INSTRUCTIONS

GEK- 34017

STATIC THREE PHASE

MHO DISTANCE RELAY

TYPE SLY51A

POWER SYSTEMS MANAGEMENT DEPARTMENT

GENERAL ELECTRIC

CONTENTS

DESCRIPTION

The Type SLY51A relay is a static, three phase, directional mho distance relay designed to provide the overreaching function in pilot relaying schemes or as a second or third zone function in step distance schemes used for protection of transmission lines. One Type SLY51A relay will detect all multi-phase faults within its reach setting. The SLY51A is packaged in one 2 rack unit case as shown in Figure 1. Component locations for the SLY51A are shown in Figure 2.

The SLY51A 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 SLY51A relay, a Type SLYG ground relay, a Type SLC overcurrent relay, a Type SLA logic relay, a Type SLAT output relay and a Type SSA power supply are required to complete a protective scheme. The static circuits in the SLY51A require ± 15V d-c which is obtained from a Type SSA50 power supply. The Type SLY51A relay outputs are d-c logic signals that feed into a Type SLA logic relay the circuitry of which depends upon the overall protection scheme. The internal connections for the SLY51A are shown in Figure 3.

The measuring functions included in the SLY51A are listed below:

MT - Three single-phase mho distance units

MOB - Single phase mho out-of-step blocking unit (optional)

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

APPLICATION

The Type SLY51A relay is designed to provide the overreaching function in pilot relaying schemes or the second or third zone function in step distance schemes. Since the transient overreach of the mho functions in the SLY51A is not sufficiently limited by design, this relay is not suited for first zone applications. The additional relays and other equipment required to complete a specific scheme are described in the logic description that accompanies the overall logic diagram for that particular scheme. Figure 4 illustrates the external connections to the SLY51A when used in a directional comparison carrier blocking scheme.

PILOT RELAYING SCHEMES

The mho tripping function MT in various pilot schemes should be set to reach at least 125%, preferably 150-200%, of the protected line section.

STEP DISTANCE SCHEMES

ZONE 2 APPLICATIONS - The M2 function should be set so that it does not reach beyond the shortest zone 1 setting of the adjacent line sections for a zero infeed condition.

ZONE 3 APPLICATIONS - The M3 function should be set so that it does not reach beyond the shortest zone 2 setting of the adjacent line sections for a zero infeed condition.

The reach of the mho functions in the SLY51A tends to pull back slightly at low fault currents. This pull back in reach is dependent on the basic tap setting used and the magnitude of fault current available. When used on the 3 ohm basic tap the pull back in reach for all three phase and phase-to-phase faults will not exceed 10 percent if the three phase fault current exceeds 1.0 ampere and the phase to phase fault current is greater than 0.87 amperes. For smaller basic tap settings the fault current required will be inversely proportional.

The sensitivity of the mho function is defined by the relation between the three phase fault currer and the reduction of the ohmic reach as the fault current decreases. To obtain the maximum sensitivity for a desired mho function setting, the highest permissable base reach tap should be used. If the desired ohmic reach at the relay angle of maximum reach was 6 ohms, this setting could be accomplished by using the 1.2 ohm base reach tap with 20% restraint or the 3 ohm base reach tap with 50% restraint. The setting should be made with the 3 ohm base reach tap rather than the 1.2 ohm tap since for a given percent pull back the 1.2 ohm tap requires a higher magnitude of fault current.

The mho functions in the SLY51A have an adjustable angle of maximum reach over the range of 60 to 75 degrees. The 60 degree angle will accommodate more arc resistance, hence it is useful on the lower voltage transmission lines with less lagging angles where arc resistance may be a problem. The 75 degree angle is most useful for the extra high voltage lines with highly lagging angles and longer lines where arc resistance is of minor importance.

OUT OF STEP BLOCKING FUNCTION

The MOB out of step blocking function should be set by means of a graphical analysis on an R-X diagram. This should include the swing lines for various system conditions showing the successive values of apparent impedance at known intervals of time as the fastest swing progresses for each of the system conditions. Refer to the section on OPERATING PRINCIPLES AND CHARACTERISTICS for a description of the MOB R-X diagram characteristic. Ideally, MOB should be set with as small a characteristic timer pickup setting as practical just so that it is not operated by load or minor system swings. The A/40 timer has an A adjustment range of 2 to 4 cycles. A setting of two cycles will cause the logic to set up blocking on faster swings than a setting of four cycles.

RATINGS

The Type SLY51A relays are designed for use in an environment where the air temperature outside the relay case does not exceed 65°C.

The current circuits of the Type SLY51A relay are rated at 5 amperes, 60 cycles, for continuous duty, and have a one second rating of 300 amperes. The potential circuits are rated 120 volts, 60 cycles.

The range of adjustment of the functions in the Type SLY51A relay are listed below:

MT Tripping:

0.3 to 30 ohms at 75° maximum reach setting.
0.3 to 32 ohms at 60° maximum reach setting.

Base Reach Taps:

3.0, 1.5, 1.2, 0.75, 0.60, 0.30

MOB Out-of-Step:

Characteristic dependent upon MT setting
(See "Operating Principles and Characteristics" section).

BURDENS

The maximum Potential Burden per phase measured at 120 VRMS line voltage is as follows:

.30 Volt Amp
.24 Watts
.18 Vars

The maximum Current Burden per phase measured at 5 amps line current is as follows:

$Z = 0.017 \angle 40^\circ$
$R = 0.013$
$X = 0.011$

OPERATING PRINCIPLES AND CHARACTERISTICS

The mho characteristic for the SLY51A relay is shown in Figure 5. 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 6. The axes are "IR" and "IX". The $\overline{IZ}$ quantity is a voltage proportional to the line current obtained by passing the line current through a network consisting of a current transformer and a reactor. The setting of this quantity establishes the "Base Reach" of the relay. The $\overline{V}$ 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 $\overline{V}$ and the operating quantity $(\overline{IZ}-\overline{V})$. The angle θ between these two quantities is greater than 90° for faults external to the relay characteristic, and is less than 90° for faults internal to the relay characteristic. For faults which cause $\overline{V}$ to terminate on the relay characteristic the angle β is equal to 90^{o}. This is true for any angular location of $\overline{V}$, because $\overline{V}$, $\overline{IZ}$, and $(\overline{IZ}-\overline{V})$ form a right triangle for any point on the relay characteristic.

The quantities $\overline{V}$ and $(\overline{IZ}-\overline{V})$ are the relay input quantities and are converted into blocks of voltage. These blocks which come out of the F101 card are out of phase. These blocks are compared with each other in the C101 card. The duration of their coincidence (having opposite polarity) is measured. Blocks which are 90^{o} apart are coincident (opposite polarity) for 4.16 milliseconds. Blocks which are less than 90^{o} apart are coincident (opposite polarity) for more than 4.16 milliseconds. This is illustrated in Figure 7.

MT TRIPPING FUNCTION

The MT function has a directional characteristic with the mho circle passing through the origin on an R-X diagram. See Figure 5.

If the 100% voltage tap is used, the phase to neutral reach of the relay at the angle ϕ is equal to the IZ base reach tap chosen. If a voltage tap other than 100% is chosen, relay reach is increased in inverse proportion to the voltage tap. For example, if the 50% 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 MT unit at the angle of maximum reach ϕ, may be calculated from the expression:

$$Z_{max} = \frac{IZ\ (Tap)}{V\ (Tap)} \times 100 \text{ (at angle } \phi) \qquad (1)$$

where V (Tap) is the restraint tap setting expressed in % and $Z_o = Z_{max} \cos(\theta-\phi)$. Z_o is the impedance the relay will be at any angle θ.

θ = Line angle
ϕ = Relay maximum reach angle

The angle of maximum reach ϕ can be adjusted by changing the setting of potentiometer P71 on the F101 printed circuit card.

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.

MOB FUNCTION

The MOB characteristic is derived from the phase 2-3 magnetics, filter card, coincidence card and a separate timer. The MOB characteristic is comprised of two lobes and has a constant chord of 75^{o}. Figure 8 shows the relationship between the MT characteristic and the MOB characteristic at both 60^{o} and 75^{o} angle of maximum MT reach.

The MOB characteristic is directly dependent on the setting of the MT characteristic. The replica angle of the MT characteristic is 75^{o}. This angle forms a constant chord for both the MT and MOB characteristics.

With the aid of Figure 8 and the following steps, the theoretical MOB characteristic can be plotted.

Step 1: Determine the length of the constant chord at 75^{o}.

$$L = Z_{max} \cos \tau = \frac{V_{max}}{2I} \cos \tau$$

where L = length of constant chord in ohms.
Z_{max} = reach at angle of maximum reach in ohms
τ = angle between angle of maximum reach and 75^{o}
V_{max} = voltage pickup for current I at angle of maximum reach
I = test current used to plot characteristic. (phase to phase test)

Step 2: Determine the pickup time setting (usually 2 to 3 msec.) for the MOB characteristic and convert that to degrees.

$\gamma = 21.6 \times t$

where γ = the pickup time expressed in degrees.
t = the pickup time in milliseconds.

Step 3: Determine the diameter angles of the two lobes.

$D_1 = 75^o - \tau + (90^o - \gamma)$
$D_2 = 75^o - \tau - (90^o - \gamma)$

where D_1 and D_2 = the angles of the diameters in degrees.
75^o= the replica angle
τ = angle between angle of maximum reach and 75^o.
γ = the pickup time expressed in degrees

The center of the circle for the lobe is the point on the diameter that is equidistant from the two ends of the constant chord L.

CIRCUIT DESCRIPTION

The internal connections of the SLY51A relay are shown in Figure 3. The points on the left designated YA2, YA3 and YA4 are the voltage inputs. The points at the lower left designated YB1 through YB12 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 transformer and the secondary current being passed through a reactor to form the IZ quantity. The V portion comes directly from the tapped potential transformer.

The block-block method is used for the MT 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 and of opposite 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^o. If the timer is set to pick-up at some angle β other than 90^o, the resulting mho unit characteristic will not be a circle. Figure 9 shows the characteristic obtained for a timer setting of 3.0 milliseconds at an angle of maximum reach of 75^o. Figure 10 shows the same characteristic at an angle of maximum reach of 60^o. Figure 11 shows the characteristic for a timer setting of 6 milliseconds at an angle of maximum reach of 75^o. Figure 12 shows the same characteristic at an angle of maximum reach of 60^o. In general, the reach for a timer setting less than 90^o is greater than the reach for a timer setting of 90^o at the same fault angle. A timer setting of greater than 90^o will give a reach less than the reach for a timer setting of 90^o, again at the same fault angle.

The MOB function measures on phases 2-3 only. The MOB characteristic is obtained by the block-block method used for the MT characteristic. During a power swing condition, when the apparent impedance seen by the relay passes through the MOB characteristic first and later through the MT characteristic, the blocking output is obtained if the swing is slow enough for the associated A/B timer (located in the SLA unit) to operate before MT operates. The fact that MT has not operated permits A/B to begin timing because of the NOT input to the AND card which feeds the A/B timer card. If the A/B card produces an output before MT operates, the A/B output is fed back to the AND card input so that later MT operation does not interrupt the A/B output.

CALCULATION OF SETTINGS

In order to illustrate the calculations required, assume a transmission line to be protected with the following characteristics:

$Z_L = 48 \angle 85^o$ primary ohms, positive sequence impedance

CT RATIO = 2000/5

PT RATIO = 3000/1

Z_L (secondary) = Z_L (primary) X $\frac{\text{CT RATIO}}{\text{PT RATIO}}$

Z_L (secondary) = 6.4 $\angle 85^{o}$ ohms

Assume it is desired that the overreaching mho function is set for 150% of the protected line length.

SETTING OF MT

1. The choice of the angle of maximum reach will depend upon the line length and the amount of arc resistance expected. The 60 degree angle will accomodate more arc resistance than a 75 degree angle. Assume the 75 degree angle of maximum reach is chosen.

2. For optimum performance, the highest possible minimum basic tap should be chosen. For this line, this would be the 3 ohm tap.

3. The restraint tap setting **T** is determined by the following formula:

$$T = \frac{100\ (T_B)}{1.5} \frac{\cos(\theta - \phi)}{(Z_L)}$$

T_B = basic minimum reach tap

ϕ = relay angle of maximum reach

Z_L = impedance of protected line

θ = angle of Z_L

1.5 = overreach factor of 50 percent

With the assumed values, the restraint tap resolved to T = 30%.

SETTING OF MOB

The only adjustment possible for MOB is the pickup setting of the characteristic timer. Refer to the sections on APPLICATION and OPERATING PRINCIPLES AND CHARACTERISTICS for detailed considerations.

CONSTRUCTION

The Type SLY51A relay is packaged in a metal enclosure designed for mounting on a 19 inch rack. The relay is 2 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 percent restraint. It also contains the printed circuit cards for protecting all three phases of a power system. The relay has a 90^{o} hinged front cover and a removable top cover.

The tap block portion of the Type SLY51A relay is located at the left of the unit. Figure 13 shows the setting of one phase pair. The tap block is divided into two sections, percent restraint and base reach. These sections are identified at the top.

To set the percent restraint simply put the top MT lead in the desired 10% hole and the bottom MT lead in the desired 1% hole. The setting for 74% restraint is shown in Figure 13.

To set base reach simply put the extreme right hand MT 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 13.

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 portion. Printed circuit cards are identified by a code number such as F101, C101, T107, etc. A test card is located in the "T" position. Test points are numbered 1 to 10 from top to bottom on the test card. The upper test point, TP1, is connected to relay reference. The bottom test point, TP10, is connected to the +15 VDC bus. TP2 is connected to the -15 VDC bus. The other seven test points are located at selected points within the logic circuitry to permit test measurement of the outputs of the various functions and 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 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. 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 SLY51A 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 SLY51 relay is usually supplied from the factory mounted and wired in a static relay equipment.

All units of a given terminal have been calibrated together at the factory and will have the same summary number on the unit nameplates.

These units must be tested and used together.

NECESSARY ADJUSTMENTS

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. MT base reach taps
2. MT reach by voltage tap setting
3. The angle of maximum reach, other than 75°.

GENERAL TESTING INSTRUCTIONS

INPUT CIRCUITS

The Type SLY51A relay has two terminal blocks on the rear of the unit identified as YA and YB. Both these terminal blocks are wired through the test panel in a static relay equipment where input 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 test points which connect to the same YA and YB terminal points as those shown on the test circuit diagram.

Where the Type SLY51A relay is furnished in a static relay equipment, reference to the job elementary will provide information concerning customer relay inputs.

OUTPUT SIGNALS

Output signals are measured with respect to the reference bus or TP1. Outputs are continuous signals of approximately +12 to +15 volts for the "ON" condition and 0 volts for the "OFF" condition. This output can be monitored with an oscilloscope, a portable high impedance d-c voltmeter, or with the test panel voltmeter if available. To connect the test panel voltmeter, place the test lead in the proper test point pin jack and the other end in the pin jack on the test panel.

DETAILED TESTING INSTRUCTIONS

REQUIRED ADJUSTMENTS

REACH TAP SETTINGS

The arrangement of the reach setting portion of the tap block is described under the section on CONSTRUCTION and the choice of tap settings is discussed under the section on CHOICE AND CALCULATION OF SETTINGS.

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 14. Input connections for testing any of the phase-pair characteristics should be made with Figure 14 and Table 1.

TABLE I

	CONNECT YA AND YB TERMINALS TO POINTS IDENTIFIED BY LETTERS						MHO OUTPUT	MOB OUTPUT
	A	B	C	D	E	F		
PHASE 1-2	YA2	YA3	YB1	YB4	YB8	YB5	TP6	
PHASE 2-3	YA3	YA4	YB5	YB8	YB12	YB9	TP7	TP9
PHASE 3-1	YA4	YA2	YB9	YB12	YB4	YB1	TP8	

By setting the current to 5 amperes (constant) the reach at any angle becomes a function of the settings 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 decreases 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 14 for the particular phase being tested. Make the AC 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 coincidence cards (C101) of the phases not being tested. Jumper the test point outputs of these cards down to reference.
Example: When testing Ø 1-2, remove the C101 cards in positions "L" and "R" and jumper TP4 and TP5 to reference.

(e) Connect the instrumentation (preferably an oscilloscope) between the mho output of the phase under test 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 pick-up, as read on Figure 14 voltmeter (V), defines the relay mho characteristic.

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

$$V = \frac{2\ IZ \cos(\alpha - \emptyset)}{\%\ \text{Restraint Tap}} \times 100 \qquad (2)$$

where: Z = base reach of the relay
I = 5 amp test current
α = the angle read at the phase angle meter
$\emptyset$ = angle of maximum reach

Any points necessary can be obtained by simply repeating steps (f) and (g) until the characteristic is clearly defined.

An alternate method of testing the relay characteristic is shown in Figure 15 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, by different than the calculated value of V it may be adjusted by turning the P10 potentiometer on the F101 card.

TESTING MOB CHARACTERISTIC

The test circuit used to check the MT characteristic may be used to check the MOB characteristic. The phase 2-3 input connections are used. The MOB output is checked at TP9.

PHASE ANGLE ADJUSTMENT

As stated earlier the angle of maximum reach, $\emptyset$, can be adjusted by changing the setting of potentiometer P71 on the F101 printed circuit card. The angle is typically factory adjusted to produce a 75° angle of maximum reach. In the Type SLY51A relay the angle of maximum reach can be adjusted down to 60°. The calibration of the angle of maximum reach can be made by using the test circuit of Figure 14. The recommended procedure is as follows:

(a) Determine what test voltage V in Figure 15 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

(b) Make the AC connections to the relay according to Table 1. The letters A thru F in Table 1 correspond to the letters in Figure 14.

(c) Adjust the variac in Figure 14 until the voltmeter reads 85% of the calculated voltage in equation (3).

(d) Rotate the phase-shifter, holding the voltage at 85% of the maximum V, and record the two angles at which the output just approaches the verge of pick-up.

(e) Add, algebraically, the two angles and divide the sum by two.

If this maximum reach angle is different than the desired angle, adjust the P71 potentiometer (on the F101 card) for the particular phase involved and repeat steps (a) to (e).

A preliminary test can be performed to aid in the setting of the angle of maximum reach. Apply voltage only to the relay. Apply 30 VAC to the input terminals of the phase pair under test (YA2-YA3 for $\emptyset$1-2). Connect a dual trace scope, channels A and B to the F101 card pins 8 and 9 respectively. Adjust pot P71 on this card to obtain coincident square wave traces if a 75° angle of maximum reach is desired. If an angle of maximum reach less than 75° is desired reduce the setting on the P71 pot. This will move channel "B" trace ahead of channel "A" trace. Measure the time interval between the two traces and convert this time into degrees. By subtracting this number of degrees from 75° will give the new angle of maximum reach. The following table (table 2) may be helpful in determining the new angle of maximum reach.

TABLE 2

DESIRED ANGLE OF MAXIMUM REACH	DIFFERENCE IN TIME BETWEEN TRACES	DIFFERENCE IN DEGREES BETWEEN TRACES
75^o	0 MSEC.	0 DEGREES
70^o	.231 MSEC.	5 DEGREES
65^o	.462 MSEC.	10 DEGREES
60^o	.693 MSEC.	15 DEGREES

After this adjustment has been made, the mho characteristic should be checked, using the test circuit described above under REQUIRED ADJUSTMENTS. If the resulting maximum reach angle is not close enough to the desired maximum reach angle, the difference in degrees should be noted, and a second adjustment of the phase angle potentiometer by this amount should be made to obtain the desired characteristic.

TIMER ADJUSTMENTS AND TESTS

The following information concerns items which have been covered in factory tests. This information is supplied for use in trouble-shooting or in checking the overall performance of the Type SLY51A relay.

F101 FILTER CARDS

The F101 filter cards have three potentiometers located on them. By number these potentiometers are P61, P71 and P10. Potentiometer P61 is for filter adjustment purposes. It has been set in factory test and sealed. This potentiometer must not be readjusted. Potentiometer P71 is for phase angle adjustment. The procedure used to set this potentiometer is described under the "Phase Angle Adjustment" section. Potentiometer P10 is for adjusting the relay reach at the angle of maximum reach. The procedure used to set this potentiometer is described under the "Testing Mho Characteristic" section.

T107 TIMER CARDS

The T107 cards have three potentiometers located on them. By number these potentiometers are P1, P2 and P3. These cards have been factory set and should not be adjusted unless a plot of the mho characteristics indicate an improper pickup time setting (See Figures 9-12). The T107 timer has a 6,4/5 time setting. The P1 potentiometer, used for transient operation, has been set in co-ordination with the P2 potentiometer at the factory and sealed. Potentiometer P1 must not be readjusted. Potentiometer P2 is set for a 4.16 millisecond pickup time. The 4.16 millisecond time is important in making the 90^o measurement and affects the shape of the mho characteristic; times longer than 4.16 milliseconds tend to narrow the characteristic and times shorter than 4.16 milliseconds tend to widen the characteristic. Turning the P2 potentiometer CW will increase the pickup time delay. Potentiometer P3 is set for a 5 millisecond dropout time delay. Turning the P3 potentiometer CW will increase the dropout time delay.

The test circuit of Figure 14 may be used to set this timer. A dual trace oscilloscope should be connected with channel "A" on the input test point (TP3 for phase 1-2) to the timer and channel "B" on the output test point (TP6 for phase 1-2) of the timer. In order to observe the pickup time delay, the dropout time delay must be reduced (turn P3 CCW) so that the 4/5 output resets each half cycle. Reduce the applied voltage until the fault condition applied to the relay is within the characteristic. The 4/5 timer should produce an output (Channel B) 4.16 milliseconds after the beginning of an input (Channel A). After the pickup time is set potentiometer P3 should be turned CW until the output (Channel B) becomes a continuous signal. At this point one additional turn should be given the P3 potentiometer.

As a final check on the accuracy of the 4.16 millisecond setting, the MT characteristic may be rechecked and compared with the desired characteristic.

Potentiometer P2 must be set for 4.16 milliseconds pickup delay before potentiometer P1 can be checked.

To check the setting of potentiometer P1 the following procedure should be used:

(a) Remove the C101 card of the phase pair being tested.
(b) Connect the test circuit of Figure 16.
(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 calibrated horizontal sweep which can be triggered 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) With the oscilloscope sensitivity set for positive slope, open the normally closed contact. The trace should step to +12 to +15V in 5.3 to 5.5 milliseconds. Turning the P1 potentiometer CW will increase the pickup time delay.

T105 TIMER CARD (OPTIONAL MOB FUNCTION)

The T105 card is a 1-5/10-80 timer. The card has two potentiometers on it. The upper potentiometer P1 is used to adjust the pickup time delay. The lower potentiometer P2 is used to adjust the dropout time delay.

To test the T105 card the following procedure should be used:

(a) Remove the C101 card in the "L" position.
(b) Connect the test circuit of Figure 16. Apply the input signal to TP4.
(c) Use an oscilloscope with a calibrated horizontal sweep which can be triggered externally. Connect the external trigger input to TP4 and the vertical input to TP9.
(d) With the oscilloscope sensitivity set for positive slope, open the normally closed contact. The trace should step to +12 to 15V in the desired pickup time (usually between 2 to 3 milliseconds). To increase the pickup time delay turn P1 clockwise.
(e) By setting the oscilloscope sensitivity for negative slope and closing the now open contact the desired dropout time delay (usually 16 milliseconds) can be set. The trace should step from +12 to 15V to 0 to 1 V. To increase the dropout time delay turn P2 clockwise.

MAINTENANCE

PERIODIC CHECKS

For any periodic testing of the Type SLY51 relay the trip coil circuit of the circuit breaker should be opened by opening the disconnect switches or other test switches provided for this purpose.

TROUBLE-SHOOTING

Test points are provided at selected points in the Type SLY51A relay to observe outputs if trouble-shooting is necessary. The use of a card adapter will make the pins on any one card available for testing.

For the physical location of components and cards refer to Figure 2, the component location diagram.

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 designation) 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 125 cards

CARD DRAWINGS

Details of the circuits of the printed circuit cards can be obtained in the printed circuit card book GEK-34148.

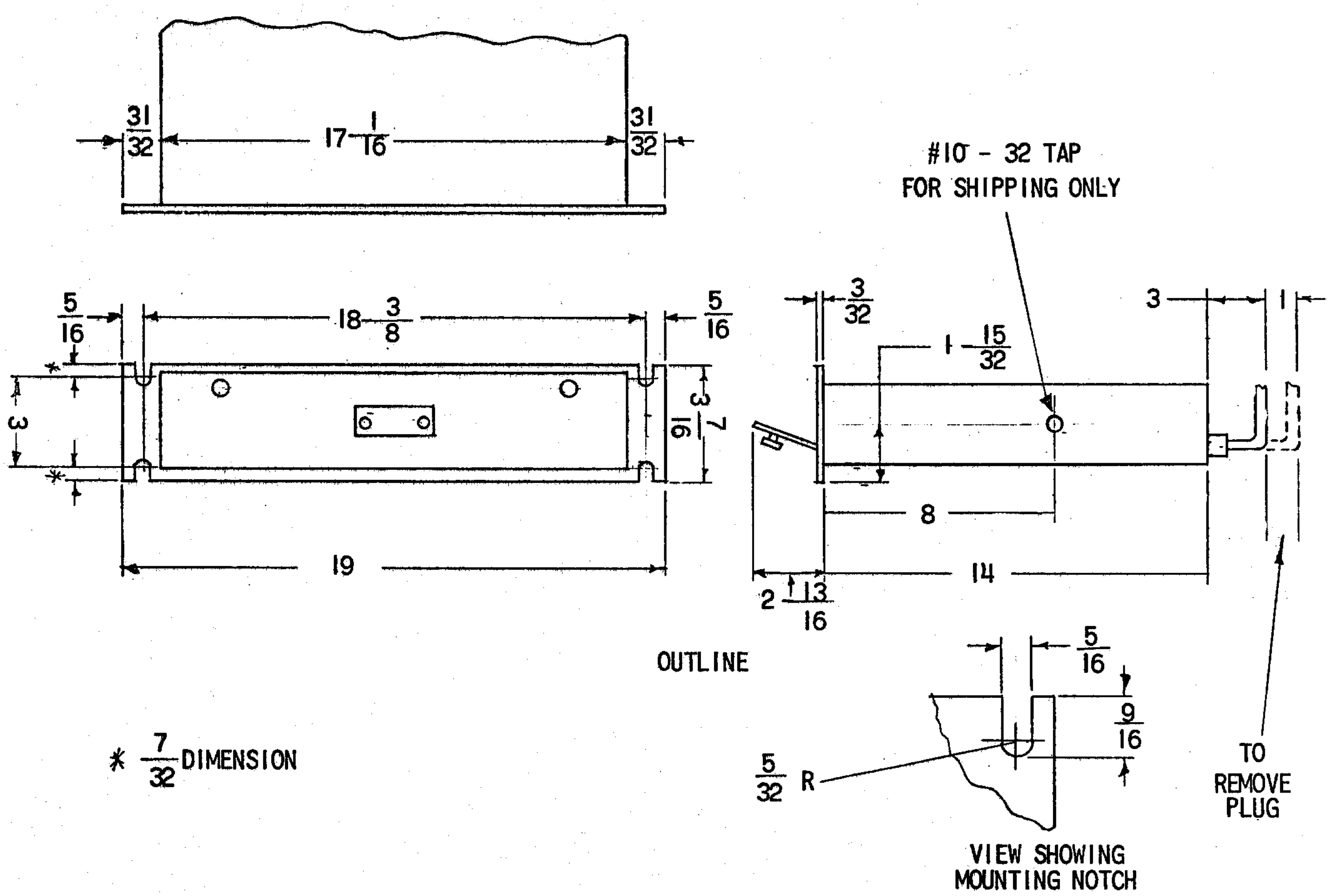


FIG. 1 (0227A2036-0) SLY51A Outline And Mounting Dimensions

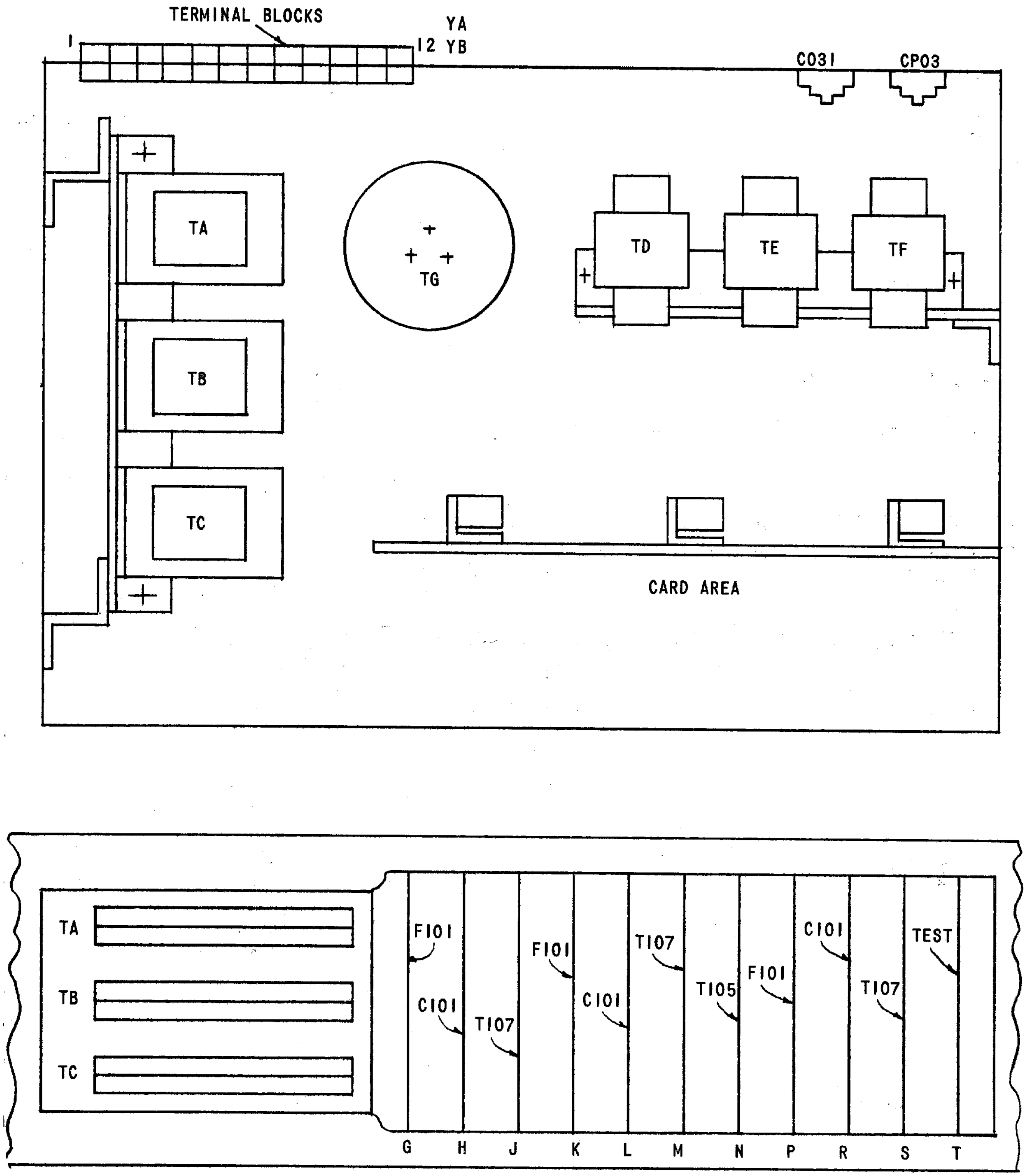


FIG. 2 (0227A2088-0) SLY51A Component Location Diagram

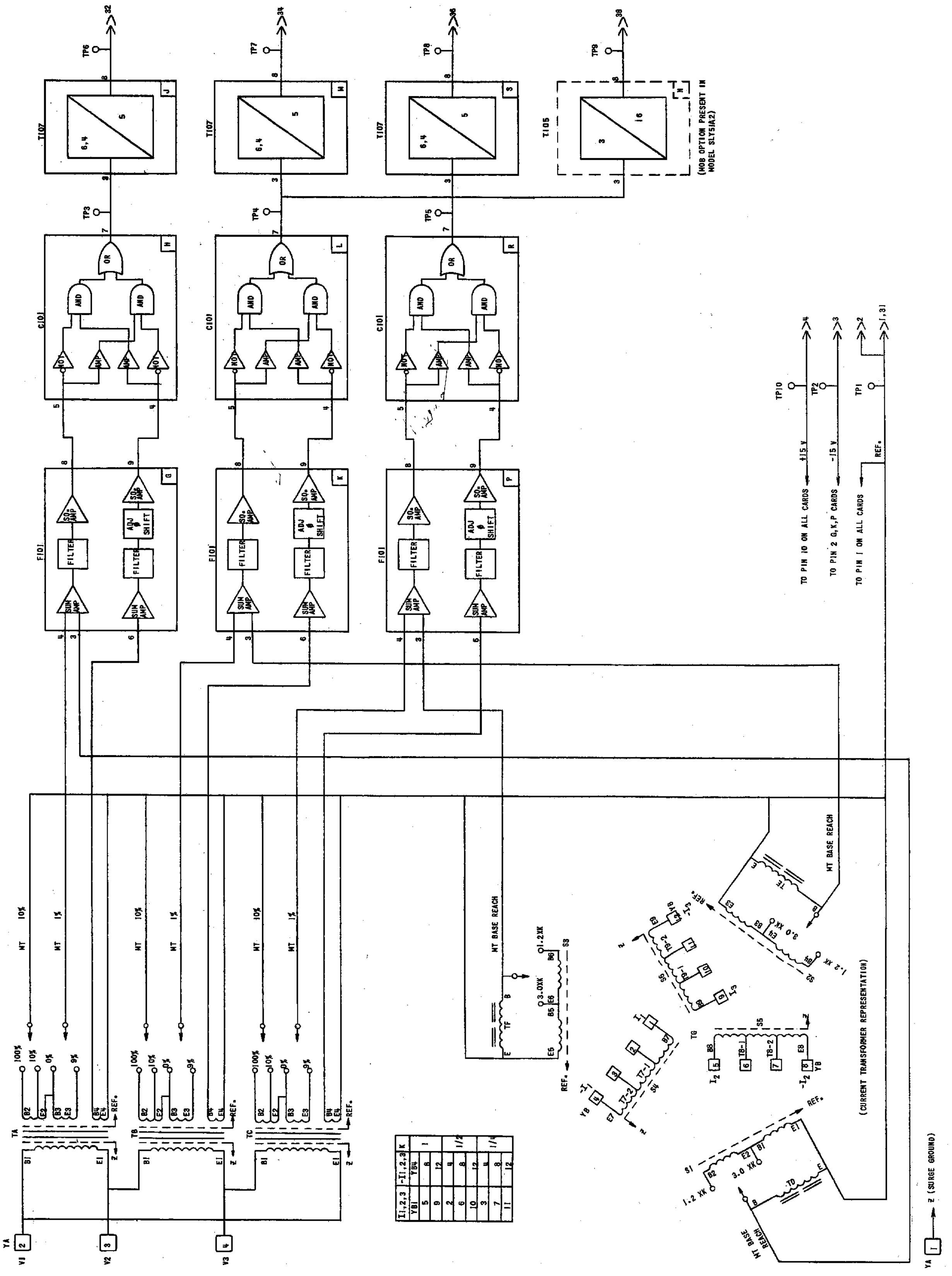
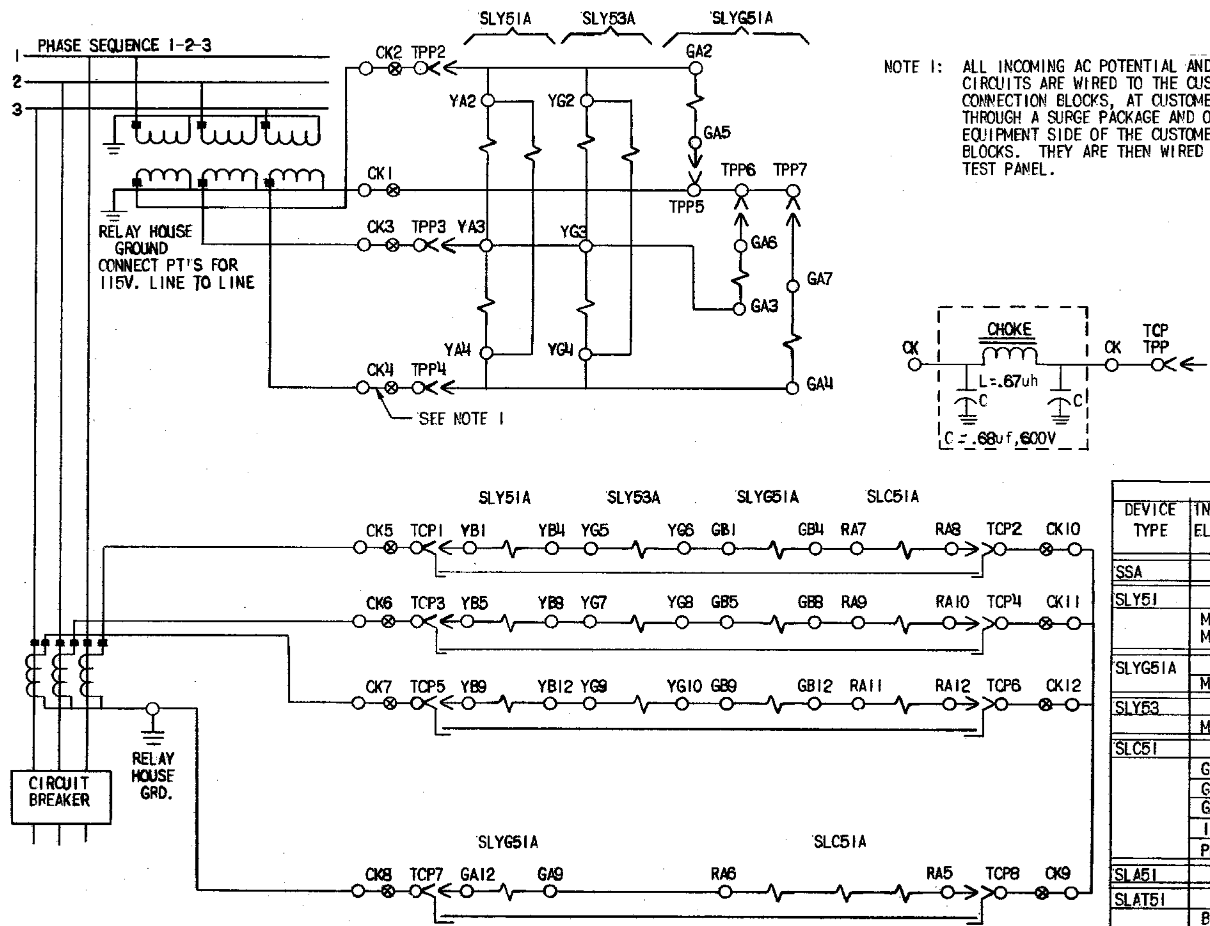


FIG. 3 (0149C7219-1) Internal Connections Diagram Of SLY51A Unit



NOTE 1: ALL INCOMING AC POTENTIAL AND CURRENT CIRCUITS ARE WIRED TO THE CUSTOMER CONNECTION BLOCKS, AT CUSTOMER SIDE, THROUGH A SURGE PACKAGE AND OUT THE EQUIPMENT SIDE OF THE CUSTOMER CONN. BLOCKS. THEY ARE THEN WIRED TO THE TEST PANEL.

REFERENCE DRAWINGS	
OVERALL LOGIC	0121D6921
EXTERNAL CONNECTIONS	0109D4459
TYPE OR DESCRIPTION	INT. CONNS.
SSA50A POWER SUPPLY	0149C7218
SLY51A	0149C7219
SLY53A	0149C7204
SLYG51A	0149C7213
SLC51A	0149C7221
SLA51A	0149C7202
SLAT51A	0149C7203
TEST PANEL	0108B9636

LEGEND		
DEVICE TYPE	INCL. ELEM.	DESCRIPTION
SSA		POWER SUPPLY
SLY51		CARRIER PHASE RELAY
	MT	PHASE DIRECTIONAL MHO TRIP ELEMENT
	MOB	OUT-OF-STEP BLOCKING ELEMENT
SLYG51A		CARRIER GROUND RELAY
	MTG	GROUND DIRECTIONAL MHO TRIP ELEMENT
SLY53		
	MB	PHASE OFFSET CARRIER START ELEMENT
SLC51		
	G1	OVERCURRENT CARRIER START ELEMENT
	G2	OVERCURRENT CARRIER TRIP ELEMENT
	G4	DIRECT TRIP INST. OVERCURRENT ELEMENT
	I30	OVERCURRENT FAULT DETECTOR
	PH4	DIRECT TRIP INST. OVERCURRENT ELEMENT
SLA51		AUXILIARY LOGIC RELAY
SLAT51		AUXILIARY TRIP RELAY
	BFI	BREAKER FAILURE TIMING INITIATION
	RI	RECLOSING INITIATION

FIG. 4 (0165B2601-0) Typical External Connections Diagram

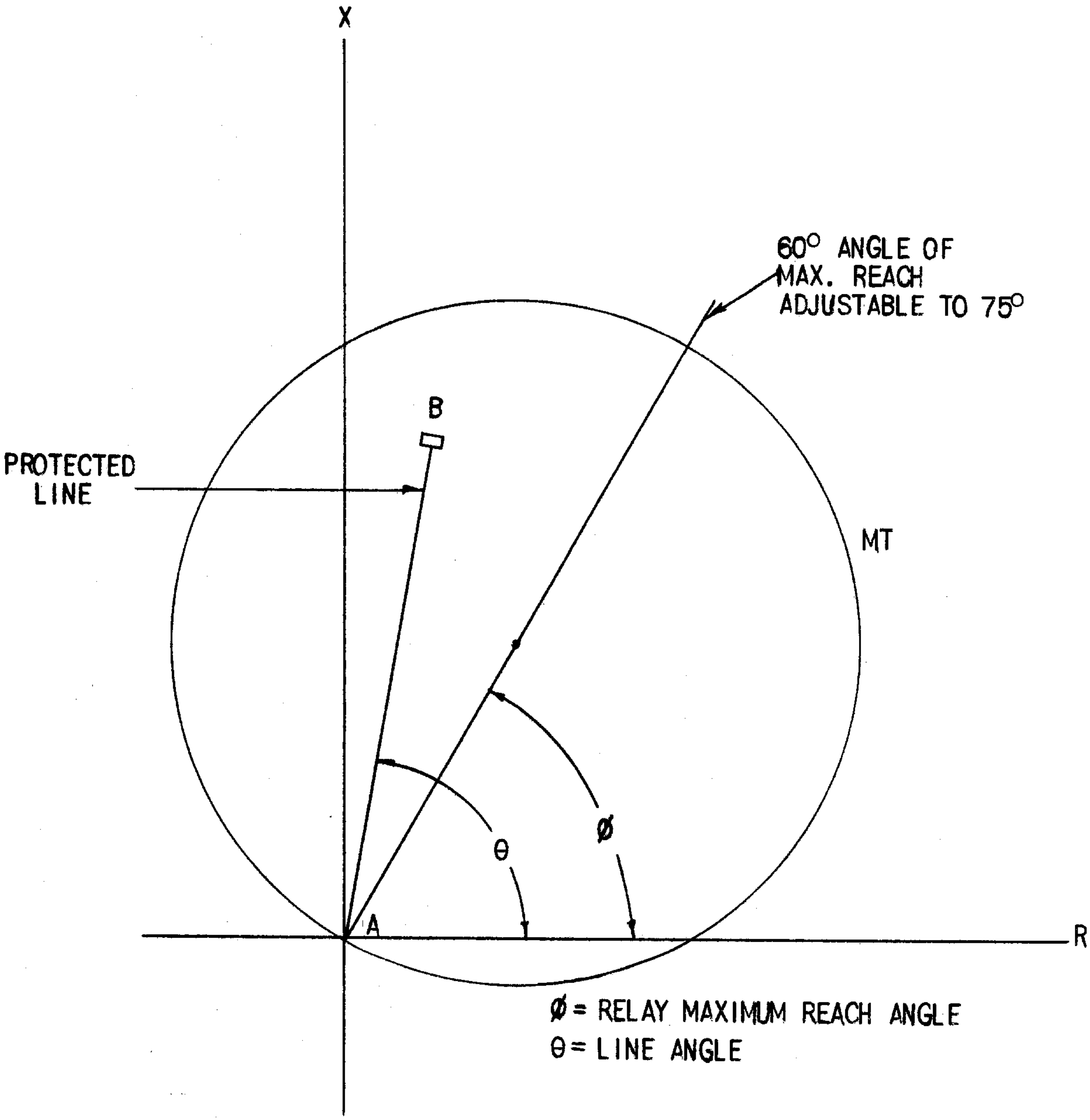


FIG. 5 (0227A2089-0) Typical MT Characteristic SLY51 Relay

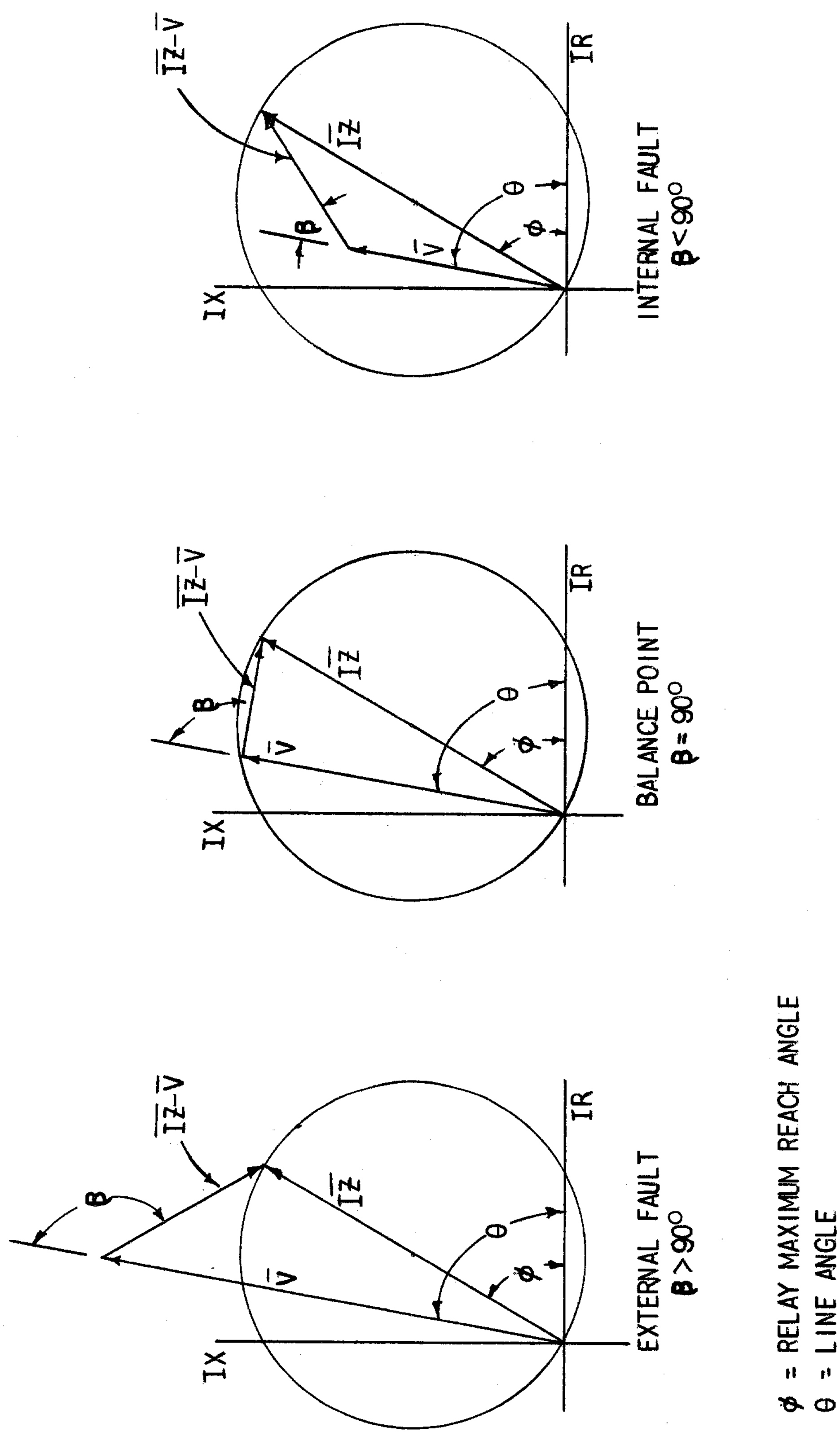


FIG. 6 (0227A2090-0) Mho Characteristic By Phase Angle Measurement

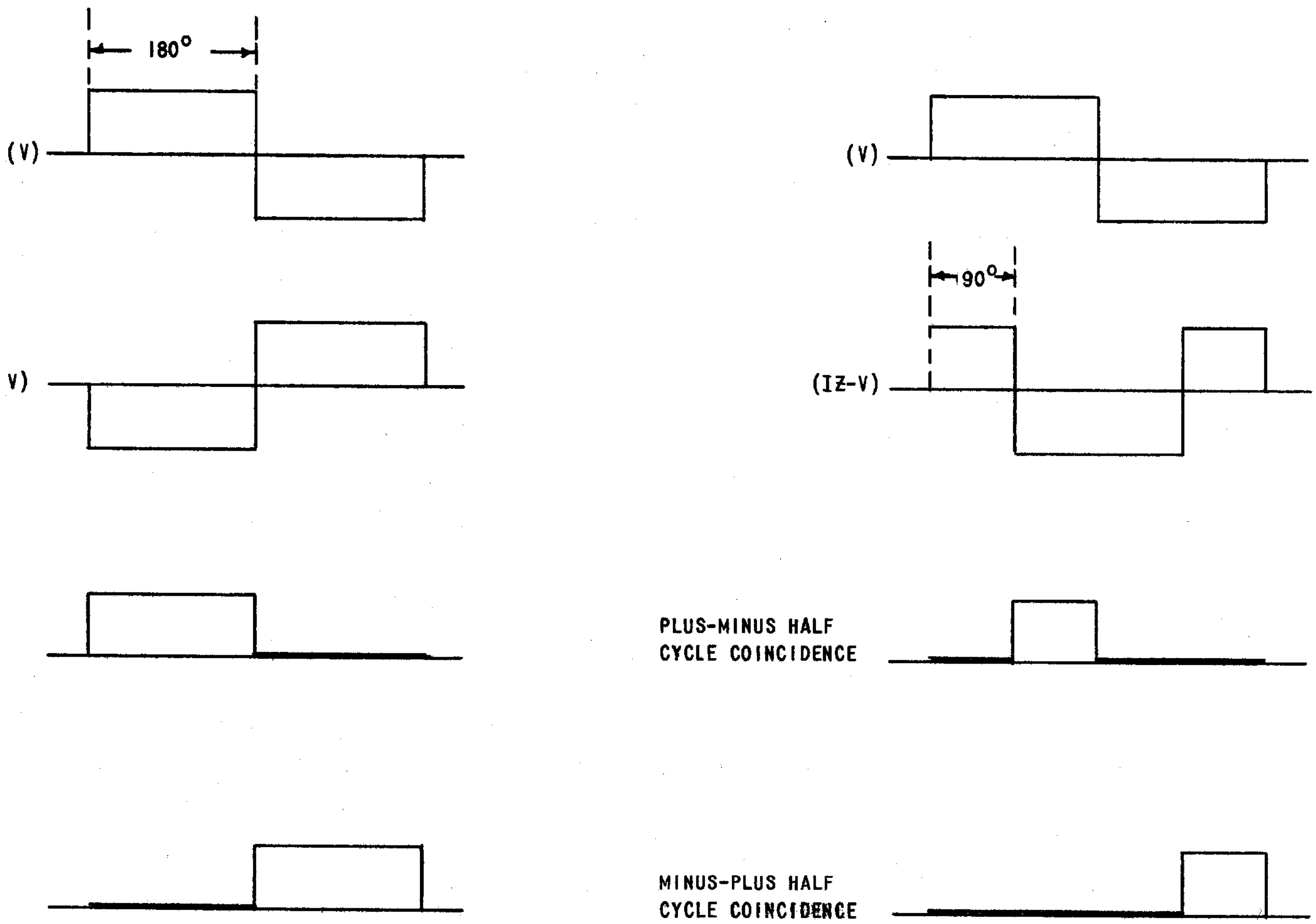
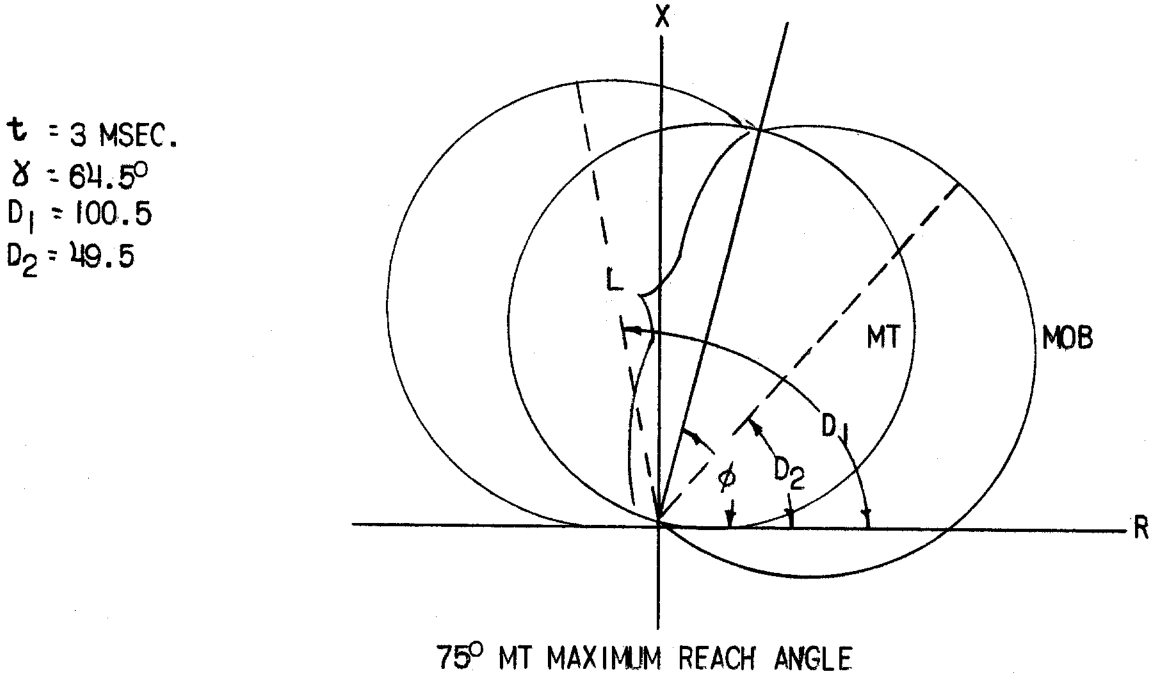


FIG. 7 (0227A2091-0) MT Measurement Principles



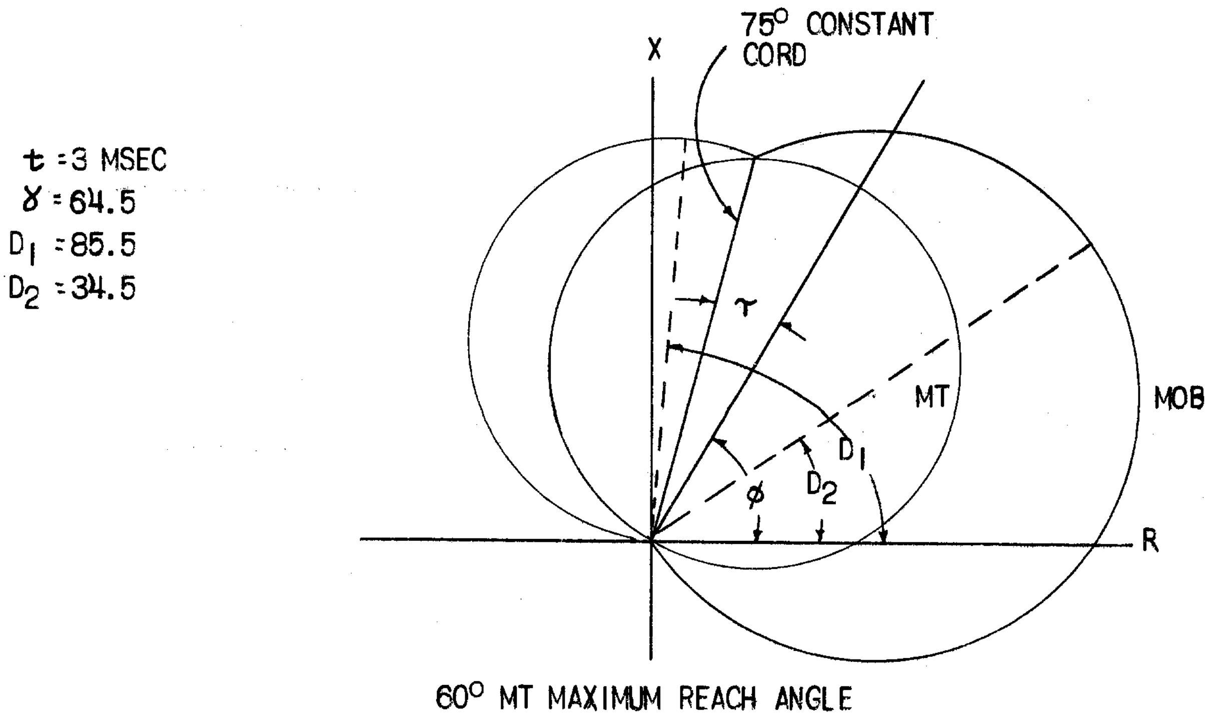


FIG. 8 (0227A2092-0) MT And MOB Characteristic At 75° And 60° Angle Of Maximum Reach

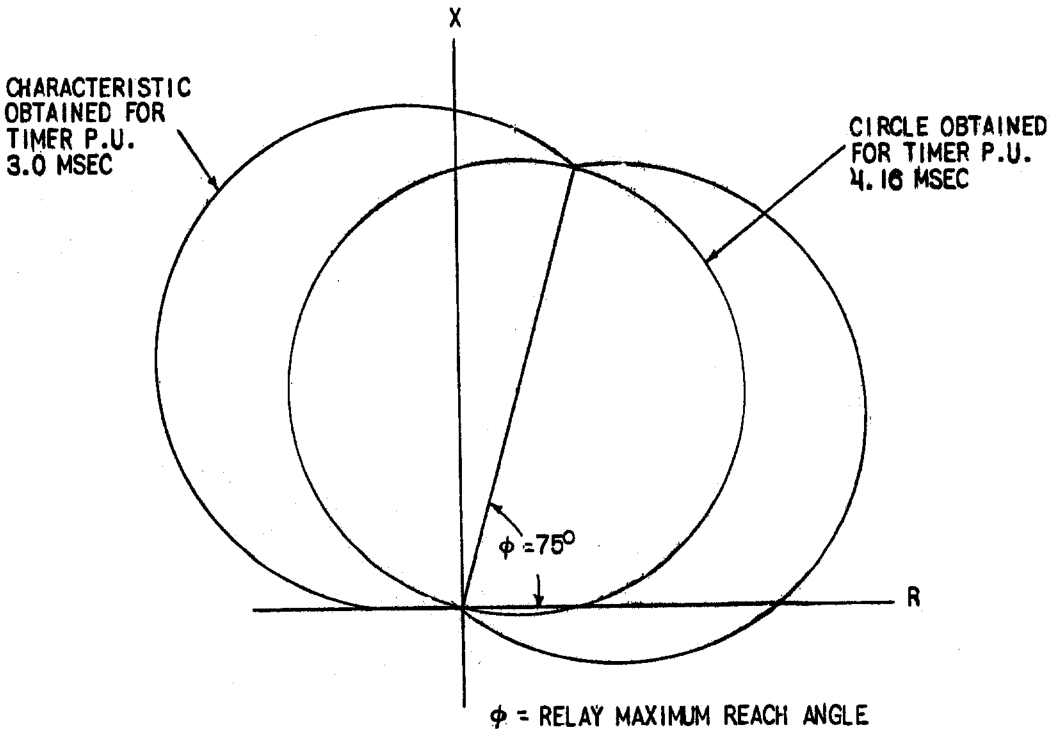
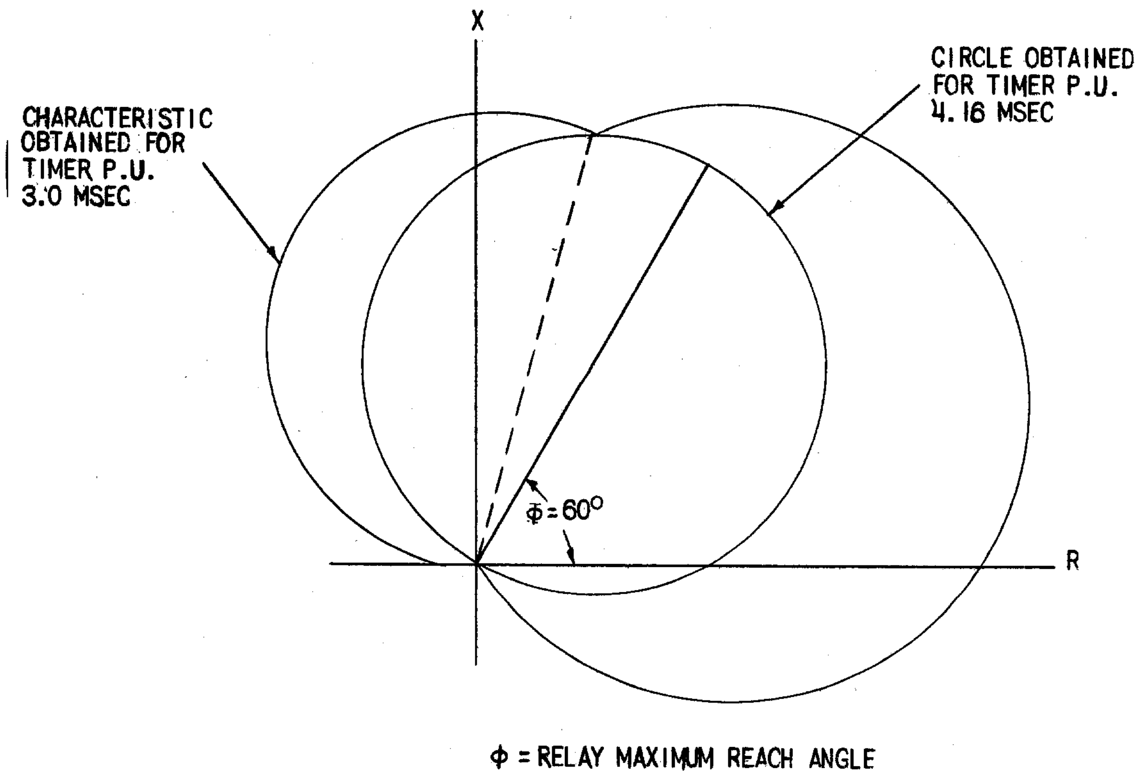


FIG. 9 (0227A2093-0) Mho Operating Characteristic At 75° Angle Of Maximum Reach With Variations In Pickup Timer Settings



[G. 10 (0227A2094-0) Mho Operating Characteristic At 60° Angle Of Maximum Reach With Variations In Pickup Timer Settings

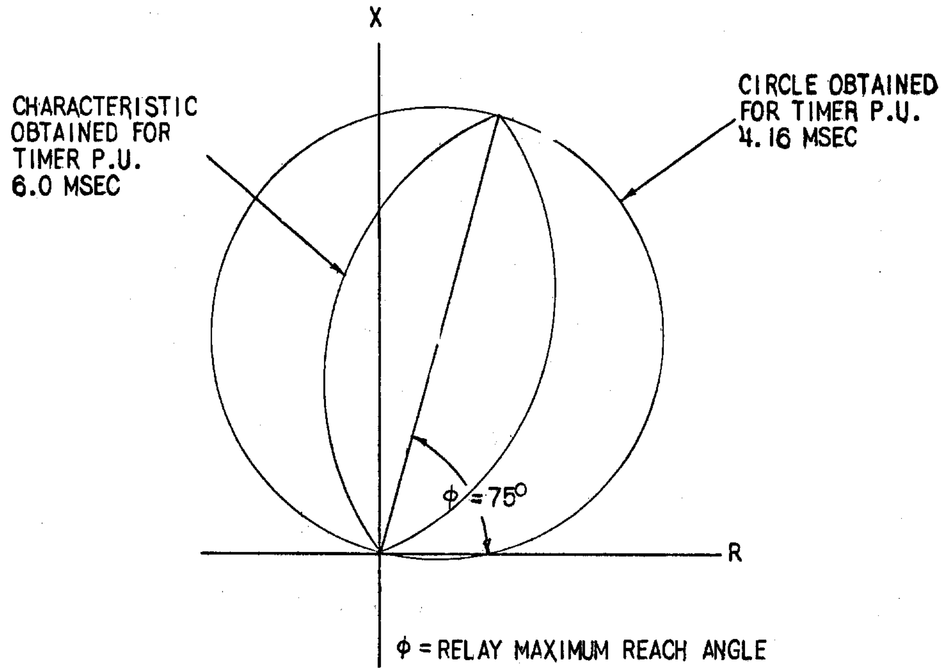


FIG. 11 (0227A2095-0) Mho Operating Characteristic At 75° Angle Of Maximum Reach With Variations In Pickup Timer Settings

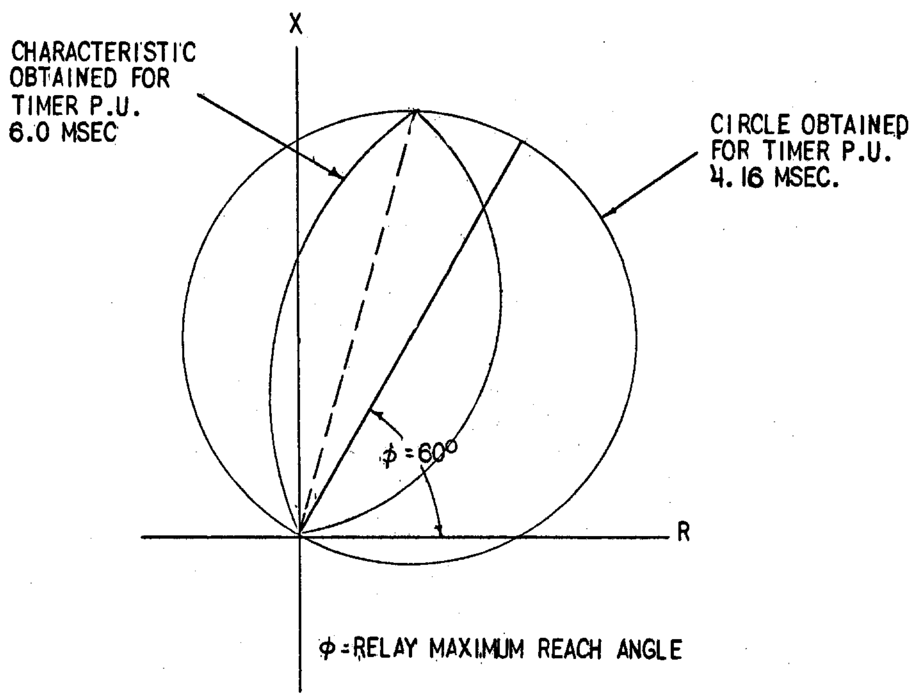


FIG. 12 (0227A2096-0) Mho Operating Characteristic At 60° Angle Of Maximum Reach With Variations In Picku Settings

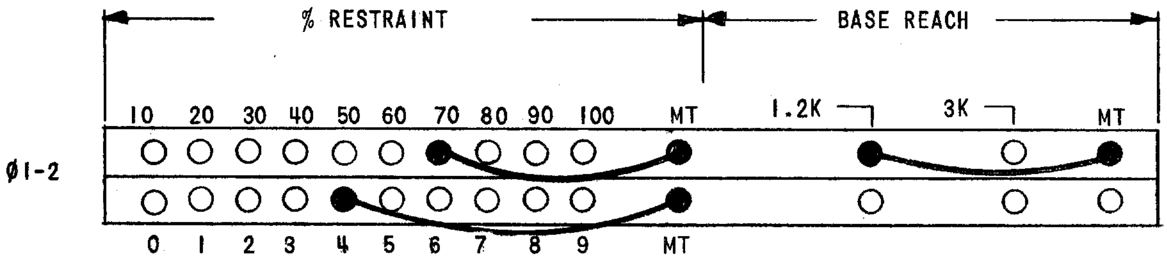


FIG. 13 (0227A2097-0) Typical SLY51 Tap Block Connections

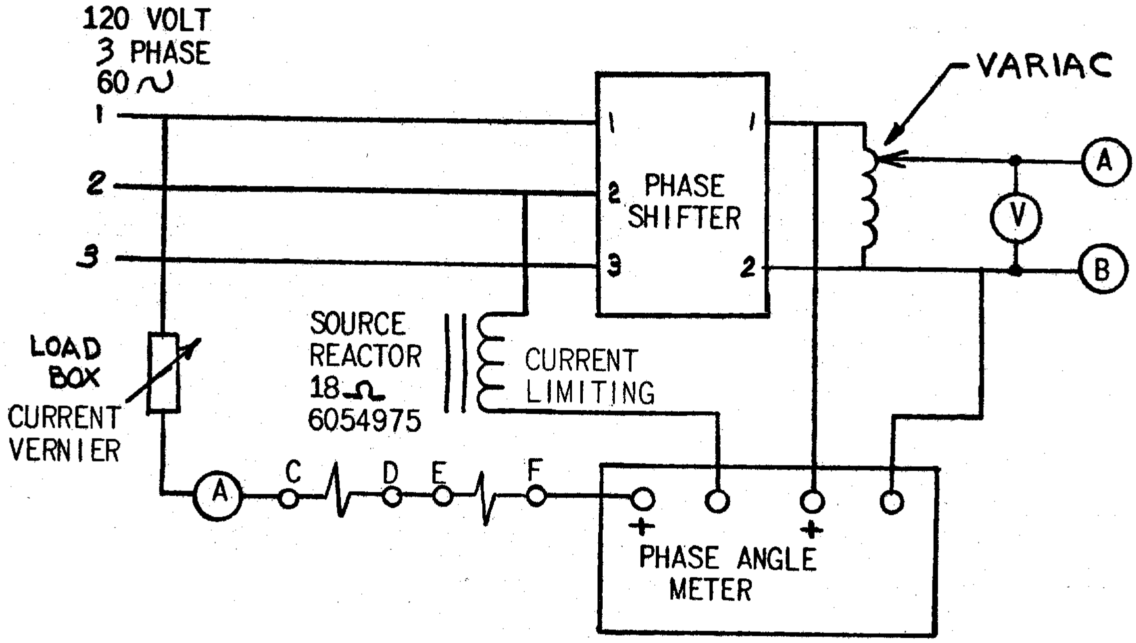


FIG. 14 (0178A7029-3) Phase Shifter Test Circuit

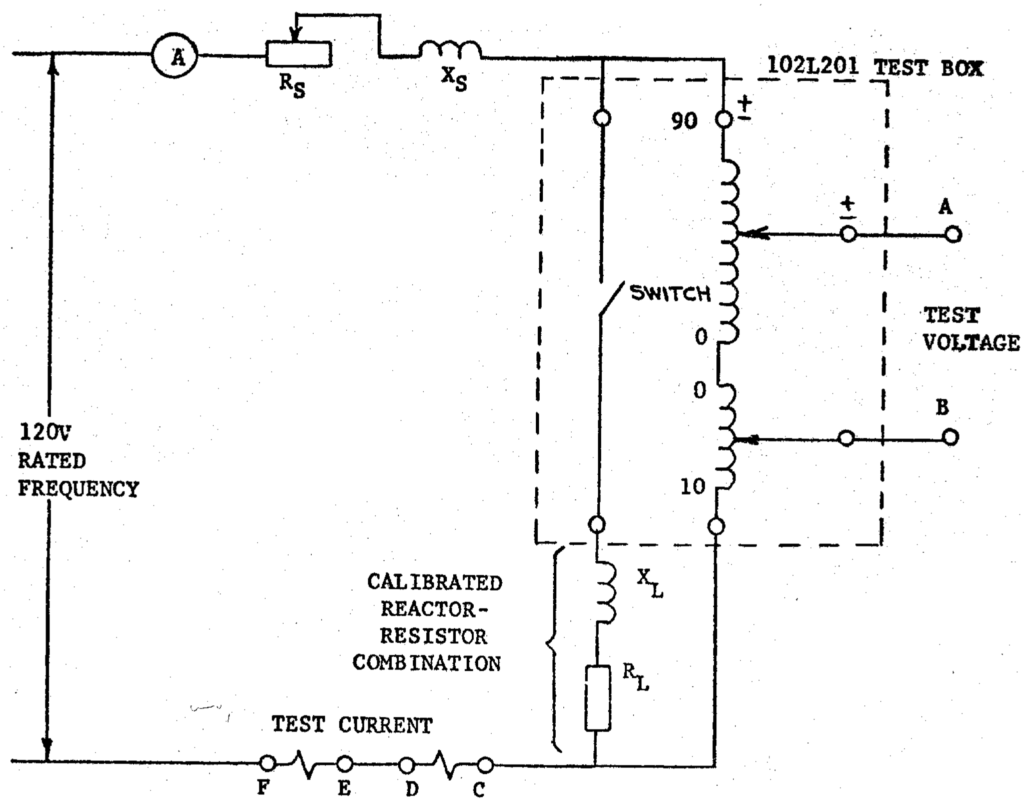


FIG. 15 (0178A7028-3) Test Circuit For Characteristic Check Using Test Box, Test Reactor, And Test Resistor Method

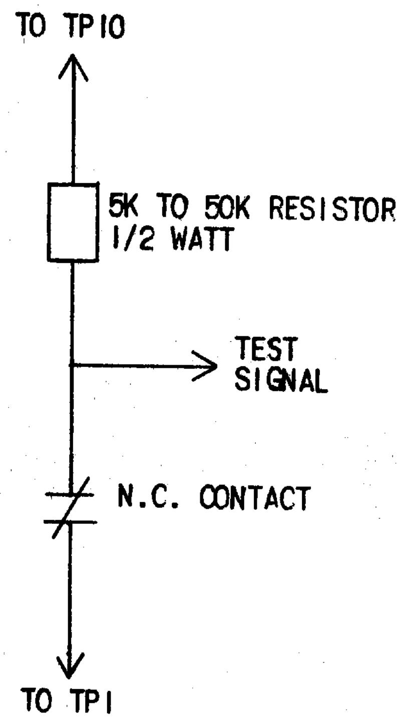


FIG. 16 (0227A2098-0) Test Circuit For Timer Card

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 . . . . . 3840 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
• * Δ (Boston) Medford 02155
. . . . 3960 Mystic Valley Pkwy.

MICHIGAN
• * Δ (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.
• Δ 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.
• * Δ 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 Δ Special Manufacturing Shop

PRINTED IN U.S.A.