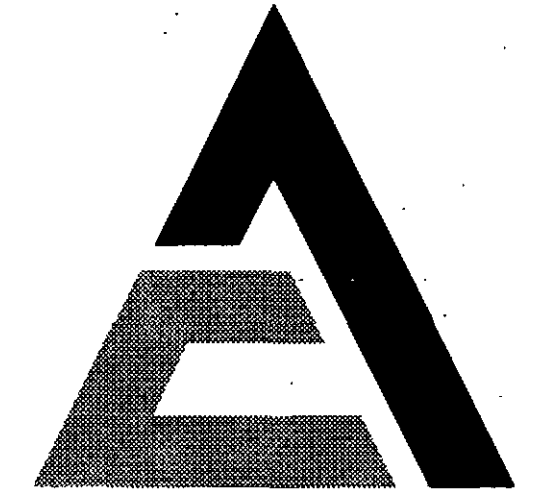
OPERATING AND MAINTENANCE MANUAL

D-175

D-262

ENGINES & POWER UNITS



ALLIS-CHALMERS

HARVEY, ILLINOIS, U.S.A.

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AVOID ACCIDENTS

MOST ACCIDENTS, WHETHER THEY OCCUR IN INDUSTRY, ON THE FARM, AT HOME OR ON THE HIGHWAY, ARE CAUSED BY THE FAILURE OF SOME INDIVIDUAL TO FOLLOW SIMPLE AND FUNDAMENTAL SAFETY RULES OR PRECAUTIONS. FOR THIS REASON MOST ACCIDENTS CAN BE PREVENTED BY RECOGNIZING THE REAL CAUSE AND DOING SOMETHING ABOUT IT BEFORE THE ACCIDENT OCCURS.

REGARDLESS OF THE CARE USED IN THE DESIGN AND CONSTRUCTION OF ANY TYPE OF EQUIPMENT THERE ARE MANY CONDITIONS THAT CANNOT BE COMPLETELY SAFEGUARDED AGAINST WITHOUT INTERFERING WITH REASONABLE ACCESSIBILITY AND EFFICIENT OPERATION.

A careful operator is the best insurance against an accident. The complete observance of one simple rule would prevent many thousand serious injuries each year. That rule is:
Never attempt to clean, oil or adjust a machine while it is in motion.

NATIONAL SAFETY COUNCIL

FOREWORD

This manual is provided to give the operator essential information regarding proper operation and maintenance of Allis-Chalmers diesel engines and auxiliary equipment.

The manual contains information and instructions on proper operation. To keep the unit operating at its maximum efficiency, the manual should be read by the operator and by those responsible for the maintenance of the unit.

An important item in prolonging the life of the unit is to keep dirt and other foreign particles away from its vital parts. Allis-Chalmers has taken precautions in the design of the equipment to safeguard against dirt and other foreign materials from reaching the working parts under normal operating conditions. The operator must also take precautions to assure that the oil, water, and fuel are always kept clean, and that air for combustion is always filtered. This can be accomplished by the proper storage and handling of fuel and lubricating oils and by following Allis-Chalmers recommendations in regard to lubricating oil specifications and change intervals, fuel specifications, maintenance of filters, air cleaner servicing, and proper care of the cooling system.

To assure the best results and maintain the high quality of the equipment, it is important that Allis-Chalmers parts are always used when new parts are required. IMPORTANT: ALWAYS FURNISH MODEL AND ENGINE SERIAL NUMBER WHEN ORDERING PARTS.

Many owners of Allis-Chalmers equipment rely upon the Service Department of our Dealers for all work other than routine maintenance and adjustment. This practice is encouraged as our Dealers are kept well informed by the factory regarding the most up-to-date methods of servicing Allis-Chalmers equipment and are equipped to render the most competent service.

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TOPIC 1. GENERAL DESCRIPTION

A. GENERAL

Engine models D-175 and D-262 are naturally aspirated, 4 cycle, water cooled, overhead valve, compression-ignition type diesel engines with vertical, in-line cylinders.

The basic engine, engine assemblies, and power units have been engineered with equipment necessary for usual installation requirements. All units can be modified for various applications by addition of optional equipment.

Engines shipped from Allis-Chalmers are equipped with an optional equipment plate, Figure 1. Catalog numbers of the various optional equipment groups as specified on the original factory order, are listed on the plate, together with the specific factory shipping order number.

NOTE: Furnishing of pertinent data regarding operation and maintenance of equipment not originally supplied by Allis-Chalmers is the responsibility of the company that assembles the equipment to the engine.

The engine serial number, model number, and engine part number are stamped on the name plate, Figure 2, located on the left side of the cylinder block.

NOTE: To obtain shipment promptly when ordering repair parts, always give the information on the engine name plate, and the repair part number and name. Order parts from the dealer covering the local territory.

B. DESCRIPTION

The fuel system consists of a dual media fuel filter, pintle type fuel injection nozzle holder assemblies, and a fuel injection pump with an integral fuel transfer pump and governor. The system cleans, prepares, and delivers accurately metered quantities of fuel under high pressure to the engine cylinders where it is ignited by heat of air compressed in the cylinders.

NOTE: Early model engines incorporate primary and secondary fuel filters.

Proper lubrication is assured by a gear type lubricating oil pressure pump driven by a gear located in the center of the camshaft. Oil is pumped under 25 to 50 psi pressure from the main oil gallery to the crankshaft, connecting rods, and rocker arm assembly. All other internal moving parts are lubricated by splash, spray, and oil in suspension. A filter connected into the system cleans the lubricating oil.

To maintain correct operating temperature of the engine and to prevent overheating, a V-belt driven centrifugal water pump circulates the coolant through the block, cylinder head, and radiator. The temperature of the coolant is controlled by a thermostat and the flowing of the coolant through the radiator.

To start the engine, a 12-volt electrical system is required. The system consists of a 12-volt storage battery to store energy and to energize the starter motor for cranking the engine. A 12-volt alternator produces the current to keep the battery charged; a voltage regulator controls the flow of current to the battery and prevents overcharge. The system also includes the electric air heater and necessary wiring, switches, and gauges.

NOTE: Early model engines incorporate a generator rather than an alternator.

C. ENGINE STROKE SEQUENCE

The combustion chamber (Fig 3) is a small, specially designed space located in the cylinder head above the cylinder. At one side of the combustion chamber is the fuel nozzle. Directly opposite the fuel nozzle there is an energy cell consisting of two chambers. The minor chamber opens out into the combustion space through a small restricted opening or orifice. Another small orifice connects the major chamber to the minor. Both of these chambers and the orifices are scientifically

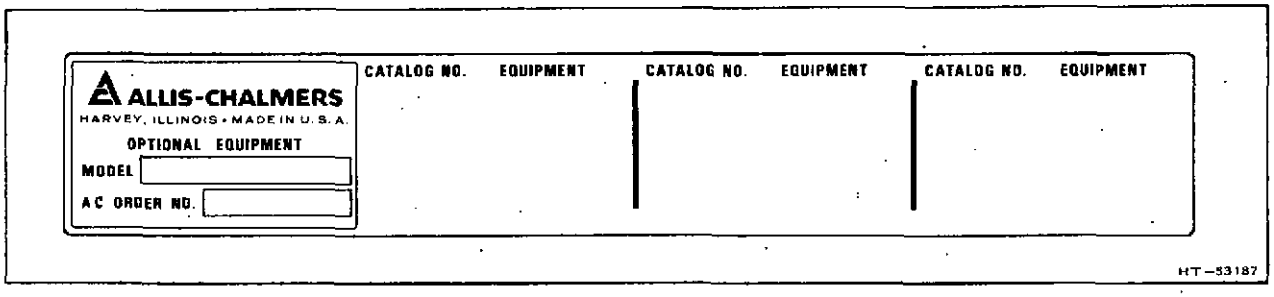


Figure 1. Engine Optional Equipment Plate

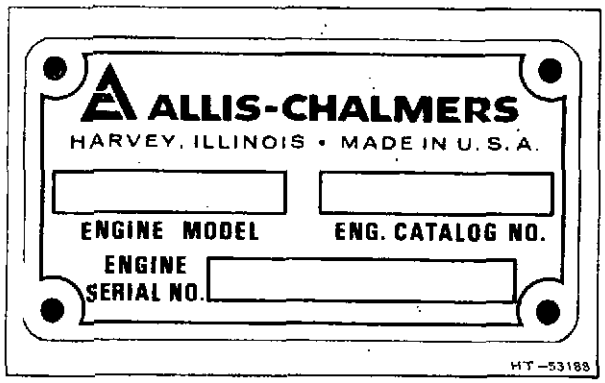
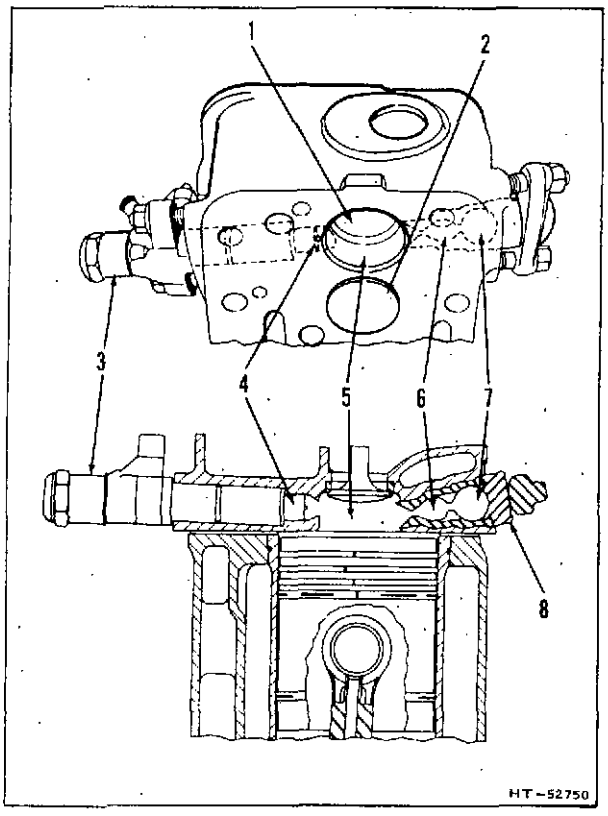


Figure 2. Engine Name Plate

designed and engineered as to their size, length, and position with respect to the fuel nozzle. The purpose of the energy cell is to produce rotary turbulence and to time and control the stirring action of the air and fuel.



1. Exhaust valve
2. Intake valve
3. Nozzle holder
4. Fuel nozzle
5. Main combustion chamber
6. Minor chamber
7. Major chamber
8. Energy cell

Figure 3. Combustion Chamber

In a 4 cycle diesel engine, a power stroke is made by each piston every two complete revolutions of the crankshaft. Sequence of strokes is 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 intake valve, which starts to open a few degrees before the piston reaches top dead center. The intake charge, consisting of air only, rushes into the cylinder.

2. Compression Stroke

   Shortly after the piston starts to move upward on the second, or compression stroke, the intake valve closes. As the piston comes up on the compression stroke, air is compressed in the combustion chamber. The restrictions or orifices connecting the chambers of the energy cell act as gates in that they allow only a predetermined amount of air to enter the cell. Because more air is compressed in the combustion chamber than in the energy cells, the pressure in the cells is slightly less than in the combustion chamber. This "pressure drop", as it is called, is created and controlled by the design of the energy cell.

   Shortly before the piston reaches the top of its compression stroke, the fuel nozzle shoots a measured amount of fuel into the combustion chamber. The fuel charge travels rapidly across the combustion chamber and a predetermined amount of fuel enters the energy cell along with additional air that is forced into the cell by the upward travel of the piston.

   At the same time, ignition begins in the main combustion chamber where the finely atomized outer edge of the fuel plume contacts the hot compressed air. A fraction of a second later the flame reaches the energy cell and ignition starts in the minor chamber.

3. Power Stroke

   As the piston starts down on its power stroke, the flame having reached the major chamber of the energy cell ignites the air fuel mixture in it. Combustion in this confined space causes a sudden pressure rise at the proper time. The energy cell is designed and built to withstand the shock of this pressure, and it cushions the force and isolates it so it cannot damage working parts such as pistons, bearings, and rings.

   The high pressure in the energy cell pushes the hot burning gases out through the orifices of the energy cell into the main combustion chamber in the form of a directed blast or backfire. As the blast first emerges from the energy cell it contacts the concentration of fuel spray in the main chamber. The cell

blast moves with such force that it breaks the fuel into small particles. The cell blast also sets up a swirling turbulence in the combustion chamber in which air, fuel and hot burning gases are thoroughly mixed, and completely burned. This turbulence and the stirring action assures complete combustion in a minimum of time. This turbulence and combustion continues during most of the downward or power stroke of the piston, and lasts long enough to assure that the maximum amount of the fuel energy is released and made available for useful work.

4. Exhaust Stroke

As the piston moves upward on the fourth, or exhaust stroke, the exhaust valve opens and burned gases are forced out of the cylinder by the upward travel of the piston. Shortly 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 the piston reaches top dead center, the exhaust valve closes completely, denoting the end of one cycle and beginning of the next.

TOPIC 2. SPECIFICATIONS

Allis-Chalmers reserves the right to make changes in the following specifications and to add improvements at any time without notice or obligation.

A. ENGINE (BASIC)

Models D-175 and D-262	Naturally Aspirated
Type	4 cycle
Number of Cylinders:	
Model D-175	4
Model D-262	6
Firing Order:	
Model D-175	1-3-4-2
Model D-262	1-5-3-6-2-4
Bore	3-9/16"
Stroke	4-3/8"
Cubic Inch Displacement:	
Model D-175	175
Model D-262	262
Crankshaft Rotation (viewed from fan end)	Clockwise
Number of Main Bearings:	
Model D-175	5
Model D-262	7
Compression Ratio (normal)	15.35:1
Compression Pressure at Sea Level, 600 rpm, hot	440 psi ± 15 psi
Maximum Permissible Exhaust Restriction	3" Hg

B. COOLING SYSTEM

Stabilized Coolant Temperature (minimum)	180°F
Water Pump Type	Centrifugal, Belt Driven
Radiator, Pressurized	7 psi
Nominal Capacities:	
Model D-175, engine only	6 qt
Model D-175, radiator and hoses	11 qt
Model D-262, engine only	10 qt
Model D-262, radiator and hoses	14 qt

C. LUBRICATING SYSTEM

Type System	Full Flow, Circulating Pressure
Oil Pump Type	Gear, Positive Displacement
Oil Pressure Range, hot, at full throttle	25-50 psi
Pressure regulation governed by	Regulation Valve
Nominal Oil Capacity:	
Model D-175 Filter and Oil Change	5 qt
Model D-262 Filter and Oil Change	8 qt
Model D-262 With Optional Oil Pan Filter and Oil Change	9 qt
Lubricating Oil Filter:	
Model D-175	Bypass
Model D-262	Full Flow
Maximum Angle of Operation:	
Model D-175	13°
Model D-262:	
Standard Oil Pan	13°
Optional Oil Pan	30°

D. FUEL INJECTION SYSTEM

Nozzle Holder Assembly Mfr	Allis-Chalmers
Fuel Injection Pump Mfr	Roosa Master
Nozzle Type	Self Cleaning, Pintle
Opening Pressure	2175 ± 25 psi

Fuel Pump Timing to Engine (static):

RPM	D-175	D-262
1200		16° BTDC
1400		16° BTDC
1500		16° BTDC
1600		16° BTDC
1800	22° BTDC	16° BTDC
2000	24° BTDC	16° BTDC
2200	26° BTDC	16° BTDC

Fuel Filters	Dual Media (Current Models) Primary and Secondary (Early Models)
Hand Primer Pump (maximum lift)	6 feet

E. VALVE DATA

1. Valve Lash Adjustment

Intake Valve Clearance (hot)	0.010"
Exhaust Valve Clearance (hot)	0.019"

2. Valve Timing

Exhaust Valve (with 0.019" tappet clearance):

	D-175	D-262
Opens BBDC	31°	39° 30'
Closes ATDC	16°	15°
Duration	227°	234° 30'
Overlap	29°	26° 30'

Intake Valve (with 0.010" tappet clearance):

	D-175	D-262
Opens BTDC	13°	11 30'
Closes ABDC	63° 30'	33° 30'
Duration	256° 30'	225°

F. GOVERNOR (MECHANICAL)

Type	Variable Speed, Flyball
Regulation (standard)	7 to 10%
Regulation (optional)	3-1/2%
Speed (standard setting):	
Full Load	2000 rpm
High Idle (no load)	2140 - 2200 rpm
Low Idle	600 - 700 rpm

G. CONVERSION FACTORS, U.S. to METRIC MEASURE

Quart x 0.9463 = Liter
Pound x 0.4536 = Kilogram
Inch x 2.5400 = Centimeter
PSI x 0.0703 = Kg/cm^2
Pound-foot x 0.1383 = Kilogram-meter

TOPIC 3. PREPARATION OF ENGINE FOR OPERATION

A. PROCEDURE

Use extreme care when unpacking the unit to avoid damaging engine parts and accessories.

For your protection, make a thorough inspection of the engine immediately upon delivery. In case of damage or shortage, have the carrier make a notation on the freight bill and notify the transit agent at once.

Install the engine in a clean, well ventilated area where it will be accessible for inspection, maintenance, and repair. The foundation must be of ample size and strength to support the unit and assure its accurate alignment with equipment to which it will furnish power.

Before starting the engine the operator should fully understand the use and function of the operating controls and instruments. (Refer to Topic 4.)

After the engine is installed and before starting it, perform the operations listed below.

1. Remove all tape and shipping caps used to seal engine openings.
2. Check radiator for damage incurred during shipment. Remove any foreign material that has collected on the radiator during shipment to prevent it from obstructing air flow around fins and between passages of the radiator.
3. If cooling system drain plugs have been removed and wired to the engine, install them properly. Fill cooling system. (Refer to Topic 11.)
4. Make certain all air cleaner connections are tight to prevent dirt being drawn into the engine cylinders.
5. Check oil level in oil pan with the dipstick. Fill air cleaner oil cups to proper level. (Refer to Topic 17.)

NOTE: The engine is shipped with CD (Service DS-Series 3), SAE 20 weight lubricating oil. Maintain proper oil pan level with any good quality CD (Service DS) oil. The factory oil is compatible with any CD (Service DS) oil supplied by any major oil company. At the first regular oil change period, drain factory oil and fill with proper classification and SAE weight of oil for the prevailing ambient temperature. (Refer to Topic 6.)

6. Check engine fan belt for correct adjustment. Deflection should be 1/2". (Refer to Topic 11.)
7. Connect storage battery to the electrical system. (Refer to Topic 14.)
8. Fill fuel tank with the recommended fuel. (Refer to Topic 7.)
9. Connect fuel supply line from the fuel tank to the first stage filter. Connect the fuel pump overflow and nozzle overflow line to the top of the fuel tank. Prime the fuel system. (Refer to Topic 12.)
10. If unit is equipped with a power take-off clutch, check adjustment of the clutch operating lever. (Refer to Topic 19.)
11. Bar the engine over by hand to make certain it turns freely.
12. Check engine intake and exhaust systems to make certain they are unobstructed by foreign material. The exhaust line should not be restricted by sharp bends/crimps but should be kept as short as possible and installed with a minimum number of elbows. Total restriction of a naturally aspirated engine exhaust system must not exceed three inches mercury back pressure at the exhaust outlet under full load, full speed conditions.

CAUTION: All muffler and exhaust pipe extensions must be adequately supported and flexibly connected to avoid excessive strain on the exhaust manifold outlet.

B. SAFETY PRECAUTIONS

1. When operating the engine in a closed area, pipe exhaust fumes outside. Continued breathing of exhaust fumes may be fatal.
2. When servicing batteries, do not smoke or use an open flame in the vicinity. Batteries generate explosive gas during charging. Make sure there is adequate ventilation when charging battery.
3. When filling fuel tank, do not smoke or use an open flame in the vicinity.
4. Be extremely careful when using a carbon tetrachloride fire extinguisher in a closed area as it produces toxic vapor. Provide adequate ventilation before entering a closed area where carbon tetrachloride has been used.

TOPIC 4. OPERATING CONTROLS AND INSTRUMENTS

Various controls and instruments are available to assist the operator in getting optimum service from the engine. Regardless of panel configuration or location, the operator must be familiar with the function of engine controls and instruments provided for operating the unit.

A. OPERATING CONTROLS

1. Engine Key Switch (Stop Control)

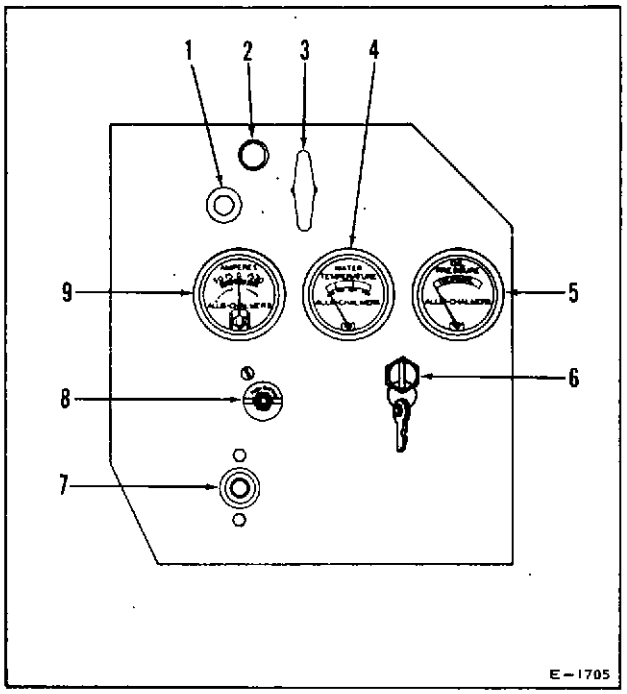
   The engine key switch energizes the governor fuel solenoid circuit.

2. Engine Stop-Control

   The engine stop-control is provided to actuate the engine stop-control lever which is located on the governor. Push the stop-control all the way in before starting the engine; pull the control all the way out to stop the engine.

3. Starter Button

   Push button to operate the engine starter. The button should be released as soon as the engine starts.



1. Starter button
2. Stop control
3. Throttle control
4. Water temperature gauge
5. Oil pressure gauge
6. Key switch
7. Air heater switch
8. Magnetic switch reset button
9. Ammeter

Figure 1. Flywheel Housing Mounted Instrument Panel (Current Type)

4. Throttle Control

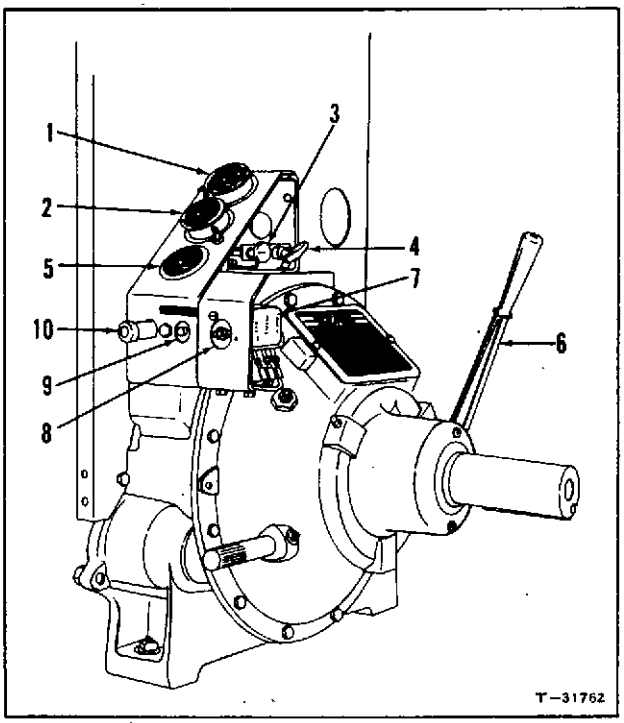
   The turn-to-lock type throttle control actuates the governor speed control lever. Engine speed is varied by pulling out on the throttle handle. The throttle is locked in position by turning the handle either clockwise or counterclockwise, and is released by returning it to mid-position.

5. Clutch Operating Lever

   The clutch operating lever actuates the clutch mechanism to connect and disconnect engine load.

6. Air Heater Switch

   The air heater switch energizes the air heater element.



1. Oil pressure gauge (Standard or Safety Shutdown)
2. Water temperature gauge (Standard or Safety Shutdown)
3. Engine stop-control
4. Throttle control
5. Ammeter gauge
6. Clutch operating lever
7. Magnetic switch
8. Push button (Reset) magnetic switch
9. Starter switch button
10. Air heater switch

Figure 2. Flywheel Housing Mounted Instrument Panel

7. Magnetic Switch Reset Button

The magnetic switch reset button is pressed to complete circuit to the electric solenoid of the fuel injection pump before engine can be started after safety shut-down.

NOTE: Magnetic switch will not reset until button on oil pressure safety switch-gauge is reset.

B. INSTRUMENTS

1. Oil Pressure Gauge

The oil pressure gauge indicates pressure at which lubricating oil is circulating through the engine.

2. Ammeter

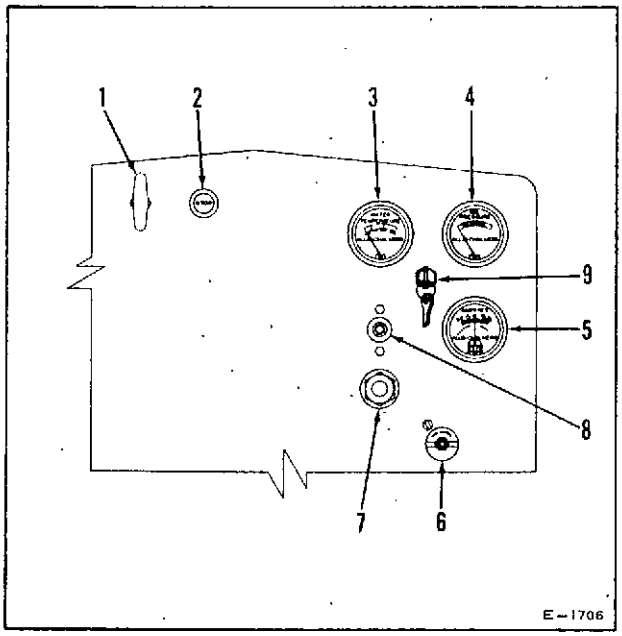
The ammeter indicates charging output of the alternator.

3. Water Temperature Gauge

The engine water temperature gauge indicates temperature of coolant being circulated in the cooling system.

4. Tachometer

The tachometer indicates engine speed in revolutions per minute (rpm). A flexible cable operates the tachometer. The drive-end of the cable connects into a drive assembly located in an opening on the camshaft side of the engine. The drive assembly engages a coupling in the drive gear of the engine lubricating oil pump.



1. Throttle control
2. Stop control
3. Water temperature gauge
4. Oil pressure gauge
5. Ammeter
6. Magnetic switch reset button
7. Starter button
8. Air heater switch
9. Key switch

Figure 3. Sheet Metal Rear Instrument Panel

C. SAFETY CONTROLS

When specified, safety controls are used instead of standard gauges. Refer to Topic 18.

TOPIC 5. OPERATING INSTRUCTIONS

A. OPERATING PRECAUTIONS

1. Always allow engine to warm up at reduced speed.
2. Keep engine and accessories clean. Check for loose connections, capscrews, bolts, and nuts while cleaning.
3. If engine overheats due to lack of coolant, replenish slowly while engine is running.
4. Do not run engine continuously at governed speed without load.
5. Do not allow engine to idle for prolonged periods except in sub-zero weather.
6. Refuel at end of daily operation to keep condensation to a minimum.
7. Check all electrical wiring for loose connections. Keep battery clean.

B. STARTING ENGINE

1. Before starting a new engine, prepare it for operation as detailed in Topic 3.
2. Make certain engine clutch is in disengaged (neutral) position.
3. Place engine stop control in RUN position and turn key switch to ON position.
4. Place throttle control in HALF LOAD position.

NOTE: If engine is equipped with safety controls, refer to Topic 18 for starting procedure.

5. Press starter button.

NOTE: For cold weather starting, refer to *Paragraph G, in this Topic.*

CAUTION: Do not use starting motor continuously for more than 30 seconds without a pause of two minutes to allow it to cool.

6. With engine running, move throttle control slowly to a fast idle position. Allow engine to warm up at this speed before applying load.
7. Oil pressure should be 25 to 50 psi at full load *rpm. If pressure is not within these* limits, stop engine immediately and correct trouble.

C. PLACING ENGINE UNDER LOAD

1. Before starting engine, refer to Topic 3, PREPARATION OF ENGINE FOR OPERATION.
2. Start engine following procedure given in preceding Paragraph B.
3. Position throttle control to operate engine at 1/4 throttle or slower.
4. Push forward slowly on clutch operating lever until load has started to move, then push forward quickly to fully engage clutch.

NOTE: Engine clutch should engage with a definite over-center snap and should require an appreciable push on operating lever for engagement. If snap is not evident or if clutch slips under load, adjust it immediately. Refer to Topic 19.

5. After engine clutch engages, set throttle control and lock in position.

D. DURING OPERATION CHECKS

1. Observe general condition of engine while it is running.
2. Look for loose bolts, leaks, and overheated assemblies. Listen for unusual noise.
3. Stop engine and make necessary repairs and adjustments.

E. STOPPING ENGINE

1. Move throttle control slowly to low idle speed.
2. Disengage engine clutch by pulling back clutch operating lever.

CAUTION: After disengaging clutch, allow engine to run at a fast idle, but not high idle, speed for at least 5 munutes to cool engine gradually and uniformly.

3. Move stop control to STOP position.
4. Cover exhaust pipe to prevent entrance of moisture when engine is idle.

F. HOT WEATHER OPERATION

1. Keep cooling system filled with clean, soft water.
2. Make certain that fins and passages of radiator *are free of foreign material.*
3. Keep external surface of engine clean.

G. COLD WEATHER OPERATION

1. Perform Steps 2 through 4 in Paragraph B. STARTING ENGINE, in this Topic.

2. Press and hold air heater switch for 45 seconds minimum.

3. Press and hold starter switch while still holding air heater switch in the ON position. When engine starts, release both switches. If engine does not run on all cylinders immediately after starting, again press air heater switch for a short period until engine is running on all cylinders.

> CAUTION: Do not use starting motor continuously for more than 30 seconds without a pause of two minutes to allow it to cool.

4. With engine running, move throttle control slowly to a fast idle position. Allow engine to warm up at this speed before applying load.

5. Oil pressure should be 25 to 50 psi at full load rpm. If pressure is not within these limits, stop engine immediately and correct trouble.

> CAUTION: Do not use a commercial cold weather starting fluid, such as an ether starting aid, without first disconnecting the air heater from the electrical system.

6. Make certain battery is fully charged and all other electrical equipment is in optimum condition.

7. Use glycol base anti-freeze solution to protect engine against damage by freezing. Refer to instructions or protection charts furnished by anti-freeze manufacturer to determine the quantity of anti-freeze required for lowest anticipated temperature.

8. Refer to Topic 17, for proper maintenance of air cleaner.

9. Provide radiator cover if thermostat proves inadequate to maintain normal coolant operating temperature.

10. At end of daily operation, drain water from fuel tank and from fuel filter (early model).

11. When ambient temperature is minus 20°F or lower, a means of warming the engine and battery is recommended in order to obtain satisfactory starting and to prevent engine damage. It is suggested that crankcase oil be drained at end of daily operation. When starting operations in minus 20°F temperatures and lower, heat oil to approximately 200°F and replace in oil pan.

H. EXERCISE OF ENGINE ON STANDBY SERVICE

Under optimum conditions, a diesel engine on standby service should be exercised at least every 30 days. However, under environmental conditions involving extreme temperatures, humidity, dust, sand, etc., it may be necessary to shorten the interval between exercise periods to as often as weekly. Exercise period should be long enough to enable the engine to attain normal operating temperature while carrying, if possible, at least 50% of its normal load.

To exercise engine, proceed as follows:

1. Before starting engine, check lubricating oil and coolant levels. Make a complete visual inspection of unit.

2. Start the engine and run for 15 minutes at one-half throttle.

3. Run engine at full throttle with whatever load is available, up to full load, for the period of time required to obtain two consecutive water temperature readings of 160°F minimum, taken at a 15 minute interval. Then continue to operate engine for 30 minutes. Check and correct any coolant or oil leaks.

> NOTE: If no load, or a very light load, must be used during exercise period, cover the radiator to hasten the warm-up period.

> CAUTION: Do not cover radiator of an unattended engine.

4. Run engine at one-half throttle with no-load for 5 minutes to allow combustion chamber temperatures to decrease gradually to a minimum.

5. Stop engine.

> NOTE: If the accumulated hours of operation during the above exercise periods do not total 100 hours (recommended lube filter and lubricating oil change period) during a six month period, it is recommended that the filter and lubricating oil be changed at a maximum of every six months. If the accumulated hours of operation during the above exercise periods do not total 500 hours (recommended fuel filter change period) during a 12 month period, it is recommended that the fuel filter elements be replaced at the end of the 12 month period.

I. ENGINE STORAGE

1. General

An engine stored for an extended period of time must be protected from corrosion and

deterioration. The following preventive measures should be adhered to promptly after the engine is shut down. Store the engine in an enclosed moisture-free building that is heated during the winter months. If a building is not available, cover the engine with a waterproof tarpaulin or a durable plastic cover that is tied securely to the engine.

An engine prepared for storage in one of the following manners can be returned to service at any time and within a minimum amount of time.

2. 30 Days Or Less Storage Period

For protection during a temporary period (30 days or less), perform the following steps:

a. Drain engine oil pan. Fill oil pan with new lubricating oil of proper classification and SAE weight. Refer to Topic 6.

b. Service the air cleaner.

c. Drain water and sediment from fuel tank and, if applicable, from fuel filters.

d. If temperatures below 32°F are expected, add a permanent type antifreeze to the cooling system.

e. Clean exterior of engine and dry it thoroughly.

f. Service battery and cables. Make certain battery is at full charge.

g. In the event the engine is to be stored outside and uncovered, it is recommended the following steps be taken to guard against excessive rusting of the crankshaft pulley grooves, due to moisture being trapped between the bottom of the pulley and the belts. This could result in increased belt wear when the engine again resumes its normal day to day usage and can be more serious when cog type belts are used.

(1) With the engine stopped, paint the exposed portion of the crankshaft pulley grooves with a fast drying paint; spray painting is acceptable.

(2) After the paint is thoroughly dry, bar the engine over part way and again paint the exposed portion of the pulley.

(3) Continue this procedure until all grooves of the crankshaft pulley are painted a full 360°.

h. Use a durable waterproof and vaporproof material to seal all engine openings.

i. Store engine inside of a building or cover it with a waterproof material that is tied securely to the engine.

3. More Than 30 Days Storage Period

Engine removed from operation for an extended period (more than 30 days and not to exceed 6 months) must be prepared for storage as follows:

a. Service the air cleaner.

b. Check exterior of radiator. Remove any foreign matter that has collected around and between the radiator fins.

c. Drain and flush the cooling system. If rust or scale is observed during the flushing operation, clean the system with a commercial cleaner following the manufacturer's instructions.

d. Fill cooling system with clean water and add a good commercial soluable oil type rust inhibitor. However, if temperatures below 32°F are expected, add a permanent type antifreeze to the cooling system instead.

e. Start engine and operate it with sufficient speed and load to enable the coolant to reach minimum temperature. At this point, the thermostats will open and the coolant will circulate through the entire system. Continue to operate engine for one hour.

f. Stop engine. Remove drain plug and drain lubricating oil from pan. Remove lubricating oil filter element(s) and install new filter element(s).

g. Install drain plug and fill oil pan to the FULL mark on the dipstick with any commercial rust preventive oil (SAE 30) meeting Military Specification MIL-L-21260. Operate engine for 10 minutes and add oil to bring oil level up to the FULL mark on the dipstick.

h. If applicable, drain water and sediment from fuel filters. Install new fuel filter elements and prime the fuel system. Then drain the fuel tank.

i. If fuel injection nozzles have not been serviced recently, check spray pattern and opening pressure of the nozzle holder assemblies; clean and adjust if necessary. This precaution will assure the nozzle holder assemblies are ready for operation when the engine is put back into service.

j. Disconnect the fuel tank to fuel filter supply line and the fuel return line at the fuel

tank. Using two clean containers, fill one with regular fuel oil and fill the other with a fuel oil containing a rust preventative such as The Texas Company "564 Rust Proofing Oil" or an equivalent.

k. Start engine using the container with the regular fuel oil. After engine is running smoothly, switch the second container to the fuel supply line. Continue to operate engine until the rust preventive fuel oil is observed at outlet of the overflow line; then stop the engine.

l. Connect fuel supply line and return line to fuel tank.

m. Clean exterior of engine and dry it thoroughly.

n. In the event the engine is to be stored outside and uncovered, it is recommended the following steps be taken to guard against excessive rusting of the crankshaft pulley grooves, due to moisture being trapped between the bottom of the pulley and the belts. This could result in increased belt wear when the engine again resumes its normal day to day usage, and can be more serious when cog type belts are used.

(1) With the engine stopped, paint the exposed portion of the crankshaft pulley grooves with a fast drying paint; spray painting is acceptable.

(2) After the paint is thoroughly dry, bar the engine over part way and again paint the exposed portion of the pulley.

(3) Continue this procedure until all grooves of the crankshaft pulley are painted a full 360°.

o. Use a durable waterproof and vaporproof material to seal all engine openings.

p. Disconnect battery from engine. Clean battery and battery cables. Add distilled water to bring electrolyte up to proper level. Charge battery to make certain it is fully charged. Store battery in a cool, dry location, shielded from direct sunlight, and away from heat duct outlets. Do not stack a battery on top of another. Check electrolyte level and specific gravity every 30 days. Add distilled water and charge battery to maintain it in full operational condition.

q. Store engine inside of a building or cover it with a waterproof material that is tied securely to the engine.

NOTE: The engine should be tagged indicating a certain storage manner has been performed. It should also be noted on the tag the importance of performing detailed procedure before returning engine to service.

4. More Than 6 Months Storage Period

An engine removed from operation for an extended period of more than 6 months must be prepared for storage as detailed in the preceding Subparagraph 3. Then after every 6 months of storage, perform the following:

a. Check fuel tank for condensation and drain if necessary.

b. If applicable, drain water from fuel filters.

c. Fill supply tank with a sufficient amount of a rust preventive fuel oil such as The Texas Company "564 Rust Proofing Oil" or an equivalent in order to exercise engine.

CAUTION: Do not allow engine to run out of fuel during the exercise period.

d. Check radiator or expansion tank coolant level and add coolant if necessary.

e. Loosen, but do not remove, oil pan drain plug to drain any moisture that may have collected. When oil free of moisture appears, tighten oil pan drain plug.

f. Remove material that was used to seal engine openings.

g. Connect the storage battery observing correct polarity.

CAUTION: If engine is operated inside of a building, pipe the exhaust gases to the outside.

h. Start engine and run 15 minutes at 1/2 speed.

i. Run engine at full speed with whatever load is available up to full load for a period of time that is required to obtain two consecutive water temperature readings (minimum 160°F) that are the same when taken at a 15 minute interval. Then continue to operate engine for 30 minutes. Check and correct any coolant or oil leaks.

If no load or very light load must be used during exercise period, it is recommended the radiator (if applicable) be covered on an attended engine to hasten the warm-up period.

j. Run engine at 1/2 speed with no-load for 5 minutes before stopping to reduce combustion chamber temperatures to a minimum.

k. Stop the engine.

l. Disconnect the storage battery and store it as detailed in the preceding Subparagraph 3.

m. Drain the fuel tank.

n. Use a durable waterproof and vaporproof material and seal all engine openings.

o. Store engine inside of a building or cover it with a waterproof material that is tied securely to the engine.

5. Returning Engine To Service

After an engine has been in storage for an extended period up to 6 months and before returning it to service, perform the following:

a. Check fuel tank for condensation and drain if necessary.

b. If applicable, drain water from fuel filters.

c. Fill fuel supply tank with specified fuel. Prime the fuel system.

d. Remove oil pan drain plug and drain rust preventive lubricating oil.

e. Install drain plug and fill oil pan with proper classification and SAE weight of lube oil to proper level. Refer to Topic 6.

f. Check radiator coolant level and add coolant if necessary.

g. Check condition of drive belts. Adjust or replace if necessary.

h. Remove material that was used to seal engine openings.

i. Connect the storage battery observing correct polarity.

TOPIC 6. LUBRICATION RECOMMENDATIONS

A. ENGINE LUBRICATING OIL

The general recommendation is to use CD lubricating oil in all turbocharged engines in all applications. This also applies to naturally aspirated (non-turbocharged) engines that are operating under severe applications or when the fuel sulphur content exceeds 0.5%. In most normal duty applications of non-turbocharged engines a CC grade oil can be used.

> NOTE: API classification CD was formerly DS, Series 3 (MIL-L-45199B) and CC was DM (MIL-L-2140B/45199)

Allis-Chalmers diesel engines are designed for optimum performance, life and lubricating oil control, at normal operating speeds, loads and temperature, with SAE 30 viscocity lubricating oil.

Lighter viscosity oils are required for satisfactory engine starting, without damage from marginal lubrication, when crankcase temperatures during engine starting are below 32° F. This is the only reason for the use of lubricating oils lighter than SAE 30 in Allis-Chalmers engines.

Crankcase Temperature When Starting Engine	Weight (Viscosity)
0° F and below	SAE 10W
0° F to 32° F	SAE 20/20W
Above 32° F	SAE 30W

The use of multigrade lubricating oils in Allis-Chalmers diesel engines is not recommended.

Our specification of 100 hours for filter and oil change periods is based on the use of high quality oils, fuels with less than .5% sulphur, and average engine loads not exceeding the continuous rating with engines in good adjustment and operating with coolant and lubricating oil temperatures between 170° and 200°. Variations from these considered normal operating conditions must be compensated for by more frequent oil change and/or filter change periods. Our recommendations for oil change periods are further based on what experience has shown to be conservative and safe hours of operation between oil changes.

Variations from these considered normal operating conditions must be compensated for by more frequent oil change and/or filter change periods. Our recommendations for oil change periods are further based on what experience has shown to be conservative and safe hours of operation between oil changes.

The quality and type of the oils and additive compounds used, and the additive quantity in various brands of lubricating oils affect their performance level. Under severe operating conditions, with engines in poor mechanical condition or when using high sulphur fuels, lubricating oils will deteriorate at a faster rate. For these reasons oil change periods can vary.

After 3,000 miles or 100 hours of operation, whichever occurs first, actual tests of the lubricating oil at an interval of 10 to 20 hours or 1,000 miles should be made. As a result of these tests the oil condition can be determined, which may either allow extended or necessitate shortening of oil and oil filter change periods. Most major lubricant suppliers provide this oil testing service on a gratis basis. We recommend that our customers take advantage of this service, not only for the protection of the engines but also to realize maximum safe usage from the lubricating oil.

Most manufacturers of lubricants recognize the importance of the quality required for use in Allis-Chalmers engines and are cooperating fully to assure the use of only those oils which fulfill these requirements. The oil distributor and oil manufacturer are to be held responsible for the results obtained from their products. Acquire your lubricants from manufacturers and suppliers with unquestioned integrity supplying known and tested products. Do not jeopardize your engine with inferior lubricating oils.

Field experience has shown that Allis-Chalmers diesel engines, in the majority of applications and under most service conditions, will perform equally well on either high ash or low ash CD lubricating oils. Our laboratory tests, however, have shown that under severe duty contitions (extended operation under full throttle conditions, high ambient temperatures, etc.) and oil having a sulfated ash level of at least 1.5% will usually outperform an oil having a lower ash level. Where a choice in lubricating oils is practical and economical, a high ash oil should therefore be selected for such applications.

Optimum oil life and also optimum engine life can be realized if the following items are given proper consideration.

1. Use of quality fuels meeting our published specifications.
2. Use of Allis-Chalmers replacement filters.
3. Adequate turbocharger and combustion chamber cooling by running engine at a fast idle for 5 minutes before shutdown.
4. Proper attention of air cleaner service

and prevention of leaks in the air intake system.

5. Engine Adjustment:

   a. Correct fuel settings

   b. Fuel injection pump timing

   c. Injection nozzle function and opening pressure.

   d. Valve clearance settings.

6. Cleanliness with lubricating oil, oil containers, oil storage facilities, and oil fill caps and pipes on engines.

7. Proper attention to entire cooling system including removal of antifreeze and flushing system for summer operation, maintaining specified operating temperature, maintaining fan belts and water pump drive belts in correct adjustment, and keeping radiator surfaces free of debris.

B. GREASE

1. Pressure Gun Lubricant

   Use a ball and roller bearing lubricant that has a minimum melting point of 300° F. It must be waterproof and have a viscosity that assures easy handling in a hand operated pressure gun at prevailing ambient temperatures.

2. Angle Adaptor Lubrication

   Use a grease conforming to MIL-G-10924 to lubricate the tachometer angle adaptor.

TOPIC 7. FUEL OIL RECOMMENDATIONS

A. GENERAL

Using any given grade of fuel oil, Allis-Chalmers engines perform as well as, or better than other diesel engines of comparable size and rating. However, from the standpoints of fuel economy and availability, as well as engine performance, maintenance and environmental control requirements, experience has shown that the fuel best suited for these engines closely approximates the fuel oil specification listed below.

This specification is within the American Society for Testing Materials (ASTM) specification for No. 1 and No. 2 fuels. The American Society for Testing Materials has established fuel oil specifications and testing methods to which the petroleum industry conforms very closely. Diesel engine manufacturers have, over the years, come to rely on the ASTM specifications as a standard of the industry and a simple means for the engine owner to identify and purchase fuel oil.

Fuel Oil Specification:

Gravity, API Degrees	30-40
Cetane Number	40 Min
Viscosity, Kinematic, (Centistokes @ 100° F)	1.4-5.8
Flash Point	100° F or Legal
Pour Point	10° F Below Ambient Temperature
Distillation Temperature-90% Point	640° F Max
Ash % by Weight	0.02 Max
Water and Sediment % by Volume	0.10 Max
Sulfur Content % by Weight	0.5 Max
Carbon Residue on 10% Ramsbottom	0.35 Max
Copper Strip Corrosion	No. 3 Max

These specifications are offered as a guide to help the diesel engine owner/operator make a satisfactory selection from the most available stocks of fuel oil. Such factors as climate, economy, and availability of fuel may at times necessitate the use of fuel with certain specifications which are outside those listed in the table.

In general the design of the Allis-Chalmers engines has been developed to take advantage of the higher energy content and generally lower cost of the No. 2 diesel fuels.

Using fuel oils that do not meet the complete specification will require shortening the filter renewal and inspection intervals to obtain a reasonable useful life from the injection equipment.

B. FUEL OIL CHARACTERISTICS

It is not within the scope of this topic to set down all diesel fuel characteristics and the details of all testing methods, but on occasion it is necessary that the engine operator, and particularly, the person responsible for buying diesel fuel, have a working knowledge of the subject.

1. API Gravity

   The API gravity rating is an index of the fuel's density or weight per unit volume. In addition, it affords an indication of the viscosity, distillation characteristics and heating value of a fuel. Since fuel is purchased on a volume basis, gravity is used when setting up purchasing specs and in delivery inspections. Low API (heavier) fuels are desirable because they contain more BTU's per gallon but if they are too heavy, combustion may be incomplete.

   Data extracted from a typical table based on degrees API at 60° F is listed in the table at the bottom of this page (Fig 1).

2. Cetane Number

   The cetane number indicates the ignition quality of fuel oil, a critical factor in both ease of starting and smooth operation of a diesel engine. The higher the cetane number, the higher the ignition quality of the fuel.

3. Viscosity

   The viscosity rating of fuel oil is a measure of its resistance to flow due to the friction that exists within the oil itself. It must have the proper body or viscosity to work properly in the fuel injection sys-

Degrees API At 60° F	Specific Gravity At 60° F	Pounds Per Gallon At 60° F	Gallons Per Pound At 60° F	BTU Per Pound	BTU Per Gallon
30	.8762	7.296	.1371	19,420	141,800
35	.8498	7.076	.1413	19,590	138,800
40	.8251	6.870	.1456	19,750	135,800

Figure 1. Data Table

tem. A fuel oil of high viscosity, i.e., a "heavy" fuel oil, may cause extemely high pressures in the fuel injection system and reduce the atomization and vaporization of the fuel spray, whereas a fuel of extremely low viscosity may not provide sufficient lubrication for the close fitting pump and injector plungers, a condition which may cause abnormal wear and permit excessive leakage past the plungers.

4. Flash Point

The flash point of a fuel is the temperature at which vapors in a standard testing apparatus are ignited by a small flame. Although the flash point rating has no quality significance, it is important with respect to safety in storing, shipping, and handling. Many states and insurance companies have mandatory flash point limitations and these must be considered when ordering fuel.

5. Pour Point

The pour point of fuel is the lowest temperature at which it will flow or can be pumped through the fuel injection system. In equipment operating in cold ambient temperatures, the pour point must be at least 10^0 F below the lowest temperature expected in order to assure satisfactory transfer and flow of fuel throughout the system.

6. Distillation Temperature, 90^0 F Point

The distillation temperature of fuel is a direct indication of its volatility and vaporization characteristics. Fuel can be completely burned in an engine only in vaporized form. Fuel that cannot be completely vaporized and burned will form sludge and other harmful deposits in the engine. Low distillation fuels will give more satisfactory performance and better economy when used in engines that operate periodically in cold ambient temperatures or at reduced speeds and loads, and in engines that normally operate under varying conditions of speed and load.

7. Ash

Fuel oil contains measurable amounts of non-burnable, ash-forming materials in the form of abrasive solids and soluble metallic soaps. These materials tend to form harmful deposits in the engine and accelerate wear of fuel injection equipment, pistons, rings, sleeves, etc.

8. Water and Sediment

Water and sediment in fuel oil promotes wear of fuel injection equipment and other engine parts. In addition, these contaminants contribute to sludge formation and shorter fuel filter life.

9. Sulfur

Sulfur in fuel oil has a marked effect on wear of engine parts and causes an increase in harmful engine deposits. Under conditions of low ambient temperatures and intermittent engine operation, condensation occurs within the engine and combines with the sulfur to form sulfurous acid (H_2SO_3), which is highly corrosive to engine parts. The sulfur content should be kept to a minimum in order to increase the intervals between oil changes and engine overhauls.

10. Carbon Residue

This specification indicates the amount of carbon deposit formed by a petroleum oil under coking conditions. Carbon residue is thought to be related to engine deposits and thoroughness of combustion.

11. Copper Strip Corrosion

The corrosive tendency of a particular fuel oil is determined by immersing a copper test strip in the oil and, after following a prescribed procedure, comparing the resultant corrosion with a standard color chart.

C. HANDLING AND STORAGE OF FUEL OIL

Improper handling and storage practices cause a major portion of all fuel system troubles. The interval between receipt of the fuel from the distributor and its final use in the engine is critical to proper functioning of the engine. The following information should be kept in mind and used as a check list from time to time in order to maintain a trouble-free fuel system.

1. Take all precautions necessary to prevent the entrance of dirt and moisture into the fuel system. Contamination by these materials accelerates sludge formation, clogs filters, lines, and nozzles, and causes abnormal wear of close fitting parts in the fuel injection pump.

2. Moisture does not accumulate as rapidly in underground storage tanks as it does in above-ground tanks because temperature is more stable.

3. Alternately cooling and heating of above-ground tanks causes condensate to accumulate rapidly. Such tanks should be placed at an angle to horizontal and be equipped with a draincock valve at the lowest point. Condensation and sediment should be drained at regular intervals.

4. Large storage tanks should be equipped with covered manholes, and small tanks should be

provided with ports and removable covers in order to facilitate tank cleaning.

5. Fuel fill pipe should extend above ground level and be equipped with a watertight, dustproof cap or cover.

6. Tanks should be vented to a safe area to allow normal "breathing" caused by expansion and contraction of the fuel and air.

7. The fuel outlet line should be connected to the tank either at the end opposite the sediment collection point or at a point that is well above the area of maximum accumulation.

8. Fuel lines should be of aluminum or steel wherever possible. Copper accelerates deterioration of fuel and induces sludge and gel formation.

9. All fuel handling equipment, such as funnels, hand pumps, and dipsticks, should be kept clean at all times and covered when not in use.

10. Do not open fuel containers or transfer fuel from drums to tanks in areas exposed to blowing dust and dirt. Also, do not use cotton waste material or linty rags to wipe containers, funnels, hand pumps, dipsticks, etc.

11. All fuel oils deteriorate at different rates depending upon such factors as the original source of the crude oil, the extent of refining and blending it has undergone, the degree of contamination introduced during storage, and age of the fuel oil.

    a. Do not use tanks of larger capacity than necessary. The maximum recommended storage period for current type diesel fuels composed of blends of straight run distillates and catalytically cracked stocks is 6 months to one year. The user is inviting clogged filters and fuel injection difficulties if fuel is used that has been stored for longer periods. When longer storage periods are anticipated, a stabilizing additive should be specified when the fuel is ordered. Regardless of storage time, a full tank is preferable to one that is only partially filled.

    b. Fuel instability is related in some degree to its sulfur content. Sulfur promotes the formation of corrosive compounds that are very destructive to metals in the fuel storage and fuel injection system.

    c. Do not continually add new fuel to old fuel in storage without occasionally draining and disposing of all fuel remaining in the tank. The chemical change already started in the old fuel accelerates deterioration of the new fuel.

TOPIC 8. LUBRICATION AND MAINTENANCE SCHEDULE AND MAINTENANCE TOOLS

A. GENERAL

Maintenance includes those functions and activities that will keep the engine in peak operating condition and prevent unnecessary trouble from developing.

Lubrication is an essential part of the maintenance program, controlling to a great extent the useful life of the engine. It is important that the instructions regarding the types of lubricants (Topic 6) and the frequency of application be closely followed. The lubrication given in the schedule is based on normal operation and the use of recommended oil. Perform the lubrication at more frequent intervals when operating under abnormal or severe conditions. The lubrication change period given in the table is only a guide. Actual tests of the lubrication should be made and the change period established in accordance with the results.

In addition to lubrication, the schedule specifies other maintenance functions that must be performed at prescribed intervals. These intervals are based on normal operation; alter the interval length to suit your particular operating conditions.

Thoroughly clean all lubrication fittings, caps, filler and level plugs, and the surrounding surfaces before servicing the engine. Prevent dirt or other contaminants from entering the lubricants and coolants.

For detailed information regarding the lubrication, inspecton, or maintenance precedure of any given component, refer to the applicable topic in this manual.

> NOTE: The varied applications to which the engines are subjected in actual service can considerably lengthen or shorten the life of operation the engines will satisfactorily run between major overhauls, piston ring replacements, and valve reconditionings. Observation of crankcase breathing, exhaust sound and color, lubricating oil consumption, engine power, and the sound of the engine in operation by a qualified diesel mechanic will determine the need for reconditioning.

B. LUBRICATION AND MAINTENANCE GUIDE

Recommended lubrication and maintenance intervals are given in the following schedule:

LUBRICATION AND MAINTENANCE SCHEDULE

	Reference		Daily	Each 100 Hours	Each 200 Hours	Each 500 Hours	Each 2000 Hours	Each 4000 Hours
	Topic	Paragraph						
Visually inspect-engine and accessories for loose connections, nuts, bolts, and capscrews, leaking seals, gaskets, fuel lines and air connections.			X					
Check engine coolant level. Fill to within 1-1/2" of filler neck.	11	D	X					
Drain water from fuel tank and check fuel supply.	5	G	X					
Drain water from primary fuel filter. (Early Model)	12	B	X					
Air cleaner - Inspect oil cups and clean when 1/2" dirt has collected.	17	B	X					
Check oil level in oil pan at start of day's operation. Bring level up to the high mark on the oil level gauge (dipstick).	13	B	X					
Grease power take-off clutch throwout collar.	19	B	X					

LUBRICATION AND MAINTENANCE SCHEDULE (CONTINUED)

	Reference		Daily	Each 100 Hours	Each 200 Hours	Each 500 Hours	Each 2000 Hours	Each 4000 Hours
	Topic	Paragraph						
Make certain radiator core is free of obstructions.	11	E		X				
Using engine oil, lubricate throttle and stop control swivels.	4	A		X				
Check condition and tension of fan drive belt. Inspect pulleys.	11	G		X				
Change engine lubricating oil and replace oil filter. Inspect oil for metal particles.	13	D		X				
Remove and clean engine breather cap.	13	E		X				
Lubricate generator with 3 or 4 drops of engine oil. (Early model engines)	14	E		X				
Check liquid level of the battery cells.	14	C		X				
Power take-off clutch - Grease the shaft bearings, pilot bearing and operating lever shaft.	19	B		X				
Check clutch for proper adjustment.	19	C		X				
Check intake and exhaust manifold mounting nuts and inspect manifolds for cracks.	16	B			X			
Inspect generator or alternator and voltage regulator.	14	E				X		
Check timing of fuel injection pump to engine.	12	E				X		
Renew fuel filter(s).	12	B				X		
Check valve lash adjustment.	15	A				X		
Inspect starter.	14	D				X		
Check specific gravity of each battery cell. Inspect and clean battery cables.	14	C				X		
Energy (air) cell - Inspect and clean if necessary.	12	J					X	
Check spray pattern and opening pressure of fuel injection nozzles.	12	G					X	
Clean exterior of engine.	5	A					X	
Clean oil pan and oil pump suction screen.	13	E					X	
Clean oil pump pressure relief valve.	13	E					X	
Clean oil pressure regulating valve.	13	E					X	

	Reference		Daily	Each 100 Hours	Each 200 Hours	Each 500 Hours	Each 2000 Hours	Each 4000 Hours
	Topic	Para-graph						
*Main and connecting rod bearings - Check for condition and excessive wear.							X	
*Intake and exhaust valves - Remove carbon and grind valves.							X	
*Piston rings - Replace piston rings.							X	
*Disassemble engine and all accessories. Make major inspection of all components. Replace or repair parts as required.							X	

*See NOTE in Paragraph A of this topic.

C. MAINTENANCE TOOLS

The following tool listing has been prepared to assist service and maintenance personnel in the selection of tools (other than standard hand or shop tools) to accomplish the various maintenance operations described and illustrated in this manual.

The tools listed must be ordered directly from the tool manufacturer.

TOOL MANUFACTURERS

(KM) Kent-Moore Organization, Inc.
Service Tool Division Order Dept.
1501 South Jackson Street
Jackson, Michigan

(SS) Standard Screw Company
Hartford Division
Hartford, Connecticut 06102

Topic	Figure No	Manufacturers' Tool Number And Description		
9	1	(KM)	J-6692	Compression Gauge Assembly
9	1	(KM)	J-22472	Compression Gauge Adaptor (Less Tip)
9	1	(KM)	J-21616	Compression Gauge Adaptor Tip (Current Engines)
9	*	(KM)	J-6423-3	Compression Gauge Adaptor Tip (Early Engines)
12	12	(SS)	13371	Seal Compressor Tool
12	*	(KM)	J-8689	Nozzle Remover Adaptor
12	20	(KM)	J-6471-1	Slide Hammer
12	21	(KM)	J-8625	Nozzle Tester Set
12	13	(SS)	13371	Plastic Timing Window (Test Gauge)
12	*	(KM)	J-6445-50	Spray Collector
	*	(KM)	J-6445-34	Carrying Case For J-8625
12	23	(KM)	J-6999	Injection Nozzle Holding Fixture
	*	(KM)	J-3179	Nozzle Lapping Kit
15	2,3	(KM)	J-3172	Feeler Gauge Set
15	5	(KM)	J-21496	Cylinder Head Guide Stud
15	5	(KM)	J-21497	Cylinder Head Guide Stud
15	5	(KM)	J-7891-2	Guide Stud Removal Wrench
16	1	(KM)	J-22462	Manometer 24"-0-24" Mercury Slack Tube Type

* Not Illustrated

TOPIC 9. TROUBLESHOOTING

A. GENERAL

It has been proven that over 90% of the troubles that occur in engine operation are avoided when those persons responsible for maintenance adhere to an adequate program of lubrication, inspection, and maintenance on a regularly scheduled basis. The time and expense involved in such programs is only a fraction of that incurred when poor maintenance practice results in a major malfunction or breakdown.

In most cases, when a trouble is detected and remedied immediately, a more expensive, time-consuming repair will be avoided. The following list of symptoms, causes, and remedies is given to aid the operator in locating and correcting mechanical and electrical troubles as quickly as possible. For detailed inspection and maintenance procedures for any given component, refer to that section or topic pertaining to the part, assembly, or system.

B. ENGINE

TROUBLE	POSSIBLE CAUSES	REMEDY
Engine will not turn	1. Battery weak.	1. Recharge or replace battery.
	2. Starting system faulty.	2. Refer to Paragraph C.
	3. Engine 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. Repair or replace defective parts.
	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. Repair or replace defective parts.
Engine will not start	1. Slow cranking speed.	1. Specific gravity of battery too low. Charge battery. Starter not delivering maximum torque. Repair or replace defective parts.
	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. Refer to Paragraph D.
	4. Fuel injection nozzles not operating properly.	4. Test and repair or replace nozzles.
	5. Fuel injection pump improperly timed.	5. Time fuel injection pump.

TROUBLE	POSSIBLE CAUSES	REMEDY
Engine hard to start	1. Battery weak.	1. Recharge or replace battery.
	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. Clogged fuel filter.	4. Replace filter.
	5. Fuel injection nozzles not operating properly.	5. Test and repair or replace nozzles.
	6. Fuel transfer pump not operating properly.	6. Test and repair or replace fuel transfer pump.
	7. Air in fuel system.	7. Refer to Paragraph D.
	8. Insufficient air supply to cylinders.	8. Refer to Paragraph E.
	9. Fuel injection pump improperly timed.	9. Time fuel injection pump.
	10. Valve lash incorrect.	10. Adjust valve lash.
	11. Piston rings or cylinder sleeves worn.	11. Replace affected parts.
	12. Valves warped or pitted.	12. 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. Refer to Paragraph D.
Engine stops suddenly	1. Out of fuel.	1. Fill fuel tank with specified fuel and prime the fuel system.
	2. Restricted fuel supply.	2. Refer to Paragraph D
	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. Cooling system faulty.	1. Refer to Paragraph F.
	2. Radiator core clogged.	2. Clean and flush radiator.
	3. Radiator air passages clogged.	3. Remove debris from radiator core.
	4. Fan drive belt too loose.	4. Adjust fan drive belt to proper tension.
	5. Thermostat inoperative.	5. Test the thermostat for proper operation. Replace if necessary.
	6. Improper engine lubrication.	6. Refer to Paragraph G.
	7. Water pump malfunctioning.	7. Repair or replace the water pump.
	8. Fuel injection pump improperly timed.	8. Time fuel injection pump.

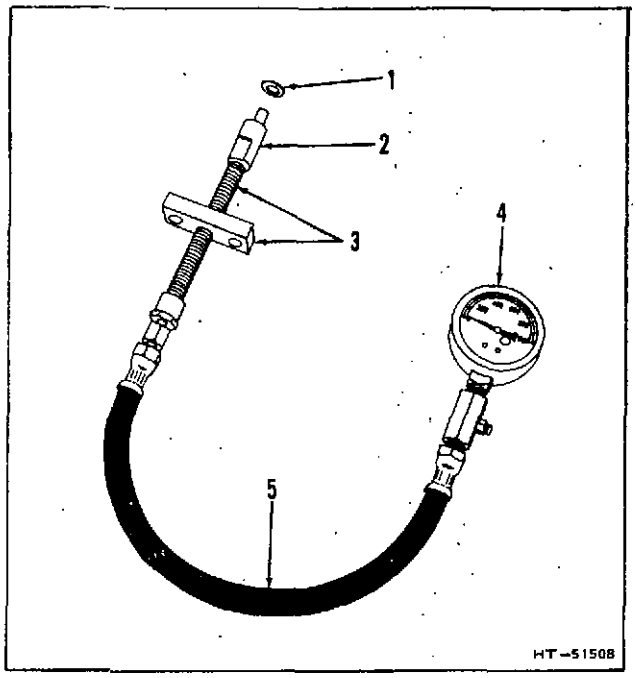
TROUBLE	POSSIBLE CAUSES	REMEDY
Engine shows loss of power	1. Insufficient supply of air to cylinders.	1. Refer to Paragraph E.
	2. Insufficient supply of fuel to fuel injection nozzles.	2. Refer to Paragraph D.
	3. Governor not operating properly.	3. Inspect and adjust governor.
	4. Air in fuel system.	4. Prime fuel system. Check for air leaks on suction side of fuel transfer pump. Refer to Paragraph D.
	5. Clogged fuel filter.	5. Change filter element.
	6. Improper valve lash.	6. Adjust valve lash.
	7. Fuel injection pump improperly timed.	7. Time fuel injection pump.
	8. Defective fuel injection pump or fuel injection nozzles.	8. Repair or replace affected parts.
	9. Cylinder cutting out.	9. Locate "missing" cylinder as follows: Run engine at low idle speed and cut out each fuel injection nozzle in turn by loosening the fuel injection line nut attaching line to fuel injection pump. A decrease in engine speed with line nut loosened indicates nozzle for that cylinder is functioning properly. If engine speed does not decrease, nozzle is malfunctioning and must be replaced.
	10. Loss of compression.	10. This may be due to leaking valves or to worn piston rings or cylinder sleeves. Use a suitable compression tester, Figure 1, and check each cylinder as detailed in following paragraphs.

Compression pressure for a normal engine at normal operating temperature firing on five cylinders at 600 rpm and at sea level conditions is 440 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 440 psi must be derated 3%.

It is common practice to consider a differential of 25 psi between one or more cylinders as an indication of possible trouble. This is not always true. 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 blow-by into the manifolds, or loss of engine power, it is safe to continue to operate the engine. However, if any of the above conditions exist, or if a difference of 50 psi or more is noted between cylinders, the 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: In order to obtain an accurate pressure indication, make certain the compression tester gauge has been properly tested and calibrated. Do not rebuild an engine because of low compression readings obtained with a compression tester unless the gauge is known to be accurate.



1. Nozzle Gasket
2. Adaptor Tip
3. Adaptor
4. Compression Gauge
5. Hose Assembly

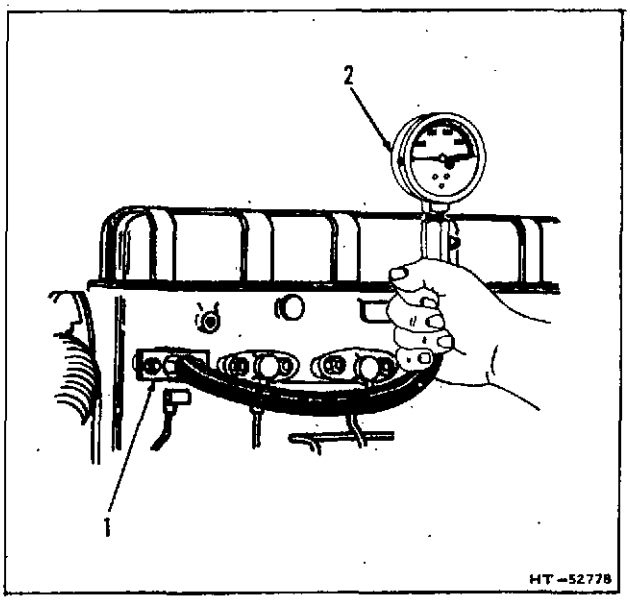
Figure 1. Tools for Checking Compression

To check compression pressure, proceed as follows:

a. Start engine and warm up to a minimum temperature of 160° F.

b. Shut off engine. Remove drip manifold from nozzle holder assemblies. Remove overflow tube assembly between drip manifold and overflow tee at fuel injection pump. Plug opening in overflow tee at fuel injection pump where overflow tube assembly was removed.

CAUTION: Do not plug return of fuel to tank.



1. Compression Tester Adaptor
2. Compression Tester Gauge Assembly

Figure 2. Checking Compression Pressure

c. *Start compression check on cylinder Number 1.* Remove the fuel injection nozzle and install compression tester adapter and nozzle gasket in same manner the fuel injection nozzle was installed. Install the compression tester hose and gauge assembly. (See Figure 2.)

d. Start engine and run at approximately 600 rpm. Take several readings on gauge.

CAUTION: Do not check compression by cranking engine with starter.

e. Stop engine and remove the compression tester assembly. Install nozzle-holder assembly. Connect fuel injection line.

f. Repeat procedure detailed above in Steps c, d, and e, to check compression of each of the remaining cylinders.

TROUBLE	POSSIBLE CAUSES	REMEDY
Engine runs unevenly and vibrates excessively	1. Governor not operating properly.	1. Adjust governor and linkage.
	2. Fuel supply erratic or insufficient.	2. Refer to Paragraph D.
	3. Engine operating temperature too low.	3. Refer to Paragraph F.
	4. Fuel injection pump malfunctions.	4. Check fuel injection pump.

TROUBLE	POSSIBLE CAUSES	REMEDY
Engine runs unevenly and vibrates excessively (Cont)	5. Valves in bad condition.	5. Recondition valves.
	6. Cylinder cutting-out.	6. Check fuel injection system, exhaust-intake valves, and valve operating mechanism.
	7. Fuel injection nozzle malfunctions.	7. Repair nozzle.
Engine emits black smoke from exhaust	1. Air system clogged.	1. Check engine air intake system. Clean as required.
	2. Fuel injection pump roller-to-roller dimension incorrect.	2. Correct roller-to-roller dimension.
	3. Improper fuel.	3. Drain fuel system and refill with specified fuel.
	4. Lack of good fuel injection nozzle spray pattern.	4. Clean and adjust nozzles. Refer to Topic 12.
Engine emits bluish-white smoke from exhaust	1. Engine operating temperature too low.	1. Check thermostat.
	2. Clogged fuel injection nozzles.	2. Clean and adjust nozzles.
	3. Low compression.	3. Make compression test and necessary repairs.
	4. Early fuel injection pump timing.	4. Test and adjust.
Engine detonates or knocks CAUTION: If a hard metallic knock indicates detonation in one or more cylinders, immediately stop the engine and make the necessary repair.	1. Fuel pump improperly timed.	1. Check and adjust.
	2. Loose bearings	2. Replace bearings.
	3. Loose piston.	3. Inspect piston assembly. Replace parts required.
	4. Loose flywheel.	4. Check tightness of flywheel bolts and dowels. Tighten/replace parts required.
	5. Improperly adjusted valve(s).	5. Check and adjust.
	6. Foreign material in cylinder(s).	6. Make necessary repairs.

C. STARTING SYSTEM

TROUBLE	POSSIBLE CAUSES	REMEDY
Starter will not crank engine	1. Battery weak.	1. Check battery.
	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.

TROUBLE	POSSIBLE CAUSES	REMEDY
Starter will not crank engine (Cont)	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 brushings 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.

D. 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. Prime fuel system.
	2. Defective fuel transfer pump.	2. Repair affected parts.
	3. Fuel injection nozzle valve binding in valve body.	3. Replace valve assembly in nozzle holder body.
	4. Fuel lines/fuel filter clogged.	4. Clean fuel system components, replace fuel filter.
	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.

E. AIR INTAKE SYSTEM

TROUBLE	POSSIBLE CAUSES	REMEDY
Insufficient air supply to cylinders	1. Air cleaner clogged.	1. Service air cleaner.
	2. Leaks in engine intake manifold.	2. Tighten loose manifold retaining nuts. Replace manifold gasket.
Rapid wear on engine parts	1. Dirt admitted with intake air.	1. Inspect air cleaner body, pipe, connecting hoses, gasket, etc., thoroughly for cracks or openings which would allow air to enter engine without passing through air cleaner. Make necessary repairs.

TROUBLE	POSSIBLE CAUSES	REMEDY
Rapid wear on engine parts (Cont)	2. Dirty lubricating oil.	2. Change engine oil and the lubricating oil filter element 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.

F. 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.
	3. Thermostat inoperative.	3. Replace thermostat.
	4. Loose or broken fan drive belt.	4. Adjust or replace fan drive belt.
	5. Lime deposits in water passages of radiator, cylinder head and/or cylinder block.	5. Thoroughly clean affected parts.
	6. Water pump defective.	6. Repair or replace water pump.
	7. Engine pulling excessive load.	7. Reduce load.
	8. Engine speed set too high.	8. 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. Engine cylinder head gasket leaking.	2. Replace gasket and torque cylinder head capscrews as specified.
	3. Engine cylinder head cracked.	3. Replace cylinder head.
	4. Engine cylinder block cracked.	4. 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.

G. 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.

TROUBLE	POSSIBLE CAUSES	REMEDY
No lubricating oil pressure (Cont)	4. Lubricating oil pump inoperative.	4. Repair or replace oil pump.
	5. Oil line 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 line in crankcase loose or broken.	3. Repair or replace affected items.
	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. Lubricating oil pump worn.	7. Repair or replace oil pump.
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.
Excessive oil consumption	1. External oil leakage (gaskets, etc.)	1. Correct all external leaks.
	2. Engine 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 specified lube oil is used and engine is at operating temperature.
	2. Engine oil viscosity too light.	2. Use oil of recommended viscosity.

TROUBLE	POSSIBLE CAUSES	REMEDY
Rapid wear on engine parts	1. Lubricating oil contaminated.	1. Drain the system and fill with clean engine oil. Replace engine oil filter.
	2. Improper engine lubricating oil being used.	2. Drain the system and fill with engine lubricating oil of proper specifications.

H. ELECTRICAL SYSTEM

TROUBLE	POSSIBLE CAUSES	REMEDY
No output from generator (early models) or alternator (current models)	1. Drive belt loose or broken.	1. Adjust or replace drive belt.
	2. Voltage regulator inoperative.	2. Remove regulator for repair or replacement.
	3. Unit not operating properly.	3. Remove unit for repairs or replacement.
Generator or alternator output low and/or unsteady	1. 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. Commutator dirty or worn.	4. Clean commutator or remove generator for repair or replacement.
	5. Voltage regulator not operating properly.	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 (regulator output excessive or cracked battery case).	4. Reduce charging rate. Remove and repair or replace battery.
	5. Voltage regulator inoperative.	5. Remove regulator for repair or replacement.

I. INSTRUMENTS

If any of the instruments fail to register proper readings while the engine is in operation, the system to which the instrument applies should be thoroughly checked as outlined in the preceding parts of this Topic to determine the cause. If failure of the instrument is suspected, test by installing a new, tested, instrument in its place. Replace inoperative instruments.

TOPIC 10. FITS AND TOLERANCES; BOLT, CAPSCREW, AND NUT TORQUE WRENCH SPECIFICATIONS; STUD GAUGE HEIGHTS

A. FITS AND TOLERANCES

The following fits and tolerances apply to both the D-175 and D-262 models of engines. However, there are some variations between the two models and when a difference exists, it will be so designated for the particular models of engine to which it applies.

DESCRIPTION	DIMENSION
1. Cylinder Sleeves	
a. Type	Replaceable Wet
b. Inside diameter	3.5623" - 3.5638"
c. Diameter of sleeve at mechanical area just below flange	3.911" - 3.913"
d. Diameter of cylinder sleeve at packing ring location	3.838" - 3.840"
e. Sleeve flange - outside diameter	3.978" - 3.982"
f. Cylinder block-to-sleeve clearance lower diameter	.001" - .005"
g. Cylinder block-to-sleeve clearance at machined area just below flange	.0005" - .0045"
h. Cylinder block-to-sleeve clearance at sleeve flange	.003" - .012"
i. Clearance of piston skirt with sleeve	.0040" - .0005"

DESCRIPTION	DIMENSION
j. Top surface of cylinder sleeve flange may be .002" above to .002" below deck of cylinder block (installed).	
k. Allowable taper	.0007"
l. Allowable out-of-round (when installed)	.001"
2. Cylinder Block	
a. Counterbore diameter in cylinder block for cylinder sleeve flange	3.985" - 3.990"
b. Depth of counterbore for cylinder sleeve flange	.249" - 251"
c. Bore in cylinder block for cylinder sleeve - Top	3.9135" - 3.9155"
d. Bore in cylinder block for cylinder sleeve - Bottom	3.841" - 3.843"
e. Bore in cylinder block for camshaft bearings -	
Front and intermediate	2.124" - 2.125"
Rear	1.374" - 1.375"
f. Bearing bore in cylinder block for main bearings (without bearing, cap in place, and capscrews tightened to specified torque)	2.6993" - 2.700"
3. Piston	
a. Material	Aluminum alloy
b. Length	4.142" - 4.150"
c. Diameter between top and second ring groove	3.537" - 3.541"
d. Diameter at bottom of skirt measured at right angle to piston pin	3.5573" - 3.5583"
e. Bore for piston pin	.99985" - 1.00005"
f. Measurement from center of piston pin bore to top of piston	2.269" - 2.273"
g. Clearance of piston skirt with sleeve	.0040" - .0065"
4. Piston Pin	
a. Type	Full Floating
b. Piston pin length	2.963" - 2.973"
c. Diameter of pin	.99955" - .99975"
d. Fit at pin in piston at room temperature	.0001" - .0005" loose
e. ID of connecting rod bushing installed	
D-175	1.0001" - 1.0006"
D-262	.9999" - 1.0004"
f. Piston pin-to-connecting rod bushing clearance	
D-175	.00035" - .00105"
D-262	.00015" - .00085"
5. Piston Rings	
a. Number of rings on each piston	5
b. Location of rings	3 compression rings and 1 oil control ring above piston pin 1 oil control ring below piston pin.

DESCRIPTION	DIMENSION
c. Gap between ends - fitted	
1st (compression)	.022" min - .037" max
2nd and 3rd (compression)	.014" min - .029" max
4th (oil control)	.014" min - .059" max
5th (oil control)	.007" min - .020" max
d. Clearance of rings in grooves	
1st (compression)	.003" - .0045"
2nd and 3rd (compression)	.002" - .004"
4th (oil control)	
Production	.002" - .0075"
Service	.0005" - .0065"
5th (oil control)	.0015" - .004"
6. Crankshaft	
a. Journal diameter for connecting rods	1.9975" - 1.9985"
b. Journal for main bearings	2.497" - 2.498"
c. Width between connecting rod journal cheeks	1.500" - 1.504"
d. Width of main bearing journals	
Front bearing	1.557" - 1.567"
Intermediate bearings	1.318" - 1.326"
Center bearing	1.875" - 1.879"
Rear bearing	2.0000"
e. Crankshaft end clearance	.003" - .009"
f. Crankshaft journals may be ground	.040" undersize
g. Fit of crankshaft gear on crankshaft	.001" - .003" tight
7. Main Bearings	
a. Number used	
D-175	5
D-262	7
b. Type	Replaceable Precision
c. Inside diameter of front, intermediate, center and rear bearings (with capscrews tightened to specified torque)	2.4993" - 2.5010"
d. Diameter of crankshaft main bearing journals	2.497" - 2.498"
e. Bearing-to-journal clearance at front, intermediate, center and rear bearings (with capscrews tightened to specified torque)	.0013" - .0040"
f. Overall length of main bearings	
Front	1.245" - 1.255"
Intermediate	1.120" - 1.130"
Center	1.870" - 1.872"
Rear	1.745" - 1.755"
g. Undersize bearings available for service	.002", .010" .020", .040"
h. Front, intermediate, center and rear bearing wall thickness (standard bearing)	.0995" - .1000"
i. Bearing bore in cylinder block (without bearing, cap in place, and capscrews tightened to specified torque)	2.6993" - 2.7000"

8. Connecting Rod Bearings

a. Type	Replaceable Precision
b. Inside diameter of bearing (with nuts tightened to specified torque)	1.9996" - 2.0011"
c. Diameter of crankshaft connecting rod journals	1.9975" - 1.9985"
d. Connecting rod bearing-to-journal clearance (with nuts tightened) to specified torque)	.0011" - .0036"
e. Overall length of connecting rod bearings	1.307" - 1.317"
f. Undersize bearings available for service	.002", .010" .002", .040"
g. Bearing wall thickness (standard bearing)	.0797" - .0802"

9. Connecting Rods

a. Type	
D-175 (non-rifled drilled)	Balanced Forging
D-262 (rifled drilled) (early engines)	Balanced Forging
D-262 (non-rifled drilled) (current engines)	Balanced Forging
b. Bolts used per rod	2
c. Connecting rod length (center-to-center)	7.373" - 7.377"
d. ID of connecting rod bushing (finished bore)	
D-175	1.0001" - 1.0006"
D-262	.9999" - 1.0004"
e. OD of connecting rod bushing	1.127"
f. Bearing bore (without bearing, cap in place, and nuts tightened to specified torque)	2.1600" - 2.1605"
g. Connecting rod bearing-to-crankshaft journal clearance (with nuts tightened to specified torque)	.0011" - .0036"
h. Connecting rod width at lower end	1.495" - 1.497"
i. Side clearance-to-crankshaft cheek	.003" - .009"
j. Piston pin diameter	.99955" - .99975"
k. Piston pin bushing length in connecting rod	1-1/4"
l. Piston pin-to-connecting rod bushing clearance	
D-175	.00035" - .00105"
D-262	.00015" - .00085"
m. Bore in connecting rod for piston pin bushing	1.124" - 1.125"

10. Exhaust Valves

a. Valve lift at valve	
D-175	.348"
D-262	.327"
b. Valve lift at cam	
D-175	.260"
D-262	.245"

c. Seat angle 45°

d. Valve seat width (contact)
- D-175 (Prior to Serial No. 119995) 3/64"
- D-175 (Effective with Serial No. 119995 thru D-05050) 3/64"
- D-175 (Effective with Serial No. D-05051) 1/16" - 3/32"
- D-262 (4513145 Basic Engine) 3/64"
- D-262 (4514288 Basic Engine) 1/16" - 3/32"

e. Valve lash (cold) .021"

f. Valve lash (engine coolant at normal operating temperature) .019"

g. Head diameter
- D-175 (Prior to Serial No. 119995) 1.371" - 1.381"
- D-175 (Effective with Serial No. 119995 thru D-05050) 1.370" - 1.380"
- D-175 (Effective with Serial No. D-05051) 1.245" - 1.255"
- D-262 (4513145 Basic Engine) 1.371" - 1.381"
- D-262 (4514288 Basic Engine) 1.245" - 1.255"

h. Overall length
- D-175 (Prior to Serial No. 119995) 4-9/16"
- D-175 (Effective with Serial No. 119995 thru D-05050) 4.5261"
- D-175 (Effective with Serial No. D-05051) 4.4379"
- D-262 (4513145 Basic Engine) 4-9/16"
- D-262 (4514288 Basic Engine) 4.4379"

i. Stem diameter .309" - .310"

j. ID of valve guide (Ream after assembly) .3125" - .3135"

k. Stem-to-guide clearance .0025" - .0045"

11. Intake Valves

a. Valve lift at valve
- D-175 .357"
- D-262 .333"

b. Valve lift at cam
- D-175 .260"
- D-262 .243"

c. Seat angle
- D-175 (Prior to Serial No. 119995) 45°
- D-175 (Effective with Serial No. 119995 thru D-05050) 30°
- D-175 (Effective with Serial No. D-05051) 30°
- D-262 (4513145 Basic Engine) 45°
- D-262 (4514288 Basic Engine) 30°

d. Valve seat width (contact)
- D-175 (Prior to Serial No. 119995) 3/64"
- D-175 (Effective with Serial No. 119995 thru D-05050) 3/64" - 1/16"
- D-175 (Effective with Serial No. D-05051) 5/64" - 3/32"
- D-262 (4513145 Basic Engine) 3/64"
- D-262 (4514288 Basic Engine) 5/64" - 3/32"

e. Valve lash (cold) .012"

f. Valve lash (engine coolant at normal operating temperature) .010"

g. Head diameter
- D-175 (Prior to Serial No. 119995) 1.370" - 1.380"
- D-175 (Effective with Serial No. 119995 thru D-05050) 1.541" - 1.551"
- D-175 (Effective with Serial No. D-05051) 1.475" - 1.485"
- D-262 (4513145 Basic Engine) 1.370" - 1.380"
- D-262 (4514288 Basic Engine) 1.475" - 1.485"

h. Overall length

D-175 (Prior to Serial No. 119995)	5-11/32"
D-175 (Effective with Serial No. 119995 thru D-05050)	5.356"
D-175 (Effective with Serial No. D-05051)	5.3564"
D-262 (4513145 Basic Engine)	5-11/32"
D-262 (4514288 Basic Engine)	5-3564"

i. Stem diameter . . . . . .309" - .310"

j. ID of valve guide (Ream after assembly) . . . . . .3125" - .3135"

k. Stem-to-guide clearance . . . . . .0025" - .0045"

12. Valve Springs (Exhaust and Intake)

	Spring Only	Spring w/Damper
a. Valve spring free length	2-3/32"	2-3/32"
b. Valve spring (valve closed)	1.756"	1.756"
c. Valve spring (valve open)	1.412"	1.412"
d. Spring load at 1.756" length	40 - 45 lb	42 - 48 lb
e. Spring load at 1.412" length	86 - 92 lb	95 - 105 lb

13. Valve Seat Inserts (Exhaust)

a. Seat angle . . . . . 45°

b. Seat width (contact)

D-175 (Prior to Serial No. D-01964)	3/64"
D-175 (Effective with Serial No. D-01964 thru D-05050)	3/64"
D-175 (Effective with Serial No. D-05051)	1/16" - 3/32"
D-262 (4513145 Basic Engine)	3/64"
D-262 (4514288 Basic Engine)	1/16" - 3/32"

c. OD (not installed)

D-175 (Prior to Serial No. D-01964)	1.4715" - 1.4725"
D-175 (Effective with Serial No. D-01964 thru D-05050)	1.4715" - 1.4725"
D-175 (Effective with Serial No. D-05051)	1.346" - 1.347"
D-262 (4513145 Basic Engine)	1.4715" - 1.4725"
D-262 (4514288 Basic Engine)	1.346" - 1.347"

d. Bore in head for insert

D-175 (Prior to Serial No. D-01964)	1.468" - 1.469"
D-175 (Effective with Serial No. D-01964 thru D-05050)	1.468" - 1.469"
D-175 (Effective with Serial No. D-05051)	1.343" - 1.344"
D-262 (4513145 Basic Engine)	1.468" - 1.469"
D-262 (4514288 Basic Engine)	1.343" - 1.344"

e. Shrink fit

D-175 (Prior to Serial No. D-01964)	.0025" - .0045" tight
D-175 (Effective with Serial No. D-01964 thru D-05050)	.0025" - .0045" tight
D-175 (Effective with Serial No. D-05051)	.002" - .004" tight
D-262 (4513145 Basic Engine)	.0025" - .0045" tight
D-262 (4514288 Basic Engine)	.002" - .004" tight

f. Run-out . . . . . .002" T.I.R.

g. Oversize insert . . . . . .005" over standard OD

14. Valve Guides

a. Exhaust Valve Guide

Length	2-1/4"
ID (Ream after assembly)	.3125" - .3135"
Stem-to-guide clearance	.0025" - .0045"
Guide stand-out above flat surface of cylinder head	5/16"

b. Intake Valve Guide

Length

D-175 (Prior to Serial No. 119995)	2-11/16"
D-175 (Effective with Serial No. 119995)	2-21/32"
D-262 (4513145 Basic Engine)	2-11/16"
D-262 (4514288 Basic Engine)	2-21/32"

ID (Ream after assembly)	.3125" - .3135"
Stem-to-guide clearance	.0025" - .0045"

Guide stand-out above flat surface of cylinder head

D-175 (Prior to Serial No. 119995)	5/16"
D-175 (Effective with Serial No. 119995)	9/32"
D-262 (4513145 Basic Engine)	5/16"
D-262 (4514288 Basic Engine)	9/32"

15. Rocker Arms

a. ID or rocker arm (finish bore)	.8420" - .8440"
b. OD of rocker arm shaft	.8405" - .8410"
c. Rocker arm shaft-to-rocker arm clearance	.0010" - .0035"
d. Rocker arm ratio	1.41:1
e. Concave expansion plug size	11/16"

16. Camshaft

a. Number of bearings used	4
b. ID of camshaft bearings (when installed)	
Front and intermediate	2.0010" - 2.0040"
Rear	1.2510" - 1.2540"
c. OD of camshaft journals	
Front and intermediate	1.998" - 1.999"
Rear	1.248" - 1.249"
d. Camshaft bearing-to-journal	
Running clearance	.002" - .006"
e. OD of camshaft bearings	
Front and intermediate	2.1285" - 2.1305"
Rear	1.3790" - 1.3805"
f. Bore in block for camshaft bearings	
Front and intermediate	2.124" - 2.125"
Rear	1.374" - 1.375"

g. Fit of camshaft in bore of cylinder block
   Front and intermediate . . . . . .0035" - .0065" tight
   Rear . . . . . .004" - .0065" tight

h. Overall width of camshaft bearings
   Front . . . . . 1-1/8"
   Intermediate . . . . . 7/8"
   Rear . . . . . 1"

i. Camshaft end clearance . . . . . .003" - .008"

j. Camshaft gear width . . . . . 1"

k. Fit of camshaft gear on camshaft . . . . . .001" - .003" tight

l. Specified thickness of thrust collar . . . . . .165" - .167"

17. Valve Lifter

a. Bore in cylinder block for lifter . . . . . .5615" - .5625"

b. OD of valve lifter stem . . . . . .5600" - .5605"

c. Fit of valve lifter in bore of cylinder block . . . . . .0010" - .0025"

18. Gear Train

a. Backlash between mating gears . . . . . .001" - .005"

19. Cylinder Head

a. ID of combustion chamber . . . . . 1.749" - 1.751"

b. Depth of combustion chamber . . . . . .947" - .949"

c. Throat diameter of energy cell . . . . . .115" - .116"

d. Energy cell plug depth . . . . . .289" - .291"

e. Valve sequence, front-to-rear
   D-175 . . . . . Cyl. 1 int-exh
   Cyl. 2 exh-int
   Cyl. 3 int-exh
   Cyl. 4 exh-int

   D-262 . . . . . Cyl. 1 exh-int
   Cyl. 2 int-exh
   Cyl. 3 exh-int
   Cyl. 4 int-exh
   Cyl. 5 exh-int
   Cyl. 6 int-exh

20. Lubricating Oil Pump

a. Radial clearance, gears-to-pump housing . . . . . .001" - .002"

b. End clearance, pump gears . . . . . .002" - .004"

c. Bore in oil pump housing for drive shaft . . . . . .5005" - .5015"

d. Bore in oil pump housing for idler shaft . . . . . .500" - .501"

e. Diameter of drive and idler gear shaft . . . . . .4990" - .4995"

f. Clearance, drive shaft to oil pump housing bore . . . . . .0010" - .0025"

g. Clearance, idler gear shaft to oil pump housing bore . . . . . .0005" - .0020"

B. TORQUE SPECIFICATIONS - BOLT, CAPSCREW, AND NUT

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.

SPECIFIC APPLICATION TORQUE VALUES

Type	Description	Size and Thread	Grade	Torque lb - ft
Capscrew	Cylinder Head Mounting	1/2-13 x 5-3/8	8	110-120
Capscrew	Cylinder Head Lifting	1/2-13 x 6-9/16	8	110-120
Capscrew	Cylinder Head and Water Outlet Cover	1/2-13 x 5-23/32	8	110-120
Capscrew	Cylinder Head and Thermostat Housing	1/2-13 x 6-7/8	8	110-120
Nut	Cylinder Head Cover	3/8-24	2	2-4
Nut	Air Cell Mounting	1/2-20	2	19-23
Nut	Nozzle Holder Mounting	3/8-24	2	12-15
Capscrew	Main Bearing Cap Mounting	9/16-12 x 3-1/2	5	110-120
Nut	Connecting Rod Cap Mounting	3/8-24	5	40
Nut	Crankshaft Pulley Retaining	1-16 x 2	-	240-260
Capscrew	Front Cover to Pan (Nylok)	3/8-16 x 1-1/8	5	18-21

2. SAE 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.)

STANDARD TORQUE VALUES

Capscrew Size	Pounds-Feet*					
	Grade 2 		Grade 5 		Grade 8 	
	NC	NF	NC	NF	NC	NF
1/4"	5-7	6-8	9-11	11-13	12-14	14-16
5/16"	11-13	13-15	18-20	21-23	25-27	28-30
3/8"	18-21	19-22	28-33	30-35	41-46	43-48
7/16"	30-33	32-35	44-49	50-55	69-74	72-77
1/2"	45-50	45-50	68-73	68-73	95-105	95-105
9/16"	60-65	60-65	95-105	95-105	130-140	130-140
5/8"	75-85	75-85	125-135	125-135	170-190	170-190
3/4"	125-135	125-135	210-230	210-230	290-310	290-310
7/8"	105-115	105-115	290-310	290-310	450-500	450-500
1"	140-150	450-475	380-410		600-630	

*Torque values in this table are calculated for threads lubricated with oil.

CAUTION: The SAE 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.

C. STUD GAUGE HEIGHTS

Description	Stud Size				Gauge Height	Driving Torque Lb-ft*
	Dia.	Thread		Length		
		Stud End	Nut End			
Air Cell to Cylinder Head	3/8	16	24	1-9/16	1-1/8	10-35
Air Cell to Cylinder Head	1/2	13	20	1-5/16	1-1/4	22-71
Manifold to Cylinder Head	7/16	14	20	5-9/16	5-1/8	15-51
Rocker Arm Shaft and Bracket to Cylinder Head	3/8	16	24	4-11/16	4-1/16	10-35
Nozzle Holder to Cylinder Head	3/8	16	24	1-7/8	1-3/8	10-35
Gear Housing and Cover to Cylinder Block	3/8	16	24	1-3/4	19/32	10-35

*Torque values in this table are calculated for threads lubricated with oil.

TOPIC 11. COOLING SYSTEM

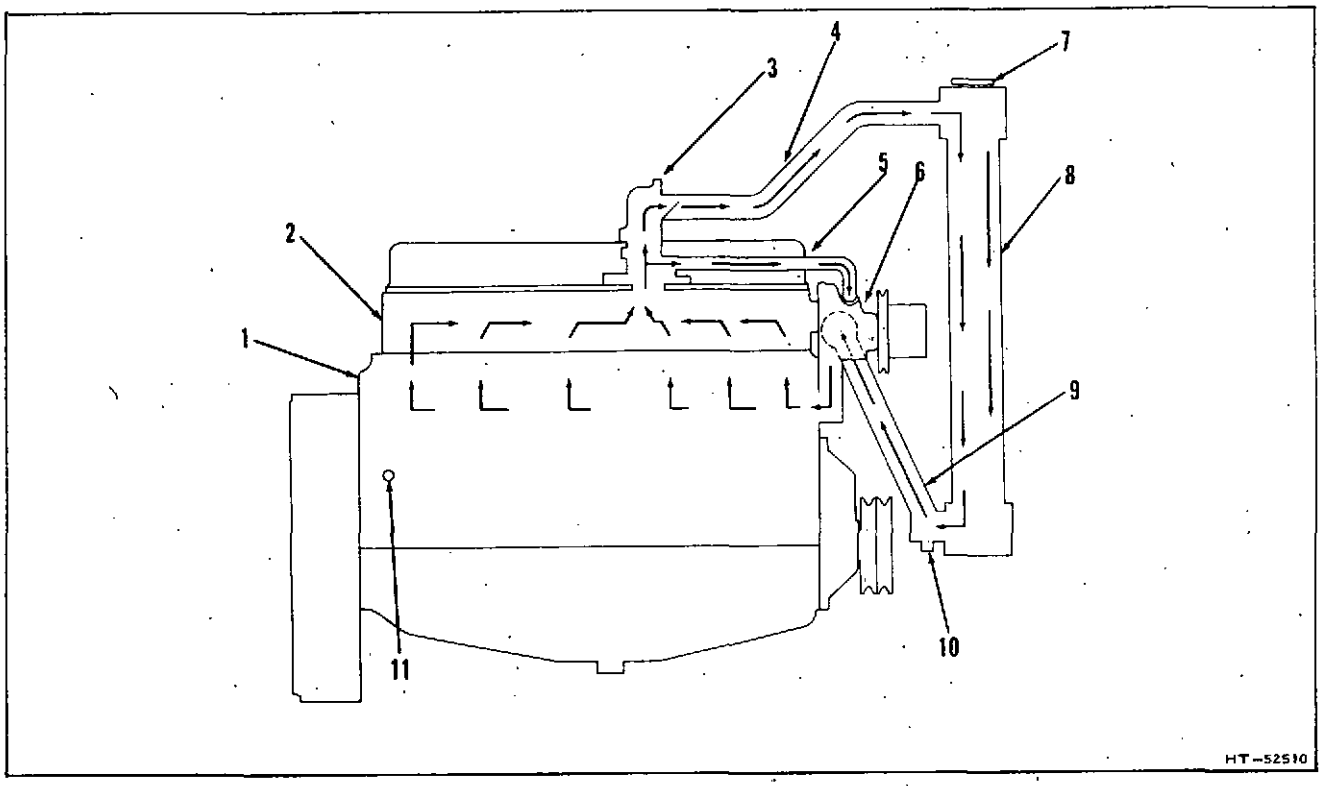
A. GENERAL

The engine cooling system includes the water pump, radiator, water inlet piping, thermostat, thermostat housing, hoses, engine coolant temperature gauge, cooling fan, and water passages in the cylinder block and cylinder head.

The water pump draws the coolant from the bottom of the radiator and circulates it through the water passages in the cylinder block and cylinder head. The coolant is discharged from the cylinder head into the water outlet manifold or water-cooled exhaust manifold (optional equipment) and passes through the thermostat and radiator inlet hose to the upper part of the radiator. The coolant dissipates its heat to the atmosphere through the radiator cooling fin surfaces as it passes from top to bottom of radiator core. Air is forced through the core by either a sucker or blower type fan. The thermostat is of the full-choke type and operates automatically to maintain a minimum coolant temperature of 180° F.

The cooling system is pressurized by a 7 psi pressure cap. By pressurizing the system, the normal boiling point of 212° F of clean water at sea level is raised approximately 3° F per psi. Consequently, coolant in the system at sea level will not boil until a temperature of 212° F, plus 21° F, or a total of 233° F is reached. Temperatures above this figure will cause loss of coolant and result in engine overheating. Altitude affects the point at which coolant will boil, that is, the higher the altitude, the sooner (lower temperature) the coolant will boil. To estimate coolant boiling point at various altitudes above sea level, deduct 1-1/2° F per 1000 ft. altitude, from 233° F, the boiling point established with a pressure cap at sea level.

A double-acting valve in the radiator pressure cap relieves air pressure caused by expansion of heated coolant, and allows atmospheric pressure to enter when cooling contraction occurs. Because this is a pressure-type cooling system, it is necessary to keep the radiator cap turned on tightly at all times to prevent loss of pressure.



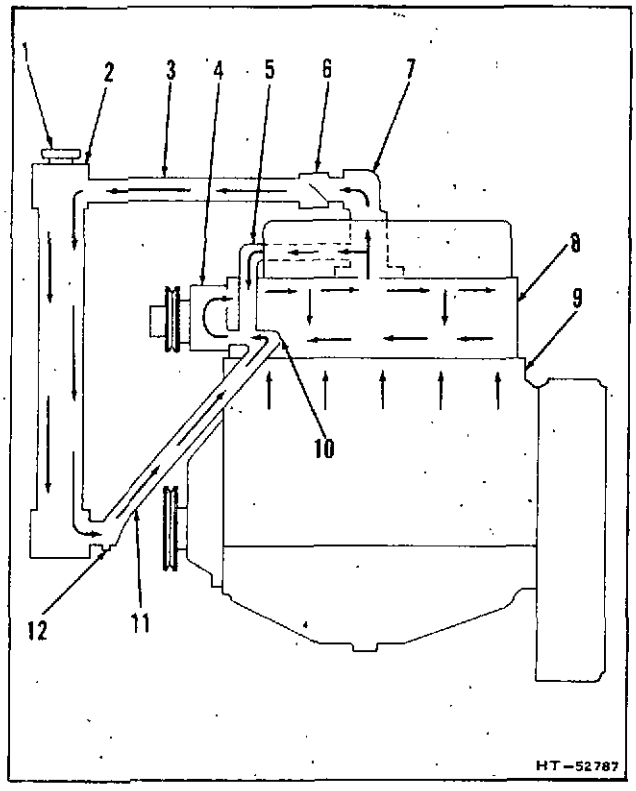
1. Cylinder block
2. Cylinder head
3. Thermostat and housing
4. Upper radiator hose
5. Water bypass tube
6. Water pump
7. Radiator pressure cap, 7 psi
8. Radiator
9. Lower radiator hose
10. Drain cock (radiator)
11. Drain cock (cylinder block)

Figure 1. Cooling System Schematic Diagram (Current Model D-262 Engine)

WARNING: THE COOLING SYSTEM IS PRESSURIZED; DO NOT OPEN FILL CAP WHILE THE COOLANT TEMPERATURE EXCEEDS 200° F. THE SUDDEN RELEASE OF PRESSURE MAY CAUSE THE COOLANT TO BOIL AND CAUSE HOT COOLANT OR STEAM TO SPEW FROM THE SYSTEM AND CAUSE INJURY.

IMPORTANT: The engine thermostats begin to open at 180° F and are fully open at 202° F to open at 180° F and are fully open at 202° F. Operating the engine in this temperature range is not harmful. However, some temperature gauges are not always exactly accurate and may indicate a higher than actual temperature. This can lead the operator to believe the engine is overheating when actually it is operating normally.

Overheating is always associated with loss of coolant. In the event of any doubt, the coolant level in the radiator should be checked.



1. Pressure cap, 7 psi
2. Radiator
3. Radiator upper hose
4. Water pump
5. Bypass tube
6. In-line thermostat
7. Water outlet elbow
8. Cylinder head
9. Cylinder block
10. Water inlet pipe
11. Radiator lower hose
12. Radiator drain cock

Figure 2. Cooling System Schematic Diagram (Model D-175 and Early Model D-262)

B. GENERAL MAINTENANCE

In warm weather, keep the cooling system filled with clean, soft water or rain water. If soft water is not available and hard water must be used, it must first be treated with a water softener. A rust inhibitor, available at Allis-Chalmers dealers, should be added to the water for warm weather operation.

In winter weather, drain and flush the cooling system and fill with a glycol base permanent antifreeze solution. After any addition of water or antifreeze compound, test the solution after it has become thoroughly mixed to ensure it will withstand prevailing or anticipated temperatures.

Refer to instructions or protection charts furnished by the antifreeze manufacturer to determine the quantity of antifreeze required for lowest anticipated temperature.

Keep radiator air passages free of leaves, trash, and other material that may restrict flow of air through the radiator.

CAUTION: Keep cylinder head capscrews, water pump mounting capscrews, hose clamps, and fitting connections tight. Correct all leaks as soon as they become evident. Inspect hoses carefully and replace them if they have deteriorated.

The engine operates most efficiently when coolant temperature is 180° F minimum. Operation with low coolant temperature will result in incomplete fuel combustion, higher fuel consumption with less power, and formation of harmful deposits in the engine. A properly functioning thermostat is required to maintain normal coolant temperature. If the coolant temperature is consistently below minimum operating temperature, the thermostat should be removed, checked for proper operation, and replaced if necessary.

C. DRAINING COOLING SYSTEM

1. If engine is installed in portable type equipment, make certain it is in a level position to assure complete draining.
2. Remove radiator filler cap and open radiator drain cock (Fig 3).
3. Open drain cock located on right side of cylinder block at rear end of engine (Fig 4).
4. If applicable, open drain cock located in bottom of water pump.

CAUTION: When draining cooling system in freezing weather, make certain coolant flows freely from drains and that the system drains completely.

D. FILLING COOLING SYSTEM

1. Close all drains that were opened to drain system. (Refer to Paragraph C above.)

2. Fill system with clean, soft water or antifreeze solution until level is approximately 1-1/2" below bottom of radiator filler neck. Install filler cap.

3. Operate engine for a period of time at normal operating temperature to vent all air from system.

4. Check level of coolant in radiator and, if necessary, add coolant to attain proper level.

E. CLEANING OF COOLING SYSTEM

1. Clean cooling system at beginning of cold weather before antifreeze is added, and again after antifreeze is drained for warm weather operation. Also, drain, flush, and refill system whenever inspection reveals an accumulation of rust or scale.

2. Many good solvents are available for cleaning coolant systems; use according to instructions.

> CAUTION: Never mix antifreeze compounds or inhibitors with any cleaning, neutralizing, or flushing compounds.

3. If radiator tubes are clogged, reverse flush radiator as follows:

   a. Disconnect upper and lower radiator hoses.

   b. Connect a pressure water hose to lower connection with a suitable adaptor.

   c. Plug upper connection and remove radiator cap.

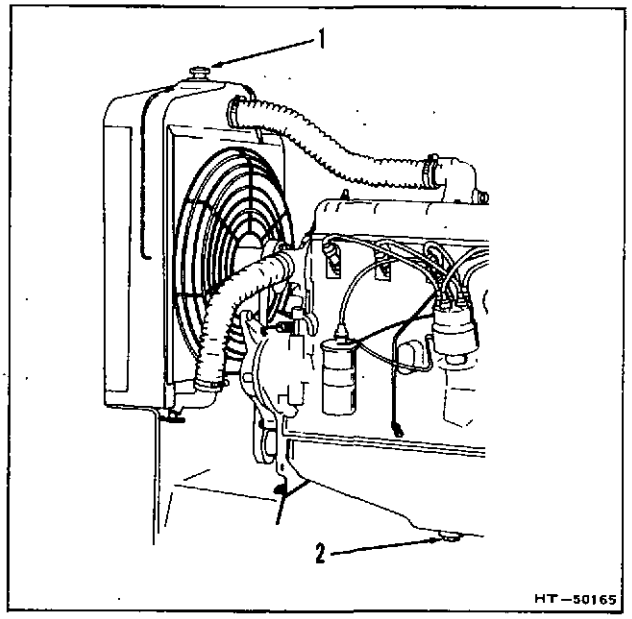
   d. Force water through radiator. Foreign material will flow out through top of radiator with the water.

> CAUTION: Do not use more than 5 or 6 psi pressure when flushing. Excessive pressure may rupture radiator.

4. Keep radiator air passages free of debris and other obstructions. Clean exterior with an air blast carrying a grease solvent of oleum spirits or carbon tetrachloride. If engine is equipped with sucker type fan, direct cleaning spray at rear (fan side) of radiator. For engines having a blower type fan, direct spray at front of radiator.

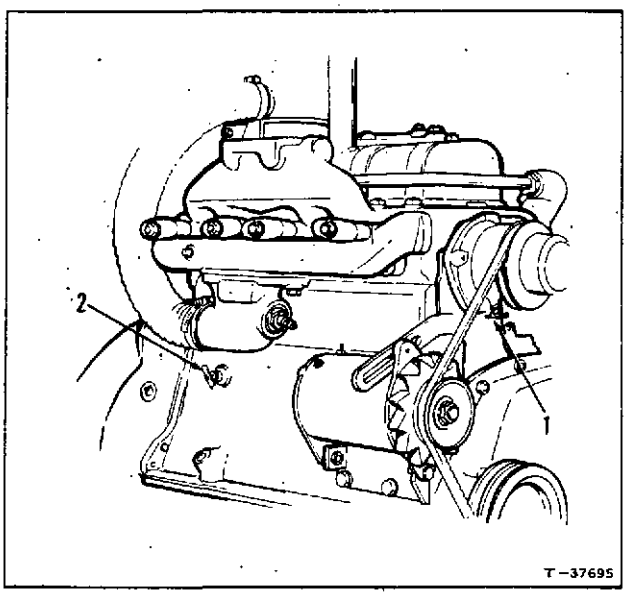
> WARNING: KEEP ENGINE COVERED DURING CLEANING OPERATION. PROVIDE ADEQUATE VENTILATION TO AVOID TOXIC EFFECTS OF THE CLEANING SPRAY. NEVER CLEAN WITH GASOLINE, FUEL OIL, OR KEROSENE.

5. After cooling system has been cleaned, flushed, and refilled, inspect entire system for coolant leaks. Correct all leaks found to avoid foaming, corrosion, and loss of solution.



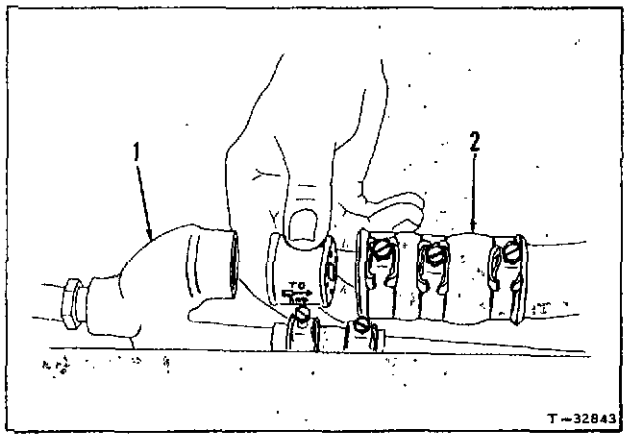
1. Radiator pressure cap (7 psi)
2. Drain cock

Figure 3. Location of Radiator Drain Cock



1. Water pump drain cock
2. Cylinder block drain cock

Figure 4. Location of Engine Drain Cocks (Model D-175)



1. Thermostat
2. Hose

Figure 5. Typical In-Line Thermostat Location

F. THERMOSTAT

The thermostat operates automatically to maintain a coolant operating temperature of 180° F (minimum). When the coolant temperature is below the setting of the thermostat, the valve is closed and the flow of coolant to the radiator is completely shut off. The flow of coolant is then directed through the water bypass tube and back to the inlet side of the water pump and is recirculated through the engine without passing through the radiator. When the temperature of the coolant exceeds the setting of the thermostat, the valve opens. The coolant then circulates through the radiator, the engine circulating system, and the bypass tube to the inlet side of the water pump. The bypass is constantly open regardless of whether the thermostat is open or closed. The thermostats for different models have various locations.

Replacement of the thermostat is necessary when the thermostat becomes corroded and sticks in the open or closed position. If the engine overheats or does not reach and maintain a minimum operating temperature, the thermostat should be removed and tested as a possible cause of trouble.

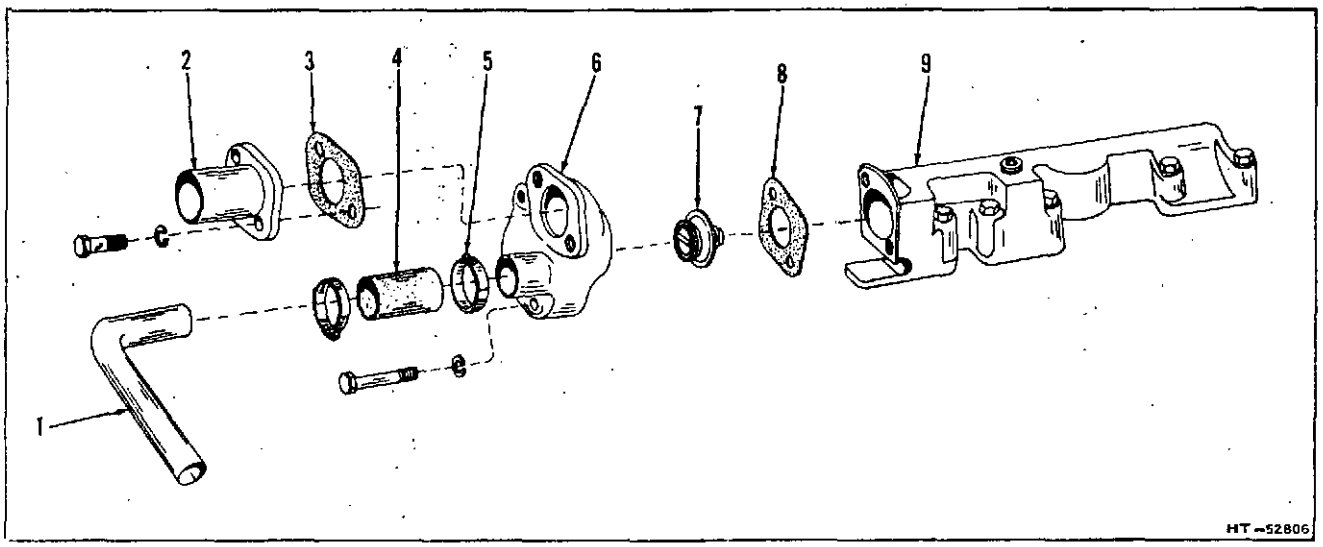
1. Model D-175 Engine (with dry type exhaust manifold)

   The thermostat (Fig 5) is located within the hose between the water outlet manifold and the inlet of the radiator. The hose-type thermostat must be installed in the hose so the arrow stamped on the side of the thermostat points toward the radiator. To hold the thermostat in position within the hose and to prevent coolant leakage between the outside of the thermostat and the hose, a hose clamp is positioned at the center of the thermostat.

CAUTION: Do not tighten hose clamp to the extent the thermostat will be distorted or crushed.

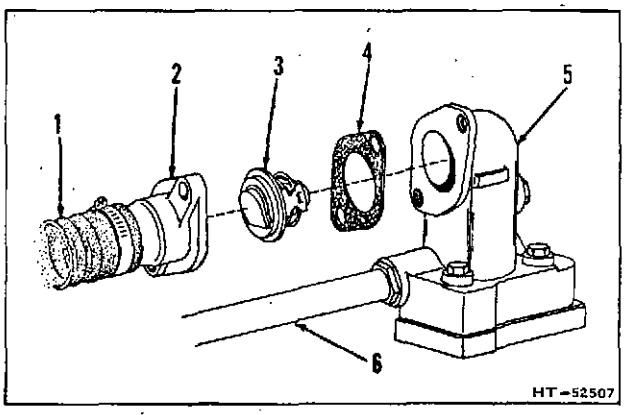
2. Model D-262 Engine (with dry type exhaust manifold)

   The thermostat is located in the thermostat housing connected to the water outlet manifold. Whenever the thermostat (early models of engines) is removed for inspection, make sure the seal cemented to the flange is in good condition (Fig 6). Do not use the thermostat



1. Bypass line
2. Water outlet pipe
3. Gasket
4. Hose
5. Clamp
6. Thermostat housing
7. Thermostat
8. Gasket
9. Water outlet manifold

Figure 6. Thermostat and Housing Details (Early Model D-262)



1. Radiator upper hose
2. Water outlet pipe
3. Thermostat
4. Water outlet pipe gasket
5. Thermostat housing
6. Water bypass tube

Figure 7. Thermostat Housing Details (Current Model D-262)

without this seal. If the seal leaks, the engine will take a long time to reach operating temperature. For details of the thermostat and housing used with current models of engines, refer to Figure 7.

3. Engines With Water Cooled Exhaust Manifold

The thermostat (Fig 8) is located in the thermostat housing on the top rear end of the water cooled exhaust manifold.

4. Thermostat Testing

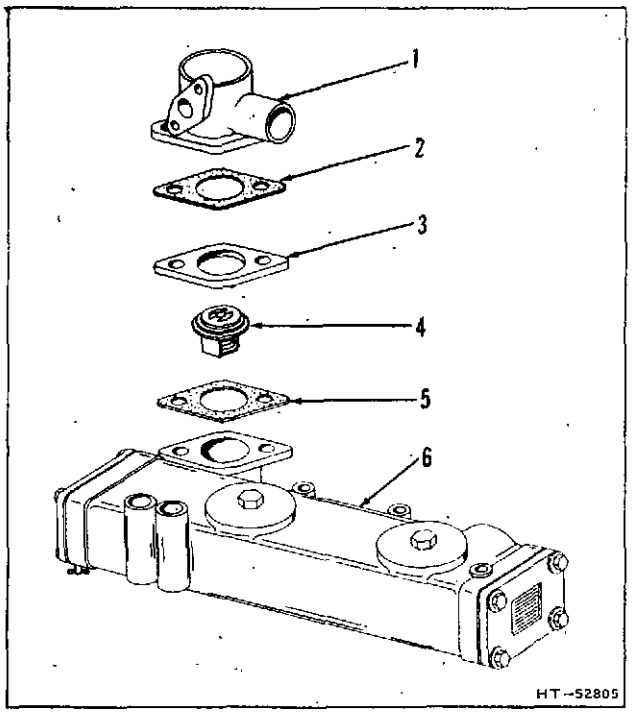
a. Suspend thermostat in a container of clean water. Thermostat must be completely immersed but not touching bottom of container (Fig 9).

b. Heat water gradually and stir so heat is evenly distributed.

CAUTION: Check temperature of water with a reliable thermometer. Do not overheat.

c. Observe thermostat as temperature of the water increases. If the thermostat is functioning properly, it should begin to open at approximately 180° F and be fully open at 202° F. The thermostat used with the water cooled exhaust manifold begins to open at approximately 170° F and is fully open at 192° F. The amount of travel between open and closed positions of the thermostats is approximately 1/2".

d. The thermostat is not adjustable. If it does not operate within the above limits, it must be replaced.



1. Thermostat housing
2. Gasket
3. Spacer
4. Thermostat
5. Gasket
6. Water cooled exhaust manifold

Figure 8. Thermostat and Housing (Water Cooled Exhaust Manifold)

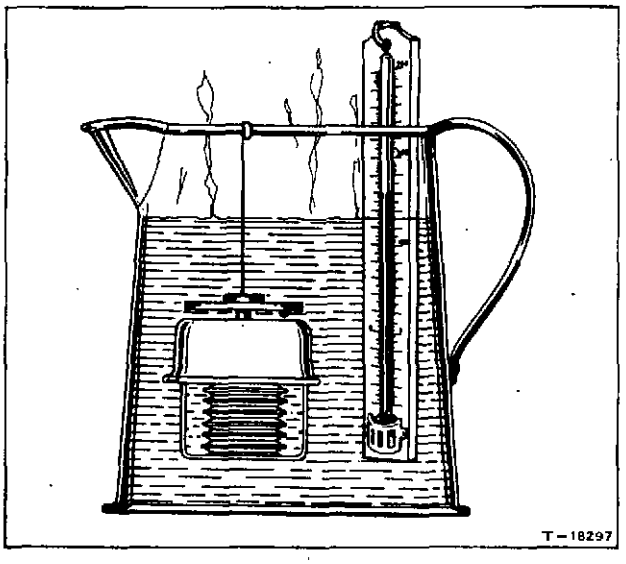


Figure 9. Testing Thermostat (Typical)

G. FAN BELT REPLACEMENT AND ADJUSTMENT

It is important that the fan drive belt is inspected frequently to make certain no oil or grease has accumulated on it and that proper belt tension is

maintained. Replace badly worn, burned, oil or grease soaked belt.

To replace and adjust the fan drive belt:

1. Loosen capscrews securing generator (early model engines) or alternator (current model engines) and force it toward the engine to relieve belt tension (Fig 10).

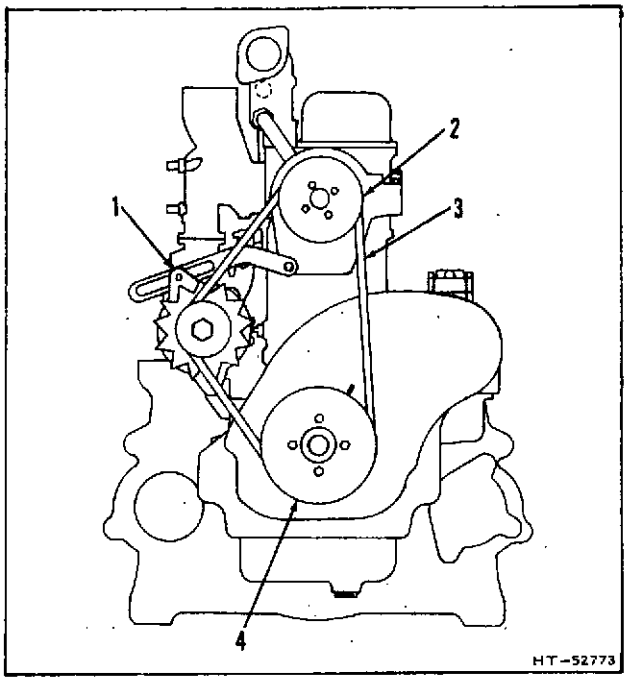
2. Remove belt from generator or alternator, water pump, and crankshaft pulleys.

3. Inspect belt for slickness, oil soak, wear, tears, cracks, and over-stretching. Replace belt if necessary. Inspect the pulleys.

4. Position new belt on pulleys.

5. Adjust fan belt to correct tension by pivoting generator or alternator on its mounting. The belt is properly adjusted when it can be pressed inward 1/2" at a point half-way between the water pump pulley and the generator or alternator pulley.

6. Tighten capscrews securing generator or alternator.



1. Adjusting brace capscrew
2. Water pump pulley
3. Fan belt
4. Crankshaft pulley

Figure 10. Fan Belt Adjustment

TOPIC 12. FUEL SYSTEM

A. GENERAL

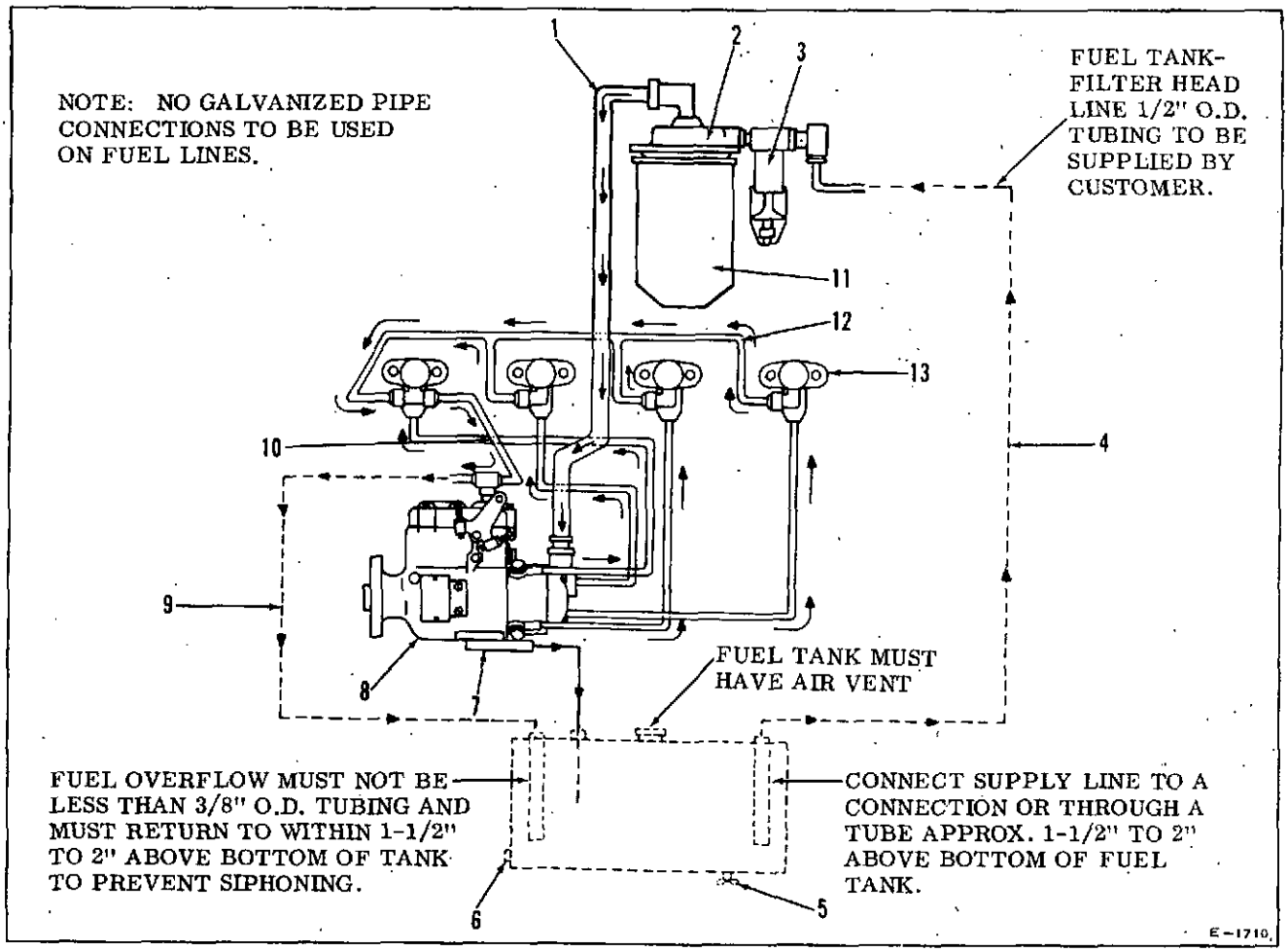
The fuel system consists of a fuel tank, hand primer pump, primary and secondary fuel filters, (early model), a dual media fuel filter (current models), transfer pump, fuel injection pump, fuel injection nozzles, and fuel lines. There are two fuel pressure systems, low pressure and high pressure.

The low pressure system is comprised of the fuel tank, hand primer pump, fuel filter(s), transfer pump, 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 thru the high pressure fuel lines connected to the fuel injection nozzles.

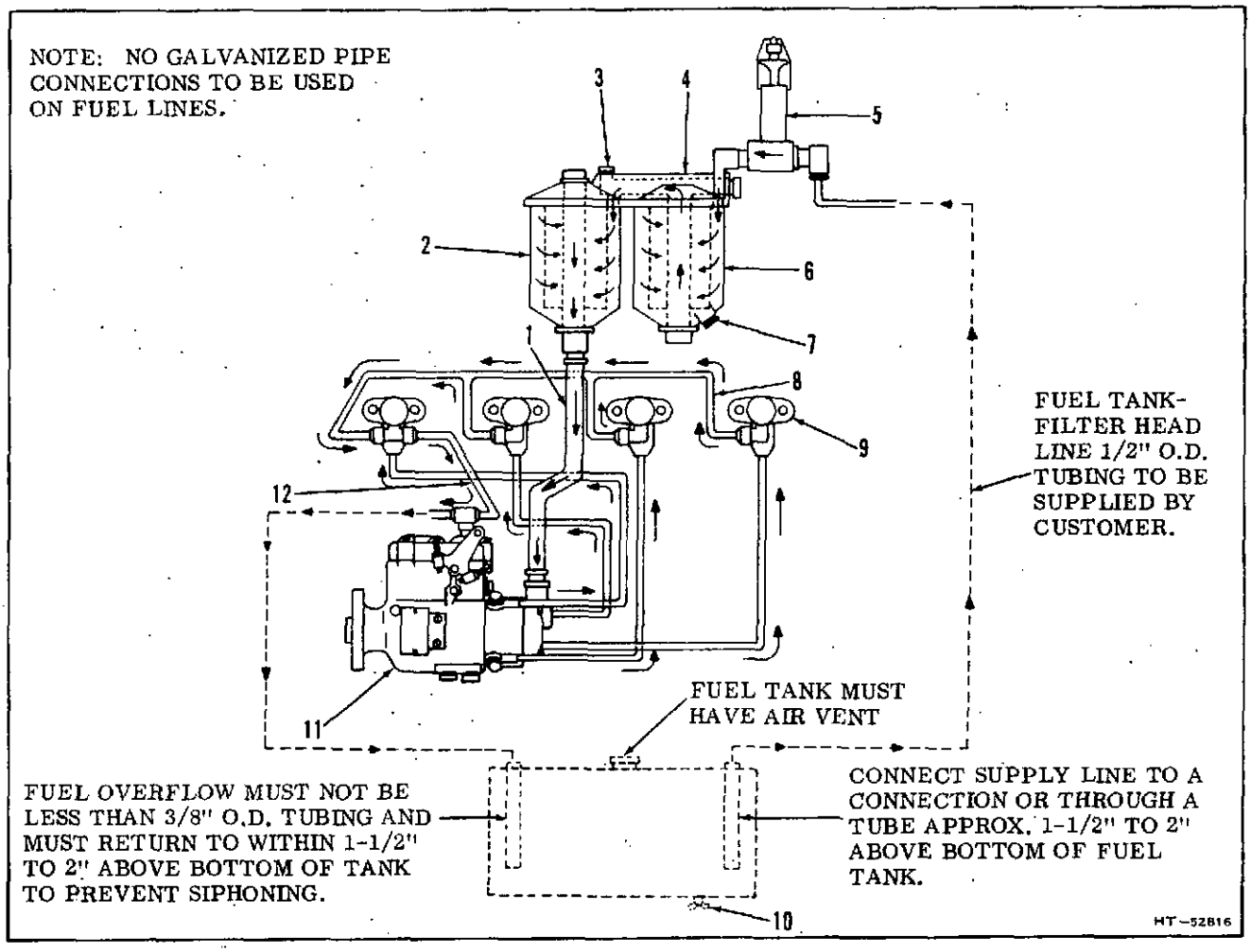
The fuel is drawn from the fuel tank through the filter(s) by the transfer pump located at the rear of the fuel injection pump. The fuel is then forced by the transfer pump to the cam actuated plungers which force the fuel under high pressure through the fuel lines to the fuel injection nozzles from which the fuel enters the combustion chambers in the form of a fine, cone-shaped spray.

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



1. Fuel inlet line
2. Fuel filter head
3. Hand primer pump
4. Fuel supply line
5. Drain cock
6. Drain plug
7. Accumulator (optional) hydraulic governor
8. Fuel injection pump
9. Fuel return line
10. Manifold return line
11. Fuel filter
12. Fuel return manifold
13. Nozzle holder assembly

Figure 1. Fuel System Schematic Diagram (Current Model D-175)



1. Fuel inlet line
2. Secondary filter
3. Vent plug
4. Filter head
5. Hand primer pump (optional)
6. Primary filter
7. Drain plug
8. Fuel return manifold
9. Nozzle injector
10. Drain cock
11. Fuel injection pump
12. Fuel return line

Figure 2. Fuel System Schematic Diagram (Early Model D-175)

the fuel injection pump to the fuel tank conveys the surplus fuel back to the fuel tank.

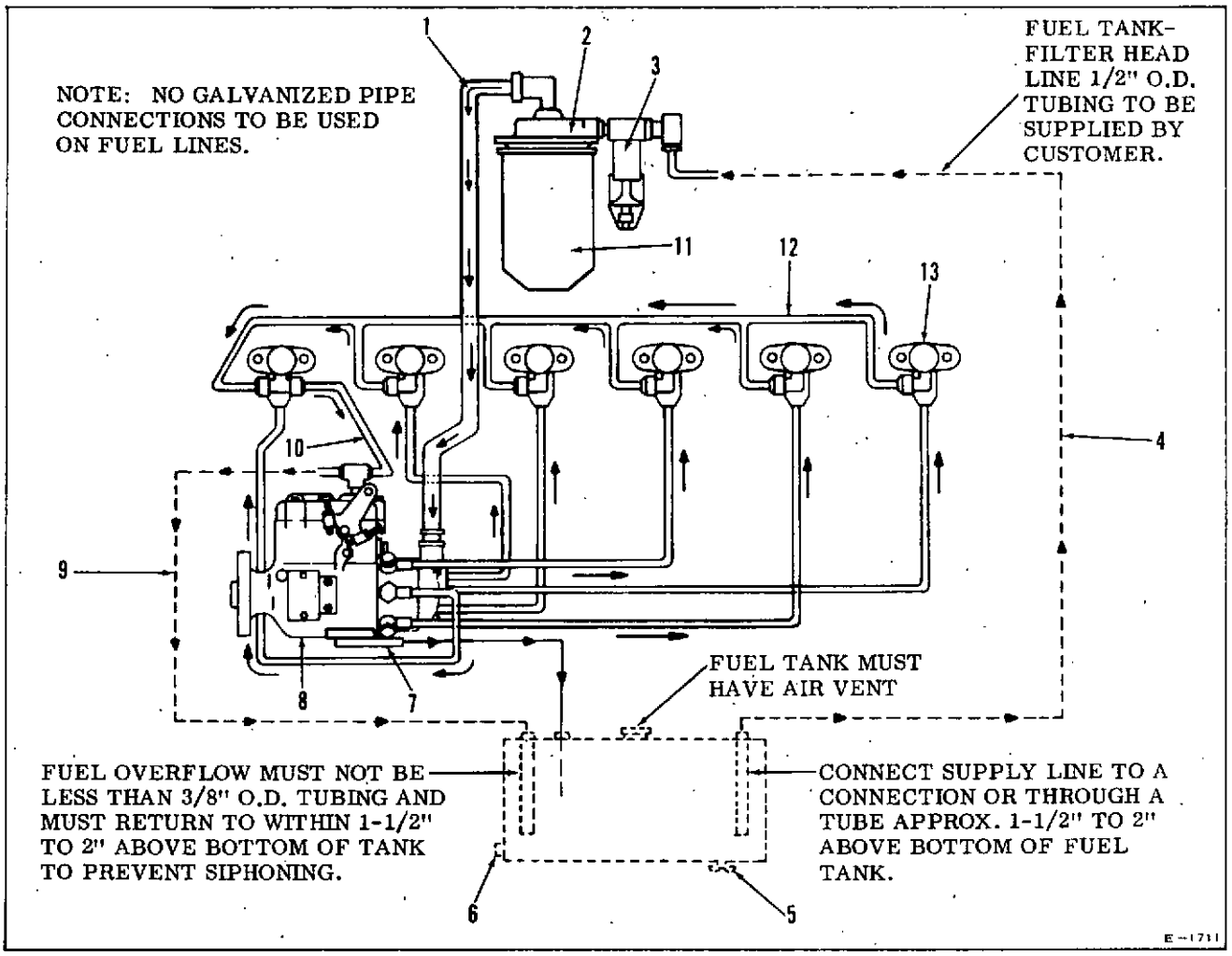
There is a certain amount of fuel seepage between the lapped surfaces of each fuel injection nozzle valve and its body, which is necessary for lubrication. This leakage of fuel accumulates around the spindle and in the spring compartment of each fuel injection nozzle holder and is returned through the fuel return manifold to the fuel return line, 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, in the transfer of fuel to the fuel tank, and in the prevention of condensation within the fuel tank, foreign matter and water will enter the fuel system and damage the fuel injection pump and fuel injection nozzles. The fuel filter(s) 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 the specifications as outlined in Topic 7.



1. Fuel inlet line
2. Fuel filter head
3. Hand primer pump
4. Fuel supply line
5. Drain cock
6. Drain line
7. Accumulator (optional) hydraulic governor
8. Fuel injection pump
9. Fuel return line
10. Manifold return line
11. Fuel filter
12. Fuel return manifold
13. Nozzle holder assembly

Figure 3. Fuel System Schematic Diagram (Current Model D-262)

2. Store and handle fuel with utmost care to prevent water and foreign matter from entering the fuel system.

3. Properly maintain fuel oil filter(s).

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 primary filter (early models).

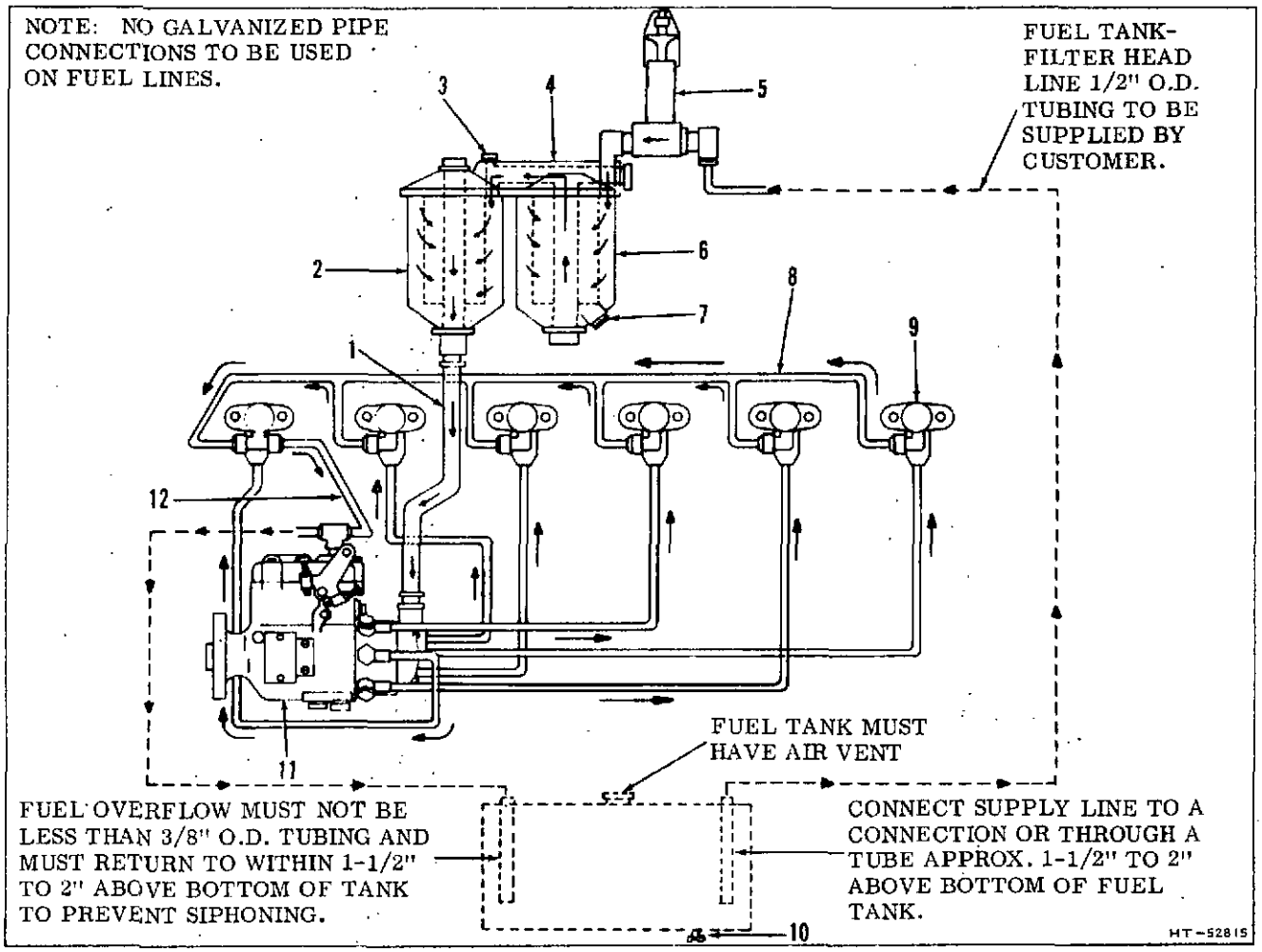
6. Periodically check injection pump timing.

7. Keep all fuel line connections, filter(s), injection pump, and injection nozzle holder assemblies tightened securely to the engine (specified torque).

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.

B. FUEL FILTERS (EARLY MODELS)

There are two filters in the fuel injection system, a primary filter and a secondary filter. Both filter shells are mounted in a common header and are located to the rear of the fuel pump. Necessary hoses are installed to connect the filters into the fuel system. Each filter shell contains a replace-



1. Fuel inlet line
2. Secondary filter
3. Vent plug
4. Filter head
5. Hand primer pump (optional)
6. Primary filter
7. Drain plug
8. Fuel return manifold
9. Nozzle injector
10. Drain cock
11. Fuel injection pump
12. Fuel return line

Figure 4. Fuel System Schematic Diagram (Early Models D-262)

able-type element. Any dirt, water or sediment which may pass through the primary filter will be trapped in the secondary filter and prevented from entering the fuel injection pump. A drain plug is provided in the bottom of the primary filter shell for the draining of water or sediment.

1. Filter Maintenance

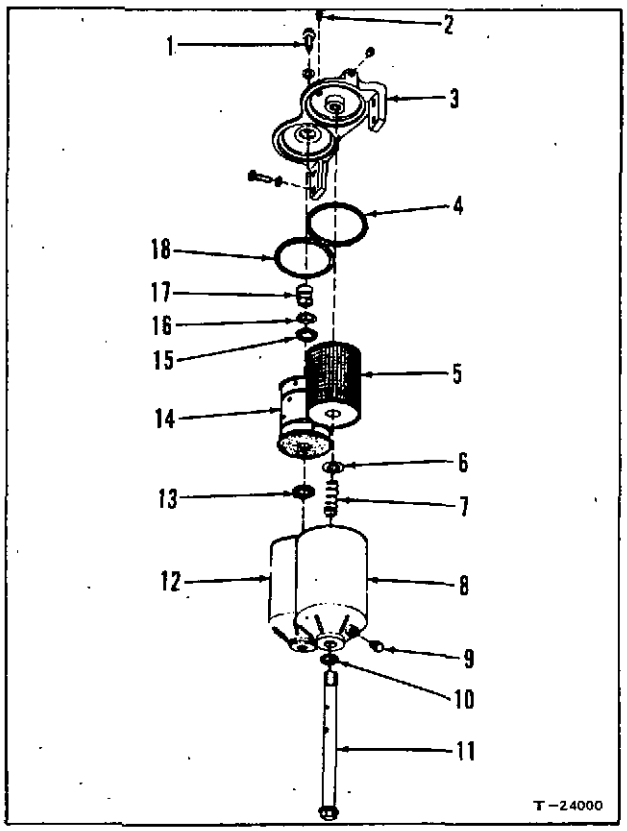
At the beginning of each day's operation in warm weather and at the end of each day's operation in freezing weather, remove the drain plug in bottom of the primary filter and allow water and sediment to flow out. Replace drain plug as soon as clean fuel is evident. No daily service is normally required for the secondary filter. Remove and discard the element in each filter after every 500 hours of operation (more often if conditions warrant), or when the fuel filters become clogged. Clogged filter elements are usually indicated by irregular engine performance.

2. Replacing Primary and Secondary Filter Elements

If the fuel level in the tank is above the fuel filters, close the tank shutoff valve. If the fuel tank is located below the filters, it is not necessary to close the shutoff valve. Thoroughly clean the fuel filter head and surrounding area. Replace the elements as follows:

a. Primary Filter Element

(1) Loosen the vent plug in the filter head and the center bolt at the bottom of the filter and allow fuel to drain.



1. Retaining capscrew
2. Vent plug
3. Filter head
4. Gasket
5. Primary filter element
6. Spring washer
7. Spring
8. Primary filter shell
9. Drain plug
10. Gasket washer
11. Center bolt
12. Secondary filter shell
13. Gasket
14. Secondary filter element
15. Gasket
16. Spring washer
17. Spring
18. Gasket

Figure 5. Fuel Filter Details (Early Models)

(2) Remove the filter from the head by turning the center bolt until it is free from the filter head.

(3) Discard the filter element and gasket. Thoroughly wash and dry the spring, washer, center bolt, and interior of the filter shell.

(4) Install the center bolt into the filter shell, *making certain the washer is in good condition.*

(5) Slip the element spring and spring washer onto the center bolt.

(6) Install new filter element (from element replacement kit) onto the center bolt.

(7) Install a new shell gasket (from the element replacement kit) in position in the filter head. Hold the filter shell in position under the filter head and engage the threads in the filter head and tighten the shell center bolt securely.

b. Secondary Filter Element

(1) Remove the shell-retaining capscrew located in the top of the filter head, and remove the filter shell and element as a unit.

(2) Remove and discard the filter element and the two element gaskets. Remove the shell gasket from the filter head and discard.

(3) Thoroughly wash and dry the interior of the filter shell.

(4) Install a new element gasket in position on the shell center tube. Install a new element in position in the filter shell and push it down firmly on the shell center tube. Install a new element gasket in position on the shell center tube and down on top of the filter element. Slip element spring washer and spring onto the center tube.

(5) Install a new shell gasket in position in the filter head.

(6) Hold the filter shell in position under the filter head and install the shell-retaining *capscrew and retaining capscrew gasket.* Tighten the shell-retaining capscrew securely.

(7) Open fuel tank shutoff valve and vent the low pressure system. Refer to Paragraph D, below.

CAUTION: Keep parts clean when replacing fuel filters.

C. FUEL FILTER (CURRENT MODELS)

The dual-media filter is a combination primary and secondary filter and is disposable. Any dirt or sediment that passes through the primary portion of the filter is collected in the secondary portion and prevented from entering the fuel injection pump.

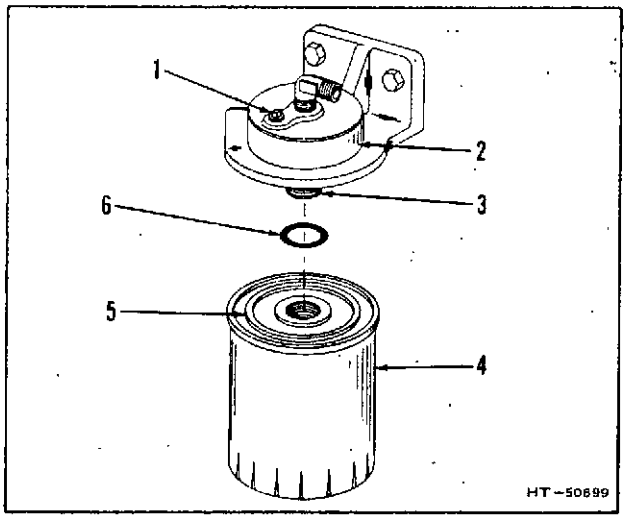
1. Filter Maintenance

Remove and discard filter and O-ring and install new filter and O-ring after each 500 hour interval of operation (more often when operating conditions warrant), or when filter becomes clogged. A clogged filter is usually indicated by irregular engine performance.

2. Fuel Filter Replacement

a. Remove dirt from around filter, and clean filter head and surrounding area.

b. Unscrew and remove filter and O-ring from filter head. Discard filter and O-ring.



1. Vent plug
2. Filter head
3. Threaded insert
4. Fuel filter
5. Gasket
6. O-ring

Figure 6. Fuel Filter (Current Model)

c. Remove dirt and sediment from filter head.

d. Position new O-ring from filter replacement kit on threaded insert in filter head. Screw new filter by hand into position until gasket contacts base of filter head. Using hand pressure, tighten filter 1/2 to 3/4 of a turn more.

CAUTION: Do not use any tools to tighten filter. Do not use sealing compounds or lubricants. Always use an Allis-Chalmers replacement filter.

e. Prime the low pressure system. Refer to following Paragraph D.

CAUTION: Keep parts clean when changing the fuel filter.

D. PRIMING FUEL SYSTEM

1. Priming Low Pressure Fuel System

a. If the fuel tank is located above the fuel filter(s), loosen the vent plug (Fig 5) on top of the filter head and open the fuel tank shutoff valve. Fuel, flowing by gravity, will force the air out of the filters. When the flow of fuel from around the vent plug is free of air bubbles, tighten the vent plug securely.

b. If the fuel tank or the fuel level in the tank is located below the fuel filter(s) and a hand primer pump is not provided, crank the engine with the starter to operate the transfer pump which will draw the fuel into the filter(s), transfer pump, injection pump cavity and expel the air through the fuel return line.

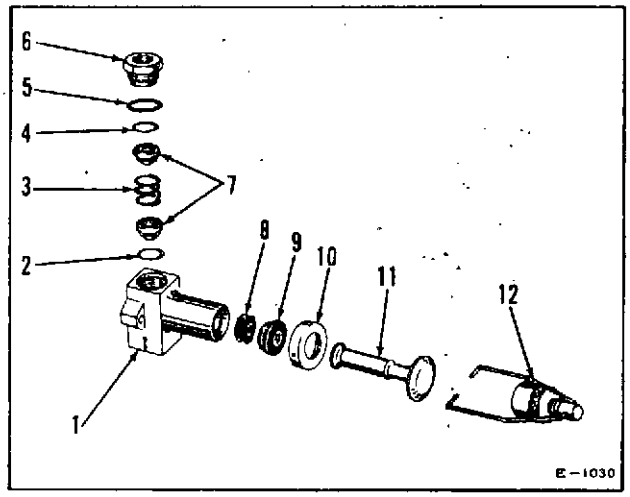
c. If the fuel system is equipped with a hand primer pump (Fig 6), remove the vent plug from top of the filter head. To operate the primer pump, loosen the locking screw on top of the plunger and move the clamp to one side. Moving the primer plunger up and down in a pumping motion will fill the filters with fuel and expel the air. When the flow of fuel from the vent hole is free of air bubbles, install and tighten the vent plug securely. Position the primer pump plunger clamp and tighten the lockscrew.

2. Priming High Pressure Fuel System

The high pressure fuel system is usually self-priming due to the fact that air trapped by the fuel injection pump is forced out through the injection nozzles and into the combustion chambers. However, if the engine has run out of fuel or has been shut down for an extended period of time, or if the fuel lines have been removed, it may be necessary to prime the high pressure system to facilitate engine starting. Proceed as follows:

a. Loosen fuel line connection nut attaching each line to its corresponding fuel nozzle-holder.

b. Pull the throttle control outward to the high speed position and place the engine stop control all the way in to the run position.



1. Primer pump body
2. Valve gasket
3. Valve retainer spring
4. Valve nut (inner) seal
5. Valve nut seal ring
6. Valve nut
7. Primer pump valve
8. Piston seal
9. Plunger guide
10. Cap
11. Pump plunger
12. Clamp assembly

Figure 7. Hand Primer Pump Details

c. Crank engine with starter until fuel flows from ends of all high pressure fuel lines. Connect fuel lines to nozzle holders and tighten connection nuts.

> CAUTION: *Do not operate starting motor* continuously for more than 30 seconds at a time without a pause of two minutes to permit starter to cool.

E. FUEL INJECTION PUMP

The single-cylinder, distributor type fuel injection pump incorporates inlet metering and opposed plungers that are operated by an internal cam ring. It is designed for self-lubrication by the fuel oil supply. Purpose of the pump is to accurately meter and deliver quantities of fuel under high pressure to 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.

Fuel shutoff is accomplished by the injection pump fuel shutoff lever which closes the metering valve to stop the flow of fuel to the pump plungers. The stop control lever is connected to the instrument panel by a stop control cable. As optional equipment, an electric fuel shutoff solenoid is available in addition to the manual shut down. The electric solenoid mechanism within the fuel pump opens or closes the metering valve to permit or stop the flow of fuel to the engine. Normally, the electric solenoid mechanism is of the energized to run type (open when energized). To activate the electric solenoid, a key switch is provided on the instrument panel.

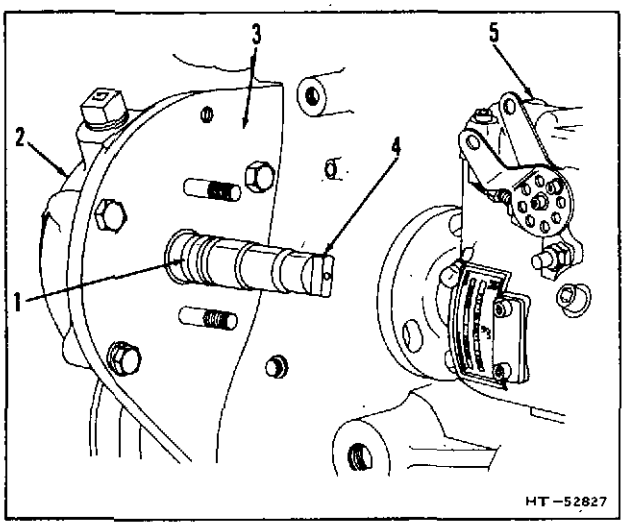
The standard fuel injection pump governor has a 10% regulation. An optional injection pump is available with an adjustable 3-1/2% speed droop regulation. Also available, under special quotation, is a fuel injection pump with an adjustable speed droop regulation and hydraulic governor. The regulation is 1 to 5%.

No lubrication service on the governor assembly is required and it seldom needs adjustment. If engine speed is irregular, check the fuel system and all other applicable engine adjustments before removing the fuel injection pump assembly for repair.

1. Fuel Injection Pump Removal

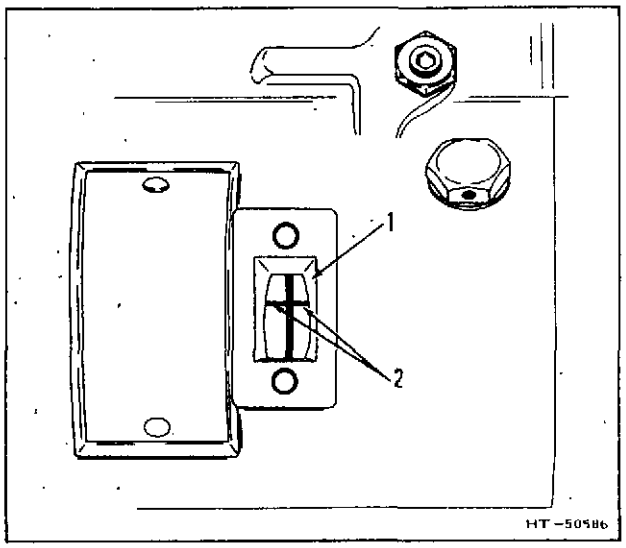
   Clean the outer surfaces of the fuel injection pump, including all fittings and line connections that are to be disconnected to eliminate any possibility of dirt from entering the system. Remove the pump as follows:

   a. Rotate the engine flywheel until No. 1 piston is near the top of its compression stroke and the fuel pump injection FPI mark (Fig 10) on the flywheel is centered in the timing hole of the flywheel housing. If engine is equipped with a front end



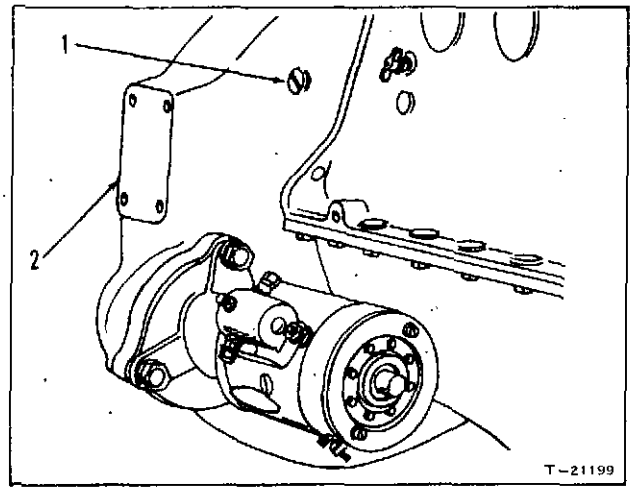
1. Drive shaft seals
2. Timing gear cover
3. Front plate
4. Pump drive shaft
5. Fuel injection pump

Figure 8. Removing Fuel Injection Pump



1. Timing window
2. Timing marks

Figure 9. Fuel Pump Timing Marks



1. FPI mark
2. Flywheel housing

Figure 10. Fuel Pump Timing Mark on Flywheel

timing pointer (Fig 11), align correct timing degree stamped on the front crankshaft pulley with the pointer on the timing gear cover. Refer to Topic 2, Paragraph D, for timing degrees per engine rpm.

b. Disconnect the throttle control cable from the speed control lever and the stop control cable from the stop control lever.

NOTE: If the fuel pump is equipped with an electric fuel solenoid, disconnect the electrical lead from the terminal on the pump cover.

c. Shut off the fuel supply if the tank or fuel level in the tank is located above the filter(s).

d. Disconnect the filter-to-fuel pump inlet line at the pump. Disconnect and remove the fuel return line from the pump and the fuel return manifold.

e. Remove the high pressure lines between the fuel pump and injection nozzles. Tape or cover all openings to prevent the entrance of dirt.

f. If the fuel filters (early models) are mounted directly to the rear of the fuel pump, remove the secondary fuel filter shell (with element) to allow room for removal of the fuel pump and to clear the pump drive shaft.

g. Remove the pump-attaching stud nuts and serrated washers. Remove the fuel injection pump assembly from the drive shaft, being careful not to damage the drive shaft seals.

CAUTION: To prevent internal damage to the fuel injection pump, wire the governor speed control lever in its high idle - no load speed position before removing fuel injection pump from the drive shaft. At this position, governor spring tension will hold the governor weights in place after the fuel injection pump is removed from the drive shaft. Otherwise it is possible for the governor weights to be jarred out of the governor weight retainer sockets whenever an injection pump is handled without the drive shaft installed.

2. Fuel Injection Pump Installation and Timing

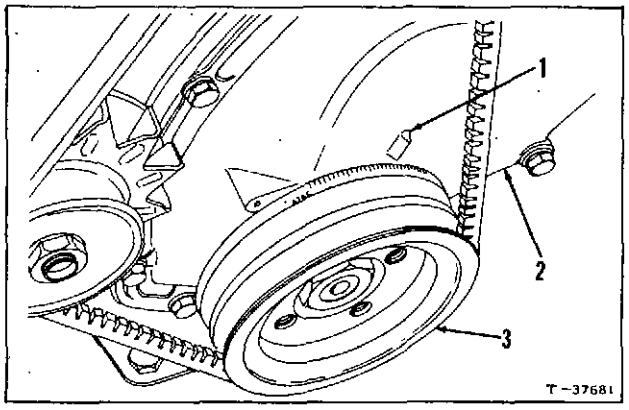
When the fuel injection pump has been serviced and is ready to be reinstalled, or if a new pump is to be installed on the engine, follow the procedure outlined below:

a. Remove timing window cover from the fuel injection pump. Two fuel pump timing marks (Fig 9) are used for timing injection of fuel into Number 1 cylinder. One mark is located on governor weight retainer hub and one is located on the cam ring. Insert screwdriver, or other suitable tool, into drive shaft end of pump and turn distributor rotor until timing marks are aligned as viewed through the timing window.

b. Rotate the engine flywheel until No. 1 piston is approaching top dead center on its compression stroke. This can be determined by observing the valves of No. 1 cylinder. With both valves closed (the valve push rods at the bottom of their travel), continue to rotate the flywheel until the FPI mark (Fig 10) stamped on the flywheel is centered in the flywheel housing timing hole. If engine is equipped with a front end timing pointer (Fig 11), align the correct degree of timing stamped on the front crankshaft pulley with the pointer on the timing gear cover. Refer to Topic 2, Paragraph D, for timing degrees per engine rpm. The engine is now properly positioned for the installation of the fuel injection pump.

CAUTION: 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 when viewed from the 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.

c. Inspect pump drive shaft seals. Replace if necessary.



1. Timing pointer
2. Timing gear cover
3. Crankshaft pulley

Figure 11. Front End Timing Marks

d. Lubricate the seals with engine oil. Slide the fuel injection pump assembly over the drive shaft and on to the pump mounting studs, using a seal compressor tool similar to the one illustrated in Figure 12 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.

e. 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.

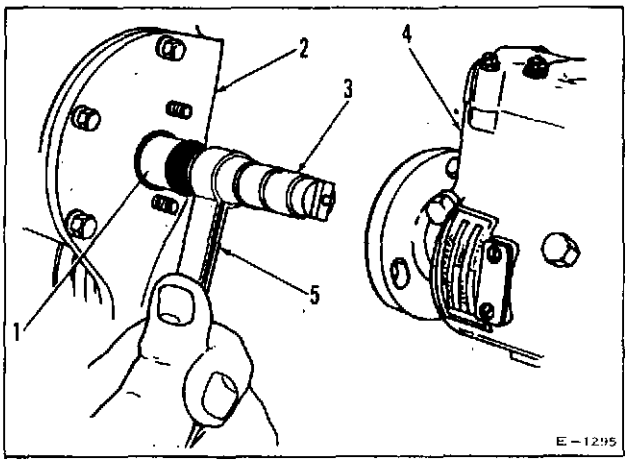
f. Install the timing window cover and gasket in position on the fuel injection pump.

g. Connect the fuel injection lines to their corresponding openings in the fuel injection pump and fuel injection nozzles.

NOTE: Use a new sealing washer on both sides of the injection line fitting at the fuel injection pump opening. Tighten the fuel injection line nuts and connector screw securely.

h. Connect the fuel injection pump fuel return line to its corresponding fittings and tighten securely. If removed, install the secondary fuel filter body (with element) and gasket on the filter head and secure with the retaining capscrew. Connect the filter-to-pump fuel inlet line to the pump.

i. Connect the fuel shutoff cable and the throttle cable to the fuel injection pump.



1. Drive shaft seals
2. Front plate
3. Pump drive shaft
4. Fuel injection pump
5. Seal compressor tool

Figure 12. Installing Fuel Injection Pump

j. Open the fuel tank shutoff valve and prime the fuel system as detailed in preceding Paragraph D.

3. Engine Fuel Shutoff Adjustment

The fuel shutoff lever adjusting screws are adjusted and sealed at the factory. The only adjustment required, when the fuel injection pump has been removed and reinstalled, is to make certain that the fuel shutoff lever adjusting screws contact the stops on the pump body in both the RUN and OFF positions. This adjustment is made by adjusting the lower end of the fuel stop control cable in the support bracket and swivel on the shutoff lever.

4. Speed Adjustments

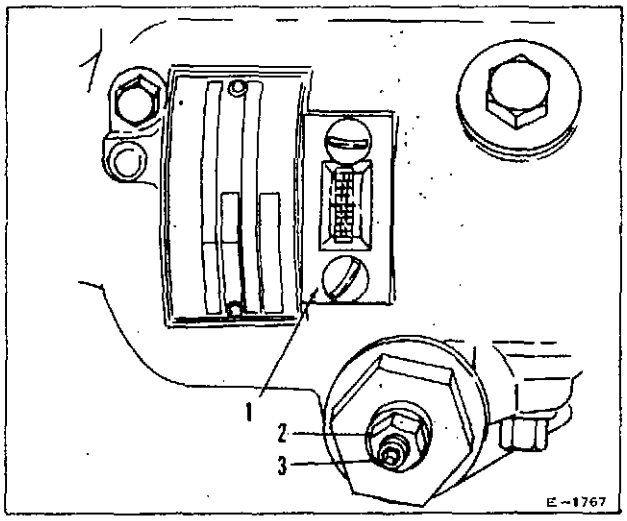
Refer to Paragraph F, GOVERNOR, for procedure to adjust the idle and full load speeds.

5. Checking And Adjusting Automatic Advance

The function of the automatic advance on the D-262 injection pumps is to advance the timing automatically as the engine speed increases.

The specified advance, as the engine speed increases, is 2° at 1200 rpm and 8° at 1800 rpm. A plastic timing window is required to test and adjust the timing advance. Test and adjust as follows:

a. Make certain the fuel injection pump static timing (engine stopped) is set at the specified 16° BTDC.



1. Plastic timing window
2. Locknut
3. Timing advance adjusting screw

Figure 13. Timing Window Installed on Fuel Injection Pump

b. Remove timing window cover and install plastic timing window (Fig 14).

c. Run engine until coolant reaches normal operating temperature.

IMPORTANT: When setting or checking the automatic advance, it must always be performed after reducing the engine speed from high idle - no load to the specified rpm.

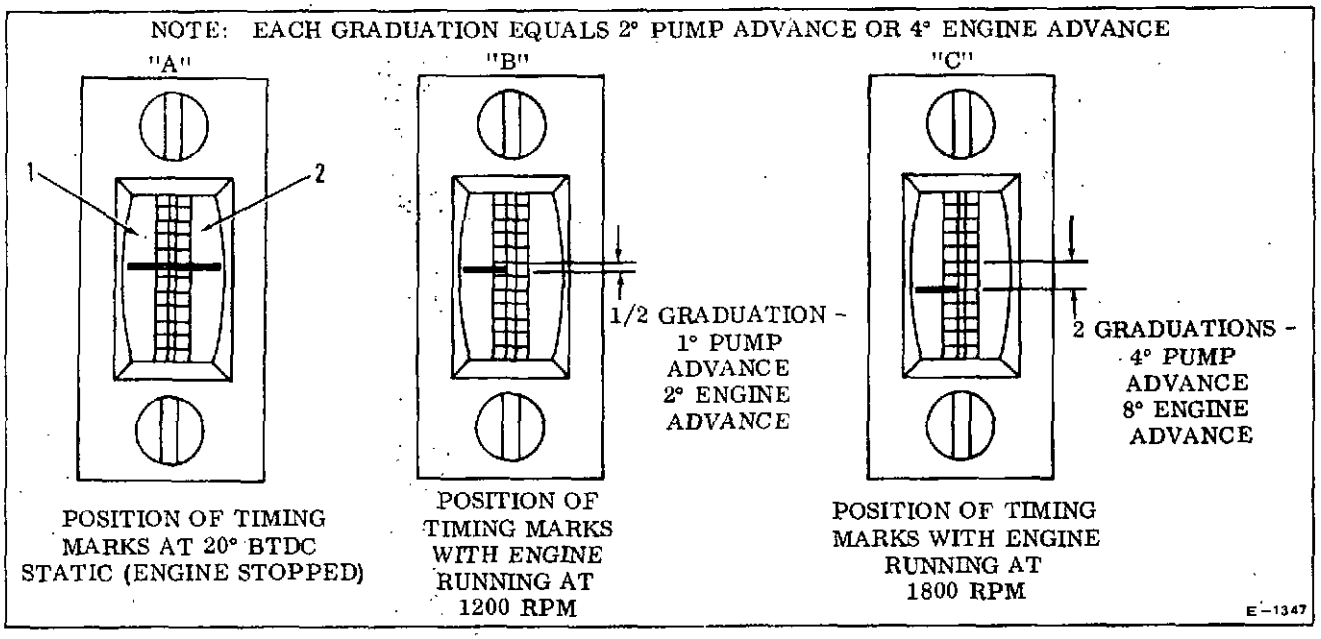
d. Run engine at high idle - no load, then reduce speed to 1200 rpm and observe timing marks. The timing mark on the governor weight retainer hub will not be visible because the assembly is rotating at one-half engine speed. The timing mark on the cam ring should have dropped 1/2 of a graduation on the timing window (Fig 14) ("B"), indicating a timing advance of 1° pump or 2° engine.

e. Run engine at high idle - no load, then reduce speed to 1800 rpm and observe timing mark on cam ring. The timing mark should have dropped 2 graduations on the timing window (Fig 14) ("C"), indicating a timing advance of 4° pump or 8° engine.

f. To adjust the automatic advance mechanism, remove the adjusting screw cover and loosen the locknut (Fig 13). Use a 1/8" Allen wrench and turn the adjusting screw (Fig 13) until the specified advance is obtained. Turning the adjusting screw clockwise advances the timing; counterclockwise retards the timing. Tighten the locknut securely after each adjustment.

6. Fuel Injection Pump Adjustments

Allis-Chalmers dealers are equipped with injection pump test stands and the special tools required for testing, adjusting, and repairing this assembly. If at any time the pump and governor assembly requires repair or adjustment, it should be removed and taken to an Allis-Chalmers dealer. It is important that the dealer be furnished with the pump serial



1. Cam ring
2. Weight retainer hub

Figure 14. Automatic Advance Timing

number, as well as engine model and serial number, to facilitate repair.

F. GOVERNOR

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 horse-power at full-load governed speeds. The specified idle speed is from 600-700 rpm. The standard fuel injection pump governor has 7-1/2 to 10% regulation. An optional fuel injection pump is available with an adjustable 3-1/2 percent regulation (speed droop).

All engines leaving the factory are equipped with fuel injection pumps and governors that have been carefully calibrated, adjusted, and sealed. No lubrication service on the governor assembly is required and it seldom needs adjustment. If engine speed is irregular, check the fuel system and applicable engine adjustments before changing the governor setting. Refer to Topic 2, Paragraph F, for standard speed settings.

1. *Checking Engine Speed*

   a. Run engine until minimum operating temperature is obtained.

   b. Move throttle control to low and high speed positions and make sure the control moves governor speed control lever through its full arc of travel.

   c. Move throttle control to LOW IDLE position. Check engine speed to make certain rpm is within specified range.

> NOTE: If engine is not equipped with a panel mounted tachometer, use a hand tachometer and hold it against front end of engine crankshaft.

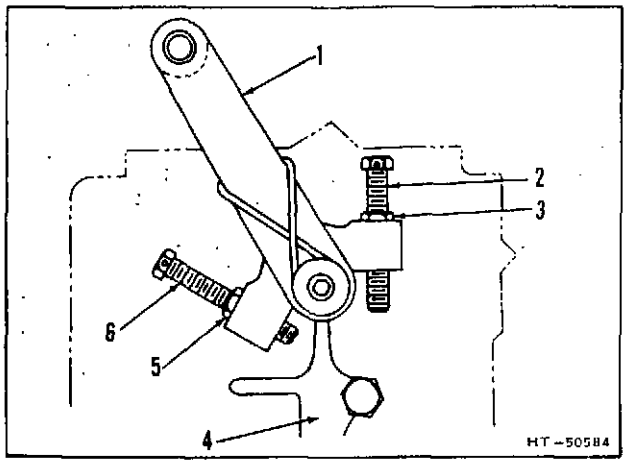
   d. Move throttle control to HIGH IDLE position. Check engine speed to see if rpm is within specified range.

   e. If engine speed is not within ranges specified, governor must be adjusted.

2. Governor Adjustments - Standard 10 Per Cent Regulation (Refer to Figure 15)

   a. Disconnect throttle control cable from fuel injection pump speed control lever so lever can be moved by hand.

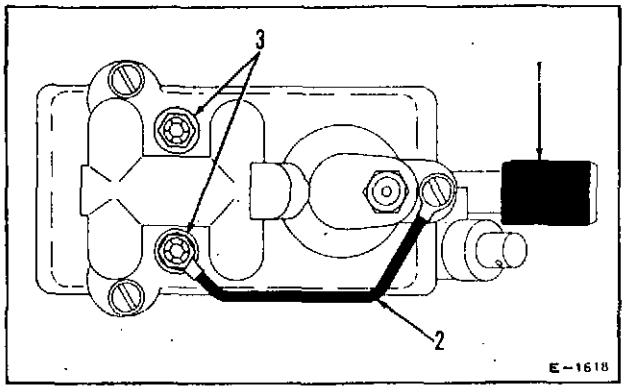
   b. With engine running at minimum temperature, loosen jam nut on the low idle adjusting screw. Hold speed control lever toward front (fan end) of engine so low idle adjusting screw contacts the lever stop. Turn low idle adjusting screw IN to increase or OUT to decrease low idle engine speed. When 500 to 600 rpm is obtained, hold adjusting screw and tighten the jam nut.



1. Speed control lever (spring loaded)
2. High speed adjustment screw
3. Jam nut
4. Lever stop
5. Jam nut
6. Low speed adjustment screw

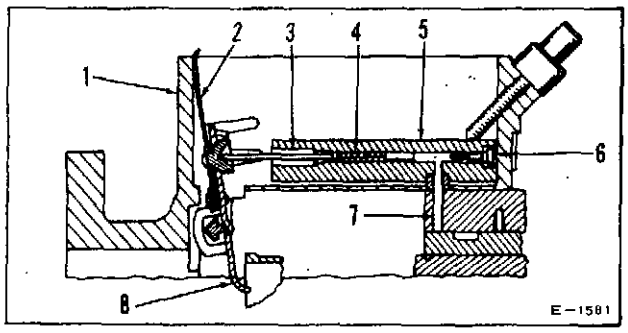
Figure 15. Engine Speed Adjustment

   c. Again with engine running at minimum temperature loosen jam nut on the high idle adjusting screw. Hold speed control lever toward rear (away from fan end) of engine so high idle adjusting screw contacts the lever stop. Turn high idle adjusting screw IN to decrease or OUT to increase high idle engine speed. When proper high idle speed is obtained, hold adjusting screw and tighten the jam nut.



1. Speed droop adjustment screw
2. Ground wire
3. Electric fuel solenoid terminals

Figure 16. Speed Droop Adjustment



1. Pump body
2. Bi-metal spring
3. Connecting link
4. Dampening spring
5. Hydraulic cylinder
6. Seal
7. Boost passage
8. Governor arm

Figure 17. Hydraulic Governor Cylinder

d. Connect throttle control cable to the speed control lever. Make certain lower end is so positioned in the control cable bracket and swivel that when throttle control cable is pushed IN, the control lever low idle adjusting screw contacts the pump housing lever stop. Likewise, when throttle cable is pulled OUT, the high speed adjusting screw also contacts the lever stop.

3. Governor Adjustments - Optional 3-1/2 Per Cent Regulation

An external speed droop adjustment screw at rear of the pump housing (Fig 16) provides precision control of governor sensitivity by decreasing or increasing effective length of the governor control spring. Turning the adjusting screw IN shortens effective length of the control spring, making it less sensitive and increasing the speed droop. Turning the screw OUT has opposite effect. Adjust governor as detailed below:

a. Make low idle and high idle speed adjustments following procedure outlined above for the standard governor.

b. To adjust speed droop:

(1) Operate engine until normal operating temperature is reached.

(2) Apply full load. With engine operating at rated speed, droop is determined by removing load and noting the no-load speed, or in the case of a diesel electric set, by noting its frequency.

(3) Turn adjusting screw clockwise to increase, or counterclockwise to decrease speed droop. A minor correction of throttle position is also necessary.

4. Governor Adjustments - Optional (Hydraulic) 1-5 Per Cent Regulation

A hydraulic booster device augments the mechanical governor in the pump. The booster is actuated by fuel pump pressure and, through a servo acts directly on the mechanical governor arm within the pump body (Fig 17).

A spring-loaded piston-type accumulator (Fig 18) prevents hunt at light loads by providing a lag to the hydraulic governor response.

CAUTION: The end of the accumulator must be piped separately back to the fuel tank. See Figure 1.

To offset temperature variations which affect governor spring rate and hydraulic governor leakage, a special bi-metal spring is employed. It is attached to the front of the governor arm within the pump body.

At low fuel temperatures the compensating spring opposes the main governor spring. As temperature of the fuel increases, the compensating spring force reduces, off-setting main governor spring rate change. Thus speed and generator frequency remain constant.

The combination of the mechanical and hydraulic features of the governor results in excellent stability.

The accumulator adjusting screw (Fig 18) is adjusted at the factory and should never require further adjustment unless a new or rebuilt fuel injection pump is installed on the engine. Adjustment is required only if a rapid surge of small intensity at light load is noted, after the speed droop adjustment has been made.

To adjust the accumulator adjustment screw, proceed as follows:

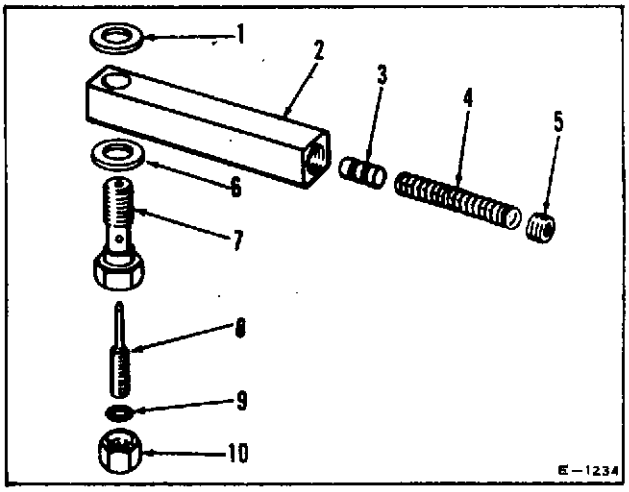
a. Install and time the fuel injection pump to the engine.

b. Operate engine until normal operating temperature is reached, and set throttle for specified no load speed.

c. Loosen accumulator adjusting screw locknut. Bottom adjusting screw and back out 1-1/4 to 1-1/2 turns.

d. Apply full load and check speed droop. Set speed droop at 3-1/2 to 5%.

e. Turn accumulator adjusting screw to dampen surge. Turning screw clockwise decreases damping.



1. Gasket
2. Accumulator
3. Piston
4. Dampening spring
5. Spring stop screw
6. Gasket
7. Head locating screw
8. Accumulator adjusting screw
9. Adjusting screw seal
10. Adjusting screw locknut

Figure 18. Accumulator Assembly

f. Again check regulation and lock accumulator adjusting screw locknut.

5. Bench Checks For Trouble Free Performance of Hydraulic Governor

a. Hydraulic governor spring and piston must slide freely in hydraulic cylinder.

b. Dampening spring must slide freely in accumulator.

c. Hydraulic governor assembly must be checked for leakage by pressurizing the head locating screw hole with 40 psi of air. The metering valve should be in the OFF position. There should be no leakage at the seal between the hydraulic head and the hydraulic cylinder.

d. Speed droop spring - the end of governor spring which engages the two tabs on the governor arm should be bent slightly into the center of the coils to prevent rocking.

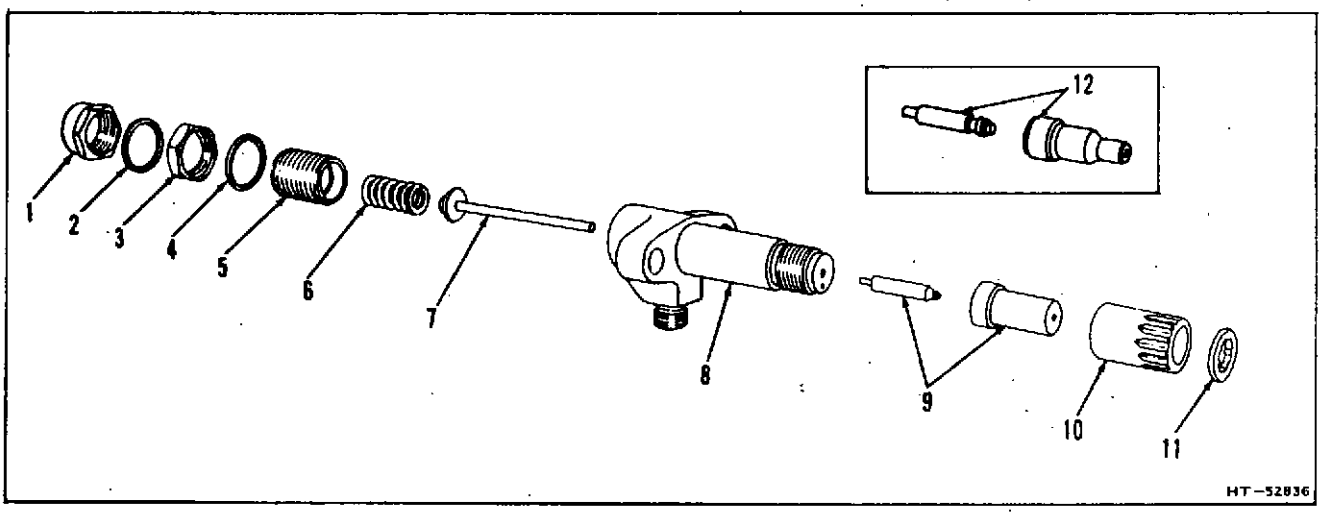
e. The bi-metal spring for the temperature compensator must not be reshaped or bent out of position. Contact with housing must be maintained at all operating speeds.

F. FUEL INJECTION NOZZLE HOLDER ASSEMBLY

1. Description

Each cylinder of the engine is provided with a throttling, pintle-type 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 to produce the most efficient performance.

Each fuel injection nozzle holder assembly (Fig 19) consists of two assemblies, the injection nozzle holder assembly and the injection nozzle assembly. The holder assembly is



1. Cap nut
2. Gasket
3. Adjusting screw locknut
4. Gasket
5. Adjusting screw
6. Spindle spring
7. Spindle
8. Holder body
9. Nozzle assembly (first type)
10. Retaining nut
11. Gasket
12. Nozzle assembly (second type)

Figure 19. Nozzle Holder Assembly

used to hold the injection 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 consists of a steel holder body, spindle, spindle spring, pressure adjusting screw, adjusting screw locknut, gaskets, nozzle holder cap, and a nozzle retaining nut. The injection nozzle assembly consists of a nozzle valve and a valve body. The nozzle valve is operated hydraulically within the valve body by the fuel delivered under pressure by the fuel injection pump.

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

2. *Maintenance*

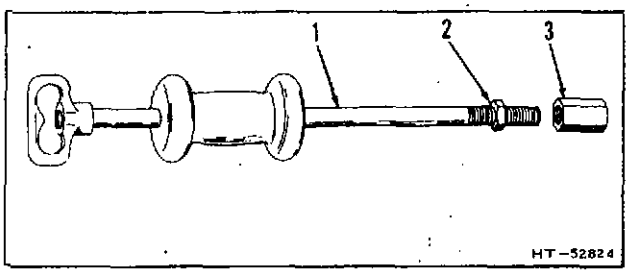
After each operating interval of approximately 2000 hours, the fuel injection nozzles should be removed, cleaned, tested, and adjusted if necessary. The specified opening ("popping") pressure is 2175 ± 25 psi. Popping pressure can be adjusted with the pressure adjusting screw. Turn the adjusting screw counterclockwise to decrease opening pressure and clockwise to increase opening pressure. A nozzle tester with an accurate pressure gauge must be used to observe the opening pressure spray pattern and general function of the nozzle.

3. Fuel Injection Nozzle Holder Removal

a. Thoroughly clean fuel injection nozzles, lines, connectors, and surrounding area.

b. Remove fuel return manifold and disconnect lines from nozzle holder assemblies.

CAUTION: Do not bend lines when disconnecting. Cover all openings immediately to prevent entrance of dirt.



1. Slide hammer puller
2. Locknut
3. Adapter

Figure 20. Nozzle Holder Removal Tools

c. Remove nozzle holder cap nut from nozzle and remove nuts and lockwashers securing nozzles to cylinder head.

d. Use a nozzle puller adapter and slide hammer puller, similar to the ones shown in Figure 20, to pull the fuel injection nozzles.

(1) Turn the nozzle puller adapter on the fuel injection nozzle.

NOTE: Make certain that the puller adapter is turned on the nozzle as far as possible, then tighten with a wrench.

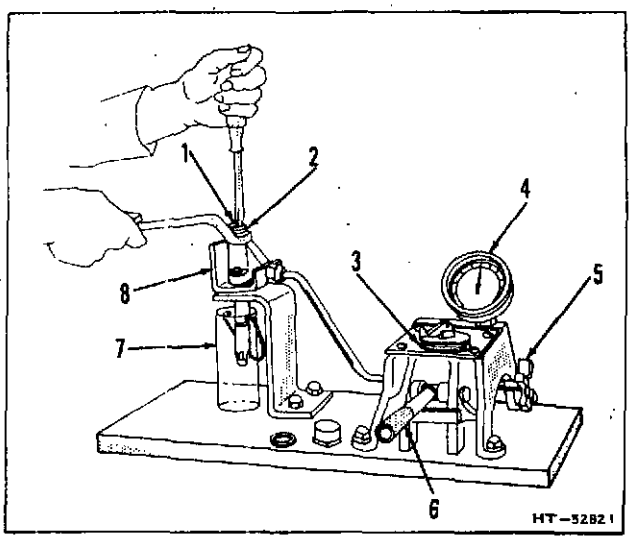
(2) Turn the end of the slide hammer into the puller adapter as shown. Before pulling the nozzle from the cylinder head, bump inward (lightly) on the nozzle with the slide hammer to loosen the nozzle, then pull the nozzle from the cylinder head.

CAUTION: Use care when removing a nozzle to prevent striking the nozzle tip against a hard object. Damage to the tip may result.

(3) Remove the slide hammer puller and nozzle puller adapter. Reinstall the nozzle holder cap in position on the nozzle.

4. Testing and Adjusting Fuel Injection Nozzle Holder

A nozzle tester similar to that illustrated in Figure 21 is required to properly test and adjust fuel injection nozzles.



1. Pressure adjusting screw
2. Adjusting screw locknut
3. Filler cap
4. Pressure gauge
5. Valve handle
6. Tester handle
7. Spray collector
8. Nozzle holder assembly

Figure 21. Fuel Injection Nozzle Tester

WARNING: KEEP HANDS AWAY FROM NOZZLE TIP WHEN POPPING A NOZZLE. THE FINELY ATOMIZED FUEL IS EJECTED WITH SUFFICIENT FORCE TO PENETRATE THE SKIN AND CAUSE BLOOD POISONING.

Test and adjust each fuel injection nozzle as follows:

a. Bolt or clamp base of nozzle tester to a work bench.

b. Turn nozzle tester valve handle to the open position. Loosen filler cap to prevent air lock in the tester. Operate handle until fuel flows from end of tester fuel line, then close valve.

c. Install nozzle holder in tester and connect line. Place spray collector under valve end of nozzle.

d. Open nozzle tester valve. Operate handle a few quick strokes and observe popping pressure indicated on pressure gauge. Specified popping pressure is 2175 ± 25 psi. If specified popping pressure is not indicated, adjustment of nozzle is necessary.

e. Adjust fuel injection nozzle to obtain specified popping pressure as follows:

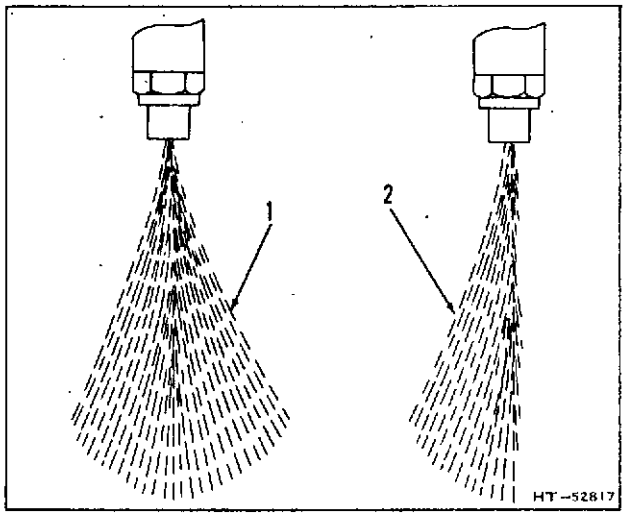
(1) Remove cap nut from upper end of nozzle and loosen adjusting screw locknut.

(2) While operating handle, turn pressure adjusting screw IN to increase or OUT to decrease popping pressure. When specified pressure is obtained, hold adjusting screw and tighten locknut to 75 to 90 lb-ft torque.

f. Dry the nozzle tip. Operate handle slowly until pressure is approximately 200 psi below popping pressure. Observe nozzle tip for fuel leakage. If nozzle does not leak, the nozzle valve is seating properly in the valve body. If drops of fuel collect at a pressure of approximately 200 psi, or less, below popping pressure, the nozzle valve is not seating properly. In this case, the pressure must be relieved by loosening one of the line nuts and the valve body and valve must be removed for cleaning and inspection.

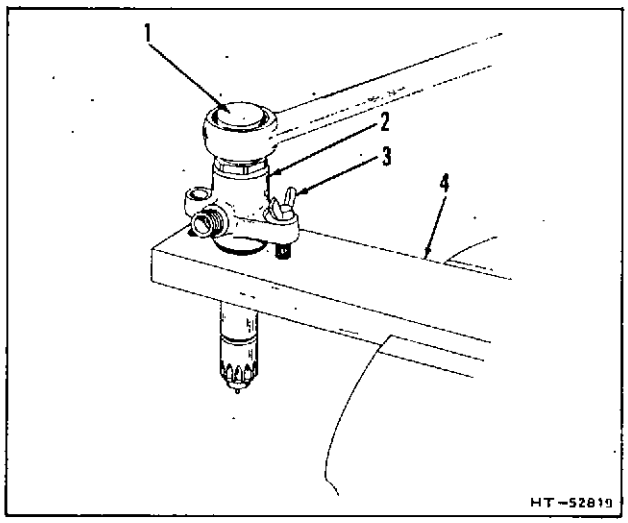
g. If the nozzle proved satisfactory when subjected to the leakage test above, operate handle at a speed of approximately 100 strokes per minute and observe nozzle spray pattern. (Refer to Figure 22.)

h. In deciding whether an injection nozzle is acceptable or should be removed for cleaning and inspection, the spray pattern area only within approximately the first three inches from the tip should be considered. The spray pattern beyond the first three inches is not important for any practical purposes. If the spray pattern is distorted, this is an indication that carbon has collected on the nozzle valve or the nozzle valve is damaged. If this condition exists, remove the fuel injection nozzle from the nozzle holder to disassemble, clean, and inspect. If the nozzle is damaged, replacement is necessary.



1. Acceptable spray pattern
2. Non-acceptable spray pattern

Figure 22. Nozzle Spray Patterns



1. Cap nut
2. Nozzle holder assembly
3. Retaining screw
4. Injection nozzle holding fixture

Figure 23. Removing Nozzle Cap Nut

5. Cleaning And Inspection of Fuel Injection Nozzle Holder Assembly

Before starting the disassembly of a fuel injection nozzle holder assembly, 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 injection nozzles. Use clean paper on the work bench, and as the nozzle is disassembled, place the components in a container of clean diesel fuel as protection against dirt and corrosion.

When more than one fuel injection nozzle (Fig 19) is disassembled, keep the components of each nozzle separate. The valve and valve body are lapped together (mated parts), and they must be kept together. Complete disassembly of the fuel injection nozzle holder assembly is seldom necessary.

In most cases where service to a fuel injection nozzle is necessary, only the removal and cleaning the valve body and valve is required to place the nozzle in good working condition.

a. Remove, clean, and inspect the valve body and valve as follows:

(1) Before disassembly, thoroughly wash the injection nozzle holder assembly to remove any loose dirt or carbon.

(2) Remove the holder cap nut from the upper end of the nozzle. Loosen the adjusting screw locknut and turn the adjusting screw out sufficiently to release the tension on the spindle spring.

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

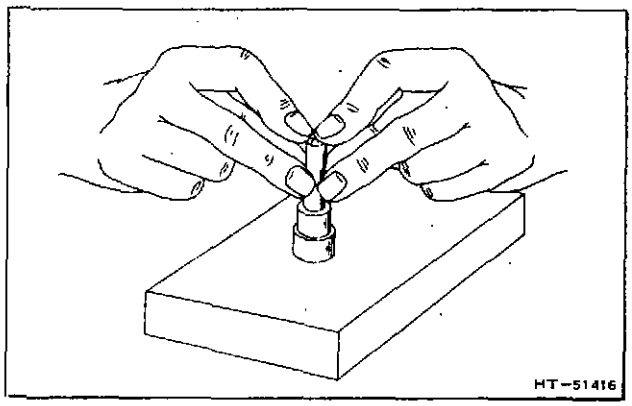


Figure 24. Lapping Fuel Injection Nozzle Valve Body

(4) 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 (with valve) 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 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, IMMEDIATELY PLACE THEM IN CLEAN DIESEL FUEL FOR NEUTRALIZING. ALWAYS HANDLE THE PARTS CAREFULLY TO PROTECT THE LAPPED SURFACES.

(5) 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 of the wear occurs in the seat in the valve body. The valve should never be lapped to the seat in the valve body.

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

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

(c) Visually inspect the condition of the valve, preferably with the aid of a magnifying glass. The lapped surface (large OD) of the valve must be smooth and free of any signs of scoring. Also, the valve must not show any wear or damage at the seat location. Particular attention must be paid to the pintle profile of the valve. This profile must not be damaged in any way or the resultant fuel spray angle will be distorted. If the valve is damaged in any

way, the valve and the valve body must be replaced.

(6) Thoroughly rinse the valve and the valve body in clean diesel fuel or calibrating oil. The valve must fit freely in the valve body. To check this fit, lift the valve about one-third of its length out of the body. The valve should slide down to its seat without aid when the 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 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 pintle end of the valve.

CAUTION: Hard or sharp tools, emery cloth, crocus cloth, jeweler's rouge, grinding compounds, or other abrasives should never be used in cleaning the pintle end of the valve.

(7) Thoroughly rinse the valve in clean diesel fuel before installing it in the valve body.

(8) Examine the flat sealing surface of the valve body which contacts the lower end of the holder body. Make certain the surface is clean and free from scratches. This surface may be lapped, if necessary, using Allis-Chalmers lapping compound, castor oil, and lapping block as shown in Figure 24. After lapping, remove all traces of the lapping compound with clean diesel fuel.

(9) Make certain that the bottom flat sealing surface of the nozzle holder body is clean and in good condition. Rinse the valve and the valve body in clean diesel fuel. Then insert the valve into position in the valve body. Position the valve body and valve on the end of the nozzle holder body and center the valve body with the holder body. Lower the nozzle retaining nut into position over the valve body. Tighten the nut to a torque of 60 to 80 lb-ft.

NOTE: It is important that the valve body be centered in the nozzle retaining nut. Use care when tightening the nozzle retaining nut so that the valve body remains centered in the nut.

(10) Adjust and test the fuel injection nozzle. Refer to sub-paragraph 4, Testing and Adjusting Fuel Injection Nozzle Holder.

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

(1) Clamp the nozzle holder assembly in a vise and remove the holder cap nut and gasket from the upper end of the nozzle. Loosen and remove adjusting screw locknut and gasket.

(2) Remove the pressure adjusting screw and gasket. Remove the spindle spring and the spindle.

(3) Remove the nozzle retaining nut; then remove the valve body and valve.

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

(5) Visually inspect the parts for damage or wear and replace the necessary parts. Examine the flat sealing surface of the holder body, which contacts the upper end of the valve body, and make certain the surface is clean and free from scratches. This surface should be lapped, if necessary, using Allis-Chalmers lapping compound, castor oil, and a lapping block as shown in Figure 25. When lapping use care to keep the nozzle holder body square with the lapping block to assure contact with the entire area being resurfaced. After lapping, remove all traces of the lapping compound with clean diesel fuel and dry with filtered compressed air.

(6) Examine the spindle spring. If the spring is scratched or petted, it must be replaced. Also, the spring must be replaced if the ends have worn from contact with the spring seats. Always replace questionable springs.

(7) Rinse the spindle in clean fuel and insert it into position in the holder body. Place

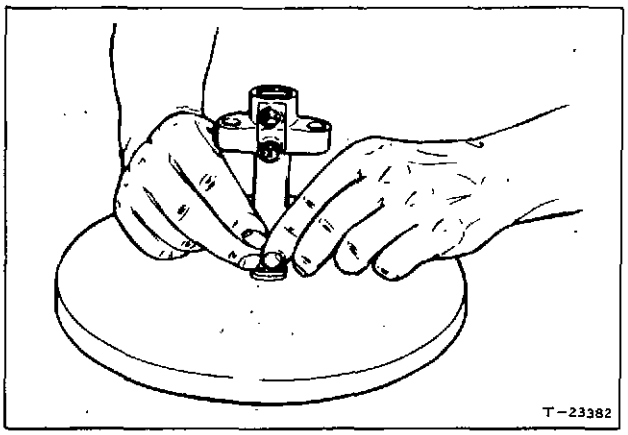


Figure 25. Lapping Fuel Injection Nozzle Holder Body

the spindle spring in position on the spindle. Install the pressure adjusting screw, the adjusting screw locknut and gasket, and the nozzle holder cap and gasket, but do not tighten at this time as the nozzle must be placed on a nozzle tester and adjusted for the specified popping pressure.

(8) Install the nozzle valve, valve body, and the nozzle retaining nut. Tighten the nut to a torque of 60 to 80 lb-ft.

(9) Adjust and test the fuel injection nozzle. Refer to sub-paragraph 4, Testing and Adjusting Fuel Injection Nozzle Holder. After testing and adjusting, tighten the nozzle holder cap nut to a torque of 75 to 90 lb-ft.

6. Installation of Fuel Injection Nozzle Holder Assembly

a. Thoroughly clean nozzle holder bores in cylinder head. When cleaning bores, make certain old nozzle holder gaskets are removed because new gaskets must be used when installing the nozzle holders. Make sure no small particles of carbon are in nozzle holder bores that could prevent nozzle holder gaskets from seating properly, thereby permitting "blow-by" from the cylinders. A round piece of wood or brass properly shaped is very effective for cleaning.

b. Place new holder gasket, concave face down, in position on nozzle holder. Carefully position nozzle holder in nozzle bore of cylinder head.

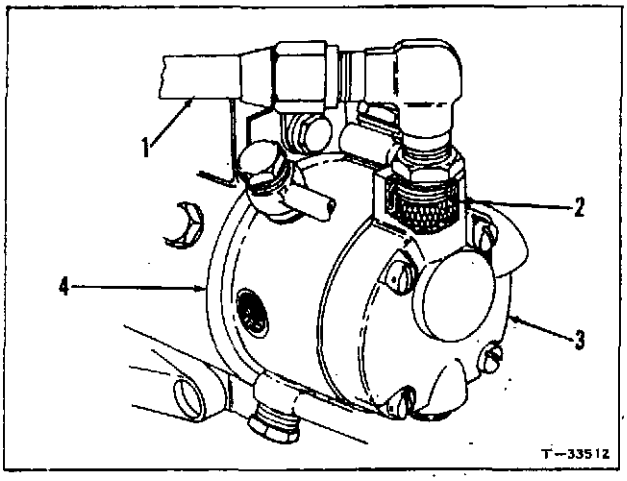
c. Install nozzle holder washers and nuts for each nozzle but do not tighten at this time. Place fuel injection tubes in position in nozzle holders. Start injection tube nuts but do not tighten at this time. Install fuel return manifold.

d. Tighten nozzle holder nuts alternately to 12 to 15 lb-ft torque. Tighten injection tube and fuel return manifold nuts securely.

e. Start engine and observe fuel injection tubes and fuel return manifold connections for fuel leakage. Correct any leaks found.

H. REMOVING CARBON FROM INJECTION NOZZLE BORE

If the cylinder head has been removed from the engine, it is advisable to remove carbon deposits from nozzle bores. A round piece of wood or brass properly shaped is very effective for cleaning. Use a wire brush to remove carbon from nozzle tip holes in the cylinder head before reinstalling it on the engine.



1. Filter to pump inlet line
2. Strainer
3. End plate
4. Fuel injection pump

Figure 26. Fuel Strainer Location

CAUTION: Under no circumstances should an engine be operated with a leaking or "blow-by" nozzle holder because localization of heat will occur that will distort the nozzle holder and result in serious damage.

I. 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 making any of the following checks, make certain there is an ample supply of clean fuel in the fuel tank and that the fuel tank shutoff valve is open.

1. Check for Admission of Air Into System

Remove fuel return line from fitting in the injection pump cover. Insert length of hose on the fitting. Place other end of hose in a container partially filled with fuel oil. Run engine at approximately 800 to 1000 rpm and observe end of hose in container for bubbles. Occasional bubbles are permissible, however, excessive bubbling or foaming indicates air is being drawn into the system. Correct this condition by tightening any loose low pressure fuel line connections, filter connections, and filter shell retaining bolts.

2. Check for Clogged Fuel Filters and Clogged or Collapsed Fuel Lines

Clogged filters or restrictions in fuel lines will cause loss of power, engine stalling, or erratic operation. A simple method of eliminating these troubles is to remove the fuel filter elements, blow out all low pressure fuel

lines with filtered compressed air, and install new filter element(s). Another method is to install a vacuum gauge at the inlet of the primary filter and also one at the outlet of the secondary fuel filter (early models). Pressure drop across clean filters should not exceed 1-1/2" to 2-1/2" of mercury at full load speed. A pressure drop of 10" mercury indicates filter elements are loaded and should be replaced. If a 10" mercury pressure drop is still obtained when new filter elements are used, inspect all low pressure lines for clogging, crimping, etc., and clean or replace as required.

To check high pressure lines between fuel pump and fuel injection nozzles, start engine and loosen each line nut, one at a time, at the injectors. If no fuel is observed at the loosened line nut, line may be clogged, crimped, or cracked. In any case, it must be replaced.

Check fuel strainer (Fig 26) in end plate of the injection pump. Remove foreign material if screen is clogged.

3. Check for Inoperative Fuel Transfer Pump

If the engine is still erratic after making the checks listed in Steps 1 and 2 above, check the operation of fuel transfer pump and end plate pressure regulating valve. Operate the engine until normal operating temperature is reached.

Remove plug marked OUT in bottom of end plate opposite the fuel inlet and install a pressure gauge. With the stop control in the STOP position and the throttle in the LOW IDLE position, crank the engine with the starter. The minimum pressure should be 6 psi at 150 rpm cranking speed. If the pressure is below 6 psi check for malfunction in the end plate and transfer pump parts.

4. Check for Inoperative Fuel Injection Nozzles

Missing or uneven running of engine and loss of power are also indicative of an inoperative fuel injection nozzle(s). To locate a faulty fuel nozzle, use following procedure:

a. Run engine at low idle speed and "cut out" each fuel nozzle in turn by loosening line nut attaching high pressure line to its corresponding fuel nozzle.

b. A decrease in engine speed with line nut loosened indicates fuel nozzle for that cylinder is functioning properly. If engine speed does not decrease, the fuel nozzle is inoperative and should be repaired or replaced.

5. Check for Inoperative Fuel Injection Pump

Do not replace the fuel injection pump before making a compression test (Refer to Topic 9 Paragraph A). The compression test is used to detect burned or stuck valves, worn or scored pistons or sleeves, worn or stuck rings, etc., that cause faulty engine operation.

If all possible 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 may be at fault and should be checked, repaired or replaced. The faulty fuel injection pump should be taken to your nearest Allis-Chalmers dealer for testing and repair.

NOTE: Do not replace the fuel injection pump until making certain that all other possible causes for improper engine operation have been eliminated.

J. ENERGY (AIR) CELL

The energy or air cells, located in the right side of the cylinder head, constitute part of the combustion chamber. The cells are subject to intense heat and may become burned or coated with carbon. The air cells should be removed periodically (every 2000 hours) for inspection.

1. Removal of Energy Cell

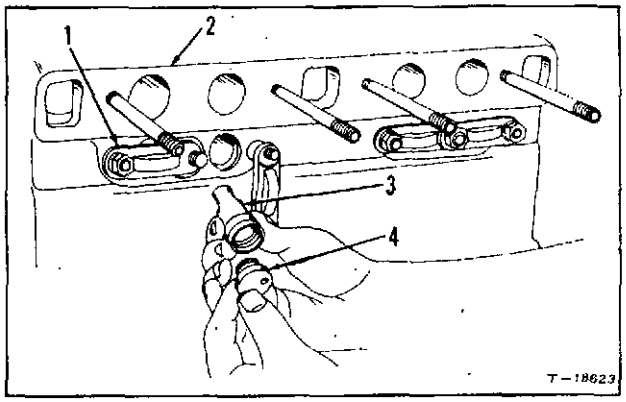
a. Remove air cleaner hose or air cleaner, if applicable, from inlet of air heater housing.

b. Disconnect electrical lead from air heater.

c. Remove nuts, washers, and clamps securing manifolds to cylinder head and remove the manifolds.

d. Remove nuts and lockwashers securing each air cell clamp to cylinder head.

e. Remove fuel injection nozzle holder assemblies.



1. Air cell clamp
2. Cylinder head
3. Energy (air) cell
4. Cell plug

Figure 27. Energy Cell and Plug

f. Tap plug of each air cell lightly and remove air cell by inserting a 5/16" x 12" long brass rod through the nozzle holder bore in the cylinder head and drive air cell out of cylinder head.

CAUTION: Brass rod must be rounded on one end so air cell throat is not damaged during removal.

g. Remove air cell plug from air cell.

NOTE: To remove air cell plug from air cell, secure plug in a vise and hold air cell with a pair of water pump pliers. Heat air cell near plug end with an acetylene torch. The cell can be easily removed from the plug as it expands from heat.

2. Inspection of Energy Cell

Note condition of each air cell. If a heavy carbon coating is present in a cell, it is an indication of a faulty fuel injection nozzle. The corresponding fuel injection nozzle should be checked. If the air cell is badly burned or has burnt spots, the cell must be replaced. If not, clean the air cell with a piece of hard wood and solvent.

3. Installation of Energy Cell

a. Make certain the air cell plugs, air cells, and the openings in the cylinder head are clean. Using fine-grained valve lapping compound, lap the seat of each air cell with its corresponding seat in the cylinder head. The air cells can be lapped in the cylinder head by using a wooden 7/8" diameter rod, resized to fit snugly in the end of the air cell, as a tool to rotate the cell.

b. Lap each air cell plug with its corresponding seat in the air cell. After lapping, remove air cell plug and clean the lapping compound from the cell, cell plug, and cylinder head.

c. Install the air cells in position in the cylinder head. Install the air cell plugs and secure them with the air cell clamps. Tighten the cell clamp retaining nuts evenly to a torque of 19 to 22 lb-ft.

d. Using new gaskets, complete the rest of the installation by a direct reversal of the removal procedure.

TOPIC 13. LUBRICATION SYSTEM

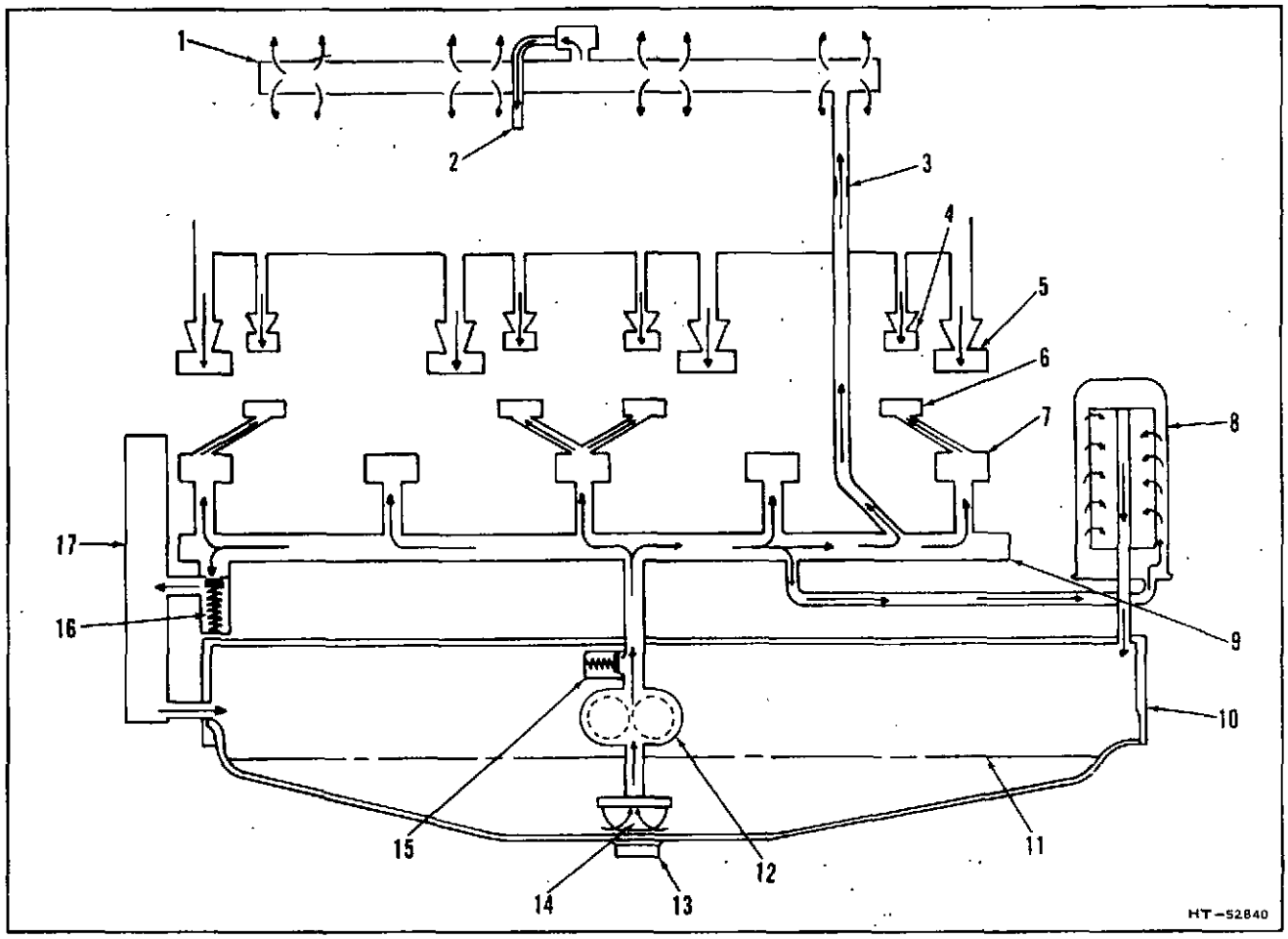
A. GENERAL

The engine lubricating system consists of the oil pan, gear-driven oil pump with relief valve, oil pump suction screen, oil filter, oil pressure regulating valve, oil lines, and oil passages within the engine.

The engine is pressure lubricated throughout by a gear type lubricating oil pressure pump, driven by the oil pump driving gear in mesh with a gear at the center of the camshaft. The engine oil pressure range is between 25 and 50 psi when the engine is operating at full throttle and with engine coolant at normal operating temperature.

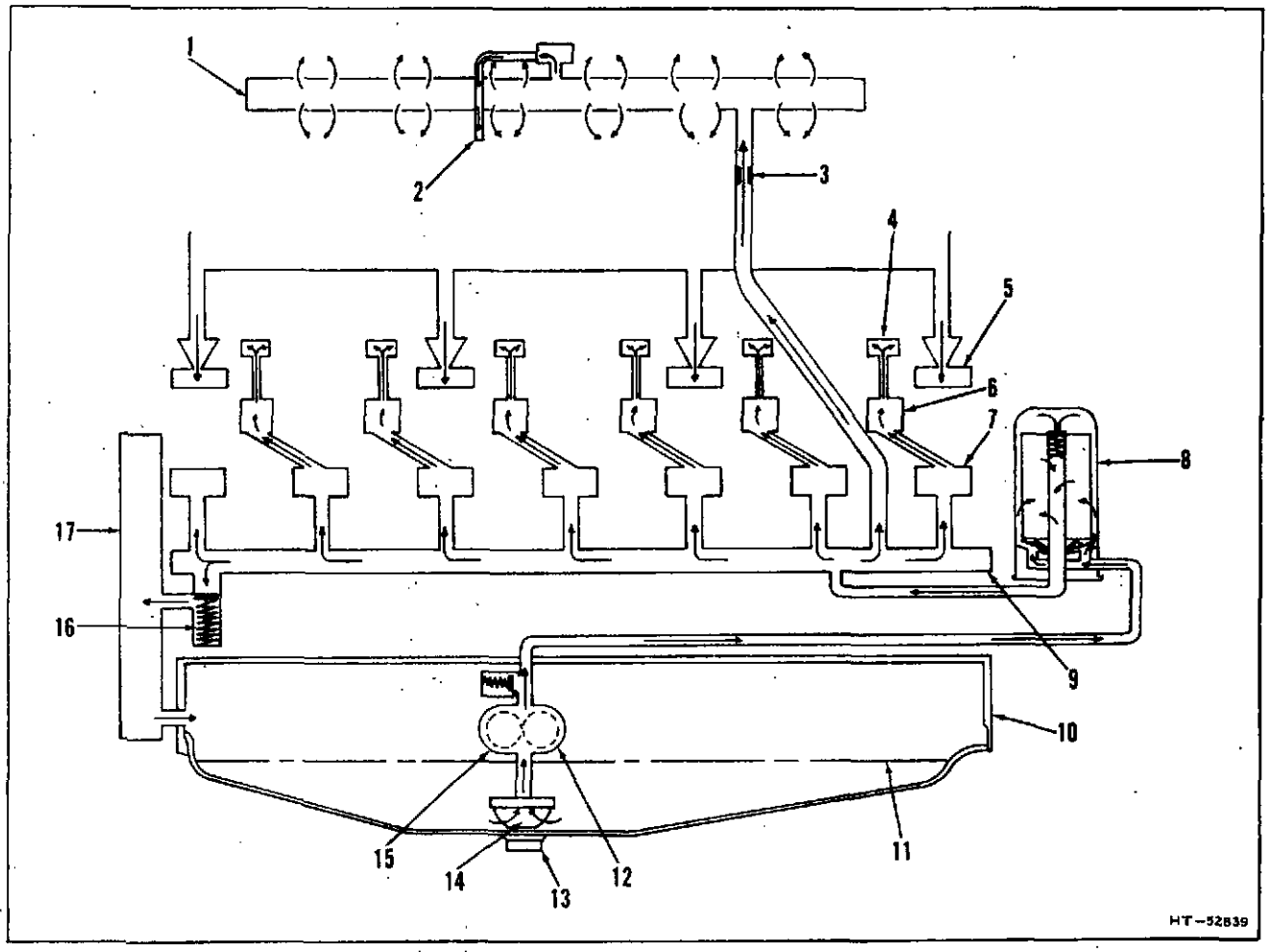
Maximum angle of operation for engine Models D-175 and D-262 is 13°, however an optional oil pan is available for Model D-262 that increases its maximum angle of operation to 30°.

Main bearings, connecting rod bearings, and rocker arms are pressure lubricated by the oil pump. Early Model D-262 engines have rifle-drilled connecting rods to supply oil, under pressure, to the piston pins and bushings. Connecting rods for current Model D-262 and Model D-175 engines are the nonrifle-drilled type. A funnel-shaped oil passage in the top of each rod supplies oil by splash and gravity to piston pins and bushings. An external oil line, extending from the main oil gallery pas-



1. Rocker arm shaft
2. Oil over-flow tube
3. Restriction in rocker arm shaft mounting stud
4. Connecting rod bushings
5. Camshaft bearings
6. Connecting rod bearings
7. Main bearings
8. Lubricating oil filter (part flow)
9. Main oil gallery
10. Oil pan
11. Oil level
12. Lubricating oil pump
13. Drain plug
14. Oil suction screen
15. Oil pressure relief valve
16. Oil pressure regulating valve
17. Gear train

Figure 1. Lubrication System Schematic Diagram (Model D-175)



1. Rocker arm shaft
2. Oil over-flow tube
3. Restriction in rocker arm shaft mounting stud
4. Connecting rod bushings
5. Camshaft bearings
6. Connecting rod bearings
7. Main bearings
8. Lubricating oil filter (full flow)
9. Main oil gallery
10. Oil pan
11. Oil level
12. Lubricating oil pump
13. Drain plug
14. Oil suction screen
15. Oil pressure relief valve
16. Oil pressure regulating valve
17. Gear train

Figure 2. Lubrication System Schematic Diagram (Model D-262)

sage in the cylinder block to the side of the cylinder head, supplies oil to the rocker arms. Oil returning by gravity from the cylinder head to the oil pan lubricates the camshaft bearings.

The oil pump is equipped with a relief valve that relieves excessive pump discharge pressure and reduces oil pump gear wear that occurs when starting a cold engine. All oil pumps used on early Model D-262 engines are equipped with an external dump type relief valve (Fig 4 and 5), located on the pump discharge flange. This type valve opens and allows oil to dump directly into the oil pan when pump discharge pressure exceeds 70 to 90 psi.

On all Model D-175 engines and on current Model D-262 engines, an internal dump type relief valve (Fig 6), located adjacent to the pump outlet, bypasses oil back to the low pressure side of the pump gears when pump discharge pressure exceeds 70 to 90 psi.

An oil pressure regulating valve (Fig 7) is located at the end of the main oil gallery on the left side of the engine. Function of the valve is to maintain correct oil pressure in the lubrication system. Excess oil bypassed through the valve is forced through a drilled capscrew at the front of the cylinder block and into the camshaft gear. Oil sprayed from the camshaft gear lubricates the crankshaft gear and the fuel injection pump driven and drive gears. Oil then drains back to the oil pan through a passage in the front plate assembly.

B. GENERAL MAINTENANCE

The level of lubricating oil in the oil pan should be checked at each period of engine operation before engine is started. If oil level is checked immediately after engine is shut off, a true reading will not be obtained for it will register low on the dipstick. Add the specified lubricant necessary to raise oil level to high mark on the oil level gauge (dipstick). Once engine has started, observe lubricating oil pressure indicated by the oil pressure gauge. If engine is cold, no pressure may be indicated by the gauge for a few seconds after engine starts, but if pressure does not then rise to normal or above, the engine must be stopped immediately and the cause determined and corrected.

Maintenance personnel must familiarize themselves with recommended lubrication intervals and grades of oil specified for use in the engine. (Refer to preceding Topics 6 and 8.) Change oil and replace filter element at operating intervals of 100 hours, or more often under adverse operating conditions.

C. LUBRICATING OIL FILTER

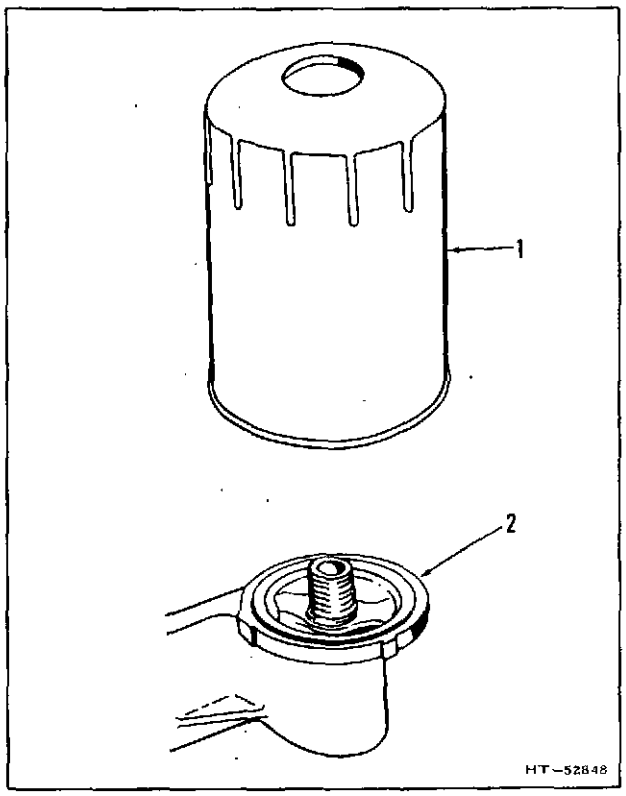
The lubricating oil filter (Fig 3) is the throw-away type. It is screwed onto a filter base fastened to a mounting pad on the side of the cylinder block.

The Model D-175 engine is equipped with a "part-flow" filter and the Model D-262 engine is equipped with a "full-flow" filter. The full-flow filter has an internal pressure relief valve that permits unfiltered oil to bypass the filtering element and go directly into the main oil gallery if the filter becomes clogged, or if, during initial starting of engine in cold weather, oil is too thick to circulate freely through the element.

D. LUBRICATING OIL AND FILTER REPLACEMENT

1. Operate engine until coolant is at minimum operating temperature. Remove drain plug from oil pan and let oil drain. Inspect the oil for metal particles.
2. Thoroughly clean filter and surrounding area.
3. Unscrew filter and remove it from the base assembly. Discard filter.
4. Inspect sediment on filter base. Clean filter base.
5. Apply light coat of lubricating oil to gasket in bottom of replacement filter. Using hand pressure, screw filter into position until gasket contacts surface of filter base assembly. Continue hand pressure and tighten filter a minimum additional one-half turn.

CAUTION: Do not use tools to tighten oil filter. Always use an Allis-Chalmers replacement filter.



1. Filter (throw-away type)
2. Filter base

Figure 3. Lubricating Oil Filter and Base

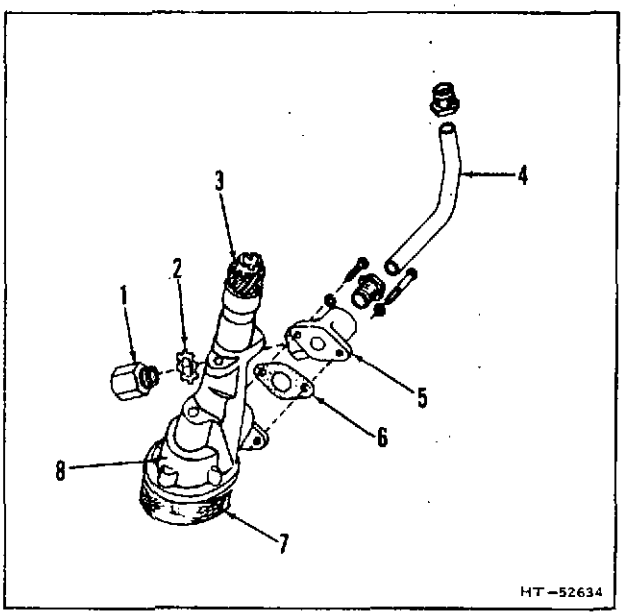
6. Install drain plug and fill oil pan with specified grade of lubricant to high mark on the oil level dipstick.
7. Crank engine for 15 seconds but do not start. This must be done to assure complete filling of the filter and to pump lubricant to engine components before it is started.
8. Start engine and run for approximately 5 minutes. Check for leaks.
9. Stop engine and allow several minutes for oil to drain back to the oil pan before checking level.
10. Check oil level with dipstick. Add oil necessary to raise level to high mark.

E. LUBRICATION SYSTEM MAINTENANCE

Proper maintenance of the lubrication system requires observance of the following checks and services.

1. Lubricating Oil

   Lubricating oil must be best quality available and of proper SAE weight for prevailing ambient temperature. (Refer to Topic 6.) Keep



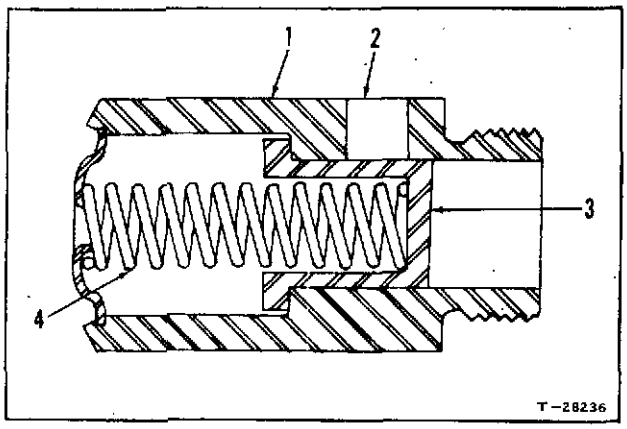
1. Relief valve assembly
2. Locking washer
3. Oil pump drive gear
4. Pump discharge tube
5. Pump discharge tube flange
6. Flange gasket
7. Suction screen
8. Oil pump body

Figure 4. Oil Pump With External Relief Valve

oil free of water and abrasives by proper handling and storage.

2. Daily Check

Before each period of operation, check oil level in the oil pan. If necessary, add oil to bring level to high mark on the oil level gauge. Inspect engine for evidence of oil leaks and make necessary repairs.



1. Relief valve body
2. Discharge port
3. Sleeve valve
4. Spring

Figure 5. Oil Pump Relief Valve Assembly (Early Model D-262 Engines)

3. Cooling System Temperature

It is important that cooling system temperature be maintained at 180°F minimum, so lubricating oil will be hot enough for proper filtering. Low cooling system temperature will cause low oil temperature, and consequently, poor filtering of lubricating oil. This, in turn, will result in rapid wear of all moving parts.

4. Oil Level Gauge (Dipstick)

The oil level gauge has a low and a high level mark. When oil level is at the high mark, the proper amount of oil is in the pan. Never fill pan above high mark. The engine cannot be operated safely after level reaches the low level mark on the dipstick and oil must be added to raise level to the high mark.

A seal in the oil level gauge cap prevents oil from leaking to the outside of the engine and foreign material from entering. For these reasons, the gauge must be kept tight on the level gauge adaptor. Each time oil is changed, inspect the seal to make certain it is in good condition.

5. Engine Breather Cap

Purpose of the breather cap is to vent interior of engine to atmosphere, thus preventing pressure buildup and allowing harmful vapors to escape. If breather cap becomes clogged, vapors will be trapped within the engine and pressure buildup will force oil past crankshaft seals, dipstick, etc.

At each recommended oil change period (100 hours), remove breather cap from engine, wash it in cleaning solvent, and dry with compressed air. Dip cap in light engine oil and allow it to drain before installing on engine.

6. Oil Pan and Oil Pump Suction Screen

After every 2000 hours of operation, remove and clean oil pan. Wash sludge from bottom of pan with cleaning solvent. Also, remove suction screen from end of oil pump and clean thoroughly in cleaning solvent. Check oil pump and oil discharge tube for tightness.

7. Oil Pump Pressure Relief Valve

When the oil pan is removed for cleaning (every 2000 hours), remove, clean, and inspect oil pump relief valve parts as follows:

a. Oil Pump With External Relief Valve

(1) Straighten tabs on locking washer (Fig 4) and remove relief valve assembly and locking washer from oil pump discharge tube flange.

(2) Wash relief valve assembly (Fig 5) in cleaning solvent. Make certain discharge port in side of relief valve body is clean.

(3) Inspect relief valve by inserting a drift in threaded end. Push down on sleeve valve to make certain it moves freely in bore. If any binding is evident after cleaning, replace relief valve assembly with a new one.

(4) Install locking washer and relief valve assembly. Tighten valve assembly to a torque of 40 to 50 lb-ft. Bend tabs on locking washer to secure relief valve assembly.

b. Oil Pump With Internal Relief Valve

(1) Depress relief valve spring and retainer (Fig 6) with 2 screwdrivers or an improvised 2-prong tool.

(2) Drive out roll pin and remove spring retainer, spring, and relief valve piston.

(3) Wash parts in cleaning solvent and inspect carefully. The piston must slide smoothly in bore of valve body.

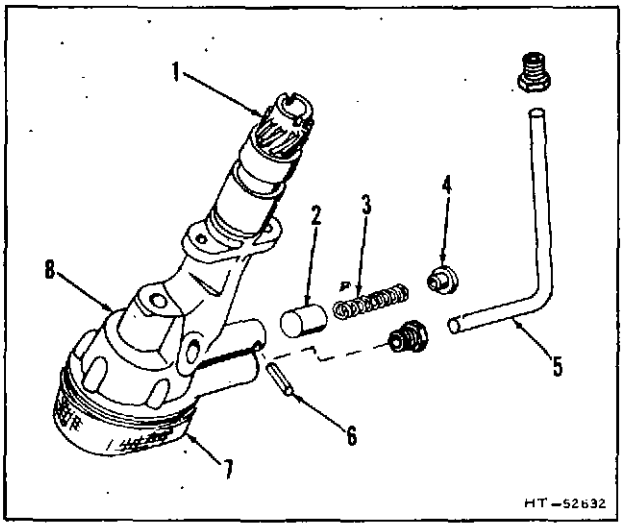
(4) If piston is scratched or shows signs of excessive wear, replace it and install in bore of relief valve. The installation is a direct reversal of removal precedure.

8. Oil Pressure Regulating Valve

The oil pressure regulating valve (Fig 7) is located in the main oil gallery on the lower lefthand side of the engine, at the front end of the cylinder block. Function of the valve is to maintain stabilized oil pressure within the lubrication system. When oil pressure at the regulating valve exceeds approximately 45 psi, the valve piston is raised off the valve piston seat, and oil is bypassed directly from the cylinder block through a drilled capscrew to the gear train.

If lubrication system is allowed to sludge, the valve may not work properly. If it sticks in open position, a sharp drop in engine oil pressure will occur. Conversely, if it sticks in closed position, a sharp rise in engine oil pressure will occur.

NOTE: A gasket is not required between the regulating valve screw jam nut and cylinder block because a nylon pellet is located in the side of the adjusting screw to prevent oil leakage past threads.

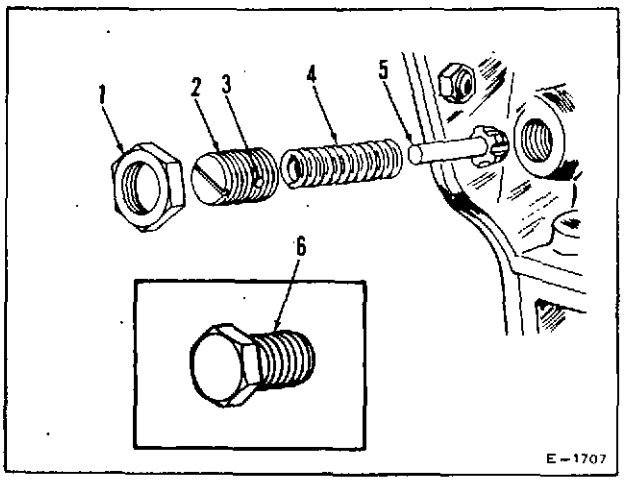


1. Oil pump drive gear
2. Relief valve piston
3. Relief valve spring
4. Spring retainer
5. Oil discharge tube (Model D-262 only)
6. Roll pin
7. Suction screen
8. Oil pump body

Figure 6. Oil Pump with Internal Relief Valve

After each operating interval of 2000 hours, remove, clean, and inspect valve parts as follows:

a. Thoroughly clean the area around the cylinder block where the pressure regulating valve is located.



1. Locknut
2. Regulator screw (early models)
3. Nylon pellet
4. Spring
5. Piston
6. Regulator screw (current models)

Figure 7. Oil Pressure Regulating Valve

b. Remove the regulator screw; note and record the number of turns required for removal (current models). Loosen lock nut and remove regulator screw, noting number of turns required for removal (early models).

c. Withdraw spring, and piston.

d. Wash valve parts in cleaning solvent and inspect carefully for wear or damage. Replace any necessary parts.

e. Inspect the valve seat (insert) in the cylinder block and clean if necessary.

f. Thoroughly clean valve bore in cylinder block, lubricate valve piston with clean oil (piston must slide smoothly in bore of cylinder block), and install the regulating valve components.

g. Turn oil pressure regulator screw into cylinder block the same number of turns required for removal.

h. Start engine and allow it to reach normal operating temperature. Adjust oil pressure regulator screw to obtain oil pressure of 30 to 45 psi at high idle engine speed, then tighten lock nut to a torque of 125 to 135 lb-ft. No further adjustment should be necessary.

TOPIC 14. ELECTRICAL SYSTEM

A. GENERAL

Due to various applications, some early models of engines were equipped with an Auto-Lite system or with an Auto-Lite starter and a Delco-Remy generator and voltage regulator. Later models were equipped with Delco-Remy starters, generators and voltage regulators. Current model engines are equipped with an alternator.

Electrical system includes the starter motor, generator (early models) or alternator (current models), voltage regulator, storage battery, ammeter and intake air heater.

Basic components of the charging circuit include the battery, generator or alternator, and voltage regulator. The wet cell battery is a storage plant for electrical energy and must be kept fully charged. Electrical energy drained from the battery is replaced by the generator or alternator. Excessive current flow can burn out the generator or alternator and damage the battery to such an extent that it will be unable to hold a charge. A regulator connected into the circuit functions to prevent this.

The battery ground for the circuit is either positive or negative, depending upon the type of voltage-current regulator used. All regulators have the polarity and voltage clearly stamped on the end of the regulator base, i.e., 12 VP (12-volt positive grounded) or 12 VN (12-volt negative grounded).

The cranking circuit is composed of electrical starting motor, storage battery and a push-button starter switch. When current flows through the starter solenoid, the starter drive pinion is shifted into mesh with the flywheel ring gear, and the main contacts in the solenoid close, connecting the battery directly to the starter motor that turns the engine. When the engine starts and the push-button starter switch is released, solenoid contacts open, and automatically disengage the drive pinion.

B. WARRANTY AND ADJUSTMENT

Manufacturers of the batteries, starter, generator, alternator and regulator are responsible for this equipment during the warranty. Any claims for replacement or repair of these items must be presented to the manufacturer, not to Allis-Chalmers. Suppliers of such equipment are represented in nearly all cities by distributors or dealers who are authorized to make simple adjustments or replacements. Always give serial number of the engine and the date it was delivered when presenting a claim of this nature.

C. BATTERY

If liquid level of battery is low, add distilled water to bring level of each cell to bottom of filler holes. Be sure filler plugs are tight and plug vents are open.

> CAUTION: Never fill battery after operation in below freezing weather because water will not mix with acid and may freeze. Always fill batteries before putting engine into service.

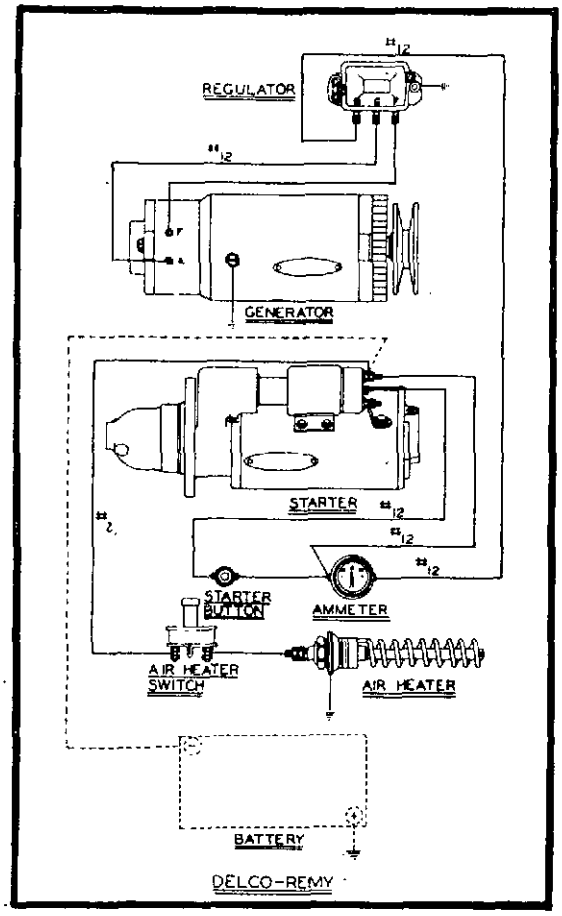
Periodically, check external conditions of battery and connecting cables. Keep batteries clean and well secured. If the battery is dirty, clean with soda solution and a brush. Filler plugs should be tight to prevent any solution from entering cells. After the foaming stops, flush surface with clean water and apply a thin coat of petroleum jelly to the posts and cable terminals.

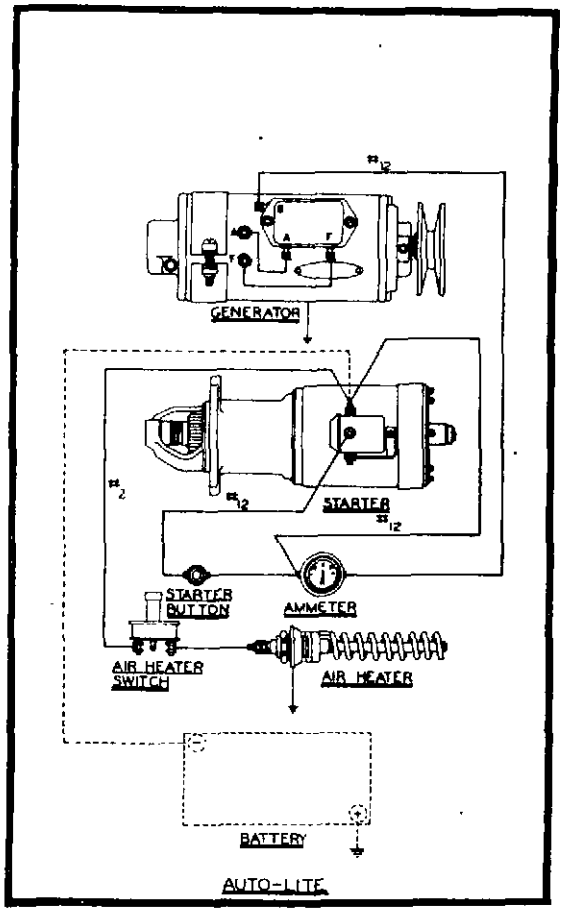
Maintain battery in a fully charged condition. Check charge condition for specific gravity with a hydrometer with electrolyte temperature corrected to 80 degrees fahrenheit.

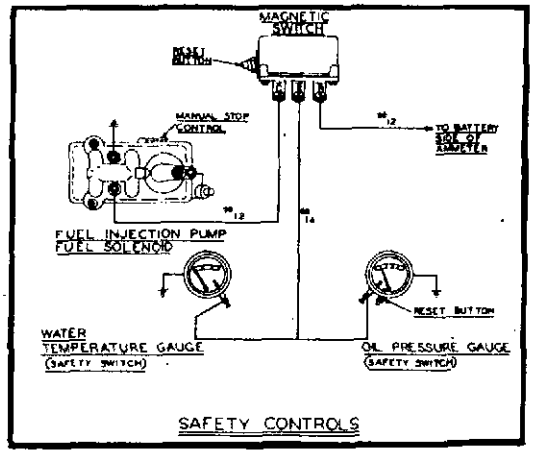
Hydrometer Indication	Charge Condition
1.110 to 1.135	Completely discharged
1.170 to 1.200	One fourth charged
1.205 to 1.230	One half charged
1.235 to 1.260	Three fourths charged
1.265 to 1.290	Fully charged

> CAUTION: The polarity of the electrical system is such that the positive battery terminal must be grounded. Make sure all grounding points are in metallic contact. When connecting either a trickle or fast type charger to the battery, it is imperative that the correct polarity be observed. That is, connect the positive lead of the charger to the positive battery post and the negative lead of the charger to the negative battery post. Observe the same polarity rule when connecting booster batteries to the engine. If any work is performed on the electrical charging system, disconnect the batteries to prevent short circuits.

> NOTE: A starting cable tabulation (Fig 1) lists the allowable maximum length of cable used for 12 volt system. Length includes distance from the battery to ground, and battery to starter terminal.







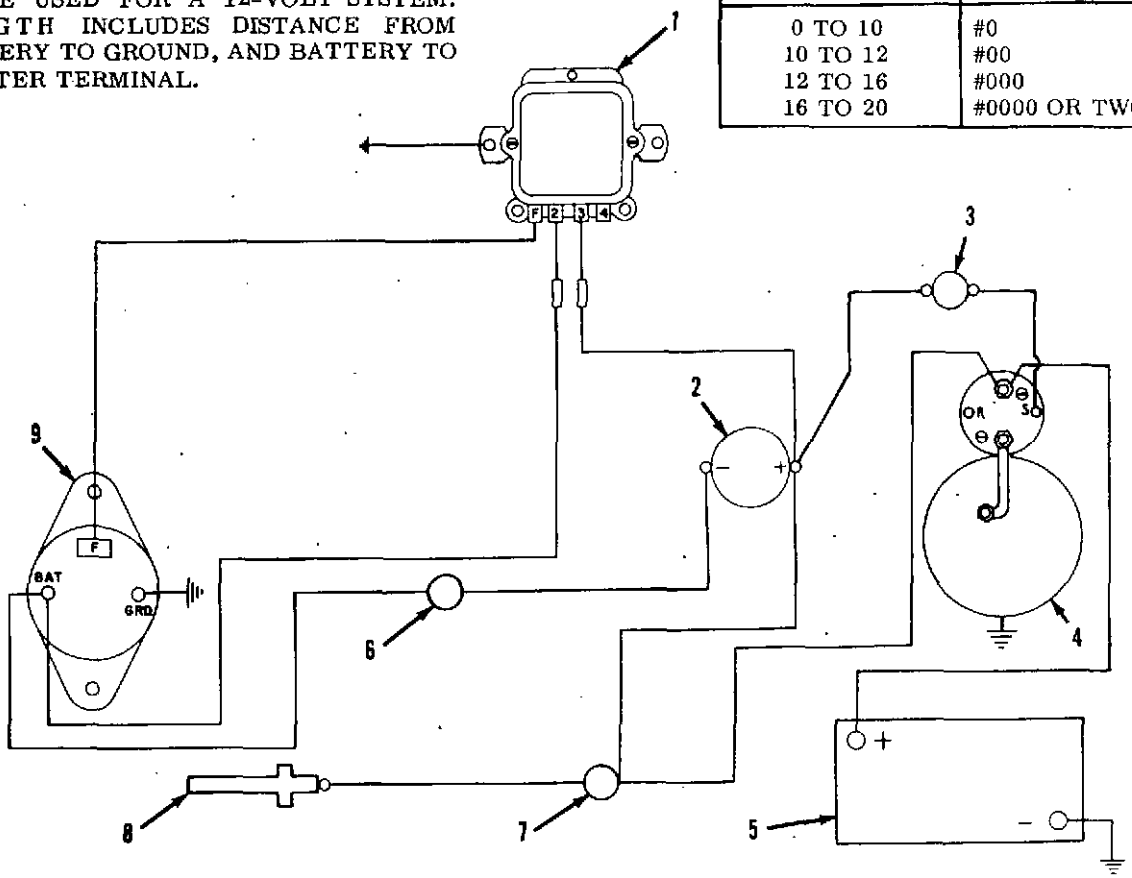
STARTING CABLE TABULATION	
LENGTH IN FEET	CABLE SIZE
0 TO 10	#0
10 TO 12	#00
12 TO 16	#000
16 TO 20	#0000 OR TWO #0
20 TO 24	TWO #00
24 TO 32	TWO #000
32 TO 40	TWO #0000

T-37690

Figure 1. Schematic Wiring Diagram - DC Generator - Positive Ground Systems

NOTE: CABLE TABULATION LISTS THE MAXIMUM ALLOWABLE LENGTH OF CABLE USED FOR A 12-VOLT SYSTEM. LENGTH INCLUDES DISTANCE FROM BATTERY TO GROUND, AND BATTERY TO STARTER TERMINAL.

STARTING CABLE TABULATION	
LENGTH IN FEET	CABLE SIZE
0 TO 10	#0
10 TO 12	#00
12 TO 16	#000
16 TO 20	#0000 OR TWO #0



NOTE: ALL ENGINE GROUNDS SHOULD HAVE A GOOD METALLIC CONTACT.

E-1715

1. Voltage regulator
2. Ammeter
3. Starter button
4. Electric starting motor
5. Battery
6. Pressure switch
7. Air heater switch
8. Air heater element
9. Alternator

Figure 2. Wiring Diagram - AC Alternator Negative Ground System (Mechanical Fuel Shutoff)

D. ELECTRIC STARTING MOTOR

1. General

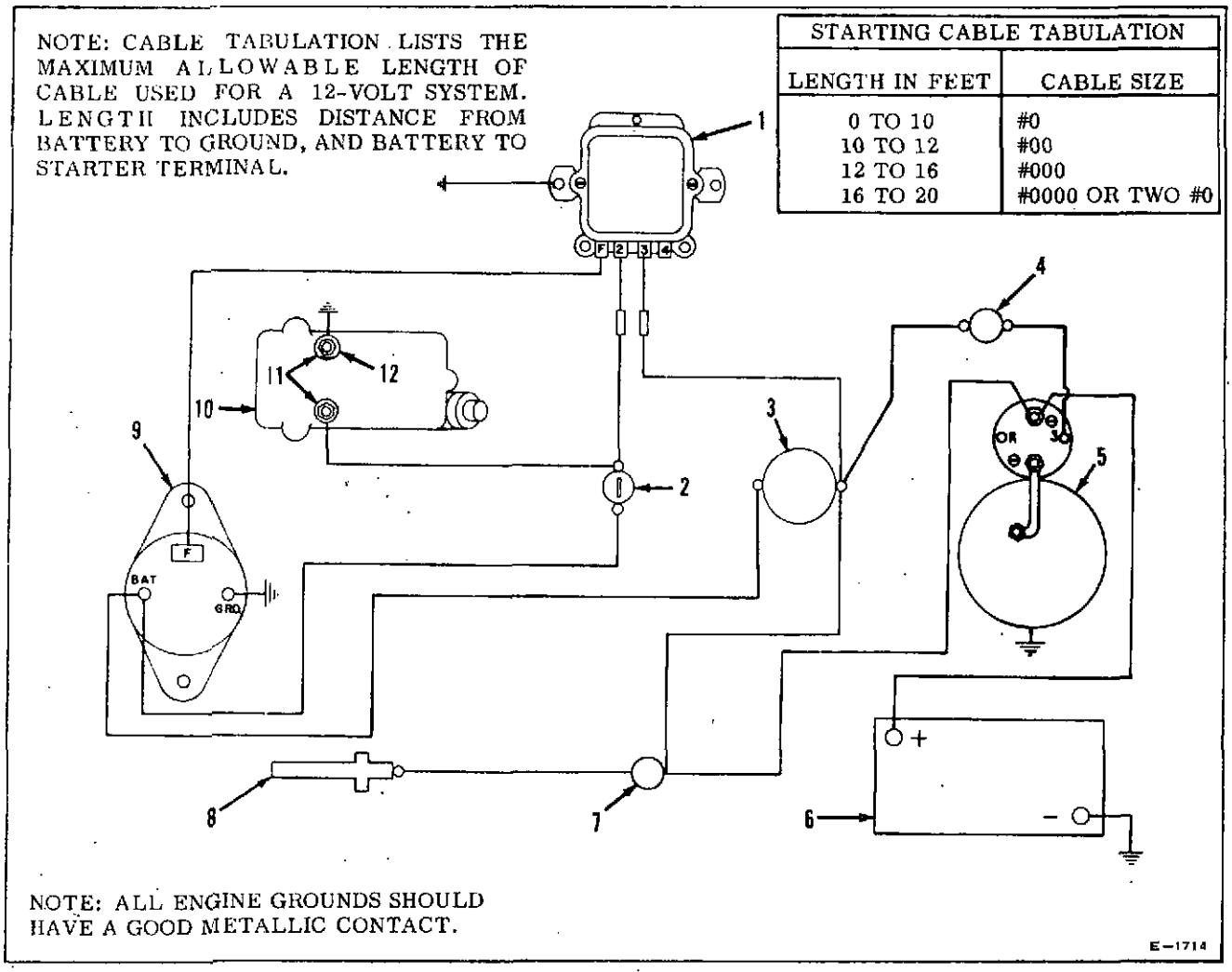
The starting motor is a heavy duty, 12 volt, overrunning clutch type unit. A solenoid switch, which is an integral part of the starting motor, is connected by linkage and a shift lever to a clutch in the starting motor nose housing. Closing the starter switch completes the electrical circuit between the storage battery and solenoid. The solenoid shifts the starter pinion gear into mesh with the engine flywheel ring gear, and holds it in mesh during the engine cranking.

CAUTION: Do not operate cranking motor continuously for more than 30 seconds without pausing to allow it to cool for at least 2 minutes. Failure to observe this rule can result in overheating or failure of the motor.

2. Starter Removal and Installation

a. Disconnect battery cables and electrical lead wires from the starter.

b. Remove capscrews and lockwashers that attach starter to flywheel. Remove starter and starter adaptor.



1. Voltage regulator
2. Key switch
3. Ammeter
4. Starter button
5. Electric starting motor
6. Battery
7. Air heater switch
8. Air heater element
9. Alternator
10. Fuel injection pump
11. Fuel injection pump fuel shutoff solenoid terminals
12. Ground washer or ground wire

Figure 3. Wiring Diagram – AC Alternator – Negative Ground System (Electric Fuel Shutoff)

c. Install starter motor on engine by a direct reversal of removal procedure. Connect cables and wires to starter.

3. Maintenance

a. During start up, note starter motor action. Starter pinion gear should mesh promptly with the flywheel ring gear and spin the engine. After the engine starts and the motor switch opens, starting motor should stop operating.

b. If the starting motor cranks the engine slowly or not at all, check the equipment. Failure to crank is normally caused by low battery charge, defective battery cables, poor connections in the starting motor to battery circuit, defective starting motor, low temperatures, or various conditions in the engine.

c. Periodically, (refer to Topic 8), check conditions of the battery, battery cables and connections, starting motor, solenoid switch, commutators, brushes, lead connections, and mountings. Check brush spring tension. Tension must not be less than 80 ounces.

d. Starter motor bearings are lubricated only when the unit is disassembled for inspection or for repair.

e. Check the length of the brushes, the original length of the brushes is 5/8 inches. The brushes should be replaced when the wear has decreased their length to 5/16 inches or less.

f. If a commutator is dirty, clean it with number 00 sandpaper.

CAUTION: Do not clean commutator with emery cloth. Emery is a conductor and can cause electrical shorts.

4. Starting System Checks

If starter motor cranks engine slowly, check the following:

a. Test for excessive resistance in starting circuit. The resistance can be checked by using a voltmeter to measure the voltage drop between the various terminals in the circuit. The readings should never show a drop of more than 0.2 volts.

b. Check for low or discharged battery.

c. Check the engine for tight bearings or pistons, heavy oil, etc., which may impose heavy loads on the starter motor.

d. Check the starter motor for defective bearings or worn brushes.

If starter will not crank the engine, check the following:

a. Check for completely discharged battery.

b. Check for open starter circuit. Check the starter switch, wiring, and solenoid switch.

c. Check the starter motor. Disassemble and repair as required.

d. Inspect drive mechanism.

e. Inspect flywheel ring gear for broken teeth.

E. DC GENERATOR AND VOLTAGE REGULATOR

The engine driven generating system is used to restore the current withdrawn from the battery during cranking, and to carry a connected electrical load, up to the capacity of the generator, when the generator is operating at a speed to produce maximum output. The voltage regulator is an electrical magnetic relay of the vibrating type. It functions to automatically control and limit the generator output.

1. DC Generator and Regulator Removal

a. Remove the capscrew, washer, and lockwasher attaching the generator to the generator adjusting brace. Remove the drive belt. Disconnect generator lead wires.

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

CAUTION: Whenever a dc generator has been removed or disconnected, it must be polarized. Refer to subparagraph E2.

c. Disconnect generator regulator wires; identify the wires to facilitate installation.

d. Remove generator regulator attaching capscrews and nuts.

e. Remove the generator regulator.

2. Maintenance

a. Periodically, the commutator should be inspected and, if necessary, cleaned. Clean only with number 00 sandpaper; never use emery cloth. Inspect the brushes.

b. If commutator is rough, out of round, or has high mica, it must be turned down in a lathe and the mica undercut. If necessary to turn down the commutator, make the cut no deeper than necessary. The mica should then be undercut 1/32 of an inch.

c. Lubricate generator oil cups with 3 to 4 drops of engine oil, after each 100 hours of operation.

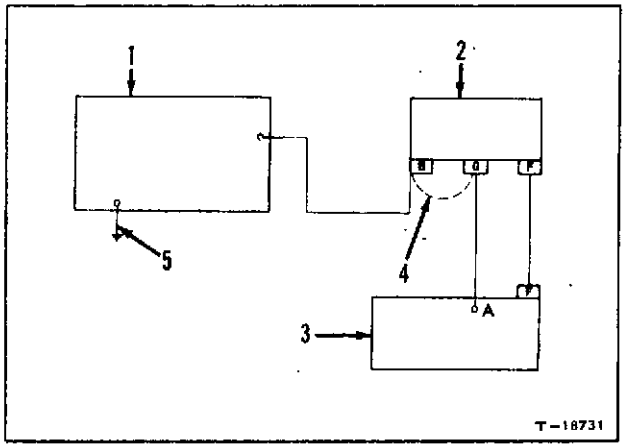
d. Clean the contacts of the voltage regulator by drawing crocus cloth between them while being held together under slight pressure. Do not use emery paper or any coarse abrasive. Blow away any dust. Use a fine mill file only to remove projections or extreme roughness. A clean piece of hard or bond paper drawn between the contacts will dislodge particles.

NOTE: Whenever the generator has been removed or regulator leads have been disconnected and reconnected, the generator must be polarized before the engine is started to prevent severe generator damage.

e. Polarize the generator as follows:

(1) When polarizing a Delco-Remy generator, use a short jumper lead and momentarily touch the jumper from the BAT to the GEN terminals of the regulator (Fig 4).

(2) When polarizing in the Auto-Lite generator, use a short jumper lead and momen-

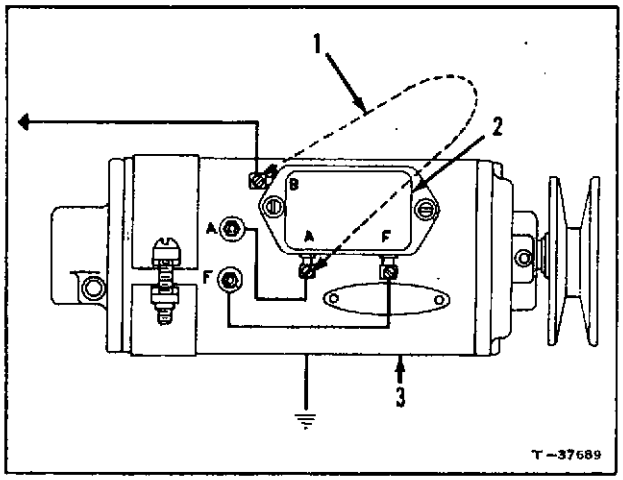


1. Battery
2. Regulator
3. Generator
4. Jumper lead
5. Ground

Figure 4. Polarizing Circuit Diagram (Delco - Remy)

tarily touch the jumper from the B terminal to the J terminal of the regulator (Fig 5).

CAUTION: Do not operate or test the generator in an open circuit. If it should become necessary to operate the generator without it being connected to the batteries, it should be short circuited; disconnect the leads connected to the GEN terminal of the Delco-Remy regulator or to the A terminal of the Auto-Lite regulator and connect to any convenient ground to accomplish the short circuit.



1. Jumper lead
2. Voltage regulator
3. Generator

Figure 5. Polarizing Circuit Diagram (Auto - Lite)

(3) DC Generator and Regulator Installation

Installation procedure is the reverse of the removal.

(4) Generator Drive Belt Adjustment

For belt adjustment, refer to paragraph G, Topic 11.

(5) DC Generator and Regulator Checks

(a) Fully charged batteries and low charging rate indicates normal generator-regulator operation.

(b) Fully charged batteries and high charging rate indicates voltage regulator unit either is not limiting the generator voltage or is set too high. This condition may be caused by:

(1) Incorrect voltage regulator setting

(2) Defective voltage regulator unit

(3) Grounded generator field circuit in either generator, regulator, or wiring.

(4) High temperature which reduces the resistance of the batteries so that they will accept a high charge rate even though the regulator setting is normal.

(5) If the trouble is not due to high temperature, determine cause of the trouble by disconnecting the lead from the regulator terminal marked F with generator operating at medium speed.

(6) If output remains high, generator field is grounded either in the generator or wiring areas.

(7) If output drops off, the regulator is at fault, and should be checked for high setting or for grounds.

(c) Low batteries and high charging rates, or low batteries and low or no charging rates may be caused by a number of conditions. Check as follows:

(1) Loose connections, frayed or damaged external wiring.

(2) Defective batteries.

(3) On a resistance circuit.

(4) Low regulator setting.

(5) Oxidized regulator contact points.

(6) Defects within the generator.

(7) Cut-out relay not closing.

(8) Open series circuit within regulator.

(9) Generator not correctly polarized.

(d) To determine whether generator or regulator is at fault, momentarily ground the F terminal of the regulator and increase generator speed. If the output does not increase, the generator is at fault. If the output increases the trouble is due to:

(1) Low voltage or current regulator setting.

(2) Oxidized contact points which insert excessive resistance into the generator field circuit so that the output remains low.

(3) Generator field circuit open within the regulator.

(4) Cut-out relay not closing.

(5) Open series circuit within the regulator.

(e) If burned resistances, windings, or contacts are noted, check for open resistance units, or loose connections in the charging circuit. Always inspect complete wiring circuit before installing a new regulator.

(f) Burned contact points may be due to reversed polarity. The correct generator polarity must be established after any checks of the regulator or generator, or after the disconnecting and reconnecting of leads. Polarize the generator (refer to item e., subparagraph (2) in paragraph e).

F. ALTERNATOR

1. General

The alternator is a continuous ouput, diode rectified unit, designed and constructed to provide extra long periods of reliable service with minimum maintenance. Two brushes carry current through two slip rings to the field coil of the rotor. The rotor is mounted on ball bearings at the drive end and on roller bearings at the slip ring end. A grease supply for each set of bearings eliminates the need for regularly scheduled lubrication.

The stator windings are assembled inside the laminated core that forms part of the alternator frame. Mounted in the slip ring end frame, are six rectifier diodes that are connected to the stator windings. These diodes replace the separately mounted rectifier that is used in other types of applications. They change ac voltage to a dc voltage that appears at the alternator terminal marked BAT.

If an engine is not equipped with a key switch, a normally open pressure switch is installed in the engine oil gallery to prevent battery discharge while the engine is stopped. With the engine running, the pressure switch is held in the closed position by oil pressure, completing the circuit to the battery.

CAUTION: Alternator ground polarity and battery ground polarity must be the same before making any connections. Instant damage to wiring and diodes will result if polarities are mismatched. Do not operate without a battery. Do not attempt to polarize alternator. Do not short across or ground alternator terminals. Never operate the alternator on an open circuit. Make absolutely certain all connections in the circuit are secure.

2. Alternator Removal

a. Remove capscrews attaching alternator to alternator adjusting brace.

b. Remove drive belt.

c. Mark alternator lead wires with subsequent identification. Disconnect lead wires.

d. Remove the capscrews attaching the alternator to the alternator mounting bracket. Remove the alternator.

e. Install the alternator in reverse order of removal.

3. Maintenance

a. Check drive belt for alignment, tension, and wear. Refer to Topic 11.

b. Check for loose alternator mounting capscrews. Check for loose drive pulley. Tighten pulley retaining nut to 50-60 lb ft.

c. Check terminals for corrosion and loose connections. Check wiring for frayed insulation.

d. Remove the four bolts that secure the slip ring end frame to the drive end frame. Remove the slip ring end frame from the drive end frame.

NOTE: If brushes come in contact with shaft lubricant, thoroughly clean them with a soft dry cloth. Also clean shaft before reassembling.

e. Measure brush length. The original length of the brushes is 1/2 inch. If the brushes are worn down 0.400 inches, which is the effective brush wear length, they must be replaced.

f. Visually inspect brush springs for discoloration, corrosion, distortion, or other damage. If there is any doubt as to the condition of the brush springs, they should be replaced.

g. Check the surface of the slip rings. If the surface is smooth but covered with a carbon-oil-dirt mixture, clean with 400 grain, or finer, polishing cloth. Spin the rotor in a lathe, or other suitable device, and hold polishing cloth against the slip rings until they are clean.

CAUTION: Cleaning the slip rings without spinning the rotor may result in flat spots on the rings, causing brush noise.

h. If slip rings are too rough or out of round, they must be turned on a lathe to within a 0.002 inch maximum indicator reading. Remove only sufficient material to make rings smooth and round. Finish with a 400 grain, or finer, polishing cloth and blow away all dust.

i. The grease reservoir provides an adequate supply of lubricant for long periods of operation. When the alternator is disassembled for overhaul or repair, fill the grease reservoir in each end frame with Delco-Remy grease, their part number 1948791, to one quarter full.

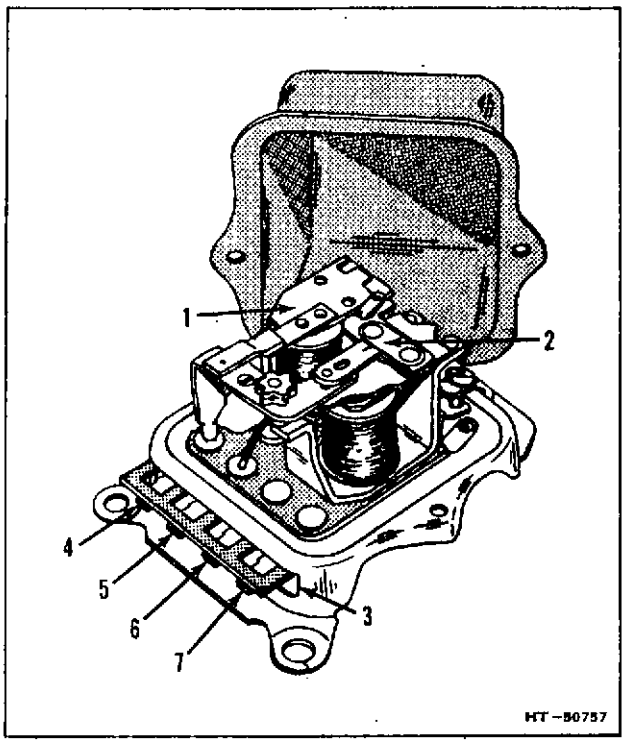
CAUTION: Do not overfill as this will cause bearings to overheat.

G. VOLTAGE REGULATOR

1. General

The voltage regulator (Fig 6) is a 2-unit regulator consisting of a voltage regulator unit and a field relay unit. The voltage regulator unit operates to limit the alternator voltage to a preset value, whereas the field relay unit connects the alternator field windings and regulator windings directly to the battery.

The 2-unit regulator has four slip connection-type terminals. A projection on the connector



1. Field relay unit
2. Voltage regulator unit
3. Latch
4. F terminal
5. No. 2 terminal
6. No. 3 terminal
7. No. 4 terminal

Figure 6. Two-Unit Voltage Regulator

body serves to latch the assembly together to prevent disconnection due to vibration. The assembly can be disconnected by lifting slightly on the latch.

CAUTION: Polarities of the regulator, alternator and batteries must be the same. Instant damage will result if polarities are mismatched. Do not short across or ground regulator terminals. Do not operate without a battery.

2. Voltage Regulator Removal

a. Mark regulator lead wires for subsequent identification. Disconnect lead wires.

b. Remove attaching capscrews, nuts, and lockwashers, and remove regulator.

c. Install voltage regulator in reverse order of removal.

3. Maintenance

Do not clean voltage regulator contacts unless performance indicates cleaning is necessary. A sooty or discolored appearance of contacts is normal after a relatively short period of

operation and is not an indication that cleaning is necessary. However, if voltage fluctuates, as evidenced by an unsteady voltmeter indication, contacts may have excessive resistance or be sticking and therefore should be cleaned.

CAUTION: Before cleaning, make sure fluctuating voltage is not caused by loose connections or high resistance elsewhere in the system.

Contacts of the voltage regulator unit are made of a soft material and must not be cleaned with a file. A strip of number 400 silicone carbide paper, or equivalent, folded over and then pulled back and forth between the contacts is recommended as a satisfactory means of cleaning. After cleaning, wash contacts with trichlorethylene or alcohol to remove any residue. If voltage control is not improved, repeat cleaning and washing process.

Clean field relay contacts with a thin, fine-cut, flat file. Never use emery cloth or sandpaper. Remove only sufficient material to clean.

H. INTAKE AIR HEATER

If the engine does not start with the aid of the intake air heater, it is advisable to stop cranking of the engine and inspect the heater circuit for the following causes of failure:

1. Open Electrical Circuit

   Check all electrical connections to the operation of the heater and make certain the connections are tight. Make certain all cables are in good condition; wrap any frayed spots in the insulation with electrical tape or replace the cables. Check operation of heater element solenoid.

2. Heater Element Broken or Burned Out

   Remove air intake heater housing and the heating element as a unit from the engine air intake manifold. Visually inspect the element for a broken or burned out element wire. Ground the housing and press the heater button; observe if the element becomes hot. Replace the heating element if necessary.

3. Inoperative Heater Button

   If the malfunction of the air heater was not due to a broken or burned out heating element, check the heater button with a jumper cable to see if it is inoperative. Replace if necessary.

CAUTION: Do not use a commercial cold weather starting fluid as an aid in starting, without first disconnecting the air heater to prevent its use.

TOPIC 15. VALVE ADJUSTMENT AND CYLINDER HEAD

A. VALVE LASH ADJUSTMENT

The correct clearance (valve lash) between the rocker arms and the intake and exhaust valves is very important in a diesel engine due to the high compression developed within the cylinders. Insufficient valve clearance can cause loss of compression, misfiring, and will eventually cause burning of the valves and valve seats. Excessive valve clearance will result in faulty engine operation, valve lifter noise, and rapid wear of the valve operating mechanism.

With the engine coolant temperature at a minimum of 160° F, the specified valve clearance is .010" for the intake valves and .019" for the exhaust valves. After any mechanical work has been done which would disturb the valve clearance, the intake valves may be set cold at .012" and the exhaust valves at .021" so the engine may be run and allowed to warm up. After engine coolant temperature has reached a minimum of 160° F, the valve clearance should again be checked.

> 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) 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.

Check the valve clearance periodically and adjust when necessary to obtain the specified hot lash setting, following the procedure as listed below:

1. Operate engine until coolant temperature of 160° F minimum is reached and then stop engine.
2. Remove rocker arm cover.
3. Crank engine until both valves for No. 1 cylinder are closed and the push rods are at their lowest position.
4. Check the clearance between the rocker arm and valve stem using the correct thicknesses of a feeler gauge. The feeler gauge should pass between the rocker arm and the corresponding valve stem with a slight drag when the valve lash is properly adjusted.
5. Adjust each valve by loosening the locknut (Fig 2) on the adjusting screw and turning the screw clockwise as necessary to decrease the clearance or counterclockwise as necessary to increase the clearance. When the proper clearance is obtained, tighten the locknut while holding the adjusting screw with screwdriver. Recheck to be sure clearance did not change when locknut was tightened.

> NOTE: The rocker arms in current engines are equipped with self-locking adjusting screws and do not require the locknuts (Fig 3).

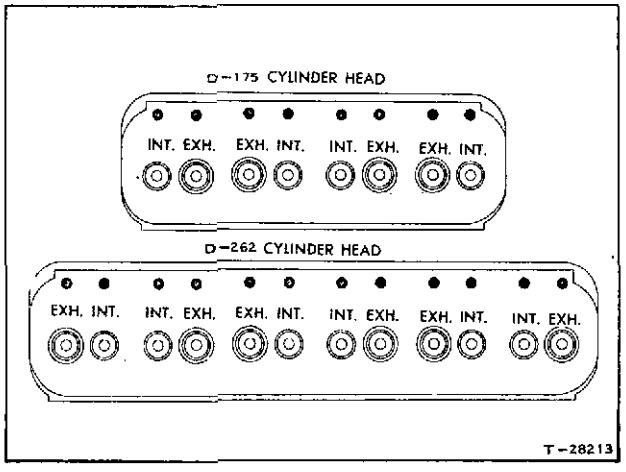
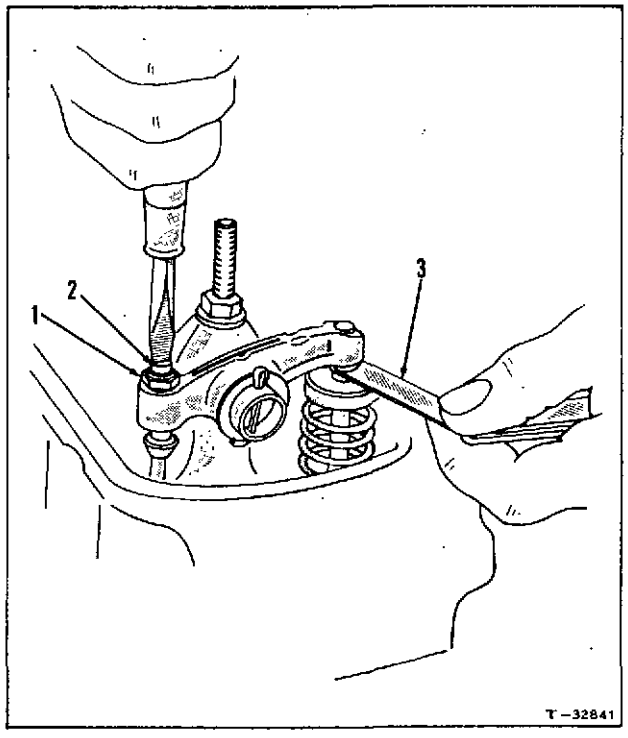
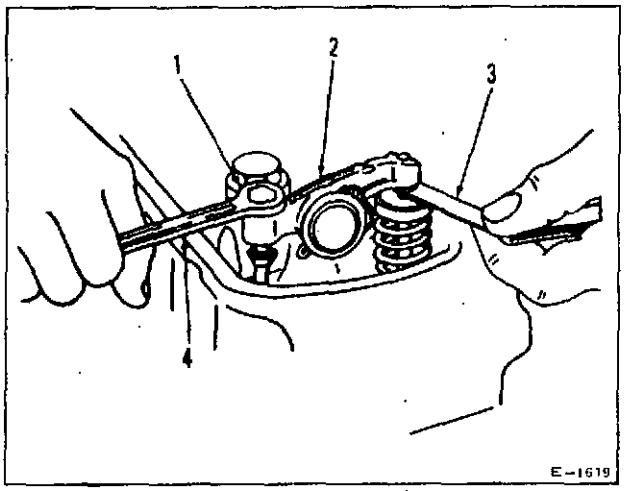


Figure 1. Valve Location



1. Locknut
2. Adjusting screw
3. Feeler gauge

Figure 2. Adjusting Valve Clearance (Early Models)



1. Adjusting screw*
2. Rocker arm
3. Feeler gauge
4. Box wrench

*Adjusting screw must be replaced when less than 36 lb-in driving torque is required to turn it.

Figure 3. Adjusting Valve Clearance
(Current Models)

6. Repeat above operations on the valves for the other cylinders. Make sure engine is cranked and that both valves are closed and push rods are at lowest position.

7. With engine idling and hot, recheck clearance. Slowly move correct thickness feeler gauge back and forth. If clearance is correct, a slight drag will be felt, followed by a tightening which momentarily prevents moving the gauge.

8. Check all valves in the same manner as outlined in Step 7, and then install rocker arm cover.

9. A quick and easy method of adjusting the valve clearance (lash) is as follows:

   a. Six Cylinder Engine

   Knowing the #1 and #6 pistons move up and down in their respective cylinders together, and when one piston is on the firing stroke the other is on the intake stroke and vice versa, and that this relationship is the same for the #2 - #5 pistons and the #3 - #4 pistons, all the valves can be adjusted in two revolutions of the crankshaft. Adjust both the intake valve and exhaust valve of each cylinder following the firing order sequence 1-5-3-6-2-4. Remember it is only necessary to turn the crankshaft 120° between cylinders - starting with #1 cylinder.

   b. Four Cylinder Engine

   In a four cylinder engine the relationship of #1 and #4 pistons and #2 - #3 pistons and the procedure of adjusting the valves is the same as in a six cylinder engine. Adjust both the intake and exhaust valves of each cylinder staring with #1 cylinder following the firing order 1-3-4-2. Remember it is only necessary to turn the crankshaft 180° between cylinders for a total of two revolutions of the crankshaft.

   c. To position the #1 cylinder for adjusting the valves, observe the valves of the rear (flywheel end) cylinder, and stop turning the engine when the rear cylinder exhaust valve is closed and the intake valve starts to open. At this point, adjust both the valves of the #1 cylinder because the piston is near top dead center on the compression stroke and both the intake and exhaust valves are completely closed. The above is true for the balance of the cylinders per the following table:

SIX CYLINDER ENGINE		FOUR CYLINDER ENGINE	
Adjust Valves of Cylinder	When the Exhaust Valve is Nearly Closed and the Intake Starts to Open on Cylinder:	Adjust Valves of Cylinder	When the Exhaust Valve is Nearly Closed and the Intake Starts to Open on Cylinder:
Number 1	Number 6	Number 1	Number 4
Number 5	Number 2	Number 3	Number 2
Number 3	Number 4	Number 4	Number 1
Number 6	Number 1	Number 2	Number 3
Number 2	Number 5		
Number 4	Number 3		

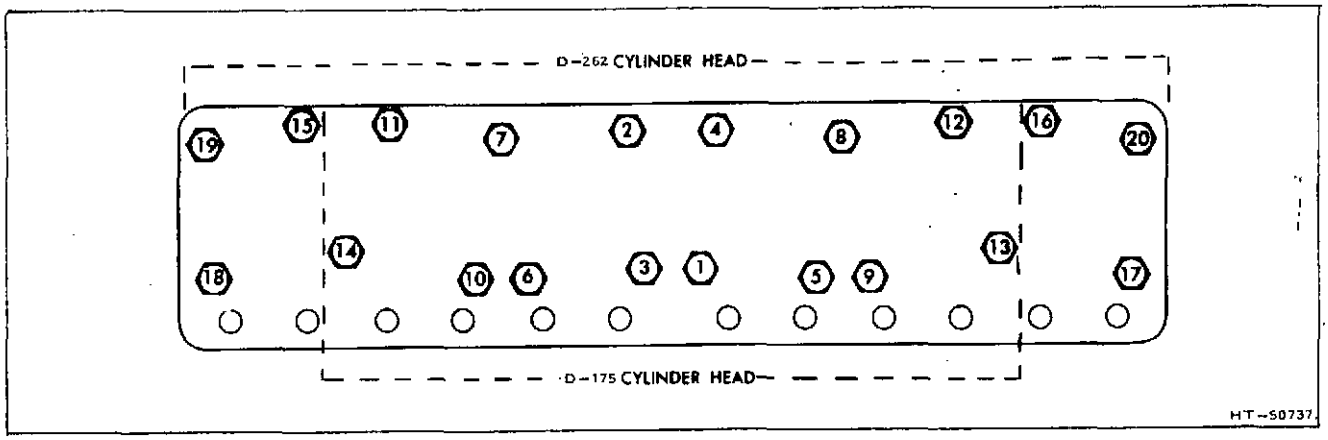


Figure 4. Cylinder Head Capscrew Torquing Sequence

B. TORQUING CYLINDER HEAD CAPSCREWS

There is a correct way to torque cylinder head capscrews that should always be followed. The capscrews should be tightened in successive stages and in the sequence as indicated in Figure 4. This will assure even pressure over the entire surface of the cylinder head and gasket and prevent burning or blowing out between cylinders.

1. Checking Cylinder Head Capscrew Torque

   Operate engine until coolant temperature is a minimum of 160° F. Remove cylinder head cover and rocker arm assembly. Using torque wrench, tighten the capscrews to the specified torque of 110-120 lbs. ft. following the numerical sequence in Figure 4. Tighten only the capscrews which are below the specified torque. Those capscrews at the specified torque or slightly over should remain as they are.

> CAUTION: Do not over-torque. If a capscrew is loosened because it has been over-torqued and then re-torqued, the sealing ability of the gasket in the area of the capscrew will be affected.

   After the capscrews have been checked, install the rocker arm assembly on the cylinder head. Set the valve lash at the cold setting and install the cylinder head cover. Operate the engine until coolant temperature of 160° F minimum is reached. Again remove the cylinder cover and adjust the valve clearance to the hot lash specification (refer to Paragraph A in this Topic). Install cylinder cover, making certain the cover gasket is in good condition.

2. Torquing Capscrews After Installing New Cylinder Head Gasket

   Tighten the capscrews in the numerical sequence as indicated in Figure 4 to 55-60 lb. ft. Next tighten the capscrews to the full torque valve following the recommended numerical sequence. Again torque the capscrews to the full torque value following the numerical sequence. Install the rocker arm assembly and adjust the valve clearance to the cold lash setting. Operate the engine until the coolant temperature reaches a minimum of 160° F. Remove the rocker arm assembly and again torque the capscrews to the full torque value following the recommended numerical sequence.

   Install the rocker arm assembly, adjust the valve clearance to the cold lash setting. Operate the engine until coolant temperature of 160° F minimum is reached. Remove the cylinder head cover and adjust the valve clearance to the hot lash setting (refer to Paragraph A in this Topic). Install cylinder head cover making certain the gasket is in good condition.

C. CYLINDER HEAD GASKET REPLACEMENT

Refer to the instruction sheet packed with the head gasket service kit.

A new cylinder head gasket must be installed each time the cylinder head is installed. Prior to installing the new gasket perform the following operations:

1. Thoroughly clean the machined surface at the top of the cylinder block and head gasket surface of the cylinder head.

2. The new part tolerance for flatness of the cylinder head gasket surface is .005" total indicator reading. Some discretion will have to be observed when checking the flatness of a cylinder head removed from an engine after a period of operation. An end to end warpage of .010" to .015" can be tolerated if it is a long even bow. Side to side warpage of .005" can be tolerated if the low or high spots are not concentrated in small areas or under gasket

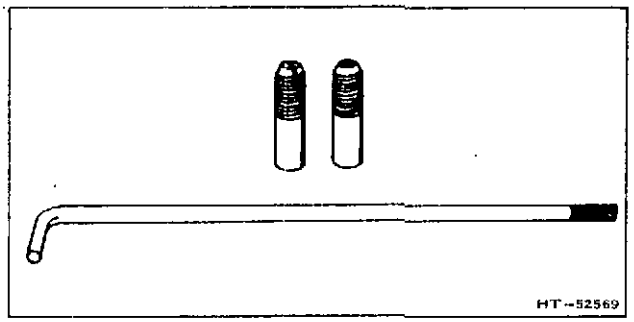


Figure 5. Guide Studs and Removal Wrench

grommets surrounding combustion chambers, water or oil passages. If it is necessary to machine the gasket surface, remove only enough metal to bring the flatness within the specified tolerance.

3. In order for the cylinder head gasket to properly seal around the combustion chambers and cylinder sleeves, check the relationship of the top surface of the cylinder sleeve flange to the top flat surface of the cylinder block. The specified dimension is .002" protrusion above the surface of the block .002" below the surface. If the dimension exceeds .002" below the top surface of the cylinder block it will be necessary to remove the original sleeve, remachine the counterbore in the cylinder block and install a service sleeve having a .020" thicker flange. It is preferable to machine the counterbore so that the top surface of the sleeve is on the high side of the tolerance (.002" above the top surface of the cylinder block).

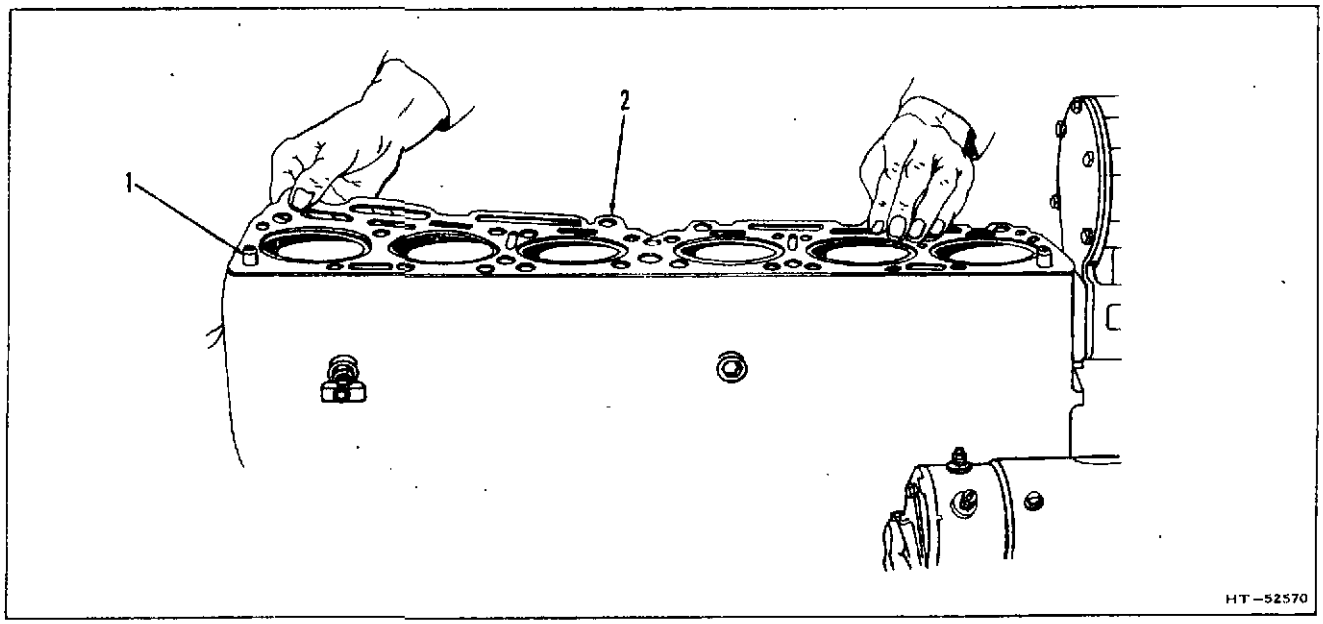
4. Always check for anything that might be left on top of the pistons before installing the cylinder head.

   Because the cylinder head is secured to the cylinder block with capscrews, it is necessary to install guide studs (Fig 5) to properly position the head gasket in relation to the cylinder sleeves and water holes. The guide studs are interchangeable and must be installed in holes 19 and 20 of the D-262 cylinder block (Fig 6) and in holes 11 and 12 of the D-175 cylinder block. It is important that guide studs be installed in proper capscrew locations in the cylinder block because corresponding holes in the head are reamed for a close fit with the guide studs.

   Place the cylinder head gasket on the guide studs.

> CAUTION: Make certain the gasket is installed with the side marked "THIS SIDE DOWN" toward the cylinder block.

   Position the steel fire rings on top the sleeves in the sleeve openings of the head gasket. Be sure they do not overlap the head gasket. Place the cylinder head in position on the guide studs. Install several cylinder head cap-



1. Guide stud in hole number 20
2. Cylinder head gasket
3. Guide stud in hole number 19

Figure 6. Positioning Cylinder Head Gasket on Guide Studs

screws and tighten enough to prevent the head from shifting.

Screw the guide stud removing tool into the studs. The thread on the removing tool is LEFT HANDED and by continuing to turn to the left, the guide studs will turn out of the block and can be withdrawn from the cylinder head (Fig 7). Install the remaining cylinder head capscrews and tighten as specified in Paragraph B in this Topic.

NOTE: Any interference encountered while removing the guide studs from the D-262 cylinder block of early model engines, can be eliminated by enlarging the top section of holes 19 and 20 (Fig 6) in the cylinder head. Using a 9/16" drill, re-drill holes 19 and 20, 2-5/8" deep from the top side. Do not drill too deep, otherwise the .531" dimension ream section, which is the locating position, will be destroyed.

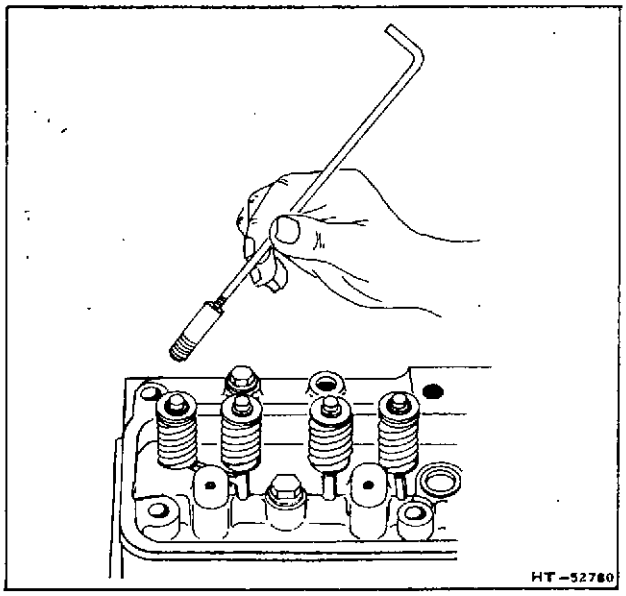


Figure 7. Removing Cylinder Head Guide Stud

TOPIC 16. INTAKE AND EXHAUST SYSTEMS

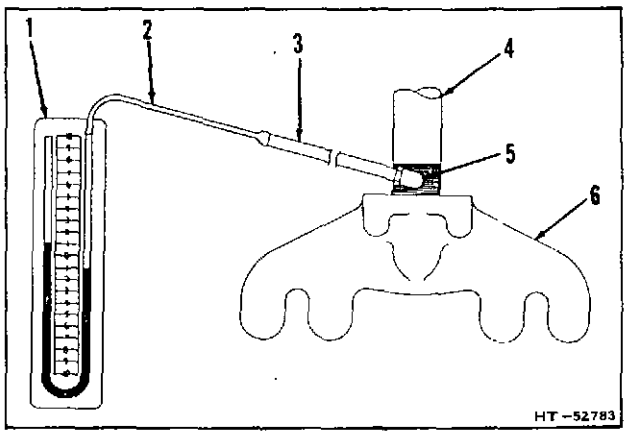
A. GENERAL

The intake and exhaust system consists of those components that convey filtered air to engine cylinders and exhaust gases to the atmosphere. The intake system consists of intake valves, intake manifold, and air cleaner. The exhaust system consists of exhaust valves, exhaust manifold, muffler, and exhaust piping extensions.

It is important that an ample supply of fresh clean air be provided to the combustion chambers. Insufficient air will limit amount of fuel the engine can burn and can lead to loss of power, excessive exhaust smoke, high fuel consumption, and eventual engine failure.

In warm weather, sufficient heat is generated by the compression of air within the cylinders to ignite the fuel and start the engine within a very short cranking period. However, in cold weather, the "drag" caused by cold oil between pistons and cylinder walls and in the bearings, reduces cranking speed of the engine. A large part of the heat generated by compression of air is absorbed by the cold pistons and cylinder walls. This heat loss and reduced cranking speed may lower the temperature of air in the cylinders to a point too low to ignite the fuel. In this case, an intake air heater may be used to assist in starting the engine.

> CAUTION: Muffler installations or exhaust pipe extensions from the manifold outlet must be adequately supported and flexibly connected to eliminate possibility of strain on the exhaust manifold outlet.



1. U-tube manometer
2. Rubber tubing
3. Copper tubing
4. Exhaust pipe
5. Reducer bushing and elbow
6. Exhaust manifold

Figure 1. Checking Exhaust Back Pressure

Total restriction of the exhaust system of a naturally aspirated engine at the exhaust outlet with engine under full speed, full load conditions, must not exceed 3" mercury back-pressure. If there is any question as to whether or not the engine has excessive exhaust back-pressure, check with a mercury manometer as depicted in Figure 1.

To connect manometer to exhaust manifold, install a 1/4" x 1/8" reducer bushing in the side of the exhaust pipe and as close to exhaust manifold flange as practicable. Fitting must be flush with inside and perpendicular to manifold to avoid false readings. Braze steel fitting on outside of pipe and file it flush inside of pipe. Fasten about 3 feet of 1/4" OD copper tubing to fitting in exhaust pipe to prevent transfer of heat from manifold to manometer. From the other end of copper tubing, connect a length of rubber tubing to one side of the manometer.

It should be noted in the illustration, Figure 1, that the manometer scale is graduated in inches both above and below the 0 mark, and each inch is divided into tenths. When manometer is set up for use, sufficient mercury must be put in the U-shaped tube so height in both columns aligns with 0 line on the scale.

Take exhaust back-pressure readings when engine is developing its maximum horsepower and rpm. When reading manometer, add height of liquid in both columns to obtain final figure. For example, if liquid is 1.5" high in left column and 1.5" low in right column, the manometer indicates 3" mercury back-pressure.

> NOTE: If mercury is 1.5" high in right column and 1.5" low in left column, the manometer indicates 3" mercury vacuum, rather than pressure. A 1" mercury indication is equivalent to 0.491 psi, and 3" of mercury is equal to 3 x 0.491 or 1.473 psi. If a manometer is not available, an accurate pressure gauge can be used.

Excessive back-pressure will result in poor engine performance and shortened engine life. Measurement of exhaust pressure will indicate whether or not capacity of exhaust system is adequate. If back-pressure reading is higher than the specified figure, one or more of the following factors is the cause:

1. Sharp right angles or excessive bends in exhaust piping. All angles and bends must be gentle sweeping curves. Piping should have as few angles/bends as possible.

2. Exhaust piping diameter too small. Pipe size must never be less than diameter of exhaust outlet opening. As piping length increases, so should the diameter.

3. Foreign material causing restrictions in muffler or piping.

4. Inadequate muffler capacity.

B. MANIFOLD MAINTENANCE

1. Use new gaskets when reinstalling manifolds.

2. Periodically check all manifold mounting nuts and clamps for tightness after engine is hot. Tighten manifold mounting nuts to specified torque, starting at the center and working alternately toward each end.

3. At time of overhaul, check manifold for carbon deposits. Clean and remove obstructions found within the manifold.

4. If manifold is cracked, repair or replace as necessary.

5. If manifold mounting surface is warped and cannot be sealed by tightening manifold nuts, all of the manifold mounting surfaces must be remachined or manifold replaced.

TOPIC 17. AIR CLEANER

A. GENERAL

The purpose of the air cleaner is to remove dust and other foreign material from air used by the engine. Engine life depends largely on efficiency of the air cleaner. Rapid wear on cylinder sleeves, pistons, and rings will result if it is not kept in good condition and properly maintained.

Frequency of servicing required depends on amount of foreign material in air surrounding working location of the engine. Until proper maintenance period can be established, the air cleaner should be inspected daily under actual working conditions.

Inspect air cleaner body periodically for dents, cracks, etc. Also check for damaged gasket and hose, loose hose clamps, and for leaks that allow air to enter engine without first passing through the air cleaner. Correct any such condition found by immediate repair or replacement of faulty parts.

> *NOTE: Always refer to instructions on* air cleaner.

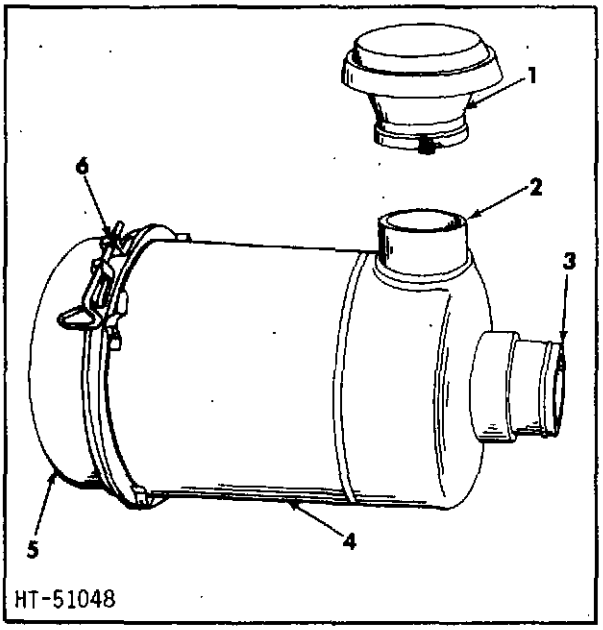
B. MAINTENANCE

Four types of air cleaners have been installed on this series of engines. The first (Fig 6) is an oil bath type, mounted directly on the intake manifold. The second (Fig 7) is an oil bath type mounted vertically at the rear of the engine and connected by a hose to the intake manifold. The third (Fig 1) is a dry type and is mounted horizontally at the rear of the engine and is the type specified for all current engines. The fourth (Fig 8) is a dry type and is mounted at the rear of the engine. This is an Extra Heavy Duty FARR cleaner equipped with precleaner and aspirator.

1. Dry Air Cleaner (Current Type)
   The dry type air cleaner (Fig 1) is mounted horizontally with the stack cap in vertical position. Inspect dust cup daily or prior to operating the engine. Do not allow dust level to build up to less than one-half inch from slot in dust cup baffle. Each time air cleaner is serviced, inspect stack cap and clean as required.

> NOTE: Empty and clean dust cup and baffle daily or more often if required. Dust level must not be allowed to build up to less than one-half inch from slot in dust cup baffle.

When servicing the air cleaner, reduce engine down time to a minimum by replacing a dirty filter element with a new element or one that has been cleaned. Service the dirty element later, using procedures detailed in Subparagraph b (Optional Service Methods).



1. Stack cap
2. Air inlet
3. Air outlet
4. Body
5. Dust cup
6. Clamp assembly

Figure 1. Dry Air Cleaner (Current Engines)

a. Air Cleaner Service

(1) Clean baffle and dust cup as follows: (See Fig 2)

(a) Loosen clamp assembly (3) and remove dust cup (1).

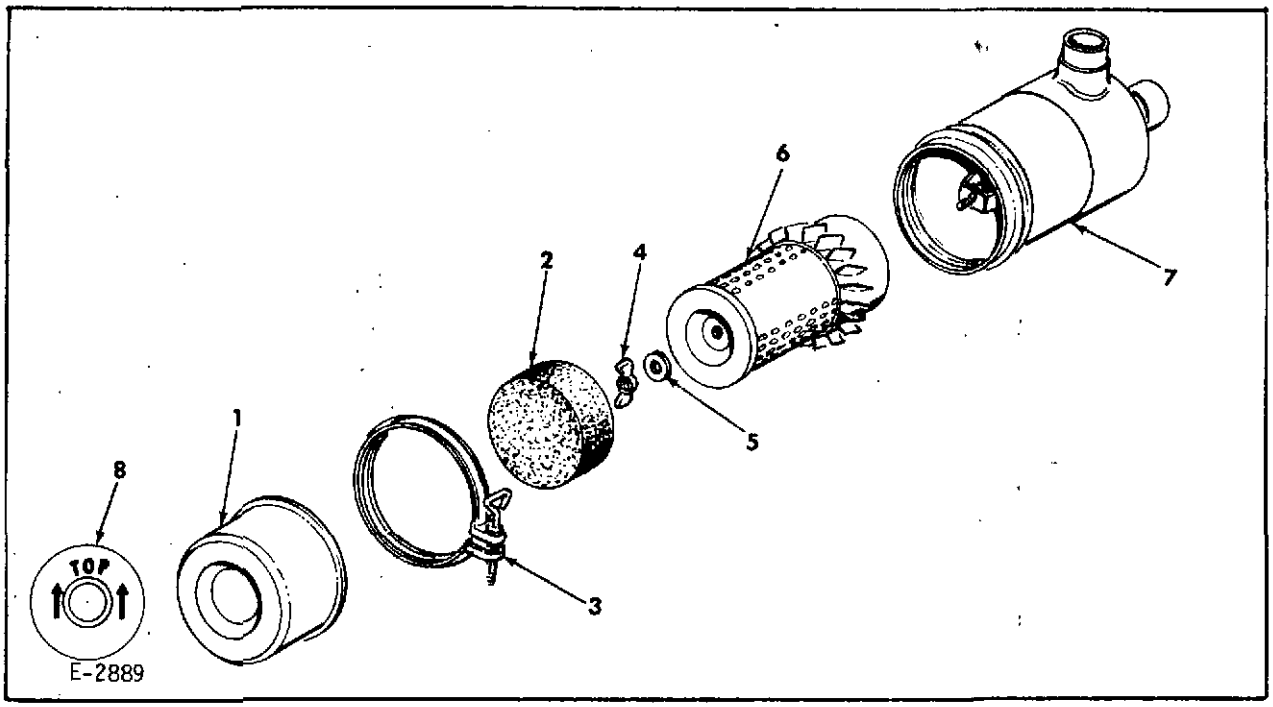
(b) Remove baffle (2) from dust cup.

(c) Empty dirt from cup. Clean cup and baffle.

(d) Remove foreign material from around filter element (6).

(e) Assemble baffle (2) to dust cup (1).

> CAUTION: Bottom of dust cup is marked with arrows and the word TOP. Air cleaner *is mounted in horizontal position. Be sure* dust cup arrows point up (8). DO NOT USE OIL IN DUST CUP.



1. Dust cup
2. Baffle
3. Clamp assembly
4. Thumb screw
5. Gasket
6. Element
7. Body
8. End view of dust cup

Figure 2. Dry Air Cleaner Details (Current Engines)

(f) Position dust cup on air cleaner body.

(2) Replace filter element as follows:

(a) Clean or replace filter element when red signal covers exposed section of window on air filter service indicator (Fig 9 and 10).

(b) Remove wing screw (Fig 2, Item 4) and gasket washer (5). Remove filter element (6).

(c) Inspect element gasket for damage.

(d) Install a new or clean element. Inspect cup gasket (if applicable) and replace if it is damaged.

CAUTION: Air cleaner is mounted in horizontal position. Be sure dust cup arrows point up (8). DO NOT USE OIL IN DUST CUP. Always refer to manufacturers instructions on air cleaner.

(e) Install dust cup on air cleaner body.

(f) Reset service indicator by pressing reset button on top of indicator. Refer to Paragraph C.

b. Optional Service Methods

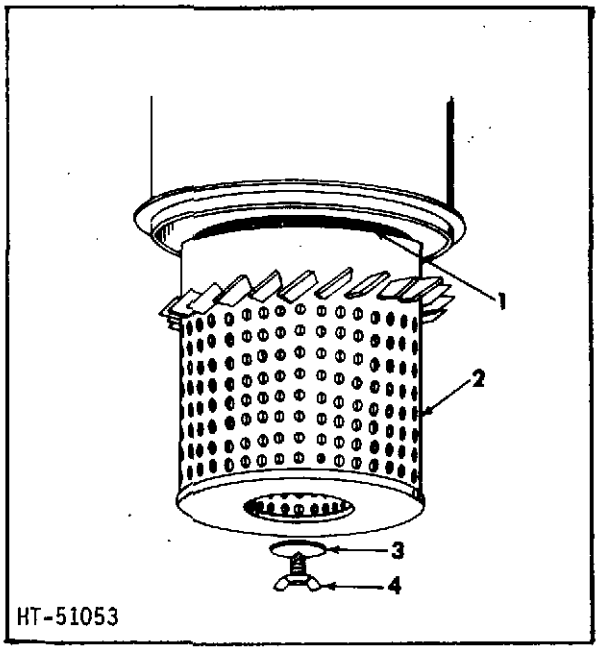
CAUTION: Pre-cleaning fins on filter element are not removable.

CAUTION: Air pressure at nozzle must not exceed 100 psi (689 kN/m^2). Maintain reasonable distance between nozzle and filter element.

The filter element can be either dry cleaned or washed as detailed below.

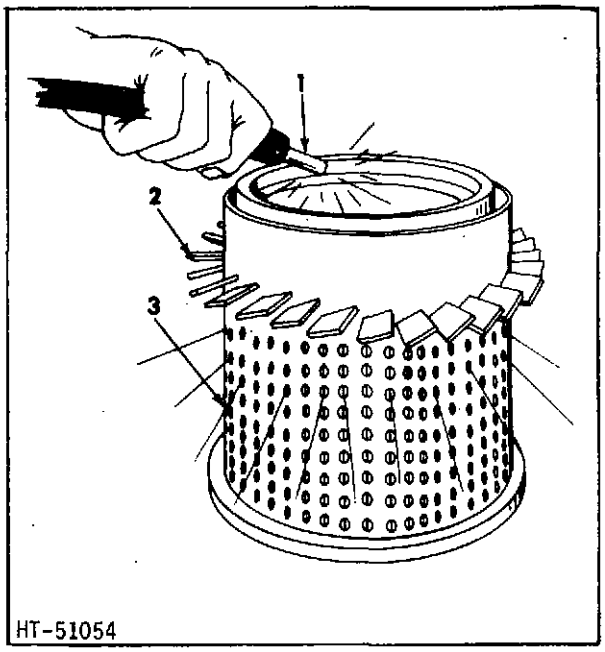
(1) To dry clean filter element, direct a jet of dry clean air up and down pleats on clean air side of element (Fig 4).

(2) If filter element is oily and soot laden, wash it in filter cleaner available from Allis-Chalmers dealers. For best results, mix 2 ounces (57 g) of cleaner with a small amount of cool tap water. Add warm



1. Element gasket
2. Filter element
3. Gasket washer
4. Wing screw

Figure 3. Removing Filter Element



1. Nozzle
2. Pre-cleaning fins
3. Filter element

Figure 4. Dry Cleaning Filter Element

(70° to 100° F) (294 - 311 K) water until total volume equals one gallon, (3.79 lts). The warmer (100° F) (311 K) the solution, the better it will clean. Soak element for 15 minutes, then remove it and rinse thoroughly with clean, running water (maximum pressure 40 psi) (276 kN/m^2). Air dry thoroughly before reusing. (A fan or air draft may be used for drying, but do not heat element to hasten drying.)

(3) Inspect for damage by placing a bright light inside element (Fig 5). Thin spots, pin holes or the slightest rupture will render the element unfit for further use.

NOTE: Replace filter element after 6 cleanings.

2. Oil Bath Air Cleaner (First Type)

Maintain air cleaner as follows (Fig 6):

a. Inspect air cleaner oil cup daily. Clean when 1/2" (12.70 mm) of dirt has collected in bottom of cup. Severe operating conditions may require several inspections daily.

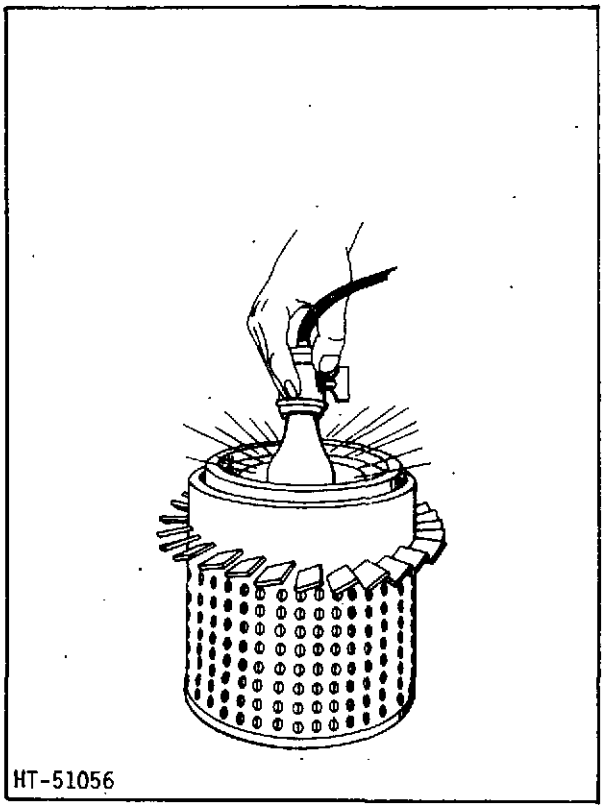
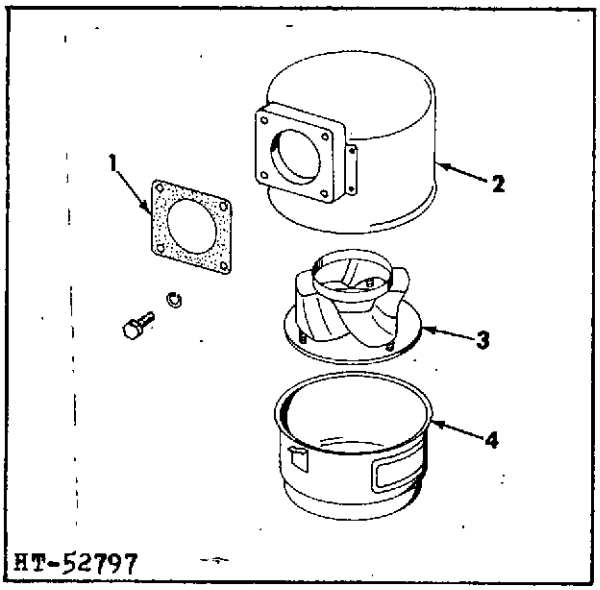


Figure 5. Inspecting Filter Element



1. Mounting gasket
2. Body
3. Chamber
4. Body

Figure 6. Oil Bath Air Cleaner (First Type)

b. With engine stopped, twist oil cup counterclockwise and remove cup from air cleaner body.

c. Remove chamber from cup and empty oil from cup. Remove sludge and wipe cup clean.

d. Install chamber and refill cup to oil level mark indicated at center of disc of chamber. Use SAE 20 oil in temperatures above freezing. In freezing temperatures use SAE 10 oil or lighter.

e. Install oil cup to air cleaner body. Twist clockwise slightly to engage.

3. Oil Bath Air Cleaner (Second Type)

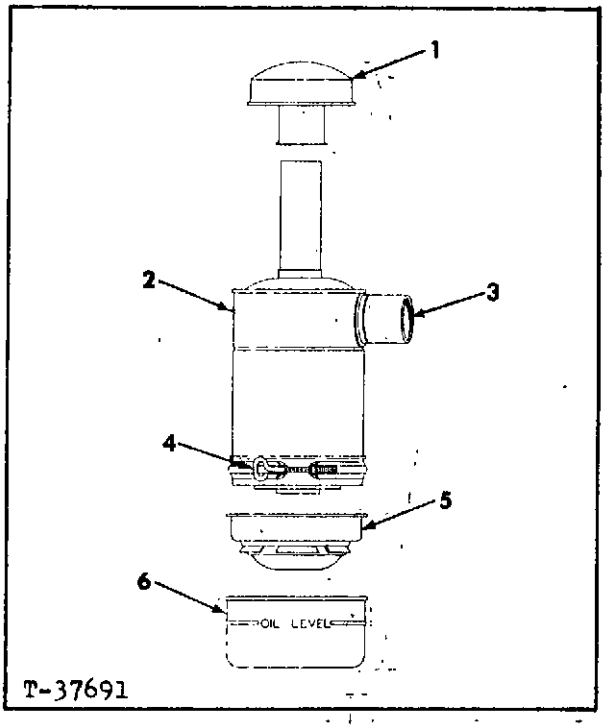
Maintain air cleaner as follows (Fig 7):

a. Inspect inner and outer oil cups daily. Clean when 1/2" (12.70 mm) of dirt has collected in bottom of either cup. Severe conditions may require several inspections daily.

(1) Loosen single clamp band and remove bottom portion of air cleaner.

(2) Empty oil from both cups and remove inner cup from outer cup. Remove sludge from cups and wipe clean.

(3) Reassemble inner cup in outer cup. Refill both cups to indicated oil level mark. Use SAE 10 oil in freezing weather, SAE 30 oil in warm



1. Air inlet cap
2. Air cleaner body
3. Air outlet
4. Clamp screw
5. Inner cup
6. Outer cup

Figure 7. Oil Bath Air Cleaner (Second Type)

weather, or SAE 40 oil in extremely hot weather.

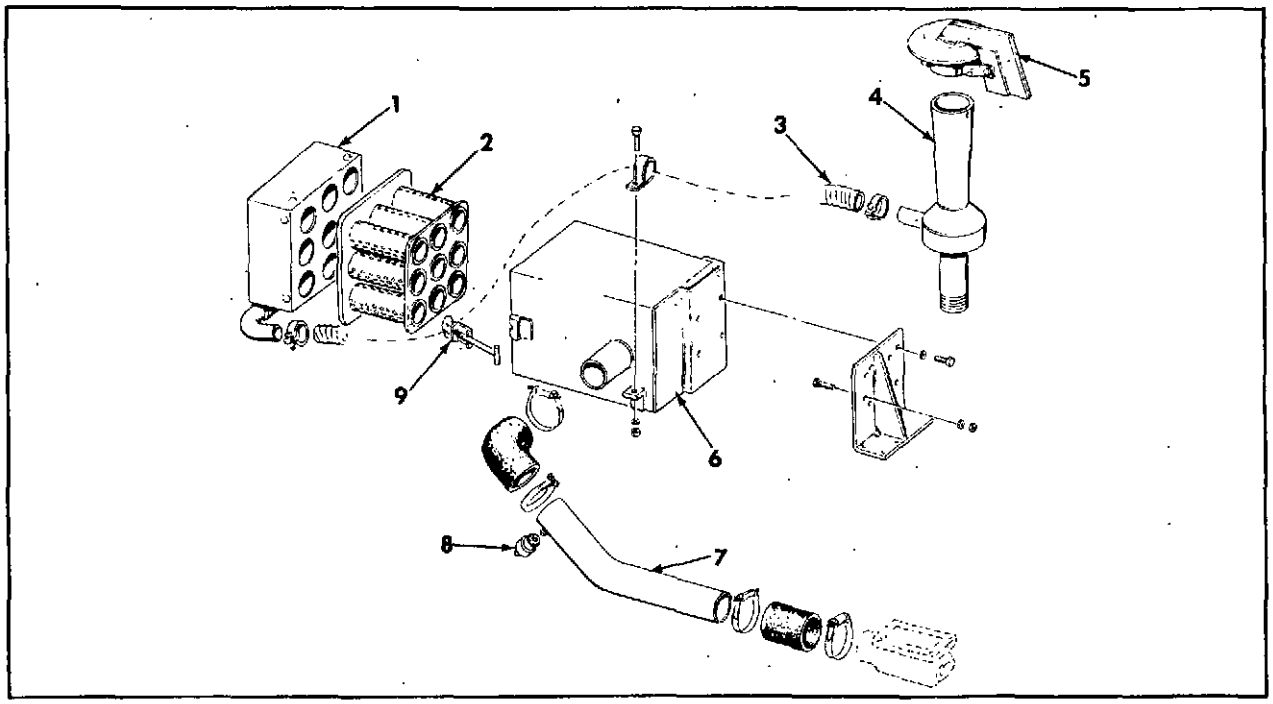
CAUTION: Do not overfill or underfill cups. Overfilling will result in loss of capacity. Underfilling will result in lack of efficiency.

(4) Inspect center tube, air inlet cap, and lower portion of body assembly each time oil cups are serviced. (Refer to Paragraph b, Body Assembly Maintenance below.)

(5) Install oil cups to air cleaner body and clamp securely.

b. Body Assembly Maintenance

The lower portion of the body assembly should be inspected each time the air cleaner is maintained. Remove and clean body assembly if there is any sign of buildup or plugging. At least once a year, remove body assembly, cover intake manifold opening while air cleaner is being serviced, and perform following steps.



1. Precleaner
2. Element
3. Precleaner to aspirator hose
4. Aspirator
5. Rain cap
6. Housing
7. Piping to intake manifold
8. Servicing indicator
9. Fastener

Figure 8. Farr Type Air Cleaner - Extra Heavy Duty

(1) Remove oil cups.

(2) Check and clean center tube.

(3) Pump solvent through air outlet with sufficient force and volume to produce a hard, even stream out bottom of body assembly. Reverse flush until all foreign material is removed.

4. FARR Extra Heavy Duty Dry-Type Cleaner

a. Loosen clamp securing flexible hose to precleaner elbow (Fig 8).

b. Loosen fasteners on air cleaner housing. Remove precleaner.

NOTE: Dust particles are removed from the precleaner through the action of the aspirator and therefore, the precleaner requires no service.

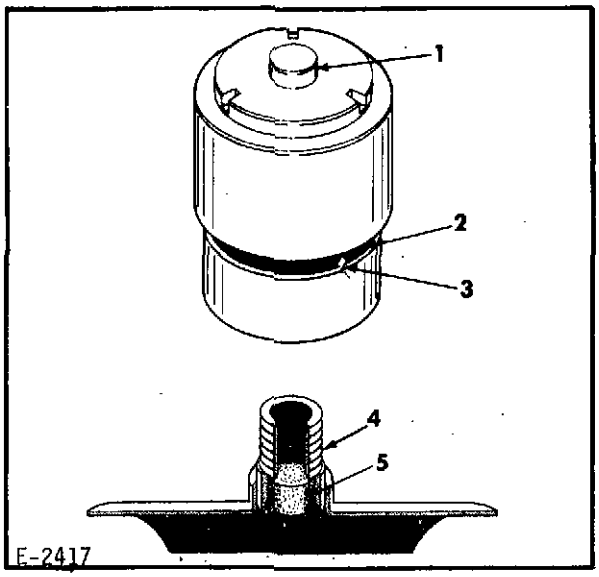
c. Insert fingers into element openings and loosen all four corners of the element one at a time by pulling straight out at each corner. After seal has been broken, remove element by pulling it straight out and slighly up so it clears the sealing frame. Discard dirty element.

NOTE: Do not clean or reuse dirty element. Inspect dirty element for soot or oil If there is soot inside the tubes, check for leaks in the engine exhaust system or exhaust from other equipment. If the element appears to have an oily film, check for fumes escaping from the breather tube. Correct any of these conditions, if necessary, before a new element is installed.

d. Inspect inside of housing and remove all foreign material.

CAUTION: Inspect new element for shipping damage before installation.

e. Install new element into housing. Avoid hitting the element tubes against the sealing flange of the housing. Firmly press all edges and corners of the element against the sealing flange with your fingers to effect a positive air seal.



1. Reset button
2. Red signal
3. Window
4. Connector with sintered filter
5. Sintered filter

Figure 9. Service Indicator-Current Type

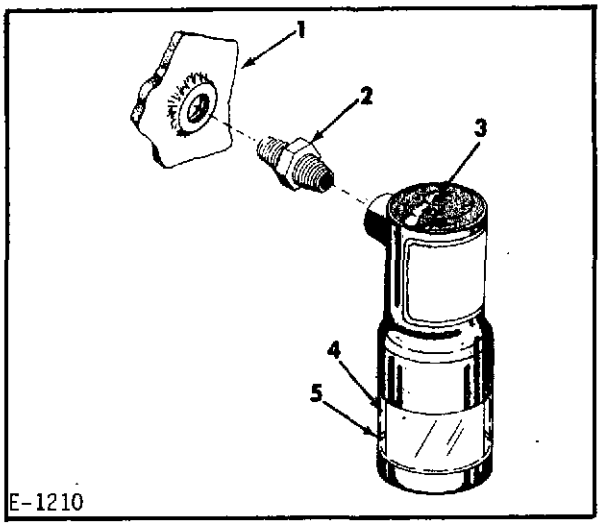
CAUTION: Do not pound in the center of the element to effect a seal.

f. Wipe off face of precleaner and position it on the housing. Secure precleaner with fasteners attached to housing and tighten fasteners to 72 lb in (8 Nm) torque. If a torque wrench is not available, tighten each fastener finger tighten, then turn each an additional one and one-half turns with a suitable wrench. Tighten fasteners in diagonal sequence, not direct sequence, to assure a uniform seating procedure.

NOTE: If, at a later date, inspection of the fasteners indicates that they are at less than 72 lb in (8 Nm) torque, this is due to a slight set in the plastic face of the element and does not impair the seal between the element and the housing. Retightening of the fasteners is not recommended, unless that are loose, as this may break the seal which has been formed.

g. Inspect flexible hose and clamps; replace if necessary. Install flexible hose over end of precleaner elbow and tighten clamp.

h. Make certain all connections, including aspirator, are air tight.



1. Cleaner housing
2. Connector with sintered filter
3. Reset button
4. Red signal
5. Window

Figure 10. Service Indicator - Early Type

i. Reset service indicator by pressing reset button on top of indicator (Fig 9 and 10).

CAUTION: The only allowable modification that can be made to the Farr aspirator is the addition of an exhaust pipe extension to the large end of the cone. A maximum of 4 feet (1219 mm) of straight exhaust pipe of at least the same diameter as the large end of the cone may be added. When an exhaust extension longer than 4 feet (1219 mm) is required, resizing of the aspirator is necessary. The size and shape of the cone of the aspirator must never be modified in service. If the aspirator system must be modified from its original configuration, or if extensions longer than 4 feet (1219 mm) are required, consult your Allis-Chalmers dealer to assist in its design and modification.

C. AIR FILTER SERVICE INDICATOR

Purpose of the service indicator (Fig 9 and 10) which is factory set, is to provide a visual signal when the air cleaner is in need of servicing. The operator can ascertain the degree of filter contamination by observing the indicator during periods of actual engine operation.

Dirt trapped by the air cleaner gradually reduces volume of air flow through the filter and increases the air cleaner-to-engine pressure drop. As pressure flow decreases, the

red signal of the filter indicator gradually moves in the window and when fully exposed is locked in position. At this time the air cleaner should be serviced or the element replaced or serviced. After servicing, reset signal by pressing reset button located on top of the service indicator.

Indicators are connected to the outlet side of the air cleaner by a connector that contains a sintered filter. If seals in the indicator rupture, the filter in the connector will prevent dust and other foreign material from entering the engine. If seals are damaged, the service indicator must be replaced.

TOPIC 18. SAFETY CONTROLS

A. GENERAL

The purpose of engine safety controls is to automatically stop the engine, thereby protecting it from damage, if oil pressure drops below safe operating pressure, or if coolant temperature rises above a safe, pre-set limit. Safety control components include an oil pressure safety switch-gauge, water temperature safety-switch gauge, magnetic switch, and a governor with electric shutoff.

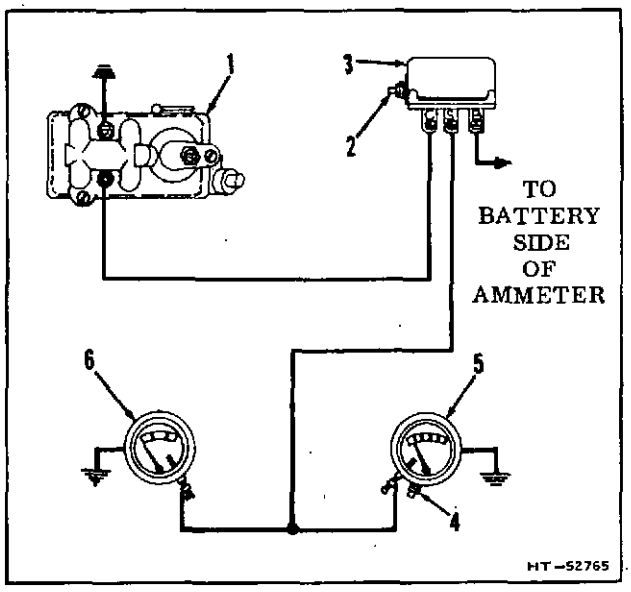
The safety switch-gauges are wired to the magnetic switch that energizes or de-energizes the electric fuel shutoff solenoid in the fuel injection pump, and opens the magnetic switch circuit after shutdown to prevent battery discharge. The fuel shutoff solenoid is of the "energized to run" type.

In general, no regularly scheduled maintenance is required other than an occasional inspection or test to make certain connections are secure and safety controls are operating properly.

B. OIL PRESSURE SWITCH-GAUGE

1. Operation

The oil pressure switch-gauge is a combination oil pressure gauge and safety switch.



1. Fuel injection pump governor with electric shutoff
2. Magnetic switch reset button
3. Magnetic switch
4. Oil pressure switch-gauge reset button
5. Oil pressure switch-gauge
6. Water temperature switch-gauge

Figure 1. Low Oil Pressure - High Water Temperature - Safety Controls - Schematic Wiring Diagram

The visible adjustable shutdown contact and pointer on the instrument dial indicates engine oil operating pressure. The gauge is connected by tubing directly to the engine oil gallery. If oil pressure drops during operation, the pointer moves to the low pressure range of the switch-gauge, contacts the adjustment screw, and stops the engine.

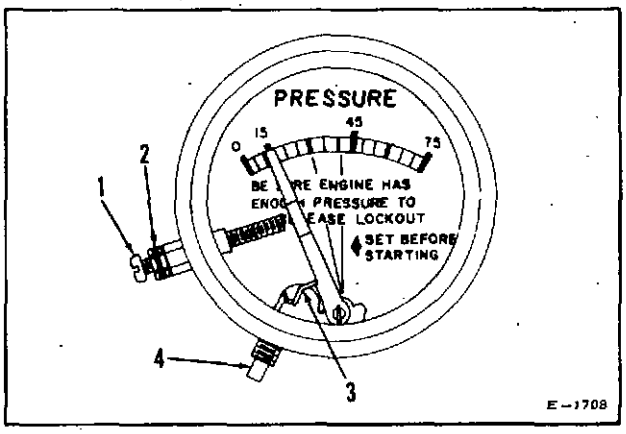
After engine has stopped for any reason, the pointer remains in contact with the adjustment screw, in which position it is impossible to start the engine. To restart engine, push reset button IN to move pointer away from contact screw. After startup, oil pressure causes the pointer to move to the operating range and the lockout arm automatically moves down to clear the pointer.

> CAUTION: After resetting gauge, make sure lockout arm moves down to clear pointer.

2. Adjustments

Gauge contacts are factory adjusted to shut down the engine when oil pressure falls below 10 psi. This setting can be changed to compensate for changes in operating pressures. To change settings, loosen locknuts on shutdown contact screw. With a small screwdriver, turn contact screw IN for higher pressure shutdown, or OUT for lower pressure shutdown.

> CAUTION: After adjustment is made, carefully tighten locknuts to avoid cracking insulator.



1. Contact screw
2. Locknuts
3. Lockout
4. Reset button

Figure 2. Oil Pressure Switch-Gauge

C. WATER TEMPERATURE SWITCH-GAUGE

1. Operation

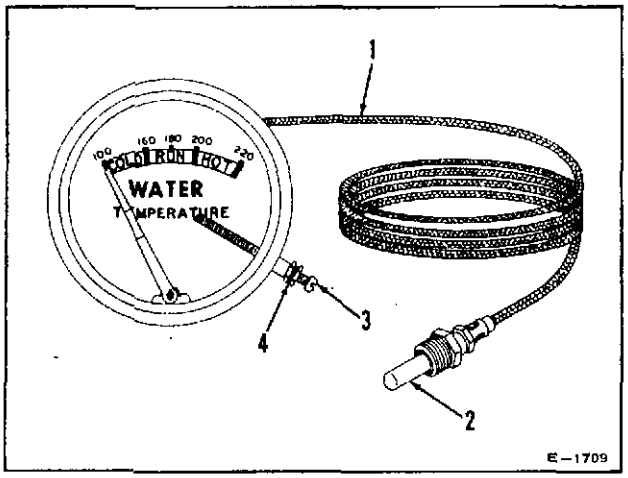
The water temperature switch-gauge is a combination coolant temperature gauge and safety switch. The visible adjustable shutdown contact and pointer on the instrument dial indicates temperature of engine coolant. The gauge is connected directly into the engine cooling system by a capillary tube and heat bulb. With engine running normally, gauge pointer should be in the RUN zone. If coolant temperature rises excessively, the pointer moves to the HOT zone and touches the adjustment screw contact, stopping the engine.

While pointer remains in contact with the adjusting screw, it is impossible to start the engine. It is necessary to allow coolant temperature to drop so pointer can move away from contact screws before engine will start.

2. Adjustment

The water temperature switch-gauge contacts have been adjusted to shut off the engine when coolant temperature reaches 205°F. This setting can be changed to compensate for altitude variations that affect the boiling point of water. To change setting, loosen locknuts on shutdown contact screw. With a small screwdriver, turn contact screw IN for lower temperature or OUT for higher temperature setting.

CAUTION: After adjustment is made, carefully tighten locknuts to avoid cracking insulator.



1. Capillary tube
2. Heat bulb
3. Contact screw
4. Locknuts

Figure 3. Water Temperature Switch-Gauge

D. STARTING AND STOPPING PROCEDURE WITH SAFETY CONTROLS

Following is procedure for starting and stopping engines equipped with safety controls.

1. Normal Starting

a. Make certain engine clutch is in disengaged (neutral) position.

b. Push IN lockout reset button on oil pressure safety switch-gauge to separate pointer from contact screw.

NOTE: After engine starts, make certain pointer lockout drops back to original position.

c. Push IN reset button on magnetic switch.

d. Place engine stop control in RUN position.

e. Move throttle control to FULL LOAD position.

f. Depress starter button.

NOTE: For cold weather starting, refer to Paragraph G, in Topic 5.

CAUTION: The starting motor must never be used continuously for more than 30 seconds at any one time without a pause of two minutes to wait until it cools.

g. As soon as engine starts, move throttle control to FAST (but not high) IDLE speed and let engine warm up.

2. Normal Stopping

a. Move throttle control knob slowly to LOW IDLE speed and disengage load from engine.

CAUTION: Run engine for at least 5 minutes at FAST (but not high) IDLE so it can cool gradually and uniformly.

b. Move stop control to STOP position.

c. As soon as oil pressure has dropped sufficiently, the pointer of the oil pressure safety switch-gauge contacts the adjustment screw and completes the circuit to the magnetic switch coil. Simultaneously, the magnetic switch armature is released, deenergizing the governor solenoid and opening the magnetic switch circuit to prevent battery discharge.

3. Automatic Safety Engine Shutdown

a. High Coolant Temperature

If shutdown is due to high coolant temperature, pointer of water temperature safety switch-gauge remains in contact with the adjustment screw, and it is impossible to start the engine until coolant temperature is lowered sufficiently for contacts to separate.

(1) Locate source of trouble causing overheating and make necessary repairs.

(2) Fill system with coolant and start engine.

b. Low Oil Pressure

(1) If shutdown is due to low oil pressure, locate source of trouble and make necessary repairs.

(2) Make certain oil pan is filled to proper level and start engine.

E. GAUGE CIRCUIT TROUBLE SHOOTING CHECKS

If fuel and electrical systems, and the oil and coolant levels have been checked, and engine operation is still not normal, check the following:

1. Check Wiring

Look for frayed wires and loose connections.

2. Check The Terminals On The Switch-Gauges

If terminals touch the panel, the magnetic switch will actuate and prevent the engine from running.

3. Check Switch-Gauges

a. If engine runs with switch-gauges disconnected, it indicates a short circuit in the switches. If engine runs but will not shutdown with switch-gauges "shorted" against the panel, it indicates an open circuit in the switch-gauge.

b. Check for gum, varnish, or dirt deposits in the damper unit on the back of the oil pressure switch-gauge.

c. Check for damage to the capillary tube or the heat bulb for coolant temperature switch-gauge.

d. Check switch-gauges for accuracy and replace if erratic performance is noted.

4. Check The Magnetic Switch

Refer to Paragraph F below.

F. MAGNETIC SWITCH

1. Purpose And Operation

A magnetic switch (circuit breaker) is wired into the circuit of the safety controls. Its purpose is to stop the engine by opening the circuit to the electric fuel solenoid coil in the fuel injection pump whenever the pointer of either the oil pressure or water temperature switch-gauge makes contact with a gauge adjustment screw. This action momentarily energizes the coil in the magnetic switch and pulls the armature latch down to release the armature, opening the circuit (de-energizing) to the electric fuel solenoid coil of the fuel injection pump, thereby stopping the engine and opening the circuit between the magnetic switch and the battery to prevent battery discharge.

The reset push button (Fig 1) on the magnetic switch must be pushed in to latch the armature in the running position and complete the circuit to the electric fuel solenoid of the fuel injection pump before the engine can be started.

NOTE: Prior to resetting the pushbutton on the magnetic switch, it is necessary to push in the reset button on the oil pressure safety switch-gauge.

If the contacts in the oil pressure safety switch-gauge are not separated, the coil in the magnetic switch is energized and will hold down the latch which locks the armature of the magnetic switch in the running position.

2. Magnetic Switch Service Checks

Whenever inspecting or testing the switch-gauges and circuits, it is also necessary to check the magnetic switch, using the following procedure:

a. Check for burned out fuse. Replace as necessary.

b. Check terminals and wiring. "Shorting" the terminal S, against the panel, will unlatch the contacts and stop the engine.

c. Test magnetic switch. Press the push-button all the way in. The ammeter should indicate discharge when button is depressed.

d. Check the S-terminal leads. If, with engine running and after normal oil pressure has separated the switch-gauge contacts, the magnetic switch will not stay latched, trouble may be isolated by removing switch-gauge leads from the S terminal, starting the engine, and touching one lead at a time to the S terminal until the faulty circuit is located.

e. Adjust switch, if necessary, as follows:

(1) Check and tighten all terminals.

(2) Check the contact latch and smooth the surface with a point file if it is rough or corroded.

(3) Make sure armature moves freely. Bend holder if necessary, to increase the spring tension.

(4) Check contacts and make certain they "make" and "break" properly with a distinct air gap when unlatched. If necessary, bend contact arm so it will "make" when contacts are latched and "break" when unlatched.

TOPIC 19. POWER TAKE-OFF CLUTCH

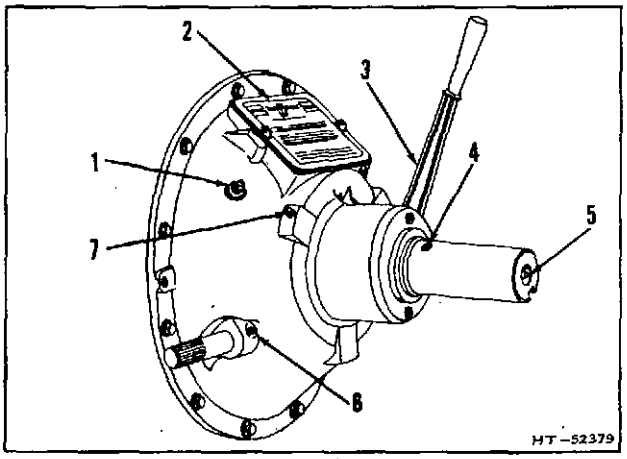
A. GENERAL

The power take-off unit contains a heavy duty, single plate, dry clutch, with an over-center engaging action. A shifting collar and bearing mechanism, carried on the power take-off shaft, is operated by a clutch operating lever to engage or disengage clutch. A threaded adjusting yoke provides a means to compensate for normal wear on clutch facings.

B. POWER TAKE-OFF CLUTCH MAINTENANCE (Fig 1)

NOTE: Refer to Topic 6, for lubrication recommendations. Apply a small amount of grease. DO NOT OVERGREASE.

1. Each day before operation, grease throwout collar through fitting on tapered part of housing.
2. Each 100 hours of operation:
   a. Check clutch adjustment.
   b. Grease pilot bearing through fitting in clutch shaft.
   c. Grease shaft bearings through fitting on housing hub.
   d. Grease operating lever shaft.



1. Throwout collar lube fitting
2. Clutch access cover
3. Clutch operating lever
4. Alternate pilot bearing lube fitting location
5. Pilot bearing lube fitting
6. Operating lever shaft lube fitting
7. Shaft bearing lube fitting

Figure 1. Power Take-Off Clutch

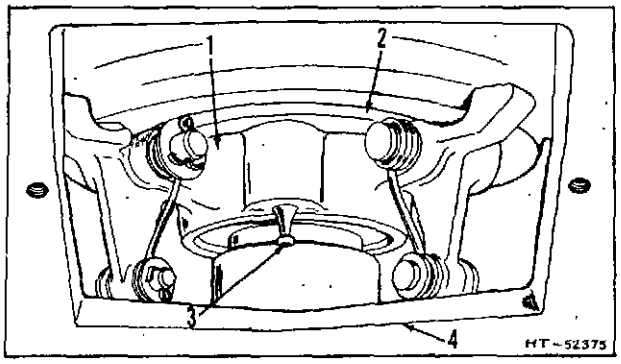
3. When the power take-off unit is used to drive through a flexible coupling, or with any other device that makes the lube fitting in end of shaft inaccessible, remove plug from cross-drilled hole in side of shaft and replace it with a lube fitting. Using plug from side of shaft, insert it into end of shaft to prevent loss of lubricant.

CAUTION: Always refer to instructions on clutch access cover.

C. POWER TAKE-OFF CLUTCH ADJUSTMENT (Fig 2)

After each 100 hour operating interval, check clutch adjustment. Clutch should engage with a definite over-center "snap" and should require an appreciable push on the operating lever for engagement. If snap is not evident, or if clutch slips under load, adjust it immediately as follows:

1. Remove clutch access cover and gasket from power take-off housing.
2. Disengage clutch. Turn clutch shaft until clutch adjusting lock pin can be reached through opening in power take-off housing.
3. Pull adjusting lock pin out and turn adjusting yoke clockwise to tighten or counterclockwise to loosen. An adjustment of two or three notches is generally sufficient.
4. Lock adjusting yoke in place by inserting adjusting lock pin into nearest notch in clutch back plate.
5. When properly adjusted, clutch should engage with a definite over-center snap.
6. Install clutch access gasket and cover.



1. Adjusting yoke
2. Clutch back plate
3. Clutch adjusting lock pin
4. Power take-off housing

Figure 2. Clutch Adjustment

ENGINE DIVISION WARRANTY

ALLIS-CHALMERS

ALLIS-CHALMERS CORPORATION (the Corporation) warrants new engines and diesel electric systems sold by it to be merchantable and free of defects in workmanship and material at the time of shipment from the Corporation's factory. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THOSE EXPRESSED HEREIN.

The Corporation will repair or replace, at its option and subject to the following provisions, any part of its new engines and diesel electric systems that fails to conform to this warranty, provided that such part is returned to the Corporation's factory or to the Corporation's dealer authorized to handle engines or diesel electric systems, transportation charges prepaid, within the following periods:

(1) 2 YEARS OR 100,000 MILES OR 3600 HOURS OF OPERATION, whichever first occurs, from the date of delivery to the first user of

(a) Engines used for on-highway vehicles and marine pleasure boat applications, and

(b) Stand-by diesel electric systems.

As to such products, the Corporation will supply all required parts free of charge. In addition, the Corporation will bear all reasonable warranty labor costs during the 2 year period, as follows:

100% in the case of parts subjected to no more than 50,000 miles or 1800 hours of operation, whichever first occurs, thereafter,

75% in the case of parts subjected to no more than 75,000 miles or 2700 hours of operation, whichever first occurs, and thereafter,

50% in the case of parts subjected to no more than 100,000 miles or 3600 hours of operation, whichever first occurs.

(2) 1 YEAR OR 3600 HOURS OF OPERATION, whichever first occurs, from the date of delivery to the first user of

(a) Engines used for off-highway, construction, industrial and marine commercial work-boat applications, and

(b) Continuous duty diesel electric systems.

As to such products, the Corporation will supply all required parts free of charge. In addition, the Corporation will bear all reasonable warranty labor costs during the 1 year period, as follows:

100% in the case of parts subjected to no more than 1800 hours of operation, thereafter,

75% in the case of parts subjected to no more than 2700 hours of operation, and thereafter,

50% in the case of parts subjected to no more than 3600 hours of operation.

(3) 3 YEARS OR 300,000 MILES OR 10,800 HOURS OF OPERATION, whichever first occurs, from the date of delivery to the first user of

(a) Crankshafts in new engines, and

(b) Engine blocks for new engines.

As to such parts, the Corporation will supply all required parts free of charge during the first 2 years or 200,000 miles or 7200 hours of operation, whichever first occurs, from the date of delivery to the first user, and thereafter the Corporation will bear one-half of the cost of such parts during the remainder of the warranty period. In addition, the Corporation will bear reasonable warranty labor costs, as follows:

100% during the first 2 years or 100,000 miles or 3600 hours of operation, whichever first occurs from date of delivery to the first user, in the case of crankshafts and blocks in engines used for on-highway vehicles and marine pleasure boat applications and stand-by diesel electric systems. Thereafter, the Corporation will not be obligated to bear warranty labor costs.

100% during the first year or 3600 hours of operation, whichever first occurs from date of delivery to the first user, in the case of crankshafts and blocks in engines used for off-highway, construction, industrial, marine commercial work-boat applications and continuous duty diesel electric systems. Thereafter, the Corporation will not be obligated to bear warranty labor costs.

The Corporation will not be obligated to bear labor costs for removing or installing engines at any time during the warranty periods set forth herein.

No warranty of any kind is made or shall be imposed upon the Corporation with respect to (1) new engines or diesel electric systems which have been subject to operation in excess of recommended capacities, misuse, negligence or accident, or have been altered or repaired in any manner not authorized by the Corporation, or (2) accessory items not manufactured by the Corporation as such items are separately warranted by their respective manufacturers.

The Corporation's liability, whether in contract or in tort arising out of warranties, or representations, instructions, or defects from any cause, shall be limited exclusively to repairing or replacing parts under the conditions as aforesaid.

ALL TECHNICAL PUBLICATIONS MUST BE ORDERED FROM AN ALLIS-CHALMERS DEALER

IMPORTANT

Always furnish the following information (available from the engine nameplate secured to side of the engine) when ordering manuals for a specific unit.

ENGINE MODEL — ENGINE CATALOG NUMBER

ENGINE SERIAL NUMBER — A-C ORDER NUMBER

MANUAL FOR CURRENT PRODUCTION UNITS

Model	Parts	Operating & Maintenance
Industrial Engines and Power Units		
G-262	TPL-512-B	TM-5016-A
D-175	TPL-489-C	TM-5018-A
D-262	TPL-454-E	TM-5018-A
2800 & 2900 MK II	TPL-4111-2	TM-5067-2
3500 MK II	TPL-4108-2	TM-5071-2
11000	TPL-4112-2	TM-5070-2
16000 H, 16000 MKII, 17000 MKII, 21000 MKII, 25000 MKII	TPL-4110-2	TM-5069-2
61000 & 65000	TPL-4109-A	TM-5064-A
Diesel Electric Systems		
NOTE: Diesel Electric Systems operating and maintenance (TM) manuals (-3) include a TM-5063, main alternator and voltage regulator manual.		
DES-90	TPL-4108-3	**TM-5071-3
DES-125	TPL-4112-3	**TM-5070-3
DES-175/200/220/250	TPL-4110-3	**TM-5069-3
DES-500/550	TPL-4109	**TM-5064-A
DES-Service Handbook		*
Marine Engines		
25000 MKII	TPL-4110-4	TM-5001-A
Diesel Generator Drive Units		
D-262	TPL-454-E	TM-5018-A
2800 & 2900 MKI	TPL-4111-1	TM-5072-1
3500 MKII	TPL-4108-1	TM-5071-1
11000	TPL-4112-1	TM-5070-1
16000 H, 16000 MKII, 17000 MKII, 21000 MKII, 25000 MKII	TPL-4110-1	TM-5069-1
61000 & 65000	TPL-4109	TM-5064
Service (Overhaul) Manuals		
G-262 (Gasoline and Natural Gas Engines)		TM-5003
D-175 & D-262		TM-5049
2800 & 2900		TM-5028
3500		TM-5066
11000		TM-5034
16000 H, 21000 H, & 25000		TM-5006
16000 MKII, 17000 MKII, 21000 MKII, & 25000 MKII		TM-*
Service Labor Guide		TM-5026
Fuel Systems		
Roosa Master Fuel Injection Pump	TPL-4059	TM-5023
Amer. Bosch APE Type Fuel Injection Pump	**	TM-5035
Robert Bosch Fuel Injection Pump	TPL-4097-B	TM-5058-A
Simms Fuel Injection Pump	TPL-4106	TM-5061
Fuel Injection Nozzle Assemblies	***	TM-5055-A
Special Application Manuals		
Turbocharger TO-4 Series (Airesearch)	***	TM-5057-A
Turbocharger T-1817, T-1818, T-1819, & T-1852		TM-5074
Engine Service Bulletins		
Historical Bulletins		*
Current Bulletins		*
Automotive Bulletins		*

*When ordering literature not assigned a number order by description. ***Not Available

**Includes: Operating & Maintenance of Voltage Regulator & Main Alternators

NOTE: When manuals are required for units not listed above, refer to Technical Publications Index, TM-5056.

The information contained herein is general in nature and is not intended for specific application purposes. Allis-Chalmers reserves the right to make changes in specifications shown herein, add improvements, or discontinue manufacture at any time without notice or obligation.