GEK-14772A

INSTRUCTIONS

STATIC EXCITER-REGULATOR EQUIPMENT

3S7501FS141

GENERAL ELECTRIC

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STATIC EXCITER-REGULATOR EQUIPMENT FOR GAS TURBINE PACKAGE POWER PLANT

INTRODUCTION

The silicon-controlled rectifier (SCR) Static Exciter-Regulator equipment performs its regulation and excitation function by monitoring AC machine line voltage and current and producing the proper excitation conditions required by the machine.

The power potential transformer (PPT) and saturable current transformers (SCT's) are the main source of power for the AC machine field; at no load all field power is obtained from the PPT while both supply power at full load with the SCT's supplying most of the power. The power from these two units is rectified by the three-phase full-wave bridge rectifier and then applied to the field of the AC machine. The currents in the primaries of the SCT's provide some inherent self-regulation. Theorectically, this self-regulation should completely compensate for load changes, however, AC machine saturation, field heating, and other secondary effects make it necessary to add more compensation. This extra compensation is obtained by saturating the SCT's with a DC control winding current. The amount of DC required is obtained from the automatic regulator whose input continuously monitors line current and voltage when in the automatic mode operation. Also, a manual control of the DC control winding is provided.

A reactive current compensator is included to permit proper division of reactive current between paralleled machines. Also included is a start-up circuit for field flashing, voltage adjusters for local control of the automatic and manual regulators, field suppression relay (when an optional AC machine field breaker is not used), and other components to assure proper operation.

Refer to the diagrams provided with the equipment to determine what material is included and what connections should be used. The diagrams shown in this book are for illustrative purposes only; they are not intended to apply to all installations.

RECEIVING, HANDLING AND STORAGE

RECEIVING AND HANDLING

Immediately upon receipt, the equipment should be carefully unpacked to avoid damaging the apparatus. Particular care should be exercised to prevent small parts being mislaid or thrown away in the packing material.

As soon as the equipment is unpacked it should be examined for any damage that might have been sustained in transit. If injury or rough handling is evident, a damage claim shall be filed immediately with the transportation company and the nearest General Electric Sales Office should be notified promptly.

STORAGE

If the equipment is not to be used as soon as it is unpacked, it should be stored in a clean dry place and protected from accidental damage. Particular care should be exercised to avoid storing the equipment in locations where construction work is in progress.

DESCRIPTION

COMPONENT ARRANGEMENT

The static exciter-regulator consists of the following:

A. Equipment mounted in the exciter compartment:

1. 3S7501FS______ Rectifier assembly consisting of a three-phase full-wave bridge rectifier, shunt, shaft voltage suppressor circuit and Thyrite* resistors. This welded angle-frame assembly is floor mounted.
2. Three 44A------ Resistor assembleies (one resistor in parallel with an SCT control winding and one resistor in parallel with the SCT suppression winding for each assembly.)
3. One floor-mounted three-phase power potential transformer. This step-down transformer supplies power for the AC machine field and the regulator.
4. Three floor-mounted single-phase saturable current transformers. These transformers also supply power to the AC machine field.
5. Three single-phase linear reactors.

B. Equipment mounted in the control cab:

1. 3S7931------ Regulator panel which contains local-control automatic regulator voltage adjuster, and regulator reset pushbutton.
2. 3S7932------ DC Control panel, which contains start-up relay and circuit, field suppression relay and local control DC regulator voltage adjusters.

STATIC MAGNETIC POWER COMPONENTS AND POWER RECTIFIERS

The power potential transformer (PPT) has its primary windings wye-connected to the AC machine terminals. The secondary of the power potential transformer is connected to the power rectifier section through linear reactors as illustrated in Figure 1. Each saturable current transformer (SCT) primary is located in a line of the AC machine on the

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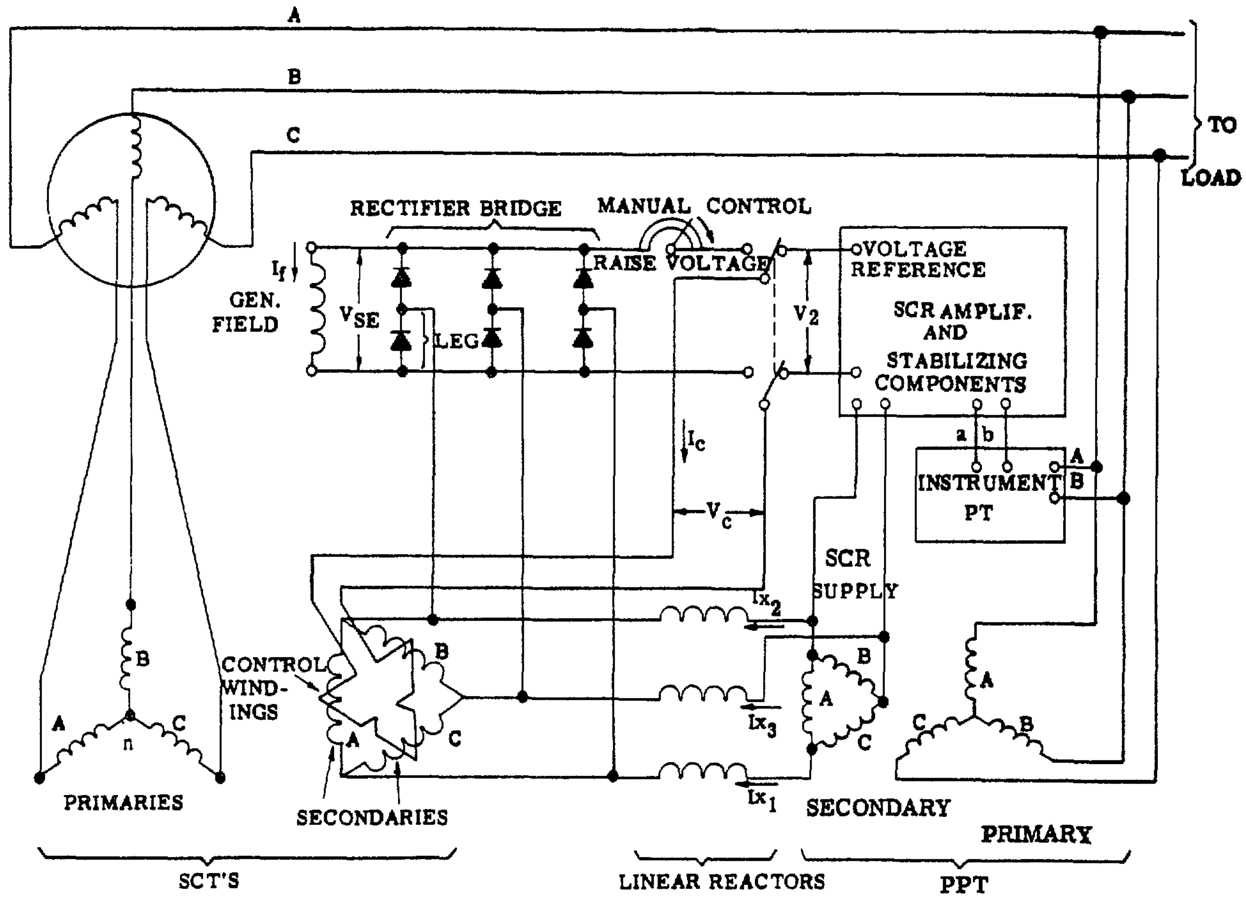

Figure 1. Simplified Static Exciter-Regulator System

neutral side. The secondary of each satuarable current transformer is connected from line to line of the bridge rectifier. When the AC machine is operating at no-load, the power potential transformer supplies voltage to the three-phase full-wave bridge rectifier so that a unidirectional voltage, VSE, is applied to the field of the AC machine. Field voltage is controlled by means of the saturable current transformers. The exciting current of the saturable current transformers is virtually proportional to the DC current, I_c, flowing in their control windings. This exciting current flows from the PPT secondary through the linear reactors into the SCT secondaries. When I_c is increased, the increased exciting current causes increased voltage drop across the linear reactors so that the input voltage to the bridge rectifier and, consequently, the field voltage is decreased. Thus, no-load terminal voltage of the AC machine is controlled by the value of I_c.

The control windings of the SCT's are connected in series. A resistor is connected across each control winding to reduce the magnitude of the AC voltage appearing across the control winding.

When the machine is supplying current to a load, the SCT primaries carry the load current. This primary current helps the secondary current excite the iron core. Therefore, an increase in primary current causes a decrease in secondary exciting current for a given value of I_c. A decrease in secondary exciting current decreases the voltage drop across the linear reactors with the result that bridge rectifier input voltage and field voltage are increased. The turns ratios of the SCT's and the PPT and the reactance of the linear reactors are selected so that this increase in field voltage which accompanies an increase in load current is approximately the increase necessary to hold terminal voltage constant.

It is an object of the design to maintain required terminal voltage on the machine without requiring a change in control current I_c.

Operation of the static magnetic power components can be better understood by referring to the equivalent circuit illustrated in Figure 2 where:

V - AC machine terminal voltage (referred to PPT secondary).

X_L - reactance of the linear reactor.

I - Load current (referred to SCT secondary).

R - resistance of the AC machine field (referred to the AC side of the rectifier).

I_f - field current (on the AC side of the rectifier).

I_m - is the magnetizing current of the saturable current transformer (referred to SCT secondary).

X_m - magnetizing reactance of the SCT (referred to the secondary). This reactance decreases with an increase in direct current from the regulator.

From this equivalent circuit the field current at no load is obtained from the AC machine terminal voltage through X_L. X_m shunts current away from the generator field, R, thus providing control. Under load, the load current, I, adds additional current, part of which goes through the AC machine field R. This equivalent circuit can be simplified by replacing the circuit to the left of point 1 - 2 with an equivalent voltage source and series impedance using Thevenin's theorem. The simplified equivalent circuit is shown in Figure 3.

Notice that the linear reactors shifts the phase of load current so that the total voltage applied to X_L, X_m, and R is V +j X_L I. This voltage is called the exciter input voltage. The amount of field current required by an AC machine for various steady state loads can be approximated by using the simplified AC machine equivalent circuit shown in Figure 4. In this Figure, E represents an imaginary voltage generated by field flux and is always proportional to field current. Xd is the synchronous reactance, which produces the same effect as armature reaction and armature leakage reactance, neglecting magnetic saturation effects. The equation for the circuit in Figure 4 is--$E = e_t + jX_d I$.

Since E is proportional to field current, this equation shows the relative amount of field current which the exciter must supply to the AC machine for various load conditions. Notice that this equation has the same form as the exciter input voltage equation shown in Figure 3. If the value of the linear reactor X_L and the transformer ratios are selected so that $V + jX_L I$ will be proportional to $e_t + j X_d I$ then the exciter will supply the proper amount of field current at a steady state, regardless of the load or power factor, without a change in regulator output.

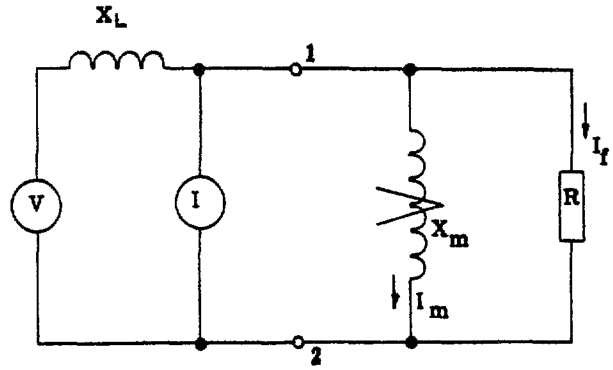

Figure 2. Equivalent Circuit of Saturable C. T. Type Static Exciter

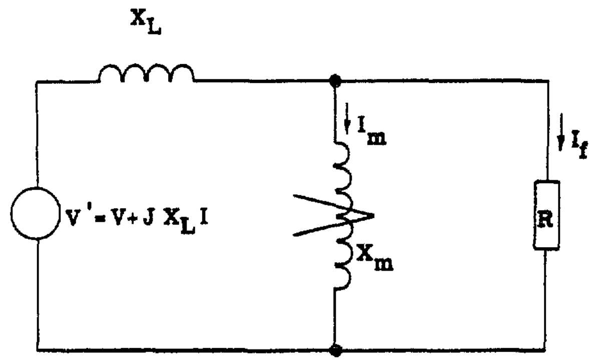

Figure 3. Thevenin's Equivalent of Figure 2

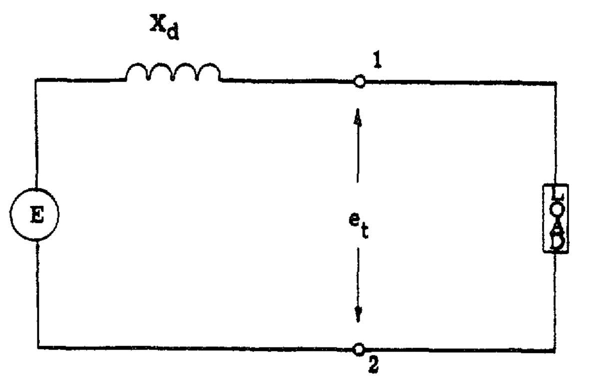

Figure 4. Simplified AC machine Equivalent Circuit

Due to various factors, such as AC machine field heating and field saturation, and other minor effects, it is necessary to trim this action of the PPT and SCT's to provide the exact compensation for load changes. This is accomplished by the automatic regulator or by manually controlling the current in the saturating windings by means of the manual regulator voltage adjuster.

The suppression windings of the SCT's are connected in series with a resistor across each winding. This resistor, like the control winding resistor, reduces the magnitude of the AC voltage appearing across the suppression winding.

When relay 41S is de-energized its power contact closes, applying power (usually 125 volts DC obtained from the station battery) to the suppression windings. The sequence of events that follows is the same as that produced by the maximum current flowing through the control windings, i.e., the exciting current increases causing and increased voltage drop across the linear reactors, therefore reducing the input voltage to the bridge rectifier and consequently the field voltage essentially to zero.

The three-phase bridge rectifier contains twelve cast aluminum finned heat sinks with two diodes mounted on each heat sink (one diode is the reverse polarity type, i.e., the stud is the anode). The bridge is convection air cooled. To insure adequate current carrying capability, two parallel rectifier bridges are furnished. No provisions for isolating one of the bridges have been made.

Each rectifier "leg" consists of two diodes in series to provide sufficient margin for the peak inverse voltages which may appear. The potted block assembly (PBA) connected across each diode will cause equal division of the peak inverse voltages which may occur due to power line transients.

The Thyrite resistor, shown in Figure 13, connected across the rectifier bridge, protects the diodes from high peak inverse voltages which may occur as a result of abnormal AC machine operation.

SILICON DIODE FUNDAMENTALS

Figure 5 is a sketch of the waveform across one diode when it is operating properly. During the time interval $t_1 - t_2$, the diode is passing current and the voltage across it is a small amount of forward drop, approximately 1 to 1.5 volts. This forward drop varies only slightly as the current changes and does not change with age.

During the time interval $t_2 - t_3$, the diode is blocking the current and the wave shape is as shown in Figure 5. The peak of this voltage is equal to the peak of the line-to-line voltage divided by the number of diodes in the "leg", if the diodes are dividing the reverse voltage equally.

Certain precautions must be taken when dealing with circuits containing silicon rectifiers. Brazing or welding should not be attempted. If soldering is necessary, something must be done to prevent the heat from being conducted to the junction. Hipotting should not be done without first shorting out the diodes. Diodes being replaced must be screwed in with the proper amount of torque.

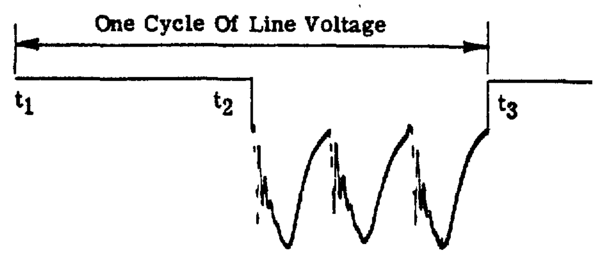

Figure 5. Wave-form Across One Diode When Operating Properly

AUTOMATIC VOLTAGE REGULATOR

Automatic Regulator Component Fundamentals

Zener Diode

The current-voltage characteristic of a zener diode is shown in Figure 6. A zener diode conducts current at a constant voltage which is nearly independent of the value of current. It is an open circuit for all voltages less than its break-down voltage.

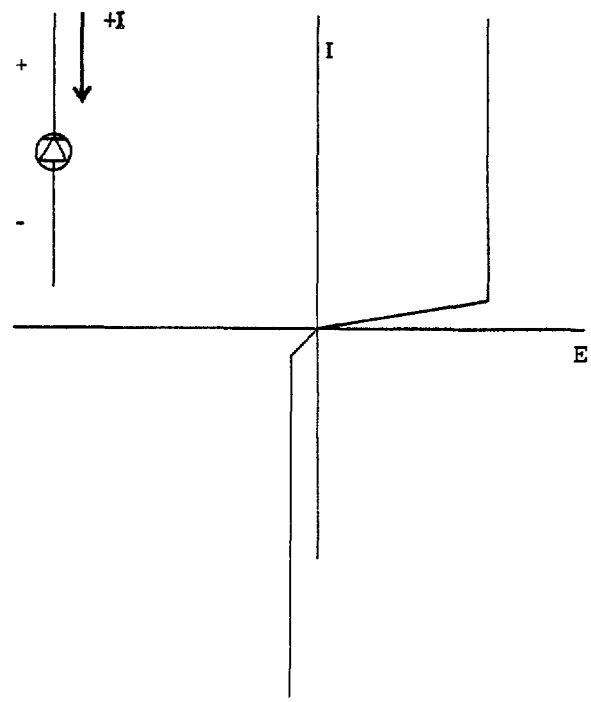

Figure 6. Current-voltage Characteristics of a Zener Diode

Saturable Reactor As a Firing Element

Figure 7 shows a simplified version of the SCR circuit used in this regulator with its associated firing reactor. The gate winding is connected between the gate and cathode of the SCR, while the reset winding is connected to a DC source. During the time that point A is positive with respect to B, the gate winding accumulates enough volt-seconds to saturate the reactor and fire the SCR. When A is negative with respect to B, the flux in the reactor is reset to a value dictated by the amount of DC current in the reset winding. Increasing and decreasing the reset current causes the SCR to fire later or earlier in the positive half cycle of the supply voltage. In this way the amount of current through the load is dependent upon the amount of reset or error signal current in the reset windings.

The saturable reactors not only fire the SCR's but they also provide stabilization and positive feedback for the system.

Operation

The signal PT monitors line voltage and feeds the single-phase bridge whose output delivers a DC signal which is proportional to the line voltage to the comparison circuit. This signal, applied to a voltage divider and reference zener diode branch connected in parallel through the reset windings of the saturable reactors, controls the firing signals for the SCR's. The voltage divider is preset in the factory such that approximately 13 ma (this may vary from 10 ma to 18 ma.) will flow through the reset windings when the machine is working at its proper voltage. If the line voltage increases, the reset current decreases, and likewise if the line voltage decreases the reset current increases. It must be emphasized at this point that current will flow through

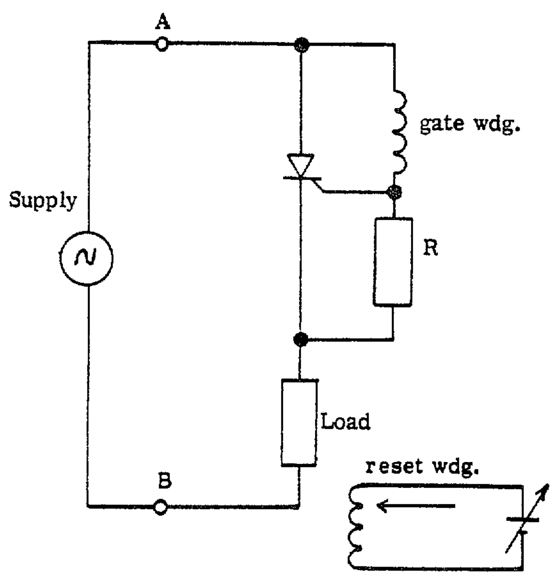

Figure 7. Simplified Version of SCR Circuit

the reset windings in only one direction because of the diode in series with these windings. To digress to the old days, a "buck" signal decreases the reset current, and "boost" signal increases the reset current.

The saturable reactors are used to provide the necessary gate pulses to fire the SCR's. Refer to Figure 13 in following this discussion. The SCR supply voltage is obtained from one phase of the PPT secondary; it is this voltage that is applied across the SCR's and their associated firing networks. The firing network for the A2CD SCR consists of a series combination of A9R, A2SX1, and A6D with the gate of A2CD connected between A9R and A2SX1. As the supply voltage increases in the positive direction A2SX1 accumulates enough volt-seconds to saturate its core, and once the core saturates, the voltage across all coils wound on the A2SX core becomes zero. When this occurs, the voltage across A2SX1 becomes zero, therefore, causing the voltage across A9R to increase rapidly and fire the A2CD SCR. When the supply voltage goes negative the same sequence of events occurs for the A1CD SCR. During the time A2CD is conducting, current flows from A14 through the control windings to A13, through the A2CD SCR and to the A1T supply transformer, from the A1T supply transformer it then goes through A3D and back to A14. The circuitry is so arranged that the current flows through the control windings in the same direction when either SCR fires. The average of these current pulses is the DC that the SCT control windings see.

The error signal current flowing through A1SX2 and A2SX2 in the comparison circuit resets each core for the next operation and dictates how many volt-seconds will be needed to fire the SCR's. If the error signal increases, the amount of reset for each SCR is greater, therefore, more volt-seconds are needed to saturate A1SX and A2SX. Since more volt-seconds are needed, the SCR's fire later in each half cycle, allowing current to flow through the control windings for a shorter period of time; hence, less DC current flows in the control windings. To become more familiar with this operation lets take the case in which the generator line voltage increases. The sequence of events at no-load is as follows:

1. PT output increases
2. DC output of bridge increases
3. Error signal current through A1SX2 and A25X2 decreases (less reset flux in each core)
4. SCR's fire earlier in each half-cycle of the supply voltage and conducts longer
5. DC current through the SCT control windings increases
6. Current through SCT secondary increases
7. Drop across reactor increases
8. Excitation decreases
9. Generator line voltage decreases

Other windings on the saturable firing reactor are A1SX3, A2SX3, A1SX4, and A2SX4. The A1SX3 and A2SX3 windings are wired in series with a linear reactor and potentiometer; together these items make up the positive feedback network used to increase the gain. Remaining are the A1SX4 and A2SX4 windings used for rate feedback stabilization and A1SX5 and A2SX5 used with the URAL panel. All windings are wound on the two saturable reactors A1SX and A2SX.

During the time that each SCR is not conducting, diodes A5D and A2D along with resistors A8R and A7R protect the SCR's from reverse voltages. The diodes appear as very high impedances when their associated SCR's are not conducting. Thus, most of the reverse voltage is across the diode and not the SCR's.

Before each unit is shipped for the factory, gain curves are taken, and potentiometers are checked and set.

Figures 8a and 8b indicate typical curves obtained from the SCR units prior to shipment.

Reactive Current Compensator (RCC)

Although the RCC potentiometer is always furnished, the signal CT may not be present. Any reference to the RCC assumes the signal CT is present.

The RCC is used to apportion reactive kva and to prevent circulating reactive current between AC machines when two or more machines with individual regulators are operating in parallel. As shown in Figure 9, a potentiometer is connected in series with the secondary of the signal potential transformer feeding the regulator averaging circuit. The potentiometer wiper is connected to one side of a signal current transformer, the current transformer located in phase C.

The compensator will vary the regulator signal voltage mainly as a function of the machine reactive current. As the machine overexcited reactive current increases, the voltage will be increased. As a result, the average single-phase signal voltage supplied to the regulator will rise. Due to this higher voltage signal, the regulator will act to reduce excitation, thereby reducing the overexcited reactive current.

If the AC machine is operating in the underexcited region, the compensator will decrease the average single-phase voltage signal presented to the regulator so that the regulator will act to increase the excitation and decrease the underexcited reactive current. The effect of the compensator can be increased by turning the knob clockwise (in the direction of the arrow).

With five amps flowing in the signal CT secondary and with all the resistance in, the total drop is ten volts. It has been experimentally determined that for proper VAR sharing, i.e. satisfactory apportionment of reactive KVA with a minimum number of adjustments, there should be 5-6% impedance between the generator and the paralleling bus. Less than 5-6% will require more frequent adjustments and more than 5-6% will cause excessive voltage droop at the high voltage bus. For generators tied directly at their buses, E_r should be approximately 6.9 volts.

Since the signal current transformer and the signal potential transformer have a common electrical connection, only one of the transformers or the common connection may be grounded.

MANUAL VOLTAGE REGULATOR

The manual voltage regulator consists of two rheostats of which either rheostat, but not both, is in series with the SCT control windings when operating under manual control. One rheostat is for "on-line" control and the other for "off-line" control.

Operation

The series combination of rheostat and SCT control windings is supplied from the exciter voltage. If the DC exciter voltage rises above normal, the SCT control current will increase. This acts to return the DC exciter voltage to normal. If the DC exciter voltage decreases below normal, the SCT control current will decrease, thereby, raising the exciter voltage toward normal.

The "on-line" rheostat will be set to give a safe value of control current to prevent the machine from pulling out of step if there should be an automatic transfer from automatic regulator to manual regulator. This setting will vary, depending upon customers needs or preference and is capable of controlling the voltage from no-load to 75% of full-load. The "off-line" rheostat will be set to give a value of control current which will reduce the AC machine terminal voltage when the AC machine is tripped off the line to a safe value, which is usually line voltage, although there may again be a customer preferred value other than line voltage. These two rheostats are adjusted at initial start-up and require no further adjustments in subsequent start-ups. They are manually operated and are mounted on the DC Control Panel.

CONTROL EQUIPMENT OPERATION

In the following paragraphs the components designated with a double asterisk (**) indicates they are not furnished by the Communication and Control Devices Department of General Electric Company. Some of the components serve functions in other circuits of the generating system but their functions discussed here will only be in conjunction with the static exciter-regulator. Refer to Figure 13 for the following paragraphs.

59** is the overvoltage relay. Its contact is in series with time delay relay 2E** to automatically transfer the regulator from automatic to manual mode. When the excitation increases above a safe value, 59E** is energized, closing its contact and energizing 2E**. If the excitation remains at this unsafe value for more than 30 seconds, 2E** seals itself in. Another 2E** contact will de-energize relay 83SR**, transferring

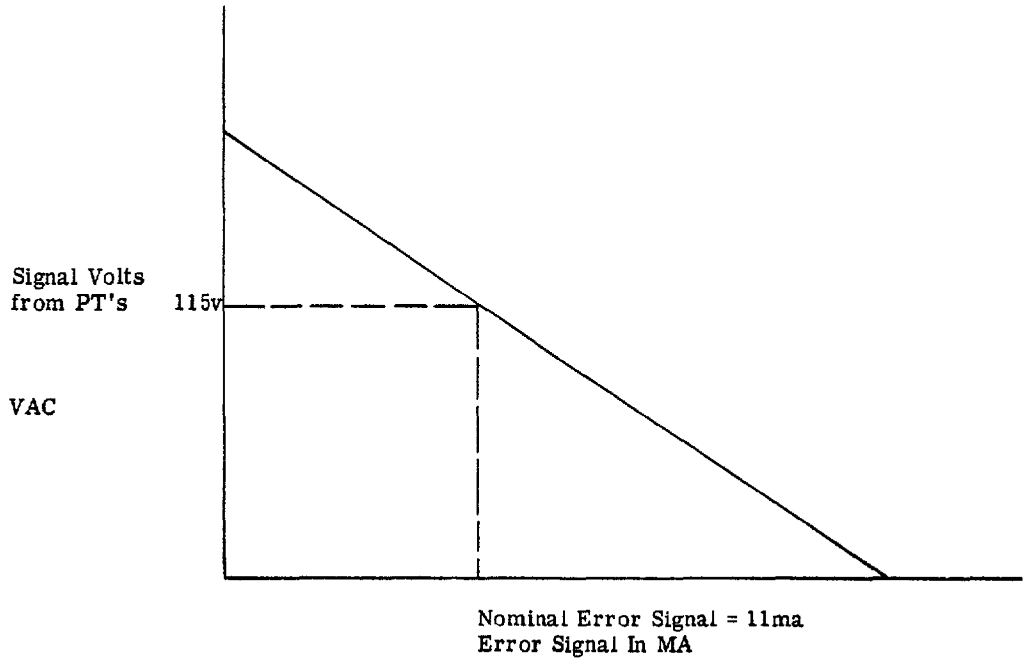

Figure (8a) Comparison Circuit Output

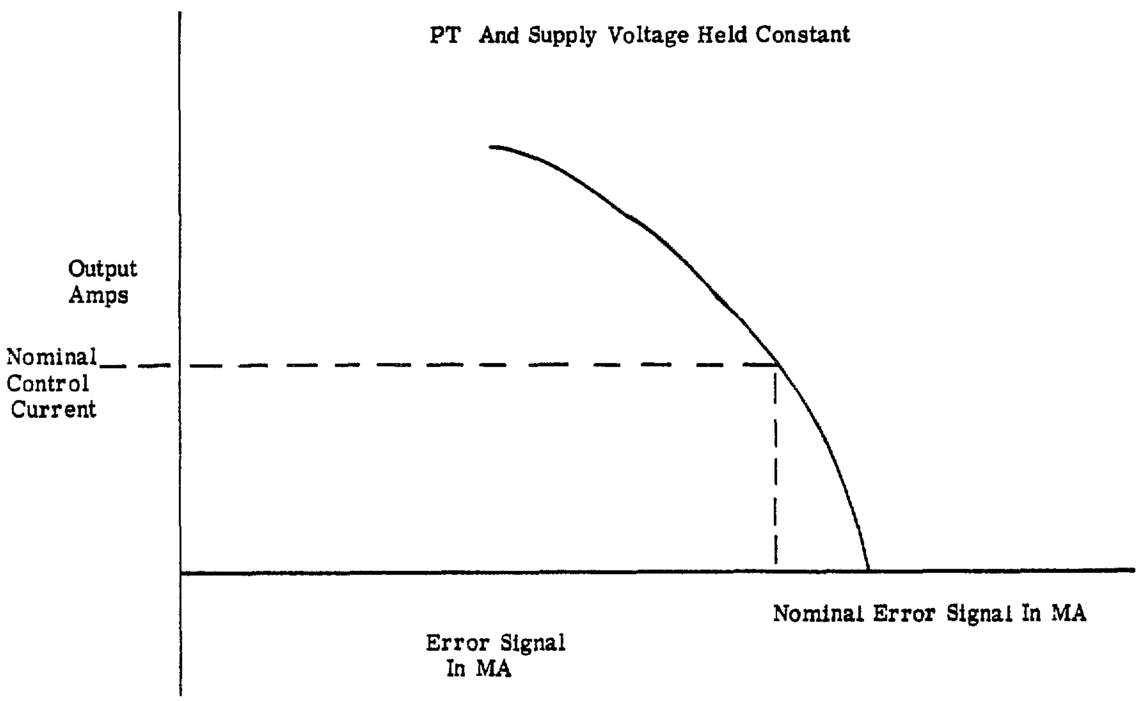

Figure (8b) Comparison Circuit Output

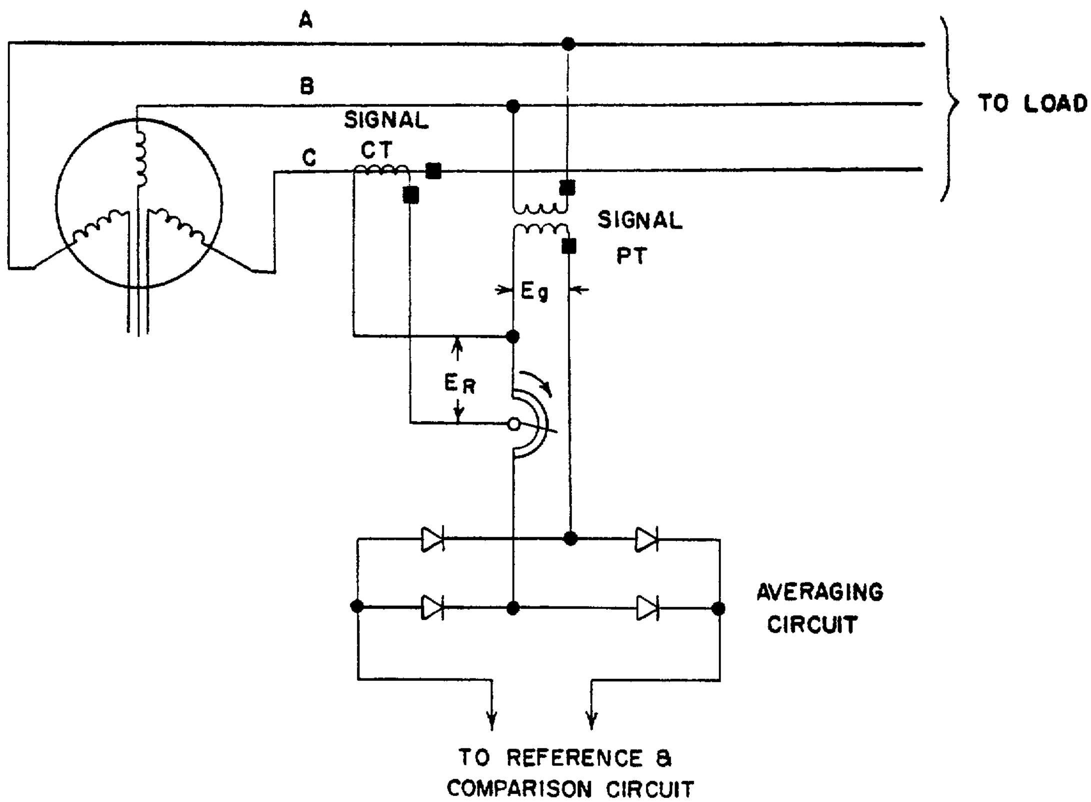

Figure 9. Reactive Current Compensator

the regulator from automatic to manual mode. To return the regulator from automatic mode, momentarily depress the regulator reset pushbutton 43SR, de-energizing 2E**.

Field flashing is automatic and occurs when relay 41F is energized. This energization results from the following sequence of contact action. 4Y is a time delay master control auxiliary relay and is energized on turbine start-up closing its contacts. Relay 94** is only energized on normal shutdown of the system; therefore, its contact remains in the normally closed condition. Speed relay 14HSX** is not energized until the AC machine attains 95% speed; therefore, its contact remains closed. As the AC machine increases speed, speed relay 14HAX** is energized at 40% speed closing its contact. At this time all the contacts in series are closed energizing 41F and flashing the field. When the AC machine exceeds 95% speed, 14HSX** is energized, opening the contact, de-energizing 41F. The start-up circuit resistance values are chosen to allow a maximum of 15% of the no-load field current. The panel is shipped with total circuit resistance which will allow approximately 10% of no-load field current. Resistor C3R may be adjusted for the 15% value, if required.

The 83SR** transfer relay's operation is controlled, in addition to that by relays 59E** and 2E, by relays 4Y**, 94**, 52GX** and 14HSY**. The 94** contact, as in the flashing circuit, is normally closed. When the AC machine exceeds 95% speed, speed relay 14HSY** closes its contact, energizing the 83SR** circuit, thereby, putting the automatic regulator in service. The 52GX** in parallel with the 94** contact prevents the regulator from being transferred to the manual mode if the shutdown relay 94** is energized before the AC machine line breaker is tripped.

41S is the field suppression relay. When de-energized, its power contact closes, applying power to the SCT suppression windings. With maximum current flowing through the suppression windings, a large voltage drop exists across the linear reactors such that the input voltage to the bridge rectifier and consequently the AC machine field is essentially zero. 41S is controlled by speed relay 14HMX**, AC machine differential relay 86G** and transformer differential relay 86T**. When the speed is above 20%, 86G** and 86T** contacts control 41S; i.e., if either or both contacts should open and lockout because of an AC machine or transformer unbalance, 41S will be de-energized. The 14HMX** contact's function is to energize 41S below 2% speed to remove power from the SCT suppression winding. 41S has two auxiliary contacts which aid in controlling the close and trip circuits of the AC machine line breaker.

CT AND PT BURDENS

The regulator imposes a maximum burden of 50 volt-amperes on the signal current transformer and 25 volt-amperes on the signal potential transformer. The URAL (when furnished) imposes a maximum burden of 300 volt-amperes on the signal PT and 250 volt-amperes on the signal CT.

INSTALLATION

LOCATION AND MOUNTING

The rectifier-reactor assembly, resistor assemblies PPT, and the SCT's are mounted in the AC machine cab. They are convection cooled. All components are floor mounted.

CONNECTIONS

Connections must be made in accordance with the diagrams supplied with the equipment for each particular installation. Care must be exercised to determine that the connections are correct to avoid damaging the equipment.

The size of the interconnecting wires for the regulator and control panels and the rectifier-reactor assembly (also the field breaker control circuit when applicable) is to be a minimum of #14 wire. The minimum size of the interconnecting cables for the rectifier-reactor assembly will vary with the rating of the equipment and is shown on the rectifier-reactor assembly outline.

Care should be taken that the DC supply is connected with the polarity shown. If reversed, the start-up circuit blocking rectifier will prevent the start-up current from flowing in the field circuit.

Instrument transformers, both current and potential, should be connected as shown in the diagram. The current transformer should be brought to the regulator through a shorting device.

POLARITY AND PHASE ROTATION

When making connections to the static exciter-regulator, polarity should be carefully checked to make certain that the connections are the same as those shown on the elementary.

It is extremely important that the PPT and SCT's are connected with the polarity-marked ends as shown on the elementary. Failure to do so can cause damage to the equipment or improper operation of the circuit.

INITIAL OPERATION, TEST AND ADJUSTMENT

CONTROL CIRCUITS

The following relays can be checked before operating the AC machine. Upon application of the DC supply voltage, relay 41S should immediately pick-up. Placing a jumper across speed relay contact 14HSY** will energize the transfer relay 83SR**.

Short 59E contact energizing 2E. Nothing else should occur for 30 seconds after which a 2E** contact will close and seal itself in (the 59E** contact can now be released). Another 2E** contact will de-energize relay 83SR**. Depressing 43SR** will return the relays to their former condition. Remove the 14HSY** jumper and place it across speed relay contact 14HAX**. 41F relay should pick up.

STATIC EXCITER

Since the automatic regulator is automatically switched into service immediately following start-up, the 83SR** circuit must be disabled to prevent this so that the "off-line" (90R5) and "on-line" (90R6) manual regulator rheostats can be adjusted. The means used to accomplish this is optional but should allow for easy connecting and disconnecting for future tests.

As the AC machine begins rotating and the start-up circuit is switched into operation, the exciter-voltage and AC machine voltage should build up to a small percentage of rated voltage. If the voltage shows no signs of building up, shutdown the equipment, turn the "off-line" voltage adjuster rheostat 90R5 clockwise, to add some resistance and try again. It should be remembered that the field circuit is highly inductive, and the build-up will be slow. Therefore, it is imperative that all adjustments be made in small increments until the operator becomes familiar with the characteristics of the particular machine. Adding too much resistance may cause the AC machine to build up to too high a value. The final setting should be noted for future start-ups.

Once the voltage has started to build up, it should be possible to control it with 90R5. With the AC machine operating at normal voltage, turn 90R5 clockwise. This will increase the resistance in series with the saturating winding and cause an increase in exciter voltage and AC machine voltage. Turning 90R5 counterclockwise will have the opposite effect. The change in exciter voltage and AC machine voltage should be smooth and easy to control.

C6R may be adjusted so there is sufficient range of voltage control on 90R5. The adjustment of the online manual regulator circuit depends upon the AC machine characteristics and customer requirements and may involve trial and error.

When finally adjusted, the values of C4R and C5R will be such that maximum desired AC machine output will occur with 90R6 at its maximum resistance position.

To accomplish this, we must start with the total resistance of the on-line circuit equal to the total resistance of the off-line circuit when 90R5 is in its proper start-up position.

With some active load on the AC machine, adjust 90R6 until the AC machine is carrying the desired reactive load.

If this is impossible to attain, shut down the equipment and increase the effective resistance of C4R and C5R. Too much resistance will make it impossible to operate as low as might be desired.

Voltage Level

The automatic regulator is designed and transformer ratios are selected to give a nominal signal voltage of approximately 115 volts to the single-phase bridge consisting of diodes A7D through A10D. 90R1 ("off-line") and 90R2 ("on-line") should provide adjustment of at least 10% above and below nominal signal voltage. It is usually preferable to delay the final voltage level adjustment until the reactive current compensator is adjusted, as it may appreciably alter the signal voltage.

Automatic Control

The reactive current compensator (A6P) control knob should be turned fully counterclockwise (minimum affect). The URAL amplifier should be removed from service by disconnecting the wire from terminal E8, Figure 13.

With the AC machine operating at rated voltage, rated speed, and disconnected from the line, and with 90R4 (90R1 if Manual adjust used) in its midposition, take whatever steps are necessary to energize 83SR**, thereby causing the AC machine to be under the control of the automatic regulator. Watch carefully for signs of instability since the system will be most unstable under these conditions. If the system is unstable, immediately de-energize 83SR**.

Attempt to obtain stable operation by adjusting rheostat A2P in series with capacitor A2C (A2C actually consists of five separate capacitors A2CA-A2CE. Refer to the regulator panel connection diagram). Reduce the resistance to a value that is about 15% less than the original value and again place the regulator in control of the AC machine excitation. If the stability still has not improved, repeat the preceding adjustment using larger and smaller values of resistance. It should be possible to stabilize the regulator by gradual adjustment of this rheostat. However, if the regulator is still unstable after the full range of resistance has been tried, the exciter stabilizer capacitors (A2CA-A2CE) should be adjusted in the same manner as previously described.

When proper regulator operation has been secured, optimum stability should be checked by the following test and the necessary additional adjustments made. With the regulator in control of the AC machine, adjust 90R4 (90R1 if Manual adjust used) to hold AC machine volts at approximately 90% or greater. De-energize 83SR**, putting manual regulator back in control of the AC machine.

When the AC machine is back at rated voltage and steady, energize 83SR**. The AC machine voltmeter should overshoot only slightly before returning to the new steady state value.

CAUTION

Before making any adjustments in the stabilizer circuit, it is necessary to transfer to manual control when adjusting A2P or to shut down the unit to adjust A2C.

The on line auto-regulator should be set to cause the generator to go on line at a voltage higher than line voltage in order to supply reactive power to the system. With the motor operated set point adjuster, this is accomplished by setting 90R1 to some small value to give a step change in voltage. With the manual set point adjuster, 90R1 should be set to hold rated line voltage and 90R2 to hold a voltage slightly higher than rated.

If the signal PT voltage is other than 115 volts, it will be necessary to adjust rheostat A3P and/or A4P to bring the regulator back to a good operating range. Failure to do this may result in the voltage adjuster not having enough range.

When smooth control and the desired operation has been obtained, the reactive current compensator potentiometer A6P can now be adjusted (turning clockwise) for the desired compensation for reactive current. Refer to the reactive current compensator circuit description under the section titled "Automatic Voltage Regulator" as a guide for the setting of A6P for optimum performance.

Final adjustment of the compensator can only be made after considerable experience with the machine operating under control of the automatic regulator. It is desirable to keep the amount of resistance used to the minimum required for proper division of reactive kva between machines to avoid excessive voltage regulation. Adjustments may be made with the compensator current transformer energized. When making adjustments, the AC machine power factor should swing toward unity as A6P resistance is increased.

Regulator Sensitivity and Voltage Regulation

Determination of AC machine voltage regulation with the regulator in service is a difficult procedure under usual operating conditions and one which will produce only qualitative results. Since the regulator is adjusted at the factory to provide adequate sensitivity for close regulation, this measurement is usually unnecessary at the time of installation, and for this reason no special test procedure is given. After the equipment has been placed in service, it is possible to obtain data which will provide a measure of voltage regulation, but results must be carefully interpreted to gain a reliable estimate of performance.

If the machine is connected to a system, the regulation will depend to a great extent upon the characteristics of this system. Regulation will also be considerably affected by the use and adjustment of compensators. Furthermore, the sensitivity of the regulator itself will be a major factor affecting voltage regulation.

GAIN MEASUREMENTS

The automatic regulator gain should be checked only when it is thought that the system is not operating properly. If the gain is to be checked, it will be necessary to use a laboratory type meter to measure the change in voltage on the secondary of the PT; the ratio of change in voltage across points A14 and A13 (See Figure 13) to the voltage change at the PT secondary is the gain of the SCR circuit. The voltage across A14 and A13 is the output of the SCR circuit.

SYSTEM SELF-COMPENSATION

It is necessary to determine the degree of self-compensation of this system to be certain that the linear reactors are set at the best taps. This can be done by measuring the value of current through the SCT control winding at no-load and at full load, rated power factor. The degree-of-correction (DOC) is the change in control current divided by the no-load value of control current. If the control current decreases from no-load to full load the system is under-compounded. If the current increases, the system is over-compounded. Changing the linear reactors to a higher reactance tap causes increased compensation, i.e., it tends to over-compound the system. CHANGE TAPS ON ALL THREE REACTORS.

UNDEREXCITED REACTIVE AMPERE LIMIT (If Furnished)

Limit Polarity

After satisfactory operation of the regulator has been obtained, the reactive-ampere limit should be tested. Reconnect the limit amplifier to the regulator, set the REACTIVE AMPERE LIMIT POWER RECALIBRATION switch at zero and the REACTIVE AMPERE LIMIT START dial at its highest numbered position.

83SR** should be disabled so that the regulator remains in Manual. Connect the test resistor furnished loose with the URAL panel to terminals A13 and A14 of the automatic regulator. This resistor is necessary in order for the regulator to supply enough current for the SCR's to conduct properly. Connect a voltmeter across A13 and A14 and adjust the automatic regulator output for about 60 volts.

With the machine carrying power load and some safe value of underexcited reactive current, slowly turn the REACTIVE AMPERE LIMIT START dial toward 0. At same setting of the dial, the limit detector meter reading will go to 0 and increase in the opposite direction. Limit signal-current will increase from 0 and the regulator output will decrease. If the limit-detector current does not reverse before the dial has been turned to zero, return the dial to the highest numbered position. Decrease the AC machine excitation to further increase the underexcited current being careful not to exceed the safe operating limit for the machine.

Again turn the REACTIVE AMPERE LIMIT START dial towards zero until the limit detector current is 10 ma. If the signal cannot be increased from zero by turning the REACTIVE AMPERE LIMIT START dial to zero, the limit polarity may be reversed. Reverse the primary connections of transformer E3T (Figure 13). Repeat the test previously described to determine if reverse limit-detector current can be obtained by turning the REACTIVE AMPERE LIMIT START dial towards zero. THIS TEST MUST GIVE PROPER RESULTS BEFORE FURTHER TESTS ARE CONDUCTED. If the limit signal-current had an initial value that went to zero as the REACTIVE AMPERE LIMIT START dial setting was reduced, the input to the limit amplifier must be reversed. If the regulator output increased, the limit DC output is reversed. Reverse the connections between the limit amplifier and the first stage amplifier of the automatic regulator. Repeat the previously described tests to obtain proper results.

With the REACTIVE AMPERE LIMIT START dial so set that the regulator output has been reduced slightly, turn the POWER RECALIBRATION switch from point 0 toward point 9. If the AC machine is delivering power, regulator output should decrease as the POWER RECALIBRATION switch is turned toward point 9.

Turn the POWER RECALIBRATION switch to 0. Readjust the regulator output to 60 volts with the REACTIVE AMPERE LIMIT START dial. Before proceeding further with the test on the underexcited reactive limit circuit, it is necessary to check the polarity of the LIMIT stabilizing circuit. Carefully disconnect one of the exciter voltage stabilizing leads from the LIMIT amplifier and short the stabilizing input terminals on the LIMIT amplifier. This should cause the regulator output to decrease. Replacing the primary lead should cause the regulator output to increase. Do not proceed with the underexcited reactive-ampere limit tests until the polarity of the limit stabilizer is correct.

Turn the REACTIVE AMPERE LIMIT START dial to its highest reading. Readjust the regulator output to 60 volts with 90R4 (or 90R2). Operate the AC machine at normal voltage and with underexcited reactive current. Remove the test resistor and then energize 83SR** so that the regulator transfers to automatic. With 90R4 (or 90R2) readjust the output for the same normal voltage and underexcited current. Slowly turn the REACTIVE AMPERE LIMIT START dial toward zero. The regulator output should decrease and the exciter voltage should increase causing the underexcited reactive current to decrease. The dial setting at which the underexcited reactive current starts to decrease is the limit-start point. If the operation is not as described, immediately remove the regulator from control of the AC machine excitation by disabling 83SR**. Repeat the limit polarity tests. Do not proceed further until satisfactory operation is obtained.

With 83SR** energized, the test resistor disconnected, and the REACTIVE AMPERE LIMIT START dial at the limit start point, observe the exciter voltmeter and the AC machine ammeter for signs of oscillation. If oscillations of the reactive current appear, remove the automatic-regulator from control of the machine excitation. Adjust the resistance in series with the exciter LIMIT stabilizing capacitors in 15 percent steps, first in the direction to decrease resistance and then in the direction to increase resistance. After each of these adjustments repeat the procedure for putting the LIMIT in service as previously described, being very careful to observe exciter voltage oscillation and reactive-current oscillations. However, if the LIMIT still is unstable after the full range of resistance has been tried, the exciter stabilizer capacitors on the LIMIT amplifier should be added and disconnected one at a time. After each change the resistance should be adjusted in the same manner as previously described. Capacitors should be changed only when the machine has no voltage on it.

NOTE

TEST RESISTOR MUST BE DISCONNECTED BEFORE OPERATING THE THE REGULATOR IN AUTO.

After stable operation of the LIMIT has been obtained, check the LIMIT operation as follows with the regulator in control of AC machine excitation. Move the REACTIVE AMPERE LIMIT START dial to the limit-start point. Record the reactive current. Decrease the underexcited reactive-ampere load on the AC machine by operating the automatic-regulator voltage adjuster to raise the voltage. The underexcited reactive current should decrease. It should be possible to adjust the underexcited reactive current to any value lower than it was at the limit-start point. Now increase the underexcited reactive current by turning the automatic-regulator voltage adjuster to lower the voltage. As the limit-start point is passed, the exciter voltage should increase and it should be impossible to raise the underexcited reactive current appreciably above the previously recorded value no matter how far the automatic-regulator voltage adjuster is turned in the direction to lower voltage.

This completes the preliminary adjustment of the LIMIT. Final adjustment can be made at any time.

Final Adjustment of The Underexcited Reactive-Ampere Limit

The final adjustment of the LIMIT may be made by use of Figure 10 and 11, unless special calibration data are supplied with the equipment.

The limit-start adjustment is determined from Figure 10. This graph shows the value of the machine current-transformer secondary underexcited reactive current which will cause the LIMIT to operate as a function of dial setting and normal AC machine potential-transformer secondary voltage. Values of voltages differing from those shown on the graph may be easily interpolated. The Power-Recalibrating Reactor adjustment is shown in Figure 11. This curve shows the amount by which the limit-start point will be reduced below the limit-start adjustment as a function of machine current-transformer secondary active current for various values of the tap-switch (EISW setting.

The two following examples are given to illustrate the method of setting the LIMIT.

EXAMPLE 1. It is required that the LIMIT should start to function when the underexcited reactive-current input to the LIMIT reaches four amperes and that the LIMIT action be independent of the power component of current. The normal voltage on the secondary of the AC machine potential transformers is 110 volts.

Figure 10 indicates that for an underexcited reactive current of four amperes, the REACTIVE AMPERE LIMIT START dial should be set at approximately 47. As can be seen from Figure 11, the tap switch on the power-recalibrating reactor must be set on tap 0, since the LIMIT action is to be independent of the power component of current.

EXAMPLE 2. It is desired to have the LIMIT start to function when the underexcited reactive-current input to the LIMIT reaches four amperes with zero active amperes, and when the underexcited reactive-current input reaches three amperes with four active amperes.

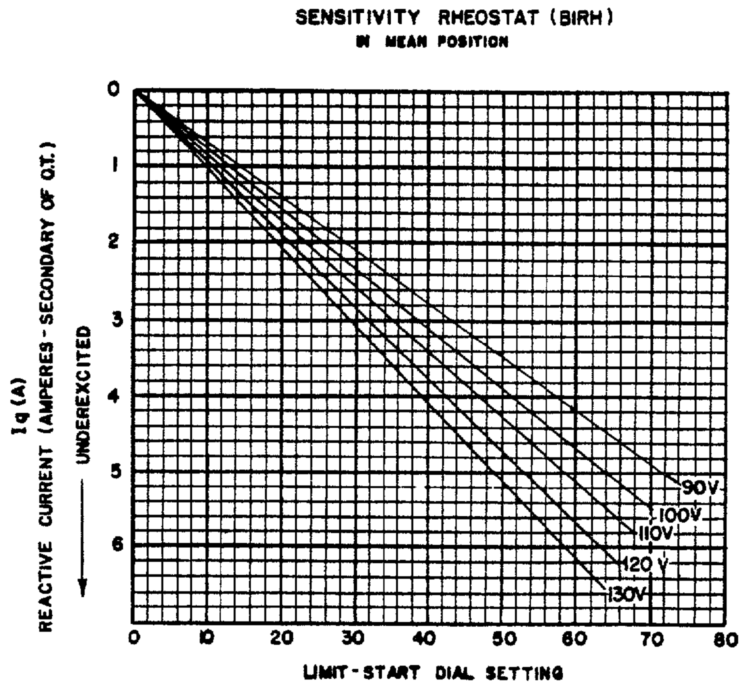

Figure 10. Calibration Curves For Reactive Ampere Limit Start Dial

Figure 10 indicates, that for an underexcited reactive current of four amperes, the REACTIVE AMPERE LIMIT START dial should be set at approximately 47. This satisfies the requirement at zero active amperes. Now, the number of reactive amperes necessary to start the limit at four active amperes must be reduced by one reactive ampere to obtain the desired power recalibration. Therefore, in Figure 11, a value of one reactive-ampere recalibration of the LIMIT and four active amperes to the LIMIT, indicates that tap switch EISW should set at tap 4.

If desired, before making the final adjustment of the LIMIT, the calibration curves (Figure 10 and 11 may be checked in the following manner.

Place Power - Recalibrating Reactor tap switch EISW on tap 8. Place the REACTIVE AMPERE LIMIT START dial at its highest scale position. Put the automatic regulator in control of the AC machine excitation. With the AC machine carrying some convenient power load at about unity power factor, move the REACTIVE AMPERE LIMIT START dial slowly toward zero. At some position of the dial, the LIMIT will start to operate. This position will be that which will just start to decrease the machine under-excited reactive-current, or increase the overexcited reactive current.

Determine the active and reactive amperes delivered by the machine current transformer to the LIMIT. Draw a vertical line from the active-ampere scale point in Figure 11 to the curve for tap 8. Read the corresponding reactive amperes recalibration of the LIMIT, and the setting of the REACTIVE AMPERE LIMIT START dial.

In Figure 10, use the dial setting and the proper AC voltage curve to determine the value of underexcited reactive current for which the LIMIT is set. From this value, subtract the reactive amperes recalibration. The result should be essentially equal to the reactive amperes delivered to the limit if the test has been carefully conducted.

Set the LIMIT adjustments to the points which are desired for final operation. If it is desired to check the adjustments, the following procedure may be followed.

Place the automatic regulator in control of the AC machine excitation. Operate the machine at the desired power load and at a reactive load which should not cause LIMIT operation. Turn the automatic regulator voltage adjuster in the direction to lower voltage until the LIMIT prevents further reduction in machine overexcited reactive current, or increase in underexcited reactive current. Determine the value of reactive current and active current supplied by the machine current transformer to the LIMIT.

Knowing the AC machine voltage and the setting of the REACTIVE AMPERE LIMIT START dial, determine the underexcited reactive current setting from Figure 10. Determine the underexcited reactive ampere recalibration from Figure 11. The result of subtracting the value of underexcited reactive amperes read in Figure 11 from the value of underexcited reactive amperes read in Figure 10 will be essentially equal to the value of underexcited reactive current to the LIMIT at the limit-start point.

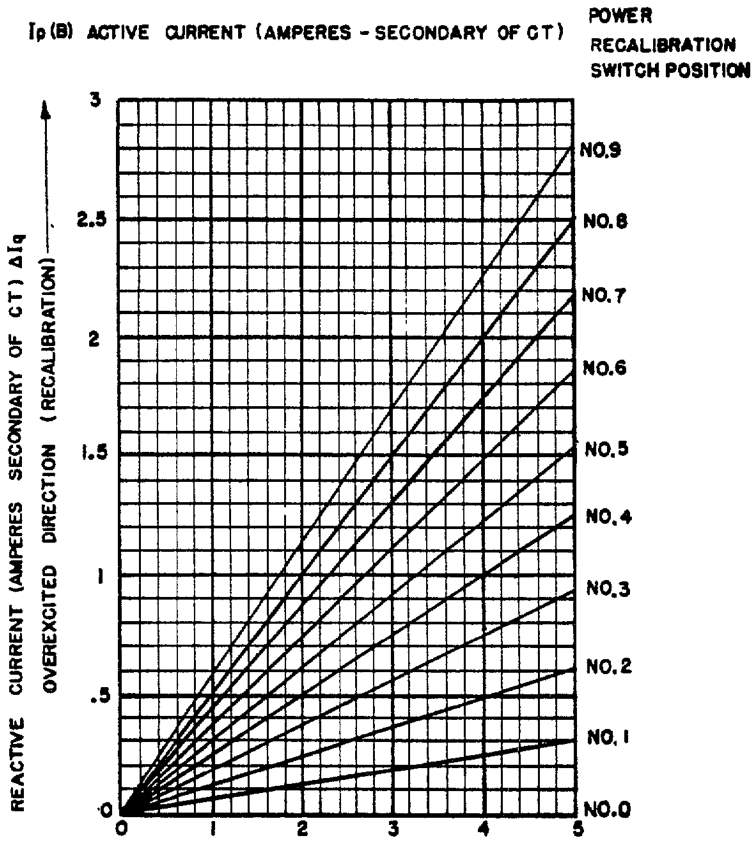

Figure 11. Calibration of Reactive-Ampere Power Recalibration Limit Circuit

NORMAL OPERATION

General

The complete voltage-regulator equipment should be placed in normal service with the AC machine only after the control circuits, regulators, and the reactive current compensator have been properly tested in general conformance with the previous described instructions. Final adjustment of these units may, of course, be delayed until operating experience has been obtained, but circuits which have not been thoroughly tested must not be employed with the automatic regulator in service if the possibilities of damage to the equipment and disturbance of the system are to be avoided.

With the automatic regulator in control of the AC machine excitation, the manual regulator voltage adjuster 90R6 is ineffective. However, additional excitation system reliability may be secured by proper adjustment of 90R6 when the automatic regulator is in control of a AC machine excitation.

For this purpose, it is recommended that a predetermined position be such that the AC machine excitation will be sufficient under all normal loads, give stable operation and avoid serious operating disturbances if the excitation system should be suddenly returned to manual control resulting in loss of the automatic regulator. It is suggested that this voltage adjuster position be selected so that when the excitation system is under manual control, it will produce rated AC machine current. It is essential that under any sustained load condition, 90R6 must be set to maintain sufficient excitation in the event of a sudden return to manual control.

The automatic regulator may be removed from service and the AC machine excitation returned to manual control under any load condition.

The proper adjustment of 90R5 is equally important when transferring from "on-line" to "off-line" condition and vice versa to prevent excessive generator armature voltages.

MAINTENANCE

PPT's and SCT's

These devices normally require little or no maintenance. It is suggested, however, that the air passages be inspected during shut down periods. Exposed connections should be inspected for corrosion and tightness.

STATIC EQUIPMENT

If vibration is present, all screw type connections should be checked regularly. Normally, the static components should require no further attention.

OTHER EQUIPMENT

All contactors and relays should be regularly inspected and maintained in accordance with applicable instructions. The automatic and manual regulator voltage adjuster contact brushes should be inspected annually and the brushes should be reset by working them back and forth across the total winding surface many times. If arcing is present, or if brush becomes worn, a complete brush assembly should be installed. Since it is made of special material, it should be obtained from the rheostat manufacturer. In addition, where discoloration is present, clean the contact surface with crocus cloth.

Silicon diodes are used in the power circuit of the static exciter. These diodes are not at this time known to age; therefore, they are either good or should be replaced. Individual diodes can be checked as shown in Figure 12. With switch in position 1, the ammeter should read approximately 12 amperes. With switch in position 2, the ammeter should read zero. The DC source should be a battery, rather than a rotating exciter, since the latter may have voltage spikes that may damage the diode.

If the diode is open, the ammeter will read zero in both switch positions. If the diode is shorted, it will read approximately 12 amps in both switch positions.

Bad diodes can be found with the equipment in service with a voltmeter and a clamp-on ammeter.

The shorted diode can be found by measuring the inverse voltage across the diodes, since the shorted diode will have no inverse voltage drop, and the other diode in the leg will have all the inverse voltage drop.

The leg containing an open diode can be found by clamping a clamp-on ammeter around one diode pigtail in each leg. Upon ascertaining that an open diode exists in a leg the faulty diode can be found by shorting each individual diode in that leg. When current flows, the open diode has been shorted.

An oscilloscope may also be used to check for an open diode.

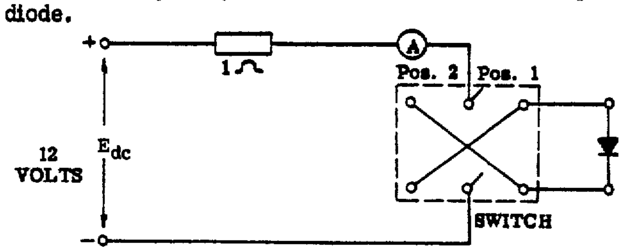

Figure 12. Diode Test Circuit

If it becomes necessary to replace a faulty diode, use the following procedure:

1. Shut down the equipment.

2. Discharge all capacitors in the AC machine field circuit.

3. Disconnect Ground Detecting relay.

4. Remove diode.

5. Screw in new diode after first applying a small amount of Wakefield type 120 thermal compound to approximately the first three threads. Also apply a little to the rectifier base. Refer to the manufacturers specifications for the required mounting torque.

RENEWAL PARTS

When ordering renewal parts, the following information should be given.

1. Catalog number, stamped on the part, with a complete description, including use and location.

2. Complete nameplate data appearing on the assembly of which the part is a component.

3. If possible, data on original order on which equipment was first supplied including all numerical references.

TROUBLESHOOTING

SYMPTOM	POSSIBLE CAUSE	POSSIBLE CURE
Voltage fails to build up after flashing (Regulator on Manual.)	Insufficient Flashing Current	Short C3R
	Shorted Power Diode	Replace Diode
	Insufficient Resistance in off-line control	Increase C6R and/or 90R5
	Loose Connections	Tighten ALL Power Circuit Connections
Generator Armature Voltage goes to ceiling after flashing (Regulator on Manual.)	Excessive resistance in 90R5, C6R, SCT circuit.	Decrease C6R or 90R5
	Incorrect PPT Secondary voltage	Check to see that PPT is on the correct tap.
	SCT control windings not in the circuit	Look for wiring error involving SCT control windings. Check contacts of 83SR**
	Insufficient Reactance in $X'_L S$	Change Taps
Generator Armature Voltage goes to zero after transfer to auto.	Incorrect Sensing Voltage	Adjust A3P and A4P
	Incorrect Zener Voltage	Check Zener and replace if necessary.
	Open Potentiometer A5P	Check and replace if faulty.
	Open diode A11D	Check and replace if faulty.
Generator Armature Voltage goes to ceiling (or higher than desired) after transfer to Auto.	Incorrect sensing voltage	Adjust A3P and A4P
	Incorrect Operation of 83SR	Check and adjust or replace
	Incorrect Zener Voltage	Check and replace if necessary
	Insufficient supply Voltage to SCR's	Check A1T
	Faulty SCR	Check output of regulator with Oscilloscope and replace the SCR if faulty.
Generator unstable at No-Load	Incorrect Stabilization	Adjust A2P, A5R and/or A2C
	Feedback circuit connected with wrong polarity	Swap leads to A15 and A16
	Excessive Gain	Increase A1P and/or A4R
Generator unstable at Load but stable at No-Load	Change in Gain caused by Excessive Ambient	Decrease Gain or Ambient Temperature
	Change in Gain caused by Phasing Error between SCT and PPT	Check control current as load is changed. If approaches zero or maximum, then check phasing of PPT and SCT.

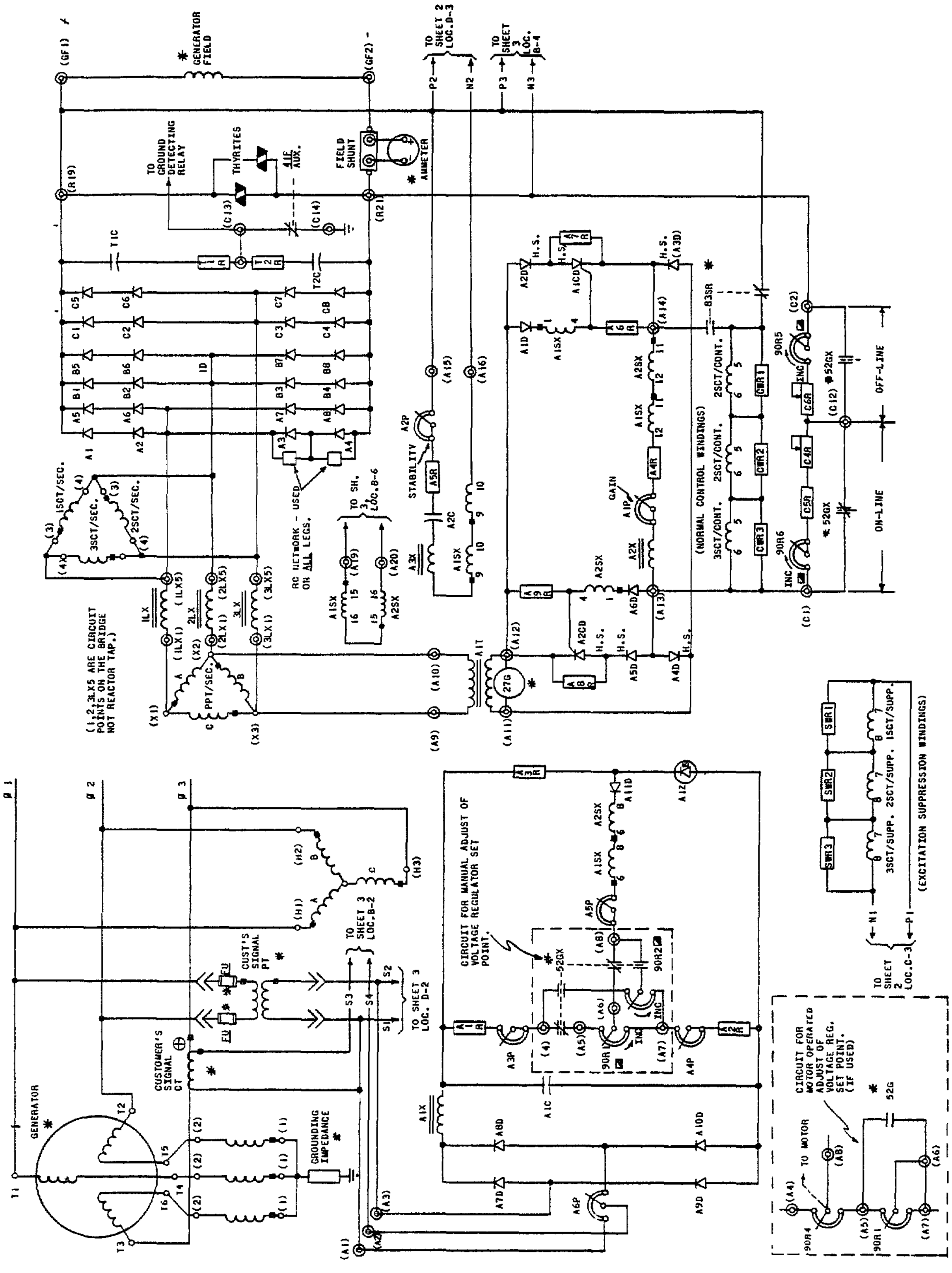

Figure 13 - Typical Elementary Diagrams of 3S7501FS141
Static Exciter Regulator Equipment
(Sheet 1 of 4)

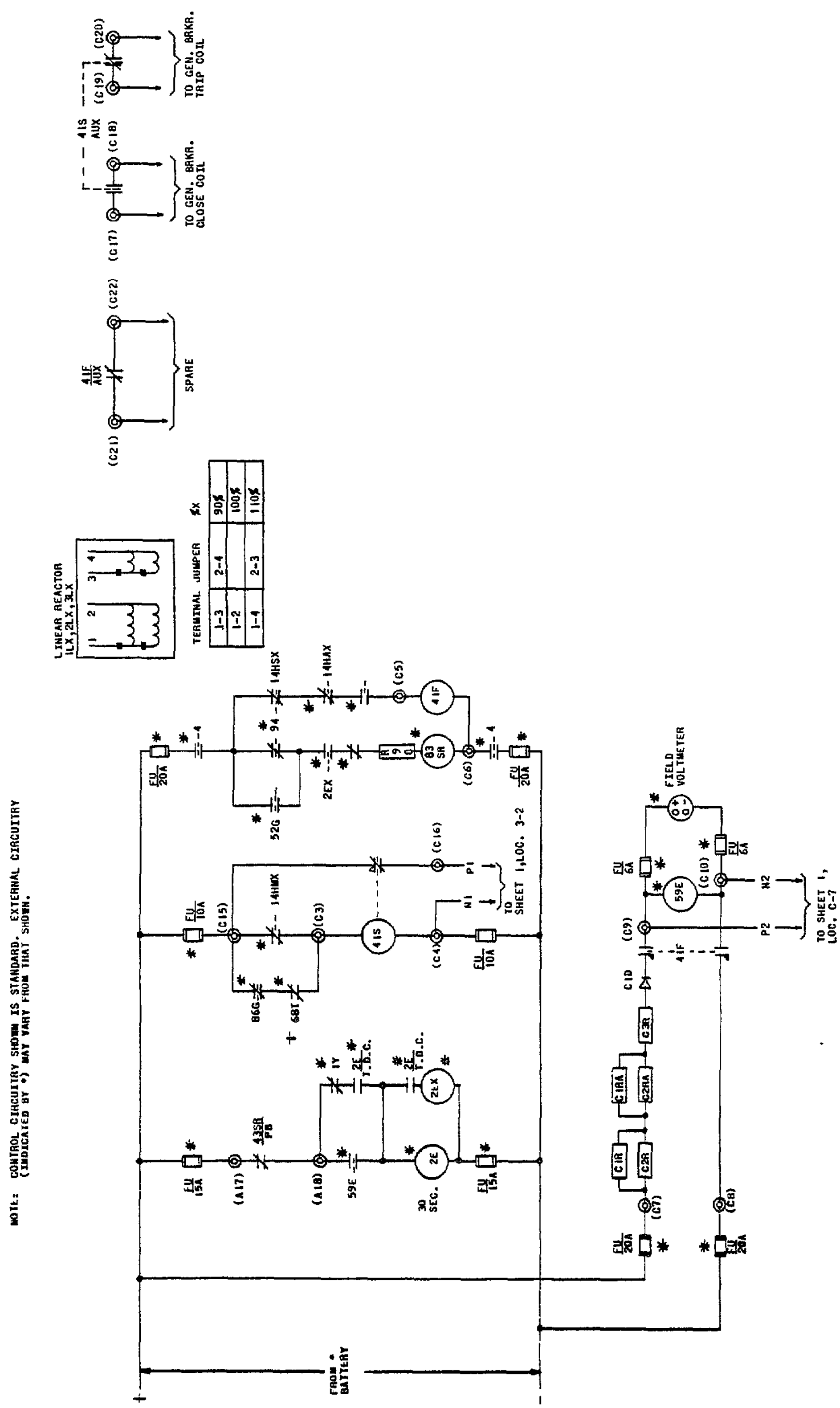

Figure 13 - Typical Elementary Diagrams of 3S7501FS141 Static Exciter Regulator Equipment (Sheet 2 of 4)

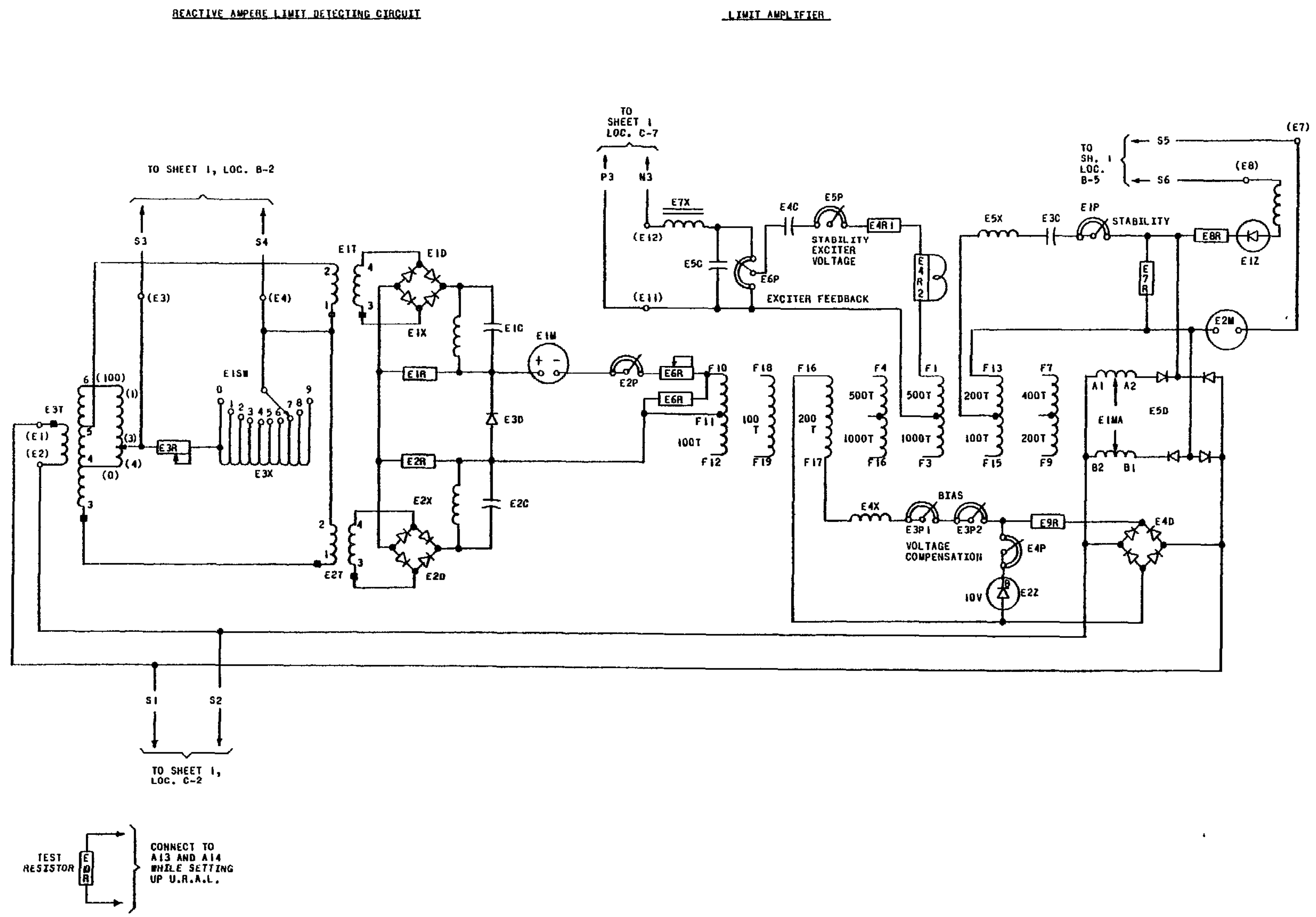

Figure 13 - Typical Elementary Diagrams of 3S7501FS141
Static Exciter Regulator Equipment
(Sheet 3 of 4)

THE FOLLOWING ITEMS ARE FURNISHED ON THE RECTIFIER ASSEMBLY 3S7501FS141A1

SHUNT	FIELD SHUNT, 100MV., 600 AMP
PBA	POTTED BLOCK ASSEMBLY, 44B314558-G01
RECTIFIERS	POWER RECTIFIERS, IN3741 AND IN3741R
T1C,T2C	CAPACITORS, 25MFD., 600WVDC
T1R,T2R	RESISTORS, 56OHM, 435 WATT
THYRITE	THYRITE RESISTOR, 9RV6A230
ELEM-CONN	44C303257
OUTLINE	44C303201

THE FOLLOWING ITEMS ARE FURNISHED ON THE REGULATOR PANEL 3S7931SA224A1 (PANEL A):

A1Z	ZENER DIODE, 36 VOLT, 125 MA, 44B212755-006
A1T	TRANSFORMER, 240 VOLT PRI., 160 VOLT SEC., 44B314075-001
A1CD,A2CD	RECTIFIERS, 44B212741-009, C35E
A2SX,A2SX	SATURABLE REACTORS, 44B219907-001
A2X	REACTOR, 395B584P1, 20 H., 25 MA DC
A3X	REACTOR, 44B210645-001, 3.8 H., 375 MA DC
90R	RHEOSTAT, 75 OHM, 75 WATT
A6R,A9R	RESISTOR, 100 OHM, 10 WATT
A4RA	RESISTOR, 4700 OHM, 10 WATT
A4RB,A5RA	
A5RB,A5RC	RESISTOR, 10,000 OHM, 10 WATT
A7R,A8R	RESISTOR, 22,000 OHM, 10 WATT
A4RC	RESISTOR, 1,000 OHM, 10 WATT
A1R	RESISTOR, 600 OHM, 20 WATT
A2R	RESISTOR, 200 OHM, 20 WATT
A3R	RESISTOR, 1,200 OHM, 20 WATT
A1P	POTENTIOMETER, 5000 OHM, 50 WATT
A2P	POTENTIOMETER, 10,000 OHM, 50 WATT
A3P	POTENTIOMETER, 250 OHM, 25 WATT
A4P	POTENTIOMETER, 250 OHM, 25 WATT
A5P	POTENTIOMETER, 75 OHM, 25 WATT
A6P	POTENTIOMETER, 2 OHM, 75 WATT
A1C	CAPACITOR, 50 MFD., 600 WVDC
A2CA,A2CB,A2CC	CAPACITOR, 10 MFD., 600 WVDC
A2CD,A2CE	CAPACITOR, 20 MFD., 600 WVDC
A1D,A6D-A11D	RECTIFIER, IN1697
A2D-A5D	RECTIFIER, IN1206A
A1X	REACTOR, 44B219991-001, 1.5 H., 200 MA DC
43SR	PUSHBUTTON, CR104A8102
ELEM-CONN	44D209431
OUTLINE	44B204757

THE FOLLOWING ITEMS ARE FURNISHED ON THE CONTROL PANEL 3S7932CD141B1 (PANEL C):

ELEM-CONN	44C303223
41S	CONTACTOR, 44A315565-001
41F	CONTACTOR, 44A315565-001
C1D	RECTIFIER, 20 AMP., 400 P.I.V., 4JA3512DH1AD1
C1R,C2R,C1RA,C2RA	RESISTOR, 5.4 OHM, 710 WATT
C3R	RESISTOR, 3.5 OHM, 710 WATT, TAPPED
C4R	RESISTOR, 33 OHM, 755 WATT, ADJ.
C5R	RESISTOR, 42 OHM, 755 WATT
C6R	RESISTOR, 26 OHM, 755 WATT, ADJ.
90R5	RHEOSTAT, 15 OHM, 300 WATT
90R6	RHEOSTAT, 25 OHM, 500 WATT
OUTLINE	44A302630
CWR1 - CWR3 } SWR1 - SWR3 }	RESISTOR ASM. 44A316002-G02
OUTLINE DIAGRAM	44C303201

THE FOLLOWING ITEMS ARE FURNISHED ON THE UNDEREXCITED REACTIVE AMPERE LIMIT PANEL, 3S7932KA118G2:

E10R	TEST RESISTOR, 200 OHMS, 130 WATTS

U.R.A.L. PANEL 3S7932KA118G1 ON WHICH IS MOUNTED:

E1SW	10 POSITION TAP SWITCH
E1R,E2R	RESISTOR, 200 OHMS, 130 WATTS
E3R	RESISTOR, 8.6 OHMS
E4R1	RESISTOR, 10,000 OHMS, 85 WATTS
E4R2	RESISTOR, 20,000 OHMS, 85 WATTS
E5R	RESISTOR, 240 OHMS, 85 WATTS
E6R	RESISTOR, 47 OHMS, 20 WATTS
E7R	RESISTOR, 510 OHMS, 85 WATTS
E8R	RESISTOR, 390 OHMS, 85 WATTS
E9R	RESISTOR, 1000 OHMS, 85 WATTS
E1C,E2C	CAPACITOR, 0.5 MFD, 2000 WVDC
E3C1-E3C9	CAPACITOR, 500 MFD, 250 WVDC
E4C1	CAPACITOR, 30 MFD, 600 WVDC
E4C2,E4C3	CAPACITOR, 10 MFD, 600 WVDC
E1P,E2P	POTENTIOMETER, 500 OHMS, 50 WATTS, WIRE WOUND
E3P1	POTENTIOMETER, 2500 OHMS, 50 WATTS, WIRE WOUND
E3P2	POTENTIOMETER, 300 OHMS, 50 WATTS, WIRE WOUND
E4P	POTENTIOMETER, 150 OHMS, 50 WATTS, WIRE WOUND
E5P	POTENTIOMETER, 10K OHMS, 50 WATTS, WIRE WOUND
E1D,E2D	RECTIFIER, 378V, PIV, 1.25 AMPS DC, 6RS25PD6ACF
E3D	RECTIFIER, 37V, PIV, 1.25 AMPS DC, 6RS25PD1ADF1
E4D	RECTIFIER, 490V, PIV, 3 AMPS DC, 4JA411EB1AD1

U.R.A.L. PANEL 3S7932KA118G1 (CONT):

E5D	RECTIFIER, 490V, PIV, 3 AMPS DC, 4JA411EM1AD1
E1VT	TRANSFORMER, VARIABLE, 115V, INPUT, 0-140V. OUTPUT, 50/60 CYCLE
E1T,E2T	TRANSFORMER, 115V, PRI., 115V. SEC., 075 KVA, 50/60 CYCLE
E5C1	CAPACITOR, 1 MFD, 600 WVDC
E5C2	CAPACITOR, 2 MFD, 600 WVDC
E6P	POTENTIOMETER, 5000 OHMS, 50 WATTS
E1M	METER, 30-0-30 MADC
E2M	METER, 250 MADC
E3T	TRANSFORMER, 130V. PRI., 102/68/34 SEC., 100KAV 50/60 CYCLE
E1X,E2X,E7X	REACTOR, 2.5 HENRIES, L8206585
E3X	REACTOR, L-8206504
E4X,E5X,E6X	REACTOR, 10 HENRIES
E1MA	MANGETIC AMPLIFIER, .090 KVA, 60 CYCLES
E1Z	ZENER DIODE, SV910,9-12 VOLT, 10 WATTS
E2Z	ZENER DIODE, SV912, 10-14 VOLT, 10 WATT

CUSTOMER RELAY FUNCTIONS

1Y	- MASTER CONTROL RELAY-TIME DELAY
2E	- EXCITER VOLTAGE TIMER
2EX	- AUX. RELAY TO 2E
4	- MASTER CONTROL RELAY
14HAX	- PICKUP AT 50% SPEED, DROPOUT AT 25% SPEED
14HMX	- PICKUP AT 20% SPEED, DROPOUT AT 2% SPEED
14HSX	- PICKUP AT 95% SPEED, NORMAL TRIP AT 75% SPEED & CUTS OFF FUEL. IMMEDIATE DROPOUT ON EMERGENCY TRIP.
14HSY	- PICKUP AT 95% SPEED, DROPOUT AT 90% SPEED
27G	- GENERATOR UNDERVOLTAGE RELAY
52GX	- GENERATOR BREAKER AUXILIARY RELAY
59E	- OVERVOLTAGE RELAY
86G	- GENERATOR DIFFERENTIAL RELAY
86T	- TRANSFORMER DIFFERENTIAL RELAY
94	- PICKUP ON NORMAL SHUTDOWN
83SR	- VOLTAGE REGULATOR CONTROL - TRANSFER RELAY

KEY

+	- IF USED
⊕	- INSTRUMENT TRANSFORMERS ARE SHOWN CONNECTED FOR PHASE SEQUENCE 1-2-3. IF GENERATOR HAS OPPOSITE PHASE SEQUENCE, REVERSE CT SECONDARY LEADS.
*	- NOT FURNISHED BY G.E. CO., WAYNESBORO
H.S.	- INDICATES STUD END OF RECTIFIER CONNECTED TO HEAT SINK.
◎	- INDICATES CUSTOMER'S TERMINAL BOARD CONNECTION

Figure 13 - Typical Elementary Diagrams of 3S7501FS141 Static Exciter Regulator Equipment (Sheet 4 of 4)

NOTES

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