INSTRUCTIONS

GEK- 34078A
Supersedes GEK-34078

STATIC POSITIVE SEQUENCE DISTANCE RELAY

TYPE SLYP51A

POWER SYSTEMS MANAGEMENT DEPARTMENT

GENERAL ELECTRIC

CONTENTS

DESCRIPTION

The SLYP51A is a solid state positive sequence distance relay that is packaged in one 2 rack unit case, the outline and mounting dimensions of which are illustrated in Figure 1.

This relay is not intended for use by itself. Rather it was designed to be employed in conjunction with other solid state measuring and logic relays to provide protection against all types of faults on series compensated lines and on uncompensated lines that are adjacent to series compensated lines. The total complement of functions that may be included in the SLYP51A are noted below.

M_1T - Short reach positive sequence directional mho tripping function.

L_1T - Long reach positive sequence directional lens tripping function.

M_1B - Offset mho positive sequence blocking function.

MOB - Positive sequence out-of-step detection function. Operates in conjunction with L_1T.

V_1 - Positive sequence voltage detector.

In general not all of the above functions are included in every SLYP51A since not all are required for all applications. Please refer to the overall logic diagram and the associated description for the specific job involved to determine which functions have been included. This information may also be obtained from the nameplate mounted on the SLYP51A relay since the nameplate lists the ranges of all the included measuring functions.

All SLYP51A relays include the wiring for all the above functions. When any function is omitted in a given relay this function may be added in the field by simply obtaining the necessary printed circuit cards and inserting them in the proper available sockets. However, in order to utilize the function, the proper logic is required in other relays that comprise the total scheme.

The internal connections for the complete SLYP51A are shown in Figure 3 while the component printed circuit card locations are indicated in Figure 2.

APPLICATION

The SLYP51A is a positive sequence relay that is intended to be an integral part of a pilot relaying scheme for use in the protection of series compensated lines or lines adjacent to series compensated lines. It is suitable for use in schemes that employ carrier channels as well as microwave channels.

Of all the above measuring functions in the SLYP51A, the L_1T and M_1B functions are essential to all schemes. The MOB function is required only if out-of-step detection is to be employed and if no SLLP POSITIVE sequence out-of-step blocking and tripping relay is a part of the scheme.

The V_1 function is used for line pick-up protection, loss of potential detection, and certain selective sequential reclosing schemes. It is required only if one or more of these schemes are to be a part of the total scheme of protection.

The M_1T function is required only for lines that are longer than 100 miles. In such applications it is used to supplement L_1T as part of the pilot scheme.

The basic protective scheme of which the SLYP51A is a part may be routinely applied to all lines up to 200 miles in length where:

a) The source of ac potential to the relays is located on the <u>line</u> side of the series capacitors in the protected line.

b) The compensation in the line does not exceed 80 percent.

c) The series capacitor protective gaps are set to flash at an instantaneous value of voltage that is equal to, or lower than, the peak value of the rated phase-to-neutral voltage of the line.

For the proper external connections for the SLYP51A relay please refer to the elementary diagrams furnished with the overall equipment.

RANGES

The SLYP51A relay has an adjustable system reach of 1 to 30 ohms in the forward (tripping) direction.

The reach of each measuring function in the SLYP51A is fixed at a specific percentage of the relay system reach. For example, if the relay system reach has been set at 4.0 ohms, and the unit nameplate indicates the M_1T reach is 75%, then the reach of the M_1T is 75% x 4 ohms = 3 ohms.

The percentage reach of each function is listed on the SLYP51A unit nameplate. Typical values are shown below:

M_1T	- 75% in the forward direction
L_1T, MOB	- 125% in the forward direction
M_1B	- 25% in the forward direction 75% in the reverse direction

The SLYP51A relay has an angle of maximum reach which is adjustable between 60 and 90 degrees.

The polarizing quantity of the mho functions may be shifted with respect to the operating quantity. Typical ranges of adjustment are listed below:

M_1T	-15° to $+30^{\circ}$
L_1T, MOB	0° to $+30^{\circ}$
M_1B	-15° to $+30^{\circ}$

The pickup range of the V_1 function is seventy to one hundred percent of the rated voltage.

All adjustment ranges for a particular SLYP51A relay are listed on the unit nameplate.

RATINGS

The Type SLYP51A relay is designed for use in an environment where the air temperature outside the relay case is between $-20^{\circ}C$ and $+65^{\circ}C$.

The Type SLYP51A relay requires a ±15 VDC power source which can be obtained from a Type SSA power supply.

The current circuits of the Type SLYP51A relay are rated at 5 amperes, rated frequency, for continuous duty and have a one second rating of 300 amperes. The potential circuits are rated 120 volts, rated frequency.

CHARACTERISTICS

Operating Principles

The Type SLYP51A relay uses positive sequence voltage and current networks to obtain the V_1 and I_1Z quantities. These quantities are used to derive the various mho characteristics employed in the SLYP51A relay. The operating theory is described in the following sections.

A. Positive Sequence Voltage Network

The positive sequence voltage network used in the SLYP51A relay is shown in Figure 4. The derivation of the output voltage is described below.

$$V_{out} = V_{B-C} \left(\frac{kP1 + R2}{R1+R2+P1}\right) + V_{C-A} \left(\frac{m\ P2}{mP2 + 1/jwc}\right)$$

where K and m are the percents of P1 and P2 used.

By design,

$$\frac{kP1 + R2}{R1 + R2 + P1} = \frac{1}{2}$$

and $$\frac{m\ P2}{m\,P2 + 1/jwc} = \frac{1}{2}\ \underline{/60^{o}}$$

Therefore:

$$V_{OUT} = 1/2\ V_{B-C} + \frac{1}{2}\ V_{C-A}\ \underline{/60^{o}}$$

$$V_{A} = V_{A0} + V_{A1} + V_{A2}$$

$$V_{B} = V_{A0} + a^{2}\ V_{A1} + a\ V_{A2}$$

$$V_{C} = V_{A0} + a\ V_{A1} + a^{2}\ V_{A2}$$

$$V_{OUT} = 1/2 \left[(V_{A0} + a^{2}\ V_{A1} + a\ V_{A2}) - (V_{A0} + a\ V_{A1} + a^{2}\ V_{A2}) \right] + 1/2\ \underline{/60^{o}} \left[(V_{A0} + a\ V_{A1} + a^{2} V_{A2}) - (V_{A0} + V_{A1} + V_{A2}) \right]$$

$$V_{OUT} = 1/2 \left[(a^{2} - a)\ V_{A1} + (a - a^{2})\ V_{A2} \right] + 1/2\ \underline{/60^{o}} \left[(a - 1)\ V_{A1} + (a^{2} - 1)\ V_{A2} \right]$$

$$V_{OUT} = .866\ (V_{A1}\ \underline{/\ \ } - 90^{o} + V_{A1}\ \underline{/\ \ }\ 210^{o} + V_{A2}\ \underline{/\ \ }\ 90^{o} + V_{A2}\ \underline{/\ \ }\ 270^{o})$$

$$V_{OUT} = 1.5\ V_{A1}\ \underline{/\ \ }\ 240^{o}$$

For a pure positive sequence input:

$$V_{OUT} = .866\ V_{C-A}\ \underline{/90^{o}}$$

B. Positive Sequence Current Network

The positive sequence current network used in the SLYP51A relay is shown in Figure 5. The network consists of two transactors (TB and TC), each with two primary windings and an adjustable resistive load across the secondary winding.

The term "transactor" is a contraction of transformer-reactor. It is essentially an air-gap current transformer with secondary current (and therefore secondary voltage across the loading resistor) proportional by its transfer impedance and the associated angle.

$$Z_{T} = \frac{V_{OUT}}{I_{IN}}\ \underline{/\ \ }\ \theta_{T}$$

Where: V_{OUT} = Secondary output voltage
I_{IN} = Vector sum of the input currents
θ_{T} = Angle by which V_{OUT} leads I_{IN}

The derivation of the positive sequence current network output voltage is given below.

By design,

$$Z_{TC} = .85\ \sqrt{3}\ Z_{TB}$$

$$\theta_{TB} = 75^{o}$$

$$\theta_{TC} = 45^{o}$$

$$V_{OUT} = k \left[Z_{TB}\ (I_{C} - I_{B})\ \underline{/75^{o}} \right] + Z_{TC}\ (I_{B} - 1/3\ I_{N})\ \underline{/45^{o}}$$

where k is the percentage of P3 used.

Let k = .85

$$V_{OUT} = .85\ Z_{TB}\ (I_C - I_B)\ \underline{/75^o} + .85\ \sqrt{3}\ Z_{TB}\ (I_B - 1/3\ I_N)\ \underline{/45^o}$$

$$V_{OUT} = .85\ Z_{TB} \left[I_{Ao} + a\ I_{A1} + a^2\ I_{A2} - (I_{Ao} + a^2\ I_{A1} + a\ I_{A1}) \right] \underline{/75^o}$$

$$+ .85 \sqrt{3}\ Z_{TB} \left[I_{A0} + a^2\ I_{A1} + a\ I_{A2} - 1/3\ (3I_o) \right] \underline{/45^o}$$

$$V_{OUT} = .85\ Z_{TB} \left[(a - a^2)\ I_{A1} + (a^2 - a) I_{A2} \right] \underline{/75^o} + .85 \sqrt{3}\ Z_{TB} \left[a^2\ I_{A1} + a\ I_{A2} \right] \underline{/45^o}$$

$$= .85\ Z_{TB}\ (\sqrt{3}\ I_{A1}\ \underline{/90^o} + \sqrt{3}\ I_{A2}\ \underline{/-90^o})\ \underline{/75^o} + .85 \sqrt{3}\ Z_{TB}\ (I_{A1}\ \underline{/240^o} + I_{A2}\ \underline{/120^o})\ \underline{/45^o}$$

$$= .85 \sqrt{3}\ Z_{TB}\ (I_{A1}\ \underline{/165^o} + I_{A1}\ \underline{/285^o} + I_{A2}\ \underline{/-15^o} + I_{A2}\ \underline{/165^o})$$

$$= .85 \sqrt{3}\ Z_{TB}\ \ I_{A1}\ \underline{/225^o}$$

By means of similar manipulations it may be shown that the positive sequence networks of the SLYP51A produce no output when pure negative sequence quantities are applied.

C. Positive Sequence Mho Characteristics

The principle used to derive the mho characteristics is illustrated in Figure 6. The I_1Z quantity is a voltage proportional to the positive sequence current in the line, and is obtained from the positive sequence current filter. The V_1 quantity is porportional to positive sequence voltage at the relay location and is obtained from the positive sequence voltage network. The quantity $(I_1Z - V_1)$ is the phasor difference between these two quantities. I_1Z' is the reverse reach of the relay. The quantity $(I_1Z' + V_1)$ is the phasor sum of I_1Z' and V_1. The angle B between $(I_1Z - V_1)$ and $(I_1Z' + V_1)$ is less than 90^o for an impedance point internal to the relay characteristic, equal to 90^o at the balance point, and greater than 90^o for an external impedance point for which the relay should not operate. The quantities V_1 and I_1Z are converted into blocks of voltage representing the quantities $(I_1Z - V_1)$ and $(I_1Z' + V_1)$. The coincidence of these blocks is then measured. Blocks which are 90^o apart are coincident for 4.17 ms. Blocks which are less than 90^o apart are coincident for more than 4.17 ms. Blocks which are more than 90^o apart are coincident for less than 4.17 ms. The mho function consists of a filter card, a coincidence card, and a timer card which measures the coincidence of $(I_1Z - V_1)$ and $(I_1Z' + V_1)$. This circuit is shown in Figure 3.

L_1T Function

The resistor R_B, which is mounted on the N101 card in position E, determines the relationship between the reach of the L_1T function and the reach of the relay unit. The L_1T reach, at the relay angle of maximum reach, may be calculated from the expression:

$$Z_{MAX} = \frac{K\ TB}{T} \times 100$$

where:

T = Voltage restraint tap setting expressed in percent
T_B = Basic minimum ohmic tap setting
$K = \frac{20K}{R_B + 10K}$ = percentage reach of $L_1T/100$

The F106 filter card (position G) is supplied with three inputs: I_1Z, $+ V_1$, $- V_1$. The outputs of the filter card are 30 VDC square waves (-15 VDC to +15 VDC). The square wave output at pin 9 is the polarizing quantity derived from the $+V_1$ input, and the square wave output at pin 8 is the operating quantity derived from $-(I_1Z - V_1)$. In addition to filtering, the F106 card provides an adjustment of the phase relationship between the output quantities by shifting the polarizing quantity relative to the operating quantity. When the polarizing quantity is shifted, the filter card outputs are $-(I_1Z - V_1)$ and V_{POL} where V_1 is the positive sequence voltage at the fault and V_{POL} is the phase shifter polarizing quantity. L_1T operation occurs when the coincidence between $I_1Z - V_1$ and V_{POL} is equal to the characteristic timer setting.

The construction of the mho characteristic for leading and lagging polarizing voltage is shown in Figure 16. The reach at the relay angle is a chord of all the characteristics. The polarizing phase shift angle (Ø) is positive in the counter clockwise direction. The angles α_1 and α_2 are determined by the characteristic timer setting (TS) and the polarizing phase shift Ø:

$$\alpha_1 = TS - \emptyset$$

$$\alpha_2 = TS + \emptyset$$

The C101 coincidence measurement card (position B) compares the positive half cycle of one square wave with the negative half cycle of the other; when both are present simultaneously an output is produced. The output blocks are thereby produced when V_1 and $(I_1Z - V_1)$ are coincident. Typical waveforms are shown in Figure 7.

The output blocks from the C101 card are the inputs to the timer card in position N. The timer card produces an output when the width of the input blocks exceeds the pickup setting of the timer. At a given angle (other than the relay angle) the pickup point changes when the pickup setting of the characteristic timer is changed. Increasing the pickup time decreases the fault voltage required for operation.

The other mho characteristics operate in a similar manner.

Operating Characteristics

The operate and reset times of each mho function is basically determined by the characteristic timer, the type of fault and the incidence angle. There is no significant time delay in the circuitry ahead of the timer.

A phase current of one ampere on a three phase fault will cause the SLYP51A relay to pull back to no less than 90% of the nominal reach, with a basic ohmic tap setting (T_B) of 3Ω.

DC Burden

The Type SLYP51A relay presents a burden to the Type SSA power supply of:

200 ma from the +15 VDC supply
100 ma from the -15VDC supply

AC Burden

Potential circuits at 120 V Ø - Ø

	PHASE A		PHASE B		PHASE C	
	100%	0%	100%	0%	100%	0%
RESTRAINT	7.0		11.5		5.5	
VOLT-AMP						
WATTS						
VARS						

Current circuits at 5A Ø-N

	PHASE A		PHASE B		PHASE C	
BASE TAP	3Ω	1Ω	3Ω	1Ω	3Ω	1Ω
R	0.0	0.0	.013		.040	
X	0.0	0.0	.013		.023	
Z	0.0	0.0	.018		.046	

CALCULATION OF SETTINGS

The proper settings for the measuring functions in the SLYP51A relay will depend to a large degree on the specific application. For this reason, it is recommended that the application information supplied with the description of the overall logic diagram of the total scheme be consulted for the proper considerations and settings. There are a number of adjustments available in this relay but only some of them are intended for field settings. They are itemized below.

The reach settings of the L_1T, M_1B, MOB (when used) and M_1T (when used) functions are all made by one common adjustment. This is done in two parts.

With this common setting, the relative reaches of all these functions are fixed at the factory for the specific application of long line (100-200 miles) or short line (less than 100 miles). If for any reason the intended application changes from long to short line or vice versa, it may be necessary to alter the relationship between the reach settings of these units. This may be simply accomplished in the field but the local General Electric Company Sales Office should be consulted for suggested settings.

Since the shape of the MOB characteristic will depend on the application and system conditions, the characteristic timer for this function will require field setting when it is used.

The pick-up voltage setting of the V_1 function must be made in the field.

Please refer to the INSTALLATION TESTS section of this instruction book for information on how to make the desired settings on this relay.

RECEIVING, HANDLING AND STORAGE

These relays will normally be supplied as a part of a static relay equipment, mounted in a rack or cabinet with other static relays and test equipment. Immediately upon receipt of a static relay equipment, it should be unpacked and examined for any damage sustained in transit. If injury or damage resulting from rough handling is evident, file a damage claim at once with the transportation company and promptly notify the nearest General Electric Sales Office.

Reasonable care should be exercised in unpacking the equipment. If the equipment is not to be installed immediately, it should be stored indoors in a location that is free from moisture, dust, and metallic chips, and severe atmospheric contaminants.

Just prior to final installation the shipping support bolt should be removed from each side of all relay units, to facilitate possible future unit removal for maintenance. These shipping support bolts are approximately 8 inches back from the relay unit front panel. Static relay equipment, when supplied in swing rack cabinets, should be securely anchored to the floor or to the shipping pallet to prevent the equipment from tipping over when the swing rack is opened.

INSTALLATION TESTS

CAUTION

THE LOGIC SYSTEM SIDE OF THE DC POWER SUPPLY USED WITH MOD III STATIC RELAY EQUIPMENT IS ISOLATED FROM GROUND. IT IS A DESIGN CHARACTERISTIC OF MOST ELECTRONIC INSTRUMENTS THAT ONE OF THE SIGNAL INPUT TERMINALS IS CONNECTED TO INSTRUMENT CHASSIS. IF THE INSTRUMENT USED TO TEST THE RELAY EQUIPMENT IS ISOLATED FROM GROUND, ITS CHASSIS MAY HAVE AN ELECTRICAL POTENTIAL WITH RESPECT TO GROUND. THE USE OF A CONNECTION TO THE EQUIPMENT, SUCH AS A TEST LEAD INADVERTANTLY DROPPING AGAINST THE RELAY CASE, MAY CAUSE DAMAGE TO THE LOGIC CIRCUITRY. NO EXTERNAL TEST EQUIPMENT SHOULD BE LEFT CONNECTED TO THE STATIC RELAYS WHEN THEY ARE IN PROTECTIVE SERVICE, SINCE TEST EQUIPMENT GROUNDING REDUCES THE EFFECTIVENESS OF THE ISOLATION PROVIDED.

The Type SLYP51A relay is usually supplied from the factory mounted and wired in a static relay equipment. The following checks and adjustments should be made by the user in accordance with the procedure given under DETAILED TESTING INSTRUCTIONS before the relays are put into service.

1. Positive sequence voltage network balance check*
2. Positive sequence current network balance check*
3. Relay angle of maximum reach setting
4. I_1Z magnitude setting*
5. Voltage restraint tap setting
6. Basic minimum ohmic tap setting
7. Mho characteristic timer setting*
8. Mho characteristic phase angle adjustment
9. Level detector pickup setting

* Factory Setting

Construction

The SLYP51A relay is packaged in an enclosed metal case with hinged front cover and removable top cover. The case is suitable for mounting on a standard 19 inch rack. The outline and mounting dimensions of the case and the physical location of the components are shown in Figures 1 and 2 respectively.

The tap blocks for making the voltage restraint settings are located on the front panel of the unit. The method of making restraint tap settings is illustrated in Figure 8. The connections are made by means of taper pin connectors; special tools are supplied with each equipment for the removal and insertion of these pin connectors.

The current and potential enter the SLYP51A on twelve point terminal strips located on the rear of the relay case. The potential connections are made on the YA terminal strip, the current connections on the YB terminal strip.

The basic minimum ohmic tap (T_B) setting is accomplished on the YB terminal strip on the rear panel of the unit. The current connections for the 1Ω and 3Ω taps are shown in Table I.

TABLE I

	I_C		I_B		$3I_0$	
	IN	OUT	IN	OUT	IN	OUT
1Ω BASE REACH	YB1	YB2	YB4	YB6	YB9	YB10
3Ω BASE REACH	YB1	YB3	YB5	YB7	YB8	YB10

The V_1 and I_1Z test jacks, the IZ magnitude reach pot (P6) are located on the front of the unit below and voltage restraint taps. The positive sequence filter potentiometers (P1, P2, P3, P4) are located inside the relay case as shown in Figure 2.

The SLYP51A relay also contains printed circuit cards identified by a code number such as F106, C101, D101, T101, N101, where F designates filter, C designates coincidence, D designates level detector, T designates time delay, and N designates network. The printed circuit cards plug in from the front of the unit. The sockets are identified by letter designations or "addresses" (D, E, F, etc.) which appear on the guide strips in front of each socket, on the component location diagram, on the internal connection diagram and on the printed circuit card itself. The test points (TP1, TP2, etc.) shown on the internal connection diagram, are connected to instrument jacks on a test card position T with TP1 at the top of the card. The internal connections of the printed circuit cards are shown in the Printed Circuit Card Instruction Book GEK-34158.

Pin number 1 on the test card in position T is connected to relay reference, number 2 to -15 VDC, and pin number 10 to +15 VDC. Output signals are measured with respect to the reference bus on the test card (TP1). Logic signals are approximately +15 VDC for the ON or LOGIC ONE condition, and less than 1 VDC for the OFF or LOGIC ZERO condition. Filter card outputs are either +15 VDC or -15 VDC for the ON condition.

These outputs can be monitored with an oscilloscope, a portable high impedance DC voltmeter, or the test panel voltmeter if available. When the test panel meter is supplied, it will normally be connected to the reference bus. Placing the relay test lead in the proper test point pin jack will connect the meter for testing. When time delay cards are to be adjusted or checked, an oscilloscope which can display two traces simultaneously and which has a calibrated horizontal sweep should be used.

Detailed Testing Instructions

Before proceeding with the following test program, be sure that the tripping circuits from the associated Type SLAT relay are open.

A. Positive Sequence Network Balance Checks

The voltage and current sequence networks have been accurately preset at the factory to obtain negative sequence cancellation. No further adjustments should be required in the field. It is recommended, however, that the networks be checked at the time of installation to insure that nothing has occurred during shipment to unbalance the networks.

Positive Sequence Voltage Network

To check the null of the sequence voltage network, use the test circuit of Figure 9 and the connections of Table II. Three three phase-phase voltages should be exactly equal in magnitude and 120° apart. For best resolution, use a voltage near the rated value. If the source voltages are not balanced (within a few percent) a single phase variac should be used to correct the unbalanced phase.

TABLE II

TEST FIGURE POINT	A	B	C
SLYP51A TERMINAL	YA2	YA4	YA3

The voltage at the V_1 test jack should consist solely of harmonics with no fundamental present. The peak to peak value of the network output will depend on the system, but should be on the order of a few tenths of a volt.

If the network needs readjustment to eliminate the 60 Hz fundamental, set P1 and P2 at midrange. Alternately make small adjustments in P1 and P2 until the desired level is achieved.

Positive Sequence Current Network

Method I - Three Phase Test Source

To check the null of the sequence current network, use the test circuit of Figure 10 and the connections of Table III. The three currents should be exactly equal in magnitude and 120° apart. Rated current (5A) will provide best resolution. If the source voltages are not balanced (within a few percent) a single phase variac should be used to correct the unbalanced phase.

TABLE III

TEST FIGURE POINT	D	E	F	G
SLYP51A TERMINAL	YB7	YB5	YB3	YB1

Jumper H to I

The voltage at the I_1Z test jack should consist solely of harmonics with no fundamental present. The peak to peak value of the network output will depend on the system, but should be on the order of a few tenths of a volt.

If the network needs readjustment to eliminate the 60 Hz fundamental, set P3 and P4 at midrange. Alternately make small adjustments to P3 and P4 until the desired level is achieved.

Method II - Single Phase Test Source

The basic circuit used in checking the network is shown in Figure 11. This arrangement provides the means of obtaining two test currents of equal magnitude but separated by 60°. Then by appropriate connections to the network it is possible to simulate a balanced negative-sequence current (Table IV). During the following tests the basic current level in each branch will be 5 amps, and since these currents will add at a 60° angle, the total load in the variac will be about 8.7 amps. It is desirable that the 110 volt scale of the phase angle meter be used to minimize the effect of this potential circuit on the relation between the two test currents. It is further desirable that the variac be set near its maximum voltage output and that the load boxes be set to obtain approximately 5 amps as a preliminary step, since this will provide the greatest possible voltage to the phase angle meter and will insure the best possible accuracy.

The negative sequence current is simulated by setting branch "A" current to lag an equal current in branch "B" by 60° and by reversing the branch "B" current at the relay. Branch "A" current now leads the reversed branch "B" current by 120°.

The following procedure is suggested.

1. Make connections per Figure 11 and Table IV.
2. Adjust the branch "B" load box to obtain approximately 5 amps when the Variac is set for 110 volts.
3. Adjust the branch "A" load box until the phase angle meter indicates a 60° lag of current with respect to voltage.
4. Readjust the branch "B" load box until branch "A" and "B" currents are equal.
5. Adjust the Variac until both currents are 5 amps.
6. Touch up branch "A" load box for angle trimming and branch "B" load box for magnitude trimming.

TABLE IV

TEST FIGURE POINT	A	B	C
SLYP51A TERMINAL	YB1	YB7	YB3, YB5

The voltage at the I_1Z jack may be a distorted wave at system frequency. With perfectly balanced currents and a network which has been perfectly adjusted, the waveform observed at the I_1Z test jack should consist solely of harmonics (primarily third and fifth).

Since perfection is seldom realized, the branch "A" and branch "B" load boxes should now be touched up until the waveform contains no fundamental component, and then the variac readjusted until the branch "B" current is again 5 amps. Branch "A" current should be 5 amps ± 0.5 amps, and the angle between the "A" and "B" currents should be $60^{\circ} \pm 3^{\circ}$. The peak-to-peak value of the network output, which now will consist solely of harmonics, will depend on the system, but should be on the order of a few tenths of a volt.

If the network needs readjustment to eliminate the 60 Hz fundamental, follow steps 1 through 6 above. Set P3 and P4 at mid-range. Alternately make small adjustments to P3 and P4 until the desired level is achieved.

B. I_1Z Magnitude Adjustment And Relay Angle Of Maximum Reach Adjustment

Since there is some interdependence between these two adjustments, if either one is changed the other should be checked.

Method I - Three Phase Test Current Source

Use the test circuit of Figure 12 and the connections of Table V. Set voltage restraint taps at 100%.

TABLE V

TEST FIGURE POINT	A	B	C	D	E	F	G
SLYP51A TERMINAL	YA2	YA3	YA4	YB5	YB7	YB1	YB3

Jumper H to I and J to K

It is the nature of this test circuit that the relay angle of maximum reach leads the apparent (measured) angle by 30°. Thus if an angle of maximum reach of 85° is desired, the apparent (measured) angle will be 55°.

The test procedure is outlined below:

1. Set $V_{\emptyset-\emptyset}$ equal to 26 V_{RMS} and the current equal to 5 amperes (each phase).

For testing at restraint taps other than 100%, the phase to phase voltage should equal:

$$V_{\emptyset-\emptyset} = \frac{26 \text{ VRMS}}{\% \text{ RESTRAINT}} \times 100$$

2. Adjust phase shifter to obtain desired angle reading on the phase angle meter (30° lagging desired angle of maximum reach).

3. Adjust P6 until the voltage at the I_1Z test jack is exactly in phase with the voltage at the V_1 test jack.

4. Adjust P5 until the voltage (RMS) at the I_1Z test jack exactly equals that at the V_1 test jack.

5. Repeat steps 3 and 4, if necessary.

Method II - Single Phase Test Current Source

Use the test circuit of Figure 13 and the connections of Table VI. These connections simulate a B-C fault.

TABLE VI

TEST FIGURE POINT	A	B	C	D	E	F	G
SLYP51A TERMINAL	YA2	YA3	YA4	YB5	YB7	YB3	YB1

It is the nature of this test circuit that the relay angle of maximum reach lags the measured, or apparent line angle by 120°. Thus if an angle of maximum reach of 85° is desired, the apparent angle will be 205°.

The test procedure is outlined below:

1. Set $V_{\emptyset-\emptyset}$ equal to 15 VRMS ($26/\sqrt{3}$), and the current equal to 5 (each phase).

2. Adjust phase shifter to obtain desired angle reading on the phase angle meter (apparent angle of maximum reach leads actual angle of maximum reach by 120°).

3. Adjust P6 until the voltage at the I_1Z test jack is exactly in phase with the voltage at the V_1 test jack.

4. Adjust P5 until the voltage (RMS) at the I_1Z test jack exactly equals that at the V_1 test jack.

5. Repeat steps 3 and 4 if necessary.

3Io Circuit Check

Apply five amperes to the relay per the test circuit of Figure 14 and the connections of Table VII. Check that the voltage (RMS) at the I_1Z test jack is one third of that obtained by Method I or $1/\sqrt{3}$ times that obtained by Method II.

TABLE VII

TEST FIGURE POINT	A	B
SLYP51A TERMINAL	YB8	YB10

C. Voltage Restraint Tap Setting

The arrangement of the voltage restraint tap blocks is described under CONSTRUCTION, and the choice of tap settings is discussed in the section on CALCULATION OF SETTINGS. The pickup voltage at the relay angle of maximum reach is given by the relationship.

$$V_1 = \frac{I_1 \times T_B \times 100}{T}$$

where: T = Voltage restraint tap setting in percent
T_B = Basic minimum ohm tap setting
I_1 = Positive sequence test current

D. Basic Minimum Ohmic Tap Setting

The arrangement of the basic ohmic taps is described under CONSTRUCTION, and the choice of tap settings is discussed in the section on CALCULATION OF SETTINGS. The reach at the relay angle of maximum reach is given by the relationship:

$$Z_{MAX} = \frac{T_B \times 100}{T}$$

where: T = Voltage restraint tap setting in percent
T_B = Basic minimum ohmic tap setting

E. Mho Characteristic Tests
Timer Adjustments And Tests

The pickup setting of the characteristic timer determines the shape of the mho characteristic. Increasing the timer pickup setting tends to narrow the characteristic; decreasing the setting widens the characteristic. The reset time delay (drop out time) of the timer provides an overlap of the next half cycle measurement and produces a continuous logic signal. The timer settings are discussed in the section CALCULATION OF SETTINGS.

Method I - Switched D.C. Input

In order to test the timer cards by this method, it is necessary to remove the card previous to the timer and to place the timer card in a card adapter. The timer test circuit is shown in Figure 15. Opening the N.C. contact causes the output to step up to +15 VDC after the pickup delay of the timer. To increase the pickup time, turn the upper potentiometer (on the T101 and T107 cards adjust P2) on the timer card clockwise. Closing the contact causes the timer output to drop out after the reset delay setting of the card. To increase the reset time, turn the lower potentiometer (on the T101 and T107 cards adjust P3) on the card clockwise.

The shorter pickup time of the T107 card can be observed at pin 7 on the card. The longer pickup time is factory adjusted by P1 for a pickup 1.2 ms longer than the shorter time. This output must be observed at pin 8.

Method II - AC Inputs

Either the three phase test current source circuit or the single phase test current source circuit shown in section B can be used to provide AC input quantities to adjust the timers.

The test procedure is outlined below:

1) Set the current equal to five amperes.

2) Adjust the voltage until blocks of the desired pick up width are present at the input to the timer card.

3) Turn the dropout potentiometer counter clockwise to decrease dropout time. This allows the pickup time to be observed.

4) Adjust the pickup potentiometer so that the timer just picks up.

5) Turn the dropout potentiometer clockwise until the output is continuous. At this point one additional turn should be given to the potentiometer.

For dropout times greater than 1/4 cycle (MOB, M_1B), the switch DC input method described above must be used. The switches DC input method must also be used to check the longer pickup setting of T107 timer card.

F. Filter Card Phase Shift Adjustment

Each filter card is equipped with an adjustable phase shift in the polarizing circuit. The setting of the polarizing quantity with respect to the operating quantity is discussed in the section CALCULATION OF SETTINGS. The effects of leading and lagging polarizing quantities are shown in Figure 16.

A 4.17 ms characteristic (circle) remains circular if the polarizing voltage is shifted leading or lagging. The area of the circle, however, increases.

To set the polarizing phase shift, use the test circuit of Figure 9 and the connections of Table VIII.

TABLE VIII

TEST FIGURE POINT	A	B	C
SLYP51A TERMINAL	YA2	YA3	YA4

With 0^o polarizing phase shift the outputs at pins 8 and 9 are in phase. Turning P71 counter clockwise causes the polarizing voltage at pin 9 to lag the operate voltage at pin 8; turning P71 clockwise causes the polarizing voltage to lead the operate voltage.

G. V_1 Level Detector Adjustment

The positive sequence voltage pickup level setting is discussed in the section CHOICE AND CALCULATION OF SETTING. Using the test circuit of Figure 9 and the connections of Table VIII apply the desired voltage to the relay. Adjust potentiometer P1 until the card just picks up. Turning P1 clockwise increases the pickup level.

PERIODIC CHECKS AND ROUTINE MAINTENANCE

Periodic Tests

All functions included in the SLYP51A relay may be checked at periodic intervals using the procedures described in the section INSTALLATION TESTS. Cable connections between the SLYP51A and the associated Type SLA relay may be checked by observing the test points in the SLA unit.

The following checks should be made during periodic testing:

1. Relay angle of maximum reach setting.
2. Voltage restraint tap setting.
3. Basic minimum ohmic tap setting.
4. Mho characteristic timer setting.
5. Mho characteristic phase angle setting.
6. V_1 level detector pickup setting.

Trouble Shooting

In any trouble shooting of equipment, it should first be established which unit is functioning incorrectly. The overall logic diagram supplied with the equipment shows the combined logic of the complete equipment and the various test points in each unit. By signal tracing, using the overall logic diagram and the various test points, it should be possible to quickly isolate the trouble.

A test adapter card is supplied with each static relay equipment to supplement the prewired test points on the test cards. Use of the adapter card is described in the card instruction book GEK-34158.

A dual-trace oscilloscope is a valuable aid to detailed trouble shooting, since it can be used to determine phase shift, operate and reset times as well as input and output levels. A portable dual-trace oscilloscope with a calibrated sweep and trigger facility is recommended.

Spare Parts

To minimize possible outage time, it is recommended that a complete maintenance program should include the stocking of at least one spare card of each type. It is possible to replace damaged or defective components on the printed circuit cards, but great care should be taken in soldering so as not to damage or bridge-over the printed circuit busses, or overheat the semi-conductor components. The repaired area should be recovered with a suitable high-dielectric plastic coating to prevent possible breakdowns across the printed busses due to moisture and dust. The wiring diagrams for the cards in the SLYP51A relay are included in the card book GEK-34158; the card types are shown on the component location diagram (Figure 2).

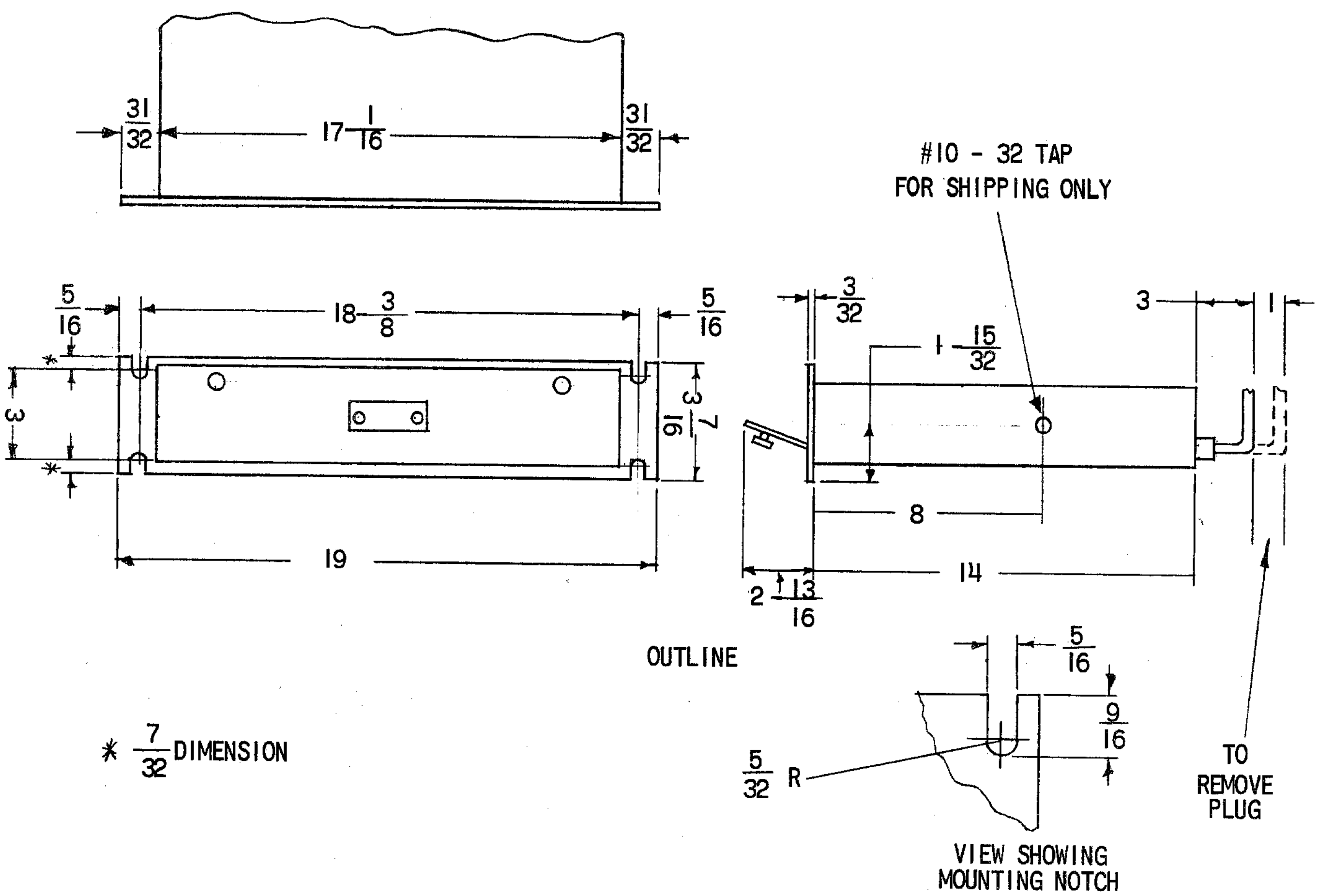
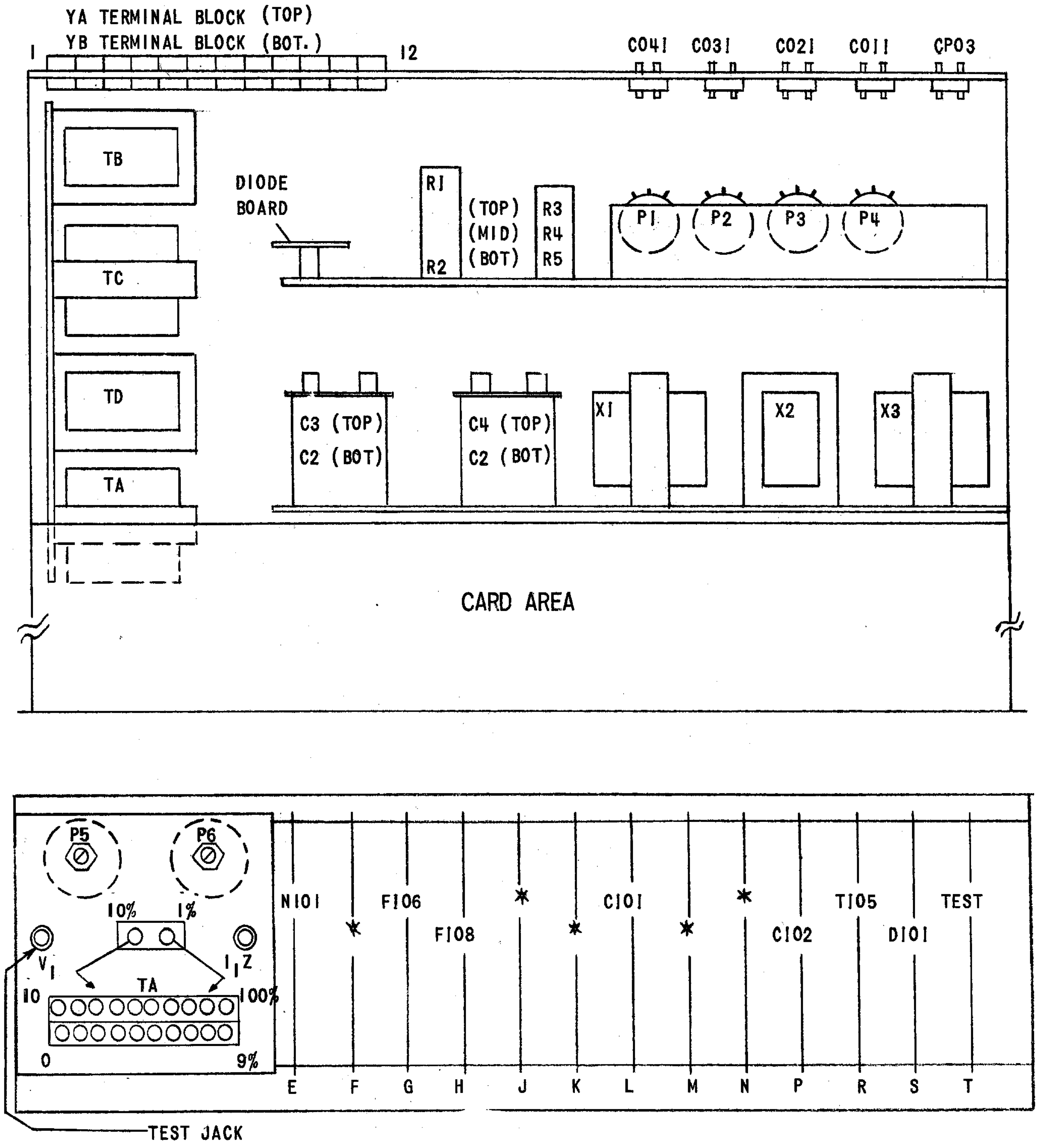


FIG. 1 (0227A2036-0) Outline And Mounting Dimensions For The Type SLYP51A Relay



* SEE INTERNAL 0149C7225 FOR CARDS IN THESE POSITIONS

FIG. 2 (0246A2491-2) Component And Card Locations For The Type SLYP51A Relay

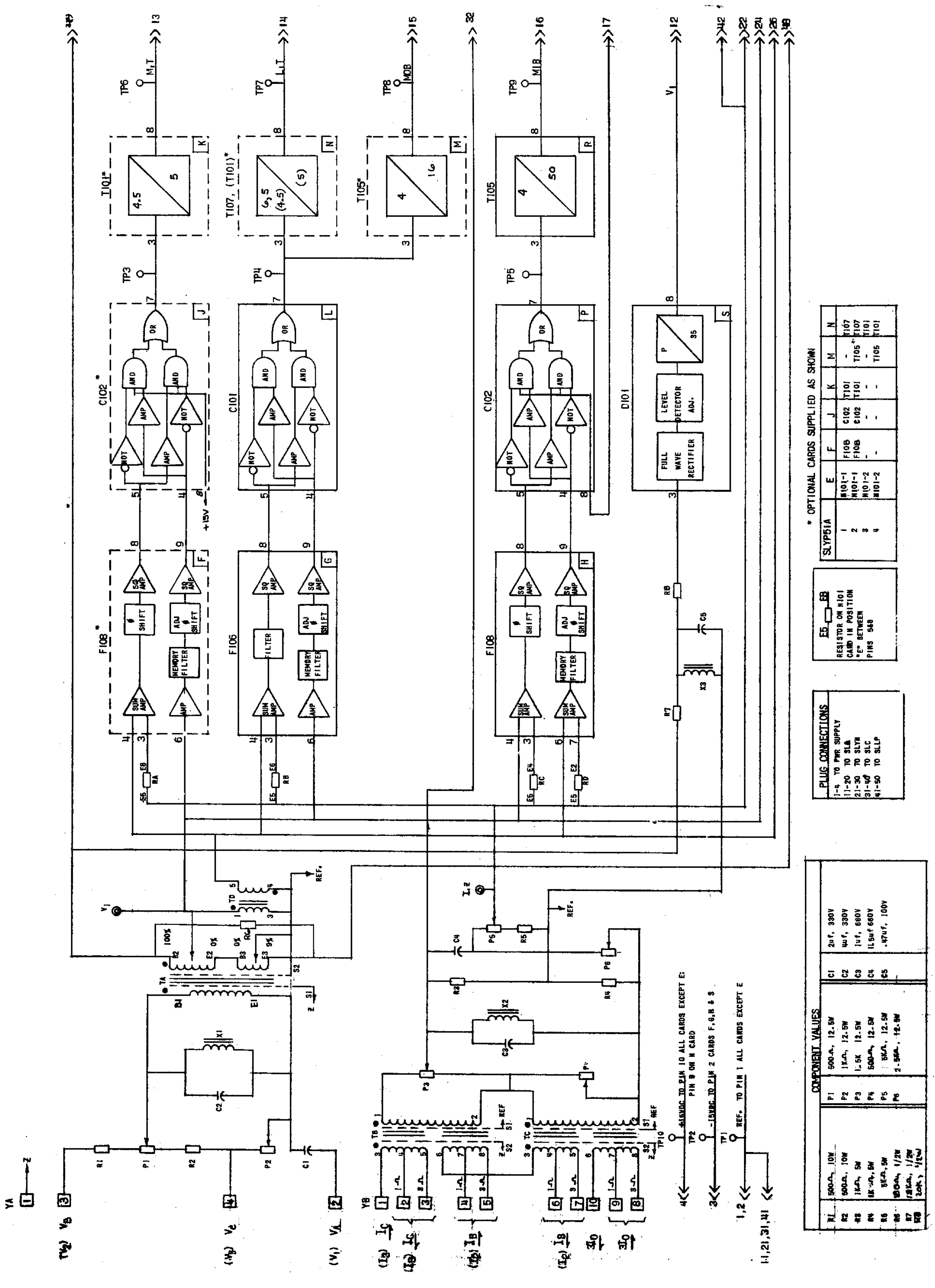


FIG. 3 (0149C7225-10) Internal Connections For The Type SLYP51A Relay

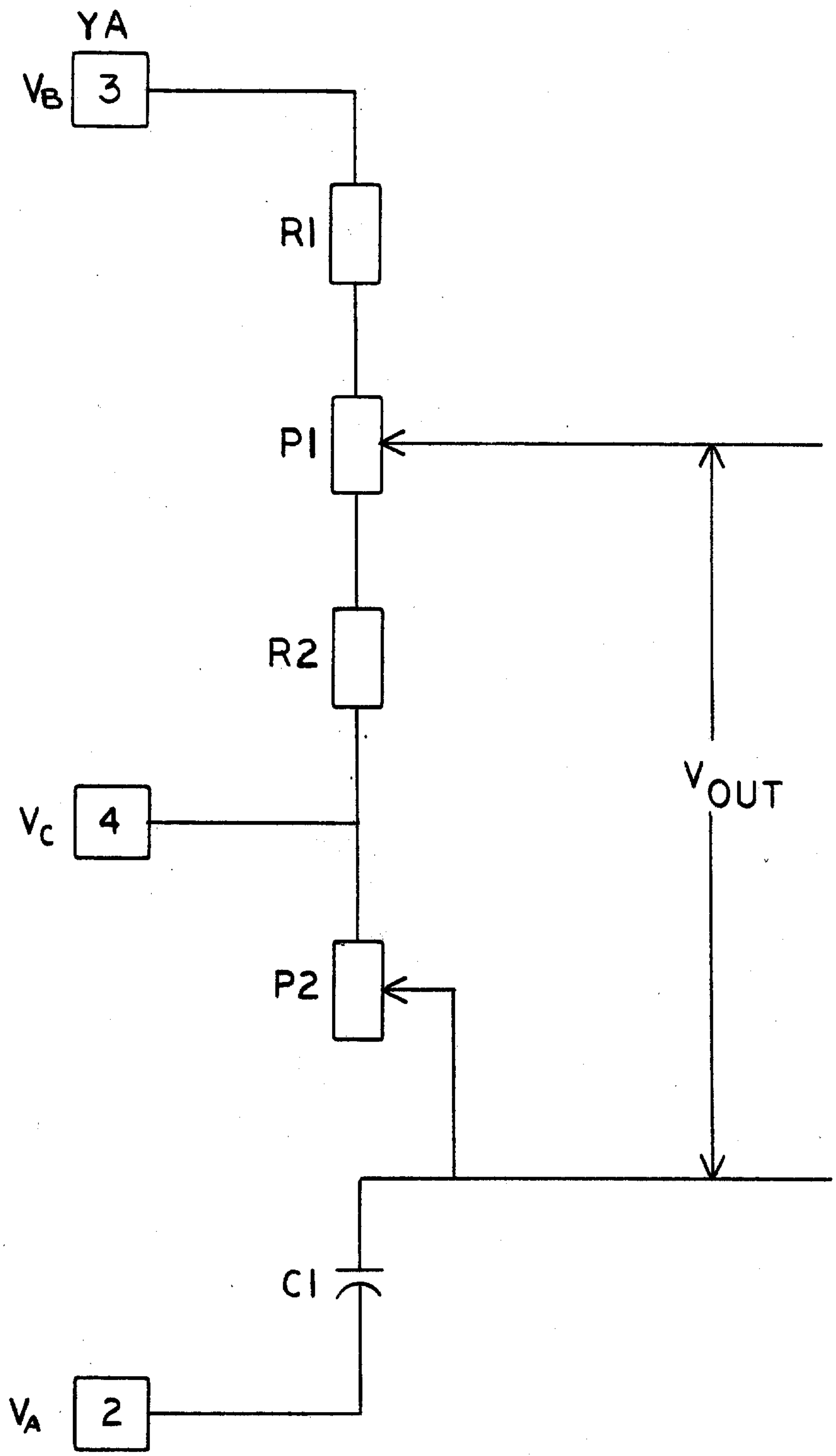


FIG. 4 (0246A6887-0) SLYP Positive Sequence Voltage Network

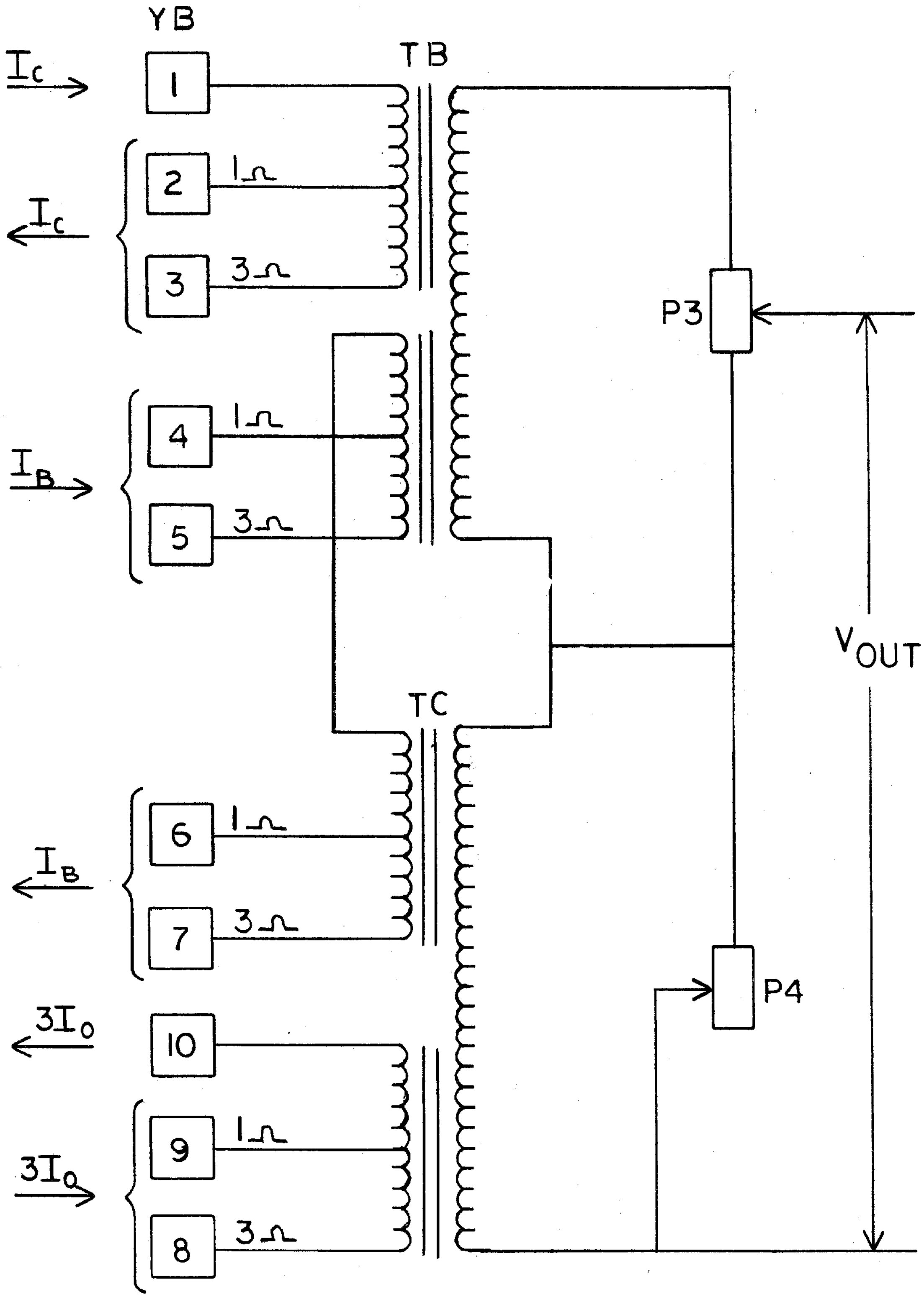


FIG. 5 (0246A6886-0) SLYP Positive Sequence Current Network

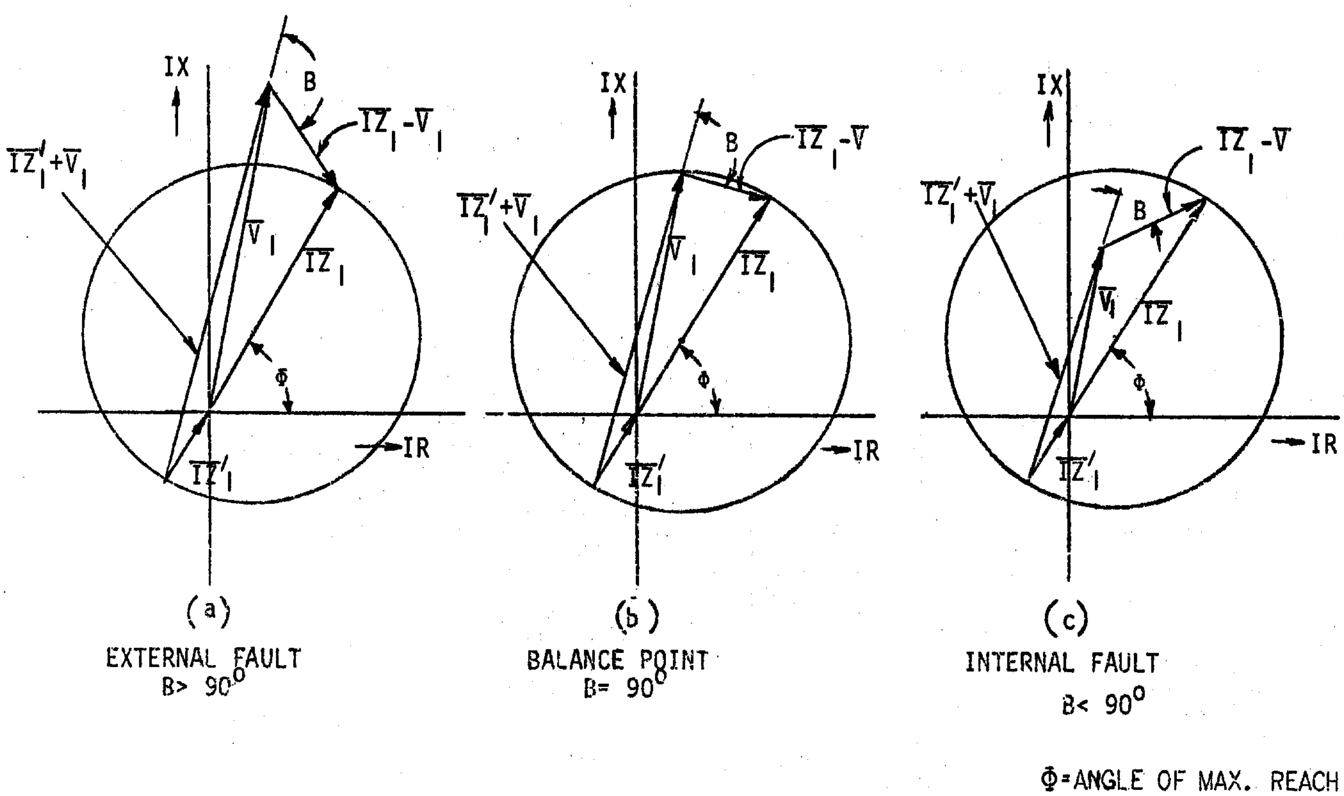


FIG. 6 (0246A7984-0) Offset Mho Characteristic By Phase Angle Measurement

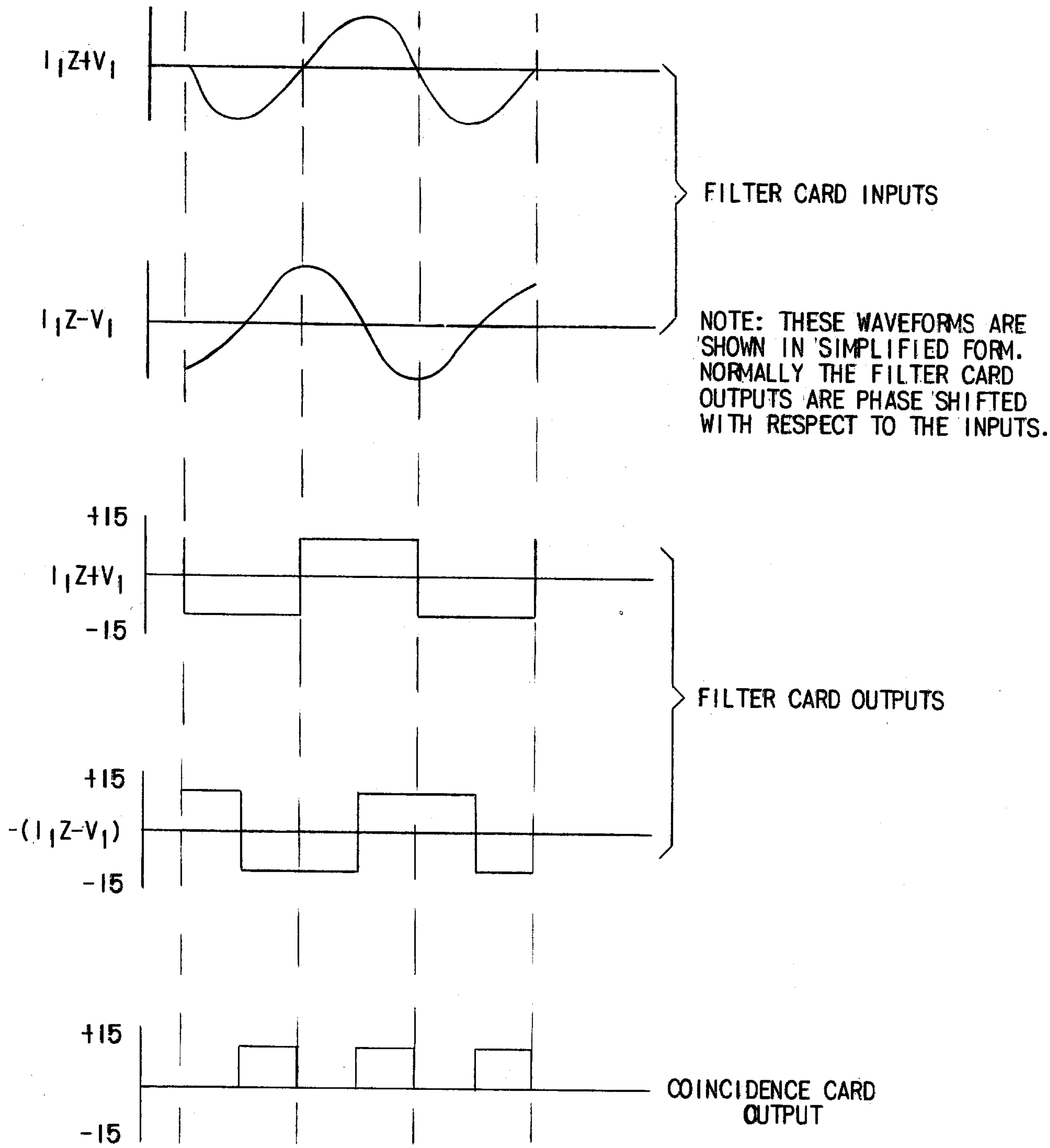


FIG. 7 (0246A7985-1) SLYP Operating Quantity Waveforms

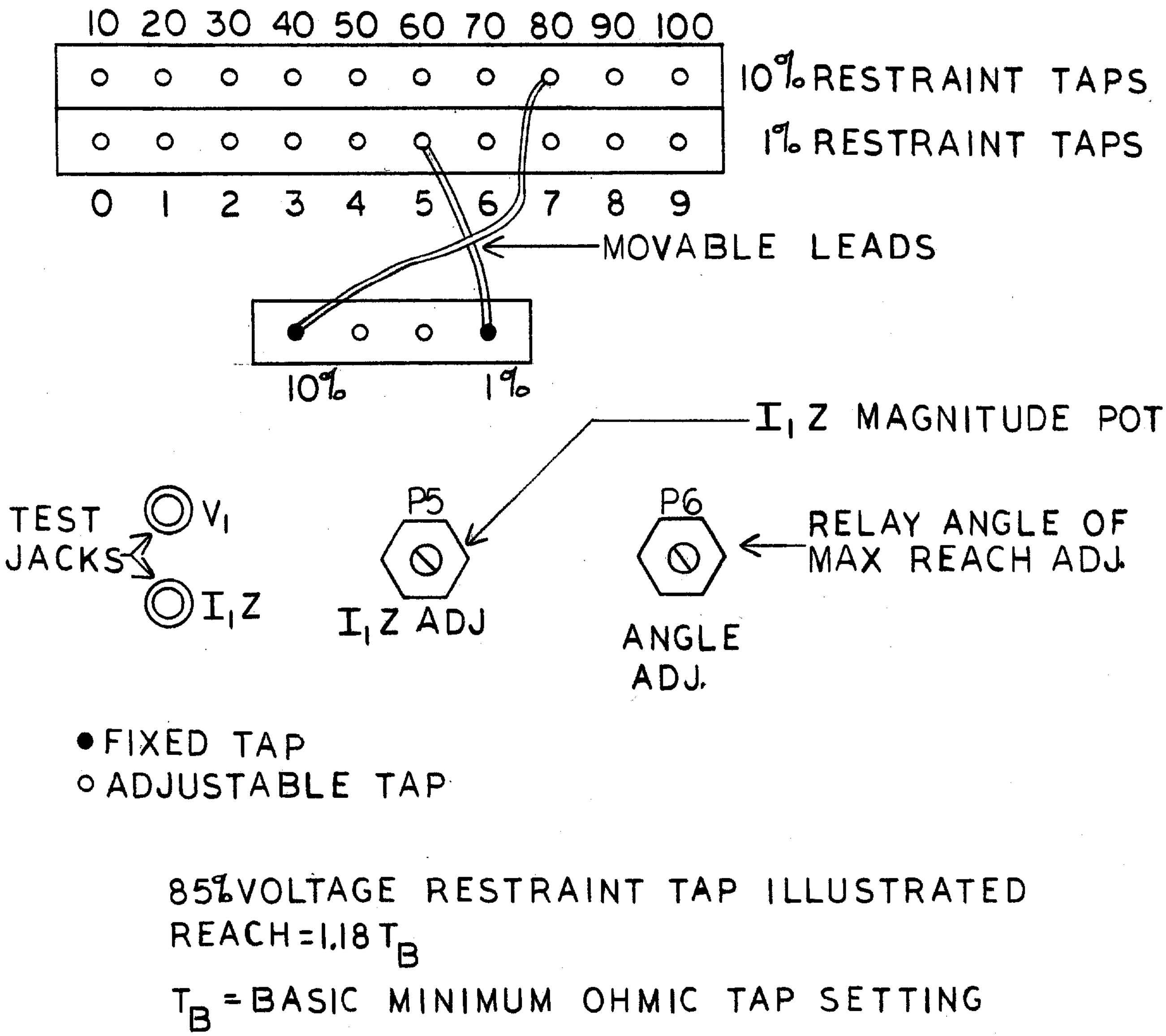


FIG. 8 (0246A6885-1) Typical SLYP Voltage Restraint Tap Settings

TEST SOURCE MUST BE BALANCED

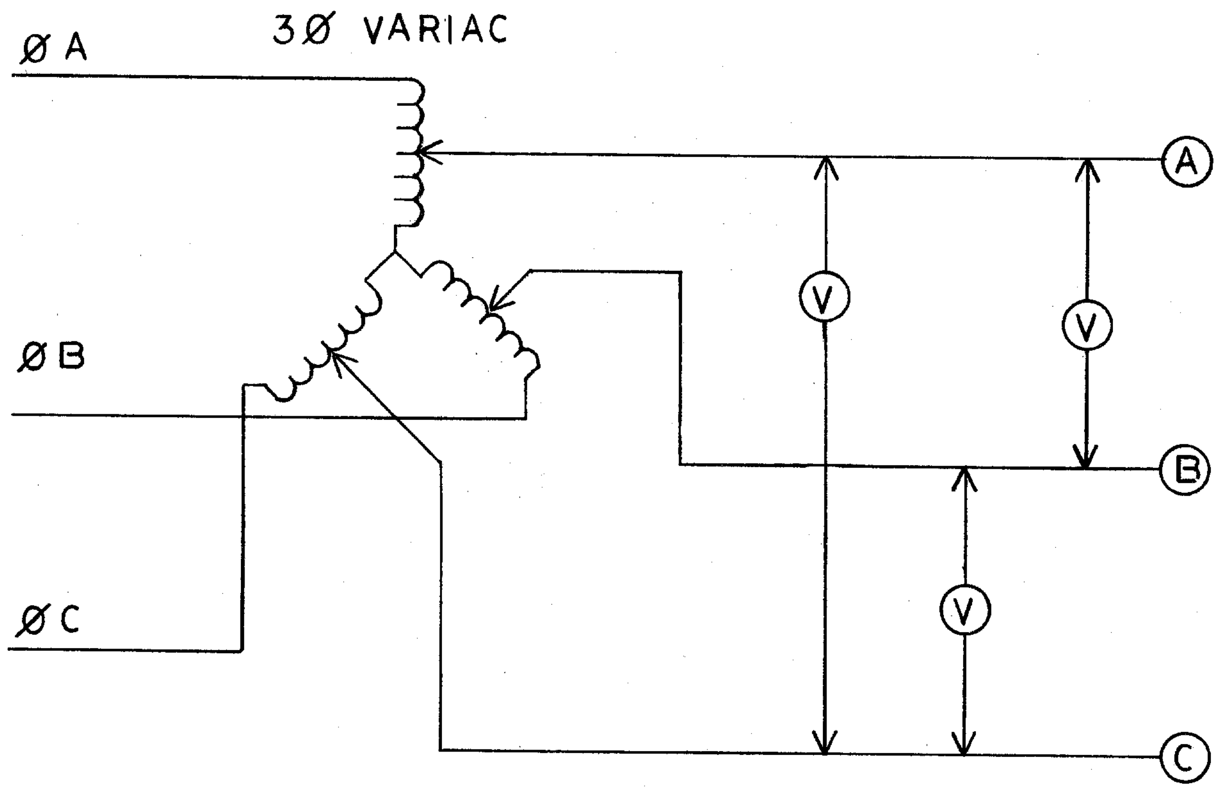


FIG. 9 (0246A6884-1) SLYP Voltage Network Test Connections

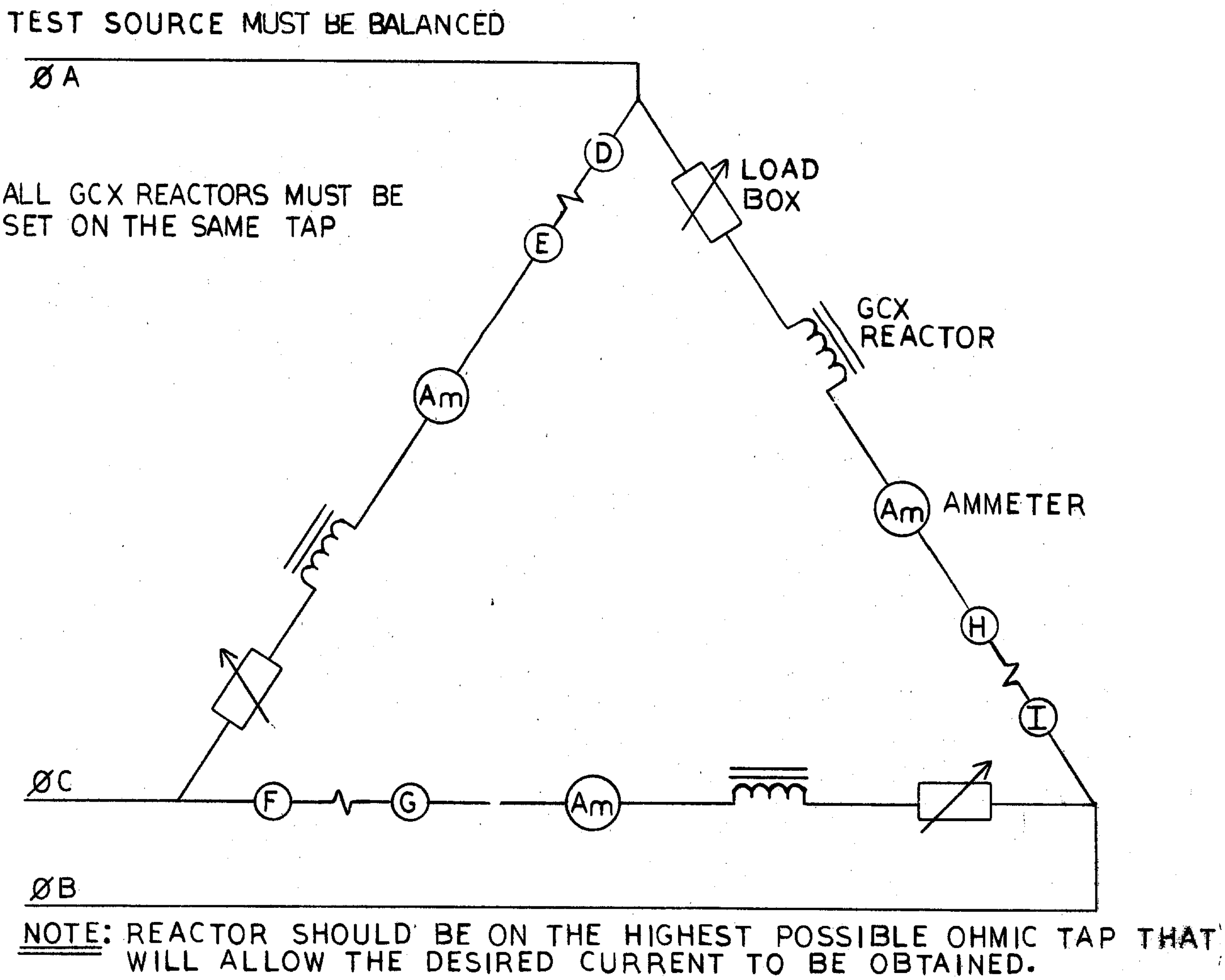


FIG. 10 (0246A6883-1) SLYP Current Network Test Connections-Method I

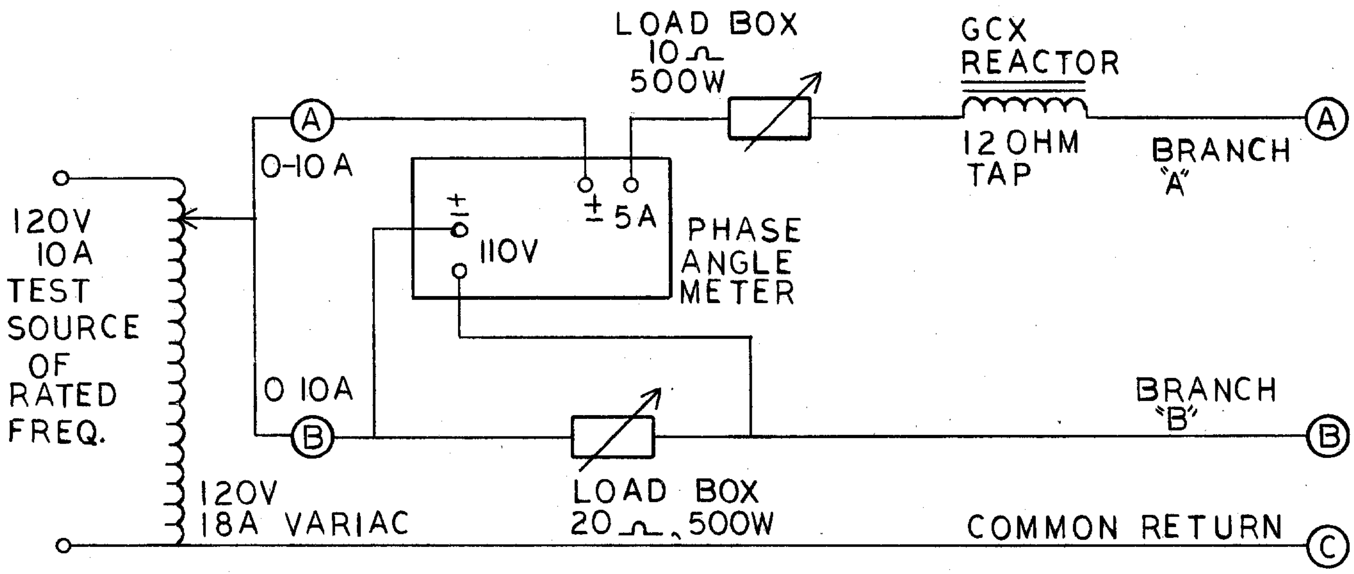


FIG. 11 (0246A6882-1) SLYP Current Network Test Connections-Method II

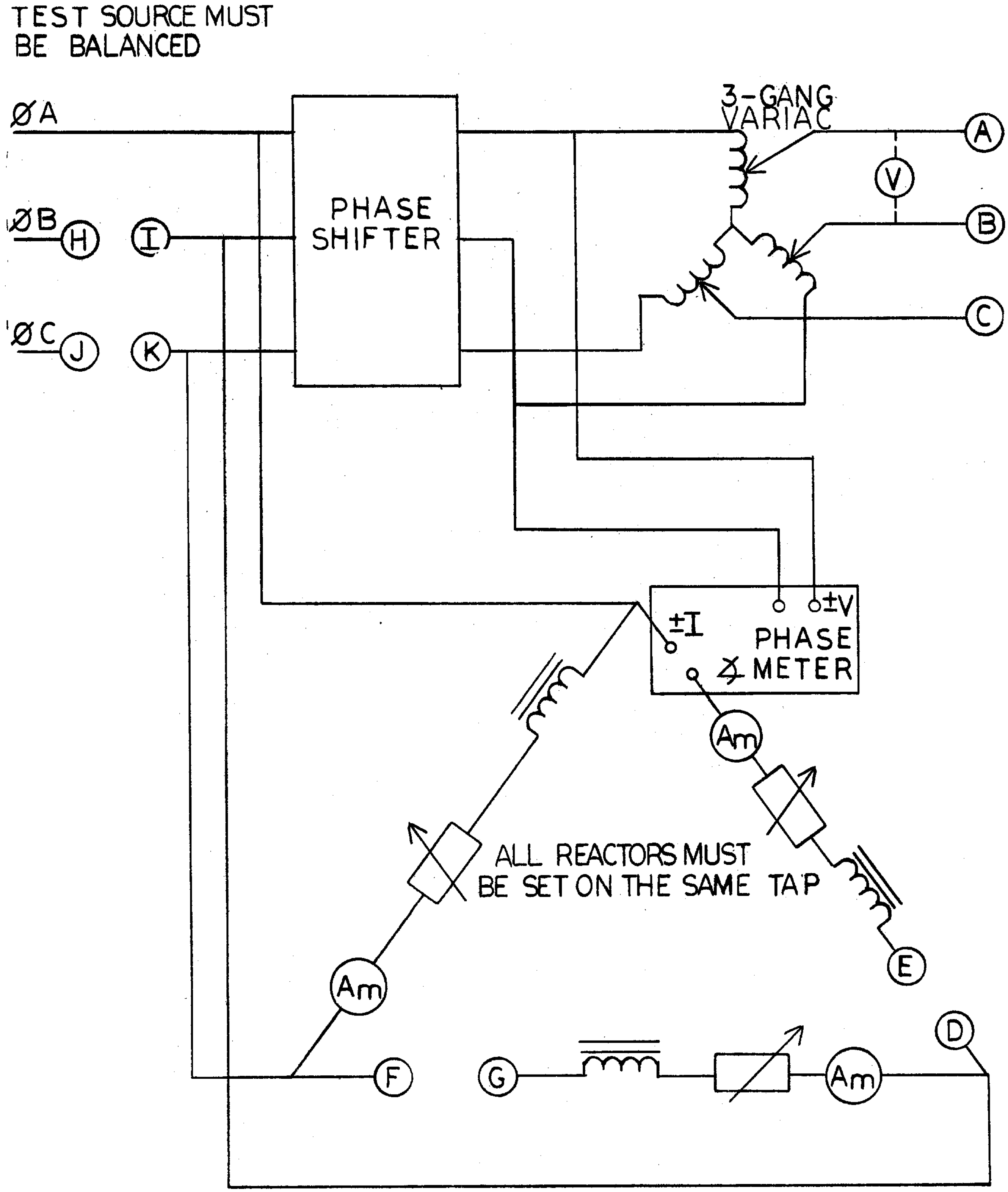


FIG. 12 (0246A6881-1) SLYP Unit Test Circuit-Method I

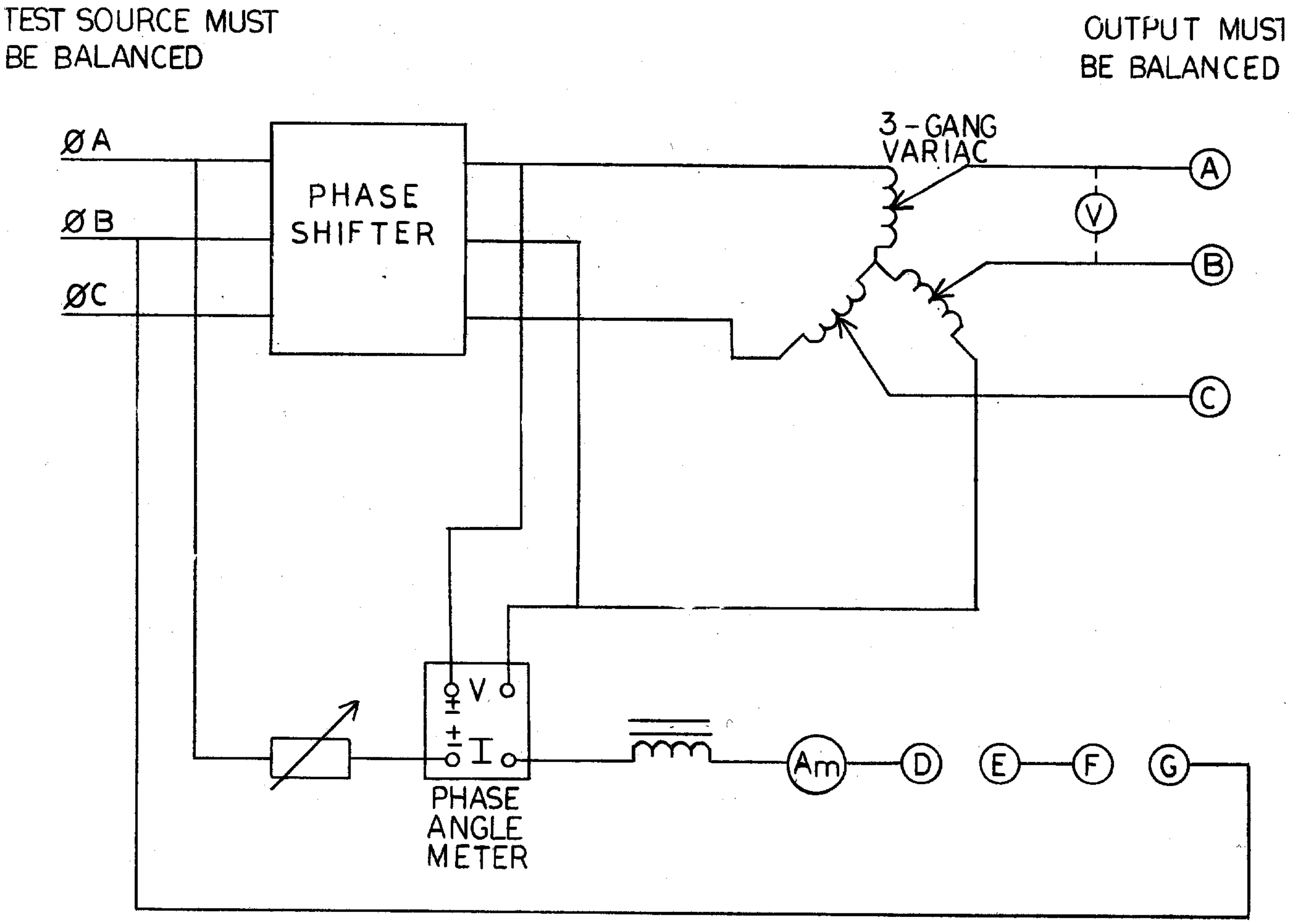


FIG. 13 (0246A6880-1) SLYP Unit Test Circuit-Method II

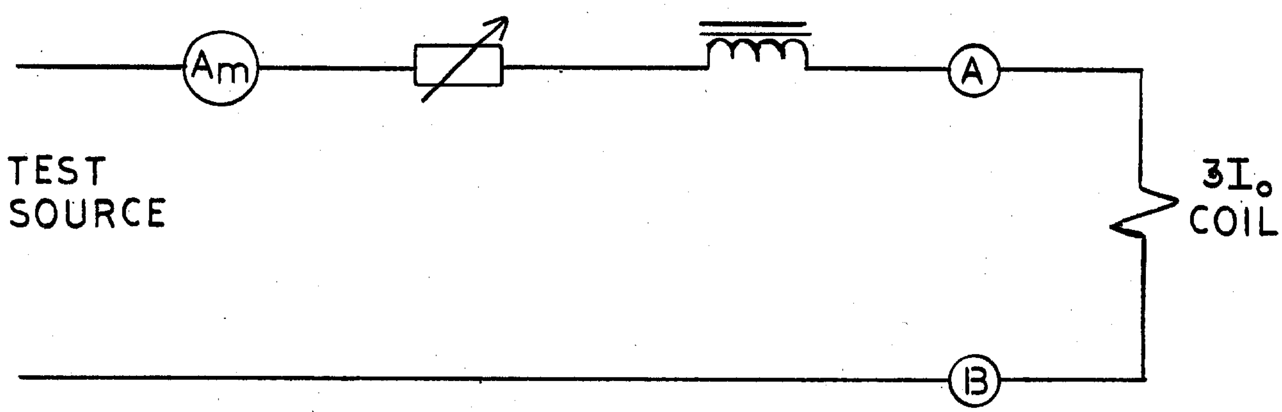


FIG. 14 (0246A6879-0) SLYP 3Io Test Circuit

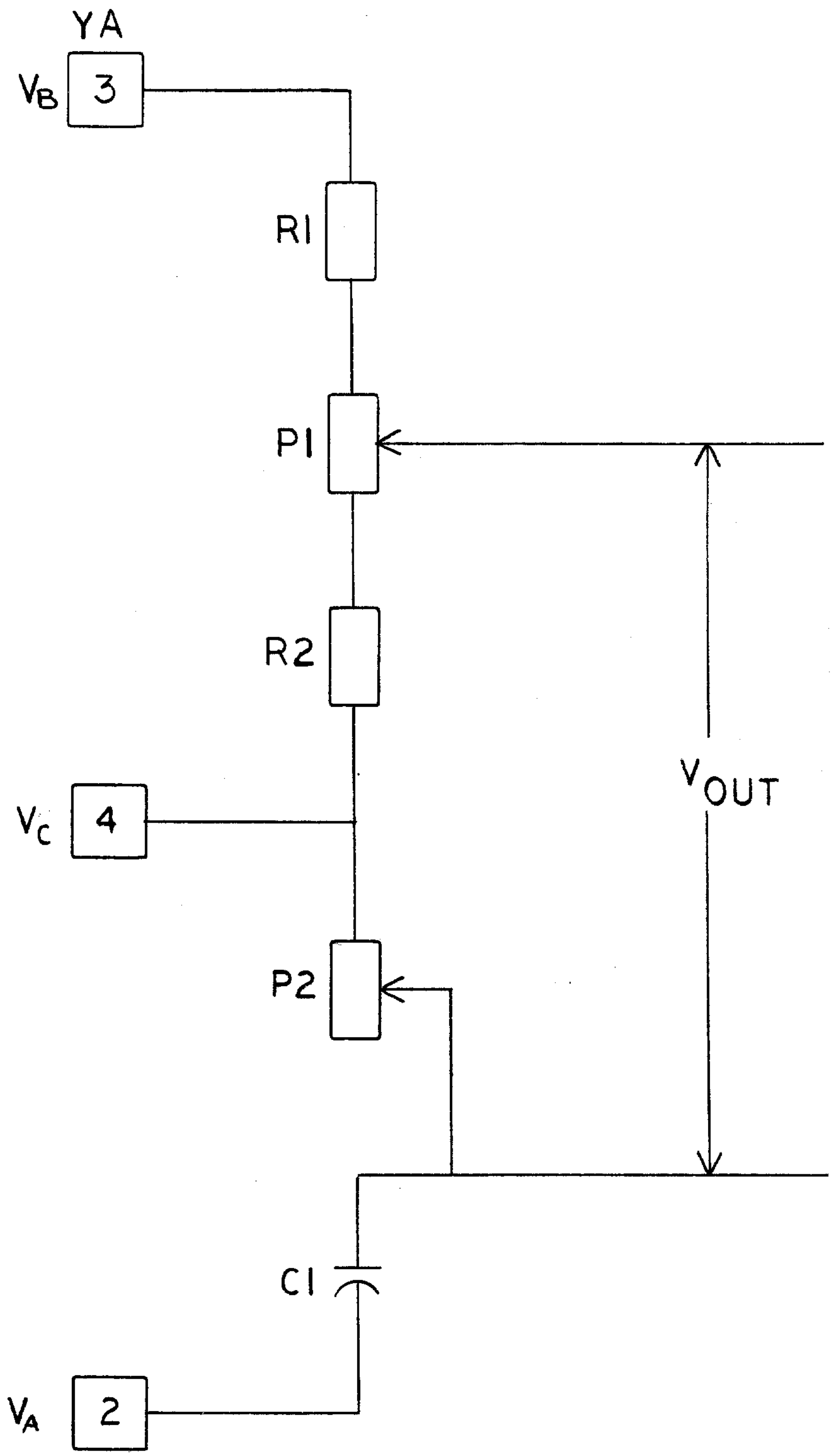


FIG. 15 (0246A7987-0) Timer Test Circuit

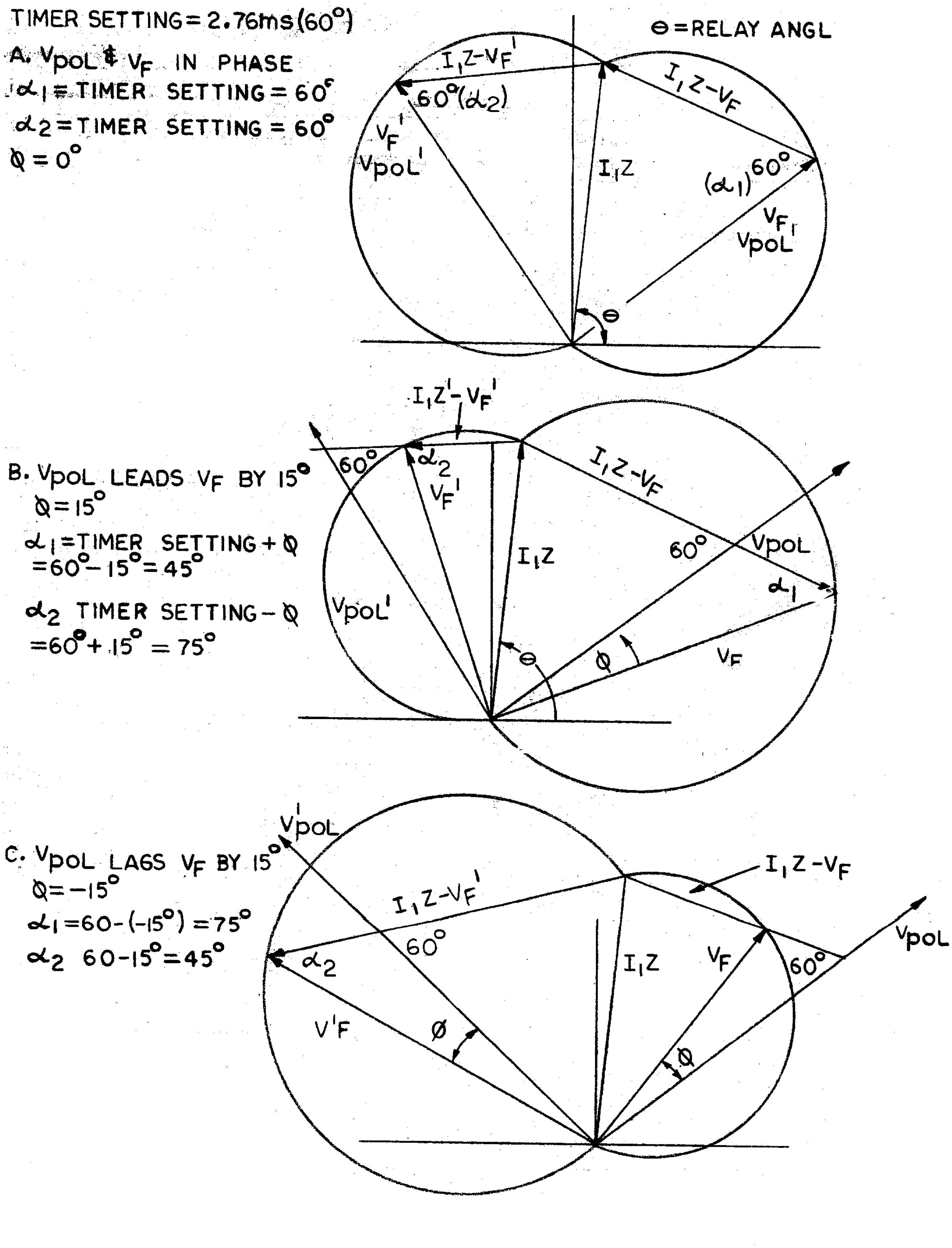


FIG. 16 (0246A6866-0) Effects Of Polarizing Quantity Phase Shift To Mho Characteristics

GENERAL ELECTRIC INSTALLATION AND SERVICE ENGINEERING OFFICES

FIELD SERVICE OFFICE CODE KEY
• Mechanical & Nuclear Service
† Electrical & Electronic Service
‡ Marine Service
x Transportation

FOR YOUR LASTING SATISFACTION . . . with the performance and availability of your General Electric equipment, GE provides this nationwide network of field service offices, serving utility, industrial, transportation and marine users. Qualified field engineers provide installation, start-up, employee training, engineering maintenance and other services, throughout the productive life of the equipment. For full information, call your nearest Installation & Service Engineering office.

ALABAMA
† Birmingham 35205 . . . . 2151 Highland Ave.
• † ‡ Mobile 36609 . . . . . 1111 S. Beltline Highway

ALASKA
† Anchorage 99501. . . . . 115 Whitney Rd.

ARIZONA
• † Phoenix 85012 . . . . . . 3550 N. Central Ave.
† Tucson 85716. . . . . 151 S. Tucson Blvd.

ARKANSAS
† North Little Rock 72119. . . . . . 120 Main St.

CALIFORNIA
• † ‡ Los Angeles 90054 . . . . . . 212 N. Vignes St.
† Palo Alto 94303 . . . . . 960 San Antonio Rd.
† Sacramento 95808. . . . . 2407 J St.
† San Diego 92103 . . . . 2560 First Ave.
• ‡ San Francisco 94119 . . . . 55 Hawthorne St.
• Vernon 90058. . . . . 3035 E. 46th St.

COLORADO
• † Denver 80206. . . . . . 201 University Blvd.

CONNECTICUT
• † Meriden 06450 . . . . 1 Prestige Dr.

FLORIDA
† ‡ Jacksonville 32203 . . . . 4040 Woodcock Dr.
† ‡ Miami 33134 . . . . 4100 W. Flagler St.
• † ‡ Tampa 33609 . . . . 2106 S. Lois Ave.

GEORGIA
• † ‡ Atlanta 30309. . . . . 1860 Peachtree Rd., NW
† ‡ Savannah 31405 . . . . 5002 Paulsen St.

HAWAII
• † ‡ Honolulu 96813. . . . . 440 Coral St.

ILLINOIS
• † ‡ x Chicago 60680 . . . . 840 S. Canal St.

INDIANA
† Evansville 47705 . . . 2709 Washington Ave.
† Fort Wayne 46807 . . . . 3606 S. Calhoun St.
• † Indianapolis 46207 . . . 3750 N. Meridian St.

IOWA
† Davenport 52805
. . . P. O. Box 630, 1039 State St., Bettendorf

KENTUCKY
† Louisville 40218 . . . . . . 2300 Meadow Dr.

LOUISIANA
† Baton Rouge 70806 . . . . 8312 Florida Blvd.
• † ‡ New Orleans 70125 . . . . 4747 Earhart Blvd.
• † Shreveport 71104 . . . 2620 Centenary Blvd.
† Monroe 71201 . . . . 1028 North 6th St.

MARYLAND
• † ‡ Baltimore 21201. . . . . 1 N. Charles St.

MASSACHUSETTS
• † ‡ Wellesley 02181 . . . . 1 Washington St.

MICHIGAN
• † ‡ Detroit 48202 . . . . 700 Antoinette St.
† Jackson 49201 . . . . 210 W. Franklin St.
† Saginaw 48607
. . . . 1008 Second National Bank Bldg.

MINNESOTA
† ‡ Duluth 55802 . . . . 300 W. Superior St.
• † ‡ Minneapolis 55416 . . . 1500 Lilac Drive So.

MISSOURI
• † Kansas City 64199. . . . . 911 Main St.
• † St. Louis 63101 . . . . 1015 Locust St.

MONTANA
† Butte 59701 . . . . 103 N. Wyoming St.

NEBRASKA
• † Omaha 68102 . . . . 409 S. 17th St.

NEW JERSEY
• † Millburn 07041. . . . . 25 E. Willow St.

NEW YORK
† ‡ Albany 12205. . . . 15 Computer Drive, West
• † ‡ Buffalo 14205 . . . . 625 Delaware Ave.
• † ‡ x New York 10022 . . . . 641 Lexington Ave.
• Rochester 14604. . . . . 89 East Ave.
• † ‡ Syracuse 13206 . . . . 3532 James St.

NORTH CAROLINA
• † ‡ Charlotte 28207 . . . . . . 141 Providence Rd.
• Wilmington
Reigelwood 28456 . . . . P.O. Box 186

OHIO
• † Cincinnati 45206. . . . . . 2621 Victory Pkwy.
• † ‡ Cleveland 44104 . . . . . . 1000 Lakeside Ave.
† Columbus 43229 . . . . 1110 Morse Rd.
† ‡ Toledo 43606 . . . . 3125 Douglas Rd.
† Youngstown 44507. . . . . 272 Indianola Ave.

OKLAHOMA
• † Oklahoma City 73106. . . 2000 Classen Blvd.
† Tulsa 74105. . P. O. Box 7646, Southside Sta.

OREGON
† Eugene 97401. . . . . 1170 Pearl St.
• † ‡ Portland 97210. . . . . . . 2929 NW 29th Ave.

PENNSYLVANIA
• Allentown 18102 . . . . 1444 Hamilton St.
• † ‡ Philadelphia 19102 . . . 3 Penn Center Plaza
• † Pittsburgh 15222 . . . . 300 6th Avenue Bldg.

SOUTH CAROLINA
† ‡ Columbia 29204 . . . . . 2700 Middleburg Dr.
† Greenville 29607. . 41 No. Pleasantburg Dr.

TENNESSEE
• † Chattanooga 37411
. . . . 5800 Bldg, Eastgate Center
† Memphis 38130. . . . . . . 3385 Airways Blvd.

TEXAS
• † Amarillo 79101 . . . . 303 Polk St.
• † ‡ Beaumont 77704 . . . . 1385 Calder Ave.
• ‡ Corpus Christi 78401. . 205 N. Chaparral St.
• † Dallas 75222 . . . . 8101 Stemmons Freeway
• † El Paso 79945 . . . . 215 N. Stanton
† Fort Worth 76102 . . . . . . 408 W. Seventh St.
• † ‡ Houston 77027 . . . . . . 4219 Richmond Ave.
† San Antonio 78204 . . . . 434 S. Main St.

UTAH
† Salt Lake City 84111 . . 431 S. Third East St.

VIRGINIA
• ‡ Newport News 23601 . . . . . . 311 Main St.
† ‡ Richmond 23230. . . . 1508 Willow Lawn Dr.
† Roanoke 24015. . . . . . . 2018 Colonial Ave.

WASHINGTON
• † ‡ Seattle 98188
. . . . 112 Andover Park East, Tukwila
† Spokane 99202 . . . . E. 1805 Trent Ave.

WEST VIRGINIA
• † Charleston 25328 . . 306 MacCorkle Ave., SE

WISCONSIN
• Appleton 54911. . . . 3003 West College Dr.
† ‡ Milwaukee 53202 . . . . . 615 E. Michigan St.

GENERAL ELECTRIC SERVICE SHOPS

WHEN YOU NEED SERVICE . . . These GE Service Shops will repair, recondition, and rebuild your electric apparatus. The facilities are available day and night, seven days a week, for work in the shops or on your premises. Latest factory methods and genuine GE renewal parts are used to maintain performance of your equipment. For full information about these services, contact your nearest service shop or sales office.

ALABAMA
● • Birmingham 35211 . . 1500 Mims Ave., S. W.
● Mobile 36609 . . . . 721 Lakeside Dr.

ARIZONA
● (Phoenix) Glendale 85019 . 4911 W. Colter St.
● Phoenix 85019 . . . . . 3640 W. Clarendon St.
● Tucson 85713. . . . 2942 So. Palo Verde Ave.

CALIFORNIA
● Los Angeles 90301 . . . . 6900 Stanford Ave.
● (Los Angeles) Anaheim 92805
. . . . 3601 E. LaPalma Ave.
• (Los Angeles) Inglewood 90301
. . . . 228 W. Florence Ave.
● Sacramento 95814. . . . . . 99 North 17th St.
● • (San Francisco) Oakland 94608
. . . . 1650 34th St.

COLORADO
● • Denver 80205 . . . . 3353 Larimer St.

CONNECTICUT
● • (Southington) Plantsville 06479
. . . . 370 Atwater St.

FLORIDA
● • Jacksonville 32203 . . . . 2020 W. Beaver St.
● (Miami) Hialeah 33010. . . 1062 East 28th St.
● • Tampa 33601 . . . . 19th & Grant Sts.

GEORGIA
● (Atlanta) Chamblee 30341
. . . . 5035 Peachtree Industrial-Blvd.
• Atlanta . . . . 2379 John Glenn Dr.

ILLINOIS
● • Chicago 60638 . . . . 6045 S. Nottingham Ave.

INDIANA
● Evansville 47711 . . . 401 N. Congress Ave.
● Ft. Wayne 46803. . . . . . . 1731 Edsall Ave.
● Hammond 46320 . . . . 1138 164th Place
● • Indianapolis 46222 . . . 1740 W. Vermont St.

IOWA
● (Davenport) Bettendorf 52722 . 1025 State St.

KENTUCKY
● Louisville 40209. . . . 3900 Crittenden Drive

LOUISIANA
● Baton Rouge 70814 . . . 10955 North Dual St.
● • New Orleans 70114 . . . . . 1115 DeArmas St.

MARYLAND
● • Baltimore 21230. . . . . . . 920 E. Fort Ave.

MASSACHUSETTS
● • △ (Boston) Medford 02155
. . . . 3960 Mystic Valley Pkwy.

MICHIGAN
● • △ (Detroit) Riverview. . . . 18075 Krause Ave.
● Flint 48505 . . . . 1506 E. Carpenter Rd.

MINNESOTA
● Duluth 55807 . . 50th Ave. W & St.Louis Bay
● • Minneapolis 55430 . . . . 2025 49th Ave., N.

MISSOURI
● • Kansas City 64120. . . . . 3525 Gardner Ave.
● • St. Louis 63110 . . . . 1115 East Rd.

NEW JERSEY
● New Brunswick 08902 . . . . . 3 Lawrence St.

NEW MEXICO
● Albuquerque 87109 . . . 4420 McLeod Rd. NE

NEW YORK
● Albany 12205. . . . . 1097 Central Ave.
● • (Buffalo) Tonawanda 14150 . . 175 Milens Rd.
● (Long Island) Old Bethpage 11804
. . . . 183 Bethpage-Sweet Hollow Rd.
● (New York City) North Bergen, N. J. 07012
. . . . 6001 Tonnelle Ave.
• (New York City) Clifton, N. J. 07012
. . . . 9 Brighton Rd.
• △ Schenectady 12305 . . . . 1 River Rd.
● Syracuse 13208. . . . 1015 E. Hiawatha Blvd.

NORTH CAROLINA
● • Charlotte 28208 . . . . 2328 Thrift Rd.

OHIO
● Akron (Canton) 44720
. . . . 7900 Whipple Ave. N. W.
● • Cincinnati 45202. . . . . 444 West 3rd St.
● • △ Cleveland 44125 . . . . . . 4477 East 49th St.
● Columbus 43229 . . . . 6660 Huntley Rd.
● • Toledo 43605 . . . . 405 Dearborn Ave.
● Youngstown 44507. . . . 272 E. Indianola Ave.

OKLAHOMA
● Tulsa 74145. . . . . . 5220 S. 100th East Ave.

OREGON
● Eugene 97402 . . . . 570 Wilson St.
● • Portland 97210 . . . . . . 2727 NW 29th Ave.

PENNSYLVANIA
● Allentown 18103 . . . . . . 668 E. Highland St.
● (Delaware Valley) Cherry Hill, N. J., 08034
. . . . 1790 E. Marlton Pike
● Johnstown 15802 . . . . 841 Oak St.
● Philadelphia 19124 . . . 1040 East Erie Ave.
● • (Pittsburgh) West Mifflin 15122
. . . . 4930 Buttermilk Hollow Rd.
● York 17403 . . . . 54 N. Harrison St.

SOUTH CAROLINA
● (Charleston) No. Charleston 29401
. . . . 2490 Debonair St.

TENNESSEE
● Knoxville 37914
. . . . 2621 Governor John Sevier Hwy.
● Memphis 38107. . . . . . . 708 North Main St.

TEXAS
● Beaumont 77705 . . . . . 1490 W. Cardinal Dr.
● Corpus Christi 78401 . . . . . . 115 Waco St.
● • Dallas 75235 . . . . 3202 Manor Way
● Houston 77036 . . . . 5534 Harvey Wilson Dr.
• Houston 77036 . . . . 6916 Harwin Dr.
● Midland 79701 . . . . 704 S. Johnston St.

UTAH
● • Salt Lake City 84110 . . . 301 S. 7th West St.

VIRGINIA
● • Richmond 23224 . . . . 1403 Ingram Ave.
● Roanoke 24013 . . . . . . 1004 River Ave., SE

WASHINGTON
● • Seattle 98134 . . . . . 3422 First Ave., South
● Spokane 99211 . . . . . . E. 4323 Mission St.

WEST VIRGINIA
● • Charleston 25328 . . 306 MacCorkle Ave., SE

WISCONSIN
● (Appleton) Menasha 54910 . . 1725 Racine St.
● Milwaukee 53207 . . . 235 W. Oklahoma Ave.

● Electrical/Mechanical Service Shop • Instrumentation Shop △ Special Manufacturing Shop

PRINTED IN U.S.A.