ABB Power T&D Company Inc.
Power Automation and Protection Division
Coral Springs, FL 33065

Instruction Leaflet

41-681.11D

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(|) Denotes changes since previous issue

Type CVE and CVE-1 Synchro-Verifier Relays For Class 1E Applications

This instruction leaflet applies to the following types of Class 1E relays:

- **CVE Synchro-Verifier Relay**
- **CVE-1 Synchro-Verifier Relay with Line and BUS Voltage Sensing Relays**

CAUTION

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

1. APPLICATIONS

These relays have been specially designed and tested to establish their suitability for Class 1E applications in accordance with the ABB Power T&D Company program for class 1E qualification testing as detailed in bulletin STR-1.

“Class 1E” is the safety classification of the electric equipment and systems in nuclear power generating stations that are essential to emergency shutdown of the reactor, containment isolation, cooling of the reactor, and heat removal from the containment and reactor, or otherwise are essential in preventing significant release of radioactive material to the environment.

2. CONSTRUCTION

The type CVE relay consists of an operating element and a restraining element mounted on a common disc. The principal parts of the relay and their location are shown in Figures 1, 3 and 4.

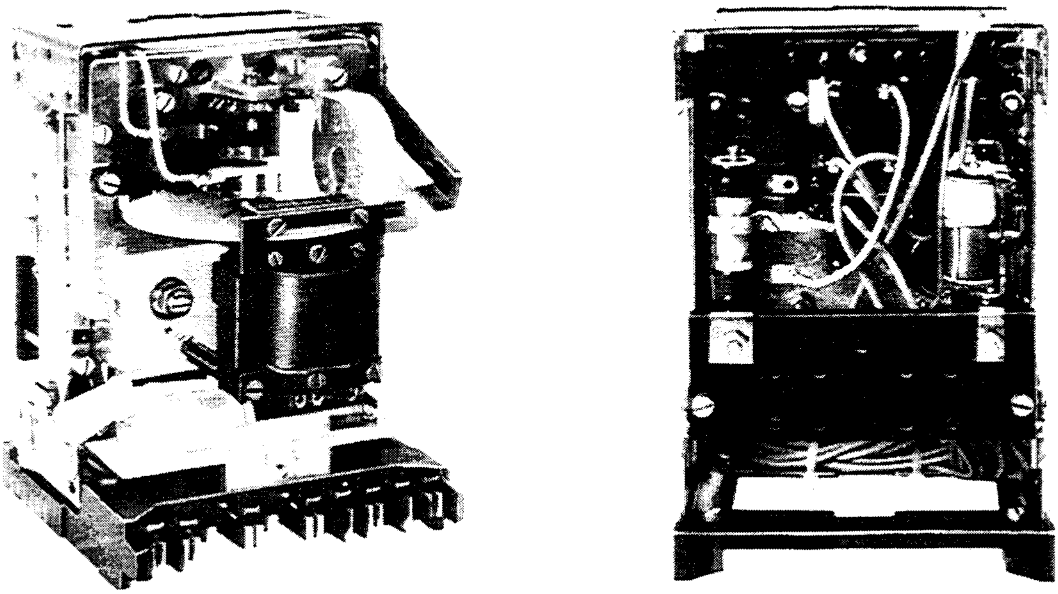
The CVE-1 relay, Figure 2, consists of two telephone type ac voltage sensing relays in addition to the components of the CVE relay. The principal parts of the relay are connected per Figures 5 and 6.

These relay utilize the CVE contact to pickup a telephone type trip relay, which has a dropout time circuit associated with it for a contact output. Also, they contain a special spring shield covering the spring, located above the disc, and the relay is wired with Exane II insulation wire.

2.1. Operating Element

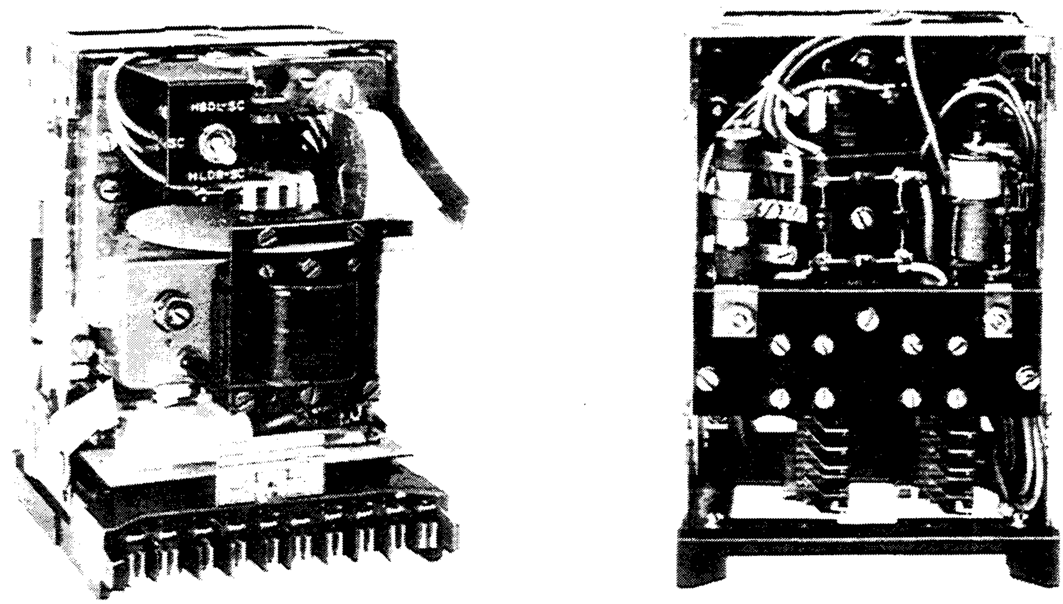
The operating unit consists of an “E” type laminated electromagnet with two main coils on the center leg and a lag coil on the left leg. A resistor is connected across the shading coil.

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



FRONT VIEW REAR VIEW

Figure 1. CVE Relay, Without Case



FRONT VIEW REAR VIEW

Figure 2. CVE-1 Relay, Without Case

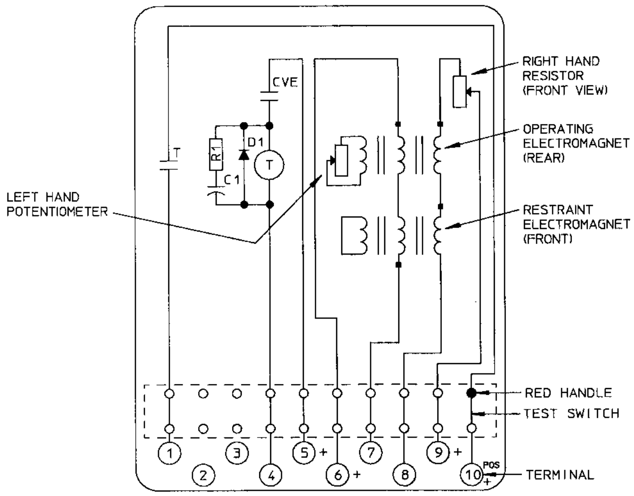


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Figure 3. Internal Schematic of CVE

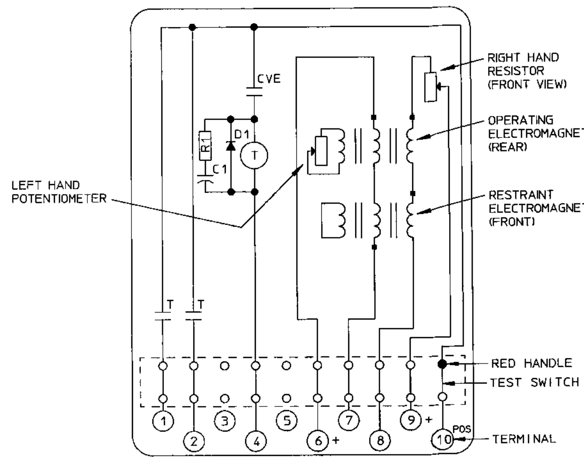

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Figure 4. Internal Schematic of CVE

coil on the left leg causes the flux in the leg to lag the main pole flux. The out-of-phase fluxes thus produced in the disc gap causes a contact closing torque.

The resistor connected across the lag coil of the electromagnet provides adjustment for different operating circles of the relay. Increasing or decreasing the amount of resistance effectively decreases or increases the contact closing torque of the relay.

2.2. Restraining Element

The restraining element consists 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 in the applied voltages to the relay. 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 causes a contact opening torque.

2.3. Telephone Relay-CVE-1 Only

The telephone relay units are fast operating types energized by the application of an ac voltage. In these relays, an electromagnet energized by ac voltage, attracts a right angle armature which operates a set of contacts.

2.4. Operation With External Voltage Relays

The connections shown in Figure 7 using external type SG voltage relays will provide the following operation:

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

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

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

It is recommended that the number of reclosures be limited by using either a single- or a multi-shot reclosing relay in conjunction with the CVE and SG relays.

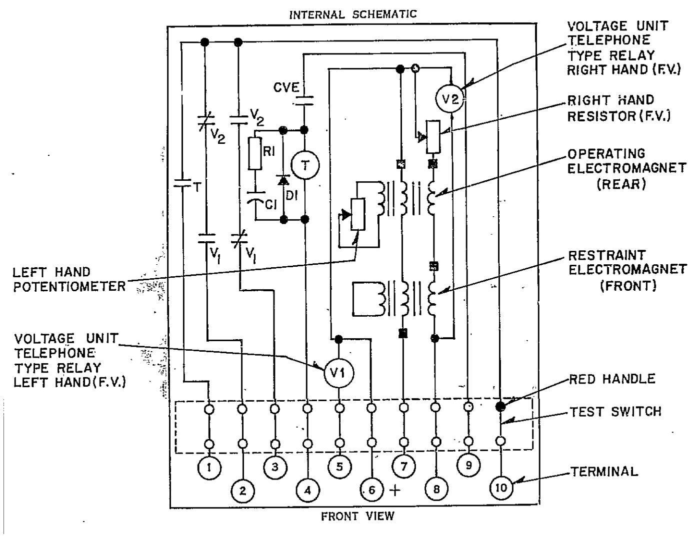

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Figure 5. Internal Schematic of CVE-1

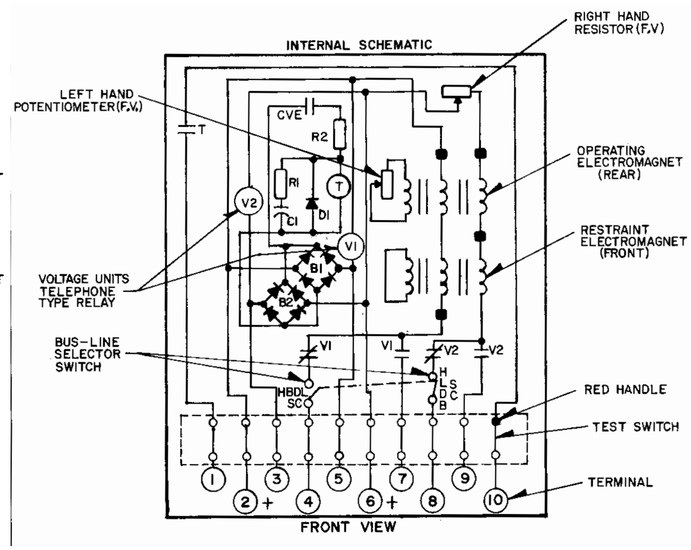

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Figure 6. Internal Schematic of CVE-1 with Internal Switch for HBDL or HLDB

2.5. CVE-1 Operation

In the CVE-1, the internal V_1 and V_2 perform the functions of external 59B and 27L relays respectively.

The connections shown in Figure 8 using the type CVE-1 relay will provide the following operation:

1. Close the breaker when the BUS is live and the line is dead, through the V_1 make contact and V_2 break contact.

2. Close the breaker when the line is alive and the BUS is dead, through the V_2 make contact and V_1 break contact.

3. Close the breaker when the line and BUS are both alive and when their respective voltage are approximately normal, equal, in phase, and of the same frequency, through the CVE contact.

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

3. CHARACTERISTICS

The type CVE and CVE-1 relays can be adjusted for operating circles from 20 to 60 degrees as shown in Figure 9. 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 relay is shown in Figure 10. These time curves are obtained from the #11 time dial setting when the applied voltages are equal to rated voltage and of the same frequency. Shorter operating times can be obtained at different time dial settings as shown in Figure 11.

The synchronism check feature of the class 1E CVE and CVE-1 relays should be used only:

1. Where the CVE contacts will be the last to close to energize the breaker close coil or

2. Where the CVE limits the permissible “close angle”, with no possible frequency difference across the breaker being controlled.

Because of the time delayed release of the “T” unit, immediate closure of the supervised breaker must take place following closure of the “T” contact to assure that synchronism exists.

Figure 12 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 18 shows typical CVE reset times for 20˚, 40˚, and 60˚ circle settings.

3.1. Burden

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

Volt-amperes - - - - - - - - - - - - - - - - -15.4
Power Factor - - - - - - - - - - - - - - - - - - - .422
Watts- 6.5
Power dc - - - - - - - - - - - - - - - - - - - 3.1

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

Voltage-amperes - - - - - - - - - - - - - - -10.8
Power Factor - - - - - - - - - - - - - - - - - - - .422
Watts- 4.6

For the CVE-1 relay, additional burden of each telephone relay at 120 volts is as follows: 10.62 volt-amperes, Power Factor 0.64.

3.2. Continuous Rating

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

4. SETTINGS

4.1. Disc Unit

As shipped from the factory the relays are calibrated for a 20 degree circle. Other operating circles from 20 to 60 degrees can be obtained by adjusting the left-hand resistor (front view) in the relay. 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 #11 time dial is recommended when the 60˚ circle setting is used. A setting of #4 time dial or higher recommended with the 40˚ circle. A setting of 1 on the time dial should be satisfactory with the 20˚ circle. Note from Figure 11 that the relay will operate in 2.8 seconds in the 1 time dial position and with the 20˚ 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 worst-case phase-angle difference between the two systems at the instant of breaker closure, refer to Figure 10. For example, assume a 40˚ circle and #4 time-dial setting. Also assume that the systems are slipping at a frequency of 0.048 hertz which is the maximum slip for which the relay will operate. This means that the relay contacts close just as the one voltage vector moves out of the circle. This would mean that the system would be 40˚ out-of-phase at the instant that the breaker close circuit is energized. The phase angle at the instant of breaker closure is:

$$0 = 40^\circ + 0.048 \times 360T_B = 40^\circ + 17.3\ T_B$$

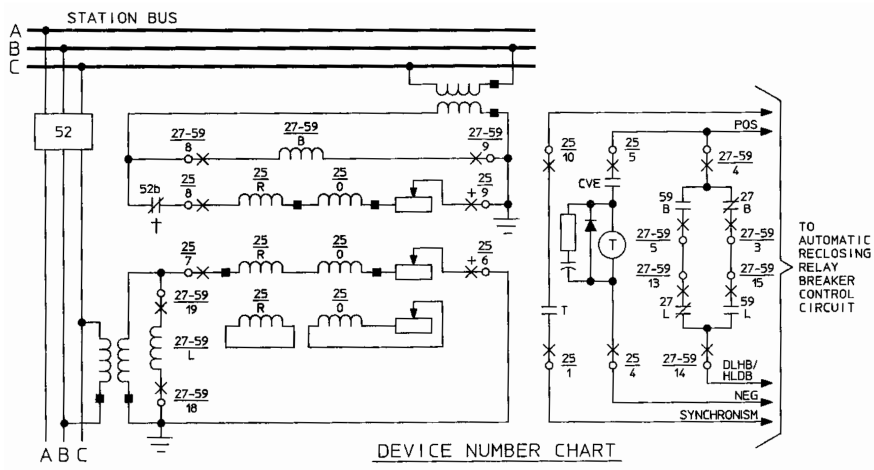
where T_B = breaker closing time in seconds

Let T_B = 0.5 seconds

Then $40^\circ + 17.3 \times 0.5 = 48.6^\circ$

5. 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 relay 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 Outline and Drilling Plan (Figure 18). For detailed FT Case information refer to I.L. 41-076.



DEVICE NUMBER CHART

25 - SYNCHRO-VERIFIER RELAY TYPE CVE, I.S.3525A98

25/0 - OPRATING ELECTROMAGNET } OF TYPE CVE

25/0 - RESTRAINT ELECTROMAGNET

27-59/B - UNDER AND OVERVOLTAGE BUS RELAY, TYPE SG

27-59/L - UNDER AND OVERVOLTAGE LINE RELAY, TYPE SG

52 - POWER CIRCUIT BREAKER

b - BREAKER AUXILIARY CONTACT

† = 52b REQUIRED IF HIGH SPEED AUTOMATIC RECLOSING IS USED

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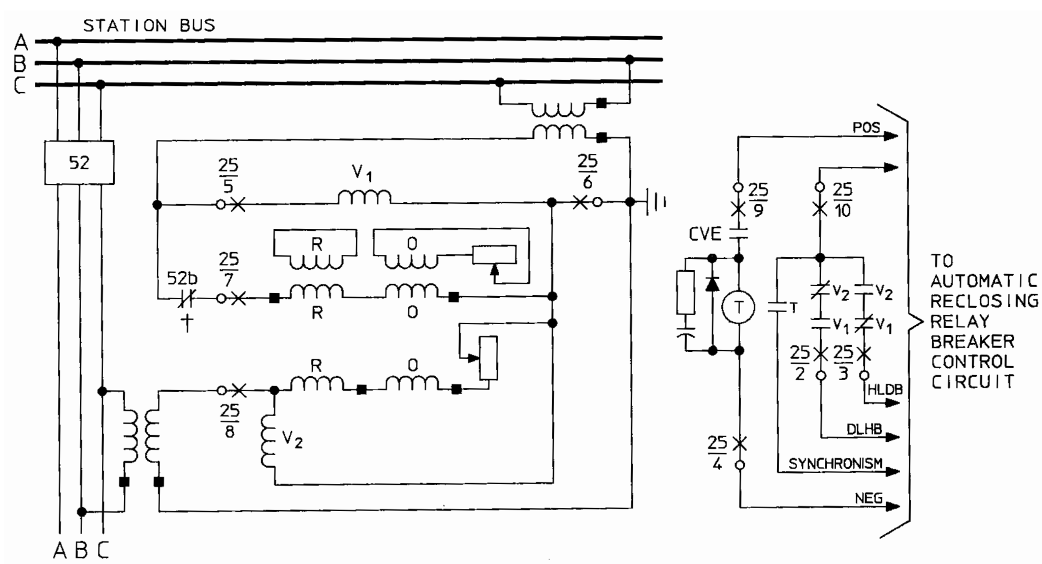
Figure 7. External Schematic of the CVE with SG Relay for Dead-Line-Hot Bus and Hot Line-Dead Bus Reclosing



DEVICE NUMBER CHART

25 - SYNCHRO-VERIFIER RELAY TYPE CVE-1, I.S. 3518A21

0 - OPERATING ELECTROMAGNET } OF TYPE CVE-1

R - RESTRAINT ELECTROMAGNET

V_1 - VOLTAGE BUS UNIT

V_2 - VOLTAGE LINE UNIT

52 - POWER CIRCUIT BREAKER

b - BREAKER AUXILIARY CONTACT

† = 52b REQUIRED IF HIGH SPEED AUTOMATIC RECLOSING IS USED.

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Figure 8. External Schematic of CVE-1 for Dead-Line-Hot-Bus and Hot-Line-Dead-Bus Reclosing

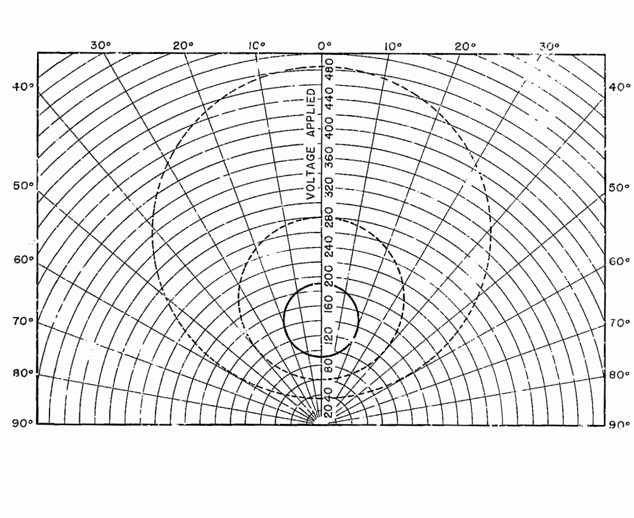

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Figure 9. Typical Voltage-Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.

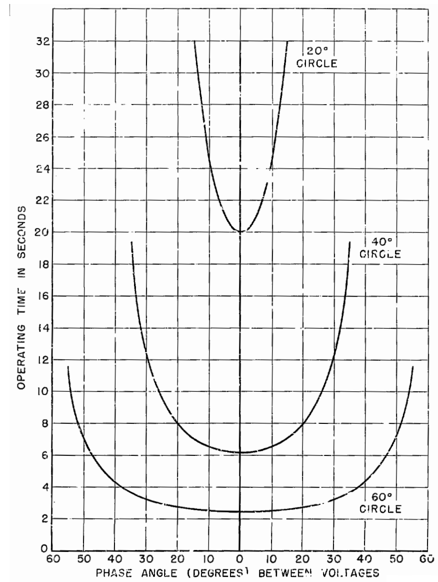

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Figure 10. Typical Time-Phase Angle Curves of CVE. Rated Voltage on Both Circuits No. #11 Dial Time Setting.

6. 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.

6.1. Disc Unit

1. Contacts

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". The placement of the various time dial positions in line with the index mark will give operating times as shown on the time curve.

2. Operating Circle

Connect the CVE or CVE-1 relay per the test diagram of Figure 13. The contacts should just close under the following conditions:

1) When $V_2 = V_1$ rated voltage and their phase difference is between 18° and 22° (either leading or lagging).

2) When V_1 = rated voltage and V_2 is increased from a low value to 94 ±4V in phase with V_1.

3. Time Curve

With the time dial set at position 11, the contact should be close in 20 ±1 seconds when V_1 and V_2, equal to rated voltage at zero phase angle, are applied.

6.2. Telephone Relays (CVE-1 Only)

Apply ac voltage to each telephone relay circuit. The telephone relay should pickup when 95 volts ac is applied.

6.3. Routine Maintenance

For Class 1E applications it is necessary to perform routine maintenance and a calibration check once a year. These checks should catch any component failures which occur on a random basis.

Potentiometer, wire wound adjustable resistor, and plastic case semi-conductor diode (D1) are treated as components that possibly could have a common mode failure characteristic and routine replacement on the following schedule is suggested.

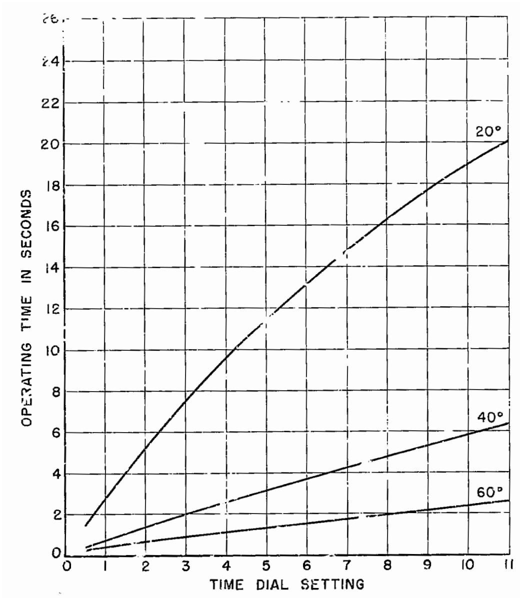

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Figure 11. Operating Time Variations with Changes in Time-Dial Settings. Rated in-Phase Voltage on Both Circuits, 20°, 40° and 60° Circle Setting.

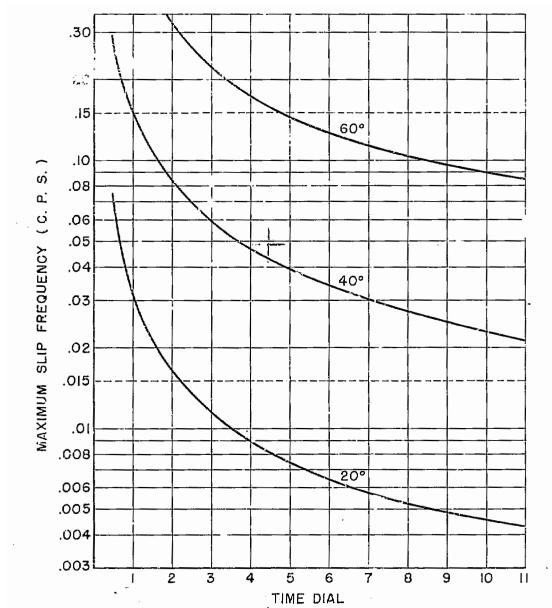

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Figure 12. Approximate Maximum Slip Frequency for which Operation Occurs – Rated Voltage on Both Sides.

Diode (D1) - - - - - - - - - - - - - - - - - 10 years
Potentiometer
(Left-Hand Potentiometer - - - - - - - - - - 10 years
Wire Wound Adjustable Resistor
(Right-Hand Resistor)- - - - - - - - - - - - 10 years

Recalibration is necessary whenever any of these components are changed.

All contacts should be periodically cleaned. A contact burnisher Style #182A836H01 is recommended for this purpose. The use of abrasive material 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.

6.4. Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs, or the adjustments have been disturbed. The special spring shield that covers the spring on this relay may be removed for making spring adjustments and then reassembled.

To remove the spring shield, requires that the damping magnet be removed first. The screw connection holding the lead to the moving contact should be removed next. The second screw holding the moving contact assembly should then be loosen ***but not removed.***

! CAUTION

This screw terminates into a nut held captive beneath the molded block. If screw is removed, difficulty will be experienced in the re-assembly of the moving contact assembly. Slide the spring shield outward and remove from relay. Tighten the screw holding the moving contact assembly to the molded block.

1. Contact

The index mark on the movement frame coincides 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”. 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.

2. Preliminary Adjustments

With the permanent magnet from the relay, 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. This 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 reason 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.

3. Spurious Torque Adjustments

With the relay set as per the preliminary adjustments, open the lag coil circuit of the rear electromagnet. This can be done by opening the screw connection on the lag coil of the rear electromagnet or by inserting a piece of insulating material under the adjustable point of the left-hand resistor (front view). Connect the relay to test circuit of Figure 13 for both CVE and CVE-1, and apply rated voltage at zone phase angle on both circuits. With the right-hand plug 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.

4. 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. Note the angle at which the contacts just close. Then adjust the phase shifter in the leading just close. Then adjust the phase shifter in the leading direction until the contacts just close with V_1 and V_2 equal to rated voltage. If the latter angle is not within ±1 degree of the former angle, adjust the right-hand resistor (front view) until the two angles are within ±1 degree of each other.

5. Spring Adjustment

Adjust the left 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˚ and 41˚, with rated voltage on both sides. Change the angle to 20˚ and adjust the reset spring until the contacts just make. Rotate the phase shifter to move V2 through zero phase angle to an angle where the contacts just make. The contacts should just close at an angle of 20 ±2 degrees with 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 ±4V in phase with V_1. If necessary, readjust spring slightly to obtain this condition. The relay is now calibrated for 20 degree circle.

6. Time Curve

Install the spring shield and permanent magnet keeper until the operating time of the relay from the number 11 time dial position is 20 ±0.6 seconds with V_1 and V_2 equal to rated voltage at zero phase angle.

7. Circles Other Than 20 Degrees

This adjustment should not be done until the above adjustments for a 20 degree circle have been completed.

If another circle other than 20 degrees is desired, adjust the left-hand resistor 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 degrees phase angle. It may be necessary to readjust the right-hand resistor to position the desired circle symmetrically about the zero degree line. See “**Centering Circle**” above for procedure. The time of operation will be as shown in the time curves of Figure 10.

7. ELECTRICAL CHECKPOINTS

With V_1 in Figure 13 equal to rated voltage the following approximate voltages should be obtained across the coils of the 120 volt relay. Relay set for 20 degree circle.

Operating Electromagnet
- Upper terminals - - - - - - - - - - - - 59 volts
- Lower terminals - - - - - - - - - - - - 57 volts
- Lag coil circuit - - - - - - - - - - - - - 22 volts

Restraint Electromagnet
- Upper terminals - - - - - - - - - - - - 58 volts
- Lower terminals - - - - - - - - - - - - 54 volts

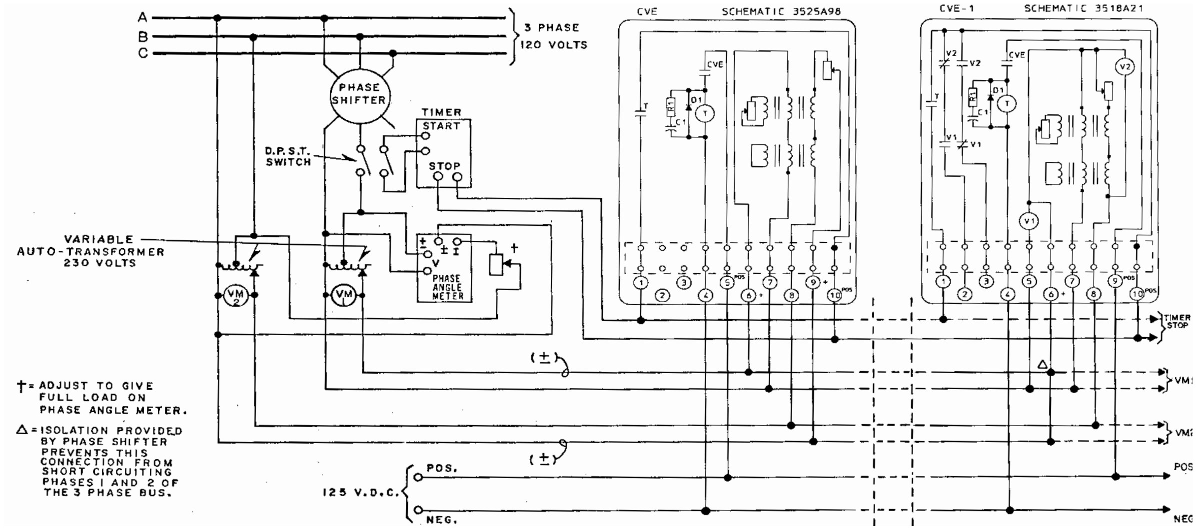

Figure 13. Diagram of CVE Test Connections

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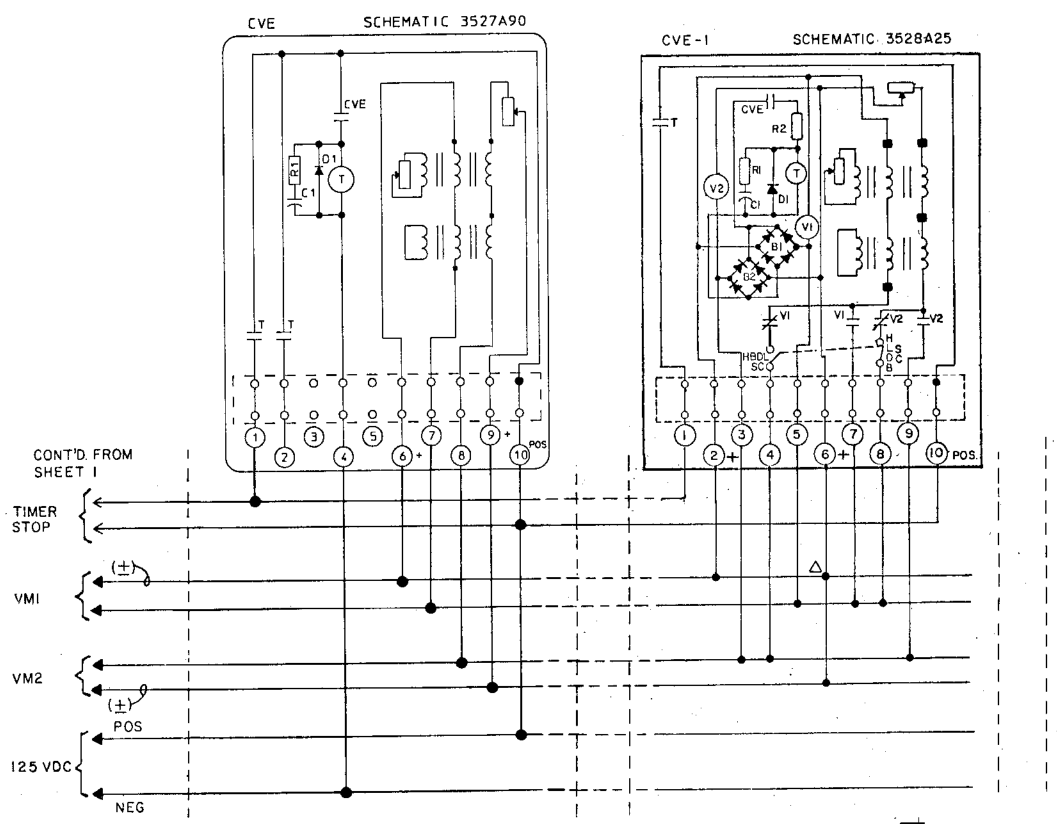

Figure 14. Diagram of CVE Test Connections

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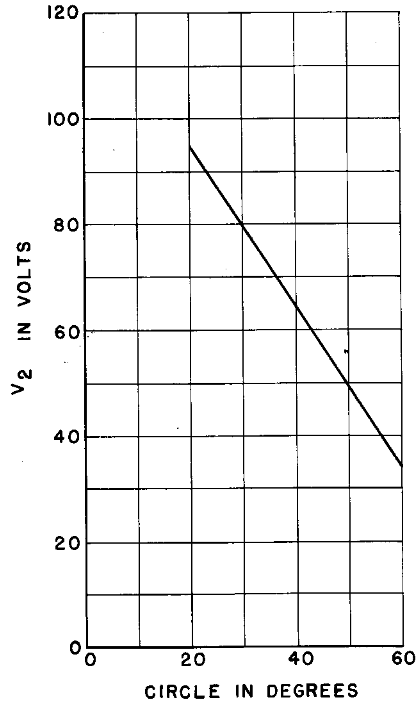

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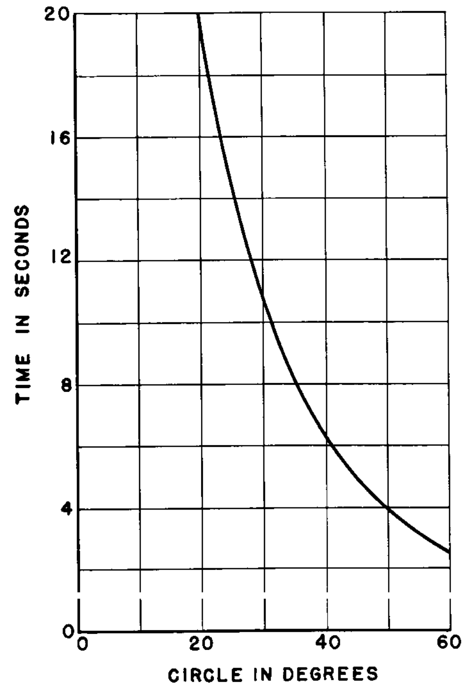
Curve

Figure 15. V_1 Voltage for Different Operating Circle. V_2 equal to rated voltage at zero phase angle



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Curve

Figure 16. 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

With 120 volts applied to V_2 circuit only:

Operating Electromagnet
- Upper terminals - - - - - - - - - - - - - 57 volts
- Lower terminals - - - - - - - - - - - - - 59 volts
- Lag coil circuit - - - - - - - - - - - - - - 22 volts

Restraint Electromagnet
- Upper terminals - - - - - - - - - - - - - 54 volts
- Lower terminals - - - - - - - - - - - - - 58 volts

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

Approximate resistance values of left-hand resistor for various operating circles. Resistance values can vary appreciably between relays.

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

8. RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

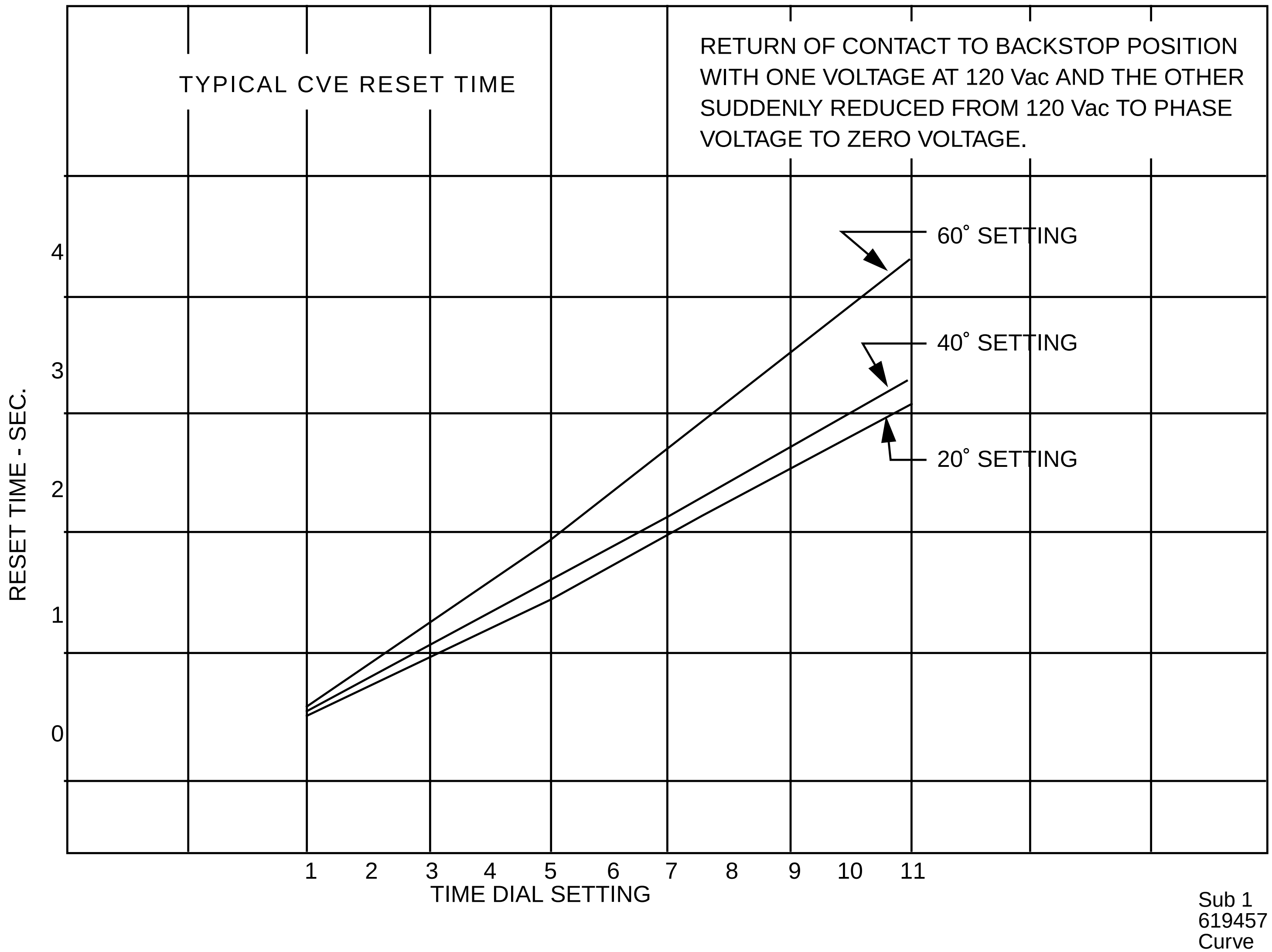

Figure 17. Typical CVE Reset Times. Return of Contact to Backstop Position with One Voltage at Rated Voltage and the Other Suddenly Reduced from Rated in Phase Voltage to Zero Voltage

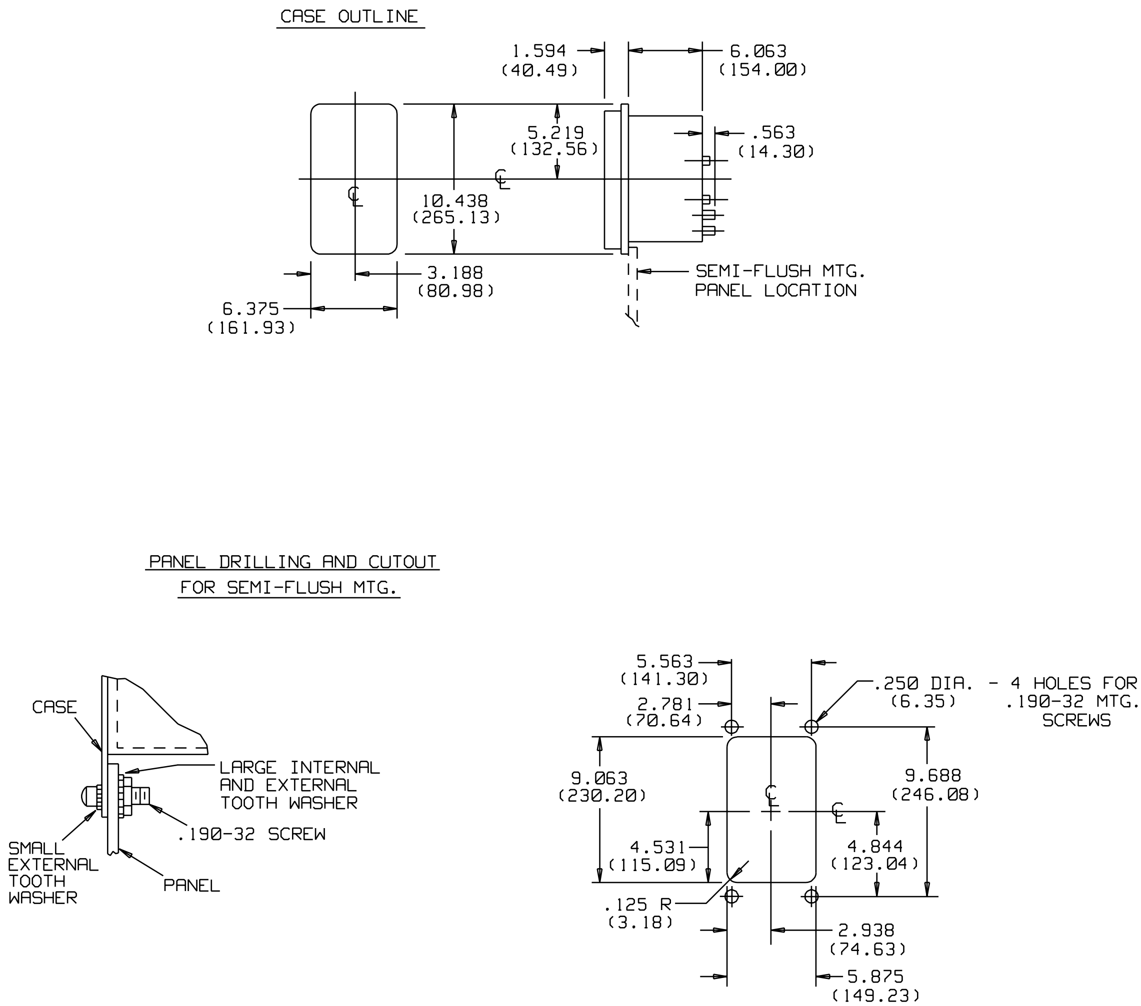

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Figure 18. Outline and Drilling Plan for the CVE and CVE-1 in FT21 Case