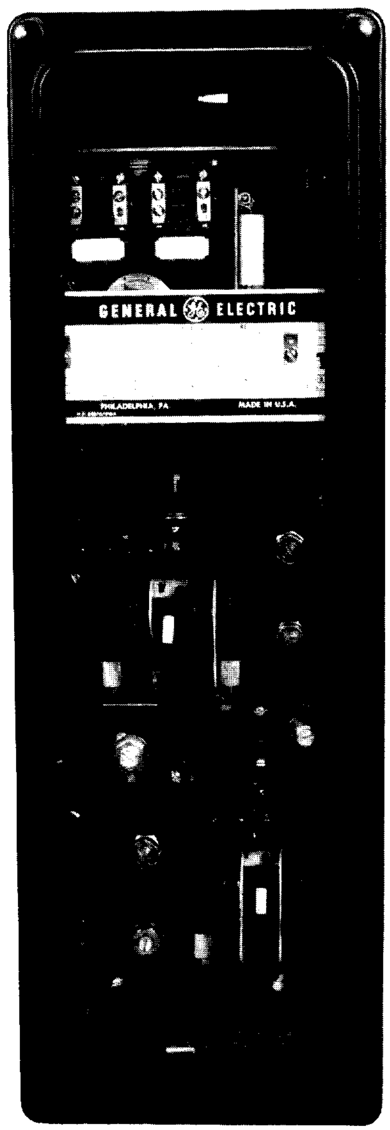
GEK-36782D

INSTRUCTIONS

SINGLE-PHASE RELAY

CEH52A



GE Meter and Control
205 Great Valley Parkway
Malvern, PA 19355-1337

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Single Phase Relay

Type CEH52A

DESCRIPTION

The CEH52A is a single phase relay designed to detect a loss of excitation on synchronous machines. Included in the relay are two independent mho functions, each capable of being set with offset. Offset is used to provide selectivity between loss of excitation and other normal or abnormal conditions that may exist on the system. One of the mho functions works in conjunction with an auxiliary relay having a 66-83 millisecond fixed time delay. The fixed time delay is provided to prevent undesired tripping due to shock, vibration, or sudden complete loss of a-c potential, any of which might result in momentarily closure of the mho function contacts. This mho function provides high speed (66-83 ms) tripping through the auxiliary relay and mho contacts. The second mho function works in conjunction with another fixed time delay (66-83 ms) auxiliary relay and a timing unit provided in the CEH52A relay. Operation of this mho function energizes the auxiliary relay, the contacts of which in turn start the timing unit. After a set time delay (adjustable from 0.05 - 3 seconds) tripping will occur through the mho function and timing unit contacts. The CEH52A is applied in those situations where two mho functions, one having an adjustable time delay, are required. This is discussed further under APPLICATION.

Each mho function of the CEH52A relay has associated with it a target seal-in unit. The CEH52A relay is packaged in a standard L2D drawout case, the outline and panel drilling dimensions for which are illustrated in Figure 14. The internal connection diagram for the CEH52A is illustrated in Figure 13.

APPLICATION

The CEH52A relay is a single phase relay and it is used to detect a loss of excitation on synchronous machines. The CEH52A relay contains two mho functions. One of the mho functions provides high speed tripping; and the second mho function, operating in conjunction with a timer, provides time delayed tripping.

Loss of excitation can be damaging to the machine and/or detrimental to the operation of the system. It is recommended that loss of excitation protection be considered for all synchronous generators.

When a synchronous generator loses excitation it will tend to act as an induction generator, it will run above normal speed, operate at reduced power and receive its excitation (VARS) from the system. The impedance seen by a relay looking into the generator will depend on the machine characteristics, the load flow prior to the loss of excitation, and the type of excitation failure.

Figure 1 illustrates a unit type generator connected to a power system with an offset mho distance relay at its terminals set as indicated on the R-X diagram. The relay is set with an offset equal to one half the direct axis transient reactance and a diameter equal to the direct axis synchronous reactance of the generator. Typical impedance loci as seen by the relay when the excitation is lost as a result of a short circuit across the field windings are also shown in Figure 1. Curve A represents loss of excitation from full load conditions. This locus terminates in a region near the negative X axis at a point located approximately at the average of the direct and quadrature axis sub-transient impedances of the generator. In the case of no load or very light load prior to the loss of excitation, the impedance seen by the relay terminates in an area near the negative X axis as shown by point C. The impedance seen in this case is approximately equal to the average of the direct and quadrature synchronous impedances of the generator. Curve B applies for some moderate condition between full and no load.

In the event of an open-circuited field in which the slip rings flash, the field will then be effectively shorted and the curves of Figure 1 apply. If the slip rings do not flash and the field remains open-circuited, the impedance loci will terminate at approximately the same points as shown in Figure 1 (for the same initial conditions), but since the slip rates are different they will generally follow different paths in getting there.

Thus, the characteristic of Figure 1 will suffice to detect a loss of excitation from any initial loading due to an open or a shorted field circuit.

Since a characteristic with settings as illustrated in Figure 1 is required to detect loss of excitation, it should be ascertained that such an application is secure against undesired operation on stable system swings resulting from system disturbances. Figure 2 illustrates typical impedance loci as viewed by an offset mho relay located at the generator terminals for different system conditions after a nearby fault is cleared.

The dash curve A represents the case for conditions of a three phase short circuit at (F), the high side of the unit transformer, occurring when the machine is running at full load and unity power factor (L_a). When the fault is cleared in nominal relay plus breaker times with the voltage regulator in service, the impedace jumps to point S_a and follows the path of the dash lines back to the region around L_a. This is a stable swing and the impedance path does not enter the required characteristic.

The solid curve B illustrates an extreme case of a similar set of circumstances. In this case:

a) The machine was running underexcited prior to the fault (L_b).

b) The fault was not cleared until the critical switching time for the machine in question.

c) The voltage regulator was out of service.

While the resultant swing was stable and would eventually settle back to the area around L_b, the impedance locus entered the larger relay characteristic. Studies indicate that the duration of its stay in the characteristic is in the order of 0.2 to 0.4 seconds. Thus, if the larger relay characteristic is employed with time delay which is set for about 0.5 to 0.6 seconds, undesired tripping will not take place.

Under these conditions it is recommended that the CEH52A relay with two mho characteristics be employed as indicated in Figure 2. Both characteristics should be set with an offset equal to the ohmic value of $\frac{X'_d}{2}$ per unit. The smaller one should be set with a diameter equal to the ohmic equivalent of (1.0) per unit impedance on the machine base and the larger one set with a diameter equal to the ohmic equivalent of X_d per unit. The relay with the smaller set characteristic would operate in conjunction with a built-in 4-5 cycle time delay auxiliary while the relay with the larger set characteristic would operate in conjunction with an internal timing relay having a range in the order of 0.05-3.0 seconds.

In actual practice, whether a fault condition will produce a swing similar to that of curve A or B in Figure 2 will depend on system and generator operating conditions. This can be fully evaluated only by a study of the system. Thus, whether a CEH52A having two mho characteristics is required will depend on the possible modes of operation of the generator, the generator characteristics and the particular system involved.

There is some concern about the performance of the voltage regulator when it is operating on the underexcited limit. It is feared that the regulator will "undershoot" while trying to maintain the limit and thereby cause the apparent impedance to momentarily enter the relay characteristic. When a CEH52A having two characteristics is used as illustrated in Figure 2, the larger characteristic is set with time delay and this problem could be avoided. The voltage regulator manufacturer should be consulted to determine the time delay to be used with the relay.

It should be recognized when using the CEH52A as illustrated in Figure 2, that a bonafide loss of excitation from the lighter load conditions may be detected only by the larger characteristic. This will result in a delayed trip which may have some adverse effects on the system. This should be evaluated by the user.

The basic considerations discussed above apply to generators with all types of prime movers. However, in the case of hydro machines which may be operated severely underexcited during light load to compensate for system distributed capacitance, the operating condition can approach the loss of field condition on terms of impedance seen by the CEH at the machine terminals. These applications, along with underexcited synchronous condenser applications should be referred to the factory for additional information.

The CEH relay is designed for use with line-to-line voltages (E_A-E_B) and delta currents (I_A-I_B). Wye or open-delta connected PT's rated 120V phase-to-phase may be used. External connection diagrams for this application are shown in Figures 3 and 4. It also may be applied with a single line-to-neutral PT with a secondary voltage rating of 69 or 120V but in this case only <u>one</u> current coil of each mho function is connected in the CT circuit. External connections for this application are shown in Figure 5. Regardless of which connections are used, the relay settings are calculated as indicated in the section under CALCULATIONS OF SETTINGS. However, it should be noted when the CEH is used with one single phase-to-ground PT that the actual PT ratio on the tap selected (69 or 120 volts) must be used in the calculation of secondary ohms.

If it is elected to use the single live-to-neutral PT connection of Figure 5, two possible conditions that may affect proper operation of the CEH relay should be considered. First, assuming that Phase One to ground potential is used as shown in Figure 5 and that the machine neutral is grounded through as distribution transformer, a ground on either Phase Two or Three of the generatior leads will cause the relay polarizing restraint voltage to increase the phase-to-phase voltage level and to shift the in-phase angle by 30 degrees in either the lagging or leading direction. This will reduce the diameter of the relay characteristics and cause the characteristics (Figure 17) to shift 30 degrees either lagging or leading. A ground fault on the Phase One generator lead will reduce the voltage applied to the relay, therefore increasing the diameter of the relay characteristic. These conditions could either interfere with a proper operation of the relay, or could cause a false operation.

The external d-c connections to the CEH52A relay as illustrated in Figure 6 indicate that breaker contacts 52/a must be used in the d-c circuits. These 52/a contacts are required in order to prevent the relay from misoperating during start-up procedures when there might be low frequencies or no voltage (restraint) applied to the relay.

An important consideration in the application of the CEH relay relates to the PT secondary fusing practice. In general, the PT's that provide potential to the CEH relay will have other burdens connected between phases and possibly between phases and neutral. If a secondary fuse or circuit breaker on one phase is open, the potential on that phase will <u>not</u> necessarily go to zero. It will generally assume some potential depending on the impedance of the total burdens connected between that phase and the other phase and ground. If this resulting potential is applied to the CEH relay the diameter of the characteristic will usually increase and the angle of maximum torque will shift clockwise or counter-clockwise depending on the circumstances. This can result in improper operation during load conditions. Thus, when PT secondary fuses are employed it is recommended that the CEH relay be fused separately from all other devices, as indicated in Figure 7, so that any blown fuse, except a main fuse, will result in either zero voltage or normal voltage to the CEH relay. This will not cause the relay to operate falsely under normal load conditions. However, if the short circuit that caused the fuse to blow or other burden is maintained across the CEH relay, false operation may occur after clearing a prolonged nearby system fault. Figure 8 illustrates two examples of how <u>not</u> to fuse the PT circuits to the CEH relay.

The blowing of a PT primary fuse (where used) presents a similar problem that cannot generally be solved as easily as the secondary fuse situation. In the case of three wye connected PT's, a blown primary fuse can result in the CEH relay receiving low and phase shifted voltage. This can result in the relay operating falsely on load or possibly after clearing a nearby system fault depending on the circumstances.

In the case of two open-delta connected PT's, with primary fuses as illustrated in Figure 3, a blown primary fuse on the associated PT can result in a characteristic that is larger than the setting and with its angle of maximum torque shifted in phase angle. However, this shift is in the direction of non-operation under load conditions.

If a single PT is used, connected either phase-to-neutral or phase-to-phase, a blown primary or secondary fuse will remove potential from the relay. The relay will not operate to trip correctly or incorrectly for this condition. Using the connections and secondary fusing shown in Figure 3 through 7 will prevent undesired tripping under load conditions when a secondary fuse is removed or blown. In order to prevent such tripping on the loss of a primary fuse with wye connected PT's, a Type CVFB voltage balance relay is suggested to supervise the CEH52A tripping contacts.

<u>CALCULATION OF SETTINGS</u>

The following settings must be made on the CEH52A relay: The offset tap setting, circle diameter restraint tap settings and time delay setting. It is recommended that the following offset and diameter settings be used.

OFFSET = one-half transient reactance ($X'_d/2$) for both mho functions

SMALL DIAMETER = 1.0 per unit reactance on machine base

LARGE DIAMETER = synchronous reactance (X_d)

The offset tap setting is made directly in terms of secondary ohms via the L and H leads on the offset tap block. Settings can be made in the range indicated on the nameplate in 0.5 ohm steps. Note that the offset setting is equal to the difference between the two offset taps used. If the offset tap setting cannot be made exactly, the next higher tap setting should be used.

Each circle diameter setting is made via the upper and lower leads on the respective restraint tap block. The tap setting is expressed in percent and is a function of the basic minimum diameter of the relay and the desired ohmic diameter in secondary ohms. It is adjustable in a range of 0 to 100 percent in one percent steps, but the setting should never be set below 10 percent.

It is calculated as follows:

$$\text{Restraint Tap Setting (\%)} = \frac{\text{(Basic minimum diameter) (x) (100)}}{\text{(Desired diameter in secondary ohms)}} \quad (1)$$

INFORMATION REQUIRED TO MAKE SETTINGS

Transient Reactance (X'_d) - in percent or per unit on the associated machine base.

Synchronous Reactance (X_d) - in percent or per unit on the associated machine base.

Base MVA - MVA base equals generator rating in MVA

Base KV - KV base equals generator rating in KV

CT Ratio

PT Ratio

EXAMPLES OF CALCULATIONS

Given the following:

X'_d = 50% = 0.50 per unit

X_d = 196% = 1.96 per unit

Base MVA = 600

Base KV = 14.0

CT Ratio = 25,000/5 = 5000/1

PT Ratio = 14,400/120 = 120/1

then,

$$Z_{base}\text{ (sec)} = \frac{\text{(KV base)}^2}{\text{MVA base}} \times \frac{\text{CT Ratio}}{\text{PT Ratio}}$$

$$= \frac{14^2}{600} \times \frac{5000}{120}$$

= 13.8 secondary ohms

X'_d (sec) = (Z_{base}) x (X'_d per unit)

= 13.8 x 0.5

= 6.9 secondary ohms

X_d (sec) = (Z_{base}) x (X_d per unit)

= 13.8 x 1.96

= 27.0 secondary ohms

1.0 per unit secondary = (Z_{base})

= 13.8 secondary ohms

a) Set offset tap on both mho functions $= \frac{X'_d}{2} = \frac{6.9}{2} = 3.45$ ohms
Use next higher tap setting = 3.5 ohms. Note that the offset setting is the difference between the two offset taps used.

b) Set small diameter mho function restraint tap to value corresponding to 1.0 per unit reactance which is given above as 13.8 ohms.

$$\text{Restraint tap} = \frac{10 \times 100}{13.8} = 72.5\%, \text{ use } 72\%$$

c) Set the larger diameter mho function restraint tap to a value corresponding to the actual synchronous reactance of machine in secondary ohms. (X_d = 27 ohms).

From equation (1) above

$$\text{Restraint tap} = \frac{10 \times 100}{27} = 37.1\%, \text{ use } 37\%$$

d) Determine time delay necessary to ride over regulator undershoot and/or stable swing and make appropriate time delay setting on the timing unit.

RATINGS

The CEH52A is available with ratings of 120 volts, 5 amperes for 50 or 60 hertz operation. The range of ohmic reach adjustment on both mho units is 10 to 100 ohms, phase to neutral (in one percent steps). Each of the two units has an offset transactor which will provide 0 to 6 ohms offset in 0.5 ohm steps along the angle of maximum torque (270^{o} lag). The auxiliary and timing circuitry has a D.C. dual rating, selectable by links on the front of the relay. Ratings from 48 to 240 volts D.C. are possible. The standard timer range is 0.05 to 3.0 seconds with calibration points at .05, .1, .2, .3, .5, 1, 2, and 3 seconds. The one second thermal rating of the current circuits of this relay is 150 amperes.

BURDENS

Because of the presence of a transactor in the circuit, the burdens imposed upon the current and potential transformers are not constant, but vary somewhat with the ohmic reach, amount of offset, and amount and phase angle of the current.

CURRENT CIRCUITS

For each unit the maximum 60 cycle burden imposed on each current transformer is:

R	X	Z
0.064	0.102	0.120

The current burden was measured under phase-to-phase conditions which yield higher burden readings than balanced three-phase conditions. Any change caused by different conditions of offset will cause the burden to be less than indicated. The impedance given above applies to terminals 3-4, 4-5, 6-7, and 7-8.

POTENTIAL BURDEN

The maximum potential burden (17-18) at 120 volts, 5 amperes, 60 cycles is:

WATTS	VARS	VOLT-AMPS
21.8	17	27.7

The potential burden will decrease as the restraint tap is decreased. The maximum burden, given above occurs with a restraint tap setting of 100 percent. The potential burden will also depend upon the angle between the voltage and current applied to the relay. Maximum potential burden occurs when the current (I_1 - I_3) lags the voltage (V_{1-3}) by 90 degrees (generator at zero P.F. overexcited).

D.C. CIRCUITS

The A and B unit circuits (11-12, 13-14) will each dissipate the watts indicated in the table below depending on the control voltage tap used.

VOLTAGE TAP	WATTS
125	2.5
250	4.38

The static timer unit circuit (terminals 15-16) will dissipate the following wattages at rated voltage (TU picked up).

VOLTAGE	MAXIMUM WATTS
48	2.5
125	7.5
250	15.5

The ratings of the seal-in units for their various taps (0.2/0.6 or 0.2/2.0) are given in Table A below.

TABLE A

	TAP					
	0.2	2.0	0.6	2.0	1.0	4.0
D.C. RESISTANCE ± 10%	8.3	0.24	0.78	0.18	0.32	0.04
MIN. OPER. "I" (+)0(-) 40%	0.2	2.0	0.6	2.0	1.0	4.0
CARRY "I" CONT. (AMP)	0.37	2.3	1.2	2.6	1.8	5.5
CARRY 30A FOR (SEC.)	0.05	2.2	0.5	3.5	0.85	13
CARRY 10A FOR (SEC.)	0.45	20	5.0	30	7.5	125
60HZ "Z" (OHMS)	50	0.65	6.2	0.65	2.6	0.16

CHARACTERISTICS

The offset mho units are similar to the basic mho unit with the addition of a transactor. The transactor is an air gap reactor with a secondary winding for obtaining the desired voltage at a given primary current. It also provides electrical isolation between the current and potential circuits. By adding the transactor-secondary voltage in series with terminal voltage of the potential transformer and applying the vector sum to the mho unit potential circuit, the effect is to offset the ohmic characteristic without changing its diameter.

The internal connections to the transactor secondary are of such polarity that the offset is in the direction to move the center of the circle away from the origin. Figure 9 shows the effect of changing the offset tap when the restraint tap is left at 100 percent. This shows that the diameter of the characteristic does not change with the offset, but that the center of the circle is moved away from the origin by the value of the offset tap. Figure 10 shows the effect of changing the restraint tap when the offset tap is set on 2 ohms. The diameter of the circle in phase-to-neutral secondary ohms is equal to $\frac{1000}{\text{restraint tap \%}}$. In other words, the diameter is 10 ohms if the restraint tap is 100, or 25 if the restraint tap is 40.

The auxiliary units A and B are telephone type relays. The purpose of these auxiliaries is to prevent the relay from tripping the breaker falsely due to vibration when no voltage is applied to the potential circuit, or contact bounce if the voltage falls to zero. The operating time of these units is 0.067 to .083 seconds.

The static timer unit measures the time it takes to charge a capacitor through an adjustable resistor after voltage is applied to the unit. Zener diode regulators keep the voltage across the resistor capacitor combination constant to produce a charging time that varies directly with the resistance in the charging circuit. When the capacitor voltage reaches a certain voltage level, it triggers a control rectifier by means of a unijunction transistor. The control rectifier picks up a telephone type unit to terminate the timing period.

For time settings less than 0.1 second the operating time will increase 4 to 5 percent at 80% of rated voltage and decrease by 1-2 percent at 120% of rated voltage. For time settings greater than 0.1 seconds the change in operating time with voltage is typically less than ±1% from 80 to 120% of rated voltage.

Figure 11 shows the timing variation as a function of ambient temperature.

Under identical conditions the unit will be repeatable within one percent of the original setting. The timing unit has practically no overtravel.

CONSTRUCTION

The Type CEH52A relays are assembled in the deep large size double ended (L2-D) drawout case having studs at both ends in the rear for external connections. The electrical connections between the relay and case studs are through stationary molded inner and outer blocks between which nests a removable connecting plug. The outer blocks have the terminals for the internal connections.

Every circuit in the drawout case has an auxiliary brush, as shown in Fig. 12, to provide adequate overlap when the connecting plug is withdrawn or inserted. Some circuits are equipped with shorting bars (see internal connections in Fig. 13), and on those circuits, it is especially important that the auxiliary brush make contact as indicated in Fig. 12 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 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. Outline and panel drilling is shown in Fig. 14.

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.

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 the relay, an examination should be made for any damage sustained during shipment. If injury or damage resulting from rough handling is evident, a claim should be filed at once with the transportation company and the nearest Sales Office of the General Electric Company notified promptly.

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

INSPECTION

Before placing a relay in service the following mechanical adjustments should be checked, and faulty conditions corrected:

The armature and contacts of the target and seal-in 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.

There should be no noticeable mechanical friction in the rotating structure of the units, and the moving contacts should return to the right when the relay is de-energized.

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

If possible, the relay contact circuit should be given an electrical test in place by closing the mho unit contacts by hand and allowing tripping current to pass through the contacts and the target and seal-in unit.

The rotating structure of the mho unit is not balanced, so that any slight torque caused by a tilt of the shaft when the relay is installed ready for operation should be compensated using the control spring adjusting arm at the top of the unit. Rotate the control spring adjusting ring so as to return the moving contact arm to the right-hand backstop. The control spring should hold the contacts definitely open.

With the TU unit de-energized each normally open contact should have a gap of .010" - .015". Observe the wipe on each normally closed contact by deflecting the stationary contact member towards the frame. Wipe should be approximately .005".

The wipe on each normally open A and B unit contact should be approximately .005". This can be checked by inserting a .005" shim between the residual screw and the pole piece and operating the armature by hand, the normally open contacts should make.

CAUTION: EVERY CIRCUIT IN THE DRAWOUT CASE HAS AN AUXILIARY BRUSH. IT IS ESPECIALLY IMPORTANT ON CURRENT CIRCUITS AND OTHER CIRCUITS WITH SHORTING BARS THAT THE AUXILIARY BRUSH BE BENT HIGH ENOUGH TO ENGAGE THE CONNECTING PLUG OR TEST PLUG BEFORE THE MAIN BRUSHES DO. THIS WILL PREVENT CT SECONDARY CIRCUITS FROM BEING OPENED.

ELECTRICAL TESTS

DRAWOUT RELAYS GENERAL

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

POWER REQUIREMENTS GENERAL

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

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

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

POLARITY CHECK

The polarity of the OM1 and OM2 units can be checked by making the connections shown in Fig. 15. With these connections the mho unit contacts should close when the restraint taps are on 10 percent and open when the restraint taps are on 100 percent, using the zero offset tap in each case. Note that the relay should be level and in its case.

A check of the OM1 and OM2 unit reach can be made as follows:

1. Connect the relay as shown in Fig. 25.

2. Set the test reactor on the 24 ohm tap.

3. Set the relay restraint tap on 55 percent and the offset tap on 2 ohms.

4. Determine the minimum test box dial setting that will cause the mho unit contacts to close. The dial setting should be between 15 and 19.

5. Determine the maximum test box dial setting that will cause the mho unit contacts to close. The dial setting should be between 60 and 70.

6. The minimum and maximum test box dial settings, between which the mho unit contacts should close, can be determined for any relay setting by the following equations. However, for low restraint setting of the mho unit the calculated dial setting will be over 100 percent if a test reactor with a maximum tap of 24 ohms is used. If the calculated dial setting, using the 24 ohm test reactor can be used by putting current through only one of the two current circuits (either circuit 3-5 or 6-8 can be used). When only one of the two current circuits is used the test box dial setting will be one half the value calculated from the following equation:

$$\text{Min. dial setting} = \frac{200 \sin \theta \text{ (offset ohms)}}{X}$$

$$\text{Max. dial setting} = 200 \sin \theta \, \frac{\frac{1000}{TR} + \text{offset ohms}}{X}$$

Where θ = the power factor angle of the test reactor

X = actual reactance of reactor

TR = restraint tap setting of relay

If the test reactor 6054975 G1 is used, the term sin θ can be assumed to be unity, as any of the taps above 3 ohms have a power factor angle of 83 degrees or more.

D-C AUXILIARIES

The auxiliaries A and B may be checked by setting the control voltage links in the proper position and suddenly applying rated voltage to terminals 11-12 or 13-14. The OM1 and OM2 contacts must be blocked closed to allow the units to operate. These units should pick-up in 67 to 83 milliseconds. If the time is not in this range, refer to the "SERVICING" section.

TIMER UNIT

The timer unit may be checked by blocking the B unit contact closed and applying rated voltage with the proper polarity to terminals 15-16. With R1 set to the maximum calibration point, the TU unit should pick-up after a three second time delay. For acceptance purposes, a timer need not be used to verify this.

INSTALLATION PROCEDURE

INSPECTION

Inspect the relay as described under "Acceptance Tests".

LOCATION

The location should be clean and dry, free from dust and excessive vibration, and 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. 14.

CONNECTIONS

Internal connections are shown in Figure 13.

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

OFFSET TAP BLOCK

The two leads to this tap block are marked L and H. The ohmic offset of the relay is the difference between the H and L tap settings. By variation, any combination of ohmic offset may be obtained up to 6 ohms in 0.5 ohm steps, phase-to-neutral. As an example, placing the L lead in the 0.5 ohm tap and the H lead in the 4.0 ohm tap give 3.5 ohms offset. The H lead must be in a higher tap than the L lead to keep the offset in the proper direction.

RESTRAINT TAP BLOCK

Variation of the restraint tap setting varies the size of the ohmic characteristic. (See Fig. 10). The variation is in 1% steps up to 10% and in 10% steps up to 100%, thus providing for a restraint adjustment of 1-100% in 1% steps.

SEAL-IN UNIT TAP SETTING

The tap screw is the screw holding the right hand stationary contact of the seal-in unit. To change the tap setting, first remove the connecting plug. Then, take a screw from the left hand stationary contact and place it in the desired tap. Next, remove the screw from the other tap and place it in the left hand contact. This procedure is necessary to prevent the right hand stationary contact from getting out of adjustment. Screws should not be in both taps at the same time.

CHECK OF CHARACTERISTIC

1. Connect as shown in Fig. 16. Allow relay potential coils to warm up by energizing at rated voltage for 15 minutes prior to testing.
2. Turn phase shifter to make angle 90 degrees (current leads voltage).
3. Set offset ohms on 4 ohms and transformer taps on 100 percent.
4. Increase current until contacts just close.

Current should be:

$$\frac{\text{Voltage across studs 17-18}}{\text{2 X Min. ohms + 2 X Offset}} = \frac{120}{20 + 8} = 4.28$$

The relay should operate within ± 5 percent of this value (4.49 to 4.07).

To check any particular setting required for a specific application, proceed as follows:

1. Calculate diameter of circle.

   $$\text{Diameter} = \frac{\text{Min. Ohms}}{\text{Tap Setting}} \quad (\emptyset - \text{N ohms})$$

   Example: Assume 23 percent tap setting.

   $$\text{Diameter} = \frac{10}{0.23} = 43.4 \text{ ohms } (\emptyset\text{-N ohms})$$

2. Center of circle = radius + offset

   $$\text{Center} = \frac{43.4}{2} + 2 = 21.7 + 2 = 23.7 \text{ ohms}$$

3. Draw relay characteristic on polar paper with center at 90 degrees lead using distance from origin and diameter calculated above. (See Fig. 17).

4. Set current in current coils at any test value.

   Calculate Ø - N ohms as follows:

   $$\text{Ohms } (\emptyset - \text{N}) = \frac{\text{Voltage on studs 17-18}}{2 \text{ X I}}$$

   Example: Assume I set at 5 amperes.

   $$\emptyset - \text{N} = \frac{120}{2\text{X}5} = 12.0 \text{ ohms. (Points A and B)}$$

5. Turn phase shifter and determine the two angles between which the contacts of the relay are closed. These should check with the angles at which the relay characteristic, drawn in step 3 above, crosses the impedance calculated for the test current I in step 4 above.

6. Set phase shifter for 90 degrees lead and determine the minimum current for which the relay contacts are closed.

   $$\text{Min. I} = \frac{\text{Voltage studs 17-18}}{2 \text{ (Diameter + Offset)}} \quad \text{(for Point C)}$$

   For example above:

   $$\text{Min. I} = \frac{120}{2\ (43.4 + 2)} = \frac{120}{90.8} = 1.32 \text{ amps}$$

Three points have now been determined on the relay characteristic. These three points should be enough to show the relay characteristic is the proper size and has the correct angle of maximum torque. If more points are desired repeat step 4 above using a different value of test current. During these checks endeavor to keep the test current in the order of 20 amperes or less. The maximum current under abnormal conditions is limited by the generator impedance and will usually be less than 20 amperes.

If the angle of maximum torque is not correct on OM1, it can be adjusted by means of R12, or X1. R13 and X2 provide a similar adjustment on OM2. If the diameter of the circle is not correct for the particular tap setting, it can be adjusted by means of R3 for OM1, or R2 for OM2.

There is no adjustment on the offset, it is determined by built-in parameters of the transactor.

ALTERNATE CHECK OF OM1 AND OM2 CHARACTERISTIC

If no phase shifter is available, the relay characteristic may be checked at the points shown in Fig. 18. The test connections are shown in Fig. 19.

Apply a low current and gradually increase the current until the contacts close. Increase the current further until the contacts reopen. The higher currents should be removed quickly as they will be several times the relay rating of 5 amperes. Set the offset taps on zero.

For connections for test 1, the points on the R-X diagram of the relay characteristic will be:

$$R = \frac{0.5V}{2\ I_{pick\text{-}up}} = \frac{0.25V}{I_{pick\text{-}up}}$$

$$X = \frac{-0.866V}{2\ I_{pick\text{-}up}} = \frac{-0.433V}{I_{pick\text{-}up}}$$

For test 2, the points on the R-X diagram will be:

$$R = \frac{-0.5V}{2\ I_{pick\text{-}up}} = \frac{-0.25V}{I_{pick\text{-}up}}$$

$$X = \frac{-0.866V}{2\ I_{pick\text{-}up}} = \frac{-0.433V}{I_{pick\text{-}up}}$$

TIMER UNIT

An electronic timer should be used in adjusting this unit. The time may be roughly set by the calibration marks on the scaleplate (± 10 percent). Rheostat R1 on the front of the relay controls the time setting. Note that the B unit must be operated to test this unit and that the polarity of the connections to terminals 15 and 16 is important.

INSTALLATION TESTS

When relay is installed and the generator is running, the following tests should be made to check the overall connections.

To avoid an undesirable drop in system voltage due to operation far into the underexcited region, this installation check is made with relay potential reversed as shown in Fig.20 , and with the OM1 and OM2 restraint reduced to zero or 5%. The reversal of potential inverts the operating characteristic from its normal position, and the reduction of restraint increases the diameter of the characteristics. Figure 21 shows these effects, and also the characteristic with zero restraint and zero offset.

With zero restraint, zero offset, and power out of the generator, the OM1 and OM2 contacts should be closed for all values of lagging power factor (overexcited), and open for all values of leading power factor (underexcited). For this polarity test, it is not necessary to change the field from the unity power factor conditon any farther than enough to open and close the relay contacts.

If the relay with potential reversed by the test plug operates opposite to the direction described for this polarity test, it will trip falsely at heavy loads if placed in service by means of the connection plug.

With 5% restraint and the value of offset chosen for the installation being checked, the relay contacts should close as the excitation is increased from the unity power factor condition sufficiently to cross the corresponding relay characteristic of Fig. 21 into the more lagging (overexcited) area.

PERIODIC CHECKS AND ROUTINE MAINTENANCE

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

CONTACT CLEANING

For cleaning relay contacts, a flexible burnishing tool should be used. This consists of a flexible strip of metal with an etched-roughened surface resembling in effect a superfine file. The polishing action is so delicate that no scratches are left, yet it will clean off any corrosion 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

The relay is adjusted at the factory and it is advisable not to disturb the adjustments. If for any reason they have been disturbed, the following points should be observed in restoring them.

CLUTCH ADJUSTMENT (OM1, OM2)

The induction-cup units have a clutch so that the cup and shaft can slip with respect to the moving contact whenever the torque in either the opening or the closing direction becomes greater than a predetermined value. The grams to slip the clutch should be measured by holding the cup and pushing with a gram gage against the moving contact. The moving contact should slip relative to the cup at approximately 50 grams pressure. The pressure at which the clutch slips can be changed by inserting a special flat open end wrench, underneath the green composition head directly above the spool body of the front coils so that it engages with the flats on the bakelite on the cup shaft. Hold this wrench and with a 5/16" open end wrench loosen or tighten the clutch by turning the nut below the spring wind up sprocket. Turn the nut clockwise (top-front view) to tighten the clutch setting, counterclockwise to loosen it. An exploded view of this unit is shown in Figure 22.

CONTACT ADJUSTMENT (OM1, OM2)

The stationary contact should rest against its felt backstop and should have about 1/16-3/32 inch gap. A typical unit is shown in Figure 23.

AUXILIARY TIME DELAY UNITS A AND B

If it should become necessary to adjust the pick-up time of these units follow the procedure outlined below. Refer to Figure 24 for telephone type unit nomenclature.

To increase the pickup time, bend the actuating arm up toward the contact springs. This will cause the armature to rest at a greater distance from the pole-face. This will also make the total stroke of the armature greater so the residual screw on the front of the armature should be turned in (clockwise) to return the stroke to normal. Note that increasing the pickup time also increases the pickup voltage, therefore, the pickup level of the A or B unit should be checked after the above procedure has been used. These units should pick-up at 80 percent or less of rated voltage when hot, or 60 percent when cold.

To decrease the pickup time, turn the residual screw out (counterclockwise) so that only 2-3 thousandths remains protruding on the inside of the armature. Push the armature in by hand and bend the actuating arm down away from the contact springs slightly. This will allow the armature to rest closer to the poleface. The stroke of the relay will now be shorter so the normally open stationary contact springs must be bent down so that the contact is just made when a 0.005" shim is between the armature and poleface, and the unit is operated by hand. Note that a gap of 0.015" must be maintained between all normally open contacts when the unit is in the de-energized position and between the normally closed contacts when the unit is in the operated position.

RENEWAL PARTS

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

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

Since the last edition, Figure 13 has been updated, Figures 26-28 and the cover photograph have been added.

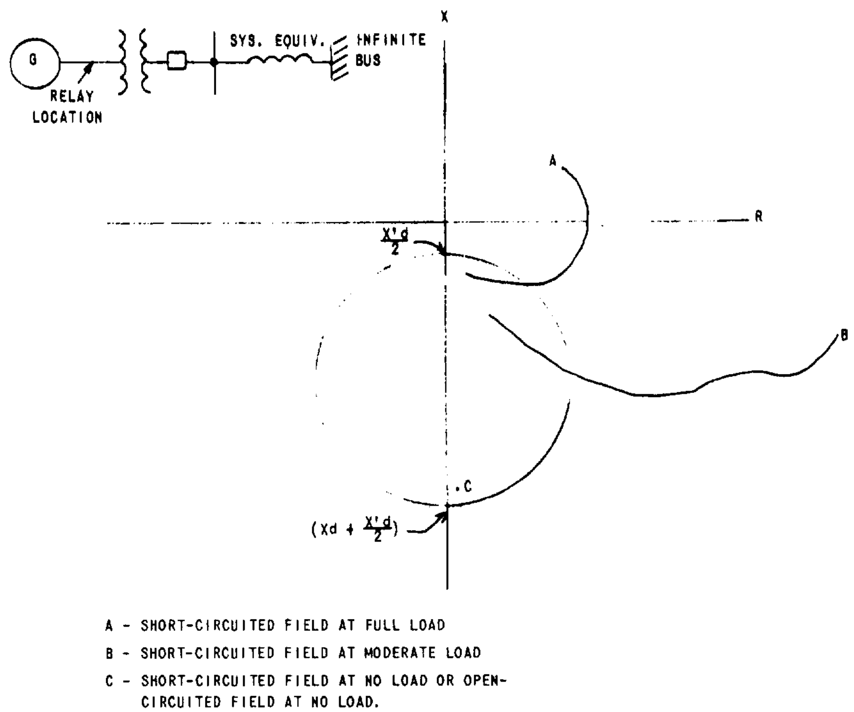


FIG. 1 (0246A3385-0) Typical Impedance Loci On Loss Of Field Excitation

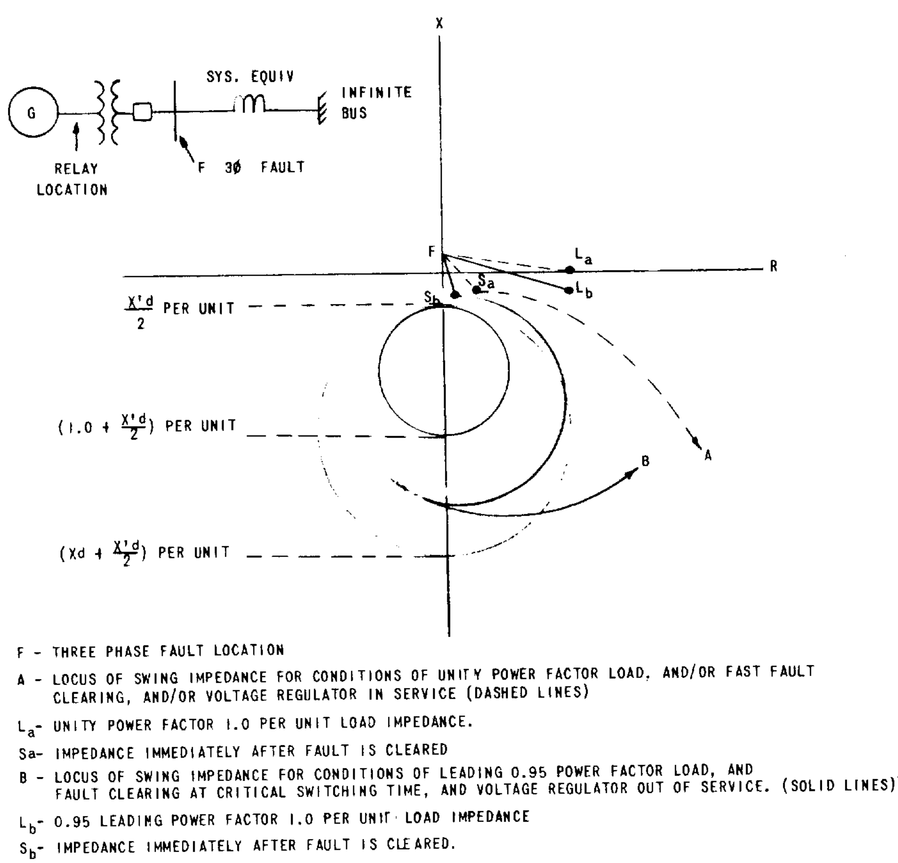


FIG. 2 (0246A3386-0) Typical Impedance Loci For Swings Resulting From System Disturbances

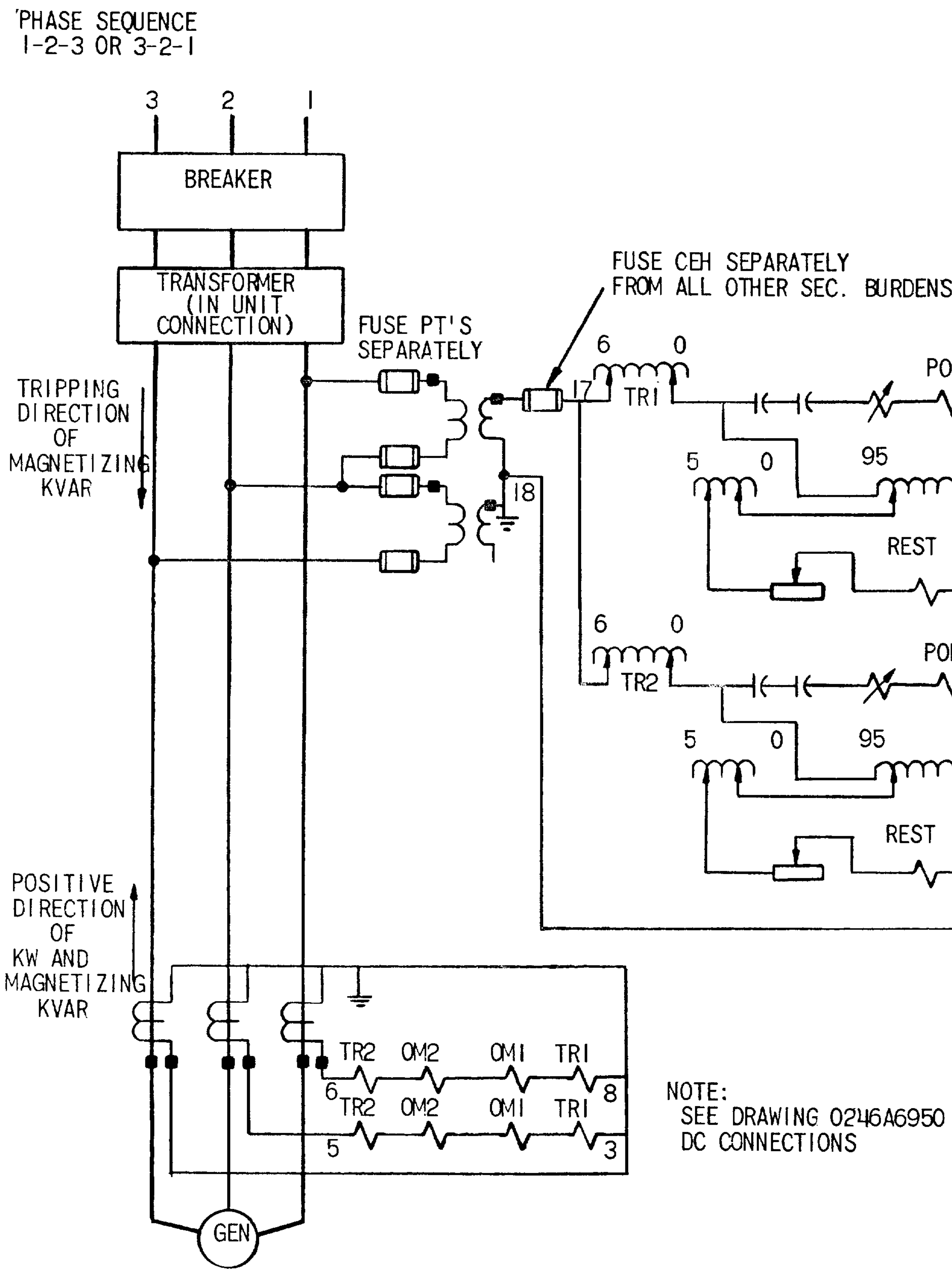


Figure 3 (0246A6947 [1]) External AC Connections for CEH52A Relay Using Open Delta Connected PTs

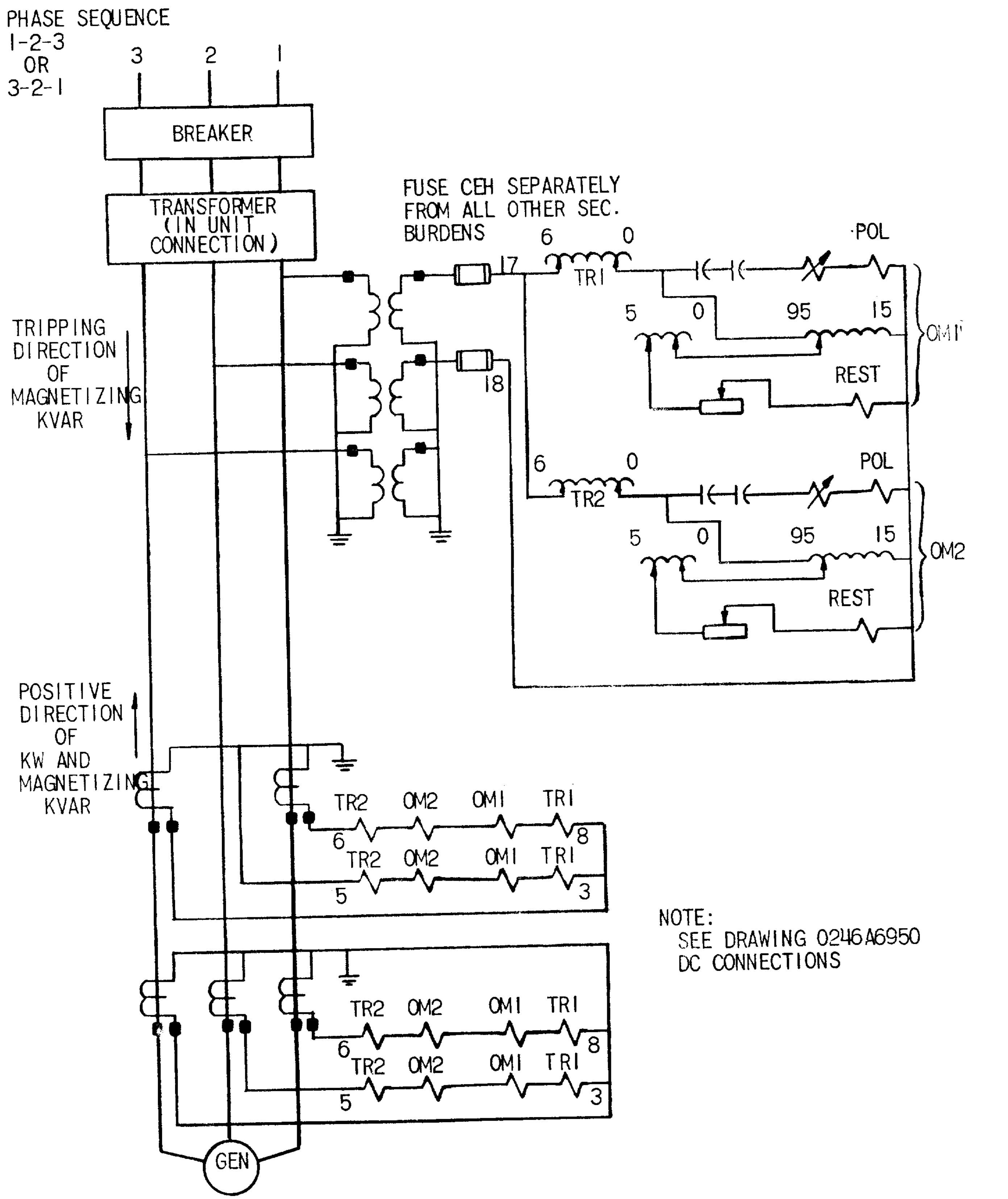


Figure 4 (0246A6948 [1]) External AC Connections for CEH52A Relay Using Wye Connected PTs

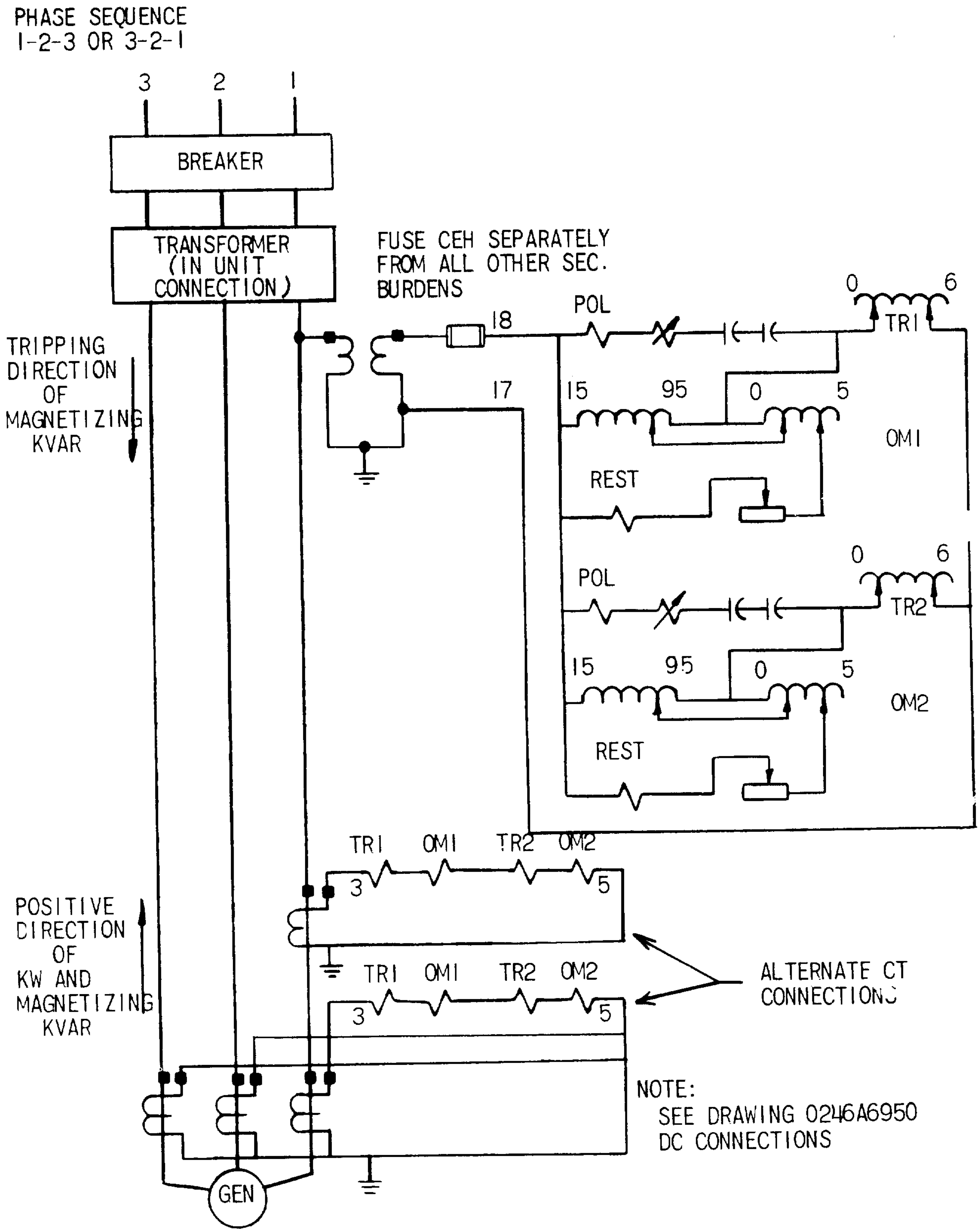


FIG. 5 (024A6949[1]) External AC Connections for CEH-52A Relay Using Line-to-Neutral Connected PT

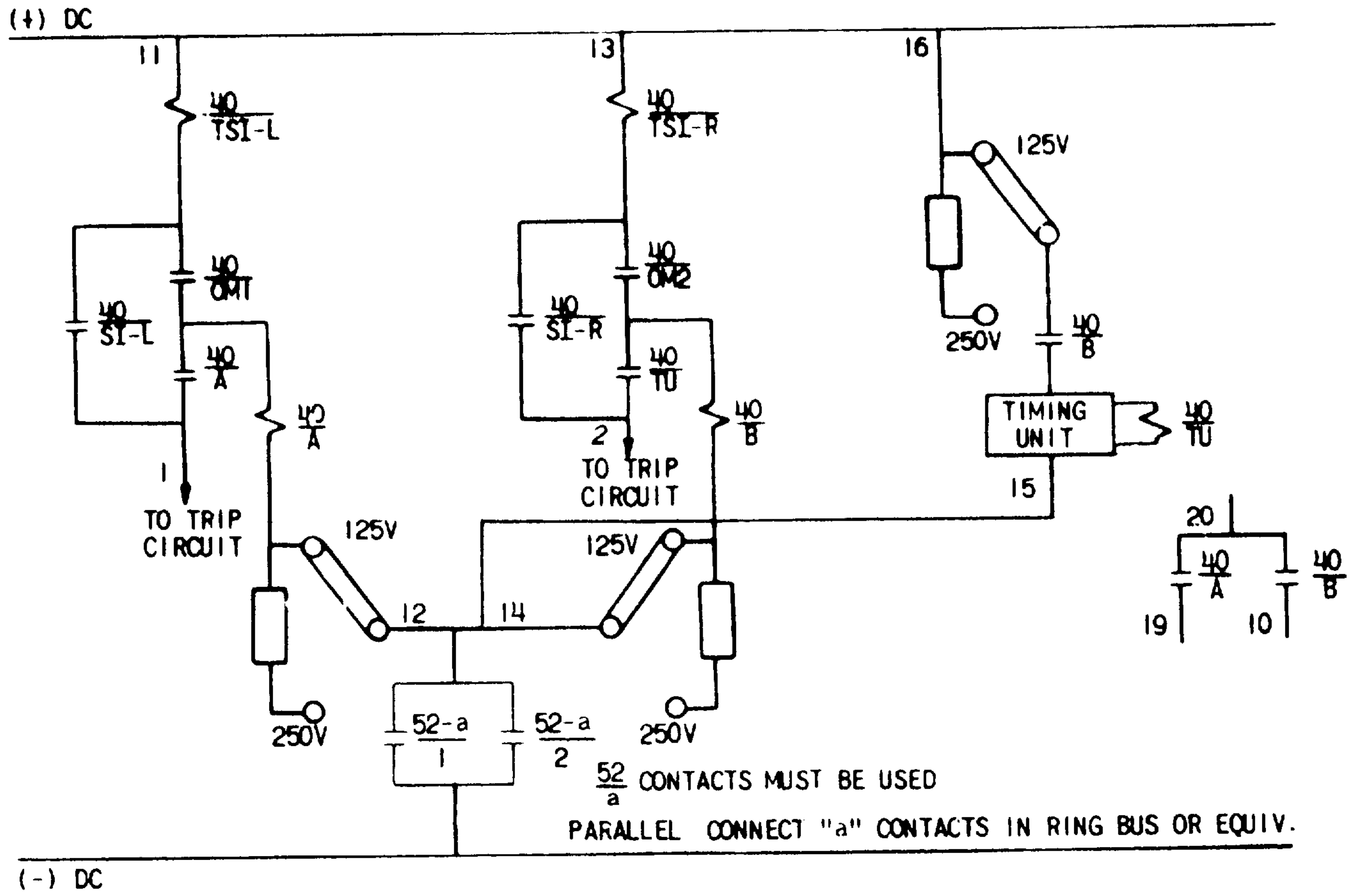


Figure 6 (0246A6950 [2]) External DC Connections for CEH52A Relay

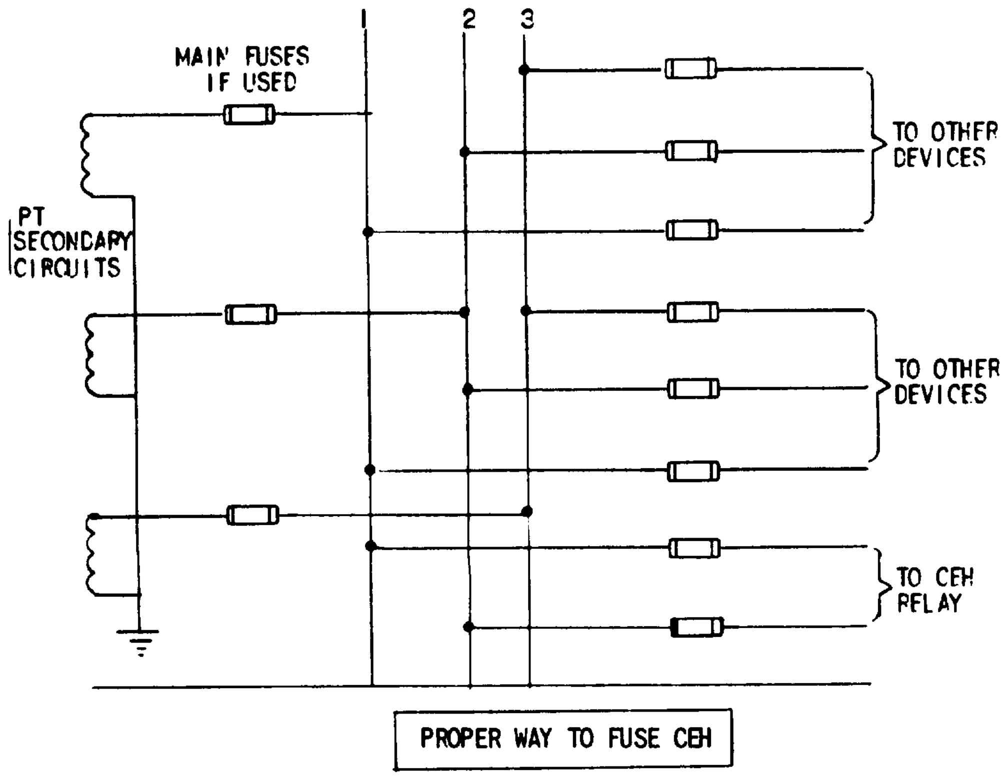


FIG. 7 (0246A3391-1) Correct Secondary PT Fusing For CEH52A Relay

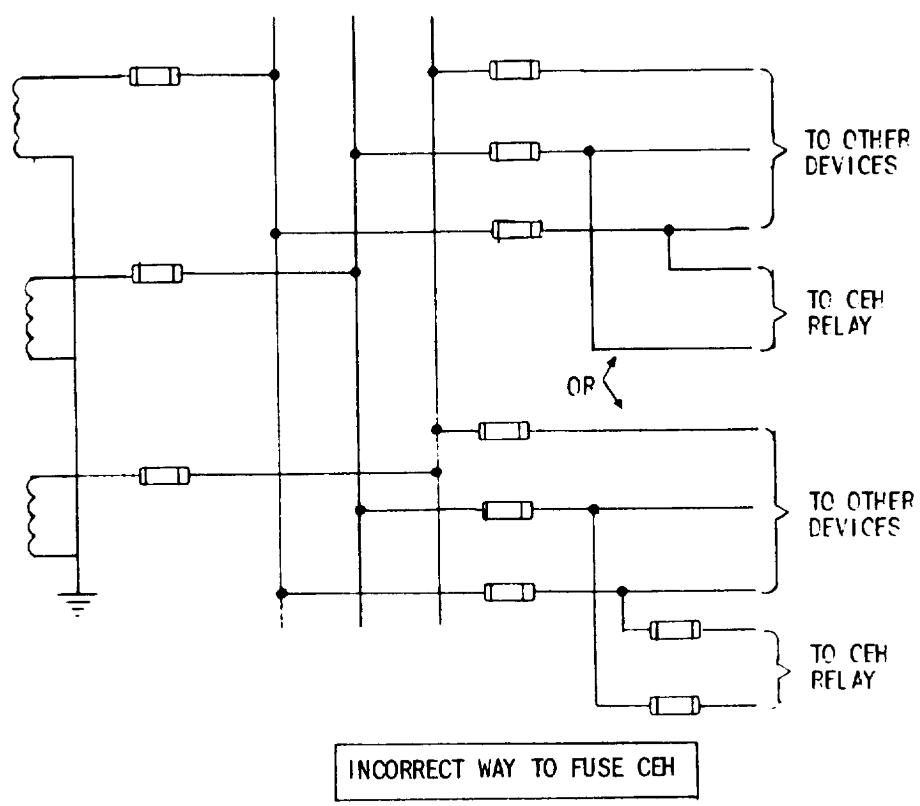


FIG. 8 (0246A3392-1) Incorrect Secondary PT Fusing For CEH52A Relay

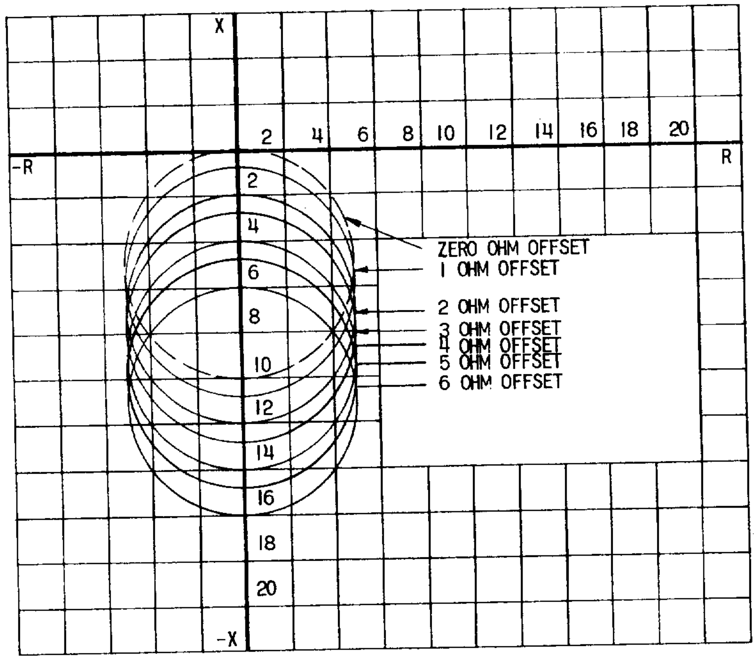


FIG. 9 (0246A7058-0) Effect Of Changing The Offset Tap Of CEH52A OM1 And OM2 Units

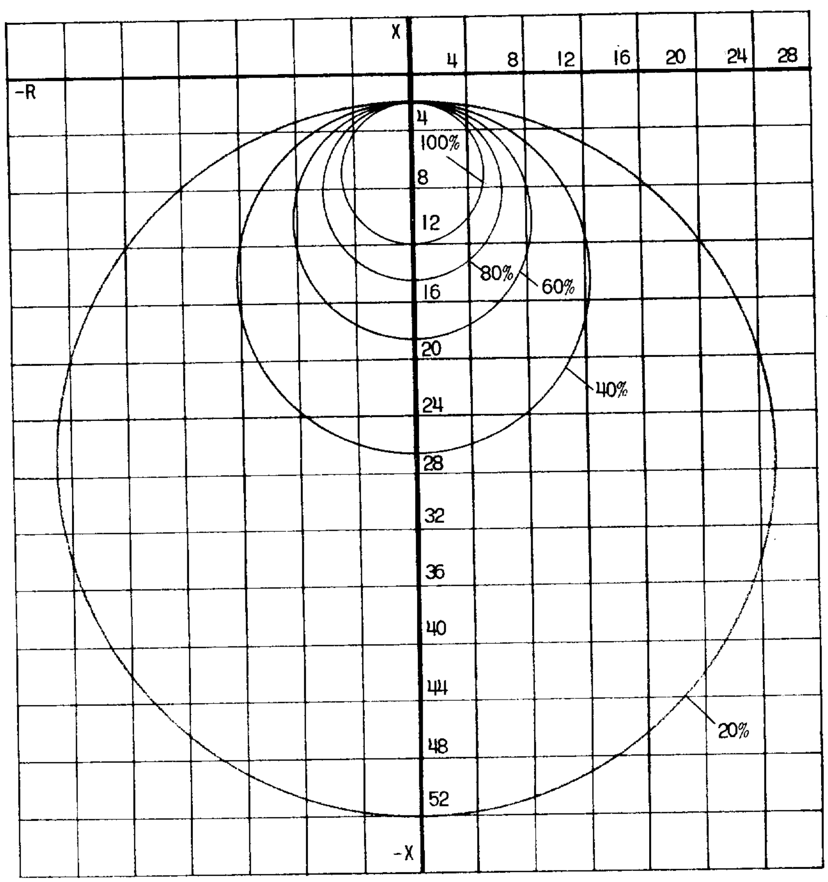


FIG. 10 (02^'A7059-0) Effect Of Changing The Restraint Tap Of CEH52A OM1 And OM2 Units

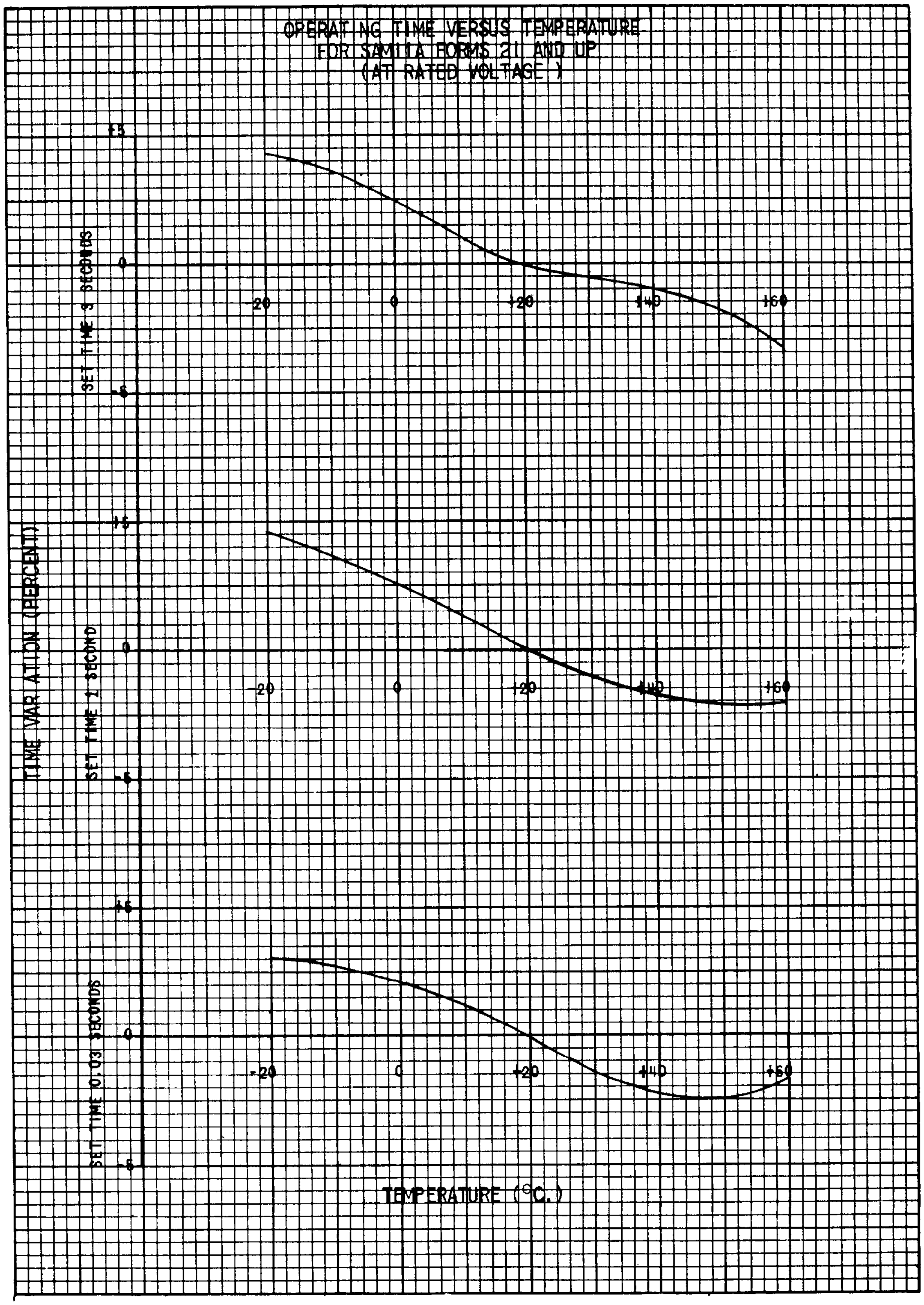


FIG. 11 (0246A2598-0) Operating Time Versus Temperature For The Timer Unit Of CEH52A

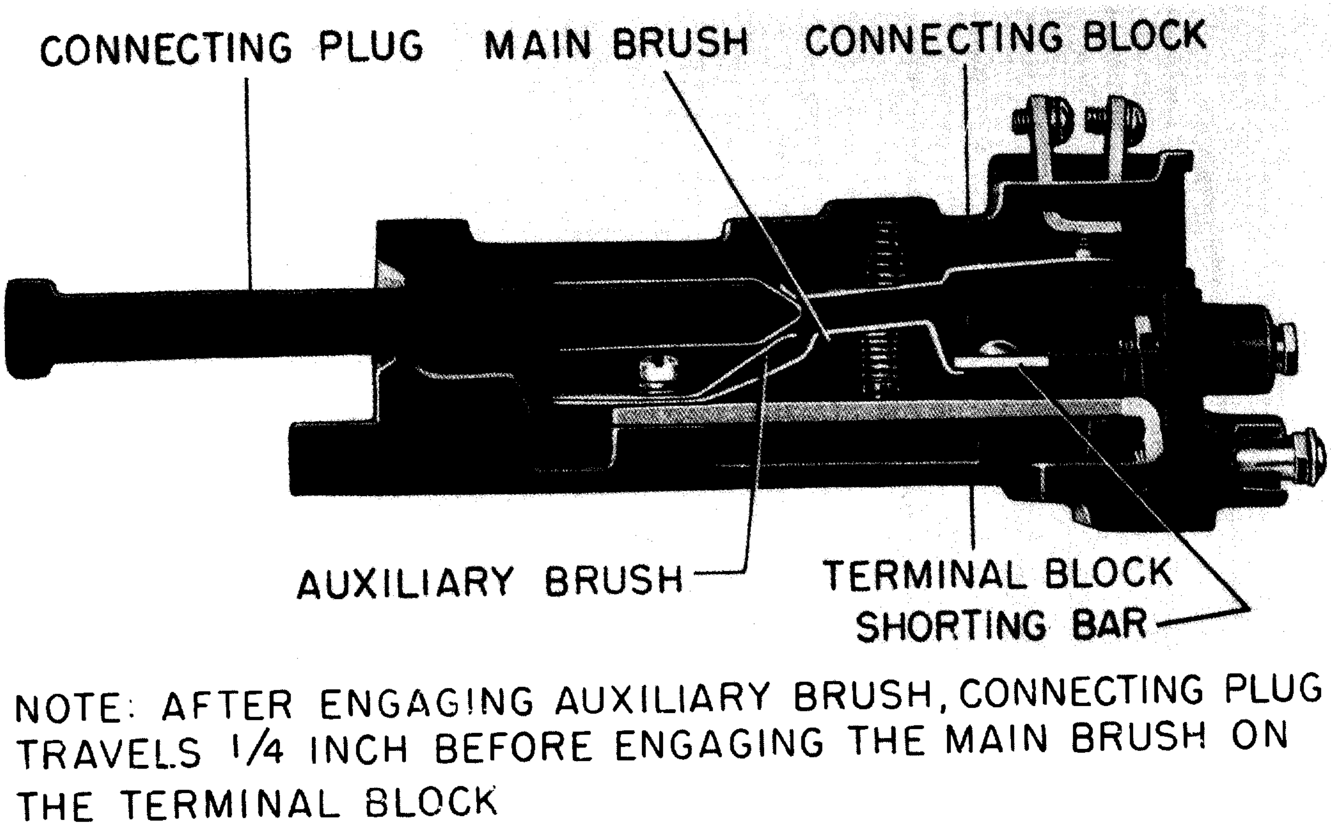
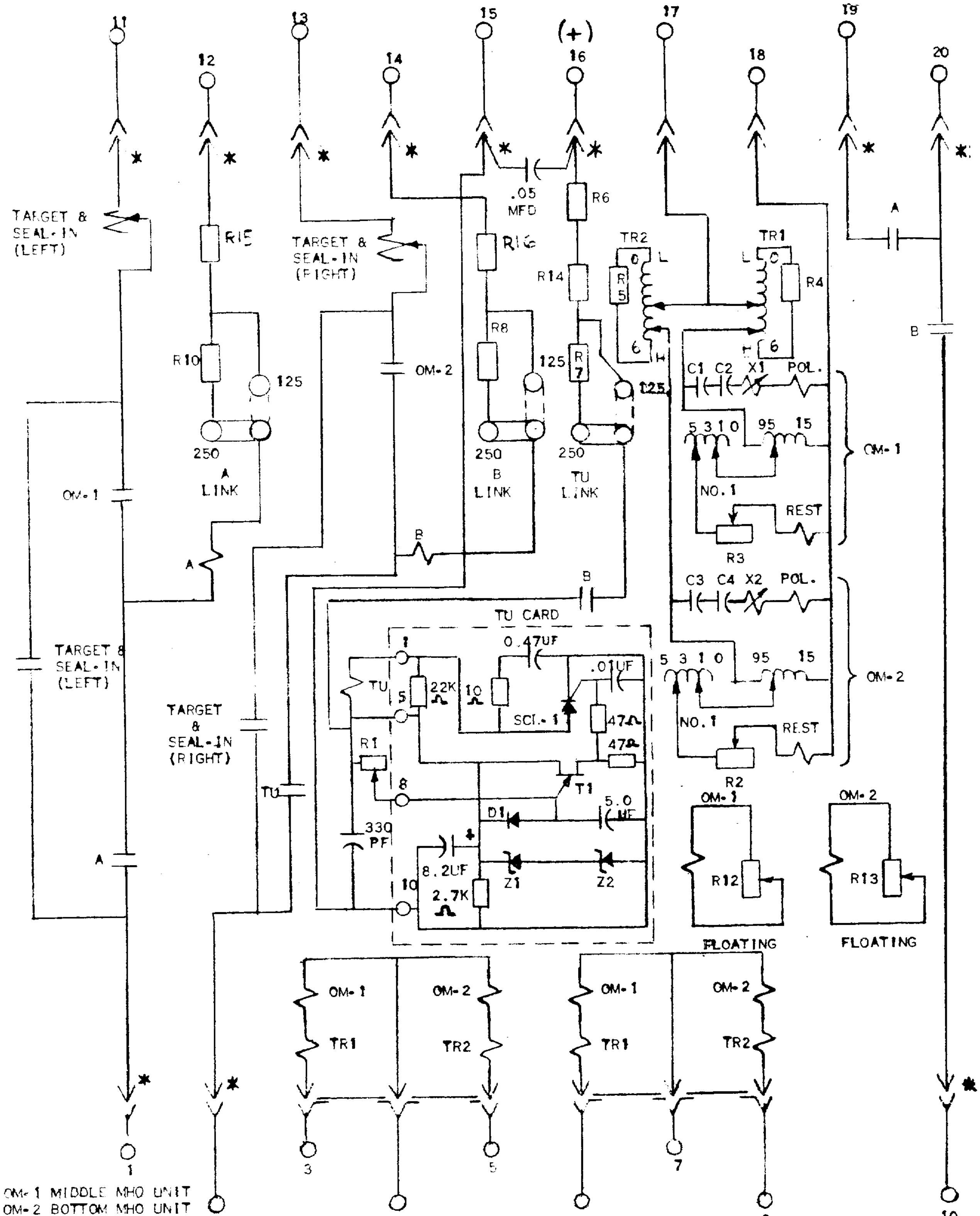


FIG. 12 (8025039) Cross Section Of Drawout Case Showing Position Of Auxiliary Brush And Shorting Bar



OM-1 MIDDLE MHO UNIT
OM-2 BOTTOM MHO UNIT
TR TRANSACTOR
* SHORT FINGER
O POST NO. ON PRINTED CARD

FIG. 13 (024A6936[2]) Internal Connections for the CEH-52A (Front View)

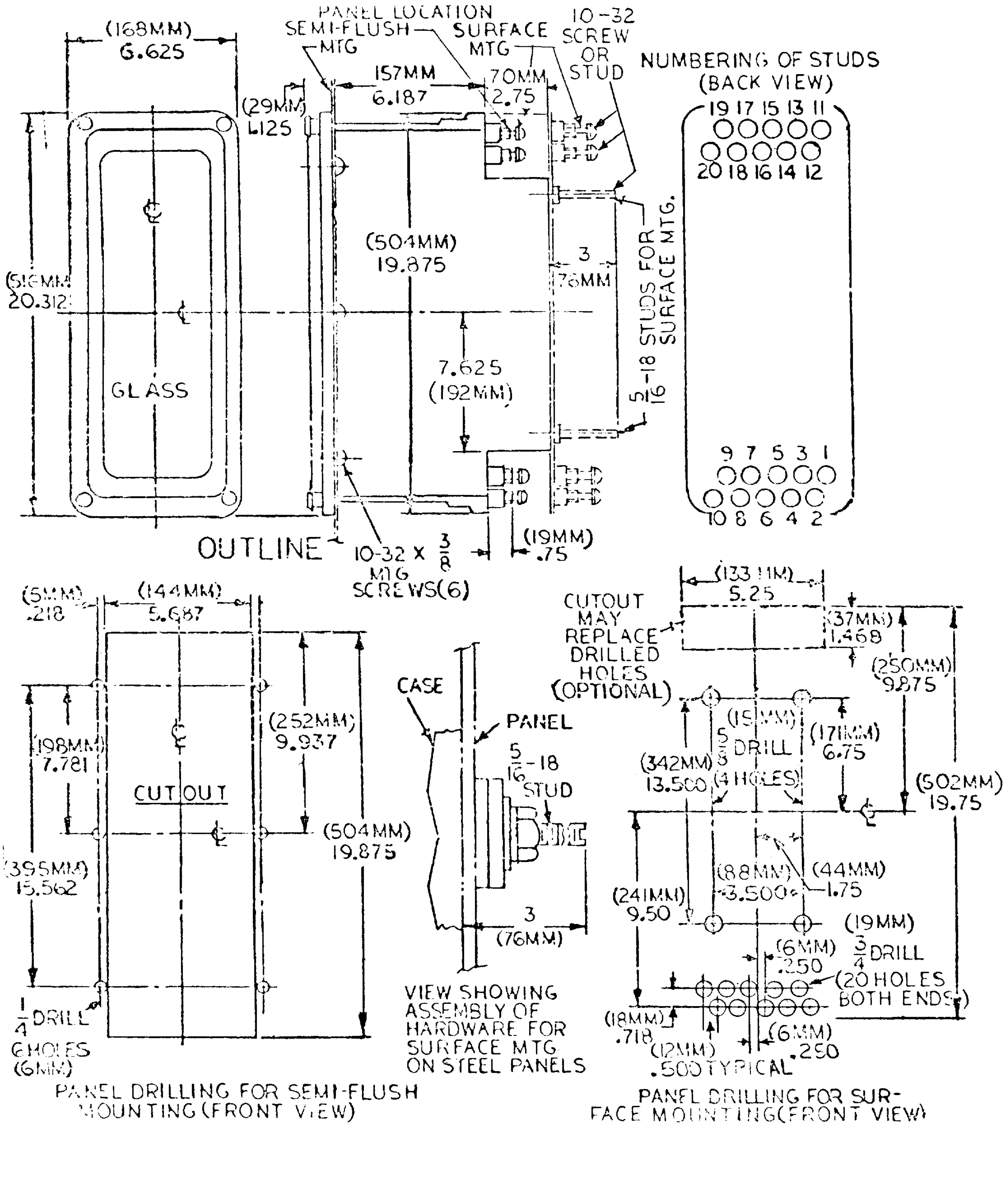


FIG. 14 (0178A7336-4) Outline And Panel Drilling Dimensions For The CEH52A (L2-D Case)

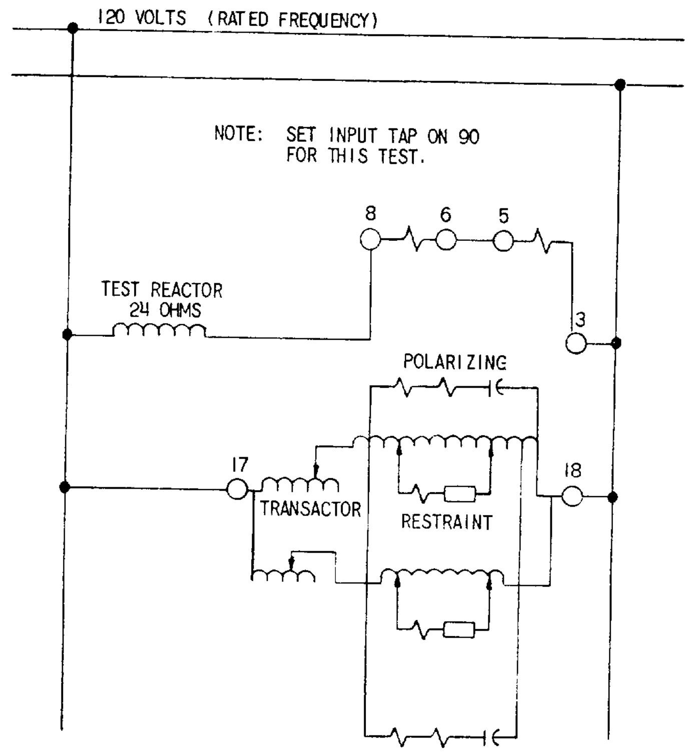


Figure 15 (0246A6939 [1]) Polarity Test Connections for CEH52A

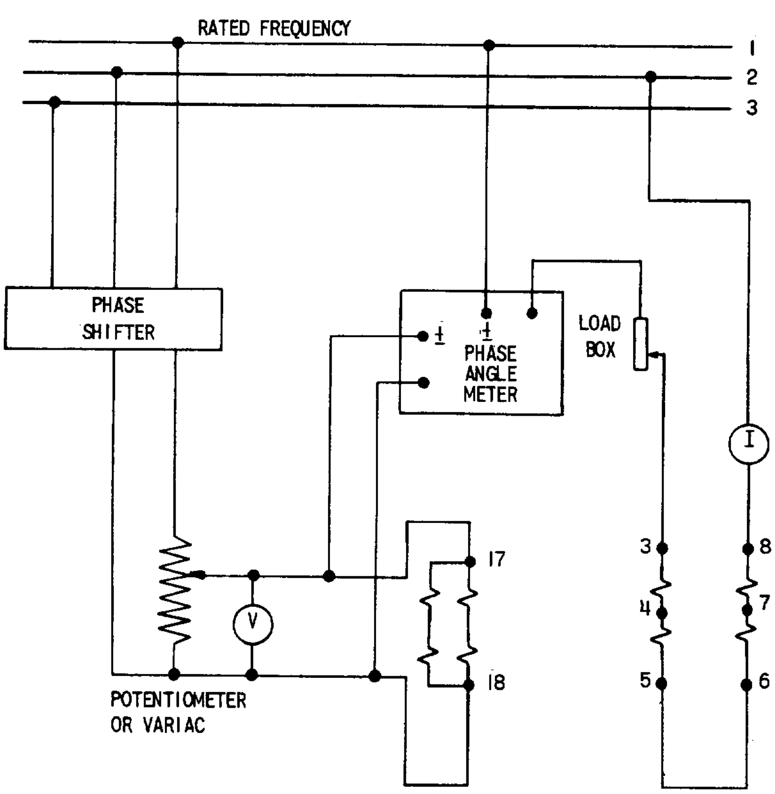


FIG. 16 (0246A6940-0) Phase Shifter Connections For Testing CEH52A

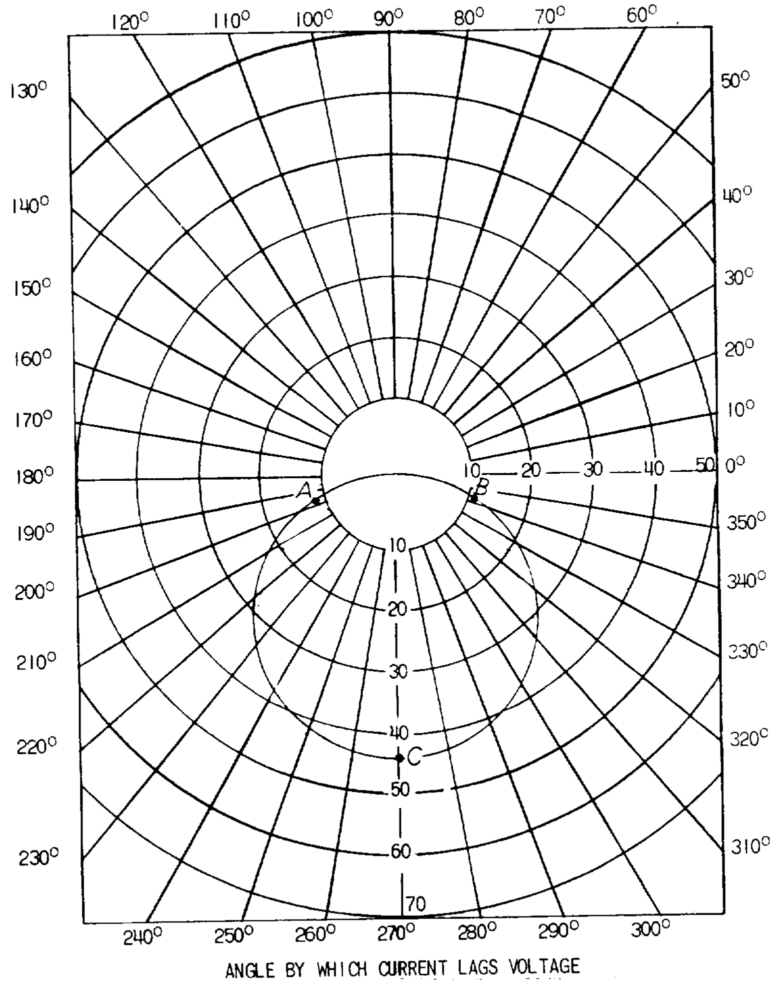


Figure 17 (0246A7060 [1]) Characteristic of CEH52 OM1 and OM2 Units With 2 Ohm (ø-N) Offset and 23 Percent Restraint Tap Setting

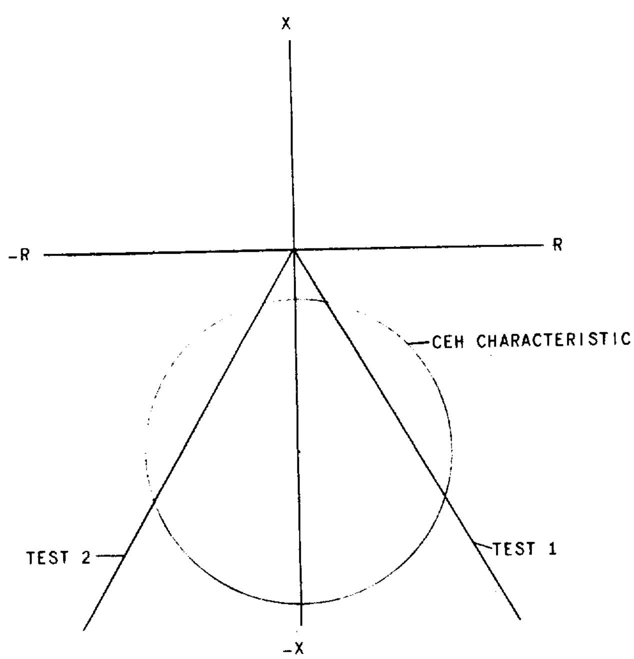
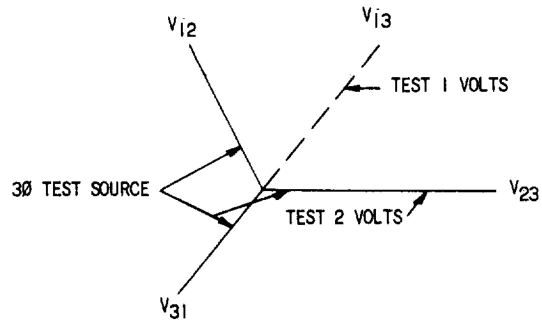


FIG. 18 (402A993) Alternate Test Points For CEH52



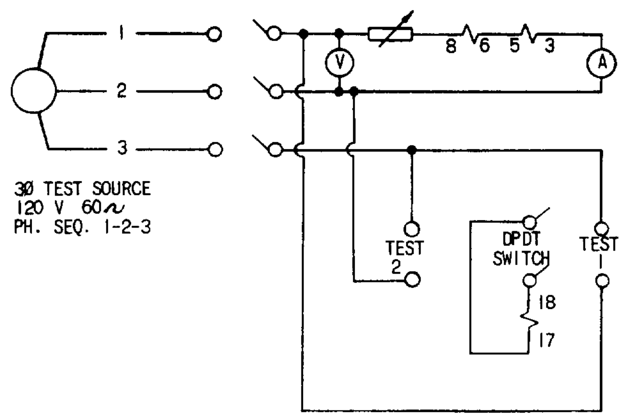
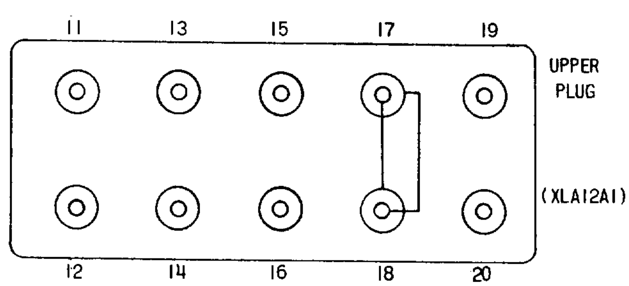


FIG. 19 (0246A6941-0) Test Connections For An Alternate Check Of CEH52A Characteristic



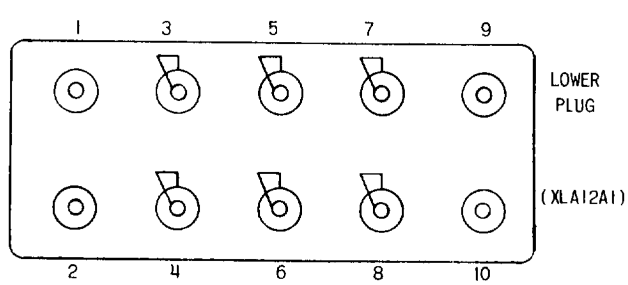


FIG. 20 (0246A6942-0) Test Plug Connections For Installation Test Of CEH52A

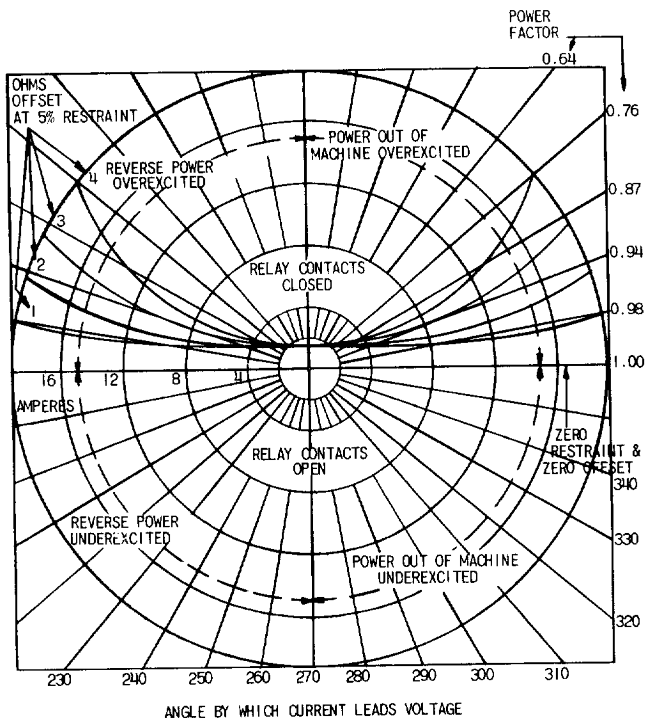


FIG. 21 (0246A7061-0) Characteristics Of CEH52A OM1 And OM2 Units With Potential Reversed And Five Percent Restraint

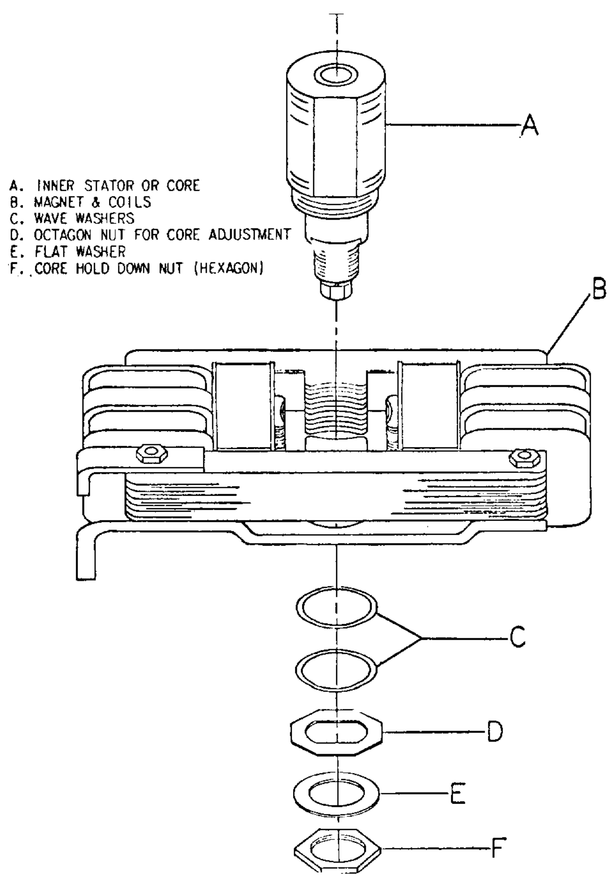


FIG. 22 (0208A3583-0) OM1 And OM2 Unit Core Assembly

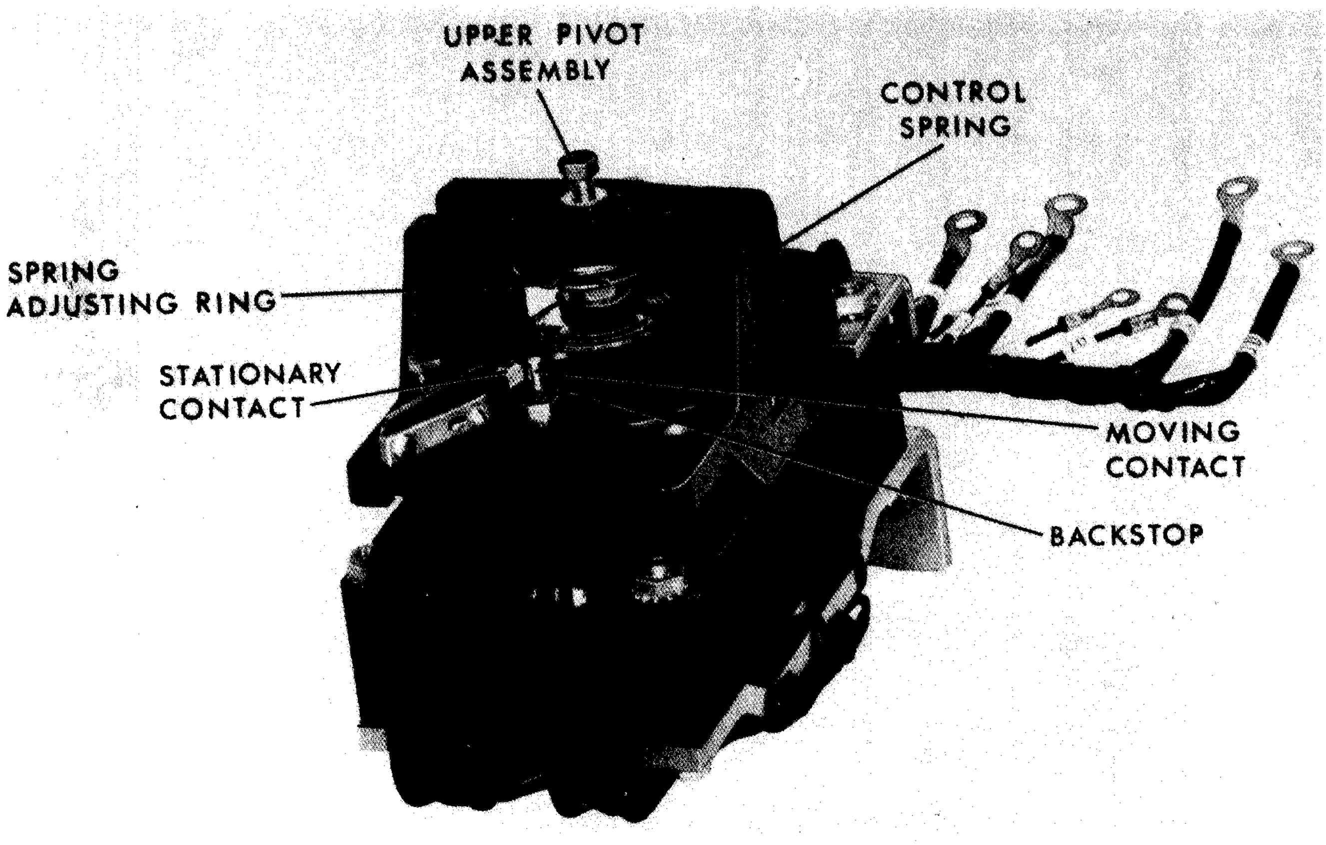


FIG. 23 (8034958) Typical Mho Unit Showing Nomenclature

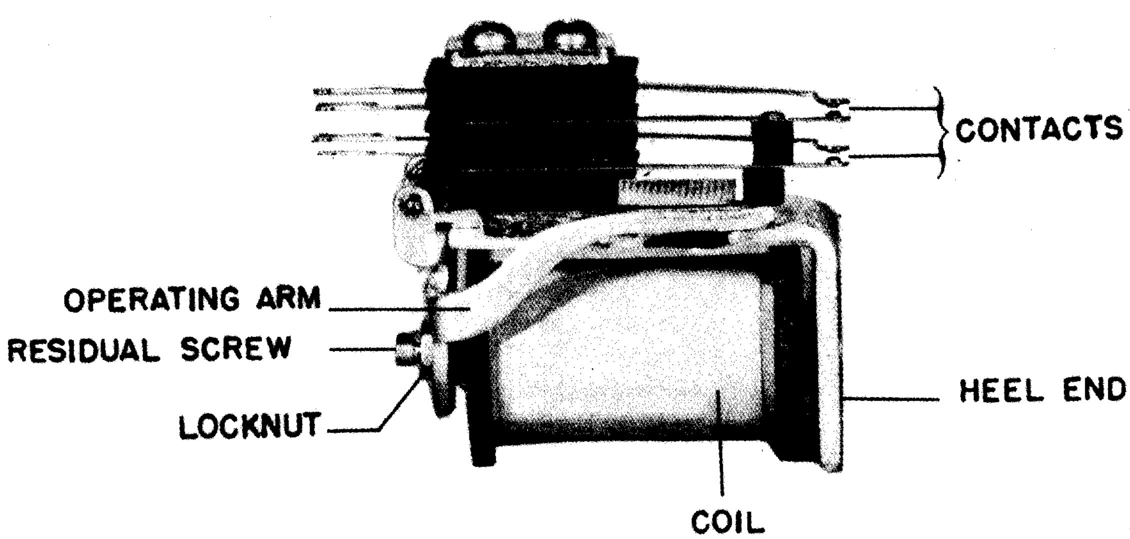


FIG. 24 (8030546) Typical Telephone Type Unit Used For A And B Units Of CEH52A

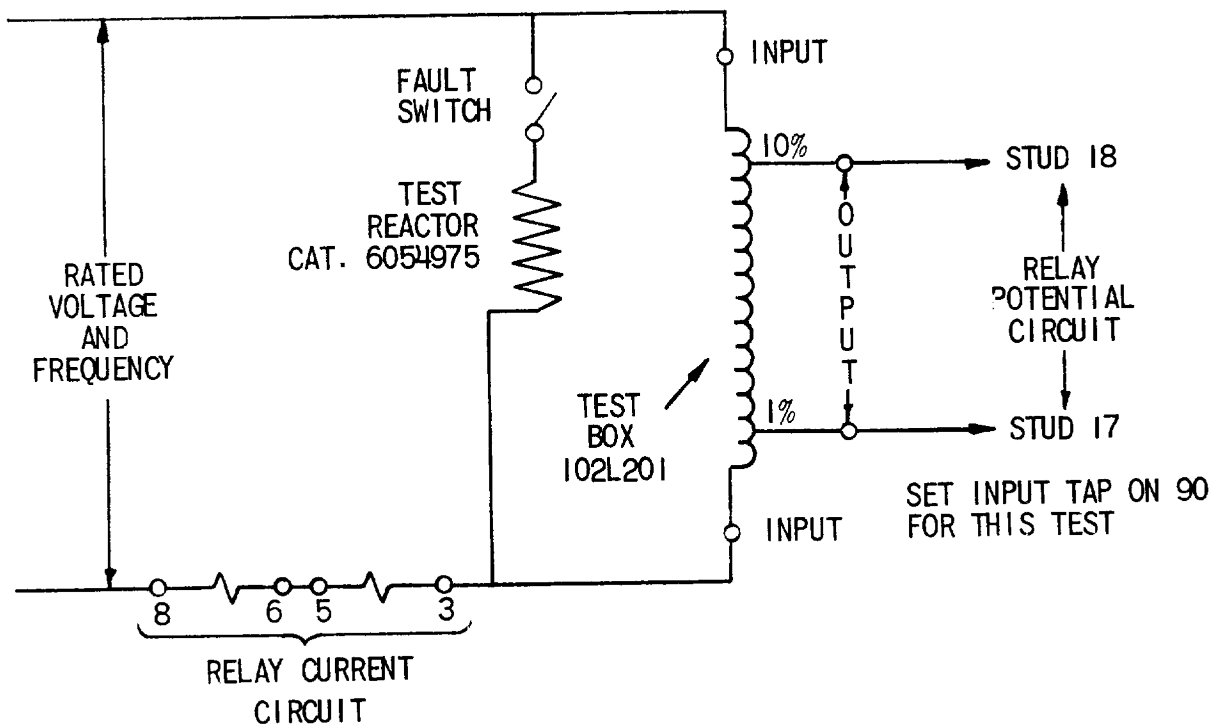


FIG. 25 (0246A6943-0) Test Connections For Checking OM1 And OM2 Reach Using Test Box And Portable Reactor

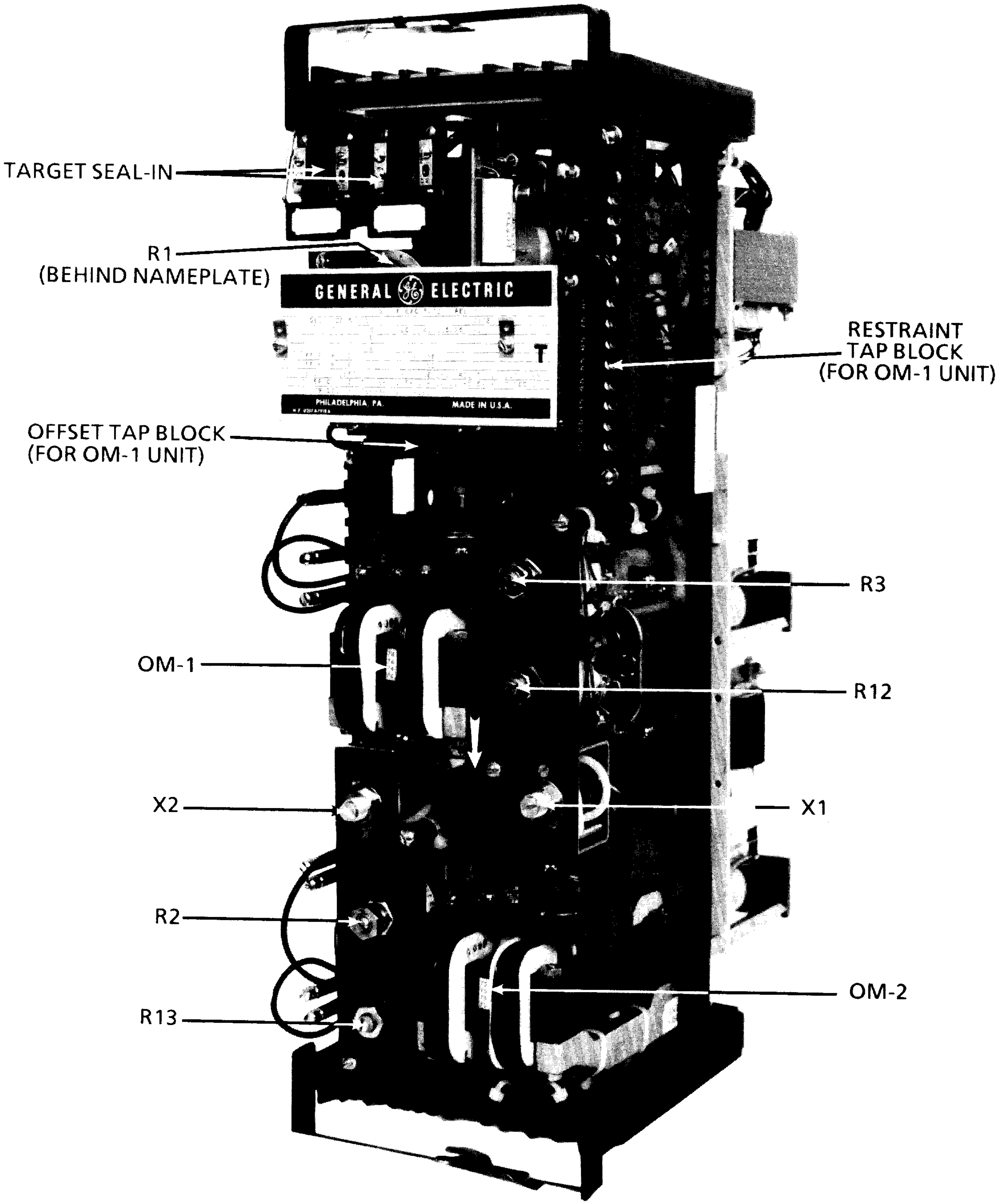


FIG. 26 (8919510) CEH-52A Removed from Case

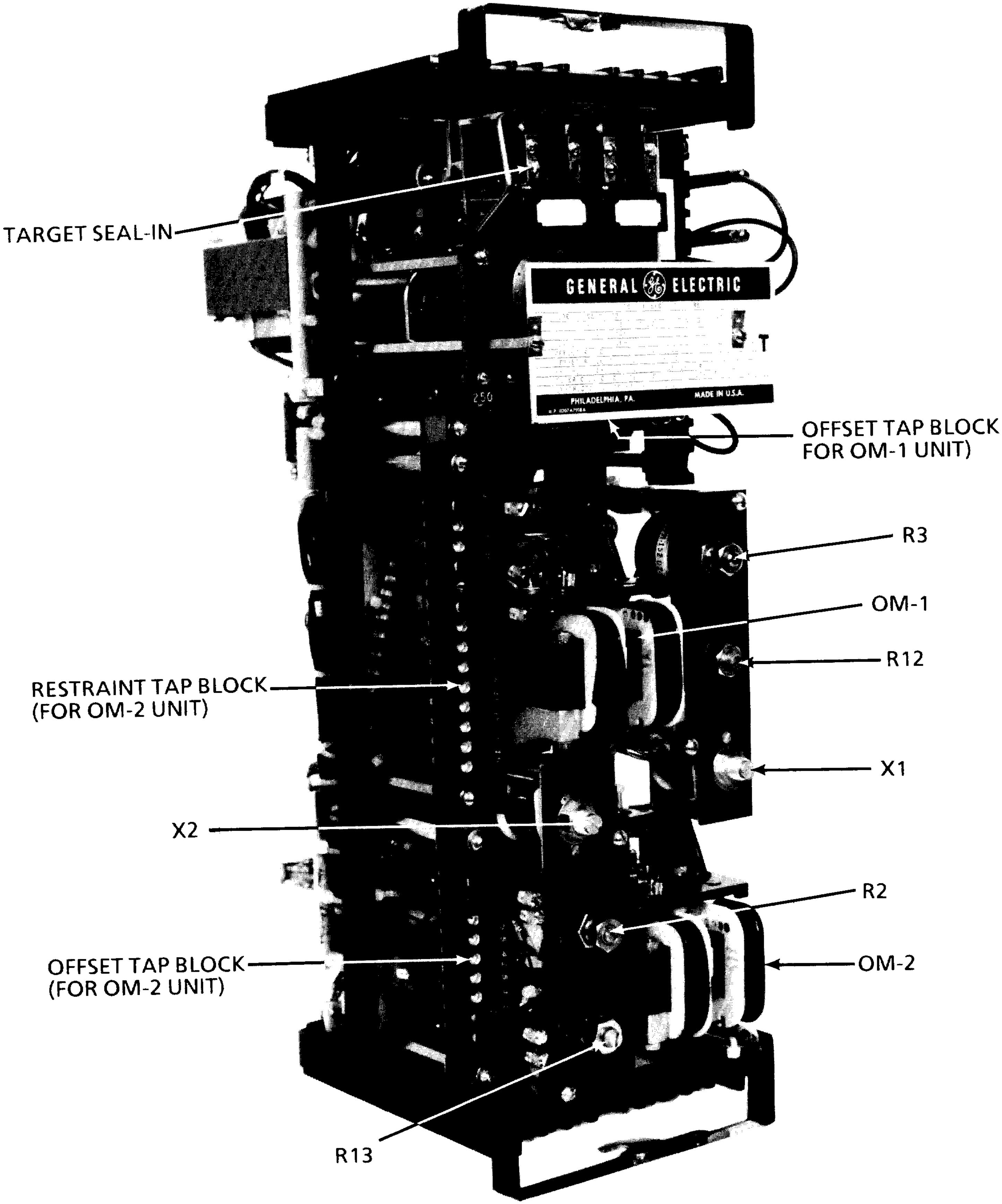


FIG. 27 (8919509) CEH-52A Removed from Case

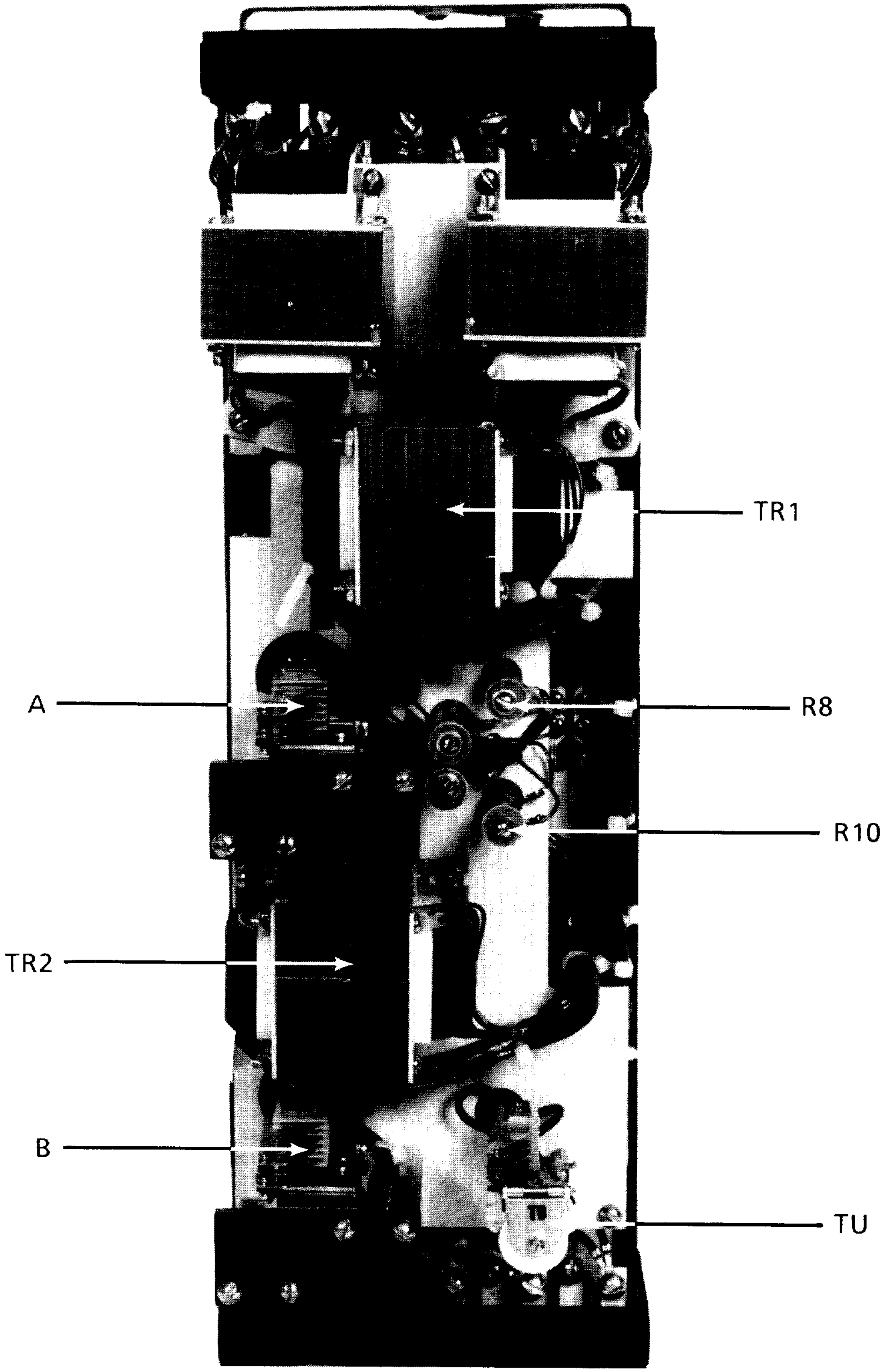


FIG. 28 (8919513) CEH-52A Removed from Case, Rear View

Since the last edition, Figure 5 has been changed and Figures 26-28 and the cover photograph have been added.

GE Power Management

215 Anderson Avenue
Markham, Ontario
Canada L6E 1B3
Tel: (905) 294-6222
Fax: (905) 201-2098
www.ge.com/indsys/pm