ENGINE-ALTERNATORS - DIESEL

AUTOMATICALLY CONTROLLED

KS-5750, 30-, 40- & 60-KW A.C.

1. GENERAL

1.01 This section describes the apparatus requirements and adjusting procedures for the automatic Diesel engine-alternator sets per KS-5750, Lists 3, 4, and 5, and air box heater equipment per List 11.

1.02 These sets are rated at 30, 40, and 60 kw, 0.8 pf. Each uses a General Motors Corporation 2-cycle, vertical type Diesel engine, which is directly connected to a 3-phase, 60 cycle, 208 to 240 volt alternator. These sets are arranged for automatic operation on an unattended basis under control of a J86621 main control cabinet.

1.03 Reference shall be made to Section A400.001 covering General Requirements and Definitions for additional information necessary for the proper application of the requirements listed herein.

1.04 Requirements and associated procedure marked with a number sign (#) need not be checked by the installer unless it is thought that the requirement is not being met or performance indicates that such a check is advisable.

1.05 Requirements and associated procedures marked with an asterisk (*) need not be checked during maintenance unless the apparatus or part is made accessible for other reasons, or its performance indicates that such a check is advisable.

1.06 The sets are arranged for emergency use in a remote unattended office to automatically furnish a-c power when the outside power supply normally supplying that office fails. For complete information on the operating methods of the sets, refer to Section A301.252.

1.07 Since the sets can start automatically at any time, it will be necessary before making any adjustments on either the engine or any of the control devices to put the EMERGENCY STOP AND CONTROL CUTOUT switch located on the main control cabinet in the STOP position. Then the B minus lead at the starting battery as well as the 1-1/3 ampere fuse at the miscellaneous equipment fuse panel, which supplies battery to the engine alarm circuits, must be removed to make all the d-c equipment in the set control cabinet dead. Next, the handle of the BY-PASS switch on the upper left panel of the main control cabinet must be operated to the down position which is the NORMAL LINE TO LOAD position. When it is in this position, alternating current is removed from the set control equipment, but the outside power supply is permitted to carry the load.

1.08 Hunting, as applied to engines, is a condition where the speed of the engine is periodically rising and falling. Hunting is sometimes present continuously and sometimes intermittently.

1.09 Successful commutation for the purpose of this section may be said to have been obtained if neither brushes nor the commutator is burned or injured to the extent that abnormal maintenance is required. The presence of some visible sparking is not necessarily evidence of unsuccessful commutation.

1.10 Procedures included in this section for maintaining the requirements parallel in part the engine manufacturer's Form DE-346-71-MM maintenance manual entitled "Standard Maintenance Manual - Revised - 1946 - Three, Four and Six Cylinder, Series 71, Two-cycle Diesel Engines." Two copies of this manual are furnished with each set. This manual covers, in detail, additional information which would be required for complete servicing or overhaul of the equipment rather than general everyday maintenance.

1.11 The information contained in this section shall take precedence over the manufacturer's manual wherever differences occur, as for example in cleaning fluids some of which are prohibited in telephone buildings.

1.12 When working around an engine, particularly near any part of the fuel system, avoid the use of an open flame or a portable lamp without a suitable protecting guard.

1.13 When adjustments on the engine involve turning of the crankshaft, a tool, which is provided for barring the engine over by hand, is to be used. This tool is of the spanner wrench type and fits into the holes punched on the periphery

of the belt pulley attached to the crankshaft just behind the radiator. Before using this tool, be sure that the PULL TO STOP-EMERGENCY ONLY shutdown knob, located just below the meters at the alternator end of the set, is pulled out. This trips the air shutdown valve and shuts off the air supply to the cylinder making it impossible to start the set during the barring over of it by hand.

Subdivisions

1.14 Information in both Part 2 requirements and Part 3 adjusting procedures has been arranged under the following headings.

1.15 Index of Figures

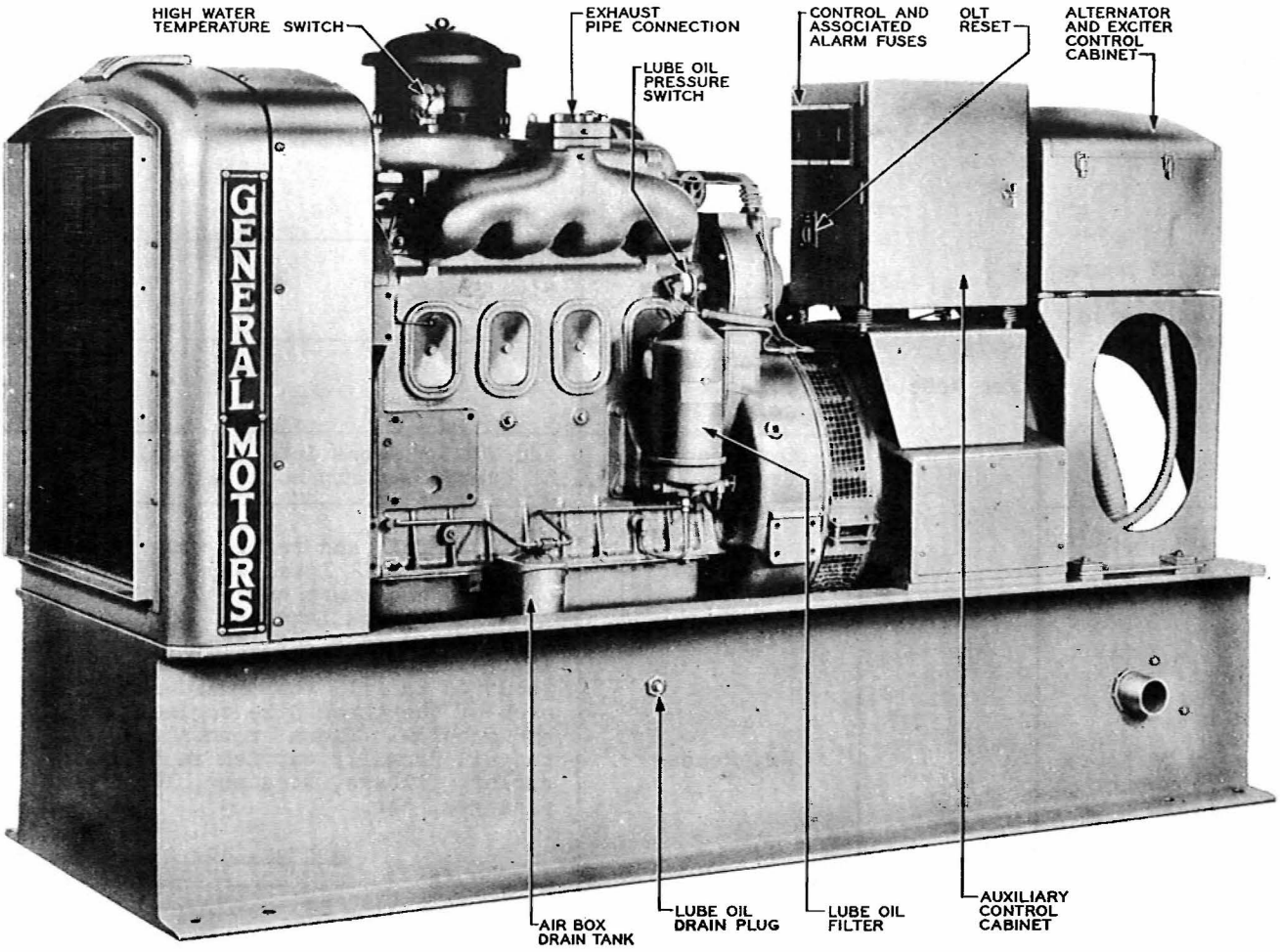

Fig. 1 - Engine-Alternator Set - 40 KW Unit - Exhaust Side

2. REQUIREMENTS

2.01 Lubrication

(a) The engine and alternator shall be lubricated in accordance with the lubrication chart which follows.

(b) During engine operation, the oil pressure shall not fall below a minimum pressure of 18 pounds.

(c) The lubricating oil pressure switch shall close and cause the engine to shut down if the oil pressure drops to 10 pounds or less during engine operation. (See 2.08(c).) Use oil pressure gauge on panel.

Lubrication Chart			
Interval	Lubricant See A710.012	Part	Amount
Beginning of each run	See Note A	Crankcase	Where oil level has fallen more than 1/3 distance from "FULL" mark to "LOW" mark on oil level gauge, fill to "FULL" mark on gauge.
Every 8 hours of continuous operation			Add oil as required to bring level up to "FULL" mark on gauge. Never let the oil level go below "LOW" mark.
Every 25 hours operation or at least once a month		Throttle solenoid bearings for throttle shaft	Five drops
		Linkage at fuel rack solenoid	Five drops
		Governor linkage joints	Five drops
		Overspeed trip	Add 2 to 3 drops into oil cup on top of overspeed trip housing.
Every 75 hours operation or at least once every 6 months		Crankcase	Drain old oil and refill with fresh lubricant until level shows "FULL" on gauge and start engine. After 5 minutes recheck level and add oil as required to bring level up to "FULL" mark. The approximate amounts of oil required to fill the crankcase for each of the three size engines are shown below. These amounts include the oil normally carried in the oil cooler, filters, strainer, lubricating passages, etc. Engine KW — Approx. No. of Quarts for Crankcase 30 — 15 40 — 17 60 — 29
	Oil 80-100S210 (SAE 50)	Air cleaners	Disassemble cleaner and remove dirty oil and sludge from reservoir. Wash the filter element in fuel oil or petroleum spirits to remove dirt. Fill reservoir with fresh oil to indicated level. Two pints per cleaner are required. After filter element has drained, reassemble cleaner. Do not pour any oil over filter element.
Every 150 hours operation or at least once every 6 months	See Note A	Alternator bearing	Fill thru oil cup. Bring level up to about 1/16" to top of cup. Every two years remove plug below oil cup and drain old oil. Replace plug and refill with fresh oil.

Interval	Lubricant See A710.012	Part	Amount
Every 150 hours operation or at least once every 6 months	See Note A	Starting motor and bendix drive bearings	Place 5 drops of oil in each plugged hole. There are 2 plugged holes, one at each end. The plugged hole at the flywheel end is not visible until the plug on the flywheel housing near the starting motor is removed. When removed, either a 1/8" screwdriver slotted plug or the tapped hole for it will be visible. If the hole is unplugged, add oil through the tapped hole. If the 1/8" plug is found in place, use care in removing it to avoid dropping it inside the flywheel housing. When removed, it may be discarded and the hole left unplugged, reinsert the plug however, in the flywheel housing when oiling has been finished. Remove plug at other end of starter, and oil to that bearing and then reinsert plug.
About 250 hours of operation	In Lubrication System	Lubricating Oil Filter	Remove bottom plug and drain oil and sludge. Remove element and replace with new element.

NOTE:

A. For air temperatures usually above 20°F, use SAE 30 Diesel engine lubricating oil. For air temperatures usually between 0°F and 20°F, use SAE 20 Diesel engine lubricating oil. For air temperatures usually below 0°F, use SAE 10 Diesel engine lubricating oil.

Engine

2.02 Speed

(a) With the factory setting on the throttle solenoid (see Fig. 2) and the governor speed droop device, the speed of the set at all loads between no load and maximum available office load not exceeding full load of the set shall be within the following limits.

Max. - 1240 rpm
Min. - 1180 rpm

Use speed indicator.

Note: Although an indication of speed may be obtained from the frequency meter on set control panel (62 cycles corresponds to 1240 rpm, and 59 cycles to 1180 rpm), it is not recommended for use in making speed adjustments. A speed indicator should be used for this purpose.

(b) There shall be no bind in the throttle solenoid linkage, the governor operating linkage, injector racks, or their control tubes. Gauge by feel.

*2.03 Power

(a) When operated on either a No.1-D fuel oil meeting the specification D-975 of the American Society for Testing Materials or water white kerosene meeting Federal Specification VV-K-211b, the engine shall be capable of developing sufficient power at all times to drive the alternator to which it is connected at full-rated output, when the set is installed at an altitude above mean sea level not exceeding 7000 feet for the 30 kw set, or 8000 feet for the 40 and 60 kw sets, with not more than 3" of mercury (40.8" of water) exhaust back pressure.

(b) At higher altitudes than specified in (a) above sea level, the output requirement (a) shall be modified in accordance with the following table.

Altitude in Feet	KW Output 30	40	60
Up to 7000	30.0	40.0	60.0
8000	29.75	40.0	60.0
9000	28.25	38.25	57.75
10000	26.8	36.3	54.75
11000	25.5	34.4	51.8
12000	23.8	32.5	49.0

*#2.04 Exhaust Valve Lash or Clearance

(a) Clearance shall be measured with the engine hot and with the cam follower on the back of the cam, (injector arm depressing the injector plunger for the particular cylinder).

(b) The clearance between the ends of the valve stems and the valve rocker arm shall be 0.009" measured as follows:

0.008"-go
0.010"-no go

Use exhaust valve feeler gauge furnished with engine or KS-6909 thickness gauge.

*#2.05 Injector Setting

(a) Timing: With the engine cold and with the exhaust valves in the cylinder to be checked having started to open, the lower edge of one of the two flats on the injector timing gauge, when held vertically in the timing gauge hole on the top face of the injector body, shall just pass over the top face of the plunger follower guide. Use timing gauge furnished with the engine.

(b) Rack Position: The injector rack position depends upon the maximum fuel adjustment of the hydraulic governor. In this connection a gap of 0.020" between the terminal lever and fuel rod collar of the hydraulic governor, when the fuel rod is held in the full-fuel position with the engine not running, is required to prevent the governor from bottoming the injector racks, so that they will not bind. Use thickness gauge.

(c) A clearance of 1/16" shall be maintained between the fuel rod knob on the governor and the end of the plunger on the fuel rack solenoid which actuates the fuel rod. Use scale.

*2.06 Filters - Air and Oil

(a) The air filters (or cleaners) (see Fig. 2) on the blower intake shall be cleaned after every 75 hours of operation, or at least once every 6 months.

(b) The lubricating oil filter (see Fig. 1) shall be drained, the element removed, and a new element added every 250 hours of engine operation.

(c) The primary fuel oil filter (see Fig. 2) element shall be cleaned every 500 hours of engine operation, or more often, if necessary.

(d) The secondary fuel oil filter (see Fig. 2) shall be removed and replaced every 500 hours of engine operation or more often if necessary.

(e) The injector filters shall be removed and replaced whenever an injector is serviced.

2.07 Leaks

(a) There shall be no leaks in the water cooling system.

(b) There shall be no leaks in the fuel system.

(c) There shall be no leaks around the cylinder head.

(d) There shall be no leaks in the exhaust piping or silencer.

(e) There shall be no water or oil leaks at the lubricating oil cooler.

(f) There shall be no air leaks at the air box handhole covers.

2.08 Automatic Shutdown Devices

(a) The centrifugal overspeed cutoff (trip) device (see Fig. 2) shall operate automatically to stop the engine by cutting off the air supply to the cylinders when the engine reaches a speed between the limits of

Min. - 1380 rpm
Max. - 1500 rpm

Use speed indicator.

(b) The fuel oil pressure switch (see Fig. 2) contacts shall close when the fuel oil pressure rises to a point between 20 and 30 pounds and shall

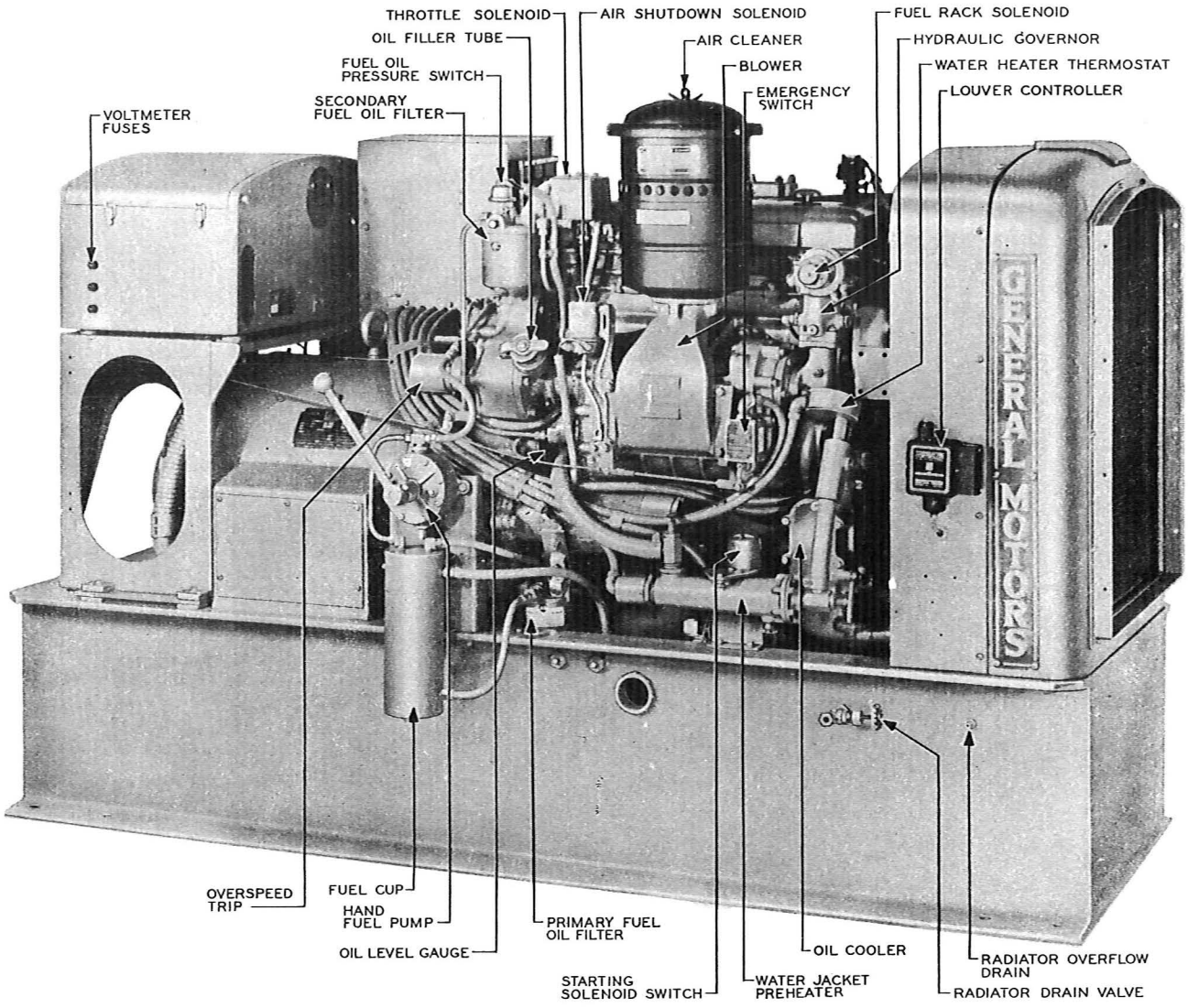

Fig. 2 - Engine-Alternator Set - 40 KW Unit - Blower Side

remain closed for any pressure above that point while the engine is running. The switch contacts shall be open when the set is not running, and shall open at any time the fuel oil pressure drops to a point between 30 and 20 pounds and shall remain open for any pressure below that point while the set is operating.

(c) The lubricating oil pressure switch (see Fig. 1) shall be closed when the engine is not running, but shall open when the engine is coming up to speed as soon as the oil pressure reaches 10 pounds (see 2.01 (c)). During engine operation, this switch shall close only in case the oil pressure drops below 10 pounds or as the engine is stopped by the operator. Use oil pressure gauge on the control panel.

(d) The high water-temperature switch (see Fig. 1) shall operate when the temperature of the water reaches the value given in 2.09(b).

(e) Since the fuel oil pressure switch covered above in (b) is required to close after the engine has started and the normal fuel oil pressure is attained, a failure resulting in either low lubricating oil pressure which will actuate the switch as covered in (c) or high water temperature

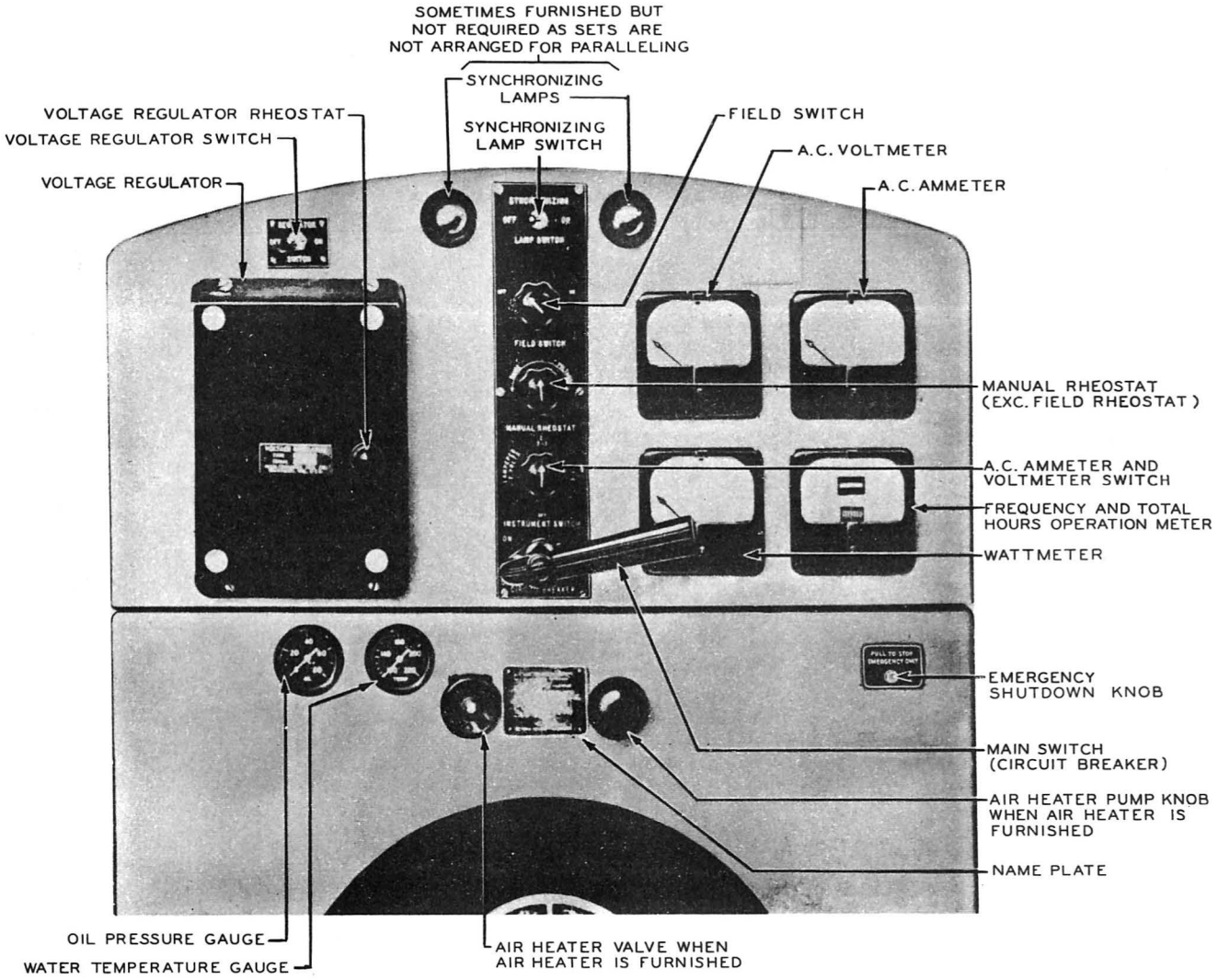

Fig. 3 - Instrument Panel on Engine Set

which will actuate the switch as covered in (d) shall complete the electrical circuit through the fuel oil pressure switch to actuate the air shutdown solenoid (see Fig. 2) to cut off the air supply to the cylinders and stop the engine. Gauge by eye.

2.09 Temperature

(a) The maximum operating temperature of the cooling system shall not exceed 185F. Use engine water temperature gauge or thermometer.

Note: When water is first placed in the radiator or whenever it is added thereto, only soft water should be used. In this connection if the water used by a particular telephone company has been deemed satisfactory in this respect for use where heating of it is involved, as for example in their heating boilers, hot water systems, etc., it should be satisfactory for use in the cooling system of these engines.

(b) The water-temperature switch shall shut the engine down when the water temperature reaches 190 ±2F. Use engine water temperature gauge or thermometer.

(c) Once a month, the 4 pound pressure cap used on the radiator shall be checked for tightness. Gauge by feel. Once every two years the pressure cap shall be replaced.

2.10 Antifreeze Solution: Antifreeze shall be used in the radiators and engine cooling system if the temperature of the cooling air is liable to fall below the freezing point.

2.11 Rust Inhibitor: Rust inhibitor shall be added to the radiator cooling liquid at the time of installation and periodically thereafter.

*#2.12 Air Box Heater

(a) To assist in starting an engine under low temperature conditions, an air heater assembly is sometimes provided and mounted in place of one of the handhole plates in the side of the engine. This air heater is essentially a small, pressure-type, oil burner with electric ignition, and functions to heat the ingoing air to the cylinders. The gap of the coil interrupter shall be maintained at 0.018" when servicing is necessary. Use thickness gauge.

(b) The gap at the wire electrode shall be maintained between 1/8" and 9/64". Use scale.

*#2.13 Water Jacket Heater

(a) To insure rapid starting of the engine, a water jacket preheater, which is a 2500-watt, 230-volt unit, is used in the cooling solution, to heat the engine jacket water, when the set is idle. Controlling this heater and electrically connected in series with it is an adjustable cooling water thermal switch, which is a Penn Electric Company's 440AT type bimetal liquid immersion control. This is shown in Fig. 2 as the water heater thermostat. Its thermal element is also immersed in the cooling solution to open and close the heater circuit at temperature above and below the desired setting respectively. This switch should be set at approximately 95F. Its operation will approximate ±5F. At temperatures above the setting, the switch remains open, as will be the case while the engine is operating. When the engine is not operating and the water temperature is dropping, this switch will close at approximately 95F, thus closing the heater circuit to keep the temperature of the water at this value. Gauge by feel. Use of the water-temperature gauge on the engine panel for this setting is not possible except to indicate when the setting is too high, since its scale starts at 100F. Gauging by the feel of the temperature of the water jacket should be sufficient.

(b) Two 15-ampere fusetrons, HEAT & FAN 1 & 2, located on the front of the main control cabinet protect this heating circuit. Before draining the water from the cooling system, the immersion heater should always be disabled by removing these two fusetrons. This is necessary to avoid damaging the immersion heater which can result if power is connected to it when it is not surrounded with water.

*#2.14 Radiator Discharge Air Louver Motor Controller: The radiator discharge air louvers are operated by a motor which is under control of a Minneapolis Honeywell T915C303XA2 controller, with a 23904A thermostat well. The thermostat element is mounted in the engine water-outlet line to the top of the radiator and the louver controller on the radiator mounting bracket. (See Fig. 2). This louver controller is set so that when the engine radiator top water is 135F to 140F, the louver motor will start to open the discharge air louvers, and when the top radiator water is 170F, the discharge air louvers will be wide open. Use water-temperature gauge on engine panel.

Alternator and Exciter

2.15 Voltage: With the engine-alternator set operating within its rated speed of 1180 to 1240 rpm, the voltage regulator shall hold the output voltage of the alternator within the limits of ±5 per cent of any voltage within the range of 208 to 240 volts under all operating conditions of temperature, hot and cold, no load to full load. Use a-c instruments on control panel.

#2.16 Brush Length

(a) Brushes on the d-c commutator shall be replaced when they are worn to a length of 3/4" as measured from the square end to the toe of the brush. Use scale.

(b) Brushes on the a-c collector rings shall be replaced when they are worn to a length of 1" as measured from the square end to the toe of the brush. Use scale.

#2.17 Brush Fit: The fit of the brushes shall be such as to permit successful brush operation and commutation (see 1.09). Each brush shall be free in its holder and at all times shall have at least 75 per cent of its area in contact with the commutator or collector rings. Gauge by eye and feel.

2.18 Brush Alignment

(a) Alignment of the brushes of the exciter shall be such that the

brushes will not overlap the end of the commutator, override the groove, if provided, or ride upon that part of the commutator used for connection to the armature conductors. Gauge by eye.

(b) The collector ring brush alignment shall be such that the brushes will not override the edges of the collector rings. Gauge by eye.

(c) A clearance of 1/8" between the bottom edge of the brush holder, on either the commutator or collector ring unit, and the commutating surface shall be maintained. Use scale.

#2.19 Commutator and Collector Ring Surfaces

(a) The surface of the commutator shall be clean and free from scoring, pitting, and other deformation of the surface or structure except that caused by normal wear. Gauge by eye

(b) The commutator shall have no high mica, no high, low, or loose segments, or flat spots. Gauge by eye.

(c) The collector rings shall be smooth, free from cuts, flats, or any unevenness. Gauge by eye.

Battery

2.20 Starting Battery (Lead acid or nickel cadmium type)

Caution: Avoid creation of sparks, including those from static electricity, or the use of an open flame near batteries, since the gas given off by the battery is explosive.

(a) Connections shall be clean and tight. On lead acid batteries, they shall also be suitably coated to protect them against corrosion. Gauge by eye.

*(b) Charge: At installation, the battery shall be fully charged and during life, the battery shall be kept charged sufficiently to crank the engine and carry the equipment load connected to it.

(c) Electrolyte level shall be maintained between the top of the separators and the bottom of the cover on lead acid cells, and between 3/4" and 1-3/4" above the top of the plates on nickel cadmium cells. Gauge by eye, on lead acid cells, and use a scale in conjunction with a glass tube furnished with nickel cadmium cells for electrolyte measuring purposes.

Test and Routine Runs

2.21 Test Run

(a) At time of turnover, a one-hour preliminary run shall be made at various loads from no load to not exceeding full load of the alternator.

At the satisfactory completion of the one-hour preliminary run, a two-hour, full-load, official test shall be made. Following this, the engine set shall then be operated for thirty-minutes, carrying the anticipated load if known, otherwise at full load. Information on test loads is covered in Section A801.910.

(b) During the test run described in (a), the requirements of this section shall be met.

#2.22 Routine Run

(a) In order to insure proper lubrication, to avoid rusting of cylinder walls and valve stems, as well as to minimize the collection of sediment in the fuel supply system, it is desirable to routine the engine set on the basis given in (b) and (c).

(b) Weekly: Routine the engine set on a remotely started basis once a week as described in A301.252 by running it at maximum available office load, not exceeding full load, for thirty minutes, in accordance with the operating instructions covered in that section.

Note: In connection with the weekly routine run, it is advisable to occacionally make the routine run during a visit to the station instead of always making it on a remotely started basis.

Short runs, such as demonstration starts, or where the cooling water does not have time to warm up to 120F or above, should be avoided as they are injurious to the engine.

(c) Annually: At least once a year, the weekly run should be extended to about 7 hours, having the set carry as nearly as possible the total load that it would be expected to carry under emergency conditions.

(d) It is not advisable to operate these engines on either the weekly or annual routine runs for the periods listed without having the sets loaded between 30 per cent and full load. If the minimum available office load is less than 30 per cent of the alternator full-load rating, supplement the office load with an artificial load to bring it up to at least 30 per cent, but not to exceed full load.

3. ADJUSTING PROCEDURES

3.001 List of Tools, Gauges, and Materials Materials (Equivalents may be substituted)

Tools

(a) The tools and instruction information listed below are furnished with each engine by the manufacturer. The tools furnished are of a size and design recommended by the engine supplier for use with the particular engine, while the instruction information covers the maintenance and adjusting procedures for the apparatus involved (see 1.10).

Quan.	Description of Part	Manufacturer and Mfr's Part No.
		General Motors Corp.
1	9/16" socket wrench, 6" long (thin wall "T" type)	3223904
1	Injector nut wrench	2133066
1	Exhaust valve feeler gauge 0.008" - 0.010"	2114372
1	Timing gauge	2114371
1	Injector puller and valve spring compressor, bushing, valve lifter	5164851
1	Tool for barring the engine over by hand	5173240
2	Diesel Standard Maintenance Manual	Form DE-346-71-MM
2	Maintenance Manual - 3-phase, 60-cycle 1200 rpm a-c Electric Generators (Delco)	Form 6-SE-18
		Allis-Chalmers Mfg. Co.
2	Generator voltage regulator instruction manual	Form X5150 for V-00 Type
		Bell Telephone Laboratories, Inc.
1	Chart, Operating Instructions and Lubrication	P-418139

(b) In addition to the tools furnished with the engine, it is desirable to have additional tools as listed below.

Bellows, hand
File, flat, pillar, #2 cut, 6" R-1051
Funnel, small
Hammer, ball peen, 1 pound, AT&TCo. Spec. 6258N
Oiler, hand
Pliers, combination
Screwdriver, regular, 5"
Test Set, 81A
Wrenches, hex. flat, open, double end. 7/32-1/4, 3/8-5/16, 7/16-5/8, 1/2-3/4, 15/16-1

Note: Various sections of the manufacturer's maintenance manual furnished with each set specify certain tools in addition to those listed above. However, as their use is intended primarily for overhaul rather than general maintenance of the set, they have not been included herein.

Gauges

Gauge, nest, thickness, KS-6909
Indicator, speed, Jones #5B
Manometer, 4" (mercury), Consolidated Ashcroft Hancock Co., Model 1370
Scale, steel, 6"
Thermometer, 0°C-200C, R-1032
Thermometer, 0-220F, Eimer & Amend Co. No. 32155
Voltmeter, D-C, Weston, Model 280, Scale 0-3-60-150 volts
Voltmeter, A-C, Weston, Model 528, Scale 150-300 volts

Materials

Boric Acid Solution
Cloth, abrasive, 100 grade
Cloth, cleaning, twill jean, D-98063
Grease, 200-250P
Lead, Red
Oil, 80-100 S 210 (SAE 50)
Oil, Diesel Lubricating, (SAE 10), (SAE 20), (SAE 30)
Packing, asbestos, 1/16" thick, width and length as required
Packing, Garlock Packing Co., No. 605, 1/16" thick, width and length as required
Packing, Pyroid, Anchor Packing Co., 1/16" thick, width and length as required
Packing, Vellumoid, Vellumoid Co., 1/64" thick, width and length as required

Pail, galvanized, (for waste oil)
Petrolatum
Sandpaper, 4/0
Shellac or Day 16462 Insulating Varnish
Soda, table (bicarbonate)
Spirits, petroleum

Engine

3.01 Lubrication (Rq.2.01)

(1) For lubrication procedures, refer to the Lubrication Chart listed in the requirements.

(2) The cooling fan bearing on the 30-, 40-, and 60-kw sets are lubricated with grease applied by means of a grease gun through an angle fitting in the fan hub. To lubricate the starting motor and Bendix drive bearings, overspeed trip, governor linkage, throttle shaft bearings, fuel rack solenoid linkage, and alternator bearings, add oil directly from a hand oiler to the oil cup, fitting, or part to be lubricated.

(3) To add oil in the crankcase, pour one of the oils, as noted on the lubrication chart, through the oil filler tube located on the side of the engine (see Fig.2), until the oil level as indicated by the bayonet type oil level gauge is at the FULL mark.

Note: Checking the oil level in the crankcase every 8 hours of engine operation as called for in the requirements assumes the set will be attended. If not, and the set is required to run for extended periods of time, some provision should be made for a periodic check of the oil level. An actual time interval can best be established after some experience in this regard on a particular set has been obtained. These engines have a crankcase capacity that is satisfactory for 50 hours of operation without adding oil provided the crankcase is full of oil at the start of the run.

(4) At the time called for in the lubrication chart for draining the old oil from the crankcase, a flushing of the complete engine is advisable. For this purpose, after draining the old oil, the crankcase should be filled with SAE 20W or SAE 20 viscosity oil to the LOW mark on the oil level gauge. Following this, run the engine at no load for 4 to 5 minutes, after which it should be shut down and the cleaning oil drained out.

Caution: No special flushing oils or compounds shall ever be used for this cleaning procedure because they may prove harmful to the copper-lined bearings.

After the cleaning oil has been drained, fill the crankcase to the proper level with the correct amount of fresh lubricant as called for in the lubrication chart under the requirements.

Note: A record of crankcase lubrication should be kept to show additions and changes of oil.

(5) To adjust the lube oil pressure switch (see Fig. 1), remove the brass cap, which is located in the center of the switch cover between the two terminals, with the aid of a small screwdriver. Exercise care not to damage the brass cap or its gasket excessively. After the brass cap is removed, the adjusting screw, which is underneath this cap, will be accessible. To adjust, loosen the locknut, if provided, which locks the adjusting screw. Turn the adjusting screw clockwise to decrease the pressure at which the switch will make. Turn the adjusting screw counterclockwise to increase the pressure at which the switch will make. After adjustment has been made, tighten the locknut, if provided, on the adjusting screw, and replace the small brass cap.

(6) Once a year, the lubricating oil pressure switch should be removed from the engine and given a pressure test using a compressed air system suitably controlled and equipped for indicating the pressure at which the switch operates. Such equipment can usually be found in a local garage if not in the telephone office. Use a buzzer test set to test the electrical circuit of the switch, whose contacts should open at the pressure covered in the requirements.

3.02 Speed (Rq.2.02)

Caution: Avoid tampering with the governor in an attempt to correct engine troubles. Always try to

locate and correct all engine troubles first. In case the governor has been damaged, the services of a competent service man should be obtained.

(1) If the speed of the engine does not remain within the specified limits, or if the operation is unsatisfactory due to hunting, be sure that the load is not excessive and that all engine cylinders are firing properly. To locate a faulty cylinder, cut out each injector in turn, by holding the injector plunger follower down with a screwdriver while the engine is operating at normal speed. If a decrease in speed is noted, it is an indication that the injector in question is working. If no decrease in speed is noted, it indicates injector trouble and the cylinder is not firing properly. Be sure that the cooling water and lubricating oil supply are satisfactory, that the fuel system is free of air leaks and is supplying adequate fuel to the engine. Check for binding in the governor operating linkage, the throttle solenoid linkage, the injector racks, and their control tubes and correct where necessary. Be sure the control tubes do not turn hard in their small ball bearings. It is expected that slight hunting will be present at no load or light loads, particularly just after first starting before the engine has a chance to warm up. Check the speed of the engine by means of a speed indicator.

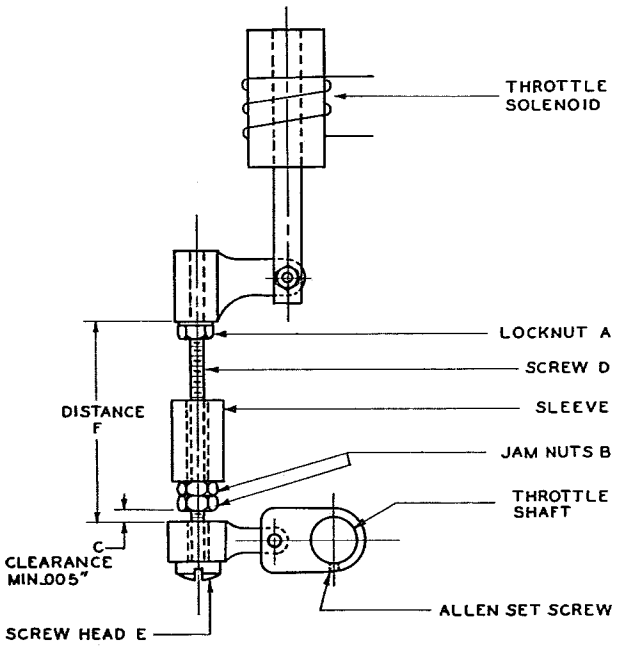

Fig. 4 - Throttle Solenoid Linkage

(2) When it is necessary to make a speed check with a speed indicator, insert it in the end of the alternator shaft. In connection with any speed adjustment, the throttle solenoid linkage (see Fig. 4) on these sets is factory set to a speed range corresponding to that of the speed droop setting on the governor, which is also factory set. In case it is ever found to be different, the speed range of the throttle solenoid linkage can be adjusted as follows:

(a) Referring to Fig. 4, the speed range can be decreased by increasing distance, F, or it can be increased by increasing distance F. For example, assume the speed is 1250 rpm at no load and 1190 rpm at full load and it is desired to obtain a speed at 1240 rpm at no load and 1180 rpm at full load. With the engine not running, loosen locknut A and turn screw head E to the left 1/4 of a turn. Then tighten locknut A, restart the set and check the speed. Repeat as necessary to obtain the correct speed.

Caution: There must always be a clearance of at least .005" for dimension C.

(3) If, after satisfactorily completing the checks outlined in (1) and (2), it is determined that neither load nor engine irregularities are the cause of speed variations, the trouble may be either in the governor or the governor drive. If the speed changes in regular oscillations, usually called hunting, it can possibly be corrected (see Fig. 5) by increasing the speed droop. By speed droop is meant the characteristic of decreasing speed with increasing load. As indicated in Fig. 5, moving the droop adjusting bracket towards the engine will decrease and away from the engine will increase the amount of droop. The bracket can be moved after the droop adjusting screw has been loosened.

Note: The speed droop bracket rides on a shoulder at the side of the terminal lever. The bracket must be told firmly in place on the shoulder when tightening the adjusting screw. If the bracket is not properly positioned, tightening the adjusting screw will bend the bracket, resulting in erratic governor action.

It is not anticipated that speed droop adjustments will have to be made since all governors are set with the correct droop at the factory. (See 1.08). However, in the case of a governor

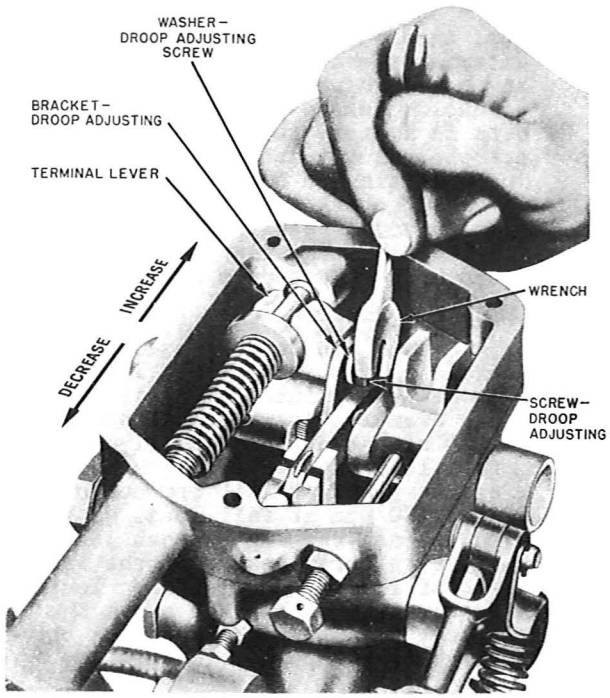

Fig. 5 - Adjusting Speed Droop on Hydraulic Governor

overhaul or where the governor droop adjustment has been changed from the original factory setting, some adjustment may be necessary.

(4) If the speed variations are erratic but small in magnitude, the fault may be in the governor drive. Excessive back-lash in the coupling or the miter drive gears, or too tight meshing of the latter, may cause this condition. Also worn blower rotor bearings or rubbing of the rotors on the housing will cause the load on the flexible coupling between the blower and the engine to vary erratically. Such variation will be transmitted to the governor as a speed change, and it, in turn, will attempt to compensate for this by changing the fuel rod position. No amount of adjustment or other work on the governor can correct this condition. When troubles of this type are suspected, the matter should be discussed with the supervisor.

(5) If the speed variations are large and erratic, and unaffected (except, perhaps, in magnitude) by changes of speed droop adjustment, or if the governor fails to control at all, the matter should be taken up with supervisor, since major repair or even replacement may be necessary.

*3.03 Power (Rq.2.03)

(1) Each engine-alternator set is provided with a nameplate on which is stamped the output capacity of the alternator. Loads on the alternator should not be such that volts, amperes, or kw are exceeded for more than a few minutes.

(2) Common causes for loss for power will be found among the following:

Injector racks not properly positioned.
Faulty injector timing
One or more cylinders cutting out
Air cleaners choked
Insufficient fuel supply
Choked fuel oil filter
Air leaks on suction side of fuel pump
Faulty injectors
Improper governor adjustment
Fuel tank air vent plugged
Engine in a closed room with inadequate air inlet

(3) In addition to the above items, the exhaust line through use may have become clogged and should be checked for excessive back pressure. To determine the back pressure, connect a manometer at the plugged hole provided in the exhaust manifold. Fill manometer to approximately the zero mark and then shift zero mark to read zero (gauge by eye). The reading of the manometer is the sum of the readings of the mercury above and below the zero mark.

(4) If the back pressure test shows it exceeds the specified amount, it may be due to an accumulation of dirt and carbon in the silencer or exhaust line. To clean the silencer on these sets, it is only necessary to remove the side cover plates and wipe out the silencer, since the type used is equipped with clean-out plates for this purpose. After cleaning the silencer, open the exhaust line drain valve to drain off any water present. Then measure the back pressure again and if it is still excessive, the exhaust line evidently is clogged due to an accumulation of dirt, scale, or carbon, and needs cleaning. Since the cleaning of an exhaust line may involve a complete disassembly of it, the matter should be referred to the supervisor.

#(5) Satisfactory performance of the engine depends upon the presence of a sufficiently high compression pressure. This, however, depends upon so many different variables that it is rather hard for an inexperienced person to diagnose the faults correctly

and it is not anticipated that this check will be applied generally. A compression testing gauge is available on order as a General Motors Cylinder Compression Gauge Part No. 3307840 (Kent Moore Tool No.J-1319-A) for Series 71 engines. The gauge is used by removing the injector of a particular cylinder and placing the gauge in its place. Use one of the two fuel lines removed from the injector as a "jumper" connection between the fuel supply and the return manifold fittings. Start the engine and operate it at approximately 1000 rpm and observe the gauge reading. Do not take the compression pressure by cranking the engine with the starter. The gauge reads directly in pounds per square inch and has a scale of 1000 pounds. Where such a gauge is used, it should be done by a person thoroughly qualified to interpret the readings obtained.

#(6) Readings with this gauge may be made on a new or reconditioned engine and recorded for future comparisons. In general, variations of more than 50 pounds between cylinders or a decrease of more than 100 pounds from original readings indicates leaky gaskets, rings, or valves and requires that the engine be taken down, valves reground, or new piston rings and gaskets installed.

*#3.04 Exhaust Valve Lash or Clearance (Rq.2.04)

(1) Adjustment of the valve lash can be changed by means of the threaded upper part of the push rod (see Fig. 6), which is screwed into the push rod clevis and locked by a locknut. The valve lash should be taken on any cylinder when the injector rocker arm (see Fig. 7) is depressing the injector plunger for that particular cylinder. The adjustment is to be made as shown in Fig. 6

Caution: Whenever a push rod (see Fig. 6) has been disconnected from the push rod clevis, the rod must be screwed back into the clevis flush with the top of the threaded portion of the clevis before the valve lash is checked. If this is not done, the piston may hit the head of the valve when the engine is being turned, owing to the small clearance between the valves and the piston head at the piston's upper position.

*#3.05 Injector Setting (Rq.2.05)

(1) Since the ignition in each cylinder is governed by the proper injection of the fuel into the combustion chamber, at the proper time, it is essential that the timing adjustment of the injector be carefully set. During the timing adjustment, the crankshaft should be rotated so that the exhaust valves of the cylinder on which the injector is to be adjusted are all the way down. Place the injector timing gauge in the timing gauge hole in the top of the injector

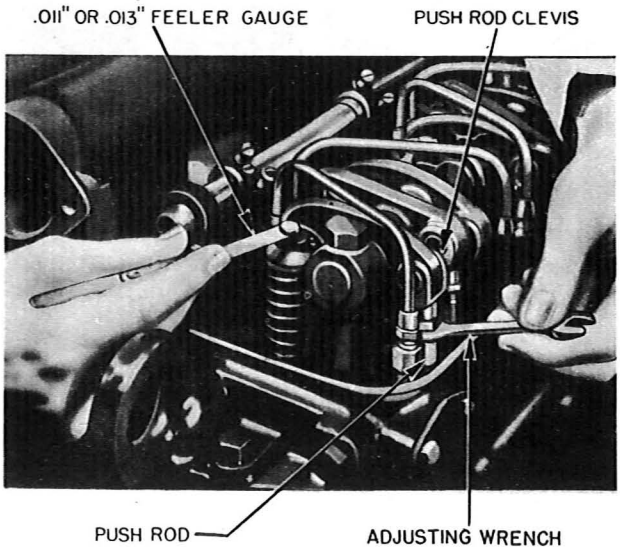

Fig. 6 - Adjusting Valve Lash

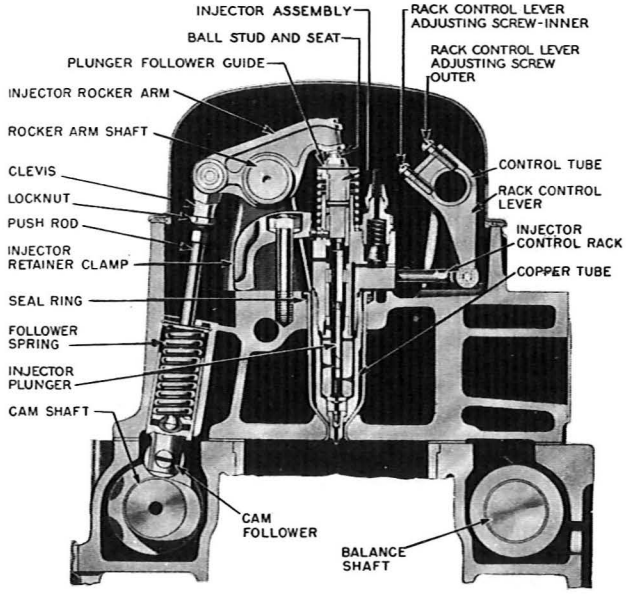

Fig. 7 - Fuel Injector Mounting

body. Loosen the locknut on the upper end of the push rod, and adjust the injector rocker arm (see Fig. 7) by means of the screw adjustment on the upper end of the push rod, until the lowest surface of the timing gauge head when rotated is passing over the top surface of the plunger follower guide. Then tighten the locknut on the push rod and recheck with the timing gauge. Repeat if necessary until the adjustment is correct.

(2) If the above timing operation was carried out on an injector just installed in an engine, do not run the engine until after the injector racks have been positioned as outlined below.

(3) In connection with the positioning of an injector control rack (see Fig. 7), two different conditions will arise, as a result of which it will be necessary to position the injector control racks differently. The two conditions are:

(a) When only one injector has been replaced and the other injectors or the governor adjustment has not been disturbed.

(b) When more than one injector have been replaced.

(4) Under the conditions mentioned in (3)(a), an injector may be installed, valves lashed, injector timed, and the rack positioned to correspond with that of the other racks without repositioning the racks of the remaining injectors, unless it happens to be the No. 1 injector, in which case the procedure would then fall in the class of (3)(b).

(5) To position an injector control rack for condition (3)(a), back off several turns on both the inner and outer adjusting screws (see Fig. 8) on the rack control lever at the injector being adjusted. Hold all the injector racks all the way IN (Full fuel position) by pushing the injector control tube lever to full fuel position. Adjust rack control lever to the full IN position by slowly turning down inner adjusting screw until injector rack can just be felt striking "bottom" and the other racks can be seen to just begin moving OUTWARD. Then tighten down outer adjusting screw and lock inner screw. After positioning rack control lever, check to see that the other racks have not moved out, by inserting a screw driver under the control tube and pressing inward on the end of an adjacent injector. If correct, there should be no further inward travel of any of the remaining racks with this injector rack in the full IN position. If the other rack control levers can be moved in, the lever being positioned of the injector just installed, has been moved in too far and should be readjusted by backing out on the inner screw and tightening the outer screw.

(6) The positioning of injector control racks for condition (3)(b) must be so done that all the cylinders carry an equal share of the load, and in addition they must also be in correct relationship with the hydraulic governor. Since the positioning of all the injector control racks involves considerable work, it is advisable before performing the recommended operations involved, to determine whether the resetting of injector racks is really necessary. To check this, hold the governor control lever securely in the full fuel position, and check the individual movement of each rack, which should be 1/64". If this value is exceeded on any of the racks, a resetting adjustment is necessary. Proceed as follows (engine not running).

(a) Adjust the No. 1 injector control rack to the full fuel position, the purpose of which is to set the No. 1 injector control rack in proper relation to the governor to

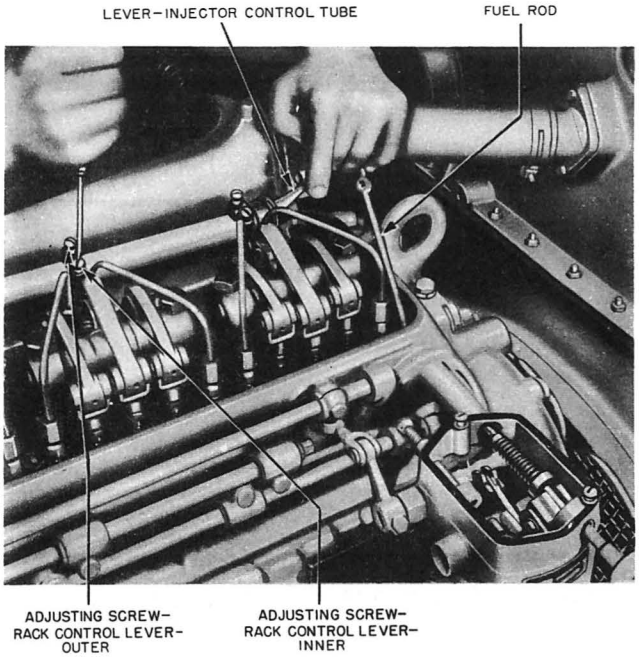

Fig. 8 - Adjusting No. 2 Injector Rack

establish a guide for the setting of all injectors at full load. To do this, first remove the bracket supporting the fuel rack solenoid and then the cover from the top of the hydraulic governor by removing the screws holding them in place. After lifting the cover, reinsert the screws (see Fig. 9) to hold the sub cap of the governor in place. Then make a check of the fuel rod shutdown knob for correct position by loosening the locknut (see Fig. 9) which holds it on the end of the fuel rod. Measure the distance from the end of the rod, after removing the knob, to the locknut and when 3/16 of an inch is obtained, replace the knob, and lock it in this position by means of the locknut. Loosen the locknut on the maximum fuel adjusting screw (see Fig. 10) of the governor and back the screw out until flush with the outer face of the boss, on the terminal lever side. While holding the fuel rod all the way "in" and the terminal lever of the governor firmly against the boss, turn down the inner rack control lever adjusting screw until the fuel rod collar contacts the terminal lever and the terminal lever just starts to leave the boss. Tighten the No. 1 outer rack control

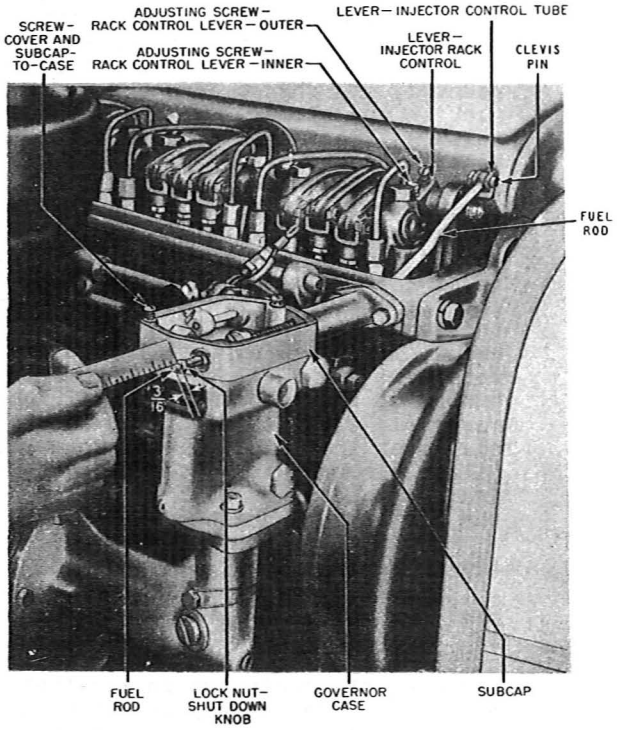

Fig. 9 - Adjusting Fuel Rod

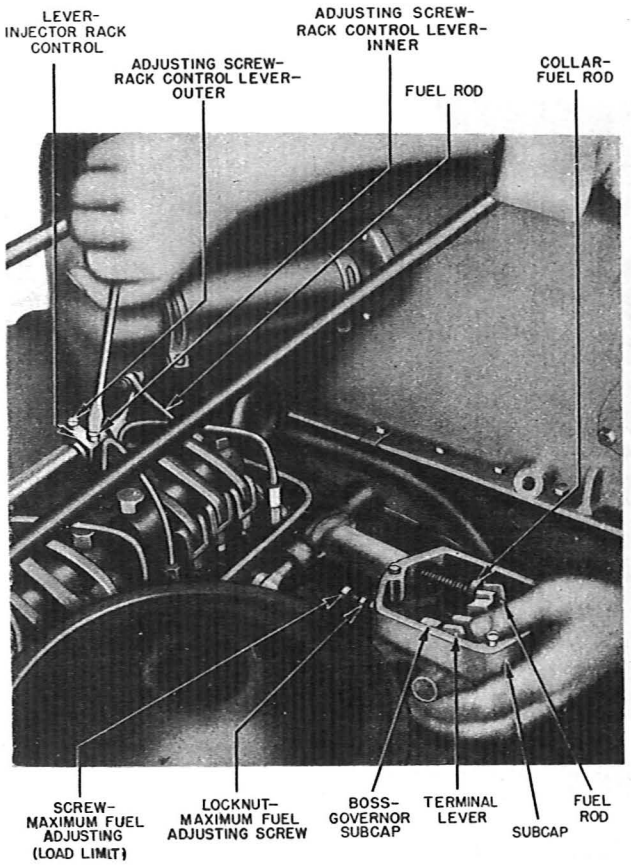

Fig. 10 - Adjusting Governor Terminal Lever With Wide Open Throttle

lever adjusting screw. Then make the maximum fuel adjustment (load limit). This is done by holding both the fuel rod in the full-fuel position and the terminal lever firmly against the fuel rod collar as shown in Fig. 11, while turning the maximum fuel adjusting (load limit) screw.

<u>Caution: Excessive pressure on the fuel rod after bottoming may cause the rod to bend. Avoid this.</u>

Turn the maximum fuel adjusting (load limit) screw in until 0.020" gap (see Fig. 11) exists between the terminal lever and the collar. Then tighten the locknut.

Note: Clearance must not exceed 0.020", as it would then be impossible to obtain full-fuel position of the injector racks.

(b) To position the remaining injector racks, proceed as follows: Remove the clevis pin (see Fig. 9) to

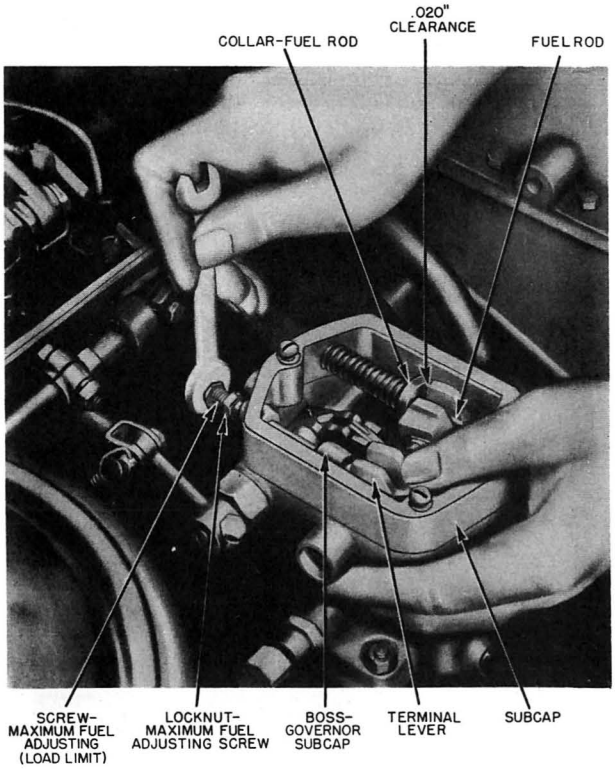

Fig. 11 - Adjusting Maximum Fuel Screw (Load Limit)

disconnect the fuel rod between the governor and the injector control tube lever. Move the injector control tube lever to hold the No. 1 injector rack in the full-fuel position and adjust the No. 2 rack (see Fig. 8). Turn the inner adjusting screw in until the injector rack can be felt striking "bottom". Tighten the outer adjusting screw. Check No. 1 and No. 2 rack with finger tip for rotary movement. If rotary movement of No. 2 rack feels different, correct by readjusting No. 2 rack. When No. 2 rack coupling feels the same as No. 1, repeat the operation on the remaining injector racks in numerical order. After all the racks have been positioned and feel alike, replace the clevis pin to connect the fuel rod again to the injector control tube lever. Following this, check the clevis pin to see that it rotates freely since binding in this pin will result in erratic governor operation.

(c) Following the adjustments in (b), replace the governor cover, the fuel rack solenoid and its mounting bracket, and fasten them in place. After the solenoid is in place, check that the solenoid plunger can be pushed a very slight amount before it bottoms on the fuel rod knob. This knob is the one attached to the left-hand end of the fuel rod shown in Fig. 12. When the solenoid is in place on top of the governor, the solenoid plunger actuates the fuel rod whenever the solenoid is energized. If no clearance is felt, or if the clearance appears excessive, adjust the solenoid mounting bracket by loosening the screws slightly and sliding the assembly in or out as required to secure the proper adjustment. Clearance between the end of the solenoid plunger and the fuel-rod knob is required to insure the return of the fuel-rod knob to the no-fuel position without touching the solenoid plunger. In measuring the clearance, hold a scale at the plunger projection and measure its travel between its normal position and the point where it bottoms when pushed in.

#3.06 Filters - Air and Oil (Rq.2.06)

(1) One or more air filters (air cleaners) are supplied with each engine. They are of the oil bath heavy duty type and are mounted on the air intake manifold (see Fig. 2). The type used is a silencer as well as a cleaner and the air which is drawn into the cleaner by the blower, passes over the top of the oil bath, where a major portion of the dirt is trapped, then up through the filter element, where the finer particles are removed, and thence down the central duct to the blower. To clean these filters, loosen the wing type through-bolt at the top until it can be withdrawn. This bolt attaches the cleaner to the air inlet housing. After removing the bolt, lift the entire assembly free of the air intake manifold, keeping it in a vertical position. Take out the air cleaner element and wash it thoroughly in fuel oil to remove all dirt. Drain the dirty oil from the oil reservoir and clean the sludge from the bottom of the reservoir. Refill the reservoir with SAE 50 oil up to the oil level indicated. Reassemble entire filter element after it has thoroughly drained, and place each in position on the air intake manifold.

(2) To replace the lubricating oil filter elements in the twin element S-2 unit, shut the engine down, if running. Remove the drain plugs at the bottom to drain off the oil, catching the drainings in a suitable container. Separately remove each shell after backing out the center stud at the top of each. Withdraw each filter element from its filter housing.

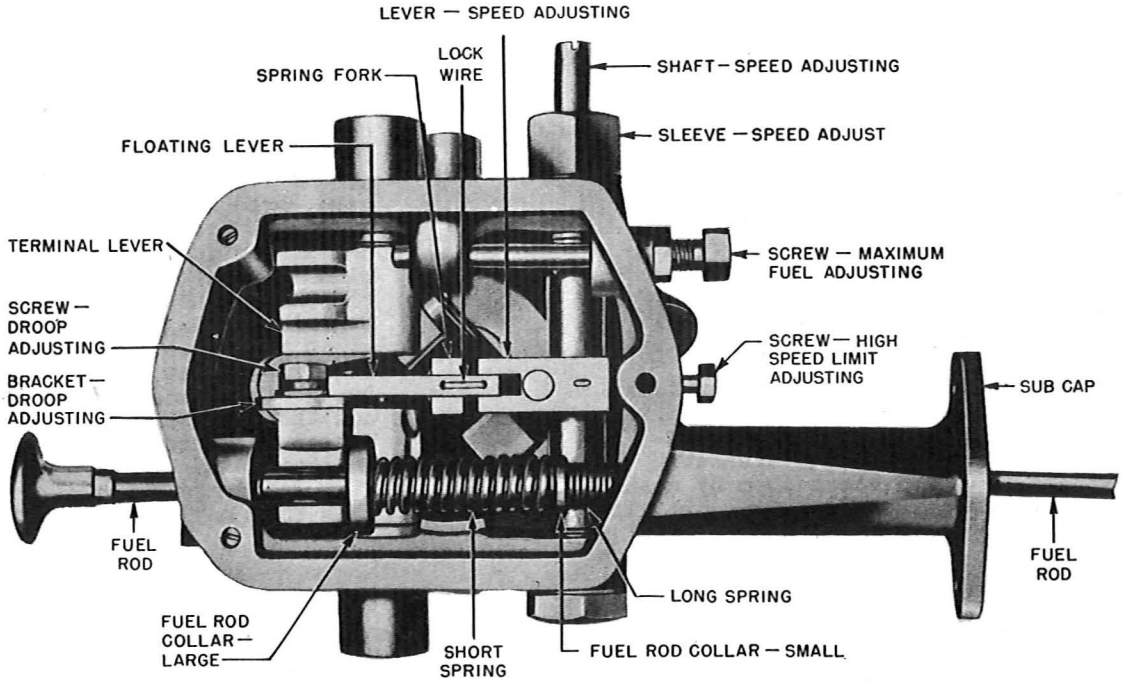

Fig. 12 - Top View of Governor - Cover Removed

Flush out the bottom housing with fuel oil or petroleum spirits. After thoroughly flushing the bottom, replace the bottom plugs and install a new element in each position. Before replacing the two shells, replace the existing cover gaskets with new gaskets. Make certain the elements are lined up properly; then replace each shell and tighten each center stud, making certain the center stud gasket is in place under the head of each stud. Each stud should then be drawn snug against its gasket, but not tight enough to bend or otherwise, deform the cover. Start the engine and then observe the unit for oil leaks at the cover gaskets or elsewhere.

(3) To clean the element in the primary fuel oil filter, stop the engine, if running, open the drain at the bottom of the filter, and, with a suitable container, catch the drainings until the tank or shell of the filter is about half empty. Then close the drain. Remove the cap screw at the top of the filter which is in the center of the cover. This holds the shell to the filter head cover. Support the shell while loosening this screw, and when free lift it away from the engine. Remove the element and wash it thoroughly in clean fuel oil. Do not use a brush for cleaning the element. Be sure the element is clean. Set element in place in the shell with coil spring below it, fill the area between the element and shell with clean fuel oil until it is about 2/3 full. Insert new gaskets, if necessary, between the shell and filter head, and between the element and filter head. Set the shell into place under the filter head cover and secure it with the cap screw in the cover, making certain the gasket under the cap screw is not damaged. If damaged, replace with a new one. Remove the plug in the top surface of the filter head, and with a small funnel placed in the plug hole, fill the remaining space in the filter shell with clean fuel oil. Reinsert plug. After running the engine for a few minutes, inspect the filter for leaks.

(4) To replace the element in the secondary fuel oil filter, stop the engine, if running, open the drain cock at the bottom of the filter bowl, and with a suitable container, catch the drainings until the tank is about half empty. Then close the drain cock. Remove the retaining bolt at the top which holds the bowl into the filter head. Lift the bowl away from the engine. Remove and discard the old element. Wash the bowl thoroughly in clean fuel oil. After setting new element in place over the coil spring, fill the area between the element and

bowl with clean fuel oil until the bowl is about two-thirds full. Using new seals, if required, between the element and the filter head and also between the bowl and the filter head, set the bowl into place and draw it up tight by means of the retaining bolt at the top. Remove the plug on the top surface of the filter head, located just in front of the retaining bolt, and using a small funnel inserted in the plug hole, fill the remaining space in the filter bowl with clean fuel oil. Reinsert plug. After running engine for a few minutes, inspect the filter for leaks.

(5) Although it is possible to remove injector filter elements (see Fig. 13), and clean them by means of petroleum spirits and fuel oil, it is preferable to discard them when servicing an injector.

Note: In case it is ever necessary to reuse old filters, it is very important when reassembling injector filters that have been used, even though they have been thoroughly cleaned in petroleum spirits or fuel oil and dried with compressed air, to reassemble them in the respective openings in the injector body from which they were removed; that is, the filter that was formerly used on the inlet side of the injector and the one that was used on the outlet side should be replaced in their same position. This will guard against small particles that may have lodged on the

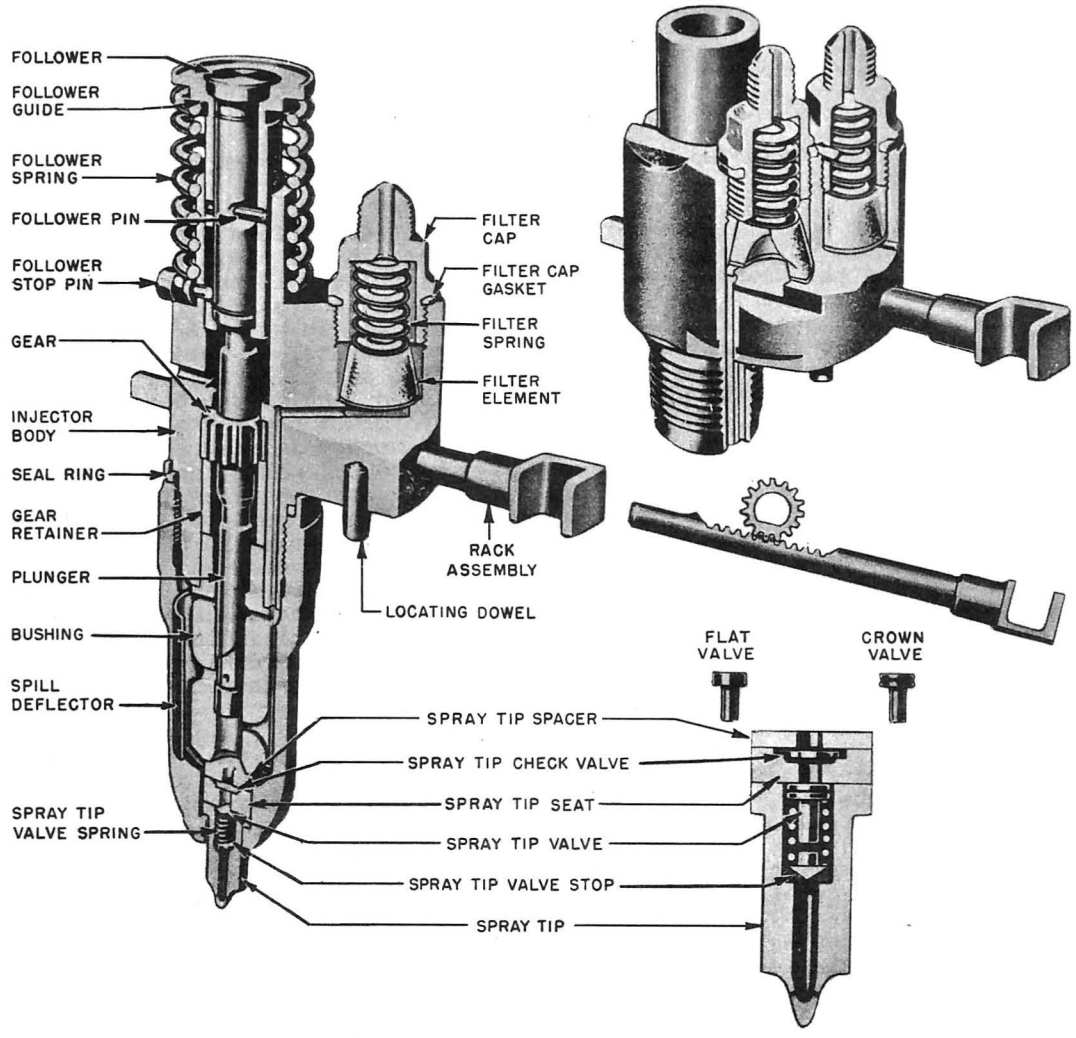

Fig. 13 - Fuel Injector Assembly

inner surface of the outlet filter from being washed into the injector if used on the inlet side.

3.07 Leaks (Rq.2.07)

(1) To stop a leak in the water cooling system, tighten connections, replace packing or gaskets, and renew rubber hose as required.

(2) Leaks of air in the fuel system, especially in the suction side of the fuel pump, will be indicated by loss of power. To check for a leak in the fuel system, disconnect the return line to the fuel tank and connect a rubber hose or flexible tube to the return manifold. Insert the other end of the rubber tube in a large container, such as a gallon glass bottle or equivalent. Start the engine with no load and permit fuel to collect in the bottle with the engine operating at exactly 1200 rpm. The amount of fuel being returned from the manifold should approximate 1/2 gallon per minute. Also observe during this check if air is being pumped through the fuel system as will be indicated by air bubbles appearing as foam on the fuel in the container. If air is present, correct this condition by tightening all fuel connections on the fuel lines on the suction side of the fuel oil pump. Then check the fuel flow again to determine that all air leaks have been stopped. Renew any packing or gaskets as required at other points in the system. Replace the return fuel line to its original connection after completing these tests.

(3) To stop cylinder head gasket leaks, install a new cylinder head compression gasket as well as a set of cylinder head oil gaskets.

(4) As a general rule, there are no dangerous quantities of carbon monoxide in the exhaust from Diesel engines and therefore no tests need be made to check for this gas. However, leaks in the exhaust system are usually indicated by smarting or watering of the eyes, or by observance of a bluish haze in the engine room air. To stop exhaust system leaks, replace gaskets as required or apply red lead or tighten the joints in the exhaust piping. When gasket replacements are necessary, use standard engine gaskets when available. Sheet asbestos packing, 1/16" thick, or equivalent, may be substituted between the manifold and the cylinders, and "Garlock" No. 605 packing or "Pyroid" packing or equivalent, 1/16" thick, may be substituted between the flanged joint of the exhaust pipe section and the engine manifold. Red lead should be used in making up all screw joints in the exhaust system, coating the male threads at the time.

(5) If occasion requires, the lubricating oil cooling unit may be removed from the cooler housing or the entire cooler assembly may be removed from the cylinder block. Since the element through which the oil passes, while being cooled, is surrounded by water in a cast iron housing, the cooling element must be well sealed against water getting into the oil or oil getting into the cooling water. Whenever, therefore, the oil cooler is disassembled, special care must be taken at assembly to have the proper gaskets in place and the retaining cap screws tight.

(6) To stop a leak of air around the air box handhole covers, remove the handhole cover, examine the gasket for rupture, and if found to be defective, replace with a new gasket. If an existing gasket is satisfactory, be sure cover is in place and tightened to avoid further leaks.

3.08 Automatic Shutdown Devices (Rq.2.08)

(1) The overspeed cutoff (or trip) is mounted on the end of the blower drive shaft which projects beyond the auxiliary drive gear housing as shown in Fig. 2. This device is properly adjusted before leaving the factory and no further adjustment in the field should be necessary, unless the unit has been damaged or put out of adjustment by someone not familiar with the device. If such is the case and an adjustment is required, the cap may be removed from the unit by loosening the two spring-type clamps or screw-type clamps, whichever is furnished, holding it in place. On each side of the cover will be found a setscrew and a locknut for securing the knurled adjusting sleeve. After loosening the nuts and setscrews, turning the knurled sleeve counterclockwise will raise the point at which the unit will make contact and clockwise will lower it.

(2) To overspeed the engine and check the setting of the overspeed trip requires the services of two men. One man should hold a speed indicator of the continuous reading type against the end of the alternator shaft, while a second man slowly pushes in on the brass rod which protrudes through the housing of the solenoid mounted at the top of the governor. (See Fig. 2). Access to the alternator shaft is

obtained after the end bell of the alternator has been removed. The speed at which the overspeed trip operates should be noted. In case it differs from that shown in the requirements, adjust the overspeed trip as described in (1) for the requirements listed. When the proper adjustment of the overspeed trip has been made, securely lock its knurled sleeve in place by means of the setscrew and then lock the setscrew in place by its locking nut. Replace the cover on the overspeed cut-off unit and fasten it with the two spring clips or screw-type clamps, whichever is provided, Reinsert the plug in the alternator end bell housing following the completion of the overspeed trip adjustment.

(3) When the overspeed trip closes, the air shutdown solenoid (see Fig. 2) is energized, which operation through its linkage closes the air shutdown valve at the inlet to the blower. This shuts off the air to the cylinders, and causes the engine to stop. While this is being accomplished, do not attempt to move the air shutdown valve linkage. Allow the engine to come to rest, investigate the cause of the overspeed, and when corrected, open the air shutdown valve by pushing the air shutdown solenoid linkage down.

(4) For adjustment of the lubricating oil pressure switch, refer to 3.01 (5) and for its test, refer to 3.01 (6). Replace the switch if found to be defective.

(5) For adjustment of the water-temperature switch, refer to 3.09 (2) and for its test, refer to 3.09 (3). Replace the switch if found to be defective.

(6) For adjustment of the fuel oil pressure switch, (see Fig. 2), follow the procedure covered in 3.01 (5) for the tube oil pressure switch since these two switches are mechanically alike. Likewise its test shall follow the procedure covered in 3.01 (6) except that its requirements for opening and closing shall be in accordance with 2.08 (b). Replace the switch if found to be defective.

Note: The fuel oil pressure, lubricating oil pressure, and water temperature switches are each properly adjusted before leaving the factory. Further adjustment in the field should not be necessary unless a particular switch shows evidence of damage or its operation appears to be faulty. In case it is impossible to adjust a switch, discuss the matter with the supervisor since replacement may be necessary. Replacements should be obtained from the General Motors Corporation.

3.09 Temperature (Rq.2.09)

(1) If the radiator inlet water temperature (as indicated by the thermometer or gauge) is not within the specified limits, see that the radiator is full of water, that any shutoff valves are open, examine the tension of the fan belt to see that there is no excessive slip and that the fan is operating satisfactorily, and check the operation of the pump. If these conditions are met and the temperature of the radiator inlet water is still outside the specified limits, the entire cooling system shall be cleaned as outlined in Section A501.231 of these practices. If the temperature is still outside the limits, it will be necessary to reduce the output or provide additional ventilation or increased cooling capacity.

(2) To adjust the water temperature switch, raise the water temperature by blocking off the radiator air. Then remove the two screws which hold the cover on the high water-temperature switch body (see Fig. 1) and lift the cover. Care must be exercised when lifting the cover not to break the wires which are soldered to it. Turn the spring-loaded adjusting screw clockwise to lower the temperature at which the switch closes and counterclockwise to increase the temperature at which the switch will break. Care should be exercised when adjusting this switch, since the switch block support may easily be bent, thus affecting the closing temperature setting.

(3) Once a year, the high water-temperature switch should be removed from the engine and given a temperature operating test. To do this, place the bulb of the switch in an open can of water and raise its temperature by heating the water, agitating the water to provide as accurate a check as possible. By means of a buzzer test set, check that the switch contacts close when the temperature rises to 190 ±2F as read on a suitable thermometer also immersed in the water as close to the switch bulb as possible. Replace switch if found to be defective.

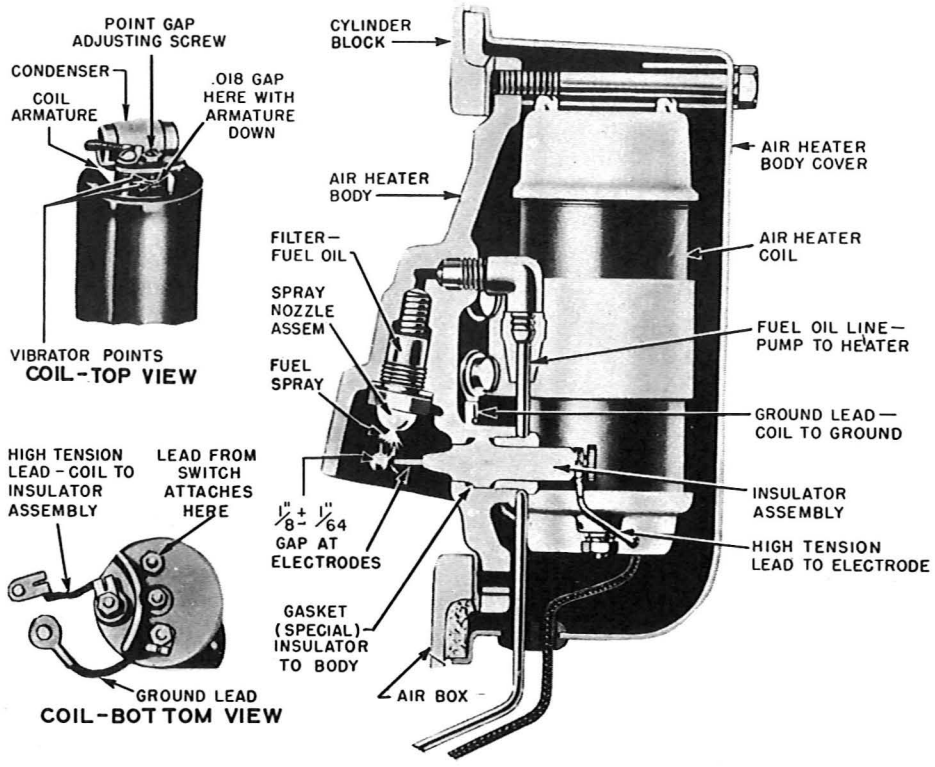

Fig. 14 - Air Box Heater for Cold Weather Starting

(4) The combination of a 4-lb pressure cap provided on the top of the radiator on these sets and the setting of the high water-temperature switch at 188 to 192F is necessary to insure that these sets will operate satisfactorily at altitudes up to 15,000 feet. In this connection the pressure cap must be tight. Periodically check it for tightness, and if found too loose, replace it with a new one.

3.10 Antifreeze Solution (Rq.2.10)

(1) When it becomes necessary to check the antifreeze or replace the water in the cooling system with a nonfreezing solution, follow the procedures as outlined in Section A501.231, in which it will be noted that only ethyleneglycol is approved as an antifreeze for engines of this type due to their high operating temperatures.

3.11 Rust Inhibiter (Rq.2.11)

(1) The addition of andperiodic renewing of a rust inhibitor shall be in accordance with the procedures outlined in Section A501.231.

*#3.12 Air Box Heater (Rq.2.12)

(1) If the engine fails to start in cold weather after two or three strokes of the heater pump knob located on the instrument panel, made while cranking the engine with wide open throttle, the engine cranking should be stopped and a check for possible causes of failure should be made.

(2) Before checking for possible causes of heater failure, make certain the engine is in running order and the cranking speed is 80 rpm or more. Having determined these to be satisfactory, investigate the heater for failure of ignition or poor oil spray.

(3) Remove the air box heater (see Fig. 14) from the cylinder block, and reassemble the heater unit away from the engine.

Caution: Since the air heater switch (see Fig. 15) is a pressure type, its contacts will close only when the air-heater hand pump is operated. Therefore, to avoid the possibility

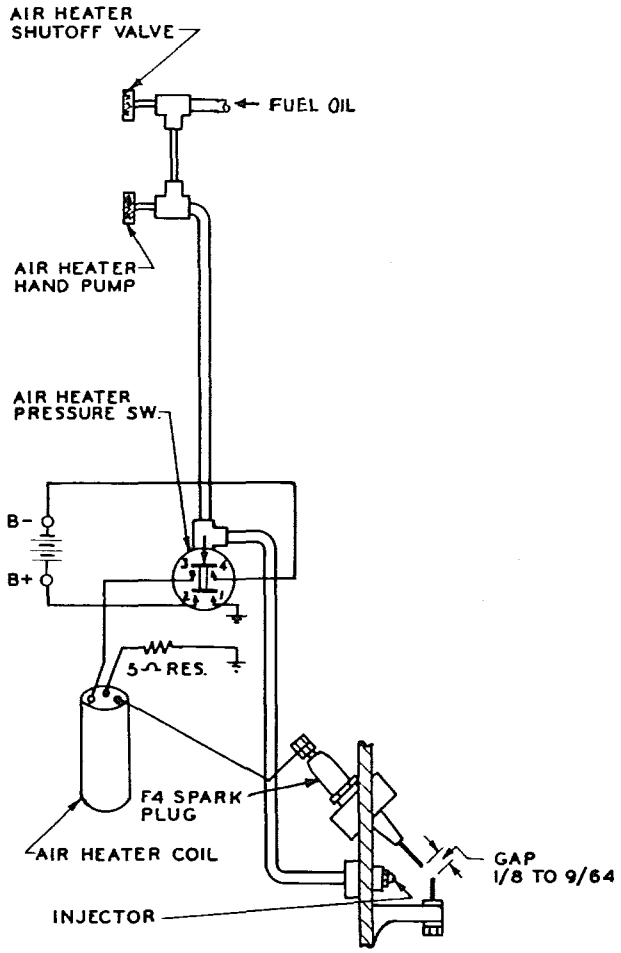

Fig. 15 - Air Box Heater Ignition Diagram

of igniting surrounding combustible material should the air-heater hand pump be operated while the air heater is removed from the engine, be sure always to disconnect the four leads from the air-heater pressure switch as soon as the air heater is removed from the engine and before ever operating the pressure pump. Be sure to tag the leads, before they are disconnected, with the terminal numbers shown in Fig. 15.

When the heater switch leads 3 to 4 and 1 to 2 in Fig. 15 are touched together, the coil interrupter should vibrate rapidly and a continuous hot spark should occur between the ignition electrodes. Then separate switch leads 1 and 2. Operate the pump and observe that a cone-shaped discharge of oil is emitted from the nozzle when the pump is operated. Should the coil interrupter not vibrate properly or the discharge of oil from the nozzle be faulty, correct the condition as required in accordance with the following procedures.

(4) If the coil interrupter does not vibrate when the heater switch leads are touched together as explained in (3), examine the coil points to determine their condition. Clean the coil points with sandpaper and reset them after cleaning in accordance with the requirements to the proper gap, with the armature or vibrator arm held against the coil body. If spark jumps across the porcelain of the electrode, check the gap and correct to meet the requirements. Clean porcelain with petroleum spirits before checking and making gap adjustment.

(5) If the spray nozzle is plugged, as may be indicated by excess resistance on the pressure pump or by failure to "fog" the fuel, the nozzle assembly must be removed and all points thoroughly washed with petroleum spirits and dried with compressed air.

Caution: Do not use a steel wire or drill to clean nozzle. The size and shape of the grooves and orifices are very important and any damage will render the nozzle useless.

(6) If the pressure pump fails, it may be due to dirt either in the check valves or plunger piston cups. In either case, remove the pump and plunger assembly, clean thoroughly in fuel oil, and examine the piston cups carefully for breaks, cracks, or evidence of wear. If any of these conditions exist, the piston cups must be replaced.

*#3.13 Water Jacket Heater (Rq.2.13)

(1) To obtain access to the adjusting means for adjustment of the cooling water heater circuit, remove the cover of the water heater thermostat (see Fig. 16) after first removing the two screws holding it in place. This will make the range adjusting pointer accessible. Then remove the HEAT & FAN 1 & 2 fusetrons at the main control cabinet.

(2) To set the opening point of this control, loosen the knurled thumb nut and move the range adjusting pointer along the temperature scale dial to the desired calibration. When reached, hold the pointer in position and lock by tightening the knurled thumb nut.

(3) The closing point is factory set and is not adjustable in the field. This point is set

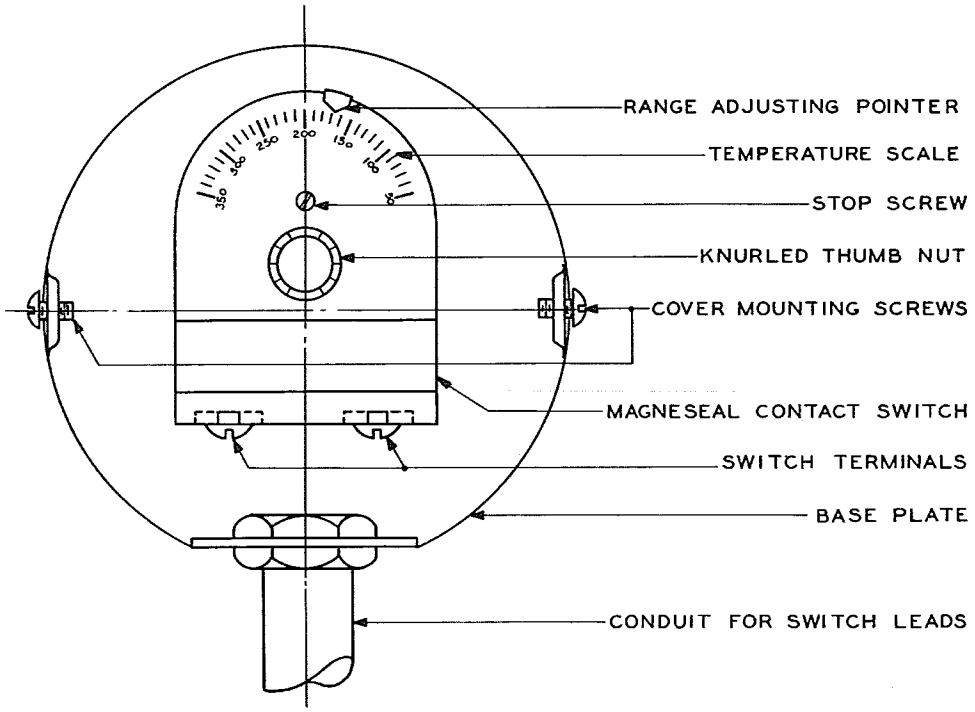

Fig. 16 - Water Heater Thermostat - Cover Removed

at approximately 14F below the cutout point.

(4) The cutout point is also factory set. This is done by the insertion of a stop screw in the dial at the point which is dependent upon the cutout setting recommended by the manufacturer for the equipment on which it is installed.

(5) When the adjustment in (2) has been made, close the circuit to the heater by inserting the HEAT & FAN 1 & 2 fusetrons on the front of the main control cabinet. Allow the cooling water to heat for about 15 to 20 minutes. When this time has elapsed, check by feel of the water jacket to determine that the heater circuit is functioning. If it is functioning, permit it to do so for a period of about 3/4 to 1 hour.

(6) Should the temperature exceed 100F, when the check of (5) is being made, the water temperature gauge on the engine instrument panel (see Fig. 3) which has a scale starting at 100F, will indicate it. Such an indication would mean that the opening point as covered in (2) has been set too high and should be corrected for a lower temperature opening point.

(7) If the solution appears to be cold, while the check of (5) is being made, check the protecting fusetrons for possible failure, and correct as required.

(8) If, after correcting the protective device as described in (7), the solution in the engine jacket still does not come up to temperature after the required time has elapsed as covered in (5), the heating element of the water heater may have been damaged. See 2.13 (b). If the heating element has been damaged, it should be replaced by a new unit.

*#3.14 Radiator Discharge Air Louver Motor Controller (Rq.2.14)

(1) Adjustment of T915C type controllers is covered in Section A401.915.

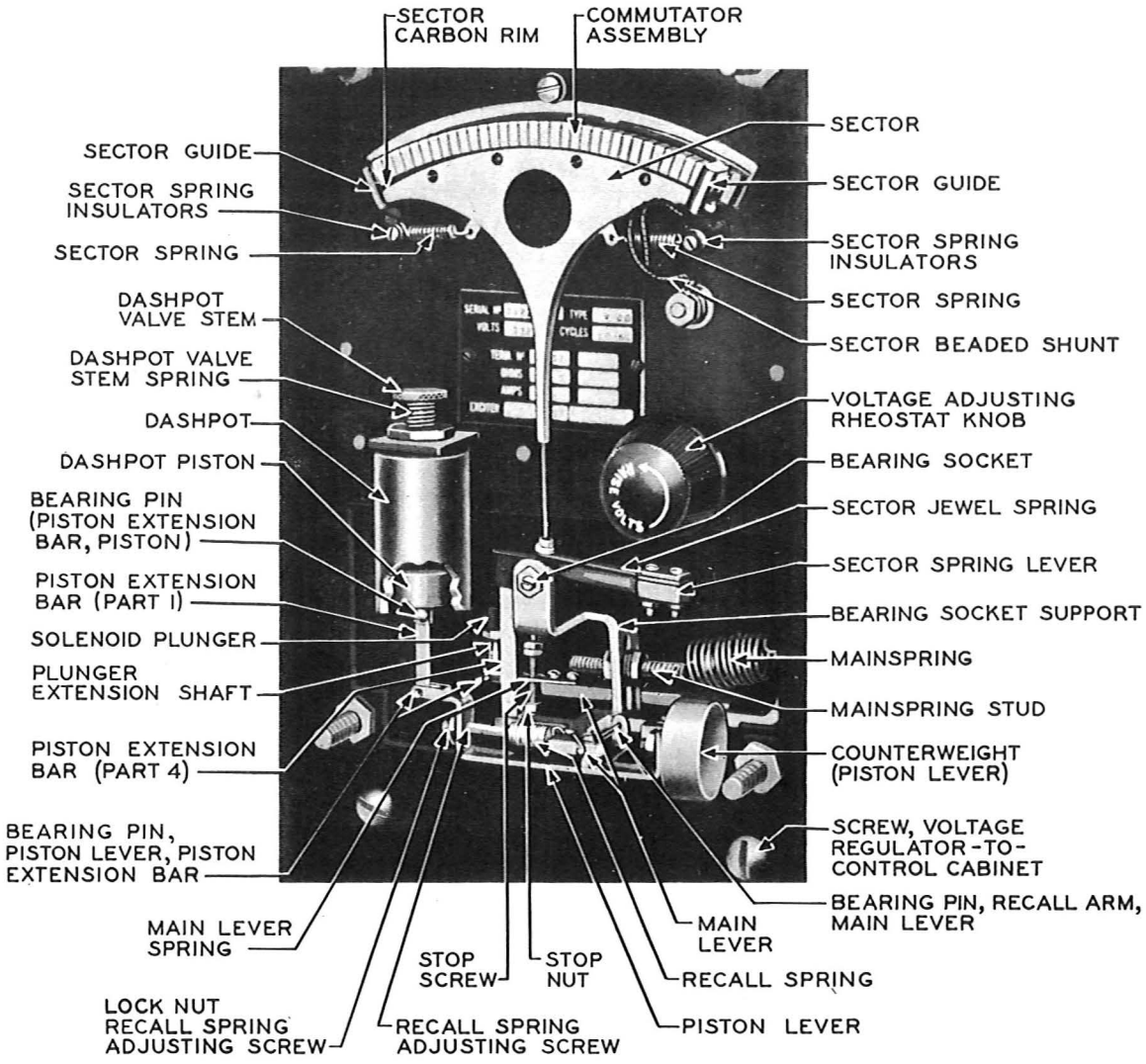

Fig. 17 - Allis-Chalmers Type V-00 Voltage Regulator With Front Cover Removed

Alternator and Exciter

3.15 Voltage (Rq.2.15)

(1) The alternator output voltage is automatically controlled during normal operation by means of a voltage regulator, of the Allis-Chalmers V-00 type. (See Fig. 17.) To determine the alternator voltage, use may be made of the a-c voltmeter on the control panel. If the voltage is not within the proper limits, examine the voltmeter, the alternator and exciter brush setting, exciter rheostat, and voltage regulator for possible injury or loose connections and replace or repair as necessary. Examine the alternator and exciter windings for possible trouble or loose connections and repair if necessary. If the alternator voltage is still outside the limits, check the speed and correct as necessary.

(2) The voltage adjusting rheostat, shown in Fig.18 which is mounted

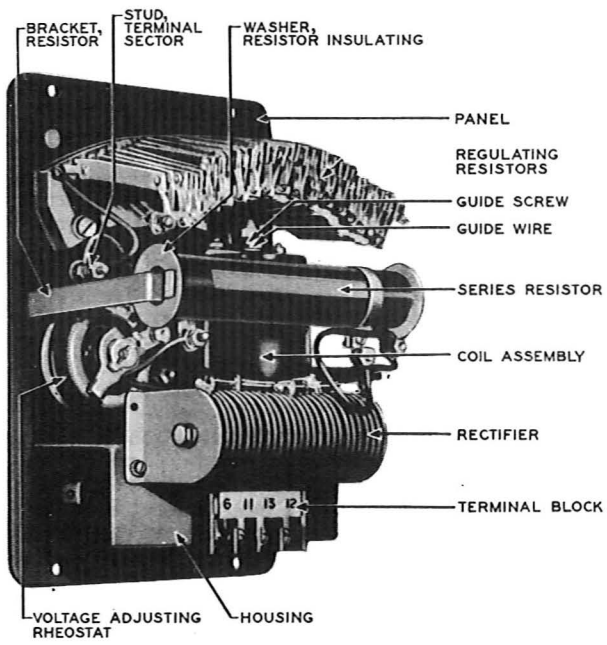

Fig. 18 - Rear View of Allis-Chalmers Type V-00 Voltage Regulator

on the rear of the voltage regulator, is controlled by the voltage adjusting rheostat knob from the front of the regulator (see Fig. 17). This rheostat is furnished to set the alternator voltage at any desired value from 208 to 240 volts. This regulator has a 10- to 12-volt rise from cold to hot condition. Therefore, if 240 volts is desired hot (after about a half hour operation, the regulator can be considered hot) set the no load, cold, a-c voltage at 228 to 230 volts. Then as the set operates, the voltage will rise to 240 and remain there.

Caution: The engine-alternator should not be operated at a-c voltages above 240 to 242 volts.

(3) The voltage regulator is a solenoid-actuated rocking contact type. Best results with this regulator should be obtained if it is left alone, since from a maintenance standpoint, no attention need be paid to it unless it is found to be dirty enough to warrant a cleaning. In this connection, every effort in its design has been made to protect it against the entry of dust and dirt. However, it is impossible to exclude foreign particles entirely, and under very severe operating conditions a deposit of carbon from the sectors will gradually appear on the commutators. When sparking occurs on the commutators, it is an indication that a cleaning is necessary. If sparking does develop, do not allow the regulator to continue operating any longer than absolutely necessary. It should be taken out of service and cleaned.

(4) To take the voltage regulator out of service, while the set is in operation, first remove the front cover of the regulator after removing the rheostat knob. Then turn the MANUAL RHEOSTAT on the instrument panel, (see Fig. 3) which is the exciter field rheostat, slowly clockwise and observe the main lever spring (see Fig. 17) of the voltage regulator, turning the rheostat until the lever drops nearly to the "O" position, and the a-c voltage as indicated on the a-c voltmeter starts to drop. When this position is reached, turn the REGULATOR SWITCH on the instrument panel to its OFF position. Then turn the MANUAL RHEOSTAT counterclockwise slowly, watching the a-c voltmeter until the desired voltage is obtained. The alternator will now be under manual voltage control and any change in alternator load requires voltage correction with the MANUAL RHEOSTAT. The set therefore has to be attended at all times while the rheostat is being used to control the voltage. Clockwise rotation of the rheostat lowers the voltage, while counterclockwise rotation will raise it.

(5) When placing the voltage regulator back in service, always do so under no-load conditions. To put the regulator back in service on an automatic basis again after having it out of service as described in (4), turn the voltage adjusting rheostat to the high voltage position (full counterclockwise), then turn the REGULATOR SWITCH to its ON position. Slowly turn the voltage adjusting rheostat in a clockwise direction until the a-c voltmeter starts to drop. Then turn the MANUAL RHEOSTAT to AUTO and leave it there. This position is the resistance-all-out position. Readjust the voltage adjusting rheostat to the desired voltage.

(6) To clean the regulator commutator and sector thoroughly, remove the sector from the regulator. Wipethe sector carbon rim and the V-groove commutator with a clean dry cloth only. Should dirt stick to the commutator after using the clean cloth, an ordinary pencil eraser may be used. Never use any abrasive, such as emery or crocus cloth. After cleaning

reinstall the sector, being very careful in handling the parts so that no damage to them will result. When reinstalled, move the regulator plunger rapidly up and down between extremes of travel several times, so the sector springs center the sector on the commutator.

(7) If sticking of the dash pot is found, clean it also. Remove its bearing pin, after which the dash pot piston and piston extension bar may be removed as one piece. Wipe out the inside of the dash pot and the surface of the piston with a clean dry nonlinting cloth. Never use oil in the air dash pot. Replace the piston after cleaning and insert the bearing pin.

(8) Should it ever become necessary to disassemble the regulator to replace a part or otherwise, and reassemble it, certain mechanical adjustment checks should be made. These checks should cover the pressure of the sector against the commutator, the parallelism of the sector with the front face of the panel, the parallelism of the sector springs with the front face of the panel, the centralizing of the sector and the commutator, and the travel of the sector in the commutator. Refer to Figs. 17 and 19.

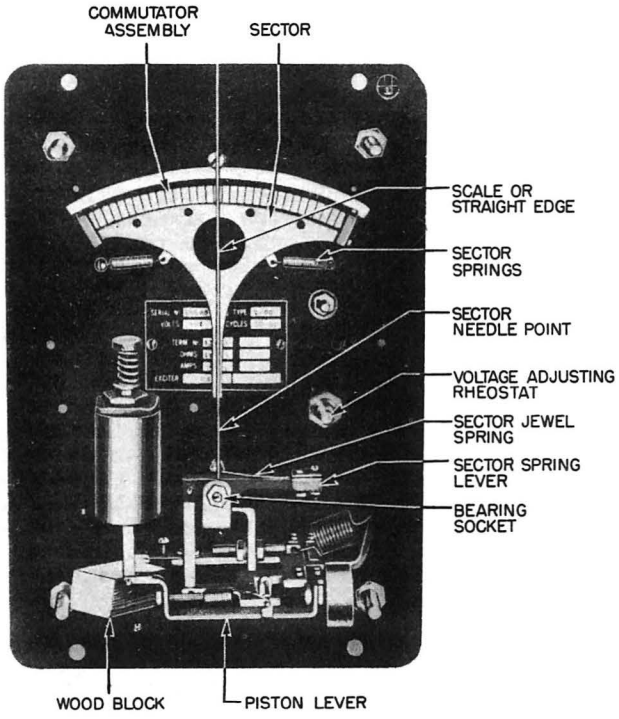

Fig. 19 - Checking Position of Sector in Commutator of Allis-Chalmers Voltage Regulator - Mechanically

(9) To check the pressure of the sector against the commutator, hold the sector spring lever in a horizontal position by inserting a wood block beneath the piston lever and suspend a weight of 110 grams from the sector to give the sector a downward pull. The sector should just move away from the commutator. In case it does not do so, flex the sector jewel spring to give more or less tension as required until the condition is satisfactory.

(10) To check that the sector is parallel with the front face of the panel, measure the distance the apex of the groove in the commutator is from the panel, and the distance the sector needle point is from the panel, using a steel scale. These two distances should be exactly alike. If not, shift the jewel end of the sector jewel spring in or out on the lever to make these spaces equal.

(11) To insure that the sector will travel in the groove of the commutator without bind at any point, each sector spring must be parallel with the front face of the panel. With a steel scale, measure the distance each spring is away from the face of the panel and if not found to be parallel therewith, bend the lug at the sector end of the spring to which the spring is attached until each spring is parallel with the front face of the panel.

(12) To check for central position of the sector in the commutator, hold the jewel spring lever in a horizontal position by means of a block of wood (see Fig. 19) beneath the piston lever, and hold a steel scale vertically through the center segment of the commutator and the center of the bearing socket. If the sector is properly positioned, this straight edge will pass through the exact center of the sector and be in line with the needle point at the sector spring jewel. If not, it is necessary to loosen the screws holding the jewel spring, and shift it to the right or to the left on the lever until the needle point at the sector spring jewel is in line with the straight edge. When so positioned the screws holding the jewel spring should be tightened to retain the adjustment.

(13) Travel of the sector in the commutator should be only far enough for the sector to contact the two

segments at each end of the commutator. To check these positions, hold a steel scale from the center of the sector shaft through the center of each end segment of the commutator and note that the needle point just comes into line. The position of the stop screw (see Fig. 17) determines this travel. If necessary, loosen the stop nut on the stop screw, and adjust as required to obtain the required setting of sector travel. When obtained, fasten the stop nut on the stop screw to maintain adjustment.

#3.16 Brush Length (Rq.2.16)

(1) Replace any short brushes. A collector ring brush or an exciter armature brush may be replaced by loosening its terminal screw, pulling back its pressure finger, and removing the old brush.

#3.17 Brush Fit (Rq.2.17)

(1) If the brushes bind in the holders be sure the brush holders are firmly secured to the brush-holder studs, that they are properly located, that the brush pressure is practically uniform for all brushes, and that the brush contact surfaces are smooth and clean. Remove brushes that bind, and clean them and the brush holder with a clean cloth. If there are any rough projections, the edges of the brush may be smoothed with fine sandpaper before cleaning.

Caution: The exciter armature brushes and collector ring brushes are similar in appearance but are not of the same composition. Do not intermix brushes.

(2) To fit a brush, cut a strip of sandpaper slightly wider than the width of the brush and at least as long as the circumference of the commutator or collector ring. Place a strip of this sandpaper under the brush, and pull the sandpaper back and forth several times being careful to see that the sandpaper follows the curvature of the commutator or collector ring so that the brush and commutator or ring will have the same curvature. On the last three of four strokes of the sandpaper, avoid the back and forth motion, and pull it only in the direction of rotation of the armature or collector ring. After sanding the brushes, clean the commutator or collector rings, brushes, brush holders, etc., with air and wipe with a clean cloth.

3.18 Brush Alignment (Rq.2.18)

(1) If the alignment of the brushes is found to be such that they override the edges of either the collector rings or commutator, shut the set down. To correct this condition, realign the brush holder units in a direction parallel to the shaft of the machine so that the brushes will ride approximately in the center of the contact surface. When properly aligned in this direction, check the distance between the bottom edge of the brush holders and the commutator or collector rings in accordance with the requirements.

#3.19 Commutator and Collector Ring Surfaces (Rq.2.19)

(1) Clean the commutator and collector ring surfaces as required by rubbing with a clean, hard, nonlinting cloth. A bronze colored, highly polished surface is very desirable and should not be mistaken for a burned condition. If a commutator or collector ring presents this condition and is smooth, polished, and commutates satisfactorily, it should be left alone. If the surface becomes smutted with oil, clean with a cloth moistened with petroleum spirits.

(2) Never allow a commutator to become more than slightly rough before corrective measures are taken. If the surface is rough or pitted, the commutator may be smoothed with sandpaper. Before sanding the commutator, remove all brushes. Start the engine manually and operate at approximately 1200 rpm. Press the sandpaper, preferably with a small wooden block behind it, firmly against the surface of the commutator, moving it back and forth in a direction parallel to the commutator segments.

(3) After sanding, stop the set and clean the commutator and windings by blowing out with air and wiping with a cloth dampened with petroleum spirits. If above the copper, the mica between segments should be undercut with a broken hacksaw blade or undercutting tool. Clean and replace the brushes.

(4) If the commutator becomes excessively rough, develops flat spots, or has loose commutator segments, it will be necessary to remove the armature for repairs or replacement, in which case the matter should be referred to the supervisor. See Section A501.905.

Battery

3.20 Starting Battery (Lead acid or nickel cadmium type) (Rq.2.20)

(1) The lead acid starting battery is a KS-15577, list 7, 32-volt storage battery or equivalent. This battery has a specific gravity of 1.210 or 1.215, and a capacity of 207- or 217-ampere hours at the 8-hour rate, depending upon the battery supplied, Gould or Exide respectively.

(2) The nickel cadmium battery is also a 32-volt battery, KS-15578 list 7, or equivalent. This battery has a specific gravity of 1.215 to 1.235 and a capacity of 141 ampere-hours at the 5-hour rate.

(3) On lead acid type batteries, the connections, including contact surfaces, should be scraped clean at time of installation and coated lightly with petrolatum. If corrosion appears on the connection, during life, it should be scraped off and the surfaces washed with a solution of bicarbonate of soda (table soda) in water (2 tablespoons of soda to a pint of water). The surfaces should then be scraped and coated as outlined above at the time of installation. On nickel cadmium type batteries, clean connections, etc., with a clean cloth only. No petrolatum or coating of any kind is required.

*(4) Within 3 months after shipment from the factory, give a lead acid type storage battery an initial charge equal to 100 per cent of the rating of the battery supplied. The nickel cadmium type battery does not require an initial charge if installed within such a 3-month period, but if it is installed between 3 months and 6 months after shipping, an initial charge equal to 25 per cent of its rated capacity is required. An initial charge equal to 100 per cent of its rated capacity is required if its installation is delayed beyond 6 months. This may be done by a garage or battery service station charge, which will be considered satisfactory, but the garage attendant should be warned that it is a low gravity battery.

(5) During life the charge should be checked periodically to make certain the voltage across the 32-volt lead acid type battery is maintained at 34.6 volts, and across the nickel cadmium type battery at 40.6 volts. Since the normal charging source is a J86207L 8-ampere, 34-volt regulated tube-type rectifier, which is mounted in the main control cabinet controlling this engine set, reference to Section A301.303 should be made for operating information on this rectifier.

(6) Failure to crank, or abnormally slow cranking of an engine free to rotate, would indicate under charge, in which case, a charge equivalent to 100 per cent of the rating of the battery is necessary. A battery that will not retain a charge and must have frequent special charges should be replaced.

(7) Electrolyte level in lead acid batteries should be maintained by quarterly additions of distilled water or water approved for storage battery use. Neutralize spilled electrolyte of lead acid batteries with bicarbonate of soda solution. In nickel cadmium batteries, use only distilled water, and maintain the level by annual additions. Neutralize spilled electrolyte of nickel cadmium cells with boric acid solution.

Test and Routine Runs

3.21 Test Run (Rq.2.21)

(1) During the test run, the various loads for the engine-alternator set may be obtained by varying the amount of load connected to the alternator load terminals. The speed of the engine shall be taken with an accurate indicator or counter placed against the end of an alternator shaft. Discuss loading arrangements with the supervisor. When sufficient office or building load is not available or service reactions are involved in its use, artificial loads may be necessary. See Section A801.910. Any troubles which are likely to develop will probably be noticed during such a test run and may be corrected before the set is needed at a time of actual power failure.

#3.22 Routine Run (Rq.2.22)

(1) On these stand-by sets with weekly operations for short periods, all working surfaces requiring lubrication

will be lubricated frequently enough so that at least some oil will remain on them, sufficient to protect them and to provide partial lubrication immediately upon starting. Where sufficient office or building load is not available, artificial loads may be necessary, in which case reference to Section A801.910 covering artificial loads should be made.

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