INSTRUCTIONS

GEK-45447A

SUPERSEDES GEK-45447

STATIC PHASE DISTANCE RELAY

TYPE SLY71A

GENERAL ELECTRIC

CONTENTS

STATIC PHASE DISTANCE RELAY

TYPE SLY71A

DESCRIPTION

The Type SLY71A relay is a static, three-phase directional mho distance relay with limited overreach intended for the detection of close-in three-phase faults on transmission lines terminating at a generating station. Normally only one SLY71A relay is associated with each transmission line. This relay with its own test-panel, and an associated equipment test panel and type SSA50 power supply, make up the total scheme.

The following measuring functions are included in the SLY71A:

M1 - Three single-phase mho distance functions

I3Ø - Three-phase overcurrent function for supervision of M1 functions

In addition to these measuring functions the SLY71A relay includes logic to detect the occurrence of a three-phase fault as indicated by the operation of all three M1 functions and the I3Ø overcurrent function. Provision is also made for the later addition of a zero sequence fault detector and logic to indicate the occurrence of a double-phase-to-ground fault. Also included are two output units identified as D3 and V3, two electromechanical hand reset targets, a d-c power switch and associated indicating lamps.

The SLY71A relay is packaged in a four-rack-unit case as illustrated in Figure 1. Component locations are shown in Figure 2 and the internal connection diagram is in Figure 3. The logic circuits of the SLY71A require ±15 volt d-c obtained from a Type SSA50 power supply which may be used in common with other SLY71A relays in the same equipment.

For a complete description of the scheme in which the SLY71A is employed, the user is referred to the scheme overall logic diagram and its associated logic description.

APPLICATION

The Type SLY71A relay is intended for application where it is desired to provide high-speed detection of three-phase faults on a transmission line within a predetermined distance from the relay location. With available optional features the relay will also detect double-phase-to-ground faults. The relay is suitable for application with potential transformers or with coupling capacitor voltage transformers having a transient response equivalent to or better than the General Electric Type CD51 device.

A typical application of the SLY71A relay is to initiate fast valving of a turbine generator upon the occurrence of three-phase faults on transmission lines within a short distance of the relay location. It can also be used to prevent high-speed reclosing following the clearing of such faults by other relays protecting the line.

RANGES

The SLY71A relay has an adjustable M1 function reach of 0.3 to 15 ohmsin the tripping direction at an angle of maximum reach of 85 degrees.

*The standard setting for the angle of maximum reach is 85 degrees. This angle can be set to either 75 or 60 degrees by means of a plug on the filter card (all three filter cards must be set the same).

*The basic ohmic taps provided in the SLY71A are 0.3, 0.6, 0.9, 1.2, and 1.5. These values are calibrated at an 85-degree angle of maximum reach. If the 70-degree angle of maximum reach is desired, the basic ohmic taps can be recalibrated to the above mentioned values using the procedure outlined in the DETAILED TESTING section of this book. On the other hand, if no recalibration is desired, the basic reach values will be 3.4 percent larger when in the 70-degree angle of maximum reach setting, i.e., 0.31, 0.62, 0.93, 1.24, and 1.55 ohms.

*Indicates Revision

The three-phase overcurrent function (13Ø) has an adjustable range of 1-15 amperes. The ground overcurrent function has an adjustable range of 0.5-8 amperes.

RATINGS

The Type SLY71A relay is designed for use in an environment where the air temperature outside the relay case ie between -20°C and +65°C.

The Type SLY71A relay requires a ±15 volt d-c power source which can be obtained from power supplies Type SSA 50 and up.

The current circuits of the type SLY71A relay are rated at 5 amperes; 60 hertz, for continuous duty and have a one second rating of 300 amperes. The potential circuits are rated 120 volts, 60 hertz.

BURDENS

DC Burden - The Type SLY71A relay presents a maximum burden to the type SSA power supply of:

* 217 ma from the +15 VDC supply
* 227 ma from the -15 VDC supply

AC Burden - Potential circuits at 120 VØ - Ø maximum

.30 volt amp
.24 watts
.18 vars

Current circuits at 5 AØ - Ø maximum

Z = .025 ∠30°
R = .022
X = .012
} Where arc resistance is of less importance.

SENSITIVITY

The sensitivity of the M1 function is measured by the relation between the three-phase fault current and the reduction in ohmic reach of the function, as the current decreases. The sensitivity is defined as the minimum three-phase fault current for a particular base reach (minimum ohm) tap which will cause the relay reach to be reduced to 90 percent of the nominal reach setting. The sensitivity of the various M1 base reach settings are as follows:

*

BASE REACH	MIN. 3-PHASE FAULT CURRENT
0.3	2.9
0.6	1.45
0.9	0.97
1.20	.72
1.50	.58

Refer to the CALCULATION OF SETTINGS section of this book for details of settings calculations and a typical example.

OPERATING PRINCIPLES AND CHARACTERISTICS

The mho characteristic for the SLY71A relay is shown in Figure 4. All measurements are made on a phase-to-phase basis. V_a-V_b is compared with I_a-I_b in order to obtain the same relay reach for a phase-to-phase, a three-phase and a double-phase-to-ground fault. The principle used to derive the characteristic is illustrated in Figure 5. The axes are "IR" and "IX". The IZ quantity is a voltage proportional to the line current obtained by passing the line current through a current transactor.

The setting of this quantity establishes the "Base Reach" of the relay. The V quantity is line voltage at the relay location, equal to IZ_F, where Z_F is the line impedance out to the fault. Comparison is between the polarizing voltage V and the operating quantity (IZ-V). The angle B between these two quantities is greater than 90 degrees for faults external to the relay characteristic, and is less than 90 degrees for faults internal to the relay characteristic. For faults which cause V to terminate on the relay characteristic the angle B is equal to 90 degrees. This is true for any angular location of $\overline{V}$, because $\overline{V}$, $\overline{IZ}$, and $\overline{(IZ-V)}$ form a right triangle for any point on the relay characteristic.

The quantities $\overline{V}$ and $\overline{(IZ-V)}$ are derived from the relay input quantities and are converted into +15 VDC to -15 VDC square waves on the F126 cards. These square waves have the same phase relationship as the AC quantities $\overline{V}$ and $\overline{(IZ-V)}$. The square waves representing $\overline{V}$ and $\overline{(IZ-V)}$ are compared on the C104 card. The output of the C104 card is a +15 VDC block equal to the duration of the coincidence of the $\overline{V}$ and $\overline{(IZ-V)}$ square waves. Blocks which are 90 degrees apart are coincident for 4.16 milliseconds. Blocks which are less than 90 degrees apart are coincident for more than 4.16 milliseconds. This is illustrated in Figure 6.

M1 TRIPPING FUNCTION

The M1 function has a directional characteristic with the mho circle passing through the origin on an R-X diagram. See Figure 4.

If the 100 percent voltage tap is used, the phase-to-neutral reach of the relay at the angle Ø is equal to the IZ base reach tap chosen. If a voltage tap other than 100 percent is chosen, relay reach is increased in inverse proportion to the voltage tap. For example, if the 50 percent voltage tap is used, relay operation still occurs for the same voltage applied to the measuring circuit, but since the actual line voltage is twice this amount, the relay reach is twice as great. The resulting mho circle has twice the reach, at any fault angle, and still passes through the origin.

Relay reach for the M1 unit at the angle of maximum reach Ø, may be calculated from the expression:

$$Z_{max} = \frac{T_B}{T} \times 100 \text{ (at angle } \emptyset)$$

where T is the restraint tap setting expressed in percent and $Z_0 = Z_{max} \cos(\theta - \emptyset)$. Z_0 is the impedance the relay will be at any angle θ. T_B is the basic ohmic tap.

θ = Line angle

Ø = Relay maximum reach angle

The angle of maximum reach (Ø) has two factory-preset angles, 70 degrees and 85 degrees. To change from one angle to the other, a jumper on the F125 filter card has to be moved. When the jumper bridges points 1,2,3, and 4, the angle of maximum reach is set to 70 degrees. When points 2,3,4, and 5 are jumpered, the angle is 85 degrees. Usually, the relay is shipped with the 85-degree angle of maximum reach.

To set the relay for the desired reach, it is necessary to first select the proper "Base Reach Tap". This tap should be the highest "Base Reach Tap" that is smaller than the desired ohmic reach. The setting of the "Base Reach Tap" is explained under the section titled CONSTRUCTION in this book. After the "Base Reach Tap" is selected the "Percent Restraint Tap" may now be chosen to produce the required relay reach.

CIRCUIT DESCRIPTION

The internal connection drawing for the SLY71A relay is shown in Fig. 3. The connection points on the left, designated YA2, YA3, and YA4 are the voltage inputs. The lower points, designated YB and YC are the current inputs.

The relay input voltage is passed through a transformer which produces the polarizing voltage. This voltage is fed directly to the filter card. The other input to the filter card is (IZ-V). The IZ component comes from the input current passing through a current transactor to form the IZ quantity. The "V" portion comes directly from the tapped potential transformers.

The block-block method is used for the M1 function. Blocks are formed from the (IZ-V) quantity and the polarizing voltage by means of the filter card. These blocks are then fed to the coincidence logic card where the blocks are compared on a time basis. The coincidence card will produce output blocks only when both inputs are coincident (the same polarity). The output blocks of the coincidence logic card are then fed to the 4/5 timer card. The characteristic of the 4/5 timer is to produce no output until the input blocks are longer in duration than 4.16 milliseconds or 90 degrees. If the timer is set to pick up at some angle B other than 90 degrees, the resulting mho unit characteristic will not be a circle. Figure 7 shows the characteristic obtained for a timer setting of 3.0 milliseconds at an angle of maximum reach of 75 degrees. Figure 8 shows the same characteristic at an angle of maximum reach of 70 degrees. Figure 9 shows the characteristic for a timer setting of 6 milliseconds at an angle of maximum reach of 85 degrees. Figure 10 shows the same characteristic at an angle of maximum reach of 70 degrees. In general, the reach for a timer setting less than 90 degrees is greater than the reach for a timer setting of 90 degrees at the same fault angle. A timer setting of greater than 90 degrees will give a reach less than the reach for a timer setting of 90 degrees, again at the same fault angle.

CALCULATION OF SETTINGS

To illustrate the calculations required in applying the SLY71A relay assume that the transmission line has the following characteristics:

$Z_L = 58 \angle 85^\circ$ primary ohms, positive sequence impedance.

CT ratio = 2000/5

PT ratio = 3000/1

$$Z_L \text{ (sec.)} = Z_L \text{ (Pri)} \times \frac{\text{CT ratio}}{\text{PT ratio}}$$

Z_L (sec.) = 7.73 $\angle 85^\circ$ ohms

For a typical application the M1 reach might be set for 25 percent of the line impedance at 85 degrees, which in this example would be 1.93 ohms. For optimum performance the highest possible base reach tap should be used, which in this case would be the 1.5 ohm tap.

The restraint tap setting is determined by the following formula:

$$T = \frac{100\, T_B \cos(\theta - \emptyset)}{.25\, Z_L}$$

where:

T_B = base reach tap

$\emptyset$ = relay angle of maximum reach

Z_L = line impedance

θ = Angle of Z_L

.25 = desired reach in per unit of Z_L

For the present example:

$$T = \frac{100\ (1.5)\ \cos\ (85-85)}{.25\ (7-73)}$$

= 78 percent tap

Note that the above calculation example assumes that the relay angle of maximum reach is 85 degrees, which is the factory-set value. Angle of maximum reach can be set for either 85 degrees or 70 degrees, as discussed in the preceding section. The angle-of-maximum reach setting should be chosen which comes closest to the line angle to insure the fastest operating time of the relay.

CONSTRUCTION

The Type SLY71A relay is packaged in a metal enclosure designed for mounting on a 19 inch rack. The relay is 4 rack units high (one rack unit is 1 3/4 inches). The relay contains the magnetics and tap blocks for setting the base reach and the precent restraint. It also contains the printed circuit cards for protecting all three phases of a power system, and an optional addition of phase-to-ground protection. The relay also contains an ON-OFF DC switch and a "POWER-ON" indicating light, two electromechanical, hand re-setable targets, one reed relay with two electrically separate 5.0 contacts' output, one telephone relay with electrically separate two normally-open and two "C"-type contact's outputs. The relay has a hinged front cover with a window on the left side, upper two rack units (see outline and mounting dimensions, Fig. 1). The targets are resetable via a push button in the window. The relay also has a removable top cover.

The tap block portion of the unit is located at the left side, lower two rack units of the case. Fig. 11 shows the settings of one phase pair. The tap block is divided into two sections, percent and basic reach.

To set the percent restraint simply put the top M1 lead in the desired 10 percent hole and the bottom M1 lead in the desired 1 percent hole. The setting for 74 percent restraint is shown in Figure 11.

To set the base reach simply put the extreme right hand M1 lead in either the 1.2K or the 3K hole. K is a ratio factor and is either 1, 1/2 or 1/4. K is determined by the terminals that are selected for current input on the YB terminal block at the back of the relay. The setting for a base reach of 1.2K is shown in Figure 11.

The base reach and percent restraint settings are made by jumpers with taper tip pins on the end. Two special tools have been supplied for these pins. One is an insertion tool and the other is an extraction tool. In order to get a proper connection and not cause any damage to the pins it is important that these tools be used.

The printed circuit cards are located to the right of the tap block and the electromechanical targets. They are identified by code numbers such as A104, C104, D102, F125, L108, and T133. The letter designations stand for A-Auxiliary, C-Coincidence, D-Detector, F-Filter, L-Logic, and T-Timer. The printed circuit card locations are identified by letter designations, or "addresses" (G,K,P, AK, AP, etc.) which appear on the card guide strip in front of each socket. These "addresses" are also shown on the component location diagram, the internal connections diagram, and on the printed circuit cards themselves.

The test points (TP1, TP2, etc.) shown on the internal connection diagram are connected to instrument jacks on a test card in position T with TP1 located at the top of the card. TP1 is connected to relay reference, TP2 is connected to the -15 VDC bus, and TP10 is connected to the +15 VDC bus. The other seventeen test points are located at selected points in the logic circuitry to permit test measurement of the outputs of the functions and to facilitate signal tracing when trouble shooting.

RECEIVING,HANDLING AND STORAGE

This relay will normally be supplied as a part of a static relay equipment, mounted in a rack or cabinet with a power supply 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, 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 eight inches back from the relay unit front panel.

WARNING:

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.

The Type SLY71A relay contains printed circuit cards with trimmer potentiometers mounted on them. Some of these trimmer potentiometers are calibrated at the factory and sealed. These potentiometers should not be adjusted by the user.

INSTALLATION TESTS

The Type SLY71A relay is usually supplied from the factory mounted and wired in a static relay equipment. All units in a given equipment have been calibrated together at the factory and will have the same summary number on the unit nameplate.

The following checks and adjustments should be made by the user in accordance with the procedures given below under DETAILED TESTING INSTRUCTIONS, before the relays are put in service. Some of the following items are checks of factory calibrations and settings, or installation connections and hence do not normally require readjustment in the field. Other items cover settings or adjustments which depend on installation conditions and hence must be made on the installed equipment.

1. M1 base reach taps
2. M1 reach by voltage tap setting
3. The angle of maximum reach
4. M1 characteristic timer setting
5. I3Ø overcurrent setting

GENERAL TESTING INSTRUCTIONS

INPUT CIRCUITS

The Type SLY71A relay has four terminal blocks on the rear of the unit. They are identified YA, YB, YC and YD. These terminal blocks are wired through the test panel in a static relay equipment where input current and voltages can be supplied through the standard Type XLA test plug. Where other test facilities are used input currents and voltages should be applied to test points which connect to the same terminal points as those shown on the test circuit diagram.

Where the Type SLY71A relay is furnished in a static relay equipment, reference to the job elementary will provide information concerning customer relay inputs.

OUTPUT CIRCUITS

The outputs of the SLY71A relay are relay contacts.

Two normally open reed relay contacts are provided for the high-speed V3 output. These contacts close within 1-2 milliseconds after a logic signal is received at the input to the printed circuit card in position AS. These contacts will reopen approximately 2-3 milliseconds after the input signal is removed from the printed circuit card in position AS.

Two normally open and two transfer telephone type contacts are provided for the auxiliary D3 output. Each of the normally open contacts has a mechanical target connected in series with it. The normally open contacts close approximately one cycle after a logic signal is received at the input to the printed circuit card in position AL. These contacts will reopen approximately 8-10 cycles after the input signal is removed from the printed circuit card in position AL.

Connections to these contacts can be make through the terminal blocks on the rear of the unit.

DETAILED TESTING INSTRUCTIONS

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 THE 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 TEST INSTRUMENT WITH A GROUNDED CHASSIS WILL NOT AFFECT THE TESTING OF THE EQUIPMENT. HOWEVER A SECOND GROUND CONNECTION TO THE EQUIPMENT, SUCH AS A TEST LEAD INADVERTENTLY 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.

BASIC MINIMUM OHMIC TAP SETTING

The selection of the basic minimum ohmic tap is discussed in the section CALCULATION OF SETTINGS. The setting of the basic minimum ohmic tap is described in the section CONSTRUCTION.

VOLTAGE RESTRAINT TAP SETTING

The selection of the voltage restraint tap is discussed in the section CALCULATION OF SETTINGS. The setting of the voltage restraint tap is described in the section CONSTRUCTION.

The reach of the relay at the angle of maximum reach is given by the relationship

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

where: Z_{MAX} is the reach at the angle of maximum reach

T_B is the basic minimum ohmic tap

T is the voltage restraint tap in percent.

ANGLE OF MAXIMUM REACH

The angle of maximum reach can be set at either 70-degrees or 85-degrees by means of a plug located on the F126 filter cards located in positions H, L and P in the SLY71A relay. The 85-degree angle of maximum reach is selected by locating Plug "X" in position OK 23 - 45. The 70-degree angle is set by locating Plug "X" in position OK 12 - 34.

TIMER CARD ADJUSTMENTS AND TESTS

The pickup setting determines the amount of coincidence that must occur between the operate (IZ-V) and restraint (V) signals before a logic output occurs. The reset time delay (dropout time) of the timer provides an overlap between inputs from the coincidence logic. This produces a continuous logic signal and in some cases provides an intentional time delay before resetting. The timer outputs are DC logic signals. The settings for the timers in a particular scheme can be found on the OVERALL LOGIC DIAGRAM for that scheme.

Note: The timers in the SLY71A relay have been adjusted at the factory. If during trouble shooting or periodic maintenance, a plot of the mho characteristic indicates an incorrect timer setting (i.e., the characteristic is too wide or too narrow) the following procedure should be used. This procedure also applies to adjustment of replacement cards.

T133

The T133 timer affects the M1 characteristic shape. Three potentiometers are provided for adjustment purposes. P1, the first pickup, is the top potentiometer. P2, which sets the dropout, is the middle potentiometer and P3, the steady-state pickup which determines the characteristic shape, is on the bottom.

There are two procedures listed below to set the T133 timer. The first procedure is used if a touch-up of the characteristic shape is required. The second procedure is used when the card is replaced or when the card is suspected of being incorrectly adjusted.

Procedure 1 - If a plot of the characteristic is too wide or too narrow indicating an incorrect steady-state pickup setting, P3 can be adjusted to obtain the correct shape. However, do not change the settings of P1 or P2 during this procedure as they have no effect on the shape of the characteristic.

Procedure 2 - Note all three potentiometers must be set in this procedure, follow the setting order shown below to obtain correct operation of the card.

To set potentiometer P1-the first pickup:

(a) Remove the C104 card of the phase pair being tested.
(b) Connect the test circuit of Figure 12.
(c) Connect the input signal to the test point on the input of the timer being tested (TP3 for phase 1-2).
(d) Use an oscilloscope with a horizontal sweep which can be trigged externally. Connect the external trigger input to the test point on the input of the timer being tested and the vertical input to the test point on the output of the timer being tested.
(e) Set P3 fully counterclockwise.
(f) With the oscilloscope set for positive slope triggering, open the normally closed contact. The trace should step to +12 to +15 volts. Adjust P1 to obtain the pickup time specified on the Logic Diagram. Clockwise rotation will increase the pickup time delay.

To set potentiometer P2-the drop-out time delay;

(a) thru (d) same as for P1.
(e) With the oscilloscope set for negative slope triggering, open the contact to allow the timer to pick up, then close the contact and the desired drop-out time can be set. To increase the drop-out time turn P2 clockwise.

To set potentiometer P3-the steady state pickup;

(a) Install the C104 card for the phase pair under test.
(b) Connect the AC test circuit of Figure 13 and Table I.
(c) Set the current to 5 amperes.
(d) Set the voltage to 25 volts
(e) Swing the phase shifter to the point that causes a square with an ON and OFF time, as measured with an oscilloscope at the input of the timer being tested, which is the same as the pickup time to be set.
(f) Move the oscilloscope input to the output of the timer being tested and adjust P3 to the point that makes the card's output just become a continuous d-c level of over 12 volts - DO NOT READJUST THE P1 AND P2 POTENTIOMETERS.
(g) Plot the characteristic using the a-c test circuit of Figure 13 and touch up the P3 setting to obtain characteristic shape desired.

TESTING MHO CHARACTERISTIC

The mho characteristic may be checked over its entire range by using the test circuit employing the phase shifter and phase angle meter shown in Figure 13. Input connections for testing any of the phase-pair characteristics should be made with Figure 13 and Table I.

TABLE I

	CONNECT TERMINALS TO POINTS IDENTIFIED BY LETTERS						M1 OUTPUT
	A	B	C	D	E	F	
PHASE 1-2	YA2	YA3	YA6	YB4	YB8	YA7	TP6
PHASE 2-3	YA3	YA4	YA7	YB8	YB12	YA8	TP7
PHASE 3-1	YA4	YA2	YA8	YB12	YB4	YA6	TP8

By setting the current to 5 amperes (constant) the reach at any angle becomes a function of the setting of both the base reach and restraint taps. Rotating the phase shifter provides a means of checking the reach on any point of the characteristic. Notice that as the percent value of the restraint taps decrease the phase-to-phase impedance increases.

To obtain any points on the relay characteristic for any one of the three phases, observe the following procedure.

(a) Set up the test circuit of Figure 13 for the particular phase being tested. Make the a-c connections according to Table I.
(b) Set the test current to 5 amps rms.
(c) Be sure that the current limiting reactor is as high as possible in ohmic value (perhaps 24 ohms). This assures the most harmonic-free current possible.
(d) Remove the coicidence cards (C104) of the phases not being tested. Jumper the test points at the outputs of these cards down to reference.
Example: When testing Ø 1-2, remove the C104 cards in positions "M" and "R" and jumper TP4 and TP5 to reference.
(e) Connect the insrumentation (preferably an oscilloscope) between the timer output of the phase under test (TP6 for Ø 1-2) and reference at TP1.
(f) Set the phase angle meter at the specific angle of interest by rotating the phase shifter.
(g) Adjust the variac until the mho function output fully picks up. Note that the point just at the verge of pickup, as read on Figure 13 voltmeter (V), defines the relay mho characteristic.

The voltage at which the relay picks up can be expressed by:

$$V_{\emptyset\text{-}A} =^{*} \frac{2I\, T_B \cos(\theta - \emptyset)}{T} \times 100$$

where:

T_B = basic minimum ohmic tap

T = voltage restraint tap in percent

I = 5 ampere test current

θ = angle between applied voltage and current

Ø = angle of maximum reach

A plot of the mho characteristic can be obtained by varying the phase angle and repeating steps f and g. The pickup setting of the timer can be adjusted to obtain the desired characteristic shape.

The reach of the relay is calibrated at the factory for an 85-degree angle of maximum reach. If the relay is used at 70 degrees, the reach should be readjusted. Using the test procedure outlined above, set $V_{\emptyset\text{-}\emptyset}$ for the desired pickup at the angle of maximum reach. Adjust P10 on the F126 card to obtain the pickup point of the function.

An alternate method of testing the relay characteristics is shown in Figure 14 where the R-X test combination is employed. The circuit uses the test box (102L201), test reactor (6054975) and test resistor (6158546) described in GEI-44236. Since a limited number of resistor-reactor fault impedances are available, only a few points on the relay characteristic can be checked.

*Indicates Revision

ANGLE OF MAXIMUM REACH CHECK

As stated earlier the angle of maximum reach Ø, can be adjusted by changing the setting of plug X on the F126 printed circuit card. The angle is typically factory adjusted to produce an 85-degree angle of maximum reach. In the Type SLY71A relay the angle of maximum reach can be adjusted to 70 degrees. A check of the angle of maximum reach can be made by using the test circuit of Figure 13. The recommended procedure is as follows:

(a) Determine what test voltage (V in Figure 13) is necessary to produce output at the relay's maximum reach angle for 5 amperes of current, and the particular tap setting. (Measure the output at TP6 for Ø 1-2, TP7 for Ø 2-3 or TP8 for Ø 3-1.)

The voltage V at the angle of maximum reach is:

$$V = \frac{2\ I\ T_B\ 100}{T}$$

I = 5 amp test current

TB = basic ohmic reach tap

T = voltage restraint tap in percent

(b) Make the AC connections to the relay according to Table I. The letters A through F in Table I correspond to the letters in Figure 13.
(c) Adjust the variac in Figure 13 until the voltmeter reads 85 percent of the calculated voltage in equation.
(d) Rotate the phase-shifter, holding the voltage at 85 percent of the maximum V, and record the two angles at which the output just approaches the verge of pickup.
(e) Add, algebraically, the two angles and divide the sum by two. The resultant should be the desired angle plus or minus 1.5 degrees.

OVERCURRENT SUPERVISION CHECKS

The overcurrent function settings may be made and tested using a single-phase test source. A possible test circuit is shown in Figure 12 with the input connections for the SLY71A given below in Table II.

CAUTION:

THIS RELAY IS RATED AT 5 AMPERES CONTINUOUS DUTY. TO SET FOR HIGHER CURRENT LEVELS, APPLY TEST CURRENT TO THE RELAY ON MOMENTARY BASIS (APPROXIMATELY ONE SECOND).

To set the test circuit for higher current levels it is recommended that a resistance be connected between points "A" and "B" of Figure 12. The value of the resistance should be equal to the impedance of the a-c circuit to be tested (see above). When the desired current level is established, remove the resistor and connect the relay per Table II. Momentarily apply test current and monitor the output. Adjust the proper potentiometer for the desired operating point (clockwise pot rotation raises the operating point).

TABLE II

	CONNECT TERMINALS TO TEST CIRCUIT POINTS			MONITOR OUTPUT AT	ADJ. POT ON CARD
FUNCTION	A	B	JUMPER		
I_N	YC2	YC3	-	TP9	AM (WHEN USED)
I3Ø, Ø1-2	YC7	YC9	YC8 TO YC10	TP11	AN
I3Ø, Ø2-3	YC9	YC11	YC10 TO YC12	TP11	*
I3Ø, Ø3-1	YC11	YC7	YC12 TO YC8	TP11	*

* The I3Ø level detector operates on the highest phase-to-phase current input; if operating point differences are observed, calibration procedure is described in the following section.

OVERCURRENT CALIBRATION

The overcurrent functions may be checked and calibrated by applying a reactance limited single-phase current per Figure 12 and Table III. The card adapter may be used to gain access to the required measurement points.

TABLE III

FUNCTION	A	B	JUMPER	INPUT CURRENT (AMPS)	MONITOR OUTPUT AT	PROCEDURE
I_N	YC2	YC3	-	4.0	PIN 3 (CARD AM)	Adjust P1 to obtain 2.9 volts
I3Ø, Ø1-3	YC7	YC9	YC8 TO YC10	0.96	TP11	With the pot on the AN card adjusted fully CCW, adjust P2 to produce an output
I3Ø, Ø1-3	YC7	YC9	YC8 TO YC10	1.0	TP11	Without readjusting P2, adjust the pot on the AN card to produce an output
I3Ø, Ø2-3	YC9	YC11	YC10 TO YC12	1.0	TP11	Without readjusting the pot on the AN card, adjust P3 to produce an output
I3Ø, Ø3-1	YC11	YC7	YC12 TO YC8	1.0	TP11	Without readjusting the pot on the AN card, adjust P4 to produce an output

PERIODIC CHECKS AND ROUTINE MAINTENANCE

PERIODIC TESTS

All functions included in the SLY71A relay may be checked at periodic intervals using the procedures described in the section INSTALLATION TESTS.

The following checks should be made during periodic testing:

1. Basic minimum ohmic tap
2. Voltage restraint tap setting
3. Angle of maximum reach setting
4. Characteristic timer settings

These four checks can be made at once by making a plot of the mho characteristic.

TROUBLESHOOTING

In any troubleshooting of equipment, it should first be established which unit is functioning incorrectly. 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 troubleshooting, 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 SLY71A relay are included in the card book GEK-34158; the card types are shown on the component location diagram (Figure 2).

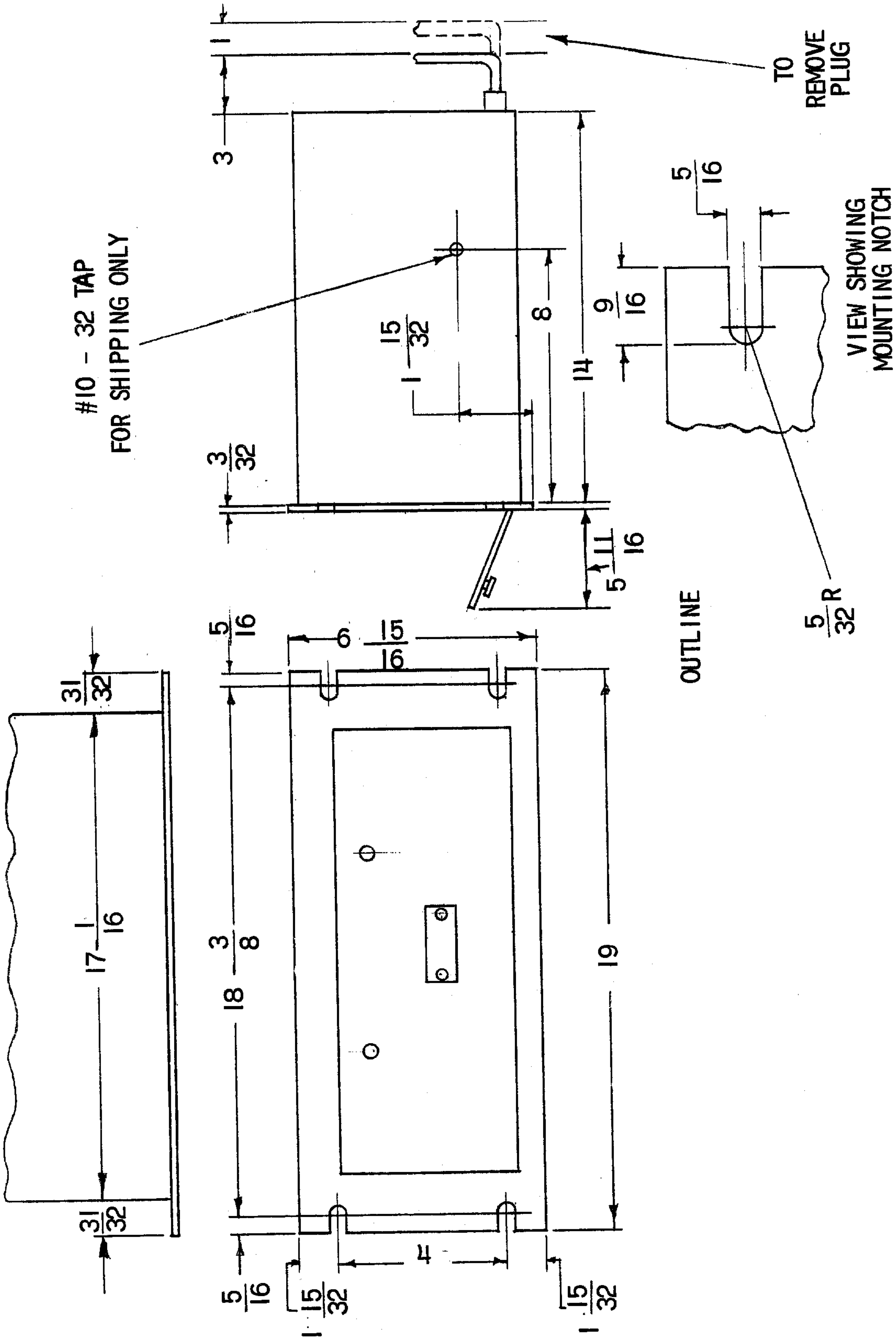


Fig. 1 (0227A2037-0) SLY71A OUTLINE AND MOUNTING DIMENSIONS

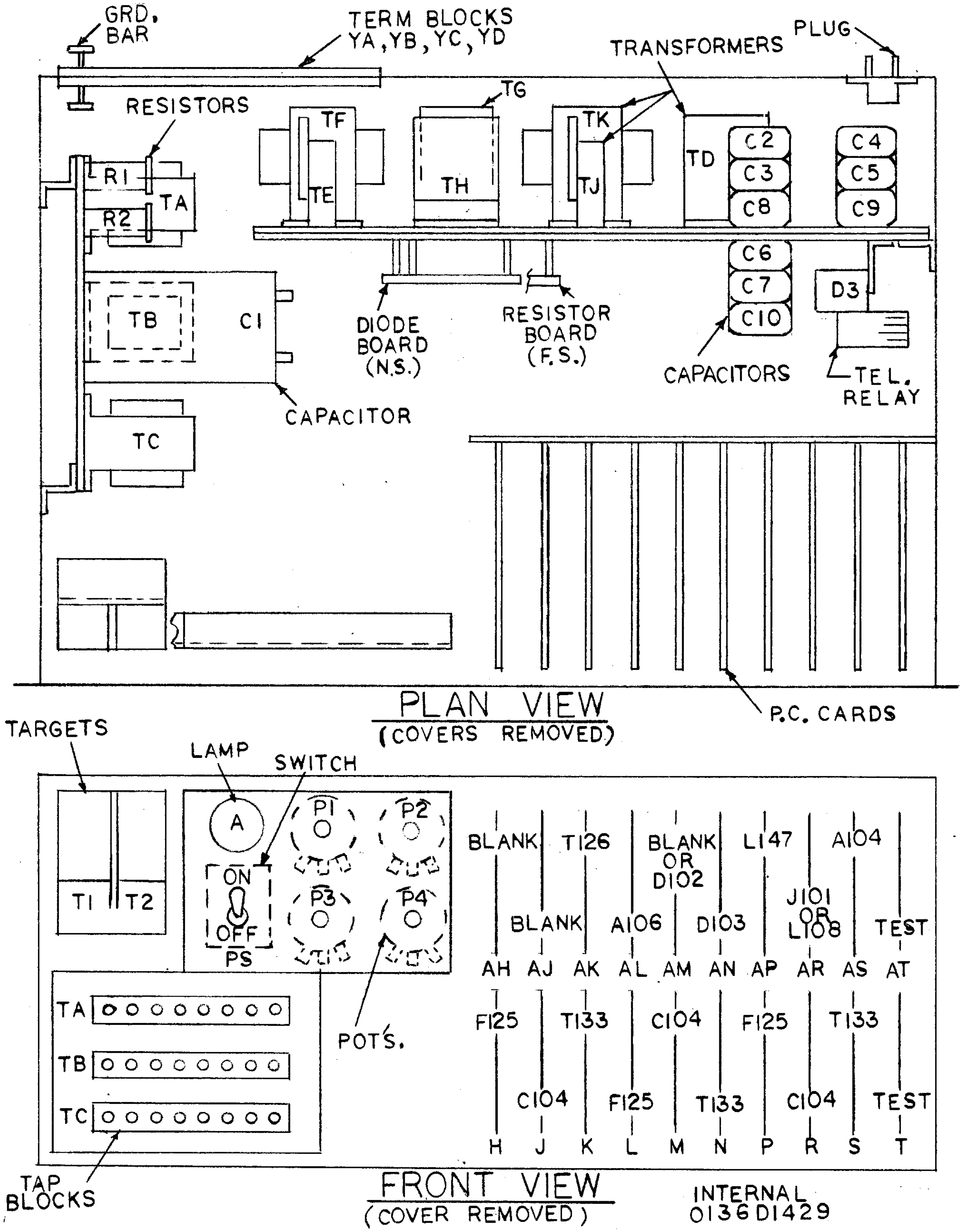


Fig. 2 (0257A8714-0) COMPONENT LOCATION DIAGRAM FOR THE SLY71A RELAY

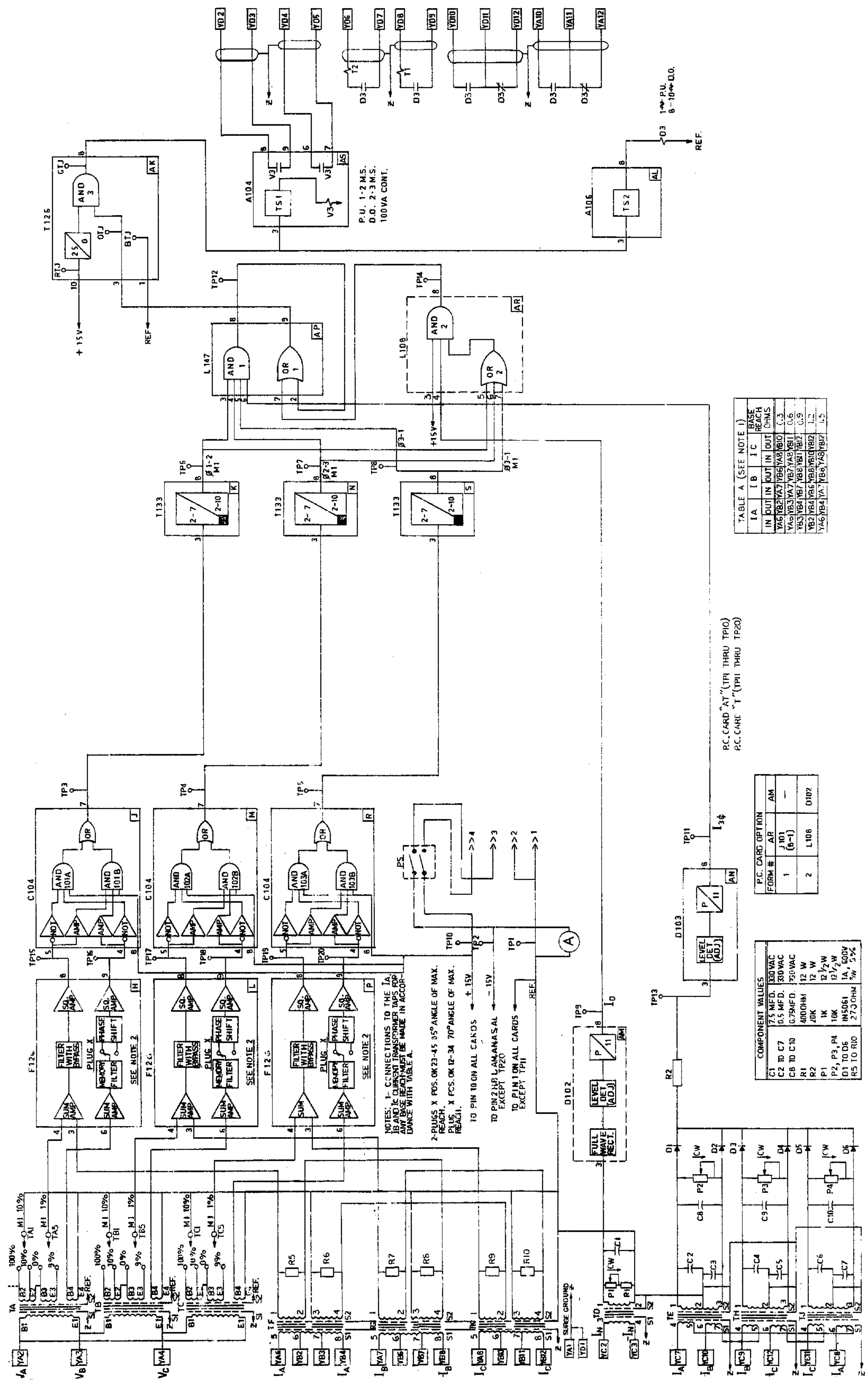


Fig. 3 (0136D1429-3) INTERNAL CONNECTIONS DIAGRAM FOR THE SLY71A RELAY

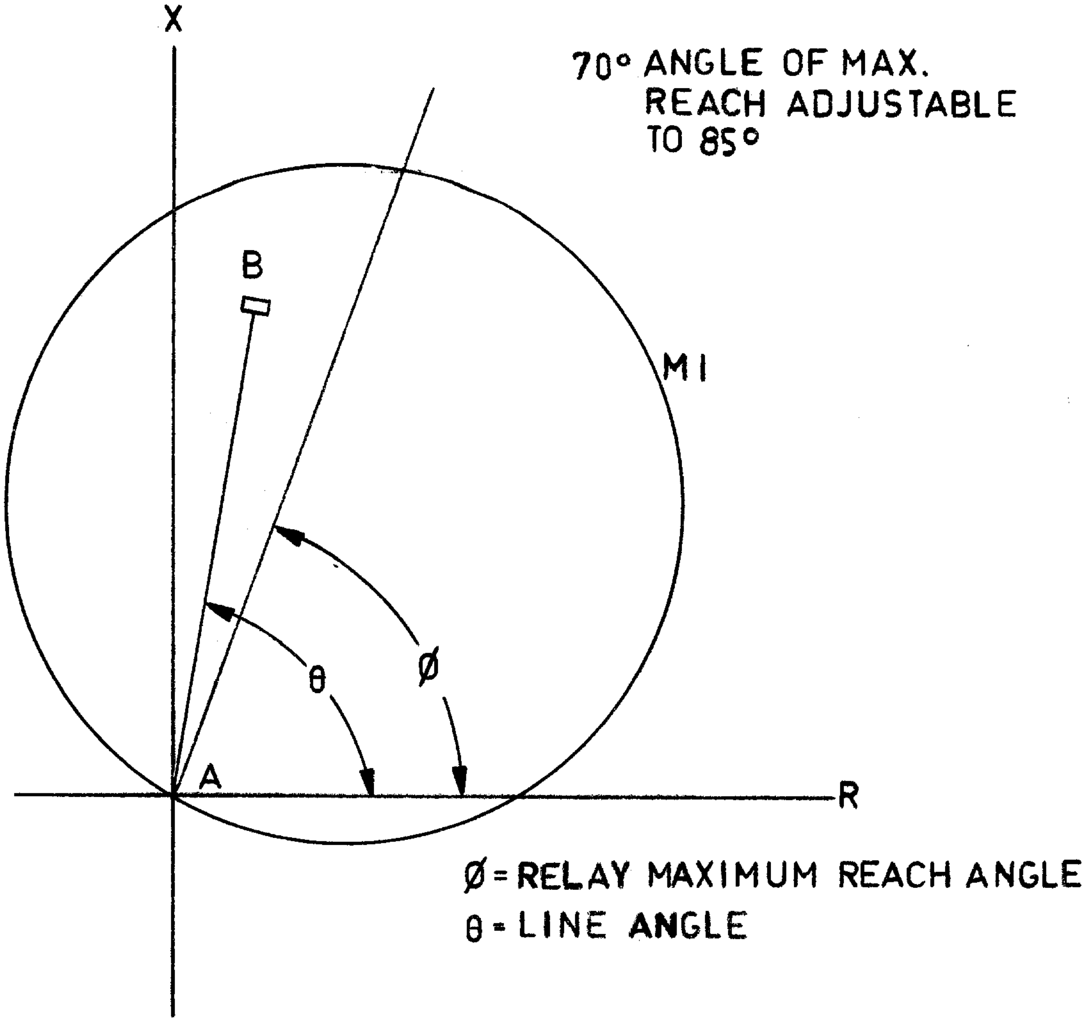


Fig. 4 (0257A8794-1) TYPICAL M1 CHARACTERISTIC FOR TYPE SLY71A RELAY

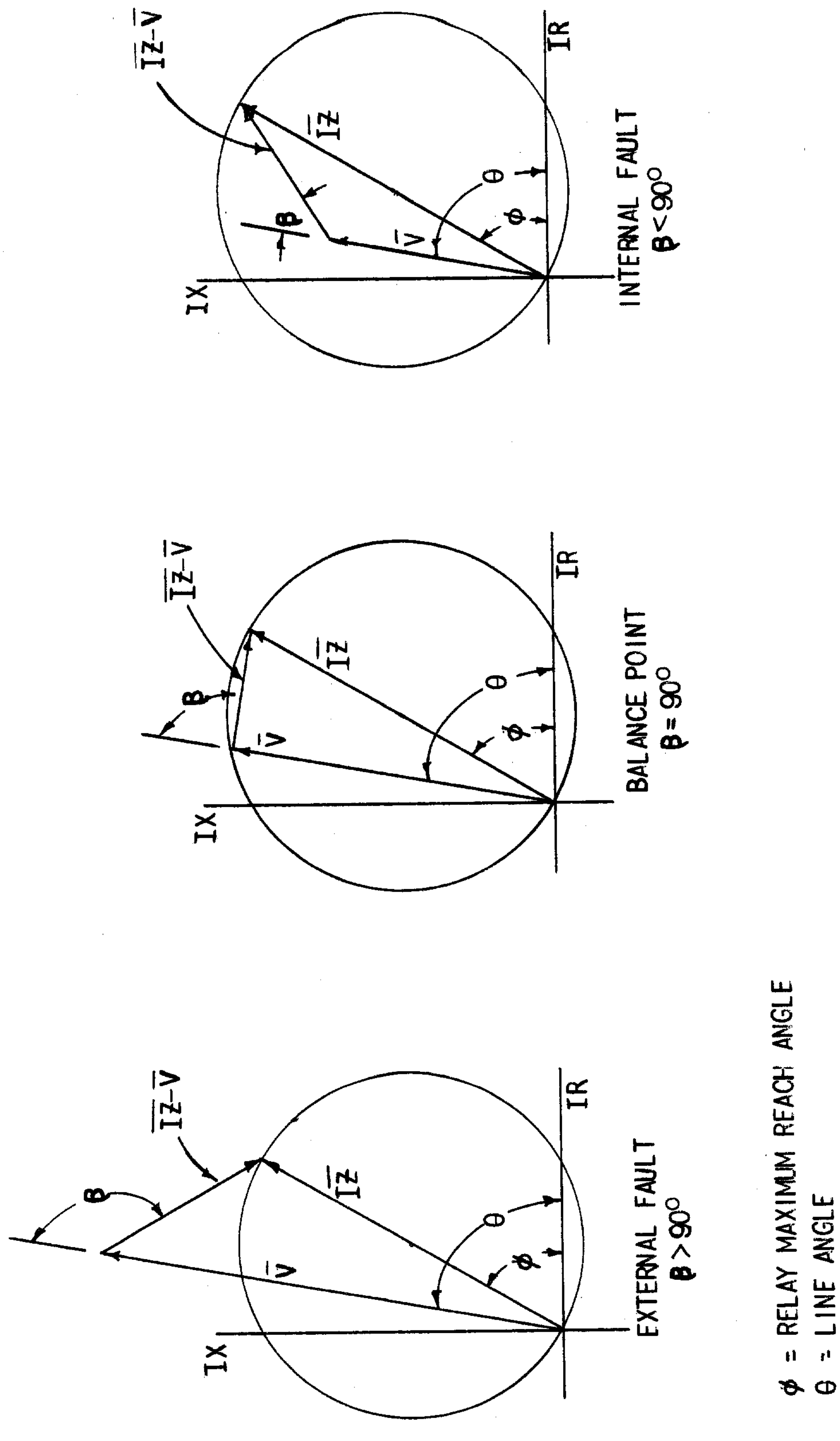
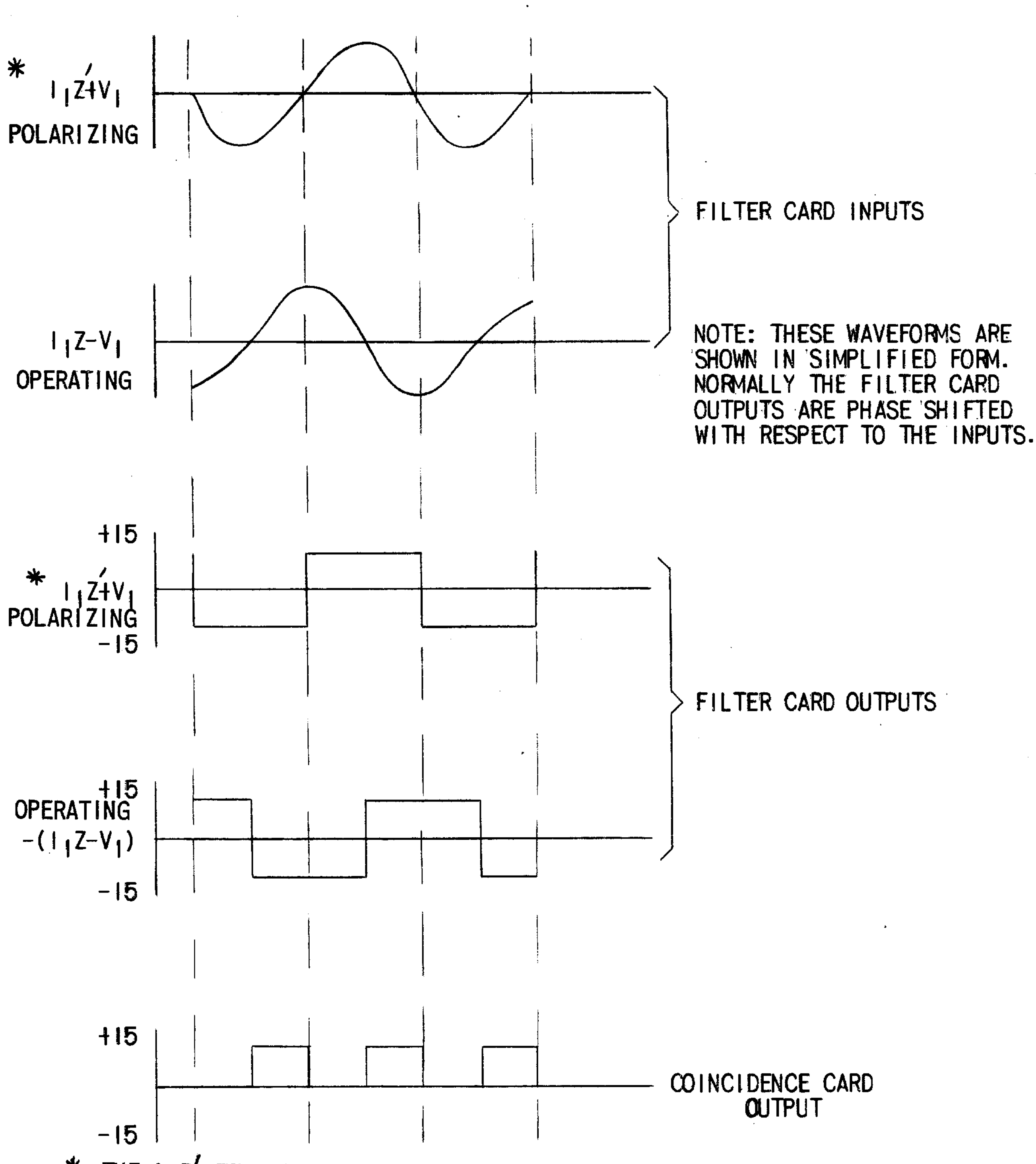


Fig. 5 (227A2090-0) MHO CHARACTER BY PHASE ANGLE MEASUREMENT



* THE I_1Z' TERM IS PART OF THE POLARIZING VOLTAGE ONLY IN CHARACTERISTICS WITH REVERSE REACH.

Fig. 6 (246A7985-2) M1 MEASUREMENT PRINCIPLES

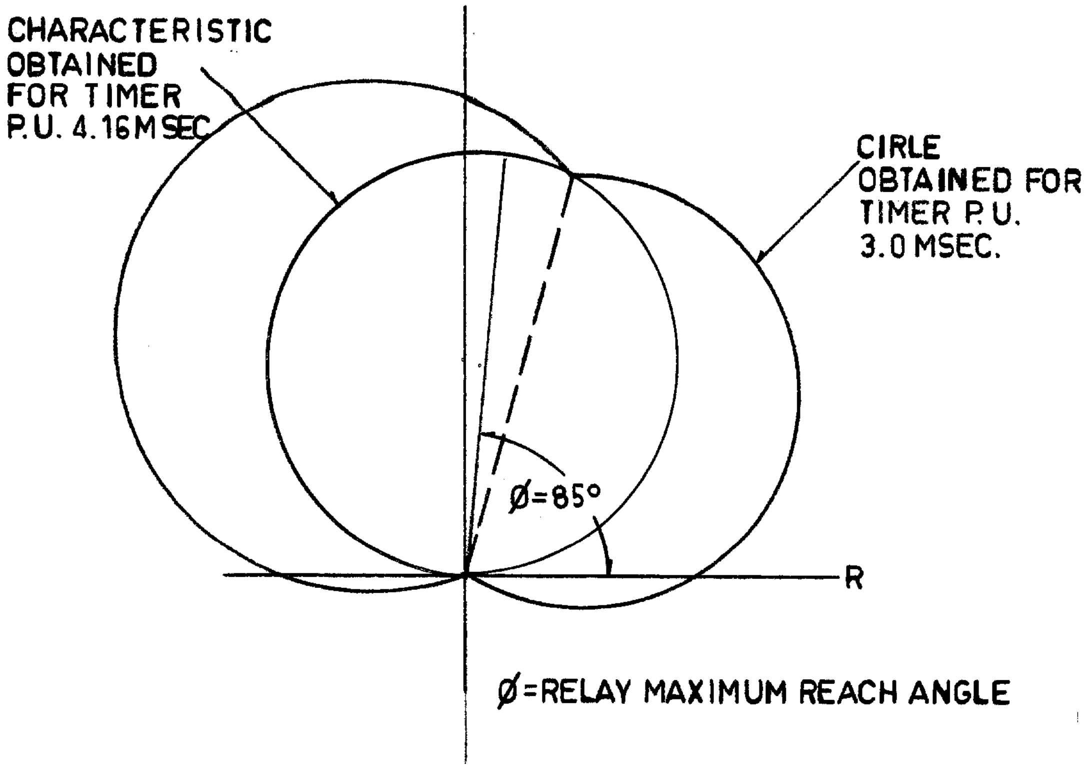


Fig. 7 (0269A3115-0) MHO CHARACTERISTIC AT 85-DEGREE ANGLE OF MAXIMUM REACH WITH VARIATIONS IN PICKUP TIMER SETTINGS

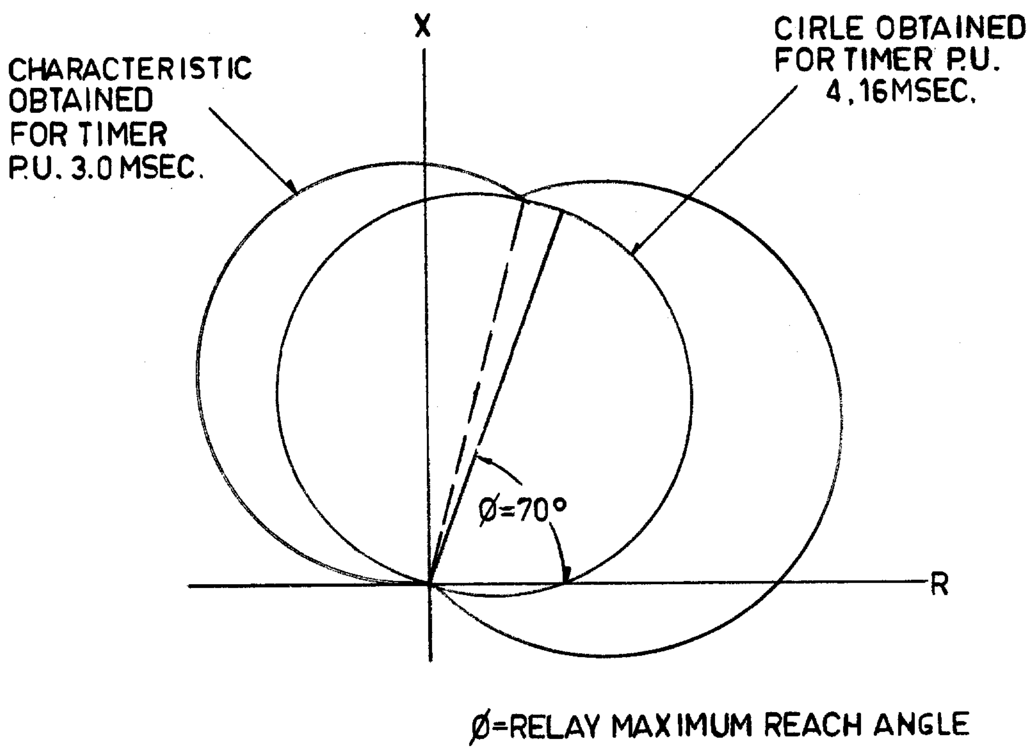


Fig. 8 (0269A3116-0) MHO CHARACTERISTIC AT 70-DEGREE ANGLE OF MAXIMUM REACH WITH VARIATIONS IN PICKUP TIMER SETTINGS

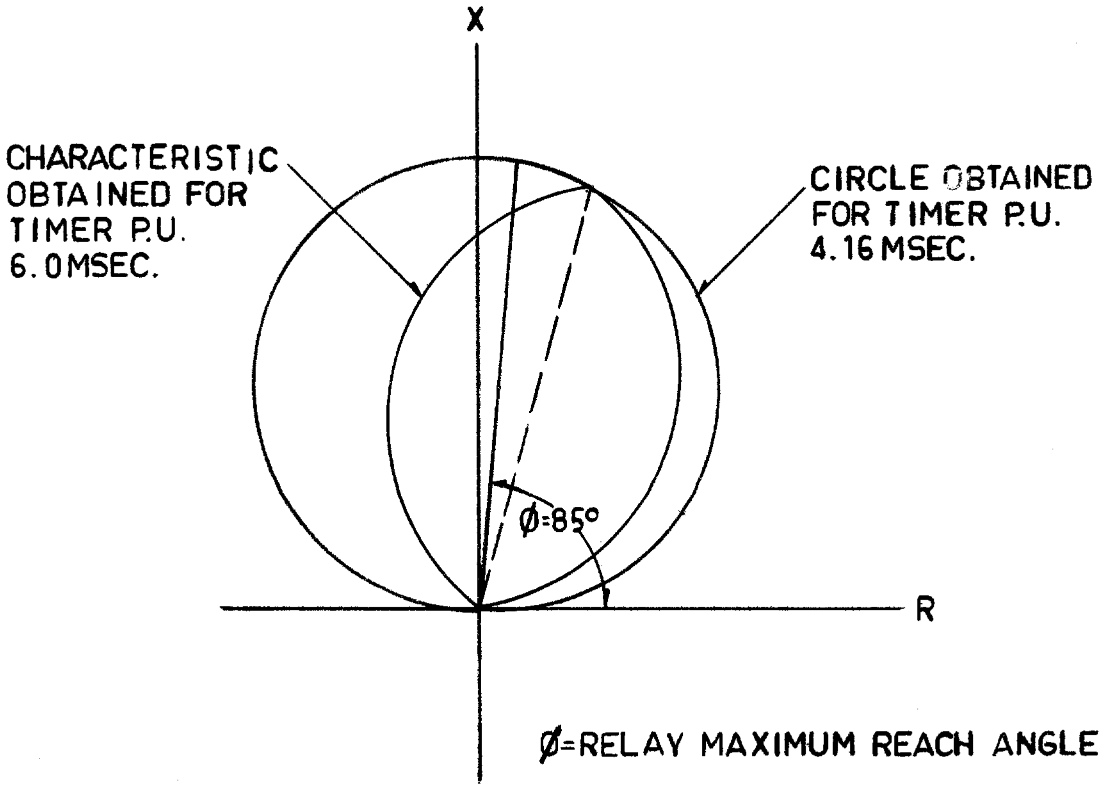


Fig. 9 (0269A3117-0) MHO CHARACTERISTIC AT 85-DEGREE ANGLE OF MAXIMUM REACH WITH VARIATIONS IN TIMER PICKUP SETTINGS

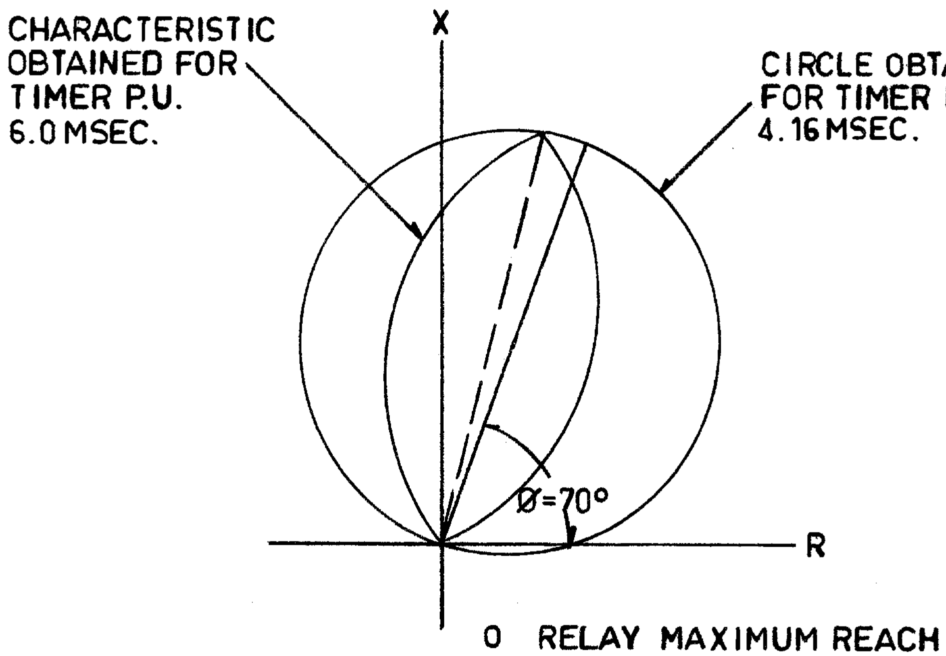


Fig. 10 (0269A3118-0) MHO CHARACTERISTIC AT 70-DEGREE ANGLE OF MAXIMUM REACH WITH VARIATIONS IN TIMER PICKUP SETTINGS.

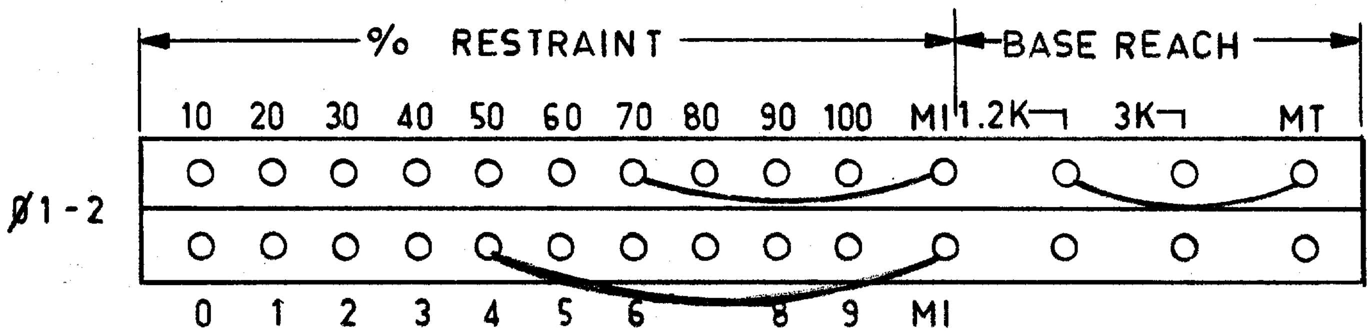
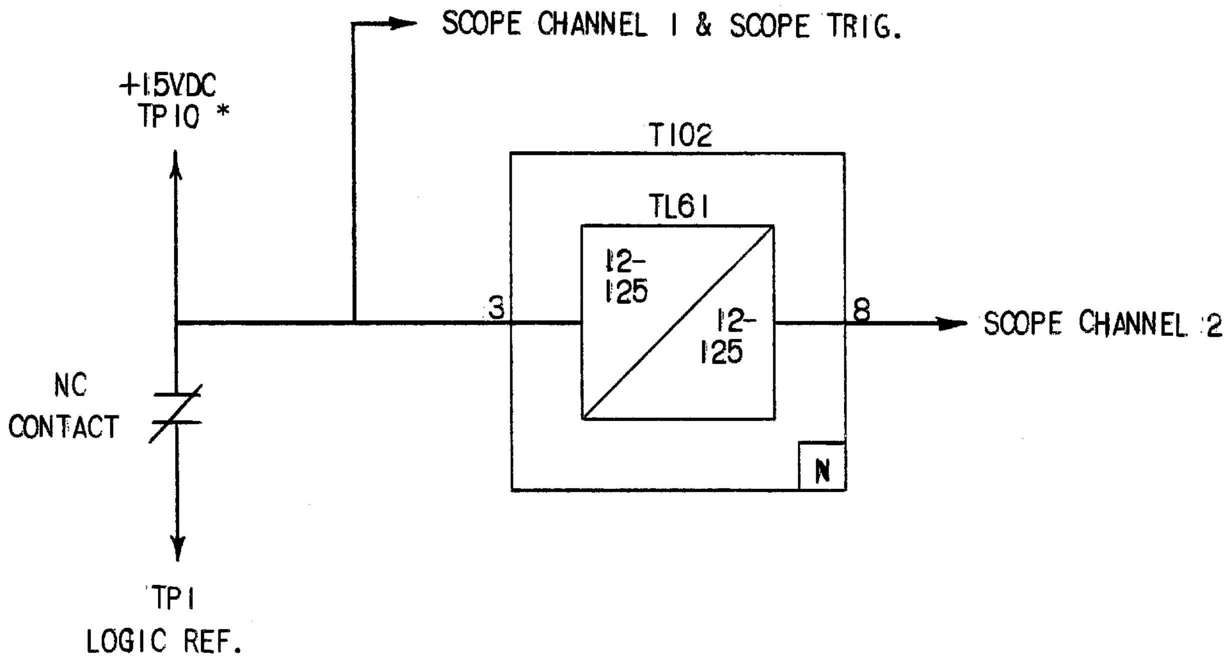


Fig. 11 (0257A8795-0) TYPICAL SLY71 TAP BLOCK CONNECTIONS



* THE 15VDC SIGNAL AT PIN 10 HAS A CURRENT LIMITING RESISTOR MOUNTED ON THE TEST CARD.

Fig. 12 (0246A7987-0) TIMER TEST CIRCUIT

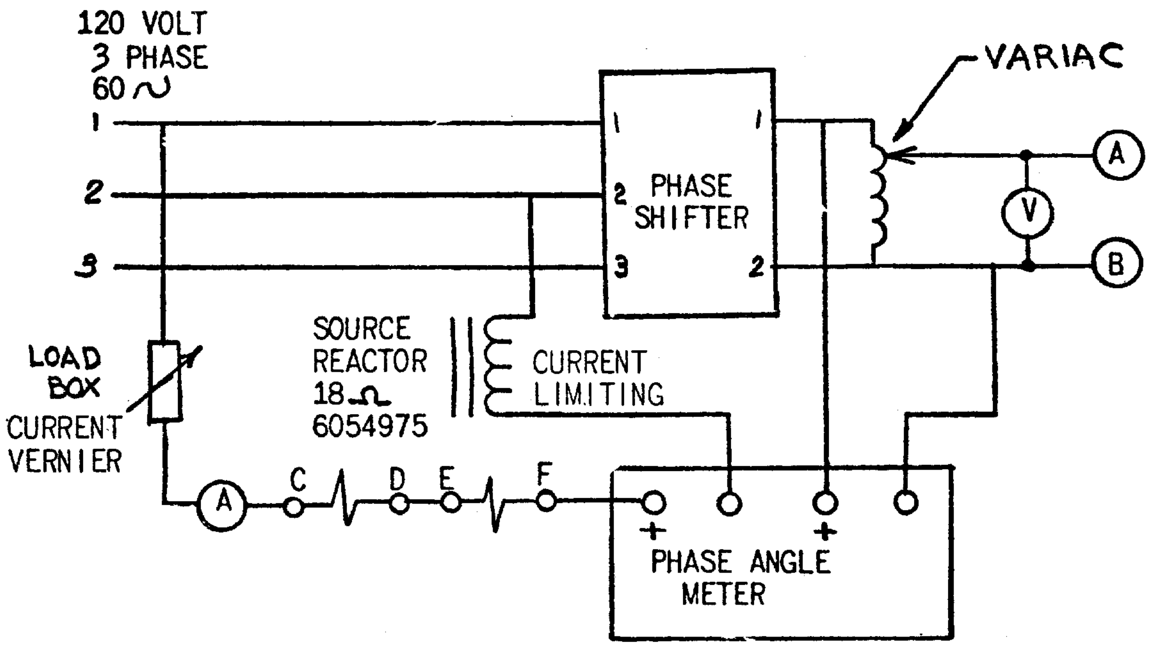
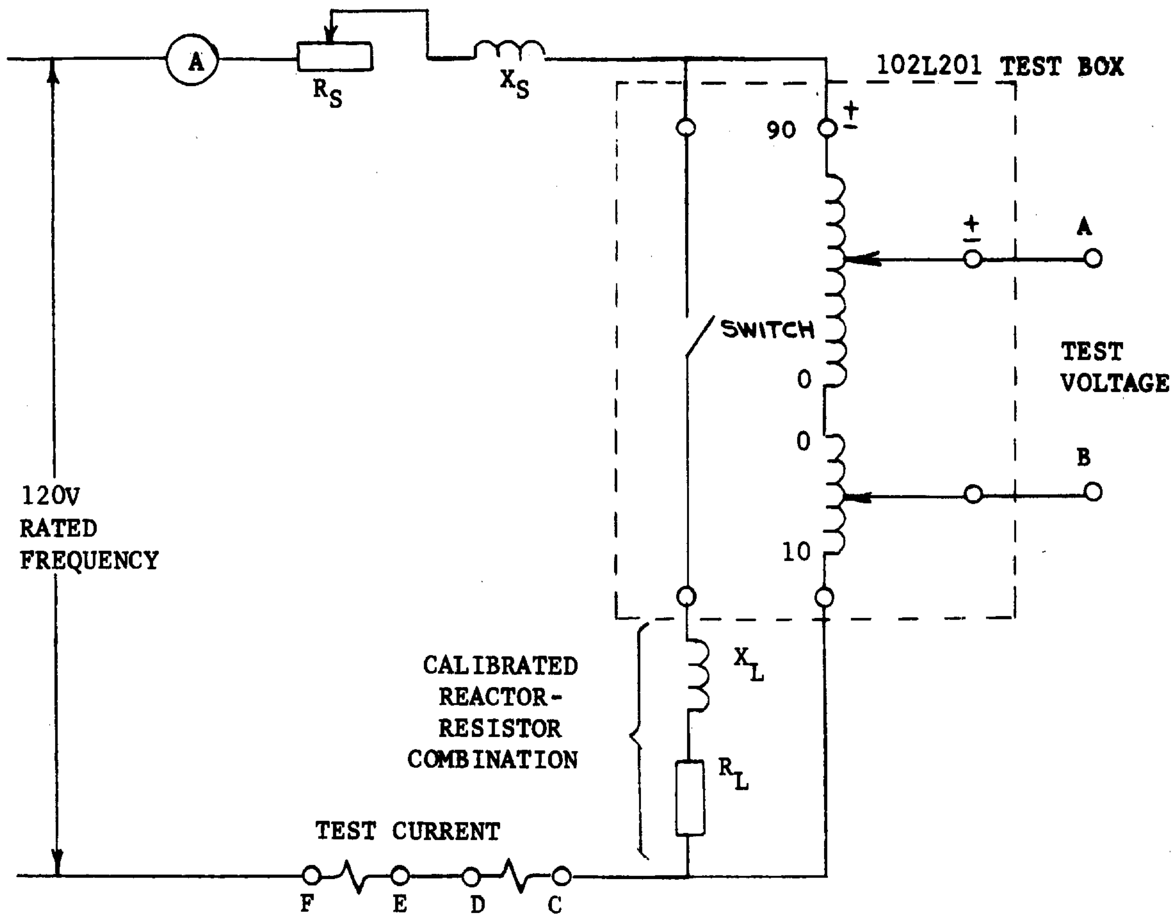


Fig. 13 (0178A7029-3) PHASE SHIFTER TEST CIRCUIT



g. 14 (0178A7028-3) TEST CIRCUIT FOR CHARACTERISTIC CHECK USING TEST BOX, TEST REACTOR AND RESISTOR METHOD

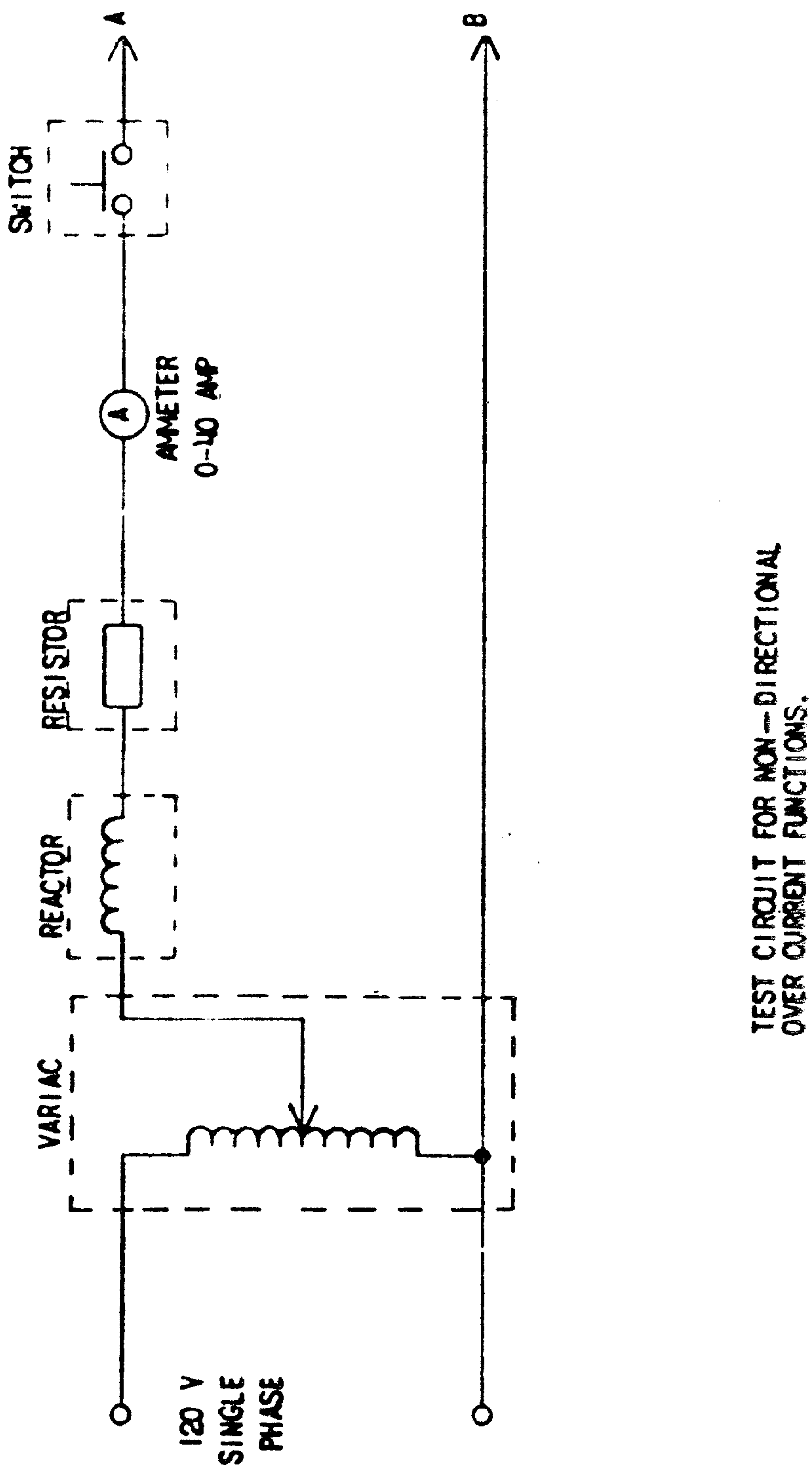


Fig. 15 (0246A3681-0) OVERCURRENT FUNCTION TEST CIRCUIT