155-128-301

ENGINE — ALTERNATOR — DIESEL
GENERAL MOTORS — SERIES 71 SETS
KS-5574
OPERATING METHODS

CONTENTS

1. GENERAL

1.01 This section describes the method of operating General Motors, Series 71, 2-cycle diesel engines, driving 10-, 30-, 40-, or 60-kw alternators covered by KS-5574. This section is also applicable to the earlier General Motors Series 71 sets furnished prior to the issuance of KS-5574 specification. The earlier sets probably had some features not covered by these instructions in which case they should be treated as exceptions.

1.02 This section is reissued to revise information covering storage of fuel oil and routine run; to amplify information for inspecting set, checking cooling water system, and checking lubrication; to add information covering checking starting battery, stopping of a set by operation of various safety devices, and voltage regulation; to explain the relation between irregular speed and hunting; and to add Fig. 3 and list of general troubles. Since this reissue covers a general revision, arrows ordinarily used to indicate changes have been omitted.

1.03 In connection with the storage of fuel oil for these sets, care should be exercised to prevent dirt from entering the fuel storage tank. Refer to Section A301.290 for information on recommended engine fuels and requirements for storage and handling them.

1.04 Routine checks should be made during a period when they will cause the least service reaction.

1.05 Reference should be made to Section A401.232 for information necessary for the proper maintenance of the equipment referred to herein.

2. OPERATION

Preparation for Starting

2.01 ***Inspecting Set***

(a) Go over the set 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) Close drain valves in exhaust line and silencer if furnished. If the engine room is equipped with an air exhaust duct extending from the engine radiator to the outside, see that any louver, etc, provided in this duct is properly operated.

(c) See that reset lever of overspeed trip on shaft of flap valve at blower air inlet housing is in the running or downward position. To set this trip, grasp lever at shaft, pull horizontally to the right, then push bottom of lever in toward the engine, and while in this position move lever to left as far as it will go and release. See that the reset lever of the air damper at the blower inlet housing is in the operating position. This air damper is operated normally by a solenoid when the engine overspeeds, the water temperature becomes excessively high, or the lubricating oil pressure fails.

2.02 ***Checking Fuel System***

(a) Make certain that there is fuel in the fuel tank sufficient for the expected run.

(b) Open valves in fuel lines.

2.03 ***Checking Cooling Water System***

Note: It is essential that the water which is used in the cooling system of the engines, which are equipped with radiators, be as soft as possible. See Section A401.232.

(a) When necessary to fill the cooling system, close all water jackets and radiator drains if open, and fill the cooling system sufficiently to bring water to within 2 inches of overflow pipe, or where expansion tank is used, see that tank is three quarters full on starting. Refer to (d). Be sure that a rust inhibitor is added to the water if the air temperature at the set will remain above 32 F at all times. If the temperature at the engine location is expected to fall below freezing, add antifreeze. If slight leaks are present, add a cooling system sealer. See Section A501.231. However, the use of a rust inhibitor is not needed if an antifreeze solution is used, since a rust inhibitor is included in the antifreeze.

(b) Adjust cooling water valves as follows. On engines equipped with radiator and fan cooling only, no manipulation of cooling water valves is required. On installations having both radiator with fan cooling and city running water cooling, use one or the other method but never a combination of the two. Position of valves should be as outlined in (c). Valves other than valve B should be operated only with engine shut down.

(c) The positioning of valves shown in Fig. 1 for the particular cooling system used should be as follows.

(1) ***When operated with radiator and fan cooling,*** check that valves A, B, and D, are closed, and valve C is wide open.

(2) ***When operating with city running water cooling,*** check that valves C and D are closed and valve A is wide open. Open valve B until water in cooling system empties into overflow funnel.

(d) For cooling water capacity of engines, refer to the operating instruction chart furnished with the engine. Engines with heat exchangers require slightly higher amounts.

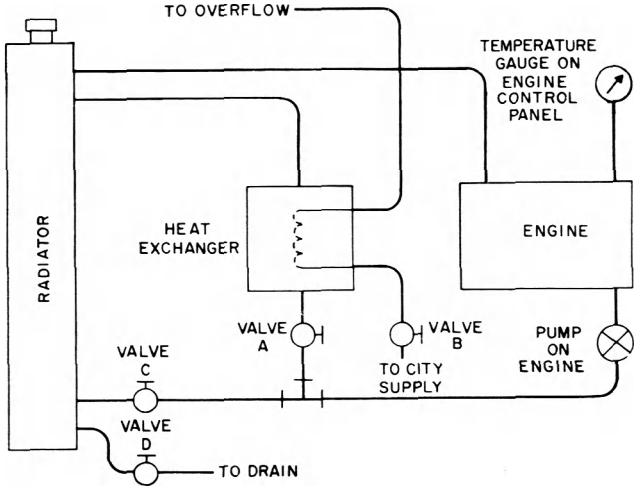

Fig. 1 – Water Cooling System — Schematic

2.04 ***Checking Lubrication***

(a) Check the oil level in the crankcase by means of the oil level gauge and add oil if required to bring it up to the FULL mark on the gauge.

(b) The oil level in the crankcase should never be permitted to fall below the LOW mark on the gauge while the engine is operating.

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

(d) The capacity of the lubricating system of each set, not including the oil normally carried in the oil cooler, filters, strainers, lubricating passages, etc, is as follows.

KW OF SET	APPROXIMATE QUARTS OF OIL	
	INDUSTRIAL CRANKCASE	AUTOMATIC CRANKCASE
10	—	7
30	12	8.5
40	16.5	10.5
60	27	15.5

(e) Whenever the crankcase is drained, fill it with fresh lubricant until the level shows at the FULL mark on the oil level gauge. However, after the set has been run for 5 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) All main bearings of the engine and of accessories such as blower, water pump, fuel pump, governor, etc, are provided with automatic lubrication and do not require lubrication by the operator. For parts requiring lubrication, refer to Section A401.232.

2.05 ***Checking Starting Battery***

Note: When a starting battery other than the 24-volt central office battery is used for starting, the following checks should be made.

(a) See that there is sufficient electrolyte in the starting battery cells. Add water as required to maintain electrolyte levels as covered in (b).

(b) Table A covers the electrolyte level limit requirements for the various types of starting battery used with these sets.

TABLE A

TYPE BAT.	SPECIFICATION KS	SPECIFICATION LIST NO.	ELECTROLYTE LEVEL MIN	ELECTROLYTE LEVEL MAX	SEE NOTE
Lead Acid	15577	5	Top of Separators	Bottom of Cover	—
Nickel cadmium	15578	5, 6	3/4 inch above plates	1-3/4 inch above plates	A
Nickel cadmium	15578	5E, 6E	3/4 inch above plates	1-1/2 inch above plates	A
Nickel cadmium	15578	5W, 6W	Top of plates	3/4 inch above plates	A

Note A: If the electrolyte level of any of these nickel-cadmium batteries now in service is found to be higher than that shown as a maximum, it will not be necessary to remove electrolyte to lower the level to meet such a maximum.

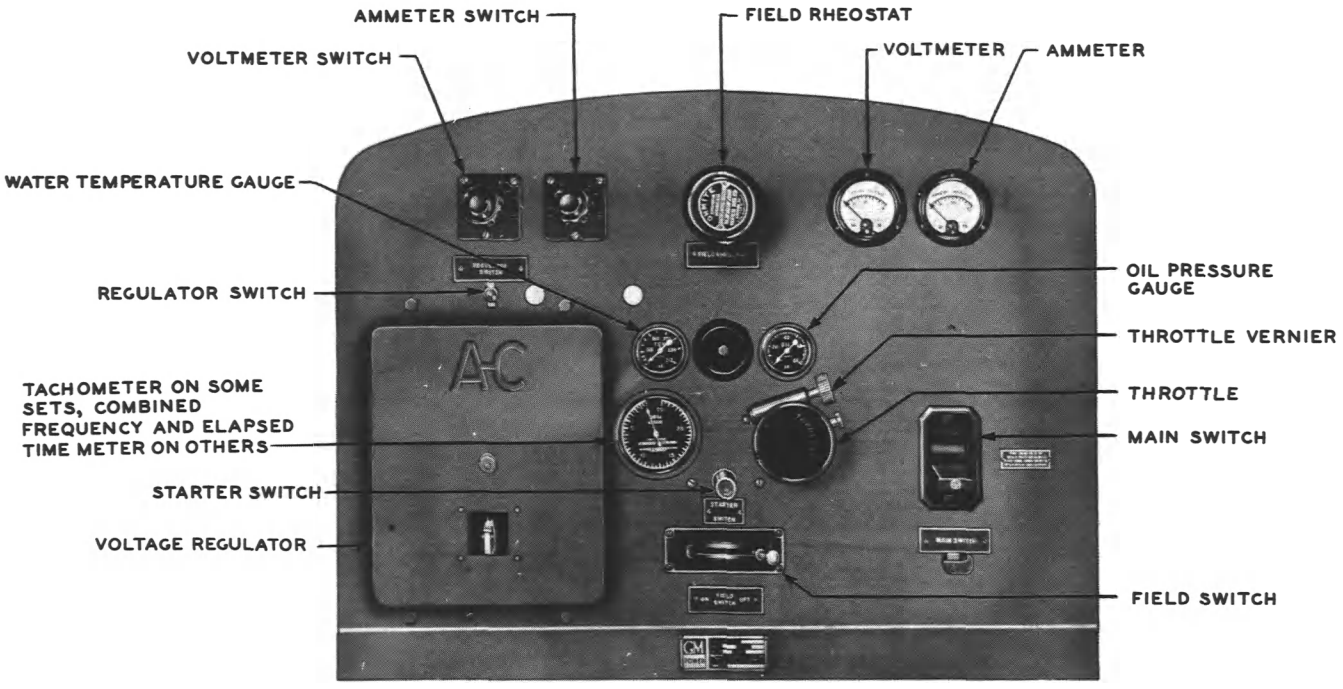

Fig. 2 – Typical Control Panel

Starting

2.06 First observe instructions under Preparation for Starting. The following instructions assume that only one set is operating. Parallel operation is covered later under Paralleling.

2.07 If set is to be started for the first time after an overhaul or major adjustment, put MAIN SWITCH (circuit breaker) on OFF position, put exciter FIELD SWITCH on OFF position, and put REGULATOR SWITCH on OFF position. Turn exciter FIELD RHEOSTAT clockwise as far as it will go to cut in all resistance. In normal operation, the exciter FIELD SWITCH and the REGULATOR SWITCH may be left in the ON position and the exciter FIELD RHEOSTAT may be left in the resistance all-out or counterclockwise position.

Starting in Normal Temperatures (+35 F and Above) Without an Air Heater

2.08 On control panel, turn throttle to the RUN position. Turn the throttle vernier knob one to one and a half turns in the SLOW direction indicated by the arrow on top of the vernier control knob.

2.09 Crank engine by operating the STARTING MOTOR SWITCH button at the governor and at the same time depressing the FUEL RACK button on the governor about 1/4 inch. If the engine does not start in 15 seconds, release the STARTING MOTOR SWITCH button and check for failure to start. To safeguard the battery, allow 1/2 minute between each attempt to start the engine.

2.10 When the engine fires, release pressure on the STARTING MOTOR SWITCH button and FUEL RACK button and adjust the engine speed to normal by turning the throttle vernier knob on the control panel in the FAST direction as required. After the engine starts, observe that the lubricating oil pressure gauge shows a positive registration indicating that oil is being supplied to moving parts. If after 10 or 15 seconds no pressure is indicated on the oil gauge, stop the engine immediately and locate the trouble. If oil pressure is indicated, permit the engine to run at its no-load speed. Proceed as covered in 2.13.

Starting in Cold Temperatures (−35 F and Below) Using an Air Heater

2.11 On control panel, turn throttle to the RUN position, turn on heater ignition switch, and release pump plunger by turning knob 1/2 turn in a counterclockwise direction. Crank engine by closing the STARTER SWITCH and then operate the plunger of the heater fuel pump using smooth, even strokes, as necessary, to start engine. If the engine does not start in 15 seconds, release the STARTER SWITCH and check for failure to start. Allow at least 1/2 minute between each starting attempt to safeguard battery.

2.12 After engine starts, regulate throttle by hand as required to keep the engine running. Push heater plunger all the way in, turn it clockwise until lock engages, and then turn off heater switch. Observe that the lubricating oil pressure gauge shows a positive registration indicating that oil is being supplied to moving parts. If after 10 or 15 seconds no pressure is indicated on oil pressure gauge, stop engine immediately and locate trouble. On sets equipped with a low lubricating oil pressure automatic shutdown device, the engine will stop operating on low oil pressure. If oil pressure is indicated, turn throttle to the RUN position permitting engine to run at its no-load speed.

2.13 Run the engine at its no-load speed for about 5 minutes to permit engine to warm up. In an emergency, this warming-up period may be reduced.

2.14 The no-load speed that will give the desired speed under office load will have to be determined for each engine installation. A no-load speed of approximately 1250 rpm will usually give a full-load speed of approximately 1200 rpm. If necessary, adjust the speed by moving the vernier throttle control in accordance with Section A401.232.

Voltage Regulation

General

2.15 The voltage regulator furnished with these sets may be a wall-mounted Burlington GB2, a cabinet-mounted Allis-Chalmers, or a Westinghouse Silverstat Jr regulator. ***The Burlington regulator is not furnished with a portable set nor for parallel operation.***

Burlington GB2 Regulator

2.16 ***Description:*** The Burlington regulator, which is composed of three essential parts, a voltage-sensitive relay, a secondary controlling relay, and an antihunting circuit, operates as follows.

(a) The voltage-sensitive relay is a contact making voltmeter type, sensitive to small changes in voltage, and consists of a solenoid, in which an iron core is floated, being supported by the magnetic flux within the solenoid windings. When in proper adjustment, the contacts are just on the verge of closing. In series with the solenoid winding is a rheostat for adjusting the generated voltage, and a series resistor for limiting the current flowing through the coil. This series resistor also is a means of reducing to a minimum the voltage error due to frequency changes. When the iron core lifts due to increased voltages, it closes the voltage-sensitive contacts, which are the main contacts. The closing of the main contacts causes energization of the coil of the secondary controlling relay and subsequent opening of the relay contacts. When the relay contacts are closed, they short out the exciter field rheostat, causing the voltage of both exciter and alternator to rise. When the relay contacts are open, exciter rheostat resistance is placed in the exciter shunt field circuit and the voltage decreases. When the main contacts are open, the secondary controlling relay coil is de-energized, and the relay spring holds the contacts closed. When the main contacts are closed, the relay is energized, and the relay contacts open.

(b) To prevent an oscillating condition of over regulation and under regulation, a vibration circuit, which is termed an antihunting circuit, is used. This circuit operates each time the relay contacts open and consists of a pair of contacts below the relay contacts which close when the relay coil is energized. Their closing lowers the ac voltage on the main coil slightly, which permits the floating core to drop sufficiently to open the main contacts, consequently permitting the relay contacts to close, whereupon the cycle is repeated.

2.17 ***Placing Regulator in Service:*** Fig. 3 — Adjust the ac voltage to the desired value by means of the FIELD RHEOSTAT on the set control panel. To place regulator in service, lower the voltage by turning the FIELD RHEOSTAT clockwise. On the front cover of each Burlington GB2 regulator, are located three switches in a line side by side. The middle switch is the voltage REGULATOR CONTROL switch while on each side of the REGULATOR CONTROL switch is a POLARITY REVERSE switch. Each polarity reversing switch should be operated to its opposite position at the beginning of each run and its position changed every day when runs of longer duration are encountered. Operate the middle switch (REGULATOR CONTROL) to its ON position.

Note: The REGULATOR CONTROL switch mounted on the regulator is used, instead of the REGULATOR SWITCH mounted on the set control cabinet, for turning this regulator on or off.

The ac voltage should come up to approximately normal voltage. Final adjustment to the normal voltage must be made by means of the regulator rheostat. Then proceed as covered in 2.22.

Allis-Chalmers Regulator

2.18 ***Description:*** The Allis-Chalmers regulator has a rheostat, which is equipped with a rocking contact sector. Its rocking feature is actuated by means of a solenoid. The pull produced by the solenoid coil is balanced against the pull of an inclined helical mainspring at each point of the regulator travel so that it has an unstable characteristic, that is, it will regulate for the same voltage value at any point of its travel and irrespective of load conditions on the generator. An increase or decrease in solenoid pull, in response to a change in the voltage energizing the solenoid, destroys this balance, resulting in an unbalanced force. The application of this force to the lever system results in

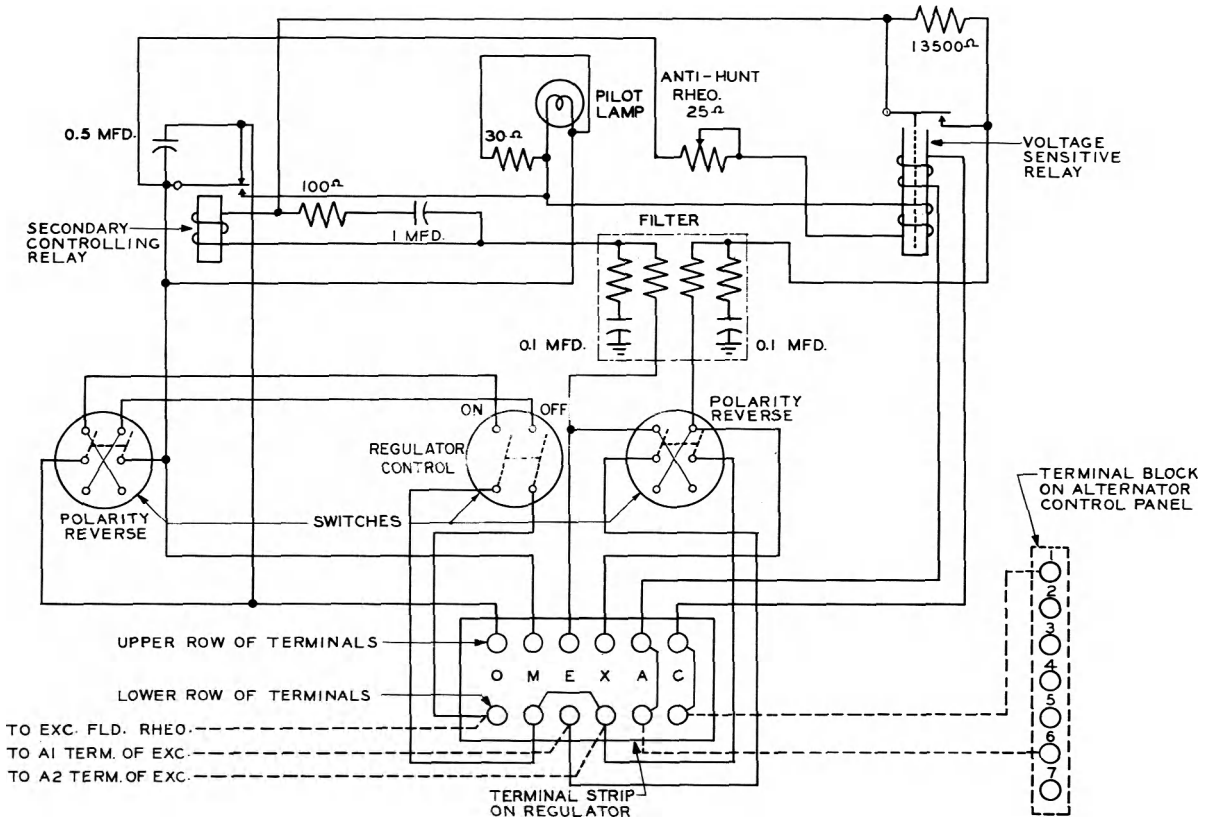

Fig. 3 – Burlington GB2 Regulator — Internal Connections

motion of the rocking contact sector over the commutator, increasing or decreasing respectively the amount of regulating resistance in the circuit. This increase or decrease of regulating resistance changes the machine excitation in the proper direction to restore the voltage across the solenoid to normal. When this voltage is restored to normal, the pulls of the mainspring and solenoid are again balanced so that no further motion of the sector results. An air dashpot is spring-coupled to the lever system to prevent hunting which would otherwise result from the time lag in excitation response due to the inductance of the machine field.

2.19 ***Placing Regulator in Service:*** Fig. 4 — With the FIELD SWITCH thrown to the ON position, turn exciter FIELD RHEOSTAT counterclockwise to cut out resistance until voltage builds up to normal and then close REGULATOR SWITCH to the ON position. Slowly turn exciter FIELD RHEOSTAT to full counterclockwise position until resistance is all out or on marked position if provided, and note that regulator maintains the voltage constant. If necessary, readjust the ac voltage to normal by means of the regulator rheostat. On some regulators, the front cover must be opened to permit access to the rheostat. Then proceed as covered in 2.22.

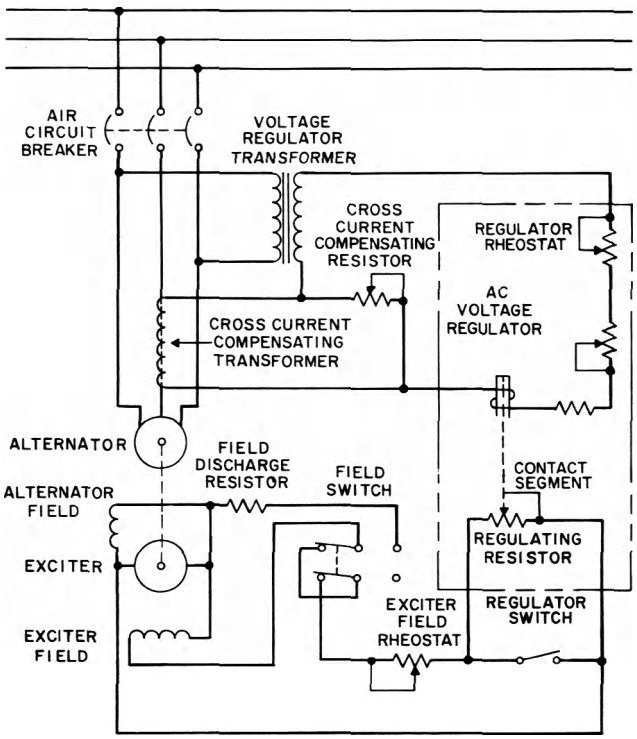

Fig. 4 – Voltage Control Circuit — 30-, 40-, and 60-kw Sets — Schematic — 3 Phase

Westinghouse Silverstat Jr Regulator

2.20 ***Description:*** Voltage correction of the Silverstat Jr regulator is obtained by the control element varying directly the regulating resistance in the machine field circuit. The voltage of the machine to be regulated is connected across the regulator coil and any change in the voltage produces a corresponding change in the magnet circuit of the regulator coil. As the pull of the magnet changes, the armature moves to close or open in sequence the silver buttons, shorting out or inserting steps of resistance in the regulating resistance assembly. The regulator operates only when voltage correction is necessary. For a given value of regulated voltage and load on the machine being regulated, there is a corresponding value of regulating resistance required in the field circuit and a corresponding position of the armature and silver buttons which will give this value of resistance. Under such conditions, the magnetic pull on the armature is balanced against the coil spring pull, at that position of its travel. Should additional load be placed on the machine, the voltage will drop and an increase in field current is required to bring the voltage back to normal. The drop in voltage decreases the magnetizing effect of the regulator coil and reduces its pull on the armature. This allows the coil spring to pull the armature away from the coil, closing in sequence more of the silver buttons. This shorts out additional small steps of the regulating resistance in the field circuit, causing the field current to be increased and the voltage to be raised back to its normal value. When the voltage is restored to its normal value, the armature is again in a balanced state, in a new position corresponding to the change in load on the machine. When load is taken off the machine, the voltage rises and the sequence is reversed; steps of regulating resistance are inserted in the field circuit, reducing the field current and causing the voltage to drop back to normal.

2.21 *Placing Regulator in Service:* Fig. 5 — Check that the exciter FIELD SWITCH is in the ON position. Operate the REGULATOR SWITCH to its ON position if not already in that position and turn the exciter FIELD RHEOSTAT counterclockwise (raise direction) to the limit of its travel. Adjust to normal voltage by means of the regulator rheostat. On some regulators, the front cover must be opened to permit access to the rheostat. Then proceed as covered in 2.22.

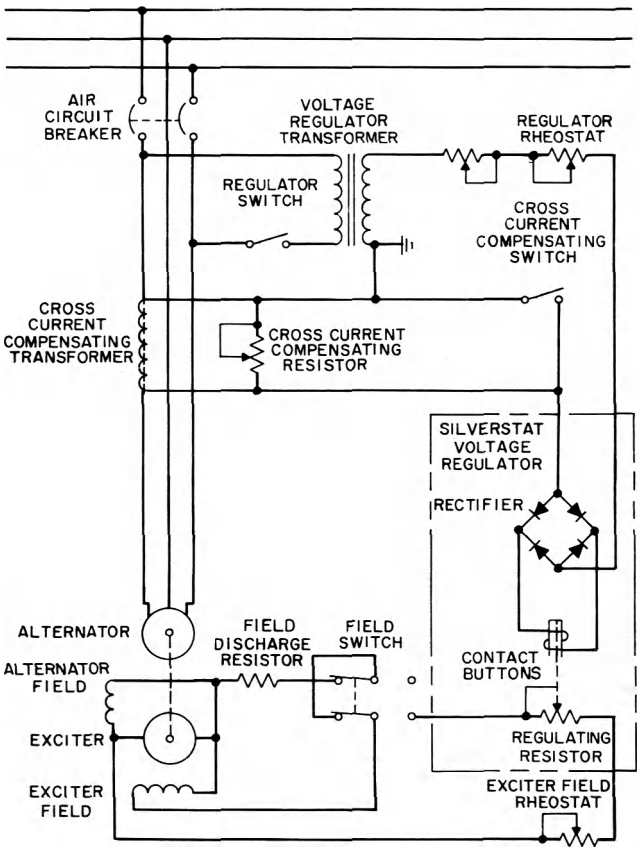

Fig. 5 – Voltage Control Circuit — 10-kw Set — Schematic — Single Phase

Connecting the Load

2.22 After a voltage regulator has been adjusted as outlined above, check to see that the ac voltage is held steady by the voltage regulator. If the voltage remains steady, the load can then be applied. If not, refer to Section A401.232 under Voltage for the proper procedure, in case work on the voltage regulator is required. Having determined that the load can be connected, operate the MAIN SWITCH (circuit breaker) to its ON position and apply the load. Gradual application of the load is desirable.

2.23 If the engine is cooled by city running water, adjust supply valve B until the temperature of the cooling water, as read on the temperature gauge on the control panel, is within the range of minimum 140 F, maximum 185 F. Adjustment of this valve will be necessary with change in load, but endeavor to keep the water temperature in the upper half of this range. On sets equipped with a high water temperature shutdown device, the engine will stop automatically if the water temperature reaches 200 ±5 F.

2.24 If the engine is cooled by a radiator and fan, the maximum temperature of the cooling water, as read on the temperature gauge, should not exceed 185 F for an installation where the surrounding air temperature is below 110 F. For an installation where the surrounding air temperature is above 110 F, the temperature of the cooling water should not exceed the 185 F limit by more than 10 degrees. On sets equipped with a high water temperature automatic shutdown device, the engine will stop automatically if the water temperature reaches 200 ±5 F.

2.25 Start the room ventilating fan, if one is provided, or open windows as much as local conditions permit.

Paralleling

2.26 It is not intended to parallel any sets which are equipped with Burlington GB2 regulators. The following paralleling method therefore applies only to sets equipped with Allis-Chalmers or Silverstat Jr regulators.

2.27 Before starting the second machine, see that its MAIN SWITCH (circuit breaker) is in the OFF position, that its REGULATOR SWITCH is in the ON position, and turn its FIELD RHEOSTAT counterclockwise to the resistance-all-out or marked position. Place its FIELD SWITCH in the ON position.

2.28 Start the engine in the usual manner, and check both engine speed and alternator voltage. Second engine should be at same

speed or slightly above (not over 1/4 of a scale division) that of the engine with which it is to be paralleled. Alternator voltages should be the same.

2.29 Perform the following operations on the second machine in sequence and as quickly as possible. Open the exciter FIELD SWITCH, close the MAIN SWITCH (circuit breaker), and reclose the exciter FIELD SWITCH.

2.30 If the sets do not approximately equalize the loads as read on the machine ammeters, raise the speed of the lighter loaded set slightly until the loads approximately balance. If necessary, adjust the vernier throttle controls and the regulator resistor for minimum cross currents.

Note: On the single-cylinder engine, the cross-current compensating switch should be in the ON position when operating in parallel with other units and in the OFF position when operating alone. No switch for this purpose is furnished on the 3-, 4-, and 6-cylinder engines.

2.31 Additional sets should be started and paralleled in a similar manner.

Note: On a set which has had a combined frequency meter and elapsed time meter added in place of the tachometer on its control panel, the above references to speed may be interpreted in terms of frequency as read on the frequency meter. For example, the frequency readings for the speeds mentioned above in 2.14 would be 60 cycles for the full-load speed of 1200 rpm and 62-1/2 cycles for the no-load speed of 1250 rpm.

Running

2.32 During a prolonged run, endeavor to keep the oil in the fuel tank above the 1/4-full level mark.

2.33 See that the lubricating oil pressure as indicated by the oil pressure gauge does not fall below 18 pounds. Normal pressure will usually be between 25 and 35 pounds. Sudden failure of the oil pressure would indicate failure of the oiling system, whereas a normal pressure when starting with oil cold, then a gradual drop in pressure below normal as the engine warms up, may indicate a low oil supply, oil dilution, wear on crankshaft bearings, or sticking oil pump relief valve. Should the oil pressure fail entirely, shut the engine down immediately. Should the oil pressure fall below normal, determine cause and remedy it. On sets equipped with a low lubricating oil pressure automatic shutdown device, the engine will stop operating if the oil pressure drops to a predetermined low value.

2.34 If the engine is city running water cooled, see that the cooling water temperature as read on the water temperature gauge is within the range specified in 2.23. The cooling water temperature will change with load, but endeavor to keep it in the upper part of this range. On sets equipped with a high temperature automatic shutdown device, the engine will stop operating if the water temperature reaches 200 $\pm$5 F.

2.35 If the engine is cooled by radiator and fan, the cooling water temperature as read on the temperature gauge shall not exceed the limits specified in 2.24. On sets equipped with a high temperature automatic shutdown device, the engine will stop operating if the water temperature reaches 200 $\pm$5 F.

2.36 Under prolonged operation, the crankcase oil level should be checked every 8 hours. Feel the cover on top of the lubricating oil filter occasionally to see that it is warm. If cold, it indicates that the filter is clogged or valve closed. Correct as necessary.

2.37 Keep the engine clean and well lubricated. Lack of lubrication causes undue wear. Care should be taken to remove all dirt from points of lubrication before lubricant is applied. On some models, the air blower housing is provided with oil drains piped to a removable container located at the base of the engine near the control panel. Periodically, check the oil level in this container, and when it is sufficiently high, dispose of the oil away from the engine plant.

2.38 If, for any reason, the engine should shut down, either due to engine overspeed causing the automatic overspeed trip to operate, or to too high water temperature, or to too low lubricating oil pressure; any one of which will cause the air damper to automatically close

and stop the engine; allow the engine to come to a complete state of rest. After determining and clearing cause of shutdown, reset air damper reset lever as covered in 2.01(c), and repeat starting operations.

Caution: Do not continuously stop the engine by manually closing the air damper as this is an emergency shutoff only and is not intended to be used as a regular means of stopping the engine.

Stopping

2.39 Remove the load. Gradual removal is preferable. If machines are operating in parallel, see that any engines remaining on the line are capable of carrying the load before removing machine from service. Then, turn the throttle of the set being removed in the direction to lower the speed until the remaining sets or set assumes and is carrying the entire load.

2.40 Open MAIN SWITCH (circuit breaker), follow immediately by opening the exciter FIELD SWITCH of machine being removed. Leave throttle in the RUN position, permitting engine to operate at its no-load speed.

2.41 After each run, or after 24 hours on a prolonged run and with the engine operating at its no-load speed, open the drain valve at the bottom of the fuel oil filter and drain out approximately 1/2 pint of fluid. If water is found, repeat until fuel oil comes clear.

2.42 Five minutes after opening the MAIN SWITCH (circuit breaker) move throttle to the OFF position. Do not change the vernier setting.

2.43 If the engine is cooled by city running water, close cooling water supply valve.

2.44 Close valves in fuel lines.

2.45 Stop the room ventilating fan, if one is provided, or close the windows, as weather conditions indicate.

2.46 Open valve or drain in exhaust line and silencer. If an air exhaust duct is provided between the engine radiator and the outside, see that any opened louver, etc, is properly closed.

2.47 If there is any danger of water freezing in the water jackets or other parts of the cooling system and an antifreeze is not used, drain cooling system and leave drains open. Be sure to open the butterfly valve at the bottom of the thermostat housing to remove the water from this part. Draining of the cooling system should only be done in an emergency, since the loss of rust inhibitor would be uneconomical as a general practice.

2.48 Clean the engine thoroughly and be sure it is in proper shape for the next run.

2.49 Check the amount of fuel in the tank and replenish as required so there will be an ample supply of fuel for the next run.

Emergency Stopping

2.50 In case it is necessary to stop the set in an emergency, pull the PULL TO STOP — EMERGENCY ONLY shutdown knob on the control panel and hold it in that position until the engine reaches a complete state of rest. The engine cannot be started again until the air damper, which was operated by the shutdown knob, is reset by hand as covered in 2.01(c).

Remote Emergency Stopping

2.51 If a remotely located EMERGENCY STOP switch is furnished, the engine may be stopped by activating this switch. Hold this momentary contact switch in the operated position until the set has come to a complete rest and then release. Before the set may again be started, the air damper must be reset by hand as outlined in 2.01(c).

Stopping of Set by Operation of Engine Safety Devices

2.52 The automatic overspeed trip operates in case the engine reaches a speed of 1500 rpm.

2.53 Safety devices where furnished on the engine, provide for the operation of a shutdown solenoid to close the engine air intake damper and stop the set in case any of the following troubles occur.

(a) Cooling water too hot — 200 ±5 F.

(b) Lubricating oil pressure drops below about 10 pounds while set is running.

Routine Run

2.54 Start engine as outlined above and make a routine check run in accordance with Section A401.232. Operation of set should be noted and any indication of trouble investigated and corrected.

2.55 Short runs, such as demonstration starts, where the engine does not have time for the cooling water to come up to a temperature of at least 120 F should be avoided as they are injurious to the engine.

3. GENERAL TROUBLES

3.01 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.

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

3.03 In the clearing of troubles, it may be necessary in some instances to refer to Section A401.232.

3.04 While an engine is warming up, hunting, which may be defined as a condition where the speed of the engine is periodically rising and falling, may be expected on these engines until the lubricating oil warms up. This may require several minutes, during which time it is not to be considered as a trouble. If, however, it persists for some time after an engine has become thoroughly warmed, the set should be shut down and the cause of its hunting investigated. See 3.05 (i).

3.05 ***Engine***

TROUBLE	POSSIBLE CAUSE
(a) High lube oil consumption	External leaks due to: Gasket or oil seal leaks
	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 (When checking, be certain that the engine water outlet temperature is 165 F 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
	Excessive wear of crankshaft bearings
	Oil pump intake screen partially plugged
	Oil pump relief valve not functioning properly
	Air leak in pump inlet system
	Pump worn or damaged
	Flange leak on pressure side of pump
(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
	Primary or secondary fuel filters restricted

TROUBLE	POSSIBLE CAUSE
	Obstruction in fuel lines or restricted fitting obstructed
	Fuel pump not functioning due to:
	Relief valve not seating
	Fuel pump suction lift too great
	Diameter of fuel suction lines too small
(d) Smoky exhaust	***Black or gray*** (incompletely burned fuel) due to:
	Insufficient combustion air
	Air box cover gasket ruptured
	High exhaust back pressure
	Restricted air inlet due to:
	Cylinder liner ports clogged
	Air cleaners or silencer clogged by dirt or damaged
	Excess fuel or irregular fuel distribution due to:
	Improper setting of injector racks
	Improper timing of injectors
	Faulty injectors
	Engine lugging
	Improper grade of fuel, which may be too heavy to completely vaporize
	Blue — due to:
	Internal fuel or lube oil leaks
	Cylinder cutting out
	Oil leaks into air box
	Engine temperature too low
	White — 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
	Piston rings worn or broken
	Breather restriction due to:
	Obstruction or damage to breather
(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
	Low temperatures
	Faulty starter
	Inoperative air heater (if provided) due to:
	No spark caused by poor or shorted connections, coil defective or points inoperative, or cracked porcelain
	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 10 F above pour point of fuel
	Low compression

TROUBLE	POSSIBLE CAUSE
	Pump and switch not operated while engine is being cranked
	No fuel [covered in (c)] due to:
	Air leaks
	Flow obstruction
	Fuel pump not functioning
	Faulty installation
(g) Lack of power	Improper engine adjustments such as governor adjustments, rack setting, injector timing, or valve lash
	Insufficient fuel [covered in (c)] due to:
	Air leaks
	Flow obstruction
	Nonfunctioning of fuel pump
	Installation faulty
	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
	Worn or broken compression rings
	Engine in a closed room with inadequate air inlet
	Faulty injector tip assembly
	Injector fuel filters restricted
(h) Engine coolant temperatures abnormal	***Above normal temperatures***
	Insufficient heat transfer due to:
	Scale or deposits in various parts of water cooling system
	Clogged radiator openings preventing normal air flow
	Fan belt loose reducing air flow
	Fan shrouding damaged causing improper recirculation of air
	Surrounding air temperature too high
	Hoses in water circulating system collapsed or disintegrated
	Thermostat damaged
	Water pump impeller loose on shaft
	Inadequate water supply on suction side of pump due to:
	Radiator clogging
	Combustion gases in cooling water due to:
	Leaking injector tube seal or cylinder head gasket
	Air in cooling water due to:
	Air leak on suction side of pump
	Thermostat housing bleeder valve, when furnished, not open when filling the system
	Clogged radiator overflow pipe

TROUBLE	POSSIBLE CAUSE
	Below normal temperatures due to:
	Thermostat housing valve in the water circulating system open or not seating
	Thermostat inoperative
	Thermostat seal damaged
(i) Irregular speed	Engine not fully warmed up
	Worn governor mechanism, or governor improperly adjusted
	Incorrect or inadequate fuel mixture
	Governor or fuel rack gummed or sticking

3.06 *Alternator and Exciter*

TROUBLE	POSSIBLE CAUSE
(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
	Unevenness
	Brush tension too weak
	Brushes not set correctly
	Oil or grease on commutator
	Open- or short-circuited armature

3.07 *Burlington GB2 Regulator*

TROUBLE	POSSIBLE CAUSE
(a) Failure to vibrate	Improper connections to generating unit
(b) Unsteady vibration without load and the ac voltage swings from about 95 to 125 per cent of normal voltage	Too low exciter voltage (less than 50 volts)
	Too low resistance in exciter field rheostat
(c) Unsteady vibration but the average voltage is about normal	Improper mounting
	Vibration of the mounting
	Improper setting of field rheostat
(d) Vibrates evenly at no load but too slow at full load, although regulation appears good	Too much resistance in the exciter field rheostat
(e) Vibrates evenly at full load but skips vibration at no load	Too low resistance in exciter field rheostat
(f) Regulation is good but the relay contacts arc badly	Too much resistance in the exciter field rheostat

3.08 *Westinghouse Silverstat Jr Regulator*

TROUBLE	POSSIBLE CAUSE
(a) Regulator not working	Open circuit due to:
	No ac voltage on ac leads of regulator
	Circuit open between exciter field and regulating resistance
	Exciter field rheostat not on the marked position
	Short circuit across regulating resistance of regulator
	Obstruction in air gap of regulator magnetic circuit

TROUBLE	POSSIBLE CAUSE
(b) AC voltage erratic or swings violently	Loose or poor connections
(c) AC voltage droops badly when alternator is loaded	Exciter speed below normal
	Exciter field rheostat not on marked position
(d) Sparking at silver buttons	Excessive dust or dirt between buttons
	Open circuit or poor connection between silver buttons and regulating resistance
	Open circuit in regulating resistance