INSTRUCTIONS

GEK-41926A

STSTIC PHASE DISTANCE RELAY

TYPE SLYL51A

POWER SYSTEMS MANAGEMENT DEPARTMENT

GENERAL ELECTRIC

CONTENTS

STATIC PHASE DISTANCE RELAY

TYPE SLYL51A

DESCRIPTION

The Type SLYL51A relay is a static, three phase, non-directional lens distance relay. It is designed to be used with other distance relays to provide a limited trip area in protection schemes for transmission lines against multi-phase faults. This relay is usually used as an overreaching function in conjunction with another phase relay of the directional mho distance type. The relay is packaged in one case. two rack units in height as shown in Figure 1. The relay component locations are shown in Figure 2 and the relay internal connections are shown in Figure 3. External connections are shown in Figure 4.

The Type SLYL51A relay is not intended to be used by itself but rather as part of a complement of equipment that forms a protective relaying scheme. Generally, in addition to the SLYL51A relay, included relays are an SLY51 directional mho phase distance relay, an SLYG ground relay, an SLC overcurrent relay, an SLA logic relay, an SLAT output relay and an SSA50 power supply. The SLYL51A relay outputs are d-c logic signals that are fed into the SLA logic relay the circuitry of which depends upon the overall protection scheme being employed.

The measuring functions included in the SLYL51A relay are:

LT - three single-phase nondirectional lens distance units

For a complete description of the overall scheme in which this relay is employed, refer to the overall logic diagram and its logic description that is supplied with each terminal of equipment.

APPLICATION

The Type SLYL51A relay is a static, three phase, non-directional lens distance relay designed to be used with other distance relays to provide a limited trip area in protection schemes for transmission lines. The typical lens LT and mho MT characterictics are shown in Figure 5. The logic circuitry in the SLA is arranged so that the trip area is what is simultaneously inside the mho and the lens characteristic. The lens characteristic is useful in making a suitable relay setting for long transmission lines without infringing on the load carrying ability of the lines. The permissible line loading is determined by LT characteristic plus a suitable margin. Care should be exercised in applying the lens LT function since it tends to restrict the amount of arc resistance that can be accomodated in a fault and still have the relay provide reliable tripping. The lens characteristic shown in Figure 5 is non-directional in that it includes the origin of the R-X diagram, which is the relay location, within its characteristic. This application provides coverage for faults with arc resistance occurring at or near the relay location. The lens characteristic also makes the relay scheme less responsive to operation on power swings.

The LT function reach in the forward direction should be set for at least 125%, preferably 150%, of the protected line section and should include an adequate margin to accomodate resistive faults occurring at any location on the protected line section.

The sensitivity of the LT functions is measured by the relation between the three phase fault current and the reduction of ohmic reach of these functions as the current decreases. The sensitivity is defined as the minimum three phase fault current required for the minimum ohmic base reach tap selected that will cause the relay reach to pull back to no less than 90% of the set or nominal reach. These sensitivity current ratings for the LT forward and LT* reverse reach taps are as follows:

LT forward Tap	Three Phase Currents
1.0 ohm	amperes
2.0 ohms	amperes
4.0 ohms	amperes

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.

LT* reverse Tap	THREE PHASE CURRENTS
0.2 ohms	amperes
0.75 ohms	amperes
3.0 ohms	amperes

From the above ratings it is obvious that the sensitivity of the LT function improves as a higher ohmic base reach tap is used. Therefore, it is recommended that the highest base reach tap that will accomodate the desired reach setting be used.

RANGES

The LT functions in the SLYL51A relay have a range of adjustment listed below:

LT (forward)	1 to 40 ohms at 82^{o}	Base reach taps: 1,2,4 ohms
LT*(reverse)	0.2 to 30 ohms at 82^{o}	Base reach taps: 0.2,0.75,3ohms

RATINGS

The Type SLYL51A relay is designed for use in an environment where the air temperature outside the relay case does not exceed 65^{o}C.

The current circuits of the SLYL51A 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.

The SLYL51A relay requires a ± 15 VDC power source which can be obtained from a Type SSA POWER SUPPLY.

BURDENS

The Potential burden per phase measured at 120 VRMS is as follows:

Volt amps

Watts

Vars

The Current burden per phase measured at 5 amperes is as follows:

Volt amps

Watts

Vars

The SLYL51A presents a maximum burden to the SSA power supply as follows:

from the + 15 VDC supply

from the - 15 VDC supply

OPERATING PRINCIPLES AND CHARACTERISTICS

A typical offset lens characteristic for the SLYL51 relay is shown in Figure 5 and measurement principles in Figure 6. The IZ quantities are voltages proportional to the phase to phase line currents. The V quantities are proportional to phase to phase voltage at the relay location equal to IZ_f where Z_f is the line impedance out to the fault.

The relay compares the phase relationship, angle B, of two square wave signals, IZ-V and IZ*+V* derived from the input phase to phase currents and voltages. Relay operation occurs when the derived "blocks" are in phase for the time duration equal to or greater than the characteristic timer setting. The timer setting establishes the characteristic included angle,C. The angle B is greater than 180-C for external faults. Angle B is equal to or less than 180-C for faults on or within the relay reach.

Typical wave forms are shown in Figure 7 with the coincidence card output occurring for in phase inputs.

The output blocks from the the coincidence cards, C104, are the inputs of the characteristic timers, T101. 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.

CALCULATION OF SETTINGS

The setting of the LT function will depend upon the application in which it is employed. As an example, assume a directional comparison scheme with the LT AND MT combination as described in the APPLICATION section. The reach of the LT function should include the protected line section plus at least a 25 percent margin in both the forward or tripping direction and in the reverse or blocking direction. There should be a 25 percent margin applied to the expected arc resistance for faults at either end of the line.

The most direct method of determining the required settings is by means of a simple graphical analysis on a R-X diagram with all values plotted in terms of secondary impedance. Figure 12 shows an example of the line section AB. The following method is suggested for determining the reach setting of the LT unit with a 120 degree included angle characteristic considering the unit at terminal "A" as an example:

1. Plot the line section.
2. Plot the points 1 and 4 by adding 25% of the protected line section in each case.
3. Plot points 2 and 3 by determining the apparent arc resistance at terminal A is the total arc resistance corresponding to the total fault current divided by the distribution constant C which is the ratio of the fault current contribution from terminal A to the total fault current.
4. Plot through point A the chord of the LT characteristic at its 82 degree angle and then by inspection pick points Y and Z as the end points of an LT characteristic which when plotted will encircle points 1 through 4.
5. To plot the characteristic which will have end points Y and Z, first construct the perpendicular bisector of line YZ. Next draw the dotted lines at Y and Z at 30° angles from line YZ as shown in the figure. The points U and V where these lines intersect the perpendicular bisector define the centers of the two intersecting circles which make up the lens characteristic of LT.
6. Plot these two intersecting circles using U as the center of Y-V-Z, and V as the center of Y-U-Z. Then determine if all points 1 through 4 are included within the resulting LT characteristic is providing more margin than necessary, adjust either point Y or point Z, or both, to enlarge (or reduce) the size of the characteristic and repeat steps 5 and 6.
7. A direct measurement of reverse ohmic reach AZ and forward ohmic reach AY will give the reach settings to be placed on the LT unit.
8. Plot the 0.85 power factor line (32 degrees) and determine the point 5 where it intersects the lens characteristic. Measure the secondary ohms and convert this into primary MVA to determine the load carring ability of this relay setting. Apply a suitable margin as desired

The foregoing graphical analysis is for a 120 degree included angle lens unit and the angle timer setting would be set for one-third cycle or 5.55 ms. If a narrower lens characteristic is desired, the unit angle timer setting should be increased. The recommended practical limit of adjustment for the lens is a 150 degree included angle. This corresponds to a 0.417 cycle or 6.95 ms timer setting.

When the required secondary ohmic reaches, LT forward and LT* reverse, have been determined from step 7 above, the various tap settings may be calculated. For optimum performance select the highest possible base reach tap, T_B. The necessary restraint tap setting T in percent is then determined by the following relation:

$$T = \frac{100\, T_B}{Z}$$

where Z = the required reach LT or LT* as determined from the graphical analysis previously described.

CONSTRUCTION

The Type SLYL51A relay is packaged in an enclosed metal case with hinged front cover and top cover. The case is suitable for mounting in a standard 19 inch rack. The outline and mounting dimensions of the case and the physical location of components are shown in Figures 1 and 2 respectively.

The tap blocks for making the reach settings for the LT function are located inside the hinged front cover. The method of making reach tap settings is illustrated in Figure 4. Since the forward, LT, and reverse LT* reaches are independently selectable, there are two jumpers associated with the restraint setting for each direction. The upper LT and LT* restraint jumpers provide 10 percent selection and the lower jumpers provide additive 1 percent increments. The pair of Base Reach jumpers associated with the forward, LT, direction must be co-nected to the same pair of forward direction base reach cavities. Likewise the reverse direction jumper pair must connect to the same pair of reverse direction base reach cavities. Tools are provided for insertion and extraction of the reach setting jumpers.

The SLYL51 relay contains printed circuit cards identified by a code number such as C104, F120 or T101 where C designates coincidence, F designates filter and T designates time delay. The printed circuit cards plug in from the front of the unit. The sockets are marked with letter designations or "addresses" which appear on the guide strip in front of each socket, on the component location diagram and on the internal connection diagram. The test points (TPI)etc. shown on the internal connection diagram are connected to instrument jacks on a test card in position T with PTI at the top of the card. TP10 is tied to +15VDC through a 1.5K resistor to limit the current when used to supply a logic signal to a card.

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, 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. 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 tripping over when the swing rack is opened.

INSTALLATION TEST

The Type SLYL51A 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 procedures given under DETAILED TESTING INSTRUCTIONS before the relays are put into service.

1. LT and LT* Base Reach Settings
2. LT and LT* Restraint Voltage Settings
3. Forward and Reverse operating points at angle of maximum reach.
4. Timer Settings

GENERAL TESTING INSTRUCTIONS

INPUT CIRCUITS

The Type SLYL51A relay has a terminal block on the rear of the unit identified as L A. In static relay equipment this terminal block is wired through the test panel where test currents 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 points which connect to the same LA terminals as those shown on the test circuit diagram. Reference to the job elementary will provide information conserning customer relay input.

OUTPUT SIGNALS

Output signals are measured with respect to the reference bus or TPI on the test card. Logic signals are approximately +15VDC for the ON condition and less thanIVDC for the OFF condition. Filter card outputs are either +15VDC or -15VDC for the ON condition. These outputs can be monitored with an oscilloscope, a portable high impedance DC voltmeter, or the test panel voltmeter. When the test panel voltmeter is supplied, it will normally be connected to the reference bus. Placing the relay test lead in the desired test point pin jack will connect the meter for testing.

When the 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

WARNING: 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 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 INADVERTENLY 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.

REACH TAP SETTING

The arrangement of the reach tap blocks is described in the section on Construction and the choice of the tap settings is discussed in the CHOICE AND CALCULATION of SETTINGS section.

LENS CHARACTERISTIC TESTING

The lens characteristic may be checked over its entire range by using the test circuit employing a phase shifter and phase angle meter as shown in Figure 5 with connections per Table I.

TABLE I

	TEST CIRCUIT CONNECTIONS						LENS
	A	B	C	D	E	F	OUTPUT
Phase 1-2	LA2	LA3	LA5	LA6	LA8	LA7	TP6
Phase 2-3	LA3	LA4	LA7	LA8	LA10	LA9	TP7
Phase 3-1	LA4	LA2	LA9	LA10	LA6	LA5	TP8

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

(a) Set up the test of Figure 5 and make the AC connections per Table for the particular phase being tested.

(b) Set the test current to 5 amps RMS. The current limiting reactors ohmic value should be as high as possible to assure the most harmonic free test current.

(c) Connect the instrumentation (preferably an oscillopcope) between the output test point and reference at TPI.

(d) Adjust the phase shifter for the desired phase angle.

(e) Adjust the variac until the function output fully picks up. The point at which the function picks up, as read on the voltmeter, defines the relay characteristic.

Steps (d) and (e) are repeated until the characteristic is clearly defined.

Since the "lens shaped" LT characteristic comes to a point at the angle of maximum reach both forward and reverse, it is suggested that the operating point be checked at 2 degree intervals for 10 degrees either side of the maximum reach angle. Pickup checks at 20 degree intervals over the remainder of the characteristic should suffice. It is suggested that the results be plotted on polar graph paper.

An alternate method of testing the relay characteristic is shown in Figure 10 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.

Should the voltage V at the angle of maximum reach, at which pickup occurs, be different than the calculated value of V it may be adjusted by turning the P10 potentiometer on the F120 card for the forward direction or P52 for the reverse direction as described below.

Determine what test voltage V in Figure 9 is necessary to produce output at the relays maximum reach angle for 5 amperes of current, and the particular tap setting.

The voltage V at the angle of maximum reach is:

$$V = \frac{2\ IZ\ 100}{\%\ \text{RESTRAINT TAP}}$$

I = 5 amp test current
Z = Base reach tap in ohms

F 120 FILTER CARD

The F 120 filter card contains four potentiometers; P61, P71, P10 and P52. P61 is a filter adjustment potentiometer that is set in factory test and sealed. This potentiometer must not be re-adjusted. The phase shift adjustment potentiometer, P71, is set to provide the proper relationship between the operating quantities (IZ-V) and (IZ*+V*). This setting may be checked by applying a single phase voltage (30VRMS) to the input terminals of the phase under test, i.e. LA2 - LA3 for Ø1-2, and monitoring a 180° phase difference in the square wave outputs at the associated filter card pins 8 and 9. P10 and P52 are forward and reverse reach calibration potentiometers respectively and are adjusted to provide the proper operating point (reach) at the angle of maximum reach. Their adjustment is made using the characteristic test circuit of Figure 5 with the phase shifter set for the forward and reverse angles of maximum reach. Clockwise potentiometer rotation raises the operating point and vice versa.

T 101 CHARACTERISTIC TIMER CARDS

The T 101 timer card has adjustable pickup and dropout time delays set by P2 and P3 potentiometers respectively. The settings for the timers in a particular scheme can be found on the overall Logic Diagram for that scheme adjustment should be made as follows:

(a) Remove the coincidence card preceeding the timer card under test.

(b) Connect the test circuit of Fig. 11 applying the input signal to the testpoint preceeding the timer card.

(c) Using an oscillopcope with an externally triggered calibrated horizontal sweep, connect the trigger to the timer card input test point and vertical input to the test point following the card.

(d) With the oscilloscope triggering sensitivity set for positive slope, the pick up time delay may be monitored by opening the normally closed contact. Clockwise rotation of the P2 potentiometer increases the pick up time delay.

(e) With the oscilloscope set for negative slope triggering, the test circuit contact closure allows measurement of the drop out time delay. Clockwise adjustment of the P3 potentiometer increases the drop out delay.

MAINTENANCE

A. PERIODIC CHECKS

For any periodic testing of the SLYL51A relay, the associated SLAT trip outputs should be disconnected from the circuit breaker.

The reach of the LT functions may be checked at periodic intervals using the instructions in the section DETAILED TESTING INSTRUCTIONS.

B. TROUBLE SHOOTING

Test points are provided at selected points in the SLYL51A logic and may be used to observe outputs if trouble shooting is necessary. The use of a card adapter will make all the pins on any one card available for testing.

All output voltages at the test points are measured with respect to the reference bus, TPI. When no signal is present the voltage is less than one volt, the output signal voltage is +15 VDC.

C. SPARE CARDS

The number of spare cards to carry in stock would depend on the total number of static relays, using similar cards, at the same location or serviced by the same test group. For each type of card (different code disignation) a suggested minimum number of spare cards would be:

1 spare for 1 to 25 cards

2 spares for 26 to 75 cards

3 spares for 76 to 150 cards

D. CARD DRAWINGS

Internal connections of the printed circuit cards can be found in the printed circuit card instruction book GEK-34158.

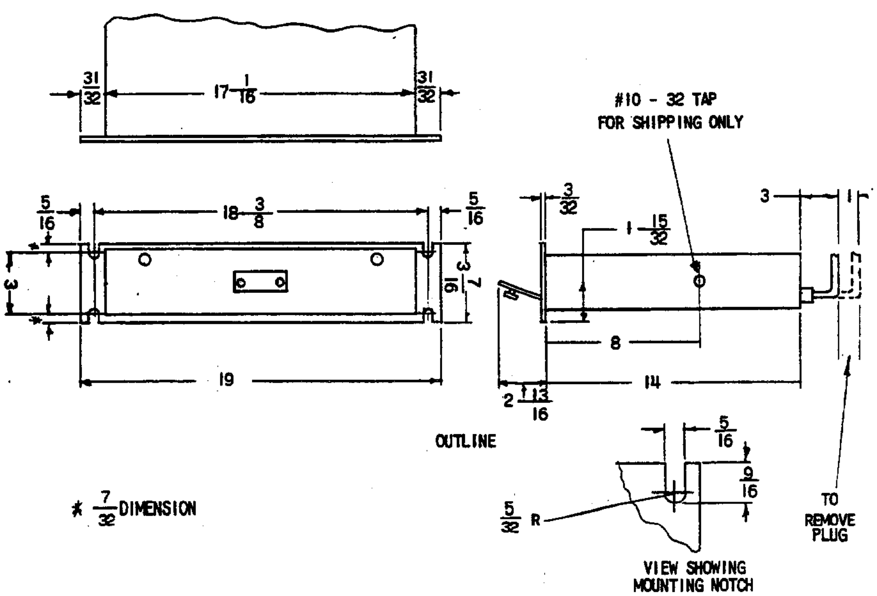
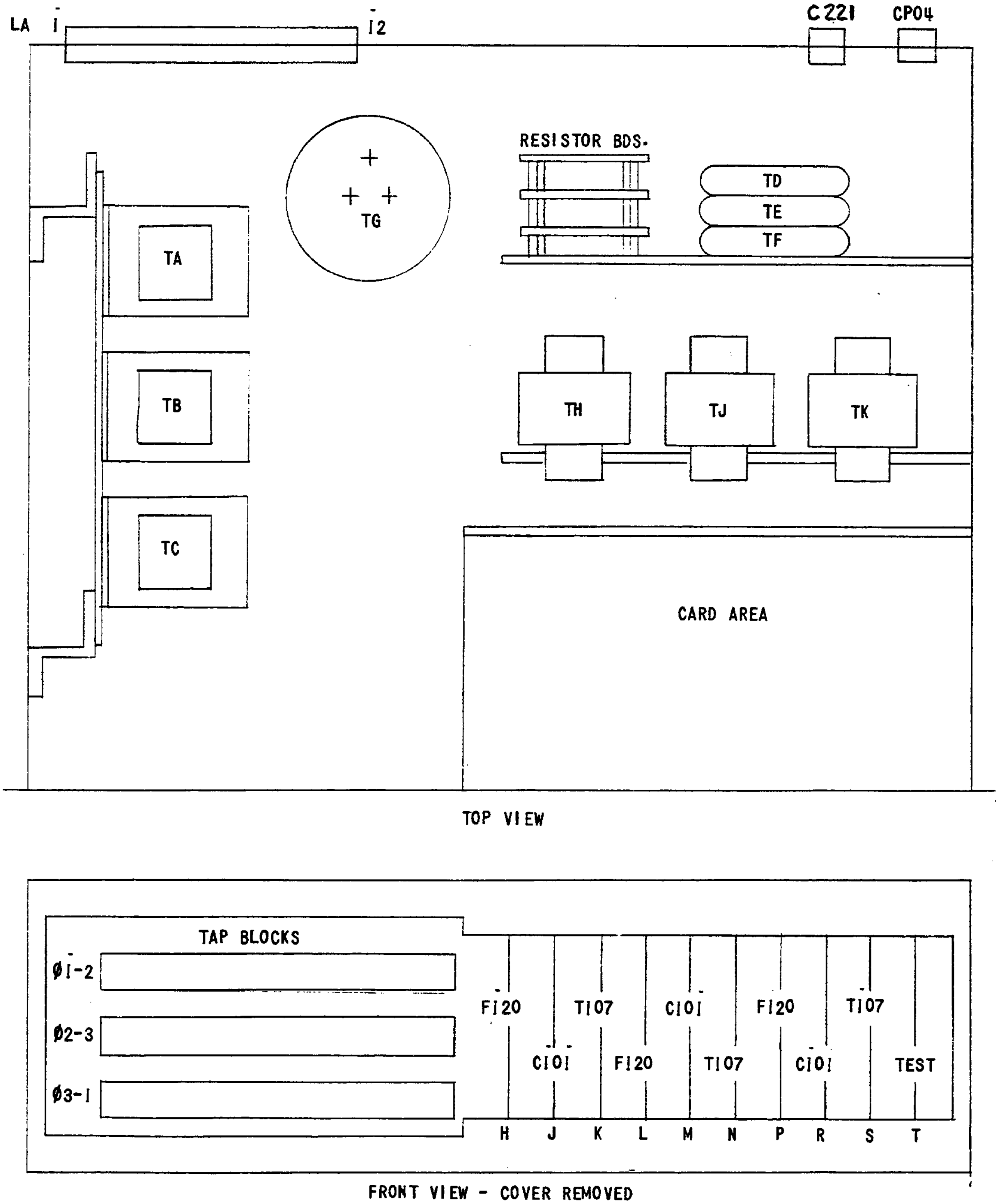


FIG. 1 (0227A2036-0) OUTLINE AND MOUNTING DIMENSIONS FOR THE SLY51A RELAY.



* FIG.2 (0227A2144 [1]) COMPONENT LOCATION DIAGRAM FOR THE SLYL51A RELAY

* Indicates revision

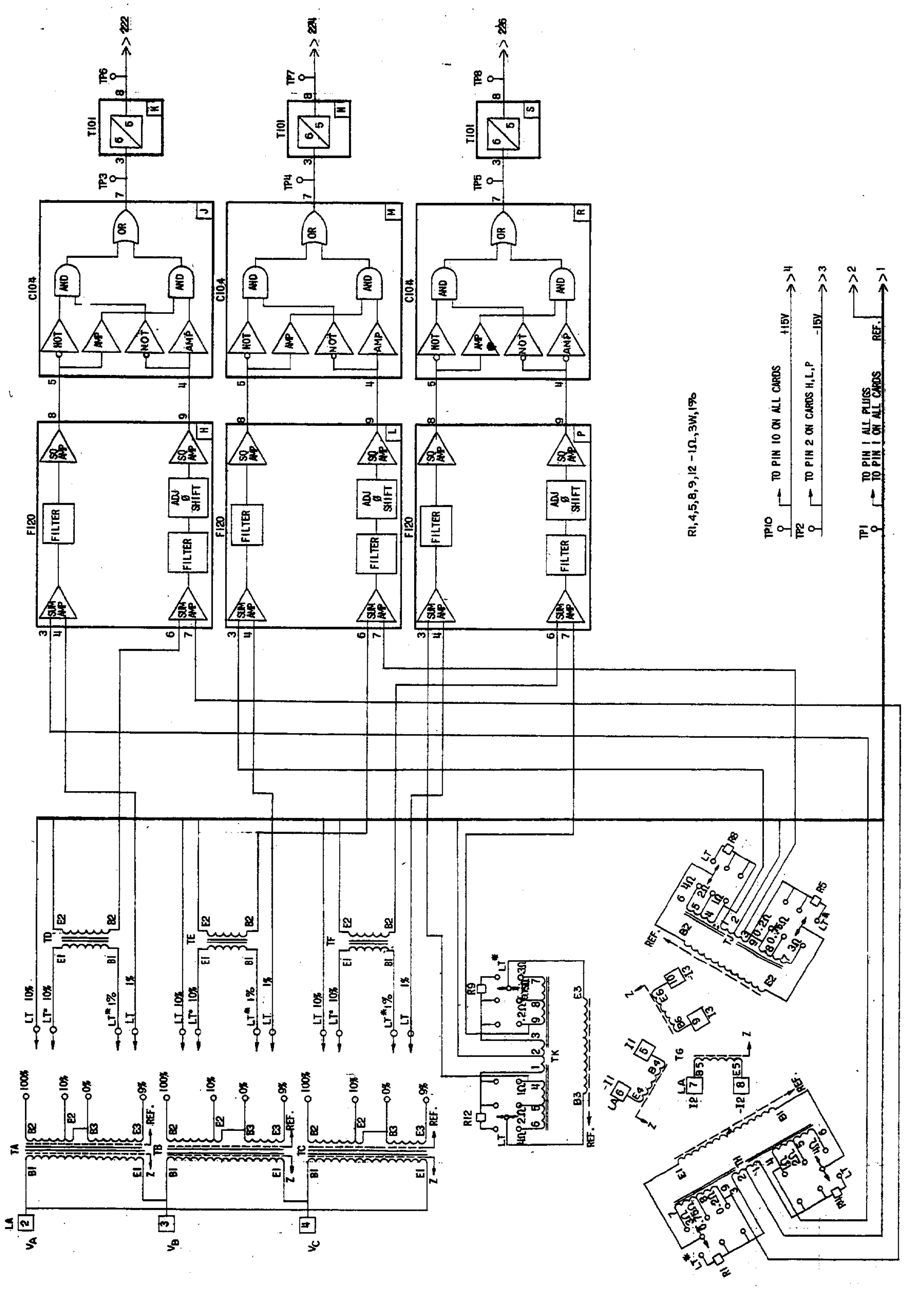


FIG. 3 (149C7366-3) INTERNAL CONNECTIONS DIAGRAM FOR THE SLYL51A RELAY

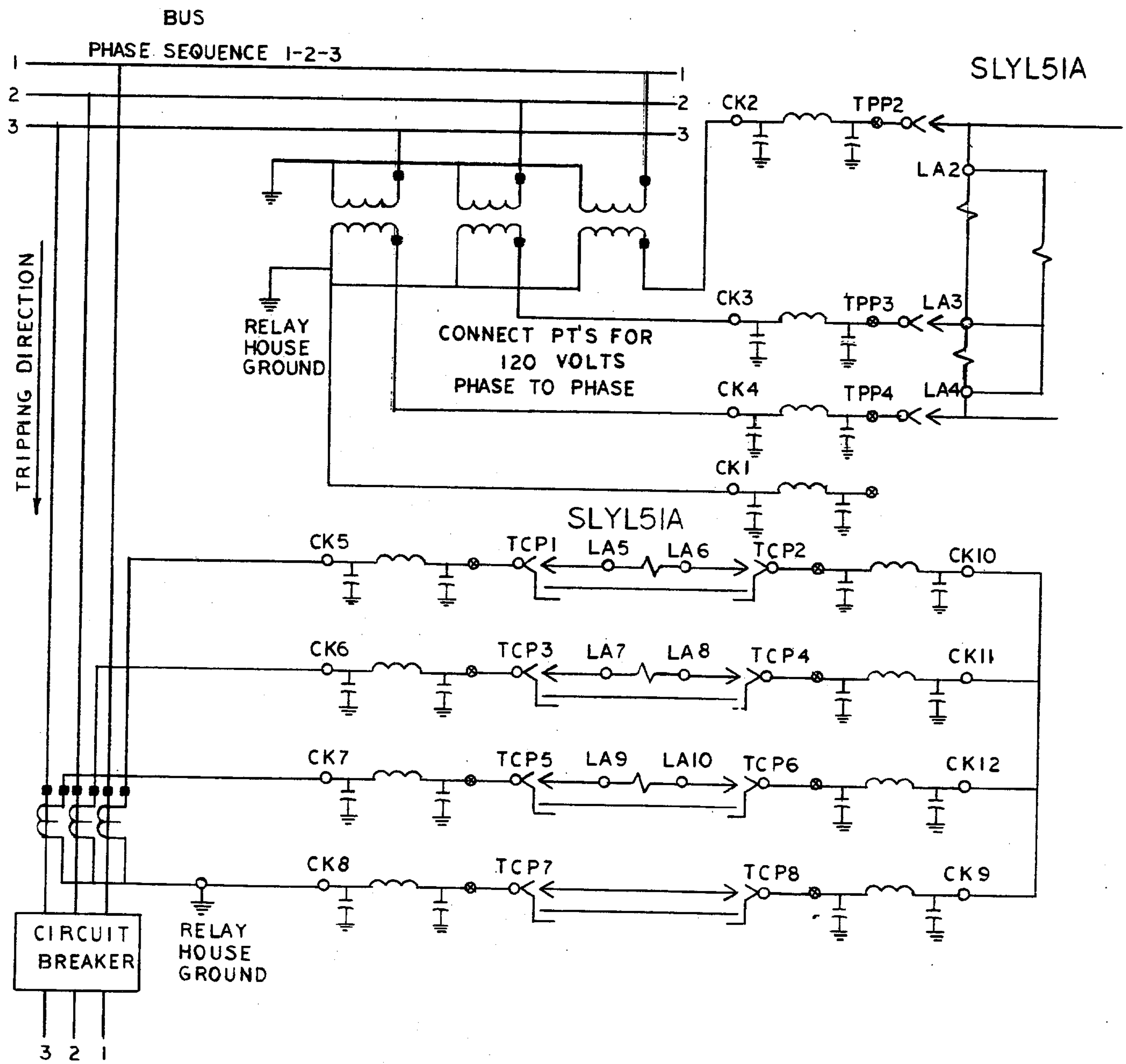


FIG. 4 (108B8927-0) EXTERNAL CONNECTIONS TYPE SLYL51A RELAY

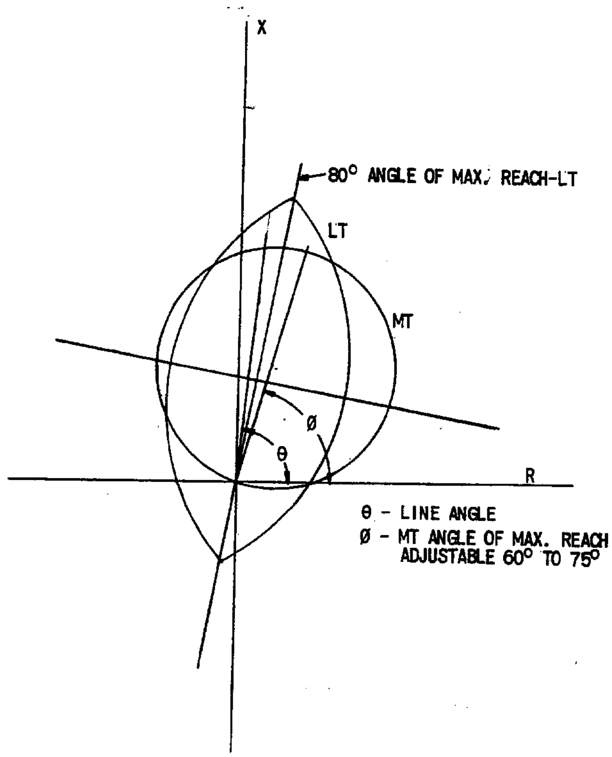


FIG. 5 (0257A8327-0) OFFSET LENS CHARACTERISTIC SLYL51A RELAY

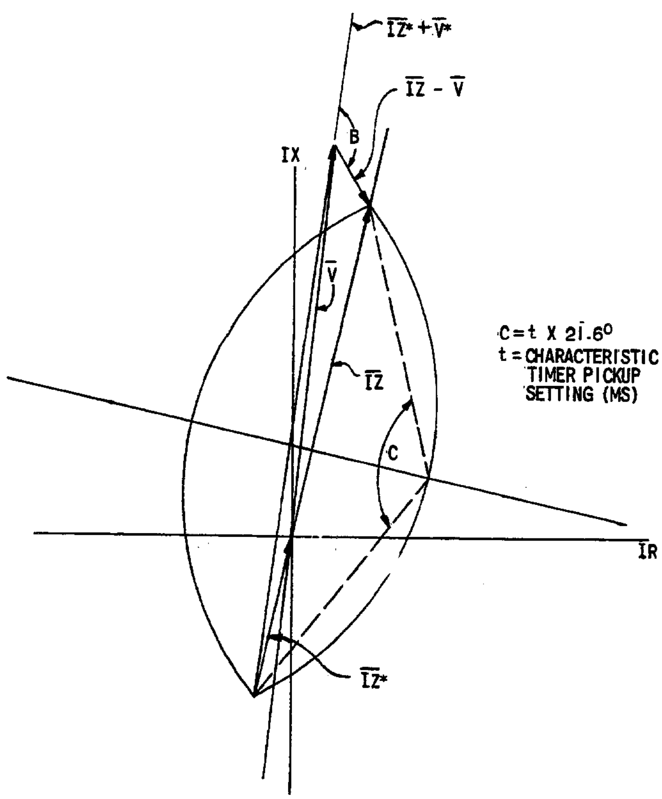


FIG.6 (0257A8328-0). LENS CHARACTERISTIC BY PHASE ANGLE MEASUREMENT

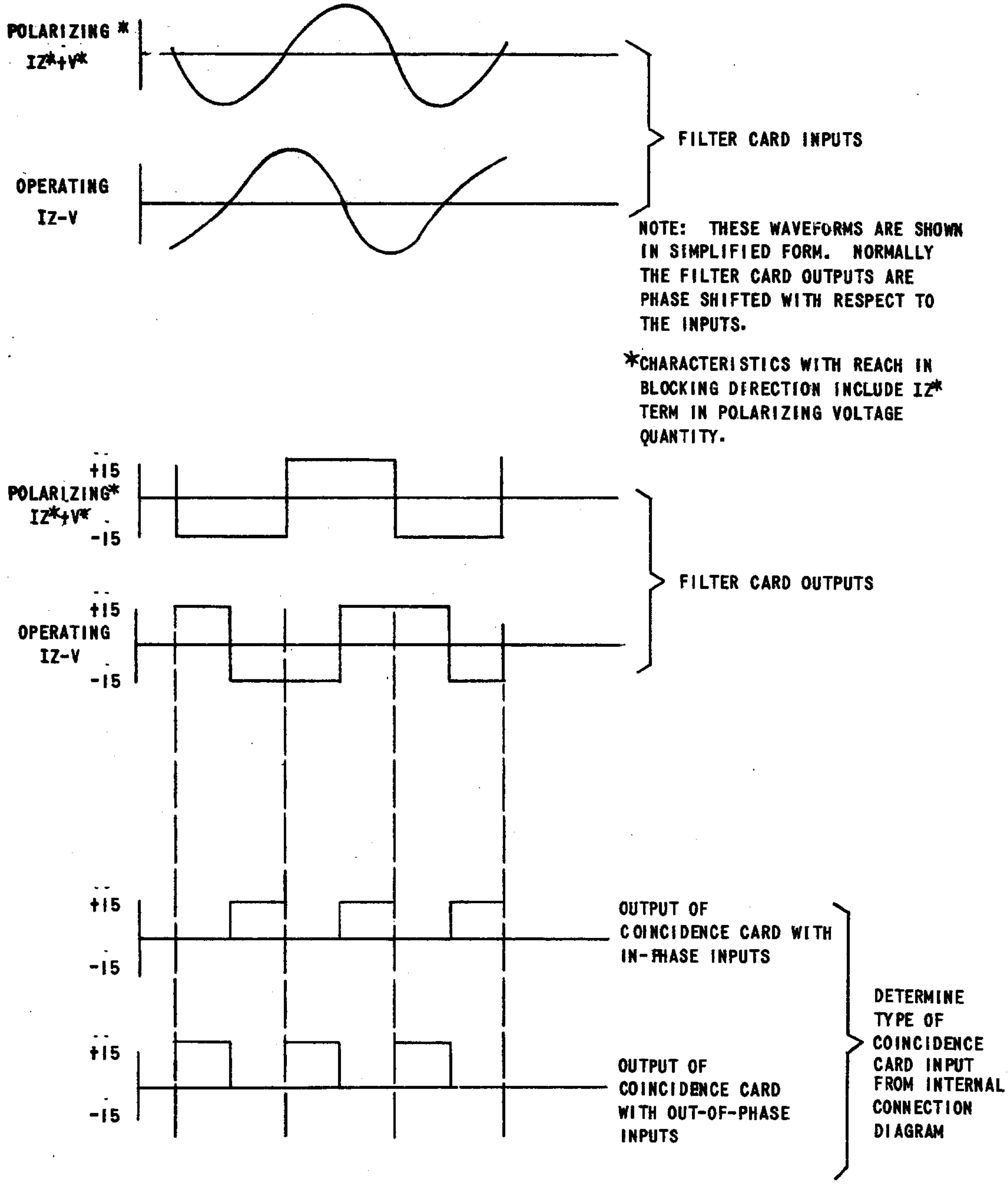


FIG. 7 (0257A8329-0)) SLYL51A OPERATING QUANTITY WAVE FORMS

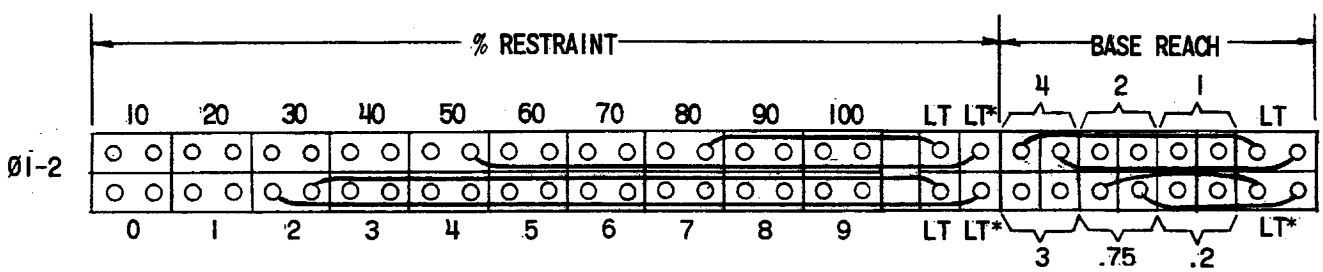


FIG. 8 (0227A2143-1) SLYL51A REACH SETTING TAP BLOCK CONNECTIONS

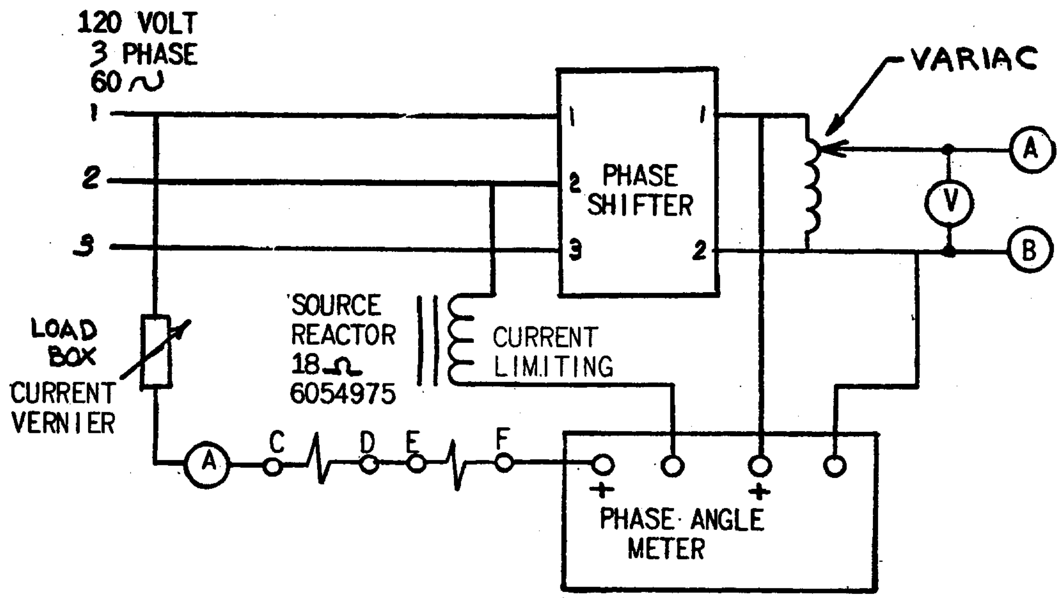


FIG. 9 (0178A7029-3) PHASE SHIFTER TEST CIRCUIT

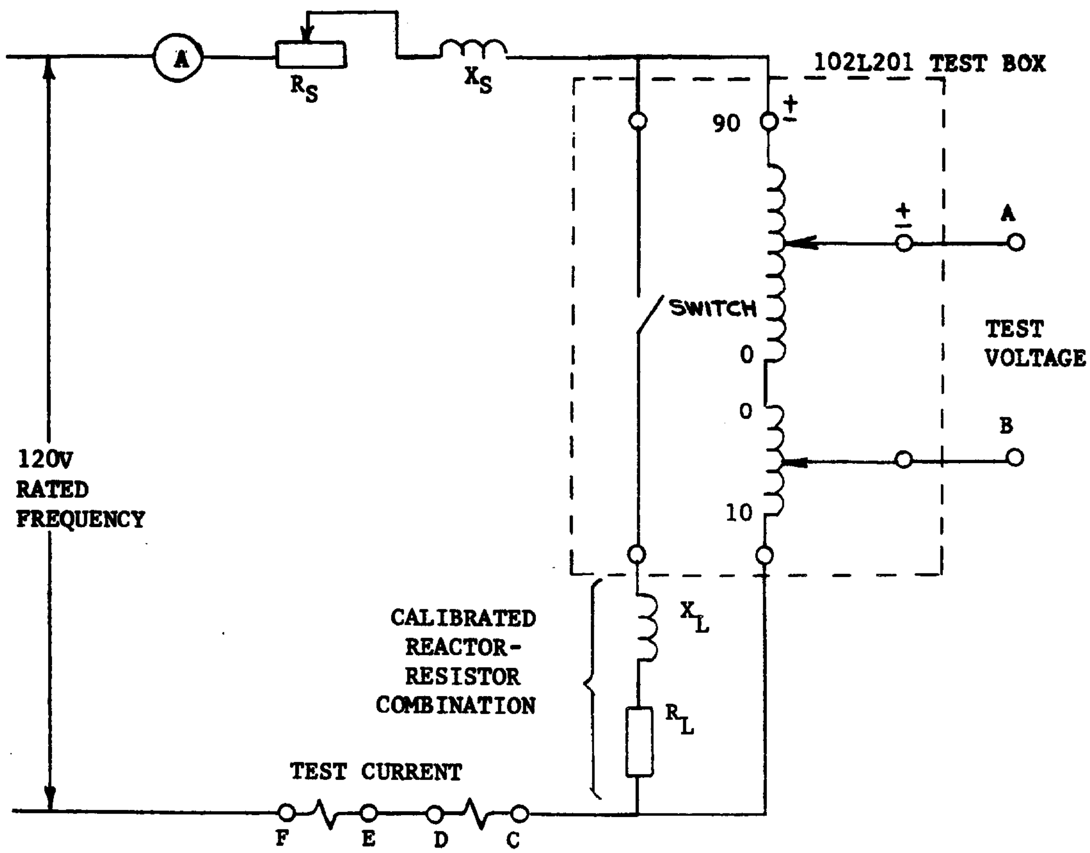
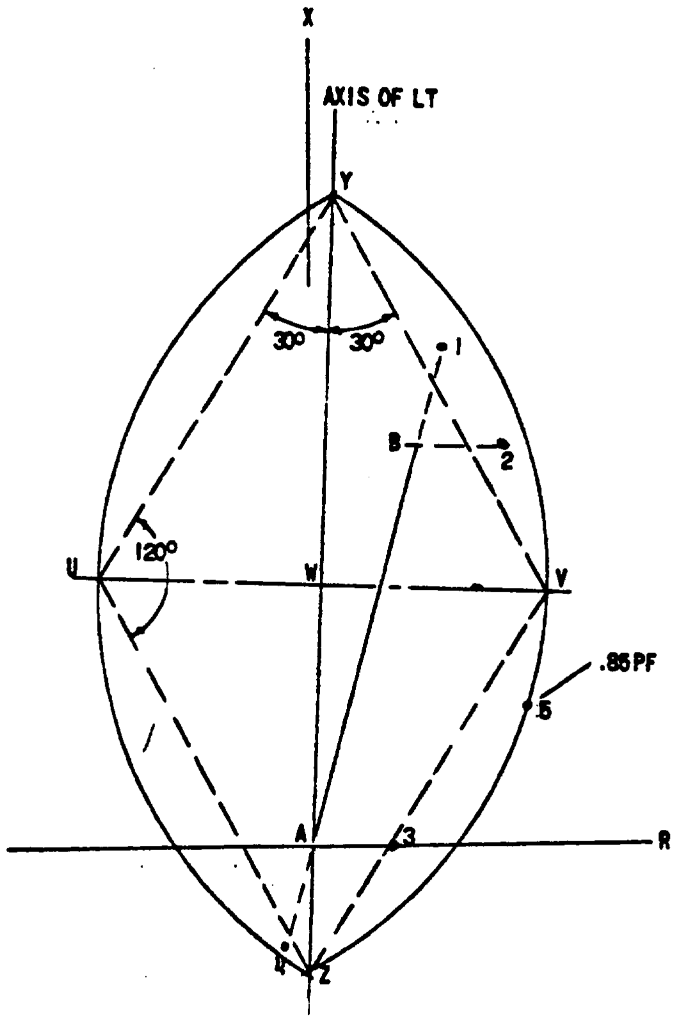
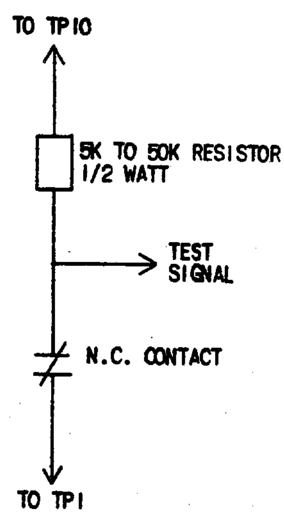


FIG. 10 (0178A7028-3) TEST CIRCUIT FOR CHARACTERISTIC CHECK USING R-X TEST SET



* FIG.11 (0227A2586 [1]) 120 DEGREE LENS CHARACTERISTIC



* FIG.12 (0227A2098 [4]) TEST CIRCUIT FOR TIMER CARDS

* Indicates revision