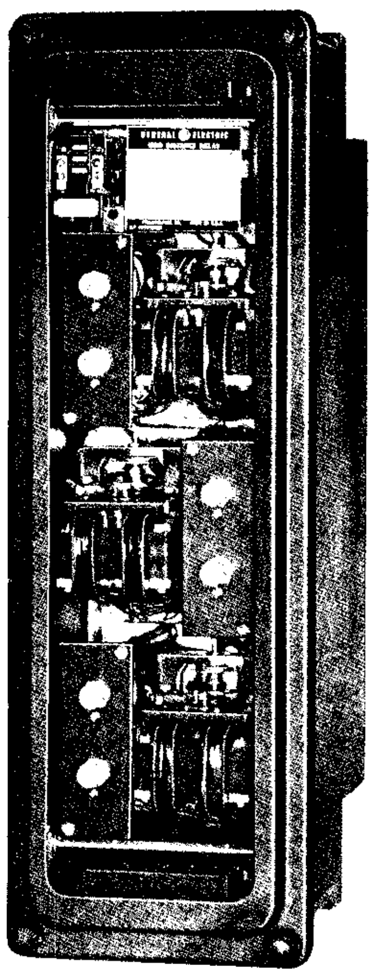
GEK-1289H

INSTRUCTIONS

MHO DISTANCE RELAY

TYPE CEY52A



GENERAL ELECTRIC

CONTENTS

Cover (8036591)

Since the last edition, Figure 16 has been changed.

MHO DISTANCE RELAY
TYPE CEY52A

INTRODUCTION

The CEY52A relay is a three-phase, high-speed, single-zone directional mho distance relay. It is constructed of three single-phase units in one L2-D case with provisions for single phase testing. One target and seal-in unit provides indication of operation for all three units. The transient overreach characteristics of the CEY52A have not been limited to the point where it is suitable for use as a first-zone relay. One CEY52A relay in conjunction with a suitable RPM or SAM timing relay will provide one zone of time-delay protection for three-phase, phase-to-phase and double-phase-to-ground faults.

APPLICATION

Because of its high speed and memory action characteristics, the CEY52A finds application as a carrier tripping relay in directional comparison schemes, as a permissive and tripping relay in permissive overreaching transferred tripping schemes, or as a permissive relay in permissive underreaching transferred tripping schemes. It is also very well suited for use as a second-zone relay in any scheme. The transient overreach characteristic of this relay has not been limited to the point where it is suitable for use as a first zone relay

Since the memory action of the CEY52A relay is only effective for several cycles after the inception of a fault, it will not provide time-delay protection for any fault that results in zero voltage at the terminals of the relay.

When applying this relay for the protection of a given circuit, it is generally advantageous to select the highest basic minimum tap setting that will accomodate the desired reach setting. This will insure the highest torque level of operation that is possible.

The basic sensitivity of the CEY52A relay will depend on the basic minimum tap setting that is used. Fig. 3 gives the steady state and dynamic sensitivity of the relay. In order to insure that the relay will reach no less than 90 percent of its setting, the minimum three phase fault current flowing in the relay for a fault at the remote end of the line should be at least the value given in the equation below:

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.

$$I_{MIN} = \frac{6 \times \quad /TAP/100}{T_M} \qquad (1)$$

T_M = Basic minimum tap setting

TAP = Restraint tap in percent

The CEY52A and its companion zone packaged (one three-phase zone per relay) relays may be combined in many ways for use in many different schemes including straight distance protection, directional comparison carrier protection, permissive overreaching and underreaching transferred tripping and miscellaneous back-up schemes. Fig. 4 illustrates the external connections to the CEY52A relay when used in conjunction with a CEY51A, CEB52A and a SAM16A for three-zone protection of a transmission circuit against all multi-phase faults.

The section under **CALCULATION OF SETTINGS** provides a worked example for a typical application of the CEY52A relay.

RATINGS

The type CEY52 relay covered by these instructions is available for 120 volts, five amperes rating. The basic minimum reach and adjustment ranges of the mho units are given in Table I.

TABLE I

BASIC MINIMUM REACH (Ø-N OHMS)	RANGE (Ø-N OHMS)	ANGLE OF MAXIMUM TORQUE	ONE SECOND RATING-AMPS
0.5/1.0/1.5	0.5-15	60**	225
1/2/3	1-30	60**	225

** The angle of maximum torque can be adjusted up to 75 degrees. The reach of the mho units at the 75 degree setting will increase to approximately 120 percent of its reach at the 60 degree setting.

It will be noted that three basic minimum reach settings are listed for the mho units. Selection of the desired basic minimum reach setting for each unit is made by means of links on a terminal board located at the back of the relay (see Fig. 2). The position of the two sets of links (for each unit), each identified as A-B, determined the basic minimum setting of the mho units. The ohmic reach of the mho units can be adjusted in one percent steps over a ten-to-one range for any of the basic minimun reach settings listed in Table I by means of autotransformer tap leads on the tap blocks at the right side of the relay.

CONTACTS

The contacts of the CEY52 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 target seal in-unit used in the CEY52 relay has ratings as shown in Table II.

TABLE II

	Dual Rated			
	0.2/2.0 AMP		0.6/2.0 AMP	
	0.2	2.0	0.6	2.0
Carry 30 Amps for (Sec)	0.05	2.2	0.5	3.5
Carry 10 Amps for (Sec)	0.45	2.0	5.0	30
Carry Continuously (Amp)	0.37	2.3	1.2	2.6
Minimum Operating (Amp)	0.2	2.0	0.6	2.0
Minimum Dropout (Amp)	0.05	0.5	0.15	0.5
DC Resistance (Ohms)	8.3	0.24	0.78	0.18
60 Hz Impedance (Ohms)	50	0.65	6.2	0.65
50 Hz Impedance (Ohms)	42	0.54	5.1	0.54
DC Resistive Interrupting Rating (Amps)	2.5 Amp @ 125 VDC			

OPERATING PRINCIPLES

The mho units of the CEY52 relay are of the four pole induction cylinder construction in which torque is produced by the interaction between a polarizing flux and fluxes proportional to the restraining or operating quantities.

The schematic connections of the mho unit are shown in Fig. 5. The two side poles, energized by phase-to-phase voltage, produce the polarizing flux. The flux in the front pole, which is energized by a percentage of the same phase-to-phase voltage, interacts with the polarizing flux to produce restraint torque. The flux in the rear pole, which is energized by the two line currents associated with the same phase-to-phase voltage, interacts with the polarizing flux to produce operating torque.

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

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

where: E = phase-to-phase voltage (E_{12})
I = delta current ($I_1 - I_2$)
θ = angle of maximum torque of the unit
ϕ = power factor angle of fault impedance
K = design constant

To prove that equation (2) 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 pick up at a constant component of admittance at a fixed angle depending on the angle of maximum torque. Hence, the name mho unit.

CHARACTERISTICS

MHO UNIT

1. Impedance Characteristic

The impedance characteristic of the mho unit is shown in Fig. 6 for the one ohm basic minimum reach setting at a maximum torque angle of 60 degrees. This circle can be expanded by means of the mho taps on the autotransformer tap block providing a range of up to ten-to-one, or by changing the basic minimum reach of the unit by means of the links on the rear, providing a total range of up to 30-to-one. The circle will always pass through the origin and have a diameter along the 60 degree impedance line equal to the ohmic reach of the unit as expressed by the following:

$$\text{Ohmic Reach} = \frac{(100)\,Z_{min}}{\text{tap setting (\%)}}$$

where: Z_{min} = basic minimum phase-to-neutral ohmic reach of the unit

The angle of maximum torque of the mho unit can be adjusted up to 75 degrees (see **SERVICING**) with resulting increase in reach to approximately 120 percent of its reach at 60 degrees for the same tap setting. This is shown by the dotted characteristic in Fig. 6.

2. Directional Action

The mho unit is carefully adjusted to have correct directional action under steady-state, low voltage and low current conditions. For faults in the non-tripping direction, the contacts will remain open at zero volts between zero and 60 amperes. For faults in the tripping direction, the unit will close its contacts between the current limits in Table III for the three basic minimum reach settings at the voltage shown. This adjustment is a function of the core (inner stator) position and should any adjustment be necessary, see **SERVICING.**

TABLE III

BASIC MINIMUM REACH TAP	††VOLTS	CURRENT RANGE FOR CORRECT DIRECTIONAL ACTION
0.5 ohm	2.0 V	12 - 60 A
1 ohm	2.0	6 - 60
1.5 ohms	2.0	4 - 60
2 ohms	2.0	3 - 60
3 ohms	2.0	2 - 60

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

For performance during transient low-voltage conditions, where the voltage was normal at 120 volts prior to the fault, refer to the paragraph below on memory action.

3. 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. 3 for the one, two and three-ohm basic minimum reach settings. 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 mho unit will operate for all points to the right of the curve. The steady-state curves of Fig. 3 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.

4. Memory Action

The dynamic curves of Fig. 3 illustrate the effect of memory action in the mho unit 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 unit to operate for low fault currents. This can be most forcefully illustrated for a zero voltage fault by referring to Fig. 3. 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. 3 shows 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. 3 shows that mho unit with a three-ohm basic minimum reach and 100 percent tap setting will operate if $I_{3\emptyset}$ is greater than 1.5 amperes.

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 as a second zone relay, and tripping is delayed by the Zone 2 setting of the type RPM relay, the static characteristic should be used. For this application to operate for nearby faults, there will be sufficient voltage to give tripping without depending on memory action.

5. Operating Time

The operating time of 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 curves in Fig. 8 are for the condition of rated volts prior to the fault. Time curves are given for four ratios of fault impedance to relay reach setting. In all cases, the mho taps were in the 100 percent position and the angle of maximum torque was set at 60-degree lag.

TAPPED AUTOTRANSFORMERS

The ohmic reach of the mho units may be adjusted by means of taps on the two autotransformers. Each autotransformer has two windings. One winding is tapped in ten percent steps from 15 percent to 95 percent. The other winding is tapped at zero percent, one percent, three percent and five percent.

The desired tap setting is made by the proper location of the leads marked No. 1 and the jumper connecting the two windings of the autotransformer. Note that the zero-to-five percent winding may be added or subtracted from the 15-95 percent winding.

The tap setting required to protect a zone Z ohms long, where Z is positive phase sequence phase-to-neutral impedance expressed in secondary terms, is determined by the following equation:

$$\text{Tap Setting} = \frac{(100)\ (\text{Minimum Ohms Setting})\ \cos(\phi - \theta)}{Z}$$

where: ϕ = Power factor angle of fault impedance

θ = Angle of maximum torque of the unit

Example:

TAP SETTING DESIRED = 91

Set one end of jumper lead to 95 percent. Set the other end to five percent. Set No. 1 on one percent. (Note the four percent setting of the zero-to-five percent winding subtracts from the 95 percent setting.)

Example 2:

TAP SETTING DESIRED = 89

Set one end of jumper lead to 85 percent. Set the other end to one percent. (Note the four percent setting of the zero-to-five percent winding adds to the 85 percent setting.)

BURDENS

CURRENT CIRCUITS

The maximum current burden imposed on each current transformer at five amperes is listed in Table IV.

TABLE IV

FREQUENCY	TAP	R	X	Z	P.F.	W	VA
60	3.0	0.043	0.026	0.050	0.86	1.08	1.25
	2.0	0.028	0.012	0.030	0.93	0.70	0.75
	1.5	0.017	0.007	0.018	0.96	0.43	0.45
	1.0	0.015	0.003	0.015	0.99	0.38	0.38
	0.5	0.009	0.001	0.009	0.99	0.23	0.23
50	3.0	0.038	0.022	0.044	0.86	0.95	1.10
	2.0	0.026	0.010	0.028	0.93	0.65	0.70
	1.0	0.017	0.003	0.017	0.99	0.43	0.43

This data is for the 3.0 ohm basic reach tap setting. The burden for the two-ohm and one-ohm tap setting will be lower.

POTENTIAL CIRCUITS

The maximum potential burden imposed on each potential transformer at 120 volts is listed in Table V.

TABLE V

FREQUENCY	CIRCUIT	R	X	P.F.	W	VAR	VA
60	POLARIZING	1530	-j130	0.99	9.4	-j0.8	9.4
	RESTRAINT	1150	+j1370	0.64	5.2	+j6.2	8.1
50	POLARIZING	2200	-j135	0.99	6.5	+J0.4	6.5
	RESTRAINT	1150	+j1600	0.59	4.3	+j5.9	7.3

The potential burden of the mho unit is maximum when the restraint tap is set for 100 percent.

The restraint circuit burden, and hence the total relay burden, will decrease when the restraint tap setting is less than 100 percent.

The potential burden at tap settings less than 100 percent can be calculated from the following formula.

$$VA = (a + jb)\left[\frac{\text{Tap Setting}}{100}\right]^2 + (c + jd)$$

The terms (a + jb) (c + jd), etc., represent the burdens of the mho unit potential circuit expressed in watts and vars with their taps on 100 percent.

TABLE VI

FREQUENCY	CIRCUIT	(WATTS +j VARS)	(WATTS ±j VARS)
60	POLARIZING	(c + jd)	9.4 - j0.8
	RESTRAINT	(a + jb)	5.2 + j6.2
50	POLARIZING	(c + jd)	6.5 + j0.4
	RESTRAINT	(a + jb)	4.3 + j5.9

CALCULATION OF SETTINGS

Consider a 230kV transmission line 50 miles long having a phase-to-neutral impedance of 0.14 + j0.80 ohms per mile.

$$Z_{pri} = 50(0.14 + j0.80) = 7 + j40 \text{ ohm total}$$

$$\text{PT Ratio} = 230{,}000/115 = 2000/1$$

$$\text{CT Ratio} = 600/5 = 120/1$$

$$Z_{sec} = Z_{pri}\frac{\text{CT Ratio}}{\text{PT Ratio}}$$

$$Z_{sec} = (7.0 + j40.0)\frac{120}{2000} = 0.42 + j2.4 \text{ ohms}$$

$$Z_{sec} = 2.43 \underline{/80.5^o} \text{ ohms}$$

Assume that the CEY52A is to be used to provide second zone reach protection and it is desired, after considering the effects of infeed, to set the relay to reach 3.64 $\underline{/80.5^o}$ secondary ohms. The minimum current in the relay for a three-phase fault at the desired reach is 3.2 amperes. For this application the three-ohm basic minimum reach setting should be used. The ohmic reach equation, given in the section under CHARACTERISTICS - TAPPED AUTOTRANSFORMERS is used.

$$\text{Percent Tap Setting} = \frac{(100)\ (\text{Minimum ohms})\ \text{Cos}\ (\emptyset-\theta)}{Z}$$

Minimum Ohms = 3.0 at 60 degrees, 3.6 at 75 degrees

$$Z = Z_{sec} = 3.64$$
$$\theta = 75^o$$
$$\emptyset = 80.5^o$$

$$\text{Percent Tap Setting} = \frac{(100)\ (3.6)\ \text{Cos}(80.5-75)}{3.64}$$

Percent Tap Setting = 98%

The table in the **APPLICATION** section of this book indicates that the 3.2 amperes available for the relay will be sufficient to provide satisfactory operation.

CONSTRUCTION

The Type CEY52 relays are assembled in a deep, large size, double-end (L2D) drawout case having studs at both ends in the rear for external connections. The electrical connections between the relay units and the case studs are made through stationary molded inner and outer blocks, between which nests a removable connection plug which completes the circuits. The outer blocks attached to the case have the studs for the external connections and the inner blocks have the terminals for the internal connections.

Every circuit in the drawout case has an auxiliary brush, as shown in Fig. 9, to provide adequate overlap when the connecting plug is withdrawn or inserted. Some circuits are equipped with shorting bars (see internal connections in Fig. 10) and on those circuits it is especially important that the auxiliary brush make contact as indicated in Fig. 9 with adequate pressure to prevent the opening of important interlocking circuits.

The relay mechanism is mounted in a steel framework called the cradle and is a complete unit with all leads terminated at the inner block. This cradle is held firmly in the case with a latch at both top and bottom and by a guide pin at the back of the case. The connecting plug, besides making the electrical connections between the respective blocks of the cradle and case, also locks the latch in place. The cover, which is drawn to the case by thumbscrews, holds the connecting plugs in place. The target reset mechanism is a part of the cover assembly.

The relay case is suitable for either semi-flush or surface mounting on all panels up to two inches thick and appropriate hardware is available. However, panel thickness must be indicated on the relay order to insure that proper hardware will be included.

A separate testing plug can be inserted in place of the connecting plug to test the relay in place on the panel either from its own source of current and voltage, or from other sources. Or the relay can be drawn out and replaced by another which has been tested in the laboratory.

Fig. 1 and 2 show the relay removed from its drawout case with all major components identified. Symbols used to identify circuit components are the same as those which appear on the internal connection diagram in Fig. 10.

The relay includes three similar mho subassembly elements mounted on the front of the cradle and a plate with transformers and tap blocks mounted on the back of the cradle. (See Fig. 1 and 2.)

The mho subassembly includes the four pole unit and associated circuit components. Rheostats (R21, R22, R23) used in setting the angle of maximum torque and rheostats R11, R12, R13 used in setting the basic minimum reach can be adjusted from the front of the relay.

The tap blocks for changing the basic minimum reach of the units are mounted on the back. The relay must be removed from its case to make the settings.

RECEIVING, HANDLING AND STORAGE

These relays, when not included as 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 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 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.

ACCEPTANCE TESTS

Immediately upon receipt of the relay, and inspection and acceptance test should be made to insure that no damage has been sustained in shipment and that the relay calibrations have not been disturbed. If the examination or test indicates that readjustment is necessary, refer to the section on **SERVICING.**

VISUAL INSPECTION

Check the nameplate stamping to insure that the model number and rating of the relay agree with the requisition.

Remove the relay from its case and check that there are no broken or cracked molded parts or other signs of physical damage, and that all screws are tight.

MECHANICAL INSPECTION

1. It is recommended that the mechanical adjustments in Table VII be checked.

2. There should be no noticeable friction in the rotating structure of the units.

3. Make sure control springs are not deformed and spring convolutions do not touch each other.

4. With the relay well leveled in its upright position the contacts of all three units must be open. The moving contacts of the units 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 inch 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 VII

CHECK POINTS	MHO UNITS
Rotating Shaft End Play	0.010 - .015 inch
Contact Gap	0.018 - .022 inch
Contact Wipe	0.003 - .005 inch

ELECTRICAL CHECKS - MHO UNITS

All tests must be made with the relay in the case. Before any electrical checks are made on the mho units, the relay should be connected as shown in Fig. 11 and be allowed to warm up for approximately 15 minutes with the potential circuit alone energized at rated voltage and the restraint taps set at 100 percent. The units were warmed up prior to factory adjustment and if rechecked when cold will tend to underreach by three or four percent. Accurately calibrated meters are, of course, essential.

It is desirable to check the factory setting and calibration by means of the test described in the following sections. The mho units were carefully adjusted at the factory and it is not advisable to disturb these settings unless the following checks indicate conclusively that the settings have been disturbed. If readjustments are necessary, refer to the section on **SERVICING** for the recommended procedures.

Test connections for checking correct mho unit operation.

(a) Control Spring Adjustment

Be sure that the relay is level in its upright position. Leave the relay connected as shown in Fig. 11 and leave the restraint taps in the 100 percent position.

Use the following procedure in checking each unit. With the current set at five amperes and the voltage across relay voltage studs at 120 volts, set the phase shifter so that the phase angle meter reads the value shown in Table VIII for the unit being tested, that is so current lags voltage by an angle equal to the angle of maximum torque of the unit. Now reduce the voltage to the low test voltage and reduce the current to about two amperes. Gradually increase the current until the contacts of the unit just close. This should occur between the currents listed in Table VIII.

(b) Clutch Adjustment

The mho units include a high-set clutch between the cup and shaft assembly and the moving contact to prevent damage during heavy fault conditions. These clutches have been set at the factory to slip at approximately 40-60 grams applied tangentially at the moving contact. This can best be checked in the field in terms of volt-amperes by the following method.

Use the connections of Fig. 11 and set the phase shifter so that the phase angle meter reads 300 degrees at 120 volts and five amperes. Disconnect the No. 1 restraint tap leads from the tap block and set the mho units for the maximum basic minimum reach tap. With the voltage across relay studs set at 120 volts, increase the current until the clutch just slips. This should occur just above 52 amperes if the 1.5-ohm tap is used or 26 amperes if the three-ohm tap is used.

(c) Ohmic Reach

With the relay still connected as shown in Fig. 11 and the restraint tap leads in the 100 percent position, make connections shown in Table IX and 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 to the value shown in Table IX and increase the current gradually until the normally open contacts of the unit just close. This should occur within the limits shown. Note that the tap screws on the current tap blocks are set to the position which gives the basic minimum reach shown in the table.

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 units in the middle tap. If the units are set on either of the remaining basic minimum reach taps, the basic reach of the units will be within plus or minus four percent of the tap plate marking.

(d) Angle of Maximum Torque

For checking the angle of maximum torque, the connections of Fig. 11 will be used with the restraint tap leads set at the 100 percent position, and with the voltage set at the value shown in Table X for the unit to be checked. The minimum reach taps should be set to the middle tap position.

In checking the mho units the following procedure should be used. First set the phase shifter so that the phase angle meter reads 330 degrees. Note that while the phase angle is being set, the current should be at five amperes and the voltage at 120 volts. Now set the voltage at the value shown in Table X; increase the current slowly until the mho unit picks up. The pickup current should be within the limits shown in the table. Now reset the phase angle at 270 degrees and again check the current required to pick up the mho unit.

This current should fall within the same limits as for the 330-degree check.

TABLE VIII - CONTROL SPRING ADJUSTMENT

UNIT LOCATION	UNIT	CONNECT LEAD TO RELAY STUDS AS FOLLOWS LEAD A	LEAD B	LEAD C	LEAD D	JUMPER RELAY STUDS	Ø-ANGLE METER READS	BASIC MIN REACH SETTING (Ø-N OHMS)	V_{A-B} SET AT	PICKUP AMPS
Top	Ø1-2	14-15	13-16-17	5	7	6-8-10	300°	1	1.5	4.5-5.5
Middle	Ø2-3	13-16-17	18-19-20	7	9	6-8-10	300°	1	1.5	4.5-5.5
Bottom	Ø3-1	18-19-20	14-15	9	5	6-8-10	300°	1	1.5	4.5-5.5
Top	Ø1-2	14-15	13-16-17	5	7	6-8-10	300°	2	1.5	2.2-2.8
Middle	Ø2-3	13-16-17	18-19-20	7	9	6-8-10	300°	2	1.5	2.2-2.8
Bottom	Ø3-1	18-19-20	14-15	9	5	6-8-10	300°	2	1.5	2.2-2.8

TABLE IX - OHMIC REACH

UNIT LOCATION	UNIT	CONNECT LEAD TO RELAY STUDS AS FOLLOWS LEAD A	LEAD B	LEAD C	LEAD D	JUMPER RELAY STUDS	Ø-ANGLE METER READS	BASIC MIN REACH SETTING (Ø-N OHMS)	V_{A-B} SET AT	PICKUP AMPS
Top	Ø1-2	14-15	13-16-17	5	7	6-8-10	300°	1	30V	14.6-15.4
Middle	Ø2-3	13-16-17	18-19-20	7	9	6-8-10	300°	1	30V	14.6-15.4
Bottom	Ø3-1	18-19-20	14-15	9	5	6-8-10	300°	1	30V	14.6-15.4

TABLE X - ANGLE OF MAXIMUM TORQUE

UNIT LOCATION	UNIT	CONNECT LEAD TO RELAY STUDS AS FOLLOWS LEAD A	LEAD B	LEAD C	LEAD D	JUMPER RELAY STUDS	Ø-ANGLE METER READING ANGLE OF MAX TORQUE	TEST ANGLES	V_{A-B} SET AT	PICKUP AMPS
Top	Ø1-2	14-15	13-16-17	5	7	6-8-10	300°	330&270	30V	16.5-18.5
Middle	Ø2-3	13-16-17	18-19-20	7	9	6-8-10	300°	330&270	30V	16.5-18.5
Bottom	Ø3-1	18-19-20	14-15	9	5	6-8-10	300°	330&270	30V	16.5-18.5

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

ELECTRICAL TESTS - TARGET SEAL-IN

The target seal-in unit has an operating coil tapped at 0.6 or 2.0 amperes, or an operating coil tapped at 0.2 or 2.0 amperes.

The relay is shipped from the factory with the tap screw in the lowest ampere position. The operating point of the seal-in unit can be checked by connecting from DC source (positive) to stud 11 of the relay and from stud 1, through an adjustable resistor, an ammeter back to negative. Connect a jumper from stud 12 to stud 1 also so that the seal-in contact will protect the mho unit contacts. Then close the mho unit 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 mho contacts.

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. 16.

CONNECTIONS

The internal connections of the CEY52A relay are shown in Fig. 10. An elementary diagram of typical external connections is shown in Fig. 4.

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 which may result from instrument inaccuracies and to permit testing the mho units from a single-phase AC test source, the test circuit shown in schematic form in Fig. 13 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 ten percent and one percent steps so that the line impedance $R_L + jX_L$ may be made to appear to the relay very nearly as 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 so that the combination may be made to match any line.

For convenience in field testing, the fault switch and tapped autotransformer of Fig. 13 have been arranged in a portable test box, Catalog 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 mho units at the settings which have been made for a particular line section.

To check the calibration of the mho units it is suggested that the portable test box, Catalog No. 102L201; portable test reactor, Catalog No. 6054975; and test resistor, Catalog No. 6158546, be arranged with Type XLA test plugs according to Fig. 14. These connections of the test box and other equipment are similar to the schematic connections shown in Fig. 13 except that the Type XLA test plug connections are now included.

Use of the source impedance $R_S + jX_S$, simulating the conditions which would be encountered in practice, is necessary only if the relay is to be tested for overreach or contact coordination, tests which 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, especially 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 unit angle of maximum reach. From Fig. 12 it is seen that twice the relay reach of the angle of the test reactor impedance is:

$$2Z \text{ Relay} = 200 \frac{Z_{min.}}{\text{Tap Setting \%}} \text{Cos } (\emptyset - \theta)$$

where:

$\emptyset$ = the angle of the test reactor impedance
θ = mho unit angle of maximum reach
Z Min = basic minimum reach of mho units

To illustrate by an example let us consider the percent tap required on the test box autotransformer for a unit that has been factory adjusted to pick up at three ohms minimum and at a maximum torque angle of 60 degrees. In determining the reactor tap setting to use, it may be assumed that the angle ($\emptyset$) of the test reactor impedance is 80 degrees. From the above, twice the relay reach at the angle of the test-reactor impedance is:

$$2Z \text{ relay} = 200 \text{ X } \frac{3}{100} \cos (80 - 60) = 5.64 \text{ ohms}$$

Therefore, use the reactor six-ohm tap. 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 degrees. The table below shows the angles for each of the reactor taps.

TABLE XI

TAP	ANGLE	COS Ø-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 above table it is seen that the angle of the impedance of the six-ohm tap is 86 degrees. Therefore:

$$2Z \text{ relay} = 200 \times \frac{3}{100} \cos(86-60) = 5.4 \text{ ohms}$$

The calibration curve for the portable test reactor should again be referred to in order to determine the exact reactance of the six-ohm tap at the current level being used. For the purpose of this illustration assume that the reactance is 6.1 ohms. Since the angle of the impedance of the six-ohm tap is 86 degrees, the impedance of this tap may be calculated as follows:

$$Z_L = \frac{X_L}{\sin 86} + \frac{6.1}{0.9976} = 6.115$$

From this calculation it is seen that the reactance and the impedance may be assumed 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 required to close the mho-unit contacts with the fault switch closed is:

$$\% = \frac{5.4}{6.1}(100) = 88.5\% \text{ (use 88\% tap)}$$

Fig. 13 should be checked to determine that the test current used is high enough so that the characteristic is not off the calculated value because of low current.

If the ohmic pickup of the mho 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 twelve and six-ohm taps of the specified test reactor, impedances at 60 degrees and 30 degrees respectively will be available for checking the mho unit reach at the 60 degree and 30 degree positions. The mho unit ohmic reach at the zero-degree 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 which gives the exact impedance and angle for each of the combinations available. The test-box auto-transformer percent tap for pickup at a particular angle is given by:

$$\% \text{ Tap} = \frac{200 \; Z_{min} \cos(\phi - \theta)}{Z_L \text{ (Tap Setting \%)}} \quad (100)$$

where θ is the angle of maximum torque of the unit, Ø is the angle of the test impedance (Z_L), Z is the 60 degree, 30 degree or zero degree impedance value taken from the calibrated resistor data sheet. As in the case of the previous tests, the load box which serves as the source impedance should be adjusted to allow approximately ten amperes to flow in the fault circuit when the fault switch is closed.

When checking the mho unit at angles of more than 30 degrees off the maximum reach position, the error becomes relatively large with phase angle error. This is apparent from Fig. 12 where it is seen, for example at the zero-degree position, that a two or three degree error in phase angle will cause a considerable apparent error in reach.

INSPECTION

Before placing a relay into service, the following mechanical adjustments should be checked, and fault conditions corrected according to instructions in the ADJUSTMENTS subsection of this section or under the **MAINTENANCE** section.

The armature and contacts of the target and seal-in units should operate freely by hand.

There should be a screw in only one of the taps on the right-hand contact of the target and seal-in unit.

The target should reset promptly when the reset button at the bottom of the cover is operated, with the cover on the relay.

MHO UNITS

There should be no noticeable friction in the rotating structure of the mho unit. The mho unit moving contact should just return to the backstop when the relay is de-energized, and in the vertical position.

There should be approximately 0.010 - 0.015 inch end play in the shafts of the rotating structures. The lower jewel screw bearing should be screwed firmly into place and the top pivot locked in place by its set screw.

If there is reason to believe that the jewel is cracked or dirty, the screw assembly can be removed from the bottom of the unit and examined. When replacing a jewel, have the top pivot engaged in the shaft while screwing in the jewel screw.

All nuts and screws should be tight, with particular attention paid to the tap plugs.

The felt gasket on the cover should be securely cemented in place in order to keep out dust.

Determine the impedance and phase angle seen by the relays. Knowing the impedance and phase angle seen by the relay, the tap value at which the relay will just operate can be calculated. It is then only necessary to reduce the tap setting of the relay until the mho units operate and see how close the actual tap value found checks with the calculated value. The calculated value should take into account the shorter reach of the mho unit at low currents. This effect is shown in Fig. 8.

A shorter test which will check for most of the possible open circuits in the AC portion of the relay can be accomplished by disconnectng the current circuits. This can be done by removing the lower connection plug. All units should have strong torque to the right when full voltage is applied.

Replace the lower plug and open the restraint taps. All units should operate if power and reactive flow are away from the station bus and into the protected line section. If the direction of reactive power flow is into the station bus, the resultant 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 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.

SERVICING

If it is found during the installation or periodic tests that the mho 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 as factory adjustments, are used in recalibrating the units. These parts may be physically located from Fig. 1 and 2. Their locations in the relay circuit are shown in the internal connection diagrams of Fig. 10.

R_{11} - $\emptyset_{1-2}$ unit ohmic reach adjustment

R_{21} - $\emptyset_{1-2}$ unit angle of maximum torque adjustment

R_{12} - $\emptyset_{2-3}$ unit ohmic reach adjustment

R_{22} - $\emptyset_{2-3}$ unit angle of maximum torque adjustment

R_{13} - $\emptyset_{3-1}$ unit ohmic reach adjustment

R_{23} - $\emptyset_{3-1}$ unit angle of maximum torque adjustment

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

CONTROL SPRING ADJUSTMENT

Make connections to the relay as shown in Fig. 11 and set the restraint tap leads on 100 percent. The basic reach taps should be set in the position for the basic minimum reach shown in Table XII.

Make sure that the relay is in an upright position so that the units are level. With the current set at five amperes and the voltage V_{A-B} at 120 volts, set phase shifter so that the phase angle meter reads the value shown in Table XII.

Now reduce the voltage to the test voltage value and set the current at the value shown in Table XII 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 Fig. 15) and turn the ring until the contacts of the unit just close. If the contacts were closing below the set point shown in Table XII, 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.

TABLE XII

PHASE ANGLE METER SETTING	BASIC OHMIC RANGE	BASIC OHM TAP	TEST VOLTAGE	PICKUP CURRENT	ADJUST
300	0.5/1/1.5	1.0	1.5 VOLT	4.5-5.5	CONTROL
300	1/2/3	2.0	1.5 VOLT	2.2-2.8	SPRING

OHMIC REACH ADJUSTMENT

The basic minimum reach of the mho units can be adjusted by means of the rheostats which are accessible from the front of the relay. Connect the relay as show in Fig. 11; leave the restraint taps at 100 percent and be sure the basic minimum reach taps are used. With current at five amperes and voltage at 120 volts, 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 V_{AB} to the set value shown in Table XIII and adjust the appropriate rheostat so that the unit picks up at the current shown in Table XIII.

TABLE XIII

PHASE ANGLE METER SETTING	BASIC OHMIC RANGE	BASIC OHM TAP	TEST VOLTAGE	PICKUP CURRENT	ADJUST
300	0.5/1/1.5	1.0	30	14.2-15.8	R_{11}-R_{12}-R_{13}
300	1/2/3	2.0	60	14.2-15.8	R_{11}-R_{12}-R_{13}

R_{11} adjusts top unit, R_{12} adjusts middle unit, R_{13} adjusts bottom unit.

ANGLE OF MAXIMUM TORQUE

The angle of maximum torque of the mho units can be adjusted by means of rheostats which are accessible from the front of the relay. Use the connections in Fig. 11. Leave the restraint taps at 100 percent and be sure that the basic minimum reach taps are in the position shown in Table XIV.

The procedure used in setting angle of maximum torque is to adjust the rheostats so that the pickup amperes, at a specified set voltage V_{AB}, will be the same at angles leading and lagging the maximum torque angle by 30 degrees. The test angles, set voltages and the pickup amperes are shown in Table XIV.

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 and Table XIV. Next set the phase shifter so that the phase angle meter reads 330 degrees (note that phase angle adjustments should be made at 120 volts and five amperes). Then set V_{AB} at 60 volts and adjust the proper rheostat so that the mho unit closes its contacts at 17.3 amperes plus or minus five percent. The pickup should then be checked at 270 degrees with the same set voltage and should be 17.3 amperes plus or minus five percent. Refine the adjustments of the rheostats until the pickup is within limits at both 270 and 330 degrees.

Note than an adjustment of the angle of maximum torque will have a secondary effect on the reach of the unit, and vice versa. Therefore, to insure 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.

TABLE XIV

PHASE ANGLE METER SETTING	BASIC OHMIC RANGE	BASIC OHM TAP	TEST VOLTAGE	PICKUP CURRENT	ADJUST
270° or 330°	0.5/1/1.5	1.0	30	16.3-18.2	R_{21}-R_{22}-R_{23}
270° or 330°	1/2/3	2.0	60	16.3-18.2	R_{21}-R_{22}-R_{23}

R_{21} adjusts top unit, R_{22} adjusts middle unit, R_{23} adjusts bottom unit.

As noted in Table I under the section on **RATINGS**, the angle of maximum torque of the mho units can be adjusted up to 75 degrees if desired. If this change is made, the reach of the mho units will increase slightly. To make this adjustment refer to Table XV and proceed as outlined below.

Set restraint tap settings at 100 percent and connections per Fig. 11. Set the phase shifter so that the phase angle meter reads 315 degrees, set voltage and current per Table XV. Now adjust the proper rheostat so that the unit just picks up. Now check the pickup current at 255 degrees. The pickup current at both test angles should be within the value listed in the table. After the setting is made make sure the rheostat lock nuts are tight.

TABLE XV

PHASE ANGLE METER SETTING	BASIC OHMIC RANGE	BASIC OHM TAP	TEST VOLTAGE	PICKUP CURRENT	ADJUST
255	0.5/1.0/1.5	1.0	30	13.6-15.1	R_{21}-R_{22}-R_{23}
315	0.5/1.0/1.5	1.0	30	13.6-15.1	R_{21}-R_{22}-R_{23}
255	1/2/3	2.0	60	13.6-15.1	R_{21}-R_{22}-R_{23}
315	1/2/3	2.0	60	13.6-15.1	R_{21}-R_{22}-R_{23}

CORE ADJUSTMENT (See Fig. 17)

This adjustment is to be made only if relay does not meet the directional tests. By means of a special wrench (Catalog No. 0178A9455 Pt. 1) the core is adjusted by inserting the wrench to engage nut "D" which rotates the core "A" to obtain the values shown under DIRECTIONAL ACTION. The core may be rotated 360 degrees in either direction, although it should not be necessary to rotate the core more than a few degrees from its set position.

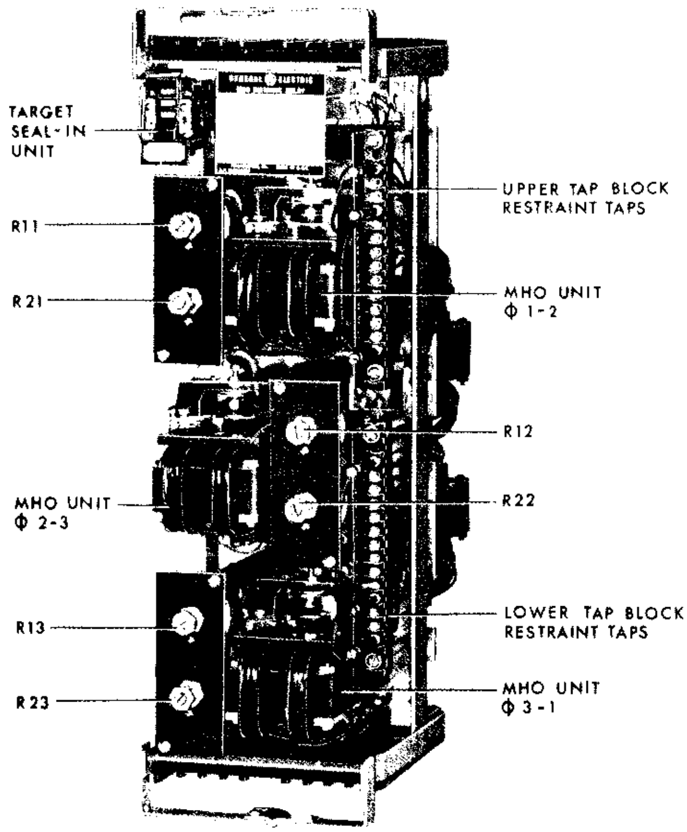


Fig. 1 (8036590) MHO Distance
Relay Removed from Case,
Front View

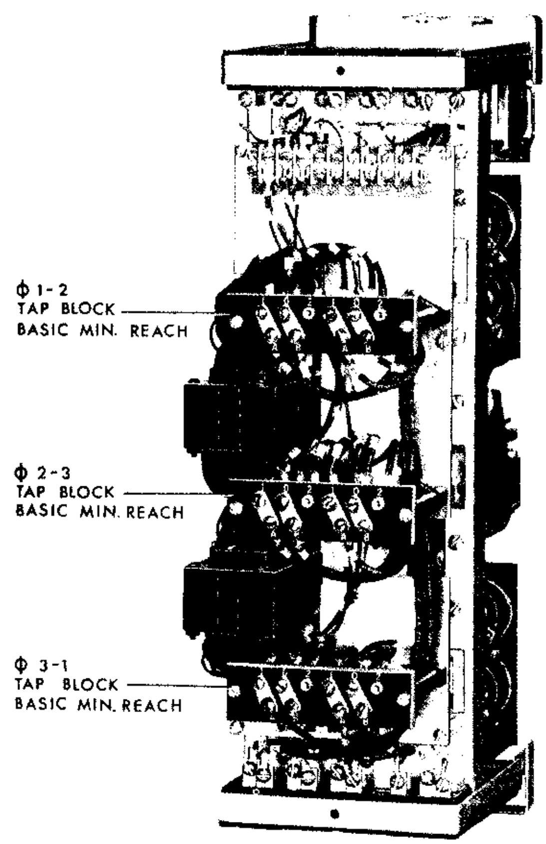


Fig. 2 (8036594) MHO Distance
Relay Removed from Case,
Front View

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 give complete nameplate data. If possible give the General Electric requisition number on which the relay was furnished.

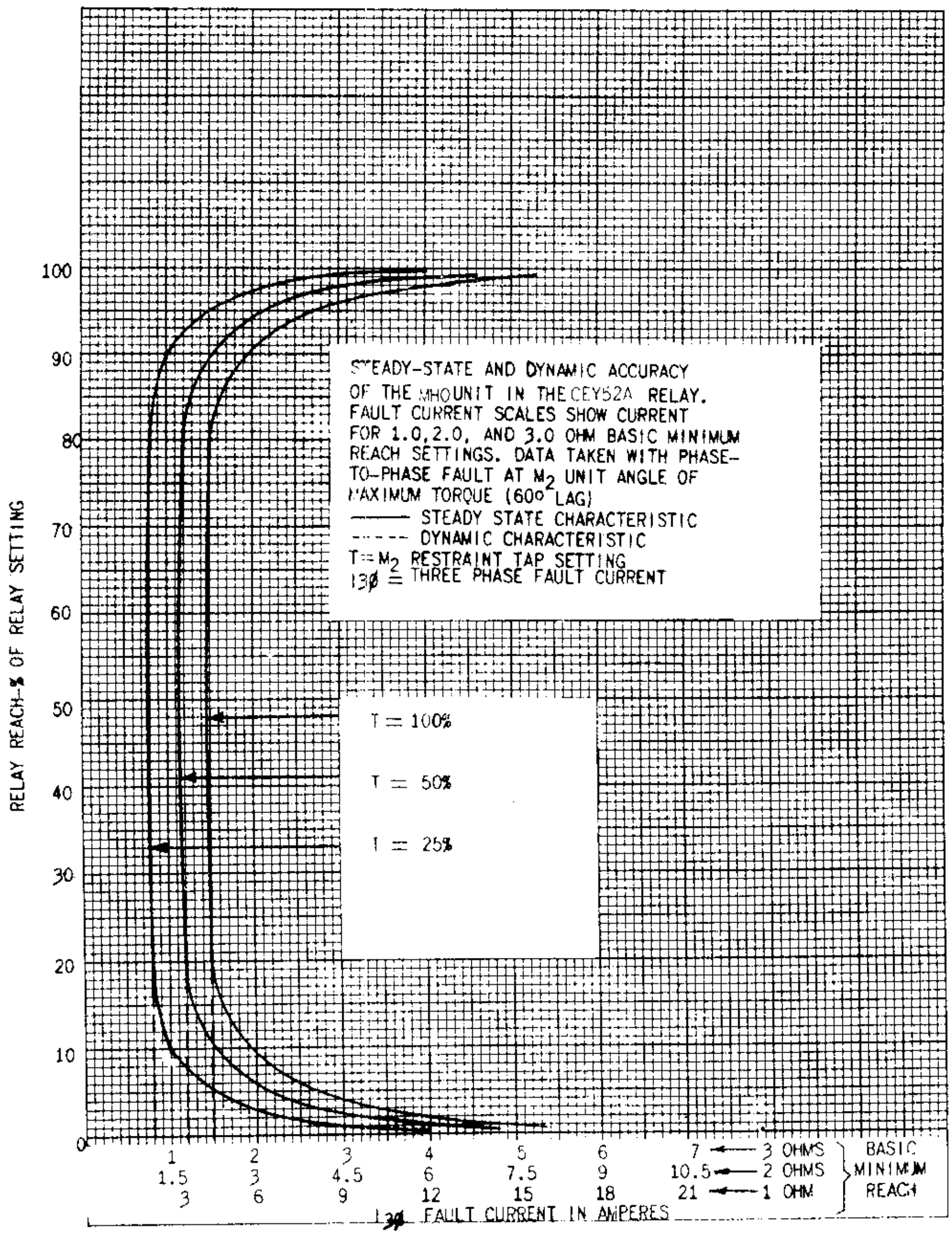
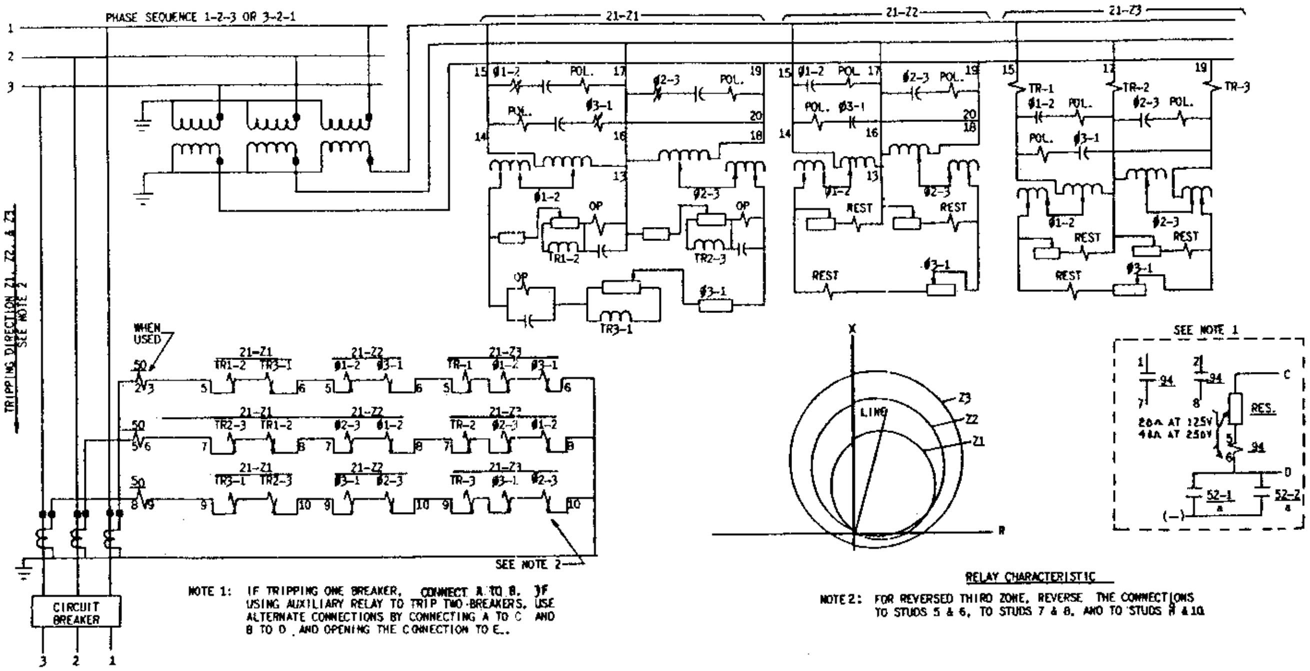
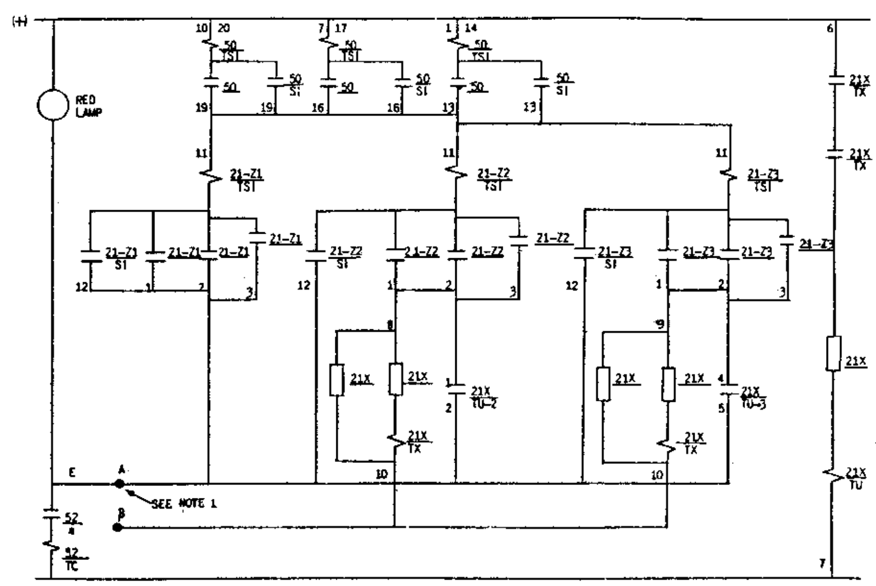


Fig. 3 (0203A8602-0) Steady State and Dynamic Reach Curves for the MHO Unit in the CEY52A Relay



LEGEND			
DEVICE NO.	DEVICE TYPE	INCL. ELEM.	DESCRIPTION
21-Z1	CEY51A		3 PHASE-1ST. ZONE MHO RELAY
		Ø 1-2	PHASE 1-2 UNIT ETC.
		TR1-2	PHASE 1-2 TRANSACTOR ETC.
		T & SI	TARGET & SEAL-IN UNIT
21-Z2	CEY52A		3 PHASE-2ND ZONE MHO RELAY
		Ø 1-2	PHASE 1-2 UNIT ETC.
		T & SI	TARGET & SEAL-IN UNIT
21-Z3	CE852A		3 PHASE-3RD ZONE OFFSET MHO RELAY
		Ø 1-2	PHASE 1-2 UNIT ETC.
		TR-1	PHASE 1 TRANSACTOR ETC.
		T & SI	TARGET & SEAL-IN UNIT
21X	RPM21D		TIMING RELAY
		TU	TIMING UNIT
		TX	AUXILIARY TO TIMING UNIT
50	PJC31C		INSTANTANEOUS PHASE FAULT DET.
		T & SI	TARGET & SEAL-IN UNIT
94	HGA14	AM or AL	AUXILIARY TRIPPING RELAY



TABULATION OF DEVICES		
TYPE OR DESCRIPTION	INTERNAL CONNS.	OUTLINE
CEY51A	0178A7132	0168A7336
CEY52A	0178A7133	0178A7336
CEB52A	0178A7134	0178A7336
RPM210	0127A9440	K-6209271
PJC31C	K-6375726	K-6209272
HGA14AM (BACK CONNS.)	K-6400533	K-6400593
HGA14AL (FRONT CONNS.)	377A139	377A139

Fig. 4 (0116B9309[5]) Typical External Connections Diagram for the CEY52A Relay

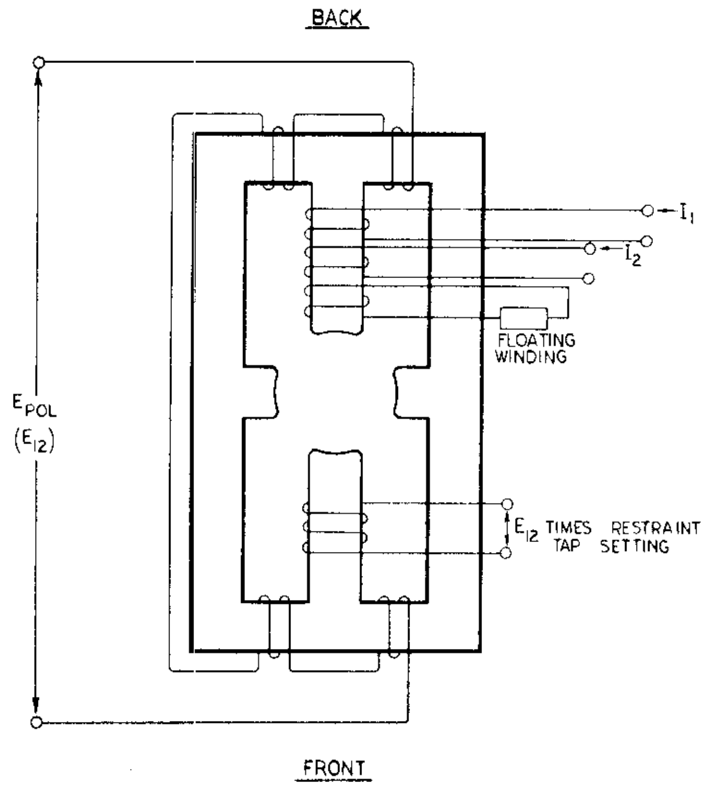


Fig. 5 (0208A5577-0) Schematic Connections of Typical M2 Unit

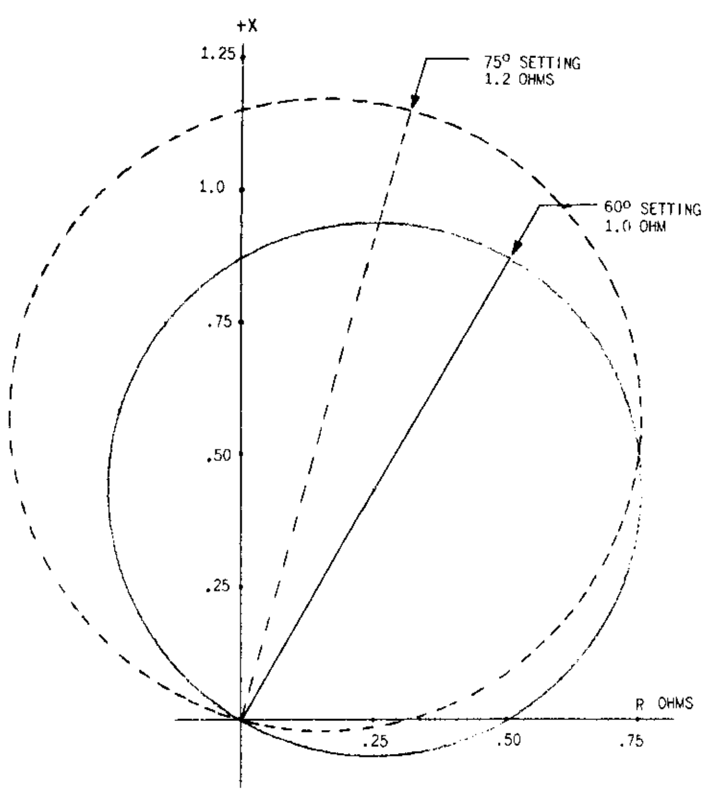


Fig. 6 (0178A8174-0) Impedance Characteristic of MHO Unit

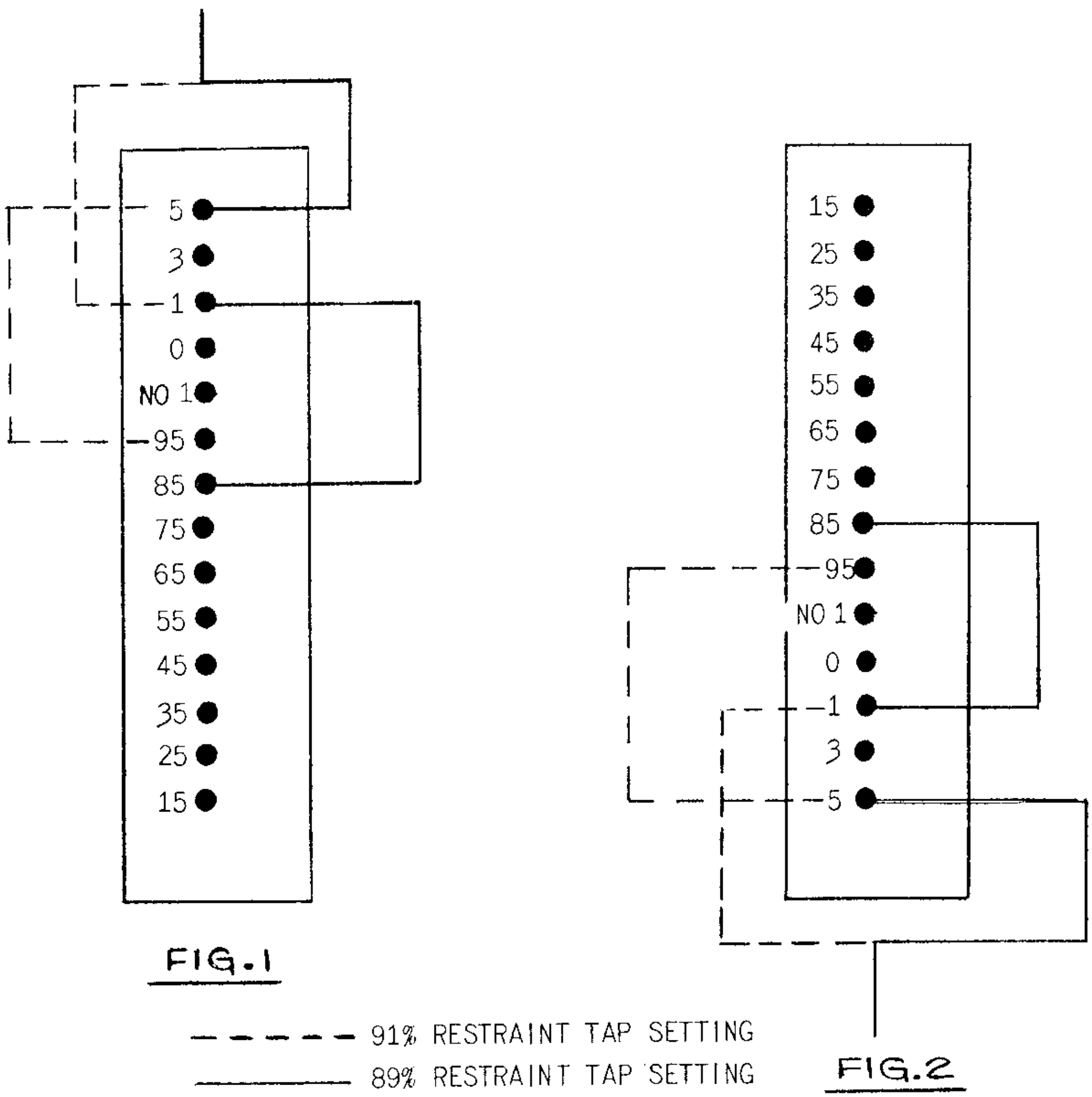


Fig. 7 (0208A3757[1]) Tap Block Arrangement and Settings

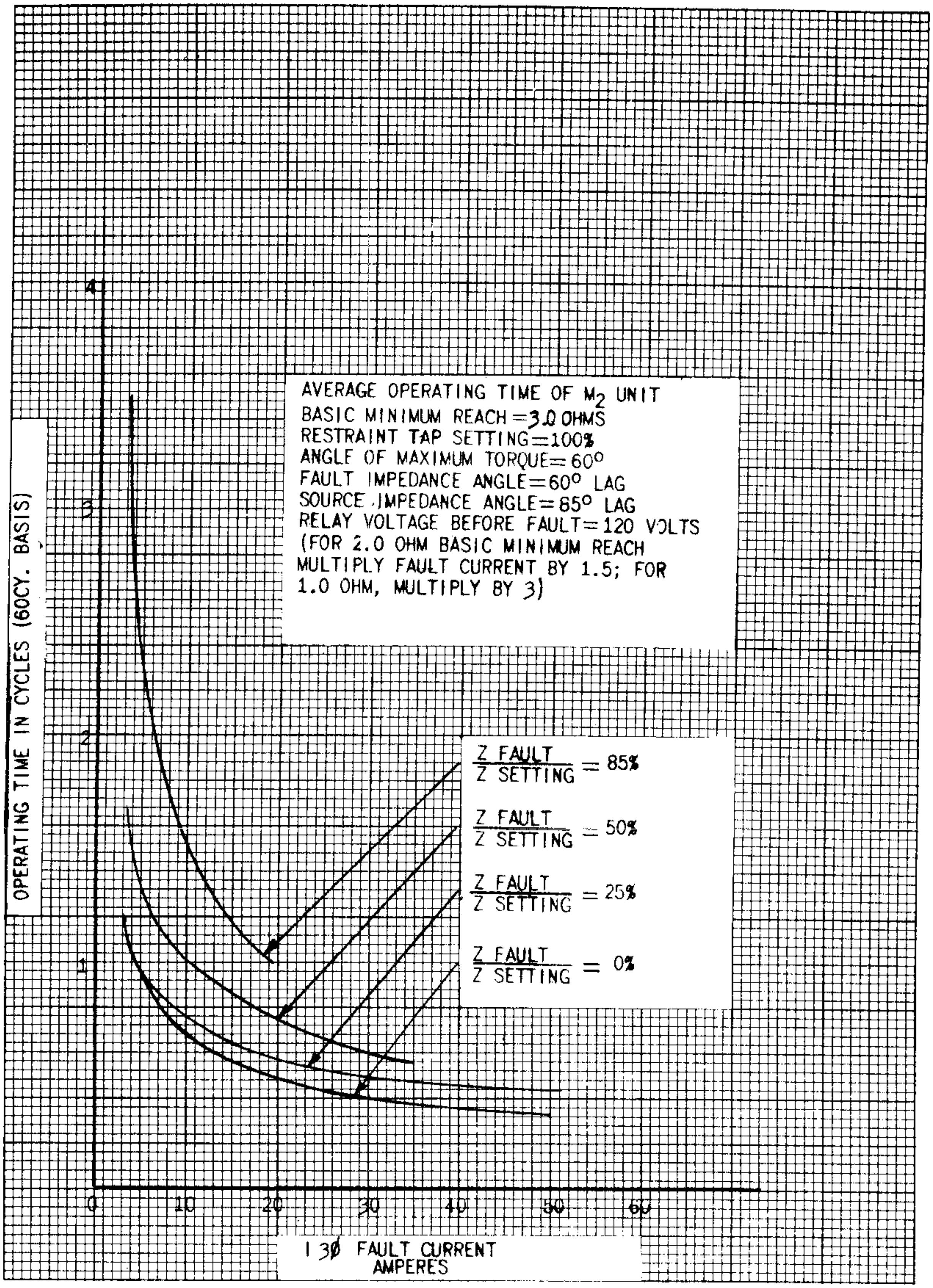
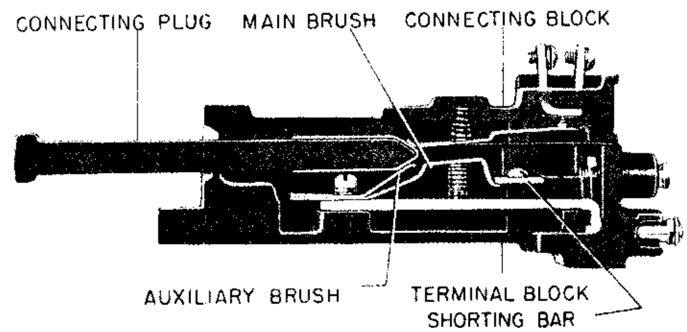
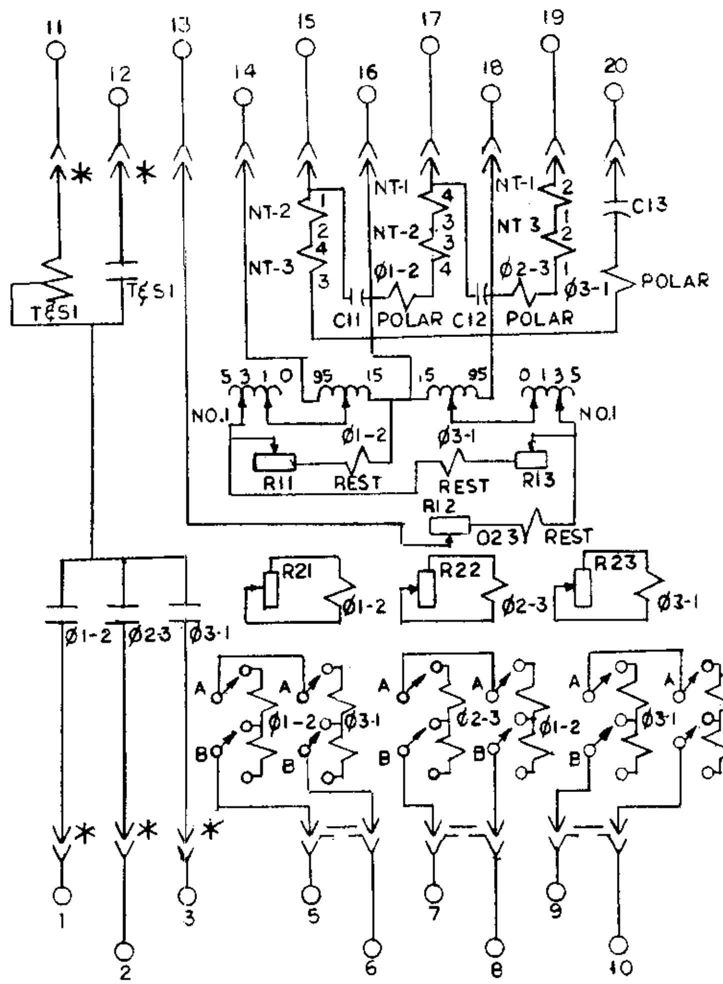


Fig. 8 (0178A8176-0) Time Curves for M_2 Unit in the CEY52A Relay



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

Fig. 9 (8025039) Cross Section of Drawout Case Showing Position of Auxiliary Brush and Shorting Bar

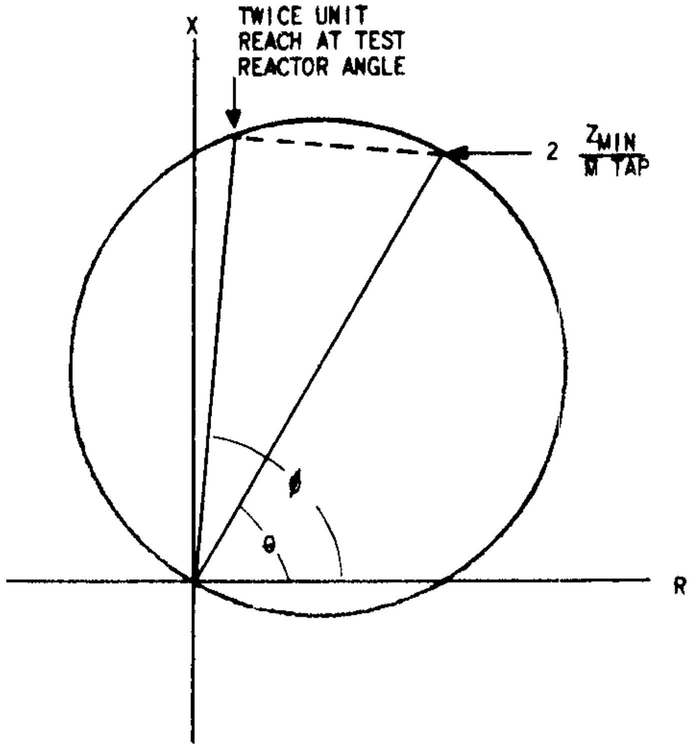


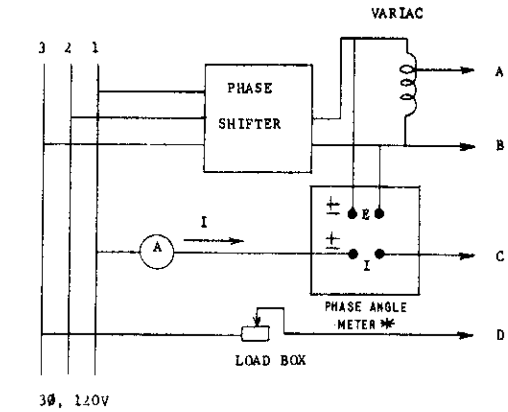
01-2=TOP UNIT
02-3=MIDDLE UNIT
03-1=BOTTOM UNIT

*=SHORT FINGER

* Fig. 10 (0178A7133[5]) Internal Connections Diagram for the CEY52A Relay (Front View

* Indicates revision



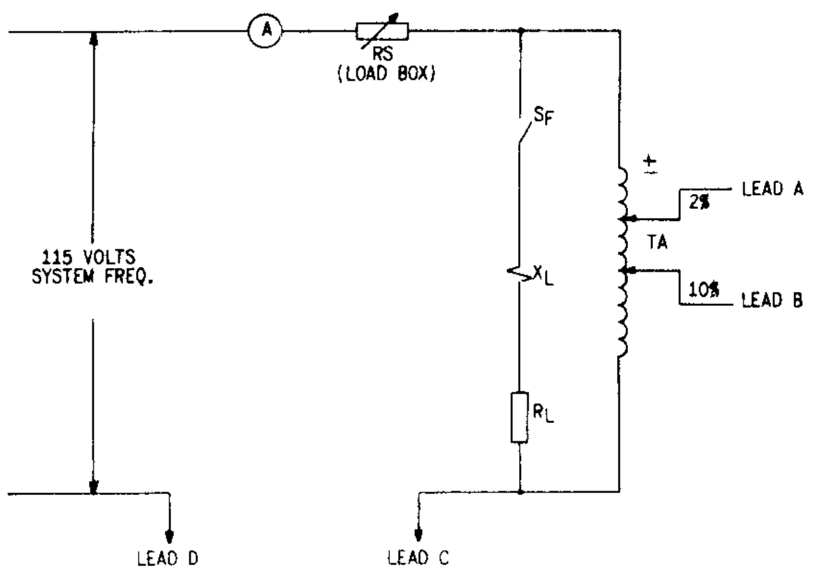


* = PHASE ANGLE METER READS THE ANGLE THAT THE CURRENT LEADS THE VOLTAGE.

UNIT LOCATION	UNIT	CONNECT LEAD TO RELAY STUDS AS FOLLOWS				JUMPER RELAY STUDS
		LEAD A	LEAD B	LEAD C	LEAD D	
TOP	φ1-2	14-15	13-16-17	5	7	6-8-10
MIDDLE	φ2-3	13-16-17	18-19-20	7	9	6-8-10
BOTTOM	φ3-1	18-19-20	14-15	9	5	6-8-10

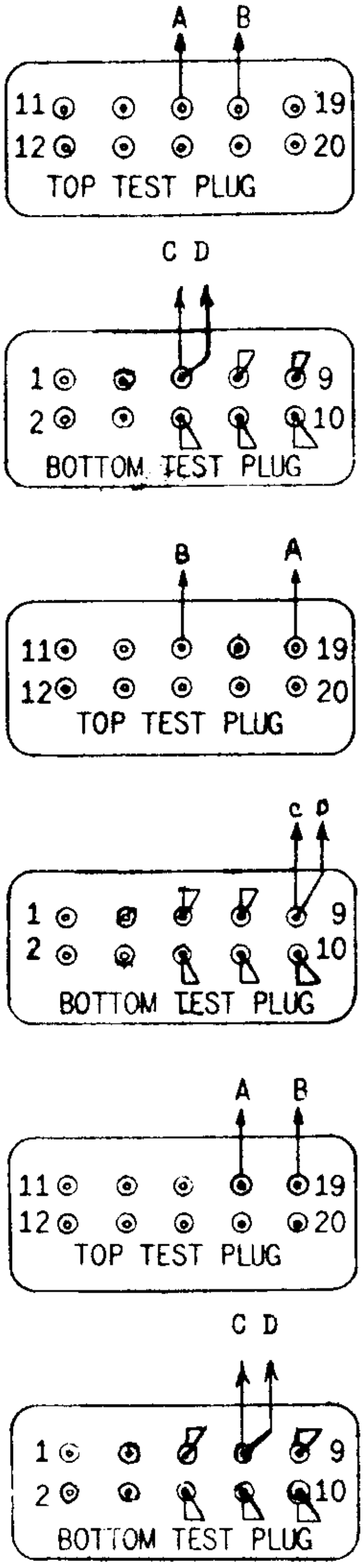
Fig. 11 (0195A4991-1) Test Connections for Checking the Correct MHO Unit Operation

Fig. 12 (0195A4992-0) Diagram Showing Reach of MHO Unit at Angle of Test Reactor



UNIT LOCATION	UNIT	CONNECT LEAD TO RELAY STUDS AS FOLLOWS				JUMPER RELAY STUDS
		LEAD A	LEAD B	LEAD C	LEAD D	
TOP	φ 1-2	14-15	13-16-17	5	7	6-8-10
MIDDLE	φ 2-3	13-16-17	18-19-20	7	9	6-8-10
BOTTOM	φ 3-1	18-19-20	14-15	9	5	6-8-10

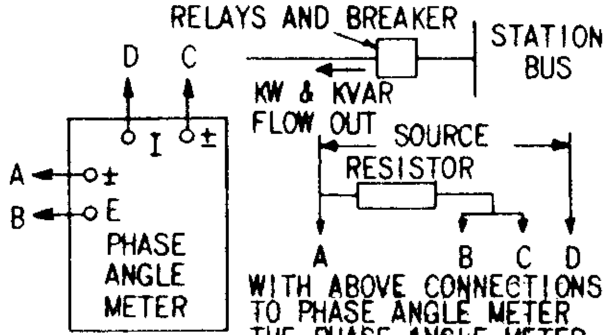
Fig. 13 (0195A4994-0) MHO Unit Test Connections



(a) CONNECTIONS TO PHASE ANGLE METER TO CHECK PHASE 1 CURRENT AND PHASE 1-2 VOLTAGE.

(b) CONNECTIONS TO PHASE ANGLE METER TO CHECK PHASE 3 CURRENT AND PHASE 3-1 VOLTAGE.

(c) CONNECTIONS TO PHASE ANGLE METER TO CHECK PHASE 2 CURRENT AND PHASE 2-3 VOLTAGE.



WITH ABOVE CONNECTIONS TO PHASE ANGLE METER THE PHASE ANGLE METER SHOULD READ ZERO DEGREES

POWER FACTOR ANGLE (DEGREES LEAD)	0-45	45-90	90-135	135-180	180-225	225-270	270-315	315-360
KW AND KVAR DIRECTION 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
PHASE ANGLE METER CONNECTIONS / **PHASE SEQUENCE**								
(a) 1-2-3	330-15	15-60	60-105	105-150	150-195	195-240	240-285	285-330
(b) 1-2-3	330-15	15-60	60-105	105-150	150-195	195-240	240-285	285-330
(c) 1-2-3	330-15	15-60	60-105	105-150	150-195	195-240	240-285	285-330
(a) 1-3-2	30-75	75-120	120-165	165-210	210-255	255-300	300-345	345-30
(b) 1-3-2	30-75	75-120	120-165	165-210	210-255	255-300	300-345	345-30
(c) 1-3-2	30-75	75-120	120-165	165-210	210-255	255-300	300-345	345-30

Fig. 14 (0195A4993[1]) Overall Test Connections for Checking of External Wiring to Relay

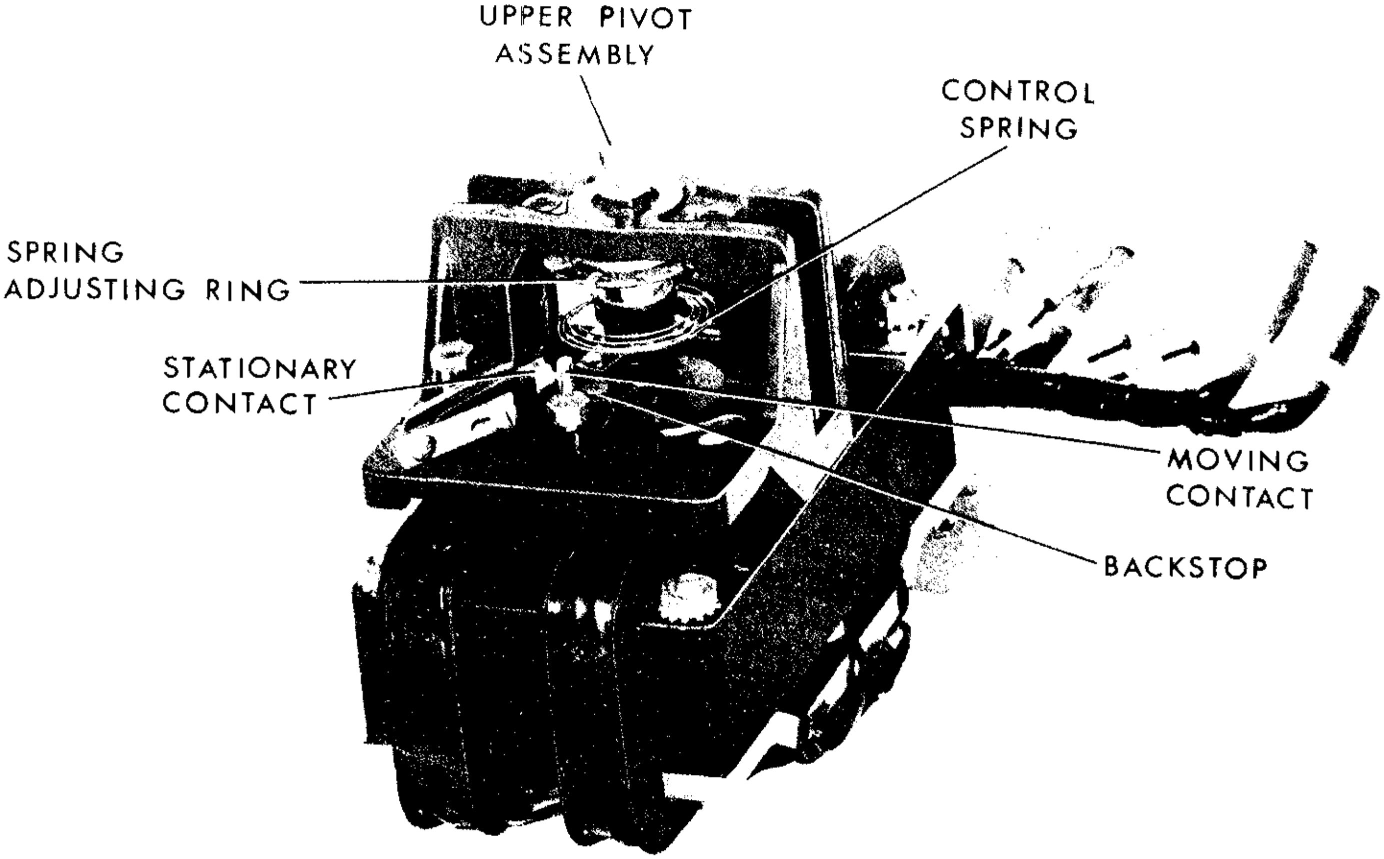


Fig. 15 (8034958) Four Pole Induction Cylinder Unit,
Typifying Construction in the CEY52A Relay

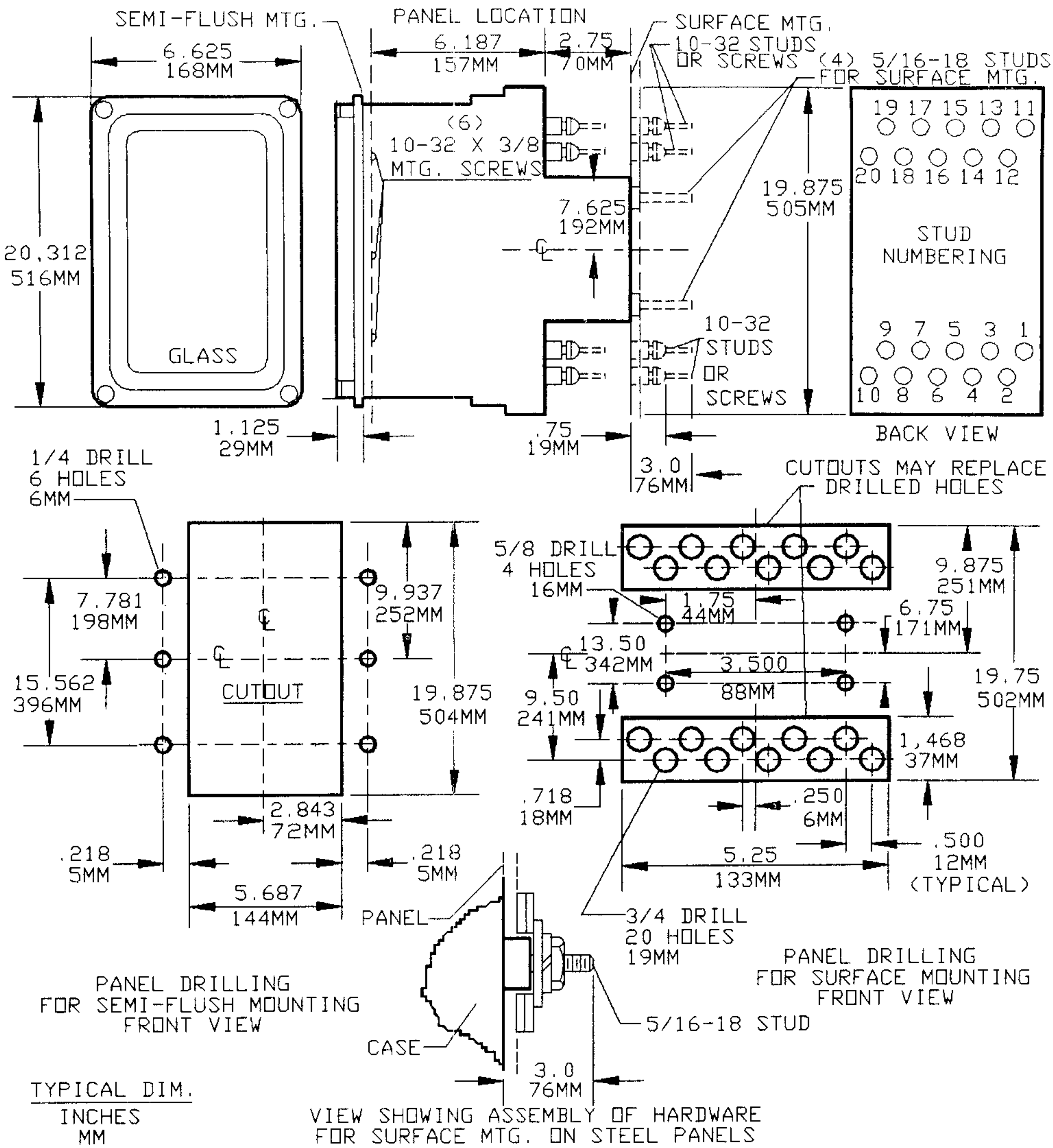


Fig. 16 (0178A7336-6) Outline and Panel Drilling Dimensions for the CEY52A Relay

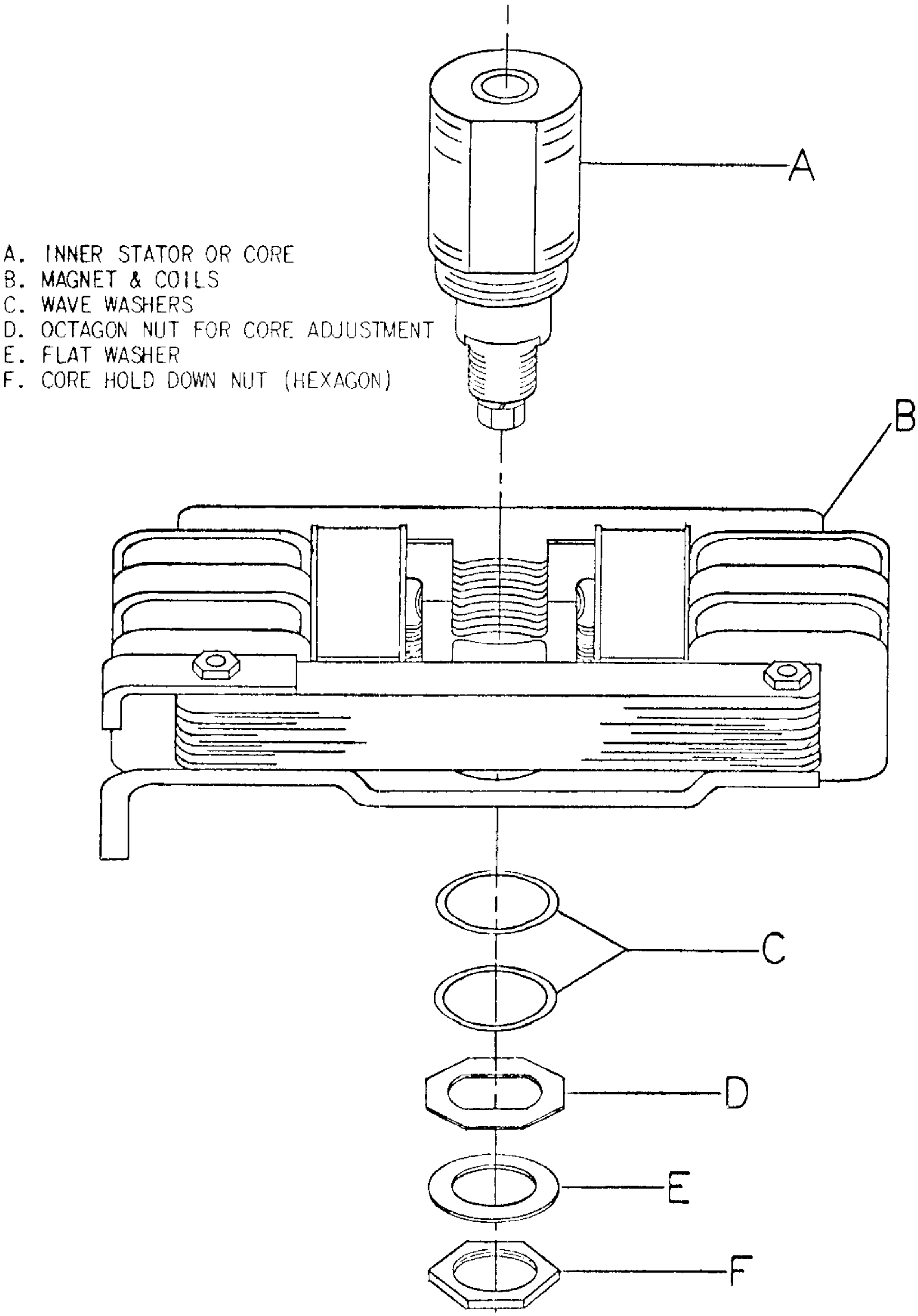


Fig. 17 (0208A3583-0) Core Adjustment