GENERAL MOTORS DIESEL

SERIES 71

OPERATOR'S MANUAL

for

THREE, FOUR, AND SIX CYLINDER INDUSTRIAL UNITS

GM GENERAL MOTORS DIESEL POWER

PRICE $3.00

PRODUCT SERVICE SECTION

DETROIT DIESEL ENGINE DIVISION

GENERAL MOTORS CORPORATION

DETROIT 28, MICHIGAN

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FORM 6SE-60

LITHO IN U. S. A. REPRINTED 6-54

FOREWORD

This manual contains instructions on the operation and preventive maintenance of the current General Motors Series 71 Diesel Engines in the 3, 4, and 6 cylinder single and multiple engine industrial models. It is not intended to cover engine repair or overhaul, as such work should be performed by an authorized Detroit Diesel Engine Division Dealer or Distributor.

Sufficient descriptive material, together with numerous illustrations, is included to enable the operator to understand the basic construction of the Series 71 engine and the principles by which it functions.

The operator should familiarize himself thoroughly with the contents of this manual before operating the engine or carrying out adjustment or maintenance procedures.

TABLE OF CONTENTS

PRINCIPLES OF OPERATION

The Diesel Principle—The Diesel engine is an internal combustion power unit, in which the heat of fuel is converted into work in the cylinder of the engine.

In the Diesel engine, air alone is compressed in the cylinder; then, after the air has been compressed, a charge of fuel is sprayed into the cylinder and ignition is accomplished by the heat of compression.

The Two-Cycle Principle—In the two-cycle engine, intake and exhaust take place during part of the compression and power strokes, respectively, as shown in Figures 1, 2, 3 and 4. In contrast, a four-cycle engine requires four piston strokes to complete an operating cycle; thus during one half of its operation, the four-cycle engine functions merely as an air pump.

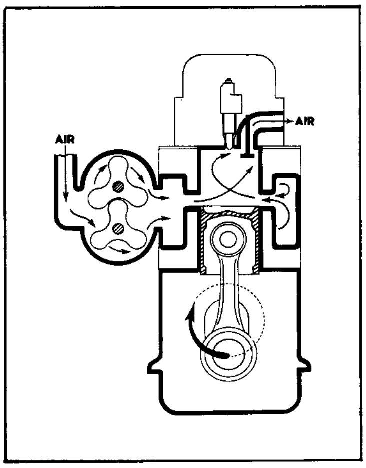


Fig. 1—Scavenging.

A blower, which is mounted on the side of the engine, forces air into the cylinders to expel the exhaust gases and to supply the cylinders with an abundance of fresh air for combustion.

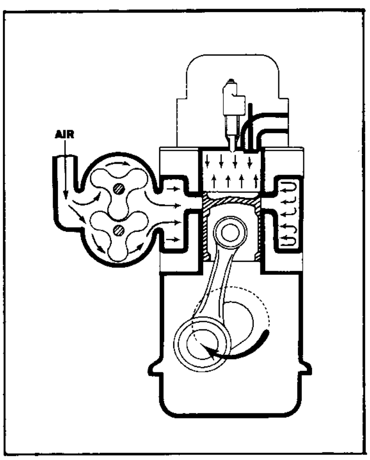


Fig. 2—Compression.

A series of ports cut into the cylinder wall, which are above the piston when it is at the bottom of its stroke, admit the air from the blower into the cylinder as soon as the top face of the piston uncovers the ports, as shown in Fig. 1. The unidirectional flow of air toward the exhaust valves produces a scavenging effect, leaving the cylinders full of clean air when the piston again covers the inlet ports.

As the piston continues on the upward stroke, the exhaust valves close and the charge of fresh air is subjected to the final compression, as shown in Fig. 2.

Shortly before the piston reaches its highest position, the required amount of fuel is sprayed into the combustion space by the unit fuel injector, as shown in Fig. 3. The intense heat generated during the high compression of the air ignites the fine fuel spray immediately, and the combustion continues as long as the fuel spray lasts. The resulting pressure forces the piston downward on its power stroke until the exhaust valves are again opened. As shown in Fig. 4, the burnt gases escape into the exhaust manifold as the downward moving piston is about to uncover the inlet ports.

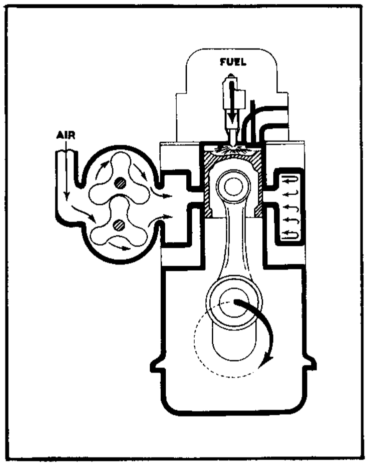


Fig. 3—Power.

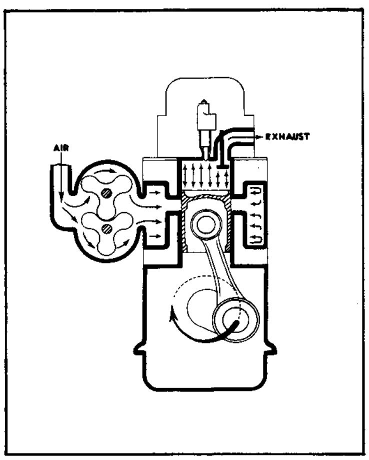


Fig. 4—Exhaust.

When these ports are uncovered, the cylinder is again swept with clean scavenging air, as shown in Fig. 1. This entire combustion cycle is completed in each cylinder for each revolution of the crankshaft, or, in other words, two strokes; hence the **"two-stroke cycle".**

ENGINE STANDARDIZATION

The two-cycle Diesel engines discussed in this text are offered in three, four, and six cylinder models having the same bore and stroke and using the same parts wherever possible. Thus, the major working parts, such as injectors, pistons, connecting rods, bearings, and other parts are interchangeable.

1

ACCESSORY ARRANGEMENT

The blower, water pump, governor, and fuel pump form a group of standard accessories which can be located on either the right or the left side of the engine, regardless of the direction of rotation. Further flexibility in meeting installation requirements is obtained by placing the exhaust manifold and the water outlet manifold on either side of the engine. This variation in the arrangement of parts is secured by having both the cylinder block and cylinder head symmetrical at both ends and with respect to each other. These various arrangements are designated by the letters A, B, C, or D in the model number. Letters R or L in the model number designate the direction of rotation.

Engine Type	On the Left Side	On the Right Side
A	All standard accessories	Exhaust outlet Water outlet
B	All standard accessories Exhaust outlet Water outlet	
C	Exhaust outlet Water outlet	All standard accessories
D		All standard accessories Exhaust outlet Water outlet

Fig. 5—Accessory and Manifold Arrangements (Engine Viewed from the Rear).

ENGINE MODELS

Flexibility in the location of the basic engine accessories (such as the blower, governor, water outlet manifold and exhaust manifold), and a wide range of power take-offs and reduction gears makes it possible to provide a suitable unit to fulfill most requirements.

In the following tabulations of some of the more common single-engine industrial models is shown the interrelation of the model numbers of the three, four, and six cylinder engine units. For each model group, the direction of rotation, the accessory arrangements, and the power take-off is indicated. However, to meet specific requirements, either right- or left-rotating engines can be furnished.

In addition to single engine industrial models, the General Motors Series 71 "Twin" and "Quad" multiple engine power units are designed to deliver increased power to a single drive shaft with important

Unit Model Number			Engine Rotation (See Fig. 5)	Accessory Arrangement (See Fig. 5)	Power Take-Off
3-Cyl.	4-Cyl.	6-Cyl.			
3028C	4028C	6028C	R	C	GM Heavy Duty, Long Shaft and Outboard Bearing.
3029C	4029C	6029C	R	C	GM Heavy Duty, Long Shaft and Outboard Bearing.
3030C	4030C	6030C	R	C	GM Heavy Duty ‡Direct Drive or GM Heavy Duty †1.76 to 1 Reduction.
3031C	4031C	6031C	R	C	GM Heavy Duty ‡Direct Drive or GM Heavy Duty †1.76 to 1 Reduction.
3045C	4045C	6045C	R	C	GM Heavy Duty *Direct Drive or GM Heavy Duty *1.76 to 1 Reduction.
3055C	4055C	6055C	R	A	GM Heavy Duty *Direct Drive or GM Heavy Duty *1.76 to 1 Reduction.
3057C	4057C	6057C	R	C	GM Heavy Duty *Direct Drive or GM Heavy Duty *1.76 to 1 Reduction.
3058C	4058C	6058C	R	C	None.
3061A	4061A	6061A	R	C	GM Heavy Duty †Direct Drive.
	4094	6094	R	A	None.
					‡Standard equipment. *Available as accessory equipment. †Available as optional equipment.

Fig. 6—Single Engine Model Chart.

savings in weight and space.

Each basic engine, making up a multiple engine unit, has an individual clutch and throttle so that one or all engines may be in use or cut out as desired. Thus, flexibility in power output is possible by varying from idling speed on one engine to full throttle on all engines as the load demands.

Below are listed the Twin and Quad models showing the rotation and available gear ratios.

Twin models are equipped with a power transfer assembly as described and illustrated in Sec. 3.

Quad models incorporate either a 1.75:1, 1.5:1, or 1.38:1 reduction gear. The description and operation of the quad reduction gear are given in Sec. 3.

Model	Power Drive Shaft Rotation	Gear Ratios Available	Cooling
8103 8104	LH RH	1:1, 1.33:1, 1.77:1, 2:1	Radiator
12103 12104	LH RH	1:1, 1.33:1, 1.77:1, 2:1	Radiator
12105 12106	LH RH	1:1, 1.33:1, 1.77:1, 2:1	Heat Exchanger
24103 24104	LH RH	1.38:1, 1.5:1, 1.75:1	Radiator

Fig. 7—Multiple Engine Model Chart.

"A" and "C" engines (see Page 5) are used in the Twin and Quad models and left-hand (LH) rotation is obtained at the power drive shaft with the arrangement shown in Figs. 8 and 9. Right-hand (RH) rotation at the power drive shaft is attained by reversing the arrangement of the engines on the base.

It is very important that the operator give the correct model number and reduction gear ratio when contracting his Detroit Diesel Engine Division Dealer or Distributor for service.

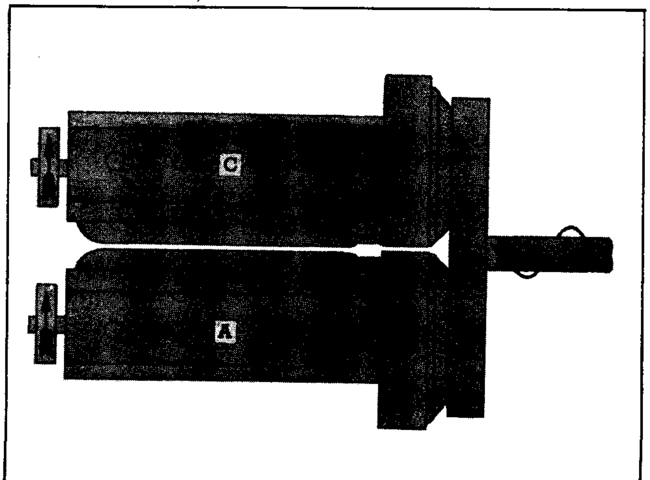


Fig. 8—Typical Twin Engine Unit.

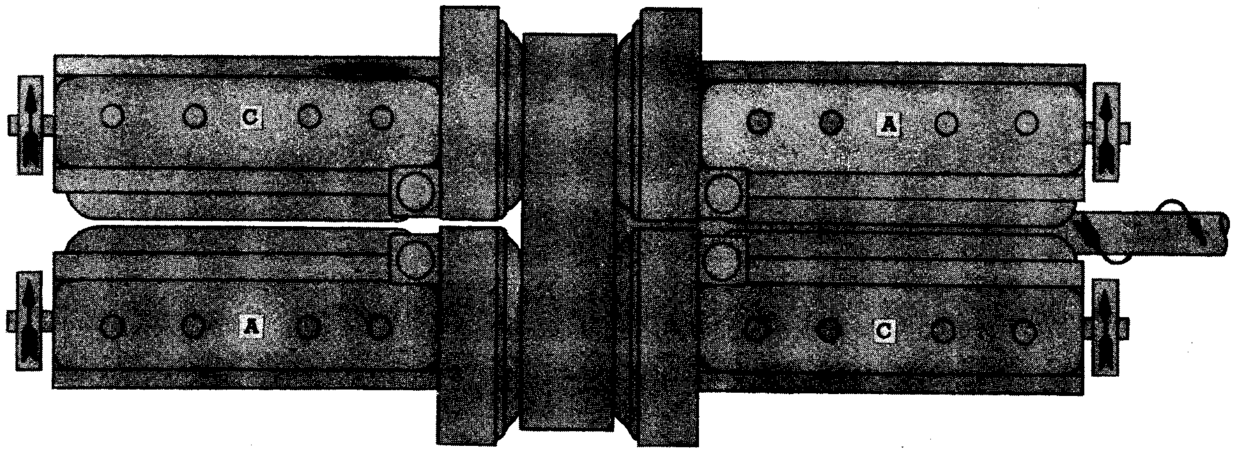


Fig. 9—Typical Quad Engine Unit.

GENERAL SPECIFICATIONS

	3-71	4-71	6-71
Number of Cylinders	3	4	6
Bore	4¼ in.	4¼ in.	4¼ in.
Stroke	5 in.	5 in.	5 in.
Compression Ratio (Nominal)	16 to 1	16 to 1	16 to 1
Total Displacement – Cubic Inches	213	284	425
Firing Order – R.H. Rotation	1-3-2	1-3-4-2	1-5-3-6-2-4
Firing Order – L.H. Rotation	1-2-3	1-2-4-3	1-4-2-6-3-5
Number of Main Bearings	4	5	7

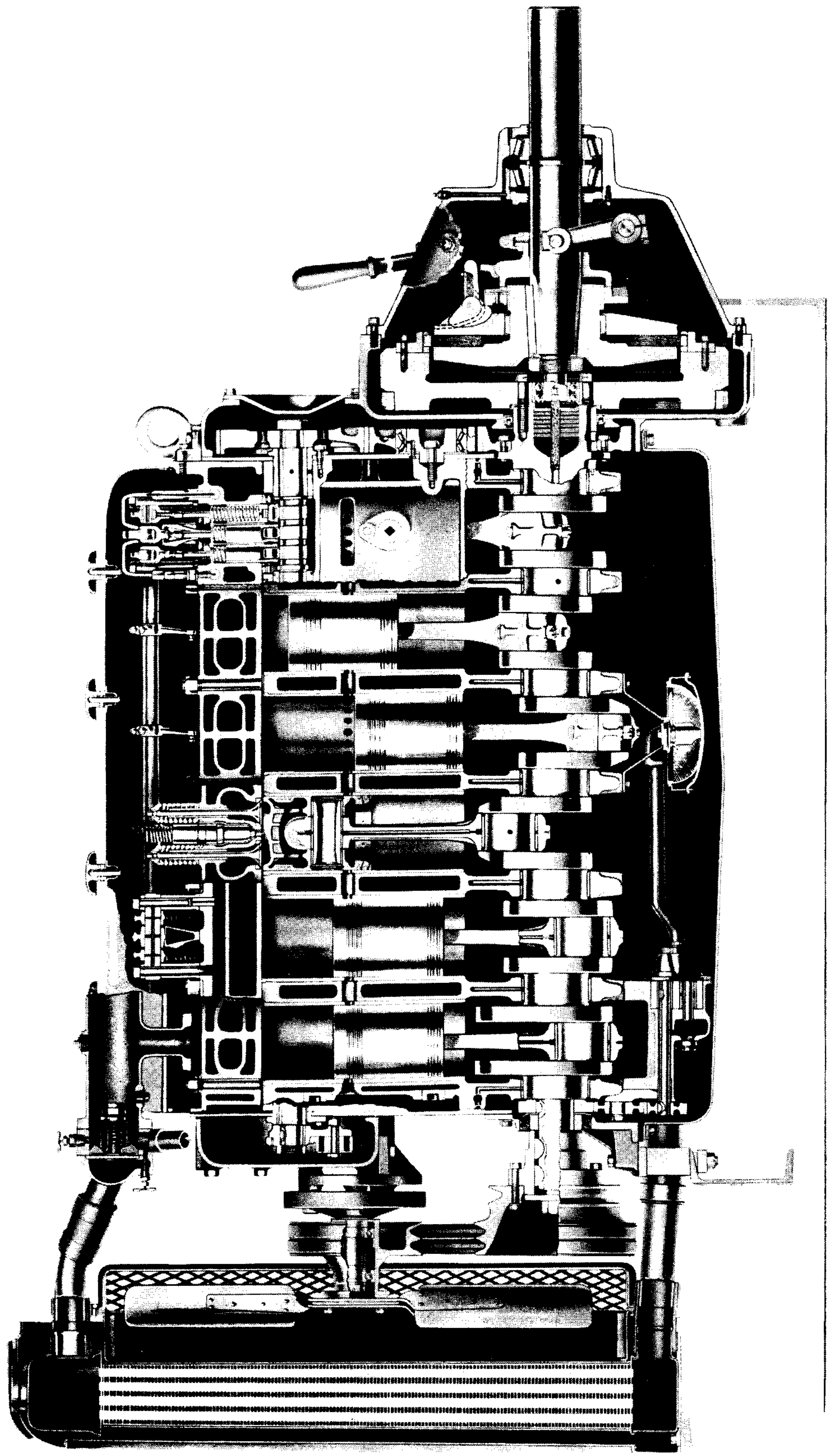


Fig. 10—Side Cross Section of a Typical Industrial Unit.

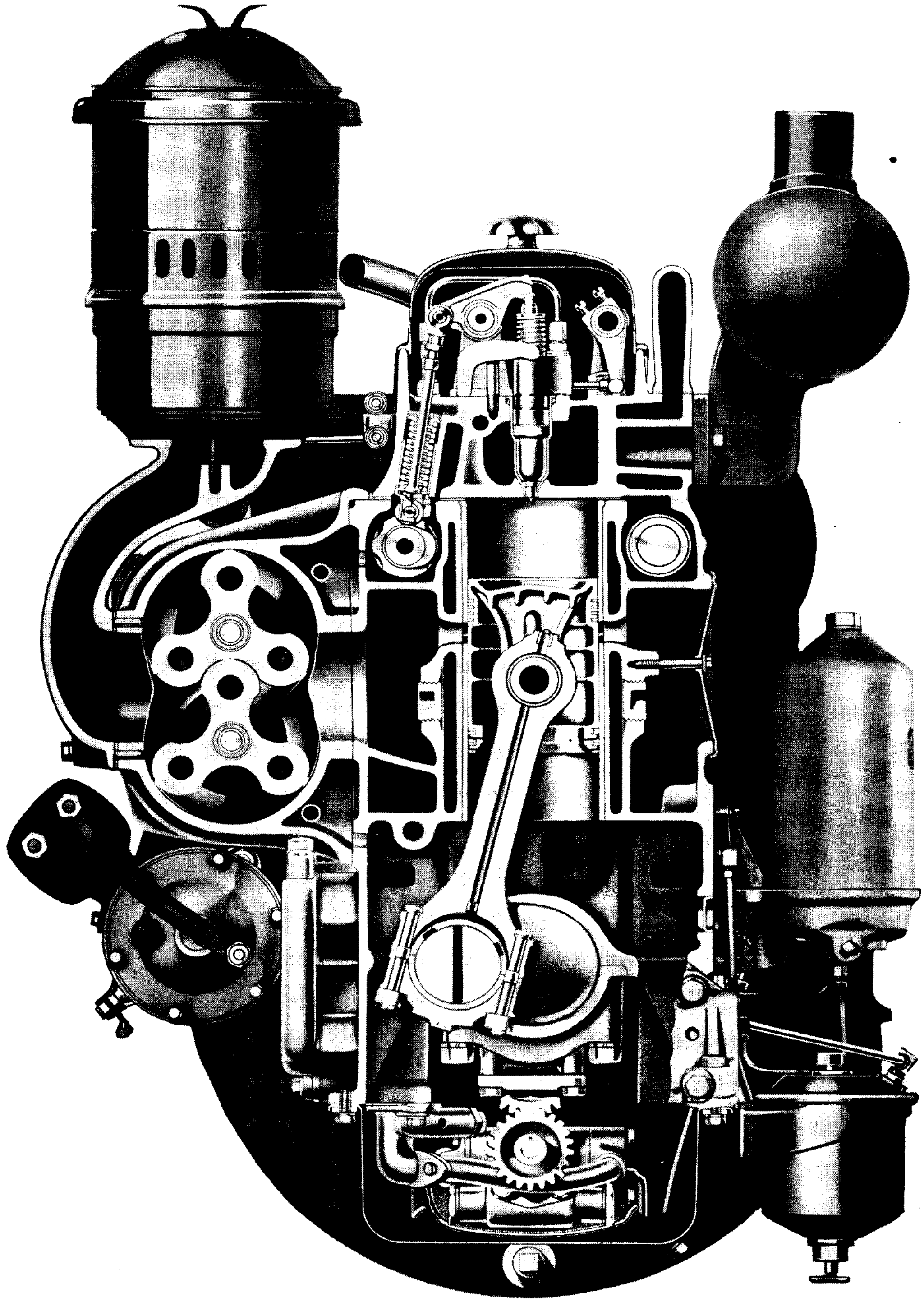
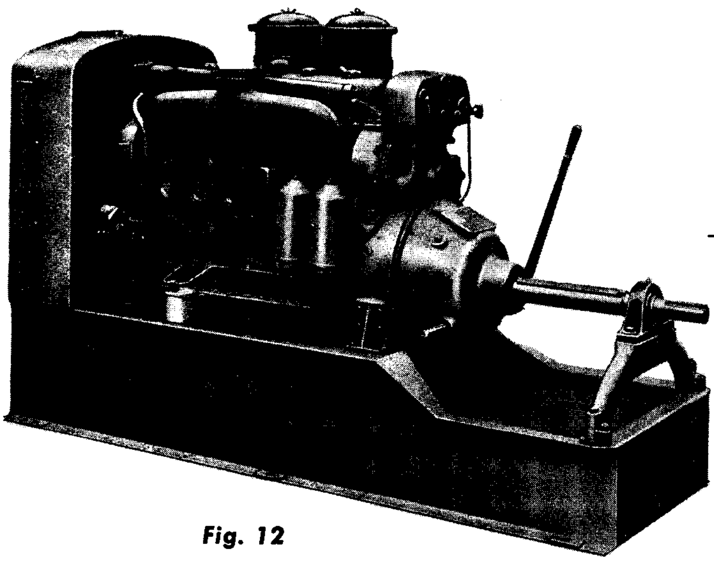


Fig. 11—End Cross Section of a Typical Industrial Unit.

TYPICAL GENERAL MOTORS THREE, FOUR AND SIX-CYLINDER SERIES 71 POWER UNITS



MODELS 3028C, 4028C, 6028C
Model 6028C Shown

Fig. 12

MODELS 3029C, 4029C, 6029C
Model 6029C Shown

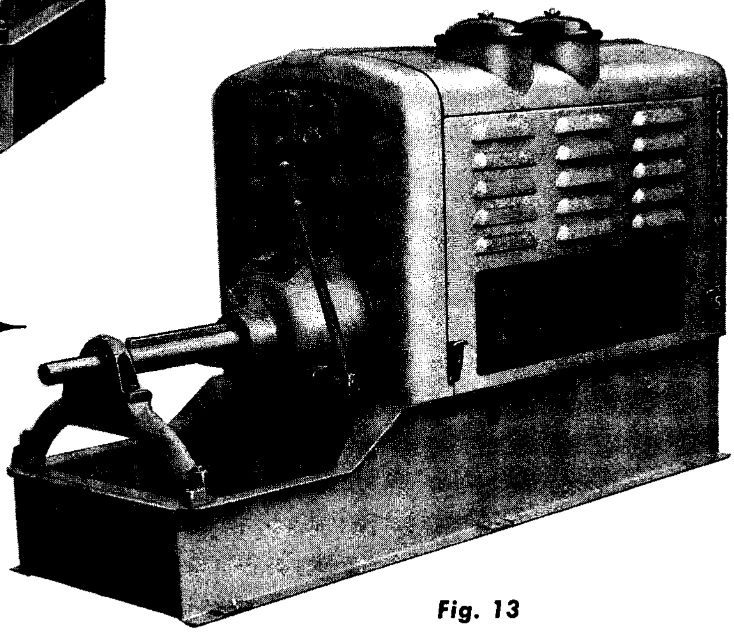
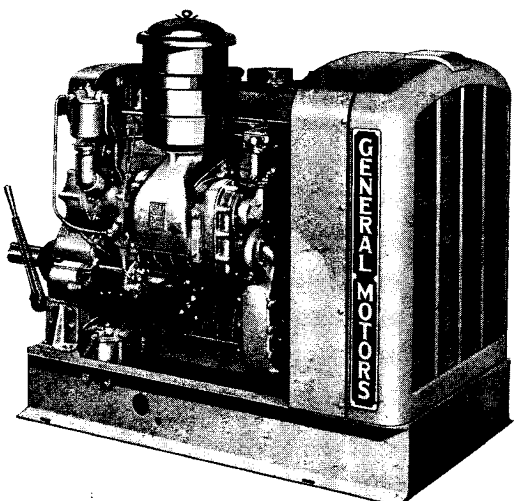


Fig. 13



MODELS 3030C, 4030C, 6030C
Model 4030C Shown

Fig. 14

MODELS 3055C, 4055C, 6055C
Model 3055C Shown

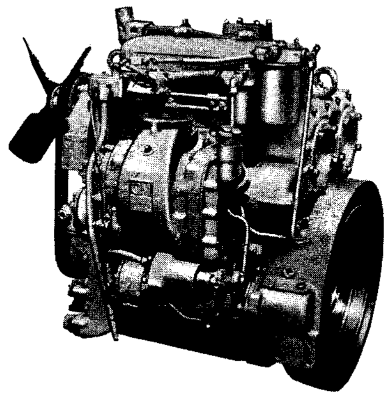


Fig. 15

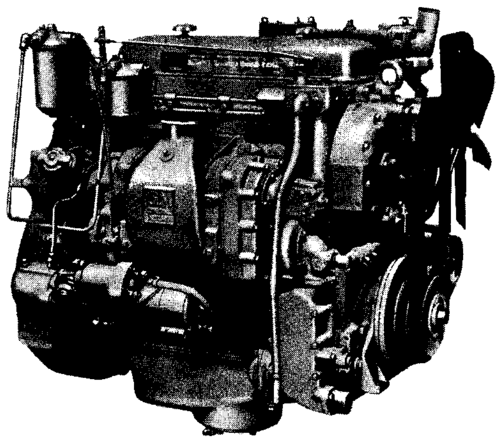


Fig. 16

MODELS 3057C, 4057C, 6057C
Model 4057C Shown

MODELS 3061A, 4061A, 6061A
Model 6061A Shown

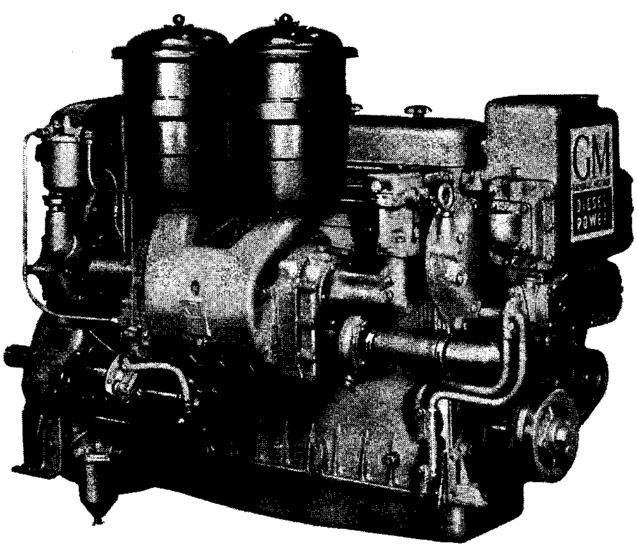


Fig. 17

MODELS 12103, 12104

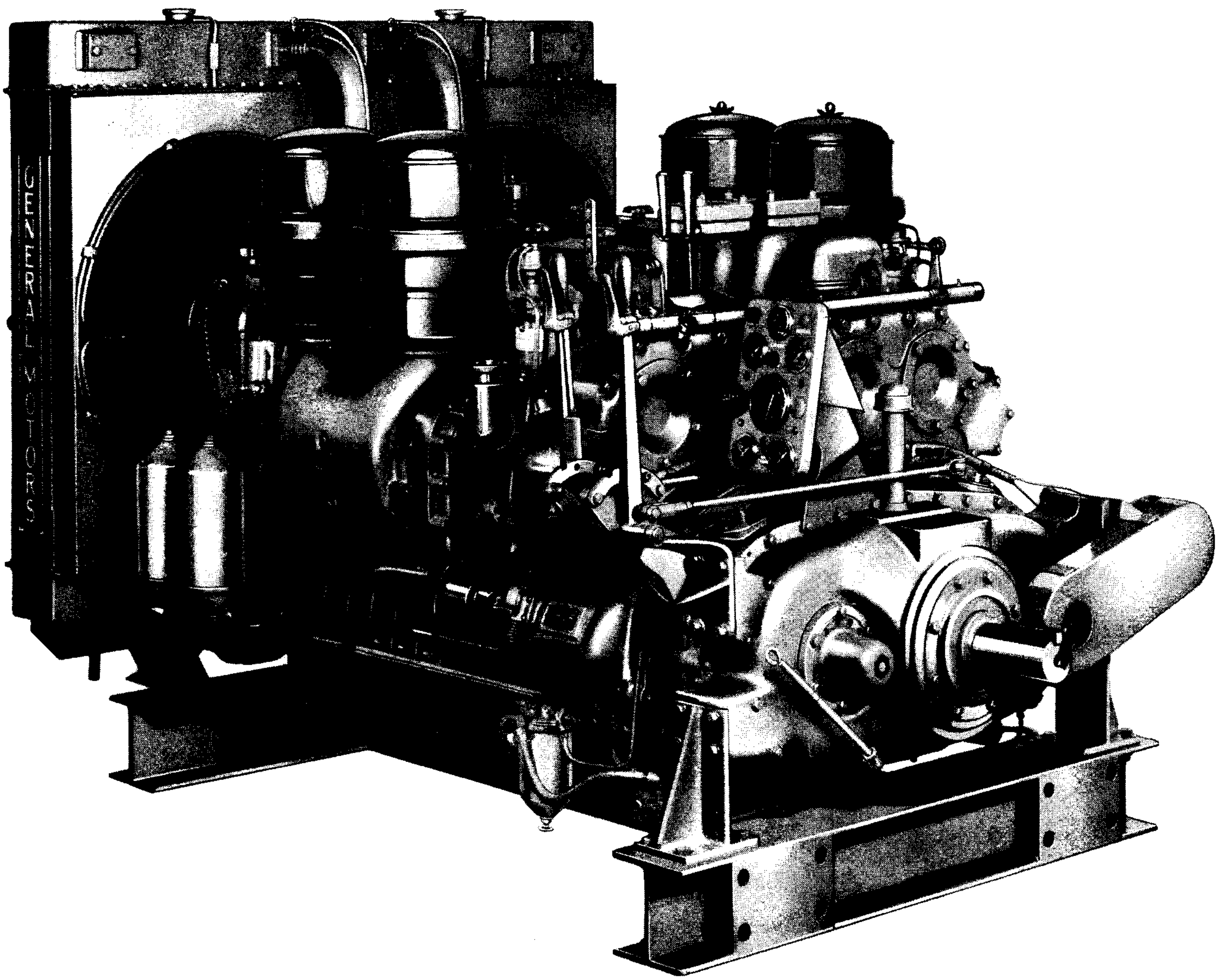


Fig. 18

MODELS 24103, 24104

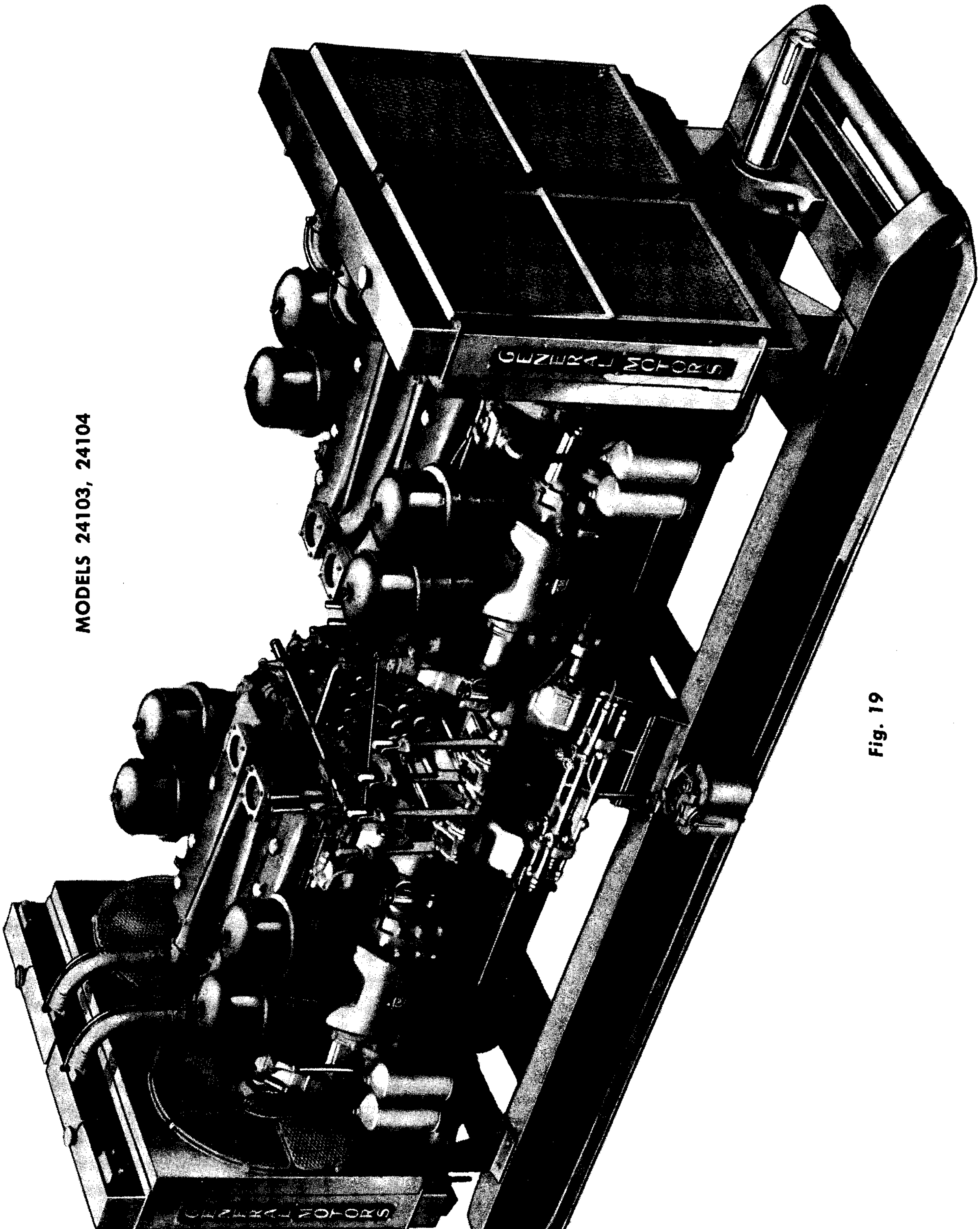


Fig. 19

MODEL, SERIAL AND UNIT DESIGNATIONS

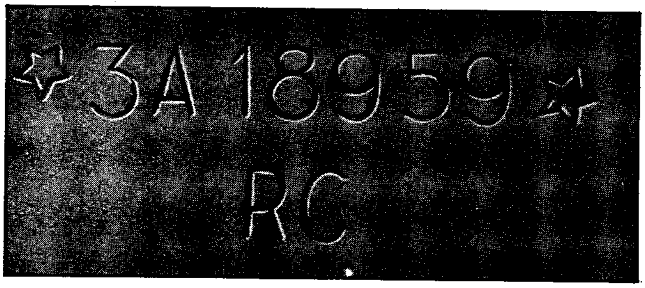


Fig. 20—Typical Unit Number and Model As Stamped on Cylinder Block of Single Engine Units.

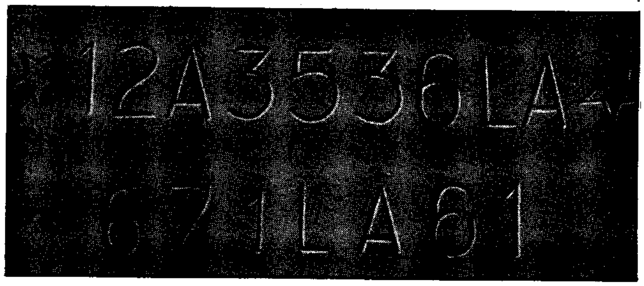


Fig. 21—Typical Unit and Model Number As Stamped on Cylinder Blocks of Multiple Engine Units

The unit number, and model, are stamped on every single engined unit at the upper right hand corner of the cylinder block, blower side (Fig. 20). On multiple engine units, a model number is stamped below the unit number (Fig. 21).

The unit number stamped on the block of each engine is the same as that stamped on the Option and Accessories Plate, which is attached to the rocker cover of each single engine unit (Fig. 22). In the case of a multiple-engine unit, it is attached to the rocker cover of only one of the engines.

The unit number stamped on the cylinder block and on the Option and Accessories Plate designates the number of cylinders (3), engine series (A for the 71 series) and the numerical serial number (such as 18959).

On single engines the suffix (RC) as shown in Fig. 20, designates the rotation and accessory arrangement of that particular engine.

On multiple engines the model number stamped on the cylinder block of each engine is the "basic engine model number" and differs from the model number stamped on the plate. The basic engine model number (671LA61) denotes the number of cylinders (6), engine series (71), rotation of the engine (L), location of the standard accessories (A), and application (61). The model number stamped on the plate indicates the number of cylinders in the entire unit and the model type.

In addition to the unit number and the model number, the Option and Accessories Plate lists the rated H.P., continuous H.P., maximum RPM no load, and all Options and Accessories included in the unit.

The option and accessories equipment installed on the unit are listed on the plate in alphabetical sequence with its type number. This enables the customer to order correctly any option or accessory listed on the plate. All groups of parts used on a unit are standard unless otherwise listed on this plate.

Power take-off assemblies, reduction gears, etc., may also carry name plates pertaining to that particular assembly.

The operator should include all data given on the Option and Accessory Plate with any order for parts.

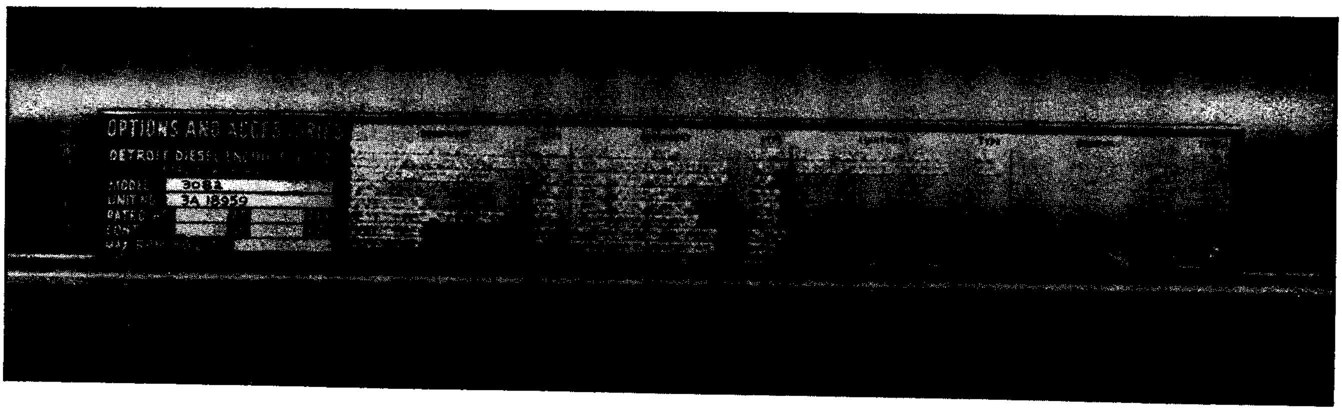


Fig. 22—Option and Accessories Plate.

OIL, WATER, AIR, AND FUEL SYSTEMS

Engine operation is the result of the functioning of four separate and distinct systems within the engine and its standard equipment. Each of these systems directs the flow of either air, water, lubricating oil or fuel to the various points where it is needed.

This section contains a brief description and operational outline of each of the four systems and its functional mechanisms.

LUBRICATING SYSTEM

Description—Figure 1 illustrates the schematic arrangement of the various units and control valves of the lubricating oil circulating system. This system consists of an oil pump, oil cooler, and oil filter, to-

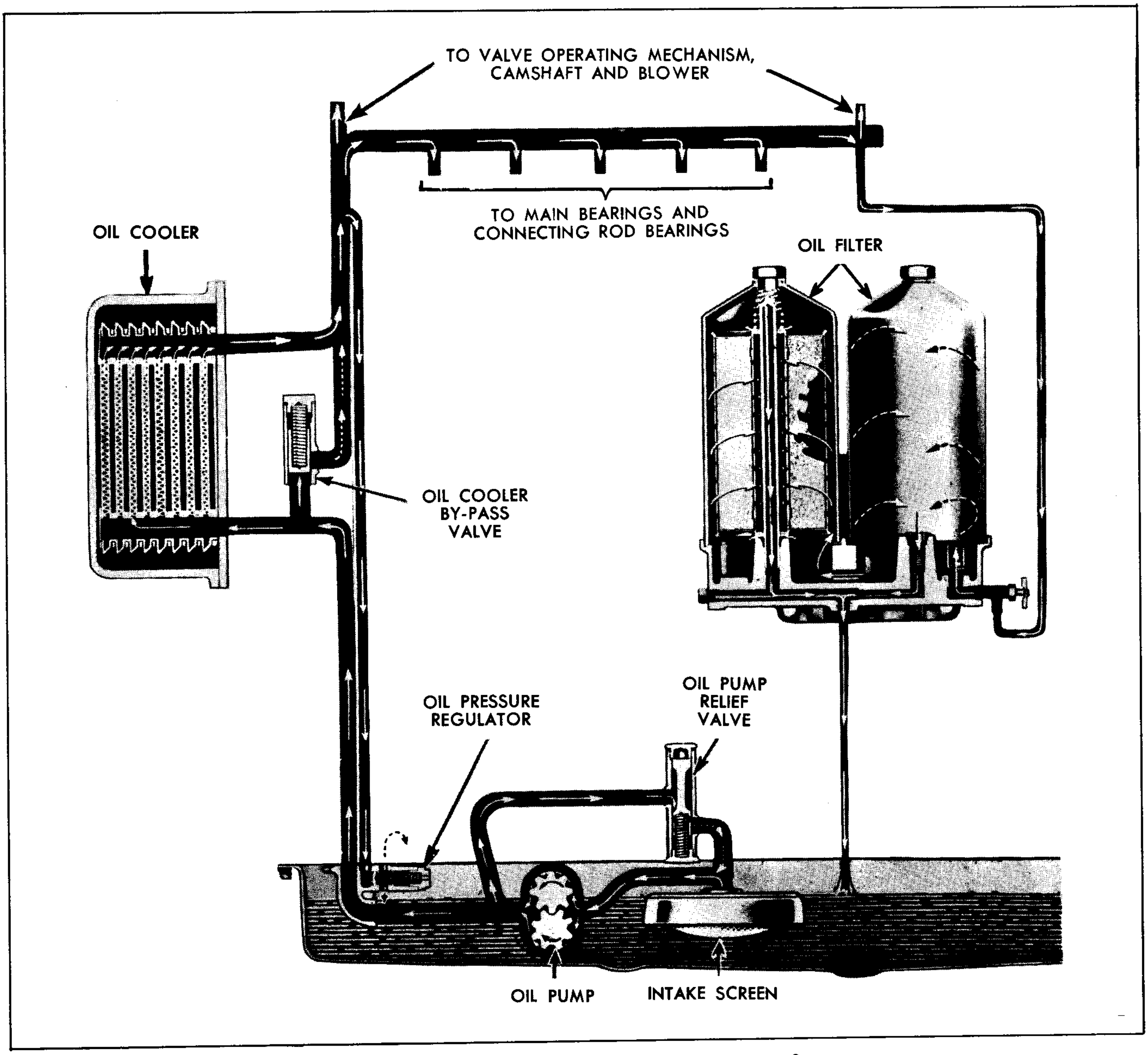


Fig. 1—Schematic Diagram of Typical Lubricating System.

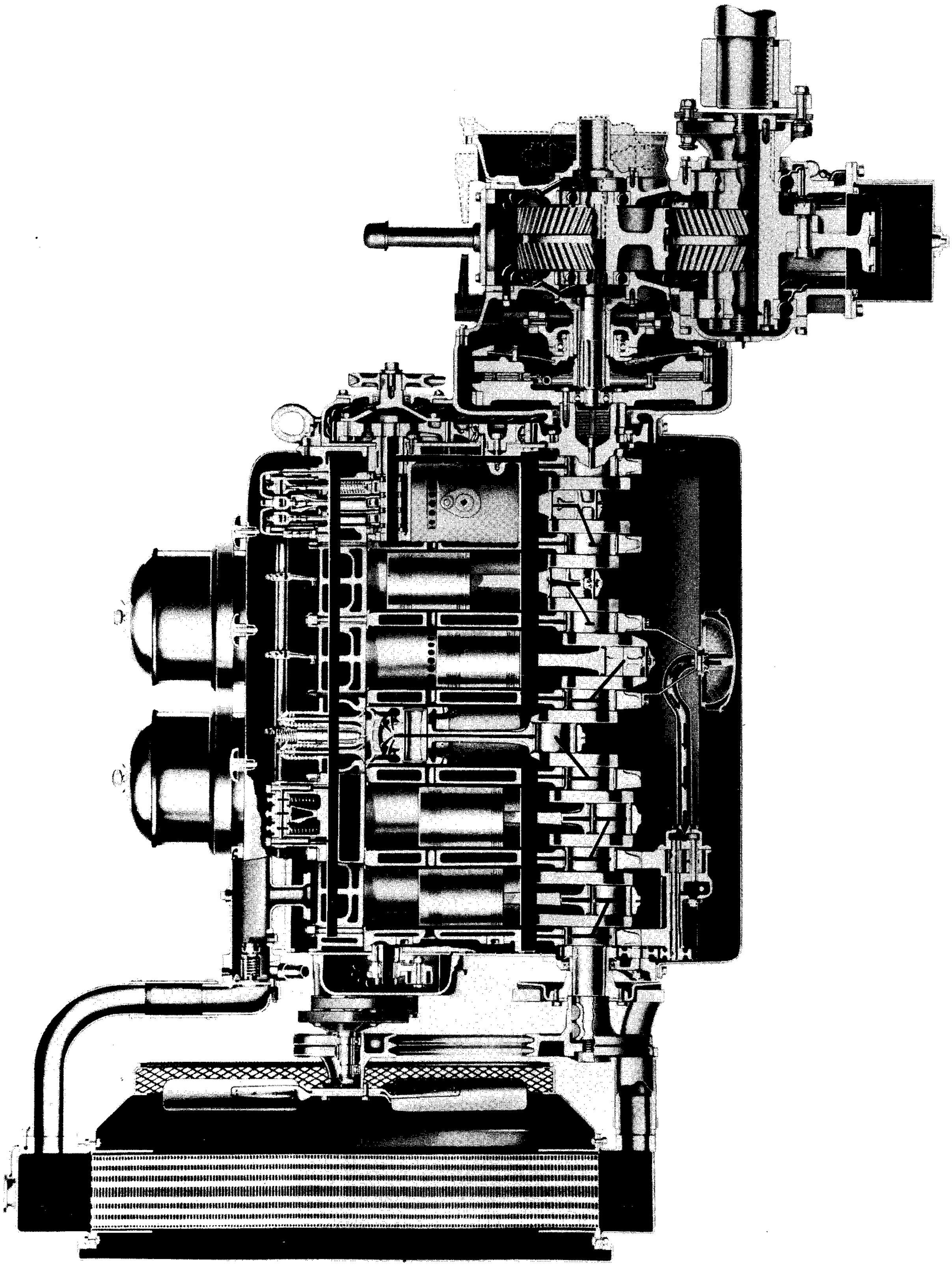


Fig. 2—Lubrication Diagram—Side Cross Section.

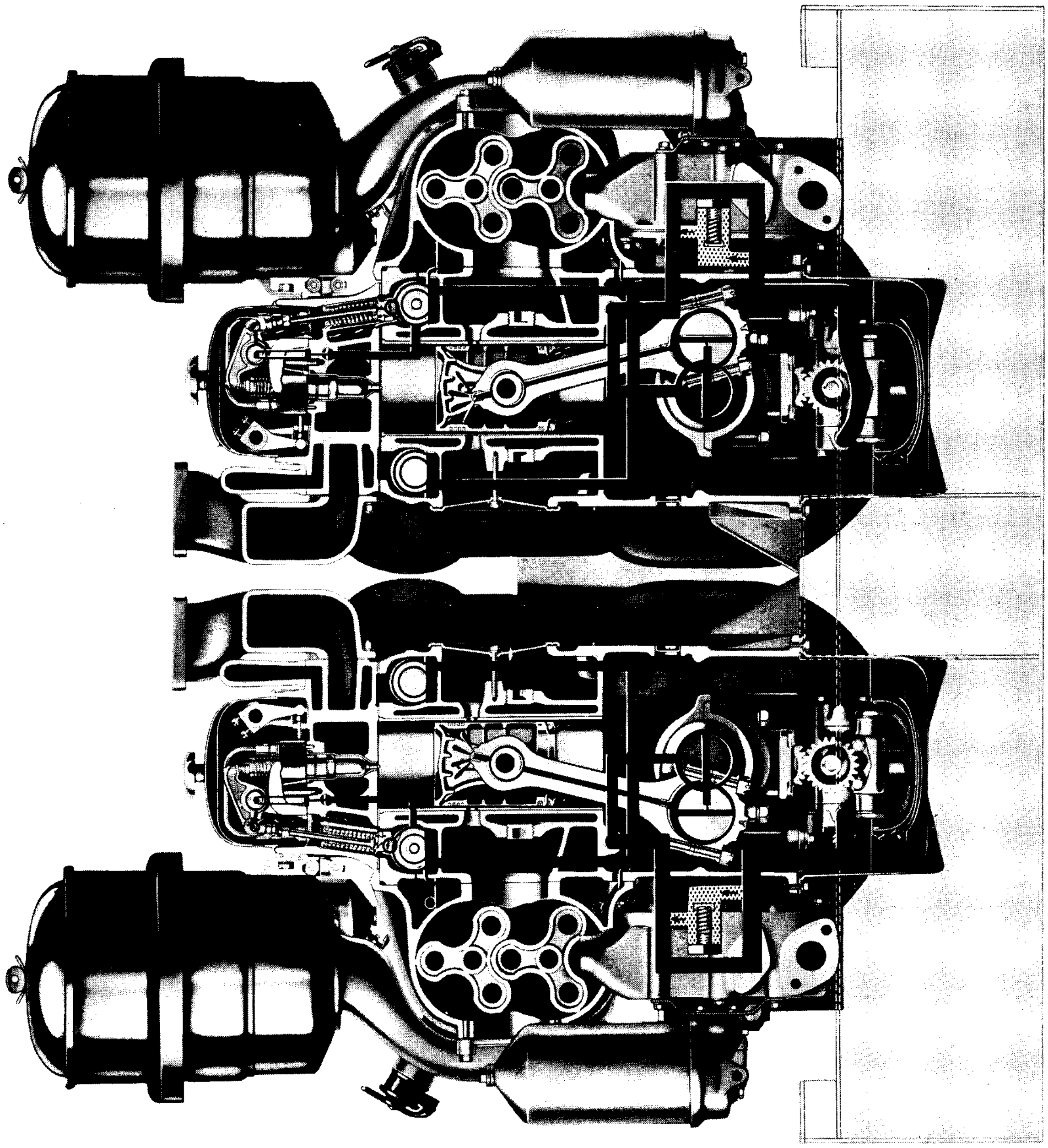


Fig. 3—Lubrication Diagram—End Cross Section.

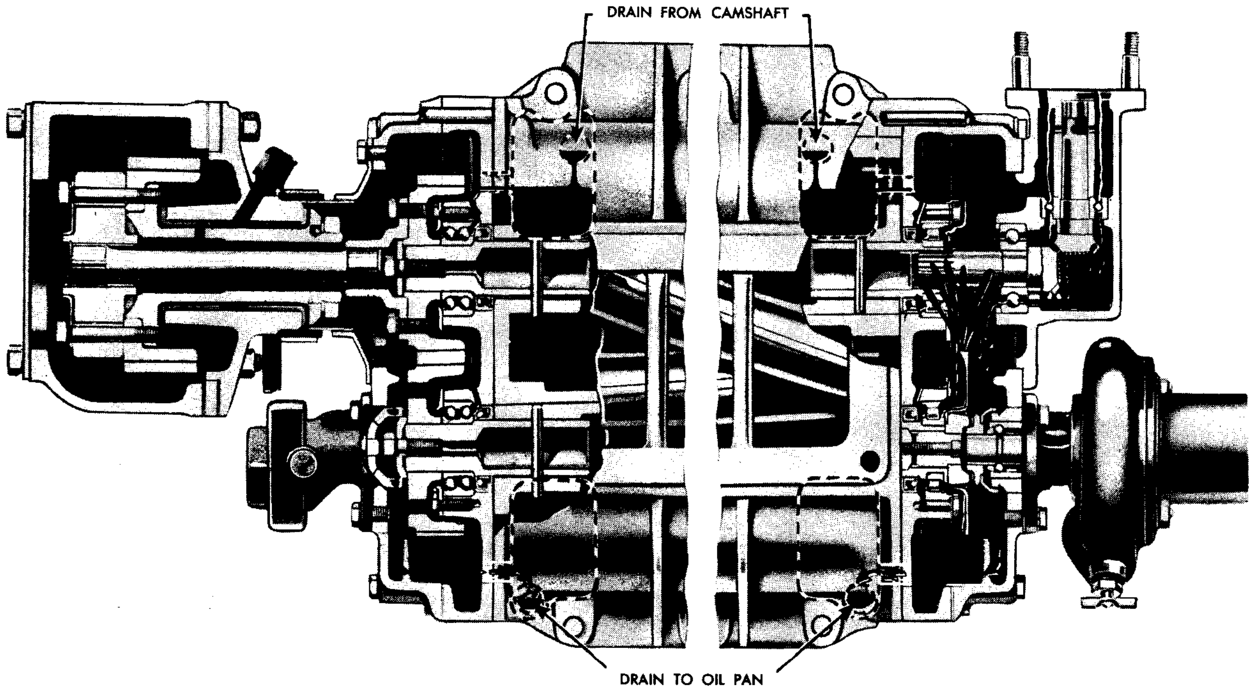


Fig. 4—Lubrication Diagram—Blower.

gether with a suitable relief valve in the pump, a by-pass valve at the oil cooler and a pressure regulator valve in the cylinder block oil gallery which insures positive lubrication at all times.

Oil for lubrication of the connecting rod bearings, piston pins, and for cooling the piston head, is provided through the drilled crankshaft from the adjacent forward main bearings. The gear train is lubricated by the overflow of oil from the camshaft pocket through a communicating passage into the flywheel housing. A certain amount of oil spills into the flywheel housing from the camshaft, balancer shaft, and idler gear bearings. The blower drive gear bearing is lubricated through an external pipe from the rear horizontal oil passage of the cylinder block.

Oil overflows through two holes, one at each end of the blower housing, as shown in Fig. 4, providing lubrication for the blower drive gears at rear end and governor mechanism at the front end.

COOLING SYSTEM

Two different cooling systems are employed in the industrial models, one having a radiator and cooling fan, the other a heat exchanger. In both systems a centrifugal type water pump, attached to and driven from the blower, circulates the engine coolant through the cylinder block water jackets, cylinder head, and engine lubricating oil cooler. A water outlet manifold is also common to both cooling systems.

The Radiator and Fan Type Cooling System is illustrated in Fig. 5. In this system the engine coolant is circulated through the radiator, and its temperature is reduced by transferring heat to the air stream, which is moved by either a blower or a suction fan driven by the crankshaft. The water pump draws the cooling liquid through the oil cooler and discharges it into the lower part of the cylinder block

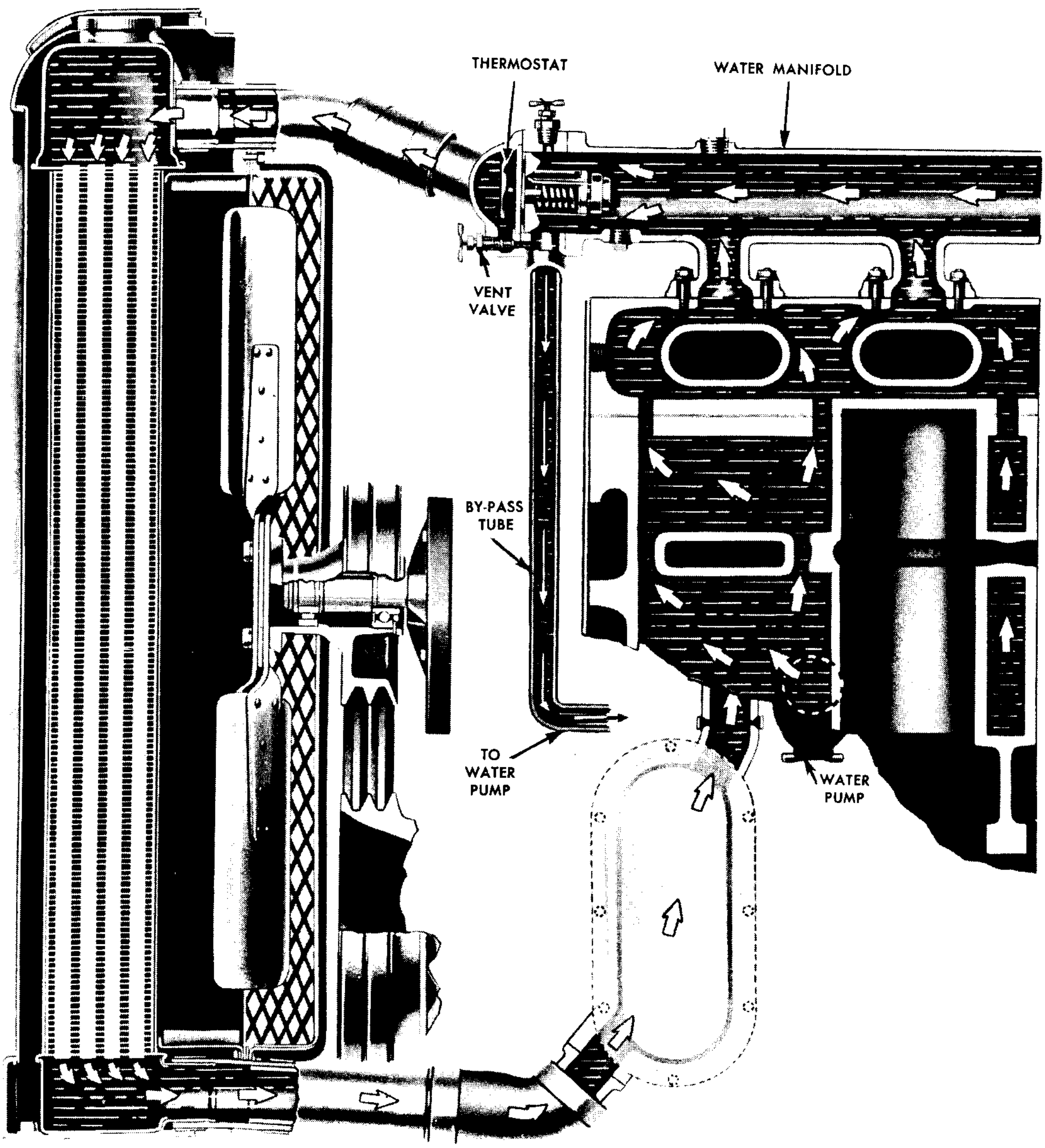


Fig. 5—Typical Engine Cooling System with Radiator and Fan.

as shown in Fig. 5. Openings in the top of the cylinder block (around the cylinders) connect with corresponding openings in the cylinder head, in which the coolant circulates around the valves and fuel injectors. A water manifold bolted to the cylinder head directs the coolant past the thermostat and into the radiator.

The Heat Exchanger Type Cooling System is illustrated in Fig. 6. In this system the engine coolant is circulated through the core of the heat exchanger, and its temperature is lowered by giving up heat to the raw water circulating around the heat exchanger element. The circulating pump draws the coolant from the heat exchanger, through the lubricating oil cooler, and discharges it into the lower portion of the cylinder block, as shown in Fig. 6. Openings in the top of the cylinder block (around the cylinders) connect with corresponding openings in the cylinder head in which the liquid circulates around the valves and fuel injectors. The water manifold, bolted to the cylinder head, directs the coolant through the thermostat and into the water tank directly above the heat exchanger.

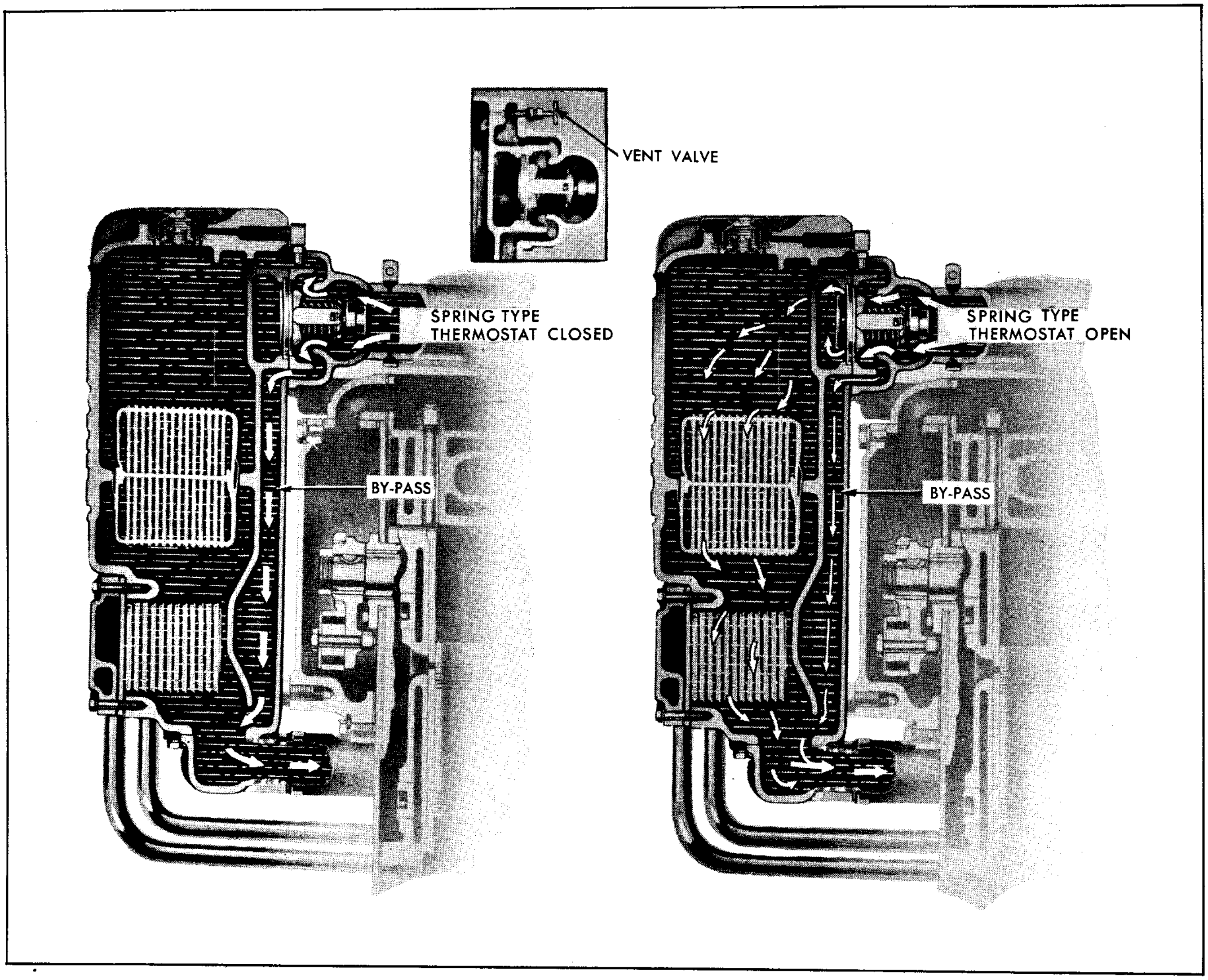


Fig. 6—Water Circulation Through By-Pass When Thermostat is Closed and Through Heat Exchanger When Thermostat is Open.

AIR INTAKE SYSTEM

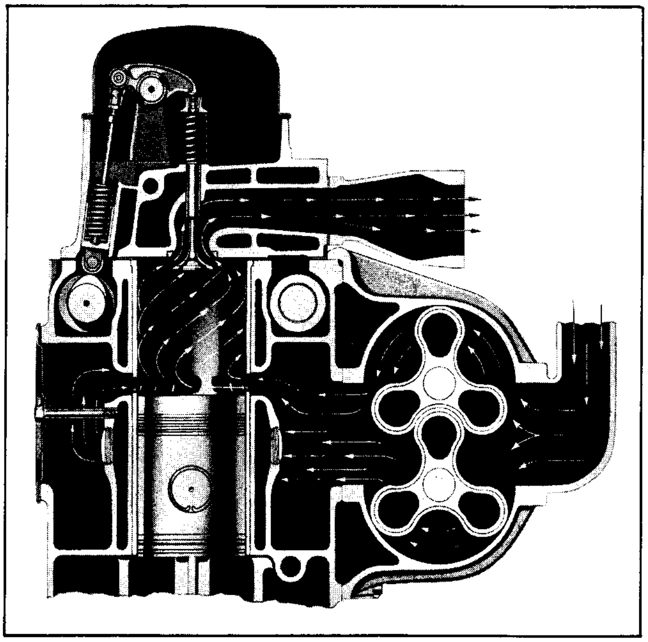


Fig. 7—Air Intake System Through Blower and Engine.

In the scavenging process used in these two-cycle engines, a charge of air is forced into the cylinders by the blower and thoroughly sweeps out all of the burnt gases through the exhaust valve ports. This air helps to cool the internal engine parts, particularly the exhaust valves (see Fig. 7). At the beginning of the compression stroke, therefore, each cylinder is filled with fresh, clean air, which provides excellent combustion.

BLOWER

The blower (designed especially for efficient Diesel operation) supplies the fresh air needed for combustion and scavenging. Its operation is similar to that of a gear-type oil pump. Two hollow three-lobe rotors are closely fitted in a housing which is bolted to the side of the engine. To provide continuous and uniform displacement of air as these rotors revolve, the rotor lobes are made with a twisted or helical form.

The air which enters the blower from the air cleaner is picked up by the lobes and carried to the discharge side of the blower as indicated by the arrows in Fig. 7. The continuous discharge of fresh air from the blower creates an air pressure of about seven pounds per square inch in the air chamber of the cylinder block at maximum engine speed. This air sweeps through the intake ports, which start to open at 46° before bottom dead center and close at 46° after bottom dead center.

EMERGENCY ENGINE SHUT-DOWN

If any combustible liquid is accidentally introduced into the combustion chamber, excessive engine speed will probably result. Damage to the engine is prevented by an emergency shut-down device, which consists of a flap valve in the air inlet housing at the blower.

The three types of emergency shut-down devices used on the Series 71 industrial engines are operated as follows:

1. Manually through a control wire (see Fig. 8).
2. Automatically by either low oil pressure or high coolant temperature (see Fig. 9).
3. Automatically by an overspeed governor trip mechanism.

The manually operated shut-down device shown in Fig. 8 is operated by a knob (8) located on the in-

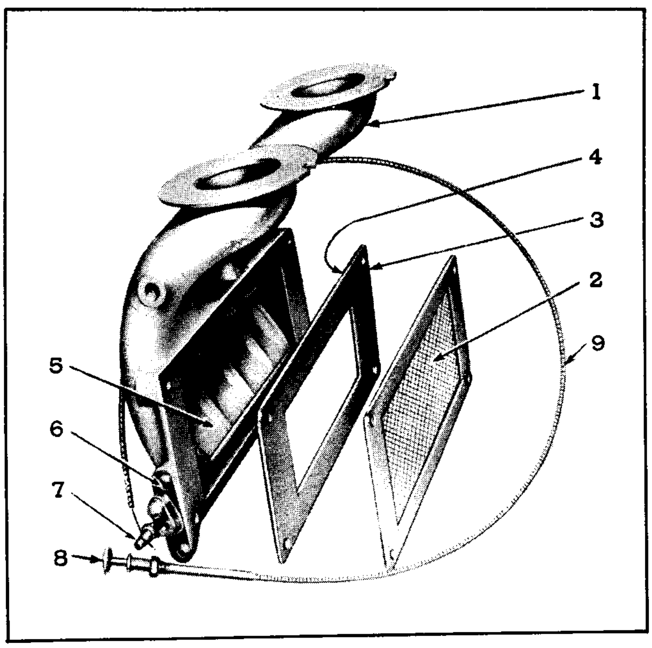


Fig. 8—Manually Operated Emergency Engine Shut-Down Assembly.

1. Housing—Air Inlet.
2. Screen—Inlet Housing.
3. Plate—Striker.
4. Gasket—Striker Plate.
5. Valve—Shut-Down.
6. Lock Plate.
7. Lever—Valve Shaft.
8. Knob—Control Wire.
9. Wire—Air Shutdown Control.

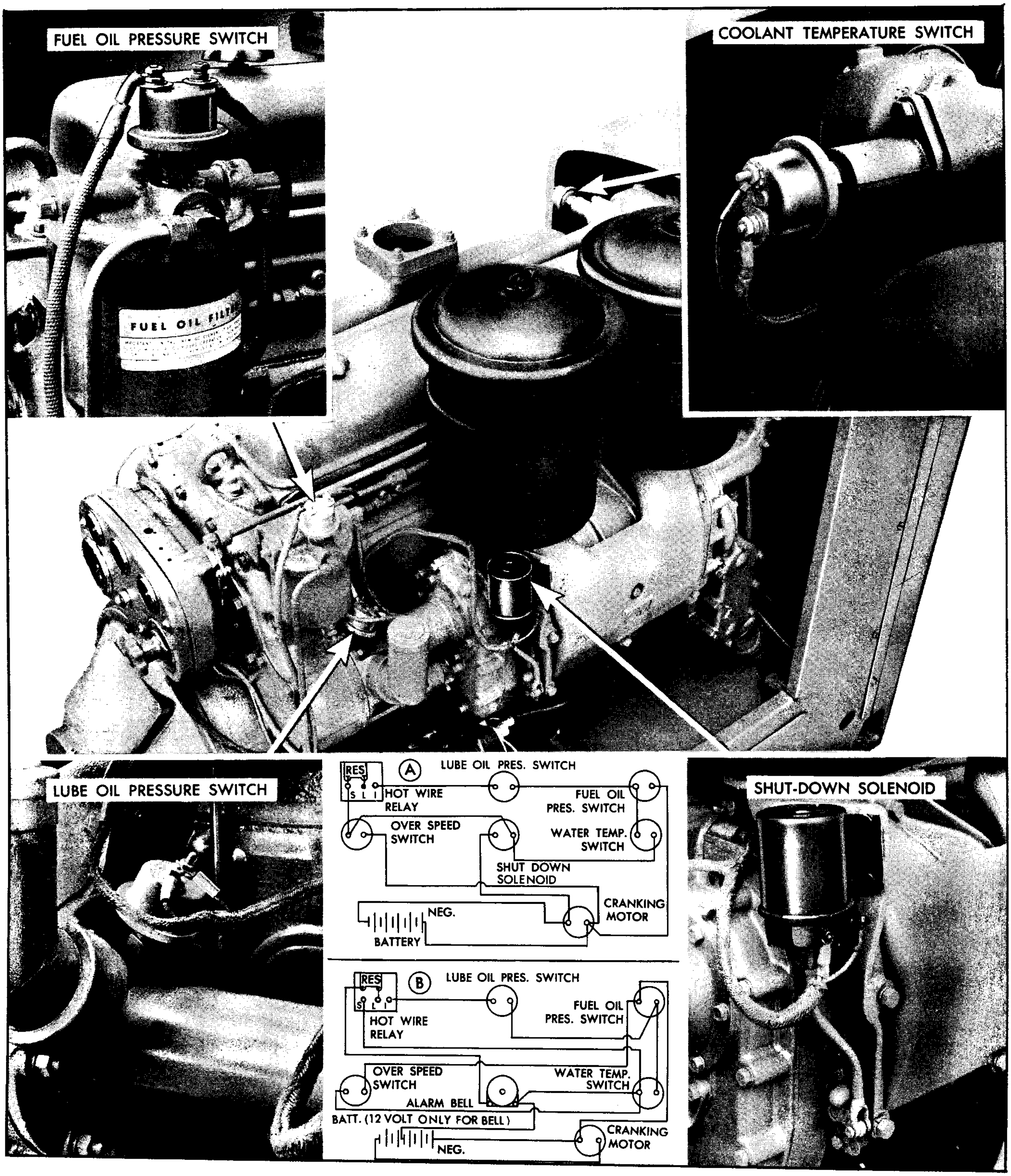


Fig. 9—Typical Installation of Electrically Operated Shut-Down Device.
(Also see engine starting system and shut-down wiring diagrams)

strument panel and connected to the valve shaft lever (7) by a control wire (9). The knob should be pulled all the way out to stop the engine.

Some industrial models are equipped with an overspeed trip shut-down mechanism which is driven by the blower drive shaft. If the engine speed accidentally exceeds the speed which has been established by the engine governor, the overspeed governor actuates an overspeed switch. This switch causes the shut-down solenoid to close the shutdown valve and thus stop the engine (see Figs. 8 and 9).

If the engine has been stopped by this overspeed trip mechanism, the shut-down valve must be reset in the open position before the engine can be started.

An automatic shut-down device, which is electrically operated by low oil pressure or high water temperature, is available as optional equipment on industrial models.

This device consists of a lubricating oil pressure switch, a coolant temperature switch, a fuel oil pressure switch, a solenoid coil, and suitable electrical wiring to complete the circuit through the storage battery. Figure 9 shows typical positions of the various switches. The lubricating oil pressure switch extends into the oil gallery, the coolant temperature switch is mounted on the water manifold, the fuel oil pressure switch connects into the fuel system, and the shut-down solenoid is attached to the air inlet housing.

Operation—The wiring diagrams in Fig. 9 show the automatic shutdown circuit (A), and the automatic shut-down alarm circuit (B). The various parts of the circuits are described in the paragraphs below. Notice that the cranking (starting) motor performs no essential function in the automatic shutdown circuit. Also notice that the voltage used through the alarm bell must be no greater than 12 volts.

WATER TEMPERATURE SWITCH

Description—The water temperature switch is a normally open switch connected in the electrical circuit to the shutdown solenoid.

Operation—When engine water temperature exceeds 195°-205°F., the water temperature switch closes and current energizes the shutdown solenoids.

LUBRICATING OIL PRESSURE SWITCH AND HOT WIRE RELAY

Description — The lubricating oil pressure switch is a normally closed switch connected, through a hot wire relay, in the electrical circuit to the shutdown solenoid.

Operation—When lubricating oil pressure falls below 10 ± 2 p.s.i., the oil pressure switch closes and current flows to the hot wire relay which must be heated by the current to complete the circuit to the solenoid. The few seconds required to heat the hot wire relay provides sufficient delay to avoid engine shutdown when low oil pressure is caused by a passing condition such as an air bubble, or temporary overlap in the operation of the lubricating oil pressure switch and fuel pressure switch during starting and stopping of the engine.

FUEL PRESSURE SWITCH

Description—The fuel pressure switch is a normally open switch connected in the electric circuit to the shutdown solenoid in series with the lubricating oil pressure switch. It is calibrated to close at fuel pressures which normally prevail at engine speeds about 700 r.p.m.

Operation—When the engine speed is below 700 r.p.m., the fuel pressure switch is open and the electrical circuit to the lubricating pressure switch is broken. Thus the shutdown solenoid is not exposed to current when the engine is not running, and it will not be energized during normal starting and stopping of the engine.

When engine speed is above 700 r.p.m., the fuel pressure switch closes, completing the electrical circuit to the lubricating oil pressure switch.

AIR CLEANER

Heavy-duty oil bath air cleaner and silencer assemblies of the type illustrated in Fig. 10 are used on most industrial models. The cleaner and silencer consists of a metal wool element supported inside a housing beneath which is contained a bath of oil.

Air drawn through the cleaner by the blower passes over the oil bath which collects the major portion of dust, then flows up through the metal wool where the finer dust particles are removed, and finally flows down the central duct to the blower. Silencing features are incorporated in the design of the cleaner.

These air cleaners should be serviced as outlined in the lubrication chart and refilled with specified oil up to the level indicated.

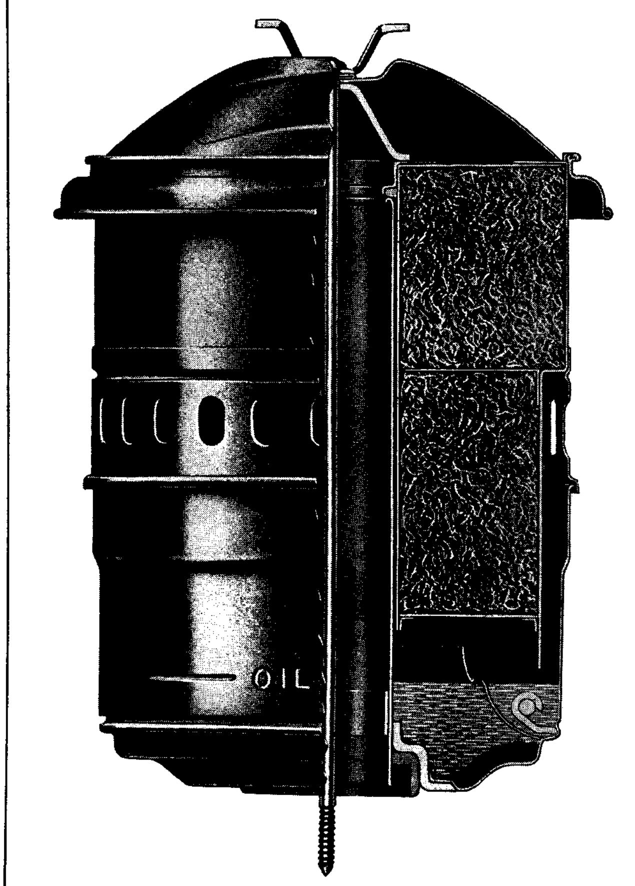


Fig. 10—Oil Bath Air Cleaner and Silencer Assembly.

AIR BOX DRAINS

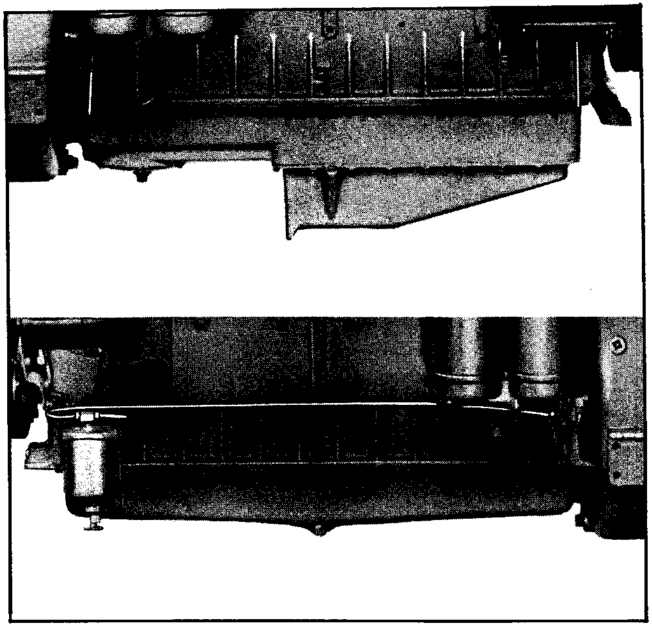


Fig. 11—Typical Air Box Drain Systems.

In normal operation, a slight amount of vapor from the air charge condenses and settles on the floor of the air box. This condensation is drained off through cored passages in the ends of the block and openings in the side of the engine block below the air box floor.

On some engines these openings are vented to the atmosphere; on late power take-off units, the drain tubes are connected to a drain tube extension which passes through the engine base thus carrying the drippings away from the engine fuel tank; other engines are equipped with a drain tank to receive the condensate which drains through tubes leading from the openings as illustrated in Fig. 11. The drain tank consists of a vented steel shell, a cover, a metal wool filtering element, and a removeable retaining tube (stud), which holds the shell and filtering element to the cover.

A draincock and drain tube, in the bottom of the air box drain tank, permits it to be drained. Air box drains must be open at all times; therefore, it is a wise practice to examine and, if necessary, clean the passages occasionally. An accumulation of liquid on the air box floor indicates plugged vents and such accumulation should be wiped out with rags or blown out with compressed air.

FUEL SYSTEM

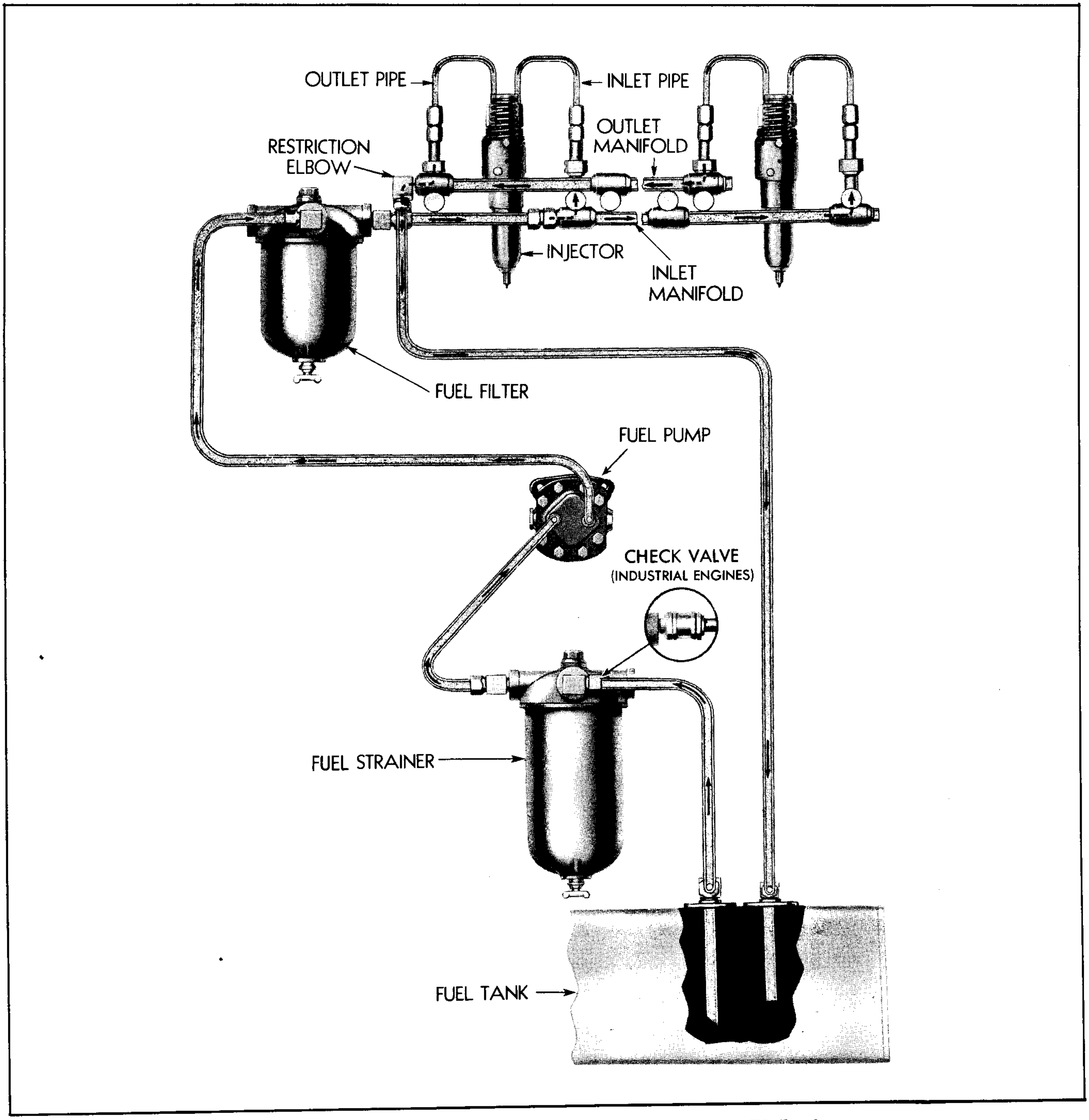


Fig. 12—Fuel Supply System Generally Used on Series 71 Engine.

One of the main requirements for satisfactory operation of a Diesel engine is that clean fuel at suitable pressure be supplied to the injectors. The necessary precautions have been observed in the design and arrangement of the various units in the fuel system to insure these requirements.

Fig. 12 illustrates the system used on the series 71 engines. In this system a fuel strainer is installed between the supply tank and the fuel pump. The fuel oil pump draws fuel from the supply tank through the fuel strainer and forces it through the fuel filter. From the filter, the oil is forced through the

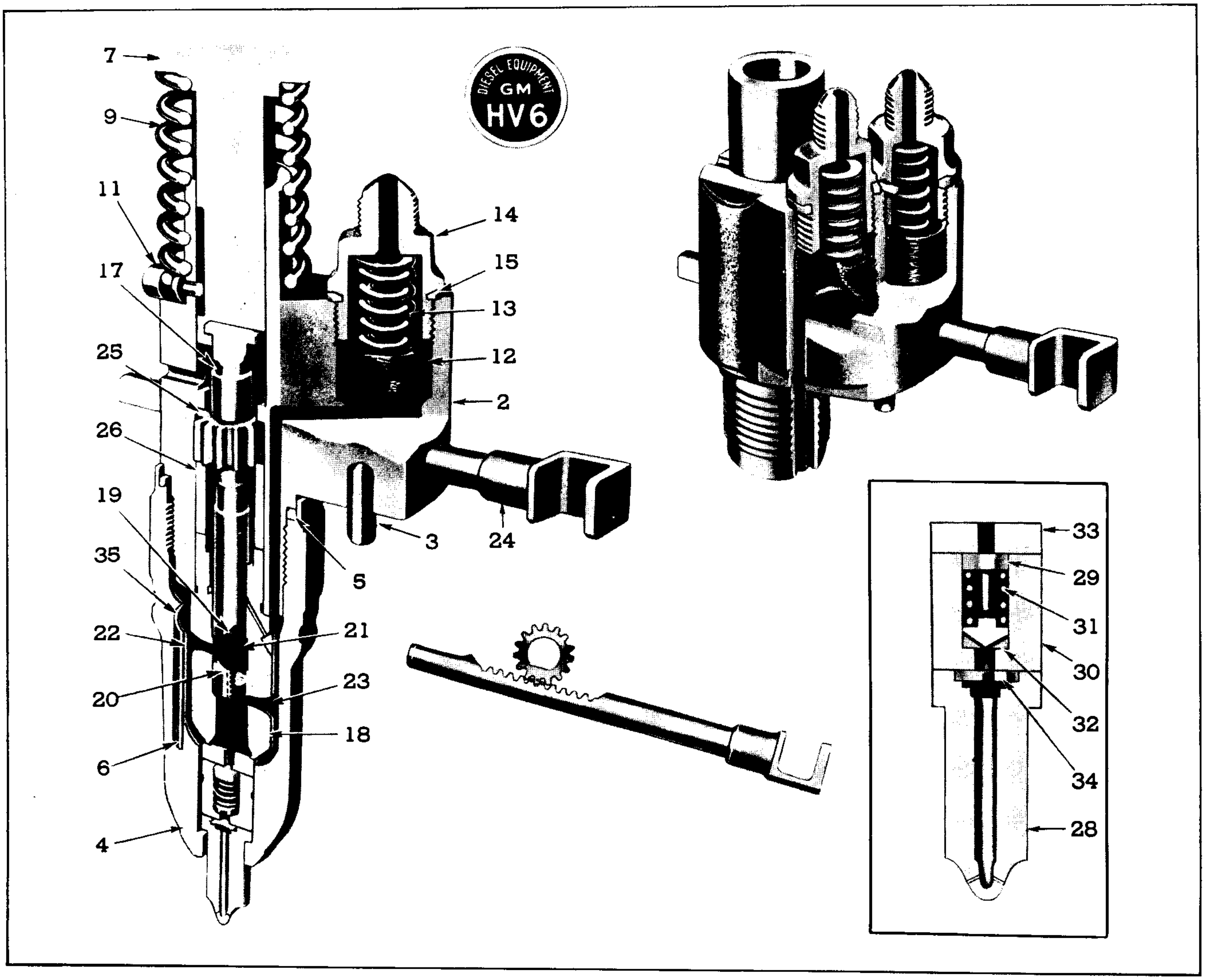


Fig. 13—Typical Fuel Injector.

2. Body—Injector.
3. Dowel—Body.
4. Nut—Injector.
5. Ring—Rubber Seal.
6. Deflector—Spill.
7. Follower—Injector.
9. Spring—Plunger.
11. Pin—Stop.
12. Element—Filter.
13. Spring—Filter.
14. Cap—Filter.
15. Gasket—Filter Cap.
17. Plunger.
18. Bushing.
19. Helix—Plunger—Upper.
20. Helix—Plunger—Lower.
21. Metering Recess.
22. Port—Bushing—Upper.
23. Port—Bushing—Lower.
24. Rack.
25. Gear.
26. Retainer—Gear.
28. Tip—Spray.
29. Valve—Spray Tip.
30. Cage—Valve.
31. Spring—Valve.
32. Stop—Valve.
33. Seat—Valve.
34. Valve—Check.
35. Chamber—Fuel Supply.

inlet manifold, then by means of the inlet pipe, through the injector filters and finally to the fuel chamber within the injectors.

The capacity of the fuel supply pump is considerably in excess of that required for engine operation. The injectors are designed to allow the surplus fuel to flow through them so that it may serve as a coolant.

In addition to serving as a coolant, circulation of the surplus fuel bleeds any air or vapor, which forms within the system, back to the supply tank where it is vented to the atmosphere. Surplus fuel leaving the injectors flows through the outlet pipe to the return manifold and then through the return pipe back to the fuel supply tank. A restriction in the outlet of the return manifold provides sufficient resistance to build up a pressure of from 40-50 lbs.

(approximately) throughout the system at 1200 engine r.p.m.

NOTE: ***Only fuel supply tanks made of black iron or terneplate should be used. Never use a galvanized tank.***

INJECTORS

Injector Mounting—The injectors are mounted in the cylinder head, with their spray tips projecting slightly below the top of the inside surface of the combustion chambers. A clamp, bolted to the cylinder head and fitting into a machined recess in each side of the injector body, holds the injector in place in a water-cooled copper tube which passes through the cylinder head.

A tight seal, formed between the tapered seat on the lower end of the injector and the copper tube, will withstand the high pressures inside the combustion chamber. A dowel pin in the injector body registers with a hole in the cylinder head for accurately locating the injector assembly.

Injector Operation—The fuel injector, illustrated in Fig. 13, performs three duties: 1st, metering and injecting the fuel; 2nd, creating high fuel pressure; 3rd, atomization. Fuel oil is supplied to the injector at a minimum pressure of about twenty pounds per square inch, passes through the filter element into the chamber between the bushing and spill deflector from whence the injector plunger, operated by a rocker arm which is mounted on the cylinder head and actuated by the camshaft, as shown in Fig. 14, pumps, meters, and times the injection of fuel into the combustion chamber.

Changing the position of the helices by rotation of the plunger, retards or advances the closing of the ports which is the same as changing the beginning and ending of injection or the effective stroke. The longer the effective stroke, the more fuel injected.

Injector Service—Since the injector is one of the most important and carefully constructed parts of the engine, we recommend that the Operator change the injector unit only and **not** attempt to repair the injector. **Authorized Detroit Diesel Engine Division Dealers and Distributors are properly equipped to service the series 71 unit injector;** therefore, if it becomes necessary to remove an injector for inspection, repair or replacement by one of these agents, follow the procedure given below:

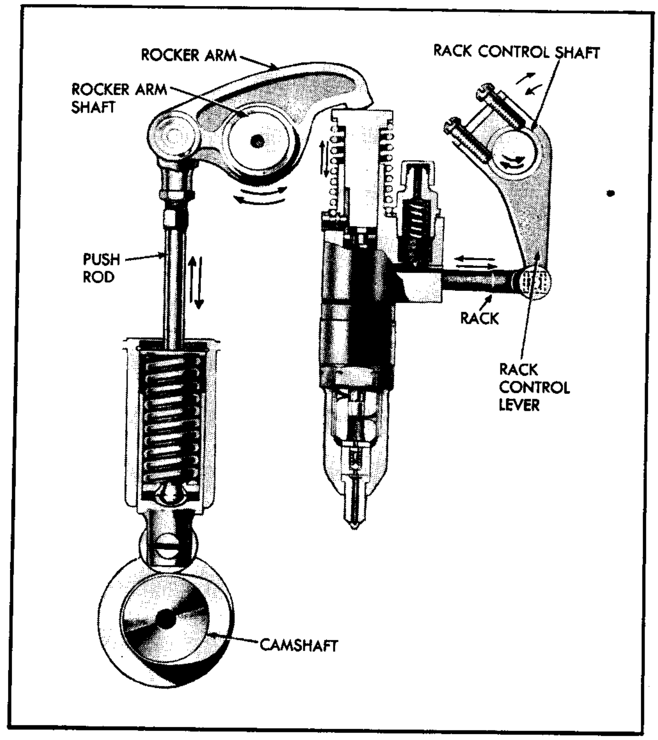


Fig. 14—Injector Operation.

1. Remove valve rocker cover.
2. Remove fuel lines from both the injector and the fuel connectors.
   Immediately after removal of the fuel lines from an injector, the two fuel feed fittings should be protected with a shipping cap, to prevent dirt from entering the injector.
3. If necessary, crank the engine with the starter or a bar at the flywheel ring gear until the three rocker arm clevis pins—at outer end of arms—are in line.
4. Loosen the two rocker arm bracket bolts holding the brackets to the cylinder head and swing the rocker arm assembly over away from valves and injector.
5. Remove injector hold-down stud nut, special washer, and injector clamp.

Injector Capacity-cu.mm.	Timing Gauge Tool No.
60	J1242
70	J1853
80	J1853

Fig. 15—Timing Gauge Chart for Injectors Used in Series 71 Engines.

6. With injector remover tool J 1227A free the injector from its seat.
7. Lift injector out of seat and at same time disengage the control rack linkage.

After injector has been inspected, repaired and tested by an authorized Detroit Diesel Dealer or Distributor it may be installed by reversing the sequence of operations for removal. Be sure dowel in injector body registers with hole in cylinder head. Tighten injector in place with hold-down clamp, spherical washer, and nut; then connect fuel lines. **Do not over-tighten injector nut as this may distort the injector and cause working parts to bind.**

Time fuel injector and position injector control racks as outlined in "Engine Tune-Up," Sec 4. Refer to Fig. 15 for correct timing gauge to be used.

FUEL OIL FILTERS

Fuel oil filters are placed in the fuel system to separate foreign matter from the engine fuel. If the fuel oil filters have been diligently serviced as recommended in the "Lubrication Chart," there should always be a supply of fuel at the injectors, provided the fuel tank or other source of supply is suitably filled.

However, should uneven running, excessive vibration, stalling when idling or loss of power be detected, conduct a flow test as outlined under "Trouble Shooting," Sec. 5.

If the fuel oil filters prove to be clean and in good condition, check for choked injector filters by following the procedure given under "Locating a Misfiring Cylinder" in Sec. 5.

GOVERNORS

Horsepower requirements on an engine may vary continually due to the fluctuating loads; therefore, some means must be provided to control the amount of fuel required to hold the engine speed reasonably constant during such load fluctuations. To accomplish this control, either a mechanical or a hydraulic governor is introduced in the linkage between the hand throttle and the fuel injectors.

Each engine is provided with that governor type which best regulates the engine speed according to the operating requirements.

Two types of mechanical governors are used on the industrial engines – limiting speed and variable speed.

Applications requiring a minimum and maximum speed control, where extremely low droop or electrical synchronization are not factors, are equipped with a **limiting speed** mechanical governor. Applications requiring uniform engine speed, which may be varied by the operator, are equipped with the **variable speed** mechanical governor. Applications requiring a constant speed with a minimum of governor droop, such as on electric generator sets, are equipped with a **hydraulic governor.** Each of the three types is discussed in the following pages.

LIMITING SPEED MECHANICAL GOVERNOR

Description—The limiting speed mechanical governor, illustrated in Fig. 16, performs two functions:

1. Controls the engine idling speed.
2. Limits the maximum operating speed of the engine.

The governor, which is mounted to the front end of the blower and driven by the blower upper rotor shaft, consists of three subassemblies: (a) the weights, shaft and bearing housing assembly; (b) the vertical shaft control mechanism housing assembly; (c) the cover assembly.

In the weight, shaft, and bearing housing assembly, two weights are pivoted on needle bearings and carried on a horizontal shaft inside the weight housing.

The weight carrier shaft is mounted on a ball bearing at the outer end, and is supported and driven by the blower rotor shaft at the inner end. A riser and thrust bearing on the weight carrying shaft transmits the motion of the revolving weights to the

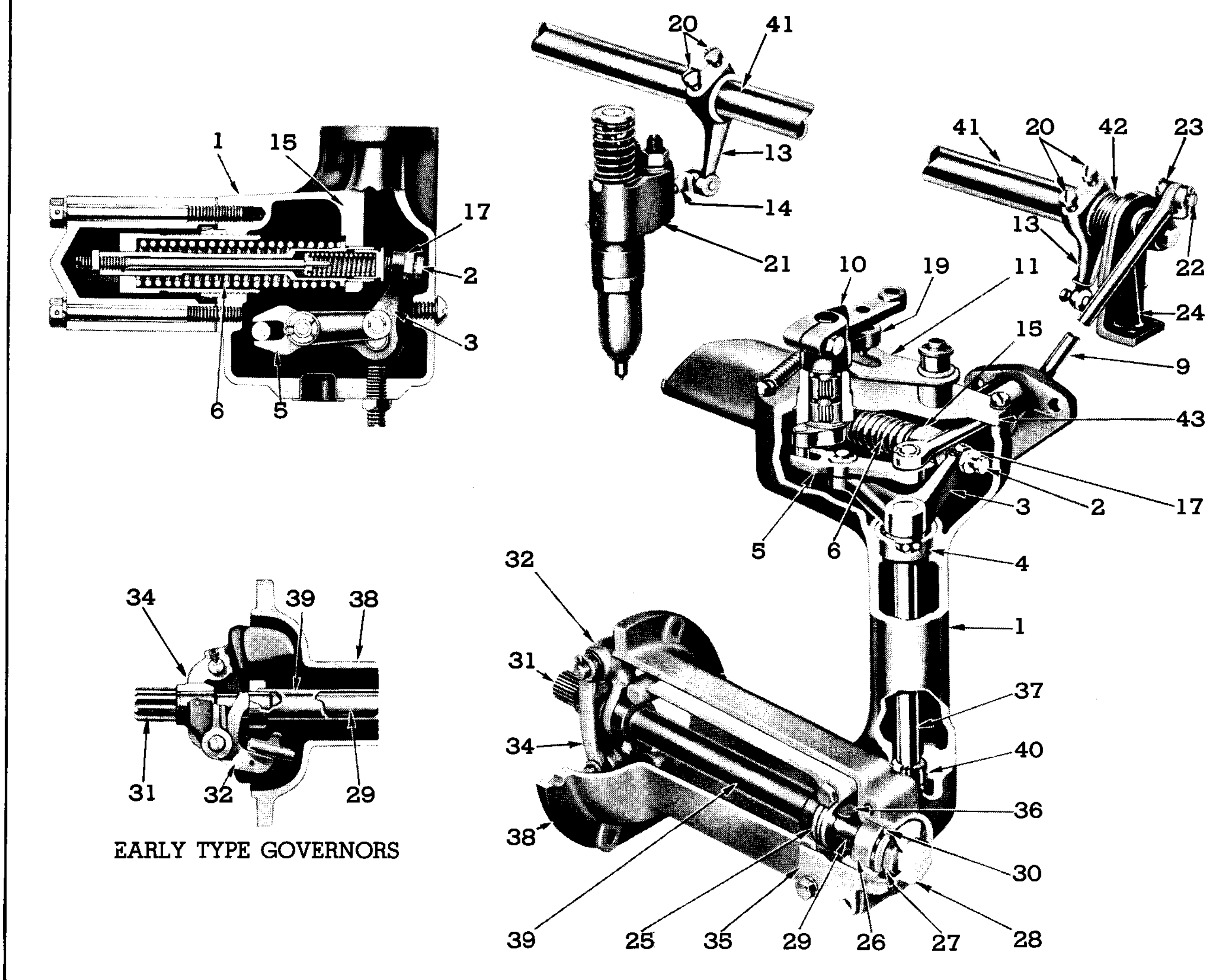


Fig. 16—Typical Limiting Speed Governor Assembly.

1. Housing—Governor Control.
2. Screw—Low-Speed Spring Gap Adjusting.
3. Lever—Operating.
4. Bearing—Operating Shaft Upper.
5. Lever—Differential.
6. Spring—High-Speed.
9. Link—Control.
10. Lever—Governor Control.
11. Cam—Control.
13. Lever—Rack Control.
14. Rack—Injector.
15. Support—Governor Spring Plunger (Integral with Control Housing).
17. Lock Nut—Low-Speed Spring Gap Adjusting Screw.
19. Lever—Governor Shaft Control.
20. Screw—Rack Control Lever Adjusting.
21. Injector.
22. Pin—Control Link.
23. Lever—Control Tube.
24. Bracket—Control Tube.
25. Bearing—Weight Shaft Thrust.
26. Bearing—Shaft.
27. Screw—Shaft Bearing Retaining.
28. Cap—Weight Housing.
29. Shaft—Weight Carrier.
30. Gasket—Weight Housing Cap.
31. Splined End of Governor Shaft.
32. Weight—Governor.
34. Weight Carrier.
35. Cover—Weight Housing.
36. Fork—Operating (Yoke).
37. Shaft—Operating.
38. Housing—Weight.
39. Riser.
40. Bearing—Operating Shaft Lower.
41. Tube—Injector Control.
42. Spring—Control Tube Return.
43. Cover—Governor.

vertical operating shaft by means of bell cranks integral with the weights and a yoke on the vertical shaft.

Governor control is brought about through the vertical operating shaft and a system of springs and levers in the upper end of the governor housing.

The vertical shaft is mounted on a ball bearing at the upper end and a needle bearing at the lower end.

Motion to the shaft, produced by the yoke at the lower end, is transferred to an operating lever (bell crank) at the upper end of the shaft. One leg of the operating lever carries a differential lever, one end of which is attached to a link leading to the injector rack control shaft; the other end is provided with a slot for the pin of the eccentric lever of the governor throttle shaft.

High and low-speed springs with suitable adjustments and retainers restrain movement of the governor weights through an adjustable screw carried in one leg of the operating lever.

VARIABLE SPEED MECHANICAL GOVERNOR

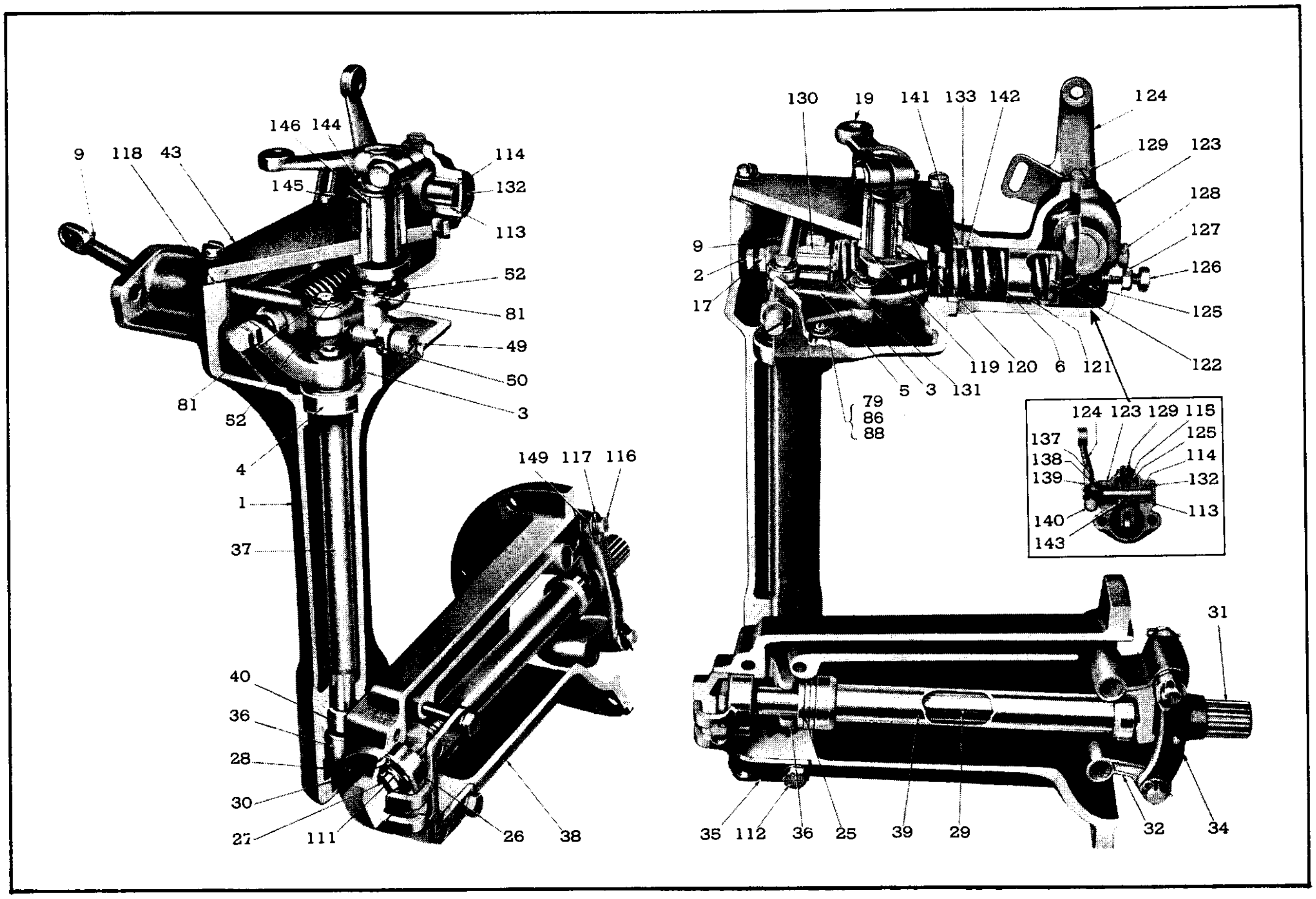


Fig. 17—Typical Variable Speed Governor Assembly.

1. Housing—Governor Control.
2. Screw—Governor Gap Adjusting.
3. Lever—Operating.
4. Bearing—Operating Shaft Upper.
5. Lever—Differential.
6. Spring—Governor.
9. Link—Control.
17. Lock Nut—Gap Adjusting Screw.
19. Lever—Governor Control.
25. Bearing—Weight Shaft Thrust.
26. Bearing—Shaft.
27. Screw—Shaft Bearing Retaining.
28. Cap—Weight Housing.
29. Shaft—Weight Carrier.
30. Gasket—Weight Housing Cap.
31. Splined End of Governor Shaft.
32. Weight.
34. Weight Carrier.
35. Cover—Weight Housing.
36. Fork—Operating (Yoke).
37. Shaft—Operating.
38. Housing—Weight.
39. Riser.
40. Bearing—Operating Shaft Lower.
43. Cover—Governor Control Housing.
49. Buffer Screw.
50. Lock Nut—Buffer Screw.
52. Pin Clip.
79. Screw.
81. Washer.
86. Flat Washer.
88. Shakeproof Lock Washer.
111. Lock Washer—Shaft Bearing Retainer Screw.
112. Bolt—Weight Housing Cover.
113. Bearing—Spring Lever Shaft.
114. Shaft—Spring Lever.
115. Set Screw—Spring Lever.
116. Pin—Weight (Pivot).
117. Cotter Pin.
118. Gasket.
119. Throttle Shaft.
120. Bearing—Throttle Shaft.
121. Spring Retainer.
122. Shim.
123. Housing—Governor Spring Lever.
124. Lever—Speed Control.
125. Lever—Governor Spring.
126. Screw—Idling Speed.
127. Lock Nut.
128. Bolt.
129. Pipe Plug.
130. Plunger Guide.
131. Spring Plunger.
132. Welch Plug.
133. Gasket.
137. Felt Washer.
138. Washer.
139. Woodruff Key.
140. Bolt.
141. Spacer—Spring Retainer.
142. Spacer—Spring Retainer.
143. Woodruff Key—Spring Lever.
144. Retaining Ring—Throttle Shaft.
145. Washers—Throttle Shaft Retaining Ring.
146. Seal Ring—Throttle Shaft.
149. Washers—Weight Pin.

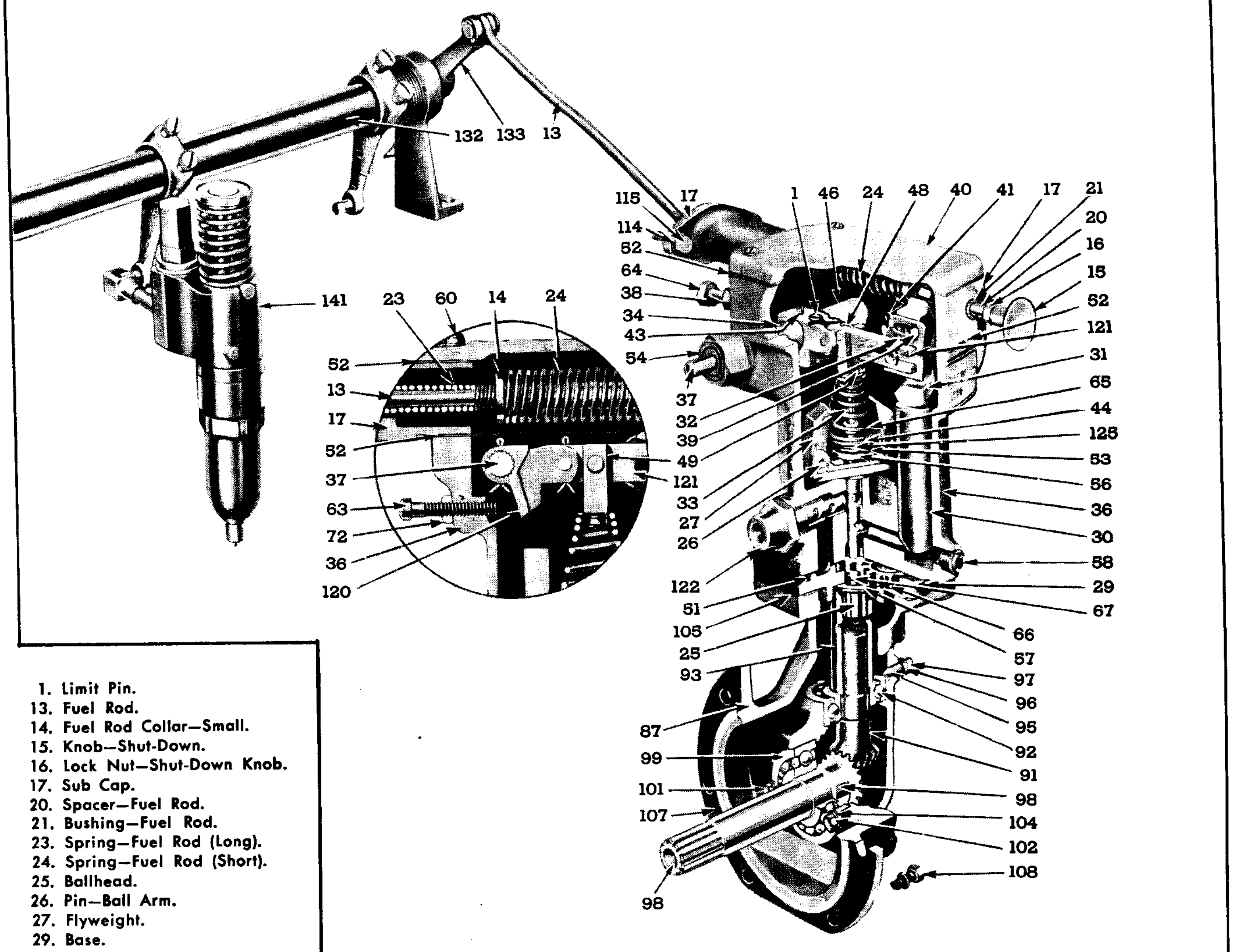
Description—The construction of the variable speed mechanical governor, as illustrated in Fig. 17 is very similar to the limiting speed type. The governor linkage mechanism consisting of the vertical shaft, its bearings, its allied parts, and load limit screw, are similar for both types. Unlike the limiting speed, however, only one spring is necessary. The plunger at one end of the single spring bears against the operating lever; the opposite end is retained and guided inside of a spring retainer, which in turn bears against a variable control speed lever.

This governor is designed to control the engine at a constant speed at any point, within the limitations of the governor spring, that the operator may desire.

Such control is made possible by adjusting the idling screw for the low engine speed, and imposing more or less tension on the spring by means of the variable speed control lever for higher speeds. The greater the tension on the spring, the higher the engine speed and vice versa.

Any speed range between idle and 2000 r.p.m. is obtainable on the governor design illustrated in Fig. 17, using with certain combinations of spring retainer stops and shims.

HYDRAULIC GOVERNOR



1. Limit Pin.
13. Fuel Rod.
14. Fuel Rod Collar—Small.
15. Knob—Shut-Down.
16. Lock Nut—Shut-Down Knob.
17. Sub Cap.
20. Spacer—Fuel Rod.
21. Bushing—Fuel Rod.
23. Spring—Fuel Rod (Long).
24. Spring—Fuel Rod (Short).
25. Ballhead.
26. Pin—Ball Arm.
27. Flyweight.
29. Base.
30. Servo Piston.
31. Terminal Lever.
32. Droop Adjusting Bracket.
33. Plunger—Pilot Valve.
34. Speed Adjusting Sleeve.
36. Governor Case.
37. Shaft—Speed Adjusting.
38. Lock Nut.
39. Droop Adjusting Screw.
40. Governor Cover.
41. Cotter Pin.
43. Cotter Pin—$\frac{3}{32}$" x ⅝".
44. Spring Seat.
46. Spacer Cap.
48. Lock Wire.
49. Spring Fork.
51. Seal Ring—Governor Case-to-Governor Base.
52. Gasket—Cover-to-Sub Cap and Sub Cap-to-Case.
53. Thrust Bearing.
54. Oil Seal.
56. Thrust Washer.
57. Collar—Drive Shaft.

Fig. 18—Typical Hydraulic Governor Assembly.

58. Pipe Plug.
60. Screw—Cover and Sub Cap-to-Case.
63. Screw—Maximum Speed Adjusting.
64. Screw—Maximum Fuel Adjusting (Load Limit).
65. Speeder Spring.
66. Gear—Pump Idler.
67. Gear—Pump Drive.
72. Lock Nut.
87. Housing—Governor Drive.
91. Gear—Governor Drive-Driven.
92. Bearing—Driven Gear.
93. Sleeve—Driven Gear.
95. Allen Screw—Conical Point.
96. Washer (Copper).
97. Nut.
98. Gear—Drive (Governor Drive).
99. Bearing—Drive Gear.
101. Bolt—Bearing Retaining.
102. Lock Washer.
104. Plain Washer—Bearing Retaining.
105. Gasket—Governor Assy-to-Governor Drive Assy.
107. Gasket—Governor Drive-to-Blower Assy.
108. Bolt—Governor Drive-to-Blower Assy.
114. Lock Washers.
115. Bolt—Sub Cap-to-Cylinder Head.
120. Lever—Speed Adjusting.
121. Floating Lever.
122. Relief Valve Assy.
125. Thrust Washer—Upper.
132. Injector Control Tube.
133. Lever—Injector Control Tube.
141. Fuel Injector.

The governor illustrated in Fig. 18 is the hydraulic type with speed droop stabilization. The hydraulic feature is brought about by oil from the engine lubricating system being admitted, under pressure, to an auxiliary oil pump in the governor. This auxiliary pump furnishes the necessary oil pressure to actuate the governor mechanism.

In this governor, the fuel is decreased by action of a fuel rod spring and increased by the opposing action of a hydraulic servo cylinder, the admission of oil to which is controlled by a pilot valve. The pilot valve is controlled by the flyweights of the governor. The flyweights are mounted on a vertical shaft and driven through a pair of miter gears from the upper rotor shaft of the blower at twice the engine speed. The centrifugal force of these flyweights in rotation is opposed by a so-called "speeder spring," the compression of which determines the speed at which the governor will control the engine. The compression on the speeder spring is varied by the throttle on the instrument panel.

In order that the governor operation may be stable, (that is, without hunting) "speed droop," adjustable in amount, is introduced into the governing system. By speed droop is meant the characteristic of decreasing speed with increasing load. The desired magnitude of this speed droop may be easily adjusted to suit conditions.

The mechanical connection of the governor to the fuel injectors is by means of a fuel rod or link attached to a lever on the injector control tube. When the engine is stopped, the fuel rod spring forces the fuel rod, and with it the injector racks, to the "Fuel Off" position.

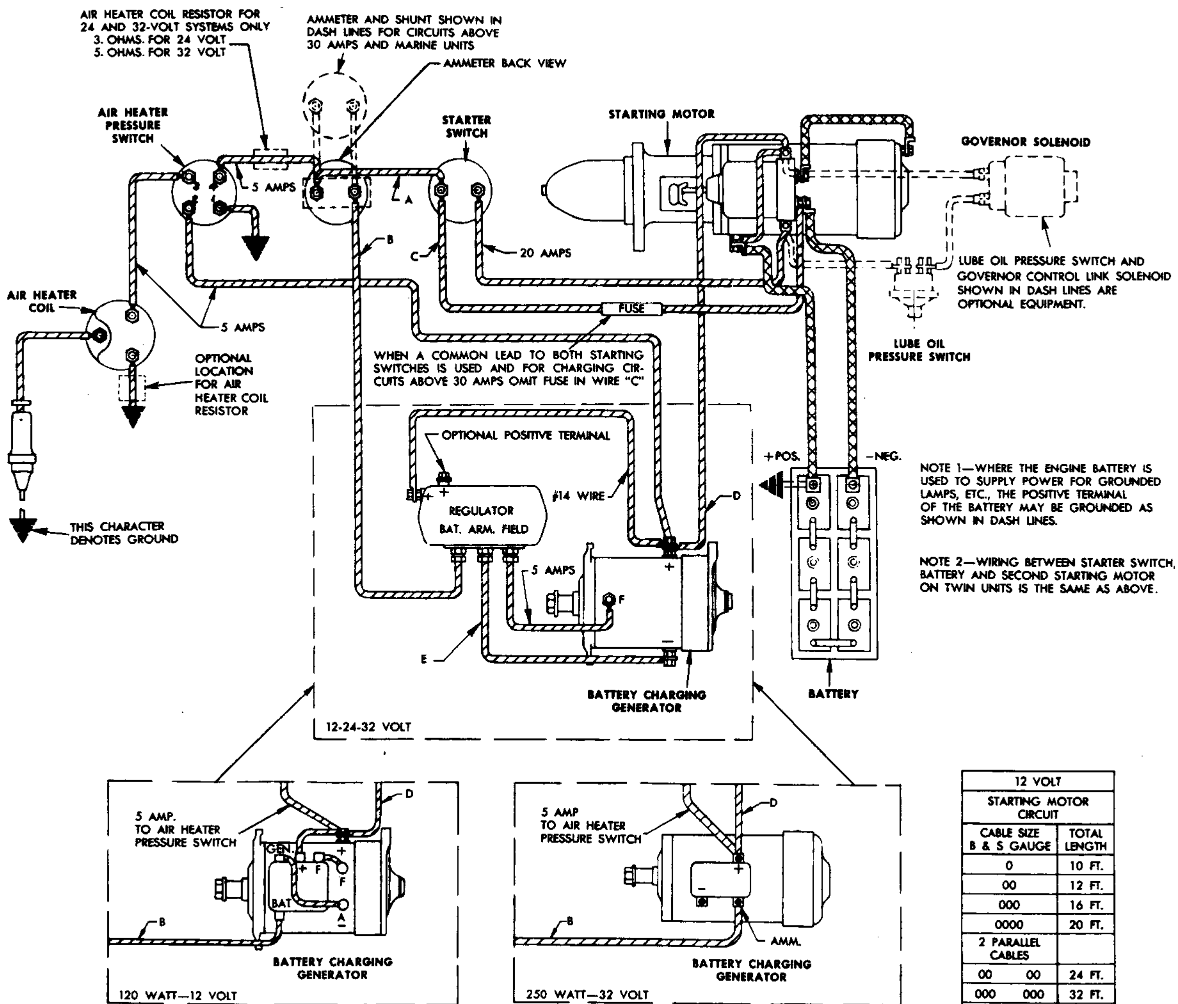
In starting a cold engine, it takes considerable time for the lubricating oil pressure to become great enough to operate the governor and thus open the throttle so the engine can start. As this delay in starting is considered objectionable, the starting time can be shortened by pressing in on the knob which projects from the side of the governor. This knob is on the fuel rod, which connects directly to the injector control tube, and pushing the knob in takes the control away from the governor.

In a similar manner, the engine can be stopped, regardless of the governor, by pulling out on the fuel rod knob. Considerable force must be exerted to do this as the oil pressure against the servo piston must be overcome. The knob thus functions also as a stopping device for the engine.

ELECTRICAL SYSTEM

Figures 19, 20 and 21 illustrate the engine starting circuit wiring diagrams and Figs. 22 and 23 illustrate the electrical automatic shutdown circuit wiring diagrams, which are used on the various Series 71, Three-, Four- and Six-Cylinder Industrial Power Units.

The engine starting system generally consists of: a battery-charging generator; a starting motor; a suit-



12 VOLT	
STARTING MOTOR CIRCUIT	
CABLE SIZE B & S GAUGE	TOTAL LENGTH
0	10 FT.
00	12 FT.
000	16 FT.
0000	20 FT.
2 PARALLEL CABLES	
00 00	24 FT.
000 000	32 FT.
0000 0000	40 FT.

RECOMMENDED WIRE SIZES FOR GENERATOR CIRCUITS													
CAPACITY OF CIRCUIT AMPERES	*WIRE-SIZE—12 VOLT CIRCUITS												
	14	12	10	8	6	4	2	0	00				
	TOTAL LENGTH OF CIRCUIT—FEET												
5	40	64	100	160									
10	20	32	50	80	127								
20	10	16	25	40	63	100							
30			17	26	42	67	107						
40				20	32	50	80	127					
50					25	40	64	102	128				
60						34	53	85	107				
70						27	46	73	92				
80							40	64	80				
120							27	42	53				

*NOTE: FOR 24 AND 32 VOLTS THE ABOVE CIRCUIT LENGTHS MAY BE DOUBLED

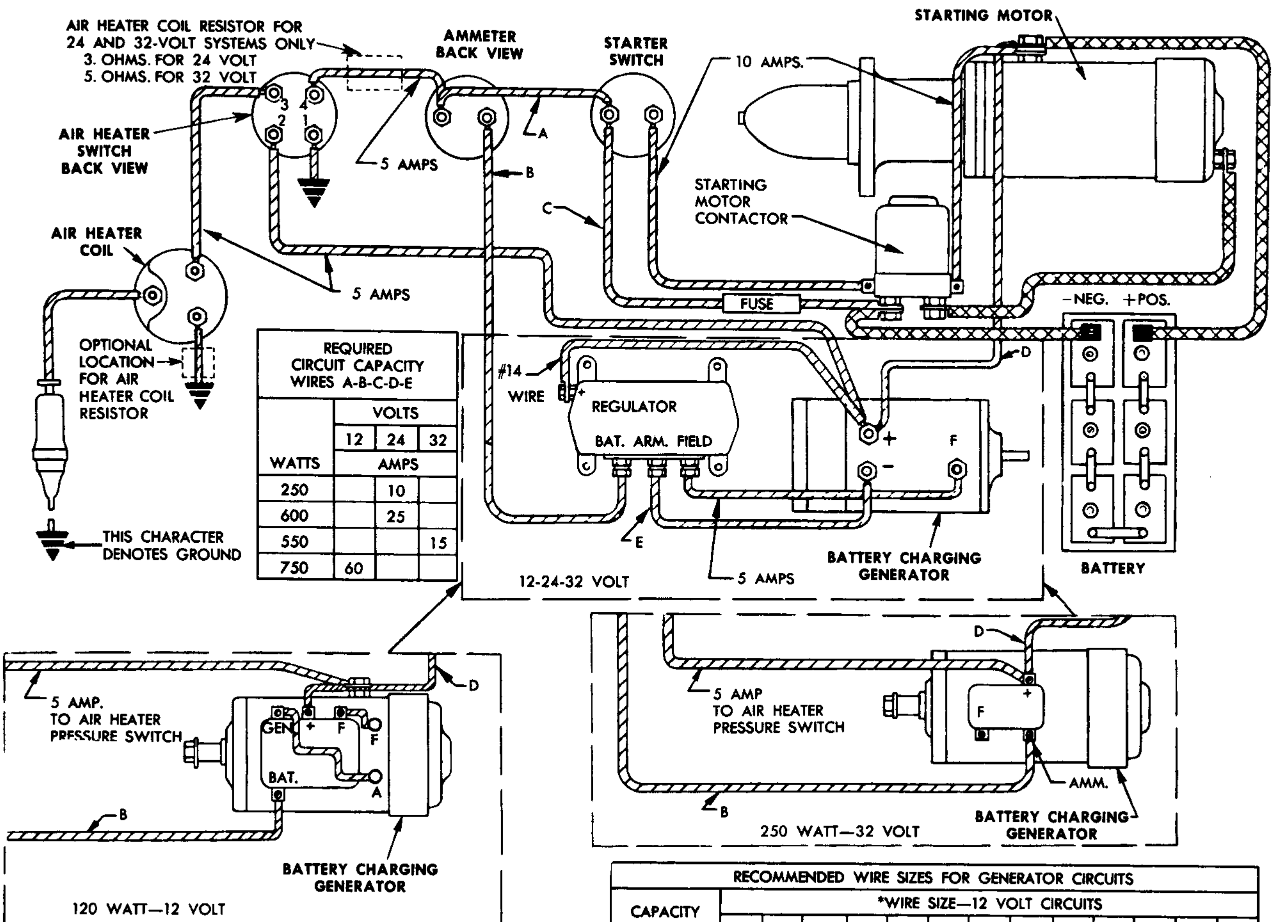
REQUIRED CIRCUIT CAPACITY WIRES A-B-C-D-E			
	VOLTS		
	12	24	32
WATTS	AMPS		
250	20	10	10
600		25	
900			25
1500		60	40
550	40	20	15
750	60		
125	10		

24-32 VOLT	
STARTING MOTOR CIRCUIT	
CABLE SIZE B & S GAUGE	TOTAL LENGTH
0	10 FT.
00	15 FT.
000	20 FT.
0000	30 FT.

Fig. 19—Starting System Wiring Diagram for 3, 4, and 6-71 Single or Twin Engines with Dyer Drive and Insulated (Ungrounded) 12, 24 or 32 Volt Circuits.

able combination voltage regulator, current regulator and relay to protect the electrical system; a storage battery to energize the system; and the necessary wiring to complete the electrical circuit.

The electrically operated automatic shutdown includes a fuel oil pressure switch, a lube oil pressure switch, a water temperature switch, an overspeed switch, a shutdown solenoid, and a hot wire relay



REQUIRED CIRCUIT CAPACITY WIRES A-B-C-D-E			
	VOLTS		
	12	24	32
WATTS	AMPS		
250		10	
600		25	
550			15
750	60		

12 VOLT	
STARTING MOTOR CIRCUIT	
CABLE SIZE B & S GAUGE	TOTAL LENGTH
0	10 FT.
00	12 FT.
000	16 FT.
0000	20 FT.
2 PARALLEL CABLES	
00 00	24 FT.
000 000	32 FT.
0000 0000	40 FT.

24-32 VOLT	
STARTING MOTOR CIRCUIT	
CABLE SIZE B & S GAUGE	TOTAL LENGTH
0	10 FT.
00	15 FT.
000	20 FT.
0000	30 FT.

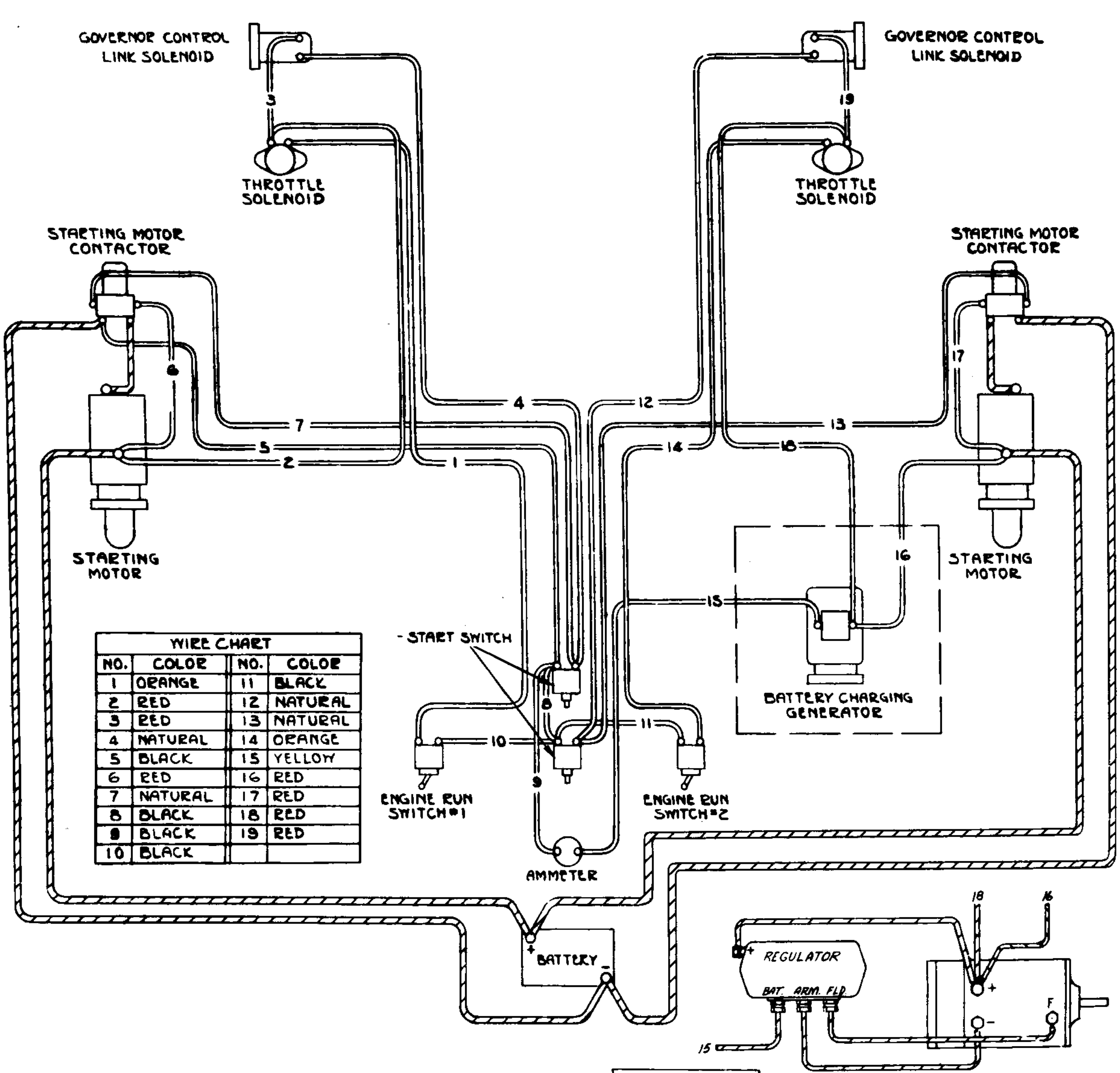
RECOMMENDED WIRE SIZES FOR GENERATOR CIRCUITS													
CAPACITY OF CIRCUIT AMPERES	*WIRE SIZE—12 VOLT CIRCUITS												
	14	12	10	8	6	4	2	0	00				
	TOTAL LENGTH OF CIRCUIT—FEET												
5	40	64	100										
10	20	32	50	80	127								
20	10	16	25	40	63	100							
30			17	26	42	67	107						
40				20	32	50	80	127					
50					25	40	64	102	128				
60						34	53	85	107				

*NOTE: FOR 24 AND 32 VOLTS THE ABOVE CIRCUIT LENGTHS MAY BE DOUBLED

Fig. 20—Starting System Wiring Diagram for 3, 4 and 6-71 Single or Twin Engines with Bendix Drive and Insulated (Ungrounded) 12, 24, or 32 Volt Circuits.

in conjunction with the starting circuit.

The three starting circuit diagrams (Figs. 19, 20 and 21) are classified into two systems according to the type of drive on the cranking motor. System No. 1, illustrated in Fig. 19, employs a Dyer drive on the cranking motor. System No. 2, illustrated in Figs. 20



WIRE CHART			
NO.	COLOR	NO.	COLOR
1	ORANGE	11	BLACK
2	RED	12	NATURAL
3	RED	13	NATURAL
4	NATURAL	14	ORANGE
5	BLACK	15	YELLOW
6	RED	16	RED
7	NATURAL	17	RED
8	BLACK	18	RED
9	BLACK	19	RED
10	BLACK		

RECOMMENDED WIRE SIZES FOR GENERATOR CIRCUITS													
CAPACITY OF CIRCUIT AMPERES	WIRE SIZE 12 VOLT CIRCUITS												
	14	12	10	8	6	4	2	0	00				
	TOTAL LENGTH OF CIRCUIT FEET												
5	40	64	100										
10	20	32	50	80	127								
20	10	16	25	40	63	100							
30			17	26	42	67	107						
40				20	32	50	80	127					
50					25	40	64	102	128				
60						34	53	85	107				

NOTE: FOR 24 AND 32 VOLT SYSTEMS DOUBLE THE ABOVE CIRCUIT LENGTHS

12 VOLT STARTING MOTOR CIRCUIT	
CABLE SIZE B. & S. GAGE	TOTAL LENGTH
0	10 FT.
00	12 "
000	16 "
0000	20 "
2 PARALLEL CABLES	
00 00	24 FT
000 000	32 "
0000 0000	40 "

24-32 VOLTS STARTING MOTOR CIRCUIT	
CABLE SIZE B & S GAGE	TOTAL LENGTH
0	10 FT.
00	15 "
000	20 "
0000	30 "

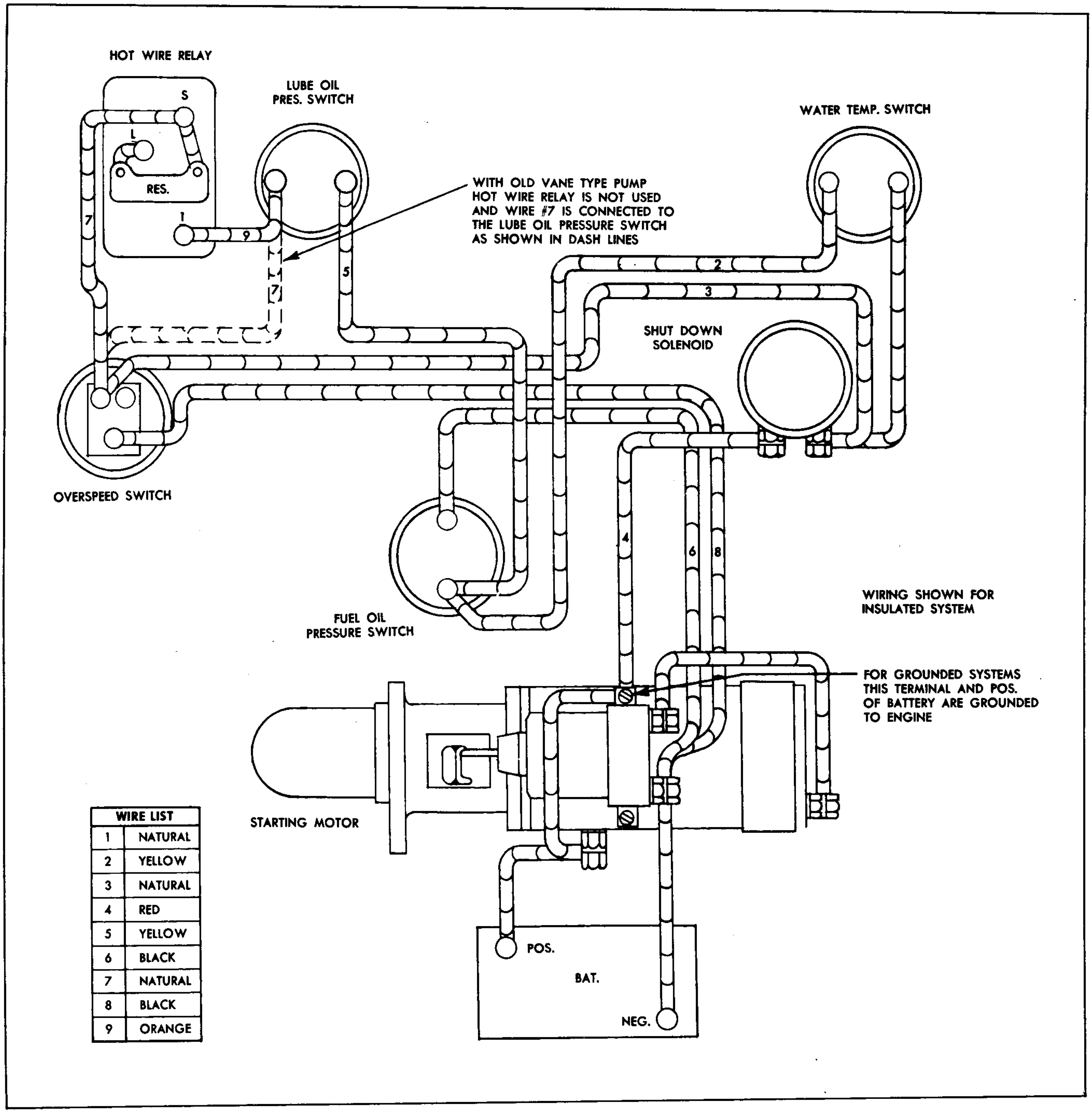
Fig. 21—Starting System Wiring Diagram for Twin 4 and 6-71 Engines with Bendix Drive; Link Solenoid and Throttle Solenoid at Governor and Insulated (Ungrounded) 12, 24 or 32 Volt Circuits.

and 21, employs a Bendix drive. A Dyer drive system may be identified by the starting solenoid attached to the cranking motor.

All of the three starting system wiring diagrams shown are ungrounded and all are applicable to 12, 24 and/or 32 volt circuits. Systems shown in Figs. 19 and 20 are used on either single or twin engine units.

The system shown in Fig. 21 is used on twin engine power generator sets where a governor control link solenoid and a throttle solenoid are used on the hydraulic governor cover to open the injector racks when starting and to position the speed adjusting shaft while running, respectively.

NOTE 1: Figures 19, 20 and 21 illustrate ungrounded starting systems only. Some early 12 volt systems



WIRE LIST	
1	NATURAL
2	YELLOW
3	NATURAL
4	RED
5	YELLOW
6	BLACK
7	NATURAL
8	BLACK
9	ORANGE

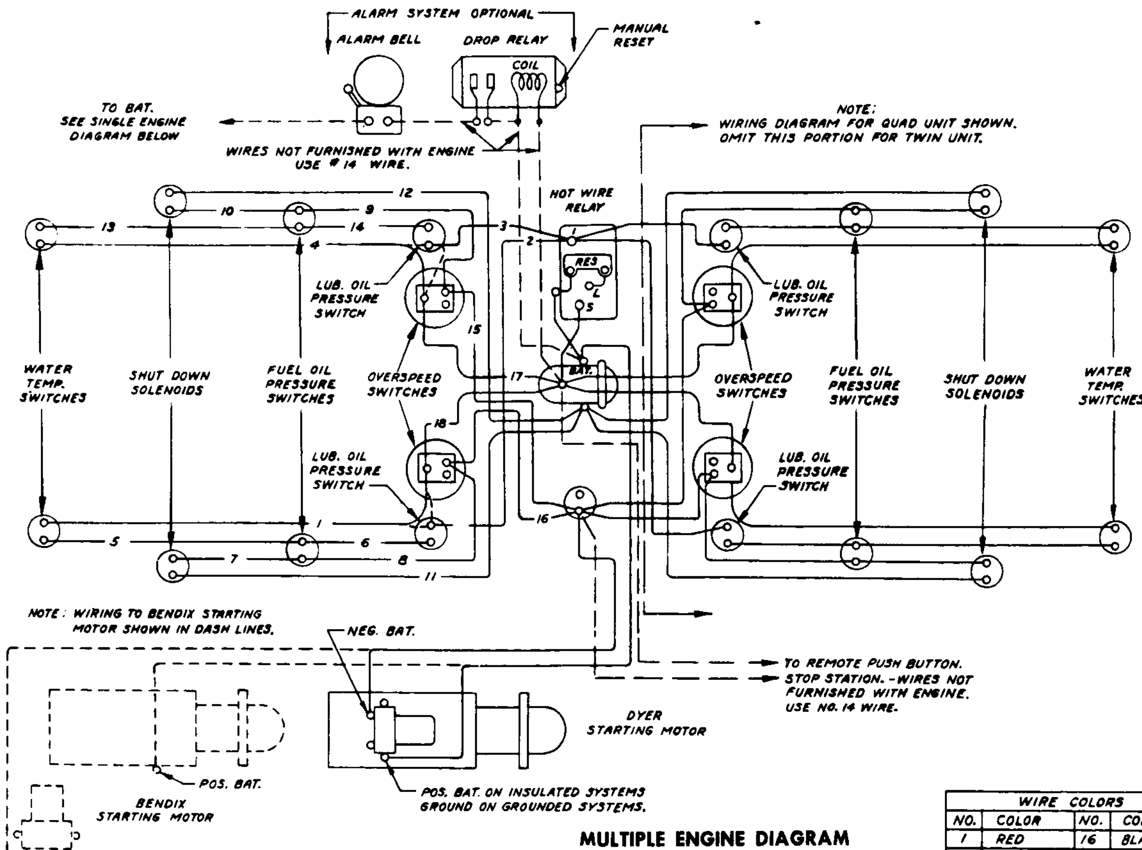
Fig. 22—Engine Shutdown Wiring Diagram for Single Engine Units.

were grounded. A 12 volt grounded system has only one heavy terminal on the starting motor; whereas an insulated (ungrounded) system has two heavy terminals on the starting motor.

NOTE 2: Figures 19, 20 and 21 also apply to grounded system; except, in a grounded system the positive (+) battery terminal is grounded to the engine and all positive connections to the starting equipment are grounded within the units. For example: The positive connection to the voltage regulator is made at the mounting foot of the regulator.

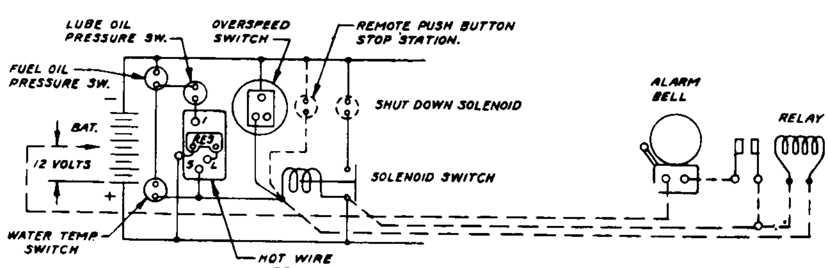
Automatic Shutdown—When the engine is running normally the shutdown electrical circuit is open. Whenever the electrical circuit is caused to close by any one of the four switches, the solenoid will operate to stop the engine.

When the engine is not running the fuel oil pressure switch is open and the lube oil pressure switch is closed. The water temperature switch is always open except in case of excessively high cooling water temperature.



MULTIPLE ENGINE DIAGRAM

WIRE COLORS			
NO.	COLOR	NO.	COLOR
1	RED	16	BLACK
2	RED	17	RED
3	RED	18	RED
4	RED		
5	ORANGE		
6	ORANGE		
7	BLACK		
8	BLACK		
9	BLACK		
10	BLACK		
11	ORANGE		
12	ORANGE		
13	ORANGE		
14	ORANGE		
15	BLACK		



SINGLE ENGINE DIAGRAM

Fig. 23—Engine Shutdown Wiring Diagram for Multiple Engine Units.

As soon as the engine starts and the lube oil pressure becomes normal, the lube oil pressure switch opens after which the fuel oil pressure switch closes.

To prevent the fuel oil pressure switch from stopping the engine before the lube oil pressure switch opens, which is manifest on the gear type fuel oil pump by a sudden build-up in fuel oil pressure and a false shutdown of the engine, a hot wire relay is introduced into the electrical circuit, as shown in Fig. 23. The hot wire relay is usually not necessary with the vane type fuel oil pump (used on early models) because the pump pressure build-up at starting is not as sudden as with the gear type pump.

When the circuit in Fig. 23 is used with the vane type fuel oil pump without the hot wire relay, then wires No. 1 and No. 4 go to the lube oil pressure switches instead of the overspeed switches; also, wires No. 2 and No. 3 go to the overspeed switches instead of the hot wire relay.

ALARM SYSTEM

An oil pressure switch, introduced into the engine oil gallery, is closed when the engine is not running, but opens after starting and remains open while the engine is running. This switch will close only in case of lowered oil pressure, thus causing the alarm to operate, or it will close if the engine is stopped by the Operator. A water temperature switch, mounted in the water manifold, always remains open except in case of high water temperature when it closes and operates the alarm.

An automatic fuel oil switch closes after the engine is started and normal fuel oil pressure has been attained.

An optional overspeed switch is sometimes introduced into the system, as shown in Fig. 24.

The water temperature switch and the oil pressure switch are similar to the same switches used in the automatic shut-down device.

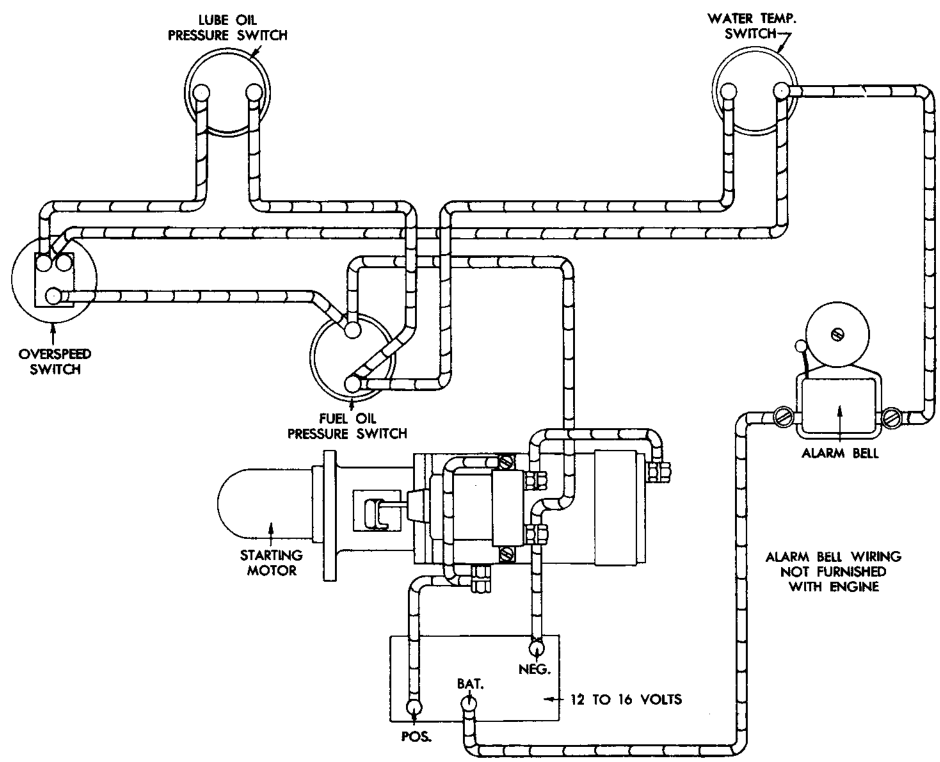


Fig. 24—Alarm System Wiring Diagram—Ungrounded.

COLD WEATHER STARTING

When starting an internal combustion engine in cold weather, a large part of the energy of combustion is absorbed by the pistons, cylinder walls, cooling water, and in overcoming friction.

Under extremely low outside temperatures, the cold oil in the bearings and between the pistons and cylinder walls creates very high friction and the effort required to crank the engine is much greater than when the engine is warm.

In a Diesel engine, the only means of igniting the fuel sprayed into the combustion chamber is the increased temperature due to compressing the air within the chamber.

This temperature becomes high enough under ordinary operating conditions, but may not be sufficiently high at extremely low outside temperatures to ignite the charge.

To assist in starting an engine under low temperature conditions, two different devices are available at the customer's option.

The first device, known as the "Air Heater," consists of two units. One unit is comprised of the pressure pump and the fuel supply valve, while the other, a heater unit, contains the nozzle, filter, ignition coil, and ignition points. In addition to the above units, an air heater pressure switch may be incorporated in some models. This switch automatically completes the electrical circuit through the coil when operating the heater pump.

The second device is known as the "Fluid Starting Aid" and consists, essentially, of a pump and nozzle for injecting a volatile fluid into the air intake and a suitable container for the fluid.

AIR HEATER

The air heater preheats the in-going charge of air to the cylinders sufficiently to insure an engine start at freezing temperatures, providing the lubricating oil in the engine is of the viscosity recommended for winter use, so that sufficiently high engine cranking speeds are possible with fully charged batteries.

Description—The air heater is essentially a small pressure oil burner with electric ignition. The burner proper is mounted in the engine air box, obtaining the necessary air for combustion from the charging blower, and discharging the products of combustion and the directly flame-heated air into the engine cylinders with practically no heat loss.

The pressure pump and fuel supply valve are usually mounted on the instrument panel. The heater unit, containing the nozzle, filter, ignition coil, and ignition points is mounted on the cylinder block as shown in Fig. 25, replacing one of the hand hole cover plates.

The pump is intended to supply fuel under pressure to the burner unit where the charge is filtered before reaching the discharge nozzle. The suction side of the pump is connected to the fuel strainer. The pump plunger, when not in use, is held in the "IN" position by a simple spring and ball mechanism and may be released merely by pulling the plunger out from the panel.

The pressure switch is introduced into the fuel line between the pump and the nozzle, so that pressure created when actuating the pump plunger closes the contacts in the switch, completes the electrical circuit through the coil, and causes a spark across the electrodes at the spray nozzle. Thus, when fuel is injected from the nozzle, the electric spark is present for ignition without the necessity of manipulating a separate outside switch.

Operation—When starting an engine in cold weather follow the "Air Heater Instructions" given on plate attached to instrument panel and repeated below for convenience of the operator.

Air Heater Instructions:

1. Open air heater valve.
2. With engine throttle wide open, engage starter.
3. Operate pump with smooth, even strokes, applying firm pressure of 10 pounds or more on pumping stroke.
4. With engine running, regulate throttle and push plunger in all the way until lock engages.

5. Close air heater valve.

CAUTION: Air heater should be used for cold weather starting only.

Engine usually starts firing during the first or second pumping stroke. At low temperatures, with heavy lubricating oil, the engine may fire for a time with the combined help of the starter and heater before developing sufficient power to run unassisted. Under these conditions, it is advisable to pause briefly at the end of each pumping stroke to allow the engine time to absorb the heat generated. Also at a temperature of 10°F. or lower, it will be found beneficial to use the heater for a short time after the engine has started.

CAUTION: Dependable starting of a Diesel engine by any means can be obtained only with adequate cranking speed. The lubricating oil used in cold weather must meet the specifications shown in Sec. 4.

The batteries (if current is supplied from batteries) must be kept in good condition. Air box drains must be open to avoid fuel accumulating in the air box.

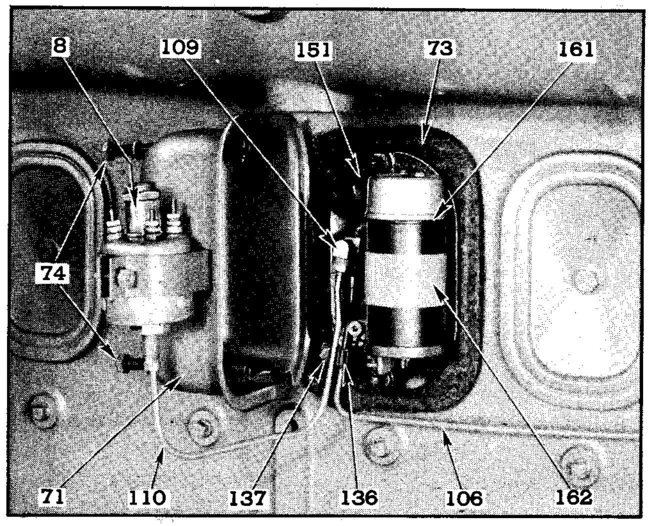


Fig. 25—Air Heater Mounting.

8. Switch—Air Heater Pressure.
71. Cover—Air Heater.
73. Gasket (Felt)—Air Heater Cover.
74. Bolt—Air Heater Cover.
106. Fuel Line—Air Heater Pump to Air Heater.
109. Elbow—Fuel Line (At Air Heater).
110. Fuel Line—Air Heater to Pressure Switch.
136. Clip—Fuel Line (At Air Heater).
137. Bolt—Fuel Line Clip.
151. Body—Air Heater.
161. Coil—Air Heater.
162. Bracket—Coil.

FLUID STARTING AID

Description—The fluid starting aid is designed to inject a highly volatile fluid into the air intake system in order to assist ignition of the fuel at low ambient temperatures. The fluid is contained in suitable capsules to facilitate handling.

Figure 26 shows the general arrangement of the fluid starting aid. It consists of a capsule container (501) which is a tight cylindrical chamber fitted with a screw cap (503). Inside the capsule container is located the sliding, plunger-like piercing shaft (504). From the capsule container a tube (507) leads to the piston type, hand-operated pump (500). Another tube (508) leads from the pump to the atomizing nozzle.

Installation—The pump (500) may be mounted on the instrument panel or in some other convenient location. The capsule container (501) must be mounted in a vertical position away from such high heat areas as the exhaust manifold, muffler, etc., and should not be located under a hood or in a cab. The atomizing nozzle is screwed into a tapped hole in the air intake housing. The tank-to-pump tube should be $3/16''$ O.D. copper tubing and the pump-to-nozzle tube $1/8''$ O. D.

Operation—

1. The cap (503) should be unscrewed from the capsule container (501) and a capsule (509) placed in the container.
2. With the piercing shaft (504) of the capsule container in the raised position (all the way out) screw the cap tightly on the container.
3. Push the piercing shaft down until it bottoms. This will break the capsule and fill the container with starting fluid vapor.
4. Move the engine throttle to the full-fuel position.
5. Engage the starter and simultaneously pull back the pump plunger all the way and then push the plunger in slowly, thus forcing the starting fluid through the nozzle and into the air intake. Continue to push the pump plunger in until the engine starts. If the plunger is not all the way in when the engine starts, push it in very slowly until it locks in the "IN" position.
6. Unscrew the cap from the capsule container body and remove the used capsule. **Do not leave the empty capsule in the container.**
7. Reinstall the cap tightly on the container body.

   NOTE: When not in use, the piercing shaft should be all the way down.

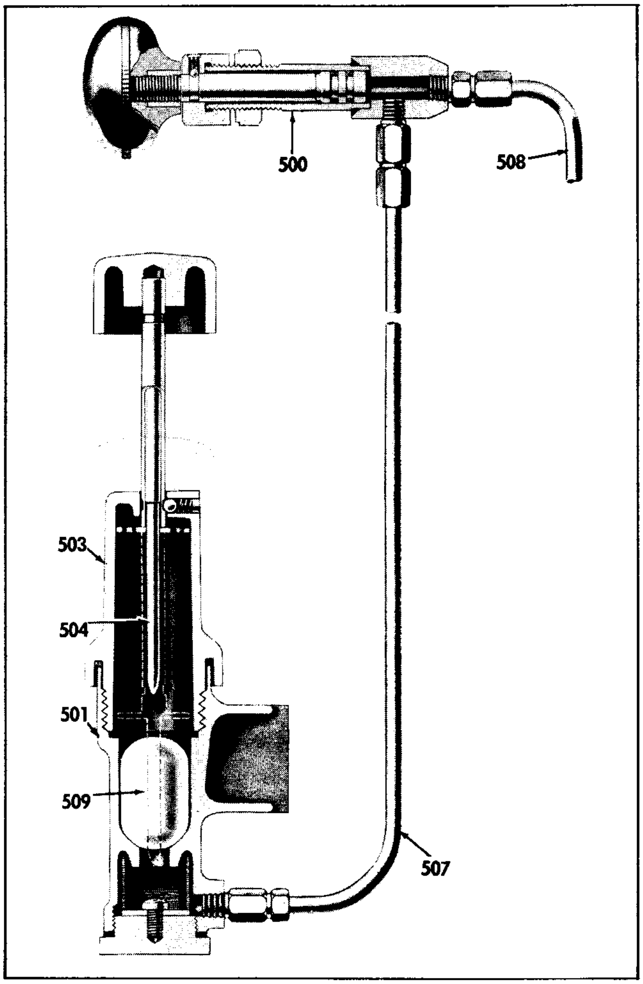


Fig. 26—Schematic Diagram of Fluid Starting Aid.

500. Pump Assy.
501. Container—Capsule.
503. Cap—Capsule Container.
504. Piercing Shaft—Capsule.
507. Tube—Capsule Container to Pump.
508. Tube—Pump to Air Valve Intake Housing.
509. Capsule.

POWER TRANSMISSIONS

In order to transmit the power developed by the engine or engines to the driven mechanism, several types of power transmissions are employed on Series 71 industrial units. The power transmissions currently used on Series 71 single engined industrial units may be generally divided into four types: (1) power take-off with short shaft, (2) power take-off with outboard bearing, (3) power take-off with double plate clutch, and (4) power take-off with reduction gear. Twin engines employ a power transmission consisting of a separate clutch for each engine plus a power transfer gear which transmits engine power to a single output shaft. This power transfer gear is available in 1 to 1, 1.33 to 1, 1.77 to 1, and 2 to 1 ratios. Quad units also have a separate clutch for each engine and a gear box for incorporating the output of the four engines into a single shaft. The quad gear boxes are available in 1.38 to 1, 1.5 to 1, and 1.75 to 1 ratios. The General Motors Torque Converter, installed on certain models, is covered in a separate manual, Form 6SE57.

POWER TAKE-OFF WITH SHORT SHAFT

Description—The power take-off with short shaft is illustrated in Fig. 1. This unit, which is bolted to the engine flywheel housing, consists of a single-plate, dry-disc clutch bolted to the engine flywheel (157) and a drive shaft (16), driven by the clutch, mounted in a single-row clutch pilot ball bearing (22) at the forward end and a taper roller bearing (58), mounted in the clutch housing (1), near the outer end. The forward bearing aligns the shaft and carries that end of the shaft. The tapered roller bearing absorbs both the thrust and radial load on the power take-off shaft. An adjustable bearing retainer (59) provides a means of adjusting the tapered roller bearing.

The clutch mechanism proper consists of a three-segment clutch facing (26) supported within and driven by a driving ring (24) bolted to the flywheel; an outer pressure plate (25) keyed to the drive shaft and an inner pressure plate (27) carried on the hub of and driven by the outer pressure plate; clutch pressure plate separator springs (28) to separate, the inner and outer pressure plates when the clutch is disengaged; an adjusting ring (30) to adjust for wear on the facing; a clutch release sleeve (41), together with linkage assembly, operated by a release collar (42), a yoke (46) and hand-operated lever (50) for engaging and releasing the clutch.

Operation—When hand lever (50) is moved toward the engine, yoke (46) moves sleeve (41) toward the clutch. This movement forces outer ends of links (36) away from the axes of rotation and causes the levers (33) to contact the inside face of adjusting ring (30), which locks the clutch facing (26) between the outer and inner pressure plates (25) and (27). Thus, the power of the engine is transmitted to the drive shaft (16).

When hand lever (50) is moved away from engine, release sleeve (41) moves away from clutch, and springs (28) return pressure plate (27) to the released position. This relieves pressure between the pressure plates and clutch facing, permitting the pressure plates and the drive shaft to cease rotating. Since the clutch facing is splined to inner diameter of driving ring (24), which is bolted to the flywheel, it continues to rotate while the engine is running.

Lubrication—Three places require lubrication on the power take-off asembly:

1. **Clutch Throw-out Bearing**—See Lubrication Chart in section 4. This bearing should be lubricated through the pressure fitting at the clutch housing with high-speed, short-fibre, ball bearing grease. Lubricate sparingly to avoid grease on clutch facings.

2. **Drive Shaft Main Bearing** should be lubricated through the pressure fitting at the bearing with high-speed, short-fibre, ball bearing grease. See Lubrication Chart in section 4.

3. **Clutch Mechanism** should be lubricated with engine oil. To lubricate: Remove handhole cover on clutch housing and lubricate toggle joints with an oil can as required to keep joints free. Lubricate shifter shaft bearings with hand oiler. See Lubrication Chart in section 4.

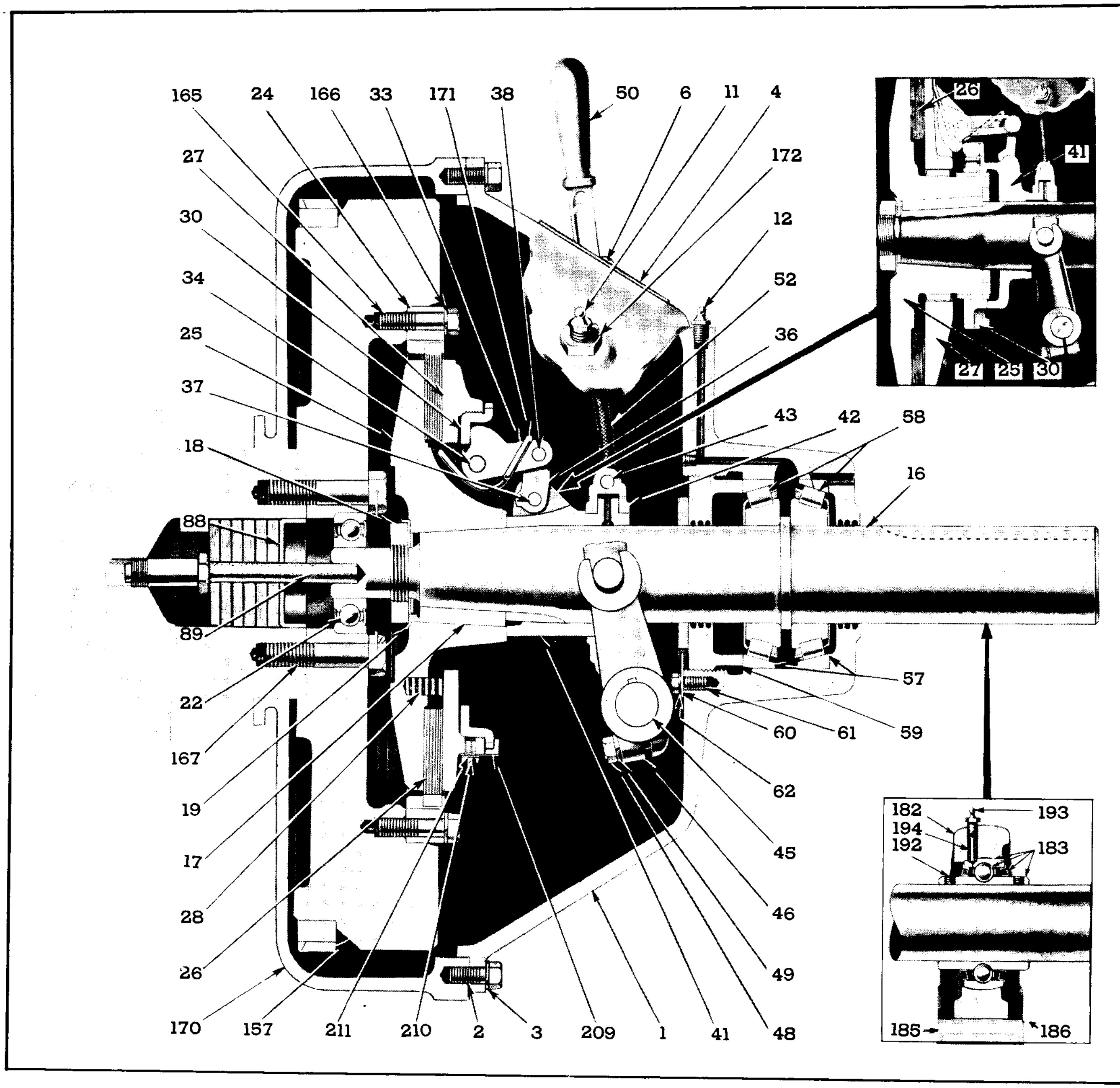


Fig. 1—G.M. Power Take-Off

Clutch Adjustment (Late Type Single Plate Clutch)—These instructions refer to field adjustment for facing wear of late type single plate clutches; for adjustments of clutches in early type single plate clutches and all double plate clutches, see page 3. Frequency of adjustment depends upon the amount and nature of the load. **To insure longest facing life and best clutch performance, the clutch should be adjusted before slippage occurs.**

When the clutch is engaged, the release lever link (36), Fig. 1, is moved over center [pin (37) is forward of pin (38)] to the locked position, the clutch release collar (42) is loose on the sleeve (41) and hand shift lever (50) has free play fore and aft. When the clutch is properly adjusted, a heavy pressure is required at the extreme outer end of the lever to move the throw-out linkage to the "over center" or locked position.

1. Disengage the clutch.

2. Refer to Fig. 1 and remove handhole cover (4)

Fig. 1—G.M. Power Take-Off Assembly.

1. Clutch Housing.
2. Bolt—Clutch Housing to Engine.
3. Lock Washer.
4. Cover—Clutch Inspection Hole.
6. Screw—Inspection Hole Cover.
11. Fitting—1/8" Hydraulic.
12. Fitting—1/8" Hydraulic.
16. Shaft—Clutch Drive.
17. Key—Clutch to Shaft.
18. Nut—Clutch Shaft.
19. Lock Washer—Clutch Shaft.
22. Ball Bearing—Clutch Pilot.
24. Ring—Clutch Driving.
25. Plate—Clutch Pressure (Outer).
26. Clutch Facing (Three Segments.)
27. Plate—Clutch Pressure (Inner).
28. Spring—Clutch Pressure Plate Separator.
30. Ring—Clutch Adjusting.
33. Lever—Clutch Release (Toggle).
34. Pin—Clutch Release Lever.
36. Link—Clutch Release Lever.
37. Pin—Clutch Release Lever Link-to-Sleeve
38. Pin—Clutch Release Lever-to-Link.
41. Sleeve—Clutch Release.
42. Collar Assy—Clutch Release Sleeve.
43. Bolt—Release Sleeve Collar.
45. Shaft—Clutch Release.
46. Yoke—Clutch Release.
48. Bolt—Yoke-to-Shaft.
49. Lock Washer.
50. Lever—Clutch Hand Control.
52. Flexible Hose Assy.
57. Cup—Roller Bearing.
58. Cone—Roller Bearing.
59. Retainer—Clutch Drive Shaft Bearing.
60. Lock Plate—Bearing Retainer.
61. Bolt—Bearing Retainer Lock Plate.
62. Lock Washer.
88. Baffle—Crankshaft Grease.
89. Oil Wick—Pilot Bearing.
157. Flywheel Assy.
165. Bolt—Clutch Driving Ring-to-Flywheel.
166. Lock Washer.
167. Bolt—Flywheel Attaching.
170. Flywheel Housing.
171. Spring—Clutch Release Lever.
172. Nut—Retainer (Flexible Hose-to-Housing).
182. Pillow Block.
183. Bearing—Pillow Block.
185. Support—Pillow Block
186. Shims—Pillow Block to Support.
192. Set Screw—Bearing Sleeve to Shaft.
193. Fitting—1/8" Hydraulic.
194. Pin—Pillow Block Bearing Lock.
209. Lock—Adjusting Nut.
210. Screw—Adjusting Nut Lock Retaining.
211. Lock Washer.

to expose clutch adjusting ring (30).

3. Insert end of long bar into notch of adjusting ring (30), and, while applying sufficient pressure on hand shift lever to prevent clutch from turning, turn **anti-clockwise** by prying over edge of handhole in housing (1).
4. Turn adjusting ring until heavy pressure is required at extreme outer end of handle to move the throw-out linkage to the "over center" or locked position. Lock (209) automatically locks the adjusting ring in position after adjustment.
5. Lubricate clutch linkage and install handhole cover.

Main Bearing Adjustment — Should adjustment for wear be required in the field on the main bearing, adjust as follows:

1. Remove handhole cover (4).
2. Loosen lock plate bolt (61) to free bearing retainer (59).
3. Place end of a long bar into notch of retainer (59) and turn it clockwise to tighten. The bearing retainer should be just tight enough to remove any end play from the shaft, yet not so tight as to impose any pre-load on the bearing which would prevent free turning of the shaft. Tighten lock plate bolt (61).

Clutch Adjustment (Early Type Single Plate Clutch And All Double Plate Clutches)—These instructions refer to field adjustment for facing wear. Frequency of adjustment depends upon the amount and nature of the load. **To insure longest facing life and best clutch performance, clutch should be adjusted before slippage occurs.**

When the clutch is engaged, the release lever link (36), Fig. 2, is moved over center [pin (37) is forward of pin (38)] to the locked position, the clutch release collar (42) is loose on the sleeve (41) and hand shift lever (50) has free play fore and aft. When the clutch is properly adjusted, a heavy pressure is required at the extreme outer end of the lever to move the throwout linkage to the "over center" or locked position.

1. Disengage the clutch.
2. Refer to Fig. 2 and remove inspection hole cover (4), to expose adjusting nut (30).
3. Insert end of long bar into notch of adjusting nut (30) and, while applying sufficient pressure on hand shift lever to prevent clutch from turning, turn nut **clockwise** by prying with bar against edge of handhole in housing (1).
4. Turn adjusting nut until heavy pressure is required at extreme outer end of handle to move the throwout linkage to the "over center" or locked position. Retainer (180) automatically locks the adjusting nut in position after adjustment.

Fig. 1—G.M. Power Take-Off Assembly.

1. Clutch Housing.
2. Bolt—Clutch Housing to Engine.
3. Lock Washer.
4. Cover—Clutch Inspection Hole.
6. Screw—Inspection Hole Cover.
11. Fitting—1/8" Hydraulic.
12. Fitting—1/8" Hydraulic.
16. Shaft—Clutch Drive.
17. Key—Clutch to Shaft.
18. Nut—Clutch Shaft.
19. Lock Washer—Clutch Shaft.
22. Ball Bearing—Clutch Pilot.
24. Ring—Clutch Driving.
25. Plate—Clutch Pressure (Outer).
26. Clutch Facing (Three Segments.)
27. Plate—Clutch Pressure (Inner).
28. Spring—Clutch Pressure Plate Separator.
30. Ring—Clutch Adjusting.
33. Lever—Clutch Release (Toggle).
34. Pin—Clutch Release Lever.
36. Link—Clutch Release Lever.
37. Pin—Clutch Release Lever Link-to-Sleeve
38. Pin—Clutch Release Lever-to-Link.
41. Sleeve—Clutch Release.
42. Collar Assy—Clutch Release Sleeve.
43. Bolt—Release Sleeve Collar.
45. Shaft—Clutch Release.
46. Yoke—Clutch Release.
48. Bolt—Yoke-to-Shaft.
49. Lock Washer.
50. Lever—Clutch Hand Control.
52. Flexible Hose Assy.
57. Cup—Roller Bearing.
58. Cone—Roller Bearing.
59. Retainer—Clutch Drive Shaft Bearing.
60. Lock Plate—Bearing Retainer.
61. Bolt—Bearing Retainer Lock Plate.
62. Lock Washer.
88. Baffle—Crankshaft Grease.
89. Oil Wick—Pilot Bearing.
157. Flywheel Assy.
165. Bolt—Clutch Driving Ring-to-Flywheel.
166. Lock Washer.
167. Bolt—Flywheel Attaching.
170. Flywheel Housing.
171. Spring—Clutch Release Lever.
172. Nut—Retainer (Flexible Hose-to-Housing).
182. Pillow Block.
183. Bearing—Pillow Block.
185. Support—Pillow Block
186. Shims—Pillow Block to Support.
192. Set Screw—Bearing Sleeve to Shaft.
193. Fitting—1/8" Hydraulic.
194. Pin—Pillow Block Bearing Lock.
209. Lock—Adjusting Nut.
210. Screw—Adjusting Nut Lock Retaining.
211. Lock Washer.

to expose clutch adjusting ring (30).

3. Insert end of long bar into notch of adjusting ring (30), and, while applying sufficient pressure on hand shift lever to prevent clutch from turning, turn **anti-clockwise** by prying over edge of handhole in housing (1).
4. Turn adjusting ring until heavy pressure is required at extreme outer end of handle to move the throw-out linkage to the "over center" or locked position. Lock (209) automatically locks the adjusting ring in position after adjustment.
5. Lubricate clutch linkage and install handhole cover.

Main Bearing Adjustment — Should adjustment for wear be required in the field on the main bearing, adjust as follows:

1. Remove handhole cover (4).
2. Loosen lock plate bolt (61) to free bearing retainer (59).
3. Place end of a long bar into notch of retainer (59) and turn it clockwise to tighten. The bearing retainer should be just tight enough to remove any end play from the shaft, yet not so tight as to impose any pre-load on the bearing which would prevent free turning of the shaft. Tighten lock plate bolt (61).

Clutch Adjustment (Early Type Single Plate Clutch And All Double Plate Clutches)—These instructions refer to field adjustment for facing wear. Frequency of adjustment depends upon the amount and nature of the load. **To insure longest facing life and best clutch performance, clutch should be adjusted before slippage occurs.**

When the clutch is engaged, the release lever link (36), Fig. 2, is moved over center [pin (37) is forward of pin (38)] to the locked position, the clutch release collar (42) is loose on the sleeve (41) and hand shift lever (50) has free play fore and aft. When the clutch is properly adjusted, a heavy pressure is required at the extreme outer end of the lever to move the throwout linkage to the "over center" or locked position.

1. Disengage the clutch.
2. Refer to Fig. 2 and remove inspection hole cover (4), to expose adjusting nut (30).
3. Insert end of long bar into notch of adjusting nut (30) and, while applying sufficient pressure on hand shift lever to prevent clutch from turning, turn nut **clockwise** by prying with bar against edge of handhole in housing (1).
4. Turn adjusting nut until heavy pressure is required at extreme outer end of handle to move the throwout linkage to the "over center" or locked position. Retainer (180) automatically locks the adjusting nut in position after adjustment.

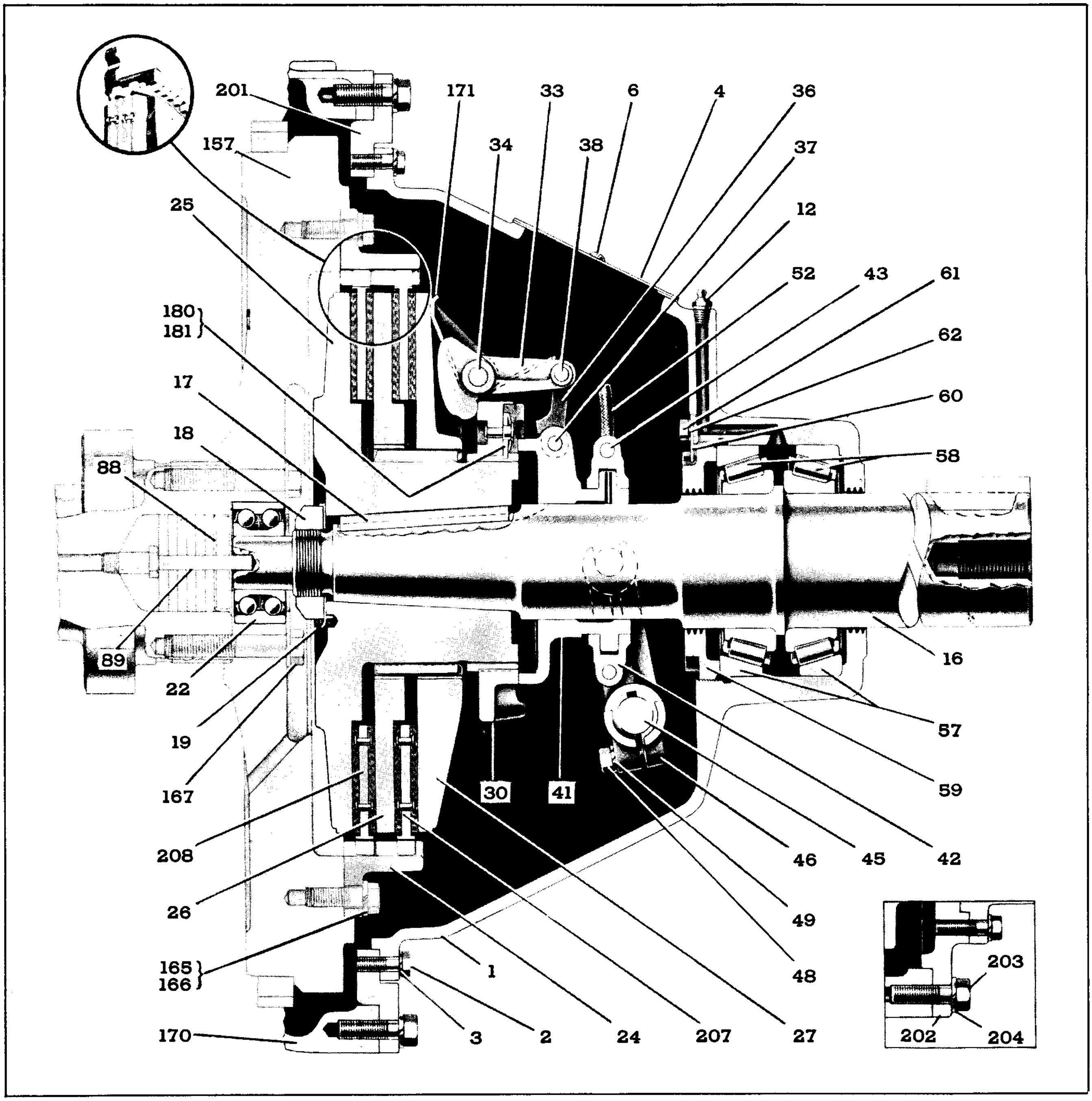


Fig. 2—G.M. Power Take-Off—With Double Plate Clutch.

POWER TAKE-OFF WITH OUTBOARD BEARING

Description—The power take-off with outboard bearing is structurally the same as the unit shown in Fig. 1 except the former has a longer shaft with an outboard bearing within a pillow block which rests on a support.

Mounting of the clutch and clutch housing to the engine is the same in both units. The pillow block for the outboard bearing is bolted to a support which is, in turn bolted to the engine base, so that the pillow block and bearing are readily removed with-

Fig. 2—G.M. Power Take-Off—With Double Plate Clutch.

1. Clutch Housing.
2. Bolt—Clutch Housing to Adapter.
3. Lock Washer.
4. Cover—Clutch Inspection Hole.
6. Screw—Clutch Inspection Hole Cover.
12. Fitting—1/8" Hydraulic.
16. Shaft—Clutch Drive.
17. Key—Clutch to Shaft.
18. Nut—Clutch Shaft.
19. Lock Washer—Clutch Shaft.
22. Ball Bearing—Clutch Pilot.
24. Ring—Clutch Driving.
25. Plate—Clutch Pressure (Outer).
26. Plate—Clutch Pressure (Center).
27. Plate—Clutch Pressure (Inner).
30. Nut—Clutch Adjusting.
33. Lever—Clutch Release (Toggle).
34. Pin—Clutch Release Lever.
36. Link—Clutch Release Lever.
37. Pin—Clutch Release Lever Link-to-Sleeve.
38. Pin—Clutch Release Lever-to-Link.
41. Sleeve—Clutch Release.
42. Collar Assy—Clutch Release Sleeve.
43. Bolt—Release Sleeve Collar.
45. Shaft—Clutch Release.
46. Yoke—Clutch Release.
48. Bolt—Yoke-to-Shaft.
49. Lock Washer
52. Flexible Hose Assy.
57. Cup—Roller Bearing.
58. Cone—Roller Bearing.
59. Retainer—Clutch Drive Shaft Bearing.
60. Lock Plate—Clutch Drive Shaft Bearing Retainer.
61. Bolt—Clutch Drive Shaft Bearing Retainer Lock Plate.
62. Lock Washer.
88. Baffle—Crankshaft Grease.
89. Oil Wick—Pilot Bearing.
157. Flywheel Assy.
165. Bolt—Clutch Driving Ring-to-Flywheel.
166. Lock Washer.
167. Bolt—Flywheel Attaching.
170. Flywheel Housing.
171. Spring—Clutch Release Lever.
180. Star Retainer.
181. Washer—Spring Cup.
201. Flush Adapter—Clutch Housing to Flywheel Housing.
202. Offset Adapter—Clutch Housing to Flywheel Housing.
203. Bolt—Adapter to Flywheel Housing.
204. Lock Washer.
207. Clutch Facing (Inner).
208. Clutch Facing (Outer).

out disturbing either the support or the clutch housing proper.

Lubrication—Lubrication for the parts within the clutch housing on this unit with the outboard bearing is the same as for the unit less the outboard bearing illustrated in Fig. 1, see "Lubrication," page 1; except, **lubricate outboard bearing** with high-grade, light ball bearing grease. Use low pressure grease gun and supply just enough grease to cause a small collar of the lubricant to form around the seal when the shaft is rotating. See Lubrication Chart in section 4.

POWER TAKE-OFF WITH DOUBLE PLATE CLUTCH

Description—The power take-off unit illustrated in Fig. 2 is similar in design, with one exception, to those previously described: a double-plate clutch is incorporated to gain more clutch surface for special engine applications.

The clutch mechanism proper consists of two clutch plates (facings) (207) and (208) supported within and driven by a driving ring (24) bolted to the flywheel. An outer pressure plate (25) keyed to the drive shaft, a center pressure plate (26) and an inner pressure plate (27) are carried on the hub of and driven by the outer pressure plate. An adjusting nut (30) provides for adjusting wear on the facing. A hand lever is provided for engaging and disengaging the clutch through yoke (46), release sleeve (41), and links (36) and (33).

Lubrication—Lubrication of the power take-off with double-plate clutch is the same as for the unit with single-plate clutch illustrated in Fig. 1 and covered under "Lubrication," page 1.

Clutch and Main Bearing Adjustments—Adjustments on the clutch and main bearing for the double-plate clutch power take-off is covered on page 3.

POWER TAKE-OFF WITH REDUCTION GEAR ASSEMBLY—USED ON SINGLE ENGINES

Description—Figure 3 illustrates the power take-off with 1.76:1 reduction gear used on the 71 Series General Motors Diesel Engines. The unit, which is attached to the engine flywheel housing (170), consists of a single-plate, dry-disc clutch bolted to the flywheel (157) and the reduction gear assembly bolted to the rear of the clutch housing (1) with gasket (90) between the members.

The clutch mechanism proper consists of a three-segment clutch facing (26) supported within and driven by a driving ring (24) bolted to the flywheel; an outer pressure plate (25) keyed to the drive shaft and an inner pressure plate (27) carried on the hub of and driven by the outer pressure plate; an adjusting nut (30) to adjust for wear on the facing; a clutch release sleeve (41), together with linkage assembly, operated by a release collar (42), a yoke (46) and hand-operated lever (50) for engaging and releasing the clutch.

A double-row ball bearing (55) is carried in the reduction gear housing (68) to support the pinion end of clutch shaft (16). Drive pinion (80) is keyed to the clutch shaft just aft of the supporting ball bear-

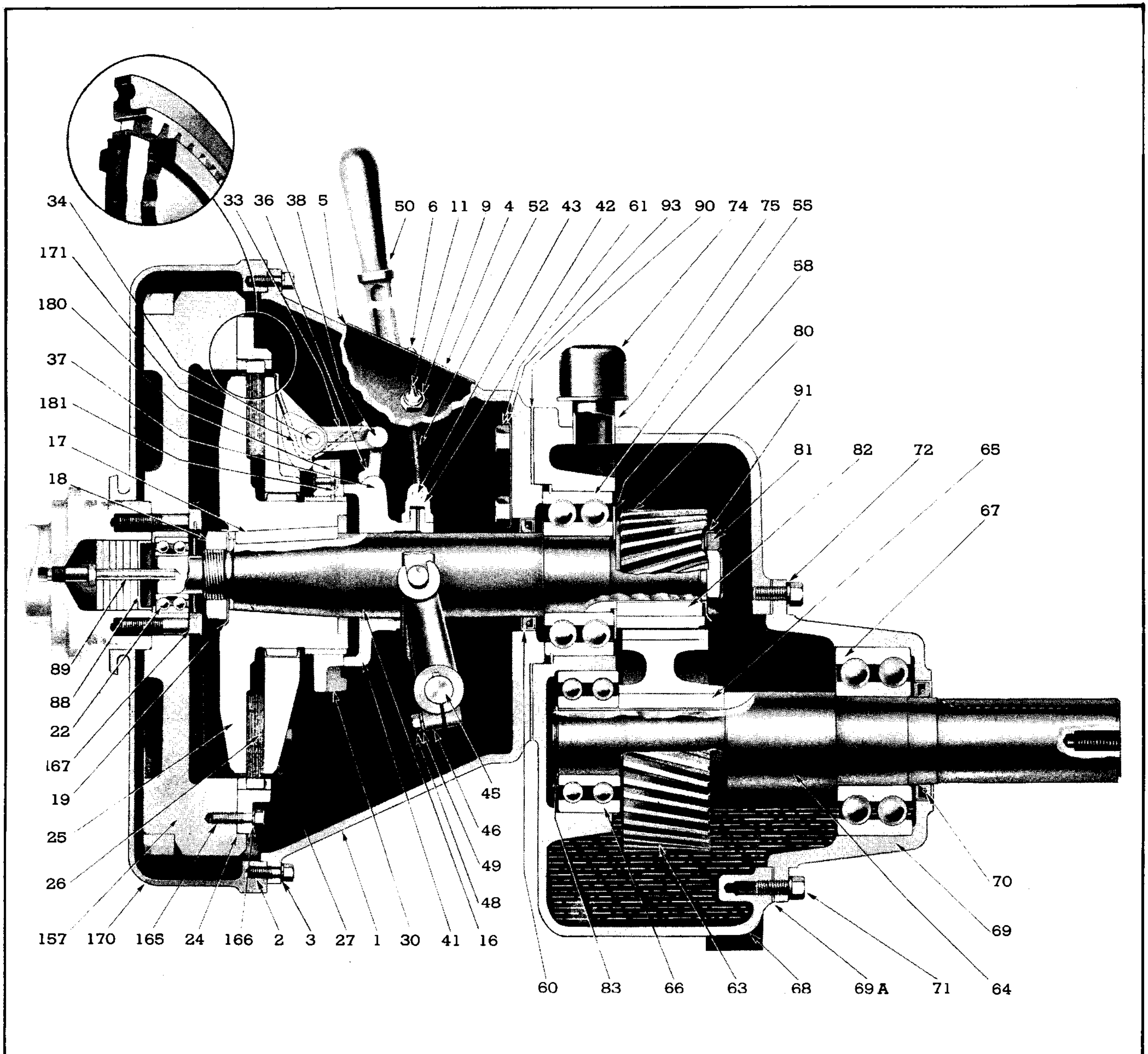


Fig. 3—Industrial Power Take-Off Reduction Gear Assembly.

ing (55) and locked in position with nut (81) and lock washer (91).

Drive gear (63), keyed to the power take-off shaft (64), meshes with pinion (80). Power take-off shaft (64) is mounted on a double-row ball bearing at each end. The forward bearing (66) is mounted in the reduction gear housing (68) and held endwise on the shaft with snap ring (83). The rear bearing (67) is mounted in a retainer (69), bolted to the main housing (68) with a gasket (69a) between the two parts.

Provision is made on the power take-off shaft for a key to drive either a belt pulley or sprocket.

Fitting (11) and filler pipe (75) provide means for lubricating clutch release bearing and reduction gears respectively, while removal of handhole cover (4) permits lubrication of clutch toggle joints. Oil seals (60) and (70) retain lubricant within the reduction gear housing.

Operation—When hand lever (50) is moved toward the engine, yoke (46) moves sleeve (41) toward the clutch. This movement throws the outer ends of links (36) away from the axis of rotation. The inner ends of levers (33) ride on the adjusting nut (30) as a fulcrum. So that, when the outer ends of links (36) move

Fig. 3—Industrial Power Take-Off Reduction Gear Assembly.

1. Clutch Housing.
2. Bolt—Clutch Housing to Engine.
3. Lock Washer.
4. Cover—Clutch Inspection Hole.
5. Gasket—Clutch Inspection Hole Cover.
6. Screw—Clutch Inspection Hole Cover.
9. Nut—Retainer (Flexible Hose to Housing).
11. Fitting—1/8" Hydraulic.
16. Clutch Shaft.
17. Key—Clutch to Shaft.
18. Nut—Clutch Shaft.
19. Lock Washer—Clutch Shaft.
22. Ball Bearing—Clutch Pilot.
24. Ring—Clutch Driving.
25. Plate—Clutch Pressure (Outer).
26. Clutch Facing (Three Segments).
27. Plate—Clutch Pressure (Inner).
30. Nut—Clutch Adjusting.
33. Lever—Clutch Release (Toggle).
34. Pin—Clutch Release Lever-to-Pressure Plate.
36. Link—Clutch Release Lever.
37. Pin—Clutch Release Lever Link-to-Sleeve.
38. Pin—Clutch Release Lever-to-Link.
41. Sleeve—Clutch Release.
42. Collar Assy—Clutch Release Sleeve.
43. Bolt—Release Sleeve Collar.
45. Shaft—Clutch Release.
46. Yoke—Clutch Release.
48. Bolt—Yoke-to-Shaft.
49. Lock Washer.
50. Lever—Clutch Hand.
52. Flexible Hose Assy.
55. Ball Bearing—Clutch Shaft.
58. Spacer—Power Take-Off Pinion.
60. Oil Seal—Clutch Housing.
61. Bolt—Clutch Housing-to-Gear Housing.
63. Gear—Power Take-Off Drive.
64. Shaft—Power Take-Off Drive.
65. Key—Power Take-Off Drive Shaft.
66. Ball Bearing—Power Take-Off Drive Shaft Pilot.
67. Ball Bearing—Power Take-Off Drive Shaft (Rear).
68. Housing—Reduction Gear.
69. Retainer—Drive Shaft Bearing and Seal.
69a. Gasket—Bearing and Seal Retainer.
70. Oil Seal—Drive Shaft Bearing Retainer.
71. Bolt—Drive Shaft Bearing Retainer.
72. Lock Washer.
74. Breather Cap.
75. Pipe—Breather (Filler).
80. Pinion—Power Take-Off.
81. Nut—Power Take-Off Pinion.
82. Key—Power Take-Off Pinion.
83. Lock Ring—Drive Shaft Ball Bearing.
88. Baffle—Crankshaft Grease.
89. Oil Wick—Clutch Pilot Ball Bearing.
90. Gasket—Reduction Gear Housing-to-Clutch Housing.
91. Lock Washer—Power Take-Off Pinion.
93. Lock—Reduction Gear Housing to Clutch Housing Bolt.
157. Flywheel Assy.
165. Bolt—Clutch Driving Ring-to-Flywheel.
166. Lock Washer.
167. Bolt—Flywheel Attaching.
170. Flywheel Housing.
171. Spring—Clutch Pressure Plate Hold Back.
180. Star Retainer.
181. Washer—Spring Cup.

out, lever pins (34) move forward toward the flywheel and lock the clutch facing (26) between the outer and inner pressure plates (25) and (27). Since pressure plate (25) is keyed to the clutch shaft (16) and pressure plate (27) is driven by gear teeth from plate (25), shaft (16) will rotate in the same direction and at the same speed as the engine flywheel. As pinion (80) has 25 teeth and gear (63) has 44 teeth, drive shaft (64) will rotate in a direction opposite to the flywheel and at a 1.76:1 ratio.

Lubrication—Three places require lubrication on the Power Take-Off Reduction Gear, as follows:

1. **Clutch Throw-out Bearing**—This bearing should be lubricated through the pressure fitting at the clutch housing with high-speed, short-fibre, ball bearing grease. Lubricate sparingly to avoid grease on clutch facings. See Lubrication Chart in section 4.

2. **Clutch Levers and Toggles** should be lubricated with engine oil. To lubricate: Remove handhole cover on clutch housing and lubricate toggle (lever and link) joints with an oil can as required to keep joints free. At the same time, lubricate clutch shifter shaft bearings as necessary with engine oil. See Lubrication Chart in section 4.

3. **Lubricate Reduction Gears** with SAE 90 to 110 transmission lubricant. See Lubrication Chart in section 4. Keep oil to "FULL" mark on bayonet gauge.

Clutch Adjustment—These instructions refer to field adjustment for facing wear. Frequency of adjustment depends upon the amount and nature of the load. **To insure longest facing life and best clutch performance, clutch should be adjusted before slippage occurs.**

When the clutch is engaged, the release lever link (36), Fig. 3, is moved over center [pin (37) is forward of pin (38)] to the locked position, the clutch release collar (42) is loose on the sleeve (41) and hand shift lever (50) has free play fore and aft. When the clutch is properly adjusted, a heavy pressure is required at the extreme outer end of the lever to move the throwout linkage to the "over center" or locked position.

1. Disengage the clutch.

2. Refer to Fig. 3 and remove inspection hole cover (4), to expose adjusting nut (30).

3. Insert end of long bar into notch of adjusting nut (30) and, while applying sufficient pressure on hand shift lever to prevent clutch from turning, turn nut clockwise by prying with bar against edge of handhole in housing (1).

4. Turn adjusting nut until heavy pressure is required at extreme outer end of handle to move the throwout linkage to the "over center" or locked position. Retainer (180) automatically locks the adjusting nut in position after adjustment.

TWIN ENGINE POWER TRANSFER GEAR

Description—Fig. 4 illustrates the power transfer gear and clutches used on twin units. Power from the two Diesel engines is transmitted to the gear unit through a heavy-duty clutch at each engine flywheel, thence

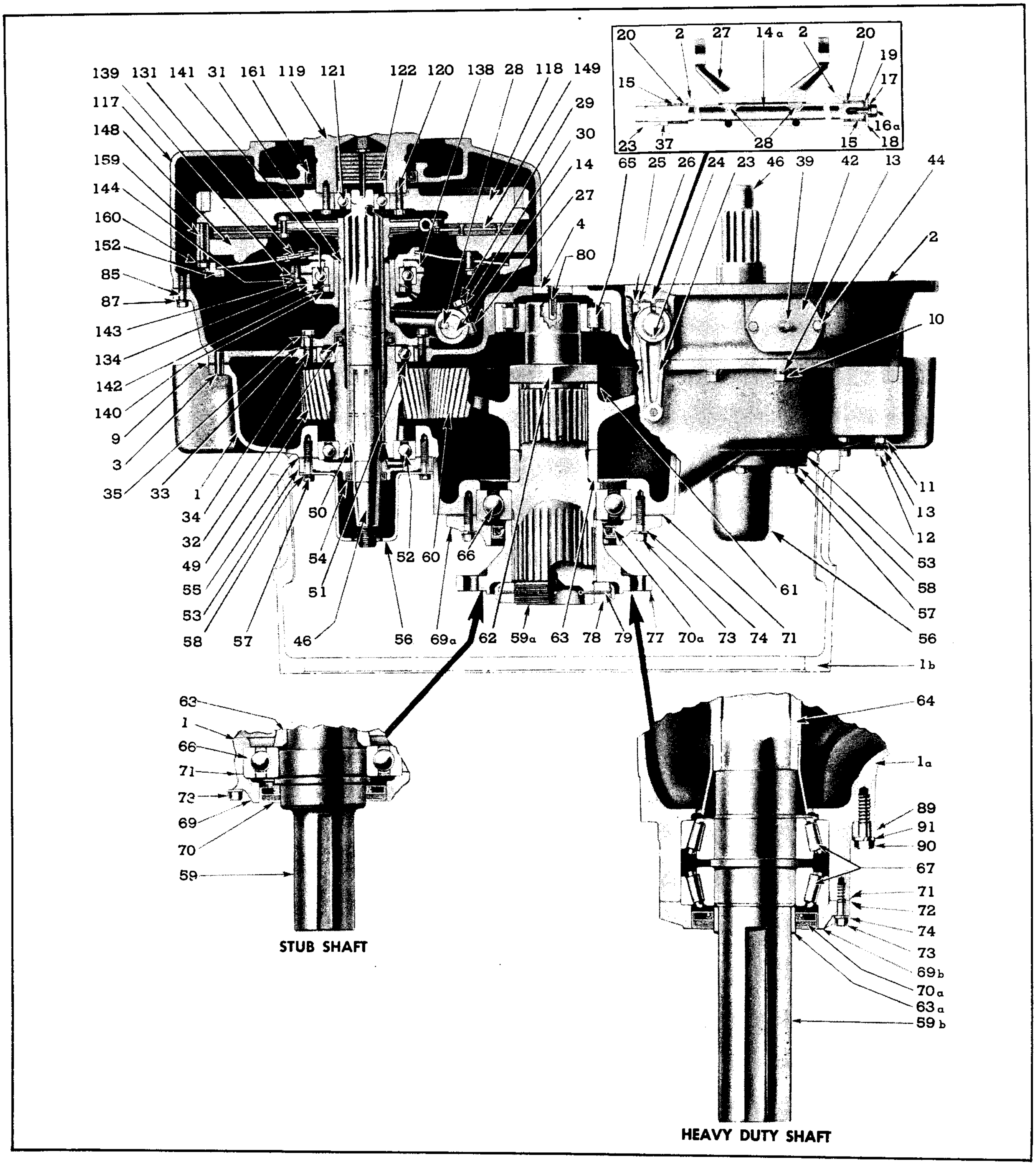


Fig. 4—Twin Engine Power Transfer Gear and Clutch Assembly.

to the drive shafts (46) and drive gears (49), and finally to the common driven gear (60) and driven shaft (59).

Each clutch driven disc (149) is splined to a drive shaft and, when the clutch is engaged by forward movement of the release sleeve assembly, it is locked between its flywheel (118) and pressure plate (148). Each helical drive gear (49) is splined to a drive shaft (46) and meshes with a common driven gear (60) which in turn is splined to the driven shaft (59). Each drive gear hub is mounted on two ball bearings. The forward ball bearing (51) is carried in the clutch housing (2); the rear bearing (52) is carried in the gear housing (1). Drive gears are retained endwise by the release bearing sleeve guide (31) at the forward bearing, and a cover (53) at the rear bearing, which holds the bearing inner races against the gear hub and locks the outer races against the release bearing sleeve guide (31) and the cover (53). To guard against oil leaks along the shaft, an oil seal (32) is carried in the release bearing sleeve guide (31) and another in the cover (53) at the forward and rear gear bearings, respectively.

Driven gear (60), which meshes with drive gears (49), is positioned between a spacer (63), bearing against a shoulder on the driven shaft, at the rear and a lock nut (62) on forward side. An oil slinger (64) is incorporated in transfer gears with heavy-duty shaft in place of spacer (63).

Three different power driven shaft adaptations are available in the transfer gear:

1. A flange drive on the driven shaft (59a) ("DF").
2. A stub shaft (59) ("SS").
3. A heavy-duty shaft (59b) ("HD").

In addition, a gear housing with a No. "0" size bell housing (1b) is available for bolting to any machine requiring rigid attachment to the power transfer gear housing.

The power driven shafts (59) and (59a) are mounted on a roller bearing (65) at the forward end and a ball bearing (on other than the heavy-duty shaft) (66) at the rear end. The forward roller bearing is carried in the clutch housing (2); the rear ball bearing is

Fig. 4—Twin Engine Power Transfer Gear and Clutch Assembly.

1. Housing—Power Transfer Gear—SS and DF.
1a. Housing—Power Transfer Gear—HD.
1b. Housing—Power Transfer Gear—OH.
2. Clutch Housing.
3. Dowel Pin.
4. Plug—Driven Shaft Cover.
9. Gasket—Gear Housing.
10. Bolt—Gear Housing to Clutch Housing —(3/8"—16 x 1 1/4").
11. Bolt—Gear Housing to Clutch Housing —(3/8"—16 x 4 1/2").
12. Bolt—Gear Housing to Clutch Housing —(3/8"—16 x 5").
13. Lock Washer.
14. Shaft—Clutch Shifter.
14a. Shaft—Clutch Shifter.
15. Bearing—Clutch Shifter Shaft.
16a. Bolt—Shifter Shaft.
17. Lock Washer.
18. Washer—Shifter Shaft Thrust.
19. Shim—Shifter Shaft.
20. Seal Ring—Shifter Shaft.
23. Lever—Clutch Shifter.
24. Woodruff Key.
25. Bolt—Shifter Lever.
26. Lock Washer.
27. Yoke—Clutch Shifter.
28. Woodruff Key.
29. Bolt—Shifter Yoke.
30. Lock Washer.
31. Guide—Release Bearing Sleeve.
32. Oil Seal—Sleeve Guide.
33. Gasket—Sleeve Guide.
34. Bolt—Sleeve Guide to Clutch Housing.
35. Lock Washer.
37. Collar—Shifter Shaft.
39. Lubrication Fitting—Release Bearing.
42. Cover—Inspection Hole.
44. Bolt—Cover to Clutch Housing.
46. Shaft—Power Drive.
49. Gear—Power Drive.
50. Snap Ring—Power Drive Gear.
51. Bearing—Power Drive Gear—Front.
52. Bearing—Power Drive Gear—Rear.
53. Cover—Power Drive Shaft.
54. Oil Seal—Drive Shaft Cover.
55. Gasket—Drive Shaft Cover.
56. Cap—Drive Shaft.
57. Bolt—Cover to Gear Housing.
58. Plain Washer.
59. Shaft—Power Driven—SS.
59a. Shaft—Power Driven—DF and OH.
59b. Shaft—Power Driven—HD.
60. Gear—Power Driven.
61. Washer—Power Driven Gear.
62. Hex Nut—Power Driven Gear.
63. Spacer—Power Drive Gear—SS, DF and OH.
63a. Sleeve—Bearing Retainer Oil Seal—HD.
64. Oil Slinger Assy—HD.
65. Bearing—Power Driven Shaft Pilot.
66. Bearing—Power Driven Shaft—Rear —SS, DF and OH.
67. Bearing Assy—Power Driven Shaft—Rear—HD.
69. Retainer—Bearing—SS.
69a. Retainer—Bearing—DF and OH.
69b. Retainer—Bearing—HD.
70. Oil Seal—Bearing Retainer—SS.
70a. Oil Seal—Bearing Retainer—DF, OH and HD.
71. Gasket—Bearing Retainer.
72. Shim—Bearing Retainer—HD.
73. Bolt—Bearing Retainer to Gear Housing.
74. Lock Washer.
77. Flange—Power Transfer Gear Coupling—DF and OH.
78. Lock Nut—Coupling Flange—DF and OH.
79. Cotter Pin—DF and OH.
80. Shaft—Tachometer Drive.
85. Bolt—Clutch Housing to Engine—(3/8"—16 x 1 3/8").
87. Lock Washer.
89. Support—Power Take-Off—HD.
90. Bolt—Power Take-Off Support to Gear Housing—HD.
91. Lock Washer.
117. Flywheel Housing.
118. Flywheel.
119. Crankshaft.
120. Bolt—Flywheel Attaching.
121. Pilot Bearing.
122. Baffle—Crankshaft Grease.
131. Spring and Hub Assy.
134. Sleeve Assy—Clutch Release Bearing.
138. Cover—Clutch Release Bearing Sleeve.
139. Gasket—Clutch Release Bearing Sleeve Cover.
140. Nut—Clutch Release Bearing.
141. Bearing—Clutch Release.
142. Lock Washer.
143. Bolt—Clutch Release Bearing Cover.
144. Lock Washer.
148. Plate—Clutch Pressure.
149. Disc (Plate) Assy—Clutch Driven.
152. Plate—Clutch Cover.
159. Bolt—Clutch-to-Flywheel.
160. Lock Washer.
161. Oil Seal—Crankshaft (Rear).

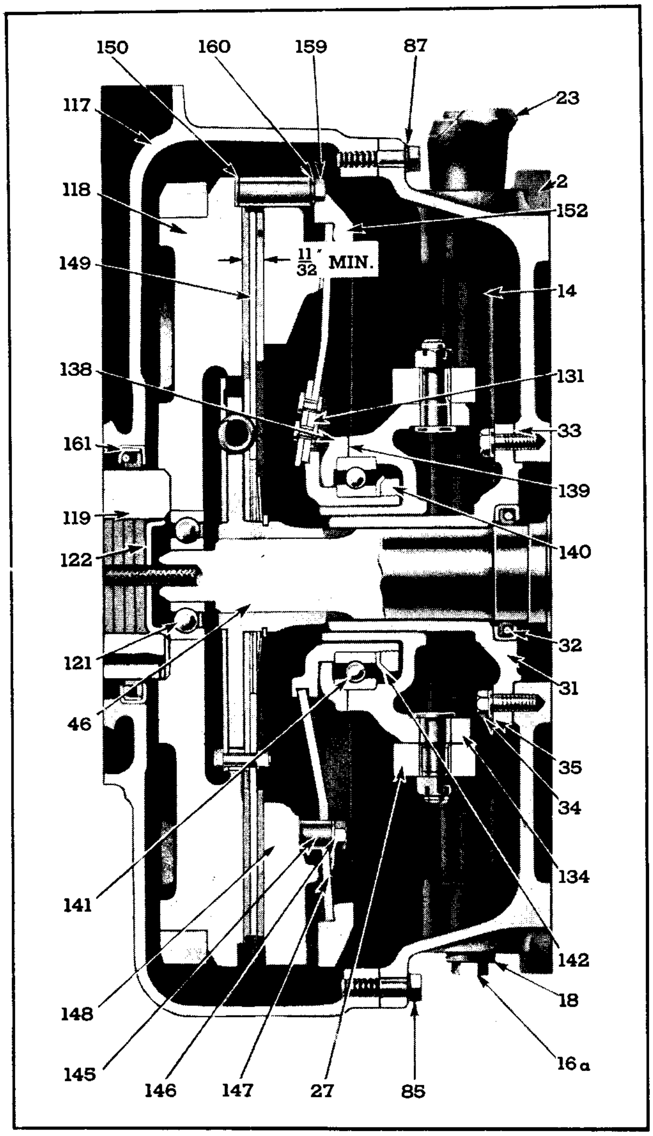


Fig. 5—Clutch Assembly.

2. Clutch Housing.
14. Shaft—Clutch Shifter.
16a. Bolt—Clutch Shifter Shaft.
18. Thrust Washer—Clutch Shifter Shaft.
23. Lever—Clutch Shifter.
27. Yoke—Clutch Shifter.
31. Guide—Clutch Release Bearing Sleeve.
32. Oil Seal—Release Bearing Sleeve Guide.
33. Gasket—Release Bearing Sleeve Guide.
34. Bolt—Sleeve Guide to Clutch Housing.
35. Lock Washer.
46. Shaft—Engine Drive.
85. Bolt—Clutch Housing to Flywheel Housing.
87. Lock Washer.
117. Flywheel Housing.
118. Flywheel.
119. Crankshaft.
121. Pilot Bearing.
122. Baffle—Clutch Pilot Bearing.
131. Spring and Hub Assy.
134. Sleeve Assy—Release (Includes Pins, Bushings, and Nuts).
138. Cover—Release Sleeve.
139. Gasket—Release Sleeve Cover.
140. Nut—Release Bearing.
141. Bearing—Clutch Release.
142. Lock Washer.
145. Spacer—Release Spring.
146. Bolt—Release Spring.
147 Spring—Pressure Plate Release.
148. Pressure Plate.
149. Disc (Plate) Assy—Clutch Driven.
150. Shim—Clutch Cover to Flywheel.
152. Plate—Clutch Cover.
159. Bolt—Clutch-to-Flywheel.
160. Lock Washer.
161. Oil Seal—Crankshaft (Rear).

carried in the gear housing (1). Driven gear (60) and shaft (59a) are restrained endwise by locking the rear bearing (66) between a shoulder on the shaft and the retainer (69a) which in turn is bolted to the gear housing. An oil seal (70a) in retainer (69a), guards against oil leaks along the drive flange (77). The rear end of the heavy-duty shaft (59b) is mounted on double taper roller bearings, an oil seal (70a) in the bearing retainer (69b), guards against oil leaks along the shaft:

As an added feature, provision is made at the rear end of the drive gear shafts (46) for installing a pulley for driving a battery-charging generator. Thus, the generator will still be driven even when one engine is shut down temporarily, as long as the clutch of the live engine is engaged.

Lubrication—The gear box proper is splash-lubricated with oil of the same SAE viscosity as that used in the engine at the prevailing outside temperature.

NOTE: Oil may be supplied through the breather opening in top of gear housing.

A bayonet oil gauge is provided for checking the oil level. Maintain oil level to "**FULL**" mark on gauge but do not overfill gear box. See Lubrication Chart in section 4.

Service—Major repairs can usually be avoided by attention to proper lubrication and to correcting small difficulties if and when they arise.

When major repairs are necessary on the transfer gear, time will usually be saved by removing the gear assembly from the engines.

CLUTCH — MULTIPLE UNITS

Description—The clutch used on multiple engine units is illustrated in Fig. 5. It consists of a driven disc assembly (149), a pressure plate (148), a clutch spring and hub assembly (131), a ball bearing-mounted clutch release bearing sleeve assembly (134), and a clutch cover plate (152).

The driven disc assembly (149) consists of a friction facing riveted to each side of a steel disc. The inner facing contacts the flywheel (118), whereas the outer facing contacts the pressure plate (148), which is carried inside clutch cover plate (152) and is driven by means of clutch spring (131) bearing against the pressure plate. Splines in the hub of the driven disc are free to move endwise in corresponding splines on the engine drive shaft (46).

The clutch is held in engagement by the large circular spring disc assembly (131), the diameter of which is slightly smaller than that of the pressure plate. When the clutch is bolted in place, the outer diameter of the spring bears against the clutch cover plate, and fulcrums over a raised seat on the pressure plate, as illustrated in Fig. 4. Three release springs (147), which ride on and are located equidistant on the face of the spring assembly (131), move the pressure plate away from the driven plate facings when the clutch is released.

A generous size ball bearing (141), lubricated through a flexible tube and grease fitting, is incorporated inside a housing and locked to the hub of the clutch spring disc assembly. The bearing housing, known as a sleeve, pilots on a release bearing sleeve guide (31) attached to the front face of the clutch housing, thus aligning the two members at all times.

Two 1/32" thick shims (150) are used at each clutch-to-flywheel bolt (159) between the flywheel and clutch cover to provide a means of properly locating the clutch throwout bearing if either the clutch pressure plate or flywheel facings, or both, become scored making refacing necessary. **Whenever the clutch is replaced, see that the two shims are installed on each clutch-to-flywheel bolt.**

Operation—In normal usage, the two or four clutches used on multiple units are operated simultaneously and the engines perform as a single power plant. However, each engine has its own shifting mechanism permitting one or more engines to be cut out, thus providing a unit power output varying from idling speed on one engine to full throttle on all engines.

The clutch hand levers, are pushed toward the center

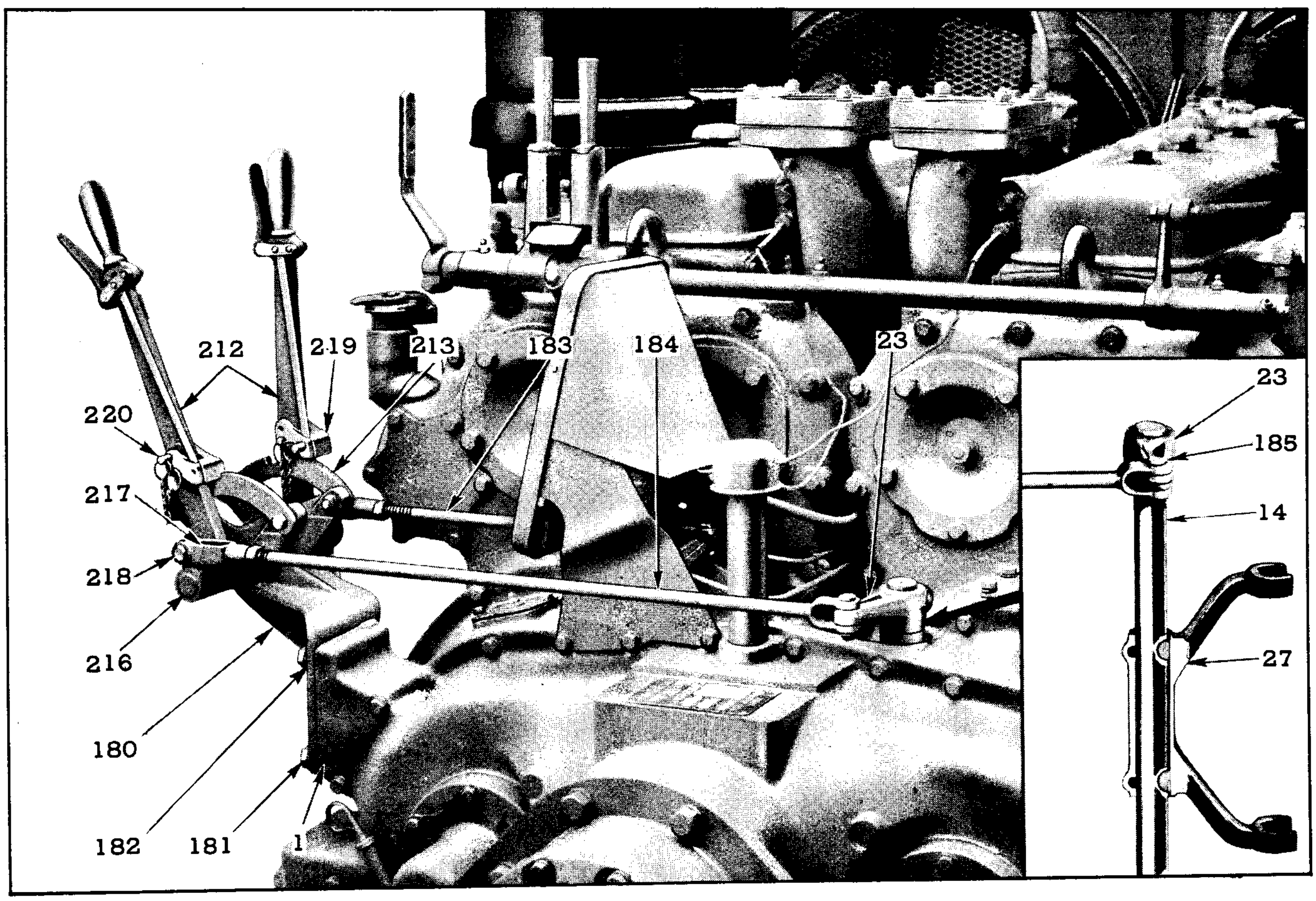


Fig. 6—Clutch Control Mechanism.

1. Housing—Power Transfer Gear.
14. Shaft—Clutch Shifter.
23. Lever—Clutch Shifter.
27. Yoke—Clutch Shifter.
180. Bracket—Clutch Control.
181. Bolt—Clutch Control Bracket.
182. Lock Washer.
183. Link—Clutch Control (Short).
184. Link—Clutch Control (Long).
185. Pin—Clutch Control Link.
212. Lever—Clutch Control Hand.
213. Quadrant—Clutch Hand Lever.
216. Shaft—Clutch Hand Lever.
217. Clevis—Clutch Control Link.
218. Clevis Pin—Clutch Control Link.
219. Lockout Latch—Clutch Hand Lever.
220. Lockout Pin—Clutch Hand Lever.

of the unit to engage clutches and pulled back to locked position to disengage clutches.

When the clutch hand lever is moved forward, yoke (27) moves sleeve (134) on guide (31) toward engine. This movement causes clutch spring (132) to bear against pressure plate (148), thus compressing driven disc (149) between the engine flywheel and clutch pressure plate.

As the driven disc is splined to shaft (46), it will drive this shaft at engine speed whenever the clutch is in locked position, and cause driven shaft (59) to rotate.

CAUTION! When working on a declutched engine with the other engine running, lock the clutch lever out on the dead engine by means of a pin in the hole provided in the clutch lever quadrant.

Lubrication—The clutch pilot bearing is automatically lubricated from an oil wick through the engine crankshaft.

Clutch Throwout Bearings are lubricated through grease fittings on the clutch housing with high-speed, short-fibre, high melting point (300° F.) ball bearing grease. Grease sparingly to avoid grease on clutch facings. See Lubrication Chart in section 4.

Clutch Shifter Shaft Bearings are pre-lubricated at assembly, and do not require any further lubrication.

Lubricate Clutch Linkage, lever pins, etc., as necessary with engine oil. See Lubrication Chart in section 4.

Clutch Adjustment—There is no adjustment, as such, of the clutches used in twin and quad industrial units and illustrated in Fig. 5. However, when the facings on the clutch disc have worn so that the over-all thickness of the disc and facings is less than $^{11}/_{32}$", as illustrated in Fig. 5, the disc assembly should be changed.

CLUTCH CONTROL

Each clutch is controlled by an individual hand lever mounted on a shaft (216) common to the two levers, as shown in Fig. 6. Shaft (216) is supported in a bracket (180) which in turn is bolted to the side of the gear box. Clutches are disengaged by pulling the levers away from the engines.

When the clutch is engaged, the lockout latch (219) rides on the lever quadrant (213) and, when the clutch is disengaged, the lockout latch enters notch in quadrant and is secured by inserting lockout pin (220) through holes of lockout latch (219) and lever (212), as shown in Fig. 6.

CAUTION: When working on a declutched engine with the other engine running, always lock the clutch lever in the disengaged position on the dead engine.

Clutch Control Adjustment — If for any reason the clutch control links (183) or (184) are replaced or the adjustment changed, readjust as follows:

1. Connect each control link at clutch shifter lever (23) with pin (185), with clutches engaged.
2. Set both hand levers (212) in a vertical position.
3. Loosen lock nut and adjust clevis (217) on each link so that a clevis pin (218) will just slip into place through clevis and lever.
4. Lock clevis pins (185) and (218) with cotter pins.

QUAD ENGINE REDUCTION GEAR

Description—The reduction gear assembly illustrated in Fig. 7, is mounted to the four Diesel engines by individual clutch housings (34)—two at the front and two at the rear of the gear housing—which pilot into and bolt to the gear housing (1); each clutch housing also pilots into and bolts to the flywheel housing of one of the Quad engines. Thus the engines and gear box are connected into one major power unit.

The drive (gears) pinions (31) and driven gear (2) are of the herringbone design for quiet operation and are mounted on annular ball bearings which absorb the radial loads associated with industrial applications. The front and rear drive pinion bearings (32) and (33) are supported in clutch housings (34). Bearing (23), supporting front end of driven gear hub (4), pilots in gear housing (1) and is retained by cover (24). Rear bearing (13) supports rear end of driven gear hub and pilots in bearing retainer (10). This bearing is retained in the hub by drive flange (19).

Drive flange (19) of the flexible coupling is, in turn, splined to the driven gear hub (4) and held firmly against driven gear bearing (13) by flange at rear end of stud (20). This flange bears against drive flange (19) and, when nut (28) at forward end of shaft is drawn tight and locked with bolts (29), drive flange (19) becomes virtually integral with the driven gear hub (4). Bolts (29) prevent nut (28) from turning after it is once tightened.

Whereas the main pinion gears (31) are of one piece construction, the main driven gear and hub are separate pieces machined to close limits so that the driven gear will pilot true on its hub. The driven gear is securely fastened to the hub by special bolts (6). Both drive pinions have internal splines which mesh with corresponding splines on the engine drive shafts (22).

A power drive shaft (100) is keyed to the special coupling (99) and transmits the power to one end of the Quad unit. This shaft is supported at its outer end by an outboard bearing.

A machined boss on the driven gear front bearing cover (24) provides a mounting pad for the tachometer drive.

An oil trough (42), with ¾" hole at the bottom, is attached to the under side of the gear housing and prevents churning of oil within the oil pan.

Lubrication—The reduction gear proper is splash-lubricated with oil of the same SAE viscosity as that used in the engines at the prevailing outside temperature.

An oil filler pipe (59), with breather cap (63), is bolted to the gear housing cover (55) for adding oil to the gear compartment and a plug (50) is located at the bottom of the oil pan for draining oil. A bayonet oil gauge (71) slips into a guide at the rear, lower side of the gear housing. The oil level should be maintained at the "**FULL**" mark on the gauge. **Do not overfill.**

Clutch Throw-out Bearings (141) are lubricated through grease fittings on the clutch housings with high-speed, short-fibre, high melting point (300F°), ball bearing grease. See Lubrication Chart in section 4. Grease sparingly to avoid grease on clutch facings.

Clutch Shifter Shaft Bearings are pre-lubricated at assembly, and do not require any further lubrication.

Lubricate Clutch Linkage, levers, pins, etc., as necessary with engine oil. See Lubrication Chart in section 4.

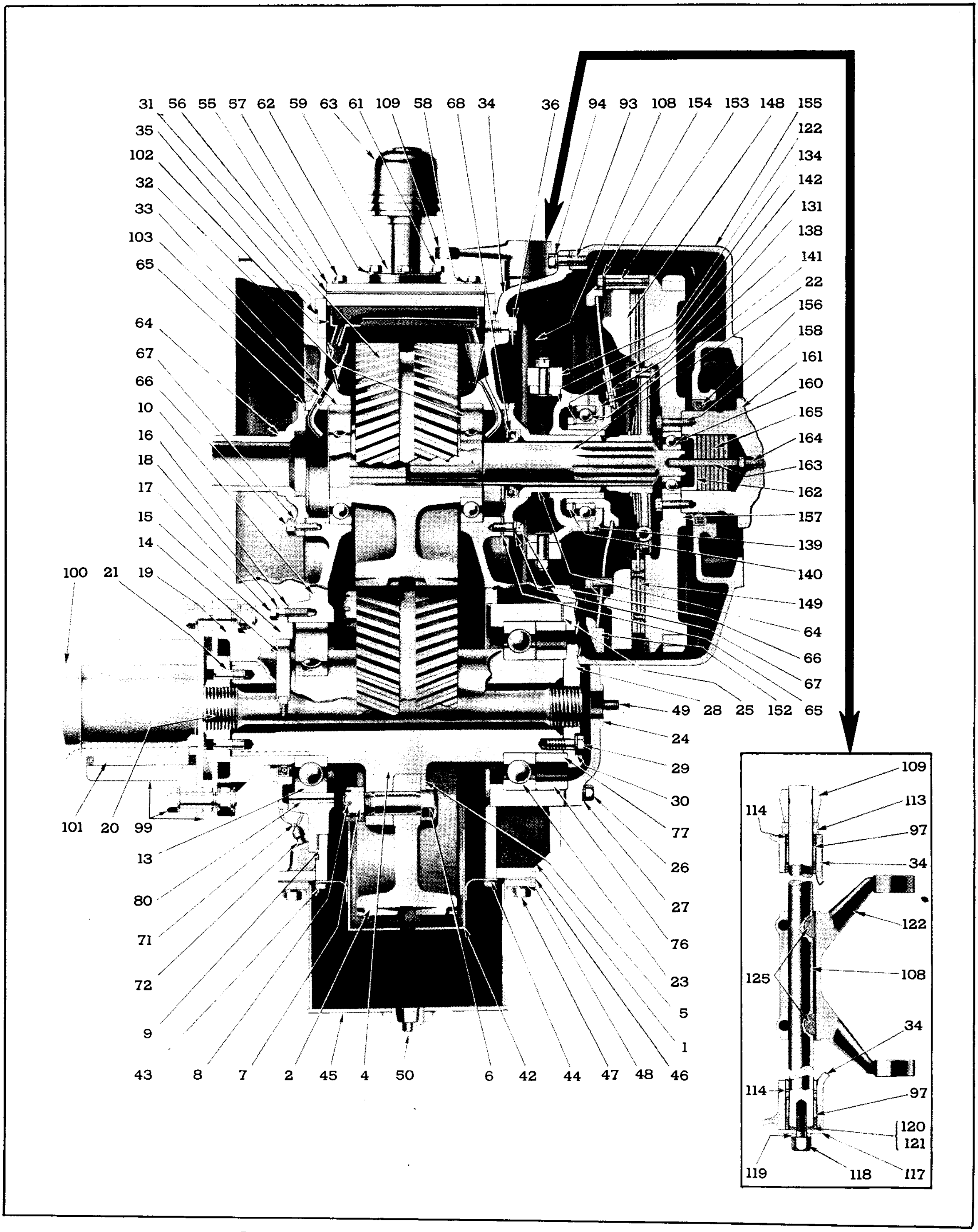


Fig. 7—Quad Engine Reduction Gear and Clutch Assembly.

Fig. 7—Quad Engine Reduction Gear and Clutch Assembly.

1. Gear Housing.
2. Gear—Main Driven.
4. Hub—Driven Gear.
5. Lock Ring—Driven Gear Bolt.
6. Bolt—Main Driven Gear.
7. Nut—1"—14 Slotted Hex.
8. Cotter Pin.
9. Gasket—Retainer to Gear Housing.
10. Retainer—Gear Housing Hub Bearing.
13. Ball Bearing—Main Driven Gear (Rear).
14. Oil Seal—Retainer.
15. Retainer—Oil Seal.
16. Gasket—Oil Seal Retainer.
17. Bolt—Oil Seal Retainer.
18. Lock Washer.
19. Flange—Drive.
20. Stud Assy—Drive Flange Retaining.
21. Lock Screw—Retaining Stud.
22. Shaft—Engine Drive.
23. Ball Bearing—Main Driven Gear (Front).
24. Cover—Driven Gear Bearing.
25. Gasket—Bearing Cover.
26. Bolt—Bearing Cover Attaching.
27. Lock Washer.
28. Nut—Drive Flange Retaining Stud.
29. Bolt—Retaining Stud Nut.
30. Lock Washer.
31. Pinion—Main Drive.
32. Ball Bearing—Drive Pinion (Front).
33. Ball Bearing—Drive Pinion (Rear).
34. Clutch Housing.
35. Gasket—Clutch Housing to Gear Housing.
36. Bolt—Clutch Housing to Gear Housing Attaching.
42. Trough—Main Driven Gear Oil Pan.
43. Bolt—Trough to Gear Housing.
44. Lock Washer.
45. Oil Pan.
46. Gasket—Oil Pan.
47. Bolt—Oil Pan to Gear Housing.
48. Lock Washer.
49. Stud—Bearing Cover.
50. Pipe Plug—Oil Pan Drain.
55. Cover—Gear Housing.
56. Gasket—Gear Housing Cover.
57. Bolt—Cover to Gear Housing.
58. Lock Washer.
59. Pipe and Flange Assy—Oil Filler.
61. Bolt—Oil Filler Pipe Flange to Cover.
62. Lock Washer.
63. Breather Cap Assy—Gear Box.
64. Guide—Clutch Release Bearing Sleeve.
65. Gasket—Clutch Release Bearing Sleeve Guide.
66. Bolt—Clutch Release Bearing Sleeve Guide.
67. Lock Washer.
68. Oil Seal—Clutch Release Bearing Sleeve Guide.
71. Oil Gauge Rod Assy.
72. Guide—Oil Gauge Rod.
76. Spacer—Thrust Bearing—Large.
77. Spacer—Thrust Bearing—Small.
80. Oil Drain Hole—Bearing Retainer.
93. Bolt—Gear Assy to Flywheel Housing.
94. Lock Washer.
97. Bearing—Clutch Shifter Shaft.
99. Coupling Assy—Power Drive Shaft.
100. Shaft—Power Drive.
101. Key—Drive Shaft to Coupling.
102. Trough—Oil Lubricating.
103. Tube—Oil Lubricating.
108. Shaft—Clutch Shifter.
109. Lever—Clutch Shifter Shaft.
113. Collar—Clutch-Shifter Shaft.
114. Seal Ring—Shifter Shaft.
117. Washer—Shaft Thrust.
118. Bolt—Clutch Shifter Shaft.
119. Lock Washer.
120. Shim .005" Shifter Shaft.
121. Shim .031" Shifter Shaft.
122. Yoke—Clutch Shifter.
125. Woodruff Key.
131. Spring and Hub Assy.
134. Sleeve Assy—Clutch Release Bearing.
138. Cover—Clutch Release Bearing Sleeve.
139. Gasket—Clutch Release Bearing Sleeve Cover.
140. Nut—Clutch Release Bearing.
141. Bearing—Clutch Release.
142. Lock Washer.
148. Plate—Clutch Pressure.
149. Disc Assy.
152. Plate—Clutch Cover.
153. Bolt—Clutch to Flywheel.
154. Lock Washer.
155. Flywheel Housing.
156. Oil Seal—Flywheel Housing.
157. Flywheel
158. Bolt—Flywheel Attaching.
160. Pilot Bearing.
161. Crankshaft.
162. Baffle—Pilot Bearing Oil Wick.
163. Wick—Pilot Bearing Oil.
164. Holder—Pilot Bearing Oil Wick.
165. Felt Washers.

CLUTCH

Description—The clutch used in connection with the Quad Reduction Gear is of the same design as that used with the Twin Transfer Gear. Therefore, the same "Description, Operation, and Lubrication," as outlined on pages 10 through 12 for the Twin Transfer Gear will apply in this case.

CLUTCH CONTROL

Since the clutch control used on both Twin and Quad Industrial Units is of the same design, except that the latter has four clutch shifter levers with their accompanying linkage instead of two shifter levers as on the former, the information on "Clutch Control" given on page 12 is applicable here.

OPERATION AND MAINTENANCE

OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME—Before using the engine for the first time, the operator should carefully read and follow the instructions below. Attempting to run the engine before studying these instructions may result in permanent damage to the unit.

NOTE: When preparing to start a new unit or after a major overhaul, perform all of the operations listed below. For routine starting (at each shift), see "Before Starting," Page 3, Sec. 4.

Air Cleaner — On units provided with oil bath air cleaners, fill air cleaner bowl to the level mark with engine oil. **Do not overfill.**

Cooling System—Replace all drain cocks in the cooling system which were removed for shipping.

Open cooling system vent at front end of water manifold, unless equipped with built-in vent.

Remove filler cap and fill cooling system with clean, soft water or with a protecting solution of non-evaporating type of anti-freeze if the engine will be exposed to below freezing temperatures. Liquid level in a radiator cooled unit should be kept to about two inches below the filler neck.

When using water alone in the cooling system, a reputable brand of rust inhibitor should be used to help retard formation of scale and rust.

Close cooling system vent after filling, unless equipped with vent tube.

Engine Crankcase—Check the oil level in crankcase by means of the bayonet oil gauge at side of crankcase. Remove the gauge, wipe lower end with a clean cloth, then insert and remove gauge to take level reading. Keep oil level to "FULL" mark on gauge.

Use **only** "Heavy-Duty" lubricating oils, as specified under "LUBRICATING OIL SPECIFICATIONS," Page 9, Sec. 4.

Valve and Injector Operating Mechanism—Remove valve rocker cover and pour two or three quarts of engine lubricating oil over rockers, valve springs, and push rods. Also apply a light oil, preferably SAE 10, to the individual valve stems by means of an oil can. Place the end of a screwdriver under the push rod lock nut and by exerting pressure on the handle of the screwdriver, work the valve up and down.

CAUTION: Before actuating any valve, make sure the piston for that particular cylinder is not at the top of its stroke.

Fuel System—Fill the fuel tank with high-speed Diesel engine fuel as specified under "FUEL OIL SPECIFICATIONS," Page 10, Sec. 4.

CAUTION: Use fuel tanks of black iron or terneplate. Never use galvanized iron for fuel storage.

Open fuel supply valve if used.

To insure prompt starting, at least that portion of the fuel system between the pump and the fuel return manifold should be filled with fuel. For an engine that has been in storage a considerable length of time, the fuel oil filter (between the fuel pump and the injectors) should be primed. To prime the filter, remove the vent plug in top of filter cover and pour fuel through the opening slowly until filter is full.

NOTE: The fuel system of a new engine is filled with fuel before leaving the factory. If the fuel is still present in the system when preparing to start, priming should be unnecessary.

Lubrication Fittings—Lubricate any pressure fittings and grease cups with short-fibre, high-speed, ball-bearing grease. Lubricate hinge cap oilers, throttle linkage, and any exposed moving parts with engine oil in a hand oiler.

Gear Cases—Fill transfer or reduction gear case to proper level with lubricating oil as specified below.

Single engine reduction gear case: transmission oil—SAE 90 to SAE 110.

Twin or quad gear case: same oil as used in engine.

Fan and Drive Belts—Adjust all belts to proper tension before starting engine.

Storage Batteries—Check storage batteries; they should show 1.275 hydrometer reading or higher.

Clutch—Disengage clutch or clutches if used.

Clear Power Unit of all tools or other obstructions that might interfere with engine operation. Set throttle in STOP position, then press starter switch and allow starting motor to crank engine a few turns. Observe entire installation carefully while cranking. If there are no unusual noises and everything seems in order, the unit should be ready to start and run.

STARTING

The following routine checks should be made each time the engine is started. When starting the unit the first time perform operations listed under "PREPARATION FOR STARTING ENGINE FIRST TIME," Page 1.

Open the throttle to idling position.

Press starting switch firmly to start engine. Do not operate cranking motor more than 30 seconds at a time to avoid overheating motor.

CAUTION: If engine fails to start, DO NOT re-press button until after cranking motor stops rotating. Serious damage to cranking motor may result if above rule is not followed.

If engine does not start after four periods of cranking, see Charts 1 and 2 in Sec. 5.

At air temperatures below 40°F., starting of these engines requires use of a cold starting aid consisting either of a fluid starting aid or an air heater as described in Sec. 2. For full information regarding cold starting aids and cold weather lubricating and fuel oil requirements consult your Detroit Diesel Distributor or Dealer.

Oil Pressure—Immediately after starting, observe the oil pressure on gauge. If no pressure is shown after 10 to 15 seconds, stop engine and check the lubricating system.

Warm-Up Period—Run engine at part throttle and no load for four or five minutes, allowing engine to warm up.

If unit is operating in a closed room, start room ventilating fan or open windows as weather conditions permit, so ample air is available for the engine.

RUNNING

Oil Pressure—See that the oil pressure, as indicated by the pressure gauge, does not fall below 25 pounds at operating speed (5 pounds is satisfactory at idle).

Check Unit—With engine running at operating temperature, check unit carefully for water, fuel oil, or lubricating oil leaks. Tighten connections where necessary to avoid leaks.

Engine Temperature—Under normal working conditions the coolant temperature should range between 160° and 185°F. with corresponding oil temperature about 40° above the water outlet temperature.

Crankcase—After engine has warmed up to operating temperature, stop the engine and check the oil level. Replenish to FULL mark on bayonet oil gauge.

NOTE: This is necessary only for the first start after a crankcase refill.

STOPPING

Clutch—Reduce engine speed to idle and disengage clutch or clutches.

Throttle—If possible, set throttle at about half speed and allow engine to run without load for about 2 minutes before shutting down.

Move throttle to NO FUEL position to stop engine.

Clean Engine—Clean the outside of the engine, wiping off all dirt, oil and grease. Keeping the engine clean makes service operations more pleasant.

LUBRICATION AND PREVENTIVE MAINTENANCE

The "BEFORE STARTING" instructions below apply to routine or daily starting of the unit. They do not apply to starting a new unit or one that has been out of operation for a considerable period. For the latter conditions, see "PREPARATION FOR STARTING," given on Page 1, Sec. 4.

NOTE: The time intervals given in this chart are actual operating hours of the unit. Example: If the unit is operated 24 hours a day or three 8 hour shifts, perform the 8 hour operations before each shift. During the fifth day when 100 hours have elapsed perform the 100 hour operations at the same time as the 8 hour operations.

The Lubrication and Maintenance Instructions listed on these pages are keyed to the chart on Page 7 by numbers in the left column of the instructions and on the chart. Example: In the instructions, under "BEFORE STARTING," key number (2) pertains to checking the engine crankcase oil. Key number (2) also appears near the upper left corner of the chart.

NOTE: Lubrication and Preventive Maintenance on General Motors Torque Converter Units is covered in a separate manual, Form 6SE–57.

BEFORE STARTING

KEY NO.	OPERATION	REMARKS
2	CHECK ENGINE CRANKCASE OIL	Check oil level with engine stopped. Oil level should be to "Full" mark on dipstick (gauge). Never let oil level fall below "LOW" mark; replenish as necessary. Select proper viscosity grade of oil in accordance with the instructions under "Lubricating Oil Specifications," Page 9, Sec. 4.
4, 5	CHECK COOLANT LEVEL IN COOLING SYSTEM	Remove heat exchanger or radiator filler cap slowly and, if necessary, add soft water to within 2 inches of overflow pipe. **Always use soft water with good grade commercial inhibitor or permanent type anti-freeze.** Check prime on raw water pump (heat exchanger systems); engine should not be operated with dry pump.
15, 22	CHECK GEAR CASE OIL LEVEL	Check oil level on dipstick with engine stopped. Oil level should be to "FULL" mark on dipstick, never let oil level fall below "LOW" mark on dipstick. See "Preparation for Starting" for selection of proper lubricant.
	CHECK FUEL TANK	Do not let fuel tank become EMPTY. Fuel pump will lose its prime and may be seriously damaged. Select the proper grade of fuel in accordance with the instructions under "Fuel Oil Specifications," Page 10, Sec. 4.
	CHECK FUEL SUPPLY VALVES	See that fuel supply valves are open.
	CHECK CLUTCH CONTROLS	Check to see that clutches are disengaged. Always disengage clutches before starting or stopping engines.

EVERY 8 HOURS

KEY NO.	OPERATION	REMARKS
2	CHECK ENGINE CRANKCASE OIL	Check oil level with engine stopped. Oil level should be at "FULL" mark on dipstick (gauge). Never let oil level fall below "LOW" mark; replenish as necessary. Select proper viscosity grade of oil in accordance with the instructions under "Lubricating Oil Specifications," Page 9, Sec. 4.

LUBRICATION AND PREVENTIVE MAINTENANCE (Cont'd.)

EVERY 8 HOURS (Cont'd.)

KEY NO.	OPERATION	REMARKS
5	CHECK COOLANT LEVEL IN COOLING SYSTEM	Remove heat exchanger or radiator filler cap slowly and, if necessary, add soft water to within 2 inches of overflow pipe. **Always use soft water with good grade commercial inhibitor or permanent type anti-freeze.** Check prime on raw water pump (heat exchanger systems). Engine should not be operated with dry pump.
	LUBRICATE RAW WATER PUMP	Tighten grease cup ½ turn. Avoid forcing excessive grease into pump, which will obstruct water passages in cooling system. While engine is running, check leakage at water pump packing. If necessary, tighten packing gland nuts evenly. Use a good grade of waterproof lubricant.
	CHECK FUEL TANK LEVEL	Do not let fuel tank become EMPTY. Fuel pump will lose its prime and may be seriously damaged. Select the proper grade of fuel in accordance with the instructions under "Fuel Oil," Specifications Page 10, Sec. 4.
12	DRAIN FUEL STRAINER	Open drain cock at bottom of strainer and drain off about one-fourth pint of fuel and sediment. Loosen vent at top of strainer to improve drainage. Close drain cock and tighten vent.
1	DRAIN FUEL FILTER	Open drain cock at bottom of filter and drain off about one-fourth pint of fuel and sediment. Loosen vent at top of filter to improve drainage. Close drain cock and tighten vent.
15, 22	CHECK GEAR CASE OIL LEVEL	Check oil level on dipstick with engine stopped. Oil level should be to "FULL" mark on dipstick. Never let oil level fall below "LOW" mark on dipstick. See "Preparation for Starting" for selection of proper lubricant.
19, 21	LUBRICATE CLUTCH THROW-OUT BEARING (Single Engine Units)	The clutch throw-out bearing should be lubricated after every 8 hours of operation. One or two strokes of pressure gun should be sufficient. Lubricate sparingly to avoid grease on clutch facings. Use short fibre high grade ball bearing lubricant.
3	SERVICE AIR CLEANERS	Remove dirty oil and sludge from reservoir. Wash reservoir in clean fuel oil and refill with engine oil to level indicated on reservoir. DO NOT ADD OIL ABOVE OIL LEVEL RING. Clean metal elements by washing in clean fuel oil, blow dry before assembly. Frequency of servicing may be varied to suit local dust conditions.

EVERY 50 HOURS

KEY NO.	OPERATION	REMARKS
		FIRST PERFORM ALL OPERATIONS LISTED UNDER "EVERY 8 HOURS"
9	LUBRICATE POWER TAKE-OFF OUTBOARD BEARING	Frequency of lubrication will depend on working conditions of the bearing, shaft speeds, and bearing loads. It may be necessary to lubricate this bearing oftener than every 50 hours. Use grease gun and lubricate with a high-grade, light ball bearing grease. Force enough grease into the bearing to cause a small collar to form around the seal as the shaft rotates.
19	LUBRICATE POWER TAKE-OFF MAIN BEARING	Frequency of lubrication will depend on working conditions of the bearing, shaft speeds, and bearing loads. It may be necessary to lubricate this bearing oftener than every 50 hours. Use grease gun and lubricate through the pressure fitting in the clutch housing. Force enough grease into the bearing to cause a small collar to form around the seal as the shaft rotates.
	LUBRICATE TACHOMETER DRIVE	Lubricate with grease gun at pressure fitting until grease is forced out at vent.
21	LUBRICATE CLUTCH THROW-OUT BEARINGS (Multiple Engine Units)	Lubricate throw-out bearings using pressure gun. Pump in sufficient lubricant to fill bearing cavity, but do not over lubricate as excessive grease may get on clutch facings. Use short fibre high grade ball bearing lubricant.

LUBRICATION AND PREVENTIVE MAINTENANCE (Cont'd.)

EVERY 100 HOURS

KEY NO.	OPERATION	REMARKS
		FIRST PERFORM ALL OPERATIONS LISTED UNDER "EVERY 50 HOURS"
18	CHANGE ENGINE CRANKCASE OIL	It is recommended that new engines be started with 100-hour oil change periods. The interval may be gradually increased, following the recommendations of the oil supplier (based on his analysis of the drained engine oil) until the most practical oil change period has been established. Select proper viscosity grade of oil in accordance with instructions under "Lubricating Oil," Specifications Page 9, Sec. 4
7	CHANGE OIL FILTER ELEMENT	Change element—With engine stopped for changing engine oil, remove drain plug and drain oil from filter shell. Remove shell retaining bolt and shell. Discard used element. Clean shell and base with fuel oil. Install new element and gaskets. Check for oil leaks after starting engine. The oil filter elements must be changed every time the engine oil is changed.
11	PERFORM ENGINE TUNE-UP	After the first 100 hours and each 500 hours thereafter, adjust valves, time injectors, and position injector control racks as outlined under "Tune-up Procedure—Single and Multiple Engine Units," in this section.
16	CHECK BATTERY	Check specific gravity (which should register approximately 1.275) and maintain water level ⅜" above plates. **Distilled water should be used to prevent accumulation of foreign matter inside battery.**
17	CHECK AIR BOX DRAINS	Air box drains should be open. Place finger at drain outlet(s) with engine running and feel for air flow. If drains are plugged, perform cleaning operation as described under "Every 500 Hours."

EVERY 200 HOURS

KEY NO.	OPERATION	REMARKS
		FIRST PERFORM ALL OPERATIONS LISTED UNDER "EVERY 100 HOURS"
10	LUBRICATE THROTTLE CONTROL MECHANISM	Lubricate pressure fittings, sparingly, with short fibre, high-speed ball bearing grease. Use engine oil in hand oiler and lubricate other control mechanisms as required.

EVERY 500 HOURS

KEY NO.	OPERATION	REMARKS
		FIRST PERFORM ALL OPERATIONS LISTED UNDER "EVERY 200 HOURS"
1, 12	CHANGE FUEL FILTER AND FUEL STRAINER ELEMENTS	With engine stopped, drain filter and strainer. Remove retaining bolts, shells, and elements. Discard old elements and gaskets. Wash shells in clean fuel oil. Install new elements and gaskets. Fill each shell with fuel oil and assemble to cover. Check for leaks after starting engine. In certain localities where fuel may become excessively dirty, shorten the interval between fuel strainer and filter element changes.

LUBRICATION AND PREVENTIVE MAINTENANCE (Cont'd.)

EVERY 500 HOURS (Cont'd.)

KEY NO.	OPERATION	REMARKS
	CHECK HEAT EXCHANGER ELECTRODES	Drain inlet and outlet pipes to heat exchanger. Remove zinc electrodes at each end of heat exchanger and examine. If electrodes are coated, clean down to the zinc with a wire brush. If the electrodes show considerable wear due to electrolytic action, they should be replaced.
5	CHECK WATER HOSE	Inspect all water hoses for signs of deterioration; replace if necessary.
6	CHECK AND LUBRICATE BATTERY—CHARGING GENERATOR	Remove cover and inspect brushes and commutator for wear. Lubricate at hinged cap oilers with engine oil. Do not lubricate with engine running. Do not over lubricate; 5 or 6 drops is sufficient.
	CHECK BELT TENSION	Check tension of any battery-charging generator, fan drive, or pump drive belts. Belts should be just tight enough to drive the moving parts without slipping. Too tight a belt is destructive to bearings of the driven part. Adjust for three-quarter inch slack from a straight line over the outer diameter of the drive and driven pulleys, midway between the two pulleys.
	DRAIN WATER AND SEDIMENT FROM FUEL OIL TANK	Open fuel oil tank drain and allow water and sediment to drain off. Replace and tighten drain.
17	CLEAN AIR BOX AND DRAINS	Remove drain tubes and blow clean with compressed air. Be sure drain passages in cylinder block are open. Remove hand hole covers and wipe air box dry with clean rags. Replace drain tubes. If engine is equipped with drain tank, open drain cocks and drain sediment from bowl. Close drain cock.
	CHECK POWER TAKE-OFF CLUTCH FOR WEAR	If power take-off clutch shows any indication of slipping, adjust as outlined in Sec. 3.
11	PERFORM ENGINE TUNE-UP	All variable adjustments should be checked and any necessary corrections made. See "Engine Tune-Up Procedure—Single and Multiple Engine Units," Page 11, Sec. 4.
	LUBRICATE CRANKING MOTOR	If cranking motor is equipped with oil cups or plugs and wicks, apply a few drops of engine oil. Do not over lubricate. Most cranking motors are semi-permanently lubricated and require lubrication only at the time of engine overhaul.
8	LUBRICATE POWER TAKE-OFF CLUTCH MECHANISM (Single Engine Units)	Remove inspection (handhole) cover on clutch housing and lubricate toggle and lever joints with hand oiler, using engine oil. Lubricate clutch release (shifter) shafts at housing bearing bores with hand oiler.
20	LUBRICATE CLUTCH CONTROL MECHANISM (Multiple Engine Units)	Lubricate points of wear (external levers, bearings, links, etc.) with hand oiler, using engine oil.

EVERY 1000 HOURS

KEY NO.	OPERATION	REMARKS
		FIRST PERFORM ALL OPERATIONS LISTED UNDER "EVERY 500 HOURS"
	INSPECT PORTS, LINERS, PISTONS AND RINGS	Remove hand hole covers at side of cylinder block and inspect cylinder liner ports. Inspect inner surface of liners and the pistons and piston rings through the ports. If ports are more than 30% restricted, or if piston rings are stuck or broken in their grooves, or if pistons or liners are scored, the engine will require attention.*
13	INSPECT BLOWER	With engine stopped and battery disconnected, remove air cleaner(s) and air inlet housing. Remove and clean air intake screen. Inspect blower for scored rotors, housing, or end plates. Check for leaks at rotor shaft oil seals, which will be indicated by a film of oil on the end plate radiating away from the seals. If scoring, or leaking seals are discovered, the blower should be removed and repaired before the condition becomes too serious.*

*Consult nearest authorized Detroit Diesel Distributor or Dealer.

LUBRICATION AND PREVENTIVE MAINTENANCE (Cont'd.)

EVERY 1000 HOURS (Cont'd.)

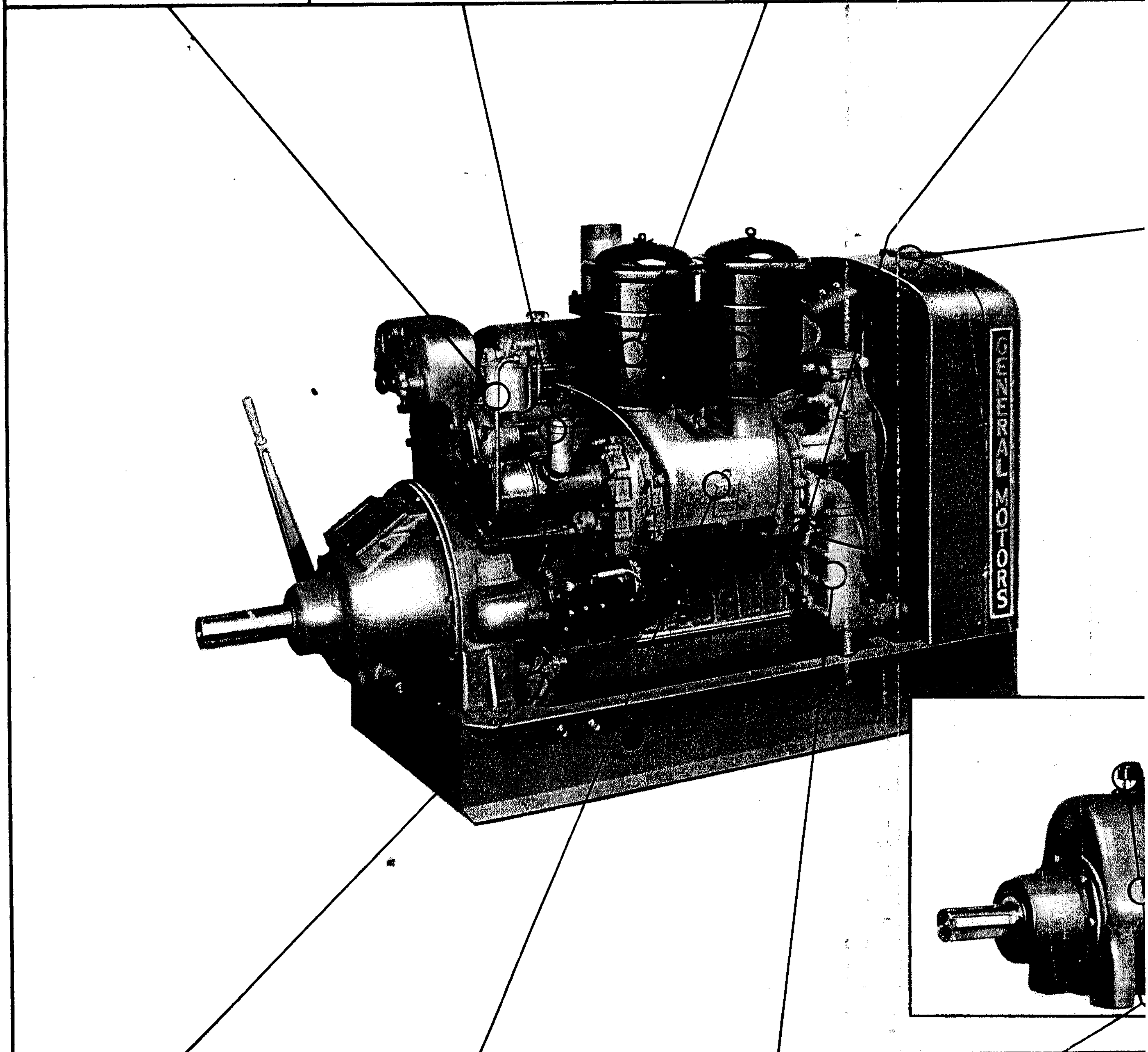
KEY NO.	OPERATION	REMARKS
	INSPECT AND CLEAN HEAT EXCHANGER	Disconnect the raw water pipe at the outlet side of the heat exchanger and remove the heat exchanger retaining cover. If the core shows a considerable amount of scale or coating, loosen the cover retaining bolts at the inlet side of the core. Pulling on the core flange at the outlet side, remove the heat exchanger from the housing. The core should be cleaned immediately after removal to prevent drying and hardening of the deposits.* After cleaning, replace the core, using new gaskets at the flange on the outlet side. Flush and refill cooling system. Prime raw water pump before starting.
14	INSPECT OIL COOLER	A clogged oil cooler will cause an increase in the engine crankcase oil temperature. Check the oil temperature with a thermometer inserted in the bayonet oil gauge opening at the 1000 hour interval immediately after stopping the hot, loaded engine. If the crankcase oil temperature reads more than 40°F. higher than the coolant temperature, other conditions being normal, the oil cooler probably needs cleaning.*
4, 5	CLEAN FRESH WATER COOLING SYSTEM	Use a good radiator cleaning compound in accordance with instructions given on the compound container. Following the cleaning operation, rinse thoroughly with fresh water; then fill with clean fresh water, adding rust-inhibitor or anti-freeze. **Do not use both rust inhibitor and anti-freeze in the coolant solution.** When a thorough cleaning of the cooling system is required, it is necessary that the system be reverse flushed by an authorized Detroit Diesel Distributor or Dealer. Do not keep coolant solution containing anti-freeze over the summer period. When draining or refilling system, open vent valve at top of thermostat housing. Close vent valve after filling system.
15	CHANGE OIL IN REDUCTION GEAR CASE (Single Units)	Remove drain plug and drain oil. Flush with light engine oil. Replace drain plug and fill to "FULL" mark on dipstick with SAE 90 to SAE 110 transmission oil. This oil change period may be reduced or lengthened according to severity of service.
22	CHANGE OIL IN GEAR CASE (Multiple Engine Units)	Remove drain plug and drain oil. Flush with light engine oil. Install drain plug and fill to "FULL" mark on dipstick with same oil as used in engine. This oil change period may be reduced or lengthened according to severity of service.

EVERY 2000 HOURS

KEY NO.	OPERATION	REMARKS
		FIRST PERFORM ALL OPERATIONS LISTED UNDER "EVERY 1000 HOURS"
6	BATTERY—CHARGING GENERATOR AND CRANKING MOTOR	Clean commutator—Remove cover band and examine commutator and brushes. Clean commutator, if necessary, with No. "00" sandpaper. Brushes must be reseated after cleaning commutator. **Never use emery cloth to seat brushes or clean commutator.** Blow out brush compartment with dry compressed air after cleaning. If brushes or commutator are excessively worn the generator or starter will require servicing.*
	INSPECT RADIATOR	Inspect outside of radiator core and, if necessary, clean with fuel oil and compressed air. It may be necessary to clean radiator more frequently where air is exceptionally dirty.

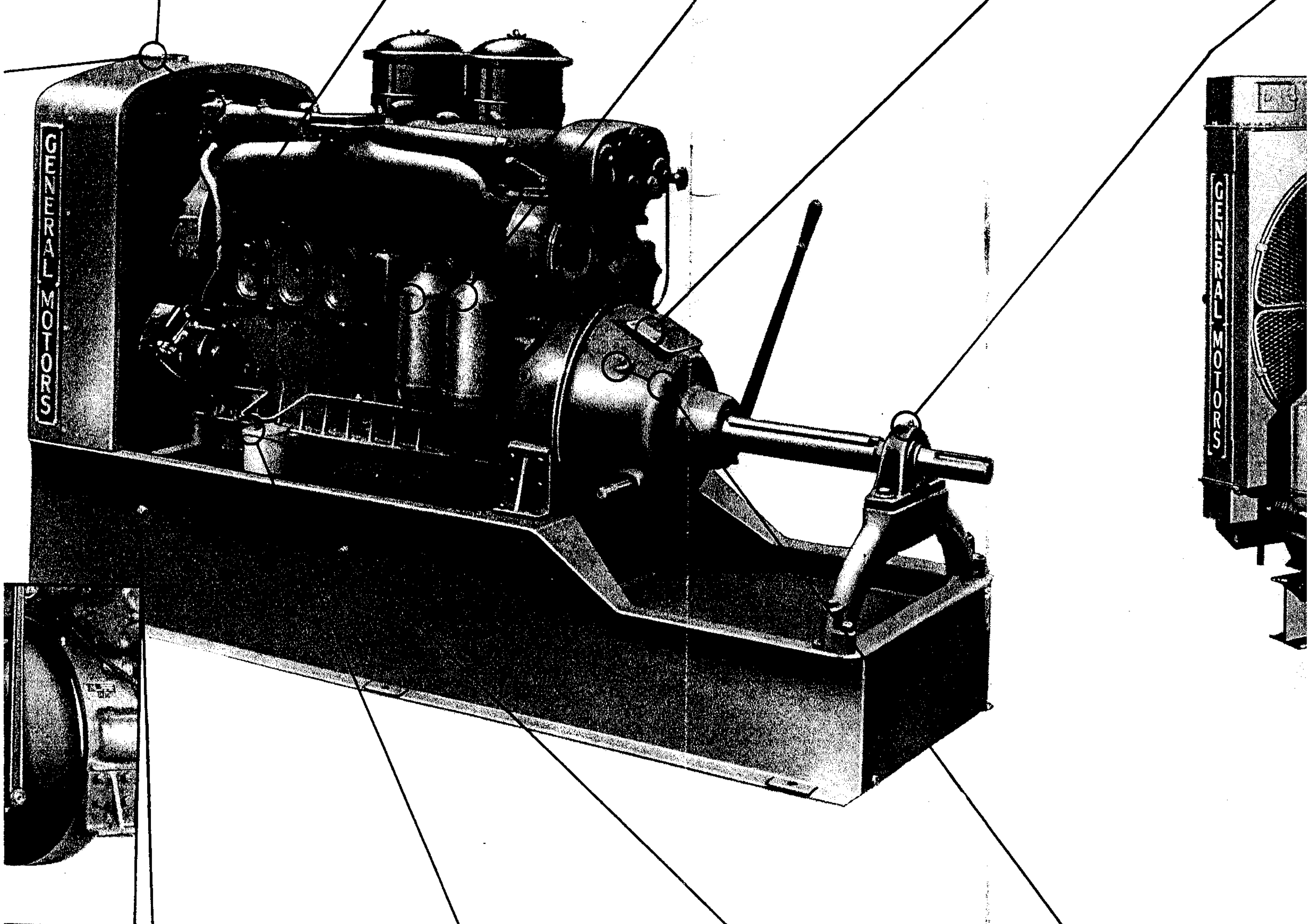
*Consult nearest authorized Detroit Diesel Distributor or Dealer.

1 8 HOURS 500 HOURS FUEL FILTER	2 BEFORE STARTING 8 HOURS ENGINE CRANKCASE OIL LEVEL	3 8 HOURS AIR CLEANERS	4 BEFORE STARTING 1000 HOURS COOLING SYSTEM DRA (SEE KEY NO. 5)



12 8 HOURS 500 HOURS FUEL STRAINER	13 1000 HOURS BLOWER	14 1000 HOURS OIL COOLER	15 BEFORE STARTING 8 HOURS 1000 HOURS GEAR CASE

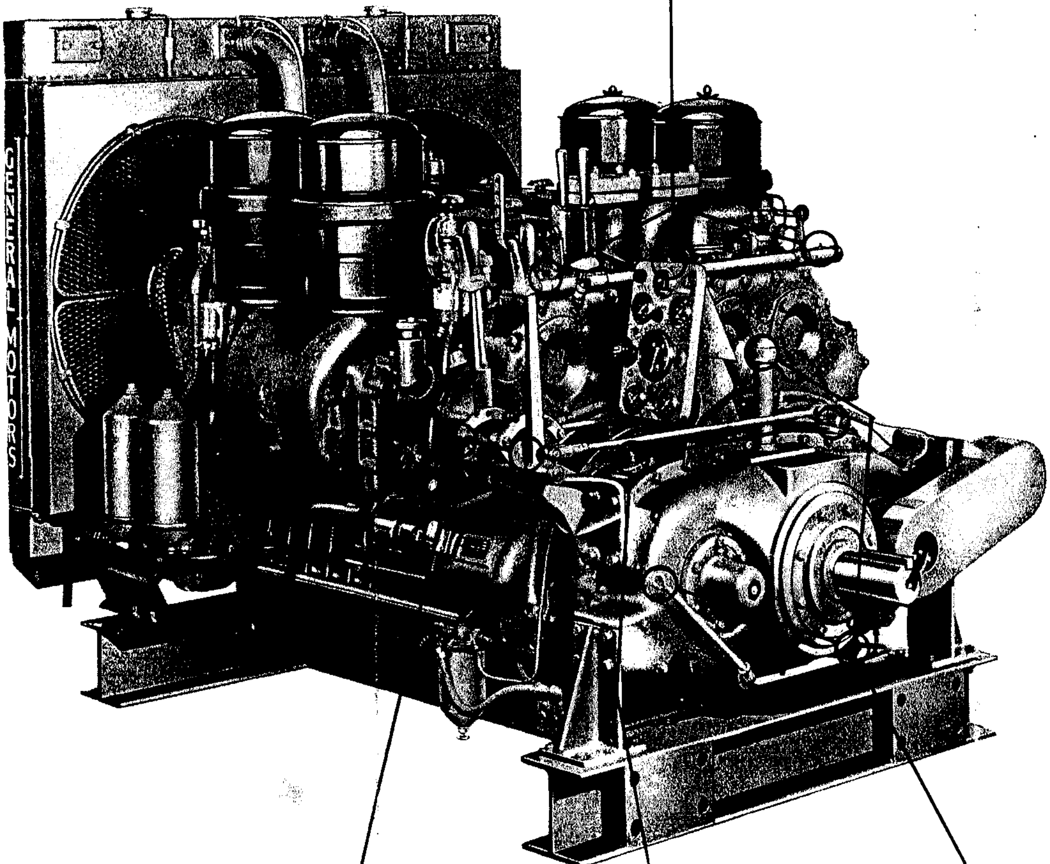
5 BEFORE STARTING 8 HOURS 500 HOURS 1000 HOURS COOLING SYSTEM	6 200 HOURS 500 HOURS 2000 HOURS BATTERY-CHARGING GENERATOR	7 100 HOURS LUBRICATING OIL FILTERS (SEE KEY NO. 18)	8 500 HOURS POWER TAKE-OFF CLUTCH CAMS AND TOGGLES



16 100 HOURS BATTERY	17 100 HOURS 500 HOURS AIR BOX DRAINS	18 100 HOURS ENGINE CRANKCASE OIL	19 8 HOURS CLUTCH THROW-OUT BEARING 50 HOURS POWER TAKE-OFF MAIN BEARING

Fig. 1—Lubrication and Preventive Maintenance C

.UTCH .LES	9 **50 HOURS** POWER TAKE-OFF OUTBOARD BEARING	10 **200 HOURS** THROTTLE CONTROL MECHANISM	11 **100 HOURS (FIRST)** **500 HOURS** ENGINE TUNE-UP



	20 **500 HOURS** CLUTCH CONTROL MECHANISM	21 **8 HOURS** CLUTCH THROW-OUT BEARING	22 **BEFORE STARTING** **8 HOURS** **1000 HOURS** GEAR CASE OIL LEVEL

LUBRICATING OIL SPECIFICATIONS

Long, satisfactory operation of heavy-duty engines require the use of specially compounded "Heavy-Duty lubricants."

Heavy-Duty lubricants are marketed by most oil companies, for use in high-speed Diesel and gasoline engines. These superior oils provide better lubrication, possess more heat resistance, and counteract sludge formation more effectively than regular or premium motor oils. Heavy-Duty lubricating oils hold foreign matter in suspension and, thus, allow the contaminants to be drained out of the crankcase when the oil is changed.

For engines manufactured by the Detroit Diesel Engine Division the recommended lubricating oil viscosity grade is SAE 30 when operating under normal conditions, at normal temperatures.

However, when prolonged exposure of the engine to temperatures below freezing is unavoidable, it is permissible to use the following lighter grades in order to facilitate starting.

Atmospheric Temperature	Viscosity Grade
+30° to 0°F.	SAE 20W
Below 0°F.	SAE 10W

Since all mineral oils deteriorate in service, it is necessary to renew the crankcase content at regular intervals to dispose of the acidic and resinous materials thus formed. The frequency of these oil changes depends upon the severity of engine service, the quality of the lubricant, and the efficiency of filtration. It is, therefore, recommended that new engines be started with 100-hour oil change periods. The interval may be gradually increased, following the recommendations of the oil supplier (based on his analysis of the drained oil) until the most practical oil change interval has been determined.

To prevent dilution of the fresh refill oil supply, flushing oils or other solvents should never be used.

Heavy-Duty lubricants will always appear dark-colored in use due to their exceptional ability to hold fine carbon particles in suspension. Therefore, the color of the oil can no longer be used as an indicator for proper filter action. The removal of abrasive dust, metal particles, and carbon must be ensured by periodic replacement of the absorption filter elements.

Oil filter elements must be changed at every oil change.

Selection of a reliable oil supplier, strict observation of his oil change period recommendations, and proper filter maintenance will ensure trouble-free lubrication, thus longer engine life for your G.M. Diesel Engine.

If lubrication difficulties are encountered when using the proper lubricants, consult the nearest authorized Distributor or Dealer.

Since specifications on lubricating oils are changed periodically to meet current conditions, it is recommended that the latest copy of Service-Forms 7SE-99 and 7SE-126, which may be obtained from your authorized Detroit Diesel Dealer or Distributor, be consulted.

FUEL OIL SPECIFICATIONS

The quality of the fuel oil used for high-speed diesel engine operation is a dominating factor for satisfactory engine life. Suitable fuel oils must be clean, completely distilled, well-refined and non-corrosive to fuel system parts.

To permit efficient combustion, the fuel oil selected must meet the volatility and ignition quality requirements of the engine which are governed largely by speed, load and atmospheric temperature. To avoid excessive deposit formation and premature wear, the sulfur content of the fuel oil must be as low as possible.

Distillation range, cetane number and **sulfur content** are, therefore, the three most important properties of high-speed diesel engine fuel oils.

The large variety of fuel oils marketed for diesel engine use may be divided into four classes with their main properties as listed in Table 1.

TABLE 1

CLASS	DISTILLATION 90% BOILING POINT (MAX.)	DISTILLATION FINAL BOILING POINT (MAX.)	CETANE NUMBER (MIN.)	SULFUR CONTENT (MAX.)
A	550°F	575°F	45	0.25%
B	575°F	625°F	45	0.50%
C	625°F	675°F	40	0.50%
D	675°F	725°F	40	*0.75%

In view of the large influence exerted upon combustion by the temperature of the intake air, and the various fuel oil requirements for different types of engine operation, the proper class of fuel oil should be selected from Table 2.

TABLE 2

TYPE OF ENGINE APPLICATION	AMBIENT AIR TEMPERATURE Above +80°F	Above +40°F	Above 0°F	Above —20°F
Industrial and R. R. Use	C	C	B	A
Heavy Mobile Equipment	*D	C	C	B

Engine operation at altitudes above 5000 feet requires use of next lighter class of fuel oil.

During cold weather engine operation, the "cloud point" (the temperature at which wax crystals begin to form in the fuel oil) must be below the lowest expected fuel temperature to prevent clogging of the fuel filters by wax crystals.

*Where use of fuel oils with higher sulfur content than 0.5% cannot be avoided, lubricating oils of the "Heavy-Duty" S-1 type should be employed.

At temperatures below —20°F. consult your nearest Detroit Diesel Distributor or Dealer, since particular attention must be given the cooling system, lubricating system, fuel system, electrical system, and to the cold weather starting aids for efficient engine operation.

Since specifications on fuel oils are changed periodically to meet current conditions, it is recommended that the latest copy of Service-Form 7SE-100, which may be obtained from your authorized Detroit Diesel Dealer or Distributor, be consulted.

ENGINE TUNE-UP PROCEDURE—SINGLE AND MULTIPLE ENGINE UNITS

Approximately 100 hours after the initial start or after overhaul, and otherwise, at 500-hour intervals, the variable adjustments of the engine should be checked and corrections made for any deviations from standard.

Three types of governor are used on Series 3, 4, and 6-71 industrial units. As each type of governor has different characteristics, the tune-up procedure will vary accordingly.

The three types are:

1. Limiting speed mechanical governor
2. Variable speed mechanical governor
3. Hydraulic governor

The tune-up procedure outlined below applies to the individual engines of twin and quad units as well as single engine units. The throttle linkage of twin and quad units must be adjusted after the individual engines have been tuned-up so that each engine will carry its share of the load.

TUNE-UP PROCEDURE FOR INDUSTRIAL UNITS WITH LIMITING SPEED MECHANICAL GOVERNORS

All checks and adjustments must be made only after the engine has reached normal operating temperatures. Before changing any of the following settings, make certain that adjustment is necessary. Then, with engine stopped, make the necessary adjustments in accordance with the following procedure:

I. Valve Clearance.

II. Injector Timing.

III. Governor Gap Setting.

IV. Injector Rack Setting.

V. Engine Idle Speed.

VI. Maximum No-Load Speed.

I. Adjust Valve Clearance—A clearance of .009" between valve rocker arm and exhaust valve stem with engine at operating temperature is important and should be maintained. Too little clearance causes a loss of compression, mis-firing of cylinders and eventual burning of valves and valve seats. Too much clearance results in noisy operation of the engine, especially in the low speed range.

1. See Fig. 2 for reference to the following operation. To adjust valve clearance, use Service Tool KMO 233, .008" GO – .010" NO GO feeler gauge set.
2. Remove valve rocker cover and set governor control lever in the no fuel position (off).
3. Rotate crankshaft clockwise to position valve rocker arms for adjustment. **DO NOT bar engine counterclockwise as the crankshaft cap retaining bolt might be loosened in this way.**
4. The valve clearance should be measured only when the injector rocker arm has completely depressed the injector plunger for that particular cylinder.
5. Valve clearance adjustment should be made with a 5/16" open end wrench and a 1/2" open end wrench, loosening push rod locknut (2) with the 1/2" wrench and turning the push rod (1) with the 5/16" wrench.
6. Place the .010" end of feeler gauge (3) between

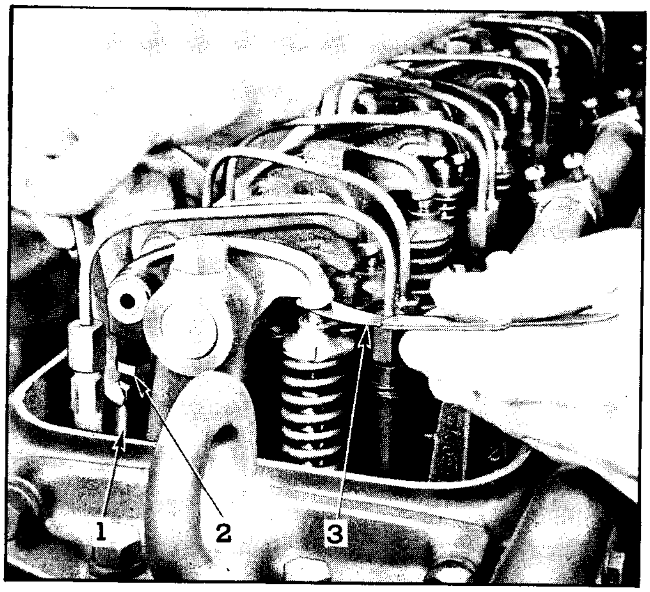


Fig. 2—Adjusting Valve Clearance and Checking with Feeler Gauge KMO 233.

1. Push Rod.
2. Locknut—Push Rod.
3. Valve Clearance Feeler Gauge, KMO 233.

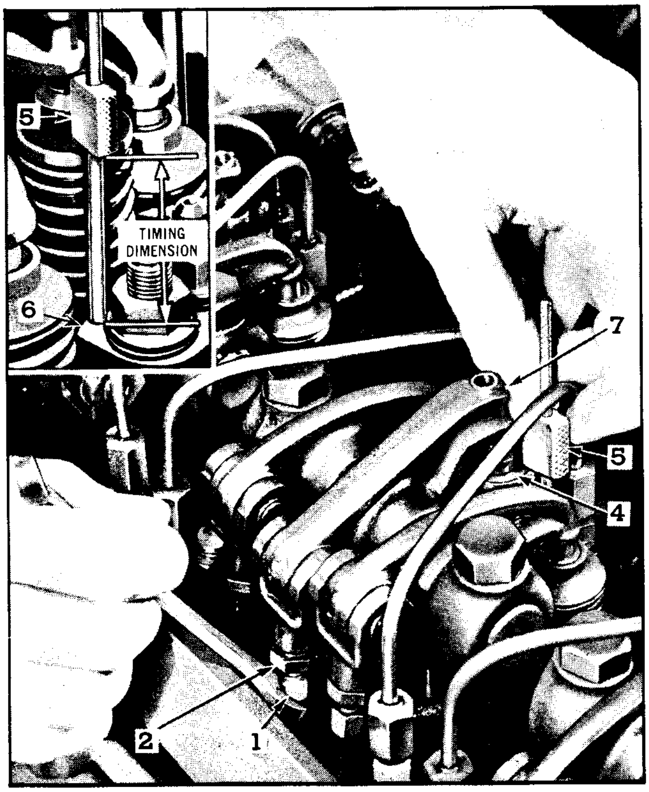


Fig. 3—Timing Fuel Injectors.

1. Push Rod.
2. Locknut—Push Rod.
4. Guide—Injector Follower.
5. Injector Timing Gauge.
6. Body—Injector.
7. Rocker Arm—Injector.

the end of the valve stem and the rocker arm, adjust push rod to obtain a smooth "pull" of feeler gauge.

7. Remove feeler gauge, hold push rod from turning and tighten push rod locknut.

8. Recheck clearance with feeler gauge. At this time the ".008" **GO"** feeler should pass between end of valve stem and valve rocker arm. The ".010" **NO GO"** feeler should not pass through. Readjust if necessary.

II. **Time Fuel Injectors**—To properly time the injectors, the injector follower guide must be adjusted to a definite height. See Fig. 3 for reference to the following operation.

1. Set governor control lever in the no fuel (off) position.

2. Rotate crankshaft clockwise until the exhaust valve rocker arms for that particular cylinder are fully depressed.

3. Place the injector timing gauge (5) in the hole

Injector	Gauge Tool No.	Timing Dimension
60 mm.	J 1242	1.484"
70 mm.	J 1853	1.460"
80 mm.	J 1853	1.460"

Fig. 4—Injector Timing Guage Identification Chart.

provided on top of the injector body with one of the "flats" toward the injector.

4. Adjust the injector rocker arm (7) by turning the push rod with a 5/16" end wrench until the bottom of the timing gauge head will just pass over (drag lightly) the top of the injector follower guide (4).

5. Hold push rod from turning and tighten locknut. Recheck adjustment with injector timing gauge and readjust if necessary.

6. Injectors are identified by a circular plate pressed into the injector body. It is important that a timing gauge of the correct height be used. See Injector Timing Gauge Identification Chart, Fig. 4, for proper timing tool to be used with various capacity injectors.

III. **Governor Gap Setting**—To obtain proper performance and full engine power, the governor low speed spring cap must be correctly set in relation to the governor spring plunger, this is referred to as "governor gap."

Adjust governor gap in accordance with the following steps:

1. Remove governor cover and lever assembly.

2. Remove connecting link (22) between governor and injector control tube lever (23) Fig. 6.

3. Remove the governor low speed adjusting screw housing.

4. Thread the low speed adjusting screw lock-nut (25) Fig. 7, out to the end of the adjusting screw (24).

5. Thread the low speed adjusting screw in until the lock-nut bottoms against the end of the governor spring plunger (9).

   When the low speed adjusting screw has increased the compression of the low speed spring to this extent, maximum collapsing of the gover-

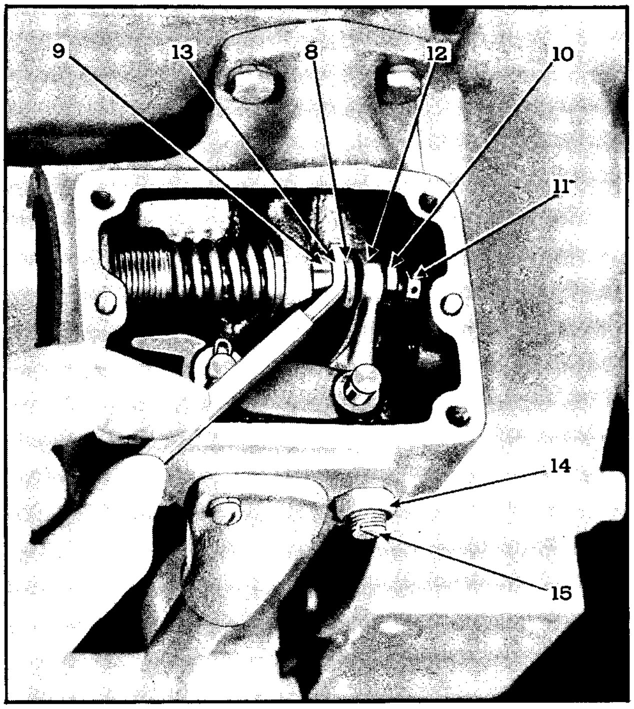


Fig. 5—Adjusting Spring Plunger Gap and Checking with Tool J 4658.

8. Cap—Low Speed Spring.
9. Plunger—Governor Spring.
10. Locknut—Gap Adjusting Screw.
11. Screw—Gap Adjusting.
12. Lever—Operating.
13. Gap Gauge and Spanner Wrench J 4658.
14. Locknut—Buffer Screw.
15. Screw—Buffer.

nor weights is assured and a true gap setting is thus possible.

6. Check the governor gap.

   The governor gap specification for this governor is .170" with the engine not running. Measure the gap between the low speed spring cap (8) and the end of the governor spring plunger (9) with Tool J 4658 as shown in Fig. 5. If gap does not meet specifications, adjust in accordance with Steps 7 and 8 below.

7. Loosen lock nut (10) and turn gap adjusting screw (11) until the gap meets the specification.

8. Hold the gap adjusting screw to prevent changing the setting, while tightening gap adjusting screw lock nut.

9. Re-check gap and re-adjust, if necessary.

10. Install the link between the governor and the injector control tube lever.

IV. **Position Injector Racks**—The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and insures equal distribution of load. Adjust No. 1 injector rack control lever (16), first, in order to establish a guide for adjusting the remaining injector rack control levers (see Fig. 6).

1. Loosen locknut and back out buffer screw (15) until it projects about ⅝" from the governor housing.
2. Loosen inner (17) and outer (18) adjusting screws of all injector rack control levers several turns. Be sure all levers "swing freely" on injector control tube (19).
3. Turn down inner adjusting screw (17) on No. 1 injector rack control lever (16) until screw "bottoms."
4. Move governor control lever (20) toward **full open** position. Do not force it past the point at which resistance to movement suddenly increases, but hold it at this point, pressing lightly toward full open position.
5. Back off inner adjusting screw (17) which will allow governor control lever (20) to move toward full open position. Continue until governor control lever just "bottoms" at end of governor cam (21).

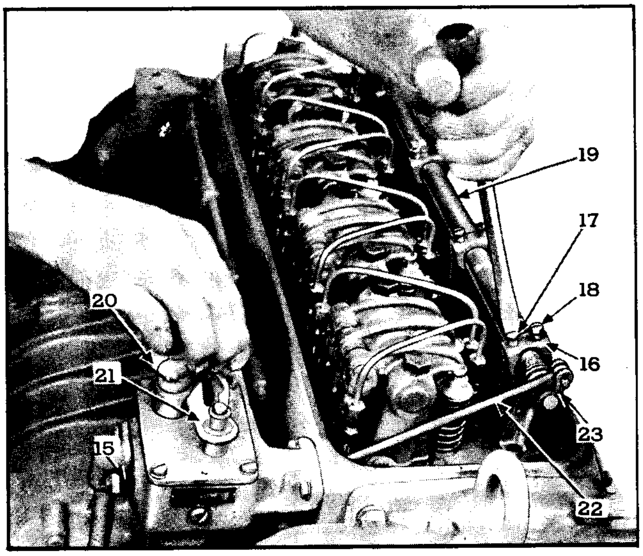


Fig. 6—Positioning Injector Control Racks.

15. Screw—Buffer.
16. Lever—Injector Rack Control.
17. Adjusting Screw—Inner.
18. Adjusting Screw—Outer.
19. Tube—Injector Rack Control
20. Lever—Governor Control.
21. Cam—Governor Cover.
22. Link—Connecting.
23. Lever—Injector Control Tube.

6. Turn down outer adjusting screw (18) until it is snug, but do not tighten. Tighten inner adjusting screw. Tighten outer adjusting screw. This should accomplish the setting of No. 1 injector rack control lever.

7. Check the adjustment as follows:

SETTING CORRECT

If the governor control lever is free to travel to the extreme end of the governor cam without encountering any step-up in resistance and, while it is held in that position, a light pressure of the finger tip reveals the rack to be tight, the rack control lever is properly adjusted.

SETTING TOO TIGHT

If the governor control lever is NOT free to travel to the extreme end of the governor cam unless the step-up in resistance is overcome, the rack is too tight and the adjustments should be corrected by:

Loosening the inner adjusting screw, **SLIGHTLY.**

Tightening the outer adjusting screw.

Tightening the inner adjusting screw.

Recheck setting.

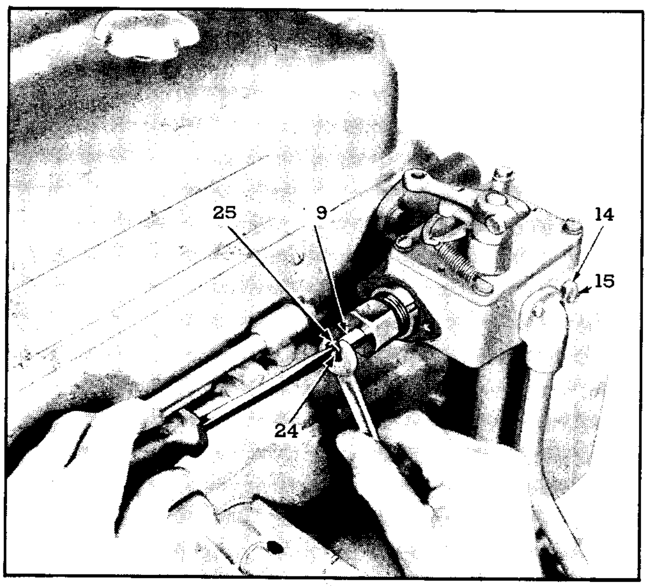


Fig. 7—Adjusting Engine Idle Speed.

9. Plunger—Governor Spring.
14. Locknut—Buffer Screw.
15. Screw—Buffer.
24. Screw—Low Speed Spring Adjusting.
25. Locknut—Low Speed Spring Adjusting Screw.

SETTING TOO LOOSE

If the governor control lever is free to travel to the extreme end of the governor cam without encountering any step-up in resistance and while it is held in that position a light pressure of the finger tip causes the rack to rotate, it is too loose and the adjustment should be corrected by:

Loosening the outer adjusting screw, **SLIGHTLY.**

Tightening the inner adjusting screw.

Tightening the outer adjusting screw.

Recheck setting.

CAUTION: After No. 1 injector rack control lever is once correctly set, it must not be changed throughout adjustment of remaining injector rack control levers.

With governor control lever (20) in **full open** position, note rotary movement of No. 1 injector rack to lever coupling. Pressure of finger tip will produce a tendency to rotate, but coupling should not be loose. All injector rack control levers must now be adjusted to the same "feel" at coupling to insure same amount of fuel injected into each cylinder at full load as follows.

8. Set governor control lever in the "IDLE-NOTCH" of governor control cam (21). Adjust No. 2 injector rack control lever by turning down inner adjusting screw while finger tip is touching No. 2 injector rack coupling. When coupling loses its rotary movement, tighten outer adjusting screw.

9. "Feel" No. 2 and No. 1 injector rack couplings with finger tip to check rotary movement.

10. If No. 1 injector rack coupling now feels loose, No. 2 injector rack coupling is too tight. Correct No. 2 injector rack adjustment by loosening inner adjusting screw and tightening outer adjusting screw.

11. If No. 2 injector rack coupling feels loose, correct by loosening outer adjusting screw slightly and tighten inner adjusting screw.

12. When No. 2 injector rack coupling "feels" the same as No. 1, repeat this procedure (operation 9, 10, 11 and 12) on all remaining injector racks. That is, compare No. 3 injector rack coupling with No. 1, etc.

V. **Engine Idle Speed Adjustment**—Adjust engine idle speed in accordance with the following steps:

1. Start engine. Continue running engine with the governor control lever in the idle notch to warm up the engine.
2. Turn low speed adjusting screw (24) until the engine is running at a speed approximately 15 r.p.m. below the desired idle speed.
3. Turn buffer screw (15) in until surge or "roll" nearly disappears.
4. Hold the low speed adjusting screw to prevent changing the setting, while tightening locknut (25).
5. Turn buffer screw in until surge or "roll" just disappears, but do not raise the engine idle speed more than 15 r.p.m. with the buffer screw. Tighten locknut (14).

VI. **Maximum No-Load Speed Adjustment**—All governors are properly adjusted before the units leave the factory and further adjustment should be unnecessary. However, in the event of a governor change, it may be necessary to adjust the maximum no-load speed.

If this adjustment is necessary the following procedure should be adhered to:

1. Start and warm up engine.
2. With clutch disengaged, place governor control lever (20) in the full fuel position.

   CAUTION: There must be no load on the engine during the maximum no-load speed adjustment.

3. Observe engine speed and compare with the speed stamped on the engine unit nameplate.
4. Remove the spring housing.

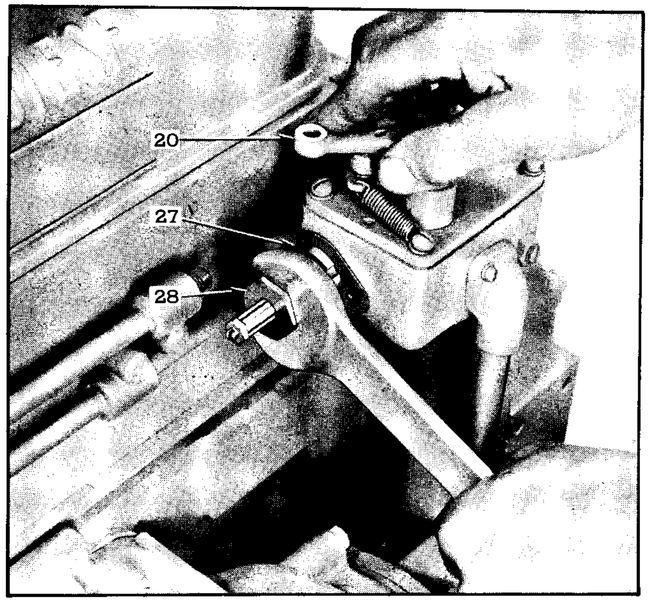


Fig. 8—Adjusting Maximum No-Load Speed

20. Lever—Governor Control.
27. Locknut—High Speed Spring Retainer.
28. Retainer—High Speed Spring.

5. Loosen the governor high speed spring retainer locknut (27) with service tool J 4658.
6. Adjust the maximum no-load engine speed by turning the governor high speed spring retainer (28) in to increase or out to decrease engine r.p.m. until proper speed is obtained.
7. Hold the governor high speed spring retainer from turning and tighten the governor spring retainer locknut.
8. Re-check and re-adjust, if necessary.
9. Replace spring housing.

This completes the tune-up adjustments on an engine equipped with a single-weight limiting speed mechanical governor.

Since the engine performance and efficiency will be governed, to a large extent, by the accuracy with which the tune-up adjustments are made, the mechanic should always perform these operations carefully.

TUNE-UP PROCEDURE FOR INDUSTRIAL UNITS WITH VARIABLE SPEED MECHANICAL GOVERNORS

All checks and adjustments must be made only after the engine has reached normal operating temperatures. Before changing any of the following settings make certain that adjustment is necessary. Then, with engine stopped, make the necessary adjustments in accordance with the following procedure:

I. Valve Clearance.

II. Injector timing.

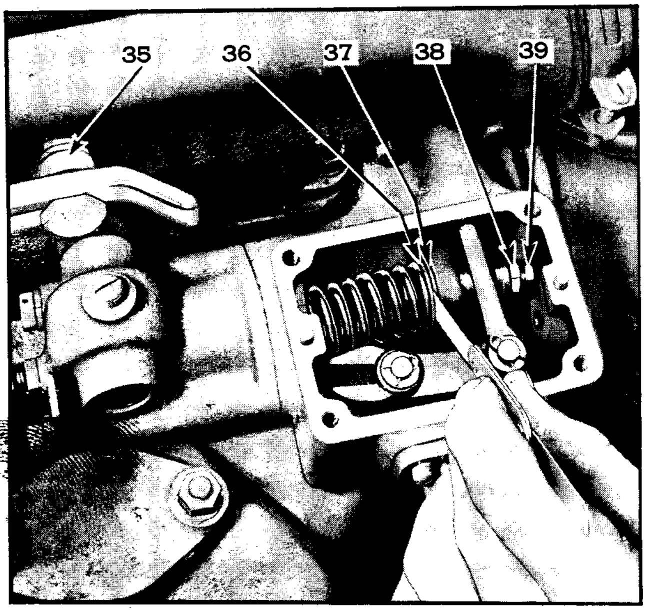


Fig. 9—Adjusting Spring Plunger Gap.

35. Lever—Variable Speed Control.
36. Plunger—Spring.
37. Guide—Spring Plunger.
38. Locknut—Gap Adjusting Screw.
39. Screw—Gap Adjusting.

III. Governor spring plunger setting.

IV. Injector rack setting.

V. Engine idle speed.

NOTE: ***The cross link equalizer springs must be removed from multiple engine units before performing the individual engine tune-up. See "Throttle Adjustment for Load Equalization on Twin or Quad Industrial Units using Variable Speed Mechanical Governors" for procedure on removing cross link equalizer springs.***

I. **Adjust Valve Clearance**—Check and adjust valve clearance as outlined under "Adjust Valve Clearance" in "Tune-up Procedure for Limiting Speed Mechanical Governors."

II. **Time Fuel Injectors**—Check and time fuel injectors as outlined under "Time Fuel Injectors" in "Tune-up Procedure for Limiting Speed Mechanical Governors."

III. **Governor Spring Plunger Setting**—To obtain proper performance and full engine power, the governor spring plunger must be correctly adjusted in relation to the spring plunger guide. This is referred to as "governor gap."

Adjust governor gap in accordance with the following steps:

1. With engine stopped, remove governor cover and lever assembly.
2. Secure speed control lever (35) at full speed position to ensure sufficient tension against the spring plunger for accurate measurement. urement.
3. Measure the "governor gap" between the spring plunger (36) and the spring plunger guide (37) with a .006" feeler gauge. Specifications are from .005" to .007".
4. If the governor gap measures within specifications, replace governor cover.
5. If the governor gap requires adjusting, loosen the gap adjusting screw locknut (38) and turn the gap adjusting screw (39) in or out to obtain the proper clearance. Always tighten the locknut BEFORE checking the governor gap setting.
6. When governor gap is correct, replace the governor cover.

IV. **Position Injector Racks**—The position of the injector racks must be correctly set in relation to the governor. Their position determines the amount of fuel injected into each cylinder and insures equal distribution of load. Adjust No. 1 injector rack control lever (42), first, in order to establish a guide for adjusting the remaining injector rack control levers.

1. Refer to Fig. 11, loosen locknut (46) and back out buffer screw (47) until it projects about 5/8" from the governor housing.
2. If a load-limit screw is used in place of screw (45), Fig. 10, loosen the locknut and back the load-limit screw all the way out.
3. Loosen inner (40) and outer (41) adjusting screws of all injector rack control levers (42) approximately three full turns. Be sure all levers swing freely on the injector control tube.
4. Secure the variable speed control lever (35) in the "full-speed" position (all the way back) and place the governor control lever (44) in the "off" position. The injector rack control lever for No. 1 cylinder must be adjusted first in order to establish the proper relationship betwen the governor and the injector rack control tube.
5. Turn down inner adjusting screw (40) on No. 1 injector rack control lever until the screw JUST bottoms.

6. Move the governor control lever (44) toward the "RUN" position. Do not force it past the point at which resistance to movement increases but hold it at this point, pressing lightly toward the "run" position.

7. Back off the inner adjusting screw on No. 1 injector rack control lever which will allow the governor control lever to move toward the "run" position. Continue until the governor control lever **JUST** bottoms at the end of its cover cam. Turn down outer adjusting screw until it is snug, but do not tighten. Tighten inner adjusting screw. Tighten outer adjusting screw. This should accomplish the setting of No. 1 injector rack control lever.

8. Check the adjustment as follows:

SETTING CORRECT

If the governor control lever is free to travel to the extreme end of the governor cam without encountering any step-up in resistance and, while it is held in that position, a light pressure of the finger tip reveals the rack to be tight, the rack control lever is properly adjusted.

SETTING TOO TIGHT

If the governor control lever is NOT free to travel to the extreme end of the governor cam unless the step-up in resistance is overcome, the rack is too tight and the adjustments should be corrected by:

Loosening the inner adjusting screw, **SLIGHTLY.**

Tightening the outer adjusting screw.

Tightening the inner adjusting screw.

Rechecking setting.

SETTING TOO LOOSE

If the governor control lever is free to travel to the extreme end of the governor cam without encountering any step-up in resistance and while it is held in that position a light pressure of the finger tip causes the rack to rotate, it is too loose and the adjustment should be corrected by:

Loosening the outer adjusting screw, **SLIGHTLY.**

Tightening the inner adjusting screw.

Tightening the outer adjusting screw.

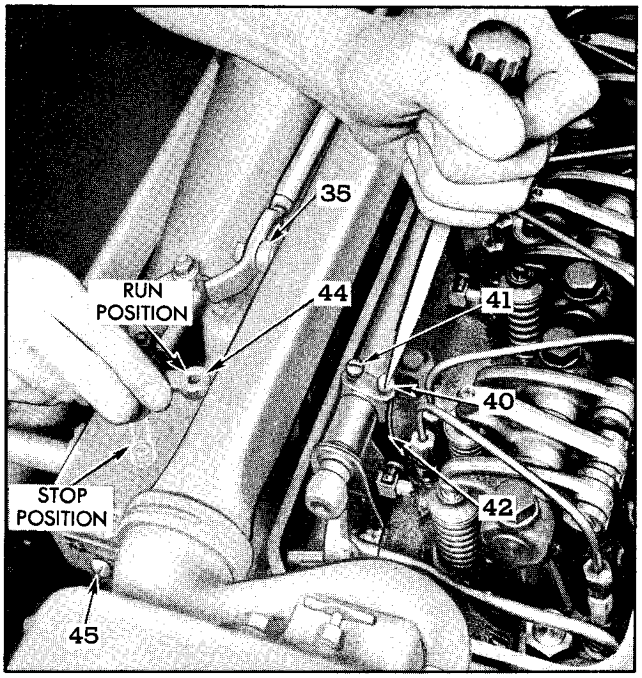


Fig. 10—Positioning Injector Control Racks.

35. Lever—Variable Speed Control.
40. Adjusting Screw—Inner.
41. Adjusting Screw—Outer.
42. Lever—Injector Rack Control.
44. Lever—Governor Control.
45. Screw.

Rechecking setting.

CAUTION: After the No. 1 injector rack control lever is once correctly set, it must not be changed throughout the adjustment of remaining injector rack control levers.

9. Secure the governor control lever in the "RUN" position at the end of the governor control cam for adjusting the remaining injector rack control levers.

10. Adjust No. 2 injector rack control lever by turning down inner adjusting screw while finger tip is touching No. 2 injector rack coupling. When coupling loses its rotary movement, turn down outer adjusting screw until it is snug, but do not tighten. Tighten inner adjusting screw. Tighten outer adjusting screw.

11. Feel No. 2 and No. 1 injector rack couplings with finger tip and compare looseness or tightness of couplings.

12. If No. 1 rack now feels loose, No. 2 rack is too tight and should be loosened. If No. 2 rack feels loose, it should be tightened. Always correct

these conditions by adjusting No. 2 rack control lever.

13. When No. 2 rack coupling feels the same as No. 1, repeat this procedure (operations 10, 11, and 12) on all remaining injector racks, comparing each with No. 1 and finally rechecking the setting of all racks against the setting of No. 1.

V. **Engine Idle Speed Adjustment**—Adjust engine idle speed in accordance with the following steps:

1. Set governor control lever (44), Fig. 11, in the "RUN" position.
2. Secure the variable speed control lever (35) in at least the "half-speed" position—slightly forward of vertical.

   When starting engines equipped with variable speed governors the governor control lever must be in the "RUN" position and the variable speed control lever should be in at least the "half-speed" position. This will ensure maximum fuel injection while engine is being cranked.
3. Start and warm up engine.
4. Set the variable speed control lever in the idle position, making sure it is all the way forward.

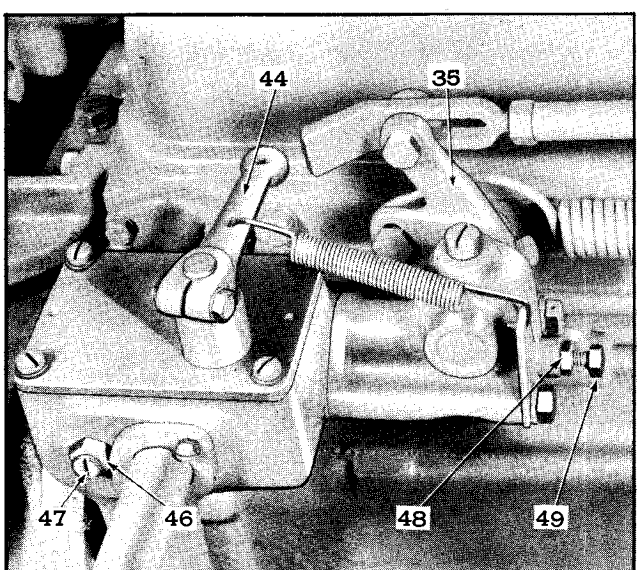


Fig. 11—Buffer and Idle Speed Adjusting Screws—Variable Speed Governor.

35. Lever—Variable Speed Control.
44. Lever—Governor Control.
46. Locknut—Buffer Screw.
47. Screw—Buffer.
48. Locknut—Idle Speed Screw.
49. Screw—Idle Speed.

5. If the engine "rolls" excessively gradually turn in buffer screw (47) until "roll" nearly disappears.

When setting the idling speed it may be necessary to approximate the engine speed due to a slight fluctuation of the tachometer indicator caused by the engine "rolling."

6. Adjust engine idling speed by loosening the idle speed screw locknut (48) and turning the idle speed screw (49) in fcr increasing the engine idling speed or out for decreasing engine idling speed. Set engine idling speed 15 r.p.m. below the desired speed and tighten locknut.
7. If engine does not "roll" increase engine idling speed 15 r.p.m. with buffer screw.
8. If engine "rolls", gradually turn the buffer screw in until the roll disappears. Do not raise the idle speed more than 15 r.p.m. with the buffer screw as it may interfere with the stopping of the engine. Tighten buffer screw locknut.

If it is necessary to increase the idle speed more than 15 r.p.m. to obtain a "smooth-idle", binding in the governor, injector racks, or control tube is indicated. Recheck carefully before continuing with remainder of engine tune-up procedure.

9. Recheck buffer screw setting by hand operation of the variable speed control lever, while observing the movement of both the injector racks and control tube. Accelerate the engine, then quickly return to "idle". The injector racks and control tube should cease movement after one or two surges.
10. If the engine has a load-limit screw, it should be set according to the desired maximum output of engine power, and the load limit screw locknut tightened in place. Procedure of adjustment depends upon application. In general, the load-limit screw is set to permit racks to move toward the "FULL-FUEL" position just far enough to permit the engine to develop the required power.

This completes the tune-up adjustments on an engine equipped with a variable speed mechanical governor.

Since the engine performance and efficiency will be governed, to a large extent, by the accuracy with which the tune-up adjustments are made, the mechanic should always perform these operations carefully.

TUNE-UP PROCEDURE FOR INDUSTRIAL UNITS WITH HYDRAULIC GOVERNORS

All checks and adjustments must be made only after the engine has reached normal operating temperatures. Before changing any of the following settings, make certain that adjustment is necessary. Then, with engine stopped, make the necessary adjustments in accordance with the following procedure:

I. Valve clearance.

II. Injector timing.

III. Fuel rod adjustment.

IV. Maximum fuel adjustment (load limit).

V. Speed droop adjustment.

VI. Maximum speed adjustment.

I. **Adjust Valve Clearance**—Check and adjust valve clearance as outlined under "Adjust Valve Clearance" in "Tune-up Procedure for Limiting Speed Mechanical Governors."

II. **Time Fuel Injectors**—Check and time fuel injectors as outlined under "Time Fuel Injectors" in "Tune-up Procedure for Limiting Speed Mechanical Governors."

III. **Fuel Rod Adjustment**—

1. Remove governor cover and replace two screws (60) through subcap (59) and into governor housing (61) to hold subcap in position, as shown in Fig. 12.

   NOTE: Late model governors have two additional allen head screws holding the subcap in position.

2. Remove valve rocker cover, then with throttle at instrument panel in "Stop" position, loosen adjusting screws (62) and (63) in all six injector rack control levers (64) four turns.

3. Loosen fuel rod lock nut (66) and remove shutdown knob.

4. Turn lock nut (66) to such a position that $^3\!/_{16}$" of the fuel rod (65) extends beyond nut.

5. Replace fuel rod knob against nut and tighten lock nut.

6. Position injector control rack on No. 1 cylinder—

   a. Refer to Figs. 13 and 14 and loosen locknut (67) on maximum fuel adjusting (load limit) screw (68) and back screw out flush with outer face of boss (69a).

   b. While holding the fuel rod (65) way in and the terminal lever (70) tight against the boss, as shown in Fig. 13, turn inner rack control adjusting screw (62) down until fuel rod collar (71) contacts terminal lever (70) and the terminal lever **just starts** to leave the boss (69a) in the subcap.

   c. Tighten outer rack control adjusting screw (63).

IV. **Maximum Fuel Adjustment (Load Limit)**—Again, while holding fuel rod way in (FULL FUEL position of injector racks) with terminal lever (70) up against fuel rod collar (71), as shown in Fig. 14, turn fuel adjusting screw (68) in until .020" space exists between terminal lever and collar. Tighten lock nut (67).

CAUTION: The purpose of turning the fuel screw (load limit) (68) in to contact the terminal lever is to move the injector rack out slightly from the Full Fuel

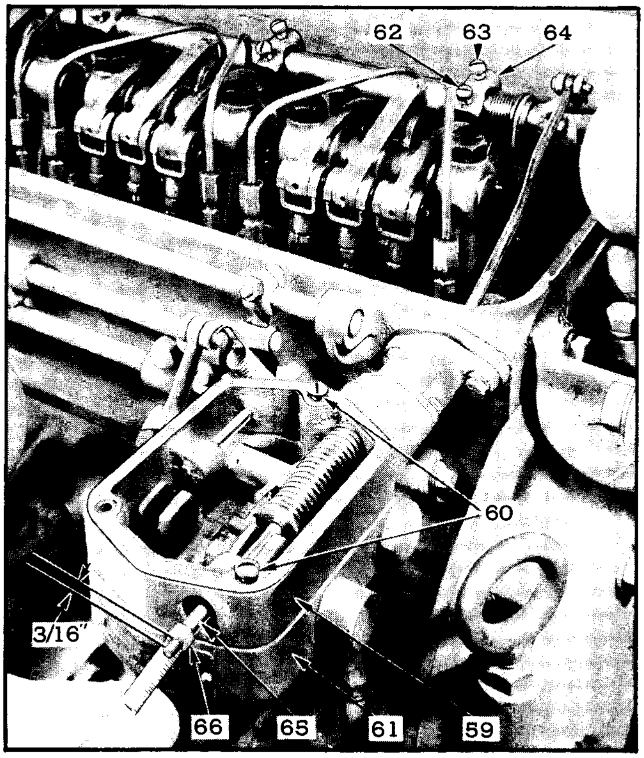


Fig. 12—Adjusting Fuel Rod.

59. Subcap—Governor.
60. Screw—Subcap to Housing.
61. Housing—Governor.
62. Adjusting Screw—Inner.
63. Adjusting Screw—Outer.
64. Lever—Injector Rack Control.
65. Fuel Rod.
66. Locknut—Fuel Rod Knob.

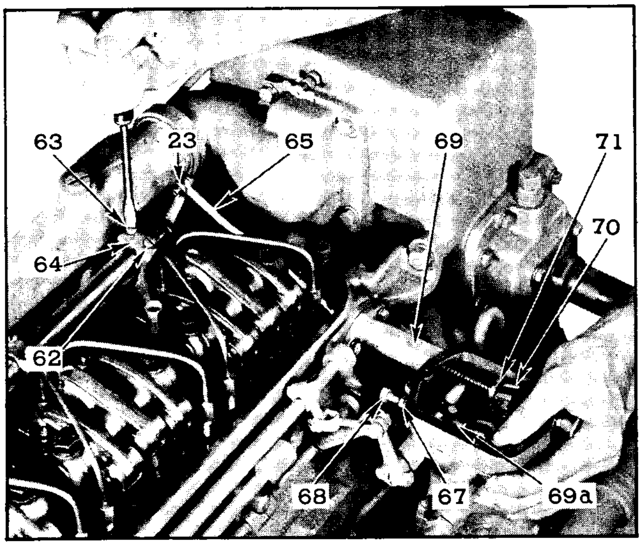


Fig. 13—Positioning No. 1 Injector Control Rack.

23. Lever—Injector Control Tube.
62. Adjusting Screw—Inner.
63. Adjusting Screw—Outer.
64. Lever—Injector Rack Control.
65. Fuel Rod.
67. Locknut—Maximum Fuel Adjusting Screw.
68. Screw—Maximum Fuel Adjusting.
69. Subcap—Governor.
69a. Boss—Governor Subcap.
70. Lever—Terminal.
71. Collar—Fuel Rod.

position so the gear teeth do not strike the end tooth of the injector rack. To move the screw in too far will prevent full open position of the injector racks. THIS MUST BE AVOIDED. The screw is in the proper distance when a .020" feeler gauge fits snugly between the fuel rod collar (71), Fig. 14, and the terminal lever (70) with the fuel rod (65) way in and the terminal lever tight against fuel adjusting screw (68).

1. Position remaining injector control racks—
   a. Disconnect fuel rod (65) from control tube lever (23) by removing clevis pin.
   b. Move control tube lever (23), to hold No. 1 injector rack all the way IN and adjust each of the remaining rack control levers (64) in turn to the full IN position by turning down on inner adjusting screw (62) until the injector rack can be felt striking "bottom" and No. 1 rack can be seen to **just begin** movement **outward.**
   c. Then tighten outer screw (63) and lock inner screw (62).
2. After positioning each rack lever, check to see that No. 1 rack has not moved out. If No. 1 rack has moved out, the lever just positioned has been moved in too far and should be readjusted by loosening the inner adjusting screw (62) and tightening outer adjusting screw (63).
3. Release control tube lever (23) permitting control tube spring to return racks to no-fuel position. Injector racks being in no-fuel position, check the distance between the body of the injector and the edge of the rack coupling. This distance should be approximately ⅞". Be sure that the no-fuel position can be reached, otherwise engine cannot be stopped when throttle is closed.

V. Speed Droop Adjustment—

Speed droop is that governor characteristic which allows engine speed to increase with decrease in load or engine speed to decrease with load increase.

Governor droop is checked and set at the factory before engines are shipped and further adjustment should be unnecessary. However, if a governor has had major repairs or has been otherwise disturbed, the speed droop should be readjusted after the governor has been installed on the engine. The purpose of adjusting is to establish a definite engine speed at no load with a known speed at full rated load.

The most reliable method of determining the engine speed during the setting of the speed droop is by use of an accurate hand tachometer.

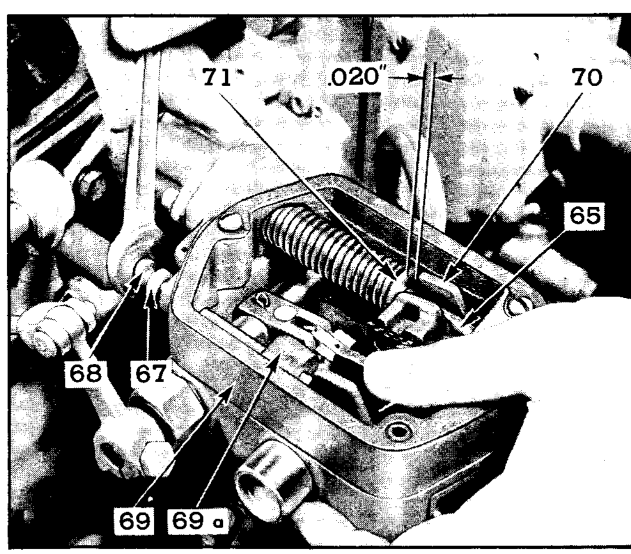


Fig. 14—Setting Maximum Fuel Adjusting Screw (Load Limit).

65. Fuel Rod.
67. Locknut—Maximum Fuel Adjusting Screw.
68. Screw—Maximum Fuel Adjusting.
69. Subcap—Governor.
69a. Boss—Governor Subcap.
70. Lever—Terminal.
71. Collar—Fuel Rod.

If a full rated load on the unit can be established, and the fuel rod and load limit screw has been set, the speed droop may be adjusted as follows:

1. Start the engine, and run at approximately one half the rated no load speed until the lubricating oil temperature stabilizes (approximately 15 minutes).

   NOTE: When the engine lubricating oil is cold the governor regulation will probably be erratic (governor will "hunt"). The regulation should become increasingly stable as the temperature of the lubricating oil increases.

2. With the engine stopped, remove the governor cover.

3. Loosen droop adjusting screw (74), shown in Fig. 15, and move bracket (72) so that screw is mid-way between ends of slot in bracket. Tighten screw.

4. Loosen lock nut (76) on the maximum speed adjusting screw (75), shown in Fig. 16, and turn screw counterclockwise until at least ⅝" of threads are exposed.

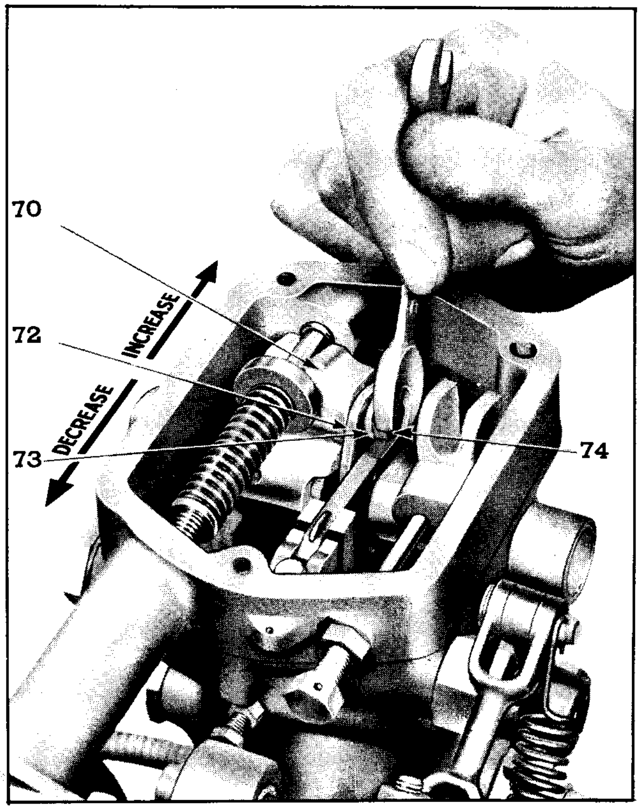


Fig. 15—Adjusting Speed Droop.

70. Lever—Terminal.
72. Bracket—Droop Adjusting.
73. Washer—Droop Adjusting Screw.
74. Screw—Droop Adjusting.

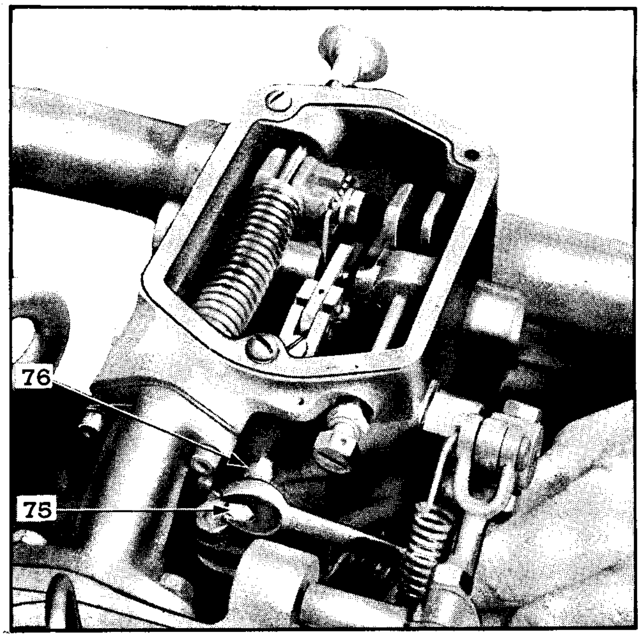


Fig. 16—Setting Maximum Speed Adjusting Screw.

75. Screw—Maximum Speed Adjusting.
76. Locknut—Maximum Speed Adjusting Screw.

5. With the throttle in RUN position, adjust the engine speed until the engine is operating at 3% to 5% above the desired full load speed.

6. Apply the full rated load on the engine, and re-adjust the engine speed to the correct full load speed.

7. Remove rated load, and note engine speed after speed stabilizes under no load. If droop is satisfactory, the engine speed will be approximately 3% to 5% higher than the full load speed. If engine speed is too high, stop engine and again loosen bolt (74), Fig. 15, and decrease droop by moving droop adjusting bracket (72) IN toward engine. To increase the droop, move droop adjusting bracket OUT, away from engine.

8. Repeat steps "3" through "7" above until the engine no-load speed is not more than 3% to 5% higher than the rated full load speed.

However, on units where a speed droop is not required, the droop adjusting bracket may be moved so that the droop adjusting bolt is midway between ends of slot in bracket. Tighten bracket securely.

VI. **Maximum Speed Adjustment** — The maximum speed adjusting screw (75), shown in Fig. 16, limits the travel of the governor speed adjusting shaft, which is in turn connected, through linkage, to the throttle at the instrument panel. Moving the screw **IN** will decrease—and **OUT** will increase—the maximum engine speed.

This adjustment should be made after the fuel rod, maximum fuel, and the speed droop adjustments have been made and in the following manner:

1. Loosen lock nut (76) on screw (75) and with engine heated to normal operating temperature and running at no load, turn screw (75) in until engine speed is 75 to 100 r.p.m. higher than the full load speed.
2. When checking engine speeds with a hand tachometer, locate the tachometer in the center spot of the crankshaft cap retaining bolt at the front of the engine.

This completes the tune-up adjustments on an engine equipped with a hydraulic governor.

Since the engine performance and efficiency will be governed, to a large extent, by the accuracy with which the tune-up adjustments are made, the mechanic should always perform these operations carefully.

THROTTLE ADJUSTMENTS FOR LOAD EQUALIZATION—TWIN AND QUAD UNITS

Each Twin unit consists of two and each Quad unit of four engines connected by clutches to a common gear box. The object of the throttle adjustment is to cause each engine of either the Twin or Quad unit to carry its share of the load. Throttle adjustments on the industrial units are divided into two groups, depending on the type of governor used to control the engine speed.

The two groups are:

1. Throttle Adjustments on Twin or Quad Units with Limiting Speed Mechanical Governors.
2. Throttle Adjustments on Twin or Quad Units with Variable Speed Mechanical Governors.

Each group is treated separately in the following pages.

THROTTLE ADJUSTMENT FOR LOAD EQUALIZATION ON TWIN OR QUAD INDUSTRIAL UNITS USING LIMITING SPEED MECHANICAL GOVERNORS

Throttle Adjustments—The individual engine tune-up is very important in the adjustment of twin and quad engine units as the engines must be closely synchronized to enable each engine to carry its full share of any given load. The following adjustments must be performed, in the order presented, on each engine in the unit before adjusting the throttle control linkage.

NOTE: All adjustments must be made with engines at operating temperature.

Disconnect governor control tube assemblies (80) from control levers (81), Figs. 18 and 19, and perform the following adjustments.

a. Exhaust Valve Clearance Adjustment (see Page 11).

b. Time Fuel Injectors (see Page 12).

c. Governor Gap Adjustment (see Page 12).

d. Position Injector Control Racks (see Page 13).

e. Idle Speed Adjustment (see Page 14).

NOTE: The amount of r.p.m. increase due to buffer screw adjustment must be the same on all engines in a twin or quad unit.

f. Maximum No-Load Speed Adjustment (see Page 15).

The above adjustments should be performed on each engine in the unit by the same mechanic to ensure uniformity between engines.

With the engines stopped:

1. Measure the distance from the center of the

clevis pin hole, to the front end of the control tube (80), (not the locknut). This distance must be 1⅝", as shown in Figs. 18 and 19.

If the aforementioned distance is not correct on all of the governor control tube assemblies, it will be necessary to proceed as follows:

a. Loosen the clevis locknut (82) of the governor control tube assembly.

b. Thread the clevis (83) in or out of the control tube, as necessary, until the centerline of the pin holes in the clevis are 1⅝" from the front of the control tube.

c. Prevent the clevis from turning in the tube, and tighten the clevis locknut.

d. Connect each of the governor control tubes (80) to the governor control levers (81) by means of a clevis pin and cotter pin. Spring washers are used between each of the clevis arms and the governor control lever.

NOTE: Position bend in governor control tube assemblies in such a manner as to clear all obstructions and not bind at either end.

2. Check the two levers on top of each governor cover (84) for vertical alignment (i.e. one exactly over the other). If the levers are not in alignment, adjust the top lever (81) on its shaft until the alignment is correct.

3. Make sure that the individual throttle control levers (85) are latched to their quadrant (86), by positioning pins (87), Fig. 17.

4. Move the master throttle control lever (88) until the forward scribe mark (the mark nearest the engine on the outer individual control lever (85) aligns with the scribe mark on the adjacent shaft bracket (89). The throttle control levers are now in the "FULL FUEL" position.

NOTE: If the aforementioned parts are not marked, the "FULL FUEL" position can be determined by moving the master throttle control lever (88) away from the engines until the attaching bolt (90) in the outer control lever (85) is 1 3/16" away from the vertical position (20° rotation). With the levers in this position, scribe mating marks on the outer control lever and the adjacent shaft bracket.

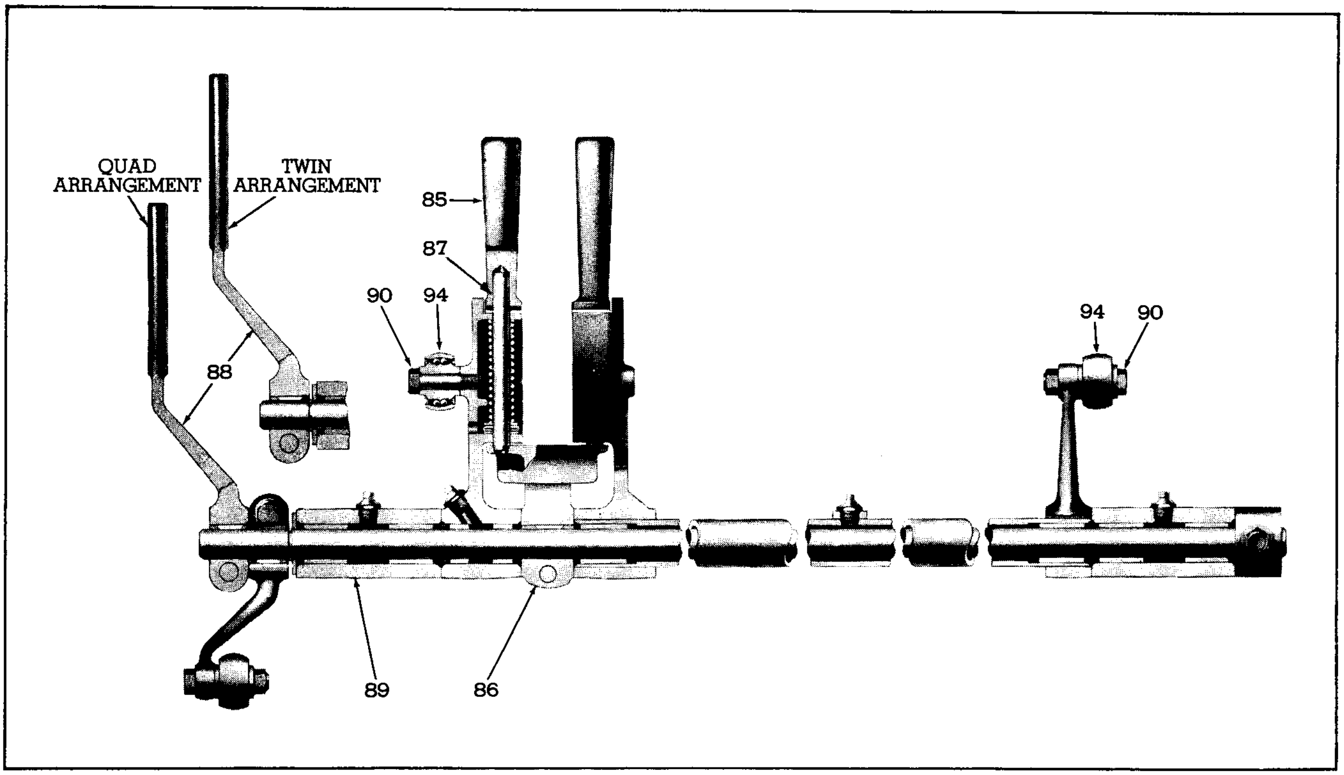


Fig. 17—Throttle Control Cross Shaft Assembly—Twin and Quad Units.

85. Lever—Throttle Control.
86. Quadrant—Throttle Control.
87. Pin—Throttle Control Lever.
88. Lever—Master Throttle Control.
89. Bracket—Throttle Control Shaft.
90. Bolt—Control Tube Attaching.
94. Bearing—Control Tube End.

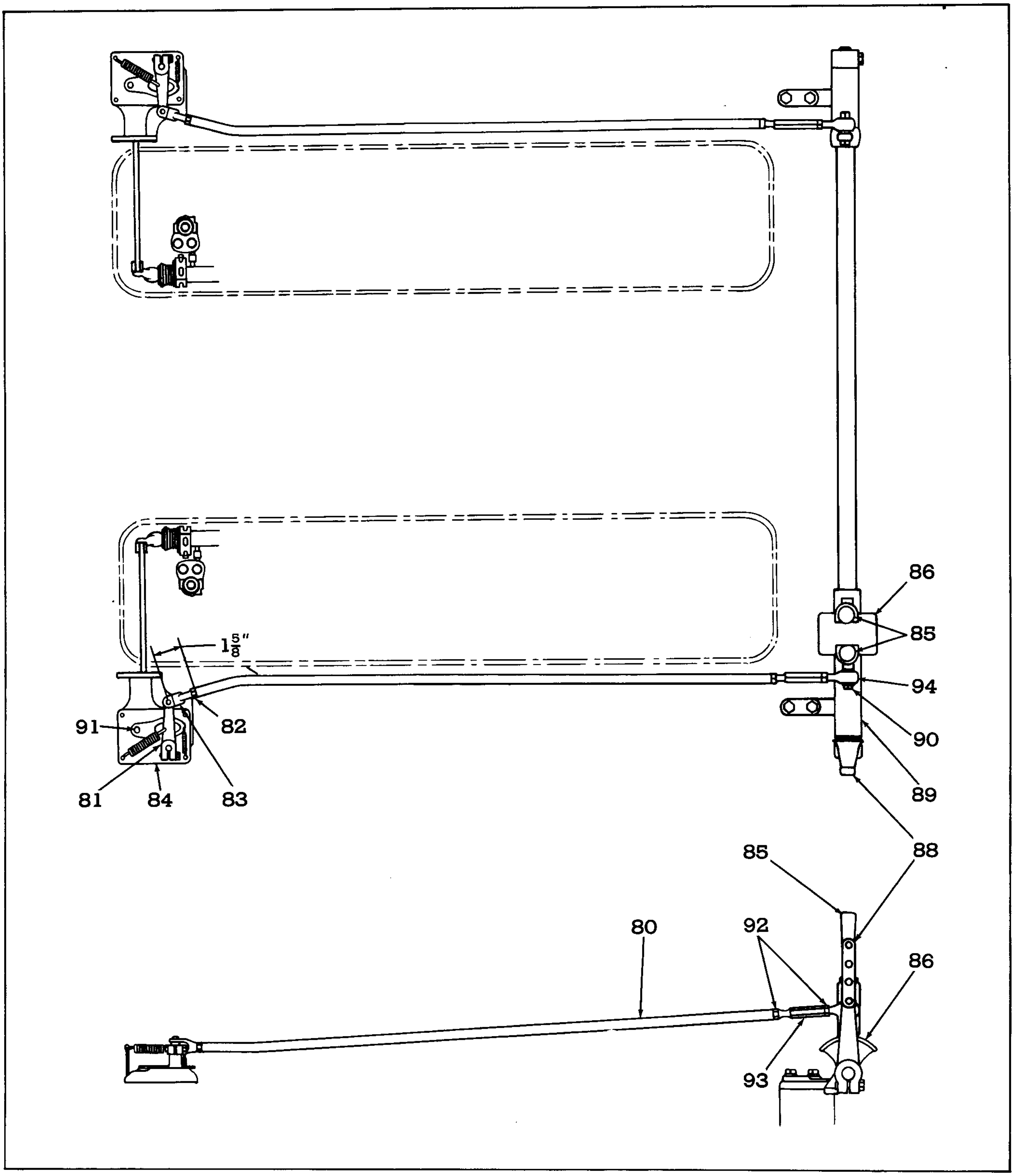


Fig. 18—Diagram of Throttle Control Linkage for Twin Units with Limiting Speed Mechanical Governors.

80. Control Tube—Governor.
81. Lever—Governor Control.
82. Locknut—Clevis.
83. Clevis—Control Tube.
84. Cover—Governor.
85. Lever—Throttle Control.
86. Quadrant—Throttle Control.
88. Lever—Master Throttle Control.
89. Bracket—Throttle Control Shaft.
90. Bolt—Control Tube Attaching.
91. Cam—Governor Cover.
92. Locknut—Control Tube Turnbuckle.
93. Turnbuckle—Control Tube.
94. Bearing—Control Tube End.

5. Secure the master throttle control lever (88) in the "FULL FUEL" position.

6. Check each governor control lever to determine if it is in the "FULL FUEL" position—at the end of its slot in cam (91).

   NOTE: The pin of the governor control lever must be just touching the end of the slot in cam (91).

7. If any of the governor control levers are not in the "FULL FUEL" position, loosen the two turnbuckle locknuts (92) of the governor control tube (80) and adjust turnbuckle (93) until all governor control levers are in the "FULL FUEL" position.

8. Tighten the turnbuckle locknuts and again check the position of the governor control lever pin in the cam. The pin must be **just touching** the end of the slot. When tightening the turnbuckle locknuts, be careful not to "cock" the end bearing (94) at the end of the governor control tube assembly (80).

9. With the clutches disengaged, move the master throttle control lever (88) to the "IDLE" position and start each engine.

10. Replace the valve rocker covers and run the engines until they are at their normal operating temperature.

11. Again place the master throttle control lever in the "IDLE" position, and compare the idling speeds of engines. This speed should be the same as that which was previously set.

12. Move the master throttle control lever (88) to the "FULL FUEL" position and note the maximum, no-load speed of each engine. This speed should be the same as that which was previously set.

13. Move the master throttle control lever to obtain a speed approximately 300 r.p.m. lower than the maximum no-load speed.

14. During Step 13, all engines should be running within 100 r.p.m. of each other. If they are not, more than likely the tune-up of each individual engine (i.e. governor gap setting, injector rack positioning, etc.) was not performed similarly on all engines and must be repeated.

If the above procedure does not bring the engines within close synchronization, it is suggested that each engine be checked for possible sources of low power such as poor compression pressures, faulty injectors, low fuel pressure, etc. All engines must be in good operating condition to secure close synchronization, especially under load, as any of the aforementioned conditions will prevent an engine from developing full power and doing its share of work.

Fig. 19—Diagram of Throttle Control Linkage for Quad Units with Limiting Speed Mechanical Governors.

80. Control Tube—Governor.
81. Lever—Governor Control.
82. Locknut—Clevis.
83. Clevis—Control Tube.
84. Cover—Governor.
85. Lever—Throttle Control.
86. Quadrant—Throttle Control.
88. Lever—Master Throttle Control.
89. Bracket—Throttle Control Shaft.
90. Bolt—Control Tube Attaching.
91. Cam—Governor Cover.
92. Locknut—Control Tube Turnbuckle.
93. Turnbuckle—Control Tube.
94. Bearing—Control Tube End.

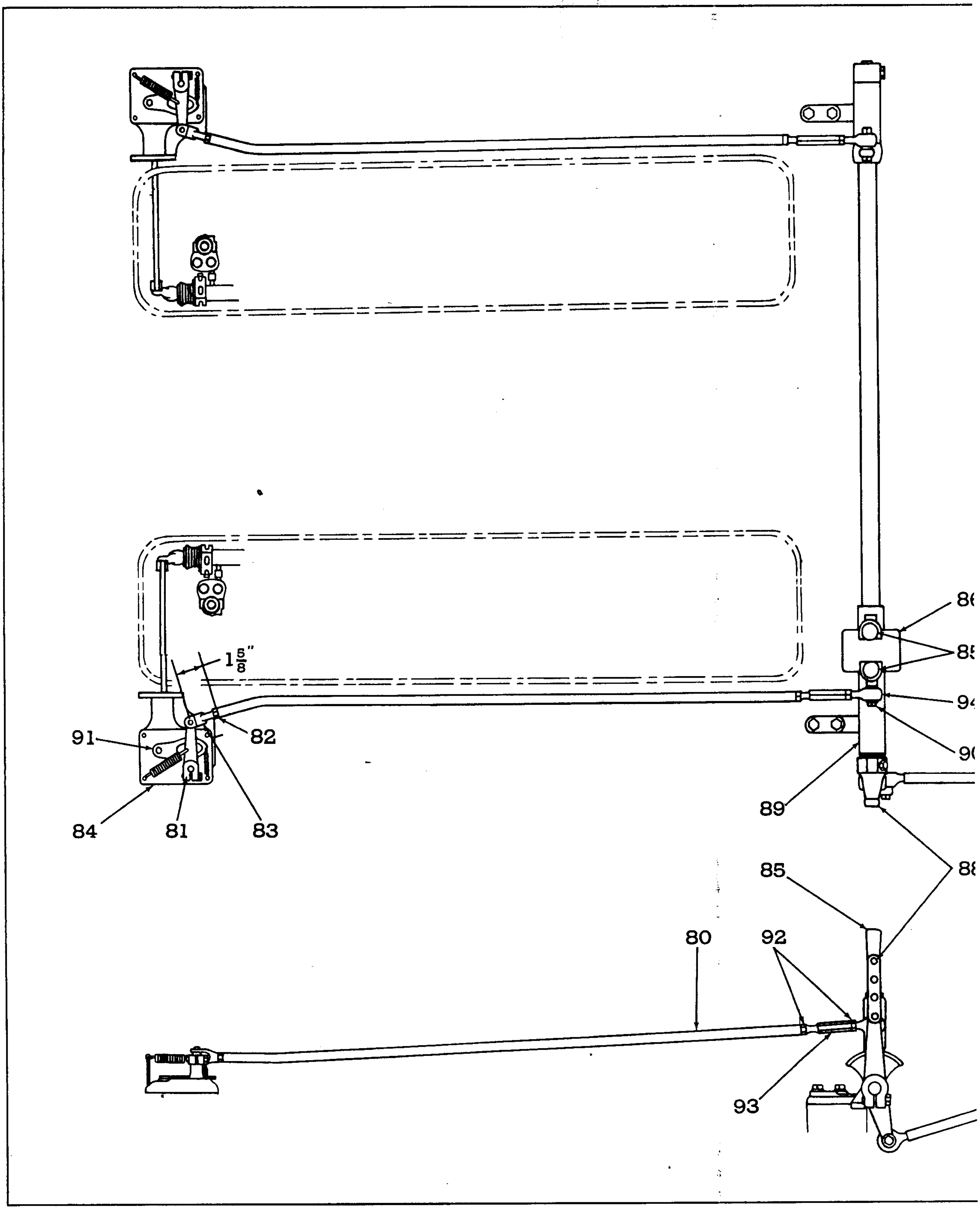
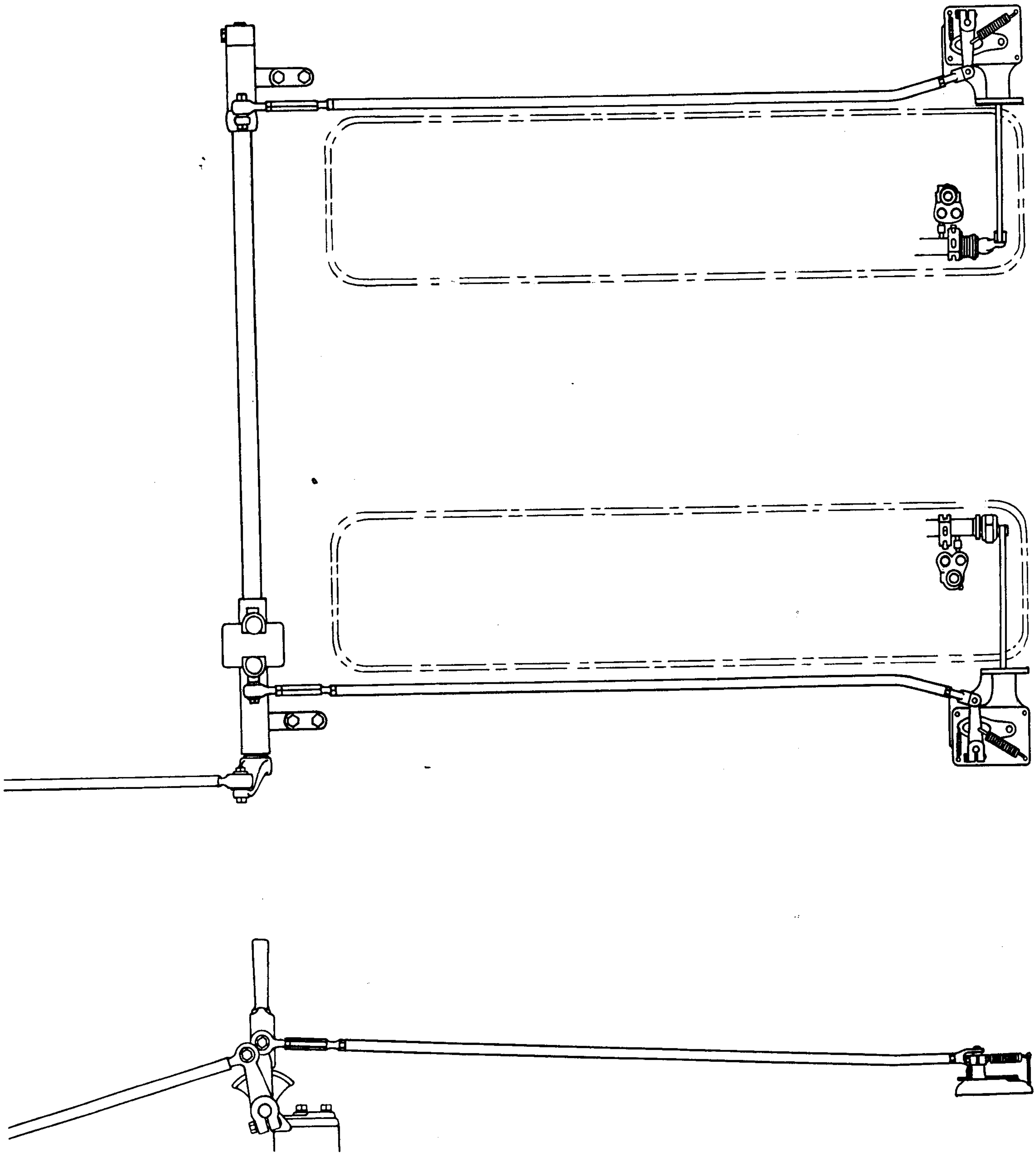


Fig. 19—Diagram of Throttle Control Linkage



ʇuad Units with Limiting Speed Mechanical Governors.

THROTTLE ADJUSTMENT FOR LOAD EQUALIZATION ON TWIN OR QUAD INDUSTRIAL UNITS USING VARIABLE SPEED GOVERNORS

Throttle Adjustments—The individual engine tune-up is very important in the adjustment of twin and quad engine units as the engines must be closely synchronized to enable each engine to carry its full share of any given load. The following adjustments must be performed, in the order presented, on each engine in the unit before adjusting the throttle control linkage.

NOTE: All adjustments must be made with engines at operating temperature.

Remove valve rocker covers and disengage all clutches. Disconnect the governor control tube assemblies (80) from the governor variable speed levers (100), Figs. 20 and 21, remove screw (101) and cross link equalizer spring (102) from the cross link equalizer of each side-by-side pair. In the case of quad units, the master control equalizer spring (103), Fig. 21, must be removed. Loosen screw (104) and remove spring.

With the above equalizer springs removed, perform the following adjustments:

a. Exhaust Valve Clearance Adjustments (see Page 11).

b. Time Fuel Injectors (see Page 12).

c. Governor Spring Plunger Setting (see Page 16).

d. Position Injector Control Racks (see Page 16).

e. Idle Speed Adjustment (see Page 18).

NOTE: The amount of r.p.m. increase due to buffer screw adjustment must be the same on all engines in a twin or quad unit.

The above adjustments should be performed on each engine in the unit by the same mechanic to ensure uniformity between engines.

With the engines stopped:

1. Measure the distance from the rear of the slot in link (105), at the front end of each governor control tube assembly (80), to the front end of its respective control tube (not the locknut). This distance as shown in Figs. 20 and 21, must be ¾".

   If the aforementioned distance is not as specified on all of the governor control tube assemblies, it will be necessary to proceed as follows:

   a. Loosen the front link locknut (106) of the governor control tube assembly (80).

   b. Then thread link (104) in or out of the governor control tube as necessary until the rear end of the slot in link is ¾" from the front of the control tube.

   c. Prevent the link from turning in the tube and tighten the link locknut.

   d. Connect each of the governor control tube assemblies (80) to its respective governor variable speed lever (100).

   NOTE: The bend in the governor tube assembly must be in a horizontal plane.

2. Make sure that the individual throttle control levers (85) are latched to their quadrant (86), by positioning pins (87), Fig. 17.

3. Move the master throttle control lever (88) until the forward scribe mark (the mark nearest the engine) on the outer individual control lever (85) aligns with the scribe mark on the adjacent shaft bracket (89). The throttle control levers are now in the "FULL FUEL" position.

Fig. 20—Diagram of Throttle Control Linkage for Twin Units with Variable Speed Mechanical Governors.

80. Control Tube—Governor.
85. Lever—Throttle Control.
86. Quadrant—Throttle Control.
88. Lever—Master Throttle Control.
89. Bracket—Throttle Control Shaft.
90. Bolt—Control Tube Attaching.
92. Locknut—Control Tube Turnbuckle.
93. Turnbuckle—Control Tube.
94. Bearing—Control Tube End.
100. Lever—Variable Speed.
101. Screw—Cross Link Equalizer Spring.
102. Spring—Cross Link Equalizer.
105. Link—Control Tube End.
106. Locknut—Control Tube End Link.
107. Spring—Variable Speed Lever Booster.
108. Pin—Governor Booster Spring.
109. Locknut—Booster Spring Adjusting.
110. Lever—Governor Control.
111. Bolt—Lever-to-Link.
112. Turnbuckle—Cross Link Equalizer.
113. Boss—Master Control Equalizer.
114. Link—Equalizer.

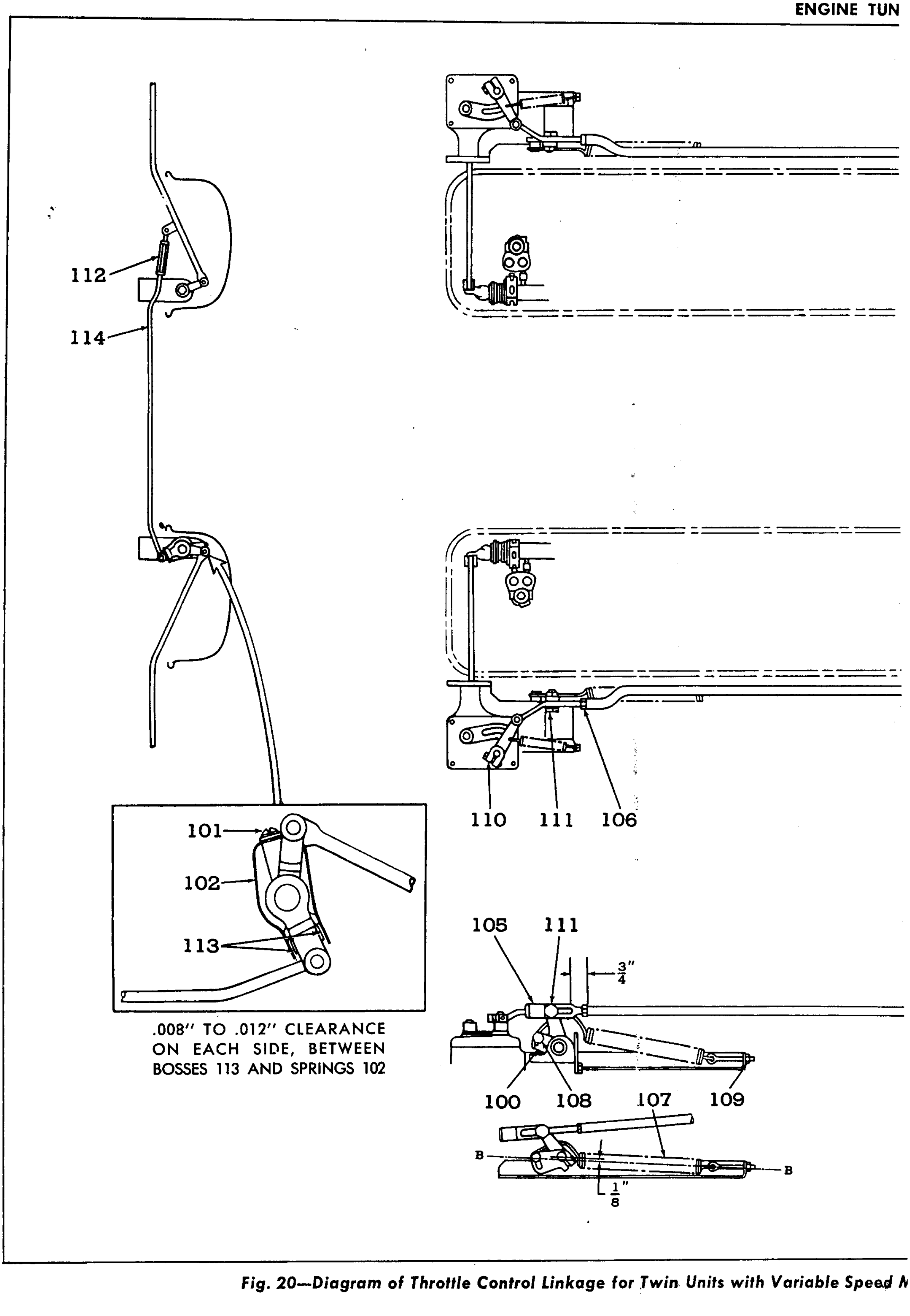
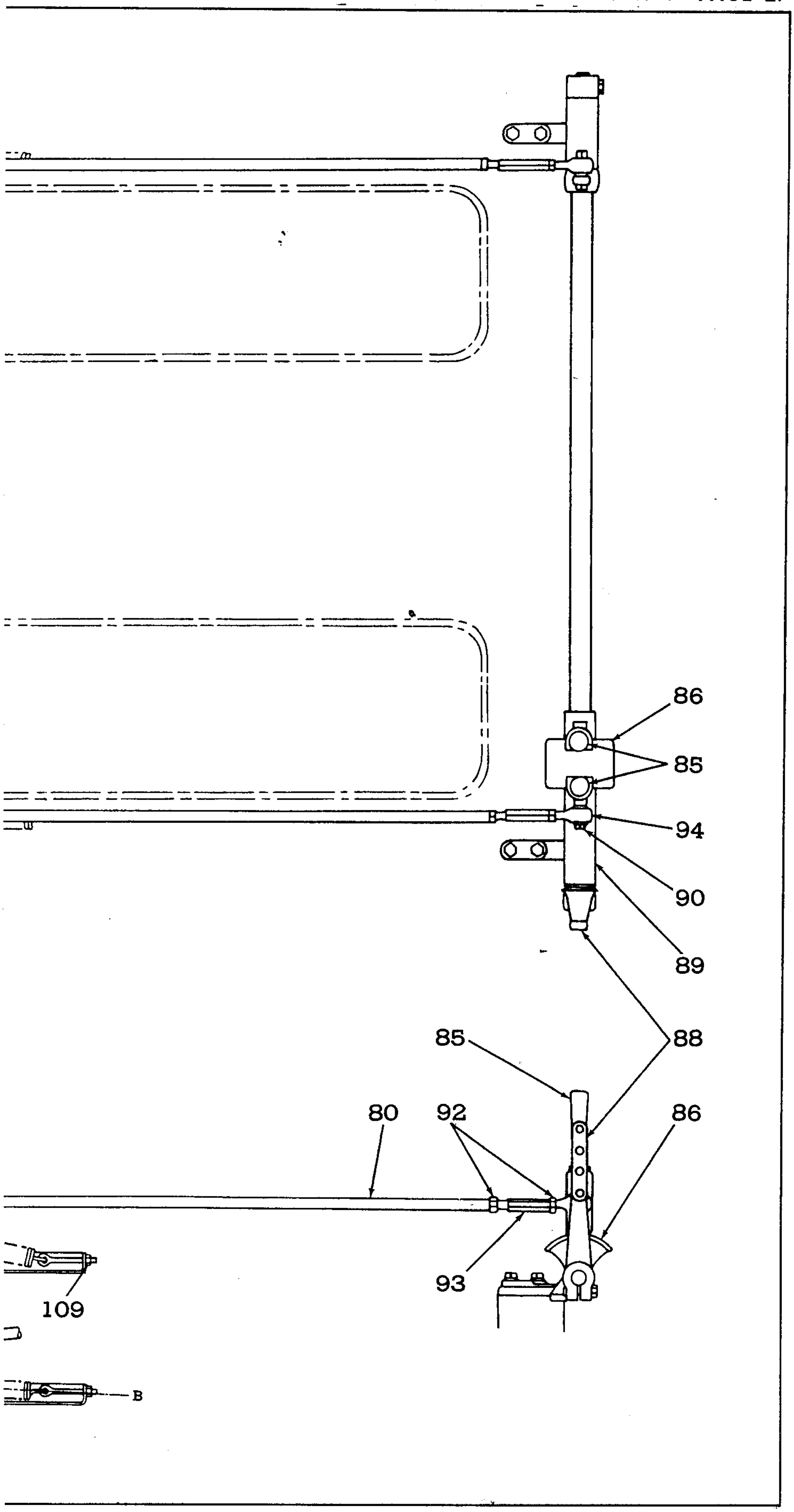


Fig. 20—Diagram of Throttle Control Linkage for Twin Units with Variable Speed M



Units with Variable Speed Mechanical Governors.

NOTE: If the aforementioned parts are not marked, the "FULL FUEL" position can be determined by moving the master control lever (88) away from the engine until the attaching bolt (90) in the outer control lever (85) is 1¾₆" away from the vertical position (20° rotation). With the levers in this position scribe mating marks on the outer control lever and the adjacent shaft bracket.

4. Secure the master throttle control lever (88) in the "FULL FUEL" position.

5. Check each governor variable speed lever to determine if it is in the "FULL FUEL" position (all the way back).

6. If any of the variable speed levers are not in the "FULL FUEL" position, loosen the two turnbuckle locknuts (92) of the governor control tube (80) and adjust turnbuckle (93) until all governor variable speed levers are in "FULL FUEL" position.

7. Then tighten the turnbuckle locknuts (92) and again check the position of each governor variable speed lever. Each lever must be **all the way back.** When tightening the turnbuckle locknuts, be careful not to "cock" the end bearing (94) at the end of the governor control tube assembly.

8. The following steps pertain to the checking and adjustment of the governor booster-spring (107) if necessary.

   a. Disconnect each of the governor throttle control tube assemblies (80) from its corresponding governor variable speed lever (100).

   b. Set the governor booster spring pin (108) ⅛" below over-center line B-B, as shown in Figs. 20 and 21.

   c. Make sure the clutches are disengaged, and start each engine.

   d. Individually release each of the variable speed levers from the "FULL FUEL" position, and note its return to the "IDLE" position. Each of the variable speed levers should return quickly to the "IDLE" position.

   If any lever does not return quickly to the "IDLE" position, back off the booster spring adjusting locknut (109) and tighten the adjusting nut until the governor variable speed lever returns sluggishly from "FULL FUEL" position to "IDLE" position when the lever is pulled back and released. Then back off the adjusting nut until the variable speed lever will return quickly when released. Tighten locknut.

   e. Next, check the force required to operate each governor variable speed lever over its range of travel. A uniform force over the entire range is desired—that is, from "IDLE" position to "FULL FUEL" position.

   If the force is greater at the beginning of the variable speed lever travel, adjust the booster spring (107) upward in the slot. If the force seems greater near the end of the variable speed lever travel, adjust the booster spring pin (108) downward, away from the over-center line B-B.

9. After the booster spring has been properly adjusted, on each engine, connect each of the governor control tube assemblies (80) to its corresponding variable speed lever (100).

10. Then, set the gap between the end of link (105) and the governor control lever (110) at $\frac{1}{16}$" to ⅛" by adjusting the position of the stop lever on its shaft. While setting this gap, the governor variable speed lever must be in the "IDLE" position, and the forward end of the slot in control tube link (105) must be contacting the variable speed lever-to-link bolt (111).

11. Secure the master throttle control lever (88) in the "FULL FUEL" position, then replace equalizer spring (102) and secure with screw (101) on each side-by-side pair.

12. Loosen the locknuts at turnbuckle (112) on each side-by-side pair and adjust the turnbuckle until there is equal clearance between each leg of the equalizer spring (102) and each lower boss (113)—approximately .010" clearance on each side.

    NOTE: As it is very difficult to measure the clearance on both sides of the equalizer spring, adjust for a gap of .010" on one side and assume the same for the other side.

13. Tighten the turnbuckle locknuts, and recheck the

aforementioned clearance. Readjust if necessary.

14. Lubricate the clevis joints of the equalizer linkage with a few drops of engine oil, and then move the master throttle control lever (88) back and forth to check for binding in the equalizer system. Particularly note if the equalizer link (114) rubs inside the link cover tube. Correct any binding that may exist.

15. Make sure the clutches are in the disengaged position. Move the master throttle control lever to the "IDLE" position and start each engine.

16. Replace the valve rocker covers, and accelerate and run the engines until they are at their normal operating temperature.

17. Again place the master throttle control lever in the "idle" position and check the idling speed of the side-by-side engines.

NOTE: The idling speed of the engine not incorporating the equalizer spring (102) will probably be less than that of the engine which has the spring due to the expansion of cross link (114). In such cases, remove the valve rocker covers and proceed as follows:

18. Loosen the equalizer turnbuckle locknuts, and adjust the turnbuckle (112) until both side-by-side engines are idling at the same speed and there is equal clearance between each leg of the equalizer spring (102) and the lower bosses (113).

19. Replace the valve rocker covers.

20. Move the master throttle control lever (88) to the "FULL FUEL" position and determine the maximum, no-load speed of each engine.

NOTE: The speed of each engine should now be the same as the maximum no-load speed which was previously set. If not, check for binding in the equalizer system.

21. With the clutches still disengaged, move the master throttle control lever until the engines are running approximately 300 r.p.m. lower than maximum, no-load speed.

22. Check the speed of the side-by-side pair with a tachometer. This check should show side-by-side engines running within 25 r.p.m. of each other.

23. If a variation in excess of 25 r.p.m. exists, then more than likely the tune-up of each individual engine (i.e. governor gap setting, rack positioning, etc.) was not similarly performed on both engines and must be repeated.

The following procedure pertains to the adjustment of the master control equalizer between the front and rear engine pairs comprising quad units (see Fig. 21).

24. Remove valve rocker covers.

25. Remove bolts (120) and lockwashers and then remove covers (121) and gaskets from equalizer housing (122) and (123).

26. Loosen clamping bolt (124) until equalizer lever (125) swings freely on equalizer shaft (126).

27. Adjust both adjusting screws (127) until they are threaded equally into the adjusting lever (128) and are contacting the flats in the equalizer shaft. These bolts should be fairly tight.

28. Replace equalizer spring (103) and screw (104). Tighten screw.

29. With the individual control levers (85) latched to their quadrants (86), move the master control lever (88) to the "FULL FUEL" position and secure the master lever.

30. Move the equalizer link (129) which is connected to equalizer adjusting lever (128) until equal clearance exists between each leg of the equalizer spring (103) and each boss (130). This clearance should be approximately .010" on each side.

31. While holding the equalizer link in this position, tighten clamping bolt (124) on equalizer lever (125).

32. Recheck the clearance between each leg of equalizer spring (103) and each lower boss (130). If the clearance is not equal on both sides, readjust adjusting screws (127) until clearance is equal.

33. Replace the valve rocker covers.

34. Move the master throttle control lever (88) to the

"IDLE" position and start each engine of the quad unit. Then accelerate the engines and run them until they are at their normal operating temperatures.

35. Move the master throttle control lever to the "FULL FUEL" position and check the maximum, no-load speed on each engine. This speed should be the same as the individual maximum, no-load speeds previously set.

36. Move the master control lever to the "IDLE" position and check the idle speed of each engine. Again, the individual idle speeds should be the same as previously set.

37. If engine speeds in Steps 35 and 36 are not as previously set, it will be necessary to readjust the master equalizer adjusting lever (128) by means of the two adjusting screws (127).

38. After these adjustments have been satisfactorily completed, replace equalizer housing gaskets and covers.

If the above procedure does not bring the engines within close synchronization, it is suggested that each engine be checked for possible sources of low power such as poor compression pressures, faulty injectors, low fuel pressure, etc. All engines must be in good operating condition to secure close synchronization, especially under load, as any of the aforementioned conditions will prevent an engine from developing full power and doing its share of work.

Fig. 21—Diagram of Throttle Control Linkage for Quad Units with Variable Speed Mechanical Governors.

80. Control Tube—Governor.
85. Lever—Throttle Control.
86. Quadrant—Throttle Control.
88. Lever—Master Throttle Control.
89. Bracket—Throttle Control Shaft.
90. Bolt—Control Tube Attaching.
92. Locknut—Control Tube Turnbuckle.
93. Turnbuckle—Control Tube.
94. Bearing—Control Tube End.
100. Lever—Variable Speed.
101. Screw—Cross Link Equalizer Spring.
102. Spring—Cross Link Equalizer.
103. Spring—Master Control Equalizer.
104. Screw—Master Control Equalizer Spring.
105. Link—Control Tube End.
106. Locknut—Control Tube End Link.
107. Spring—Variable Speed Lever Booster.
108. Pin—Governor Booster Spring.
109. Locknut—Booster Spring Adjusting.
110. Lever—Governor Control.
111. Bolt—Lever-to-Link.
112. Turnbuckle—Cross Link Equalizer.
113. Boss.
114. Link—Equalizer.
120. Bolt—Master Equalizer Housing.
121. Cover—Equalizer Housing.
122. Housing—Master Control Equalizer.
123. Housing—Master Equalizer.
124. Bolt—Clamping.
125. Lever—Master Equalizer.
126. Shaft—Master Equalizer.
127. Screw—Adjusting.
128. Lever—Master Control Equalizer.
129. Link—Master Control Equalizer.
130. Boss—Master Control Equalizer.

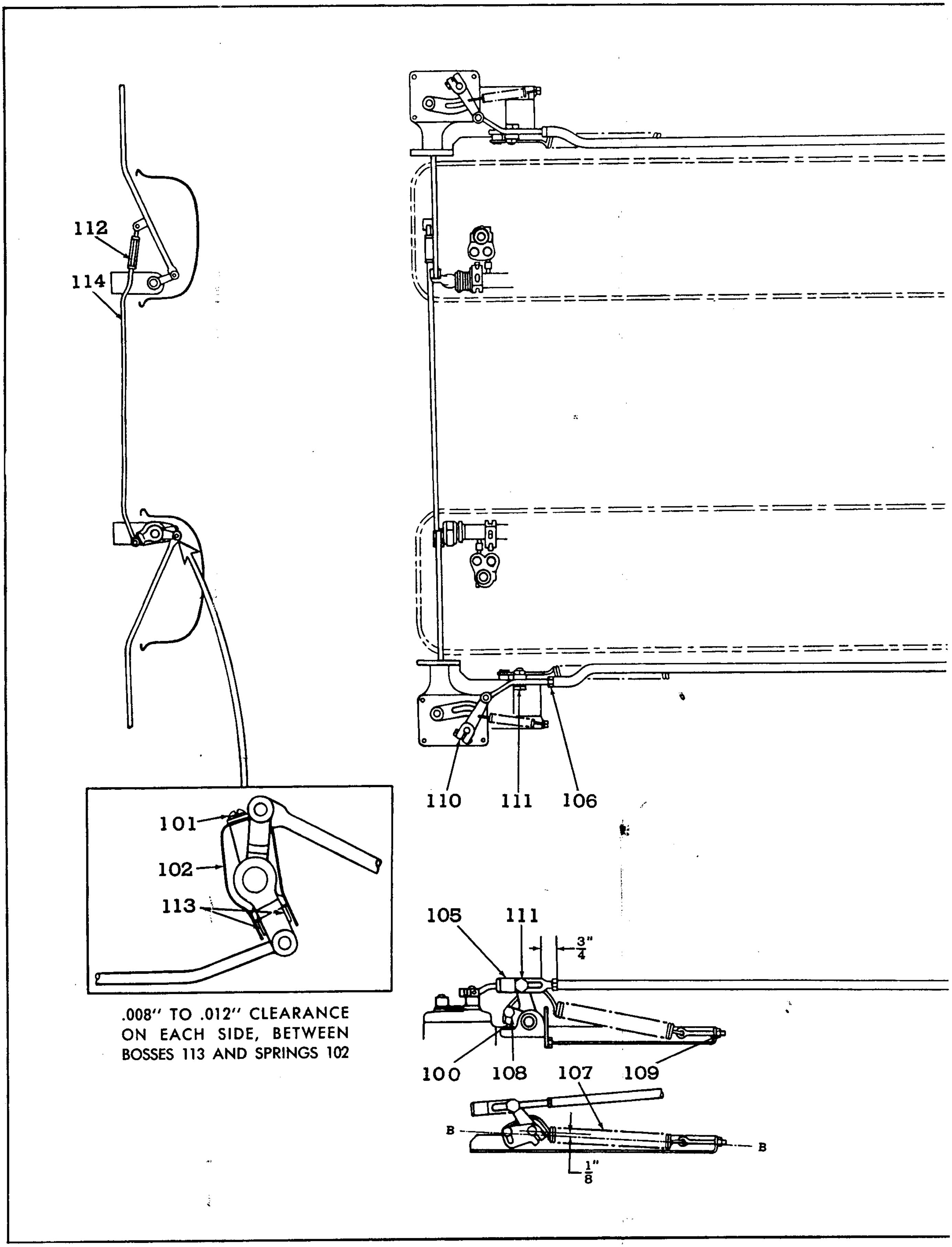
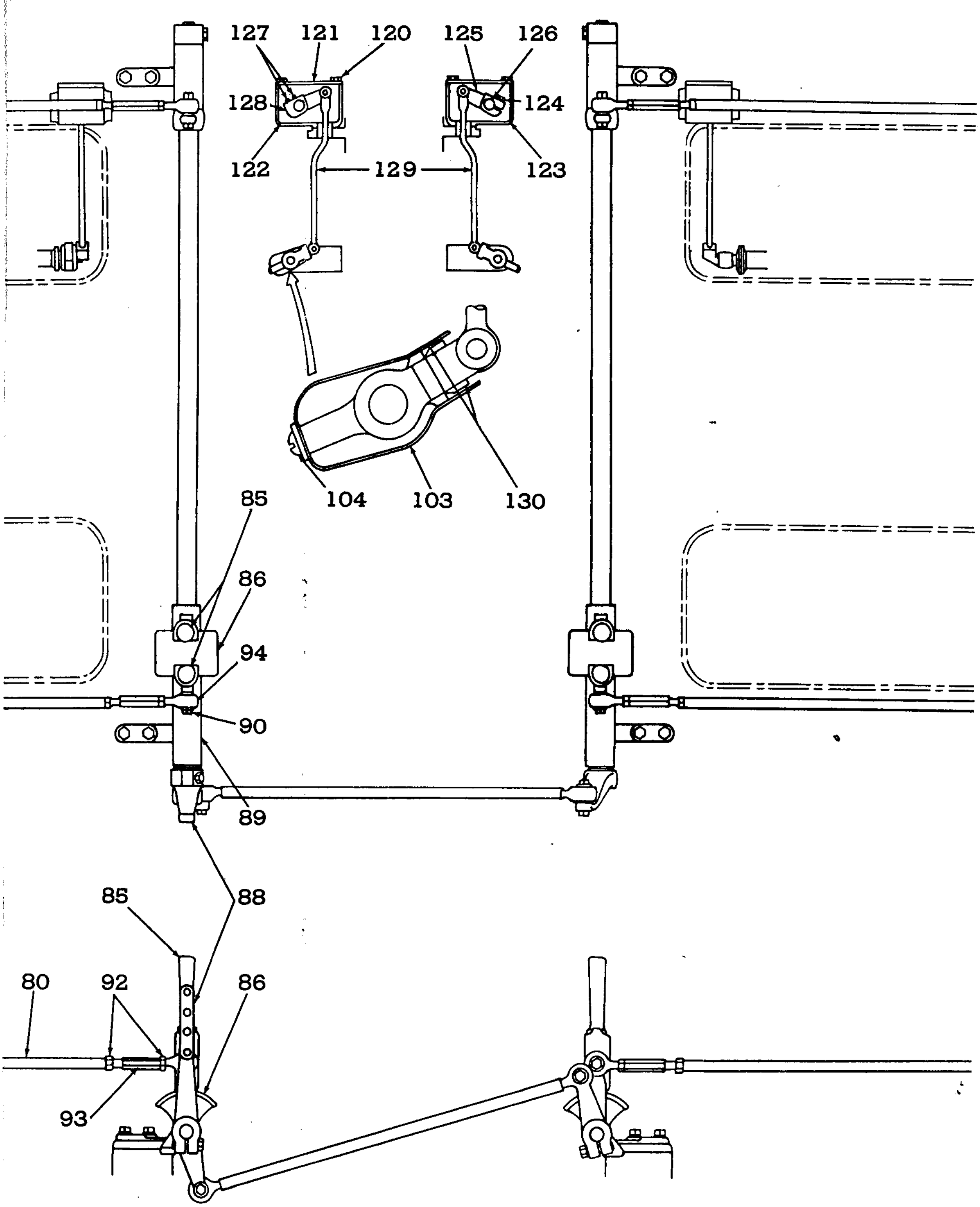
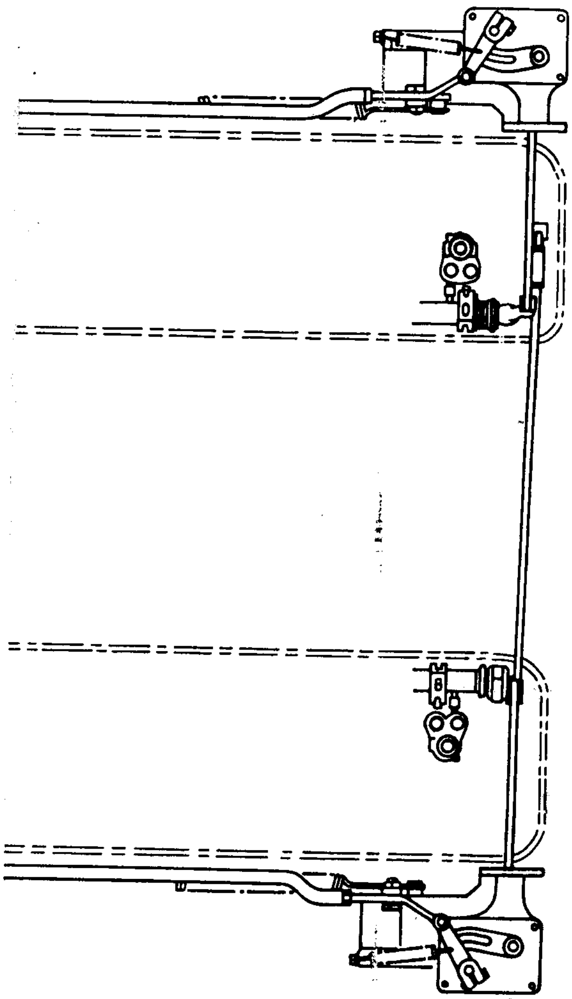
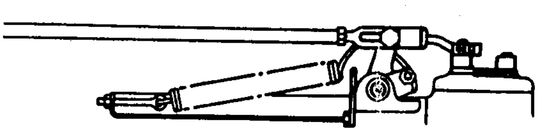


Fig. 21—Diagram of Thr



ıttle Control Linkage for Quad Units with Variable Speed Governors.





TROUBLE SHOOTING

The satisfactory performance of a Diesel engine depends on two items of foremost importance:

1. The presence of sufficiently high compression pressure.
2. The injection of the proper amount of fuel at the right time.

The first of these items depends almost entirely on pistons, piston rings, and valves with their operating mechanism; the second item depends on the injectors and their operating mechanism.

Lack of engine power, uneven running, excessive vibration, and a tendency to stall when idling may be caused either by a compression loss or faulty injector action.

Some of the more common conditions that might interrupt continuous operation, and their corrections, are listed in the charts in this section.

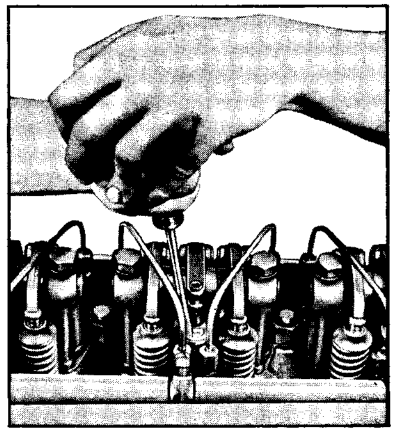


Fig. 1—Locating a Misfiring Cylinder.

LOCATING A MISFIRING CYLINDER

If the cutting-out of a cylinder is suspected, the following procedure will lead quickly to the discovery of the faulty cylinder.

(a) Remove valve cover.

(b) Start engine and run it at idle speed.

(c) Check exhaust valve clearance on all cylinders with engine hot. Clearance should be .009".

(d) Hold the No. 1 injector plunger down with a screwdriver (see Fig. 1) thus preventing operation of the injector.

This is similar to short-circuiting a spark plug of a gasoline engine. If the cylinder is misfiring there will be no noticeable difference in the sound and operation of the engine. If the cylinder has been firing properly, there will be a noticeable difference in the sound and operation when the injector is cut out.

(e) If cylinder No. 1 is firing properly, repeat the above procedure successively on all other cylinders until the faulty one has been located.

(f) If the valve springs and other valve and injector operating mechanism in the faulty cylinder are satisfactory, remove the fuel injector (see Fig. 2) and install a new one as outlined under "Injector Service" in Sec. 2.

(g) If the installation of the new injector does not eliminate the misfiring, the compression pressure of the cylinder in question should be checked. This may be done with Tool J 1319-A, as illustrated in Fig. 3.

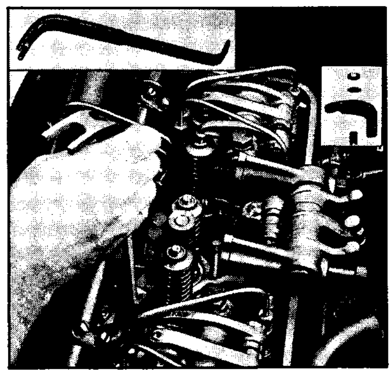


Fig. 2—Removing an Injector.

CHECKING COMPRESSION PRESSURE

(a) Remove valve rocker cover.

(b) Start at No. 1 cylinder and remove fuel lines from both the injector and the fuel connectors.

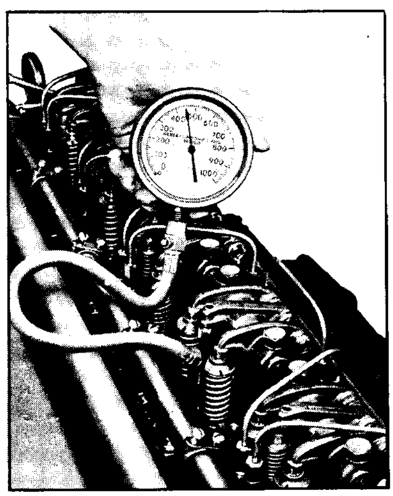


Fig. 3—Checking Compression Pressure.

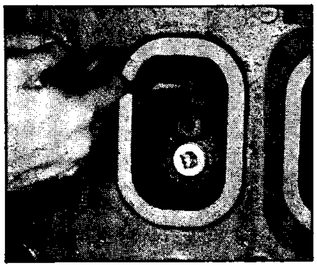


Fig. 4—Inspecting for Broken Piston Rings Through Cylinder Liner Air Ports.

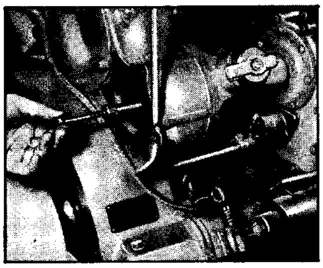


Fig. 5—Inspecting for Broken Blower Drive Shaft.

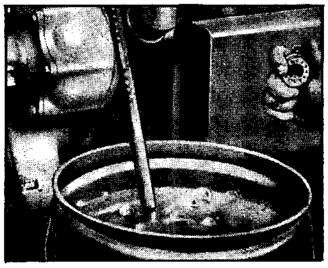


Fig. 6—Checking for Air in Fuel System.

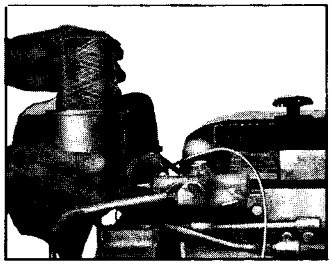


Fig. 7—Changing Fuel Filter Element.

(c) Remove the injector from No. 1 cylinder (see "Injector Service" in Sec. 2) and install the pressure gauge adapter in its place, in the same manner as when installing an injector (see Fig. 3).

(d) Use one of the two fuel lines as a "jumper" connection between the fuel inlet and the return manifold connectors. This will permit fuel from the inlet manifold to flow directly to the return manifold.

(e) Start the engine and run it at approximately 600 r.p.m. During this operation, take readings on the compression pressure gauge.

Do not turn the crankshaft with the cranking motor in obtaining the compression pressures.

(f) Perform this same operation on each cylinder in turn. The compression pressure in any one cylinder should be not less than 400 lbs./sq. in. (at 600 r.p.m.): in addition, the variation in compression pressures between cylinders of the engine **MUST NOT EXCEED** 25 p.s.i. at approximately 600 engine r.p.m. For example:

If the compression pressure readings of an engine were as shown in the following table, it would be evident that No. 3 cylinder should be examined and

Cylinder	Gauge Reading
1	445 p.s.i.
2	440 p.s.i.
3	405 p.s.i.
4	435 p.s.i.
5	450 p.s.i.
6	445 p.s.i.

the cause of the low compression pressure determined and eliminated.

Note that all of the cylinder pressures are above the low limit for satisfactory operation of the engine. Nevertheless, the No. 3 cylinder compression pressure indicates that something unusual has occurred and that a localized pressure leak has developed. Therefore, the cause should be determined and corrective measures taken.

Low cylinder pressures may result from any one of several causes; namely,

1. Piston rings may be stuck or broken. To determine the condition of these rings, inspect them as shown in Fig. 4.
2. Air may be leaking past the cylinder head gasket or the valve seats.
3. Valve stems may be sticking in the valve guides.

To correct any of these conditions, consult your authorized Detroit Diesel Engine Division Dealer or Distributor to obtain the necessary service.

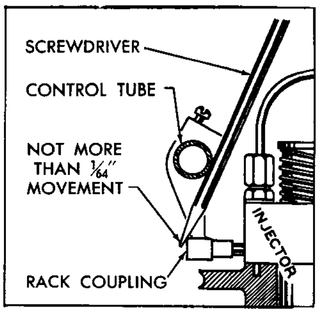


Fig. 8—Injector Rack in Full Throttle Position.

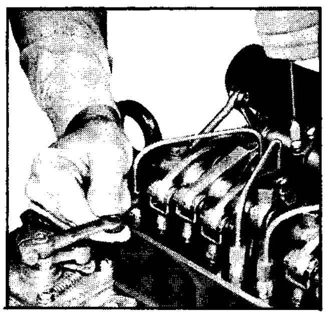


Fig. 9—Removing Bind From Injector Rack.

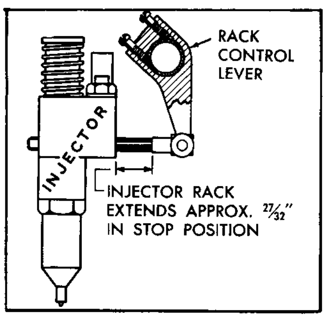


Fig. 10—Rack Stop Position.

Fig. 11—Cleaning Air Box Drains.

1

HARD STARTING

CHECK FOR

LOW STARTING RPM

- IMPROPER LUBE OIL VISCOSITY GRADE.
- LOW BATTERY OUTPUT.
  - A. POOR OR SHORTED CONNECTIONS.
  - B. UNDERCHARGED OR DEFECTIVE BATTERY.
  - C. LOW AMBIENT TEMPERATURE.
- FAULTY STARTER OR LOOSE STARTER CONNECTIONS.

LOW COMPRESSION

- EXHAUST VALVES STICKING OR BURNED.
- COMPRESSION RINGS WORN OR BROKEN.
- CYLINDER HEAD GASKET LEAKING.
- IMPROPER VALVE CLEARANCE ADJUSTMENT
- BLOWER NOT FUNCTIONING.

NO FUEL

- DIFFICULTIES LISTED ON "NO FUEL OR INSUFFICIENT FUEL" CHART.
  - A. AIR LEAKS.
  - B. FLOW OBSTRUCTION.
  - C. FUEL PUMP.
  - D. FAULTY INSTALLATION.
- INJECTOR RACKS NOT IN FULL FUEL POSITION.

INOPERATIVE AIR HEATER AT LOW AMBIENT TEMPERATURES

- NO SPARK.
  - A. POOR OR SHORTED CONNECTIONS.
  - B. COIL DEFECTIVE OR POINTS INOPERATIVE.
  - C. CRACKED PORCELAIN.
  - D. INOPERATIVE OR IMPROPERLY ADJUSTED PRESSURE SWITCH.
- NO. FUEL.
  - A. DEFECTIVE PUMP.
  - B. PLUGGED SPRAY NOZZLE OR FILTER.
  - C. AIR LEAK IN PUMP SUCTION LINE.
  - D. VALVE CLOSED IN PUMP SUCTION LINE.
  - E. DIRT IN PUMP VALVES.
  - F. TEMPERATURE LESS THAN 10° ABOVE POUR POINT OF FUEL.
  - G. FAULTY INSTALLATION.
- IMPROPER OPERATION OF AIR HEATER OR STARTING AID—OPERATE ACCORDING TO INSTRUCTIONS.

2

NO FUEL OR INSUFFICIENT FUEL

CHECK FOR

ADEQUATE FUEL SUPPLY

AIR LEAKS

- A. LOW FUEL SUPPLY.
- B. LOOSE CONNECTIONS OR CRACKED LINES BETWEEN FUEL PUMP AND TANK OR SUCTION LINE IN TANK.
- C. DAMAGED FUEL STRAINER GASKET.
- D. AIR HEATER FUEL SYSTEM.
- E. FAULTY INJECTOR TIP ASSY. (CHECK BY SUBMERGING END OF FUEL RETURN LINE IN CONTAINER OF FUEL AND NOTING IF AIR BUBBLES ARE PRESENT)

FLOW OBSTRUCTION

- FUEL FILTER OR LINES RESTRICTED
  - A. FUEL STRAINER.
  - B. FUEL FILTER.
  - C. INJECTOR FUEL FILTERS.
  - D. OBSTRUCTION IN LINES. (CHECK ABOVE ITEMS BY DISCONNECTING FUEL RETURN LINE AND NOTING RATE OF FLOW—SHOULD BE APPROX. ½ GAL. PER MIN. AT 1200 RPM) REPLACE FILTER ELEMENT AND IF PRESSURE DOES NOT BECOME NORMAL THEN CLEAN OR REPLACE STRAINER ELEMENT. IF LOW PRESSURE PREVAILS CHECK FUEL LINES.
- TEMPERATURE LESS THAN 10° ABOVE THE POUR POINT OF THE FUEL.

FAULTY FUEL PUMP

- RELIEF VALVE NOT SEATING.
- WORN OR SCORED VANES, GEARS, OR HOUSING.
- FUEL PUMP NOT ROTATING.

FAULTY INSTALLATION

- FUEL PUMP SUCTION LIFT TOO GREAT. (SHOULD BE LESS THAN 48")
- DIAMETER OF FUEL SUCTION LINES TOO SMALL.
- RESTRICTED FITTING MISSING FROM RETURN MANIFOLD. (CHECK PRESSURE)
- INOPERATIVE FUEL INLET LINE CHECK VALVE. (WHEN USED)

3

LOW OIL PRESSURE

CHECK FOR

CHECKS TO BE MADE WITH ENGINE WATER OUTLET TEMPERATURE OF 165° F. MINIMUM

- **LUBE OIL**
  - SUCTION LOSS DUE TO LOW OIL LEVEL OR EXCESSIVE INSTALLATION ANGLE.
  - LUBE OIL VISCOSITY.
    A. NOT ACCORDING TO RECOMMENDATIONS.
    B. OIL BY-PASSING COOLER.
  - LOW VISCOSITY. (AS RESULT OF DILUTION) CHECK FOR PRESENCE OF FUEL OIL IN LUBE OIL. FUEL ODOR CAN BE EASILY IDENTIFIED. IF FUEL IS PRESENT CHECK FOLLOWING ITEMS FOR LEAKS THEN REPLACE LUBE OIL.
    A. INJECTOR SEAL RING.
    B. FUEL INLET AND OUTLET PIPES (JUMPER LINES).
    C. FUEL MANIFOLD CONNECTORS.
- **PRESSURE GAGE**
  - A. FAULTY GAGE.
    B. GAGE LINE OBSTRUCTION.
    C. ORIFICE PLUGGED. (CHECK ABOVE ITEMS BY CONNECTING NEW GAGE IN MAIN OIL GALLERY OF CYLINDER BLOCK)
    D. ON ELECTRICAL PANELS, CHECK FOR FAULTY SENDING UNITS.
- **CIRCULATION**
  - STRAINER CLOGGED.
  - COOLER CLOGGED.
  - COOLER BY-PASS VALVE NOT FUNCTIONING PROPERLY.
  - PRESSURE REGULATOR VALVE NOT FUNCTIONING PROPERLY.
  - EXCESSIVE WEAR OF CRANKSHAFT BEARINGS.
  - GALLERY, CRANKSHAFT OR CAMSHAFT PLUGS MISSING.
- **OIL PUMP**
  - INTAKE SCREEN PARTIALLY CLOGGED.
  - RELIEF VALVE NOT FUNCTIONING PROPERLY.
  - AIR LEAK IN PUMP INLET SYSTEM.
  - PUMP WORN OR DAMAGED.
  - FLANGE LEAK PRESSURE SIDE.

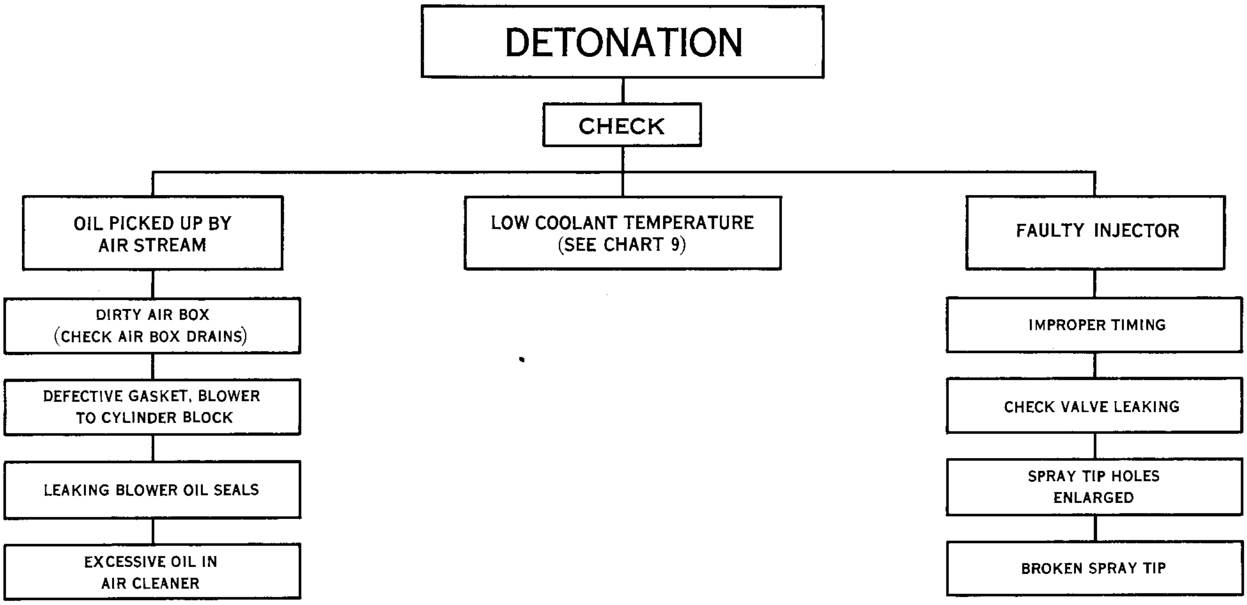
4

UNEVEN RUNNING OR FREQUENT STALLING

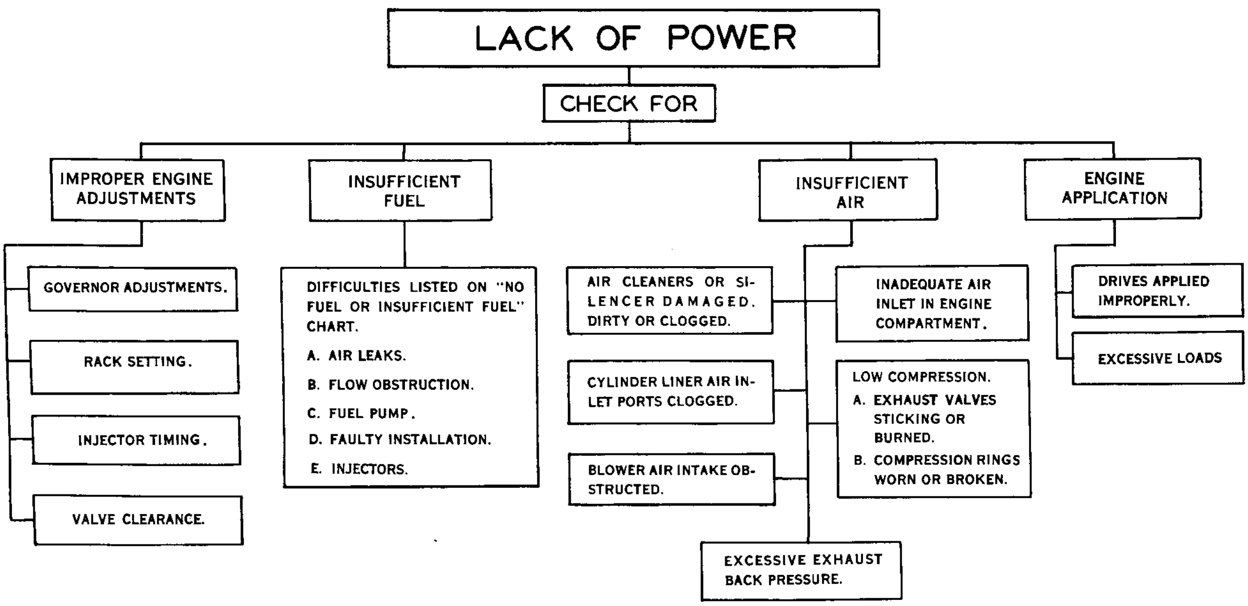
CHECK THE

- **COOLING SYSTEM**
  - COOLANT TEMPERATURE BELOW NORMAL. (SEE CHART 9).
- **FUEL SYSTEM**
  - NO FUEL OR INSUFFICIENT FUEL. (SEE CHART 2).
  - INJECTORS
    A. IMPROPER TIMING.
    B. INCORRECT RACK SETTINGS.
    C. LEAKY SPRAY TIPS.
- **CYLINDER PRESSURES**
  - LOW COMPRESSION. (SEE CHART 1).
  - INJECTOR SPRAY TIPS LEAKING.
- **GOVERNOR**
  - INSTABILITY (HUNTING).
    A. BINDING RACK.
    B. FAULTY ADJUSTMENTS.

5


DETONATION
CHECK
OIL PICKED UP BY AIR STREAM
LOW COOLANT TEMPERATURE (SEE CHART 9)
FAULTY INJECTOR
DIRTY AIR BOX (CHECK AIR BOX DRAINS)
DEFECTIVE GASKET, BLOWER TO CYLINDER BLOCK
LEAKING BLOWER OIL SEALS
EXCESSIVE OIL IN AIR CLEANER
IMPROPER TIMING
CHECK VALVE LEAKING
SPRAY TIP HOLES ENLARGED
BROKEN SPRAY TIP

6


LACK OF POWER
CHECK FOR
IMPROPER ENGINE ADJUSTMENTS
INSUFFICIENT FUEL
INSUFFICIENT AIR
ENGINE APPLICATION
GOVERNOR ADJUSTMENTS.
RACK SETTING.
INJECTOR TIMING.
VALVE CLEARANCE.
DIFFICULTIES LISTED ON "NO FUEL OR INSUFFICIENT FUEL" CHART.
A. AIR LEAKS.
B. FLOW OBSTRUCTION.
C. FUEL PUMP.
D. FAULTY INSTALLATION.
E. INJECTORS.
AIR CLEANERS OR SILENCER DAMAGED, DIRTY OR CLOGGED.
CYLINDER LINER AIR INLET PORTS CLOGGED.
BLOWER AIR INTAKE OBSTRUCTED.
INADEQUATE AIR INLET IN ENGINE COMPARTMENT.
LOW COMPRESSION.
A. EXHAUST VALVES STICKING OR BURNED.
B. COMPRESSION RINGS WORN OR BROKEN.
EXCESSIVE EXHAUST BACK PRESSURE.
DRIVES APPLIED IMPROPERLY.
EXCESSIVE LOADS

7

EXHAUST SMOKE ANALYSIS

CHECK FOR

CHECKS TO BE MADE WITH ENGINE WATER OUTLET TEMPERATURE OF 165° F. MINIMUM

- **BLACK OR GRAY** — INCOMPLETELY BURNED FUEL
  - INSUFFICIENT COMBUSTION AIR.
    - HIGH EXHAUST BACK PRESSURE.
      - A. MEASURE WITH MANOMETER.
      - B. REMOVE MUFFLER.
      - C. REMOVE MANIFOLD.
    - RESTRICTED AIR INLET.
      - A. CYLINDER LINER PORTS CLOGGED.
      - B. AIR CLEANERS OR SILENCER CLOGGED BY DIRT OR DAMAGED.
      - C. EMERGENCY STOP NOT COMPLETELY OPEN OR RESTRICTED SCREEN.
      - D. INSPECT ENGINE ROOM FOR ADEQUATE AIR INLET.
  - EXCESS FUEL OR IRREGULAR FUEL DISTRIBUTION.
    - IMPROPER SETTING OF INJECTOR RACKS.
    - IMPROPER TIMING OF INJECTORS.
    - FAULTY INJECTORS.
      - A. POP INDIVIDUAL INJECTORS WITH ENGINE STOPPED.
      - B. CUT OUT INDIVIDUAL INJECTORS WITH ENGINE RUNNING.
    - LUGGING ENGINE.
  - IMPROPER GRADE OF FUEL.
    - HEAVY FUEL DOES NOT COMPLETELY VAPORIZE. (IF SMOKE IS PRESENT WHILE WARMING UP AND IS OBJECTIONABLE, USE OF LIGHTER FUEL IS INDICATED)—RUN ENGINE ON NO. 1 FUEL OIL OR KEROSENE AND OBSERVE EXHAUST.
- **BLUE** — FUEL OR LUBE OIL NOT BURNED IN CYLINDER. (BLOWN THROUGH CYLINDER DURING SCAVENGING PERIOD)
  - INTERNAL FUEL OR LUBE OIL LEAKS.
    - A. FOLLOW CHART ON HIGH OIL CONSUMPTION.
    - B. AIR HEATER LEAKING FUEL.
  - PULLOVER OF LUBE OIL FROM AIR CLEANER—CHECK OIL LEVEL IN CLEANER.
- **WHITE** — MIS-FIRING CYLINDERS
  - FAULTY INJECTORS.
    - A. POP INDIVIDUAL INJECTORS WITH ENGINE STOPPED.
    - B. CUT OUT INDIVIDUAL INJECTORS WITH ENGINE RUNNING.
  - LOW COMPRESSION.
  - LOW CETANE FUEL. RUN ENGINE ON NO. 1 FUEL OR KEROSENE.

8

EXCESSIVE CRANKCASE PRESSURE

CHECK FOR

- **CYLINDER BLOW-BY**
  - CYLINDER HEAD GASKET LEAKING.
  - PISTON OR LINER DAMAGED.
  - PISTON RINGS WORN OR BROKEN.
- **BREATHER RESTRICTION**
  - OBSTRUCTION OR DAMAGE TO BREATHER.
- **AIR FROM BLOWER OR AIR BOX**
  - DAMAGED BLOWER-TO-BLOCK GASKET
  - ENGINE BLOCK END PLATE GASKETS LEAKING
- **EXCESSIVE EXHAUST BACK PRESSURE**
  - EXCESSIVE MUFFLER RESISTANCE.
  - OBSTRUCTION IN MUFFLER
  - EXHAUST PIPING.
    - A. TOO SMALL IN DIAMETER.
    - B. TOO LONG.
    - C. EXCESSIVE NUMBER OF BENDS.
    - D. USE OF STREET ELBOWS INSTEAD OF PIPE ELBOWS.

9

ABNORMAL ENGINE COOLANT TEMPERATURES

CHECK FOR

- **ABOVE NORMAL**
  - **INSUFFICIENT HEAT TRANSFER**
    - SCALE OR DEPOSITS IN SYSTEM.
      A. FRESH WATER SYSTEM.
      B. RAW WATER SIDE OF HEAT EXCHANGER OR KEEL COOLER.
    - RADIATOR OPENINGS CLOGGED PREVENTING NORMAL AIR FLOW.
    - FAN BELT LOOSE REDUCING AIR FLOW.
    - IMPROPER INSTALLATION.
      A. RECIRCULATION OF AIR CAUSED BY IMPROPER FAN SHROUDING.
      B. SURROUNDING AIR TEMPERATURE TOO HIGH. (RADIATOR UNIT) RAW WATER TEMPERATURE TOO HIGH. (HEAT EXCHANGER UNIT)
      C. KEEL COOLER INADEQUATE.
      D. INSUFFICIENT RADIATOR OR HEAT EXCHANGER AREA.
  - **CIRCULATION**
    - **FRESH WATER**
      - LOW COOLANT LEVEL.
      - HOSES COLLAPSED OR DISINTEGRATED.
      - THERMOSTAT DAMAGED.
      - WATER PUMP IMPELLER LOOSE ON SHAFT.
      - INADEQUATE WATER SUPPLY ON SUCTION SIDE OF PUMP.
        A. RADIATOR CLOGGED.
        B. KEEL COOLER INADEQUATE OR CLOGGED.
        C. COMBUSTION GASES IN COOLING WATER.
        INJECTOR TUBE SEAL LEAKING.
        CYLINDER HEAD GASKET LEAKING.
        D. AIR IN COOLING WATER.
        AIR LEAK ON SUCTION SIDE OF PUMP.
        THERMOSTAT HOUSING VENT VALVE NOT OPEN WHEN FILLING SYSTEM.
    - **RAW WATER**
      - HEAT EXCHANGER CLOGGED.
      - PUMP IMPELLER DAMAGED.
      - INLET RESTRICTED.
      - AIR LEAK ON SUCTION SIDE.
- **BELOW NORMAL**
  - **CIRCULATION**
    - A. THERMOSTAT HOUSING VENT VALVE OPEN OR NOT SEATING.
      B. THERMOSTAT INOPERATIVE.
      C. THERMOSTAT SEAL DAMAGED.
      (OUTDOOR OPERATION IN COLD CLIMATES, ESPECIALLY DURING LONG IDLING PERIODS, REQUIRES USE OF ENGINE HOODS, AND RADIATOR SHUTTERS)

10

HIGH LUBE OIL CONSUMPTION

CHECK FOR

- **EXTERNAL LEAKS**
  - OIL LINES AND CONNECTIONS.
    GASKET OR OIL SEAL LEAKS.
    HIGH CRANKCASE PRESSURE CONTRIBUTES TO EXTERNAL LEAKS (SEE CHART 8).
    IF EXCESS LUBE OIL IS FOUND AT AIR BOX DRAINS CHECK "INTERNAL LEAKS"—OR INSTALLATION ANGLE.
- **INTERNAL LEAKS**
  - BLOWER OIL SEAL LEAKING.
  - OIL COOLER CORE LEAKING.
  - CYLINDER BLOCK END PLATE GASKETS LEAKING.
- **OIL CONTROL AT CYLINDER**
  - OIL CONTROL RINGS WORN, BROKEN, OR IMPROPERLY INSTALLED.
  - PISTON PIN RETAINER LOOSE.
  - SCORED LINERS, PISTONS OR OIL RINGS.
  - PISTON AND ROD ALIGNMENT. (WORN CRANKSHAFT THRUST WASHERS)
  - EXCESSIVE INSTALLATION ANGLE.

CHECKING ELECTRICAL STARTING SYSTEM

GROUNDED SYSTEM

The following **quick checks** can be made to determine whether or not the units in the electrical starting system are operating properly. If not, the checks will indicate whether the generator or regulator is at fault, then precise corrective measures may be taken.

CASE No. 1—A Fully Charged Battery and Low Charging Rate Indicates normal voltage regulator operation.

To check the current regulator:

1. Use the cranking motor for about 15 seconds with the engine throttle set in the NO FUEL position.

2. With the engine running at a medium speed, note quickly charging rate on ammeter. This is the output value for which the current regulator is set.

3. Allow the engine to continue running. As soon as the generator has restored the battery power consumed in cranking, the voltage regulator (if operating normally) will gradually decrease the output to a few amperes.

CASE No. 2—A Fully Charged Battery and a High Charging Rate. It must be remembered in analyzing trouble of this nature that the charging rate at any given voltage depends as much on battery temperature as on battery specific gravity. The charging rate to a fully charged **hot** battery may be greater than that obtained with a cool battery which has a fairly low specific gravity. If, considering the battery temperature and specific gravity, the charging rate is excessive, refer to Fig. 12 and proceed as follows to determine the cause:

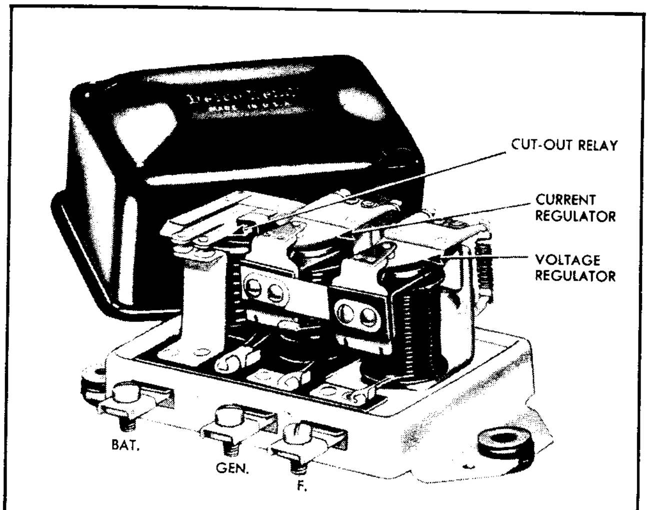


Fig. 12—Current and Voltage Regulator Assembly.

1. Disconnect the field "F" terminal lead from the regulator. This opens the generator field circuit and the output should normally drop off. If it does not, the generator field circuit is grounded either internally or in the external wiring.

2. If the output drops to zero with the "F" terminal lead disconnected, the trouble has been isolated in the regulator.

3. Reconnect the "F" terminal lead, remove the regulator cover (3), Fig. 13, and depress the voltage regulator armature (12) manually to open the points.

4. If the output now drops off, the voltage regulator unit has been failing to reduce the output as the battery came up to charge, and the necessity for voltage regulator adjustment is indicated.

5. If separating the voltage regulator contacts does not cause the output to drop off, inspect the field circuit within the regulator for shorts.

   Give particular attention to the bushings (19) and insulators (17) under the contact point supports of the two regulator units, and make sure the insulators are correctly assembled.

CASE No. 3 – A Low Battery and a Low or No Charging Rate.

1. Check the circuit for loose connections, and for frayed or damaged wires. High resistance resulting from these conditions will prevent a normal charge from reaching the battery. If the wiring is in good condition, then either the regulator or generator is at fault.

2. Temporarily ground the "F" terminal of the regulator and increase the generator speed to determine which unit needs attention. **Use care to avoid excessive speed, since under these conditions the generator may produce a dangerously high output.**

3. If the output does increase, the regulator needs

attention. Check for dirty or oxidized contact points, or for a low voltage setting.

4. If the generator output remains at a few amperes with the "F" terminal grounded, the generator is at fault and should be checked further.

5. If the generator does not show any output at all (either with or without the "F" terminal grounded) **very quickly** disconnect the lead from the "GEN" terminal of the regulator and strike it against a convenient ground while the generator is operating at a medium speed. If there is no sparking at the lead, the trouble has now been definitely isolated in the generator. If no sparking occurs, (although the generator output may build up) the cutout relay is not operating to permit the current to flow to the battery. This relay failure may be caused by burned points, failure of points to close, open shunt winding, ground high-voltage setting, or other reasons. **Do not operate the generator with the "GEN" terminal lead disconnected** for any length of time, since this is "open circuit" operation and the units will be damaged.

CAUTION: A burned resistance unit, regulator winding or fused contacts can result only from OPEN CIRCUIT OPERATION, or extreme resistance in the charging circuit. When these conditions exist, check all wiring before reinstalling regulator.

Do not run or test generator on open circuit. To do so will destroy regulator or generator.

If it is necessary to remove the batteries while the engine is operating and the generator is turning, the field terminal on the generator must be disconnected to safeguard generator and regulator against burning out.

INSULATED SYSTEM

The following **quick checks** can be made to determine whether or not the units in the electrical system are operating properly. If not, the checks will indicate whether the generator or regulator is at fault; then proper corrective measures may be taken.

CASE No. 1 — A Fully Charged Battery and Low Charging Rate, (Indicates Normal Voltage Regulator Operation).

To check the current regulator:

1. Use the cranking motor for about 15 seconds with the engine throttle set in the NO FUEL position.

2. With the engine running at a medium speed, note quickly the charging rate on ammeter. This is the value for which the current regulator is set.

3. Allow the engine to continue running. As soon as the generator has restored the battery power consumed in cranking, the voltage regulator, if operating normally, will gradually decrease the output to a few amperes.

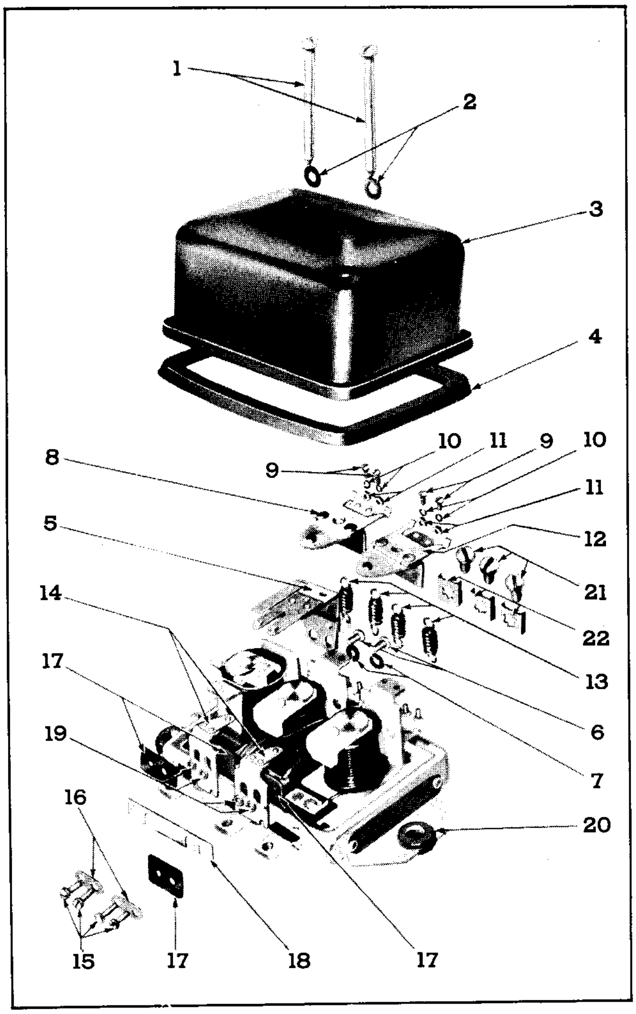


Fig. 13—Typical Current and Voltage Regulator Details and Relative Location of Parts.

1. Cover Screw.
2. Washer.
3. Regulator Cover.
4. Cover Gasket.
5. Relay Armature.
6. Armature Screw.
7. Lockwasher.
8. Current Regulator Armature.
9. Armature Screw.
10. Lockwasher.
11. Nut.
12. Voltage Regulator Armature.
13. Armature Spring.
14. Contact Point and Support.
15. Screw.
16. Lockwasher.
17. Insulated Washer.
18. Connector Strap.
19. Insulated Bushing.
20. Base Grommet.
21. Terminal Screw.
22. Terminal Clamp.

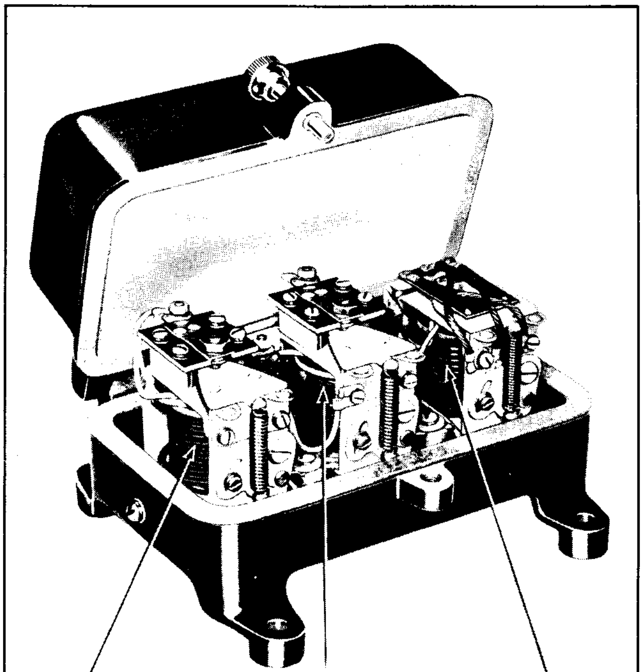


Fig. 14—Delco-Remy Heavy-Duty Three-Unit Regulator with Hinge Cover.

CASE No. 2—A Fully Charged Battery and a High Charging Rate. This indicates that the voltage regulator is not reducing the generator output as it should. A high charging rate to a fully charged battery will damage the battery and the accompanying high voltage is very injurious to all electrical equipment.

This operating condition may result from:

1. Improper voltage regulator setting.
2. Defective voltage regulator unit.
3. Short circuit between the charging circuit and field circuit, either in the generator, regulator or wiring.
4. High temperature which reduces the resistance of the battery to an electrical charge. Under this condition the battery will accept a high charging rate even though the voltage regulator setting is normal.

If the trouble is not attributable to high temperatures, determine the cause by disconnecting the lead from the regulator field terminal while the generator is operating at medium speed. If the output remains high, the generator is at fault. If the output drops off, the regulator is at fault and it should be inspected for high setting or short circuits.

CASE No. 3—A Low Battery and a Low or No Charging Rate. This condition could be due to loose connections, frayed or damaged wires, low regulator setting, oxidized regulator contact points, or defects within the generator. If the condition is not caused by loose connections, frayed or damaged wires, proceed as follows to locate the reason for the trouble.

To determine whether the generator or the regulator is at fault, bridge the regulator armature and field terminals momentarily with a jumper lead while the generator is operating at medium speed. If the output does not increase, the generator is probably at fault.

If the generator output increases, the trouble is caused by:

1. A low voltage (or current) regulator setting.
2. Oxidized regulator contact points which increase the resistance in the generator field circuit; this results in a low regulator output.
3. Open generator field circuit (within the regulator) either at the connections or in the regulator windings.

STORAGE CHART

When an engine is to be stored or removed from operation for an extended period of time, special precautions should be taken to protect the engine against rust accumulations, corrosion on the wiring, and gumming in the fuel system. The parts requiring attention and the recommended preparations to use are shown in the chart below.

PREPARATION OF UNITS FOR STORAGE

All units not intended for immediate use must receive special treatment. The purpose of this treatment is to protect interior and exterior engine and transmission surfaces against rusting or corrosion, and to prevent sticking of moving parts due to formation of gummy fuel and oil oxidation products.

TEMPORARY (30 DAYS OR LESS)			INDEFINITE (30 DAYS OR MORE)	
SPECIFICATIONS	REMARKS		SPECIFICATIONS	REMARKS
Lube Oil (see Sec. 4)	1. Drain crankcase. 2. Fill crankcase with new lube oil.	LUBRICATION SYSTEM	Lube Oil (see Sec. 4)	1. Drainn crankcase. 2. Renew lube oil filter element. 3. Fill crankcase with new lube oil. NOTE: Do not use any special rust proofing oils, solvents, or flushing oils in crankcase.
Lube Oil (see Sec. 4)	1. Drain gear box. 2. Flush out gear box with fuel oil. 3. Fill gear box with new lube oil.	GEAR BOXES	Lube Oil (see Sec. 4)	1. Drain gear box. 2. Flush out gear box with fuel oil. 3. Fill gear box with new lube oil.
High-Speed Short Fiber Ball Bearing Grease	Lubricate through fitting at rear of clutch housing with grease gun. Force just enough grease into the bearing to cause a small collar of to form around the seal when shaft is rotated.	POWER TAKE-OFF MAIN BEARING	High-Speed Short Fiber Ball Bearing Grease	Lubricate through fitting at rear of clutch housing with grease gun. Force just enough grease into the bearing to cause a small collar of grease to form around the seal when shaft is rotated.
High-Speed Short Fiber Ball Bearing Grease	Lubricate through the fitting in clutch housing nearest to engine with grease gun. Lubricate sparingly to avoid grease spilling onto clutch facings.	POWER TAKE-OFF CLUTCH RELEASE SLEEVE BEARING	High-Speed Short Fiber Ball Bearing Grease	Lubricate through the fitting in clutch housing nearest to engine with grease gun. Lubricate sparingly to avoid grease spilling onto clutch facings.
Fuel Oil (see Sec. 4)	Fill fuel tank. Operate engine for 2 minutes at 1200 r.p.m., no load. NOTE: Do not drain fuel system nor crankcase after this run.	FUEL SYSTEM	Good Grade of Rust Preventive for fuel system	1. Drain fuel tank completely. 2. Pour 3 gallons of good grade rust preventive into fuel tank. 3. Clean fuel strainer. 4. Renew fuel strainer and filter elements. 5. Run engine for 2 minutes at approximately 600 r.p.m., no load. NOTE: Do not drain fuel tank after this run.
Lube Oil (see Sec. 4)	Check oil level and refill if necessary.	AIR CLEANER	Lube Oil (see Sec. 4)	Drain old oil. Wash clean with fuel oil and blow dry with air. Refill to oil level with new lube oil.
Permanent Type Anti-freeze	If freezing weather is expected during the storage period add permanent type anti-freeze solution to cooling water in proportion. Drain raw water system. Leave drain cocks open.	COOLING SYSTEM		1. Drain all coolant water from system. 2. Drain raw water system. 3. Leave drain cocks and vent valves open. 4. Attach tag showing cooling system to be dry.
	1. Clean entire exterior of engine with fuel oil and wipe or blow dry. 2. Seal all engine openings. The material used for this purpose must not only be waterproof and vaporproof, but also possess sufficient physical strength to resist puncture and damage due to expansion of entrapped air.	ENGINE EXTERIOR	Good Grade of Rust Preventive	1. Clean entire exterior of engine with fuel oil and wipe or blow dry. 2. Protect all exposed ferrous parts with a thin coat of commercial rust preventive. 3. Insert a strip of grease-proof paper approximately 2" wide between each V-belt pulley to prevent rubber from bonding to pulley. 4. Seal all engine openings. The material used for this purpose must not only be waterproof and vaporproof, but also possess sufficient physical strength to resist puncture and damage due to expansion of entrapped air.
		STORAGE BATTERY	Distilled Water	1. Remove battery from engine. 2. Be sure battery is filled with distilled water and is fully charged. 3. Store in a dry place above freezing temperature.
Engines prepared in this manner can be put into service at any time by simply removing the seals at engine openings, checking coolant water, fuel oil, lubricating oil, gear box, and prime raw water pump, if used.			Engines prepared in this manner can be put into service at any time by simply removing the seals at engine openings, filling cooling and fuel systems, checking crankcase, gear box oil levels, and prime raw water pump, if used.	

INSTALLATION

For industrial applications, set the power unit on a solid, level foundation regardless of whether the installation is temporary or permanent. Setting the unit level will avoid distortions in the base, and permit accurate reading of the bayonet oil gauges.

Provide as clean source of air as possible to the engine blower and make sure engine compartment is adequately ventilated.

If possible, mount the exhaust silencer horizontally and provide a drain. Where silencer is mounted vertically, use hood over outlet to prevent water and foreign matter from entering. Make sure exhaust piping is of ample size with the least number of bends to reduce back pressure to a minimum. Exhaust back pressure should not exceed 1.2 pounds/sq. in. or 2.4 inches mercury at 1600 r.p.m. no load, as measured adjacent to the outlet flange of the exhaust manifold.

If fuel supply is remote from and below the power unit, the lift for the fuel oil pump should not exceed forty-eight inches vertical lift with a ⅜ inch suction pipe. A larger suction pipe is necessary where the tank is located several feet away from the engine.

Where fuel supply and water supply are remote from the engine, be sure that pipes are of ample size to prevent restriction and that all joints are leakproof.

ALPHABETICAL INDEX

ALPHABETICAL INDEX—Continued