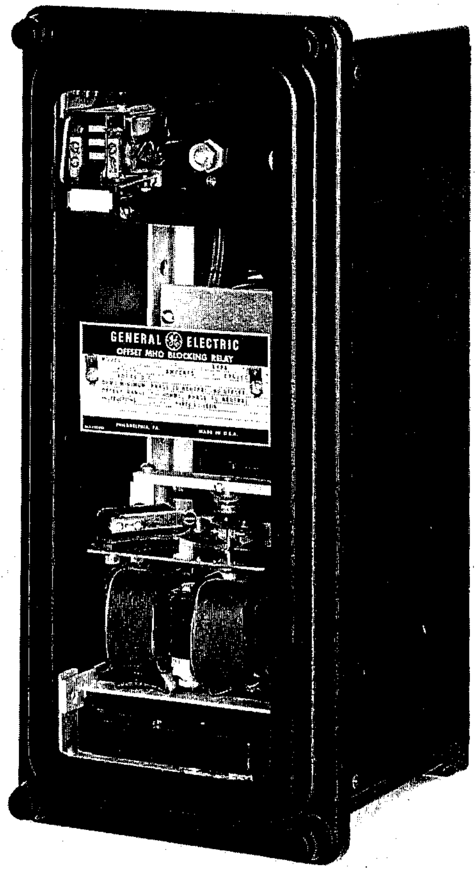
**INSTRUCTIONS**

GEI-98316A
Supersedes GEI-38892B

# OFFSET MHO DISTANCE RELAY




## Type CEB12C

**POWER SYSTEMS MANAGEMENT DEPARTMENT**

**GENERAL ELECTRIC**

**PHILADELPHIA, PA.**

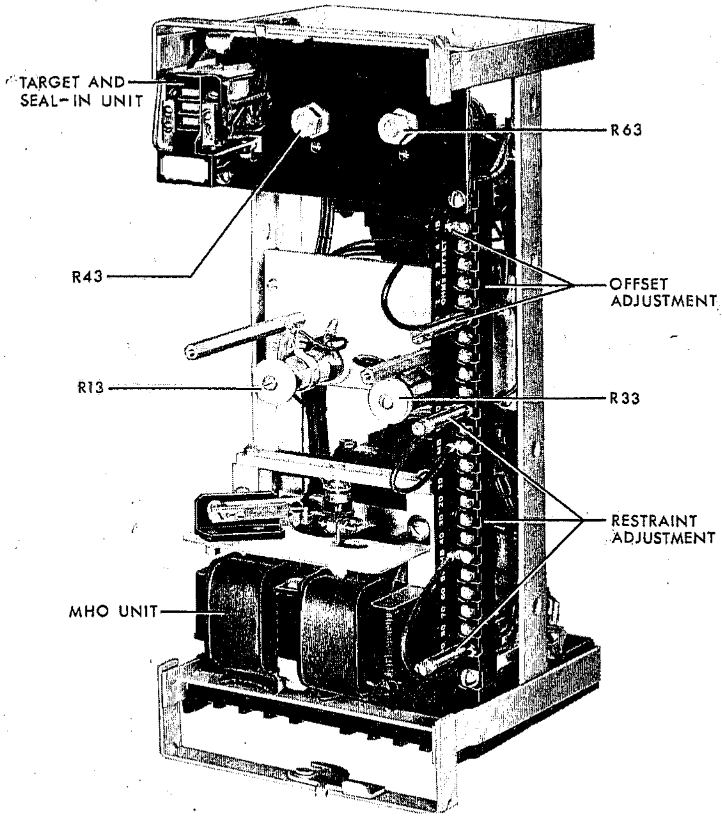



Fig. 1 (8034881) Type CEB12C Relay Withdrawn From Case (Front View)

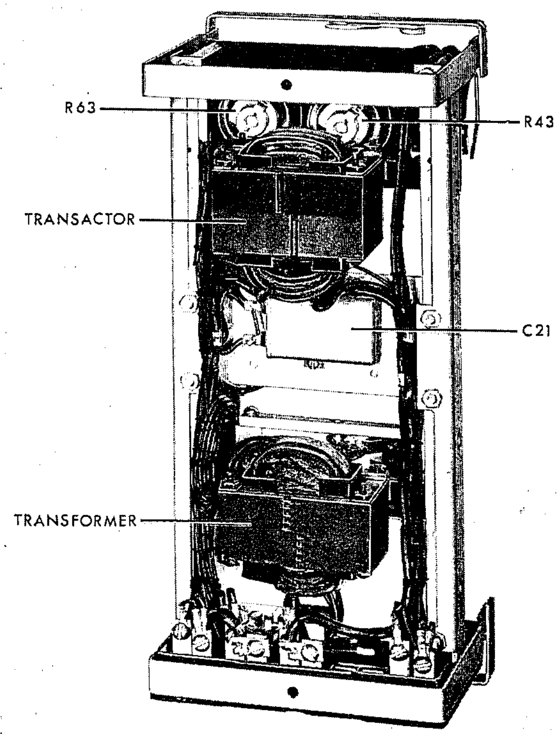



Fig. 2 (8034880) Type CEB12C Relay Withdrawn From Case (Rear View)

Cover (8034882)

# OFFSET MHO DISTANCE RELAY TYPE CEB12C

## INTRODUCTION

The CEB12C is a single phase, single zone general purpose mho distance relay with provisions for offsetting the characteristic by a fixed amount. The mho unit together with its target seal-in unit are installed in an M1 case. Three CEB12C relays plus a suitable RPM timing relay are required per terminal to provide one zone of time delay distance protection for three phase, phase-to-phase and double-phase-to-ground faults.

## APPLICATION

The CEB12C relays may be applied wherever one zone of back-up distance protection is required. These relays are not suitable for first zone applications because the transient response has not been controlled to minimize overreach.

Probably the most common application of the CEB12C relays is in generator back-up protection schemes where the relays are used to protect the generator from faults on the adjacent system which are not cleared by the first line relays. Fig. 3 illustrates the external a-c and d-c connections to the CEB12C relays for this type of protection. In this scheme a separate auxiliary tripping relay, device 94, is used to isolate the d-c supply to the back-up relaying from the d-c supply to the generator main breaker. This will make it possible for the relay to shut the generator down in the event that a high voltage bus fault occurs during a loss of d-c supply to the main breaker trip circuit.

The a-c connections to the CEB12C relays will depend on the location of the CT's and PT's in relation to the main delta-wye power transformer. All the different possibilities are shown in Fig. 3.

The impedance seen by the CEB12C relays will depend on the location of the PT's and CT's that supply them and these relations are given in Table A.

This table indicates that when there is no power bank between the fault and the relay supply, the relay sees the normal expected impedance.

* TABLE A

| CT CONNECTION FIG. 3 | PT CONNECTION FIG. 3 | SECONDARY IMPEDANCE SEEN BY RELAY OHMS |
|---|---|---|
| Ⓐ | ① | $KZ_L \left(\frac{CT_A \text{ Ratio}}{PT_1 \text{ Ratio}}\right)$ |
| Ⓑ | ② | $0.866\,(Z_T + KZ_L) \left(\frac{V_L}{V_H}\right)^2 \left(\frac{CT_B \text{ Ratio}}{PT_2 \text{ Ratio}}\right)$ |
| Ⓐ | ② | $(Z_T + KZ_L) \left(\frac{V_L}{V_H}\right) \left(\frac{CT_A \text{ Ratio}}{PT_2 \text{ Ratio}}\right)$ |
| Ⓑ | ① | $0.866\, KZ_L \left(\frac{V_L}{V_H}\right) \left(\frac{CT_B \text{ Ratio}}{PT_1 \text{ Ratio}}\right)$ |

Where:

$Z_L$ = Primary Ohms of Line Impedance

K = Ratio of current in Line ($Z_L$) to current in Line Side of Power Transformer. This Constant Corrects for Infeed. See Fig. 5.

$V_L/V_H$ = Low Side to High Side Voltage Ratio of Power Bank on Taps Used.

$Z_T$ = Power Transformer Impedance in Ohms Referred to the High Side Winding.

*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.*

* Denotes change since superseded issue.

The section on CALCULATION OF SETTINGS contains an example which illustrates how to calculate a suitable relay setting for a given set of conditions.

## RATINGS

The CEB12C relay has a rating of 115 volts, 5 ampere, 50 or 60 cycles.

The MHO unit has an adjustable reach of 3.0/30 ohms phase-to-neutral. The adjustment can be made in one per cent steps by positioning the autotransformer tap leads. The MHO characteristic can also be offset 1, 2, 3 or 4 ohms phase-to-neutral along the line of the relay angle of maximum torque which is when the current lags the voltage by 75 degrees.

The contacts between studs 1 and 2 are for tripping duty and their rating is limited by the rating of the seal-in unit coil as shown in Table B.

TABLE B

| TARGET AND SEAL-IN UNIT | | |
|---|---|---|
| | 2.0 Amp Tap | 0.2 Amp Tap |
| DC Resistance | 0.13 Ohms | 7.0 Ohms |
| Min. Operating | 2.0 Amps | 0.2 Amps |
| Carry Continuously | 3.0 Amps | 0.3 Amps |
| Carry 30 Amps For | 4.0 Sec. | 0.2 Sec. |

## CHARACTERISTICS

### OPERATING PRINCIPLE

The MHO unit of the CEB12C relay is a four pole induction cylinder type relay with schematic connections as shown in Fig. 4. The operating torque will be proportional to the product of the voltage impressed on the polarizing coil and the vector sum of the currents in the operating coils times the cosine of difference between the relay maximum torque angle and the power factor angle. The restraining torque is proportional to the product of the voltages impressed on the polarizing coil and the restraint coil plus the control spring torque. The autotransformer taps permit adjustment of the restraining voltage in one percent steps to provide relay settings of 3 to 30 ohms. The transactor voltage permits the relay characteristic to be offset, as illustrated in Fig. 6. Taps are provided on the transactor secondary to permit an offset of 0, 1, 2, 3 or 4 ohms.

The minimum 3-phase fault current for which the MHO unit will operate on a steady state basis is given in Fig. 7. The three-phase fault current which will just operate the unit is 1.15 times the minimum phase-to-phase fault current required to operate the unit since the relay has the same reach for both types of faults. The minimum current to operate relay with 100% restraint, one ohm offset, zero voltage and a 3∅ fault is 2.5 amperes.

## BURDENS

The CEB12C relay burdens are given in Table C.

TABLE C

BURDENS OF CURRENT CIRCUITS

| STUDS | CURRENT | WATTS | VARS | VA |
|---|---|---|---|---|
| 5-6<br>7-8 | 5<br>5 | 2.66<br>2.66 | 1.40<br>1.40 | 3.0<br>3.0 |
| * Burdens of Potential Circuits | | | | |
| 9-10 | 115 | 12.6 | 8.8 | 15.4 |

* Potential circuit burdens may be calculated from the following equation.

$$W + jVARS = \frac{(115)^2}{Z} \left(1 \pm \frac{Z_o}{Z_L}\right)$$

Where

$Z_o$ = Secondary offset ohms

$Z_L$ = Secondary fault or load ohms

$$Z = \frac{(1720-j300)(520+j1040)^2 \left[\frac{100}{T}\right]^2 Z^2}{(1720-j300)+(520+j1040)\left[\frac{100}{T}\right]^2} \; (4.5+j14.5)$$

T = Restraint tap setting in percent

## CALCULATION OF SETTINGS

Assume a system such as that illustrated in Fig. 5.

Assume that the following parameters describe the system

$V_L/V_H$ = 13.8/132

$Z_L$ = 0.81 $\angle 80^o$ ohms per mile

$Z_T$ = 10% on 100,000 KVA base at 86 deg. lagging

Since the CT's and PT's supplying the CEB relays are both on the generator side of the power transformer, PT connections (2) and CT connections (B) would be used as shown in Fig. 3. Referring to Table A we find that

$$Z_{relay} = 0.866\,(Z_T + KZ_L)\left(\frac{V_L}{V_H}\right)^2 \left(\frac{CT_B \text{ Ratio}}{PT_2 \text{ Ratio}}\right) \text{(B-2)}$$

It will be noted that three auxiliary PT's will be required. These should have a winding ratio of 120/69 volts so that when they are connected in delta-wye, the line-to-line ratio is 1.0.

On the system described above, the PT ratio would be

$PT_2$ = 14,400/120 = 120

Assume that the generator CT ratio is 5000/5 which is a reasonable rating for CT's used on a 100,000 KVA, 13.8 KV unit.

$$CT_B = 5000/5 = 1{,}000$$

The primary ohms of the transformer ($Z_T$) referred to the 132 KV side may be obtained from the following equation

$$Z_T = \text{Per Unit Impedance } \frac{(KV)^2}{\text{MVA Base}}$$

$$Z_T = 0.10 \frac{(132)^2}{100} = 17.4 \text{ ohms}$$

Assume now that it is desired for the CEB to reach no further than 30 miles out from the high voltage bus on any of the three circuits under any condition of infeed from the other two. Thus

$$Z_L = 30 \times 0.81 \angle 80^o = 24.3 \text{ primary ohms}$$

Assume that a fault study indicates that the minimum value of infeed under any reasonable system conditions will result in K being no smaller than 1.2. Thus,

$$K = 1.2$$

(It should be noted that on a radial system, K will be equal to 1.0. In order to be absolutely certain that the relay does not reach beyond the desired distance under any conditions on any system, K should be assumed equal to 1.0).

From equation B-2, the relay should be set with a forward reach of

$$Z_{relay} = 0.866 \left( 17.4 \angle 86^o + 1.2 (24.3 \angle 80^o) \right) \left( \frac{13.8}{132} \right)^2 \left( \frac{1000}{120} \right)$$

$$Z_{relay} = ( 40.2 \angle 82.1^o ) \ (0.01093) \ (8.34)$$

$$Z_{relay} = 3.67 \angle 82.1^o ) \text{ secondary ohms}$$

Thus, the relays should be set with a forward reach of about 3.7 ohms at 82 degrees. However, in applications of this kind some people prefer to set the relay with offset in order to obtain some additional back-up protection for faults in the leads between the generator and the transformer. If this is the case, it is suggested that the relay be set with 2 ohms offset. It is now necessary to determine the restraint tap setting required with a 2 ohm offset setting to obtain a forward reach of 3.7 ohms at 82 degrees. This is most easily done by graphical construction.

Refer to Fig. 6, draw the R-X diagram and perform the following construction to scale. Through the origin (0) draw line AB at the angle of maximum torque of the CEB12C relay. Now draw the line $\overline{OL}$ equal in length to the desired forward reach of the relay and at the desired impedance angle ($\theta$). Locate point P on line AB so that $\overline{OP}$ is equal to the offset. Now, by trial draw a circle with its center (C) on line AB and its circumference passing through points P and L. Measure the line $\overline{PR}$ and set the restraint tap to

$$T = \frac{Z_{min}}{PR} \times 100$$

where $Z_{min}$ is the minimum reach of the relay as stamped on the nameplate.

In the case of the above example

$\theta$ = 82 degrees

$\phi$ = 75 degrees

$\overline{OP}$ = 2 ohms

$\overline{OL}$ = 3.7 ohms

From measurement RP = 5.7 ohms. Thus, the desired tap setting is

$$T = \frac{3}{5.7} \times 100 = 52.7\% \text{ or } 53\%$$

## CONSTRUCTION

The CEB12C relay is mounted in a cradle assembly which is latched into a drawout case when the relay is in operation but it can be easily removed when desired. To do this, the relay is first disconnected by removing the connection plug which completes the electrical connections between the case block and the cradle block. To test the relay in its case this connection plug can be replaced by a test plug. The cover, which is attached to the front of the relay case, contains the target reset mechanism and an interlock arm which prevents the cover from being replaced until the connection plugs have been inserted.

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

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. By providing this overlap the auxiliary brushes relieve the main brushes from any arcing damage. Also on circuits which are equipped with shorting bars (see Fig. 8) it is especially important that the auxiliary brush makes positive contact as indicated in Fig. 9 to prevent the opening of C.T. secondary circuits or important interlock circuits.

Figs. 1 and 2 show the CEB12C relay withdrawn from its case and all units are identified.

## 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. 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

Upon receipt of the relay, an examination and tests should be made to insure that the relay has not been damaged in shipment and that the relay calibrations have not been disturbed.

### VISUAL INSPECTION

Remove the relay from its case and check that there are no broken or cracked components parts and that all screws are tight. Check the nameplate stamping to insure that the model number, rating and calibration range agree with the requisition.

Check that the shorting bars are in the correct locations as indicated in Fig. 8 and that the auxiliary brushes are properly adjusted.

### MECHANICAL INSPECTION

1. Check the MHO unit to insure the following:-
   a. That the rotating shaft end play is 5-8 mils.
   b. That the contact gap is 1/8 inch approximately.
   c. Contact wipe is .005 to .010 inches.
   d. That the element moves without binds or friction.
2. Target and Seal-In Unit

The target and seal-in unit should be checked as follows: The armature and seal-in contacts should move freely when operated by hand. There should be a screw in only one of the tap positions on the right stationary contact strip. Operate the armature by hand and check that there is at least 1/32" wipe on the seal-in contacts. Check that the target latches in the exposed position before the contacts close.

### ELECTRICAL TESTS

Before electrical tests are made on the MHO unit, the relay voltage coils should be connected to power and allowed to warm up for approximately 15 minutes with the auto-transformer tap set at 100 percent. The relay must be in a vertical position and carefully leveled for these tests. Connect the relay as shown in Fig. 10 and check the following:

1. With the auto-transformer on the 100% tap check that the relay picks up between 18 and 20 amperes when the phase angle meter reads 285$^{o}$ (current lags the voltage by 75$^{o}$ and no offset voltage is used).
2. With the auto-transformer on the 100% tap, check that the relay picks up at about 36 amperes when the phase angle meter reads 225$^{o}$ and no offset voltage is used.
3. With the auto-transformer on the 100% tap, check that the relay picks up at about 36 amperes when the phase angle meter reads 345$^{o}$ and no offset voltage is used.
4. Connect a variable source of DC voltage to studs 1 and 2 and check that the target seal-in unit operates at or below its rating.

## INSTALLATION PROCEDURE

If after the ACCEPTANCE TESTS the relay is held in storage before shipment to the job sit it is recommended that the visual and mechanical inspection described under the section on ACCEPTANCE TESTS be repeated before installation.

### ELECTRICAL TESTS

The relay should be mounted in its final location and should be allowed to warm up as described under ACCEPTANCE TESTS.

The MHO unit should be tested for the setting to be used in its final location. To eliminate the errors which may result from possible instrument inaccuracies a test circuit has been selected which requires no instruments. Such a circuit is shown in Fig. 11 and in this diagram $R_S + jX_S$ is the source impedance, $S_F$ is the fault switch and RL + jXL is the impedance of the line section for which the relay is being tested. The auto-transformer $T_A$ which is across the fault switch and line impedance is tapped in 10 percent and 1 percent steps so that the line impedance $R_L + X_L$ may be made to appear to the relay very nearly as the actual line on which the relay is to be used. The auto-transformer is necessary since it is not feasible to provide the portable test reactor $X_L$ and the test resistor with enough adjustment so that they can be made to match any line.

For convenience in field testing the fault switch and tapped auto-transformer of Fig. 11 have been arranged in a portable test box, Cat. 102L201 which is particularly suitable 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, refer to GEI-38977A.

Check relay pickup with one ohm offset on zero voltage fault (see CHARACTERISTICS section).

To check the calibration of the MHO unit is is recommended that the unit pick up be checked using the test reactor Cat. 6054975 alone for the line reactance. This is desirable because for reactance of this test reactor may be very accurately determined from its calibration curve. It should be noted that due account must be taken of the angular difference between the line reactance $X_L$ and the relay angle of maximum torque. The line reactance $X_L$ selected should be the test reactor tap nearest above twice the MHO unit reach with account being taken of the difference in angle of the test reactor tap impedance and the relay angle of maximum reach.

From Fig. 6 it is seen that twice the relay reach at the angle of the test reactor impedance is:

$$2Z = \frac{Z_{min}\ \text{(ohms)} \times 100}{T_A\ \text{Tap}\ (\%)} \cos(\phi - \theta)$$

Where $\phi$ is the angle of the test reactor impedance and $\theta$ is the relay angle of maximum reach. The test box auto-transformer percent tap for the MHO unit pick up is given by

$$\%\ \text{Tap} = \frac{2Z_R}{Z_L}(100)$$

To illustrate the above the relay setting given in the example in section on CALCULATION OF SETTINGS will be used. In this example it was found that the relay auto-transformer tap setting should be 53 percent. Since the MHO unit angle of maximum reach is 75 degrees and we will assume that the reactor impedance will be 80 degrees, we can find the impedance tap as follows:-

$$2Z_R = 2 \times RP \cos(80-75) = 11.4 \times .996 = 11.35$$

therefore the reactor 12 ohm tap should be used. Now twice the relay reach at the angle of test reactor impedance should be recalculated using the actual angle of the reactor tap impedance rather than the assumed 80°. Table G shows the angle for each of the reactor taps.

TABLE D

| TAP | ANGLE ($\phi$) |
|---|---|
| 24 | 87.5 |
| 12 | 87.0 |
| 6 | 86.5 |
| 3 | 84.3 |
| 2 | 83.0 |
| 1 | 80.7 |
| 0.5 | 78.0 |

From this table it is seen that the angle of the impedance of the 12 ohm tap is 87.0 degrees.

$$2Z_R = 11.4 \cos(87-75) = 11.4 \times .978 = 11.18$$

It is recommended that a current of about 10 amperes be used for the test. The calibration curve for the portable test reactor should be referred to in order to determine exact reactance of the 12 ohm tap at the current level being used. For the purpose of this illustration let us assume that this reactance is 12.2 ohms. The impedance will be

$$Z_L = \frac{12.2}{\cos 3^\circ} = \frac{12.2}{.999} = 12.2 \text{ ohms}$$

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 taps of 3, 2, 1 or 0.5 ohms.

The angle of impedance of the 12 ohm tap at 10 amperes is 87.0 degrees and the impedance to just cause the relay to operate will be

$$2Z_R = 2\left(\frac{300}{53}\right) \cos(87.0-75) = 11.1 \text{ Ohms}$$

The test box auto-transformer tap setting required to close the MHO unit contacts with the fault switch closed is

$$\% = \frac{11.1}{12.2} = 91$$

The MHO unit should pick up between the 90 and 92 percent tap.

If the MHO unit pick up checks correctly according to the above test it may be assumed that the angle of the characteristic is correct. However, this angle may be checked very easily by using the calibrated test resistor in combination with various reactor taps. The calibrated test resistor taps are pre-set in such a manner that when used with 12 and 6 ohm taps of the specified test reactor, impedance at 60 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 reach may be checked at the zero degree position by using the calibrated test resistor alone as the line impedance. The MHO unit should just pick up at approximately the value of Z indicated on the characteristic circle as shown in Fig. 6. When checking the MHO unit at angles of more than 30 degrees away from the angle of maximum torque, any error in the angle of the test impedance will cause an increasingly larger error in the relay pickup.

With a variable source of DC power connected to relay studs 1 and 2 check that the target seal-in unit operates at or below the tap rating used.

## 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.

## SERVICING

If it is found that the calibrations do not check during installation tests or periodic tests, recalibration should be made by adjusting as necessary elements normally called factory adjustments. The adjustments are listed below. These devices may be located from Figs. 1 and 2.

1. Control Spring Adjustment

   Adjust the control spring so that the contacts just fully reset when the relay is mounted in its ultimate location. Check zero voltage fault pickup with one ohm offset (see CHARACTERISTICS section).

2. Ohmic Reach Adjustment

   Connect relay as shown in Fig. 10 without offset and with rated voltage and 100% tap. Adjust the R13 resistor until the relay just closes its contact at 18.75 - 19.5 amperes when phase angle meter reads 285 degrees.

3. Angle of Maximum Torque Adjustment

   Connect relay as shown in Fig. 10. Set $T_A$ at 50 percent, the phase angle meter at 345° and check that MHO unit picks up at 16.75 - 18.25 amperes with no offset. Then set phase angle meter to 225 degrees and check that unit picks up at same current. Adjust R43 and/or R33 until the pickup at the two angles is approximately equal. Recheck the relay reach at 285 degrees and adjust if necessary. Then recheck the angle of maximum torque and continue with this sequence until correct values are achieved.

## 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 part wanted, and give complete nameplate data. If possible, give the G. E. Co. requisition number on which the relay was furnished.

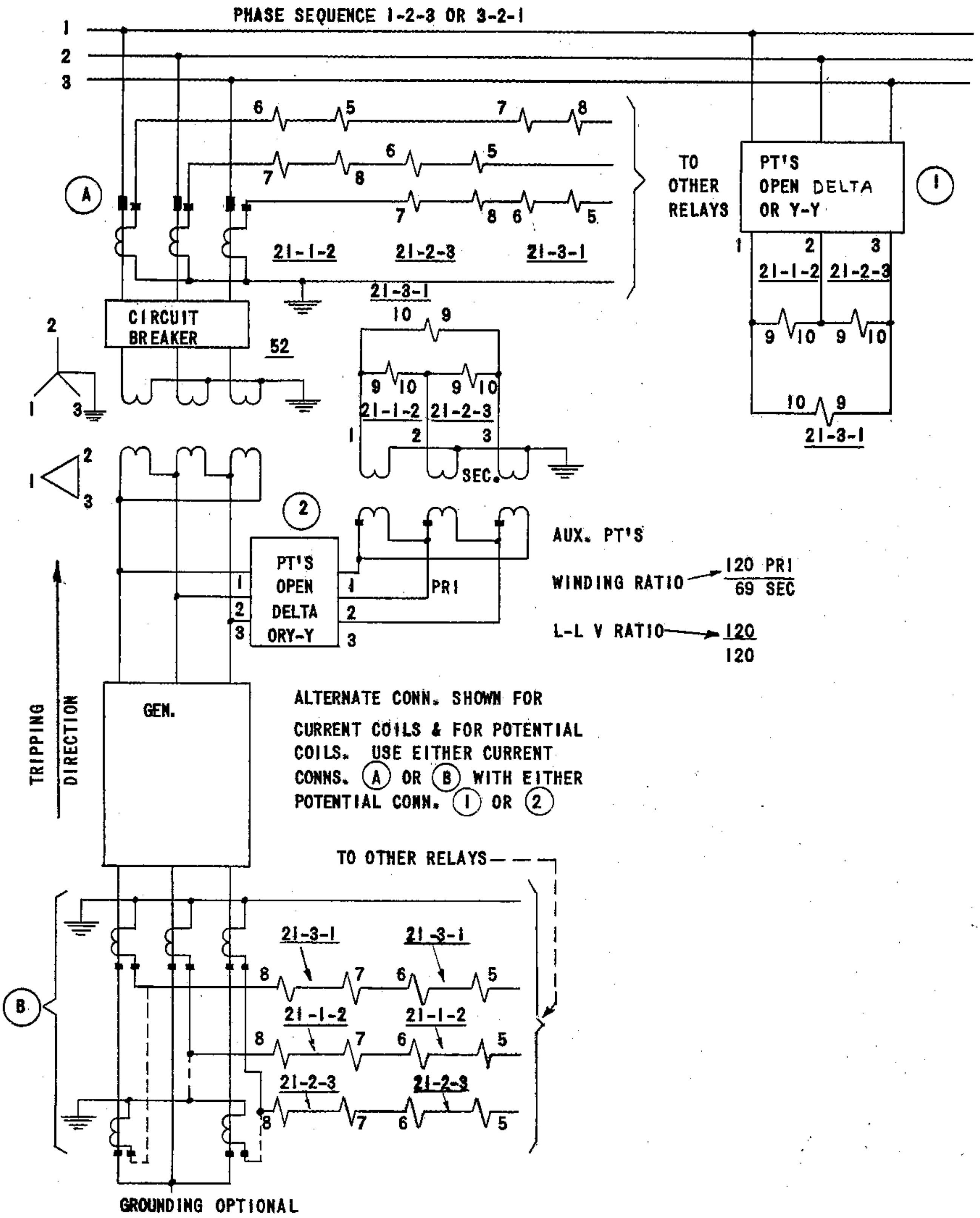



Fig. 3 (403A118-5 Sh.1) External Connections For Type CEB12C And RPM13A Relays For Back-up Protection Of A Generator Against Prolonged System Faults

| LEGEND | | |
|---|---|---|
| DEVICE NO. | DEVICE TYPE | FUNCTION |
| 21 | CEB12C | BACK UP DISTANCE RELAY |
| 94 | HGA14AM OR AL | AUXILIARY TRIPPING RELAY |
| 86 | HEA | LOCKOUT RELAY |
| 62 | RPM13A,13B OR 13D | TIMING RELAY |

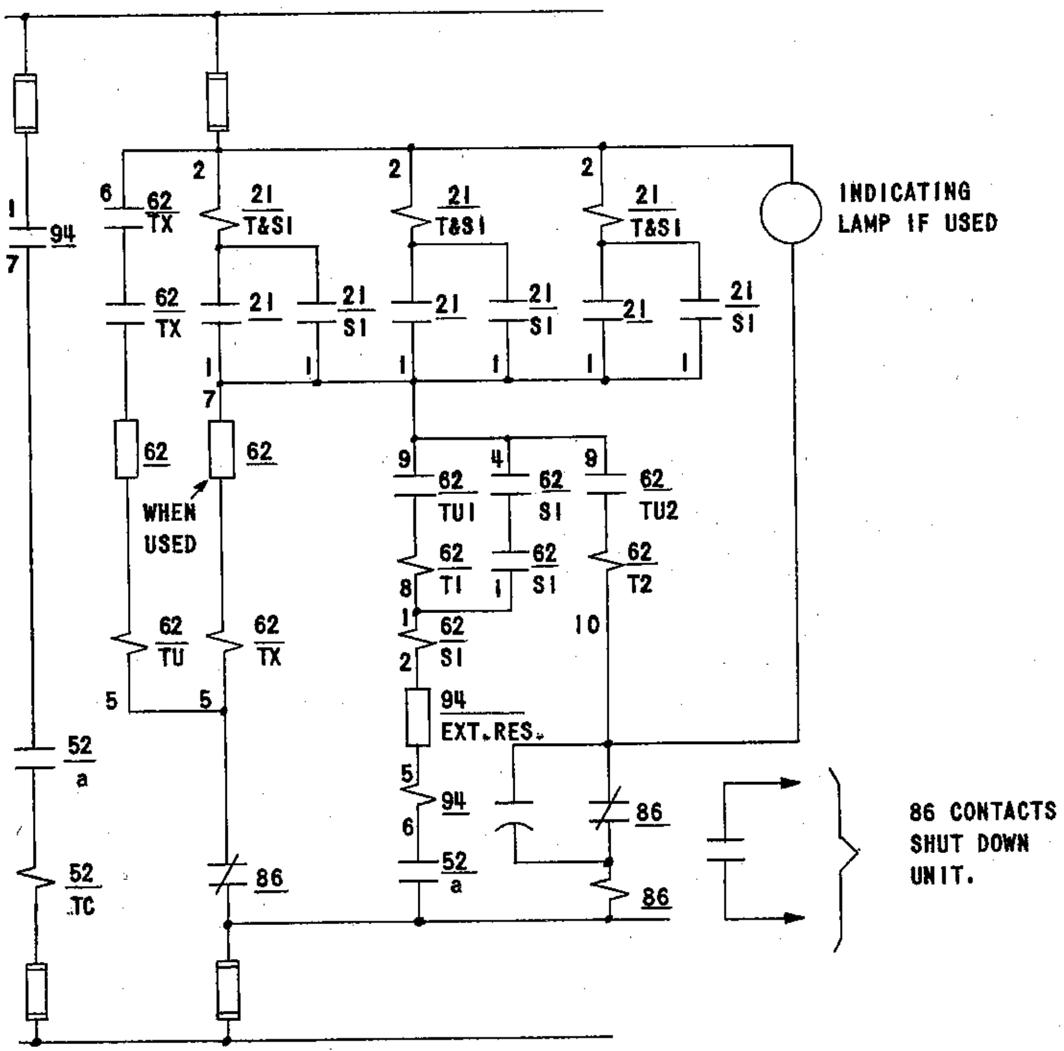



Fig. 3A (403A118-0 Sh.2) Continued

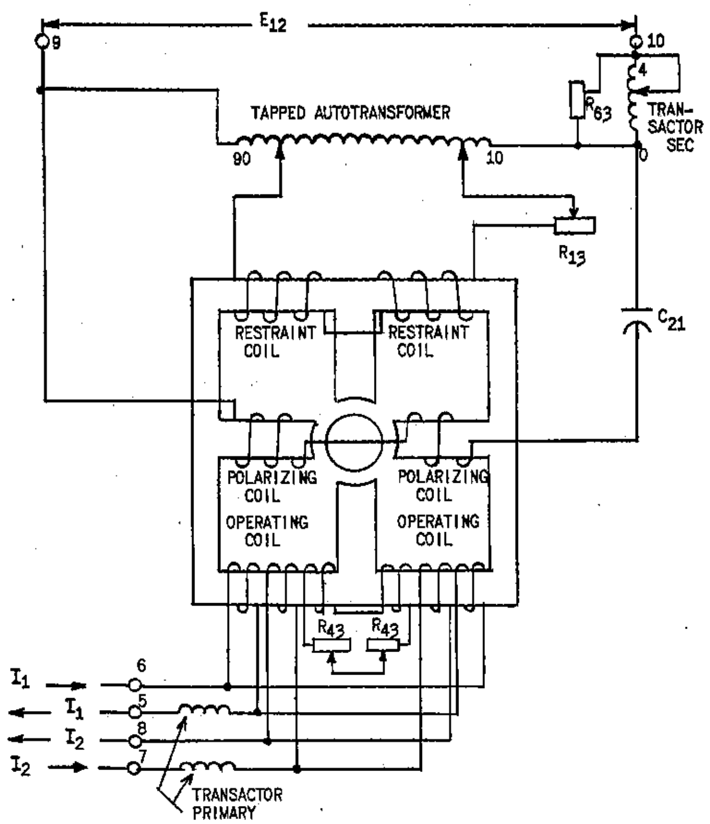



Fig. 4 (0165A7773-0) Schematic Connections For MHO Unit Of Type CEB12C Relay

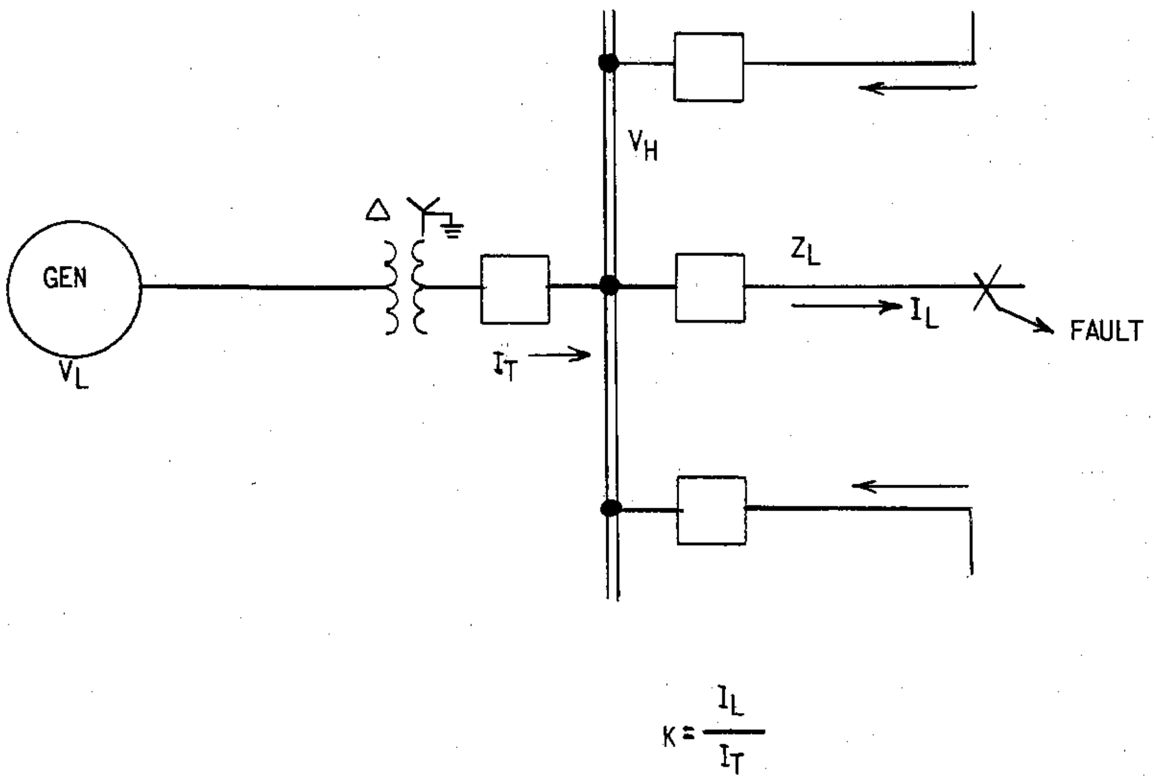



Fig. 5 (0165A7772-0) Typical High Voltage Bus In A Generating Station Showing Ratio Of Current In Line ($Z_L$) To Current In Line Side Of Power Transformer

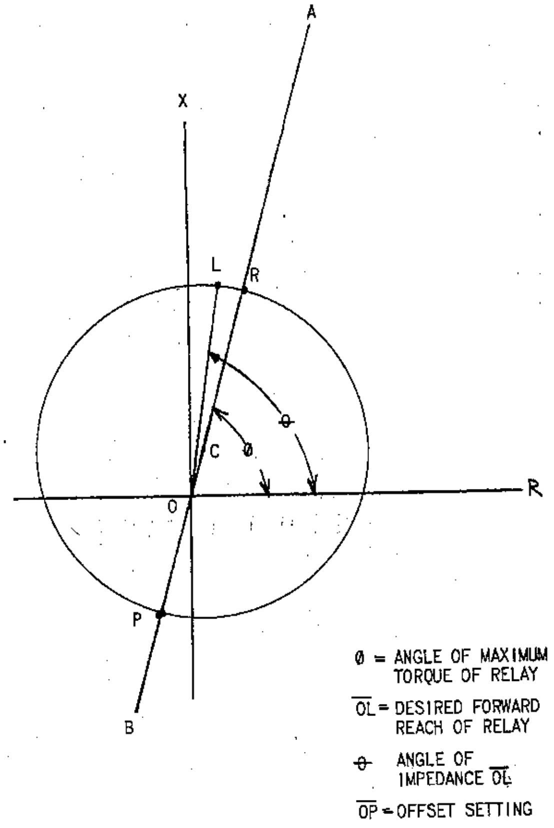



Fig. 6 (0165A7770-0) Offset Characteristic Of Type CEB12C Relay

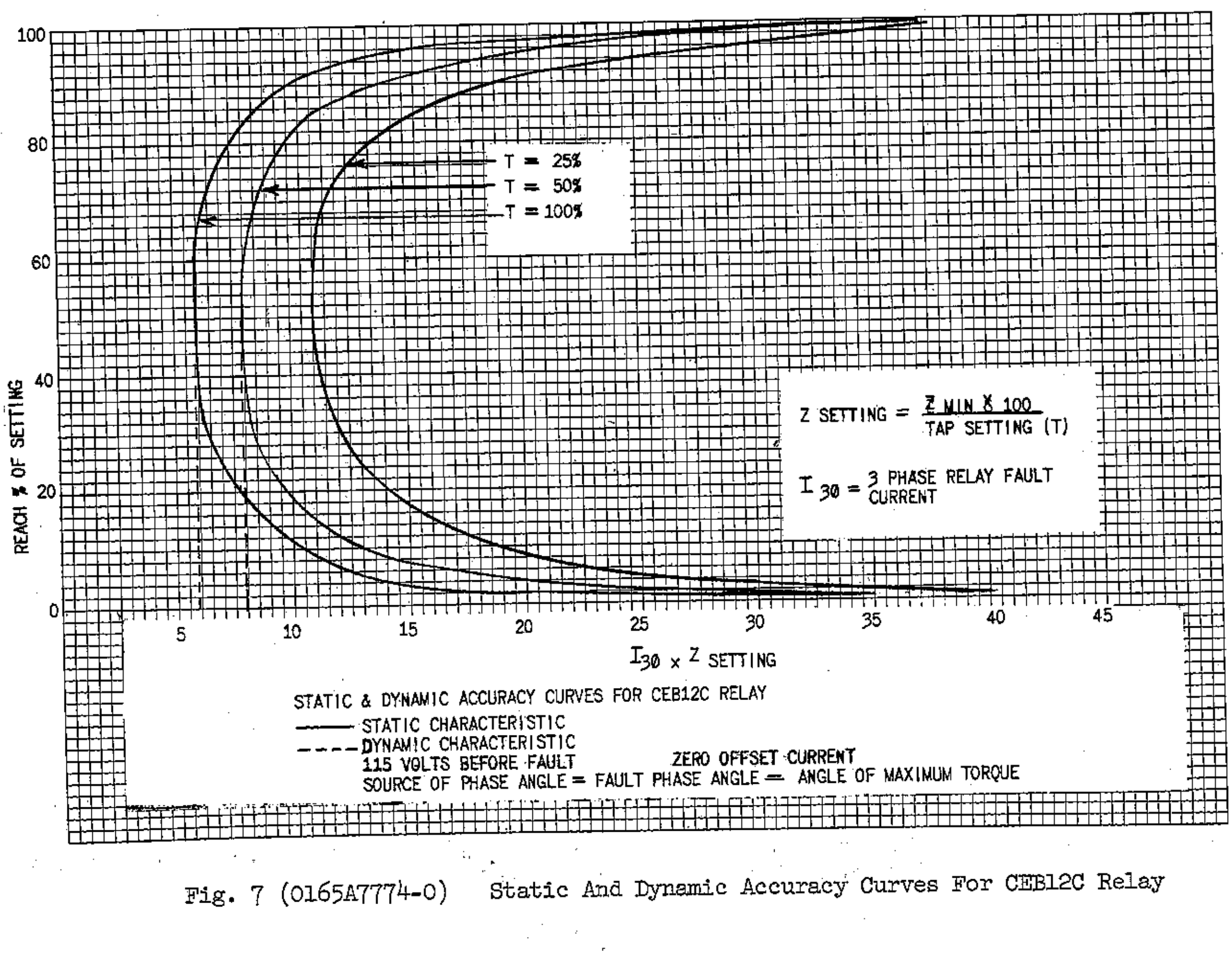



Fig. 7 (0165A7774-0) Static And Dynamic Accuracy Curves For CEB12C Relay

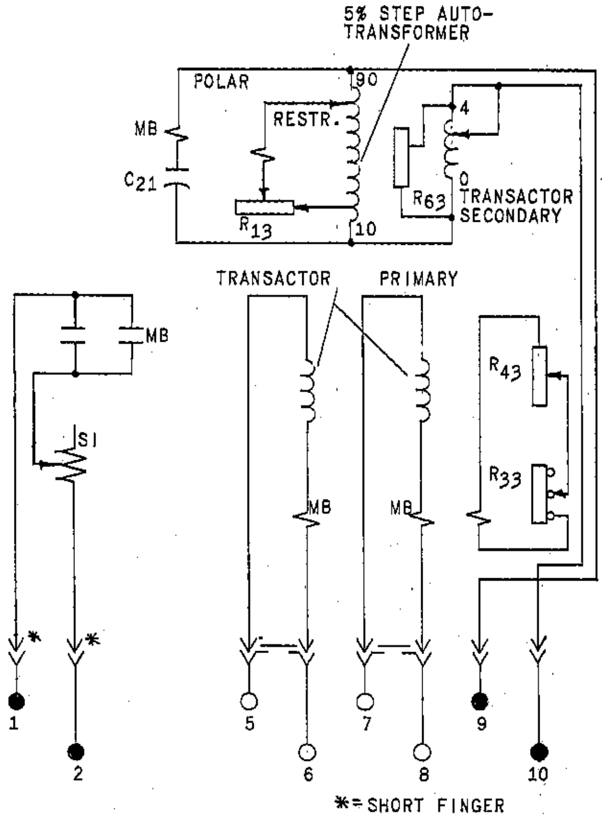
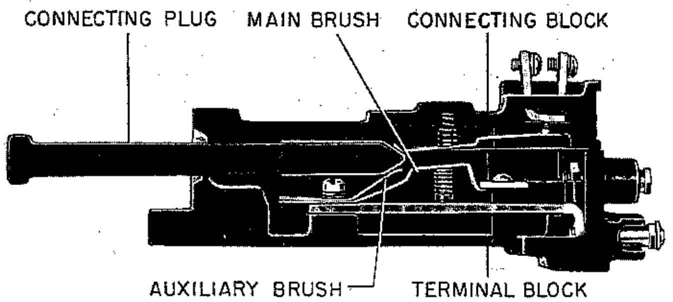



Fig. 8 (376A962-0) Internal Connection Diagram For Type CEB12C Relay (Front View)




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

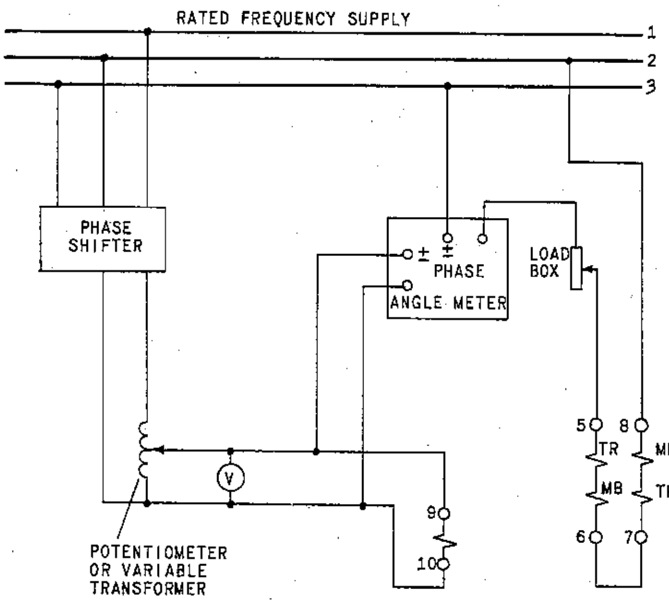



Fig. 10 (376A961-0) Test Connections For Setting Maximum Torque Angle Of Type CEB12C Relay

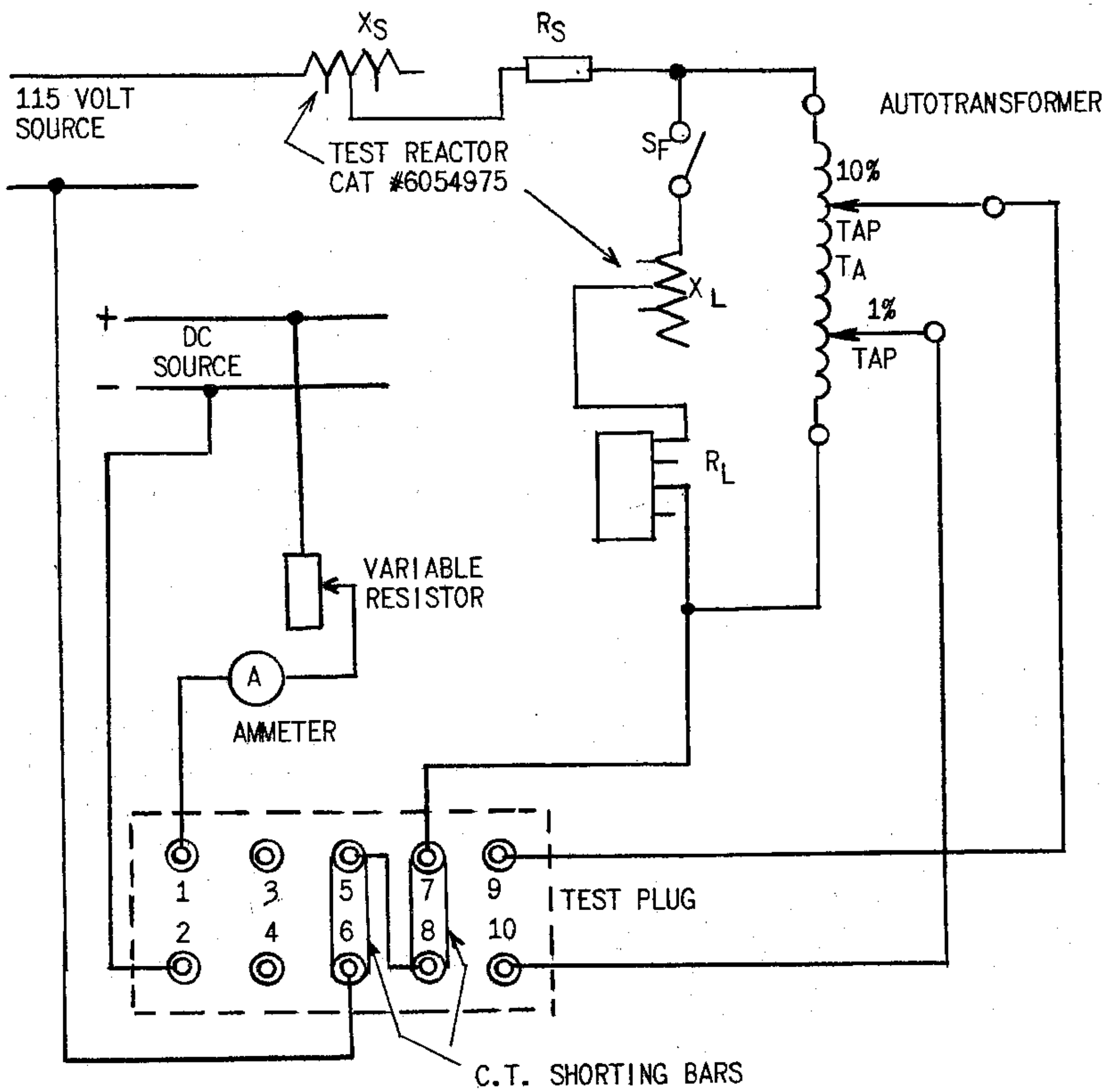



Fig. 11 (0165A7771-0) Field Test Connections Of Type CEB12C Relay

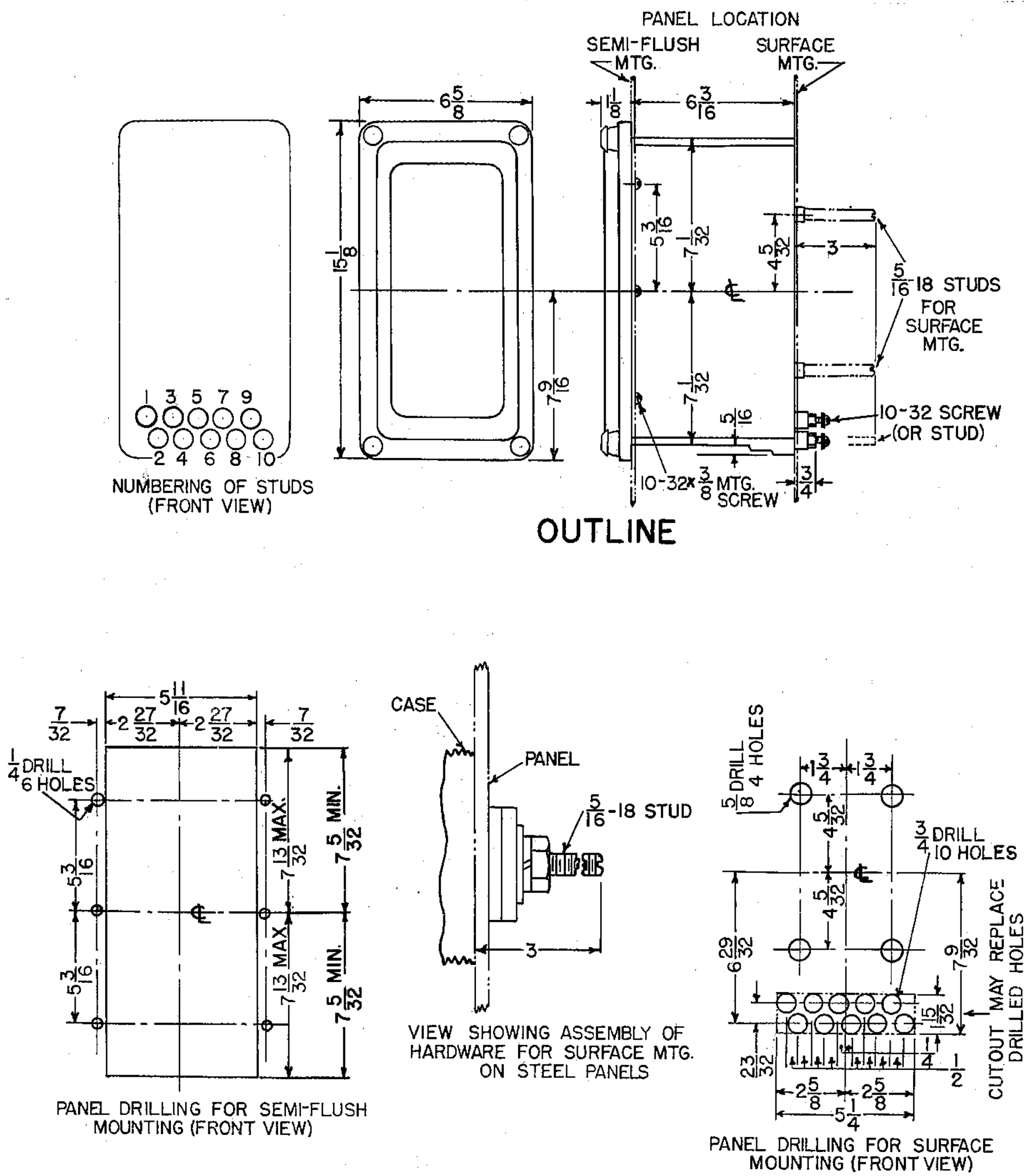



Fig. 12 (6209273-2) Outline And Panel Drilling Dimensions Diagram For Type CEB12C Relay

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