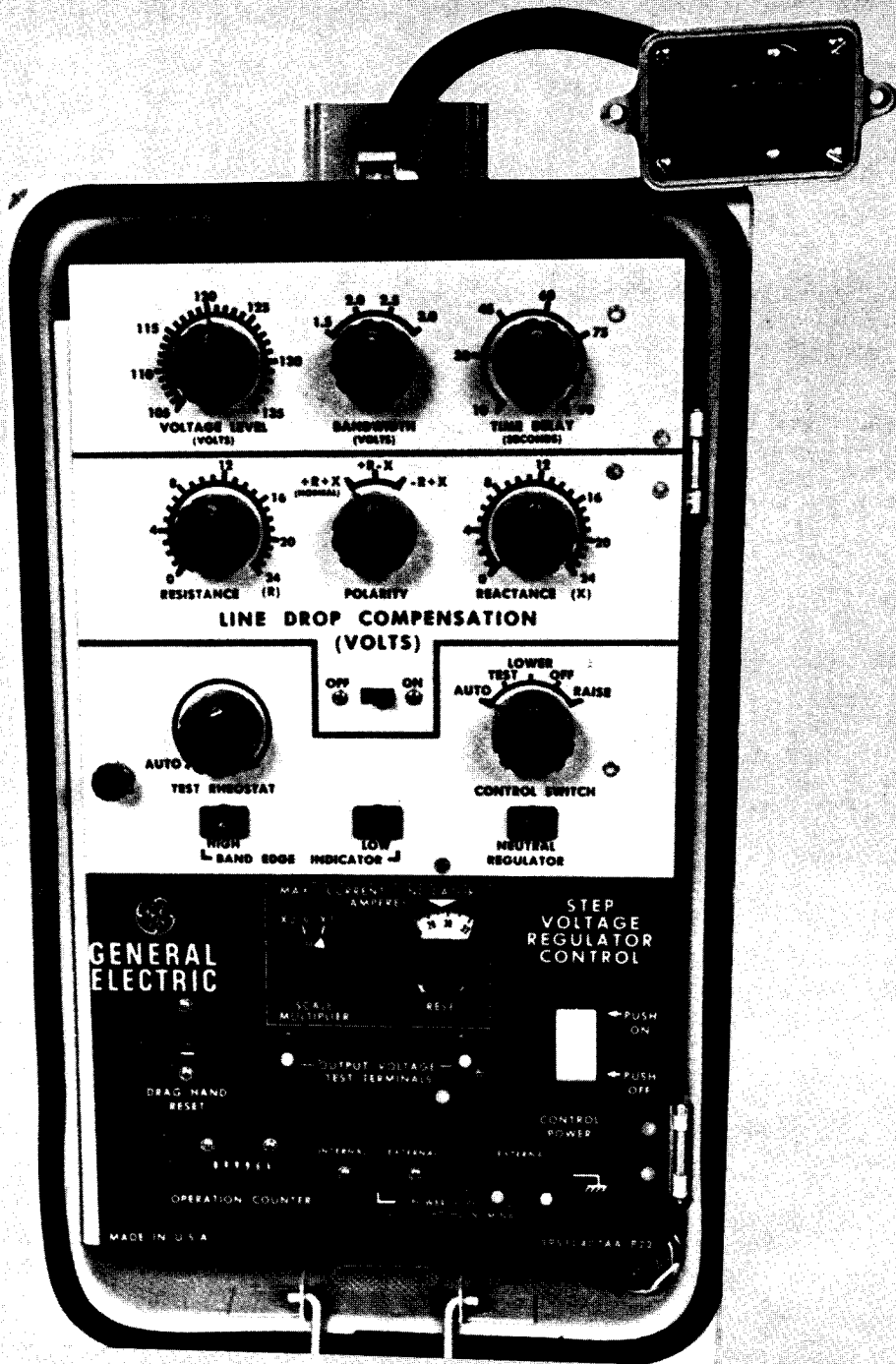


INSTRUCTIONS



MAXIMUM CURRENT INDICATOR FOR AUTOMATIC STEP VOLTAGE REGULATOR STATIC CONTROL



SAFETY HAZARD INFORMATION

GENERAL

The text of this instruction manual includes information concerning hazards to safety which are common to all regulators. This information is offered for guidance when installing, operating, and maintaining the equipment.

The Maximum Current Indicator is a special feature for the General Electric automatic step voltage regulator static control. It is necessary, therefore, to review, understand and be guided by all caution and warning notices that appear in the standard instruction book for this type of regulator. For convenience, some of these notices are repeated here.

When reading this text, and inspecting and maintaining this equipment, it is important that the meaning and content of the safety hazard statements be understood and followed carefully.

The equipment covered by these operating instructions should be operated and serviced only by competent technicians familiar with good safety practices, and these instructions are written for such personnel and are not intended as a substitute for adequate training and experience in safe procedures for this type of equipment.

BY-PASSING

CAUTION: TO AVOID DAMAGE TO WINDINGS, THE BY-PASS SWITCH MUST NEVER BE CLOSED WITH LOAD CURRENT FLOWING THROUGH THE REGULATOR UNLESS THE REGULATOR IS FIRST BROUGHT TO THE NEUTRAL POSITION.

GROUNDING

WARNING: TO PROVIDE MAXIMUM PROTECTION TO THE OPERATOR, THOROUGHLY AND EFFECTIVELY GROUND THE TANK. THE GROUNDING CONDUCTOR SIZE SHOULD BE IN ACCORDANCE WITH NEC REQUIREMENTS TO ELIMINATE THE POSSIBILITY OF BURNING-OFF THE GROUND CONDUCTOR IN CASE OF A LINE GROUND. DO NOT REMOVE THE GROUND WHILE THE REGULATOR IS ENERGIZED.

SEALED-TANK PRESSURE

WARNING: ALWAYS RELEASE ANY POSSIBLE PRESSURE IN THE TANK (WHICH MAY ACCUMULATE DUE TO LOADING CYCLE OR AMBIENT TEMPERATURE CHANGE) BY SLOWLY LOOSENING THE HANDHOLE

COVER BAND. DO NOT ATTEMPT TO REMOVE THE COVER OR HANDHOLE COVER UNTIL THE PRESSURE HAS BEEN RELEASED.

EXCITING THE CONTROL FROM AN EXTERNAL SOURCE

WARNING: WHEN EXCITING THE CONTROL FROM AN EXTERNAL SOURCE WITHOUT EXCITING THE REGULATOR, SHORT-CIRCUIT AND GROUND THE HIGH-VOLTAGE TERMINALS OF THE REGULATOR AS A SAFEGUARD AGAINST DANGEROUS VOLTAGE FROM ACCIDENTAL EXCITATION OF THE HIGH-VOLTAGE WINDINGS.

WHEN TROUBLE SHOOTING THE CONTROL AND POSITION INDICATOR

WARNING: SINCE TROUBLE SHOOTING ENTAILS WORKING WITH ENERGIZED EQUIPMENT, CAUTION SHOULD BE TAKEN TO AVOID PERSONAL SHOCK.

WARNING: SHORT-CIRCUIT CAPACITOR TERMINALS OR LEADS BEFORE RECONNECTING INTO ANY CIRCUIT.

WARNING: BEFORE DISCONNECTING ANY PLUG CONNECTOR BETWEEN THE CONTROL PANEL, COMPONENT BOARD AND NN TERMINAL BOARD OR DISCONNECTING ANY CONNECTION TO THE NN TERMINAL BOARD, REMOVE THE CONTROL CABLE PLUG FROM THE BOTTOM OF THE POSITION INDICATOR HOUSING.

CAUTION: TO PREVENT CONTROL CIRCUIT DAMAGE THE POSITION INDICATOR PLUG MUST BE COMPLETELY ENGAGED AND THE SCREWS TIGHTENED PRIOR TO APPLYING VOLTAGE FROM ANY SOURCE.

WARNING: DE-ENERGIZE THE REGULATOR BEFORE REMOVING THE INDICATOR DIAL ASSEMBLY FROM THE POSITION INDICATOR HOUSING.

CURRENT-TRANSFORMER WIRING

WARNING: SHORT-CIRCUIT THE CURRENT-TRANSFORMER SECONDARIES. IF LEFT OPEN-CIRCUITED, CURRENT TRANSFORMERS DEVELOP SECONDARY VOLTAGES HAZARDOUS TO PERSONNEL. THE CURRENT TRANSFORMER IS SHORT-CIRCUITED AUTOMATICALLY WHEN THE CONTROL-CABLE PLUG IS REMOVED FROM THE BOTTOM OF THE POSITION-INDICATOR HOUSING.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

MAXIMUM CURRENT INDICATOR FOR AUTOMATIC STEP VOLTAGE REGULATOR STATIC CONTROL

INTRODUCTION

The MAXIMUM CURRENT INDICATOR is an optional feature available only as an integral part of the General Electric step voltage regulator static control. The function of the Maximum Current Indicator is to show the maximum regulator load current which has occurred since the device was last reset. A time-lag response results in an indication of the average current over a period of time. The existing average current level is readily obtained after the maximum reading is recorded.

DESCRIPTION

GENERAL

The device itself consists of two assemblies, a component board containing the electronic sensing circuitry mounted on the left-side wall of the control cabinet, and a motor and indicating-dial unit mounted on the front panel of the static control. Refer to Figs. 1, 2, and 3.

The static control with Maximum Current Indicator and the standard static control are interchangeable on the step voltage regulator. It is necessary, however, to interchange the complete cabinet assemblies.

When the Maximum Current Indicator is an integral part of the step voltage regulator static control, it is important to refer to the standard instruction book for detailed information concerning this voltage control. It is particularly necessary when checking this device to review the sections concerning OPERATION and GENERAL TEST PROCEDURES.

SPECIFICATIONS

1. Supply voltage: 105 to 140 volts, 60 hertz.
2. Ambient temperature: -30C to +40C.

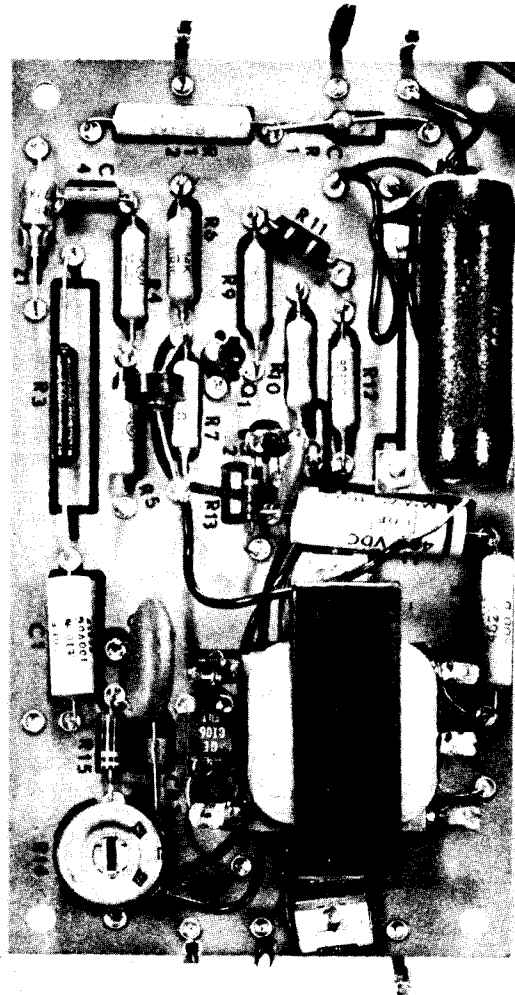


Fig. 1. Component-board assembly

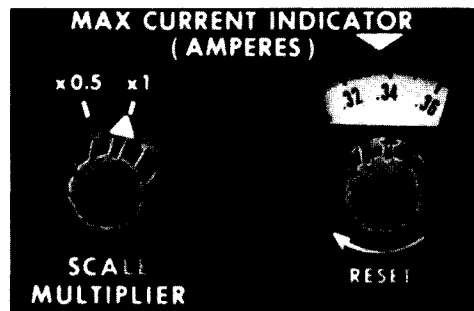


Fig. 2. Indicating-dial assembly, front view

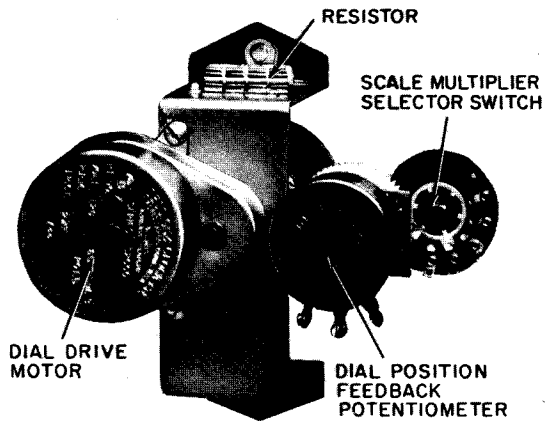


Fig. 3. Indicating-dial assembly, rear view

3. Burden on current transformer (with 0.2 ampere current):

X0.5 scale - 8 volt-amperes

X1 scale - 4 volt-amperes

4. Accuracy: The dial indication shall be within ± 10 percent for a constant current applied for 30 minutes or longer.

5. Time response for a step change in current level: See Fig. 4.

NOTE: The indication is within 10 percent of the final value after approximately 11 minutes have elapsed.

OPERATION

INTRODUCTION

Before explaining the theory of operation of the Maximum Current Indicator, resetting, calculation of load current, and scale multiplier selection are described.

RESETTING

The reset knob, (see Fig. 2) is located below the indicating-dial window. The Maximum Current Indicator is reset by turning the knob clockwise until the mechanical

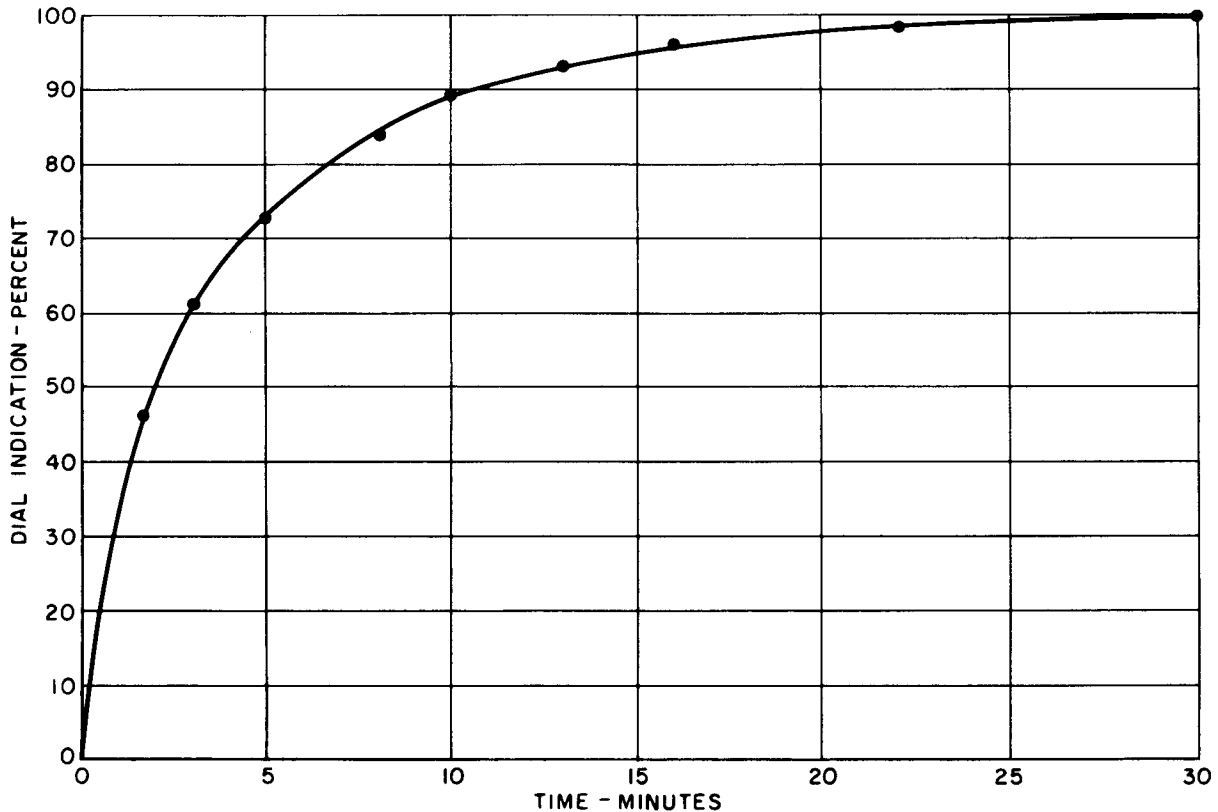


Fig. 4. Maximum current indicator response to a step change in current level

stop is reached. A friction clutch in the motor allows the reset operation to be performed.

After the reset knob is released, the dial will be driven up-scale and will *immediately* indicate the *present* average current level (assuming the current is high enough to be within the range of the selected scale). The exception to this is the situation where the dial was at full-scale reading prior to resetting and the range is changed; in which case, 15 minutes must elapse after resetting, before an accurate indication can be obtained.

CALCULATION OF LOAD CURRENT

Load Current = Dial Reading x Scale Multiplier x Current-transformer Ratio.

NOTE: *The current-transformer ratio will be found on the regulator nameplate.*

SCALE MULTIPLIER SELECTION (SEE FIG. 2)

The X0.5 range should be selected if the maximum demand is expected to be less than the rated load current of the regulator. X0.5 provides a range of current measurement, looking at the secondary of the regulator current transformer, from 0.07 to 0.2 amperes.

The X1 range should be selected if the maximum demand is expected to equal or exceed the rated current of the regulator. X1 provides a range of current measurement from 0.14 to 0.4 amperes.

If loads exceed the values for the scale chosen, no harm will result because the Maximum Current Indicator is protected against overloads on both ranges by the limit switch which is actuated by the dial, slightly ahead of the FULL-SCALE position.

CAUTION: *IF THE SCALE MULTIPLIER IS CHANGED FROM X0.5 TO X1, THE DIAL MUST BE RESET TO MINIMUM, BUT NO SOONER THAN 15 MINUTES AFTER THE SCALE MULTIPLIER CHANGE WAS MADE, BEFORE AN ACCURATE INDICATION CAN BE OBTAINED.*

IF THE SCALE MULTIPLIER IS CHANGED FROM X1 TO X0.5, NO RESETTING OPERATION IS REQUIRED; HOWEVER, AN ACCURATE INDICATION CANNOT BE OBTAINED UNTIL 15 MINUTES HAVE ELAPSED.

THEORY OF OPERATION (SEE FIG. 5A.)

The secondary current of the regulator's output current transformer is passed through the heater resistor, R1. The sensor resistor, R2, is coupled to the heater so that a thermal time constant exists between them. The steady-state temperature of the sensor is directly proportional to the power dissipated in the heater resistor; therefore, the temperature is a function of the input current to the heater ($T = aI^2R1$). The sensor is a resistor wound with a high positive coefficient wire; therefore, its terminal resistance is a function of temperature. This resistor, R2, is placed in a voltage-divider circuit branch consisting principally of resistors R2, R3, R4, and R17. The voltage across the divider is determined by the breakdown diode Z1, which clips the half-wave rectified supply voltage at a constant peak level. The divider output voltage is determined by resistance R2, a function of heater current, and resistance R17, a function of the indicator dial position.

Transistors Q1 and Q2 are arranged in an emitter-coupled binary circuit, which functions as a bi-stable level-detection circuit. With an input voltage to the base of Q1 below the threshold voltage, Q2 is conducting and Q1 is nonconducting. When the input voltage exceeds the threshold, the conduction states of the transistors interchange rapidly, causing a pulse to be applied through the coupling capacitor C2 to the gate of thyristor SCR1, thereby causing it to conduct for that half-cycle of line frequency. Isolation transformer T1 and SCR1 form a switch to control the drive motor M. If SCR1 is conducting, the primary has a low impedance and current can flow to the motor; if SCR 1 is not conducting, a high impedance exists and the motor is de-energized.

Mechanically coupled to the drive-motor shaft are the position-feedback potentiometer R17 and the dial which indicates the maximum current level. The motor is unidirectional, but equipped with a clutch so the dial can be reset manually to the minimum-current position. Potentiometer R17 is connected as a rheostat such that its resistance decreases as the indicated current increases.

The function of this device is to indicate the maximum average current level; therefore, over any given period the device must respond only to current levels that are higher than the current indicated on the dial. This is accomplished by the emitter-coupled binary which calls for motor energization only when the divider voltage exceeds the threshold value. If the current level, higher than the dial is indicating, is passed through the heater, the resistance of R2 will increase causing the divider voltage to exceed the threshold. The motor will drive the dial to the new higher

GEK-47287, Maximum Current Indicator

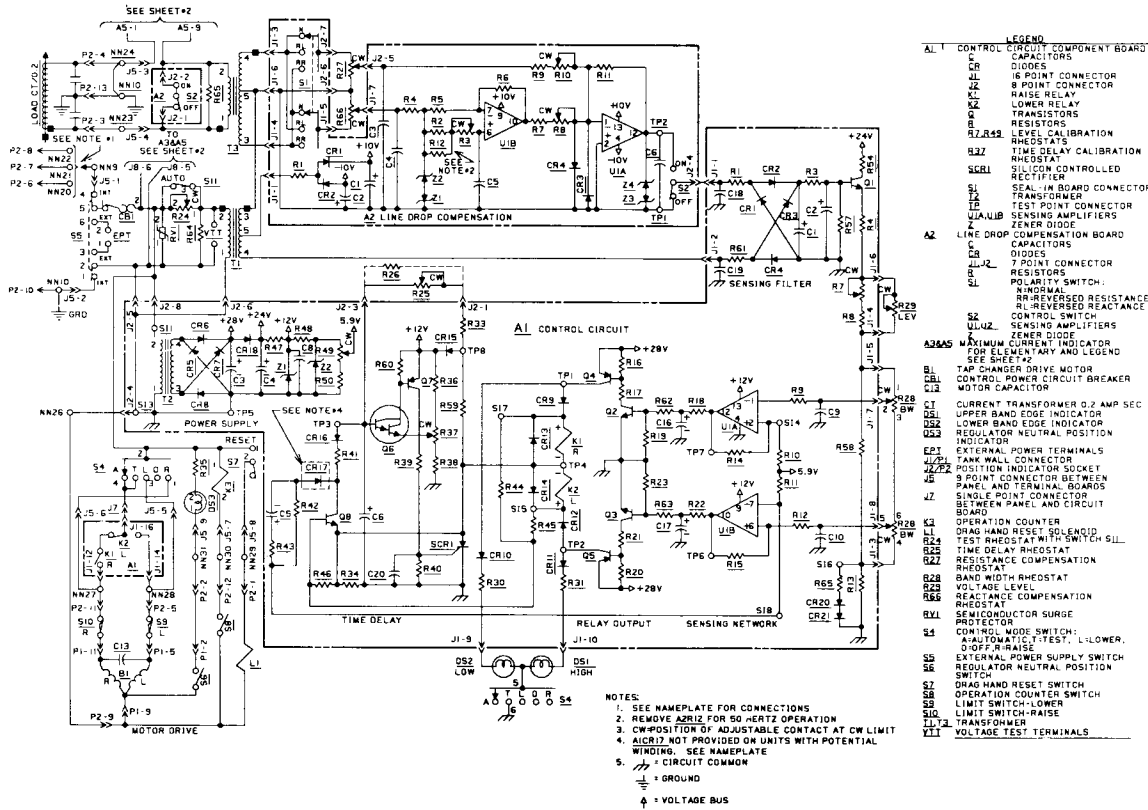


Fig. 5A. Schematic diagram

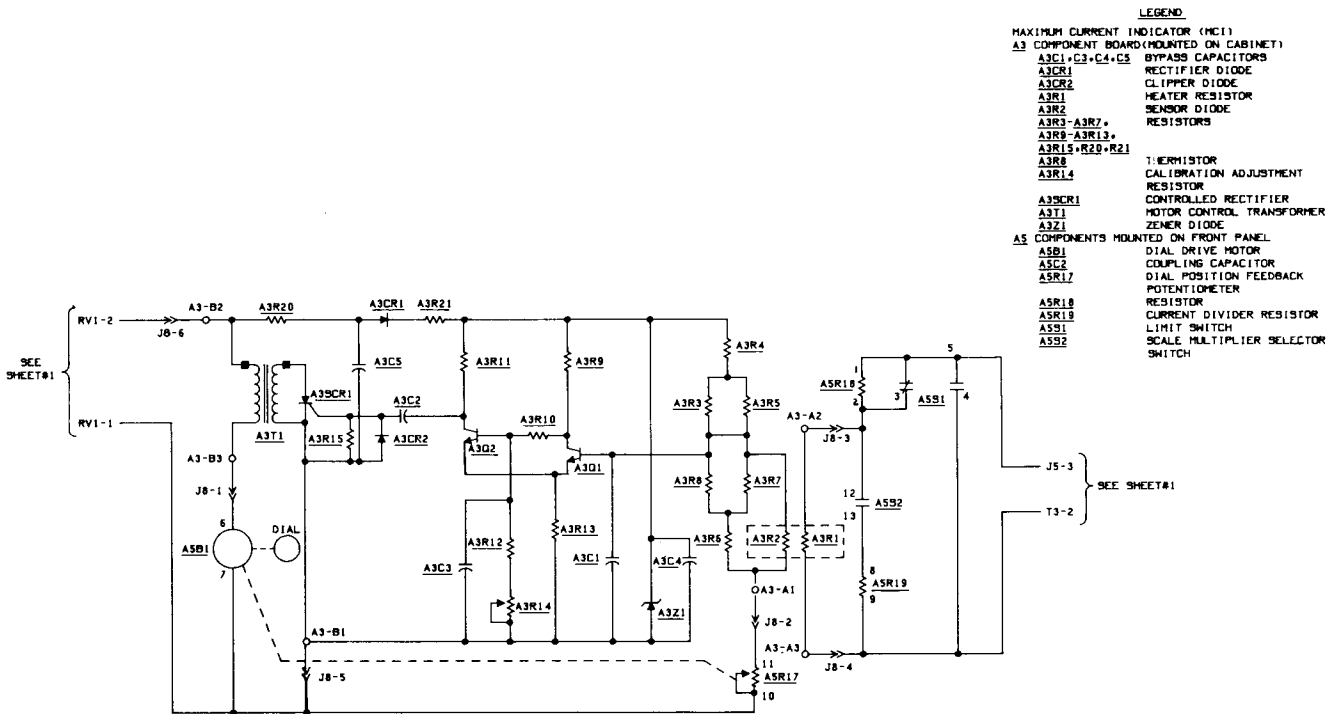


Fig. 5B. Schematic diagram

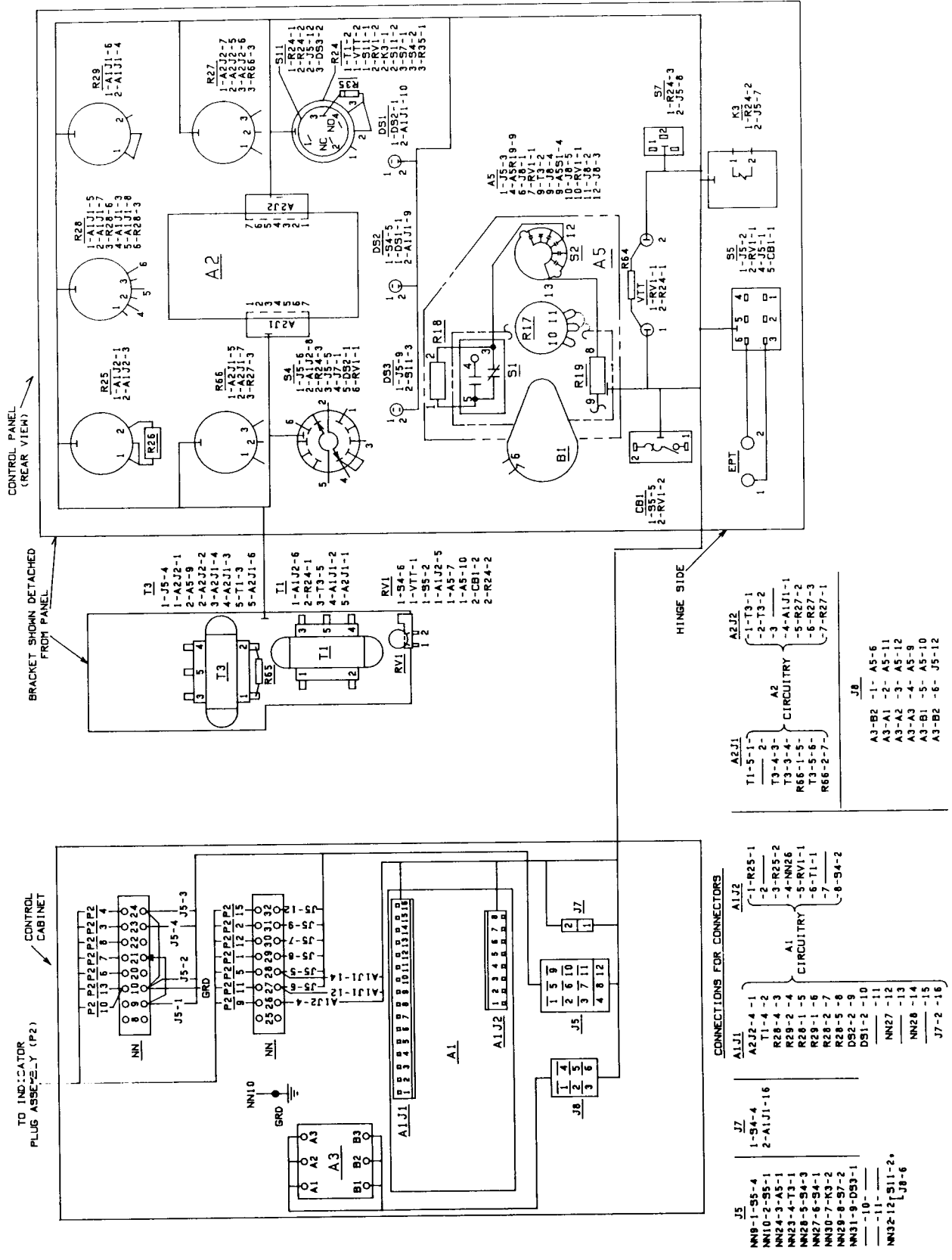


Fig. 6. Wiring diagram

GEK-47287, Maximum Current Indicator

indication and, simultaneously, reduce the resistance of R17 to bring the divider voltage below the threshold once again.

The device may be employed to indicate the present average current level simply by resetting the dial to its minimum position, after which the dial will be driven up-scale to the present current level.

Since a change in ambient temperature would affect the resistance of sensor R2 and appear to be a change in current level, accurate temperature compensation is a necessity. The compensation is accomplished by exposing to the ambient the network of resistors R3, R5, R6, R7 and R8 in the voltage-divider branch. R3, has a high positive temperature coefficient similar to R2; R8 is a thermistor which has a negative temperature coefficient; R5, R6 and R7 are insensitive to temperature change and serve to modify the characteristics of R3 and R8.

Scale Multiplier selection is accomplished as follows: on the X0.5 position of S2, the entire current-transformer secondary current passes through the heater resistor, R1; on the X1 position, half the current-transformer current passes through the heater resistor and half passes through the equal-valued current-divider resistor, R19.

Limit switch S1 is actuated near the upper end of the scale by the cam surface of the indicator dial. S1 removes the current-transformer current from the Maximum Current Indicator components. Resistor R18 assists S1 by limiting the voltage developed across the contacts of S1 during contact transfer.

MAINTENANCE

GENERAL

This section describes interchangeability, motor replacement, calibration check, and adjustment. It includes troubleshooting and voltage-measurement charts.

NOTE: *When performing test procedures, it is necessary to have in mind the general precautions that must be taken when working with electrically energized equipment. Also, it is necessary to review the particular precautions that are stated in the GENERAL TEST PROCEDURE SECTION of the standard instruction book.*

INTERCHANGEABILITY

The static control with Maximum Current Indicator and the standard static control can be directly interchanged on

a step voltage regulator. To accomplish this operation, remove the control cable from the position-indicator housing; then, remove the control cabinet from the regulator tank. Replace it with the other control cabinet by attaching to the regulator tank and reconnecting the control cable to the position indicator.

MOTOR REPLACEMENT

WARNING: *BEFORE DISCONNECTING ANY PLUG CONNECTOR INSIDE THE CONTROL CABINET, REMOVE THE CONTROL-CABLE PLUG FROM THE BOTTOM OF THE POSITION-INDICATOR HOUSING.*

If it becomes necessary to replace the dial drive-motor, the proper relationship between the dial and potentiometer R17 must be maintained; specifically, with the reset knob turned fully clockwise, the indicating arrow on the front panel should point to the first mark on the dial. This relationship is strictly a function of the meshing of the two plastic gears and is not affected by the position of the motor. The set screw which bears on the motor shaft should bear on the flat on that shaft. Before reassembly, the motor shaft may be turned by using pliers to aid in positioning the flat on the shaft.

CALIBRATION CHECK AND ADJUSTMENT

To check the calibration of the Maximum Current Indicator, remove the control cabinet from the regulator. Then, connect in the test circuit as shown in Fig. 7 and proceed as follows:

1. With the Internal-External Power Switch on EXTERNAL, the Scale Multiplier Switch on X0.5, and the Control-Power Circuit Breaker ON, close the test switch and adjust the current level to 0.08 ampere. Maintain this current level for 30 minutes. At the end of this period, the dial should read 0.16 ampere ($0.16 \times 0.5 = 0.08$). If it does not, turn the trimmer resistor R14 on the component board fully clockwise and reset the indicator dial to MINIMUM. Maintain the 0.08 ampere current. Turn R14 slowly counterclockwise until the dial indicates 0.16 ampere. Reset the dial to MINIMUM. It should run back to 0.16 immediately. Repeat the adjustment if necessary.

2. To check the X1 scale, place the selector on X1 and adjust the current level to 0.3 ampere. After a 30-minute period, the dial should indicate 0.3 ampere (± 10 percent).

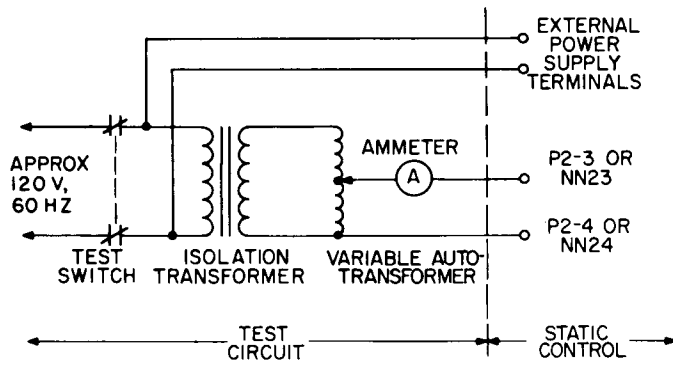


Fig. 7. Calibration test circuit

TROUBLESHOOTING

WARNING: SINCE TROUBLESHOOTING INVOLVES WORKING WITH ENERGIZED EQUIPMENT, CARE SHOULD BE TAKEN TO AVOID PERSONAL SHOCK.

WARNING: BEFORE DISCONNECTING ANY PLUG CONNECTOR INSIDE THE CONTROL CABINET, REMOVE THE CONTROL-CABLE PLUG FROM THE BOTTOM OF THE POSITION-INDICATOR HOUSING.

WARNING: SHORT-CIRCUIT THE CURRENT-TRANSFORMER SECONDARIES. WHEN OPEN-CIRCUITED, CURRENT-TRANSFORMERS DEVELOP SECONDARY VOLTAGES HARMFUL TO PERSONNEL.

VOLTAGE MEASUREMENT CHART (SEE FIG. 8)

Using an Average-reading Multimeter (10000 Ohms/Volt)

Test Point	Reading	Remarks
X	9 volts	
Y	4.5 volts	
Z	7 to 9 volts	Calling for motor operation
Z	4.5 volts	Not calling for motor operation

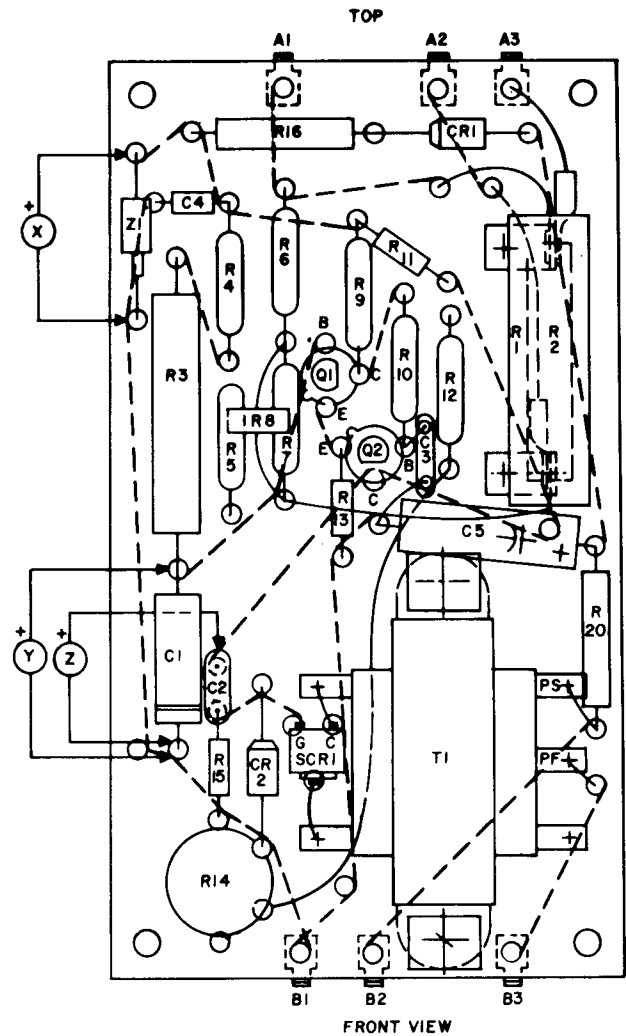
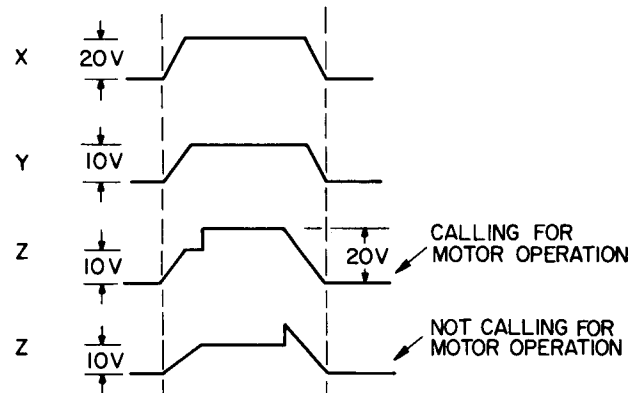


Fig. 8. Component-board arrangement

Using an Oscilloscope

Test Point	Waveform	Remarks
------------	----------	---------



TROUBLE-SHOOTING CHART

TROUBLE	CAUSE	CHECK
<p>I. Indicating dial remains at the MINIMUM position.</p>	<p>1. Low current level.</p> <p>2. Malfunction.</p> <p style="padding-left: 20px;">a. Defective motor or connecting cable to the motor.</p> <p style="padding-left: 20px;">b. Loss of a-c supply voltage to the electronic component board (open connection).</p> <p style="padding-left: 20px;">c. Loss of d-c supply voltage on the electronic component board (open CR1, open R16, shorted Z1).</p> <p style="padding-left: 20px;">d. Defective output stage (open T1 winding, open SCR1, open C2, shorted CR2).</p> <p style="padding-left: 20px;">e. Open calibrating resistor R14.</p> <p style="padding-left: 20px;">f. Defective transistors (Q1 or Q2).</p> <p style="padding-left: 20px;">g. Defective capacitors (C1 or C3 shorted).</p> <p style="padding-left: 20px;">h. Defective limit switch (S1).</p>	<p>1. Place the scale multiplier switch in the X0.5 position.</p> <p>2. If the heater resistor (R1) is hot or warm, the dial should be up-scale from the MINIMUM position. CAUTION: THE SURFACE TEMPERATURE OF THE HEATER RESISTOR CAN EXCEED 100 C (212 F) UNDER NORMAL OPERATING CONDITIONS.</p> <p style="padding-left: 20px;">a. Connect a high-impedance a-c voltmeter (multimeter) to component-board points B1 and B3. Approximately 110 volts will be present if the electronic sensing circuit is calling for the motor to drive the dial up-scale.</p> <p style="padding-left: 20px;">b. Connect an a-c voltmeter to component-board points B1 and B2. Approximately 110 volts should be continuously present.</p> <p style="padding-left: 20px;">c. Check diodes CR1, Z1 and resistor R16 with an ohmmeter. WARNING: REMOVE CONTROL POWER FIRST.</p> <p style="padding-left: 20px;">d. Check continuity of T1 transformer windings. WARNING: REMOVE CONTROL POWER FIRST.</p> <p style="padding-left: 20px;">e. Check continuity with an ohmmeter. WARNING: REMOVE CONTROL POWER FIRST. Do not disturb the setting of the potentiometer.</p> <p style="padding-left: 20px;">f. Replace.</p> <p style="padding-left: 20px;">g. Replace.</p> <p style="padding-left: 20px;">h. Check switch operation manually, using an ohmmeter. WARNING: REMOVE THE CONTROL PLUG FROM THE BOTTOM OF THE POSITION-INDICATOR HOUSING BEFORE PERFORMING THIS TEST.</p>
<p>II. Indicating dial runs to the full-scale position.</p>	<p>1. High current level.</p> <p>2. Malfunction.</p> <p style="padding-left: 20px;">a. Defective output stage (shorted T1, shorted C2, shorted SCR1).</p> <p style="padding-left: 20px;">b. Defective feedback potentiometer R17 or open connection between it and the component board.</p> <p style="padding-left: 20px;">c. Defective current-divider resistor (R19) or scale multiplier switch (S2).</p>	<p>1. Place the scale multiplier in the X1 position.</p> <p>2.</p> <p style="padding-left: 20px;">a. Check transformer windings with an ohmmeter (PRI 140 ohms, SEC 4 Ohms). WARNING: REMOVE CONTROL POWER FIRST.</p> <p style="padding-left: 20px;">b. Check across the terminals of R17 with an ohmmeter. WARNING: REMOVE CONTROL POWER FIRST. (465 ohms at minimum dial position; 0 at maximum)</p> <p style="padding-left: 20px;">c. Check R19 (200 ohms) with an ohmmeter. WARNING: REMOVE THE CONTROL PLUG TO THE POSITION-INDICATOR HOUSING FIRST. Inspect switch S2.</p>

LOAD AMPERE CONVERSION CHART

Maximum Current Indicator Dial Reading	Scale Multiplier	Internal Current Transformer Primary Rating / 0.2 Amps												
		25	50	75	100	150	200	250	300	400	600	800	1200	1600
0.14	0.5	8.7	17.5	26.2	35	52.5	70	87.5	105	140	210	280	420	560
	1.0	17.5	35	52.5	70	105	140	175	210	280	420	560	840	1120
0.16	0.5	10	20	30	40	60	80	100	120	160	240	320	480	640
	1.0	20	40	60	80	120	160	200	240	320	480	640	960	1280
0.18	0.5	11.2	22.5	33.7	45	67.5	90	112.5	135	180	270	360	540	720
	1.0	22.5	45	67.5	90	135	180	225	270	360	540	720	1080	1440
0.20	0.5	12.5	25	37.5	50	75	100	125	150	200	300	400	600	800
	1.0	25	50	75	100	150	200	250	300	400	600	800	1200	1600
0.22	0.5	13.7	27.5	41.2	55	82.5	110	137.5	165	220	330	440	660	880
	1.0	27.5	55	82.5	110	165	220	275	330	440	660	880	1320	1760
0.24	0.5	15	30	45	60	90	120	150	180	240	360	480	720	960
	1.0	30	60	90	120	180	240	300	360	480	720	960	1440	1920
0.26	0.5	16.2	32.5	48.7	65	97.5	130	162.5	195	260	390	520	780	1040
	1.0	32.5	65	97.5	130	195	260	325	390	520	780	1040	1560	2080
0.28	0.5	17.5	35	52.5	70	105	140	175	210	280	420	560	840	1120
	1.0	35	70	105	140	210	280	350	420	560	840	1120	1680	2240
0.30	0.5	18.7	37.5	56.2	75	112.5	150	187.5	225	300	450	600	900	1200
	1.0	37.5	75	112.5	150	225	300	375	450	600	900	1200	1800	2400
0.32	0.5	20	40	60	80	120	160	200	240	320	480	640	960	1280
	1.0	40	80	120	160	240	320	400	480	640	960	1280	1920	2560
0.34	0.5	21.2	42.5	63.7	85	127.5	170	212.5	255	340	510	680	1020	1360
	1.0	42.5	85	127.5	170	255	340	425	510	680	1020	1360	2040	2720
0.36	0.5	22.5	45	67.5	90	135	180	225	270	360	540	720	1080	1440
	1.0	45	90	135	180	270	360	450	540	720	1080	1440	2160	2880
0.38	0.5	23.8	47.5	71.2	95	142.5	190	237.5	285	380	570	760	1140	1520
	1.0	47.5	95	142.5	190	285	380	475	570	760	1140	1520	2280	3040
0.40	0.5	25	50	75	100	150	200	250	300	400	600	800	1200	1600
	1.0	50	100	150	200	300	400	500	600	800	1200	1600	2400	3200

EXAMPLE A ↑ ← EXAMPLE B

This conversion chart is designed to cover all ratings of Voltage Regulators with maximum current indicator accessory. To determine which column applies, refer to regulator nameplate for the current transformer rating.

Example A: Regulator rated 76.2 kva, 7620 V, 100 amp., ±10%

1. From regulator nameplate, the C.T. primary rating is 100/0.2 A
2. Use column headed 100
3. Assuming, with regulator under load, the maximum current indicator dial reading is 0.22 with the scale multiplier set at 1.0. **LOAD CURRENT FROM CHART IS 110 AMPERES.**

Example B: Regulator rated 167 kva, 7620 V, 219 amp., ±10%

1. From regulator nameplate, the C.T. primary rating is 250/0.2 A
2. Use column headed 250
3. Assuming, with regulator under load, the maximum current indicator dial reading is 0.32 with the scale multiplier set at 0.5. **LOAD CURRENT FROM CHART IS 200 AMPERES.**

NOTE: A duplicate of this chart can be found inside the control cover.

REPLACEMENT PARTS LIST

ITEM	CATALOG NO.
Component Board Assembly	3907B983 G1
Motor - Indicator Assembly	3923B389 G1
Motor	3932A374 P21
Scale Multiplier Selector Switch (S2)	3917A112AB G1

**GENERAL ELECTRIC COMPANY
LARGE TRANSFORMER OPERATION
PITTSFIELD, MASSACHUSETTS 01201**

