Instruction Manual

Installation
Operation
Maintenance

Voltage Regulator
KAMAG II

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KATO ENGINEERING™

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This manual provides information for operation and maintenance of KATO KAMAG II Voltage Regulator. Additional information is contained in the Generator Operation and Maintenance Manual. Keep this booklet with the Generator Set.

Features of the KATO KAMAG Voltage Regulator not normally found on other regulators of comparative cost are:

* Load compensation circuit (current boost) provides field forcing during motor starting or for short circuit fault clearance.

* Saturable transformer magnetic amplifier power stage with inherent high tolerance to overload.

* Saturable transformer magnetic amplifier does not produce electromagnetic interference.

* Antihunt negative feedback stability circuit ensures stable generator output.

* Designed for 50 or 60 hertz, single or three phase systems.

* Auto voltage adjust potentiometer provides wide voltage adjust range.

* Voltage Regulator shock and vibration resistant and all components are protected against corrosive environment.

* Factory replacement Voltage Regulators carried in stock at all times.

Options Available on Request:

* Voltage droop option permits parallel operation of generators.

* Manual voltage adjust option consisting of auto/manual switch and manual voltage adjust rheostat.

* Remote auto voltage adjust potentiometer mounted externally.

* Generator voltage shutdown switch permits engine warm-up at idle speed without damage to generator set.

CAUTION

MEGGERS AND HIGH POTENTIAL TEST EQUIPMENT SHOULD NOT BE USED. INCORRECT USE OF SUCH EQUIPMENT COULD DESTROY THE RECTIFIERS, TRANSISTORS AND CAPACITORS IN THE REGULATOR.

WHEN TESTING THE INSULATION RESISTANCE OF GENERATOR WINDINGS WITH MEGGER, FIRST DISCONNECT LEADS BETWEEN REGULATOR AND GENERATOR.

FIELD CIRCUIT FROM VOLTAGE REGULATOR TERMINALS F+ AND F− MUST NOT BE OPENED OR GROUNDED WHILE THE GENERATOR IS RUNNING. GROUNDING OR OPENING THE FIELD CIRCUIT CAN RESULT IN REGULATOR FAILURE.

VOLTAGE SHUTDOWN AND FIELD CIRCUIT BREAKER WHEN USED WITH THIS EQUIPMENT MUST CLOSE THE FIELD CIRCUIT BETWEEN REGULATOR TERMINALS F+ AND F− WHENEVER DEVICE IS SET OR TRIPPED TO OFF POSITION. THE DEVICE MUST NOT OPEN OR GROUND THE FIELD CIRCUIT.

WARNING

VOLTAGES CAPABLE OF CAUSING SERIOUS ELECTRICAL SHOCK OR ELECTROCUTION ARE PRESENT AT THE VOLTAGE REGULATOR TERMINALS AND INTERNAL CIRCUITRY WHEN GENERATOR IS RUNNING. TO AVOID ELECTRICAL SHOCK HAZARD STOP GENERATOR SET WHILE REPAIRING THIS EQUIPMENT AND WHILE MAKING ELECTRICAL CONNECTIONS.

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SECTION 1 INTRODUCTION AND THEORY OF OPERATION

1.1 INTRODUCTION

The KAMAG II Voltage Regulators are used on KATO KAMAG 14 and KAMAG 18 Alternating Current Generators. The voltage regulator consists of a solid state preamplifier and a magetic amplifier type power controller. The voltage regulator can be used equally well on single or three phase, 50 or 60 Hertz systems. This series of voltage regulators provide plus or minus 2 percent regulation.

The regulators include load compensation circuitry which provides additional excitation as load is increased. This current boost feature also provides field forcing during motor starting and short circuit fault clearance. The system is capable of providing the excitation required to provide 200 percent of rated full load current during motor starting or short circuit fault clearance. The voltage regulator also includes an adjustable negative feedback stability circuit which ensures optimum transient response to load changes and prevents hunting during parallel operation of generators.

The KAMAG II Voltage Regulator is designed to provide a maximum continuous output current of 1.25 amperes at 50 degrees centigrade ambient. Two minute field forcing capacity of the regulator is 1.75 amperes at 50 degrees centigrade ambient. Voltage regulator input power is single phase, 118 to 142 VAC at 60 Hertz and 98 to 115 VAC at 50 Hertz. Except when otherwise specified, sensing is single phase, 236 to 283 VAC at 60 Hertz and 196 to 230 VAC at 50 Hertz.

1.2 THEORY OF OPERATION

The block diagram (figure 1) shows the generator and its voltage regulating system divided into basic function blocks. Generator field excitation is provided by a brushless exciter. Generator output voltage is regulated by controlling the excitation. This is done by controlling the DC power applied to the exciter field windings. The voltage regulator continuously measures the generator output voltage and automatically supplies the amount of excitation required to keep the generator voltage at the pre-set level. Figure 4 is an electrical schematic of the KAMAG II regulating system.

1.2.1 Power Controller

The power controller portion of the voltage regulator consists of a single phase saturable transformer, a linear reactor and a full wave power rectifier.

The saturable transformer input excitation develops power in its output winding. The power developed in the output winding is rectified by diodes D7 through through D10, and its rectified output is applied to the exciter field. The saturable transformer input excitation is a combination of the power applied to three seperate windings. They are: a primary winding, a load compensation winding and a control winding.

The power applied to the primary winding is obtained from the generator output across linear reactor L1. The functions of linear reactor L1 are to maintain the correct phase relationship between the power applied to the primary and load compensation winding when the generator is operating with a load applied and to keep the voltage applied to the primary winding at the preset level during no-load operation.

The power applied to the control winding is obtained from the control signal amplifer located on the circuit board. It will automatically change proportional to a deviation in the generator output voltage from the preset level. When generator voltage drops below the pre-established level the control signal amplifier will provide less power to the control winding. This action causes an increase in saturable transformer output which results in an increase of the DC excitation thereby returning the generator output to the preset level. When generator voltage exceeds the preset level, as occurs when load is dropped, the regulator senses this deviation and supplies more control power which decreases the saturable transformer output.

The load compensation winding provides an increasing proportion of the saturable transformer input excitation converted to output power as the load is increased from no-load to full-load. In addition, the load compensation winding will provide field forcing during motor starting and short circuit fault clearance. Under sustained short circuit conditions, the load compensation circuitry provides current of at least 200 percent of full load-rating.

An additional current boost transformer is used in applications where generator line current differs from the load compensation winding input excitation requirements. This transformer is included in the regulating system of the KAMAG 18 generator. Generator line current provides power to the transformer's primary winding. Power developed in the secondary winding is applied to the load compensation winding of the saturable transformer.

1.2.2 Regulator Preamplifier And Power Rectifier Assembly

This assembly includes the regulator chassis, sensing transformer T1, regulator power transformer T2, voltage adjust potentiometer R1, and a circuit board assembly. The circuit board includes the sensing rectifiers D1 through D4, circuit board power rectifiers D12 through D15, the regulator output power rectifiers D7 through D10, an error detector circuit, a control power amplifier and the negative feedback stability circuit. Output of the control power amplifier, provides the DC control power to the control winding of the saturable transformer.

Voltage from the generator output is applied to the primary winding on transformer T1. The secondary voltage of T1, which is proportional to its primary voltage, is applied to sensing rectifiers D1 through D4 where it is rectified and then filtered by capacitor C1 and choke L2. This voltage which is proportional to the generator output is applied across a voltage divider.

The voltage divider consists of resistors R2, R5, voltage range adjust potentiometer R3 and voltage adjust potentiometer R1. A portion of this voltage, sampled at the junction of R2 and R3, is applied as input to one side of an error detector.

The error detector consists of an emitter coupled differential signal amplifier (Q1, Q2). Base drive for transistor Q1 is a representative portion of the sensing voltage. Transistor Q2 is the reference side of the differential signal amplifier. Its base drive is kept at the fixed zener voltage level of zener diode Z1.

The difference between the input signal applied to Q1, which is proportional to the sensing voltage obtained from the generator and the fixed reference voltage applied to Q2, is the error signal. This error signal is applied to a differential signal amplifier Q3 and Q4 which amplifies the error signal. This signal in turn drives amplifier Q5 and Q6. The output of amplifier Q5 and Q6 provides the control power for the control winding of the saturable transformer.

The voltage regulator includes a negative feedback stabilization network. Components comprising this network are: capacitors C2 and C3, resistors R6 and R8 and, potentiometer R4. This R-C network injects a stabilizing signal from the regulator output to the error detector to prevent oscillations (hunting). R4 determines the amount of stability signal applied to the error detector.

1.3 OPTIONS

Options that can be provided with this series of voltage regulators are: a remote voltage adjust potentiometer, an auto/manual control module, parallel operation voltage droop components, and a voltage shutdown switch.

1.3.1 Remote Voltage Adjust Potentiometer

A remote voltage adjust potentiometer may be mounted at any convenient remote location such as on a generator set control panel assembly or a meter box.

In applications where a remote voltage adjust potentiometer is used, the jumper wire across terminal 7 and 8 on the voltage regulator must be removed. Interconnecting wires are run from the remote voltage adjust potentiometer to voltage regulator terminals 8 and 9 as illustrated in figures 7b or 7d. Where a remote voltage adjust potentiometer is installed, the local voltage adjust potentiometer is inoperative and the remote voltage adjust is used to adjust the generator output.

1.3.2 Parallel Operation Voltage Droop Option

When parallel operation is required, additional components are required in the regulating system. These components are an adjustable voltage droop resistor, a 5 volt ampere current transformer, and a unit/parallel switch. In a parallel equipped voltage regulator, the jumper bar across terminals CT1 and CT2 is removed and interconnecting wires from the parallel operation components are connected onto the terminals as illustrated in figure 8b.

These components allow the paralleled generators to share reactive load and reduce circulating currents between them. (This is accomplished in the following manner.)

A 5 volt ampere current transformer is installed in line B of each generator. The current transformer develops a signal that is proportional in amplitude and phase to the line current.

This current develops a voltage across the voltage droop resistor. A slider on the resistor supplies part of this voltage to the sensing rectifiers. The AC voltage applied to the sensing rectifiers is the vector sum of the stepped-down sensing voltage from transformer T1 and a portion of the parallel compensation signal. The portion of the voltage applied to the sensing rectifier by the parallel compensation signal terminals CT1 and CT2 must be connected to the generator system so as to provide correct phase and polarity relationship.

When a resistive (unity P.F.) load is applied to the generator, the voltage that appears across the droop resistor leads the sensing voltage by 90 degrees and the vector sum of two voltages is nearly the same as the original sensing voltage; consequently, almost no change occurs in generator output voltage.

When lagging power (inductive) load is applied to the generator, the voltage across the droop resistor becomes more in phase with the sensing voltage and the combined vectors of the two voltages result in a larger voltage being applied to the sensing rectifiers. Since the action of the regulator is to maintain a constant voltage at the sensing rectifiers, the regulator reacts by decreasing the generator output voltage.

When a leading power factor (capacitive) load is applied to the generator, the voltage across the droop resistor becomes out of phase with the sensing voltage and the combined vectors of the two voltages result in a smaller voltage being applied to the sensing rectifiers. Then the regulator reacts by increasing the generator voltage.

When two generators are operating in parallel, if the field excitation on one generator should become excessive causing a circulating current to flow between generators, this current will appear as a lagging power factor (inductive) load to the generator with excessive field current and a leading power factor (capacitive) load to the other. The parallel compensation circuit will cause the voltage regulator to decrease the field excitation on the generator with the lagging power factor load, and increase the field excitation on the generator with the leading power factor load, in order to minimize the circulating currents between the generators.

This action and circuitry is called voltage droop compensation. It allows two or more paralleled generators to proportionally share inductive loads by causing a decrease or droop in the generator system voltage.

1.3.3 Auto/Manual Control Option

The auto/manual control option includes a single-pole double-throw switch and a 800 ohm, 50 watt rheostat. Interconnection of this option in the regulating system is illustrated in figures 7c and 8d.

The function of this option is to provide a means of operating the generator set should a failure of the voltage regulator occur. It can also be used in order to isolate the cause of a generator set malfunction.

When used to isolate a malfunction, if the output voltage can be adjusted to its normal output and controlled when the set is operated in the manual mode, the problem usually will be in the voltage regulator. However, if the correct generator output voltage cannot be obtained in either the automatic or manual mode of operation the problem usually will be within the generator or rotating exciter.

1.3.4 Underspeed Protection Voltage Shutdown Switch (Engine Idle Switch)

The regulator may be equipped with a switch to allow removal of excitation from the exciter field in an emergency or when the prime mover must be operated at reduced speed. The switch is connected between the voltage regulator terminals F- and F+ as shown in figure 10.

Operation of the switch is as follows:

1. Manually close the switch during underspeed operation. Make certain output circuit breaker is set to its OFF position during underspeed operation.
2. Open switch when unit is running at rated speed. Then, when system voltmeter indicates generator voltage is at its pre-set level, close the output circuit breaker and apply the load.

SECTION 2 INSTALLATION

2.1 RECEIVING INSPECTION

The KAMAG II Voltage regulator is mounted in the generator outlet box and is completely interwired. Upon receipt of the generator, remove the outlet box cover and inspect mounting hardware and terminal connections to make certain they are tight. Also inspect wiring for signs of frayed or damaged insulation.

2.2 ELECTRICAL INTERCONNECTIONS

KAMAG voltage regulators are designed for use with broad range multiple voltage KAMAG 14 and KAMAG 18 generators. The generator lead wires and interconnecting wires to the voltage regulator have been connected at the factory to develop and operate at the voltage given in the purchase order.

In applications where generator must operate at voltage different than given in the purchase order, the generator stator lead wires, lead wires to the regulator terminal board and wires A through D on the saturable transformer must be reconnected. Refer to appropriate connection diagram contained in the generator operating and maintainance manual. If additional information is needed, contact Kato Engineering Company, Controls Design Department. When requesting information, always include the generator serial number and generator type number.

2.2.1 Load Compensation Winding Connections A, B, C, and D

KAMAG 14 Generator application utilizes a saturable transformer which includes winding A, B, C, and D. Interconnect as shown on the generator set wiring diagram.

KAMAG 18 Generator application includes a separate boost transformer. Leads A, B, C, D are the primary winding on this boost transformer. Secondary winding leadwires E and F on the boost transformer are connected to the current winding on the saturable transformer. Connect leads A, B, C, D, E, and F as shown on the generator set wiring diagram.

2.2.2 Field Power (Terminals F- and F+)

Connect the exciter lead wires F- and F+ onto terminals F- and F+.

2.2.3 Optional Underspeed Voltage Shutdown Switch (Engine Idle Switch)

This switch, when provided, is connected between regulator terminals F- and F+ as illustrated in Figure 11.

The switch should be manually closed during underspeed operation. Manually open the switch when unit is at rated speed and make certain generator output builds up to rated voltage before applying load.

2.2.4 Regulator Terminals 7, 8 and 9

In applications where the remote voltage adjust option is not included, make certain jumper wire is installed across regulator terminals 7 and 8. Generator output voltage can be adjusted by turning the voltage adjust located on the side of the regulator chassis. Refer to Figure 7a.

In applications where the remote voltage adjust option is provided, remove jumper from terminals 7 and 8 and interconnect the remote voltage adjust to regulator terminals 8 and 9. Make certain a wire jumper is connected from terminal 1 to terminal 2 on the remote voltage adjust as shown in figure 7B. During operation of the generator set, use the remote voltage adjust to set the generator output voltage at desired value.

2.2.5 Regulator Terminals 9, 10, and 11

In applications where the auto/manual control option is not provided, make certain jumper is installed across terminals 10 and 11 as shown in figure 7a.

In applications where the auto/manual option is provided, remove jumper from terminal 10 and 11 and connect the auto/manual switch and the 800 ohm, 50 watt, manual voltage adjust rheostat as shown in figure 7c.

2.2.6 Regulator Terminals CT1, CT2

In applications where the parallel voltage droop option is provided, remove jumper from terminals CT1 and CT2; connect the current transformer, droop resistor and, when included, the unit/parallel switch as illustrated in figure 8b. Make certain a jumper bar is connected from the slider terminal on the resistor to its end terminal as illustrated in figure 8b. Polarity of the current transformer must be as shown in figure 8b.

In applications where generator set operates singly, that is, parallel voltage droop option is not provided, make certain jumper is installed across regulator terminals CT1 and CT2 as illustrated in figure 8a.

2.2.7 Regulator Sensing (Terminals E1 and E3)

Connect interconnecting wires from the generator to terminals E1 and E3 as shown in the wiring diagrams supplied with the generator set.

The standard factory connection of the primary winding on the sensing transformer T1 as illustrated in figure 9a is in series and the sensing voltage applied to terminals E1 and E3 is 204 to 283 VAC at 60 Hertz and 170 to 230 VAC at 50 Hertz.

In single phase two wire 98 to 142 VAC applications the sensing transformer primary winding must be connected parallel as illustrated in figure 8b. A parallel connected sensing transformer primary requires 98 to 142 VAC sensing applied to terminals E1 and E3.

2.2.8 Regulator Power (Terminals L and N)

In applications where generators are operating at 60 Hertz connect 118 to 142 VAC from the generator to terminals L and N as shown on the wiring diagram supplied with the generator set.

In applications where generator is operated at 50 Hertz connect 98 to 115 VAC from the generator to terminals L and N as shown on the wiring diagram supplied with the generator set.

2.2.9 Saturable Transformer Connector

Connect plug from saturable transformer into the socket located on the top of the regulator chassis.

2.2.10 Control Winding

A terminal board containing three terminals is located on the side of the saturable transformer assembly chassis. Before operating the generator set at 60 Hertz, a jumper must be installed from the terminal marked (C) to the terminal marked (60) as shown in figure 6c. Before operating the generator set at 50 Hertz, the jumper must be installed from the terminal marked (50) to the terminal marked (C) as shown in figure 6d.

2.2.11 Interconnections of reactor L1

The reactor is factory connected with wires to reactor terminals X1 and X3.

If no load voltage is too high and cannot be reduced sufficiently by adjusting the voltage adjust (R1) and voltage range set adjust (R3), remove wire from reactor tap X3 and connect the wire onto reactor tap X4.

If no load voltage is too low and cannot be increased sufficiently by turning (R1) and (R3), remove wire from reactor tap X3 and connect wire onto tap X2.

SECTION 3 OPERATION

3.1 WIRING

Before initial operation is attempted, verify that the generator and regulating system is connected to provide the correct output voltage. Review the wiring diagram supplied with the generator set. Also, review Section 2 paragraphs 2.2 through 2.2.11 and the drawings contained in Section 6 of the manual. Special attention should be given to insure correct interconnection of optional controls and use of jumper bars on the regulator and saturable transformer terminals.

3.2 ADJUSTMENTS

The adjustable controls pertaining to the regulating system are described in the paragraphs which follow. Each control has been set at the factory; however, because each application is different, adjustment may be necessary during initial operation. The adjusments and their functions are as follows:

3.2.1 Generator Voltage Adjust Potentiometer R1

This potentiometer is provided to establish the operating voltage of the generator. It is located on the side of the regulator chassis. It is adjusted by loosening the potentiometer shaft locknut and then turning the potentiometer shaft with a screwdriver.

Turning this adjustment clockwise will increase generator output voltage. When adjusted to its fully counterclockwise position, minimum generator output voltage is obtained.

After adjusting potentiometer to position that provides the correct generator output voltage for the application, hold the shaft to prevent further movement and tighten the locknut.

Adjust the potentiometer during initial operation with no-load applied. Then apply load and if necessary, make final adjustment.

3.2.2 Remote Voltage Adjust Option

In applications where the remote voltage adjust potentiometer is included, this device rather than the voltage adjust located on the voltage regulator establishes the generator voltage.

This control is adjusted in the same manner as Voltage Adjust R1 described in the preceeding paragraph.

3.2.3 Nominal Voltage Range Set Adjust R3

This adjustment is provided to vary the limits of the voltage adjust potentiometer. It is located on the inner side of the regulator chassis and can be adjusted by turning the potentiometer with a small screwdriver inserted through the access hole in the chassis. It has been set at the factory. Further adjustment of this control should be made only in the event the required minimum voltage or maximum voltage cannot be obtained by adjusting the voltage adjust potentiometer. Turning R3 counterclockwise lowers the minimum voltage setting and turning it clockwise raises the maximum voltage setting.

NOTE

Between fifteen and twenty revolutions of the potentiometer shaft results in full travel of the potentiometer from zero resistance to maximum resistance. A slight click can be heard when either the zero resistance or maximum resistance adjustment has been reached.

3.2.4 Stability Adjust Potentiometer R4

The stability adjust potentiometer R4 is located on the inner surface of the regulator chassis. Adjustment is made by inserting a small screwdriver through an access hole in the chassis. It has been set at the factory. If during operation of the generator output voltage ocillates or poor response occurs, additional adjustment of R4 may be necessary. Turning stability adjust R4 clockwise injects a stabilizing signal into the error detector. Excessive clockwise rotation can, however, slow down response. Stability adjust should be set so that the output voltage is stable both during no-load operation and with load applied. For accurate adjustment an oscillograph should be used to measure output voltage during adjustment of the stability adjust potentiometer.

NOTE

Between fifteen and twenty revolutions of the potentiometer shaft results in full travel of the potentiometer from zero resistance to its maximum resistance or maximum resistance adjustment has been reached.

NOTE

Unstable governors are frequently the cause of generator voltage instability. If a stability problem cannot be corrected by adjusting R4, a thorough check of the prime mover governor should be made.

3.2.5 Manual Voltage Adjust Rheostat

This device is included in regulating systems that include the auto/manual voltage control option. It controls the generator output voltage during operation of the generator set in the manual voltage control mode. Voltage is increased by turning the rheostat clockwise. Minimum output voltage is obtained when the rheostat is turned to its full counterclockwise position.

3.2.6 Auto/Manual Switch

This switch is included in regulating systems equipped with the auto/manual voltage control option.

Normal operation of the generator set should be with the switch in the AUTO position. In the automatic mode of operation the generator voltage is set through adjustment of the local voltage adjust potentiometer R1 or, if included, the optional remote voltage adjust potentiometer. The generator voltage is automatically controlled by the voltage regulator.

Operation of the generator in the manual mode of operation should be used for emergency operation in the event that faulty operation of the automatic regulating portion of the system occurs. The manual mode of operation may also be used during troubleshooting or system checkout as a means of isolating a system malfunction in the regulating system or in the generator.

Operation of the generator set in the manual voltage control mode consists of setting the auto/manual switch to the manual position and retaining the generator output voltage at the required level by turning the manual voltage adjust rheostat.

3.2.7 Unit/Parallel Switch

This switch may be included in regulating systems that include the parallel voltage droop option.

Open the unit/parallel switch before parallel operation of generators.

Close the unit/parallel switch during single generator operation when no voltage droop upon application of inductive load is desired.

3.2.8 Parallel Voltage Droop Adjust

An adjustable resistor is included in regulating systems that have the parallel droop option. The function of the resistor is to provide a means of obtaining optimum reactive kilovolt ampere load sharing during parallel generator operation, thereby minimizing the circulating currents flowing between the generators.

General procedure for setting the parallel voltage droop adjust resistor is as follows:

1. Make certain unit/parallel switch, if provided, is open.
2. Measure droop when nductive load is applied as given in the parallel operation instruction.
3. If droop is not of desired level, adjust droop resistor as given in steps 4 and 5.
4. To increase KVAR voltage droop, increase the resistance across the droop resistor.
5. To decrease KVAR voltage droop, decrease the resistance across the droop resistor.
6. Repeat steps 1 through 5 for each individual generator that will be operating in parallel.

3.2.9 Underfrequency Voltage Shutdown Switch (Engine Idle Switch)

This switch provides generator underfrequency protection during severe underspeed operation such as during engine idling.

Close the switch during underspeed operation.

Open the switch during normal operation.

CAUTION

The voltage shutdown switch must be opened in order to obtain rated output. Do not attempt to adjust the generator voltage or close the output circuit breaker before making sure the voltage shutdown switch has been opened.

3.3 INITIAL OPERATION

The initial operating instructions are contained in the paragraphs which follow. These procedures should be reviewed and understood before system operation is attempted. (See paragraph 3.4)

3.3.1 Single Unit Operation

1. Open the generator circuit breaker.
2. In applications that include the voltage shutdown switch option, open the switch.
3. In applications that include the parallel operation option and a unit/parallel switch, close the switch.

4. In applications that include the auto/manual switch, set the switch to its automatic position.

5. Start the prime mover and increase to rated speed.

6. Monitor the generator output voltage. The following conditions could occur:

   (a) No voltage buildup. If this condition exists, field flashing may be necessary. (See paragraph 3.4)

   (b) Undervoltage (–15 percent or less) or overvoltage (+15 percent or less). If one of these conditions occurs, correct by adjusting the voltage adjust potentiometer and, if necessary, the nominal voltage range adjust potentiometer R3.

NOTE

If required no load operating voltage cannot be attained by adjusting R1 and R3, it may be necessary to change wires at taps on reactor L1 as described in paragraph 2.2.11.

   (c) Undervoltage (lower than –15 percent) or overvoltage (higher than +15 percent). If one of these conditions occurs, stop the prime mover and determine cause of the abnormal condition.

   (d) Oscillating Voltage (Hunting). If this condition occurs, verify that prime mover speed is stable. Then, if oscillation still occurs, adjust the stability adjust potentiometer R4.

7. The voltage regulator is now ready for load test.

8. Close output circuit breaker and apply load to generator.

9. Verify that steady state voltage regulation is within 2%.

10. Alternately remove and apply load to determine if generator voltage is stable.

11. In applications that include the auto/manual voltage control option, generator operation in the manual voltage control mode can be tested as described in steps 12 through 17 which follow.

12. Remove load.

13. Set auto/manual switch to manual position.

14. Turn the manual voltage adjust rheostat to position where correct operating voltage is indicated on the system voltmeter.

15. Apply load. Adjust the manual voltage control rheostat to obtain required output voltage. Verify that voltage is stable.

16. Remove load and adjust the manual voltage control rheostat to obtain required no-load voltage.

17. Set the auto/manual switch to its automatic position.

3.3.2 Initial Parallel Operation Pre-Paralleling Procedure

Before attempting to parallel generators, adjust and test each generator as given in steps 1 through 10 that follow:

1. Make certain the paralleling signal at terminals CT1 and CT2 of the regulator has the proper phase relationship with that of the sensing voltage. Wires must be connected from the generator to regulator terminals E1 and E3 as shown on the connection diagram which is provided with the generator. The parallel operation current transformer must be installed in phase B line with polarity toward the generator as shown in figure 8b.

2. Make certain the machines have the same voltage sequence (phase rotation).

3. Make certain unit/parallel switch, if included, is set to its open position.

4. Make certain auto/manual switch, if included, is set to its automatic position.

5. Place one of the sets in operation in accordance with the preceeding "Single Unit Operation" instructions, paragraph 3.3.1, steps 1 through 10.

6. Apply a 25 to 100% unity power factor load. Frequency should decrease if governor is set for droop operation. For optimum KW load-sharing, the governors on each individual set should be set for identical droop when their share of the total KW load is applied.

7. Apply a 25 to 100% inductive load. If droop is not of desired value, adjust the droop resistor. Refer to the voltage droop resistor adjustment procedure for optimum reactive KVA sharing. The voltage of each individual generator should droop an identical amount when its share of the total KVAR load is applied.

NOTE

If voltage rises instead of droops, reverse the CT leads.

8. During these tests, verify that the voltage and speed do not drift or jump erratically.

9. Shutdown generator set.

10. Individually operate each generator that is intended for use in the parallel operation as given in preceeding steps 1 through 9.

3.3.3 Paralleling Generators

After each generator set has been individually tested, generators may be paralleled as given in the following general procedure.

1. Start generator set NO. 1.
2. Connect the generator set output to the bus by closing its output circuit breaker.
3. Adjust generator voltage and frequency to nominal.
4. Apply the load.
5. Start generator set NO. 2.
6. Adjust generator voltage to nominal.
7. Adjust speed of generator set NO. 2 slightly higher than that of generator set NO. 1.
8. Observing the synchroscope (or lights), when generator NO. 2 is in phase with generator NO. 1, close the circuit breaker for generator NO. 2.
9. Immediately after closing the circuit breaker, measure line current of generator NO. 2. It should be well within the rating of the generator. Also, immediately after closing the circuit breaker, observe the KW or power factor meters. The following conditions could occur:

   (a) A high ammeter reading accompanied by a large KW unbalance. When this condition exists, the speed governor is either not adjusted correctly or is faulty.

   (b) A high ammeter reading accompanied by a large KVAR unbalance. When this condition exists, the voltage regulating system is either not adjusted correctly or is faulty.

10. Adjust the speed of generator set NO. 2 to the point where each generator is carrying the desired share of KW load. (See note following step 11).

11. Adjust the voltage of generator NO. 2 until the ammeter readings of both generators are near minimum. (See following note).

NOTE

If KVAR or power factor meters are available, adjust voltage adjust potentiometer for equal or porportional KVAR or power factor readings.

NOTE

To obtain best results, final adustments should be made with full load on the bus.

12. With full load applied, readjust the speed and voltage of generator No. 2 until the desired load division is obtained.

NOTE

The best adjustment is obtained when each generator supplies the same percent of its rated current, the power factor readings are equal, or the sum of the ammeter currents is minimum.

3.4 FIELD FLASHING

CAUTION

DO NOT ATTEMPT TO FLASH THE MACHINE WHILE IT IS ROTATING. THE POSITIVE OF THE FLASHING SOURCE MUST BE CONNECTED TO F+ AND THE NEGATIVE TO F-. BE CAREFUL TO OBSERVE POLARITIES. IF THESE LEADS ARE REVERSED, THE REGULATOR WILL FAIL.

Usually there is sufficient residual voltage to allow the generator to build up without flashing. However, if field flashing is required, with the prime mover at rest, apply a 12 or 24 volt DC flashing source across the terminals of F+ and F- on the regulator. This action remagnetizes the field poles and allows build up when the system is restarted.

SECTION 4 MAINTENANCE

4.1 PREVENTIVE MAINTENANCE INSPECTION AND CLEANING

Periodically inspect and clean the voltage regulating system. In applications where generator sets are operating under normal conditions, inspection and cleaning at six month intervals is sufficient. In applications where excessive dust, moisture, or engine-transmitted vibration is present, determine the extent of the abnormal condition and reduce the length of time between periodic inspection or cleaning accordingly.

4.1.1 Periodic Visual Inspection

1. Inspect interwiring and terminal connections. Repair or replace wiring that has frayed or burnt insulation. Clean, then tighten any connectors found to have loosened.

2. Inspect mounting hardware that holds the regulator, transformer, and other controls within the generator outlet box. Tighten any mounting bolts or screws that have loosened.

3. Visually inspect components for signs of overheating.

4.1.2 Cleaning

Remove excessive dust or the abrasive material. A vacumm cleaner or compressed air at a pressure of 25 to 50 psi may be used.

4.2 TROUBLESHOOTING

The more common generator system malfunctions, causes of the malfunctions, and the appropriate repair procedure are listed in Table 4-1.

Incorrect electrical hookup and poor connections are often the cause of system malfunction. Before assuming a failure of the generator or regulator has occured, check interwiring against the drawings contained in Section 6, the wiring diagram provided with the generator, and the instructions contained in Sections 2 and 3 of this instruction manual. Also make certain all connections are tight and free of corrosion.

TABLE 4-1 TROUBLE SHOOTING CHART

SYMPTOM	PROBABLE CAUSE	PROBABLE REMEDY
No generator output voltage	Exciter rectifiers open.	Test. Replace defective rectifiers.
	Surge suppressor shorted. (Kamag 18 application)	Test. Replace shorted surge suppessor.
	No residual magnetism in exciter field.	Disconnect F+, F– leads from regulator and flash field. See paragraph 3.4.
	Shorted or open exciter fields coils, generator field coils, or exciter armature windings.	Test winding resistance.
Generator no-load output voltage low but can be varied by adjusting the voltage adjust potentiometer	Generator or voltage regulator not connected correctly.	Check electricial connections. Refer to the wiring diagram provided with the generator set and review Section 2, paragraph 2.2.1 through 2.2.11.
	Prime mover underspeed	Increase to rated RPM and hertz of generator.
	Exciter rectifier open	Test rectifiers. Replace if defective.
	Voltage adjust R1 and Voltage adjust R3 not properly adjusted.	Adjust potentiometers. Review Section 3, paragraphs 3.2.1, 3.2.2 and 3.2.3.
	Voltage regulator malfunction	Check sensing, error detector, amplifier and output rect fier diodes. Replace either the failed parts or the voltage regulator.

TABLE 4-1 TROUBLESHOOTING CHART (cont).

SYMPTOM	PROBABLE CAUSE	PROBABLE REMEDY
Generator no load output voltage at level established by exciter field residual magnetism and drops when load is applied. NOTE Residual level can be determined by disconnecting power to voltage regulator and running generator at rated RPM.	Engine idle switch, when used, closed.	Open Switch.
	Generator or voltage regulator not connected correctly.	Check all interwiring with the wiring diagrams provided with the generator set, the drawings contained in Section 6 and the instructions contained in paragraphs 2.2.1 through 2.2.11.
	Voltage regulator malfunction.	Test. Replace either the failed parts or the voltage regulator.
	Shorted or open exciter field coils.	Test. Replace defective exciter field.
Generator no load voltage too high	Prime mover overspeed	Reduce to rated RPM and frequency of generator.
	Generator or voltage regulator not connected correctly.	Check all electrical interconnections with the wiring diagram provided with the generator set, the drawings contained in Section 6 and the instructions given in Section 2, paragraphs 2.2.1 through 2.2.11.
	Voltage adjust potentiometers not adjusted correctly	Adjust potentiometers. See Section 3, paragraphs 3.2.1, 3.2.2 and 3.3.3.
	Voltage regulator error detector and amplifier circuit malfunction.	Test. Replace either the failed parts or the voltage regulator.
	Load imbalance and regulator sensing taken from overloaded phase and voltmeter monitoring underloaded phase.	Measure voltage across phase A-B, phase A-C, and phase B-C. Measure current through line A, line B and line C. On single phase application, test L1 to N and L2 to N. Balance load.
Generator output voltage rises excessively when load is applied.	Parallel voltage droop current transformer secondary leads reversed (on parallel equipped generator sets)	See Section 6, Figure 8b and Section 2, paragraph 2.2.6.
	Incorrect turns on current winding on saturable transformer or in Kamag 18 application, the current boost transformer.	Contact factory for information regarding correct transformer for application. Provide generator set serial number, operating KW, the required output voltage, and connection diagram used.
	Incorrect connection of reactor L1 or control winding jumper	Refer to the drawings contained in Section 6 and paragraph 2.2.11.
	Voltage regulator error detector or amplifier circuit malfunction	Test. Replace either the failed parts or the voltage regulator.
Generator output voltage drops or collapses when load is applied.	Prime mover underspeed	Increase to rated RPM. If prime mover speed droops excessively when load is applied, adjust the prime mover speed governor.
	Overload or load inbalance	Reduce and balance load.

TABLE 4-1 TROUBLE SHOOTING CHART (cont).

SYMPTOM	PROBABLE CAUSE	PROBABLE REMEDY
Generator output voltage drops or collapses when load is applied (cont).	On parallel equipped generator operating singly, unit/parallel switch open	Set switch to UNIT position during single unit operation.
	On parallel equipped generators operating parallel, unit/parallel switch closed, droop resistor requires adjustment, jumper not removed from terminals CT1 and CT2, or systems otherwise adjusted incorrectly causing incorrect reactive KVA load sharing	Review Section 2, Section 3, the drawing in Section 6, and the wiring diagram supplied with the generator set.
	Incorrect connections.	Review paragraphs 2.2.1 through 2.2.11, the drawings contained in Section 6, and the wiring diagram supplied with the generator set.
	Incorrect current winding on saturable transformer or in Kamag 18 applications. the current boost transformer.	Contact factory. Provide serial number, KVA, required operating voltage, and the connection diagrams used.
	Voltage regulator malfunction.	Test. Replace either the failed parts or the voltage regulator.
Generator output drops when load is applied and poor voltage regulation.	Generator or voltage regulator not connected correctly.	Check. Refer to wiring diagram provided with generator set; drawings contained in Section 6 and paragraphs 2.2.1 through 2.2.11
	Prime mover speed drops and fluctuates when load is applied.	Adjust prime mover speed governor.
	Load imbalance or overload.	Reduce and balance load.
	Paralleled generators not adjusted for equal or proportional KW and reactive KVA load sharing	Adjust prime mover speed governor for KW load sharing and adjust generator voltage droop resistor and voltage adjust rheostat for KVAR load sharing
	Saturable transformer or current boost transformer not correct for application.	Contact factory. Give generator serial number, KVA, operating voltage, and wiring connection used.
	Voltage regulator malfunction.	Test. Replace either the failed parts or the voltage regulator.
	Exciter rectifiers open.	Test. Replace failed diodes.
	Defective exciter field or generator field.	Test. Replace faulty parts.
Poor regulation or slow response on load application or removal.	Regulator stability adjust potentiometer requires adjustment	Adjust. See Section 3, paragraph 3.3.4.

TABLE 4-1 TROUBLE SHOOTING CHART (cont).

SYMPTOM	PROBABLE CAUSE	PROBABLE REMEDY
Voltage fluctuates, oscillates, or hunts.	See items contained in preceding symptom entitled "Poor regulation or slow response on load application or removal."	
	Prime mover speed fluctuating.	Check. Repair defective governor.
	Load too heavy for engine.	Reduce maximum load to within engine rating.
	Variable load.	If excessive, contact factory stating load conditions.
	Regulator Stability Adjust Resistor R4 requires adjustment.	Adjust as described in Section 3. Normally a regulator which is stable at no-load will remain stable when steady state load is applied.
	Variable load.	If excessive, contact factory stating load conditions.

4.3 COMPONENT TEST PROCEDURE

4.3.1 Rectifier Test

Test with ohmmeter or three-volt test light as follows:

1. Connect ohmmeter or test light leads across rectifier. Observe ohmmeter reading, or if test light is used, observe if bulb lights.

2. Reverse leads. Again observe ohmmeter reading; or, if test light is used, observe if bulb lights.

3. A good rectifier will have high resistance in one direction and low resistance in the opposite direction. If a test lamp is used, the bulb should light in the direction where resistance is low, and should not light in the direction where resistance is high. If a low resistance is indicated in both steps 1 and 2, the rectifier is probably shorted. High resistance in both steps 1 and 2 indicates an open rectifier.

4.3.2 Capacitor Test

Capacitors may be checked on a capacitor bridge to measure the capacitors capacitance and leakage. Capacitance should not vary more than plus or minus 10% of their rated values.

An approximate check may be made with an ohmmeter set to a high-resistance scale. The meter should initially indicate low resistance and then gradually increase until capacitor is fully charged.

4.3.3 Saturable Transformer Test

Typical defects are open or shorted windings. Open windings can be determined by disconnecting the transformer from the circuit and then testing continuity of the windings. Shorted windings generally may be detected by checking resistance of the transformer windings with the winding resistance of an identical transformer known to be in good condition.

4.3.4 Power Transformer Test

With rated voltage on the primary winding, check the secondary voltages. Measured voltages, taken when a transformer is unloaded, run up to 10% higher than those taken when the transformer is wired into its circuit.

Typical transformer defects are shorts between windings, open windings, and shorted turns. These usually may be detected by checking resistances and voltages. When the transformer overheats and the existence of shorted turns cannot be proved by resistance measurement, check the no-load alternating current in the primary winding. This excitation current will be excessive if there are shorted turns.

4.3.5 Current Transformer Test

Current transformers have a fixed ratio of current between primary and secondary. The ratio between these currents is determined by the turns ratio. The following test should be made for shorted turns.

CAUTION

DO NOT OPEN THE SECONDARY OF A CURRENT TRANSFORMER WHILE THE CIRCUIT IS ENGERIZED.

1. Load the generator to produce primary current in the transformer.
2. Measure the secondary current.

The ratio of primary to secondary current is approximately the same as the ratio of secondary turns to primary turns. If secondary current is considerably less than it should be, shorted turns are indicated.

4.3.6 Potentiometer and resistor Test

Check resistance values with an ohmmeter. Potentiometers and adjustable resistors should be checked over their full range. Care should be taken to avoid damage to the fine wire when setting adjustment bands on adjustable resistors. The adjustment band should be loosened until it slides freely on the resistor tube.

4.3.7 Transistor Test

Silicon transistors can be tested with a three-volt test light. Test by test light method will normally indicate if a transistor is open or short circuited. Remove transistor from circuit to prevent other components in circuit from affecting readings. The light indications listed in Table 4-2 are those which should be observed if transistor is not shorted or open.

4.3.8 Zener Diode Test

A zener diode may be checked with an ohmmeter in much the same manner that a normal rectifier is checked or, if DC power supply is available, a check on the actual operation of the zener may be performed. Utilizing the test setup illustrated in Section 6, Figure 14, the voltage across the diode will increase until it reaches the zener voltage. As the DC input voltage is increased, the voltage across the diode will remain constant and the current through the diode will increase rapidly. Care should be taken not to exceed the current rating of the diode. The DC power supply should have a low ripple. A battery is preferred.

TABLE 4.2 TRANSISTOR TEST CHART

Type Transistor	Tester Positive Lead Connected To	Tester Negative Lead Connected To	Normal Light Indication
NPN	BASE	COLLECTOR	LIGHT
	BASE	EMITTER	LIGHT
	COLLECTOR	BASE	NO LIGHT
	EMITTER	BASE	NO LIGHT
PNP	BASE	COLLECTOR	NO LIGHT
	BASE	EMITTER	NO LIGHT
	COLLECTOR	BASE	LIGHT
	EMITTER	BASE	LIGHT

SECTION 5 REPLACEMENT PARTS

5.1 GENERAL

The KAMAG II voltage regulating system includes the regulator, a saturable transformer and, for use with KAMAG 18 Generators, a series boost current transformer. Options are: A remote voltage adjust potentiometer, auto/manual control, parallel voltage droop, and an idle switch.

When ordering replacement parts, always give the generator serial number. In addition, when ordering current transformers, give the operating voltage of the generator and its full load line current.

The following list contains only those parts which are maintenance significant.

5.2 REPLACEMENT PARTS LIST

1. **Saturable Transformer Assembly** - Give generator set serial number.
2. **Current Boost Transformer for use with the KAMAG 18 Generators.** Give generator serial number and KVA.
3. **Voltage Regulator:** part number 838-00201-00.
4. **Optional Remote Voltage Adjust Potentiometer:** 250 ohm, 2 watt, RV4 type, part number 867-32522-80.
5. **Parallel Voltage Droop Resistor:** 5 ohm, 25 watt, part number 866-15075-13.
6. **Unit/Parallel Switch:** part number 520-11011-10. for use with parallel equipped regulators where no voltage droop during single unit operation is desired.
7. **Parallel Voltage Droop Current Transformer:** 5 va, 1 amp secondary. Give generator serial number, KVA, and operating voltage.
8. **Auto/Manual Voltage Control Selector Switch:** part number 520-10131-20.
9. **Manual Voltage Adjust Rheostat,** 800 ohm, 50 watt, part number 867-38075-23.
10. **Generator Voltage Shutdown Switch (Engine Idle Switch(:** 15 amp., 250 volt, part number 520-11011-10.

5.3 OPTION KITS

Parts are available for the following options as factory kits with instructions:

1. KAMAG II Parallel Voltage Droop Kit: Part Number 508-00156-00
2. KAMAG II Auto/Manual Kit: Part Number 508-00155-00

SECTION 6 DRAWINGS

GENERAL

This section contains drawings and diagrams to facilitate the installation, operation and maintenance of the voltage regulating system.

NOTE: Separate boost transformer included in KAMAG 18 generator application. Boost winding is included on saturable transformer in KAMAG 14 generator applications (See figures 6a and 6b).

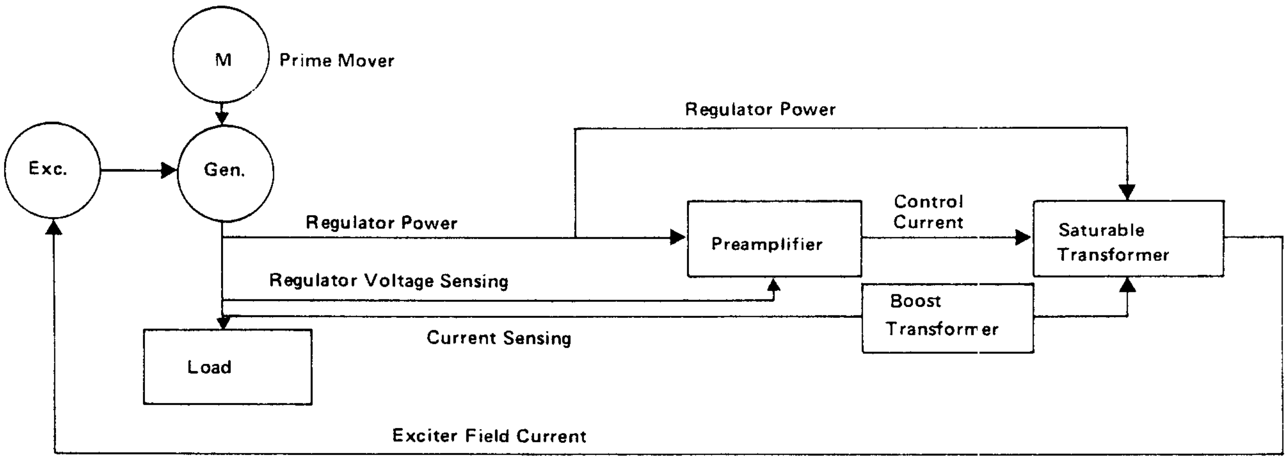
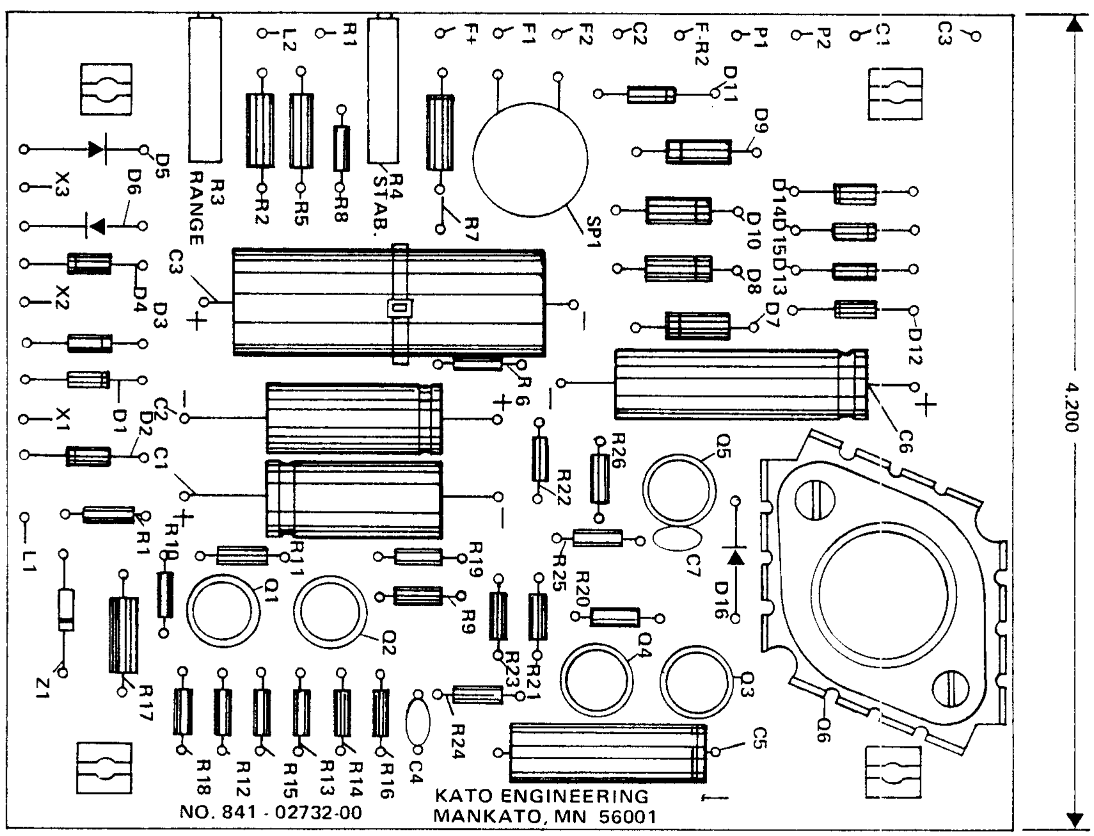
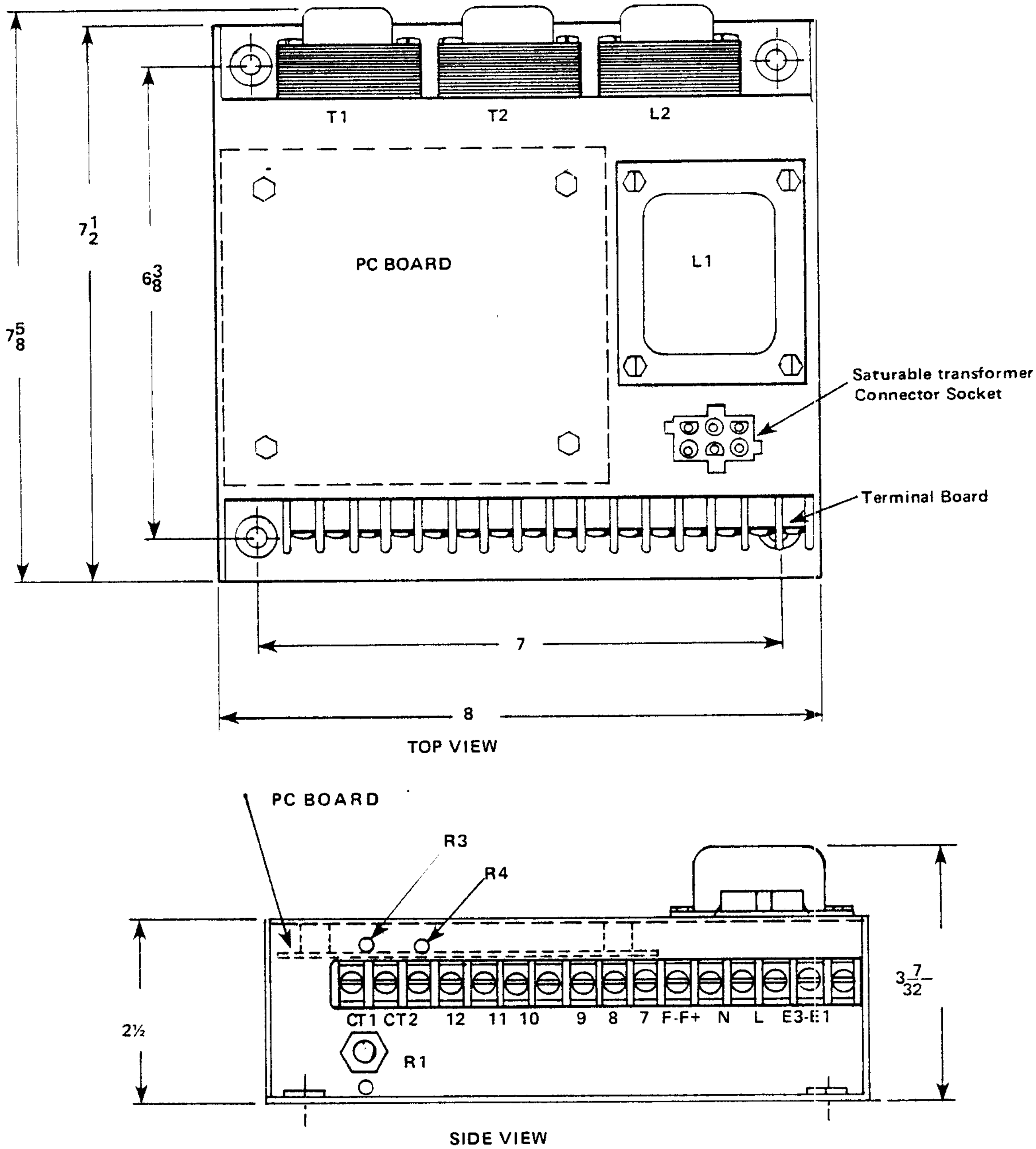


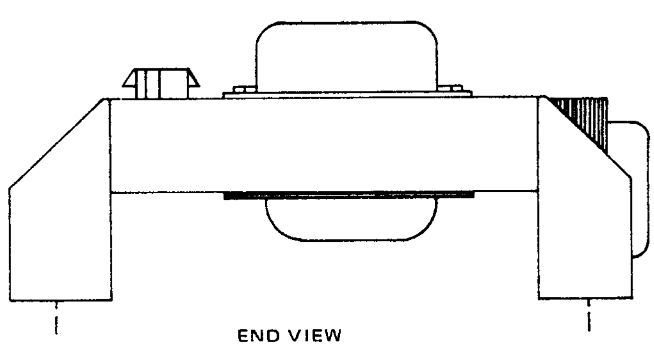
FIGURE 1. CLOSED LOOP CONTROL DIAGRAM: GENERATOR AND VOLTAGE REGULATING SYSTEM.



Note: Diodes D5 & D6 are not included in the single phase sensing Kamag II Voltage Regulator

FIGURE 2. OUTLINE DRAWING: PRINTED CIRCUIT BOARD ASSEMBLY.





ADJUSTMENTS

R1: Voltage Adjust (see note)
R3: Nominal Voltage Range Set Adjust
R4: Stability Adjust

NOTE:

In applications where remote voltage adjust option is provided, voltage adjust is external to the voltage regulator.

FIGURE 3: OUTLINE DRAWING KAMAG II
VOLTAGE REGULATOR PART NUMBER 838-00201-00

(1) See Figure 6. for KAMAG 14 application leads A, B, C & D are the current winding of the saturable transformer. Kamag 18 application includes separate boost CT with leads E & F from the saturable transformer.

(2) See Figure 7. Terminals 8 and 9 provide means of connecting the Remote Voltage Adjust option. Bus type jumper must be removed when Remote Voltage Adjust Option is provided.

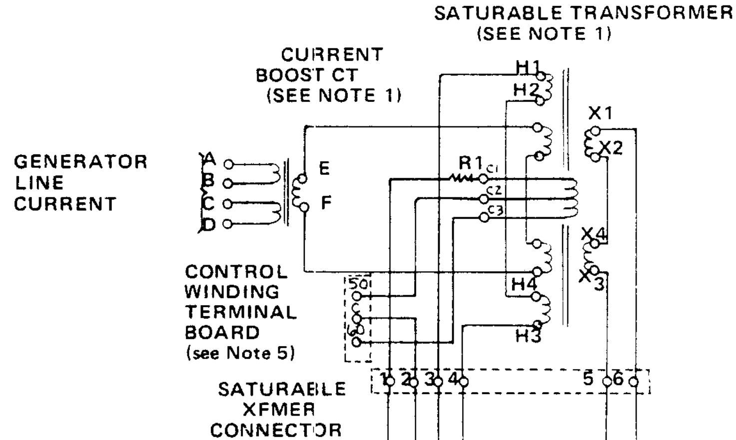
(3) See Figure 8. Terminals CT1 and CT2 provide means of connecting Parallel Voltage Droop Option . Bus type jumper must be removed when parallel Voltage Droop Option is provided.

(4) See Figure 7. Terminals 9, 10, and 11 provide means of connecting the Auto/Manual Control Option. Bus type jumper must be removed when Auto/Manual Control option is provided.

(5) Control winding terminal board is located on saturable transformer chassis. For 60 Hertz operation connect jumper across terminals 60 and C. Connect the jumper across the terminals 50 and C for 50 Hertz operation.

(6) Standard Factory connection of sensing transformer primary is series as illustrated for 170-283 VAC sensing. See figure 9b for optional single phase, 98-142 VAC connection.

(7) Standard connection of reactor L1 is to taps X1 and X3. If no-load voltage is either too high or too low, and all other connection are correct and abnormal conditions cannot be corrected by voltage adjust, refer to section 2, paragraph 2.2.11.



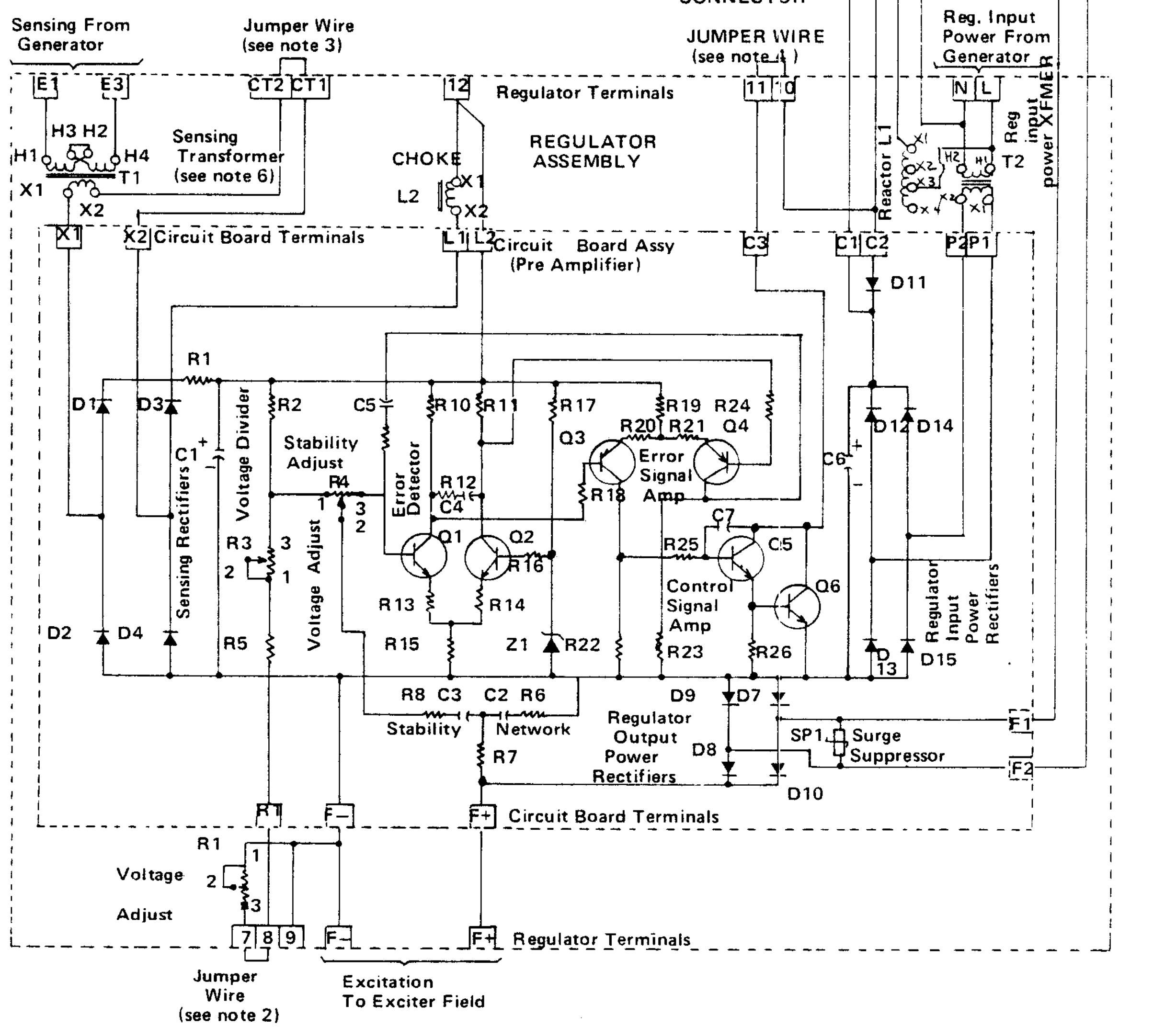
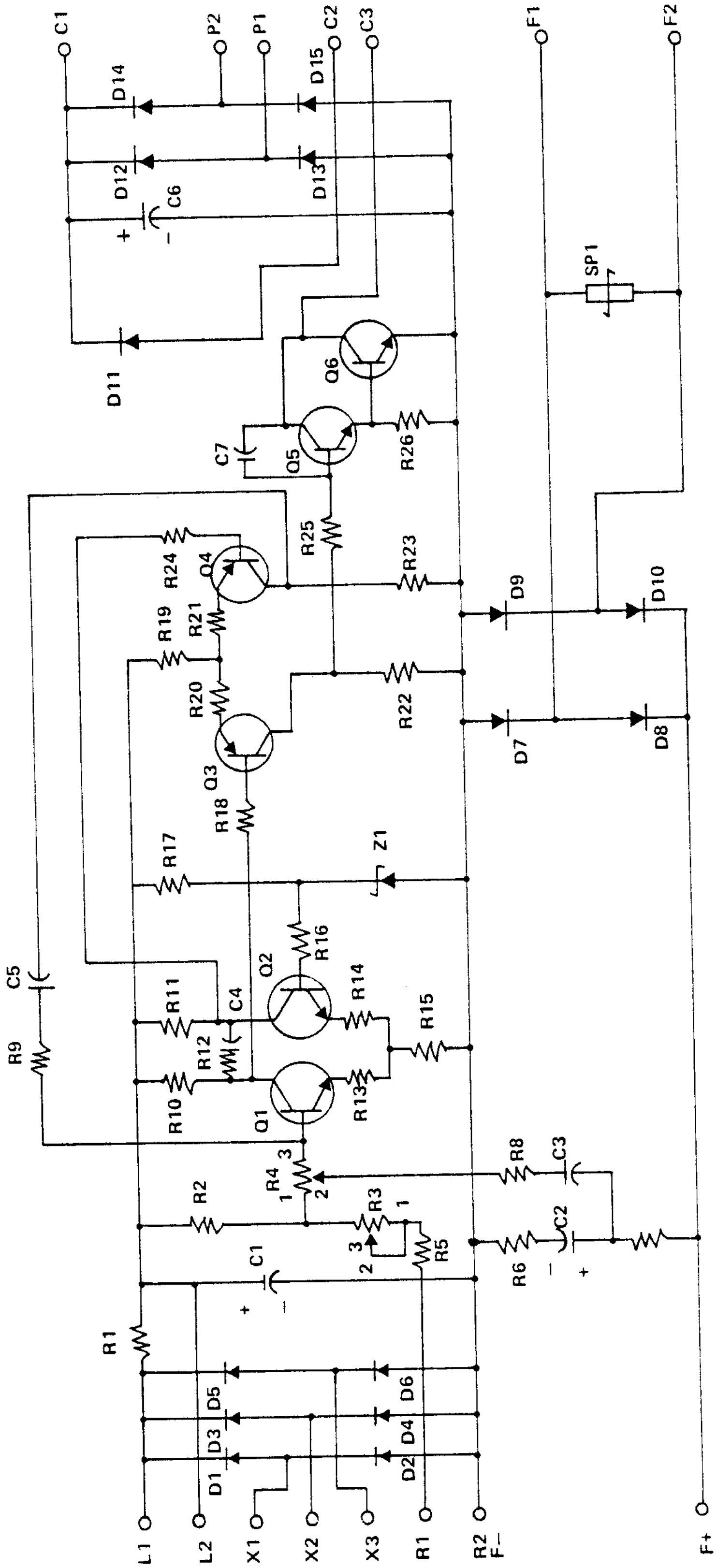


FIGURE 4. SCHEMATIC DIAGRAM: KAMAG II REGULATING SYSTEM



NOTE:
Diodes D5 and D6
are not included in
single phase sensing
Kamag II voltage regulators.

FIGURE 5. SCHEMATIC DIAGRAM: PRINTED CIRCUIT BOARD ASSEMBLY

NOTE: CONNECT LEADS A, B, C, & D as shown on wiring diagram provided with generator
For KAMAG 14 application, leads A, B, C & D are from winding on saturable transformer
For KAMAG 18 application, leads E & F connect to the secondary winding on the separate current boost transformer and leads A, B, C & D are from the boost CT current winding.

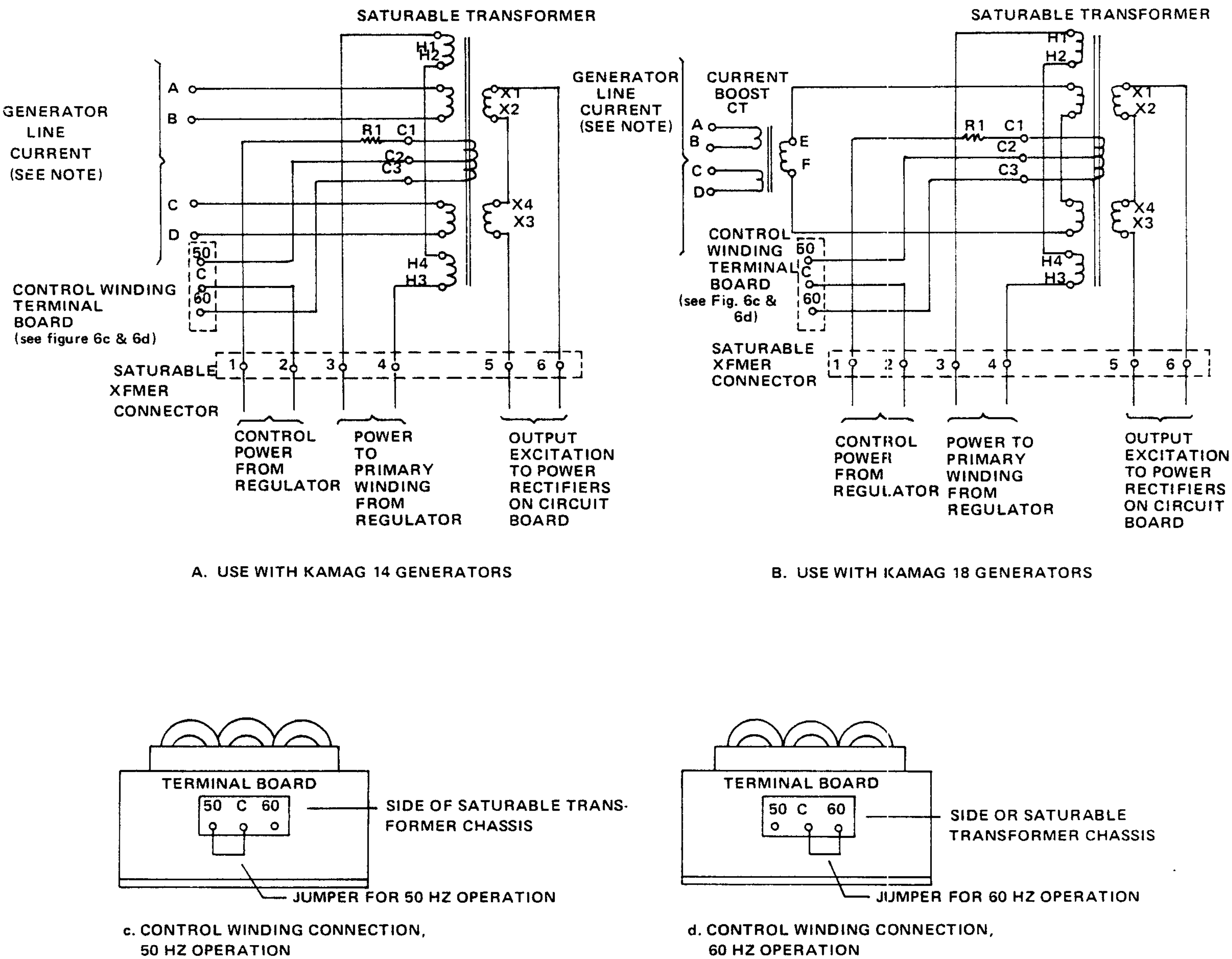
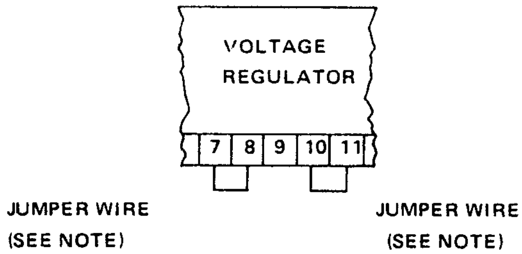
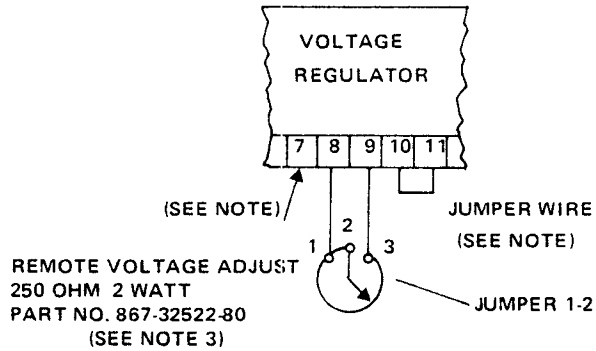


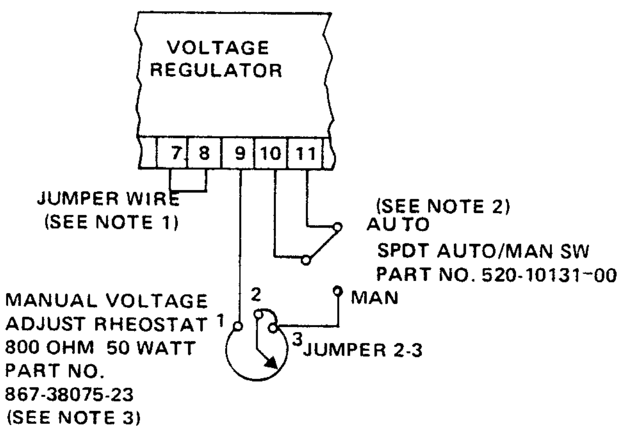
FIGURE 6. CONNECTION DIAGRAM: SATURABLE TRANSFORMER ASSEMBLY.



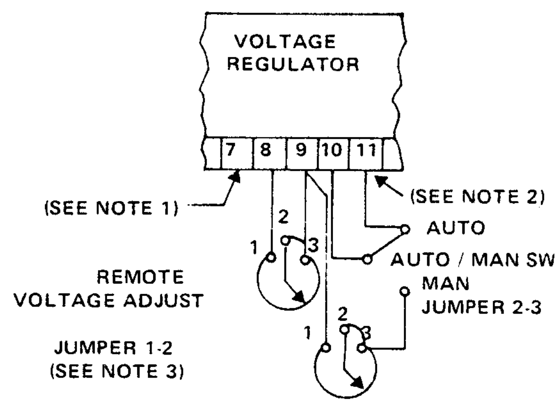
a. KAMAG II VOLTAGE REGULATOR WITH VOLTAGE ADJUST R1 MOUNTED ON REGULATOR CHASSIS.



b. KAMAG II VOLTAGE REGULATOR WITH REMOTE VOLTAGE ADJUST OPTION.



c. KAMAG II VOLTAGE REGULATOR WITH AUTO/MANUAL VOLTAGE OPTION.



d. KAMAG II VOLTAGE REGULATOR WITH REMOTE VOLTAGE ADJUST OPTION AND AUTO/MANUAL CONTROL OPTION.

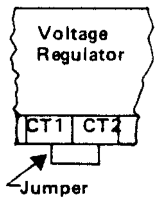
NOTES

1. JUMPER WIRE ACROSS TERMINALS 7 & 8 WHEN AUTO VOLTAGE ADJUST IS FROM R1 LOCATED ON REGULATOR CHASSIS. JUMPER WIRE MUST BE REMOVED WHEN REMOTE VOLTAGE ADJUST OPTION IS SUPPLIED.
2. JUMPER WIRE ACROSS TERMINALS 10 & 11 WHEN REGULATOR DOES NOT INCLUDE THE AUTO/MANUAL VOLTAGE CONTROL OPTION. REMOVE JUMPER WIRE FROM TERMINALS 10-11 WHEN AUTO/MANUAL VOLTAGE CONTROL OPTION IS PROVIDED.
3. TERMINALS AS VIEWED FROM BACK OF RHEOSTAT.
4. JUMPERS MAY BE BAR TYPE OR WIRE TYPE.

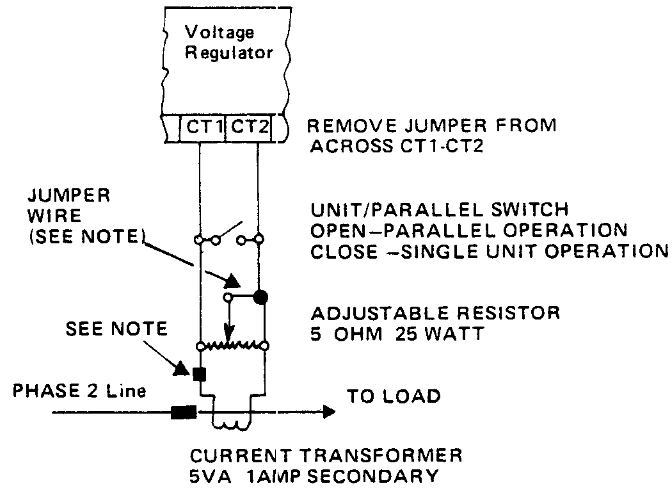
FIGURE 7. CONNECTION DIAGRAM: TERMINALS 8, 9, 10, 11, 12 & AUTO VOLTAGE ADJUST OPTION OR AUTO/MANUAL VOLTAGE CONTROL OPTION.

NOTE: (■) INDICATES POLARITY MARKING ON CURRENT TRANSFORMER SECONDARY WINDING LEAD WIRE

INSTALL JUMPER WIRE FROM THE TERMINAL ON RESISTOR SLIDER TO THE RESISTOR END TERMINAL

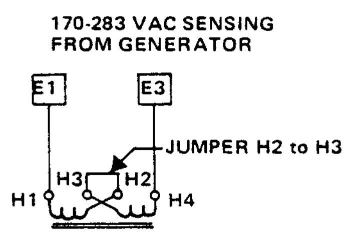


a. SINGLE UNIT OPERATION REGULATING SYSTEM

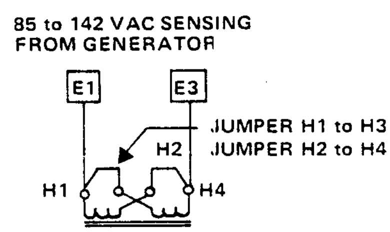


b. STANDARD PARALLEL VOLTAGE DROOP OPTION AND UNIT/PARALLEL SWITCH

FIGURE 8. CONNECTION DIAGRAM: TERMINALS CT1, CT2 and PARALLEL VOLTAGE DROOP OPTION.



a. STANDARD FACTORY CONNECTION:
PRIMARY WINDING CONNECTED SERIES
FOR 170-283 VAC SENSING



b. OPTIONAL CONNECTION
PRIMARY WINDING CONNECTED PARALLEL
FOR GENERATOR CONNECTED SINGLE
PHASE TWO-WIRE 85-142 VAC

FIGURE 9. CONNECTION DIAGRAM; PRIMARY WINDING OF SENSING TRANSFORMER T1.

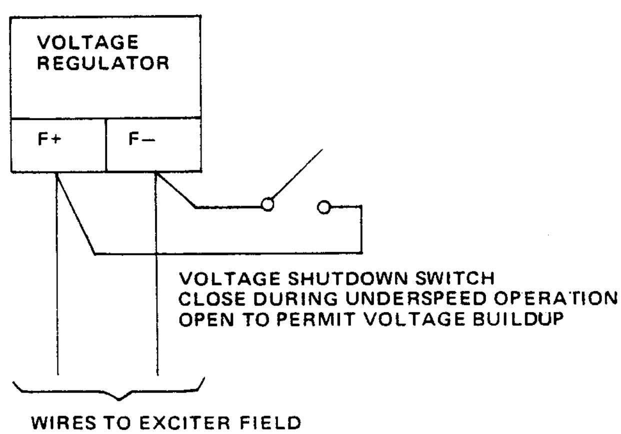


FIGURE 10. CONNECTION DIAGRAM: VOLTAGE SHUTDOWN (ENGINE IDLE SWITCH)

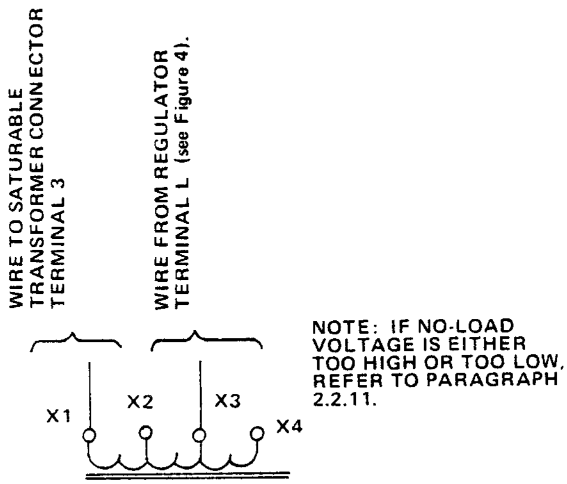


FIGURE 11. STANDARD CONNECTION REACTOR L1.

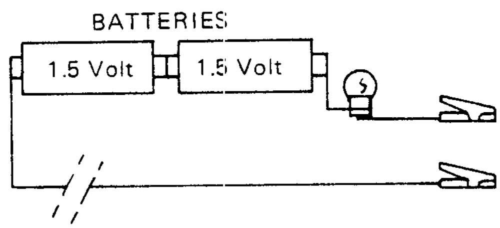


FIGURE 12. ILLUSTRATION: THREE-VOLT TEST LAI

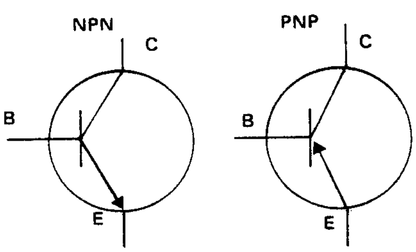


FIGURE 13. SCHEMATIC: TRANSISTORS

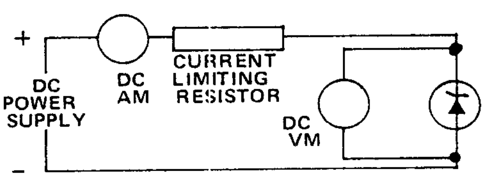
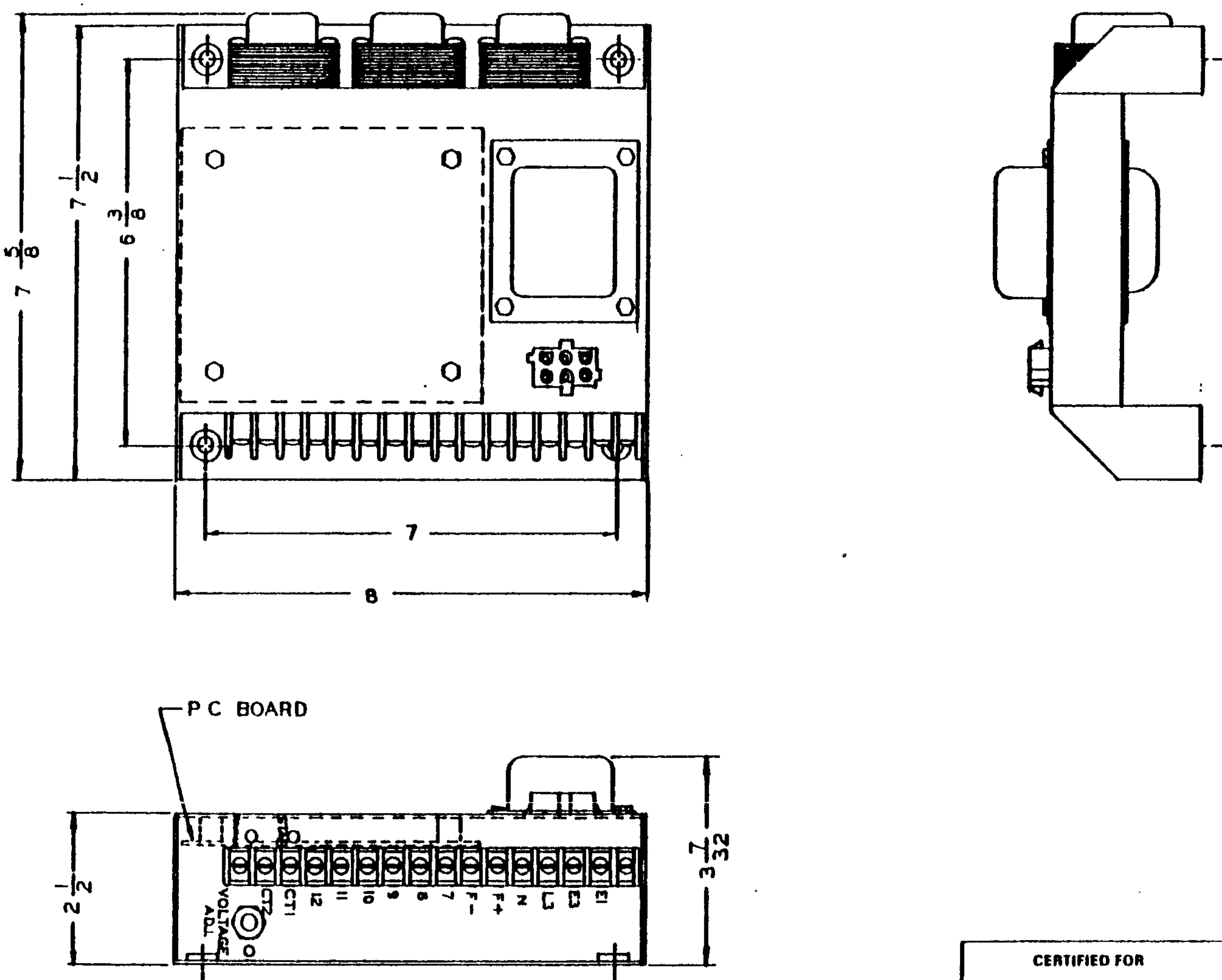


FIGURE 14. TEST EQUIPMENT: ZENER DIODE TEST.



CERTIFIED FOR		KATO ENGINEERING CO. ELECTRICAL GENERATING EQUIPMENT MANKATO, MINNESOTA		C					
				B					
				A					
				ORIGINAL		dk	R.L.	RWS	8-8-78
P.O.		SCALE 1/2 = 1	MATL.	REV	ECO	ENGR	DR	CK	DATE
KATO S/N		DATE 2-8-78	1st S/N	DRAWING NUMBER			SH 1	OF 2	
DATE	SIGN	TITLE REGULATOR		838-00201-00					

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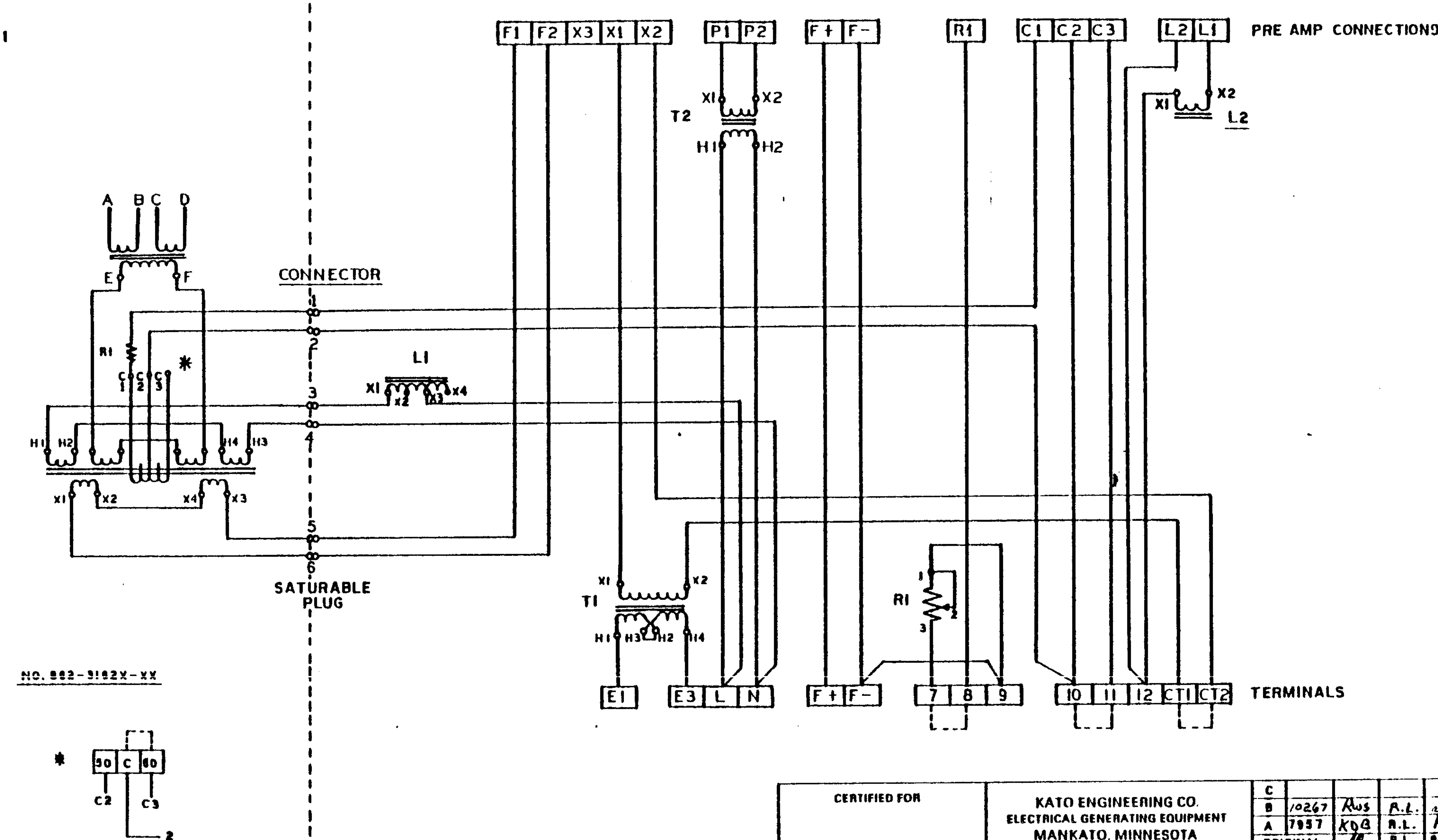

CERTIFIED FOR		KATO ENGINEERING CO. ELECTRICAL GENERATING EQUIPMENT MANKATO, MINNESOTA		C					
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				A	7957	KDG	R.L.	RWS	4-27-7?
				ORIGINAL		[illegible]	R.L.	RWS	1-10-78
P.O.		SCALE	MATL.	REV	ECO	ENGR	DR	CK	DATE
KATO S/N		DATE 1-10-78	1st S/N	DRAWING NUMBER			SH 2	OF 2	
DATE	SIGN	TITLE REGULATOR		838-00201-00					

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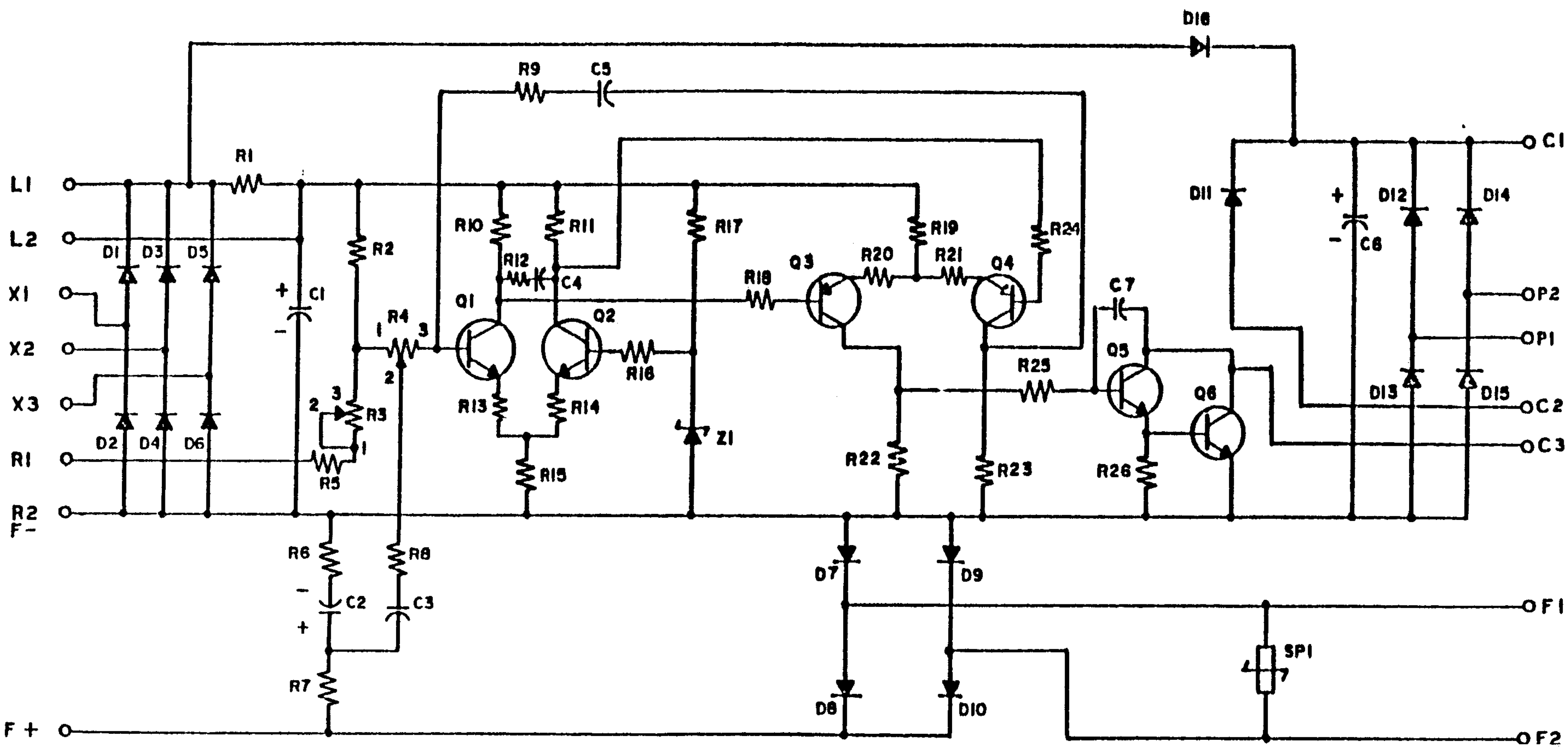

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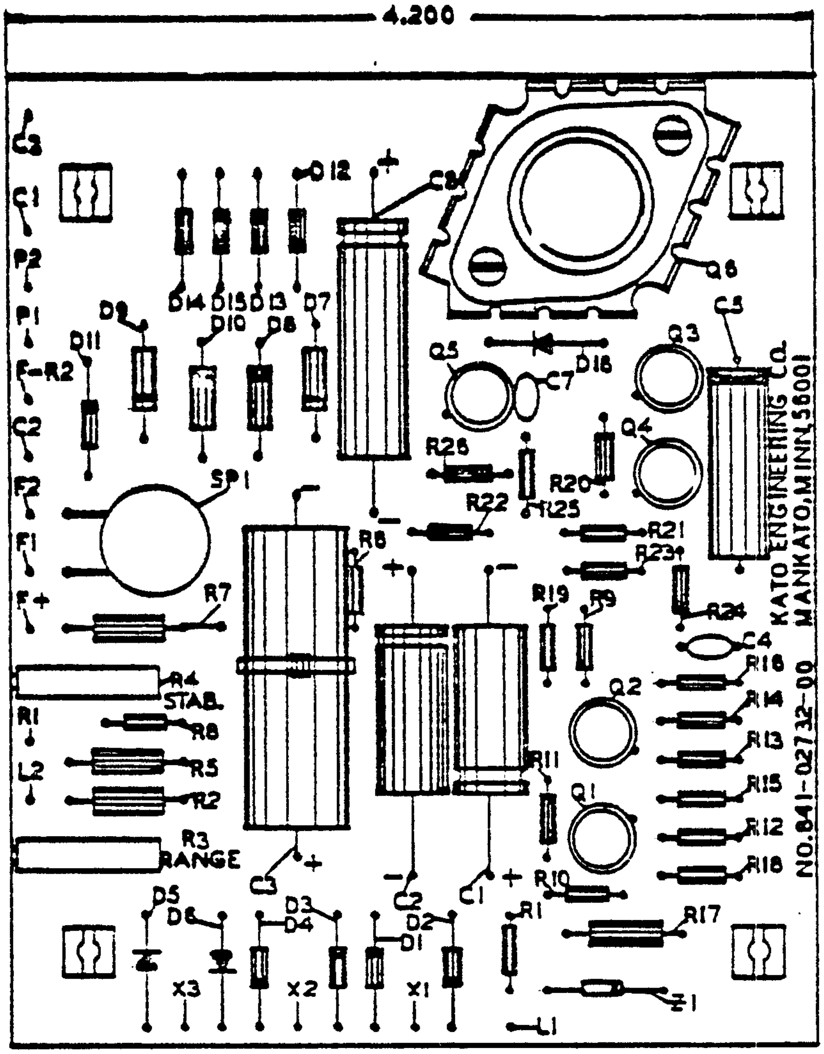
CERTIFIED FOR		KATO ENGINEERING CO. ELECTRICAL GENERATING EQUIPMENT MANKATO, MINNESOTA		C				
				B				
				A				
				ORIGINAL				
P.O.		SCALE	MATL.	REV	ECO	ENGR	DR	CK	DATE
KATO S/N		DATE 2-3-78	1st S/N 13857	DRAWING NUMBER		SH 2 OF 2		
DATE	SIGN	TITLE PC BOARD ASSY.		841-02732-00				



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				B					
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P.O.		SCALE FULL	MATL	REV	ECO	ENGR	DR	CX	DATE
KATO S/N		DATE 1-10-78	1st S/N	DRAWING NUMBER			SH 1	OF 2	
DATE	SIGN	TITLE P. C. BOARD ASSY.		841-02732-00					

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