

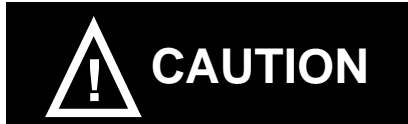


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( | ) Denotes Change Since Previous Issue

## Types CVE, CVE-1, CVE-2 AND CVE-3 Synchro-Verifier Relays



**Before putting the Synchro-Verifier into service, remove all blocking inserted for the purpose of securing all parts during shipment. Make sure that all moving parts operate freely. Inspect the contacts to see that they are clean and close properly. Operate the relay to check the settings and electrical connections.**

### 1. APPLICATION

The types CVE, CVE-1, CVE-2 and CVE-3, figures 1, 2, and 3, synchro-verifier relays are used to check the voltages on both sides of a breaker to see that they are approximately the same in magnitude and phase. The synchro-verifier relays are not automatic synchronizers and should not be used as such. Automatic synchronizers are available with permit closing ahead of synchronism at an angle of phase-advance proportional to the beat frequency and determined by the speed of operation of the circuit breaker so that the two systems are connected at synchronism.

The CVE type relays supervise the automatic or manual closing of a circuit breaker. A common application of the synchro-verifier relay is in conjunction with automatic reclosing equipment or loop systems fed by generating stations at two or more points. When a line section trips out, the synchro-verifier is used at

one terminal to check synchronism after the remote terminal is reclosed. If the two systems are in synchronism, the synchro-verifier permits that automatic equipment to reclose the breaker.

The CVE-1 has the CVE unit and is additionally equipped with line and bus voltage sensing, telephone type relays. These permit the relay reclosing to be initiated when the bus is hot and the line is dead (HBDL) or vice versa (HLDB). When both the line and the bus are live and in synchronism, the synchro-verifier relay permits the automatic reclosing equipment to reclose the breaker.

The CVE-2 relay is comprised of three (3) telephone type relays and two (2) over or under voltage toggle-type relays in addition to the CVE unit and is used for selective initiation of reclosures. The reclosing is modified by the nature of the trip; high-speed relay trips initiate high-speed and delayed-time reclosures; time-delayed relay trips initiate only time-delayed synchronism reclosures; and manual trips which do not initiate reclosures.

The CVE-3 relay also has the CVE unit. A telephone relay is added for the purpose of sealing-in the CVE contacts once they have closed. The CVE-3 relay is capable of being energized with the CVE unit contacts closed and will carry current continuously.

### 2. CONSTRUCTION

#### A. Operating Element (Rear Element) Figure 1

An "E" type laminated electromagnet is part of the operating element of the synchro-verifier

*All possible contingencies which may arise during installation, operation or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding this particular installation, operation or maintenance of this equipment, the local ABB Power T&D Company Inc. representative should be contacted.*

relays. The center leg has two (2) main coils and the left leg contains a lag coil. A variable resistor or a potentiometer connected across the lag coil provides adjustment for the different operating circles of the relay. Increasing or decreasing the amount of resistance effectively decreases or increases the contact closing torque of the relay.

When the relay is energized with two voltages, a flux is produced that is proportional to the sum of the applied voltages. This flux divides and returns through the outer legs of the electromagnet. The lag coil on the left leg causes the flux in that leg to lag the main pole flux. The out-of-phase fluxes thus produced in the disc gap cause a contact closing torque.

#### **B. Restraining Element (Front Element) Figure 2**

The restraining element is comprised of an "E" type laminated electromagnet with two main coils on its center leg and a lag coil on its left leg.

A flux is produced that is proportional to the difference of the applied voltages. This flux divides and returns through the outer legs of the electromagnet. The lag coil causes the flux through the left leg to lag the main pole flux. The out-of-phase fluxes thus produced in the disc gap cause a contact opening torque.

#### **C. Indicating Contactor Switch Unit (ICS) - (when used)**

The dc indicating contactor switch is a small clapper-type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also, during this operation, two fingers on the armature deflect a spring located on the front of the switch, which allows the operation indicator target to drop.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pick-up value of the switch.

#### **D. AC Indicating Contactor Switch (ACS) - (when used)**

The ACS is similar in construction to the ICS. It is

used where the ac current is too large for the ICS to handle or when the ICS will have to carry the ac current for too long a period.

### **3. OPERATION**

#### **A. CVE Operation With External Voltage Relays (Figure 4)**

Figure 4 shows the external connections of the CVE relay with two type SG relays for the line and bus voltage relays. Connected in this manner, the scheme will provide the following operations:

##### **1. Hot Line - Dead Bus, HLDB**

Close the breaker when the bus is hot and the line is dead, through the bus 59B make contact and the line 27L break contact.

##### **2. Hot Bus - Dead Line, HBDL**

Close the breaker when the line is live and the bus dead, through the line 59L make contact and the bus 27B break contact.

##### **3. Synchronism-check**

Close the breaker when the line and the bus are both live, and when their respective voltages are approximately normal, equal in phase and of the same frequency, through the CVE contact.

In the CVE with external relay arrangement, it is recommended that the number of reclosures be limited by using a single-shot or multi-shot reclosing relay in the scheme.

#### **B. CVE-1 Operation (Figure 5)**

The CVE-1 relay shown in Figure 5 operates as the CVE described above and with its internal telephone relays,  $V_1$  and  $V_2$ , it performs the same functions as the external SG relays described above.

Like the CVE, it is recommended that the number of reclosures be limited by using either a single-shot or a multi-shot reclosing relay in conjunction with the CVE-1 relay.

### C. CVE-2 Operation

The CVE-2 relay has two (2) drop-out telephone relays which have buffered contacts. Also, the CVE-2 relay has two (2) SX auxiliary relays where one is used to initiate high-speed reclosure and the other initiates time-delayed reclosures. The reclosing action is dictated by the nature of the trip, i.e., a high speed relay trip will initiate high speed and time-delayed reclosures; time delayed relay trips will initiate only time delayed synchronism check reclosures; and manual trips do not initiate reclosures.

### D. CVE-3 Operation

The CVE-3 relay, figure 6, incorporates a circuit to seal-in the CVE function of the relay. This circuit is comprised of a SPDT CVE contact and a DPST telephone relay contact.

## 4. CHARACTERISTICS

The relays containing the type CVE units can be adjusted for operating circles from 20 to 60 degrees as shown in figure 7. As shipped from the factory, the relay is calibrated for the 20 degree circle. These circles apply when one side has rated voltage. The relay operates if the other voltage falls within the appropriate circle.

The operating time of the CVE element of the relay is shown in figure 8. These time curves are obtained from the number 11 time-dial setting when the applied voltages are equal to rated voltage, of the same frequency and the phase angle between the voltages is varied for three typical settings. Shorter operating times can be obtained at different time-dial settings for values of voltage which are equal and in-phase as shown in figure 9.

Figure 10 shows the maximum slip frequency for which operation of the CVE element can occur. The maximum slip frequency is a function of the circle and time-dial settings. This characteristic is of interest in estimating the worst-case angular difference at the instant of breaker closure, for cases where the two systems are slipping slowly.

Figure 11 shows typical CVE reset times for the 20, 40 and 60 degree circle settings.

### A. Burden

#### 1. CVE Unit

The burden imposed on each potential source by the CVE relay, with rated voltage applied to both circuits of the relay as follows:

	60 Hertz	50 Hertz
Volt-Amperes	15.4	23.3
Power Factor	.422	.309
Watts	6.5	7.2

The burden of the CVE relay with rated voltage applied to one circuit is as follows:

	60 Hertz	50 Hertz
Volt-Amperes	10.8	13.8
Power Factor	.422	.309
Watts	4.6	4.2

#### 2. Auxiliary Relays

For the CVE-1 relay, the additional burden of each telephone relay at 120 Vac is as follows:

	60 Hertz	50 Hertz
Volt-Amperes	10.62	13.29
Power Factor	0.64	0.47
Watts	6.8	6.2

For the CVE-2 relay, the additional burden of each at 120 Vac is as follows:

	V <sub>1</sub>		V <sub>2</sub>	
	60 Hz	50 Hz	60 Hz	50 Hz
Volt-Amperes	3.36	4.16	7.92	9.80
Power Factor	.997	.733	.997	.733
Watts	3.35	3.05	7.90	7.18

#### 3. SX Units (CVE-2)

The SX auxiliary relay units contained in the CVE-2 each has a burden of 5.5 watts at rated voltage and one (1) watt at rated current.

#### 4. Continuous Ratings

These relays will continuously stand 110% of rated voltage applied to the line and bus circuits, either separately or simultaneously.

### 5. SETTINGS

#### A. Disc Unit

As shipped from the factory the relays are calibrated for a 20 degree circle. Other operating circles from 20 degrees to 60 degrees can be obtained by adjusting the left-hand resistor or potentiometer (front view). The procedure is described under "Adjustments and Maintenance".

Set the time-dial so that the relay will not operate when the systems are swinging too fast. The number 11 time-dial setting is recommended when the 60 degree circle setting is used. A setting of number 4 or higher on the time-dial is recommended with the 40 degree circle. A setting as low as 1/2 on the time-dial should be satisfactory with the 20 degree circle. From figure 9 note that the relay will operate in 1.4 seconds in the 1/2 time-dial position and with the 20 degree setting. If a longer delay is desired a higher time-dial setting may be used.

To evaluate the effect of time-dial and circle settings on the worse-case phase-angle difference between the two systems at the instant of breaker closure, refer to figure 8. For example, assume that the systems are slipping at a frequency of 0.048 hertz which is the maximum slip for which the relay will operate at a 1/2 time-dial position and a 20 degree setting.

This means that the voltage vector moves out of the circle an indication that the systems would be 40 degrees out-of-phase at the instant that the breaker close circuit is energized. The phase angle at the instant of breaker closure is:

$$0 = 40^\circ + 0.048 \times 350T_B = 40^\circ + 17.3T_B$$

where  $T_B$  = breaker closing time in seconds

Let  $T_B = 0.5$  seconds

Then  $40^\circ + 17.3 \times .05 = 48.6^\circ$

#### B. Indication Contactor Switch (ICS) - (When used)

Tap settings of either 0.2 or 2.0 amperes are required

on the ICS unit. Selection is made by connecting the lead located in the front of the tap block to the desired setting by means of the connecting screw.

### 6. INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relays vertically by means of the four mounting holes on the flanges for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench. See figures 32 and 33 for the Outline and Drilling Plan. For detailed FT case information refer to Instruction Leaflet 41-076. For mounting hardware information, see Technical Data sheet No-41-020.

### 7. ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory. Upon receipt of the relay, no customer adjustments, other than those covered under "Settings" should be required.

### 8. ACCEPTANCE CHECK

#### A. General

It is recommended that upon receipt of a synchro-verifier relay, the following checks be made to assure it is in proper working order. Although some of the checks appear to be and are the same, ***care should be taken that the test set-up used is for the unit under test.***

#### B. CVE (Figure 12)

1. Indicating Contactor Switch (ICS) -  
(When Used)

Close the main relay contacts and pass

sufficient dc current through the disc unit contact circuit to close the contacts of the ICS. This value of current should not be greater than the value marked on the nameplate. The operation indicator target should drop freely.

The contact gap should be approximately 0.047 inches between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

## 2. AC Contactor Switch - (When Used)

The core screw, which is adjustable from the top of the ACS unit, determines the pickup value. The making of the contacts and target indication should occur at approximately the same instant. Position the stationary contact for a wipe of 1/64 to 3/64 inches with the armature against the core pin. For units with double trip contacts, the adjustment procedure is the same as with the single trip unit.

Close the main relay contacts and pass sufficient ac current through the trip circuit to close the ACS contacts no later than 98 percent of the value given on the relay nameplate. Dropout must occur at 90 percent of that rating.

## 3. Disc Unit

a. **Contacts (Mechanical)** - The index mark on the movement frame will coincide with the "0" mark on the time-dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "0" mark by approximately 0.020 inches. The placement of the various time-dial positions in line with the index mark will give operating times as shown on the time curve.

b. **Operating Circle-Setup the CVE relay** per the test diagram in figure 12. When

$V_2 = V_1 =$  rated voltage and their phase difference is between 18 and 22 degrees, (either leading or lagging), the contacts should just close. Another condition for the contacts to just close is when  $V_1 =$  rated voltage and  $V_2$  is increased from a low value to  $94 \pm 4$  volts.

c. **Time Curve** - The contacts should close when with the time-dial set at position 11 and  $V_1$  and  $V_2$  are equal to rated voltage and in phase, the contacts should close in  $20 \pm 1$  second.

## C. CVE-1 (Figures 13 and 14)

### 1. Indicating Contactor Switch (ICS) - (When Used)

Close the main relay contacts and pass sufficient dc current through the disc unit contact circuit to close the contacts of the ICS. This value of current should not be greater than the value marked on the nameplate. The operation indicator target should drop freely.

The contact gap should be approximately 0.047 inches between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

### 2. AC Contact Switch (ACS) - (When Used)

The core screw, which is adjustable from the top of the ACS unit, determines the pickup value. The making of the contacts and target indication should occur at approximately the same instant. Position the stationary contact for a wipe of 1/64 to 3/64 inches with the armature against the core pin. For units with double trip contacts, the adjustment procedure is the same as with the single trip units.

Close the main relay contacts and pass sufficient ac current through the trip circuit to close the ACS contacts no later than 98 percent of the value given on the relay nameplate. Dropout must occur at 90 percent of that rating.

## 3. Disc Unit

- a. Contacts (Mechanical) - The index mark on the movement frame will coincide with the "0" mark on the time-dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "0" mark by approximately 0.020 inches. The placement of the various time-dial positions in line with the index mark will give operating times as shown on the time curve.
- b. Operating Circle - Set up the CVE relay per the test diagram in figures 13 and 14. When  $V_2 = V_1 =$  rated voltage and their phase difference is between 18 and 22 degrees, (either leading or lagging), the contacts should just close. Another condition for the contacts to just close is when  $V_1 =$  rated voltage and  $V_2$  is increased from a low value to  $94 \pm 4$  volts in phase with  $V_1$ .
- c. Time Curve - With the time-dial set at position 11, the contacts should close in 20 ac  $\pm 1$  second when  $V_1$  and  $V_2$ , equal to the rated voltage at zero phase angle, are applied.

## 4. Telephone Relays

Apply an ac voltage to each telephone relay circuit. The telephone relay must pickup when 95 volts are applied.

**D. CVE-2 (Figure 15)**

## 1. Indicating Contactor Switch (ICS) - (When Used)

Close the main relay contacts and pass sufficient dc current through the disc unit contact circuit to close the contacts of the ICS. This value of current should not be greater than the value marked on the nameplate. The operation indicator target should drop freely.

The contact gap should be approximately 0.047 inches between the bridging moving

contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

## 2. AC Contactor Switch (ACS) - (When Used)

The core screw, which is adjustable from the top of the ACS unit, determines the pickup value. The making of the contacts and target indication should occur at approximately the same instant. Position the stationary contact for a wipe of 1/64 to 3/64 inches with the armature against the core pin. For units with double-trip contacts, the adjustment procedure is the same as with the single trip unit.

Close the main relay contacts and pass sufficient ac current through the trip circuit to close the ACS contacts no later than 98 percent of the value given on the relay nameplate. Dropout must occur at 90 percent of that rating.

## 3. Disc Unit

- a. Contacts (Mechanical) - The index mark on the movement frame will coincide with the "0" mark on the time-dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "0" mark by approximately 0.020 inches. The placement of the various time-dial positions lined with the index mark will give operating times as shown on the time curve.
- b. Operating Circuit - Set up the CVE-2 relay per the test diagram in figure 15. When  $V_2 = V_1 =$  rated voltage and their phase difference is between 18 and 22 degrees, (either leading or lagging), the contacts should just close. Another condition for the contacts to just close is when  $V_1 =$  rated voltage and  $V_2$  is increased from 10 W value to  $94 \pm 4$  volts in phase with  $V_1$ .

- c. Time Curve - With the time-dial set at position 11, the contacts should close in  $20 \pm 1$  second when  $V_1$  and  $V_2$ , equal to the rated voltage at zero phase angle, are applied.

#### 4. Telephone Relays

- a. A rated dc voltage applied to terminals 17 (positive) and 19 (negative) will check telephone relay "X". The telephone relay should pickup at 80% of rated voltage and dropout when de-energized.
- b. Telephone relay  $V_1$  can be checked by applying an ac voltage to terminals 12 and 14. The unit should pickup between 72 and 96 volts and dropout between 64 to 84 volts. Pickup can be varied by adjusting the middle left-hand resistor (front view).
- c. Telephone relay unit  $V_2$  is checked by applying an ac voltage to terminals 16 and 15. The unit should pickup between 36 and 38 volts and dropout between 6 to 30 volts. Pickup of the unit can be varied by adjusting the upper left-hand resistor (front view) of the relay. ***The pickup should not be adjusted for values of voltage less than 36 volts ac to avoid exceeding the continuous rating of the circuit.***

### E. CVE-3 (Figure 16)

- 1. Indicating Contactor Switch (ICS) - (When Used)

Close the main relay contacts and pass sufficient dc current through the disc unit contact circuit to close the contacts of the ICS. This value of current should not be greater than the value marked on the nameplate. The operation indicator target should drop freely.

The contact gap should be approximately 0.047 inches between the bridging moving contact and the adjustable stationary contacts. The bridging, moving contact should touch both stationary contacts simultaneously.

#### 2. Disc Unit

- a. Contacts (Mechanical) - The index mark on the movement frame will coincide with the "0" mark on the time-dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "0" mark by approximately 0.020 inches. The placement of the various time-dial positions in line with the index mark will give operating times as shown on the time curve.
- b. Operating Circle - Set up the CVE-3 relay per the test diagram in figure 16. A dc power source supplying 125 volts must be connected to terminal 10 (positive) and 2 (negative). A light or trip-coil type indicator is to be connected between terminals 1 (positive) and 2 (negative).

After the above set-up is accomplished, the contacts should just close when either of the following two conditions is applied.

- 1) When  $V_2 = V_1 =$  rated voltage and their phase difference is between 18 and 22 degrees, (either leading or lagging).
- 2) When  $V_1 =$  rated voltage and  $V_2$  is increased from a low value to  $94 \pm 4$  volts in phase with  $V_1$ .
- c. Time Curve - With the time-dial set at position 11, the contacts should close in  $20 \pm 1$  second when  $V_1$  and  $V_2$ , equal to the rated voltage at zero phase angle, are applied.

#### 3. Telephone Relay

In order to check the pickup of the CVE-3 telephone relay, the time-dial must be turned to zero to close the CVE contact continuously. Then apply a dc voltage across terminal 10 (positive) and 2 (negative). Pickup should occur at 80% of rated voltage and dropout when de-energized.

## 9. ROUTINE MAINTENANCE

All relays should be inspected periodically and the time of operation should be checked at least once every two years or at such other time intervals as may be dictated by experience to be suitable to the particular application.

All contacts should be periodically cleaned. A contact burnisher Style Number 182A836H01 is recommended for this purpose. The use of abrasive materials for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver contact and thus impairing the contact.

## 10. CALIBRATION

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments have been disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order (See Acceptance Check).

### A. Contacts

The index mark on the movement frame coincides with the "0" mark on the time-dial when the stationary contacts has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "0" mark by approximately 0.020 inches. The placement of the various time-dial positions in line with the index mark will give operating times as shown on the respective time curves.

### B. Preliminary Adjustments

Remove the permanent magnet from the relay and set the time-dial on the number 11 position. Next unwind the spring for zero tension on the number 11 position. This can best be noticed by unwinding the spring until the contact will not move when the time-dial is moved a small distance beyond the number 11 position.

The spring convolutions may touch during this operation and the outer convolutions may hit other surfaces of the relay. This interference should be disregarded because its effect on the final calibration will be negligible. The purpose for unwinding the spring is that the amount of tension on the reset spring affects the diameter of the circle. Hence, the

spring tension has to be removed initially so that only the left-hand resistor will affect the operating circle.

### C. Spurious Torque Adjustments

With the relay set as per the preliminary adjustments, open the lag coil circuit of the rear electromagnet. This is done by opening the screw connection on the lag coil or by inserting a piece of insulating material under the adjustable point of the left-hand potentiometer or resistor (front view). Connect the relay per the following test circuits:

CVE	figure 12
CVE-1	figures 12 and 14
CVE-2	figure 15
CVE-3	figure 16

Apply rated voltage at zero phase angle on both circuits. With the right-hand plugged all the way in, adjust the left-hand plug of the rear electromagnet such that the disc does not move from the number 11 time-dial position. This can be determined by no movement of the disc when the time-dial is moved beyond the number 11 position.

### D. Centering Circle

Close the lag coil circuit of the rear electromagnet and set the left-hand resistor at approximately one-third of its resistance. Adjust the phase shifter in the lagging direction until the contacts just close the  $V_1$  and  $V_2$  equal to rated voltage. If the latter angle is not within  $\pm 1$  degree of the former angle, adjust the right-hand resistor (front view) until the two angles are within  $\pm 1$  degree of each other.

### E. Spring Adjustment

Adjust the left potentiometer or resistor (front view) such that the moving contact just leaves and returns to the backstop of the time-dial at the number 11 position between 40 degrees and 41 degrees, with rated voltage on both sides. Change the angle to 20 degrees and adjust the reset spring until the contacts just make. Rotate the phase shifter to move  $V_2$  through zero phase angle to an angle where the contacts just make. The contacts should just close at an angle of  $20 \pm 2$  degrees either  $V_1$  and  $V_2$  equal to rated voltage. With  $V_1$  equal to rated voltage the contacts should just close when  $V_2$  is increased to  $94 \pm 4$  volts in phase with  $V_1$ . If necessary, readjust the spring slightly to obtain this condition. The relay is now calibrated for a 20 degree circle.



## F. Time Curve

Install the permanent magnet on the relay. Adjust the permanent magnet keeper until the operating time of the relay from the number 11 time-dial position is  $20 \pm 0.6$  seconds with  $V_1$  and  $V_2$  equal to rated voltage at zero phase angle.

## G. Circles Other Than 20 Degrees

This adjustment should not be attempted until the adjustments for a 20 degree circle has been completed.

If a circle other than 20 degrees is desired, adjust the left-hand potentiometer or resistor (front view) to obtain the desired circle.

## FOR EXAMPLE

If a 40 degree circle is desired, adjust the left-hand resistor until the contacts just close with  $V_1$  and  $V_2$  equal to rated voltage at 40 degree phase angle. It may be necessary to readjust the right-hand resistor to position the desired circle symmetrically about the zero degree line. See Calibration, Paragraph D, "Circle Centering" for this procedure. The time of operation will be shown in the time curves of figure 8.

## 11. ELECTRICAL CHECKPOINTS

### A. Approximate voltage across coils (Figures 12 thru 16)

With  $V_1$  equal to rated voltage, the following approximate voltages should be obtained across the coils of the 120 volt relay. The relay is set for a 20 degree circle.

With 120 volts applied to $V_1$ circuit only:		
	60 Hz	50 Hz
<b>Operating Electromagnet:</b>		
Upper terminals	59 volts	61 volts
Lower terminals	57 volts	59 volts
Lag coil circuit	22 volts	24 volts
<b>Restraint Electromagnet:</b>		
Upper terminals	58 volts	61 volts
Lower terminals	54 volts	58 volts

With  $V_2$  equal to rated voltage, the following approximate voltages should be obtained across the coils of the 120 volt relay. The relay is set for a 20 degree circle.

With 120 volts applied to $V_2$ circuit only:		
	60 Hz	50 Hz
<b>Operating Electromagnet:</b>		
Upper terminals	57 volts	58.5 volts
Lower terminals	59 volts	61 volts
Lag coil circuit	22 volts	24 volts
<b>Restraint Electromagnet:</b>		
Upper terminals	54 volts	57 volts
Lower terminals	58 volts	61 volts

B. Approximate dc resistances of the coils are as follows:

Operating Electromagnet:	
Upper terminals	59 ohms
Lower terminals	80 ohms
Lag coil-open circuit	245 ohms
Restraint Electromagnet:	
Upper terminals	66 ohms
Lower Terminals	92 ohms

C. Approximate resistance values of the left-hand resistor for various operating circles.

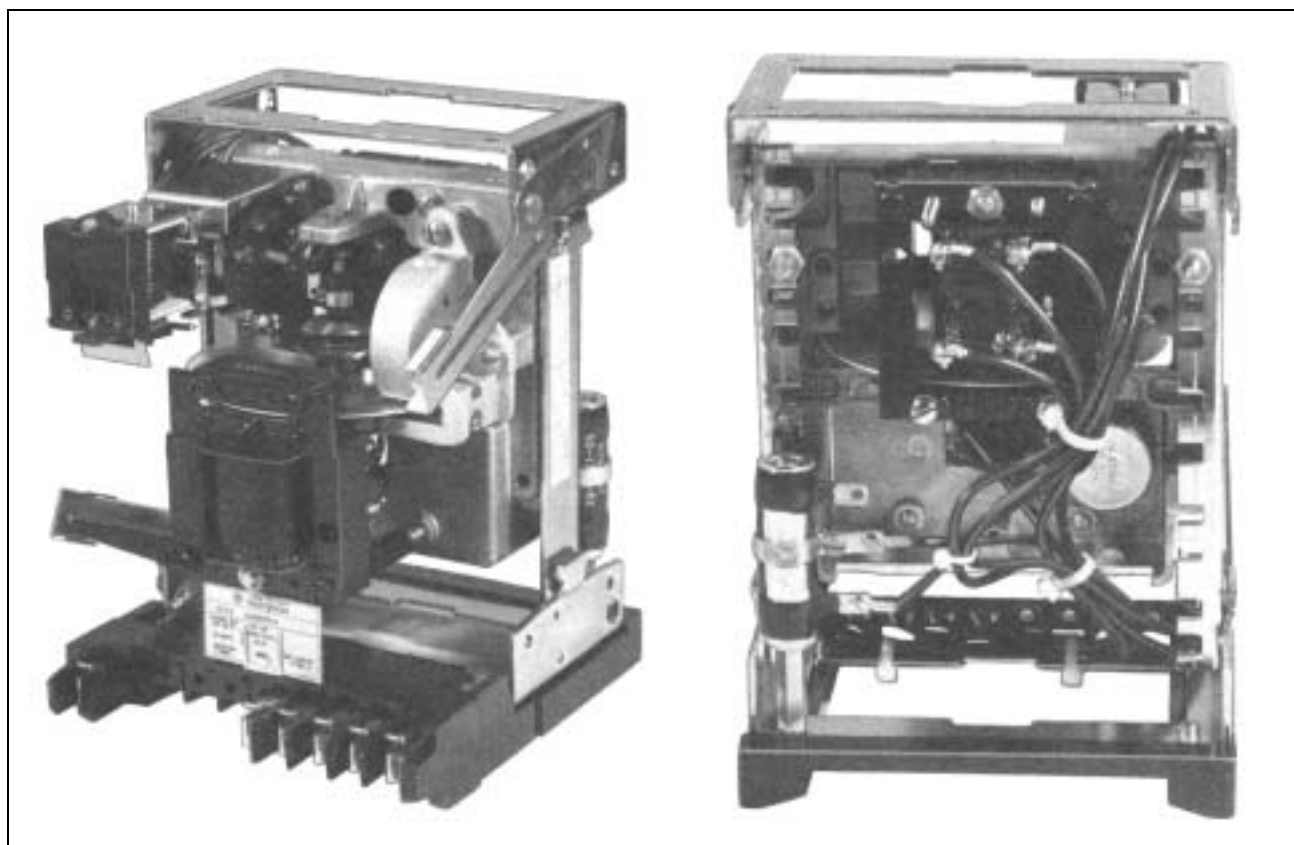
20 degree circle	4800 ohms
40 degree circle	2250 ohms
60 degree circle	890 ohms

## 12. RENEWAL PARTS

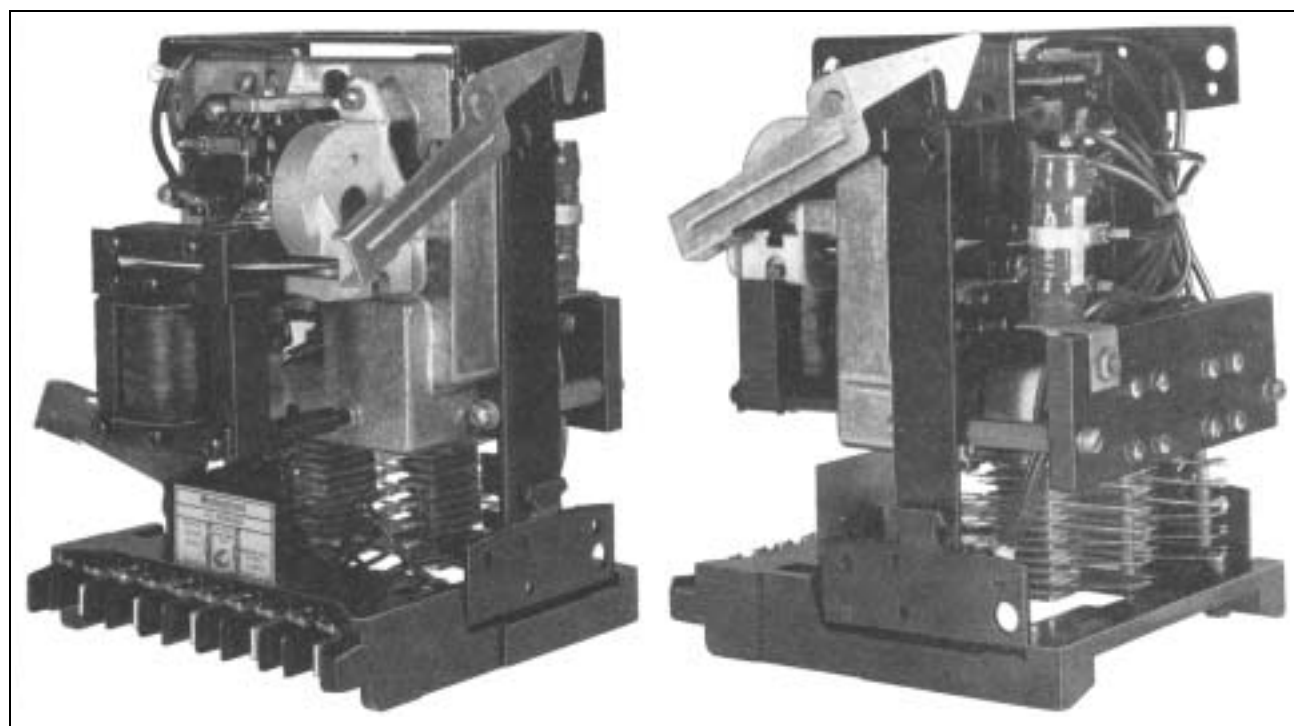
Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be ordered by customers equipped for doing repair work. When ordering parts, always furnish complete data from the nameplate.

### LIST OF FIGURES CONTAINED IN THIS INSTRUCTION LEAFLET

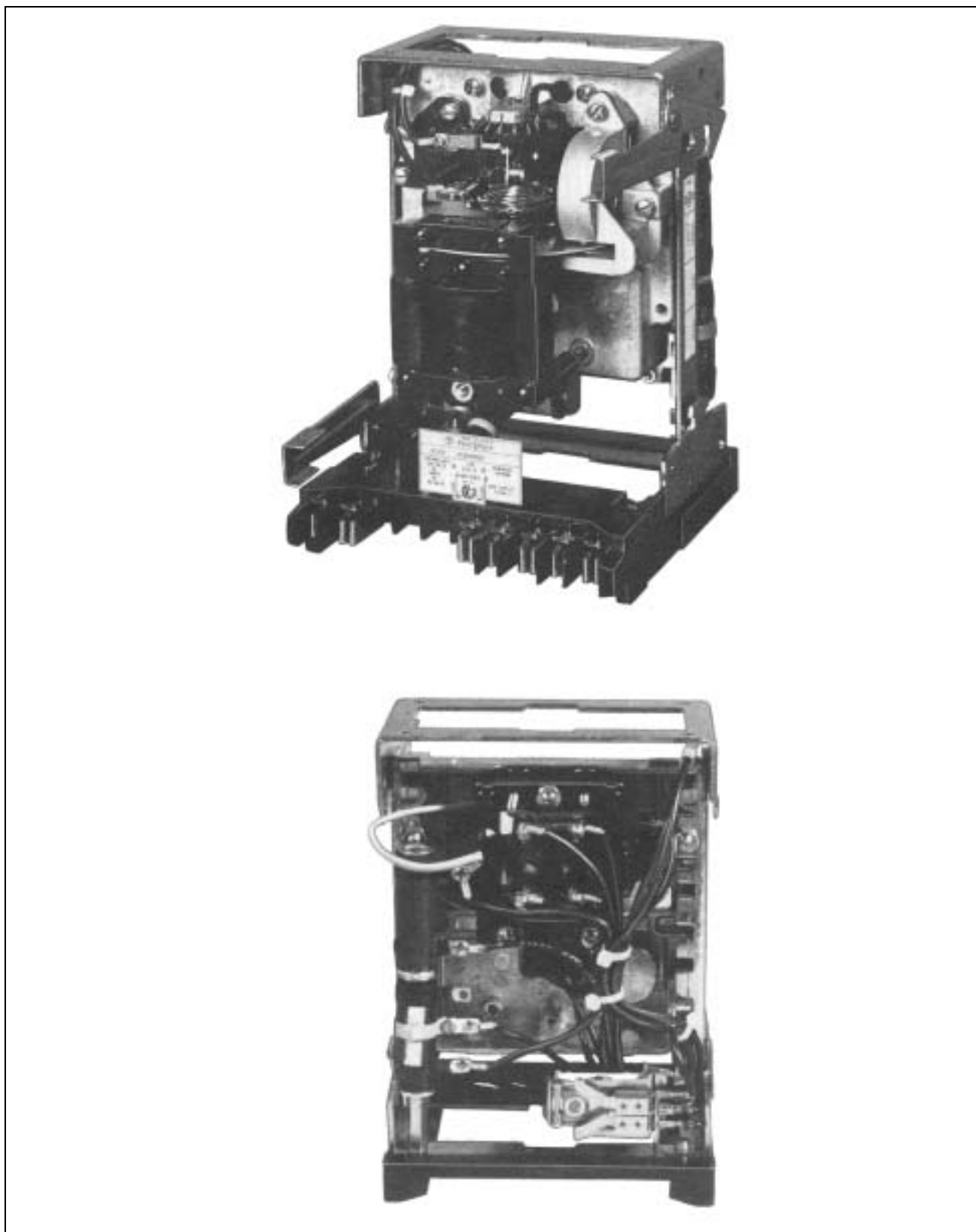
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Figure 31.	Internal Schematic CVE-1	-880A759
Figure 32.	Outline & Drilling Diagram	-57D7901
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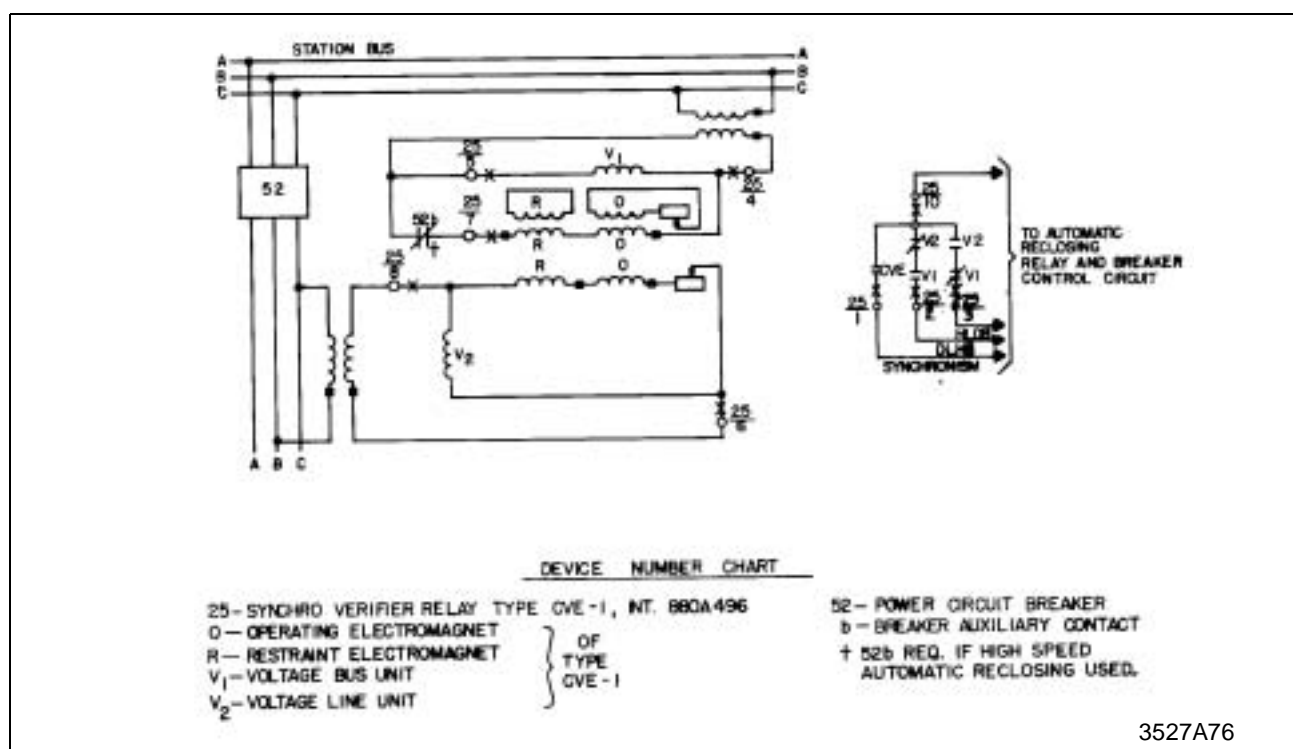
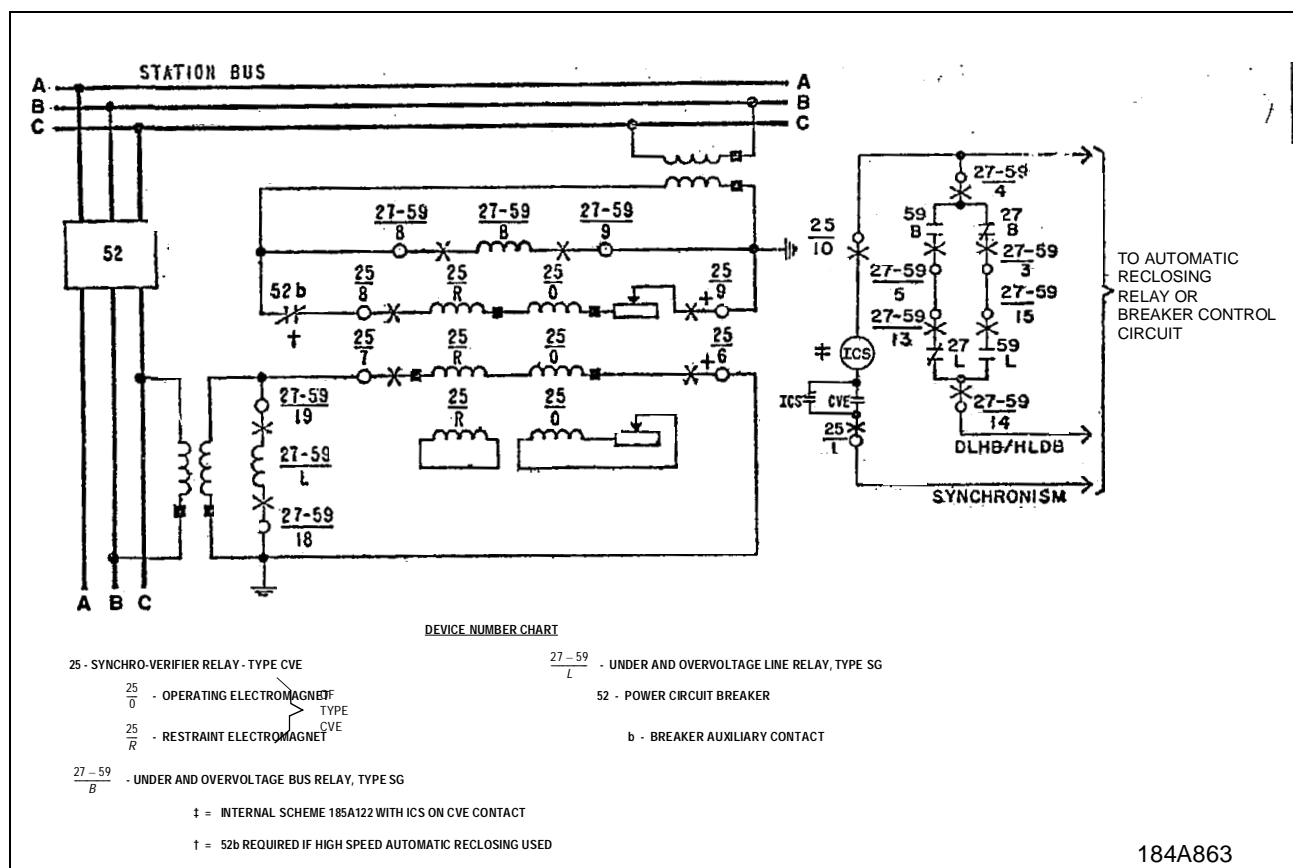
*Figure 1. CVE Relay Front & Rear Views, Out of Case*

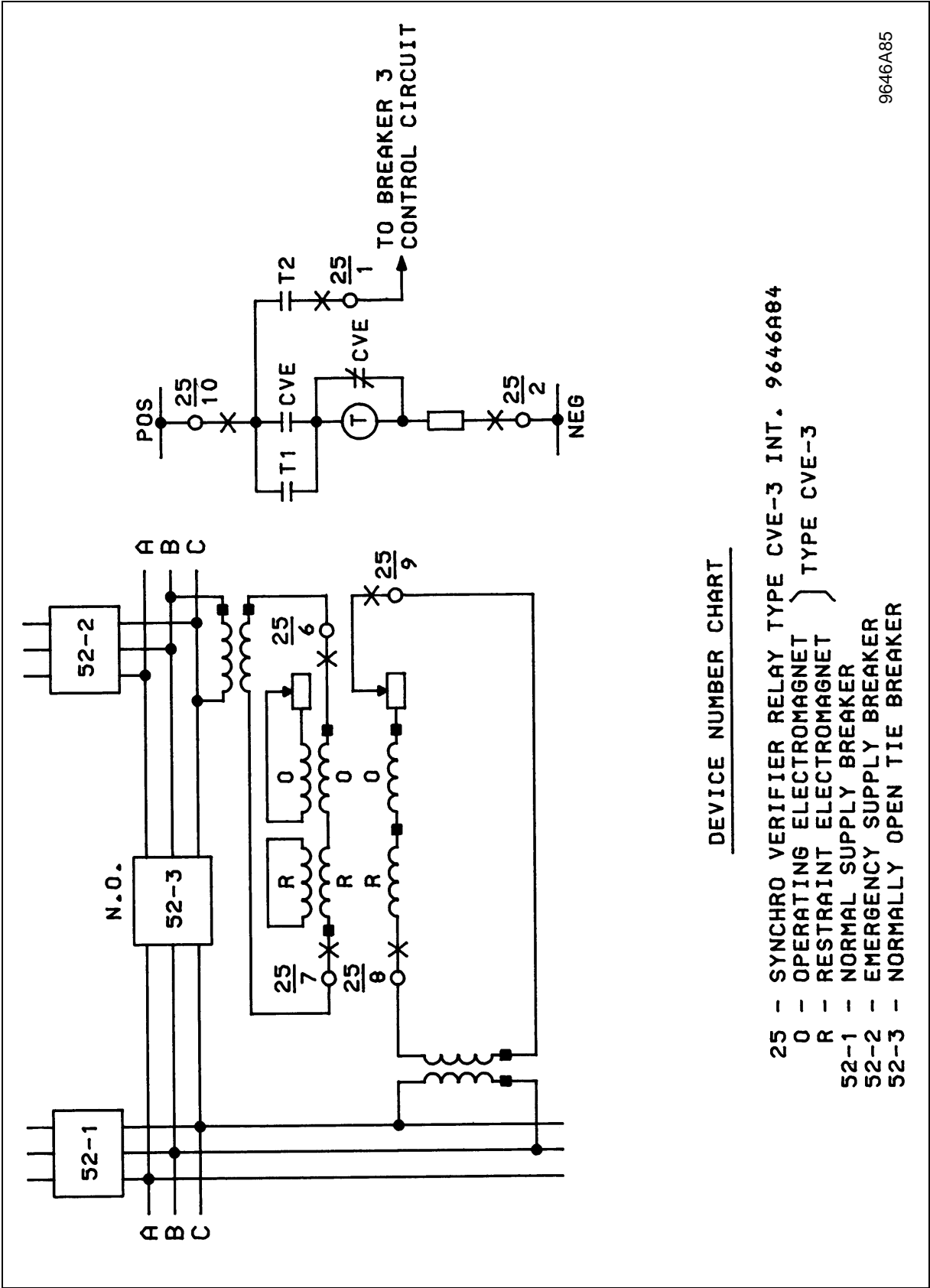


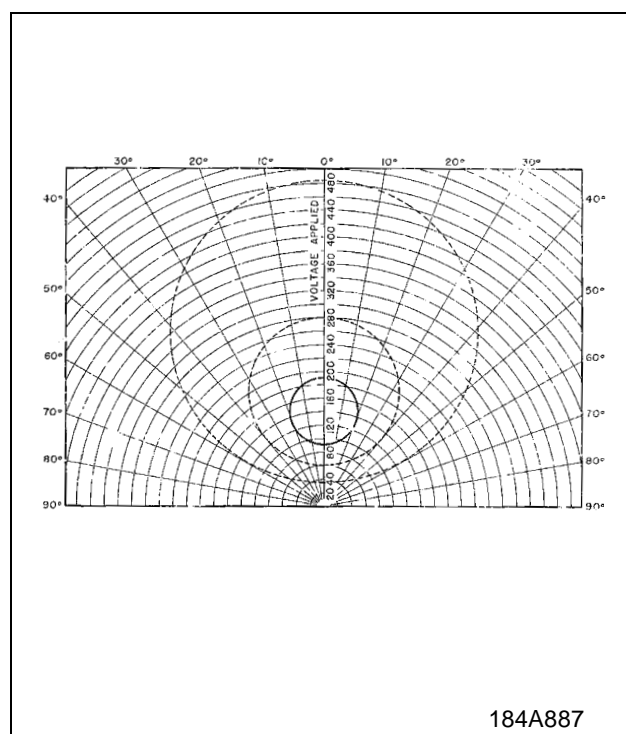
*Figure 2 .CVE-1 Relay Front & Rear View, Out of Case*



*Figure 3 .CVE-3 Relay Front & Rear Views, Out of Case*

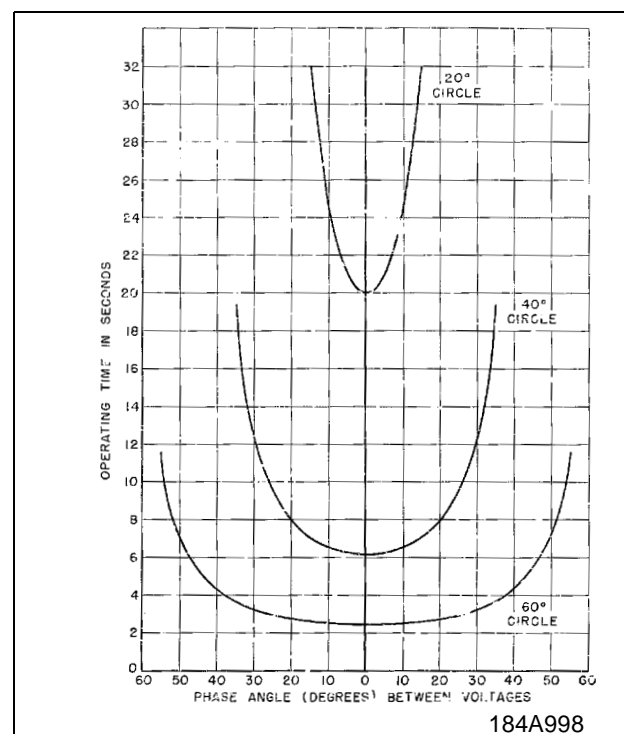






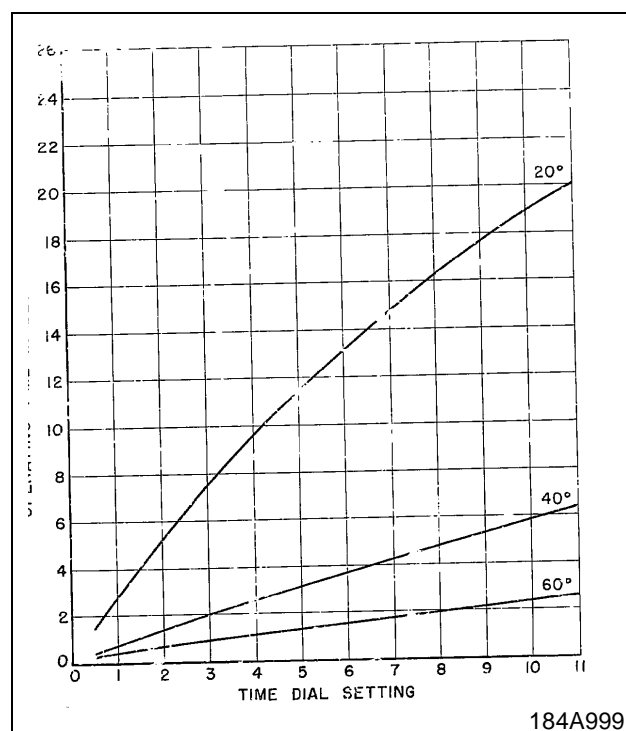
184A887

Figure 7. Typical Voltage Angle Characteristic of CVE for Various Closing angle Settings. Rated Voltage on One Circuit.



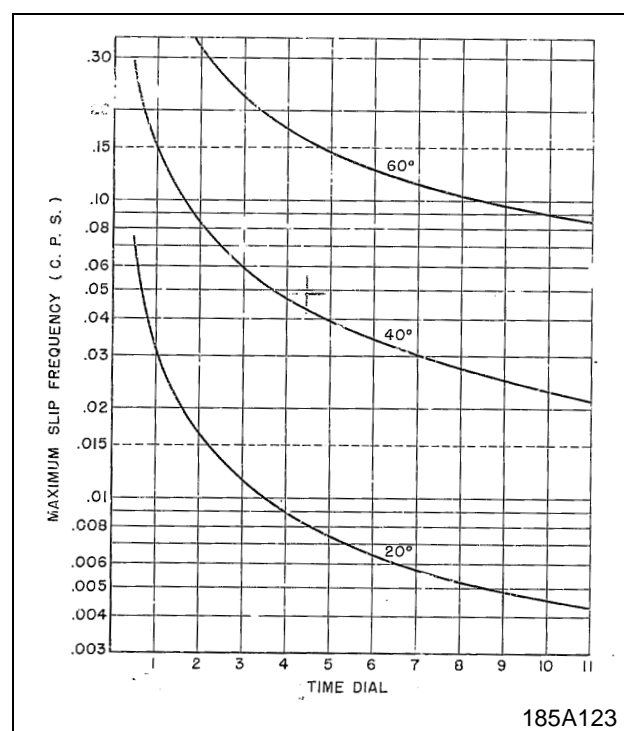
184A998

Figure 8. Typical Time Phase Angle Curves of CVE. Rated Voltage on Both Circuits No. 11 Dial Time Settings.



184A999

Figure 9. Operating Time Variations with Changes in Time-dial Settings. Rated In-Phase Voltage on Both Circuits, 20°, 40° and 60° Circle Settings.



185A123

Figure 10. Approximate Maximum Slip Frequency for which Operation Occurs - Rated Voltage on Both Sides.

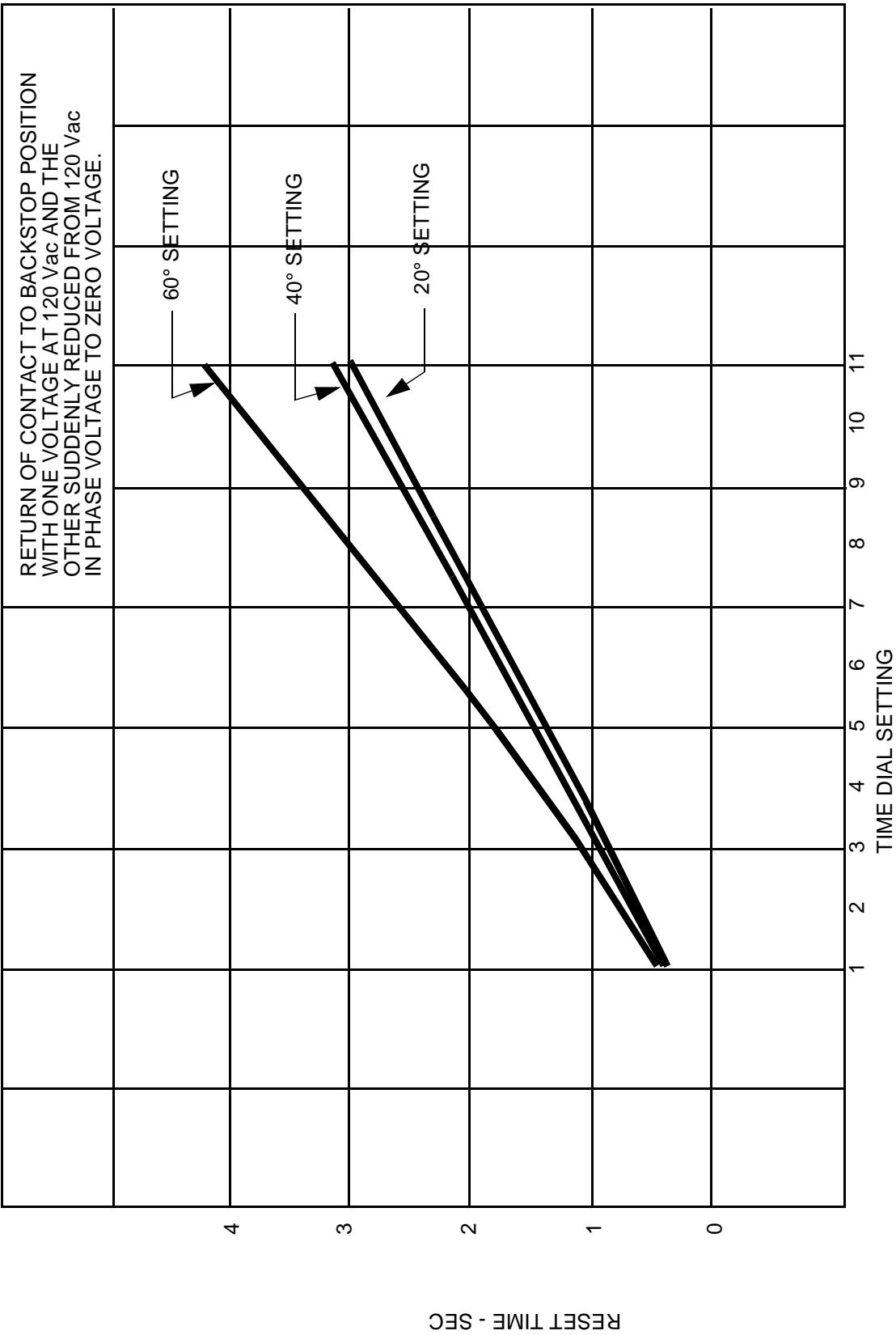


Figure 11. Typical CVE Reset Times. Return of Contact to Backstop Position with One Voltage at Rated Voltage and the Other Suddenly reduced from Rated in Phase Voltage to Zero Voltage.

619457



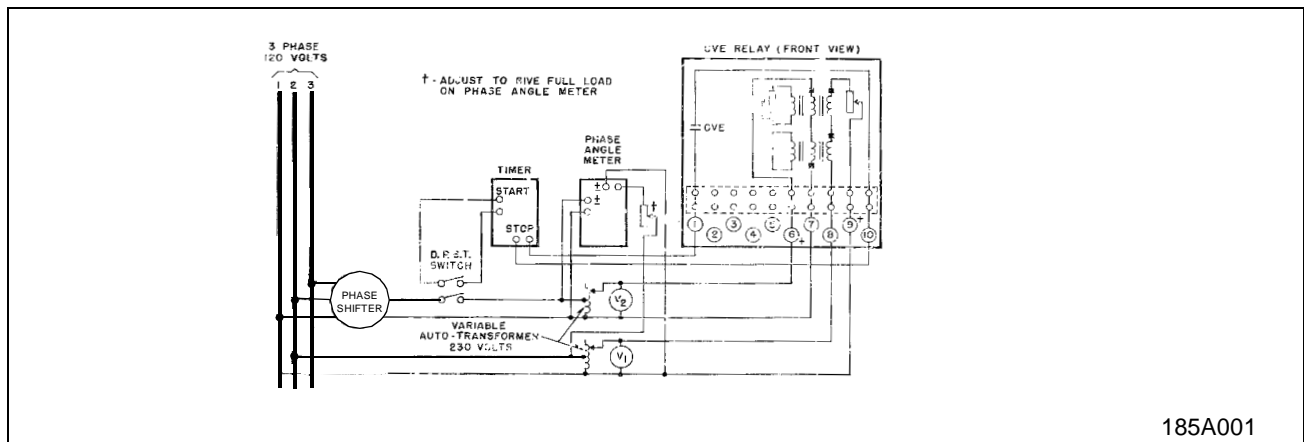


Figure 1 2 Diagram of CVE Test Connections

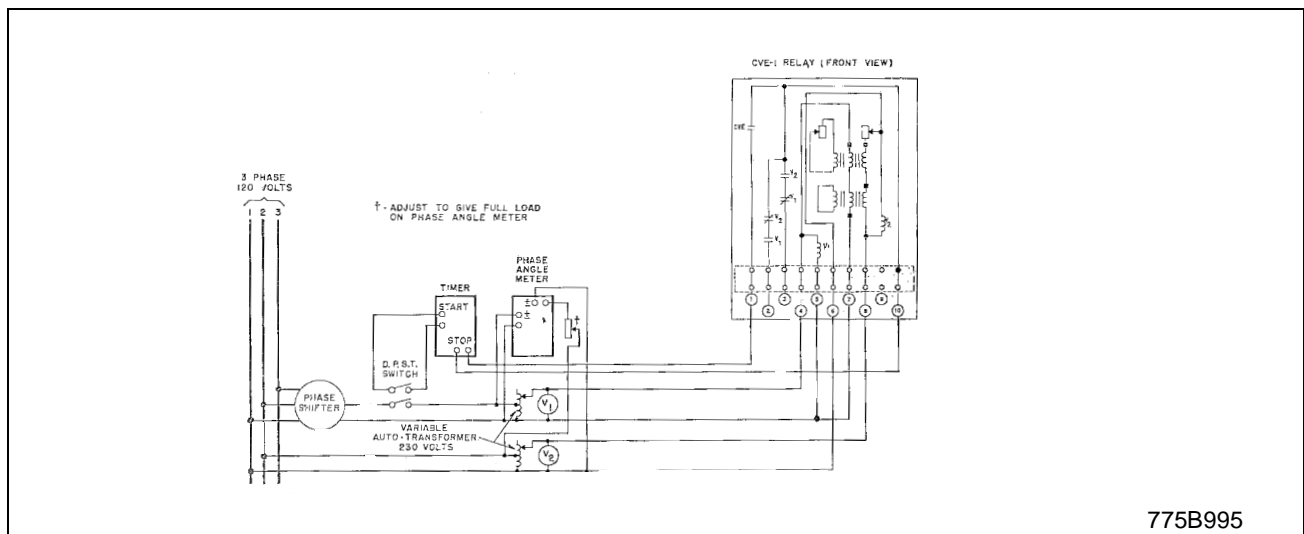


Figure 13. Diagram of CVE-1 Test Connections without Commoned Potential Coils.

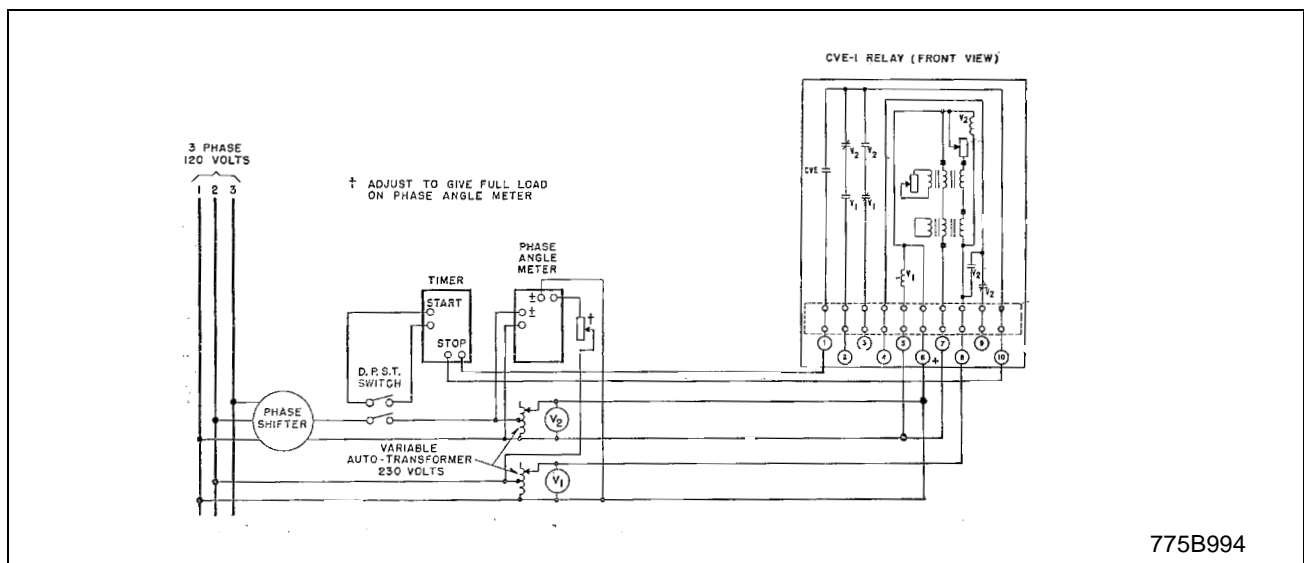
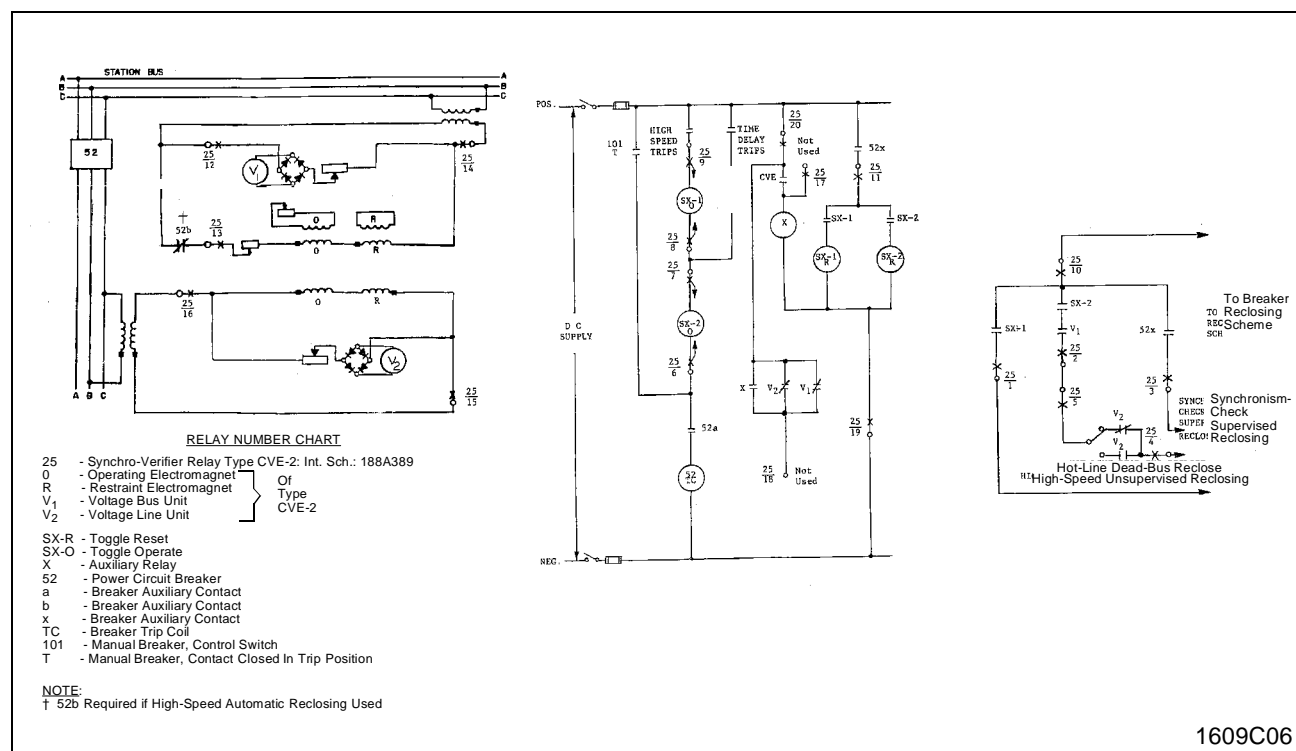
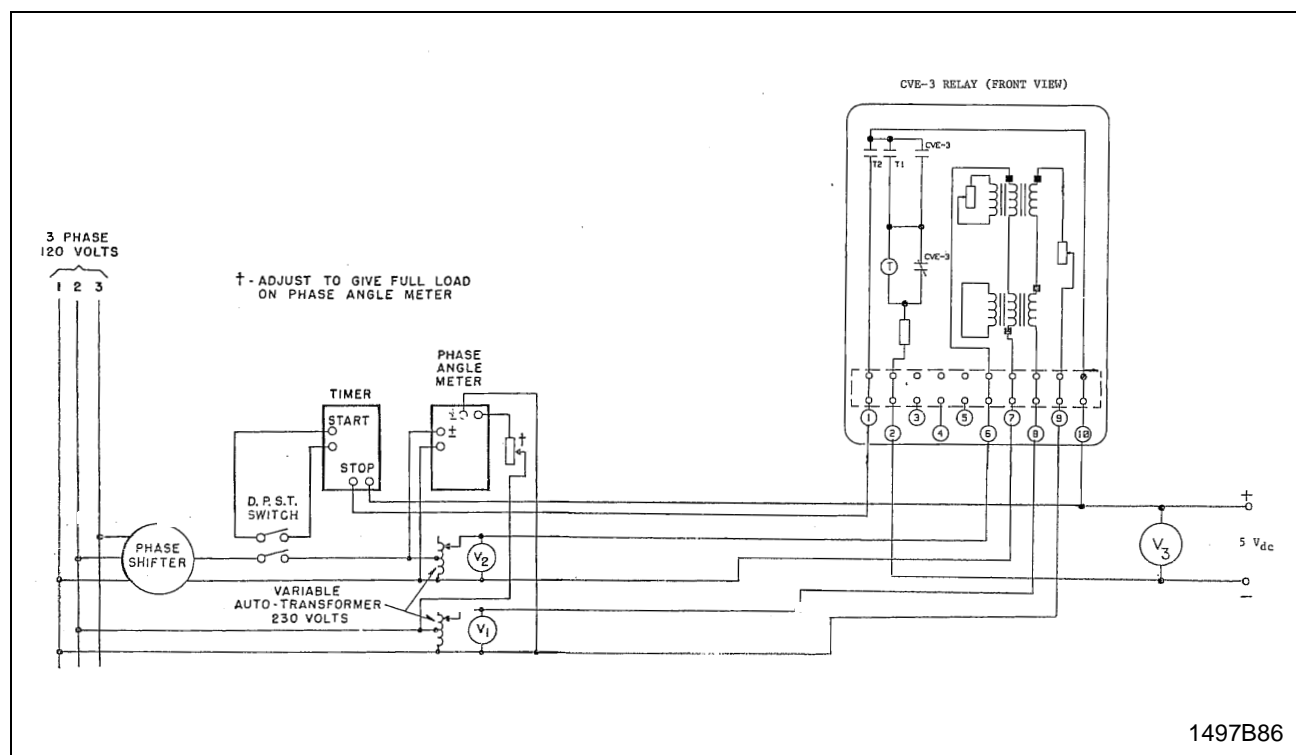


Figure 1 4 Diagram of CVE-1 Test Connections with Commoned Potential Coils.



1609C06

Figure 1 5 External Schematic CVE-2 Relay



1497B86

Figure 1 6 Test Connections CVE-3 Relay

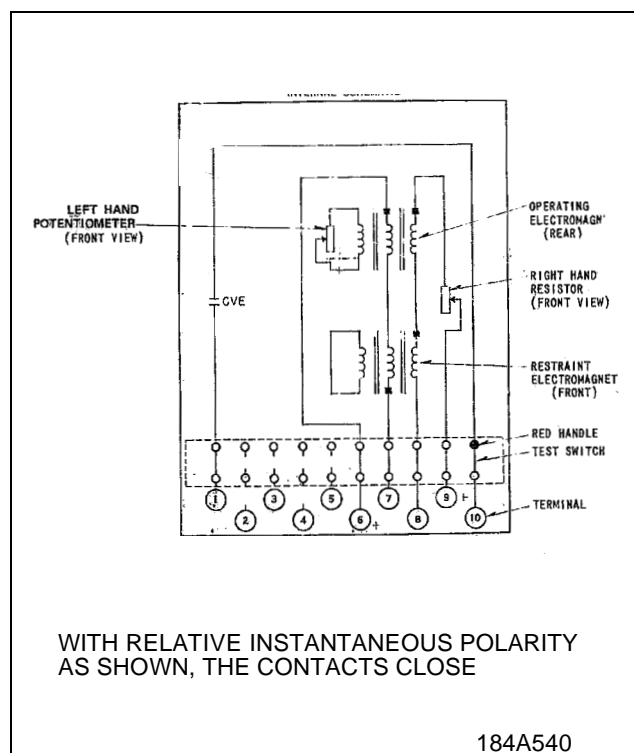


Figure 17. Internal Schematic CVE Relay without ICS Unit

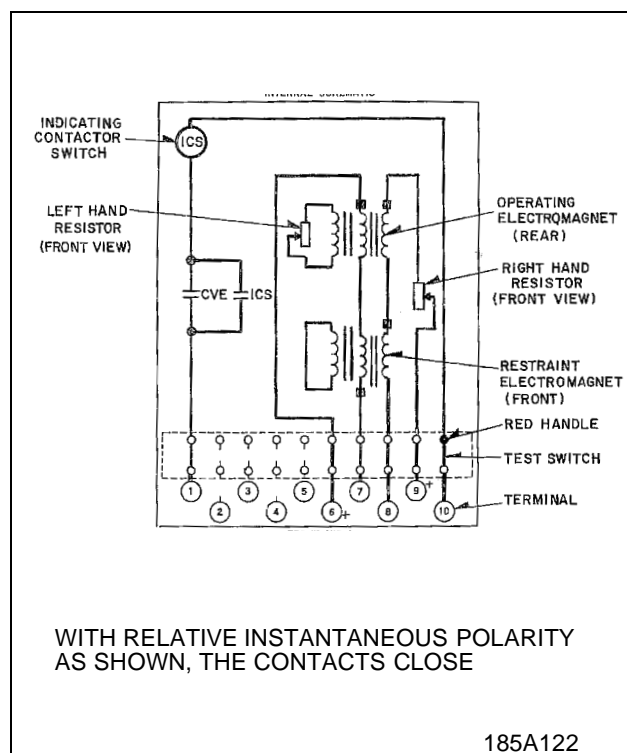


Figure 18. Internal Schematic CVE Relay with ICS Unit.

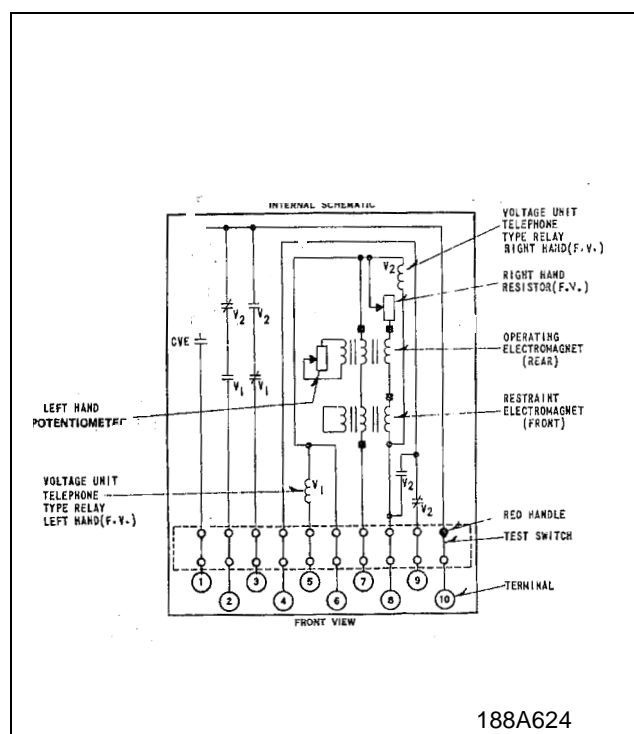


Figure 19. Internal Schematic CVE-1 for use with RC Reclosing (See Figure 27 for external schematic) with Commoned Voltage Coils, Use with Phase-to-Phase connected vt's.

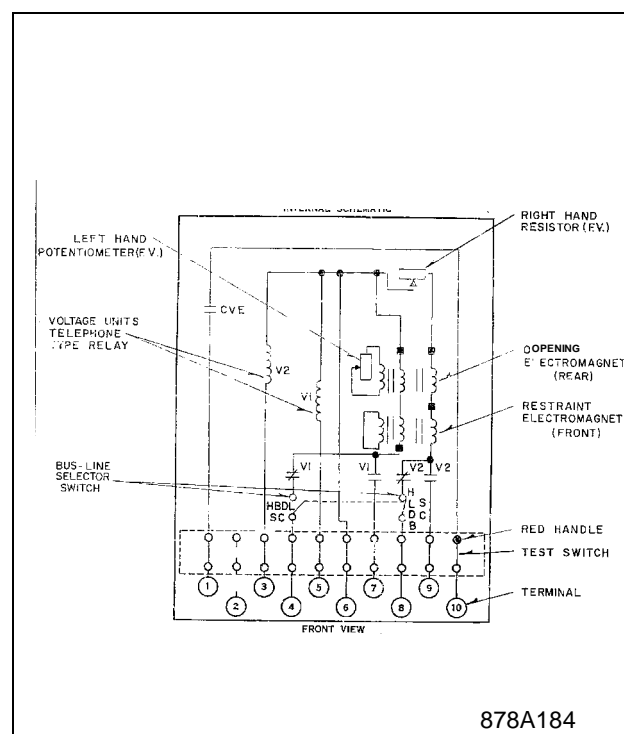


Figure 20. Internal Schematic CVE-1 with Internal Switch for HBDL or HLDB. (See Figure 26 External Schematic) with Commoned Voltage Coils, Use with Phase-to-Phase connected vt's.

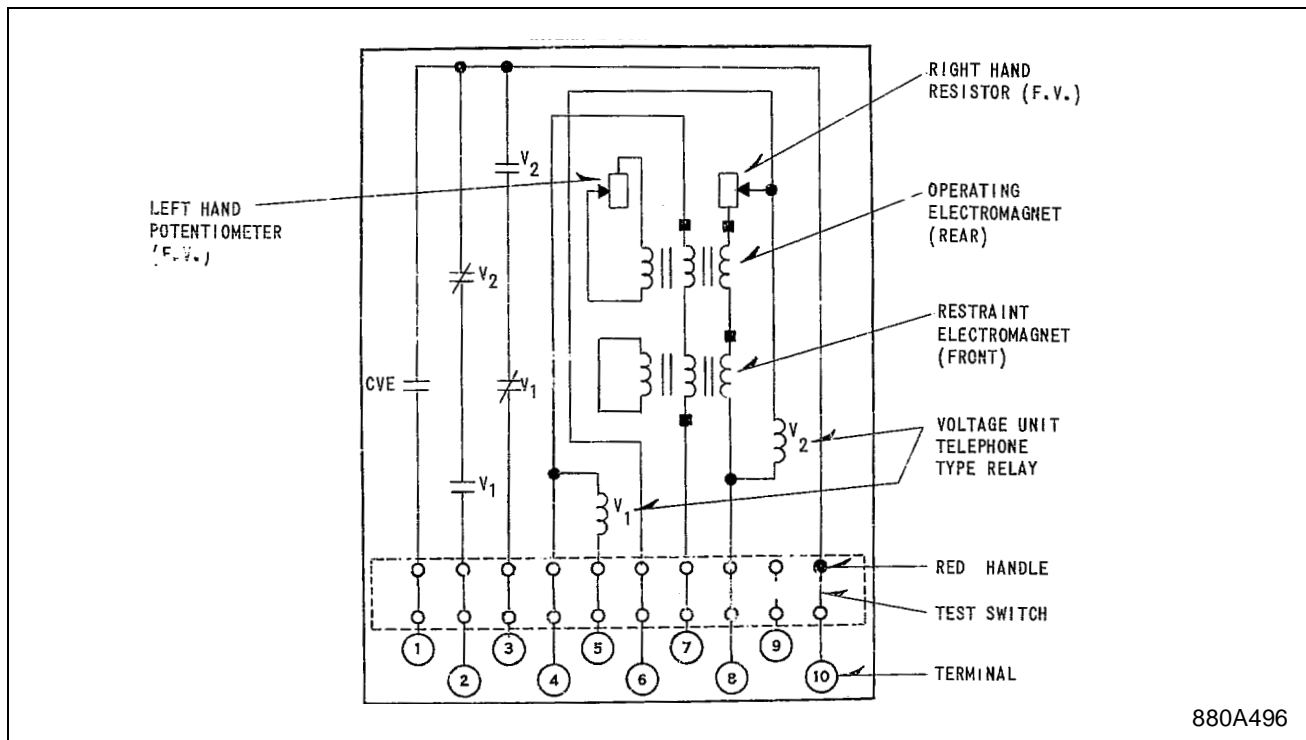
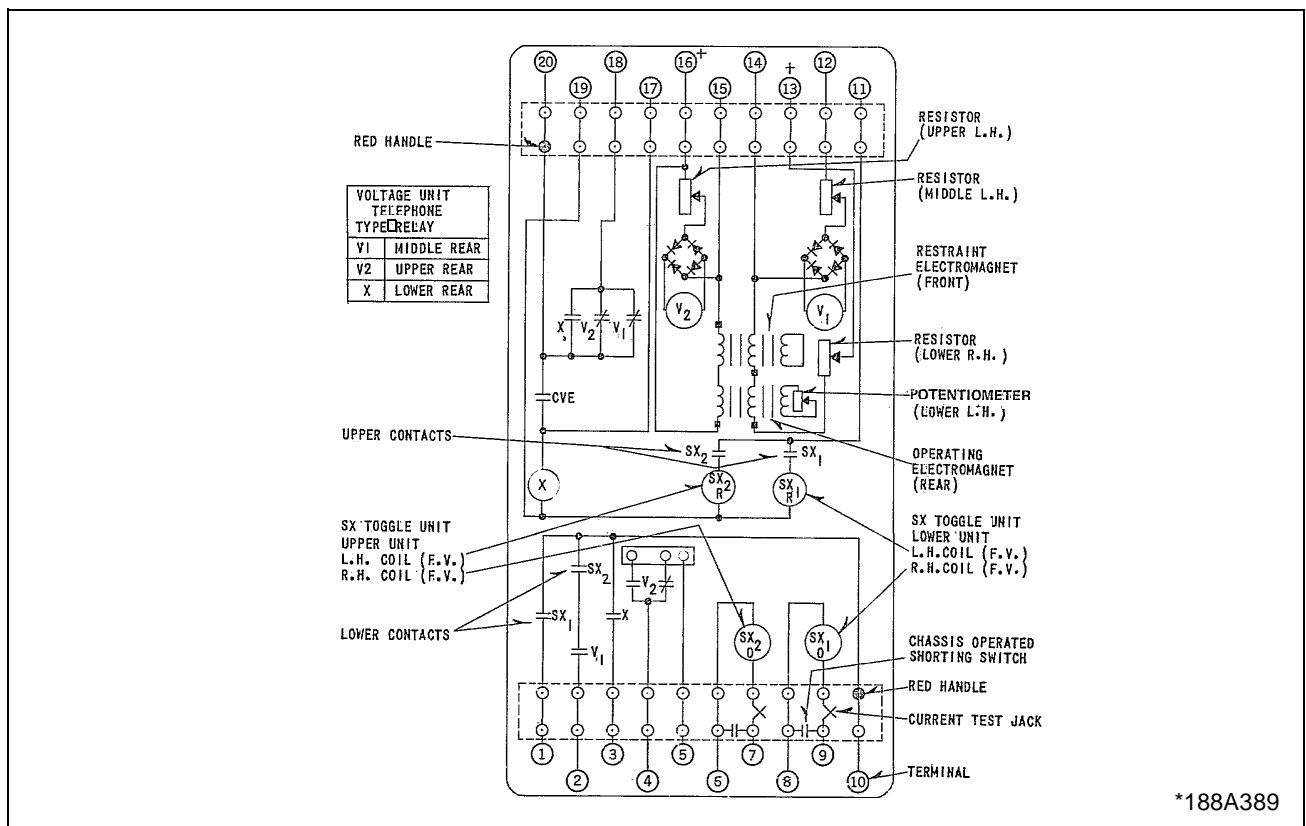
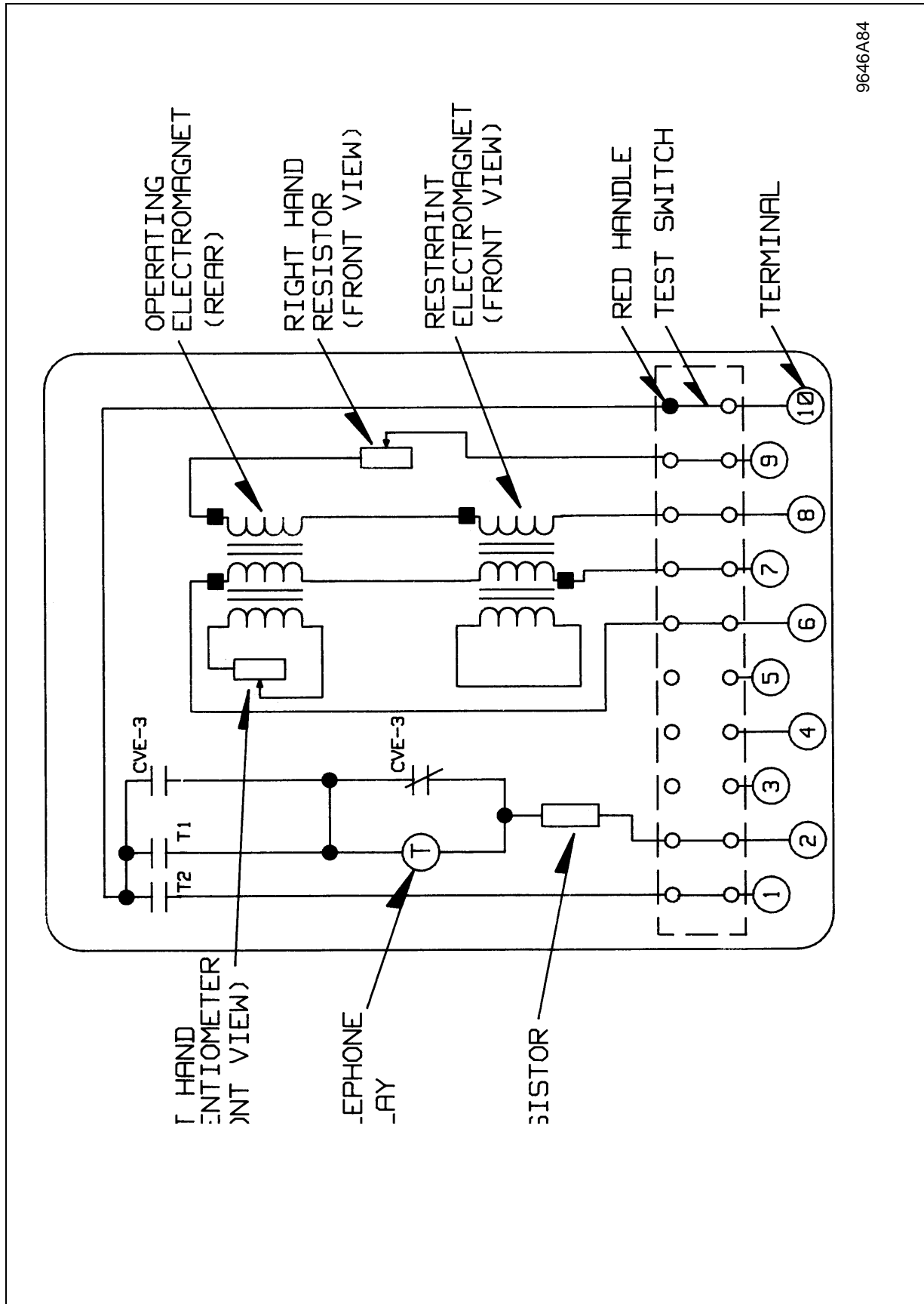


Figure 21 .Internal Schematic CVE-1 without Commoned Potential Coils (See Figure 5 for External Schematic).



\* Denotes Changed since previous issue

Figure 22 .Internal Schematic CVE-2



9646A84

Figure 23. Internal Schematic CBE-3.

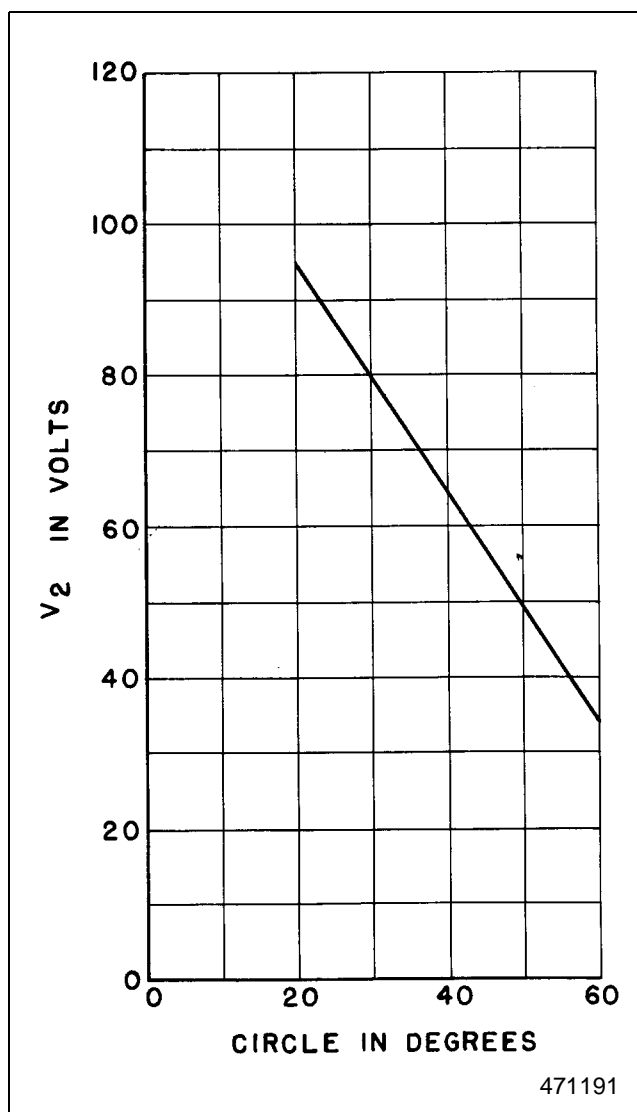


Figure 24.  $V_1$  Voltage for Different Operating Circle.  $V_2$  Equal to Rated Voltage at Zero Phase Angle.

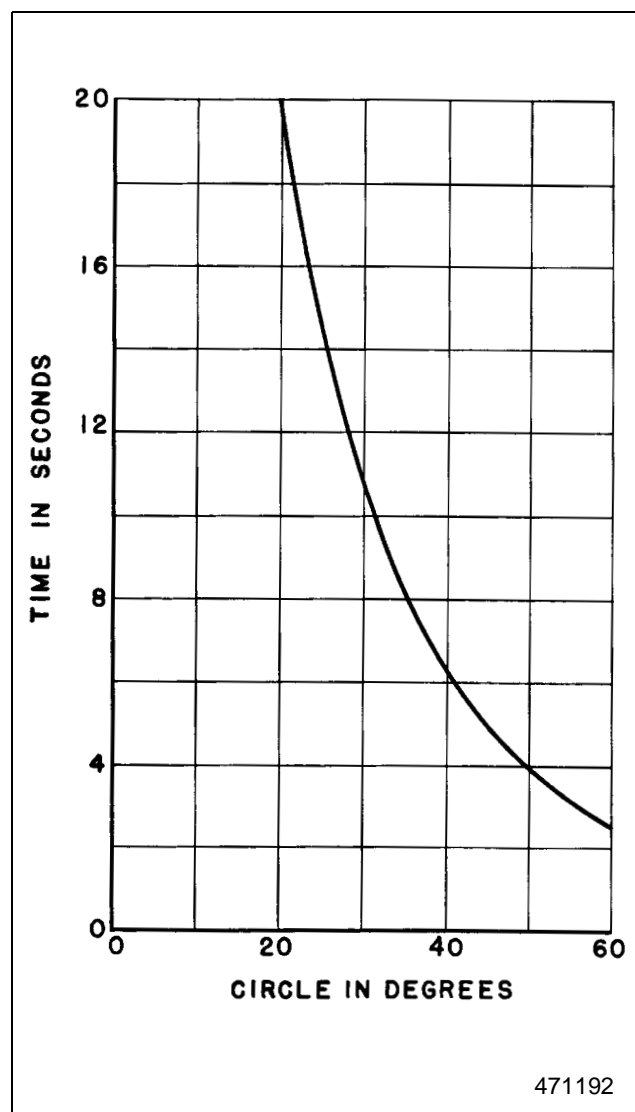
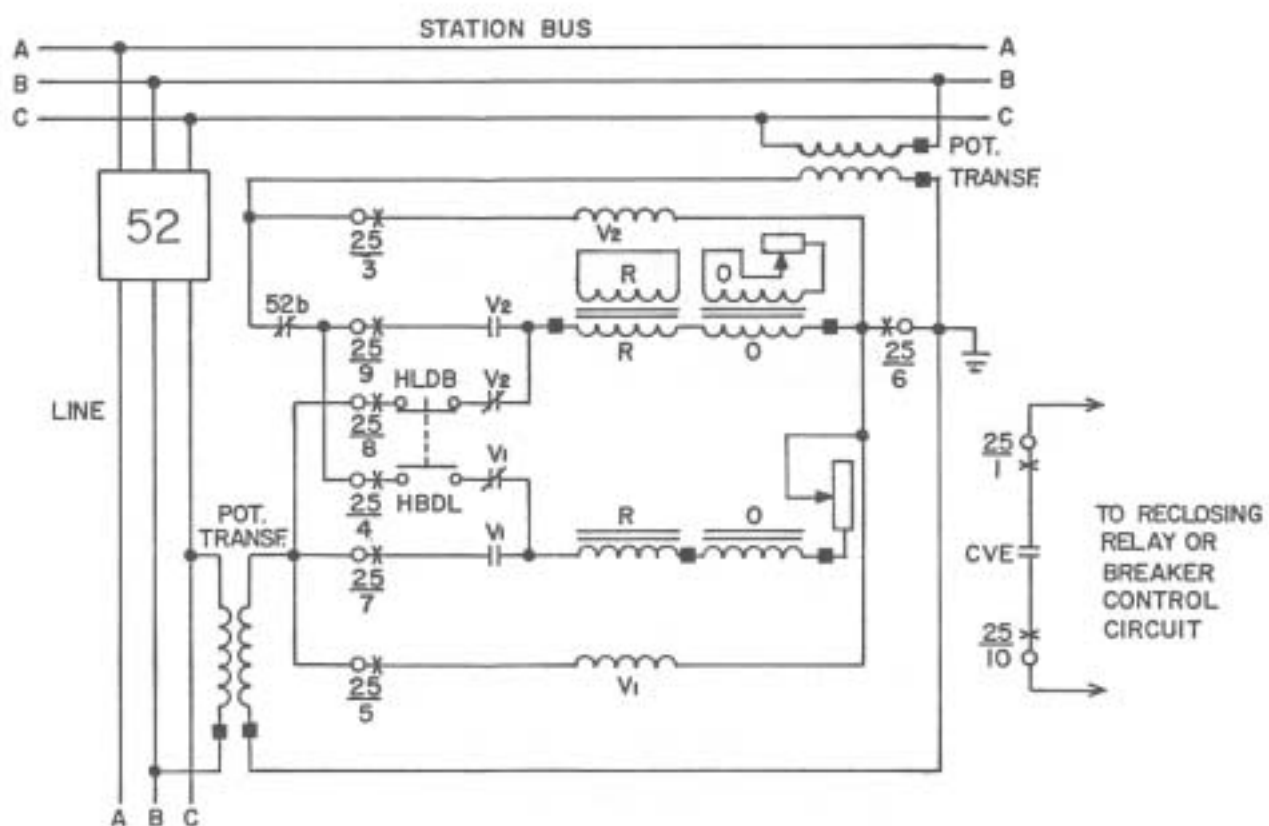


Figure 25. Operating Times from the No. 11 Time-Dial Position for the Type CVE Relay Set for Different Operating Circles.  $V_1$  and  $V_2$  Equal to Rated Voltage at Zero Phase Angle.



3511A01  
Sub 1

Figure 26. External Schematic CVE-1.

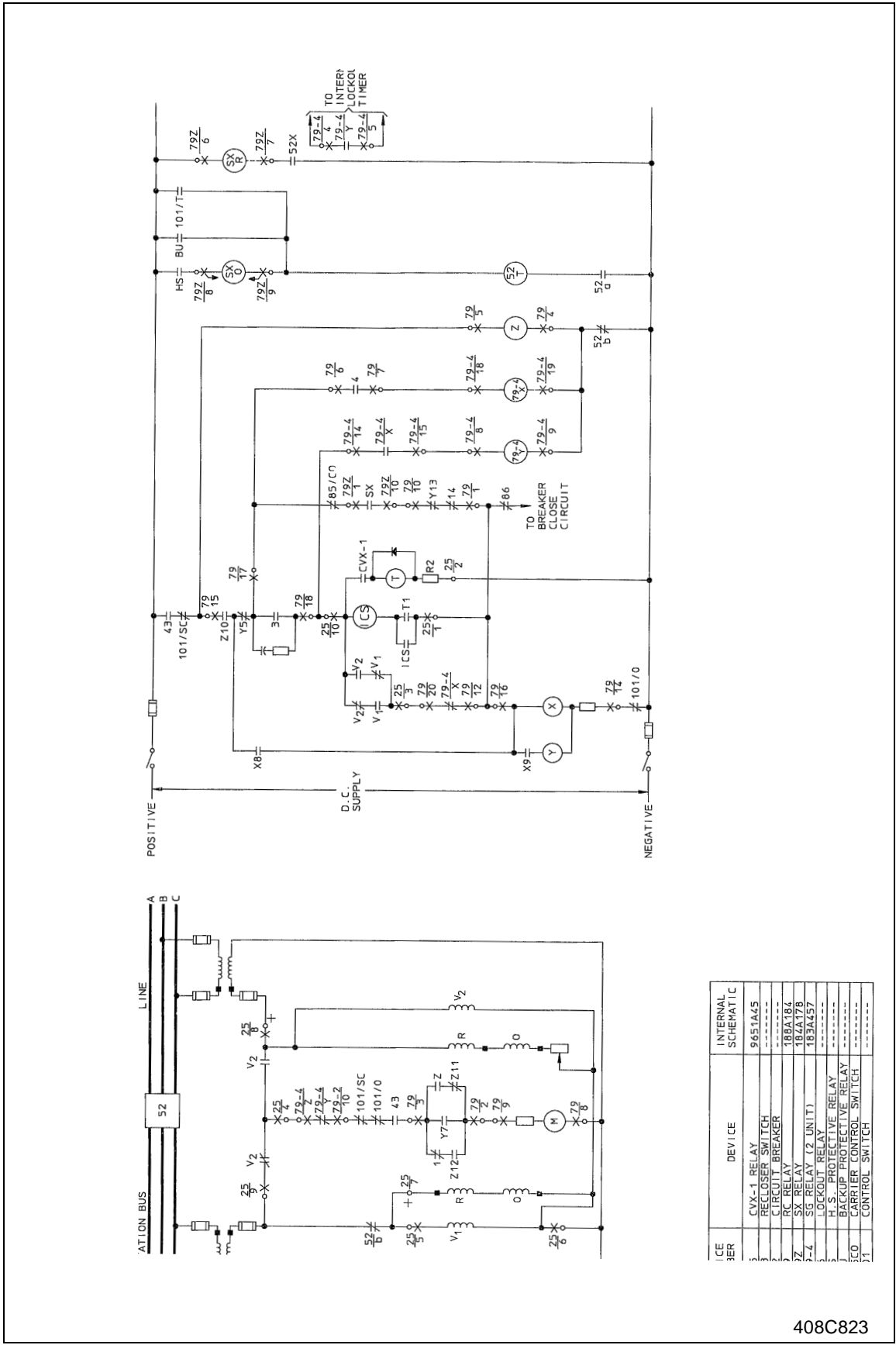
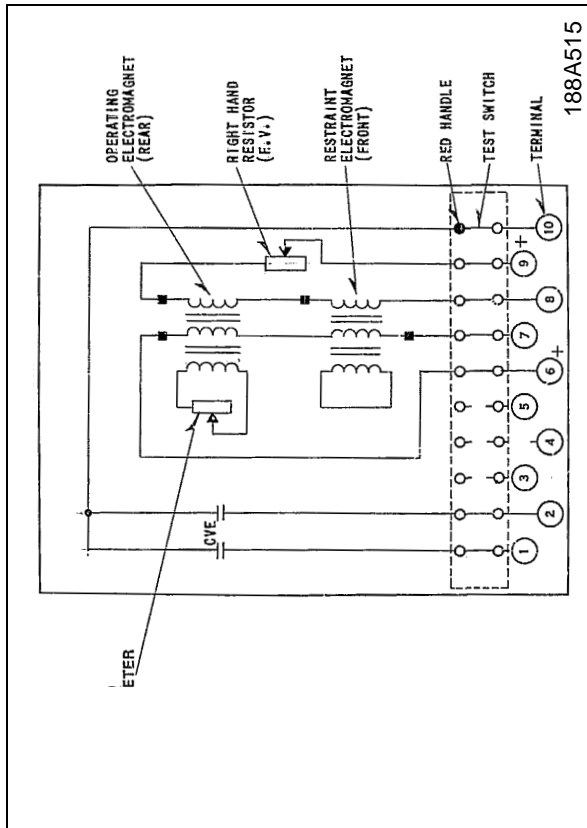


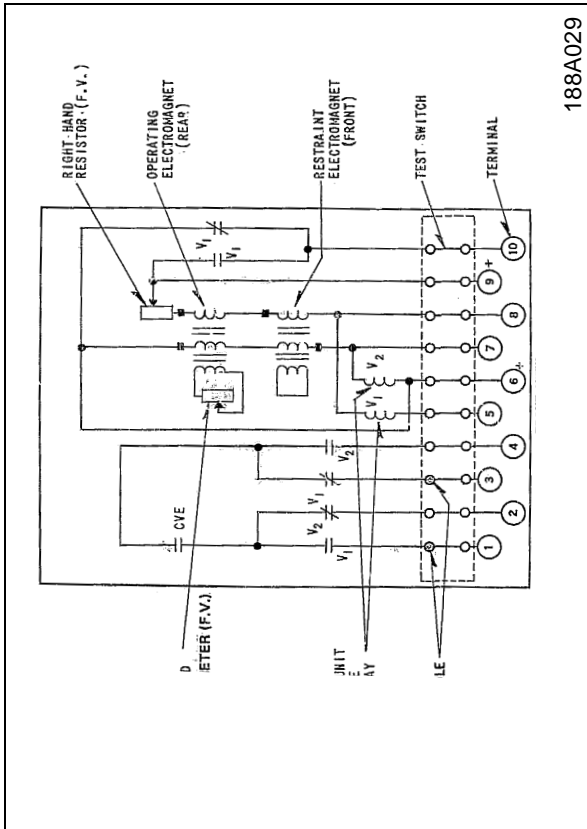
Figure 27. External Schematic CVE-1





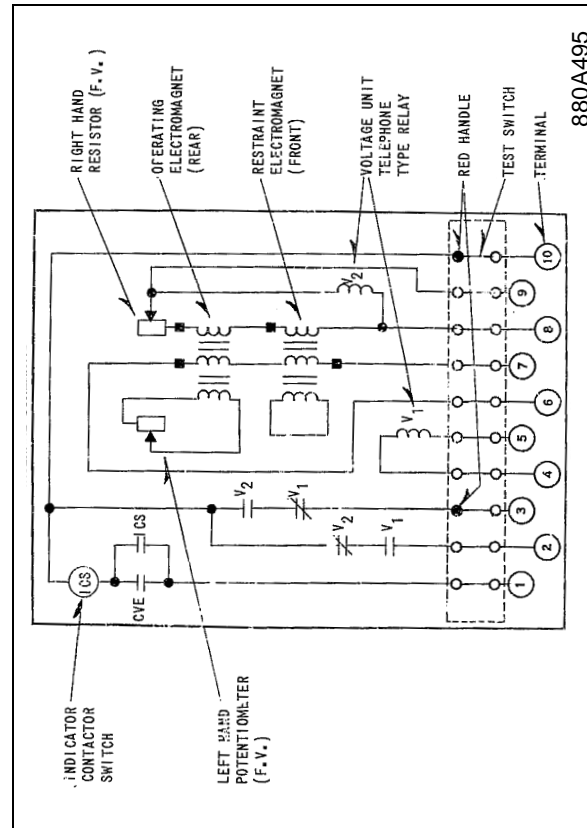
188A515

Figure 30. Internal Schematic of CVE-1 without Commoned Potential Coils, with ICS.



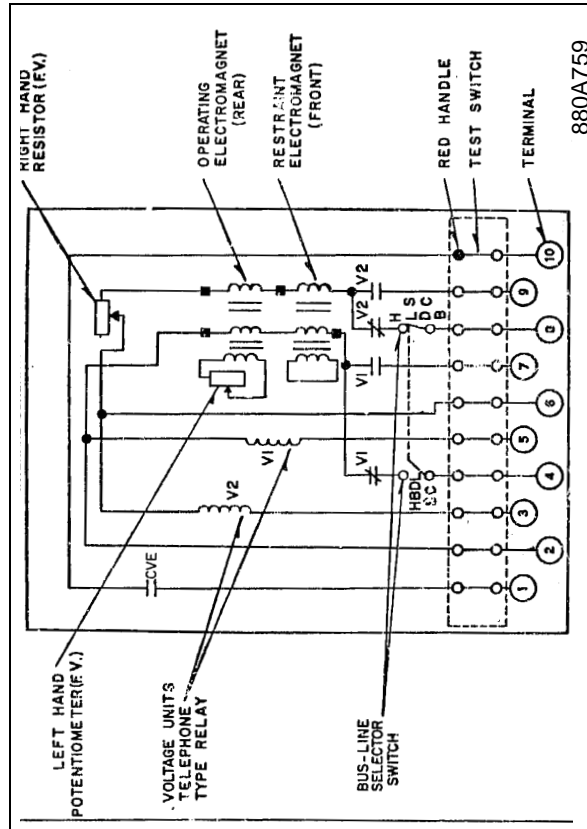
188A029

Figure 28. Internal Schematic of CVE Synchro-Verifier DPST Contacts.



880A495

Figure 31. Internal Schematic of CVE-1 with DPDT Switch, without Commoned Potential Coils.



880A759

Figure 29. Internal Schematic of CVE-1 with CVE Contacts Supervised by Voltage Contacts.

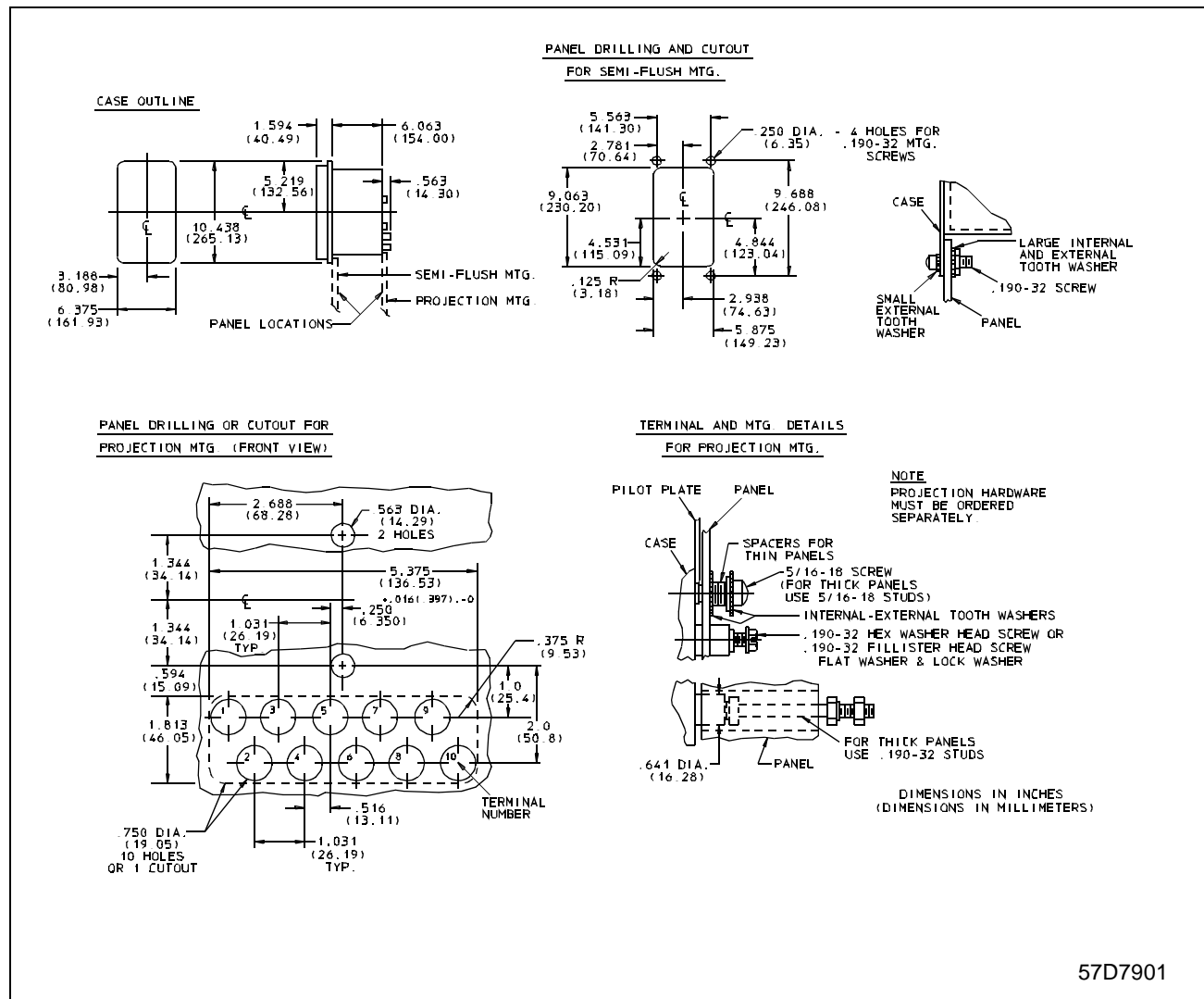


Figure 32. Outline &amp; Drilling Diagram for Relay Case Type FT-21.

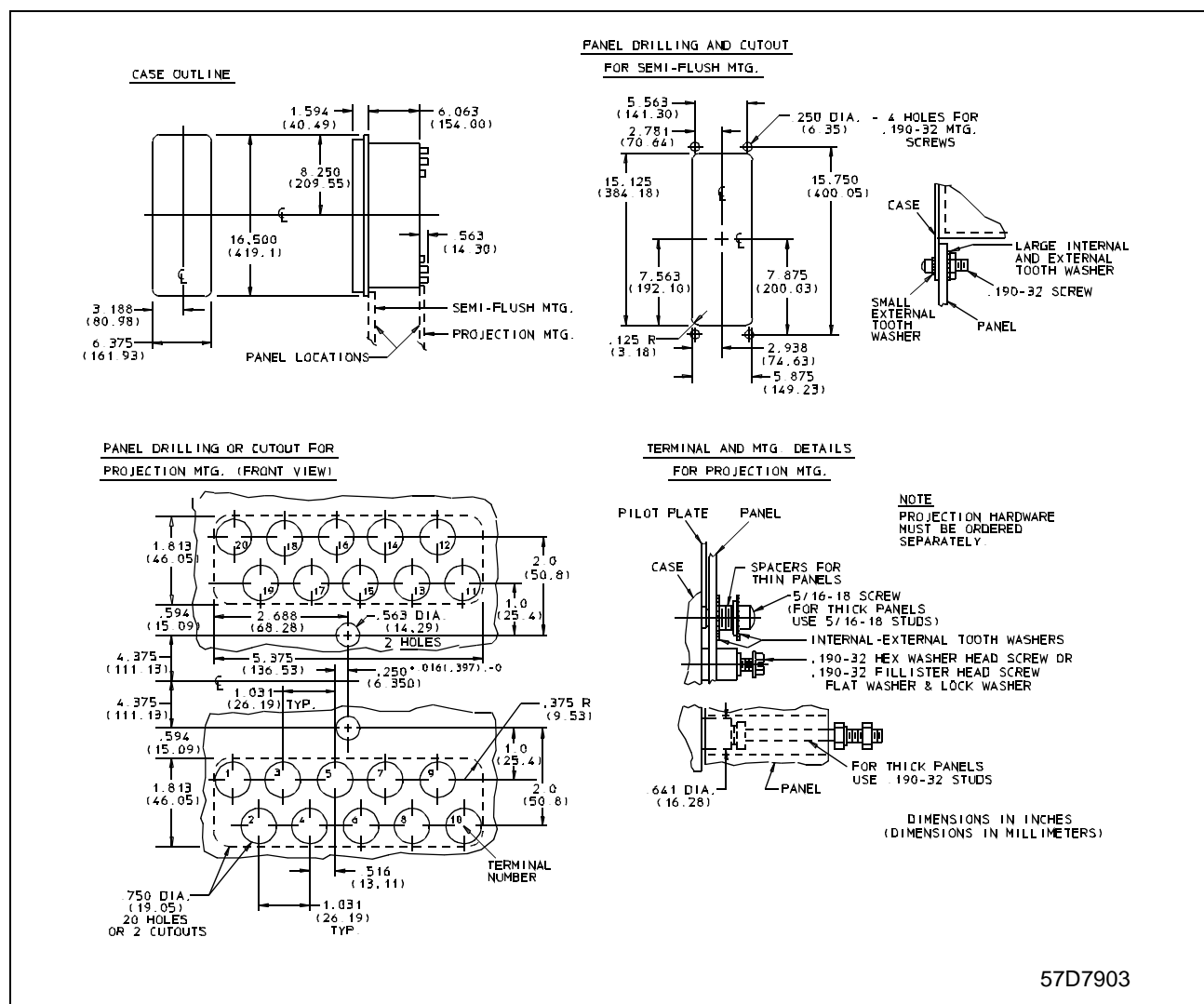


Figure 33. Outline &amp; Drilling diagram for Relay Case Type FT-32.



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ABB Automation Inc.  
4300 Coral Ridge Drive  
Coral Springs Florida 33065  
TEL: 954-752-6700  
FAX: 954-345-5329