

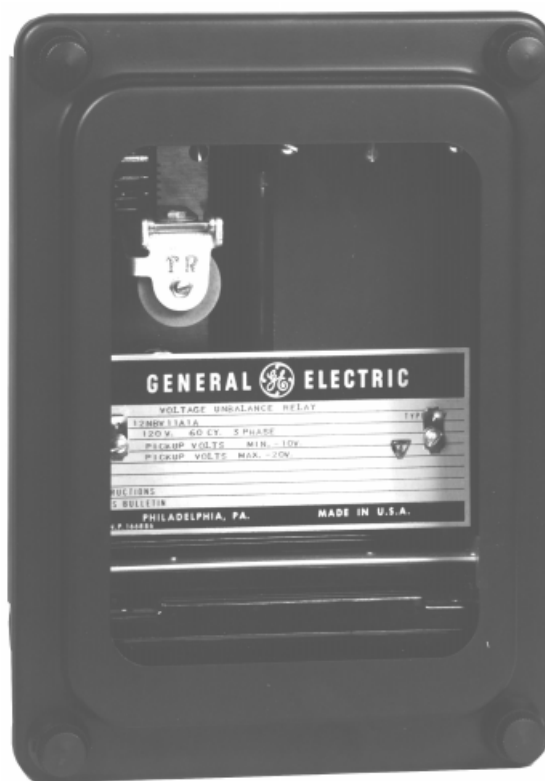


INSTRUCTIONS

NBV 11A

VOLTAGE UNBALANCE RELAY

Manual Part Number: GEI-50261L
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Manufactured under an
ISO9002 Registered System

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These instructions do not purport to cover all details or variations in equipment nor 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 (USA).

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

DESCRIPTION

The NBV11A relay is a high-speed sensitive three-phase voltage unbalance relay that is capable of detecting a small voltage unbalance in a three-phase system. The NBV11A, when applied as a protective device, is normally used in conjunction with a time-delay relay such as the IAV51D (see Figure 12). One NBV11A relay and one timing relay are required at each terminal to provide protection against operating a three-phase system on single phase.

The NBV11A relay is mounted in an S1 case. Figures 1, 2, and 3 identify the principal parts and show their locations.

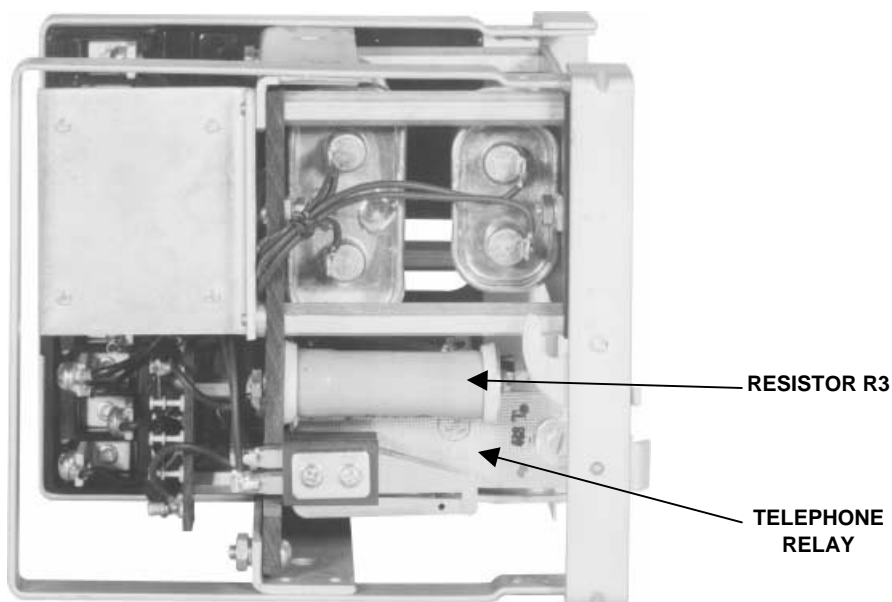


Figure 1 (8031805): TYPE NBV11A RELAY – TOP VIEW

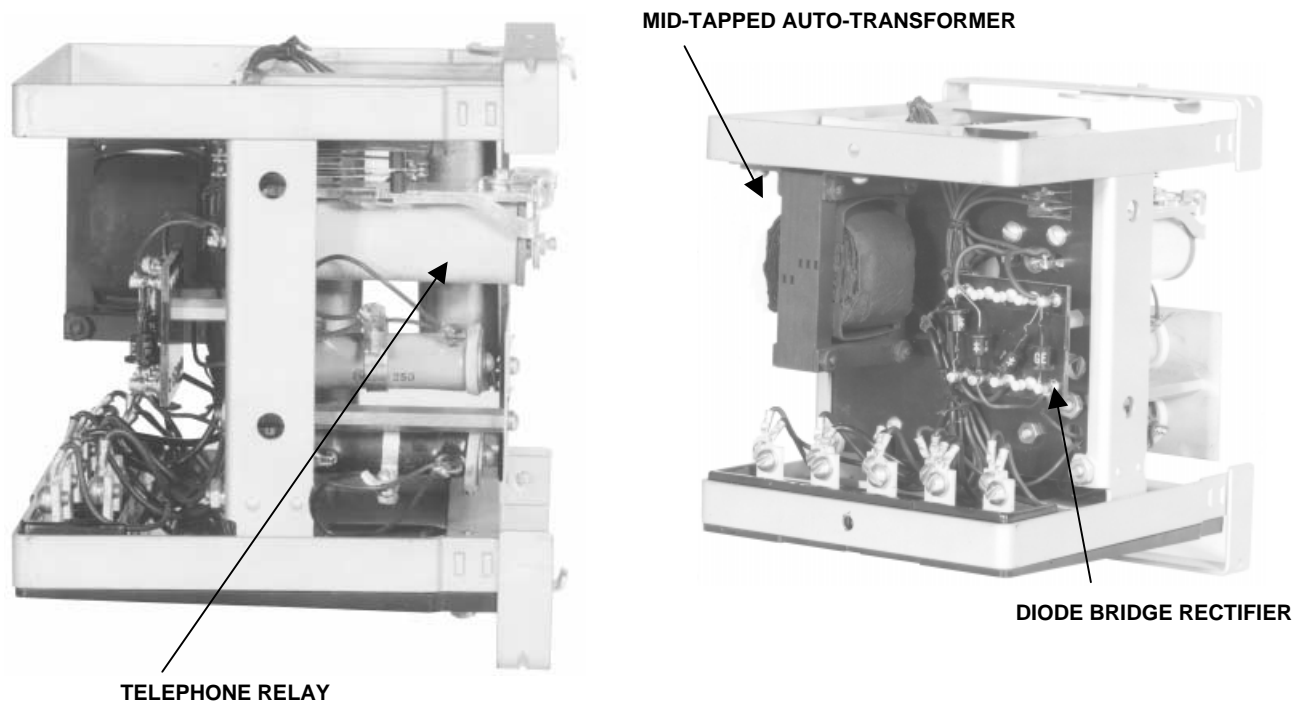


Figure 2 (8031804): NBV11A LEFT SIDE VIEW

Figure 3 (8031803): NBV11A OBLIQUE REAR VIEW

APPLICATION

The principal application of the NBV11A relay is to protect three-phase motors from the damage that may be caused by single-phase operation. When one fuse blows in a three-phase supply to a group of motors, these motors will continue to run on single-phase power. At this time, the voltage unbalance will be small since the motors maintain nearly full voltage across the open phase and a sensitive voltage unbalance relay is required to detect the single-phase operation. Since the motors will overheat and be damaged if they are more than fractionally loaded on single-phase power, the NBV11A is used to trip the supply breaker or to sound an alarm. The NBV11A operates on a percentage of the unbalance in line voltages – as such, it will detect a single-phase condition on light load as well as on heavy load. The NBV11A is usually connected to a bus and will effectively protect a group of many motors when the open circuit is between the source and the bus. As shown in Figure 4, the NBV11A is a high-speed relay, and a timing relay should be used to prevent false tripping or alarm. When undervoltage tripping is permissible, the scheme using an ANSI 27 device should be used. If a reliable source of DC power is available, a DC timing relay may be used. In this last application, the relay also provides protection against reverse phase-sequence operation.

Another application of the NBV11A is to block tripping when a fuse blows in the potential transformer circuit supplying a CEH relay.

CHARACTERISTICS

OPERATING PRINCIPLES

The NBV11A relay is basically a negative-sequence voltage relay. The relay is connected to the three line voltages and does not see any zero-sequence voltage.

The negative-sequence voltage will be proportional to the unbalance in the line voltages. When a balanced three-phase voltage of correct phase sequence is connected to the relay studs 5, 6, and 7, as shown in Figure 8, then the voltage across the relay coil TR, which is proportional to the negative-sequence voltage, will be zero. When the voltages supplied to the relay are unbalanced in either of the two possible ways (see Figure 9) then the voltage across the relay coil will be proportional to the voltage unbalance (see the CALCULATIONS section). On reverse phase voltage, the relay will pick up even on balanced voltage

It should be noted that other non-motor loads connected to the bus will, in most cases, tend to increase the unbalance in the voltages. Thus, if the relay is set to detect a single-phase condition with only motors on the system, then any additional non-motor load, such as lighting, will either make the relay's operation more positive or leave it unchanged.

PICKUP AND OPERATING TIME

To avoid confusion and facilitate testing, we shall define the relay pickup voltage V_R as the single-phase voltage that, when connected as shown in Figure 10, will just cause the relay to pick up. This will be between 10 and 20 volts for the 120 V relay and between 17 and 34 volts for the 208 V relay. The corresponding negative phase-sequence voltages are 5.8 to 11.5 volts for the 120 V relay and 10 to 20 volts for the 208 V relay.

The operating characteristics are shown in Figures 4 and 5. Figure 4 shows the time to open the normally-closed contact, and the time to close the normally-open contact, as functions of multiples of pickup. The dropout time, or the time to return the contact to their normal positions when the unbalance voltage is removed, is shown in Figure 5.

RATINGS AND BURDENS**VOLTAGE/FREQUENCY**

The NBV11A relay will withstand rated voltage continuously with normal phase sequence and for 60 minutes with reverse phase sequence. The relay will withstand single-phase rated voltage continuously.

Table 1: NBV11A VOLTAGE/FREQUENCY RATINGS

RELAY MODEL	RATED VOLTAGE	RATED FREQUENCY	PICKUP VOLTS MIN to MAX ($\pm 10\%$)
12NBV11A1A	120 V	60 Hz	10 to 20 V
12NBV11A2A	120 V	50 Hz	10 to 20 V
12NBV11A3A	208 V	60 Hz	17 to 34 V
12NBV11A4A	240 V	60 Hz	20 to 40 V
12NBV11A5A	208 V	50 Hz	17 to 34 V
12NBV11A7A	216 V	60 Hz	17 to 34 V

The telephone-type relay contact ratings are shown in Table 2 below:

Table 2: INTERRUPTING RATINGS

VOLTAGE	CURRENT	
	INDUCTIVE	NON-INDUCTIVE
115 V AC	0.75 A	2.0 A
230 V AC	0.50 A	1.5 A
48 V DC	1.00 A	3.0 A
125 V DC	0.50 A	1.5 A
250 V DC	0.25 A	1.0 A

BURDEN DATA

With the potential transformers connected in Wye (see Figure 6) the relay burden is shown in Table 3 below:

Table 3: BURDENS – WYE CONNECTION

RATING		CURRENT (mA)			VA BURDEN per P.T.		
VOLTS	FREQ	I ₅	I ₆	I ₇	P.T. 1	P.T. 2	P.T. 3
120	60 Hz	77	115	38	5.32	7.97	2.63
120	50 Hz	40	95	66	2.77	6.57	4.57
208	60 Hz	38	59	23	3.96	7.07	2.76

If the potential transformers are connected in Open Delta (see Figure 6), the burden is shown in Table 4 below. For the best division of burden, it is recommended that Terminal No. 6 of the relay be connected to the “MID” point of the delta-connected potential transformers.

Table 4: BURDENS – OPEN DELTA CONNECTION

RATING		CURRENT (mA)			VA BURDEN per P.T.	
VOLTS	FREQ	I ₅	I ₆	I ₇	P.T. 1	P.T. 2
120	60 Hz		115	38	9.23	4.56
120	50 Hz	40	95	66	4.80	7.82
208	60 Hz	38	59	23	7.90	4.78

With unbalanced voltage applied to the relay, the burden will depend on the nature and amount of unbalance. However, the maximum burden will occur when rated single-phase voltage is applied to Terminals 5 and 6. The burden data for this condition is shown in Table 5 below.

Table 5: BURDENS – UNBALANCED VOLTAGE APPLIED

VOLTAGE	FREQUENCY	CURRENT	VOLT-AMPS
120 V	60 Hz	0.114 A	13.68 VA
120 V	60 Hz	0.995 A	11.40 VA
208 V	60 Hz	0.056 A	11.60 VA

CALCULATIONS

To demonstrate how the V_R pickup voltage, as defined in the CHARACTERISTICS section, is related to the negative phase sequence voltage, we will first show how the negative phase sequence voltage is computed.

$$V_N = \frac{1}{3}(V_{12} + a^2 V_{23} + a V_{31}) \quad (\text{Equation 1})$$

where: V_N = negative phase-sequence voltage

$$a = 1 \angle 120^\circ$$

$$b = 1 \angle 240^\circ$$

In this analysis, V_N is based on line-to-line voltages and so will be greater by $\sqrt{3}$ than the negative-sequence voltages as calculated from phase-to-neutral quantities.

When we apply a single-phase voltage to the relay, as shown in Figure 10, the resultant voltages seen by the relay are the same as the relay would see if it were connected to a three-phase system that had one phase shorted. Thus, if we assume V_{12} is shorted, then in Equation 1:

$$V_{12} = 0 \quad \text{and} \quad V_{23} = -V_{23}$$

Thus, Equation 1 reduced to:

$$V_N = \frac{V_{23}}{\sqrt{3}} \quad (\text{Equation 2})$$

At pickup:

$$V_R = \sqrt{3} \times V_N \quad \text{since } V_R = V_{23} \text{ in this case}$$

After the amount of unbalance that can be tolerated in the line voltage (V_N) has been determined, then the pickup voltage can be readily obtained from equation 2.

For the two types of unbalance shown in Figure 9, the sensitivity of the NBV relay is the same in terms of negative-sequence voltage V_N but not in terms of voltage shift V_s . The following example illustrates how the relay setting may be determined from the voltage unbalance that it is desired to detect.

EXAMPLE 1

Consider an unbalance voltage that results from a shift of the apex of the voltage triangle shown in Figure 9. In this illustration, V_s represents the voltage unbalance of the line voltages. The V_s voltage in this case is equal to $\sqrt{3} \times V_N$ and therefore at pickup:

$$V_s = V_R$$

For example, if we wish the relay to pick up when the unbalance represented by V_s is 20 volts, then we set the relay to pick up when a single-phase voltage of 20 volts is applied, shown in Figure 10.

EXAMPLE 2

Consider an unbalance voltage similar to V_T shown in Figure 9c. In this illustration, V_T is the voltage shift in each of two corners from the balanced condition. Here, V_T is equal to V_N , and at pickup:

$$V_R = \sqrt{3} \times V_T$$

Therefore, if we wish the relay to pick up when the unbalance represented by V_T is 10 volts, then the relay should be set to pick up when

$$V = \sqrt{3} \times 10 = 17.3 \text{ volts}$$

CONSTRUCTION

The relay components are mounted in a cradle assembly that is latched into a drawout case when the relay is in operation, but it can be easily removed if desired. To do this, the relay is first disconnected by removing the connection plug that completes the electrical connections between the case block and the cradle block. To test the relay in its case, this connection block can be replaced by a test plug. The cover, which is attached to the front of the relay case, contains an interlock arm that prevents the cover from being put back in place 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 ensure that proper hardware is included. For outline and drilling dimensions, see Figure 14.

Every circuit in the drawout case has an auxiliary brush (see Figure 11) 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 that are equipped with shorting bars (see Figure 8), it is especially important that the auxiliary brush make positive contact as indicated in Figure 11, to prevent opening of important interlock circuits.

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 GE Power Management.

Reasonable care should be exercised in unpacking the relay in order that none of the parts are injured nor the adjustments disturbed.

If the relays are not to be installed immediately, they should be stored in their original cartons in a place 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 relay operation.

ACCEPTANCE TESTS

Immediately upon receipt of the relay, an inspection and acceptance test should be performed to ensure that no damage has been sustained in shipment and that the relay calibrations have not been disturbed.

VISUAL INSPECTION

Check the nameplate stamping to ensure that the model number, rating and calibration range of the received relay match the requisition.

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

MECHANICAL INSPECTION

It is recommended that the telephone-type relay be checked as follows:

With the telephone-type relay de-energized, each normally-open contact should have a gap of 0.010 to 0.015 inch. Observe the wipe on each normally-closed contact by deflecting the stationary contact member towards the frame. The wipe should be approximately 0.005 inch.

The wipe on each normally-open contact should be approximately 0.005 inch. This can be checked by inserting a 0.005 inch shim between the residual screw and the pole piece and operating the armature by hand. The normally-open contacts should make before the residual screw strikes the shim. When the telephone relay is picked-up, the normally-closed contact should have a gap of 0.010 to 0.015 inch.

ELECTRICAL TESTS

If the relay has not been damaged in shipment, it is very unlikely that the adjustments have been disturbed. When evidence of rough handling is observed, the following electrical tests should be made.

1. *Balanced three-phase tests*

Connect a balanced three-phase voltage of correct phase sequence, rated frequency, and good waveform to the relay as shown in Figure 7. Check the voltage across relay studs 3 and 4 with a high-resistance voltmeter (1000 Ω/V or more). The voltage observed should be less than 1.5 volts for a 208 V relay, and 1.0 volts for a 120 V relay.

NOTE: If a suitable three-phase source of rated voltage is not available, the relay may be tested at some lower balanced three-phase voltage having a good wave shape and rated frequency. For example, a 208 V relay may be tested at 120 volts. If this is done, the voltage observed across studs 3 and 4 should be proportionally lower – for a 208 V relay tested at 120 volts, the observed voltage should be less than 0.865 volts:

$$V_{34} = \frac{120 \text{ V}}{208 \text{ V}} \times 1.5 = 0.865 \text{ V}$$

If the relay is found to be out of balance and the three-phase test voltage is known to have a good wave shape and is well-balanced (not over 0.5 V unbalanced on a 120 V source), then the setting of resistor R1 should be adjusted until adequate balance is obtained. If adequate balance cannot be achieved, then the test source probably contains harmonics.

NOTE: If the voltage across terminals 3 and 4 cannot be made low enough by adjusting R1, the problem may be harmonics in the voltage source. This can be checked by connecting an oscilloscope across terminals 3 and 4 instead of a voltmeter. With R1 set for minimum resistance, there should be a sinewave of fundamental frequency on the oscilloscope. The distortion due to harmonics may be hard to see at this point. Now start increasing the resistance of R1 – the magnitude of the sinewave should decrease. Continue increasing R1 until the minimum voltage occurs. As the magnitude of the wave decreases, it will be due to the fundamental wave decreasing – the harmonic content of the wave will remain the same. When the fundamental reaches a minimum value, if there is much harmonic content in the wave, then this content will predominate. If practically no fundamental can be seen. If practically no fundamental can be seen, then the voltage left is all harmonic. At this point, the wave on the oscilloscope will probably look like a sinewave but with a frequency higher than the fundamental. For example, if the harmonic is all second harmonic, then the wave on the oscilloscope will have a frequency of twice the fundamental frequency.

If the voltage across terminals 3 and 4 is above the minimum value (1.0 V for 120 V relays; 1.5 V for 208 V relays) and is all caused by harmonics, then a harmonic filter is required.

A harmonic filter is available for use with the NBV relay when the line supply to the motor has a harmonic content. The harmonic filter consists of a parallel-tuned circuit. When connected across terminals 3 and 4 (balanced three-phase network output), the filter has high impedance to the fundamental frequency (50 or 60 Hz) but lower impedance to harmonics above the fundamental frequency. The harmonic filter therefore will bypass the harmonic content around the NBV relay and minimize its effects.

The harmonic filter models available are:

0165A6788G1	60 Hz
0165A6788G2	50 Hz

Only one filter is required for each relay. The filter is mounted as shown in Figure 14 and connected across terminals 3 and 4 of the NBV as shown in Figure 12.

2. *Pickup Test*

Connect a single-phase voltage source to the relay as shown in Figure 10 and check that the pickup agrees with the values given in the CHARACTERISTICS section. The voltage required to pick up the relay can be changed by adjusting resistor R2.

INSTALLATION

If, after the performance of the ACCEPTANCE TESTS, the relay is held in storage before shipment to the job site, it is recommended that the visual and mechanical inspection described in the ACCEPTANCE TESTS section be repeated before installation.

Before any electrical tests are made, the relay should be in its case, mounted in a vertical position, and preferably in its final location.

The balance three-phase test described in ACCEPTANCE TESTS should be repeated if a suitable three-phase source is available. After the balance test, the relay pickup should be checked and adjusted with resistor R2.

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. 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 below checked every one to two years.

1. The tests recommended under ACCEPTANCE TESTS should be repeated at the intervals described above. The relay pickup and balance can be set by adjusting resistors R1 and R2 as described earlier.
2. 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 corroded material will be removed rapidly and thoroughly. The flexibility of the tool ensures the cleaning of the actual points of contact.

Contacts should not be cleaned with knives, files, or abrasive paper or cloth. Knives or files may leave scratches that increase arcing and deterioration of the contacts. Abrasive paper or cloth may leave minute particles of insulating abrasive material in the contacts and thus prevent closing.

The burnishing tool described above can be obtained from the factory.

3. Telephone relay contact gaps may be adjusted by bending the stationary contact brush to obtain a 0.015 inch gap. When the adjustment is made, the wipe of the circuit-closing contacts should be checked to be 0.005 inch; wipe adjustment can be made by bending the moving contact brush as required.

RENEWAL PARTS

Sufficient quantities of renewal parts should be kept in stock for the prompt replacement of any that are worn, broken or damaged.

When ordering renewal parts, address the nearest GE Power Management sales office. Specify the name of the part, quantity required, and complete nameplate data, including the serial number, of the relay. If possible, provide the GE requisition number on which the relay was furnished.

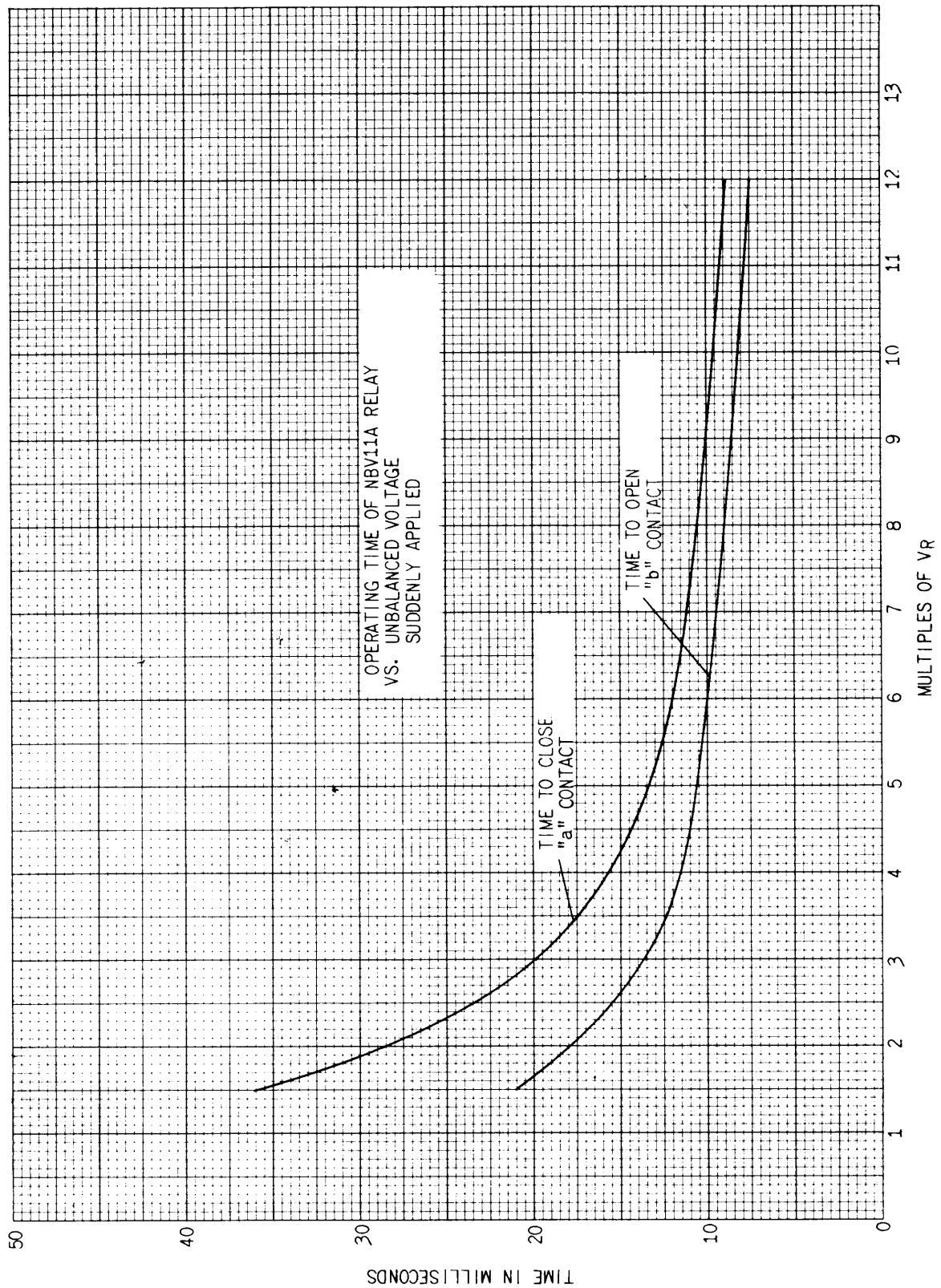


Figure 4 (0459A0251): CONTACT OPERATING TIMES WHEN UNBALANCED VOLTAGE SUDDENLY APPLIED

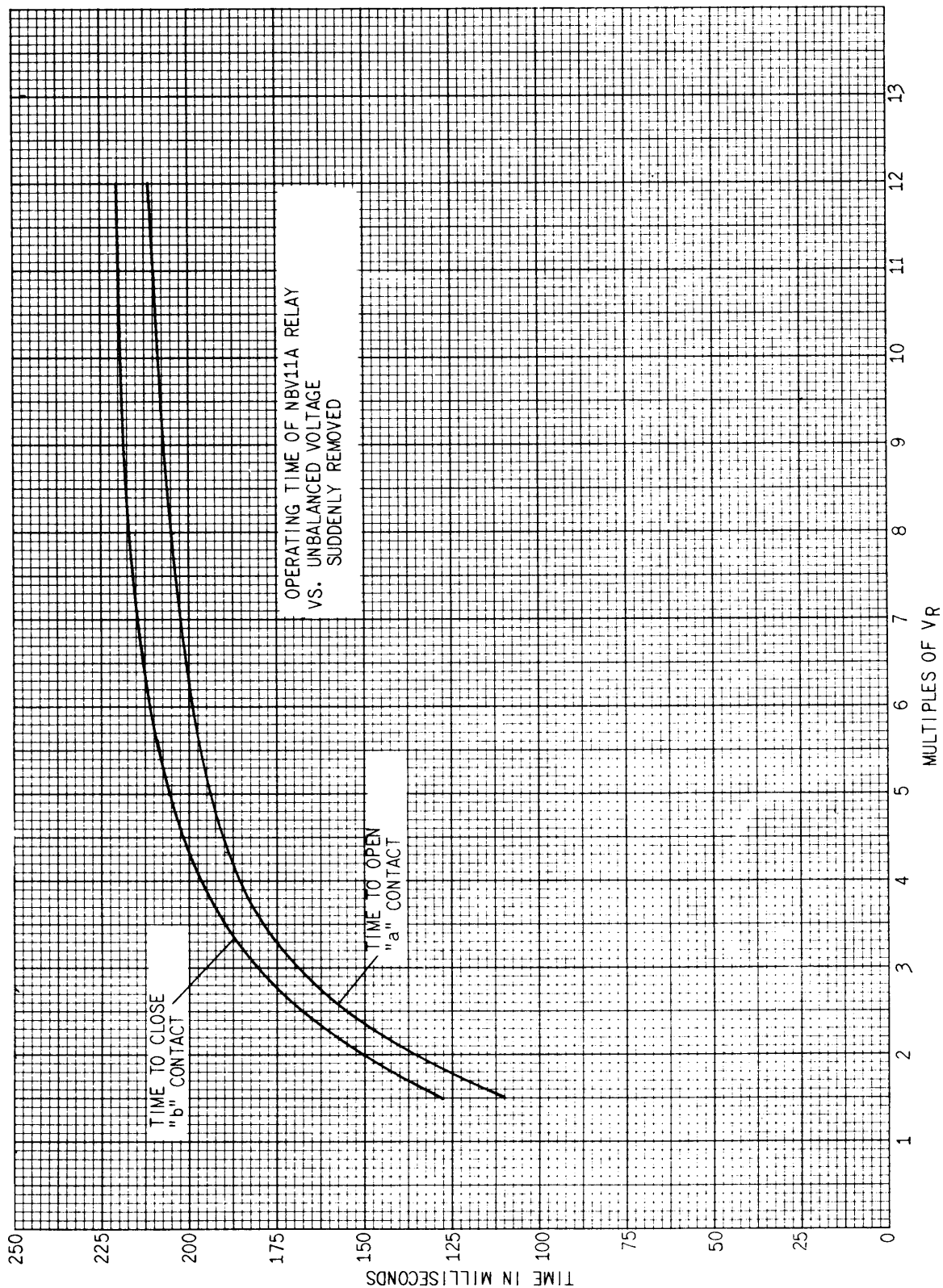
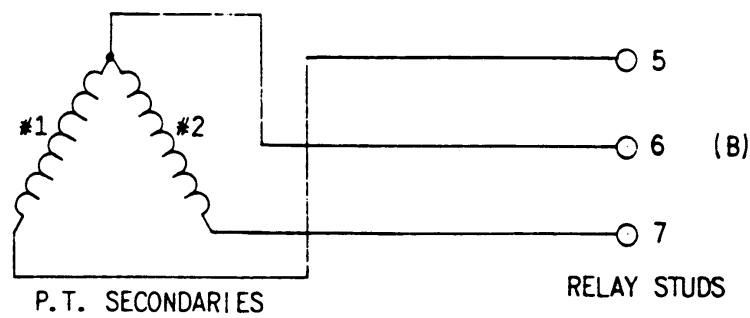
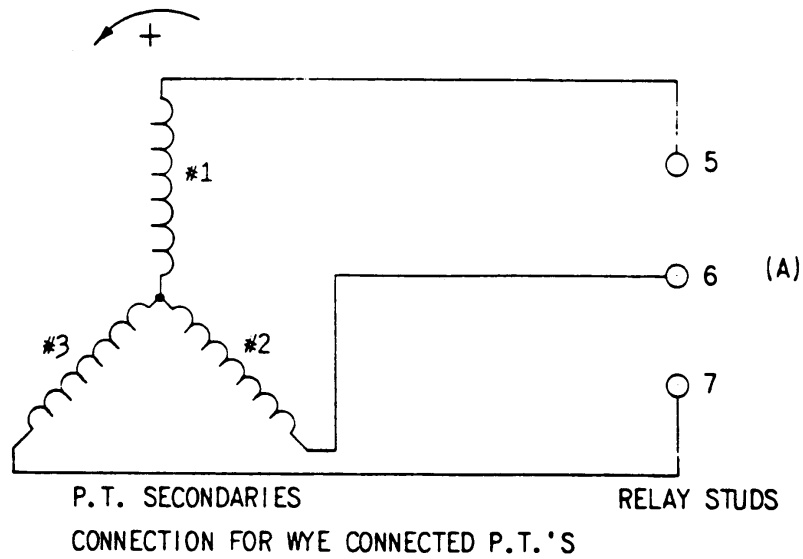


Figure 5 (0459A0250): CONTACT OPERATING TIMES WHEN UNBALANCED VOLTAGE SUDDENLY REMOVED



RECOMMENDED CONNECTION FOR OPEN DELTA P.T.'S

Figure 6 (0459A0254): POTENTIAL TRANSFORMER CONNECTIONS

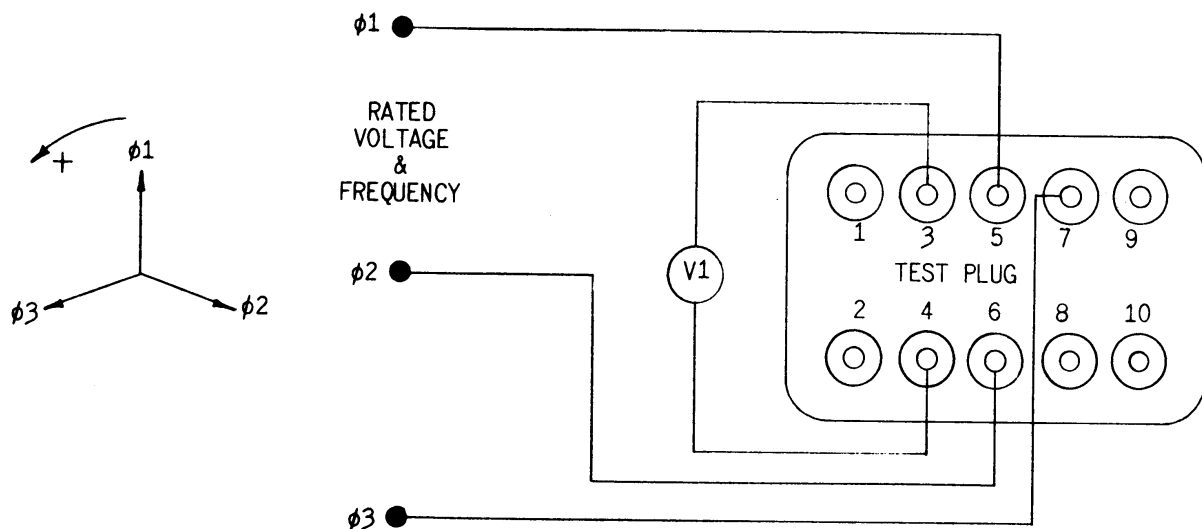
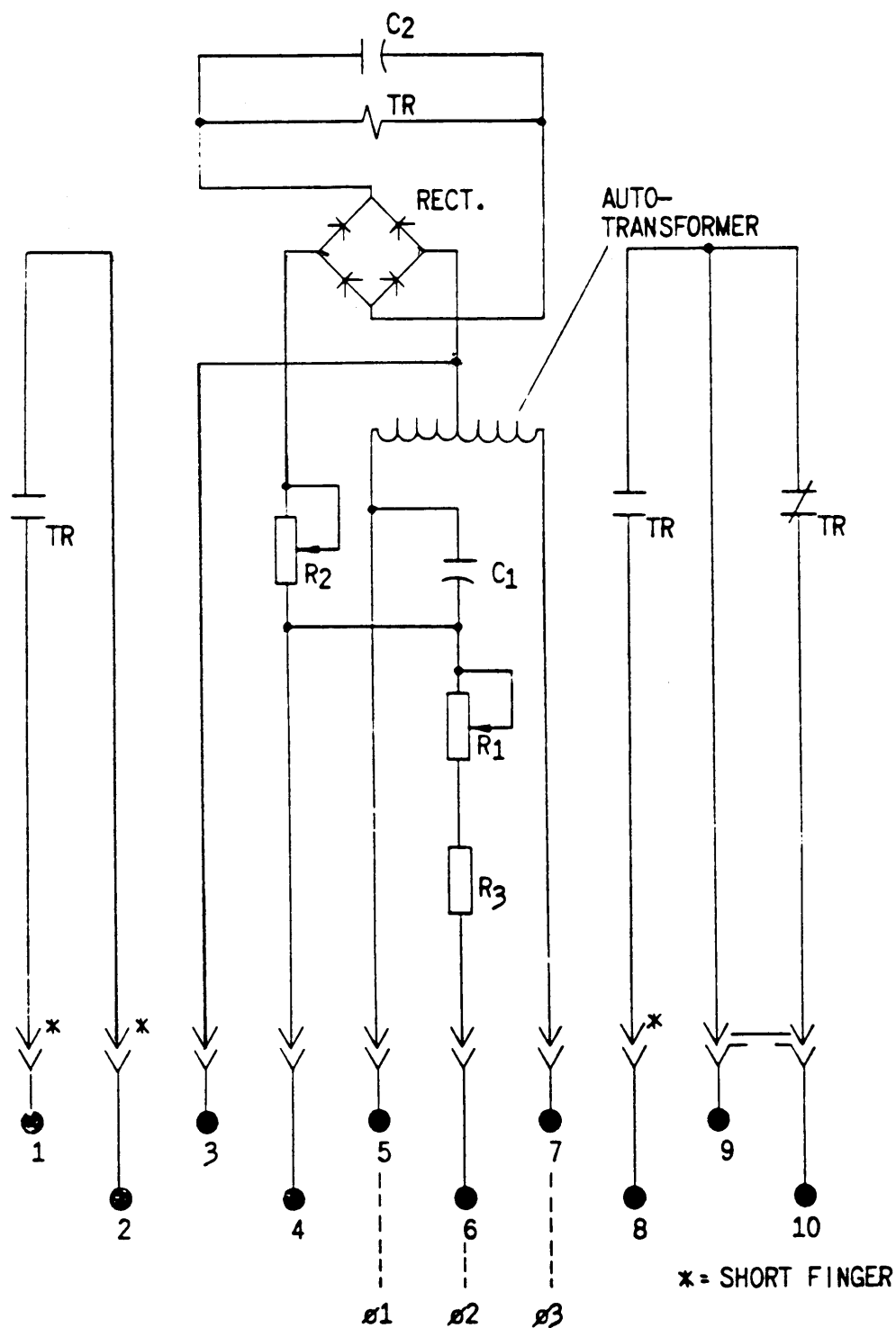
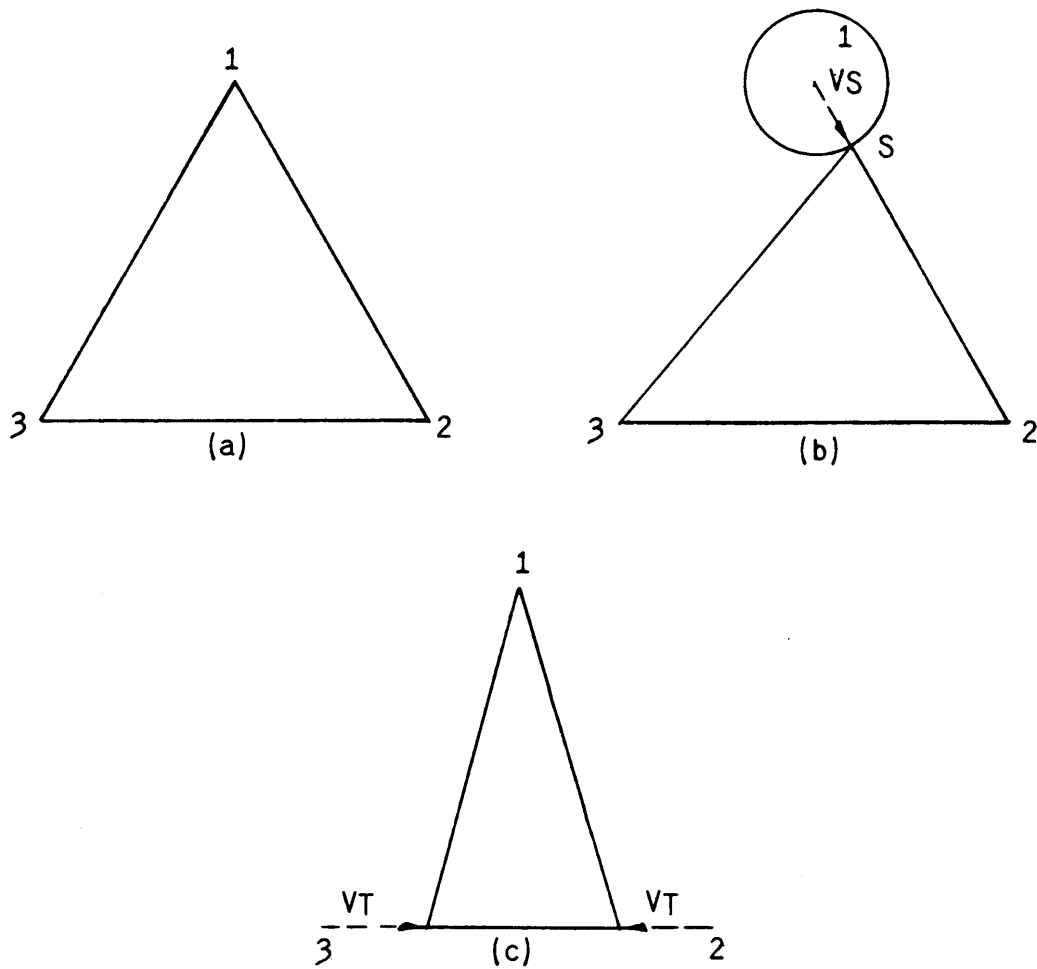


Figure 7 (0418A0807-2): TEST CONNECTIONS FOR R-C CIRCUIT ADJUSTMENT





SYSTEM VOLTAGES

- (a) BALANCED CONDITIONS
- (b) UNBALANCED BY SHIFT OF ONE CORNER
- (c) UNBALANCED BY SHIFTING TWO CORNERS TOWARD EACH OTHER ALONG VECTOR BETWEEN THEM.

Figure 9 (0459A0252): SYSTEM VOLTAGES – BALANCED & UNBALANCED CONDITIONS

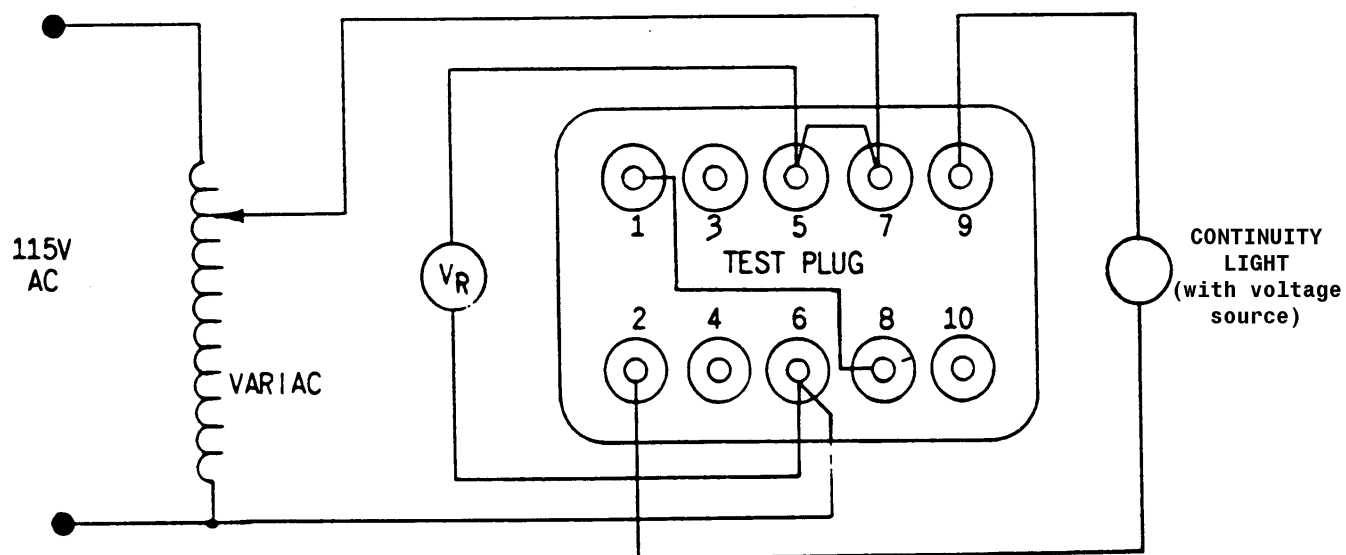
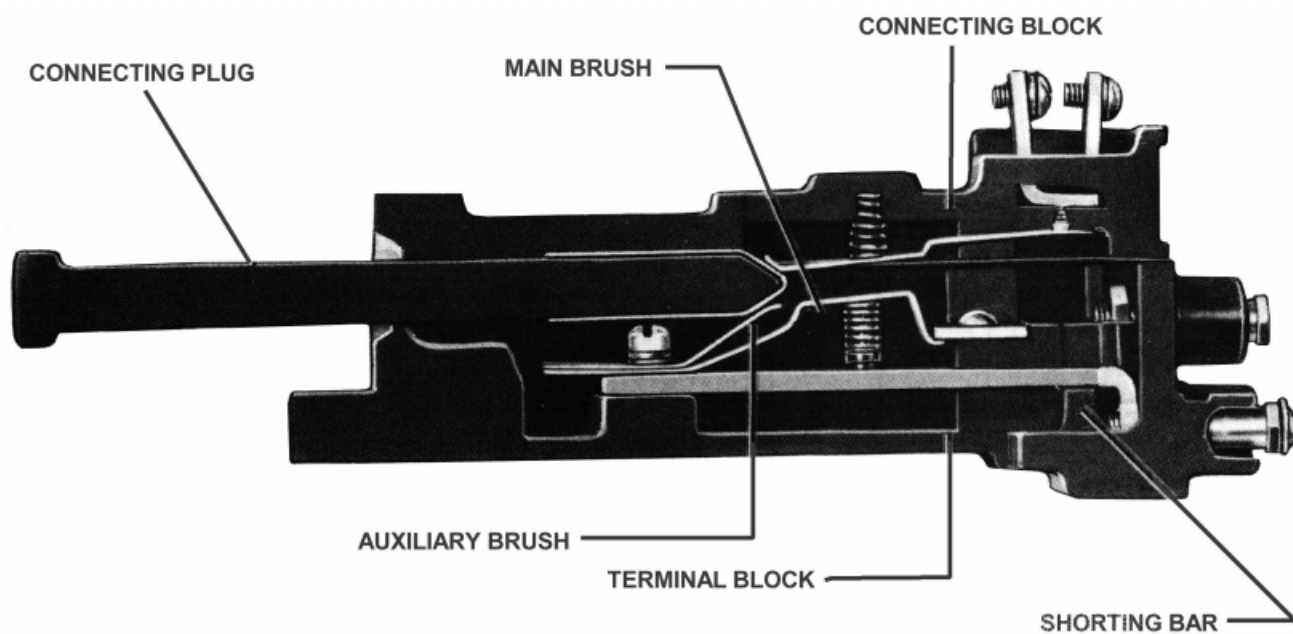


Figure 10 (0459A0223-2): TEST CONNECTIONS FOR SETTING PICKUP



NOTE: After engaging auxiliary brush, connecting plug travels ¼-inch before engaging the main brush on the terminal block

Figure 11 (8025039): DRAWOUT CASE CROSS-SECTION SHOWING POSITION OF AUXILIARY BRUSH

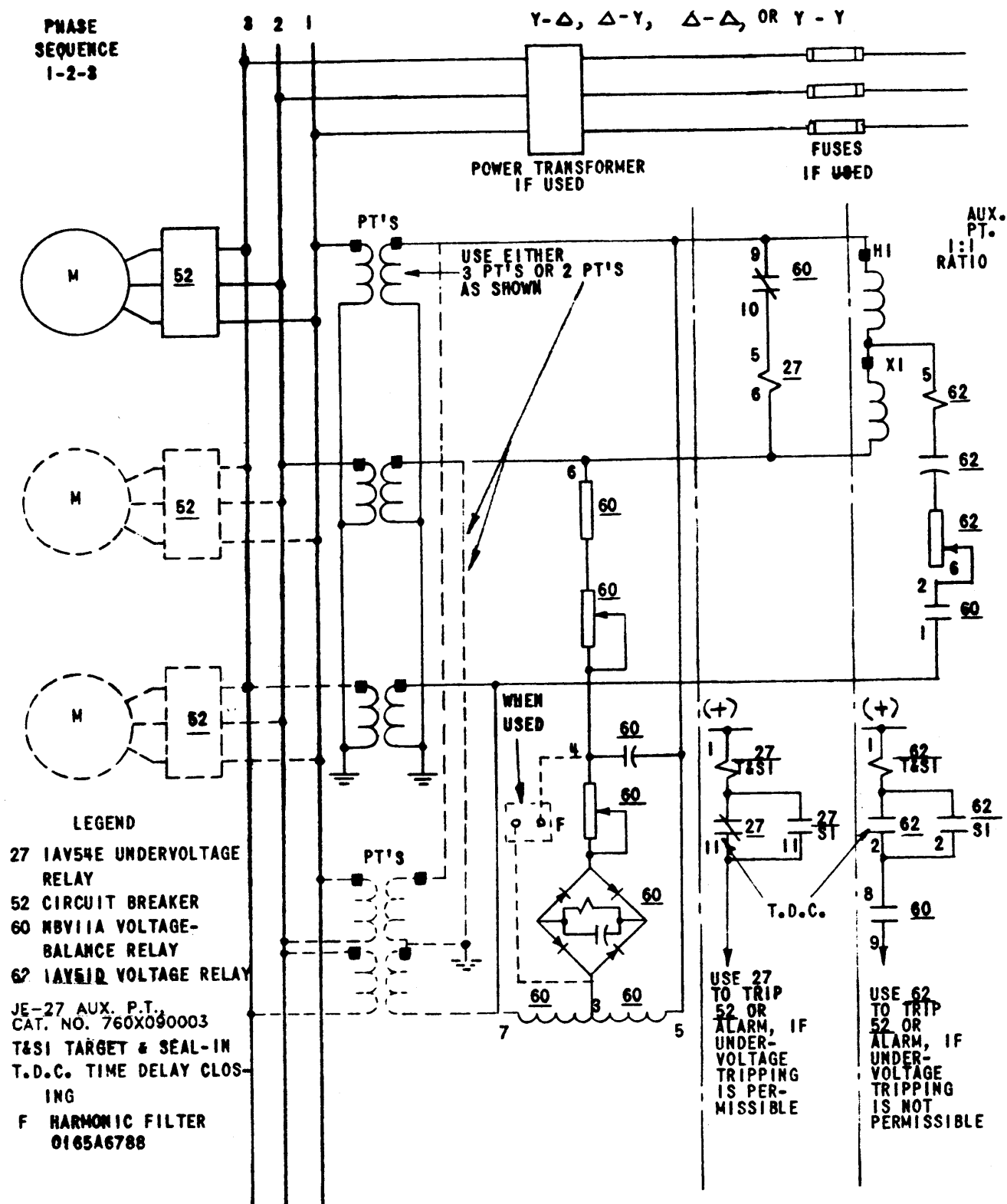


Figure 12 (0459A0253SH01-4): TYPICAL EXTERNAL CONNECTIONS

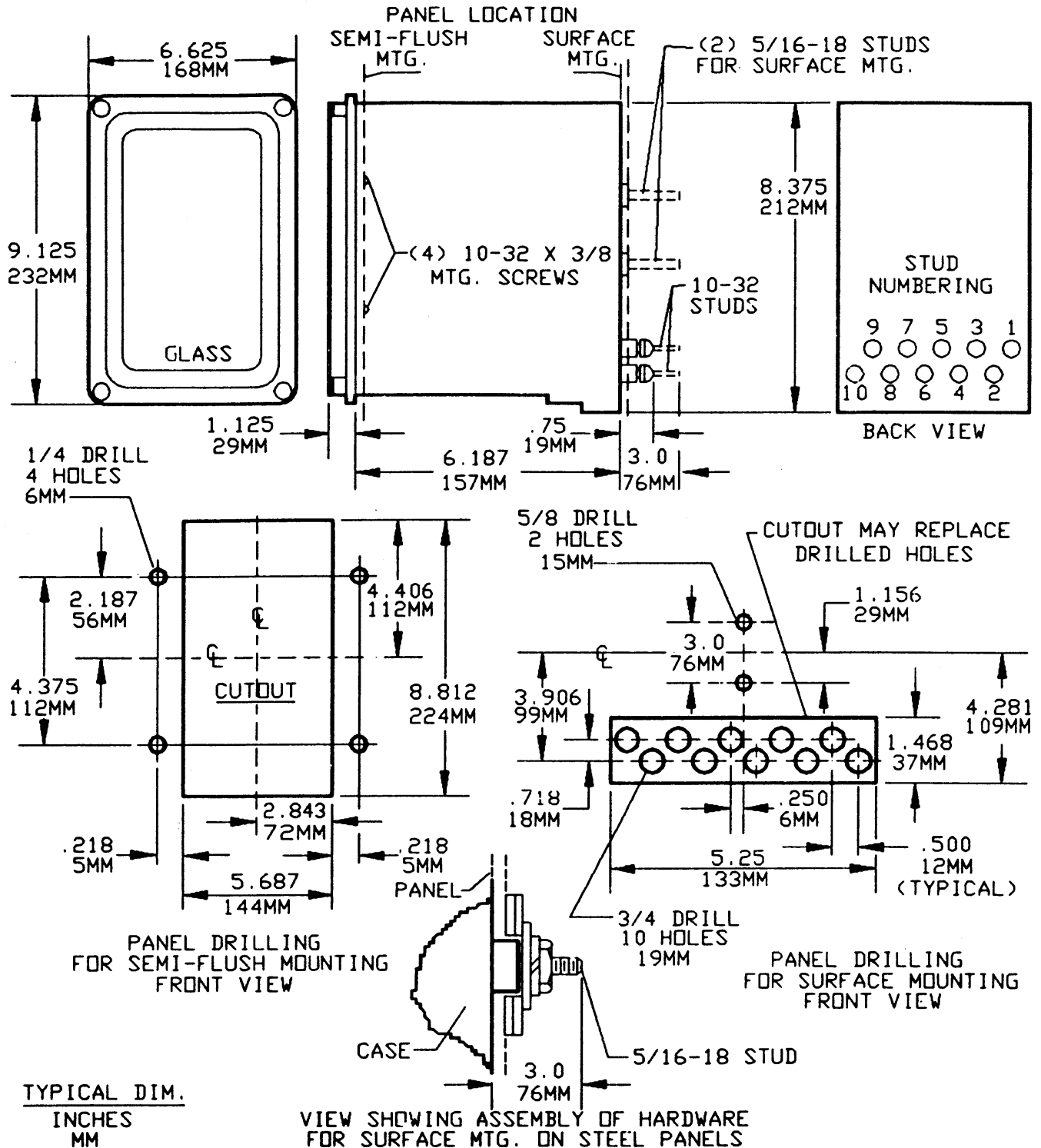
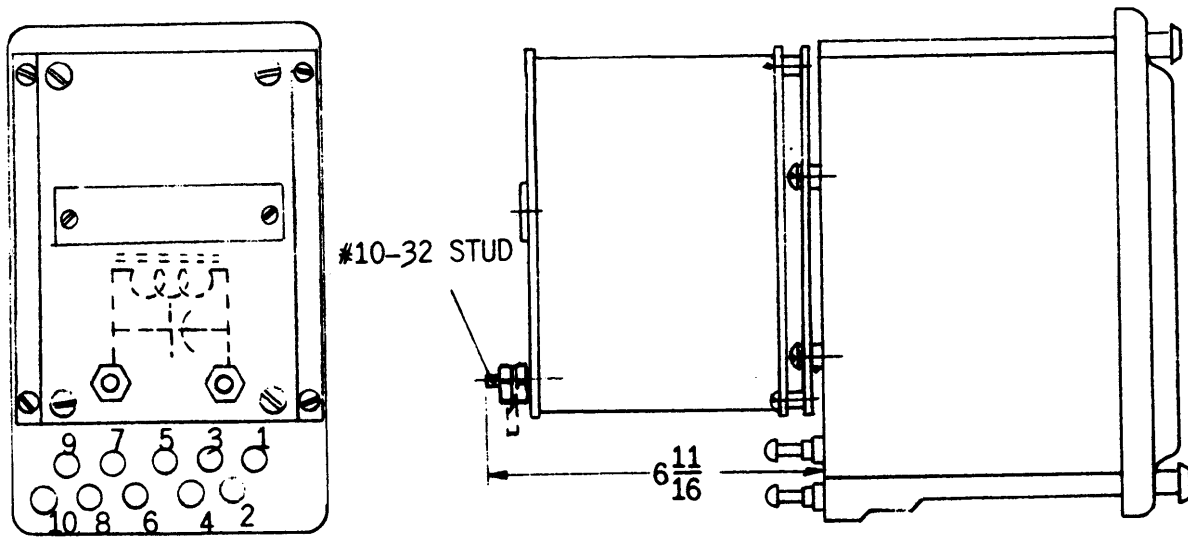


Figure 13 (6209271-8): OUTLINE AND PANEL DRILLING DIMENSIONS



BACK VIEW OF CASE

Figure 14 (0178A5834) HARMONIC FILTER OUTLINE & MOUNTING DIMENSIONS

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