OPERATORS MANUAL

GM
GENERAL MOTORS
DIESEL POWER

MODEL 3-71 ENGINES

DETROIT DIESEL

Warranty

There are no warranties, expressed or implied, made by Seller on GM Diesel engine units, engines, products, or parts furnished hereunder except as provided in the manufacturer's standard warranty as follows:

"Manufacturer warrants new GM Diesel products (including original equipment placed thereon by the manufacturer except batteries) to be free from defects in material or workmanship under normal use and service. The Manufacturer's obligation under this warranty is limited to making good at its factory any part or parts of such products which shall be returned to it with transportation charges prepaid within six (6) months from date of delivery of said products to the original purchaser, and which its examination shall disclose to its satisfaction to have been thus defective. This warranty is in lieu of all other warranties, expressed or implied, and all other obligations and liabilities on its part, and it neither assumes nor authorizes any person to assume for it any other liability in connection with its products."

This warranty shall not apply to any product which shall have been repaired or altered outside of an authorized Detroit Diesel Engine Division Service Station in any way so as in the judgment of the Manufacturer to affect its stability and reliability nor which has been subject to misuse, negligence or accident.

The Manufacturer reserves the right to make changes in design or add any improvements on its products at any time without incurring any obligations to install same on units previously delivered by it.

DETROIT DIESEL

MODEL
~~SERIES~~ 3-71

OPERATOR'S MANUAL

for

THREE, ~~FOUR, AND SIX~~ CYLINDER

SINGLE ~~AND MULTIPLE~~ ENGINE UNITS

DETROIT DIESEL ENGINE DIVISION
GENERAL MOTORS CORPORATION
DETROIT 28, MICHIGAN

LITHO IN U.S.A.

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FOREWORD

This manual contains instructions on the operation and preventive maintenance of the current General Motors Series 371 Diesel Engines used in 3, ~~4, and 6~~ cylinder single ~~and multiple~~ engine units. This manual does not cover engine repair or overhaul, since 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 3-71 engine and the principles by which it functions.

The operator should familiarize himself thoroughly with the contents of the manual before running an 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.

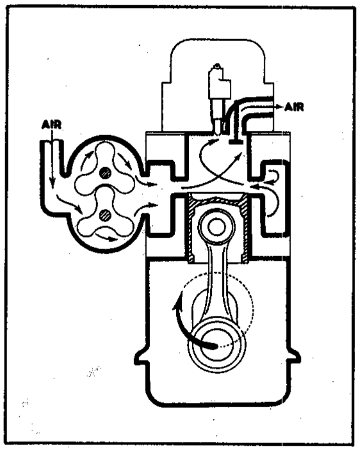

Fig. 1—Scavenging.

A blower is provided to force air into the cylinders for expelling the exhaust gases and to supply the cylinders with fresh air for combustion. The cylinder wall contains a row of ports which are above the piston when it is at the bottom of its stroke. These ports admit air from the blower into the cylinder as soon as the top face of the piston uncovers the ports, as shown in Fig. 1.

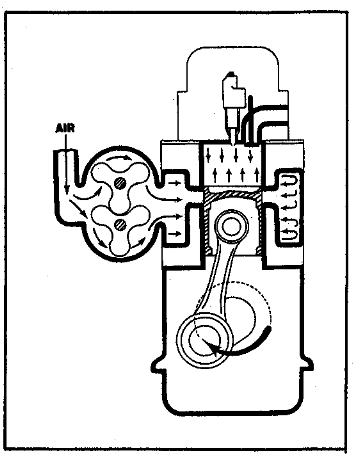

Fig. 2—Compression.

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 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 combustion continues as long as the fuel spray lasts.

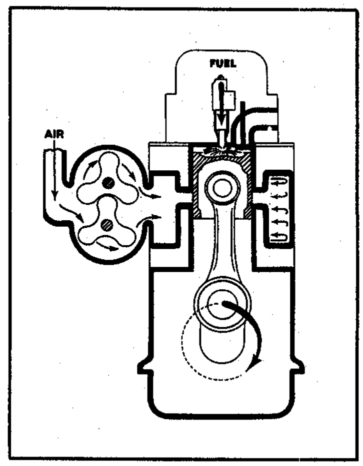

Fig.3—Power.

The resulting pressure forces the piston downward on its power stroke. The exhaust valves are again opened when the piston is about half way down, allowing the burnt gases to escape into the exhaust manifold as shown in Fig. 4. Shortly thereafter, the downward moving piston uncovers the inlet ports and 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, in two strokes; hence the "two-stroke cycle".

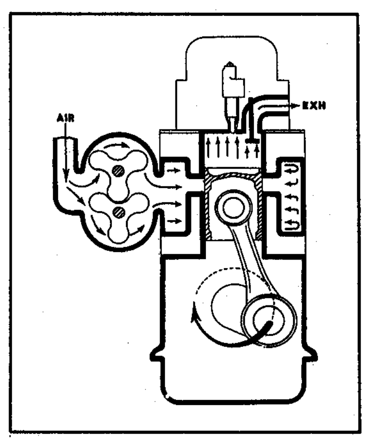

Fig. 4—Exhaust.

GENERAL DESCRIPTION

The two-cycle Diesel engines discussed in this manual 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.

The blower, water pump, governor, and fuel pump form a group of standard accessories which on some models 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 accomplished by having both the cylinder block and cylinder head symmetrical at both ends with respect to each other. These various arrangements are designated by the letters A, B, C, or D in the model number. Letter R (right) or L (left) in the model number designates the direction of rotation.

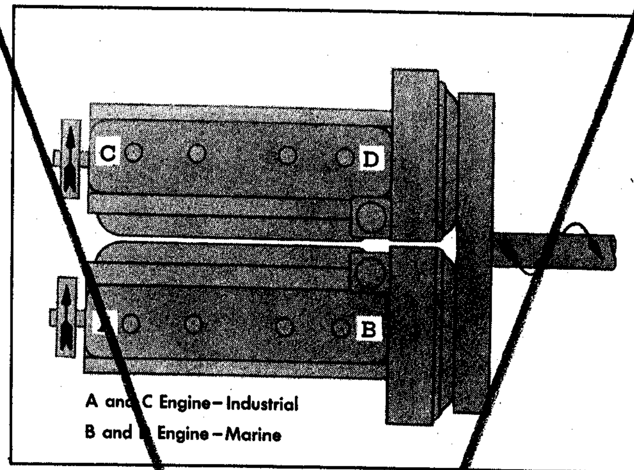

Fig. 5—Typical Twin Engine Unit.

In addition to single engine models, the General Motors Series 71 side-by-side twin, tandem twin, and quad multiple engine power units are designed to deliver increased power to a single drive shaft with important savings in weight and space.

Each basic engine of a multiple engine unit has an individual clutch and throttle so that one or all engines may be used or cut out as desired. Thus, the power output may be varied from idling speed on one engine to full throttle on all engines as the load demands.

A and C engines are used in the twin and quad industrial models and in the tandem marine models. B and D engines are used in the twin and quad marine models.

Left-hand (LH) rotation is obtained at the power drive shaft with the arrangement shown in Figs. 5, 6, and 7. Right-hand (RH) rotation at the power drive shaft is attained by reversing the arrangement of the engines on the base as shown in Fig. 5 and 6.

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

Accessory and Manifold Arrangements as Viewed from the Rear End of Engine.

N.A.

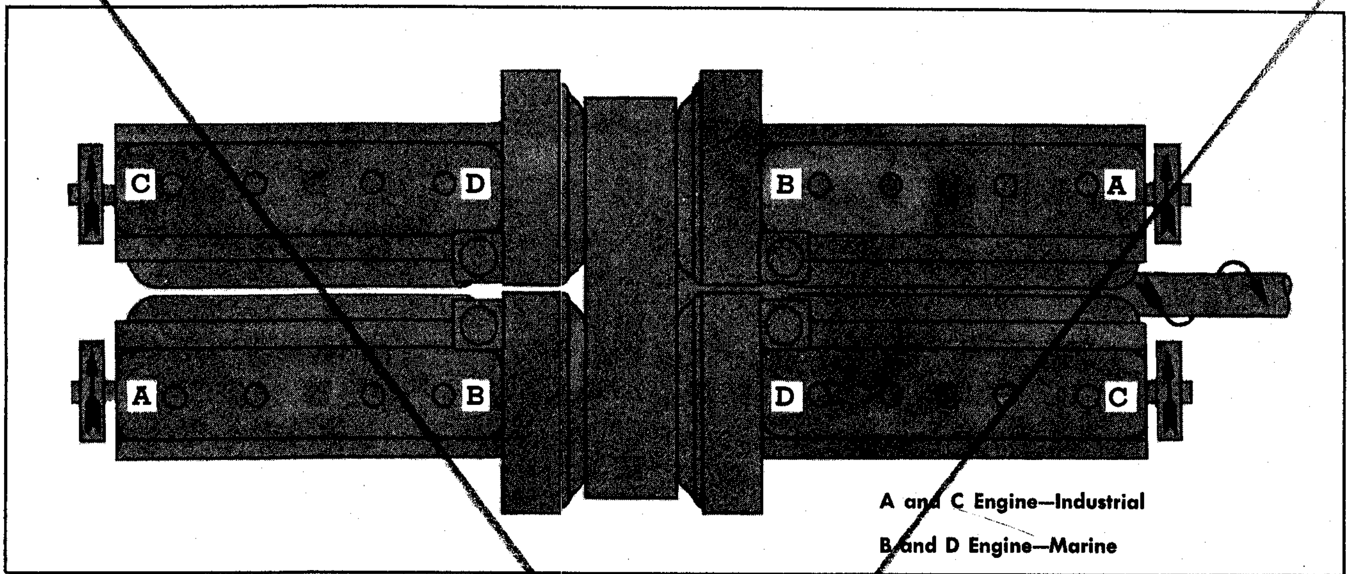

Fig. 6—Typical Quad Engine Unit.

Inclined engines are available in two models (RB and LD) for marine propulsion, each with its own reduction gear and drive shaft.

The tandem twin marine model uses an RA and an LC engine. On starboard models, the drive shaft turns clockwise and on port models the drive shaft turns counterclockwise.

It is very important that the correct model number and reduction ratio be given when contacting a Detroit Diesel Engine Division Dealer or Distributor for service.

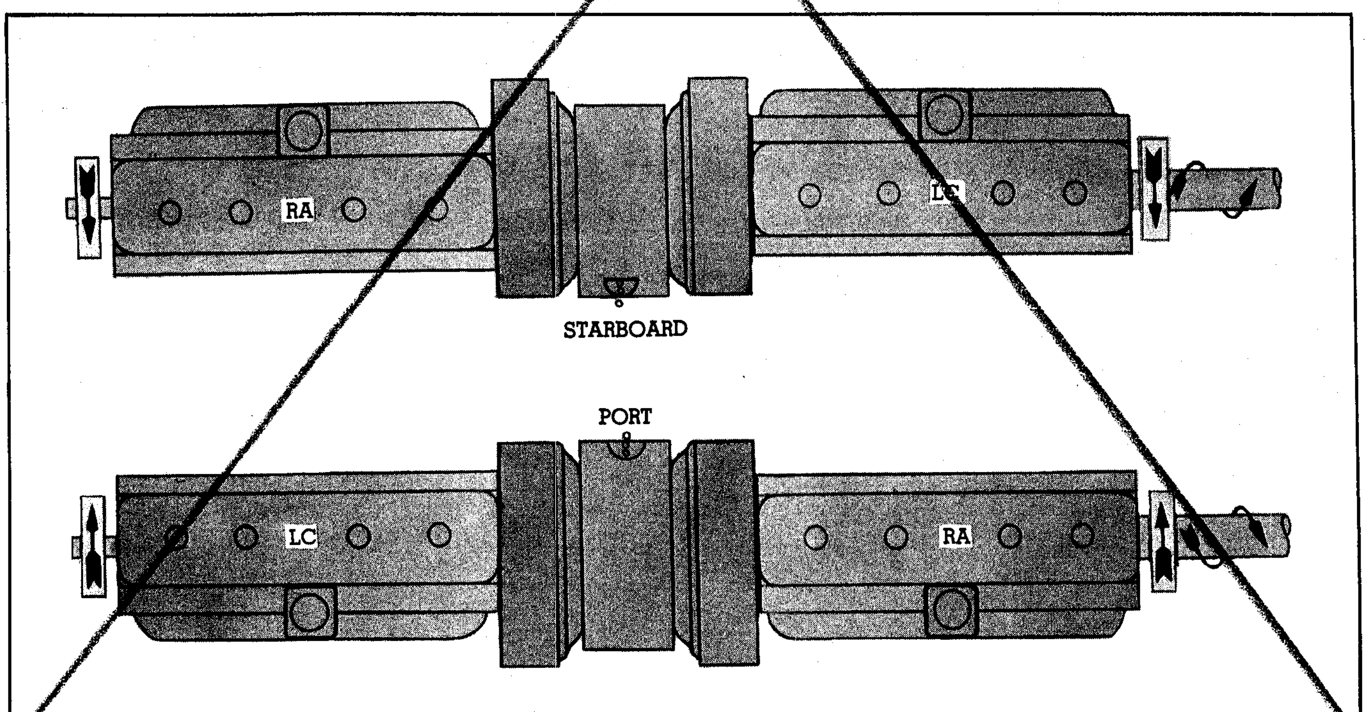

Fig. 7—Typical Tandem Engine Unit.

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)	17 to 1	17 to 1	17 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

MODEL, SERIAL AND UNIT DESIGNATIONS

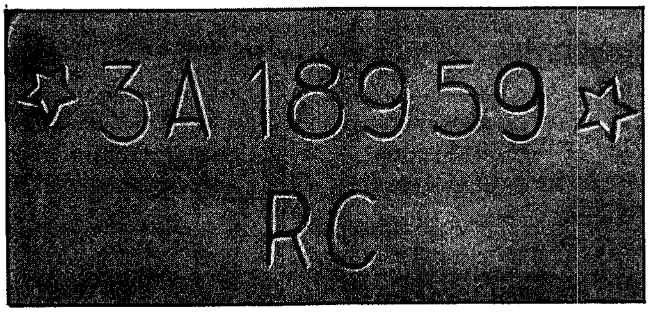

Fig. 8—Typical Unit Number and Model Number As Stamped on Cylinder Block of Single Engine Units.

~~*Fig. 9—Typical Unit Number and Model Number As Stamped on Cylinder Blocks of Multiple Engine Units.*~~

On Series 71 single engine units, the unit serial number, the rotation (R) or (L), and accessory arrangement (A, B, C or D), are stamped on the blower side of the cylinder block at the right hand corner, as shown in Fig. 8. On certain single engine units such as model 6084, the model number is shown rather than rotation and accessory arrangement.

On multiple engine units, the basic unit serial number and model number cover the unit as a whole, however, each individual engine of the unit has a like number with suffix added to indicate rotation and accessory arrangement. For example; unit 12A3536, Fig. 9, would be comprised of two engines, one marked on the cylinder block as 12A3536LA and the other as 12A3536LC. Also shown are the engine model numbers 671LA61 and 671LC61, respectively.

The unit serial number stamped on the cylinder block of each engine is also stamped on the Option and Accessories Plate along with the model number such as 4057C as shown in Fig. 10.

Always give the model and serial number of your engine. This is stamped on the Options and Accessories Plate on the valve rocker cover on your engine; if a type number is shown covering the equipment required, be sure to include this number on your order. All parts orders should be placed with your nearest G. M. Diesel distributor or dealer. Do not place orders directly with the factory.

Power take-off assemblies, torque converters, hydraulic marine gears, etc., may also carry name plates pertaining to the particular assembly to which they are attached.

Fig. 10—Option and Accessories Plate.

LUBRICATING, COOLING, AIR, AND FUEL SYSTEMS AND CONTROLS

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 lubricating oil, water, air 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

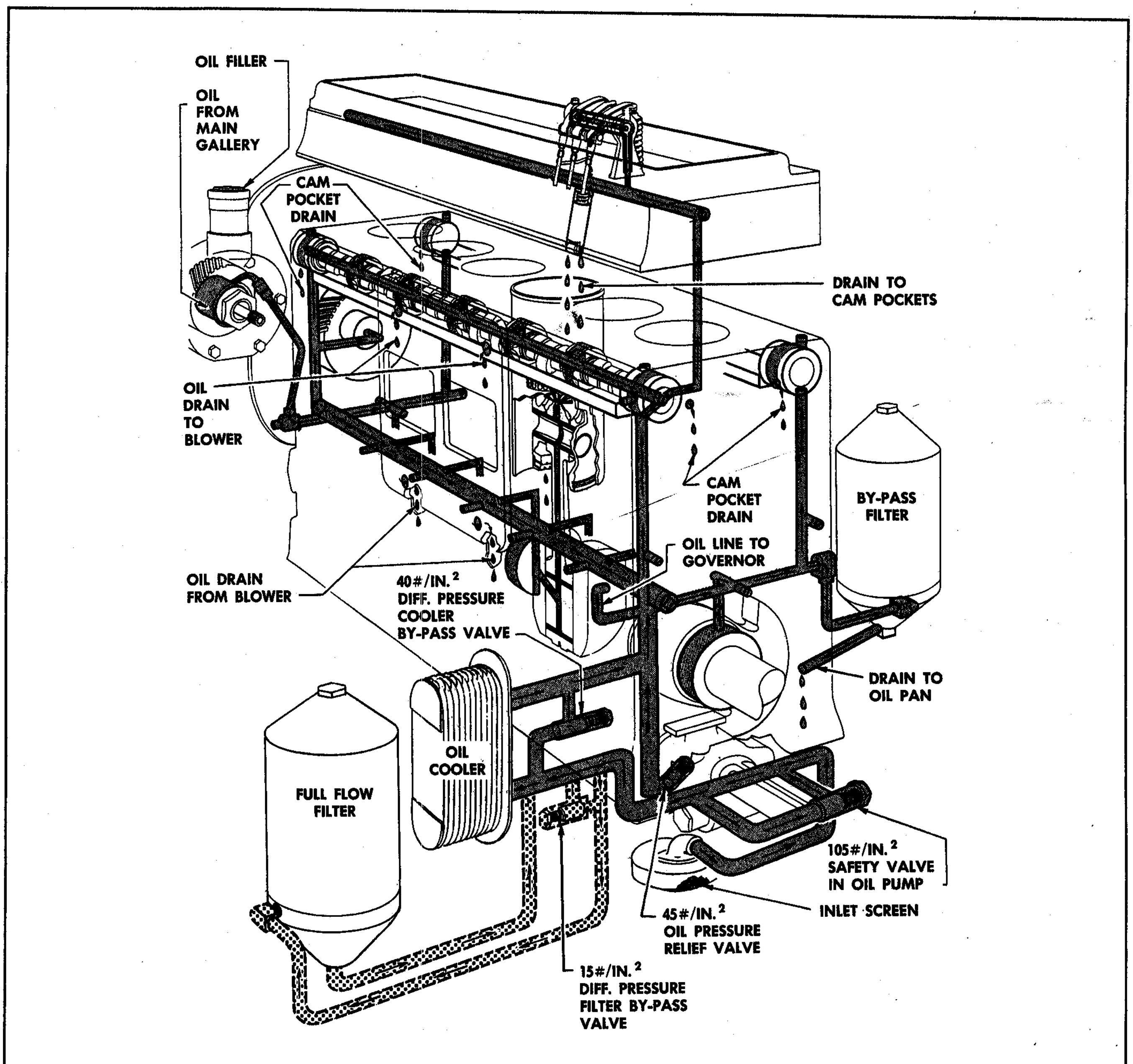

Fig. 1—Schematic Diagram of a Typical Lubricating System.

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 a by-pass oil filter, together 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. A full flow oil filter with by-pass valve is also incorporated in some engines at the owner's option.

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, providing lubrication for the blower drive gears at the rear end and governor mechanism at the front end.

COOLING SYSTEM

Three different types of cooling systems are used on series 71 engines:

1. Radiator and Fan.
~~2. Heat Exchanger.~~
~~3. Keel Cooling.~~

A centrifugal type water pump circulates the coolant through the cylinder block, water jackets, cylinder head, and engine lubricating oil cooler on all systems.

The **Radiator and Fan Cooling System** is illustrated in Fig. 2. In this system the coolant temperature is reduced by the air steam from a blower or suction type fan. A water pump draws the coolant from the bottom of the radiator core, through the oil cooler and forces it into the lower part of the cylinder block.

The coolant circulates up through the cylinder block into the cylinder head, then to the water manifold and thermostat housing. From the thermostat

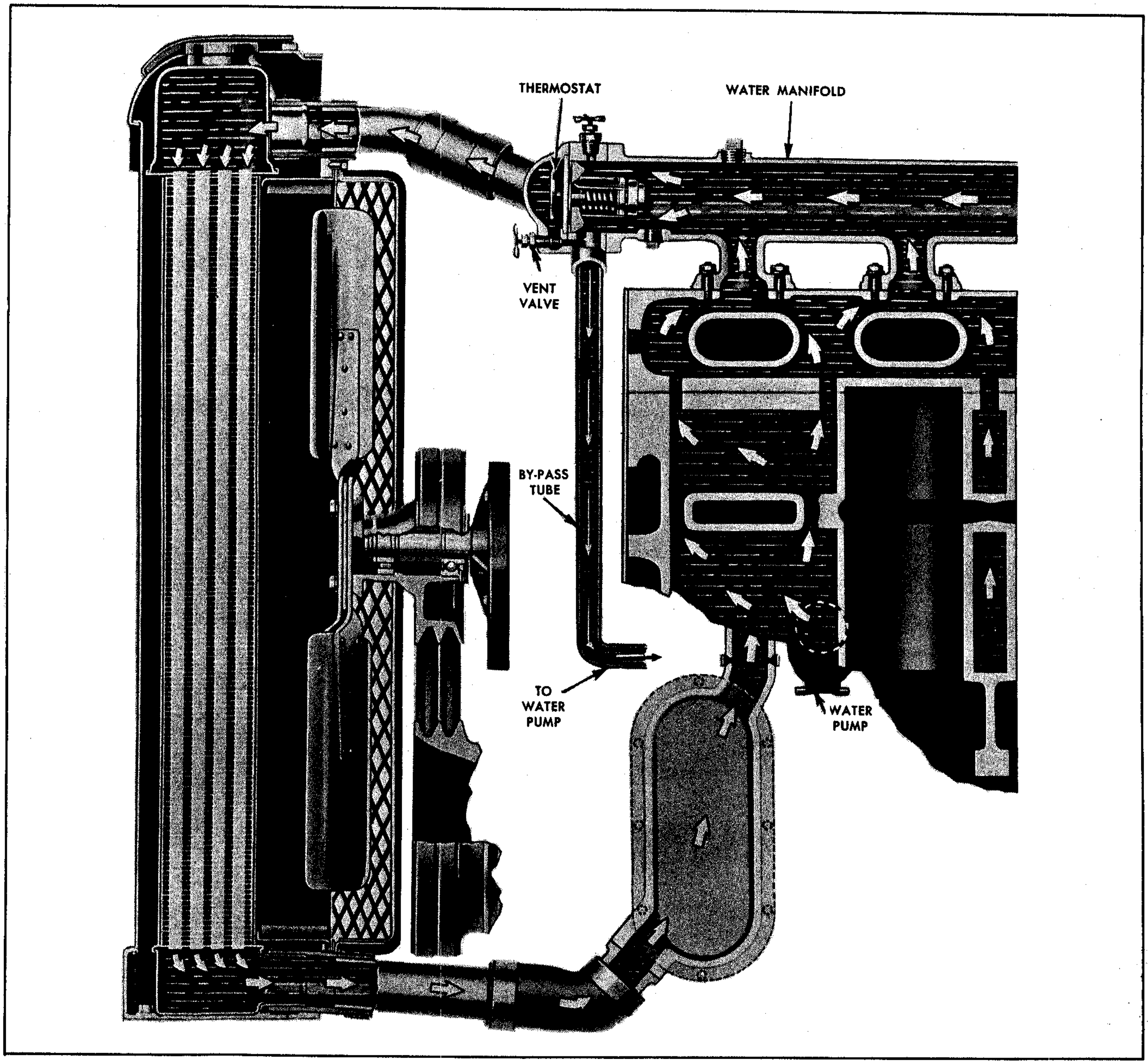

Fig. 2—Typical Engine Cooling System with Radiator and Fan.

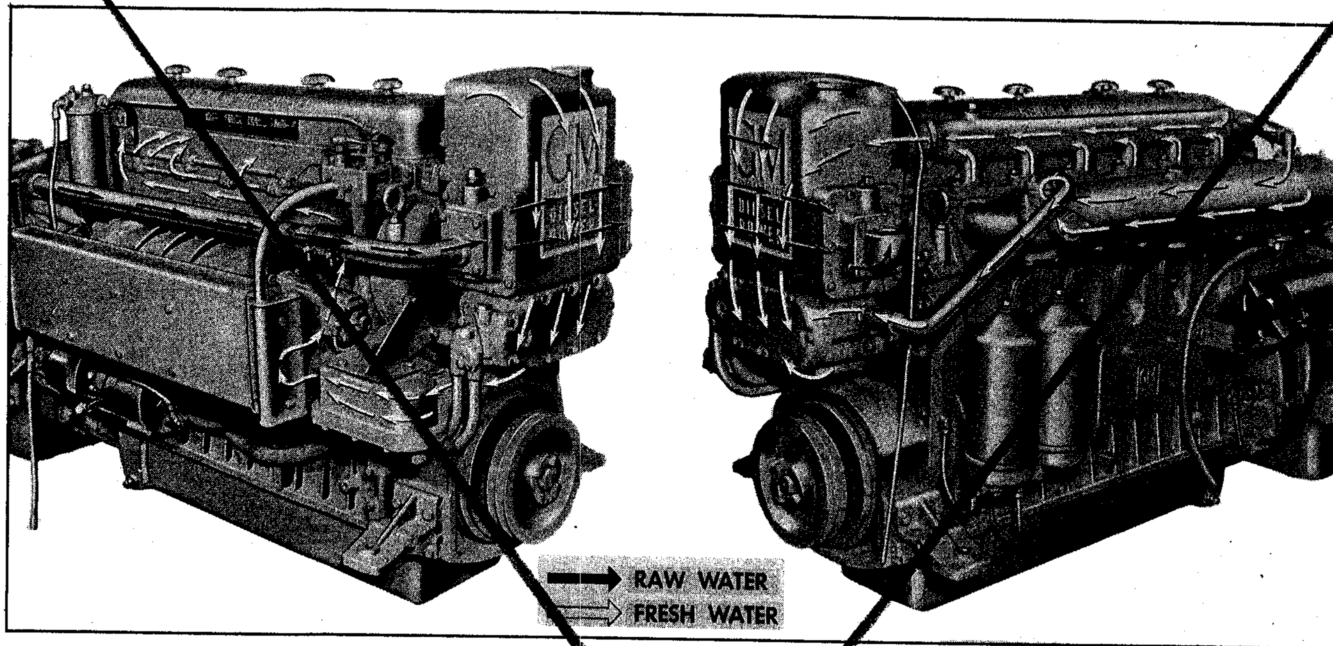

Fig. 3—Water Circulation Through Heat Exchanger.

housing, the coolant returns to the radiator, or by-passes to the water pump, depending on the temperature of the coolant.

The Heat Exchanger Type Cooling System is illustrated in Fig. 3. In this system the coolant is drawn by the circulating pump from tthe bottom of the expansion tank through the reverse gear oil cooler and engine oil cooler (on six cylinder engine units, circulation is first through the engine oil cooler, then the reverse gear oil cooler), then through the engine the same as in the radiator and fan system. Upon leaving the thermostat housing, the coolant either passes through the heat exchanger core and oil coolers or by-passes the heat exchanger and oil coolers and flows directly to the water pump, depending on the coolant temperature.

While passing through the core of the heat exchanger, the coolant temperature is lowered by raw water, which is drawn by the raw water pump from an outside supply. The raw water enters the heat exchanger at one side and is discharged at the opposite side.

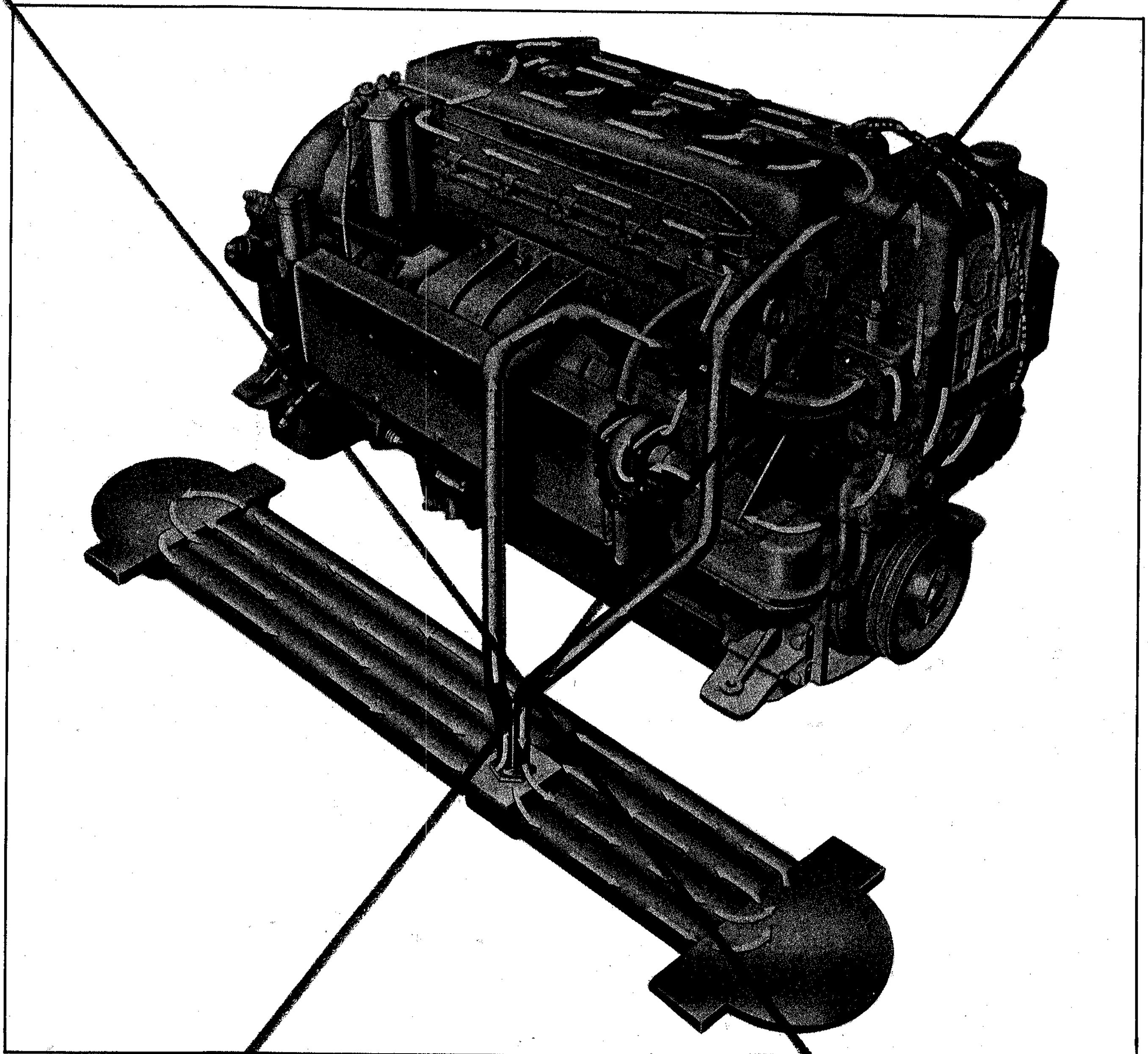

Fig. 4—Water Flow In Keel Cooled Engine.

The **Keel Cooling** system, illustrated in Fig. 4, is similar to the heat exchanger, except that the coolant temperature is reduced in the keel cooler. In this system, the coolant is drawn by the circulating pump from the bottom of the expansion tank through the reverse gear oil cooler and engine oil cooler (on six cylinder engine units circulation is first through the engine oil cooler, then the reverse gear oil cooler). From the coolers the flow is the same as in other systems. Upon leaving the thermostat housing, the coolant is by-passed directly to the bottom of the expansion tank until the engine operating temperature, controlled by the thermostat, is reached. As the engine temperature increases toward normal, the proper amount of coolant is directed to the keel cooler, where the temperature of the coolant is reduced, in order to maintain correct temperature, before flowing back to the expansion tank.

AIR SYSTEM

In the scavenging process used in two-cycle engines and illustrated in Fig. 5, a charge of air, forced into the cylinders by the blower, sweeps all of the burnt gasses out through the exhaust valve ports, leaving the cylinder filled with fresh air for combustion at the end of each upward stroke of the engine. This air also assists in cooling the internal engine parts.

The blower supplies fresh air required for combustion and scavenging. Two hollow three-lobe rotors are closely fitted in a blower housing bolted to the cylinder block. The revolving motion of these rotors pulls fresh air through the air cleaner or silencer and provides a continuous and uniform displacement of air in each combustion chamber.

The continuous discharge of fresh air from the blower creates a pressure in the air box (air box pressure).

Heavy-duty oil bath air cleaner assemblies of the type illustrated in Fig. 6, are used on most models.

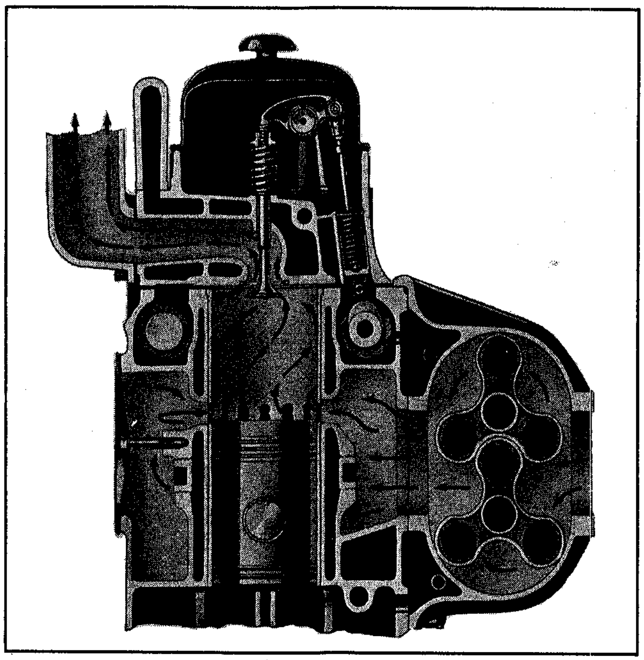

Fig. 5—Air Intake System Through Blower and Engine.

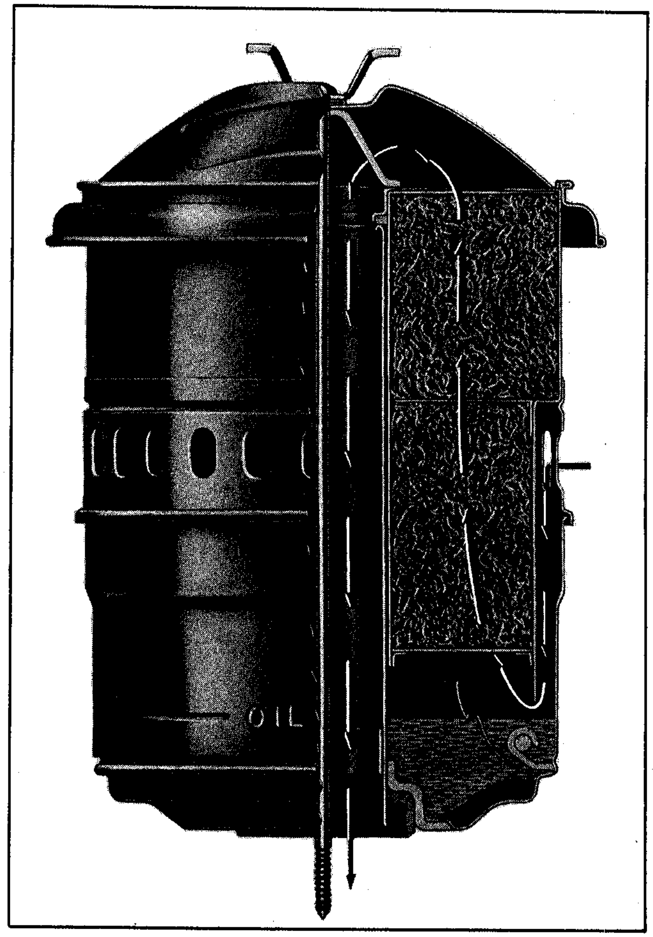

Fig. 6—Oil Bath Air Cleaner and Silencer Assembly.

The cleaner consists of a metal wool element supported inside a housing, beneath which is contained an oil bath.

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

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

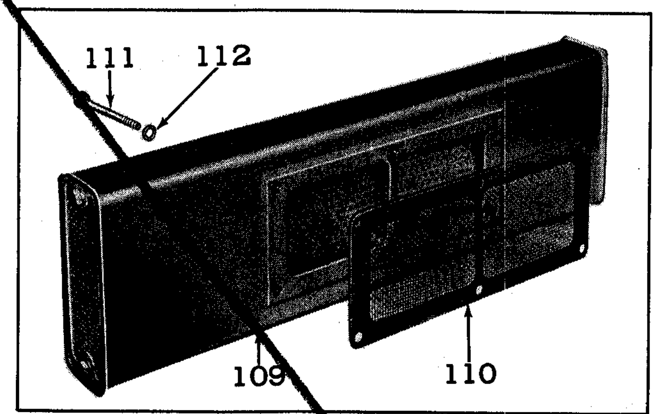

Fig. 7—Blower Air Inlet Silencer Assembly.

109. Silencer Assy.
110. Screen—Air Intake.
111. Bolt—Silencer to Blower.
112. Washer.

The air silencer, Fig. 7, is bolted to the intake side of the blower housing. The silencer has a perforated steel partition welded in place parallel with the outside faces, enclosing flame proof, felted cotton waste which serves as a silencer for air entering the blower.

While no servicing is required on the air silencer proper, it may be removed, when necessary to replace the air intake screen. This screen is used to filter out any large foreign particles which might seriously damage the blower assembly.

In normal operation, a slight amount of vapor from the air condenses and settles at the bottom of the air box. This condensation is drained through drilled passages in the ends of the block into tubes, Fig. 8, which direct the expelled air and vapor down away from the engine.

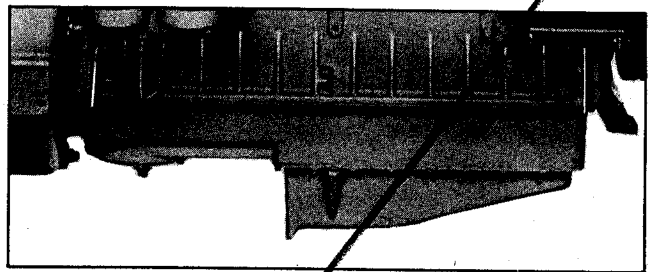

Fig. 8—Air Box Drains.

1. Tube—Air Box Drain.
2. Cover—Hand Hole.

Air Box drains must be open at all times; otherwise, water and oil may accumulate in the air box and be drawn into the cylinders with the incoming fresh air. Therefore, periodic checks should be made to ensure they are open. Remove the hole covers and examine the air box floor for oil or an accumulation of water. If oil or water is found, wipe air box dry with clean rags and, also, remove and clean drain tubes.

Harmful vapors which may form within the engine are removed from the crankcase and injector compartment by a continuous ventilation system.

A slight pressure is maintained within the engine crankcase and injector compartment by the seepage of a small amount of air past the piston rings.

Crankcase ventilation on the series 71 units is accomplished by the air seepage past the piston rings sweeping up through the flywheel housing and balance weight cover into the valve compartment, where it is expelled through a vent attached to the valve cover, or through a vent pipe attached to the governor.

ENGINE SHUT-DOWN

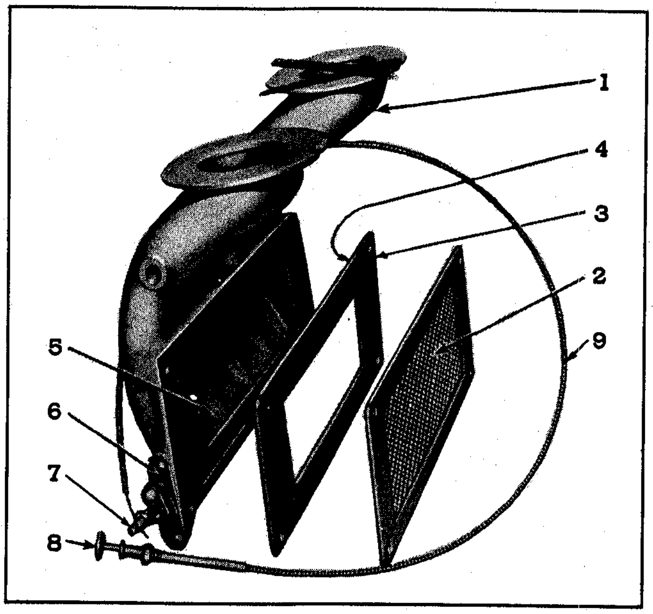

Fig. 9—Manually Operated Emergency Engine Shut-Down Assembly.

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.

Three emergency shut-down devices are used on the Series 71 engine:

1. Manual through a control wire.
2. ~~Automatic by either low oil pressure or high coolant temperature.~~
3. ~~Automatic by an overspeed governor.~~

The manually operated shut-down device shown in Fig. 9 is operated by a knob (8), located on the instrument panel and connected to the valve shaft lever by a control wire (9). Pulling the knob all the way out will stop the engine. Push the knob all the way in to reset valve after engine has been stopped.

Automatic shut-down devices, electrically operated, are available as optional equipment on some models.

One device consists of a lubricating oil pressure switch (161), a coolant temperature switch (160), a fuel oil pressure switch (162), a solenoid coil (159), and suitable electrical wiring to complete the circuit through the storage battery. Fig. 10 shows the 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.

Some models are equipped with an over-speed shut-down device (158) which is driven by the blower drive shaft. If the engine speed exceeds the speed which has been established by the governor, the overspeed governor actuates an overspeed switch, which is electrically connected to the shut-down solenoid.

If the engine has been stopped by an automatic device, the shut-down valve must be reset in the open position before the engine can be started.

The **water temperature switch** is normally open and connected in the electrical circuit to the shut-down solenoid.

When engine coolant temperature exceeds 195°-205° F., the switch closes and current energizes the shut-down solenoid.

The **lubricating oil pressure switch** is normally open and connected through a hot wire relay in the electrical circuit to the shut-down solenoid.

When the lubricating oil pressure falls below 10 ± 2 lbs. p.s.i., the 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 shut-down when low oil pressure is caused by a passing condition, 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.

The **fuel pressure switch** is normally closed and connected in the electric circuit to the shut-down solenoid in series with the lubricating oil pressure switch. It is calibrated to close at fuel pressures which prevail at engine speeds of about 700 r.p.m.

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

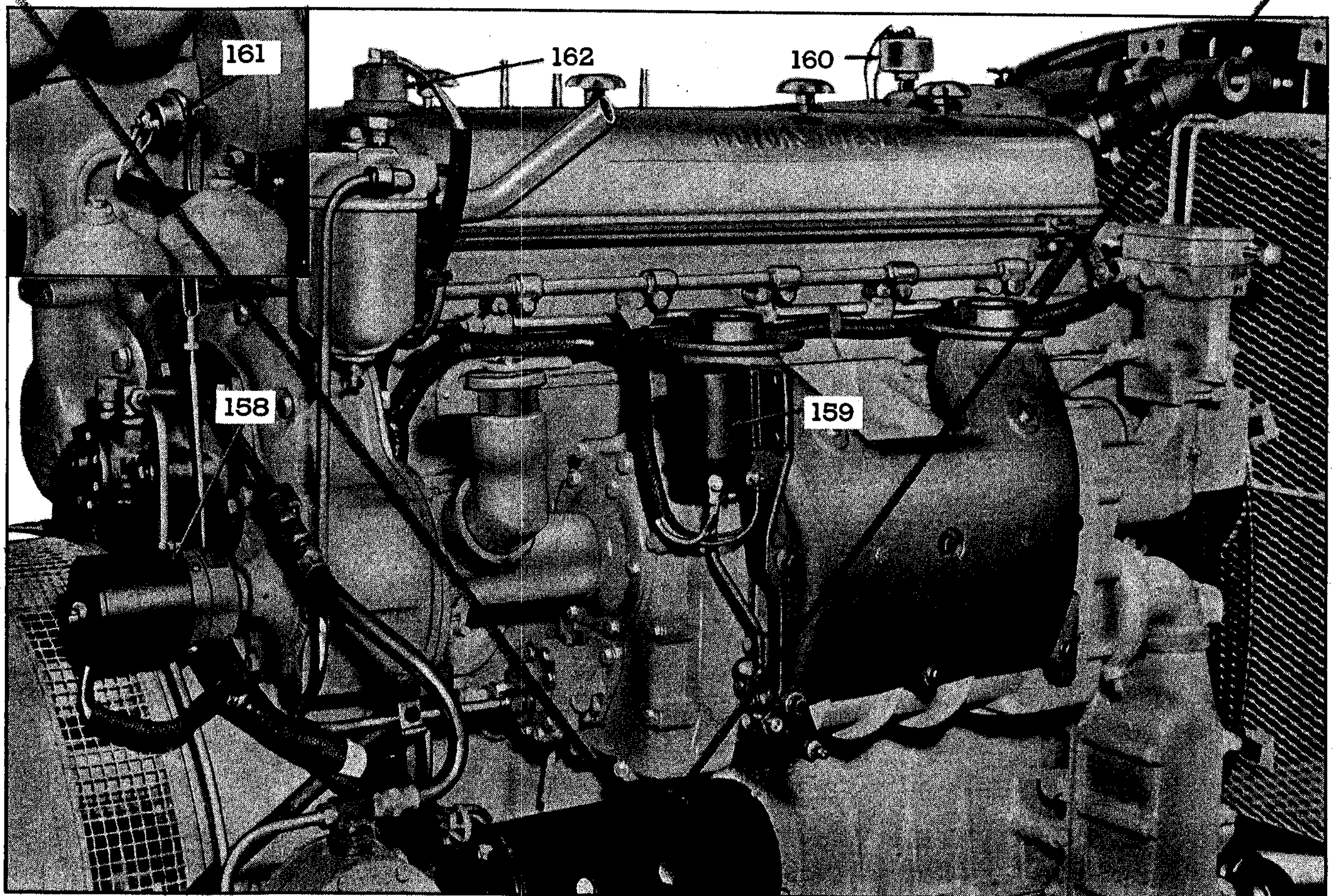

Fig. 10—Typical Installation of Electrically Operated Shut-Down Device.
(Also see engine starting system and shut-down wiring diagrams)

158. Switch—Overspeed Governor.
159. Solenoid—Shut-down.
160. Switch—Water Temperature.
161. Switch—Lube Oil Pressure.
162. Switch—Fuel Oil Pressure.

FUEL SYSTEM

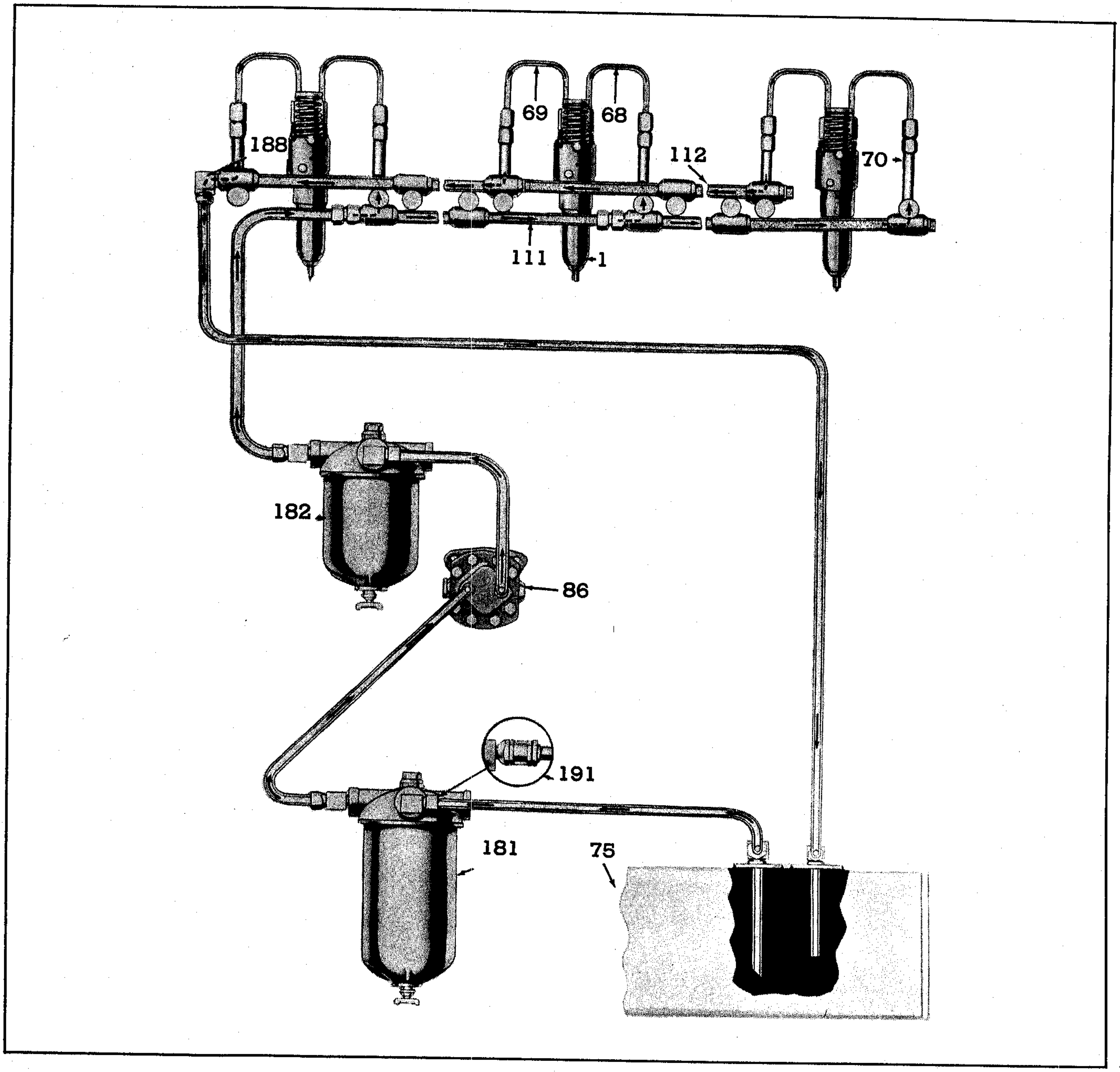

Fig. 11—Fuel Supply System Generally Used on Series 71 Engine.

1. Injector.
68. Pipe—Fuel Inlet.
69. Pipe—Fuel Outlet.
70. Connector.
75. Tank—Fuel.
86. Pump—Fuel.
111. Manifold—Upper.
112. Manifold—Lower.
181. Strainer—Fuel.
182. Filter—Fuel.
188. Elbow—Restriction.
191. Valve—Check.

The fuel system illustrated in Fig. 11 includes the following: injectors, fuel pipes (inlet and outlet), fuel manifold (upper and lower), fuel pump, fuel strainer, fuel filter, and connecting fuel lines required to and from the source of supply.

A restricted fitting, placed in the end of the return fuel manifold, assists in maintaining a pressure of approximately 40-50 lbs. which is necessary for efficient operation.

A check valve may be installed between the fuel strainer and the source of supply to prevent the fuel from draining back when the engine is not running.

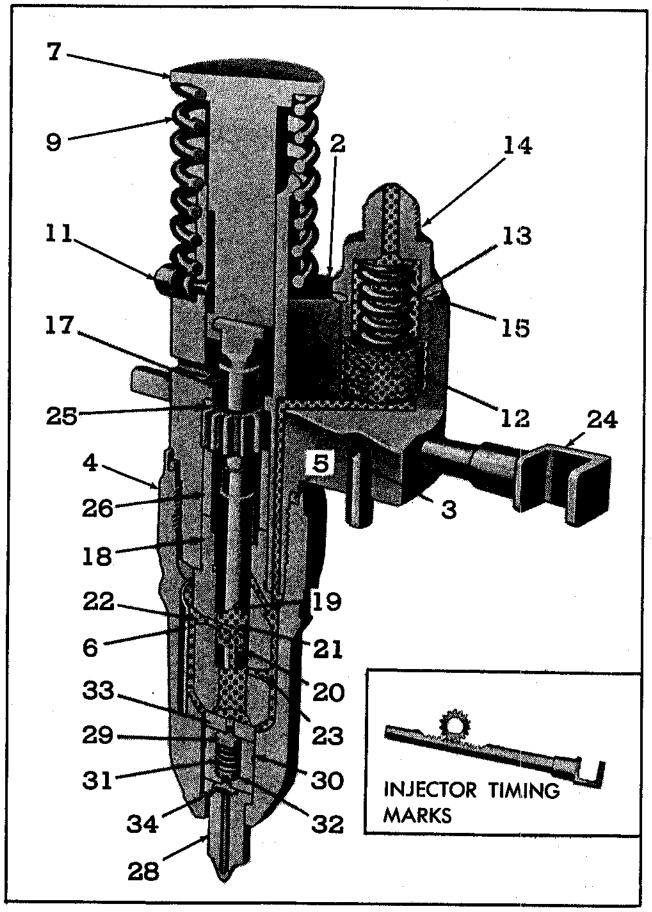

Fig. 12—Typical Fuel Injector.

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. Seat—Spray Tip.
31. Spring—Valve.
32. Stop—Valve.
33. Spacer—Spray Tip.
34. Valve—Check.

Fuel is drawn from the supply tank through the fuel strainer and enters the fuel pump at the inlet side. Upon leaving the pump under pressure, the fuel is forced through the fuel filter and into the fuel manifold, thence through fuel pipes into the inlet side of the injectors. Surplus fuel returning from the outlet side of the injectors passes through the outlet fuel pipes and into the fuel return manifold from whence it is returned to the source of supply.

The fuel injector shown in Fig. 12 performs four important functions:

1. Pressurizes the fuel for proper injection.
2. Meters and injects the fuel.
3. Atomizes the fuel.
4. Permits continuous fuel flow.

Combustion required for satisfactory engine operation is obtained by injecting fuel, accurately metered and finely atomized, under pressure into the cylinder. Metering of the fuel is accomplished by upper and lower helixes machined in the lower end of the injector plunger.

The continuous fuel flow through the injector serves as a coolant for those injector parts subjected to high combustion temperatures, and to prevent air pockets in the fuel system.

Each injector has a circular disc pressed into a recess at the front of the injector body that identifies its output capacity in cubic millimeters.

The fuel injector combines in a single unit all the parts necessary to provide complete and independent fuel injection at each cylinder.

The injector is mounted in the cylinder head, with the spray tip projecting below the inside surface of the combustion chamber. A dowel pin in the injector body registers with a hole in the cylinder head for accurately locating the injector. 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 injector tube which passes through the cylinder head.

A tight seal, formed between the tapered seat on the lower end of the injector and the injector tube, will withstand the high pressure inside the combustion chamber.

Since the injector is one of the most important and carefully constructed parts of the engine, it is recommended that the injector be changed as a unit and that no attempt be made to repair the injector.

Authorized Detroit Diesel Engine Division Dealers and Distributors are properly equipped to service injectors.

If it becomes necessary to remove or replace an injector, the following procedure should be followed:

1. Remove the valve rocker cover.
2. Remove the fuel lines from the injector and fuel connectors.

NOTE: Install shipping caps on the injector to prevent dirt from entering the injector.

3. Loosen the two rocker arm bracket bolts holding the brackets to the cylinder head and swing the rocker arm assembly away from valves and injector.
4. Remove injector hold-down nut, washer, and injector clamp.
5. Using tool J1227-A pry injector loose from injector tube.
6. Lift injector out of tube and disengage the control rack from injector control tube.

If required, a new injector or one that has been inspected, repaired and tested by an authorized dealer or distributor may be installed by reversing the sequence of operations given for removal. Be sure the dowel pin in injector body registers with hole in cylinder head. Secure the injector in place with hold-down clamp, washer, and nut; then connect fuel pipes. Tighten clamp nut to 20-25 ft-lb; **do not over-tighten injector nut as this may distort the injector and cause working parts to bind.**

Time the injector and position control rack as outlined in "Engine Tune-up," in section 4. Select the correct tool for timing injector from those listed in the timing gauge chart.

A fuel oil strainer and filter are placed in the fuel system to separate foreign matter from the fuel. If they have been diligently serviced, as recommended in the Lubrication Chart, there should always be a clean supply of fuel at the injectors, provided the fuel tank is filled.

The length of time that strainer and filter elements can be used will be governed by the operating conditions and the cleanliness of the fuel; however, they should be removed and new elements installed at least every 500 hours of engine operation. One quarter pint of fuel should be drained daily from both strainer and filter to remove any dirt and water accumulations. Drain cocks are provided for this purpose.

If uneven running, excessive vibration, stalling at idle or loss of power is detected, make a fuel flow test as outlined in Trouble Shooting in section 5.

If the fuel filters are clean and in good condition, check for plugged injector filters by following the procedure given under Locating A Misfiring Cylinder in section 5.

GOVERNORS

Horsepower requirements of 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, one of the three types of governors listed below is introduced in the linkage between the governor control lever throttle and the fuel injectors.

1. Limiting Speed Mechanical Governor.

[redacted]

Each engine is provided with that type of governor and throttle controls which best regulate the engine speed according to the operating requirements.

The **limiting speed mechanical governor** is used on applications requiring minimum and maximum speed control, but where the intermediate speed is controlled manually.

[redacted]

[redacted]

LIMITING SPEED MECHANICAL GOVERNOR

The limiting speed mechanical governor illustrated in Fig. 13 is a single weight type and performs two functions:

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

The governor is mounted on the front end of the blower and is driven by the upper blower rotor.

The limiting speed mechanical governor provides full fuel for starting when the control lever (21) is in the idle position. Immediately after starting, the governor moves the injector racks to that position required for idling.

The centrifugal force of the revolving governor weights (76) is converted into linear motion which is transmitted through the riser (67), operating shaft (26) to the operating shaft lever (27). One end of the lever (27) operates against the high and low speed springs through spring cap (47), while the other end provides a changing fulcrum on which the differential lever (23) pivots.

When the centrifugal force of the revolving governor weights balances out the tension on the high or low speed spring, depending on the speed range, the governor stabilizes the engine speed for a given setting of the governor control lever.

In the low speed range the centrifugal force transmitted, operates against the low speed spring. As the engine speed is increased, the centrifugal force compresses the low speed spring (46) until the spring cap (47) is tight against the high speed plunger (44). This removes the low speed spring from operation and the governor is then in the intermediate speed range. In this range the centrifugal force is operating against the high speed spring (48) and thus the engine speed is manually controlled.

When the engine speed is increased to a point where the centrifugal force overcomes the pre-load of the high speed spring, the governor will move the injector rack to that position required for maximum no-load.

The engine idle speed is determined by the centrifugal force required to balance out that tension on the low speed spring. Adjustment of the engine idle speed is accomplished by changing the tension on the low speed spring by means of the idle adjusting screw (55).

The maximum no-load speed is determined by the centrifugal force required to balance out the tension on the high speed spring.

Adjustment of the maximum no-load speed is accomplished by the high speed spring retainer nut (50). Movement of the high speed spring retainer nut will increase or decrease the tension on the high speed spring.

VARIABLE SPEED MECHANICAL GOVERNOR

The variable speed mechanical governor illustrated in Fig. 14 is a single weight type with one governor spring and performs three functions:

1. Controls the engine idling speed.
2. Limits the maximum no-load speed.
3. Holds the engine at constant speed, between idle and maximum, as desired by the operator.

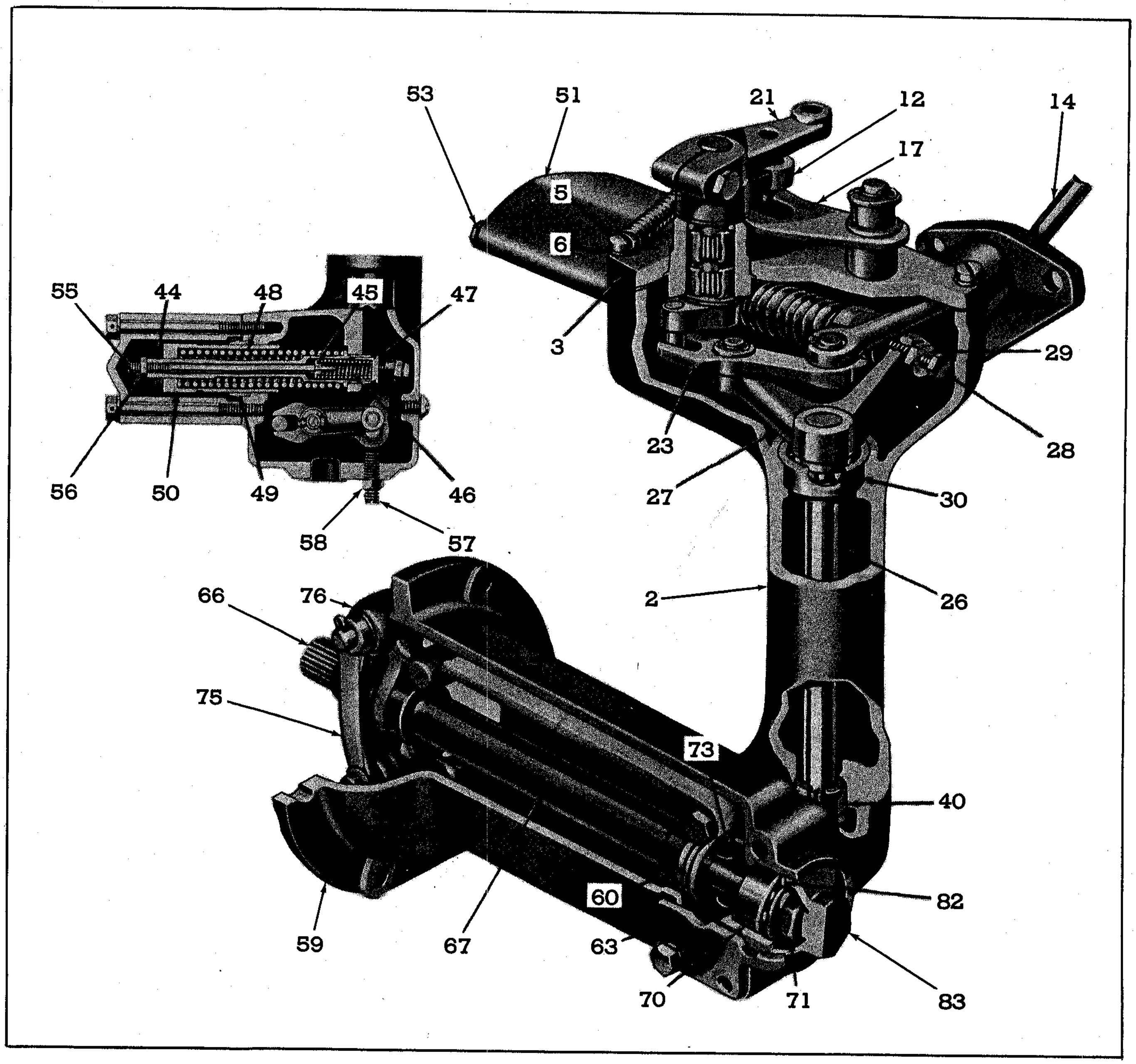

Fig. 13—Typical Limiting Speed Governor Assembly.

2. Housing—Governor.
3. Cover—Governor.
5. Bolt.
6. Lock Washer.
12. Lever—Control (lower).
14. Rod—Fuel.
17. Cam.
21. Lever—Control.
23. Lever—Operating Shaft.
26. Shaft—Operating.
27. Lever—Differential.
28. Screw—Gap Adjusting.
29. Lock Nut—Adjusting Screw.
30. Bearing—Operating Shaft.
40. Bushing—Operating Shaft.
44. Plunger—High Speed Spring.
45. Seat—Low Speed Spring.
46. Spring—Low Speed.
47. Cap—Low Speed Spring.
48. Spring—High Speed.
49. Lock Nut—Spring Retainer.
50. Retainer—High Speed Spring
51. Cover—High Speed Spring.
53. Bolt.
55. Screw—Idle Speed Adjusting.
56. Lock Nut—Adjusting Screw.
57. Screw—Buffer.
58. Lock Nut.
59. Housing—Weight.
60. Bearing—Riser.
63. Cover—Weight Housing.
66. Shaft Assy.—Weight.
67. Riser.
70. Bearing—Weight Shaft End.
71. Bolt.
73. Fork—Operating.
75. Carrier—Weight.
76. Weight and Bearing Assy.
82. Gasket—Weight Housing Plug.
83. Plug—Weight Housing.

The governor is mounted on the front end of the blower and is driven by the upper blower rotor.

Two manual controls are provided on the variable speed governor: a governor control lever (12), Fig. 14

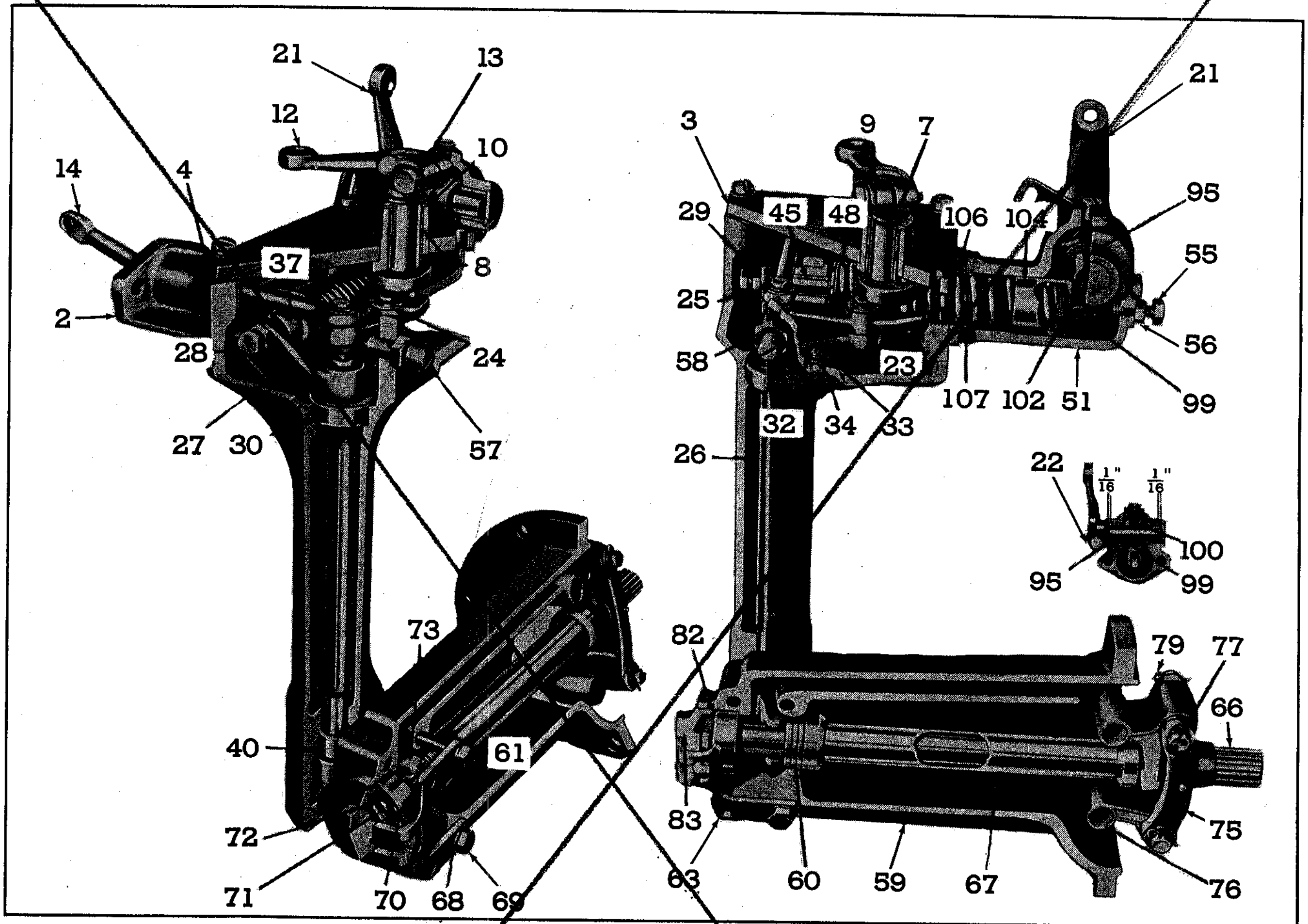

Fig. 14—Typical Variable Speed Governor Assembly.

2. Housing—Governor.
3. Cover—Governor.
4. Gasket.
7. Shaft—Control Lever.
8. Bearing—Throttle Shaft.
9. Ring—Throttle Shaft Seal.
10. Retainer—Seal Ring.
12. Lever—Governor Control.
13. Bolt.
14. Rod—Fuel.
21. Lever—Speed Control.
22. Bolt.
23. Lever—Differential.
24. Washer—Lever Pin.
25. Spring—Retainer.
26. Shaft—Operating.
27. Lever—Operating Shaft.
28. Screw—Gap Adjusting.
29. Lock Nut.
30. Bearing—Operating Shaft.
32. Screw.
33. Washer—Plain.
34. Lock Washer.
37. Guide—Plunger.
40. Bushing—Operating Shaft.
45. Plunger—Variable Speed.
48. Spring.
51. Housing—Variable Speed Spring.
55. Screw—Idle Speed Adjusting.
56. Lock Nut.
57. Screw—Buffer.
58. Lock Nut.
59. Housing—Weight.
60. Bearing—Thrust.
61. Gasket—Weight Housing Cover.
63. Cover—Weight Housing.
66. Shaft Assy.—Weight.
67. Riser.
68. Lock Washer.
69. Bolt.
70. Bearing—Weight.
71. Bolt.
72. Lock Washer.
73. Fork—Operating Shaft.
75. Carrier—Weight.
76. Weight and Bearing Assy.
77. Pin—Weight.
79. Lock Ring.
82. Gasket—Weight Housing Plug.
83. Plug.
95. Shaft—Spring Lever.
99. Lever—Variable Speed Spring.
100. Screw—Set.
102. Shim.
104. Plunger—Variable Speed Spring.
106. Stop—Plunger.
107. Stop—Plunger.

for starting and stopping, and a speed control lever (21). For starting, the governor control lever is moved to the RUN position, which moves the injector control racks in the FULL FUEL position. Upon starting, the governor moves the injector racks out to that position required for idling. The engine speed is then controlled manually by movement of the speed control lever (21).

The centrifugal force of the revolving flyweights is converted into linear motion, which is transmitted through the riser (67), operating shaft (26), to the operating shaft lever (27). One end of the operating lever operates against the spring seat (45), while other end provides a changing fulcrum on which the differential lever (23) pivots. A fuel rod (14), connected to the differential lever and injector control tube lever, provides means for the governor to change the fuel settings of the injector control racks.

N.A.

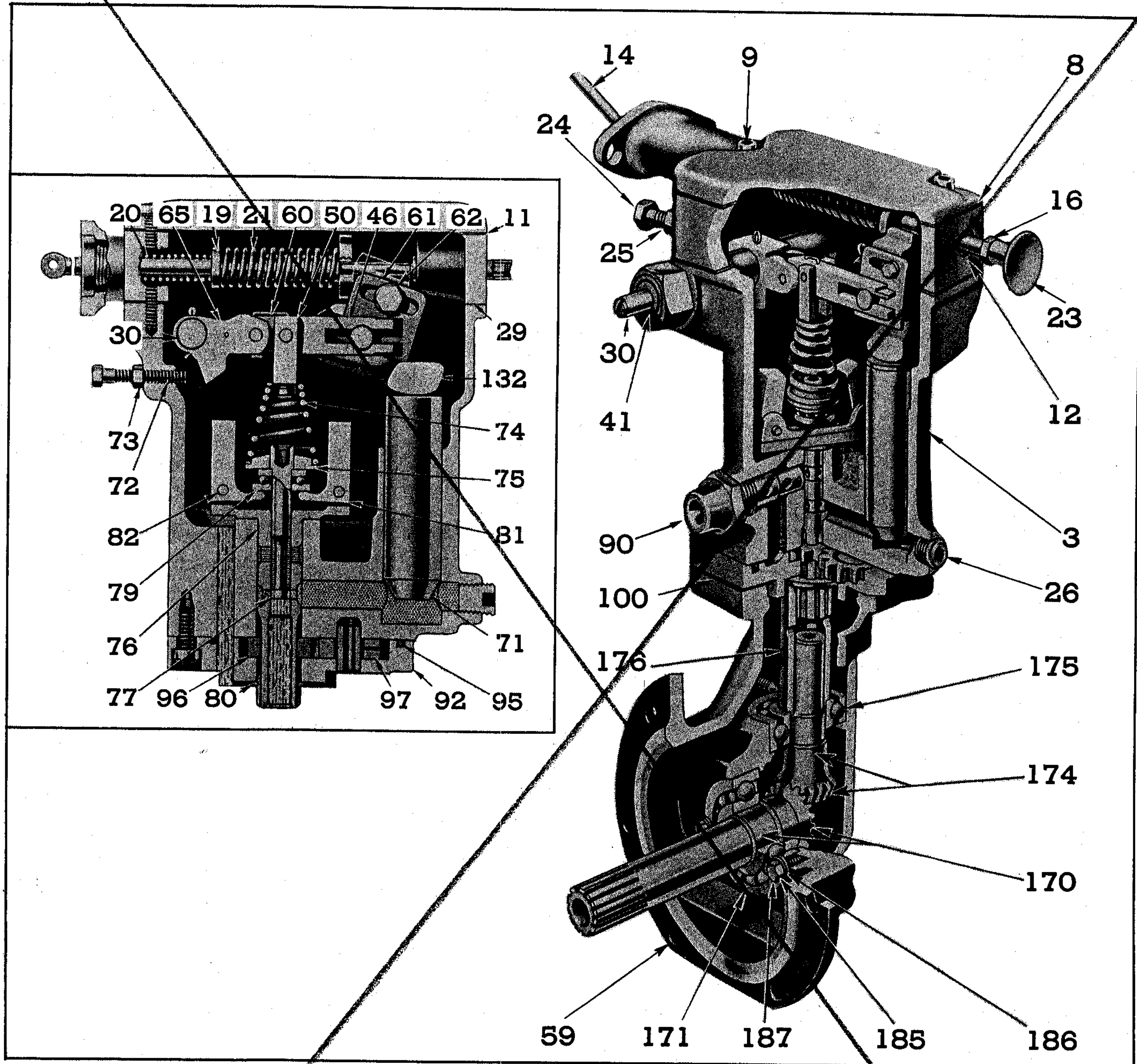

Fig. 15—Typical Hydraulic Governor Assembly.

3. Housing—Governor.
8. Cover—Governor.
9. Screw—Hex Socket Head.
11. Gasket—Sub Cap.
12. Sub Cap.
14. Rod—Fuel.
16. Lock Nut—Shut-down Knob.
19. Disc.—Fuel Rod.
20. Spring.
21. Spring—Fuel Rod.
23. Knob—Fuel Rod.
24. Screw—Load Limit.
25. Lock Nut.
26. Plug.
29. Gasket.
30. Shaft—Speed Adjusting.
41. Seal—Speed Adjusting Shaft.
46. Lever—Floating.
50. Spring Fork.
59. Housing—Governor Drive.
60. Lock Wire—Spring Fork.
61. Bracket—Droop Adjusting.
62. Bolt—Droop Adjusting.
65. Lever—Speed Adjusting.
71. Piston—Power.
72. Screw—Speed Adjusting.
73. Lock Nut.
74. Spring—Speeder.
75. Spring—Seat.
76. Ballhead.
77. Plunger—Pilot Valve.
79. Bearing—Thrust.
80. Lock Ring.
81. Flyweight.
82. Pin.
90. Valve Assy.—Relief.
92. Base—Governor.
95. Ring—Oil Seal.
96. Gear—Driven.
97. Gear—Drive.
100. Gasket.
132. Terminal Lever.
170. Shaft—Drive.
171. Bearing.
174. Shaft—Driven.
175. Bearing.
176. Sleeve—Driven Shaft.
185. Lock Washer.
186. Washer—Plain.
187. Bolt.

The centrifugal force of the governor weights is opposed by the variable speed spring (48). Load changes or movement of the speed control lever creates an unbalanced force between the revolving governor weights and the tension on the variable speed spring. When the two forces are equal, the engine speed stabilizes for a setting of the speed control.

The engine idle speed is determined by the centrifugal force required to balance out the tension on the variable speed spring in the low speed range.

Adjustment of the engine idle speed is accomplished by changing the tension on the variable speed spring by means of the idle speed adjusting screw (55).

Adjustment of the maximum no-load speed is accomplished by varying the tension on the variable speed spring by the installation or removal of stops (106) and (107), Fig. 14, and shims (102) as required.

HYDRAULIC GOVERNOR

The governor illustrated in Fig. 15 is of the hydraulic type with a speed droop stabilization mechanism. Hydraulic action is transmitted by oil which is admitted under pressure from the engine lubricating system to an auxiliary oil pump in the governor. The auxiliary pump then develops the oil pressure necessary to actuate the governor mechanism.

The amount of fuel injected into the cylinder is decreased by the action of the fuel rod spring (21) and is increased by the opposing action of the power (servo) piston (71). Admission of oil under the power piston is controlled by vertical movement of the pilot valve plunger (77). This plunger is, in turn, controlled by the flyweights (81) of the governor.

The two flyweights (81) are mounted on the ball head (76) and are driven through gears (174) and 170). The centrifugal force of the flyweights, in rotation, is opposed by a speeder spring (74) located between a spring fork (50) at the top and the spring seat (75) at the bottom. Compression of the speeder spring, which is controlled by the throttle, determines the speed at which the governor will control the engine.

To stabilize the governor (that is, to prevent "hunting"), a speed droop adjustment is incorporated in adjusted through the droop adjusting bracket (61) the governor mechanism. The speed droop may be attached to the side of the terminal lever (132). A pin attached to the adjusting bracket (61) supports the floating lever (46). Movement of the droop adjusting bracket **in** (toward the engine) decreases the governor droop. Movement in the opposite direction increases the governor droop.

When starting a cold engine, considerable time may be required to develop sufficient oil pressure to actuate the governor and thus open the throttle for starting. To overcome this delay in starting, press in on the fuel rod knob (23), thus taking control of the injectors away from the governor.

The engine can be stopped, regardless of the governor, by pulling out on the fuel rod knob.

Aside from its function of holding the engine speed constant under varying load conditions, the hydraulic governor acts as an automatic engine shut-down device in case of lubricating oil pressure failure. Should the engine fail to supply oil to the governor, the power piston will drop, letting the fuel rod return to the **no fuel** position, thus shutting down the engine.

ELECTRICAL SYSTEM

The series 71 engines are equipped with [redacted], 24, [redacted] volt electrical systems depending on the requirements of the particular application. A typical electrical system generally consists of a cranking (starting) motor, a battery charging generator, a suitable combination voltage regulator, current regulator and cutout relay to protect the electrical system, a storage battery and the necessary wiring.

~~Additional optional equipment such as an air heater, alarm system, and automatic shut-down system may also be included. Refer to wiring diagrams shipped with engine, for proper wiring~~. Since information on the maintenance and repair of electrical equipment used on Series 71 engines can be found in the service manuals and in bulletins issued by the equipment manufacturers, this book does not contain detailed disassembly, inspection and assembly procedures. In most instances, the repair and overhaul of electrical equipment should be made by an authorized repair station of the manufacturer of the equipment.

COLD WEATHER STARTING AIDS

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

When the outside temperature is extremely low, the oil between the pistons and cylinder walls and in the bearings tends toward greater friction between the parts, thus increasing the effort required to crank the engine.

The fuel injected into the combustion chamber of a Diesel engine is ignited by the increased temperature due to compression. This temperature becomes high enough under ordinary operating conditions, but may not be sufficiently high at extremely low outside temperatures to ignite the fuel charge.

One of two types of starting aids may be installed as optional equipment and used to assist in starting an engine under low temperature conditions.

They are:

~~1. Air Heater.~~

2. Fluid Starting Aid.

AIR HEATER STARTING AID

An air heater is essentially a small pressure oil burner with electric ignition. The heater unit, containing the nozzle, filter, ignition coil, and ignition points is mounted on the cylinder block, replacing one of the hand hole covers as illustrated in Fig. 16.

A hand operated pressure pump and a fuel supply valve are usually mounted on the instrument panel.

The pump draws fuel from the fuel strainer and delivers it under pressure to the burner unit where the charge is filtered before reaching the spray nozzle. The pump plunger, when not in use, is held in the IN position by a spring and ball mechanism and may be released merely by pulling the plunger out.

A pressure switch is located in the fuel line between the pump and nozzle, so that the pressure, created when actuating the pump plunger, will close the contacts in the switch, thus completing the electrical circuit through the coil, causing a spark across the electrodes at the spray nozzle. Thus, when fuel is injected from the nozzle, the electric spark is present for ignition.

When starting an engine in cold weather, follow the Air Heater Instructions given on the plate attached to the instrument panel and listed below:

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

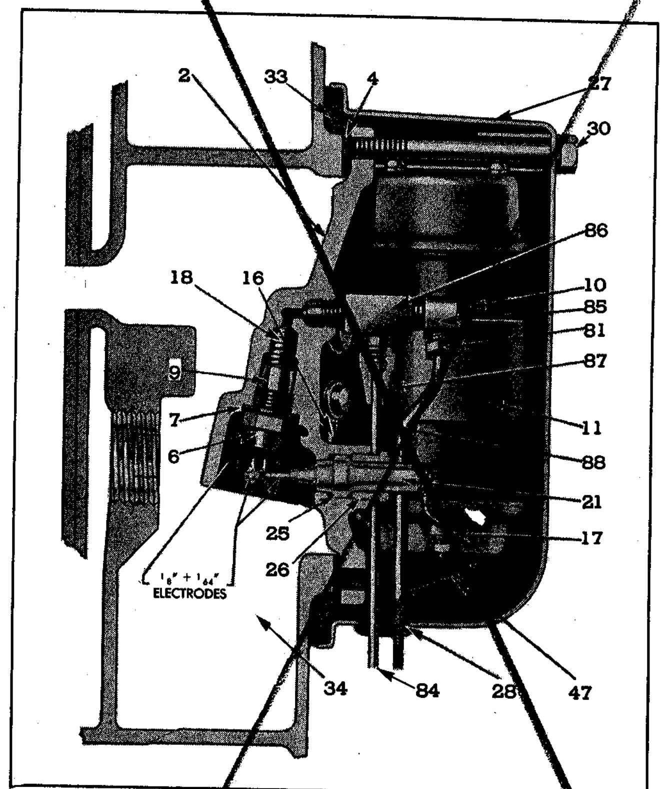

Fig. 16—Air Heater Assembly.

2. Body—Air Heater.
4. Gasket (Cork)—Air Heater Body.
6. Nozzle—Air Heater Spray.
7. Washer—Spray Nozzle.
9. Filter—Spray Nozzle.
10. Coil—Air Heater.
11. Bracket—Coil.
16. Lead—Coil Ground.
17. Lead—Air Heater High Tension.
18. Spring—Fuel Filter.
21. Electrode and Insulator—Air Heater.
25. Gasket—Electrode Insulator.
26. Nut—Electrode.
27. Cover—Air Heater.
28. Grommet.
30. Bolt—Air Heater Cover.
33. Gasket (Felt)—Air Heater Cover.
34. Air Box—Cylinder Block.
47. Wire—Air Heater Pressure.
81. Connector—Fuel Tube.
84. Tube—Air Heater Pump.
85. Elbow—Fuel Tube (at Air Heater).
86. Two-Way Tee—Tube (at Air Heater).
87. Union—Fuel Tube.
88. Tube—Air Heater to Pressure Switch.

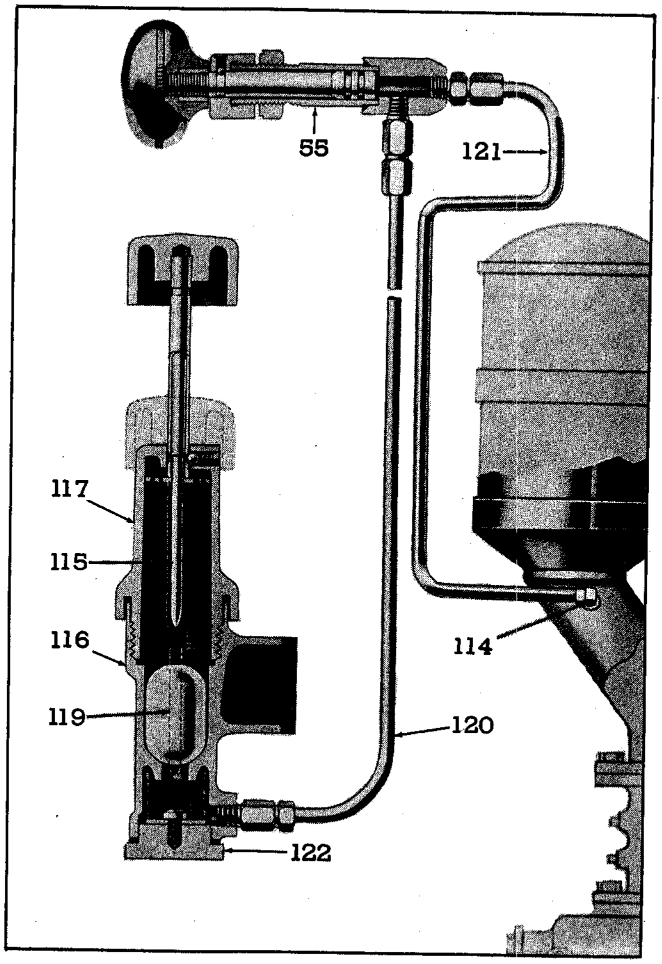

Fig. 17—Schematic Diagram of Fluid Starting Aid.

55. Pump Assy.
114. Nozzle.
115. Piercing Shaft—Capsule.
116. Container—Capsule.
117. Cap—Capsule Container.
119. Capsule.
120. Tube—Capsule Container to Pump.
121. Tube—Pump to Air Intake Housing.
122. Plug.

plunger in all the way until lock engages.

5. Close air heater valve.

CAUTION: Use air heater for cold weather starting only.

The 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 at the end of each pumping stroke to allow the engine time to absorb the heat generated. At a temperature of 10° F. or lower, it will be beneficial to use the heater for a short time after the engine has started.

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 given in section 4.

The batteries (if current is supplied from batteries) must be maintained in good condition. [redacted].

FLUID STARTING AID

Fluid starting aid, schematically illustrated in Fig. 17, is designed to inject a highly volatile fluid into the air intake system at low ambient temperatures to assist in the ignition of the fuel. The fluid is contained in suitable capsules to facilitate handling.

The fluid starting aid consists of a cylindrical capsule container or chamber with a screw cap, inside of which a sliding, piercing shaft operates. A tube leads from the capsule container to the hand-operated pump and another tube leads from the pump to the atomizing nozzle.

The capsule container should be mounted in a vertical position and away from any heat (exhaust manifold or muffler). The atomizing nozzle is screwed into a tapped hole in the air intake housing.

To operate the fluid starting aid, refer to Fig. 17:

1. Unscrew the cap (117) and insert a 7 c.c. fluid capsule (119) in the container (116).
2. Pull the piercing shaft (115) all the way out and screw the cap tightly on the container.
3. Push the piercing shaft down. This will break the capsule and fill the container with starting fluid.
4. Move engine throttle to **full fuel** position.
5. Engage the starter and simultaneously pull pump plunger out, then push the plunger in slowly, thus forcing the starting fluid through tube (121) and nozzle (114) into the air intake. Continue to push the pump plunger in and, when the engine starts, push the plunger in until it locks in the IN position.
6. Unscrew the cap (117) from container and remove the used capsule.

   Do not leave empty capsule in the container.

7. Screw cap back on the container.

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

The cold weather fluid starting aid should require very little service. Leakage in the pump is usually the result of worn plunger seal rings, which can be corrected by installing new seal rings.

The nozzle is relatively trouble-free; but a plugged nozzle is usually indicated by excessive resistance to pumping and may be remedied by breaking the tube-to-nozzle connection, then removing and cleaning the nozzle.

POWER TRANSMISSIONS

This manual includes information for the convenience of the Operator on the lubrication and preventive maintenance of the transmissions. It also includes cross sectional views and adjustment procedures covering some of the more common power transmissions.

Problems relating to the repair and overhaul of these transmissions should be referred to an authorized Detroit Diesel Distributor or Dealer.

G. M. POWER TAKE-OFF

The power take-off units used on Series 71 engines are basically similar in design, varying in clutch size to meet the requirements of a particular application.

The direct drive power take-off unit illustrated in Fig. 1 is attached to the engine flywheel housing and consists of a single-plate, dry-disc clutch bolted to the engine flywheel (157) and a drive shaft (16), driven by the clutch and mounted in a single-row or a double row clutch pilot ball bearing (22) at the forward end and tapered roller bearings (58), mounted in the clutch housing (1) near the outer end. The pilot bearing also aligns the shaft at the forward end.

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, 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 inspection hole cover (4) to expose the clutch adjusting ring (30).
3. Insert end of long bar in notch of adjusting ring (30) and, while applying sufficient pressure on the hand lever (50) to prevent clutch from turning, turn adjusting ring by prying over edge of inspection hole in the clutch housing.

   NOTE 1: On 8", 10" and 11½" diameter clutches turn adjusting ring anti-clockwise to tighten.

   NOTE 2: On 14" diameter clutches turn adjusting ring clockwise to tighten.

4. Turn the adjusting ring until a heavy pressure is required at the 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 inspection hole cover.

Bearing Adjustment — Adjustment for wear of the drive shaft bearings should be done as follows:

1. Remove inspection hole cover (4).
2. Loosen lock plate bolt (61) to free bearing retainer (59).
3. Place end of a long bar in 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).

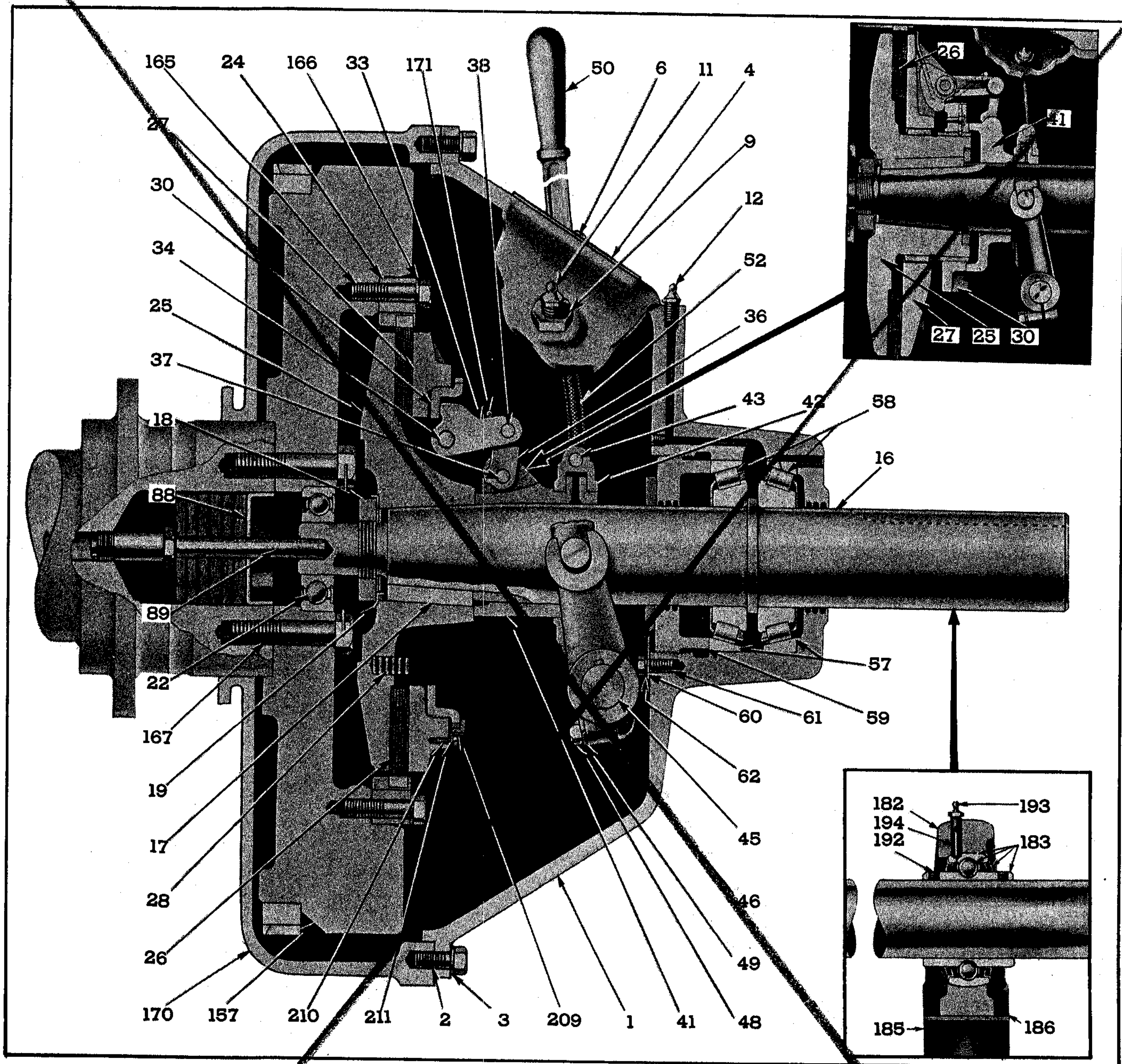

Fig. 1—G. M. Power Take-Off Assembly.

1. Clutch Housing.
2. Bolt—Clutch Housing to Engine.
3. Lock Washer.
4. Cover—Clutch Inspection Hole.
6. Screw—Inspection Hole Cover.
9. Nut—Retainer—Flexible Tube to Housing.
11. Fitting—Grease.
12. Fitting—Grease.
16. Shaft—Clutch Drive.
17. Key—Clutch 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—Pressure Plate Separator.
30. Ring—Clutch Adjusting.
33. Lever—Clutch Release (Toggle).
34. Pin—Release Lever-to-Pressure Plate.
36. Link—Clutch Release Lever.
37. Pin—Release Lever Link-to-Sleeve.
38. Pin—Release Lever-to-Link.
41. Sleeve—Clutch Release.
42. Collar Assy—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 Tube Assy.
57. Cup—Roller Bearing.
58. Cone—Roller Bearing.
59. Retainer—Bearing.
60. Lock Plate—Bearing Retainer.
61. Bolt—Retainer Lock Plate.
62. Lock Washer.
88. Baffle—Crankshaft Grease.
89. Oil Wick—Pilot Bearing.
157. Flywheel Assy.
165. Bolt—Driving Ring-to-Flywheel.
166. Lock Washer.
167. Bolt—Flywheel.
170. Flywheel Housing.
171. Spring—Clutch Release Lever (Holdback).
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—Grease.
194. Pin—Pillow Block Bearing Nut.
209. Lock—Adjusting Nut.
210. Screw—Lock Retaining.
211. Lock Washer.

POWER TRANSFER GEAR

Figure 2 illustrates a typical power transfer gear used on Series 71 twin engine units. The transfer gear is connected to the engines by means of mechanical clutches on industrial units and by General Motors hydraulic marine gears on marine units.

Power of the two engines is transmitted through the clutches or hydraulic marine gears to the drive gears (49), thence through a common driven gear (60) to the power driven shaft (59). The power shaft of marine transfer gears is carried in a single row ball bearing at the front end and a double row ball bearing at the rear end. A roller bearing supports the front end of the driven shaft in industrial transfer gears while single row ball or double row tapered bearings support the rear end, depending upon the application.

Three different power driven shaft adaptations are available in the twin engine transfer gear for industrial units:

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

CLUTCH

The clutch used on twin engine units is illustrated in Fig. 2. 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).

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 a clutch is installed, be sure the two shims are used on each clutch-to-flywheel bolt.**

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

The clutch hand levers, are pushed toward the center of the unit to engage the clutches and pulled back to the locked position to disengage the clutches.

When the clutch hand lever is moved forward, yoke (27) moves sleeve (134) on guide (31) toward engine. This movement causes the clutch spring (131) to bear against pressure plate (148), thus compressing the driven disc (149) between the engine flywheel and clutch pressure plate.

Since the driven disc is splined to shaft (46), it will drive this shaft at engine speed whenever the clutch is in the 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 inserting pin provided in the hole in clutch lever quadrant.

Clutch Adjustment—The clutches used in twin industrial units require no adjustment, as such; however, when the facings on the clutch disc have worn so that the over-all thickness of the disc and facings is less than $11/32''$, the disc assembly should be changed.

CLUTCH CONTROL

Each clutch is controlled by an individual hand lever mounted on a shaft common to the two levers. The shaft is supported in a bracket which in turn is bolted to the side of the gear box. Clutches are disengaged by pulling the levers away from the engines.

When a clutch is engaged, the lockout latch rides on the lever quadrant and, when the clutch is disengaged, the lockout latch enters a notch in the quadrant and is secured by inserting a lockout pin through holes of lockout latch and lever.

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

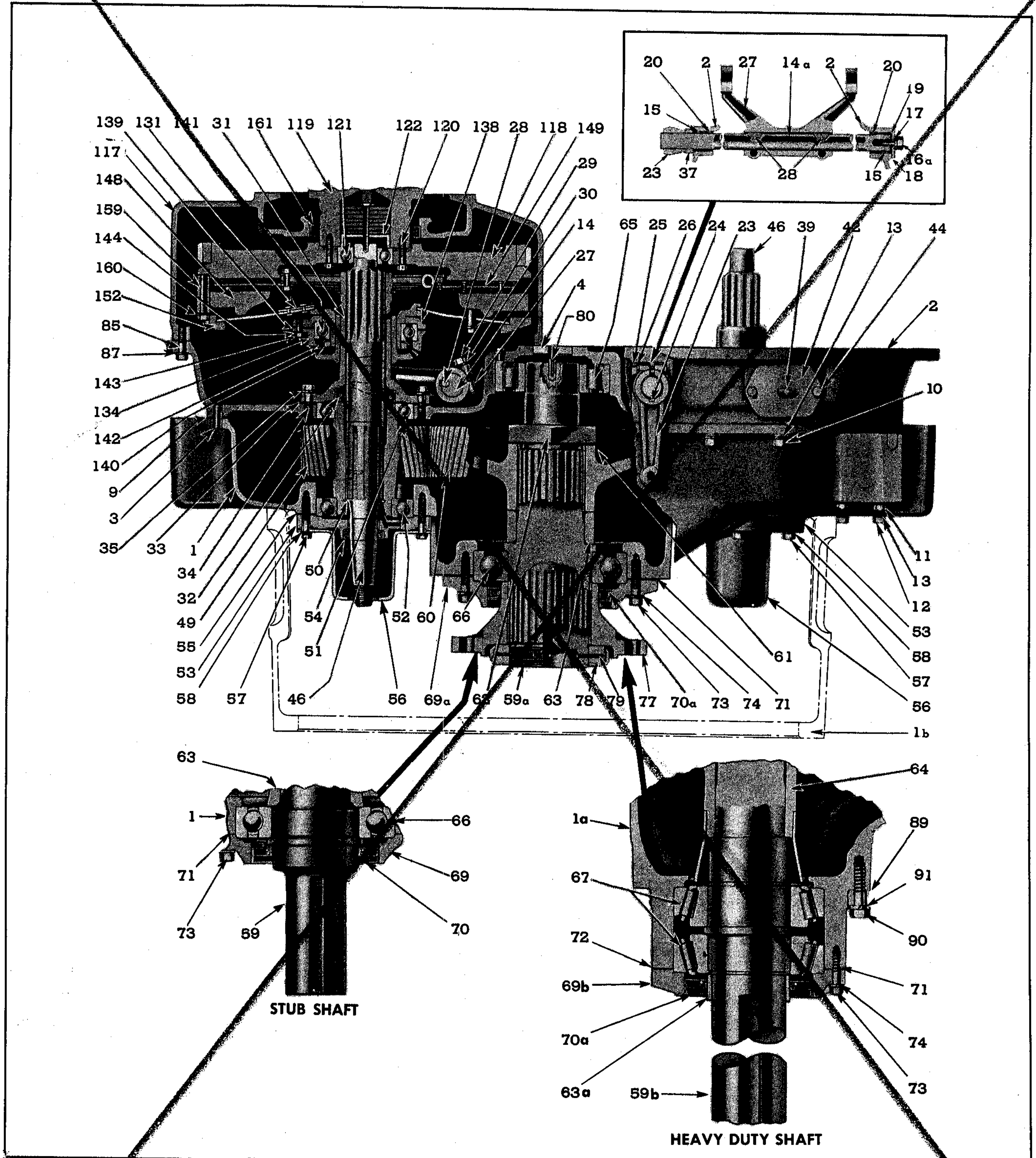

Fig. 2—Twin Engine Power Transfer Gear and Clutch Assembly for Industrial Units.

N-A.

Fig. 2—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. Housing—Clutch.
3. Dowel Pin.
4. Plug—Driven Shaft Cover.
9. Gasket—Gear Housing.
10. Bolt—Gear Housing to Clutch Housing—(⅜"—16 x 1¼").
11. Bolt—Gear Housing to Clutch Housing—(⅜"—16 x 4½").
12. Bolt—Gear Housing to Clutch Housing—(⅜"—16 x 5").
13. Lock Washer.
14. Shaft—Clutch Shifter.
14a. Shaft—Clutch Shifter.
15. Bearing—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.
35. Lock Washer.
37. Collar—Shifter Shaft.
39. Fitting—Release Bearing Grease.
42. Cover—Inspection Hole.
44. Bolt—Cover.
46. Shaft—Power Drive.
49. Gear—Power Drive.
50. Snap Ring—Drive Gear.
51. Bearing—Drive Gear—Front.
52. Bearing—Drive Gear—Rear.
53. Cover—Drive Shaft.
54. Oil Seal—Drive Shaft Cover.
55. Gasket—Cover.
56. Cap—Drive Shaft.
57. Bolt—Cover.
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—Driven Gear.
62. Nut—Driven Gear.
63. Spacer—Driven Gear—SS, DF and OH.
63a. Sleeve—Bearing Retainer Oil Seal—HD.
64. Oil Slinger and Spacer Assy.—HD.
65. Bearing—Driven Shaft Pilot.
66. Bearing—Driven Shaft—Rear—SS, DF and OH.
67. Bearing—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—(⅜"—16 x 1⅜").
87. Lock Washer.
89. Support—Power Take-Off—HD.
90. Bolt—Support to Gear Housing—HD.
91. Lock Washer.
117. Housing—Flywheel.
118. Flywheel.
119. Crankshaft.
120. Bolt—Flywheel.
121. Pilot Bearing.
122. Baffle—Crankshaft Grease.
131. Spring and Hub Assy.
134. Sleeve Assy.—Release Bearing.
138. Cover—Release Bearing Sleeve.
139. Gasket—Sleeve Cover.
140. Nut—Release Bearing.
141. Bearing—Clutch Release.
142. Lock Washer.
143. Bolt—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).

Clutch Control Adjustment—If the clutch control links are replaced or the adjustment changed, readjust as follows:

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

N.A.

QUAD REDUCTION GEAR

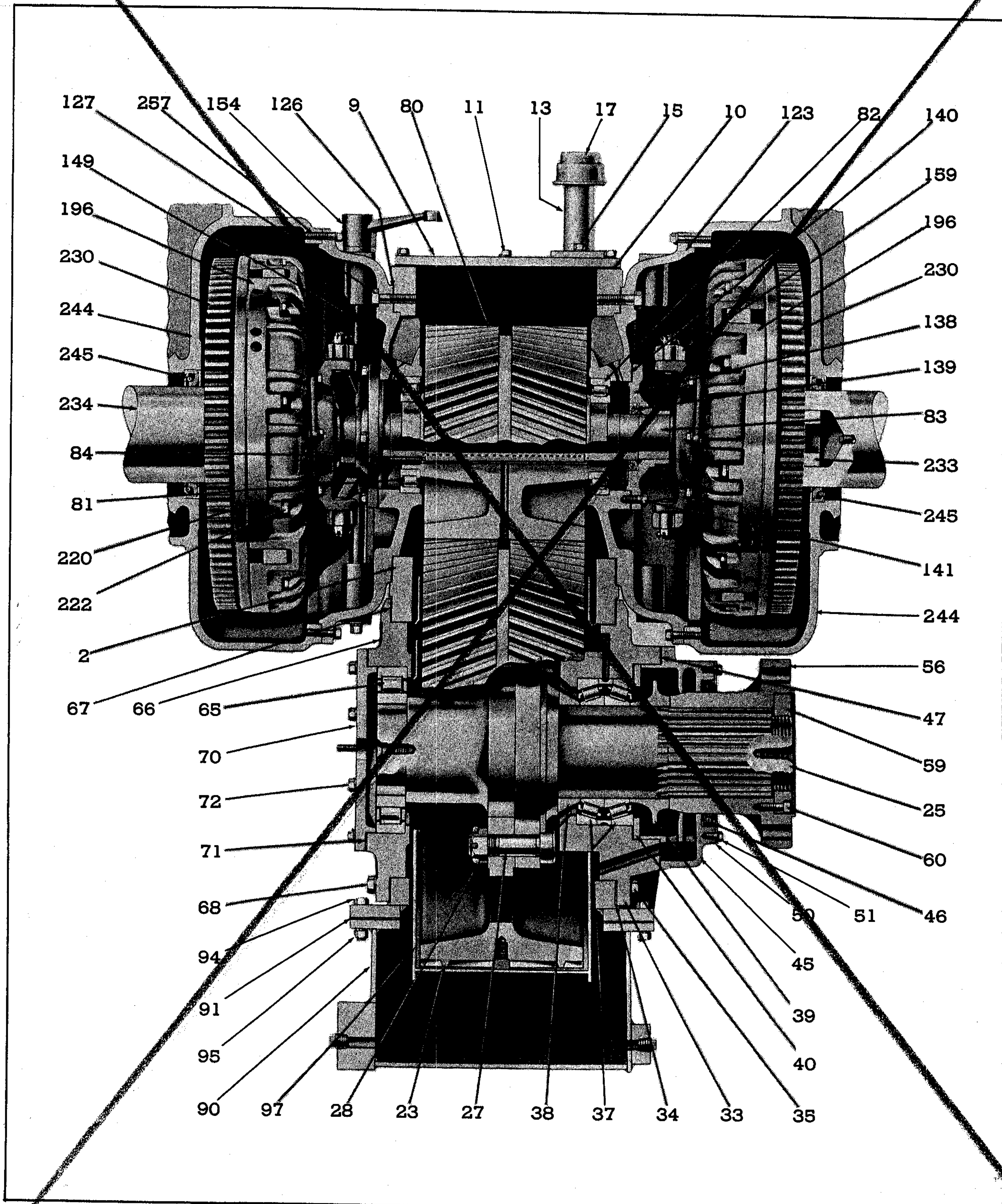

Fig. 3—Quad Engine Reduction Gear and Clutch Assembly.

N.A.

Fig. 3—Quad Engine Reduction Gear and Clutch Assembly.

2. Housing—Reduction Gear.
9. Cover—Gear Housing.
10. Gasket—Gear Housing Cover.
11. Bolt—Cover to Gear Housing.
13. Pipe—Oil Filler.
14. Gasket—Oil Filler Pipe.
15. Bolt—Pipe to Cover.
17. Breather Cap.
23. Gear—Power Driven.
25. Shaft—Power Driven.
27. Bolt—Power Driven Gear.
28. Nut—Slotted Hex.
33. Cage—Roller Bearing (Rear).
34. Gasket—Bearing Cage.
35. Bolt—Bearing Cage.
37. Bearing—Roller (Rear).
38. Spacer—Roller Bearing (Inner).
39. Slinger and Spacer—Oil.
40. Adaptor—Bearing (Spacer).
45. Retainer—Oil Seal.
46. Oil Seal—Retainer.
47. Gasket—Oil Seal Retainer.
50. Plate—Oil Seal Retaining.
51. Bolt—Retaining Plate.
56. Flange—Drive.
59. Nut—Drive Flange Retaining.
60. Screw—Drive Flange Lock.
65. Bearing—Roller (Front).
66. Cage—Roller Bearing (Front).
67. Gasket—Bearing Cage.
68. Bolt—Bearing Cage.
70. Cover—Bearing Cage End.
71. Gasket—End Cover.
72. Bolt—End Cover.
80. Gear—Drive Pinion.
81. Bearing—Pinion Gear Roller (Front).
82. Bearing—Pinion Gear Roller (Rear).
83. Shaft—Pinion Drive.
84. Key—Pinion Drive Shaft.
90. Oil Pan (Outer).
91. Gasket—Oil Pan.
94. Bolt—Oil Pan.
95. Nut.
97. Oil Pan (Inner).
123. Clutch Housing—R.H.
126. Gasket—Clutch Housing to Gear Housing.
127. Bolt—Clutch Housing to Gear Housing.
138. Guide—Clutch Release Bearing Sleeve.
139. Oil Seal—Sleeve Guide.
140. Gasket—Sleeve Guide.
141. Bolt—Sleeve Guide.
149. Shaft—Clutch Shifter.
154. Lever—Shifter Shaft.
159. Yoke—Clutch Shifter.
196. Clutch Assy.
220. Shim—Clutch Cover to Flywheel.
222. Bolt—Clutch to Flywheel.
230. Flywheel.
233. Pilot—Clutch Hub.
234. Crankshaft.
244. Flywheel Housing.
245. Oil Seal—Flywheel Housing.
257. Bolt—Clutch Housing to Flywheel.

The reduction gear assembly illustrated in Figure 3 is used on industrial quad units and is mounted to the four 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 engines.

A similar reduction gear, differing only in certain internal details, is used on marine quad units. On the marine units, however, the gear box is connected to the engines by General Motors hydraulic reverse gears.

N.A.

GENERAL MOTORS HYDRAULIC MARINE GEAR

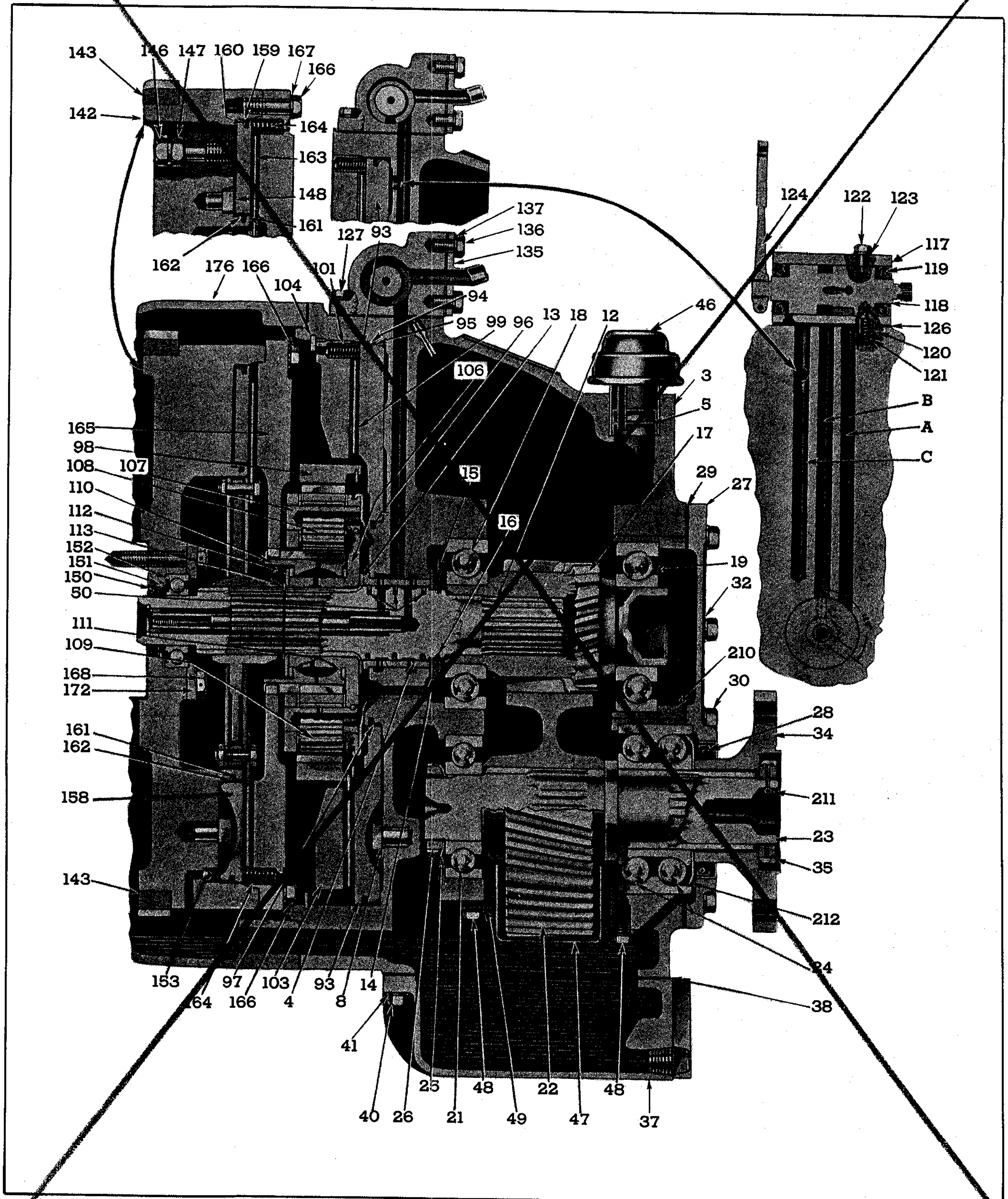

Fig. 4—Typical Hydraulic Marine Gear Assembly—M Gear Shown.

N.A.

The General Motors hydraulic marine gear is used on both single and multiple engine marine units. When used on single engine units, the marine gear consists of a reverse gear section and a reduction gear section. This gear is produced in two different models, "M" and "MH", each being available in several gear ratios. These two models are basically similar and are typically illustrated in Fig.4.

The reverse gear section of the hydraulic marine gear is used on multiple engine units, in conjunction with either a transfer gear case, similar to that shown in Fig. 2, or a reduction gear for quad units similar to that shown in Fig. 3.

Oil for operating the hydraulic clutches and for lubricating the reverse gear is contained in the reverse gear sump and is circulated throughout the system by a hydraulic oil pump mounted on the flywheel housing and driven from the blower drive shaft through a flexible coupling.

Pump pressures, indicated on the hydraulic gear oil pressure gauge, for reverse gears operating at 500 engine r.p.m. should read approximately 80 lbs. per sq. in. and at maximum engine r.p.m. should read approximately 125 lbs. per sq. in.

A strainer is introduced between the oil sump and the pump to remove harmful solids. From the pump the oil passes through a cooler, then through a pipe connected to the control valve and the reverse gear with a pressure regulator valve at the discharge into the reverse gear. The pressure regulator valve insures constant oil pressure to operate the reverse gear at all times.

Lubrication of the marine gear is partly by pressure and partly by splash. The moving parts of the reverse gear are lubricated by oil under pressure from the hydraulic oil pump whenever the engine is running while the reduction gear dips in at all times.

The reverse gear is lubricated with the same heavy-duty oil that is used in the driving Diesel engine. For vessels equipped with keel cooling, SAE 30 oil is recommended for all operating conditions.

Oil level should be checked at each change of shift or daily. For horizontal applications, keep oil level to FULL mark on the bayonet oil gauge; otherwise, oil level should be raised $\frac{1}{16}$" above the FULL mark per degree of angularity. If propulsion unit is set at an angle, a true FULL mark may be established on the bayonet oil gauge after the ship is water-borne. Renew the oil in the reverse gear each time the oil is renewed in the Diesel engine.

If for any reason the clutches cannot be engaged hydraulically, the forward drive may be engaged with six bolts (146), Fig. 4, as follows:

1. Remove a large pipe plug from the forward face of the flywheel housing (176).

Fig. 4—Typical Hydraulic Marine Gear Assembly—M Gear Shown.

3. Housing—Reverse Gear.
4. Sleeve—Oil Transfer.
5. Nipple—Oil Filler.
8. Pin—Clutch Drive.
12. Shaft—Reverse Gear Drive.
13. Washer—Thrust.
14. Washer—Drive Shaft Thrust.
17. Gear—Drive Pinion.
18. Bearing—Pinion Gear (Front).
19. Bearing—Pinion Gear (Rear).
21. Bearing—Power Driven Shaft Ball (Front).
22. Gear—Power Driven.
23. Shaft—Power Driven.
24. Bearing—Power Driven Shaft Ball (Rear).
25. Lock Washer.
26. Nut—Ball Bearing Retaining.
27. Cover—Reduction Gear Bearing.
28. Oil Seal—Bearing Cover.
29. Gasket—Bearing Cover.
30. Bolt—Bearing Cover.
31. Lock Washer.
34. Flange—Drive.
35. Nut—Drive Flange.
37. Sump—Reduction Gear Oil.
38. Gasket—Oil Sump.
40. Bolt—Oil Sump.
41. Lock Washer.
46. Cap—Oil Filler (Breather).
47. Baffle—Oil Sump.
48. Bolt—Oil Sump Baffle.
49. Lock Washer.
50. Ring—Drive Shaft Oil Seal.
93. Piston—Reverse Clutch.
94. Seal Ring—Reverse Clutch Piston (Outer).
95. Expander—Piston Seal Ring (Outer).
96. Seal Ring—Reverse Clutch Piston (Inner).
97. Expander—Piston Seal Ring (Inner).
98. Gear—Reverse Ring.
99. Plate—Reverse Clutch.
101. Spring—Clutch Release.
103. Plate—Reverse Clutch Drive.
104. Snap Ring—Driving Plate.
106. Carrier—Reverse Planet.
107. Shaft—Reverse Planet Gear.
108. Gear—Reverse Planet.
109. Gear—Reverse Planet.
110. Gear—Reverse Sun.
111. Washer—Sun Gear Thrust.
112. Washer—Planetary Gear Retaining.
113. Snap Ring—Planetary Retaining Washer.
117. Housing—Control Valve.
118. Selector—Control Valve.
119. Seal—Selector Valve Oil.
120. Poppet—Control Valve.
121. Spring—Control Valve Poppet.
122. Screw—Control Valve Locating.
123. Washer—Locating Screw.
124. Lever—Control Valve Selector.
126. Gasket—Control Valve Body.
127. Bolt—Control Valve Body.
135. Flange—Control Valve Oil Tube.
136. Bolt—Oil Tube Flange.
137. Lock Washer.
142. Flywheel.
143. Ring Gear—Flywheel.
144. Plug—Oil Passage.
146. Bolt—Emergency Engagement.
147. Nut—Engagement Bolt Jam.
148. Pin—Clutch Drive.
150. Seal—Flywheel Oil.
151. Ring—Oil Seal Retaining.
152. Bearing—Flywheel Pilot.
153. Valve—Forward Clutch Dump Ball Type.
158. Piston—Forward Clutch.
159. Seal Ring—Forward Clutch Piston (Outer).
160. Expander—Piston Seal Ring (Outer).
161. Seal Ring—Forward Clutch Piston (Inner).
162. Expander—Piston Seal Ring (Inner).
163. Plate—Forward Clutch.
164. Spring—Clutch Release.
165. Plate—Forward Clutch Drive.
166. Bolt—Forward Clutch Drive Plate.
167. Lock Washer.
168. Bolt—Flywheel.
172. Plate—Flywheel Pilot Bearing Retaining.
176. Housing—Flywheel.
210. Spacer—Pinion Bearing.
211. Cotter Pin.
212. Slinger—Ball Bearing Oil.

2. With throttle in STOP position, rotate the flywheel until one of the bolts (146), Fig. 4, aligns with the opening in the flywheel housing from which the plug was removed.
3. Remove bolt (146) being careful not to loose jam nut (147) when removing bolt.
4. Remove and save jam nut (147); then screw bolt back into flywheel **finger-tight only.**
5. Remove the remaining five bolts (146) and jam nuts (147) in the same manner, and screw bolts in place, finger-tight only.
6. Again, starting on the first bolt, tighten all six bolts **uniformly**, thus locking clutch plate (163) between piston (158) and drive plate (165). Install pipe plug in flywheel housing.

***NOTE 1:** The six bolts (146) must be tightened uniformly to prevent bind between the close-fitting piston (158) and the bore in the flywheel.*

***NOTE 2:** If emergency bolts are in use, reverse cannot be used. If attempted, the reverse gear will be damaged.*

***NOTE 3:** Whenever the forward clutch is engaged with the emergency bolts at least one additional gallon of oil should be poured into the gear box to eliminate the possibility of overheating the gear box when the hydraulic oil pump is not running.*

TORQUE CONVERTERS

A torque converter transfers and multiplies the torque of the prime mover by the action of oil within the converter. The General Motors torque converter, in addition to possessing this torque multiplying characteristic, operates as a fluid coupling. The converter transmits power from the prime mover to automotive or stationary equipment and will automatically adjust the output torque to the load requirements. The converter has adequate and efficient power drive for all operations where the torque demand requires torque multiplication within the series range of operation.

General Motors torque converters can be obtained in various combinations of the following features: automotive or industrial shaft, hydraulically operated lock-[redacted] input disconnect clutch, hydraulically operated output disconnect clutch, and an accessory drive for either a governor or tachometer.

REDUCTION GEAR FOR MARINE SIDE-BY-SIDE TWIN UNITS

Two hydraulic marine gears are mounted on the forward side of the reduction gear used with side-by-side twin marine units. Each reverse gear drive shaft is splined to and drives a pinion gear and the two pinion gears mesh with a common power driven gear which is bolted to a driven shaft. A flange is provided at the aft end of the power driven shaft for coupling a propeller shaft.

REDUCTION GEAR FOR MARINE TANDEM TWIN UNITS

A hydraulic marine gear is mounted on the forward and aft side of the reduction gear used with tandem twin marine units. Each reverse gear drive shaft is splined to and drives a pinion gear and the two pinion gears mesh with a common power driven gear which is bolted to a driven shaft. A flange is provided at the aft end of the power driven shaft for coupling a propeller shaft.

OPERATION AND MAINTENANCE

OPERATING INSTRUCTIONS

PREPARATION FOR STARTING ENGINE FIRST TIME

Before starting an engine the first time, the operator should carefully read and follow the instructions in this manual. 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 complete overhaul, perform all of the operations listed below. Before a routine start, see "BEFORE STARTING" on page 3.

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

Cooling System—Install all drain cocks in the cooling system. Drain cocks are removed for shipping.

Open cooling system vent, if unit is so equipped.

Remove filler cap and fill cooling system with clean, soft water or with a protecting solution of a non-evaporating type of anti-freeze if the unit will be exposed to below freezing temperatures. The liquid level 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.

Close cooling system vent after filling, if unit is so equipped.

~~On marine installations, prime the raw water cooling system and open any sea cocks in raw water intake line.~~

Lubricating System—Remove rocker cover and pour approximately two quarts of lubricating oil (of the same viscosity as that used in the engine crankcase) over the rocker arms and push rods.

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

Use only **Heavy-Duty** lubricating oils, as specified under "LUBRICATING OIL SPECIFICATIONS" in this section.

Transmission—Fill transmission to proper level with lubricating oil as specified under "LUBRICATION AND PREVENTIVE MAINTENANCE" in this section.

Fuel System—Fill the fuel tank with Diesel engine fuel as specified under "FUEL OIL SPECIFICATIONS" in this section.

Open fuel supply valve, if unit is so equipped.

To ensure prompt starting, at least that portion of the fuel system between the pump and the fuel return manifold should be filled with fuel. The fuel oil filter (between the fuel pump and the injectors) on any engine that has been out of service a considerable length of time, should be primed. To prime a filter, remove the vent plug in top of filter cover and pour fuel slowly through the opening 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.

CAUTION: Use fuel tanks of black iron or terneplate. Never use a fuel tank made of galvanized iron.

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

Drive Belts—Adjust all drive belts, such as fan and battery charging generator belt, to proper tension.

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

Clutch—Make sure clutch ~~or clutches are~~ disengaged, if unit is so equipped.

STARTING

Before starting an engine the first time, perform the operations listed under "PREPARATION FOR STARTING ENGINE FIRST TIME".

Before a routine start, see "BEFORE STARTING" in this section.

Place the throttle in IDLE 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 the engine fails to start, DO NOT re-press button until after cranking motor stops rotating. Serious damage to cranking motor may result if the above rule is not followed.

If the engine does not start after four periods of cranking, see TROUBLE SHOOTING CHART 1 in this section.

Starting at air temperatures below 40° F. requires the use of a cold starting aid. See STARTING AIDS in section 2.

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. See TROUBLE SHOOTING CHART 3 in this section.

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

If the 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—Immediately after starting, observe the oil pressure as indicated on pressure gauge. The pressure should not fall below 30 pounds at operating speed, and normal pressure should be higher.

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

Engine Temperature—Under normal operating conditions, the coolant temperature should range between 160° and 185° F. with a corresponding oil temperature of 200° to 235° F.

Crankcase—After the normal operating temperature has been reached, stop engine and check the oil level. Replenish to FULL mark on the dipstick.

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

Use only specially compounded **Heavy-Duty** lubricating oils as specified under "LUBRICATING OIL SPECIFICATIONS" in this section.

Cooling System—After the engine has reached its normal operating temperature, remove the radiator ~~or heat exchanger~~ cap slowly and check level of coolant. Level should be near top with engine at operating temperature. Add sufficient soft water or permanent type anti-freeze to bring coolant to proper level.

STOPPING

Throttle—Release the load and at the same time decrease engine speed. Allow the engine to run at half speed or lower with no-load for four or five minutes before closing the throttle and stopping engine.

Fuel System—Close valves in fuel lines.

Check the amount of fuel oil in the supply tank and replenish as required. A full fuel tank reduces condensation.

Exhaust System—Open drain or valve, if one is used in exhaust line or silencer, to drain condensation.

Cooling System—If there is no anti-freeze in the cooling system and freezing temperatures are anticipated, drain the cooling system and leave drains open. ~~Also open raw water drains of heat exchanger cooled system.~~

Crankcase—Check and replenish oil in the crankcase, as required, to bring to proper level.

Transmission—Check and replenish with specified oil as required to bring to proper level.

Clean Engine—Clean and check unit thoroughly to make certain it will be ready for the next run.

Refer to "LUBRICATION AND PREVENTIVE MAINTENANCE" in this section and perform all daily maintenance operations. Also, perform all operations required for the number of hours the unit has been in operation.

Make any routine adjustments and minor repairs needed to correct difficulties which became apparent to the Operator during the last run.

LUBRICATION AND PREVENTIVE MAINTENANCE

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

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 Preventive Maintenance Instructions listed on these pages are keyed to the chart on page 9 by numbers in the left column of the instructions and on the chart. Example: In the instructions, under "BEFORE STARTING," key number (22) pertains to checking the engine crankcase oil. Key number (22) also appears on the chart.

BEFORE STARTING

KEY NO.	OPERATION	REMARKS
22	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 grade of oil in accordance with the instructions given in "Lubricating Oil Specifications" in this section.
10	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 a good grade commercial inhibitor or permanent type anti-freeze. Check prime on raw water pump (heat exchanger systems); engine should not be operated with a dry pump.
	CHECK FUEL TANK	Do not let fuel tank become empty. Fuel pump will lose its prime and injectors and fuel pump may be damaged. Select the proper grade of fuel in accordance with the instructions given in "Fuel Oil Specifications" in this section.
	CHECK FUEL SUPPLY VALVES	See that fuel supply valves are open.
	CHECK CLUTCH CONTROLS	Make sure clutch is disengaged before starting or stopping engine.
23	CHECK OIL IN HYDRAULIC MARINE GEAR	Oil level should be to FULL mark on dipstick. Use SAE 30W oil when sea water temperature is above 60°F., SAE 20W oil between 45°F. and 60°F., and SAE 10W oil below 45°F.*
	CHECK OIL IN TORQUE CONVERTER	Oil level should be to FULL mark on dipstick. Use hydraulic transmission fluid, type C, and, if not available, use SAE 10 oil.*
~~29~~	~~CHECK OIL IN TRANSMISSION GEAR CASE (Multiple Engine Units)~~	~~Oil level should be to FULL mark on dipstick. Industrial units, use same viscosity oil as is used in the engine. In marine units, use SAE 30W oil when sea water temperature is above 60°F., SAE 20W oil between 45°F. and 60°F., and SAE 10W oil below 45°F.*~~
	CHECK OIL IN REDUCTION GEAR CASE (Single Engine Industrial Units with 1.76 to 1 ratio)	Oil level should be to FULL mark on dipstick. Use SAE 90 or 110 oil.

*Heavy Duty oil, see Lubricating Oil Specifications in this section.

EVERY 8 HOURS

KEY NO.	OPERATION	REMARKS
	FIRST PERFORM ALL OPERATIONS LISTED UNDER "BEFORE STARTING"	
27	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 aid drainage. Close drain cock and tighten vent.
7	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 aid drainage. Close drain cock and tighten vent.
	CHECK OIL IN TORQUE CONVERTER	Check oil level with torque converter operating. Oil level in converter oil supply tank should be to FULL mark on dipstick. Use hydraulic transmission fluid type C, and, if not available, use SAE 10 oil.*
18	LUBRICATE CLUTCH THROWOUT BEARING	The clutch throw-out bearing should be lubricated after every 8 hours of operation. Use short fibre, high grade, ball bearing lubricant. One or two strokes of pressure gun should be sufficient. Lubricate sparingly to avoid grease on clutch facings.
11	SERVICE AIR CLEANERS	Remove dirty oil and sludge from cup. Wash cup in clean fuel oil and refill with engine oil to level indicated on cup. Do not add oil above oil level ring. Clean metal elements by washing in clean fuel oil; blow dry before assembly. See instructions on air cleaner. Frequency of servicing may be varied to suit local dust conditions.

EVERY 50 HOURS

KEY NO.	OPERATION	REMARKS
	FIRST PERFORM ALL OPERATIONS PREVIOUSLY LISTED IS THIS LUBRICATION AND PREVENTIVE MAINTENANCE CHART	
18	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.
~~4~~	~~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 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.

*Heavy Duty oil, see Lubricating Oil Specifications in this section.

EVERY 100 HOURS

KEY NO.	OPERATION	REMARKS
	FIRST PERFORM ALL OPERATIONS PREVIOUSLY LISTED IS THIS LUBRICATION AND PREVENTIVE MAINTENANCE CHART	
22	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 given under "Lubricating Oil Specifications" in this section.
8	CHANGE OIL FILTER ELEMENTS	With engine stopped for changing engine oil, remove drain plugs and drain oil from filter shells. Remove shell retaining bolts and shells. Discard used elements. Clean shells and base with fuel oil. Install new elements and gaskets. Check for oil leaks after starting engine. The oil filter elements must be changed every time the engine oil is changed.
15	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" in this section.
	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 the battery.
17	CHECK AIR BOX DRAINS	Air box drains should be open. Place finger over 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 PREVIOUSLY LISTED IS THIS LUBRICATION AND PREVENTIVE MAINTENANCE CHART	
16	LUBRICATE BATTERY-CHARGING GENERATOR	Lubricate at hinged cap oilers with engine oil. Do not lubricate with engine running. Do not over lubricate; 5 or 6 drops is sufficient.
14	LUBRICATE THROTTLE CONTROL MECHANISM	Lubricate pressure fittings, sparingly, with short fibre, high-grade ball bearing grease. Lubricate other control mechanisms as required with engine oil in hand oiler.
	CHANGE OIL IN HYDRAULIC MARINE GEAR (Single Engine Units)	Remove drain plug and drain oil. Install plug and add oil to FULL mark on dipstick. Use SAE 30W oil when sea water temperature is above 60°F., SAE 20W oil between 60°F. and 45°F., and SAE 10W oil below 45°F.*
	CHANGE OIL IN POWER TRANSFER GEAR (Twin Engine Marine Units)	Remove drain plug and drain oil. Flush with light engine oil. Install drain plug and fill to FULL mark on dipstick. Use SAE 30W oil when sea water temperature is above 60°F., SAE 20W oil between 60°F. and 45°F., and SAE 10W oil below 45°F.*
	CHANGE OIL IN REDUCTION GEAR (Twin and Quad Engine Marine Units)	Remove drain plug and drain oil. Flush with light engine oil. Install drain plug and fill to FULL mark on dipstick. Use SAE 30W oil when sea water temperature is above 60°F., SAE 20W oil between 60°F. and 45°F., and SAE 10W oil below 45°F.*
	CLEAN HYDRAULIC MARINE GEAR OIL SCREEN	Remove plug and screen and rinse screen in clean fuel oil, then install.

*Heavy Duty oil, see Lubricating Oil Specifications in this section.

EVERY 500 HOURS

KEY NO.	OPERATION	REMARKS
FIRST PERFORM ALL OPERATIONS PREVIOUSLY LISTED IS THIS LUBRICATION AND PREVENTIVE MAINTENANCE CHART		
7, 27	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.
5	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.
12	CHECK WATER HOSES	Inspect all water hoses for signs of deterioration; replace if necessary.
16	CHECK BATTERY-CHARGING GENERATOR	Remove cover and inspect brushes and commutator for wear.
9, 30	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 TANK	Open fuel tank drain and allow water and sediment to drain off. Close drain tight.
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. Install drain tubes. If engine is equipped with drain tank, open drain cock and drain sediment from bowl. Close drain cock.
15	PERFORM ENGINE TUNE-UP	All adjustments should be checked and any necessary corrections made. See "Tune-Up Procedure" in this section.
21	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.
3	CHECK POWER TAKE-OFF CLUTCH FOR WEAR	If power take-off clutch slippage occurs, adjust clutch as outlined in section 3 of this manual.
19	LUBRICATE POWER TAKE-OFF CLUTCH MECHANISM (Single Engine Units)	Remove inspection (handhole) cover on clutch housing and lubricate toggle and lever joints with engine oil in hand oiler. Lubricate clutch release (shifter) shaft at housing bearing bores with hand oiler.
26	~~LUBRICATE CLUTCH CONTROL MECHANISM (Multiple Engine Units)~~	~~Lubricate points of wear (external levers, bearings, links, etc.) with engine oil in hand oiler.~~
	CHANGE OIL IN TORQUE CONVERTER	Remove drain plug, drain oil from converter, and reinstall drain plug. Fill converter to FULL mark on dipstick with hydraulic transmission fluid, type C; and, if fluid is not available, use SAE 10 oil.* Check oil level after running a few minutes and add as necessary. Engine must be running at idle speed and converter must be operating when checking oil level. Change the oil oftener if it shows traces of dirt or the effects of high operating temperature.

*Heavy Duty oil, see Lubricating Oil Specifications in this section.

EVERY 1000 HOURS

KEY NO.	OPERATION	REMARKS
		FIRST PERFORM ALL OPERATIONS PREVIOUSLY LISTED IS THIS LUBRICATION AND PREVENTIVE MAINTENANCE CHART
2	INSPECT PORTS, LINERS, PISTONS, AND RINGS	Remove handhole 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 the ports are more than 30% restricted, if piston rings are stuck or broken in their grooves, or if pistons or liners are scored, the engine will require attention.*
6	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 system 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 should be reverse flushed preferably by an authorized Detroit Diesel Distributor or Dealer. Do not keep coolant solution containing anti-freeze in the system over the summer period. When draining or filling cooling system, open vent valve at top of thermostat housing. Close vent valve after filling system.
6	INSPECT AND CLEAN HEAT EXCHANGER	Drain system, 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, install the core, using new gaskets at the flange on the outlet side. Flush and refill fresh water system. Remove plug in top of inlet elbow and prime raw water pump before starting engine whenever raw water system is cleaned.
24	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 engine crankcase dipstick opening at the 1000 hour interval immediately after stopping the hot, loaded engine. The crankcase oil temperature should range between 200° and 235°F. If the crankcase oil temperature exceeds this range, the oil cooler, no doubt needs cleaning. Drain system, remove and clean cooler element; then install element and refill system.*
20	INSPECT BLOWER	With engine stopped and battery disconnected, remove air cleaner(s) or silencer(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 plates 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.*
	CHANGE OIL IN REDUCTION GEAR (Single Engine Industrial 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 or SAE 110 transmission oil. This oil change period may be reduced or lengthened according to severity of service.
	CHANGE OIL IN POWER TRANSFER GEAR (Twin Engine Industrial Units)	Remove drain plug and drain oil. Flush with light engine oil. Install drain plug and fill to FULL mark on dipstick with same viscosity grade oil as used in engines. Do not overfill.
	CHANGE OIL IN REDUCTION GEAR (Quad Engine Industrial Units)	Remove drain plug and drain oil. Flush with light engine oil. Install drain plug and fill to FULL mark on dipstick with same viscosity grade oil as used in engines. Do not overfill.

*Consult nearest authorized Detroit Diesel Distributor or Dealer.

**With use of the proper anti-freeze or rust inhibitor, this interval may be lengthened until, normally, this cleaning is done only in the spring and fall. The length of this interval will, however, depend upon an inspection for rust or other deposits on the internal walls of the cooling system.

LUBRICATION AND PREVENTIVE MAINTENANCE

EVERY 2000 HOURS

KEY NO.	OPERATION	REMARKS
	FIRST PERFORM ALL OPERATIONS PREVIOUSLY LISTED IS THIS LUBRICATION AND PREVENTIVE MAINTENANCE CHART	
16, 21	BATTERY-CHARGING GENERATOR AND CRANKING MOTOR	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 by the nearest authorized Detroit Diesel Distributor or Dealer.
13	INSPECT RADIATOR	Inspect outside of radiator core and, if necessary, clean with fuel oil and compressed air. It may be necessary to clean the radiator more frequently where air is exceptionally dirty.

EVERY 5000 HOURS

KEY NO.	OPERATION	REMARKS
	FIRST PERFORM ALL OPERATIONS PREVIOUSLY LISTED IS THIS LUBRICATION AND PREVENTIVE MAINTENANCE CHART	
	GREASE FAN SHAFT BEARINGS	Remove one of the ⅛" pipe plugs and loosen the other to let out trapped air. Add all purpose grease as required to pack cavity between inner and outer shaft bearings. Install pipe plug that was removed and tighten both.

LUBRICATING OIL SPECIFICATIONS

Satisfactory operation of Series 71 engines requires the use of highly detergent **HEAVY-DUTY** lubricants. These oils provide more efficient lubrication, possess greater heat resistance, and counteract sludge formation more effectively than standard motor oils.

Several types of detergent lubricating oils are provided by the petroleum industry to meet the various service requirements of diesel engines.

For engines manufactured by the Detroit Diesel Engine Division **HEAVY-DUTY** lubricating oils of the "Supplement 1" or "S-1" type are recommended. However, if fuel oils having less than 0.5 per cent sulfur content are used, lubricating oils of the MIL-L-2104A, S-1 and S-2 types may be used.

"Supplement 2" or "S-2" lubricating oils are recommended for use at temperatures below 0°F. to offset the increased crankcase contamination.

Lubricating oils of multiple viscosity such as 5W-20 or 10W-30 should not be used.

For Series 71 engines 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

All mineral oils deteriorate in service; therefore, it is necessary to change the crankcase oil at regular intervals to dispose of acidic and resinous materials formed. The frequency of these oil changes depends upon the quality of the lubricant, engine service requirements, and the efficiency of filtration. Therefore, it is recommended that new engines be started with 100 hour oil change periods.

Flushing oils or solvents should not be used in these engines.

Heavy-duty detergent lubricating oil will appear dark colored in use due to its ability to hold carbon particles in suspension. Therefore, the color of the oil must not be used as an indicator of oil cleanliness or proper filter action. The removal of dirt, metal, and carbon particles must be ensured by replacement of the oil filter elements at each oil change.

Selection of a reliable supplier, strict adherence to his oil change period recommendations, and proper filter maintenance will ensure trouble-free lubrication.

Any changes in lubricating oil specifications will be contained in Service Form 7SE99.

FUEL OIL SPECIFICATIONS

The quality of the fuel oil used for high-speed diesel engine operation is a dominating factor in satisfactory engine operation.

Distillation range, cetane rating, and sulfur content are the three most important properties of high-speed diesel fuel oils. Therefore, to permit efficient combustion and avoid excessive carbon formation, the fuel oil selected must meet the specifications outlined in Table 1.

The variety of fuel oils available for diesel operation is divided into four classes with their main properties listed in Table 1.

Since the air intake temperature and the type of operation have an effect upon combustion, the proper class of fuel oil should be selected from Table 2.

TABLE 1

DISTILLATION			CETANE RATING	SULFUR CONTENT
CLASS	90% BOILING POINT (MAX.)	FINAL BOILING POINT (MAX.)	(MIN.)	(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	1.00% *

TABLE 2

TYPE OF ENGINE APPLICATION	AMBIENT AIR TEMPERATURE			
	Above +80°F	Above +40°F	Above 0°F	Above −20°F
~~Marine~~	~~C~~	~~B~~	~~B~~	~~A~~
Industrial and ~~Railroad 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 used.

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

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

ENGINE TUNE-UP PROCEDURE—SINGLE ~~AND MULTIPLE~~ ENGINE UNITS

Approximately 100 hours after the first start or after overhaul, and at 500 hour intervals thereafter, the various adjustments of the engine should be checked and the necessary corrections made.

Three types of governor are used on the Series 71 engines. Each type of governor has characteristics different from the others; therefore, the tune-up procedure for the three types will vary.

The three types of governor are:

1. Limiting Speed Mechanical—Single-Weight.
2. Variable Speed Mechanical.
3. Hydraulic.

The tune-up procedures outlined in this section apply to the individual engines of multiple engine units in addition to single engine units. The throttle linkage of multiple units must be adjusted after the individual engines have been tuned-up. Engine Tune-Up Set J 4756-B provides those tools required for performing engine tune-up.

TUNE-UP PROCEDURE FOR ENGINE UNITS WITH LIMITING SPEED SINGLE-WEIGHT MECHANICAL GOVERNORS

All changes and adjustments must be made **only after an engine has reached its normal operating temperature.** Since the adjustments are normally made with the engine stopped, it may be necessary to run the engine between adjustments to prevent it from cooling off excessively. The various adjustments should be made in the following sequence:

1. Adjust Valve Clearance.
2. Time Fuel Injectors.
3. Adjust Governor Gap.
4. Position Injector Rack Control Levers.
5. Adjust Maximum No-Load Speed.
6. Adjust Idle Speed.
7. Adjust Buffer Screw.

Adjust Valve Clearance — Clearance between the valve rocker arm and the exhaust valve stem should be set at .009″ with the **engine at normal operating temperature. Maintenance of normal operating temperature is particularly important when adjusting valve clearance.** If the engine is allowed to cool off before setting any of the valves, the clearance, when running at full load, may become too small. Insufficient valve clearance will result in the loss of compression, misfiring of cylinders and eventual burning of the valves and valve seats. Excessive clearance will result in noisy operation, especially in the low speed range.

All valve clearances can be adjusted in sequence of firing order during one full revolution of the crankshaft. For firing order, refer to general specifications in section 1.

Some mechanics may prefer to adjust the valve clearance with the engine running at idle speed. If this method is used, extreme care must be exercised by the mechanic to prevent bending the valve.

Before changing any of the following settings, make certain the adjustment is necessary.

1. Place governor control lever (21), Fig. 5, in the NO FUEL position.

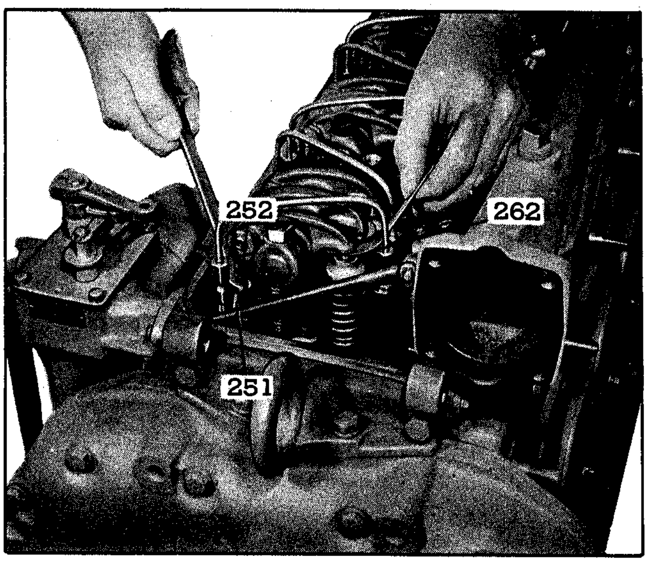

Fig. 2—Adjusting Valve Clearance— Feeler Gauge KMO 233.

251. Rod—Push.
252. Lock Nut.
262. Gauge—Feeler—Tool KMO 233.

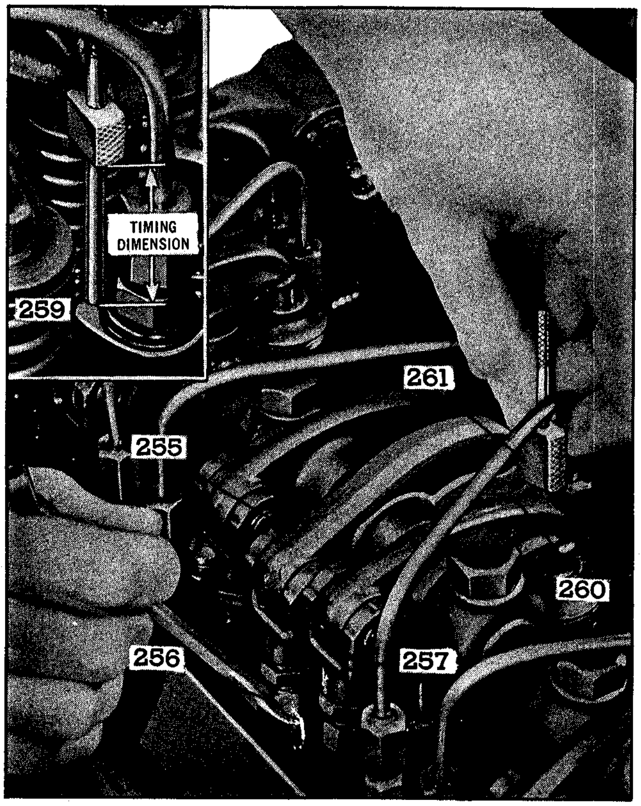

Fig. 3—Timing Fuel Injectors.

255. Arm—Injector Rocker.
256. Rod—Push.
257. Lock Nut.
259. Injector—Fuel.
260. Follower—Injector.
261. Gauge—Injector Timing.

2. Turn crankshaft in the **direction** of **engine rotation** until the injector follower for number one cylinder is **fully depressed.**

3. Refer to Fig. 2 and loosen push rod lock nut (252).

4. Place the .010" end of feeler gauge (262) between the end of valve stem and rocker arm. Adjust push rod (251) to obtain a smooth "pull" of the feeler gauge.

5. Remove feeler gauge. Hold push rod with 5/16" wrench and tighten lock nut with ½" wrench.

6. Recheck clearance with feeler gauge. At this time, an .008" feeler gauge should pass between the end of the valve stem and valve rocker arm and the .010" feeler should not pass through. Readjust if necessary.

7. Check and adjust the remaining valves as outlined in items 1 through 6.

Time Fuel Injectors—To properly time the injectors, the injector follower must be adjusted to a definite height in relation to the injector body.

All injectors can be timed in sequence of firing order during one full revolution of the crankshaft.

1. Place governor control lever (21), Fig. 5, in the NO FUEL position.
2. Turn crankshaft, **in direction of engine rotation,** until the exhaust valves for number one cylinder are fully depressed.
3. Place small end of injector timing gauge (261) in hole provided in the top of injector body, with flat of gauge toward the injector follower (260) as shown in Fig. 3.
4. Loosen push rod lock nut (257).
5. Turn push rod (256) and adjust injector rocker arm (255) until the **extended part of the gauge will just pass over the top of the injector follower.**
6. Hold push rod and tighten locknut. Check adjustment and readjust if necessary.
7. Time remaining injectors as outlined in items 1 through 6.

Injector	Timing Gauge
Capacity-cu.mm.	Tool No.
60	5164385 (J1242)
70	J1853
80	J1853

Timing Gauge Chart for Injectors Used in Series 71 Engines.

Adjust Governor Gap — With engine at operating temperature, the governor gap may be set as follows:

1. With engine operating, loosen idle speed adjusting screw lock nut (56). Turn idle screw (55) to obtain the recommended idle speed.

   The recommended idle speed is 550 r.p.m. for single weight governors, but may vary with special engine applications.

2. With engine stopped, remove governor cover.
3. Remove fuel rod (14), Fig. 5, between the governor and injector control tube lever (265).

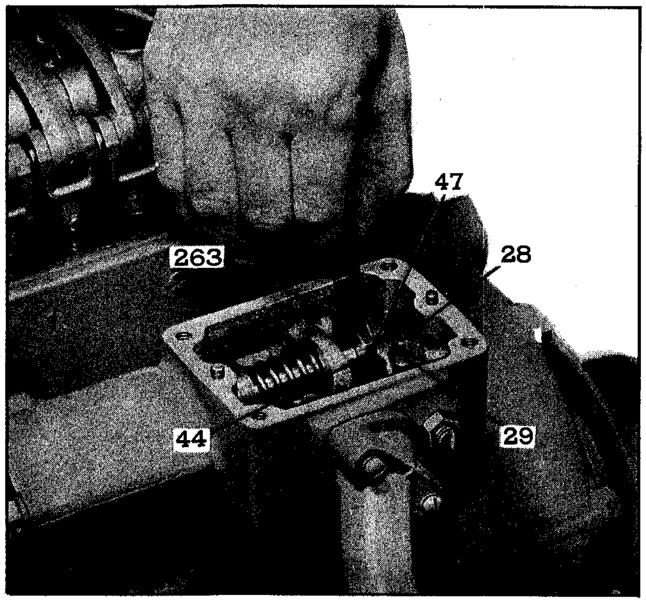

Fig. 4—Adjusting Governor Gap—Tool J 5407.

28. Screw—Gap Adjusting.
29. Lock Nut.
44. Plunger—High Speed Spring.
47. Cap—Low Speed Spring.
263. Gauge—Governor Gap—Tool J 5407.

4. Using tool J 5407, check the gap between the low speed spring cap (47) and high speed spring plunger (44), as shown in Fig. 4.
5. If required, loosen lock nut (29) and turn gap adjusting screw (28) until a slight drag is felt on gauge.
6. Hold adjusting screw and tighten lock nut.
7. Recheck gap and readjust if necessary.
8. Install the fuel rod between the governor and injector control tube lever.
9. Install governor cover.

Position Injector Control 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 ensures equal distribution of the load.

Adjust No. 1 injector rack control lever (267) first to establish a guide for adjusting the remaining injector rack control levers.

1. Refer to Fig. 5 and disconnect any linkage attached to control lever (21).
2. Loosen lock nut (58) and back out buffer screw (57) approximately ⅝″.

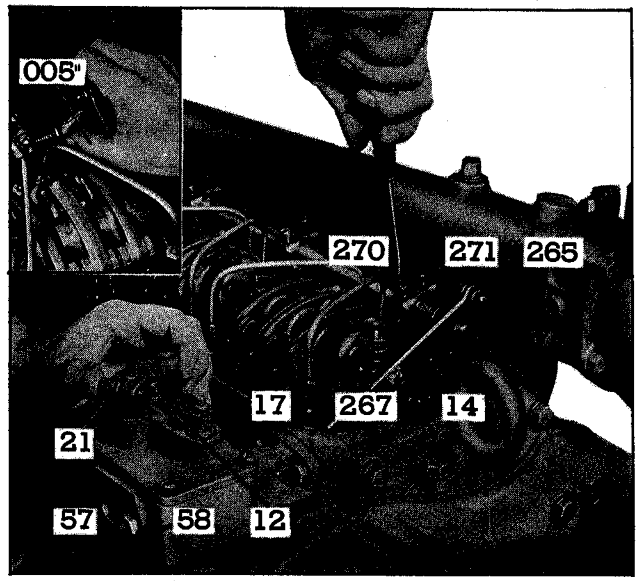

Fig. 5—Positioning No. 1 Injector Control Rack Lever.

12. Lever—Throttle Control.
14. Rod—Fuel.
17. Cam—Cover.
21. Lever—Governor Control.
57. Screw—Buffer.
58. Lock Nut.
265. Lever—Injector Control Tube.
267. Lever—Injector Rack Control.
270. Screw—Control Lever Adjusting.
271. Screw—Control Lever Adjusting.

3. Loosen all inner adjusting screws (270) and outer adjusting screws (271). Be sure all control levers (267) are free on the injector control tube.
4. Move control lever (21) to the FULL FUEL position as shown in Fig. 5. Turn inner adjusting screw down until a **slight movement** of the control lever is observed. Tighten outer adjusting screw.
5. With the governor control lever held in the FULL FUEL position, check for a slight movement of the injector control tube lever as shown in Fig. 5. **This movement should not exceed .005″.**
6. If no movement is observed, back off inner adjusting screw approximately ⅛ of a turn and tighten outer adjusting screw.

   If the movement exceeds that specified, back off outer adjusting screw approximately ⅛ of a turn and tighten inner adjusting screw.

   When the setting is correct, the injector rack will be snug on the pin of the rack control lever and still maintain the movement specified in item 5.
7. Place finger on injector rack of No. 2 injector

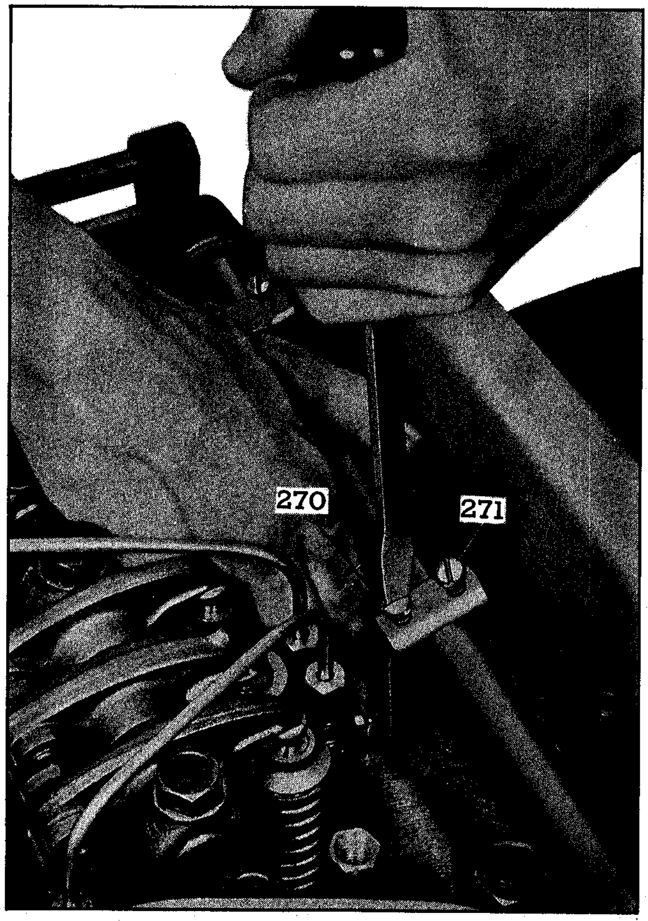

Fig. 6—Positioning No. 2 Injector Control Rack Lever.

270. Screw—Control Lever Adjusting.
271. Screw—Control Lever Adjusting.

as shown in Fig. 6. Turn inner adjusting screw down until control rack tightens on pin of rack control lever. Tighten outer adjusting screw.

8. Make sure the rack remains snug on the pin of the rack control lever at No. 1 injector. If the rack of No. 1 injector has become loose, back off slightly on the inner adjusting screw at No. 2 injector rack control lever. Tighten outer adjusting screw.

   When the settings are correct, the rack of both injectors must be snug on the pin of their respective rack control levers and still maintain that movement of the control tube lever specified in item 5.

9. Position the remaining control rack levers as outlined in items 7 and 8.

   When the settings are correct, the rack of all injectors must be snug on the pin of the control

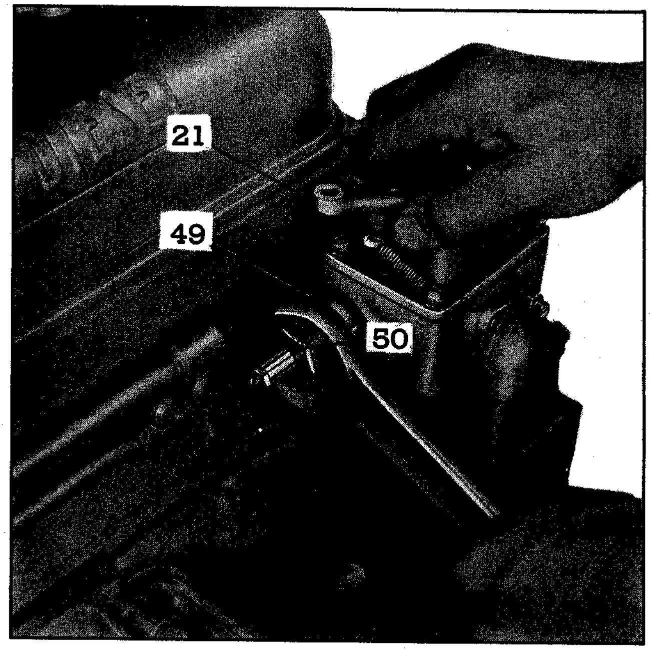

Fig. 7—Adjusting Maximum No-Load Speed.

21. Lever—Governor Control.
49. Lock Nut—Spring Retainer.
50. Retainer—High Speed Spring.

rack levers and still maintain that movement of the control tube lever specified in item 5.

Adjust Maximum No-Load Speed—All governors are properly adjusted before leaving the factory. However, if the governor has been reconditioned or replaced, and to ensure the engine speed will not exceed the recommended no-load speed as given on the unit name plate, the maximum no-load speed may be set as follows:

1. Loosen lock nut (49), Fig. 8, and back off high speed spring retainer (50) approximately five turns.

2. With engine at operating temperature, no load on the engine, place control lever (21) in the FULL FUEL position. Turn high speed spring retainer in until the engine is operating at the recommended no-load speed.

   The best method of determining the engine r.p.m. is by the use of an accurate hand tachometer.

3. Hold spring retainer (50) and tighten lock nut (49).

Adjust Idle Speed—With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

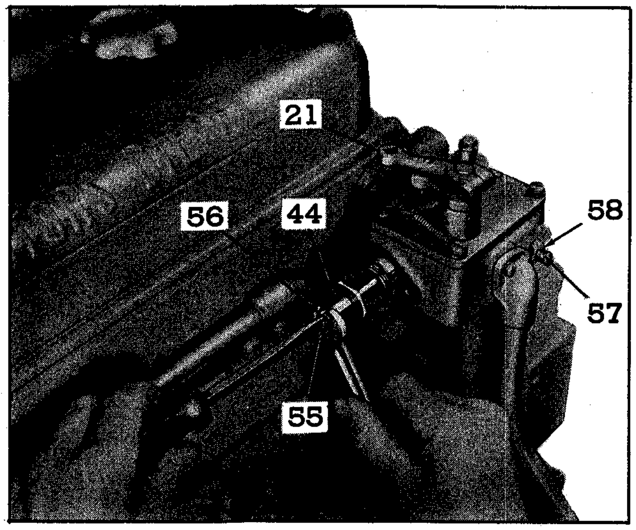

Fig. 8—Adjusting Engine Idle Speed.

21. Lever—Governor Control.
44. Plunger—High Speed Spring.
55. Screw—Idle Speed Adjusting.
56. Lock Nut.
57. Screw—Buffer.
58. Lock Nut.

1. With engine running at normal operating temperature and with buffer screw (57), Fig. 8, backed out to avoid contact with the differential lever, turn idle speed adjusting screw (55) until the engine idles at 15 r.p.m. below the recommended idle speed.

   The recommended idle speed is 550 r.p.m. for single weight governors, but may vary with special engine applications.

2. Hold idle screw and tighten lock nut (56).

Adjust Buffer Screw — With the idle speed set at approximately 15 r.p.m. below the recommended idle speed, the buffer screw may be set as follows:

1. Turn buffer screw (57) **IN** until engine runs at the recommended idle speed.

   Do not raise the engine speed more than 15 r.p.m. with the buffer screw.

2. Hold buffer screw and tighten lock nut (58).

N.A.

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

All changes and adjustments must be made only after the engine has reached its normal operating temperature. Since the adjustments are normally made while the engine is stopped, it may be necessary to run the engine between adjustments to prevent it from cooling off excessively.

Make the various adjustments in accordance with and in the following sequence:

1. Adjust Valve Clearance.
2. Time Fuel Injectors.
3. Adjust Governor Gap.
4. Position Injector Rack Control Levers.
5. Adjust Maximum No-Load Speed.
6. Adjust Idle Speed.
7. Adjust Buffer Screw.
8. Adjust Throttle Booster Spring.

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

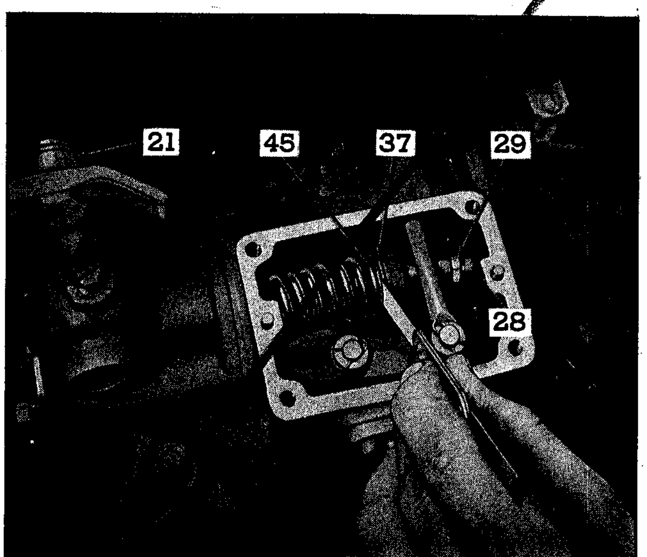

Fig. 9—Adjusting Governor Gap.

21. Lever—Speed Control.
28. Screw—Gap Adjusting.
29. Lock Nut.
37. Guide—Plunger.
45. Plunger—Variable Speed Spring.

Adjust Valve Clearance—Adjust valve clearance as outlined under "Tune-Up Procedure for Units with Limiting Speed Single Weight Mechanical Governors" in this section.

Time Fuel Injectors—Time fuel injectors as outlined under "Tune-Up Procedure for Units with Limiting Speed Single Weight Mechanical Governors" in this section.

Adjust Governor Gap—With engine stopped, the governor gap may be set as follows:

1. Remove governor cover.
2. Place speed control lever (21), Fig. 9, in the FULL FUEL position.
3. Insert a .006" feeler gauge between the spring plunger (45) and the plunger guide (37). If required, loosen lock nut (29) and turn adjusting screw in or out until a slight drag is noted on the feeler gauge.
4. Hold adjusting screw and tighten lock nut. Check gap. If necessary, reset.
5. Install governor cover.

Position Injector Rack Control Levers—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 ensures equal distribution of the load.

Adjust No. 1 injector rack control lever (267) first to establish a guide for adjusting the remaining control rack levers.

1. Loosen lock nut (58), Fig. 12 and back off buffer screw (57) approximately ⅝".
2. Loosen all inner adjusting screws (270) and outer adjusting screws (271). Be sure all control levers (267) are free on the injector control tube.
3. Place governor control lever (12) and speed control lever (21) in FULL FUEL position as shown in Fig. 10.
4. Turn inner adjusting screw (270) down until a **slight** movement of the governor control lever (12) is observed. Tighten outer adjusting screw.
5. With governor control lever held in the FULL FUEL position, check for a slight movement of the

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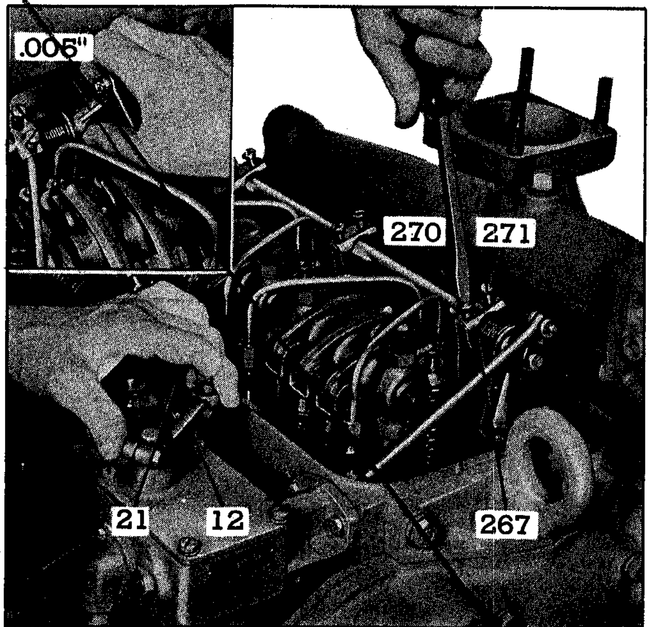

Fig. 10—Positioning No. 1 Injector Rack Control Lever.

12. Lever—Governor Control.
21. Lever—Speed Control.
267. Lever—Injector Rack Control.
270. Screw—Control Lever Adjusting (Inner).
271. Screw—Control Lever Adjusting (Outer).

injector control tube lever as shown in Fig. 10. **This movement should not exceed .005".**

6. If no movement is observed, back off inner adjusting screw approximately ⅛ of a turn and tighten outer adjusting screw.

   If the movement exceeds that specified, back off outer adjusting screw approximately ⅛ of a turn and tighten inner adjusting screw.

   When the setting is correct, the injector rack will be snug on the pin of the rack control lever and still maintain the movement specified in item 5.

7. Place finger on rack of No. 2 injector as shown in Fig. 11. Turn inner adjusting screw down until rack tightens on pin of rack control lever. Tighten outer adjusting screw.

8. Make sure the rack remains snug on the pin of the rack control lever at No. 1 injector.

   If the rack of No. 1 injector has become loose, back off slightly on the inner adjusting screw at No. 2 injector rack control lever. Tighten outer adjusting screw.

   When the settings are correct, the rack of both injectors must be snug on the pin of their respective rack control levers and still maintain that movement of the control tube lever specified in item 5.

9. Position the remaining rack control levers as outlined in items 7 and 8.

   When the settings are correct, the rack of all injectors must be snug on the pin of the rack control levers and still maintain that movement of the control tube lever specified in item 5.

Adjust Maximum No-Load Speed—The maximum no-load speed on units equipped with variable speed governors must not be less than 125 r.p.m. or more than 150 r.p.m. above the recommended full load speed.

Using an accurate hand tachometer, determine the maximum no-load speed of the engine then, make the following adjustments, if required:

1. Refer to Fig. 12 and disconnect booster spring

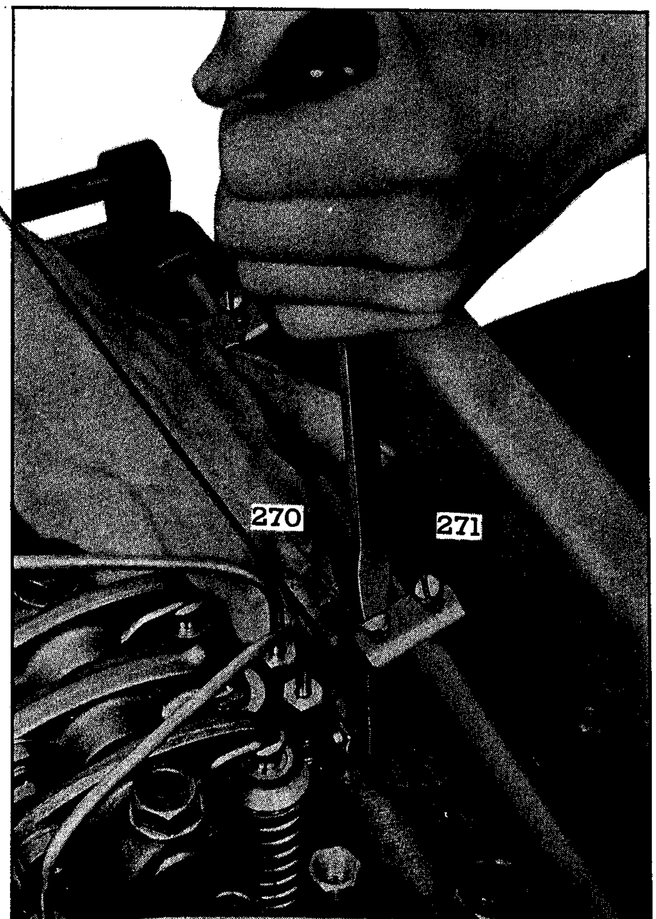

Fig. 11—Positioning No. 2 Injector Rack Control Lever.

270. Screw—Control Lever Adjusting (Inner).
271. Screw—Control Lever Adjusting (Outer).

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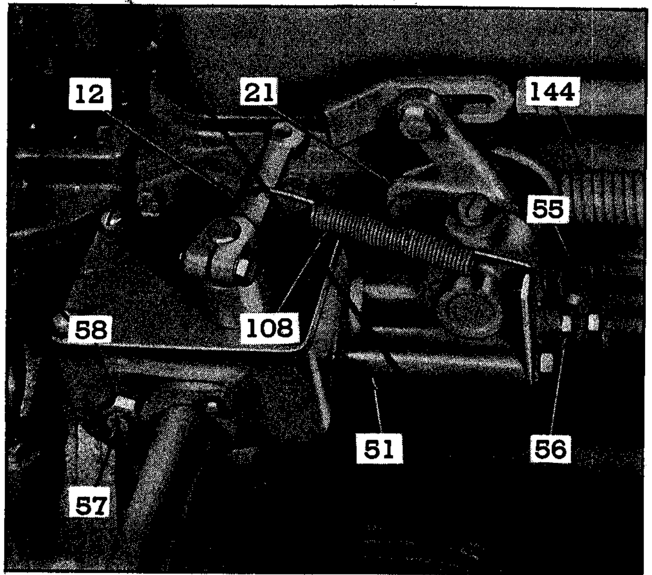

Fig. 12—Buffer and Idle Speed Adjusting Screws.

12. Lever—Governor Control.
21. Lever—Speed Control.
51. Housing—Variable Speed Spring.
55. Screw—Idle Speed Adjusting.
56. Lock Nut.
57. Screw—Buffer.
58. Lock Nut.
108. Spring—Lever Retracting.
144. Spring—Variable Speed Booster.

(144) and retracting spring (108).

2. Remove two bolts and withdraw variable speed spring housing (51) and also variable speed spring plunger (104), Fig. 16 in section 2.

3. Refer to table 3 and determine the stops (107) or (108) required for the desired no-load speed.

TABLE 3

No Load Speed	Stops	Shims
1200 to 1425 r.p.m.	2	Up to .325"
1426 to 1825 r.p.m.	1	Up to .325"
1826 to 2000 r.p.m.	0	Amount required to get necessary speed.

4. Install variable speed spring housing and re-check maximum no-load speed.

5. If required, refer to Fig. 16 in section 2 and add shims (102) as required.

   Governor shims are available in .010" and approximately .078".

NOTE: If the maximum no-load speed is raised or lowered more than 50 r.p.m. by the installation or removal of the governor shims, the governor gap should be rechecked.

If re-adjustment of the governor gap is required, the position of the injector racks must be re-checked.

Adjust Idle Speed—With the maximum no-load speed properly adjusted, the idle speed may be adjusted as follows:

1. Place governor control lever (12) in the RUN position and the speed control lever (21) in IDLE position as shown in Fig. 12.

2. With engine operating, loosen lock nut (56). Turn idle adjusting screw (55) until engine idles at approximately 15 r.p.m. below the recommended idle speed.

   The recommended idle speed is 500 r.p.m., but may vary with special engine applications.

3. Hold idle screw and tighten lock nut.

Adjust Buffer Screw—With idle speed properly adjusted, the buffer screw may be adjusted as follows:

1. Turn buffer screw (57) **IN** until engine runs at recommended idle speed.

   Do not raise the engine idle speed more than 15 r.p.m. with the buffer screw.

2. Hold buffer screw and tighten lock nut (58).

Adjust Booster Spring—With idle speed set, the booster spring may be adjusted as follows:

1. Refer to Fig. 12 and loosen booster spring retaining nut on speed control lever (21). Loosen nut and lock nut on eyebolt at opposite end of spring (144).

2. Move bolt up or down in slot of lever (21) to a position that will allow speed control lever to move from the FULL FUEL position to the IDLE position. Hold bolt and tighten spring retaining nut.

3. Turn nut on eye bolt to a position that will allow the speed control lever to be moved to the FULL FUEL position with the least amount of effort.

TUNE-UP PROCEDURE FOR INDUSTRIAL UNITS WITH HYDRAULIC GOVERNORS

All checks and adjustments must be made only after the engine has reached normal operating temperature. **Maintenance of normal operating temperature is extremely important when adjusting the valve clearance.** Before changing any of the following settings, make certain that the adjustment is necessary. Then, with the engine stopped, make the necessary adjustments in accordance with and in the following sequence.

1. Adjust Valve Clearance.
2. Time Fuel Injectors.
3. Adjust Fuel Rod.
4. Position Injector Rack Control Levers.
5. Adjust Load Limit.
6. Adjust Speed Droop.
7. Adjust Maximum No-Load Speed.

Adjust Valve Clearance—Adjust valve clearance as outlined under "Tune-Up Procedure for Units with Limiting Speed Single Weight Mechanical Governors" in this section.

Time Fuel Injectors—Time fuel injectors as outlined under "Tune-Up Procedure for Units with Limiting Speed Single Weight Mechanical Governors" in this section.

Adjust Fuel Rod—

1. Remove governor cover. Refer to Fig. 14 and loosen all inner adjusting screws (270) and outer adjusting screws (271). Be sure all control levers (267) are free on the injector control tube.

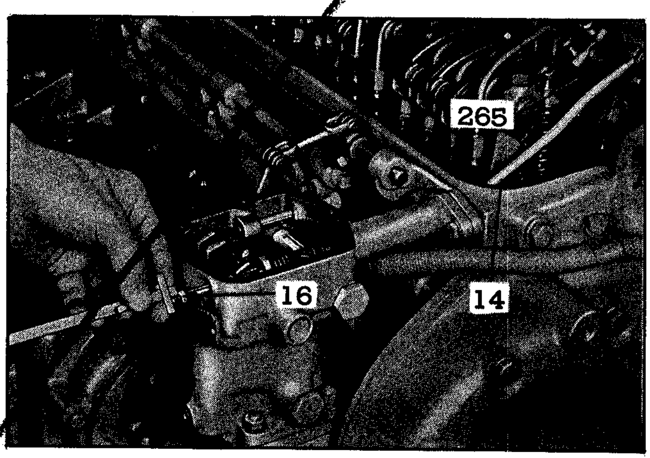

Fig. 13—Adjusting Fuel Rod.

14. Rod—Fuel.
16. Lock Nut.
265. Lever—Injector Control Tube.

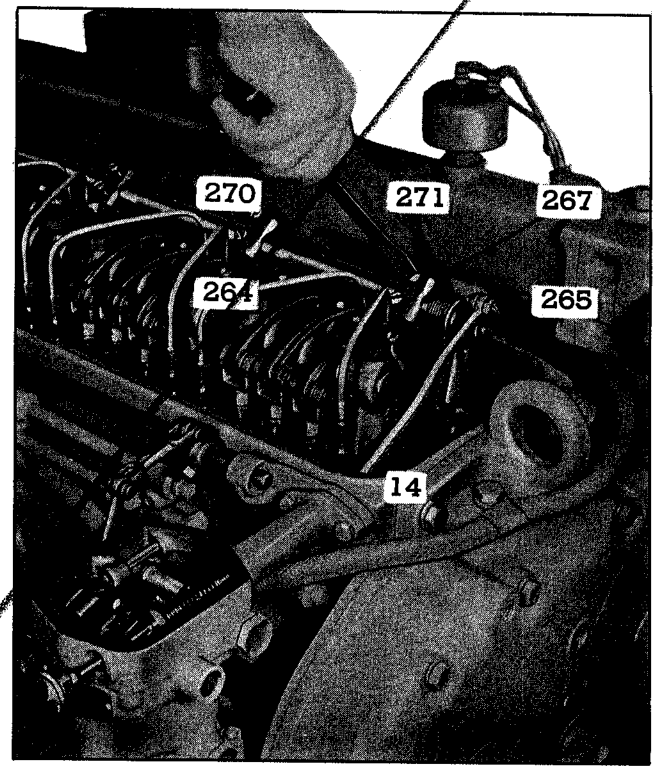

Fig. 14—Positioning No. 1 Injector Rack Control Lever.

14. Rod—Fuel.
264. Tube—Injector Control.
265. Lever—Injector Control Tube.
267. Lever—Injector Control Rack.
270. Screw—Control Lever Adjusting.
271. Screw—Control Lever Adjusting

2. Loosen fuel rod lock nut (16), Fig. 13, and remove fuel rod knob.
3. Turn lock nut to a position so that $\frac{3}{16}$" of the fuel rod extends beyond the nut. Install fuel rod knob and tighten lock nut.

Position Injector Rack Control Levers—With fuel rod properly adjusted, the rack control levers may be adjusted as follows:

1. Turn outer adjusting screw (271), Fig. 14, in until **a slight movement of the injector control tube lever (265) is observed.** Tighten inner adjusting screw (270).
2. Pull out on fuel rod and check for $\frac{1}{32}$" to $\frac{1}{16}$" movement.

N-A.

If movement exceeds that specified, back off inner adjusting screw approximately 1/8 of a turn and tighten outer adjusting screw.

If movement is less than that specified, back off outer adjusting screw approximately 1/8 of a turn and tighten inner adjusting screw.

3. Disconnect fuel rod (14) from injector control tube lever (265).

4. With control tube lever held in the FULL FUEL position, turn inner adjusting screw (270), at No. 2 injector rack control lever, IN until rack tightens on pin of rack control lever. Tighten outer adjusting screw.

5. Make sure the rack remains snug on the pin of the rack control lever at No. 1 injector.

   If the rack of No. 1 injector has become loose, back off slightly on the inner adjusting screw at No. 2 injector rack control lever. Tighten outer adjusting screw.

   When the settings are correct, the rack of both injectors must be snug on the pin of their respective rack control levers.

6. Position the remaining rack control levers as outlined in items 4 and 5.

   When the settings are correct, the rack of all injectors must be snug on the pin of the rack control levers when control tube lever is held in the FULL FUEL position.

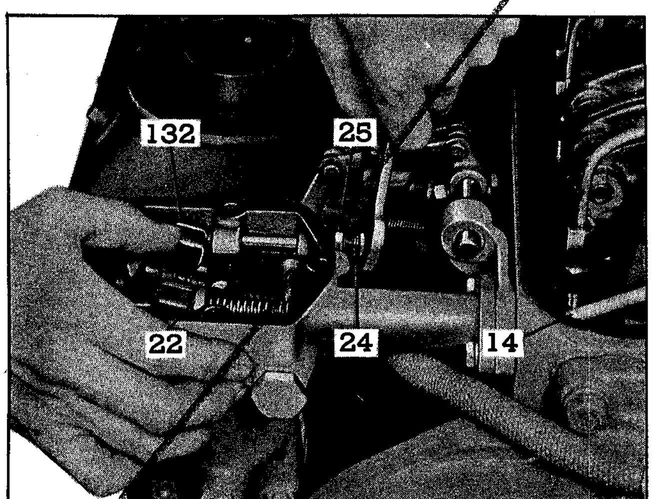

Fig. 15—Adjust Load Limit.

14. Rod—Fuel.
22. Collar—Fuel Rod.
24. Screw—Load Limit Adjusting.
25. Lock Nut.
132. Lever—Terminal.

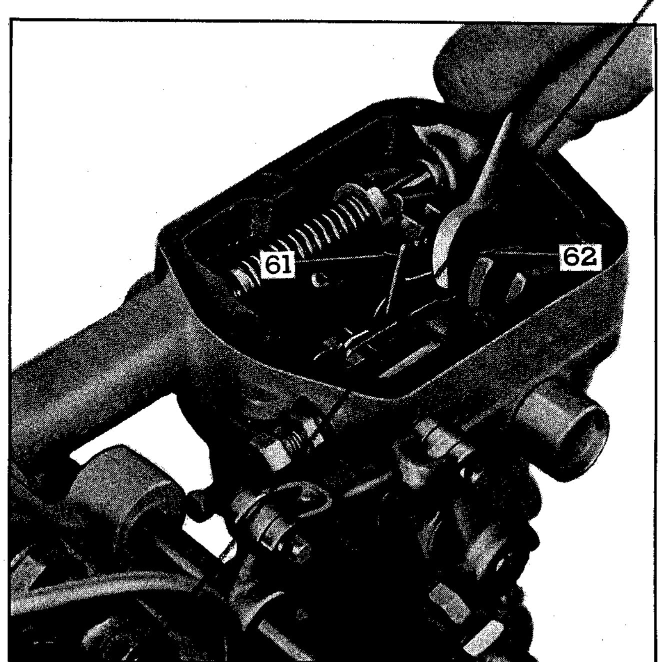

Fig. 16—Adjusting Speed Droop.

61. Bracket—Droop Adjusting.
62. Bolt.

Adjust Load Limit—The load limit is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs or the injector rack control levers have been repositioned, the speed droop should be re-adjusted.

With the injector rack control levers properly adjusted, the load limit may be set as follows:

1. Place fuel rod (14) and terminal lever (132) in the FULL FUEL position as shown in Fig. 15.

2. Loosen lock nut (25). Turn adjusting screw (24) until a .020" space exists between the fuel rod collar (22) and the terminal lever (132). Hold screw and tighten lock nut.

Adjust Speed Droop—The purpose of adjusting the speed droop is to establish a definite engine speed at no-load with a given speed at rated full load.

The governor droop is set at the factory and further adjustment should be unnecessary. However, if the governor has had major repairs, the speed droop should be re-adjusted.

The best method of determining the engine speed is by the use of an accurate hand tachometer.

If a full rated load on the unit can be established, the fuel rod, injector control rack levers, and load limit have been adjusted, the speed droop may be

N.A.

adjusted as follows:

1. Start engine and run at approximately one-half the rated no-load speed until the lubricating oil temperature stabilizes.

   ***NOTE:** When the engine lubricating oil is cold, the governor regulation may be erratic. The regulation should become increasingly stable as the temperature of the lubricating oil increases.*

2. With engine stopped, remove the governor cover.

3. Loosen lock nut (73), Fig. 17, and back off maximum speed adjusting screw (72) approximately ⅝″.

4. Refer to Fig. 16 and loosen droop adjusting bolt (62). Move bracket (61) so that bolt is midway between ends of slot in bracket. Tighten bolt.

   Be sure the bracket remains on the shoulder of the terminal lever.

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

6. Apply the full rated load on the engine and readjust the engine speed to the correct full load speed.

7. Remove the rated load and note engine speed after speed stabilizes under no-load. If the speed droop is correct, the engine speed will be approximately 3% to 5% higher than the full load speed.

   If the speed droop is too high, stop engine and again loosen bolt (62) and move droop adjusting bracket **IN** toward engine. Tighten bolt.

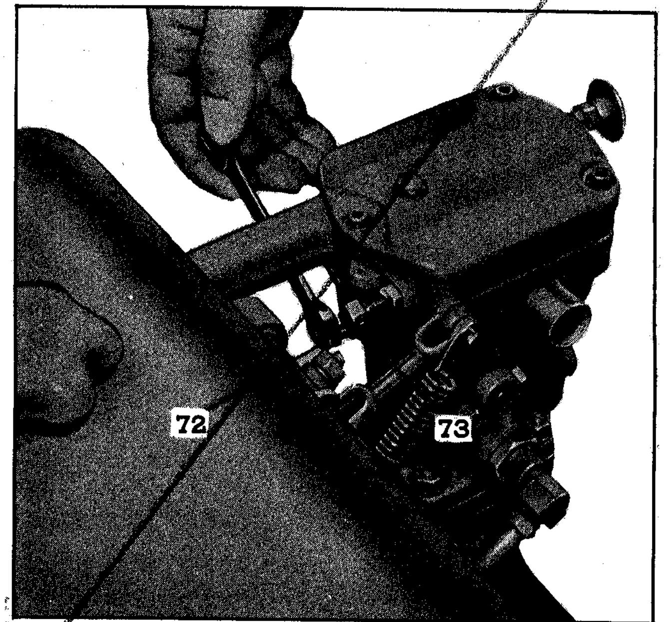

Fig. 17—Adjusting Maximum No-Load Speed.

72. Screw—Maximum Speed Adjusting. 73. Lock Nut.

To increase the speed droop, move droop adjusting bracket **OUT**, away from engine.

Adjust Maximum No-Load Speed—With the speed droop properly adjusted, the maximum no-load speed may be set as follows:

1. With engine operating at no-load loosen lock nut (73), Fig. 17. Turn screw (72) in until engine speed is approximately 8% higher than the rated full load speed.

2. Tighten lock nut (73). Install governor cover.

N.A.

THROTTLE ADJUSTMENTS FOR LOAD EQUALIZATION—TWIN AND QUAD UNITS

Each twin unit consists of two engines and each quad unit of four engines connected by clutches to a common gear box. The throttle adjustment is made so that each engine of a twin or quad unit will carry its share of the load. Throttle adjustments are divided into two groups, depending on the type of governor used.

The two groups are:

1. Throttle adjustments on twin or quad units with limiting or variable speed mechanical governors.

2. Throttle adjustments on tandem twin marine units with variable speed mechanical governors.

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

The individual engine tune-up is very important in the adjustment of twin and quad units as the engines must be closely synchronized to enable each to carry its full share of the load.

Therefore, disconnect the control rods (157) from control levers (21) and perform the tune-up procedures for single engines given in this section before adjusting the throttle control linkage. Then, with engines stopped and valve covers removed:

1. Check the two levers (12 and 21), Fig. 5, on top of each governor for vertical alignment (i.e. one exactly over the other). If the levers are not in alignment, adjust the top lever (21) on its shaft until the alignment is correct.

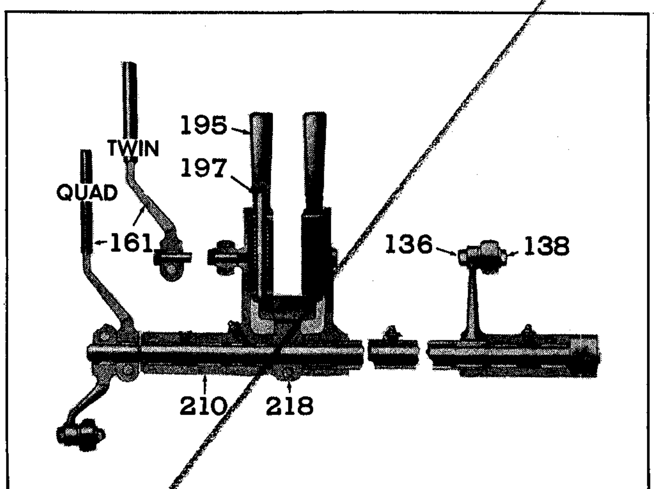

Fig. 18—Throttle Control Shaft Assembly—Twin and Quad Units.

136. Bearing—Control Rod End.
138. Bolt—Control Rod.
161. Lever—Master Throttle Control.
195. Lever—Throttle Control.
197. Pin—Throttle Control Lever.
210. Bracket—Control Shaft.
218. Quadrant—Throttle Control.

2. Make sure that the individual throttle control levers (195) are latched to their quadrant (218), by positioning pins (197), Fig. 18.

3. Move the master throttle control lever (161) to the FULL FUEL position.

4. Make sure each control lever (12) is in the FULL FUEL position. The pin of the lever (12) must be just touching the end of the slot in cam (17).

5. If the governor control levers are not in the FULL FUEL position, loosen the two turnbuckle nuts (141) and adjust turnbuckles (115) until all levers are in their FULL FUEL position, see Fig. 19 and 20.

6. Tighten the turnbuckle lock nuts (141) and check the position of lever (12). When tightening the lock nuts, be careful not to "cock" the end bearing (136).

7. Move the master control lever (161) to the IDLE position and start the engines.

   CAUTION: Be sure the clutches are disengaged before starting engines.

8. Run the engines, until they are at normal operating temperature.

9. Move the master control lever (161) to the IDLE position and check idle speed of each engine.

10. Move the master control lever (161) to the FULL FUEL position and check no-load speed of each engine.

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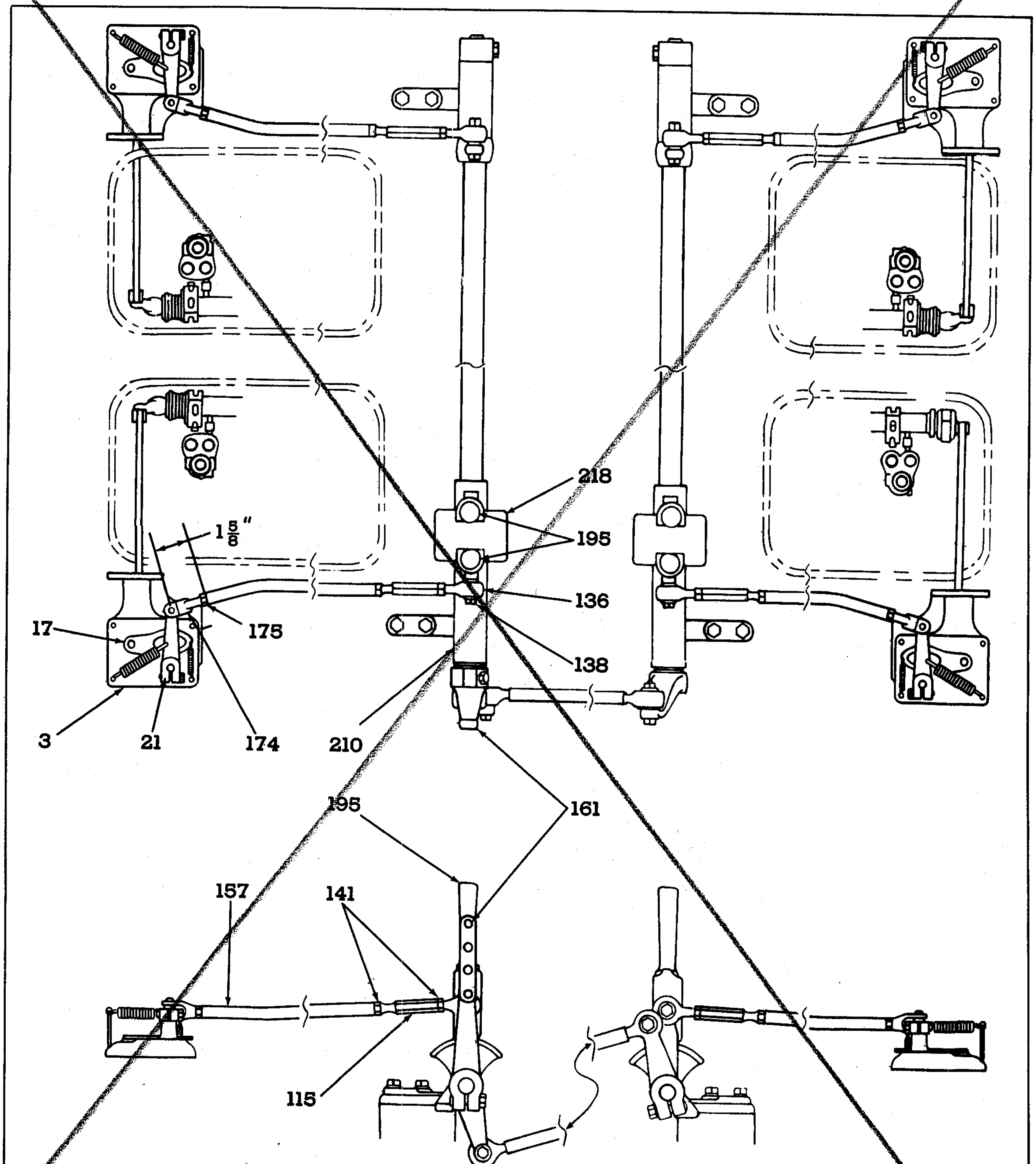

Fig. 19—Diagram of Throttle Control Linkage for Quad Units With Limiting Speed Mechanical Governors.

3. Cover—Governor.
17. Cam—Cover.
21. Lever—Governor Control.
115. Turnbuckle.
136. Bearing—Control Rod End.
138. Bolt—Control Rod.
141. Lock Nut—Turnbuckle.
157. Rod—Control.
161. Lever—Master Throttle Control.
174. Clevis—Control Rod.
175. Lock Nut—Clevis.
195. Lever—Throttle Control.
210. Bracket—Control Shaft.
218. Quadrant—Throttle Control.

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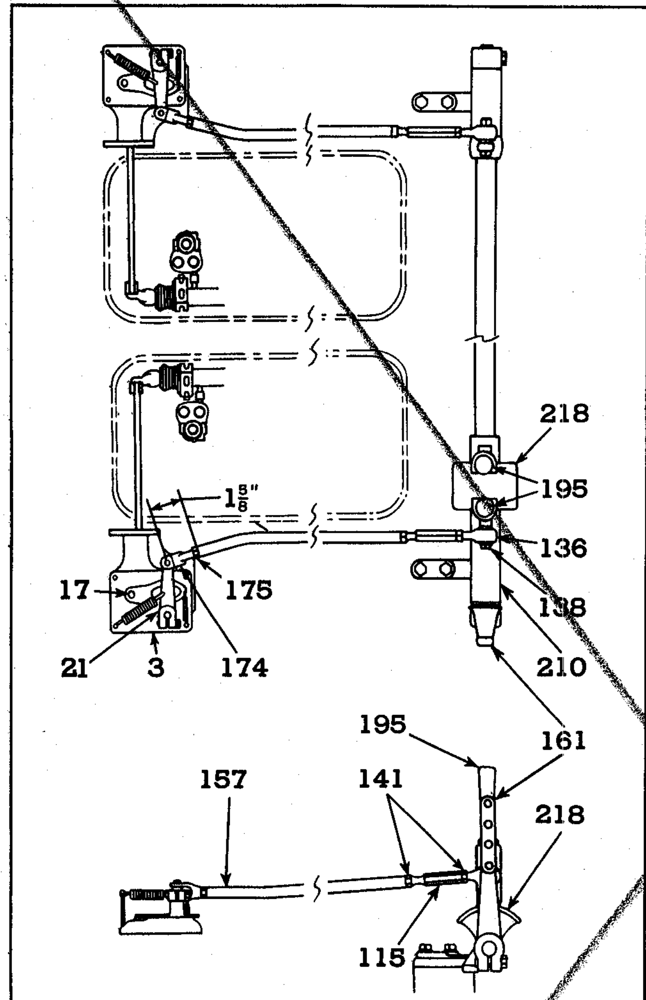

Fig. 20—Diagram of Throttle Control Linkage for Twin Units With Limiting Speed Mechanical Governors.

3. Cover—Governor.
17. Cam—Cover.
21. Lever—Governor Control.
115. Turnbuckle.
136. Bearing—Control Rod End.
138. Bolt—Control Rod.
141. Lock Nut—Turnbuckle.
157. Rod—Control.
161. Lever—Master Throttle Control.
174. Clevis—Control Rod.
175. Lock Nut—Clevis.
195. Lever—Throttle Control.
210. Bracket—Control Shaft.
218. Quadrant—Throttle Control.

11. Move the master control lever (161) to a position approximately 200 r.p.m. below the no-load speed. Check the engine r.p.m.s. Engines should be running within 50 r.p.m. of each other.

    a. Move the master control lever (161) to a position, approximately 200 r.p.m. below step 11. Check the engine r.p.m.s again. Engine should be running within 50 r.p.m. of each other.

    b. Move the master control lever (161) to a position, approximately 200 r.p.m. below step a. Check the engine r.p.m.s again. They should be within 50 r.p.m. of each other.

    If this procedure does not bring the engines within close synchronization, recheck each engine for poor compression, faulty injectors, low fuel oil pressure, or other conditions which may cause unsatisfactory engine operation. See Trouble Shooting in section 5.

12. Install valve covers.

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

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 to carry its full share of the load. Therefore, disconnect the control rods (157) from control levers (21) and cross link equalizer spring (239) from cross link (114) (see Fig. 21). On quad units, loosen screw (147) Fig. 22, and remove the master control equalizer spring (103). Then with engines stopped and valve covers removed:

1. Check the link (234) on each engine. Be sure the bolt (111) is just touching the end of link in idle position.

2. Make sure that the individual throttle control levers (12) are latched to their quadrant (218), by positioning pins (197), Fig. 18.

3. Move the master throttle control lever (161) to the FULL FUEL position.

4. Make sure each control lever (21), Fig. 22, is in the FULL FUEL position (all the way back).

5. If the governor control levers are not in the FULL FUEL position, loosen the two turnbuckle nuts (141) and adjust turnbuckles (115) until all levers are in their FULL FUEL position.

6. Tighten the turnbuckle lock nuts (141), and check the position of each governor lever. Levers must be all the way back. Be careful not to "cock" the end bearing (136).

The following steps should be performed to adjust the booster spring (144) if necessary.

With idle speed set, the booster spring may be adjusted as follows:

a. Set the governor booster spring pin (134) ⅛" below over-center line B-B, as shown in Figs. 21 and 22.

b. Make sure the clutches are disengaged and start each engine.

c. Release each speed lever individually from the FULL FUEL position, and note its return to the idle position. The lever should return quickly.

d. Refer to Fig. 21 and loosen booster spring retaining nut on speed control lever (21). Loosen nut and lock nut on eyebolt at opposite end of spring (144).

e. Move bolt up or down in slot of lever (21) to a position that will allow speed control lever to move from the FULL FUEL position to the IDLE position. Hold bolt and tighten spring retaining nut.

f. Turn nut on eyebolt to a position that will allow the speed control lever to be moved to the FULL FUEL position with the least amount of effort.

7. Connect each of the governor control rods (157) to lever (21).

8. Set the gap between the end of link (234) and governor control lever (21) at $\frac{1}{16}$" to ⅛" by adjusting the lever (21) on its shaft. While setting the gap, the governor lever must be in the IDLE position, and the forward end of the slot in link (234) must be contacting the lever-to-link bolt (111).

9. Secure the master throttle control lever (161) in the FULL FUEL position, then replace equalizer spring (239) and secure with screw (240).

10. Loosen the lock nut (141) at turnbuckle (112).

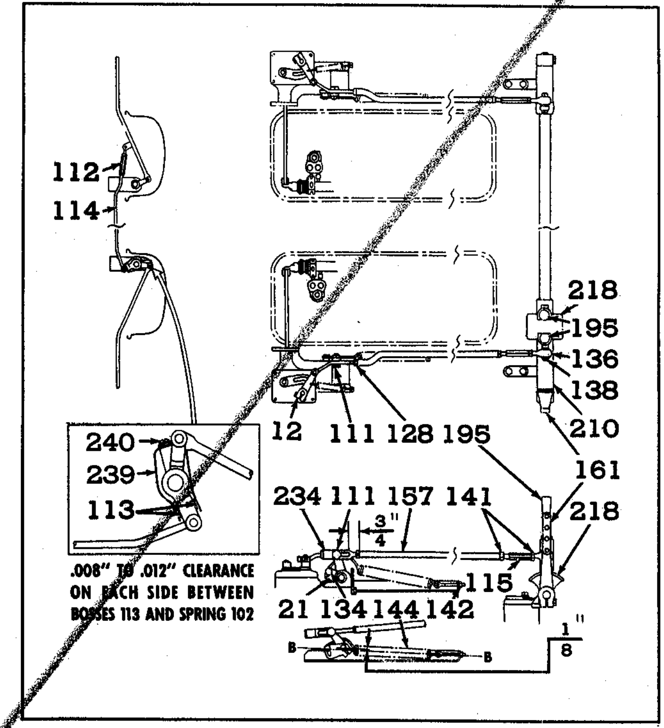

Fig. 21—Diagram of Throttle Control Linkage for Twin Units With Variable Speed Mechanical Governors.

12. Lever—Governor Control.
21. Lever—Speed Control.
111. Bolt—Lever-to-Link.
112. Turnbuckle—Cross Link Equalizer.
113. Boss.
114. Link—Equalizer.
115. Turnbuckle.
128. Lock Nut.
134. Pin—Booster Spring.
136. Bearing—Control Rod End.
138. Bolt—Control Rod.
141. Lock Nut—Turnbuckle.
142. Lock Nut—Booster Spring Adjusting.
144. Spring—Booster.
157. Rod—Control.
161. Lever—Master Throttle Control.
195. Lever—Throttle Control.
210. Bracket—Control Shaft.
218. Quadrant—Throttle Control.
234. Link—Control Rod End.
239. Spring—Link Equalizer.
240. Screw—Equalizer Spring.

Adjust the turnbuckle until there is equal clearance between each leg of the equalizer spring (239) and lower boss (113), approximately .010" clearance on each side.

11. Tighten turnbuckle lock nut (141) and recheck clearance. Readjust if necessary.

12. Lubricate the link joints of the equalizer linkage with a few drops of engine oil. Move the master throttle control lever (161) back and forth to check for binding in the equalizer. Note if the equalizer link (114) rubs inside the tube. Correct any binding that may exist.

13. Disengage clutches. Move master throttle control lever (161) to IDLE position and start engine.

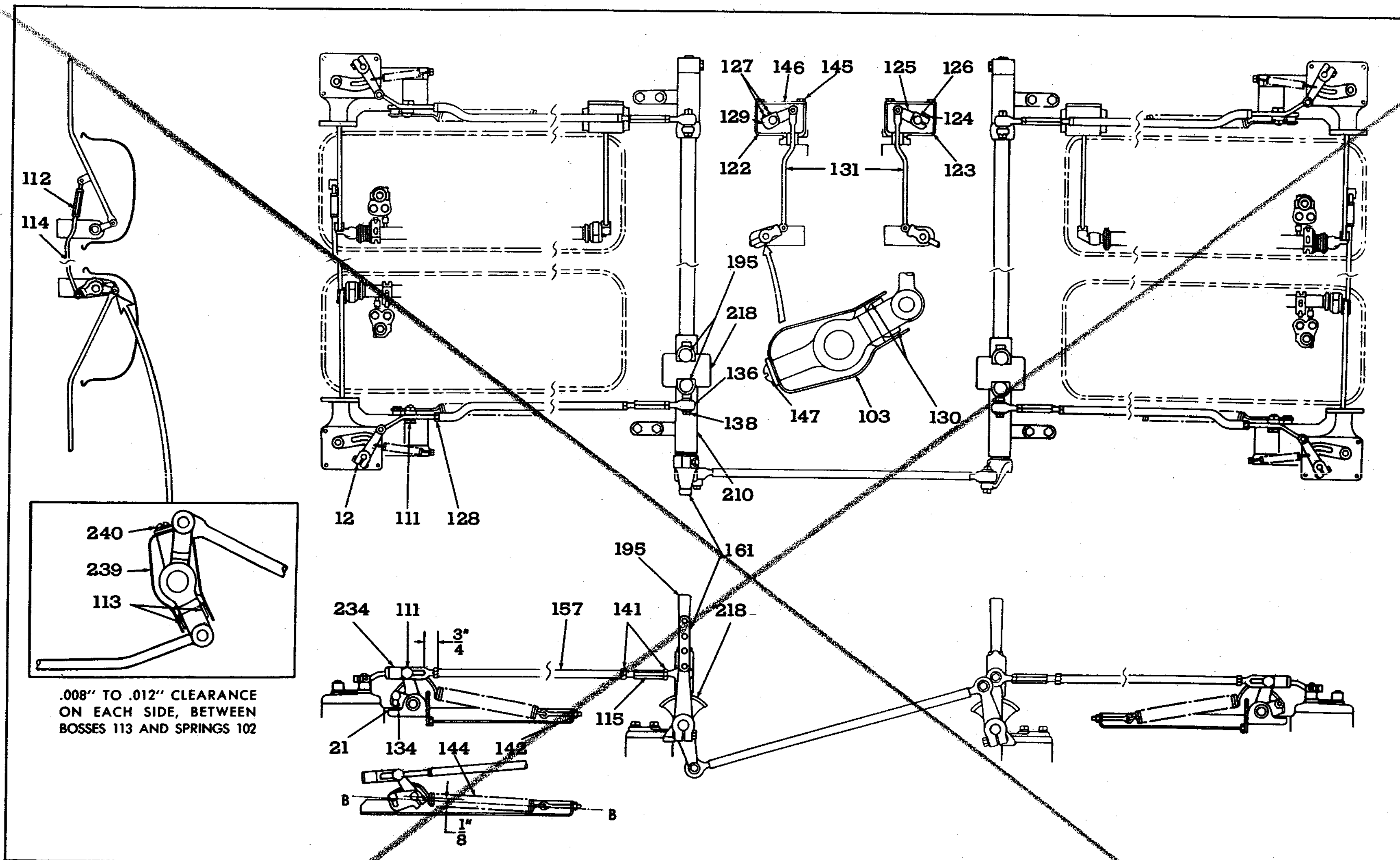

Fig. 22—Diagram of Throttle Control Linkage for Quad Units with Variable Speed Governors.

12. Lever—Governor Control.
21. Lever—Speed Control.
103. Spring—Master Control Equalizer.
111. Bolt—Lever-to-Link.
112. Turnbuckle—Cross Link Equalizer.
113. Boss.
114. Link—Equalizer.
115. Turnbuckle.
122. Housing—Master Control Equalizer.
123. Housing—Master Equalizer.
124. Bolt.
125. Lever—Master Equalizer.
126. Shaft—Equalizer.
127. Screw—Adjusting.
128. Lock Nut.
129. Lever—Master Control Equalizer.
130. Boss—Master Control Equalizer.
131. Link—Master Control Equalizer.
134. Pin—Booster Spring.
136. Bearing—Control Rod End.
138. Bolt—Control Rod.
141. Lock Nut—Turnbuckle.
142. Lock Nut—Booster Spring Adjusting.
144. Spring—Booster.
145. Bolt—Equalizer Housing.
146. Cover—Equalizer Housing.
147. Screw—Master Control Equalizer Spring.
157. Rod—Control.
161. Lever—Master Throttle Control.
195. Lever—Throttle Control.
210. Bracket—Throttle Control Shaft.
218. Quadrant—Throttle Control.
234. Link—Control Rod End.
239. Spring—Link Equalizer.
240. Screw—Equalizer Spring.

14. Run engines until they are operating at normal temperature.

15. Move master throttle control lever (161) to IDLE position and check idling speed.

    The idling speed of the engine, not incorporating the equalizer spring (239), will probably be less than that of the engine which has the spring due to the expansion of the cross link (114). In such cases, remove the valve cover and proceed as follows:

16. Loosen the equalizer turnbuckle lock nut (141), and adjust the turnbuckle (112), until both engines are idling at the same speed. Clearance between each leg of the equalizer spring (239) and lower bosses (113) should be equal.

17. Install valve covers.

18. Start engines and move throttle control lever (161) to the FULL FUEL position and check the maximum no-load speed of each engine.

    The speed should now be the same as previously set. If not, check for binding in the equalizer.

19. With the clutches still disengaged, move the master throttle control lever until the engines are running approximately 200 r.p.m. lower than the maximum no-load speed.

20. Using a hand tachometer, check the speed of the engines. They should be running within 25 r.p.m. of each other.

21. If a variation of more than 25 r.p.m. exists, check the tune-up of each individual engine as outlined in this section.

    Then adjust the master control equalizer between the front and rear engine pairs comprising the quad unit (see Fig. 22).

22. Remove valve covers, if not previously removed.

23. Remove bolts (145), covers (146) and gaskets from equalizer housing (122) and (123).

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

25. Adjust screws (127) until they are threaded equally into the adjusting lever (129) and are contacting the flats in the equalizer shaft. Bolts should be fairly tight.

26. With the individual control levers (195) latched to their quadrants (218), move the master control lever (161) to the FULL FUEL position and secure master lever.

27. Move the equalizer link (131) connected to equalizer adjusting each leg of the equalizer spring (103) and each boss (130).

    The clearance should be approximately .010″ on each side.

28. Hold the equalizer link in this position and tighten clamping bolt (124) on equalizer lever (125).

29. Recheck the clearance between each leg of the equalizer spring (103) and lower bosses (130). Readjust if necessary.

30. Install valve covers.

31. Move the master throttle control lever (161) to the IDLE position and start engines.

32. Move master throttle control lever (161) to accelerate engines until they reach normal operating temperatures.

33. Move the master throttle control lever to the FULL FUEL position and check the maximum no-load speed on each engine.

34. Move the master throttle control lever (161) to the IDLE position and check the idle speed of each engine.

    The maximum no-load speed and idle speed of each engine should be the same as previously set.

35. If speeds in steps (33) and (34) are not as previously set, it will be necessary to readjust the master equalizer adjusting lever (129) by means of adjusting screws (127).

36. After these adjustments have been satisfactorily completed, install equalizer housing gaskets and covers.

    If this procedure does not bring the engines within close synchronization, it is suggested that each engine be checked for possible causes of low power, such as poor compression, 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 mentioned conditions will prevent an engine from developing full power.

N.A.

THROTTLE ADJUSTMENT FOR LOAD EQUALIZATION ON TANDEM TWIN UNITS USING VARIABLE SPEED MECHANICAL GOVERNORS

Figures 23 and 25 illustrate the arrangement of the throttle and reverse gear controls on Tandem Twin Units, while Figs. 24 and 25 illustrate the master control and individual throttle lever assemblies.

Master throttle levers and master reverse gear control levers are provided in both the engine room and pilot house, thus permitting operation of the propulsion unit at either location through this dual control arrangement.

The individual engine tune-up is very important in the adjustment of these twin units as the engines must be closely synchronized to enable each to carry its full share of the load.

Therefore, disconnect the control rods (157) from control levers (21) and perform the tune-up procedures for single engines given in this section before adjusting the throttle control linkage. Then, with engines stopped and valve covers removed:

1. Remove any bind or excess play from clevis pins.
2. Refer to Figs. 24 and 26 and move master throttle lever (129) toward FULL OPEN position until the two clevis pins in the upper and lower arms of the throttle lever shank are in a vertical

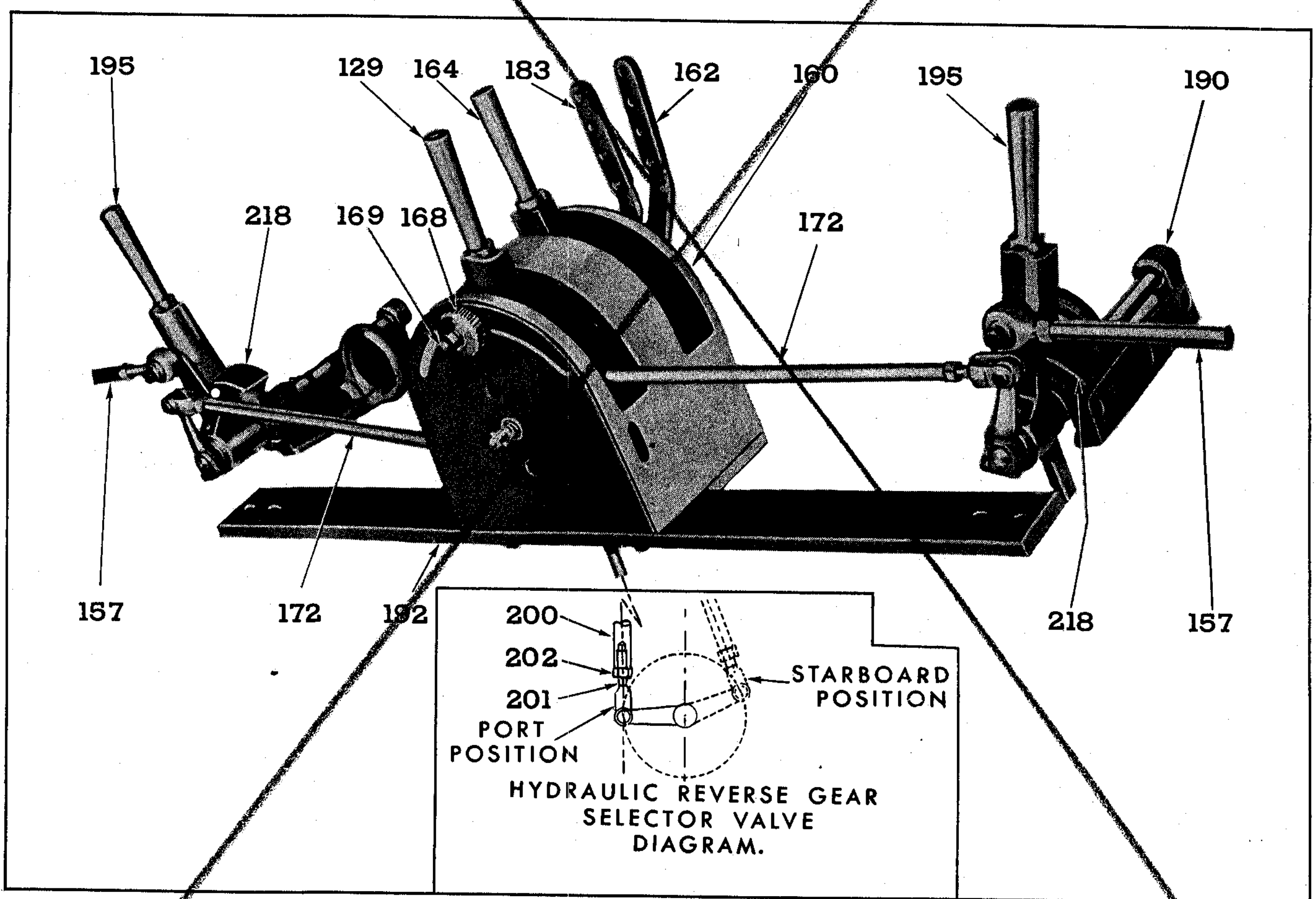

Fig. 23—Arrangement of Throttle Levers on a Tandem Twin Marine Unit.

129. Lever—Master Control Equalizer.
157. Rod—Control.
160. Housing—Master Throttle and Control Valve Lever.
162. Lever—Master Throttle Remote Control.
164. Lever—Master Remote Control Valve.
168. Nut—Master Hand Throttle Locking.
169. Nut—Retaining.
172. Rod—Master Throttle Control.
183. Lever—Reverse Gear Control Valve (Remote Control).
190. Bracket—Engine Lifting.
192. Support—Throttle Control Valve Housing.
195. Lever—Throttle Control.
200. Rod—Valve Control.
201. Clevis—Valve Control Rod.
202. Nut—Valve Control Rod.
218. Quadrant—Throttle Lever.

straight line, as observed through the two holes at the side of the lever housing (160). Secure the throttle lever in this position by means of the knurled lock nut (168).

3. Disconnect both master throttle control rods (172) from the cross shaft operating levers (199) of the individual throttle levers (195) at the "A" and "C" engines.

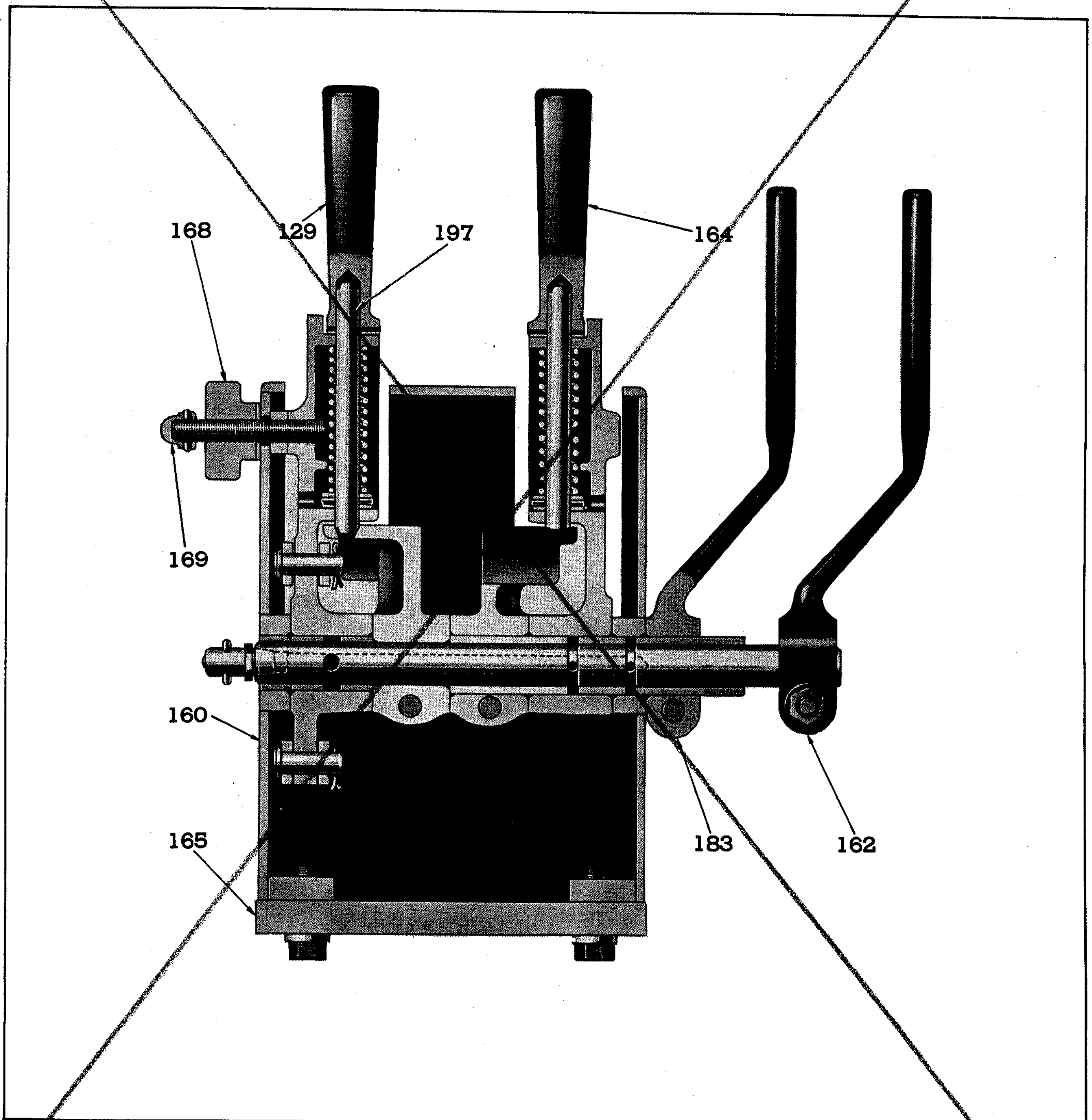

Fig. 24—Master Throttle Assembly on a Tandem Twin Unit.

129. Lever—Master Control Equalizer.
160. Housing—Master Throttle and Control Valve Lever.
162. Lever—Master Throttle Remote Control.
164. Lever—Master Remote Control Valve.
165. Support—Throttle and Control Valve.
168. Lock Nut—Master Throttle Control Lever.
169. Nut—Retaining.
183. Lever—Reverse Gear Control Valve (Remote Control).
197. Pin—Throttle Control Lever.

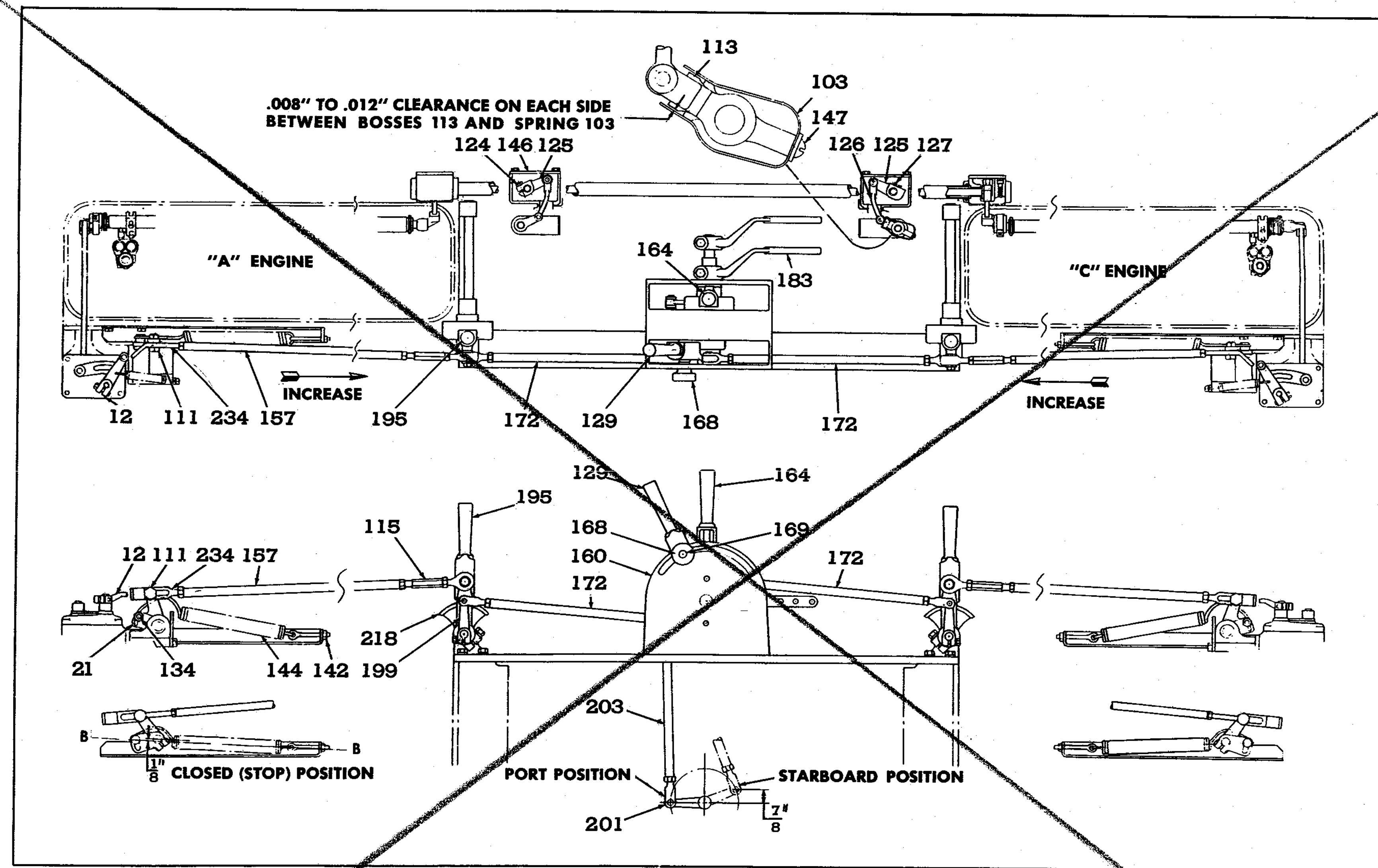

Fig. 25—Diagram of Throttle Control Linkage for Tandem Twin Marine Unit with Variable Speed Governors.

12. Lever—Governor Control.
21. Lever—Speed Control.
103. Spring—Equalizer.
111. Bolt—Link.
113. Boss—Master Equalizer.
115. Turnbuckle.
124. Bolt.
125. Lever—Master Equalizer.
126. Shaft—Equalizer.
127. Screw—Adjusting.
129. Lever—Master Control Equalizer.
134. Pin—Booster Spring.
142. Lock Nut—Booster Spring Adjusting.
144. Spring—Booster.
146. Cover—Equalizer Housing.
147. Screw—Master Control Equalizer Spring.
157. Rod Control.
160. Housing—Master Throttle and Control Valve Lever.
164. Lever—Master Remote Control Valve.
168. Lock Nut—Master Throttle Control Lever.
169. Nut—Retaining.
172. Rod—Master Throttle Control.
183. Lever—Reverse Gear Control Valve (Remote Control).
195. Lever—Throttle Control.
199. Lever—Throttle Control Cross Shaft.
201. Clevis—Valve Control Rod.
203. Rod—Valve Control.
218. Quadrant—Throttle Lever.
234. Link—Control Rod End.

4. Lock both throttle levers (195) to their quadrants (218) and fix them in a vertical position.

5. Loosen clamp bolt on quadrant (218), if necessary, and set both cross shaft operating levers (199) vertically with holes for clevis pins on an imaginary line extending through the centers of cross shafts and rod end bearings, and between these centers. Tighten clamp bolts on quadrants.

6. While maintaining levers (195) in a vertical position, adjust the master throttle control rods (172) by means of the clevises, to such length that the clevis pins will just slide into position through the holes in the clevises and levers (199). Install cotter pins.

7. Loosen knurled lock nut (168) and move master throttle lever (129) toward FULL OPEN position until the locking stud (169) is within ⅜″ to ½″ from end of slot in housing (2). Tighten lock nut (168).

8. Adjust length of throttle control rods (157), by means of turnbuckles (115), until the speed control levers (21), at the governor, are fully open. Tighten turnbuckle lock nuts.

When tightening lock nuts on turnbuckles, be careful to keep rod end bearings perpendicular to the bearing support bolt to avoid damage to the bearing seal.

9. If all of the above adjustments have been carefully made, the speed of each engine should be the same as when checked individually for top speed. To check top speed of the individual engines:

   a. Disconnect equalizer link at lever on the "A" engine.

   b. Warm engines up to operating temperature, then run each engine at top speed and compare the speeds with original top speed to check proper length of control rod (157).

   c. If engine speeds are O.K., connect equalizer link and install cotter pin; if speeds are unsatisfactory, adjust length of rod or rods (157) as necessary.

10. With the reverse gear control valve lever (164) set in a vertical position, check the position of the selector valve lever on the reverse gear. On a port propulsion unit, the center of the clevis pin hole in selector valve lever will lie on a horizontal center line drawn through the center of selector valve shaft, as shown in Fig. 25, and point forward. On a starboard propulsion unit, the clevis pin hole in the selector valve lever will point aft and lie ⅞″ above the horizontal center line drawn through the center line of the selector valve shaft.

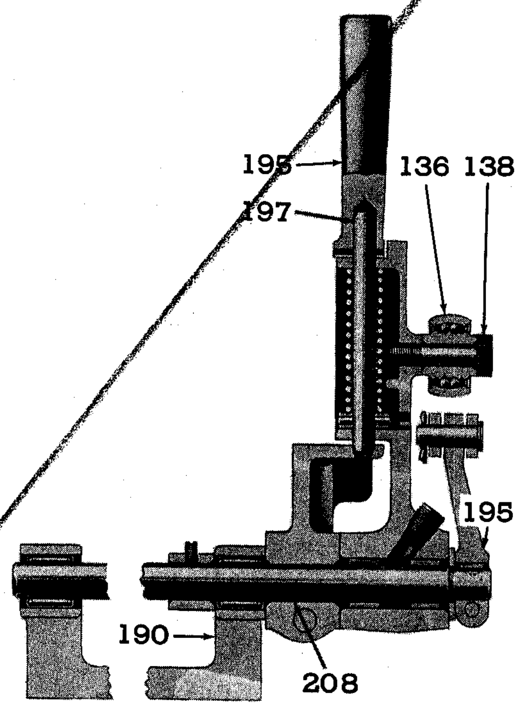

Fig. 26—Individual Throttle Assembly on a Tandem Twin Unit.

136. Bearing—Rod End.
138. Bolt—Control Rod.
190. Bracket—Engine Lifting.
195. Lever—Throttle Control.
197. Pin—Throttle Control Lever.
208. Shaft—Throttle Lever.

11. Adjust equalizer levers so each engine will carry its share of the load as follows:

   a. With engines stopped, and master throttle lever (129) in the FULL OPEN position and equalizer links connected at the "A" and "C" engines, loosen clamp bolt (124) in equalizer shaft lever (125) at the "A" engine so the lever can turn on the equalizer shaft.

   b. Set the two adjusting screws (127) in adjustable equalizer lever (125) at the "C" engine the same height in the lever so that lever can be adjusted later if necessary.

N-A.

c. Rotate lever (125) on shaft until the free ends of the equalizer spring (103) are resting—without strain—against the two bosses on the injector control tube lever and are an equal distance from the bosses (113) at each side of the equalizer link lever. While maintaining the clearance between lever bosses and spring, tighten clamp bolt in lever (125).

d. Again check clearance between bosses and spring; and if clearance was changed while tightening clamp bolt in lever, adjust screws (127) and change position of lever (125) until clearance between bosses (113) and spring (103) is the same on both sides of equalizer link lever.

e. With clutches disengaged, move throttle to IDLE position and start engines.

f. With engines up to operating temperature, clutches still disengaged and the individual throttle levers (195) locked to their quadrants (218), move master throttle lever (129) to FULL OPEN position and check the speed of each engine with a tachometer and record the speed.

The speed of each engine should now be the same as the no load top speed previously set on the individual engines.

g. Now move the master throttle to IDLE position and check the speed of the individual engines.

If either the idle or top speed is not the same as that previously established on the individual engines, readjust the clearance between the bosses (113), on equalizer link lever and the spring (103) if necessary, as outlined in item "4" above.

12. Install valve covers.

TROUBLE SHOOTING

Certain abnormal conditions which sometimes interfere with satisfactory engine operation, together with methods of determining the cause of such conditions, are covered in the Trouble Shooting Charts 1 through 10 on the following pages. Charts 11 through 14 will help locate hydraulic marine gear trouble quickly.

The ability of the engine to start and operate properly depends primarily on:

1. The presence of an adequate supply of air compressed to a sufficiently high compression pressure.
2. The injection of the proper amount of fuel at the right time.

Lack of power, uneven running, excessive vibration, stalling at idle, and hard starting may be caused by either low compression, faulty injection in one or more cylinders, or lack of sufficient air.

Since proper compression, fuel injection and the proper amount of air are important to good engine performance, detailed procedures for their investigation are given as follows:

LOCATING A MISFIRING CYLINDER

1. Start engine and run at part load until it reaches normal operating temperatures.
2. Remove valve cover.
3. Run engine at IDLE speed and check valve clearance. The clearance should be .009".
4. Hold the No. 1 injector follower down with a screw driver (see Fig. 1), thus preventing operation of the injector.

   If the cylinder has been 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 plunger is held down. This is similar to short-circuiting a spark plug of a gasoline engine.
5. If cylinder No. 1 is firing properly, repeat the procedure on the other cylinders until the faulty one has been located.
6. Providing that the injector operating mechanism of the faulty cylinder is functioning satisfactorily, remove the fuel injector and install a new one by:

   a. Disconnect and remove fuel pipes (68) and (69) from the injector and fuel connector (70). See Fig. 2.

   Immediately after disconnecting fuel pipes from the injector, install shipping caps on filter caps to prevent dirt from entering the injector.

   b. Bar engine or crank engine with cranking motor, if necessary, to bring the push rod end of the three rocker arms in line horizontally.

   c. Loosen the two rocker arm bracket bolts (61) holding the brackets to the cylinder head and

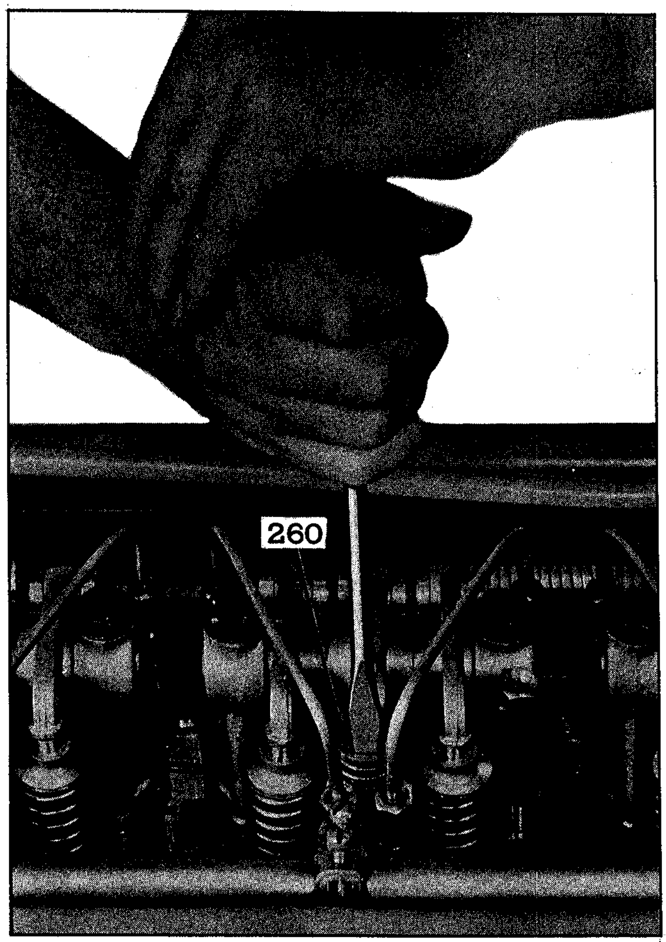

Fig. 1—Locating a Misfiring Cylinder.

260. Follower—Injector.

5

swing the rocker arm assembly over away from the valves and injectors.

d. Remove the injector hold-down nut (39), washer (38), and injector clamp (36).

e. Free the injector from its seat with tool J 1227-A and lift it from the cylinder head; at the same time disengage the injector control rack.

f. Install new injector by reversing the procedure given for removal.

7. If the installation of the new injector does not eliminate the misfiring, the compression pressure of the cylinder in question should be checked.

CHECKING COMPRESSION PRESSURE

1. Start engine and run at approximately one-half rated load until normal operating temperature is reached.
2. With engine stopped, remove fuel pipes (68) and (69) from the injector and fuel connectors (70).
3. Remove the injector from No. 1 cylinder and install adaptor of the pressure gauge (tool J 1319-A) in its place.

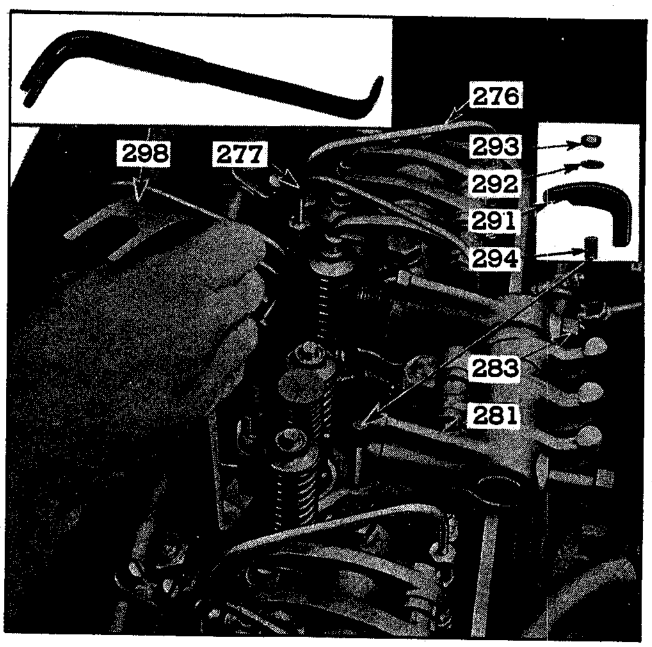

Fig. 2—Removing an Injector.

276. Pipe—Fuel (Inlet).
277. Pipe—Fuel (Outlet).
278. Manifold—Fuel.
281. Bracket—Rocker Shaft.
283. Bolt—Bracket Retaining.
291. Clamp—Injector.
292. Washer—Injector Clamp.
293. Nut—Clamp Retaining.
294. Stud—Injector Clamp.
298. Remover—Injector—Tool J 1227-A.

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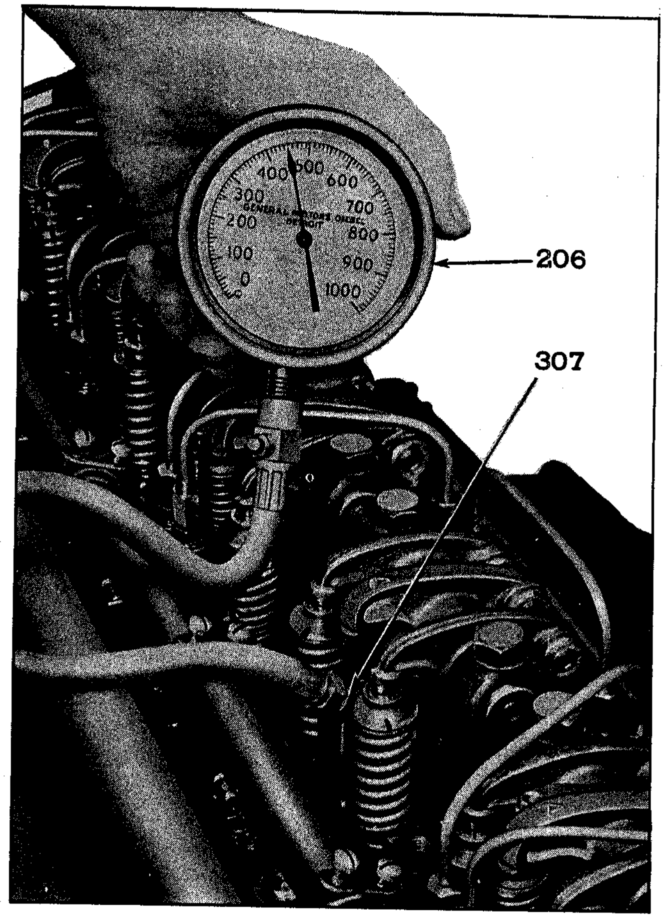


Fig. 3—Checking Compression Pressure.

206. Gauge—Cylinder Compression—Tool J 1319-A.
307. Adaptor—Cylinder Compression Gauge.

4. Use one of the two fuel pipes (68) or (69) as a jumper connection between the fuel inlet and return manifold to permit fuel to flow directly to the return manifold.
5. Start the engine and run it at 600 r.p.m. Observe and record the compression pressure indicated on the gauge.

   Do not crank the engine with cranking (starting) motor to obtain the compression pressure.

6. Perform this operation on each cylinder. The compression pressure in any one cylinder should be not less than 400 p.s.i. (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 600 r.p.m. For example:

   If the compression pressure readings of an en-

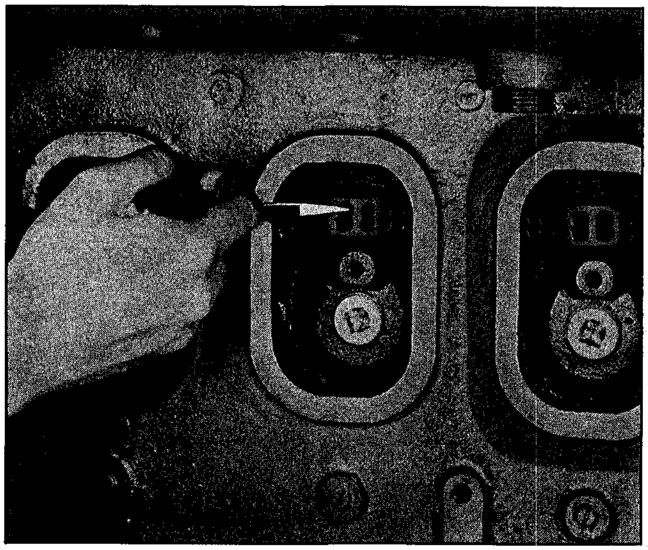


Fig. 4—Inspecting for Broken Piston Rings Through Cylinder Liner Air Ports.

gine were as shown in the following table, it would be evident that No. 3 cylinder should be examined and the cause of the low compression pressure determined and corrected.

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 above pressures are for engines operating at altitudes near sea level.

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.

Low cylinder pressures may result from any one of several causes:

a. Piston rings may be stuck in their ring grooves. To determine the condition of the rings, examine them as shown in Fig. 4.

b. Compression may be leaking past the cylinder head gasket, the valve seats, the injector tubes, or a hole in the piston.

To correct any of these conditions, consult your authorized Detroit Diesel Engine Division Dealer or Distributor.

Compression pressure is affected by altitudes as follows:

Minimum Compression Pressure, p.s.i.	Altitude, Feet Above Sea Level
360	2,500
324	5,000
292	7,500
263	10,000

FUEL FLOW TEST

1. Disconnect the fuel return tube and hold the open end in a convenient receptacle. See Fig. 5.

2. Start and run the engine at approximately 1200 r.p.m. and measure the fuel flow from the return tube for one minute.

   At least one-half gallon of fuel should flow from the return tube per minute.

3. Be sure all tube connections between the fuel supply and the pump are tight so that no air will be drawn into the fuel system; then immerse the end of the fuel tube in the fuel in the container. Air bubbles rising to the surface of the fuel will indicate a leak on the suction side of the pump.

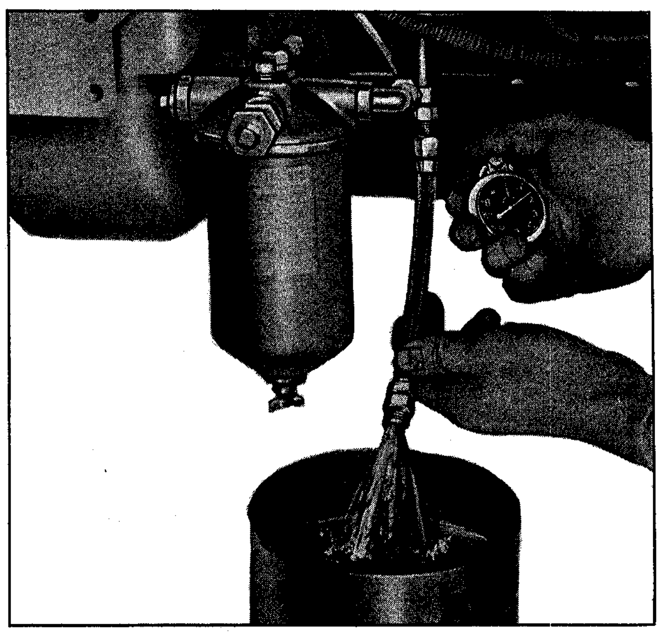


Fig. 5—Checking for Air in Fuel System.

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~~ [redacted] 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 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.

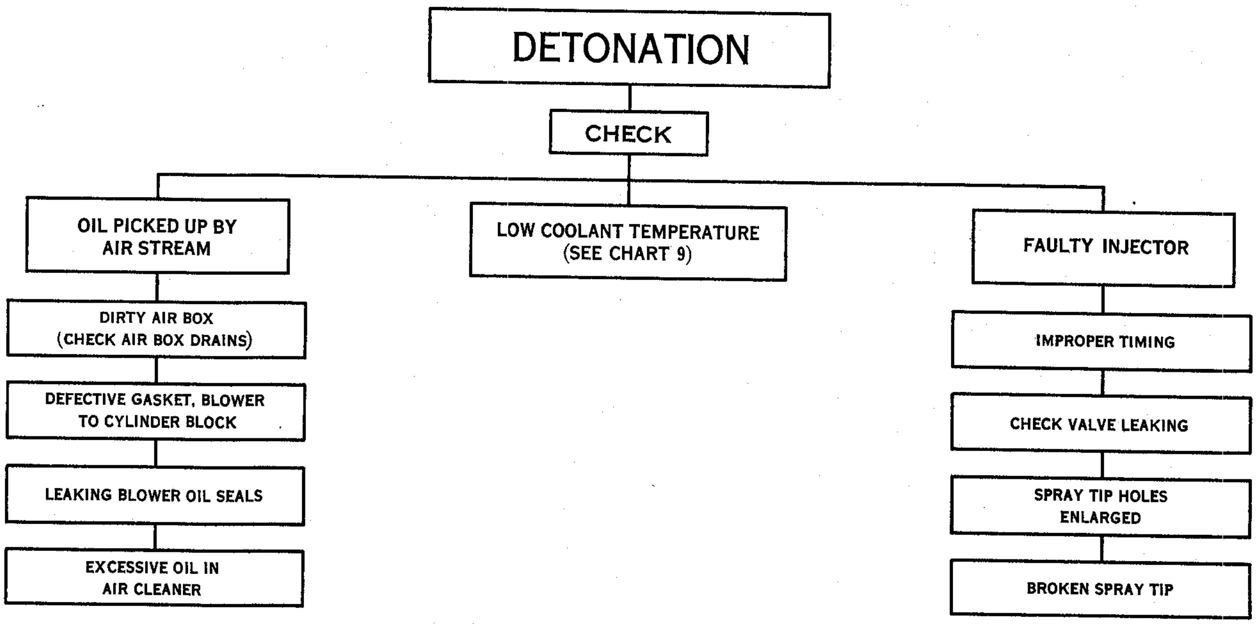
CYLINDER PRESSURES

- LOW COMPRESSION. (SEE CHART 1).
- INJECTOR SPRAY TIPS LEAKING.

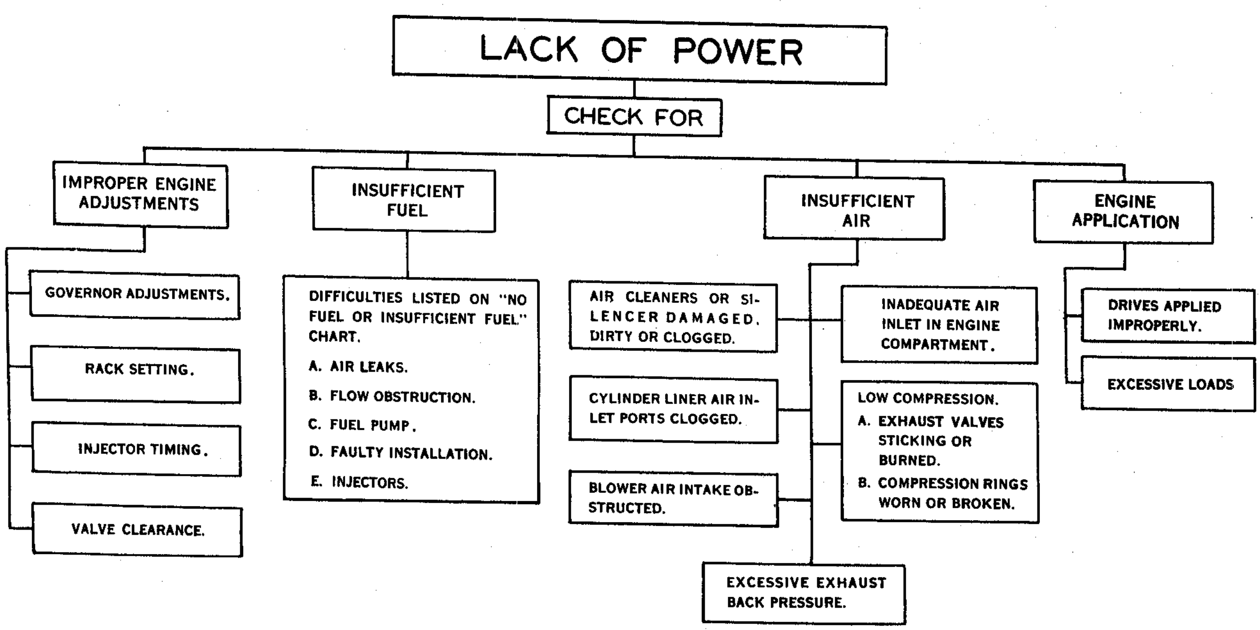
GOVERNOR

- 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.
    - [redacted]
  - 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 [redacted]**
  - 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.
      [redacted]R.
    - 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) [redacted]
      C[redacted]
      D. INSUFFICIENT RADIATOR [redacted] 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. [redacted]
        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
      - [redacted]
      - 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.
- 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.

N.A.

11

LOW OIL PRESSURE

WHEN SELECTOR VALVE IS PLACED IN ANY POSITION:—FORWARD, NEUTRAL OR REVERSE

CHECK FOR

- LUBRICATING OIL
  - A. SUCTION LOSS DUE TO LOW OIL LEVEL.
  - B. NOT USING RECOMMENDED GRADE OF OIL.
- AIR LEAK ON SUCTION SIDE OF PUMP
  - A. LOOSE SUCTION LINE FLANGE RETAINING BOLTS.
  - B. POOR SEALING SUCTION LINE FLANGE GASKETS.
  - C. POOR SEALING SUCTION LINE CONNECTIONS AT OIL STRAINER.
  - D. POOR SEALING OIL STRAINER GASKETS OR PIPE PLUGS.
  - E. CRACKED SUCTION LINES OR FLANGES.
  - F. OIL DIPSTICK INSTALLED ON SAME SIDE OF GEAR HOUSING AS SUCTION LINE. (SHOULD BE ON OPPOSITE SIDE.)
- IMPROPERLY OPERATING HYDRAULIC PUMP
  - A. LEAKING PUMP SEALS.
  - B. BY-PASS VALVE HELD IN "OPEN" POSITION.
  - C. BROKEN BY-PASS VALVE SPRING.
  - D. WORN OR DAMAGED PUMP.
  - E. POROUS PUMP CASTINGS.
- OIL LEAKS ON PRESSURE DISCHARGE SIDE OF PUMP.
- MULTIPLE ENGINE UNITS
  - A. PRESSURE REGULATOR BY-PASS VALVE HELD IN "OPEN" POSITION.
  - B. BROKEN PRESSURE REGULATOR BY-PASS VALVE SPRING.
- BROKEN OR BADLY WORN FORWARD SEAL RING ON REVERSE GEAR DRIVE SHAFT.
- RESTRICTED OR DAMAGED OIL LINES.
- INOPERATIVE STRAINER BY-PASS VALVE IN CLOGGED STRAINER.

WHEN SELECTOR VALVE IS PLACED IN REVERSE POSITION

CHECK FOR

- BROKEN OR WORN REVERSE PISTON SEALS.

WHEN SELECTOR VALVE IS PLACED IN FORWARD POSITION

CHECK FOR

- BROKEN OR WORN FORWARD PISTON SEALS.
- BADLY LEAKING FLYWHEEL PILOT OIL SEAL.
- LOOSE DUMP VALVE COVER (LOOSE RETAINING BOLTS).
- POOR SEALING DUMP VALVE COVER GASKET.
- BADLY WORN DUMP VALVE.
- LEAKING PLUG IN FLYWHEEL FORWARD OIL PASSAGEWAY.
- LOOSE EMERGENCY ENGAGEMENT BOLT.
- BROKEN OR BADLY WORN REAR SEAL RING ON REVERSE GEAR DRIVE SHAFT.

12

GEAR INOPERATIVE
(DRIVE SHAFT DOES NOT ROTATE)

WITH SELECTOR VALVE IN FORWARD POSITION

CHECK FOR

- LOW OIL PRESSURE. (SEE CAUSES LISTED ON LOW OIL PRESSURE CHART.)
- EXCESSIVELY WORN FORWARD CLUTCH FACINGS.
- RESTRICTED DUMP VALVE MOVEMENT (REMAINS IN "OUT" POSITION.)
- FORWARD CLUTCH PLATE SHEARED FROM HUB.

WITH SELECTOR VALVE IN REVERSE POSITION

CHECK FOR

- LOW OIL PRESSURE. (SEE CAUSES LISTED ON LOW OIL PRESSURE CHART.)
- EXCESSIVELY WORN REVERSE CLUTCH FACINGS.
- FAILURE OF PLANETARY ASSEMBLY.
- FAILURE OF REDUCTION GEAR

N.A.

13

GEAR DRAGGING
(DRIVE SHAFT ROTATES WITH SELECTOR VALVE IN NEUTRAL)

AFTER MOVING SELECTOR VALVE FROM FORWARD TO NEUTRAL

CHECK FOR

- FORWARD CLUTCH PLATE STICKING TO FORWARD PISTON OR REACTION PLATE.
- CLUTCH FACING MATERIAL BROKEN LOOSE FROM FORWARD CLUTCH PLATE AND JAMMED BETWEEN PISTON, CLUTCH PLATE, AND/OR REACTION PLATE.
- FORWARD CLUTCH PISTON OR CLUTCH DRIVE PIN BURRED PREVENTING PISTON FROM DISENGAGING.
- BADLY WARPED FORWARD PISTON, REACTION PLATE, OR DRIVE PLATE.
- BINDING IN PLANETARY ASSEMBLY.
- STICKING DUMP VALVE—REMAINS IN "IN" POSITION.
- BROKEN OR BADLY WORN CENTER SEAL RING ON THE REVERSE GEAR DRIVE SHAFT.

AFTER MOVING SELECTOR VALVE FROM REVERSE TO NEUTRAL

CHECK FOR

- REVERSE CLUTCH PLATE STICKING TO REVERSE PISTON OR REACTION PLATE.
- CLUTCH FACING MATERIAL BROKEN LOOSE FROM REVERSE CLUTCH PLATE AND JAMMED BETWEEN PISTON, CLUTCH PLATE, AND/OR REACTION PLATE.
- REVERSE CLUTCH PISTON OR CLUTCH DRIVE PIN BURRED PREVENTING PISTON FROM DISENGAGING.
- BADLY WARPED REVERSE PISTON, REACTION PLATE, OR DRIVE PLATE.
- BINDING IN PLANETARY ASSEMBLY.

14

GEAR SLIPPING OR SLOW TO ENGAGE

WITH SELECTOR VALVE IN FORWARD POSITION

CHECK FOR

- LOW OIL PRESSURE. (SEE CAUSES LISTED ON LOW OIL PRESSURE CHART.)
- WARPED FORWARD CLUTCH PLATE, PISTON, OR REACTION PLATE.
- WORN FORWARD CLUTCH FACINGS.
- RESTRICTED TRAVEL OF DUMP VALVE.

WITH SELECTOR VALVE IN REVERSE POSITION

CHECK FOR

- LOW OIL PRESSURE. (SEE CAUSES LISTED ON LOW OIL PRESSURE CHART.)
- WARPED REVERSE CLUTCH PLATE, PISTON, OR REACTION PLATE.
- WORN REVERSE CLUTCH FACINGS.

CHECKING ELECTRICAL STARTING SYSTEM

GROUNDED 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 the ammeter. This is the output value for which the current regulator is set.
3. Allow the engine to continue running, and 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 indicates that the voltage regulator is not reducing the generator output as it should. 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. 6 and proceed as follows to determine the cause:

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, and depress the voltage regulator armature 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 and insulators 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 may be due to loose connections, frayed or damaged wires, low regulator setting, oxidized regulator contact points, or defects within the generator.

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

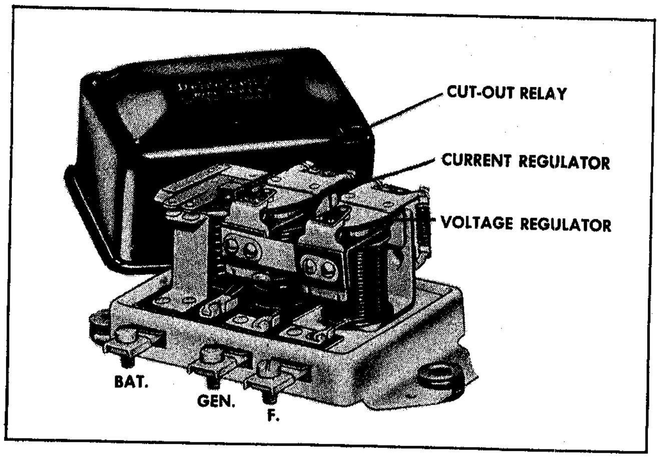


Fig. 6—Current and Voltage Regulator Assembly.

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 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 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 the ammeter. This is the value for which the current regulator is set.
3. Allow the engine to continue running and, 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 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 may 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.

INSTALLATION

Although the Series 71 engine is designed for a variety of applications, there are certain basic principles of installation which must be followed for all applications. Therefore, general procedures covering all applications, and not detailed procedures for each, are given below.

Wherever possible, the unit should be mounted in such a position as to prevent dirt blowing onto the unit. This is particularly true when the unit is installed on a stone crusher, gravel machinery, etc. When a unit is used where the air is laden with lint or chaff, it may be necessary to surround the air intake with a fine mesh screen to keep it from plugging up. **Provide a clean source of fresh air for the blower at all times.**

If a unit is installed in a compartment or small room, provisions should be made to maintain good circulation for cooling and efficient operation. **It may be necessary to expose the radiator to an outside air supply.**

Wherever possible, mount the exhaust silencer horizontally and provide a drain. When the silencer is mounted vertically, use a can cap over the 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. Long exhaust or air intake pipes should be enlarged by one size for each ten feet in length.

If the fuel supply is below the unit, the vertical lift for the fuel pump should not exceed forty-eight inches with a ⅜″ suction tube. A larger suction tube is necessary when the fuel tank is located several feet away from the unit. The fuel return tube should lead to the supply tank (or day tank) and should never be connected to the inlet side of the fuel strainer. Be sure that all fuel tubes and fittings are of corect size to prevent restrictions, and that all connections are leakproof.

For stationary industrial applications, set the 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 ensure accurate readings of fuel oil, lube oil, and water levels.

Install an engine in a vehicle or other type of moving machine so that it will be as nearly level as possible when in its normal working position, and also make sure the engine is securely attached to its supporting frame or siderails.

In marine propulsion installations, the unit and propellers should be aligned when the boat is in the water and fuel and water tanks on board are full. The unit bed should be rigid to preserve the alignment. Particular attention should be given to the installation of the raw water or keel cooling system to ensure adequate circulation. Strainers of ample capacity are usually necessary in raw water systems. Additional equipment, such as water jacketed mufflers or water cooled exhaust systems, should be incorporated according to accepted marine practices. Marine Installations should be carefully planned together by the installing distributor or dealer and the boat builder.

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 interior and exterior of the engine, transmission and other parts from rust accumulation as well as preventing 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.

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. Drain 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 BOX	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-Grade 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.	POWER TAKE-OFF MAIN BEARING	High-Grade 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-Grade 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-Grade 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. Renew fuel strainer element. 4. Renew fuel filter element. 5. Run engine for 2 minutes at approximately 600 r.p.m. with 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 proper proportion. Drain raw water system. Leave drain cocks open.	COOLING SYSTEM		1. Drain all coolant from fresh water system. 2. Drain raw water system. 3. Leave drain cocks and vent valves open. 4. Attach tag showing cooling system is 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 and 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 priming 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 and gear box oil levels, and priming raw water pump, if used.

ALPHABETICAL INDEX

ALPHABETICAL INDEX—Continued