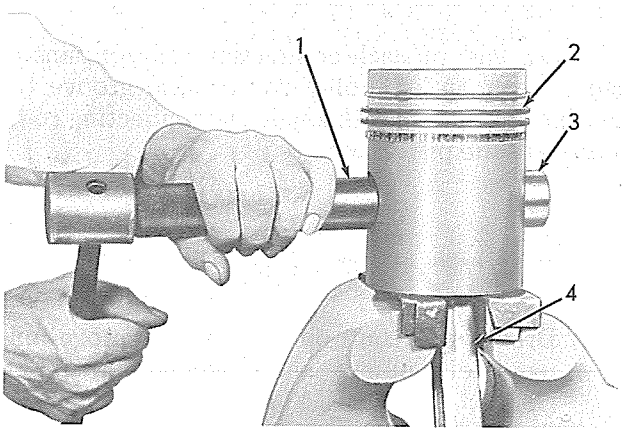


Fig. 2 — Removing Piston Pin From Piston (T-27631)

1. Piston Pin Driver
2. Piston
3. Piston Pin
4. Connecting Rod

NOTE

Later model engines are equipped with self locking nuts instead of slotted nuts and cotter pins.

Remove bearing caps and free lower end of connecting rods from crankshaft. The connecting rod bearings may now be removed if desired.

5. Remove each piston and connecting rod assembly by pushing assembly out through top of the cylinder.

B. REMOVAL OF CONNECTING ROD AND PISTON RINGS FROM PISTON

1. Remove the piston rings using a ring remover and installer tool similar to the one shown in Fig. 1.

2. Using a pair of Truarc pliers, remove the piston pin retainer ring at each end of piston pin.

3. Using a piston pin remover and installer tool, Fig. 2, drive the piston pin from the piston. The specified clearance between a new piston and pin is .0001'' - .0003'' tight on Type I pistons and .0001'' - .0005'' loose on Type II.

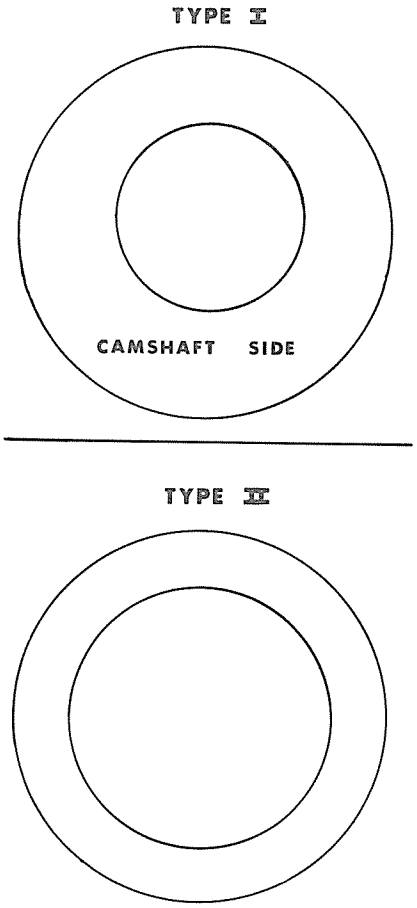


Fig. 2a – Top of Piston T-76830

C. PISTON AND PISTON RING INSPECTION

The normal pattern of wear on pistons will show maximum wear in the compression ring grooves. Seldom is piston replacement required because of excessive wear in the oil ring grooves or because the piston skirt or piston pin bores are excessively worn.

As gummy desposits are not always easily removed from the piston walls and ring grooves with fuel, these parts may be cleaned by using a non-toxic, non-flammable cleaning solution and then blowing off with dry compressed air. After cleaning, the piston skirt, piston rings, and ring grooves must be thoroughly inspected. Be sure oil drain holes in the oil ring groove are open and clean. If the cleaning solution does not remove all carbon from the bottom of the ring grooves, break the old rings in half and use the butt ends as scrapers. Be careful to remove only carbon or foreign material; do not scrape away any metal from the side or bottom of the ring grooves.

Do not use cleaning solutions which are harmful to aluminum parts.

The skirt of the piston must be carefully examined for score marks or other indications of improper piston clearance. Inspect the inside of pistons for cracks; scored or cracked pistons must be replaced.

Check pistons for wear:

Type I Piston: The bottom skirt diameter of a new piston is 4.429" - 4.430" (112.50-112.52 mm) (measured at right angles to piston pin); the inside diameter of a new cylinder sleeve is 4.4370" - 4.4385", (112.70-112.74 mm) giving a running clearance of .0070" - .0095" (0.12-0.24 mm). Any deviation from these measurements will indicate the amount of wear on the piston and/or the cylinder sleeve.

Type II Piston: The bottom skirt diameter of a new piston is 4.4310" - 4.4320 (112.55-112.57 mm) (measured at right angles to the piston pin); the inside diameter of a new cylinder sleeve is 4.4370" - 4.4385" (112.70-112.74 mm) giving a running clearance of .0050" - .0075" (0.13 - 0.19 mm). Any deviation from these measurements will indicate the amount of wear on the piston and/or the cylinder sleeve.

If the piston rings are removed from the pistons, even after a short period of operation, do not reinstall the same rings because in most cases they will not again seat properly. The O. D. of new piston rings have tool marks and reasonably rough surfaces which allow for a fast wear-in and seating of the rings to the cylinder walls, After a period of operation, the rings wear or lap themselves to fit perfectly with the cylinder walls and the rings "seat".

If the wear in the piston compression ring grooves does not create side clearance with new piston rings greater than .008" (0.20 mm), if piston pin bore does not exceed 1.6276 in (41.34 mm) and if no cracks or scores are detected in piston pin bosses, on the skirt, or in the combustion chamber area, pistons may be reused with a reasonable life expectancy of one-half to three-fourths of new pistons.

D. FITTING PISTONS TO CYLINDER SLEEVES

Measurement of the pistons and the cylinder sleeves, and running clearances between the pistons and the cylinder sleeves, must be taken at room temperature 70° F. (21° C.). Pistons must be fitted to their respective cylinder sleeves, before the piston rings are installed, to provide a running clearance of not less than .005 (0.13 mm). Insufficient clearance will result in premature failure of pistons and/or cylinder sleeves.

1. Using an inside micrometer, measure the I. D. of the cylinder sleeve (refer to "CYLINDER BLOCK AND CYLINDER SLEEVES" Section).

2. Using an outside micrometer, measure the O.D. of the piston "skirt" at the bottom edge and at right angles to piston pin. The difference between the two readings is the running clearance.

E. FITTING PISTON RINGS TO PISTONS

1. The gap between ends of piston rings must be measured before rings are installed on pistons. Insufficient end gap will cause scored rings, scored cylinder sleeves, and other damage. Check the ring gap by inserting each ring into the cylinder sleeve in which it is to be used. Use a piston to push ring squarely down in the bore of the cylinder sleeve and far enough to be on the ring travel area. Check ring gap with a feeler gauge as shown in Fig. 3.

   The specified ring end gaps using standard size cylinder sleeves of 4.4370" - 4.4385" (112.70-112.74 mm) bore are:

Top ring	First Type Piston	0.013-0.033 in (0.33 - 0.84 mm)
	Second Type Piston	0.013-0.028 in (0.33-0.71 mm)
2nd and 3rd rings		0.013 - 0.033 in (0.33 - 0.84 mm)
4th ring		0.008 - 0.028 in (0.20 - 0.71 mm)

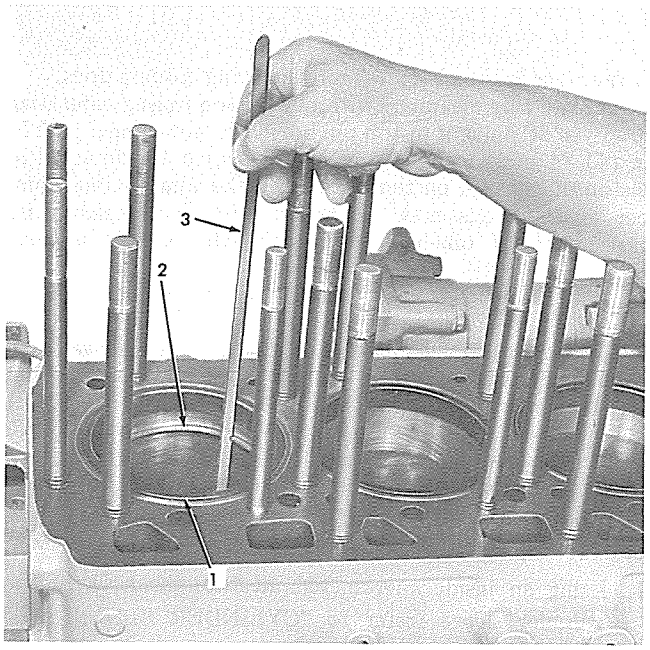


Fig. 3 — Checking Piston Ring Gap (T-20222)

1. Cylinder Sleeve 2. Piston Ring 3. Feeler Gauge

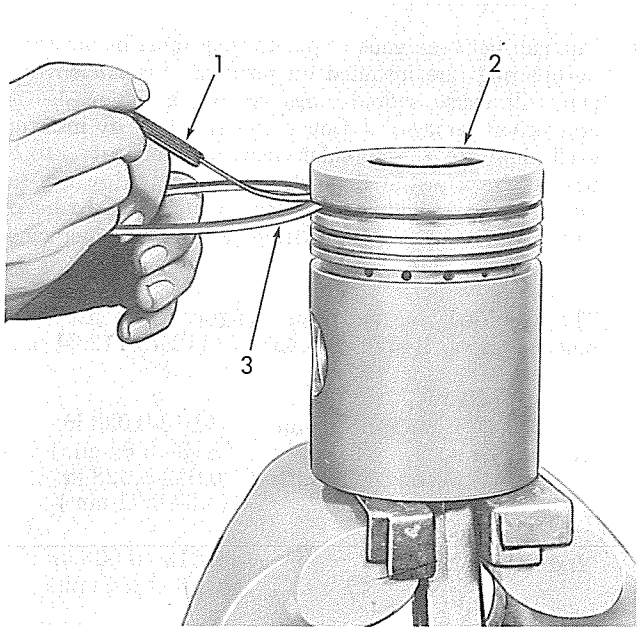


Fig. 4 — Checking Piston Ring-To-Groove Clearance (T-27633)

1. Feeler Gauge 2. Piston 3. Piston Ring

The top compression ring should never be filed to open the gap because the chrome plating might be loosened by the file and later distributed through the engine, causing damage or scoring of the piston and the cylinder sleeve.

2. Measure ring-to-groove clearance (top of ring to top of groove in piston) as shown in Fig. 4. The specified ring-to-groove clearances, using a new piston and new rings are as follows:

Top ring	0.004-0.007 in (0.10-0.18 mm)
2nd and 3rd rings	0.009-0.005 in (0.08-0.13 mm)
4th ring	0.0015-0.004 in (0.04-0.10 mm)

F. PISTON RING INSTALLATION

After piston rings have been properly fitted, install them on piston, using a piston ring remover and installer tool as shown in Fig. 1.

NOTE

When installing rings on pistons, do not spread the rings more than necessary.

Type I Piston (Fig. 2a)

1. Place stainless steel expander spacer, of three-piece ring, in bottom groove of piston with ends butted (do not overlap).
2. Install chrome-plated steel segment on bottom side of expander spacer, with gap of segment approximately 90° beyond gap of expander spacer, making certain expander spacer is still in a butted position.
3. Install second segment on top side of expander spacer with segment gap approximately 90° from expander spacer gap in opposite direction from which the bottom segment has been installed.
4. Install 3rd, 2nd, and top rings (with side marked "Top" or "T" toward top of piston).
5. Recheck the three-piece ring assembly. Rings should be free to move in the grooves; however, a slight drag will be evident because of side sealing action of the ring assembly. Be sure expander spacer remains in butted position.

Type II Piston (Fig. 2a)

1. Remove coil spring from oil control ring, lubricate and install spring in bottom groove of piston.

2. Install oil control ring over the spring with ring gap approximately 180° from joint in the spring.

3. Install 3rd ring with groove side toward bottom of piston.

4. Install 2nd ring with mark and/or groove side toward top of piston.

5. Install top (chrome plated) compression ring. This ring may be installed either side up.

G. ASSEMBLY OF CONNECTING ROD TO PISTON

1. Install one of the piston pin retainers in one end of the piston pin hole in the piston.

2. Insert upper end of connecting rod into position.

NOTE

When assembling Type I piston to connecting rod, make certain side of piston stamped "CAMSHAFT SIDE" is toward side of connecting rod stamped with numbers identifying the cap with upper portion of rod.

3. Lubricate piston pin with clean oil and with a piston pin remover and installer tool as shown in Fig. 2, tap piston pin into piston and connecting rod.

4. Install the other piston pin retainer at the opposite end of the piston pin.

H. PISTON, CONNECTING ROD, AND CONNECTING ROD BEARING INSTALLATION

Install each piston, with rings and connecting rods as an assembly. The lower end of each connecting rod, as well as the connecting rod bearing caps, are numbered 1, 2, 3, etc. for identification, and must be installed in the corresponding numbered cylinder with the numbered side of rod toward the camshaft side of engine.

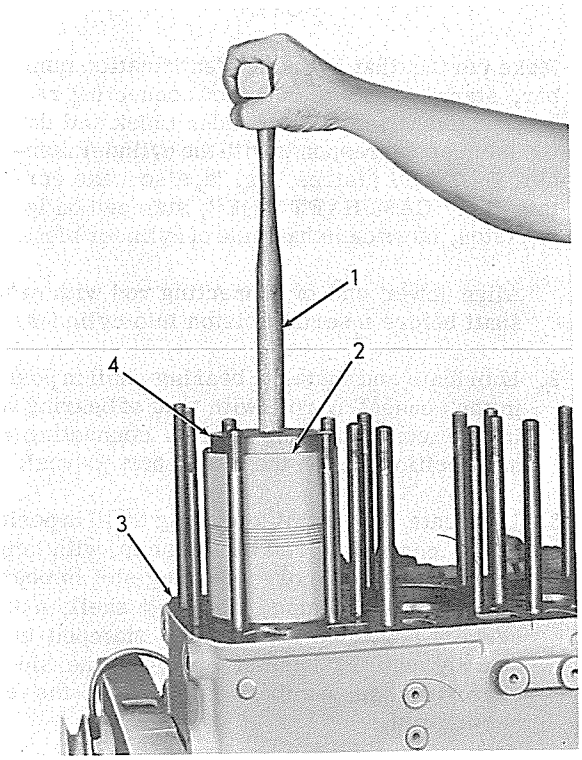


Fig. 5 — Installing Piston Assembly In Cylinder Sleeve (T-20225)

1. Hammer
2. Piston Inserter
3. Cylinder Block
4. Piston

1. Stagger piston ring gaps evenly around piston and apply clean engine oil to pistons and rings. With a piston inserter similar to the one shown in Fig. 5, install the piston and connecting rod in the cylinder sleeve by tapping on top of piston with wooden handle of a hammer. If any difficulty is encountered, however slight, the piston inserter must be removed and ring set inspected for correct installation in piston grooves.

NOTE

Make certain that cylinder identification number, stamped on lower end of connecting rod, faces camshaft side of cylinder block and that the number corresponds with the cylinder number. On Type I pistons, Fig. 2a, also make certain that "CAMSHAFT SIDE", stamped on top of piston, faces camshaft side of cylinder block.

Align lower end of connecting rod with crankshaft before inserting piston into cylinder.

2. Lubricate and install a bearing shell in position in the connecting rod, with tang of bearing shell in the corresponding slot in connecting rod, and position rod on the crankshaft journal.

3. Lubricate and install a bearing shell in position in the connecting rod bearing cap, with tang of bearing shell in corresponding slot in bearing cap. Install bearing cap and shell, making certain identification number stamped in the bearing cap is located on the same side as corresponding number stamped in the connecting rod.

4. Three types of connecting rod bolt nuts, Fig. 6, have been used in engines covered in this manual. It is recommended that whenever connecting rods equipped with Type I or Type II nuts are installed in an engine, the old nuts be discarded and replaced with the Type III nut (Part No. 74354748). The specified torque, no matter which nut is used, is 120 - 130 lb-ft (16.6-18.0 kg-m). On current engines with twelve-point capscrews instead of nuts, tighten capscrews to 160 lb-ft (22.1 kg-m).

5. Check to see that there is sufficient side clearance between connecting rods and crankshaft journals. The specified clearance is .004" - .009".

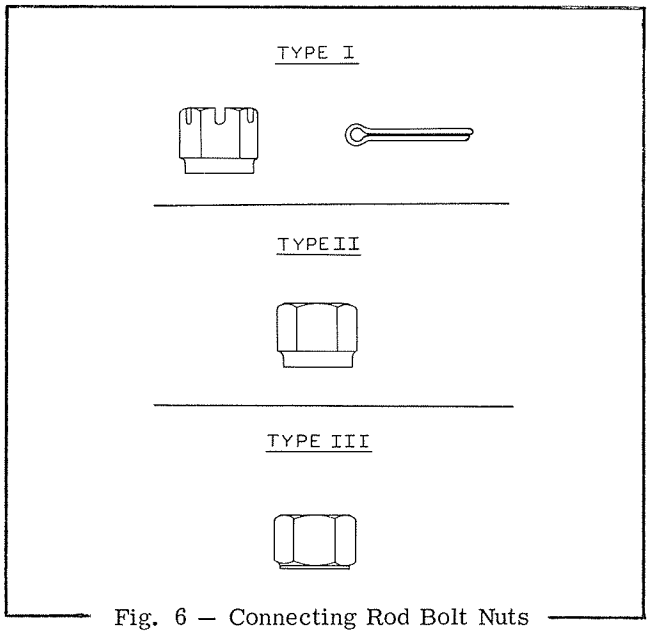


Fig. 6 — Connecting Rod Bolt Nuts (T-72726)

TOPIC 3 - CONNECTING RODS AND CONNECTING ROD BEARINGS

A. CONNECTING ROD AND CONNECTING ROD BEARING INSPECTION

Whenever connecting rods are removed from an engine it is good practice to check alignment of the piston pin bushing end with the big bore end. Alignment can be checked with a direct reading alignment gauge similar to the one shown in Fig. 7. With this type alignment gauge the rod can be checked with or without the piston assembled to it.

1. Measure outside diameter of the piston pin to determine wear. The specified diameter of a new piston pin is 1.6265" - 1.6267". The specified inside diameter of the bushing in the connecting rod is 1.6277" - 1.6282". These dimensions of pin and bushing provide a clearance of .001" - .0017"; clearances up to .003" are permissible. If clearance is close to or more than .003", replace the connecting rod bushing.

2. Blow dry compressed air through the oil passage in connecting rod.

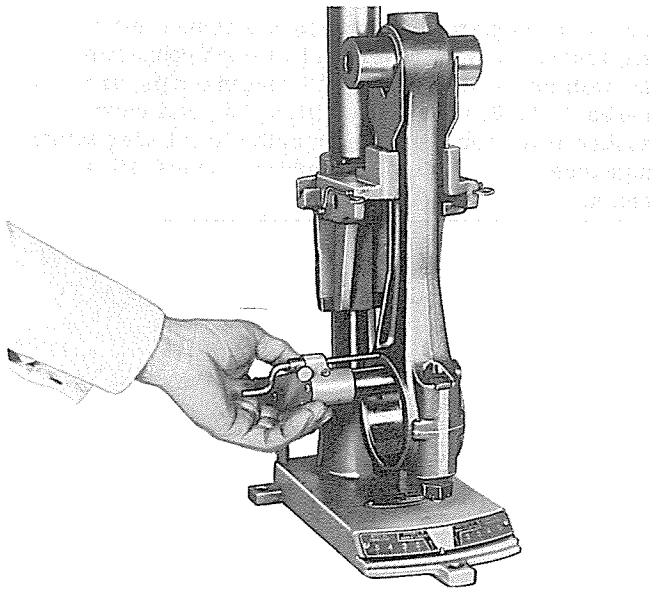


Fig. 7 — Checking Connecting Rod Alignment (T-29510)

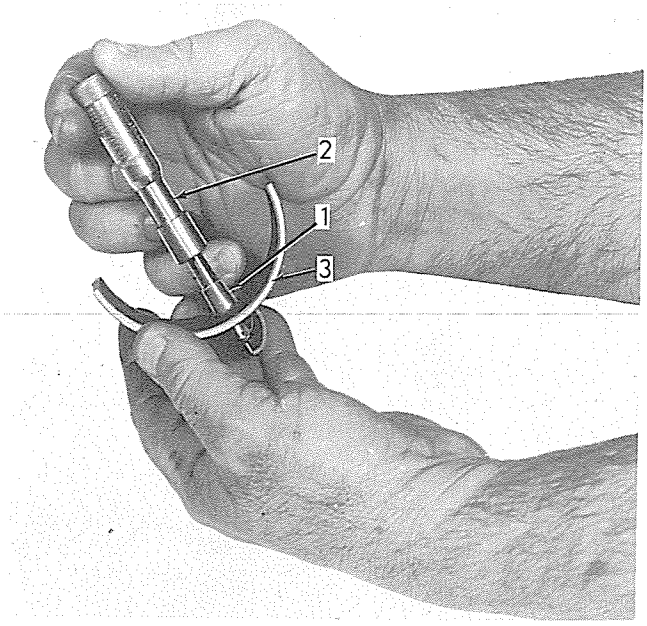


Fig. 8 — Measuring Bearing Shell Thickness (T-19046)

1. Sleeve with Steel Ball 2. Micrometer 3. Bearing Shell

IMPORTANT

Be sure that all oil passages are open.

3. Inspect connecting rod bearing shells for scoring, chipping, corrosion, cracking, or signs of overheating; discard bearing shells if any of these conditions are apparent. The backs of bearing shells should be inspected for bright spots and discarded if any bright spots are found; this condition indicates that bearing shells have been moving in their supports.

4. Inspect bearing shells for wear. The specified inside diameter of bearing shells, (when installed and bearing cap retaining nuts tightened to the specified torque 120 - 130 lbs. ft.) is 2.7745" - 2.776". This provides a running clearance of .002" - .0045"; new bearing shells must be installed when this clearance exceeds .009".

5. Measure bearing shells for wear as shown in Fig. 8; standard connecting rod bearings have a specified thickness of .12475" - .12525"; bearing shells that measure less than .123" at the center should be discarded and new ones installed.

   In event that the crankshaft is worn or damaged and must be reground, bearing shells .010", .020", .030", and .040" undersize are available.

NOTE

Never file or shim the bearing caps to make the bearings fit; install new bearing shells if the fit is unsatisfactory. The crankshaft must turn freely after all the connecting rod nuts have been tightened to the specified torque.

As a general recommendation, if removed bearings have seen 2,000 to 3,000 hours of service, the cost of new replacement bearings will offset the gamble of undetected fatigue or accelerated fatigue from minute repositioning upon reinstallation of used bearings, and warrant installation of new bearings.

B. CONNECTING ROD BUSHING REPLACEMENT

If the connecting rod bushing-to-piston pin clearance is more than .003", the connecting rod bushing must be pressed out and a new bushing pressed into the connecting rod. When a new bushing is installed, be sure oil hole in bushing lines up with rifle-drilled hole in connecting rod. The specified diameter of a new piston pin is 1.6265" - 1.6267", and inside diameter of the bushing is 1.6277" - 1.6282"; this provides a clearance of .001" - .0017" between pin and bushing. It will be necessary to ream connecting rod bushing to obtain this clearance. The bore in piston for the piston pin is 1.6264" - 1.6266" in Type I pistons and 1.6268" - 1.6270" in Type II. Pin fit in Type I pistons is .0001" - .0003" tight and in Type II pistons is .0001" - .0005" loose.

NOTE

Whenever it is necessary to replace a connecting rod bushing, it is recommended that the work be done by a reputable machine shop suitably equipped.

SECTION 14 - CRANKSHAFT AND CRANKSHAFT GEAR, MAIN BEARINGS, AND MAIN BEARING CAPS

TOPIC NO.	TITLE	PAGE
1.	CRANKSHAFT AND CRANKSHAFT GEAR	
	A. General	14-1
	B. Crankshaft Removal and Inspection	14-1
	C. Crankshaft Reconditioning	14-2
	D. Crankshaft Installation	14-3
	E. Crankshaft Gear Removal and Installation	14-5
2.	MAIN BEARINGS	
	A. General	14-5
	B. Main Bearing Removal, Inspection, and Installation	14-5
	C. Main Bearing Replacement With Engine Installed	14-6
3.	MAIN BEARING CAPS	
	A. General	14-9
	B. Main Bearing Cap Replacement	14-9

TOPIC 1 - CRANKSHAFT AND CRANKSHAFT GEAR

A. GENERAL

The seven bearing, counterbalanced crankshaft is a steel drop forging, carefully heat-treated to assure utmost strength and durability. The crankshaft is balanced dynamically. End thrust of the crankshaft is taken up by thrust flanges, Fig. 1 (4) (9), at the center main bearing. The specified end play of the crankshaft is .006" - .014" and must not exceed .022". Thrust flanges are available in standard size and .005", .010" and .015" oversize.

The crankshaft gear is keyed and pressed onto the front end of the crankshaft with a .0005" - .0025" interference fit.

B. CRANKSHAFT REMOVAL AND INSPECTION

1. Remove the engine (refer to "ENGINE REMOVAL AND INSTALLATION" Section). Drain engine lubricating oil.

2. Remove flywheel and flywheel housing (refer to "FLYWHEEL AND RING GEAR, FLYWHEEL HOUSING AND CRANKSHAFT REAR OIL SEAL" Section).

3. Remove the timing gear housing cover (refer to ("FRONT END AND GEAR TRAIN" Section).

4. Remove oil pan, oil pump(s), and associated tubing (refer to "LUBRIFICATING SYSTEM" Section).

5. Remove connecting rod bearing caps and connecting rod bearing shells (refer to "PISTONS, PISTON RINGS, CONNECTING RODS, AND CONNECTING ROD BEARINGS" Section).

6. Remove main bearing caps and lower main bearing shells.

7. Remove the crankshaft.

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

9. Clean crankshaft thoroughly and inspect the journals for scoring, chipping, cracking, or signs of over-heating. If crankshaft has been overheated (usually indicated by discolored or blue bearing journal surfaces), or is scored or excessively worn, reconditioning or replacement will be required. Examine bearing journals for cracks if over-heating has occurred.

10. Measure the crankshaft main bearing and connecting rod journals at several places on their diameter to check for roundness. The specified diamenter of main bearing journals is 3.498" - 3.499"; connecting rod journals 2.7715" - 2.7725".

    If out-of-round or taper of journals exceeds .002", crankshaft must be reground to a standard undersize or replaced.

11. Remove the hex-socket pipe plugs from crankshaft and blow out all oil passages in crankshaft

with compressed air. Reinstall plugs, tighten them securely until they are 1/16" below crankshaft surface. Peen area around plugs to prevent them from loosening.

C. CRANKSHAFT RECONDITIONING

Experience has indicated that crankshaft reconditioning in the field can be accomplished with reasonable success if a few basic items are taken into consideration.

1. Engines operating near maximum published horsepower and RPM figures have less available reserve in all components of the engine. Any alterations to components that reduces their strength can reduce their life and can increase the possibility of premature failure. The extent of reconditioning must be weighed against the overall cost and the risk involved.

2. Main and connecting rod service bearings are available for all current production engines in standard and .010", .020", .030", and .040" undersize.

3. The effect of regrinding on crankshaft life will be determined by engine operating conditions and observance of proper regrinding procedures.

4. Normally, a crankshaft that has survived in engine operation long enough to have enough wear to require regrinding, and satisfactorily passes magnetic particle inspection before and after regrinding, can be considered satisfactory for reuse. The quality of the regrind thus becomes the major factor for continued satisfactory life for the reground crankshaft.

5. Crankshaft magnetic particle inspection MUST be accomplished before attempting to regrind a crankshaft to determine if it is in satisfactory condition for regrinding. After regrinding, it MUST again be magnetic particle inspected to be sure any detrimental sub-surface inclusions have not been uncovered in the grinding operation.

   Magnetic particle inspection should only be attempted by qualified personnel who have been properly trained to perform this function.

6. Reground crankshaft journal fillet radii MUST be one continuous radius, within the new shaft specified tolerances as tabulated on the attached chart, and blended and polished smoothly into the journals and crank cheeks. When fillet radii are ground below minimum tolerance, the possibility of failure is greatly increased. Fillet radii above the maximum tolerance can cause interference with the bearings.

7. Grinding burns CANNOT be tolerated.

8. Hard chrome plating or metalizing on crankshafts has in general proved UNSATISFACTORY. We recommend that none be attempted on our crankshafts.

9. Cold working of crankshaft fillets under field conditions, either by shot peening or rolling, is NOT recommended.

10. The engines covered in this manual are provided with separate crankshaft thrust flanges that are not an integral part of the center main bearing. Service thrust flanges are available in standard thickness and .005", .010", and .015" oversize.

11. The following table lists the measurements and tolerance specified for new crankshafts and will be helpful when inspecting and regrinding crankshafts.

12. Crankshaft regrinding MUST BE performed by a shop with adequate equipment and fully trained personnel which assumes the responsibility for the quality of its work. Allis-Chalmers will not assume any responsibility for the results.

13. To reduce the generation of burrs during machining of journal surfaces, the following recommendations should be followed:

    a. Always include a polishing operation following the grinding operation.

    b. Always polish in the direction opposite to grinding. Openings at all oil holes should have a polished radius.

ENGINE MODEL	MAIN BEARING JOURNAL SIZE	CONNECTING ROD BEARING JOURNAL SIZE	MAIN JOURNAL TO CRANK PIN RADIUS	FILLET RADIUS	CENTER MAIN JOURNAL LENGTH
10000	3.498" / 3.499"	2.7715" / 2.7725"	2.779" / 2.784"	.167" / .197"	2.688" / 2.692"
11000	3.498" / 3.499"	2.7715" / 2.7725"	2.779" / 2.784"	.167" / .197"	2.688" / 2.692"

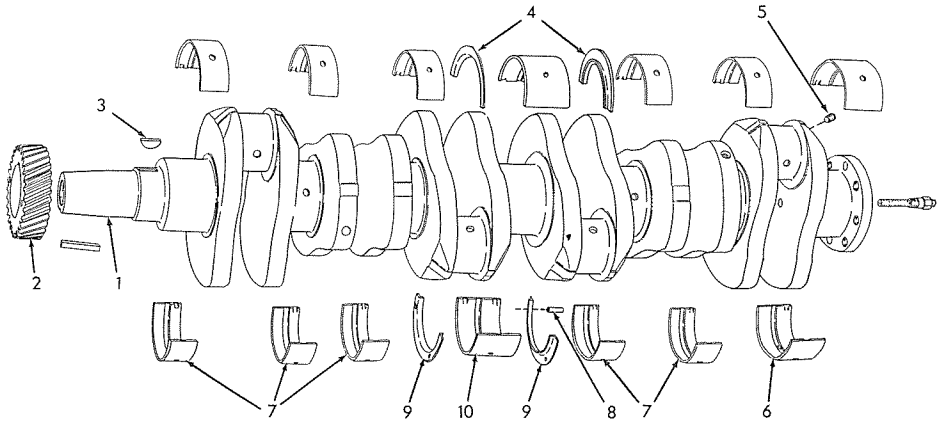


Fig. 1 — Crankshaft and Main Bearing Details
(T-13152)

1. Crankshaft
2. Crankshaft Gear
3. Woodruff Key (Used prior to eng. s/n 11-19386)
4. Upper Thrust Flanges
5. Pipe Plug
6. Rear Main Bearing
7. Front and Intermediate Main Bearings
8. Dowel Pin
9. Lower Thrust Flanges
10. Center Main Bearing

c. Always polish in the same direction as the journal will rotate in the bearing.

Care should be taken to remove as little metal as possible (.0002" maximum on the diameter) so that polishing does not produce harmful burrs comparable to those produced during grinding.

The importance of polishing opposite to grinding cannot be overemphasized. Polishing in the same direction simply lays the burrs down rather than removing them. During operation, they again raise up and produce damage to the bearing surface.

D. CRANKSHAFT INSTALLATION

1. Install upper halves of main bearing shells in the bearing seats of cylinder block. Make certain tangs on bearing shells are properly located in corresponding slots in bearing seats of block.
2. Lubricate all crankshaft main bearing journals and lower crankshaft into position in the cylinder block with flywheel flange end of crankshaft toward the rear.

CAUTION

Make certain that timing mark on crankshaft gear is aligned with timing mark on camshaft gear, when crankshaft is installed, Fig. 2.

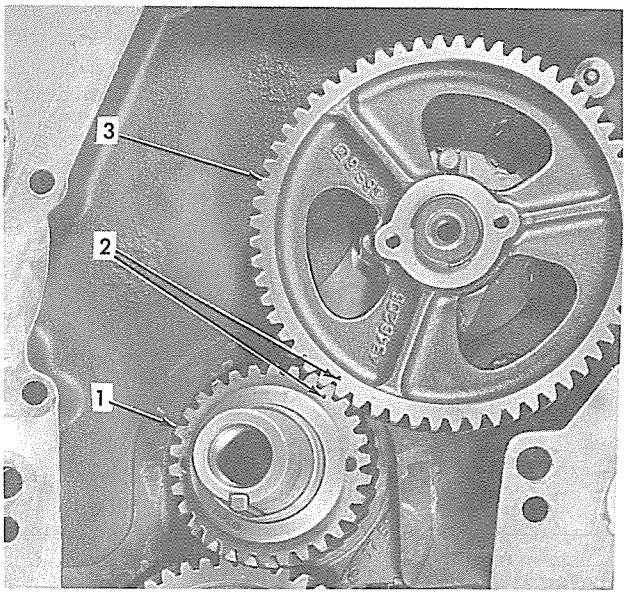


Fig. 2 — Typical Camshaft Gear and Crankshaft Gear Timing Marks Aligned
(T-27622)

1. Crankshaft Gear
2. Timing Marks
3. Camshaft Gear

Place lower halves of main bearing shells in main bearing caps, inserting tangs of shells into slots in caps. The bearing caps are numbered 1, 2, 3, etc. Fig. 8, indicating their respective positions. Before installing center main bearing cap, insert upper thrust flanges Fig. 1 (4) (flanges without dowel pin holes) with oil grooves of thrust flanges located next to cheeks of the crankshaft. Position lower

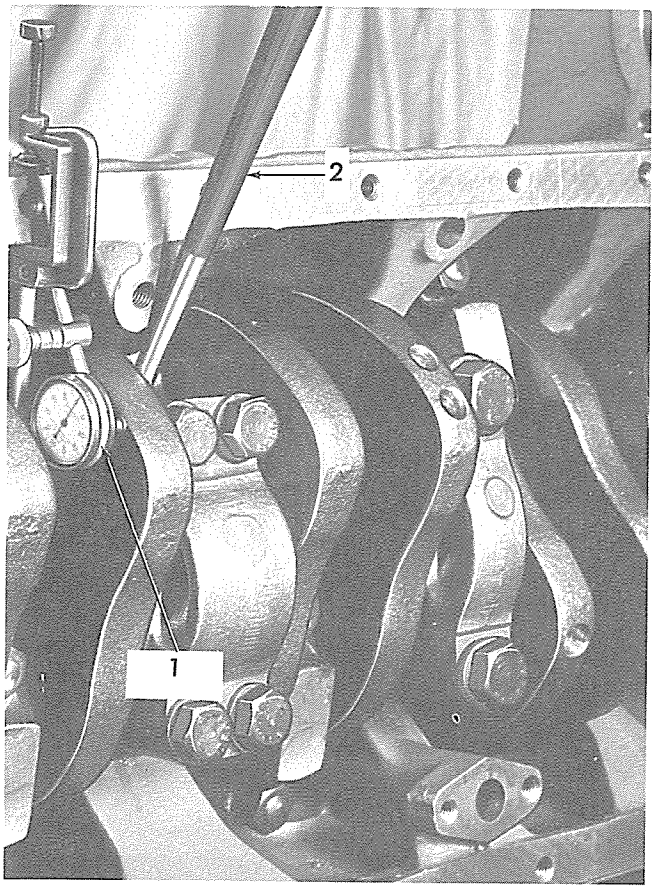


Fig. 3 — Measuring End Play of Typical Crankshaft (T-71528)

1. Dial Indicator
2. Pry Bar

thrust flanges (9) on dowel pins (8) with the oil grooves in the thrust flanges to the outside of the bearing cap.

Install main bearing caps with numbers facing camshaft side of the engine and corresponding to number stamped on lower edge of cylinder block as shown in Fig. 8. Install the main bearing cap attaching capscrews, lockwashers, and locking plates.

NOTE

On later model engines, lockwashers and locking plates are not used and plain hardened steel washers are used instead.

Using a torque indicating wrench, tighten the 3/4" capscrews to 210 - 230 lbs. ft. at the front, intermediate, and rear main bearing cap locations. Tighten the 5/8" capscrews used on the center main bearing cap to a torque of 160 - 170 lbs. ft. Lock capscrews with lockwashers and at center main bearing cap with locking plates if so equipped.

CAUTION

Do not overtighten main bearing capscrews. If these capscrews are overtightened, bearing caps may be distorted, causing bearings to be drawn tight against the crankshaft and premature failure will result. The crankshaft should turn freely after all capscrews are properly torqued. Never file or shim a bearing cap to make the bearing shell fit; install new bearing shells if fit on the crankshaft is unsatisfactory.

3. Check end play of the crankshaft using a dial indicator as shown in Fig. 3. The specified end play is .006" - .014" and must not exceed .022". The end play is controlled by thrust flanges at the center main bearing, Fig. 1 (4) (9). If end play is not within the specified range, replace thrust flanges. Thrust flanges are available in standard thickness (.126" - .127") and .005", .010", and .015" oversize.

4. Lubricate and install a bearing shell in position in each connecting rod, with tang of bearing shell in corresponding slot in connecting rod, and position the rod on the crankshaft journal.

5. Lubricate and install a bearing shell in position in each connecting rod bearing cap, with tang of bearing shell in corresponding slot in bearing cap. Install bearing cap and shell, making certain identification number stamped in bearing cap is located on the same side as corresponding number stamped in connecting rod and facing camshaft side of engine.

6. Install connecting rod nuts, and tighten to a torque of 120-130 lb-ft (16.6-18.0 kg-m). On current engines with twelve-point capscrews instead of nuts, tighten capscrews to 160 lb-ft (22.1 kg-m).

On earlier model engines, secure the nuts with cotter pins (if slot in nut does not align with cotter pin hole after tightening to proper torque, continue to tighten nut until alignment is made with nearest slot).

On later model engines, a self locking type nut is used and cotter pins are not required.

7. Check to see that there is sufficient side clearance between connecting rods and crankshaft journals. The specified clearance is .004" - .009".

8. Install oil pump and associated tubing, install oil pan (refer to "LUBRICATING SYSTEM" Section).

9. Install the timing gear housing cover (refer to "FRONT END AND GEAR TRAIN" Section).

10. Install flywheel housing and flywheel (refer to "FLYWHEEL AND RING GEAR, FLYWHEEL HOUSING AND CRANKSHAFT REAR OIL SEAL" Section).

11. Install the engine (refer to "ENGINE REMOVAL AND INSTALLATION" Section). Fill engine crankcase to proper level with the specified oil.

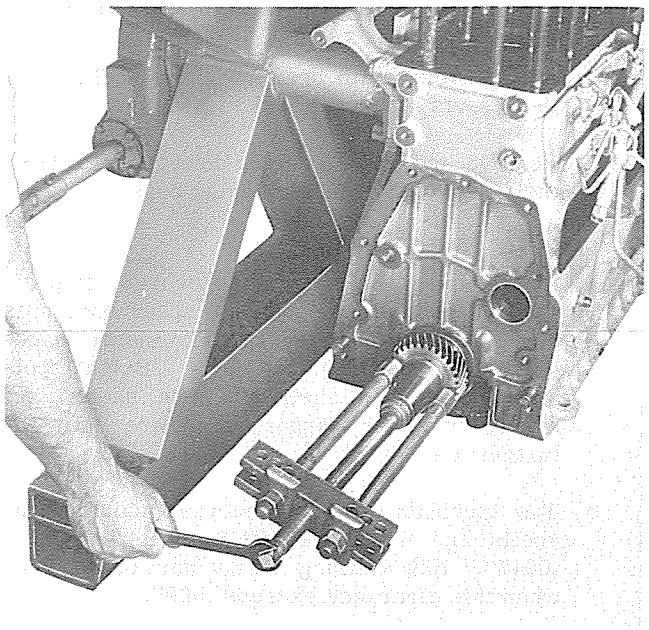


Fig. 4 — Removing Crankshaft Gear (T-19805)

E. CRANKSHAFT GEAR REMOVAL AND INSTALLATION

The crankshaft gear may be removed from the crankshaft by the use of tools similar to those shown in Fig. 4. The gear may be removed either with the crankshaft installed in the engine or after the crankshaft has been removed.

To install crankshaft gear on crankshaft, install Woodruff key, Fig. 1 (3) in crankshaft. Heat gear in oil to a temperature of approximately 275° F. and drive or press gear onto crankshaft.

CAUTION

If crankshaft is installed in engine, make certain that timing mark on crankshaft gear is aligned with timing mark on camshaft gear when crankshaft gear is installed, Fig. 2.

TOPIC 2 - MAIN BEARINGS

A. GENERAL

The main bearings are precision type and are replaceable without machining. The front and intermediate main bearings are 1.348" - 1.358" long, the rear main bearing is 1.991" - 2.001" long; and the center main bearing is 2.244" - 2.254" long. The center main bearing includes four thrust flanges and four dowel pins which prevent the flanges from moving radially.

All the main bearings have an inside diameter of 3.501" - 3.5027" when installed and with bearing caps properly torqued.

The upper halves of the main bearing shells are seated in the cylinder block. The lower halves are held in place by the main bearing caps, each of which is attached to the cylinder block by capscrews. The bearing shells are prevented from movement in the cylinder block and bearing caps by tangs which are located at one end of each bearing at the parting line. The halves of the bearing shells are identical, therefore, they may be installed in either the upper or lower positions.

B. MAIN BEARING REMOVAL, INSPECTION AND INSTALLATION

1. MAIN BEARING REMOVAL

a. Remove the crankshaft (refer to "CRANK-

SHAFT REMOVAL, INSPECTION AND INSTALLATION" in this Section).

b. Remove the main bearing upper shells from their seats in the cylinder block.

c. Remove the main bearing lower shells from their seats in the main bearing caps.

2. MAIN BEARING INSPECTION

a. Any bearing shells that are scored, chipped, pitted, or worn beyond the specified limits given below must be replaced. Inspect backs of the shells for bright spots. Bright spots on backs of the shells indicate shells have shifted in their supports and are unfit for further use.

b. The specified clearance between main bearing shells and the crankshaft journals is .002" - .0047". New bearing shells must be installed when this clearance exceeds .009".

With crankshaft removed, measure inside diameter of the bearing at a point 90° from the parting line with bearing cap installed and tightened to the specified torque. Bearing shells when in place are .002" larger in diameter at the parting line than they are 90° from the parting line, and do not form a true circle. The two halves of the shells have a crush fit in their bore in the block and must be tight when the cap is secured in place. Do not measure inside diameter at the parting line.

The specified inside diameter of new main bearings is 3.501" - 3.5027" and any reading above 3.5027" indicates the amount of bearing wear. Measure diameter of the crankshaft journal at the corresponding bearing location and subtract this dimension from inside diameter measurement of the bearing (as determined above); the difference between these two measurements is the crankshaft-to-bearing clearance.

c. Another method for determining amount of wear on bearing shells is by measuring each shell with a micrometer at a point 90° from the parting line as shown in Fig. 5. New shells, measured as shown, are .1549" - .1554" thick. Bearing shells less than .153" thick are worn beyond the allowable limits and must be replaced.

d. The most accurate method of determining main bearing clearance is by using micrometers as described in the preceding paragraphs. However, if the proper size micrometers are not available or the crankshaft is installed in the engine, bearing clearance may be measured by using a plastic strip manufactured for this purpose. The plastic strip must be used in accordance with the manufacturer's instructions.

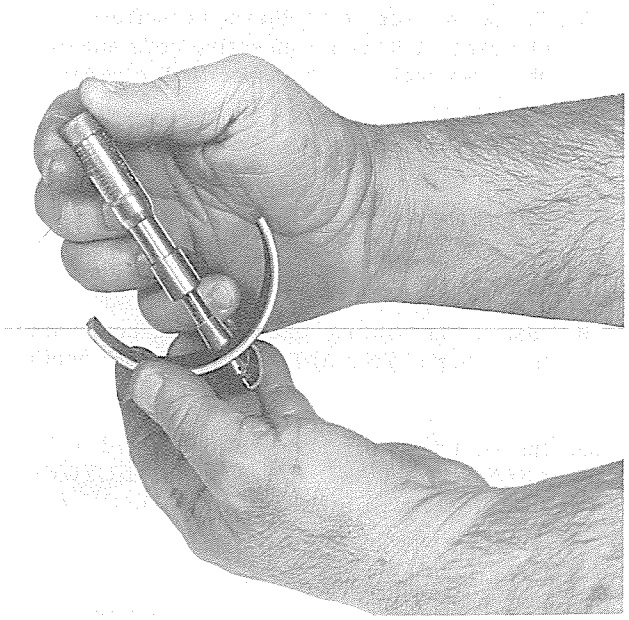


Fig. 5 — Measuring Bearing Shell Thickness (T-19046)

e. Main bearings are available in standard thickness (.1549" - .1554") and .010", .020", .030" and .040" undersize.

3. MAIN BEARING INSTALLATION

a. Install a main bearing shell in each of the bearing seats in the cylinder block.

b. Lubricate all crankshaft main bearing journals, install crankshaft and main bearing caps, check crankshaft end play, and reassemble engine (refer to "CRANKSHAFT REMOVAL, INSPECTION, AND INSTALLATION" in this Section).

C. MAIN BEARING REPLACEMENT WITH ENGINE INSTALLED

It is unwise to replace main bearings without removing the engine and taking it into a clean shop where disassembly and inspection can be effected properly; however, when removal of the engine is impractical or in emergency cases, the following procedure may be used:

NOTE

On some engine applications the engine must be removed from the unit in order to remove the oil pan. In this case the engine must be removed from the unit before proceeding as follows:

1. MAIN BEARING REMOVAL WITH ENGINE INSTALLED

a. Remove fuel injection nozzle-holders from engine (refer to "FUEL SYSTEM" Section) in order to relieve compression and allow free turning of the crankshaft.

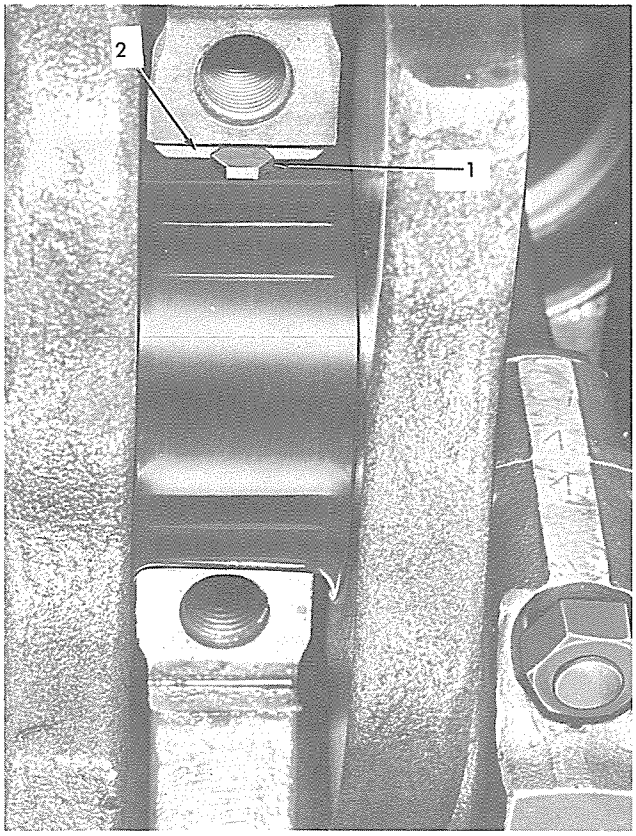


Fig. 6 — Removing Main Bearing Upper Shell (T-71026)

1. Capscrew with Ground Head
2. Main Bearing Upper Shell

b. Drain oil from oil pan and remove the oil pan, oil pump, and associated tubing (refer to "LUBRICATING SYSTEM" Section).

c. Remove only one main bearing cap, install new bearing, reinstall bearing cap, and tighten cap retaining capscrews to the specified torque before removing next bearing cap.

d. The lower bearing shell can be removed from the bearing cap after cap is removed. Remove upper bearing shell as follows:

(1) On early models insert a 1/4" x 1" capscrew, with the head ground down to a thickness of approximately 3/32" into the crankshaft main bearing oil hole as shown in Fig. 6, then rotate crankshaft in the direction that will turn head of the bolt against end of bearing shell that has no locking tang. Continue rotating crankshaft until bearing shell has been pushed out. On late engine w/cross drilled oil holes, use method shown in Fig. 7.

(2) The upper half of the rear main bearing shell may be rolled out of place by driving on the edge of bearing shell with a small curved rod as shown in Fig. 7, while rotating the crankshaft.

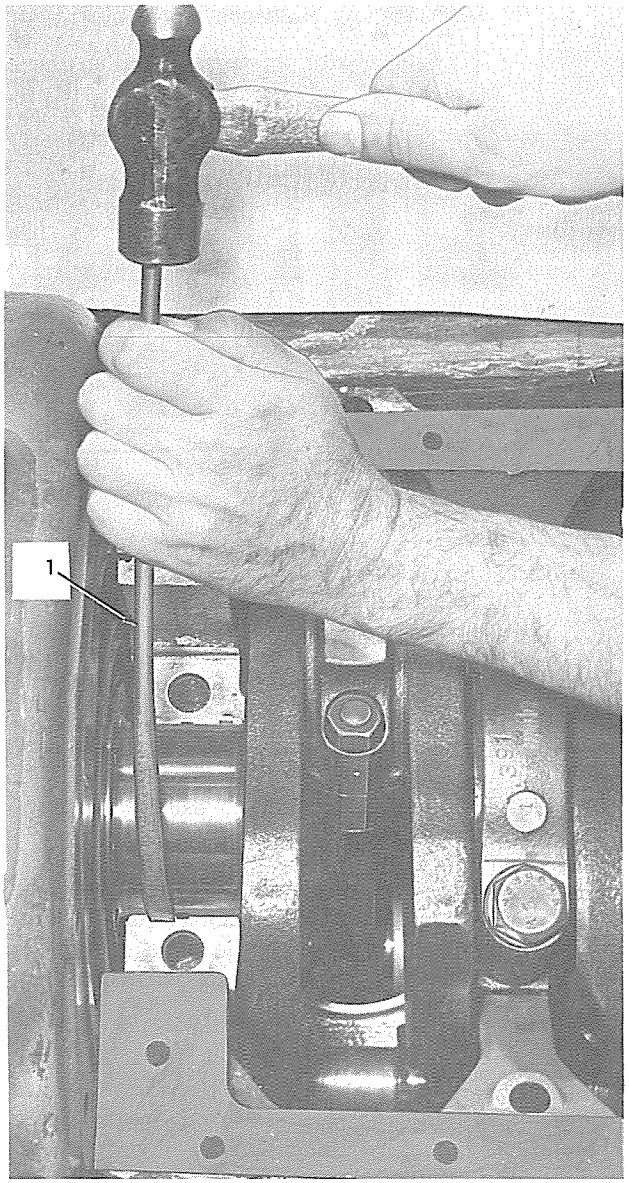


Fig. 7 — Removing Rear Main Bearing Upper Shell (T-71027)

1. Curved Rod

NOTE

Identify bearing shells as to their original location in cylinder block and main bearing caps in the event inspection proves they can be reused.

e. Inspect the crankshaft journals for scoring, chipping, cracking, or signs of overheating. If crankshaft has been overheated (usually indicated by discolored or blue bearing surfaces), or is scored or excessively worn, reconditioning or replacement will be required. Examine the bearing journals for cracks if overheating has occurred.

f. Inspect each main bearing shell as described

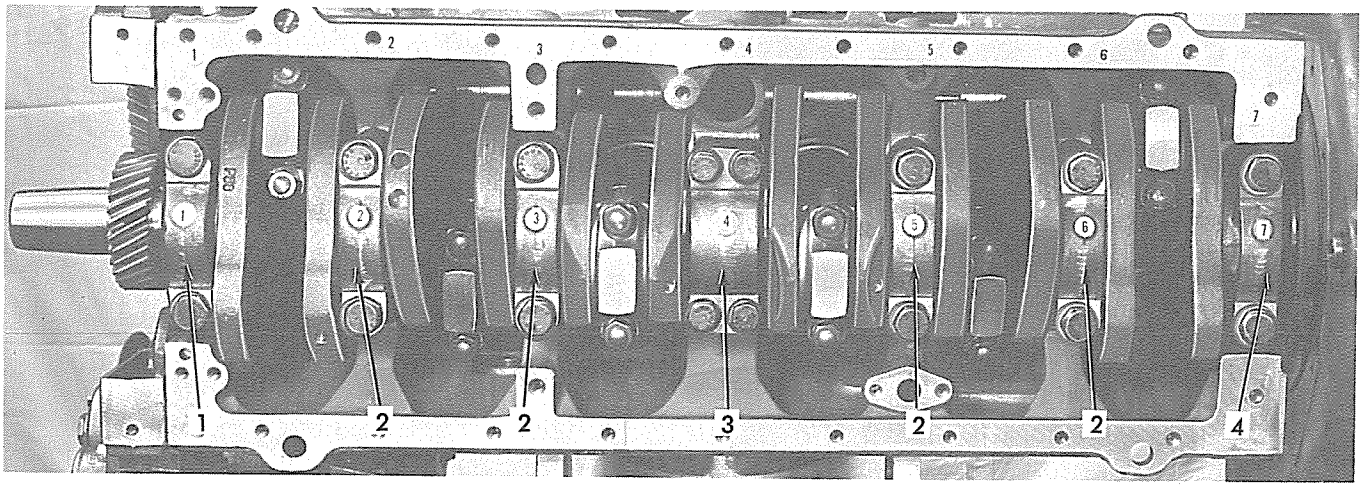


Fig. 8 — Main Bearing Caps Location
(T-71444)

1. Front Main Bearing Cap
2. Intermediate Main Bearing Cap
3. Center Main Bearing Cap
4. Rear Main Bearing Cap

in "MAIN BEARING REMOVAL, INSPECTION, AND INSTALLATION" in this Section).

2. MAIN BEARING INSTALLATION WITH ENGINE INSTALLED

a. Install all main bearings, except the center main, as follows:

Lubricate a bearing shell with clean oil and start end of bearing shell (end having no tang) around crankshaft bearing journal, so that when bearing shell is in place, tang will fit into slot in shell seat.

NOTE

The halves of the main bearing shells are identical, therefore, they may be installed in either the upper or lower positions.

The main bearing caps are numbered 1, 2, 3, etc. indicating their respective positions, refer to Fig. 8.

Install a bearing shell in position in the bearing cap with tang of shell in corresponding slot in bearing cap. Install the cap retaining capscrews and lockwashers, tighten the capscrews evenly to a torque of 210 - 230 lbs. ft.

NOTE

On later model engines, lockwashers and locking plates are not used and plain hardened steel washers are used instead.

b. Lubricate and install the upper half of center main bearing shell making certain that tang of shell engages with slot in seat. Install the upper halves of the thrust flanges (flanges without dowel pin holes) with oil grooved side of flanges toward cheeks of crankshaft. Install the bearing shell in center main bearing cap with tang of shell in corresponding slot in bearing cap. Install the lower halves of the thrust flanges on the dowel pins in the center main bearing cap with the oil grooved side of flanges to the outside of bearing cap. Lubricate and place bearing cap in position on cylinder block. Install cap retaining capscrews and locking plates, if so equipped. Tighten the capscrews evenly to a torque of 160 - 170 lbs. ft.

c. After all bearing shells have been installed, retighten main bearing capscrews using a torque indicating wrench. Tighten 3/4" capscrews to a torque of 210 - 230 lbs. ft. and tighten 5/8" capscrews used on center main bearing to 160 - 170 lbs. ft. Lock capscrews with lockwashers and center main bearing capscrews with locking plates, if so equipped.

CAUTION

Do not overtighten main bearing capscrews. If these capscrews are overtorqued, bearing caps will be distorted, causing bearing to be drawn tight against the crankshaft journals and premature failure will result. The crankshaft should turn freely after all capscrews are tightened to the specified torque.

d. Check crankshaft end play (refer to "CRANKSHAFT AND CRANKSHAFT GEAR" in this Section).

e. Install oil pump and associated tubing (refer to "LUBRICATING SYSTEM" Section). Install oil pan. Fill engine crankcase to the proper level with the specified oil.

f. Install fuel injection nozzle-holders (refer to "FUEL SYSTEM" Section).

TOPIC 3 - MAIN BEARING CAPS

A. GENERAL

Replacement caps for front, intermediate, and rear bearings locations are machine finished except for the bore which is semi-finished. The replacement center cap is machine finished except for the bore and the thrust faces.

Main bearing caps are not interchangeable, and if replacement becomes necessary, new caps must be machined in place. To maintain correct alignment and size in the main bearing bore in the block, caps must be installed to the specified torque before machining. Replacement of main bearing caps is a machine shop job.

B. MAIN BEARING CAP REPLACEMENT

When it is necessary to do any machining to the main bearing bore in the block, it is important that the center line of the crankshaft is not altered from its original center line, especially at the timing gear end. Raising the bore .003" - .004" at the flywheel end of the engine can be tolerated if the bore is made straight and the front main bore is not repositioned. When installing a replacement cap, make certain the casting or part number on the cap is in the same relative position as the number on the old cap when installed.

If a main bearing burns out with enough heat to cause distortion at one or more of the main bearing bores or saddles, generally the block and bearing caps will pull in at their joint causing an oblong bore. If the flat areas, where the cap contacts the block around the main bearing attaching capscrews, have distorted so they are no longer flat and straight, the area will have to be hand filed and fitted to the replacement bearing cap so that when the new cap is installed it will not be distorted from being pulled down on an out-of-square surface. A thin coat of Prussian Blue can be used on the new cap to detect any out-of-squareness at this point.

SECTION 15 - CYLINDER BLOCK AND CYLINDER SLEEVES

TOPIC NO.	TITLE	PAGE
1.	CYLINDER BLOCK	
	A. Description	15-1
	B. Cylinder Block Cleaning and Inspection	15-1
2.	CYLINDER SLEEVES	
	A. Cylinder Sleeve Inspection and Removal	15-2
	B. Cylinder Sleeve Installation	15-3
	C. Cylinder Sleeve Reseating	15-6

TOPIC 1 - CYLINDER BLOCK

A. DESCRIPTION

The cylinder block, which is the main structural part of the engine, is a one-piece casting made of alloy cast iron. Transverse members, cast integral, provide rigidity and strength, assuring perfect alignment of crankshaft bearings and cylinder sleeves. The cylinder block is bored to receive removable "wet-type" cylinder sleeves. The cylinder sleeves are completely surrounded by water jackets which extend the full length of cylinder walls for maximum cooling.

The cylinder block contains a main oil gallery which extends lengthwise through the cylinder block. Oil passages direct oil from main oil gallery to main bearings and camshaft bearings, and through rifle drilled connecting rods to the piston pins. A horizontal and vertical oil passage through center of cylinder block extends from the main oil gallery to a cavity in left side of block, from this cavity there is an opening that aligns with oil passages in the cylinder heads that allows oil to flow through #3 and 4 rocker shaft brackets to the hollow rocker arm shafts and through drilled holes to each rocker arm.

Short dowel pins, pressed into top deck of the cylinder block, properly position cylinder head gasket and head assembly in relation to cylinder sleeves and the combustion chamber in the pistons.

The cylinder block, when ordered for service, is furnished with cam bearings, main bearing caps and studs, and the necessary plugs.

The removable "wet-type" cylinder sleeves are made of alloy cast iron. Two packing rings, fitted into grooves in the lower outside circumference of sleeve, prevent water leakage into crankcase. The sleeve is sealed at the top by a flange which fits into a machined recess in cylinder block. The cylinder head gasket is compressed between this flange and cylinder head, holding sleeve in place and serving as a coolant seal at upper end of the sleeve.

B. CYLINDER BLOCK CLEANING AND INSPECTION

Whenever the engine is being overhauled, the block should be thoroughly inspected for any conditions that would render it unfit for further use. Such inspection must be made after all the parts have been removed and it has been thoroughly cleaned with live steam, or a suitable solvent, and dried with compressed air.

All the oil passages in the cylinder block must be cleaned before assembling the engine. Effective cleaning of these passages can be accomplished only with the use of high steam pressure with a solvent used in the water to dissolve the sludge and foreign material that has collected. Remove the oil pressure regulating valve and the various plugs of the oil galleries to clean the passages. After cleaning, flush the passages with clean water (under pressure) to remove all traces of the solvent.

To clean the water jacket of the cylinder block, apply high pressure steam and water to the block and turn the block in various positions while this is being done so that the loose scale will be washed out.

IMPORTANT

Note the location of the plugs removed for cleaning of the passages in the cylinder block and be sure all the plugs are reinstalled in their proper places after the block has been cleaned and dried. The plugs must be installed so that they do not interfere with attached parts.

TOPIC 2 - CYLINDER SLEEVES

A. CYLINDER SLEEVE INSPECTION AND REMOVAL

The cylinder sleeves may be removed and replaced while the engine is installed in the unit by removing the cylinder head, oil pan, oil pump and associated tubing, and the piston and connecting rod assemblies.

NOTE

This applies to all units except those in which the engine must be removed in order to remove the oil pan; however, removal of the cylinder sleeves while the engine is installed is only recommended in emergencies or when it is impractical to remove the engine from the unit.

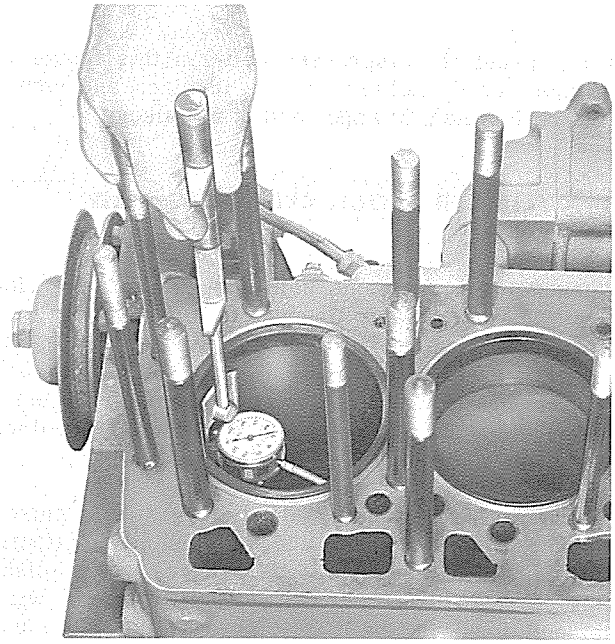


Fig. 1 — Checking Cylinder Sleeve for Roundness (T-20224)

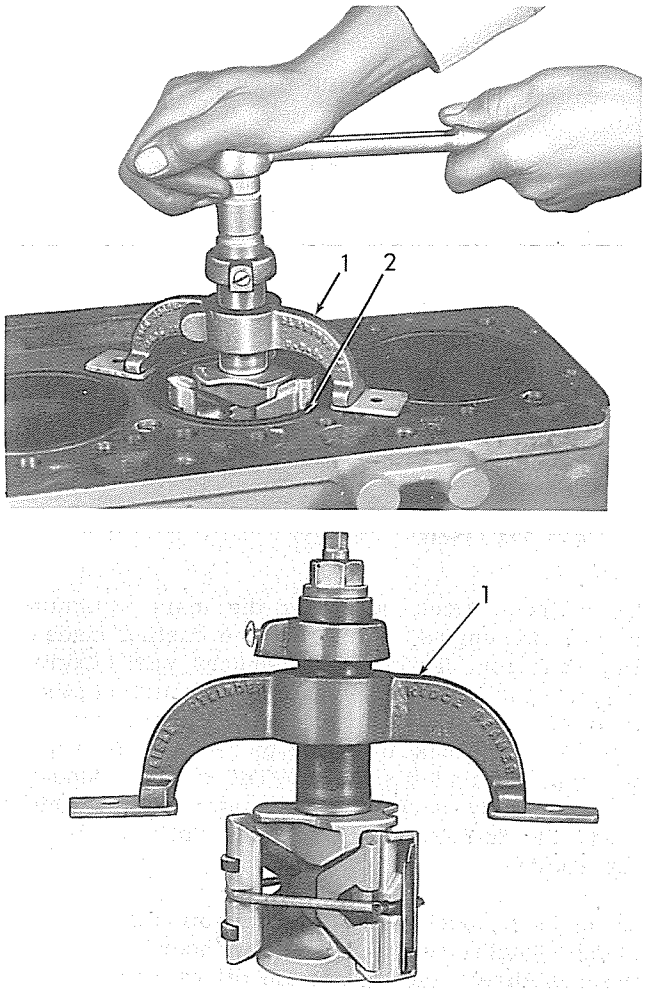


Fig. 2 — Removing Ring Travel Ridge from Cylinder Sleeve (T-27616 — T-27617)

1. Ridge Reamer Tool
2. Cylinder Sleeve

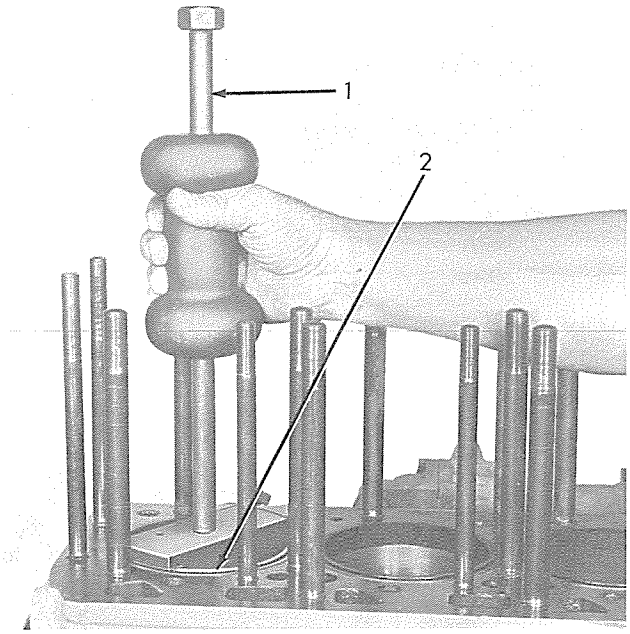
1. Check cylinder sleeves for roundness by means of a gauge similar to the one shown in Fig. 1. Using an inside micrometer, measure cylinder sleeve for taper and wear. The specified inside diameter of a cylinder sleeve is 4.4370" - 4.4385".

   When measuring cylinder sleeves with an inside micrometer, first measure in a position parallel to crankshaft and then at right angles to crankshaft. These measurements should be taken at several locations within the area of piston ring travel. The normal pattern of wear in cylinder sleeves will show maximum wear at the top three-fourths of ring travel. If maximum sleeve wear at top of ring travel does not exceed .003" out-of-round, .008" total wear, and no deterioration of the flange has occurred to decrease the specified protrusion (standout), the sleeves may be reinstalled with a life expectancy of approximately one-half to three-fourths of new sleeves. The sleeves must be free of cracks, scores, and other physical defects.

2. If the cylinder sleeves are to be reused, it is important that the ridge above the ring travel is removed with a hone or a ridge removing tool similar to the one shown in Fig. 2, and that the glaze in ring travel area is broken.

3. Remove cylinder sleeves using removal tool as shown in Figs. 3 and 4.

4. Remove all dirt, carbon, and oil from cylinder sleeves and machined recess and bore in cyl-



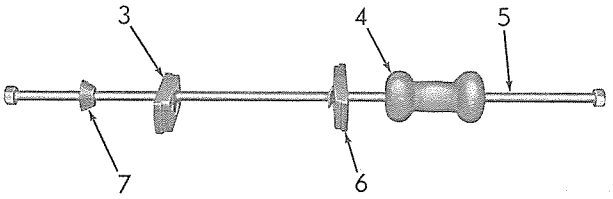


Fig. 3 — Removing Cylinder Sleeve — Top View (T-20217 — T-19306)

1. Cylinder Sleeve Remover Tool
2. Cylinder Sleeve
3. Puller Shoe
4. Slide Hammer
5. Puller Rod
6. Top Shoe Assembly
7. Shoe Centering Cone

inder block. Replace sleeves if scored or cracked.

B. CYLINDER SLEEVE INSTALLATION

1. Thoroughly clean cylinder sleeve and the bore in cylinder block. Make certain bottom surface of flange on cylinder sleeve and the counterbore in cylinder block are clean and free from nicks or burrs. Before installing packing rings on sleeve, insert sleeve into bore of cylinder block to make sure sleeve can be pushed down into place and turned in the bore by hand pressure. If the sleeve cannot be inserted and turned in the above manner, more cleaning is necessary.
2. Check the out-of-square relationship of the cylinder sleeve counterbore to the center line of the cylinder, using a special sleeve tool with an attached dial indicator as shown in Fig. 6. Rotate the sleeve with the contact point

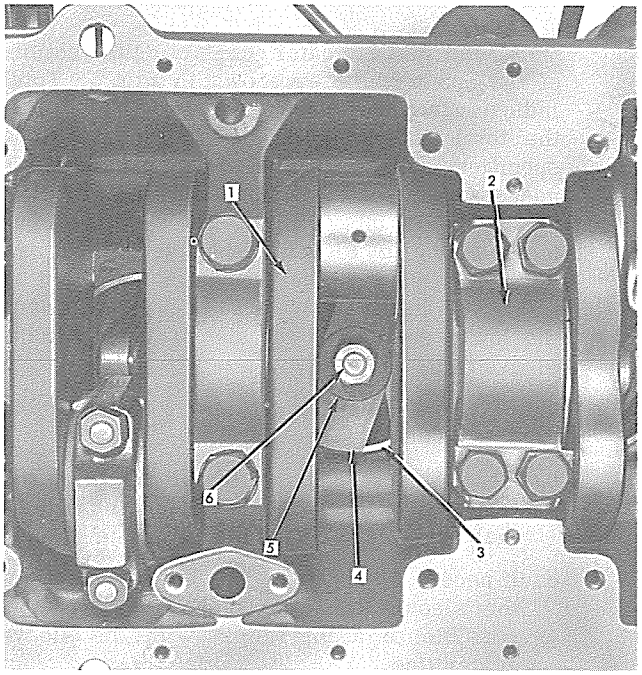
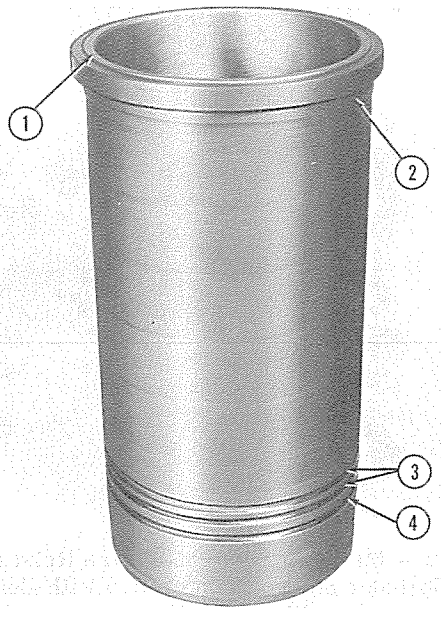


Fig. 4 — Removing Cylinder Sleeve — Bottom View (T-19373)

1. Crankshaft
2. Main Bearing Cap
3. Cylinder Sleeve
4. Cylinder Sleeve Puller Shoe
5. Shoe Centering Cone
6. Puller Rod



T-27305

Fig. 5 — Cylinder Sleeve

1. Fire wall
2. Flange
3. Top grooves for black rings
4. Lower groove for silicone (red) ring

(2) of the dial indicator, contacting the bottom of the counterbore as shown in Fig. 6. Total indicator reading should not exceed .002". If the total dial indicator reading exceeds the specified limit, reworking of the counterbore is necessary (refer to "CYLINDER SLEEVE RE-SEATING" in this Topic). The special sleeve tool, shown in Fig. 6, is made from a new cylinder sleeve. The sleeve is machined as follows to assure proper relationship between the lower surface of the sleeve flange and the sleeve center line.

a. Place the flange end of a new sleeve in the chuck of a lathe.

b. True the center line of the sleeve as closely as possible to the lathe center by using dial indicators at each end of the sleeve.

c. If necessary, machine the bottom surface of the sleeve flange to make it as true as possible to a 90^{o} angle with the sleeve center line.

d. Refer to Fig. 6 (4) and cut a V-section out of the sleeve to allow the dial indicator to contract the sleeve counterbore in the cylinder block. Drill and tap two holes in the sleeve and attach a strap or bar (5) as shown.

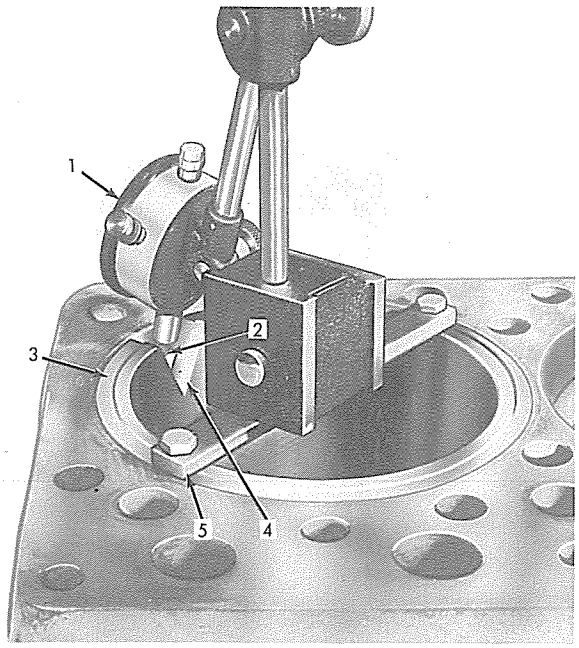


Fig. 6 — Measuring Out-of-Square Relationship of Cylinder Sleeve Counterbore with Center Line of Cylinder
(T-40261)

1. Dial Indicator
2. Indicator Contact Point
3. Cylinder Sleeve Tool
4. V-Section (Cut from Sleeve)
5. Mounting Bar

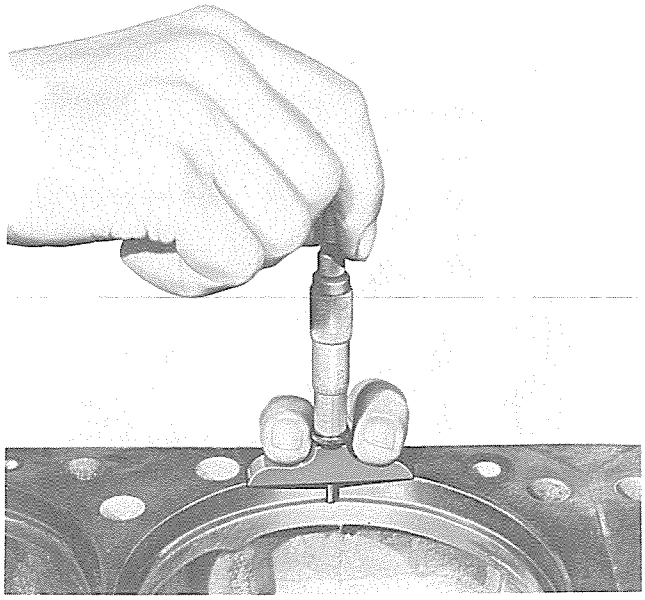


Fig. 7 — Measuring Depth of Cylinder Sleeve Counterbore
(T-40259)

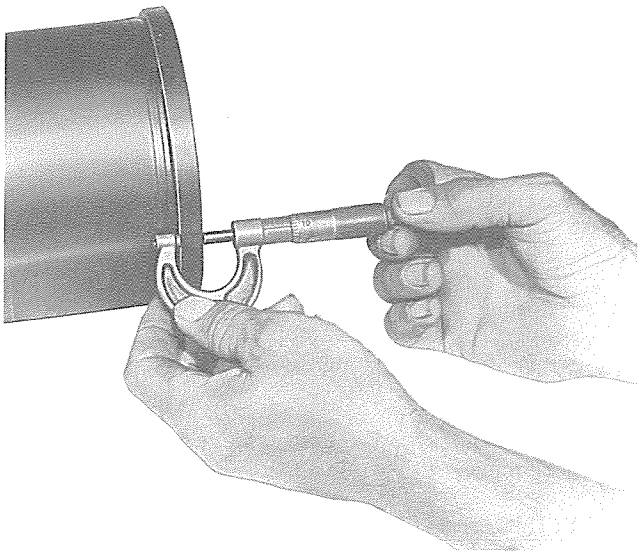


Fig. 8 — Measuring Width of Cylinder Sleeve Flange
(T-40260)

3. The protrusion (standout) of the cylinder sleeve flange above the top flat surface of the cylinder block is very important.

   a. Using a depth micrometer, as shown in Fig. 7 measure depth of cylinder sleeve counterbore in the cylinder block (measure at two or more locations). The specified depth is .3125" - .3135".

b. Using an outside micrometer, as shown in Fig. 8, measure thickness of cylinder sleeve flange (measure at two or more locations). The specified flange thickness on sleeves used in early model engines is .320"-.322" and on late model engines the specified thickness is .3155"-.3175".

c. Subtract counterbore depth from width of cylinder sleeve flange; the result is the cylinder sleeve standout. The specified standout for early model sleeves having a flange .320"-.322" thick is .0065"-.0095" and for later model sleeves having a flange .3155"-.3175" thick, the specified sleeve standout is .002"-.005". If the sleeve standout is not within the specified limits, install a cylinder sleeve shim of the proper thickness in the sleeve counterbore in the cylinder block. Cylinder sleeve shims are available in .005", .008", .010", .015" and .020" thickness. If shimming will not correct the cylinder sleeve standout, reworking of the counterbore will be necessary (refer to "CYLINDER SLEEVE RESEATING" in this Topic).

4. Cylinder sleeve packing rings can be identified by their color and/or color code marks. Silicone packing rings are red, Buna-N rings are black, and ethylene propylene rings are black with color code marks.

   New packing rings must be used at each installation of a new or used cylinder sleeve.

CAUTION

Silicone rubber backing rings are very tender, having less than half the tensile strength of the ethylene propylene rings. Use extreme care in handling and installing these rings in order not to cut or shear them.

Silicone and ethylene propylene packing rings swell and expand after short contact with petroleum products and certain types of permanent antifreeze. This makes installation of cylinder sleeve into cylinder block impossible. For this reason, do not presoak or apply lubricant to the packing rings until immediately prior to installation of cylinder sleeve into cylinder block.

A special cylinder sleeve packing ring lubricant may be purchased from your Fiat-Allis dealer. If this lubricant is not available, use liquid edible vegetable oil.

Use of white lead, grease, or any other lubricant of heavy consistency when installing the cylinder sleeve can displace the packing rings from their grooves and cause damage to them. Use lubricant specified for the cylinder sleeve packing rings when installing cylinder sleeves in cylinder block.

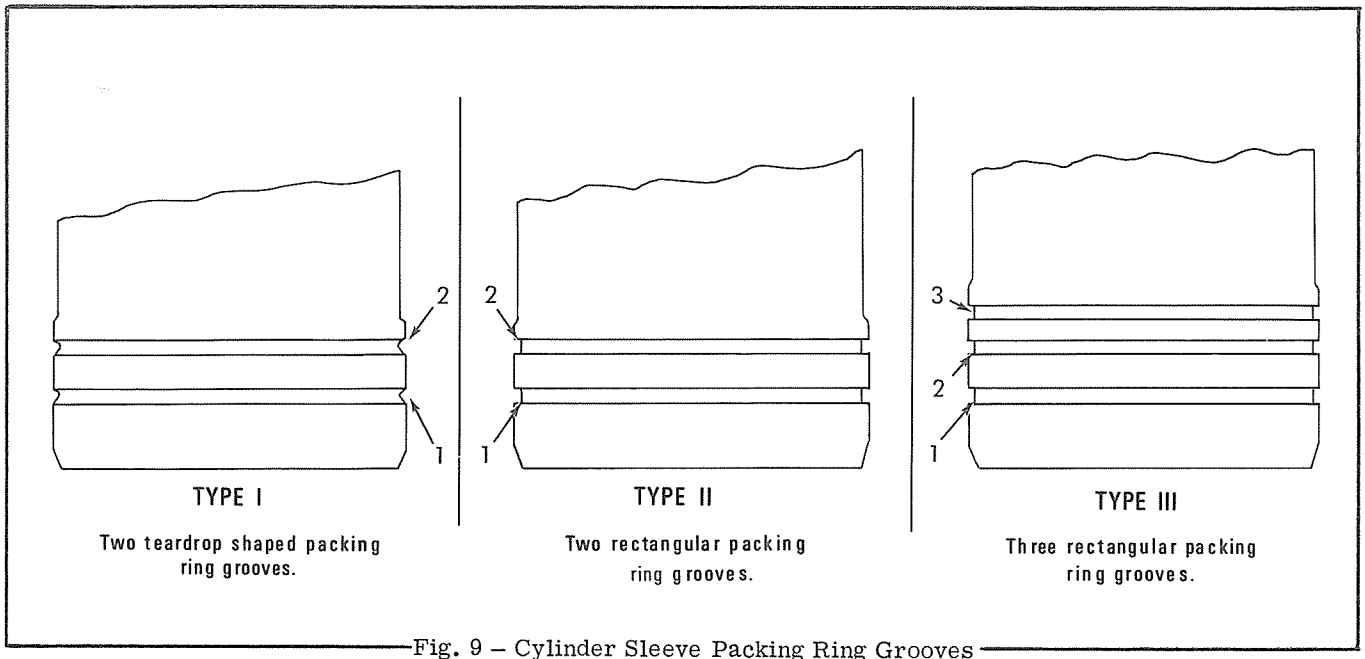


Fig. 9 – Cylinder Sleeve Packing Ring Grooves (T-35341)

1. Bottom Groove
2. Second Groove
3. Third Groove

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

5. Thoroughly clean packing ring grooves in the cylinder sleeve. Stand sleeve on a clean work bench, packing ring end up. Refer to Fig. 9 and install dry packing rings on dry cylinder sleeve as follows:

   Type I: Install a Buna-N (black) packing ring in each groove. Silicone packing rings cannot be used in this type groove.

   Type II: Install an ethylene propylene (black with two white color bands) packing ring in second groove (2) and a silicone (red) packing ring in bottom groove (1).

   Type III: Install an ethylene propylene (black with two white color bands) packing ring in third groove (3). The white bands indicate a special size ring for the third groove. Install an ethylene propylene (black with two blue dots or slash marks) packing ring in second groove (2) and a silicone (red) packing ring in bottom groove (1).

6. Brush a light coat of the specified lubricant in the lower sleeve bores in the cylinder block and a light coat of the specified lubricant to the packing rings immediately before installing the cylinder sleeve, into the cylinder block.

7. Install the cylinder sleeve in the block by hand; do not force. Be extremely careful so packing rings are not cut on sharp edges of bore in block when installing.

C. CYLINDER SLEEVE RESEATING

Cylinder sleeve reseating may become necessary if the cylinder sleeves have been allowed to move due to incorrectly torqued cylinder head nuts, deteriorated head gaskets, or from block counterbore or sleeve flanges eroding from long use. It is important that the cylinder sleeve standout from the top surface of the cylinder block be held at the specified dimension. Variation of more than .003" between adjacent sleeves must not be allowed.

Use of a cylinder sleeve reseating tool similar to the one shown in Fig. 10 is recommended. Cylinder sleeve shims are available in .005", .008", .010", .015" and .020" thicknesses to re-establish the specified cylinder sleeve standout. After using the reseating tool, determine the thickness of the shim required by measuring the depth of the counterbore with a depth micrometer, Fig. 7, and the thickness of the cylinder sleeve flange with an outside micrometer, Fig. 8.

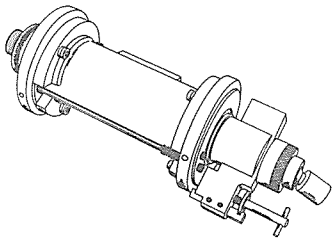


Fig. 10 – Cylinder Sleeve Reseating Tool (T-51419)

SECTION 16 - ENGINE REMOVAL AND INSTALLATION

TOPIC NO.	TITLE	PAGE
1.	GENERAL	16-1
2.	ENGINE REMOVAL AND INSTALLATION	
	A. Engine Removal (Track-Type Tractors)	16-1
	B. Engine Removal (Tractor Shovels)	16-2
	C. Engine Removal (Motor Graders)	16-2
	D. Engine Removal (Tractor Loaders and Tractor Dozers)	16-2
	E. Engine Installation	16-2

TOPIC 1 - GENERAL

Many repair and replacement procedures may be accomplished with the engine installed in the unit. However, some replacements such as the crankshaft, camshaft bearings, flywheel housing, etc. require that the engine be removed. When an adequate hoist is available and extensive repair work is contemplated, it is usually advisable to remove the engine and place it on an engine stand. The advantage of having all parts of the engine easily accessible will more than compensate for the time required to remove the engine. When an engine is to be overhauled or rebuilt it is imperative that the engine be removed from the unit so that all parts, including the cylinder block, may be thoroughly cleaned.

Clean the unit, before removing the engine, with emphasis on the engine compartment. Steam clean the engine after it is removed from the unit.

Depending upon the engine application, an engine clutch and/or torque converter is bolted to the flywheel housing, and on some applications the transmission is bolted to the torque converter. On some units it is easier to remove the engine with these components attached to it than it is to remove them first. After the engine is removed from the unit, these components may be removed with a minimum of effort.

All engines are equipped with lifting eyes located at the front and rear of the cylinder block and a lifting sling, spacing bar, or equivalent equipment is required to lift the engine.

The hoist must have a capacity of 2000 - 3000 lbs. (3000 lb. minimum capacity when transmission is removed with engine) and have sufficient raise to permit the engine to clear the unit.

The following procedures cover removal of the engine in a general rather than a specific way because of the many units in which the engines are used and the large variety of special equipment items which may be installed on the unit. Specific locations of disconnect points are left to the discretion of the mechanic and are determined to a great extent by the tools which are available to him.

CAUTION

When removing the engine, make certain all necessary wiring, lines, linkage, etc. are disconnected and that no parts are damaged by careless handling.

TOPIC 2 - ENGINE REMOVAL AND INSTALLATION

A. ENGINE REMOVAL (TRACK-TYPE TRACTORS)

1. Turn electrical system master switch to off position. Shut off fuel.
2. Remove engine hood and front fenders.
3. Drain cooling system.
4. Remove fan and lower it into fan shroud.
5. Disconnect necessary wiring and lines from the cowl and remove the cowl.
6. Disconnect drive shaft universal joint. If a hydraulic pump is driven by the crankshaft pulley, disconnect the pump drive shaft.
7. Disconnect the fuel lines, wiring, hydraulic lines, and control rods necessary to remove the engine.
8. Remove high nuts and capscrews attaching the engine front mounting cross member and rear mounting brackets to the main frame.

9. Raise engine slightly and move it toward the rear. When engine is free from all obstructions, raise and remove engine, engine clutch and/or torque converter as a unit.

B. ENGINE REMOVAL (TRACTOR-SHOVELS)

1. Tip bucket forward as far as it will go and lower to ground.
2. Turn electrical system master switch to off position. Shut off fuel.
3. Remove engine hood and front fenders.
4. Remove radiator guard or tilt it forward.
5. Drain cooling system and remove radiator and radiator support.
6. Remove floor plates and disconnect drive shaft universal joint.
7. Drain shovel hydraulic system.
8. Disconnect the fuel lines, wiring, hydraulic lines, and control rods necessary to remove the engine.
9. Remove high nuts and capscrews attaching the engine front mounting cross member and rear mounting brackets to the main frame.
10. Raise engine slightly and move it forward. When engine is free from all obstructions, raise and remove engine, engine clutch and/or torque converter as a unit.

C. ENGINE REMOVAL (MOTOR GRADERS)

1. Disconnect batteries and shut off fuel.
2. Remove engine hood and radiator grill.
3. Drain cooling system and remove radiator.
4. Disconnect the fuel lines, wiring, hydraulic lines, and control rods necessary to remove the engine.

NOTE

Mark all lines for reassembly.

5. Loosen and remove power take-off drive belts.
6. Remove capscrews and lockwashers securing power take-off supporting bracket to engine.
7. Remove the engine mounting bolts.
8. Raise engine slightly and move away from transmission until splined universal joint shaft is disconnected. Move engine until it is free from all obstructions then raise and remove engine and engine clutch as a unit.

D. ENGINE REMOVAL (TRACTOR LOADERS AND TRACTOR DOZERS)

1. Remove side panels and engine hood.
2. Disconnect the batteries.
3. Drain cooling system and disconnect radiator inlet and outlet hoses.
4. Bleed air tank and disconnect all air lines between tank and engine.
5. Remove radiator support braces, fan shroud, and fan.
6. Disconnect the fuel lines, wiring, hydraulic lines, air lines, and control rods necessary to remove the engine. NOTE: Mark all lines for reassembly.
7. Remove the capscrews attaching the transmission to the flywheel housing.

CAUTION

On later model units, first remove the capscrews attaching the flex plate drive to the flywheel.

8. Remove the engine mounting bolts.
9. Raise engine slightly and move away from transmission. Move engine until it is free from all obstructions then raise and remove engine and torque converter as a unit.

E. ENGINE INSTALLATION

The engine, in all units, may be installed by a reversal of the removal procedure.

When lowering the engine into the unit, use care to prevent crushing any tubes, lines, or wiring by careless handling.

On track-type tractors, the drive shaft universal joint may be connected by assembling the spider after the engine is installed in the unit.

On motor graders, the drive shaft universal joint must be guided onto the splined end of the transmission shaft as the engine is being moved into position.

On tractor loaders equipped with a flex plate drive, it is advisable to fabricate, out of light gauge metal, a semi-circular trough about 6" long to be used as a safety retainer when installing the capscrews attaching the flex plate drive to the flywheel.

After engine is installed, fill the cooling system. Fill the engine crankcase and the hydraulic systems to the proper level, with the specified oil. Vent the fuel system. After the engine has been run for a short period of time check for oil, water, or air leaks and correct any leaks found. Recheck the water and oil levels and add water or oil as necessary.

SECTION 17 - ENGINE DISASSEMBLY AND ASSEMBLY

TOPIC NO.	TITLE	PAGE
1.	GENERAL INFORMATION	
	A. Cleaning	17-1
	B. Ball and Roller Bearings	17-1
	C. Bushings	17-2
	D. Lip Type Oil Seals	17-2
	E. Gaskets	17-2
	F. Piping or Tubing	17-2
	G. Fasteners	17-2
	H. Shims	17-2
2.	ENGINE DISASSEMBLY AND ASSEMBLY	
	A. Engine Disassembly	17-2
	B. Engine Assembly	17-3
	C. Engine Run-in Schedule	17-3

TOPIC 1 - GENERAL INFORMATION

This general information will be helpful when disassembling or assembling an engine. It should be read and kept in mind while the work is being performed.

A. CLEANING

After electrical equipment is removed, the exterior of the engine should be thoroughly cleaned, preferably steam cleaned.

In many repair shops and service departments, caustic compounds are used to clean grease, dirt, paint, gasket remnants, etc., off parts. These compounds are very effective and very useful when used properly, but can cause considerable damage to certain materials.

Materials such as aluminum, rubber, fiber, sintered bronze and bonding agents are particularly sensitive to all highly concentrated caustic cleaners. There are many of these cleaning compounds on the market, under various trade names, but the majority of them are based on the same active agent — sodium hydroxide. Steam jenny compounds also generally contain this agent.

Some current oil coolers and radiators are being manufactured with aluminum fins. A few cleaning solutions have been found to react with aluminum to the extent of dissolving the metal.

We recommend that Trichlorethylene solvent or equivalent be used for both internal and external cleaning of oil coolers and radiators used in Fiat-Allis units since there is no reaction between the aluminum and the solvent. Radiator service stations should be advised accordingly.

In all cleaning operations care should be taken in the selection of cleaning materials. When any doubt exists as to whether or not caustic compounds would damage the materials to be cleaned, the use of such compounds should be avoided.

B. BALL AND ROLLER BEARINGS

After removal, thoroughly clean the bearings in clean solvent and dry with compressed air free of moisture. Inspect bearings to see that they roll freely and are free from cracked, pitted, or worn balls, rollers, and races. Make certain that the shield(s) and the ball retainers are in good condition and are not dented or damaged.

Badly worn ball bearings can be detected by the presence of excessive end play between the outer and inner races. This condition can be detected by holding one race steady and moving the other race endwise, comparing the difference in movement of the races of the used bearing and a new bearing. Check the outer and inner races for indications of bearing creepage. This can be detected by marks on the bearing races or on the bearing area of the bore or shaft where the bearing has been used. Always lubricate a bearing at assembly with clean lubricant. Do not use a bearing which is in bad condition.

After the bearings have been removed, keep the bearings spotlessly clean, well lubricated, and wrap the bearings in clean oil proof paper to prevent the entrance of dirt and rusting. When installing new bearings, do not remove the bearings from package until ready for assembling. Do not wash the lubricant from a new bearing.

Use a press and a suitable sleeve or driver when installing bearings. If these are not available, a cold rolled soft steel rod and hammer may be used to drive the bearings into position; do not strike the bearing shield or ball retainer when installing.

Bearings may be heated to expand the bore, thus facilitating the installation of the bearing on a shaft. One method of transferring heat to bearings is through the use of hot oil. The bearings should never be placed directly on the bottom of a tank or container, but should be suspended in the oil on hooks or placed on a screen so that they may be heated uniformly. A light or medium grade of clean lubricating oil should be used and the temperature must never exceed 300° F.

When installing a bearing on a shaft, drive or press on the inner race, when installing it in a bore, drive or press on the outer race.

Be careful not to strike the shield, snap ring, ball retainer, or balls when using a rod and hammer to install the bearings.

C. BUSHINGS

Do not remove the bushings for inspection unless the bushings are loose in their bores or are excessively worn, then they must be removed and replaced.

Use a press and a suitable sleeve or driver to install bushings. Ream the bushings to the specified dimensions when reaming is required.

D. LIP TYPE OIL SEALS

When any work has been done which involves the removal of a shaft from an oil seal, or the removal of an oil seal from its bore, the sealing lip of the seal must be carefully examined.

The sealing lip must not be scratched, folded over, torn, or charred from heat. The lip must be flexible and the spring, located inside the lip, must have the proper tension to return the lip to its proper position when the lip is pressed in by hand.

Be sure that the surface of the shaft contacted by the lip of the oil seal is smooth and free from burrs.

When installing an oil seal on a shaft, or a shaft through an oil seal, be sure to protect the sealing lip from damage which might be caused from a keyway, splines, threads, or a hole through the shaft. A small scratch or cut, or a fold in the lip of the seal, will render the seal useless.

Use an oil seal installing bushing, or a thin sheet of stiff paper wrapped around the sharp portion of the shaft, then slide the seal over the bushing or paper.

Use an oil seal installing tool or a press when installing seals into their bores, to prevent damage to the outer case of the seals. If the proper installing tools are not available, a smooth piece of metal or a block of wood can be placed flat against the face of the seal and the seal can be driven into position with a hammer.

When a new oil seal is to be installed, always lubricate the sealing lip before installing.

E. GASKETS

When the gasket is removed, clean the gasket and inspect it for damage. If it is in good condition, and is to be used again, immerse it in a container of oil and keep it in the container until it is needed. Do not use a gasket which is torn, hardened, or shrunken out of shape.

Never use cork or felt gaskets or seals a second time.

F. PIPING OR TUBING

Tighten fittings only tight enough to prevent leakage. If the fittings are drawn up too tight, damage may result.

Always be sure that the fittings and nuts are clean before tightening.

G. FASTENERS

Keep all nuts, bolts, hose clamps, etc., tight at all times. A periodic check of these parts does not take long and may prevent the occurrence of a major failure.

Replace any broken or missing capscrews, nuts, or lockwashers.

H. SHIMS

Shims should be flat and the surfaces clean and free from foreign substances or corrosion. When removing or adding shims, check the thickness of each shim with a micrometer to obtain accurate adjustments.

TOPIC 2 - ENGINE DISASSEMBLY AND ASSEMBLY

A. ENGINE DISASSEMBLY

Removal and installation of engine components such as cylinder head, cylinder sleeves, pistons, crankshaft, etc. are covered in the Section of the Manual which pertains to that particular component. The sequence of the order in which they are removed is left to the discretion of the mechanic.

An engine stand should be used whenever extensive repair or a complete overhaul of the engine is required. An adequate supply of pans or boxes should

be available for storage of small parts as they are removed. Parts having machined surfaces which could be damaged should be stored on wooden racks or blocks.

The extent of the work to be done on the engine determines what accessories such as starter, generator, water pump, hydraulic pumps, etc., must be removed. When an engine is to be completely overhauled, all accessories should be removed, disassembled, inspected, and repaired or replaced before they are reinstalled on the engine.

Parts which are identical, such as valves, should be marked or stored in suitable racks so they can be reinstalled in their original position. When shims are removed, tie them together and identify them. Keep them clean and flat until they are reinstalled.

B. ENGINE ASSEMBLY

Removal and installation of engine components such as cylinder head, cylinder sleeves, pistons, crankshaft, etc., are covered in the Section of the Manual which pertains to that particular component.

The working area where the engine is assembled must be kept as clean as possible. Keeping parts clean before and during assembly cannot be over emphasized. Dirt which enters the engine during assembly will cause abnormal wear and the engine will again need overhaul in a fraction of the time normally expected.

Use of the service tools illustrated in this Manual is recommended. Most jobs are accomplished faster and more accurately when the proper tools are used.

Whenever possible, press bushings into position with a press. If it is necessary to use a hammer to install a bushing, use a bushing driver or a suitable bar having a smooth flat end. If a bushing is equipped with an oil hole, make certain the hole is aligned with its corresponding oil supply hole. Some bushings require that an oil hole be drilled in the bushing after it is installed and some bushings require burnishing or reaming after installation. Always refer to pertinent Sections of this Manual for specific instructions on bushing replacement.

Lubricate ball bearings prior to installation. Lubricate bushings before the shaft is installed. Lubricate the sealing lip of all lip type seals before installing the seal. New seals should be used whenever possible.

New gaskets should be used wherever gaskets are required. New cylinder head gaskets MUST be used.

Use capscrews of the correct size and length. Size and length of the various capscrews are listed in the Parts List furnished with the unit. Lockwashers, cotter pins, locking wire, etc. must be used wherever indicated.

A torque indicating wrench is an indispensable tool when assembling the engine. A table of standard torques as well as a list of special torques is furnished in the "FITS AND TOLERANCE AND TORQUE SPECIFICATIONS" Section of this Manual and should be referred to whenever capscrews or nuts are tightened.

Refer to "VALVES, VALVE OPERATING MECHANISM, AND CYLINDER HEAD" Section for cylinder head capscrew torque and torque sequence and for valve lash adjustment.

When filling the engine crankcase, after engine has been overhauled, pour about two quarts of the crankcase lubricant over the rocker arm assemblies and the cylinder head components. This will assure initial lubrication of the valve and push rod mechanism.

C. ENGINE RUN-IN SCHEDULE

After installation of new cylinder sleeves or piston rings, engine must be run-in to allow rings to seat and avoid the possibility of cylinder sleeve scoring and excessive oil consumption. When an engine is first started after installation of cylinder sleeves or piston rings, excessive smoke, raw fuel, and lubricating oil may appear in the exhaust. This condition will correct itself as the engine is run-in.

Before starting engine after overhaul, inspect levels of engine oil, fuel oil, and cooling system, and see that air cleaner has been properly serviced.

The most important factor in running-in a new engine, or one which has been rebuilt, is OPERATING TEMPERATURE. The thermostat must function properly to maintain a minimum operating temperature of 180°F.

In field applications the run-in schedule will, of necessity, be governed largely by the degree to which the engine's load and speed can be controlled. However, in all cases, prolonged idle or low load operation should be avoided for the first 50 hours. Likewise, avoid sustained operation at maximum rated load for the first 24 hours. The following run in schedule is recommended:

1. Run at about 1000 RPM, no load, long enough to ascertain that oil and water are circulating properly and normal operating temperature has been reached.
2. Put engine into service at reduced loading for the next 24 hours.

   Short periods of full power are desirable to obtain maximum ring pressure on piston ring lands and cylinder walls to accelerate ring seating.
3. Resume normal operation within above underlined limitations of first 50 hours of operation.

NOTE

Make certain the proper type of engine lube oil is used. Refer to Operating Instructions and Field Maintenance Manuals. The same type and same SAE viscosity oil is used for engine run-in.

SECTION 18 - FITS AND TOLERANCES; BOLT, CAPSCREW, AND NUT TORQUE WRENCH SPECIFICATIONS; STUD GAUGE HEIGHTS

PARAGRAPH	TITLE	PAGE
A	FITS AND TOLERANCES	
	1. Cylinder Sleeves	2
	2. Cylinder Block	2
	3. Pistons	3
	4. Piston Pins	4
	5. Piston Rings	4
	6. Crankshaft	5
	7. Main Bearings	5
	8. Connecting Rod Bearings	6
	9. Connecting Rods	7
	10. Exhaust Valves	7
	11. Exhaust Valve Springs	8
	12. Intake Valves	8
	13. Intake Valve Inner Springs	9
	14. Intake Valve Outer Springs	9
	15. Exhaust Valve Seat Inserts	9
	16. Intake Valve Seat Inserts	10
	17. Exhaust and Intake Valve Guides	10
	18. Rocker Arms	11
	19. Camshaft	11
	20. Valve Lifters and Valve Lifter Bracket	12
	21. Front Gear Train	12
	22. Cylinder Head	12
	23. Lubricating Oil Pressure and Scavenging Pumps - Current Type	12
	24. Lubricating Oil Pressure Pump - Early Type	13
	25. Scavenging Oil Pump - Early Type	14
	26. Water Pump	14
	27. Fan Hub Assembly	15
	28. Auxiliary Drive Pulley - Front Housing Mounted	15
	29. Fan Drive Assembly (Crawler Tractors)	15
	30. Hydraulic Pump Drive (Crawler Tractors and Motor Graders with American Bosch Fuel Injection Pump)	16
	31. Hydraulic Pump Drive (Crawler Tractors and Motor Graders with Roosa Master DB or DC Fuel Injection Pump)	16
	32. Fan Belt Tightener (Crawler Tractors)	17
	33. Fan Belt Tightener (Motor Graders)	17
B	BOLT, CAPSCREW, AND NUT TORQUE WRENCH SPECIFICATIONS	18
	1. Specific Application Torque Values	18
	2. Standard Torque Values	19
C	STUD GAUGE HEIGHTS AND DRIVING TORQUES	20

A. FITS AND TOLERANCES

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
1. Cylinder Sleeves		
a. Type	Replaceable Wet	Replaceable Wet
b. Inside diameter	4.4370 - 4.4385	112.70 - 112.74
c. Diameter of sleeve at machined area just below flange	5.030 - 5.032	127.62 - 127.81
d. Diameter of cylinder sleeve at packing ring location	4.967 - 4.969	126.16 - 126.21
e. Sleeve flange outside diameter	5.249 - 5.253	133.32 - 133.43
f. Cylinder block-to-sleeve clearance at sleeve lower diameter	.001 - .005	.03 - .13
g. Cylinder block-to-sleeve clearance at machined area just below flange	.0005 - .0045	.01 - .11
h. Cylinder block-to-sleeve clearance at sleeve flange	.003 - .012	.08 - .30
i. Clearance of piston skirt with sleeve	.0050 - .0075	.13 - .19
j. Fire wall height above cylinder sleeve flange	.042 - .045	1.07 - 1.14
k. Cylinder sleeve flange thickness:		
Early	.320 - .322	8.13 - 8.18
Current	.3155 -.3170	8.01 - 8.05
l. Top surface of cylinder sleeve flange above cylinder block with sleeve installed:		
Early	.0065 - .0095	.17 - .24
Current	.0020 - .0055	.05 - .14
m. Flange height adjusting shims available	.005, .010, .015 and .020	.13 - .25 .38 - .51
n. Allowable taper	.0015	.04
o. Allowable out-of-round (when installed)	.0015	.04
2. Cylinder Block		
a. Counterbore diameter in cylinder block for cylinder sleeve flange	5.256 - 5.261	133.50 - 133.63

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
b. Depth of counterbore for cylinder sleeve flange	.3115 - .3135	7.90 - 7.96
c. Bore in cylinder block for cylinder sleeve - Top	5.0325 - 5.0345	127.83 - 127.88
d. Bore in cylinder block for cylinder sleeve - Bottom	4.970 - 4.972	126.24 - 126.29
e. Bore in cylinder block for camshaft bearings	2.4975 - 2.4985	63.44 - 63.46
f. Bearing bore in cylinder block for main bearings (without bearing, cap in place, and capscrews tightened to specified torque)	3.8118 - 3.8125	96.82 - 96.84
3. Pistons		
NOTE: Combustion chamber is in top of piston.		
a. Combustion chamber depth:		
Second type	.733 - .737	18.62 - 18.72
First type	1.183 - 1.187	30.05 - 30.15
b. Combustion chamber I. D.:		
Shallow combustion chamber - Current Engines	2.998 - 3.002	76.15 - 76.25
Deep combustion chamber - Early Engines	2.258 - 2.262	57.35 - 57.45
c. Material	Aluminum Alloy	Aluminum Alloy
d. Length	5.993 - 5.997	152.22 - 152.32
e. Diameter between top and second ring groove:		
Shallow combustion chamber - Current Engines	4.402 - 4.406	111.81 - 111.91
Deep combustion chamber - Early Engines	4.406 - 4.410	111.91 - 112.01
f. Diameter at bottom of skirt at right angle to piston pin		
Second type	4.431 - 4.432	112.55 - 112.57
First type	4.429 - 4.430	112.50 - 112.52

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
g. Bore for piston pin:		
Shallow combustion chamber - Current Engines		
First type - straight bore	1.6268 - 1.6272	41.32 - 41.33
Current - oval bore		
Vertical (minor axis)	1.6268 - 1.6272	41.32 - 41.33
Horizontal (major axis)	1.6307 - 1.6312	41.02 - 41.03
Deep combustion chamber - Early Engines	1.6264 - 1.6266	41.31 - 41.32
h. Measurement from center of piston pin bore to top of piston	3.609 - 3.613	91.67 - 91.77
i. Clearance of piston skirt with sleeve		
Second type	0.0050 - 0.0075	.13 - .19
First type	0.0070 - 0.0095	0.12 - 0.24
4. Piston Pins		
a. Type	Full Floating	Full Floating
b. Piston pin length	3.789 - 3.804	96.24 - 96.62
c. Diameter of pin	1.6265 - 1.6267	41.31 - 41.32
d. Fit of pin in piston at room temperature		
Second type	.0001 - .0007 tight	.002 - .018 tight
First type	.0001 - .0003 tight	.002 - .008 tight
e. Inside diameter of connecting rod bushing	1.6277 - 1.6282	41.34 - 41.37
f. Piston pin-to-connecting rod bushing clearance	.001 - .0017	.03 - .04
5. Piston Rings		
NOTE: Only standard size rings are available.		
a. Number of rings on each piston	4	4
b. Location of rings	All above piston pin	All above piston pin
c. Gap between ends - fitted		
1st ring (chrome compression		
First type pistons	.013 min - .033 max	.33 min - .84 max
Second type pistons	.013 min - .028 max	.33 min - .71 max
2nd and 3rd rings (compression)	.013 min - .033 max	.33 min - .84 max
4th ring (oil control)	.008 min - .028 max	.20 min - .71 max

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
d. Clearance of rings in grooves		
1st ring (chrome compression)	.004 - .007	.10 - .18
2nd and 3rd rings (compression)	.003 - .005	.08 - .13
4th ring (oil control)	.0015 - .004	.04 - .10
6. Crankshaft		
a. Journal diameter for connecting rods	2.7710 - 2.7725	70.38 - 70.42
b. Journal diameter for main bearings	3.4975 - 3.4990	88.84 - 88.87
c. Width between connecting rod journal cheeks	1.750 - 1.754	44.45 - 44.55
d. Width of main bearing journals		
Front	2.250 - 2.255	57.15 - 57.28
Intermediate	1.623 - 1.627	41.22 - 41.33
Center	2.688 - 2.692	68.28 - 68.38
Rear	2.230 - 2.240	56.64 - 56.90
e. Crankshaft end clearance	.006 - .014	.15 - .36
f. Separate type thrust flanges - standard and oversizes	.005, .010, and .015	.13, .25, and .38
g. Crankshaft journals may be ground	.010, .020, .030 or .040 undersize	.25, .51, .76 or 1.02 undersize
h. Fit of crankshaft gear on crankshaft	.0010 - .0028 tight	.03 - .07 tight
7. Main Bearings		
a. Number used	7	7
b. Type	Replaceable Precision	Replaceable Precision
c. Inside diameter of front, intermediate, center and rear bearing (with capscrews tightened to specified torque) (measured vertically)	3.501 - 3.5027	88.93 - 88.97
d. Diameter of crankshaft main bearing journals	3.4975 - 3.499	88.84 - 88.87
e. Bearing-to-journal clearance at front, intermediate, center and rear bearings (with capscrews tightened to specified torque)	.002 - .0052	.05 - .13

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
f. Overall length of main bearings		
Front and Intermediate	1.348 - 1.358	34.24 - 34.49
Center	2.244 - 2.254	57.00 - 57.25
Rear	1.991 - 2.001	50.57 - 50.83
g. Undersize bearings available for service	.010, .020, .030 and .040	.25, .51, .76 and 1.02
h. Separate type thrust flanges - Standard and oversize	.005, .010, and .015	.13, .25 and .38
i. Front, intermediate, center and rear bearing wall thickness (standard bearings)	.1549 - .1554	3.93 - 3.95
j. Bearing bore in cylinder block (without bearing, cap in place, and capscrews tightened to specified torque)	3.8118 - 3.8125	96.82 - 96.84
8. Connecting Rod Bearings		
a. Type	Replaceable Precision	Replaceable Precision
b. Inside diameter of bearing (with fasteners tightened to specified torque) (Measured vertically)	2.7745 - 2.7760	70.47 - 70.51
c. Diameter of crankshaft connecting rod journals	2.7710 - 2.7725	70.38 - 70.42
d. Connecting rod bearing-to-journal clearance (with nuts tightened to specified torque)	.0025 - .0050	.06 - .13
e. Overall length of connecting rod bearings	1.363 - 1.373	34.62 - 34.87
f. Undersize bearings available for service	.010, .020, .030 and .040	.25, .51, .76 and 1.02
g. Bearing wall thickness (standard bearing)	.12475 - .12525	3.17 - 3.18

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
9. Connecting Rods		
a. Type	Balanced Forging	Balanced Forging
b. Fasteners per rod-socket head cap-screw type	2	2
c. Connecting rod length (center-to-center)	10.498 - 10.502	266.65 - 266.75
d. Inside diameter of connecting rod bushing (finished bore)	1.6277 - 1.6282	41.34 - 41.36
e. Outside of diameter of connecting rod bushing	1.8170 - 1.8202	46.15 - 46.23
f. Bearing bore (without bearing, cap in place, and nuts tightened to specified torque)	3.025 - 3.0255	76.84 - 76.85
g. Connecting rod bearing-to-crankshaft journal clearance (with nuts tightened to specified torque)	.0025 - .0050	.06 - .13
h. Connecting rod width at lower end	1.744 - 1.746	44.30 - 44.35
i. Side clearance-to-crankshaft journal	.004 - .010	.10 - .25
j Piston pin diameter	1.6265 - 1.6267	41.31 - 41.32
k. Piston pin bushing length in connecting rod	1.552 - 1.572	39.42 - 39.93
l. Piston pin-to-connecting rod bushing clearance	.001 - .0017	.03 - .04
m. Bore in connecting rod for piston pin bushing	1.8120 - 1.8125	46.02 - 46.04
10. Exhaust Valves		
a. Valve lift (at valve) w/.018 in (0.46 mm) lash	.473	12.01
b. Valve lift (at cam)	.321	8.15
c. Seat angle	30°	30°
d. Valve seat contact width	Nominal .078 (5/64)	Nominal 1.98
e. Valve lash (cold)	.020	.51

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
f. Valve lash (engine coolant at normal operating temperature)	.018	.46
g. Head diameter	1.625	41.28
h. Overall length	6.789 - 6.819	172.44 - 173.20
i. Stem diameter	.3715 - .3720	9.44 - 9.45
j. Valve must be recessed (in head)		
Minimum	.057	1.45
Maximum	.081	2.06
11. Exhaust Valve Springs		
a. Valve spring free length	2.765	70.23
b. Valve spring length (valve closed)	2.312	58.72
c. Valve spring length (valve open)	1.832	46.53
d. Spring load at 2.312 (58.72 mm) length	57 - 64 lb	25.8 - 29.0 kg
e. Spring load at 1.832 (46.53 mm) length	136 - 146 lb	61.6 - 66.2 kg
NOTE: Install new spring when old spring is 5% below the low limit or 5% above the high limit.		
12. Intake Valves		
a. Valve lift (at valve) w/.018 in (0.46 mm) lash	.473	12.01
b. Valve lift (at cam)	.321	8.15
c. Seat angle	30°	30°
d. Valve seat contact width	Nominal .078(5/64)	Nominal 1.98
e. Valve lash (cold)	.020	.51
f. Valve lash (engine coolant at normal operating temperature)	.018	.46
g. Head diameter	1.850 - 1.860	46.99 - 47.24
h. Overall length	6.796 - 6.811	172.62 - 173.00

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
i. Stem diameter	.3722 -.3727	9.45 - 9.47
j. Valve must be recessed (in head)		
Minimum	.043	1.09
Maximum	.066	1.68
13. Intake Valve Inner Springs		
a. Valve spring free length	2.625	66.68
b. Valve spring length (valve open)	1.578	40.08
c. Valve spring length (valve closed)	2.062	52.37
d. Spring load at 1.578 in (40.08 mm) length	66 - 72 lb	29.9 - 32.6 kg
e. Spring load at 2.062 in (52.37 mm) length	30 - 35 lb	13.6 - 15.8 kg
NOTE: Install new spring when old spring is 5% below the low limit or 5% above the high limit.		
14. Intake Valve Outer Springs		
a. Valve spring free length	3.062	77.77
b. Valve spring length (valve open)	1.828	46.43
c. Valve spring length (valve closed)	2.312	58.72
d. Spring load at 1.828 in (46.43 mm) length	88 - 97 lb	39.9 - 43.9 kg
e. Spring load at 2.312 in (58.72 mm) length	40 - 45 lb	18.1 - 20.4 kg
NOTE: Install new spring when old spring is 5% below the low limit or 5% above the high limit.		
15. Exhaust Valve Seat Inserts		
a. Seat angle	30 ^{o}	30^{o}
b. Seat contact width	Nominal .078 (5/64)	Nominal 1.98
c. Seat run-out	.002	.05
d. Insert press fit	.0020 - .0035	.05 - .09

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
e. Insert O. D. - not installed		
Prior to engine s/n 10-11863 & 11-10327	1.690 - 1.691	42.93 - 42.95
Effective with engine s/n 10-11863 & 11-10327	1.6445 - 1.6450	41.77 - 41.78
f. Bore in cylinder head for insert		
Prior to engine s/n 10-11863 & 11-10327	1.6865 - 1.6875	42.84 - 42.86
Eff. with engine s/n 10-11863 & 11-10327	1.6415 - 1.6425	41.69 - 41.72
g. Oversize insert	.005 over standard	.13 over standard
16. Intake Valve Seat Inserts		
a. Seat angle	30°	30°
b. Seat width	Nominal .078 (5/64)	Nominal 1.98
c. Seat run-out	.002	.05
d. Insert press fit	.002 -.004	.05 - .10
e. Insert O. D. - not installed		
Prior to engine s/n 10-11863 & 11-10327	1.8745 - 1.8755	47.61 - 47.64
Eff. with engine s/n 10-11863 & 11-10327	1.8645 - 1.8655	47.36 - 47.38
f. Bore in cylinder head for insert		
Prior to engine s/n 10-11863 & 11-10327	1.871 - 1.872	47.52 - 47.55
Eff. with engine s/n 10-11863 & 11-10327	1.8615 - 1.8625	47.28 - 47.31
g. Oversize insert	.005 over standard	.13 over standard
17. Exhaust and Intake Valve Guides		
a. Length	3.500	88.90
b. Inside diameter after assembly (reamer size)	.375	9.53
c. Stem-to-guide clearance.		
Exhaust	.0023 - .0028	.06 - .07
Intake	.0030 - .0035	.08 - .09

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
d. Guide stand-out from bottom to counterbore in cylinder head		
Exhaust	1.062 (1-1/16)	26.97
Intake	.875 (7/8)	22.23
NOTE: Valve guides in new production and new factory service heads do not require reaming in the field. They are factory sized and checked with a straightness gauge of .37320 -.37324 (9.479 - 9.480 mm) diameter by 3.620 (91.95 mm) long which must pass through the installed guides. A Go Gauge of .37420 -.37424 (9.505 - 9.506 mm) diameter .500 (12.70 mm) long must pass 1.000 (25.40) into top of guide.		
18. Rocker Arms		
NOTE: Curent type rocker arms do not have bushings.		
a. Bore in rocker arm for shaft - current type	1.001 - 1.002	25.43 - 25.45
b. O. D. of rocker arm shaft (current and early types)	.999 - 1.000	25.37 - 25.40
c. Rocker arm to shaft clearance - current type	.001 - .003	.03 - .08
d. Rocker arm ratio	1.53:1	1.53:1
e. Bore in rocker arm for bushing - early type	1.061 - 1.062	26.95 - 26.97
f. I. D. of rocker arm bushing - early type	1.001 - 1.0015	25.43 - 25.44
g. Rocker arm to shaft clearance (early type	.001 - 0025	.03 - .06
19. Camshaft		
a. Number of bearings used	4	4
b. I. D. of camshaft bearings (installed)	2.2494 - 2.2520	57.13 - 57.20
c. I.D. of .010 in (.25 mm) undersize camshaft bearing (installed)	2.2394 - 2.2420	56.88 - 56.95
d. O. D. of camshaft journals	2.2465 - 2.2475	31.66 - 31.69

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
e. Camshaft bearing-to-journal running clearance	.0019 - .0055	.05 - .04
f. O. D. of camshaft bearings	2.5005 - 2.5015	63.51 - 63.54
g. Bearing bore in cylinder block	2.4975 - 2.4985	63.44 - 63.46
h. Fit of camshaft bearings in bore of cylinder block	.002 - 004 tight	.05 - .10 tight
i. Overall width of camshaft bearings		
Front	1.560 - 1.564	39.62 - 39.73
Intermediate	.935 - .939	23.75 - 23.85
Rear	1.0	25.40
j. Camshaft end play	.003 - .010	.08 - .25
k. Camshaft gear width	.6875 (11/16)	17.46
l. Fit of camshaft gear on camshaft	.0012 - .0032 tight	.03 - .08 tight
m. Specified thickness of thrust collar	.204 - .206	5.18 - 5.23
20. Valve Lifters and Valve Lifter Brackets		
a. Bore in valve lifter bracket for lifter	.8127 - .8137	20.64 - 20.67
b. O. D. of valve lifter stem	.8102 - .8107	20.58 - 20.59
c. Fit at valve lifter in bore of valve lifter bracket	.002 - .0035	.05 - .09
21. Front Gear Train		
a. Backlash between mating gears	.003 - .007	.08 - .18
22. Cylinder Head		
a. Valve sequence (front-to-rear in each head)	Intake-Exhaust	Intake-Exhaust
23. Lubricating Oil Pressure and Scavenging Pumps Current Type		
a. Radial clearance - gear-to-pump body	.002 - .0045	.05 - .11

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
b. End clearance - gear-to-pump body with gasket in place	.004 - .009	.10-.23
c. I. D. of bore in body and cover for bushings	.9995 - 1.0035	25.39 - 25.41
d. O. D. of bushing	1.0025 - 1.0035	25.46 - 25.49
e. Fit of bushing to body and cover	.002 - .004 tight	.05 - .10
f. I. D. of bushing in body and cover after assembly	.873 - .875	22.17 - 22.22
g. O. D. of shafts	.8715 - .872	22.14 - 22.15
h. Clearance - shafts to bushings	.001 - 0035	.03 - .09
i. I. D. of bore in gears	.8695 - .8705	22.08 - 22.11
j. Fit of gears to shafts	.001 - .0025 tight	.03 - .06 tight
k. Distance of upper gear from end of shaft (Pressure pump)	1.107 - 1.112	28.12 - 28.24
l. Distance of lower gear from end of shaft (Pressure pump)	.490 - .500	12.45 - 12.70
m. I. D. of bore in pump drive gear	.8695 - .8705	22.08 - 22.11
n. Fit of pump drive gear to shaft	.001 - .0025 tight	.03 - .06 tight
24. Lubricating Oil Pressure Pump -		
Early Type		
a. Radial clearance - gears-to-pump body	.00175 - .00275	.04 - .07
b. End clearance - pump gears	.002 - .004	.05 - .10
c. I. D. of gear shaft bushings (finished bore)		
Front cover	1.2495 - 1.2505	31.74 - 31.76
Housing	.937 - .938	23.80 - 23.83
d. Upper shaft O. D. at cover bushing location	1.247 - 1.248	31.67 - 31.70
e. Upper shaft O. D. at housing bushing location	.9350 - .9355	23.75 - 23.76

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
f. Clearance - upper shaft-to-shaft bushings		
Cover	.0015 - .0035	.04 - .09
Housing	.0015 - .0030	.04 - .08
g. I. D. of bore in cover and housing for lower shaft	.7495 - .7505	19.04 - 19.06
h. Lower shaft O.D.	.7485 - .7490	19.01 - 19.02
i. Clearance - lower gear bushing-to-shaft	.0005 - .0020	.01 - .05
25. Scavenging Oil Pump - Early Type		
a. Radial clearance - gears-to-pump housing	.00175 - .00275	0.04 - 0.07
b. End clearance - pump gears	.002 - .004	0.05 - 0.10
c. I. D. of pump body bushing and idler gear bushing	.7495 - .7505	19.02 - 19.05
d. Diameter of drive shaft and stub shaft	.7475 - .7480	18.97 - 19.00
e. Clearance - drive shaft to pump body bushing and idler gear shaft to idler gear bushing	.0015 - .0030	0.04 - 0.08
26. Water Pump		
a. Clearance between impeller and water pump body	.015 - .072	.38 - 1.83
b. Front bearing		
Bearing bore (I.D. for shaft)	.78725 - .78740	19.99 - 20.00
Shaft diameter	.7871 - .7876	19.99 - 20.01
Fit - shaft to bearing	.00035 tight-.0003 loose	.009 tight-.008 loose
Bearing O.D.	2.0470 - 2.0472	51.99 - 52.00
Bore in water pump body (For bearing)	2.0467 - 2.0477	51.99 - 52.01
Fit - bearing O. D. to body	.0005 tight-.0007 loose	.01 tight - .02 loose
c. Rear bearing		
Bearing bore (I.D. for shaft)	.78725 - .78740	19.99 - 20.00
Shaft diameter	.7871 - .7876	19.99 - 20.01
Fit - shaft to bearing	.00035 tight-.0003 loose	.009 tight -.008 loose
Bearing O. D.	1.8502 - 1.8504	46.99 - 47.00
Bore in water pump body (for bearing)	1.8499 - 1.8509	46.99 - 47.01
Fit - bearing O. D. to body	.0005 tight-.0007 loose	.01 tight-.02 loose

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
d. Pulley driving flange bore	.7856 - .7866	19.95 - 19.98
Fit - flange I.D. to shaft	.0005 - .002 tight	.01 - .05 tight
e. Impeller		
Bore I. D. in impeller for shaft	.6225 - .6235	15.81 - 15.84
Shaft diameter	. 6262 - .6267	15.91 - 15.92
Fit - shaft to impeller	.0027 - .0042 tight	.07 - .11 tight
27. Fan Hub Assembly		
a. Front bearing		
Bearing bore (I.D. for shaft)	.98415 - .98430	24.99 - 25.00
Shaft diameter	.9835 - .9840	24.98 - 24.99
Fit - shaft to bearing	.00015 - .0008 loose	.003 - .020 loose
Bearing O. D.	2.0470 - 2.0472	51.99 - 52.00
Bore in hub (for bearing)	2.0466 - 2.0476	51.98 - 52.01
Fit - bearing to hub	.0006 loose-.0006 tight	.015 loose - .015 tight
b. Rear bearing		
Bearing bore (I.D. for shaft)	1.18095 - 1.18110	29.99 - 30.00
Shaft diameter	1.18030 - 1.18080	29.98 - 29.99
Fit - shaft to bearing	.00015-.0008 loose	.003-.020 loose
Bearing O. D.	2.4407 - 2.4409	61.99 - 62.00
Bore in hub (for bearing)	2.4403 - 2.4413	61.98 - 62.01
Fit - bearing to hub	.0006 loose-.0006 tight	.015 loose-.015 tight
28. Auxiliary Drive Pulley (Front Housing Cover Mounted)		
Bearing bore (I. D. for shaft)	1.500 - 1.5005	37.10 - 37.11
Shaft diameter	1.5010 - 1.5015	38.13 - 38.14
Fit - shaft to bearing	.0005-.0015 tright	0.01 - 0.04 tight
Bearing O. D.	2.5625 - 2.5635	65.09 - 65.11
Bore in cover flange (for bearing)	2.5635 - 2.5645	65.11 - 65.14
Fit - bearing to cover flange	.000 - .002 loose	0.00 - 0.05 tight
29. FAN DRIVE ASSEMBLY (TRACK-TYPE TRACTORS)		
1. Flange mtg. (Fan drive pulley) I.D.	1.1785 - 1.1790	29.93 - 29.95
2. Gear - drive (shaft O.D.)for flange mtg.	1.1804 - 1.1808	29.98 - 29.99
3. Flange mtg. to gear - drive shaft fit	.0014 - .0023 tight	0.04 - 0.06 tight
4. Bearing sleeve insert O.D.	4.5615 - 4.5620	115.86 - 115.87

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

(Added 5-78)

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
5. I. D. in bearing sleeve insert	3.1260 - 3.1270	79.40 - 79.43
6. O. D. of bearing outer race	3.125 - 3.126	79.38 - 79.40
7. Bearing outer race to bearing sleeve insert fit	.000 - .002 loose	0.00 - 0.05 loose
8. Gear - drive shaft O. D. for bearing	1.8135 - 1.8140	46.06 - 46.08
9. I. D. of inner race of bearing	1.8125 - 1.8130	46.04 - 46.05
10. Bearing inner race to gear - drive shaft fit	.0005 - .0015 tight	0.01 - 0.04 tight

30. HYDRAULIC PUMP DRIVE (TRACK-TYPE TRACTORS AND LATE MODEL MOTOR GRADERS WITH AMERICAN BOSCH FUEL INJECTION PUMP)

1. O. D. of bushing - drive gear	.940 - .941	23.88 - 21.36
2. Bore in gear for bushing	.937 - .938	23.80 - 23.83
3. Press fit	.002 - .004 tight	0.05 - 0.10 tight
4. I. D. of bushing - isntalled and burnished	.8120 - .8130	20.62 - 20.65
5. Clearance - shaft to gear bushing	.0015 - .0035	0.04 - 0.09
6. O. D. of shaft	.8095 - .8105	20.56 - 20.59
7. Gear - end clearance	.002 - .007	0.05 - 0.18
8. Thrust washer thickness	.186 - .188	4.72 - 4.78
9. Clearance - pump drive to timing gear housing cover	.0005 - .002	0.01 - 0.05
10. O. D. on gear for sleeve retainer	1.6595 - 1.6600	42.15 - 42.16
11 I. D. of sleeve retainer	1.6565 - 1.6575	42.08 - 42.10
12. Press fit	.002 - .0035 tight	0.05 - 0.09 tight

31. HYDRAULIC PUMP DRIVE (TRACK-TYPE TRACTORS AND LATE MODEL MOTOR GRADERS WITH ROOSA MASTER FUEL INJECTION PUMP)

1. Front bearing		
Bearing bore (I.D. for shaft)	.9843 -.9845	25.001 - 25.006
Gear shaft diameter	.9842 -.9846	24.999 - 25.008
Fit - gear to bearing	.0003 loose-.0003 tight	0.008 loose-0.0008 tight

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
Bearing O.D.	2.0470 - 2.0472	51.993 - 51.998
Bore in retainer (for bearing)	2.047 - 2.048	51.99 - 52.02
2. Rear bearing		
Bearing bore (I.D. for shaft)	.9843 - .9845	25.001 - 25.006
Gear shaft diameter	.9842 - .9846	24.999 - 25.008
Fit - gear to bearing	.0003 loose - .0003 tight	0.008 loose-0.0008 tight
Bearing O.D.	2.0470 - 2.0472	51.993 - 51.998
Bore in timing gear housing (for bearing)	2.047 - 2.048	51.99 - 52.02
Fit - timing gear housing to bearing	.001 loose - .0002 tight	0.03 loose - 0.005 tight

32. FAN BELT TIGHTENER (TRACK-TYPE TRACTORS)

1. Bearing bore (I.D. for shaft)	.9839 - .9843	24.99 - 25.00
2. Shaft diameter	.9836 -.9840	24.98 - 24.99
Fit - shaft to bearing	.0001 - .0007 loose	0.003 - 0.017 loose
3. Bearing O. D.	2.0467 - 2.0472	51.99 - 52.00
4. Bore in Pulley (I.D. for bearing)	2.0466 - 2.0472	51.98 - 52.00
Fit - bearing to pulley	.0005 loose - .0006 tight	0.01 loose - 0.02 tight

33. FAN BELT TIGHTENER (MOTOR GRADERS)

1. Front bearing:		
Bearing bore (I.D. for shaft)	.7825 - .78740	19.996 - 19.999
Shaft diameter	.78670 - .78710	19.98 - 19.99
Bearing O.D.	2.0470 - 2.0472	51.993 - 51.998
Bore in pulley (I.D. for bearing)	2.0464 - 2.0472	51.978 - 51.998
Fit - bearing O.D. to pulley	.0002 - 0008 loose	0.005 - 0.020 loose
2. Rear bearing:		
Bearing bore (I.D. for shaft)	.98415 - .98430	24.997 - 25.001
Shaft diameter	.98360 - .98400	24.983 - 24.993
Bearing O.D.	2.0470 - 2.0472	51.993 - 51.998
Bore in pulley (I.D. for bearing)	2.0464 - 2.0472	51.978 - 51.998
Fit - bearing O.D. to pulley	.0002 loose - .0008 tight	0.005-0.020 loose
3. Pulley shaft diameter	1.1255 - 1.1275	28.59 - 28.64
Bore in fan idler arm for shaft	1.1245 - 1.1255	28.56 - 28.59
Fit - shaft to arm	.002 - .004 tight	0.05 - 0.10 tight
4. Mounting shaft diameter	.9854 - .9859	25.02 - 25.04
Bore in fan idler arm for shaft	.9839 - .9849	24.99 - 25.01
Fit - shaft to arm	.0005 - .002 tight	0.01 - 0.05 tight

B. BOLT, CAPSCREW, AND NUT TORQUE WRENCH SPECIFICATIONS

1. Specific Application Torque Values

The torque values tabulated below have been calculated for specific applications. SAE standard torque values must not be used where those listed in this table apply.

NOTE: Torque values are in pound-feet and all torque values in this table are calculated for threads lubricated with engine oil.

ITEM	APPLICATION	SIZE & THREAD	ENGLISH lb-ft	METRIC Nm
Nut	Bearing Cap, Center Main	5/8-18	160-170	217-231
Capscrew	Bearing Cap, Center Main (74339036)	5/8-11	160-170	217-231
Capscrew	Bearing Cap, Center Main (74035387)	5/8-11	190	258
Nut	Bearing Cap, Front, Inter., and Rear Main	3/4-16	210-230	285-312
Capscrew	Bearing Cap, Front, Inter., and Rear Main	3/4-10	210-230	285-312
Capscrew	Connecting Rod Cap - Current - 12 pt hd	9/16-18	160	217
Capscrew	Connecting Rod Cap - Hex Socket Head	9/16-18	160	217
Nut	Connecting Rod Cap - Early	9/16-18	120-130	163-177
Capscrew	Crankshaft Pulley Retainer	1-1/4-12	290-310	393-421
Nut	Cylinder Head Cover Mounting	7/16-20 Nylok	10-15	14-20
Capscrew	Cylinder Head Mounting - Current	1/2-13	115	156
Capscrew	Cylinder Head Mounting - Current	5/8-11	185	251
Nut	Cylinder Head Mounting - Early	1/2-20	100	136
Nut	Cylinder Head Mounting - Early	5/8-18	185	251
Nut	Tube Support Bracket - Center of Heads Current	1/2-20	50	68
Capscrew	Intake, Manifold Mounting	1/2-13	70	95
Capscrew	Exhaust Manifold Mounting - Current	1/2-13 Nylock	70	95
Nut	Exhaust Manifold Mounting - Early	1/2-13 Seez-Proof	45-50	61-68
Capscrew	Flywheel Mounting - Current - Socket Hd.	1/2-20	135	183
Bolt	Flywheel Mounting - Early - Place Bolt	1/2-20	95-105	129-143
Capscrew	Front Support Mounting	1/2-13	95-105	129-143
Nut	Fuel Injection Line Nozzle End	9/16-18	20-25	27-34
Capscrew	Fuel Injection Nozzle Holder Mounting	3/8-16	12-15	16-20
Nut	Intake Manifold Mounting	1/2-13	45-50	61-68
Nut	Oil Pump Drive Gear Retaining (Lock Type)	5/8-18	80	108
Bolt	Oil Filter Center Bolt Bolt	1-14	45-50	61-68
Nut	Oil Pressure Regulator Screw Lock	3/4-16	125-135	170-183
Nut	Turbocharger Mounting	3/8-16 Stnls.	18-21	24-28
Bolt	Valve Lifter Cover Mounting	5/16-18	18-20	24-27
Nut	Water Pump Impeller Retainer	1/2-20	30-35	41-47
Nut	Water Pump Pulley Retainer	3/4-16	115	156
Locknut	Auxiliary Drive Pulley Flange Retaining	1-1/8-12	200-220	271-298

2. Standard Torque Values

The heads of capscrews used in Allis-Chalmers engines bear grade marks conforming to standards specified by the Society of Automotive Engineers (SAE). The three grades of capscrews used are identified as follows: Grade 2, no marks; Grade 5, three marks, 120° apart; Grade 8, six marks, 60° apart.

(See figures in table below.)

IMPORTANT: The standard torque values tabulated above are for use when specific torque data is not available. Do not use these values in place of those specified elsewhere in this manual:

a. Grade 2 Capscrews 

Capscrew Size (inches)	Grade 2			
	NC		NF	
	English lb-ft	Metric Nm	English lb-ft	Metric Nm
1/4	5-7	7-9	6-8	8-11
5/16	11-13	15-18	13-15	18-20
3/8	18-21	24-28	19-22	26-30
7/16	30-33	41-45	32-35	43-47
1/2	45-50	61-68	45-50	61-68
9/16	60-65	81-88	60-65	81-88
5/8	75-85	102-115	75-85	102-115
3/4	125-135	170-183	125-135	170-183
7/8	105-115	143-156	105-115	143-156
1	155-165	211-224	140-150	190-204

b. Grade 5 Capscrews

Capscrews 

Capscrew Size (inches)	Grade 5			
	NC		NF	
	English lb-ft	Metric Nm	English lb-ft	Metric Nm
1/4	9-11	12-15	11-13	15-18
5/16	18-20	24-27	21-23	28-31
3/8	28-33	38-45	30-35	41-47
7/16	44-49	60-66	50-55	68-75
1/2	68-73	92-99	68-73	92-99
9/16	95-105	129-143	95-105	129-143
5/8	125-135	170-183	125-135	170-183
3/4	210-230	285-312	210-230	285-312
7/8	290-310	393-421	290-310	393-421
1	420-450	569-610	380-410	515-556

c. Grade 8 Capscrew 

Capscrew Size In (inches)	Grade 8			
	NC		NF	
	English lb-ft	Metric Nm	English Nm	Metric Nm
1/4	12-14	16-19	14-16	19-22
5/16	25-27	34-37	28-30	38-41
3/8	41-46	56-62	43-48	58-65
7/16	69-74	94-100	72-77	98-104
1/2	95-105	129-143	95-105	129-143
9/16	130-140	177-190	130-140	177-190
5/8	170-190	231-258	170-190	231-258
3/4	290-310	393-421	290-310	393-421
7/8	450-500	610-678	450-500	610-678
1	670-700	908-949	600-630	813-864

C. STUD GAUGE HEIGHTS AND DRIVING TORQUES

Stud Description	Stud Size					Gauge Height		Driving Torque*	
		Thread		Length					
	Dia	Stud End	Nut End	in	mm	in	mm	Eng. lb-ft	Metric Nm
Cylinder Head to Block - Early	5/8	11	18	6.531	165.89	5.343	135.71	45-120	61-163
Cylinder Head to Block - Early	1/2	13	20	6.093	154.76	5.093	129.36	45-120	61-163
Cylinder Head to Block - Early	1/2	13	20	7.250	174.15	6.312	160.32	45-120	61-163
Cylinder Head to Block - Early	1/2	13	20	7.406	188.11	6.468	164.29	45-120	61-163
Fuel Pump Housing to Gear Housing	3/8	16	24	1.500	38.10	0.937	23.80	10-37	14-50
Gear Cover to Housing to Block	1/2	13	20	3.750	95.25	2.843	72.21	22-71	30-96
Manifold Intake and Exhaust to Cylinder Head	1/2	13	13	2.125	53.98	1.375	34.93	22-71	30-96
Manifold to Turbocharger	3/8	16	16	1.875	47.63	1.312	33.32	10-35	14-47
Nozzle Holder to Cylinder Head - Early	3/8	16	24	1.937	49.20	1.437	36.50	10-35	14-47
Rocker Arm Shaft and Bracket to Cylinder Head-First Type	3/8	16	24	1.562	39.67	1.312	33.32	10-35	14-47
Rocker Arm Shaft and Bracket to Cylinder Head - Second Type	7/16	20	20	2.687	68.25	2.062	52.37	14-45	19-61

*Torque values in this table are calculated for threads lubricated with engine oil.

SECTION 19 - TROUBLE SHOOTING

TOPIC NO.	TITLE	PAGE
1.	ENGINE	19-1
2.	STARTING SYSTEM	19-5
3.	FUEL SYSTEM	19-5
4.	AIR INTAKE SYSTEM	19-6
5.	COOLING SYSTEM	19-6
6.	LUBRICATING SYSTEM	19-7
7.	ELECTRICAL SYSTEM	19-8
8.	INSTRUMENTS	19-9

It cannot be repeated too often that over 90% of engine trouble can be prevented by good periodic lubrication, inspection, and maintenance. The time and energy consumed in so doing is only a fraction of what must be incurred when trouble ties up the operator and his operations.

To remedy as quickly as possible any trouble that may develop, the following list of symptoms, causes and remedies is given. For the detailed inspection and service procedure for any given component, refer to that Section or Topic in the manual pertaining to the part, assembly, or system.

TOPIC 1 - ENGINE

TROUBLE	POSSIBLE CAUSES	REMEDY
Engine will not turn	1. Batteries weak.	1. Recharge or replace batteries.
	2. Starter or starter switch inoperative.	2. Repair or replace affected parts.
	3. Engine is locked or seized.	3. This can be due to extended idle or storage periods, or to improper preparation of the engine for storage, in which case the parts may be rusted or corroded and seized. Broken piston rings, gears, etc., may also cause locking. The engine should be disassembled to determine the cause, and the necessary parts replaced.
	4. Hydro-static lock.	4. This can be due to rain water entering uncovered exhaust pipe, leaking cylinder head gasket, cracked block or cylinder head. The engine should be disassembled to determine the cause and the necessary parts replaced.
Engine will not start	1. Slow cranking speed.	1. The specific gravity of the batteries may be too low or the starter may not be delivering its maximum torque to provide adequate cranking speed. Cold weather starting requires the use of the cold weather starting aids.
	2. Engine controls out of adjustment.	2. Check all engine control linkages for proper adjustment.
	3. Insufficient supply of fuel to fuel injection nozzles.	3. Check fuel system.
	4. Fuel injection nozzles not operating properly.	4. Test and repair or replace nozzles.

TROUBLE	POSSIBLE CAUSES	REMEDY
	5. Fuel injection pump improperly timed.	5. Time fuel injection pump.
Engine hard to start	1. Batteries weak.	1. Recharge or replace batteries.
	2. Insufficient fuel in fuel tank.	2. Check fuel level in tank. Fill with specified fuel if necessary.
	3. Incorrect grade of fuel.	3. Drain fuel system. Fill the tank with the specified fuel.
	4. Fuel injection nozzles not operating properly.	4. Test and repair or replace nozzles.
	5. Fuel transfer pump not operating properly.	5. Test and repair or replace fuel transfer pump.
	6. Air in fuel system.	6. Correct air leaks in suction side of fuel system. Vent fuel system.
	7. Insufficient air supply to cylinders.	7. Clean air system.
	8. Fuel injection pump improperly timed.	8. Time fuel injection pump.
	9. Valve lash incorrect.	9. Adjust valve lash.
	10. Piston rings or cylinder liners worn.	10. Replace affected parts.
	11. Valves warped or pitted.	11. Recondition or replace valves and/or valve guides.
Engine stops frequently	1. Idling speed too low.	1. Adjust low idling speed.
	2. Restricted fuel supply.	2. Check fuel system.
Engine stops suddenly	1. Out of fuel.	1. Fill fuel tank with specified fuel and vent the fuel system.
	2. Restricted fuel supply.	2. Check fuel system.
	3. Broken or loose fuel lines.	3. Correct or replace affected parts.
	4. Fuel transfer pump or fuel injection pump inoperative.	4. Replace inoperative parts.
Engine overheats	1. Leak in cooling system.	1. Correct all leaks and fill cooling system.
	2. Radiator core clogged.	2. Clean and flush radiator.
	3. Radiator air passages clogged.	3. Remove debris from radiator core.
	4. Fan drive belts too loose.	4. Adjust fan drive belts to proper tension.
	5. Thermostat inoperative.	5. Test the thermostat for proper operation.
	6. Engine oil cooler clogged.	6. Clean or replace the oil cooler core.
	7. Improper engine lubrication.	7. Check for proper operation of engine lubricating oil pump.
	8. Water pump malfunctioning.	8. Repair or replace the water pump.

TROUBLE	POSSIBLE CAUSES	REMEDY
	9. Fuel injection pump improperly timed.	9. Time fuel injection pump.
Engine shows loss of power	1. Insufficient supply of air to cylinders.	1. Clean air system.
	2. Insufficient supply of fuel to fuel injection nozzles.	2. Check fuel system.
	3. Governor not operating properly.	3. Inspect and adjust governor (Contact your Fiat-Allis Construction Machinery Dealer).
	4. Air in fuel system.	4. Vent fuel system. Check for air leaks on suction side of fuel transfer pump.
	5. Clogged fuel filters.	5. Change filter elements.
	6. Improper valve lash.	6. Adjust valve lash.
	7. Fuel injection pump improperly timed.	7. Time fuel injection pump.
	8. Inoperative fuel injection pump or fuel injection nozzles.	8. Repair or replace affected parts.
	9. Loss of compression.	9. This may be due to leaking valves or to worn piston rings or cylinder sleeves. Use a suitable compression tester, Fig. 1, and check each cylinder as follows:

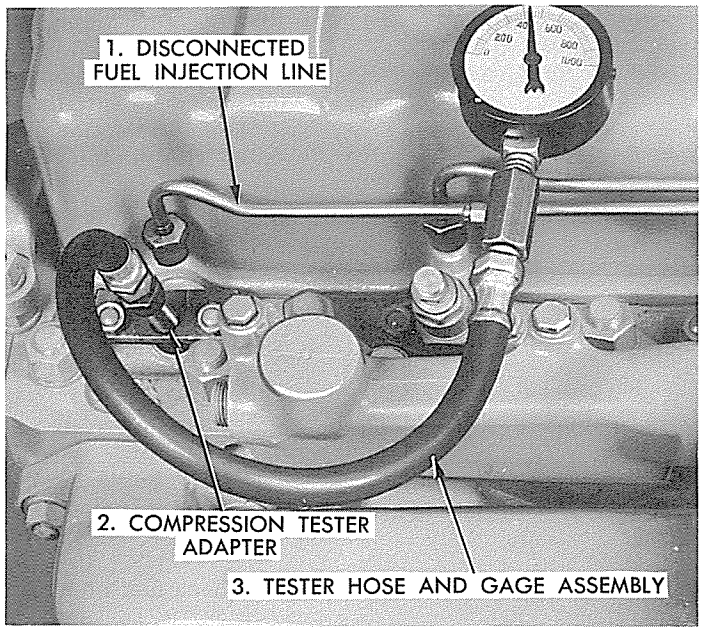


Fig. 1 Checking Compression Pressure
(T-27645)

Compression pressure for a normal engine at normal operating temperature firing on five cylinders at 600 rpm and at sea level conditions is 445 psi.

When checking compression pressure, altitude at which engine is located must be taken into consideration for an accurate evaluation of test, because the density of air decreases as altitude increases. For each 1000 feet of altitude above sea level the specified sea level figure of 445 psi must be derated 3%.

It is common practice to consider a difference of 25

psi, between one or more cylinders, as an indication of possible trouble. This is not always true. Specified compression figures are calculated at 600 rpm due to the limitation of most pressure gauges in the field and pressure readings taken at 600 rpm are not always representative of what is happening within the engine at 1800 or 2000 rpm under load.

If a spread between cylinders of 25 psi or more at 600 rpm is noted and there is no evidence of excessive oil consumption, intake or exhaust valve blowby into the manifolds, or loss of engine power, it is safe to continue to operate engine. However, if any of the above conditions exist, or a difference of 50 psi or more is noted between cylinders, cylinder head should be removed and a detailed inspection made of cylinder head, valves, pistons, rings, and cylinder sleeves and necessary repairs should be made to eliminate cause of the low compression pressure.

NOTE

When using a compression tester, make certain gauge has been properly tested so an accurate pressure reading can be obtained. In no case should an engine be rebuilt because of low compression readings unless gauge is known to be accurate.

To check compression pressure, proceed as follows:

a. Start engine and allow to warm up to a minimum temperature of 160°F.

b. Shut off engine.

c. Start with No. 1 cylinder when checking the compression. Remove the fuel injection nozzle and install the compression tester adapter in the same manner as the fuel injection nozzle was installed. Install the compression tester hose and gauge assembly.

d. Start engine, run at approximately 600 rpm and take several readings on gauge. NOTE: Do not check compression by cranking engine with starter.

e. Remove tester assembly, install nozzle-holder, connect fuel injection line and fuel return line.

f. Repeat operation on each of remaining cylinders.

TROUBLE	POSSIBLE CAUSES	REMEDY
	10. Cylinder cutting out.	10. Locate a "missing" cylinder as follows: Run the engine at low idle speed and "cut-out" each fuel injection nozzle in turn by loosening the fuel injection line nut attaching the fuel injection line to the fuel injection pump. A decrease in engine speed with the injection line nut loosened indicates that the nozzle for that cylinder is functioning properly. If the engine speed does not decrease, the nozzle is malfunctioning and should be replaced.
Engine runs uneven and excessive vibration	1. Governor not operating properly.	1. Adjust governor and linkage (contact your Fiat-Allis Construction Machinery Dealer).
	2. Fuel supply erratic or insufficient.	2. Check fuel system.
	3. Engine operating temperature too low.	3. Check thermostats.
	4. Fuel injection pump malfunctions.	4. Check fuel injection pump.
	5. Valves in bad condition.	5. Recondition valves.
	6. Cylinder "cutting-out."	6. Correct cause.
	7. Fuel injection nozzle malfunctions.	7. Repair nozzle.
Engine detonates	If a hard metallic knock indicates detonation in one or more cylinders, the engine must be stopped immediately to prevent serious damage due to the excessive pres-	

TROUBLE	POSSIBLE CAUSES	REMEDY
	sures accompanying the detonation. Detonation is caused by the presence of fuel or lubricating oil in the charge of air that has been delivered to the cylinder during the compression stroke. Check for leaky fuel injection nozzles or improper timing of the fuel injection pump.	
Engine emits black smoke from exhaust	1. Air system clogged.	1. Check engine air intake system.
	2. Governor torque cam or stop plate incorrectly adjusted.	2. Correct the adjustment (contact your Fiat-Allis Construction Machinery Dealer).
	3. Improper fuel.	3. Drain fuel system and refill with fuel of proper specification.
Engine emits blue smoke from exhaust	1. Engine operating temperature too low.	1. Check thermostat.
	2. Fuel injection nozzles not operating properly.	2. Test and adjust nozzles.

TOPIC 2 - STARTING SYSTEM

TROUBLE	POSSIBLE CAUSES	REMEDY
Starter will not crank engine	1. Batteries weak.	1. Check batteries.
	2. Cables and/or connections loose or corroded.	2. Tighten all loose connections and clean corrosion from all terminals.
	3. Starter switch inoperative.	3. Replace switch.
	4. Starter brushes worn or not contacting properly.	4. Install new brushes or fit brushes to conform to contour of commutator.
	5. Starter brush springs weak.	5. Check brush spring tension, replace springs if necessary.
	6. Starter commutator dirty or worn.	6. Polish commutator, machine commutator and under-cut mica if necessary.
	7. Starter armature shaft bushings worn (armature drags on fields).	7. Replace worn bushings and related items.
	8. Starter armature burned out.	8. Replace armature.
Starter pinion will not engage with flywheel ring gear	1. Grease and/or dirt in starter drive mechanism.	1. Disassemble and clean the drive assembly.
	2. Broken or excessively worn parts.	2. Replace broken or worn parts.

TOPIC 3 - FUEL SYSTEM

TROUBLE	POSSIBLE CAUSES	REMEDY
Insufficient fuel supply to fuel injection nozzles	1. No fuel in fuel tank.	1. Fill fuel tank with specified fuel. Vent fuel system.
	2. Inoperative fuel transfer pump.	2. Repair or replace transfer pump.
	3. Fuel injection nozzle valve binding in valve body.	3. Replace valve assembly in nozzle holder body.

TROUBLE	POSSIBLE CAUSES	REMEDY
	4. Fuel lines and/or fuel filters clogged.	4. Clean fuel lines, replace fuel filter elements.
	5. Fuel injection pump malfunctioning.	5. Replace fuel injection pump.
	6. Fuel injection nozzles improperly adjusted.	6. Adjust fuel injection nozzles.
Air in fuel system	1. Loose fuel line fitting or leak in fuel line on suction side of fuel transfer pump.	1. Tighten loose fitting or replace damaged line.
	2. Damaged gasket on first stage fuel filter.	2. Replace gasket.

TOPIC 4 - AIR INTAKE SYSTEM

TROUBLE	POSSIBLE CAUSES	REMEDY
Insufficient air supply to cylinders	1. Air cleaner clogged.	1. Replace air filter element.
	2. Foreign material lodged in turbocharger impeller or turbine.	2. Disassemble and clean.
	3. Excessive dirt buildup on turbocharger compressor impeller vanes.	3. Thoroughly clean compressor assembly.
	4. Excessive dirt buildup on turbocharger compressor impeller vanes in short period of time.	4. Clean compressor assembly, and pressure test air intake system for leaks.
	5. Leaks in engine intake and/or exhaust manifolds reducing turbocharger efficiency.	5. Tighten loose manifold retaining nuts or capscrews. Replace manifold gaskets.
	6. Turbocharger rotating assembly bearing seized.	6. Overhaul turbocharger.
Rapid wear on engine parts	1. Dirt admitted with intake air.	1. Pressure test air intake system and correct any leaks found.
	2. Dirty lubricating oil.	2. Change engine oil and the lubricating oil filter elements at the intervals recommended. Keep oil clean when filling engine.
	3. Improper fuel.	3. Use the proper fuel. It is important that the fuel be within the specified limits for ash, carbon, sulphur, etc., to prevent excessive wear on engine parts.

TOPIC 5 - COOLING SYSTEM

TROUBLE	POSSIBLE CAUSES	REMEDY
Engine operating temperature too high with ample coolant in system	1. Temperature gauge inoperative.	1. Check gauge. Replace if necessary.
	2. Radiator air passages restricted.	2. Clean exterior of radiator.

TROUBLE	POSSIBLE CAUSES	REMEDY
	3. Thermostat inoperative.	3. Replace thermostat.
	4. Loose or broken fan drive belts.	4. Adjust or replace fan drive belts.
	5. Lime deposits in water passages of radiator, cylinder heads and/or cylinder block.	5. Thoroughly clean affected parts.
	6. Water passages in oil cooler restricted.	6. Remove and clean oil cooler core.
	7. Water pump inoperative.	7. Repair or replace water pump.
	8. Excessive load on tractor.	8. Reduce load.
	9. Engine speed set too high.	9. Adjust speed to within specified rpm limits.
Engine operating temperature too high due to loss of coolant	1. External leaks.	1. Repair affected parts.
	2. Ruptured oil cooler core (oil in coolant).	2. Replace oil cooler core.
	3. Engine or air compressor cylinder head gaskets leaking.	3. Replace gaskets and torque cylinder head nuts as specified.
	4. Engine or air compressor cylinder heads cracked.	4. Replace cylinder head.
	5. Engine or air compressor cylinder block cracked.	5. Replace cylinder block.
Engine operating temperature too low	1. Thermostat stuck in open position.	1. Replace thermostat.
	2. Operating in extremely cold weather.	2. Provide covers for radiator and engine side openings. Do not restrict air intake on models which have air cleaner located within engine compartment.

TOPIC 6 - LUBRICATING SYSTEM

TROUBLE	POSSIBLE CAUSES	REMEDY
No lubricating oil pressure	1. Insufficient oil in crankcase.	1. Fill crankcase to proper level.
	2. Oil pressure gauge inoperative.	2. Replace gauge.
	3. Lubricating oil pump screen clogged.	3. Remove and clean the screen.
	4. Lubricating oil pump inoperative.	4. Repair or replace oil pump.
	5. Oil lines loose or broken inside crankcase.	5. Repair or replace affected parts.
Low lubricating oil pressure with proper oil level in crankcase	1. Oil pressure gauge inaccurate.	1. Check gauge. Replace if necessary.
	2. Oil pressure relief valve or regulator valve stuck in open position.	2. Clean, repair, or replace affected parts.
	3. Oil lines in crankcase loose or broken.	3. Repair or replace affected items.

Study SAFETY RULES, pages I thru III, thoroughly for the protection of personal and machine safety.

TROUBLE	POSSIBLE CAUSES	REMEDY
	4. Improper lubricant.	4. Fill crankcase with specified lubricant.
	5. Main and/or connecting rod bearings worn.	5. Replace bearings.
	6. Camshaft bearings worn.	6. Replace bearings.
	7. Accessory drive shaft bushings worn.	7. Replace bushings and inspect related parts.
	8. Lubricating oil pump worn.	8. Repair or replace oil pump.
	9. Air compressor connecting rod bearings worn.	9. Replace bearings.
Excessive lubricating oil pressure	1. Oil pressure gauge inaccurate.	1. Check gauge. Replace if necessary.
	2. Oil pressure regulating valve improperly adjusted.	2. Adjust valve to obtain proper pressure.
	3. Improper lubricant.	3. Fill crankcase with specified lubricant.
Overheating of lubricating oil	1. Insufficient oil in crankcase.	1. Fill crankcase to proper level.
	2. Improper lubricant.	2. Fill crankcase with specified lubricant.
	3. Engine oil cooler clogged.	3. Clean or replace the oil cooler.
Excessive oil consumption	1. External oil leakage (gaskets, etc.).	1. Correct all external leaks.
	2. Engine or air compressor oil seals worn or damaged.	2. Replace oil seals.
	3. Lubricating oil too light.	3. Fill crankcase with specified lubricant.
	4. Pistons, rings, and/or cylinder sleeves worn.	4. Replace affected parts.
	5. Oil control rings stuck in piston ring grooves.	5. Clean ring grooves and replace rings.
	6. Valve guides worn.	6. Replace valve guides. Check related parts.
Excessive oil consumption during first 250 hours of operation and no indication of improvement.	1. Rings not seated properly.	1. Allow more time for break-in. Make certain engine is at operating temperature and "Service DS" or "Series 3" Oil is used.
	2. Engine oil viscosity too light.	2. Use recommended viscosity.
Rapid wear on engine parts	1. Lubricating oil contaminated.	1. Fill system with clean engine oil. Replace engine oil filters.
	2. Improper engine lubricating oil being used.	2. Fill system with engine lubricating oil of proper specifications.

TOPIC 7 - ELECTRICAL SYSTEM

TROUBLE	POSSIBLE CAUSES	REMEDY
Generator not charging	1. Generator drive belt loose or broken.	1. Adjust or replace drive belt.

TROUBLE	POSSIBLE CAUSES	REMEDY
	2. Generator regulator inoperative.	2. Remove regulator for repair or replacement.
	3. Generator inoperative.	3. Remove generator for repairs or replacement.
Generator output low and/or unsteady	1. Generator drive belt improperly adjusted.	1. Adjust drive belt.
	2. Brushes sticking in brush holders.	2. Free brushes in holders.
	3. Brush spring tension too low.	3. Replace brush springs.
	4. Generator commutator dirty or worn.	4. Clean commutator or remove generator for repair or replacement.
	5. Generator regulator operating improperly.	5. Remove regulator for repair or replacement.
Batteries will not hold charge	1. Loose terminals or connections.	1. Tighten affected parts.
	2. Short in electrical system.	2. Correct short.
	3. Short circuit in battery.	3. Remove and repair or replace battery.
	4. Electrolyte level low (generator output excessive or cracked battery case).	4. Reduce charging rate. Remove and repair or replace battery.
	5. Generator regulator inoperative.	5. Remove regulator for repair or replacement.

TOPIC 8 - INSTRUMENTS

If any of the instruments fail to register proper readings while the tractor is in operation, the system to which the instrument applies should be thoroughly checked as outlined in the preceding parts of this Section to determine the cause. If failure of the instrument is suspected, test by installing a new tested instrument in its place. Replace any inoperative instruments.

SECTION 20 - SERVICE TOOLS

In many cases the use of service tools for disassembly and assembly are required to perform the particular operation and to obtain the best results. The use of service tools enables the serviceman, or mechanic, to perform the operation in the proper manner and in the least amount of time.

The following service tool listing was prepared to assist service and maintenance personnel in the selection of proper tools and combinations of tools to accomplish the various service and maintenance operations described and illustrated in this manual.

Order the service tool from Fiat-Allis if there is a Fiat-Allis part number for the tool. If there is no Fiat-Allis part number, order the tool from the manufacturer.

TOOL MANUFACTURERS

(KM) Kent-Moore Organization, Inc.
1501 South Jackson Street
Jackson, Michigan 49203
517-784-8561

(OTC) Owatonna Tool Company
375 Cedar Street
Owatonna, Minnesota 55060
507-451-5310

(WIL) Williams Tool Co.
(Local Supplier)

(SON) Snap-On Tools Co.
(Local Supplier)

(SWE) Sweeney Mfg. Co.
6300 Stapleton South Drive
Denver, Colorado 80216
303-320-4800

(KD) Kiene Diesel Accessories, Inc.
325 S. Fairbanks
Addison, Il. 60101
312-543-5950

(STR) L. S. Starrett Co.
(Local Supplier)

Section No. Figure No.	Fiat-Allis Part No.	Manufacturer's Part No.	Description
4-8		(KM) J-6765	Fuel Injection Tube Nut Wrench (Nozzle End)
4-9		(KM) J-6865	Injection Nozzle Removal Adapter
4-9		(KM) J-2619-5	Slide Hammer
4-10		(KD) DT-1300	Nozzle Tester
4-10		(KD) DT-6026	Nozzle Tester Connector Kit
4-11		(KM) J-4298-01	Pin Vise
8-13		(KM) J-8062	Valve Spring Compressor
8-15, 16	75294458		Valve Guide Removal/Installation Tool
8-18	75294640		Valve Seat Insert Installation Kit
10-2, 3		(KM) J-5959-01	Dial Indicator and Attachment Set
12-5		(OTC) 817	Camshaft Bearing Removal and Installation Set
13-1		(OTC) ACTP-2018	Piston Ring Expander
13-5		(KM) J-7061	Piston Inserter
14-3		(KM) J-5959-01	Dial Indicator and Attachment Set
15-1		(KM) J-8060	Cylinder Sleeve Diameter Checking Gauge
15-2		(KM) J-9325	Cylinder Sleeve Ridge Reamer
15-3,4		(OTC) 974-A	Cylinder Sleeve Puller
15-11		(SWE) 7092-100	Counterbore Drive Unit
15-11		(SWE) 6092-71	Tool Bit
19-1		(KD) 3015	Compression Gauge Adapter
19-1		(KD) C-400	Compression Gauge

TOOLS NOT ILLUSTRATED

Fiat-Allis Part No.	Manufacturer's Part No.	Description
75300773		Vibrating Reed Tachometer
75294628		Valve Guide Reamer
75300072		Piston Cooling Modification Kit
75300772		Engine Diagnosis Kit
75300008		Engine Diagnosis Calculator
	(KD) 900	Portable Engine Stand
	(KD) 921	Engine Stand Adapter Plate
	(WIL) STW-3RCF	Torque Wrench, 0-250 lb-ft (0 - 34.6 kg-m)
	(OTC) 27797	Master Driver Set
	(OTC) 27810	Board for Master Driver Set
	(SON) IMFD 242	Socket, 3/4 in
	(KM) 21762	Nozzle Cleaner and Reamer
	(STR) S436C-RL	Micrometer, Set, 0-6 in
	(STR) 445B9RL	Depth Gauge Set, 0-9 in

CONVERSION TABLES

DECIMAL AND METRIC EQUIVALENTS OF FRACTIONS OF AN INCH

Inches				Inches			
Fractions	Decimals	*Nom. Dec.	Milli-meters	Fractions	Decimals	*Nom. Dec.	Milli-meters
1/64	.015625	.02	.397	33/64	.515625	.52	13.097
1/32	.03125	.03	.794	17/32	.53125	.53	13.494
3/64	.046875	.05	1.191	35/64	.546875	.55	13.891
1/16	.0625	.06	1.588	9/16	.5625	.56	14.288
5/64	.078125	.08	1.984	37/64	.578125	.58	14.684
3/32	.09375	.09	2.381	19/32	.59375	.59	15.081
7/64	.109375	.11	2.778	39/64	.609375	.61	15.478
1/8	.125	.12	3.175	5/8	.625	.62	15.875
9/64	.140625	.14	3.572	41/64	.640625	.64	16.272
5/32	.15625	.16	3.969	21/32	.65625	.66	16.669
11/64	.171875	.17	4.366	43/64	.671875	.67	17.066
3/16	.1875	.19	4.763	11/16	.6875	.69	17.463
13/64	.203125	.20	5.159	45/64	.703125	.70	17.859
7/32	.21875	.22	5.556	23/32	.71875	.72	18.256
15/64	.234375	.23	5.953	47/64	.734375	.73	18.653
1/4	.250	.25	6.350	3/4	.750	.75	19.050
17/64	.265625	.27	6.747	49/64	.765625	.77	19.447
9/32	.28125	.28	7.144	25/32	.78125	.78	19.844
19/64	.296875	.30	7.541	51/64	.796875	.80	20.241
5/16	.3125	.31	7.938	13/16	.8125	.81	20.638
21/64	.328125	.33	8.334	53/64	.828125	.83	21.034
11/32	.34375	.34	8.731	27/32	.84375	.84	21.431
23/64	.359375	.36	9.128	55/64	.859375	.86	21.828
3/8	.375	.38	9.525	7/8	.875	.88	22.225
25/64	.390625	.39	9.922	57/64	.890625	.89	22.622
13/32	.40625	.41	10.319	29/32	.90625	.91	23.019
27/64	.421875	.42	10.716	59/64	.921875	.92	23.416
7/16	.4375	.44	11.113	15/16	.9375	.94	23.813
29/64	.453125	.45	11.509	61/64	.953125	.95	24.209
15/32	.46875	.47	11.906	31/32	.96875	.97	24.606
31/64	.484375	.48	12.303	63/64	.984375	.98	25.003
1/2	.500	.50	12.700	1	1.000	1.00	25.400

VOLUME AND WEIGHT CONVERSION CONSTANTS — U.S. TO METRIC

Pints x .4732 = Liters
Quarts x .9463 = Liters
Gallons x 3.7853 = Liters
Pounds x .4536 = Kilograms
Cubic Yards x .7645 = Cubic Meters

TORQUE & PRESSURE CONVERSION CONSTANTS –

lb. ft. x 0.1383 = m-kg
lb. in. x 1.1521 = cm-kg
psi x 0.070 = kg/cm^2

LENGTH CONVERSION CONSTANTS — U.S. TO METRIC

Inches x 25.400 = Millimeters
Inches x .0254 = Meters
Feet x .3048 = Meters
Statute Miles x 1.60935 = Kilometers

*Nominal decimals are used in place of fractions of an inch, with exception of such items as bolts, screws, washers, tubing, wire, etc.