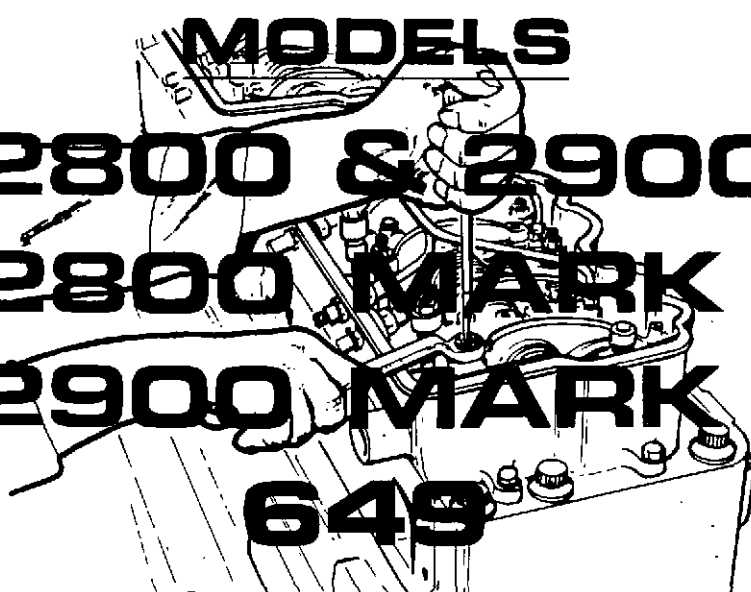


# OPERATING AND MAINTENANCE MANUAL

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**MODELS**  
**2800 & 2900**  
**2800 MARK I**  
**2900 MARK I**  
**649**

A technical line drawing of a generator drive engine, showing various components like the cylinder head, valves, and cooling fins. The drawing is partially obscured by the overlaid text.

**GENERATOR DRIVE  
ENGINES**



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

**Form: TM-5072-1  
Part No: 4007658  
Printed in USA (8-80)**



**A CENTURY OF SERVICE**

## **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.

# SAFETY PRECAUTIONS



This symbol is used to call your attention to safety precautions that should be followed by the operator, maintenance, and service personnel to avoid accidents. When you see this symbol - heed its warning - become alert - your safety is involved. Many hours of lost time and much suffering is caused by the failure to practice simple safety rules.

It is too late to remember what should have been done after the accident has happened.

## OPERATION

1. Read this manual carefully to acquaint yourself with the engine. Operating unfamiliar equipment can cause accidents.
2. Do not wear rings, wrist watches, jewelry, loose or hanging apparel, such as ties, torn clothing, scarves, unbuttoned, or unzipped jackets that can catch on moving parts. Do wear proper safety equipment as authorized for the job. Examples: hard hats, safety shoes, heavy gloves, ear protectors, and safety glasses or goggles.
3. Long hair should be tied up short to prevent it from becoming entangled in moving parts.
4. Engine should be operated only by those who are responsible and delegated to do so.
5. Quick access to a FIRST AID KIT should be provided at all times to treat minor cuts and scratches.
6. It is recommended that a FIRE EXTINGUISHER be provided at an easy to get to location.
7. Keep engine exhaust system and exhaust manifolds clear of combustible material. Equip machine with screens and guards when working under conditions of flying combustible material.
8. Do not run the engine in closed area without proper ventilation to remove deadly exhaust gases.
9. Starting fluid is flammable. Follow the recommendations outlined in this manual and those marked on the containers. Store containers in cool, well-ventilated place secure from unauthorized personnel. Do not puncture or burn containers. Follow the recommendations of the manufacturer for storage and disposal.
10. Never use starter fluid near lighted smoking materials or open flame or sparks due to the flammability of the fluid.
11. Do not place head, body, limbs, feet, fingers, or hands near a rotating fan or belt. Be especially alert around a pusher fan.
12. Keep the operator's area clean and free of obstructions.
13. Always shift transmission to neutral, stop engine, set brake and remove start key before permitting anyone to inspect, clean, lubricate adjust or repair any part of the engine or its attachments, unless otherwise specifically recommended in this manual.
14. Be sure that the gear shift lever is neutral before starting the engine.
15. Be sure that everyone is clear of the machine before starting the engine and mechanism.
16. Use extreme caution when removing the radiator cap. Loosen very slowly and avoid pressurized steam that might be in the radiator. Allow engine to cool before removing cap.
17. Electric storage batteries give off highly inflammable hydrogen gas. To prevent possible explosion, never allow lighted smoking material, an open flame or electrical sparks near the battery. Do not lay tools or other conductive materials on the battery where they may cause short circuits and sparks.
18. Fluid in electric storage batteries contains sulfuric acid which can cause severe burns. Avoid all contact of fluid with eyes, skin or clothing. If contact does occur, flush off immediately with large amounts of water. Get prompt medical attention.
19. Always stop engine when refueling. Always place the fuel nozzle against the side of the filler opening before starting and during fuel flow. To reduce the chance of a static electricity spark. Keep contact until after fuel flow is shut off. Do not smoke or have open flame in the refueling area.
20. Always be sure that all shields, guards, and access covers are in place when engine is in operation.
21. Never attempt to check or adjust fan belts when engine is running.
22. Always permit parts that contain hot fluid to cool to a safe temperature before handling or disconnecting.

## SAFETY PRECAUTION (CONTINUED)

### MAINTENANCE AND SERVICE

1. Follow all safety precautions listed above and those listed below.
2. Shop or field service platforms and ladders used to maintain or service engine should be constructed and maintained according to OSHA requirements.
3. Disconnect batteries and TAG all controls according to OSHA requirements to warn that work is in progress.
4. Never use gasoline or diesel fuel or other flammable fluid for cleaning parts. Use authorized commercial, non-flammable, non-toxic solvents.
5. When using compressed air for cleaning parts use safety glasses with side shields or goggles. Limit the pressure to 30 psi (207 kPa) according to OSHA requirements.
6. Lift and handle all heavy parts with a lifting device of proper capacity. Be sure parts are supported by proper slings and hooks. Use lifting eyes if provided. Watch out for people in the vicinity.
7. Never align holes with finger or hands. Use the proper aligning tool.
8. Remove sharp edges and burrs from reworked parts.
9. Do not use an open flame as a light source to look for leaks or for inspection anywhere on the machine.
10. Be sure all mechanics tools are in good condition. Do not use tools with mushroomed heads. Always wear safety glasses with side shields.
11. Handle all parts with extreme care. Keep hands and fingers from between parts. Wear authorized protective equipment such as safety glasses, heavy gloves, safety shoes.
12. Do not adjust engine fuel pump when the machine is in motion.
13. Never lubricate engine while in operation.
14. Avoid running engine with open unprotected air inlets. If such running is unavoidable for service reasons, place protective screens over all inlet openings before servicing engine.
15. Disconnect batteries before working on electrical system.
16. Be sure to connect the booster cables to the proper terminals (+ to +) and (- to -) at both ends. Avoid shorting clamps.
17. BATTERY GAS IS HIGHLY FLAMMABLE. Leave battery box open to improve ventilation when charging batteries. Never check charge by placing metal objects across the posts. Keep sparks or open flame away from batteries. Do not smoke near battery to guard against the possibility of an accidental explosion.
18. Do not charge batteries in a closed area. Provide proper ventilation to guard against an accidental explosion from an accumulation of gases given off in the charging process.
19. Fluid escaping under pressure from a very small hole can almost be invisible and can have sufficient force to penetrate the skin. Use a piece of cardboard or wood to search for suspected pressure leaks. DO NOT USE HANDS. If injured by escaping fluid, see a doctor at once. Serious infection or reaction can develop if proper medical treatment is not administered immediately.
20. Shut off engine and be sure all pressure in system has been relieved before removing panels, housing covers, and caps.
21. When making pressure checks use the correct gauge for expected pressure.

## 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

# 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 3600 HOURS OF OPERATION, whichever first occurs, from the date of delivery to the first user of
- (a) Engines used for 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 1800 hours of operation, whichever first occurs; thereafter,  
75% in the case of parts subjected to no more than 2700 hours of operation, whichever first occurs; and thereafter,  
50% in the case of parts subjected to no more than 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 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 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 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 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 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 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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NOTE: MODEL 649 NATURAL ASPIRATED IS IDENTICAL TO  
THE 2800 MARK I WHEN NAMEPLATED WITH LIKE  
NUMBERS.

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## TOPIC 1. DESCRIPTION

### A. GENERAL

The engine models covered in this manual are 4-cycle, water cooled, overhead valve, compression-ignition type diesel engines with 6 vertical, in-line cylinders. One model is naturally aspirated and the other model is equipped with a turbocharger.

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

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 numbers 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 a fuel filter,

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, idler gear, 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 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 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.

CATALOG NO.	OPT. EQUIP.	CATALOG NO.	OPT. EQUIP.	CATALOG NO.	OPT. EQUIP.

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

SERIAL NO.	CATALOG NO.
MODEL	

E-2398

Combination Engine Name Plate and  
Optional Equipment Plate

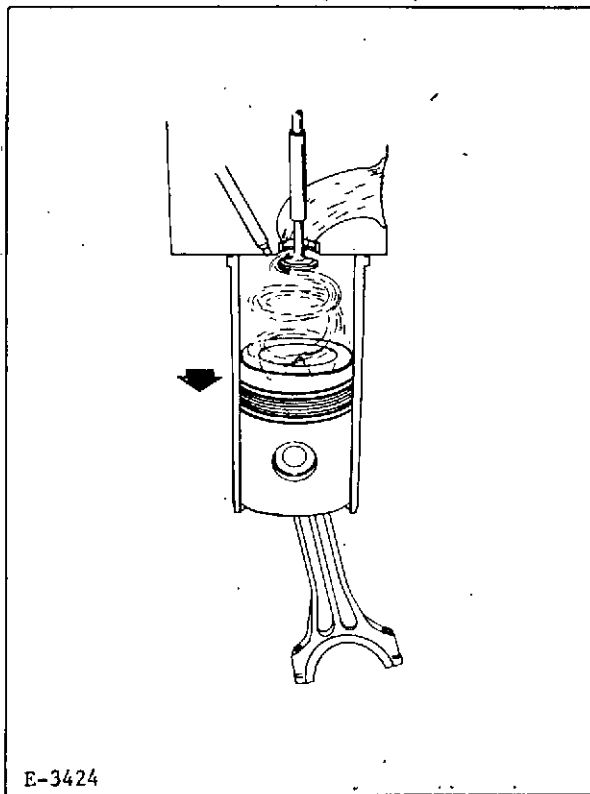


Figure 1. Intake Stroke

## 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.

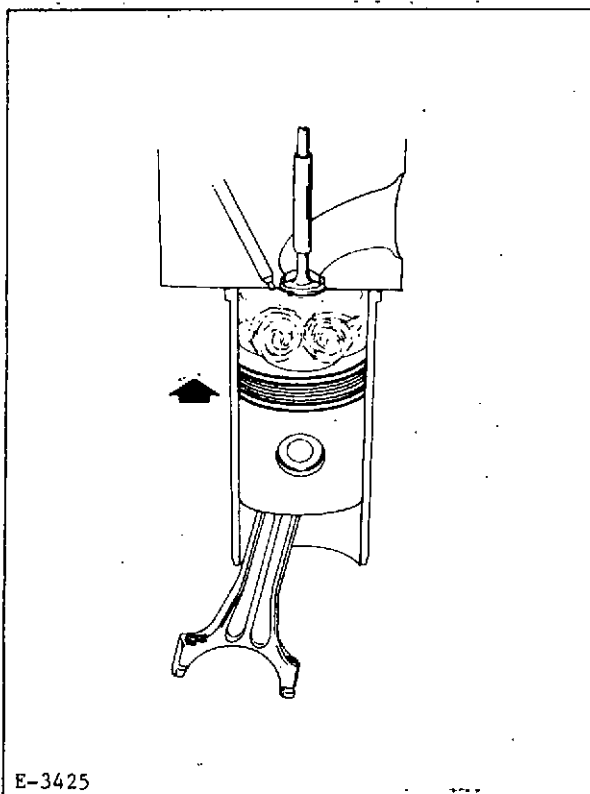
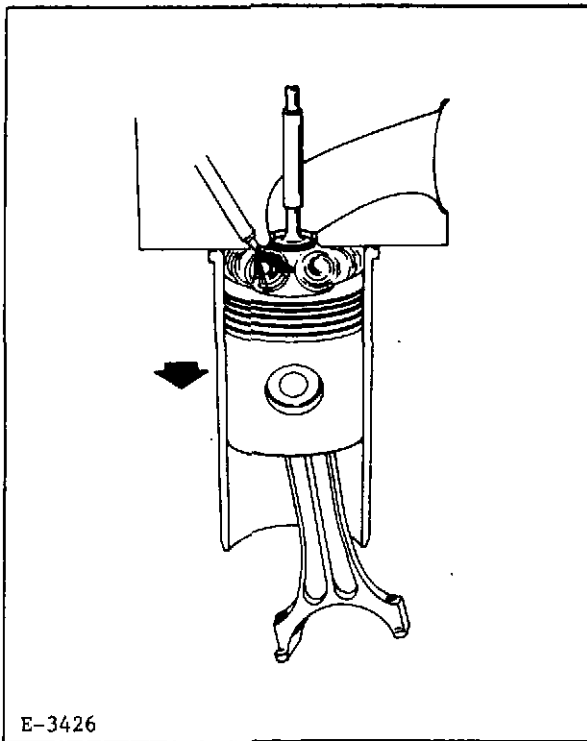


Figure 2. Compression Stroke

## 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.

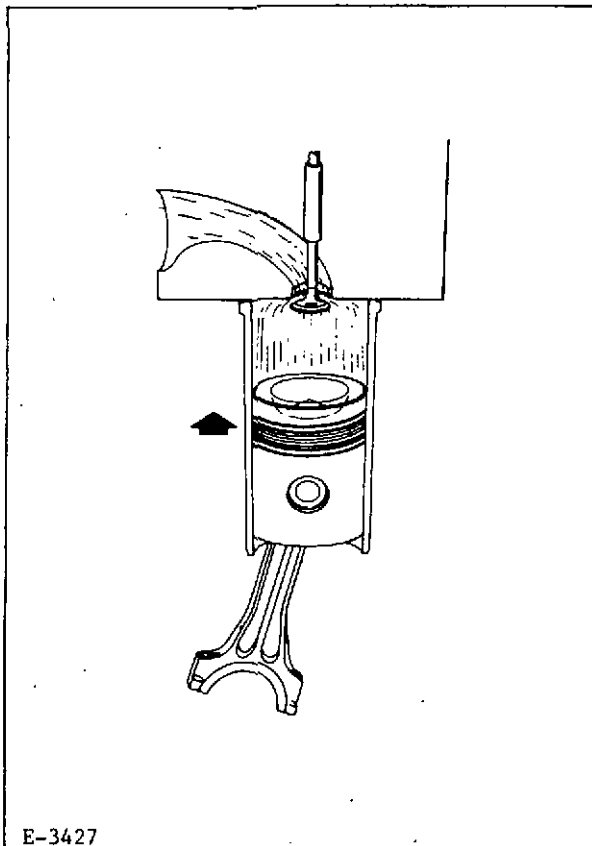


E-3426

Figure 3. Power 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.



E-3427

Figure 4. Exhaust Stroke

### 4. Exhaust Stroke

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

## TOPIC 2. SPECIFICATIONS

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

### A. ENGINE (BASIC)

Models 2800 2800MKI and 649 .....  
 Models 2900 2900MKI.....  
 Type.....  
 Number of Cylinders.....  
 Firing Order.....  
 Bore.....  
 Stroke.....  
 Displacement.....  
 Crankshaft Rotation (viewed from fan end)....  
 Number of Main Bearings.....  
 Compression Ratio (nominal).....  
 Compression Pressure at Sea Level, 600 rpm,  
 Hot.....  
 Maximum Permissible Exhaust Restriction:  
 Models 2800 2800MKI and 649 .....  
 Models 2900 2900MKI.....

### B. COOLING SYSTEM

Water Pump, Centrifugal Type.....  
 Stabilized Coolant Temperature (minimum).....  
 Nominal Capacities:  
 Engine only.....  
 Radiator and hoses.....  
 Radiator, Pressurized.....

### C. LUBRICATION SYSTEM

Circulating Pressure Type System.....  
 Oil Pump.....  
 Oil Pressure Range, Hot:  
 Full Speed (2000 rpm).....  
 Idle Speed (725-775 rpm).....  
 Pressure Regulation Governed by.....  
 Lubricating Oil Filters.....  
 Nominal Oil Capacities - Standard Oil Pans:  
 Models 2800 2900 - Filter and Oil Change...  
 Models 2800MKI 2900MKI - Filter and Oil  
 Change.....

### D. FUEL INJECTION SYSTEM

Nozzle Holder Assembly:  
 Nozzle, Spring Loaded Type.....

ENGLISH	METRIC
<p>Naturally Aspirated                      Turbocharged                      4 cycle                      6                      1-5-3-6-2-4                      3.875 in.                      4.25 in.                      301 cu. in.                      Clockwise                      7                      16.25:1                      500 psi ± 15 psi                      3 in. Hg                      2 in. Hg</p>	<p>Naturally Aspirated                      Turbocharged                      4 cycle                      6                      1-5-3-6-2-4                      98.43 mm                      107.95 mm                      4933 cm<sup>3</sup>                      Clockwise                      7                      16.25:1                      3447 kN/m<sup>2</sup> ± 103 kN/m<sup>2</sup>                      0.103 kg/cm<sup>2</sup>                      0.069 kg/cm<sup>2</sup></p>
<p>Belt Driven                      180° F                      11 qts                      16 qts                      7 psi</p>	<p>Belt Driven                      355 K                      10.40 lts                      15.10 lts                      48 kN/m<sup>2</sup></p>
<p>Full Flow                      Gear Type                      30 to 55 psi                      15 psi minimum                      Regulation Valve                      Full Flow                      *11 qts.                      *15 qts.</p>	<p>Full Flow                      Gear Type                      207 to 379 kN/m<sup>2</sup>                      103 kN/m<sup>2</sup> minimum                      Regulation Valve                      Full Flow                      *10.40 lts                      *14.20 lts</p>
<p>*If engine is equipped with a bypass filter                      add 4 qts (3.78 lts)</p>	
<p>Four Hole                      Orifice</p>	<p>Four Hole                      Orifice</p>

	ENGLISH	METRIC
Fuel Injection Pump: Manufacturer.....	Roosa Master	Roosa Master
Fuel Transfer Pump and Hand Primer Pump: Maximum Lift.....	3 ft Disposable Type	914.40 mm Disposable Type
Fuel Oil Filter.....		
Fuel Pump Timing to Engine (Static)		
NOTE: The number of degrees the injection is timed to the engine depends upon the type of injection pump. See the appropriate data listed below:		
Injection Pumps with Automatic Advance 1200 - 2600 rpm.....	20° BTDC	20° BTDC
Injection Pumps with Hydraulic Governor 1500 - 1800.....	28° BTDC	28° BTDC
E. VALVE DATA		
1. Valve Lash Adjustment:		
Intake Valve Clearance - Hot.....	0.015 in.	0.38 mm
Exhaust Valve Clearance - Hot.....	0.015 in.	0.38 mm
2. Valve Timing:		
Exhaust Valve w/ Tappet Clearance of....	0.0195 in.	0.50 mm
Opens BBDC.....	56°	56°
Closes ATDC.....	16°	16°
Duration.....	252°	252°
Intake Valves w/ Tappet Clearance of....	0.0195 in.	0.50 mm
Opens BTDC.....	20°	20°
Closes ABDC.....	48°	48°
Duration.....	248°	248°
Overlap.....	36°	36°
CAUTION: Tappets must be set with 0.0195 in. (0.50 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.		
F. GOVERNOR		
1. Mechanical Type		
Regulation (Power Units).....	10%	10%
2. Mechanical with Speed Droop Adjustment		
Regulation (Generator Drive).....	3.5 - 5%	3.5 - 5%
3. Hydraulic Type		
Regulation (Optional).....	1 - 5%	1 - 5%
4. Speed Settings		
Power Units		
Full Load (Standard).....	1800 rpm	1800 rpm
Idle.....	500 - 600 rpm	500 - 600 rpm
Generator Drive		
Full Load.....	1500 and 1800 rpm	1500 and 1800 rpm
Low Speed.....	1400 rpm	1400 rpm

G. ELECTRICAL SYSTEM

Starter (Standard).....  
 Starter (Optional).....  
 Alternator (Standard) - Early Style  
   Models 2800 2900.....  
   Models 2800MKI 2900MKI.....  
 Alternator (Optional) - Early Style  
   Models 2800 2900.....  
   Models 2800MKI 2900MKI.....  
 Alternator - Late Style  
   Models 649 and 2900MKI.....

ENGLISH	METRIC
12 v	12 v
24 v	24 v
12 v, 32 amp	12 v, 32 amp
12 v, 37 amp	12 v, 37 amp
12 v, 42 amp	12 v, 42 amp
12 v, 55 amp	12 v, 55 amp
12 v, 61 amp	12 v, 61 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.
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.)

NOTE: The oil pans of engines shipped wet are filled with SAE 20 or 10W30 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.)

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

12. If fuel injection pump has both the electric solenoid and the manual shut-off, 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.

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. 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.

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.

#### C. BYPASS TYPE OIL FILTER - OPTIONAL

For mounting, connecting the bypass filter into the lubricating system, and maintaining it, refer to Paragraph E in the following Topic 13.

## 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 equipment and the engine. The operator must become

familiar with the function of the controls and instruments provided for operating the unit. Refer to the owner's manual covering the equipment being driven by the engine 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 tank, fuel filter and water separator.
- 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 CD oil. 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 filter.
- 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 filter.
- 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

It is important to be selective in the lubricating oils, grease, and coolants used in the operation of your Allis-Chalmers engine. By following these recommendations, you can be assured of most efficient and longest trouble-free engine life.

For all turbocharged engines, in all applications, the general recommendation is to use oils meeting the American Petroleum Institute (API) classification CD and Military Specification MIL-L-45199B. This also applies to naturally aspirated (non-turbocharged) engines that are operating under severe application or when the fuel sulphur content exceeds 0.5%. In most normal duty applications of the non-turbocharged engines, an API classification CC, MIL-L-2104B, oil can be used.

SAE 30 or 15W40 viscosity oil is the lubricant weight around which Allis-Chalmers diesels have been designed. Use of SAE 30 or 15W40 weight will, in most cases, provide optimum performance life and lube oil control at normal operating speeds.

When crankcase temperatures are below 32°F (0°C), during engine starting, lighter viscosity oils can be used for easier starting without damage from marginal lubrication. Freezing cold is the only reason to use less than SAE 30 or 15W40 weight oil in Allis-Chalmers engines.

Crankcase Temperature When Starting Engine	Weight (Viscosity)
0°F & Below (-18°C)	SAE 10W or SAE 10W30
0°F to 32°F (-18°C to 0°C)	SAE 20/20W or SAE 15W40
32°F to 95°F (0°C to 35°C)	SAE 30 or SAE 15W40
Above 95°F (35°C)	SAE 40 or SAE 15W40

### MULTI VISCOSITY LUBE OILS

Any multi viscosity lubricating oil conforming with API classification CD and Military Specification MIL-L-45199B test requirements is approved for use in Allis-Chalmers diesel engines.

### SYNTHETIC LUBE OILS

Any synthetic or partially synthetic oil conforming with API classification CD and Military Specification MIL-L-45199-B test requirements is approved.

Mixing grades of lubricating oils in Allis-Chalmers diesels is not recommended.

### OIL AND FILTER CHANGE PERIOD

In general, it is recommended to renew the oil and standard engine mounted full flow type oil filters after each 100 hours of operation. This period is based on use of high quality oils, fuels with less than .5%

sulphur, average engine loads, and operating conditions. If engine has approved optional by-pass filter, renew the oil, full flow filters, and bypass filter elements every 250 hours.

Under severe operating conditions, with engine in poor operating condition, or when using high sulphur fuels, lubricating oils deteriorate at a faster rate. Because of this, oil change periods can vary.

### LUBRICATION OIL TESTING

After recommended oil change interval has been reached, actual tests of the oil should be made at intervals of 10 and 20 hours. These tests will determine condition of oil and indicate if change periods should be lengthened or shortened. Your lubricant supplier provides this testing service, usually on a gratis basis.

### HIGH ASH LUBRICATING OILS

Allis-Chalmers diesel engines will operate equally well on either high ash or low ash CD lubricants. Our tests, however, show that under severe service (extended operation under full throttle, high ambient temperatures, etc.) oils having an ash level of at least 1.5% will usually out-perform oils of lower ash contents.

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.

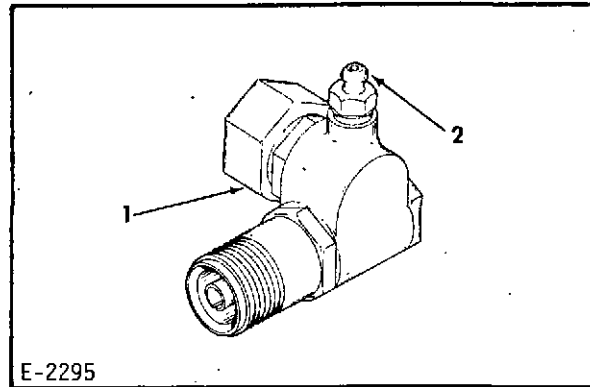
### 2. Angle Adaptor Lubrication

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 sulfurous acid ( $H_2SO_3$ ), which is highly corrosive to engine parts. The sulfur content should be kept to a minimum in order to increase the intervals between oil changes and engine overhauls.

#### 10. Carbon Residue

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

#### 11. Copper Strip Corrosion

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

### C. HANDLING AND STORAGE OF FUEL OIL

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

1. Take all precautions necessary to prevent the entrance of dirt and moisture into the fuel system. Contamination by these materials accelerates sludge formation, clogs filters, lines, and nozzles, and causes abnormal wear of close fitting parts in the fuel injection pump.
2. Moisture does not accumulate as rapidly in underground storage tanks as it does in above-ground tanks because temperature is more stable.
3. Alternately cooling and heating of above-ground tanks causes condensate to accumulate rapidly. Such tanks should be placed at an angle to horizontal and be equipped with a draincock valve at the lowest point. Condensation and sediment should be drained at regular intervals.

4. Large storage tanks should be equipped with covered manholes, and small tanks should be provided with ports and removable covers in order to facilitate tank cleaning.
5. Fuel fill pipe should extend above ground level and be equipped with a watertight, dustproof cap or cover.
6. Tanks should be vented to a safe area to allow normal "breathing" caused by expansion and contraction of the fuel and air.
7. The fuel outlet line should be connected to the tank either at the end opposite the sediment collection point or at a point that is well above the area of maximum accumulation.
8. Fuel lines should be of aluminum or steel wherever possible. Copper accelerates deterioration of fuel and induces sludge and gel formation.
9. All fuel handling equipment, such as funnels, hand pumps, and dipsticks, should be kept clean at all times and covered when not in use.
10. Do not open fuel containers or transfer fuel from drums to tanks in areas exposed to blowing dust and dirt. Also, do not use cotton waste material or linty rags to wipe containers, funnels, hand pumps, dipsticks, etc.
11. All fuel oils deteriorate at different rates depending upon such factors as the original source of the crude oil, the extent of refining and blending it has undergone, the degree of contamination introduced during storage, and age of the fuel oil.
  - a. Do not use tanks of larger capacity than necessary. The maximum recommended storage period for current type diesel fuels composed of blends of straight run distillates and catalytically cracked stocks is 6 months to one year. The user is inviting clogged filters and fuel injection difficulties if fuel is used that has been stored for longer periods. When longer storage periods are anticipated, a stabilizing additive should be specified when the fuel is ordered. Regardless of storage time, a full tank is preferable to one that is only partially filled.
  - b. Fuel instability is related in some degree to its sulfur content. Sulfur promotes the formation of corrosive compounds that are very destructive to metals in the fuel storage and fuel injection system.
  - c. Do not continually add new fuel to old fuel in storage without occasionally draining and disposing of all fuel remaining in the tank. The chemical change already started in the old fuel accelerates deterioration of the new fuel.

## TOPIC 8. LUBRICATION AND SERVICE 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 prescribe intervals. These intervals are based on normal operation, alter the interval 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, lubricating oil consumption, engine power, and the sound of the engine in operation by a qualified diesel mechanic will determine the need for reconditioning.

### B. LUBRICATION AND MAINTENANCE GUIDE

Checks should be made at the intervals shown (miles or hours, whichever occurs first).

1. Daily/Each 8 Hours		
Description	Reference	
	Topic	Para-graph
<b>a. Before Starting Engine</b>		
(1) Visually inspect belts and hoses for deterioration, 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	B
(4) Drain water from fuel tank	12	A
(5) Drain fuel water separator.	12	B
(6) Check air cleaner restriction indicator. Replace air cleaner element if red indicator is visible.	17	C
(7) Check/correct air cleaner to turbo loose clamps or deteriorated hose.	18	D
(8) Drain moisture from air compressor air reservoir.	21	B
<b>b. Start Engine</b>		
(1) Check/correct starter performance	14	D
(2) Check/correct oil pressure.	13	A
(3) Check/correct alternator charging rate.	14	E
<b>C. After Engine Reaches Operating Temperature</b>		
(1) If applicable, check engine oil level with engine running. Maintain between running ADD and FULL level marks on dipstick.	13	B
(2) Observe the following for normal operation:		
(a) Coolant temperature	11	D-J
(b) Lube oil pressure	13	A-F
(c) Idle/full load speed	12	E
(d) Air cleaner service indicator	17	C
(3) Check/correct for knocks or other unusual noises.	9	B
(4) Check/correct air compressor operation/air reservoir pressure.	21	B

2. Each 100 Hours		
Description	Reference	
	Topic	Para-graph
a. Check/correct radiator for external cleanliness and restriction of air through fins.	11	G
b. Make initial replacements of coolant filter.	11	L
c. Renew engine lubricating oil.	13	C
d. Renew lubricating fullflow oil filter. See note below.	13	D
e. If applicable renew bypass lubricating oil filter.	13	E
f. Check/correct liquid level of battery cells.	14	C
g. Check/correct leaks: (1) Lube oil (4) Air (2) Fuel (5) Exhaust (3) Coolant		

\*NOTE:

3. Each 250 Hours		
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	C
b. Renew full flow oil filters	13	D
c. Renew bypass oil filter	13	E

4. Each 600 Hours		
Description	Reference	
	Topic	Para-graph
a. Renew fuel filter.	12	B-C
b. Renew coolant filter.	11	L
c. Check tension and condition of alternator and water pump drive belts.	11	K
d. Check/clean engine breather tube.	13	F
e. Check/correct turbocharger for loose mounting nuts and piping.	18	D
f. Check/correct air compressor mounting fasteners and piping.	21	B
g. Clean or replace air compressor governor filters.	21	B

5. Each 1200 Hours		
Description	Reference	
	Topic	Para-graph
a. Inspect/check nozzle holder opening pressure and nozzle spray pattern.	12	G
b. Check specific gravity of battery fluid.	14	C
c. Inspect/clean/tighten electrical connections: (1) Battery (3) Alternator (2) Starter (4) Regulator.	14	C-E D-E
d. Check/tighten exhaust and intake manifold fasteners.	16	D
e. Check/tighten engine mounting fasteners.		
f. Check/correct air compressor or discharge valves and spring for excessive carbon.	21	B

6. Each 2250 Hours		
Description	Reference	
	Topic	Para-graph
a. Recondition nozzle-holder assemblies.	12	G
b. Check/correct turbocharger: (1) Wheels for dirt and carbon (2) Bearing clearance (3) Shaft endplay.	18	E
* c. Recondition intake and exhaust valves and seats.		Service Manual
* d. Check/correct cylinder sleeve bores for excessive wear.		Service Manual
e. Clean exterior of engine and radiator.		

7. Each 4500 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

TOOL MANUFACTURERS

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 illustrated in the Topic and Figure as indicated in the following tabulation.

The tools must be ordered directly from the tool manufacturer.

- (BI) Bacharach Instrument Company  
Division of American Bosch ARMA Corp.  
200 North Braddock Avenue  
Pittsburgh, Pennsylvania - 15208
- (BT) Borrough Tool & Equipment Corp.  
2429 North Burdick Street  
Kalamazoo, Michigan - 49007
- (KM) Service Tool Division  
Kent-Moore Corporation  
28635 Mound Road  
Warren, Michigan - 48092
- (OT) Owatonna Tool Company  
Owatonna, Minnesota - 55060

TOPIC	FIGURE NO.	MANUFACTURER'S 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-33-74 Belt Tension Gauge
12	14	(OT) 13371 Seal Compressor Tool (Injection Pump)
12	15-16	(OT) 13366 Plastic Timing Window (Test Gauge)
12	26	(BI) 65-030D Nozzle Tester (Only)
12	26	(BI) 65-481 Connector Set (Used With Above)
12	26	(BI) 65-317 Plastic Cup (Spray Collector)
12	*	(BI) 65-808 Carrying Case For 65-030D
12	27	(KM) J-6999-01 Nozzle Holder Fixture
12	29	(BI) 66-0021 Pin Vise (To Hold Spray Hole Cleaning Needles)
12	29	(BI) 66-0036 Spray Hole Cleaning Needles - 5 Per Set (0.010" Diameter)
12	29	(BI) 66-0038 Spray Hole Cleaning Needles - 5 Per Set (0.023" Diameter)
12	*	(BI) 66-0030 Brass Wire Brush
12	30	(KM) J-21609-7 Injection Nozzle Bore Cleaner

\* Not Illustrated

## TOPIC 9. TROUBLESHOOTING

PARAGRAPH	TITLE	PAGE
A	GENERAL.....	1
B	ENGINE.....	1
C	STARTING SYSTEM.....	4
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K	MAKING COMPRESSION CHECK.....	9

### 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.
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.		

### 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).	4. Starter brushes worn or not contacting properly. 5. Starter brush springs weak. 6. Starter commutator dirty or worn. 7. Starter armature shaft bushings worn (armature drags on fields). 8. Starter armature burned out.	4. Install new brushes or fit brushes to conform to contour of commutator. 5. Check brush spring tension; replace springs if necessary. 6. Polish commutator, machine commutator and under-cut mica if necessary. 7. Replace worn bushings and related items. 8. Replace armature.
Starter pinion will not engage with fly-wheel ring gear.	1. Grease and/or dirt in starter drive mechanism. 2. Broken or excessively worn parts.	1. Disassemble and clean the drive assembly. 2. Replace broken or worn parts.

#### D. FUEL SYSTEM

Insufficient fuel supply to fuel injection nozzles.	1. No fuel in fuel tank. 2. Inoperative fuel feed (transfer) pump. 3. Fuel injection nozzle valve binding in valve body. 4. Clogged fuel filters, fuel lines and sediment bowl on early engines. 5. Fuel injection pump malfunctioning. 6. Fuel injection nozzles improperly adjusted.	1. Fill fuel tank with specified fuel. Prime fuel system. 2. Repair or replace feed (transfer) pump. 3. Replace valve assembly in nozzle holder body. 4. Clean fuel system components, replace fuel filter elements. 5. Replace fuel injection pump. 6. Adjust fuel injection nozzles.
Air in Fuel system.	1. Loose fuel line fitting or leak in fuel line on suction side of fuel feed (transfer) pump. 2. Damaged fuel filter or gasket.	1. Tighten loose fitting or replace damaged line. 2. Replace filter.

#### E. AIR INTAKE SYSTEM

Insufficient air supply to cylinders.	1. Air cleaner clogged. 2. Foreign material lodged in turbocharger impeller or turbine.	1. Replace air filter element. 2. Disassemble and clean.
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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 alternator.	1. Drive belt loose or broken. 2. Regulator inoperative. 3. Alternator inoperative.	1. Adjust or replace drive belt. 2. Remove regulator for repair or replacement. 3. Remove unit for repairs or replacement.
Alternator 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
Alternator output low and/or unsteady (cont).	3. Brush spring tension too low. 4. Alternator circuit components damaged.	3. Replace brush springs. 4. Remove alternator 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 idle (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.

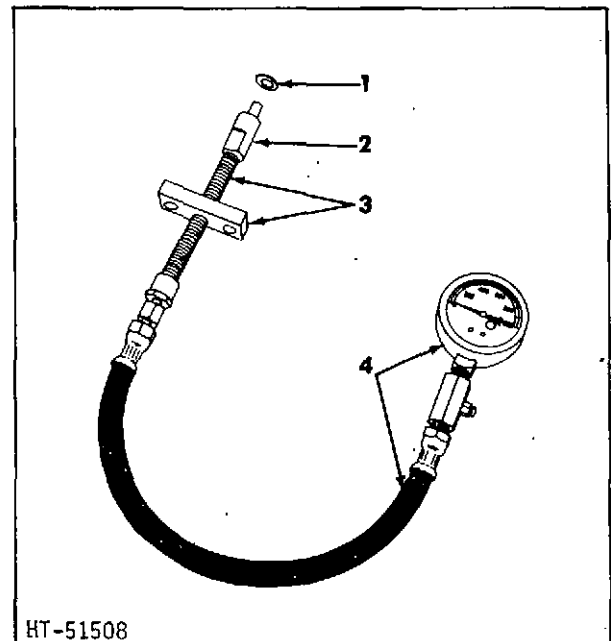
#### K. MAKING COMPRESSION TEST

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.

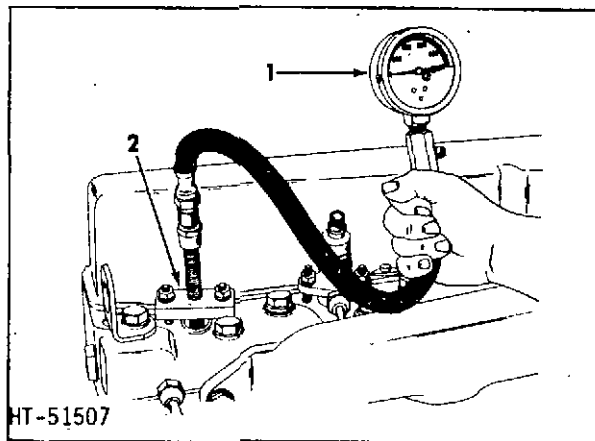
Compression pressure for a normal engine at normal operating temperature firing on five cylinders at 600 rpm and at sea level conditions is 500 psi (3447 kN/m<sup>2</sup>) (nominal).

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 500 psi (3447 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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**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.....
- i. Clearance of piston skirt with sleeve.....
- j. Fire wall height above cylinder sleeve flange.....
- k. Cylinder flange thickness.....

	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
	Replaceable Wet	Replaceable Wet
	3.8770 - 3.8775	98.48 - 98.49
	4.436 - 4.438	112.67 - 112.73
	4.374 - 4.376	111.10 - 111.15
	4.624 - 4.628	117.45 - 117.55
	.001 - .005	.03 - .13
	.0005 - .0045	.01 - .11
	.003 - .012	.08 - .30
	.0045 - .0070	.11 - .18
	.0445 - .0475	1.13 - 1.21
	.3185 - .3200	8.09 - 8.13

SIZE OF NEW PARTS

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
l. Top surface of cylinder sleeve flange above cylinder block with sleeve installed.....	.002 - .005	.05 - .13
m. Flange height adjusting shims available.....	.005, .010, .015 and .020	.13, .25, .38 and .50
n. Allowable taper.....	.0015	.04
o. Allowable out-of-round (when installed).....	.0015	.04
<b>2. Cylinder Block</b>		
a. Counterbore diameter in cylinder block for cylinder sleeve flange.....	4.631 - 4.636	117.63 - 117.75
b. Depth of counterbore for sleeve flange.....	.3150 - .3165	8.00 - 8.04
c. Bore in cylinder block for top of sleeve...	4.4385 - 4.4405	112.74 - 112.79
d. Bore in cylinder block for bottom of sleeve	4.377 - 4.379	111.18 - 111.23
e. Bore in cylinder block for camshaft bearings.....	2.259 - 2.260	57.38 - 57.40
f. Bearing bore in cylinder block for main bearings (without bearing, cap in place, and capscrews tightened to specified torque)...	2.9368 - 2.9375	74.59 - 74.61
<b>3. Pistons</b>		
NOTE: Combustion chamber in head of piston.		
a. Combustion chamber inside diameter.....	2.560 - 2.564	55.02 - 55.13
b. Combustion chamber depth.....	.559 - .563	14.20 - 14.30
c. Material.....	Aluminum Alloy	Aluminum Alloy
d. Length.....	4.575 - 4.579	116.21 - 116.31
e. Diameter between top and second ring groove	3.8515 - 3.8555	97.83 - 97.93
f. Diameter at bottom of skirt measured at right angle to piston.....	3.870 - 3.871	98.30 - 98.32
g. Bore in piston for pin-2800 2900.....	1.2519 - 1.2521	31.79 - 31.80
h. Bore in piston for pin-2800MKI 2900MKI: Oval shape hole-Horizontal dimension.....	1.2536 - 1.2538	31.84 - 31.85
Vertical dimension.....	1.2519 - 1.2521	31.79 - 31.80
i. Measurement from center of piston pin bore to top of piston.....	2.513 - 2.517	63.83 - 63.93
j. Clearance of piston skirt with sleeve.....	.0045 - .0070	.11 - .18
<b>4. Piston Pins</b>		
a. Type.....	Full Floating	Full Floating
b. Piston pin length.....	3.285 - 3.305	83.44 - 83.95
c. Diameter of pin.....	1.2515 - 1.2517	31.78 - 31.79
d. Fit of pin in piston at room temperature...	.0002 Loose - .0006 Loose	.00 Loose - .01 Loose
e. Inside diameter of connecting rod bushing...	1.2527 - 1.2532	31.82 - 31.83
f. Piston pin to connecting rod bushing clearance.....	.001 - .0017	.03 - .04
<b>5. Piston Rings</b>		
a. Number of rings on each piston.....	4	4
b. Location of rings.....	3 Compression and 1 Oil Control; all above Piston Pin	3 Compression and 1 Oil Control; all above Piston Pin
c. Gap between ends - Fitted		
1st Ring (chrome compression).....	.013 Min - .024 Max	.33 Min - .61 Max
2nd Ring (compression).....	.021 Min - .036 Max	.36 Min - .91 Max
3rd Ring (compression).....	.008 Min - .023 Max	.20 Min - .58 Max
4th Ring (oil control)(ventilated w/spring).....	.008 Min - .023 Max	.20 Min - .58 Max
d. Clearance of rings in grooves		
Top (compressing ring, chrome plated)...	.0050 - .0075	.13 - .19
2nd (compression ring).....	.0035 - .0055	.09 - .14
3rd (compression ring).....	.0035 - .0055	.09 - .14
4th (oil control ring) (ventilated w/spring).....	.0015 - .0035	.04 - .09

NOTE: Only standard size rings are available.

DESCRIPTION	SIZE OF NEW PARTS	
	INCHES	MILLIMETERS
6. Crankshaft		
a. Journal diameter for connecting rods.....	2.3720 - 2.3735	60.25 - 60.29
b. Journal diameter for main bearings.....	2.7465 - 2.7480	69.76 - 69.80
c. Width between connecting rod journal cheeks	1.4985 - 1.5015	38.06 - 38.14
d. Width of main bearing journals		
Front bearing.....	2.199 - 2.239	55.85 - 56.87
Intermediate bearings.....	1.685 - 1.689	42.80 - 42.90
Center bearing.....	2.061 - 2.064	52.35 - 52.43
Rear bearing.....	1.951 - 1.961	49.56 - 49.81
e. Crankshaft end clearance.....	.004 - .010	.10 - .25
f. Type and location of thrust bearing.....	Integral with Center Main Bearing	Integral with Center Main Bearing
g. Crankshaft journals may be ground.....	.010, .020 or .040 Undersize	.25, .51, 1.02 Undersize
h. Fit of crankshaft gear on crankshaft.....	.001 - .003 Tight	.03 - .08 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).....	2.7496 - 2.7513	69.84 - 69.88
d. Diameter of crankshaft main bearing journals.....	2.7465 - 2.7480	69.76 - 69.80
e. Bearing-to-journal clearance at front, intermediate, center and rear bearings (with capscrews tightened to specified torque).....	.0016 - .0048	.04 - .12
f. Overall length of main bearings		
Front and intermediates.....	1.287 - 1.317	32.69 - 33.45
Center.....	2.054 - 2.057	52.17 - 52.25
Rear.....	1.524 - 1.554	38.71 - 39.47
g. Undersize bearings available for service...	.010, .020, .040	.25, .51, 1.02
h. Type and location of thrust bearing.....	Integral with Center Main Bearing	Integral with Center Main Bearing
i. Front, intermediate center and rear bearing wall thickness (standard bearing).....	.0931 - .0936	2.36 - 2.38
j. Bearing bore in cylinder block (without bearing, cap in place and capscrews tightened to specified torque).....	2.9368 - 2.9375	74.59 - 74.61
8. Connecting Rod Bearings		
a. Type.....	Replaceable Precision	Replaceable Precision
b. Inside diameter of bearing (with capscrews tightened to specified torque).....	2.3744 - 2.3759	60.31 - 60.35
c. Diameter of crankshaft connecting rod journals.....	2.372 - 2.3735	60.25 - 60.29
d. Connecting rod bearing-to-journal clearance (with capscrews tightened to specified torque).....	.0009 - .0039	.02 - .10
e. Overall length of connecting rod bearings..	1.155 - 1.185	29.34 - 30.10
f. Undersize bearings available for service...	.010, .020, .040	.25, .51, 1.02
g. Bearing wall thickness (standard bearing)..	.0933 - .0938	2.37 - 2.38
9. Connecting Rods		
a. Type - non-rifled.....	Balance Forged	Balance Forged
b. Bolts used per rod.....	2	2
c. Connecting rod length (center-to-center)...	7.248 - 7.252	184.10 - 184.20
d. Inside diameter of connecting rod bushing (finished bore).....	1.2527 - 1.2532	31.82 - 31.83

SIZE OF NEW PARTS

DESCRIPTION	INCHES	MILLIMETERS
	Split Type	Split Type
e. Outside of diameter of connecting rod bushing.....	2.5620 - 2.5625	65.07 - 65.09
f. Bearing bore (without bearing, cap in place and capscrews tightened to specified torque)	.0009 - .0039	.02 - .10
g. Clearance-rod bearing-to-crankshaft journal (capscrews tightened to specified torque)	1.4915 - 1.4935	37.88 - 37.93
h. Connecting rod width at lower end.....	.005 - .010	.13 - .25
i. Side clearance-to-crankshaft journal.....	1.2515 - 1.2517	31.78 - 31.79
j. Piston pin diameter.....	1.391 - 1.411	35.33 - 35.84
k. Piston pin bushing length in connecting rod.	.001 - .0017	.03 - .04
l. Piston pin to rod bushing clearance.....		
m. Bore in connecting rod for piston pin bushing.....	1.3750 - 1.3755	34.93 - 34.94
<b>10. Exhaust Valves</b>		
a. Valve lift (at valve) w/.015" lash.....	.354	8.99
b. Valve lift (at cam).....	.246	6.25
c. Seat angle - 2800MKI 2900MKI.....	30°	30°
d. Seat angle (original)-2800 2900.....	45°	45°
Note: Service 2800 2900 with seat angle.....	30°	30°
e. Valve seat contact width.....	.0625	1.59
f. Valve lash (cold).....	.018	.46
g. Valve lash (engine coolant at normal operating temperature).....	.015	.38
h. Head diameter.....	1.439 - 1.449	36.55 - 36.80
i. Overall length.....	5.997	152.32
j. Stem diameter.....	.3705 - .3710	9.41 - 9.42
k. Valve must be recessed (in head).....	Minimum .046	Minimum 1.17
<b>11. Exhaust and Intake Valve Springs</b>		
a. Valve spring free length.....	2.860 Approx.	72.64 Approx.
b. Valve spring length (valve closed).....	2.230	56.64
c. Valve spring length (valve open).....	1.780	45.21
d. Spring load at 2.230" length.....	57-63 lb	25.9 - 28.6 kg
e. Spring load at 1.780" length.....	121-133 lb	54.9 - 60.3 kg
NOTE: Install new spring when old spring is 5% below low limit or 5% above high limit.		
<b>12. Intake Valves</b>		
a. Valve lift at valve w/.015" lash.....	.4005	10.17
b. Valve lift at cam.....	.277	7.01
c. Seat angle-2800 2900 2800MKI 2900MKI.....	30°	30°
d. Valve seat contact width.....	.0625	1.59
e. Valve lash (cold).....	.018	.46
f. Valve lash (hot).....	.015	.38
g. Head diameter.....	1.615 - 1.625	41.02 - 41.28
h. Overall length.....	5.996	152.30
i. Stem diameter.....	.3715 - .3720	9.44 - 9.45
j. Valve must be recessed (in head).....	Minimum .0345	Minimum .88
<b>13. Exhaust Valve Seat Inserts</b>		
a. Seat angle - 2800MKI 2900MKI.....	30°	30°
b. Seat angle (original)2800 2900.....	45°	45°
Note: Service 2800 2900 with seat angle.....	30°	30°
c. Seat contact width.....	.0625	1.59
d. Seat runout.....	.002	.05
e. Insert press fit.....	.001 - .003	.03 - .08
f. Insert O.D. not installed.....	1.4825 - 1.4835	37.66 - 37.68
g. Bore in cylinder head for insert.....	1.4805 - 1.4815	37.60 - 37.63
h. Depth of counterbore in cylinder head for insert (from bottom deck of head)	.4465 - .4485	11.32 - 11.39

DESCRIPTION

SIZE OF NEW PARTS

DESCRIPTION	INCHES	MILLIMETERS
i. Oversize insert.....	.005 Over Standard	.13 Over Standard
14. Intake Valve seat Inserts		
a. Seat angle.....	30°	30°
b. Seat contact width.....	.0625	1.59
c. Seat runout.....	.002	.05
d. Insert press fit.....	.001 - .003	.03 - .08
e. Insert O.D. not installed.....	1.6055 - 1.6065	40.78 - 40.81
f. Bore in cylinder head for insert.....	1.6035 - 1.6045	40.73 - 40.75
g. Depth of counterbore in cylinder head for insert (from bottom deck of head).....	.3825 - .3845	9.72 - 9.77
h. Oversize insert.....	.005 Over Standard	.13 Over Standard
15. Exhaust and Intake Valve Guides		
a. Length.....	2.875	73.03
b. Inside diameter ream after assembly - (factory sized - field reaming not required)....	.3735 - .3742	9.49 - 9.50
c. Stem-to-guide clearance after reaming		
Exhaust.....	.0025 - .0037	.06 - .09
Intake.....	.0015 - .0027	.04 - .07
d. Guide stand-out from bottom of counterbore in cylinder head		
Exhaust.....	.880	22.35
Intake.....	.660	16.76
16. Rocker Arms with Non-Replaceable Bushings		
a. I.D. of bore for shaft - (finish bore).....	1.001 - 1.002	25.43 - 25.45
b. O.D. of rocker arm shaft.....	.999 - 1.000	25.37 - 25.40
c. Rocker arm shaft-to-rocker arm bushing clearance.....	.001 - .003	.03 - .08
d. Rocker arm ratio.....	1.5:1	1.5:1
e. Oil feed restrictor line.....	I.D. .093	I.D. 2.36
17. Camshaft		
a. Number of bearings used.....	4	4
b. I.D. of camshaft bearings (when installed)..	2.133 - 2.135	54.18 - 54.23
c. O.D. of camshaft journals.....	2.130 - 2.131	54.10 - 54.13
d. Camshaft bearing-to-journal running clearance.....	.002 - .005	.05 - .13
e. O.D. of camshaft bearings.....	2.263 - 2.265	57.48 - 57.53
f. Bore in cylinder block for bearing.....	2.259 - 2.260	57.38 - 57.40
g. Fit of camshaft bearings in bore of cylinder block.....	.003 - .006 Tight	.08 - .15 Tight
h. Overall width of camshaft bearings		
Front bearings.....	1-3/8	34.93
Intermediate bearings.....	1	25.40
Rear bearings.....	1	25.40
i. Camshaft end play.....	.001 - .011	.03 - .28
j. Camshaft gear width.....	1	25.40
k. Fit of camshaft gear on camshaft.....	.0025 - .004 Tight	.06 - .10 Tight
l. Specified thickness of thrust plate.....	.204 - .206	5.18 - 5.23
18. Valve Lifters		
a. Bore in cylinder block for valve lifter.....	.7495 - .7505	19.04 - 19.06
b. O.D. of valve lifter stem.....	.7480 - .7485	19.00 - 19.01
c. Fit of valve lifter in bore of cylinder block	.001 - .0025	.03 - .06
19. Front Gear Train Backlash		
a. Crankshaft gear to camshaft gear.....	.0046 - .0077	.12 - .20
b. Crankshaft gear to idler gear.....	.0045 - .0072	.11 - .18
c. Fuel pump drive gear to fuel pump driven gear	.0045 - .0067	.11 - .17
d. Camshaft gear to auxiliary drive gear.....	.0064 - .0095	.16 - .24
e. Crankshaft to oil pump .....	.0025 - .0099	.06 - .25

DESCRIPTION

SIZE OF NEW PARTS		
	INCHES	MILLIMETERS
20. Cylinder Head		
a. Valve sequence (front to rear in head).....Cylinder #1-	Intake-Exhaust	Intake-Exhaust
#2-	Exhaust-Intake	Exhaust-Intake
#3-	Intake-Exhaust	Intake-Exhaust
#4-	Exhaust-Intake	Exhaust-Intake
#5-	Intake-Exhaust	Intake-Exhaust
#6-	Exhaust-Intake	Exhaust-Intake
21. Lubricating Oil Pressure Pump-Crankshaft Gear Driven		
a. Radial clearance - gears to pump body.....	.0020 - .0045	.05 - .11
b. End clearance - pump gears.....	.0010 - .0065	.03 - .17
c. O.D. of driver and idler shafts.....	.8715 - .8720	22.14 - 22.15
d. I.D. of driver shaft bushing (installed)....	.8730 - .8750	22.17 - 22.23
e. O.D. of driver shaft bushing.....	1.0025 - 1.0035	25.46 - 25.49
f. Clearance - driver shaft to bushing.....	.0010 - .0035	.03 - .09
g. I.D. in pump body for driver shaft bushing..	.9995 - 1.0005	25.39 - 25.41
h. Fit - driver shaft bushing to pump body....	.002 - .004 Tight	.05 - .10 Tight
i. I.D. - bore in drive, driver, and idler gears.....	.8695 - .8705	22.09 - 22.11
j. Fit - drive, driver and idler gears to shafts	.0010 - .0025 Tight	.03 - .06 Tight
k. I.D. in pump body for idler shaft.....	.8740 - .8750	22.20 - 22.23
l. Clearance - idler shaft to pump body.....	.0010 - .0035	.03 - .09
m. I.D. in pump cover for drive and idler shafts	.8740 - .8750	22.20 - 22.23
n. Clearance - driver and idler shafts to cover.	.0020 - .0035	.05 - .09
22. Lubricating Oil Pressure Pump - Bayonet Type		
a. Radial clearance - gears to pump body.....	.00075 - .00175	.02 - .05
b. End clearance - pump gears.....	.002 - .004	.05 - .10
c. I.D. in pump body for oil pump drive shaft..	.6240 - .6250	15.85 - 15.87
d. O.D. of drive shaft.....	.6220 - .6225	15.80 - 15.81
e. O.D. of idler shaft.....	.6185 - .6190	15.70 - 15.72
f. I.D. in gear driver for drive shaft.....	.6200 - .6210	15.75 - 15.77
Fit - drive shaft to gear driver.....	.001 - .0025 Tight	.03 - .06
g. Clearance - O.D. of drive shaft to bore in oil pump body.....	.0015 - .0030	.04 - .08
h. I.D. in lower pump body for idler gear shaft.....	.6165 - .6175	15.66 - 15.68
Fit - idler gear shaft to body.....	.001 - .0025 Tight	.03 - .06
i. I.D. in idler gear.....	.6200 - .6210	15.75 - 15.77
j. Clearance - idler shaft to gear.....	.001 - .0025	.03 - .06
k. I.D. in drive gear - for shaft.....	.6205 - .6215	15.76 - 15.79
Fit - shaft-to-drive gear.....	.0005 - .002 Tight	.01 - .03
23. Lubricating Oil Pressure Pump - Externally Mounted		
a. Radial clearance - gears to pump body.....	.002 - .004	.05 - .10
b. End clearance - pump gears (with gasket in place).....	.0037 - .0104	.09 - .26
c. I.D. in pump body for oil pump driver shaft.	.7488 - .7498	19.02 - 19.04
d. O.D. of driver shaft in pump body.....	.7458 - .7468	18.92 - 20.00
e. O.D. of driver shaft for driver gear.....	.7533 - .7538	19.13 - 19.15
f. O.D. of idler shaft.....	.7538 - .7543	19.15 - 19.16
g. I.D. in gear driver for driver shaft.....	.7513 - .7523	19.08 - 19.12
Fit - drive shaft to gear driver.....	.001 - .0025 Tight	.02 - .06
h. Clearance - O.D. of driver shaft to bore in oil pump body.....	.002 - .004	.05 - .10

DESCRIPTION

SIZE OF NEW PARTS		
	INCHES	MILLIMETERS
i. I.D. in lower pump body for idler gear shaft.....	.7518 - .7528	19.09 - 19.12
Fit - idler gear shaft to body.....	.001 - .0025 Tight	.02 - .06
j. I.D. of idler gear bushing in body.....	.7558 - .7573	19.20 - 19.22
k. Clearance - idler shaft to gear bushing....	.0015 - .0035	.04 - .09
l. I.D. of cover bushing for driver shaft.....	.7558 - .7573	19.20 - 19.22
m. Clearance - driver shaft to cover bushing..	.002 - .004	.05 - .10
24. Water Pump		
a. Clearance - Impeller to housing.....	.015 Max	.38 Max
b. Bearing		
Bearing O.D.....	1.4995 - 1.5000	38.09 - 38.10
Bore in water pump body (for bearing)...	1.4979 - 1.4989	38.05 - 38.07
Fit - bearing O.D. to body.....	.0005 - .0020 Tight	.01 - .05 Tight
c. Impeller		
Bore in impeller for shaft.....	.6235 - .6245	15.84 - 15.86
Shaft diameter.....	.6262 - .6267	15.88 - 15.89
Fit - shaft diameter to impeller bore	.0017 - .0032 Tight	.04 - .08 Tight
d. Hub - for water pump pulley		
Bore in hub for shaft.....	.7435 - .7445	18.88 - 18.91
Shaft diameter.....	.7460 - .7465	18.95 - 18.96
Fit - shaft diameter to hub bore.....	.0015 - .0030 Tight	.04 - .08 Tight
25. Idler Gear Assembly		
a. Idler gear bearing		
Bearing bore (I.D. for idler shaft).....	1.000 - 1.0008	25.40 - 25.42
Shaft diameter.....	.9990 - 1.0000	25.37 - 25.40
Fit - shaft to bearing.....	.0000 - .0018 Loose	.00 - .05 Loose
Bearing O.D.....	1.980 - 1.981	50.29 - 50.32
Bore in idler gear.....	1.9785 - 1.9795	50.25 - 50.28
Fit - bearing O.D. to idler gear.....	.0005 - .0025 Tight	.01 - .06 Tight
Bore in cylinder block for idler gear shaft.....	.998 - .999	25.35 - 25.37
Fit - idler shaft to bore in cylinder block.....	.0000 - .002 Tight	.00 - .05 Tight
Bearing installed end play.....	.002 - .011	.05 - .28
26. Oil Pump or Accessory Drive Assembly		
a. Inside diameter of bearing for drive shaft.	1.500 - 1.5005	38.10 - 38.11
b. Drive shaft outside diameter for bearing...	1.4995 - 1.5005	38.09 - 38.11
c. Fit of drive shaft to bearing.....	Tight .0005- .0010 Loose	Tight .01- .03 Loose
d. Outside diameter of bearing.....	2.5625 - 2.5635	65.09 - 65.11
e. Bore in housing for bearing.....	2.5615 - 2.5625	65.06 - 65.09
f. Fit of bearing in housing.....	.000 - .002 Tight	.00 - .05 Tight
g. Bearing installed end play.....	.002 - .006 Tight	.05 - .15 Tight

B. TORQUE SPECIFICATIONS - BOLT, CAPSCREW, AND NUT

SAE standard torque values must 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.

IMPORTANT: All torque values in this table are calculated for threads lubricated with engine oil.

TYPE	DESCRIPTION	SIZE AND THREAD	GRADE	ENGLISH TORQUE LB-FT	METRIC TORQUE Nm
Capscrew	Bearing Cap, Main	9/16-12 x 3-11/16	8	135	183
Capscrew	Connecting Rod Cap	3/8-24 x 2	8	45	61
Capscrew	Cylinder Head Mounting (Short)	9/16-12 x 5-1/16	8	165	224
Capscrew	Cylinder Head Mounting (Long)	9/16-12 x 8-1/8	8	165	224
Screw	Cylinder Head Cover	1/4-20 x 5/8	2	*35	3.95
Nut	Camshaft Gear Retaining	7/16-14 x 4	8	72	98
Nut	Nozzle Retaining-Type I Units	Special	-	55	75
Nut	Nozzle Retaining-Type II Units	Special	-	44	60
Locknut	Nozzle Adjusting Screw-Type I	7/8-20	-	55	75
Nut	Nozzle Fuel Line	Ermetto Nut	-	25	34
Capscrew	Nozzle Holder Assembly to Cylinder Head (Current)	5/16-18 x 1-3/4	2	*180	20.34
Nut	Nozzle Holder Assembly to Cylinder Head (Early)	5/16-24	2	14	19
Nut	Injection Pump Shaft Retaining (Roosa Master)	Special	-	38	52
Screw	Fuel Return Manifold(Banio)	Metric M6 x 1.0	-	44	5
Capscrew	Crankshaft Pulley Retaining	7/8-14 x 1-3/4	5	182	247
Capscrew	Intake Manifold Mounting	5/16-18	8	20	27
Nut	Auxiliary and Oil Pump Drive Bearing Retaining	1-3/8 - 16	8	250	340
Capscrew	Flywheel Mounting (Socket Head)	1/2-20	100	135	183
Nut	Farr Air Cleaner Clamp	5/16-18	2	6	8
Nut	Turbocharger Mounting	3/8-16	Stn. Steel	20	27
Nut	Turbocharger Compressor Housing to Center Housing V-Band Coupling		-	*60	6.75
Capscrew	Turbocharger Turbine Housing to Center Housing		-	*115	13
Nut	Turbocharger Impeller		-	*19	2.15
Capscrew	Turbocharger Back Plate to Center Housing		-	*82	9.26

\*1b-inch

2. Standard Torque Values

The heads of capscrews used in Allis-Chalmers engines bear grade marks conforming to standards specified by the Society of Automotive Engineers (SAE). The three grades of capscrews used are identified as follows: Grade 2, no marks; Grade 5, three marks, 120° apart; Grade

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

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

Grade 2 Capscrew Standard Torque Values					
National Coarse (NC) Thread			National Fine (NF) Thread		
Size Inches(")	English lb-ft	Metric Nm	Size Inches(")	English lb-ft	Metric Nm
1/4-20	5-7	7-9	1/4-28	6-8	8-11
5/16-18	11-13	15-18	5/16-24	13-15	18-20
3/8-16	18-21	24-28	3/8-24	19-22	26-30
7/16-14	30-33	41-45	7/16-20	32-35	43-47
1/2-13	45-50	61-68	1/2-20	45-50	61-68
9/16-12	60-65	81-88	9/16-18	60-65	81-88
5/8-11	75-85	102-115	5/8-18	75-85	102-115
3/4-10	125-135	170-183	3/4-16	125-135	170-183
7/8-9	105-115	143-156	7/8-14	105-115	143-156
1-8	155-165	211-224	1-14	140-150	190-204

CONTINUED ON FOLLOWING PAGE

b. Grade 5 Capscrews

Grade 5 Capscrew Standard Torque Values					
National Coarse (NC) Thread			National Fine (NF) Thread		
Size Inches(")	English lb-ft	Metric Nm	Size Inches(")	English lb-ft	Metric Nm
1/4-20	9-11	12-15	1/4-28	11-13	15-18
5/16-18	18-20	24-27	5/16-24	21-23	28-31
3/8-16	28-33	38-45	3/8-24	30-35	41-47
7/16-14	44-49	60-66	7/16-20	50-55	68-75
1/2-13	68-73	92-99	1/2-20	68-73	92-99
9/16-12	95-105	129-143	9/16-18	95-105	129-143
5/8-11	125-135	170-183	5/8-18	125-135	170-183
3/4-10	210-230	285-312	3/4-16	210-230	285-312
7/8-9	290-310	393-421	7/8-14	290-310	393-421
1-8	420-450	569-610	1-14	380-410	515-556

c. Grade 8 Capscrews

Grade 8 Capscrew Standard Torque Values					
National Coarse (NC) Thread			National Fine (NF) Thread		
Size Inches(")	English lb-ft	Metric Nm	Size Inches(")	English lb-ft	Metric Nm
1/4-20	12-14	16-19	1/4-28	14-16	19-22
5/16-18	25-27	34-37	5/16-24	28-30	38-41
3/8-16	41-46	56-62	3/8-24	43-48	58-65
7/16-14	69-74	94-100	7/16-20	72-77	98-104
1/2-13	95-105	129-143	1/2-20	95-105	129-143
9/16-12	130-140	177-190	9/16-18	130-140	177-190
5/8-11	170-190	231-258	5/8-18	170-190	231-258
3/4-10	290-310	393-421	3/4-16	290-310	393-421
7/8-9	450-500	610-678	7/8-14	450-500	610-678
1-8	670-700	908-949	1-14	600-630	813-854

C. STUD GAUGE HEIGHTS

Stud Description	Stud Size					Gauge Height		Driving Torque*	
	Dia	Thread		Length		in.	mm	lb-ft	Nm
		Stud End	Nut End	in.	mm				
Turbocharger Mounting to Exhaust Manifold.	3/8	16	16	1.562	39.288	1	25.4	10-35	14-47
Auxiliary and oil pump drive assembly or cover	3/8	24	24	1.380	35.05	1.062	26.97	10-35	14-47
Roosa Master pump to front plate (Current)	3/8	24	24	1.380	35.05	1.062	26.97	10-35	14-47
Roosa Master pump to pump adaptor (Early)	3/8	16	16	1.437	36.50	.937	23.80	10-35	14-47
Pump adaptor to front plate (Early)	3/8	16	16	1.380	35.05	1.062	26.97	10-35	14-47
Nozzle-Holder assembly to cylinder head (Early)	5/16	18	24	1.968	49.98	1.468	37.29	7-22	9-30

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

## TOPIC 11. COOLING SYSTEM

### A. GENERAL

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 (Fig 1). If the heat exchanger and expansion tank cooling system (Fig 2) is utilized, the owner must supply ample raw water under pressure to the heat exchanger.

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

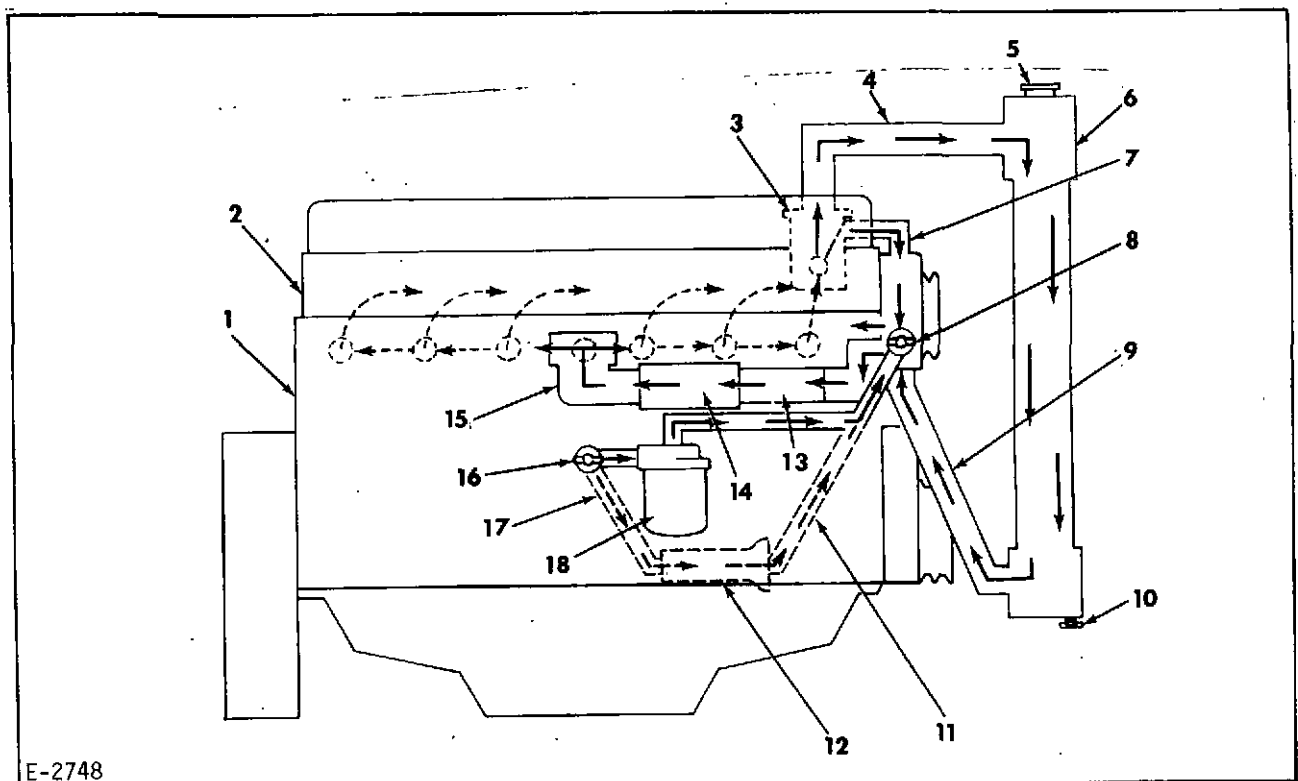
The function of the cooling system is to prevent

temperatures in the combustion chamber from damaging the engine and at the same time keep operating temperatures within safe limits.

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

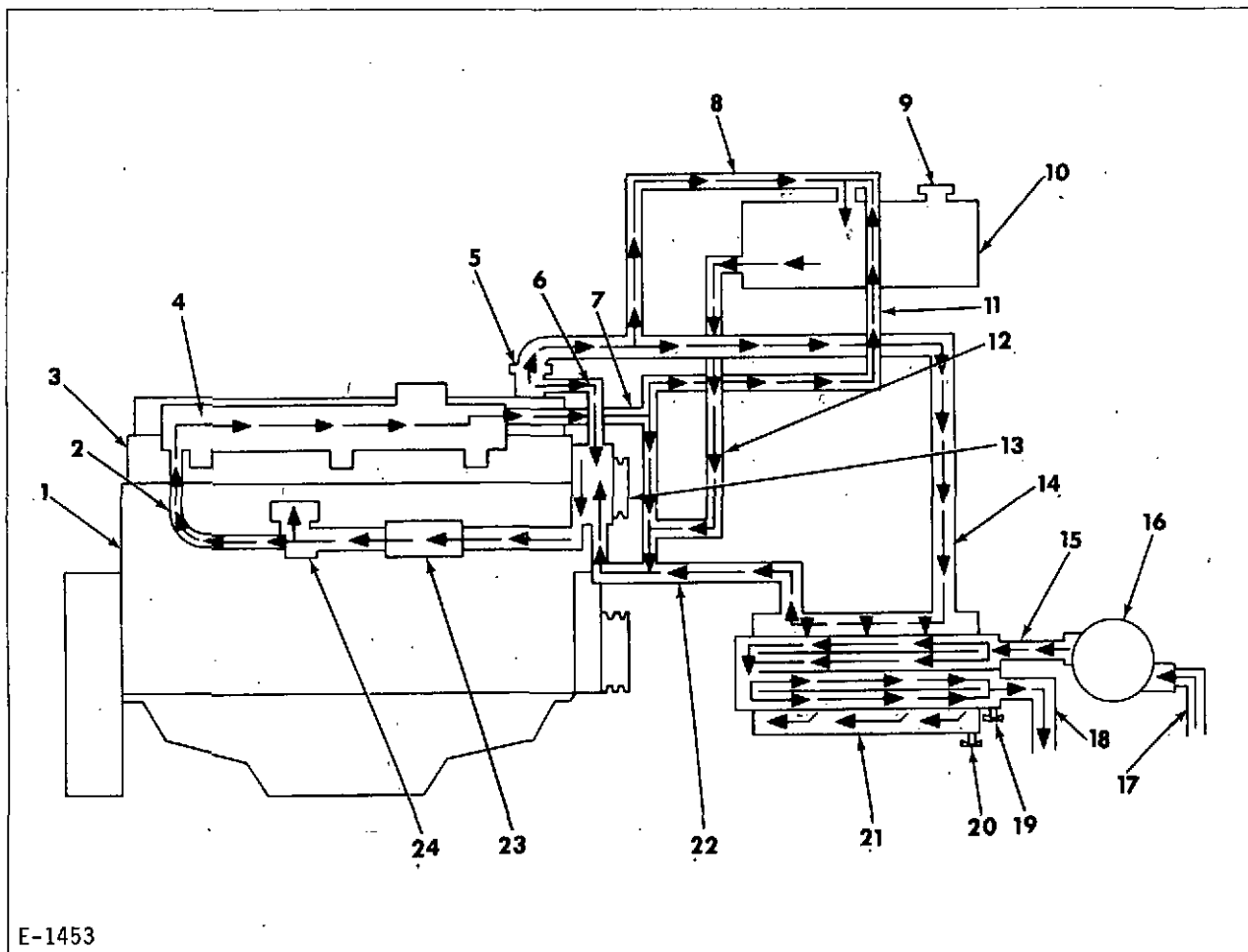
### B. RADIATOR AND FAN TYPE COOLING SYSTEMS

Coolant is drawn from the bottom of the radiator into the inlet side of the coolant pump. For those applications without an oil cooler, the coolant is forced from the outlet side of the pump into the inlet manifold, which is cast into the side of the block opposite the cylinders. From the manifold, coolant circulates around the cylinder sleeves and into the cylinder head. The coolant then passes



- |   |   |
|---|---|
| 1. Cylinder block                               | 10. Drain cock                              |
| 2. Cylinder head                                | 11. Coolant filter outlet hose              |
| 3. Thermostat housing and thermostat            | 12. Coolant filter (Models 2800 2900)       |
| 4. Radiator inlet hose                          | 13. Water pipe (used with oil cooler)       |
| 5. Pressure cap (7 psi) (48 kN/m <sup>2</sup> ) | 14. Oil cooler (standard only for 2900MKI)  |
| 6. Radiator                                     | 15. Oil cooler outlet hose                  |
| 7. Bypass hose                                  | 16. Coolant filter shutoff valve            |
| 8. Coolant filter shutoff valve                 | 17. Coolant filter inlet hose               |
| 9. Radiator outlet hose                         | 18. Coolant filter (Models 2800MKI 2900MKI) |

Figure 1. Radiator and Fan Cooling System Schematic Diagram



E-1453

- |  |  |
|--|--|
| <ol style="list-style-type: none"> <li>1. Cylinder block</li> <li>2. Pipe (coolant inlet to exhaust manifold)</li> <li>3. Cylinder head</li> <li>4. Water cooled exhaust manifold</li> <li>5. Thermostat housing</li> <li>6. Bypass hose</li> <li>7. Pipe (coolant outlet to pump inlet)</li> <li>8. Vent line (exhaust manifold to expansion tank)</li> <li>9. Filler cap (vented)</li> <li>10. Expansion tank</li> <li>11. Vent line (coolant outlet pipe to expansion tank)</li> <li>12. Pipe (coolant return to pump inlet)</li> <li>13. Water (coolant) pump</li> </ol> | <ol style="list-style-type: none"> <li>14. Pipe (thermostat housing to heat exchanger inlet)</li> <li>15. Raw water inlet</li> <li>16. Raw water pump (customer supplied)</li> <li>17. Customer supplied source of raw water</li> <li>18. Raw water discharge</li> <li>19. Raw water drain cock</li> <li>20. Engine coolant drain cock</li> <li>21. Heat exchanger</li> <li>22. Pipe (heat exchanger to water pump inlet)</li> <li>23. Oil cooler</li> <li>24. Coolant to block inlet elbow</li> </ol> |
|--|--|

Figure 2. Heat Exchanger and Expansion Tank Cooling System Schematic Diagram

into the thermostat housing, the upper radiator hose and the top tank of the radiator.

The flow of coolant in those applications with an oil cooler is the same except that the coolant from the outlet side of the pump enters external piping and passes through the engine oil cooler. The coolant enters the engine block through an elbow connected to the water inlet manifold, which is cast in the engine block.

As the coolant passes from top to bottom through the radiator, heat is dissipated to the air that is being forced through the radiator by the cool-

ing fan.

The radiator and fan type cooling system is pressurized by a 7<sup>1</sup> 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.

A double-acting valve in the pressure 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.

**WARNING:** DO NOT REMOVE THE RADIATOR FILL CAP WHILE THE COOLANT TEMPERATURE EXCEEDS 212°F (373 K). THE SUDDEN RELEASE OF PRESSURE MAY CAUSE THE COOLANT TO BOIL AND CAUSE HOT COOLANT OR STEAM TO SPEW FROM THE SYSTEM AND CAUSE INJURY.

#### C. HEAT EXCHANGER AND EXPANSION TANK TYPE COOLING SYSTEM

The heat exchanger and expansion tank perform the same functions that the radiator and fan do in the radiator and fan type cooling system. The expansion tank is the reservoir for the engine coolant. As the coolant is heated and expands, it enters the expansion tank and is retained there until it recirculates. The tank is always located above the highest point in the engine cooling system, thereby maintaining a head (solid fill) on the coolant in the engine and heat exchanger. The expansion tank filler cap is the vented type.

**CAUTION:** Never replace the vented type filler cap with a pressure type cap.

The customer-supplied raw water pump circulates

the raw water through the inside of the heat exchanger tubes. The engine coolant is circulated around the outside of the tubes by the engine coolant pump. Heat in the engine coolant is dissipated to the raw water.

The coolant is drawn, from the heat exchanger, to the inlet side of the water pump. The coolant is forced from the pump outlet into external piping, through the engine oil cooler and into the cylinder block through an elbow connected to the inlet manifold, which is cast into the side of the cylinder block. Piping connected to the elbow at the coolant inlet manifold routes part of the coolant to the rear end of the water cooled exhaust manifold. Piping at the front of the exhaust manifold is connected to the inlet of the water pump causing the coolant to flow through the exhaust manifold.

From the coolant inlet manifold, the coolant flows around the cylinder sleeves and into the cylinder head. After leaving the cylinder head, the coolant passes through the thermostat housing and piping to the engine coolant inlet side of the heat exchanger.

Vent lines are connected from the expansion tank to the water cooled exhaust manifold and coolant outlet piping at the thermostat housing. These lines vent the engine cooling system of all air and return coolant to the expansion tank. A pipe connected between the expansion tank and the inlet side of the water pump returns coolant to the engine cooling system.

#### D. GENERAL MAINTENANCE

A coolant filter is provided that extends engine life by establishing and maintaining a rust, scale, and corrosion free cooling system.

When operating the engine in areas where the ambient temperature is above freezing, keep the cooling system filled with clean water that is low in chemical impurities.

In winter use a permanent type antifreeze solution in the system to protect against damage from freezing. After any addition of water or antifreeze compound, test the solution after it has become thoroughly mixed to assure it will withstand prevailing or anticipated temperatures.

**CAUTION:** Do not use antifreeze solutions that are harmful to aluminum.

Refer to instructions on protection charts furnished by the antifreeze manufacturer for information on quantity required for lowest

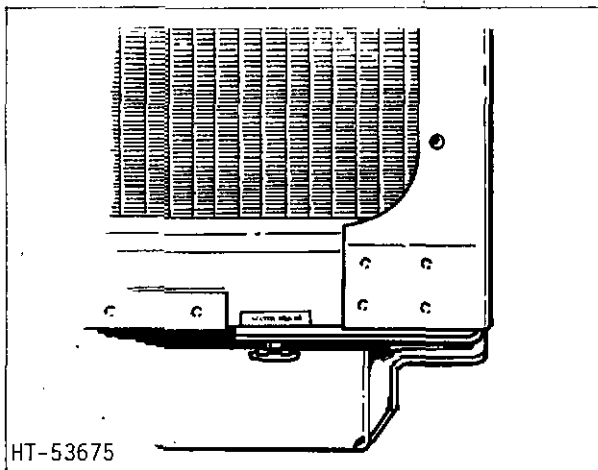


Figure 3. Radiator Drain Cock Location

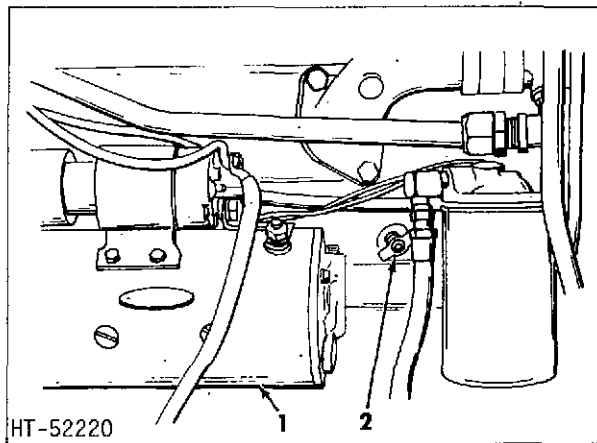
anticipated temperature. Keep radiator air passages free of leaves, trash, and other material that may restrict flow of air through the radiator.

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

The engine operates most efficiently when coolant temperature is 180°F (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.

#### E. DRAINING COOLING SYSTEM

1. If engine is installed in portable type equipment, make certain it is in a level position to assure complete draining.
2. Remove radiator filler cap and open radiator drain cock (Fig 3) or the expansion tank filler cap and the heat exchanger drain cocks (Fig 5).
3. Open drain cock located on right side of cylinder block (Fig 4).
4. Leave coolant filter shutoff valves open. For models 2800MKI or 2900MKI, remove coolant filter (Fig 9) and empty or replace with new filter. If engine is a Model 2800 or 2900, loosen coolant filter (Fig 10) clamp and remove hose from fitting in filter cover.



1. Starter
2. Block drain cock

Figure 4. Cylinder Block Drain Cock Location

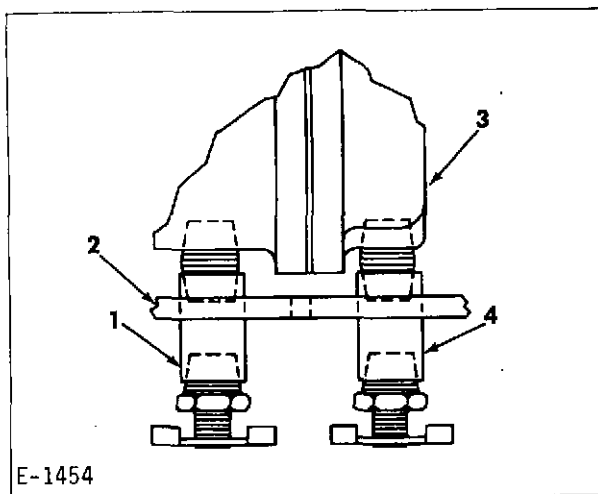
**CAUTION:** When draining cooling system in freezing weather, make certain coolant flows freely from drains and that the system drains completely.

#### F. FILLING COOLING SYSTEM

1. Close all drains that were opened to drain system. (Refer to Paragraph E above.)
2. Fill system with clean, soft water or antifreeze solution until level is approximately 1-1/2 (38.10 mm) below bottom of radiator filler neck. With heat exchanger and expansion tank type cooling, fill system until expansion tank is 2/3 full. Replace filler cap.
3. Operate engine for a period of time at normal operating temperature to vent all air from system.
4. Check level of coolant in radiator or expansion tank and, if necessary, add coolant to attain 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, if the cooling system does require cleaning, close the coolant filter inlet and outlet shutoff



E-1454

1. Engine coolant drain cock
2. Heat exchanger support plate
3. Heat exchanger
4. Raw water drain cock

Figure 5. Heat Exchanger Drain Cock Locations

valves. After the system has been cleaned, service the coolant filter and open the inlet and outlet shutoff valves.

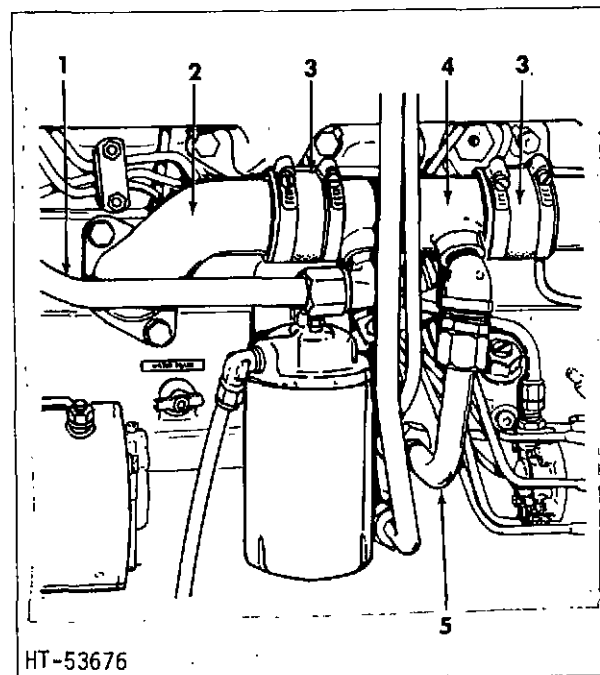
3. Many good solvents are on the market for cleaning of cooling systems; use according to instructions.

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

4. 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 connections 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 to 6 psi (35 or 41 kN/m<sup>2</sup>) pressure when flushing. Excessive pressure may rupture radiator.

5. 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



HT-53676

1. Oil cooler oil inlet tube
2. Coolant outlet elbow
3. Hose and hose heat shield
4. Oil cooler
5. Oil cooler oil outlet tube

Figure 6. Engine Oil Cooler

(fan side) of radiator. For engines having a blower type fan, direct spray at front of radiator.

**WARNING:** Keep engine covered during cleaning operation. Provide adequate ventilation to avoid toxic effects of the cleaning spray. Never clean with gasoline, fuel oil, or kerosene.

6. After the cooling system has been cleaned and flushed, open coolant filter shutoff valves, if applicable, and 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. ENGINE OIL COOLER

The engine oil cooler (Fig 6), located on the right side of the engine, consists of a bundle of corrosion resistant cooling tubes, a baffle, and a shell. The water pump circulates coolant through the tubes and the engine oil pressure pump circulates oil through the shell around the outside of the tubes, thereby controlling oil temperature.

The cooling tubes dissipate heat from the oil to the coolant. If proper lubricating oil

maintenance procedure is followed, the oil cooler will function efficiently. However, if the oil in the engine is not changed at recommended intervals, impurities will be deposited in the cooler that will eventually restrict the flow of oil around tubes of the cooling core. Restriction of oil flow through the cooler is usually indicated by a drop in oil pressure because of the oil overheating. If this occurs, the oil cooler must be cleaned or replaced with a new one.

**IMPORTANT:** It is absolutely necessary that the oil cooler be kept clean for proper oil cooling.

Whenever an engine is equipped with an oil cooler, a plug is installed in the oil passage across the rear of the block, causing the oil to flow through the cooler. Refer to Figures 2 and 3, lubrication oil flow schematic diagrams in Topic 13, LUBRICATION SYSTEM.

**CAUTION:** If an engine previously equipped with an oil cooler is to be run with the oil cooler removed, the internal plug must be removed from the cylinder block in order to maintain proper oil pressure and lubrication.

## 1. Engine Oil Cooler Removal and Installation

- a. Drain cooling system.
- b. Remove oil inlet tube (Fig 6 Item 1) from cylinder block and cooler.
- c. Remove oil outlet tube (5) from cooler (4) and cylinder block.
- d. Loosen hose clamp at front of cooler.
- e. Remove capscrews and lockwashers from coolant outlet elbow (2).
- f. With a twisting motion, force oil cooler outlet elbow and cooler to rear of engine freeing cooler from front hose connector.
- g. Loosen hose clamp at rear of cooler and remove from elbow.
- h. After inspecting and cleaning, install oil cooler in reverse order of removal. Use a new coolant outlet elbow-to-block gasket. Inspect hoses and hose heat shields and replace if necessary.

## 2. Engine 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.

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

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

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

We recommend 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.

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.

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

### 3. Engine Oil Cooler Testing

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

- a. Install a 3/4" pipe plug in the oil inlet opening of cooler shell. Reduce the outlet opening to accept an air hose fitting.
- b. Attach an air hose to the fitting and submerge the oil cooler in hot water until the cooler is approximately 150°F (339 K) temperature. Test for leaks with air pressure. Pressure should not exceed 200 psi (1379 kN/m<sup>2</sup>).
- c. Air bubbles observed at either open end of the oil cooler indicates that a cooling tube has a puncture or may be defective in another way. Replace cooler if any faulty tubes are found. If repair of the shell is necessary, it should be made by a reputable radiator repair shop.

#### I. HEAT EXCHANGER

The heat exchanger of the heat exchange type cooling system, located at the front of the engine, consists of a bundle of corrosion resistant tubes, a shell, and end bonnets. The raw water pump circulates raw water through the tubes. Engine coolant is circulated around the tubes and through the shell by the engine coolant pump. The tubes dissipate heat from the engine coolant to the raw water.

The amount of maintenance required to keep the heat exchanger operating efficiently depends upon the mineral content and amount of solid material (dirt) in the raw water. At periodic intervals, depending upon the contaminants in the water, remove, clean, and test the heat exchanger for leaks.

Clean and test the heat exchanger in the same manner as the engine oil cooler. Refer to paragraph H, ENGINE OIL COOLER.

#### J. THERMOSTAT

The thermostat is the bypass type and is located in the thermostat housing at the front of the engine (Fig 7). It is so positioned in the system that when closed, coolant flow from the engine to the radiator is 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 as well as through the engine circulating system.

### 1. Thermostat Removal

Replacement of the thermostat is necessary when the thermostat becomes corroded and sticks in the open or closed position. If the engine overheats or does not reach and maintain a minimum temperature of 180°F (355 K), the thermostat should be removed and tested as a possible cause of trouble.

- a. Drain the cooling system.
- b. Remove capscrews and lockwashers that secure water outlet flange (Fig 7, Item 1) to top of thermostat housing (4).
- c. Raise water outlet flange with hose intact and position it to one side.
- d. Remove outlet flange gasket (2) and thermostat (3).
- e. Clean and inspect thermostat housing (4).

### 2. Thermostat Testing

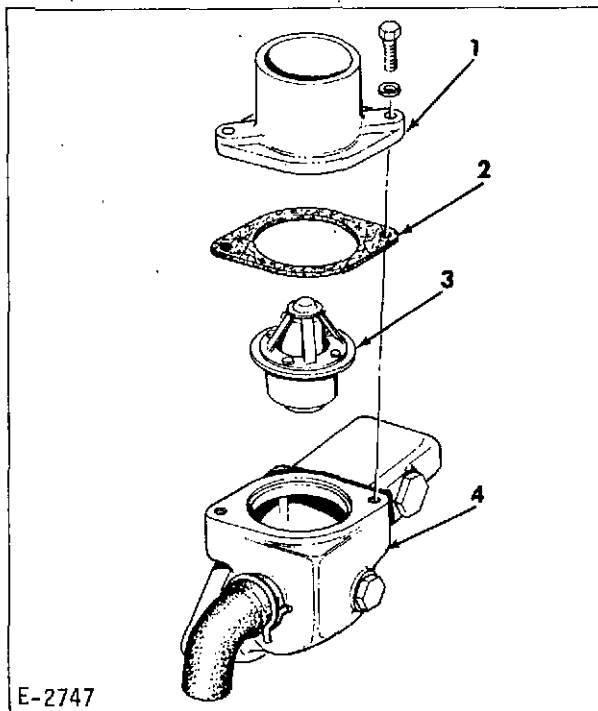
- a. Suspend thermostat in a container of clean water. Thermostat must be completely immersed but not touching bottom of container.
- b. Heat water gradually and stir so heat is evenly distributed.

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

- c. Observe thermostat as temperature of the water increases. If the thermostat is functioning properly, it should begin to open between 175° to 182°F (353 to 355 K) and be fully open at 202°F (368 K). The amount of travel between open and closed positions of the thermostat should be a minimum of 0.265 in (6.7 mm).
- d. The thermostat is not adjustable. If it does not operate within the above limits it must be replaced.

### 3. Thermostat Installation

- a. Install thermostat in thermostat housing with arrow stamped on thermostat pointing up.



1. Water outlet flange
2. Flange gasket
3. Thermostat
4. Thermostat housing

Figure 7. Thermostat and Housing

- b. Use a new outlet flange gasket and position it on top of the thermostat housing.
- c. Inspect water outlet flange and clean if necessary.
- d. Position water outlet flange on thermostat housing and secure with lockwashers and capscrews. Tighten capscrews to a torque of 44 to 49 lb-ft (60 to 66 Nm).
- e. Fill cooling system with coolant. Operate engine until operating temperature is reached and check for leaks.

#### K. BELTS AND ADJUSTMENT

The alternator and water pump, as well as the fan mounted on the water pump pulley, are driven simultaneously by the crankshaft pulley with an identical, matched pair of belts.

1. Inspect drive belts frequently.
2. 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. After replacement, approximately 24 hours operating time is required to properly seat a new pair of belts.

3. Check tension of each drive belt using a Burroughs Tension Gauge (BT-33-74) or equivalent. New drive belts are installed with a tension of 110 pounds (49.8 kg). Belts must be retightened whenever tension drops to 85 pounds (38.5 kg). Always retighten belts to 105 pounds (47.6 kg).
4. To obtain proper belt tension, loosen the alternator adjusting brace capscrew and mounting bolt and move alternator in or out as required.

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

5. Retighten the adjusting brace capscrew and mounting bolt.

**NOTE:** If a belt tension gauge is not available to check the belt tension, it may be done by hand. The alternator, fan and water pump drive belts are correctly adjusted when belts can be depressed (by hand) approximately .25 in. (6.4 mm) to .50 in. (12.7 mm) halfway between the alternator pulley and water pump pulley. Adjust belts when slippage is evident.

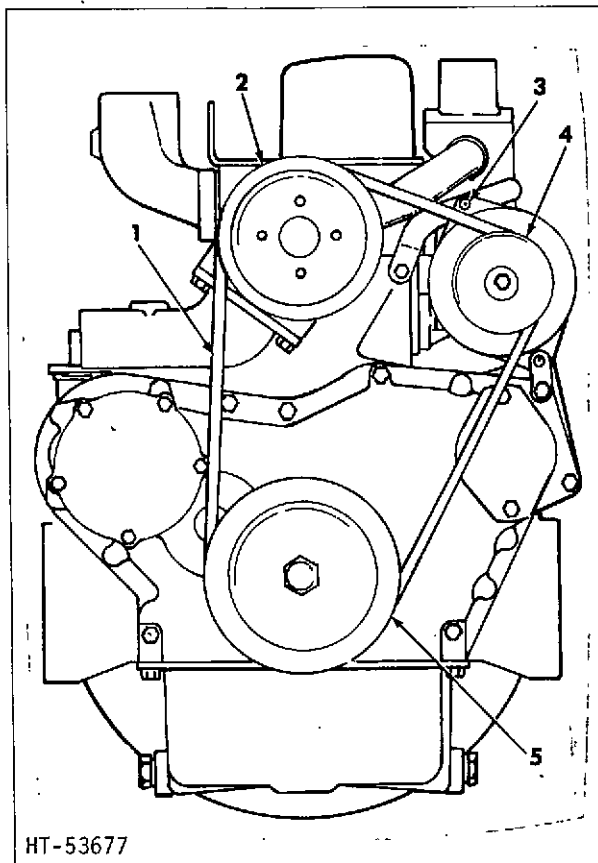
#### L. COOLING SYSTEM FILTER

##### 1. General

The cooling system conditioner filter is of two types, the current spin-on type (Fig 9) and the former replaceable element type (Fig 10). They can be either engine mounted or remote mounted off the engine depending upon the owners requirements.

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 conditioner to operate properly. If filter is remote mounted off the engine, a ground wire must be connected between it and the engine.

The piping connecting the filter into the engine cooling system is fitted with



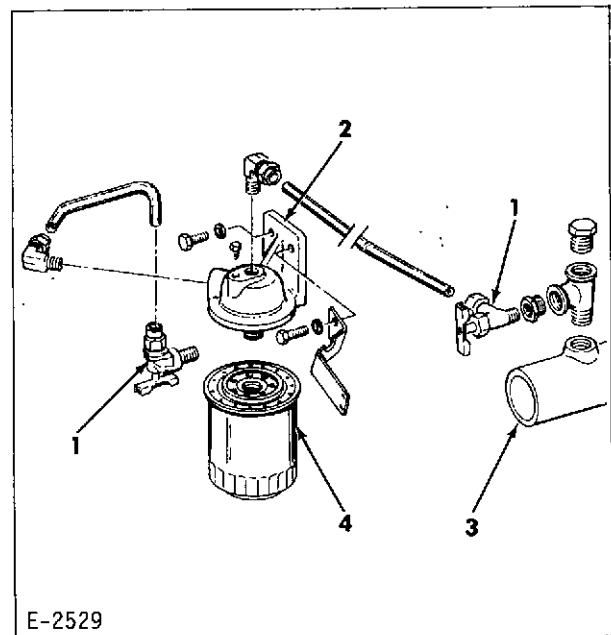
1. Drive belt
2. Water pump pulley
3. Adjusting brace cap screw
4. Alternator pulley
5. Crankshaft pulley

Figure 8. Belt Adjustment

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.

**NOTE:** The type of water conditioner filter or element in a new engine is the all purpose type and can be used with 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.

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



E-2529

1. Shutoff valves
2. Filter base
3. Water pump inlet pipe
4. Filter

Figure 9. Coolant Filter-Spin-on Type

The coolant conditioner performs the following functions:

- a. By mechanical filtration, it removes suspended foreign material which may be circulating through the cooling system.
- b. It prevents precipitation of water hardness scale on all cooling system surfaces by the ion exchange method of water softening.
- c. The chemicals present in the water conditioner element protect against corrosion activity in the engine.
- d. Electrolytic control is accomplished by the use of a sacrificial plate.
- e. 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 coolant, do not allow it to circulate through the water conditioner. Shut-off valves are provided in inlet and outlet lines for isolating the water conditioner 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 800 hours. Maintain the coolant conditioner as follows:

NOTE: Whenever the cooling system is filled with plain water, the first filter change should be made at 100 hours. This is not necessary when system is filled with antifreeze.

## 3. Spin-on Type Coolant Filter

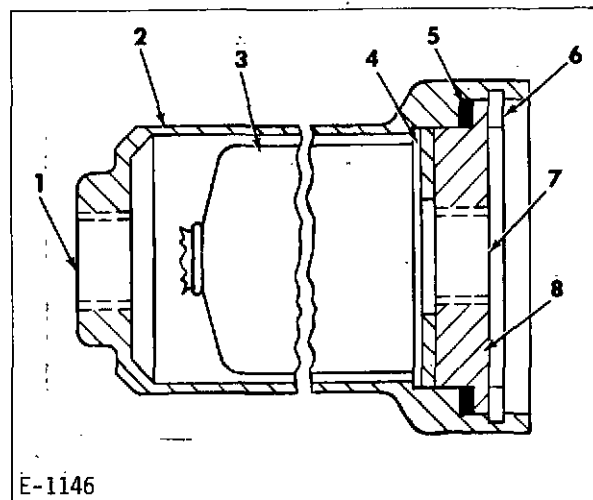
The removal and installation of the spin-on type coolant filter (Fig 9) is as follows:

- a. Thoroughly clean base and surrounding area.
- b. Close coolant inlet and outlet shut-off valves.
- c. Remove exhausted spin-on filter and discard.
- d. Lubricate gasket with a thin film of oil.
- e. Install filter until gasket contacts base of mounting housing.
- f. Hand tighten 1/2 turn more.
- g. Open inlet and outlet shutoff valves.
- h. Operate engine and check for leaks.

## 4. Replaceable Element Type Coolant Filter

The removal and installation of the replaceable element (Fig 10) is as follows:

- a. Thoroughly clean filter body housing and surrounding area.
- b. Close coolant inlet and outlet shut off valves.
- c. Loosen clamp and remove hose from the



- |                      |                   |
|----------------------|-------------------|
| 1. Coolant inlet     | 5. Gasket         |
| 2. Body housing      | 6. Retaining ring |
| 3. Element           | 7. Coolant outlet |
| 4. Sacrificial plate | 8. Cover          |

Figure 10. Coolant Filter-Replaceable Element Type

fitting in filter cover.

- d. Remove cover retaining ring.
- e. Remove cover with fitting, gasket, sacrificial plate, and filter element. Discard gasket and element.
- f. Clean sump area in filter body housing.
- g. Inspect sacrificial plate. Replace it if it is thin and pliable or if it has developed large pit marks or holes. If sacrificial plate is satisfactory for further use, buff it to a bright finish.
- h. Install new filter element.
- i. Install sacrificial plate, new gasket, cover, and cover retaining ring.
- j. Install hose on fitting in cover and tighten clamp.
- k. Open coolant inlet and outlet shutoff valves.
- l. Operate engine and check for leaks.

## TOPIC 12. FUEL SYSTEM

### A. GENERAL

The standard fuel system consists of a fuel tank, single throw-away type fuel filter, hand primer pump, fuel transfer pump, fuel injection pump, fuel injection nozzle-holder assemblies and low and high pressure systems. A fuel and water separator assembly is included with engine models 2800MKI and 2900MKI where as it is optional with engines 2800 and 2900. The fuel and water separator eliminates the need for the fuel sediment bowl.

In areas where fuel contaminated with water is a problem or improper storage and handling of fuel on the job site results in the fuel being contaminated with water and foreign matter, additional fuel filtering components are available as optional equipment to supplement the standard fuel filtering system or replace the standard fuel filtering components with a heavy duty filtering system.

The low pressure system is comprised of the fuel tank, water separator, filter, hand primer pump, transfer pump, fuel lines between the fuel tank and the fuel pump and fuel return lines.

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

The fuel is drawn from the fuel tank through the water separator, filter, and primer pump 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 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 (Type I) and in the spring compartment (Type II) 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 pump end plate allows a large percentage of the fuel to be

bypassed back to the inlet side. The fuel bypassed increases in proportion to speed, and the regulating valve is designed so the transfer pump pressure also increases with speed.

If necessary precautions are not taken in the storage of fuel, in the transfer of fuel to the fuel tank, and in 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 filter is 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:

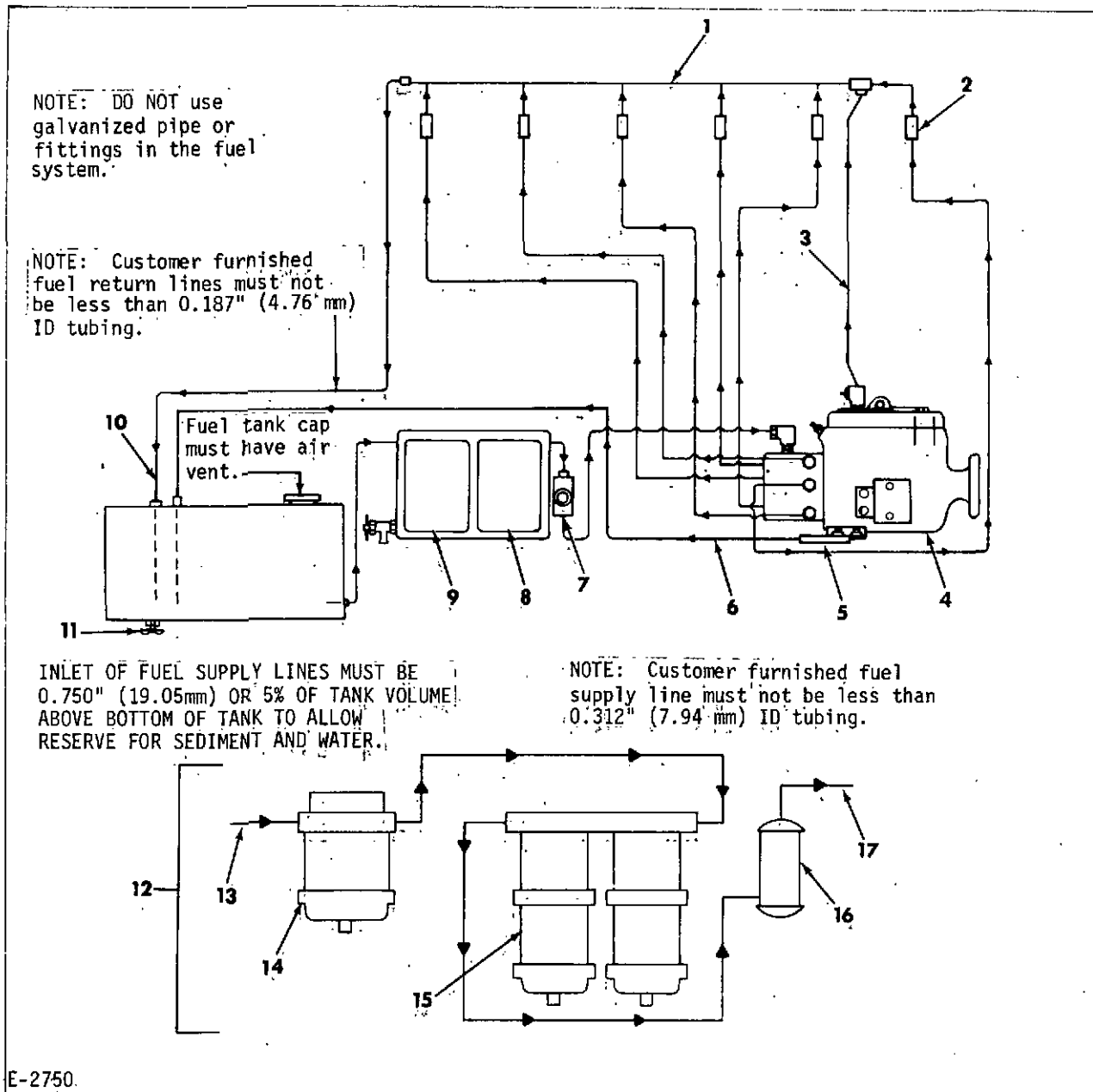
1. Use only fuel meeting the specifications as outlined in Topic 7.
2. Store and handle fuel with utmost care to prevent water and foreign matter from entering the fuel system.
3. Properly maintain fuel oil filter.
4. Remove injection nozzle holder assemblies at the prescribed intervals; adjust the opening pressure and check the spray pattern.
5. Daily drain the water from the sediment bowl and from the fuel tank. Check the 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 FILTER-STANDARD

The standard fuel filters (Figs 3 and 4) are the disposable, throw-away type. The filtering media within the filter prevents dirt and sediment from entering the fuel injection pump.

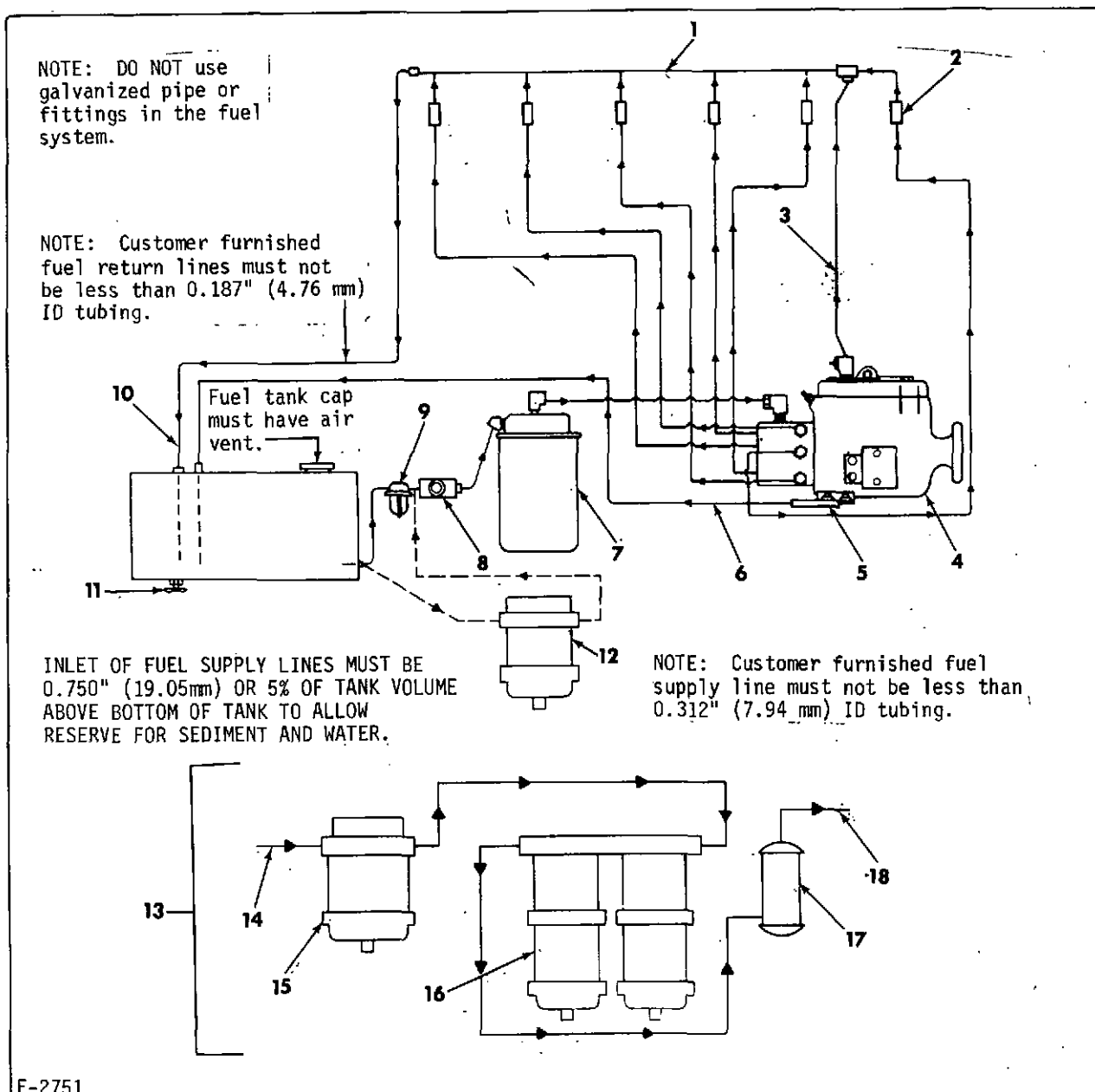
#### 1. Filter Maintenance

Inspect components of the filtering system for leaks and make the necessary repairs to eliminate them.



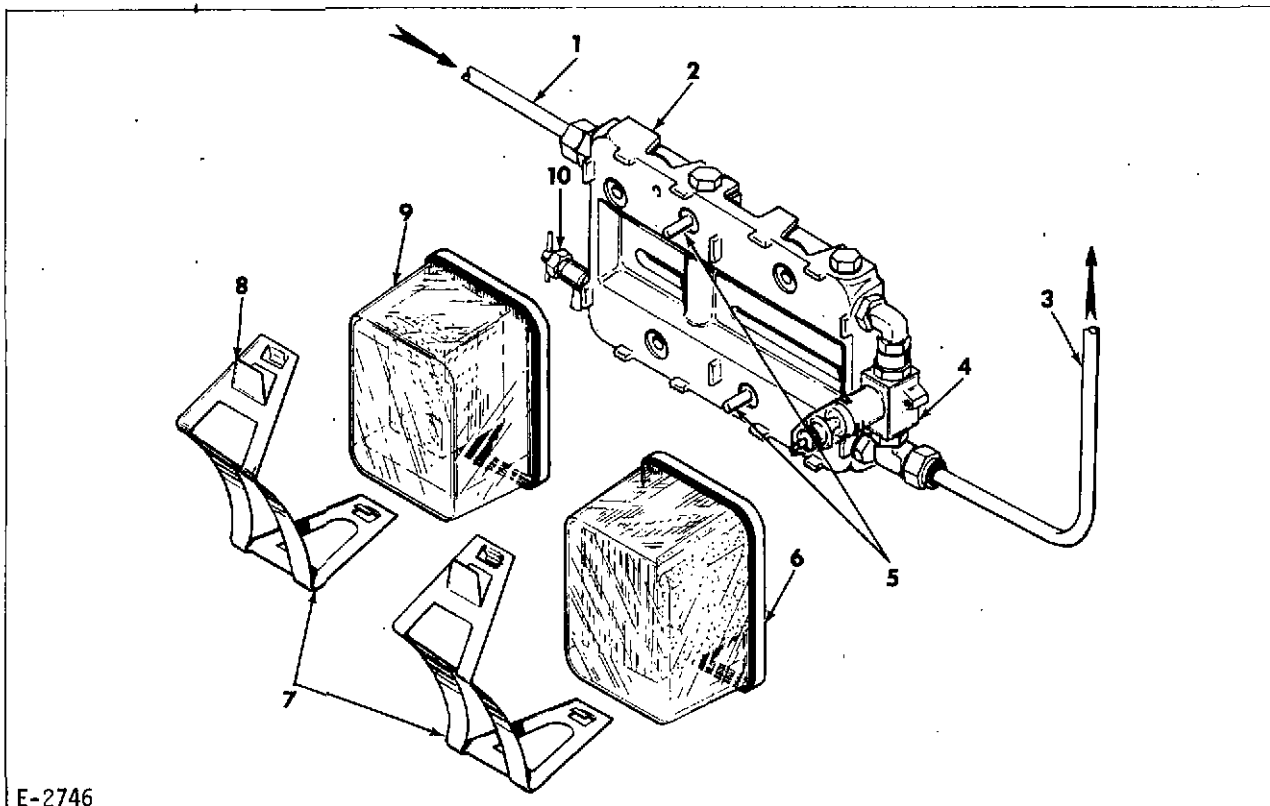
- |  |   |
|--|---|
| 1. Drip manifold                             | 10. Fuel return line  |
| 2. Nozzle holder assembly                    | 11. Drain cock  |
| 3. Manifold to injection pump line           | 12. Items 13 thru 17 - option water separator and heavy duty fuel filters |
| 4. Fuel injection pump                       | 13. From fuel tank  |
| 5. Accumulator (optional hydraulic governor) | 14. Water separator (use with heavy duty filters)                         |
| 6. Return line from accumulator              | 15. Fuel filters (heavy duty)   |
| 7. Hand primer pump                          | 16. Electric fuel pump  |
| 8. Fuel filter (standard)                    | 17. To fuel injection pump  |
| 9. Water separator (standard)                |   |

Figure 1. Fuel System Schematic Diagram - Models 2800MKI 2900MKI



- |  |   |
|--|---|
| 1. Drip manifold                             | 10. Fuel return line  |
| 2. Nozzle holder assembly                    | 11. Drain cock  |
| 3. Manifold to injection pump line           | 12. Water separator (light duty) (optional)                               |
| 4. Fuel injection pump                       | 13. Items 13 thru 17 - option water separator and heavy duty fuel filters |
| 5. Accumulator (optional hydraulic governor) | 14. From fuel tank  |
| 6. Return line from accumulator              | 15. Water separator (heavy duty)  |
| 7. Fuel filter (standard)                    | 16. Fuel filters (heavy duty)   |
| 8. Hand primer pump                          | 17. Electric fuel pump  |
| 9. Fuel sediment bowl (early engines only)   | 18. To fuel injection pump  |

Figure 2. Fuel System Schematic Diagram - Models 2800 2900



E-2746

- |                      |                  |                    |
|----------------------|------------------|--------------------|
| 1. From fuel tank    | 4. Primer pump   | 8. Clamp top       |
| 2. Filter base       | 5. Locating pins | 9. Water separator |
| 3. To injection pump | 6. Fuel filter   | 10. Drain cock     |
|                      | 7. Clamps        |                    |

Figure 3. Standard Fuel Filter and Water Separator - 2800MKI 2900MKI

Renew the filter each 600 hour interval of operation, or more often when operating conditions warrant, or when filter becomes clogged. A clogged filter is usually indicated by irregular engine performance.

The design of the water separator is such that it does not need replacement unless it is accidentally damaged. Drain water daily from separator or when it reaches a maximum depth of 0.750" (19.05 mm).

**NOTE:** If engine is early type, close the sediment bowl shutoff valve and remove bowl daily before start of operation during warm weather, and shortly after end of days operation during freezing weather. Dump out water and sediment, clean bowl and screen, and replace bowl securely.

## 2. Standard Filters - 2800MKI 2900MKI

The filtering system (Fig 3) consists of a water separator assembly mounted on a

common base with a throw-away type filter assembly. The filter consists of two sections of pleated paper filtering media in series and packaged in a heat resistant glass case.

The water separator consists of a nylon stretch sock with one end closed and the other end enclosing the fuel inlet opening. A perforated aluminum baffle encloses the sock to prevent it from covering the fuel outlet opening. All fuel passes through the porous surface of the sock which diffuses the fuel flow, reducing its rate of flow. Water droplets are repelled by the nonwetting surface of the nylon sock and tend to collect into large drops which are eventually forced through weave of the sock. These larger drops due to the reduced rate of fuel flow settle to the bottom of the separator. The water level in the separator must not exceed 3/4 full.

All openings in the filter and separator are fitted with grommets to seal them to the base. A hollow locating pin is positioned in the base for the filter and

separator so that they cannot be installed incorrectly. A spring type clamp retains each unit in position on the base.

A hand primer pump is connected to the outlet of the filter and is used to purge air from the system after a new filter is installed or after performing other service repairs.

Remove and install the filter or water separator as follows:

- a. Remove dirt from around filter, and water separator base and surrounding area.

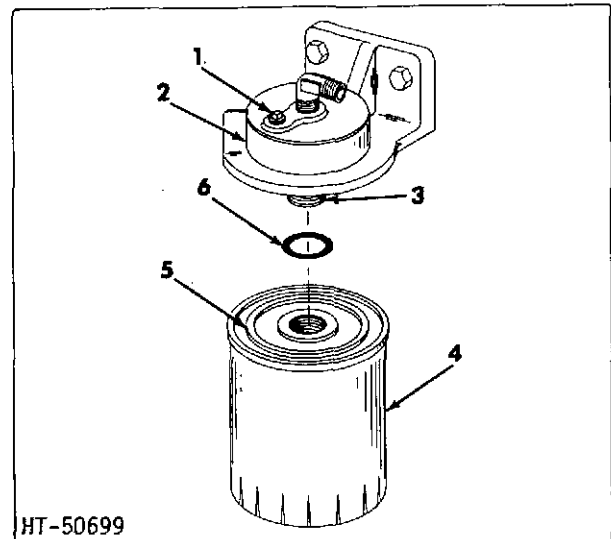
NOTE: Close fuel tank shutoff valve if fuel level in tank is above level of fuel filter.

- b. With thumb and forefinger squeeze the protrusions at the top of the clamp, lifting up and moving the clamp away from the filter or water separator.
  - c. Remove the filter or water from the base.
  - d. Inspect and clean base.
  - e. Position filter or water separator on its locating pin.
  - f. Hook lower end of clamp on base and force top into position.
  - g. Refer to Paragraph D and prime the fuel system.
3. Standard Filter and Optional Water Separator - 2800 2900

The standard fuel filter (Fig 4) is the disposable, throw-away type. The filtering media within the filter is the pleated paper type and prevents dirt and sediment from entering the fuel injection pump.

In areas where the fuel is contaminated with excessive water, an optional equipment water separator should be added to the standard fuel system (Fig 5).

The water separator removes water from the fuel by the design of the cone within the body of the water separator assembly (Fig 6). The large area of the cone reduces the unit flow rate at the base of the cone so that gravity separates the water globules from the fuel.



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

Figure 4. Standard Fuel Filter - 2800 2900

(a) Fuel Filter Replacement

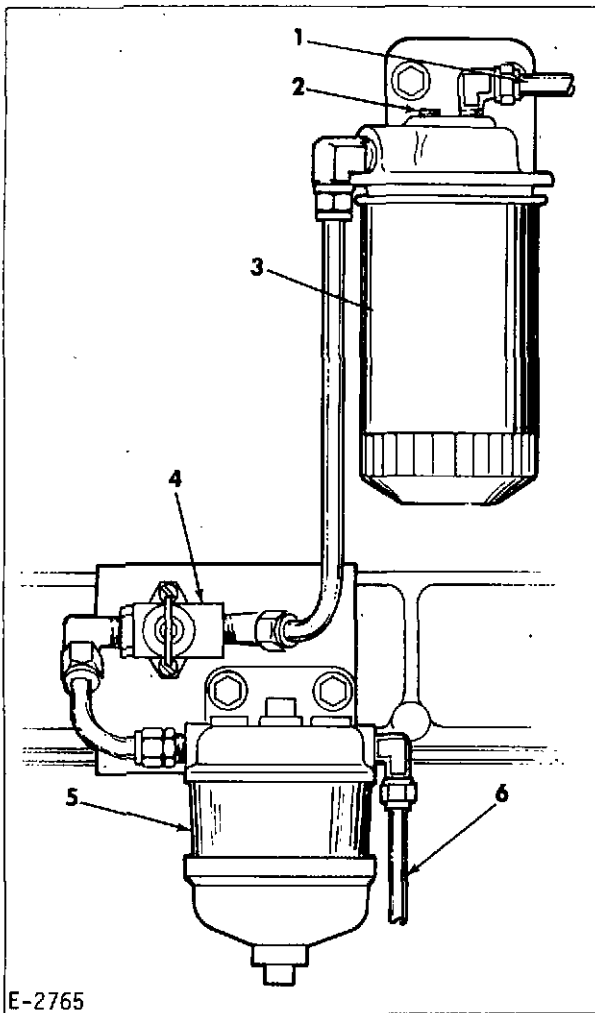
- (1) Remove dirt from around filter (Fig 4), and clean filter head and surrounding area.

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

- (2) Unscrew and remove filter and O-ring from filter head. Discard filter and O-ring.
- (3) Remove dirt and sediment from inside of filter head.
- (4) Position new O-ring from filter replacement kit on threaded insert in filter head. Screw new filter by hand into position until gasket contacts base of filter head. Using hand pressure, tighten filter 1/2 to 3/4 of a turn more.

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

- (5) If applicable, open fuel tank or sediment bowl shutoff valve and prime the low pressure system. Refer to following Paragraph D.



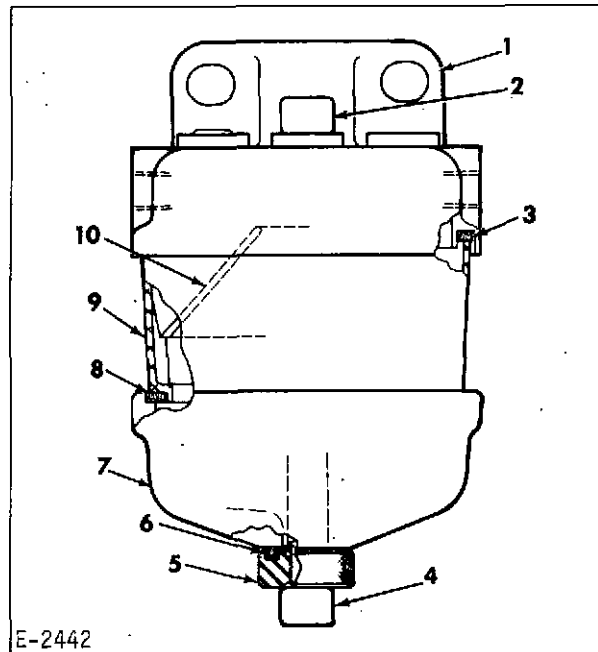
1. Fuel outlet
2. Vent plug
3. Filter
4. Hand primer pump
5. Water separator - optional
6. Fuel inlet

Figure 5. Fuel Filter and Optional Water Separator - 2800 2900

**CAUTION:** Keep parts clean when changing the fuel filter.

- (b) Water Separator - Optional for 2800 2900 Engines
- (1) Daily or more often inspect the glass sediment bowl (Fig 6 Item 7).
- (2) To drain water, loosen drain plug (4) several turns. Tighten plug securely after draining.

**NOTE:** The water separator is on the suction side of the hand primer pump and the injection pump. It is important



1. Header
2. Vent plug
3. Upper body gasket
4. Drain plug
5. Center screw
6. Center screw seal
7. Glass sediment bowl
8. Lower body gasket
9. Body
10. Cone

Figure 6. Water Separator Details

ant to keep all line fittings, the center screw (5), vent plug (2), and drain plug (4) tight to prevent air from being drawn into the fuel system.

- (3) Annually disassemble and inspect the parts of the water separator. Renew gaskets, seals and cone, if damaged.

#### C. OPTIONAL HEAVY DUTY FUEL FILTERS WITH WATER SEPARATOR - 2800 2900 2800MKI 2900MKI

##### 1. General

In areas where the fuel is contaminated with water, an optional equipment water separator should be added to the standard fuel system. If the fuel is contaminated with water and foreign matter due to poor fuel storage and handling, the standard fuel filter system should be replaced with an optional equipment heavy duty filter system (Fig 7) which consists of larger than standard fuel filter and a water separator assembly.

The water separator removes water from the fuel by the design of the cone within the body of the water separator assembly (Fig 8 Item 7). The larger area of the cone reduces the unit flow rate at

the base of the cone so that gravity separates the water globules from the fuel.

The combination water separator and heavy duty fuel filters consists of the water separator, filters with large filtering capacity, and electric fuel pump with push button switch.

The electric fuel transfer pump (Fig 7 Item 12) and push button switch (4) are located adjacent to the filter assembly (7). They are wired to the starter solenoid (13) in such a manner that the electric transfer pump is energized only when the starter is activated. Once the engine is running, the initial assist from the electric fuel transfer pump is no longer required, and the fuel is drawn through the water separator, fuel filter assembly, and the electric fuel transfer pump by the fuel transfer pump which is integral with the fuel injection pump. The push button switch is provided to energize the electric fuel transfer pump to purge air from the filtering system, if the engine runs out of fuel or after servicing any component of the filtering system.

The fuel filter assembly consists of a header (Fig 9 Item 3) 4 identical pleated paper filter elements (5), 2 spacer assemblies (7), and sediment bowls (8). The filter elements are mounted on the header in pairs. Each filter element is sealed at the top and bottom with gaskets (6) and the top center with an O-ring type seal (4). All vent plugs (1) and drain plugs (12) and the knurled flange of the lower filter screws (10) have seals (9). It is important that all seals and gaskets are maintained in good condition and leak proof to prevent air from entering the system because the filters are on the suction side of the fuel injection pump transfer pump. The upper filter elements are secured to the header by the filter spacer assemblies. The lower elements and sediment bowls (8) are secured to the spacer assemblies by the filter screws. To drain sediment, a drain plug is located in the bottom of each filter screw.

The pairs of filter elements are connected in parallel and the 2 elements in each pair are connected in series. Fuel is drawn into the header assembly and flows down the passage in each center screw of the spacer assemblies. These passages connect with passages in the lower filter element retaining screws. Fuel enters the bottom of the lower filters and is filtered as it passes through the elements. From the top of the lower filters, it

passes through the spacer elements into the bottom of the upper filters. The fuel is filtered a second time as it passes through the upper elements. From the filter header, the fuel flows through the electric fuel transfer pump to the fuel injection pump.

## 2. Maintenance

### a. Water Separator

- (1) Daily or more often inspect the glass sediment bowl (Fig 8 Item 10).
- (2) To drain water, loosen drain plug (14) several turns. Tighten plug securely after draining.

NOTE: The water separator is on the suction side of the electric fuel transfer pump and the injection pump. It is important to keep all line fittings, the center screw (12), vent plug (1), and drain plug (14) tight to prevent air from being drawn into the fuel system.

- (3) Annually disassemble and inspect the parts of the water separator. Renew gaskets, seals and cone, if damaged.

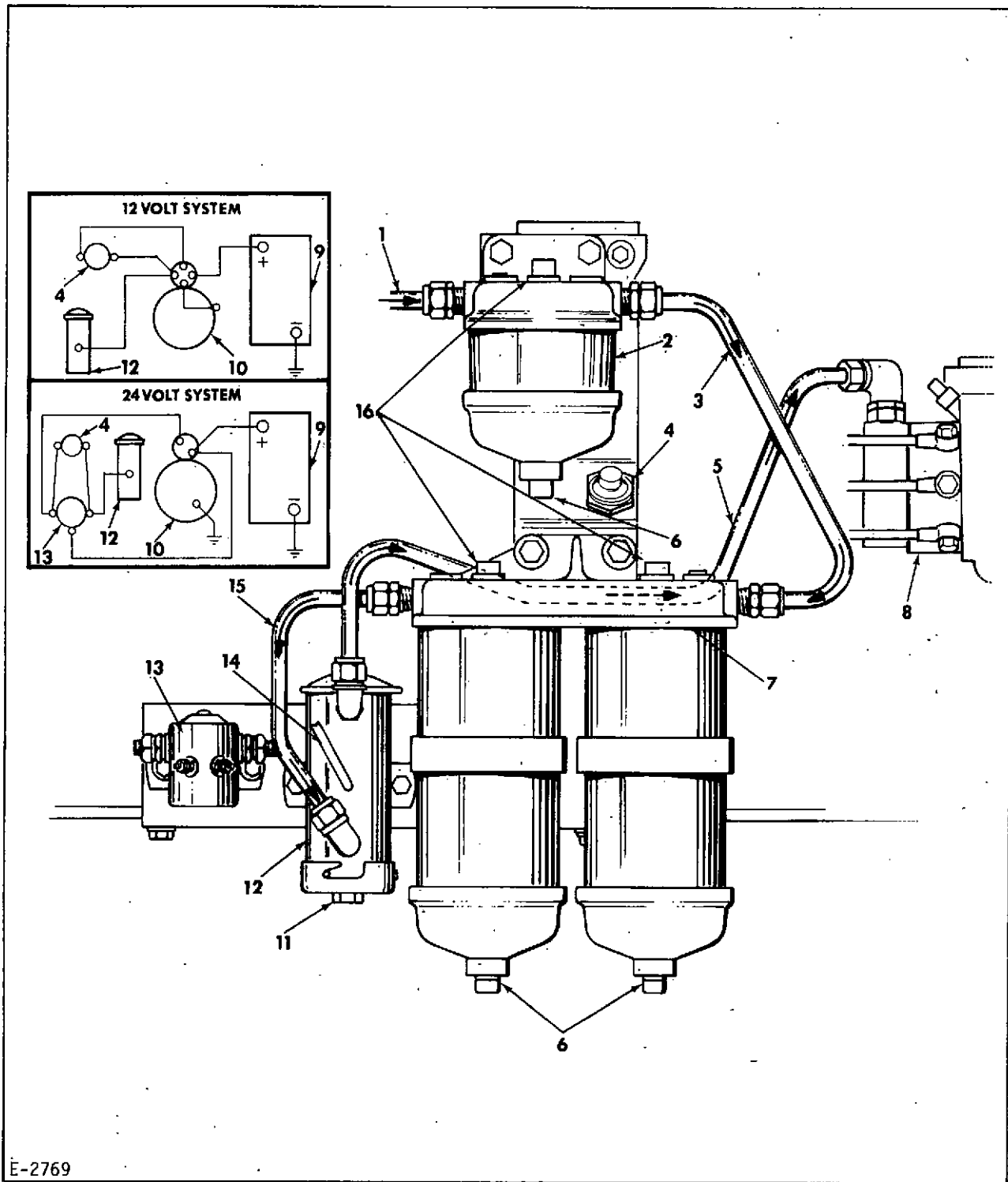
### b. Filters - Heavy Duty

#### (1) General

Because the fuel passes through the lower filter elements first and then through the upper elements, the lower elements will load with foreign matter in a shorter length of time than the upper elements. For this reason, the suggested element renewal interval is 250 to 300 hours for the lower elements, with the upper elements being renewed every second renewal of the lower elements or 500 to 600 hours. Actual operation of the engine and the degree of contamination in the fuel will dictate the hours of operation between element renewal intervals. Loss of engine power is an indication of clogged filter elements.

#### (2) Filter Element Removal and Installation

- (a) Close fuel tank shutoff valve, if tank or fuel level in tank is above fuel filter assembly. Clean filter assembly and surrounding area before removing filter elements.
- (b) Remove drain plugs (Fig 9 Item 12)



E-2769

- |   |   |
|---|---|
| 1. Fuel inlet                             | 9. Battery                                |
| 2. Water separator                        | 10. Starter                               |
| 3. Tube-water separator to filter         | 11. Cover                                 |
| 4. Push button switch                     | 12. Electric fuel transfer pump           |
| 5. Tube - transfer pump to injection pump | 13. Solenoid switch - 24 volt system only |
| 6. Drain plugs                            | 14. Lead - fuel transfer pump             |
| 7. Heavy duty filter assembly             | 15. Tube - transfer pump to filter        |
| 8. Injection pump                         | 16. Vent plugs                            |

Figure 7. Optional Heavy Duty Fuel Filters with Water Separator - 2800 2900 2800MKI 2900MKI

and drain fuel from filter assembly.

(c) To remove lower filter elements, unscrew the knurled filter screws (10) that secure the sediment bowls (8) and filter element (5) to the spacer assemblies (7). Remove filter screw, sediment bowl, and element.

(d) Make certain the filter element gaskets (6) are in good condition and properly seated in the grooves of the spacer assemblies and the sediment of bowls (8), also the seals (4) in the groove of center posts of the spacer assemblies which seals the upper internal portion of the filter elements. Inspect the drain plug seals (11) and the seals in the knurled knob of the filter screws. Replace all gaskets or seals which appear damaged or show evidence of deterioration. Lubricate all gaskets and seals with fuel oil before installing filter elements.

(f) To install the lower filter elements, place the sediment bowl on the filter screw. Position the filter element on the center post of the spacer assembly, making certain the crimped edge of the filter is properly seated on the gasket in the spacer assembly. Secure the filter element with the sediment bowl and filter screw. Tighten the filter screws securely.

(g) Install drain plugs in filter screws and tighten securely.

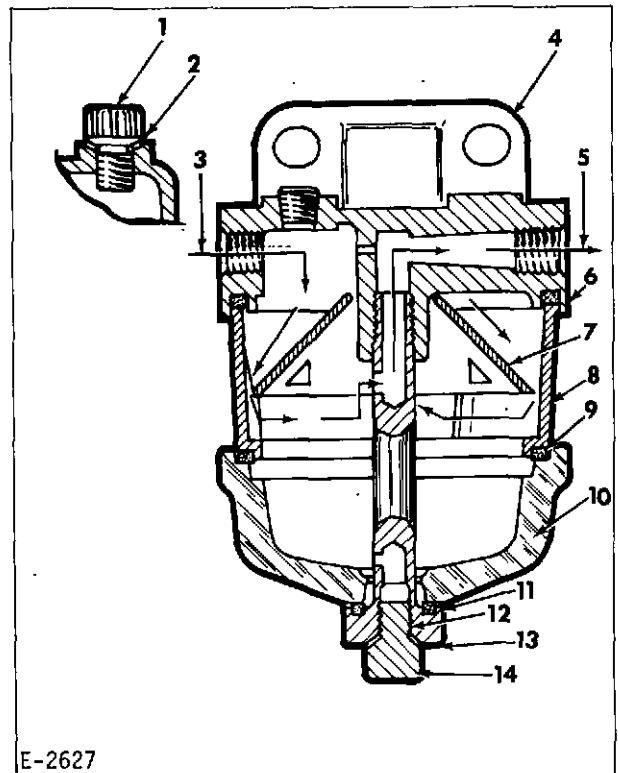
(h) Vent air from filters following procedure in following step (n).

(i) To remove the upper filter elements, first remove the lower filter elements following steps (a) thru (d).

(j) Using a filter strap wrench, remove the spacer assemblies and remove the filter elements from the center posts of the filter header.

(k) Inspect the seal in the groove of the center posts of the header which seals the upper internal portion of the upper filter elements. Inspect all other gaskets and seals according to instructions in Step (d) above.

(l) To install the upper filter elements, position them on the center posts of the header with the crimped edge of the element properly seated on the gasket in the header. Secure the filter elements finger tight with



1. Vent plug	8. Body
2. Seal	9. Gasket
3. Fuel inlet	10. Glass bowl
4. Header	11. Seal
5. Fuel outlet	12. Center screw
6. Gasket	13. Seal
7. Cone	14. Drain plug

Figure 8. Water Separator Details

the spacer assembly. Use a strap wrench to snug-up the spacer assemblies.

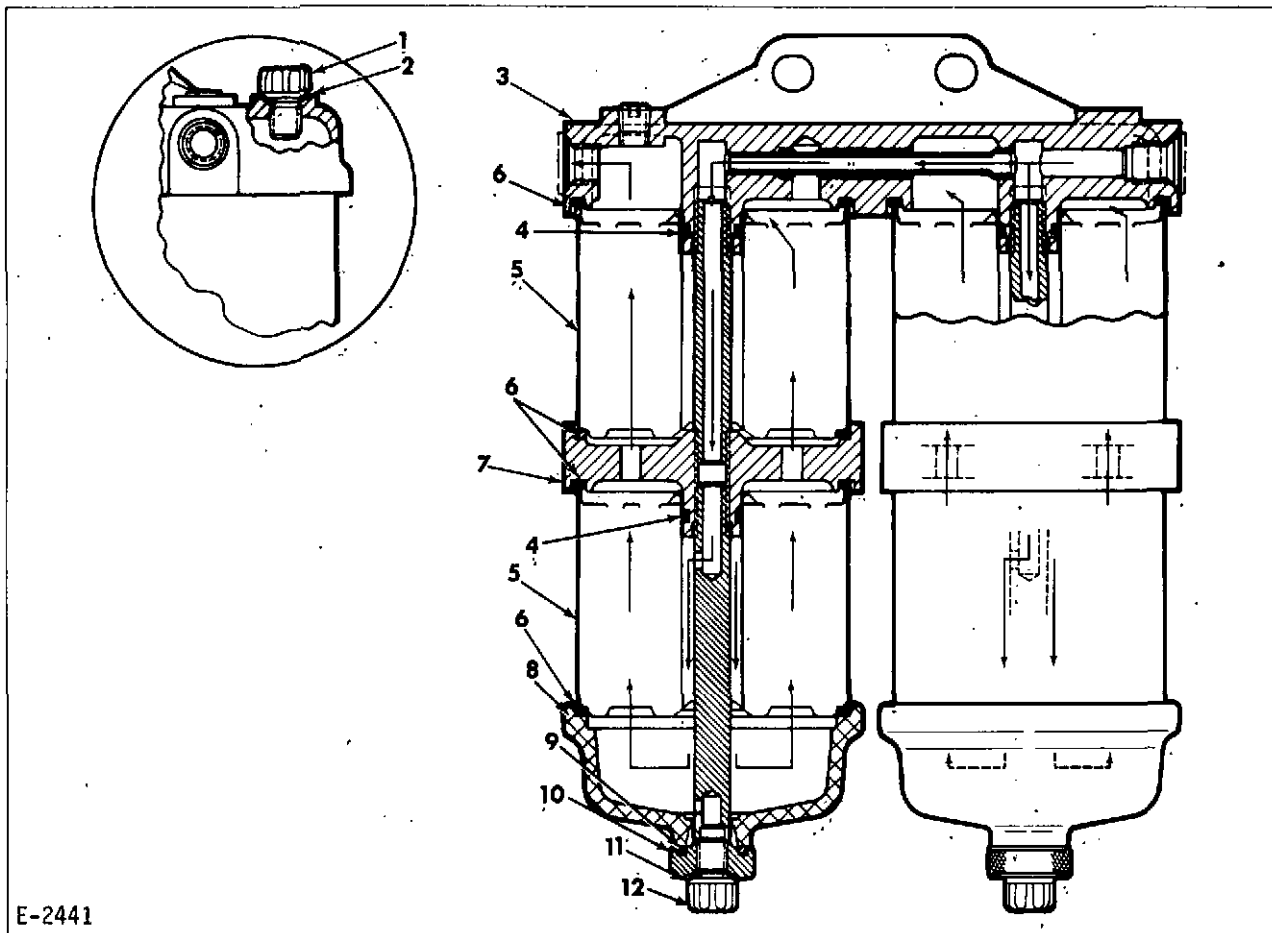
(m) Install lower filter elements following instructions in steps (d) thru (g) above.

(n) Vent the air from the filtering system. Refer to Paragraph D, titled Priming Fuel System.

### c. Electric Fuel Transfer Pump

#### (1) General

A filter (Fig 10 Item 4) is located in the bottom of the transfer pump body (12). Because the pump is located on the cleaned fuel outlet side of the fuel filter assembly (Fig 7), the filter in the pump should require little attention, provided the fuel filter assembly elements have been changed at the prescribed change intervals. However, it is recommended that once a year the cover (Fig 10



E-2441

- |                          |                          |                      |
|--------------------------|--------------------------|----------------------|
| 1. Vent plug             | 5. Filter elements       | 9. Filter screw seal |
| 2. Vent plug seal        | 6. Filter element gasket | 10. Filter screw     |
| 3. Header                | 7. Spacer assembly       | 11. Drain plug seal  |
| 4. Internal filter seals | 8. Sediment bowl         | 12. Drain plug       |

Figure 9. Heavy Duty Fuel Filter Assembly Details

Item 1) be removed from the bottom of the pump and the filter be cleaned or if necessary replaced.

(2) Wiring

The pump is internally grounded, therefore, the mounting surfaces must be free of paint, rust, or oil to obtain a good ground. The solenoid switch (Fig 7 Item 13) is also internally grounded, so its mounting surfaces must also be clean.

All wire from the starter solenoid (10), to the switches (4 and 13) and pump should be 12 gauge wire (2.06 mm).

(3) Maintenance

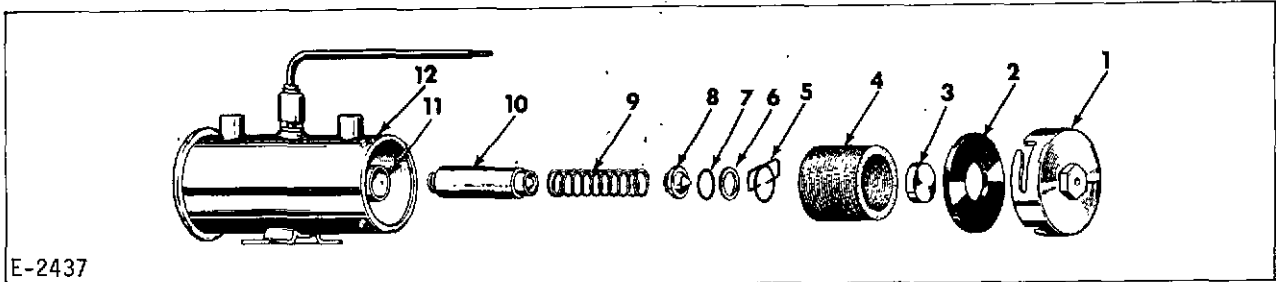
Pumps containing a brown, laminated filter element are serviced as follows:

(4) Disassembly

- (a) With a wrench release bottom cover (Fig 10 Item 1) from body (12).
- (b) Remove filter (4) magnet (3) and cover gasket (2). Wash filter in cleaning solvent and blow out dirt and cleaning solvent with air pressure. Check cover gasket and replace if deteriorated. Clean cover.
- (c) Remove retainer spring (5) from plunger tube (11) using thin nose pliers to spread and remove ends of retainer from tube. Then remove washer (6), O-ring seal (7), cup valve (8), plunger spring (9) and plunger (10) from tube (11).

(5) Assembly

- (a) Prior to assembly, wash parts in cleaning solvent and blow out with



- |                    |                   |
|--------------------|-------------------|
| 1. Cover           | 7. O-ring         |
| 2. Cover gasket    | 8. Cup valve      |
| 3. Magnet          | 9. Plunger spring |
| 4. Filter          | 10. Plunger       |
| 5. Retainer spring | 11. Plunger tube  |
| 6. Washer          | 12. Pump body     |

Figure 10. Electric Fuel Transfer Pump

air pressure. If plunger does not wash clean or if there are any rough spots, gently clean surface with crocus cloth. Sloss the pump assembly in cleaning solvent. Blow out the tube with air pressure. To do a complete job, swab the inside of the tube with a cloth wrapped around a stick.

- (b) Insert the plunger assembly (10) in the tube with the buffer end first. Check fit by slowly raising and lowering the plunger in the tube. It should move fully without any tendency to stick. If a click cannot be heard, the interrupter assembly is not functioning properly in which case the pump should be replaced.
- (c) To complete the assembly, install the plunger spring (9), cup valve (8), O-ring seal (7) and washer (6) as shown, see Figure 10. Compress spring (9) and assemble retainer (5) with ends of retainer in side holes of tube (11).
- (d) Place cover gasket (2) and magnet (3) in bottom cover (1) and assemble filter (4) and cover assembly. Twist cover by hand to hold in position on pump housing. With wrench, securely tighten bottom cover.

**CAUTION: DO NOT TAMPER WITH SEAL** at center of mounting bracket at side of pump as it retains the dry gas, which surrounds the Electrical System, in the upper portion of the pump

#### D. PRIMING FUEL SYSTEM

The procedure for priming the low pressure fuel system depends upon whether the fuel

system has the standard filter or the optional heavy duty filters.

#### 1. Priming Low Pressure Fuel System - Standard Filters

##### a. Models 2800MKI and 2900MKI

- (1) Due to the water separator (Fig 3 Item 9) and the filter (6) being on the suction side of the hand primer pump (4) and the transfer pump at the rear of the injection pump, make certain all plugs and line fittings are tight otherwise air will be drawn into the system when the pumps are activated.
- (2) Loosen the injection pump end of the fuel supply tube between the hand primer pump and the injection pump.
- (3) Make certain there is fuel in the tank and the tank shutoff valve is open.
- (4) Loosen locking screw on top of hand primer (4) pump plunger and move clamp to one side.
- (5) Move primer plunger back and forth in a pumping motion to fill the filter with fuel and expel the air.
- (6) When flow of fuel around line nut is free of air bubbles, tighten nut securely.
- (7) Position primer pump plunger clamp and retighten locking screw.

##### b. Models 2800 and 2900

- (1) Loosen filter vent plug (Fig 4 Item 1) or (Fig 5 Item 2) on top of filter head.

- (2) Make certain the fuel tank or sediment bowl (early engines) shutoff valve is open.
- (3) Loosen locking screw on top of hand primer (4) pump plunger and move clamp to one side.
- (4) Move primer plunger back and forth in a pumping motion to fill the filter with fuel and expel the air.
- (5) When flow of fuel around vent plug is free of air bubbles, tighten vent plug securely.
- (6) Position primer pump plunger clamp and retighten locking screw.

## 2. Priming Low Pressure Fuel System - Optional Heavy Duty Filters

- a. Because the water separator (Fig 7 Item 2) and the filter assembly (7) are on the suction side of the electric fuel transfer pump (12), make certain all vent plugs (16), drain plugs (6), are tight and all filter elements and body gaskets are air tight, otherwise, air will be drawn into the system when the fuel transfer pump is activated.
- b. Expel air from the system by loosening the injection pump end of the fuel supply line (5) at the injection pump. Press electric fuel transfer pump push button switch (4) until fuel free of air bubbles appears at the line fitting, then tighten line fitting.

## 3. Priming High Pressure Fuel System

The high pressure fuel system is usually selfpriming 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.
- b. Place speed control in high speed position and place stop control in the RUN position.
- c. Press starter switch and crank engine with starting motor until fuel flows from ends of all high pressure fuel

lines. Connect fuel lines to nozzle holders and tighten connection nuts.

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

## E. FUEL INJECTION PUMP

The 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. Depending upon the engine model and its application, the injection pump, will or will not have the automatic advance device (Fig 15).

Purpose of the pump is to accurately meter and deliver quantities of fuel under high pressure to injection nozzles through which the fuel is introduced into the engine combustion chambers at a definite timing in relation to the engine firing cycle and within the required injection period.

An integral governor of the mechanical-centrifugal type controls fuel delivery and, therefore, engine speed. The governor is driven directly off of the pump drive shaft without gearing. The direction of rotation of the drive shaft is clockwise.

The transfer or supply pump, in the opposite end of the rotor from the pumping cylinder, is of the positive displacement, vane type and is covered by the end-plate.

Fuel shutoff is accomplished by 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 power unit injection pump governor has 10% regulation. The generator drive engine 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 optional.

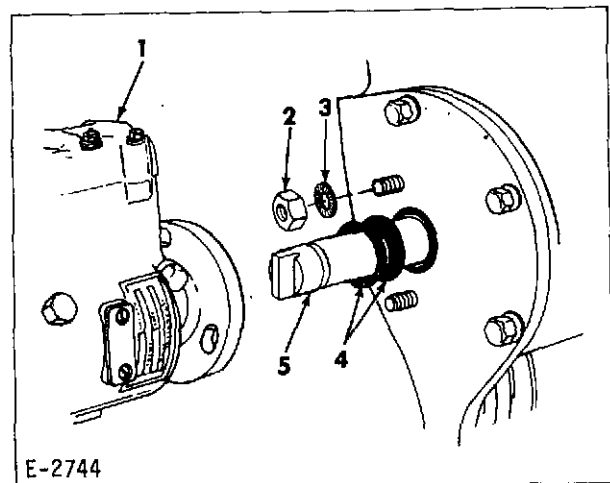
The governor is lubricated by fuel oil and seldom needs adjustments. If engine speed is irregular, check all other components in the fuel system and other applicable engine adjustments before removing the injection pump for repairs.

### 1. Fuel Injection Pump Removal

- a. Clean external surfaces of the

injection pump, including all line connections and fittings that are to prevent dirt from entering system.

- b. Rotate engine flywheel until Number 1 piston is near top of its compression stroke and pointer on timing gear cover is aligned with proper number of timing degrees stamped on the crankshaft pulley. Refer to Topic 2, Paragraph D, for timing degrees per engine rpm.
- c. Disconnect speed control cable from speed control lever.
- d. Disconnect fuel solenoid leads from terminal on fuel pump cover.
- e. Shut off fuel supply if the tank or fuel level in tank is above filter.
- f. Disconnect and remove fuel line between injection pump and drip manifold.
- g. If applicable, disconnect fuel return line from tee on top of injection pump.
- h. Disconnect and remove filter-to-pump inlet line.
- i. If engine is equipped with an oil cooler, drain cooling system and remove oil cooler. Refer to Topic 11 for cooler removal procedure.
- j. If engine is equipped with a turbocharger, remove turbocharger oil feed and drain lines. Also remove air cleaner hose from turbocharger and exhaust pipe from exhaust elbow.
- k. Unscrew and remove fuel filter from filter head.
- l. Remove exhaust manifold (with turbocharger if so equipped) from cylinder head.
- m. Disconnect fuel injection lines from nozzle holders and injection pump. Remove injection lines with clamps as an assembly from engine. Cover all openings to prevent entrance of dirt.
- n. Remove the pump stud nuts and serrated washers. Remove fuel injection pump assembly from the drive shaft, being careful not to damage drive shaft seals (Fig 11).



- |                    |                |
|--------------------|----------------|
| 1. Injection pump  | 4. Shaft seals |
| 2. Nut             | 5. Drive shaft |
| 3. Serrated washer |                |

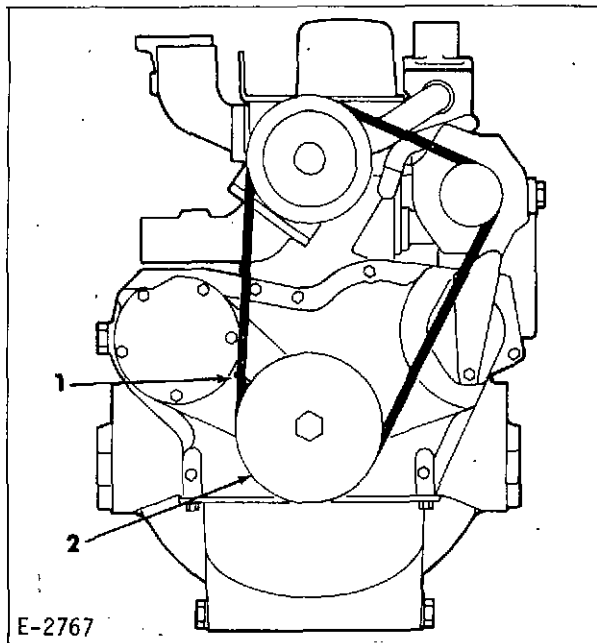
Figure 11. Removing Fuel Injection Pump

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

## 2. Fuel Injection Pump Installation and Timing

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

- a. If the engine 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 was rotated or has been overhauled, make certain the #1 piston is on its



1. Timing pointer
2. Crankshaft pulley

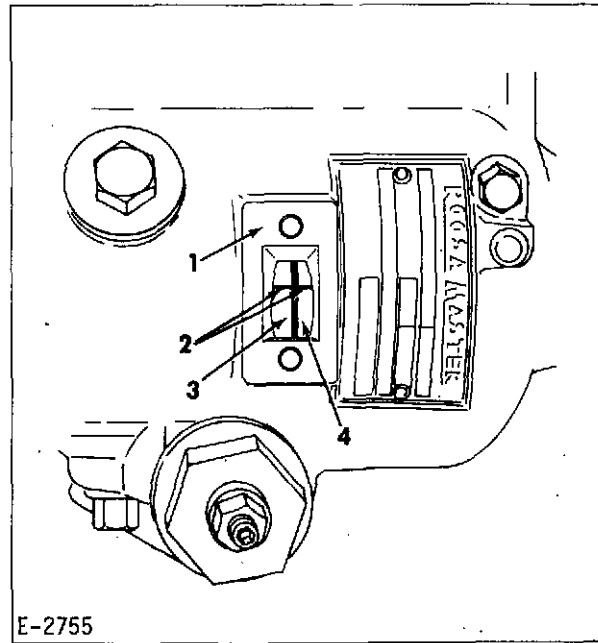
Figure 12. Timing Pointer Location

compression stroke. This may be determined as follows:

- (1) Remove the cylinder head cover so valve action can be observed.
- (2) Rotate engine flywheel 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 12) is aligned with the specified number of degrees BTDC on the crankshaft pulley. 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 engine a few degrees and again come up to the timing mark in the direction of normal engine rotation (clockwise when viewed from the front). The engine is now in correct position for beginning of fuel injection into number one cylinder and for installing the fuel injection pump or for checking its timing.

- b. Inspect pump drive shaft seals (Fig 14 Item 4). Replace if necessary. Install pilot seal (8) on mounting



1. Timing window
2. Timing marks
3. Cam ring
4. Governor weight retainer

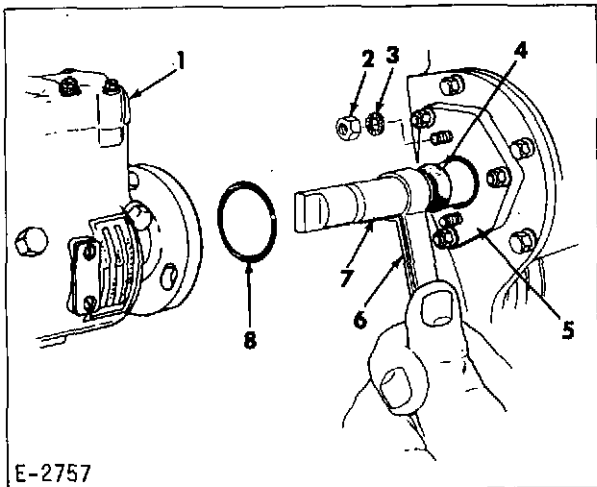
Figure 13. Fuel Pump Timing Marks

pilot of injection pump.

- c. Remove timing window cover from the fuel injection pump. Two fuel pump timing marks (Fig 13) are used for timing injection of fuel into Number 1 cylinder. One mark is located on governor weight retainer hub and one is located on the cam ring. Insert screwdriver, or other suitable tool, into drive shaft end of pump and turn distributor rotor until timing marks are aligned as viewed through the timing window.

NOTE: Before aligning pump timing marks, check to make certain the distributor rotor turns freely. If it does not, it is possible one or more of the governor weights is not properly positioned in the governor weight retainer and the injection pump must be disassembled to correct this condition.

- d. Lubricate the seals with engine oil. Slide the fuel injection pump assembly over the drive shaft and on to the pump mounting studs, using a seal compressor tool similar to the one illustrated in Figure 14 to prevent damage to the seals. Install the serrated washers and the pump-attaching stud nuts but do not tighten the nuts at this time.



- E-2757
1. Injection pump
  2. Nut
  3. Serrated washer
  4. Shaft seals
  5. Adaptor (early engines)
  6. Seal compressor tool
  7. Drive shaft
  8. Pilot seal

Figure 14. Installing Fuel Injection Pump

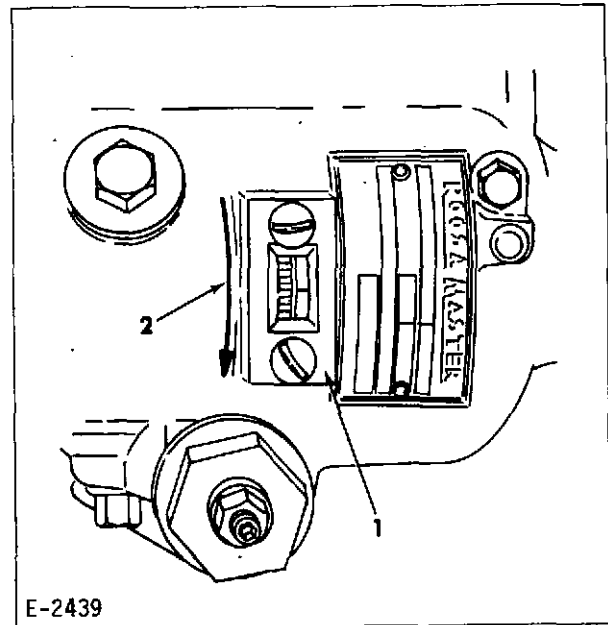
- e. Turn pump until timing marks (Fig 13) are aligned. Tighten attaching stud nuts securely to a torque of 18 to 21 lb-ft (24 to 28 Nm).

**NOTE:** Mounting holes in pump housing are elongated so pump can be turned to align timing marks within the timing window.

- f. Install timing window cover and gasket.
- g. Install fuel injection lines to nozzle holders and fuel injection pump.

**NOTE:** Use a new gasket on both sides of each injection line fitting at the fuel pump. Tighten nuts and connecting screws securely.

- h. Install exhaust manifold (with turbo-charger if so equipped) to cylinder head.
- i. Install fuel filter to filter head.
- j. If engine is equipped with a turbo-charger, install turbocharger oil feed and oil drain lines. Also install air cleaner hose and exhaust pipe.
- k. If engine is equipped with an oil cooler, install oil cooler and oil cooler outlet tube.
- l. Install filter-to-pump inlet line.
- m. If applicable, connect fuel return line to tee on top of injection pump.



- E-2439
1. Plastic timing window
  2. Direction of advance

Figure 15. Timing Window Installed on Fuel Injection Pump

- n. Install fuel line between injection pump and drip manifold.
- o. If fuel supply valve was previously turned off, open valve and prime fuel system as detailed in preceding Paragraph D.
- p. Connect electrical lead/s to fuel solenoid terminal/s of fuel pump cover (Fig 18).
- q. Connect speed control cable to speed control lever.
- r. If oil cooler was removed to facilitate removal of injection pump, fill cooling system.

### 3. Checking Automatic Advance

The function of the automatic advance, is to advance the timing automatically as the engine speed increases. Injection pumps with the hydraulic type governor do not have the automatic advance device.

If the automatic advance is stuck in the full advance position the engine will be hard to start, but will pull its load at rated rpm.

If the advance device does not advance the timing, the starting characteristics will be normal but when the load is applied at rated rpm there will be excessive black smoke in the exhaust and a noticeable lack of power.

A quick method to determine if the speed advance is operating properly is as follows:

- a. Remove the timing window cover and install a plastic timing window (Fig 15).
- b. Check the static timing of the injection pump to the engine. The pump is properly timed to the engine when the pump timing marks (Fig 16 Items 3 and 4, View "A") are aligned and the timing pointer (Fig 12) is aligned with the 20° mark on the crankshaft pulley.
- c. Crank the engine with the starter and with the throttle in the full load position. At cranking speed there should be no movement of the timing mark on the cam ring (Fig 16 Item 4).
- d. Operate the engine until operating temperature is reached. Apply load at full load rpm and observe the pump timing mark on the cam ring (Fig 16 Item 4, View "B"). The automatic advance is operating properly if the timing mark moves downward.

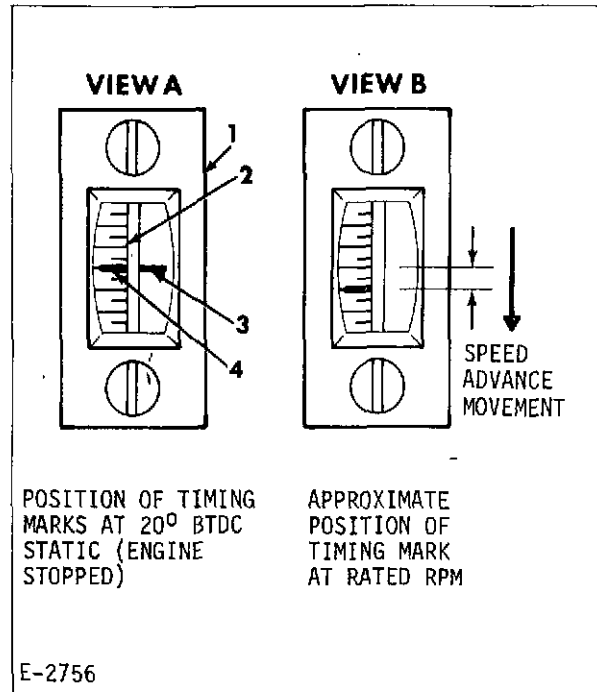
**NOTE:** The timing mark on the governor weight retainer hub (Fig 16 Item 3) will not be visible because the assembly is rotating at one-half engine speed.

- e. Remove plastic timing window and install timing window cover.

The recommended methods to check or adjust the automatic advance is with the engine connected to a dynamometer so that the specified full load can be applied to the engine or the injection pump removed from the engine and mounted on a pump test stand so it can be adjusted according to the pump test specifications.

#### 4. 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 an Allis-Chalmers dealer. It is important that the dealer be furnished with the pump serial number, as well as engine model and serial number, to facilitate repair.



1. Plastic timing window
2. Graduations on timing window - each mark represents 2° pump, or 4° engine
3. Timing mark on weight retainer hub
4. Timing mark on cam ring

Figure 16. Checking Automatic Advance Device

#### F. GOVERNOR

##### 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 fuel 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. Depending upon the engine application, the idle speed is set 600 - 700 rpm for power units and 1400 rpm low speed for generator drive engines.

The standard fuel injection pump governor has 10% regulation and the generator drive engines have and adjustable 3.5 to 5% speed droop regulation governor as standard. A hydraulic type governor with 1 to 5% adjustable speed droop regulation is available as optional equipment.

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

## 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 (344 K) is reached.
- c. Check speed of engines with throttles as follows:

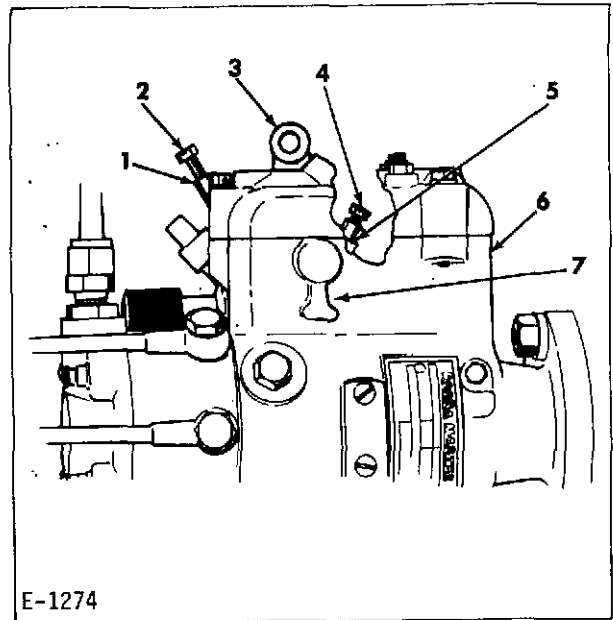
- (1) Move speed control to low and high speed positions and make sure the control moves governor speed control lever through its full arc of travel.
- (2) Move speed control to LOW IDLE position. Check engine speed to make certain rpm is within specified range.
- (3) Move speed control to HIGH IDLE 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:

- (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

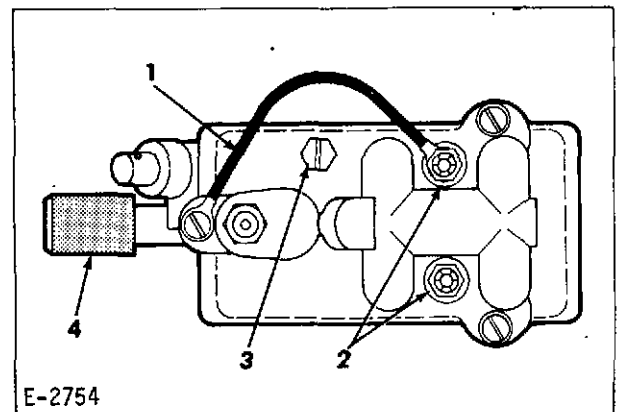


E-1274

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

Figure 17. Engine Speed Adjustment

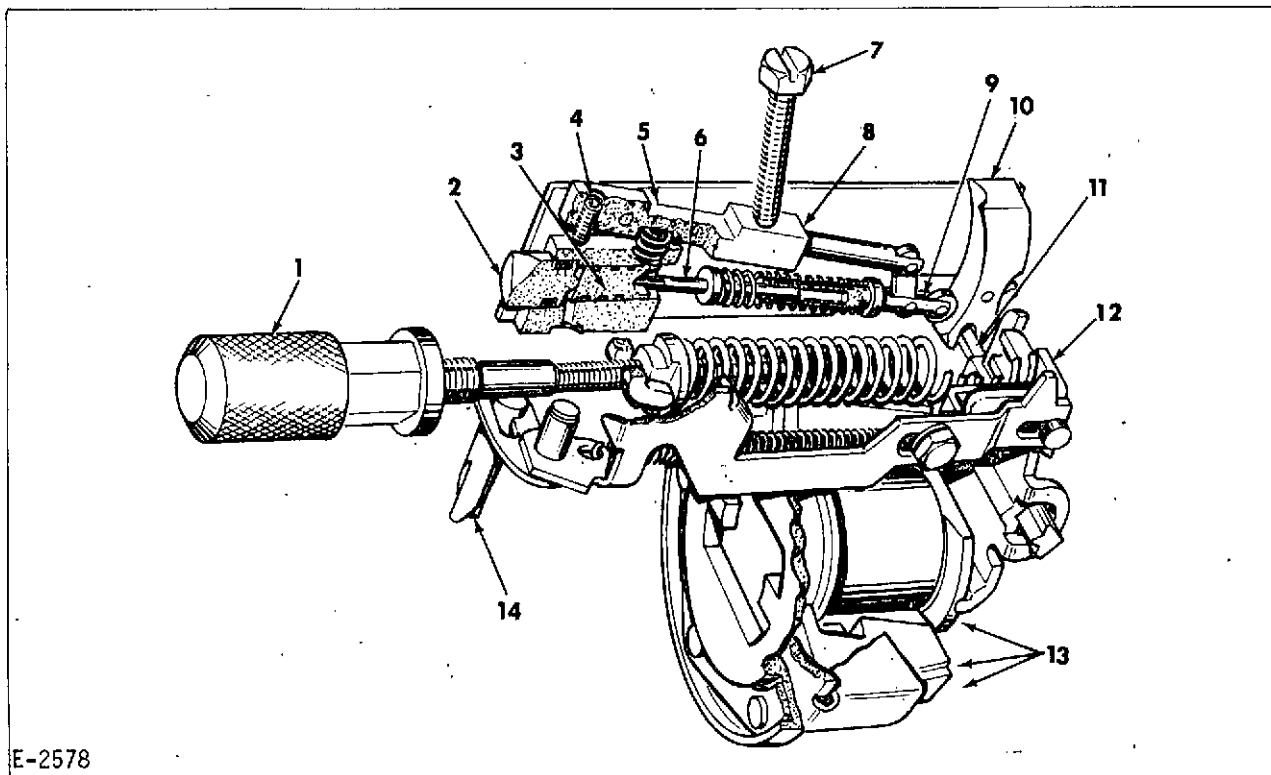
so low speed adjusting screw contacts the lever stop. Turn low speed adjusting screw IN to increase or OUT to decrease low engine speed. After proper low speed is obtained, hold adjusting screw and tighten the locknut.



E-2754

1. Ground wire (power units only - not used with generator drive engines)
2. Electric fuel solenoid terminals
3. Adjusting screw - hydraulic type governor only
4. Speed droop adjusting screw

Figure 18. Speed Droop Adjustment



E-2578

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

Figure 19. Hydraulic Governor Boost Device

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 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

An external speed droop adjusting screw at rear of the pump housing (Fig 18) 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 3.

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 rpm or frequency from no load to full load if engine is powering a generator set. 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.

#### 5. Optional Governor - 1 to 5% Regulation

a. 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 20 Item 3) is provided to reduce hydraulic governor sensitivity and prevents hunting at light loads or at near zero regulation speed. The needle valve adjusting screw (8) 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 accumulator must be piped separately back to the fuel tank (Fig 1 and 2). The fuel passes the hollow spring stop screw into the fuel return line connected to the end of the accumulator.

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.

b. Adjustments - Hydraulic Type Governor

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.

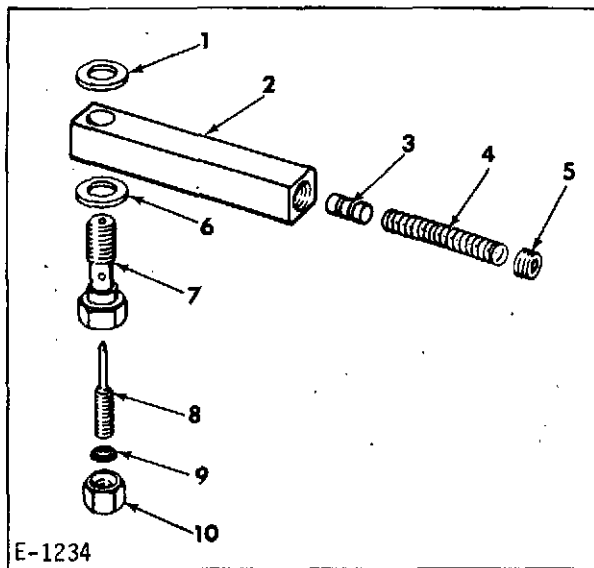
Adjust the governor as follows:

(1) Adjustments Prior to Starting Engine

(a) Loosen accumulator adjusting screw locknut (Fig 20 Item 10). Turn adjusting screw (8) into accumulator until it is seated, then back it out one turn and tighten locknut.

(b) Back out hydraulic governor boost device adjusting screw (Fig 19 Item 7) 6 to 7 turns so that it will have no effect on regulation.

(c) Turn speed droop adjusting screw (Fig 18 Item 4) or (Fig 19 Item 1) counterclockwise until it stops and



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 20. Accumulator Assembly

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.

(2) Adjustments with Engine Running

- (a) Operate engine until a minimum coolant temperature of 160°F (344 K) is reached.
- (b) Apply load to engine and adjust speed to the specified full load rpm.
- (c) With load on engine turn speed droop adjusting screw (Fig 18 Item 4) clockwise until engine is running without hunting.
- (d) 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.

- (e) Again apply load and reset high speed to the specified full load rpm.
- (f) Repeat steps (b), (c), (d), and (e) 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.
- (g) With load applied to engine, turn the hydraulic device adjusting screw (Fig 18 Item 3) 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.
- (h) To shorten governor response time, loosen accumulator adjusting screw locknut (Fig 20 Item 10) and turn the adjusting screw (8) clockwise. To lengthen governor response time, turn adjusting screw counterclockwise.

- (i) Tighten accumulator adjusting screw locknut.

G. FUEL INJECTION NOZZLE HOLDER ASSEMBLY

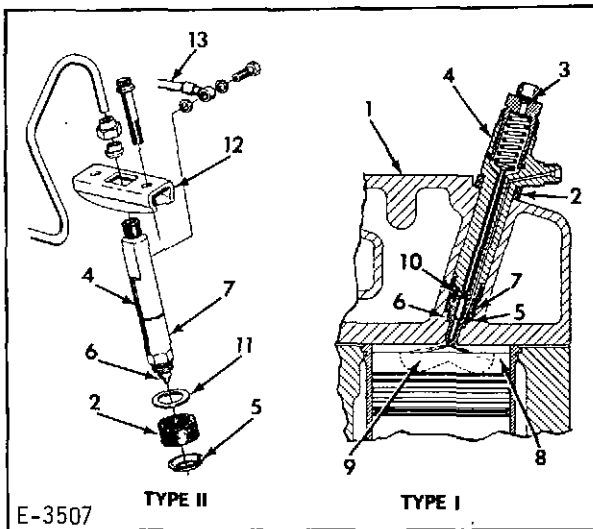
1. Description

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 the 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 a manner as to produce the most efficient performance.

Two styles of fuel injection nozzles have been used.

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 Type I holder (Fig 22) 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



1. Cylinder head
2. Dust shield
3. Felt filter
4. Nozzle holder assembly
5. Nozzle gasket
6. Nozzle assembly
7. Nozzle retaining nut
8. Piston
9. Combustion chamber
10. Dowel
11. Washer
12. Flange - hold-down
13. Fuel return

Figure 21. Combustion Chamber and Nozzle Holder Location

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.

**NOTE:** The top end of the late style Type I nozzle holder assembly is approximately 1 inch (25.40 mm) lower than the early style Type I nozzle. When the late style is intermixed with early style nozzle holder assemblies and drip manifold, an adaptor (Fig 22 Item 1) and gasket (2) are required.

The early style Type I 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 Type II holder consists of a steel holder body, two locating dowels, shim pack, pressure adjusting spring, spring seat and valve stop spacer assembly.

The nozzle assembly, both Type I and Type II, 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 by two dowels whereby the four spray orifices are fixed on a plane parallel to the piston top (Fig 21), 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.

In the Type I nozzle 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 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. In the Type II nozzle, at the instant the pressure of the fuel in the pressure chamber exceeds pressure exerted on the spring seat and nozzle valve by the pressure adjusting spring, the nozzle valve is lifted off its seat and fuel is forced through orifices in the valve body end and into the corresponding combustion chamber. The nozzle valve is returned to its seat by pressure exerted by the pressure adjusting spring when the fuel injection pump has ceased to deliver fuel to the nozzle.

In both type nozzles, a certain amount of seepage between the lapped surfaces of each nozzle valve and valve body is normal and necessary for lubrication. This fuel accumulates around the spindle (Type I) and in the spring compartment (Type II) of the fuel nozzle, and is returned through the fuel drip manifold and fuel return line to the fuel tank.

Dust shields are installed on each nozzle holder to prevent moisture and foreign matter from entering nozzle holder bore in cylinder head.

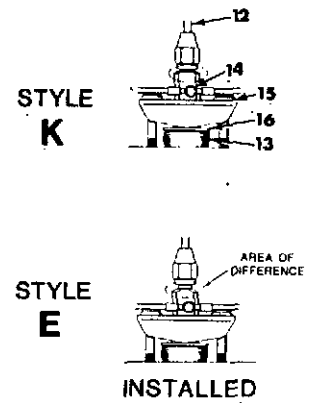
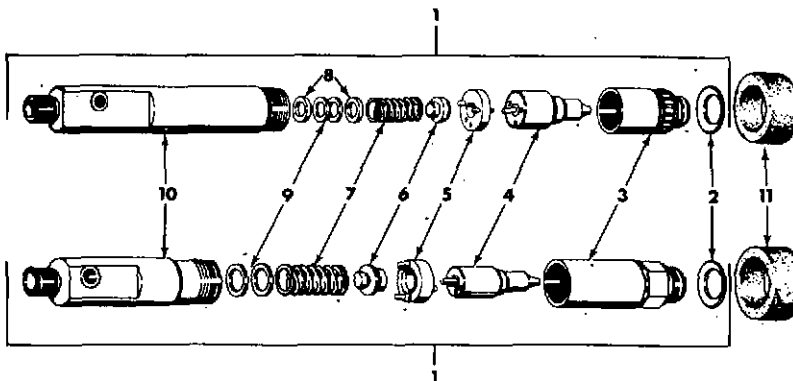
## 2. Maintenance

After each operating interval of approximately 1200 hours the fuel injection nozzles should be removed, cleaned, tested, and adjusted if necessary.

If an opening pressure loss of 15% below minimum is observed the assembly should be re-adjusted to original specifications (Fig 22).

NOZZLE-HOLDER ASSEMBLY  
TYPE II - LOWER SPRING TYPE

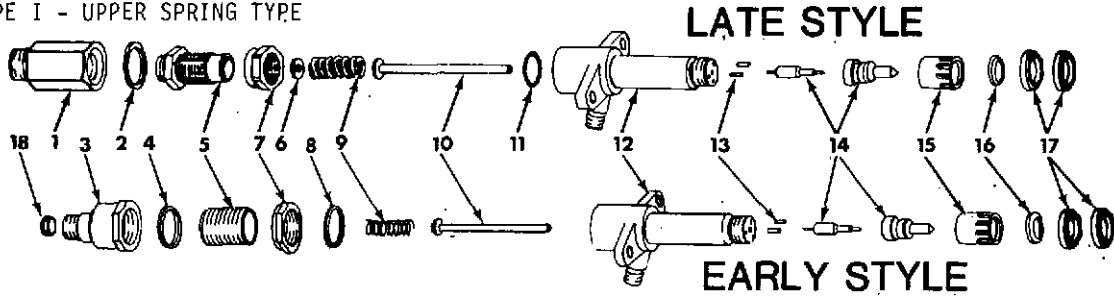
	NOZZLE ORIFICE SIZE		NOZZLE OPENING PRESSURE		NOZZLE RETAINING NUT TORQUE	
	ENGLISH	METRIC	ENGLISH	METRIC	ENGLISH	METRIC
STYLE 'E' ... 2800 Mark I & 649	0.0102 in.	0.26mm	3450-3624 psi	23800-24990 kPa	44 lb-ft	60Nm
STYLE 'K' ... 2800 Mark I & 649	0.0104 in.	0.265mm	3450-3600 psi	23800-24800 kPa	32 lb-ft	44Nm
STYLE 'E' ... 2900 Mark I	0.0118 in.	0.30mm	3842-4016 psi	26500-27690 kPa	44 lb-ft	60Nm
STYLE 'K' ... 2900 Mark I	0.0126 in.	0.32mm	3950-4100 psi	27230-28270 kPa	32 lb-ft	44Nm



1. Nozzle-holder assembly
2. Nozzle gasket
3. Nozzle retaining nut
4. Nozzle assembly (valve)
5. Spacer assembly (valve stop)
6. Spring seat
7. Spring (pressure)
8. Spacers (.062") Style 'K'
9. Shims (pressure adjusting)
10. Holder (steel body)
11. Dust shield (separate item)
12. Fuel inlet
13. Dust shield
14. Banjo fitting (return manifold)
15. Flange - hold-down
16. Washer - hold-down

NOTE: TWO (2) EACH OF ITEM 8 SPACERS ARE CONSTANT - BOTH ABOVE AND BELOW SHIMS IN STYLE 'K' UNITS ONLY.

NOZZLE-HOLDER ASSEMBLY  
TYPE I - UPPER SPRING TYPE



1. Adaptor (See note 1)
2. Gasket (See note 1)
3. Cap nut
4. Gasket
5. Adjusting
6. Wear washer
7. Locking nut
8. Gasket
9. Spindle spring
10. Spindle rod
11. O-Ring
12. Holder body
13. Dowel pins
14. Nozzle body & needle valve
15. Retaining nut
16. Gasket
17. Nozzle-holder dust shields
18. Filter (felt)

NOTE 1 - Items 1 & 2 are separate items to enable in field change over.

ENGINE MODEL	NOZZLE ORIFICE SIZE		NOZZLE OPENING PRESSURE		NOZZLE RETAINING NUT TORQUE		LOCKNUT AND CAPNUT TORQUE	
	ENGLISH	METRIC	ENGLISH	METRIC	ENGLISH	METRIC	ENGLISH	METRIC
2800	0.0106 in.	0.27mm	2800-2850 psi	19306-19651 kPa	55 lb-ft	75Nm	55 lb-ft	75Nm
2900	0.0126 in.	0.32mm	3100-3150 psi	21373-21718 kPa	55 lb-ft	75Nm	55 lb-ft	75Nm
2800 Mark I	0.0106 in.	0.27mm	3450-3500 psi	23787-24131 kPa	55 lb-ft	75Nm	55 lb-ft	75Nm
2900 Mark I	0.0126 in.	0.32mm	3450-3500 psi	23787-24131 kPa	55 lb-ft	75Nm	55 lb-ft	75Nm
649	0.0106 in.	0.27mm	3450-3500 psi	23787-24131 kPa	55 lb-ft	75Nm	55 lb-ft	75Nm

COMMON INFORMATION:

NOZZLE HOLD-DOWN CAPSCREW TORQUE 180 LB. INCH (20.34 Nm)

FIGURE 22. NOZZLE-HOLDER ASSEMBLY

New nozzle and holder assemblies will experience a loss in opening pressure as components wear in during engine operation. A loss of 10% of opening pressure below the minimum specified pressure will not adversely affect engine operation if seat leakage and spray pattern are acceptable. If the nozzle and holder assembly is acceptable except for nozzle opening pressure, the assembly can be reset to the specified opening pressure and reinstalled.

A felt filter (Fig 22 Item 18) is installed in the bottom of the fuel outlet opening of the adjusting screw of the nozzle holder assembly (Type I Only). This filter is required for production test and may be discarded at the first scheduled nozzle servicing period. The filter will maintain cleanliness of the nozzle and will not affect engine or nozzle performance.

Since the fuel return side of the nozzle and holder assembly has a minimal flow of low pressure fuel, contaminants, such as small metal chips, may vibrate from the drip (return) manifold through the fuel return outlet passage and settle on the top of the nozzle (needle) valve. The filter will stop these contaminants, which, if allowed to pass, might reduce the needle valve lift or cause erratic valve operation, leading to improper nozzle operation and a poor spray pattern.

The filter is not required as a service replacement item, but they are suggested to be used on each nozzle and holder assembly when replacing a drip manifold tube assembly.

### 3. Fuel Injection Nozzle Holder Removal

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



**WARNING:** Never use gasoline or other toxic or flammable fluids to clean parts.

- b. Remove fuel drip manifold and disconnect injection lines from nozzle holder assemblies. Refer to Fig 24.

**NOTE:** 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 25.

**NOTE:** 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 26 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. Also wear safety glasses with side shields of goggles when popping a nozzle.

Test and adjust fuel injection nozzle as follows:

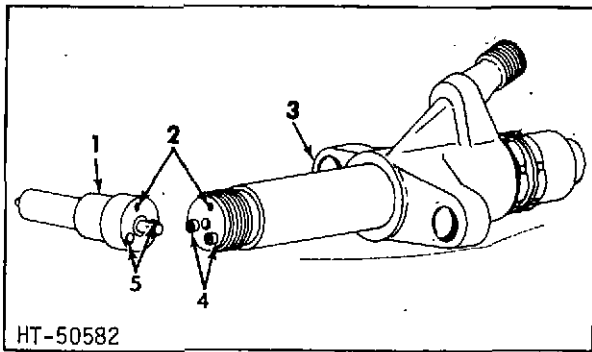
- a. Bolt or clamp base of nozzle tester to a work bench.
- b. Turn nozzle tester valve handle to the open position. Loosen filler cap to prevent air lock in the tester. Operate handle until fuel flows from end of tester fuel line, then close valve.
- c. Connect nozzle holder to fuel line of tester. 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.
- e. Adjust fuel injection nozzle to obtain specified opening pressure as follows:

Type I Nozzle-Externally Adjustable

- (1) Loosen adjusting screw locknut.
- (2) While slowly operating handle, turn pressure adjusting screw IN to increase or OUT to decrease opening pressure. When specified pressure is obtained, hold adjusting screw and tighten locknut to 55 lb-ft (75NM) torque.

Type II Nozzle-Requires Disassembly

- (1) Remove nozzle from test stand.



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

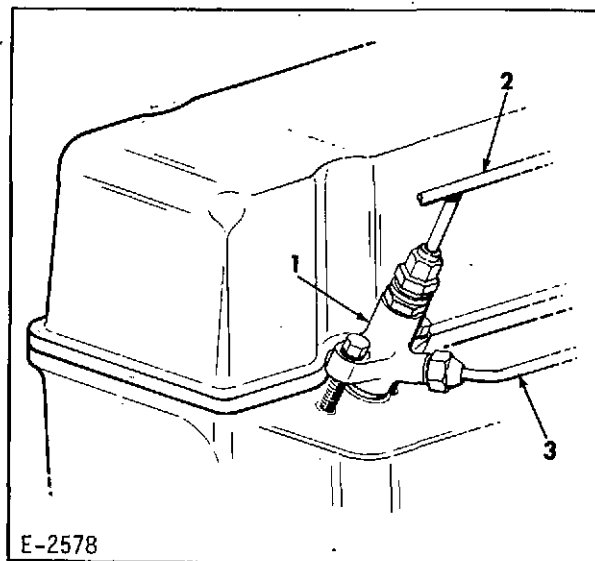
Figure 23. Fuel Injection Nozzle Holder Dowel Location

- (2) Clamp nozzle holder body in a vise having copper jaws or similar protective material.
- (3) Loosen and remove nozzle retaining nut.
- (4) Remove nozzle valve, valve stop spacer, spring seat and pressure adjusting spring and place in clean diesel fuel. Keep each lot of shims taken out of nozzle holder with the respective assembly as they will vary.

- (5) Nozzle opening pressure is determined by the total thickness of the shims added between pressure adjusting spring and holder body. To increase opening pressure, increase the thickness of the shim pack. To decrease opening pressure, decrease the thickness of the shim pack.

A shim of .001" will modify pressure approximately 50 psi whereas a shim of .05mm will modify pressure approximately 100 psi:

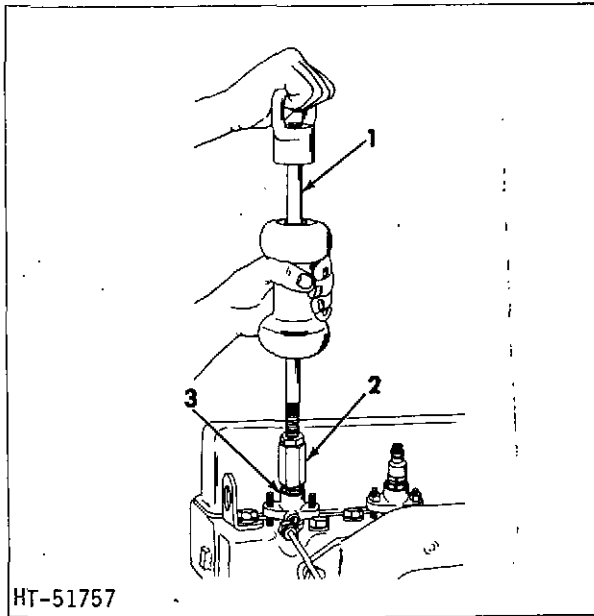
- (6) Install the shims, the pressure adjusting spring, spring seat, and valve stop spacer into the holder body.
  - (7) Install the nozzle valve, nozzle body and nozzle retaining nut. Tighten nut to a torque of 44 lb-ft (60Nm).
  - (8) Test the nozzle assembly as outlined in paragraph a thru d.
- f. Dry the nozzle tip. Operate handle slowly until pressure is approximately 200 psi (1379 kPa) below open-



1. Nozzle holder assembly
2. Drip manifold
3. Injection line

Figure 24. Nozzle Holder Assembly Location

- ing 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 kPa), 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 28).
  - i. If the fuel is not discharged evenly from all 4 holes, a plugged hole(s) is indicated, in which case, the nozzle must be removed and cleaned using a proper size cleaning wire (Fig 29). 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 to relieve tension on spindle rod, then remove nozzle retaining nut and nozzle (Type I) (Fig 22). Remove nozzle retaining nut from holder to remove nozzle from holder (Type II).



1. Slide hammer
2. Adaptor
3. Nozzle holder

Figure 25. Removing Fuel Injection Nozzle Holder

k. Install new or cleaned nozzle on holder and tighten retaining nut to specified torque.

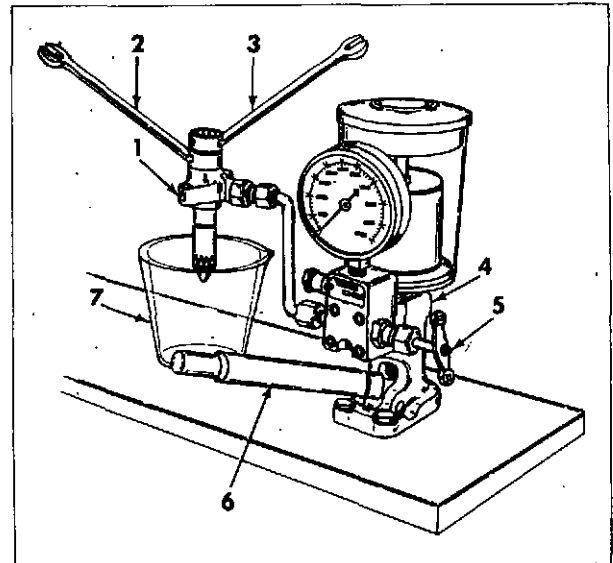
l. Connect nozzle holder assembly to tester and adjust nozzle to the specified opening pressure.

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.

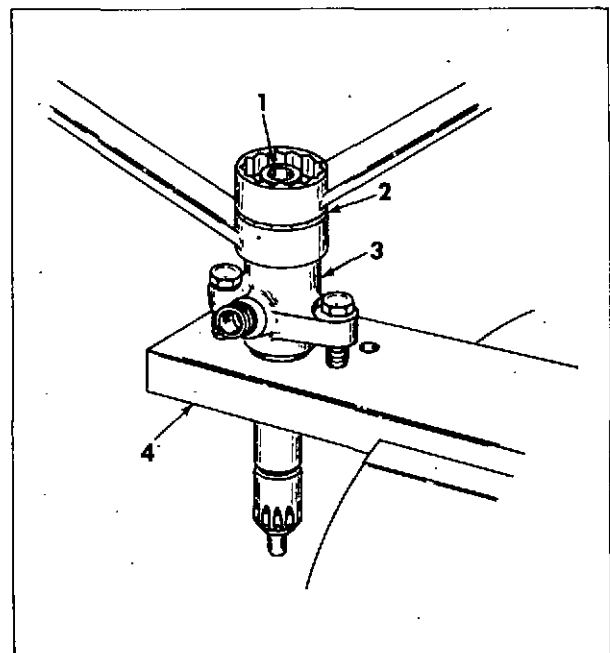
b. Install dust shields (Fig 22 Item 17) on nozzle holder (12) and place new nozzle gasket (16), convex face (rounded side) toward the nozzle retaining nut in position on the nozzle. Install nozzle retaining washer on nozzle assembly (Type II Units).

NOTE: Coat nozzle holder body with never-seize compound to prevent seizure in cylinder head.



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 26. Adjusting Nozzle Opening Pressure



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

Figure 27. Loosening Pressure Adjusting Screw Locknut (Type I)

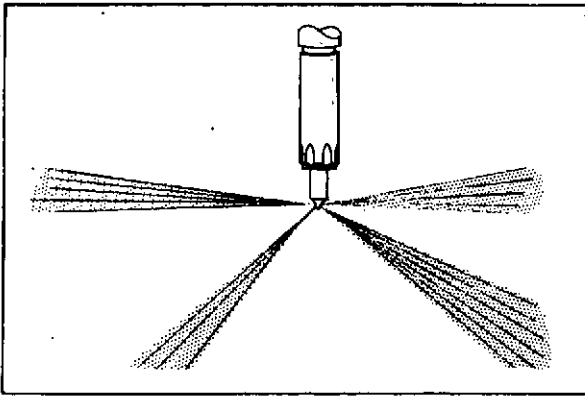


Figure 28. Acceptable Spray Pattern

- c. Carefully position nozzle holder in nozzle bore of cylinder head. Install hold-down flange on Type II units. Install nozzle holder retaining (12 point) 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 capscrews on one side to 90 lb-in (10Nm) torque. Tighten capscrew on opposite side to full specified torque 180 lb-in (20Nm). Then tighten first capscrew to full specified torque.
- e. Tighten injection tube and drip manifold nuts securely.
- f. Start engine and observe fuel injection tubes and fuel drip manifold connections for fuel leakage. Correct any leaks found.

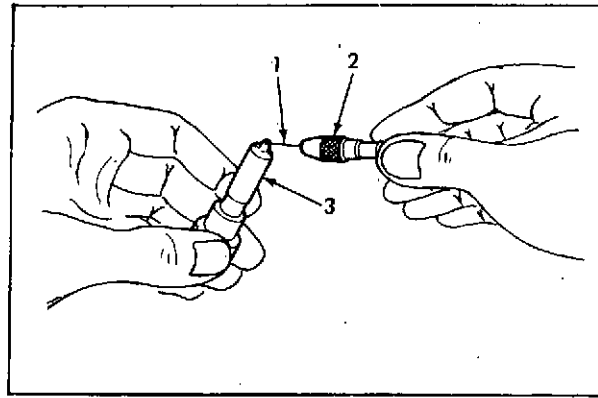
#### H. REMOVING CARBON FROM FUEL INJECTION NOZZLE BORE

If 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 30 before reinstalling it on the engine.

**CAUTION:** Under no circumstances should an 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



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

Figure 29. Cleaning Nozzle Orifices

loss of power are indications on 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 is open.

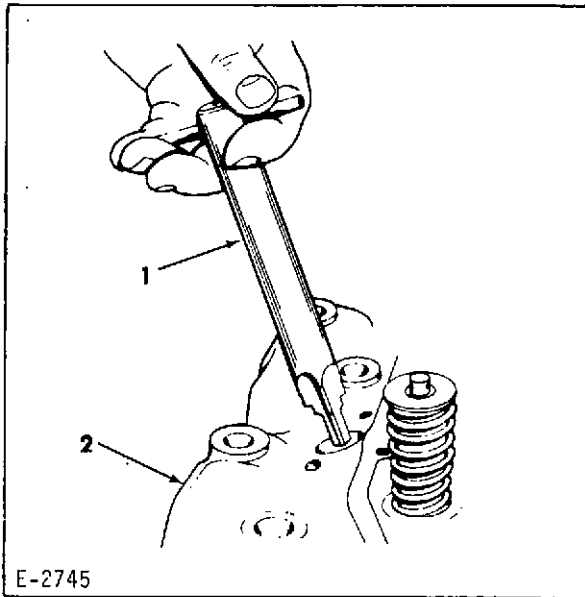
#### 1. Check For Admission Of Air Into System

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.

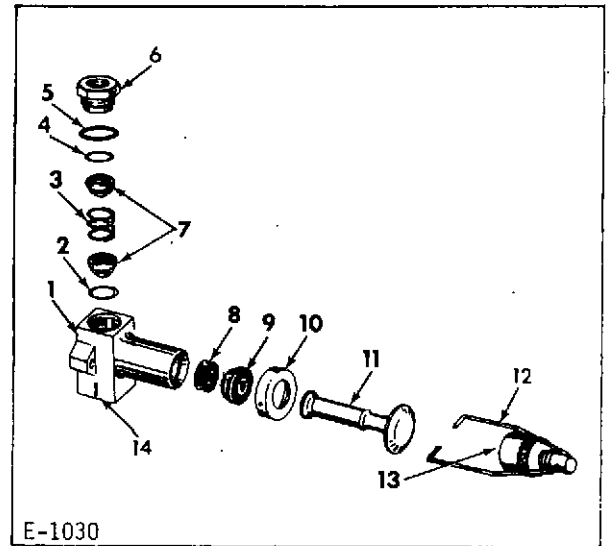
#### 2. Check For Clogged Fuel Filter And Clogged Or Collapsed Fuel Lines

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



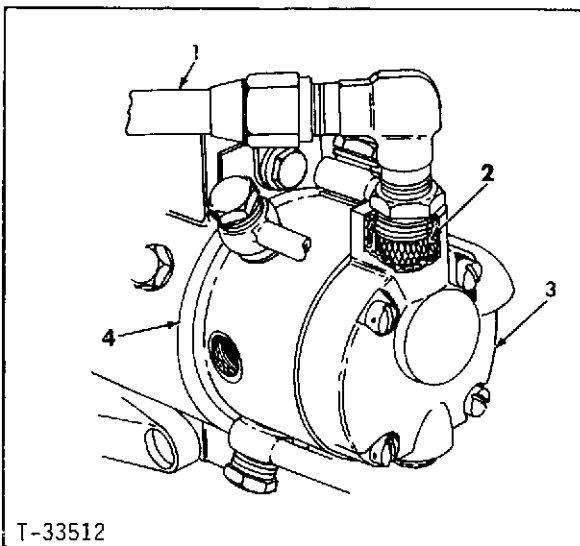
1. Fuel injection nozzle sleeve carbon removing tool
2. Cylinder head

Figure 30. Removing Carbon From Fuel Injection Nozzle Bore



- |                   |                            |
|-------------------|----------------------------|
| 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 | 12. Clamp                  |
| 6. Valve nut      | 13. Clamp screw            |
| 7. Valve          | 14. Direction of fuel flow |

Figure 32. Hand Primer Pump



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

Figure 31. Fuel Strainer Location

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" (33768 N/m<sup>2</sup>) mercury pressure drop is still obtained when a new filter is used, inspect all low pressure lines for clog-

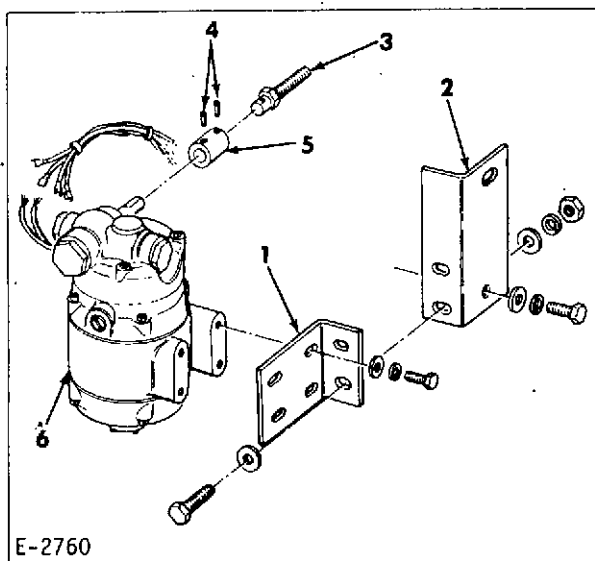
ging, crimping, etc., and clean or replace as required.

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 31) 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 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.



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

Figure 33. Speed Control Motor Mounting

4. Check For Inoperative Fuel Injection Nozzles

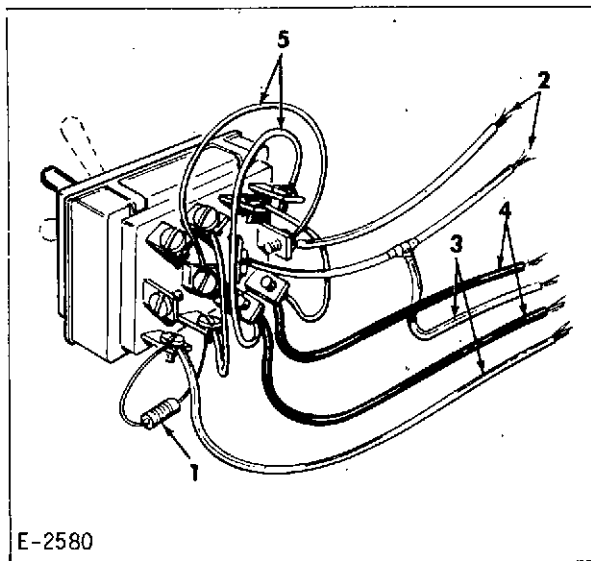
Missing or uneven running of engine and loss of power are indicative of an inoperative fuel injection nozzle(s). To locate a faulty fuel nozzle, use following procedure:

**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 inoperative and should be repaired or replaced.

5. Check For Inoperative Fuel Injection Pump

Do not replace the fuel injection pump before making a compression test. 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).



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

Figure 34. Wiring Diagram (Speed Control Switch)

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 32 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, 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 either 12 or 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.

## TOPIC 13. LUBRICATION SYSTEM

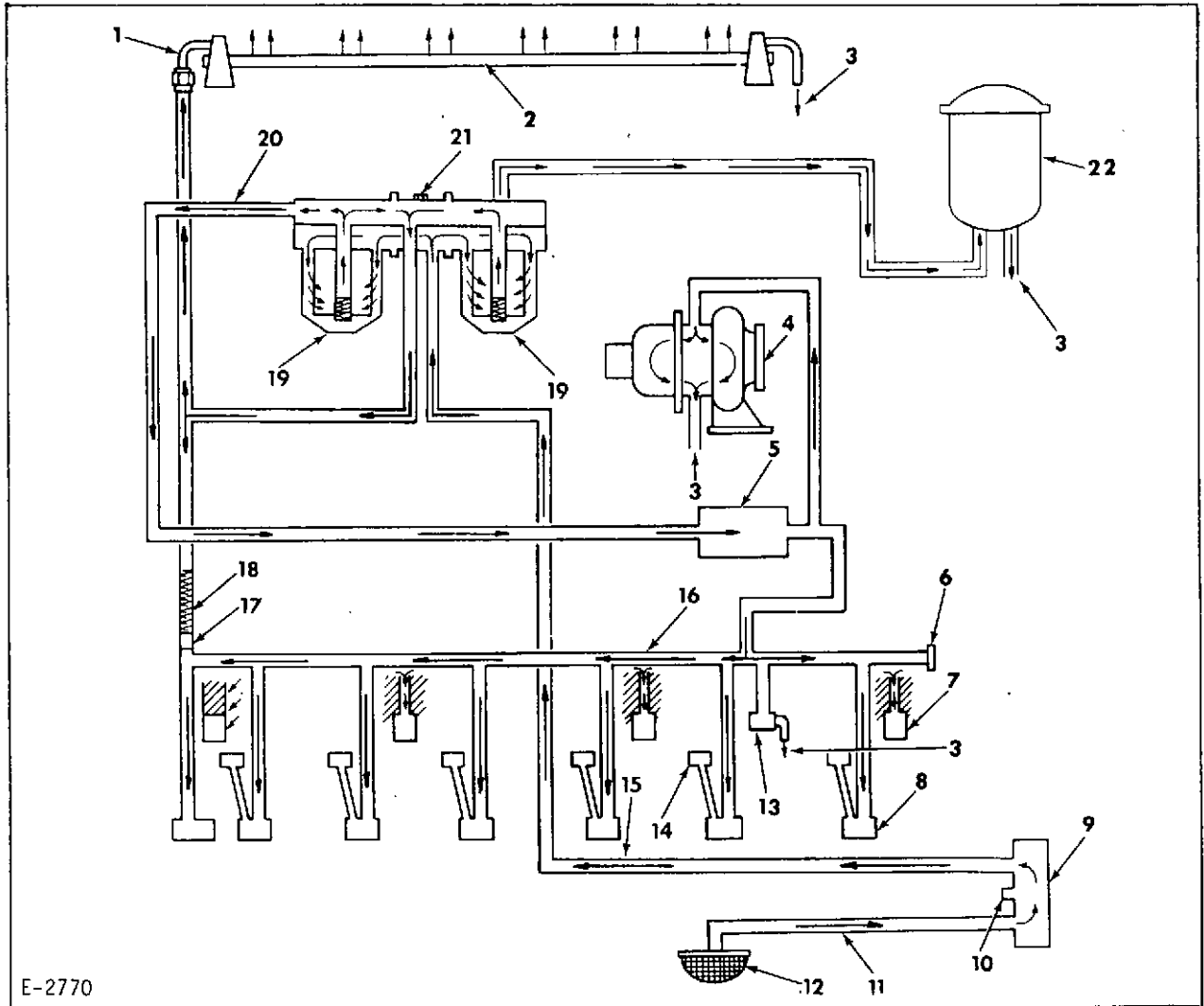
### A. GENERAL

The engine is pressure lubricated by a gear type oil pressure pump. The current engine oil pump is driven by the pump drive gear in-mesh with the crankshaft gear.

The design of the oil pan determines the maxi-

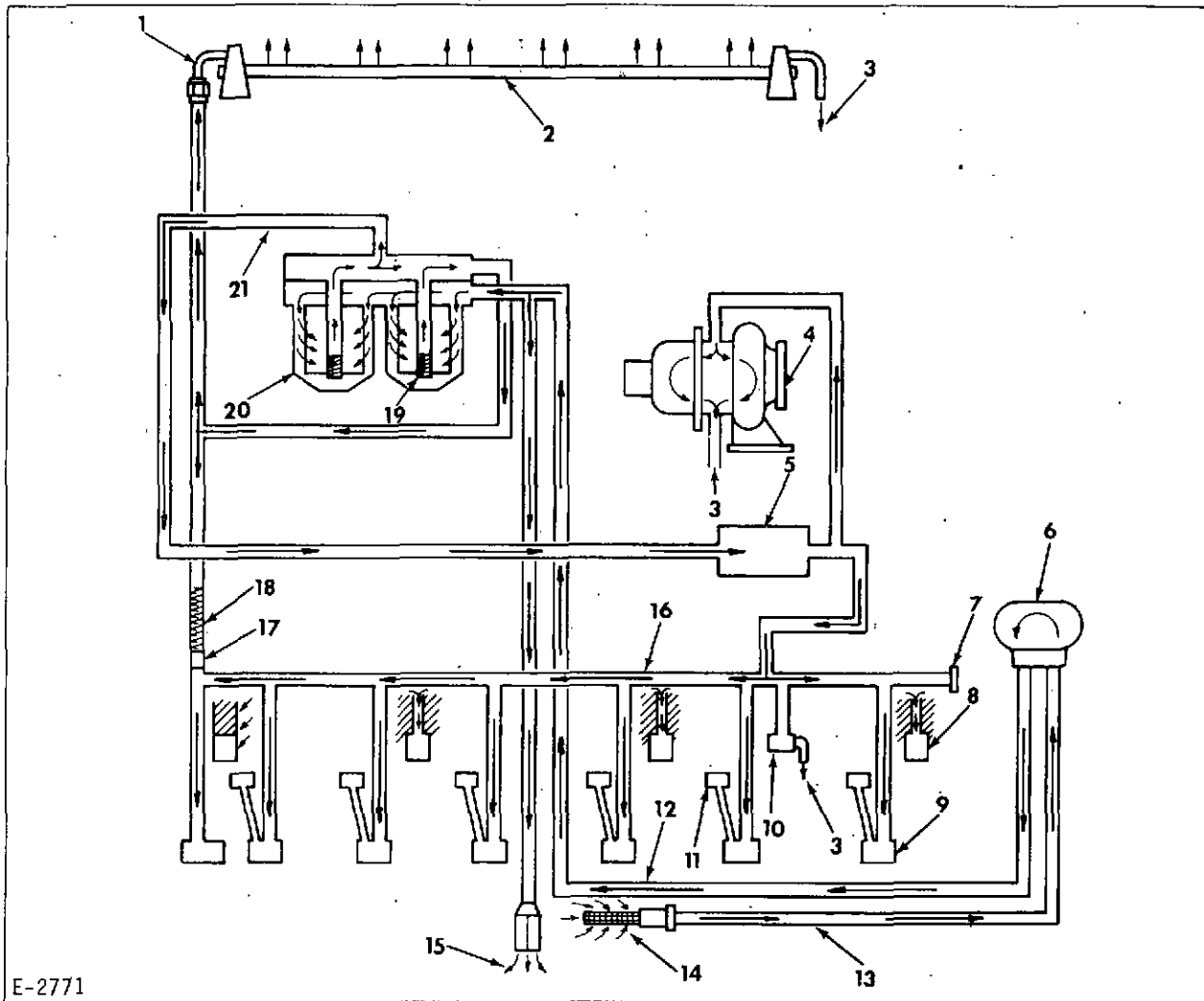
mum angle the engine can safely operate. For the maximum angle of operation, refer to Paragraph C, of Topic 2.

With the engine operating at full speed and with the coolant at normal operating temperature, the engine oil pressure should range between 30 and 55 psi (207 and 379 kN/m<sup>2</sup>).



- |                                       |   |
|---------------------------------------|---|
| 1. Rocker arm shaft oil feed tube     | 12. Suction screen                                      |
| 2. Rocker arm shaft                   | 13. Oil pressure regulating valve                       |
| 3. Oil - return to oil pan            | 14. Connecting rod bearing                              |
| 4. Turbocharger                       | 15. Pressure tube                                       |
| 5. Oil cooler                         | 16. Main oil gallery                                    |
| 6. Oil for gear train 1/16 restrictor | 17. Internal gallery plug (used with oil cooler)        |
| 7. Camshaft bearing                   | 18. Internal gallery plug spring (used with oil cooler) |
| 8. Main bearing                       | 19. Lube oil filter                                     |
| 9. Oil pressure pump                  | 20. External oil tube (to oil cooler)                   |
| 10. Oil pump pressure relief valve    | 21. Bypass valve  |
| 11. Oil pick up tube                  | 22. Optional bypass type filter                         |

Figure 1. Lubrication System Schematic Diagram (Crankshaft Gear Driven Type Oil Pump)



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- |   |   |
|---|---|
| 1. Rocker arm shaft oil feed tube       | 11. Connecting rod bearing                              |
| 2. Rocker arm shaft                     | 12. Pressure tube                                       |
| 3. Oil - return to oil pan              | 13. Suction tube  |
| 4. Turbocharger                         | 14. Oil pick up tube (in oil pan)                       |
| 5. Oil cooler                           | 15. Oil pump pressure relief valve                      |
| 6. Oil pressure pump (external mounted) | 16. Main oil gallery                                    |
| 7. Oil for gear train 1/16 restrictor   | 17. Internal gallery plug (use with oil cooler)         |
| 8. Camshaft bearing                     | 18. Internal gallery plug spring (used with oil cooler) |
| 9. Main bearing                         | 19. Bypass valve  |
| 10. Oil pressure regulating valve       | 20. Lube oil filter                                     |
|   | 21. External oil tube (to oil cooler)                   |

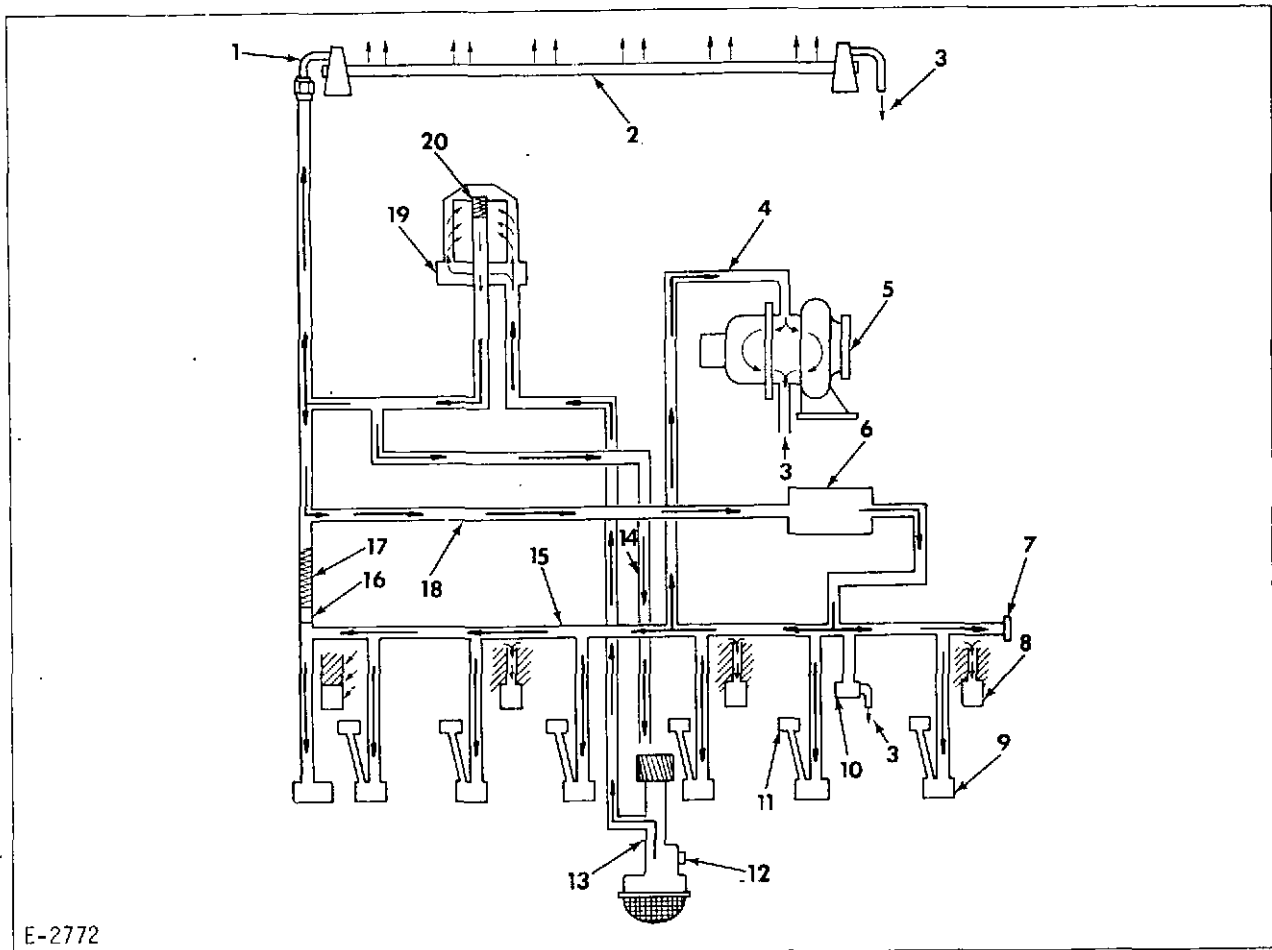
Figure 2. Lubrication System Schematic Diagram (External Front Mounted Type Oil Pump)

Engine mounted lubricating oil filters (Fig 5, 6 and 7) are the full flow, throw away type. They are screwed onto the filter header located on the left side of the engine near the fly-wheel housing. Each 100 hours renew lubricating oil and filters.

An unmounted bypass type filter (Figs 8 and 9) to assist the engine mounted full flow filter is available as optional equipment for models 2800MKI and 2900MKI engines.

A bypass valve in the filter/header permits unfiltered oil to bypass the filter elements and go directly into the main gallery if filters become clogged or if oil becomes too thick in cold weather to circulate freely through the filters.

The oil is drawn from the oil pan and pressurized by the oil pump. Oil under pressure is forced to the filters. The filters are positioned on the header/base with oil inlet



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- |                                       |   |
|---------------------------------------|---|
| 1. Rocker arm shaft oil feed tube     | 11. Connecting rod bearing                              |
| 2. Rocker arm shaft                   | 12. Relief valve (dumps internally)                     |
| 3. Oil - return                       | 13. Oil pump (bayonet type)                             |
| 4. Oil supply tube                    | 14. Oil feed line (lube oil to oil pump drive gear)     |
| 5. Turbocharger                       | 15. Main oil gallery                                    |
| 6. Oil cooler                         | 16. Internal gallery plug (used with oil cooler)        |
| 7. Oil for gear train 1/16 restrictor | 17. Internal gallery plug spring (used with oil cooler) |
| 8. Camshaft bearing                   | 18. External oil tube (to oil cooler)                   |
| 9. Main bearing                       | 19. Fuel filter   |
| 10. Oil pressure regulating valve     | 20. Bypass tube   |

Figure 3. Lubrication System Schematic Diagram (Bayonet Type Oil Pump)

openings adjacent to the annular cavity. Pressurized oil fills the area between element and shell. Oil is filtered as it passes through and into the hollow center area of the element.

A pressure regulating valve connected to the main oil gallery controls the pressure within the lubricating system.

To protect oil pump gears and filter elements from excessive pressures created by thick oil during cold weather starting, a pressure relief valve is located in the cover of the oil pump or on the rail of the cylinder block inside the oil pan if the engine has an external front mounted type oil pump.

#### B. GENERAL MAINTENANCE

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

The oil level gauge (dipstick) of current engines 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 4). The oil level gauge of early engines was stamped only on one side and

engine had to be stopped to check the oil level.

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.

If the oil level is low, add lubricating oil as specified in Topic 6, to bring the level of the oil to the FULL mark on the gauge.

Once the engine has started, observe the engine lubricating oil pressure indicated by the oil pressure gauge. If the engine is cold, no pressure may be indicated by the gauge for a few seconds after the engine starts, but if the pressure does not then rise to normal or above, the engine must be stopped immediately and the cause determined and corrected.

**CAUTION:** Never operate an engine with the oil level below the ADD mark on the oil level gauge. Failure to observe this caution will result in damage to the engine.

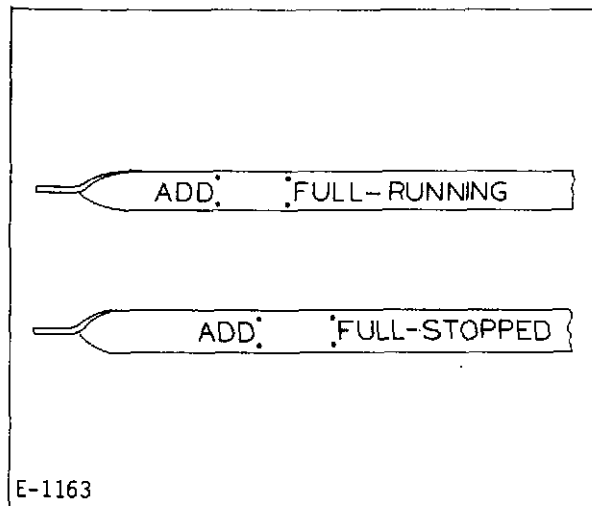
After starting a turbocharged engine, it is extremely important that it be allowed to operate at a fast idle for 3 to 5 minutes without load. Starting the engine in this manner assures free circulation of lubricant through the turbocharger bearings.

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 the engine be allowed to operate at a 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.

#### G. DRAINING AND FILLING THE LUBRICATING SYSTEM

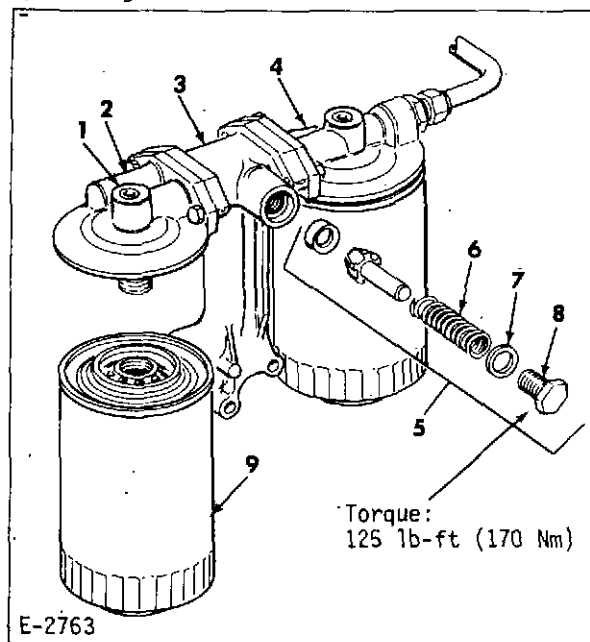
1. Before draining the system, operate the engine until the normal operating temperature is reached. Stop the engine.
2. Remove the drain plug from the oil pan and allow the oil to drain. As a caution, allow the sediment to settle in the drained oil, pour off the oil and examine the sediment, if any.
3. Renew oil filters. Refer to following Paragraph D and E.



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Figure 4. Oil Level Gauge (Dipstick)

4. Reinstall the oil pan drain plug and fill the system with the specified grade and type of lubricant. FILL to the FULL mark on the dipstick.
5. Crank the engine, without starting for 15 seconds. This will assure that the filters are filled and that lubricant has been pumped to the turbocharger and other engine components before the engine is started.

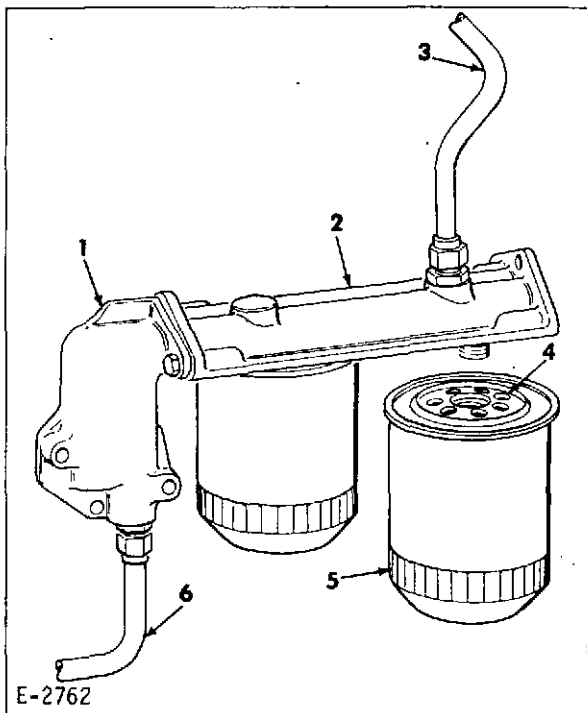


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- |                 |                  |
|-----------------|------------------|
| 1. Plug         | 6. Spring        |
| 2. Left header  | 7. Copper gasket |
| 3. Manifold     | 8. Capscrew      |
| 4. Right header | 9. Filters       |
| 5. Bypass valve |                  |

Figure 5. Full Flow Type Oil Filters (Used with Crankshaft Gear Driven Type Oil Pump)

2800 2900  
2800MKI 2900MKI



- |                         |                                  |
|-------------------------|----------------------------------|
| 1. Oil manifold         | 4. Filter gasket                 |
| 2. Filter header        | 5. Filter                        |
| 3. Tube - to oil cooler | 6. Pressure tube - from oil pump |

Figure 6. Full Flow Type Oil Filters (Used with External Front Mounted Type Oil Pump)

6. Start the engine and allow it to run for approximately 5 minutes.
7. Stop the engine, allow several minutes for the oil to drain back to the sump, and recheck the oil level. Add lubricant as required.
8. Inspect the lubrication system for leaks.

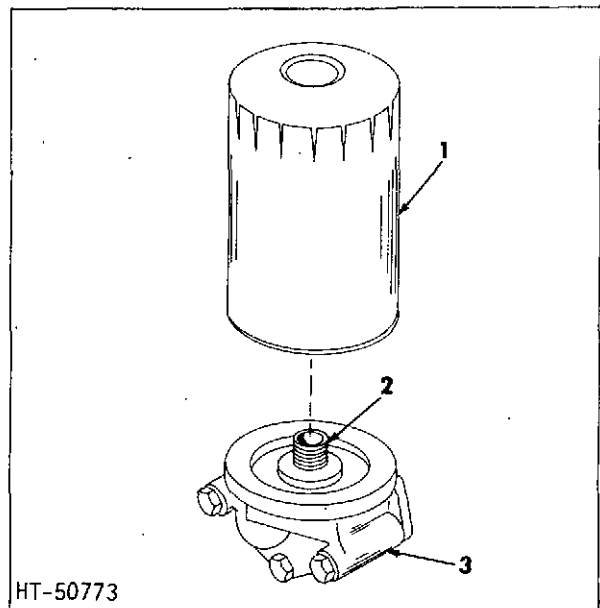
#### D. FULL FLOW TYPE FILTERS - Standard

##### 1. General

Each full-flow, throw away type, filter has an integral gasket to prevent oil leaks between the filter and the filter header. The filters are retained on the header by being screwed onto a threaded insert at each filter location.

##### 2. To renew the oil filter proceed as follows:

- a. Operate engine until coolant is at minimum operating temperature.
- b. Thoroughly clean filters and surrounding area.
- c. Unscrew filters and remove them from



1. Filter (disposable type)
2. Filter base nipple
3. Base assembly

Figure 7. Full Flow Type Oil Filter (Used with Bayonet Type Oil Pump)

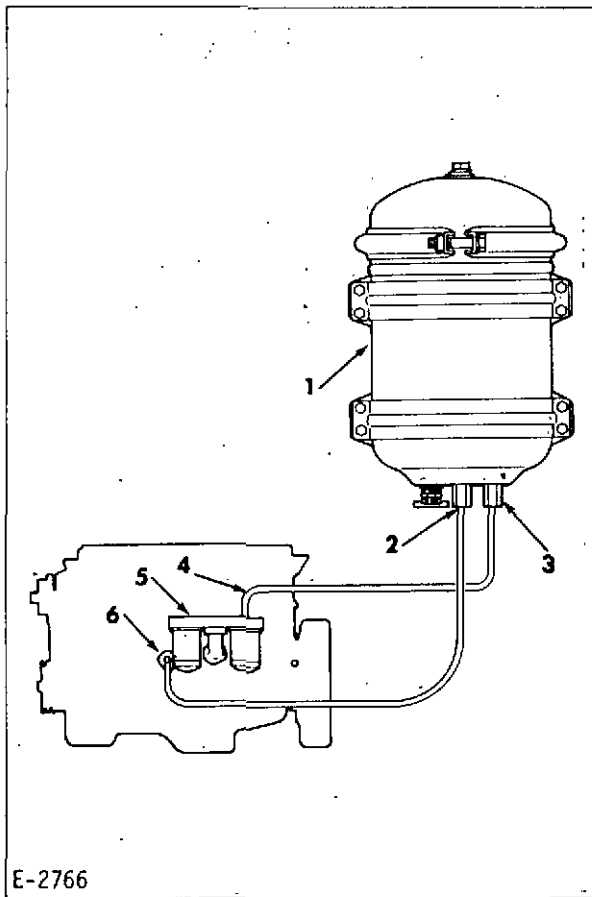
their header or base assemblies. Discard both filters.

- d. Apply light coat of lubricating oil to gasket of both replacement filters. Using hand pressure, screw each filter into position until gasket contacts surface of filter base assembly. Continue hand pressure and tighten each filter a minimum additional one half turn.

**CAUTION:** Do not use tools to tighten oil filters.

**CAUTION:** Always use Allis-Chalmers replacement filters.

- e. Start engine and run for approximately 5 minutes.
- f. With engine running, check filters for leakage and make certain they are properly installed.
- g. Stop engine and allow several minutes for oil to drain back to the oil pan before checking level.
- h. Check oil level with dipstick. Add oil, if necessary, to raise level to FULL mark.



1. Bypass filter
2. Outlet .125 pipe thread
3. Inlet .125 pipe thread
4. Outlet .500 pipe thread (Use tap nearest block)
5. Full flow filters
6. Oil return .250 pipe thread

Figure 8. Optional Bypass Type Oil Piping Schematic

#### E. BYPASS TYPE OIL FILTER- OPTIONAL

##### 1. General

A bypass type oil filter (Figs 8 and 9) which assists the full flow filter to remove impurities from the engine lubricating oil is available for models 2800MKI and 2900MKI engines.

The filter is shipped unmounted with instructions for installing it. Mount the filter to a rigid location on the vehicle or sub-base as near as possible to the engine oil and drain locations. Consideration should be given to the ease of filter cartridge removal and filter draining.

The use of the bypass filter may permit the lubrication change period to be

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

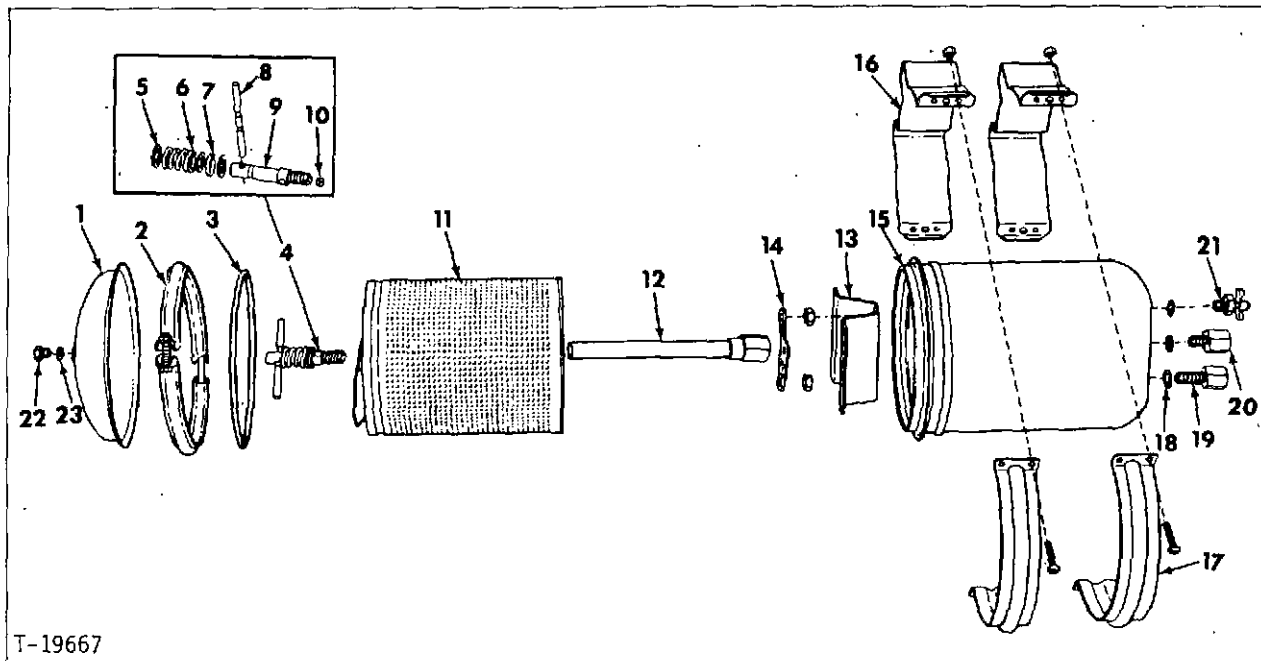
#### 2. Element Removal and Installation

The filter element must be changed at each lubrication change period. Refer to Figure 9 and replace the element as follows:

- a. Clean the filter cover (1) and surrounding area. Loosen the drain cock (21) in the bottom of the filter housing and allow filter to drain. Remove the cover clamp ring (2) and lift the cover from the filter housing. Do not damage the gasket. (3)
- b. Unscrew and remove the T-handle hold-down (4) from the center-tube (12). Remove the filter element (11) from the housing (15) 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. Be certain the hole in the orifice plug, (10) 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 oil pan with the specified quantity of engine oil. Refer to Topic 2, SPECIFICATIONS.
- h. Loosen vent plug (22) on top of filter cover. Start engine and operate at idle speed until oil appears at vent plug then tighten plug.
- 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.

#### F. LUBRICATION SYSTEM MAINTENANCE

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



T-19667

- |                       |                      |                                   |
|-----------------------|----------------------|-----------------------------------|
| 1. Housing cover      | 9. Stud              | 17. Mounting bracket band         |
| 2. Cover clamp ring   | 10. Plug             | 18. Gasket                        |
| 3. Cover gasket       | 11. Element          | 19. Check valve assembly (inlet)  |
| 4. Hold-down assembly | 12. Tube assembly    | 20. Check valve assembly (outlet) |
| 5. Washer             | 13. Element support  | 21. Drain cock                    |
| 6. Spring             | 14. Retainer         | 22. Vent plug                     |
| 7. Seal               | 15. Filter housing   | 23. Vent plug washer              |
| 8. Handle             | 16. Mounting bracket |                                   |

Figure 9. Bypass Oil Filter

#### 1. Lubricating Oil

Lubricating oil must be of the best quality available and be of proper SAE weight. (Refer to Topic 6.) Keep oil free of water and abrasives by proper handling and storage.

#### 2. Daily Check

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

#### 3. Cooling System Temperature

It is important the cooling system temperature be maintained at 180° F (355 K) minimum, so lubricating oil will be hot enough for proper filtering. Low cooling system temperature will cause low oil temperature, and consequently, poor filtering of lubricating oil. This, in turn, will result in rapid wear of all moving parts.

#### 4. Engine Breather Tube

The purpose of the breather tube is to vent the inside of the engine to the atmosphere thus preventing pressure build-up and removing harmful vapors from the crankcase, gear train, and valve compartment. If the tube becomes clogged, vapors are trapped within the engine, and pressure buildup will force oil past crankcase seals, dipstick, cylinder headcover gasket, etc.

At each 600 hours of operation, remove breather tube from the cylinder head cover. Clean inside of tube with cleaning solvent, blow out with compressed air, and replace on engine.

#### 5. Oil Pressure Regulating Valve

The oil pressure regulation valve (Fig 10) is located in the main oil gallery on the right side of the cylinder block near the end of the injection pump. Function of the valve is to maintain stabilized oil pressure within the lubrication system. When oil pressure

at the regulating valve exceeds approximately 50 psi (345 kN/m<sup>2</sup>), the valve piston is raised off the valve piston seat, and oil is bypassed directly from the cylinder block to the oil pan.

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

NOTE: The current adjusting screw has a Lok-thread and therefore does not require a gasket, nylon pellet or jam nut to prevent oil leakage or loosening, as was the case with the early type adjusting screw.

After each operating interval of 4500 hours, remove, clean, and inspect the valve parts as follows:

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

a. Valve Adjusting Screw (Current Type)

Remove the regulating valve adjusting screw, noting number of turns required for removal.

b. Valve Adjusting Screw (Early Type)

Loosen jam nut and remove regulating valve screw, noting number of turns required for removal.

c. Withdraw the spring, and piston.

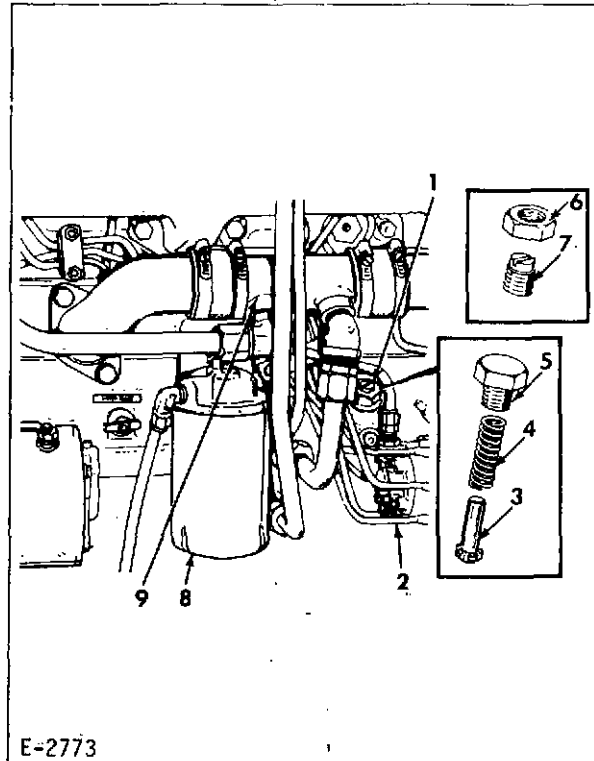
d. Wash valve parts in cleaning solvent and inspect carefully for wear or damage. Replace any necessary parts.

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

f. Thoroughly clean valve bore in cylinder block and install the regulating valve components.

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

g. Start engine and allow it to reach normal operating temperature. Adjust oil pressure regulating valve screw to obtain oil pressure of 45 psi



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1. Regulating valve location
2. Injection pump
3. Piston
4. Spring
5. Valve adjusting screw (current type replaces early type)
6. Jam nut (early type)
7. Valve adjusting screw (early type)
8. Fuel filter
9. Oil cooler

Figure 10. Oil Pressure Regulating Valve Location and Details

(310 kN/m<sup>2</sup>) at high idle engine speed. No further adjustment should be necessary.

NOTE: On early type units make certain the jam nut is tightened securely.

G. ENGINE OIL COOLER

After the engine oil passes through the filter assembly it is directed to 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 cooler 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 installations procedures of the oil cooler.

## TOPIC 14. ENGINE ELECTRICAL SYSTEM

### A. GENERAL

A conventional electrical system includes the starter, alternator, voltage regulator, and batteries. Current is supplied by the wet cell type storage batteries. The system has a negative ground.

NOTE: The starter, battery charging alternator, and regulator are supplied by either the OEM manufacturer or Allis-Chalmers. Ascertain the supplier of the equipment. The data in this topic is for the electrical equipment assembled to the engine by Allis-Chalmers.

The basic units of the charging circuit are the batteries, alternator, and regulator. The batteries are the storage plant for electrical energy and must be kept fully charged while using a minimum amount of water. Electrical energy, drained from the batteries, is replaced by the alternator. Too much power output will usually burn out the alternator or damage the batteries. To prevent this a voltage regulator is connected into the circuit.

### B. WARRANTY AND ADJUSTMENT

Manufacturers of the battery, starter, 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 manufacturer, not to Allis-Chalmers. Suppliers of such equipment are represented by distributors or dealers in nearly all cities who are authorized to make reasonable adjustments or replacements. Always provide model and serial number of the engine and date it was delivered.

### C. BATTERY

1. If liquid level is low, add distilled water to bring level of each cell up to bottom of filler hole. DO NOT OVERFILL.
2. Be sure filler plugs are tight and plug vents are open.

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

3. Periodically check external condition of batteries and cables. Keep batteries clean and secured. If batteries are dirty, clean with a soda solution and

brush; filler plugs must be tight to prevent solution from entering cells. After foaming stops, flush with clean water.

CAUTION: When any work is performed on the electrical charging system, disconnect the battery ground cable to prevent short circuits.

4. After cleaning, apply a thin coat of vaseline to posts and cable terminals.
5. In below freezing temperatures, keep batteries in a fully charged condition.

CAUTION: When charging battery it is very important that the polarities of the battery and charger agree; connect positive to positive and negative to negative. When using booster batteries observe the same polarity rule.

6. Check charge condition or specific gravity with a hydrometer with electrolyte temperature at 80° F (300K).

1.110 to 1.135... Completely discharged  
1.170 to 1.200..... 1/4 charged  
1.205 to 1.230..... 1/2 charged  
1.235 to 1.260..... 3/4 charged  
1.265 to 1.290..... Fully charged

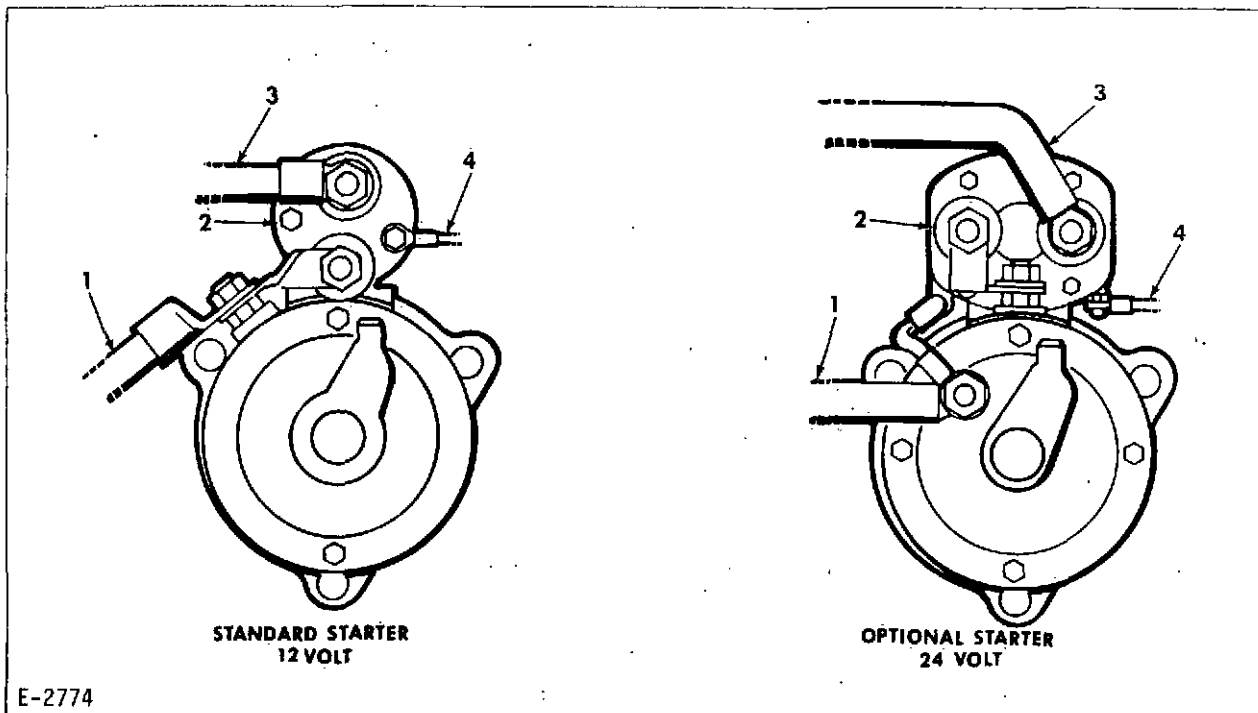
Specific gravity readings without correction for temperature are practically meaningless. For each 10° F (5.55 K) that the temperature of the electrolyte is above 80° F (300 K) add 4 points to the hydrometer reading, and for each 10° F (5.55 K) that the temperature is below 80° F (300 K) subtract 4 points to obtain true specific gravity.

Example:

Hydrometer reading..... 1.250  
Electrolyte temperature.... 20° F (267 K)  
Degrees below 80° F (300 K)... 60° F (289 K)  
Four (4) points each 10° F (5.55 K)... 24

Hydrometer reading	1.250
No. of points subtracted	24
True specific gravity	1.226

CAUTION: In cold weather batteries with a specific gravity of 1.110 will freeze at 18° (265 K); batteries with a specific gravity of 1.220 will freeze at -31° F (238 K).



1. Cable (ground)  
2. Starter solenoid

3. Cable (to positive post of battery)  
4. To starter switch

Figure 1. Starter

#### D. ELECTRIC STARTING MOTORS

Both the standard starter (12 volts) and the optional (24 volts) are the heavy duty type.

The solenoid switch for closing the starting circuit is an integral part of the starter. A shift lever in the drive housing is connected by linkage to the solenoid switch so that operation of the solenoid not only closes the circuit between battery and starting motor, it also shifts the drive pinion into mesh. The starting motor electrically cranks the engine when the starting switch closes the circuit between it and the storage battery. During starting, the action of the starting motor should be noted. The starting motor should take hold promptly and spin the engine. After the engine starts, and the starting motor switch is opened, the starting motor should stop operating.

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

#### 2. Removal and Installation

- a. Disconnect battery ground cable at battery.

- b. Disconnect cables and lead wires from the starter.
- c. Remove capscrews and lockwashers attaching the starter to the flywheel housing and remove starter and starter adaptor.
- d. Install starter by a direct reversal of removal procedure. Connect cables and wires to starter.

#### 3. Maintenance

- a. During startup, note starting motor action. The starter 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. Inspection checks include a periodic investigation of battery condition, battery cables and connections, starting motor, solenoid switch, commutator,

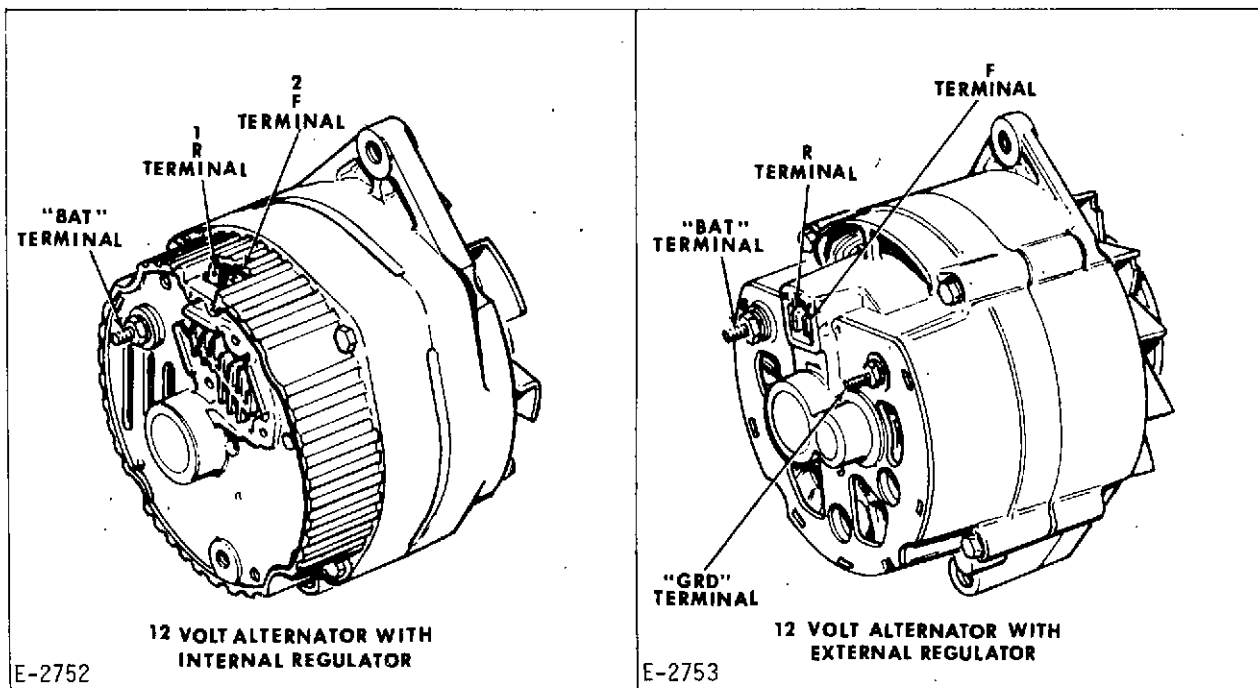


Figure 2. Alternators

brushes, lead connections, and mounting.

- d. Starter motor bearings are lubricated with SAE No. 10 oil only when unit is disassembled for inspection or repair.
- e. Inspect the brushes for wear. If they are worn excessively when compared with a new brush, they should be replaced. Make sure the brush holders are clean and the brushes are not binding in the holders. The full brush surface should ride on the commutator to give proper performance. Check by hand to insure that the brush springs are giving firm contact between the brushes and commutator. If the springs are distorted or discolored, they should be replaced.
- f. A dirty commutator should be cleaned with #00 sandpaper.

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

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 a lead and damaging the diodes when removing and installing an alternator or regulator, always remove the ground cable from the battery.

2. Description

The alternators (Fig 2) are similar in construction except for the voltage regulators. One type has an internal (built in) regulator and the other an external regulator (Fig 3). The internal regulator is a solid state type regulator that is mounted inside the alternator slip ring end frame. All regulator components are enclosed into a solid mold, and this unit along with the brush holder assembly is attached to the slip ring end frame. The regulator voltage setting never needs adjusting, and no provision for adjustment is provided. Six rectifier diodes are located at the slip ring end of the alternators and change the a.c. to d.c. voltage which appears at the BAT (battery) terminal of the alternators.

E. ALTERNATOR

1. General

The standard equipment alternator and regulator is rated at 12 volt. See Topic 2, titled Specifications, for ratings of alternators.

### 3. 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.**

### 4. 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" (0.05 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 alternator rotor bearings contain a supply of lubricant sufficiently adequate to eliminate the need for periodic lubrication. 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.

### F. VOLTAGE REGULATOR

#### 1. General

The voltage regulator (Fig 3) is used with the alternator (Fig 2) requiring an external regulator.

The voltage regulator is a two-unit regulator consisting of a voltage regulator unit and field relay unit. The voltage regulator unit operates to limit alternator voltage to a preset value, whereas the field relay unit connects the alternator field winding and regulator winding directly to the battery.

The two-unit 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.

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

#### 2. Voltage Regulator Removal

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

- b. Remove attaching capscrews, nuts and lockwashers and remove regulator.
- c. Install voltage regulator in reverse order of removal.

### 3. Maintenance

Do not clean voltage regulator contacts unless performance indicates cleaning is necessary. A sooty or discolored appearance of contacts is normal after a relatively short period of operation and is not an indication that cleaning is necessary. However, if the voltage fluctuates, as evidenced by an unsteady voltmeter indication, contacts may have excessive resistance or be sticking and therefore should be cleaned.

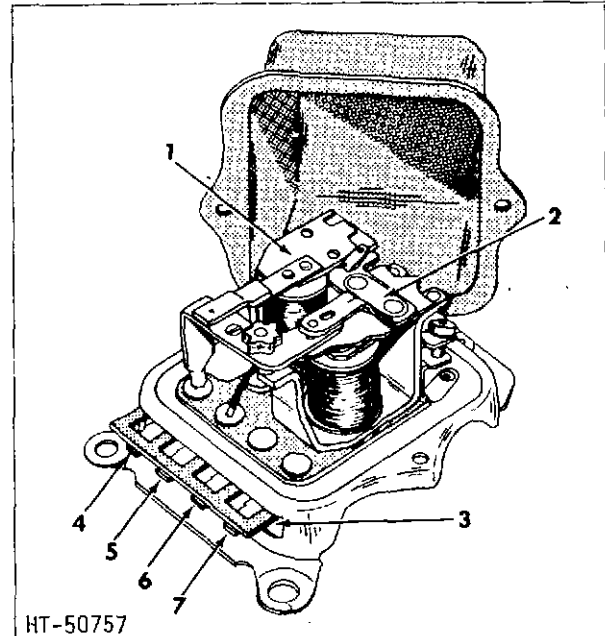
**CAUTION:** Before cleaning, make sure fluctuating voltage is not caused by loose connections or high resistance elsewhere in the system.

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 trichloroethylene 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. 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-33-74) 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



- |                           |                   |
|---------------------------|-------------------|
| 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 3. Two-Unit Voltage Regulator

retighten old belts and pulleys to 105 pounds (48 kg).

3. To obtain proper belt tension, loosen the alternator adjusting brace capscrew and mounting screw and move alternator in or out as required.

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

4. Retighten the capscrew.

### H. WIRING DIAGRAM

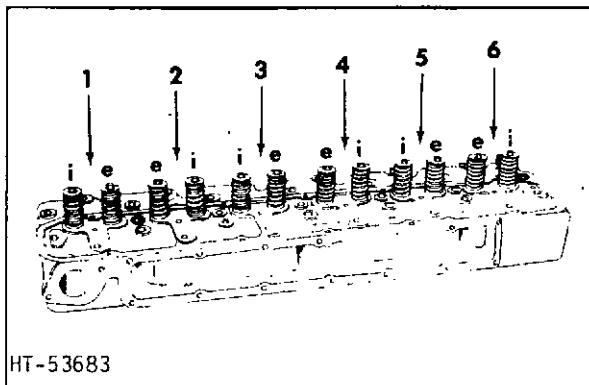
To connect the electrical components, refer to the interconnection wiring diagrams in the owner's manual covering the equipment being driven by the engine.

## TOPIC 15. VALVE ADJUSTMENT AND CYLINDER HEAD

### A. VALVE LASH ADJUSTMENT

Correct clearance (valve lash) between end of intake valve stem, exhaust valve stem, and related rocker areas, is very important in diesel engine performance because of high compression developed within the cylinders. Insufficient valve lash will cause loss of compression, misfiring, and eventually lead to burning of valves and valve seats. Excessive valve lash will result in faulty engine operation, valve lifter noise, and cause rapid wear on the valve operating mechanism. With engine coolant temperature at a minimum of 160°F (344 K), specified valve lash for both intake and exhaust valves is 0.015" (0.38 mm). After any mechanical work has been done that may have disturbed the valve lash adjustment, set valves "cold" at 0.018" (0.45 mm) clearance so engine can be run and allowed to warm to normal operating temperature. After engine coolant temperature has reached a minimum of 160°F (344 K), check valve lash again for proper clearance.

**CAUTION:** After any mechanical work has been done that may have disturbed the valve lash adjustment, make certain the rocker arm adjusting screws are turned upward (counter clockwise) high enough to prevent rocker arms and push rods from opening valves too far. If rocker arms and push rods open valves too far, the piston will strike the valves when engine is cranked.

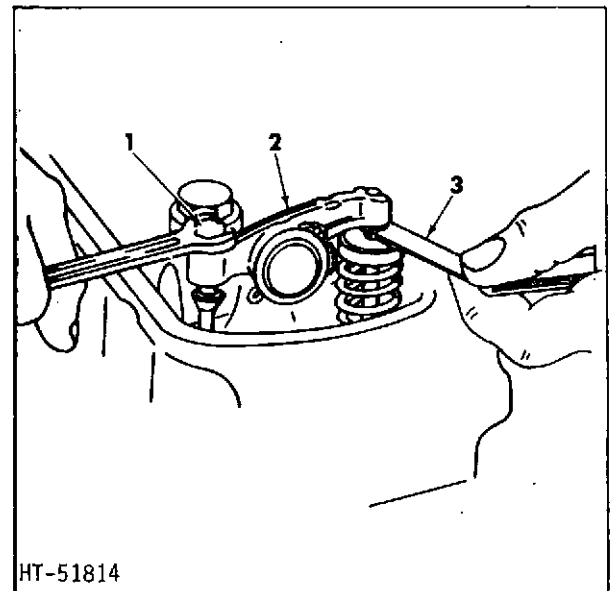


- |  |  |
|--|--|
| 1. No. 1 Cylinder<br>i. Intake Valve<br>e. Exhaust Valve | 4. No. 4 Cylinder<br>e. Exhaust Valve<br>i. Intake Valve |
| 2. No. 2 Cylinder<br>e. Exhaust Valve<br>i. Intake Valve | 5. No. 5 Cylinder<br>i. Intake Valve<br>e. Exhaust Valve |
| 3. No. 3 Cylinder<br>i. Intake Valve<br>e. Exhaust Valve | 6. No. 6 Cylinder<br>e. Exhaust Valve<br>i. Intake Valve |

Figure 1. Valve Locations

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 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. Run engine until coolant temperature of 160°F (344 K) minimum is reached. Stop the engine.
2. Thoroughly clean cylinder head cover and surrounding area.
3. Remove breather tube, capscrews, washers, and cylinder head cover.



1. Adjusting Screw \*
2. Rocker Arm
3. Feeler Gauge

\* Adjusting screw must be replaced when less than 36 lb-in (4.07 Nm) driving torque is required to turn it.

Figure 2. Adjusting Valve Lash

4. Crank engine until exhaust valve for Number 6 cylinder is almost closed and intake valve starts to open, then check and adjust intake and exhaust valve lash for Number 1 cylinder.
5. Use a 0.015" (0.38 mm) 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 turning adjusting screw clockwise to decrease clearance or counterclockwise to increase clearance as necessary.
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

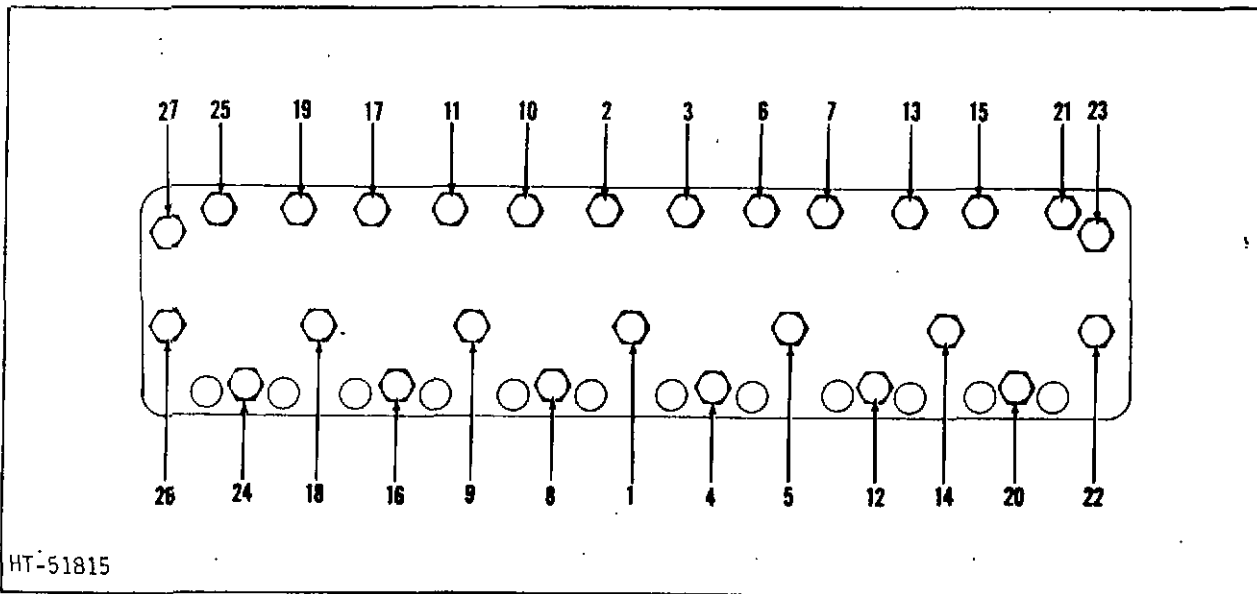
for intake and exhaust valves for Number 2 cylinder, following procedure in preceding Steps 5 and 6.

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.

#### B. TORQUING CYLINDER HEAD

If the cylinder head is removed for any reason, such as repair, overhaul, etc., the cylinder head capscrews must be tightened evenly and in the sequence illustrated in Figure 3. A new cylinder head gasket must be used when installing the cylinder head. Make certain the gasket is installed with the indicated side down. Install cylinder head as follows:

1. Thoroughly clean top deck of cylinder block and under-side of cylinder head.
2. Check for specified 0.002" to 0.005" (0.05 to 0.12 mm) cylinder sleeve protrusion above top deck of block. Correct, if necessary, by reconditioning sleeve seat in block with recommended tool and installing sleeve shims under sleeve flange to obtain 0.002" to 0.005" (0.05 to 0.12 mm) protrusion.
3. Install new gasket on cylinder block with indicated side down as stamped on gasket. Follow instructions packaged with service cylinder head gasket. Do not use sealer or gasket dope. The gasket as supplied has been pre-coated with phenolic sealer and an anti-stick compound.



HT-51815

Figure 3. Cylinder Head Capscrew Locations and Torquing Sequence

4. Install the cylinder head, rocker arm assembly, and all capscrews after lubricating their threads and underhead areas with a light coat of engine lubricating oil. Tighten 3/8" (9.525 mm) capscrews in rocker arm brackets to 30 lb-ft (41 Nm) torque. Torque 9/16" (14.288 mm) capscrews to 70 lb-ft (95 Nm) in the numerical sequence as specified in illustration.

CAUTION: Torque figures in this and following steps are based on engine oil lubricated threads. To prevent over-stressing of capscrews, do not use extreme pressure lubricants of any kind.

5. Tighten all 9/16" (14.288 mm) capscrews in the numerical sequence specified in illustration to 165 lb-ft (224 Nm) torque.
6. Retighten all 9/16" (14.288 mm) capscrews in the numerical sequence specified in illustration to 165 lb-ft (224 Nm) torque. Also recheck torque on 3/8" (9.525 mm) capscrews in the rocker arm brackets (30 lb-ft) (41 Nm).
7. Adjust both intake and exhaust valves to a cold valve lash clearance setting of .018" (0.45 mm). Run the engine preferably under load with a minimum water temperature of 160°F (344 K).
8. Retighten capscrews in the numerical sequence specified to 165 lb-ft (224 Nm) torque. If a capscrew does not move when this specified torque is reached, loosen slightly and retighten to the specified torque. (This is important to eliminate possible false torque readings due to temporary thread seizure.)
9. Adjust valve lash clearance settings to .015" (0.38 mm) hot (refer to preceding Paragraph A).

## 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.

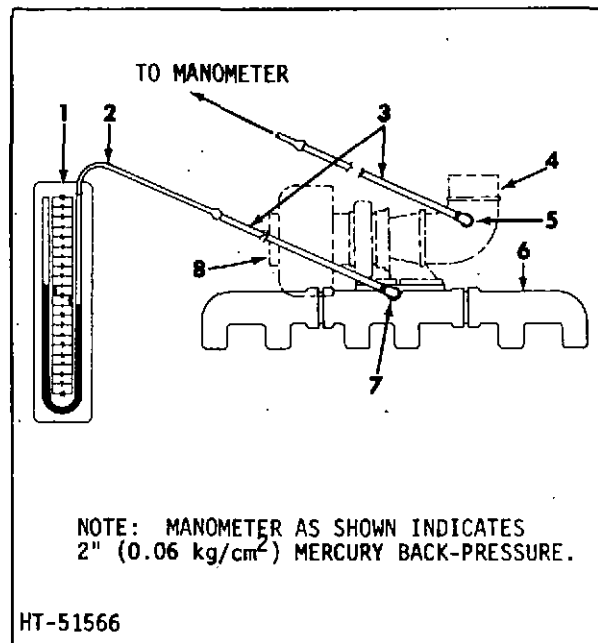
Total restriction of the entire exhaust system of a naturally aspirated engine at the exhaust outlet with engine under full speed, full load conditions, must not exceed 3" (0.104 kg/cm<sup>2</sup>) mercury back-pressure. Total restriction of the entire exhaust system of a turbocharged engine must not 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 material from air used by the engine. Engine life depends largely on efficiency of the air cleaner. Rapid wear on cylinder sleeves, pistons, and rings will result if it is not kept in good condition and properly serviced.

Light duty and heavy duty air cleaners are available for this series of engines. Frequency of servicing required, regardless of air cleaner used, depends on amount of foreign material in air surrounding working location of the engine.

Allis-Chalmers supplied air cleaners are equipped with a filter service indicator. Service the filter when so indicated. However, 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.

Inspect air cleaner body periodically for dents, cracks, etc. Also check for damaged gaskets and hoses, loose hose clamps, and for leaks that allow air to enter engine without first passing through the filter element. Correct any such condition found by immediate repair or replacement of faulty parts.

NOTE: Always refer to instruction on air cleaner.

### B. SERVICE

#### 1. Donaldson Air Cleaner - Dry Type

The Donaldson Dry Type air cleaner is mounted horizontally with the stack cap in vertical position. Inspect dust cup daily or prior to operating the engine. Do not allow dust level to build up to less than one-half inch from slot in dust cup baffle. Each time air cleaner is serviced, inspect stack cap and clean as required.

When servicing the air cleaner, reduce engine down time to a minimum by replacing a dirty filter element with a new element or one that has been cleaned. Service the dirty element later, using procedures detailed below in Optional Service Methods.

##### a. Air Cleaner Service

(1) Clean baffle and dust cup as follows:

(See Figure 2).

- (a) Loosen clamp assembly and remove dust cup.
- (b) If applicable loosen wing nut securing baffle to dust cup. Remove baffle from dust cup.
- (c) Empty dirt from cup. Clean cup and baffle.

NOTE: Empty and clean dust cup and baffle daily or more often if required. Dust level must not be allowed to build up to less than one-half inch from slot in dust cup baffle.

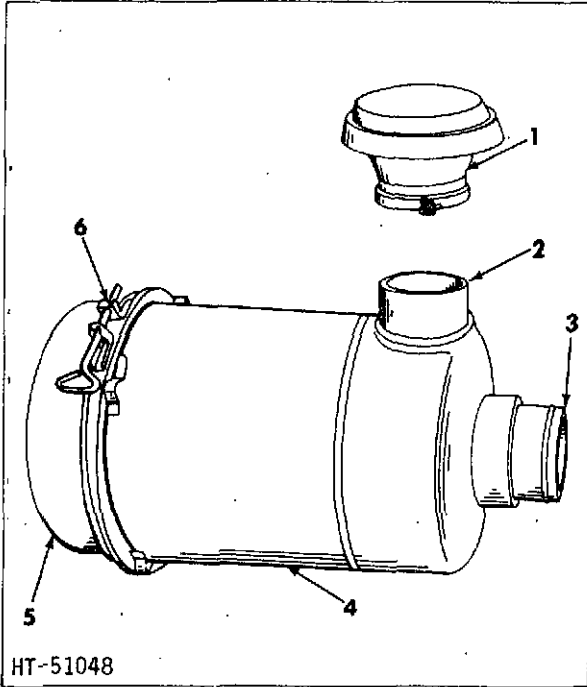
- (d) Remove foreign material from around filter element.
- (e) Assemble baffle to dust cup. Tighten wing nut.
- (f) Position dust cup on air cleaner body.

CAUTION: Bottom of dust cup is marked with arrows and the word TOP. Air cleaner is mounted in horizontal position. Be sure dust cup arrows point up (Fig 2). Do not use oil in dust cup.

(2) Replace filter element as follows:

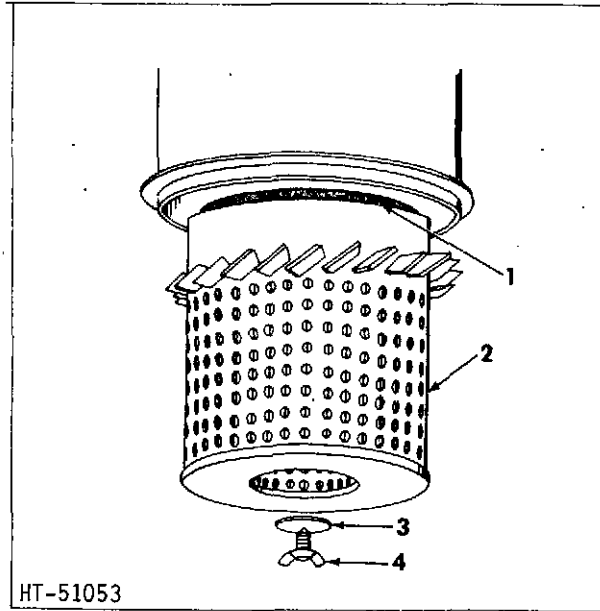
- (a) Clean or replace filter element when red signal covers exposed section of window on air filter service indicator.
- (b) Remove wing screw and gasket washer. Remove filter element.
- (c) Inspect element gasket for damage.
- (d) Install a new or clean element. Inspect cup gasket (if applicable) and replace if it is damaged.
- (e) Install dust cup on air cleaner body.

CAUTION: Air cleaner is mounted in horizontal position. Be sure dust cup arrows point up. (See Fig. 2. Do not use oil in dust cup. Always refer to manufacturers instructions on air cleaner.



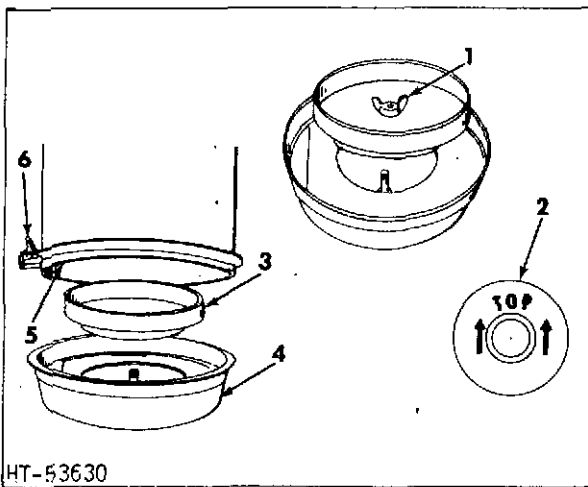
- 1. Stack cap
- 2. Air inlet
- 3. Air outlet
- 4. Body
- 5. Dust cup
- 6. Clamp assembly

Figure 1. Donaldson Dry Type Air Cleaner



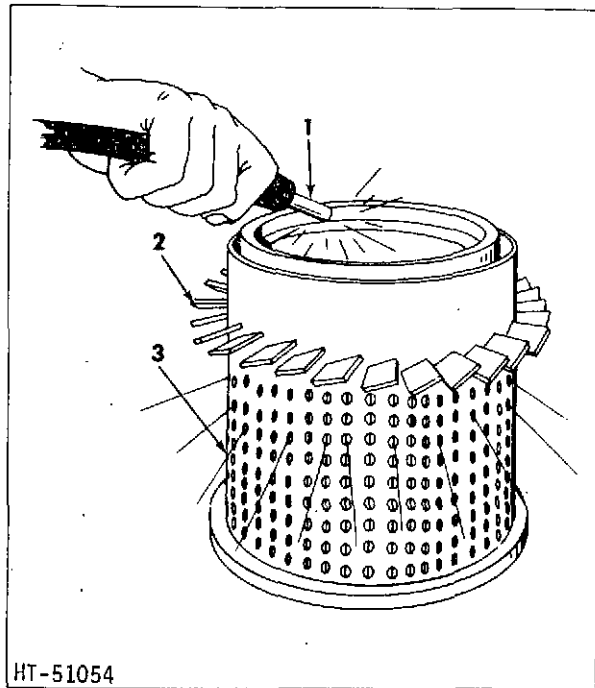
- 1. Element gasket
- 2. Filter element
- 3. Gasket washer
- 4. Wing screw

Figure 3. Removing Filter Element



- 1. Wing nut
- 2. Dust cup bottom
- 3. Baffle
- 4. Dust cup
- 5. Cup gasket
- 6. Clamp assembly

Figure 2. Baffle and Dust Cup Details



- 1. Nozzle
- 2. Pre-cleaning fins
- 3. Filter element

Figure 4. Dry Cleaning Filter Element

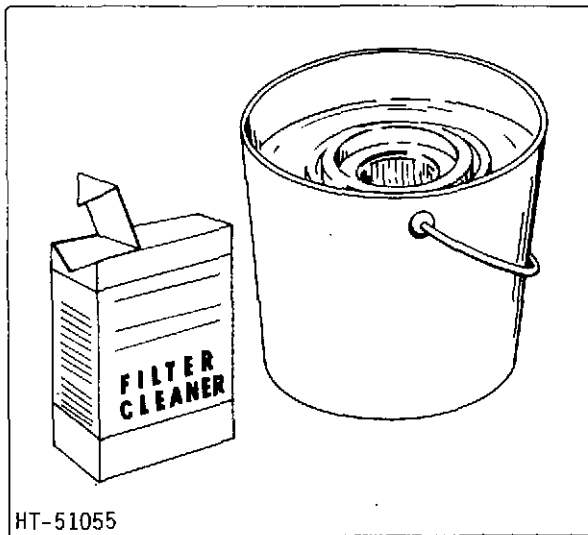


Figure 5. Washing Filter Element

(f) Reset service indicator by pressing reset button on top of indicator.

b. Optional Service Methods

The filter element can be either dry cleaned or washed as detailed below.

**CAUTION:** Pre-cleaning fins on filter element are not removable.

(1) To dry clean filter element, direct a jet of dry clean air up and down pleats on clean air side of element.

**CAUTION:** Air pressure at nozzle must not exceed 100 psi (689 kN/m<sup>2</sup>). Maintain reasonable distance between nozzle and filter element.

(2) If filter element is oily and soot laden, wash it in filter cleaner available from Allis-Chalmers dealers. For best results, mix 2 ounces (56.70 g) of cleaner with a small amount of cool tap water. Add warm (70° to 100°F) (294 to 311 K) water until total volume equals one gallon (3.875 lts). The warmer (100°F) (311 K) the solution, the better it will clean. Soak element for 15 minutes, then remove it and rinse thoroughly with clean, running water (maximum pressure 40 psi) (276 kN/m<sup>2</sup>). Air dry thoroughly before reusing. (A fan or air draft may be used for drying, but do not heat element to hasten drying.)

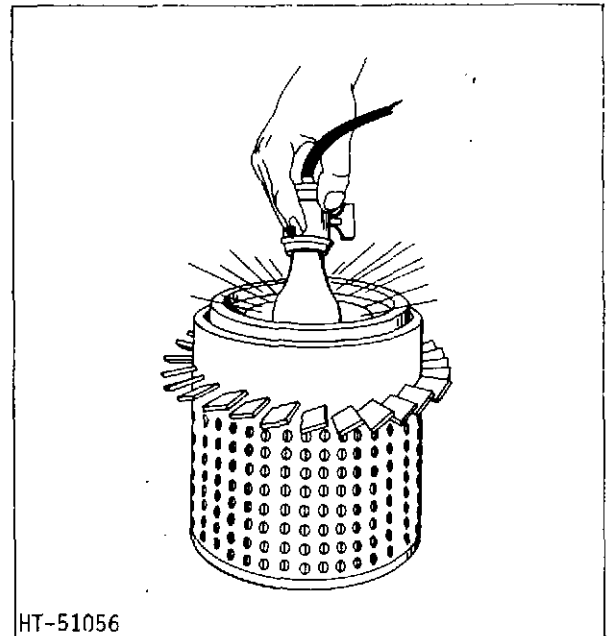


Figure 6. Inspecting Filter Element

(3) Inspect for damage by placing a bright light inside element (Fig 6). Thin spots, pin holes or the slightest rupture will render the element unfit for further use.

**NOTE:** Replace filter element after 6 cleanings.

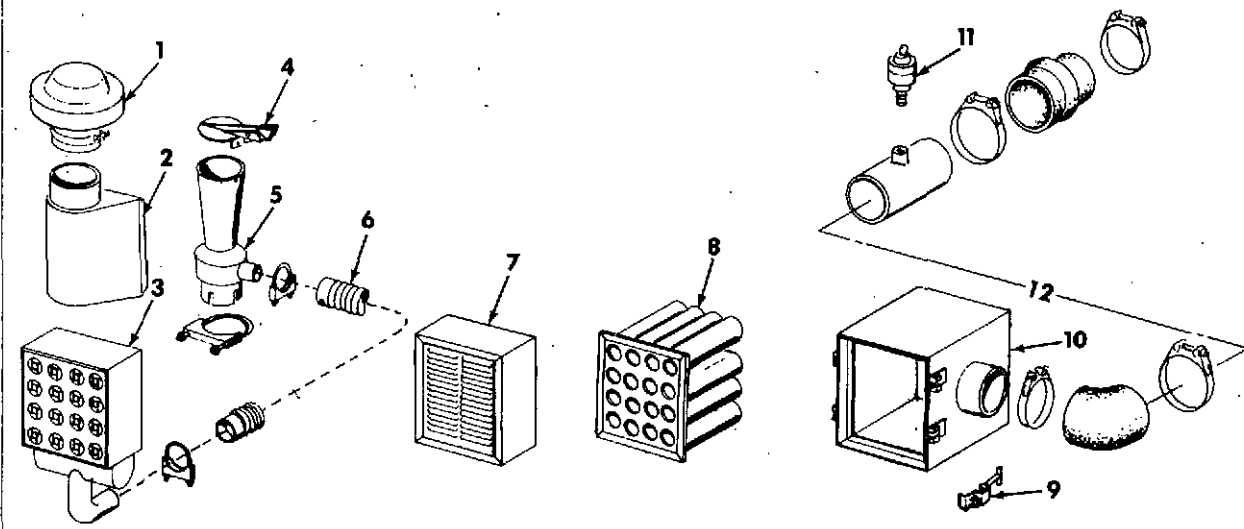
2. FARR Extra Heavy Duty Dry-Type Cleaner

- a. Loosen clamp securing flexible hose to precleaner elbow (Fig 7).
- b. Loosen fasteners on air cleaner housing. Remove precleaner.

**NOTE:** Dust particles are removed from the precleaner through the action of the aspirator and therefore, the precleaner requires no service.

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

Heavy Duty Air Cleaner consist of items 7 through 12. Extra Heavy Duty Air Cleaner consist of all items illustrated except item 1, 2, and 7.



E-2749

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|--|--|
| <ul style="list-style-type: none"> <li>1. Stack cap (2800 2900)</li> <li>2. Vertical inlet adaptor (2800 2900)</li> <li>3. Precleaner</li> <li>4. Rain cap</li> <li>5. Aspirator</li> <li>6. Precleaner to aspirator hose</li> </ul> | <ul style="list-style-type: none"> <li>7. Moisture eliminator (2800 2900)<br/>(cannot be used with precleaner)</li> <li>8. Element</li> <li>9. Clamp</li> <li>10. Housing</li> <li>11. Service indicator</li> <li>12. Piping to intake manifold</li> </ul> |
|--|--|

Figure 7: Farr Type Air Cleaner - Extra Heavy Duty

NOTE: Do not clean or reuse dirty element. Inspect dirty element for soot or oil. If there is soot inside the tubes, check for leaks in the engine exhaust system or exhaust from other equipment. If the element appears to have an oily film, check for fumes escaping from the breather tube. Correct any of these conditions, if necessary, before a new element is installed.

d. Inspect inside of housing and remove all foreign material.

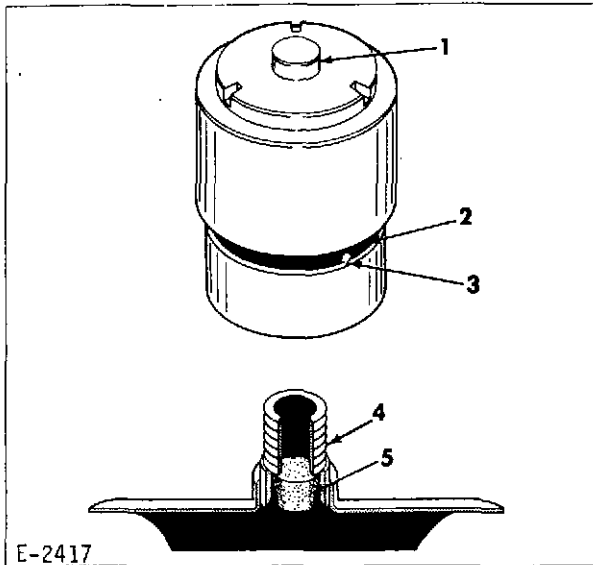
CAUTION: Inspect new element for shipping damage before installation.

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

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

f. Wipe off face of precleaner and position it on the housing. Secure precleaner with fasteners attached to housing and tighten fasteners to 72 lb in (8 Nm) torque. If a torque wrench is not available, tighten each fastener finger tighten, then turn each an additional one and one-half turns with a suitable wrench. Tighten fasteners in diagonal sequence, not direct sequence, to assure a uniform seating procedure.

NOTE: If, at a later date, inspection of the fasteners indicates that they are at less than 72 lb in (8 Nm) torque, this is due to a slight set in the plastic face of the element and does not impair the seal between the element and the housing. Retightening of the fasteners is not recommended, unless that are loose, as this may break the seal which has been formed.

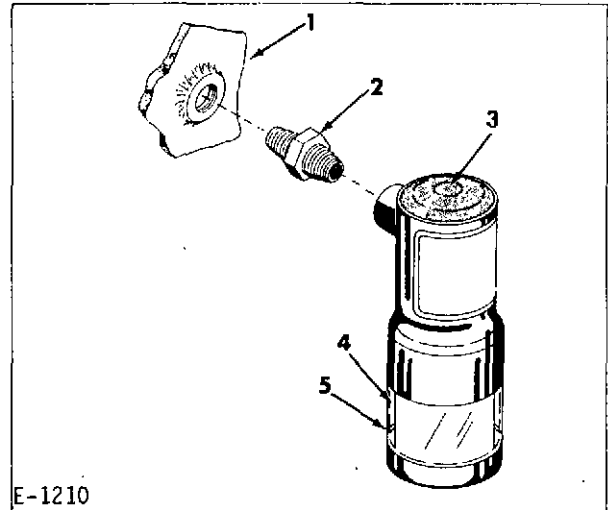


1. Reset button
2. Red signal
3. Window
4. Connector with sintered filter
5. Sintered filter

Figure 8. Service Indicator - Current Type

- g. Inspect flexible hose and clamps; replace if necessary. Install flexible hose over end of pre-cleaner elbow and tighten clamp.
- h. Make certain all connections, including aspirator, are air tight.
- i. Reset service indicator by pressing reset button on top of indicator (Figure 8 and 9).

**CAUTION:** The only allowable modification that can be made to the Farr aspirator is the addition of an exhaust pipe extension to the large end of the cone. A maximum of 4 feet (101.60 mm) of straight exhaust pipe of at least the same diameter as the large end of the cone may be added. When an exhaust extension longer than 4 feet (101.60 mm) is required, resizing of the aspirator is necessary. The size and shape of the cone of the aspirator must never be modified in service. If the aspirator system must be modified from its original configuration, or if extensions longer than 4 feet (101.60 mm) are required, consult your Allis-Chalmers dealer to assist in its design and modification.



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

Figure 9. Service Indicator - Early Type

#### C. AIR FILTER SERVICE INDICATOR

Purpose of the service indicator (Fig 8 and 9) which is factory set, is to provide a visual signal when the air cleaner is in need of servicing. The operator can ascertain the degree of filter contamination by observing the indicator during periods of actual engine operation.

Dirt trapped by the air cleaner gradually reduces volume of air flow through the filter and increases the air cleaner-to-engine pressure drop. As pressure flow decreases, the red signal of the filter indicator gradually moves in the window and when fully exposed is locked in position. At this time the air cleaner should be serviced or the element replaced or serviced. After servicing, reset signal by pressing reset button located on top of the service indicator.

Indicators are connected to the outlet side of the air cleaner by a connector that contains a sintered filter. If seals in the indicator rupture, the filter in the connector will prevent dust and other foreign material from entering the engine. If seals are damaged, the service indicator must be replaced.

## TOPIC 18. TURBOCHARGER

### A. GENERAL

An AiResearch Model T-04B turbocharger is used to boost the power output of an engine over that of a naturally aspirated engine by increasing the supply of air to the cylinders. The turbocharger is a 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.

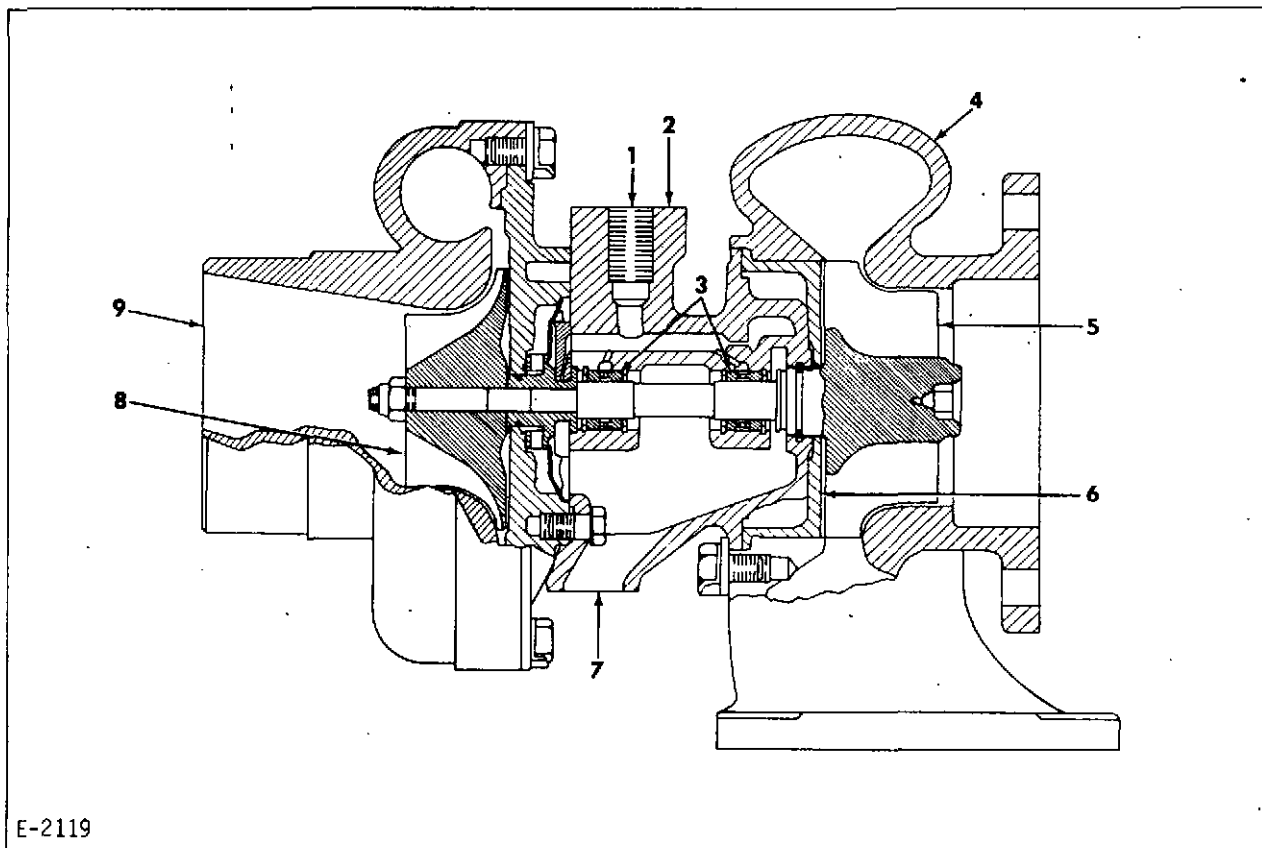
### B. OPERATION

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

to the intake manifold. After combustion, the exhaust gases enter the 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 bearings are lubricated and

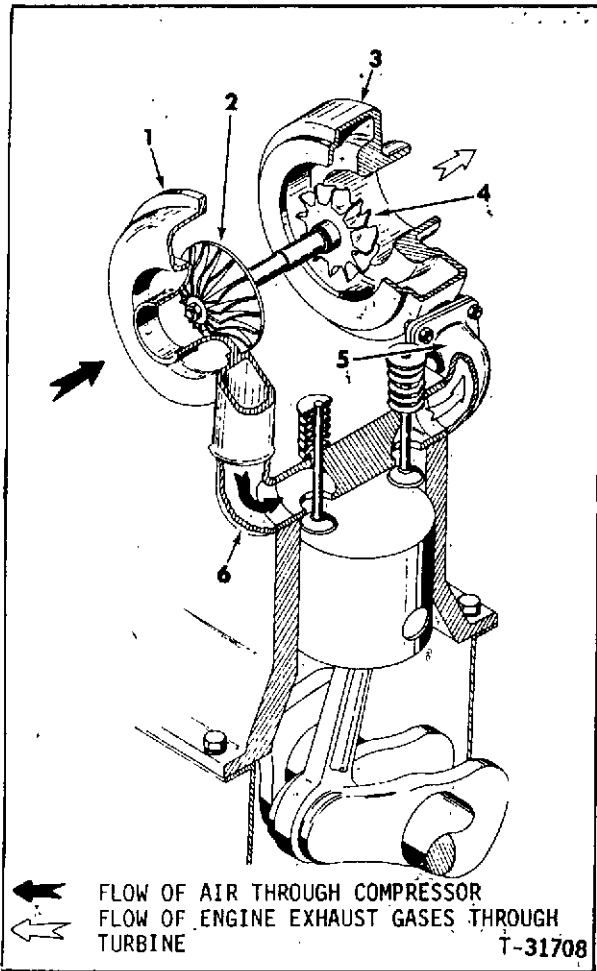


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|----------------------------|-----------------------|
| 1. Oil inlet               | 6. Turbine shield     |
| 2. Center housing assembly | 7. Oil outlet         |
| 3. Bearings                | 8. Compressor wheel   |
| 4. Turbine housing         | 9. Compressor housing |
| 5. Turbine wheel           |                       |

Figure 1. Turbocharger - Sectional View

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.

**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.**



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

Figure 2. Turbocharger Operation Diagram

### 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. In continuous type operation the turbocharger must not exceed 130,000 rpm.
2. In an intermittent type operation the turbocharger must not exceed 135,000 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 304.8 m) 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 exhaust temperature before the 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.

- 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.

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