INSTRUCTIONS

OFFSET MHO DISTANCE RELAY

TYPE CEB52A

GENERAL ELECTRIC

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NOTE: This instruction book has had a major revision. Please check your previous revision to compare material.

OFFSET MHO DISTANCE RELAY

TYPE CEB52A

INTRODUCTION

The CEB52A relay is a three-phase, high speed, single zone directional mho distance phase relay with provisions for offsetting the characteristic a fixed amount. It is constructed of three-single-phase units in one L2-D case with facilities for single-phase testing. One target and seal-in unit provides indication of operation on all three units. The transient over-reach characteristics of the CEB52A relay have not been limited to the point where it is suitable for use as a first zone relay. This relay was designed primarily for use as a carrier starting relay in directional comparison schemes. It is also applicable as a second or third zone relay in straight distance schemes.

APPLICATION

The CE852A was specifically designed for application as a carrier starting relay in directional comparison relaying schemes. To serve this purpose the relay is equipped with normally closed contacts as well as with normally open contacts. Since many originally straight distance terminals are later converted to directional comparison terminals, the CEB52A should be used as the third zone relay in straight distance schemes to facilitate any future conversion.

The offset feature should always be used when the relay is employed to start the carrier or when it is required to operate in conjunction with some time delay for zero voltage faults.

In carrier starting applications the normally closed contacts are closed under normal conditions to hold off carrier. When line side potentials are employed, and the line is deenergized, the relay will have no electrical restraint and will depend on the control spring to provide sufficient contact pressure to keep carrier turned off. It is for this reason that this relay has a relatively strong spring setting. Figs. 5 and 6 give the operating characteristics for this relay with the strong spring setting, with and without offset.

When the relay is employed with bus potentials, or if it is used in straight distance schemes, a weaker spring setting may be employed. The section under SERVICING describes how the spring setting can be changed. Figs. 7 and 8 give the operating characteristics for the weaker spring setting with and without offset. The CEB52A will be calibrated in the factory with the strong setting.

The CE852A relay and its comparison zone packaged relays may be combined in several different ways for use in straight distance and directional comparison relaying schemes. Fig. 17 illustrates how the CEY51A, CEY52A, and CEB52A relays plus the RPM21D timing relay may be employed for three zone directional distance protection of transmission circuits against all multi-phase faults. Separate ground fault relays are required for single-phase-to-ground faults. Fig. 18 shows how these same distance relays plus a SAM16A static timing relay and the necessary ground and auxiliary relays are combined in a directional comparison relaying scheme.

The section under CALCULATION OF SETTINGS provides a typical worked example covering the setting of this relay.

CALCULATION OF SETTINGS

Consider one terminal of a two terminal 69KV transmission line, 17.3 miles long having a phase-to-neutral impedance of

$$Z_{prim} = 0.14 + j\ 0.80 \text{ ohms per mile}$$

$$Z = 17.3\ (0.14 + j\ 0.80) = 2.4 + 13.9 \text{ ohms total}$$

$$\text{PT Ratio} = 69{,}000/116 = 600/1$$

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

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

$$Z_{sec} = (2.4 + j\ 13.9)\ \frac{120}{600} = 0.48 + j\ 2.78 \text{ ohms}$$

$$Z_{sec} = 2.82 \angle 80.2^{o} \text{ ohms}$$

Assume that the CEB52A is to be used to provide third zone protection in the forward direction and it is desired to set the forward reach for 6.0 ohms at an angle of 80.2 degrees. This setting having been arrived at after due consideration to coordinate with the phase relays on adjacent circuits and taking current infeed into account.

Case I - No offset required

With the angle of maximum torque of the relay at 75 degrees, the percent tap setting required is obtained from the following equation.

$$\text{Output Tap} = \frac{100\ (3.0)\text{Cos}(80.2 - 75)}{6.00}$$

$$= 49.8 \text{ percent}$$

Set the output tap at 50 percent.

Case II - Offset required

Since the offset setting is along the reactance axis on the R-X diagram, it is easiest to arrive at the proper tap setting by means of a graphical solution as outlined below.

1. Draw the R-X diagram as in Fig. 2.
2. Draw line OA at the impedance angle of the line and measure off the length to be protected. In this case it is 6.0 ohms.
3. Through the point S, representing the offset, which in this case is (R = 0, X, = 0.5), draw the line BC at the angle of maximum torque for which the relay is set. In this case it is 75 degrees.
4. By trial and error draw a circle which has its center on line BC and which passes through both points P and S. This circle represents the desired setting.
5. Measure the diameter of the circle SM. In this case it measures 6.55 ohms.
6. The desired OUTPUT TAP setting in percent is given by the following equation:

$$\text{Output Tap} = \frac{(100)\ (\text{Minimum Reach})}{\text{Desired Diameter}}$$

$$\text{Output Tap} = \frac{(100)\ (3.0)}{6.55} = 45.8$$

Set the OUTPUT TAP for 46 percent.

RATINGS

The type CEB52A relays covered in these instructions are available with ratings given in Table I.

TABLE I

Rated Voltage (Volts)	120	120	120	120	120
Rated Frequency (Hertz)	60	60	60	60	50
Rated Current (Amperes)	5.0	5.0	5.0	5.0	5.0
Basic Ohm Reach Taps	0.5/1.0/1.5	1/2/3	1/2/3	2/4/6	1/2/3
Offset Ohm Tap	0.25	0.20	0.5	0.5	0.5
Angle of Max. Torque**	75	75	75	75	75
One Second Rating (Offset Out) (Amps)	260	260	260	1.45	260
One Second Rating (Offset In) (Amps)	145	225	90	90	145

**The angle of maximum torque can be adjusted to 60 degrees lag with the connections shown in Fig. 13 and by adjusting R_{21} for the top unit, R_{22} for the middle unit and R_{23} for the bottom unit, but the reach at the 60 degree setting will be 20 percent less than the reach at the 75 degree setting.

It will be noted that three basic minimum reach settings are listed for the OM 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 realy (see Fig. 2). The position of the two sets of links, (for each unit), each identified as A-B determines the basic minimum setting of the mho units. The basic minimum reach setting = (A + 8) line settings. The ohmic reach of the OM units can be adjusted in one percent steps over a 10/1 range for any of the basic minimum reach settings listed in Table II by means of autotransformer tap leads on the tap blocks at the right side of the relay. The OM units may be offset. Selection of either zero or 0.5 ohms offset is made by means of links on terminal boards located on the rear of the relay.

CONTACTS

The contacts of the CEB52A 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 CEB52A relays has ratings as shown in Table II.

TABLE II

TARGET SEAL-IN UNIT

Pickup Rating	0.2	2.0		0.6	2.0
Tap Used	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	20		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 drop-out (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 amps @175 VDC			2.5 amps @125 VDC	

OPERATING PRINCIPLES

OM UNIT - ZERO OFFSET

The OM units of the CEB52A relay are of the four pole induction cylinder construction in which torque is produced by the interaction between a polarizing flux or fluxes proportional to the restraining or operating quantities.

The schematic connections of the mho unit are shown in Fig. 3. 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:

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

where:

E = phase-to-voltage (E_{12})
I = delta current ($I_1 - I_2$)
θ = angle of maximum torque of the unit
$\emptyset$ = 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:

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

or:

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

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.

When offset is used the transactors ($\emptyset 1$, $\emptyset 2$ and $\emptyset 3$) are energized with line currents and introduce a voltage (proportional to the current) added to the line-to-line voltage received by the units. This voltage offsets the circular characteristic of the OM units in the R-X diagram.

CHARACTERISTICS

OM UNIT - WITH OFFSET

When the offset is used the circular characteristic is moved along the X-axis as shown in Fig. 4.

OM UNIT - ZERO OFFSET

Impedance Characteristic

The impedance characteristic of the OM unit is shown in Fig. 4 for the three ohm basic minimum reach setting at a maximum torque angle 75 degrees. This circle can be expanded by means of the mho taps on the autotransformer tap block providing a range of up to 10/1, 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 30/1. The circle will always pass through the origin and have a diameter along the 75 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

Directional Action

The OM unit is carefully adjusted so that when it is connected for zero offset it will 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:

TABLE III

Basic Min Reach Tap	**Volts (Studs 17-18)	Current Range for Correct Directional Action (Amps)
0.5	4.0	12 - 60
1.0	4.0	6 - 60
1.5	4.0	4 - 60
2.0	4.0	3 - 60
3.0	4.0	2 - 60
4.0	4.0	2 - 60
6.0	4.0	1 - 60

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

The values given in the above table are for the "strong spring setting". For the "weak spring setting" the same currents limits apply at 2.0 volts. The relay is shipped with "strong setting". If the "weak spring setting" is desired refer to CONTROL SPRING ADJUSTMENTS under SERVICING for instructions.

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.

Underreach

At reduced voltage the ohmic value at which the OM unit will operate may be somewhat lower than the calculated value. This "pullback" or reduction in reach is shown in Figs. 5 and 6 for the "Strong Spring Setting". 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 OM unit will operate for all points to the right of the curve. The steady-state curves of Figs. 5, 6, 7, and 8 were determined by tests performed with no voltage supplied to the relay before the fault was applied. The dynamic curves were obtained with full rated voltage of 120 volts supplied to the relay before the fault was applied.

Memory Action

The dynamic curves of Figs. 5 and 7 illustrate the effect of memory action in the OM 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 OM unit to operate for low fault currents. This can be most forcefully illustrated for a zero voltage fault by referring to Figs. 5 and 7. A zero voltage fault must be right at the relay bus and therefore, to protect for this fault, it is imperative that the relay reach zero percent of its setting. Figs. 5 and 7 show that the mho unit, under static conditions will not see a fault at zero percent of the relay setting regardless of the tap setting. However, under dynamic conditions when the memory action is effective, Fig. 5 shows that the mho unit with a three ohm basic minimum reach and 100 percent tap setting will operate if $I_{3\phi}$ is greater than two 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 to trip the breaker through the contacts of a timing relay the static characteristic should be used. For this application the relay is not required to operate for nearby faults and there will be sufficient voltage to give tripping without depending on memory action.

Transient Overreach

Under transient conditions the OM unit has a tendancy to close its contact momentarily for a fault impedance greater than its impedance setting. This tendency is called transient overreach and is a function of the degree of asymmetry in the fault current wave, and the circuit angle (the angle of system from the point of the fault to the source of generation). For normal CEB52A applications, transient overreach is of no significance since the OM unit does not perform a precise measuring function.

Operating Time

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

The operating time curves for the OM unit are shown in Figs. 9 and 10. All curves in these figures are for the condition of rated volts prior to the fault with 100 percent restraint tap setting.

The curves in Fig. 9 show the average operating time of the unit, that is the time to close the normally open contact with the unit connected for zero offset. These curves also apply for faults in the forward direction if the unit is connected for 0.5 ohm offset.

The curves in Fig. 10 show opening times of the normally closed contact, with the unit connected for 0.5 ohm offset for faults in the direction of the offset (reverse). It will be noted that for equivalent conditions, that is for the same operating current and the same ratio of fault impedance to reach setting (or offset), the OM unit is faster for faults in the forward direction. This results from the strong initial "memory action" inherent in the unit which tends to sustain the polarizing flux for a few cycles following inception of the fault. For faults in the forward direction this produces a higher operating torque and hence faster operation.

TAPPED AUTOTRANSFORMER

The ohmic reach of the OM units may be adjusted by means of taps on the two autotransformers. Each autotransformer has two windings. One winding is tapped in 10 percent steps from 15 percent to 95 percent. The other winding is tapped at 0 percent, 1 percent, 3 percent and 5 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 0-5 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 the positive phase sequence phase-to-neutral impedance expressed in secondary terms, is determined by the following equation:

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

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 5 percent. Set No. 1 on 1 percent. (Note the 4 percent setting of the 0-5 percent winding subtracts from the 95 percent settings.

Example 2:

TAP SETTING DESIRED = 89

Set one end of jumper lead to 85 percent. Set the other end to 1 percent. Set No. 1 to 5 percent. (Note the 4 percent setting of the 0-5 percent winding adds to the 85 percent setting).

BURDENS

CURRENT CIRCUITS

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

TABLE IV

Rated Frequency	Ohmic Reach	R	X	P.F.	Watts	VA
60	0.5-15	0.108	0.022	0.98	2.70	2.75
60	1-30	0.153	0.056	0.94	3.83	4.08
60	2-60	0.610	0.328	0.88	15.2	17.3
50	1-30	0.100	0.020	0.98	2.50	2.55

This data is for the maximum basic reach tap setting. The burden on the two lower basic reach tap settings will be lower. The above data includes the burden of the transactor used to offset the mho characteristic. If the offset tap is in zero the burden will be slightly less.

POTENTIAL CIRCUITS

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

TABLE V

Circuit	Rated Frequency	R	X	P.F	Watts	VA
Polarizing	60	1540	-j162	0.99	9.1	9.2
Restraint	60	1025	+j1460	0.57	4.6	8.0
Polarizing	50	1800	-j175	0.99	7.9	8.0
Restraint	50	1020	+j1440	0.58	4.7	8.2

The potential burden of the OM 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) and (c + jd) represent the burden of the mho unit potential circuits expressed in watts and vars with their taps on 100 percent. The values of these terms are given in Table VI.

TABLE VI

Rated Frequency	"a" Watts	"b" Vars	"c" Watts	"d" Vars
60	4.6	+j6.5	9.1	-j1.0
50	4.7	+j6.6	7.9	-j0.8

CONSTRUCTION

The type CEB52A 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 connecting 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. 11, to provide adequate overlap when the connecting plug is withdrawn or inserted. Some circuits are equipped with shorting bars (see internal connections in Fig. 12), and on those circuits, it is especially important that the auxiliary brush make contact as indicated in Fig. 11 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 blocks. 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 semiflush 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 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 shows 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. 12.

The relay includes three similar mho sub-assembly 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).

The mho sub-assembly includes the four pole unit and the 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 and for selecting the offset 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 a part of a control panel, will be shipped in cartons designed to protect them against damage. Immediately upon receipt of a relay, examine it for any damage 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 Company 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, an 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	OM UNITS
Rotating Shaft End Play	0.010 - 0.015 Inch
Contact Gap	0.040 - 0.060 Inch
Contact Wipe	0.003 - 0.005 Inch

ELECTRICAL CHECKS - OM UNITS

Before any electrical checks are made on the mho units the relay should be connected as shown in Fig. 13 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 calibrations by means of the tests described in the following sections. The OM 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 OM unit operation are shown in Fig. 13.

1. CONTROL SPRING ADJUSTMENT

Be sure that the relay is level in its upright position. Leave the relay connected as shown in Fig. 13 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 studs at 120 volts, set the phase shifter so that the phase angle meter reads the value shown in Table VIIIa 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 one ampere. Gradually increase the current until the contacts of the unit just close. This should occur between the current listed in Table VIII.

TABLE VIII-a

Basic Minimum Reach Tap	Tap Used	Phase Angle Meter Reads	Set V_{AB} (Volts)	Pickup Current (Amps)	Offset
0.5 - 1.5	1.0	285	4.0	4.25 - 5.75	Out
1.0 - 3.0	2.0	285	4.0	2.12 - 2.88	Out
2.0 - 6.0	4.0	285	4.0	1.06 - 1.44	Out

2. CLUTCH ADJUSTMENT

The OM 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. 13 and set the phase shifter so that the phase angle meter reads the value in Table IX for the unit to be checked, at 120 volts and five amperes. Disconnect the No. 1 restraint tap leads from the tap block and set the mho units for maximum basic minimum reach and offset "out". With the voltage across relay studs set at 120V, increase the current until the clutch just slips. This should occur between the values given below:

TABLE VIII-b

Basic Ohmic Range	Use Tap	Current to just Slip Clutch (Amps)
0.5 - 1.5	1.5	over - 60 amps
1 - 3	3.0	34 - 56
2 - 6	6.0	16.0 - 28

3. OHMIC REACH

With the relay still connected as shown in Fig. 13 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 in Table IX. Note that the links on the tap blocks are set to the position which gives the basic minimum reach shown in the table.

Note that for the test conditions, the OM units sees 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 setting. If the units are set on either of the remaining basic minimum reach taps, the basic reach of the units will be within ±5 percent of the tap plate marking.

NOTE: Basic minimum reach is equal to (A + B) link settings.

TABLE IX

Basic Minimum Reach Tap	Tap Used	Phase Angle Meter Reads	Set V_{AB} (Volts)	Pickup Current (Amps)	Offset
0.5 - 1.5	1.0	285	40	19.2 - 20.8	Out
1.0 - 3.0	2.0	285	60	14.4 - 15.6	Out
2.0 - 6.0	4.0	285	60	7.2 - 7.8	Out

4. ANGLE OF MAXIMUM TORQUE

For checking the angle of maximum torque the connections of Fig. 13 will be used with the restraint tap leads set at 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 on the middle reach position.

In checking the mho units the following procedure would be used. First set the phase shifter so that the phase angle meter reads 315 degrees. Note that while the phase angle is being set, the current should be at five amperes and the voltage 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 255 degrees and again check the current required to pick up the mho unit. This current should fall within the same limits as for the 315 degree check.

Note that the two angles used in the previous check, i.e. 315 degrees and 255 degrees, are 30 degrees away from the angle of maximum torque. An examination of the OM unit impedance characteristic in Fig. 4 shows that the ohmic reach of the unit should be the same at both 315 degrees and 255 degrees and should be 0.866 times the reach at the angle of maximum torque.

TABLE X

Basic Minimum Ohmic Tap	Use Tap	Phase Angle Meter Reading			V_{AB} Set at (Volts)	Pickup (amps)	Offset
		Maximum Torque Angle	Test Angles				
0.5 - 1.5	1.0	285	315	255	40	21.7 - 24.5	Out
1 - 3.0	2.0	285	315	255	60	16.5 - 18.5	Out
2 - 6	4.0	285	315	255	60	8.2 - 9.2	Out

5. OFFSET CHECK

With the relay connected as shown in Fig. 13 and the restraint tap leads in the 100 percent position, make settings shown on Table XI and set the phase shifter so that the phase angle meter reads the angle shown in the table for the unit to be checked.

Reduce the voltage to the value shown and increase the current gradually until the normally open contacts of the unit just close. This should occur within the current limits shown in Table XI.

TABLE XI

Basic Minimum Ohmic Tap	Use Tap	Phase Angle Meter Reads	Offset	V_{AB} Set at (Volts)	Pickup (Amps)
0.5 - 1.5	1.0	105	0.25	10	18 - 22
1.0 - 3.0	2.0	105	0.20	8	18 - 22
1.0 - 3.0	2.0	105	0.50	20	18 - 22
2.0 - 6.0	4.0	105	0.50	20	18 - 22

ELECTRICAL TESTS - TARGET SEAL-IN UNIT

The target seal-in unit has operating coils as given in Table II.

The relay is shipped from the factory with the tap screw in the maximum ampere position. The operating point of the seal-in unit can be checked by connecting from 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 12 to stud 1 also so that the seal-in contact will protect the OM unit contacts. Then close the OM 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 OM 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. 20.

CONNECTIONS

The internal connections of the CEB52A relay are shown in Fig. 12. An elementary diagram of typical external connections is shown in Figs. 17 and 18.

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 under 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. 14 is recommended. In this first $R_S + jK_S$ is the source impedance, SF 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 TA, which is across the fault switch and line impedance is tapped in 10 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.

OFFSET CHECK

With the relay connected as shown in Fig. 13 and the restraint tap leads in the 100 percent position, make settings shown on Table XI and set the phase shifter so that the phase angle meter reads the angle shown in the table for the unit to be checked.

Reduce the voltage to the value shown and increase the current gradually until the normally open contacts of the unit just close. This should occur within the current limits shown in Table XI.

For convenience in field testing, the fault switch and tapped autotransformer of Fig. 14 have been arranged in a portable test box, Cat. No. 102-L201, 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 OM UNITS

The manner in which reach settings are made forthe OM 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 OM units at the settings which have been made for a particular line section.

To check the calibration of the OM units, it is suggested that the portable test box, Cat. No. 102-L201; portable test reactor, Cat No. 6054975; and test resistor, Cat. No. 6158546 be arranged with Type XLA test plugs according to Fig. 15. These connections of the test box and other equipment are similar to the schematic connections shown in Fig. 14 except that the Type XLA test plug connections are now included.

Use of the source impedance $R_S + kX_S$, 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 the unit angle of maximum reach. From Fig. 16 it is seen that twice the relay reach of the angle of the test reactor impedance is:

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

where:

ϕ = 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 75 degrees. In determining the reactor tap setting to use, it may be assumed that the angle (ϕ) of the test reactor impedance is 80 degrees. From the above twice the relay reach at the angle of the test-reactor impedance is

$$2Z \text{ Relay} = 200 \text{ X} \frac{3}{100} \cos (80-75) = 5.98$$

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. Table XII shows the angles for each of the reactor taps.

TABLE XII

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 Table XII it is seen that the angle of the impedance of the six-ohm tap is 86 degrees. Therefore:

$$2\ Z\ \text{relay} = 200\ X \frac{3}{100} \cos\ (86-75) = 5.89\ \text{ohms}$$

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:

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

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's 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:

$$\% = \frac{5.89}{6.1} (100) = 96.6\% \text{ (use 97\% tap)}$$

Fig. 6 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 position. 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 autotransformer percent tap for pickup at a particular angle is given by:

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

where θ is the angle of maximum torque of the unit. $\emptyset$ is the angle of the test impedance (Z_L), Z_L 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 source impedance should be adjusted to allow approximately 10 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. 16 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 faulty 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 unit 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.

All nuts and screws should be tight, with particular attention 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 taken into account the shorter reach of the mho unit at low currents. This effect is shown in Fig. 6 or 7.

A shorter test which will check for most of the possible open circuits in the AC portion of the relay is to disconnect the current circuits. 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 AND 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. Their locations in the relay circuit are shown in the internal connection diagram of Fig. 12.

R_{11} - ϕ_1-2 unit ohmic reach adjustment.

R_{21} - ϕ_1-2 unit angle of maximum torque adjustment.

R_{12} - ϕ_2-3 unit ohmic reach adjustment.

R_{22} - ϕ_2-3 unit angle of maximum torque adjustment.

R_{13} - ϕ_3-1 unit ohmic reach adjustment.

R_{23} - ϕ_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.

DIRECTIONAL ADJUSTMENTS

Set the reach taps in the middle reach position on all taps. Set the restraint tap leads on 100%. Adjust the control spring so the moving contact just floats in the center of its travel. With offset at zero (0), connect the relay per Figure 13, but remove the voltage from leads "A-B" and short the terminals on the relay corresponding to "A-B" for the unit under test.

Adjust the core of the unit under test so that the contacts remain in the neutral position or have a slight opening bias as the current is increased from 0 to 60 amperes.

Unshort the potential studs.

CONTROL SPRING ADJUSTMENTS

Make connections to the relay as shown in Fig. 13 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 XIII. 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 XIII.

Now reduce the voltage to the test voltage value and set the current at the value shown in Table XIII for the unit being adjusted. Insert a blade of a thin screwdriver into one of the slots in the edge of the spring adjusting ring and turn the ring until the contacts of the unit just close. If the contacts were closing below the set point shown in Table XIII, 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 OM units can be adjusted by means of the rheostats which are accessible from the front of the relay. Connect the relay as shown in Fig. 13, leave the restraint taps at 100 percent, and be sure that the basic minimum reach taps are in the position shown in Table XIV. 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 XIV and adjust the appropriate rheostat so that the unit picks up at 15 amperes plus or minus two percent.

ANGLE OF MAXIMUM TORQUE

The angle of maximum torque of the OM units can be adjusted by means of rheostats which are accessible from the front of the relay. Use the connections in Fig. 13. Leave the restraint taps at 100 percent and be sure that the basic minimum reach taps are in the position shown in Table XIII.

The procedure used in setting angle of maximum torque is to adjust the reactor 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 XV. First, the reach of the unit at its angles of maximum torque should be checked and adjusted if necessary as described in OHMIC REACH ADJUSTMENT and Table XV. Next set the phase shifter so that the phase angle meter reads 315 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 reactor so that the ohm unit closes its contacts at 17.3 amperes plus or minus two percent. The pickup should then be checked at 255 degrees with the same set voltage and should be 17.3 amperes plus or minus two percent. Refine the adjustments or rheostats until the pickup is within limits at both 255 degrees and 315 degrees.

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 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.

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.

TABLE XIII

Basic Minimum Reach Taps	Tap Used	Phase Angle Meter Reads	Set V_{AB} (Volts)	Set Value of Current		Offset
				Strong Spring (Amps)	Weak Spring (Amps)	
0.5 - 1.5	1.0	285°	4.0	4.25-5.75	2.35-3.20	Out
1.0 - 3.0	2.0	285°	4.0	2.12-2.88	1.17-1.50	Out
2.0 - 6.0	4.0	285°	4.0	1.06-1.44	0.60-0.80	Out

TABLE XIV

Basic Minimum Reach Taps	Tap Used	Phase Angle Meter Reads	Set V_{AB} (Volts)	Pickup Current (Amps)	Adjustment Unit			Offset
					Top	Middle	Bottom	
0.5 - 1.5	1.0	285°	30	14.8-15.2	R_{11}	R_{12}	R_{13}	Out
1.0 - 3.0	2.0	285°	60	14.8-15.2	R_{11}	R_{12}	R_{13}	Out
2.0 - 6.0	4.0	285°	90	11.1-11.4	R_{11}	R_{12}	R_{13}	Out

TABLE XV

Basic Minimum Reach Tap	Tap Used	Phase Angle Meter Reads			Set V_{AB} (Volts)	Pickup (Amps)	Adjustment Unit			Offset
		Maximum Torque Angle	Test Angles				Top	Middle	Bottom	
0.5-1.5	1.0	285°	315	255	30	17.0-17.5	R_{21}	R_{22}	R_{23}	Out
1.0-3.0	2.0	285°	315	255	60	17.0-17.5	R_{21}	R_{22}	R_{23}	Out
2.0-6.0	4.0	285°	315	255	90	12.8-13.2	R_{21}	R_{22}	R_{23}	Out

Since the last edition, Figure 20 has been revised.

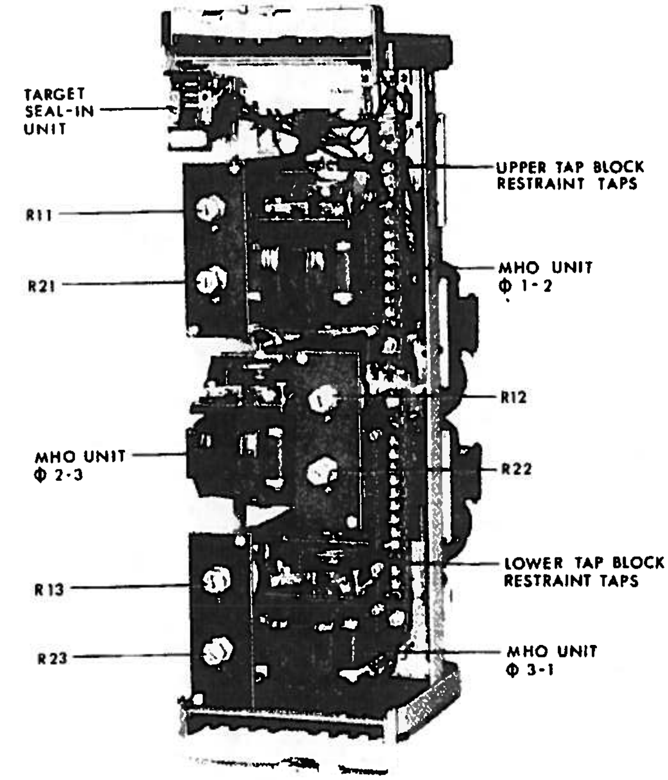


FIG. 1A (8036592) Front View

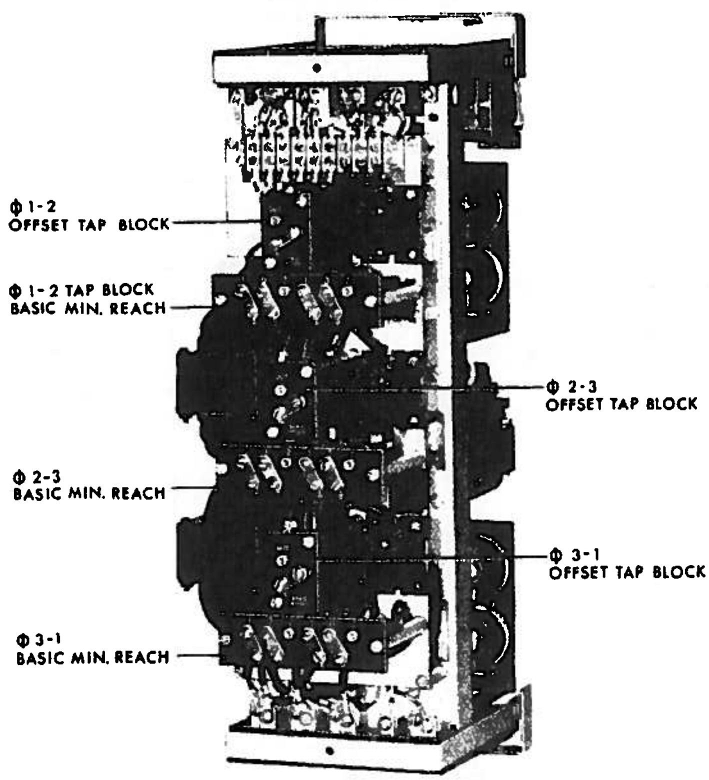


FIG. 1B (8036593) Back View

FIG. 1 Offset MHO Distance Relay CEB52A

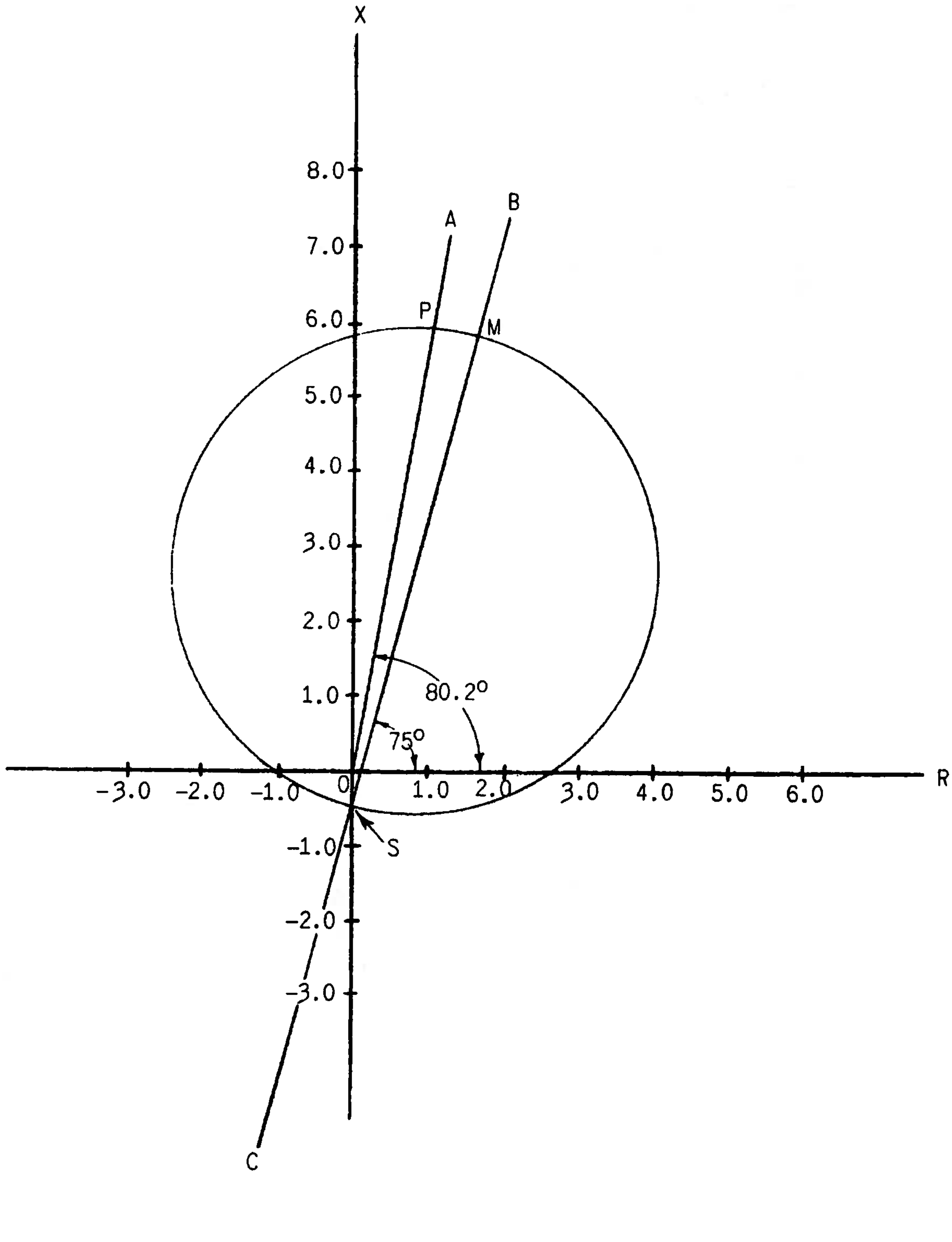


FIG. 2 (0127A9443-0) Graphical Construction of Offset MHO Diagram

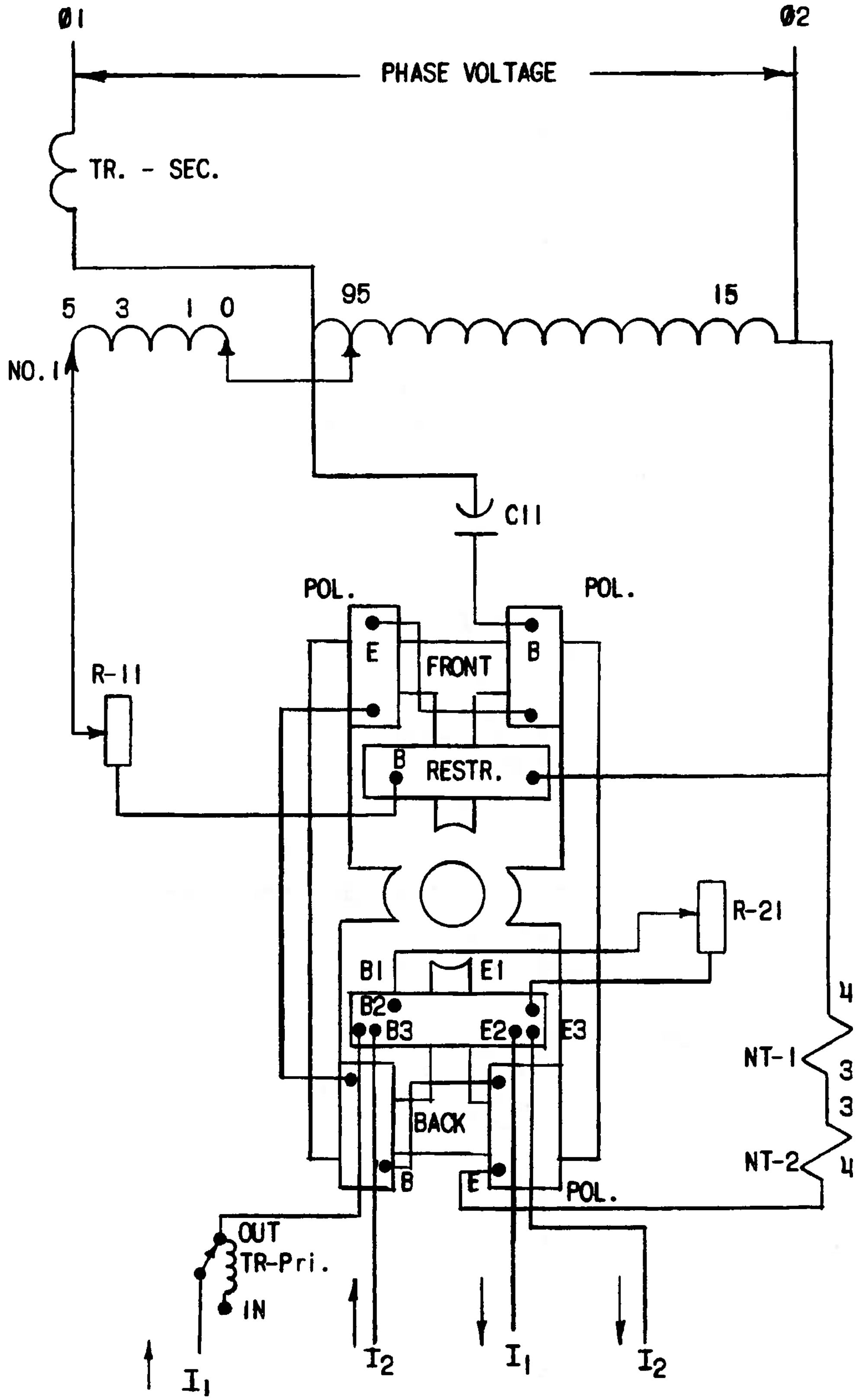


FIG. 3 (0246A3363-0) Schematic Connections of the MHO Unit

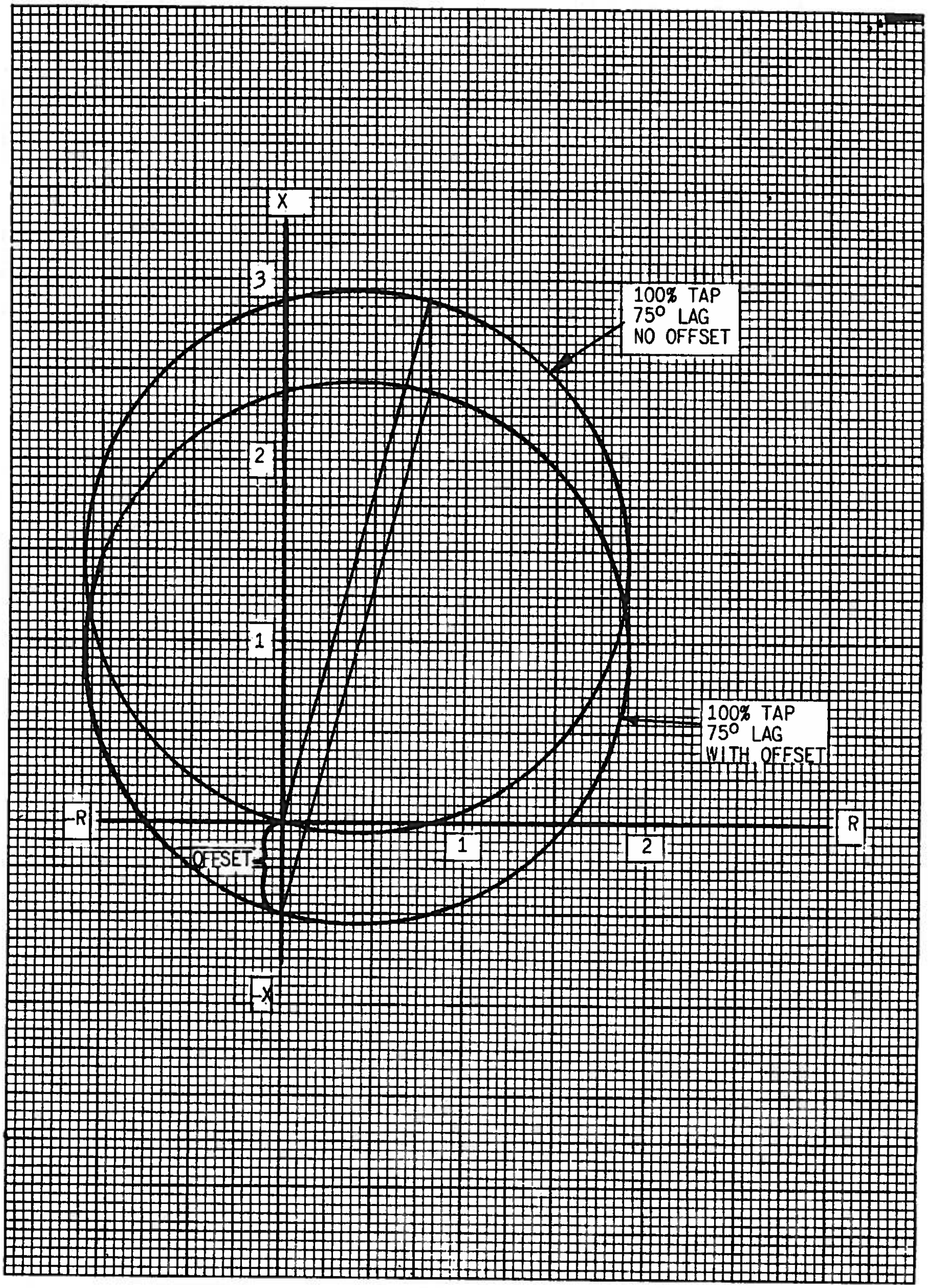


FIG. 4 (0127A9528) Steady State Impedance Characteristic of the OM Unit

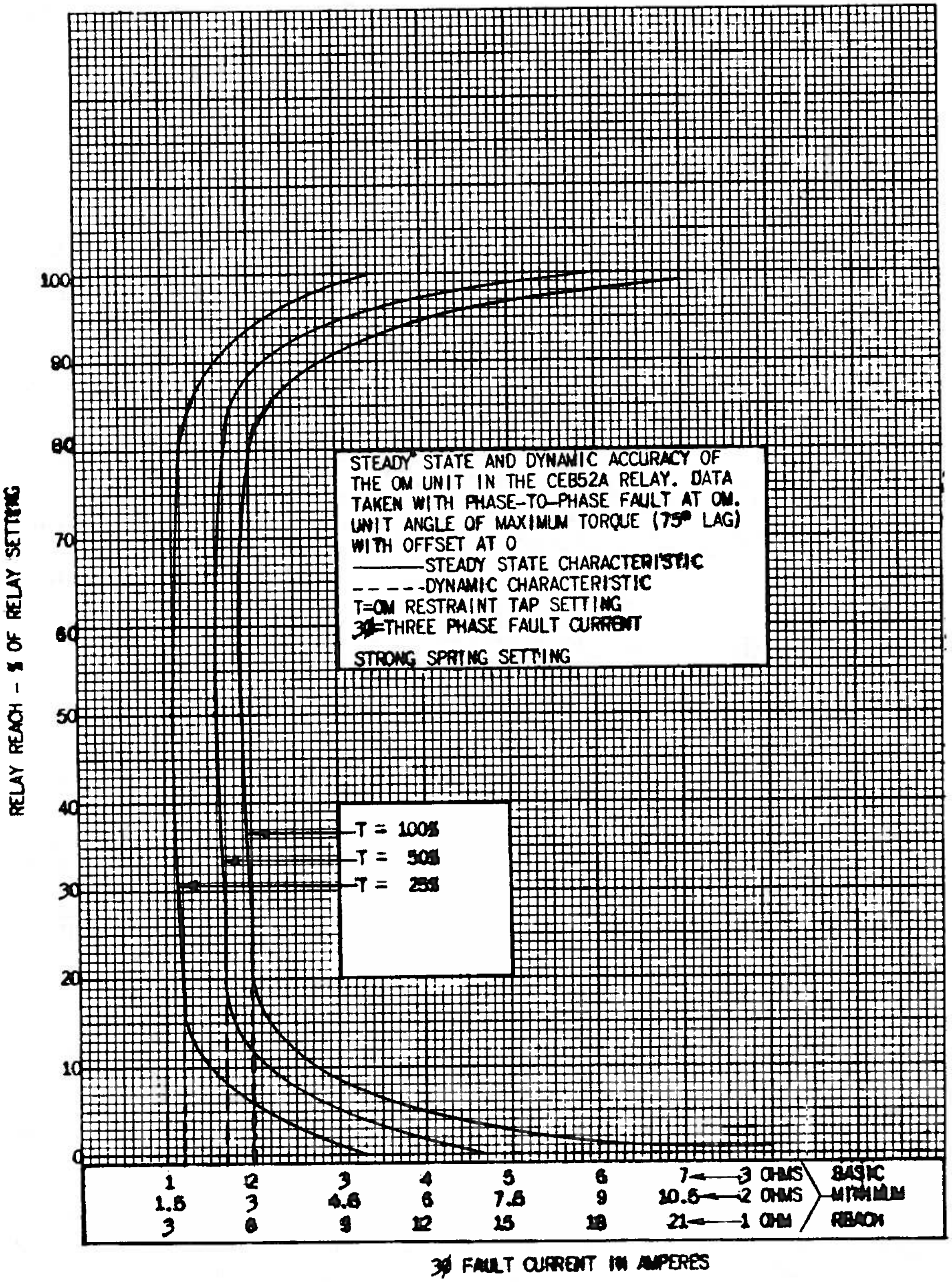


FIG. 5 (0203A8545-1) Steady State and Dynamic Accuracy of the OM Unit in the CEB52A Relay - Strong Spring Setting

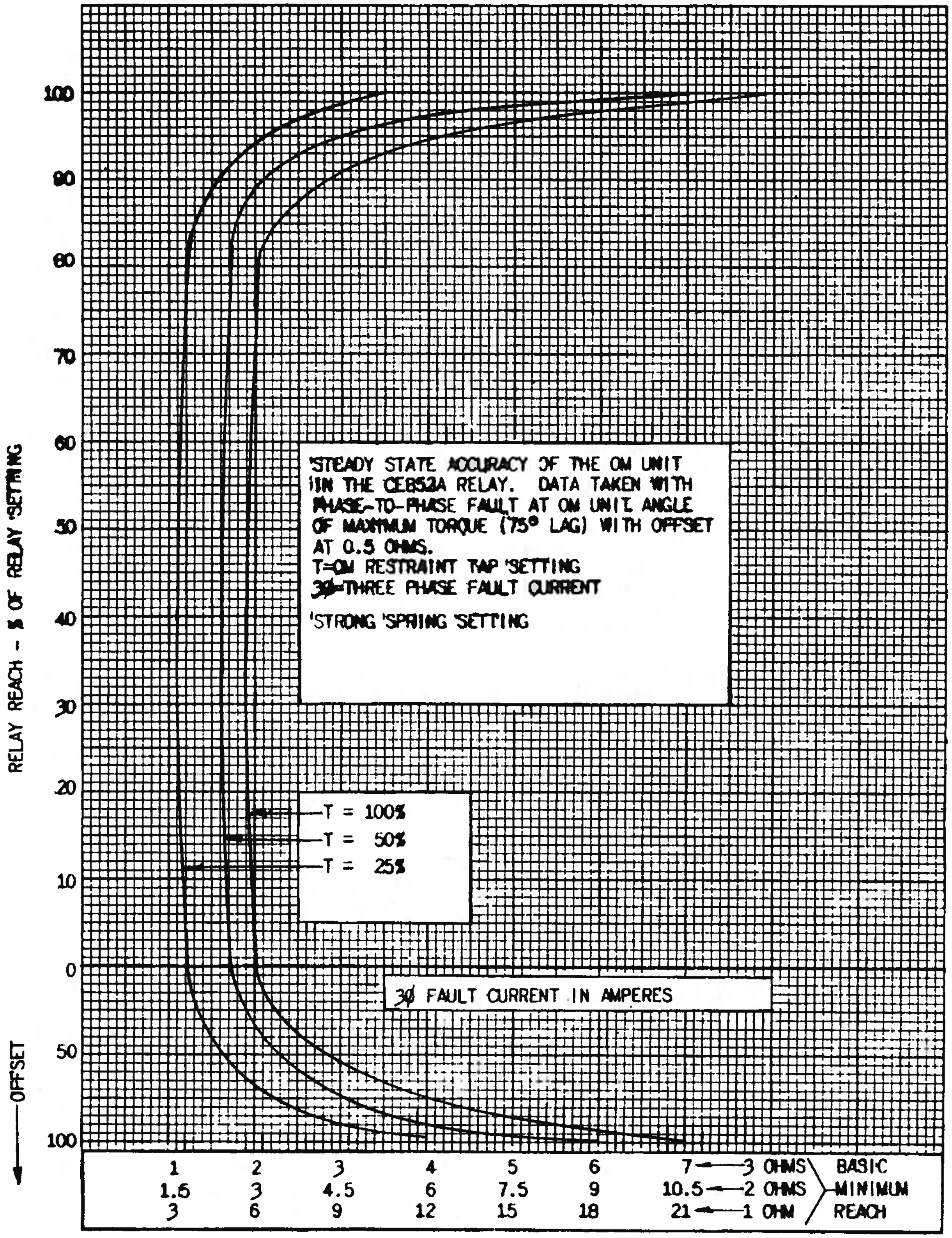


FIG. 6 (0203A8546-1) Steady State Accuracy of the OM Unit in the CEB52A Relay - Strong Spring Setting

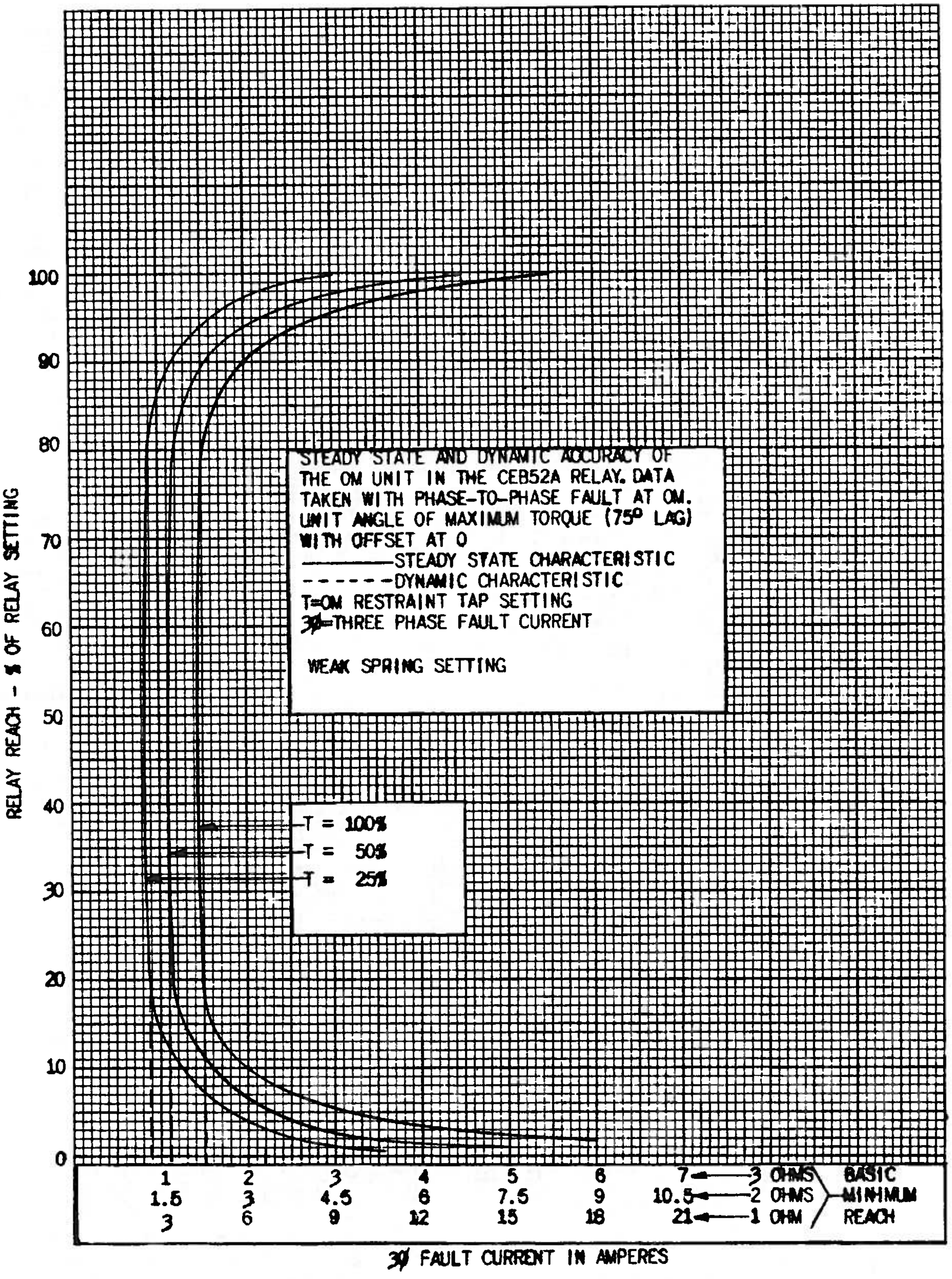


FIG. 7 (0203A8547-0) Steady State and Dynamic Accuracy of the OM Unit in the CEB52A Relay - Weak Spring Setting

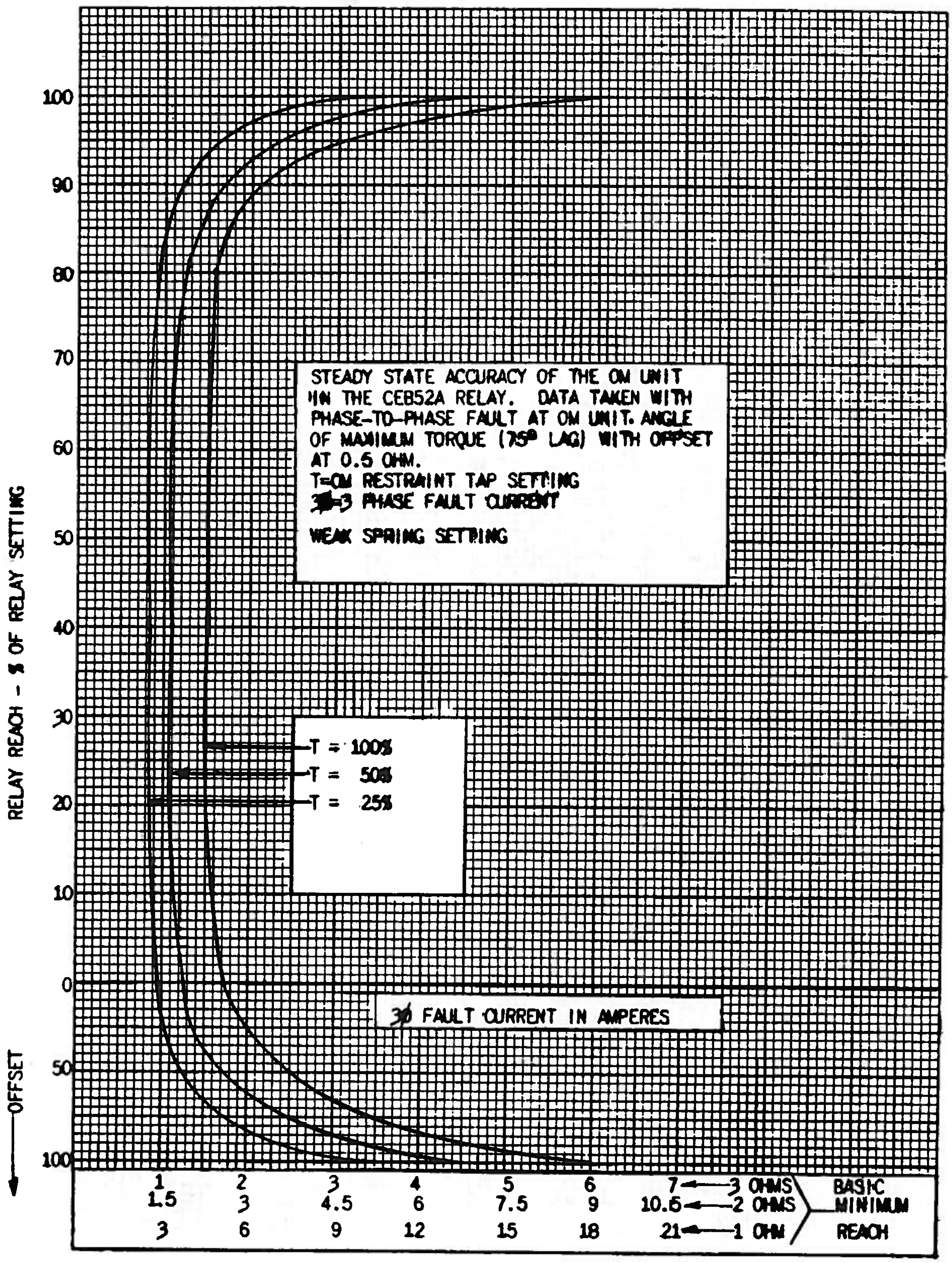


FIG. 8 (0203A8548-1) Steady State Accuracy of the OM Unit in the CEB52A Relay - Weak Spring Setting

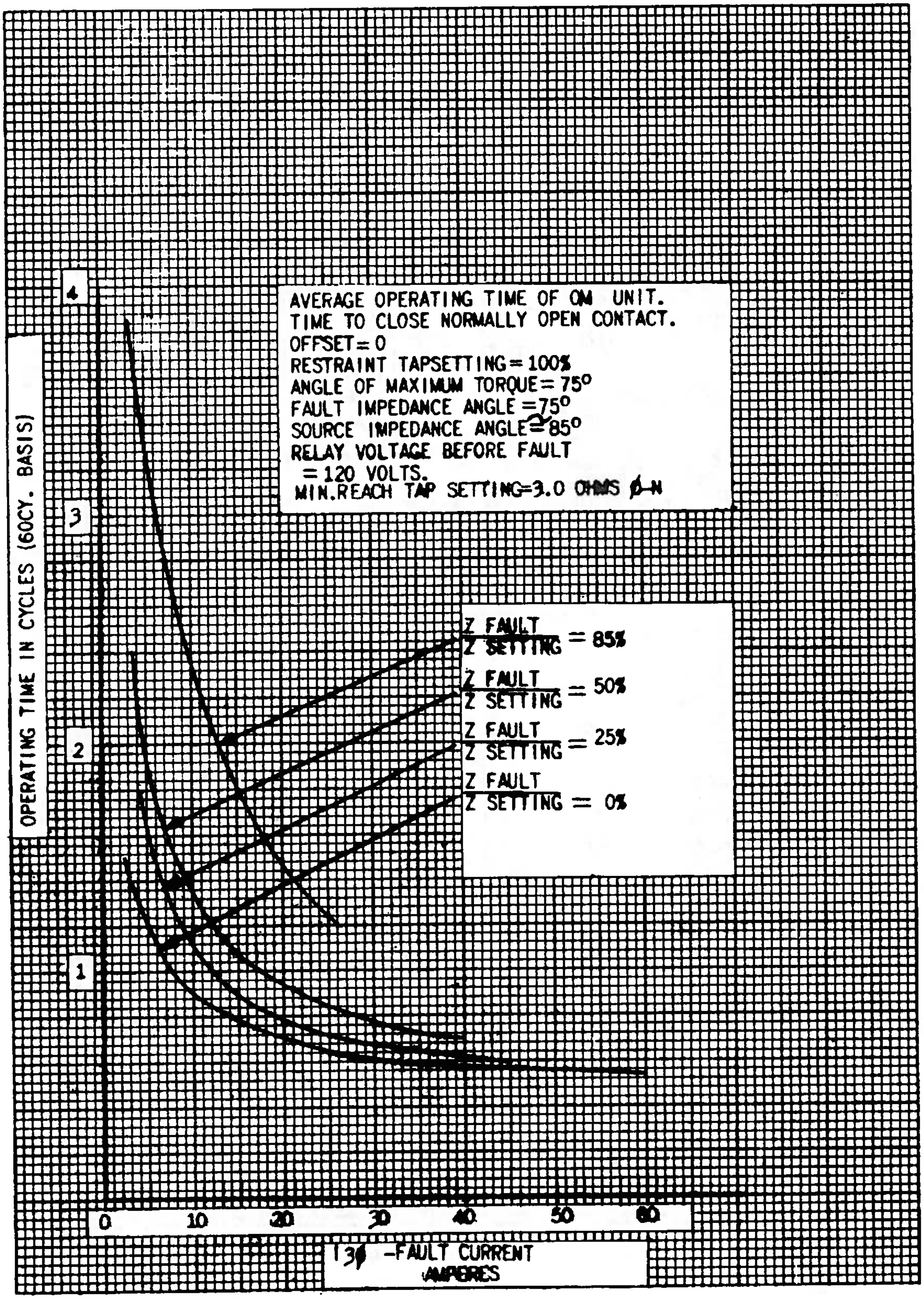


FIG. 9 (0203A8549-0) Operating Time Curves for the OM Unit with the Zero Offset Showing Time to Close Normally Open Contact

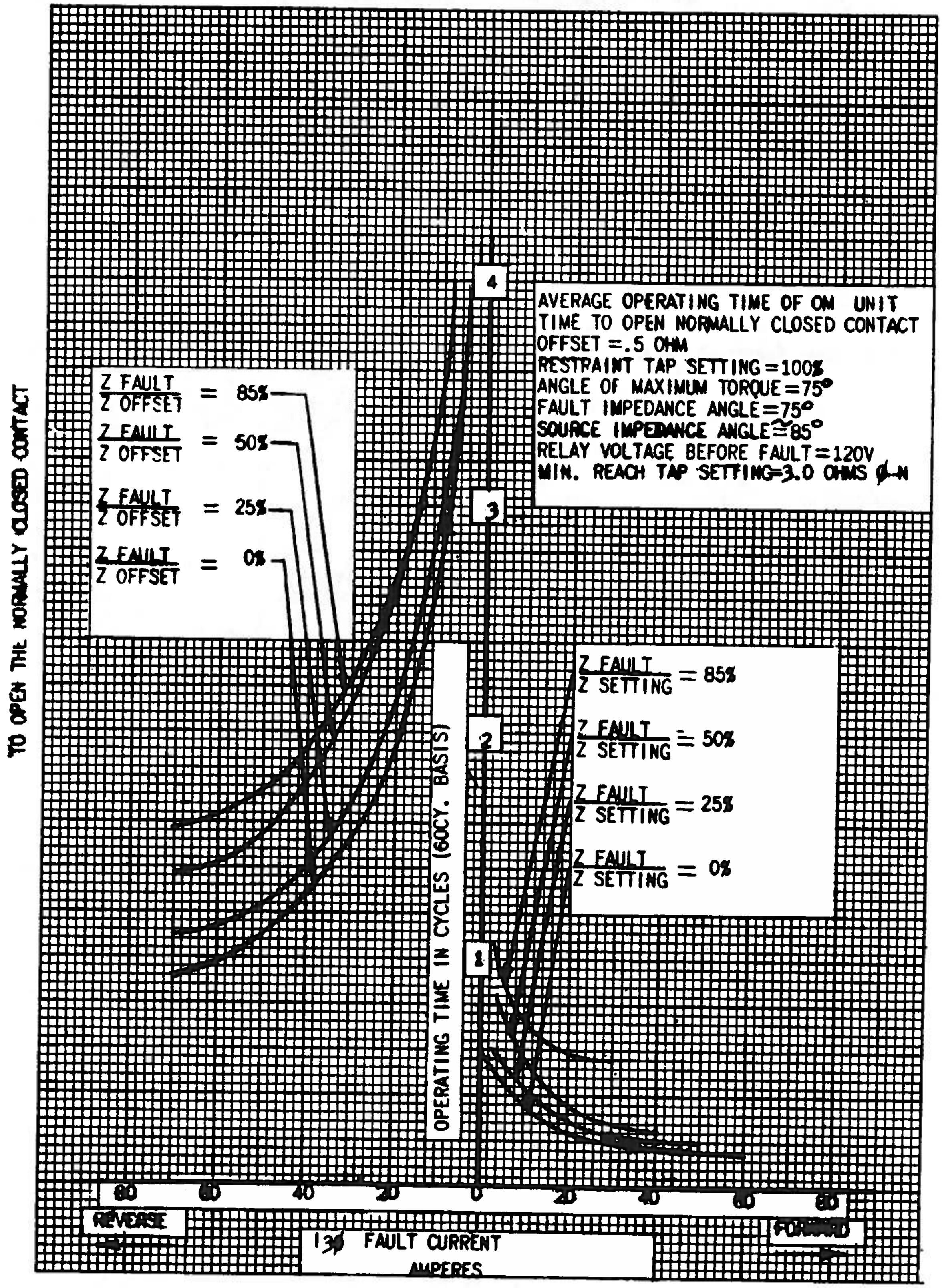


FIG. 10 (0203A8550-1) Operating Time Curves for the OM Unit with 0.5 Ohm Offset Showing Time to Open the Normally Closed Contact

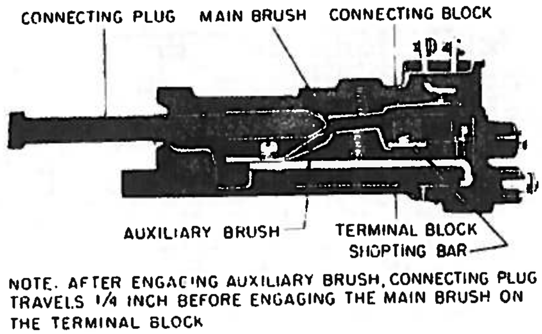


FIG. 11 (8025039) Cross Section of Drawout Case Showing Position of Auxiliary Brush and Shorting Bar

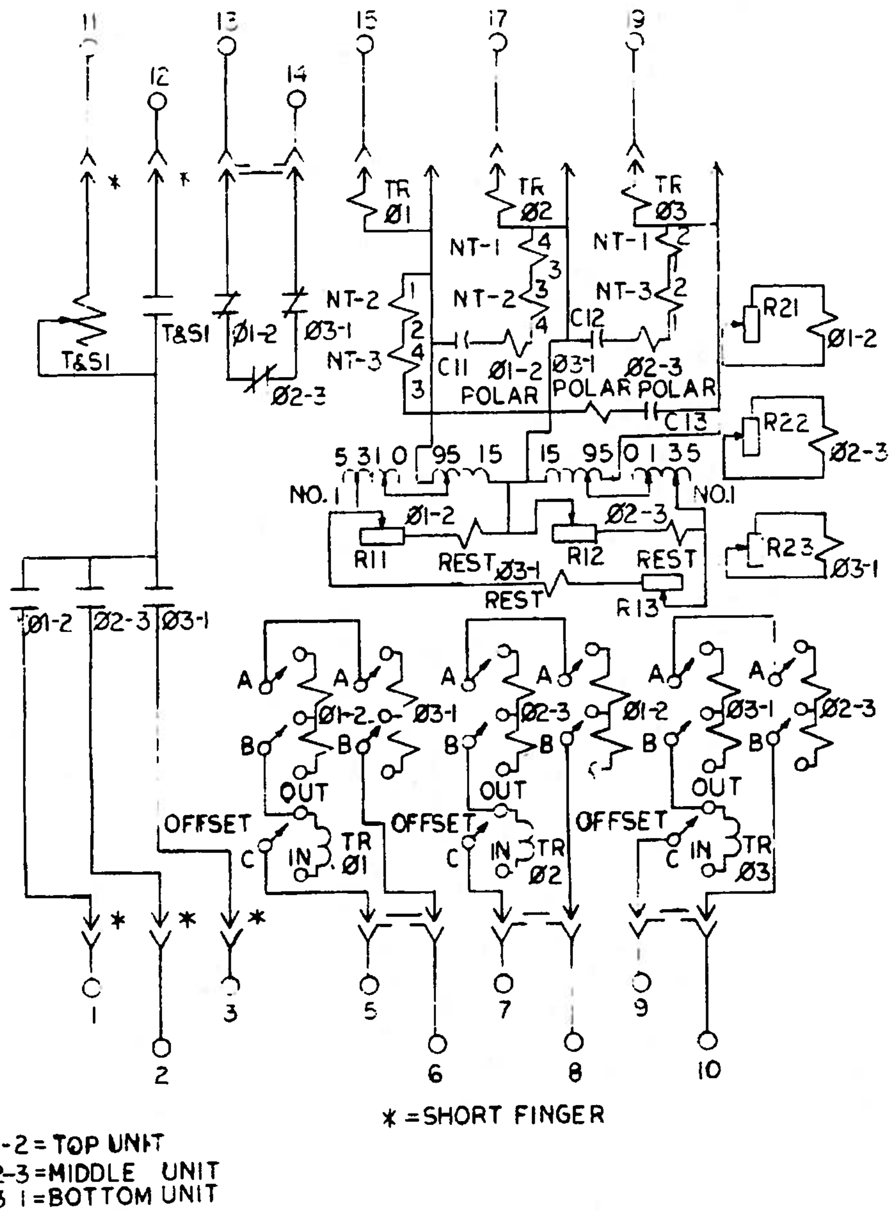
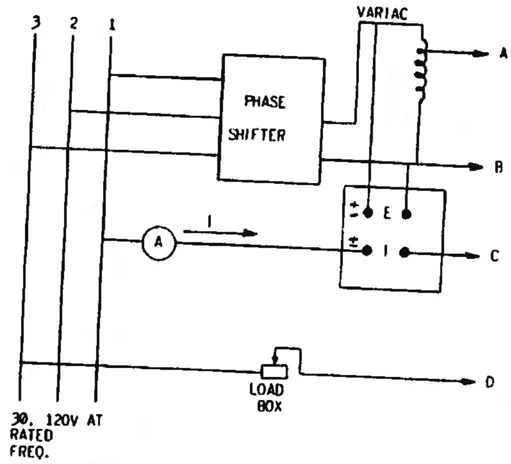
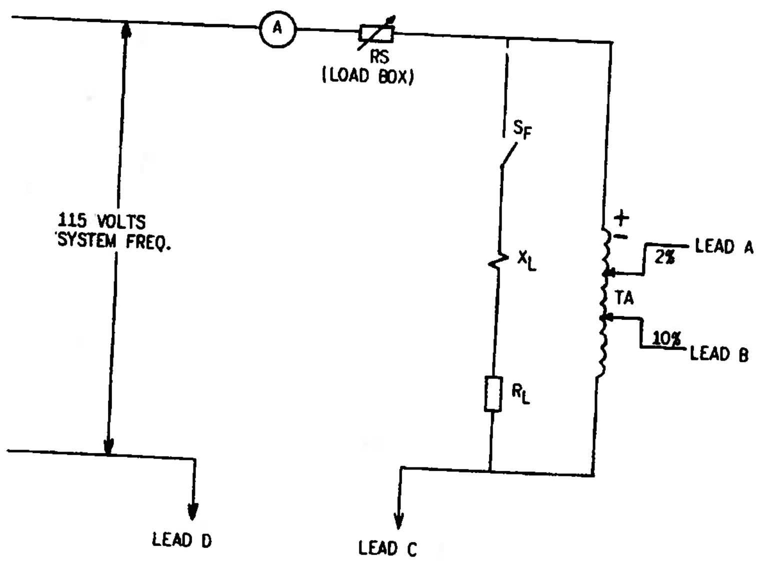


Figure 12 (0178A7134 [4]) Internal Connection Diagram for the CEB52A Relay (Front View)



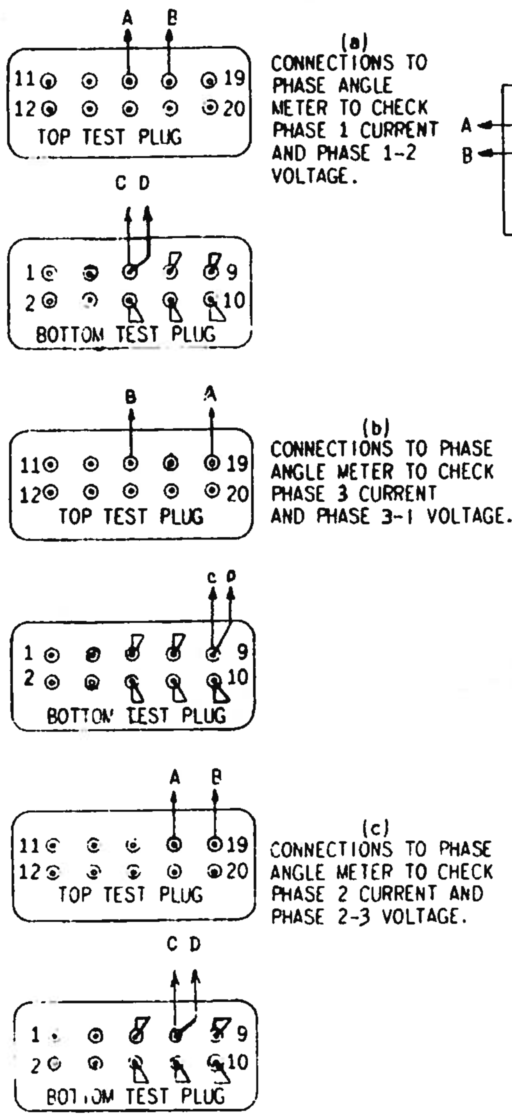
UNIT LOCATION	UNIT	CONNECT LEAD TO RELAY STUDS AS FOLLOWS				JUMPER RELAY STUDS
		LEAD A	LEAD B	LEAD C	LEAD D	
TOP	Ø1-2	15	17	5	7	6-8-10
MIDDLE	Ø2-3	17	19	7	9	6-8-10
BOTTOM	Ø3-1	19	15	9	5	6-8-10

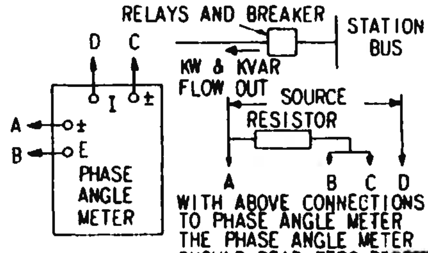
FIG. 13 (0203A8617-0) Rated Frequency Test Connections for Checking Correct MHO Unit Operation



UNIT LOCATION	UNIT	CONNECT LEAD TO RELAY STUDS AS FOLLOWS				JUMPER RELAY STUDS
		LEAD A	LEAD B	LEAD C	LEAD D	
TOP	Ø1-2	15	17	5	7	6-8-10
MIDDLE	Ø2-3	17	19	7	9	6-8-10
BOTTOM	Ø3-1	19	15	9	5	6-8-10

FIG. 14 (0203A8616-0) MHO Unit Test Connections





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. 15 (0195A4993-1) Overall Test Connections for Checking of External Wiring to Relay

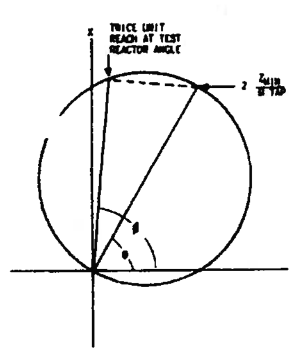
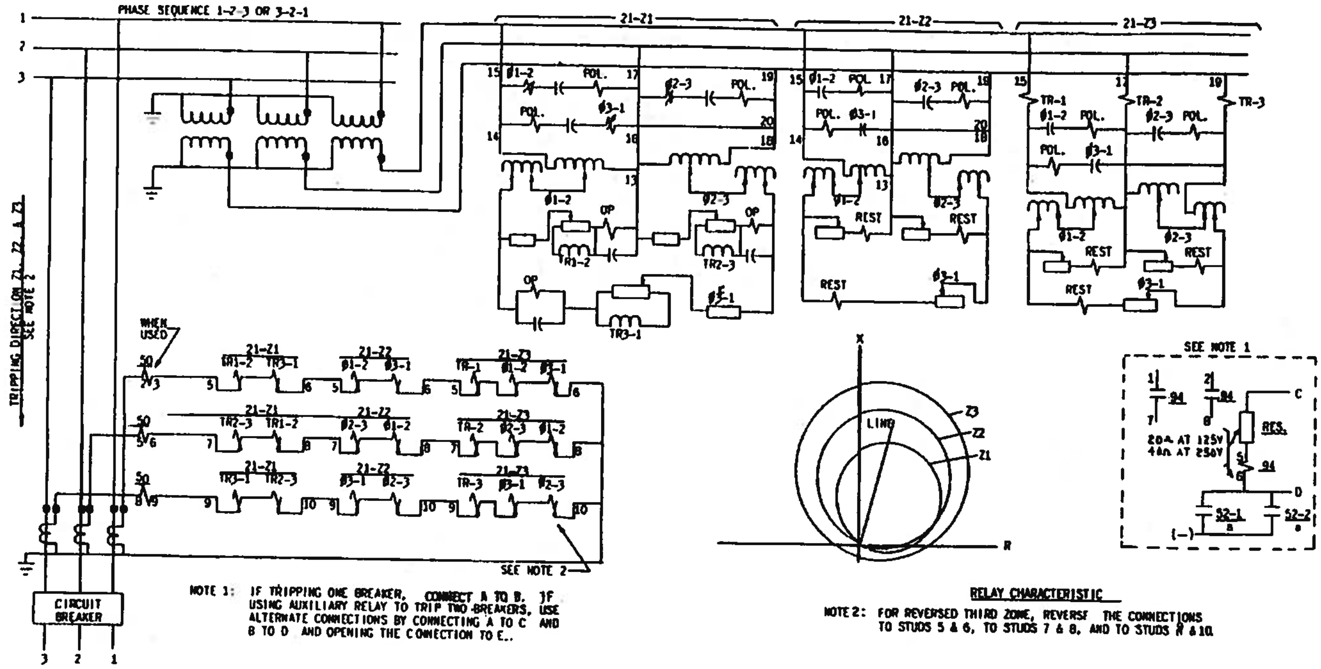


FIG. 16 (0195A4992-0) Diagram Showing Reach of MHO Units at the Angle of the Test Reactor



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	CEB52A		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
RPM21D	0127A9440	K-6209271
PJC31C	K-6375126	K-6209272
HGA14AM (BACK CONNS.)	K-6400533	K-6400633
HGA14AL (FRONT CONNS.)	377A139	377A139

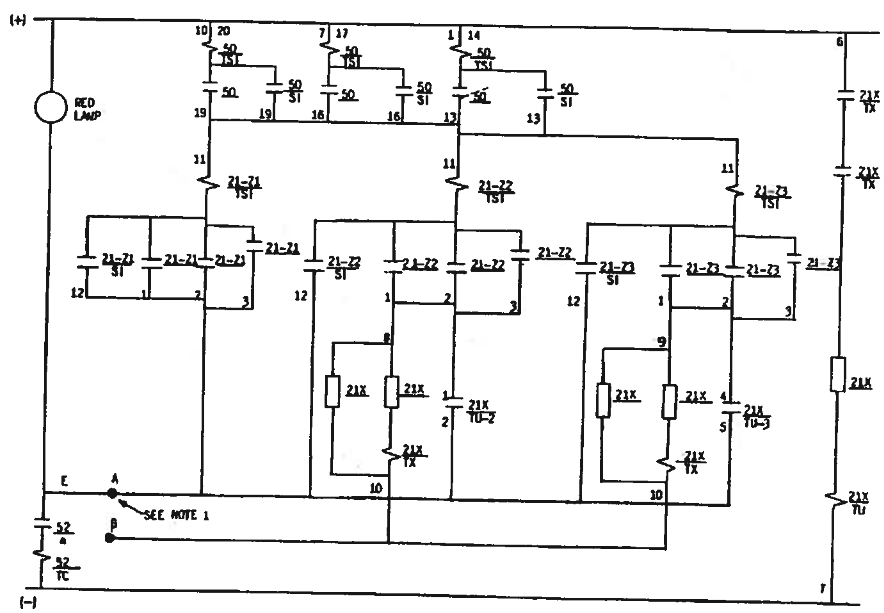
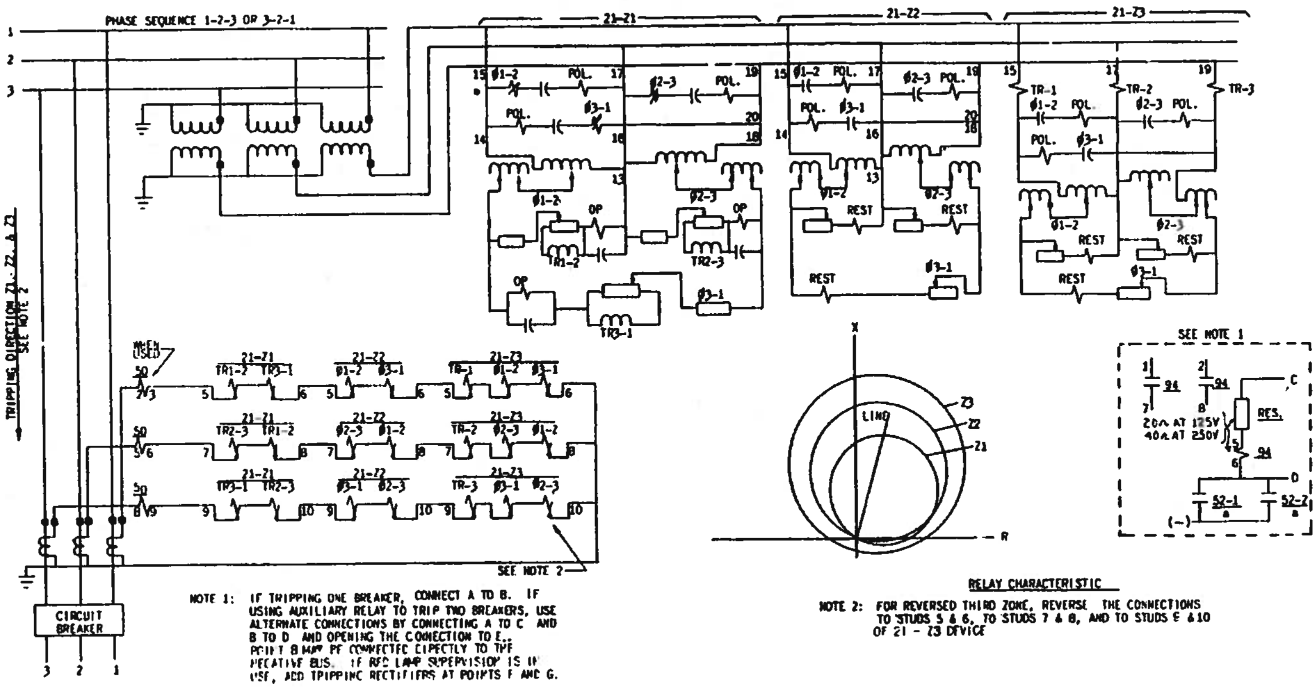
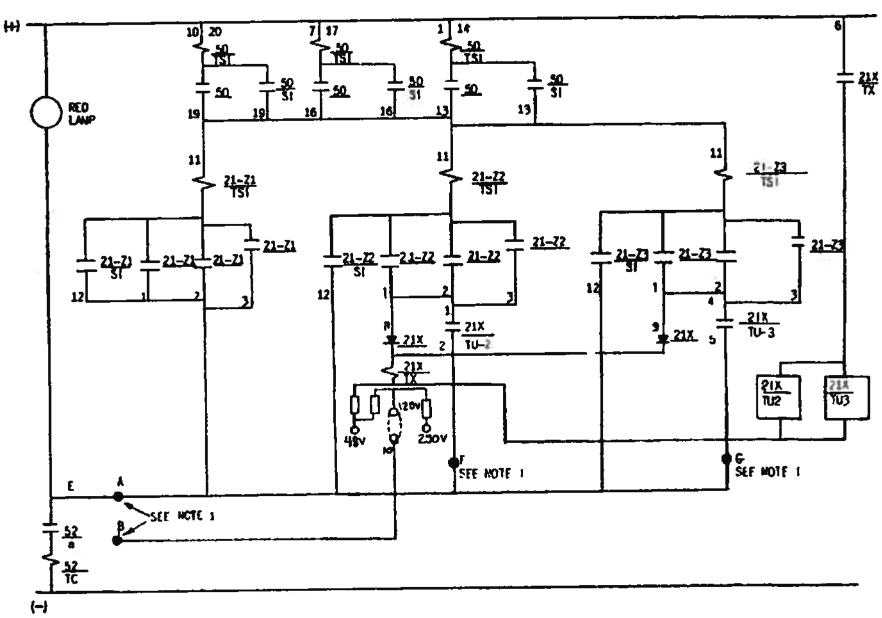


Fig. 17 (0116B9309 [5]) Typical External Connection Diagram Using CEY51A, CEY52A, CEB52A and RPM21D Relays Three Zone Distance Protection



NOTE 1: IF TRIPPING ONE BREAKER, CONNECT A TO B. IF USING AUXILIARY RELAY TO TRIP TWO BREAKERS, USE ALTERNATE CONNECTIONS BY CONNECTING A TO C AND B TO D AND OPENING THE CONNECTION TO E.. POINT B MAY BE CONNECTED DIRECTLY TO THE NEGATIVE BUS. IF RED LAMP SUPERVISION IS IN USE, ADD TRIPPING RECTIFIERS AT POINTS F AND G.

NOTE 2: FOR REVERSED THIRD ZONE, REVERSE THE CONNECTIONS TO STUDS 5 & 6, TO STUDS 7 & 8, AND TO STUDS 9 & 10 OF 21 - Z3 DEVICE



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	CEB52A		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	SAM16A		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
SAM16A		K-6209271
PJC31C	K-6375726	K-6209272
HGA14AM (BACK CONNS.)	K-6400533	K-6400533
HGA14AL (FRONT CONNS.)	377A139	377A139

FIG. 18 (0116B9333-5) Typical External Connection Diagram Using CEY61A, CEY52A, CEB52A and SAM16A Relays Three Zone Distance Protection

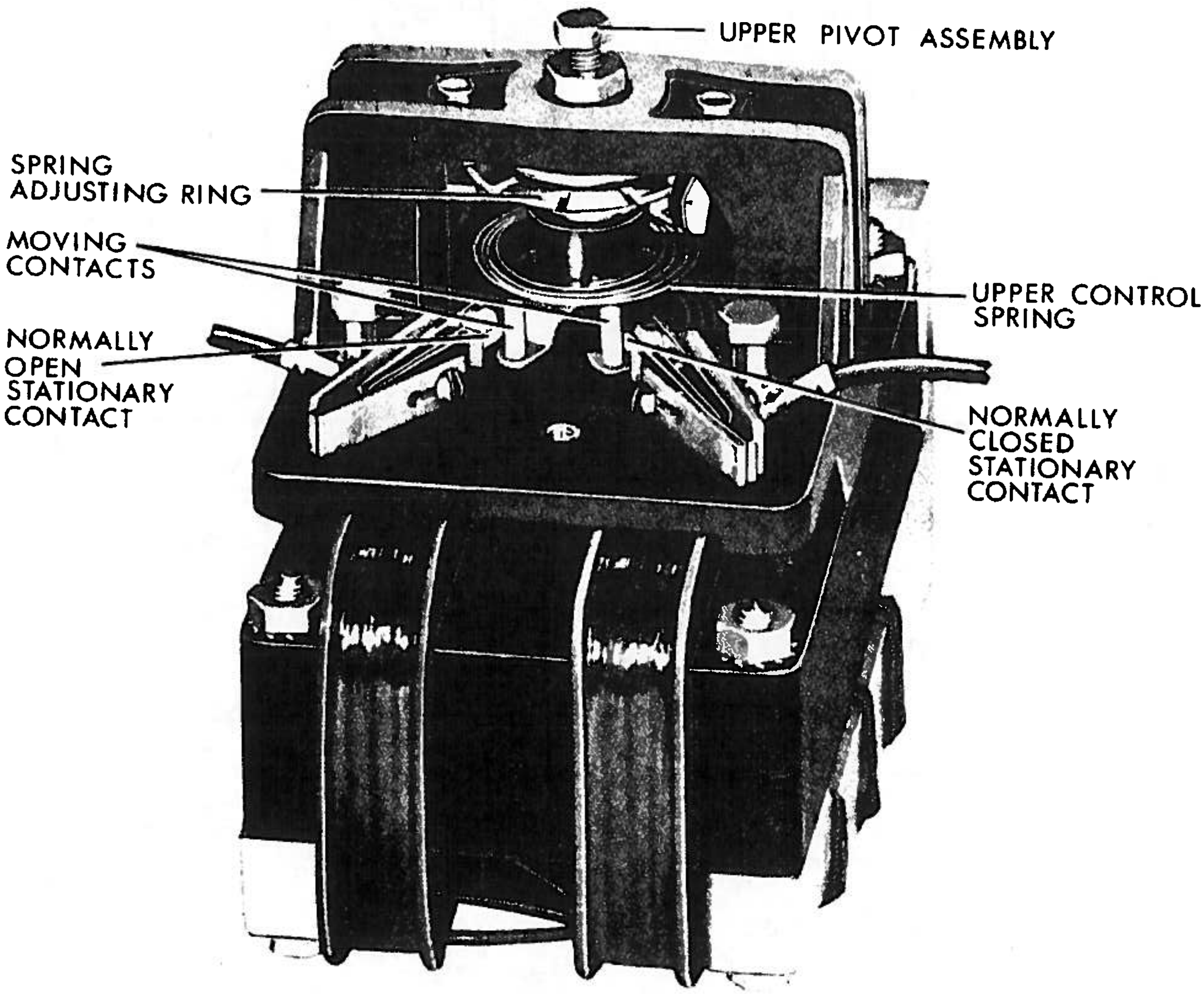


FIG. 19 (8041447) Four Pole Induction Cylinder Unit Typifying Construction of the MHO Units in the CEB52 Relay

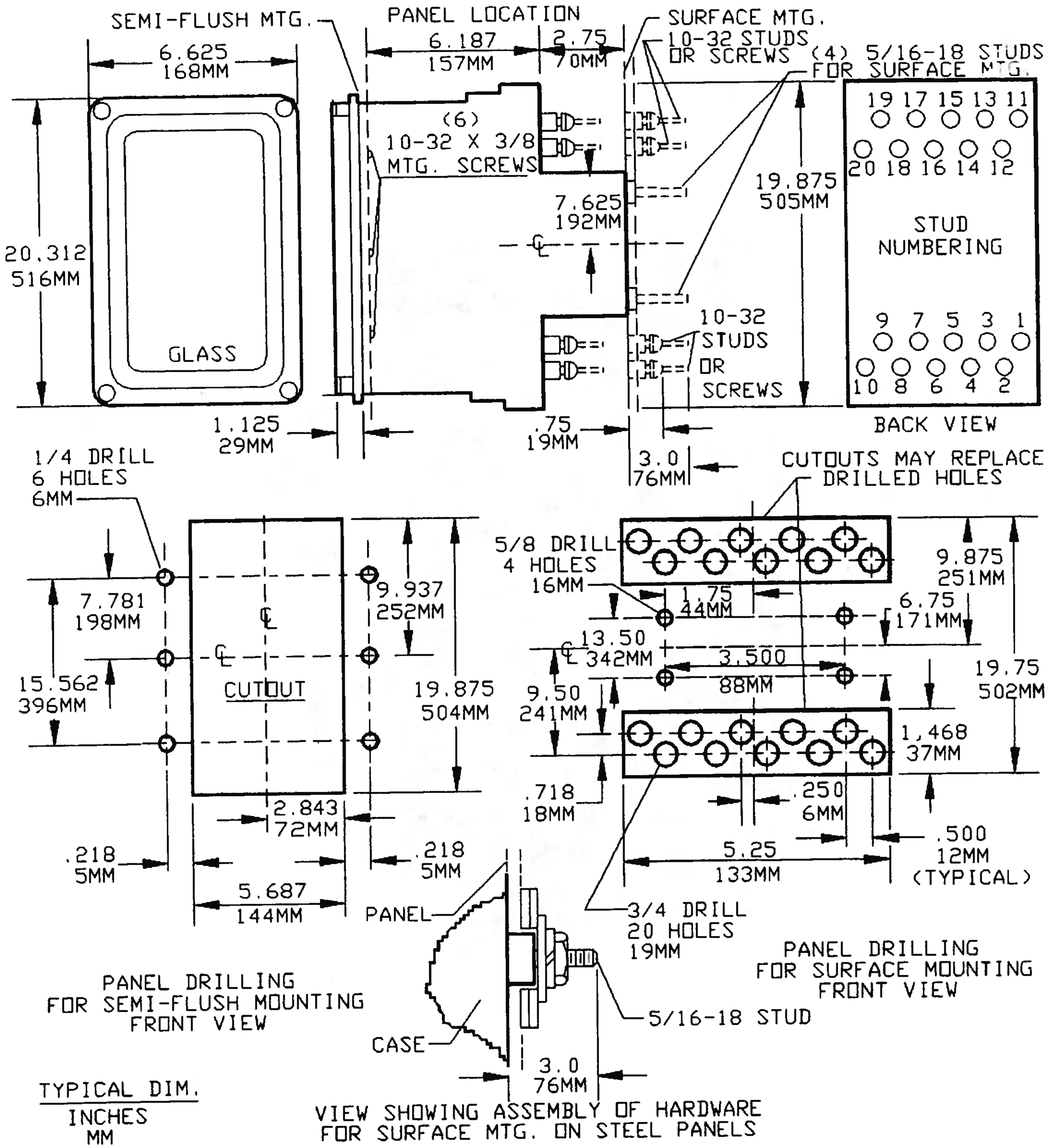


Figure 20 (0178A7336 [6]) OUTLINE & Panel Drilling for the Type CEB52 Relay

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