GEK-12514B

INSTRUCTIONS

OBSOLETE

STATIC VOLTS/CYCLE REGULATOR

FOR

AC GENERATORS

3S7930SA201A4

3S7930SA211A4

GENERAL ELECTRIC

PUBLICATIONS INCLUDED

INTRODUCTION

The static regulator controls the voltage of an AC generator by controlling its excitation. Silicon controlled rectifiers control the power delivered to the field. The regulator is completely static, having no moving parts or vacuum tubes to perform the regulating function. Relays, if required, are used only for startup and protective functions.

RECEIVING

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

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

STORAGE

If the equipment is not 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 a location where construction work is in progress.

INSTALLATION

The regulator should be mounted so that it is accessible. If furnished without an enclosure, it should be mounted in an enclosure to protect personnel from exposed voltages. The enclosure should allow a reasonable circulation of air to keep the ambient temperature below 55°C. If the ambient temperature is more than 55°C, the regulator should be derated per factory instructions. The panel, or enclosure should be mounted upright as indicated on the outline drawings furnished with the regulator. Make all connections to panel per connection diagram furnished with the regulator. Read all notes on the diagrams furnished to check possible variations of application.

ADJUSTMENTS

CAUTION

The heat sinks on the panel are at above ground potential.

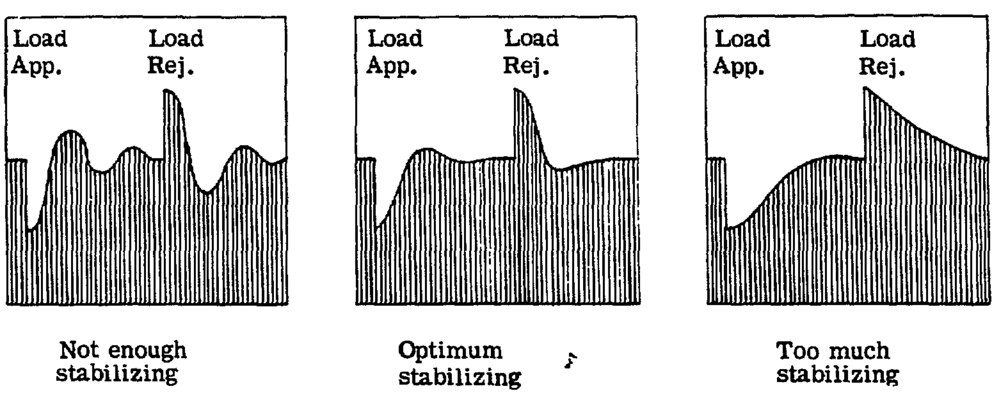
Never assume the generator voltage will not build up until field is flashed. Generator residual voltage may be enough to initiate voltage buildup. Always open input and output to regulator before servicing.

INITIAL ADJUSTMENTS

Before starting prime mover, check all connections to the regulator. Check notes on diagram, and also check that all input transformers to the voltage regulator are connected for the proper voltage. Set "Voltage Adjust" potentiometer and "Stability" potentiometer at their midpoints. Set the "Gain" potentiometer fully counterclockwise. Set the jumpers on the coarse stability adjust terminal board for maximum; refer to "Stabilizing and Positive Feedback Circuit", under "Principles of Operation". Start prime mover and bring up the speed; flash generator field if this is required. Flashing may be initiated by automatic relaying. Set "Voltage Adjust" potentiometer to obtain proper generator voltage.

To obtain optimum response, when applying or rejecting a load, vary the "Stability" potentiometer and the capacity at the coarse stabilizing terminal board. Starting with the maximum stability setting, adjust the "Stability" potentiometer for best response.

Too much of the coarse stability adjust will cause the system to be overdamped. While not enough will cause the system to be underdamped. See Figure 1.



Typical oscillograms or recordings looking at amplified portion of generator a-c voltage.

Figure 1. Stabilizing Adjustment

Adjusting the stability potentiometer will give the optimum response for each step of coarse stability adjust. System may be unstable at either end of the stability potentiometer adjustment.

With stabilizing circuit near optimum, increase the "Gain" potentiometer until the generator voltage drops between .1 percent and .5 percent as the generator changes from no load to rated load condition. The "Voltage Adjust" potentiometer will need to be reset as the "Gain" potentiometer is varied.

Go back and recheck stability and adjustment for optimum performance after gain has been set.

PERIODIC ADJUSTMENTS

Any adjustment described above may be checked periodically as required.

MAINTENANCE

Since there are no moving parts in this regulator, little maintenance will be required. Periodic checks would consist of checking the voltage level, voltage regulation, and performance as required for the particular application. The regulator should be cleaned with a blower as required to prevent accumulation of dirt and dust.

PRINCIPLES OF OPERATION

GENERAL

Refer to typical elementary diagram at rear of this book or to the complete elementary diagram furnished with the equipment for actual component numbers assigned to each circuit.

POWER RECTIFIER CIRCUIT

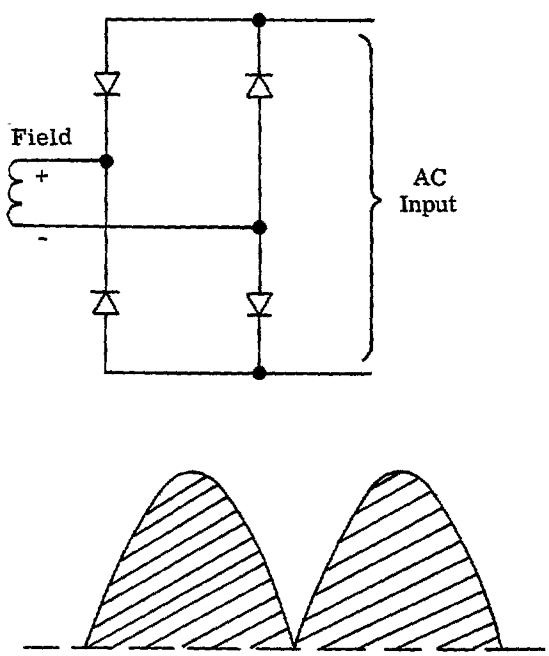
The excitation power for the field is furnished by the full wave rectifier bridge consisting of power rectifiers and silicon controlled rectifiers (SCR's). Without the SCR's the output would be that of a full wave bridge. (See Figure 2a.) When the SCR's are added in the bridge circuit legs, they allow control of the output voltage by delaying the point on the supply voltage cycle at which the respective leg conducts. (See Figure 2b.) If the silicon controlled rectifiers are fired early during the positive half cycle, the output voltage is higher and the later in the cycle they are fired, the lower the output voltage. By phase controlling the SCR's, the DC output voltage can be controlled from near zero to maximum voltage capable of the full wave bridge.

The power rectifier circuit is designed to operate at a particular voltage level and where the generator operates at a different voltage level, a transformer must be provided to change the voltage to the proper level (refer to complete elementary diagram furnished with equipment).

As the SCR firing is retarded the output voltage wave goes to zero as shown in Figure 2b; thus the rectifier bridge will not supply current to the field. The field is highly inductive and current must continue to flow. The freewheeling rectifiers carry the field current during the off portion of the output voltage wave.

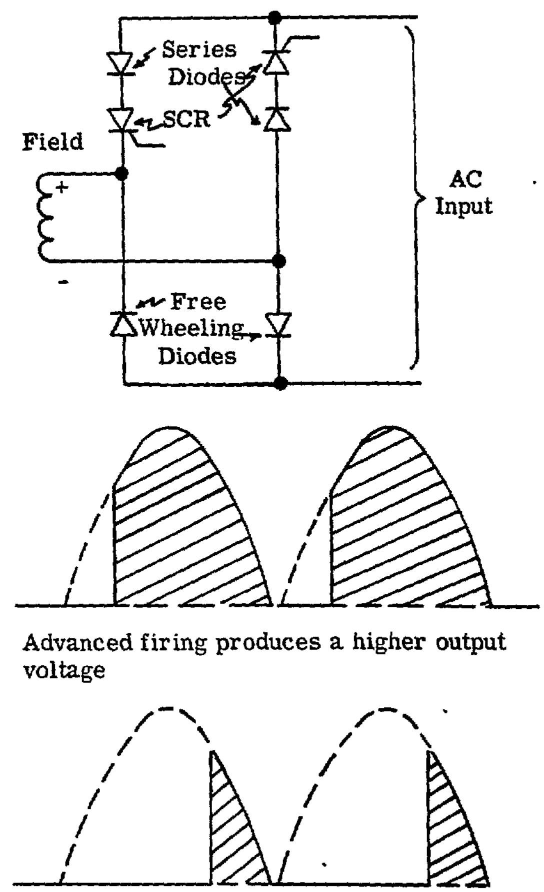
FIRING CIRCUIT

An SCR is similar to a thyratron tube in that it remains non-conductive until the firing pulse of current is applied through its gate to the cathode junction. If the anode is positive with respect to the cathode when the pulse is applied, the SCR will conduct and remain conducting until the anode voltage goes negative and the anode to cathode current goes to zero. By delaying the firing pulse during the period when the anode is positive, the SCR is phased controlled as described in Figure 2.



Voltage output of the full-wave bridge is proportional to AC voltage input

(a) Full-wave bridge without SCR's



Advanced firing produces a higher output voltage

Retarded firing produces a lower output voltage

(b) Full-wave bridge with SCR's

Figure 2. POWER RECTIFIER BRIDGE

For a typical firing circuit for the SCR, refer to Figure 3. As soon as the anode voltage becomes positive, the SCR can be fired. How soon it is fired is determined by how far the saturable reactor is reset by the control circuitry. The more it is reset the greater portion of the sine wave is required to saturate it and the smaller the remaining portion of the sine wave that is left to be applied to the field (Figure 3b and 3c) and the lower the average field volts. The phase controlled diode in series with the saturable reactor allows only the positive half cycle to be applied to the reactor. During the time the total line voltage is dropped across saturable reactor and its SCR, the field current is being carried by the free-wheeling diodes (Figure 3d and 3e). Since the reactor's impedance is high until it saturates, only a very small amount of current flows through it and this current is shunted off by the bleeder resistor. When the reactor saturates, its impedance drops sharply to the DC resistance of the winding. The increase of current that results causes the voltage to rise across the bleeder resistor and current flows into the gate of the SCR. The SCR is turned on. Once the SCR is turned on it shorts out the firing voltage existing across the saturable reactor and the bleeder resistor and the remaining portion of the positive half cycle of the sine wave is applied to the field.

The series diode and the by-pass resistor are used to protect the SCR from possible excessive inverse voltage which may destroy the device.

The other half of the bridge circuit works in exactly the same manner except it operates on the alternate positive half cycle.

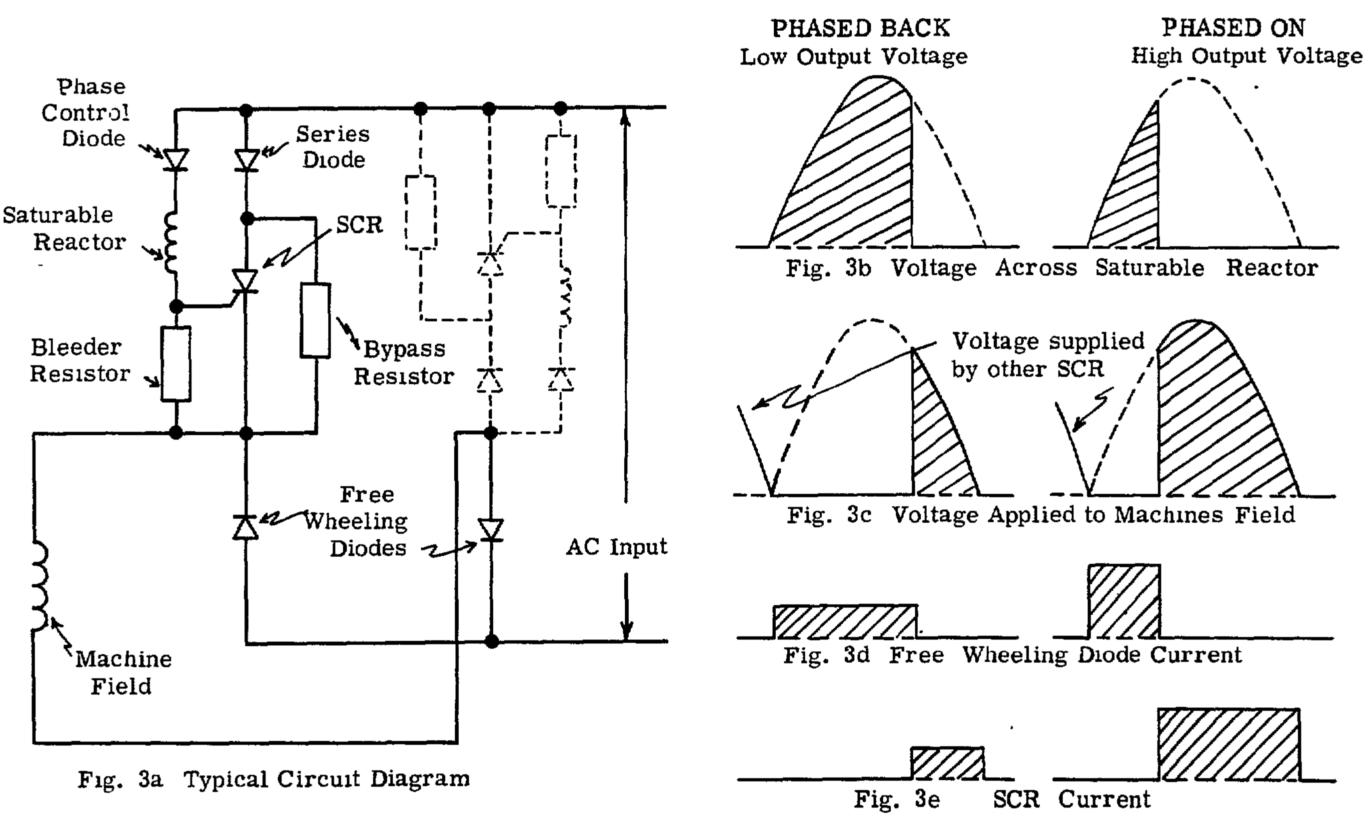


Figure 3. TYPICAL SCR FIRING CIRCUIT AND OUTPUT WAVEFORMS

Control Circuitry

The generator output is stepped down by remotely mounted transformers in an open delta configuration. The three phase sensing voltage is rectified by the input diode bridge and divided down by the resistor network and the voltage adjust potentiometer, 1P. (Refer to Figure 4.) The saturable reactor reset windings are connected between the wiper of the voltage adjust potentiometer and the reference which is the tach feedback.

The action of the circuitry is to hold the voltage drop across the resistor divider equal to the tach feedback voltage. Therefore, as the tach feedback voltage falls off, the generator output voltage is held directly proportional to it.

The control diode in series with the saturable reactor windings allows only a reset voltage to be applied to the control windings of the saturable reactor.

To improve the linearity of the generator output voltage with respect to frequency, a negative bias circuit is used with the tachometer reference. The circuit is comprised of a transformer, a full wave bridge, a smoothing capacitor, a limiting resistor and a Zener diode. The circuit has very little effect at the higher frequencies, but does cause the regulator to follow closer to a true volts per cycle relationship at lower frequencies.

The capacitor on the tach input to the regulator is used to smooth the ripple inherent in the tach, especially at the lower frequencies.

Stabilizing and Positive Feedback Circuit

Control windings of the saturable reactor are also provided for positive feedback to increase the system gain and transient negative feedback to stabilize the system.

Both positive and negative feedback circuits take the regulator output or machine field voltage and feedback signals to the saturable reactor windings for "Gain" and "Stabilizing". (Refer to Figure 5.) The series reactor is a filter to provide a reasonably smooth DC feedback voltage.

The positive feedback signal aids the original error signal through the control windings to increase the system's gain and provides close control of AC line voltage.

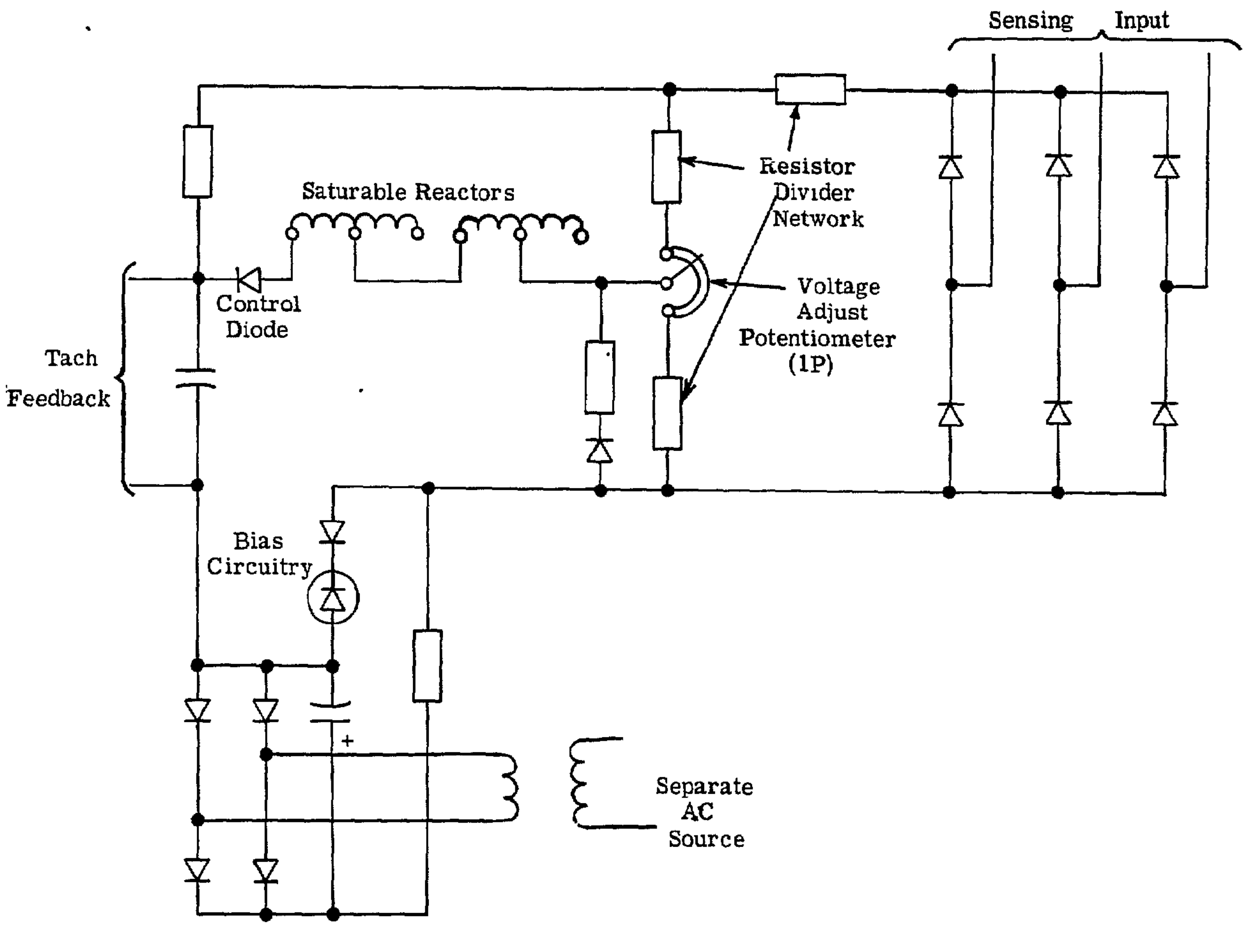


Figure 4. CONTROL CIRCUITRY

The transient negative feedback signal opposes the original error signal through the windings and retards the action of the system as required for stabilizing.

Changing jumper connections on 2TB provides a range of stabilizing capacitance. For maximum stability jumper A to B and C to D, for medium stability jumper A to B, and for minimum stability jumper B to C.

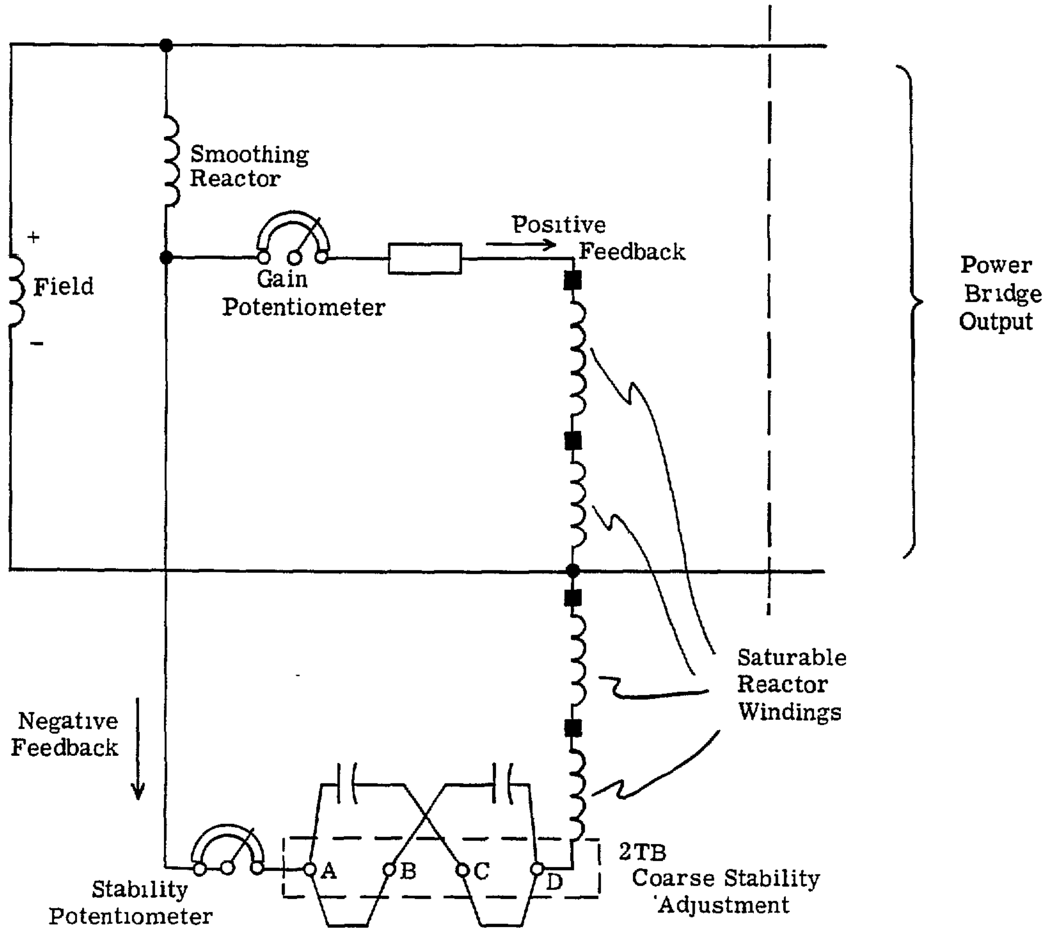


Figure 5. STABILITY CIRCUITRY

TROUBLE SHOOTING

The following chart may be helpful for troubleshooting and locating faulty components; however, a thorough study of the "Principles of Operation" will be the greatest aid to troubleshooting.

TROUBLE	PROBABLE CAUSE	CHECK
I. Generator voltage will not build up	1. No power to generator field	a. Connections to regulator panel b. Fuses, input lines (if used) c. Power rectifiers or SCR's d. Connections between exciter and generator
	2. No residual voltage out of generator	a. Reverse exciter field connections b. Try flashing field, observe polarity on elementary diagram
II. Generator voltage goes to ceiling	1. No feedback voltage	a. Connections to sensing circuit b. "Volt. Adj" potentiometer connections c. Sensing circuit rectifier bridge
	2. No control of SCR	a. Shorted SCR b. Saturable Reactor(s) (continuity of reset winding)
III. Poor voltage regulation	1. Loss of system gain	a. Adjust "Gain" potentiometer per "Initial Adjustments" b. Loss of one section or series diode the full wave power bridge c. Rotating rectifiers in brushless generator
	2. Distorted input to sensing circuit	a. Unbalanced load on generator b. Generator wave shape c. Sensing transformer connection and fuses (if used)

(Continued)

TROUBLE	PROBABLE CAUSE	CHECK
IV. System Unstable	1. Excess system transient gain	a. Repeat "Initial Adjustments" b. Exciter field resistance too low c. Add additional capacitance to "Course Stability Terminal Board"
V. Slow system response	1. Low Transient system gain	a. Repeat "Initial Adjustments" b. Section III, part 1

RENEWAL PARTS

Should a component fail, a replacement part can be ordered from the nearest sales office of the General Electric Company. When ordering renewal parts, specify the quantity required, give the catalog number and describe the required parts in detail. In addition, give the 3S model number and the complete nameplate rating of the equipment. A principal renewal parts list is furnished with each equipment.

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