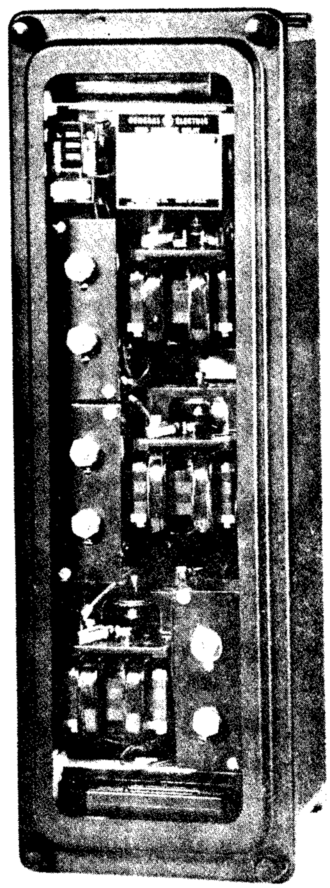
Instructions

GEI-98338E
SUPERSEDES GEI-98338D

MHO DISTANCE RELAYS

TYPE
GCY51A



(8035287)

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.

To the extent required the products described herein meet applicable ANSI, IEEE and NEMA standards; but no such assurance is given with respect to local codes and ordinances because they vary greatly.

The M_1 and M_2 units of these relays each have an angle of maximum torque of 60° that can be adjusted in the field to 75°, if desired. However, it is recommended that the M_1 unit be set at 60° because it will accommodate more arc resistance for close-in faults with the 60° setting than it will with the 75° setting. This is particularly true for the shorter-reach settings. For short-reach settings it is also desirable to set the M_2 unit on 60° so that it will accommodate more fault resistance. This becomes more important in pilot applications where the M_2 unit operates in conjunction with the channel to provide high-speed tripping, and so must operate for close-in faults.

When the GCY51A is used in step-distance applications, the third zone OM_3 unit may be set with or without offset, looking either into the line section or away from it, as desired. However, in directional-comparison pilot schemes where the OM_3 unit is required to initiate a blocking signal during external faults, it **must** be set with offset, and with its longest reach in the **reverse** direction, to insure positive high-speed operation to start and maintain the blocking carrier signal during external faults. The curves of Figure 14 indicate that the OM_3 unit with 100% tap setting and 0.5 ohm offset requires a minimum 3-phase fault current of 2 amperes to operate on a steady-state basis for a zero-voltage fault.

In order to obtain maximum possible performance, it is suggested that the M_1 and M_2 units be set on the highest basic minimum-reach tap that will accommodate the desired settings. Since the maximum transient overreach on the M_1 unit is 5% regardless of setting, this unit can be set to protect as much as 90% of the distance to the remote terminal.

The section on **CALCULATION OF SETTINGS** provides a typical worked example for setting the GCY51A relay in a step-distance application. Figure 3 is an elementary diagram for three-step distance protection using three GCY51A relays and one RPM11D timer.

RATINGS

The Type GCY51 relay covered by these instructions is available for 120 volts, 5 amperes, 60 cycle rating. The 1-second rating of the current circuits is 225 amperes. The basic minimum reach and adjustment ranges of the M_1, M_2, and OM_3 units are given in Table II.

TABLE II

UNIT	BASIC MIN. REACH (ϕ-N OHMS)	RANGE (ϕ-N OHNS)	ANGLE OF MAX. TORQUE	OFFSET (ϕ-N OHMS)
M_1	0.75/1.5/3*	0.75/30	60°**	----
M_2	1/2/3*	1/30	60°**	----
OM_3	3	3/30	75°	0/0.5

* Adjustment taps are set for 1.5 ohms (M_1) or 2 ohms (M_2) basic minimum reach prior to shipment.

** The angle of maximum torque of the M_1 and M_2 units can be adjusted up to 75°. The reach of the M_1 unit will increase slightly; the reach of the M_2 unit will increase to approximately 120% of its reach at the 60° setting.

It will be noted that three basic minimum-reach settings are listed for the M_1 and M_2 units. Selection of the desired basic minimum reach for the M_1 unit is made by means of two tap screws on a two-section tap block located on the right side of the M_1 unit subassembly (see Figure 1). The position of these screws determines the tap setting of the two primary windings of transactor TR-1.

Selection of the desired basic minimum reach for the M_2 unit is made by means of links on a terminal board located on the rear of the M_2 unit subassembly (see Figure 2). The positions of the two sets of links, each identified as A-B, determine the tap setting of the two current-operating coils of the M_2 unit.

Selection of either 0 or 0.5 ohm offset for the OM_3 unit is made by means of links on a terminal board located on the rear of the OM_3 unit subassembly (see Figure 2).

The ohmic reach of the M_1, M_2 or OM_3 units can be adjusted in 1% steps over a 10/1 range for any of the basic minimum-reach settings listed in Table II by means of auto-transformer tap leads on the tap block at the right side of the relay (see Figure 1).

Contacts

The contacts of the GCY51 relay will close and carry momentarily 30 amperes DC. However, the circuit breaker trip circuit must be opened by an auxiliary switch contact or other suitable means, since the relay contacts have no interrupting rating.

Target Seal-in Unit

The 0.6/2 ampere target seal-in unit used in the GCY51 relay has ratings as shown in Table III.

TABLE III

TARGET SEAL-IN UNIT		
	0.6 Amp Tap	2.0 Amp Tap
Minimum Operating	0.6 amp	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 ohm	0.13 ohm
60 Cycle Impedance	6 ohms	0.53 ohm

contacts of the unit just close. This should occur within the limits shown in Table XII. Note that for the M_1 and M_2 units the tap screws or links should be in the position that gives the basic minimum reach shown in the table.

TABLE XII

UNIT	φ-ANGLE METER READS	BASIC MIN. REACH (φ-N OHMS)	V_{17-18} SET AT	PICKUP AMPS	EQUIV. TEST REACH (φ-φ OHMS)
M_1	300°	1.5	45V	1.46-1.54	3
M_2	300°	2	60	1.46-1.54	4
OM_3	285°	3	90	1.46-1.54	6

Note that for the test conditions, the mho units see a phase-to-phase fault of twice the basic minimum reach.

The relays are normally shipped from the factory with the basic minimum reach adjustment taps of the M_1 and M_2 units in the intermediate setting, that is, 1.5 ohms for M_1 and 2 ohms for M_2. If the units are set on either of the remaining basic minimum reach taps, 0.75 or 3.0 ohms for M_1, 1.0 or 3.0 ohms for M_2, the basic reach of the units will be within ± 4% of the tap plate marking.

4. Angle of Maximum Torque

For the angle of maximum torque check, the connections of Figure 22 will be used with the M_1, M_2, and OM_3 tap leads still in the 100% position, and with the voltage set at the value shown in Table XIII for the unit to be tested. Pickup of the unit should then be checked with the current displaced 30° from the maximum torque position in both the lead and lag direction.

TABLE XIII

UNIT	φ-ANGLE METER READING: ANGLE OF MAXIMUM TORQUE	φ-ANGLE METER READING: TEST ANGLES	V_{17-18} SET AT	PICKUP AMPS
M_1	300°	330°-270°	45V	16.5-18.2
M_2	300°	330°-270°	60	16.5-18.2
OM_3	285°	315°-255°	90	16.5-18.2

In checking the M_1 unit, the following procedure would be used. First, set the phase shifter so that the phase angle meter reads 300°. Note that while the phase angle is being set, the current should be at 5 amperes and the voltage on studs 17-18 should be increased temporarily to 120 volts. With voltage again at the value shown in Table XIII, increase the current slowly until the M_1 unit picks up. The pickup current should be within the limits shown in the table. Now reset the phase angle at 270° and again check the current required to pick up the M_1 unit. This should fall within the same limits as for the 330° check.

Note that the two angles used in the previous check, i.e. 330° and 270°, are 30° away from the angle of maximum torque. An examination of the mho unit impedance characteristic in Figure 6 shows that the ohmic reach of the unit should be the same at both 330° and 270° and should be 0.866 times the reach at the angle of maximum torque.

The angle of maximum torque of the M_2 and OM_3 units can be checked in a similar manner. The OM_3 unit should be set for **zero offset** while the angle of maximum torque is being checked.

Electrical Tests - Target Seal-In

The target seal-in unit has an operating coil tapped at 0.6 or 2.0 amperes. The relay is shipped from the factory with the tap screw in the 0.6 ampere position. The operating point of the seal-in unit can be checked by connecting from a DC source (+) to stud 11 of the relay and from stud 1 through an adjustable resistor and ammeter back to (-). Connect a jumper from stud 15 to stud 1 also, so that the seal-in contact will protect the M_1 unit contact. Then close the M_1 contact by hand and increase the DC current until the seal-in unit operates. It should pick up at tap value or slightly lower. Do not attempt to interrupt the DC current by means of the M_1 contact.

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 Figure 29.

Connections

The internal connections of the GCY51A relay are shown in Figure 21. An elementary diagram of typical external connections is shown in Figure 3.

Note on the internal connection diagram (Figure 21) that the mho unit restraint circuits are connected to terminals 17-18, and the polarizing circuits to 19-20, with internal jumper leads between 17-19 and 18-20. On some installations it may be desirable to separate the restraint and polarizing circuits, either because of application considerations or to achieve better accuracy in testing. This can be accomplished by removing the internal jumpers and making the necessary external connections to 17-18 and 19-20.

Visual Inspection

Remove the relay from its case and check that there are no broken or cracked component parts and that all screws are tight.

Mechanical Inspection

Recheck the six adjustments mentioned under Mechanical Inspection in the section on **ACCEPTANCE TESTS.**

Portable Test Equipment

To eliminate the errors that may result from instrument inaccuracies, and to permit testing the mho units from a single-phase A-C test source, the test circuit shown in schematic form in Figure 23 is recommended. In this figure $R_S + jX_S$ is the source impedance, S_F is the fault switch, and $R_L + jX_L$ is the impedance of the line section for which the relay is being tested. The autotransformer, T_A, which is across the fault switch and line impedance, is tapped in 10% and 1% steps so that the line impedance $R_L + jX_L$ may be made to appear to the relay very similar to the actual line on which the relay is to be used. This is necessary since it is not feasible to provide the portable test reactor, X_L, and the test resistor with enough taps to permit matching every possible line.

For convenience in field testing, the fault switch and tapped autotransformer of Figure 23 have been arranged in a portable test box, Cat. No. 102L201, which is particularly adapted for testing directional and distance relays. The box is provided with terminals to which the relay current and potential circuits as well as the line and source impedances may be readily connected. For a complete description of the test box, the user is referred to GEI-38977.

Electrical Tests on the Mho Units

The manner in which reach settings are made for the mho units is briefly discussed in the **CALCULATION OF SETTINGS** section. Examples of calculations for typical settings are given in that section. It is the purpose of the electrical tests in this section to check the ohmic pickup of the M_1, M_2 and OM_3 units at the settings that have been made for a particular line section.

To check the calibration of the mho units, it is suggested that the portable test box, Cat. No. 102L201; portable test reactor, Cat. No. 6054975; and test resistor, Cat. No. 6158546 be arranged with Type XLA test plugs according to Figure 24. These connections of the test box and other equipment are similar to the schematic connections shown in Figure 23, except that the Type XLA test plug connections are now included.

Use of the source impedance, $R_S + jX_S$, simulating the conditions that would be encountered in practice, is necessary only if the relay is to be tested for overreach or contact coordination, tests that are not normally considered necessary at the time of installation or during periodic testing. Some impedance will usually be necessary in the source connection to limit current in the fault circuit to a reasonable value, expecially when a unit with short-reach setting is to be checked, and it is suggested that a reactor of suitable value be used for this purpose since this will tend to limit harmonics in the fault current.

Since the reactance of the test reactor may be very accurately determined from its calibration curve, it is desirable to check mho unit pickup with the fault reactor alone, due account being taken of the angular difference between the line reactance, X_L, and mho unit angle of maximum reach. The line reactance (X_L) selected should be the test reactor tap nearest above twice the mho unit phase-to-neutral reach, with account being taken of the difference in angle of the test reactor tap impedance and the unit angle of maximum reach.

Explanation of the "twice" factor is as follows: The relay as normally connected (V_{1-2} potential and I_1-I_2 current) measures positive sequence phase-to-neutral impedance. For a phase-to-phase fault, the fault current is forced by the phase-to-phase voltage through the impedance of each of the involved phases. In the test circuit the line impedance, Z_L, is in effect the sum of the impedance of each of the phase conductors and must be so arranged in order to be equivalent to the actual fault condition. Since the impedance of each phase must be used to make up the line impedance in the test circuit, its value will be twice that of the phase-to-neutral mho unit reach.

From Figure 25 it is seen that twice the unit reach (i.e. 2Z relay) at the angle of the test reactor impedance is:

$$2Z_{Relay} = \frac{2\ ZMin}{M\ Tap} \cos(\phi-\theta) \qquad (7)$$

where:

Z_{min} = Basic minimum reach of M_1, M_2, or OM_3 unit.
ϕ = Angle of test reactor impedance.
θ = Mho Unit Angle of maximum reach.
M Tap = Tap Setting of M_1, M_2, or OM_3.

The test-box autotransformer percent tap for nominal mho unit pickup is then given by the equation:

$$\%\ Tap = \frac{2Z_{Relay}}{Z_L}(100)$$

> NOTE: **Before** proceding with the checks of the M_1, M_2 and OM_3 operating points the relay should be allowed to **warm up** for about **15 minutes** with potential circuit **alone** (studs 17-18) energized at rated voltage and with tap leads all set for 100%. Then change the tap leads to the percent settings determined for the application, and proceed at once with the tests.

Example of M_1 Test

As an illustration of the above, the example in the section on **CALCULATION OF SETTINGS** will be used. In this example the desired reach of the M_1 unit was 2.25 ohms at the line angle of 80°. To obtain this reach it was calculated that the M_1 unit basic minimum reach should be 1.5 ohms, determined by the setting of the two tap screws in the tap block on the front of the lower unit, and that the M_1 restraint tap leads should be in the 63% position. This is accomplished by connecting the lower M_1 tap lead to the 60% position and the upper M_1 tap lead to the 3% position. The angle of maximum torque was 60°, which is the normal factory setting.

In determining the test reactor tap setting to use in checking this M_1 setting, it can be assumed as an approximation that the angle, ϕ, of the test reactor impedance is 80°. Based on this assumption, twice the reach of the M_1 unit at the assumed angle of the test reactor will be:

$$2Z_{Relay} = 2\,\frac{1.5 \times 100}{63}\cos(80-60) \qquad (8)$$

$$= 4.48 \text{ ohms}$$

Therefore, the 6-ohm tap of the test reactor should be used. Twice the relay reach at the angle of test reactor impedance should be recalculated, using the actual angle of the reactor tap impedance rather than the assumed 80°. Table XIV shows the angles for each of the reactor taps.

TABLE XIV

TAP	ANGLE	COS (ϕ-60)
24	88	0.883
12	87	0.891
6	86	0.899
3	85	0.906
2	83	0.921
1	81	0.934
0.5	78	0.951

From the table it is seen that the angle of the impedance of the 6 ohm tap is 86°. Therefore, twice the M_1 unit reach at the actual angle of the test reactor is:

$$2Z_{Relay} = 2\,\frac{1.5 \times 100}{63}\cos(86-60) \qquad (9)$$

$$= 4.29 \text{ ohms}$$

The calibration curve for the particular portable test reactor in use should be referred to, in order to determine exact reactance of the 6 ohm tap at the current level being used. For the purpose of this illustration, assume that the reactance is 6.15 ohms. Since the angle of the impedance of the 6 ohm tap is 86°, the impedance of this tap may be calculated as follows:

$$Z_L = X_L / \cos 4^{\circ} = \frac{6.15}{.9976}$$

$$= 6.18 \text{ ohms}$$

From this calculation it is seen that the reactance and the impedance may be assumed to be the same for this particular reactor tap. Actually, the difference need only be taken into account on the reactor 3, 2, 1, and 0.5 ohm taps.

The test-box autotransformer tap setting that is required to close the mho unit contact with the fault switch closed can now be determined as follows:

$$\%\ Tap = \frac{4.29}{6.18}(100) = 69.4\%$$

Thus theorectically the M_1 unit contact should remain open with a test-box tap setting of 70%, and close at 69%. This of course assumes that twice the M_1 unit reach at the test reactor angle is exactly 4.29 ohms. At the 1.5 ohm basic minimum reach setting the M_1 unit reach should check within $\pm$ 3% of the value indicated by the tap setting. So if the close-open points fall within a range of 67% to 72% test box tap setting, the M_1 unit is within factory tolerance. Note that if the 0.75 or 3 ohm basic minimum reach setting were used, the M_1 unit reach should check within $\pm$ 4%.

Although the M_1 unit reach is within factory tolerance, it may be desirable to obtain an operating point closer to the calculated reach as indicated by the above equation. This can be accomplished by changing the upper M_1 tap lead in 1% steps until the unit operates at the test box percent tap indicated in the above equation. If the M_1 operating point is outside factory tolerance, refer to the section on SERVICING.

If the ohmic pickup of the M_1 unit checks correctly according to the above, the chances are that the angle of the characteristic is correct. The angle may, however, be very easily checked by using the calibrated test resistor in combination with various reactor taps. The calibrated test resistor taps are pre-set in such a manner that when used with 12 and 6 ohm taps of the specified test reactor, impedance at 60^o and 30^o respectively will be available for checking the mho-unit ohmic reach at the 60^o and 30^o positions. The mho unit ohmic reach at the 0^o position may be checked by using the calibrated test resistor alone as the line impedance. The calibrated test resistor is supplied with a data sheet that gives the exact impedance and angle for each of the combinations available. The test-box autotransformer percent tap for pickup at a particular angle is given by:

$$\% \text{ Tap} = \frac{2\ (1.5)\ \cos\ (\theta - \phi)}{(\text{M Tap } \%)\ Z_L}\ (100) \qquad (10)$$

where:

θ = Angle of maximum torque of mho unit (60^o in example).
ϕ = Angle of test impedance Z_L.
Z_L = The 60^o, 30^o, or 0^o impedance value from calibrated test resistor data sheet.
M = Mho Unit restraint tap setting.

As in the previous tests, the source impedance should be readjusted in each instance to maintain approximately the same fault current level for each check point.

When checking the angle of maximum reach of the M_1 unit as indicated above, there are two factors to keep in mind that affect the acuracy of the results. First, when checking the unit at angles of more than 30^o off the maximum reach position, the error becomes relatively large with phase angle error. This is apparent from Figure 25 where it is seen, for example at the 0^o position, that a 2^o or 3^o error in phase angle will cause a considerable apparent error in reach. Secondly, the effect of the control spring should be considered since the mho unit can only have a perfectly circular characteristic when the control spring torque is negligible. For any normal level of polarizing voltages, the control spring may be neglected, but in testing the unit as indicated above it may be necessary to reduce the test-box autotransformer tap setting to a point where the voltage supplied to the unit may be relatively low. This reduces the torque level since the polarizing as well as the restraint voltage will be low, with the result that the control spring torque will no longer be negligible and the reach of the M_1 unit will be somewhat reduced.

The internal connections of the GCY51 relays (see Figure 21) are arranged so that the inaccuracies introducted by low polarizing voltage under test conditions can be avoided. This can be accomplished by removing the internal jumpers between terminals 17-19 and 18-20, and making these jumper connections externally for the test. The restraint and polarizing circuits can then be energized separately as shown by the optional test connections if Figures 23 and 24. Be sure to restore the internal jumpers after the test is completed, unless the restraint and polarizing circuits are to be supplied separately on the installation.

In order to see the effect of the errors mentioned above in their true proportion it is suggested that the reach characteristic, determined by test, be plotted on an R-X impedance diagram as typified by Figure 6. It is obvious that the apparent errors in reach, resulting from phase angle error at angles well off the maximum reach position, occur in a region where the fault impedance vector will not lie.

M_2 Tests

The reach setting and angle of maximum torque of the M_2 unit can be checked in the same manner as the M_1 unit, using the connections of Figure 24 and the explanation in the preceding sections. When using equations (7), (8), and (9) in determining twice the M_2 unit reach at the test reactor angle, and equation (10) in determining the test-box percent tap setting, be sure to use the proper value of the M_2 unit basic minimum reach, as selected by the link settings on the rear of the middle element. If the 2 ohm basic minimum reach setting is used, with angle of maximum torque at 60^o, the operating point of the unit should be within $\pm$ 3% of the calculated test-box setting. If the 1 ohm or 3 ohm basic minimum reach setting is used, a $\pm$ 4% tolerance can be expected.

The links used in selecting the basic minimum reach of the M_2 unit (see Figure 2 and the internal connections, Figure 21) are on a two-section terminal block on the rear of the middle unit. Each section includes two links, labeled A and B, that determine the tap setting of the two current coils of the M_2 unit. Table XV shows the link settings for the 1, 2, or 3 ohm basic minimum reach. Both sets of links should always be set in the same postion.

TABLE XV

BASIC MIN. REACH (Φ-N OHMS)	A LINKS TO	B LINKS TO
1.0	1	0
2.0	0	2
3.0	1	2

In the example in the **CALCULATION OF SETTINGS** section, the M_2 angle of maximum torque was set at 75°. Therefore, in equations (8), (9), and (10) the angle θ will be 75°. At this angle the basic minimum reach will be approximately 1.2 times the reach at the 60° angle of maximum torque. (see Table II in the section of RATINGS). This figure should be used as Z_{min} in equations (8), (9), or (10). The operating point with the 75° setting should be within ± 6% of the calculated test box setting.

OM_3 Tests

The forward reach and angle of maximum torque of the OM_3 unit can be checked by means of the connections in Figure 24, following the explanation and equations in the preceding paragraphs covering the M_1 unit tests. Note that the angle of maximum torque (θ) is 75° and the basic minimum reach (Z_{min}) is 3 ohms when using equations (7), (8), (9), and (10). Note that the forward reach, measured from the origin on the R-X diagram, will be the same whether or not the unit is connected for offset. (See section on **CHARACTERISTICS** - OM_3 Unit, and Figure 12).

If the unit is to be applied with offset it can be checked as follows, using Type XLA test plugs and the connections if Figure 26. With the potential circuit deenergized and shorted, increase the current slowly in the OM_3 operating circuit until the left hand contact just closes. This should occur between 1.5 and 2 amperes for the 100% restraint setting (see Figure 14).

Electrical Tests - Seal-in Unit

Check that the target seal-in unit is operating at tap value. This can be done by arranging a series circuit from +125 VDC to stud 11 of the relay, and from stud 1 through a loading resistor that will draw a DC current approximately equal to the target seal-in tap setting, and from the loading resistor back to negative. If the M_1 unit contact is closed by hand, the target seal-in unit should operate. As a precautionary measure a jumper should be connected between studs 1 and 16 so that the seal-in contacts will protect the M_1 contact.

If it is necessary to change the tap setting of the target seal-in unit from 0.6 to 2 amps, or vice-versa, observe the following procedure. Assuming the tap is being changed for 0.6 to 2A, remove one of the screws from the left-hand contact strip and insert it into the 2A position in the right-hand strip, being sure that it is securely tightened. Then remove the screw from the 0.6A position and insert it in the vacant hole in the left-hand strip. This procedure ensures that the contact adjustment of the unit will not be disturbed while the tap setting is being changed.

Overall Tests

An overall check of current transformer polarities, and connections to the relay, can be made on the complete installation by means of the test connections and tabulation in Figure 27. A check of the phase angle meter readings shown in the table for power factor angle and phase sequence involved will indicate whether the relay is receiving the correct voltage and currents for the conventional connections shown in Figure 3.

Remove the lower test plug from the relay, disconnecting the current circuits, and replace the upper test plug with the connection plug. The M_1, M_2, and OM_3 (if connected for forward reach) units should develop strong torque to the right with normal voltage on the relay. Now insert the lower plug and open the M_1, M_2, and OM_3 taps on the main tap block. If the direction of power and reactive flow is away from the bus and into the protected line section, the M_1, M_2 and OM_3 (if connected for forward reach) units should operate. If the reactive power flow is into the station bus, the resulting phase angle may be such that the units will not operate.

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 fine silver 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 thoroughly and rapidly. Its flexibility ensures the cleaning of the actual points of contact. Do not use knives, files, abrasive paper or cloth of any kind to clean relay contacts.

SERVICING

If it is found during installation or periodic tests that M_1, M_2, or OM_3 unit calibrations are out of limits, they should be recalibrated as outlined in the following paragraphs. It is suggested that these calibrations be made in the laboratory. The circuit components listed below, which are normally considered to be factory adjustments, are used in recalibrating the units. These parts may be physically located from Figures 1 and 2. Their locations in the relay circuit are shown in the internal connection diagram of Figure 21.

R_{11} - M_1 unit reach adjustment
X_{11} - M_1 unit phase angle adjustment
R_{12} - M_2 unit reach adjustment
R_{22} - M_2 unit phase angle adjustment
R_{13} - OM_3 unit reach adjustment
R_{23} - OM_3 unit phase angle adjustment

> NOTE: **Before** making pickup or phase angle adjustments on the mho units, the unit should be allowed to **heat up** for approximately 15 minutes energized with **rated voltage alone** and with the restraint tap leads (M_1, M_2, and OM_3) set for 100%. Also it is important that the relay be mounted in an upright position so that the units are level.

Control Spring Adjustments

Make connections to the relay as shown in Figure 22 and set the tap leads for the unit to be adjusted (M_1, M_2, and OM_3) on 100%. The M_1 tap screws and M_2 links should be in the position for the basic minimum reach shown in Table XVI and the OM_3 unit should be set for zero offset. Make sure that the relay is in an upright position so the units are level. With the current set at 5 amperes and the voltage across studs 17-18 at 120 volts, set the phase shifter so that the phase angle meter reads the value shown in Table XVI for the unit being tested.

TABLE XVI

UNIT	BASIC MIN. REACH (ϕ-N OHMS)	ϕ ANGLE METER READS	TEST VOLTAGE	SET VALUE OF CURRENT
M_1	1.5	300°	1.5	2.75
M_2	2	300°	1.5	2.5
OM_3	3	285°	4	1.4

Now reduce the voltage to the test voltage value and set the current at the value shown in Table XVI for the unit being adjusted. Insert the blade of a thin screwdriver into one of the slots in the edge of the spring-adjusting ring (see Figure 28) and turn the ring until the contacts of the unit just close. If the contacts were closing below the set point shown in Table XVI, the adjusting ring should be turned to the right. If they were closing above the set point, the adjusting ring should be turned to the left.

Ohmic Reach Adjustment

The basic minimum reach of the M_1, M_2, or OM_3 units can be adjusted by means of rheostats that are accessible from the front of the relay. Connect the relay as shown in Figure 22, leave the M_1 M_2, and OM_3 tap leads at 100%, and be sure that the basic minimum reach taps for M_1 and M_2 are in the position shown in Table XVII. With current at 5 amperes and voltage at 120V, set the phase shifter so that the phase angle meter reads the angle shown in the table for the unit to be checked. Now reduce the voltage on studs 17-18 to the set value shown in Table XVII and adjust the appropriate rheostat so that the unit picks up at 15 amperes within ± 2%.

TABLE XVII

UNIT	BASIC MIN. REACH (ϕ-N OHMS)	ϕ ANGLE METER READS	V_{17-18} SET AT	PICKUP AMPS	ADJUST-MENT
M_1	1.5	300°	45V	15	R_{11}
M_2	2	300°	60	15	R_{12}
OM_3	3	285°	90	15	R_{13}

Angle of Maximum Torque

The angle of maximum torque of the mho units can be adjusted by means of a reactor (M_1) or rheostats (M_2 and OM_3) accessible from the front of the relay. Use the connections in Figure 22, leave the M_1, M_2, and OM_3 tap leads at 100%, and be sure that the basic minimum reach selection taps for M_1 and M_2 are in the position shown in Table XVIII.

TABLE XVIII

UNIT	BASIC MIN. REACH (ϕ-N OHMS)	ϕ-ANGLE METER READINGS: ANGLE OF MAX. TORQUE	ϕ-ANGLE METER READINGS: TEST ANGLES	V_{17-18} SET AT	PICKUP AMPS	ADJUSTMENT
M_1	1.5	300°	330° & 270°	45V	17.3	X_{11}
M_2	2	300°	330° & 270°	60	17.3	R_{22}
OM_3	3	285°	315° & 255°	90	17.3	R_{23}

The procedure used in setting the angle of maximum torque is to adjust the reactor (M_1) or rheostat (M_2 and OM_3) so that the pickup amperes, at a specified set voltage on studs 17-18, will be the same at angles leading and lagging the maximum torque angle by 30°. The test angles, set voltages, and pickup amperes are shown in Table XVIII. For example if the M_1 unit is to be adjusted the following procedure would be used. First, the reach of the unit at its angle of maximum torque should be checked and adjusted if necessary as described in Ohmic Reach Adjustment in this section and Table XVII. Next set the phase shifter so that the phase angle meter reads 330° (Note that phase angle adjustments should be made at 120 volts and 5 amperes). Then set V_{17-18} at 45 volts and adjust X_{11} so that the M_1 unit closes its contacts at 17.3 amperes ± 2%. The pickup should then be checked at 270° with the same set voltage and should be 17.3 amperes ± 2%. Refine the adjustments of X_{11} until the pickup is within limits at both 270° and 330°.

Note that an adjustment of the angle of maximum torque will have a secondary effect on the reach of the unit, and vice-versa. Therefore, to be sure of accurate settings it is necessary to recheck the reach of a unit whenever its angle of maximum torque setting is changed, and to continue a "cross" adjustment routine of reach and angle of maximum torque until **both** are within the limits specified above.

As noted in Table II under the section on **RATINGS**, the angle of maximum torque of the M_1 and M_2 units can be adjusted up to 75°, if desired. If this change is made, the reach of the M_1 unit will increase only slightly, but the M_2 unit reach will increase to about 1.2 times its value at the 60° angle. To make this adjustment, refer to Table XIX and proceed as follows:

TABLE XIX

UNIT	BASIC MIN. REACH AT 75° (ϕ-N OHMS)	ϕ-ANGLE METER READINGS ANGLE OF MAX. TORQUE	TEST ANGLES	V_{17-18} SET AT	PICKUP AMPS	ADJUSTMENT
M_1	1.5	285°	315° & 255°	45V	17.3	X_{11}
M_2	2.4	285°	315° & 255°	60	14.4	R_{22}

Since the values in Table XIX for basic minimum reach at 75° will not be exact unless refinements in the reach adjustment are made, a tolerance of ± 4% should be allowed when checking pickup amperes at the 30° leading and lagging positions.

For example, if the M_2 unit is to be reset for a 75° angle of maximum torque, set the phase shifter so the phase angle meter reads 315°. Then with V_{17-18} at 60 volts, adjust R_{22} until the unit picks up at 14.4 amperes ± 4%. Then reset the phase shifter for a 255° phase angle meter reading and check that the pickup amperes are within the same limits.

If desired, the reach at 75° can now be checked by setting the phase shifter so the phase angle meter reads 285° and checking pickup current with 60 volts on studs 17-18. The unit should pick up between 11.5 and 13.5 amperes. If desired, the reach adjustment (R_{12}) can be refined to obtain a pickup current closer to the 12.5 ampere nominal value. If this is done, the 75° angle of maximum torque should be rechecked.

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, give the name of the part wanted, and complete nameplate data. If possible, give the General Electric requisition number on which the relay was furnished.

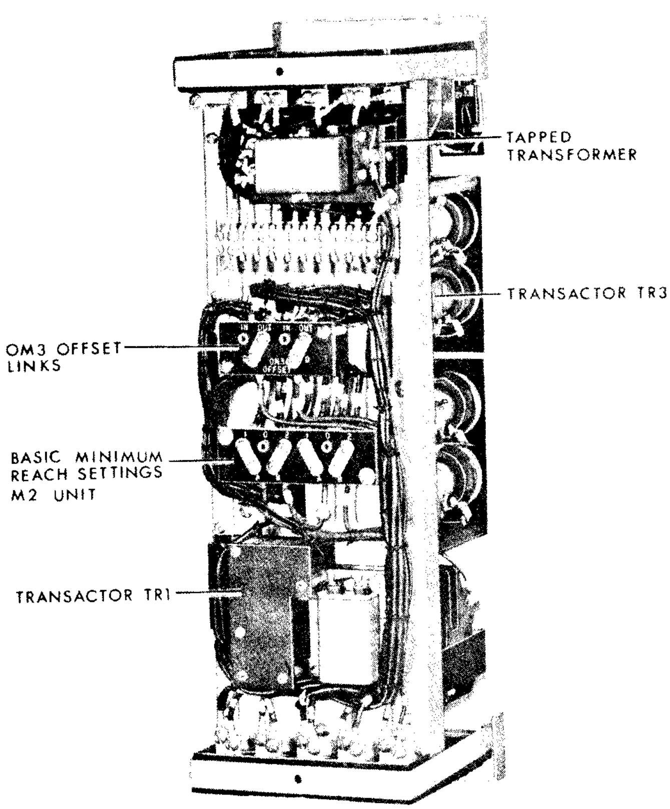


Figure 1 (8035286) Type GCY51A relay removed from case (front view)

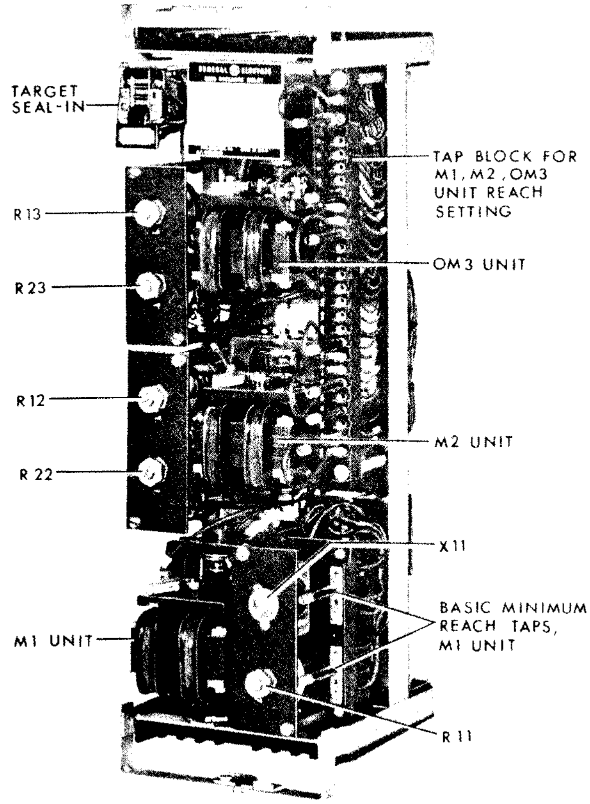


Figure 2 (8035293) Type GCY51A relay removed from case (rear view)

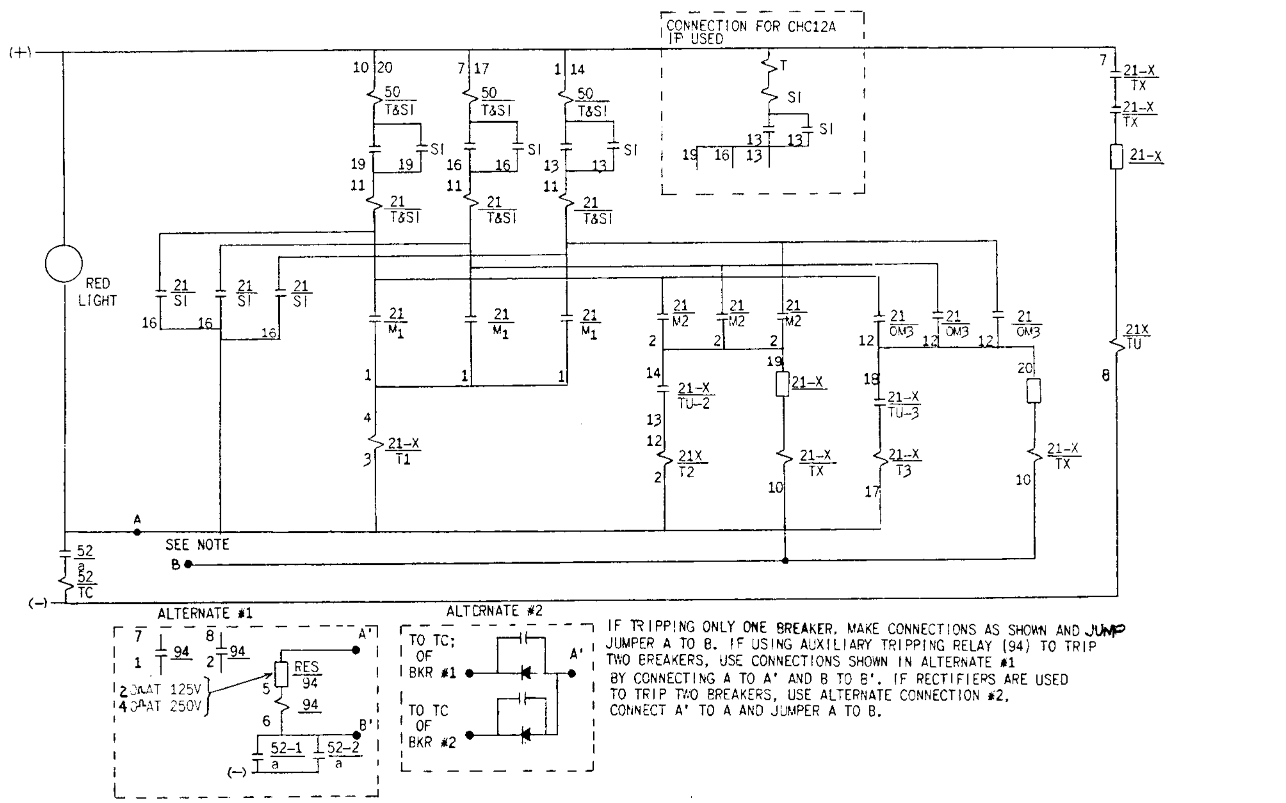
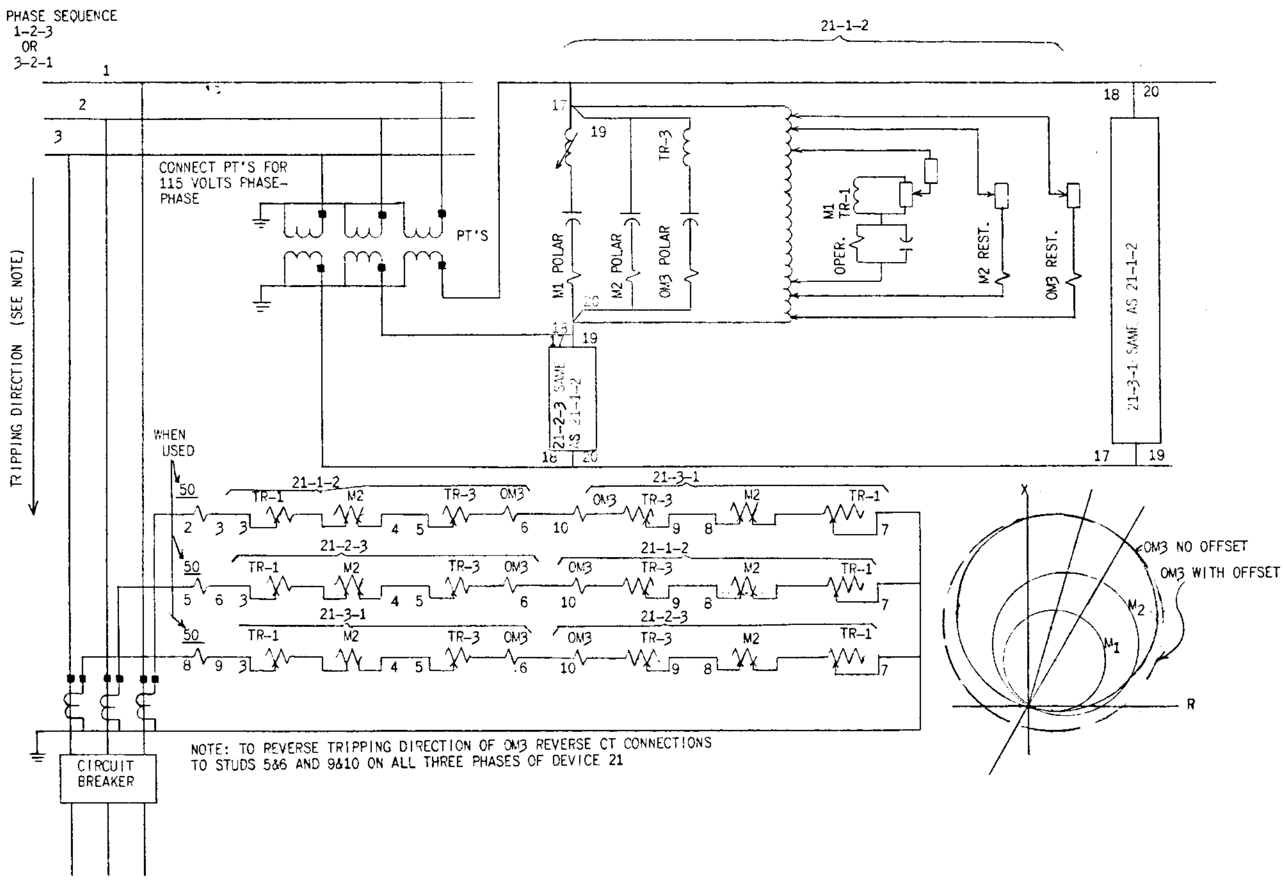


Figure 3 (0116B9303-2) Typical external connection diagram showing three-step distance protection of a transmission line using three GCY51A relays and one RPM timer (more)



LEGEND			
DEVICE NO.	DEVICE TYPE	INC. ELEM.	DESCRIPTION
21	GCY		MHO TYPE STEP DISTANCE RELAY
		M1	1ST ZONE MHO UNIT
		M2	2ND ZONE MHO UNIT
		OM3	3RD ZONE MHO UNIT
		TR-1	TRANSACTOR INPUT TO M1
		TR-3	TRANSACTOR INPUT TO OM3
		T&SI	TARGET AND SEAL-IN
21X	RPM	T1	ZONE 1 TARGET
		T2	ZONE 2 TARGET
		T3	ZONE 3 TARGET
		TU	TIMING UNIT
		TU-2	FIRST TIMING CONTACT TO CLOSE
		TU-3	SECOND TIMING CONTACT TO CLOSE
		TX	AUXILIARY FOR TIMING ELEMENT
50	PJC		CURRENT FAULT DETECTOR
		T&SI	TARGET AND SEAL-IN
52			CIRCUIT BREAKER
		a	AUXILIARY SWITCH
		TC	TRIP COIL
50	CHC		CURRENT FAULT DETECTOR
94	HGA14AM OR AL		AUXILIARY TRIPPING RELAY

TABULATION OF DEVICES			
TYPE OR DESCRIPTION		INT. CONN.	OUTLINE
GCY51A		0178A7049*	K-6209276
RPM11D & H		0178A7092	K-6209271
PJC31C		K-6375726	K-6209272
CHC12A		0148A3956	K-6209272
TRIP RECTIFIER(10212186-2)	125V.		104A8584
TRIP RECTIFIER(10212186-4)	250V.		104A8584

Figure 3 (continued) (0116B9303-2) Typical external connection diagram showing three-step distance protection of a transmission line using three GCY51A relays and one RPM timer

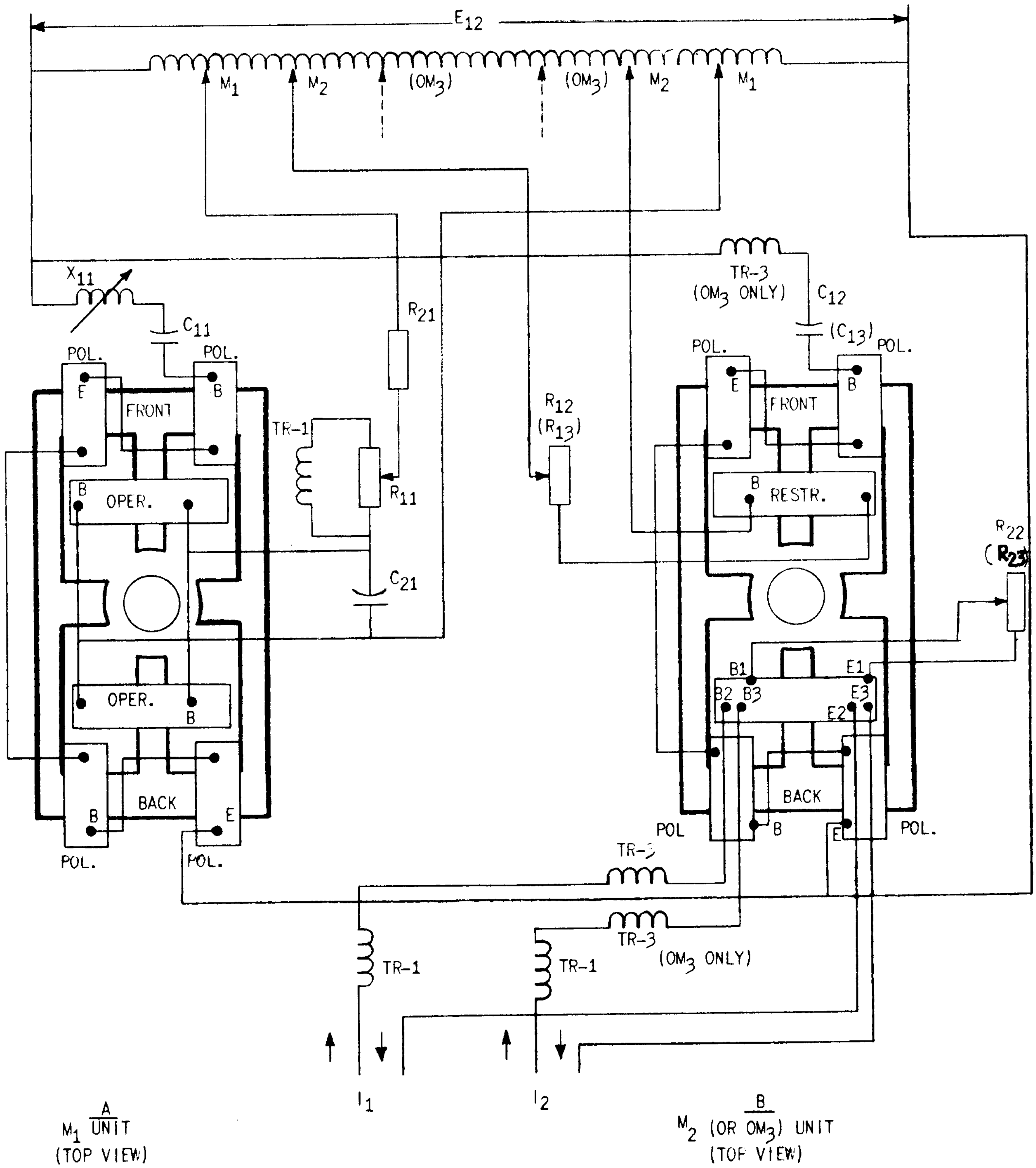


Figure 4 (0116B6891-1) Schematic connections of the M_1, M_2, and OM_3 units in the GCY51A relay

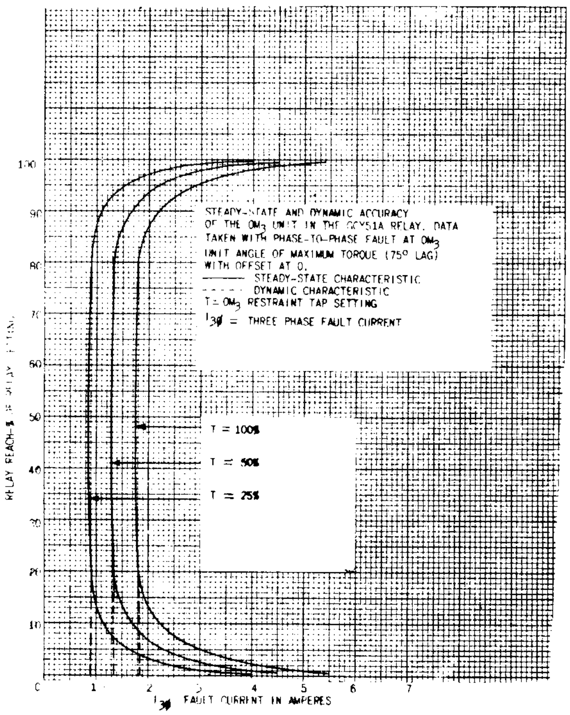


Figure 13 (0178A8178) Steady-state and dynamic reach curves for the OM3 unit with offset at zero

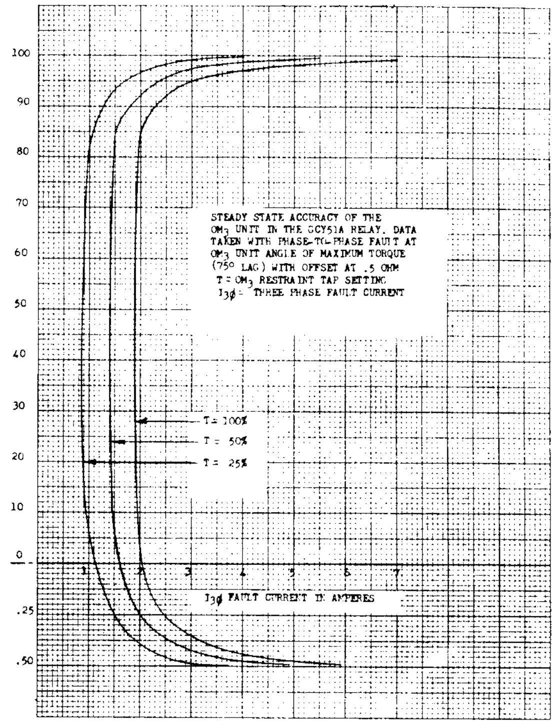


Figure 14 (0178A8179-1) Steady-state reach curves for the OM3 unit with offset at 0.5 ohm

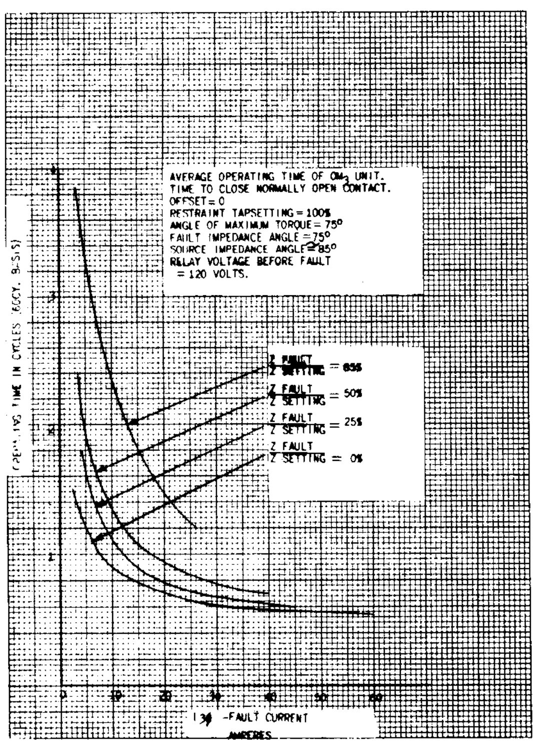


Figure 15 (0178A8180) Operating time curves for the OM3 unit with zero offset showing time to close normally-open contact

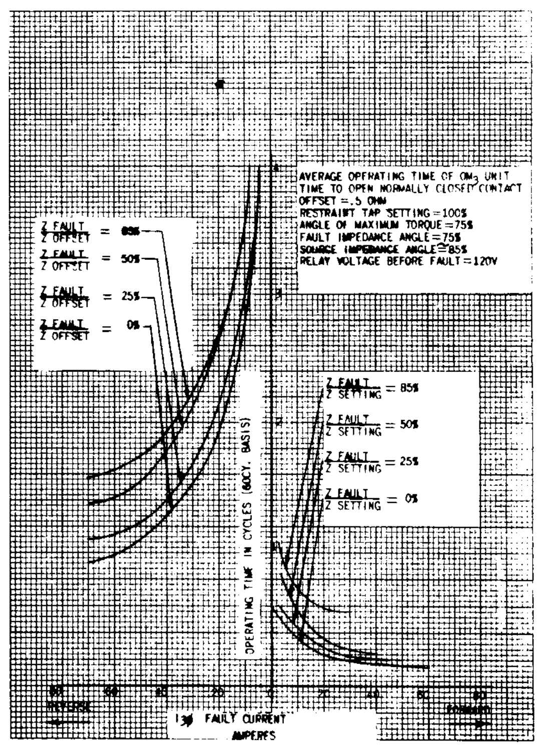


Figure 16 (0178A8181) Operating time curves for the OM3 unit with 0.5 ohm offset showing time to open the normally-closed contact

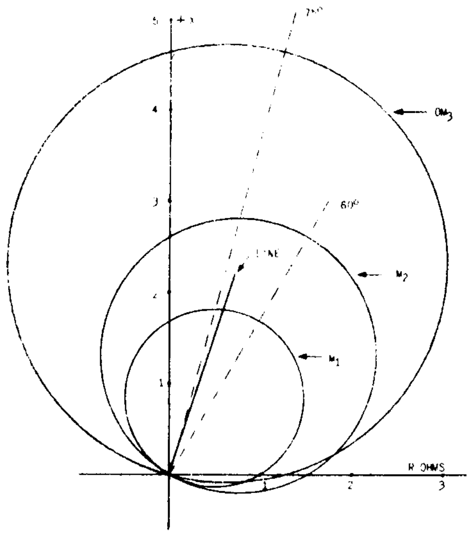


Figure 17 (0178A8182) Impedance characteristics of M_1, M_2, and OM_3 units for a typical step distance application

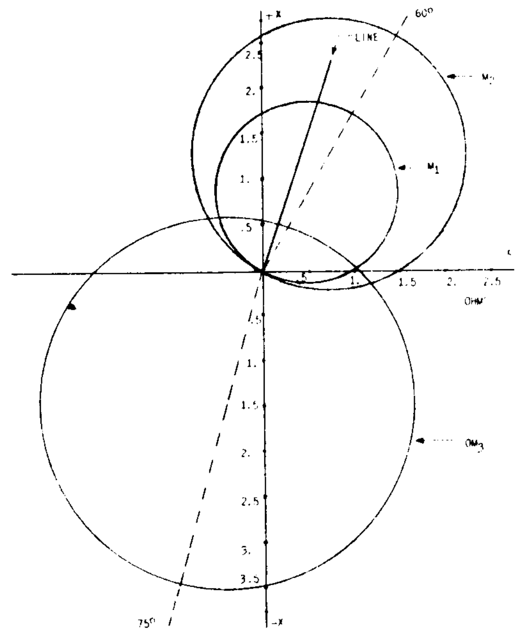


Figure 18 (0178A8183) Impedance characteristics of M_1, M_2, and OM_3 units for a typical directional comparison pilot relaying application

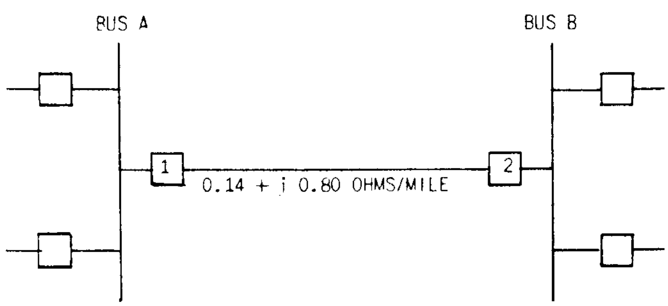


Figure 19 (0178A7169-1) Schematic diagram of typical two-terminal line

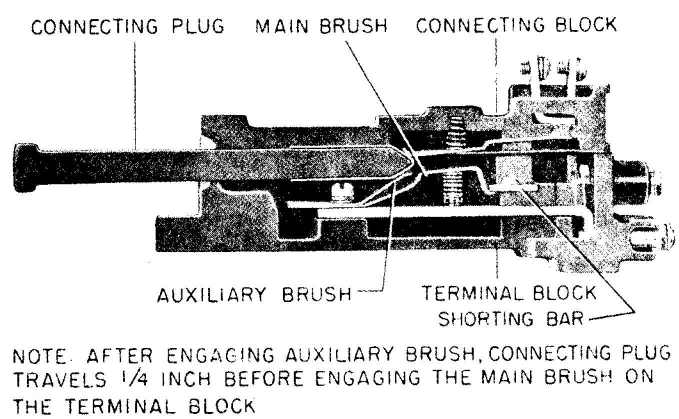


Figure 20 (8025039) Cross section of case and cradle block showing auxiliary brush and shorting bar

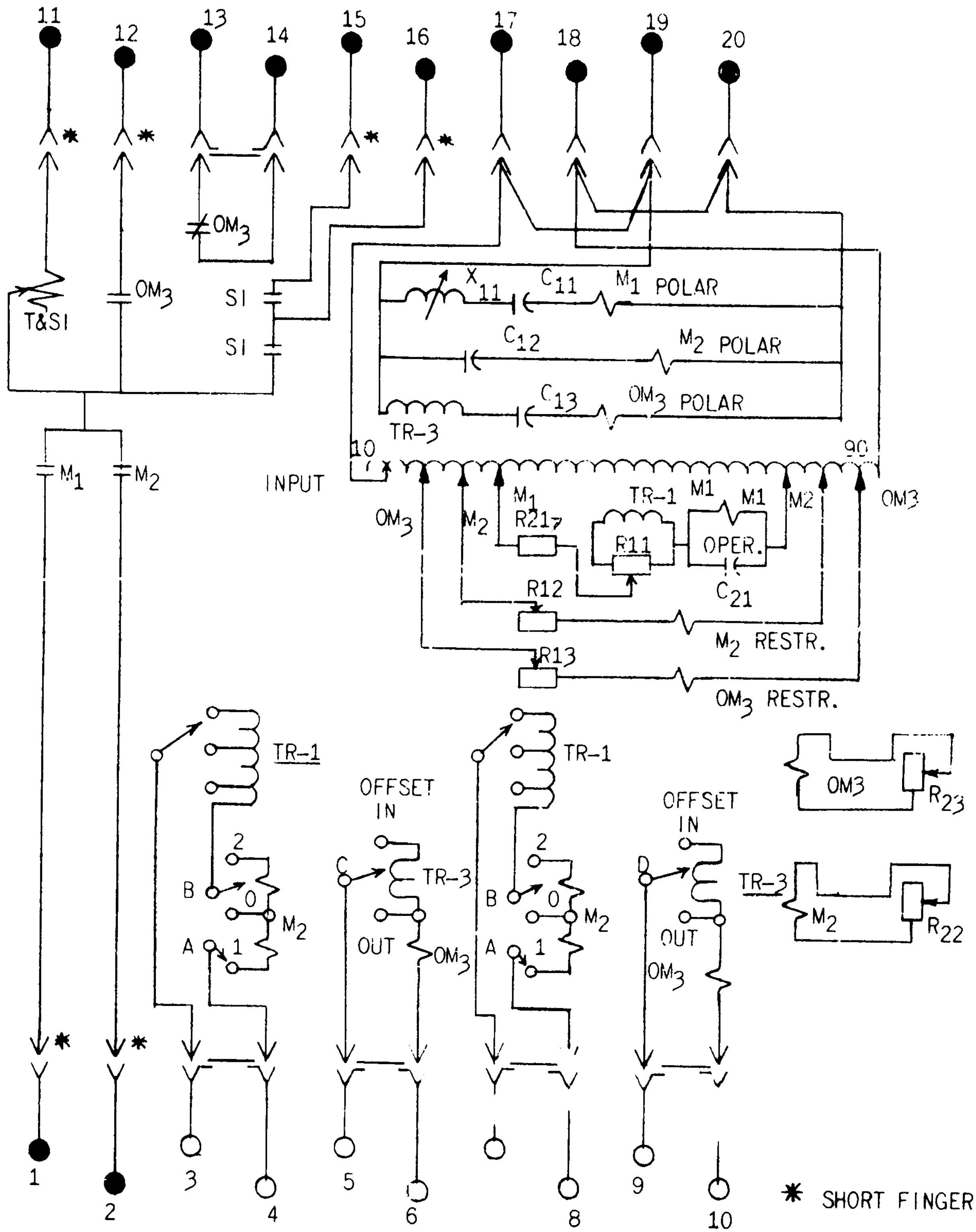
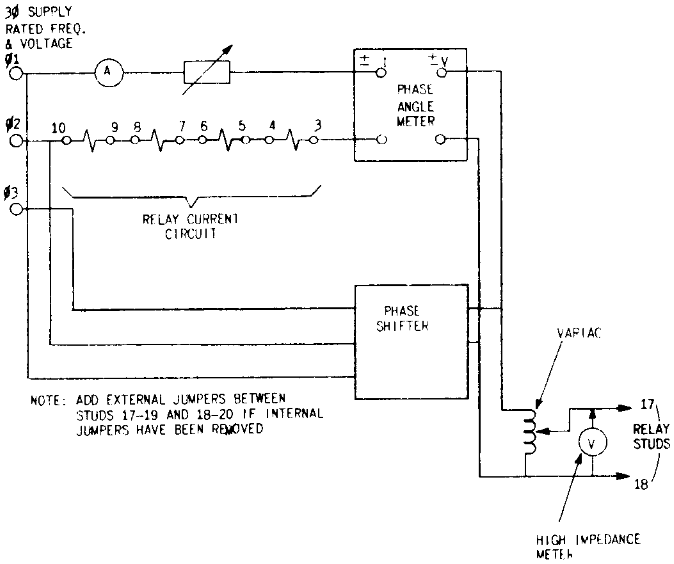
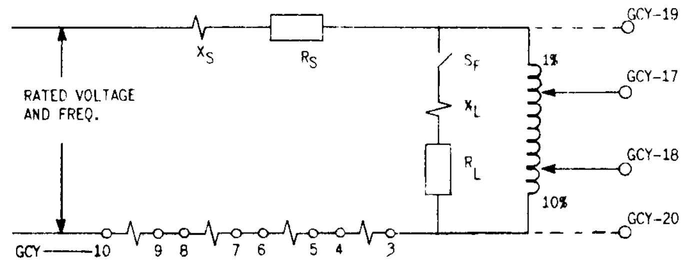


Figure 21 (0178A7049-3) Internal connections (front view) of type GCY51A relay



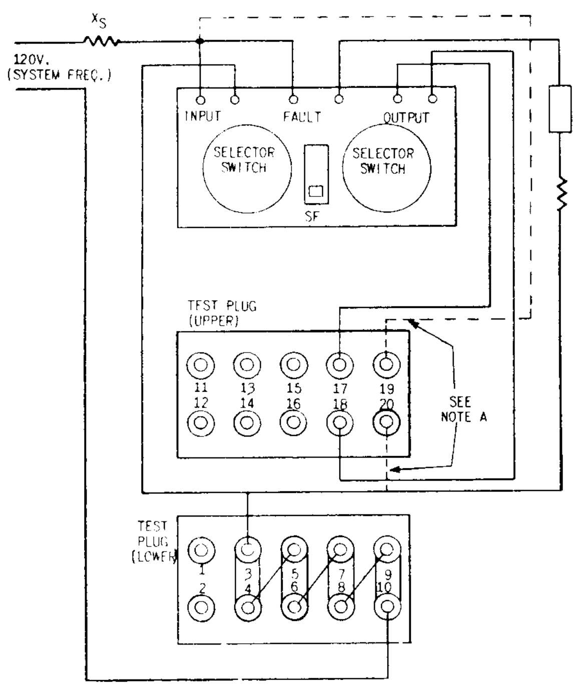
NOTE: ADD EXTERNAL JUMPERS BETWEEN STUDS 17-19 AND 18-20 IF INTERNAL JUMPERS HAVE BEEN REMOVED

Figure 22 (0178A8184) Test circuit for the type GCY51A relay using a phase shifter.



NOTE:
DOTTED LINES SHOW OPTIONAL CONNECTIONS TO SUPPLY POLARIZING CIRCUIT DIRECTLY FROM FAULT VOLTAGE. REMOVE INTERNAL JUMPERS BETWEEN 17-19 AND 18-20 WHEN USING DOTTED CONNECTIONS.

Figure 23 (0178A8185) Schematic diagram of GCY test circuit



NOTE A: DOTTED CONNECTIONS TO STUDS 19-20 SHOW OPTIONAL CONNECTIONS TO SUPPLY POLARIZING CIRCUIT DIRECTLY FROM FAULT VOLTAGE
REMOVE INTERNAL JUMPERS FROM BETWEEN 17-19 & 18-20 WHEN USING OPTIONAL CONNECTIONS.

Figure 24 (0178A8186) Connections for field testing of the type GCY51A relay using type XLA test plugs

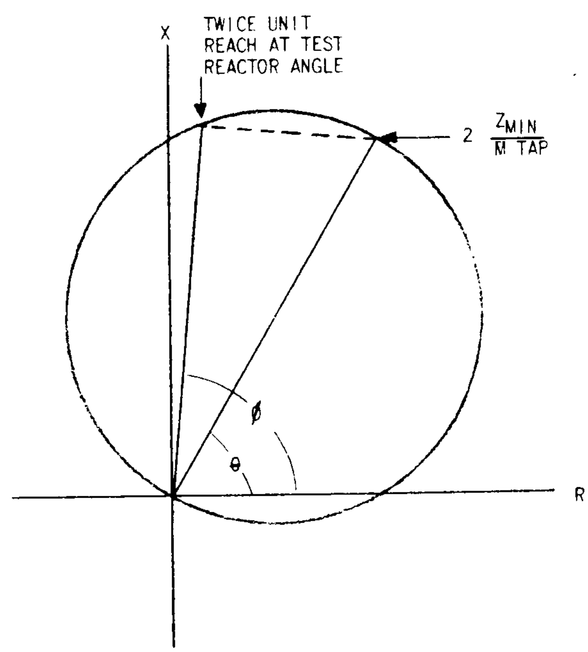


Figure 25 (0178A8187) Reach of mho unit M_1, M_2, or OM_3 at the angle of the test reactor

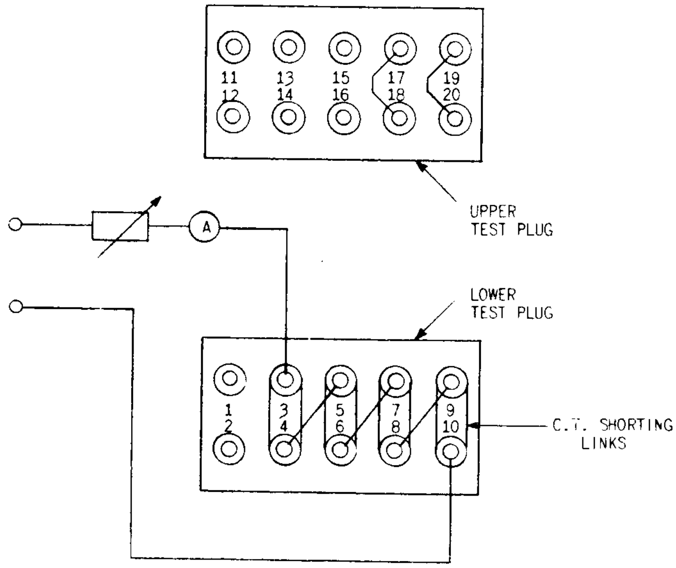
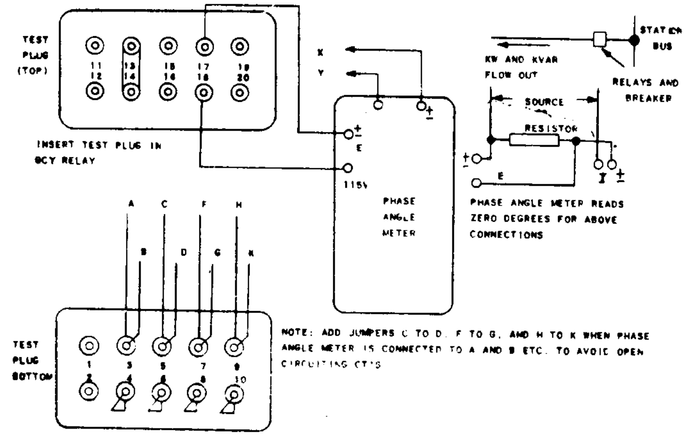


Figure 26 (0178A8188) Connections for checking offset of the OM3 unit



POWER FACTOR ANGLE (DEG. LEAD)		(PROPER READING FOR PHASE SEQUENCE 1-2-3)							
		0-45	45-90	90-135	135-180	180-225	225-270	270-315	315-360
KW AND KVAR DIRECTIONS WITH RESPECT TO THE BUS		KW OUT KVAR IN	KVAR IN KW OUT	KVAR IN KW IN	KW IN KVAR IN	KW IN KVAR OUT	KVAR OUT KW IN	KVAR OUT KW OUT	KW OUT KVAR OUT
RELAY CONNECTIONS	(E) (I) X TO A OR C, Y TO B OR D	330-15	15-60	60-105	105-150	150-195	195-240	240-285	285-330
	(E) (I) X TO F OR H, Y TO G OR K	30-75	75-120	120-165	165-210	210-255	255-300	300-345	345-30
		(PROPER READING FOR PHASE SEQUENCE 1 3 2)							
	(E) (I) X TO A OR C, Y TO B OR D	30-75	75-120	120-165	165-210	210-255	255-300	300-345	345-30
	(E) (I) X TO F OR H, Y TO G OR K	330-15	15-60	60-105	105-150	150-195	195-240	240-285	285-330

THE ABOVE RANGES OF PHASE ANGLE METER READINGS ARE THE ANGLES BY WHICH THE CURRENT LEADS THE VOLTAGE WITH THE DESCRIBED CONDITIONS OF POWER (KW) AND REACTIVE POWER (KVAR) FLOW WITH THE STATION BUS CONSIDERED AS THE REFERENCE IN ALL CASES.

CAUTION: MAKE CORRECTIONS FOR METER ERRORS ON LOW CURRENTS, INHERENT IN SOME PHASE-ANGLE METERS.

Figure 27 (0178A8189) Test connections for overall test of type GCY51A relays

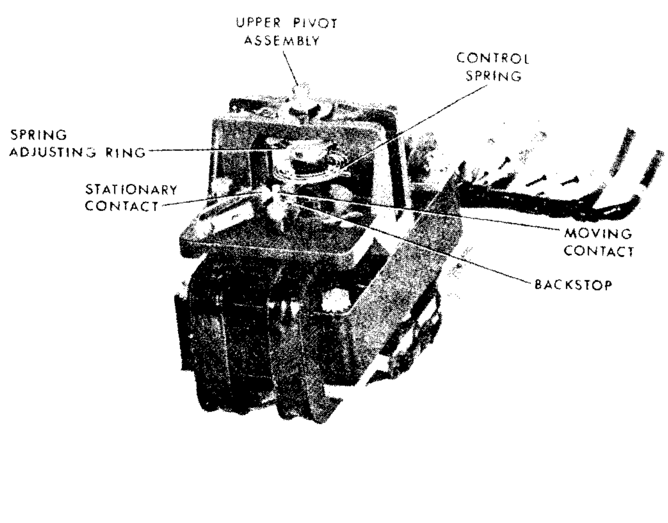


Figure 28 (8034958) Four pole induction cylinder unit typifying construction of the M_1, M_2, and OM_3 units in the GCY51A relay

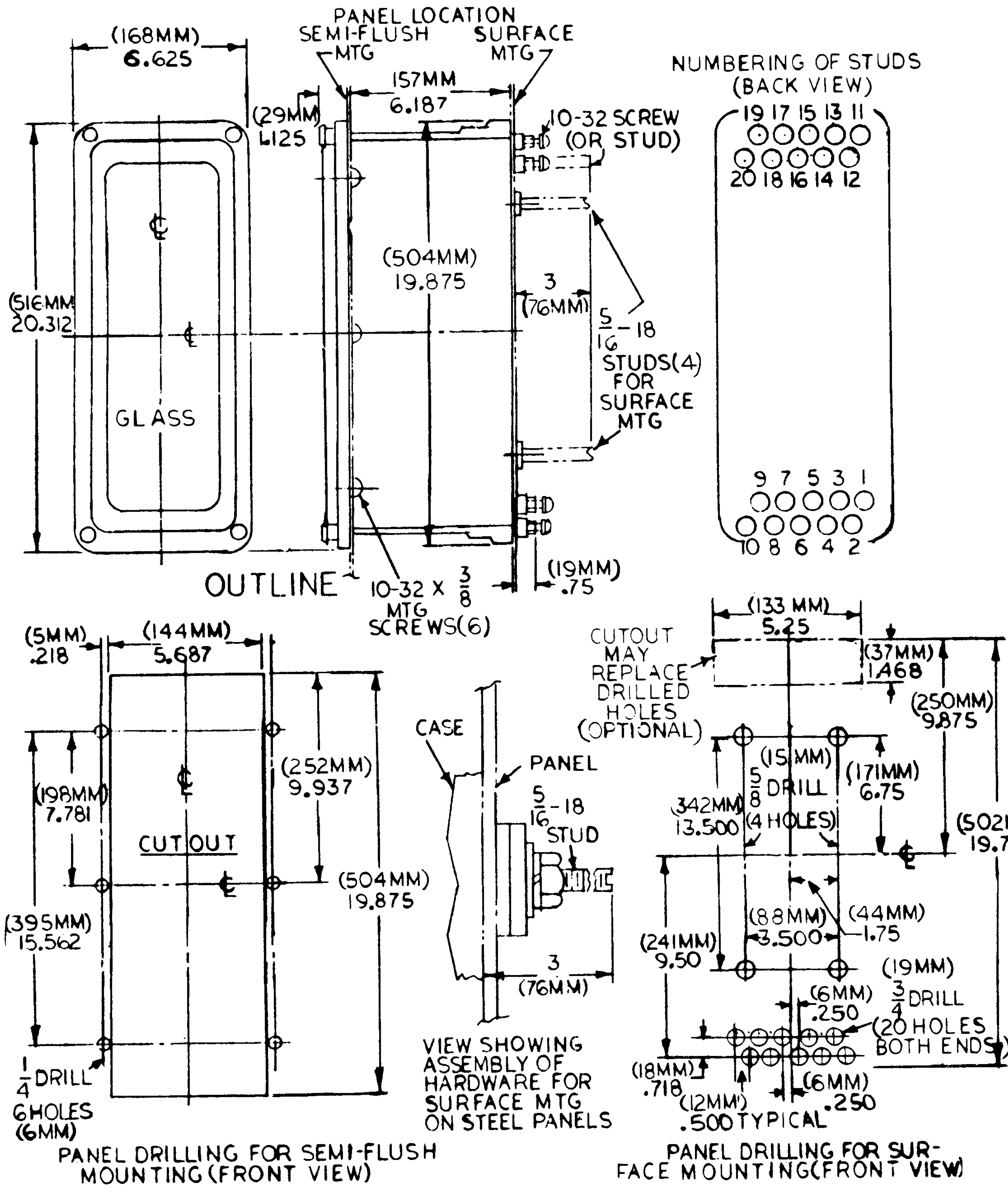


Figure 29 (6209276-3) Outline and panel drilling dimensions for type GCY51A relay

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Meter and Control Business Department

General Electric Company
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Malvern, PA 19355