INSTRUCTIONS

GEK-36789

0208A8440

OUT OF STEP ANGLE IMPEDANCE RELAY

(OFFSET MHO & NAA19B)

GENERAL ELECTRIC

FIG. 1 FRONT AND REAR VIEW OF RELAY OUT OF THE CASE
(PHOTO NOT AVAILABLE)

CONTENTS

OUT OF STEP ANGLE IMPEDANCE RELAY

TYPE NAA

DESCRIPTION

The Type NAA relay covered by 0208A8440 was designed specifically for use in conjunction with the Type CEX17E angle impedance relay to detect an out-of-step condition on a power system. The relay includes a Mho-type distance unit with provision for offsetting its characteristic, six telephone-type auxiliary relay units, and a target seal-in unit, all mounted in an L2 case, the outline and panel drilling dimensions for which are given in Figure 2. The internal connections are shown in Figure 3.

APPLICATION

The usual application of the 0208A8440 type NAA relay and its associated Type CEX17E angle impedance relay is at the terminals of a generator to provide out-of-step protection of the machine. Formerly system and generator impedance characteristics were such that the electrical center during a loss of synchronism condition generally was located out on the transmission system. Hence the swing impedance loci generally intersected transmission lines and could be readily detected by line relaying or out-of-step relaying schemes at line terminals.

With the advent of EHV systems, larger generators and the general expansion of transmission systems, generator and step-up transformers impedances have increased in magnitude while system impedances have tended to decrease. As a result, on many systems today the system impedance center and the electrical center during swings can occur in the generator or in the generator step-up transformer.

The combination of the 0208A8440 Type NAA and the CEX17E angle impedance relay, located at the machine terminal, is intended to detect an out-of-step condition when the swing locus passes through the machine or step-up transformer. The scheme detects the out-of-step condition by the sequential operation of the Mho unit in the NAA and the angle impedance units in the CEX17E relay as an apparent power swing impedance sweeps across the relay characteristic, as shown on the R-X diagram in Figure 4. This typical application of the NAA and the CEX17E at the terminals of a generator is covered by the external connection diagram also shown in Figure 4A.

OPERATION OF THE SCHEME

The operating principles of the scheme can be explained with the aid of the R-X diagram and contact circuit in Figure 4. Assume that the swing impedance locus passes through the characteristics from C to K. Before the swing reaches point D, the Mho unit (21M) will be dropped out, angle impedance unit A will be picked up (i.e., contact A2 closed), and angle impedance unit B will be dropped out (i.e., contact B2 closed).

When the swing locus enters the Mho characteristic at point D, the 21M/b contact opens and 21M/a contact closes picking up unit X. The X contact then picks up unit X_1 through contact B2, which is still closed. As the swing locus passes from E to G, angle impedance unit B picks up, opening contact B2 and closing contact B1. This deenergizes the X_1 unit and picks up unit X_2 through contact A2, which is still closed, and the contact of X_1, which has a 12-cycle dropout time. X_2 seals in around the X_1 contact.

When the swing passes from G to H, angle impedance unit A drops out, contact A2 opens and contact A1 closes picking up unit X_4. The opening of contact A_2 deenergizes unit X_2, but its 12-cycle dropout time permits X_3 to pick up through the X_2 and X_4 contacts, and seal in around these contacts.

A contact of X_3 sets up the circuit to the trip coil so that when the swing reaches point J and 21M drops out closing 21M/b, the breaker will be tripped.

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.

The scheme operates in much the same manner for a "left-to-right" swing, except that the sequence now starts with 21M/a picking up X which then picks up X_4 through the B1 and A1 contacts.

It is important to note that with this scheme a trip signal does not occur until the swing passes out of the Mho characteristic on the side opposite from its entry point. For instance if the swing enters at D there will be no trip output until it leaves at point J. If the swing reverses direction (i.e. recovers) after entering the zone between the A and B angle impedance characteristics, and leaves the Mho characteristic on the same side that it entered, there will be no trip output.

RELAY SETTINGS

The R-X plot of the Mho and angle-impedance unit characteristic shown in Figure 5 is typical of an application where system impedance, viewed from the relay location at the generator terminals, is small in comparison with the generator and transformer reactances. The external connections for this example, shown in Figure 4, were selected so that the forward reach of the unit is into the generator and the reverse offset is through the transformer.

A purpose for using the Mho unit to supervise the angle-impedance units is of course to restrict the tripping area. It would be desirable to restrict out-of-step tripping of the generator to swings that pass through the generator or step-up transformer. Thus if system conditions should subsequently be such that the electrical center is out in the system, the generator would not be needlessly tripped during an out-of-step swing which could be detected by line relaying or out-of-step relaying at line terminals. However, other limitations on the scheme usually will make it impossible to realize this goal fully.

The principle objective of the scheme is of course to detect any out-of-step condition which results in an impedance swing that passes through the generator or transformer impedance at any point. Obviously if the Mho unit setting were to restrict tripping only to swings that pass through the generator or transformer, as typified by the dotted circle of Fig. 5, the Mho and blinder combination would not detect swings that passed through the transformer but near the system, at point d for example. Consequently it will be necessary to set the Mho unit so that its characteristic includes a portion of the system impedance as typified by the solid circle of Figure 5.

Since the combination of Mho unit and blinders typically cannot be set to restrict tripping exclusively to out-of-step swings that pass through the generator or transformer, a compromise setting that meets the following objectives is necessary:

1. Separation of the blinder characteristics A and B in the associated CEX relay must be sufficient so that the combination of blinders and auxiliary units will respond to any out-of-step swing that passes through the generator or transformer at the maximum predicated slip-cycle rate for the first slip cycle.

2. The Mho unit characteristic (i.e. forward reach and reverse offset) must be set so that for any swing that passes through the generator or transformer this unit and its associated auxiliary (X) will operate before the blinder B operates. (Assumes locus of swing is from right to left.)

3. The Mho unit characteristic also determines the angle of system separation at the instant an out-of-step trip is initiated. It is the user's responsibility to check that the associated breakers can handle an interruption at this angle.

It is apparent that with settings that meet these requirements the scheme will operate on some out-of-step swings that intersect the system impedance beyond the transformer. This compromise is necessary if the scheme is to respond to all swings that may pass through the generator or transformer.

The following example illustrates these general objectives with the aid of the diagram in Figure 5. This plot has been made on the basis of a generator reactance (X_G) of 4 ohms (direct axis transient reactance), transformer reactance (X_T) of 2 ohms, and minimum system impedance Z_s of 1.5 ohms at 80 degrees, all on a secondary basis.

With this combination the electrical center would fall at point C. If the system impedance were to increase to Z's the elctrical center would fall at point d, and the locus of an out-of-step swing might be a-d-b, that is just barely passing through the transformer. The Mho unit and blinder unit settings illustrated in Figure 5 are intended to illustrate typical settings which would be required to detect such an out-of-step swing, as well as swings which pass nearer the center of the generator-transformer combined reactance. Note that the blinders are not symmetrically set with reference to the system impedance line m-n. The"B" blinder has been set closer in to provide more traverse time of the of the swing between the Mho and blinder "B" characteristics. This assumes that an out-of-step swing that traverses the generator-transformer reactances will always travel from right to left.

For the example shown if the swing rate is 1.5 slip cycles per second, the time for the a-d-b swing to traverse the distance from the Mho circle to the "B" blinder characteristic is approximately 90 milli-seconds, and from blinder "B" to blinder "A" is approximately 170 milli-seconds, times which are adequate to operate the measuring units and associated auxiliaries. When the swing passes out of the Mho characteristic on the left, where tripping will be initiated, the system separation angle will be less than 90 degrees.

It is again emphasized that settings in the previous example are mentioned solely to illustrate the points which must be considered when applying this scheme. It is essential that the user determine the swing impedance loci and expected maximum slip cycle rate for his specific installation for a variety of conditions, considering such things as effect of the voltage regulators, changes in system impedance, effect of other generators, and maximum clearing time if the disturbance is caused by a fault. A generalized example such as provided here cannot possibly consider all the many variables that can exist on an actual system.

RATINGS

The 0208A8440 relay is rated at 120 volts, 5 amperes and it is available for 50 or 60 hertz.

The basic minimum reach range is 1, 2, 3 ohms phase to neutral at the relay angle of maximum torque of 75 degrees lag when the restraint circuit is connected for 100 percent on the relay restraint transformer.

Each basic minimum reach can be selected with a link arrangement located at the rear of the relay. The link arrangement consists of 2 sections on one ohmic reach block, with each section marked A-B (common connections) and 1, 0, 2. By connecting both sections as shown in table I, the basic minimum ohmic reach of the relay can be set.

TABLE I

Minimum Reach P-N	Links	
	"A"	"B"
1.0 ohm	1	0
2.0 ohm	0	2
3.0 ohm	1	2

The basic minimum reach can then be extended to 10 times this reach by reducing the restraint circuit setting on the tapped restraint transformer inversely as the basic minimum reach is increased. The following equation illustrates this change.

$$(@\ 75^0 \text{ lag})\ Z \text{ relay} = \frac{100\ (\%)}{\text{transformer setting } (\%)} \times \text{basic minimum reach.}$$

Therefore, the ohmic reach range of this relay for each basic minimum reach tap is shown in table II, when the restraint circuit is set from 100-10 percent on the restraint transformer.

TABLE II

Minimum Reach P-N	Restraint Circuit Set At 100-10 Percent On The Restraint Transformer
1.0 ohm	1-10 ohms
2.0 ohm	2-20 ohms
3.0 ohm	3-30 ohms

Ohmic reach settings within the range of the relay can be set in 1 percent increments by selecting the proper taps on the restraint transformer which is tapped in 10 percent and 1 percent steps.

The relays also contain a 0-4 ohm, phase to-neutral, offset transactor with taps that can be selected in 1 ohm increments. The offset transactor tap block is located in the front of relay above the mho unit and by moving the tap lead to the desired offset tap, the impedance characteristic of the unit will be offset by that amount in the reverse direction. (255 deg. lag.)

The angle of maximum torgue of the mho unit can be adjusted continuously from 75 degrees lag (factory setting) to 60 degrees lag, with the R21 rheostat, located at the lower left side of the relay next to the mho unit. This adjustment will decrease the basic minimum reach to approximately 80 percent of the reach at 75 degrees.

Current Circuits

The current circuit is rated at 5 amperes with a 1 second rating of 260 amperes. Higher currents can be applied for shorter periods of time according to the following equation.

$I^2t = k$

Where: I = The applied current in amperes.
T = Time in seconds.
K = Constant = 67,600/1 second.

Potential Circuit

The potential circuit is continuously rated for 120 volts at rated frequency.

Relay Ambient

The relays are designed to operate continuously at rated voltage and current in an ambient temperature not to exceed 40 degrees centigrade.

D. C. Ratings

The D. C. voltage circuits are available at 125 or 220 volts D. C.. These circuits consist of telephone relays which have contacts that will close and carry 30 amperes for 1 second, with a continuous rating of 3 amperes. However, these contacts are only capable of interrupting a circuit according to that shown in table III.

TABLE III

Volts D.C.	Interrupting rating in amperes Inductive	Non-Inductive
125	0.50	1.5
220	0.25	0.75

Mho Unit Contacts

The mho unit contacts will close and carry 30 amperes momentarily. However, these contacts do not have an interrupting rating, therefore some other suitable means is necessary to open the trip circuit.

Target/Seal-in

The ratings of the target/seal-in unit are shown in table IV.

TABLE IV

TARGET SEAL-IN UNIT

	0.6 Amp Tap	2.0 Amp Tap
Minimum operating	0.6 amps	2.0 amps
Carry Continuously	1.5 amps	3.5 amps
Carry 30 amps for	0.5 sec.	4 secs.
Carry 10 amps for	4 secs.	30 secs.
DC Resistance	0.6 ohms	0.13 ohms
60 Cycle Impedance	6 ohms	0.53 ohms

Operating Principles

The mho unit of the 0208A8440 relay is of the four pole induction cylinder construction in which torque is produces by the interaction between a polarizing flux and the fluxes proportional to the restraining and/or operating quantities.

The torque at the balance point of the unit can be expressed by the following equation:

$$\text{Torque} = 0 = EI \cos(\phi - \theta) - KE^2$$

Where:

E = phase-to-phase voltage
I = Delta current (I1 - I2)
θ = angle of maximum torque of the unit
Ø = power factor angle of fault impedance
K = design constant

To prove that the equation defines a mho characteristic divide both sides by E^2 and transpose. The equation reduces to:

$$\frac{1}{Z} \cos(\phi - \theta) = K$$

or

$$Y \cos(\phi - \theta) = K$$

Thus, the unit will pickup at a constant component of admittance at a fixed angle depending on the angle of maximum torque. Hence, the name mho unit.

When offset is used the transactor is energized with line current and introduces a voltage (proportional to the current) added to the line-to-line voltage received by the unit. This voltage offsets the circular characteristic of the mho unit as shown in the R-X diagram, Figure 6.

Sensitivity

The sensitivity of the mho unit without offset is shown in Fig. 7. Figure 8 shows the effect of offset.

Directional Action

The mho unit has been carefully adjusted to have correct directional action under steady state, low voltage, and low current conditions. For faults in the non-tripping direction (zero offset) from 0-30 amperes. For faults in the tripping direction, the unit will close its contacts with as little as 2% voltage applied over the range of current shown in table IV.

TABLE IV

Basic Min. Reach Tap	*Volts (Studs 17-18)	Current Range for Correct Directional Action
1 ohm	2.4	6 - 60A
2 ohms	2.4	3 - 60
3 ohms	2.4	2 - 60

*The unit is set at the factory on the 2 ohm tap for correct directional action over the indicated current range. A variation of ±10 percent can be expected on the values listed.

BURDENS

Current Circuit

The burden of the current circuit is little affected by the offset tap used and the value imposed on each current transformer is as shown in table V.

TABLE V

Amps	Frequency (HZ)	R	+jx	P. F.	Watts	Volt Amps
5	60	.14	.14	.7	3.5	5

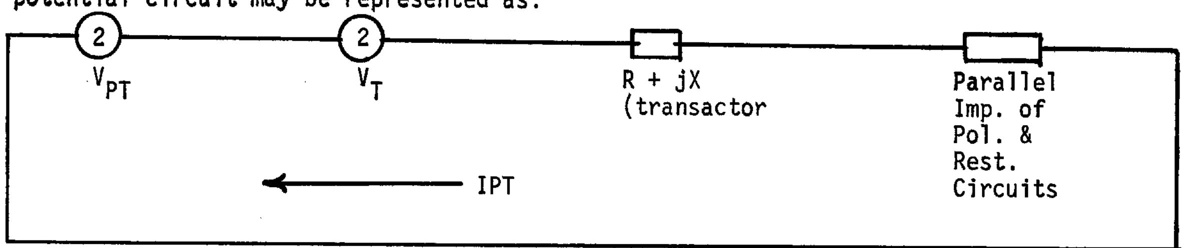
Potential Circuit

The potential burdens imposed on each potential transformer at 120 volts with the restraint taps at 100%, and the offset at zero is as shown in table VI.

TABLE VI

Circuit	R	X	P. F.	Watts	Vars	Va
Polarizing	1400	-j50	.99	10.3	----	10.3
Restraint	740	+j1750	.39	3.0	7.0	7.7

When offset is used, the potential circuit burden may be calculated as follows.
The potential circuit may be represented as:



Thus the burden on the PT would be:

VPT X IPT
and

$$IPT = \frac{VPT \pm VT}{Zs}$$ (Positive if load or fault current is opposite of Offset)

Where:
IPT = current in Potential Circuit
VPT = input voltage to relay
VT = output voltage of transactor
Zs = impedance of Potential Circuit

and:

$$VT = \sqrt{3}\, I'_T \times Z'_T \angle \theta - 75$$

where:

I_L = load current

Z_T = ohmic offset

θ = P. F. angle of I_L

and:

$$Zs = \frac{Zp \cdot Zr \left(\frac{100}{T}\right)^2}{Zp + Zr \left(\frac{100}{T}\right)^2} + Zt^2 \; (4.5 + j14.5)$$

$$Zs = (a + jb) + (c + jd)$$

To aid in the calculation of burden, the following values have been calculated:

Restraint Tap (T)	a + jb
100	845 452
50	1260 160
25	1370 0

ZT	c + jd
0	0
1	4.5 14.5
2	18 58
3	41 131
4	72 232

Thus, for 0.86 power factor load of 5 amperes into the protected line, the potential burden has been calculated for the following conditions:

Restraint Tap (T)	Offset Ohms	Watts	Vars
100	0	13.3	7.0
100	1	13.3	8.2
50	2	11.9	3.3
25	3	11.6	2.7
25	4	11.3	3.9

Underreach

At reduced voltage the ohmic value at which the Mho unit will operate may be somewhat lower than the calculated value. This "pullback" or reduction in reach is shown in Fig. 7. The unit reach in percent of setting is plotted against the three-phase fault current for three ohmic reach tap settings. Note that the fault current scale changes with the basic minimum reach setting. The M unit will operate for all points to the right of the curve. The steady-state curves of Fig. 7 were determined by tests performed with no voltage supplied to the relay before the fault was applied. The dynamic curves were obtained with full rated voltage of 120 volts supplied to the relay before the fault was applied.

Memory Action

The dynamic curves of Fig. 7 illustrate the effect of memory action in the mho units which maintains the polarizing flux for a few cycles following the inception of the fault. This memory action is particularly effective at low voltage levels where it enables the Mho units to operate for low fault currents. This can be most forcefully illustrated for a zero voltage fault by referring to Fig. 7. A zero voltage fault must be right at the relay bus and therefore, to protect for this fault, it is imperative that the relay reach zero percent of its setting. Fig. 7 show that the mho unit under static conditions, will not see a fault at zero percent of the relay setting regardless of the tap setting. However, under dynamic conditions when the memory action is effective, Fig. 7 shows that the mho units with a 3 ohm basic minimum reach and 100% tap setting will operate if $I_{3\phi}$ is greater than 1.75.

The memory action will close the contact for only a short period of time and therefore, memory action cannot be relied on if the tripping is delayed. When the relay is used to trip the breaker through the contacts of a timing relay the static characteristic should be used. For this application the relay is not required to operate for nearby faults and there will be sufficient voltage to give tripping without depending on memory action.

Transient Overreach

Under transient conditions the Mho unit has a tendency to close its contact momentarily for a fault impedance greater than its impedance setting. This tendency is called transient overreach and is a function of the degree of assymetry in the fault current wave, and the circuit angle (The angle of system).

Operating Time

The operating time curves for the Mho unit is determined by a number of factors such as the basic minimum reach setting of the unit, fault current magnitude, ratio of fault impedance to relay reach, and magnitude of relay voltage prior to the fault.

The operating time curves for the Mho unit are shown in Fig. 9. All curves are for the condition of rated volts prior to the fault with 100% restraint tap setting.

Telephone Relays

The telephone relays in the 0208A8440 relay are of the standard type and a typical picture with all parts labeled is shown in Fig. 10.

The relays are adjusted at the factory for the specifications shown in table VII with the connections shown in Figure 12.

TABLE VII

Telephone Relay	P. U. Voltage in % of rated	Pickup Time - Seconds	Dropout Time - Seconds
X	80 or less	0.009 or less	0.100-0.110
X_1	80 " "	0.008 " "	0.200-0.220
X_2	80 " "	0.008 " "	0.200-0.220
X_3	80 " "	0.009 " "	0.100-0.110
X_4	80 " "	0.008 " "	0.200-0.220
X_5	80 " "	0.008 " "	0.200-0.220

The contacts that are used for timing are as follows:

X - studs 13 and 14
X_1 - stud 15 and R2
X_2 - stud 4 and R3 - close X4 manually.
X_3 - stud 1 and m/b (N. C. contact).
X_4 - stud 15 and R5.
X_5 - stud 4 and R3 - close X1 manually.

CONSTRUCTION

The 0208A8440 relay consists of 6 telephone relays with associated resistors, one mho unit with offset and one target/seal-in unit, all mounted in a cradle and contained in an L2 double-ended drawout case. The electrical connections between the case blocks and cradle blocks are completed through a removable connection plug. A cross section of these parts are shown in Figure 11. The outline and panel drilling for the L2 case is shown in Fig. 2. The cover attaches to the case from the front and includes the target reset mechanism and a mechanical interlock that prevents the cover from being attached to the case before the connection plugs have been inserted in the relay.

The case is suitable for either semi-flush or surface mounting on panels up to 2 inches thick.

Panel thickness must be specified on the order to insure that the proper hardware is provided.
The Internal Connections diagram Figure 3 shows the electrical connections for all components in the complete relay.

RECEIVING, HANDLING AND STORAGE

These relays, when not included as a part of a control panel, will be shipped in cartons designed to protect them against damage. Immediately upon receipt of a relay, examine it for any damage substained 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 Apparatus Sales Office.

Reasonable care should be exercised in unpacking the relay in order that none of the parts are injured or the adjustments disturbed.

If the relays are not to be installed immediately, they should be stored in their original cartons in a place that is free from moisture, dust and metallic chips. Foreign matter collected on the outside of the case may find its way inside when the cover is removed and cause trouble in the operation of the relay.

PERIODIC CHECKS AND ROUTINE MAINTENANCE

In view of the vital role of protective relays in the operation of a power system it is important that a periodic test program be followed. It is recognized that the interval between periodic checks will vary depending upon environment, type of relay and the user's experience with periodic testing. Until the user has accumulated enough experience to select the test interval best suited to his individual requirements it is suggested that the points listed under INSTALLATION PROCEDURE be checked at an interval of from one to two years.

Contact Cleaning

For cleaning relay contacts, a flexible burnishing tool should be used. This consists of a flexible strip of metal with an etched-roughened surface resembling in effect a superfine file. The polishing action is so delicate that no scratches are left, yet it will clean off any corrosion throughly and rapidly. Its flexibility insures the cleaning of the actual points of contact. Do not use knives, files, abrasive paper or cloth of any kind to clean relay contacts.

ELECTRICAL TESTS

Drawout Relays General

Since all drawout relays in service operate in their case, it is recommended that they be tested in their case or an equivalent steel case. In this way any magnetic effects of the enclosure will be accurately duplicated during testing. A relay may be tested without removing it from the panel by using a 12XLA13A test plug. This plug makes connections only with the relay and does not disturb any shorting bars in the case. Of course, the 12XLA12A test plug may also be used. Although this test plug allows greater testing flexibility, it also requires C. T. shorting jumpers and the exercise of greater care since connections are made to both the relay and the external circuitry.

Power Requirements General

All alternating current operated devices are affected by frequency. Since non-sinusoidal waveforms can be analyzed as a fundamental frequency plus harmonics of the fundamental frequency, it follows that alternating current devices (relays) will be affected by the applied waveform.

Therefore, in order to properly test alternating current relays it is essential to use a sine wave of current and/or voltage. The purity of the sine wave (i.e. its freedom from harmonics) cannot be expressed as a finite number for any particular relay, however, any relay using tuned circuits, R-L or RC networks, or saturating electromagnets (such as time overcurrent relays) would be essentially affected by non-sinusoidal wave forms.

Similarly, relays requiring dc control power should be tested using dc and not full wave rectified power. Unless the rectified supply is well filtered, many relays will not operate properly due to the dips in the rectified power. Zener diodes, for example, can turn off during these dips. As a general rule the dc source should not contain more than 5% ripple.

MECHANICAL INSPECTION

1. It is recommended that the mechanical adjustments in Table VIII be checked.
2. There should be no noticable friction in the rotating structure of the units.
3. Make sure control spring is not deformed and spring convolutions do not touch each other.

4. With the relay well leveled in its upright position the contacts of the unit must be open. The moving contact should rest against the backstop.
5. The armature and contacts of the seal-in unit should move freely when operated by hand. There should be at least 1/32" wipe on the seal-in contacts.
6. Check the location of the contact brushes on the cradle and case blocks against the internal connection diagram for the relay.

TABLE VIII

Mho Unit	
Rotating shaft end play Contact Gap Contact Wipe	0.010 to 0.015" 0.040 to 0.060" 0.003 to 0.005"

ELECTRICAL CHECKS

Drawout Relays General

Since all drawout relays in service operate in their case, it is recommended that they be tested in their case or an equivalent steel case. In this way any magnetic effects of the enclosure will be accurately duplicated during testing. A relay may be tested without removing it from the panel by using a 12XLA13A test plug. This plug makes connections only with the relay and does not disturb any shorting bars in the case. Of course, the 12XLA12A test plug may also be used. Although this test plug allows greater testing flexibility, it also requires C. T. shorting jumpers and the excercise of greater care since connections are made to both the relay and the external circuitry.

INSTALLATION PROCEDURE

Location

The location of the relay should be clean and dry, free from dust, excessive heat and vibration, and should be well lighted to facilitate inspection and testing.

Mounting

The relay should be mounted on a vertical surface. The outline and panel drilling dimensions are shown in Fig. 2.

Connections

The internal connection of the Mho relay is shown in Fig. 3.

Unless mounted on a steel panel which adequately grounds the relay case, it is recommended that the case be grounded through a mounting stud or screw with a conductor not less than #12 B&S gage copper wire or its equivalent.

Settings on the target seal-in unit are made using the tap selection screw. The tap screw is the screw holding the right-hand stationary contact of the seal-in unit. To change the tap setting, first remove the connecting plug. Then, take a screw from the left-hand stationary contact and place it in the desired tap. Next, remove the screw from the other tap and place it in the left-hand contact. This should not be in both taps at the same time.

SERVICING

If it is found that the relay is out of calibration during installation or during periodic testing the relay should be recalibrated as described below.

The relay should be connected as shown in Figure 13, and the following table IX.

TABLE IX

Test Connection	Relay Stud	Jumper Studs
A B	17 18	17 to 19
C D	7 10	8 to 9

With rated voltage and current applied to the relay, set the phase angle meter for 75 degrees lag.

Check the reach of the relay for its ohmic setting which can be determined as follows.

1. Check the restraint transformer setting.
2. Check the offset transformer setting.
3. Check the basic minimum reach tap setting.

$$(\phi - \phi) Z = 2 \left(\frac{100\%}{t\ (\%)} \times \text{min reach setting}\right) - (2 \times \text{offset setting})$$

offset tap = tap setting Ø - N
min. reach = OM unit - basic min reach, Ø - N
t % = restraint transformer setting in percent.
Z = Ø - Ø ohmic reach @ 75 degree lag.

This will determine the relay reach in the forward direction (75 degrees lag). With rated voltage applied calculate the current necessary for the above "Z" setting.

$$I = \frac{\text{Rated voltage}}{(\phi - \phi) Z \text{ @ 75 degrees lag}}$$

The relay should operate at ($\pm$) 3 percent of this current value at the 75 degrees lag setting.

Keep the current between 15 and 20 amperes by reducing the applied voltage if necessary in order to stay within the bullet curve operating torque shown in Figure 7. If this test point is too far out of calibration, adjust Ril to bring it within test limits.

Set the phase angle meter for 255 degrees lag and determine the reach in the offset direction.

$$(\phi - \phi) Z \text{ @ 255 degrees lag} = 2 \times \text{offset } \phi - N \text{ setting}$$

$$I = \frac{\text{Rated voltage}}{(\phi - \phi) Z \text{ @ 255 degrees lag}}$$

The same limits apply as in the forward reach setting. Adjust R63 if necessary to bring the relay into calibration, but be careful not to adjust R63 below 250 ohms.

ANGLE OF MAXIMUM TORQUE

Check the angle of maximum torque in the forward direction by applying rated voltage and 10 percent more current than calculated in the reach test. Find the two angles of minimum torque by varing the phase shifter until the contact just opens. Find this point on both sides of the angle of maximum torque, then:

$$\angle \text{ max. torque} = \frac{\angle \text{ min. torque}_1 + \angle \text{ min. torque}_2}{2}$$

This angle should be at 75 degrees ($\pm$) 2 degrees. Adjust R_{21} if necessary to bring into calibration.

Cross check and adjust the units forward (75 degrees lag) and reverse (255 degrees lag) reach along with the unit angle of maximum torque, until the desired parameters are met without any further adjustment of R11, R63, and R_{21}.

The relay when adjusted as above for a specific set of conditions can then be set to other reach and/or offset settings by changing the reach and/or offset taps to the desired position. However, because of the impedance changes within the unit and offset transactor, as these taps are changed to a new set of conditions, the relay should be tested and readjusted to the new specifications as described previously.

Figures 14, 15, 16, 17, 18 and 19 will illustrate the effect of tap changes on a calibrated relay Fig. 14 without any further adjustments.

A typical setting of 16 ohms Ø - Ø at 75 degrees lag forward reach and an 8 ohm Ø - Ø at 255 degrees lag reverse reach is used as an example. The relay was first set for the total reach (forward plus reverse) of 24 ohms Ø - Ø (16 + 8) at 75 degrees with offset set at 0. Then 8 ohm Ø - Ø offset was inserted and the relay fine adjusted for 16 ohm Ø - Ø forward reach and 8 ohm Ø - Ø reverse reach. This is illustrated in Figure 14.

With these conditions set, the offset tap was changed and the results are shown in Figures 15, 16, 17.

With the relay offset tap held constant at 4 ohms (8 ohms Ø - Ø) and the restraint transformer varied from 25 percent (initial setting) to 50 and 100 percent with the results shown in Figures 18, 19.

Although this variation exists as the taps are changed, the relay can be set for any parameters within the range of the relay as described previously in the initial calibration setting.

RENEWAL PARTS

It is recommended that sufficient quantities of renewal parts be carried in stock to enable the prompt replacement of any that are worn, broken, or damaged.

When ordering renewal parts, address the nearest Sales Office of the General Electric Company, specify quantity required, name of the part wanted, and the complete model number of the relay for which the part is required.

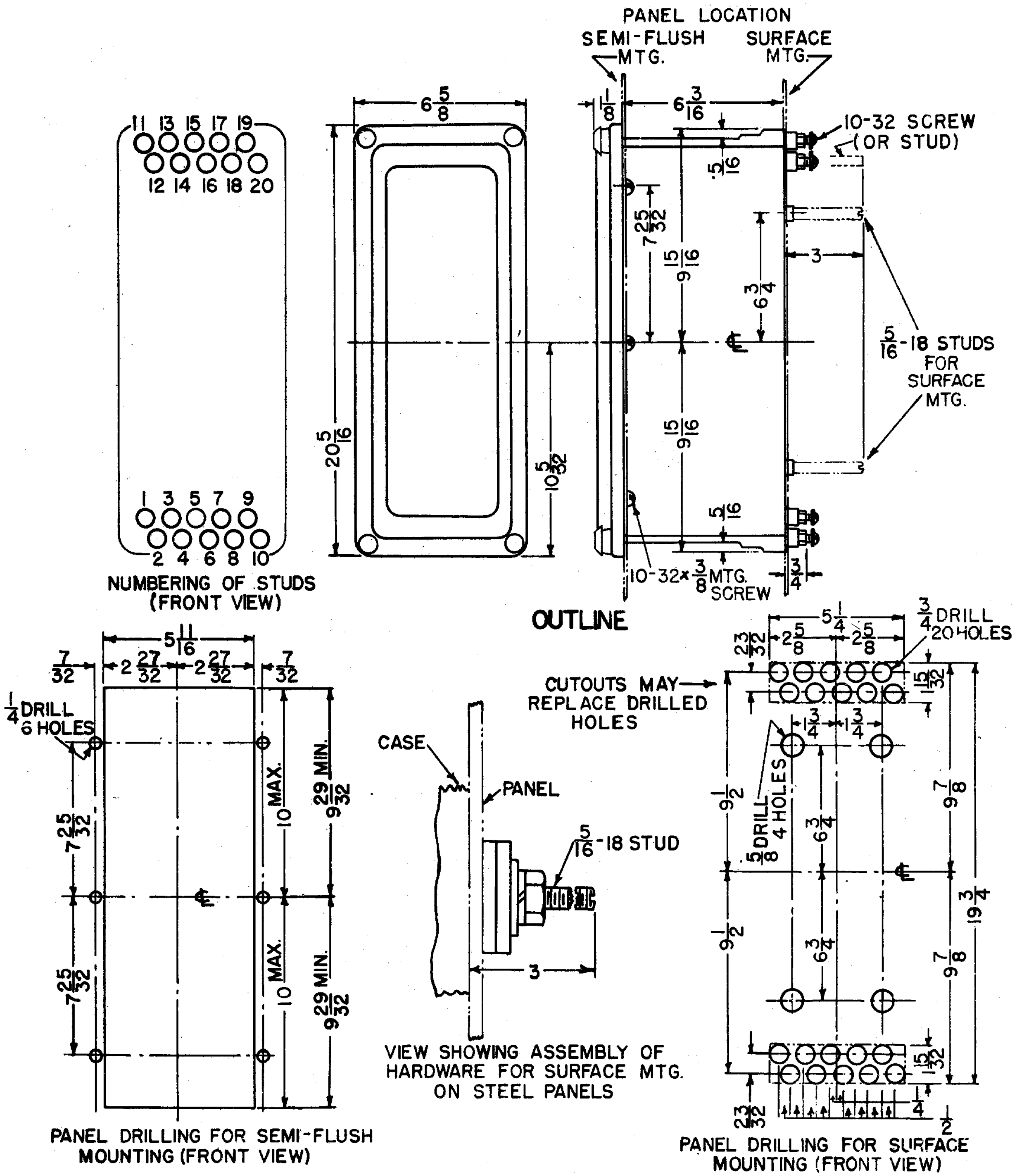


FIG. 2 (6209276-1) OUTLINE AND PANEL DRILLING

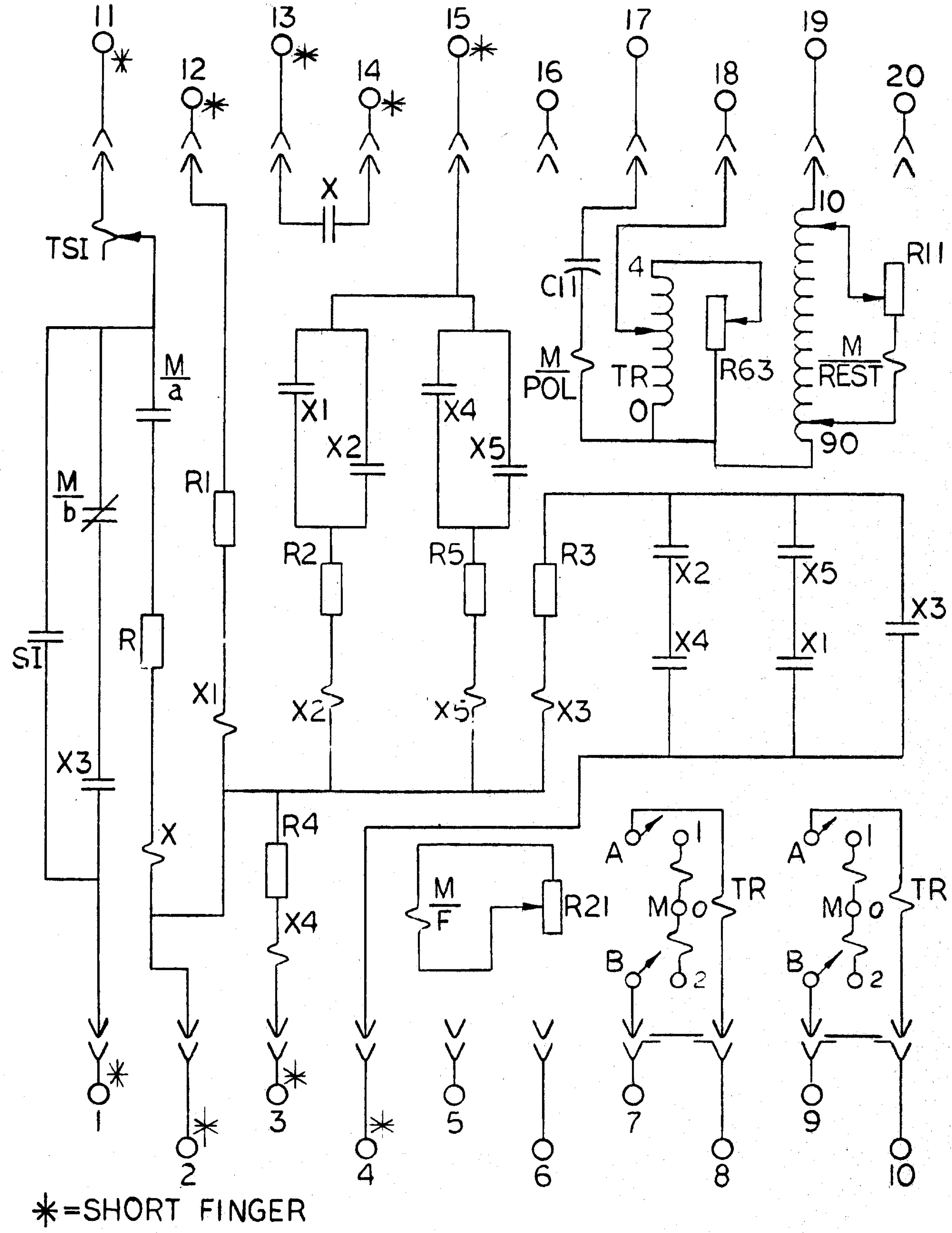


FIG. 3 (0246A6822-0) INTERNAL CONNECTIONS DIAGRAM FOR THE 0208A8440 RELAY

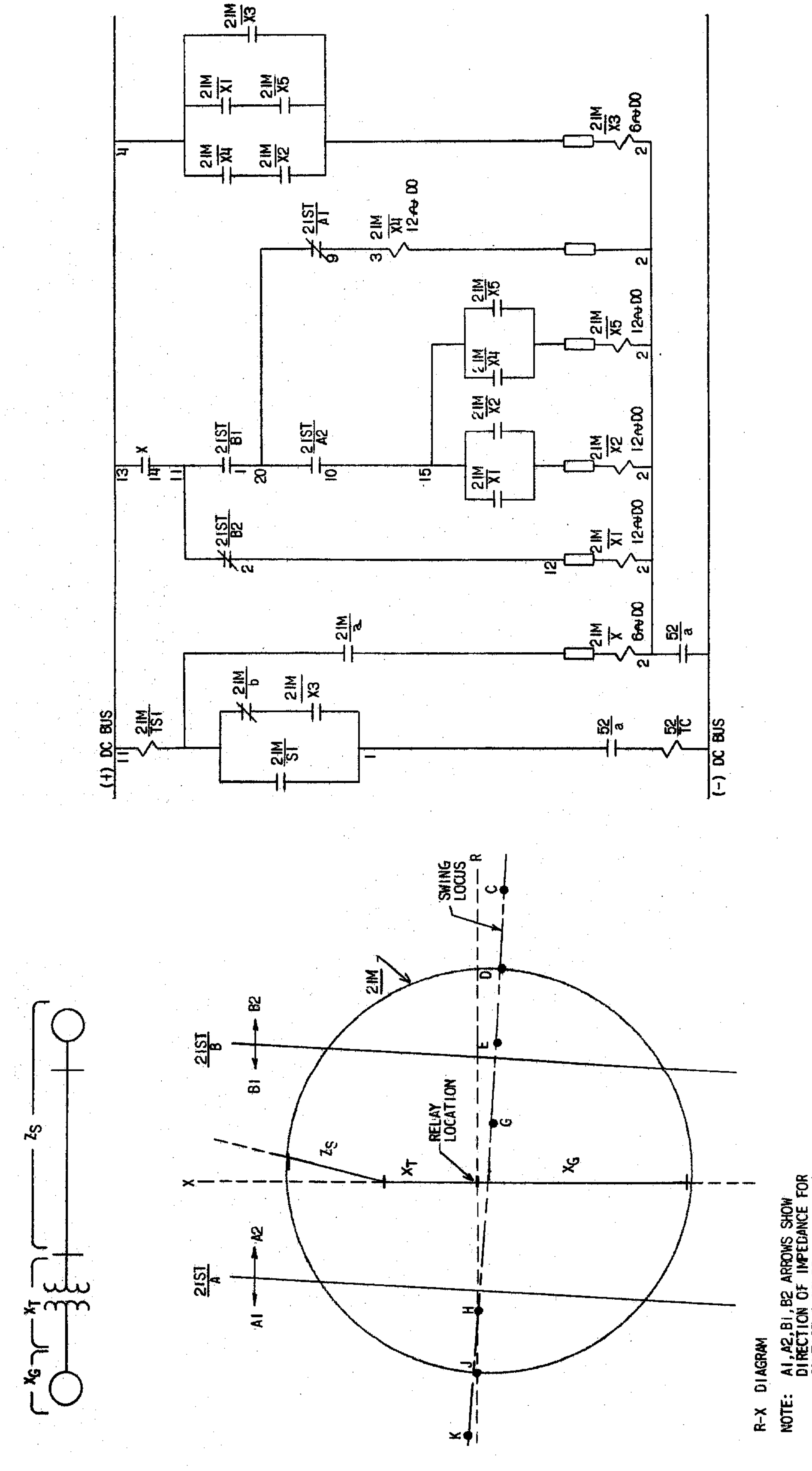
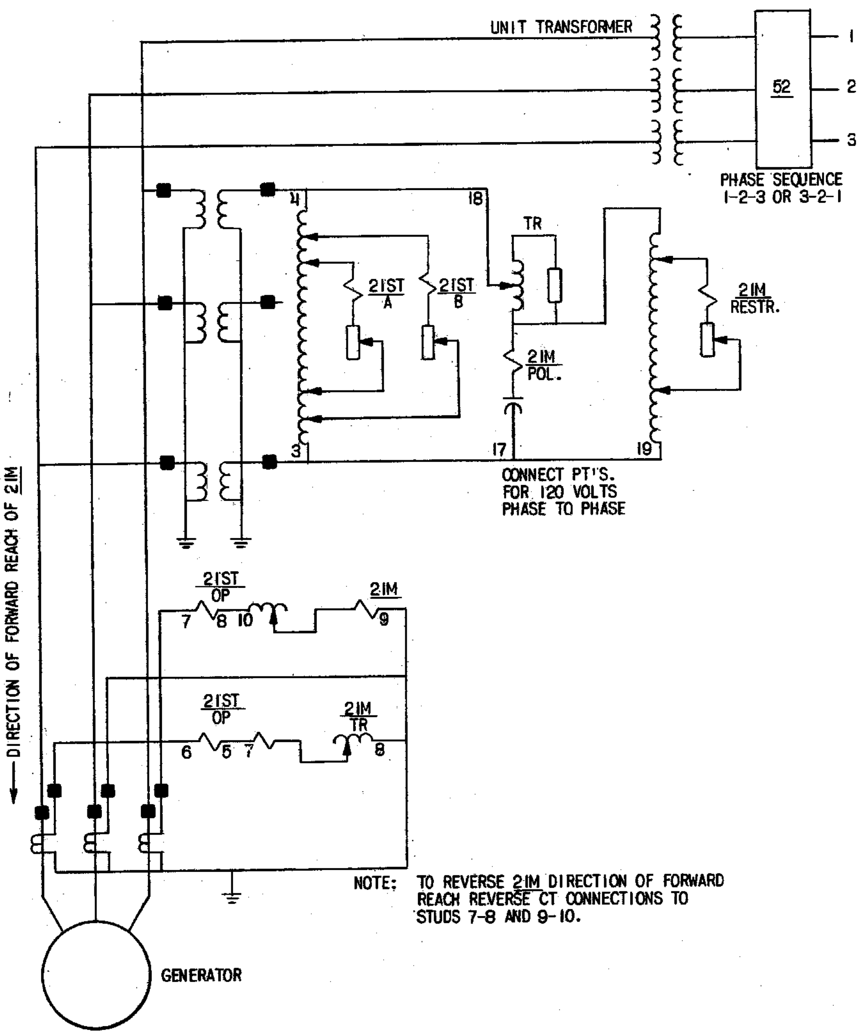


FIG. 4 (0165B2610-1) SH. 2 TYPICAL EXTERNAL TRIP CIRCUIT CONNECTIONS AND RELAY CHARACTERISTICS R-X DIAGRAM



LEGEND			
NO.	DEVICE	UNIT	DESCRIPTION
21M	NAA		OFFSET MHO SUPERVISING UNIT
		a	NORMALLY OPEN CONTACT
		b	NORMALLY CLOSED CONTACT
		POL.	POLARIZING CIRCUIT
		RESTR.	RESTRAINT CIRCUIT
		OP	OPERATING CIRCUIT
		TR	OFFSET TRANSACTOR
		X, XI, ETC	AUXILIARY TELEPHONE RELAYS
		TSI	TARGET SEAL-IN
21ST	CEX17E		OUT-OF-STEP BLINDER UNITS
		A	LOWER BLINDER UNIT
		B	UPPER BLINDER UNIT
52			CIRCUIT BREAKER
		a	AUXILIARY CONTACT
		TC	TRIP COIL

DRAWINGS		
DEVICE	INTERNAL	OUTLINE
CEX17E	0418A0759	K-6209274
NAA (0208A8440)	0246A6822	K-6209276

FIG. 4A (0165B2610-1) SH. 1 TYPICAL EXTERNAL CONNECTIONS DIAGRAM

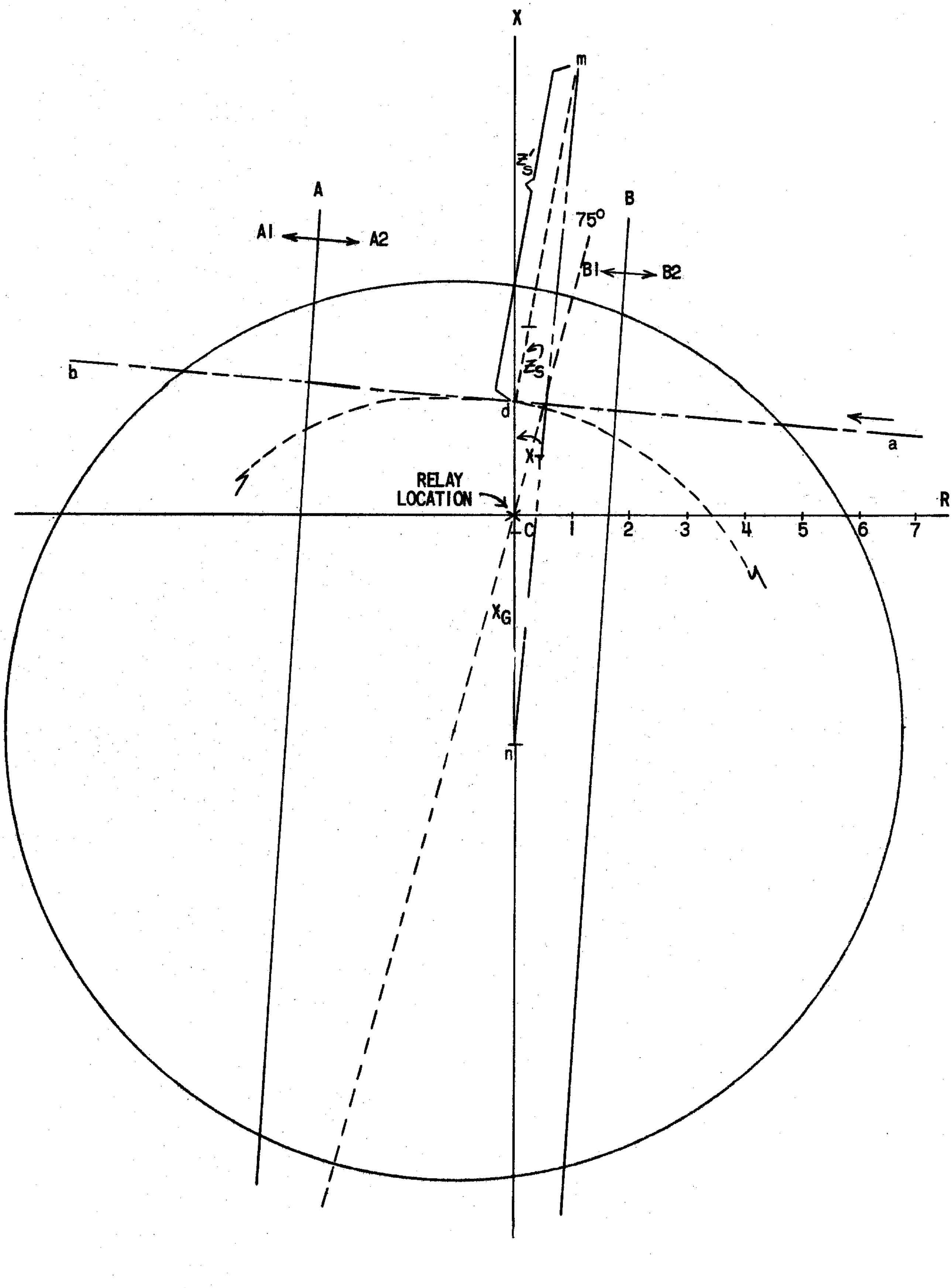


FIG. 5 (0183B7856-0) CHARACTERISTIC PLOT ILLUSTRATING THE MHO UNIT SETTINGS

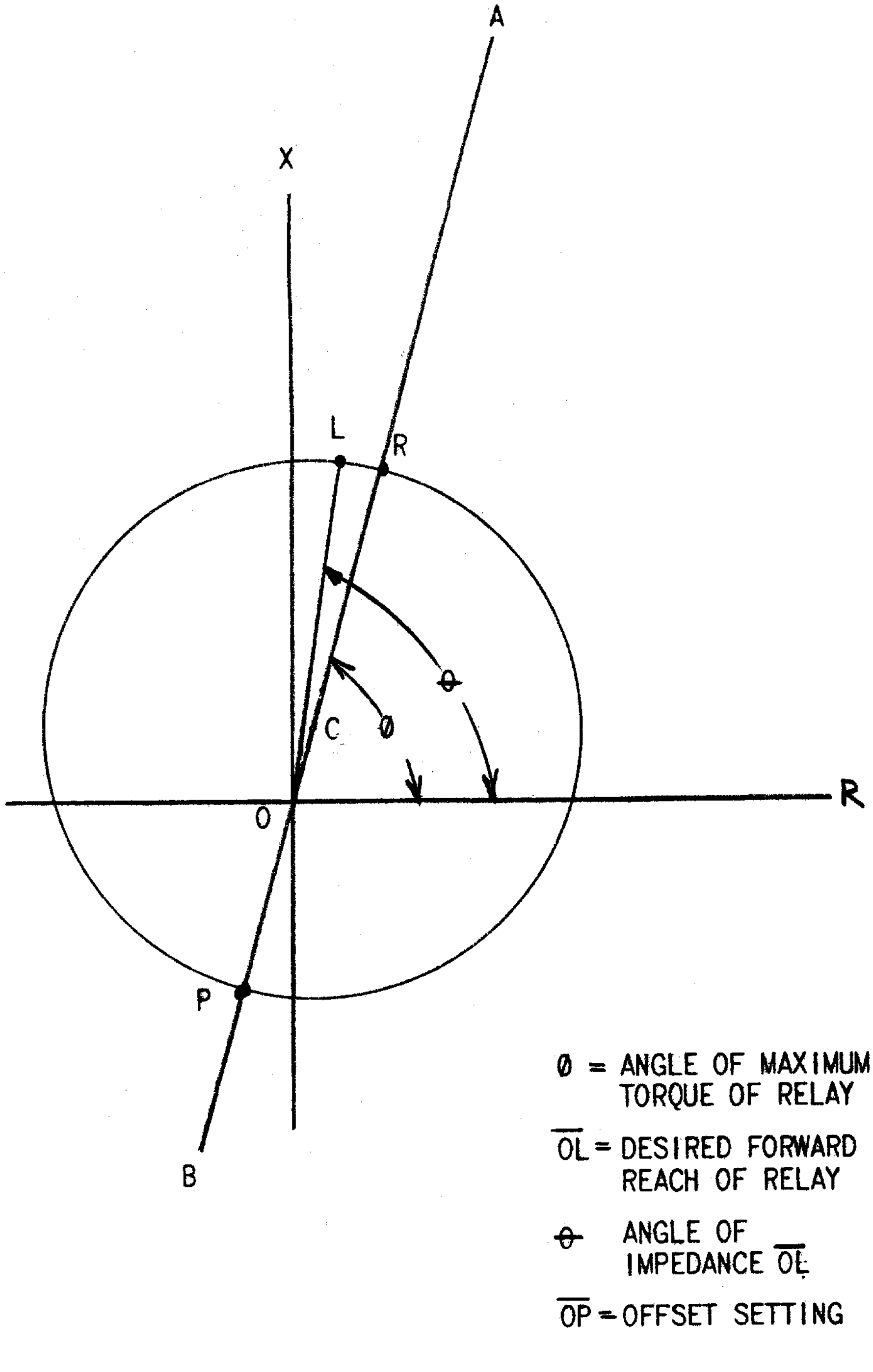


FIG. 6 (0165A7770-0) R-X DIAGRAM WITH OFFSET CHARACTERISTIC

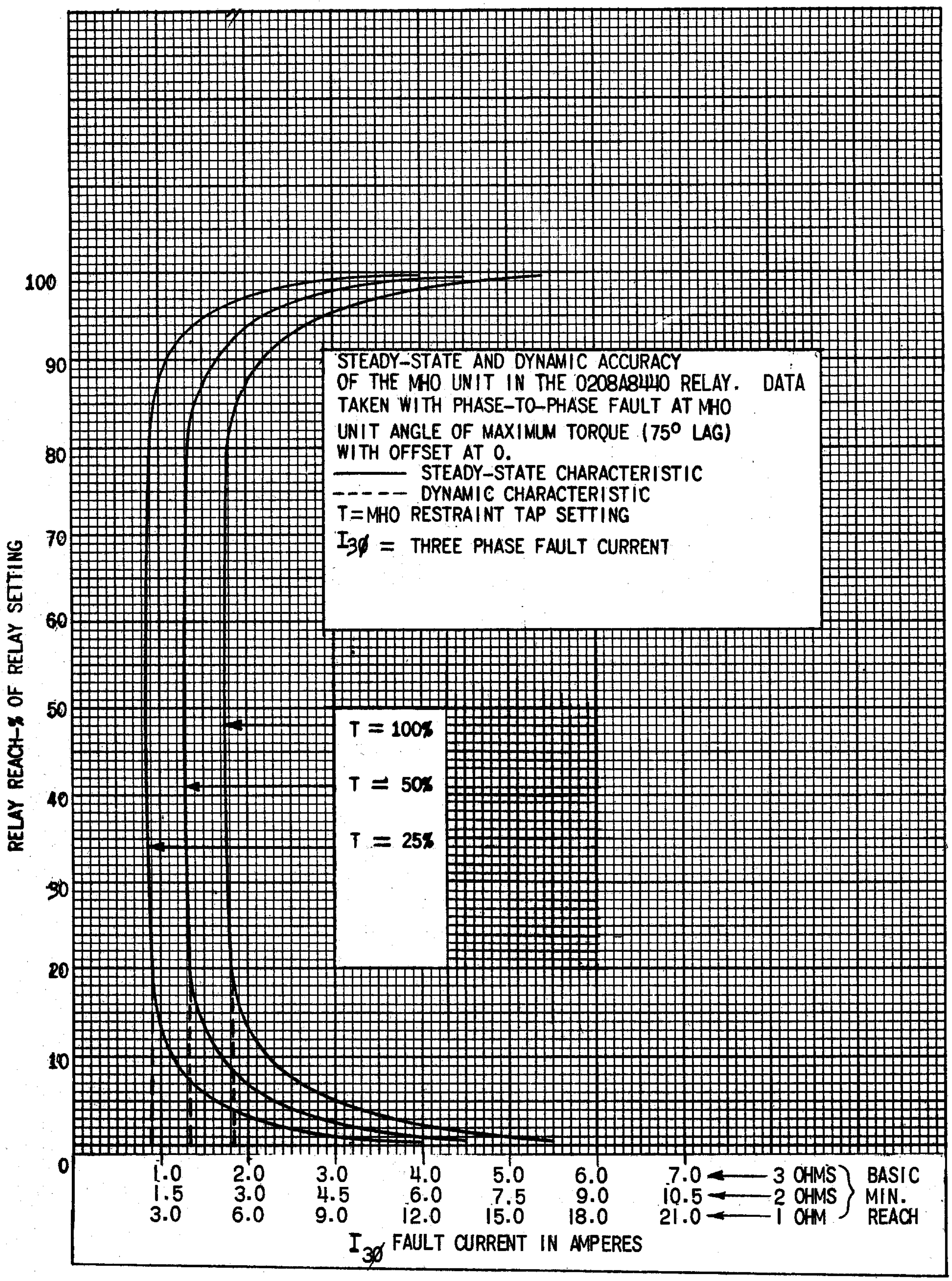


FIG. 7 (0208A8575-0) STEADY STATE AND DYNAMIC ACCURACY OF THE 0208A8440 RELAY WITHOUT OFFSET

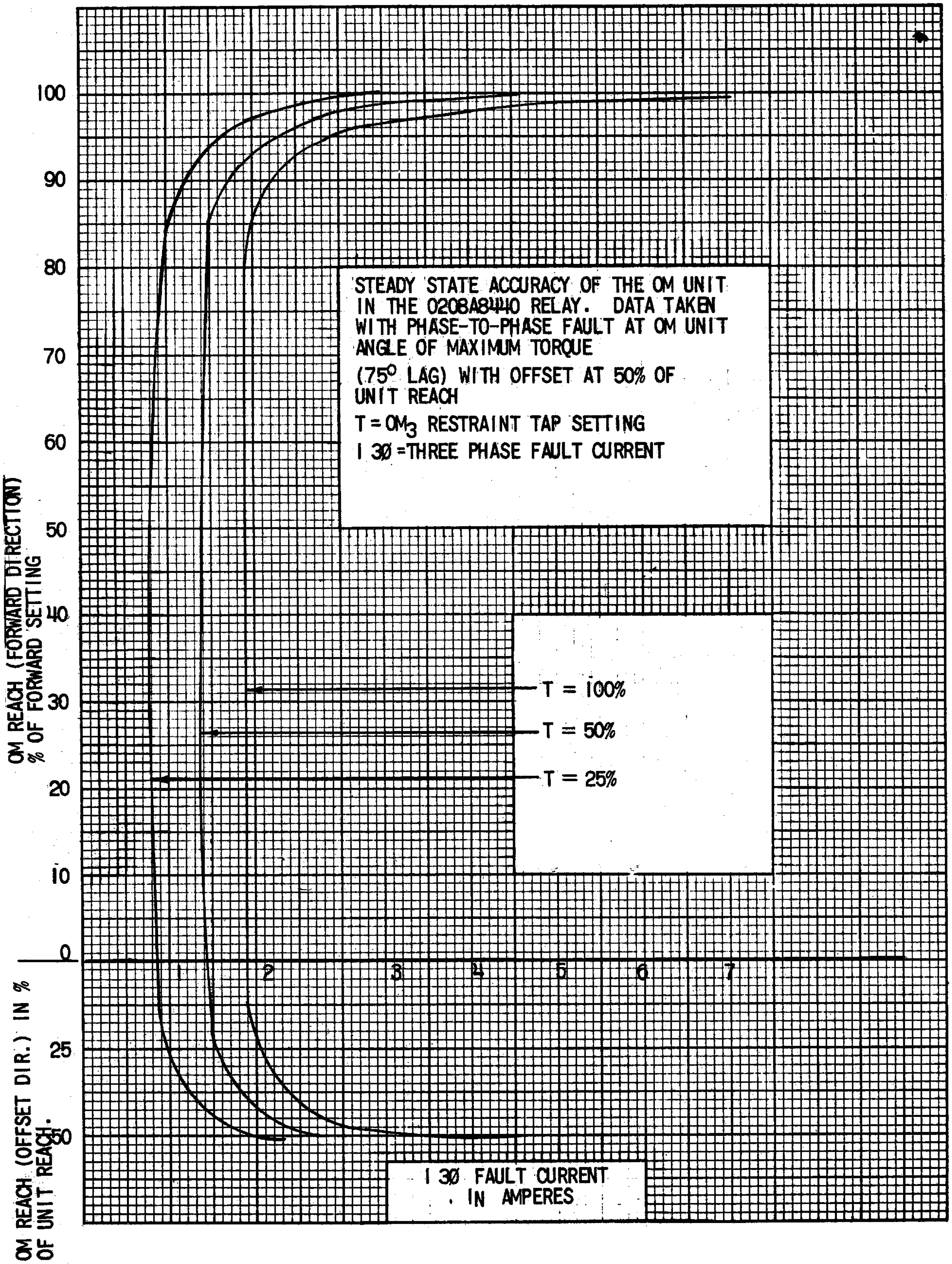


FIG. 8 (0208A8591-0) STEADY STATE REACH CURVES FOR THE 0208A8440 WITH OFFSET

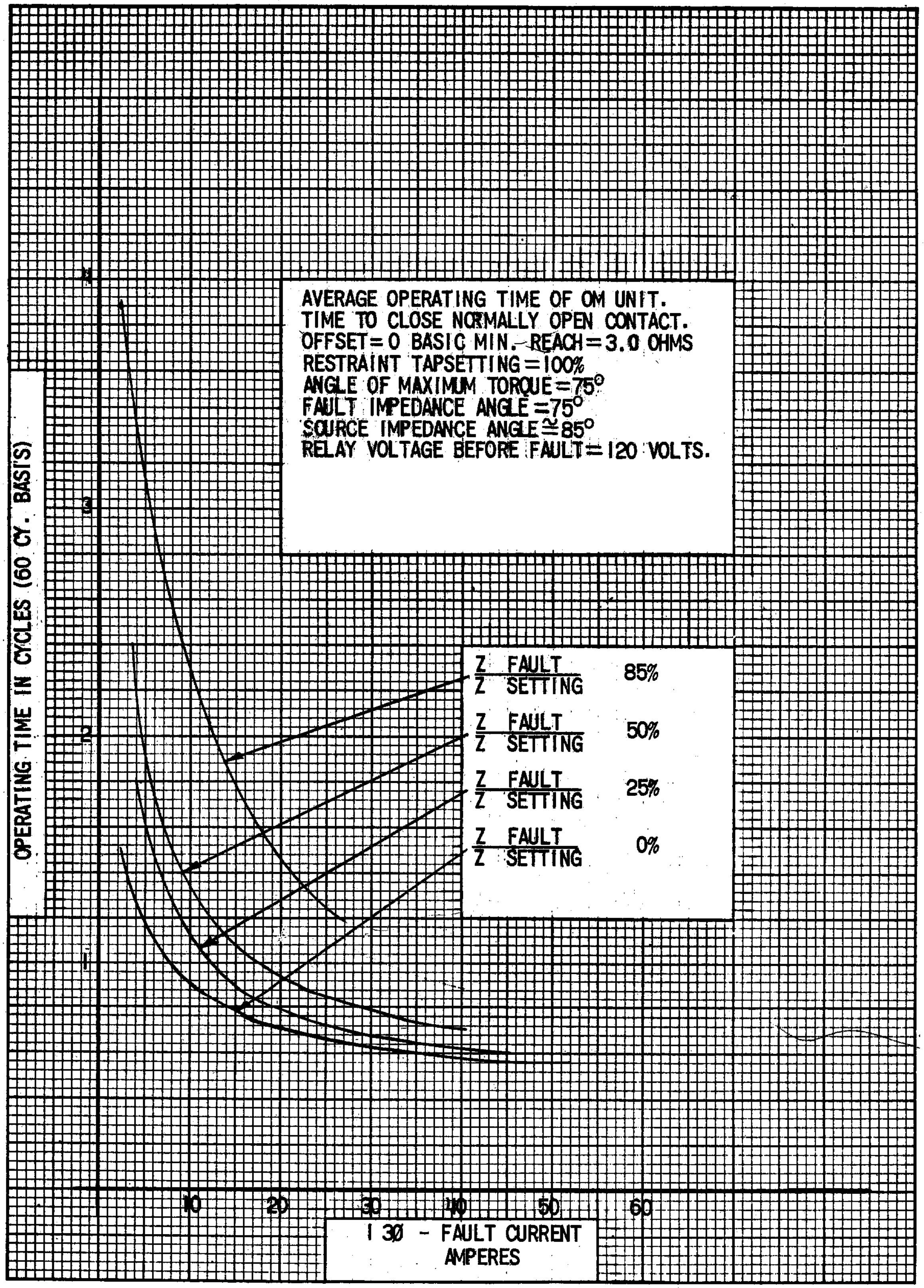


FIG. 9 (0208A8590-0) OPERATING TIMES FOR THE 0208A8440 RELAY

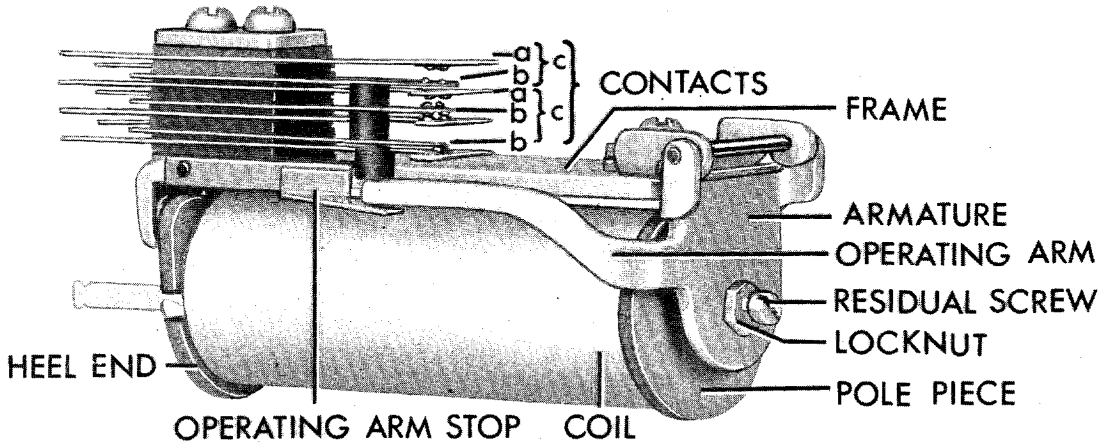
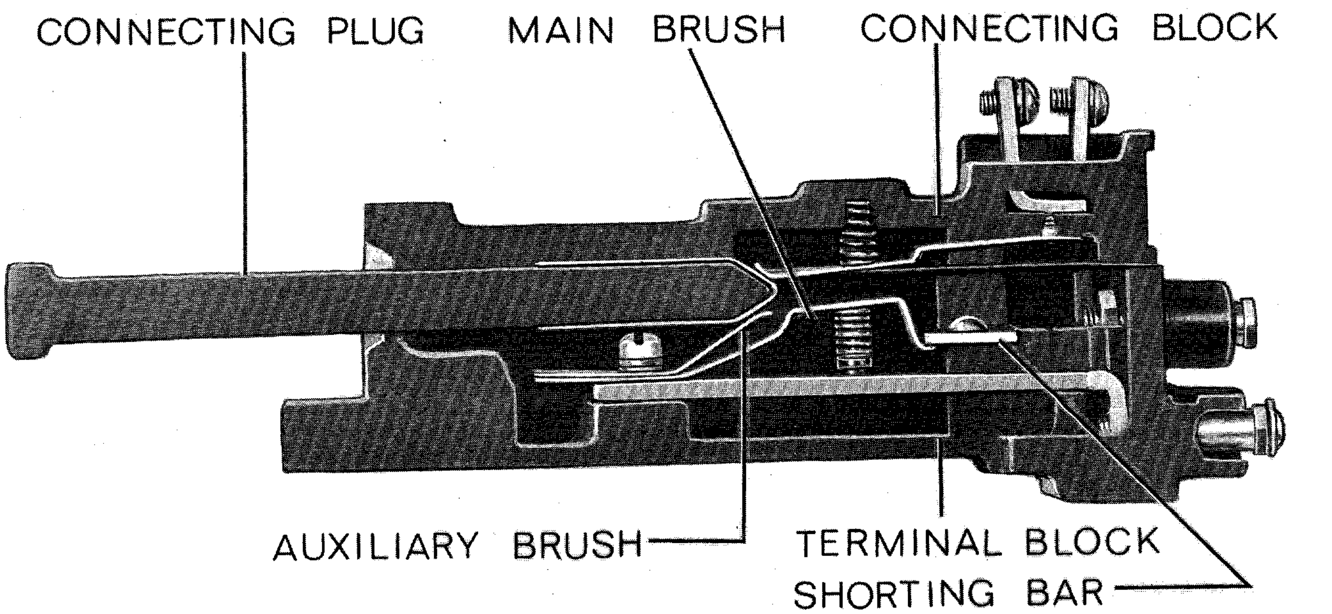


FIG.10 (8012106) TELEPHONE RELAY TYPE USED IN THE 0208A8440 RELAY



NOTE: AFTER ENGAGING AUXILIARY BRUSH, CONNECTING PLUG TRAVELS 1/4 INCH BEFORE ENGAGING THE MAIN BRUSH ON THE TERMINAL BLOCK

FIG. 11 (8025039) CROSS SECTION OF DRAWOUT CASE SHOWING POSITION OF AUXILIARY BRUSH AND SHORTING BAR

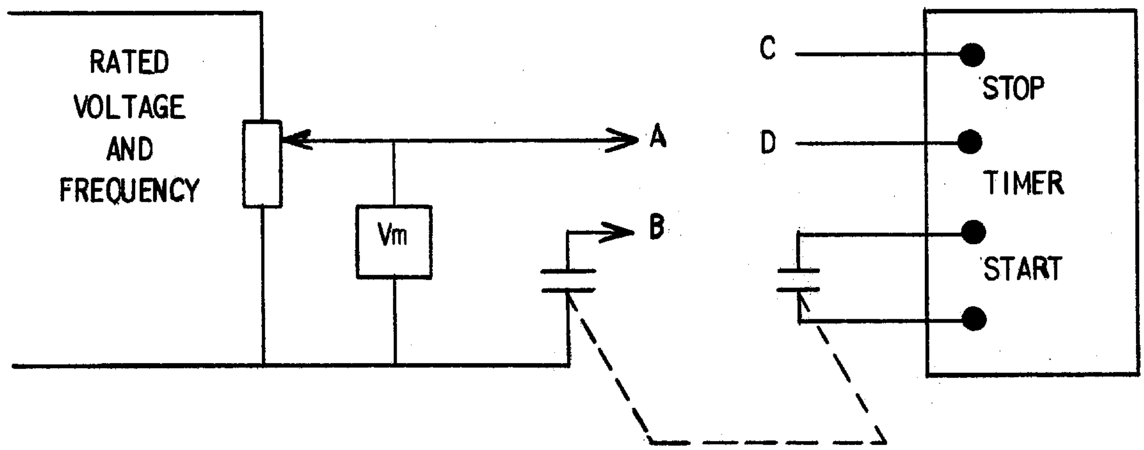


FIG. 12 (0246A3787-) TELEPHONE RELAY TEST CONNECTIONS
CONNECT A AND B TO RELAY COIL
C AND D TO RELAY CONTACT

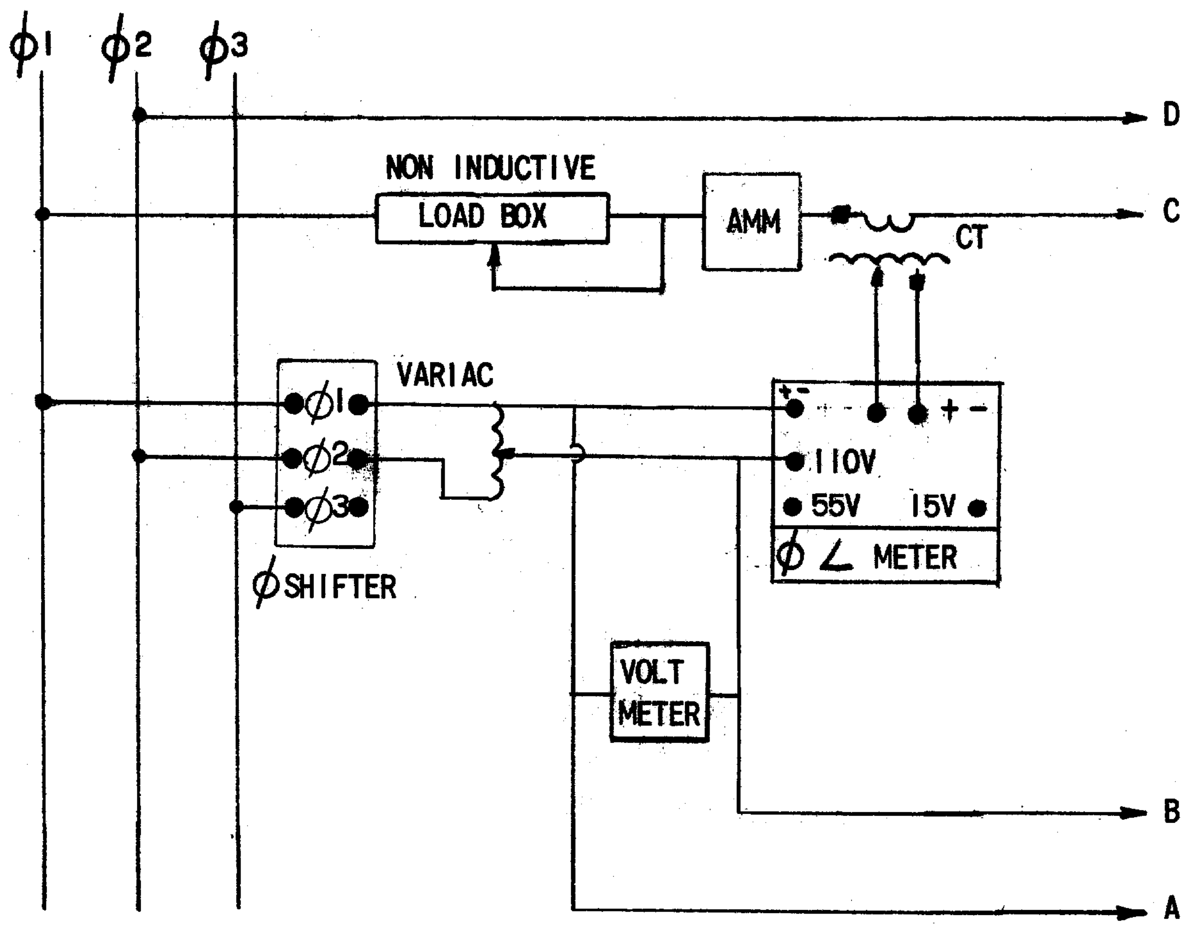


FIG. 13 (0227A8407-0) TEST CONNECTION DIAGRAM FOR THE 0208A8440 OM UNIT

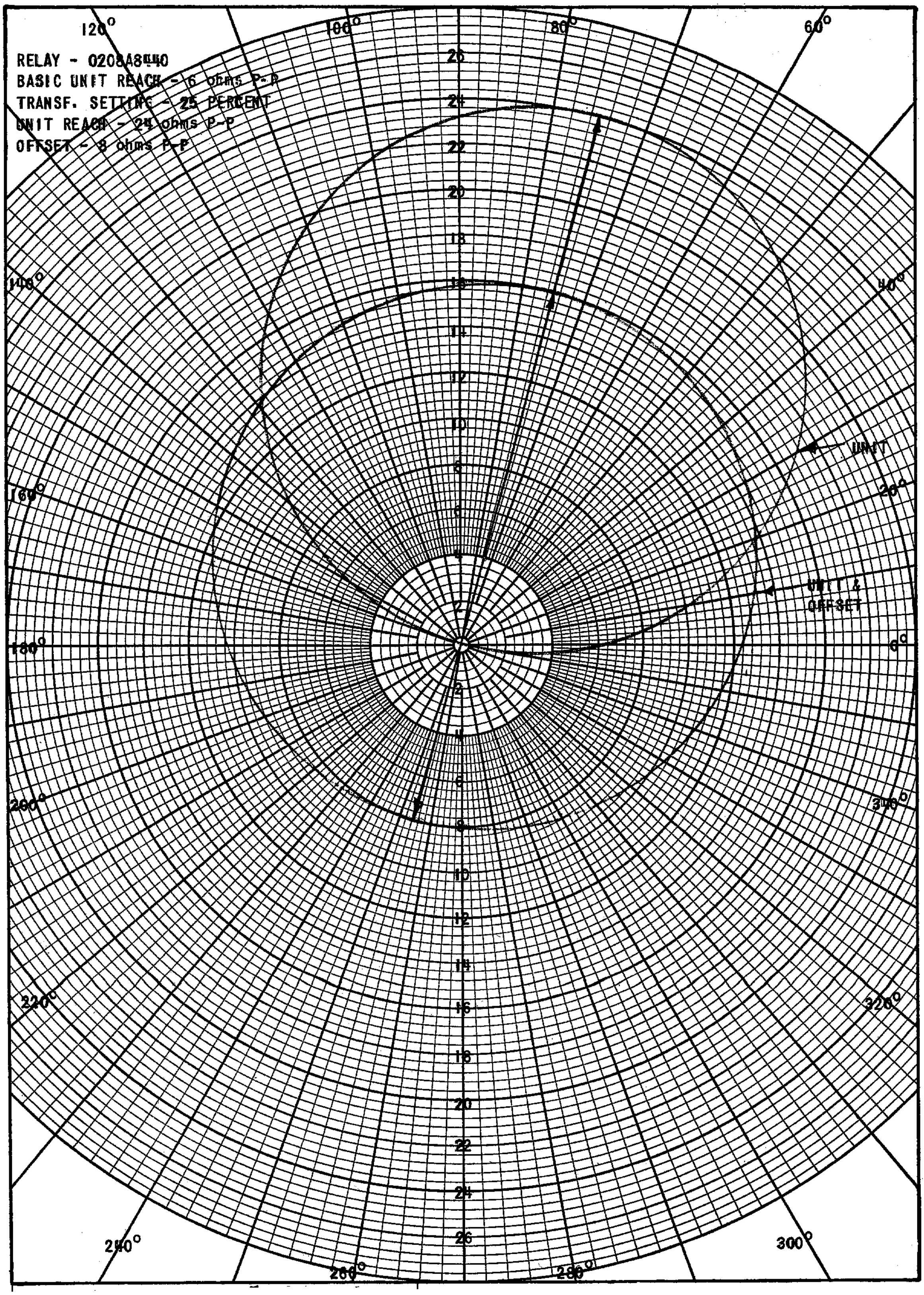


FIG. 14 (0246A7055-0) TYPICAL OM UNIT SETTING WITHOUT OFFSET AND WITH OFFSET FOR 8 OHMS Ø-N FORWARD REACH AND 4 OHMS Ø-N REVERSE REACH

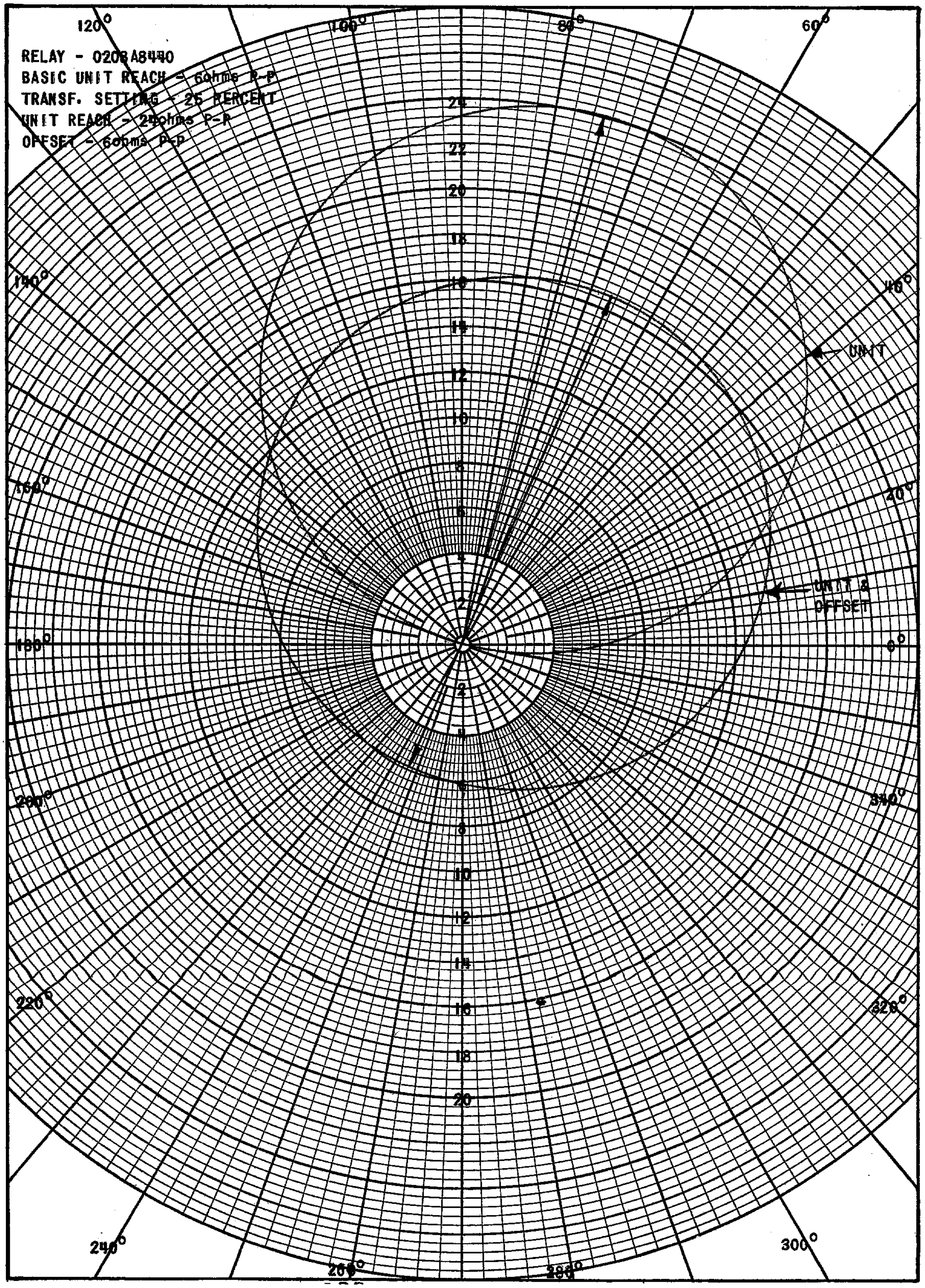


FIG. 15 (0246A7053-0) CHARACTERISTIC CHANGE AS OFFSET IS CHANGED FROM 8 TO 6 OHMS Ø-N (REFER TO FIG. 14)

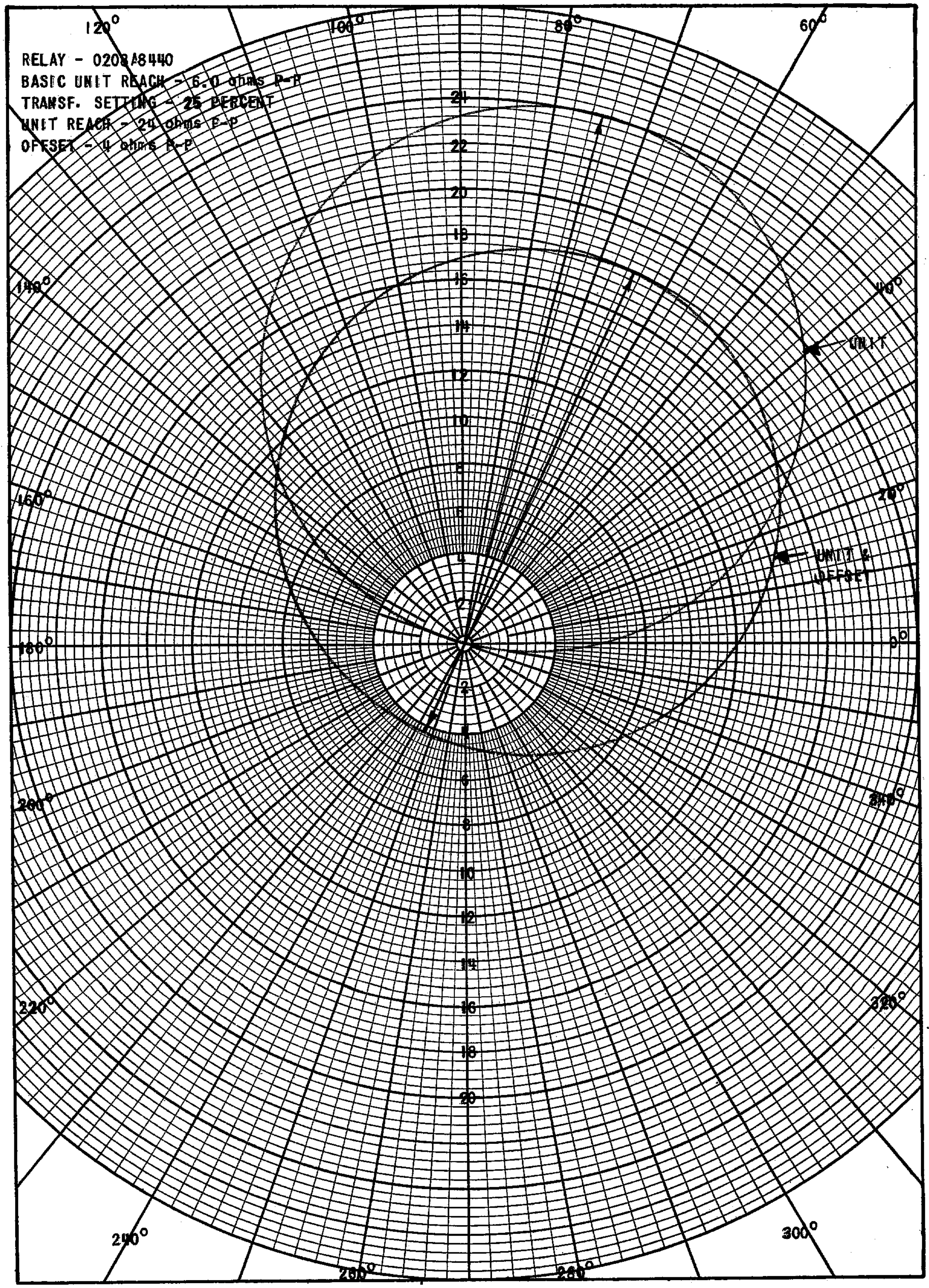


FIG. 16 (0246A7054-0) CHARACTERISTIC CHANGE AS OFFSET IS CHANGED FROM 8 TO 4 OHMS Ø-N (REFER TO FIG. 14)

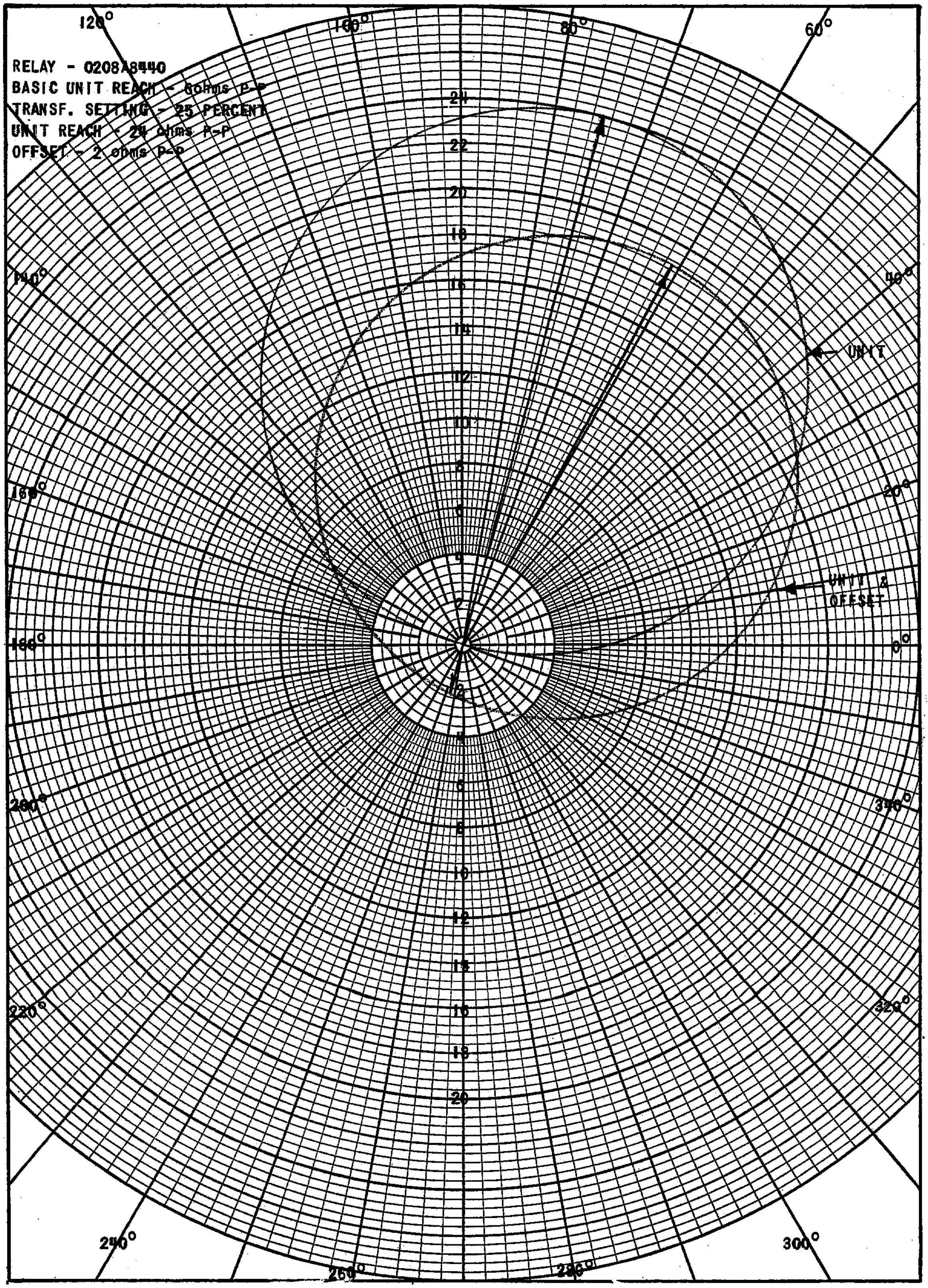


FIG. 17 (0246A7052-0) CHARACTERISTIC CHANGE AS OFFSET IS CHANGED FROM 8 TO 2 OHMS Ø-N (REFER TO FIG. 14)

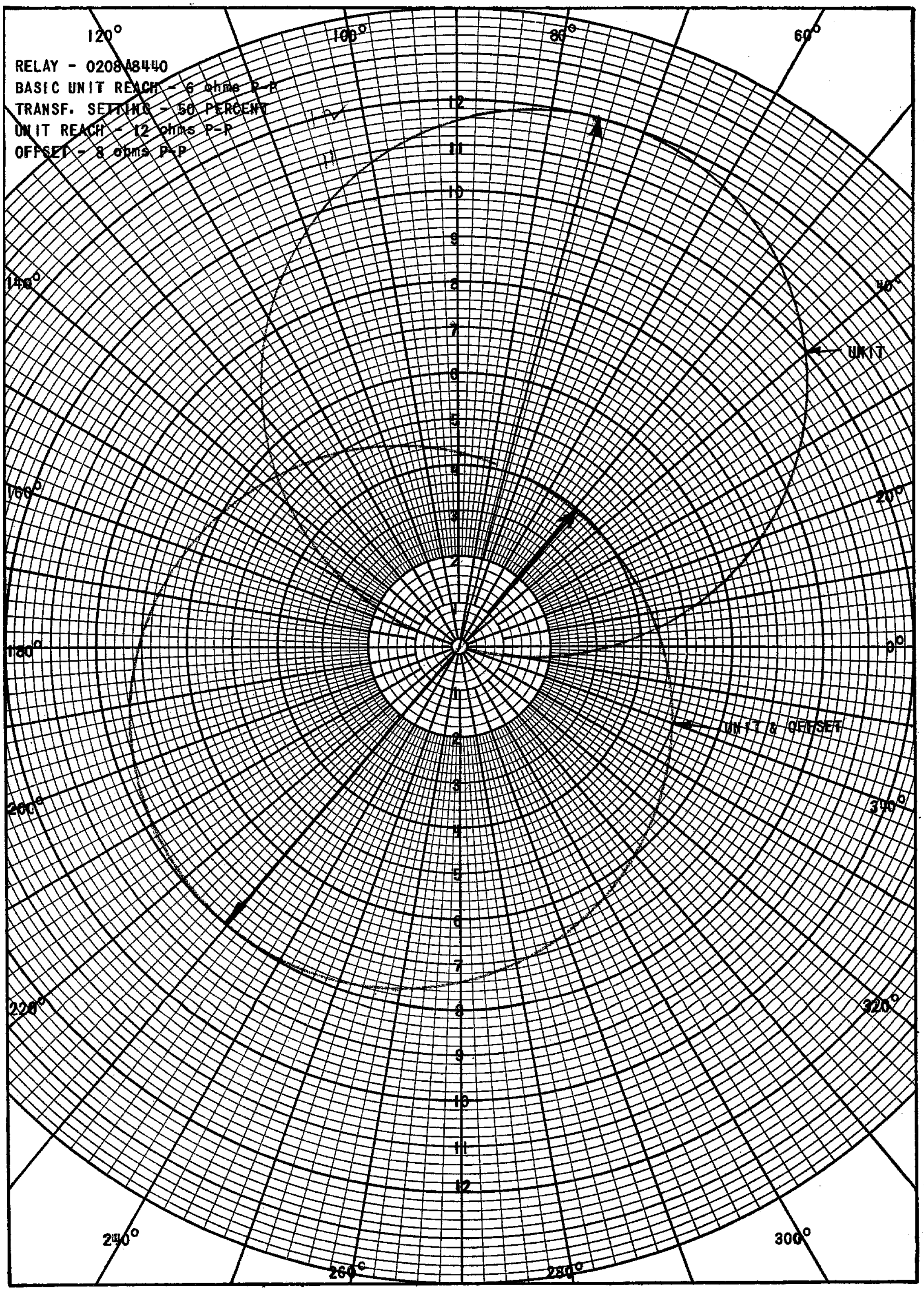


FIG. 18 (0246A7056-0) CHARACTERISTIC CHANGE AS RESTRAINT TRANSFORMER IS CHANGED FROM 25-50% (REFER TO FIG. 14)

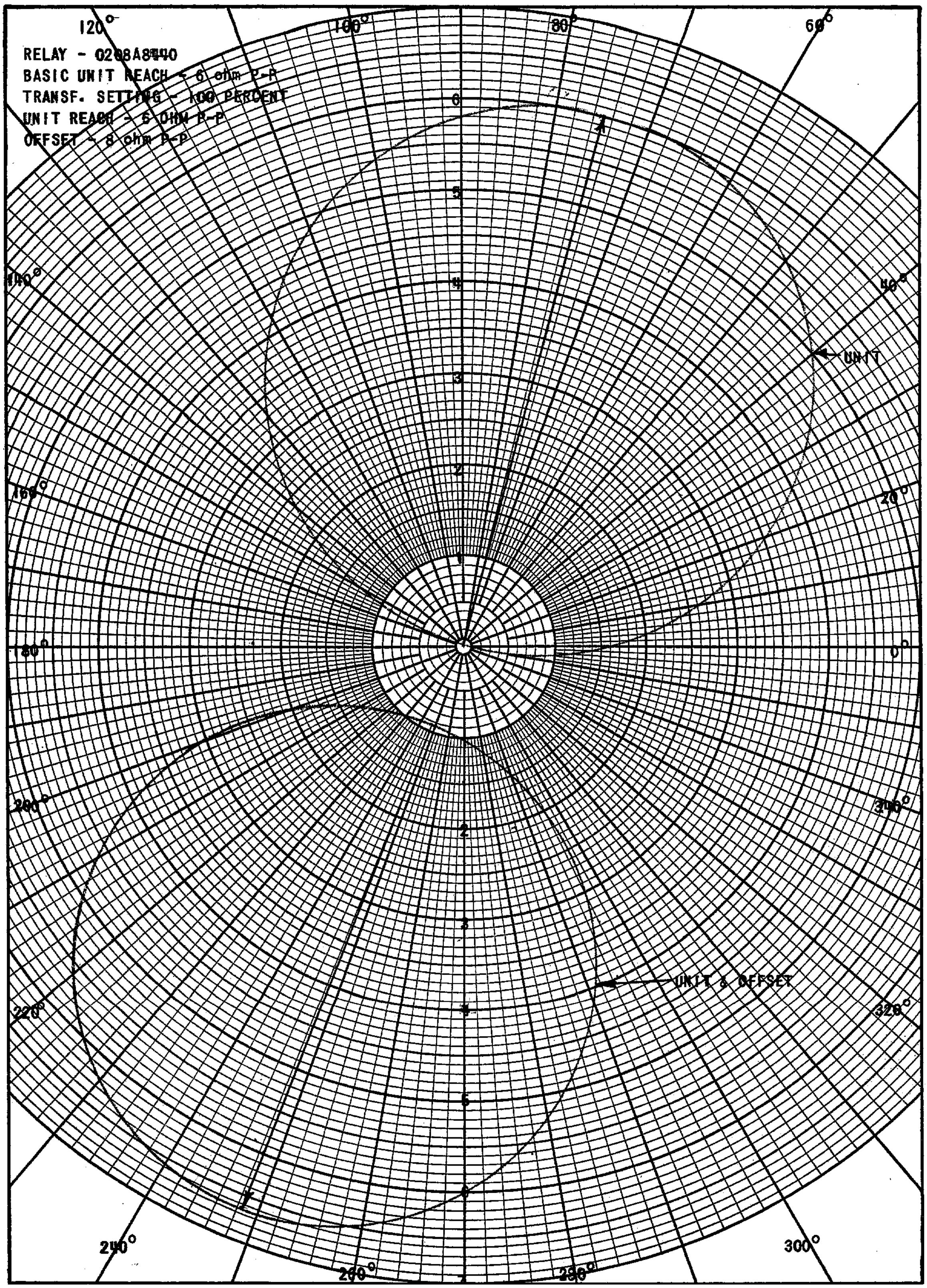


FIG. 19 (0246A7057-0) CHARACTERISTIC CHANGE AS RESTRAINT TRANSFORMER IS CHANGED FROM 25-100% (REFER TO FIG. 14)

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