

**OPERATING AND  
MAINTENANCE  
MANUAL**

**MODEL  
11000 & 11000MKII**

**GENERATOR DRIVE  
ENGINES**



**ENGINE DIVISION  
HARVEY, ILLINOIS 60426, USA**

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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.

IT IS THE RESPONSIBILITY OF USERS TO PROVIDE AND INSTALL GUARDS OR SAFETY DEVICES WHICH MAY BE REQUIRED BY RECOGNIZED SAFETY STANDARDS OR BY THE OCCUPATIONAL SAFETY AND HEALTH ACT OF 1970 AND ITS SUBSEQUENT PROVISIONS.

**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.**

## FOREWORD

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

# THE METRIC SYSTEM OF MEASUREMENT

Today's rapid communication and transportation between the nations of the world has resulted in the use of more of each other's products and services. This has caused a trend among the nations to adapt a standardization of units for use in both scientific and technical fields.

The customary United States (English) units and some metric units are being replaced with those of a modernized metric system known as the International System of Units which is officially abbreviated SI in all languages.

The SI or modernized metric system consists of six basic units:

Meter for length  
Kilogram for mass  
Second for time  
Ampere for electric current  
Kelvin for temperature  
Candela for luminous intensity

Because Allis-Chalmers' products are used worldwide and the adaptation of the SI metric system by all nations is getting nearer, both English and metric system of units appear in this manual.

To assist those not completely familiar with the metric system, the following nomenclature and tables will be of assistance.

## A. GENERAL NOMENCLATURE USAGE

	METRIC	ENGLISH
Length	millimeter (mm)	inch (in)
Pressure	kilonewton/meter <sup>2</sup> (kN/m <sup>2</sup> )	pounds per square inch (PSI)
Force	newton (N)	pound (lb)
Mass	kilogram (kg)	pound (lb)
Time	second (s)	second (s)
Volume (liquid)	liter (l)	gallon (gal)
Temperature	kelvin (K)	degrees fahrenheit (° F)
Torque	newton-meter (Nm)	pound foot (lb-ft)
Power	kilowatt (kw)	horsepower (hp)
Frequency	hertz (Hz)	cycles per second (cps)

## B. CONVERSIONS FACTORS

TO CONVERT	TO OBTAIN	MULTIPLY BY
Cubic Feet (cu ft)	Cubic Centimeters (cu cm)	28320
Cubic Inches (cu in)	Cubic Centimeters (cu cm)	16.39
Degree Centigrade (° C)	Kelvin (K)	° C + 273.15
Degree Fahrenheit (° F)	Kelvin (K)	(° F - 32) 5/9 + 273.15
Feet (ft)	Meter (m)	0.3048
Gallon (gal)	Liter (l)	3.785
Inch (in)	Millimeter (mm)	25.40
Inches of Mercury (in of Hg)	Newton per square meter (N/m <sup>2</sup> )	3376.85
Inches of Water (in of H <sub>2</sub> O)	Newton per square meter (N/m <sup>2</sup> )	248.84
Mile (mi)	Meter (m)	1609.344
Miles per Hour (mi/hr)	Kilometer per hour (km/hr)	1.6093
Ounces (oz)	Grams (g)	28.349
Ounces (oz)	Liter (l)	0.02957
Pound (lb)	Kilogram (kg)	0.4536
Pounds per square inch (PSI)	Kilonewton per square meter (kN/m <sup>2</sup> )	6.894757
Pounds per inch (lb in) (torque)	Newtons per meter (Nm)	0.1129848
Pounds per foot (lb ft. (torque)	Newtons per meter (Nm)	1.355818
Quart (qt)	Liter (l)	0.9463
Yard (yd)	Meter (m)	0.9144

**C. QUICK REFERENCES CONVERSIONS (APPROXIMATE VALUES)**

- One (1) Fahrenheit Degree: approximately equals .55 Centigrade Degree
- One (1) gallon: approximately equals 3 - 3/4 liters
- One (1) PSI: approximately equals 7 kN/m<sup>2</sup>
- One (1) in-lb of torque: approximately equals 0.11 Nm
- One (1) ft-lb of torque: approximately equals 1.35 Nm

**D. DECIMAL AND METRIC EQUIVALENTS OF FRACTIONS OF AN INCH**

INCHES		MILLI-METERS	INCHES		MILLI-METERS
FRACTIONS	DECIMALS		FRACTIONS	DECIMALS	
1/64	.015625	.40	33/64	.515625	13.10
1/32	.03125	.79	17/32	.53125	13.49
3/64	.046875	1.19	35/64	.546875	13.89
1/16	.0625	1.59	9/16	.5625	14.29
5/64	.078125	1.98	37/64	.578125	14.68
3/32	.09375	2.38	19/32	.59375	15.08
7/64	.109375	2.78	39/64	.609375	15.48
1/8	.125	3.18	5/8	.625	15.88
9/64	.140625	3.57	41/64	.640625	16.27
5/32	.15625	3.97	21/32	.65625	16.67
11/64	.171875	4.37	43/64	.671875	17.07
3/16	.1875	4.76	11/16	.6875	17.46
13/64	.203125	5.16	45/64	.703125	17.86
7/32	.21875	5.56	23/32	.71875	18.26
15/64	.234375	5.95	47/64	.734375	18.65
1/4	.250	6.35	3/4	.750	19.05
17/64	.265625	6.75	49/64	.765625	19.45
9/32	.28125	7.14	25/32	.78125	19.84
19/64	.296875	7.54	51/64	.796875	20.24
5/16	.3125	7.94	13/16	.8125	20.64
21/64	.328125	8.33	53/64	.828125	21.03
11/32	.34375	8.73	27/32	.84375	21.43
23/64	.359375	9.13	55/64	.859375	21.83
3/8	.375	9.53	7/8	.875	22.23
25/64	.390625	9.92	57/64	.890625	22.62
13/32	.40625	10.32	29/32	.90625	23.02
27/64	.421875	10.72	59/64	.921875	23.42
7/16	.4375	11.11	15/16	.9375	23.81
29/64	.453125	11.51	61/64	.953125	24.21
15/32	.46875	11.91	31/32	.96875	24.61
31/64	.484375	12.30	63/64	.984375	25.00
1/2	.500	12.70	1	1.000	25.40

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# Engine Division Warranty

ALLIS-CHALMERS CORPORATION (the Company) 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 Company's factory. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THOSE EXPRESSED HEREIN.

The Company 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 Company's factory or to the Company'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 Company will supply all required parts free of charge. In addition, the Company 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 Company will supply all required parts free of charge. In addition, the Company 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 Company 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 company will bear one-half of the cost of such parts, during the remainder of the warranty period. In addition, the Company 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.

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.

The Company 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 Company 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 Company, or (2) accessory items not manufactured by the Company as such items are separately warranted by their respective manufacturers.

THE COMPANY'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. IN NO EVENT SHALL THE COMPANY BE LIABLE FOR INCIDENTAL, INDIRECT, SPECIAL OR CONSEQUENTIAL DAMAGES.

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## TOPIC 1. DESCRIPTION

### A. GENERAL

The models 11000 and 11000MKII are turbocharged, 4-cycle, water cooled, overhead valve, compression ignition type diesel engines with 6 vertical, in-line cylinders. The model 11000MKII has oil cooled pistons.

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

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

Engines shipped from Allis-Chalmers are equipped with a combination name plate and optional equipment plate. The engine serial number and engine catalog number are stamped in the name plate section, the remainder of the plate is used to list the catalog number of the various optional equipment groups as specified on the original factory order, together with the specific factory shipping order number.

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. PRINCIPLES OF OPERATION

The fuel system consists of 2 throw-away

type fuel filters, differential needle type fuel injection nozzle holder assemblies, and fuel injection pump with 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.

Proper lubrication is assured by a gear type lubrication oil pressure pump. Oil is pumped under 30-55 psi (207-379 kN/m<sup>2</sup>) 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 turbocharger is used to obtain greater power output over that of the naturally aspirated model engine by increasing the supply of air to the cylinders. The turbocharger is essentially a rugged yet highly efficient exhaust driven blower.

The turbocharger responds to engine load demands by reacting to the flow of expanding exhaust gases and supplying a correlated volume of air to engine cylinders. During a heavy load/lugging operation, the increase flow of exhaust gases turns the turbine wheel faster, causing the compressor impeller to turn faster to supply more air to the intake manifold. Conversely, when engine load is light and the radial flow of gases within the turbine decreases, the turbocharger compressor reduces air supply to the intake manifold.

### C. ENGINE STROKE SEQUENCE

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.

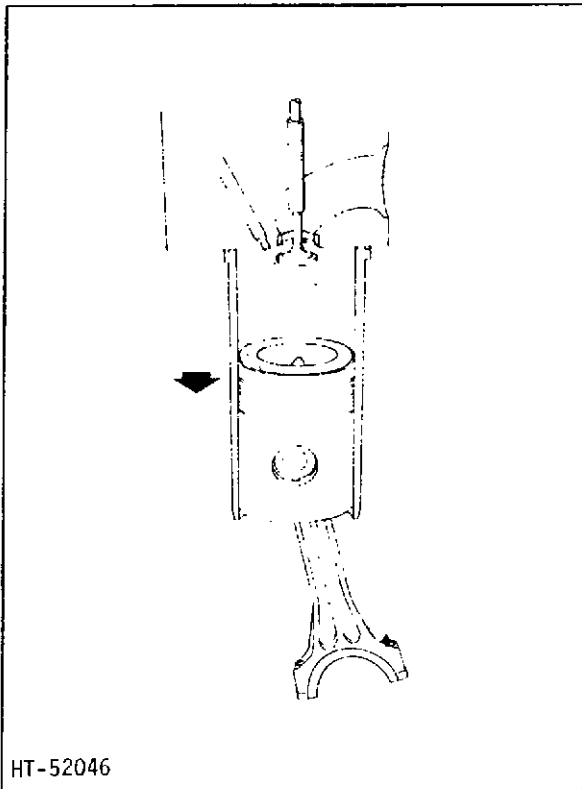
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**ALLIS-CHALMERS**  
HARVEY, ILLINOIS • MADE IN U.S.A.

SERIAL NO.	CATALOG NO.
MODEL	

E-2398

Combination Engine Name Plate and  
Optional Equipment Plate

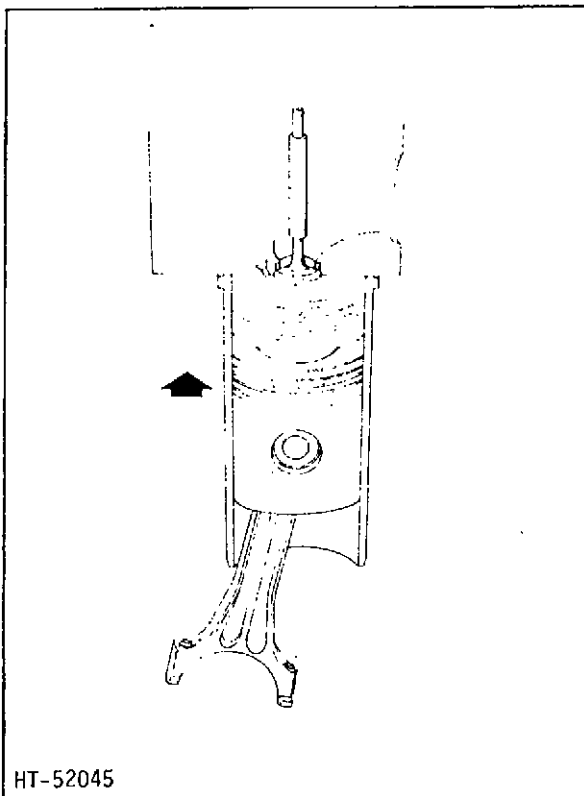


HT-52046

Figure 1. Intake Stroke

## 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 and is given a swirling motion by directional ports in the cylinder head.



HT-52045

Figure 2. Compression Stroke

## 2. Compression Stroke

Shortly after the piston starts to move upward on the second, or compression stroke the intake valve closes. The swirling motion of air admitted on the intake stroke is intensified during the compression stroke and its temperature is raised to approximately 1000°F (811 K). The contoured piston top compresses and simultaneously forces the air toward its center, giving it an additional rolling motion and greater velocity. At the proper instant during the compression stroke, a metered quantity of fuel is injected into the combustion chamber in a four-jet pattern under extremely high pressure. When the finely atomized fuel has mixed thoroughly with the turbulent air it is ignited by heat of the compressed air and immediately starts to burn.

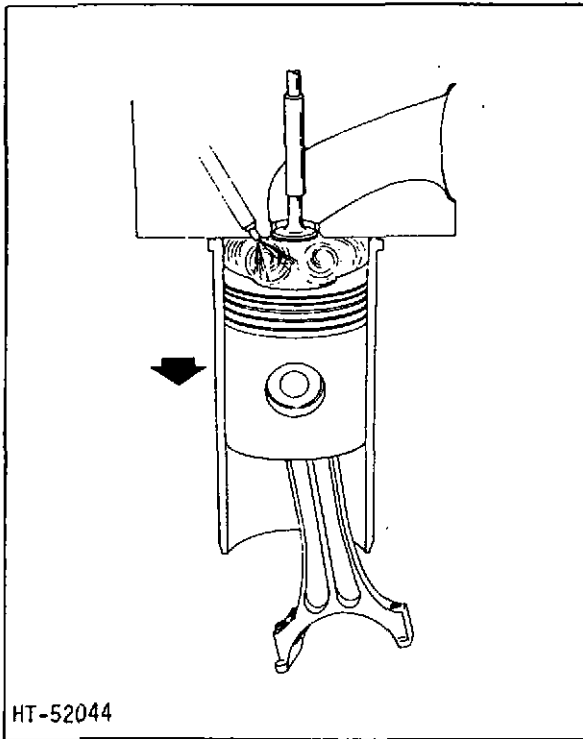


Figure 3. Power Stroke

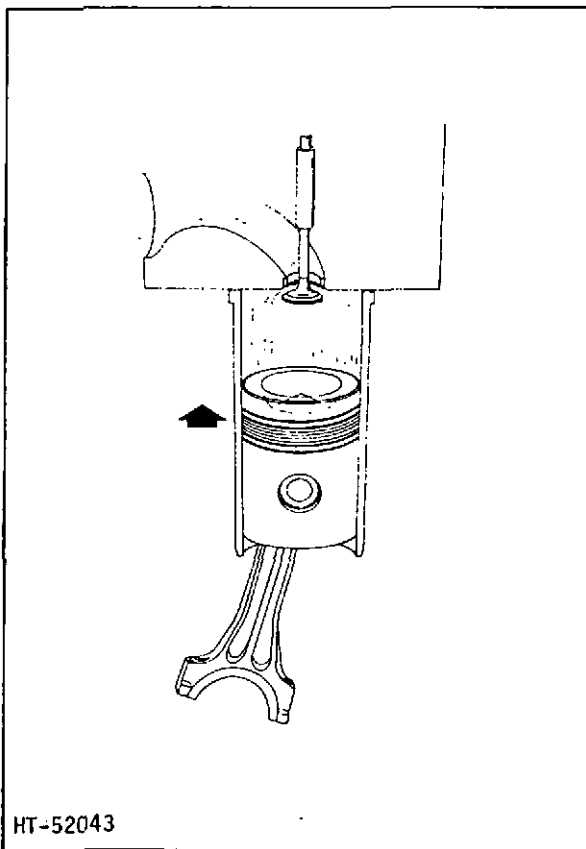


Figure 4. Exhaust Stroke

### 3. Power Stroke

Because the fuel and air is thoroughly mixed in the cylinder, it burns smoothly and evenly. As the burning gases expand they force the piston downward on its third, or power stroke. Near bottom of the power stroke the exhaust valve starts to open.

### 4. Exhaust Stroke

As the piston moves upward on the fourth, or exhaust stroke, the exhaust valve 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 of obligation.

	ENGLISH	METRIC
<b>A. ENGINE (BASIC)</b>		
Model 11000.....	Turbocharged	Turbocharged
Model 11000MK11.....	Turbocharged and piston cooled	Turbocharged and piston cooled
Type.....	4 cycle	4 cycle
Number of Cylinders.....	6	6
Firing Order.....	1-5-3-6-2-4	1-5-3-6-2-4
Bore.....	4.44 in	112.78 mm
Stroke.....	5.56 in	141.22 mm
Displacement.....	516 cu in	8457 cm <sup>3</sup>
Crankshaft Rotation (viewed from fan end)	Clockwise	Clockwise
Number of Main Bearings.....	7	7
Compression Ratio (Nominal).....	15.6:1	15.6:1
Compression Pressure at Sea Level 600 rpm, Hot.....	445 psi ± 15 psi	3068 kN/m <sup>2</sup> ± 103 kN/m <sup>2</sup>
Pressure Differential Between Cylinders.....	30 psi max	207 kN/m <sup>2</sup>
Maximum Permissible Exhaust Restriction.....	2 in HG	6754 N/m <sup>2</sup>
<b>B. COOLING SYSTEM</b>		
Water Pump, Centrifugal Type.....	Belt Driven	Belt Driven
Stabilized Coolant Temperature (minimum).....	180°F	355 K
Thermostat (fully open).....	200°F	366 K
Radiator, Pressurized.....	7 psi	48 kN/m <sup>2</sup>
Nominal Coolant Capacities:		
1. Basic Engine Only.....	22 qt	20.82 lts
*NOTE: To obtain total capacity of cooling system for particular engine model, add basic engine capacity to capacity of the applicable optional cooling system equipment listed below.		
2. Optional Cooling System Equipment		
Radiator and Hoses for:		
Engine w/Dry Manifold.....	22-1/4 qt	20.06 lts
Engine w/Water Cooled Manifold..	21-1/2 qt	20.35 lts
Water Cooled Exhaust Manifold and Water Outlet Piping.....	6 qt	5.68 lts
Combination Heat Exchanger.....	2 qt	1.89 lts
<b>C. LUBRICATION SYSTEM</b>		
Circulating Pressure Type System.....	Full Flow	Full Flow
Oil Pump.....	Gear Type	Gear Type
Oil Pressure Range, Hot, Full Throttle.....	30 to 55 psi	207 to 379 kN/m <sup>2</sup>
Oil Filter Type.....	Full Flow	Full Flow
Pressure Regulation Governed by.....	Regulation Valve	Regulation Valve
Oil Capacities Nominal:		
Prior to Serial Number 11-24163:		
Filter and Oil Change.....	21 qt	19.87 lts
Effective with Serial Number 11-24163		
Filter and Oil Change.....	31 qts	29.34 lts

	ENGLISH	METRIC
<b>D. FUEL INJECTION SYSTEM</b>		
Fuel Injection Pump .....	Roosa Master	Roosa Master
Pump Speed Ratio to Crankshaft.....	0.5:1	0.5:1
Fuel Injection Nozzle .....	Allis-Chalmers	Allis-Chalmers
Type, Spring Loaded .....	4 Hole Orifice	4 Hole Orifice
Nozzle Opening Pressure Prior to S/N 11-27951.	2800-2850	19306-19651 KN/m <sup>2</sup>
Nozzle Opening Pressure Eff. with S/N 11-27951	3800/3850	26200-26545 kN/m <sup>2</sup>
Orifice Size.....	0.0126 in	.320 mm
Fuel Injection Pump Timing to Engine (Static).		
1500 rpm and 1800 rpm.....		
Pump with automatic speed advance.....	24° BTDC	24° BTDC
Pumps without automatic speed advance.....	36° BTDC	36° BTDC
Pumps with hydraulic governors.....	36° BTDC	36° BTDC
Governor		
Standard .....	Mechanical	Mechanical
Optional .....	Hydraulic	Hydraulic
Regulation :		
Standard .....	3 1/2 to 5%	3 1/2 to 5%
Optional .....	1 to 5%	1 to 5%
Speed Settings:		
Full Load, 50 Hertz .....	1500 rpm	1500 rpm
Full Load, 60 Hertz .....	1800 rpm	1800 rpm
Minimum Speed .....	1400 rpm	1400 rpm
Hand Primer Pump (Roosa Master) .....		
Maximum Lift .....	3 ft	914.40mm
<b>E. VALVE DATA</b>		
1. Valve Lash Adjustment:		
Intake Valve Clearance - Hot .....	0.018 in	0.46 mm
Exhaust Valve Clearance - Hot .....	0.018 in	0.46 mm
2. Valve Timing:		
Camshaft (4337723)		
Effective Serial 117427 and Up		
*(Tappets set at .024")		
Exhaust Valve Opens .....	53° BBDC	53° BBDC
Exhaust Valve Closes .....	23° ATDC	23° ATDC
Intake Valve Opens .....	21° BTDC	21° BTDC
Intake Valve Closes .....	55° ABDC	55° ABDC
Intake and Exhaust Duration .....	256°	256°
Intake and Exhaust Overlap .....	44°	44°
<p>*CAUTION: Tappets must be set with 0.024" in. (0.61 mm) clearance to obtain proper valve opening and closing in degrees tabulated for the camshaft. Do not confuse this setting with valve lash adjustment data.</p>		
<b>F. ENGINE ELECTRICAL SYSTEM</b>		
Starter .....	24 Volt	24 Volt
Battery Charging Generators:		
Generator - Positive Ground .....	24 Volt, 10 Amp	24 Volt, 10 Amp
Generator - Negative Ground .....	24 Volt, 10 Amp	24 Volt, 10 Amp
Generator - Positive Ground .....	24 Volt, 18 Amp	24 Volt, 18 Amp
Battery Charging Alternator		
Alternator - Negative Ground .....	24 Volt, 30 Amp	24 Volt, 30 Amp

## TOPIC 3. PREPARATION OF ENGINE FOR OPERATION

### A. 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 batteries.
3. When filling fuel tank, always provide metal-to-metal contact between the container and fuel tank. This will prevent a spark from being generated as fuel flows over the metallic surfaces.
4. When filling fuel tank, do not smoke or use an open flame in the vicinity.
5. Always use a lifting device of more than adequate capacity when lifting or moving the engine.

### B. PROCEDURE

Use extreme care when unpacking the unit to avoid damage to 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.

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

1. Remove all tape and shipping caps used to seal the engine openings.
2. Check the radiator for damage and for proper cooling capacity. Remove any foreign material that has collected on the radiator which would obstruct the flow of air past the fins and through the air passages.
3. If the cooling system drain plugs have been removed and wired to the engine, install them properly. Fill the system with coolant (refer to Topic 11).

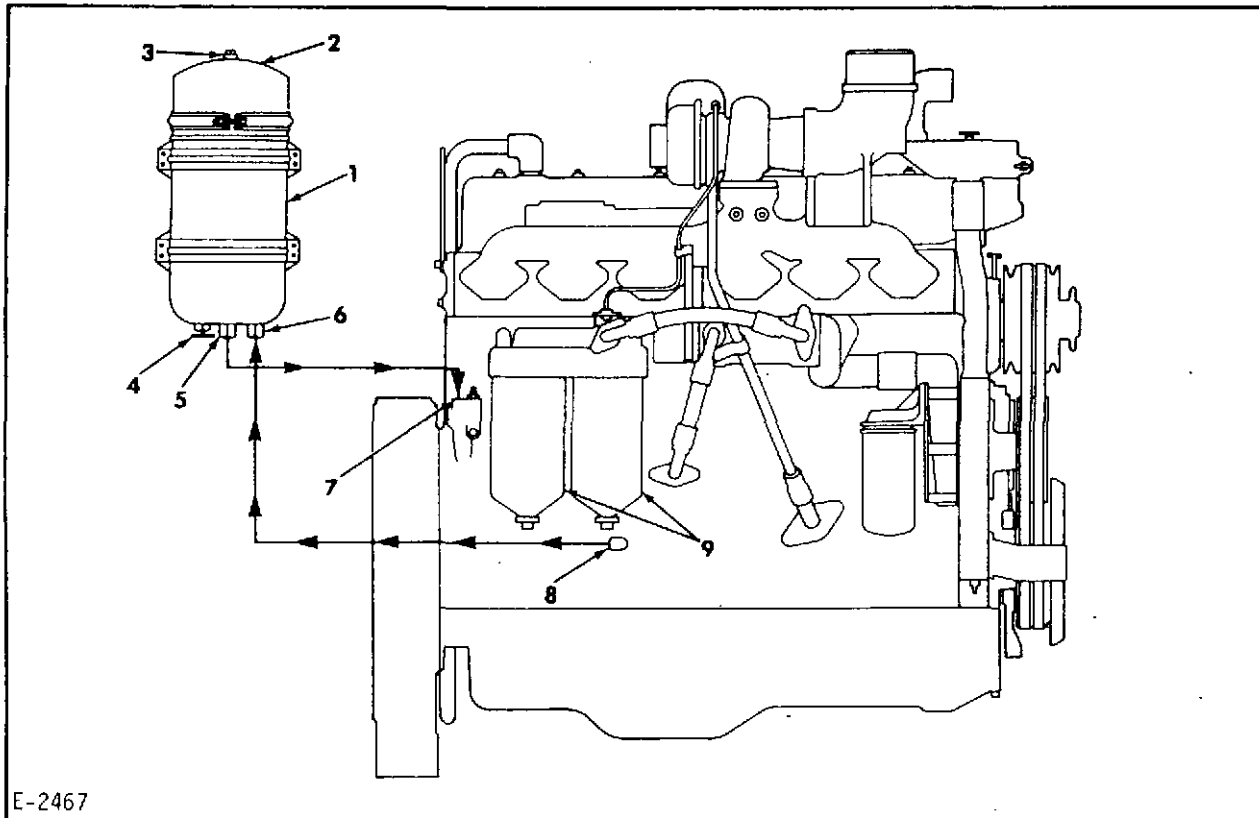
4. Open the inlet and outlet valves to the coolant system conditioner (refer to Topic 11).
5. Make certain all air cleaner connections are tight and the filter element is installed.
6. If an oil bath type air cleaner is applied to the engine, fill the oil cup with grade of oil and to level specified by the instruction plate on the air cleaner.
7. Engine are shipped from the factory without lubricating oil (dry) or with lubricating oil (wet) depending upon whether or not oil is specified on the engine purchase order.

If engine is ordered without oil, add oil to the oil pan following the procedure in TOPIC 13, LUBRICATION SYSTEM using a quality oil of the classification specified in TOPIC 6, LUBRICATION RECOMMENDATION.

If engine is ordered with oil in the oil pan, check oil level with the side of the dipstick stamped ADD, FULL, and STOPPED before initial start of engine.

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

8. Check the engine drive belts for correct adjustment. The deflection should be .25 in (6.35 mm) to .50 in (12.70 mm) at midpoint on the belts. Refer to Topic 11.
9. Connect the storage batteries to the electrical system. Refer to Topic 2, Paragraph F. for ground polarity.
10. Fill the fuel tank with the recommended fuel. Refer to Topic 7.
11. If fuel injection pump is equipped with an optional hydraulic governor (Roosa Master), the fuel leakage from the end of the accumulator must be piped to the fuel tank via a separate return line. (Refer to Fig 1 in Topic 12.)



- |                              |   |
|------------------------------|---|
| 1. Bypass filter             | 6. Inlet - 1/2" pipe thread             |
| 2. Cover                     | 7. Engine oil inlet - 3/8" pipe thread  |
| 3. Vent                      | 8. Engine oil outlet - 3/8" pipe thread |
| 4. Drain cock .              | 9. Full flow oil filters                |
| 5. Outlet - 1/2" pipe thread |   |

Figure 1. Optional Bypass Type Oil Filter Piping Connections

**CAUTION:** Do not plug the stop screw end of the accumulator.

This test is made with the engine running under full load, full speed conditions. Refer to Topic 16 for the procedure to make this test.

12. If fuel injection pump has both the electric solenoid and the manual shutoff, wire the manual shutoff lever in the RUN position when it is not required.
13. Bar the engine over by hand to make certain it turns freely.

14. 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.

**CAUTION:** Any muffler installations or exhaust pipe extensions from the manifold or turbocharger outlet must be adequately supported and flexibly connected to eliminate any possibility of strain on either the manifold or the turbocharger outlet. Total restriction for the exhaust system must not exceed the specified number of inches of mercury listed in Topic 2, Paragraph A.

C. OPTIONAL BYPASS TYPE OIL FILTER INSTALLATION

1. Installation Instructions

Mount the filter on a rigidly constructed support and position it in a location as near as possible to the oil supply and drain openings on the right side of the engine (Fig 1).

Select oil supply and drain hose size

based on the length required:

No. 6 hose for lengths under 10 ft  
(3048.0 mm)

No. 8 hose for lengths over 10 ft  
(3048.0 mm)

Adequately support hoses and give consideration to routing hoses away from exhaust manifolds and moving parts.

Refer to Paragraph D of Topic 13 for details of how to service filter.

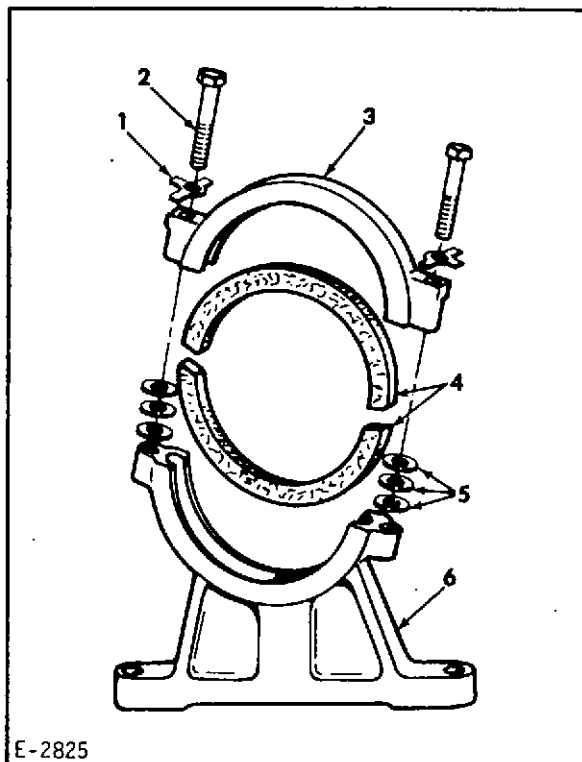
#### D. FRONT SUPPORT BRACKET

To provide 3 point mounting for the engine, a front support bracket (Fig 2) is secured to a trunnion on the timing gear cover. The other 2 mounting points are the pads with threaded holes on each side of the flywheel housing.

If the front support bracket is removed from the engine to facilitate the installation of the engine, note the number of shimming washers removed from each side. When assembling the cap to the mounting bracket, install the same amount of shimming washers to each side as where removed. Tighten the flanged screw to 95-105 lb-ft (129-143 Nm) torque.

The liners are made from a nylon like material and it is essential that the front support bracket is a tight fit on the trunnion to avoid "beating out" the liners. If the liners are replaced after a period of operation, they must be installed as follows:

1. Clean grooves of cap and mounting bracket and install liners.
2. Install flanged screws and tighten by alternating from one screw to the other until a torque of 50 lb-ft (68 Nm) is obtained.
3. Measure the gap between the cap and mounting bracket and determine the amount of shimming washers required for each side. If measurement is between shim thickness add full shim.



- |                   |            |
|-------------------|------------|
| 1. Locking washer | 4. Liners  |
| 2. Capscrew       | 5. Shims   |
| 3. Cap            | 6. Bracket |

Figure 2. Engine Front Support Bracket

4. Remove capscrews and install shimming washer to equal the gap.

NOTE: Shimming washers are .031" (.792 mm) thick and must be evenly distributed on both sides of bracket.

5. Reinstall capscrews and torque to 95-105 lb-ft (129-143 Nm).

## TOPIC 4. OPERATING CONTROLS AND INSTRUMENTS

### A. GENERAL

Various controls and instruments are supplied by the generator set manufacture to assist the operator to monitor and operate the equip-

ment and the engine. The operator must become familiar with the function of the controls and instruments provided for operating the unit. Refer to the generator set operating and maintenance manual for this information.

## TOPIC 5. OPERATING INSTRUCTIONS

### A. GENERAL

Before initial startup of the diesel engine complete the procedures detailed in Topic 3, PREPARATION OF ENGINE FOR OPERATION. Refer to your OWNERS MANUAL for instructions on operating the unit.

### B. OPERATING PRECAUTIONS

1. Do not operate the engine without having the air cleaner filter element installed.
2. Always allow the engine to warm up at reduced speed without load.
3. Keep the engine and accessories clean; inspect the engine while cleaning.
4. If the engine overheats due to lack of coolant, replenish slowly while engine is running.
5. Do not allow the engine to idle for prolonged periods except in cold weather below 0°F (255 K).
6. Refuel at the end of daily operation to keep condensation to a minimum.
7. In extreme cold weather optional ether starting aids or immersion heaters are available.

**CAUTION:** To prevent damage to the starting motor, do not crank engine for more than 30 seconds without a pause of 2 minutes to allow it to cool.

### C. STARTING AND STOPPING ENGINE

Refer to the generator set operating and maintenance manual for procedure to start and stop the engine.

If engine is equipped with an optional equipment ether starting aid (manually operated generator sets only), refer to TOPIC 20, titled Cold Weather Starting Aid, for procedure to start engine.

### D. DURING OPERATION CHECKS

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

### E. COLD WEATHER OPERATION

1. Make certain battery is fully charged and all other electrical equipment is in optimum operating condition.
2. Use a permanent type antifreeze solution to protect engine from damage by freezing. Refer to instructions on Protection Charts furnished by antifreeze manufacturer for quantity of antifreeze required for lowest anticipated temperature.
3. Provide radiator cover if thermostat proves inadequate to maintain normal coolant operating temperature.

**CAUTION:** Do not leave engine running unattended while radiator is covered. Overheating and damage may result.

4. At end of daily operation, drain water from fuel tank.
5. When the ambient temperature is -20°F (244 K) or lower, warming the engine and battery is recommended in order to obtain satisfactory starting and to prevent engine damage. Consult your dealer for information regarding availability of special cold weather equipment. Immersion heater kits and ether base fluid starting aid kits are available.

### F. HOT WEATHER OPERATION

1. Keep cooling system filled with clean water that is low in chemical impurities.
2. Make certain that fins and passages of radiator are free of foreign material.
3. Keep external surface of engine clean.

### G. EXERCISE OF ENGINE ON STANDBY SERVICE

**NOTE:** It is recommended that standby Diesel Electric Systems be equipped with an optional rectifier type battery charger.

Under optimum conditions, a diesel engine on standby service should be exercised at least every 30 days. However, under environmental conditions including extreme temperatures, humidity, dust, sand, etc., it may be found necessary to shorten the interval between exercise periods to as often as weekly.

Exercise periods should be long enough to enable the engine to attain normal operating temperature while carrying, if possible, at least 50 percent of its normal load. To exercise engine proceed as follows:

1. Before starting engine check lubricating oil and coolant levels. Make complete visual inspection of unit to be sure that it is in operating condition.
2. Start engine and run 5 minutes with no load.
3. Run engine at rated speed 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 (344 K) minimum, taken at 15 minute intervals. Continue to operate engine for 40 minutes. Check and correct any coolant or oil leaks.

**CAUTION:** If no load or a very light load must be used during exercise period cover the radiator to hasten the warmup period, but do not leave the unit unattended. Overheating and damage may result.

4. Run engine with no load for 5 minutes to allow combustion chamber temperature to decrease gradually to a minimum.
5. Stop engine.

**NOTE:** If the accumulated hours of operation during the above exercise periods is less than 100 hours (recommended lube, filter, and lubricating oil change periods) during the 6 months period, it is recommended that the lubricating oil and filter be changed every 6 months or sooner. If the accumulated hours of operation during the exercise periods is less than 600 hours (recommended fuel filter change period) during the 12 months period, it is recommended that the fuel filter element be replaced at the end of the 12 months period.

## H. 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), follow the instructions indicated below:

- a. Drain engine oil pan. Fill oil pan with new lubricating oil of proper classification and SAE weight.
- b. Service the air cleaner.
- c. Drain water and sediment from fuel filters and fuel tank.
- d. If a temperature below 32°F (273 K) is 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. Use a durable water and vaporproof material and seal all engine openings.
- h. 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

Engines 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 manufacturers instructions.

NOTE: Close the coolant filter inlet and outlet shutoff valves before cleaning system. Do not allow a commercial cleaner to circulate through the coolant filter.

- d. Renew coolant filter element or spin-on-can type filter. Refer to Topic 11 for procedure.
- e. Fill cooling system with clean water and add a good commercial soluble oil type rust inhibitor. However, if a temperature below 32°F (273 K) is expected, add a permanent type anti-freeze to the cooling system instead.
- f. Start engine and operate it with sufficient speed and load to enable the coolant temperature to reach 180° to 185°F (355 to 358 K). At this point the thermostats will open and the coolant will circulate through the entire system. Continue to operate engine for one hour.
- g. Stop engine. Remove drain plug and drain lubricating oil from pan. Remove lubricating oil filter elements and install new filter elements.
- h. 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.
- i. Drain water and sediment from fuel system. Install new fuel filter/elements and prime the fuel system. Then drain the fuel tank.
- j. 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.
- k. Disconnect the fuel tank to primary 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.
- l. Start engine using the container with the regular fuel oil. After engine is running smoothly, switch the fuel supply line to the second container. Continue to operate engine until the rust preventive fuel oil is observed at outlet of the overflow line; then stop the engine.
- m. Connect fuel supply line and return line to fuel tank.
- n. Clean exterior of engine and dry it thoroughly.
- o. 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 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°.
- p. Use a durable water and vaporproof material and seal all engine openings.
- q. Disconnect battery from engine. Clean battery and battery cables. Add distilled water to bring electrolyte up to the 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.
- r. 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

NOTE (cont): 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. Drain water from fuel filters.
- c. Fill supply tank with a sufficient amount of 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 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 (344 K) 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 appli-

cable) 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 water and vaporproof material and seal all engine openings.
- o. Again 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. 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.
- f. Open coolant filter inlet and outlet shutoff valves.

NOTE: If a soluble oil type rust inhibitor was added to the cooling system before engine was stored, drain and flush the cooling system before opening the coolant filter inlet and outlet shutoff valves.

- g. Check radiator or expansion tank coolant level and add coolant if necessary.
- h. Check condition of drive belts. Adjust or replace if necessary.

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

j. 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 viscosity 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 (255 K)	SAE 10W
0°F to 32°F (255 to 273 K)	SAE 20/20W
32°F to 95° (273 to 308 K)	SAE 30
Above 95°F (308 K)	SAE 40

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

**OIL AND FILTER CHANGE PERIOD** - The general recommendation is to renew the oil and standard engine mounted full flow type oil filters every 100 hours of operation. If the engine is equipped with an optional Model 750-C Lubr-Finer bypass type filter, renew the oil, full flow filters and bypass filter element every 250 hours. This change period 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°F (350 K) to 200°F (336 K).

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 the recommended oil change interval has been reached, actual tests of the lubricating oil at intervals of 10 to 20 hours should be made. As a result of these tests the oil condition can be determined, which may either allow extending 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 conditions (extended operation under full throttle conditions, high ambient temperatures, etc.) an 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 to 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 (422 K). It must be waterproof and have a viscosity that assures easy handling in a hand operated pressure gun at prevailing ambient temperatures.

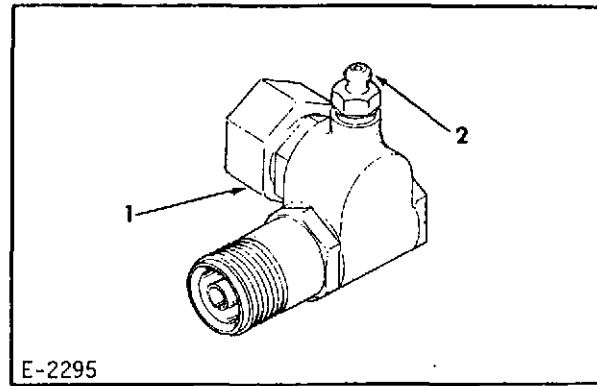
### 2. Angle Adaptor Lubrication

The angle adaptor is equipped with a grease fitting for low pressure greasing every 600 hours. Lubricate with grease conforming to MIL-G-10924, or equivalent. Do not overgrease.

## C. PROCEDURE FOR TAKING OIL SAMPLE

It is most important that crankcase oil samples for laboratory testing be correctly taken from the engines to ensure an accurate analysis.

Any oil sample should be taken with the engine oil at normal operating temperature.



1. Angle adaptor
2. Grease fitting

Figure 1. Angle Adaptor

The sample preferably should be taken from oil circulating within the oil passages in the engine.

If the sample is drawn from the oil pan, it should never be drained from the bottom of the pan. It can be sucked out of the pan through the dipstick hole with a suitable hand pump equipped with a small enough suction tube to enter the dipstick hole. If taken in this manner, be sure the engine is running and the suction tube is not inserted into the pan below the low level oil mark on the dipstick.

Do not take an oil sample from an engine immediately after adding make-up oil to the crankcase. Either delay until the make-up oil is thoroughly mixed with the oil crankcase oil or take the sample prior to adding the make-up oil.

Be sure the containers, pump, etc. are absolutely clean when taking the oil samples and be sure the container is properly sealed after the sample is taken. A sample that is contaminated by dirty containers or equipment will give a false laboratory analysis.

Generally, a one half pint sample is all that is required, but check with the oil company or laboratory making the analysis to determine the exact quantity they require.

## 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 (311 K).....	1.4-5.8
Flash Point.....	100°F (311 K) or Legal
Pour Point 10°F (6 K).....	Below Ambient Temp
Distillation Temp. 90% Point 640°F (611 K) 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 (289 K) is listed in the table at the bottom of this page (Figure 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

Degrees API At 60°F (289 K)	Specific Gravity At 60°F (289 K)	Pounds Per Gallon At 60°F	Kilogram Per Liter At 289 K	Gallons Per Pound At 60°F	Liter Per Kilogram At 289 K	BTU Per Pound	Kilogram Joule Per Liter	BTU Per Gallon	Kilogram Joule Per Liter
30	.8762	7.296	.876	.1371	1.1413	19,420	45 171	141,800	39 522
35	.8498	7.076	.850	.1413	1.1767	19,590	45 566	138,800	38 686
40	.8251	6.870	.825	.1456	1.2120	19,750	45 938	135,800	37 850

injection system. A fuel oil of high viscosity, i.e., a "heavy" fuel oil, may cause extremely 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°F (261 K) below the lowest temperature expected in order to assure satisfactory transfer and flow of fuel throughout the system.

#### 6. Distillation Temperature, 90°F (305 K) 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 sulfuric acid ( $H_2SO_4$ ), 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.

#### D. FUEL TANK AND PIPING

The fuel tank should be made of aluminum, monel, stainless steel, black iron, or welded sheet steel.

CAUTION: Galvanized steel plate, piping, or pipe fittings should not be used in the fuel system because of possible corrosion caused by reaction with fuel impurities.

The tank should have a vent, preferably from the center top of the tank, to reduce the possibility of air entrapment and fuel blow-back while filling the tank. A low point in the tank should be equipped with a drain valve in an accessible location, to allow periodic removal of contaminants. Draining tanks frequently will extend life of filters.

Fuel lines may be either steel, black iron pipe, brass (marine) or flexible hose. Copper tubing will become brittle due to "cold working" when subjected to vibration and is not recommended. If flexible hose is used, it must have a fuel oil resistant synthetic rubber inner tube, reinforcing inner braid, and a cover resistant to fuel, lubricating oils, mildew, and abrasion. As a minimum requirement, it must be suitable to withstand a maximum suction of 12 inches of mercury (40.5 kN/m<sup>2</sup>) without collapsing, a pressure of 100 psi (589 kN/m<sup>2</sup>) without bursting, and temperatures between minus 40°F. (277K) and plus 200°F. (366K)

## 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 lubricant (Topic 6) be closely followed. The lubrication intervals given in the schedule are based on normal engine operation, using the recommended oil and filters. This maintenance schedule is designed to be used as a guide until adequate data has been acquired to establish a schedule to fit a specific operation. Actual tests of the lubricant should be made to increase or decrease the interval as the actual condition of the oil may dictate.

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 intervals length to suit your particular operating conditions.

Thoroughly clean all lubrication fittings, caps, filter 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, inspection or service procedure of any given components, refer to the applicable topic in this manual.

NOTE: The environment and load conditions to which engines are subjected can considerably lengthen or shorten the intervals they will efficiently operate between valve reconditioning, piston ring replacement, and complete overhaul. Observation of crankcase breathing, exhaust sound and color, lubrication oil consumption, engine power, and the sound of the engine in operation by a qualified diesel mechanic will determine the need of reconditioning.

### B. LUBRICATION AND MAINTENANCE GUIDE

Checks must be made at the intervals shown (hours or months) whichever occurs first.

Generally the hours listed in the following guide are for prime power units and the months for standby units.

1. Daily/Each 8 Hours/At Time Standby Unit is Exercised		
Description	Reference	
	Topic	Paragraph
<b>a. Before Starting Engine</b>		
(1) Visually inspect belts and hoses for deterioration and engine accessories for signs of fuel, lubricant, coolant, air or exhaust leaks. Make corrections as required.		
(2) Check/correct coolant level.	11	F
(3) Check oil level with side of dipstick marked STOPPED to assure safe level for starting engine	13	D
(4) Drain water from fuel tank, and check fuel supply before start up/end of operation.	12	A
(5) Check air cleaner restriction indicator. Replace air cleaner element if red indicator is visible.	17	D
(6) Check/correct air cleaner to turbo loose clamps or deteriorated hoses.	18	D
(7) Drain moisture from air compressor air reservoir.	-	-
<b>b. Start Engine</b>		
(1) Check/correct starter performance	14	D
(2) Check/correct oil pressure	13	A
(3) Check/correct charging rate.	14	E
<b>c. After Engine Reaches Operating Temperature</b>		
(1) Check engine oil level at low speed. Maintain between running high and low marks on dipstick.	13	B
(2) Observe the following for Normal operation:		
(a) Coolant temperature	11	H
(b) Lube oil pressure	13	A,E
(c) Full load speed	12	E,F
(d) Air cleaner service indicator	17	D
(3) Check/correct for knocks or other unusual noises.	9	B
(4) Check/correct air compressor operation/air reservoir pressure.	-	-

2. Each 100 Hours/6 Months		
Description	Reference	
	Topic	Para-graph
a. Check/correct radiator for external cleanliness and restriction of air through fins.	11	D
b. Make initial replacement of coolant filter.	11	M
c. Change engine lubricating oil.	13	D
d. Renew lubricating fullflow oil filter. See note below:	13	C
e. Check/correct liquid level of battery cells.	14	C
f. If applicable, lubricate the battery charging generator with engine oil.	14	E
g. Check/correct leaks: (1) Lube oil (4) Air (2) Fuel (5) Exhaust (3) Coolant		
h. Using engine oil lubricate governor/throttle/stop control swivels.		

\*NOTE:

3. Each 250 Hours/6 Months		
Description	Reference	
	Topic	Para-graph
If engine is equipped with an optional bypass type oil filter in addition to the standard full flow filters, renew the lubricating oil, full flow filters, bypass filter element each 250 hours.		
a. Change engine lubricating oil	13	D
b. Renew full flow oil filters	13	C
c. Renew bypass oil filter	13	D

4. Each 600 Hours/12 Months		
Description	Reference	
	Topic	Para-graph
a. Renew fuel filter.	12	B
b. Grease water pump bearings.	11	D
c. Grease fan drive pulley hub bearings.	11	I
d. Check tension and condition of generator and water pump drive belts.	11	I
e. Clean immersion heater.	11	L
f. Renew coolant filter.	11	M
g. Check/clean engine breather tube.	13	E
h. Check/correct turbocharger for loose mounting nuts and piping.	19	D

5. Each 1000 Hours/24 Months		
Description	Reference	
	Topic	Para-graph
a. Check specific gravity of battery fluid.	14	C
b. Inspect/clean/tighten electrical connections: (1) Battery (3) Generator (2) Starter (4) Regulator.	14	C,D, E
c. Check/tighten exhaust and intake manifold fasteners.	16	B
d. Check/tighten engine mounting fasteners.	-	-
e. Check/correct air compressor discharge valves and springs for excessive carbon.	-	-

6. Each 3000 Hours		
Description	Reference	
	Topic	Para-graph
a. Recondition nozzle-holder assemblies.	12	H
b. Recondition intake and exhaust valves and seats.		Service Manual
c. Check/correct cylinder sleeve bores for excessive wear.		Service Manual
d. Check/correct turbocharger: (1) Wheels for dirt and carbon. (2) Bearing clearance (3) Shaft endplay.	18	D
e. Renew grease in governor speed control motor gear housing.	12	K
f. Clean exterior of engine and radiator		

7. Each 6000 Hours		
Description	Reference	
	Topic	Para-graph
* a. Make major inspection of engine. Repair or replace parts with excessive wear.		Service Manual

\*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 are illustrated in the Topic and Figure as indicated in the following tabulation.

The tools must be ordered directly from the tool manufacturer.

TOOL MANUFACTURERS

(BI) Bacharach Instrument Company  
 Division of American Bosch ARMA Corp.  
 200 North Braddock Avenue  
 Pittsburgh, Pennsylvania 15208

(BT) Borrough Tool and Equipment Corp.  
 2429 N. Burdick Street  
 Kalamazoo, Michigan 49007

(KM) Service Tool Division  
 Kent-Moore Corporation  
 28635 Mound Road  
 Warren, Michigan 48092

(OTC) Owatonna Tool Co.  
 Owatonna, Minnesota 55060

(SO) Snap-On Tools Corporation  
 2905 60th Street  
 Kenosha, Wisconsin 53140

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
11	*	(BT) BT-33-72C	Belt Tension Gauge
12	17	(KM) J-6765	Fuel Injection Line Nut Wrench (Nozzle End)
12	19	(BI) 65-0300	Nozzle Tester (only)
12	19	(BI) 65-481	Connector Set (used with above)
12	19	(BI) 65-317	Plastic Cup (spray collector)
12	*	(BI) 65-808	Carrying Case (nozzle tester)
12	20	(KM) J-6999	Injection Nozzle Holding Fixture
12	22	(KM) J-4298-1	Pin Vise
12	22	(KM) J-7854-1	Nozzle Hole Cleaning Wire
12	23	(KM) J-21762	Injection Nozzle Sleeve Cleaner
12	8	(OTC) 13371	Seal Compressor (Injection Pump Drive Shaft Seal)
15	*	(SO) IMFD-242	Flank Drive Type Jacket - Size 3/4", 12 Point with 3/4" Drive

\*Not Illustrated

## TOPIC 9. TROUBLESHOOTING

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### A. GENERAL

It has been proved that over 90% of the troubles that occur in engine operation are avoided when those responsible for maintenance adhere to an adequate program of lubrication, inspection, and maintenance. 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 troubles, 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 service procedures for any given components, refer to that section or topic pertaining to the part, assembly, or system.

### B. ENGINE.

TROUBLE	POSSIBLE CAUSES	REMEDY
Engine will not crank.	<ol style="list-style-type: none"> <li>1. Batteries weak.</li> <li>2. Starting system faulty.</li> <li>3. Engine is locked or seized.</li> <li>4. Hydro-static lock.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check specific gravity.</li> <li>2. Refer to Paragraph C.</li> <li>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.</li> <li>4. Check for rain water having entered an uncovered exhaust pipe, leaking cylinder head gasket and cracked block or cylinder head. Repair or replace defective parts.</li> </ol>
Engine will not start.	<ol style="list-style-type: none"> <li>1. Incorrect starting procedure.</li> <li>2. Slow cranking speed.</li> <li>3. Engine controls out of adjustment.</li> </ol>	<ol style="list-style-type: none"> <li>1. Follow correct starting procedure.</li> <li>2. Specific gravity of battery too low. Charge battery. Starter not delivering maximum torque. Repair or replace defective parts. Use cold weather starting aids if applicable.</li> <li>3. Check all engine control linkages for proper adjustment.</li> </ol>

TROUBLE	POSSIBLE CAUSES	REMEDY
Engine will not start (cont.).	4. Insufficient supply of fuel to fuel injection nozzles. 5. Fuel injection nozzles not operating properly. 6. Fuel injection pump improperly timed.	4. Refer to Paragraph D. 5. Test and repair or replace nozzles 6. Time fuel injection pump.
Engine hard to start.	1. Incorrect starting procedure. 2. Batteries weak. 3. Insufficient fuel in fuel tank. 4. Incorrect grade of fuel. 5. Clogged fuel filters. 6. Fuel injection nozzles not operating properly. 7. Fuel transfer pump not operating properly. 8. Air in fuel system. 9. Insufficient air supply to cylinders. 10. Fuel injection pump improperly timed. 11. Valve lash incorrect. 12. Piston rings or cylinder sleeves worn. 13. Valves warped or pitted.	1. Follow correct starting procedure. 2. Recharge or replace batteries. 3. Check fuel level in tank. Fill with specified fuel if necessary. 4. Drain fuel system. Fill the tank with the specified fuel. 5. Replace filter elements. 6. Test and repair or replace nozzles. 7. Test and repair or replace fuel feed (transfer) pump. 8. Refer to Paragraph D. 9. Refer to Paragraph E. 10. Time fuel injection pump. 11. Adjust valve lash. 12. Replace affected parts. 13. Recondition or replace valves and/or valve guides.
Engine stops frequently.	1. Idling speed too low (not applicable to generator drive engines). 2. Restricted fuel supply.	1. Adjust low idling speed. 2. Check fuel system.
Engine stops unexpectedly.	1. Out of fuel. 2. Restricted fuel supply. 3. Broken or loose fuel lines. 4. Fuel feed (transfer) pump or fuel injection pump inoperative.	1. Fill fuel tank with specified fuel and prime the fuel system. 2. Check fuel system. 3. Correct or replace affected parts. 4. Replace inoperative parts.

TROUBLE	POSSIBLE CAUSES	REMEDY
Engine overheats.	<ol style="list-style-type: none"> <li>1. Cooling system faulty.</li> <li>2. Radiator core coolant passages clogged.</li> <li>3. Radiator air passages clogged.</li> <li>4. Fan drive belts loose.</li> <li>5. Thermostats inoperative.</li> <li>6. Engine oil cooler clogged.</li> <li>7. Improper engine lubrication.</li> <li>8. Water pump malfunctioning.</li> <li>9. Fuel injection pump improperly timed.</li> </ol>	<ol style="list-style-type: none"> <li>1. Refer to Paragraph F.</li> <li>2. Clean and flush radiator.</li> <li>3. Remove debris from radiator core.</li> <li>4. Adjust fan drive belts to proper tension.</li> <li>5. Test the thermostats for proper operation; replace if necessary.</li> <li>6. Clean or replace the oil cooler core.</li> <li>7. Refer to Paragraph G.</li> <li>8. Repair or replace the water pump.</li> <li>9. Time fuel injection pump.</li> </ol>
Engine shows loss of power.	<ol style="list-style-type: none"> <li>1. Insufficient supply of air to cylinders.</li> <li>2. Insufficient supply of fuel to fuel injection nozzles.</li> <li>3. Governor not operating properly.</li> <li>4. Air in fuel system.</li> <li>5. Clogged fuel filters.</li> <li>6. Improper valve lash.</li> <li>7. Fuel injection pump improperly timed.</li> <li>8. Inoperative fuel injection pump or fuel injection nozzles.</li> <li>9. Cylinder cutting out.</li> <li>10. Loss of compression.</li> </ol>	<ol style="list-style-type: none"> <li>1. Refer to Paragraph E.</li> <li>2. Refer to Paragraph D.</li> <li>3. Inspect and adjust governor.</li> <li>4. Refer to Paragraph D.</li> <li>5. Change filter elements.</li> <li>6. Adjust valve lash.</li> <li>7. Time fuel injection pump.</li> <li>8. Repair or replace affected parts.</li> <li>9. Refer to Paragraph J.</li> <li>10. Refer to Paragraph K.</li> </ol>
Engine runs unevenly with excessive vibration.	<ol style="list-style-type: none"> <li>1. Governor not operating properly.</li> <li>2. Fuel supply erratic or insufficient.</li> <li>3. Engine operating temperature too low.</li> <li>4. Fuel injection pump malfunctions.</li> <li>5. Valves in bad condition.</li> </ol>	<ol style="list-style-type: none"> <li>1. Remove fuel injection pump and make necessary repairs to governor.</li> <li>2. Refer to Paragraph D.</li> <li>3. Refer to Paragraph F.</li> <li>4. Check fuel injection pump.</li> <li>5. Recondition valves.</li> </ol>

TROUBLE	POSSIBLE CAUSES	REMEDY
Engine runs unevenly with excessive vibration (cont).	6. Cylinder "cutting-out." 7. Fuel injection nozzle malfunctions.	6. Correct cause. 7. Repair nozzle.
Engine emits black smoke from exhaust.	1. Air system clogged. 2. Fuel injection pump roller-to-roller dimension incorrect. 3. Improper fuel. 4. Lack of good fuel injection nozzle spray pattern.	1. Check engine air intake system. 2. Correct roller-to-roller dimension. 3. Drain fuel system and refill with specified fuel. 4. Clean and adjust nozzles.
Engine emits bluish-white smoke from exhaust.	1. Engine operating temperature too low. 2. Fuel injection nozzle valve stuck in open position. 3. Low compression. 4. Early fuel injection pump timing.	1. Check thermostat. 2. Test and adjust nozzles. 3. Make compression test and necessary repairs. 4. Test and adjust.
Engine detonates or knocks.	1. Fuel pump improperly timed. 2. Loose bearings. 3. Loose piston. 4. Loose flywheel. 5. Improperly adjusted valve(s). 6. Foreign material in cylinder(s).	1. Check and adjust. 2. Replace bearings. 3. Inspect piston assembly. Replace parts required. 4. Check tightness of flywheel bolts and dowel. Tighten/replace parts required. 5. Check and adjust. 6. Clean and make necessary repairs.
<p>CAUTION: If a hard metallic knock indicates detonation in one or more cylinders, the engine must be stopped immediately to prevent serious damage due to the excessive pressure accompanying the detonation.</p>		

### C. STARTING SYSTEM

Starter will not crank engine.	1. Batteries weak. 2. Cables and/or connections loose or corroded. 3. Starter switch inoperative.	1. Check batteries. 2. Tighten all loose connections and clean corrosion from all terminals. 3. Replace switch.
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TROUBLE	POSSIBLE CAUSES	REMEDY
Engine will not crank engine (cont).	<ol style="list-style-type: none"> <li>4. Starter brushes worn or not contacting properly.</li> <li>5. Starter brush springs weak.</li> <li>6. Starter commutator dirty or worn.</li> <li>7. Starter armature shaft bushings worn (armature drags on fields).</li> <li>8. Starter armature burned out.</li> </ol>	<ol style="list-style-type: none"> <li>4. Install new brushes or fit brushes to conform to contour of commutator.</li> <li>5. Check brush spring tension; replace springs if necessary.</li> <li>6. Polish commutator, machine commutator and under-cut mica if necessary.</li> <li>7. Replace worn bushings and related items.</li> <li>8. Replace armature.</li> </ol>
Starter pinion will not engage with fly-wheel ring gear.	<ol style="list-style-type: none"> <li>1. Grease and/or dirt in starter drive mechanism.</li> <li>2. Broken or excessively worn parts.</li> </ol>	<ol style="list-style-type: none"> <li>1. Disassemble and clean the drive assembly.</li> <li>2. Replace broken or worn parts.</li> </ol>

#### D. FUEL SYSTEM

Insufficient fuel supply to fuel injection nozzles.	<ol style="list-style-type: none"> <li>1. No fuel in fuel tank.</li> <li>2. Inoperative fuel feed (transfer) pump.</li> <li>3. Fuel injection nozzle valve binding in valve body.</li> <li>4. Clogged fuel filters, fuel lines and sediment bowl on early engines.</li> <li>5. Fuel injection pump malfunctioning.</li> <li>6. Fuel injection nozzles improperly adjusted.</li> </ol>	<ol style="list-style-type: none"> <li>1. Fill fuel tank with specified fuel. Prime fuel system.</li> <li>2. Repair or replace feed (transfer) pump.</li> <li>3. Replace valve assembly in nozzle holder body.</li> <li>4. Clean fuel system components, replace fuel filter elements.</li> <li>5. Replace fuel injection pump.</li> <li>6. Adjust fuel injection nozzles.</li> </ol>
Air in Fuel system.	<ol style="list-style-type: none"> <li>1. Loose fuel line fitting or leak in fuel line on suction side of fuel feed (transfer) pump.</li> <li>2. Damaged fuel filter or gasket.</li> </ol>	<ol style="list-style-type: none"> <li>1. Tighten loose fitting or replace damaged line.</li> <li>2. Replace filter.</li> </ol>

#### E. AIR INTAKE SYSTEM

Insufficient air supply to cylinders.	<ol style="list-style-type: none"> <li>1. Air cleaner clogged.</li> <li>2. Foreign material lodged in turbocharger impeller or turbine.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace air filter element.</li> <li>2. Disassemble and clean.</li> </ol>
---------------------------------------	--	---

TROUBLE	POSSIBLE CAUSES	REMEDY
Insufficient air supply to cylinders (cont).	3. Excessive dirt buildup in compressor or turbocharger. 4. Excessive dirt buildup in compressor in short period of time. 5. Leaks in engine intake and/or exhaust manifolds reducing turbocharger efficiency. 6. Turbocharger bearings seized.	3. Thoroughly clean compressor assembly. 4. Clean compressor assembly, and service air intake system for leaks. 5. Tighten loose manifold retaining capscrews. Replace manifold gaskets. 6. Overhaul turbocharger.
Rapid wear on engine parts.	1. Dirt admitted with intake air. 2. Dirty lubricating oil. 3. Improper fuel.	1. Inspect air cleaner body, pipe, connecting hoses, gaskets, etc., thoroughly for cracks or openings which would allow air to enter engine without passing through air cleaner. Make necessary repairs. 2. Change engine oil and the lubricating oil filter elements at the intervals recommended. Keep oil clean when filling engine. 3. Use the proper fuel. It is important that the fuel be within the specified limits for ash, carbon, sulfur, etc. to prevent excessive wear on engine parts.

#### F. COOLING SYSTEM

Engine operating temperature too high, even with ample coolant in system.	1. Temperature gauge inoperative. 2. Radiator air passages restricted. 3. Thermostats inoperative. 4. Loose or broken fan drive belts. 5. Lime deposits in coolant passages of radiator, cylinder heads and/or cylinder block. 6. Coolant passages in oil cooler restricted. 7. Water pump inoperative. 8. Engine pulling excessive load. 9. Engine speed set too high.	1. Check gauge. Replace if necessary. 2. Clean exterior of radiator. 3. Replace thermostats. 4. Adjust or replace fan drive belts. 5. Thoroughly clean affected parts. 6. Remove and clean oil cooler core. 7. Repair or replace water pump. 8. Reduce load. 9. Adjust speed to within specified rpm limits.
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TROUBLE	POSSIBLE CAUSES	REMEDY
Engine operating temperature too high due to loss of coolant.	<ol style="list-style-type: none"> <li>1. External leaks.</li> <li>2. Ruptured oil cooler core (oil in coolant).</li> <li>3. Engine cylinder head gaskets leaking.</li> <li>4. Engine cylinder heads cracked.</li> <li>5. Engine cylinder block cracked.</li> </ol>	<ol style="list-style-type: none"> <li>1. Repair affected parts.</li> <li>2. Replace oil cooler core.</li> <li>3. Replace gaskets and torque cylinder head nuts or capscrews to specified torque.</li> <li>4. Replace cylinder head.</li> <li>5. Replace cylinder block.</li> </ol>
Engine operating temperature too low.	<ol style="list-style-type: none"> <li>1. Thermostats stuck in open position.</li> <li>2. Operating in extremely cold weather.</li> </ol>	<ol style="list-style-type: none"> <li>1. Replace thermostats.</li> <li>2. Provide covers for radiator and engine side openings.</li> </ol>

#### G. LUBRICATING SYSTEM

No lubricating oil pressure.	<ol style="list-style-type: none"> <li>1. Insufficient oil.</li> <li>2. Oil Pressure gauge inoperative.</li> <li>3. Lubricating oil pump screen clogged.</li> <li>4. Lubricating oil pump inoperative.</li> <li>5. Oil lines loose or broken inside engine.</li> </ol>	<ol style="list-style-type: none"> <li>1. Fill oil pan to proper level.</li> <li>2. Replace gauge.</li> <li>3. Remove and clean the screen.</li> <li>4. Repair or replace oil pump.</li> <li>5. Repair or replace affected parts.</li> </ol>
Low lubricating oil pressure with proper oil level in oil pan.	<ol style="list-style-type: none"> <li>1. Oil pressure gauge inaccurate.</li> <li>2. Oil pressure relief valve or regulator valve stuck in open position.</li> <li>3. Oil lines loose or broken.</li> <li>4. Improper lubricant.</li> <li>5. Main and/or connecting rod bearings worn.</li> <li>6. Camshaft bearings worn.</li> <li>7. Lubricating oil pump worn.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check gauge. Replace if necessary.</li> <li>2. Clean, repair, or replace affected parts.</li> <li>3. Repair or replace affected items.</li> <li>4. Fill oil pan with specified lubricant.</li> <li>5. Replace bearings.</li> <li>6. Replace bearings.</li> <li>7. Repair or replace oil pump.</li> </ol>
Excessive lubricating oil pressure.	<ol style="list-style-type: none"> <li>1. Oil pressure gauge inaccurate.</li> <li>2. Oil pressure regulating valve improperly adjusted.</li> </ol>	<ol style="list-style-type: none"> <li>1. Check gauge. Replace if necessary.</li> <li>2. Adjust valve to obtain proper pressure.</li> </ol>

TROUBLE	POSSIBLE CAUSES	REMEDY
Excessive lubricating oil pressure (cont).	3. Improper lubricant.	3. Fill oil pan with specified lubricant.
Overheating of lubricating oil	1. Insufficient oil. 2. Improper lubricant. 3. Engine oil cooler clogged.	1. Fill oil pan to proper level. 2. Fill oil pan with specified lubricant. 3. Clean or replace the oil cooler.
Excessive oil consumption.	1. External oil leakage (gaskets, etc.). 2. Crankshaft oil seals worn or damaged. 3. Lubricating oil too light. 4. Pistons, rings, and/or cylinder sleeves worn. 5. Oil control rings stuck in piston ring grooves. 6. Valve guides worn.	1. Correct all external leaks. 2. Replace oil seals. 3. Fill oil pan with specified lubricant. 4. Replace affected parts. 5. Clean ring grooves and replace rings. 6. Replace valve guides. Check related parts.
Rapid wear on engine parts.	1. Lubricating oil contaminated. 2. Improper engine lubricating oil being used. 3. Dirt admitted with intake air.	1. Fill system with clean engine oil. Replace engine oil filters. 2. Fill system with engine lubricating oil of proper specifications. 3. Inspect air cleaner body, pipe, connecting hoses, gaskets, etc., thoroughly for cracks or openings which would allow air to enter engine without passing through air cleaner. Make necessary repairs.

#### H. ELECTRICAL SYSTEM

No output from battery charging generator	1. Drive belt loose or broken. 2. Regulator inoperative. 3. Generator inoperative	1. Adjust or replace drive belt. 2. Remove regulator for repair or replacement. 3. Remove unit for repairs or replacement.
Generator output low and/or unsteady.	1. Drive belt improperly adjusted. 2. Regulator operating improperly.	1. Adjust drive belt. 2. Remove regulator for repair or replacement.

TROUBLE	POSSIBLE CAUSES	REMEDY
Generator output low and/or unsteady (cont).	3. Brush spring tension too low. 4. Generator circuit components damaged.	3. Replace brush springs. 4. Remove generator for repair or replacement.
Batteries will not hold charge.	1. Loose terminals or connections. 2. Short in electrical system. 3. Short circuit in battery. 4. Electrolyte level low (regulator output excessive or battery case cracked). 5. Regulator inoperative.	1. Tighten affected parts. 2. Correct short. 3. Remove and repair or replace battery. 4. Reduce charging rate. Remove and repair or replace battery. 5. Remove regulator for repair or replacement.

#### I. INSTRUMENTS

If any of the instruments/gauges fail to register proper readings while engine is in operation, the system/circuit to which the instrument applies should be thoroughly checked/ tested. If failure of the instrument is suspected, test by installing a new tested instrument. Replace any inoperative instrument.

#### J. LOCATING CYLINDER CUTOUT

**CAUTION:** The tests in Paragraph J and K require the engine to be operated at speeds below 1400 rpm. If the engine is powering a generator set, the main generator voltage regulator must be disconnected from the system to protect it from damage at the lower speeds.

Locate "missing" cylinders by following the procedure indicated below.

Run engine at low speed (500 rpm) speed and cut out each fuel injection nozzle, one at a time, by loosening the fuel injection line nut attaching line to fuel injection pump or nozzle holder assembly.

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.

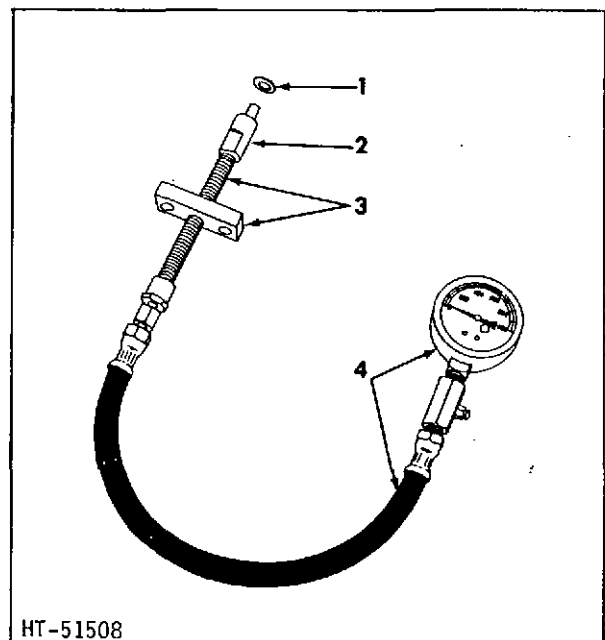
#### K. MAKING COMPRESSION TEST

Loss of compression may be due to leaking valves, worn piston rings, or cylinder sleeves. Using a suitable compression tester, check and

record the compression of each cylinder.

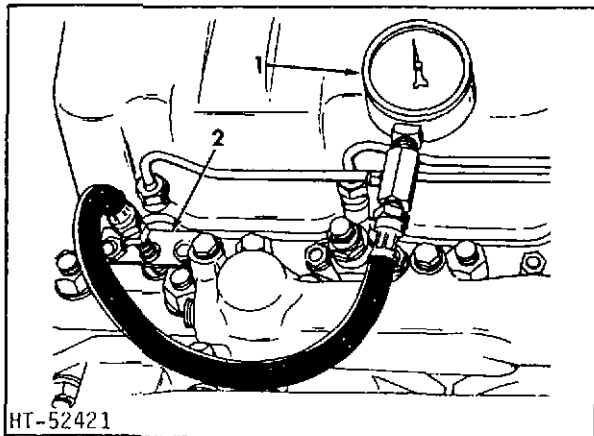
Compression pressure for a normal engine at normal operating temperature firing on five cylinders at 600 rpm and at sea level conditions is 445 psi (3068 kN/m<sup>2</sup>) (nominal).

When checking the compression pressure, the altitude at which the engine is located must



1. Nozzle gasket
2. Adaptor tip
3. Adaptor
4. Compression gauge assembly

Figure 1. Tools for Checking Compression



1. Compression tester gauge assembly
2. Compression tester adaptor

Figure 2. Checking Compression Pressure

be taken into consideration for an accurate evaluation of the test, because the density of air decreases as altitude increases. For each 1000 feet (304.8 m) of altitude above sea level the specified sea level figure of 445 psi (3068 kN/m<sup>2</sup>) must be derated by 3%.

It is common practice to consider a differential of 30 psi (207 kN/m<sup>2</sup>) 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 30 psi (207 kN/m<sup>2</sup>) 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 (345 kN/m<sup>2</sup>) or more is noted between cylinders, the cylinder heads should be removed and a detailed inspection made of cylinder heads, 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.

To check compression pressure, proceed as follows:

1. Start the engine and warm up to minimum temperature of 160°F (344 K).
2. Stop the engine. Remove drip manifold from the nozzle holder assemblies.

NOTE: To prevent spillage of fuel, when the drip manifold is removed, connect a hose to the fuel return line from the pump and replace the open end in a container to receive the overflow fuel from the injection pump while the engine is running.

3. Start with the number 1 cylinder when checking the compression. Remove the fuel injection nozzle and install the compression tester adaptor in the same manner as the fuel injection nozzle was installed. Install the compression tester hose and gauge assembly (Figure 2).
4. Start the engine, run at approximately 600 rpm, and take several readings on gauge.

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

5. Remove the tester assembly, install nozzle holder, connect fuel injection line and fuel return line.
6. Repeat the operation on each remaining cylinder.
7. Install the drip manifold.

# TOPIC 10. FITS AND TOLERANCES; BOLT, CAPSCREW, AND NUT TORQUE WRENCH

## SPECIFICATIONS; STUD GAUGE HEIGHTS

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C	STUD GAUGE HEIGHTS AND DRIVING TORQUES . . . . .	15

**A. FITS AND TOLERANCES**

DESCRIPTION

**1. Cylinder Sleeves**

- a. Type . . . . .
- b. Inside diameter . . . . .
- c. Diameter of sleeve at machined area just below flange . . . . .
- d. Diameter of cylinder sleeve at packing ring location . . . . .
- e. Sleeve flange outside diameter . . . . .
- f. Cylinder block-to-sleeve clearance at sleeve lower diameter . . . . .
- g. Cylinder block-to-sleeve clearance at machined area just below flange . . . . .
- h. Cylinder block-to-sleeve clearance at sleeve flange . . . . .

	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
Replaceable Wet	Replaceable Wet	Replaceable Wet
4.4370 - 4.4385	112.70 - 112.74	112.70 - 112.74
5.030 - 5.032	127.62 - 127.81	127.62 - 127.81
4.967 - 4.969	126.16 - 126.21	126.16 - 126.21
5.249 - 5.253	133.32 - 133.43	133.32 - 133.43
.001 - .005	.03 - .13	.03 - .13
.0005 - .0045	.01 - .11	.01 - .11
.003 - .012	.08 - .30	.08 - .30

DESCRIPTION

SIZE OF NEW PARTS		
	INCHES	MILLIMETERS
i. Clearance of piston skirt with sleeve. . . . .	.0050 - .0075	.13 - .19
j. Fire wall height above cylinder sleeve flange . . . . .	.042 - .045	1.07 - 1.14
k. Cylinder sleeve flange thickness:		
Early. . . . .	.320 - .322	8.13 - 8.18
Current. . . . .	.3155 - .3170	8.01 - 8.05
l. Top surface of cylinder sleeve flange above cylinder block with sleeve installed:		
Early. . . . .	.0065 - .0095	.17 - .24
Current. . . . .	.0020 - .0055	.05 - .14
m. Flange height adjusting shims available. . . . .	.005, .010, .015 and .020	.13 - .25 .38 - .51
n. Allowable taper . . . . .	.0015	.04
o. Allowable out-of-round (when installed). . . . .	.0015	.04
2. Cylinder Block		
a. Counterbore diameter in cylinder block for cylinder sleeve flange. . .	5.256 - 5.261	133.50 - 133.63
b. Depth of counterbore for cylinder sleeve flange . . . . .	.3115 - .3135	7.90 - 7.96
c. Bore in cylinder block for cylinder sleeve - Top. . . . .	5.0325 - 5.0345	127.83 - 127.88
d. Bore in cylinder block for cylinder sleeve - Bottom . . . . .	4.970 - 4.972	126.24 - 126.29
e. Bore in cylinder block for camshaft bearings. . . . .	2.4975 - 2.4985	63.44 - 63.46
f. Bearing bore in cylinder block for main bearings (without bearing, cap in place, and capscrews tightened to specified torque) . . . . .	3.8118 - 3.8125	96.82 - 96.84
3. Pistons		
NOTE: Combustion chamber is in top of piston.		
a. Combustion chamber depth:		
Shallow combustion chamber - Current Engines. . . . .	.733 - .737	18.62 - 18.72
Deep combustion chamber - Early Engines. . . . .	1.183 - 1.187	30.05 - 30.15

DESCRIPTION

	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
b. Combustion chamber I.D.:		
Shallow combustion chamber - Current Engines. . . . .	2.998 - 3.002	76.15 - 76.25
Deep combustion chamber - Early Engines. . . . .	2.258 - 2.262	57.35 - 57.45
c. Material. . . . .	Aluminum Alloy	Aluminum Alloy
d. Length. . . . .	5.993 - 5.997	152.22 - 152.32
e. Diameter between top and second ring groove:		
Shallow combustion chamber - Current Engines. . . . .	4.402 - 4.406	111.81 - 111.91
Deep combustion chamber - Early Engines. . . . .	4.406 - 4.410	111.91 - 112.01
f. Diameter at bottom of skirt at right angle to piston pin . . . . .	4.431 - 4.432	112.55 - 112.57
g. Bore for piston pin:		
Shallow combustion chamber - Current Engines		
First type - straight bore ...	1.6268 - 1.6272	41.32 - 41.33
Current - oval bore		
Vertical (minor axis) .....	1.6268 - 1.6272	41.32 - 41.33
Horizontal (major axis) ...	1.6307 - 1.6312	41.02 - 41.03
Deep combustion chamber - Early Engines .....	1.6264 - 1.6266	41.31 - 41.32
h. Measurement from center of piston pin bore-to-top of piston . . . . .	3.609 - 3.613	91.67 - 91.77
i. Clearance of piston skirt with sleeve	0.0050 - 0.0075	.13 - .19
4. Piston Pins		
a. Type. . . . .	Full Floating	Full Floating
b. Piston pin length . . . . .	3.789 - 3.804	96.24 - 96.62
c. Diameter of pin . . . . .	1.6265 - 1.6267	41.31 - 41.32
d. Fit of pin in piston at room temper- ature		
Shallow combustion chamber piston . . . . .	.0001 - .0007 tight	.002 - .018 tight
Deep combustion chamber piston . . .	.0001 - .0003 tight	.002 - .008 tight
e. Inside diameter of connecting rod bushing . . . . .	1.6277 - 1.6282	41.34 - 41.37
f. Piston pin-to-connecting rod bushing clearance . . . . .	.001 - .0017	.03 - .04
5. Piston Rings		
NOTE: Only standard size rings are available.		
a. Number of rings on each piston. . . .	4	4

DESCRIPTION

SIZE OF NEW PARTS		
	INCHES	MILLIMETERS
b. Location of rings . . . . .	All above piston pin	All above piston pin
c. Gap between ends - fitted		
1st ring (chrome compression)		
Shallow combustion chamber piston . . . . .	.013 min - .028 max	.33 min - .71 max
Deep combustion chamber piston . . . . .	.013 min - .033 max	.33 min - .84 max
2nd and 3rd rings (compression) . . . . .	.013 min - .033 max	.33 min - .84 max
4th ring (oil control) . . . . .	.008 min - .028 max	.20 min - .71 max
d. Clearance of rings in grooves		
1st ring (chrome compression) . . . . .	.004 - .007	.10 - .18
2nd and 3rd rings (compression) . . . . .	.003 - .005	.08 - .13
4th ring (oil control) . . . . .	.0015 - .004	.04 - .10
6. Crankshaft		
a. Journal diameter for connecting rods.	2.7710 - 2.7725	70.38 - 70.42
b. Journal diameter for main bearings. . . . .	3.4975 - 3.4990	88.84 - 88.87
c. Width between connecting rod journal cheeks. . . . .	1.750 - 1.754	44.45 - 44.55
d. Width of main bearing journals		
Front. . . . .	2.250 - 2.255	57.15 - 57.28
Intermediate . . . . .	1.623 - 1.627	41.22 - 41.33
Center . . . . .	2.688 - 2.692	68.28 - 68.38
Rear . . . . .	2.230 - 2.240	56.64 - 56.90
e. Crankshaft end clearance. . . . .	.006 - .014	.15 - .36
f. Separate type thrust flanges - standard and oversizes. . . . .	.005, .010, and .015	.13, .25, and .38
g. Crankshaft journals may be ground . . . . .	.010, .020, .030 or .040 undersize	.25, .51, 76 or 1.02 undersize
h. Fit of crankshaft gear on crankshaft.	.0010 - .0028 tight	.03 - .07 tight
7. Main Bearings		
a. Number used . . . . .	7	7
b. Type. . . . .	Replaceable Precision	Replaceable Precision
c. Inside diameter of front, intermediate, center and rear bearing (with capscrews tightened to specified torque) (measured vertically) . . . . .	3.501 - 3.5027	88.93 - 88.97
d. Diameter of crankshaft main bearing journals. . . . .	3.4975 - 3.499	88.84 - 88.87
e. Bearing-to-journal clearance at front, intermediate, center and rear bearings (with capscrews tightened to specified torque). . . . .	.002 - .0052	.05 - .13

DESCRIPTION

	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
f. Overall length of main bearings. . . . .		
Front and Intermediate. . . . .	1.348 - 1.358	34.24 - 34.49
Center. . . . .	2.244 - 2.254	57.00 - 57.25
Rear. . . . .	1.991 - 2.001	50.57 - 50.83
g. Undersize bearings available for service. . . . .	.010, .020, .030 and .040	.25, .51, .76 and 1.02
h. Separate type thrust flanges - Standard and oversize. . . . .	.005, .010, and .015	.13, .25 and .38
i. Front, intermediate, center and rear bearing wall thickness (standard bearings). . . . .	.1549 - .1554	3.93 - 3.95
j. Bearing bore in cylinder block (without bearing, cap in place, and capscrews tightened to specified torque). . . . .	3.8118 - 3.8125	96.82 - 96.84
8. Connecting Rod Bearings		
a. Type . . . . .	Replaceable Precision	Replaceable Precision
b. Inside diameter of bearing (with fasteners tightened to specified torque) (Measured vertically). . . . .	2.7745 - 2.7760	70.47 - 70.51
c. Diameter of crankshaft connecting rod journals . . . . .	2.7710 - 2.7725	70.38 - 70.42
d. Connecting rod bearing-to-journal clearance (with nuts tightened to specified torque). . . . .	.0025 - .0050	.06 - .13
e. Overall length of connecting rod bearings . . . . .	1.363 - 1.373	34.62 - 34.87
f. Undersize bearings available for service. . . . .	.010, .020, .030 and .040	.25, .51, .76, and 1.02
g. Bearing wall thickness (standard bearing) . . . . .	.12475 - .12525	3.17 - 3.18
9. Connecting Rods		
a. Type . . . . .	Balanced Forging	Balanced Forging
b. Fasteners per rod-socket head cap-screw type . . . . .	2	2
c. Connecting rod length (center-to-center). . . . .	10.498 - 10.502	266.65 - 266.75
d. Inside diameter of connecting rod bushing (finished bore) . . . . .	1.6277 - 1.6282	41.34 - 41.36

DESCRIPTION

SIZE OF NEW PARTS		
	INCHES	MILLIMETERS
e. Outside diameter of connecting rod bushing. . . . .	1.8170 - 1.8202	46.15 - 46.23
f. Bearing bore (without bearing, cap in place, and nuts tightened to specified torque). . . . .	3.025 - 3.0255	76.84 - 76.85
g. Connecting rod bearing-to-crankshaft journal clearance (with nuts tightened to specified torque). . . . .	.0025 - .0050	.06 - .13
h. Connecting rod width at lower end. . . . .	1.744 - 1.746	44.30 - 44.35
i. Side clearance-to-crankshaft journal . . . . .	.004 - .010	.10 - .25
j. Piston pin diameter. . . . .	1.6265 - 1.6267	41.31 - 41.32
k. Piston pin bushing length in connecting rod. . . . .	1.552 - 1.572	39.42 - 39.93
l. Piston pin-to-connecting rod bushing clearance. . . . .	.001 - .0017	.03 - .04
m. Bore in connecting rod for piston pin bushing. . . . .	1.8120 - 1.8125	46.02 - 46.04
10. Exhaust Valves		
a. Valve lift (at valve) w/.018" lash . . . . .	.473	12.01
b. Valve lift (at cam). . . . .	.321	8.15
c. Seat angle . . . . .	30°	30°
d. Valve seat contact width . . . . .	Nominal .078 (5/64)	Nominal 1.98
e. Valve lash (cold). . . . .	.020	.51
f. Valve lash (engine coolant at normal operating temperature) . . . . .	.018	.46
g. Head diameter. . . . .	1.625	41.28
h. Overall length . . . . .	6.789 - 6.819	172.44 - 173.20
i. Stem diameter. . . . .	.3715 - .3720	9.44 - 9.45
j. Valve must be recessed (in head)		
Minimum . . . . .	.057	1.45
Maximum . . . . .	.081	2.06
11. Exhaust Valve Springs		
a. Valve spring free length . . . . .	2.765	70.23
b. Valve spring length (valve closed) . . . . .	2.312	58.72
c. Valve spring length (valve open) . . . . .	1.832	46.53
d. Spring load at 2.312 (58.72 mm) length . . . . .	57 - 64 lb	25.8 - 29.0 kg

DESCRIPTION

SIZE OF NEW PARTS		
	INCHES	MILLIMETERS
e. Spring load at 1.832 (46.53 mm) length. . . . .	136 - 146 lb	61.6 - 66.2 kg
NOTE: Install new spring when old spring is 5% below the low limit or 5% above the high limit.		
12. Intake Valves		
a. Valve lift (at valve) w/.018" lash. . . . .	.473	12.01
b. Valve lift (at cam) . . . . .	.321	8.15
c. Seat angle. . . . .	30°	30°
d. Valve seat contact width. . . . .	Nominal .078 (5/64)	Nominal 1.98
e. Valve lash (cold) . . . . .	.020	.51
f. Valve lash (engine coolant at normal operating temperatures) . . . . .	.018	.46
g. Head diameter . . . . .	1.850 - 1.860	46.99 - 47.24
h. Overall length. . . . .	6.796 - 6.811	172.62 - 173.00
i. Stem diameter . . . . .	.3722 - .3727	9.45 - 9.47
j. Valve must be recessed (in head)		
Minimum. . . . .	.043	1.09
Maximum. . . . .	.066	1.68
13. Intake Valve Inner Springs		
a. Valve spring free length. . . . .	2.625	66.68
b. Valve spring length (valve open). . . . .	1.578	40.08
c. Valve spring length (valve closed). . . . .	2.062	52.37
d. Spring load at 1.578 (40.08 mm) length. . . . .	66 - 72 lb	29.9 - 32.6 kg
e. Spring load at 2.062 (52.37 mm) length. . . . .	30 - 35 lb	13.6 - 15.8 kg
NOTE: Install new spring when old spring is 5% below the low limit or 5% above the high limit.		
14. Intake Valve Outer Springs		
a. Valve spring free length. . . . .	3.062	77.77
b. Valve spring length (valve open). . . . .	1.828	46.43
c. Valve spring length (valve closed). . . . .	2.312	58.72
d. Spring load at 1.828 (46.43 mm) length. . . . .	88 - 97 lb	39.9 - 43.9 kg

DESCRIPTION

SIZE OF NEW PARTS		
	INCHES	MILLIMETERS
e. Spring load at 2.312 (58.72 mm) length. . . . .	40 - 45 lb	18.1 - 20.4 kg
NOTE: Install new spring when old spring is 5% below the low limit or 5% above the high limit.		
15. Exhaust Valve Seat Inserts		
a. Seat angle. . . . .	30 <sup>0</sup>	30 <sup>0</sup>
b. Seat contact width. . . . .	Nominal .078 (5/64)	Nominal 1.98
c. Seat run-out. . . . .	.002	.05
d. Insert press fit. . . . .	.0020 - .0035	.05 - .09
e. Insert O.D. - not installed . . . . .	1.6445 - 1.6450	41.77 - 41.78
f. Bore in cylinder head for insert. . .	1.6415 - 1.6425	41.69 - 41.72
g. Oversize insert . . . . .	.005 over standard	.13 over standard
16. Intake Valve Seat Inserts		
a. Seat angle. . . . .	30 <sup>0</sup>	30 <sup>0</sup>
b. Seat width. . . . .	Nominal .078 (5/64)	Nominal 1.98
c. Seat run-out. . . . .	.002	.05
d. Insert press fit. . . . .	.002 - .004	.05 - .10
e. Insert O.D. - not installed . . . . .	1.8645 - 1.8655	47.36 - 47.38
f. Bore in cylinder head for insert. . .	1.8615 - 1.8625	47.28 - 47.31
g. Oversize insert . . . . .	.005 over standard	.13 over standard
17. Exhaust and Intake Valve Guides		
a. Length. . . . .	3.500	88.90
b. Inside diameter after assembly (reamer size) . . . . .	.375	9.53
c. Stem-to-guide clearance		
Exhaust. . . . .	.0023 - .0028	.06 - .07
Intake . . . . .	.0030 - .0035	.08 - .09
d. Guide stand-out from bottom of counterbore in cylinder head		
Exhaust. . . . .	1.062 (1-1/16)	26.97
Intake . . . . .	.875 (7/8)	22.23

DESCRIPTION

NOTE: Valve guides in new production and new factory service heads do not require reaming in the field. They are factory sized and checked with a straightness gauge of .37320 - .37324 (9.479 - 9.480 mm) diameter by 3.620 (91.95 mm) long which must pass through the installed guides. A Go Gauge of .37420 - .37424 (9.505 - 9.506 mm) diameter .500 (12.70 mm) long must pass 1.000 (25.40) into top of guide.

18. Rocker Arms

NOTE: Current type rocker arms do not have bushings.


- a. Bore in rocker arm for shaft - current type. . . . .
- b. O.D. of rocker arm shaft (current and early types). . . . .
- c. Rocker arm to shaft clearance - current type. . . . .
- d. Rocker arm ratio. . . . .
- e. Bore in rocker arm for bushing - early type. . . . .
- f. I.D. of rocker arm bushing - early type . . . . .
- g. Rocker arm to shaft clearance (early type . . . . .

19. Camshaft

- a. Number of bearings used. . . . .
- b. I.D. of camshaft bearings (installed) . . . . .
- c. I.D. of .010" (.25 mm) undersize camshaft bearing (installed) . . . . .
- d. O.D. of camshaft journals. . . . .
- e. Camshaft bearing-to-journal running clearance. . . . .
- f. O.D. of camshaft bearings. . . . .
- g. Bearing bore in cylinder block . . . . .
- h. Fit of camshaft bearings in bore of cylinder block. . . . .



SIZE OF NEW PARTS		
	INCHES	MILLIMETERS
	1.001 - 1.002	25.43 - 25.45
	.999 - 1.000	25.37 - 25.40
	.001 - .003	.03 - .08
	1.53:1	1.53:1
	1.061 - 1.062	26.95 - 26.97
	1.001 - 1.0015	25.43 - 25.44
	.001 - .0025	.03 - .06
	4	4
	2.2494 - 2.2520	57.13 - 57.20
	2.2394 - 2.2420	56.88 - 56.95
	2.2465 - 2.2475	31.66 - 31.69
	.0019 - .0055	.05 - .04
	2.5005 - 2.5015	63.51 - 63.54
	2.4975 - 2.4985	63.44 - 63.46
	.002 - .004 tight	.05 - .10 tight

DESCRIPTION

SIZE OF NEW PARTS		
	INCHES	MILLIMETERS
i. Overall width of camshaft bearings		
Front . . . . .	1.560 - 1.564	39.62 - 39.73
Intermediate . . . . .	.935 - .939	23.75 - 23.85
Rear . . . . .	1.0	25.40
j. Camshaft end play . . . . .	.003 - .010	.08 - .25
k. Camshaft gear width . . . . .	.6875 (11/16)	17.46
l. Fit of camshaft gear on camshaft. . .	.0012 - .0032 tight	.03 - .08 tight
m. Specified thickness of thrust collar.	.204 - .206	5.18 - 5.23
20. Valve Lifters and Valve Lifter Brackets		
a. Bore in valve lifter bracket for lifter. . . . .	.8127 - .8137	20.64 - 20.67
b. O.D. of valve lifter stem . . . . .	.8102 - .8107	20.58 - 20.59
c. Fit at valve lifter in bore of valve lifter bracket. . . . .	.002 - .0035	.05 - .09
21. Front Gear Train		
a. Backlash between mating gears . . . . .	.003 - .007	.08 - .18
22. Cylinder Head		
a. Valve sequence (front-to-rear in each head) . . . . .	Intake-Exhaust	Intake-Exhaust
23. Lubricating Oil Pressure Pump - Current Type 		
a. Radial clearance - gears-to-pump body	.002 - .0045	.05 - .11
b. End clearance - gear-to-pump body with gasket in place	.004 - .009	.10 - .23
c. I.D. of bore in body and cover for bushings	.9995 - 1.0005	25.39 - 25.41
d. O.D. of bushing	1.0025 - 1.0035	25.46 - 25.49
e. Fit of bushing to body and cover	.002 - .004 tight	.05 - .10
f. I.D. of bushing in body and cover after assembly	.873 - .875	22.17 - 22.22
g. O.D. of shafts	.8715 - .872	22.14 - 22.15
h. Clearance - shafts to bushings	.001 - .0035	.03 - .09
i. I.D. of bore in gears	.8695 - .8705	22.08 - 22.11
j. Fit of gears to shafts	.001 - .0025 tight	.03 - .06 tight
k. Distance of upper gear from end of shaft	1.107 - 1.112	28.12 - 28.24

DESCRIPTION

SIZE OF NEW PARTS

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
l. Distance of lower gear from end of shaft	.490 - .500	12.45 - 12.70
m. I.D. of bore in pump drive gear	.8695 - .8705	22.08 - 22.11
n. Fit of pump drive gear to shaft	.001 - .0025 tight	.03 - .06 tight
24. Lubricating Oil Pressure Pump - Early Type 		
a. Radial clearance - gears-to-pump body	.00175 - .00275	.04 - .07
b. End clearance - pump gears. . . . .	.002 - .004	.05 - .10
c. I.D. of gear shaft bushings (finished bore)		
Front cover. . . . .	1.2495 - 1.2505	31.74 - 31.76
Housing. . . . .	.937 - .938	23.80 - 23.83
d. Upper shaft O.D. at cover bushing location. . . . .	1.247 - 1.248	31.67 - 31.70
e. Upper shaft O.D. at housing bushing location. . . . .	.9350 - .9355	23.75 - 23.76
f. Clearance - upper shaft-to-shaft bushings		
Cover. . . . .	.0015 - .0035	.04 - .09
Housing. . . . .	.0015 - .0030	.04 - .08
g. I.D. of bore in cover and housing for lower shaft . . . . .	.7495 - .7505	19.04 - 19.06
h. Lower shaft O.D. . . . .	.7485 - .7490	19.01 - 19.02
i. Clearance - lower gear bushing-to-shaft . . . . .	.0005 - .0020	.01 - .05
25. Water Pump 		
a. Clearance between impeller and water pump body. . . . .	.015 - .072	.38 - 1.83
b. Front bearing		
Bearing bore (I.D. for shaft) . . . . .	.78725 - .78740	19.99 - 20.00
Shaft diameter. . . . .	.7871 - .7876	19.99 - 20.01
Fit - shaft to bearing . . . . .	.00035 tight-.0003 loose	.009 tight-.008 loose
Bearing O.D. . . . .	2.0470 - 2.0472	51.99 - 52.00
Bore in water pump body (for bearing). . . . .	2.0467 - 2.0477	51.99 - 52.01
Fit - bearing O.D. to body . . . . .	.0005 tight-.0007 loose	.01 tight-.02 loose
c. Rear bearing		
Bearing bore (I.D. for shaft) . . . . .	.78725 - .78740	19.99 - 20.00
Shaft diameter. . . . .	.7871 - .7876	19.99 - 20.01
Fit - shaft to bearing . . . . .	.00035 tight-.0003 loose	.009 tight-.008 loose
Bearing O.D. . . . .	1.8502 - 1.8504	46.99 - 47.00
Bore in water pump body (for bearing). . . . .	1.8499 - 1.8509	46.99 - 47.01
Fit - bearing O.D. to body . . . . .	.0005 tight - .0007 loose	.01 tight-.02 loose

DESCRIPTION

SIZE OF NEW PARTS

	INCHES	MILLIMETERS
d. Pulley driving flange bore . . . . .	.7856 - .7866	19.95 - 19.98
Fit - flange I.D. to shaft. . . . .	.0005 - .002 tight	.01 - .05 tight
e. Impeller		
Bore I.D. in impeller for shaft . . . . .	.6225 - .6235	15.81 - 15.84
Shaft diameter. . . . .	.6262 - .6267	15.91 - 15.92
Fit - shaft to impeller . . . . .	.0027-.0042 tight	.07 - .11 tight
26. Fan Hub Assembly		
a. Front bearing		
Bearing bore (I.D. for shaft) . . . . .	.98415 - .98430	24.99 - 25.00
Shaft diameter. . . . .	.9835 - .9840	24.98 - 24.99
Fit - shaft to bearing. . . . .	.00015-.0008 loose	.003-.020 loose
Bearing O.D. . . . .	2.0470 - 2.0472	51.99 - 52.00
Bore in hub (for bearing) . . . . .	2.0466 - 2.0476	51.98 - 52.01
Fit - bearing to hub. . . . .	.0006 loose-.0006 tight	.015 loose-.015 tight
b. Rear bearing		
Bearing bore (I.D. for shaft) . . . . .	1.18095 - 1.18110	29.99 - 30.00
Shaft diameter. . . . .	1.18030 - 1.18080	29.98 - 29.99
Fit - shaft to bearing. . . . .	.00015-.0008 loose	.003-.020 loose
Bearing O.D. . . . .	2.4407 - 2.4409	61.99 - 62.00
Bore in hub (for bearing) . . . . .	2.4403 - 2.4413	61.98 - 62.01
Fit - bearing to hub. . . . .	.0006 loose-.0006 tight	.015 loose-.015 tight
27. Auxiliary Drive Pulley (Front Housing Cover Mounted)		
Bearing bore (I.D. for shaft). . . . .	1.500" - 1.5005"	37.10 - 37.11
Shaft diameter . . . . .	1.5010" - 1.5015"	38.13 - 38.14
Fit - shaft to bearing . . . . .	.0005"- .0015" tight	0.01 - 0.04 tight
Bearing O.D. . . . .	2.5625" - 2.5635"	65.09 - 65.11
Bore in cover flange (for bearing) . . . . .	2.5635" - 2.5645"	65.11 - 65.14
Fit - bearing to cover flange . . . . .	.000"- .002" loose	0.00 - 0.05 tight
28. Auxiliary Fuel Transfer Pump Drive		
a. Shaft O.D. . . . .	.8095 - .8105	20.56 - 20.59
b. Burnished I.D. of gear in bushing. . . . .	.812 - .813	20.62 - 20.65
c. Clearance - shaft to bushing . . . . .	.0025 - .0035	.06 - .09
d. Bore I.D. in gear for bushing. . . . .	.937 - .938	23.80 - 23.82
e. O.D. of bushing. . . . .	.940 - .941	23.88 - 23.90
f. Fit of bushing in gear . . . . .	.002 - .004 tight	.05 - .10 tight
g. Thrust washer thickness. . . . .	.186 - .188	4.72 - .477
h. Gear end play after assembly . . . . .	.002 - .007	.05 - .18
29. Tachometer - Overspeed Governor - Cranking Limit Switch Drive Assembly		
a. Adaptor shaft O.D. . . . .	.3721 - .3726	9.45 - 9.60
b. Bushing I.D. installed . . . . .	.375 - .376	9.52 - 9.55
c. Clearance - shaft to bushing . . . . .	.0024 - .0039	.06 - .10
d. Bore in drive housing for bushing. . . . .	.624 - .625	15.85 - 15.87
e. Bushing O.D. . . . .	.626 - .627	15.90 - 15.92
f. Fit bushing to drive housing . . . . .	.001 - .003 tight	.05 - .08 tight
g. Adaptor shaft O.D. . . . .	.7480 - .7485	19.00 - 19.01
h. Bushing I.D. . . . .	.752 - .753	19.10 - 19.13
i. Clearance - shaft to bushing . . . . .	.0035 - .0050	.09 - .13
j. Thrust washer thickness. . . . .	.1225 - .1275	3.11 - 3.24
k. Gear end play. . . . .	.0005 - .0395	.01 - 1.00

B. BOLT, CAPSCREW, AND NUT TORQUE WRENCH SPECIFICATIONS

not be used where those listed in this table apply.

1. Specific Application Torque Values

The torque values tabulated below have been calculated for specific applications. SAE standard torque values must

NOTE: Torque values are in pound-feet and all torque values in this table are calculated for threads lubricated with engine oil.

ITEM	APPLICATION	SIZE AND THREAD	ENGLISH	METRIC
			TORQUE LB-FT	TORQUE Nm
Nut	Bearing Cap, Center Main	5/8-18	160-170	217-231
Capscrew	Bearing Cap, Center Main (4339036)	5/8-11	160-170	217-231
Capscrew	Bearing Cap, Center Main (4035387)	5/8-11	190	258
Nut	Bearing Cap, Front, Inter., and Rear Main	3/4-16	210-230	285-312
Capscrew	Bearing Cap, Front, Inter., and Rear Main	3/4-10	210-230	285-312
Capscrew	Connecting Rod Cap - Current - 12 point head	9/16-18	160	217
Capscrew	Connecting Rod Cap - Hex Socket Head	9/16-18	160	217
Nut	Connecting Rod Cap - Early	9/16-18	120-130	163-177
Capscrew	Crankshaft Pulley Retainer	1-1/4-12	290-310	393-421
Nut	Cylinder Head Cover Mounting	7/16-20 Nylok	10-15	14-20
Capscrew	Cylinder Head Mounting - Current	1/2-13	115	156
Capscrew	Cylinder Head Mounting - Current	5/8-11	185	251
Nut	Cylinder Head Mounting - Early	1/2-20	100	136
Nut	Cylinder Head Mounting - Early	5/8-18	185	251
Nut	Tube Support Bracket - Center of Heads - Current	1/2-20	50	68
Capscrew	Intake, Manifold Mounting	1/2-13	70	95
Capscrew	Exhaust Manifold Mounting - Current	1/2-13 Nylock	70	95
Nut	Exhaust Manifold Mounting - Early	1/2-13 Seez-Proof	45-50	61-68
Capscrew	Flywheel Mounting - Current - Socket Head	1/2-20	135	183
Bolt	Flywheel Mounting - Early - Place Bolt	1/2-20	95-105	129-143
Capscrew	Front Support Mounting	1/2-13	95-105	129-143
Nut	Fuel Injection Line Nozzle End	9/16-18	20-25	27-34
Capscrew	Fuel Injection Nozzle Holder Mounting	3/8-16	12-15	16-20
Nut	Intake Manifold Mounting	1/2-13	45-50	61-68
Nut	Oil Pump Drive Gear Retaining (Lock Type)	5/8-18	80	108
Bolt	Lube Oil Filter Center Bolt	1-14	45-50	61-68
Nut	Oil Pressure Regulator Screw Lock	3/4-16	125-135	170-183
Nut	Turbocharger Mounting	3/8-16 Stnls.	18-21	24-28
Bolt	Valve Lifter Cover Mounting	5/16-18	18-20	24-27
Nut	Water Pump Impeller Retainer	1/2-20	30-35	41-47
Nut	Water Pump Pulley Retainer	3/4-16	115	156
Locknut	Auxiliary Drive Pulley Flange Retaining	1-1/8-12	200-220	271-298

(Continued on next page)

2. Standard Torque Values

six marks, 60° apart. (See figures in table below.)

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,

CAUTION: The standard torque values tabulated above are for use when specific torque data is not available. Do not use these values in place of those specified elsewhere in this manual:

a. Grade 2 Capscrews



Capscrew Size	Grade 2			
	NC		NF	
Inches (")	English lb-ft	Metric Nm	English lb-ft	Metric Nm
1/4	5-7	7-9	6-8	8-11
5/16	11-13	15-18	13-15	18-20
3/8	18-21	24-28	19-22	26-30
7/16	30-33	41-45	32-35	43-47
1/2	45-50	61-68	45-50	61-68
9/16	60-65	81-88	60-65	81-88
5/8	75-85	102-115	75-85	102-115
3/4	125-135	170-183	125-135	170-183
7/8	105-115	143-156	105-115	143-156
1	155-165	211-224	140-150	190-204

b. Grade 5 Capscrews



Capscrew Size	Grade 5			
	NC		NF	
Inches (")	English lb-ft	Metric Nm	English lb-ft	METRIC Nm
1/4	9-11	12-15	11-13	15-18
5/16	18-20	24-27	21-23	28-31
3/8	28-33	38-45	30-35	41-47
7/16	44-49	60-66	50-55	68-75
1/2	68-73	92-99	68-73	92-99
9/16	95-105	129-143	95-105	129-143
5/8	125-135	170-183	125-135	170-183
3/4	210-230	285-312	210-230	285-312
7/8	290-310	393-421	290-310	393-421
1	420-450	569-610	380-410	515-556

c. Grade 8 Capscrews



Capscrew Size	Grade 8			
	NC		NF	
Inches (")	English lb-ft	Metric Nm	Metric Nm	Metric Nm
1/4	12-14	16-19	14-16	19-22
5/16	25-27	34-37	28-30	38-41
3/8	41-46	56-62	43-48	58-65
7/16	69-74	94-100	72-77	98-104
1/2	95-105	129-143	95-105	129-143
9/16	130-140	177-190	130-140	177-190
5/8	170-190	231-258	170-190	231-258
3/4	290-310	393-421	290-310	393-421
7/8	450-500	610-678	450-500	610-678
1	670-700	908-949	600-630	813-854

C. STUD GAUGE HEIGHTS AND DRIVING TORQUES

Stud Description	Stud Size					Gauge Height		Driving Torque*	
	Dia	Thread		Length		in.	mm	English lb-ft	Metric Nm
		Stud End	Nut End	in.	mm				
Cylinder Head to Block-Early	5/8"	11	18	6.531	165.89	5.343	135.71	45-120	61-163
Cylinder Head to Block-Early	1/2"	13	20	6.093	154.76	5.093	129.36	45-120	61-163
Cylinder Head to Block-Early	1/2"	13	20	7.250	174.15	6.312	160.32	45-120	61-163
Cylinder Head to Block-Early	1/2"	13	20	7.406	188.11	6.468	164.29	45-120	61-163
Fuel Pump Housing to Gear Housing	3/8"	16	24	1.500	38.10	0.937	23.80	10-37	14-50
Gear Cover to Housing to Block	1/2"	13	20	3.750	95.25	2.843	72.21	22-71	30-96
Manifold Intake and Exhaust to Cylinder Head	1/2"	13	13	2.125	53.98	1.375	34.93	22-71	30-96
Manifold to Turbocharger	3/8"	16	16	1.875	47.63	1.312	33.32	10-35	14-47
Nozzle Holder to Cylinder Head-Early	3/8"	16	24	1.937	49.20	1.437	36.50	10-35	14-47
Rocker Arm Shaft and Bracket to Cylinder Head-Early	3/8"	16	24	1.562	39.67	1.312	33.32	10-35	14-47
Rocker Arm Shaft and Bracket to Cylinder Head Cover	7/16"	20	20	2.687	68.25	2.062	52.37	14-45	19-61

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

## TOPIC 11. COOLING SYSTEM

### A. GENERAL

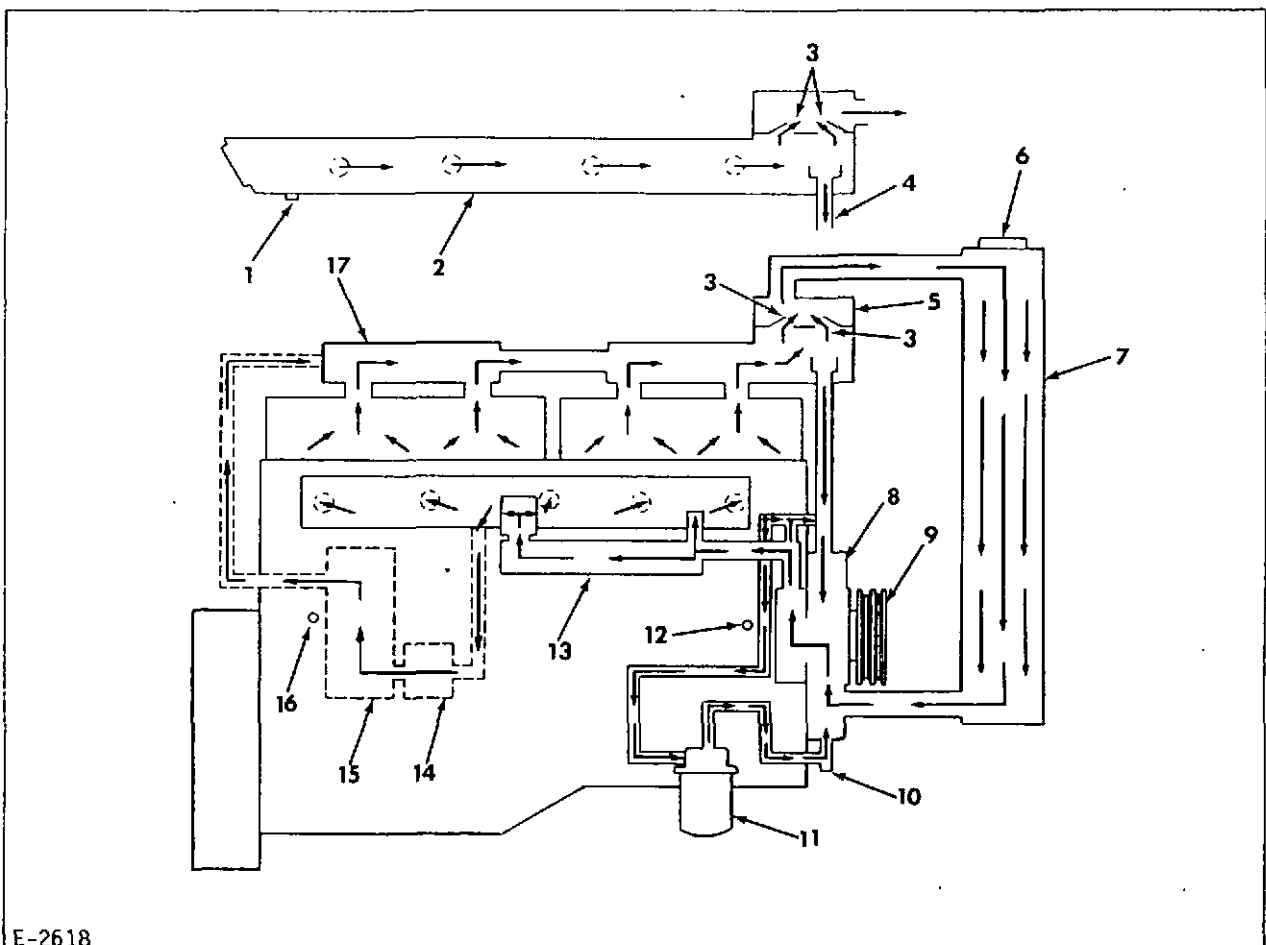
WARNING: THE COOLING SYSTEM IS PRESSURIZED. DO NOT REMOVE THE RADIATOR FILL CAP WHILE THE COOLANT TEMPERATURE EXCEEDS 200°F (366 K). THE SUDDEN RELEASE OF PRESSURE MAY CAUSE THE COOLANT TO BOIL. HOT COOLANT OR STEAM ESCAPING FROM THE SYSTEM MAY CAUSE INJURY.

Depending upon the optional cooling system components selected for a particular engine application, proper temperature of engine coolant is maintained by a radiator and fan combination, or by a heat exchanger and expansion tank. The most commonly used system

is the radiator and fan combination. If the heat exchanger and expansion tank cooling system is utilized, the owner must supply ample raw water.

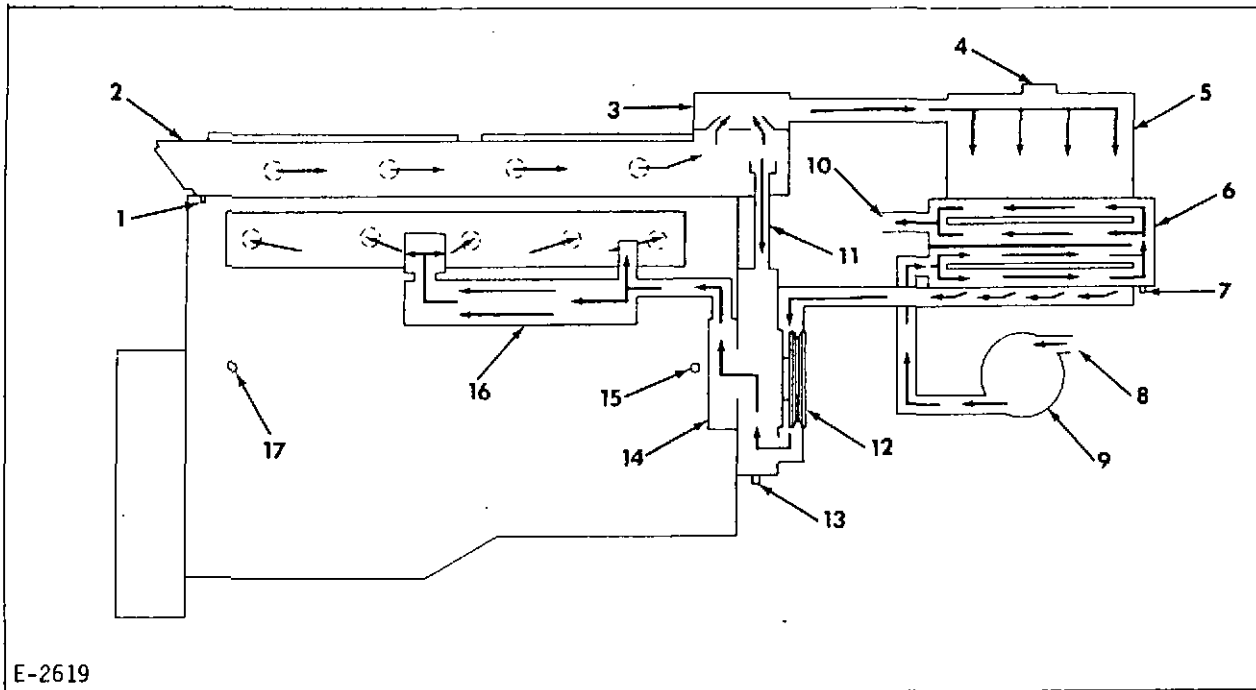
In addition to the major components mentioned above, the engine cooling system also includes a water pump, water inlet manifold, water outlet manifold, thermostats, engine oil cooler, coolant passages in cylinder block and heads, plus coolant temperature gauge, coolant filter, and a water cooled exhaust manifold.

The function of the cooling system is to prevent temperatures in the cylinder combustion chambers from damaging the engine and at the same time keep operating temperatures within



- |   |                      |                                 |
|---|----------------------|---------------------------------|
| 1. Drain cock                                   | 7. Radiator          | 13. Engine oil cooler           |
| 2. Water cooled exhaust manifold                | 8. Water pump        | 14. Immersion heater (optional) |
| 3. Thermostat                                   | 9. Water pump pulley | thermostat                      |
| 4. Bypass pipe                                  | 10. Drain cock       | 15. Immersion heater            |
| 5. Thermostat housing cover                     | 11. Coolant filter   | 16. Drain cock                  |
| 6. Pressure cap (7 psi) (48 kN/m <sup>2</sup> ) | 12. Drain cock       | 17. Water outlet manifold       |

Figure 1. Cooling System Schematic



- |   |                         |                  |
|---|-------------------------|------------------|
| 1. Drain cock                                   | 7. Drain cock           | 13. Drain cock   |
| 2. Water cooled exhaust manifold                | 8. Raw water pump inlet | 14. Coolant pump |
| 3. Thermostat cover                             | 9. Raw water pump       | 15. Drain cock   |
| 4. Pressure cap (7 psi) (48 kN/m <sup>2</sup> ) | 10. Raw water outlet    | 16. Oil cooler   |
| 5. Expansion tank                               | 11. Bypass tube         | 17. Drain cock   |
| 6. Dual pass heat exchanger                     | 12. Coolant pump pulley |                  |

Figure 2. Cooling System Schematic Diagram (Heat Exchanger Type)

safe limits.

Proper maintenance of the cooling system is important. Engine temperature must be brought up to and maintained within a specific range for efficient operation, and engine must be kept from overheating in order to prevent damage to valves, pistons, and bearings.

The cooling system is pressurized by a 7 psi (48 kN/m<sup>2</sup>) pressure cap. By pressurizing the system, the normal boiling point of 212°F (373 K) of clean water at sea level is raised approximately 3°F per psi (0.24 K per kN/m<sup>2</sup>). Consequently, coolant in the system at sea level will not boil until a temperature of 212°F (373 K), plus 21°F (12 K), or a total of 233°F (385 K) is reached. Temperatures above this figure will cause loss of coolant and result in engine overheating. Altitude effects 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. (0.83 K per 304.8 m) altitude, from 233°F (385 K), the boiling point established with a 7 psi (48 kN/m<sup>2</sup>) pressure cap at sea level.

**IMPORTANT:** The engine thermostats begin to open at 180°F (355 K) and are fully open at 200°F (366 K). 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 or expansion tank should be checked.

Both the radiator and fan, and heat exchanger and expansion tank type cooling systems utilize a coolant filler cap of the pressure type. A double-acting valve in the cap relieves 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 cap turned on tightly at all times to prevent loss of pressure.



anticipated temperature.

The engine operates most efficiently when coolant temperature is 180°F (355 K) 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 180°F (355 K) the thermostat should be removed, checked for proper operation, and replaced if necessary.

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 heat exchanger is provided with a square head zinc pencil located in each end bonnet (Fig 6). Whenever sea water is used in the raw water system, the zinc pencils should be inspected every 100 hours of operation and replaced when over fifty percent disintegrated.

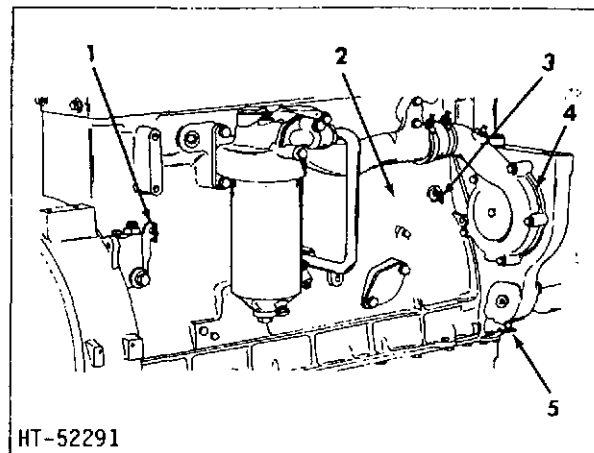
After each 600 hours interval of operation, apply one or two shots of grease in fitting in water pump housing (Fig 23 Item 4).

**CAUTION:** Do not overgrease water pump bearings.

#### E. DRAINING OF COOLING SYSTEM

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

1. If engine is installed in portable type equipment, make certain it is in a level position to assure complete draining.
2. Remove radiator or expansion tank cap.
3. Open vent cocks located in thermostat housing cover (Fig 3).
4. Open drain cocks located on the right-hand side of the cylinder block (Fig 4).
5. Open drain cock at bottom of timing gear housing below the water inlet to the water pump (Fig 4).
6. Open drain cock located in bottom of



- |                   |               |
|-------------------|---------------|
| 1. Drain cock     | 4. Water pump |
| 2. Cylinder block | 5. Drain cock |
| 3. Drain cock     |               |

Figure 4. Cylinder Block And Water Pump Drain Cocks

radiator, if applicable.

7. If applicable, open drain cock or plug at rear of water-cooled exhaust manifold (Fig 5).
8. Leave coolant filter shut-off valves open. If current type (Fig 23) remove filter. If early type (Fig 24) remove drain plug from bottom of filter.
9. If applicable, open drain cock in end bonnet of the expansion tank to drain raw water (Fig 6).
10. If engine is equipped with raw water pump, loosen end cover screws and end cover to drain raw water from pump.

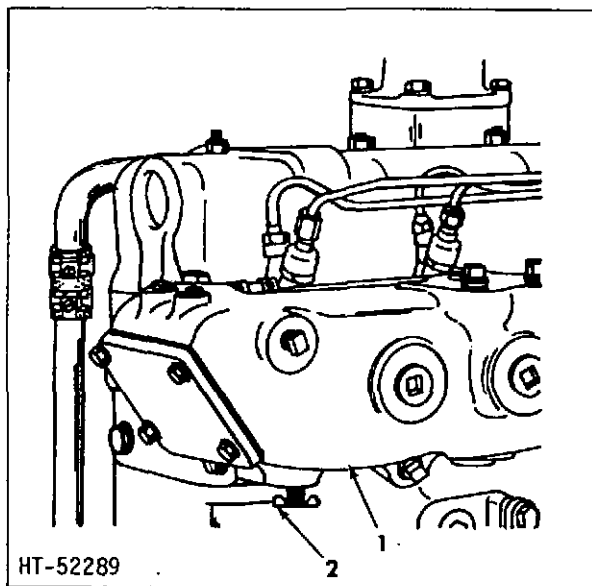
**NOTE:** Be sure to tighten cover screws before starting engine.

11. If applicable, open air compressor coolant drain cock.

#### F. FILLING OF COOLING SYSTEM

1. Install coolant filter or filter drain plug.
2. Close all drain cocks that were opened to drain system in Paragraph E in this Topic.

**CAUTION:** If applicable, tighten raw water pump cover retaining screws before filling cooling system.



1. Water cooled exhaust manifold
2. Drain cock

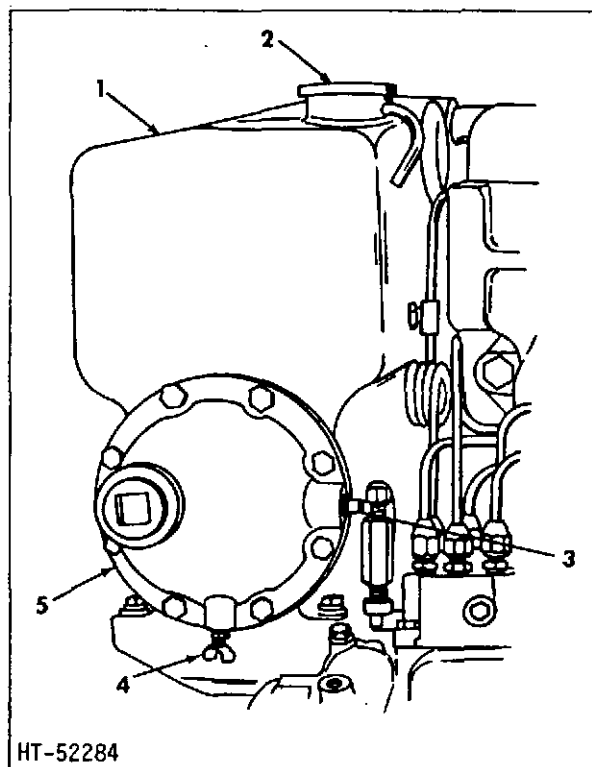
Figure 5. Drain Cock Location (Water Cooled Exhaust Manifold)

3. Check to assure vent cocks in thermostat housing are open.
4. Pour coolant into radiator or expansion tank until it flows from vent cocks.
5. Close vent cocks and continue filling until coolant level is approximately 1-1/2 in. (38 mm) below bottom of filler neck.
6. Install filler cap.

**NOTE:** Operate the engine for a period of time at normal operating temperature to vent all air from the system. Check the level of the coolant in the radiator or expansion tank and if necessary, add coolant to bring it up to the proper level.

#### G. 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 and scale.
2. If engine is provided with a coolant filter that has been properly maintained, cleaning of system should not be necessary. However, the coolant filter's



1. Expansion tank
2. Pressure cap
3. Zinc pencil
4. Drain cock
5. End bonnet

Figure 6. Drain Cock Location (Expansion Tank)

effectiveness is only as good as the maintenance it receives. If inspection reveals coolant to be a brown and rusty color, drain, flush, and refill cooling system; replace coolant filter element.

3. Many good solvents are on the market for cleaning of cooling systems; use according to manufacturer's instructions.

**CAUTION:** Do not mix antifreeze compounds or inhibitors with any cleaning, neutralizing, or flushing compounds.

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

5. Some current oil coolers and radiators are being manufactured with aluminum fins. A few cleaning solutions have been found to react with aluminum to the extent of dissolving the metal.
6. We recommend a trichloroethane type solvent or equivalent be used for both internal and external cleaning of oil coolers and radiators used in Allis-Chalmers units since there is no reaction between the aluminum and the solvent.

**CAUTION:** Trichloroethane is toxic and very volatile. Use only in a well ventilated room or area. Do not inhale the fumes for any length of time.

7. In all cleaning operations care should be taken in the selection of cleaning materials. When any doubt exists as to whether or not caustic compounds would damage the materials to be cleaned, the use of such compounds should be avoided.
8. 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 (35 or 41 kN/m<sup>2</sup>) pressure when flushing. Excessive pressure may rupture radiator.

9. Keep radiator air passages free of debris and other obstructions. Clean exterior with an air blast carrying a grease solvent. 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. Do not clean with gasoline, fuel oil, or kerosene.

10. Before putting cleaning solvent in radiator, close coolant filter inlet and outlet shutoff valves (Fig 23).

After the cooling system has been cleaned and flushed, open coolant filter shutoff valves. Install new coolant filter. Fill cooling system to proper level. Inspect entire system for coolant leaks. Correct any leaks found to avoid foaming, corrosion, and loss of coolant.

#### H. THERMOSTATS

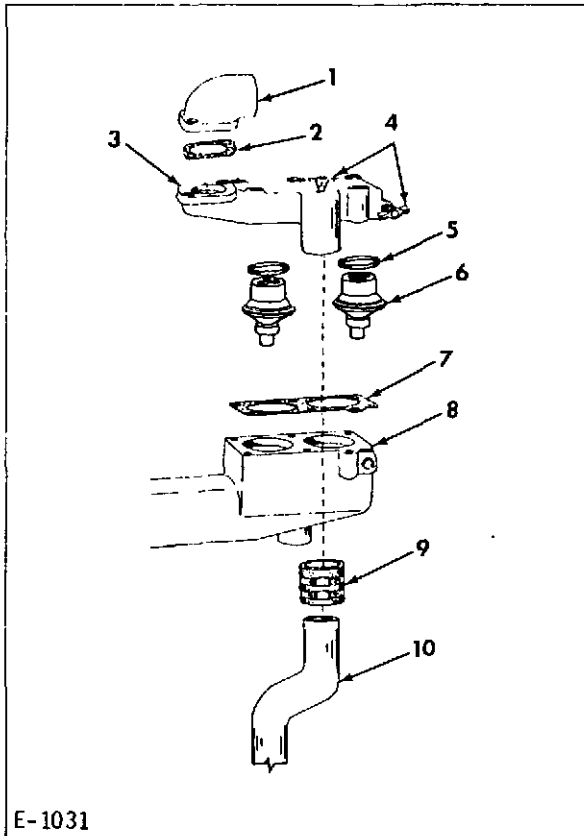
Current models of engines are equipped with two "bypass" type thermostats that begin to open at 180°F (355 K). The thermostats are located in the thermostat housing cover and water outlet manifold, at the front of the engine (Fig 7). They are so positioned in the system that when closed, coolant flow from the engine to the radiator is completely shut off. Coolant is then directed from the engine through the water bypass tube to the inlet side of the water pump, then back through the engine circulating system. When coolant temperature reaches 180°F (355 K) the thermostat starts to open allowing coolant to pass to the radiator or heat exchanger for a reduction in its temperature.

Early engine models had two thermostats (Fig 8) of the "full choke" type. One thermostat begins to open at 170°F (350 K); the other thermostat begins to open at 180°F (335K). It makes no difference in their operation which thermostat is in the front or rear openings in the water outlet manifold.

Operation of the engine when coolant temperature is below normal operating temperature will result in incomplete fuel combustion, higher fuel consumption with less power, and cause harmful deposits to form within the engine. Maintenance of normal coolant operating temperature depends on properly functioning thermostats. Replacement of the thermostats is necessary when the thermostats become corroded, sticking in the open or closed position. If the engine overheats or does not reach and maintain minimum operating temperature, the thermostats should be removed and tested as a possible cause of trouble.

##### 1. Thermostat Removal

- a. Drain cooling system (refer to preceding Paragraph E).
- b. If applicable, loosen water bypass pipe upper hose clamp to facilitate removal of thermostat housing cover (Fig 7).
- c. Remove the capscrews from the water outlet elbow and remove the elbow



- |                       |                                |
|-----------------------|--------------------------------|
| 1. Water outlet elbow | 6. Thermostat                  |
| 2. Gasket             | 7. Gasket                      |
| 3. Thermostat housing | 8. Front water outlet manifold |
| 4. Vent cocks         | 9. Hose with clamps            |
| 5. Thermostat seal    | 10. Bypass pipe                |

Figure 7. Thermostats (Current Type)

and gasket.

- d. Remove the thermostat housing cover from the water outlet manifold. Remove the thermostats and gasket from their positions on the water outlet manifold.
- e. Clean and inspect the thermostat housing cover and examine the gasket and seals; replace the gasket or seals if necessary.

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

## 2. Thermostat Testing

- a. Suspend the thermostat to be tested

in a pan of clean water so it is completely immersed but not touching bottom of container.

- b. Gradually heat the water and use a reliable thermometer to check water temperature.

NOTE: Stir water during heating so heat is evenly distributed in the volume of water.

- c. Observe the thermometer and note temperature at which the current engine thermostat starts to open and at which it is fully open. The amount of travel between open and closed positions must be a minimum of 0.310" (7.87 mm).

NOTE: The early engine 170°F (350 K) thermostat is designed to start opening at 170°F (350 K) and be fully open at 185°F (358 K). The 180°F (355 K) thermostat is designed to start opening at 180°F (355 K) and be fully open at 200°F (366 K). The amount of travel between the open and closed positions must be a minimum of 0.310" (7.87 mm).

- d. Thermostats are not adjustable. If they do not operate within the above limits they must be replaced.

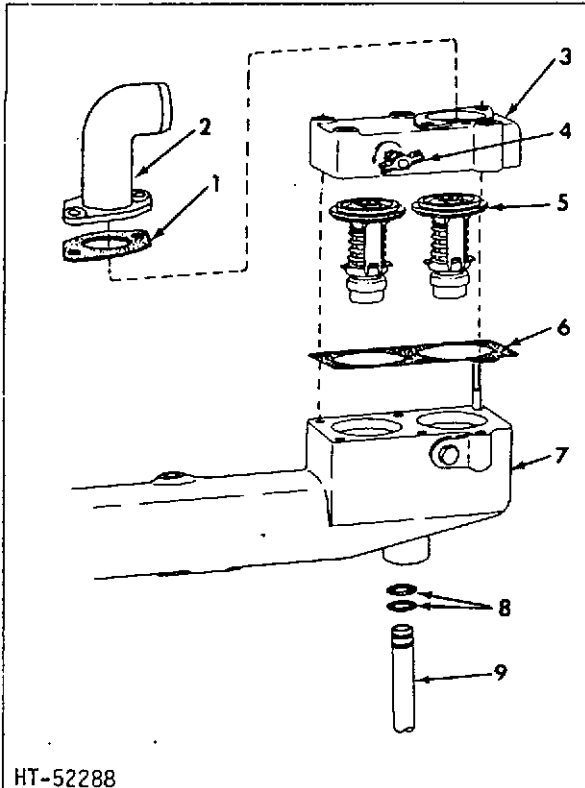
## 3. Thermostat Installation

- a. Place a gasket in position on the water outlet manifold and install the thermostats.
- b. Position thermostat housing cover on water outlet manifold and secure with capscrews and lockwashers. If applicable, connect bypass pipe to thermostat housing cover with hose and clamps. Tighten hose clamps securely.
- c. Install water outlet elbow and gasket on top of thermostat housing cover with capscrews and lockwashers.
- d. Fill the cooling system (refer to preceding Paragraph F).

## I. FAN, FAN HUB, FAN BELTS AND BELT ADJUSTMENT

### 1. General

The fan pushes or pulls (according to the type fan used) air through the radiator and the engine coolant is cooled as it circulates from the top to the bottom of the radiator core. The fan hub assembly is mounted on a bracket which is bolted



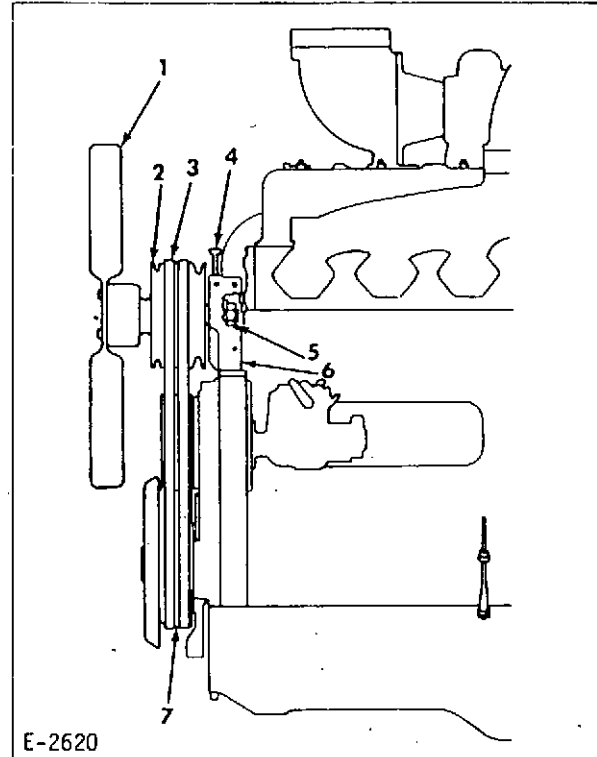
1. Gasket
2. Water outlet elbow
3. Thermostat housing cover
4. Vent cock
5. Thermostat
6. Gasket
7. Front water outlet manifold
8. O-rings
9. Bypass tube

Figure 8. Thermostats (Early Type)

to the front of the engine cylinder block. The fan is bolted to the fan hub assembly, which rotates on two ball bearings, and is driven by two matched drive belts from the crankshaft pulley.

The original fan driving belts supplied on the engine are a matched pair of identical length. If only one belt replacement is required, it is imperative that both belts are replaced with a matched pair, otherwise satisfactory belt life will not be obtained.

It is important that the fan drive belts, which also drive the water pump, are inspected frequently to make certain no oil or grease has accumulated on them, and that proper belt tension is maintained. Replace badly worn, burned, oil/grease soaked belts.



1. Fan
2. Fan hub
3. Belts
4. Adjusting screw
5. Locknut
6. Bracket
7. Crankshaft pulley

Figure 9. Belt Adjustment

## 2. Belt Replacement And Adjustment

Replace fan drive belts as follows:

- a. Remove battery charging generator drive belt.
- b. Loosen locknut at rear of the fan hub spindle (shaft) so spindle can be moved in slot of the fan hub mounting bracket.
- c. An adjustment screw passes through the bracket top and a tapped hole in the hub spindle, and bottoms in the lower part of the bracket slot. Lower the hub by turning the adjustment screw counterclockwise.
- d. Remove both old belts. Inspect belts for slickness, oil soak, wear, tears, cracks, and overstretching. Replace both belts if either is defective.
- e. Position belts on pulley grooves.

- f. Raise the hub and adjust proper tension of belts by turning the adjustment screw clockwise.
- g. After proper adjustment is obtained, tighten the spindle locknut securely.
- h. Install battery charging generator drive belt. Adjust belt according to the instruction in Topic 14.

Check and adjust fan drive belts as follows:

- a. Check tension of each drive belt using a Burroughs Tension Gauge (BT-33-72C) or equivalent. New drive belts are installed with a tension of 143-150 pounds (65-68 kg). Belts must be retightened whenever tension drops to 100 pounds (45 kg). Always retighten belts to 118-124 pounds (54-56 kg).
- b. After replacement, approximately 24 hours operating time is required to properly seat a new pair of belts.

**NOTE:** If a belt tension gauge is not available to check the belt tension, it may be done by hand. The fan and water pump drive belts are correctly adjusted when belts can be depressed (by hand) approximately .50 in. (12.7 mm) to .75 in. (19.05 mm) halfway between the crankshaft pulley and water pump pulley. Adjust belts when slippage is evident.

### 3. Fan Hub Lubrication

Bearings in the fan hub must be lubricated at prescribed intervals with a pressure type lubricant. For ease of accessibility and balance, the fan hub is equipped with two fittings.

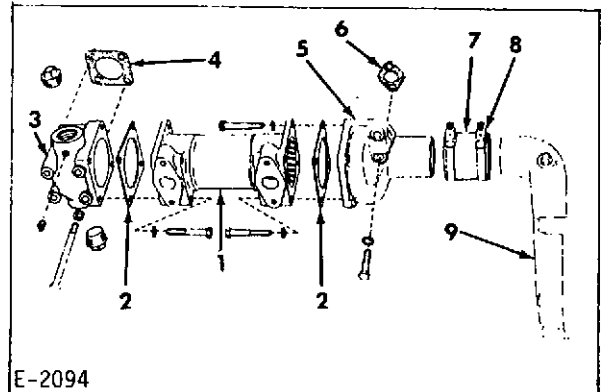
**CAUTION:** Do not overgrease the fan hub bearings.

After each 600 hour interval of operation, apply one or two shots of grease with a low pressure, hand operated grease gun in either of the two fittings.

## J. ENGINE OIL COOLER

### 1. General

The engine oil cooler is located on the right side of the engine and consists of a corrosion resistant core and jacket.



- |                            |                           |
|----------------------------|---------------------------|
| 1. Oil cooler              | 5. Connection-water inlet |
| 2. Gasket                  | 6. Gasket                 |
| 3. Connection-water outlet | 7. Hose                   |
| 4. Gasket                  | 8. Clamp                  |
|                            | 9. Water pump             |

Figure 10. Water Inlet Manifold and Lube Oil Cooler

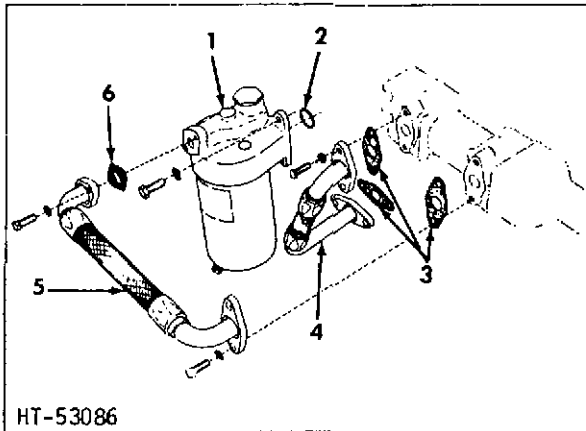
Coolant is circulated through the cooling core tubes and engine lubricating oil is circulated around the tubes. The coolant absorbs heat from the oil, thereby controlling the oil temperature.

**CAUTION:** It is important that the oil cooler be kept clean and free of deposits in order to maintain proper cooling.

The cooling core consists of small tubes which transfer the heat from the oil to the engine coolant. If the recommended maintenance and lubrication is not performed at the indicated interval, deposits may form in the oil cooler and restrict the flow of oil or coolant. Restriction of the flow of oil is usually indicated by a drop in oil pressure and a rise in oil temperature.

### 2. Oil Cooler Removal And Disassembly

- a. Drain the cooling system.
- b. Loosen clamps on water pump hose and push hose toward water pump (Fig 10).
- c. Remove capscrews and lockwashers securing oil inlet and outlet hoses to oil cooler. Remove inlet and outlet hoses from oil cooler (Fig 11).
- d. Remove capscrews and lockwashers securing oil cooler connections to the cylinder block (Fig 10).
- e. Remove oil cooler from engine.



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1. Oil filter
2. O-ring
3. Gaskets
4. Oil outlet hose (cooler to block)
5. Oil inlet hose (filter to cooler)
6. Gasket

Figure 11. Oiler Cooler Inlet and Outlet Hoses

- f. Remove capscrews and lockwashers securing oil cooler connections to the oil cooler. Remove the connections and gaskets.

### 3. Oil Cooler Cleaning

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

**NOTE:** If oil cooler core is badly clogged, a new oil cooler core must be installed.

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

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

**CAUTION:** Trichloroethane is toxic and very volatile. Use only in a well ventilated room or area. Do not inhale the fumes for any length of time.

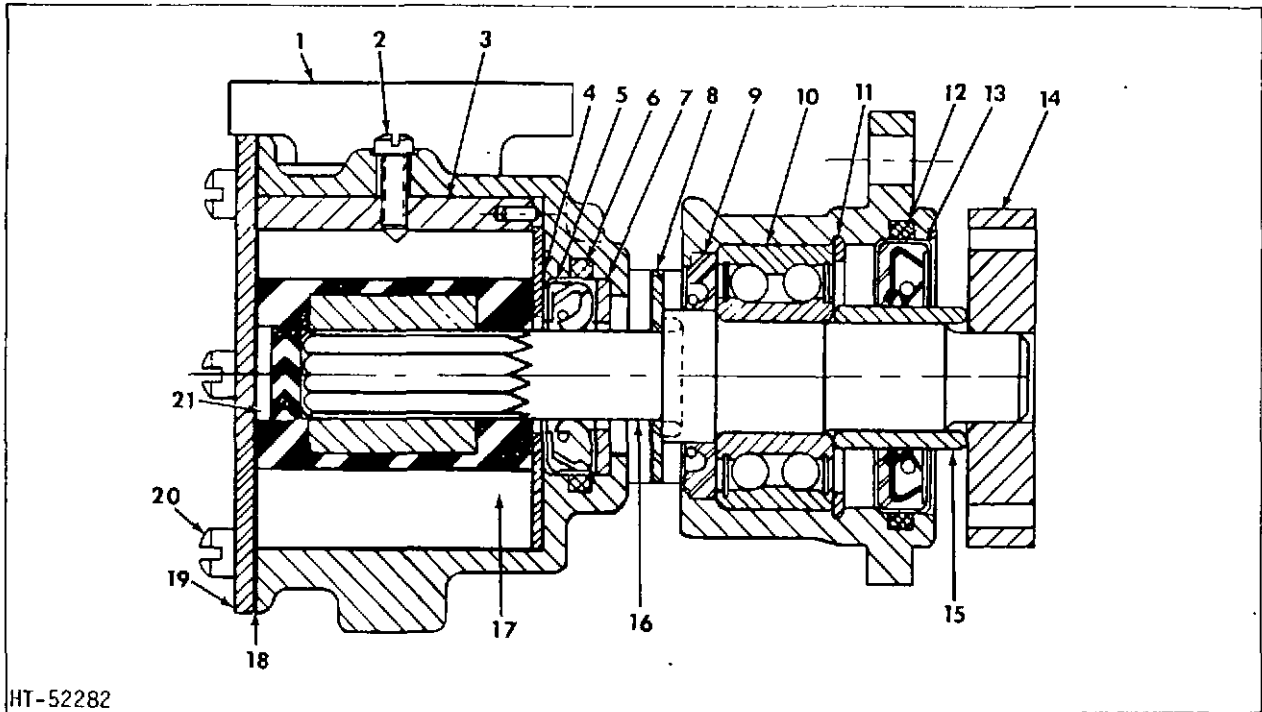
### 4. Oil Cooler Testing

Before testing the oil cooler, it must be cleaned thoroughly and inspected. To test the oil cooler, proceed as follows:

- a. Make up two suitable improvised plates, one with a drilled and tapped hole to accept an air hose fitting, and secure them with gaskets, capscrews, and lockwashers to cover the oil inlet and outlet openings in the side of the oil cooler.
- b. Attach an air hose to the drilled and tapped plate; submerge the oil cooler in hot water for a sufficient length of time until the oil cooler is up to approximately 150°F (339 K) temperature. Test for leaks with air pressure of 100 psi (689 kN/m<sup>2</sup>) or as near to that pressure as possible.
- c. Air bubbles observed at either open end of the oil cooler indicates that the cooler core has a puncture or may be defective in another way. If the cooling core is faulty, the oil cooler must be replaced. If repair of the shell is necessary, the repair should be made by a reputable radiator repair shop.

### 5. Oil Cooler Assembly And Installation

- a. Cement new gaskets to ends of oil cooler core, install connections on core and secure with capscrews and lockwashers.
- b. Using new gaskets install oil cooler, securing inlet and outlet water connections to the cylinder block with capscrews and lockwashers.
- c. Using new gaskets, secure the oil inlet and outlet hoses to the oil cooler with capscrews and lockwashers (Fig 8).
- d. Install water pump hose and secure with clamps.
- e. Fill the cooling system.
- f. Operate the engine and check for oil and water leaks at the oil cooler connections. Correct any leaks found.



- |                       |                        |
|-----------------------|------------------------|
| 1. Pump body          | 12. O-ring             |
| 2. Cam screw          | 13. Bearing outer seal |
| 3. Cam                | 14. Drive coupling     |
| 4. Wear plate         | 15. Shaft sleeve       |
| 5. Shaft seal         | 16. Shaft              |
| 6. O-ring             | 17. Impeller           |
| 7. Seal spacer        | 18. Gasket             |
| 8. Slinger            | 19. End cover          |
| 9. Bearing inner seal | 20. End cover screw    |
| 10. Bearing           | 21. Impeller plug      |
| 11. Retaining ring    |                        |

Figure 12. Raw Water Pump Assembly

- g. Stop engine and check oil level in oil pan; add oil necessary to raise level to the full mark on oil level gauge (dipstick).
- h. Check coolant level and add coolant if necessary.

K. RAW WATER PUMP, BELT ADJUSTMENT, AND BELT REPLACEMENT

1. General

The raw water pump (Fig 12) is of bronze construction, self-priming, with a neoprene compound impeller and sealed bearings. Because the pump is of the self-priming type, it is necessary that all lines on the suction side of the pump are kept tight, otherwise it will not pick up its prime. The pump depends upon the water it pumps for lubrication of the impeller.

CAUTION: The impeller will burn if the pump is run dry for longer than the time normally required for the pump to prime itself.

In freezing weather the pump should be drained to prevent damage. In order to drain the pump, it is necessary to loosen the pump end cover; do so by turning out the cover screws and jarring the cover loose.

Whenever an engine is equipped with an expansion tank and raw water pump, the engine water pump is driven from the crankshaft pulley by a V-type belt. For longer belt life, it must be kept free of oil and grease and adjusted to the proper tension. It should be inspected periodically for cracks and other signs of deterioration.

## 2. Impeller and Shaft Seal Replacement

If the impeller or shaft seal is damaged, a field repair can be made by replacing the parts, following the procedure listed below:

- a. Remove end cover screws, end cover and gasket.
- b. Remove impeller plug.
- c. Remove impeller by grabbing it with two pairs of pliers and pulling it from the pump body and shaft.
- d. Remove cam screw securing the cam and remove cam and wear plate.
- e. Using a hooked wire, remove the shaft seal. Remove O-ring and seal spacer.
- f. Lubricate inside of pump body with engine oil and install seal spacer, O-ring, and shaft seal.
- g. Apply Permatex on top surface of cam, backface of cam and cam screw. Install wear plate and cam.

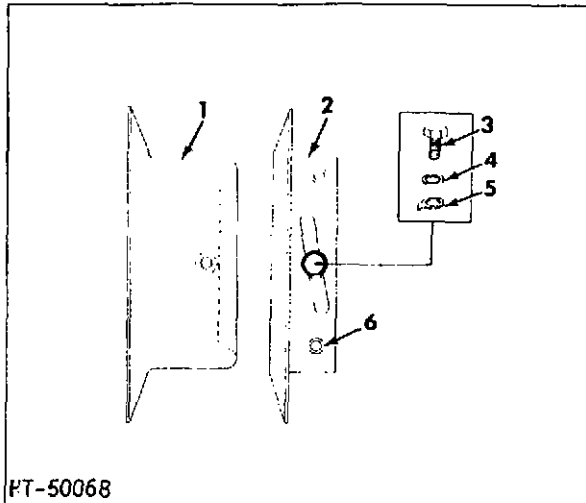
**NOTE:** When wear plate shows signs of wear, reverse or replace it.

- h. Lubricate impeller bore with light coat of Marfak 2 HD or equivalent and start impeller onto shaft with a rotary motion until splines engage, then push into pump bore.
- i. Install impeller plug, new gasket, and end cover securing with end cover screws.

## 3. Belt Adjustment

Check tension of drive belt using a *Burroughs Tension Gauge (BT-33-72C)* or equivalent. New drive belt is installed with a tension of 143-150 pounds (65-68 kg). Belt must be retightened whenever tension drops to 100 pounds (45 kg). Always retighten belt to 118-124 pounds (54-56 kg).

The means for adjusting the belt tension is provided in the construction of the adjustable - pitch water pump pulley (Fig 12). The pulley consists of two parts, the front and rear halves. The rear half is secured to the water pump shaft. The front half has diagonal slots and is secured to the rear half with lug washers, lockwashers and capscrews. With the capscrews loosened, the front half can be turned separately to vary the distance between the sides of the belt



- |               |                         |
|---------------|-------------------------|
| 1. Rear half  | 4. Lockwasher           |
| 2. Front half | 5. Lug washer           |
| 3. Capscrew   | 6. 5/16" (7.94 mm) hole |

Figure 13. Water Pump Pulley  
(Adjustable - Pitch)

groove. By narrowing the distance, the belt rides higher (faster to the outside of the groove) on the pulley and belt tension is therefore increased.

**NOTE:** If a belt tension gauge is not available to check the belt tension, it may be done by hand. The belt is correctly adjusted when belt can be depressed (by hand) approximately .50 in (12.7 mm) to .75 in (19.05 mm) halfway between the crankshaft pulley and water pump pulley. Adjust belt when slippage is evident.

Adjust the belt as follows:

- a. Loosen the three capscrews securing the front half of the pulley.
- b. To tighten the belt, hold the rear half of the pulley stationary and turn the front half to the right (clockwise).

**NOTE:** If the front half cannot be turned by hand, insert the end of a metal rod in one of the three 5/16" (7.94 mm) holes and tap on the side of the rod near its inserted end with a hammer.

- c. Adjust the front half of the pulley until proper belt tension is obtained.
- d. Tighten the capscrews securely.

NOTE: Make certain there is no excessive run-out of adjustable half of pulley and belt, otherwise belt and pulley must be readjusted. This can be corrected by loosening one of the three adjusting capscrews when it is positioned to the outside of the engine. Bar engine over until pulley turns one complete revolution; then tighten capscrew securely. Repeat this operation for the remaining adjusting capscrews one at a time.

#### 4. Belt Replacement (Figure 14)

To replace water pump belt without removing raw water pump and pump mounting bracket, proceed as follows:

- a. Loosen and back off capscrews with lockwashers securing flexible coupling between raw water pump drive coupling and water pump adaptor. Bar the engine over for access to the capscrews.
- b. Remove laminated shim and flexible coupling with the capscrews in the coupling.
- c. Remove capscrews and lockwashers securing water pump adaptor to water pump hub spacer and remove water pump adaptor.
- d. Remove capscrews, lockwashers, and lug washer (Fig 13) from adjustable pulley. With rear half of pulley on spacer pilot diameter, slide adjustable half off of rear half and remove it from the engine.

NOTE: It may be necessary to scrape some paint to facilitate removal of the adjustable half of the pulley from the rear half.

- e. Slide rear half of pulley off of spacer pilot diameter. Slide belt off of rear half of pulley. Position rear half of pulley back on spacer pilot diameter. Remove belt through the bottom opening and remove belt from crankshaft pulley.

NOTE: It is necessary to remove the generator drive belt from the crankshaft pulley before removing the water pump belt.

- f. Install new belt in proper groove of crankshaft pulley and on rear half of water pump pulley. Position rear half of pulley on spacer pilot diameter after belt is installed on pulleys.

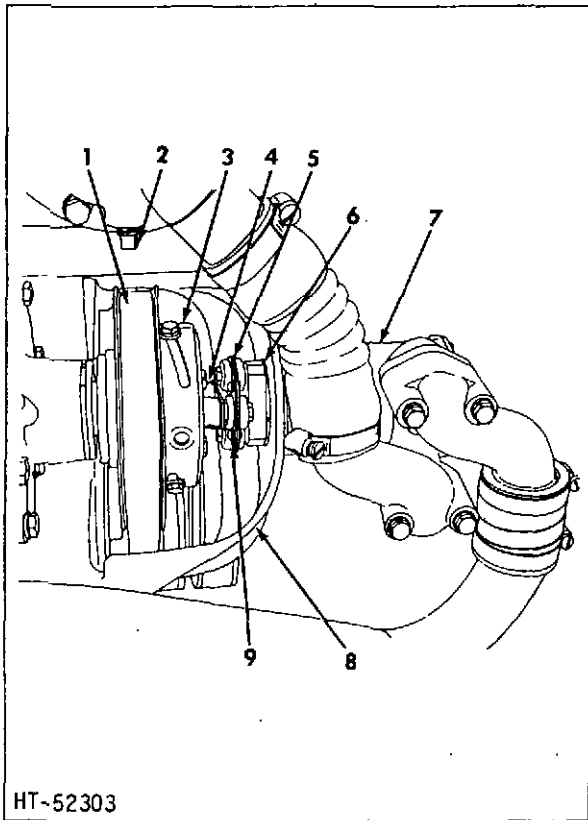
- g. With rear half of pulley on the pilot install the adjustable half of pulley onto the rear half.
- h. Install the water pump adaptor and secure the pulley and adaptor with capscrews and lockwashers.
- i. Install the capscrews, lockwashers, and lug washers securing the adjustable half of the pulley. This can be accomplished by pressing the two halves of the pulley together at the crankshaft pulley side (refer to Item 8, Fig 15). Line up the slot (at its lowest adjustment point) with the threaded hole and install the capscrews one at a time, repositioning the pulley after each capscrew is installed. Make certain the lug washers and capscrews are positioned so that the belt tension is completely relaxed.
- j. Adjust the belt to proper tension. Refer to Belt Adjustment, Item 3 above.

NOTE: With pulley capscrews loosened, the belt can be adjusted by inserting the end of a pry bar between the bosses of the water pump adaptor and pulling pry bar downward. However, it may be necessary to hold crankshaft pulley stationary with a socket on the crankshaft pulley retaining nut and a long handle to achieve proper belt tension.

- k. After proper belt adjustment is obtained, tighten pulley capscrews securely.

NOTE: Make certain there is no excessive run-out of adjustable half of pulley and belt, otherwise belt and pulley must be readjusted. This can be corrected by loosening one of three adjusting capscrews when it is positioned to the outside of the engine. Bar engine over until pulley turns one complete revolution; then tighten capscrew securely. Repeat this operation for the remaining adjusting capscrews one at a time.

- l. With the lockwashers and capscrews inserted in the flexible coupling, position the flexible coupling between the water pump adaptor and the raw water pump drive coupling. Place a screwdriver between the head of the capscrew and the adaptor to get the capscrew started. Tighten the capscrews securely in the threaded holes of the raw water pump drive coupling.



HT-52303

1. Water pump drive belt
2. Zinc pencil
3. Water pump pulley (adjustable - pitch)
4. Water pump adaptor
5. Flexible coupling
6. Raw water pump drive coupling
7. Raw water pump
8. Pump mounting bracket
9. Laminated shim

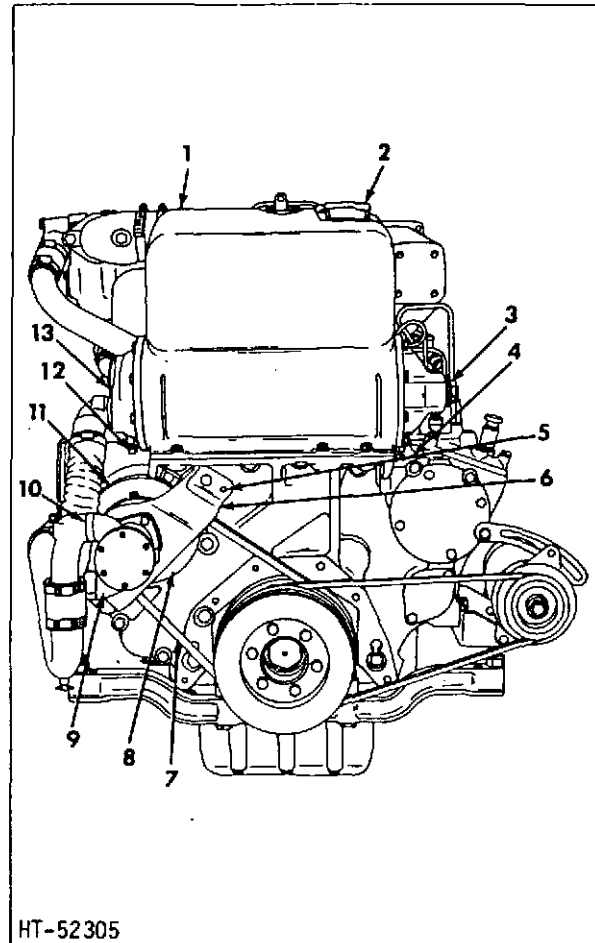
Figure 14. Raw Water Pump Installed

- m. Position laminated shim between water pump adaptor bosses and flexible coupling. Line up the holes and install capscrews securing the flexible coupling to water pump adaptor. Tighten capscrews alternately and securely.

NOTE: It may be necessary to bar the engine over to facilitate installation of the capscrews into the water pump adaptor.

#### 5. Emergency Split-Type Belt Replacement

To reduce the time required to replace

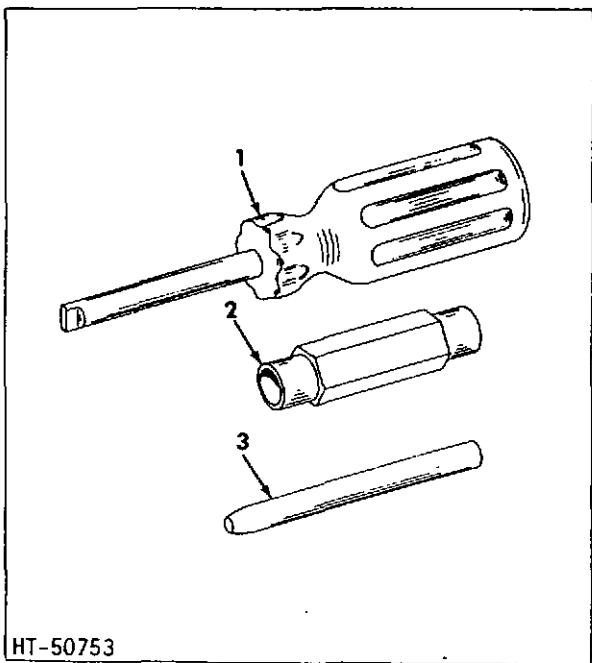


HT-52305

1. Expansion tank
2. Pressure cap (7 psi) (48 kN/m<sup>2</sup>)
3. End bonnet
4. Drain cock
5. Dowel pin
6. Pump mounting bracket
7. Water pump drive belt
8. Position where pulley halves can be pressed together and adjusting capscrews installed one at a time.
9. Raw water pump
10. Raw water inlet
11. Water pump pulley
12. Zinc pencil
13. Inlet end bonnet

Figure 15. Expansion Tank and Raw Water Pump

the water pump belt under emergency conditions, a split-type belt is available from Allis-Chalmers dealers. A tool kit is available to facilitate the installation of the belt (Fig 16) and a spare parts kit (Fig 17) is available to replace the possible loss of any of the loose parts.



HT-50753

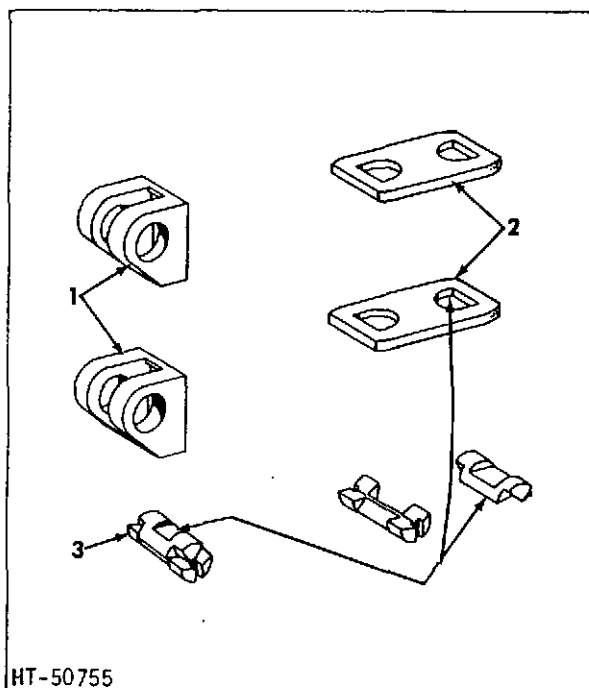
1. Rocker pin tool
2. Plastic sleeve
3. Alignment pin

Figure 16. Rocker Pin Tool Kit

**CAUTION:** This belt is to be used for emergency only and not as a direct replacement for permanent duty. Replacement with the standard endless type belt should be made as it is possible.

Replace belt as follows:

- a. Loosen capscrews securing the front half of the adjustable-pitch pulley so that the belt is at its lowest possible position and giving as much slack as possible for the installation of the emergency belt.
- b. Cut the old belt in two and remove it from the crankshaft and water pump pulleys.
- c. Separate one end of the emergency split-type belt from the fastener by using the rocker pin tool to turn the screwdriver slot in the fastener one half turn; push the rocker pin through and withdraw the rocker pin tool. The belt may now be separated.



HT-50755

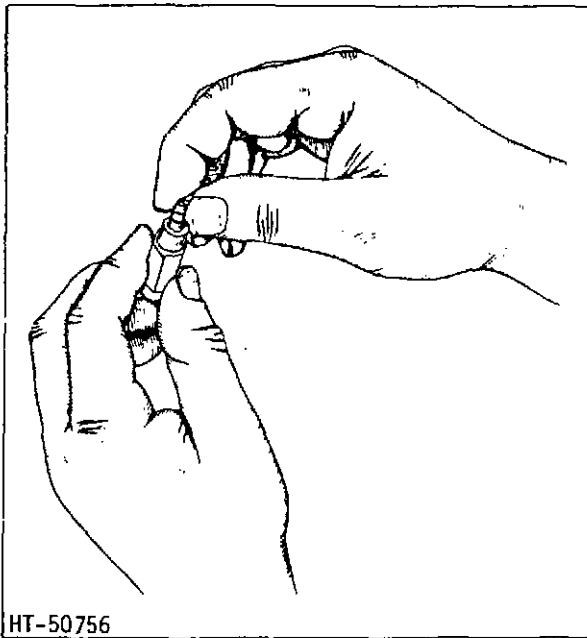
1. Bushings
2. Links
3. Rocker pin

Figure 17. Spare Parts Kit

d. Prior to installing belt on the crankshaft and water pump pulley grooves, insert the rocker pin into the rocker pin tool sleeve as follows:

- (1) Assemble the rocker pin into the plastic sleeve as shown in Figure 18.
  - (2) Place alignment pin and rocker pin tool into sleeve with the assembled rocker pin in position between them as indicated in Figure 19.
- e. Thread belt into position on crankshaft and water pump pulley grooves.
  - f. Bring the end of the belt into position in the fastener and insert the tool assembly into the fastener bushing, capturing the link on the alignment pin (Fig 19). When the front end of the tool sleeve is against the fastener bushing, force the rocker pin into position with a slight twisting motion.

**CAUTION:** When the rocker pin is forced into position in the fastener, the tool alignment pin will fall out of fastener. Do not allow the tool alignment pin to fall into any of the engine components.



HT-50756

Figure 18. Assembling Rocker Pin Into Plastic Sleeve

- g. Turn the rocker pin slots with the screwdriver type rocker pin tool until the slots are parallel with the direction of belt travel and away from belt ends as shown in Figure 20.
- h. Adjust belt to proper tension. Refer to preceding Subparagraph 3, Belt Adjustment.

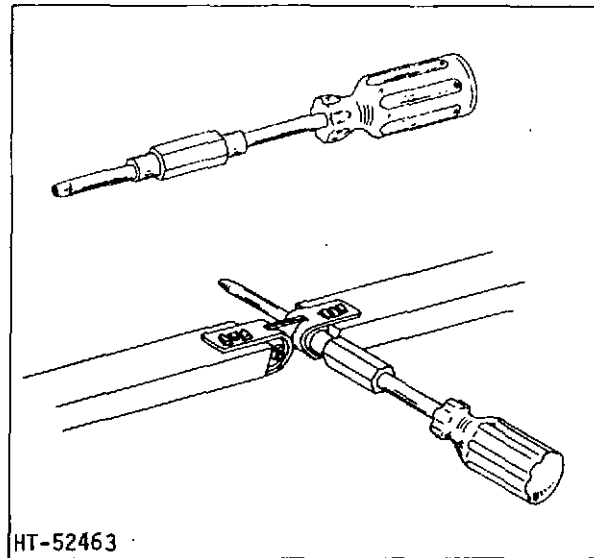
#### L. IMMERSION HEATER AND THERMOSTAT (OPTIONAL)

##### 1. General (Figs 21 and 22)

**CAUTION:** The heater does not eliminate the use of antifreeze.

The immersion heater operates on the thermosiphon principle of heating the coolant and circulating it through the cooling system. A pulsating valve located in the water inlet of the heater bottom casting assists the circulation. A safety thermostat located on the top casting is connected into the wiring circuit to prevent damage from overheating. Operating current for the immersion heater must be 120 volt, 60 Hertz, single-phase alternating current and connected by the contractor.

**NOTE:** As a convenience and safety factor, it is recommended a switch be provided between the thermostat and the power source to de-energize the immersion heater



HT-52463

Figure 19. Tool Kit Assembled and Inserting Alignment Pin

**NOTE (cont):** and thermostat whenever the coolant is drained from the engine cooling system, or when personnel are working around the engine.

The temperature control thermostat is designed to control the temperature of the coolant. It contains a single-pole, double-throw control of which only one set of contacts are utilized. The control is quick to respond to temperature changes because of the low mass bimetal actuator which assures accurate temperature regulation. The thermostat is equipped with a positive snap action switch to assure a long life of trouble-free service. If thermostat becomes faulty, it must be replaced as an assembly.

The temperature control thermostat is suspended by the coolant hoses and hose clamps. With the thermostat in position, the coolant passing through the thermostat must reach the temperature set on the dial (80°F to 140°F) (300 to 333 K) before the unit will automatically shut off. When the coolant passing through the thermostat cools down 7° to 15°F (4 to 8 K) below the setting on the dial, the thermostat automatically resets and the coolant is heated again.

##### 2. Operating And Maintenance

- a. Before applying current to the heater for the first time, be sure:

- (1) The air has been bled from the cooling system.

- (2) The radiator is full.
- (3) All hose connections are tight.
- b. If the cylinder block remains cold, and both the inlet and outlet hoses to the immersion heater are hot, it indicates lack of circulation caused by:

- (1) Trapped air preventing siphoning action.
- (2) Water too low in radiator.

**CAUTION:** Never use a glycol solution stronger than the mixtures recommended for each particular brand.

- (3) Antifreeze solution too strong.
- (4) Frozen coolant.
- c. When the heater is operating properly, the lower inlet hose will be warm.
- d. If the radiator gets warm before the engine block has warmed, a faulty engine thermostat may be the cause.
- e. At least once a year or every 2000 hours of operation, whichever occurs first, disassemble the immersion heater unit in order to inspect and clean all scale and foreign matter from the components.

Corrosion, sludge, and scale affect the efficient operation of the immersion heater:

- (1) Corrosion is caused by the mineral content in the water.
- (2) Sludge is caused by impurities in the cooling system.
- (3) Scale is caused by the combination of heat and impurities in the

**CAUTION:** Screw driver slots of the rocker pins must be parallel with the direction of belt travel and away from belt end as shown.



HT-50752

Figure 20. Rocker Pins Properly Aligned In Fastener

cooling system.

### 3. Troubleshooting

- a. If the heater has been working satisfactorily for a length of time and then fails, the following items should be checked:

- (1) Electric wiring. Make sure current is supplied to the heater.
- (2) Coolant level in the radiator. Level may be too low.
- (3) Condition of coolant. Coolant may have been frozen or in a mushy condition when current was furnished to the heater.
- (4) Air in system. Cooling system may have been drained, refilled, but not vented.
- (5) Sediment in the system. A layer of sediment in the bottom of the heater may have clogged the lower inlet.

- b. If temperature control thermostat or heater element is suspected of being inoperative, perform the following checks:

- (1) Remove temperature control thermostat cover. Place the leads of a 120-volt test lamp across #2 and #4 terminals of thermostat. Test lamp will light

if circuit to thermostat is energized.

- (2) Increase temperature dial to its highest setting so thermostat contacts close. Place test lamp leads across #1 and #4 thermostat terminals. If test lamp lights, thermostat is operating properly to energize the heater circuit.
- (3) Remove terminal cover from heater top casting. Place test lamp leads across element terminals. If test lamp lights and top outlet hose is cold, the element must be replaced. If test lamp does not light, place test lamp leads against element terminal where the lead from the safety control thermostat is connected and against the safety thermostat terminal where the lead from the control thermostat is soldered. If test lamp lights, the safety thermostat or the short lead between the safety thermostat and the element terminal requires replacement. Move the test lamp lead that was against the safety thermostat terminal and place it against the other terminal of the safety thermostat. If test lamp does not light, the safety thermostat must be replaced. If test lamp does light, the short lead between the safety thermostat and the element terminal must be replaced.

- (4) Return thermostat temperature dial to its normal setting.

- c. If circulation is prevented by an air lock or other obstruction, the thermostat will trip. After the heater has cooled, the thermostat will reset automatically. However, if the reason for overheating is not corrected, the engine block will remain cold even though the heater is hot.

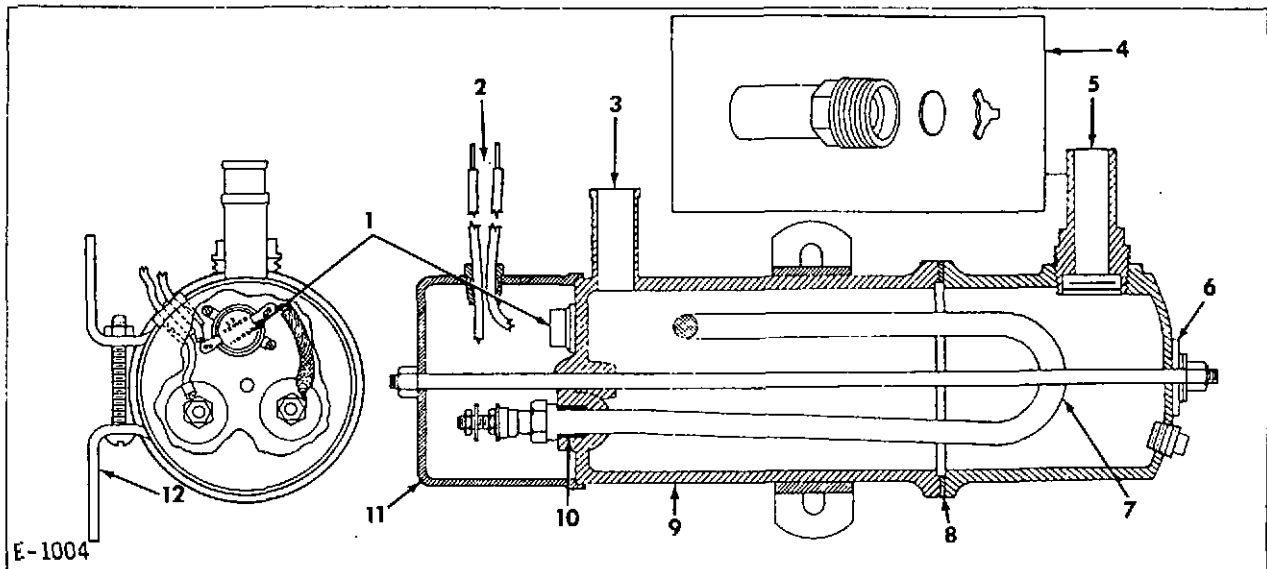
#### 4. Immersion Heater And Thermostat Removal

**CAUTION:** Disconnect power source from immersion heater thermostat.

- a. Drain the cooling system.
- b. Remove cover from temperature control thermostat.
- c. Tag and disconnect all electrical leads from thermostat to facilitate removal of it. Remove leads and clamps from thermostat.
- d. Loosen hose clamps, remove thermostat

inlet and outlet connections from hoses, and remove control thermostat.

- e. Loosen hose clamps and remove hoses from immersion heater outlet and inlet connections.
  - f. Remove nuts, lockwashers, washers, and capscrews that secure immersion heater to mounting bracket and remove immersion heater.
  - g. Remove water inlet and outlet tube assemblies.
- #### 5. Immersion Heater Disassembly And Assembly
- a. Remove nut from top of heater and remove terminal cover from top casting.
  - b. Remove screws that secure snap-acting type safety thermostat to top casting. Remove electrical leads from heater element terminals. If safety thermostat is to be replaced, disconnect electrical leads from it. Solder end of leads to new safety thermostat terminals.
  - c. Remove nut, washer, and lead seal washer from bottom heater and remove bottom casting and gasket. Do not pry the two castings apart. If necessary, break gasket seal by tapping heater sharply on the edge of a wooden block.
  - d. Unscrew and remove coolant inlet valve assembly from bottom casting (Fig 21). If pulsating valve does not operate freely in the coolant inlet tube, it must be replaced as an assembly.
  - e. Remove nuts, washers, procelain sleeves, rubber washers, and compression nuts from ends of element. Twist element slightly at the lower end to loosen it and remove it from the top casting.
  - f. Remove element seals from top casting with a sharp pointed tool such as an ice pick. Be careful not to damage the threads.
  - g. Insert new silicone rubber seals into top casting and also start compression nuts in slightly but do not tighten them.
  - h. Insert element through seals and compression nuts until the steel sheath of the element ends is showing above the compression nuts. Then tighten the compression nuts firmly.



- |                                      |                  |                          |
|--------------------------------------|------------------|--------------------------|
| 1. Safety thermostat                 | 5. Coolant inlet | 9. Top casting           |
| 2. To temperature control thermostat | 6. Lead washer   | 10. Silicone rubber seal |
| 3. Coolant outlet                    | 7. Element       | 11. Terminal cover       |
| 4. Pulsating valve in coolant inlet  | 8. Gasket        | 12. Bracket              |

Figure 21. Immersion Heater

- i. Use a new gasket and lead seal washer and complete the assembly of the immersion heater by a direct reversal of the disassembly procedure.

#### 6. Inspection

**WARNING: TRICHLOROETHANE SOLVENT IS TOXIC AND VERY VOLATILE. USE ONLY IN A WELL VENTILATED ROOM OR AREA. DO NOT INHALE FUMES FOR AN EXTENDED LENGTH OF TIME.**

- a. Inspect immersion heater components and thermostat for corrosion, sludge and scale. If necessary, clean with trichloroethane and a wire brush.
  - b. Inspect hoses for deterioration or damage. Replace if necessary.
- #### 7. Immersion Heater And Thermostat Installation
- a. Install immersion heater and thermostat by a direct reversal of the removal procedure as detailed under preceding Subparagraph 4.
  - b. Connect power source to immersion heater thermostat and repeat procedure in Subparagraph 2, before applying current to the heater.

#### M. COOLING SYSTEM FILTER

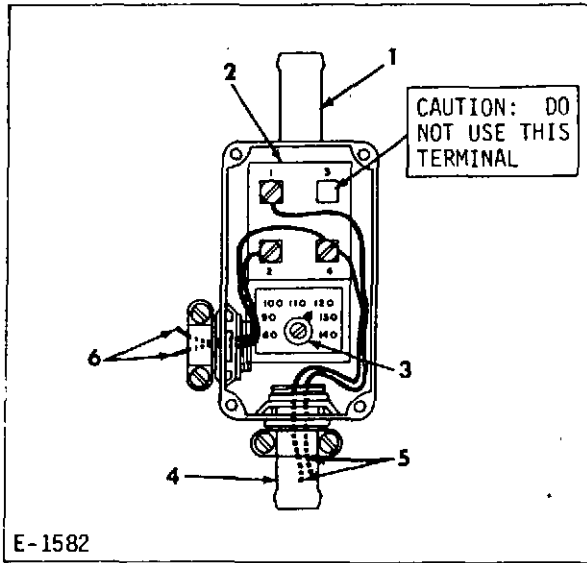
##### 1. General

The cooling system filter is of two types, the current spin-on type (Fig 23) and the former replaceable element type (Fig 24).

Both types of filters function in the same manner, to extend engine life by establishing and maintaining a rust, scale, and corrosion free cooling system. The filter header or housing must make a good ground with the engine for the cooling system filter to operate properly.

The piping connecting the filter into the engine cooling system is fitted with coolant inlet and outlet shutoff valves. The valves are closed when an engine is shipped from the factory and must be opened after it is installed in a unit. Also, the valves are closed when renewing a filter or element to prevent the loss of engine coolant.

The type of water filter or element in a new engine is an all purpose type and can be used with plain water and all types of permanent and non-permanent antifreezes, with the exception of Dowtherm 209. Refer to Parts Manual for the element to be used with Dowtherm 209.



- |                     |                        |
|---------------------|------------------------|
| 1. Coolant inlet    | 4. Coolant outlet      |
| 2. Terminal block   | 5. To immersion heater |
| 3. Temperature dial | 6. To AC source        |

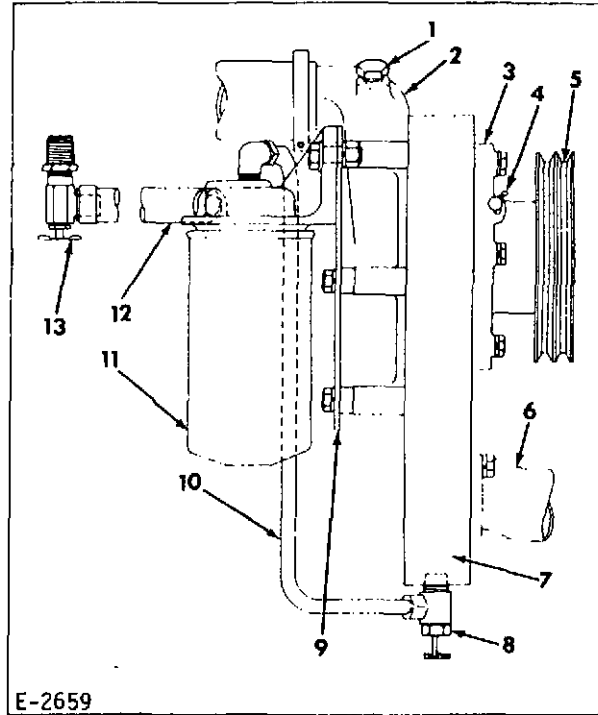
Figure 22. Immersion Heater Thermostat

**CAUTION:** Whenever element is changed from one type element to the other, it is necessary to drain and flush the cooling system.

The coolant filter performs the following functions:

- By mechanical filtration, it removes suspended foreign material which may be circulating through the cooling system.
- It prevents precipitation of water hardness scale on all cooling system surfaces by the ion exchange method of water softening.
- The chemicals present in the water conditioner element protect against corrosion activity in the engine.
- Electrolytic control is accomplished by the use of a sacrificial plate.
- The natural tendency toward rust formation and chemical deterioration of cooling system metal surfaces is reduced by the effective buffering agents contained in the element.

**CAUTION:** Do not use soluble oil or other conditioners in the cooling system of an engine equipped with a coolant filter. If a leak stopper is added to the cool-



1. Filter inlet shutoff valve
2. Water pump volute
3. Water pump
4. Grease fitting
5. Water pump drive pulley
6. Water pump inlet
7. Timing gear housing
8. Filter outlet shut-off valve
9. Mounting bracket
10. Filter outlet tube
11. Filter
12. Filter inlet hose
13. Filter inlet shut-off valve

Figure 23. Coolant Filter-Spin-on Type

**CAUTION (cont):** ant, do not allow it to circulate through the water filter. Shut-off valves are provided in inlet and outlet lines for isolating the water from remainder of cooling system.

## 2. Maintenance

The all-purpose type element or filter should be replaced each 600 to 800 hours. The chromate-type element or filter used with Dowtherm 209 antifreeze should be replaced each 300 to 500 hours. Maintain the coolant filter as follows:

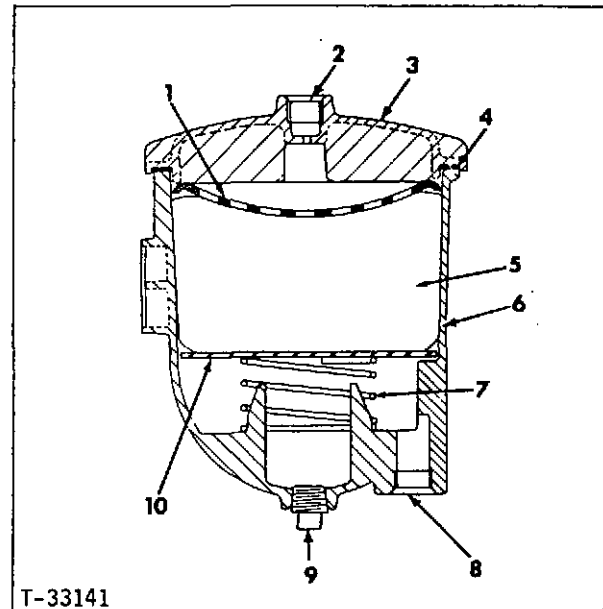
**NOTE:** Whenever all the liquid in the cooling system is replaced with new coolant, the first filter must be replaced after 100 hours of operation.

a. Spin-on Type Filter (Figure 23)

- (1) Thoroughly clean base and surrounding area.
- (2) Close coolant inlet and outlet shut-off valves.
- (3) Remove exhausted spin-on element and discard.
- (4) Lubricate gasket with a thin film of oil.
- (5) Install element until gasket contacts base of mounting housing.
- (6) Hand tighten 1/2 turn more.
- (7) Open inlet and outlet shutoff valves.
- (8) Operate engine and check for leaks.

b. Replaceable Element Filter (Figure 24)

- (1) Thoroughly clean the filter body and surrounding area. Close the inlet and outlet shutoff valves.
- (2) Remove drain plug from the bottom of filter body and allow coolant to drain.
- (3) Remove capscrews attaching filter cover to filter body; remove cover and gasket.
- (4) Lift the upper plate and filter element out of the filter body.
- (5) Discard the filter element and cover gasket.
- (6) Remove the lower corrosion resistor plate and spring from the filter body.
- (7) Clean sump area in filter body.
- (8) Install the spring and a new lower corrosion resistor plate (included in filter element service kit).
- (9) Install a new filter element in the filter body.
- (10) Install a new upper plate in filter body.
- (11) Install a new cover gasket. Then, install the filter cover and secure it with attaching capscrews.
- (12) Replace the drain plug and open the inlet and outlet shutoff valves.



- |                |                                    |
|----------------|------------------------------------|
| 1. Upper plate | 6. Body                            |
| 2. Outlet      | 7. Spring                          |
| 3. Cover       | 8. Inlet                           |
| 4. Gasket      | 9. Drain plug                      |
| 5. Element     | 10. Lower corrosion resistor plate |

Figure 24. Coolant Filter - Replaceable Element Type

- (13) Operate engine and check for leaks.

3. Removal and Installation of Filter Assembly

- a. Close coolant filter inlet and outlet shutoff valves.
- b. Remove outlet hose from top of filter and water pump inlet.
- c. Remove inlet hose from side of filter and water pump volute.
- d. Remove lockwashers, washers and capscrews that secure coolant filter to its mounting bracket.
- e. Remove hose fittings from inlet and outlet of coolant filter.
- f. Inspect inlet and outlet hoses for deterioration or damage. Replace if necessary.
- g. Install hoses fittings in coolant filter inlet and outlet openings.
- h. Install coolant filter and secure with capscrews, washers, and lockwashers.

NOTE: Make certain filter header or body makes a clean, tight, metal-to-metal contact with the engine, otherwise connect a ground wire between them.

- i. Install hoses on fittings and tighten hose securely.

- j. Install new coolant filter element.
- k. Open coolant filter inlet and outlet shutoff valves.
- l. Check coolant level; add coolant if necessary.
- m. Operate engine and check for leaks.

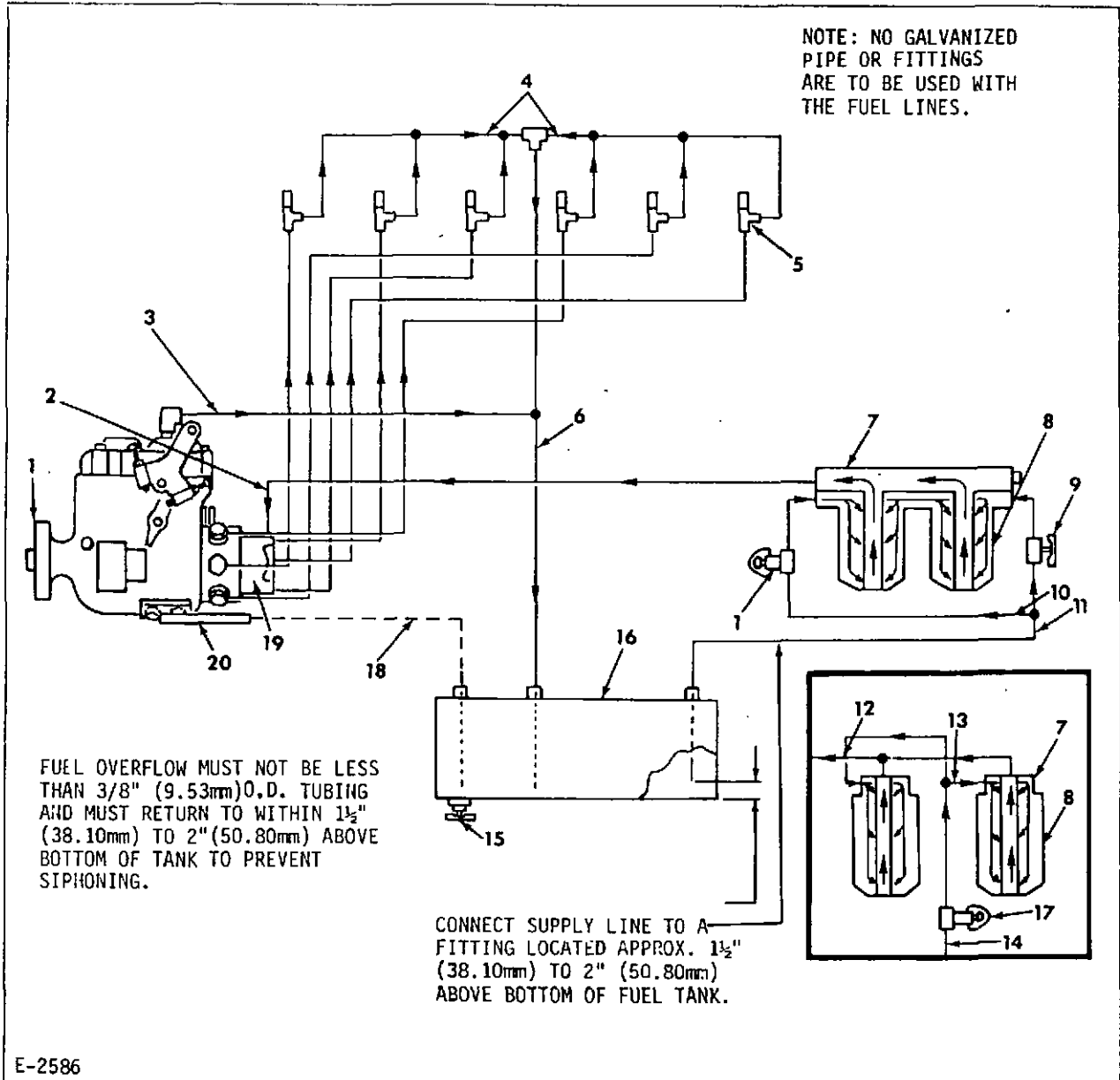
## TOPIC 12. FUEL SYSTEM

### A. GENERAL

The fuel system (Fig 1) consists of a fuel tank, hand primer pump, two fuel filters connected in parallel, transfer pump, fuel in-

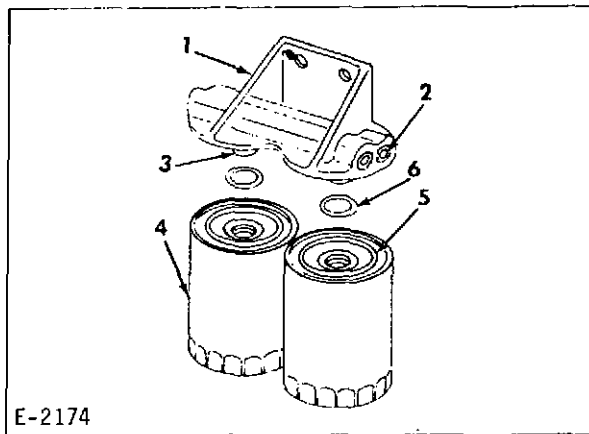
jection pump, fuel injection nozzles, and fuel lines. There are two fuel pressure systems, low pressure and high pressure.

The current engine low pressure system is



- |                              |                            |   |
|------------------------------|----------------------------|---|
| 1. Fuel injection pump       | 8. Filter                  | 15. Drain cock                                |
| 2. Fuel supply tube          | 9. Shut-off valve          | 16. Fuel tank                                 |
| 3. Fuel return tube          | 10. Bypass hose            | 17. Hand primer pump                          |
| 4. Drip manifold             | 11. Fuel supply hose       | 18. Accumulator to tank line                  |
| 5. Nozzle holder assembly    | 12. To fuel injection pump | 19. Fuel transfer pump                        |
| 6. Drip manifold return line | 13. Inlet tee              | 20. Accumulator - optional hydraulic governor |
| 7. Fuel filter header        | 14. From fuel tank         |   |

Figure 1. Fuel System Schematic Diagram



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

Figure 2. Fuel Filter -  
(Current Arrangement)

comprised of the fuel tank, hand primer pump and bypass hose with shut-off valve, fuel filters, transfer pump, fuel lines between the fuel tank and the fuel pump, and leakage return lines. Early engines did not have the bypass hose or shut-off valve.

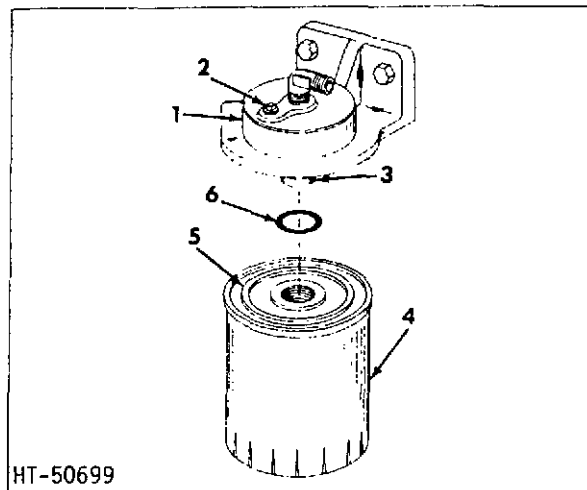
The high pressure system begins in the fuel injection pump where the fuel is forced by the action of cam-actuated plungers into the outlet ports and through the high pressure fuel lines connected to the fuel injection nozzles.

The fuel is drawn from the fuel tank, through the hand primer pump (early engines only) and the fuel filters, 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 four, fine, cone-shaped sprays.

The fuel transfer pump (integral with injection pump) delivers more fuel to the fuel sump of the injection pump than is required for engine operation. A fuel return line conveys 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 drip manifold to the fuel return line, extending to the fuel tank.

A regulating valve in the injection pump end



HT-50699

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

Figure 3. Fuel Filter (Early Arrangement)

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 keeping the fuel tank full to prevent condensation, foreign matter and water will enter the fuel system and damage the fuel injection pump and fuel injection nozzles. The fuel filters are installed in the fuel injection system to clean the fuel before it enters the fuel injection pump.

It is essential that personnel responsible for the care and operation of the engine adhere to the following maintenance recommendations:

1. Use only fuel meeting the specifications as outlined in Topic 7.
2. Store and handle fuel with utmost care to prevent water and foreign matter from entering the fuel system.
3. Properly maintain fuel oil filters.
4. Remove injection nozzle holder assemblies at the prescribed intervals; adjust the opening pressure and check the spray pattern.
5. Daily, drain the water from the fuel tank and check fuel supply.
6. Periodically check injection pump timing.
7. Keep all fuel line connections, filter, 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

The two identical fuel filters are the disposable throw-away type. The function of the filters is to remove foreign matter from the fuel before it enters the fuel injection pump.

In both filter arrangements, the filters are connected in parallel, that is, fuel enters both filters at the same time passing around the outside and through the filter medium. Clean fuel from the center of each filter flows into a common passage in the filter header (current engines) or piping connecting the individual headers (early engines) and then flows through a tube to the injection pump.

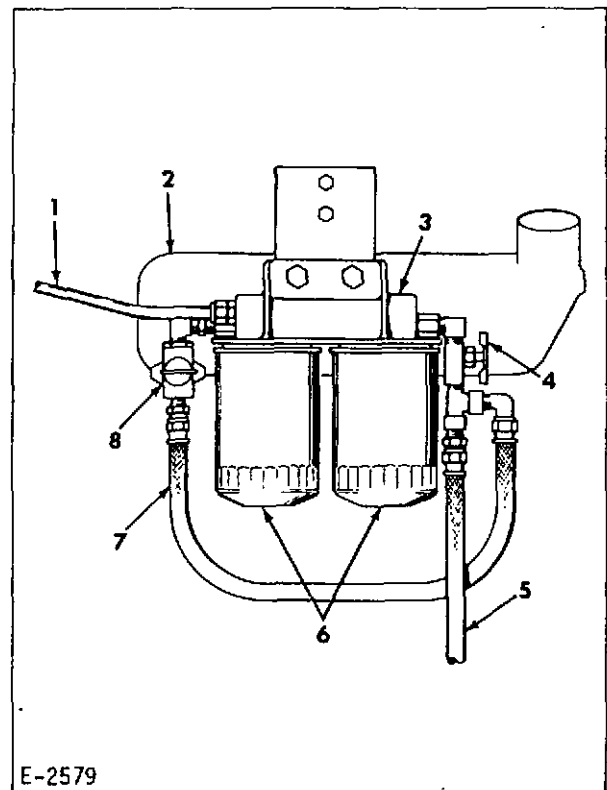
The filter is sealed to the header by a gasket which is cemented to the top of the filter and prevents fuel oil from leaking to the outside. An o-ring, which is part of the service filter kit, is placed around the threaded insert in the filter header to prevent the raw fuel from mixing with the cleaned fuel. The filter is mounted on the header by screwing it onto the threaded insert.

There are two filter piping arrangements. The first type (early engines) had separate filter headers and the hand primer pump was located in the fuel supply line just ahead of the filters.

The second arrangement (current engines) is mounted lower on the engine with a common filter header on a level, even with the injection pump. The hand primer pump is connected to one inlet of the common fuel inlet passage in the header. A bypass hose connects the hand primer pump to the fuel supply line from the tank. At the other inlet of header a shut-off valve is located and to which the upper end of the fuel supply line is connected. When the fuel system is being primed the shut-off valve is closed and all of the fuel is routed through the hand primer. Under normal operation the shut-off valve is left open, thus allowing fuel flow to both inlets of the filter header. This eliminates any restriction caused by the hand primer and possible fuel aeration.

### 1. Filter Maintenance

Remove and discard filter and o-ring and install new filter and o-ring after each 500 hour interval of operation



E-2579

1. To injection pump
2. Rear valve lifter cover.
3. Filter header
4. Shut-off valve
5. From fuel tank
6. Filters
7. Bypass hose
8. Hand primer pump

Figure 4. Current Filter Components

(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.

NOTE: Close fuel tank shutoff valve if fuel level in tank is above level of fuel filter.

- b. Unscrew and remove filter and o-ring from filter head. Discard filter and o-ring.
- c. With lint free cloth wipe clean filter contact surface of header.
- d. Position new o-ring from filter replacement kit on threaded insert in

filter head. Apply light coating of lubricating oil to filter gasket. 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. Always use an Allis-Chalmers replacement filter.

- e. Open fuel tank shutoff valve and prime the low pressure system. Refer to following Paragraph C.

CAUTION: Keep parts clean when changing the fuel filter.

### C. PRIMING FUEL SYSTEM

It is necessary to prime the fuel system to force the air from it whenever new fuel filters are installed or the engine runs out of fuel.

#### 1. Priming Low Pressure System

- a. If engine ran out of fuel, fill fuel tank. If fuel tank is equipped with a fuel shutoff valve, make certain it is in the open position.
- b. Loosen filter vent. Refer to Fig 2 or 3, Item 2.

NOTE: If filter system is current engine type as shown in Fig 4, close shut-off valve Item 4.

- c. Loosen locking screw on top of hand primer pump plunger and move clamp to one side.
- d. Move primer plunger back and forth in a pumping motion to fill the filter with fuel and expel the air.
- e. When flow of fuel around vent plugs is free of air bubbles, tighten vent plugs securely.
- f. Position primer pump plunger clamp and retighten locking screw.

IMPORTANT: If filter system is current engine type (Fig 4) open shut-off valve at filter header.

#### 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 connecting nut attaching each line to its corresponding fuel nozzle holder assembly.
- b. Place controls in the RUN position.
- c. Crank engine with starting motor until fuel flows from ends of all high pressure fuel lines. Connect fuel lines to nozzle holder assemblies 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.

### D. FUEL INJECTION PUMP

The 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 the nozzle holder assemblies 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.

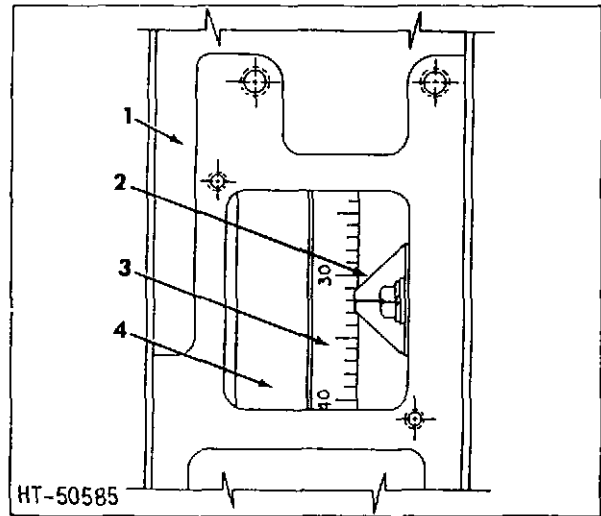
Fuel shutoff is accomplished by de-energizing the fuel shutoff solenoid. The electric solenoid mechanism within the fuel pump opens or closes the metering valve to permit or stop the flow of fuel to the engine. The electric solenoid mechanism is the energized to run type (open when energized).

The standard fuel injection pump governor has an adjustable 3-1/2 to 5% speed droop regulation. A fuel injection pump with a governor having hydraulic features and adjustable 1 - 5% speed droop regulation is available as an option.

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

- a. Clean external surfaces of the injection pump, including all line connections and fittings that are to be disconnected to prevent dirt from entering system.
- b. Rotate engine flywheel until Number 1 piston is near the top of its compression stroke and the timing pointer (Fig 5) in the flywheel housing is aligned with proper number of timing degrees stamped on the flywheel. Refer to Topic 2, Paragraph D. for timing degrees per engine rpm.
- c. Disconnect speed control cable from speed control lever.
- d. Disconnect electrical leads from terminals on fuel pump cover.
- e. Close fuel supply tank shutoff valve.
- f. Disconnect and remove filter-to-pump inlet piping.
- g. Disconnect and remove fuel line between injection pump and drip manifold.
- h. Disconnect all injection lines from the nozzle holders and injection pump.
- i. To facilitate the removal of the injection pump, remove the capscrew and lockwasher securing the lower injection line support bracket to the cylinder block and the nut and lockwasher securing the upper injection line support bracket to the cylinder head.
- j. Remove nylock type capscrews (Fig 6 Item 3) and lockwashers securing injection pump adaptor cover (5) to rear of timing gear housing (2).
- k. Carefully withdraw fuel injection



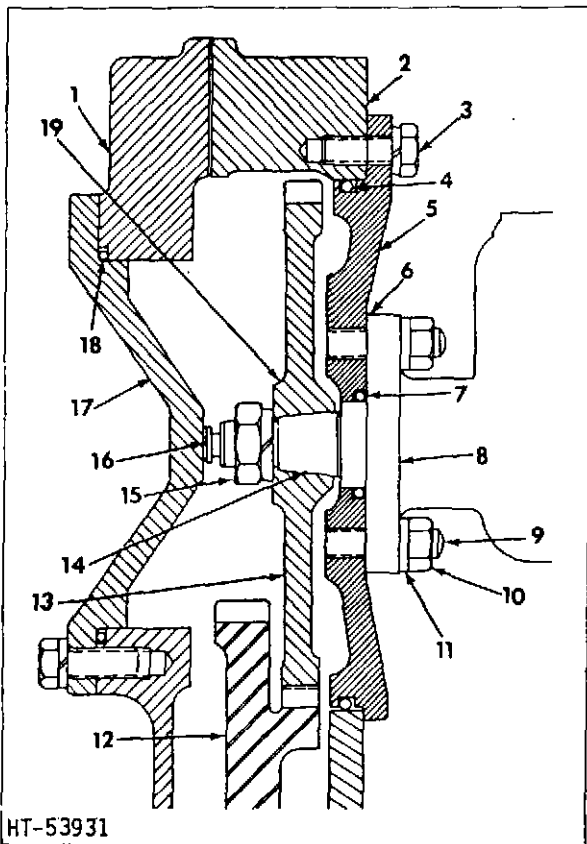
1. Flywheel housing
2. Timing pointer
3. Timing degrees
4. Flywheel

Figure 5. Timing Marks on Flywheel

pump (8) adaptor cover (5), o-ring (4), and fuel pump driven gear (13) as an assembly from timing gear housing.

**CAUTION:** Be careful that thrust button (16) and spring in end of fuel injection pump drive shaft (14) does not drop down inside of timing gear housing when removing fuel injection pump.

- l. Remove thrust button and spring from end of fuel injection pump drive shaft.
- m. Remove studs nuts (10) and serrated washers (11) securing fuel injection pump to adaptor cover and slide fuel injection pump from injection pump drive shaft being careful not to damage drive shaft seals (Fig 7 Item 6).
- n. If so desired, remove adaptor cover (Fig 6 Item 5) from fuel pump drive shaft being careful not to damage drive shaft seals.
- o. If necessary, remove fuel pump driven gear (13) from pump drive shaft (14) as follows:
  - (1) Remove fuel pump driven gear retaining nut (15) and lockwasher from end of drive shaft.
  - (2) Using a shaft protector on end of



- |                                 |                                 |
|---------------------------------|---------------------------------|
| 1. Timing gear housing cover    | 11. Serrated washer             |
| 2. Timing gear housing          | 12. Camshaft gear               |
| 3. Capscrew-nylock type         | 13. Injection pump driven gear  |
| 4. O-ring                       | 14. Injection pump drive shaft  |
| 5. Adaptor cover                | 15. Driven gear retaining nut   |
| 6. Mark on adaptor cover        | 16. Thrust button               |
| 7. Pilot seal                   | 17. Auxiliary drive cover plate |
| 8. Fuel injection pump flange   | 18. O-ring                      |
| 9. Injection pump mounting stud | 19. Driven gear key or pin      |
| 10. Stud nut                    |                                 |

Figure 6. Fuel Injection Pump Drive Details

pump drive shaft, press drive shaft from fuel pump driven gear.

## 2. Fuel Injection Pump Installation And Timing

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

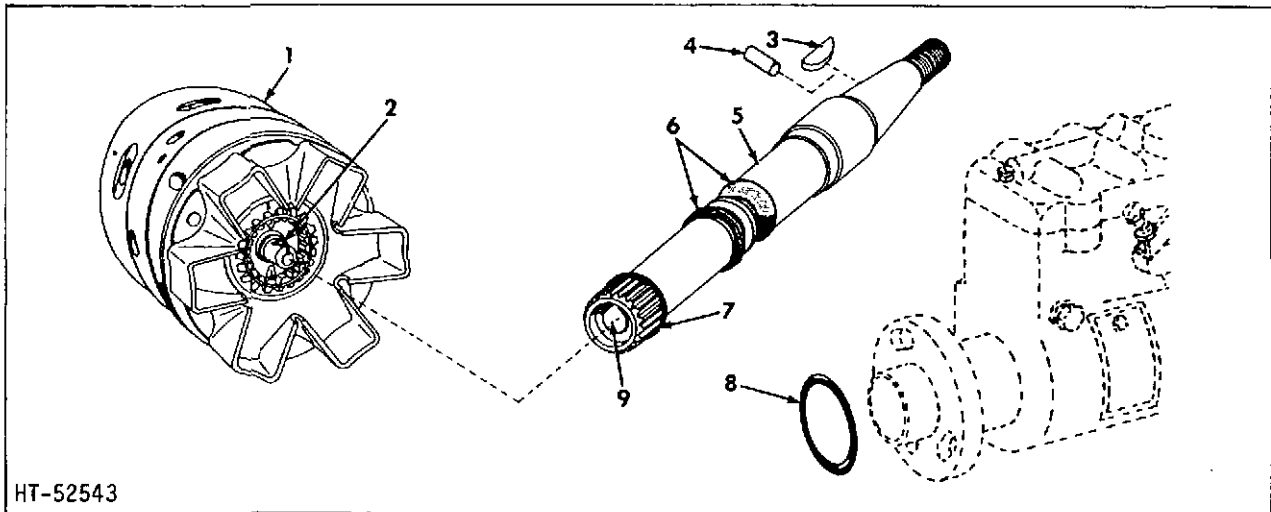
- a. If the engine crankshaft was not rotated from its position since the injection pump was removed as indicated in preceding Subparagraph

1, the engine is properly positioned for installation of the injection pump. If the engine crankshaft was rotated or has been overhauled, make certain the #1 piston is on its compression stroke. This may be determined as follows:

- (1) Remove the rocker arm rear cover so valve action can be observed.
- (2) Bar the engine over by hand until #6 cylinder exhaust valve is nearly closed and #6 cylinder intake valve is just beginning to open. This will position #1 piston near the top on its compression stroke.
- (3) Continue rotating the flywheel until the timing pointer. (Fig 5) indicates the specified number of degrees BTDC on the flywheel. Refer to Topic 2, Paragraph D, for the proper number of timing degrees per engine rpm.

NOTE: To be sure that all slack is out of the timing gears, back up the flywheel 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.

- b. Inspect pump drive shaft seals (Fig 7 Item 6), end seal (7), and pilot seal (8) and replace if necessary. Preferable, install new seals in their respective locations.
- c. If fuel pump drive gear was removed from drive shaft, install gear on drive shaft. Secure with retaining nut and lockwasher. Tighten nut to a torque of 40 lb ft (54 Nm).
- d. Insert fuel pump drive shaft with gear into adaptor cover, be careful not to damage the shaft seals.
- e. Lubricate seals with engine oil. Slide injection pump over drive shaft and on to pump mounting studs in adaptor cover using care to prevent damage to shaft seals. Install serrated washers and pump stud nuts; tighten stud nuts; tighten stud nuts finger tight after positioning fuel injection pump so that the center line of the lines scribed on top of the injection pump housing flange is in line with the mark stamped on the adaptor cover.



- |  |                                      |                         |
|--|--------------------------------------|-------------------------|
| 1. Hydraulic head and rotor assembly   | 4. Gear locating key (early engines) | 7. Drive shaft end seal |
| 2. Internal tang                       | 5. Pump drive shaft                  | 8. Pilot seal           |
| 3. Gear locating pin (current engines) | 6. Drive shaft seals                 | 9. Internal groove      |

Figure 7. Fuel Pump Drive Shaft, Head and Rotor, and Seals

**CAUTION:** In order to prevent installation of fuel pump 180° out of time, an internal groove is provided in the splined end of the pump drive shaft. The splin splined end must be engaged by an internal tang of the fuel pump distributor rotor before drive shaft will engage distributor rotor splines. (See Fig 7)

until timing marks (Fig 9) are aligned. Tighten attaching stud nuts securely to a torque of 20 lb ft (27 Nm).

**NOTE:** Mounting holes in pump housing are elongated so pump can be turned to align timing marks within the timing window. However, if timing marks cannot be aligned, remove fuel injection pump, adaptor cover, o-ring, and driven gear as an assembly from timing gear housing. Turn driven gear so that position of gear is at least one tooth over and in the direction to facilitate alignment of fuel pump timing marks. Again install fuel injection pump, adaptor cover, o-ring, and fuel pump driven gear as an assembly as mentioned in preceding Step h. If necessary, repeat operation until timing marks are aligned.

- f. Insert spring and thrust button in end of fuel injection pump drive shaft (Fig 6).
- g. Remove timing window cover from fuel injection pump. Two fuel pump timing marks (Fig 9) are used for timing injection of fuel into #1 cylinder. One mark is located on governor weight retainer hub and one is located on the cam ring. Turn gear until timing marks are aligned as viewed through the timing window.
- h. Holding fuel injection pump in a horizontal position and top straight up, install fuel injection pump, adaptor cover, o-ring, and fuel pump driven gear as an assembly into timing gear housing making certain fuel pump driven gear is in mesh with fuel pump drive gear which is integral with the camshaft gear. Secure adaptor cover with capscrews and lockwashers.

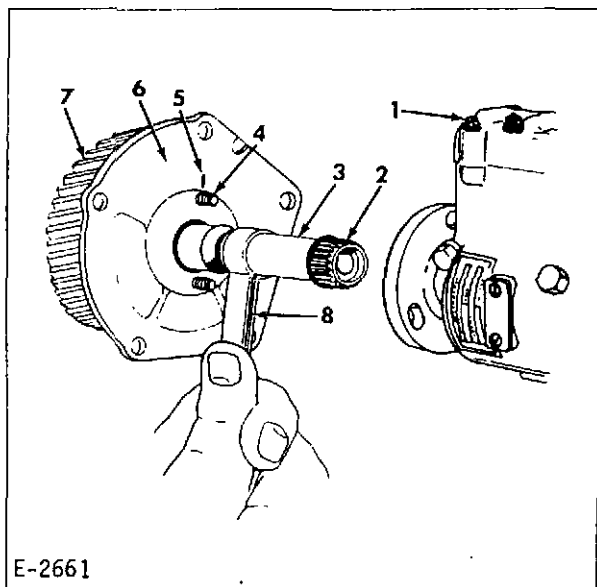
j. Install timing window cover and gasket.

k. Install fuel injection lines.

**NOTE:** Use a new fuel line connector copper gasket on both sides of each injection line fitting at the fuel injection pump.

- i. Turn injection pump on mounting studs

1. Install fuel return line to top of fuel injection pump.



- |                   |                         |
|-------------------|-------------------------|
| 1. Injection pump | 5. Mark                 |
| 2. Shaft end seal | 6. Adaptor cover        |
| 3. Drive shaft    | 7. Gear                 |
| 4. Mounting studs | 8. Seal compressor tool |

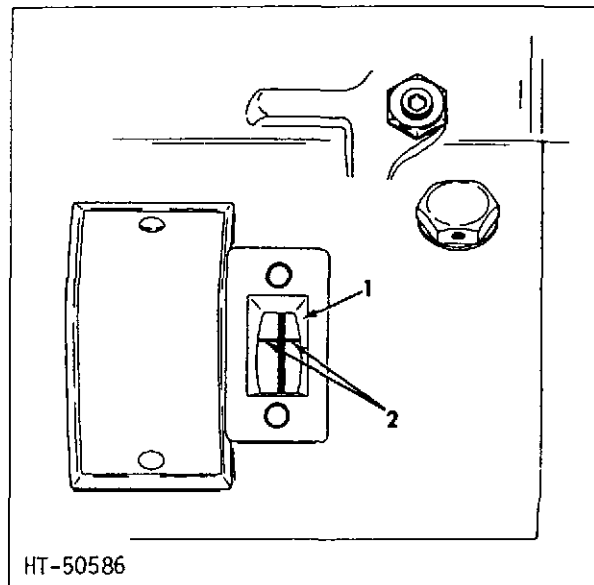
Figure 8. Assembling Injection Pump to Shaft

- m. Install fuel supply hose to rear of fuel injection pump.
- n. Open fuel supply tank shutoff valve and prime the fuel system, (refer to preceding Paragraph C., PRIMING FUEL SYSTEM).
- o. Connect electrical leads to terminals on pump cover (Fig 11). If mechanical type shutdown connects top control to pump shutoff lever.
- p. If applicable, connect the speed control cable to the pump speed control lever.

NOTE: Units which are not operated in parallel do not require a throttle, and the pump speed control lever is locked at the specified speed by jamming both the low and high speed adjusting screw against their stops (Fig 10).

### 3. Fuel Injection Pump Adjustments

Most 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 Allis-



- |                  |
|------------------|
| 1. Timing window |
| 2. Timing marks  |

Figure 9. Fuel Pump Timing Marks

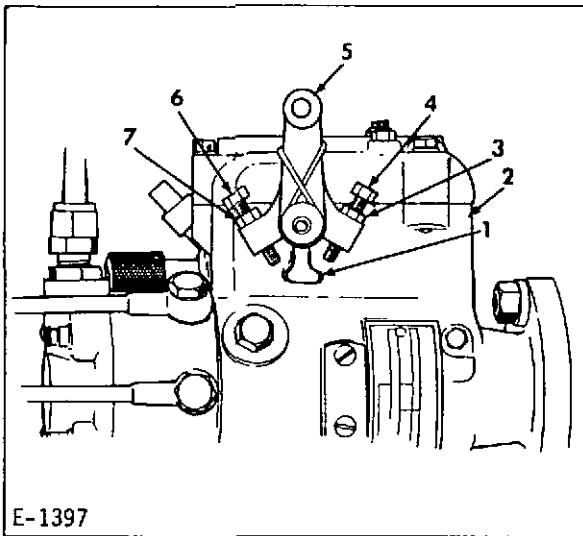
Chalmers dealer. It is important the dealer be furnished with the pump serial number, as well as engine model and serial number, to facilitate repair.

## E. GOVERNOR - STANDARD 3 1/2 to 5% REGULATION

### 1. General

The fuel injection pump contains its own mechanical or flyweight-type governor which controls the amount of fuel delivered to the engine. The movement of the flyweights against the governor thrust sleeve rotates the metering valve. The rotation varies the position of the metering valve slot with the passage to the rotor, controlling the flow of fuel. The governor is adjusted at the factory to provide for the proper horsepower at full-load governed speeds. The fuel injection pump governor has an adjustable 3-1/2 to 5% speed droop regulation.

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, for speed settings.



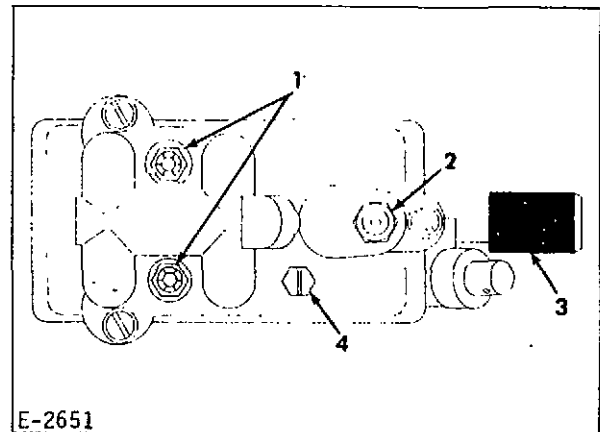
E-1397

1. Lever stop
2. Fuel injection pump
3. Locknut
4. Low speed adjusting screw
5. Speed Control Lever (spring loaded)
6. High speed adjusting screw
7. Locknut

Figure 10. Engine Speed Adjustment

## 2. Check Engine Speed

- a. Use a stroboscope type tachometer to check engine speed. Make an rpm count of the crankshaft pulley or the main alternator rotor shaft.
- b. Run engine until a minimum operating temperature of 160°F (344K) is reached.
- c. Check speed of engines with throttles as follows:
  - (1) Move speed control to low and high speed positions and make sure the control moves governor speed control lever through its full arc of travel.
  - (2) Move speed control to LOW IDLE position. Check engine speed to make certain rpm is within specified range.
  - (3) Move speed control to HIGH IDLE position. Check engine speed to see if rpm is within specified range.
  - (4) If engine speed is not within ranges specified, governor speed adjustment screws must be adjusted.
- d. Check speed of engine with locked type throttle as follows:



E-2651

1. Electric fuel solenoid terminals
2. Fuel return line connector
3. Speed droop adjusting screw
4. Adjusting screw - hydraulic governor only

Figure 11. Speed Droop Adjustment

- (1) Check engine full load speed.

- (2) If engine speed is not within ranges specified, governor speed adjustment screws must be adjusted.

## 3. Speed Adjustments

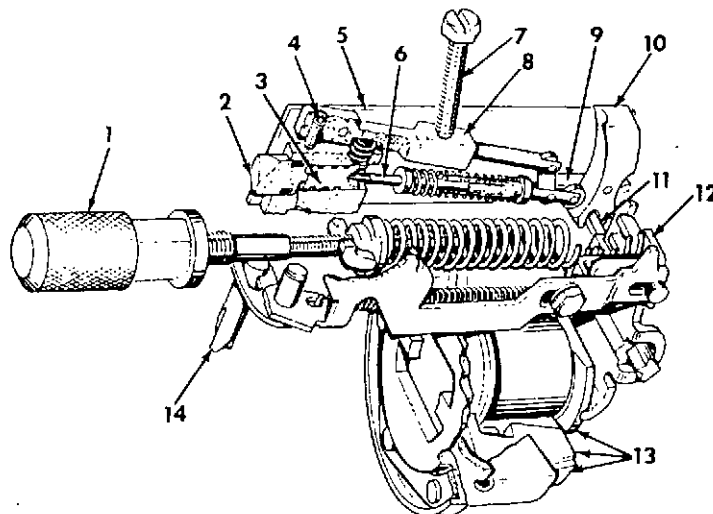
- a. Adjust speed of engines with throttles as follows:

- (1) Disconnect speed control cable from fuel injection pump speed control lever so lever can be moved by hand.
- (2) With engine running at minimum temperature of 160°F (344 K), loosen locknut on the low idle adjusting screw. Hold speed control lever toward front (fan end) of engine so low speed adjusting screw contacts the lever stop. Turn low speed adjusting screw IN to increase or OUT to decrease low engine speed. After proper low speed is obtained, hold adjusting screw and tighten the locknut.

**CAUTION:** Adjusting low speed below 1400 rpm will damage voltage regulator.

- (3) Again with engine running at minimum temperature loosen locknut 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

1. Speed droop control
2. Piston stop
3. Servo piston
4. Stop screw
5. Hydraulic boost device
6. Governor rod tip
7. Adjusting screw
8. Adjusting lever
9. Rod roller
10. Pivot bar
11. Governor arm shaft
12. Governor arm
13. Mechanical governor
14. Metering valve - 2 slotted



E-2578

Figure 12. Hydraulic Governor Boost Device

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 locknut.

- (4) Connect speed control cable to the speed control lever. Make certain lower end is so positioned in the control cable bracket and swivel that when speed control is pushed IN, the control lever low idle adjusting screw contacts the pump housing lever stop. Likewise, when speed control is pulled OUT, the high idle adjusting screw must also contact the lever stop.
  - b. Adjust speed of engines with locked type throttle as follows:
    - (1) Depending upon whether the high speed is to be increased or decreased, loosen the high speed adjusting screw (Fig 10) or the low speed adjusting screw. Hold the governor speed control lever in the direction of the speed increase or decrease with the adjusting screw against its stop. Tighten the other adjusting screw until it is against its stop.
    - (2) When the specified speed is obtained tighten the adjusting screw locknuts.
    - (3) After tightening the locknuts, again check the speed because a slight change in speed may have occurred when the final tightening was made. Again adjust the speed to the specified rpm.

#### 4. Speed Droop Adjustments

And external speed droop adjusting screw at rear of the pump housing (Fig 11) provides precision control of governor sensitivity by decreasing or increasing effective length of 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 high idle - no load speed adjustment following procedure outlined in preceding Subparagraph 2.
- 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 the load and noting the difference in frequency from no load to full load. Each Hertz is 30 rpm.
  - (3) Turn adjusting screw clockwise to increase, or counterclockwise to decrease speed droop. A minor correction of speed control position is also necessary.

#### F. GOVERNOR - OPTIONAL 1 TO 5% REGULATION

##### 1. General

This governor has features similar to the

standard governor such as flyweights and external speed droop adjustment, however, a hydraulic booster device augments the mechanical governor in the pump.

This device used in conjunction with the variable speed droop control, is adjustable from near 1% to 5% regulation. Mechanical reaction to load change is amplified by the hydraulic booster which provides extremely rapid metering valve response.

During steady state load the pump governs with the mechanical governor. A load increase causes a charging pressure increase which for descriptive purposes will be called "boost" pressure. A second cut on the rear of the metering valve allows fuel under boost pressure to flow to the servo piston in the hydraulic governor body. Forward movement of the servo piston, acting through the device linkage exerts a forward thrust against the governor arm.

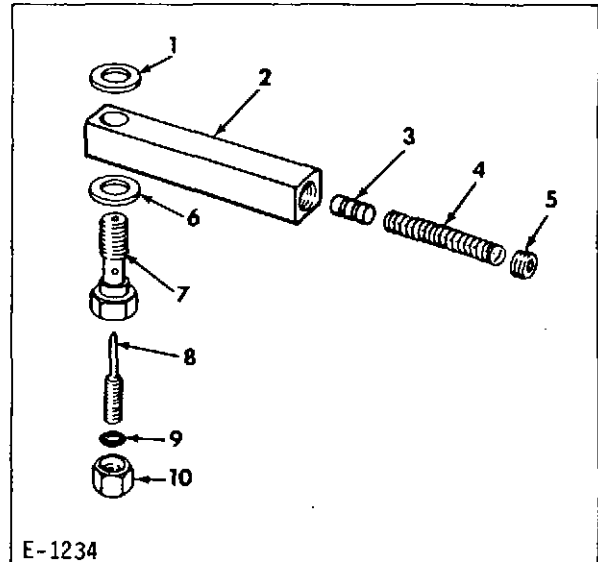
This thrust at increasing load conditions assists the main governor spring opening the metering valve. Thus, the fuel required to meet the oncoming load is provided before an appreciable speed change can occur. A decreasing load reduces the boost pressure, removing the force from the mechanical governor.

A piston type accumulator (Fig 13) is provided to reduce hydraulic governor sensitivity and prevents hunting at light loads or at near zero regulation speed. The needle valve adjusting screw is used for fine adjustment of governor response with the generator set in operation. The fuel leakage from the accumulator piston is conducted to the tank via a separate return line.

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

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

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, for standard speed settings.



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

Figure 13. Accumulator Assembly

## 2. Adjustments

The governor is adjusted at the factory and should not require further adjustment unless a new or rebuilt fuel injection pump is installed on the engine.

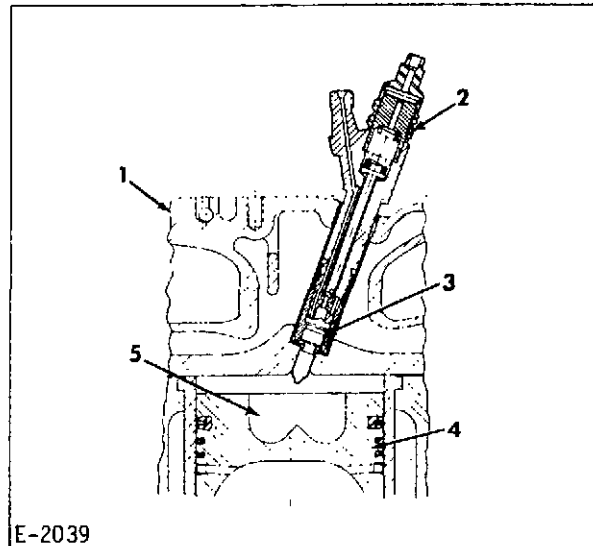
Adjust the governor as follows:

- (a) Adjustments Prior to Starting Engine
  - (1) Loosen accumulator adjusting screw locknut (Fig 13 Item 10). Turn adjusting screw (8) into accumulator until it is seated, then back it out one turn and tighten locknut.
  - (2) Back out hydraulic governor boost device adjusting screw (Fig 11 Item 7) 6 to 7 turns so that it will have no effect on regulation.
  - (3) Turn speed droop adjusting screw (Fig 11 Item 3) or (Fig 12 Item 1) counterclockwise until it stops and then turn it clockwise 1 1/2 turns.

**CAUTION:** If operating the engine below 1400 rpm will damage the main alternator voltage regulator, be sure to disconnect the sensing circuit from the regulator by the means provided with the unit. This can be by a circuit breaker, switch, or disconnecting the sensing lead from the regulator.

(b) Adjustments with Engine Running

- (1) Operate engine until a minimum coolant temperature of 160°F (344 K) is reached.
- (2) Apply load to engine and adjust speed to the specified full load rpm.
- (3) With load on engine turn speed droop adjusting screw (Fig 10 Item 3) clockwise until engine is running without hunting.
- (4) After engine is running steady at full load rated speed, remove the load and turn the speed droop adjusting screw clockwise to remove hunt at no load.
- (5) Again apply load and rest high speed to the specified full load rpm.
- (6) Repeat steps (2), (3), (4), and (5) until engine can be run at no load without hunting and when the load is applied the engine will return to the full load rated speed.
- (7) With load applied to engine, turn the hydraulic device adjusting screw (Fig 10 Item 4) clockwise until a change in regulation is noted. Continue to turn adjusting screw at 1/2 turn increments until near zero regulation is obtained. After each adjustment, the full load to no load regulation must be checked and the high speed adjusting screw readjusted to maintain rated speed and load. When the regulation is less than one percent, the adjusting screw should be turned in 1/4 turn increments. If a negative droop occurs, (full load speed higher than no load) the screw has been turned in too far.
- (8) To shorten governor response time, loosen accumulator adjusting screw locknut (Fig 13 Item 10) and turn the adjusting screw (8) clockwise. To lengthen governor response time, turn adjusting screw counterclockwise.
- (9) Tighten accumulator adjusting screw locknut.



1. Cylinder head
2. Fuel injection nozzle holder assembly
3. Fuel injection nozzle
4. Piston
5. Combustion chamber

Figure 14. Combustion Chamber and Nozzle Holder Location (Typical)

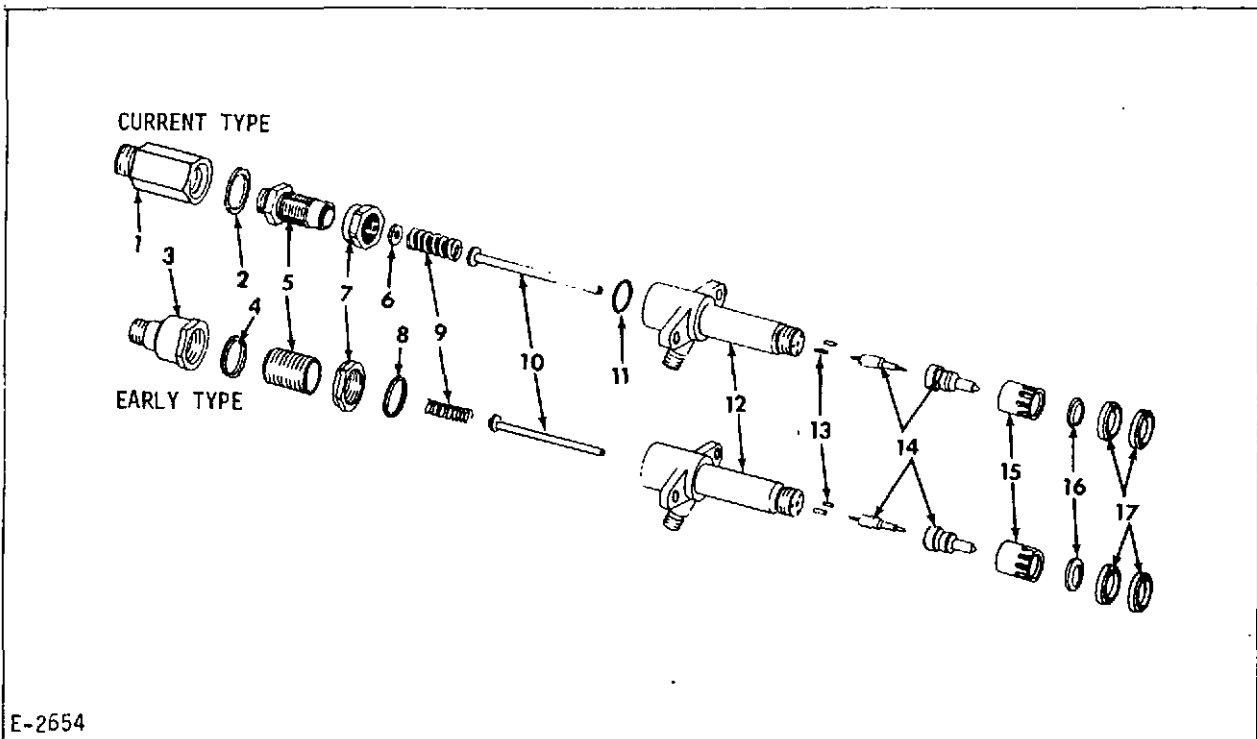
G. FUEL INJECTION NOZZLE HOLDER ASSEMBLY

1. Description

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

Each fuel injection nozzle holder assembly consists of two assemblies: an injection nozzle holder assembly and an injection nozzle assembly. The holder assembly positions the nozzle in the cylinder head and provides a means of conducting fuel received from the fuel injection pump to the nozzle.

The current holder (Fig 15) consists of a steel holder body, two locating dowels, spindle, spindle spring, wear washer, pressure adjusting screw, adjusting screw locknut, a nozzle retaining nut, and an O-ring located in an internal groove of the body spring compartment. This O-ring and the lower portion of the adjusting screw form a seal which prevents fuel oil leakage from the spring compartment.



E-2654

- |            |                    |                   |                                |
|------------|--------------------|-------------------|--------------------------------|
| 1. Adaptor | 5. Adjusting screw | 9. Spindle spring | 13. Dowel pins                 |
| 2. Gasket  | 6. Wear washer     | 10. Spindle rod   | 14. Nozzle body & needle valve |
| 3. Cap nut | 7. Locking nut     | 11. O-ring        | 15. Retaining nut              |
| 4. Gasket  | 8. Gasket          | 12. Holder body   | 16. Gasket                     |
|            |                    |                   | 17. Nozzle holder dust shields |

Figure 15. Nozzle Holder Assembly

NOTE: The top end of the current nozzle holder assembly is approximately 1 inch (25.40 mm) lower than the early type. When the current type is intermixed with early type nozzle holder assemblies and drip manifold, an adaptor (Fig 15 Item 1) and gasket (2) are required.

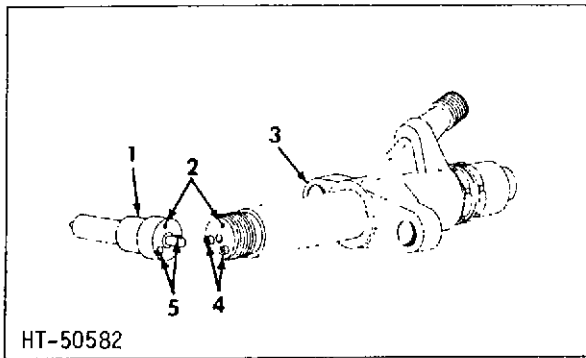
The early type nozzle holder assembly consists of a steel holder body, two locating dowels, spindle, spindle spring, pressure adjusting screw, adjusting screw locknut, gaskets, cap nut, and a nozzle retaining nut.

The nozzle assembly (Fig 15 Item 14) consists of a nozzle valve and a nozzle body in which are located four spray orifices, equally spaced 90° apart. The nozzle valve is operated hydraulically within the valve body by fuel delivered under pressure by the fuel injection pump. The nozzle is positioned on the holder by two dowels (Fig 16 Item 4) whereby the four spray orifices are fixed on a plane parallel to the piston top (Fig 14), and the nozzle fuel duct

is registered with the holder fuel duct.

Fuel enters the nozzle holder fuel inlet passages, passes through the holder fuel duct into the nozzle fuel duct via an annular groove in the nozzle body, and then into the pressure chamber above the nozzle valve seat. At instant the pressure of fuel in the pressure chamber exceeds pressure exerted on spindle and nozzle valve by the spindle spring, the nozzle valve is lifted off its seat and fuel is forced through orifices in the valve body end and into the corresponding engine combustion chamber. The nozzle valve is returned to its seat by pressure exerted by the spindle spring when the fuel injection pump has ceased to deliver fuel to the nozzle holder.

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



1. Nozzle assembly
2. Fuel ducts
3. Holder assembly
4. Dowels
5. Dowel holes

Figure 16. Fuel Injection Nozzle Holder Dowel Location

Two dust shields (Fig 15 Item 17) are installed on each nozzle holder to prevent moisture and foreign matter from entering nozzle holder bore in cylinder head.

## 2. Maintenance

After each operating interval of approximately 3000 hours, the fuel injection nozzles should be removed, cleaned, tested, and adjusted if necessary. The specified opening ("popping") pressure for the turbocharged (model 11000) engines is 2800 to 2850 psi (19305 to 19650 kN/m<sup>2</sup>).

The opening pressure is adjusted with the pressure adjusting screw (Fig 15 Item 5). 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 drip manifold and disconnect injection lines from nozzle holder assemblies. Refer to Fig 17.

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

- c. Remove capscrews and lockwashers securing nozzles to cylinder head.
- d. Remove nozzles from cylinder head by using two small pry bars, or by using a slide hammer with adaptor similar to the one illustrated in Fig 18.

**NOTE:** If the thermostat housing interferes with the removal of the NO. 1 cylinder nozzle holder assembly, remove the nozzle holder cap nut.

**CAUTION:** Use care when removing an injection nozzle to prevent striking nozzle tip against a hard object which could result in damage to the tip.

- e. Remove dust shields from nozzle holders. If dust shields are brittle, torn or deteriorated, they must be replaced.

## 4. Testing and Adjusting Fuel Injection Nozzle Holder

A nozzle tester similar to the one illustrated in Fig 19 is required to properly test and adjust fuel injection nozzles.

**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 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. Connect nozzle holder to fuel line of tester. Place spray collector under valve end of nozzle.
- d. Open nozzle tester valve. Operate handle a few quick strokes and observe nozzle opening pressure indicated on pressure gauge. Specified nozzle opening pressure is 2800 to 2850 psi (19305 to 19650 kN/m<sup>2</sup>).
- e. Adjust fuel injection nozzle to obtain specified opening pressure as follows:

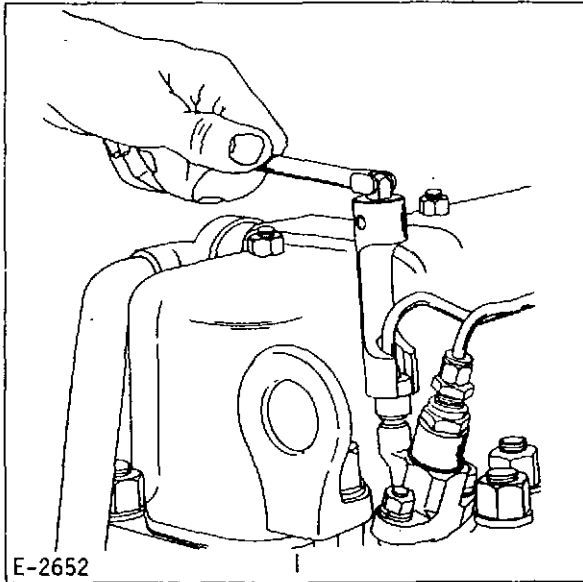
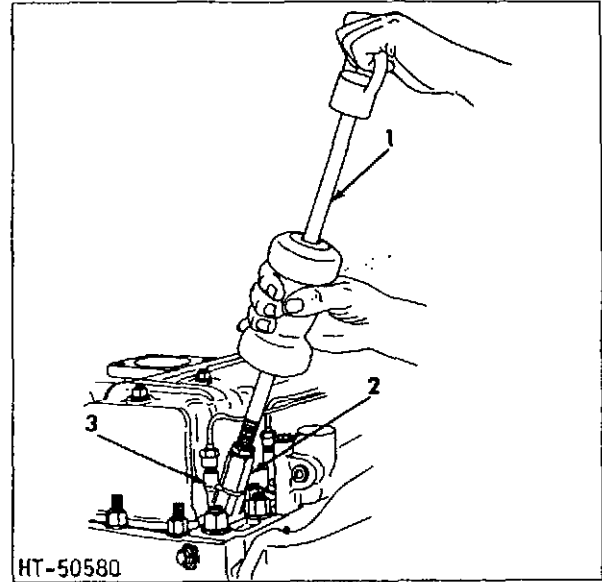


Figure 17. Disconnecting Injection Line from Nozzle Holder Assembly

- (1) Loosen adjusting screw locknut.
  - (2) While operating handle, turn pressure adjusting screw IN to increase or OUT to decrease opening pressure. When the specified pressure is obtained, hold adjusting screw and tighten locknut to 60 lb-ft (81 Nm) torque.
- f. Dry the nozzle tip. Operate handle slowly until pressure is approximately 200 psi (1379 kN/m<sup>2</sup>) below opening 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 (1379 kN/m<sup>2</sup>), or less, below opening pressure, the nozzle valve is not seating properly. In this case, 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.
  - h. The nozzle tip has 4 equally spaced holes, 90° apart. Size and spacing of these holes determines the spray pattern. If fuel is discharged evenly through all 4 holes at the specified opening pressure, the spray pattern is considered satisfactory (Fig 21).
  - i. If the fuel is not discharged evenly from all 4 holes, a plugged hole(s)

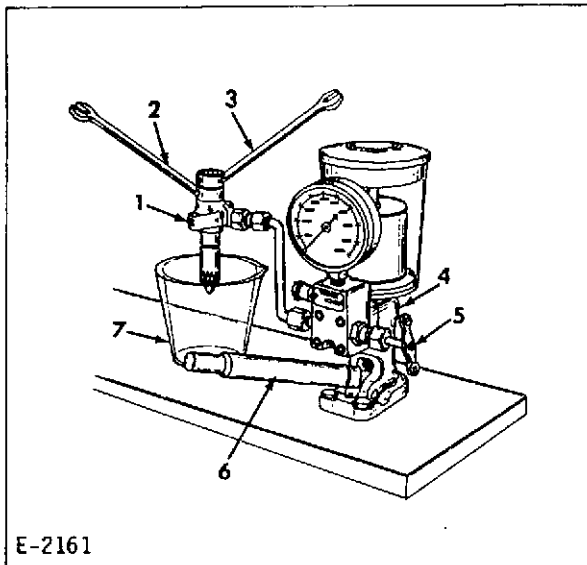


1. Slide hammer
2. Nozzle holder remover adaptor
3. NOzzle holder

Figure 18. Removing Fuel Injection Nozzle Holder

is indicated, in which case, the nozzle must be removed and cleaned using a proper size cleaning wire (Fig 22). Refer to Paragraph D of Topic 2 and Paragraph C of Topic 8 for cleaning wire size and tool part number.

- j. To remove nozzle from holder, loosen pressure adjustment locknut (Fig 15) to relieve tension on spindle rod, then remove nozzle retaining nut and nozzle.
  - k. Install new or cleaned nozzle on holder and tighten retaining nut to 60 lb-ft (81 Nm) torque.
  - l. Connect nozzle holder assembly to tester and adjust nozzle opening pressure to 2800 - 2850 psi (19305 to 19650 kN/m<sup>2</sup>). Tighten adjusting screw locknut to 60 lb-ft (81 Nm) torque.
5. 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.



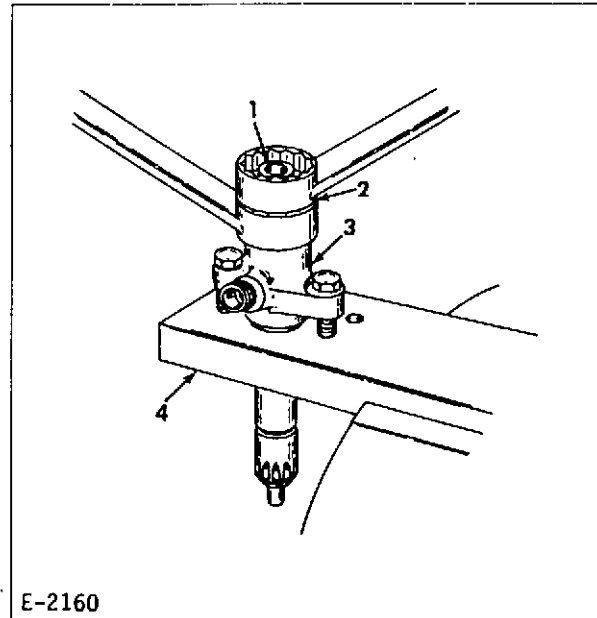
1. Nozzle holder assembly
2. Wrench-holding locknut
3. Wrench-turning adjusting screw
4. Nozzle tester
5. Valve handle
6. Tester handle
7. Spray collector

Figure 19. Adjusting Nozzle Opening Pressure (Current Type Nozzle Holder Assembly)

- b. Install dust shields (Fig 15 Item 17) on nozzle holder (12) and place new nozzle gasket (16), convex face (rounded side) toward the nozzle retaining nut in position on the nozzle.

**NOTE:** Coat nozzle holder body with neverseize compound to prevent seizure in cylinder head.

- c. Carefully position nozzle holder in nozzle bore of cylinder head. Install nozzle holder lockwashers and capscrews 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 drip manifold.
- d. Tighten nozzle holder capscrews alternately. Tighten capscrew on one side to 8 lb-ft (11 Nm) torque. Tighten capscrew on opposite side to full specified torque 14 lb-ft (19 Nm). Then tighten first capscrew to full specified torque.
- e. Tighten injection tube and drip manifold nuts securely.



1. Adjusting screw
2. Locknut
3. Nozzle-holder assembly
4. Holding fixture

Figure 20. Loosening Pressure Adjusting Screw Locknut

- f. Start engine and observe fuel injection tubes and fuel drip manifold connections for fuel leakage. Correct any leaks found.

#### H. REMOVING CARBON FROM FUEL INJECTION NOZZLE BORE

If the cylinder head has been removed from the engine, it is advisable to remove carbon deposits from the nozzle holder to cylinder gasket seat and the nozzle bores within the cylinder head with a tool similar to the one illustrated in Fig 23 before reinstalling it on the engine.

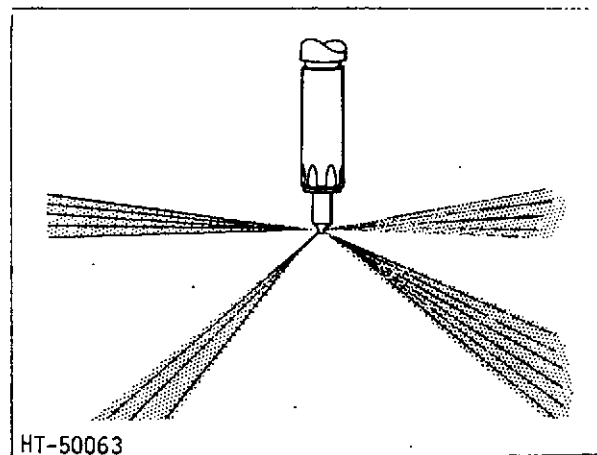
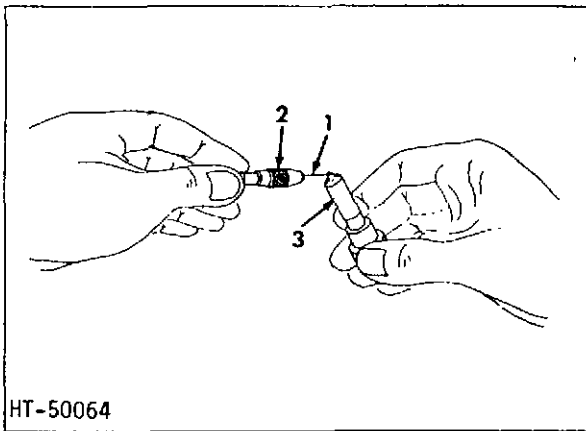


Figure 21. Acceptable Spray Pattern



1. Cleaning wire
2. Pin vise
3. Valve body

Figure 22. Cleaning Nozzle Orifices

**CAUTION:** Under no circumstances should and engine be operated with a leaking nozzle holder to cylinder head gasket because localization of heat will destroy the nozzle.

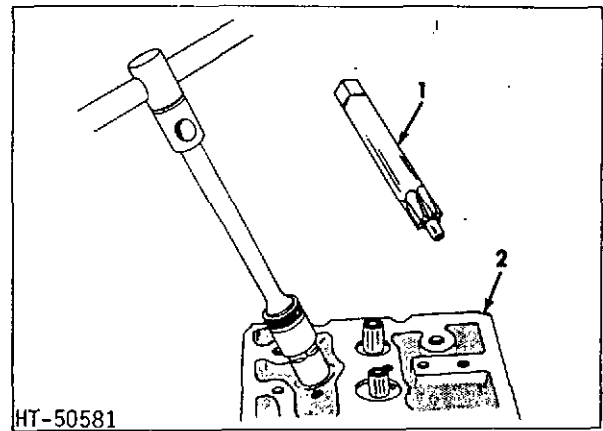
#### I. CHECKING FUEL SYSTEM

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 and fuel filter 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 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 and filter connections.

**CAUTION:** The following tests require the engine to be operated at speeds below 1400 rpm. If the engine is powering a generator set, the main generator voltage regulator must be disconnected from the system to protect it from damage at the lower speeds.



1. Fuel injection nozzle sleeve carbon removing tool
2. Cylinder head

Figure 23. Removing Carbon from Fuel Injection Nozzle Bore

##### 2. Check For Clogged Fuel Filter And Clogged Or Collapsed Fuel Lines

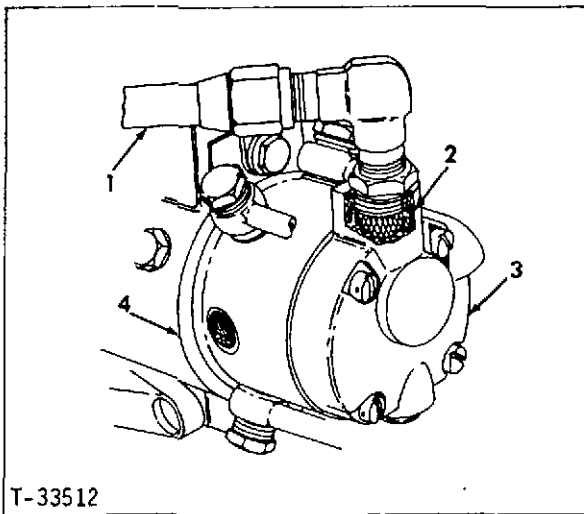
A clogged filter or restriction(s) in fuel lines will cause loss of power, engine stalling, or erratic operation. A simple method of eliminating these troubles is to remove the fuel filter, blow out all low pressure fuel lines with filtered compressed air, and install a new filter. Another method is to install a vacuum gauge at the inlet and also one at the outlet of the fuel filter. Pressure drop across a clean filter should not exceed 1.5 in. to 2.5 in. (5065 to 8442 N/m<sup>2</sup>) of mercury at full load speed. A pressure drop 10" of mercury indicates filter is loaded and should be replaced. If a 10 in. (33768 N/m<sup>2</sup>) mercury pressure drop is still obtained when a new filter is 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 nozzle holders. 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 24) in end plate of the injection pump. Remove foreign material if screen is clogged.

##### 3. Check For Inoperative Fuel Transfer Pump

If engine is still erratic after making checks detailed in preceding Steps 1 and 2, check operation of the fuel transfer pump and end plate pressure regulating



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

Figure 24. Fuel Strainer Location

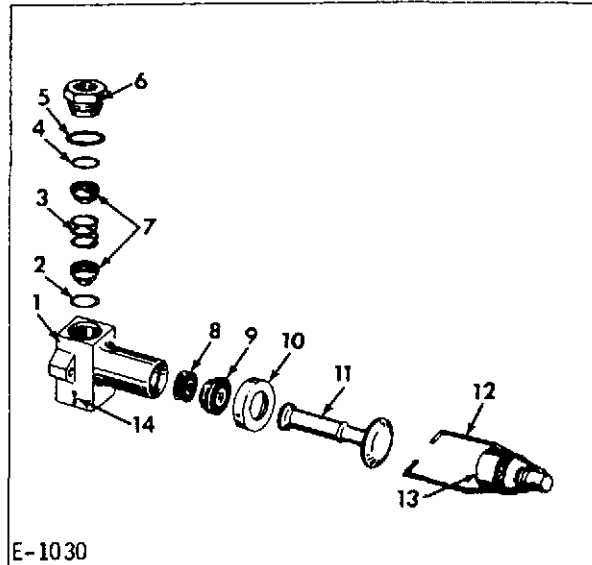
valve. Run engine until normal operating temperature is reached, then shut it down. Remove plug marked OUT in bottom of end plate opposite fuel inlet, and install a pressure gauge. With the speed control in IDLE position, crank engine with the starting motor. Minimum pressure should be 6 psi (41 kN/m<sup>2</sup>) at 150 rpm cranking speed. If pressure is less than 6 psi (41 kN/m<sup>2</sup>) check for malfunction in end plate and transfer pump parts.

#### 4. Check For Inoperative Fuel Injection Nozzles

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

**WARNING: KEEP HANDS AWAY FROM THE LOOSENED LINE NUTS WHILE PERFORMING THIS TEST.**

- a. Run engine at low idle speed and "cut out" each fuel nozzle in turn by loosening line nut attaching fuel injection 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 inoper-



- |                        |                            |
|------------------------|----------------------------|
| 1. Body                | 8. Piston seal             |
| 2. Valve gasket        | 9. Plunger guide           |
| 3. Spring              | 10. Retaining cap          |
| 4. Valve nut seal      | 11. Plunger                |
| 5. Valve nut seal ring | 12. Camp                   |
| 6. Valve nut           | 13. Camp Screw             |
| 7. Valve               | 14. Direction of fuel flow |

Figure 25. Hand Primer Pump

ative 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. The compression test is used to detect burned or stuck valves, worn or scored pistons/sleeves, worn or stuck rings, etc., that cause faulty engine operation (refer to Topic 9).

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 fuel injection pump should be taken to your nearest Allis-Chalmers dealer for testing and repair.

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

## J. HAND PRIMER PUMP

The main function of the hand primer pump is to force air from the fuel system which enters when the engine runs out of fuel, the fuel filters are renewed, or from servicing the injection pump.

### 1. Disassembly

- a. Unscrew the clamp screw (Fig 25 Item 13) and swing clamp wire off plunger (11).
- b. Spread clamp wire (12) ends to disengage from body (1). Remove plunger (11), guide (9), and piston seal (8), and retaining cap (10) as an assembly.
- c. Place body (1) in a soft-jaw vise and remove nut (6), seal ring (5), valve seal (4), upper valve (7), spring (3), second valve (7), and valve gasket.

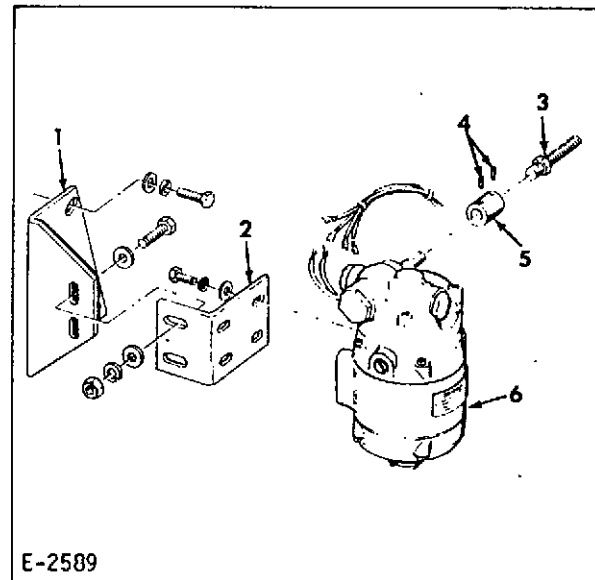
NOTE: Hand primer pumps of early manufacture had paper gaskets instead of current type valve gasket (2) and the valve seal (4). If the valve nut is reusable, replace it using paper gasket.

### 2. Inspection

- a. Examine valve gaskets for tears and replace as needed. Check piston seal (8) on bottom of plunger (11) for damage, and replace if necessary. Check for foreign matter in valves (7) and body (1).
- b. If rubber plunger guide (9) is worn, cut it for removal from plunger (11).

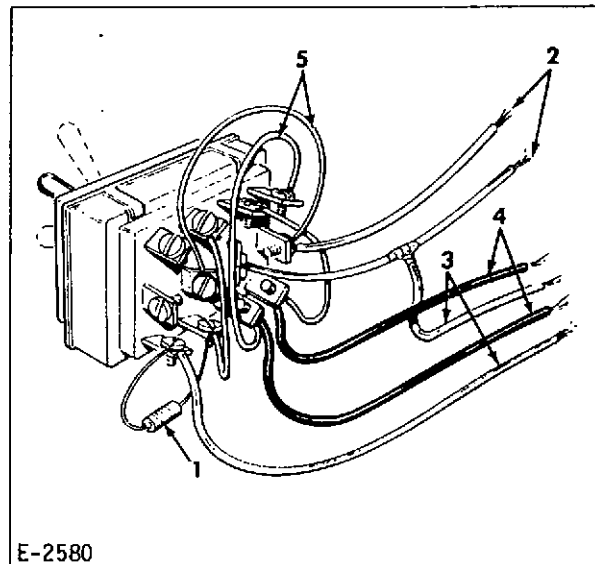
### 3. Assembly

- a. Position retaining cap (10) on plunger (11). Using clean grease to lubricate, slip plunger guide (9) onto plunger with the chamfered side down. Position piston seal (8) on end of plunger.
- b. Assemble lower valve gasket (2) in pump body (1). The two valves (7) are identical; place one of them in the body followed by the valve spring (3) and the second valve. Make certain the valves are positioned in the body so that they open in the direction of the arrow (14) on the side of the pump body.
- c. Assemble valve nut seal (4) valve nut seal ring (5), and valve nut (6). Tighten nut securely.
- d. Assemble plunger with piston seal,



1. Motor Bracket
2. Bracket
3. Throttle control screw
4. Setscrew
5. Coupling
6. Motor

Figure 26. Speed Control Motor Mounting



1. Resistor
2. Source 24 V.DC
3. Blue lead  
motor armature
4. Black lead  
motor coil
5. Jumper

Figure 27. Wiring Diagram (Speed Control Switch)

and plunger guide in pump body.

e. Align holes in plunger retaining cap with holes in body. Spread clamp wire ends and insert them in cap and body.

f. Position clamp over plunger and tighten clamp screw.

## K. SPEED CONTROL MOTOR

### 1. General

An electrically controlled motor to regulate engine speed is available as an option when the optional hydraulic governor is specified. When the engine is equipped with a speed control motor, the manually operated SPEED CONTROL mounted on the engine control panel is eliminated. The speed control motor is activated by a two position toggle switch.

### 2. Operation

The shaft of the speed control motor is connected directly to the throttle shaft of the fuel injection pump by a flexible coupling. The motor is a 24 volt dc, 4 lead, reversible, shunt type with speed reduction gears. It is activated by the two position toggle switch. Putting the switch in the RAISE position will increase engine speed and, conversely, placing it in the LOWER position will decrease engine speed.

### 3. Maintenance

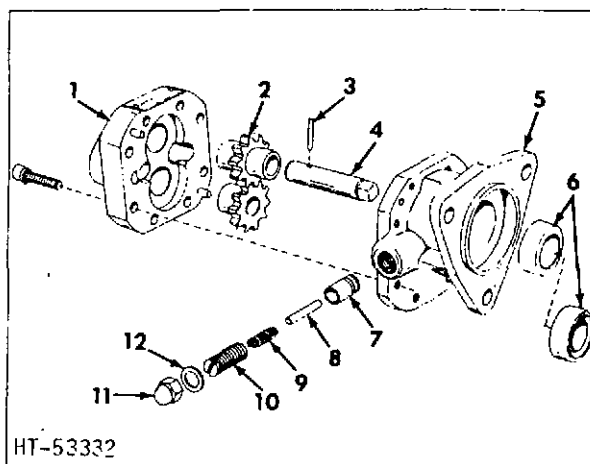
The motor is lubricated for life. The setscrews securing the coupling to shafts of the motor and fuel injection pump must be kept tight to avoid straining the shafts. The holes in the motor support bracket are elongated so that alignment of the motor and coupling with the shaft in the fuel injection pump can be maintained without any strain on the shaft.

## L. FUEL SUPPLY TRANSFER PUMP

### 1. Description

The engine is equipped with a positive displacement, gear-type fuel supply transfer pump (Fig 28) mounted on the engine timing gear housing. The pump is driven at two times crankshaft speed from the drive assembly by means of a coupling fork. The direction of rotation of the pump is clockwise when viewed from the drive end of the pump.

The fuel supply transfer pump is provided with a spring loaded, plunger-type pressure relief valve. The pressure relief



- |                 |                     |
|-----------------|---------------------|
| 1. Housing      | 8. Pin              |
| 2. Driving gear | 9. Spring           |
| 3. Shear pin    | 10. Adjusting screw |
| 4. Shaft        | 11. Hex cap nut     |
| 5. Stator       | 12. Gasket          |
| 6. Shaft seals  | 13. Driven gear     |
| 7. Plunger      | 14. Dowel pin       |

Figure 28. Fuel Supply Transfer Pump Details

valve bypasses fuel back to the inlet side of the pump when the outlet pressure exceeds 7 to 10 psi (48 to 69 kN/m<sup>2</sup>). This valve normally does not open since its purpose is to relieve excessive pressure in case clogging occurs in the fuel filters or fuel lines.

The seals, shaft, gears, and relief valve parts are the only serviceable items. The pump stator and housing are not serviceable and if worn or damaged they must be replaced with a new pump assembly.

### 2. Removal Of Fuel Supply Transfer Pump

If it becomes necessary to repair or replace the pump, it may be removed as follows:

- Disconnect fuel lines from the pump.
- Remove the three Nylok capscrews attaching the pump to the timing gear housing and remove the pump as an assembly.

### 3. Disassembly Of Fuel Supply Transfer Pump

The pressure relief valve assembly may be removed from the pump stator, without disassembly of the other parts of the pump, by removing the relief valve hex cap nut and adjusting screw and jarring the valve parts from the stator.

NOTE: Remove adjusting screw, noting the number of turns required for removal.

If the relief valve only is to be inspected, no further disassembly is necessary. If the pump is to be disassembled proceed as follows:

- a. Remove the screws attaching the pump housing to the stator and install capscrews 1/4" NC x 3" long, so that the heads of the capscrews extend out from the pump housing.
- b. Holding the pump assembly in the hand, tap the heads of the capscrews with a soft hammer, separating the stator and housing.

CAUTION: Do not pry the stator and housing apart.

- c. Remove the pump driven gear.
- d. Remove the pump shaft and driving gear from the stator, using care to prevent damage to the pump shaft seals.
- e. Remove the dowel pins from the pump housing if necessary.
- f. If it is necessary to remove the shaft seals, drive or press the seals out of the stator.

#### 4. Inspection Of Fuel Supply Transfer Pump Parts

- a. Wash all the parts in clean fuel or solvent and inspect them carefully. New shaft seals should be installed when the pump is reassembled.
- b. Inspect the pump gears. If the gears are slightly worn on the involute surfaces, they should be replaced. If the pump is operated until an appreciable amount of wear is noticeable, the delivery capacity of the pump will be affected. The shear pin holding the driving gear to the pump shaft must be tight. Replace any worn or damaged parts.
- c. Check the fit of the gear hubs in the bores of the stator and housing. If the stator and housing are worn or scored, the entire pump must be replaced.
- d. Inspect the surfaces inside the stator and housing contacted by the gear faces. If the surfaces show excessive wear or are scored, the entire pump must be replaced.
- e. Check the pressure relief valve

plunger. If the plunger does not form a tight seal on its seat in the stator, lap the plunger and seat using fine grind lapping compound. A piece of wood about the size of a pencil may be used as a holder for the hand lapping. Use only a small amount of compound so that only the seat of the plunger and the seat in the stator is lapped. Thoroughly wash all the lapping compound and foreign material off the plunger and out of the stator after lapping. It is recommended that a new plunger spring be used when the valve is reassembled.

#### 5. Assembly Of Fuel Supply Transfer Pump Parts

- a. Install a pump shaft seal in the stator, with the sealing lip of the seal directed toward the pump housing end of the stator. Install the other shaft seal in the stator with the sealing lip of the seal directed toward the mounting flange end of the stator.
- b. Lubricate the pump driving gear shaft and seals and install the pump shaft (with driving gear pinned in place) in the stator. Push the shaft through the seals using care not to damage the sealing lips.
- c. Install the driven gear in place in the housing. Lubricate the gears with light engine oil.
- d. Coat the mating machined surfaces of the stator and the pump housing with a commercial non-hardening sealing compound.

CAUTION: Do not allow any sealing compound inside the pump. Place the pump housing in position on the stator, turn the pump shaft to mesh the gear teeth, and push the parts together. Install the attaching screws with lockwashers and tighten securely.

- e. Turn the pump shaft and test it for bind. The shaft should turn smoothly, with a slight drag, but should not bind or have tight spots.
- f. Lubricate and install the pressure relief valve parts, making certain that the parts are installed in their proper sequence.

NOTE: Turn the adjusting screw into the pump stator the same number of turns that was required for removal. For final

NOTE (cont): adjustment, refer to Item 7, Relief Valve Adjustment.

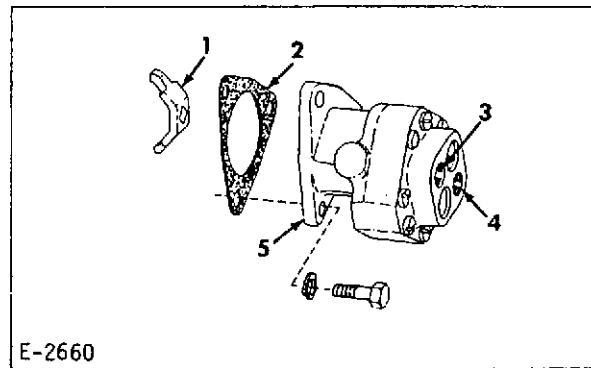
#### 6. Installation Of Fuel Supply Transfer Pump

Install the pump on the timing gear housing by reversing the removal procedure, making certain that the gasket used between the pump and the timing gear housing is in good condition. Be sure the coupling fork used to couple the pump driving gear shaft to the drive assembly gear is in good condition and properly installed (Fig 29).

#### 7. Relief Valve Adjustment

After the fuel supply transfer pump is installed on the engine, final adjustment of the pressure relief valve must be made with new fuel filters installed, otherwise a false pressure indication will be obtained. Check the relief valve for proper pressure as follows:

- a. Install a pressure gauge between the fuel filter inlet tee and the day tank to filter inlet line.
- b. Start engine and observe fuel pressure on gauge installed at filter inlet. If specified pressure of 7 to 10 psi (48 to 69 kN/m<sup>2</sup>) is not obtained, relief valve must be adjusted.
- c. Stop engine. Remove hex cap nut and



1. Coupling fork
2. Gasket
3. Fuel outlet
4. Fuel inlet
5. Pump assembly

Figure 29. Fuel Transfer Pump

turn adjusting screw IN or OUT as necessary to obtain specified 7 to 10 psi (48 to 69 kN/m<sup>2</sup>). Install hex cap nut.

**CAUTION:** Hex cap nut must be installed securely on pump while pressure check is being made.

- d. Start engine and again observe fuel pressure. If specified pressure is not obtained, repeat step c.

## TOPIC 13. LUBRICATION SYSTEM

### A. DESCRIPTION

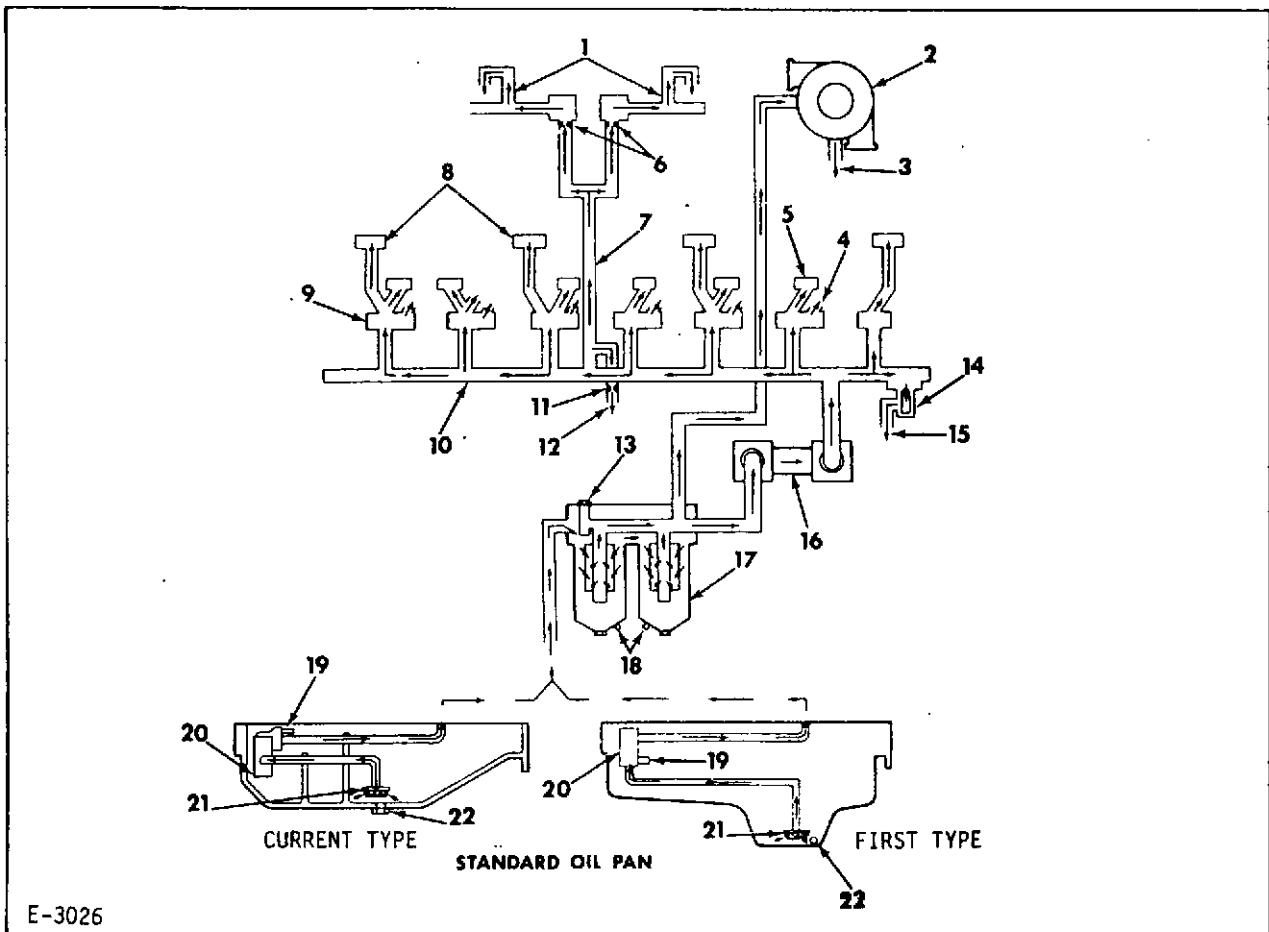
Models 11000 and 11000MKII are pressure lubricated throughout by a gear-type lubricating oil pressure pump, driven by the oil pump driving gear in mesh with the crankshaft gear located on the front end of the crankshaft. The engine oil pressure should be between 30 and 55 psi (207 and 379 kN/m<sup>2</sup>) when the engine is operating at full throttle and with the engine coolant at normal operating temperature.

The lubrication system of the model 11000 is designed so that the engine can operate at an angle of 20° and the 11000MKII at 30° in any direction from horizontal.

The pistons of the 11000MKII engine are cooled by engine lubricating oil. The cooling is accomplished by directional jets located in the upper main bearing support members of the cylinder block. These jets direct a metered amount of oil to the underside of the piston domes. Oil is routed to the jets by a passage (hole) which is connected to the annular oil groove in the main bearing.

### B. GENERAL MAINTENANCE

The level of lubricating oil in the oil pan should be checked at the start of each period of engine operation with the unit in a level position.



- |  |                                   |                                    |
|--|-----------------------------------|------------------------------------|
| 1. Rocker arm shaft drain tubes (drains back to oil pan) | 7. To rocker arm shafts           | 15. Return to oil pan              |
| 2. Turbocharger  | 8. Camshaft bearings              | 16. Engine oil cooler              |
| 3. Return to oil pan                                     | 9. Main bearings                  | 17. Lubricating oil filters        |
| 4. Piston cooling jets - 11000MKII only                  | 10. Main oil gallery              | 18. Filter drain plugs             |
| 5. Connecting rod bearings and to piston pins            | 11. Restrictor                    | 19. Oil pump pressure relief valve |
| 6. Restricted rocker arm bracket (no. 3 and no. 4)       | 12. Return to oil pan             | 20. Oil pressure pump              |
|  | 13. Oil filter bypass valve       | 21. Suction screen                 |
|  | 14. Oil pressure regulating valve | 22. Drain plug                     |

Figure 1. Lubrication System Schematic Diagram

The current type oil level gauge (dipstick) is shielded to allow the operator to check the oil level with the engine either stopped or running. The gauge is stamped to indicate the two different oil levels. The RUNNING side is stamped ADD, FULL, and RUNNING. The STOPPED side is stamped ADD, FULL, and STOPPED (Fig 2).

To check the oil level with the engine stopped, use the side of the dipstick marked STOPPED. If the engine is stopped after a period of operation, allow at least 5 minutes for the oil to drain into the oil pan before checking the oil level.

To check the oil level with the engine running, the oil must be at operating temperature and the engine running. Use the side of the dipstick stamped RUNNING.

The early type oil level gauge (Fig 2) was stamped FULL and LOW, and with the operating range. With this gauge, the oil level could only be checked with the engine stopped.

If the oil level is low, add the specified lubricating oil to bring the level to the FULL mark on the gauge.

Once the engine has started, observe the engine oil pressure gauge. If the engine is cold, wait several seconds for the pressure gauge to indicate normal pressure. If after a few seconds, the gauge does not indicate normal pressure, stop the engine and correct the cause.

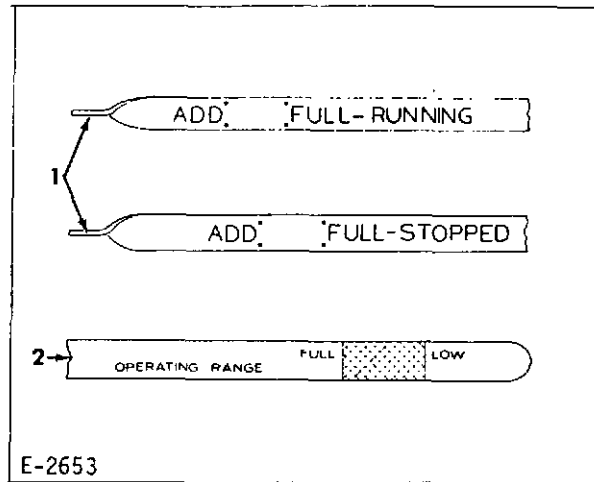
**CAUTION:** Never operate an engine with the oil pressure below the specified minimum. Failure to observe this caution will result in damage to the turbocharger and other engine components.

After starting a turbocharged engine, it is extremely important that it be allowed to operate at a fast idle for 3 to 5 minutes without load. Permitting the engine to operate in this manner assures a free circulation of lubricant through the turbocharger bearings.

Allowing the turbocharger to operate at high speed without sufficient lubrication can result in turbocharger bearing failure within 30 seconds.

It is equally important that all engines be allowed to operate at a fast idle without load for 5 minutes before shutting down. This assures an even cooling of components and allows the turbocharger speed to be minimal when the supply of lubricant is cut off.

Maintenance personnel should familiarize themselves with the recommended lubrication change



1. Current type oil level gauge
2. Early type oil level gauge

Figure 2. Oil Level Gauges

periods specified in Topic 8 and with the recommended lubricant specified in Topic 6.

### C. LUBRICATING OIL FILTERS-STANDARD (Fig 3)

The engine lubricating oil filters are of the full-flow type and contain replaceable elements. A drain plug in each filter shell permits draining of the filters when replacing the filter elements. New elements must be installed each time the oil pan lubricant is changed (100 hours), or more often if conditions warrant.

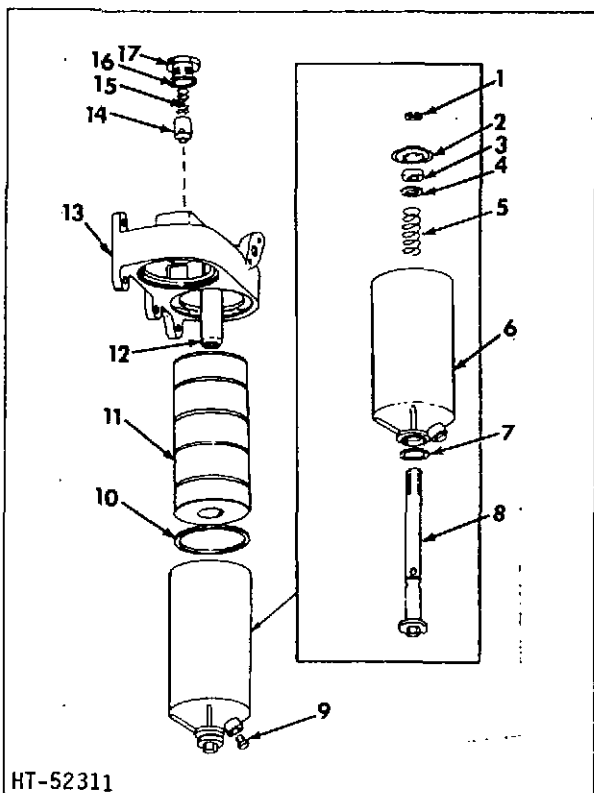
A bypass (pressure relief) valve, located in the oil filter head permits oil to pass directly to the main oil gallery if the oil filters become clogged, or when in cold weather the oil is too thick to flow freely through the filters.

To change engine oil and replace oil filter element, proceed as follows:

1. Drain the engine oil pan and reinstall drain plug(s) in oil pan.

**NOTE:** The engine should be brought up to operating temperature and shut down before draining the lubricant.

2. Thoroughly clean filter head, filter body, and surrounding area. Remove oil drain plug from the oil filter body and allow to drain.
3. Loosen body center bolt and remove center bolt, filter body, and filter element as an assembly from the oil filter head.
4. Remove the filter element from the filter



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- |                        |  |
|------------------------|--|
| 1. Snap ring           | 10. Body gasket                        |
| 2. Element adaptor     | 11. Filter element                     |
| 3. Seal                | 12. Center bolt adaptor                |
| 4. Element seal washer | 13. Filter head assembly               |
| 5. Spring              | 14. Piston                             |
| 6. Oil filter body     | 15. Piston spring                      |
| 7. Gasket              | 16. Cap gasket                         |
| 8. Center bolt         | 17. Bypass (pressure relief) valve cap |
| 9. Drain plug          |  |

Figure 3. Dual Lube Oil Filter Details

body and discard the element. Remove and discard body gasket.

5. Thoroughly wash and dry interior of filter body. Install the new element in position in the filter body.
6. Install filter body assembly in position on the filter head using a new body gasket. Tighten body center bolt to a torque of 45 to 50 lb-ft (61 to 68 Nm). Install the filter drain plug and tighten securely.

#### D. BYPASS TYPE OIL FILTER ASSEMBLIES - OPTIONAL

##### 1. General (Figs 4 and 5)

The bypass type filter is of 2 designs, the Luber-Finer type and the Fleetguard type.

The purpose of the bypass type filter is to supplement the full flow type filters mounted on the side of the

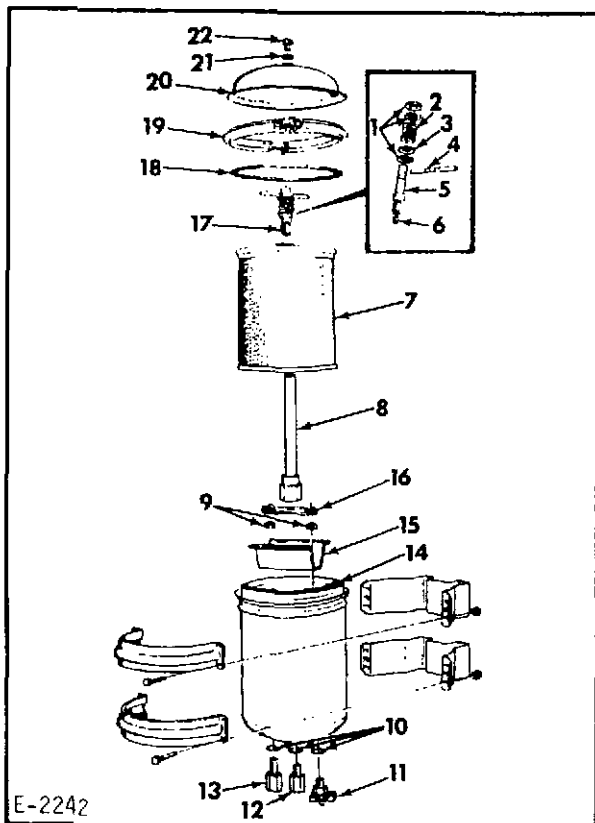
engine. Its function is to filter out impurities that may cause sludge, acid, or varnish to form. The use of the bypass filter permits the lubrication change period to be extended.

The change period should be established only after laboratory analysis of the oil has been made. (Refer to Topic 6)

#### 2. Maintenance

The filter element must be changed at each lubrication change period. Replace the element as follows:

- a. Clean the filter cover and surrounding area. Loosen the drain cock in the bottom of the filter housing and allow filter to drain. Remove the cover clamp ring and lift the cover from filter housing. Do not damage the gasket.
- b. Unscrew and remove the T-handle hold-down from the center-tube. Remove the filter element from the housing by lifting with pull-out bail; discard element.
- c. Clean the interior of housing and tighten drain cock.
- d. To assure leak-proof sealing, examine center-tube seat at each end of new filter element to see that seats are clean and in good condition. Insert the new element in the filter housing and press down firmly.
- e. If filter is the Luber-Finer type make certain the hole in the orifice plug, located in the T-handle hold-down, is open. Install hold-down and tighten securely.
- f. Install cover gasket and place the cover in position on filter housing. Install cover clamp ring and tighten securely.
- g. Fill engine crankcase with specified lubricant.
- h. Be sure engine shut-off control is in the STOP position; crank engine with starter to 15 seconds to assure filling filters and complete engine lubrication before engine is started. Start engine and operate it at 1/4 speed for about 5 minutes.
- i. Stop the engine and check oil level; add oil as necessary to raise oil to FULL mark on dipstick.
- j. Observe filter for leakage; correct any leaks.



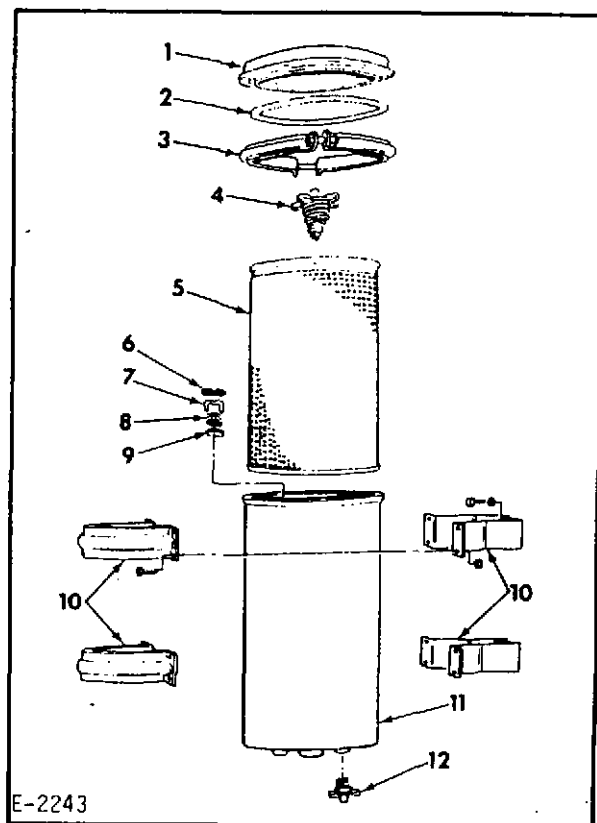
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- |                 |                           |
|-----------------|---------------------------|
| 1. Washers      | 12. Valve, check (outlet) |
| 2. Spring       | 13. Valve, check (inlet)  |
| 3. Seal         | 14. Housing               |
| 4. Handle       | 15. Support               |
| 5. Stud         | 16. Retainer              |
| 6. Orifice plug | 17. T-handle              |
| 7. Element      | 18. Gasket (O-ring)       |
| 8. Center tube  | 19. Ring, clamp           |
| 9. Nuts         | 20. Cover                 |
| 10. Gaskets     | 21. Washer                |
| 11. Cock, drain | 22. Plug, vent            |

Figure 4. Bypass Filter Assembly  
(Luber-Finer Design)

#### E. DRAINING AND FILLING OIL SYSTEM

1. Before draining the oil system, operate the engine until a minimum coolant temperature of 160°F (344 K) is obtained. Remove the drain plug from the oil pan and allow the oil to drain.
2. Install the drain plug and fill the oil pan with the specified grade of lubricant to the top mark of the oil level gauge (dipstick).
3. Crank the engine for 15 seconds but do not start. This will assure filling of the filters and that lubricant has been pumped to engine components before engine is started. Operate the engine for approximately 5 minutes.



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- |   |                 |
|---|-----------------|
| 1. Cover                                    | 7. Cage         |
| 2. Gasket                                   | 8. Spring       |
| 3. Ring, clamp                              | 9. Disc         |
| 4. T-handle/support<br>assembly with O-ring | 10. Bracket     |
| 5. Element                                  | 11. Housing     |
| 6. Ring                                     | 12. Cock, drain |

Figure 5. Bypass Filter Assembly  
(Fleetguard Design)

4. Stop the engine and allow several minutes for the oil to drain back to the oil pan before checking the oil level.
5. Using the oil level gauge, check the oil level and add oil as necessary to raise the level even with the uppermost mark on the gauge.
6. Observe the engine lubricating oil filter for oil leakage and be certain that the body and body gasket is properly installed.

#### F. LUBRICATION SYSTEM MAINTENANCE

Lubrication system maintenance requires the observance of the following checks and services.

##### 1. Lubricating Oil

The lubricating oil must be of the best quality, proper SAE weight for the pre-

vailing ambient temperature, and kept free of water and abrasives by proper handling and storage. Refer to Topic 6, LUBRICATION RECOMMENDATIONS.

## 2. Daily Check

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

## 3. Cooling System Temperature

It is important to maintain the cooling system temperature at a minimum of 180°F (355 K) so that the lubricating oil will be hot enough for proper filtering. A low cooling system temperature will cause low oil temperature and poor filtering of the lubricating oil, which will result in rapid wear of all moving parts.

## 4. Oil Level Gauge (Dipstick)

The oil level gauge (current models) is the shielded type which allows the operator to check oil level while the engine is either stopped or running.

**CAUTION:** Use appropriate ADD and FULL marks depending upon whether the engine is stopped or running.

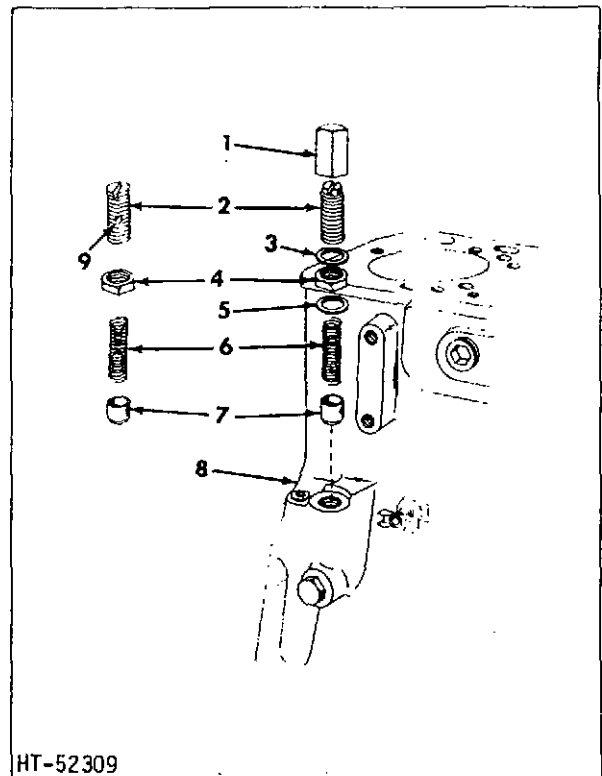
The oil level gauge used on early models has a low level mark and a full mark. It is stamped on one side only and the oil level must be checked when the engine is stopped.

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 Tube

The purpose of the breather tube is to vent the inside of the engine to the atmosphere, thus preventing pressure buildup and removing harmful vapors from



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- |                   |                   |
|-------------------|-------------------|
| 1. Cap nut        | 6. Spring         |
| 2. Screw          | 7. Piston         |
| 3. Cap nut gasket | 8. Cylinder block |
| 4. Jam nut        | 9. Nylon pellet   |
| 5. Jam nut gasket |                   |

Figure 6. Oil Pressure Regulating Valve Details

the crankcase, gear train, and valve compartments. If the tube becomes clogged, vapors are trapped within the engine, and pressure buildup will force oil past crankcase seals, dipstick, cover gasket, etc.

After each operating interval of 600 hours, remove breather tube from the rocker covers. Clean inside of tube with cleaning solvent, blow out with compressed air, and replace on engine.

## 6. Lubricating Filter Bypass Valve (Fig 3)

Whenever a major inspection of the engine is made, remove, clean, inspect the parts of the bypass valve. The piston must slide smoothly in the I.D. of the sleeve pressed into the filter head.

When piston, or I.D. of sleeve shows excessive wear, the parts must be replaced.

Reinstall the parts in the filter head and tighten the cap securely.

## 7. Oil Pump Pressure Relief Valve

If the oil pan is removed for any reason, remove the oil pump pressure relief valve from the oil pump.

Disassemble, clean and inspect the parts. The piston must slide smoothly in the bore of the valve body. When piston or bore of the valve body shows excessive wear, a new valve assembly must be installed.

Reinstall the pressure relief valve into the rear of the oil pump and secure it with the pressure relief valve body lock.

## 8. Oil Pressure Regulating Valve (Fig 6)

The oil pressure regulating valve is located in the main oil gallery at the right-rear corner of the cylinder block. The pressure regulating valve maintains stabilized oil pressure within the lubrication system. When the oil pressure exceeds the valve setting, the valve piston is raised off the valve piston seat, and the oil is bypassed directly from the cylinder block to the oil pan.

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

Every 3000 hours of operation, remove and inspect the oil pressure regulating valve.

NOTE: On early model engines the regulating valve assembly consists of a cap nut, screw, cap nut gasket, jam nut, jam nut gasket, spring, and piston. On current models the valve assembly consists of a regulating screw with a nylon pellet, jam nut, spring, and piston.

Remove pressure regulating valve screw, noting the number of turns required for

removal. Withdraw the valve spring and piston. Wash all parts thoroughly and inspect carefully. Replace any parts that are worn.

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

NOTE: Turn the valve screw into the cylinder block the same number of turns that was required for removal.

Start engine and allow it to reach normal operating temperature. Adjust the oil pressure regulating valve screw to obtain oil pressure of 45 to 50 psi (310 to 345 kN/m<sup>2</sup>) at 1800 rpm.

## G. ENGINE OIL COOLER

The engine oil is directed to the oil cooler after leaving the filter assembly. Coolant is circulated through the cooling core tubes and engine lubricating oil is circulated around the tubes. The coolant absorbs heat from the oil, thereby controlling the oil temperature.

CAUTION: It is important that the oil cooler be kept clean and free of deposits in order to maintain proper cooling.

The cooling core consists of small corrosion resistant tubes which transfer the heat from the oil to the engine coolant. If the recommended maintenance and lubrication is not performed at the indicated interval, deposits may form in the oil cooler and restrict the flow of oil or coolant. Restriction of the flow of oil is usually indicated by a drop in oil pressure and a rise in oil temperature. See Topic 11, COOLING SYSTEM, for complete removal, cleaning, testing, and installation procedures.

## TOPIC 14. ENGINE ELECTRICAL SYSTEM

### A. GENERAL

The engine electrical system includes the starting motor, battery charging generator or alternator, voltage regulator, and storage battery (customer supplied).

Basic components of the charging system include the battery, generator or alternator, and voltage regulator. The battery is the storage plant for electrical energy and must be kept fully charged. The generator or alternator functions to recharge the battery. Excessive current flow can burn out the generator or alternator and damage the battery to the extent that it cannot hold a charge. A voltage regulator is connected into the circuit to prevent such damage.

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

NOTE: For specific ratings and polarity of the generator or alternator and voltage regulator refer to SPECIFICATIONS, Topic 2, Paragraph F.

### B. WARRANTY AND ADJUSTMENT

Manufacturers of the battery, starting motor, generator or alternator, and regulator are responsible for this equipment during the warranty period. Any claim for replacement or repair of these items must be presented to the equipment manufacturer, not to Allis-Chalmers. Suppliers of such equipment are represented in nearly all cities by distributors or dealers who are authorized to make reasonable adjustments or replacements. Always give the serial number of the engine and the date on which 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 hole. 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 battery before putting engine into service.

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

Maintain battery in a fully charged condition. Check charge condition or specific gravity with a hydrometer with electrolyte temperature corrected to 80°F (300 K). Add .004 for every 10° above 80°F (5.55 K above 300 K); subtract .004 for every 10° below 80°F (5.55 K below 300 K).

<u>Hydrometer Indication</u>	<u>Charge Condition</u>
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 ground polarity of the generator or alternator and the battery must be the same before connecting. Make sure all grounding points have a metallic contact. When connecting either a trickle or fast type charger to the battery, it is imperative that correct polarity be observed. That is, connect the positive lead of the charger to the positive battery post and the negative lead to the negative battery post. Observe the same polarity rule when connecting booster batteries. When any work is performed on the electrical charging system, disconnect the battery to prevent short circuits.

### D. ELECTRIC STARTING MOTOR

#### 1. General

The starting motor is a heavy duty, 24 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 of the starter switch completes the electrical circuit between 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 engine cranking.

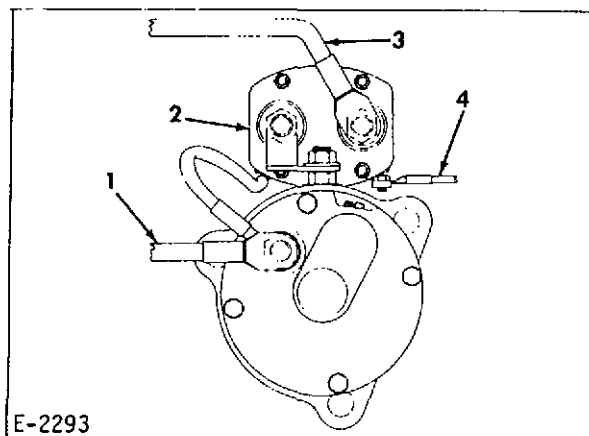
**CAUTION:** Do not operate starting motor continuously for more than 30 seconds without pausing to allow it to cool for at least 2 minutes. Failure to observe this rule can result in overheating and failure of the motor.

## 2. Removal And Installation

- a. Tag and disconnect battery cables and electrical lead wires from starting motor.
- b. Remove capscrews and lockwashers that attach starting motor to flywheel housing. Remove starting motor and adaptor.
- c. Install starting motor on engine by a direct reversal of the removal procedure. Connect cables and wires to it.

## 3. Maintenance

- a. During startup, note starting motor action. The pinion gear should mesh promptly with the flywheel ring gear and spin the engine. After engine starts and motor switch opens, the starting motor should stop operating.
- b. If starting motor cranks 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 starting motor to battery circuit, defective starting motor, low temperatures, or various conditions in the engine.
- c. Periodically check condition of battery, battery cables and connections, starting motor, solenoid switch, commutator, brushes, lead connections, and mounting.
- d. Starting motor bearings are lubricated only when unit is disassembled for inspection or repair.
- e. Brushes must make good contact with the commutator. Minimum tension of brushes is 80 ounces (2.27 kg).
- f. Check length of brushes. Original brush length is 1/2" (12.70 mm).



1. Cable (ground)
2. Starter solenoid
3. Cable (to battery)
4. To starter switch

Figure 1. Starter

**NOTE:** CABLE TABULATION LISTS THE MAXIMUM ALLOWABLE LENGTH OF CABLE USED FOR 24 OR 32 VOLT SYSTEMS. LENGTH INCLUDES DISTANCE FROM BATTERY TO GROUND, AND BATTERY TO STARTER TERMINAL.

### STARTING CABLE TABULATION 24 AND 32 VOLT SYSTEMS

CABLE MAXIMUM LENGTH		CABLE SIZE	
INCH	CENTIMETER (CM)	AWG	MM
188	477	#0	0.835
237	602	#00	0.865
300	762	#000	1.179
380	965	#0000 or two #0	1.326

They should be replaced if wear has decreased their length to 5/16" (7.94 mm) or less.

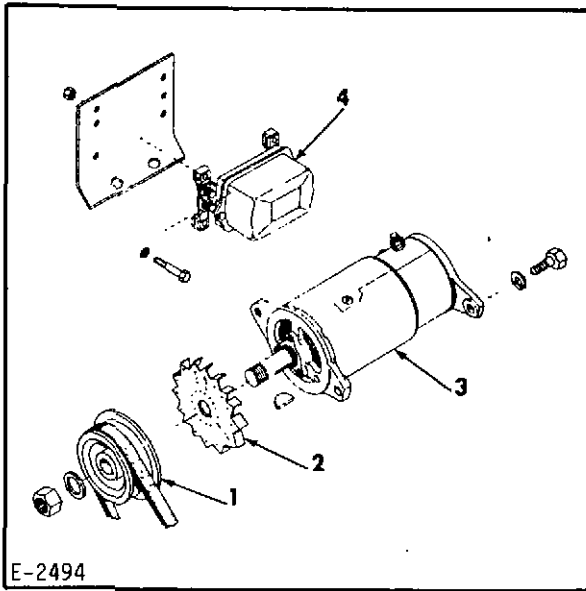
- g. If commutator is dirty, clean with #00 sandpaper.

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

## 4. Starting System Checks

If starting motor cranks engine slowly, check the following:

- a. Test for excessive resistance in starting circuit. Resistance can be



- |           |                      |
|-----------|----------------------|
| 1. Pulley | 3. DC generator      |
| 2. Fan    | 4. Voltage regulator |

Figure 2. DC Generator and Voltage Regulator

checked by using a voltmeter to measure the voltage drop between the various terminals in the circuit. Readings should never show a drop of more than 0.2 volt.

- b. Check for low or discharged battery.
- c. Check engine for tight bearings, pistons, heavy oil, etc., which imposes heavy loads on the starting motor.
- d. Check starting motor for bent armature, defective bearings or worn brushes.

If starting motor will not crank the engine, check the following:

- a. Check for completely discharged battery.
- b. Check for open starting circuit - starter switch, open wiring, defective solenoid switch.
- c. Check starting motor. Disassemble and repair as required.
- d. Check drive mechanism.
- e. Check flywheel ring gear - teeth may be broken out.

#### E. DC GENERATORS AND VOLTAGE REGULATORS

The generating system (Fig 2) restores to the battery the current withdrawn during cranking.

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The system also carries the 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 electromagnetic relay of the vibrating type. It consists of three units (1) a cutout relay which connects and disconnects battery, (2) a voltage regulator which prevents battery overcharge and high voltage, and (3) a current regulator to protect generator or alternator from overloads.

#### 1. Generator And Regulator Removal

- a. Remove the capscrew and lockwasher attaching the generator to the generator adjusting brace. Remove the drive belt. Disconnect generator lead wires.
- b. Remove the capscrews and lockwashers 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.

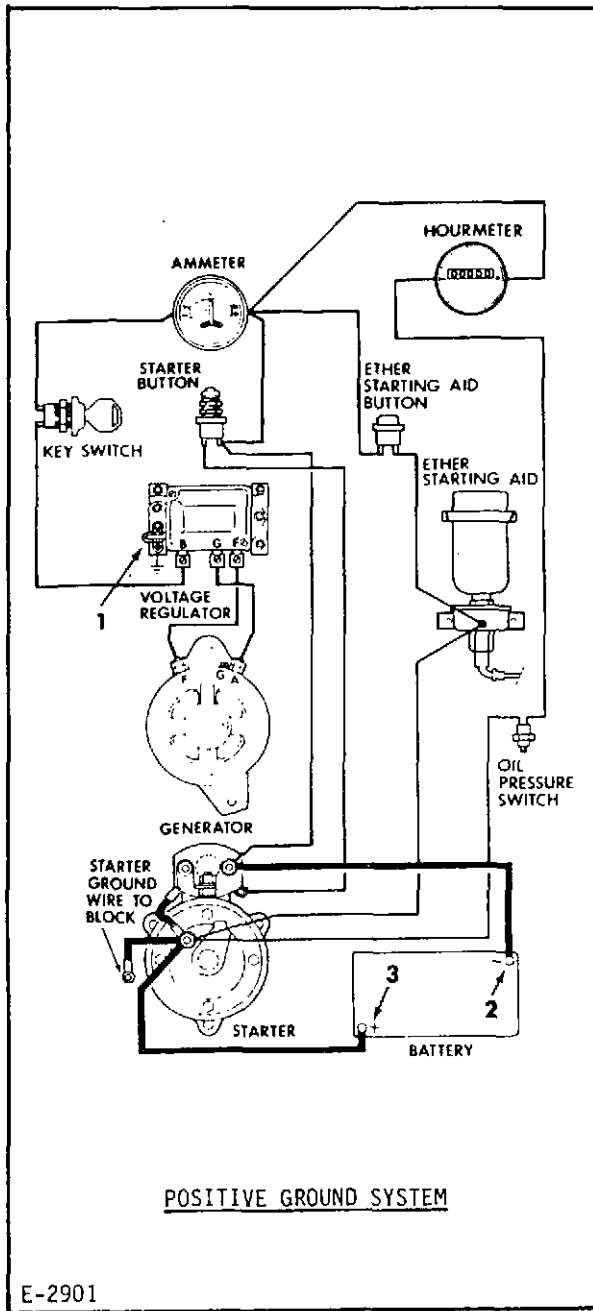
- c. Disconnect generator regulator wires; identify the wires to facilitate installation.
- d. Remove generator regulator attaching capscrews, nuts, and lockwashers.
- e. Remove the generator regulator.

#### 2. Generator Maintenance

- a. Periodically the commutator should be inspected and cleaned, if necessary. Clean only with #00 sandpaper, never use emery cloth. Also 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 commutator, make cut no deeper than necessary. The mica should be undercut 1/32" (0.031 mm).

**CAUTION:** Make certain cut is not made on commutator riser bars because solder will be removed, thereby weakening the coil connection at this section.

- c. If generator is equipped with oil cups, lubricate with 3 to 5 drops of engine oil at each engine lubricating oil renewal interval.

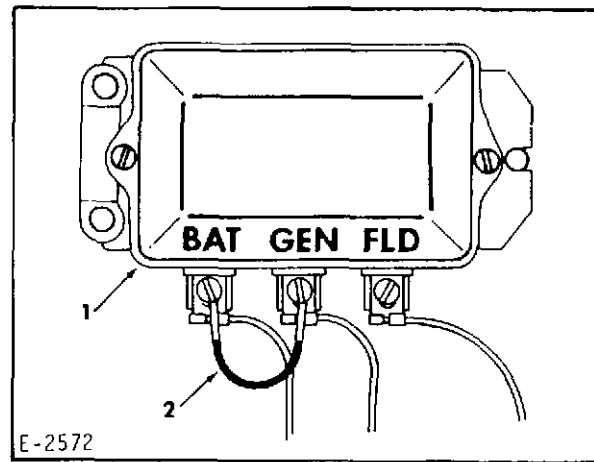


1. Ground wire
2. Battery negative terminal
3. Battery positive terminal

NOTE: If engine is powering a generator set, disregard this wiring diagram and refer to the DC wiring diagram furnished with the generator set.

NOTE: If engine is equipped with safety controls refer to Topic 19, titled, Safety Controls, for additional instructions and wiring diagrams.

Figure 3. DC Generator and Voltage Regulator Wiring Diagram (Positive Ground System)



1. Generator regulator
2. Jumper lead

Figure 4. Polarizing Circuit Diagram (DC Generator ONLY)

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

d. Polarize the generator as follows (Fig 4):

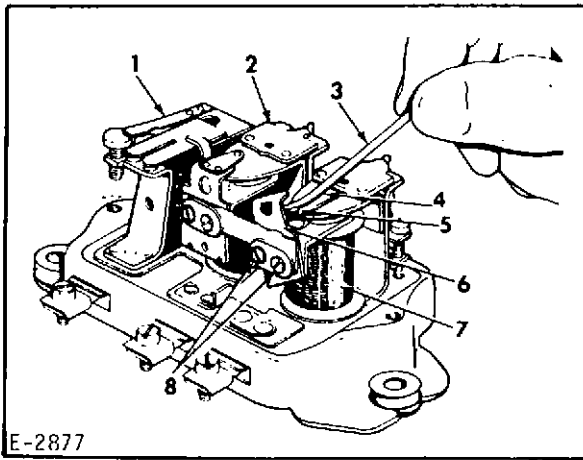
- (1) Insulate generator brushes from the armature by placing cardboard between brushes and armature.
- (2) Using a short jumper lead, momentarily touch the jumper from the BAT to the GEN terminal of the regulator. A solid contact between jumper lead and terminal is required, and a flash or arc will be noted when lead is removed.

(3) Remove the cardboard from under the brushes.

CAUTION: Do not test or operate the generator on 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 lead connected to the GEN terminal of the regulator and connect to any convenient ground to accomplish the short circuit.

3. Generator And Regulator Installation

a. Installation procedure is the reverse



- |                         |                             |
|-------------------------|-----------------------------|
| 1. Cutout relay         | 5. Large flat point         |
| 2. Current regulator    | 6. Contact mounting bracket |
| 3. Spoon or riffle file | 7. Voltage regulator        |
| 4. Armature             | 8. Mounting bracket screws  |

Figure 5. Cleaning Contact Points

of removal.

- b. Adjust drive belt to proper tension. See procedure in Paragraph G this topic.

#### 4. Regulator 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 the voltage fluctuates, as evidenced by an unsteady voltmeter indication, contacts may have excessive resistance or by sticking and therefore, should be cleaned, and possibly readjusted.

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

The large flat point located on the armature of the voltage regulator should be cleaned with a spoon or riffle file (Fig 5). A similar flat point is located on the upper contact support of the current regulator of negative grounded regulator unit. This contact point will usually require the most attention. It

is not necessary to have a flat surface on this contact point but all oxides should be removed with a riffle file so that pure metal is exposed and should be followed by a thorough wash with clear carbon tetrachloride. On regulators which have the flat contact point on the armature, loosen the upper contact bracket mounting screws so that the bracket can be tilted to one side. On regulators which have the flat contact on the upper contact bracket, the bracket must be removed for cleaning the points.

The small soft-alloy contact point, located on the upper contact support bracket of the voltage regulator and on the armature of the current regulator for the negative grounded regulators, does not oxidize. This contact point may be cleaned with crocus cloth or fine abrasive material followed by a thorough wash with clear trichloroethane to remove any foreign material remaining on the contact surface.

Remove all oxides from the contact points but note that it is not necessary to remove any cavity that may have developed.

**CAUTION:** Never use emery cloth or sandpaper to clean the contacts points.

#### F. ALTERNATORS AND VOLTAGE REGULATORS

##### 1. General

The alternator (negative ground) requires a separately mounted voltage regulator.

**NOTE:** If engine are driving generator sets, follow the schematic wiring diagram furnished with the unit.

**NOTE:** For specific ratings and polarity of the alternators and regulators, refer to SPECIFICATIONS, TOPIC 2, Paragraph F.

**CAUTION:** The ground polarity of these alternators and the ground polarity of the battery must be the same before making connections. Instant damage to the wiring and diodes will result if the alternator is connected to the battery with ground polarities not matched.

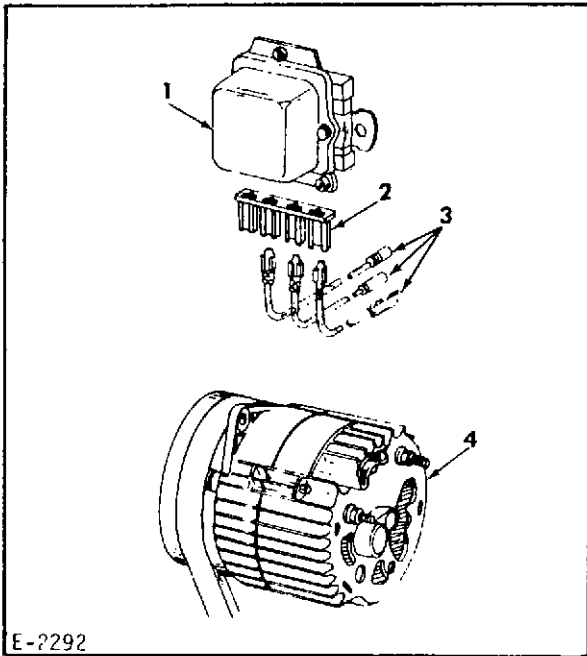
To prevent accidental grounding of a lead and damaging the diodes when removing

CAUTION (Cont): and installing an alternator or regulator, always remove the ground cable from the battery.

NEVER ATTEMPT TO POLARIZE THE ALTERNATOR.

These alternators are designed and constructed to provide long periods of reliable service.

## 2. Alternators and Voltage Regulator

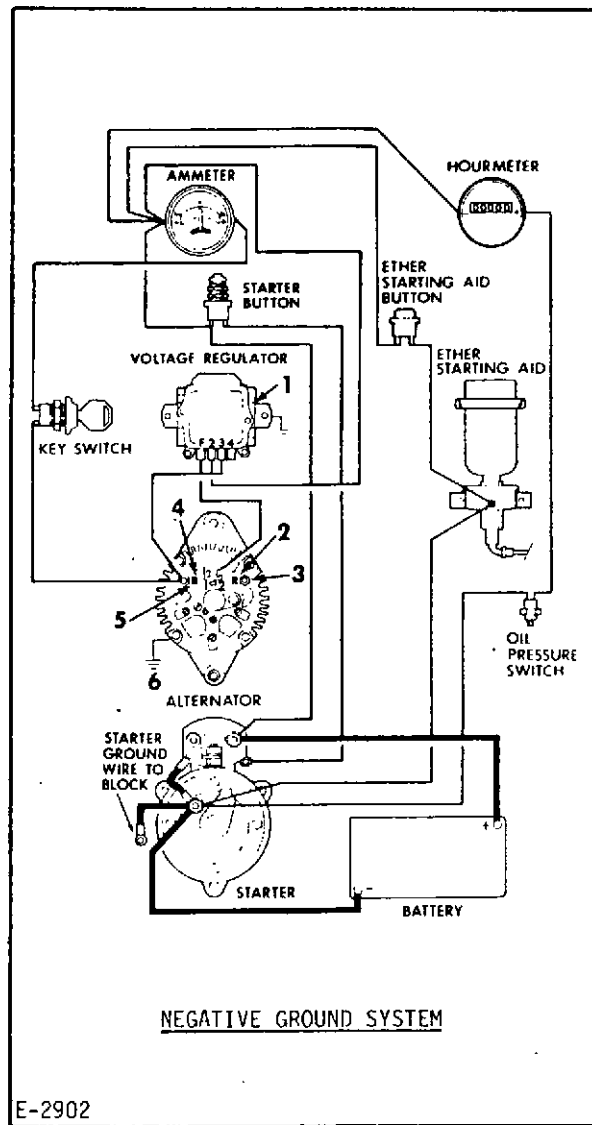


- |              |               |
|--------------|---------------|
| 1. Regulator | 3. Leads      |
| 2. Connector | 4. Alternator |

Figure 6. Alternator with Two Unit Regulator

The alternator features two brush assemblies, each of which has two brushes, and two slip rings. A brush assembly rides on each of the two slip rings. A special constant-tension spring holds each brush in contact with the slip rings. The brushes, springs, and slip rings are enclosed in a special shield which prevents entry of dust and foreign material. By removing two plates located on the outside frame a quick inspection can be made of the brush assemblies and slip rings. This feature also permits brush replacement without disassembly of the unit.

The rotor is mounted on ball bearings that have a grease reservoir which eliminates the need for periodic lubrication. Six rectifier diodes mounted in the slip ring end frame change the AC



1. Ground wire
2. Relay terminal
- CAUTION: Do not ground relay terminal
3. Field terminal (2)
4. Indicator light terminal (1)
5. Battery terminal
6. Ground terminal

NOTE: If engine is powering a generator set, disregard this wiring diagram and refer to the DC wiring diagram furnished with the generator set.

NOTE: If engine is equipped with safety controls refer to Topic 19, titled, Safety Controls, for additional instructions and wiring diagrams.

Figure 7. Alternator and Voltage Regulator Wiring Diagram (Negative Ground System)

to DC and this voltage appears at the BAT terminal on the alternator.

The function of the regulator in the charging circuit is to limit the alternator voltage to a pre-set value by controlling the alternator field current.

The voltage at which the alternator is limited is determined by the regulator adjustment. Once adjusted, the voltage remains practically constant because the regulator is relatively unaffected by length of service, temperature changes, or changes in alternator output.

The regulator has 4 slip connection type terminals. A projection on the connector body serves to latch the assembly together and prevent disconnections due to vibration. The assembly can be disconnected by lifting slightly on the latch.

#### a. Alternator Removal and Installation

Remove ground cable from battery.

Remove electrical leads from alternator terminals.

Remove capscrew, lockwasher, and flat washer securing adjusting brace to alternator.

Loosen capscrews securing the alternator end frames to the mounting bar.

Force alternator toward the engine and remove the drive belt.

Remove alternator by supporting it and removing the capscrews and washers that secure it to the mounting bar.

Install the alternator in reverse order of the removal procedure.

Adjust drive belt to proper tension. See procedure in Paragraph G this topic.

**IMPORTANT: DO NOT POLARIZE ALTERNATOR AFTER INSTALLATION OR AT ANY OTHER TIME.**

#### b. Alternator Maintenance

Periodic maintenance is limited to inspection for loose mounting bolts, a loose drive pulley, or a loose drive belt.

If the alternator is noisy, it may be caused by any of the above mentioned defects, plus worn or dirty bearings, a defective diode or a grounded or shorted stator.

If after tightening the mounting bolts and/or adjusting the drive belt, the alternator is still noisy, it must be removed from the engine and disassembled for further checks.

Check the drive belt for alignment, tension, and wear. Alternator belt tension is a bit more critical than with a d.c. generator. Check for loose drive pulley. Specified pulley retaining nut torque is 40-60 lb-ft (54-81 Nm).

Inspect the terminals for corrosion and loose connections. Check wiring for frayed insulation.

If slip rings are rough or out of round, the alternator must be disassembled so the slip rings can be trued in a lathe to a .002" (.005 mm) maximum indicator reading. Remove only enough material to make rings smooth and round. Finish with 400 grain or finer polishing cloth and blow all dust away.

The grease reservoir provides an adequate supply of lubricant for long periods of operation. When alternator is disassembled for overhaul or repair, inspect bearings and replace if necessary. Fill the grease reservoir in each end frame with Delco-Remy (their Part No. 1948791) to one-half full.

**CAUTION: Do not overfill reservoirs because this will cause the bearings to overheat.**

When alternator is disassembled, inspect brushes and brush springs. Compare brushes from alternator with new brushes and replace if necessary. Inspect brush springs for evidence of damage or corrosion. If there is any doubt as to the condition of the springs, they should be replaced.

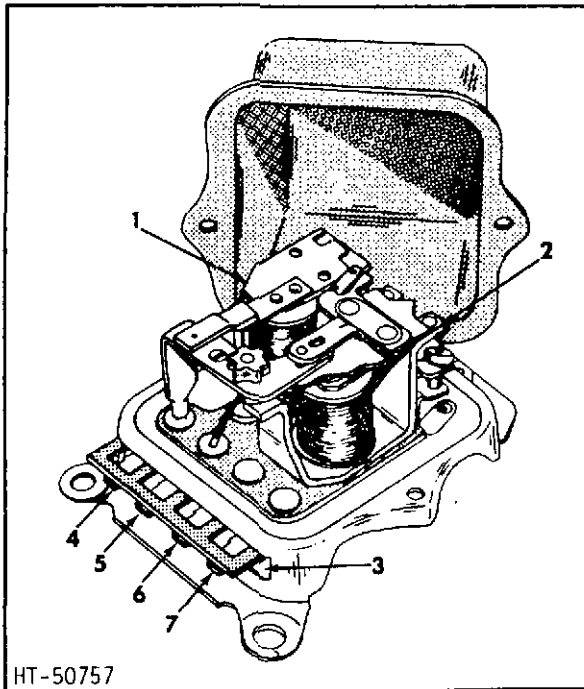
#### c. Voltage Regulator Removal and Installation

Remove battery ground cable.

Lift connector latch and withdraw the connector from the regulator.

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

Install voltage regulator in reverse order of removal.



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

Figure 8. Two Unit Voltage Regulator

d. Voltage Regulator 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 the 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 soft material and must not be cleaned with a file. A strip of No. 400 silicon carbide paper, or equivalent, folded over and then pulled back and forth between the contacts is recommended as a satisfactory method of cleaning. After cleaning; wash contacts with trichloroethane or alcohol to remove any residue. If voltage control has 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.

G. GENERATOR/ALTERNATOR DRIVE BELT ADJUSTMENT

1. Replace belts if they are damaged, badly worn, or soaked with oil and grease. Even though only one belt may need replacement because of damage or excessive wear, it is imperative that both belts be replaced to obtain satisfactory belt life.
2. Check tension of drive belts using a Borroughs Tension Gauge (BT-33-72C) or equivalent. New drive belts are installed with a tension of 125 pounds (57 kg). Belts must be retightened whenever tension drops to 85 pounds (38 kg). Always retighten old belts and pulleys to 105 pounds (48 kg).
3. To obtain proper belt tension, loosen the generator/alternator adjusting brace cap-screw and mounting screw and move generator/alternator in or out as required.

**CAUTION:** When adjusting belt tension, apply force against stator laminations between generator/alternator end frames, not against the end frames.

4. Retighten the capscrew.

**NOTE:** If belt tension gauge is not available, check new belt tension by hand. Belt is adjusted within limits when it can be pressed inward 3/16" to 1/2" (4.76 to 12.70mm) at a point half-way between the generator/alternator pulley and the fan pulley. About 24 hours of operation is required to properly seat a new belt.

## TOPIC 15. VALVE ADJUSTMENT AND CYLINDER HEAD

### A. GENERAL

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.

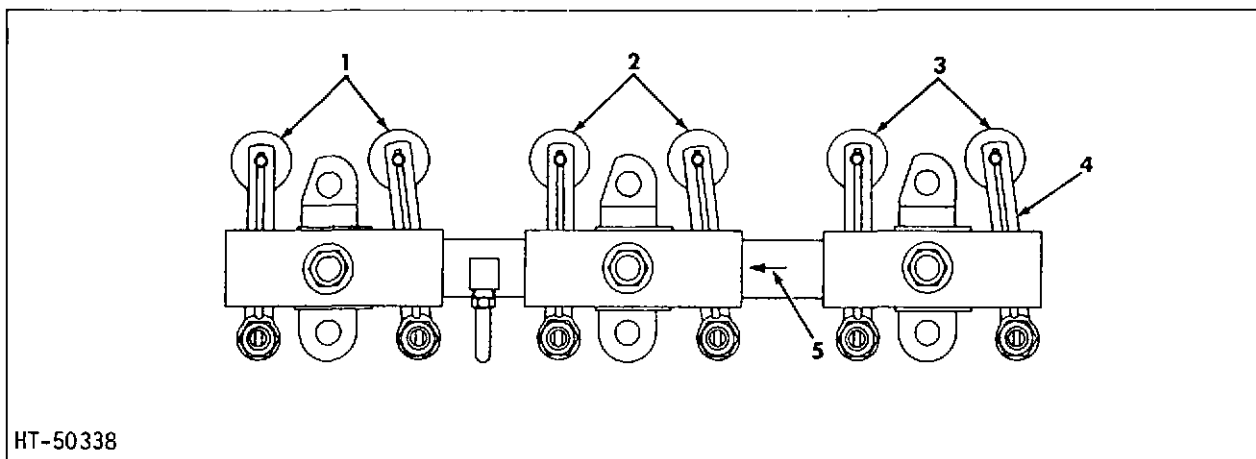
With the engine coolant temperature at a minimum of 160°F (344 K), the specified valve clearance is 0.018" (0.46 mm) for both the intake and the exhaust valves. After any mechanical work has been done which would disturb the valve clearance, the valves may be set cold at 0.020" (0.51 mm) so the engine may be run and allowed to warm up. After engine has reached a minimum of 160°F (344 K) coolant temperature, the valve clearance should again be checked at the specified hot setting of 0.018" (0.46 mm).

**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.

### B. VALVE LASH ADJUSTMENT (Figure 2)

Valve lash must be adjusted when the piston is near top dead center on its compression stroke and intake and exhaust valves are closed. Number 1 and Number 6 pistons move up and down in their respective cylinders simultaneously. When one piston is on its compression stroke, the other is on its exhaust stroke, and vice versa. Observe valves for Number 6 cylinder; when the exhaust valve is almost closed and the intake valve starts to open, Number 6 piston is near top dead center on its exhaust stroke and Number 1 piston is in the same position on its compression stroke. At this point, both valves for Number 1 cylinder are closed and valve lash can be adjusted. Engine firing order is 1-5-3-6-2-4, and if this sequence is followed, the lash for all valves can be checked and adjusted in 2 complete revolutions of the crankshaft. Check valve clearance periodically. When adjustment is necessary, proceed as follows to obtain specified clearance:

1. Operate the engine until it reaches 160°F (344 K) minimum. Stop the engine.
2. Thoroughly clean the valve rocker covers and surrounding area.
3. Remove upper section of breather tube, valve rocker cover nuts, sealing washers, and rocker covers.
4. Crank engine until exhaust valve for Number 6 cylinder is almost closed and



1. No. 1 Cylinder
  - i. Intake Valve
  - e. Exhaust Valve
2. No. 2 Cylinder
  - i. Intake Valve
  - e. Exhaust Valve

3. No. 3 Cylinder
  - i. Intake Valve
  - e. Exhaust Valve
4. Rocker Arm
5. To front of engine

Figure 1. Rocker Arms and Valves Location (Front Head Shown - Rear Head Identical)

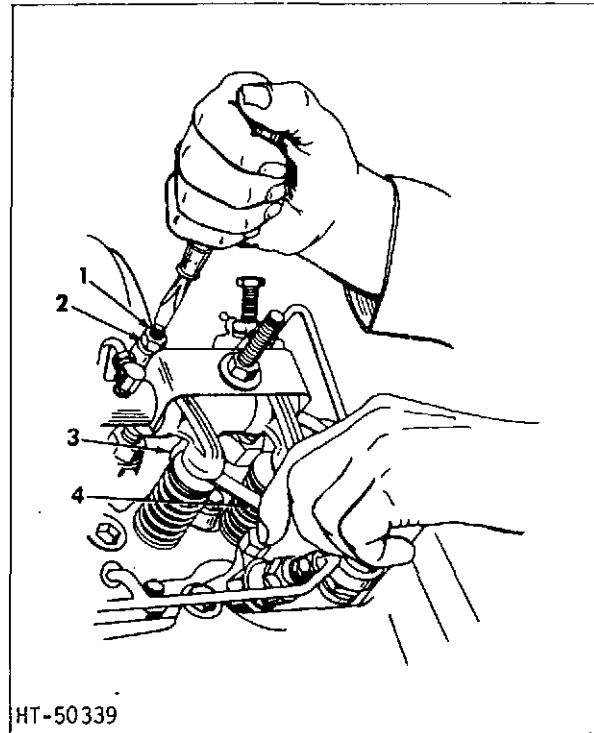
intake valve starts to open, then check and adjust intake and exhaust valve lash for Number 1 cylinder.

5. Use a 0.018" feeler gauge and check clearance between valve stems and rocker arms. Gauge should pass between rocker arm and corresponding valve stem with a slight drag when valve lash is properly adjusted.
6. Adjust each valve by loosening the locknut on the adjusting screw and turning the screw clockwise to decrease the clearance or counterclockwise to increase the clearance as necessary. When the proper clearance is obtained, hold the rocker arm adjusting screw stationary and tighten the locknut. Recheck the lash to make certain the clearance did not change when the locknut was tightened.
7. Crank engine until Number 2 cylinder exhaust valve is almost closed and intake valve starts to open, then adjust lash for intake and exhaust valves for Number 5 cylinder, following procedure in preceding Steps 5 and 6.
8. Crank engine until Number 4 cylinder exhaust valve is almost closed and intake valve starts to open, then adjust lash for intake and exhaust valves for Number 3 cylinder, following procedure in preceding Steps 5 and 6.
9. Crank engine until Number 1 cylinder exhaust valve is almost closed and intake valve starts to open, then adjust lash for intake and exhaust valves for Number 6 cylinder, following procedure in preceding Steps 5 and 6.
10. Crank engine until Number 5 cylinder exhaust valve is almost closed and intake valve starts to open, then adjust lash for intake and exhaust valves for Number 2 cylinder, following procedure in preceding Steps 5 and 6.
11. Crank engine until Number 3 cylinder exhaust valve is almost closed and intake valve starts to open, then adjust lash for intake and exhaust valves for Number 4 cylinder, following procedure in preceding Steps 5 and 6.

#### C. TORQUING CYLINDER HEADS

If the cylinder heads are removed for any reason, the cylinder head fasteners must be tightened evenly following the numerical sequence illustrated in Figure 3 and to the specified torque.

The specified torque for the fasteners with



- |                    |                 |
|--------------------|-----------------|
| 1. Adjusting Screw | 3. Rocker Arm   |
| 2. Locknut         | 4. Feeler Gauge |

Figure 2. Adjusting Valve Lash

engine oil lubricated threads is listed below.

Engines with studs and nuts:

- |                                      |
|--------------------------------------|
| 1/2" (12.70 mm) - 100 lb-ft (136 Nm) |
| 5/8" (15.88 mm) - 185 lb-ft (251 Nm) |

Engines with capscrew:

- |                                      |
|--------------------------------------|
| 1/2" (12.70 mm) - 115 lb-ft (156 Nm) |
| 5/8" (15.88 mm) - 185 lb-ft (251 Nm) |

#### D. INSTALLING CYLINDER HEADS

Install the cylinder heads and tighten the fasteners as follows:

1. Thoroughly clean the top deck of the cylinder block and the under side of the cylinder heads.
2. Check cylinder sleeve protrusion above top deck of cylinder block. The desirable protrusion for the current head gaskets 0.002" - 0.005" (0.05 - 0.13 mm). Current production engines have this protrusion. Reasonable results have been obtained when using the current head gasket with the early engine sleeve protrusion of .0065" - .0095" (0.17 - 0.24 mm). It is important that all sleeves, under any one head, have no more than 0.003" (0.08 mm) difference in

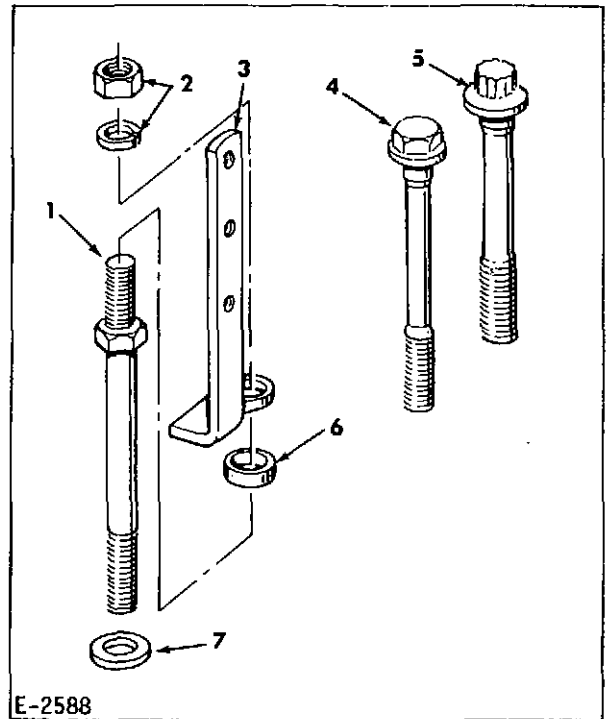
protrusion whether with the old or new protrusion specification. Protrusion must be checked with sleeves clamped down in their bores in the cylinder block.

3. Install the head gaskets in their correct front or rear positions and with the indicated side down as stamped on gaskets. Do not use sealer or gasket dope on these cylinder head gaskets. Install the fire rings on each cylinder sleeve being sure no over-lapping fire rings and gaskets occurs.
4. Install the front and rear cylinder heads.

NOTE: For engines having studs and nuts (not capscrews) use nylok inserted head nuts in positions 9, 12, 25 and 27 (Fig 3) to prevent possibility of oil seepage through threads and out tapped holes in ends of heads.

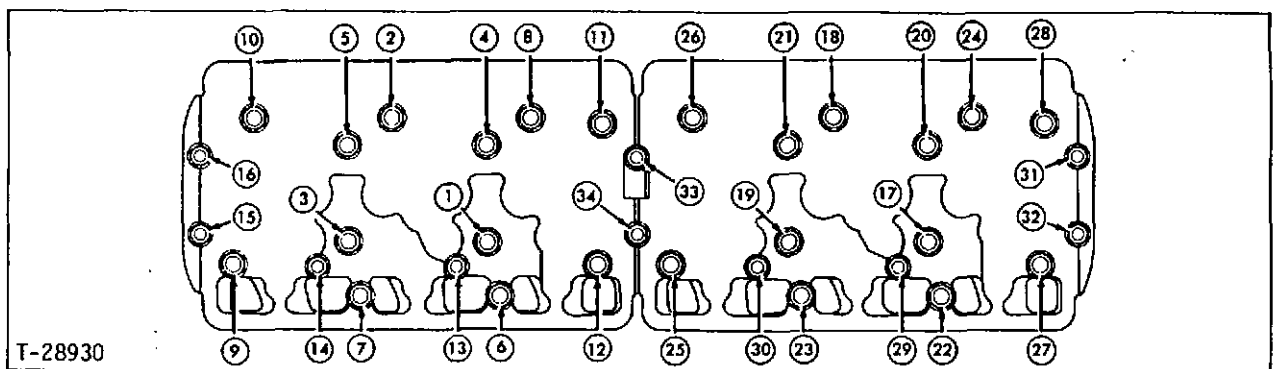
NOTE: A "Flank Drive" 3/4" - 12 point socket must be used to tighten the 5/8" (15.88 mm) capscrews.

5. Using engine oil, lubricate the fastener threads and the underside of the bolt heads. Install the fasteners in their proper locations. Refer to Figures 3 and 4.
6. Tighten the cylinder head fasteners in the following manner:
  - a. Tighten fasteners in specified numerical sequence to 1/2 final recommended torque.



1. Type 1, head bolt
2. Nut and lockwasher
3. Injection line bracket
4. Type 2, head bolt-hex head
5. Type 3, head bolt - 12 point head
6. Spacer, 0.083 (2.11mm) thick (not all applications require spacer)
7. Flat washer 0.125" (3.18mm) thick

Figure 3. Cylinder Head Fasteners - Current Engines



Cylinder Head Bolt Locations  
Refer to Figure 3 for type of cylinder head bolts

- Type 1 bolt - location 33
- Type 2 bolt - locations, 13, 14, 15, 16, 29, 30, 31, 32, and 34
- Type 3 bolt - all other locations

Figure 4. Torquing Sequence and Cylinder Head Bolt Locations

- b. Tighten fasteners in specified numerical sequence to full recommended torque.
- c. Retighten fasteners in specified numerical sequence to full recommended torque.
- d. Run engine until coolant temperature reaches minimum 160°F (344.26K). (Approximately one hour). Retighten fasteners to the full recommended torque by following the specified numerical sequence.

NOTE: The procedure for installing the

NOTE (cont.): current cylinder gasket does not require the engine to be warmed-up or the head fasteners to be retorqued as indicated in the above Step d. Follow the procedure listed on the instruction sheet packaged with the head gasket.

- 7. Adjust valve lash (refer to Paragraph B of this Topic).

NOTE: The valve rocker cover nuts are Nylok inserted nuts and must be tightened to 10-15 lb-ft (14-20 Nm) when the rocker covers are installed.

## 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. If the engine is equipped with a turbocharger, its compressor side is part of the intake system and its turbine side is part of the exhaust system.

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 lead to loss of power, excessive exhaust smoke, high fuel consumption, and eventually to engine failure.

In warm weather, sufficient heat is generated by 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 temperature of air in the cylinders to a point too low to ignite the fuel. In this case an intake air heater is used, or in extreme cold weather engine starting may be assisted by use of an optional equipment cold weather starting aid.

**CAUTION:** Heavy muffler installations or exhaust pipe extensions from the exhaust outlet must be adequately supported and flexibly connected to eliminate possibility of strain on either the exhaust manifold outlet or turbocharger outlet.

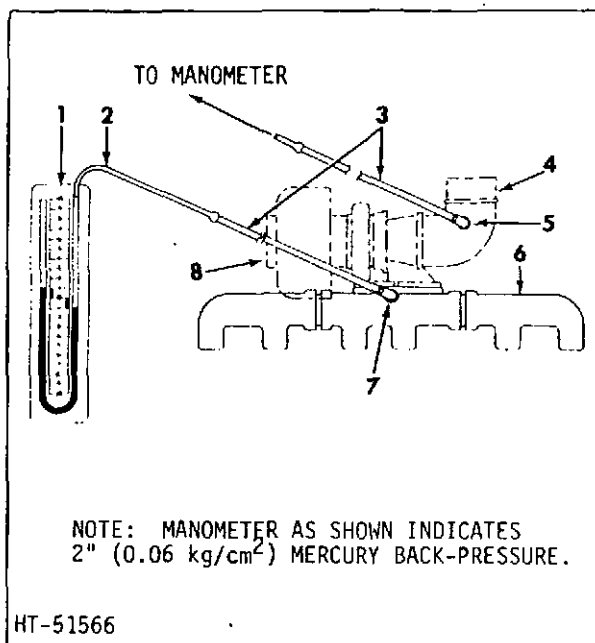
Total restriction of the entire exhaust system of a naturally aspirated engine at the exhaust outlet with engine under full speed, full load conditions, must not exceed 3" (0.104 kg/cm<sup>2</sup>) mercury back-pressure. Total restriction of the entire exhaust system of a turbocharged engine must not exceed 2" (0.069 kg/cm<sup>2</sup>) 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.

Most manifolds on naturally aspirated engines are provided with a .25" (6.35 mm) pipe threaded hole in the side of the exhaust outlet to facilitate manometer installation. If necessary, drill and tap a .25" (6.35 mm) pipe threaded hole in side of manifold near the

exhaust outlet opening. On turbocharged engines, the manometer is connected to the exhaust elbow. (See Figure 1.) To connect manometer to exhaust manifold, screw a .25" X .125" (6.35 X 3.175 mm) reducer bushing into hole in side of manifold. Fitting must be flush with inside and perpendicular to manifold to avoid false readings. Fasten about 3 feet (914 mm) of .25" (6.35 mm) OD copper tubing to fitting in manifold. From 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 1.0" (0.03 kg/cm<sup>2</sup>) high in left column and 1.0" (0.03 kg/cm<sup>2</sup>) low in right column, the manometer indicated 2.0" (0.06 kg/cm<sup>2</sup>) mercury back-pressure.



1. U-tube manometer
2. Rubber tubing
3. Copper tubing
4. Exhaust elbow
5. Location of fitting for turbocharged engines
6. Exhaust manifold
7. Location of fitting for naturally aspirated engines
8. Turbocharger

Figure 1. Checking Exhaust Back-Pressure

NOTE: If mercury is 1" (0.03 kg/cm<sup>2</sup>) high in the right column and 1" (0.03 kg/cm<sup>2</sup>) low in the left column, the manometer indicates 2" (0.06 kg/cm<sup>2</sup>) mercury vacuum, rather than pressure. A 1" (0.03 kg/cm<sup>2</sup>) mercury indication is equivalent to 0.491 psi (3.38 kN/m<sup>2</sup>), 2" (0.06 kg/cm<sup>2</sup>) of mercury is equal to 2 x 0.491 (3.38 kN/m<sup>2</sup>) or 0.982 psi (6.76 kN/m<sup>2</sup>). 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 capscrews for tightness after engine is hot. Tighten manifold mounting capscrews 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

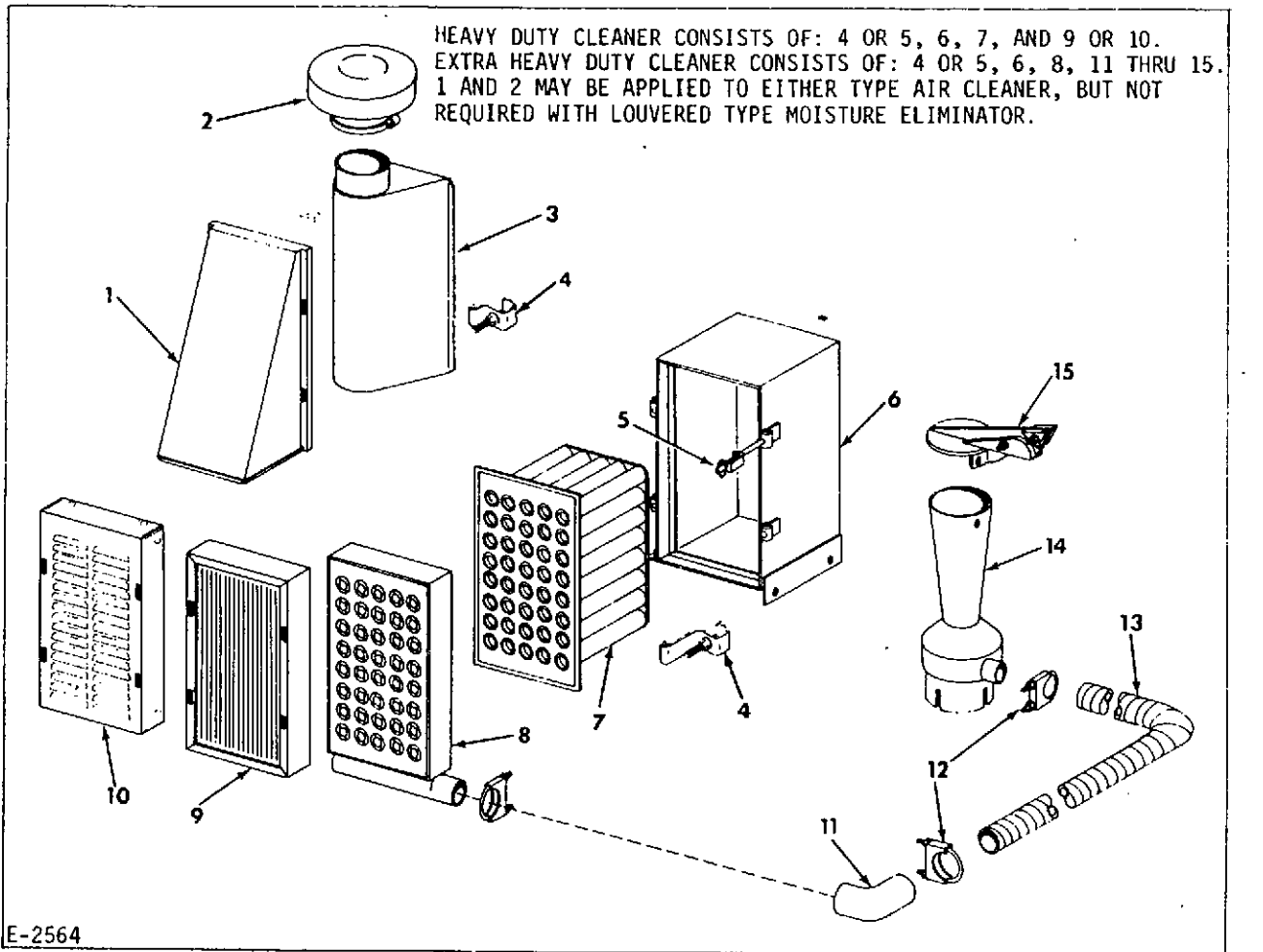
### A. GENERAL

The purpose of the air cleaner is to remove dust and other foreign matter from the air used by the engine. The amount of servicing required and frequency of element change is completely dependent upon the abrasives (dirt) in the air surrounding the engine.

A filter service indicator provides the most accurate and convenient means of determining when the filter cartridge should be changed. If a service indicator is not utilized, a cartridge renewal period should be determined by daily inspection of the air cleaner under actual operating conditions, until the period can be established.

The heavy duty dry type air cleaner consists of a housing (Fig 1 Item 6), cartridge (7), and moisture eliminator (9) or (10). Moisture is removed from the air by it striking the screening in the moisture eliminator and draining from the bottom of it. The air is cleaned while passing through the pleated paper sides of the cartridge tubes. Cleaned air leaves the housing and passes on to the engine.

The extra heavy duty dry type air cleaner consists of a housing (Fig 1 Item 6), cartridge (7), pre-cleaner (8), aspirator (14), and rain cap (15). Automatic self-cleaning of the pre-cleaner is achieved by the use of an aspirator in the exhaust system. Air enters



- |                   |                       |                                       |                   |
|-------------------|-----------------------|---------------------------------------|-------------------|
| 1. Rain guard     | 5. Wingnut type clamp | 9. First type moisture eliminator     | 11. Elbow         |
| 2. Stack cap      | 6. Housing            | 10. Louvered type moisture eliminator | 12. Clamps        |
| 3. Vertical inlet | 7. Cartridge          |                                       | 13. Flexible hose |
| 4. Nut type clamp | 8. Pre-cleaner        |                                       | 14. Aspirator     |
|                   |                       |                                       | 15. Rain cap      |

Figure 1. Dry Type Air Cleaners

the precleaner and is spun to remove moisture and 90% of the dust particles. The separated moisture and dust falls into the dust bin and are drawn out through the aspirator. Precleaned air then enters the filter cartridge for second-stage cleaning. The aspirator is connected to the precleaner panel by means of a flexible metal hose. The rain cap (15) prevents moisture from entering the exhaust system when the engine is stopped.

**CAUTION:** Do not under any circumstances cover up the precleaner face.

## B. MAINTENANCE

Periodic inspection of air cleaner body for dents, cracks, etc., should be made. Also check for damaged hoses, loose hose clamps, damaged gaskets, or any kind of leak that allows air to enter engine without first passing through the air cleaner. If any of the above conditions exist immediate corrective action must be taken.

Do not clean the cartridge. Experience has shown that attempting to clean a dirty cartridge by washing, shaking, or compressed air, frequently results in damage to it. Internal damage caused by cleaning often is too minute to be seen, or may develop after re-installation.

Under normal conditions the precleaner is self-cleaning, however, under extreme conditions the precleaner may require cleaning. It may be cleaned by steam cleaning, washing, or by blowing air through the front and back of the cyclonic tubes and dust bin.

If necessary, the moisture eliminator can be cleaned in a similar manner as the pre-cleaner, making certain all foreign matter and cleaning solutions are drained out through the holes in the bottom of it.

The fasteners of the clamps which secure the cartridge, precleaner, or moisture eliminator to the housing are of 2 types. The first type (Fig 1 Item 5) uses a wingnut, whereas the second type (4) uses a flanged hex nut.

Replace cartridge and clean air cleaner housing when red signal is visible in window of service indicator (Fig 2). Refer to following the paragraphs to service air cleaner and the procedure to replace cartridge.

## C. SERVICE

Replace cartridge and service air cleaner as follows:

1. Loosen wing/nuts (Fig 1 Item 4 or 5) and clamps and remove moisture eliminator, (9 or 10) or precleaner (8) after

removing its flexible hose (13) from elbow (11).

2. Insert fingers into cartridge (7) openings and loosen all four corners of the cartridge one at a time by pulling straight out at each corner. After seal has been broken, remove cartridge by pulling it straight out and slightly up so cartridge clears the sealing frame. Discard dirty cartridge.

**NOTE:** Do not clean or reuse dirty cartridge. Inspect dirty cartridge 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 cartridge appears to have an oily film, check for fumes escaping from the breather tube. Correct any of these conditions, if necessary, before a new cartridge is installed.

3. Inspect inside of housing (6) and remove all foreign material.

**CAUTION:** Inspect new cartridge for shipping damage before installation.

4. Install new cartridge into housing. Avoid hitting the cartridge tubes against the sealing flange of the housing. Firmly press all edges and corners of the cartridge against the sealing flange with your fingers to effect a positive air seal.

**CAUTION:** Do not pound in the center of the cartridge to effect a seal.

5. If necessary, clean moisture eliminator or precleaner.
6. If heavy duty type air cleaner, install moisture eliminator (9 or 10) with drain holes to bottom. If the air cleaner is the extra heavy duty type, install the precleaner (8) with dust bin to the bottom.
7. Tighten the moisture eliminator and precleaner clamp fasteners in a diagonal sequence. If wingnut type (5), tighten finger tight and 1 1/2 to 2 additional turns with pliers or wrench. If hex nut type (4) tighten to 72 lb-in (8 Nm).

**NOTE:** If, at a later date, inspection of the wing/nuts indicates that they are at less than specified torque, this is due to a slight set in the plastic face

NOTE (Cont): of the cartridge and does not impair the seal between the cartridge and the housing. Retightening of the wing/nuts is not recommended, unless they are loose, as this may break the seal which has been formed.

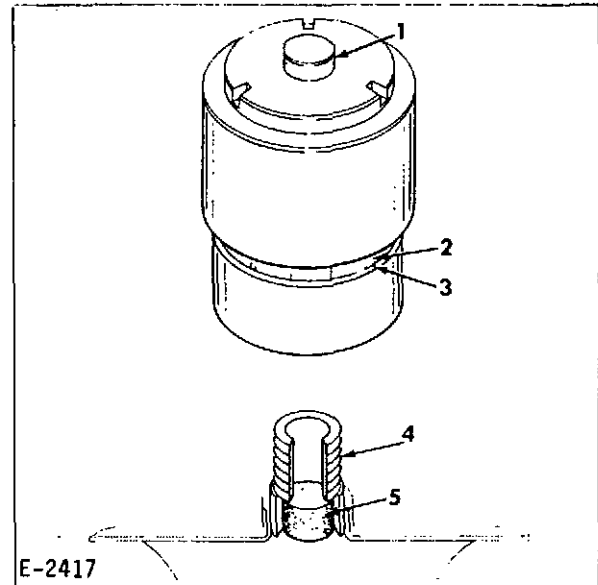
8. If extra heavy duty type air cleaner, install flexible hose (13) over end of precleaner elbow (11) and tighten clamp (12). Inspect flexible hose and clamps. Make certain all connections, including aspirator (14), are air tight.
9. Reset service indicator by pressing reset button on top of indicator (Fig 2).

CAUTION: The only allowable modification that can be made to the aspirator is the addition of an exhaust pipe extension to the large end of the cone. A maximum of 4 feet (122 cm) 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 (122 cm) is required, resizing of the aspirator is necessary. The size and the 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 (122 cm) are required, consult your Allis-Chalmers dealer to assist in its design and modification.

#### D. AIR FILTER SERVICE INDICATOR

Purpose of the service indicator (Fig 2), 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 re-



1. Reset button
2. Red signal
3. Window
4. Connector with sintered filter
5. Sintered filter

Figure 2. Air Filter Service Indicator

duces 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 sinter 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. TURBOCHARGER

### A. GENERAL

The Model 11000 engine with dry type exhaust manifold is equipped with an AiResearch Model T-04 turbocharger and the 11000 engine with water cooled exhaust manifold is equipped with an AiResearch Model TE-06 turbocharger.

The turbocharger boosts the power output of the Model 11000 engine over that of a naturally aspirated engine by increasing the supply of air to the cylinders.

The turbocharger is highly efficient, yet rugged and easy to install, exhaust-driven blower. The simple, compact design of the turbocharger incorporates a single stage radial inflow turbine wheel, mounted on a common shaft with a single stage centrifugal compressor impeller. It has a one-piece bearing housing with floating sleeve type bearing, a turbine housing and a compressor housing. All rotating parts are individually precision balanced.

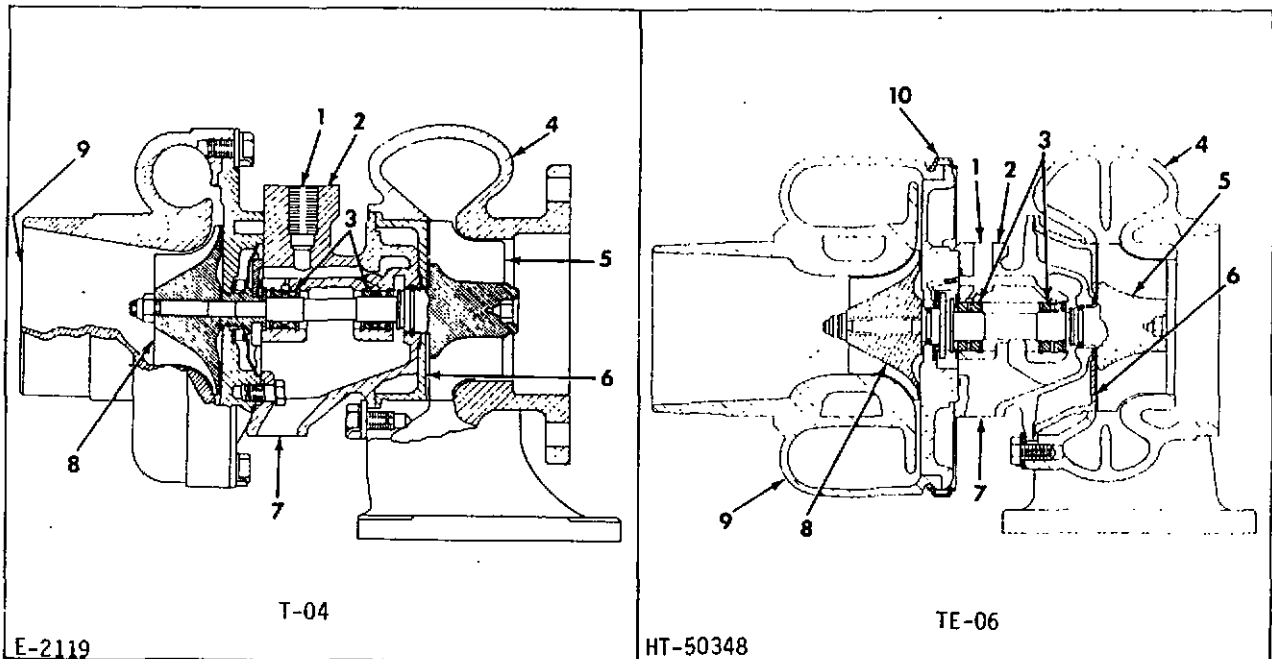
### B. OPERATION

During engine operation, air enters the turbocharger at center of compressor housing, Figure 2, and is discharged from compressor out-

let to the intake manifold. After combustion the exhaust gases enter the exhaust manifold and flow to turbine side of the turbocharger. The expanding gases flow rapidly through the turbine housing causing turbine wheel to spin. The turbine wheel drives the compressor impeller which is mounted on the same shaft.

The turbocharger responds to engine load demands by reacting to the flow of expanding exhaust gases and supplying a correlated volume of air to the engine cylinders. During a heavy load/lugging operation, the increased flow of exhaust gases turns the turbine wheel faster, causing the compressor impeller to turn faster to supply more air to the intake manifold. Conversely, when engine load is light and the radial flow of gases within the turbine decreases, the turbocharger compressor reduces the supply of air to the intake manifold.

The turbocharger bearing is lubricated and cooled by filtered engine oil circulating through the bearing housing under normal oil pump pressure. This oil is supplied to the bearing housing through an external line from the engine main oil gallery. Oil returns to the crankcase through an external line which extends from the bearing housing to the side of the cylinder block.



1. Oil inlet
2. Center housing assembly
3. Bearings
4. Turbine housing
5. Turbine wheel

6. Turbine shield
7. Oil outlet
8. Compressor wheel
9. Compressor housing
10. V-Clamps (TE-06)

Figure 1. Turbocharger - Sectional View

**WARNING: NEVER OPERATE THE ENGINE WITH AIR INLET PIPING OR EXHAUST ELBOW REMOVED FROM TURBOCHARGER. CLOTHING OR FOREIGN OBJECTS CAN BE DRAWN INTO THE COMPRESSOR INLET. DISCHARGED CARBON PARTICLES AND HOT GASES FROM THE TURBINE OUTLET CAN CAUSE PERSONAL INJURY.**

### C. EFFECT OF ALTITUDE ON TURBOCHARGED ENGINES

**CAUTION:** To prevent damage to the engine from excessive exhaust temperatures and turbocharger overspeeding when operating at altitudes above sea level, it is necessary to consider a reduction in the maximum fuel setting of the fuel injection pump. The amount of derating is dependent upon several interrelated factors.

Altitude affects a turbocharged engine in the amount of an approximate 1% decrease in horsepower per thousand feet (304.8 m) of altitude until an altitude is reached at which the engine must be derated and the maximum fuel setting of the fuel injection pump reduced for one of the following reasons:

1. Model T-04B Turbocharger
  - a. In continuous type operation the turbocharger must not exceed 130,000 rpm.
  - b. In an intermittent type operation the turbocharger must not exceed 135,000 rpm.
2. Model TE-06 Turbocharger
  - a. In continuous type operation the turbocharger must not exceed 109,500 rpm.
  - b. In an intermittent type operation the turbocharger must not exceed 117,500 rpm.
3. Maximum allowable exhaust temperature is 1300°F (978 K).
4. Turbocharger cavitation (surging) cannot be tolerated.

An engine operating under conditions of continuous type loading must be derated more than an engine operating under conditions of intermittent loading where loading intervals are of a time duration that does not allow stabilization of manifold temperatures and pressures, even though both may be set to deliver the

same amount of horsepower. Likewise, an engine delivering near maximum horsepower must be derated more than a similar engine set to deliver a conservative amount of horsepower.

At governed speeds, exhaust temperature increases at the rate of approximately 20°F per 1000 ft (267 K per 304.8m) altitude. However, when the engine is lugged down to 1400 to 1500 rpm the temperature may increase at a rate of 35°F per 1000 ft (275 K per 304.8 m) altitude.

Engines equipped with the specified AiResearch turbocharger, will exceed the 1300°F (978 K) maximum allowable speed of the turbocharger is reached. Therefore, as a practical field approach, safe control of turbocharger speed and exhaust temperature during altitude operation can be maintained by reducing the fuel injection pump flow, thereby limiting the exhaust temperature so that it does not exceed 1300°F (978 K).

**NOTE:** The exhaust temperature must be taken before it enters the turbocharger. The exhaust manifold is provided with a 1/4" (6.35 mm) pipe plug below the turbocharger mounting flange for installing thermocouples of temperature indicators.

### D. MAINTENANCE

Each time engine lubricating oil and filter elements are replaced, or when routine service operations are performed, inspect turbocharger as follows:

#### 1. Air Cleaner and Intake System

Restriction in the air intake system will cause malfunction of both turbocharger and engine. The restriction is measured as a vacuum at the turbocharger air inlet, under engine full-speed, full-load conditions and it should never exceed 30" (7465 N/m<sup>2</sup>) of water.

- a. Inspect gaskets, hose connections, air cleaner-to-turbocharger inlet tubing, and clamps for loose or damaged condition that permits air leaks in system.
- b. Inspect for restrictions due to dented tubing or collapsed hoses.

#### 2. Lubrication System

- a. Replace engine lubricating oil and filter elements at specified intervals to assure clean supply of oil to the turbocharger.
- b. Minimum oil flow to turbocharger with engine running is 10 psi (68.94 kN/m<sup>2</sup>)

with oil temperature of 180°F (355 K). Loss of engine oil pressure will quickly damage or destroy a turbocharger.

**CAUTION:** If an engine has been in storage for several months without being operated, it is recommended that the oil inlet connection at the turbocharger be removed and 3 to 4 ounces (85 to 113 g) of lubricant be placed in the oil inlet of the center housing. Also, fill oil inlet line with oil. Perform the above BEFORE operating engine.

c. Inspect oil inlet lines, drain lines, and fittings for leakage, clogging, and damage.

### 3. Exhaust System

Total restriction of the entire exhaust system must not exceed 2" (6753 N/m<sup>2</sup>) mercury back-pressure at the turbocharger turbine housing exhaust outlet, under engine full-speed, full-load conditions. Excessive back-pressure will reduce turbine speed and subject it to excessive temperatures.

a. Inspect for exhaust leaks due to damaged gaskets, cracks in exhaust manifold, loose manifold mounting, or loose turbocharger-to-manifold mounting.

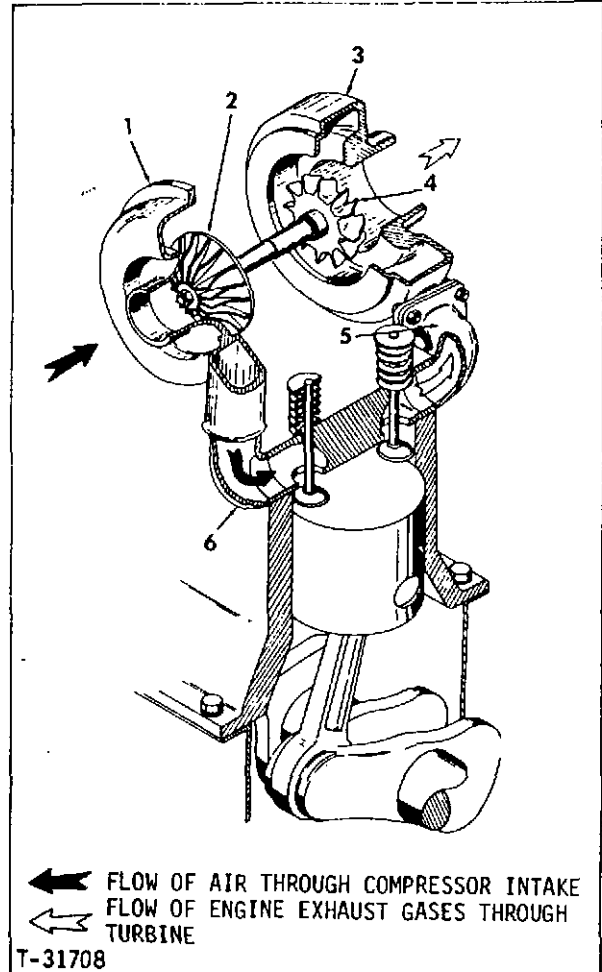
b. Observe engine exhaust. Excessive smoke may indicate a restricted air cleaner or air intake pipe, over-fueling, or faulty turbocharger operation. Check air filter service indicator and maintain the air cleaner as required.

### 4. Fuel Injection Pump

Under no circumstances should the factory maximum fuel delivery specification for the injection pump be exceeded in order to increase power output of the engine. Resulting turbocharger and engine damage will be costly and offset any benefit that might have been derived from increased engine power.

### 5. Engine Breather System

A clogged engine breather tube will cause pressure build-up in the engine. This pressure will prevent the oil from draining down the oil return line and force it out the low pressure side of the turbocharger and into the engine air intake system.



1. Compressor housing
2. Impeller
3. Turbine housing
4. Turbine wheel
5. Exhaust manifold
6. Intake manifold

Figure 2. Turbocharger Operation Diagram

a. Check engine breather tube to make certain it is not clogged.

### 6. Operating Checks

a. Operate engine at approximate rated output and listen for unusual turbocharger noise. (Do not mistake whine heard during run-down for one that indicates impeller shaft bearing failure during operation.) Other unusual noises can result from improper clearance between turbine impeller and turbine housing. If such noises are heard, the turbocharger must be removed, disassembled, and inspected.

E. 2250 - HOUR INSPECTION

A major inspection of the turbocharger, by an experienced turbocharger mechanic, should be made after each 75,000 miles or 2250 - hours

interval of operation. This inspection requires removal of the turbocharger from the engine, and removal of the compressor housing and turbine housing from the turbocharger, to check shaft radial movement and shaft end play.

## TOPIC 19. SAFETY CONTROLS

### A. GENERAL

The purpose of the optional engine safety controls is to automatically stop the engine or audibly warn the operator to stop the engine, thereby protecting it from damage if oil pressure drops below safe operating pressure, if

the coolant temperature rises above a safe preset limit, or if the engine should overspeed.

For information covering these safety devices, refer to the owner's manual covering the equipment being driven by the engine.

## TOPIC 20. COLD WEATHER STARTING AIDS

### A. GENERAL

Two types of cold weather starting aids are available as optional equipment to assist engine starting in extreme cold weather. The first, is a manually operated type and the second is an electrically operated type. Both types use a very volatile type starting fluid stored in a can or tank under pressure which comply with ICC regulations.

The discharger or control is mounted on or near the engine control panel where it is accessible to the operator during startup. The spray nozzle is connected to the discharge by a length of nylon tubing. The position of the nozzle in the air intake system is such that discharged starting fluid is distributed proportionally to all engine cylinders.

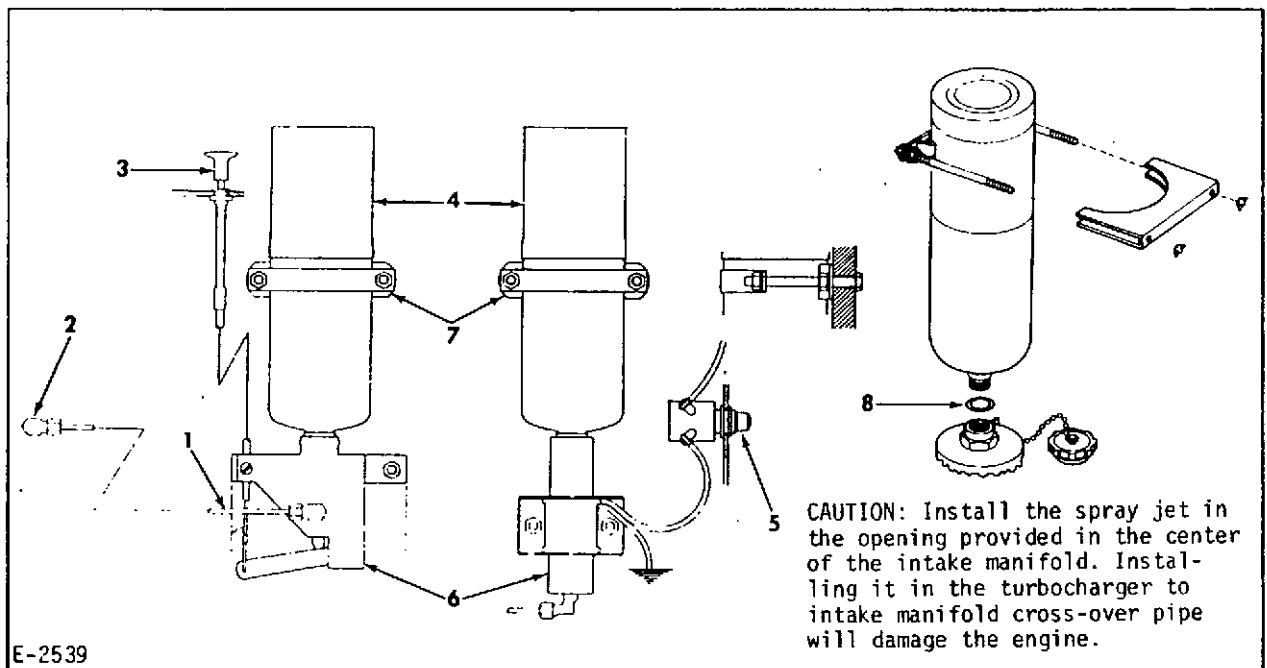
**CAUTION:** Starting fluid containers are under pressure and extremely flammable. Keep away from heat, sparks, or open flame. Avoid contact with the skin and avoid breathing of fumes. Observe the precautions printed on the containers.

**IMPORTANT:** Make certain the tubing is supported and routed so it does not contact any hot surfaces or areas where it may be damaged by mechanical action or vibration.

### B. HANDLING PRECAUTIONS

**CAUTION:** When the fuel cylinder is removed from the discharger valve assembly, always keep top of valve assembly covered with the plastic cap that is attached to the chain provided with the assembly to prevent entrance of foreign material into the discharger valve assembly. If it is ever decided to remove the starting aid assembly and operate the engine without it in the air intake system, first disconnect the tube from the spray fitting. Then remove the spray fitting from the air intake system and replace it with a pipe plug.

- a. Do not heat fuel cylinders.
- b. Starting fluid contained in the cylin-



- |                         |                             |
|-------------------------|-----------------------------|
| 1. Discharge tube       | 5. Electric push button     |
| 2. Spray fitting        | 6. Discharge valve assembly |
| 3. Manual control lever | 7. Mounting clamp assembly  |
| 4. Fuel cylinder        | 8. O-ring                   |

Figure 1. Cold Weather Starting Aid

ders is volatile and highly flammable. When discharger is being tested or inspected and is not installed on engine, do not discharge spray in a confined area or near an open flame.

- c. The ether component of the starting fluid is toxic. Avoid prolonged breathing of fumes.
- d. Do not puncture or incinerate cylinder.

#### C. FUEL CYLINDER INSTALLATION

- a. Remove plastic cap from top of discharger valve assembly.
- b. Place o-ring (furnished with fuel cylinder) in metering chamber well.
- c. Install fuel cylinder by placing it in position to engage threads, and screw hand tight. Then secure cylinder with clamp. Refer to instructions printed on cylinder.

#### D. OPERATION OF DISCHARGER

- a. Crank engine with stop control in the STOP position (fuel off) for 5 seconds maximum.
- b. Set stop control in RUN position
- c. Place throttle in the FULL LOAD position, then return it to the 1/4 to 1/2 position.
- d. Crank engine with stop control in RUN position for 2 - 3 seconds.
- e. Inject one shot of starting fluid while cranking engine.
- f. To inject one shot of starting fluid:
  - (1) Electric Type:  
Push and hold starting aid button for 3 - 5 seconds.
  - (2) Manual Type:  
Pull and hold starting aid control for 3 - 5 seconds.

NOTE: If engine is equipped with safety controls, refer to Topic 19, Paragraph D, for starting procedure.

- g. Wait 2 seconds and press starter button on engine control panel.
- h. If temperature is 0°F (255K) or below, repeat steps f and g.

CAUTION: Too much ether in an engine can produce any or all of the following harmful conditions; premature detonation, with resulting undue pressures on pistons, rings, and crankshaft; "ether wash" which reduces or eliminates the oil film on the cylinder walls causing scoring or premature engine failure; and accumulations of excess ether in the intake system which can cause disastrous effects when the ether is sucked into the engine after it is running.

CAUTION: Do not use starting motor continuously for more than 30 seconds without a pause of 2 minutes to allow it to cool.

- i. Once the engine is firing on most cylinders, in one quick motion, move throttle to near the full load position and return it 1/4 to 1/2 position. This will clear the exhaust during the initial starting.
- j. After the engine is running smoothly, allow it to warm up to normal operating temperature at 1/4 throttle before applying load.

NOTE: If the throttle is left in the full load position while cranking, excessive smoke will result until the engine reaches high idle rpm.

- k. Oil pressure should be 30 to 55 psi (207 to 379 kN/m<sup>2</sup>) at full load rpm. If pressure is not within these limits, stop engine immediately and correct the trouble.

#### E. MAINTENANCE

The ether starting aid assembly is ruggedly constructed and ordinarily does not require servicing. If the assembly sustains major damage, remove and replace the complete unit.

- a. When replacing empty fuel cylinder, wipe dirt from around valve inlet and follow instructions in preceding Paragraph C. Fuel Cylinder Installation. Use care in wiping dirt from valve inlet to prevent dirt from entering valve.
- b. Periodically remove fuel cylinder and lubricate the valve.

WARNING: CONTENTS OF FUEL CYLINDER ARE TOXIC AND EXTREMELY FLAMMABLE, DO NOT DISCHARGE IN A CONFINED AREA OR NEAR AN OPEN FLAME.

- c. Periodically check all connections for leaks. Correct any leaks found.
- d. Check mounting bolts and clamp for tightness.
- e. Periodically test unit for proper functioning by disconnecting the spray fitting from air inlet system. The side of the fitting is marked (chisel mark) to indicate the location of the spray orifices. Note location mark when removing the fitting. Install the fitting with location mark on the same position.
- f. Reassemble spray fitting to tube.
- g. Actuate system.
- h. A fine mist-like spray should be emitted from the orifice in the spray fitting.

#### F. TROUBLESHOOTING

If an inoperable condition exists, perform the following:

- a. Check fuel cylinder for hand tightness and check fuel supply. An empty fuel cylinder weighs 17 ounces (0.48 kg), a full fuel cylinder weighs 37 ounces (1.05 kg). Make certain fuel cylinder is tight, if empty, replace it.
- b. If system is still not functioning, replace entire unit.

#### G. FIELD INSTALLATION

CAUTION: If applicable, disconnect and remove air heater from engine.

- a. Mount starting aid assembly within 10° of vertical.
- b. Install starting fluid tank (Fig 1 Item 4) according to instruction in above Paragraph C.

- c. Remove pipe plug from center of intake manifold.

IMPORTANT: Never install jet (spray fitting) in cross-over pipe between turbocharger and intake manifold.

- d. Install jet in intake manifold with chisel mark or dot that is located on the hex part of the jet to the top. This will properly locate the spray orifices within the intake manifold.
- e. Cut plastic tubing to length. Using compression fittings connect tube to jet and discharge valve assembly.

CAUTION: Support and route plastic tubing so that it does not contact any hot surfaces or areas where it may be damaged by mechanical action or vibration.

#### 5. Mount controls as follows:

##### a. Manual Type

Pass control cable through .375" (9.53 mm) hole in instrument panel and secure in place.

Pull wire out of cable 3.750" (95.25 mm) before cutting to length. Push in control knob and secure cable to discharge valve assembly and wire to discharge arm as shown in Figure 1.

Attach starting procedure decal to instrument panel close to control knob.

##### b. Electrically Controlled

Install push button in .625" (15.88 mm) hole in instrument panel. Attach starting procedure decal to instrument panel close to push button.

Using No. 14 gauge (AWG) connect one terminal of the push button switch to the battery side of the ammeter and the other terminal of the push button to one the wires of the discharge valve assembly solenoid. Ground the other solenoid wire to the starter ground terminal.

**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.

<u>ENGINE MODEL</u>	<u>ENGINE CATALOG NUMBER</u>
<u>ENGINE SERIAL NUMBER</u>	<u>A-C ORDER NUMBER</u>

**MANUAL FOR  
CURRENT PRODUCTION UNITS**

Model	Parts	Operating & Maintenance
<b>Industrial Engines and Power Units</b>		
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
<b>Diesel Electric Systems</b>		
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		
<b>Marine Engines</b>		
25000 MKII	TPL-4110-4	TM-5001-A
<b>Diesel Generator Drive Units</b>		
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
<b>Service (Overhaul) Manuals</b>		
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
<b>Fuel Systems</b>		
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
<b>Special Application Manuals</b>		
Turbocharger TO-4 Series (Airesearch)	***	TM-5057-A
Turbocharger T-1817, T-1818, T-1819, & T-1852		TM-5074
<b>Engine Service Bulletins</b>		
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.**

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