

ENGINE-ALTERNATORS - DIESEL

AUTOMATICALLY CONTROLLED

KS-5750 - 30, 40, AND 60 KW

1. GENERAL

- 1.01 This section describes the method of operating 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 manufactured by the Detroit Diesel Engine Division of the General Motors Corporation and are rated at 30, 40, and 60 kw, 0.8 pf, 3 phase, 60 cycles, 208 to 240 volts, while the control equipment unit for its automatic operation is manufactured by the Western Electric Company as J86621. The 2-cycle engines are of the vertical type, operating at 1200 rpm. Each engine is directly connected to its associated alternator. The engine, radiator, alternator, exciter and associated alternator and exciter controls are mounted on a common fabricated steel subbase. The complete set is mounted on rubber supports. All sets have radiators and pusher-type fans for cooling the engines. Each engine is started automatically when used with the J86621 automatic control cabinet. Sets are furnished with 32-volt starting motors.
- 1.03 Routine checks should be made preferably during a period when they will cause the least service reaction.
- 1.04 In connection with the storage of fuel oil for these sets, care should be exercised to prevent dirt entering the fuel storage tank. Always see that the supplier or attendant thoroughly cleans all equipment used in filling the tank before placing any fuel in it. Whenever new fuel oil is added, always allow such fuel oil to settle for at least six hours before using it, if at all practicable. Fuel oil stored for long periods has a tendency to form gum. It is recommended that at least annually, new fuel be added to the storage tank, the amount of new fuel to equal or exceed the estimated amount of old fuel remaining in the tank. In some cases, this may necessitate removal of part of the old fuel but this can usually be avoided by limiting the quantities of fuel stored.
- 1.05 The instructions in this section cover the operation of the engines. Instructions for the operation of the automatic devices which are part of a separately

mounted main control cabinet are covered in Section A301.552. Operation of the sets is based on circuit drawings SD-81106-01 for the engine-alternator, and SD-81092-01 for the automatic control of it. Operation of alarms is based on circuit drawing SD-81100-01 insofar as its relation to the two above mentioned circuits is concerned. For a detailed description of the operation of the individual circuits, see the corresponding circuit description.

1.06 Reference should be made to Section A401.252 for information necessary for the proper maintenance of the equipment referred to herein. Some additional engine information is contained in the General Motors Maintenance Manual, Form DE-346-71-MM, two copies of which are supplied with each engine. However, when using the General Motors manual, use only such of it as is found to apply to these engines. Where differences occur between the General Motors manual and these practices, the information contained in these practices shall take precedence over the manufacturer's manual.

Working on the Engine or Its Control

1.07 Whenever it is necessary to work on the engine or the control, operate the toggle switch, designated EMERGENCY STOP AND CONTROL CUTOUT, located on the front of the main control cabinet, to its STOP position. This will render the automatic control inoperative. Next remove the B-minus lead at the starting battery. Also on the office equipment fuse panel, remove the 1-1/3-ampere fuse, which supplies battery to the engine alarm circuits. Removal of this fuse and the B-minus battery lead makes all the d-c equipment dead. Then put the BY-PASS switch handle, which is on the front of the main control cabinet, in its down position. This is its NORMAL LINE TO LOAD position, and 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.

Caution: If the BY-PASS switch is operated before disconnecting the B-minus lead at the battery, the set will start and run unless the EMERGENCY STOP AND CONTROL CUTOUT switch on the main control cabinet

is placed in its STOP position, or the PULL TO STOP-EMERGENCY ONLY shutdown knob on the engine panel is pulled out.

1.08 At the completion of work on the set or its control, be sure to reinsert the 1-1/3-ampere engine alarm circuit fuse which was removed in accordance with 1.07 from the office fuse panel. Next be certain the EMERGENCY STOP AND CONTROL CUTOFF switch on the front of the main control cabinet is in its STOP position, or that the PULL TO STOP-EMERGENCY ONLY shutdown knob at the engine panel is pulled out. Then reconnect the B-minus lead to the starting battery terminal. When the battery lead is properly connected, place the BY-PASS switch handle on the front of the main control cabinet in its up position, which is the NORMAL LINE TO TRANSFER position. Then observe the procedures outlined in paragraphs 2.06 to 2.13 inclusive, to make certain the set is left in the proper condition to start automatically when a power condition requires it.

1.09 Information in this section is arranged under the following headings

<u>Part</u>	<u>Page</u>
1. GENERAL	1
1.07 Working on the Engine or Its Control	1
2. OPERATION	2
2.01 Description of Sets	2
2.04 How the Sets Operate	3
<u>Preparation for Starting</u>	
2.06 Inspecting Set and Starting Battery	3
2.07 Checking Fuel System	3
2.08 Checking Cooling Water System	4
2.09 Checking Lubrication	4
<u>Preparation for Automatic Operation of Set</u>	
2.12 Setting of Switches and Valves on Engine Set	6
2.13 Setting of Control Devices at Main Control Cabinet	7
<u>Automatic Starting, Running, and Stopping</u>	
2.15 Running	7
2.23 Emergency Stopping	8
<u>Stopping of Set by Operation of Engine Trouble Controls</u>	
2.27 Starting Motor Overload	9

<u>Part</u>	<u>Page</u>
2.28 Overtime Cranking	9
2.29 Overspeed Cutoff	9
2.30 Low Oil Pressure or Cooling Water High Temperature	10
2.31 Blowing of Control Fuses and Associated Alarm Fuses	10
<u>Operation of Alarms</u>	
2.33 Engine Alarms	10
<u>Determining Trouble Responsible for Automatic Shutdown of Set</u>	
2.34 Locating Engine Troubles	11
<u>Air Box Heater for Cold Weather Starting</u>	
2.35 Starting Set When Equipped with Air Box Heater	11
<u>Final Checks</u>	
2.36 Leaving Set Unattended	12
3. ROUTINE CHECKS	12
<u>Weekly Routine Run</u>	
3.01 By Remote Control	12
<u>Local Testing of Plant</u>	
3.03 Test Runs at No Load	12
3.04 Test Runs at Office Load with All Timing Devices in Use	13
3.05 Test Runs at Office Load With All Timing Devices in Use Except the Starting Timers	13
<u>Testing of Alarms</u>	
3.06 Fuse Alarm	13
3.07 Overspeed Alarm	13
3.08 Low Lubricating Oil Pressure Alarm	14
3.09 Cooling Water High Temperature Alarm	14
<u>Battery</u>	
3.10 Periodic Checks	14
4. GENERAL TROUBLES	14
4.04 Engine	14
4.05 Alternator and Exciter	16
<u>2. OPERATION</u>	
<u>Description of Sets</u>	
2.01 The engine, alternator, and exciter, together with their mechanical and electrical controls, exclusive of those for automatic operation, are mounted on a common fabricated steel subbase, arranged	

for floor mounting on rubber supports. A separate main control cabinet, in which are mounted the automatic controls, is arranged for mounting on the floor, either of the engine room or an adjacent room.

2.02 The engine is of the 3, 4, or 6 cylinder, 2-cycle, vertical type and operates at 1200 rpm. Normally, each engine is started automatically. Means for disabling the automatic control are provided so that the engine can be operated on a nonautomatic (manual) basis when required.

2.03 Each alternator is directly connected to its engine by means of a coupling. The type of alternator used is for 3-phase, 4-wire, 60-cycle, 208 to 240-volt distribution. Each alternator is of the single bearing type and has a directly connected exciter supported from the alternator bearing housing opposite the coupling end.

How the Sets Operate

2.04 The normal operation of these engine-alternator sets is on a fully automatic, unattended basis, with their starting, running, and stopping entirely under control of preset automatic devices. They are designed to operate in the following manner. When the outside power supply fails or drops to approximately 88 per cent of normal voltage, or lower, a delay of approximately 2 minutes in starting the engine is provided, to prevent starting during momentary dips in voltage. At the end of this delay, the engine starts automatically and operates at no load for 4 to 5 minutes. Then the engine-alternator set assumes the load if the outside power is still off. A delay of 4 or 5 minutes, after the outside power is again available at approximately 94 per cent of normal voltage, or higher, is provided to prevent transferring the office load to the power service, in case the restoration of power should be only temporary. After this delay, the office load is transferred automatically and the engine is stopped in a condition for automatic starting. Each engine is started from a 32-volt storage battery operated starting motor.

2.05 Provision is made in the main control cabinet circuit for routing the engine-alternator set without visiting the station. The arrangement provides for starting the set from a remote location, operating at no load for about 5 minutes, and operating it on the station load for 25 minutes, following which the set will automatically stop 4 to 5 minutes after the 30 minutes have elapsed, and its controls are restored to their normal positions for automatic operation. The radiator fan is of sufficient size to care for

usual conditions of room ventilation in addition to cooling the engine cooling water. A set of room air intake louvers opens as soon as the engine starts, and closes as soon as the engine stops, both operations being automatically controlled. A radiator discharge air louver controller, working in conjunction with a thermostat in the engine cooling water, starts to open louvers located in the radiator discharge air duct when the engine cooling water reaches a temperature of approximately 140F. At lower temperatures these louvers are closed. Also in the top of the discharge air duct, inside of the engine room, another set of automatically controlled louvers is mounted. Their operation is under control of a thermostat in the engine room, the function of which is to open the louvers to recirculate part of the heated air from the engine radiator fan when the engine is running and the room temperature is below 75F, to help heat the engine room, particularly in cold weather. When the room temperature is 75F, or above, these louvers are closed. Refer to Section A401.915 for information on power room ventilation and air discharge duct equipment.

Preparation for Starting

2.06 Inspecting Set and Starting Battery

- (a) Go over the engine carefully to see that it is clean, that no parts are loose, and that no tools or other objects are in or on the set to interfere with its operation.
- (b) If a condensate drain is provided in the exhaust line, make certain that it is closed. Close the exhaust line silencer drain if the silencer is of the MU2 type mounted in the engine room.
- (c) See that there is sufficient electrolyte in the starting battery cells. Add water to bring the level of the electrolyte up to the bottom of the cover in each cell, if required.

2.07 Checking Fuel System

- (a) Make certain that there is fuel in the fuel tank. Before the set is left unattended, always check the amount of fuel in the tank and replenish as required so that there will be an ample supply for the next run.
- (b) Open the fuel valve in the suction line at the engine room floor.

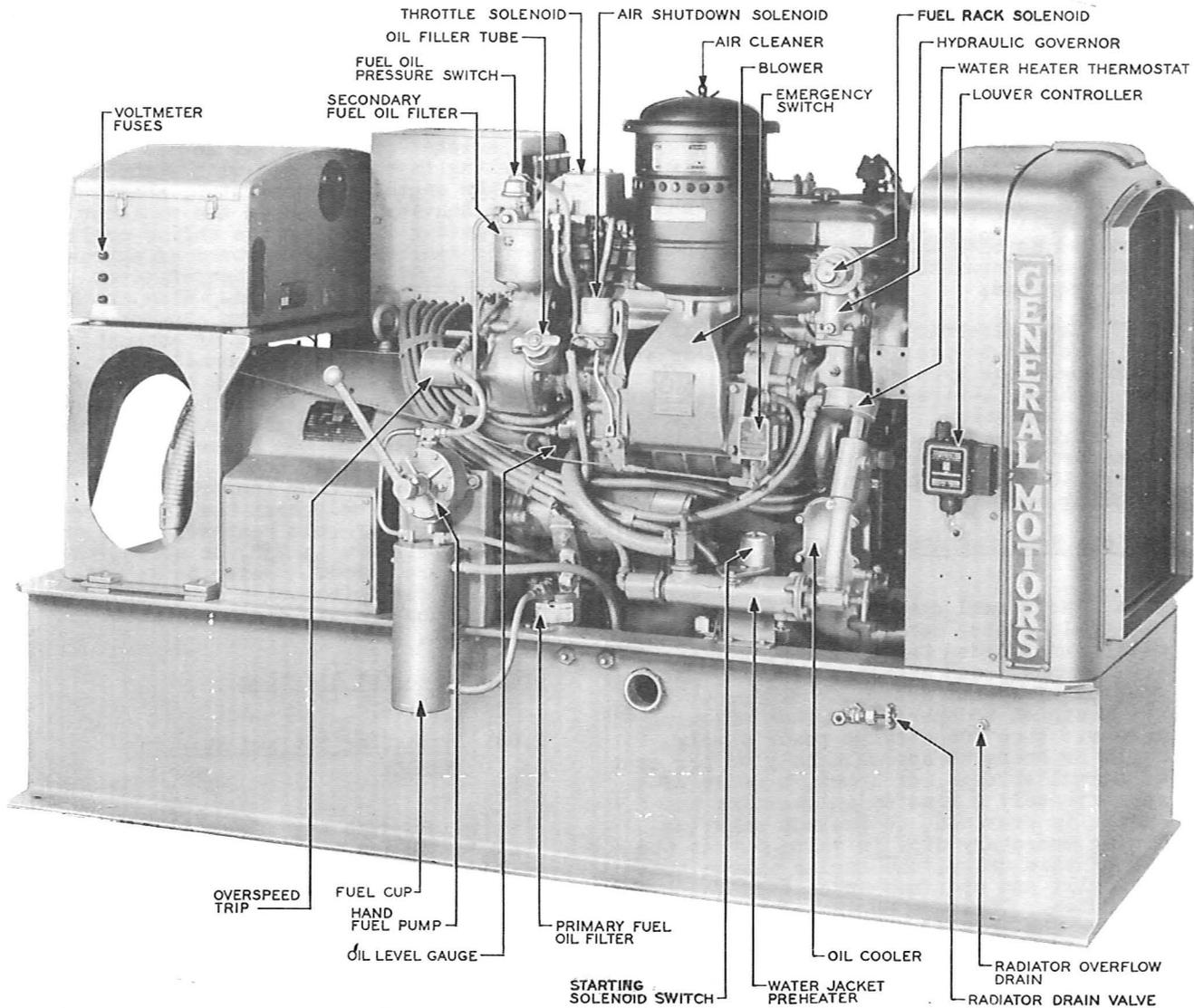


Fig. 1 - Engine-Alternator Set - 40 KW Unit - Blower Side

- (c) Operate the hand fuel pump (Fig.1) until the fuel cup is full.

2.08 Checking Cooling Water System

- (a) Make certain that all water-jacket and radiator drains are closed, and observe that they do not leak.
- (b) Check the radiator and cooling system to make certain it is filled with water. The cooling system of each set requires the following quantity of water to fill it.

<u>KW of Set</u>	<u>Gals. of Water</u>
30	6
40	7
60	9

Note: Make certain pressure cap on radiator is tight after adding water. This cap must be tight at all times. If found to be loose, replace it with a new cap.

2.09 Checking Lubrication

- (a) Check the oil level in the crank-case by means of the oil level gauge, (see Fig. 1) which is located on the blower side of the set, and add oil if required to bring it up to the FULL mark on the gauge.
- (b) Never allow the oil level to fall more than one-third the distance between the FULL and LOW marks on the oil level gauge.

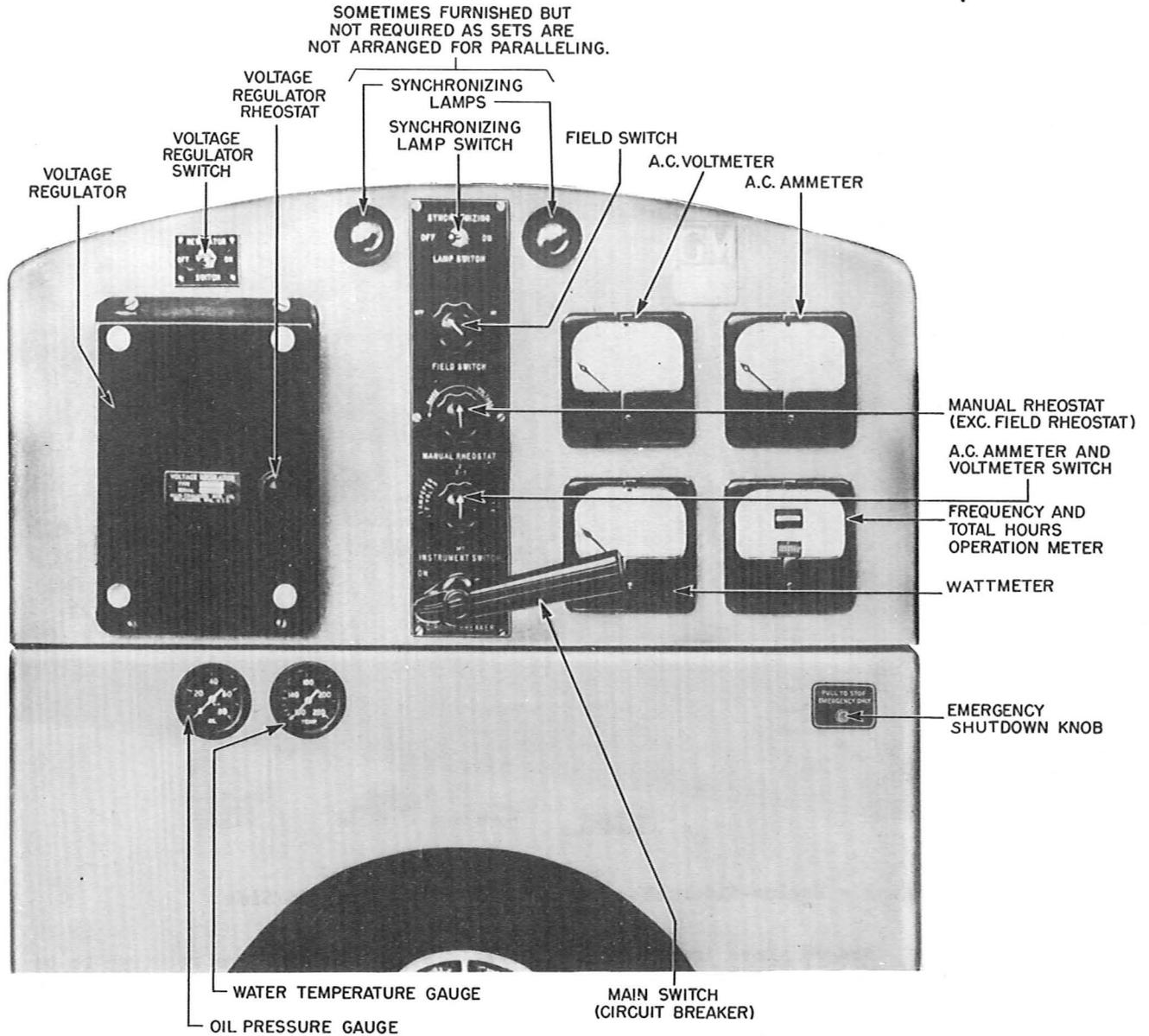


Fig. 2 - Instrument Panel on Engine Set

(c) Whenever the oil level is checked, observe whether the oil shows a higher level than a previous reading. If this ever occurs, examine the odor of the oil for traces of fuel oil. If fuel oil is present, tighten any loose connections, drain crankcase and refill with fresh lubricating oil.

(d) The capacity of the lubricating system of each set, including the oil normally carried in the oil cooler, filters, strainers, lubricating passages, etc. is as follows:

<u>KW of Set</u>	<u>Approximate Quarts of Oil</u>
30	15
40	17
60	29

(e) Whenever the oil is changed, it is necessary after draining the old oil, to refill the crankcase with fresh lubricant until the level shows at the FULL mark on the oil level gauge. The amount of oil required to bring it to this level will usually be

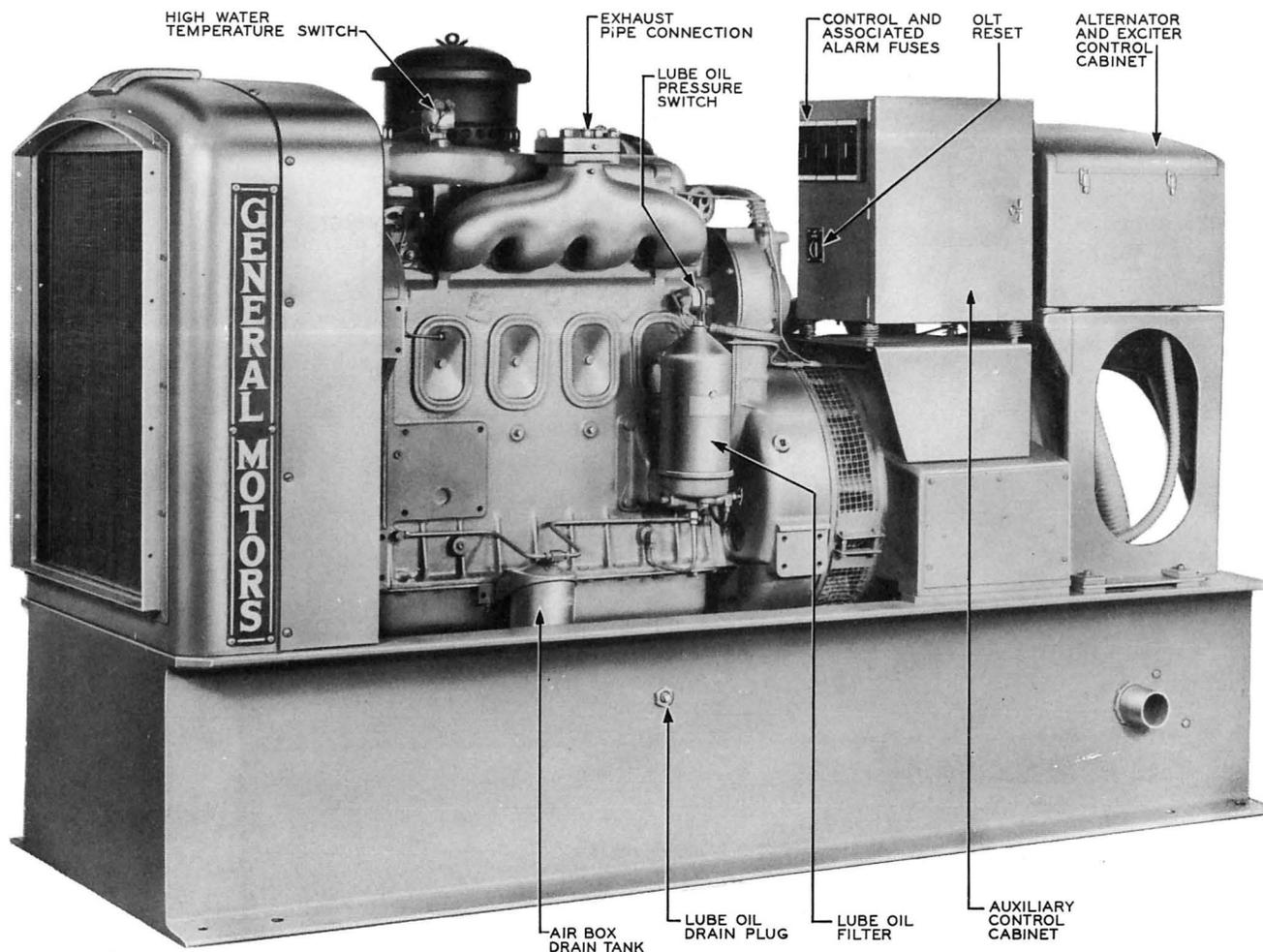


Fig. 3 - Engine-Alternator Set - 40 KW Unit - Exhaust Side

less than that covered above in (d). However, after the set has been run for five minutes, recheck the oil level and add oil as required to bring the level up to the FULL mark on the oil level gauge.

- (f) Lubricate the parts requiring lubrication.

Preparation for Automatic Operation of Set

2.10 Any one of these sets can be operated automatically when a separately mounted main control cabinet unit per J86621 is supplied with and electrically connected to it. Preparation of the set for automatic operation therefore requires positioning certain switches and valves on the set itself and also at the main control cabinet. Setting of these devices on the set itself are outlined below. Information for setting such at the main control cabinet is covered in Section A301.552.

2.11 Since these sets are required to be in readiness for starting automatically as a normal condition, and operated normally on a fully automatic basis, the automatic controls should always be left in the positions covered below to insure that automatic operation is possible, unless covered otherwise in these practices.

2.12 Setting of Switches and Valves on Engine Set

(a) On Instrument Panel at Alternator End of Set (See Fig. 2):

1. Operate REGULATOR SWITCH to its ON position.
2. Operate FIELD SWITCH to its ON position.
3. Turn MANUAL RHEOSTAT knob until arrow points to AUTO.
4. Turn handle of MAIN SWITCH (CIRCUIT BREAKER) to its ON position.

(b) On Exhaust Side of Engine (See Fig. 3):

1. Push in the OLT RESET button located on the outside of the auxiliary control cabinet mounted above the alternator.
2. When a valve is provided at the lubricating oil filter, be sure to open this valve.

(c) On Blower Side of Engine (See Fig. 1):

1. Push the link at the bottom of the EMERG. SW. towards the radiator.
2. Open the AIR SHUTDOWN VALVE by pulling down on the solenoid shaft linkage at the air damper solenoid.
3. Open the fuel valve in the fuel suction line just above the floor. (Valve not shown in Fig. 1.)
4. Close the water drain valve in the subbase if open.
5. Open each of the two water heater shut off valves.
6. Make certain the radiator cooling system is filled with water.
7. Check the crankcase oil level by means of the oil level gauge, and add oil if required to bring it up to the FULL mark on the gauge.

2.13 Setting of Control Devices at Main Control Cabinet

(a) The function of the control devices in the main control cabinet is to provide for starting the set automatically if low incoming power service voltage persists for a 2 minute period; to run the set for a 5 minute period to allow the engine to warm up; to transfer the load to it at the expiration of the warm-up interval; to keep the set running under load as long as required until the power service is restored; to continue running the set under load after the power has been restored for another 5 minutes, at the end of which to switch the load to the outside power service and stop the set. As soon as the engine stops, the automatic control devices are restored automatically to provide for automatic starting and running again when required.

(b) Set the control devices at the main control cabinet as outlined in Section A301.552.

Automatic Starting, Running, and Stopping

2.14 Having completed the various items covered in 2.06 to 2.13 inclusive, the set is now ready for automatic starting whenever the power fails as described in 2.04 or whenever the engine is to be routed without visiting the station as described in 2.05. When once started it will also stop automatically 4 to 5 minutes after either the outside power has been available (as also described in 2.04) if a power failure started it, or after 30 minutes of operation on a remote routing basis, as described in 2.05.

Running

2.15 Whenever the set is running, and an attendant is at the station, observe the following instructions.

2.16 See that the oil pressure as indicated on the engine oil pressure gauge on the engine panel remains above 18 pounds. The normal pressure is between 25 and 35 pounds.

2.17 Feel the top of the lubricating oil filter (see Fig. 3) occasionally to see that it is warm. If cold, it indicates the filter is clogged or the lubricating oil filter valve, if furnished, is closed. (See 2.12(b)2). Correct as necessary.

2.18 Check that the radiator is full and that the fan is operating properly. Check the indication on the water temperature gauge on the engine to see that the cooling water temperature does not exceed 190F.

2.19 Keep the engine clean and well lubricated. Lack of lubrication causes undue wear. Where lubrication is necessary, care should be exercised to remove all dirt from the surfaces to be lubricated, so that clean lubricant will reach the bearing surface.

2.20 The air box is provided with drains-piped to a container located near the subbase on the exhaust side of the set. (See Fig. 3). This container has a drain valve at the bottom which should be opened at each visit to the office. Its capacity is such that it will suffice for approximately 100 hours of operation before draining is required.

2.21 Check the fuel supply in the buried tank to be certain there is sufficient fuel available to keep the engine running. If low, replenish as requirements demand.

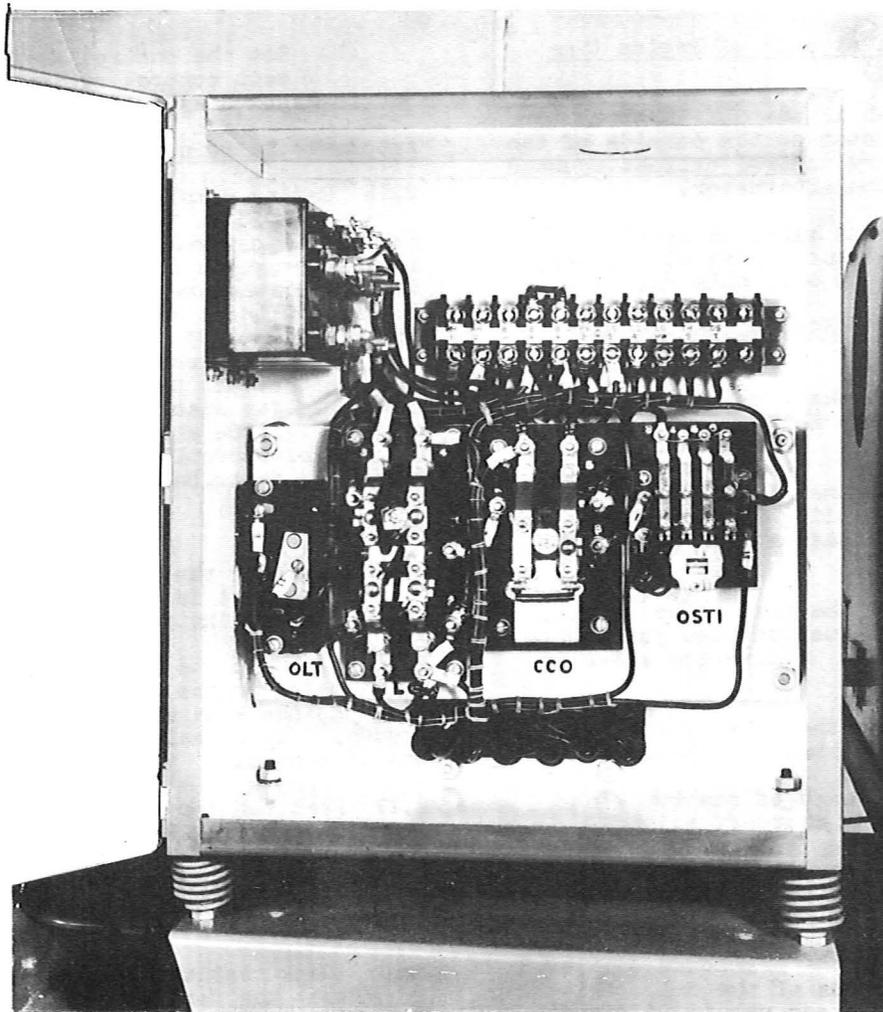


Fig. 4 - Auxiliary Control Cabinet on Engine Set - Interior View

2.22 Should an emergency arise while the set is running, which necessitates shutting it down hurriedly, either one of the methods of emergency stopping outlined below can be used by the attendant.

Emergency Stopping

2.23 To stop the set in an emergency, if near the engine, pull the PULL TO STOP-EMERGENCY ONLY shutdown knob, located just below the meters at the alternator end of the set. Pulling this knob trips the engine air shutdown valve (see Fig. 1) and shuts off the air supply to the cylinders, causing the engine to stop. Pulling this knob also opens the EMERG. SW., which in turn opens the engine starting circuit and prevents the set from cranking.

Note: Before the engine can again be started, the air shutdown

valve and the EMERG. SW. must both be reset manually. (See 2.25).

Irrespective of whether the set is operating automatically or manually, pulling this shutdown knob immediately stops it.

2.24 The set may also be stopped in an emergency, if near the main control cabinet, by operating the toggle switch, designated EMERGENCY STOP AND CONTROL CUTOUT, located on the front of the main control cabinet, to its STOP position as described in A301.552.

Note: Before the set can again be started automatically, the EMERGENCY STOP AND CONTROL CUTOUT switch must be operated to its RUN position.

Caution: Following any emergency stopping of the set described in either 2.23 or 2.24, observe the

instructions under 1.07 and 1.08 if it is determined that either the engine or its control must be worked upon.

2.25 If the set was stopped as outlined in 2.23, the EMERG. SW. must be reset by pushing the emergency switch lever towards the radiator (see Fig. 1), and the air shutdown valve reset (or opened) by pulling down on the solenoid shaft linkage.

Stopping of Set by Operation of Engine Trouble Controls

2.26 Certain controls are provided on the engine set, and also in the main control cabinet controlling the engine, which operate automatically to shut the set down when any one of the following engine troubles occur. At the same time, an alarm condition is set up by these trouble controls, which immediately notifies the personnel at the attended office that the engine or its control at the unattended office is in trouble, and the set has been shut down.

2.27 Starting Motor Overload

(a) In case the engine set becomes hard to turn over, due perhaps to such troubles as seized engine bearings, pistons, etc., the starting motor will become overloaded, due to the starting motor inrush current continuing. If this excessive current continues for 3 to 5 seconds, the heater of the starting motor overload timer OLT in the auxiliary control cabinet on the engine (see Fig. 4) will have been energized long enough to operate the timer contact. This opens the circuit to the main control relay MC, located in the main control cabinet, causing its release, and the engine cranking is stopped.

(b) Whenever the starting motor overload timer OLT operates, the engine cannot again be cranked by means of the starting motor until the reset button on the OLT timer (see Fig. 3) is operated manually.

2.28 Overtime Cranking

(a) In case the engine fails to fire after cranking for 30 seconds, a starting motor timer CRT located in the main control cabinet will close its contacts and the engine cranking will cease. See A301.552.

(b) At the termination of the 30 second interval described in (a), an overtime cranking alarm condition will have been set up in the main con-

trol cabinet by which the attendant at the attended office will be notified of this failure-to-start condition. See A301.552.

Note: The CRT timer must be reset manually before the engine can again be cranked.

2.29 Overspeed Cutoff

(a) Should the engine reach a speed between 1380 and 1500 rpm, contacts 1 of the overspeed trip (see Fig. 1), which is a centrifugal device, will close, causing the overspeed trip relay OST1, located in the auxiliary control cabinet on the engine (see Fig. 4), to operate. Its operation closes one set of its contacts to apply battery to the air shutdown solenoid ASD, (see Fig. 1), causing it to operate to cut off the air supply to the cylinders. A second set of contacts on the OST1 relay also close, applying battery over the OST lead to the main control cabinet to disable the starting control circuit and to set up an overspeed trip alarm condition in the main control cabinet by which the attendant at the attended office will be notified that a trouble exists and that the set has been shut down.

(b) As soon as the air shutdown valve is closed, the engine speed drops. When it has fallen to about 1350 rpm, contacts 1 of the overspeed trip, which closed as described in (a) on the higher speed, will open and the OST1 relay will be released, and the air shut down solenoid ASD deenergized. While the speed is still continuing to fall, the cranking cut-out relay CCO in the auxiliary control cabinet on the engine (see Fig. 4) will also release, but the engine cannot now be started. This condition maintains because, by the procedure in (a), the air shutdown valve was closed, and must be manually reset before the engine can again be started. Also, the cranking circuit was disabled making starting impossible under these conditions.

Note: To reset the air shutdown valve requires manually operating the solenoid shaft linkage at the air damper solenoid on the engine (see Fig. 1) by pulling the linkage down. The overspeed trip on the engine does not require manual resetting as it will reset automatically, but the overspeed trip circuit in the main control cabinet must be reset manually to restore the circuit.

This is done as described in A301.552 by momentarily operating the momentary contact switch OST RESET on the front of the main control cabinet. Since this is a normally closed type of switch, its momentary opening releases the OST and OS relays thus restoring the circuit so that the set can again be started.

2.30 Low Oil Pressure or Cooling Water High Temperature

(a) Should the lubricating oil pressure drop to 10 pounds per square inch or the engine cooling liquid temperature rise to $200 \pm 5F$, the set is automatically stopped. When the engine fuel oil is 30 pounds per square inch or above, the fuel oil pressure switch FPS (see Fig. 1) contacts are closed. If the lubricating oil pressure drops to about 10 pounds per square inch, the lubricating oil pressure switch LOPS (see Fig. 3) contacts close, or if the temperature of the engine cooling liquid reaches $200 \pm 5F$, the high water temperature switch (HWTS) (see Fig. 3) contacts close, the closing of either one of which will cause the low oil pressure (LOP) relay to operate. When this low oil pressure relay operates, one set of its contacts closes and furnishes battery over the LOHW lead to the alarm circuit in the main control cabinet. The other set of its contacts operates the air shutdown solenoid. When the engine fuel oil pressure is below 30 pounds per square inch as the engine is coming to rest, the fuel oil pressure switch (FPS) contacts open, which releases the low oil pressure relay LOP. See 2.32.

Note: A delay of a few seconds is furnished in the circuit to the low oil pressure relay LOP by the oil pressure delay timer OPD to allow the oil pressure to build up during the engine starting period so that the starting of the engine is not interrupted at that time by the low oil pressure protection circuit.

2.31 Blowing of Control Fuses and Associated Alarm Fuses

(a) Three control fuses and associated alarm fuses are mounted on the side of the auxiliary control cabinet on the engine set (see Fig. 3).

These control fuses supply battery for operating the overspeed trip circuit on the engine, the low oil pressure and high water temperature circuit also on the engine, as well as the d-c control circuits contained in the main control cabinet. (see A301.552). Reading from left to right in Fig. 3, these fuses are designated OST, LOHW and CONT SUPPLY. In case one of these control fuses should blow, its associated alarm type fuse, which is bridged across it, also blows. When blown, the alarm fuse makes contact to supply battery over the OST lead to the main control cabinet to disable the starting control circuit and to set up in the main control cabinet an overspeed trip alarm condition by which the attendant at the attended office will be notified that a trouble exists and that the set has been shut down.

2.32 Whenever an engine set is automatically shut down because of any one of the troubles covered above in 2.29 to 2.31 inclusive, the air shutdown valve is automatically closed because the engine trouble control has actuated the air shutdown solenoid (see Fig. 1) to which this air valve is connected by a linkage. Once this air shutdown valve has thus been closed, it must be reset (opened) by hand, otherwise the air supply to the cylinders will remain cut off which will make it impossible to restart the set. As explained above in each case, an alarm is transmitted to an attended office to notify the attendant there that the set has shut down, necessitating a visit to the unattended office to determine the exact trouble. The attendant should therefore remember to reset the air shutdown valve by pulling the linkage at the solenoid down before attempting to restart the engine.

Operation of Alarms

2.33 Engine Alarms

(a) Alarms which originate at the engine are provided for as follows:

1. Engine fuse failure
2. Engine overspeed
3. Low lubricating oil pressure
4. Cooling water high temperature
5. Starting motor overload

Each of these alarms is carried over to the main control cabinet where they are consolidated with other alarms

originating in that cabinet. See A301.552. From this cabinet they connect to the office alarm panels, the power alarm circuit for which is universally used for various a-c low voltage and engine failure alarms with power restore alarm feature. The function of this power alarm circuit is to transmit alarm signals to the office alarm and station alarm sending or alarm trunk circuits. Over the alarm trunk circuits are transmitted the various engine failure alarms to notify the attendant at the attended office that an engine failure has occurred and the set has shut down.

- (b) For operation of the engine fuse failure alarm, refer to 2.31.
- (c) For operation of the engine over-speed alarm, refer to 2.29.
- (d) For operation of the low oil pressure or cooling water high temperature alarm, refer to 2.30.

(e) When power conditions are such that the set has to be started automatically, there is a delay of 2 minutes before the starting motor attempts to start the set. In case of starting motor overload as described in 2.27, cranking ceases after 3 to 5 seconds of attempted cranking at the overload. The attendant at the attended office however is not advised at the end of this 3 to 5 second period that the engine failed to start. However, after an additional 5 minutes elapses, which would be the period normally required by the WUT warm up timer in the main control cabinet to complete its cycle before the engine if running could assume the load, the attendant, who was advised of the power failure when he received the outside power failure alarm, would look for the proper operation alarm to tell him that the engine had started satisfactorily and assumed the load. Since the engine failed to start, however, he does not receive a proper operation alarm at the end of the additional 5 minute interval, and therefore he knows for the first time that the engine failed to start. The total period of time the attendant must wait after he receives the outside power failure alarm until he realizes the set has failed to start because of starting motor overload is therefore 7 minutes.

Determining Trouble Responsible For Automatic Shutdown of Set

2.34 Locating Engine Troubles

(a) When an attendant arrives at the unattended office, a check of each reset device, which is associated with a particular engine trouble control as outlined in 2.26 to 2.32 inclusive, should first be made. In case the trouble is evidenced by a particular reset device, its cause should be determined and corrected before an attempt to start the set is made.

(b) If the trouble is not readily apparent from the procedure in (a), a more thorough check should be made to determine it. In this connection, if it is necessary to start and run the set, the methods for local testing as outlined in 3.02 to 3.05 inclusive should be followed.

Note: Before attempting to start an engine, be sure to observe the operating procedures involved in stopping of sets, as certain adjustments are usually necessary before a set can again be started when it has once been shut down under a trouble condition control.

During one of the local tests, it may be indicated that the cause of engine shutdown was due to the control in the main control cabinet rather than in the engine. If so, refer to A301.552 and correct the trouble as necessary.

Air Box Heater for Cold Weather Starting

2.35 Starting Set When Equipped With Air Box Heater

(a) Some of these sets, particularly those installed where abnormally cold climates are experienced, may be equipped with an air box heater to assist an attendant when at the unattended office in starting the set under low temperature conditions. For this purpose, a KS-5750, List 11 air box heater is furnished. This equipment however is not arranged to be operated automatically.

(b) When the main control cabinet is in the same room with the engine, one man can perform the air box heater operation at the engine as well as operate the switch at the main control cabinet to start the set. However, when the main control cabinet is not located in the same room, two men may

sometimes be required. This is due to the fact that operation of the air box equipment which is located on the engine usually requires that one person be at that point, while another is at the main control cabinet to operate the NO LOAD TEST switch there to start the set.

Note: Should the main control cabinet be in a separate room but not too far from the engine, it might be possible for one man to perform both operations, since as soon as he operates the NO LOAD TEST switch to its START position, the cranking starts and continues for 30 seconds, during which time he must get back to the air heater equipment at the engine and operate it before the cranking period ends.

(c) To manually start the set equipped with the air box heater, open the air heater fuel valve on the engine control panel designated AIR HEATER - USE WHILE CRANKING ONLY. Release the plunger of the air heater pump by turning its knob one-half turn in a counterclockwise direction. Then go to the main control cabinet and operate the NO LOAD TEST switch on the front of the cabinet to its START position. If the engine is free to turn, it should start cranking and still be cranking when the attendant returns to the set to operate the plunger of the heater fuel pump. Operate the pump plunger using smooth, even strokes, as necessary, to start the engine. The air heater is supplied with a pressure type switch which operates as soon as the hand pumping builds up a slight pressure. It is not necessary to turn this switch off as the loss of pressure will automatically insure the switch opening. If the engine does not start in about 15 to 20 seconds, cease pumping and check for failure to start. Allow at least one-half minute between each starting attempt.

(d) After successfully starting the engine manually, allow it to operate long enough for the cooling water to rise to at least 120F. In cold weather, this may require running it for a period of 15 to 30 minutes.

(e) To stop the set once it has been started as covered in (c), put the NO LOAD TEST switch at the main control cabinet in its STOP position.

Final Checks

2.36 Leaving Set Unattended

(a) Before leaving the set unattended, make certain that it is in proper shape for the next run. This includes a complete check of the procedures outlined in 2.06 to 2.13 inclusive to make certain that the set is left in condition to be automatically operated when the occasion demands.

(b) Since satisfactory operation of the set on an automatic basis depends also upon the main control cabinet's operation, a complete check of the procedures outlined in A301.552 for that equipment must be made in addition to that required by (a) before the set is left unattended.

3. ROUTINE CHECKS

Weekly Routine Run

3.01 By Remote Control

(a) The weekly routine run can be made without visiting the station. The attendant at the remote point holds a key or button in its operated position for about 15 seconds, which is the time required to start the circuit going through a power failure sequence to start the set. Once the set has started, it will operate for 30 minutes after which time the circuit will then go through a power return sequence to restore itself to its original condition, wherein it will be ready to start automatically in case a power failure occurs.

Local Testing of Plant

3.02 Once the engine has been started always allow it to operate for at least 15 minutes or until the water temperature indicator registers at least 120F before shutting it down. This will prevent undue condensation.

3.03 Test Runs at No Load

(a) Starting: To start the set and operate it at no load, put NO LOAD TEST switch, which is on the front of the main control cabinet in the START position.

(b) Stopping: To stop the set, put NO LOAD TEST switch in its STOP position.

3.04 Test Runs at Office Load With All Timing Devices in Use

(a) Starting: In order to have the set operate and pick up the office load after a fixed time has elapsed as determined by the operation of the time-delay switches, put the FULL LOAD TEST switch, which is on the front of the main control cabinet, in its START position. The set should then start and automatically transfer the office load to the engine-alternator set after the 2-minute start-delay timer SDT and the 5-minute warm-up timer WUT have operated.

(b) Stopping: On the main control cabinet, put the FULL LOAD TEST switch in its STOP position, after which the set will continue to run and carry the load from 4 to 5 minutes before it will stop. This is due to the HOT (holdover) timer, which will not return the load to the outside power until the outside power has been on the engine set control relays for a period of 4 to 5 minutes.

Caution: Under this test condition, stopping by use of any emergency stop device (see 2.23 and 2.24) will drop the load unless the FULL LOAD TEST SWITCH is operated to its STOP position.

3.05 Test Runs at Office Load With All Timing Devices in Use Except the Starting Timers

(a) Starting: To start the set and have it take the load at once, operate both the WUT TIMER switch on the front of the main control cabinet to eliminate the warm-up time and the SDT TIMER (start-delay timer) switch to their OFF positions. Then put FULL LOAD TEST switch on the main control cabinet in START position. The engine will then start and take the load immediately.

(b) Stopping: On the main control cabinet put FULL LOAD TEST switch in its STOP position after which the set will continue to run and carry the load from 4 to 5 minutes before the engine will stop. This is due to the HOT (Holdover) timer, which will not return the load to the outside power until the outside power has been on the engine set control relays for a period of 4 to 5 minutes.

Caution: Under this test condition, stopping by use of an emergency stop device (see 2.23 and 2.24) will drop the load unless the FULL LOAD TEST switch is operated to its STOP position.

Testing of Alarms

Note: From time to time, it will be necessary to check for satisfactory operation of the various engine alarms. Whenever any one of the following alarm tests is made, the engine set will automatically shut down, due to the automatic closing of the air shutdown valve at the time the alarm functions. This is due to the fact that an engine trouble will have been simulated with each of the following alarm tests. It must therefore be remembered that the air shutdown valve has to be reset manually by pulling down on the linkage at the air shutdown solenoid (see Fig. 1) on the engine after each shut down, before attempting to restart the engine.

3.06 Fuse Alarm

(a) To test any one of the cartridge type alarm fuses which shunt a larger cartridge type fuse, remove the particular alarm fuse and insert a blown cartridge type alarm fuse in its place. Note that the fuse alarm operates when the blown fuse is inserted. Also note that the engine set shuts down under this test. Following completion of the test, reinsert the unused alarm fuse.

3.07 Overspeed Alarm

(a) To test the overspeed alarm requires overspeeding of the engine while it is operating. To overspeed the engine, slowly push in on the brass rod which protrudes through the housing of the fuel rack solenoid mounted at the top of the governor (see Fig. 1). When a speed between 1380 and 1500 rpm is reached, note that the alarm operates and the engine shuts down.

(b) Following an overspeed alarm test, the air shutdown valve must be opened manually as outlined above in the note. The overspeed trip on the engine resets itself

SECTION A301.252

automatically, but the overspeed trip circuit in the main control cabinet (see A301.552) must be reset manually to restore the circuit.

3.08 Low Lubricating Oil Pressure Alarm

(a) To test the low oil pressure alarm, remove the tape from the terminals of the lube oil pressure switch (see Fig. 3). When removed, start the set and allow it to warm up until the temperature as indicated on the water temperature gauge on the engine panel is 120F. When this point has been reached, place a short by means of a screwdriver across the two exposed terminals of the lube oil pressure switch and note that the engine shuts down, and the alarm lamp in the office alarm bay lights. Retape the terminals at the conclusion of this test.

(b) Following a low lubricating oil pressure alarm test, the air shutdown valve must be opened manually as outlined above in the note.

3.09 Cooling Water High Temperature Alarm

(a) To test the cooling water high temperature alarm, remove the tape from the two terminals of the high water temperature switch (see Fig. 3). When they are exposed, start the set and allow it to warm up until the temperature of the water is 120F. Then place a short by means of a screwdriver across the two exposed terminals of the high water temperature switch and note that the engine shuts down and the alarm lamp in the office alarm bay lights. Retape the terminals at the conclusion of this test.

(b) Following a cooling water high temperature alarm test, the air shutdown valve must be opened manually as outlined above in the note.

Battery

3.10 Periodic Checks

(a) Check that the voltage of the starting battery is being maintained at 34.6V ±0.3, the electrolyte level is satisfactory, the battery is clean, its connections are tight, and free from corrosion.

4. GENERAL TROUBLES

4.01 Avoid the use of an open flame or a portable lamp without a protecting guard while working around the engine, particularly near any part of its fuel system.

4.02 In case any of the following troubles are found, check the possible causes and take the necessary action to clear the trouble.

4.03 In the clearing of any troubles, suggested means for correcting them are covered in the manufacturer's maintenance manuals which are furnished with each engine set by the manufacturer. (See 1.06)

4.04 Engine

<u>Trouble</u>	<u>Possible Cause</u>
(a) High lube oil consumption	External leaks due to: Gasket or oil seal leaks. High crankcase pressure contributing to external leaks. Excessive lube oil at air box drains (check internal leaks when found). Internal leaks due to: Blower oil seals leaking. Cylinder block end plate gasket leaking. Faulty oil control at cylinder due to: Worn oil control rings. Broken oil control rings. Control rings improperly installed. Piston pin retainer loose. Scored liners, pistons, or oil rings. Faulty piston and rod alignment (worn crankshaft thrust washers).
(b) Low oil pressure Note: When checking be certain the engine water outlet temperature is 165F minimum	Low oil level. Lube oil viscosity not in accordance with specifications. Low viscosity as a result of dilution. Faulty oil pressure gauge Obstruction in oil pressure gauge line. Pressure gauge orifice plugged. Oil strainer clogged. Oil cooler clogged. Cooler by-pass valve not functioning properly. Pressure regulator valve not functioning properly. Excessive wear of crankshaft bearings. Gallery or crankshaft plugs missing. Oil pump intake screen partially plugged.

<u>Trouble</u>	<u>Possible Cause</u>	<u>Trouble</u>	<u>Possible Cause</u>
	Oil pump relief valve not functioning properly. Air leak in pump inlet system. Pump worn or damaged. Flange leak on pressure side of pump.		Excess fuel or irregular fuel distribution due to: Improper setting of injector racks, improper timing of injectors, faulty injectors, or engine lugging. Improper grade of fuel, which may be too heavy to completely vaporize.
(c) No fuel or insufficient fuel	Air leaks. Low fuel supply. Loose connections or cracked lines between fuel pump and tank or suction line in tank. Damaged primary fuel filter gasket. Air heater fuel system leaks on the suction side of the air heater pump, if provided. Primary, secondary, or fuel filters restricted. Obstruction in fuel lines or restricted fitting obstructed. Fuel pump not functioning due to: Relief valve not seating. Worn or scored valves or housing. Fuel pump not rotating. Fuel pump suction lift too great. Diameter of fuel suction lines too small. Restricted fitting missing from return manifold.		<u>Blue</u> - fuel or lube oil not burned in cylinder (blown through cylinder during scavenging period). Internal fuel or lube oil leaks. Cylinder cutting out. Oil leaks into air box. Engine temperature too low. <u>White</u> - misfiring cylinders - due to: Faulty injectors. Low compression. Poor fuel - low cetane.
		(e) Excessive crankcase pressure	Cylinder blow-by due to cylinder head gasket leaking, piston or liner damaged, or piston rings worn or broken. Breather restriction due to obstruction or damage to breather. Air escaping from blower or air box due to excessive exhaust back pressure, blower to block gasket damaged, or engine end plate gaskets damaged.
(d) Smoky exhaust	<u>Black or gray</u> (incompletely burned fuel) due to: Insufficient combustion air. Air box cover gasket ruptured. High exhaust back pressure. Restricted air inlet caused by cylinder liner ports clogged, air cleaners or silencer clogged by dirt or damaged, emergency stop not completely open or restricted or possibly the engine room air inlet is inadequate.	(f) Difficult starting in cold weather	Low starting RPM due to: High lube oil viscosity. Infrequent oil changes. Low battery output due to state of charge or low temperatures. Faulty starter. No fuel (see 4.04 (c)) due to air leaks, flow obstruction, fuel pump not functioning, or faulty installation. Inoperative air heater (if provided) due to: No spark caused by poor or shorted connections, coil defective or points inoperative, or cracked porcelain.

<u>Trouble</u>	<u>Possible Cause</u>	<u>Trouble</u>	<u>Possible Cause</u>
	No fuel caused by defective pump, plugged spray nozzle or filter, air leak in air heater pump suction line, valve in air heater fuel line not open, dirt in pump valves, temperature less than 10F above pour point of fuel.		Fan belt loose reducing air flow.
	Low compression.		Fan shrouding damaged causing improper recirculation of air.
	Pump and switch not operated while engine is being cranked.		Surrounding air temperature too high.
(g) Lack of power	Improper engine adjustments such as governor adjustments, rack setting, injector timing, or valve lash.		Hoses in water circulating system collapsed or disintegrated.
	Insufficient fuel (see 4.04 (c)) due to air leaks, flow obstruction, nonfunctioning of fuel pump, or installation faults.		Thermostat damaged.
	Insufficient air due to air cleaners or silencer damaged, dirty, or clogged, cylinder liner air inlet ports clogged, blower air intake obstructed, excessive exhaust back pressure, low compression caused by burned or sticky exhaust valves or worn or broken compression rings, or engine in a closed room with inadequate air inlet.		Water pump impeller or drive coupling loose on shaft.
	Faulty injector tip assembly.		Inadequate water supply on suction side of pump due to radiator clogging.
	Injector fuel filters restricted.		Combustion gases in cooling water caused by leaking injector tube seal or cylinder head gasket.
(h) Engine coolant temperatures abnormal	<u>Above normal temperatures</u> Insufficient heat transfer due to: Scale or deposits in water parts of radiator.		Air in cooling water caused by air leak on suction side of pump or thermostat housing bleeder valve not open when filling the system.
	Clogged radiator openings preventing normal air flow.		<u>Below normal temperatures</u> due to thermostat housing valve in the water circulating system open or not sealing, thermostat inoperative, or thermostat seal damaged.
<u>4.05 Alternator and Exciter</u>			
	<u>Trouble</u>	<u>Possible Cause</u>	
	(a) Poor commutation	Worn brushes Commutator rough or uneven, high, low, or loose segments, high mica, or flat spots. Collector rings (slip rings) not smooth due to flat spots, cuts, or unevenness. Brush tension too weak. Brushes not set correctly. Oil or grease on commutator. Open- or short-circuited armature.	

Bell Telephone Laboratories, Inc.