



INSTALLATION • OPERATION • MAINTENANCE INSTRUCTIONS

TYPE CVE SYNCHRO-VERIFIER RELAY

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.

APPLICATION

The type CVE synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The contacts will close when these voltage are equal, within set limits, in phase, and of the same frequency.

The type CVE synchro-verifier is not an automatic synchronizer and should not be used as such. Automatic Synchronizers are available which permit closing ahead of synchronism at an angle of phase-advance proportional to the beat frequencies and determined by the speed of operation of the circuit breaker so that the two systems are connected right on synchronism.

A common application of the synchro-verifier is in conjunction with automatic reclosing equipment on 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 the automatic reclosing equipment to reclose the breaker.

CONSTRUCTION AND OPERATION

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 Figs. 1, 2, 3, and 4.

Operating Element

The operating unit consists of an "E" type lamination 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 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 causes a contact closing torque.

The resistor connected across the shading 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.

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.

Indicating Contactor Switch Unit (ICS) - When Used

The d-c 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.

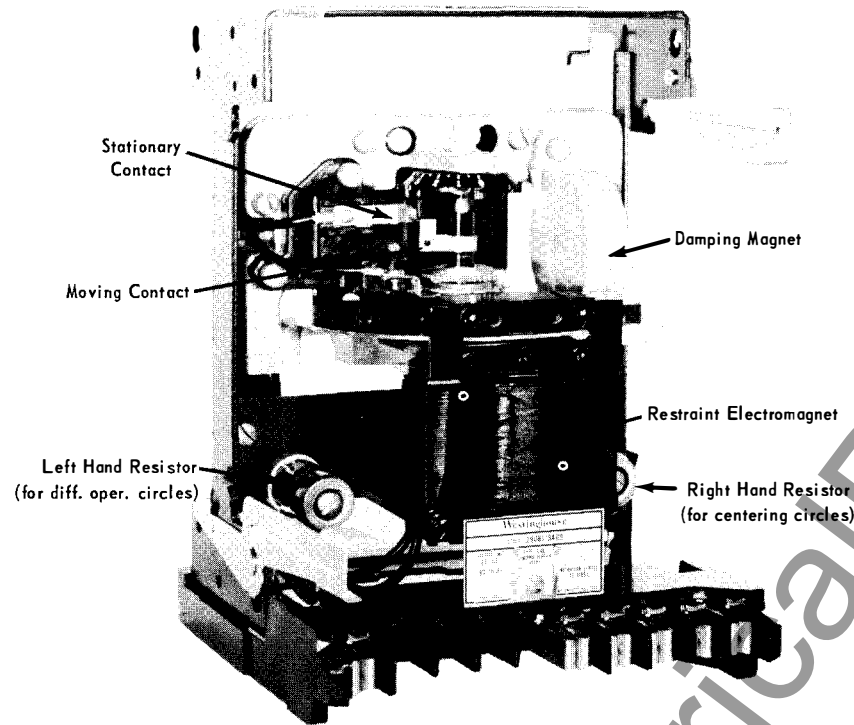


Fig. 1. Type CVE Relay, without Case (Front View)

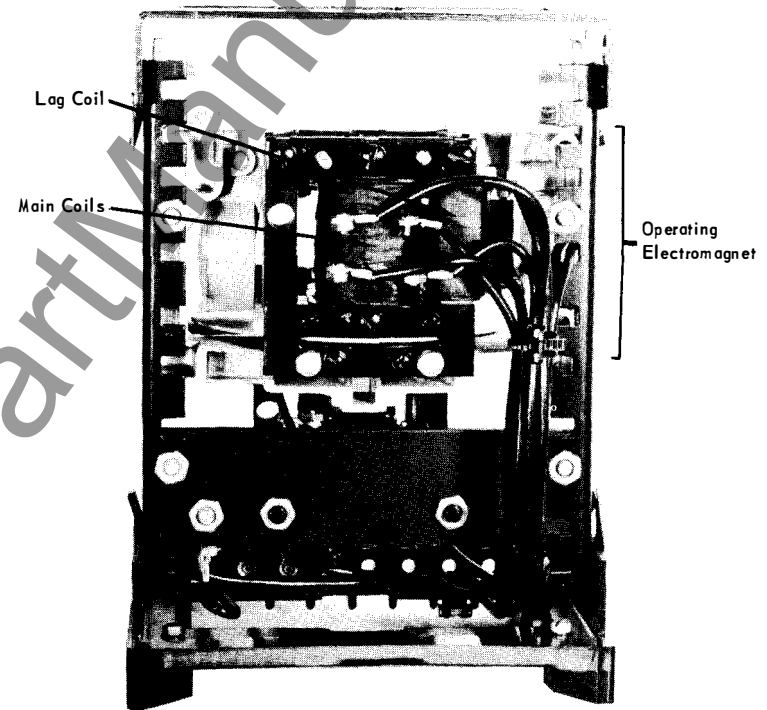


Fig. 2. Type CVE Relay, without Case (Rear View)

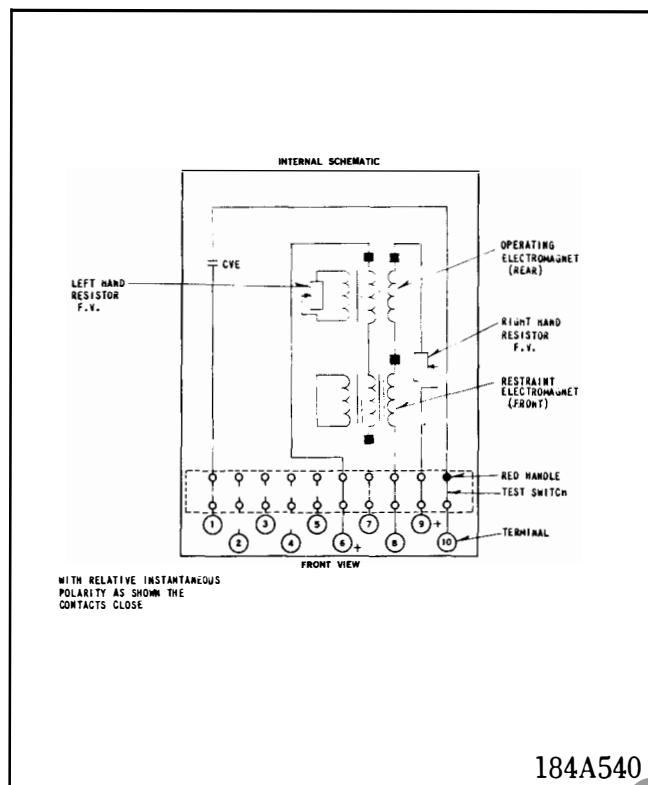


Fig. 3. Internal Schematic of CVE, without ICS Unit.

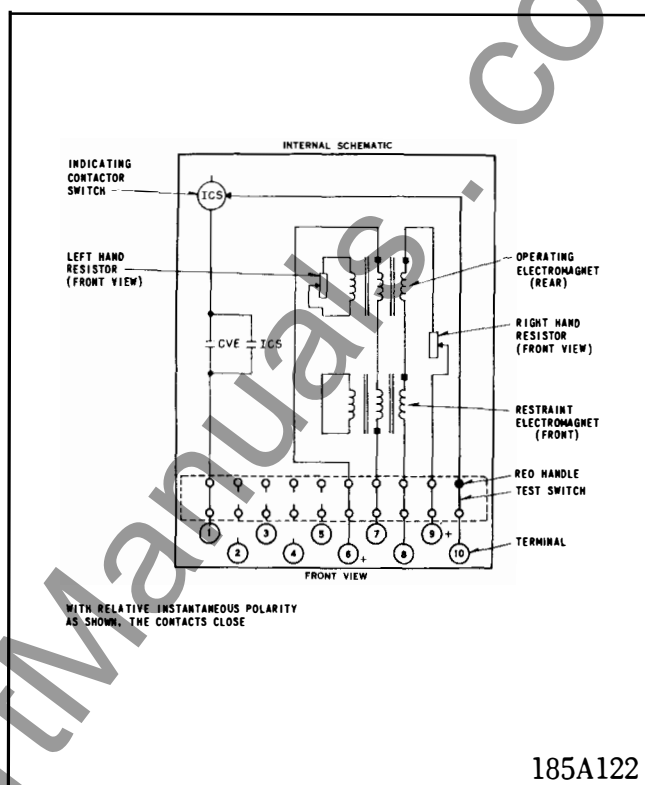


Fig. 4. Internal Schematic of CVE, with ICS Unit.

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

Operation With Voltage Relays

The connections shown in Fig. 5 using type SG voltage relays will provide the following operation:

1. Close the breaker when the bus is alive and the line is dead, through the 59B make contact and 27L break contact.
2. Close the breaker when the line is alive and the bus is dead, through the 27L make contact and 59B 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 and SG relays.

CHARACTERISTICS

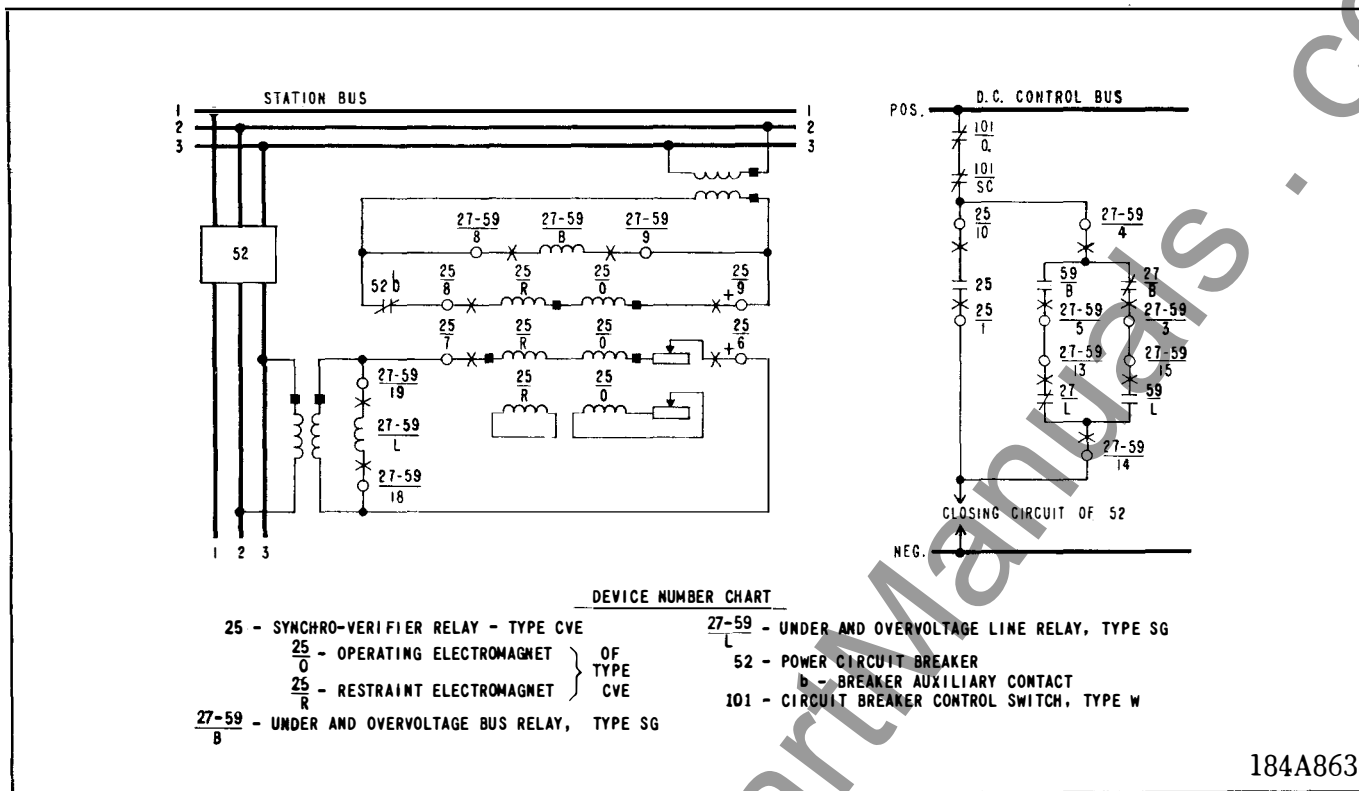
The type CVE relay can be adjusted for operating circles from 20 to 60 degrees as shown in Fig. 6. As shipped from the factory the relay is calibrated for the 20 degree circle. These circles apply when one side has rated voltage. The relay operates, if the other voltage falls within the appropriate circle.

The operating time of the relay is shown in Fig. 7. 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 Fig. 8.

Fig. 9 shows how high a slip frequency will cause operation. The maximum slip frequency is a function of the circle and time dial settings. This characteristic is of interest in estimating the angular difference at the instant of breaker closure, for cases where the two systems are slipping slowly.

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:



184A863

Fig 5. External Schematic of the CVE with SG Relay for Dead-Line-Hot Bus and Hot Line-Dead Bus Reclosing.

	Voltages in Phase	Voltages 180 Degrees Out of Phase
Volt-amperes	15.4	13.5
Power Factor	.422	.422
Watts	6.5	5.7

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

Volt-amperes	10.8
Power Factor	.422
Watts	4.6

Continuous Rating

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

SETTINGS

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 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 as low as the 1/2 time dial should be satisfactory with the 20° circle. Note from Fig. 8 that the relay will operate in 1.4 seconds in the 1/2 time dial positions 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 phase-angle difference between the two systems at the instant of breaker closure, refer to Fig. 9. For example, assume a 40° circle and #4 time-dial setting. Also assume that the systems are slipping at a frequency of 0.048 cycles per second, 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 systems 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:

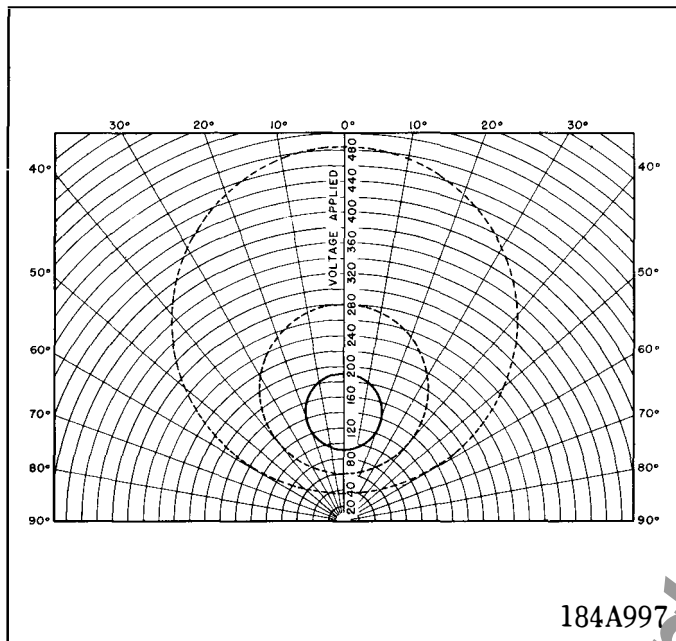


Fig. 6. Typical Voltage - Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.

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

where T_B = breaker closing time in seconds

Let $T_B = 0.5$ seconds

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

Indicating Contactor Switch (ICS) - When Used

No setting is required on the ICS unit except the selection of the 0.2 or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw.

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 flangs for semi-flush mounting or by means of the rear mounting stud or studs for pro-

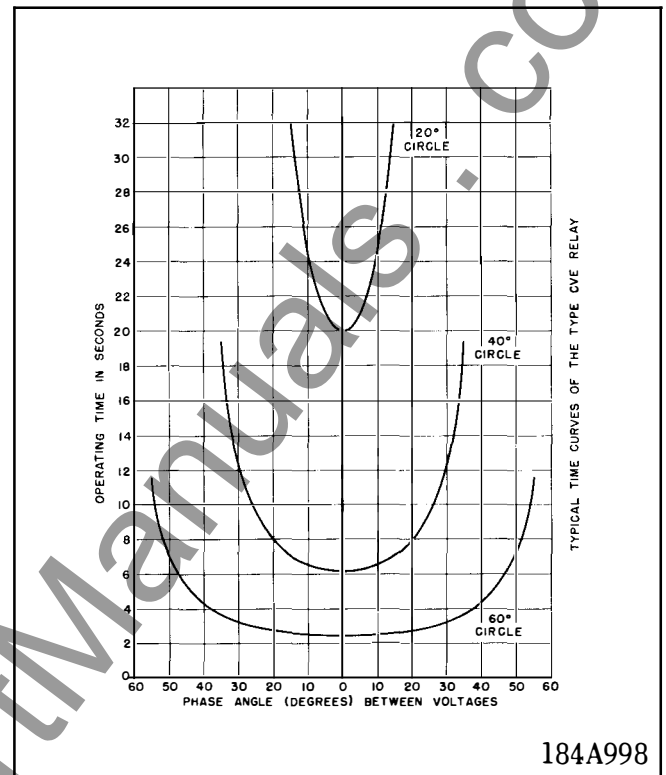


Fig. 7. Typical Time - Phase Angle Curves of CVE. Rated Voltage on Both Circuits. No. #11 Time Dial Setting.

jection 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.

For detailed FT Case information refer to I.L. 41-076.

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.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order:

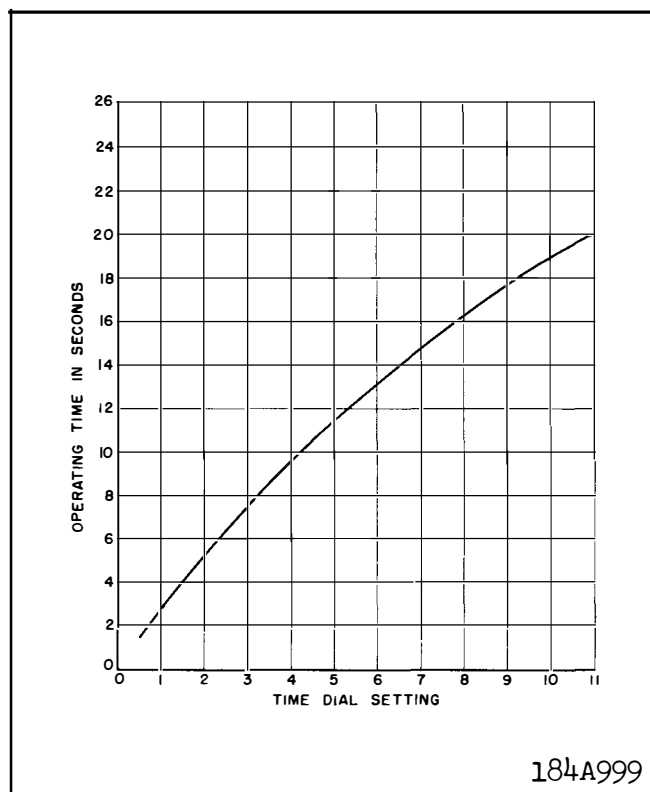


Fig. 8. Operating Time Variations with Changes In Time-Dial Settings. Rated In-Phase Voltage on Both Circuits, 20 Degree Circle Setting.

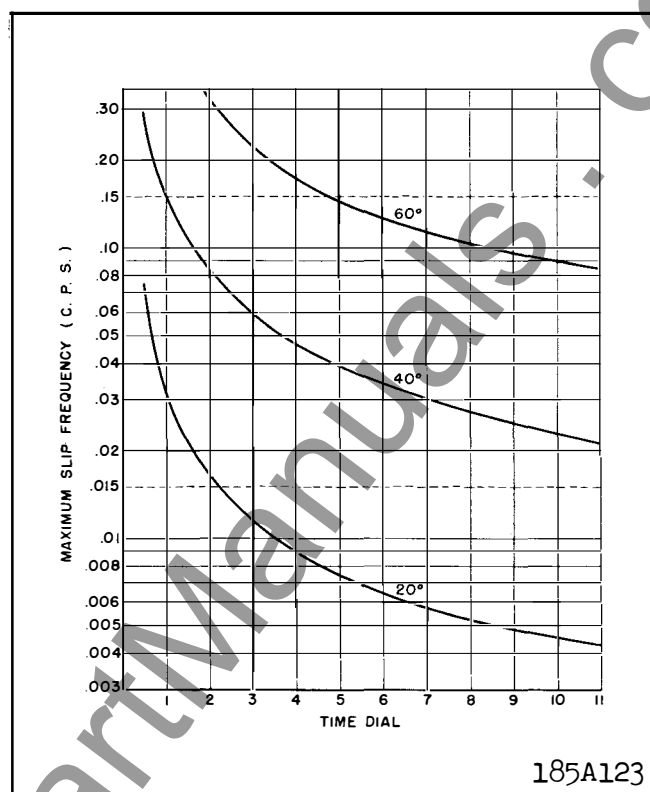


Fig. 9. Approximate Maximum Slip Frequency for which Operation Occurs - Rated Voltage on Both Sides.

Indicating Contactor Switch (ICS) - When Used

Close the main relay contacts and pass sufficient d-c current through the disc-unit contact circuit to close the contacts of the ICS. This value of current should be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

Disc Unit

1. Contacts - The index mark on the movement frame will coincide with the "O" 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 "O" 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 relay per the test diagram of Fig. 10. The contacts should just close when V_B is within ± 4 volts of the values shown in Fig. 6 for different angles on the 20 degree circle when V_1 is equal to rated voltage.

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

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 S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the

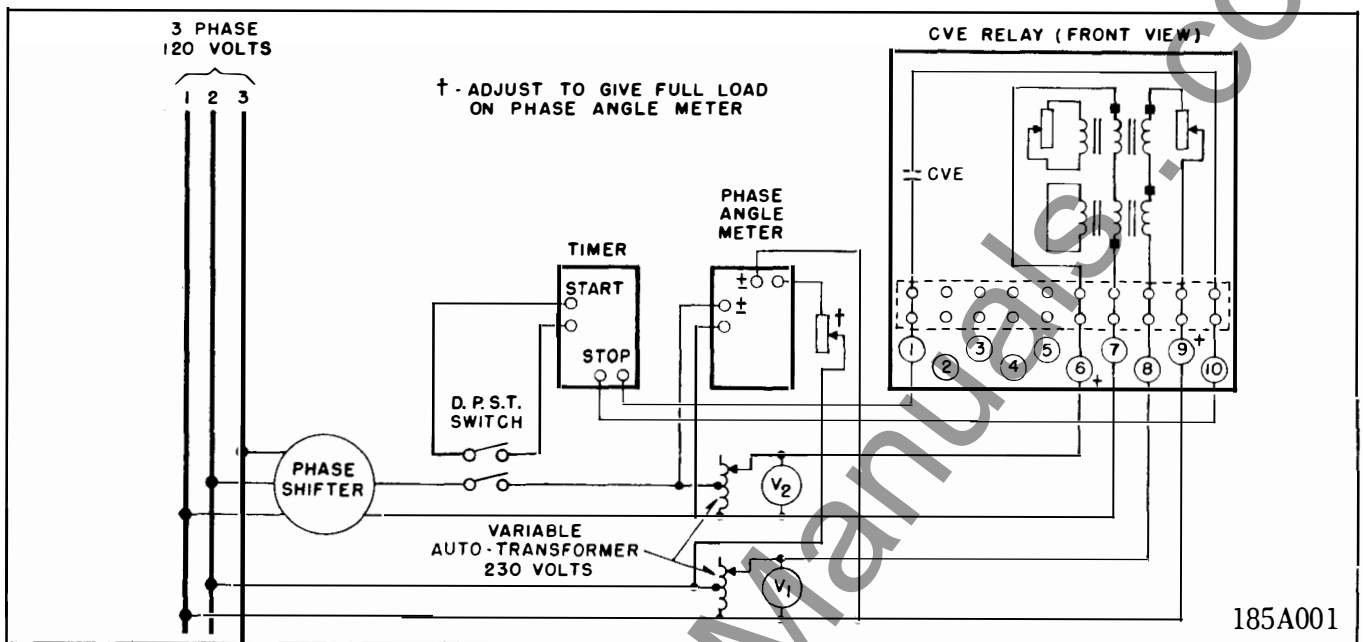


Fig. 10. Diagram of CVE Test Connections.

danger of embedding small particles in the face of the soft silver contact and thus impairing the contact.

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").

1. Contact — The index mark on the movement frame coincides with the "O" 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 "O" 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 — 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 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. Connect the relay to test circuit of Fig. 10 and apply rated voltage at zero phase angle on both circuits. 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 — Reconnect 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 with 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 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 such that the moving contact just leaves and returns to

TYPE CVE RELAY

the backstop at the number 11 position between 37° and 38°, 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 in the leading direction until the contacts are just equal to rated voltage. The contacts should just close at an angle of 20 ± 2 degrees.

The relay is now calibrated for a 20 degree circle. Other points of the circle may be checked by applying the proper value of V_2 at the proper angle. The 20 degree circle should be within ± 4 volts of the curve value.

6. 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 Fig. 7.

ELECTRICAL CHECKPOINTS

With V_1 in Fig. 10 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
Lag coil circuit	22

Restraint Electromagnet	
Upper terminals	58
Lower terminals	54

With 120 volts applied to V_2 circuit only

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

Restraint Electromagnet	
Upper terminals	54
Lower terminals	58

Approximate d.c. 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

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.

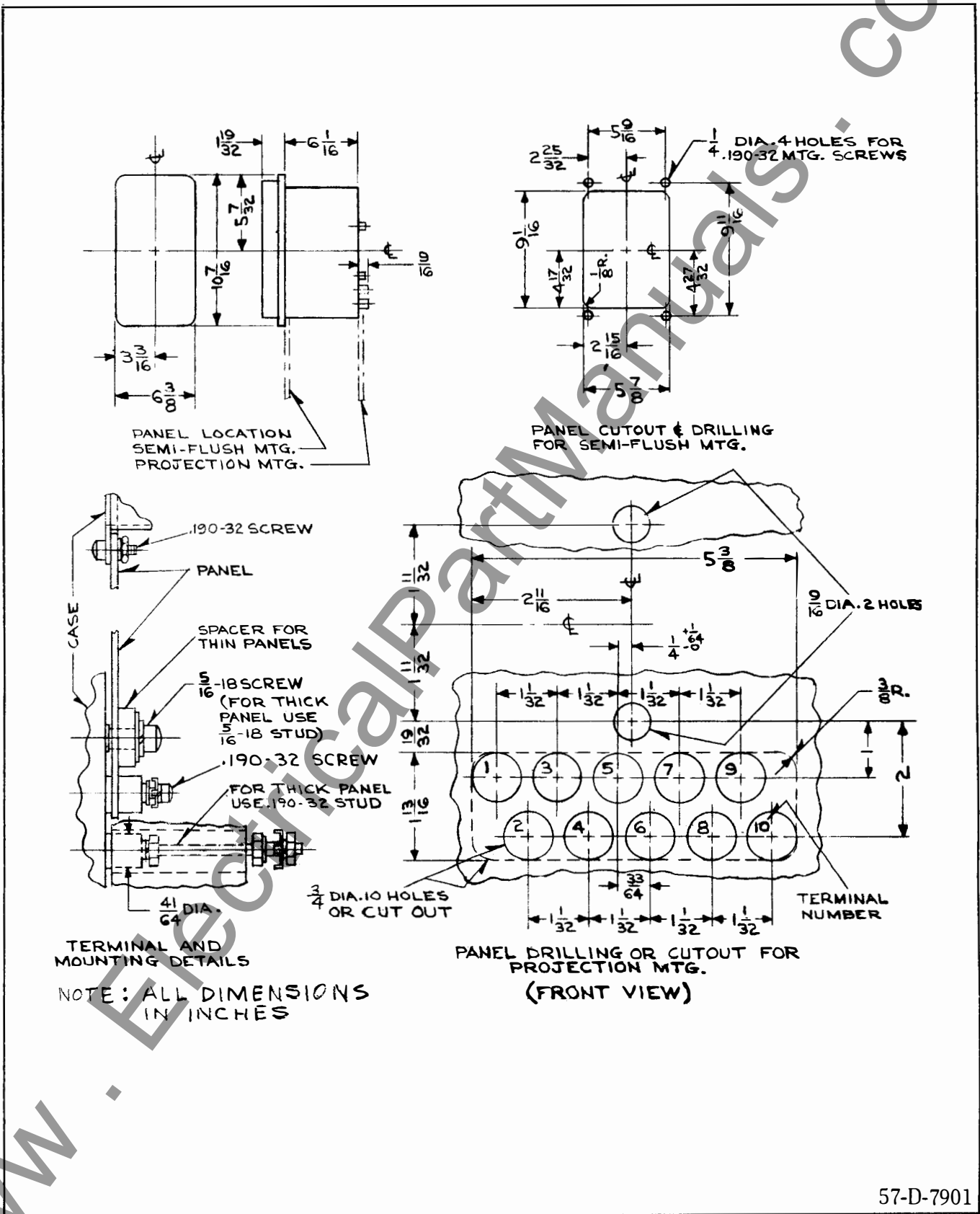
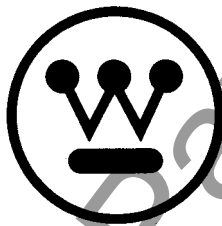


Fig. 11. Outline and Drilling Plan for the CVE In FT21 case.

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APPLICATION

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A common application of the synchro-verifier is in conjunction with automatic reclosing equipment on 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 the automatic reclosing equipment to reclose the breaker.

CONSTRUCTION AND OPERATION

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 Figs. 1, 2, 3, and 4.

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 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 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.

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.

Indicating Contactor Switch Unit (ICS) - When Used

The d-c 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.

SUPERSEDES I.L. 41-681.1

*Denotes change from superseded issue

EFFECTIVE JANUARY 1962

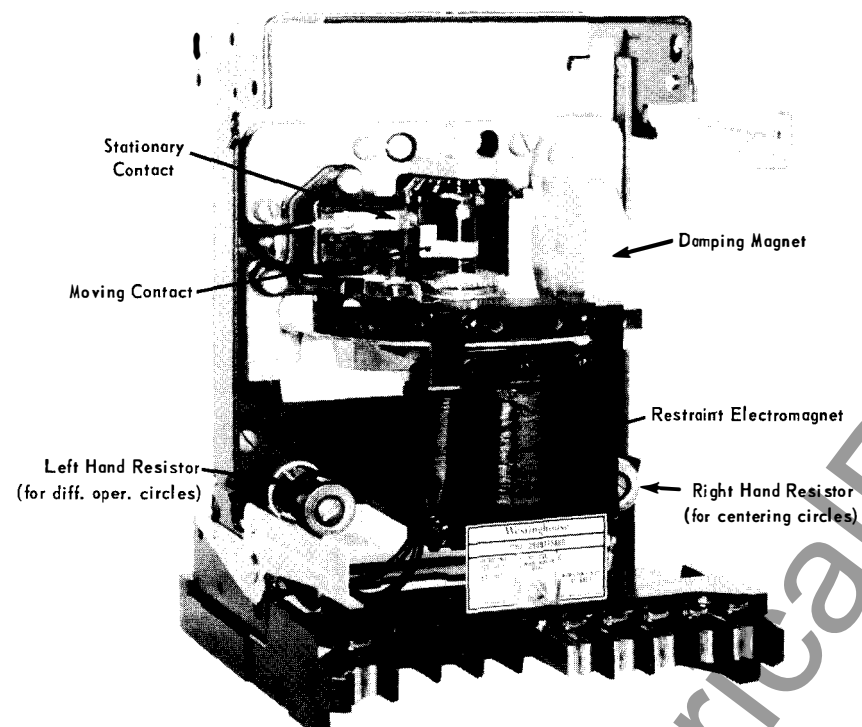


Fig. 1. Type CVE Relay, without Case (Front View)

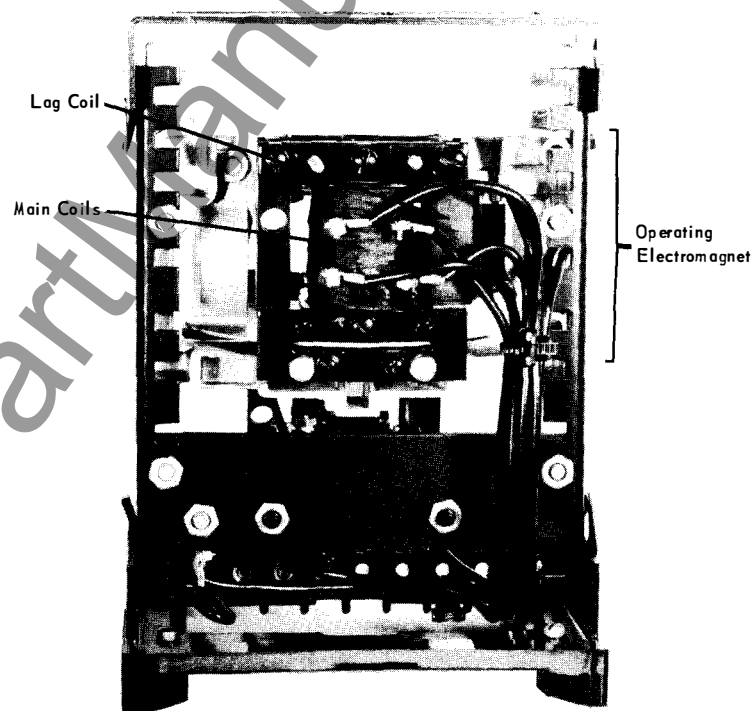
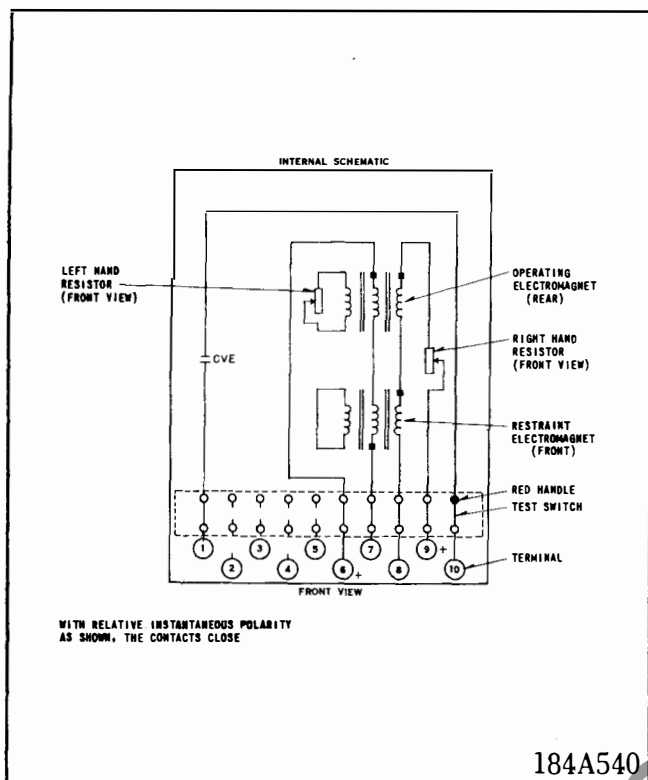
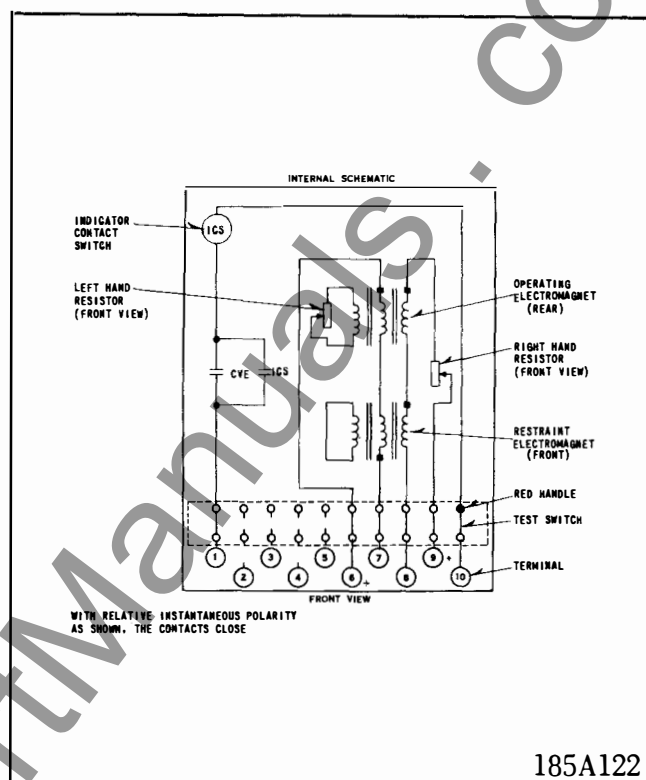


Fig. 2. Type CVE Relay, without Case (Rear View)



* Fig. 3. Internal Schematic of CVE, without ICS Unit.



* Fig. 4. Internal Schematic of CVE, with ICS Unit.

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

Operation With Voltage Relays

The connections shown in Fig. 5 using type SG voltage relays will provide the following operation:

1. Close the breaker when the bus is alive and the line is dead, through the 59B make contact and 27L break contact.
2. Close the breaker when the line is alive and the bus is dead, through the 27L make contact and 59B 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 and SG relays.

CHARACTERISTICS

The type CVE relay can be adjusted for operating circles from 20 to 60 degrees as shown in Fig. 6. 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.

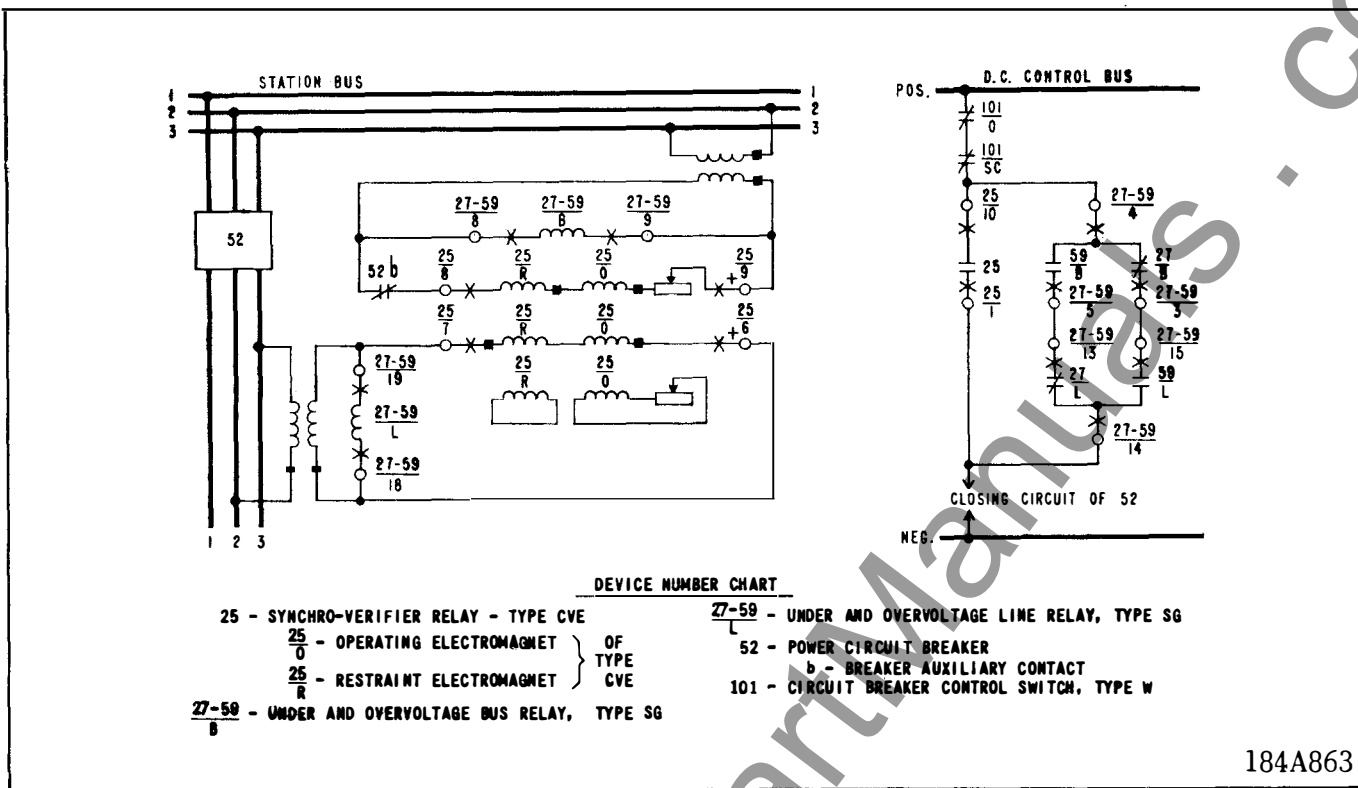
The operating time of the relay is shown in Fig. 7. These time curves are obtained from the #11 time dial setting when the applied voltages are equal to rated voltage and of the same frequency. Shorter operating times can be obtained at different time dial settings as shown in Fig. 8.

Fig. 9 shows how high a slip frequency will cause operation. The maximum slip frequency is a function of the circle and time dial settings. This characteristic is of interest in estimating the angular difference at the instant of breaker closure, for cases where the two systems are slipping slowly.

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:

TYPE CVE RELAY



* Fig 5. External Schematic of the CVE with SG Relay for Dead-Line-Hot Bus and Hot Line-Dead Bus Reclosing.

	Voltages in Phase	Voltages 180 Degrees Out of Phase
Volt-amperes	15.4	13.5
Power Factor	.422	.422
Watts	6.5	5.7

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

Volt-amperes	10.8
Power Factor	.422
Watts	4.6

Continuous Rating

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

SETTINGS

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 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 as low as the ½ time dial should be satisfactory with the 20° circle. Note from Fig. 8 that the relay will operate in 1.4 seconds in the ½ time dial positions 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 phase-angle difference between the two systems at the instant of breaker closure, refer to Fig. 9. For example, assume a 40° circle and #4 time-dial setting. Also assume that the systems are slipping at a frequency of 0.048 cycles per second, 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 systems 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:

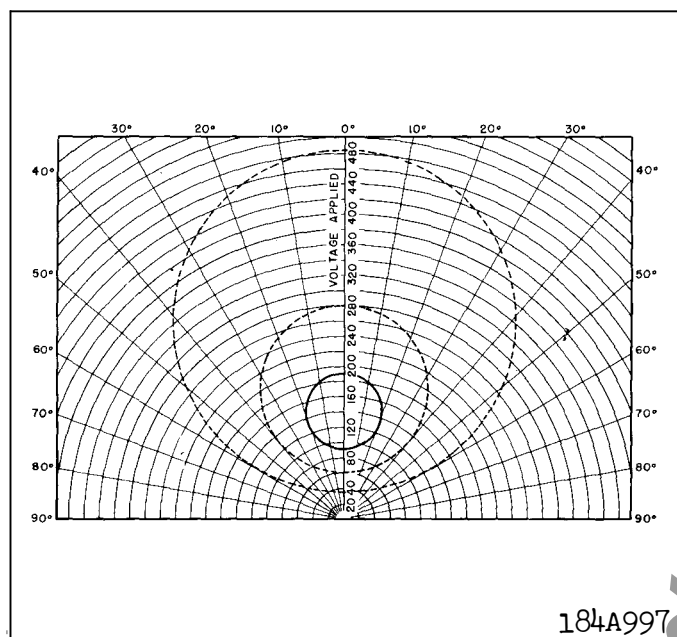


Fig. 6. Typical Voltage - Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.

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

where T_B = breaker closing time in seconds

Let $T_B = 0.5$ seconds

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

Indicating Contactor Switch (ICS) - When Used

No setting is required on the ICS unit.

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 flangs 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

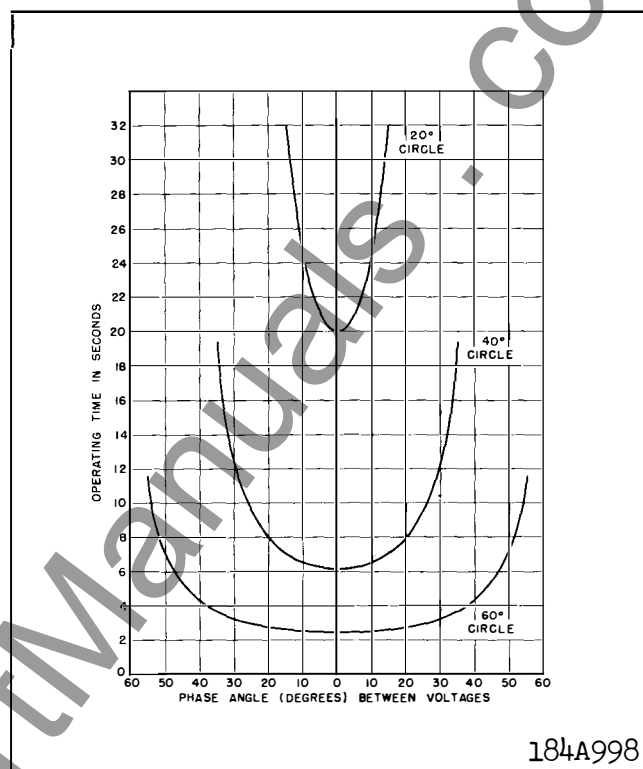


Fig. 7. Typical Time - Phase Angle Curves of CVE. Rated Voltage on Both Circuits. No. #11 Time Dial Setting.

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.

For detailed FT Case information refer to I.L. 41-076.

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.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order:

Indicating Contactor Switch (ICS) - When Used

Close the main relay contacts and pass sufficient

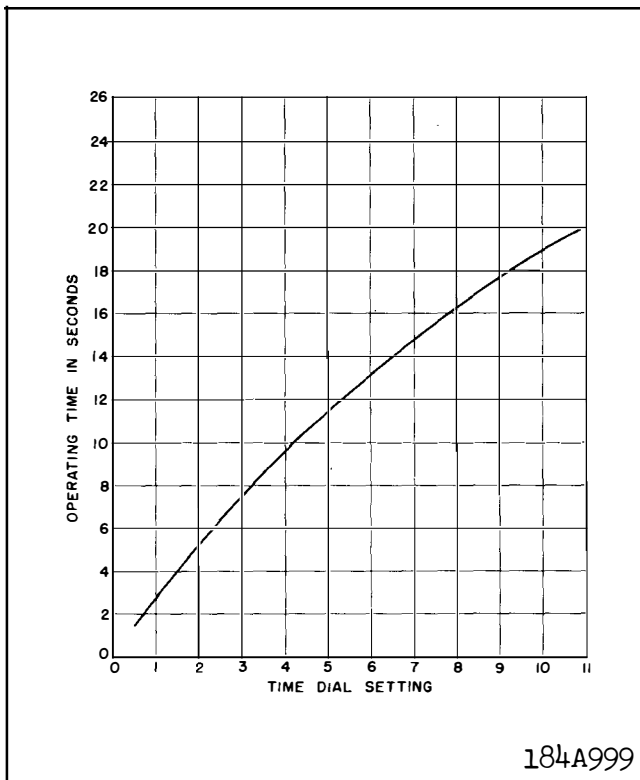


Fig. 8. Operating Time Variations with Changes in Time-Dial Settings. Rated In-Phase Voltage on Both Circuits, 20 Degree Circle Setting.

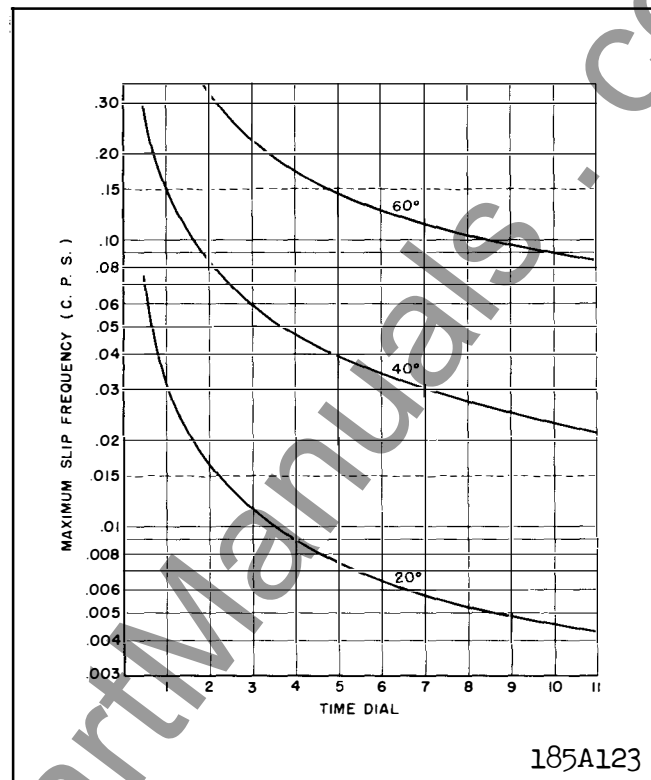


Fig. 9. Approximate Maximum Slip Frequency for which Operation Occurs - Rated Voltage on Both Sides.

d-c current through the disc-unit contact circuit to close the contacts of the ICS. This value of current * should be not greater than the value marked on the name plate. The operation indicator target should drop freely.

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

Disc Unit

1. Contacts - The index mark on the movement frame will coincide with the "O" 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 "O" 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 relay per the test diagram of Fig. 10. The contacts should just close when V_2 is within ± 4 volts of the values shown in Fig. 6 for different angles on the 20 degree circle when V_1 is equal to rated voltage.

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

* 4. Single Phase Test - Where a phase shifter and phase angle meter is not available, the relay can be tested with in-phase voltages. Connect the inputs of the variable auto-transformers of figure 10 to a common source. To check the operating circle, apply V_1 equal to rated voltage and vary V_2 . The relay contacts should just close when V_2 is raised to 94 ± 4 volts and should just open when V_2 is increased to 190 ± 4 volts.

To check the time curve, set the time dial in position 11 and apply V_1 and V_2 equal to rated voltage. The contacts should close in 20 ± 1 seconds.



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 Fig. 10 and apply rated voltage at zero phase angle on both circuits. With the right hand plug all the way

TYPE CVE RELAY

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 with 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 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 37° and 38° , 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 ± 2 degrees with V_1 and V_2 equal to rated voltage.

The relay is now calibrated for a 20 degree circle. Other points of the circle may be checked by applying the proper value of V_2 at the proper angle. The 20 degree circle should be within ± 4 volts of the curve value.

- * 6. 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 ± 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 Fig. 7.

* Calibration With-in Phase Voltages

If a phase angle meter and a phase shifter are not available, the relay can be calibrated with in phase voltages for approximate circles in the following manner:

1. 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 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.

2. 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 either by opening the screw connection on the lag of the rear electromagnet or by inserting a piece of insulating material under the adjustable point of the left hand resistor (front view). Apply rated voltage at zero phase angle to both circuits of the relay. (This can be done by connecting the inputs of the variable auto-transformers of Fig. 10 to a common source. With the right hand plug all the way in, adjust the left hand plug 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.

3. Centering Circle — To center the circle, set the right hand resistor (front view) between one-third to one-half of its adjustment. This will set the center of the circle within two degrees of zero.

4. Spring Adjustment — Adjust the left hand resistor (front view) such that the moving contact just leaves the backstop of the time dial at the number 11 position with V_1 equal to 120 volts and V_2 equal to 64 volts. Then adjust the reset spring such that the contacts will just close with V_1 equal to 120 volts and V_2 equal to 94 volts.

The relay is now calibrated for approximately a 20 degree circle. Check the other in phase point of the circle by applying V_1 equal to 120 volts and increasing the value of V_2 until the contacts are just making. V_2 should be 190 ± 8 volts.

4. Time Curve — Install the permanent magnet on the relay. Adjust the permanent magnet keeper until the operating time of the relay from the 11 time dial position is 20 ± 6 seconds with V_1 and V_2 equal to rated voltage at zero phase angle.

5. Circles Other Than 20 Degrees — This adjustment should not be done until the above adjustment for a 20 degree circle has been completed.

Set V_1 equal to noted voltage and apply V_2 to a value as determined by Fig. 11. Adjust the left hand resistor until the contacts just close.

Check the circle by timing the relay with V_1 and V_2 equal to rated voltage. The relay should operate from the number 11 time dial position within ± 7 percent of the times shown in Fig. 12.

ELECTRICAL CHECKPOINTS

With V_1 in Fig. 10 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
Lag coil circuit	22
Restraint Electromagnet	
Upper terminals	58
Lower terminals	54

With 120 volts applied to V_2 circuit only

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

Restraint Electromagnet	
Upper terminals	54
Lower terminals	58

Approximate d.c. resistances of the coils are as follows:

Operating Electromagnet	
Upper terminals	59 ohms
Lower terminals	80 ohms
Lag coil—open circuit—	245 ohms

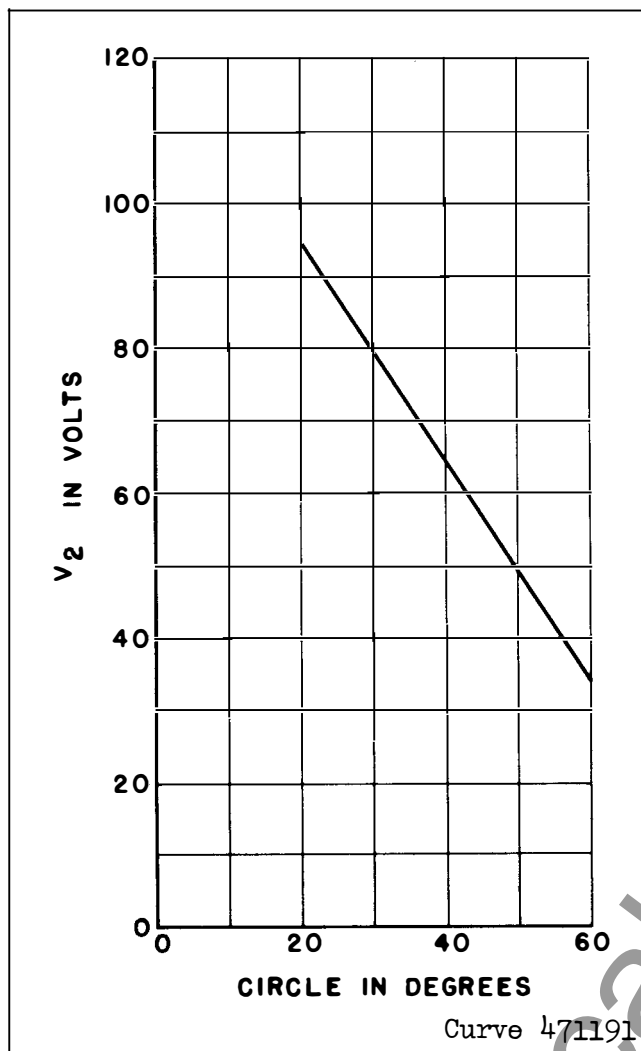
Restraint Electromagnet	
Upper terminals	66 ohms
Lower terminals	92 ohms

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

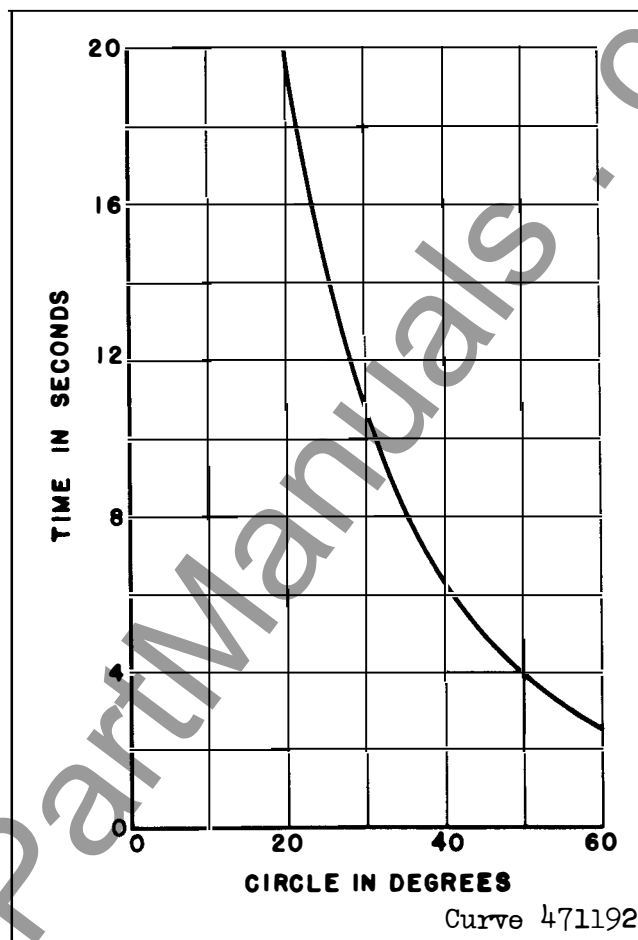
20 degree circle	4800	ohms
40 degree circle	2250	ohms
60 degree circle	890	ohms

RENEWAL PARTS

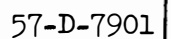
Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.



* Fig. 11. V_2 Voltage for Different Operating Circles. V_1 equal to rated voltage at zero phase angle. (Curve 471191)



* Fig. 12. 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. (Curve 471192)



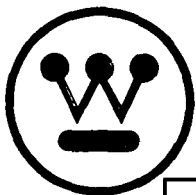
11



WESTINGHOUSE ELECTRIC CORPORATION
RELAY - INSTRUMENT DEPARTMENT

NEWARK, N. J.

Printed in U. S. A.



INSTALLATION • OPERATION • MAINTENANCE I N S T R U C T I O N S

TYPE CVE SYNCHRO-VERIFIER RELAY

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.

APPLICATION

The type CVE synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The contacts will close when these voltage are equal, within set limits, in phase, and of the same frequency.

The type CVE synchro-verifier is not an automatic synchronizer and should not be used as such. Automatic Synchronizers are available which permit closing ahead of synchronism at an angle of phase-advance proportional to the beat frequencies and determined by the speed of operation of the circuit breaker so that the two systems are connected right on synchronism.

A common application of the synchro-verifier is in conjunction with automatic reclosing equipment on 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 the automatic reclosing equipment to reclose the breaker.

CONSTRUCTION AND OPERATION

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 Figs. 1, 2, 3, and 4.

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 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 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.

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.

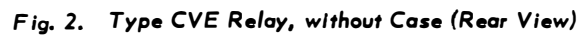
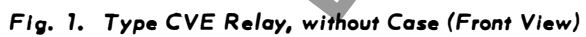
Indicating Contactor Switch Unit (ICS) - When Used

The d-c 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.

SUPERSEDES I.L. 41-681.1A

*Denotes change from superseded issue

EFFECTIVE OCTOBER 1962



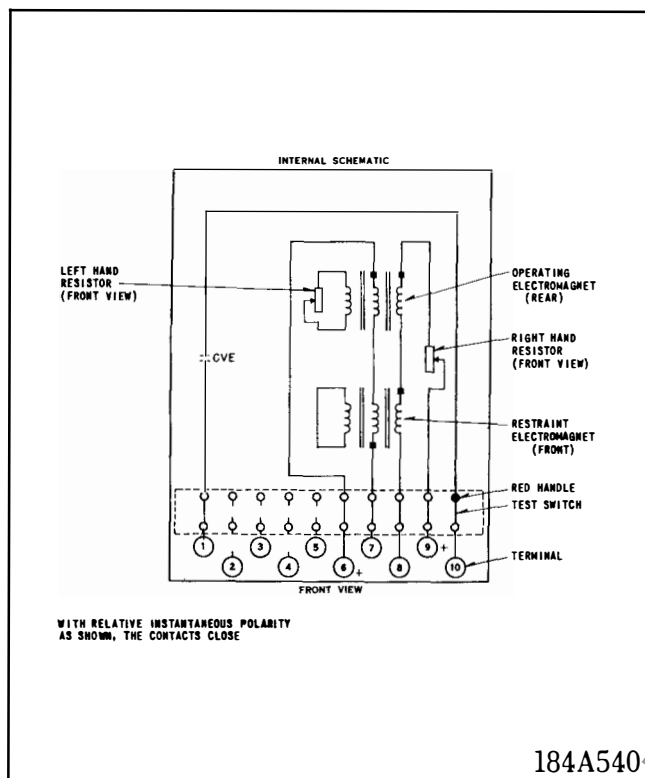
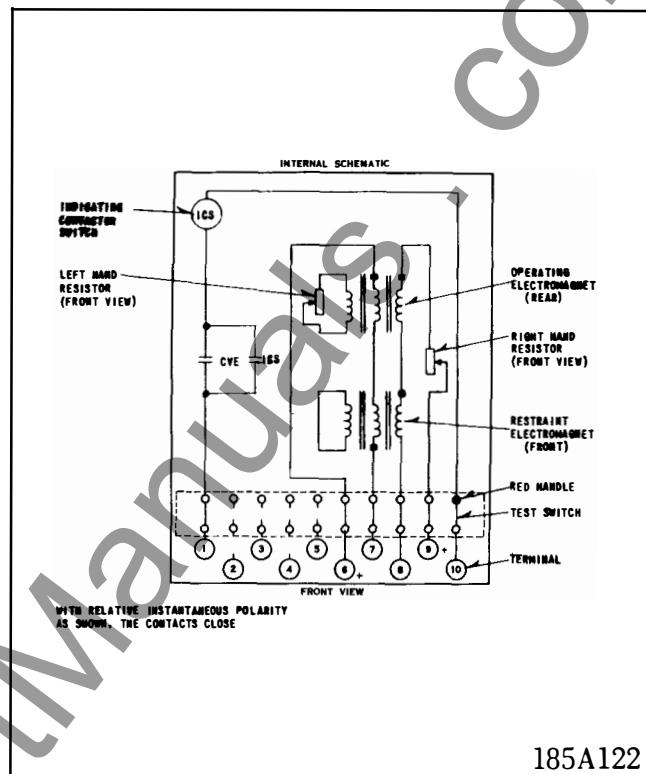


Fig. 3. Internal Schematic of CVE, without ICS Unit.



* Fig. 4. Internal Schematic of CVE, with ICS Unit.

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

Operation With Voltage Relays

The connections shown in Fig. 5 using type SG voltage relays will provide the following operation:

1. Close the breaker when the bus is alive and the line is dead, through the 59B make contact and 27L break contact.
2. Close the breaker when the line is alive and the bus is dead, through the 27L make contact and 59B 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 and SG relays.

CHARACTERISTICS

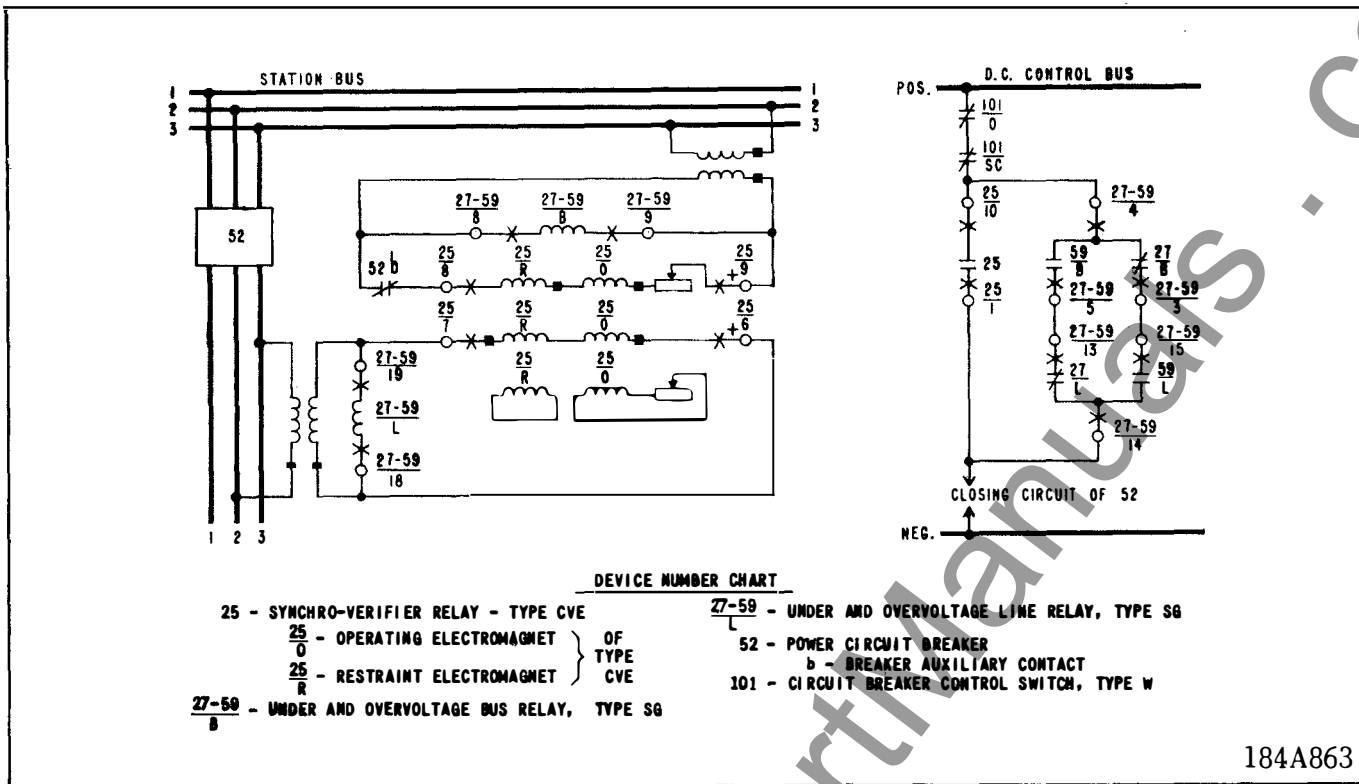
The type CVE relay can be adjusted for operating circles from 20 to 60 degrees as shown in Fig. 6. As shipped from the factory the relay is calibrated for the 20 degree circle. These circles apply when one side has rated voltage. The relay operates, if the other voltage falls within the appropriate circle.

The operating time of the relay is shown in Fig. 7. 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 Fig. 8.

Fig. 9 shows how high a slip frequency will cause operation. The maximum slip frequency is a function of the circle and time dial settings. This characteristic is of interest in estimating the angular difference at the instant of breaker closure, for cases where the two systems are slipping slowly.

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:



184A863

Fig 5. External Schematic of the CVE with SG Relay for Dead-Line-Hot Bus and Hot Line-Dead Bus Reclosing.

	Voltages in Phase	Voltages 180 Degrees Out of Phase
Volt-amperes	15.4	13.5
Power Factor	.422	.422
Watts	6.5	5.7

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

Volt-amperes	10.8
Power Factor	.422
Watts	4.6

Continuous Rating

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

SETTINGS

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 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 as low as the ½ time dial should be satisfactory with the 20° circle. Note from Fig. 8 that the relay will operate in 1.4 seconds in the ½ time dial positions 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 phase-angle difference between the two systems at the instant of breaker closure, refer to Fig. 9. For example, assume a 40° circle and #4 time-dial setting. Also assume that the systems are slipping at a frequency of 0.048 cycles per second, 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 systems 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:

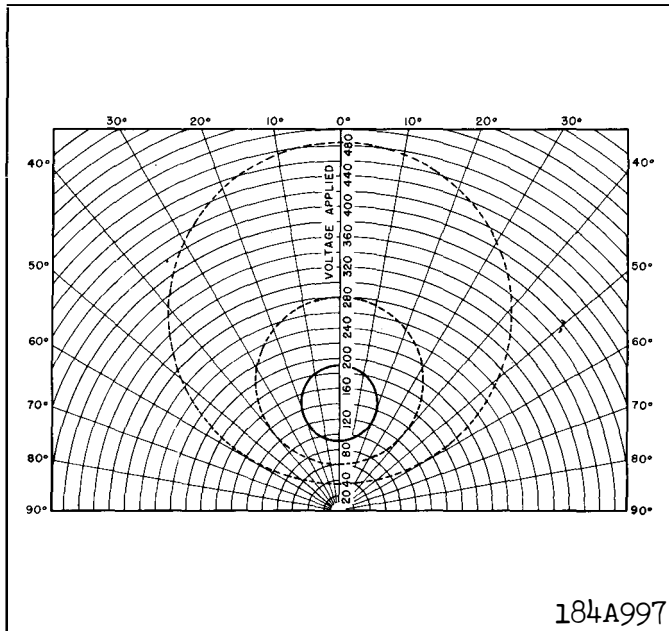


Fig. 6. Typical Voltage - Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.

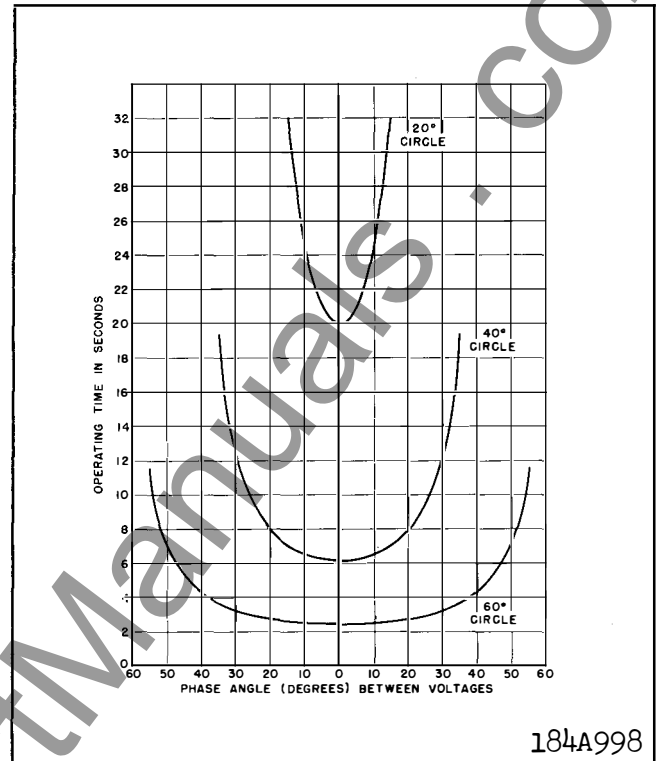


Fig. 7. Typical Time - Phase Angle Curves of CVE. Rated Voltage on Both Circuits. No. #11 Time Dial Setting.

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

where T_B = breaker closing time in seconds

Let $T_B = 0.5$ seconds

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

Indicating Contactor Switch (ICS) - When Used

No setting is required on the ICS unit.

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 flangs 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.

For detailed FT Case information refer to I.L. 41-076.

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.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order:

Indicating Contactor Switch (ICS) - When Used

Close the main relay contacts and pass sufficient

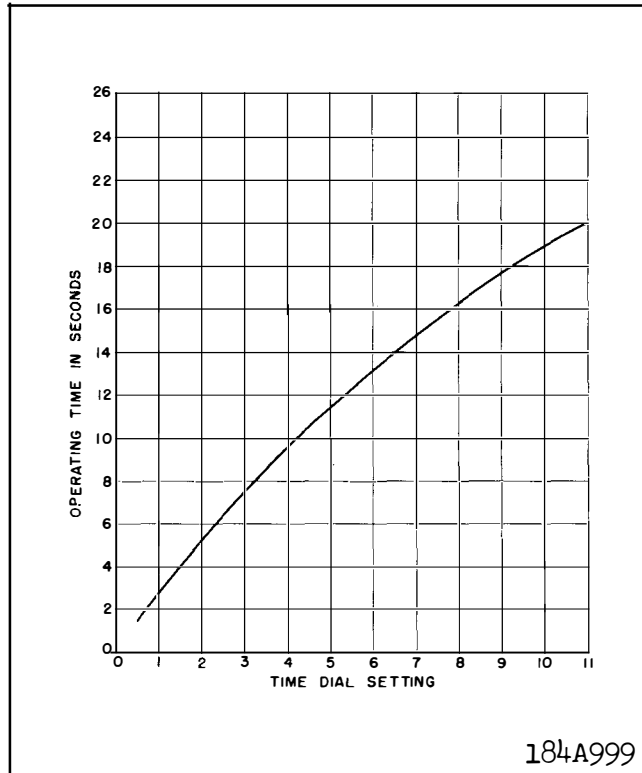


Fig. 8. Operating Time Variations with Changes in Time-Dial Settings. Rated In-Phase Voltage on Both Circuits, 20 Degree Circle Setting.

d-c current through the disc-unit contact circuit to close the contacts of the ICS. This value of current should be not greater than the value marked on the name plate. The operation indicator target should drop freely.

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

Disc Unit

1. Contacts — The index mark on the movement frame will coincide with the "O" 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 "O" 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.

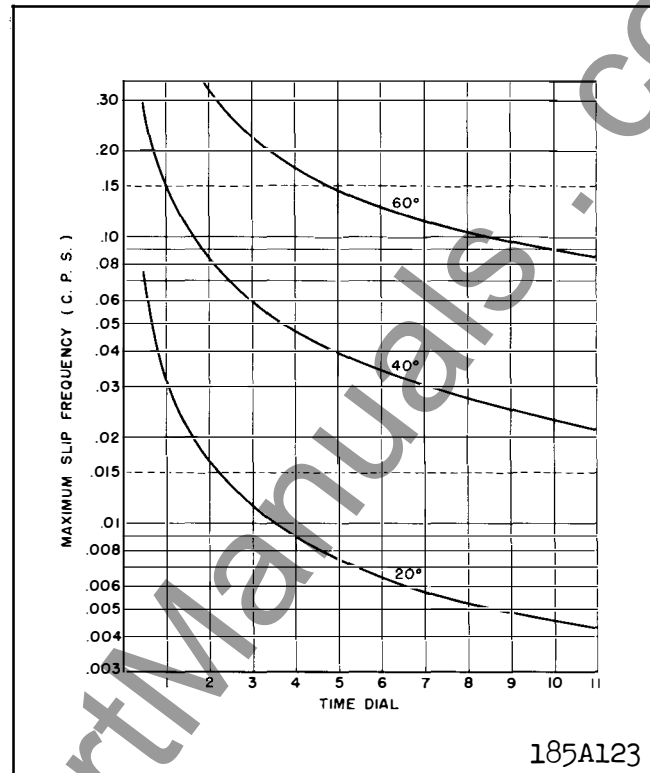


Fig. 9. Approximate Maximum Slip Frequency for which Operation Occurs - Rated Voltage on Both Sides.

2. Operating Circle — Connect the relay per the test diagram of Fig. 10. The contacts should just close when V_2 is within ± 4 volts of the values shown in Fig. 6 for different angles on the 20 degree circle when V_1 is equal to rated voltage.

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

- * 4. Single Phase Test — Where a phase shifter and phase angle meter are not available, the relay can be tested with in-phase voltages. Connect the inputs of the variable auto-transformers of figure 10 to a common source. To check the operating circle, apply V_1 equal to rated voltage and vary V_2 . The relay contacts should just close when V_2 is raised to 94 ± 4 volts and should just open when V_2 is increased to 190 ± 4 volts.

To check the time curve, set the time dial in position 11 and apply V_1 and V_2 equal to rated voltage. The contacts should close in 20 ± 1 seconds.

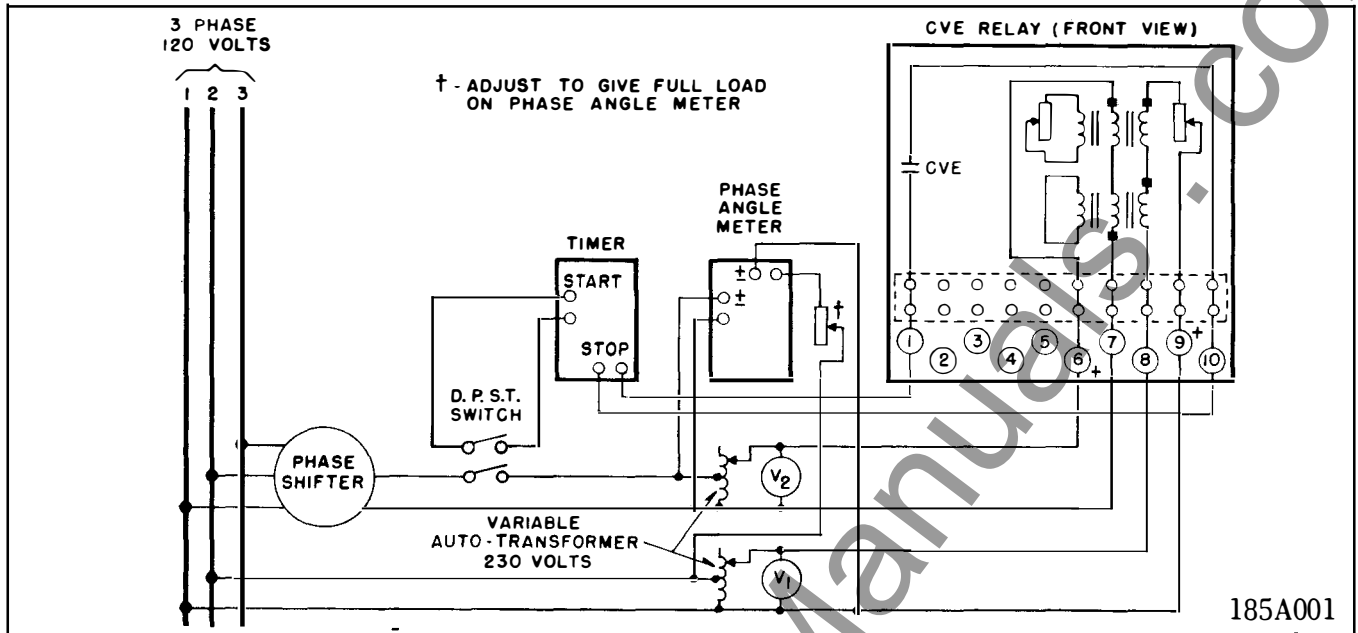


Fig. 10. Diagram of CVE Test Connections.

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 S#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.

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").

1. Contact — The index mark on the movement frame coincides with the "O" 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 "O" 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 — 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 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 Fig. 10 and apply rated voltage at zero 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 timedial 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 with 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 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 37° and 38° , 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 ± 2 degrees with V_1 and V_2 equal to rated voltage.

The relay is now calibrated for a 20 degree circle. Other points of the circle may be checked by applying the proper value of V_2 at the proper angle. The 20 degree circle should be within ± 4 volts of the curve value.

* 6. 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 ± 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 Fig. 7.

Calibration With-in Phase Voltages

If a phase angle meter and a phase shifter are not available, the relay can be calibrated with in phase voltages for approximate circles in the following manner:

1. 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 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.

2. 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 either by opening the screw connection on the lag of the rear electromagnet or by inserting a piece of insulating material under the adjustable point of the left hand resistor (front view). Apply rated voltage at zero phase angle to both circuits of the relay. (This can be done by connecting the inputs of the variable auto-transformers of Fig. 10 to a common source. With the right hand plug all the way in, adjust the left hand plug 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.

3. Centering Circle — To center the circle, set the right hand resistor (front view) between one-third to one-half of its adjustment. This will set the center of the circle within two degrees of zero.

4. Spring Adjustment — Adjust the left hand resistor (front view) such that the moving contact just leaves the backstop of the time dial at the number 11 position with V_1 equal to 120 volts and V_2 equal to 64 volts. Then adjust the reset spring such that the contacts will just close with V_1 equal to 120 volts and V_2 equal to 94 volts.

The relay is now calibrated for approximately a 20 degree circle. Check the other in phase point of the circle by applying V_1 equal to 120 volts and increasing the value of V_2 until the contacts are just making. V_2 should be 190 ± 8 volts.

- * 4. Time Curve — Install the permanent magnet on the relay. Adjust the permanent magnet keeper until the operating time of the relay from the 11 time dial position is 20 ± 0.6 seconds with V_1 and V_2 equal to rated voltage at zero phase angle.

5. Circles Other Than 20 Degrees — This adjustment should not be done until the above adjustment for a 20 degree circle has been completed.

Set V_1 equal to noted voltage and apply V_2 to a value as determined by Fig. 11. Adjust the left hand resistor until the contacts just close.

Check the circle by timing the relay with V_1 and V_2 equal to rated voltage. The relay should operate from the number 11 time dial position within ± 7 percent of the times shown in Fig. 12.

ELECTRICAL CHECKPOINTS

With V_1 in Fig. 10 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
Lag coil circuit	22
Restraint Electromagnet	
Upper terminals	58
Lower terminals	54

With 120 volts applied to V_2 circuit only

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

Restraint Electromagnet	
Upper terminals	54
Lower terminals	58

Approximate d.c. 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

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.

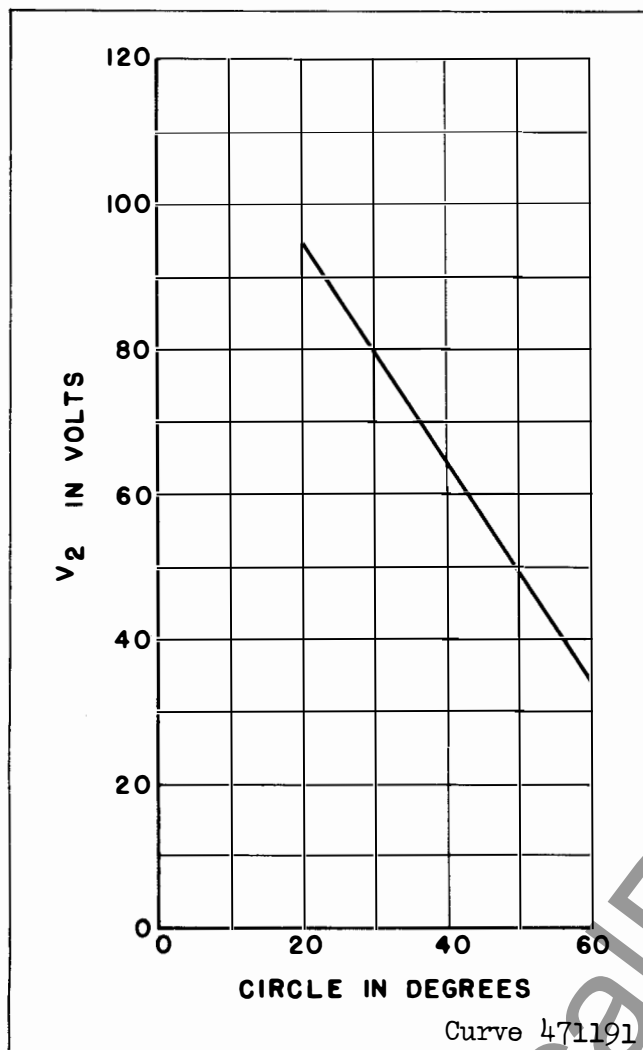


Fig. 11. V_2 Voltage for Different Operating Circles. V_1 equal to rated voltage at zero phase angle. (Curve 471191)

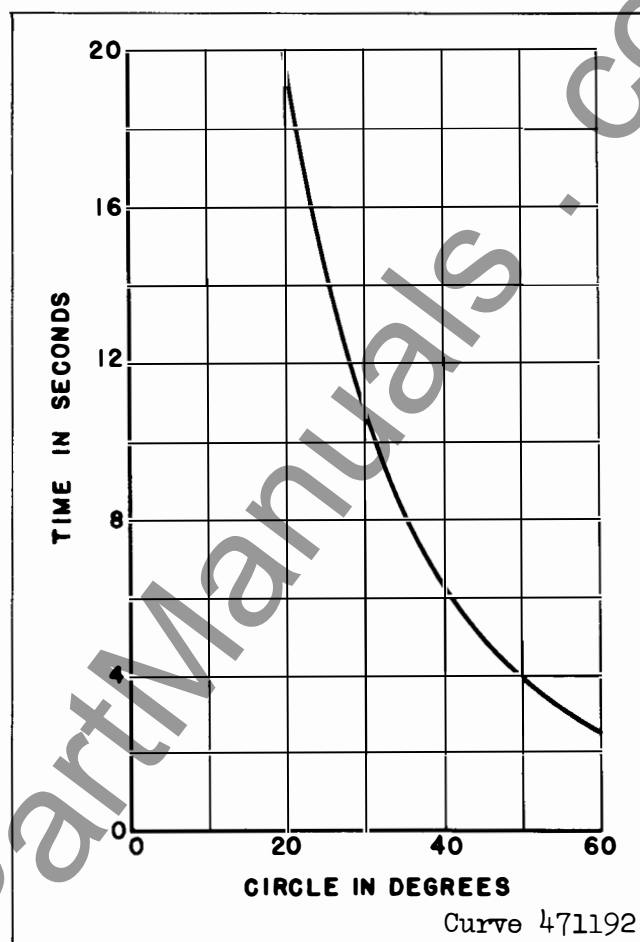
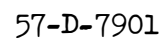
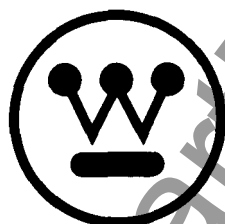


Fig. 12. Operating Times from the No. 11 Time Dial Position for the Type CVE Relay set for Different Operating Circles. V_1 and V_2 equal to rated voltage at zero phase angle. (Curve 471192)



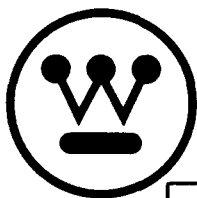
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WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION

NEWARK, N. J.

Printed in U.S.A.



INSTALLATION • OPERATION • MAINTENANCE I N S T R U C T I O N S

TYPE CVE AND CVE-1 SYNCHRO-VERIFIER RELAYS

Buffalo Office
Mr. F. N. Hubley
Electric Service Manager
RIL

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.

APPLICATION

The synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The contacts will close when these voltage are equal, within set limits, in phase, and of the same frequency.

The synchro-verifier is not an automatic synchronizer and should not be used as such. Automatic Synchronizers are available which permit closing ahead of synchronism at an angle of phase-advance proportional to the beat frequencies and determined by the speed of operation of the circuit breaker so that the two systems are connected right on synchronism.

A common application of the synchro-verifier is in conjunction with automatic reclosing equipment on 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 the automatic reclosing equipment to reclose the breaker.

CONTENTS

This instruction leaflet applies to the following types of relays:

- CVE - Synchro-Verifier Relay
- CVE-1 Synchro-Verifier Relay

CONSTRUCTION AND OPERATION

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 Figs. 1, 2, 3, and 4.

The CVE-1 relay consists of two telephone type relays in addition to the components of the CVE Relay. The principal parts of the relay are connected as per figure 5.

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 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 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.

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.

Indicating Contactor Switch Unit (ICS) - When Used

The d-c indicating contactor switch is a small

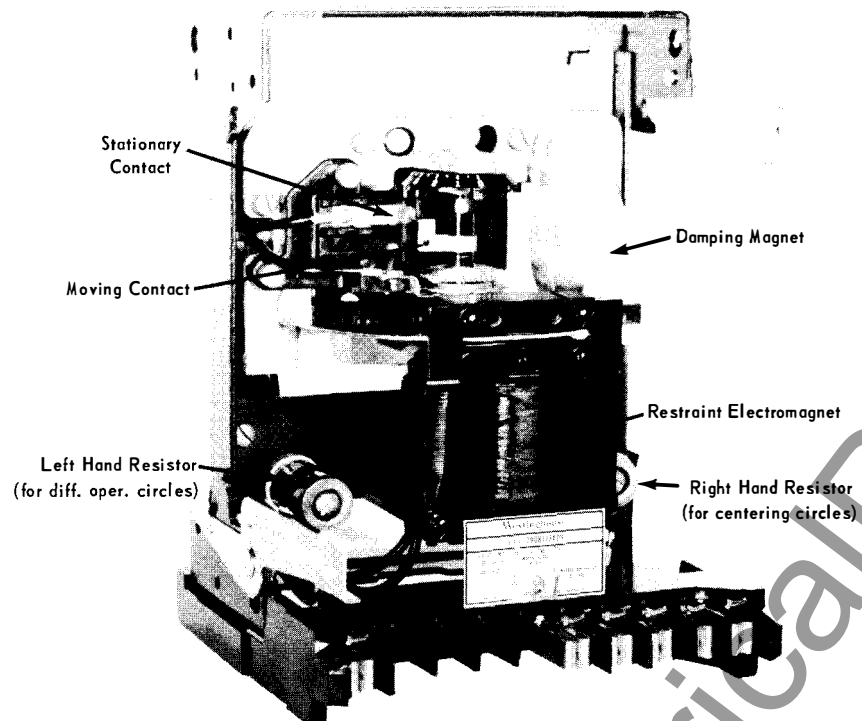


Fig. 1. Type CVE Relay, without Case (Front View)

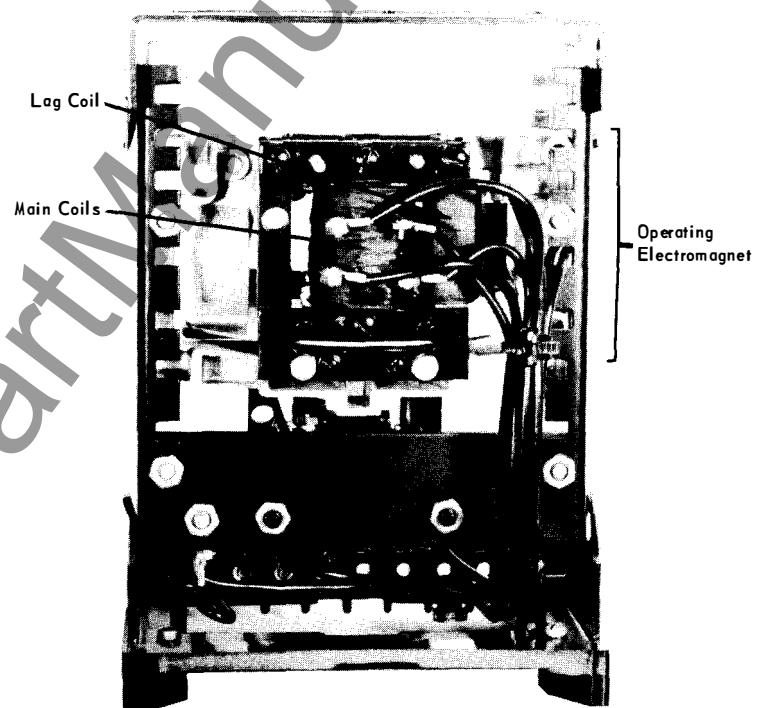


Fig. 2. Type CVE Relay, without Case (Rear View)

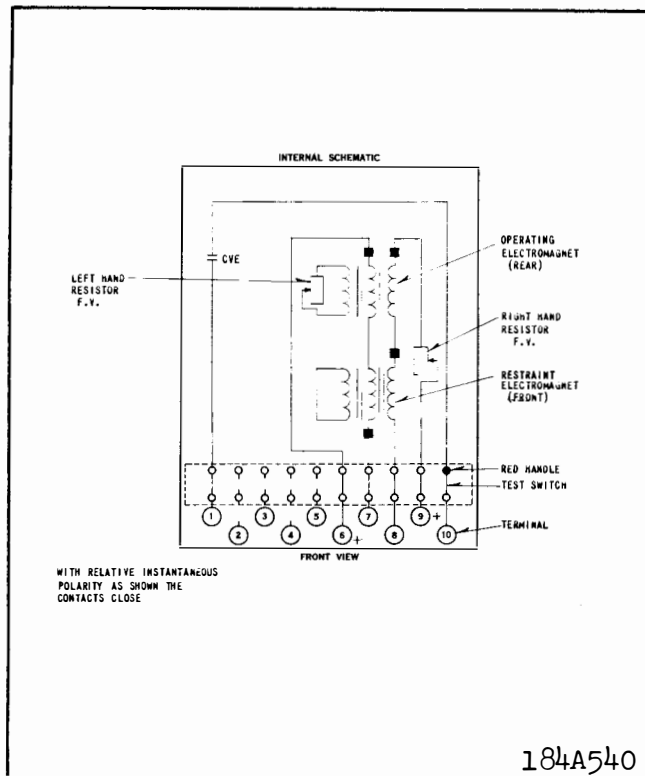


Fig. 3. Internal Schematic of CVE, without ICS Unit.

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.

Telephone Relay

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

Operation With Voltage Relays

The connections shown in Fig. 6 using type SG voltage relays will provide the following operation:

1. Close the breaker when the bus is alive and the line is dead, through the 59B make con-

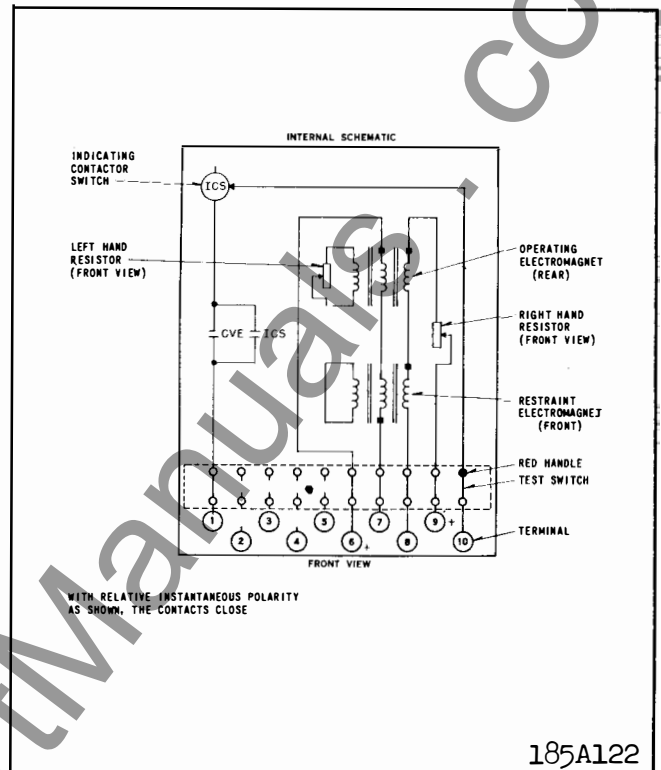


Fig. 4. Internal Schematic of CVE, with ICS Unit.

tact and 27L break contact.

2. Close the breaker when the line is alive and the bus is dead, through the 59L make contact and 27B 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 and SG relays.

CVE - 1 Operation

The connections shown in Figure 7 using the type CVE-1 relay will provide the following operation:

1. Close the breaker when the bus is alive and the line is dead, through the V2 make contact and V1 break contact.
2. Close the breaker when the line is alive and the bus is dead, through the V1 make contact and V2 break contact.

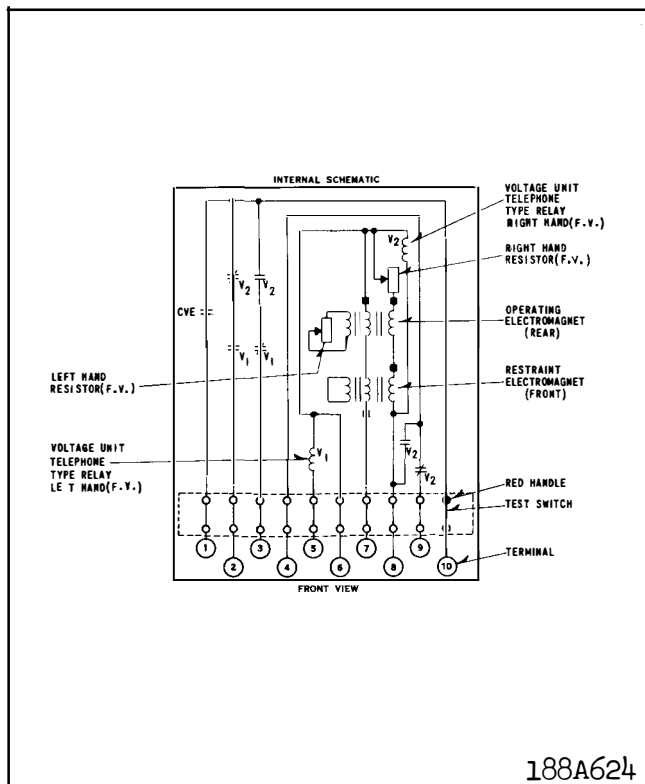


Fig. 5. Internal Schematic of CVE-1

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:

CHARACTERISTICS

The type CVE relay and CVE-1 can be adjusted for operating circles from 20 to 60 degrees as shown in Fig. 8. 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 Fig. 9. 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 Fig. 10.

Fig. 11 shows how high a slip frequency will cause operation. The maximum slip frequency is a function of the circle and time dial settings. This characteristic is of interest in estimating the angular difference at the instant of breaker closure, for cases where the two systems are slipping slowly.

Burden

The burden imposed on each potential source by the CVE relay and CVE-1 relay, with rated voltage applied to both circuits of the relay is as follows:

	Voltages in Phase	Voltages 180 Degrees Out of Phase
Volt-amperes	15.4	13.5
Power Factor	.422	.422
Watts	6.5	5.7

The burden of the CVE relay and CVE-1 relay with rated voltage applied to one circuit is as follows:

Volt-amperes	10.8
Power Factor	.422
Watts	4.6

The burden of each telephone relay at 120 volts is as follows:

10.62 volt-amperes Power Factor 0.64

Continuous Rating

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

SETTINGS

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 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 as low as the ½ time dial should be satisfactory with the 20° circle. Note from Fig. 10 that the relay will operate in 1.4 seconds in the ½ time dial positions and with the 20° setting. If a longer delay is desired a

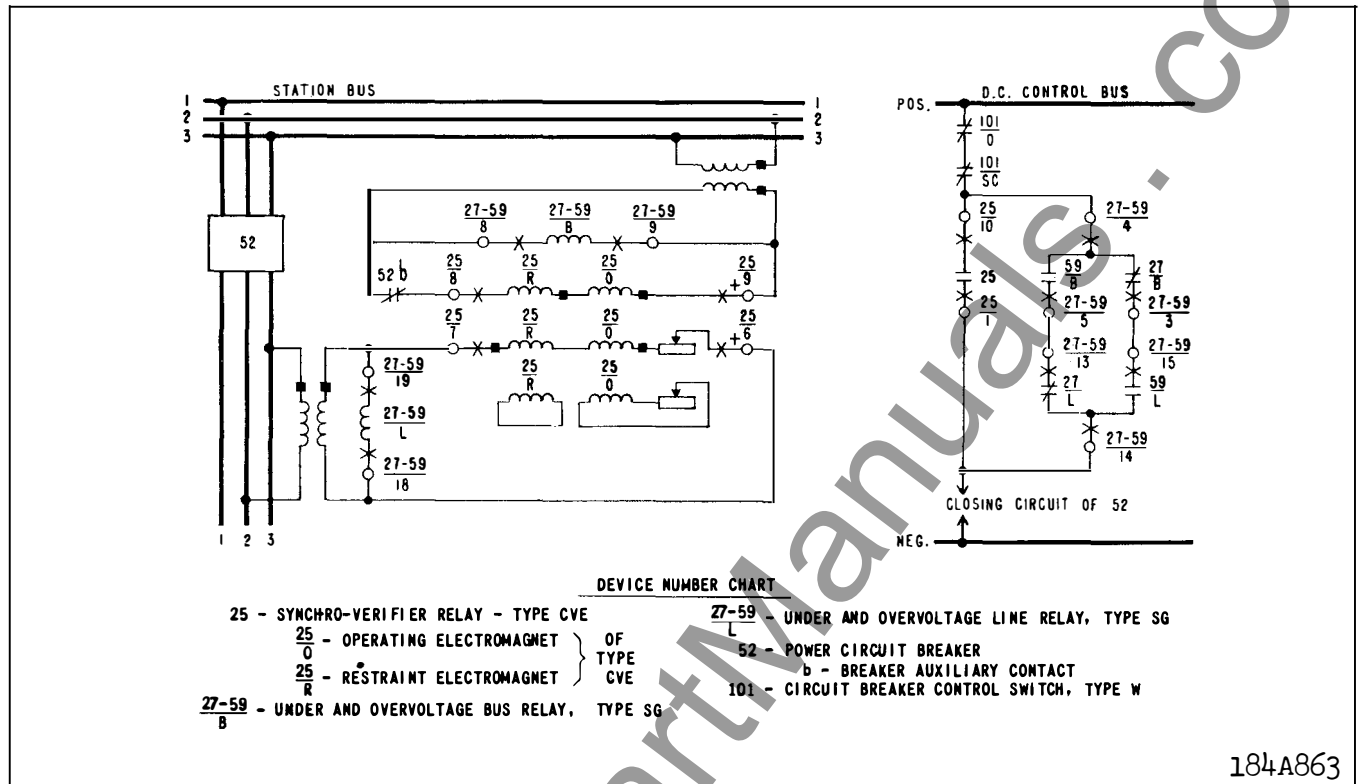


Fig. 6 External Schematic of the CVE with SG Relay for Dead-Line-Hot Bus and Hot Line-Dead Bus Reclosing.

higher time-dial setting may be used.

To evaluate the effect of time-dial and circle settings on the phase-angle difference between the two systems at the instant of breaker closure, refer to Fig. 9. For example, assume a 40° circle and #4 time-dial setting. Also assume that the systems are slipping at a frequency of 0.048 cycles per second, 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 systems 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:

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

where T_B = breaker closing time in seconds

Let $T_B = 0.5$ seconds

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

Indicating Contactor Switch (ICS) - When Used

No setting is required on the ICS unit.

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.

For detailed F'T Case information refer to I.L. 41-076.

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.

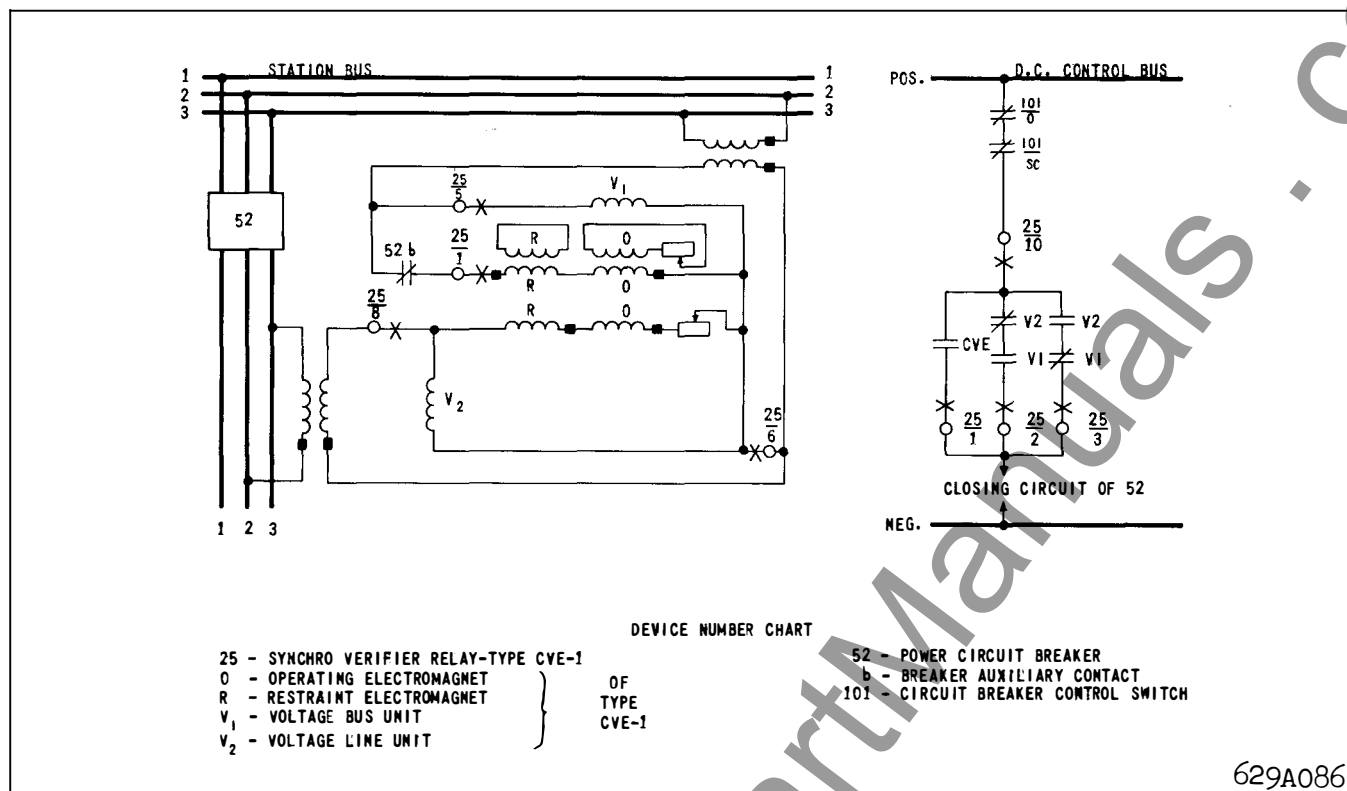


Fig. 7 External Schematic of CVE-1 for Dead-Line-Hot and Hot Line-Dead-Bus Reclosing.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order:

Indicating Contactor Switch (ICS) - When Used

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

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

Disc Unit

1. Contacts - The index mark on the movement frame will coincide with the "O" 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 "O" 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 relay per the test diagram of Fig. 12. The contacts should just close when V₂ is within ± 4 volts of the values shown in Fig. 8 for different angles on the 20 degree circle when V₁ is equal to rated voltage.

3. Time Curve - With the time dial set at position 11, the contact should close in 20 ± 1 seconds when V₁ and V₂ are equal to rated voltage at zero phase angle.

4. Single Phase Test - Where a phase shifter and phase angle meter are not available, the relay can be tested with in-phase voltages. Connect the inputs of the variable auto-transformers of figure 12 to a common source. To check the operating circle, apply V₁ equal to rated voltage and vary V₂. The relay contacts should just close when V₂ is raised to 94 ± 4 volts and should just open when V₂ is increased to 190 ± 4 volts.

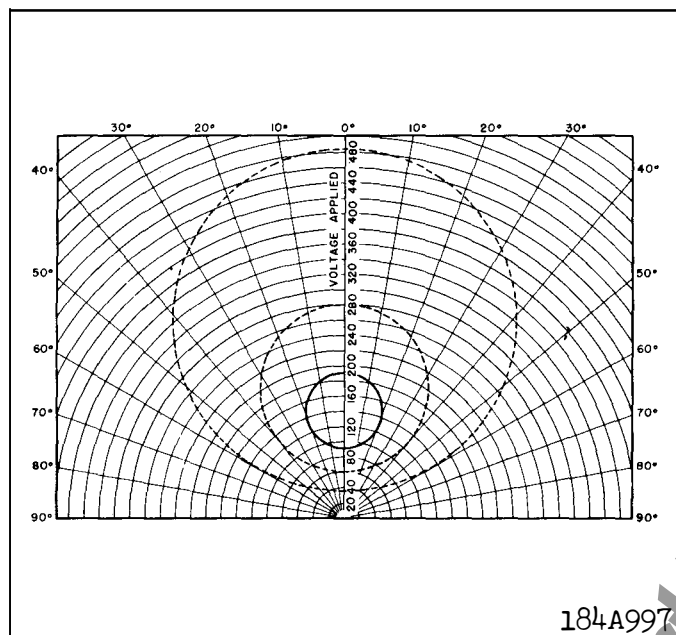


Fig. 8 Typical Voltage-Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.

To check the time curve, set the time dial in position 11 and apply V_1 and V_2 equal to rated voltage. The contacts should close in 20 ± 1 seconds.

Telephone Relays (CVE-1 only)

Apply a.c. volts to each telephone relay circuit. The telephone relay should pickup when 95 volts a.c. is applied.

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 S#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.

Calibration

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs,

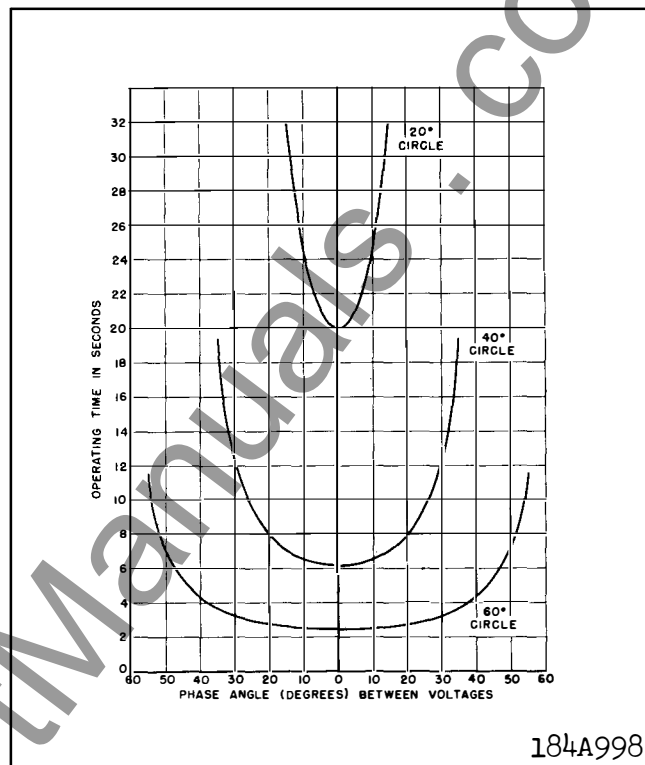


Fig. 9 Typical Time-Phase Angle Curves of CVE. Rated Voltage on Both Circuits No. #11 Dial Time Setting.

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").

1. Contact – The index mark on the movement frame coincides with the "O" 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 "O" 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 – 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

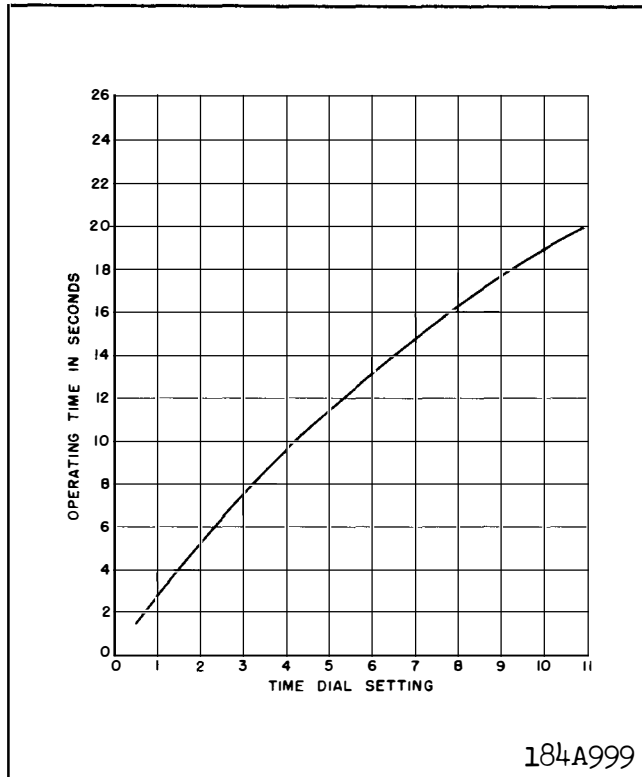


Fig. 10 Operating Time Variations with Changes in Time-Dial Settings. Rated In-Phase Voltage on Both Circuits, 20 Degree Circle Setting.

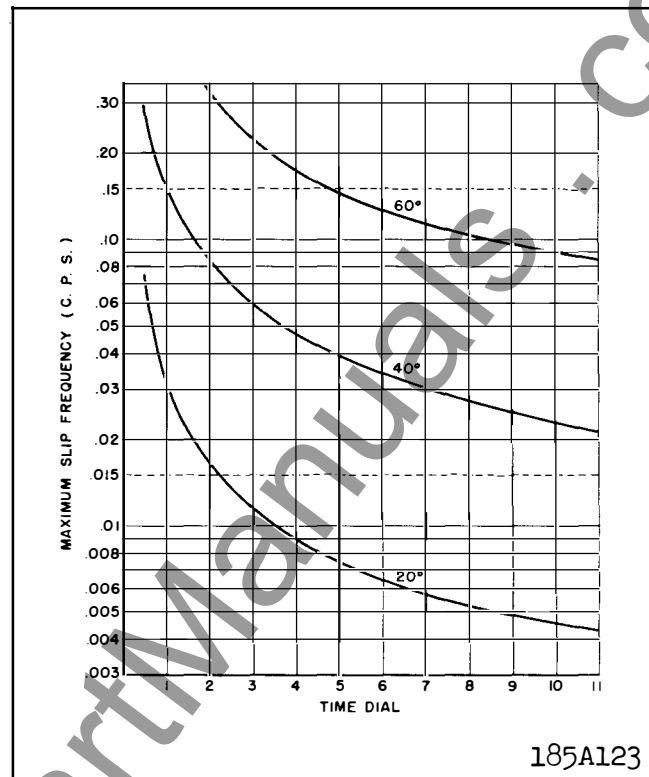


Fig. 11 Approximate Maximum Slip Frequency for which Operation Occurs - Rated Voltage on Both Sides.

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 Fig. 12 and apply rated voltage at zero 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 timedial 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 with 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 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 37° and 38° , 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 ± 2 degrees with V_1 and V_2 equal to rated voltage.

The relay is now calibrated for a 20 degree circle. Other points of the circle may be checked by apply-

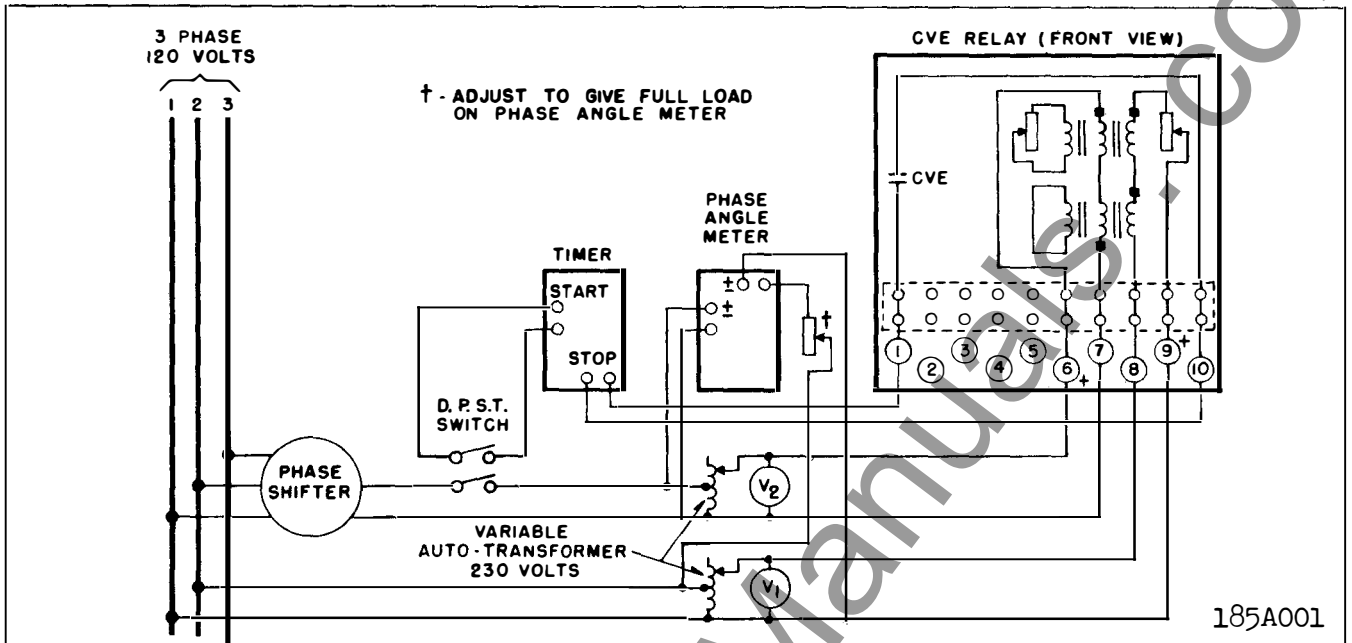


Fig. 12 Diagram of CVE Test Connections.

ing the proper value of V_2 at the proper angle. The 20 degree circle should be within ± 4 volts of the curve value.

6. 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 ± 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 Fig. 9.

Calibration With-in Phase Voltages

If a phase angle meter and a phase shifter are not available, the relay can be calibrated with in phase

voltages for approximate circles in the following manner:

1. 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 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.

2. 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 either by opening the screw connection on the lag of the rear electromagnet or by inserting a piece of insulating material under the adjustable point of the left hand resistor (front view). Apply rated voltage at zero phase angle to both circuits of the relay. (This can be done by connecting the inputs of the variable auto-transformers of Fig. 12 to a common source. With

the right hand plug all the way in, adjust the left hand plug 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.

3. Centering Circle — To center the circle, set the right hand resistor (front view) between one-third to one-half of its adjustment. This will set the center of the circle within two degrees of zero.

4. Spring Adjustment — Adjust the left hand resistor (front view) such that the moving contact just leaves the backstop of the time dial at the number 11 position with V_1 equal to 120 volts and V_2 equal to 64 volts. Then adjust the reset spring such that the contacts will just close with V_1 equal to 120 volts and V_2 equal to 94 volts.

The relay is now calibrated for approximately a 20 degree circle. Check the other in phase point of the circle by applying V_1 equal to 120 volts and increasing the value of V_2 until the contacts are just making. V_2 should be 190 ± 8 volts.

4. Time Curve — Install the permanent magnet on the relay. Adjust the permanent magnet keeper until the operating time of the relay from the 11 time dial position is 20 ± 0.6 seconds with V_1 and V_2 equal to rated voltage at zero phase angle.

5. Circles Other Than 20 Degrees — This adjustment should not be done until the above adjustment for a 20 degree circle has been completed.

Set V_1 equal to noted voltage and apply V_2 to a value as determined by Fig. 13. Adjust the left hand resistor until the contacts just close.

Check the circle by timing the relay with V_1 and V_2 equal to rated voltage. The relay should operate from the number 11 time dial position within ± 7 percent of the times shown in Fig. 14.

ELECTRICAL CHECKPOINTS

With V_1 in Fig. 12 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
Lag coil circuit	22
Restraint Electromagnet	
Upper terminals	58
Lower terminals	54

With 120 volts applied to V_2 circuit only

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

Restraint Electromagnet	
Upper terminals	54
Lower terminals	58

Approximate d.c. 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

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.

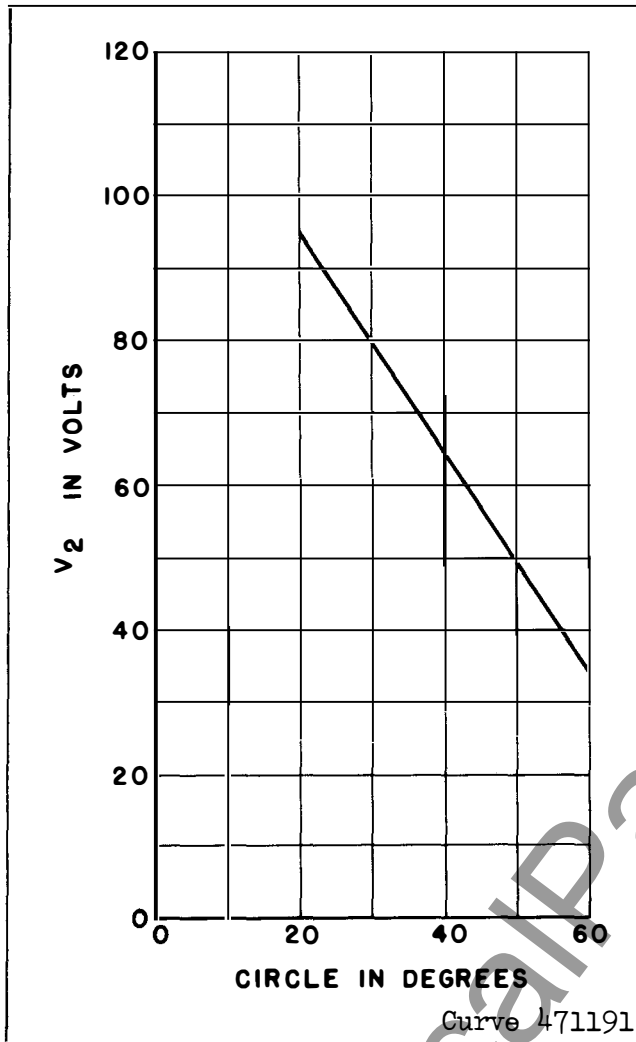


Fig. 13 V_2 Voltage for Different Operating Circles. V_1 equal to rated voltage at zero phase angle. (Curve 471191)

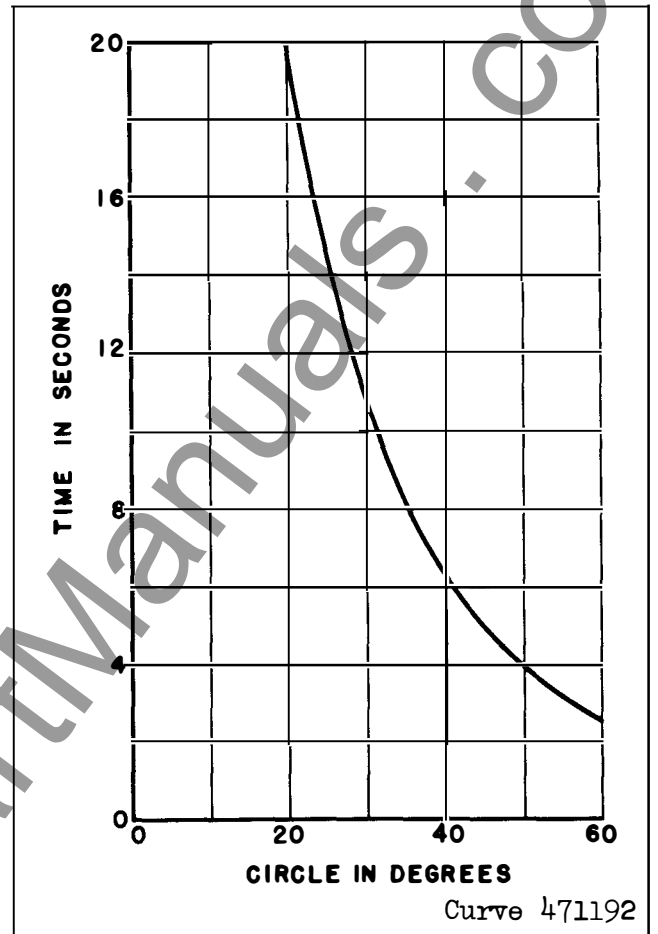


Fig. 14 Operating Times from the No. 11 Time Dial Position for the Type CVE Relay set for Different Operating Circles. V_1 and V_2 equal to rated voltage at zero phase angle. (Curve 471192)

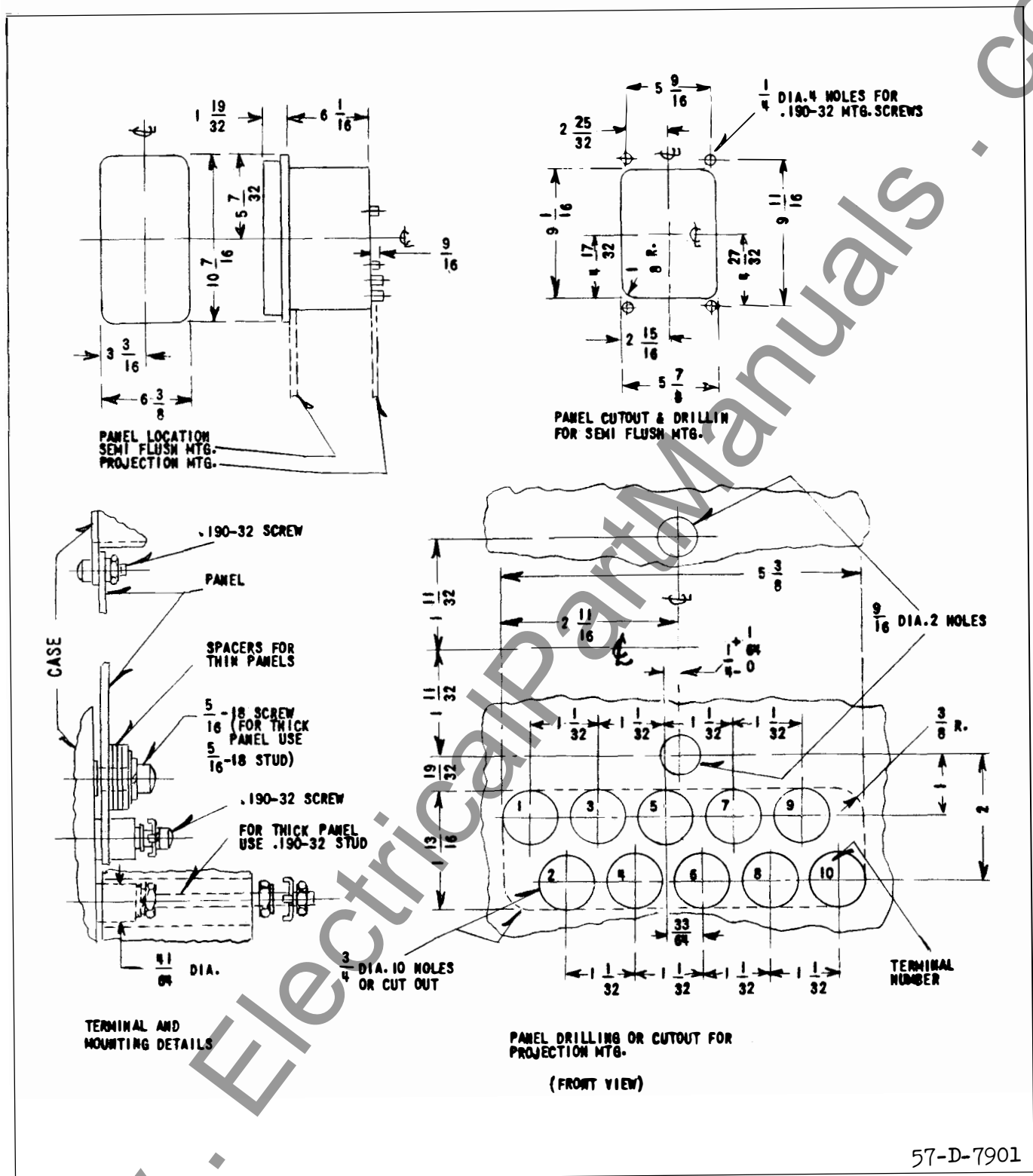


Fig. 15 Outline and Drilling Plan for the CVE and CVE-1 in FT21 case.



INSTALLATION • OPERATION • MAINTENANCE I N S T R U C T I O N S

TYPE CVE AND CVE-1 SYNCHRO-VERIFIER 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.

APPLICATION

The synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The contacts will close when these voltages are within set limits.

The synchro-verifier is not an automatic synchronizer and should not be used as such. Automatic Synchronizers are available which permit closing ahead of synchronism at an angle of phase-advance proportional to the beat frequencies and determined by the speed of operation of the circuit breaker so that the two systems are connected right on synchronism.

A common application of the synchro-verifier is in conjunction with automatic reclosing equipment on 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 the automatic reclosing equipment to reclose the breaker.

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- CVE-1 Synchro-Verifier Relay

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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 Figs. 1, 2, 3, and 4.

The CVE-1 relay consists of two telephone type relays in addition to the components of the CVE Relay. The principal parts of the relay are connected as per figure 5.

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 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 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.

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.

Indicating Contactor Switch Unit (ICS) - When Used

The d-c indicating contactor switch is a small

SUPERSEDES I.L. 41-681.1E

*Denotes change from superseded issue.

EFFECTIVE OCTOBER 1965

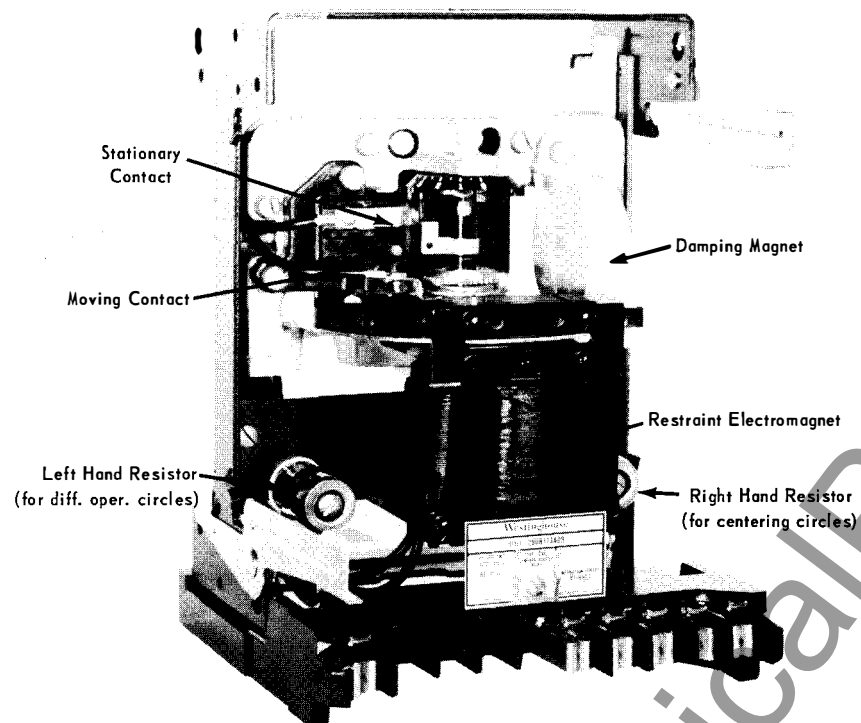


Fig. 1. Type CVE Relay, without Case (Front View)

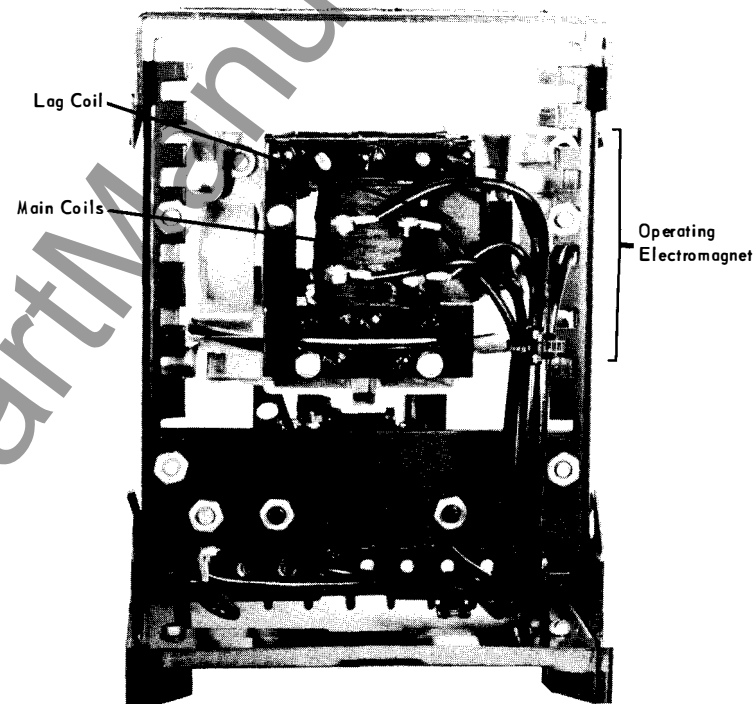


Fig. 2. Type CVE Relay, without Case (Rear View)

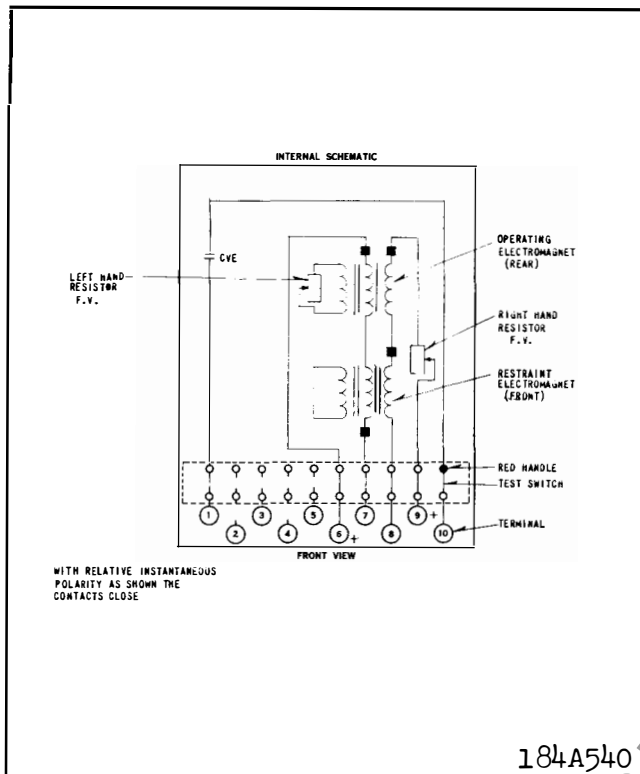


Fig. 3. Internal Schematic of CVE, without ICS Unit.

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.

Telephone Relay

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

Operation With Voltage Relays

The connections shown in Fig. 6 using type SG voltage relays will provide the following operation:

1. Close the breaker when the bus is alive and the line is dead, through the 59B make con-

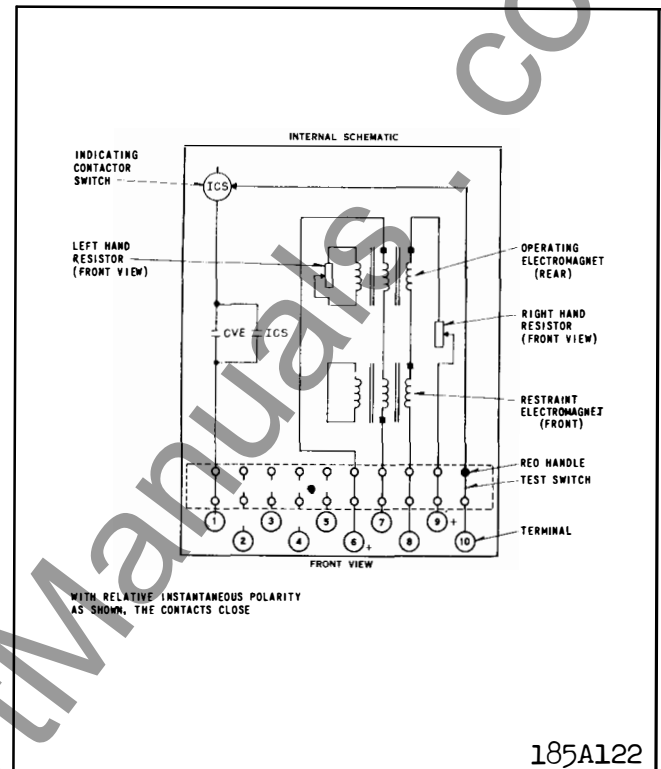


Fig. 4. Internal Schematic of CVE, with ICS Unit.

tact and 27L break contact.

2. Close the breaker when the line is alive and the bus is dead, through the 59L make contact and 27B 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 and SG relays.

CVE - 1 Operation

The connections shown in Figure 7 using the type CVE-1 relay will provide the following operation:

1. Close the breaker when the bus is alive and the line is dead, through the V₂ make contact and V₁ break contact.
2. Close the breaker when the line is alive and the bus is dead, through the V₁ make contact and V₂ break contact.

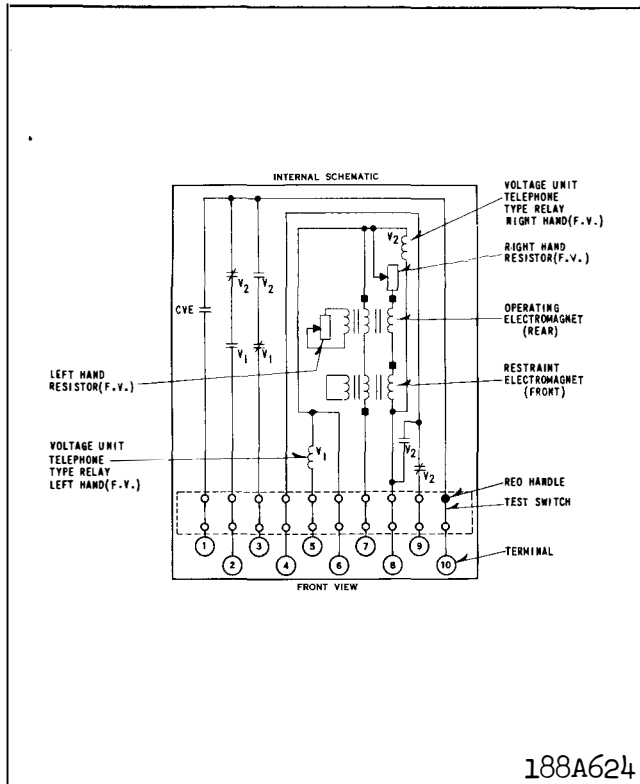


Fig. 5. Internal Schematic of CVE-1

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:

CHARACTERISTICS

The type CVE relay and CVE-1 can be adjusted for operating circles from 20 to 60 degrees as shown in Fig. 8. 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 Fig. 9. 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 Fig. 10.

Fig. 11 shows how high a slip frequency will cause operation. The maximum slip frequency is a function of the circle and time dial settings. This characteristic is of interest in estimating the angular difference at the instant of breaker closure, for cases where the two systems are slipping slowly.

Burden

The burden imposed on each potential source by the CVE relay and CVE-1 relay, with rated voltage applied to both circuits of the relay is as follows:

	Voltages in Phase	Voltages 180 Degrees Out of Phase
Volt-amperes	15.4	13.5
Power Factor	.422	.422
Watts	6.5	5.7

The burden of the CVE relay and CVE-1 relay with rated voltage applied to one circuit is as follows:

Volt-amperes	10.8
Power Factor	.422
Watts	4.6

The burden of each telephone relay at 120 volts is as follows:

10.62 volt-amperes Power Factor 0.64

Continuous Rating

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

SETTINGS

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 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 as low as the ½ time dial should be satisfactory with the 20° circle. Note from Fig. 10 that the relay will operate in 1.4 seconds in the ½ time dial positions and with the 20° setting. If a longer delay is desired a

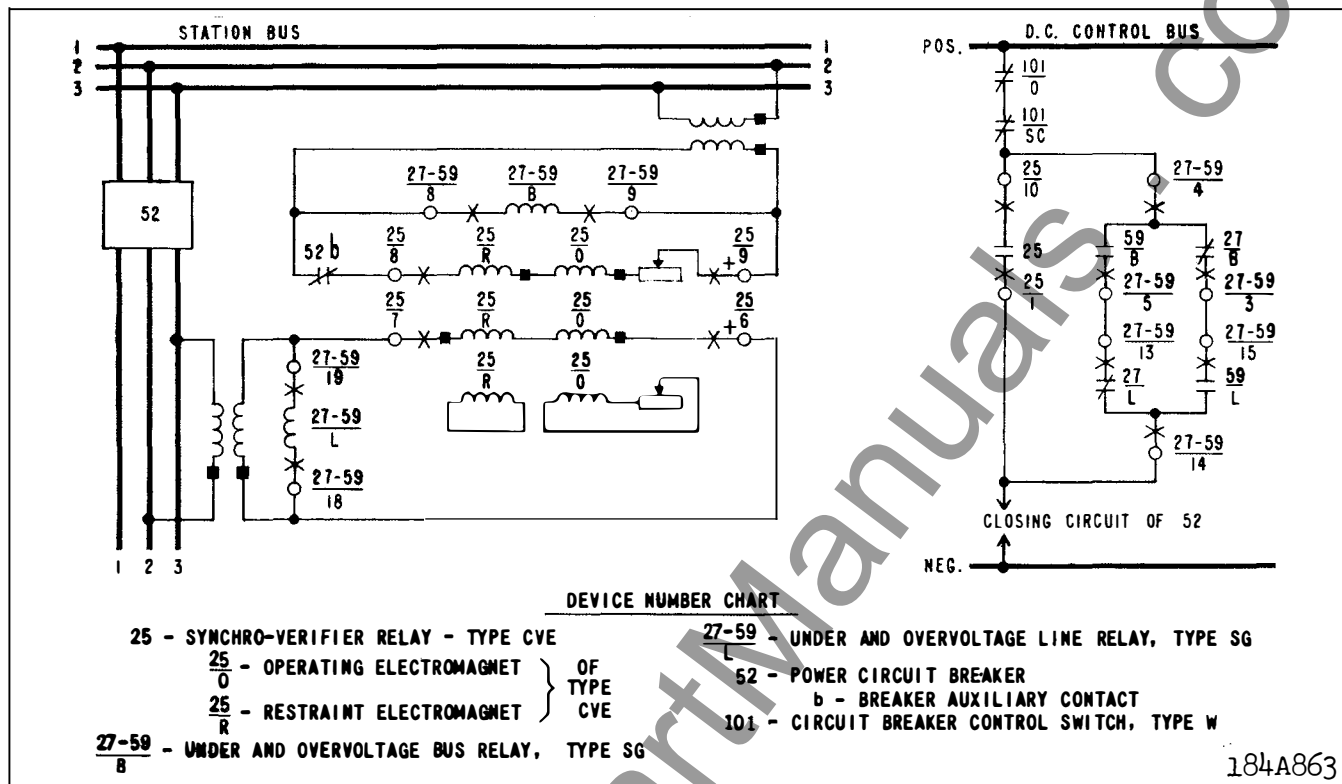


Fig. 6 External Schematic of the CVE with SG Relay for Dead-Line-Hot Bus and Hot Line-Dead Bus Reclosing.

higher time-dial setting may be used.

To evaluate the effect of time-dial and circle settings on the phase-angle difference between the two systems at the instant of breaker closure, refer to Fig. 9. For example, assume a 40° circle and #4 time-dial setting. Also assume that the systems are slipping at a frequency of 0.048 cycles per second, 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 systems 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:

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

where T_B = breaker closing time in seconds

Let $T_B = 0.5$ seconds

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

Indicating Contactor Switch (ICS) - When Used

No setting is required on the ICS unit.

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.

For detailed FT Case information refer to I.L. 41-076.

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.

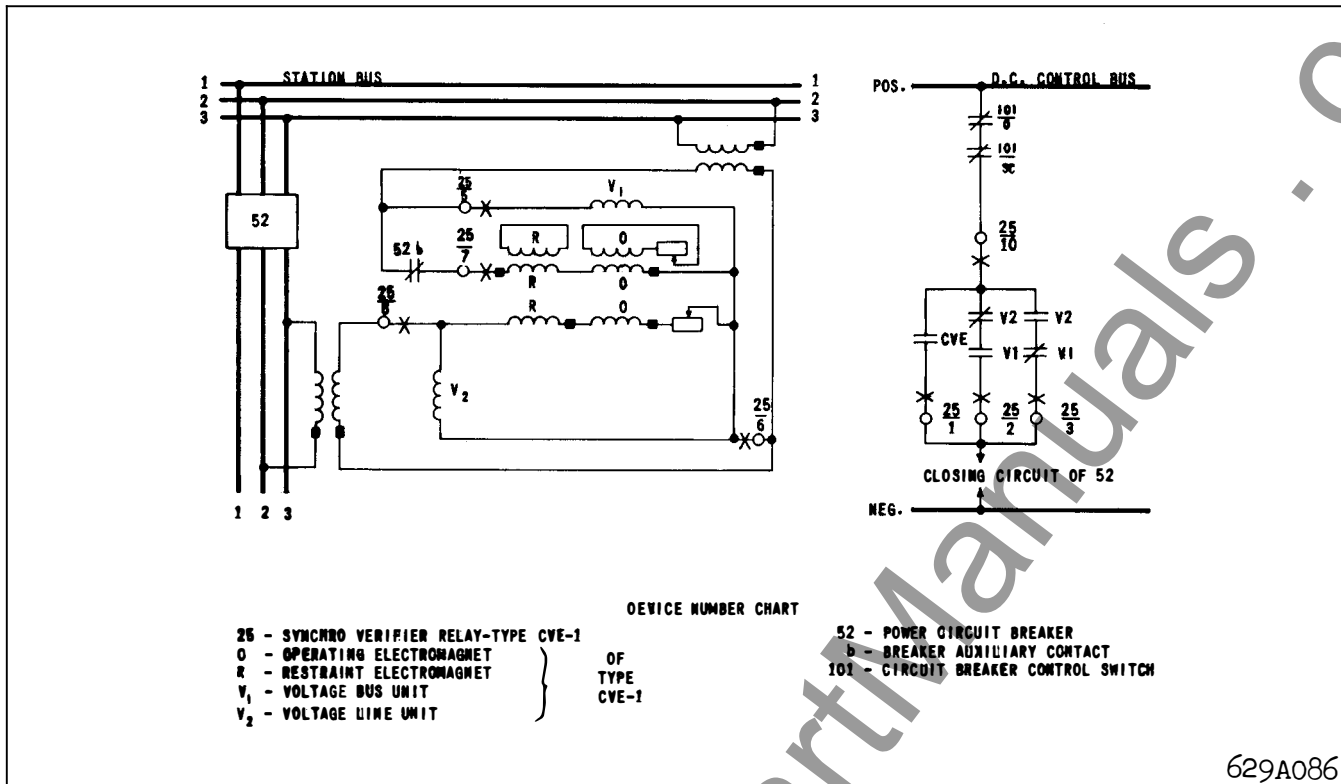


Fig. 7 External Schematic of CVE-1 for Dead-Line-Hot and Hot Line-Dead-Bus Reclosing.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order:

Indicating Contactor Switch (ICS) - When Used

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

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

Disc Unit

1. Contacts - The index mark on the movement frame will coincide with the "O" 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 "O" 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 relay per the test diagram of Fig. 12. The contacts should just close under the following two conditions:

- 1) When $V_2 = V_1 = \text{rated voltage}$ and their phase difference is between 18° and 22° (either leading or lagging).
- 2) When $V_1 = \text{rated voltage}$ and V_2 is increased to $94 \pm 4V$, in phase with V_1

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

To check the time curve, set the time dial in position 11 and apply V_1 and V_2 equal to rated voltage. The contacts should close in 20 ± 1 seconds.

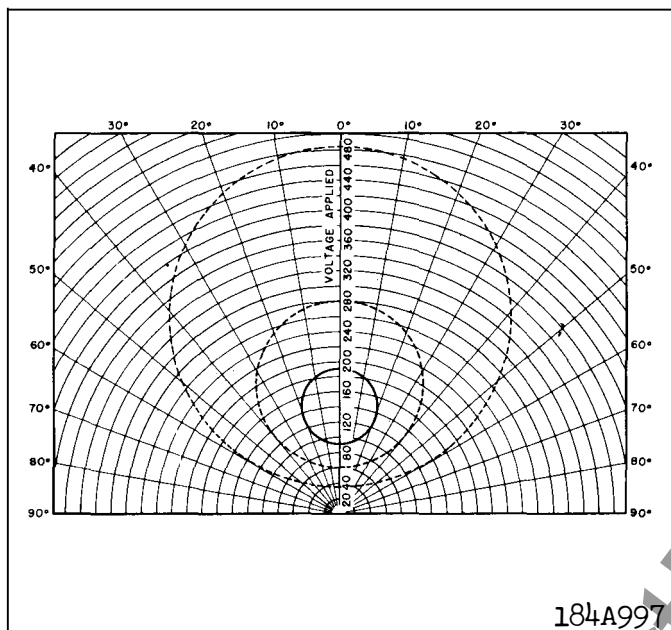


Fig. 8 Typical Voltage-Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.

Telephone Relays (CVE-1 only)

Apply a.c. volts to each telephone relay circuit. The telephone relay should pickup when 95 volts a.c. is applied.

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 S#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.

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

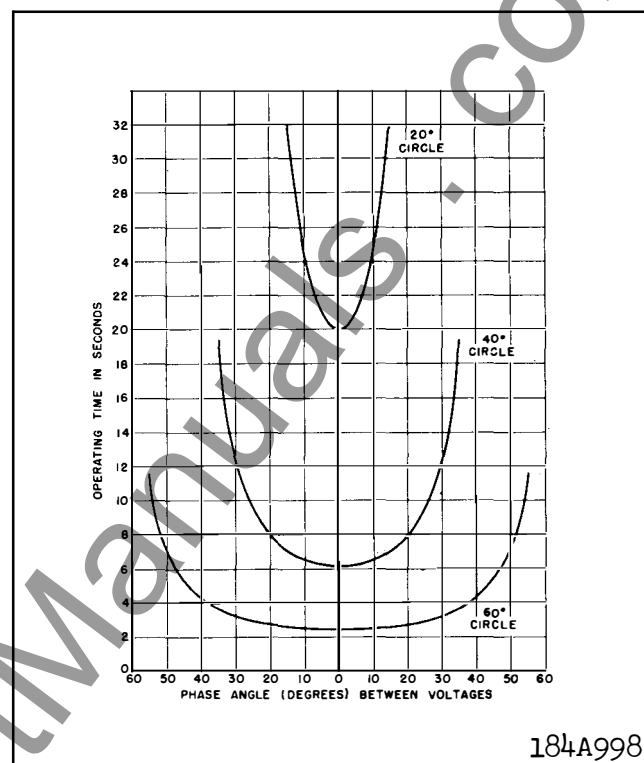


Fig. 9 Typical Time-Phase Angle Curves of CVE. Rated Voltage on Both Circuits No. #11 Dial Time Setting.

the relay is not in proper working order (See "Acceptance Check").

1. Contact – The index mark on the movement frame coincides with the "O" 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 "O" 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 – 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

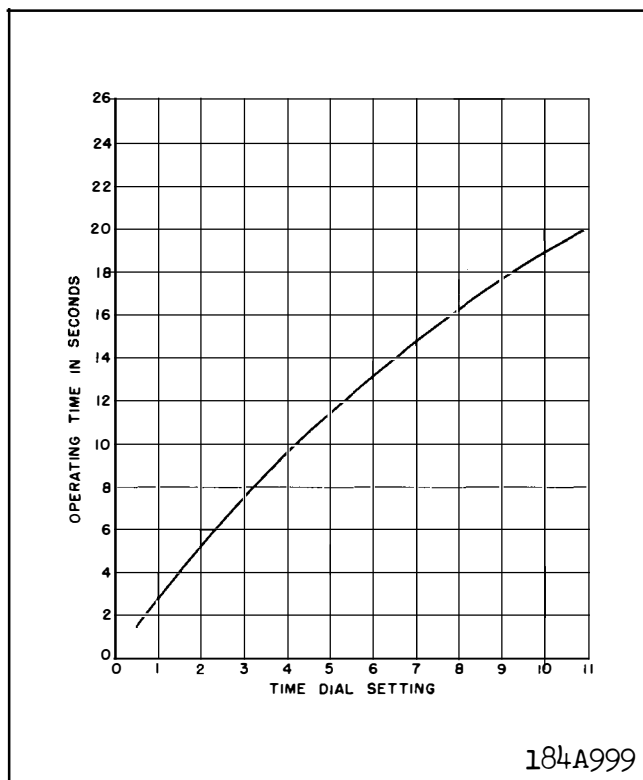


Fig. 10 Operating Time Variations with Changes in Time-Dial Settings. Rated In-Phase Voltage on Both Circuits, 20 Degree Circle Setting.

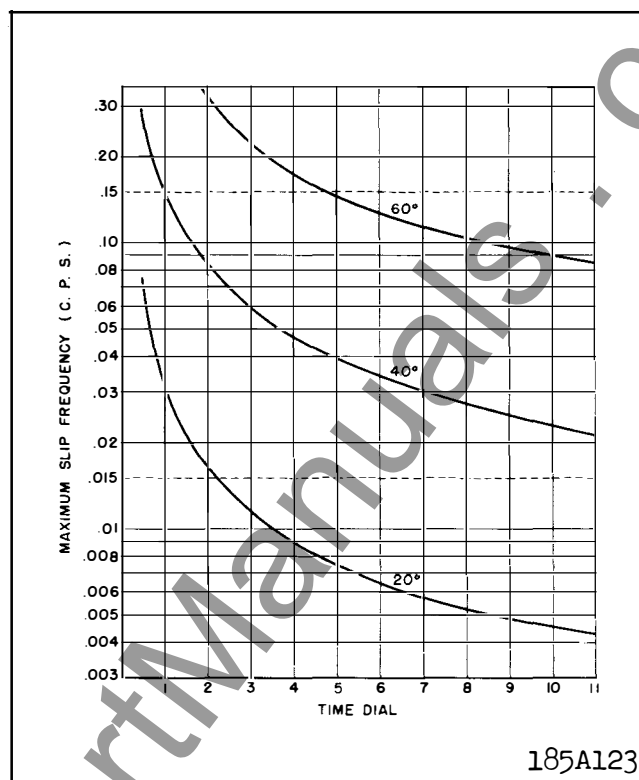


Fig. 11 Approximate Maximum Slip Frequency for which Operation Occurs - Rated Voltage on Both Sides.

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 Fig. 12 and apply rated voltage at zero 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 with 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 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° 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 ± 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 $94 \pm 4V$, in phase with V_1 . If necessary, readjust spring slightly to

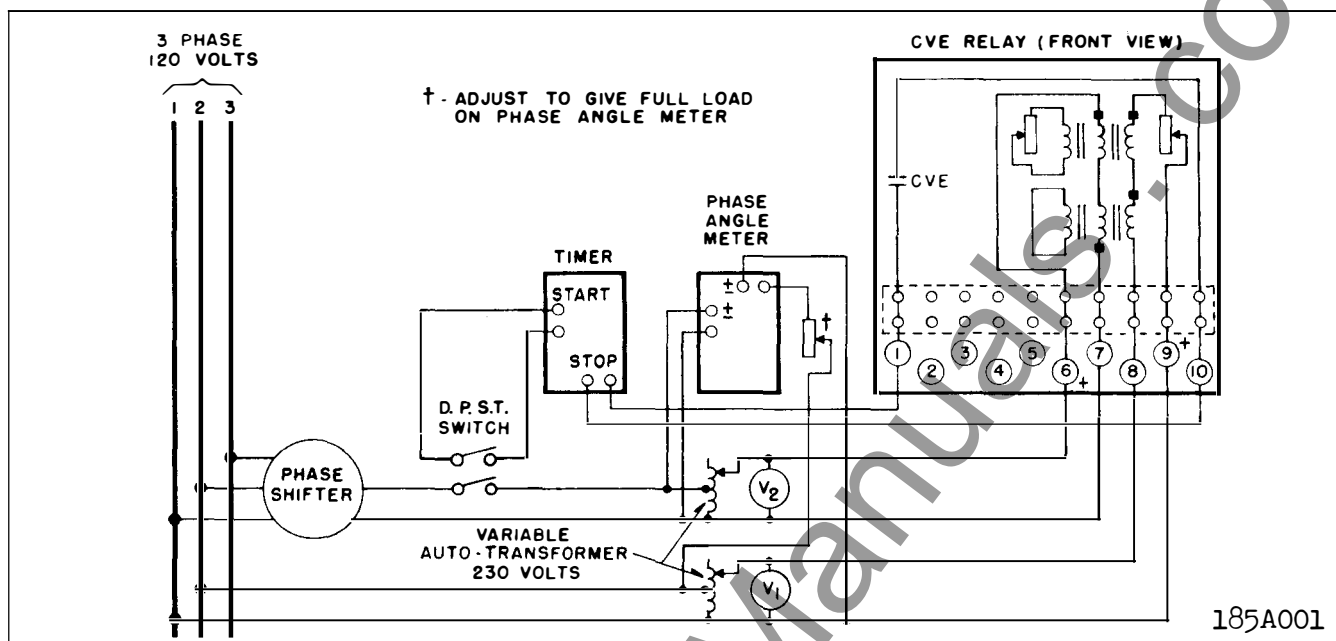


Fig. 12 Diagram of CVE Test Connections.

obtain this condition. The relay is now calibrated for a 20 degree circle.

6. 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 ± 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 Fig. 9.

ELECTRICAL CHECKPOINTS

With V_1 in Fig. 12 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
Lag coil circuit	22

Restraint Electromagnet

Upper terminals	58
Lower terminals	54

With 120 volts applied to V_2 circuit only

Operating Electromagnet

Upper terminals	57
Lower terminals	59
Lag coil circuit	22

Restraint Electromagnet

Upper terminals	54
Lower terminals	58

Approximate d.c. 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

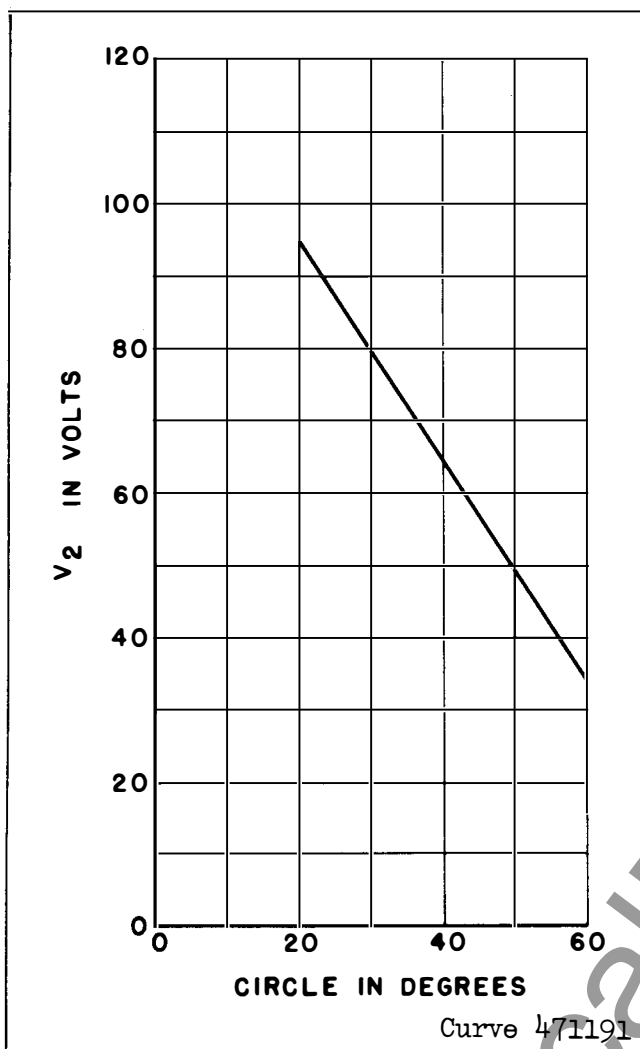


Fig. 13 V_2 Voltage for Different Operating Circles. V_1 equal to rated voltage at zero phase angle. (Curve 471191)

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

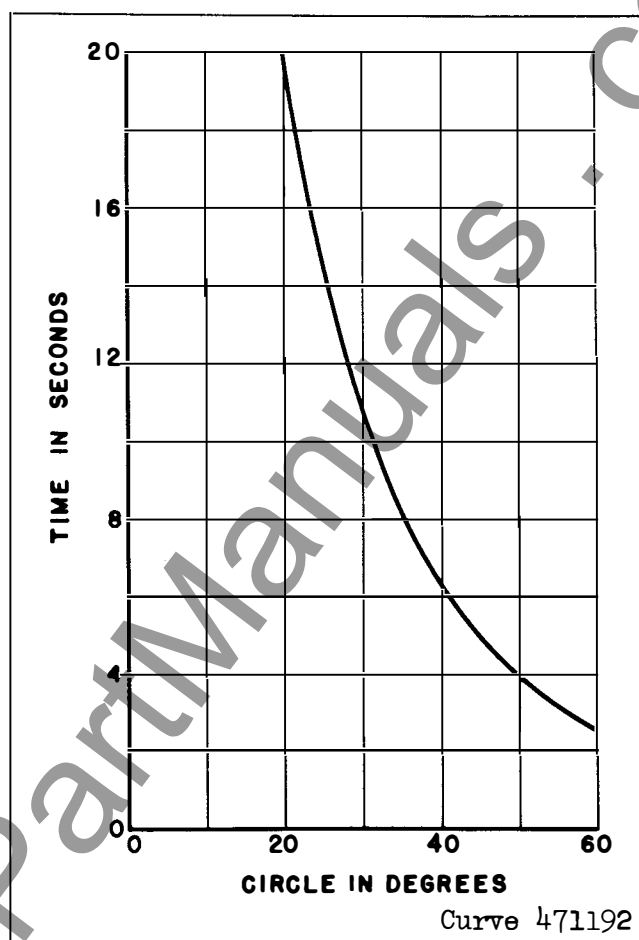


Fig. 14 Operating Times from the No. 11 Time Dial Position for the Type CVE Relay set for Different Operating Circles. V_1 and V_2 equal to rated voltage at zero phase angle. (Curve 471192)

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.

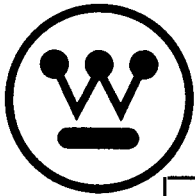




WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION

NEWARK, N. J.

Printed in U.S.A.



INSTALLATION • OPERATION • MAINTENANCE INSTRUCTIONS

TYPE CVE AND CVE-1 SYNCHRO-VERIFIER 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.

APPLICATION

The synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The contacts will close when these voltages are within set limits.

The synchro-verifier is not an automatic synchronizer and should not be used as such. Automatic Synchronizers are available which permit closing ahead of synchronism at an angle of phase-advance proportional to the beat frequencies and determined by the speed of operation of the circuit breaker so that the two systems are connected right on synchronism.

A common application of the synchro-verifier is in conjunction with automatic reclosing equipment on 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 the automatic reclosing equipment to reclose the breaker.

CONTENTS

This instruction leaflet applies to the following types of relays:

- CVE-- Synchro-Verifier Relay
- CVE-1 Synchro-Verifier Relay

CONSTRUCTION AND OPERATION

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 Figs. 1, 2, 3, and 4.

The CVE-1 relay consists of two telephone type relays in addition to the components of the CVE Relay. The principal parts of the relay are connected as per figure 5.

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 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 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.

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.

Indicating Contactor Switch Unit (ICS) - When Used

The d-c indicating contactor switch is a small

SUPERSEDES I.L. 41-681.1F

*Denotes change from superseded issue.

EFFECTIVE JULY 1967

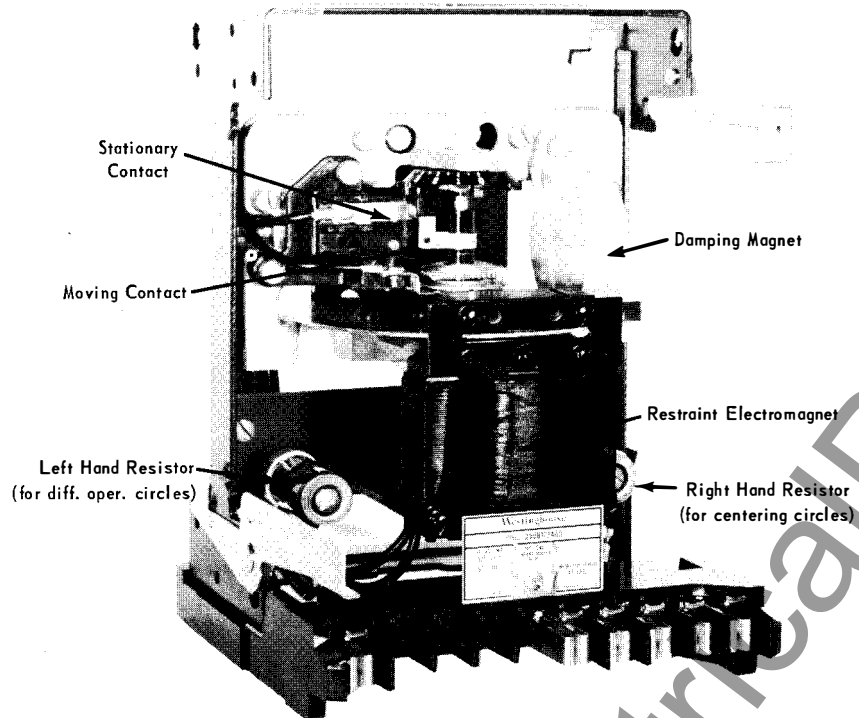


Fig. 1. Type CVE Relay, without Case (Front View)

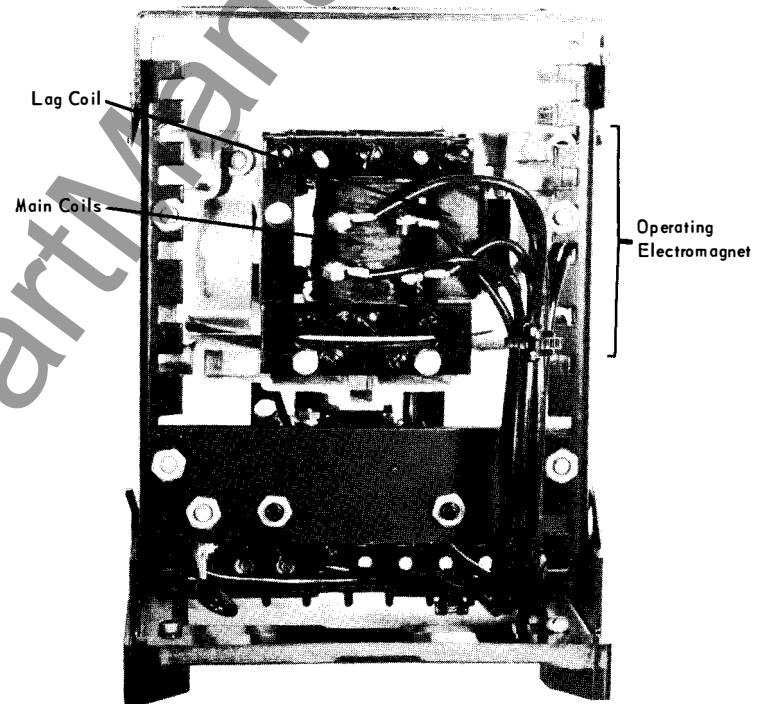


Fig. 2. Type CVE Relay, without Case (Rear View)

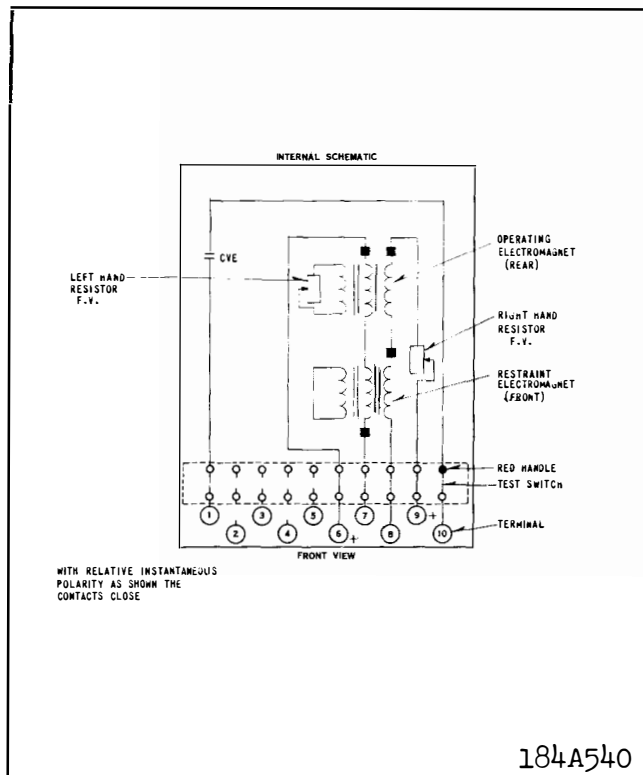


Fig. 3. Internal Schematic of CVE, without ICS Unit.

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.

Telephone Relay

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

Operation With Voltage Relays

The connections shown in Fig. 6 using type SG voltage relays will provide the following operation:

1. Close the breaker when the bus is alive and the line is dead, through the 59B make con-

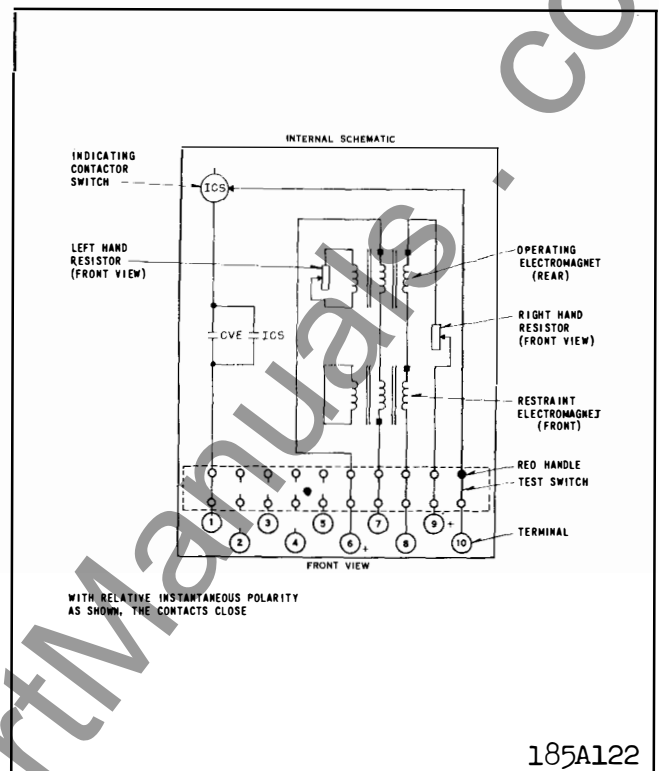


Fig. 4. Internal Schematic of CVE, with ICS Unit.

tact and 27L break contact.

2. Close the breaker when the line is alive and the bus is dead, through the 59L make contact and 27B 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 and SG relays.

CVE - 1 Operation

The connections shown in Figure 7 using the type CVE-1 relay will provide the following operation:

1. Close the breaker when the bus is alive and the line is dead, through the V₂ make contact and V₁ break contact.
2. Close the breaker when the line is alive and the bus is dead, through the V₁ make contact and V₂ break contact.

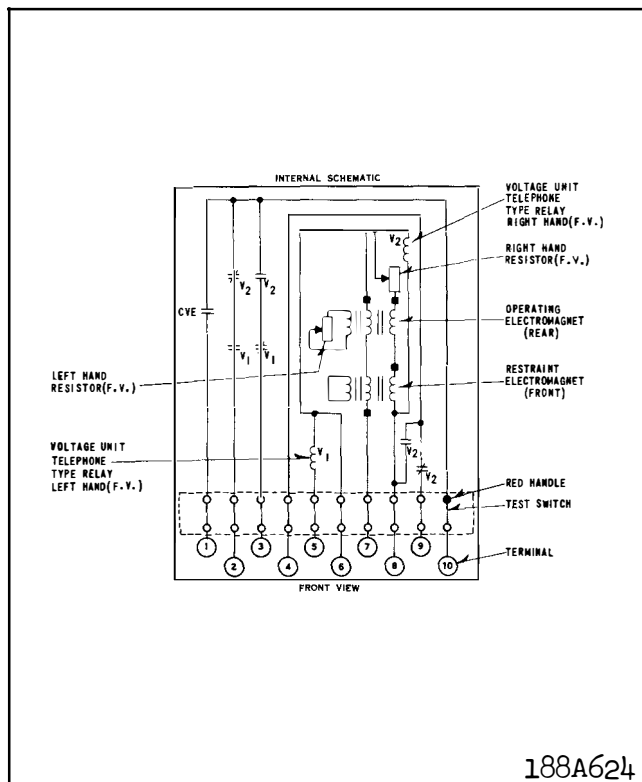


Fig. 5. Internal Schematic of CVE-1

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:

CHARACTERISTICS

The type CVE relay and CVE-1 can be adjusted for operating circles from 20 to 60 degrees as shown in Fig. 8. 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 Fig. 9. 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 Fig. 10.

Fig. 11 shows how high a slip frequency will cause operation. The maximum slip frequency is a function of the circle and time dial settings. This characteristic is of interest in estimating the angular difference at the instant of breaker closure, for cases where the two systems are slipping slowly.

Burden

The burden imposed on each potential source by the CVE relay and CVE-1 relay, with rated voltage applied to both circuits of the relay is as follows:

	Voltages in Phase	Voltages 180 Degrees Out of Phase
Volt-amperes	15.4	13.5
Power Factor	.422	.422
Watts	6.5	5.7

The burden of the CVE relay and CVE-1 relay with rated voltage applied to one circuit is as follows:

Volt-amperes	10.8
Power Factor	.422
Watts	4.6

The burden of each telephone relay at 120 volts is as follows:

10.62 volt-amperes Power Factor 0.64

Continuous Rating

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

SETTINGS

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 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 as low as the ½ time dial should be satisfactory with the 20° circle. Note from Fig. 10 that the relay will operate in 1.4 seconds in the ½ time dial positions and with the 20° setting. If a longer delay is desired a

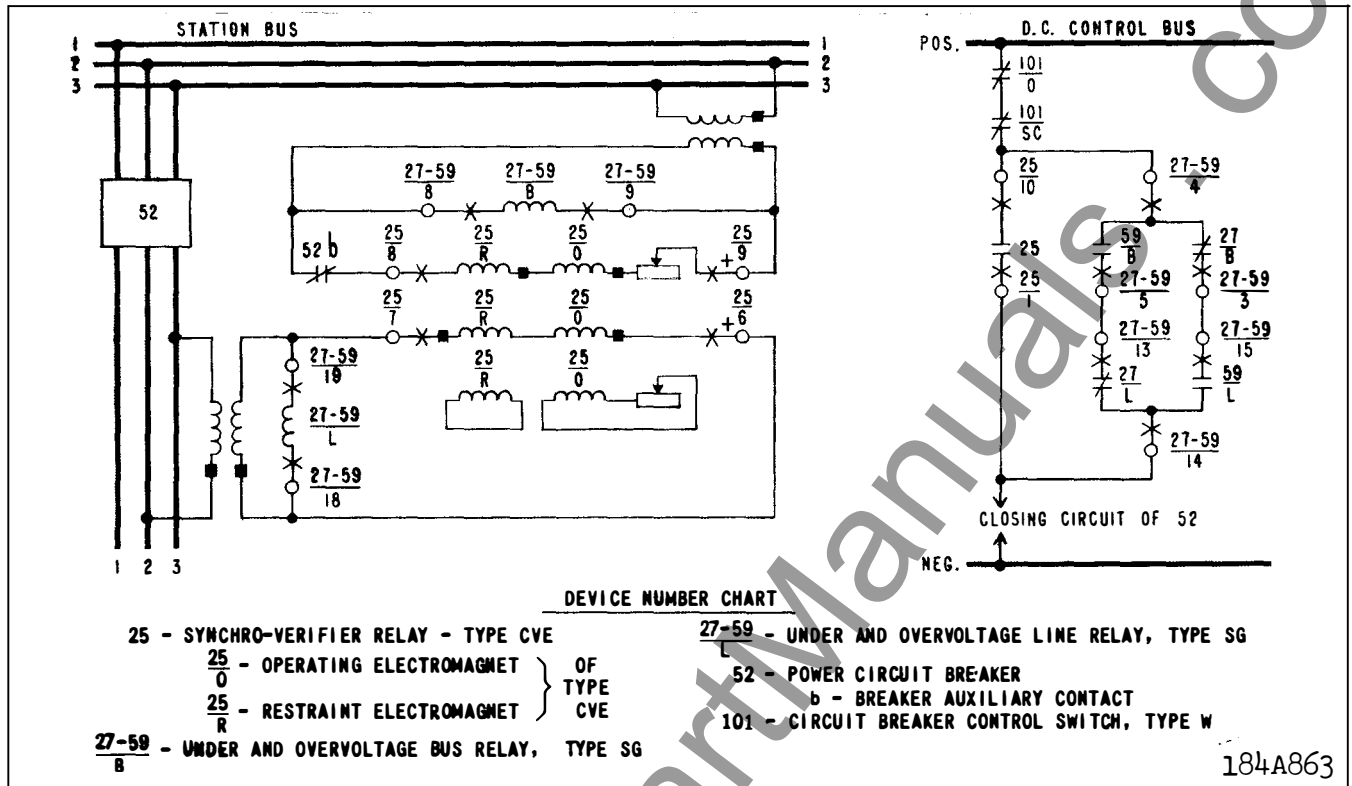


Fig. 6 External Schematic of the CVE with SG Relay for Dead-Line-Hot Bus and Hot Line-Dead Bus Reclosing.

higher time-dial setting may be used.

To evaluate the effect of time-dial and circle settings on the phase-angle difference between the two systems at the instant of breaker closure, refer to Fig. 9. For example, assume a 40° circle and #4 time-dial setting. Also assume that the systems are slipping at a frequency of 0.048 cycles per second, 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 systems 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:

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

where T_B = breaker closing time in seconds

Let $T_B = 0.5$ seconds

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

Indicating Contactor Switch (ICS) - When Used

No setting is required on the ICS unit.

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 flangs 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.

For detailed F'T Case information refer to I.L. 41-076.

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.



Acceptance Check

Indicating Contactor Switch (ICS) – When Used

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

1. Contacts - The index mark on the movement frame will coincide with the "O" 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

2. Operating Circle – Connect the relay per the test diagram of Fig. 12. The contacts should just close under the following two 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 to $94 \pm 4V$, in phase with V_1

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

To check the time curve, set the time dial in position 11 and apply V_1 and V_2 equal to rated voltage. The contacts should close in 20 ± 1 seconds.

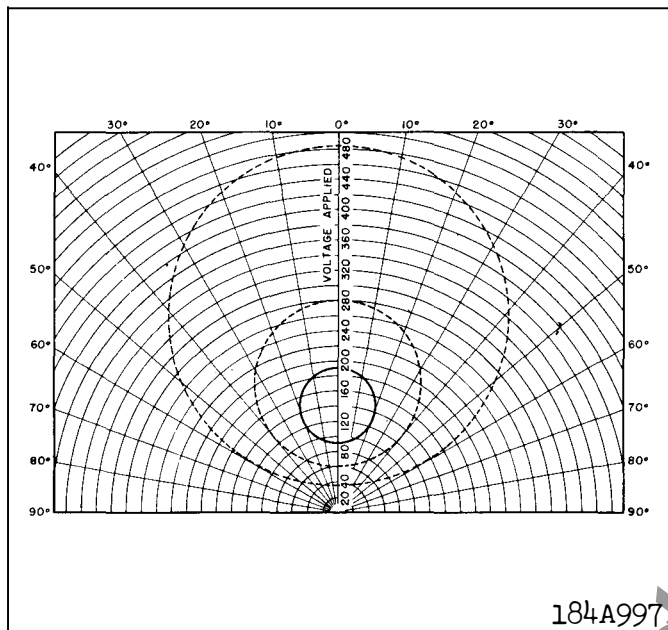


Fig. 8 Typical Voltage-Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.

Telephone Relays (CVE-1 only)

Apply a-c. volts to each telephone relay circuit. The telephone relay should pickup when 95 volts a.c. is applied.

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 S#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.

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

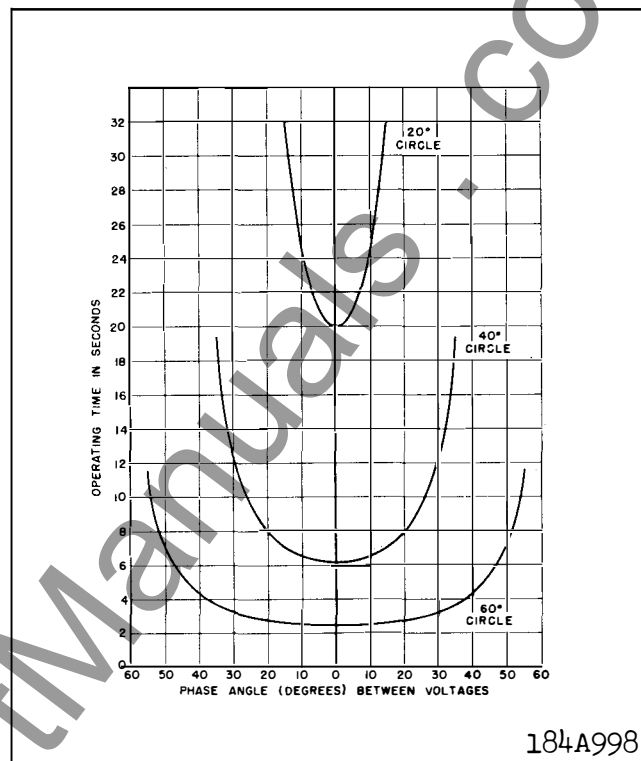
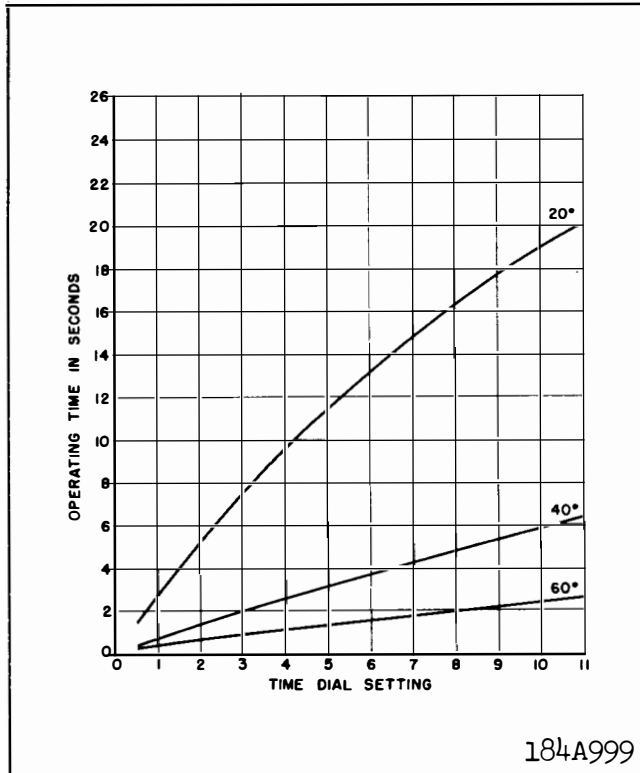


Fig. 9 Typical Time-Phase Angle Curves of CVE. Rated Voltage on Both Circuits No. #11 Dial Time Setting.

the relay is not in proper working order (See "Acceptance Check").

1. Contact – The index mark on the movement frame coincides with the "O" 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 "O" 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 – 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



* Fig. 10 Operating Time Variations with Changes in Time-Dial Settings. Rated In-Phase Voltage on Both Circuits, 20°, 40° and 60° Circle Setting.

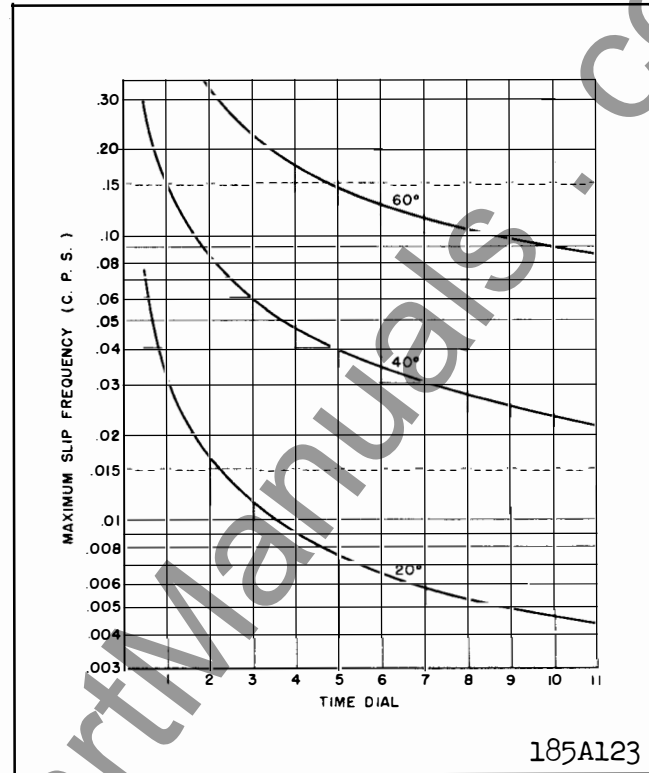


Fig. 11 Approximate Maximum Slip Frequency for which Operation Occurs - Rated Voltage on Both Sides.

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 Fig. 12 and apply rated voltage at zero 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 with 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 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° 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 ± 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 $94 \pm 4V$ in phase with V_1 . If necessary, readjust spring slightly to

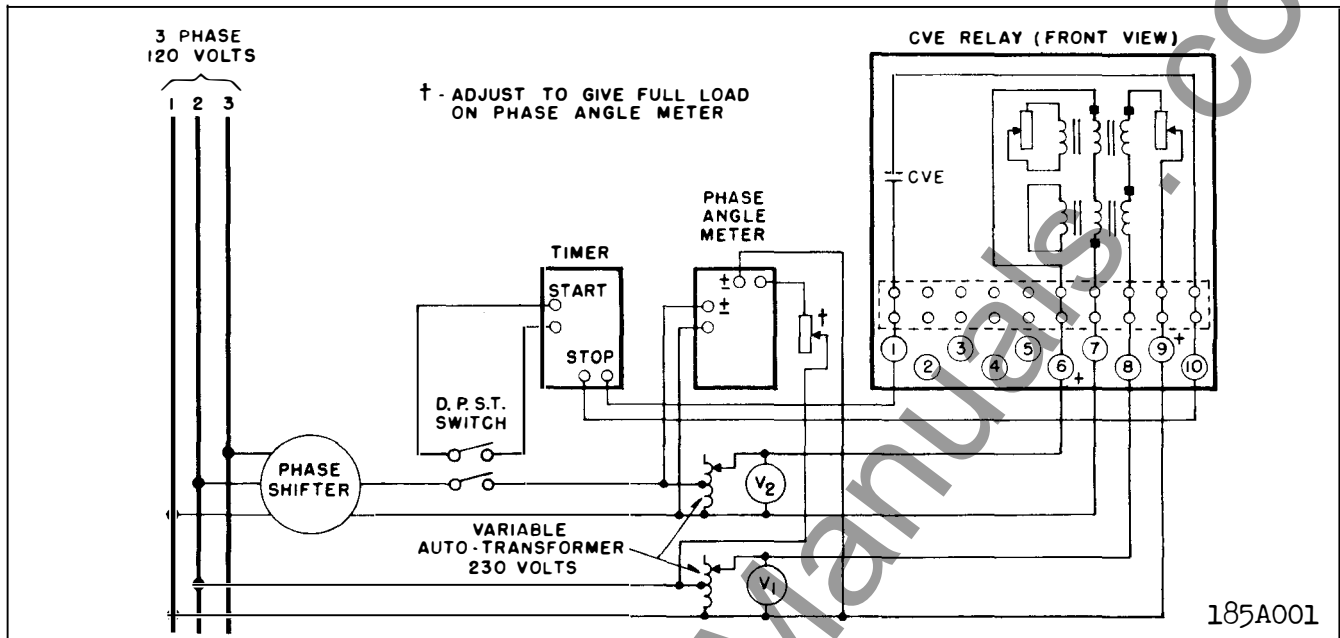


Fig. 12 Diagram of CVE Test Connections.

obtain this condition. The relay is now calibrated for a 20 degree circle.

6. 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 ± 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 Fig. 9.

ELECTRICAL CHECKPOINTS

With V_1 in Fig. 12 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
Lag coil circuit	22
Restraint Electromagnet	
Upper terminals	58
Lower terminals	54

With 120 volts applied to V_2 circuit only	
Operating Electromagnet	
Upper terminals	57
Lower terminals	59
Lag coil circuit	22

Restraint Electromagnet	
Upper terminals	54
Lower terminals	58

Approximate d.c. 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

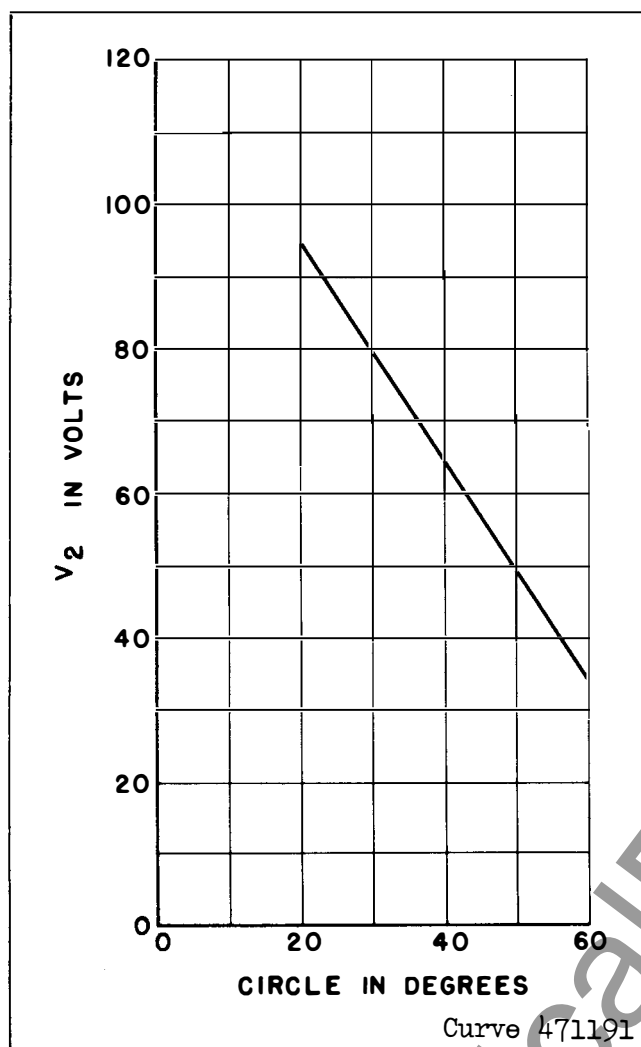


Fig. 13 V_2 Voltage for Different Operating Circles. V_1 equal to rated voltage at zero phase angle. (Curve 471191)

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

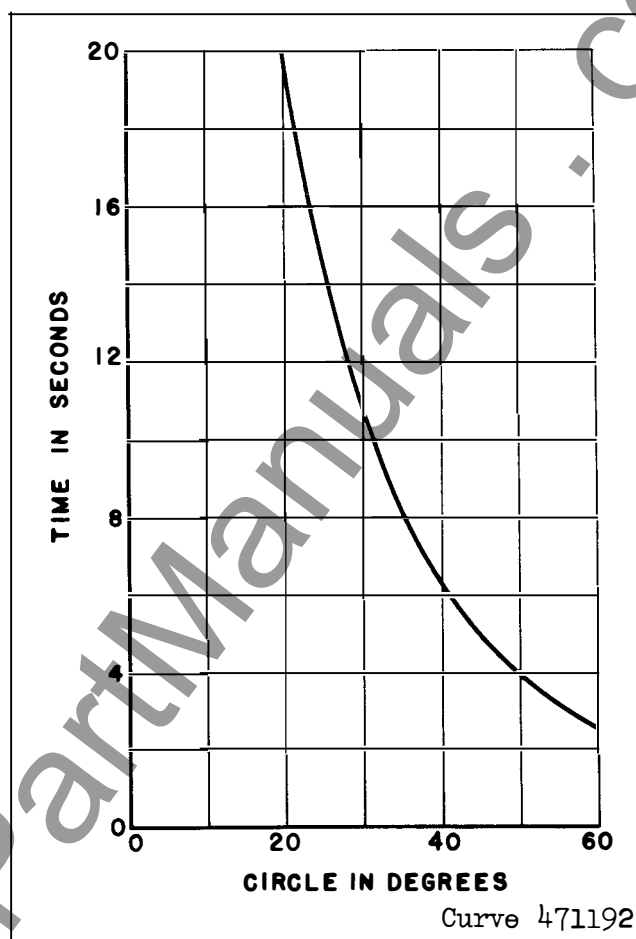


Fig. 14 Operating Times from the No. 11 Time Dial Position for the Type CVE Relay set for Different Operating Circles. V_1 and V_2 equal to rated voltage at zero phase angle. (Curves 471192)

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.

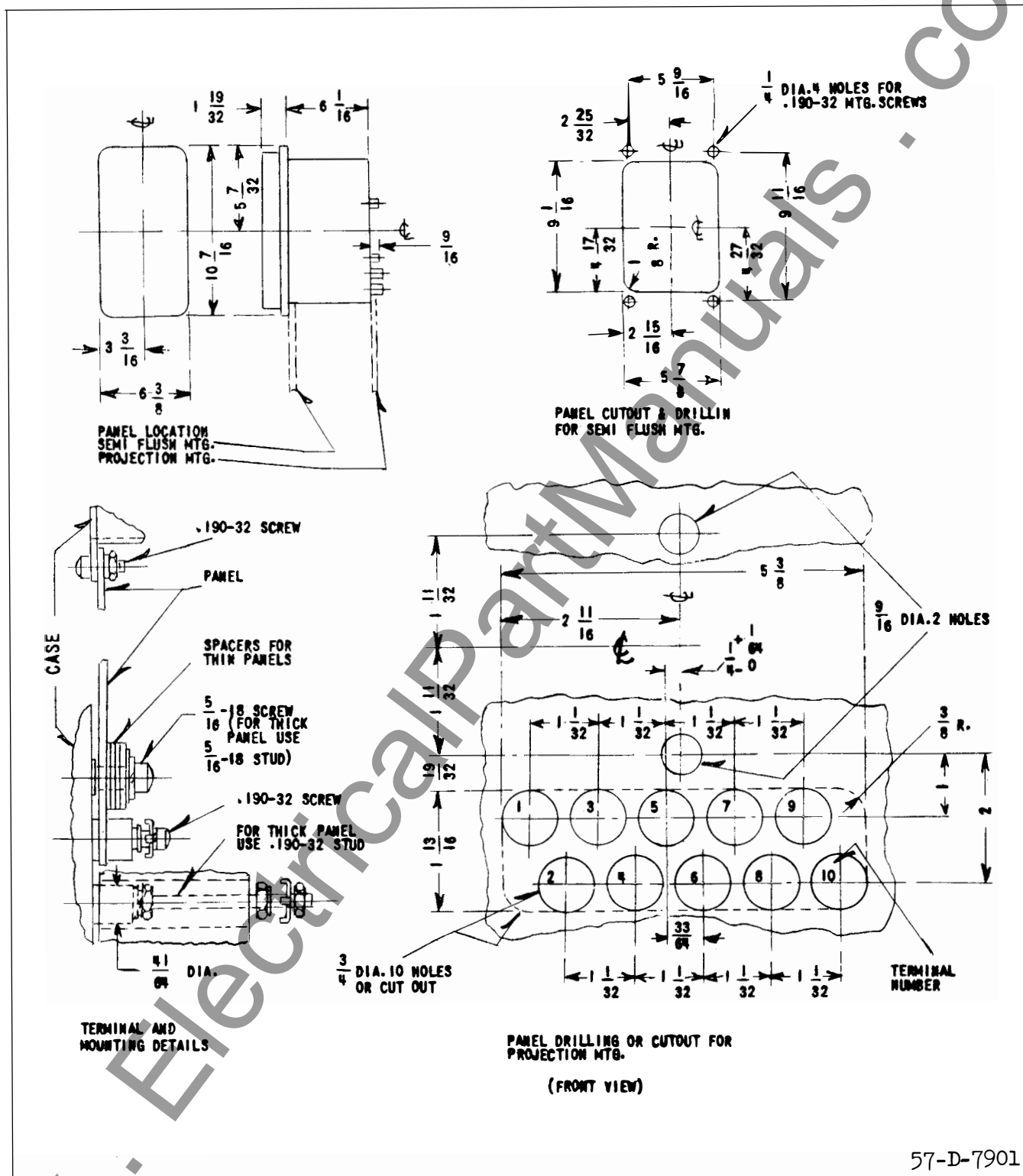


Fig. 15 Outline and Drilling Plan for the CVE and CVE-1 in FT21 case.



WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION

NEWARK, N. J.

Printed in U.S.A.



INSTALLATION • OPERATION • MAINTENANCE I N S T R U C T I O N S

TYPE CVE AND CVE-1 SYNCHRO-VERIFIER 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.

APPLICATION

The synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The contacts will close when these voltages are within set limits.

The synchro-verifier is not an automatic synchronizer and should not be used as such. Automatic Synchronizers are available which permit closing ahead of synchronism at an angle of phase-advance proportional to the beat frequencies and determined by the speed of operation of the circuit breaker so that the two systems are connected right on synchronism.

A common application of the synchro-verifier is in conjunction with automatic reclosing equipment on 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 the automatic reclosing equipment to reclose the breaker.

CONTENTS

This instruction leaflet applies to the following types of relays:

- CVE- Synchro-Verifier Relay
- CVE-1 Synchro-Verifier Relay

CONSTRUCTION AND OPERATION

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 Figs. 1, 2, 3, and 4.

The CVE-1 relay consists of two telephone type relays in addition to the components of the CVE Relay. The principal parts of the relay are connected as per figure 5.

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 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 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.

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.

Indicating Contactor Switch Unit (ICS) - When Used

The d-c indicating contactor switch is a small

SUPERSEDES I.L. 41-681.1G

*Denotes change from superseded issue.

EFFECTIVE NOVEMBER 1968

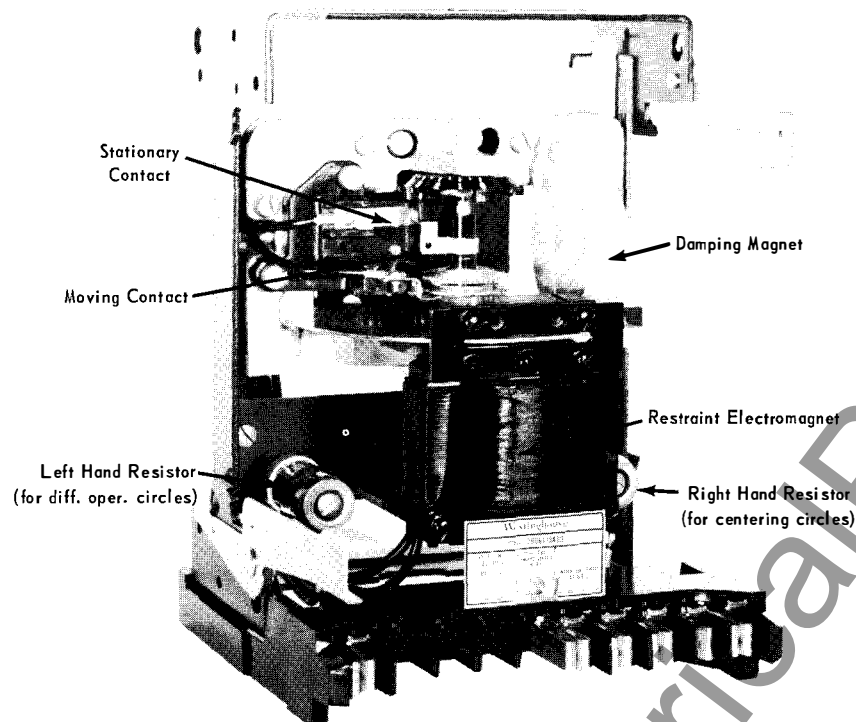


Fig. 1. Type CVE Relay, without Case (Front View)

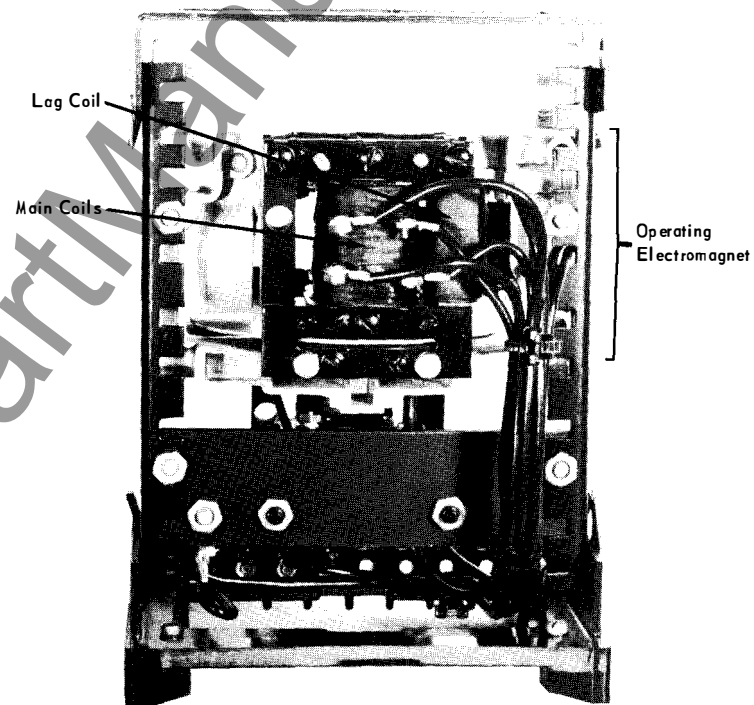


Fig. 2. Type CVE Relay, without Case (Rear View)

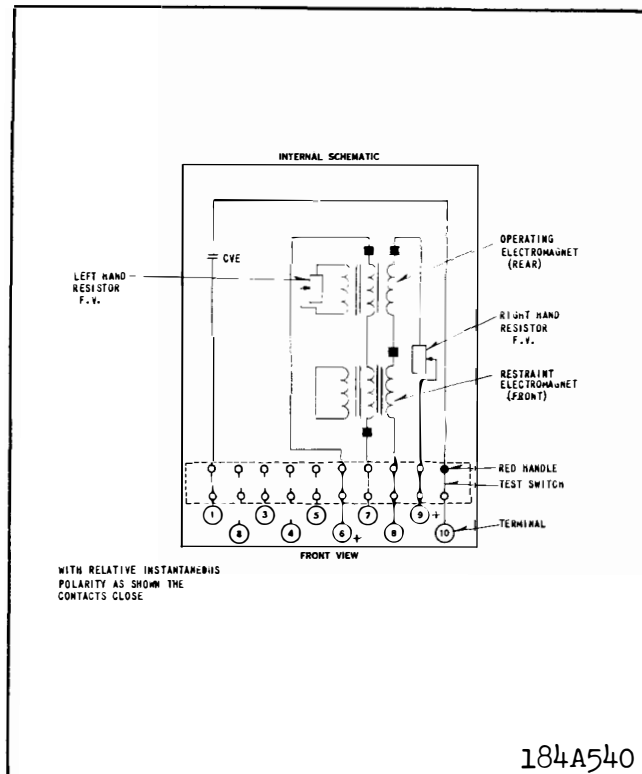


Fig. 3. Internal Schematic of CVE, without ICS Unit.

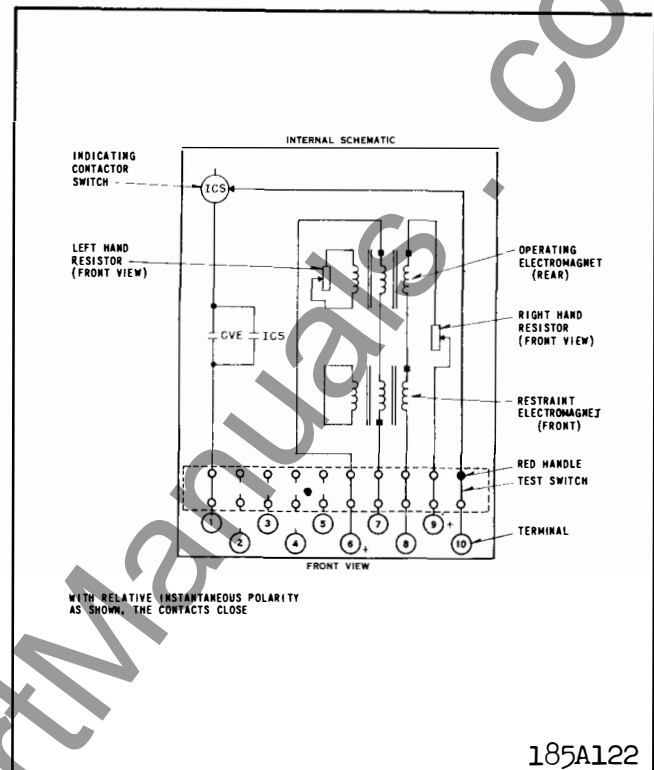


Fig. 4. Internal Schematic of CVE, with ICS Unit.

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.

Telephone Relay

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

Operation With Voltage Relays

The connections shown in Fig. 6 using type SG voltage relays will provide the following operation:

1. Close the breaker when the bus is alive and the line is dead, through the 59B make con-

tact and 27L break contact.

2. Close the breaker when the line is alive and the bus is dead, through the 59L make contact and 27B 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 and SG relays.

CVE - 1 Operation

The connections shown in Figure 7 using the type CVE-1 relay will provide the following operation:

1. Close the breaker when the bus is alive and the line is dead, through the V₂ make contact and V₁ break contact.
2. Close the breaker when the line is alive and the bus is dead, through the V₁ make contact and V₂ break contact.

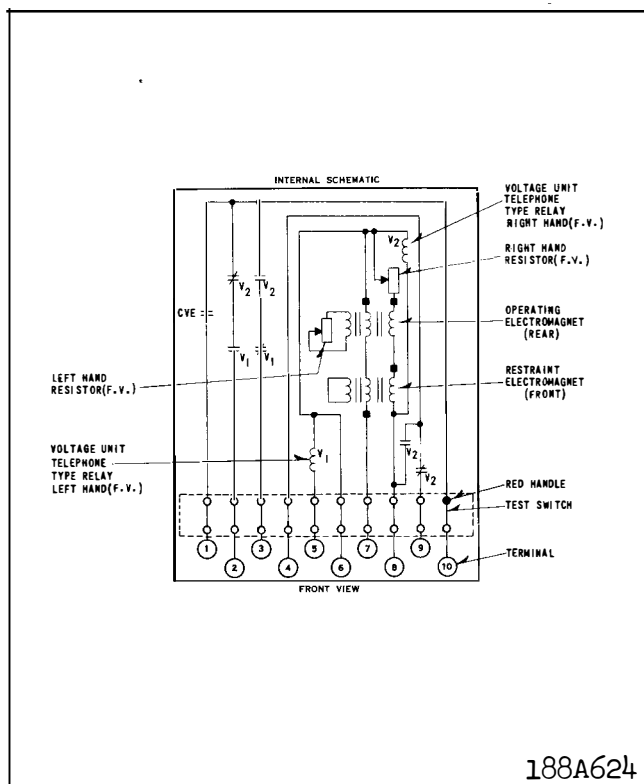


Fig. 5. Internal Schematic of CVE-1

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:

CHARACTERISTICS

The type CVE relay and CVE-1 can be adjusted for operating circles from 20 to 60 degrees as shown in Fig. 8. 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 Fig. 9. 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 Fig. 10.

Fig. 11 shows how high a slip frequency will cause operation. The maximum slip frequency is a function of the circle and time dial settings. This characteristic is of interest in estimating the angular difference at the instant of breaker closure, for cases where the two systems are slipping slowly.

Burden

The burden imposed on each potential source by the CVE relay and CVE-1 relay, with rated voltage applied to both circuits of the relay is as follows:

	Voltages in Phase	Voltages 180 Degrees Out of Phase
Volt-amperes	15.4	13.5
Power Factor	.422	.422
Watts	6.5	5.7

The burden of the CVE relay and CVE-1 relay with rated voltage applied to one circuit is as follows:

Volt-amperes	10.8
Power Factor	.422
Watts	4.6

The burden of each telephone relay at 120 volts is as follows:

10.62 volt-amperes Power Factor 0.64

Continuous Rating

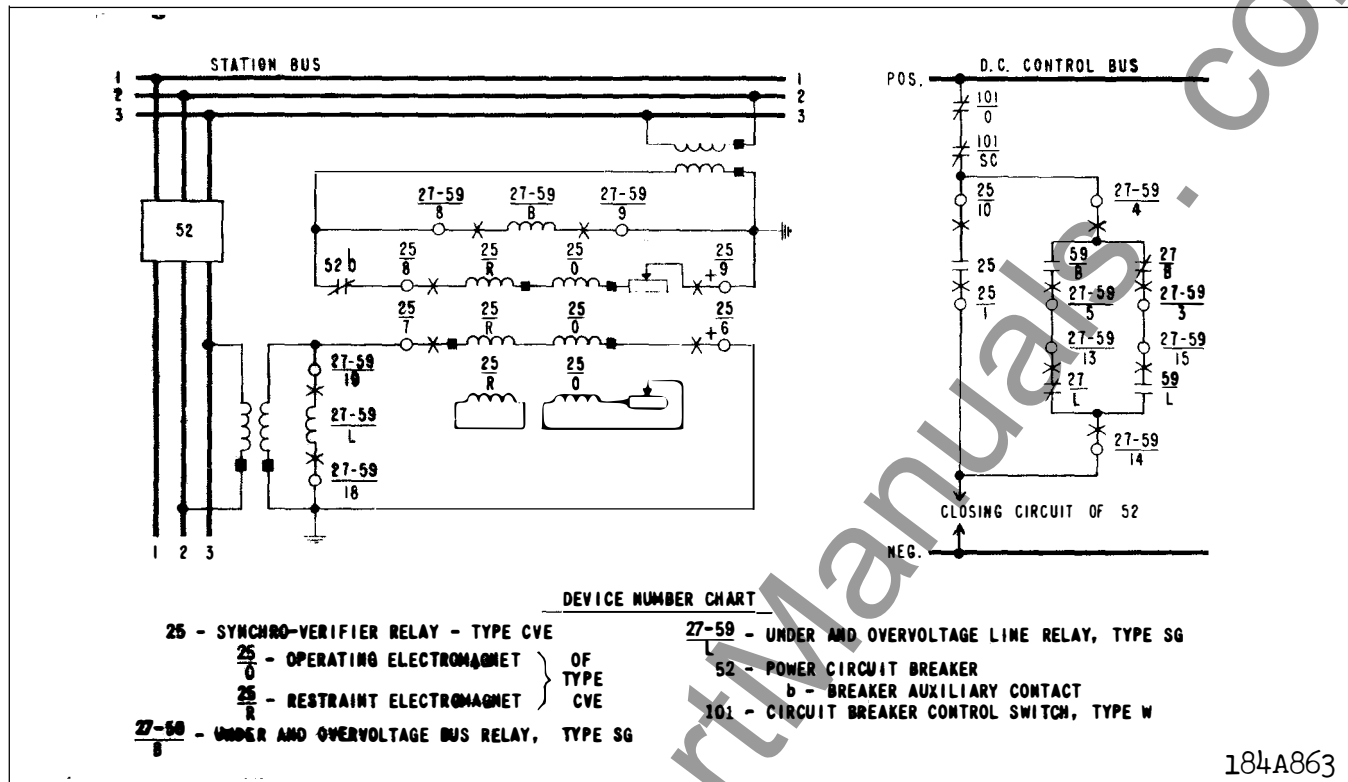
These relays will continuously stand 110% of rated voltage applied to the two circuits, either separately or simultaneously.

SETTINGS

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 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 as low as the ½ time dial should be satisfactory with the 20° circle. Note from Fig. 10 that the relay will operate in 1.4 seconds in the ½ time dial positions and with the 20° setting. If a longer delay is desired a



* Fig. 6 External Schematic of the CVE with SG Relay for Dead-Line-Hot Bus and Hot Line-Dead Bus Reclosing.

higher time-dial setting may be used.

To evaluate the effect of time-dial and circle settings on the phase-angle difference between the two systems at the instant of breaker closure, refer to Fig. 9. For example, assume a 40° circle and #4 time-dial setting. Also assume that the systems are slipping at a frequency of 0.048 cycles per second, 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 systems 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:

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

where T_B = breaker closing time in seconds

Let $T_B = 0.5$ seconds

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

Indicating Contactor Switch (ICS) - When Used

No setting is required on the ICS unit.

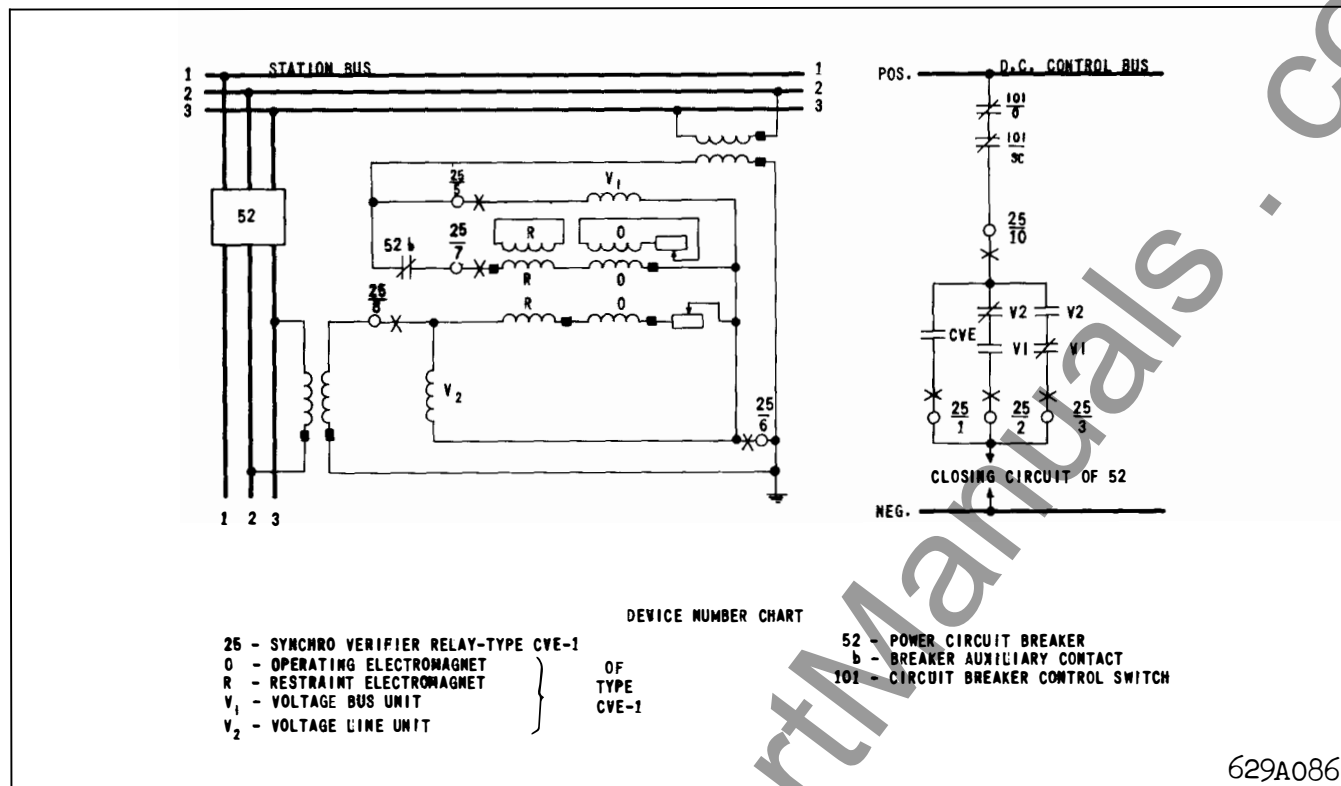
INSTALLATION

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.

For detailed FT Case information refer to I.L. 41-076.

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.



629A086

* Fig. 7 External Schematic of CVE-1 for Dead-Line-Hot-Bus and Hot-Line-Dead-Bus Reclosing.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order:

Indicating Contactor Switch (ICS) - When Used

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

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

Disc Unit

1. Contacts - The index mark on the movement frame will coincide with the "O" 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

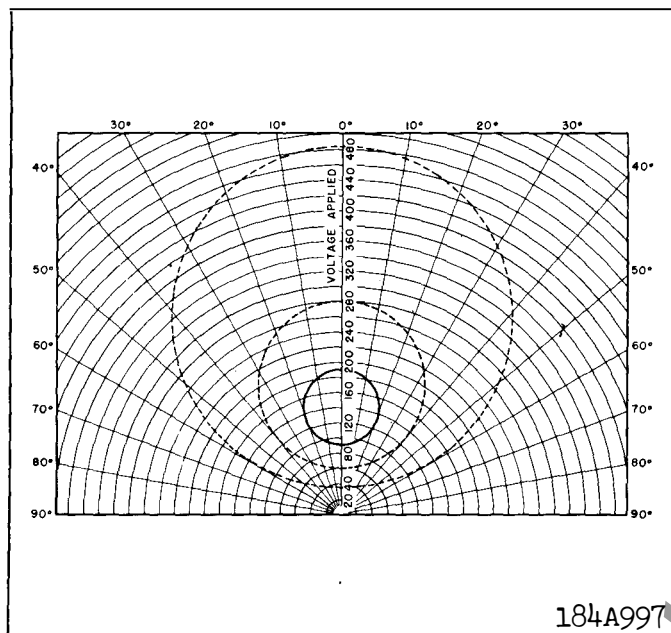
backstop, the index mark is offset to the right of the "O" mark by approximately 0.020". The placement of the various time dial positions in line with the index mark will give operating times as shown on the time curve.

2. Operating Circle - Connect the relay per the test diagram of Fig. 12. The contacts should just close under the following two 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 to $94 \pm 4V$ in phase with V_1

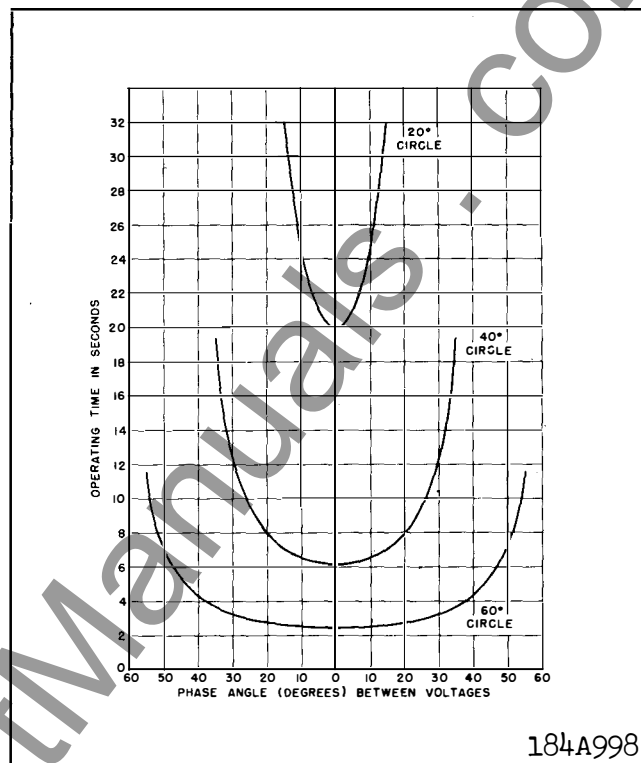
3. Time Curve - With the time dial set at position 11, the contact should close in 20 ± 1 seconds when V_1 and V_2 are equal to rated voltage at zero phase angle.

To check the time curve, set the time dial in position 11 and apply V_1 and V_2 equal to rated voltage. The contacts should close in 20 ± 1 seconds.



184A997

Fig. 8 Typical Voltage-Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.



184A998

Fig. 9 Typical Time-Phase Angle Curves of CVE. Rated Voltage on Both Circuits No. #11 Dial Time Setting.

Telephone Relays (CVE-1 only)

Apply a.c. volts to each telephone relay circuit. The telephone relay should pickup when 95 volts a.c. is applied.

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 S#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.

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").

1. **Contact** — The index mark on the movement frame coincides with the "O" 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 "O" 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** — 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

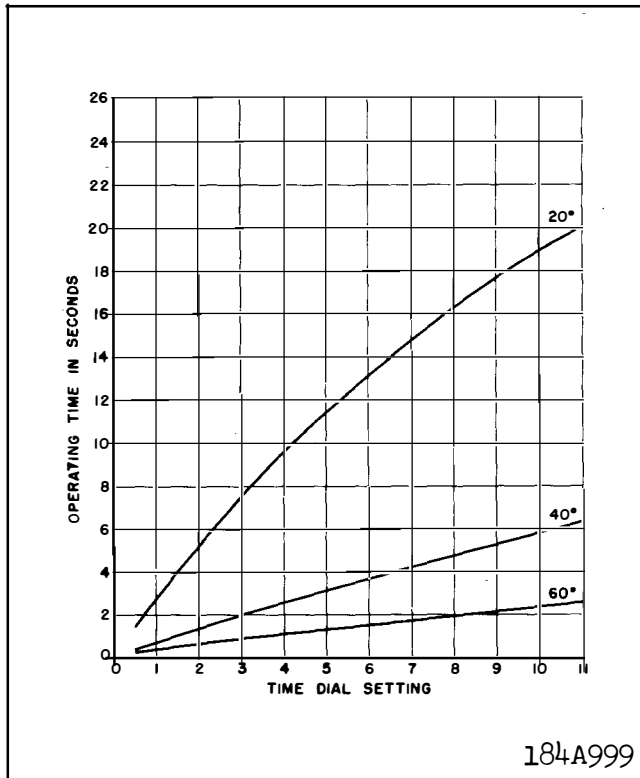


Fig. 10 Operating Time Variations with Changes in Time-Dial Settings. Rated In-Phase Voltage on Both Circuits, 20°, 40° and 60° Circle Setting.

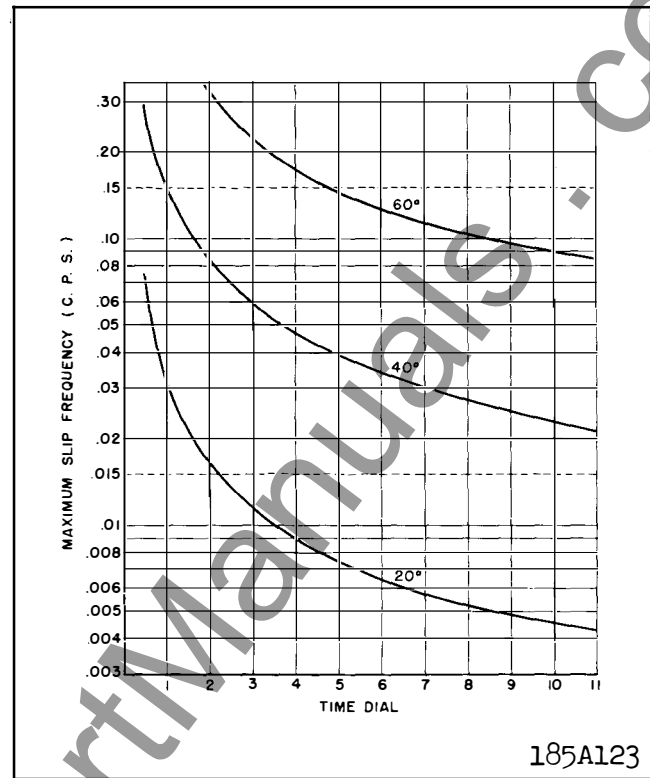


Fig. 11 Approximate Maximum Slip Frequency for which Operation Occurs - Rated Voltage on Both Sides.

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 Fig. 12 and apply rated voltage at zero 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 timedial 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 with 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 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° 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 ± 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 $94 \pm 4V$ in phase with V_1 . If necessary, readjust spring slightly to

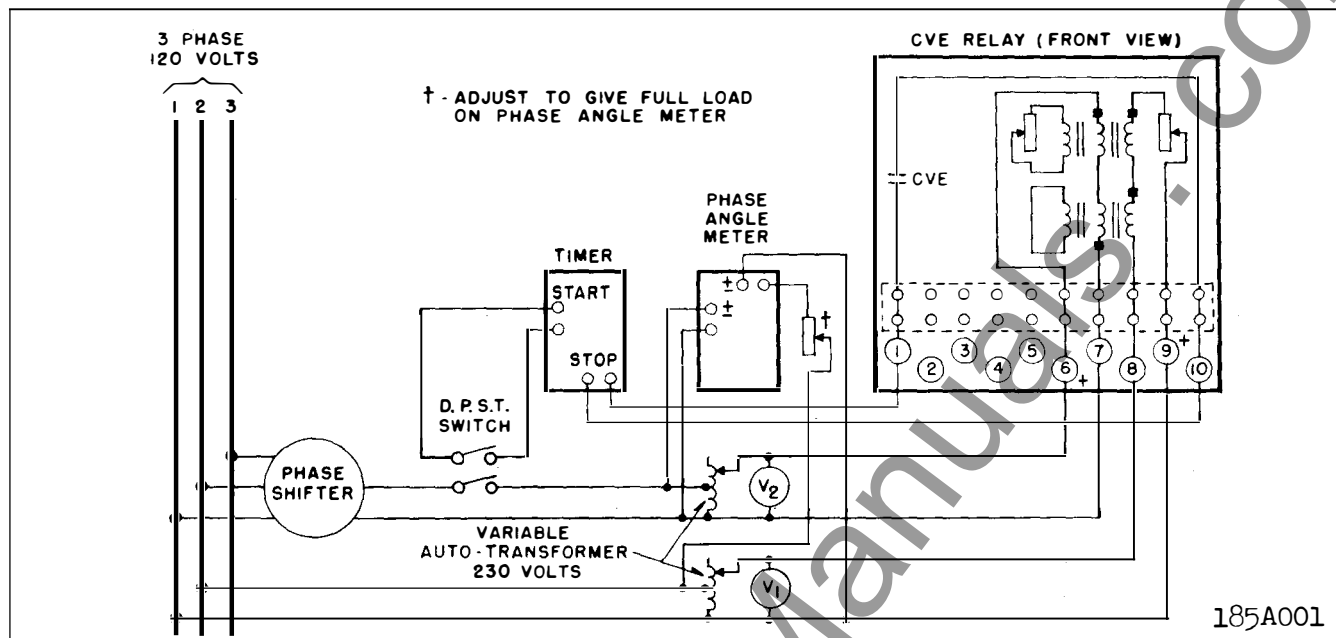


Fig. 12 Diagram of CVE Test Connections.

obtain this condition. The relay is now calibrated for a 20 degree circle.

6. 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 ± 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 Fig. 9.

ELECTRICAL CHECKPOINTS

With V_1 in Fig. 12 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
Lag coil circuit	22

Restraint Electromagnet

Upper terminals	58
Lower terminals	54

With 120 volts applied to V_2 circuit only

Operating Electromagnet

Upper terminals	57
Lower terminals	59
Lag coil circuit	22

Restraint Electromagnet

Upper terminals	54
Lower terminals	58

Approximate d.c. 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

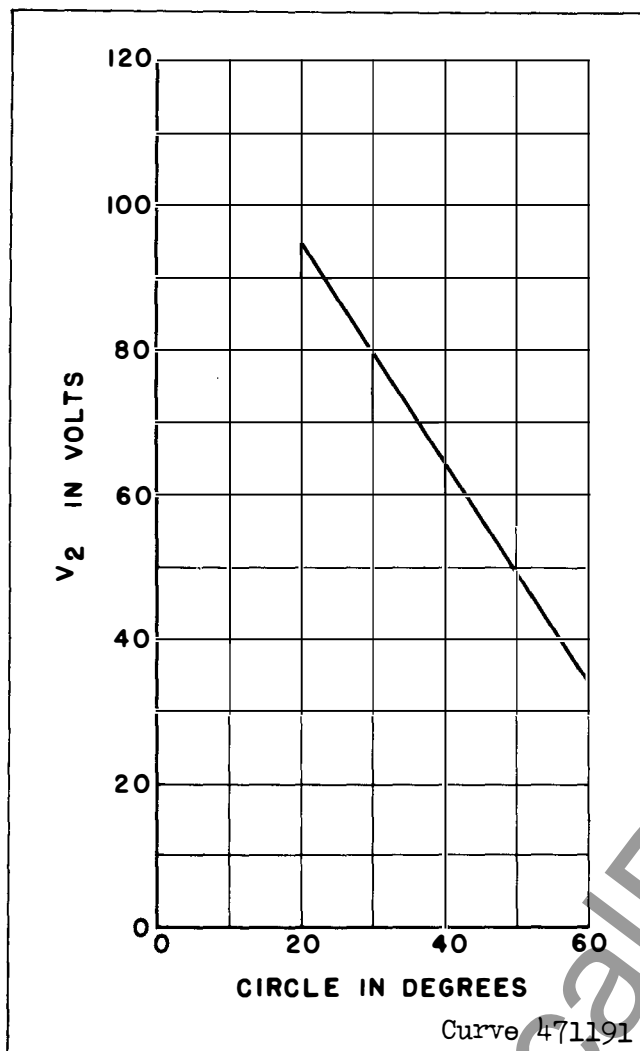


Fig. 13 V_2 Voltage for Different Operating Circles. V_1 equal to rated voltage at zero phase angle. (Curve 471191)

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

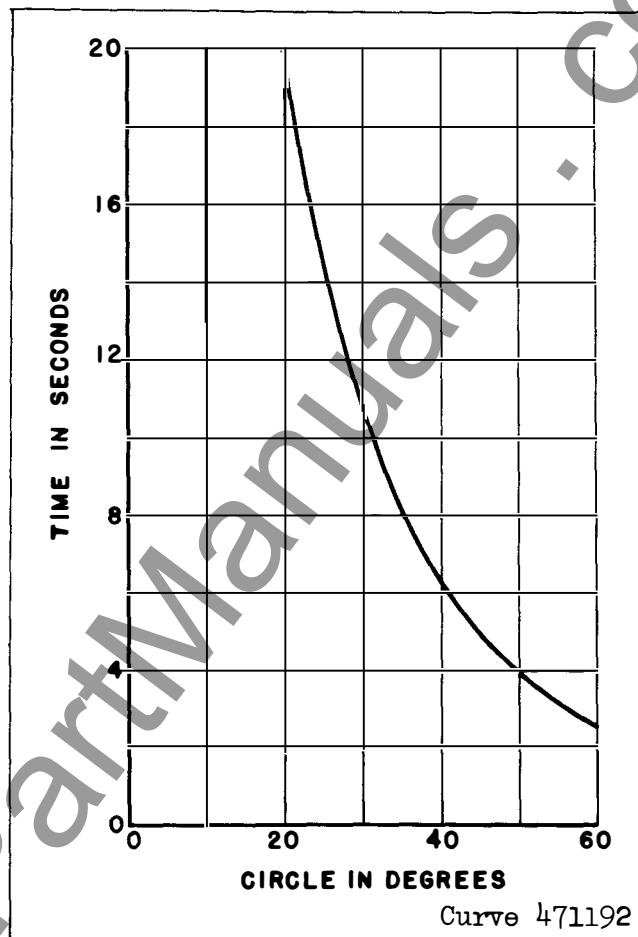
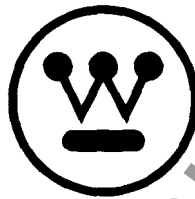


Fig. 14 Operating Times from the No. 11 Time Dial Position for the Type CVE Relay set for Different Operating Circles. V_1 and V_2 equal to rated voltage at zero phase angle. (Curves 471192)

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.

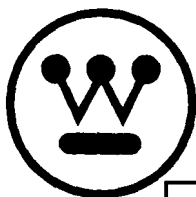




WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION

NEWARK, N. J.

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INSTALLATION • OPERATION • MAINTENANCE I N S T R U C T I O N S

TYPE CVE AND CVE-1 SYNCHRO-VERIFIER 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.

APPLICATION

The synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The contacts will close when these voltages are within set limits.

The synchro-verifier is not an automatic synchronizer and should not be used as such. Automatic Synchronizers are available which permit closing ahead of synchronism at an angle of phase-advance proportional to the beat frequencies and determined by the speed of operation of the circuit breaker so that the two systems are connected right on synchronism.

A common application of the synchro-verifier is in conjunction with automatic reclosing equipment on 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 the automatic reclosing equipment to reclose the breaker.

CONTENTS

This instruction leaflet applies to the following types of relays:

- CVE-- Synchro-Verifier Relay
- CVE-1 Synchro-Verifier Relay

CONSTRUCTION AND OPERATION

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 Figs. 1, 2, 3, and 4.

The CVE-1 relay consists of two telephone type relays in addition to the components of the CVE Relay. The principal parts of the relay are connected as per figure 5.

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 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 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.

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.

Indicating Contactor Switch Unit (ICS) - When Used

The d-c indicating contactor switch is a small

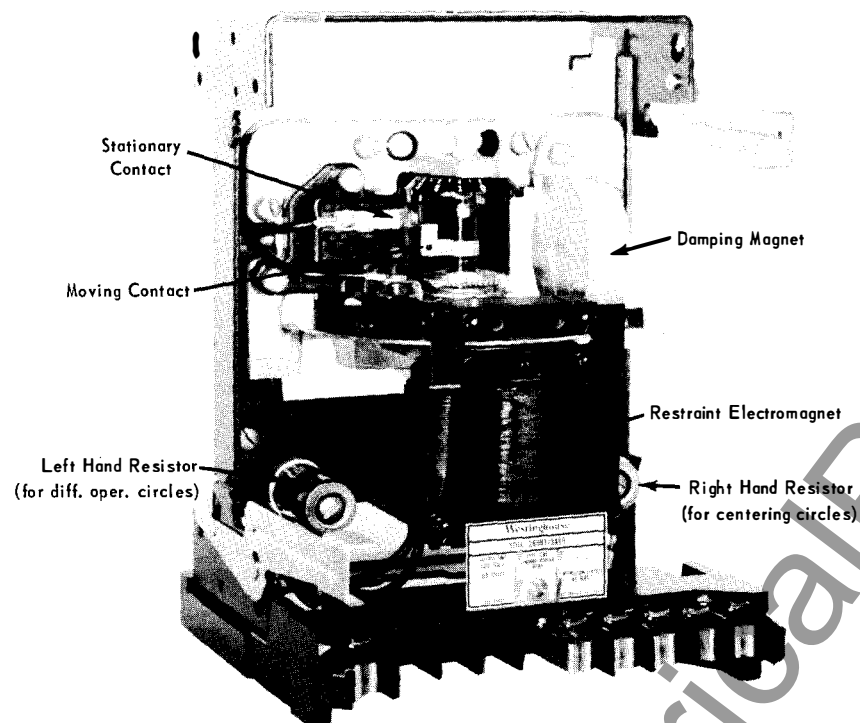


Fig. 1. Type CVE Relay, without Case (Front View)

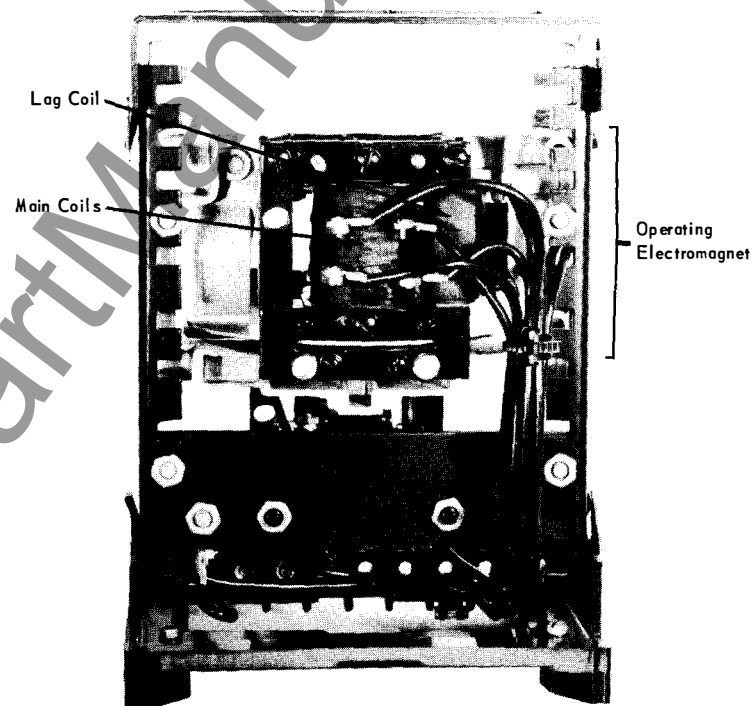


Fig. 2. Type CVE Relay, without Case (Rear View)

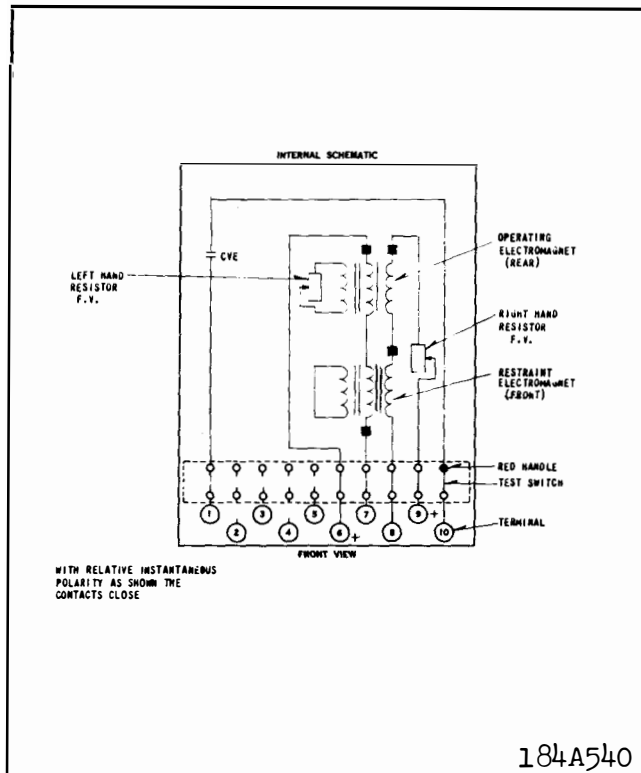


Fig. 3. Internal Schematic of CVE, without ICS Unit.

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.

Telephone Relay

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

Operation With Voltage Relays

The connections shown in Fig. 6 using type SG voltage relays will provide the following operation:

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

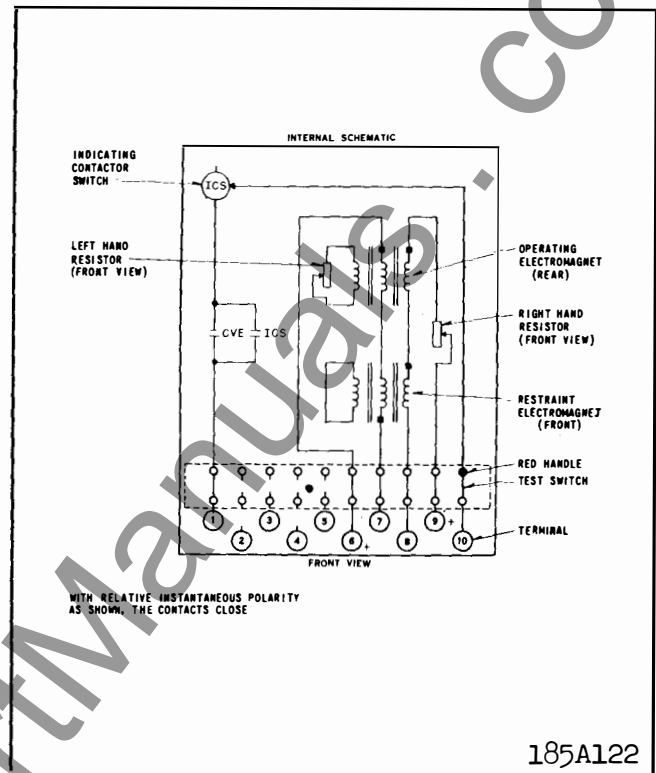


Fig. 4. Internal Schematic of CVE, with ICS Unit.

2. Close the breaker when the line is alive and the bus is dead, through the 59L make contact and 27B 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 and SG relays.

* CVE - 1 Operation

The connections shown in Figure 7 using the type CVE-1 relay will provide the following operation:

1. Close the breaker when the bus is alive 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.

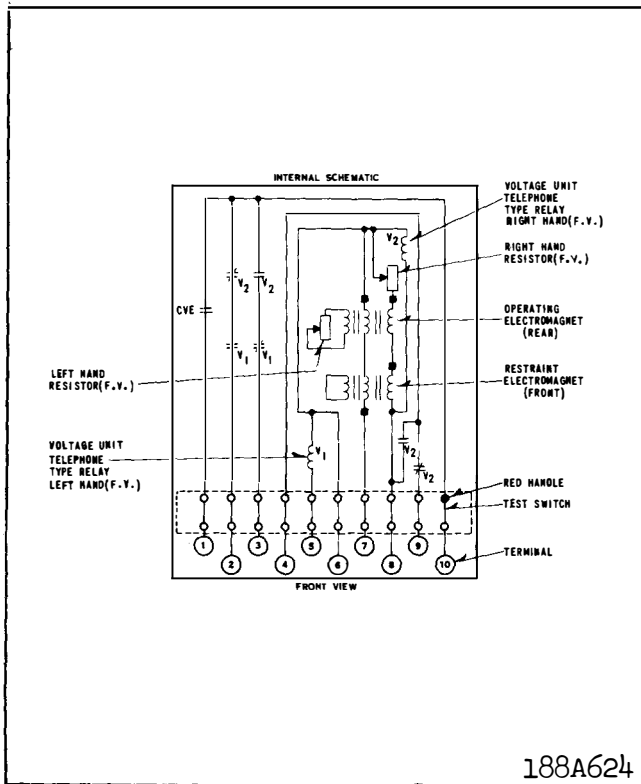


Fig. 5. Internal Schematic of CVE-1

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.

CHARACTERISTICS

The type CVE relay and CVE-1 can be adjusted for operating circles from 20 to 60 degrees as shown in Fig. 8. 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 Fig. 9. 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 Fig. 10.

* Fig. 11 shows how high a slip frequency will cause operation. The maximum slip frequency is a function of the circle and time dial settings. This characteristic is of interest in estimating the angular difference at the instant of breaker closure, for cases where the two systems are slipping slowly.

Fig. 15 shows typical CVE reset times for 20°, 40°, and 60° circle settings.

Burden

The burden imposed on each potential source by the CVE relay and CVE-1 relay, with rated voltage applied to both circuits of the relay is as follows:

	Voltages in Phase	Voltages 180 Degrees Out of Phase
Volt-amperes	15.4	13.5
Power Factor	.422	.422
Watts	6.5	5.7

The burden of the CVE relay and CVE-1 relay with rated voltage applied to one circuit is as follows:

Volt-amperes	10.8
Power Factor	.422
Watts	4.6

The burden of each telephone relay at 120 volts is as follows:

10.62 volt-amperes Power Factor 0.64

Continuous Rating

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

SETTINGS

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 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 as low as the ½ time dial should be satisfactory with the 20° circle. Note from Fig. 10 that the relay will operate in 1.4 seconds in the ½ time dial positions and with the 20° setting. If a longer delay is desired a higher time-dial setting may be used.

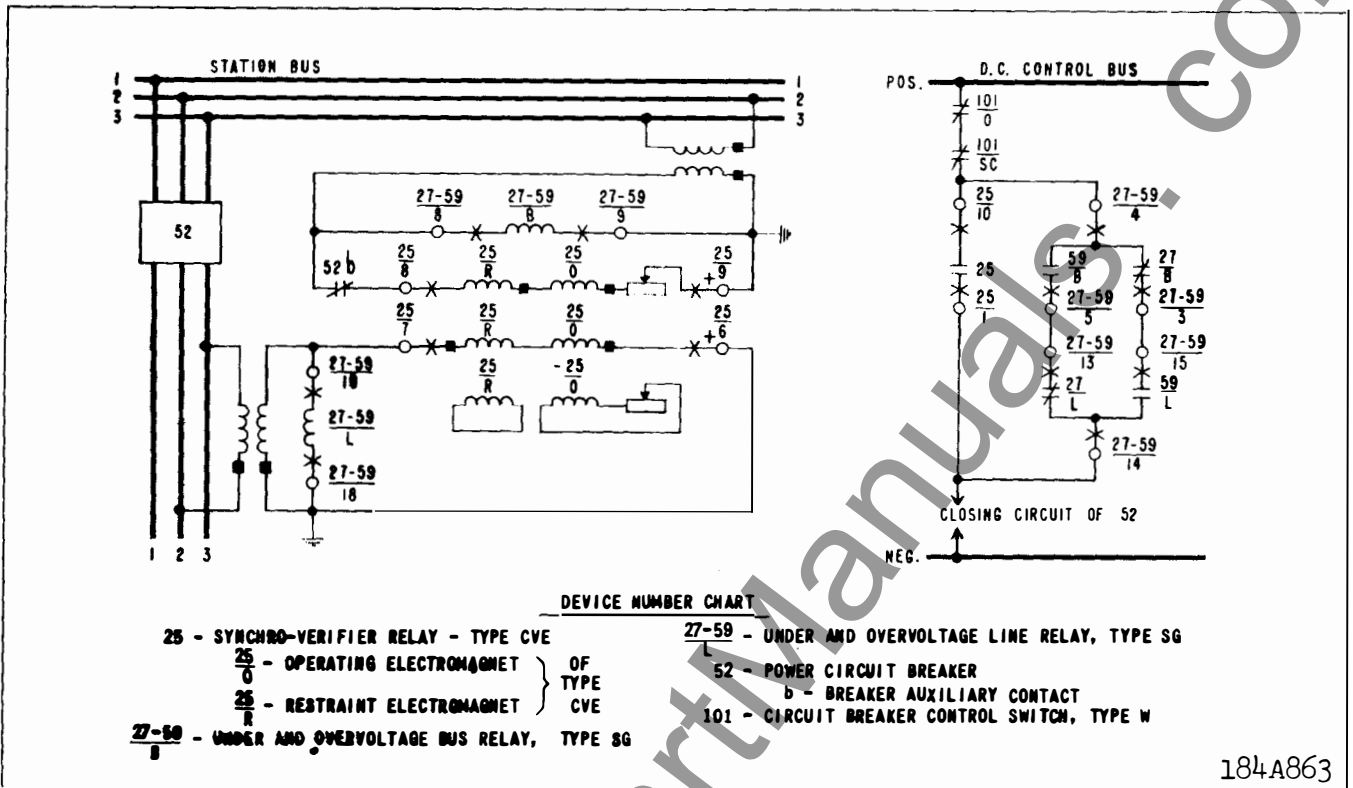


Fig. 6 External Schematic of the CVE with SG Relay for Dead-Line-Hot Bus and Hot Line-Dead Bus Reclosing.

To evaluate the effect of time-dial and circle settings on the phase-angle difference between the two systems at the instant of breaker closure, refer to Fig. 9. For example, assume a 40° circle and #4 time-dial setting. Also assume that the systems are slipping at a frequency of 0.048 cycles per second, 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 systems 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:

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

where T_B = breaker closing time in seconds

Let $T_B = 0.5$ seconds

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

Indicating Contactor Switch (ICS) - When Used

No setting is required on the ICS unit.

* 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 Figure 16 for Outline and Drilling Plan. For detailed FT Case information refer to I.L. 41-076.

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.

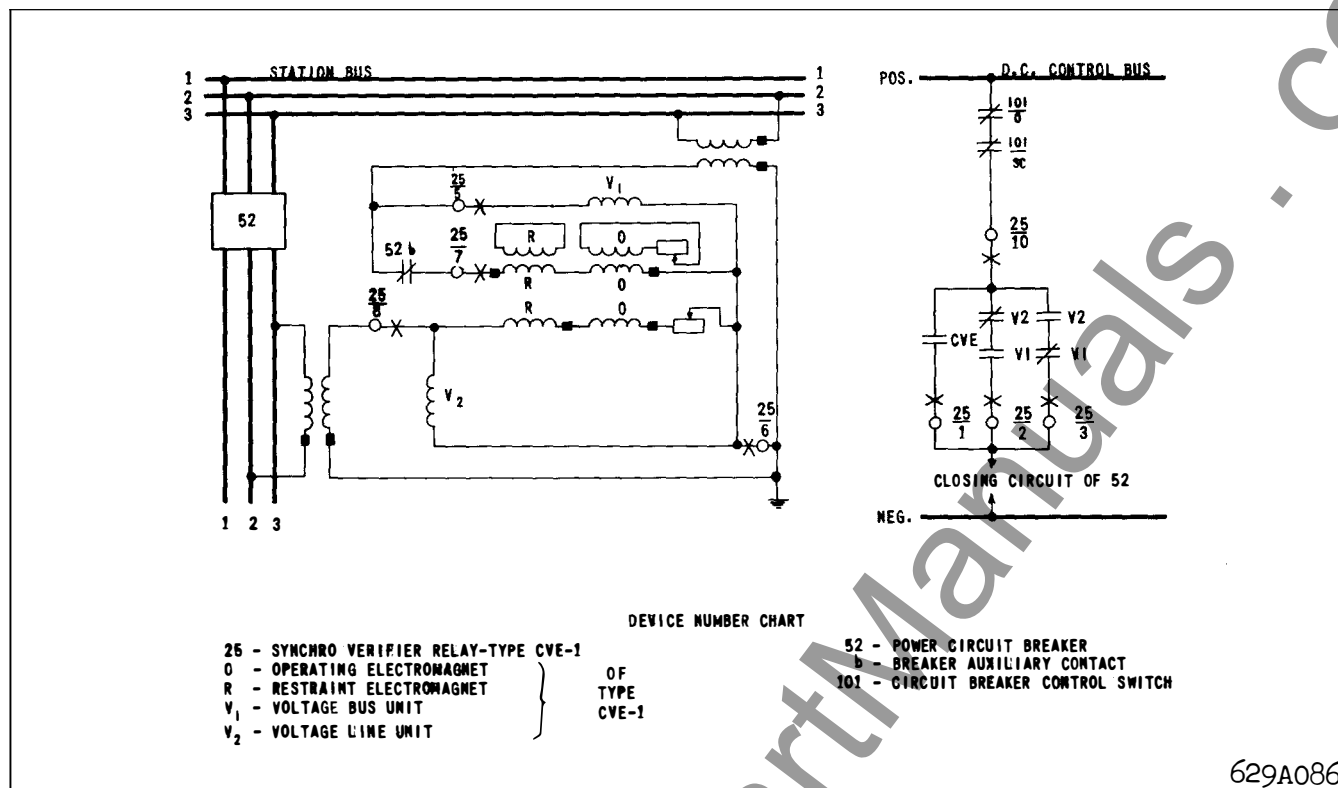


Fig. 7 External Schematic of CVE-1 for Dead-Line-Hot-Bus and Hot-Line-Dead-Bus Reclosing.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order:

Indicating Contactor Switch (ICS) - When Used

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

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

Disc Unit

1. Contacts - The index mark on the movement frame will coincide with the "O" 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 "O" 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 relay per the test diagram of Fig. 12. The contacts should just close under the following two 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 to $94 \pm 4V$ in phase with V_1

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

To check the time curve, set the time dial in position 11 and apply V_1 and V_2 equal to rated voltage. The contacts should close in 20 ± 1 seconds.

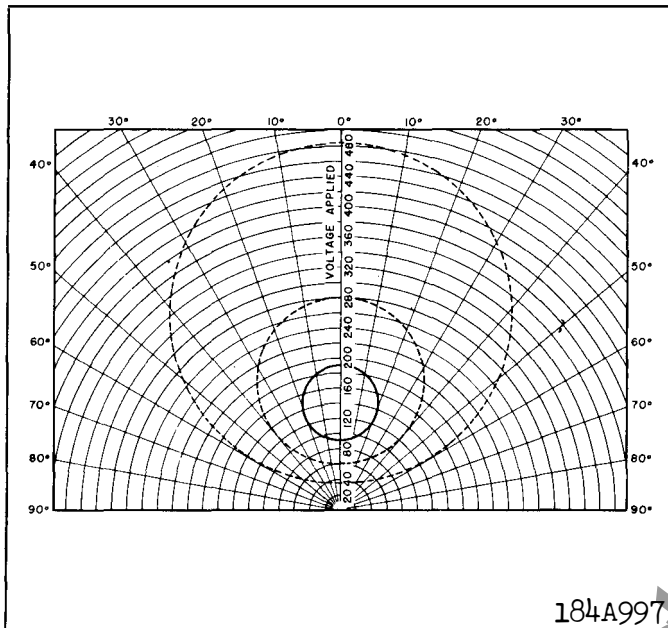


Fig. 8 Typical Voltage-Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.

Telephone Relays (CVE-1 only)

Apply a-c. volts to each telephone relay circuit. The telephone relay should pickup when 95 volts a.c. is applied.

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 S#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.

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

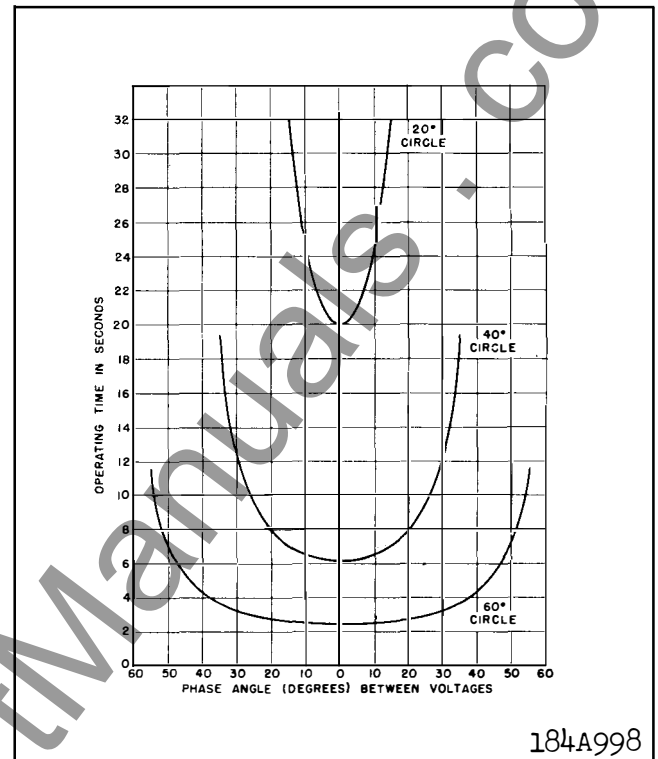


Fig. 9 Typical Time-Phase Angle Curves of CVE. Rated Voltage on Both Circuits No. #11 Dial Time Setting.

the relay is not in proper working order (See "Acceptance Check").

1. Contact — The index mark on the movement frame coincides with the "O" 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 "O" 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 — 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

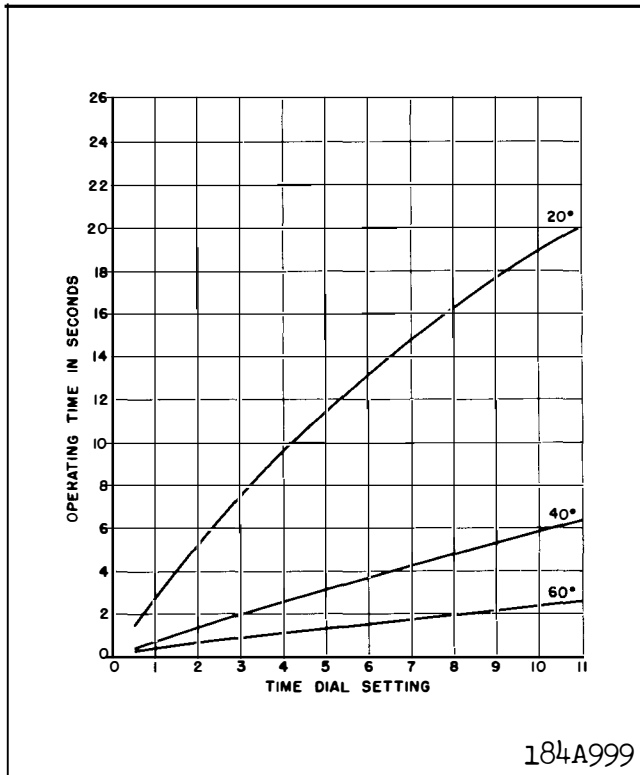


Fig. 10 Operating Time Variations with Changes in Time-Dial Settings. Rated In-Phase Voltage on Both Circuits, 20°, 40° and 60° Circle Setting.

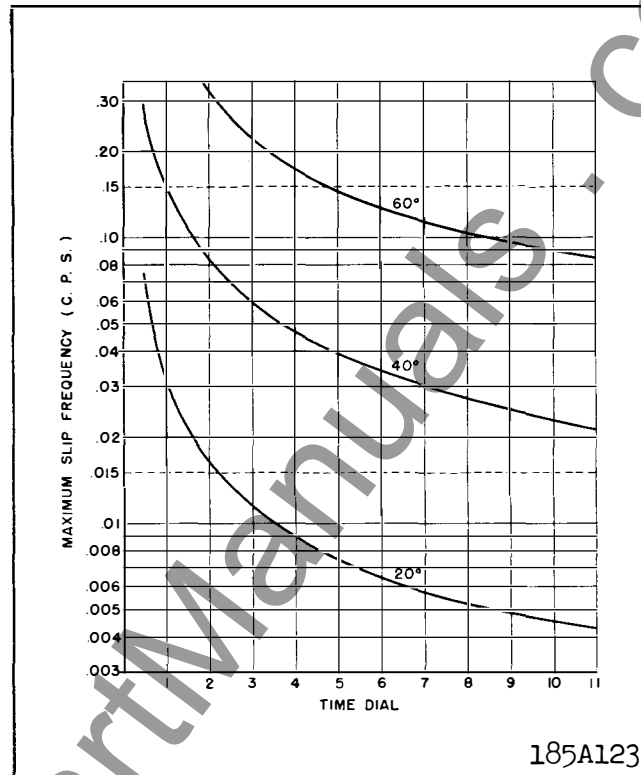


Fig. 11 Approximate Maximum Slip Frequency for which Operation Occurs - Rated Voltage on Both Sides.

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 Fig. 12 and apply rated voltage at zero 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 timedial 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 with 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 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° 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 ± 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 ± 4 V. in phase with V_1 . If necessary, readjust spring slightly to

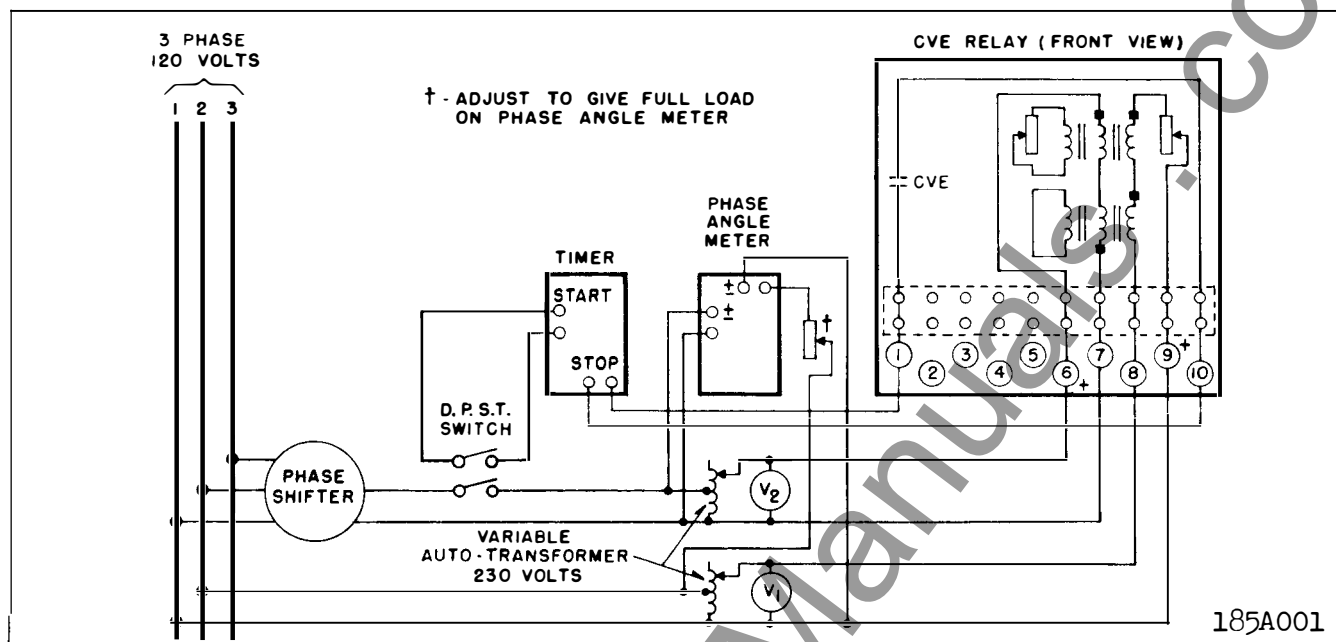


Fig. 12 Diagram of CVE Test Connections.

obtain this condition. The relay is now calibrated for a 20 degree circle.

6. 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 ± 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 Fig. 9.

ELECTRICAL CHECKPOINTS

With V_1 in Fig. 12 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
Lag coil circuit	22

Restraint Electromagnet

Upper terminals	58
Lower terminals	54

With 120 volts applied to V_2 circuit only

Operating Electromagnet

Upper terminals	57
Lower terminals	59
Lag coil circuit	22

Restraint Electromagnet

Upper terminals	54
Lower terminals	58

Approximate d.c. 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

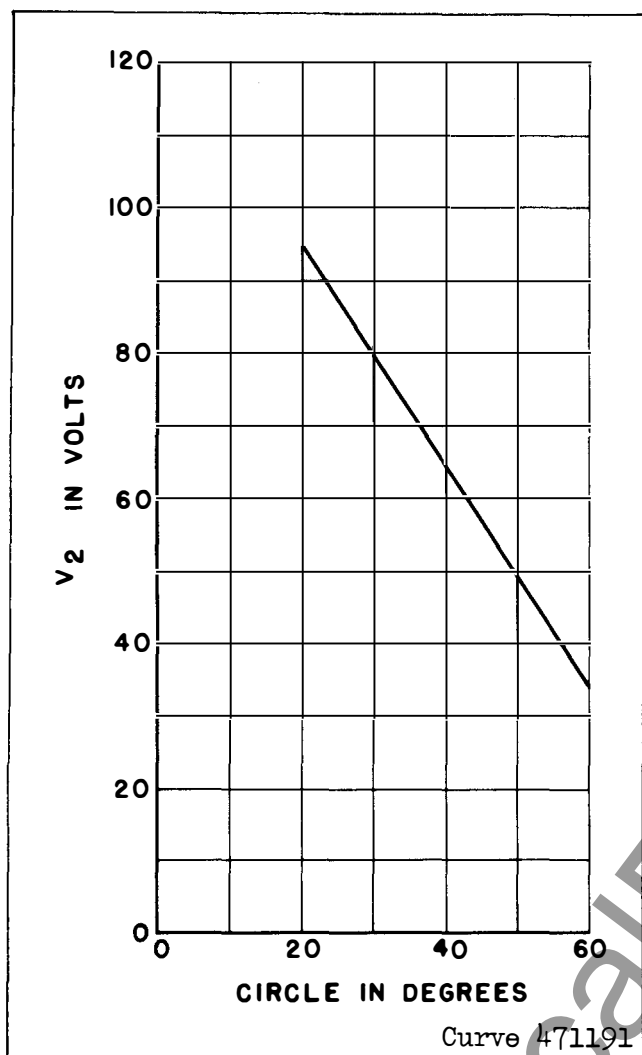


Fig. 13 V₂ Voltage for Different Operating Circles. V₁ equal to rated voltage at zero phase angle. (Curve 471191)

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

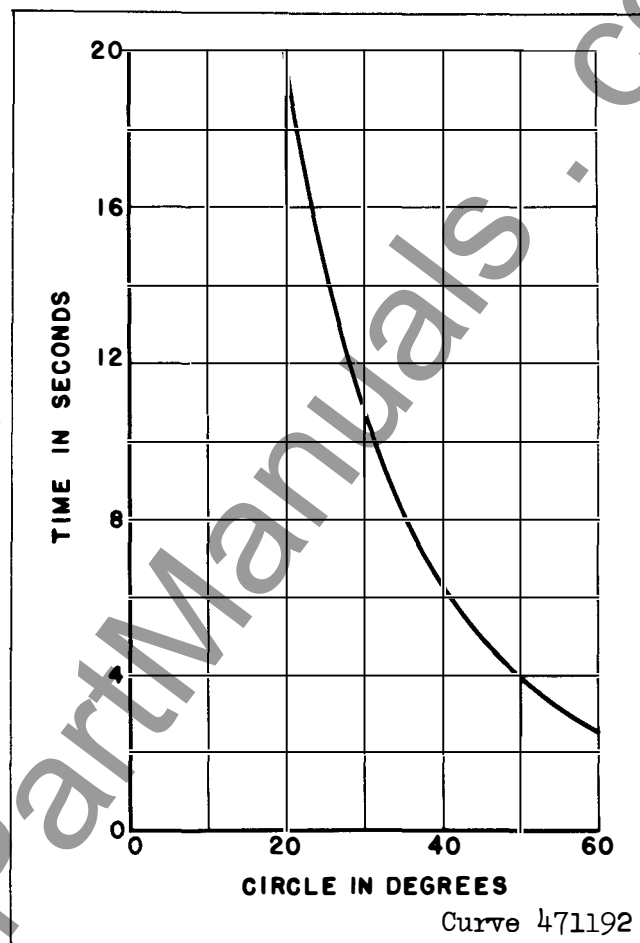
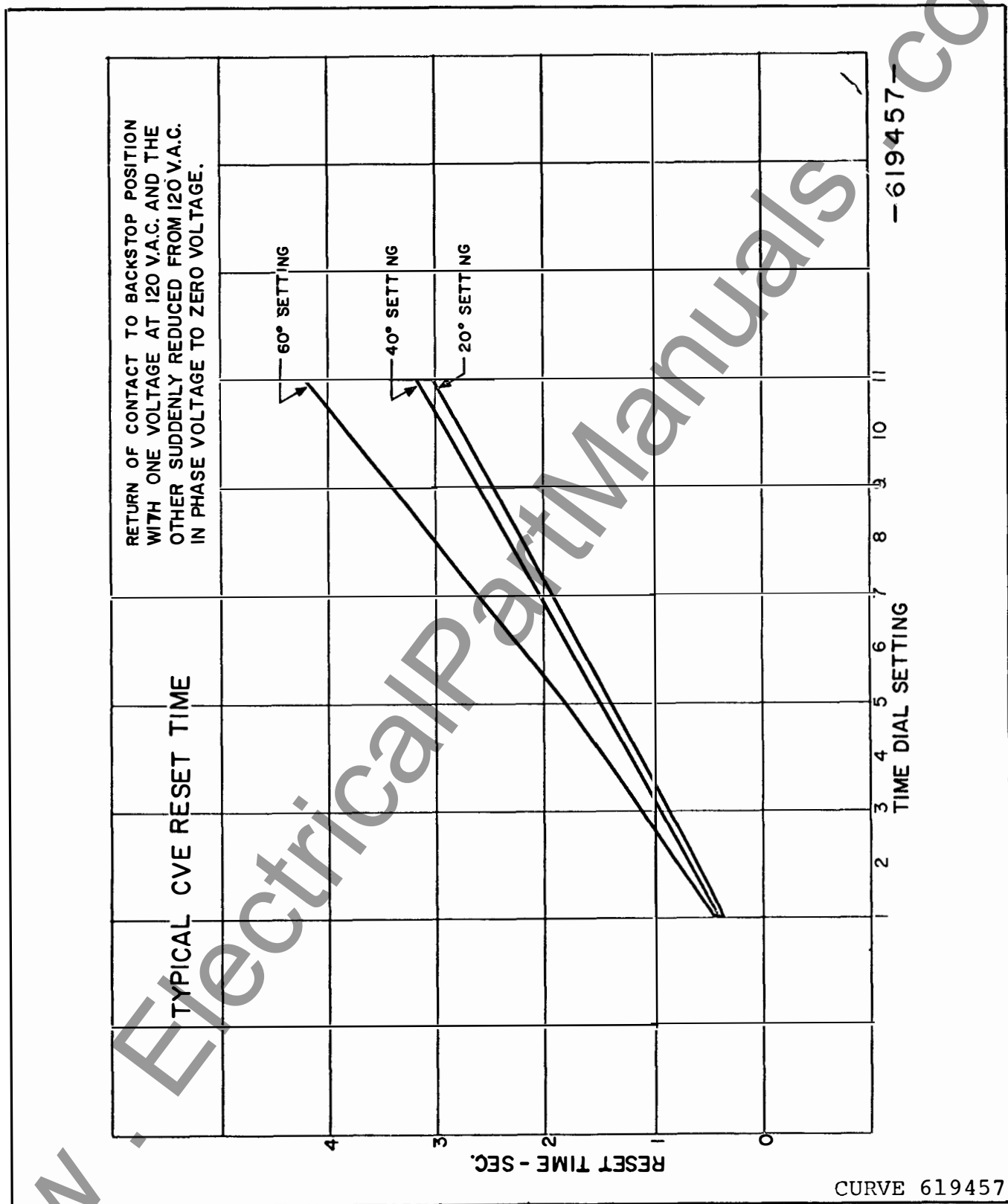


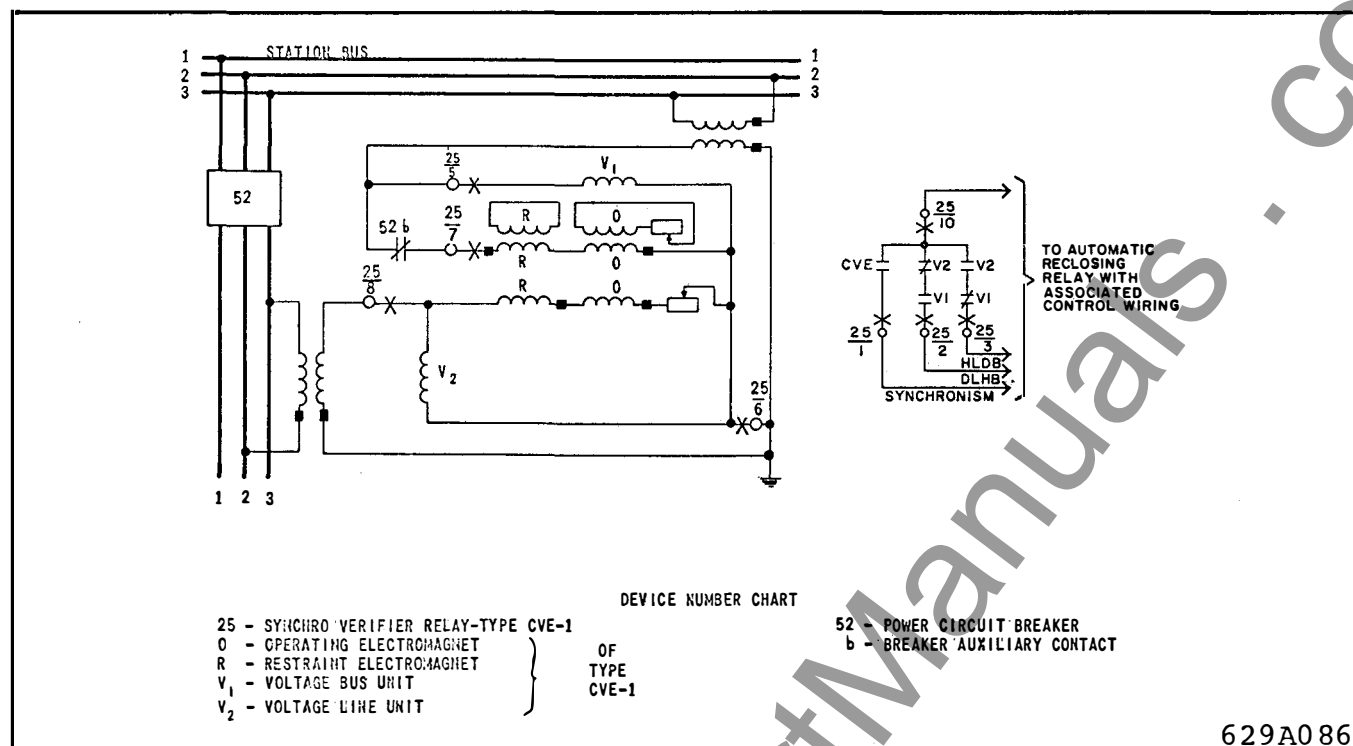
Fig. 14 Operating Times from the No. 11 Time Dial Position for the Type CVE Relay set for Different Operating Circles. V₁ and V₂ equal to rated voltage at zero phase angle. (Curves 471192)

RENEWAL PARTS

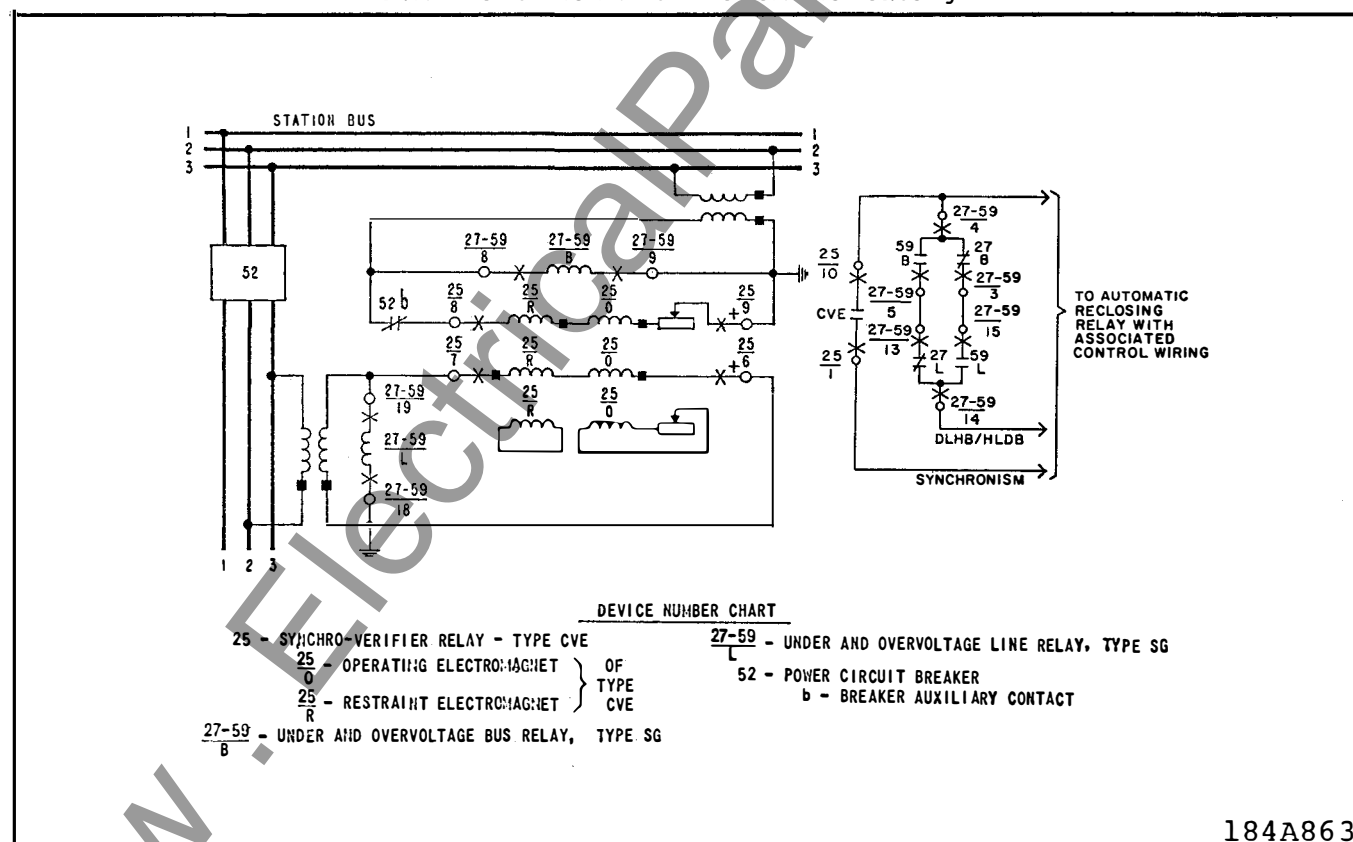
Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.



* Fig. 15 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.



* Fig. 16 External Schematic of Type CVE-1 Synchro-Verifier Hot Line-Hot Bus, Dead Line-Hot Bus and Hot Line-Dead Bus Reclosing



* Fig. 17 External Schematic of the Type CVE Synchro-Verifier, and Two Unit SG Relay for Dead Line-Hot Bus and Hot Line-Dead Bus Reclosing

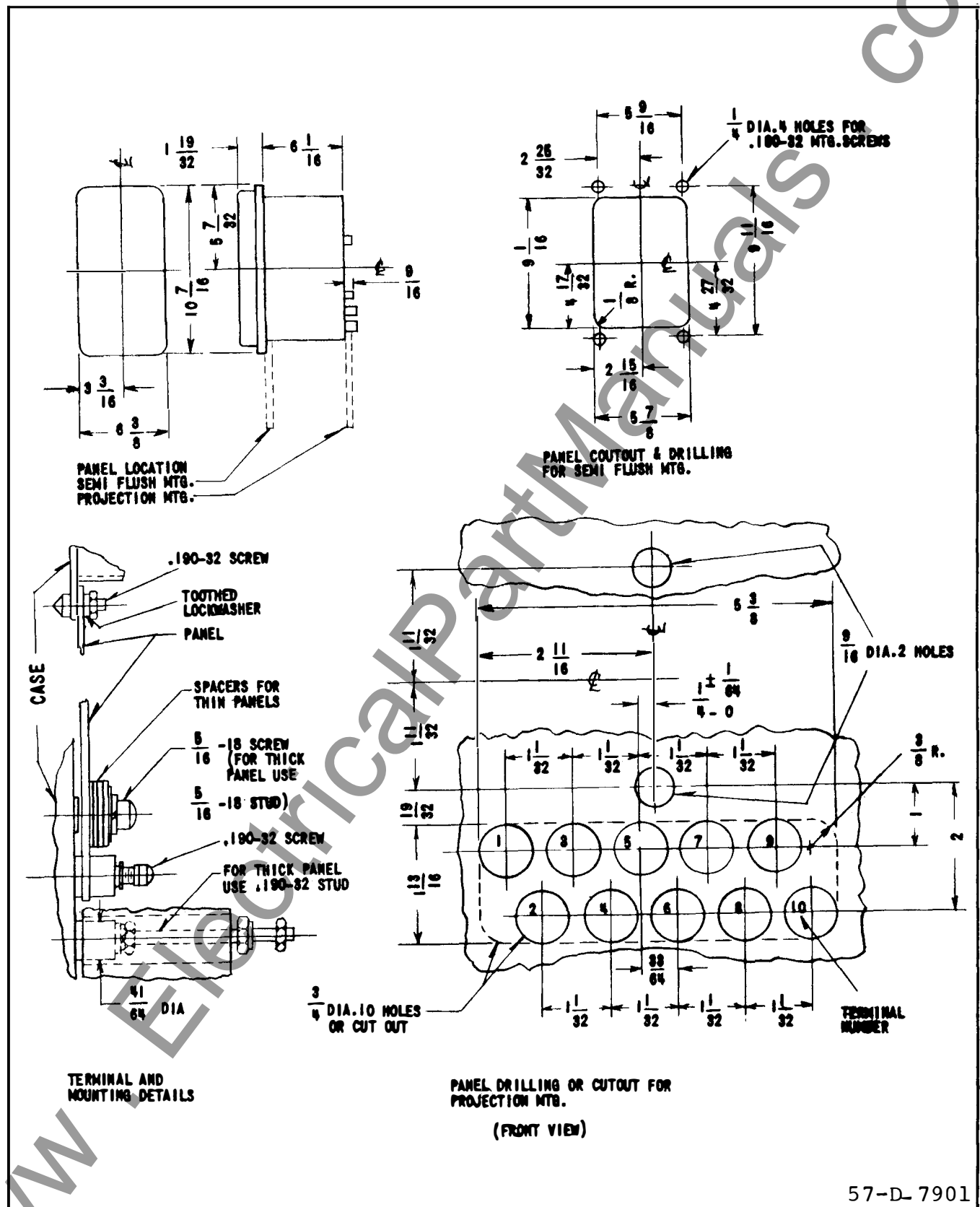
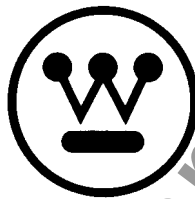


Fig. 18 Outline and Drilling Plan for the CVE and CVE-1 in FT21 case.

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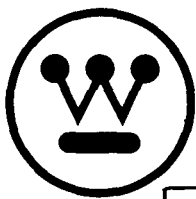
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RELAY-INSTRUMENT DIVISION

NEWARK, N. J.

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INSTALLATION • OPERATION • MAINTENANCE I N S T R U C T I O N S

TYPE CVE AND CVE-1 SYNCHRO-VERIFIER 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 clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

This instruction leaflet applies to the following types of relays:

- CVE Synchro-Verifier Relay
- *CVE-1 Synchro-Verifier Relay with
line and bus voltage
sensing relays

The synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The contacts will close when these voltages are within set limits.

The synchro-verifier is not an automatic synchronizer and should not be used as such. Automatic Synchronizers are available which permit closing ahead of synchronism at an angle of phase-advance proportional to the beat frequencies and determined by the speed of operation of the circuit breaker so that the two systems are connected right on synchronism.

A common application of the synchro-verifier 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 the automatic reclosing equipment to reclose the breaker.

CONSTRUCTION AND OPERATION

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 Figs. 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 as per Figure 5.

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 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 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.

Restraining Element

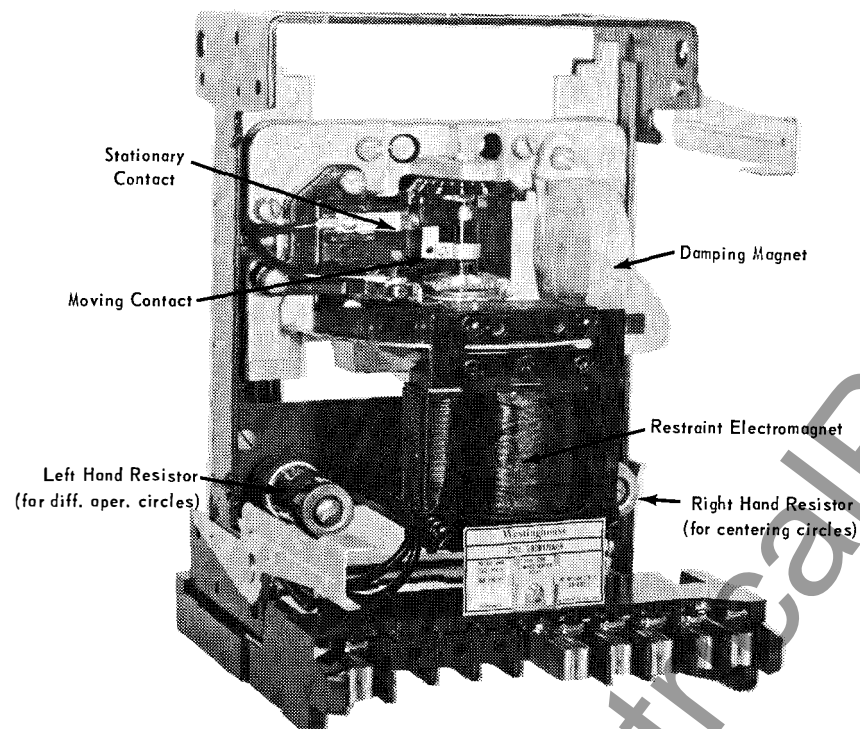
The restraining element consists of an "E" type laminated electromagnet with two main coils on its center leg and a lag coil on its left leg. A flux is produced that is proportional to the difference in the applied voltages to the relay. This flux divides and returns through the outer legs of the electromagnet. 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.

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.

SUPERSEDES I.L. 41-681.1J, dated July 1974
***denotes changes from superseded issue.**

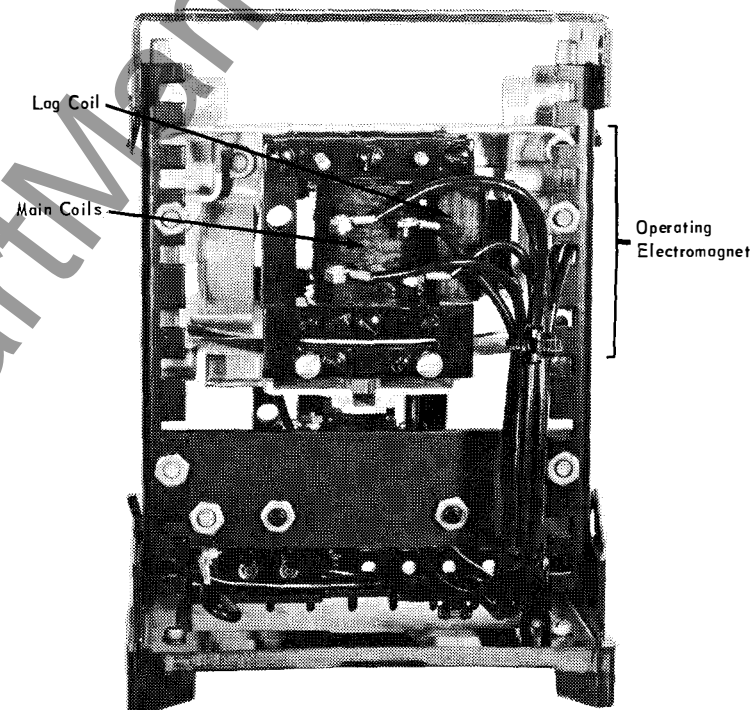
EFFECTIVE AUGUST 1975



Front View

Fig. 1

Type CVE Relay, without Case



Rear View

Fig. 2

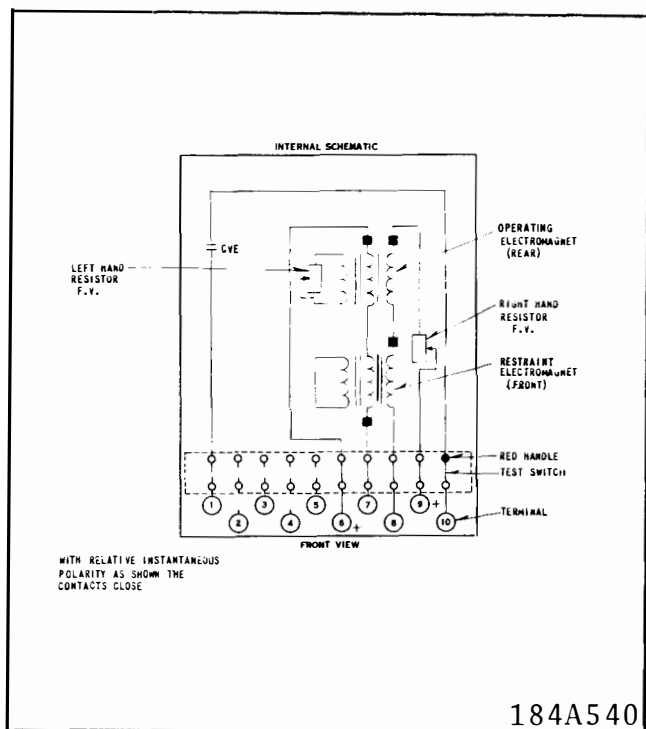


Fig. 3 Internal Schematic of CVE, without ICS Unit.

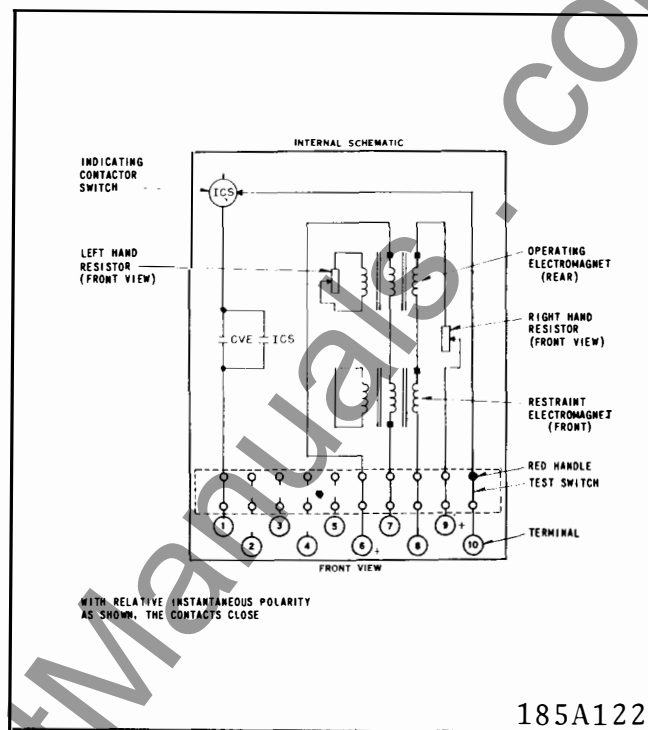


Fig. 4 Internal Schematic of CVE, with ICS Unit.

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

Telephone Relay—CVE-1 Only

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

Operation With External Voltage Relays

The connections shown in Fig. 8 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 the 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.

*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 9 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.

CHARACTERISTICS

The type CVE and CVE-1 relays can be adjusted for operating circles from 20 to 60 degrees as shown in Fig. 10. As shipped from the factory the relay is calibrated for the 20 degree circle. These circles apply when one side has rated

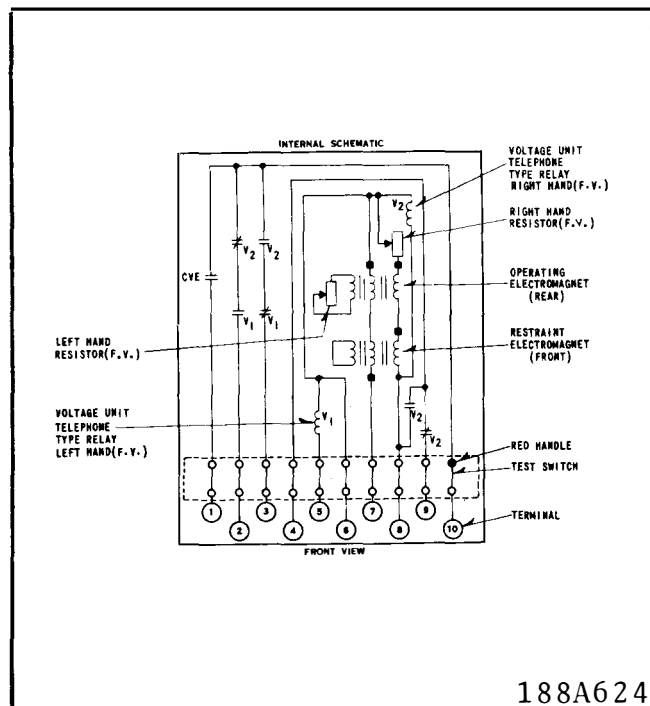


Fig. 5 Internal Schematic of CVE-1 for use with RC Reclosing Relay. (See Fig. 19 for External Scheme)

voltage. The relay operates if the other voltage falls within the appropriate circle.

The operating time of the relay is shown in Fig. 11. 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 Fig. 12.

*Fig. 13 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.

Fig. 17 shows typical CVE reset times for 20°, 40°, and 60° circle settings.

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:

	Voltages in Phase	Voltages 180 Degrees Out of Phase
Volt-amperes	15.4	13.5
Power Factor	.422	.422
Watts	6.5	5.7

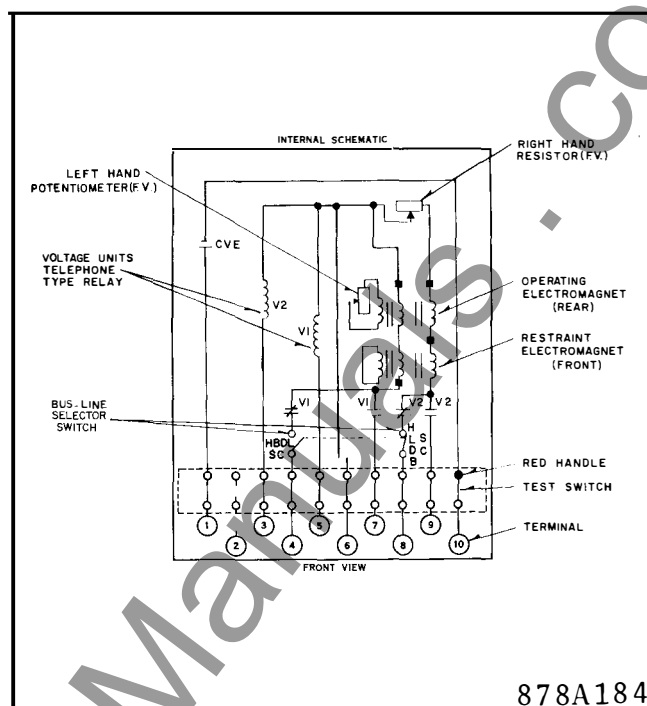


Fig. 6 Internal Schematic of CVE-1 with Internal Switch for HBDL or HLDB. (See Fig. 18 for External Scheme)

*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.

Continuous Rating

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

SETTINGS

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

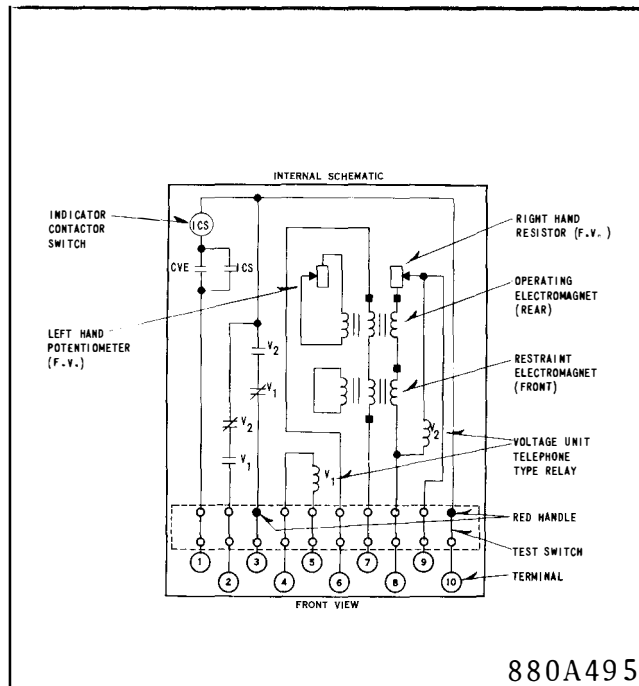


Fig. 7 Internal Schematic of CVE-1 without commoned Potential Coils, with ICS. (See Fig. 9 for External Scheme)

setting as low as $\frac{1}{2}$ time dial should be satisfactory with the 20° circle. Note from Fig. 12 that the relay will operate in 1.4 seconds in the $\frac{1}{2}$ 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 Fig. 11. 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 systems 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:

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

where T_B = breaker closing time in seconds

$$\text{Let } T_B = 0.5 \text{ seconds}$$

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

Indicating Contactor Switch (ICS)—When Used

No setting is required on the ICS unit.

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 Figure 20 for Outline and Drilling Plan. For detailed FT Case information refer to I.L. 41-076.

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.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order:

Indicating Contactor Switch (ICS)—When Used

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

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

Disc Unit.

1. **Contacts**—The index mark on the movement frame will coincide with the "O" 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 "O" 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 relay per the test diagram of Fig. 14. CVE-1 relays should be connected in a



- 184A863

- 629A086

Fig. 9 External Schematic of CVE-1 for Dead-Line-Hot-Bus and Hot-Line-Dead-Bus Reclosing.

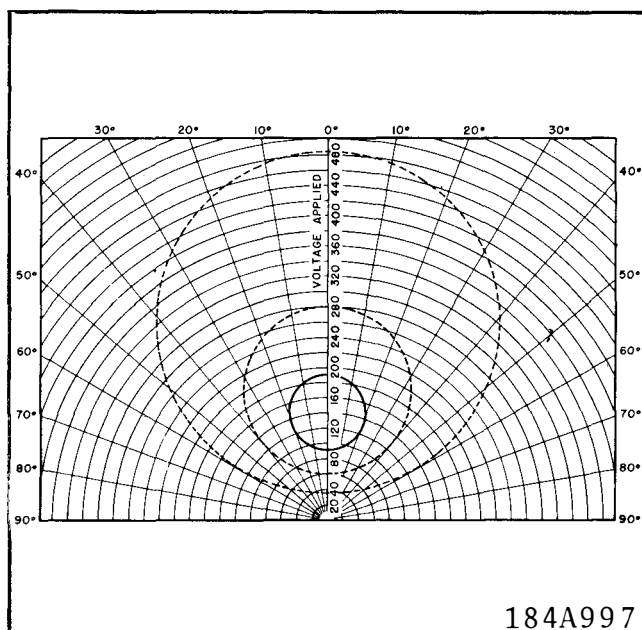


Fig. 10 Typical Voltage-Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.

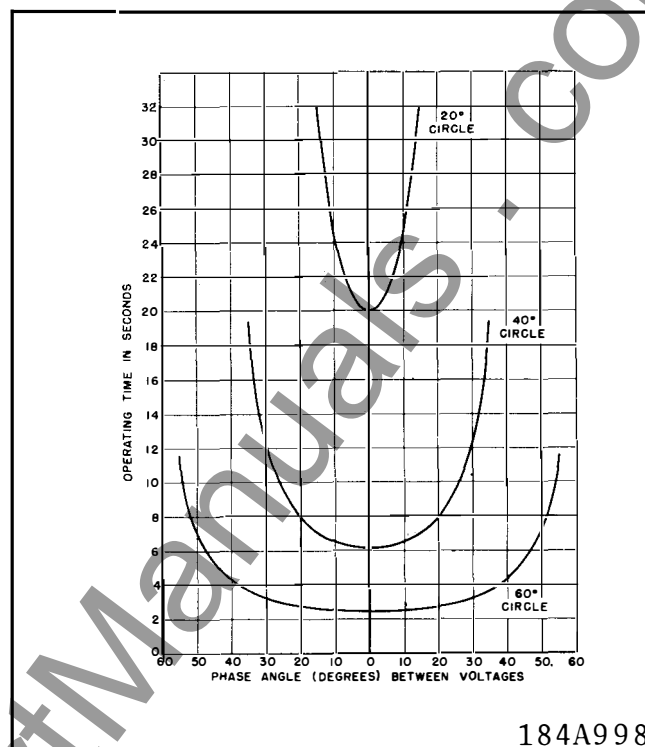


Fig. 11 Typical Time-Phase Angle Curves of CVE. Rated Voltage on Both Circuits No. #11 Dial Time Setting.

similar manner to correspond with the wiring of the particular style CVE-1. The contacts should just close under the following two 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 $94 \pm 4V$ 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.

Telephone Relays (CVE—1 only)

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

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 S#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.

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*).

1. **Contact**—The index mark on the movement frame coincides with the "O" 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 "O" 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**—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.

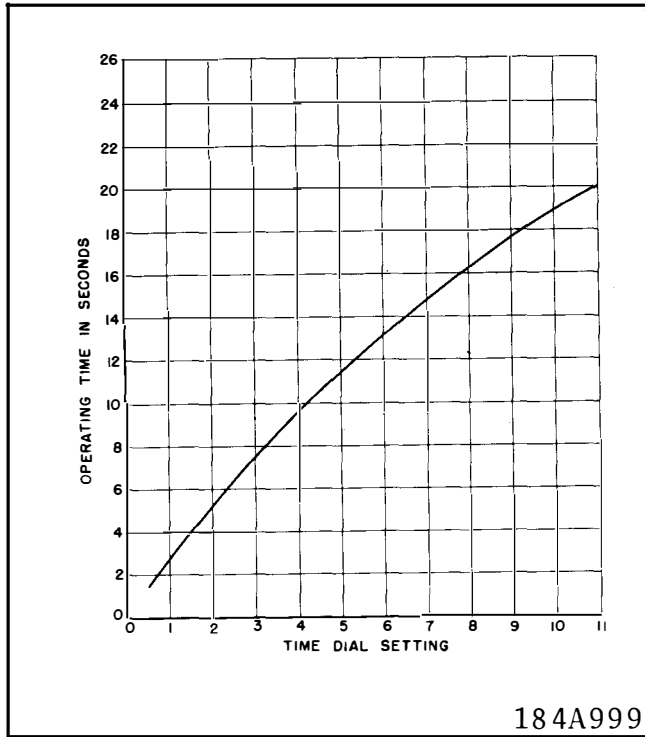


Fig. 12 Operating Time Variations with Changes in Time-Dial Settings. Rated In-Phase Voltage on Both Circuits, 20°, 40° and 60° Circle Setting.

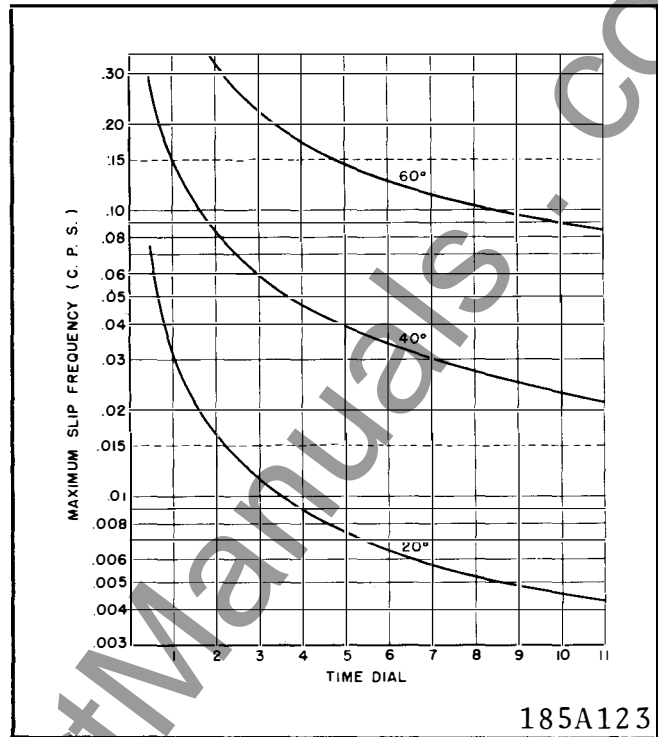


Fig. 13 Approximate Maximum Slip Frequency for which Operation Occurs—Rated Voltage on Both Sides.

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 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 Fig. 14 for CVE, or similar circuit for CVE-1, and apply rated voltage at zero 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 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 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 ± 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 $94 \pm 4V$ in phase with V_1 . If necessary, readjust spring slightly to obtain this condition. The relay is now calibrated for a 20 degree circle.

6. *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 ± 0.6 seconds with V_1 and V_2 equal to rated voltage at zero phase angle.

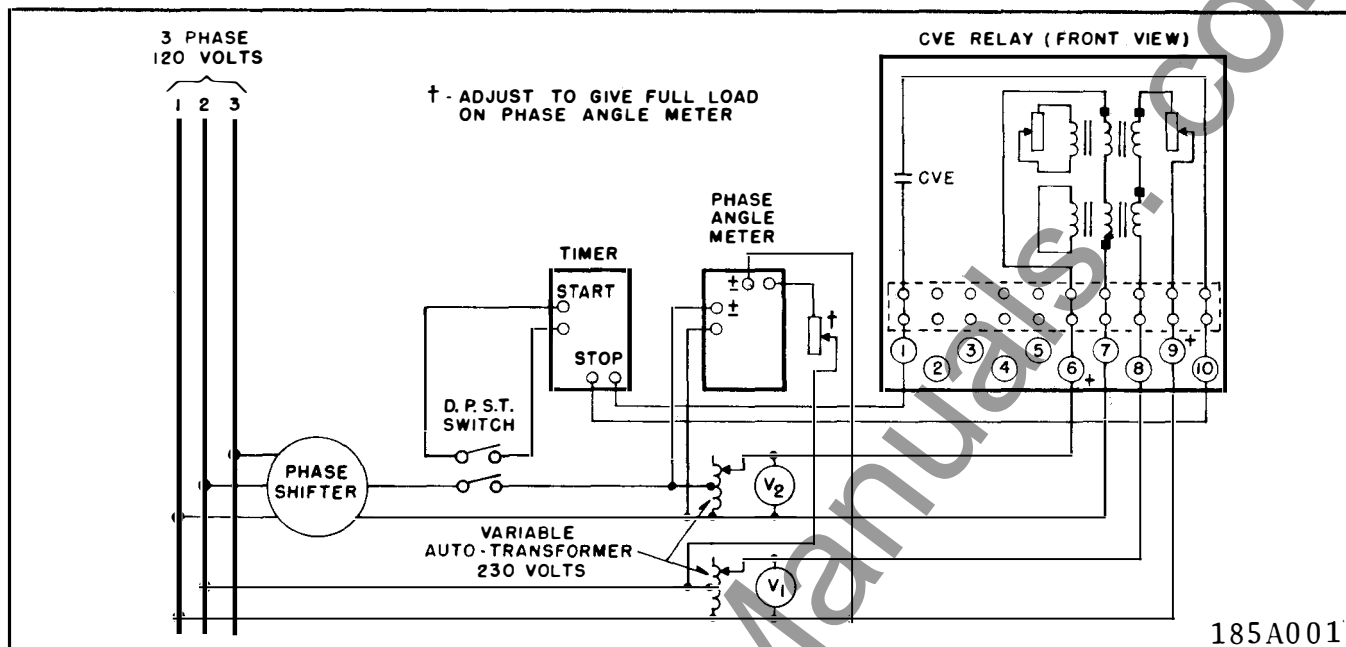


Fig. 14 Diagram of CVE Test Connections.

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 Fig. 11.

ELECTRICAL CHECKPOINTS

With V_1 in Fig. 14 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

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 d.c. 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

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.

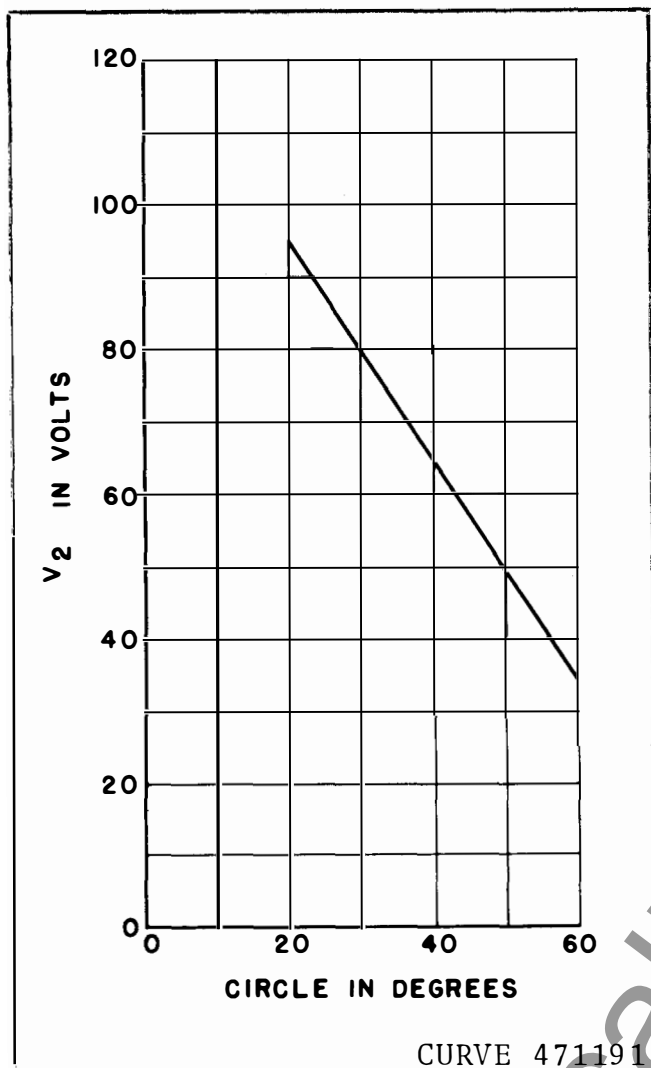


Fig. 15 V_1 Voltage for Different Operating Circle. V_2 equal to rated voltage at zero phase angle. (Curve 471191)

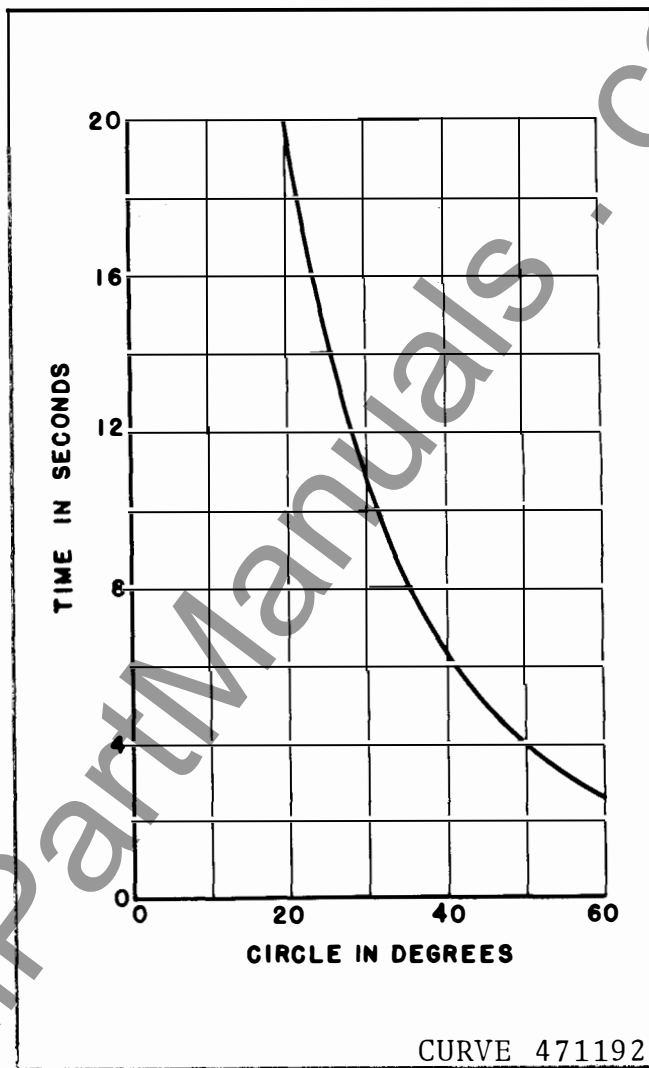


Fig. 16 Operating Times from the No. 11 Time Dial Position for the Type CVE Relay set for Different Operating Circles. V_1 and V_2 equal to rated voltage at zero phase angle. (Curves 471192)

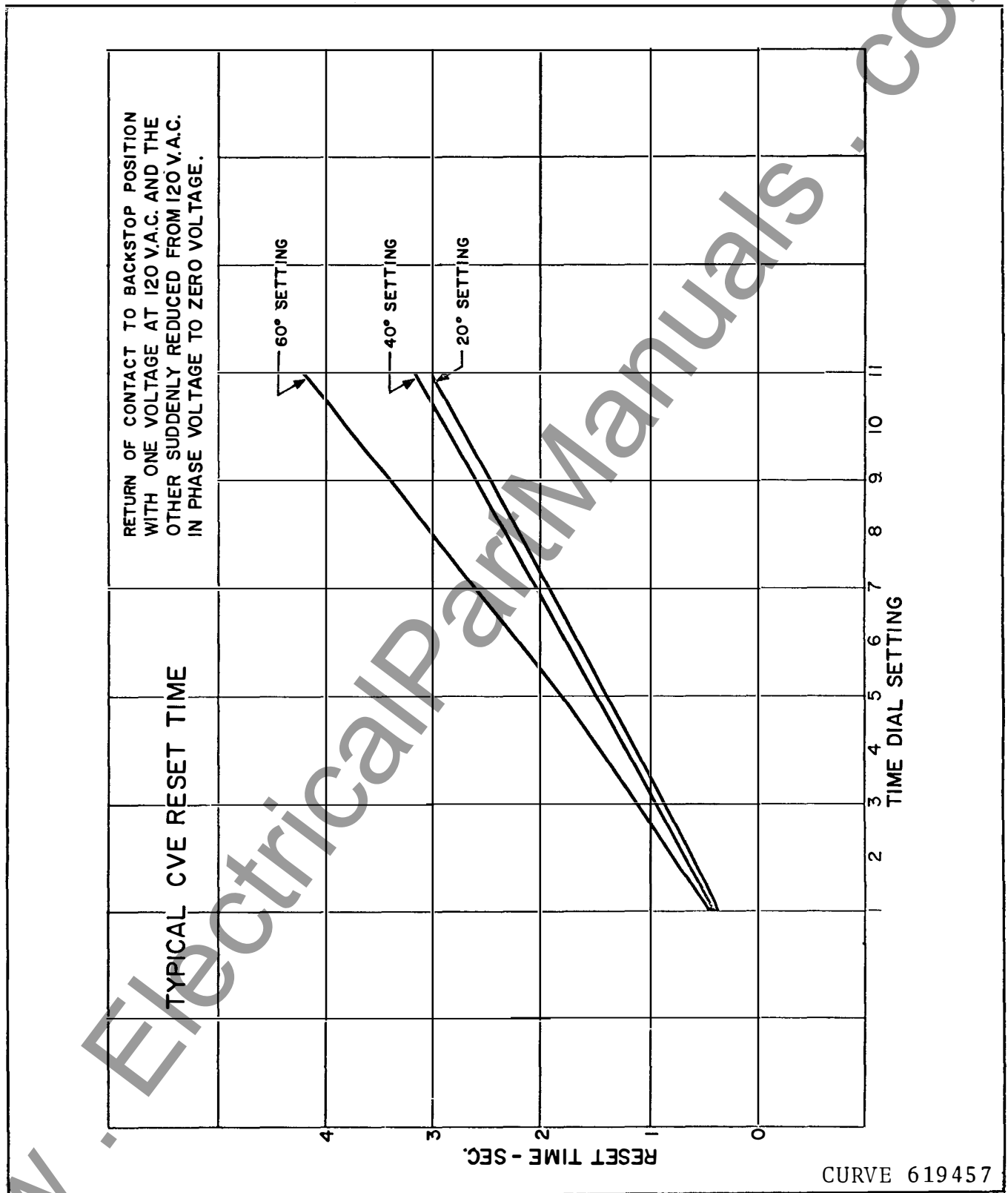
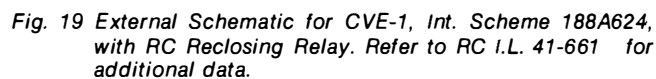


Fig. 17 Typical CVE Reset Times. Return of Contact to Backstop Position with One Voltage at Rated Voltage and the Other Suddenly Reduced from Rated In Phase Voltage to Zero Voltage.



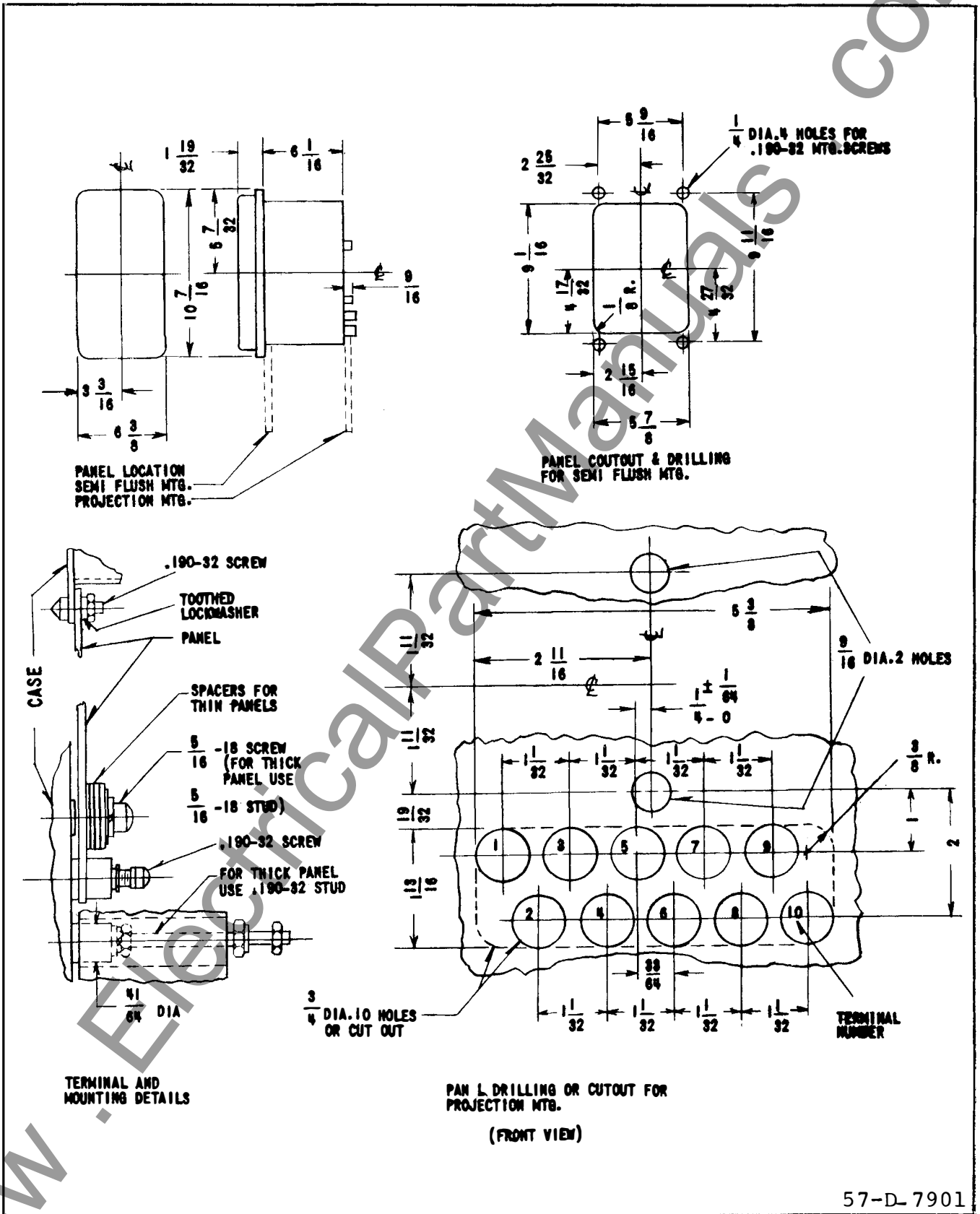
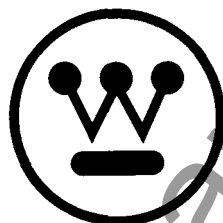


Fig. 20 Outline and Drilling Plan for the CVE and CVE-1 in FT21 case.

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INSTALLATION • OPERATION • MAINTENANCE I N S T R U C T I O N S

TYPE CVE AND CVE-1 SYNCHRO-VERIFIER 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 clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

This instruction leaflet applies to the following types of relays:

- CVE Synchro-Verifier Relay
- CVE-1 Synchro-Verifier Relay with
line and bus voltage
sensing relays

The synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The contacts will close when these voltages are within set limits.

The synchro-verifier is not an automatic synchronizer and should not be used as such. Automatic Synchronizers are available which permit closing ahead of synchronism at an angle of phase-advance proportional to the beat frequencies and determined by the speed of operation of the circuit breaker so that the two systems are connected right on synchronism.

A common application of the synchro-verifier 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 the automatic reclosing equipment to reclose the breaker.

Some provision, such as a reclosing relay, must be used to control closing through the CVE(-1) contacts to avoid the possibility of pumping when closing into a fault.

CONSTRUCTION AND OPERATION

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 Figs. 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 as per Figure 5.

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.

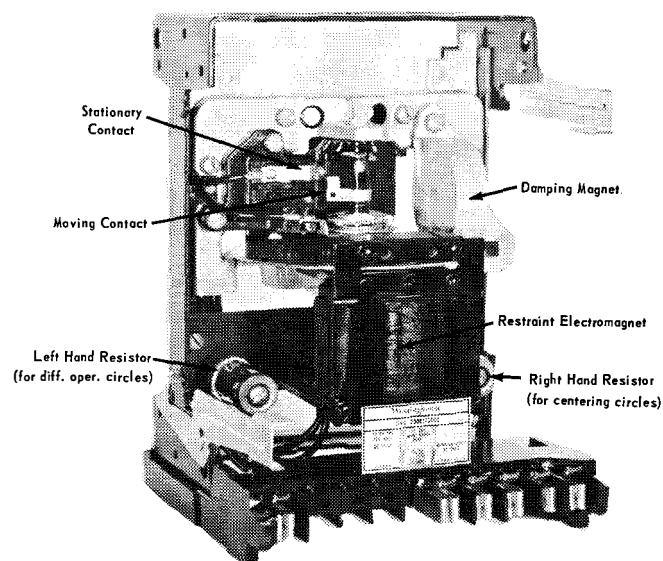
When the relay is energized with two voltages, a flux is produced that is proportional to the sum of the applied voltages. This flux divides and returns through the outer legs of the electromagnet. The lag coil on the left leg causes the flux in that leg to lag the main pole flux. The out-of-phase fluxes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

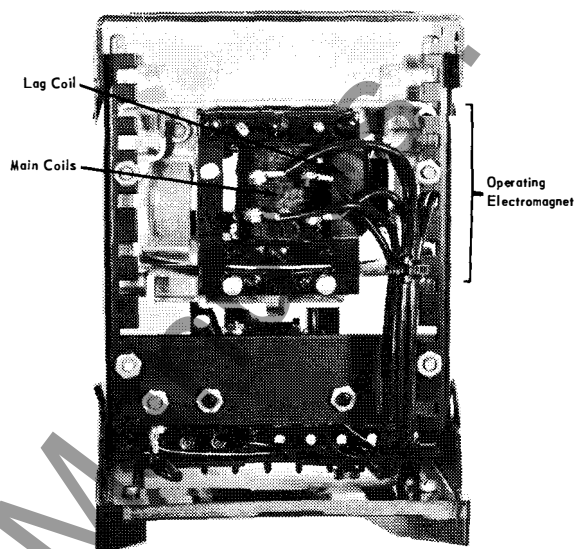
Restraining Element

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.

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 his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

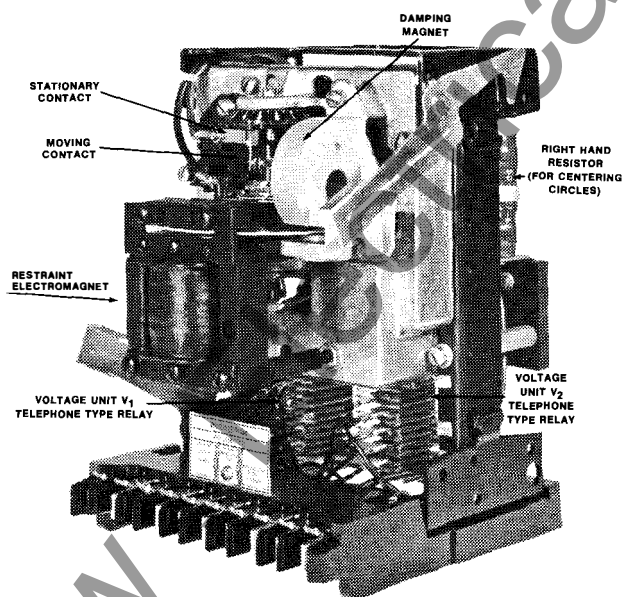


Front View

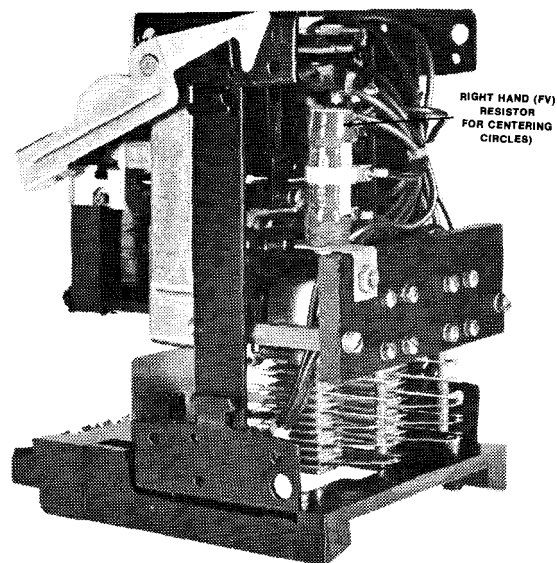


Rear View

Fig. 1. CVE Relay, Without Case



Front View



Rear View

Fig. 2. CVE-1 Relay, Without Case

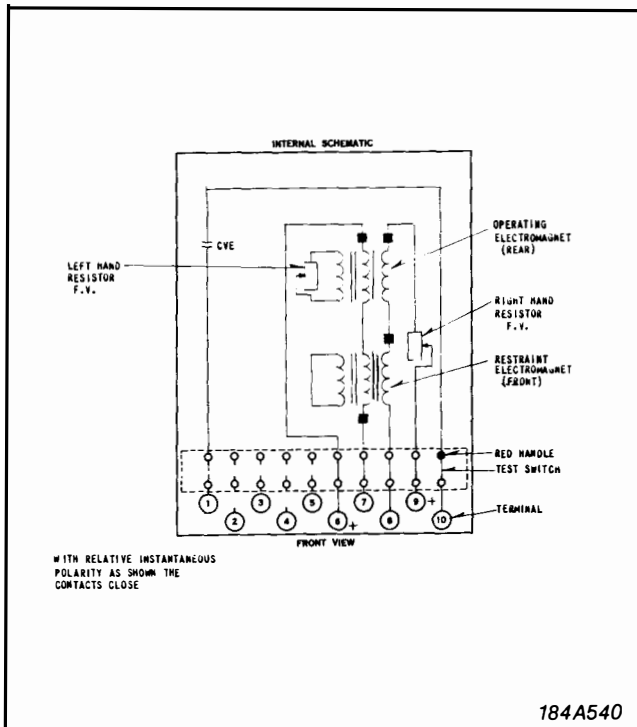


Fig. 3 Internal Schematic of CVE, without ICS Unit.

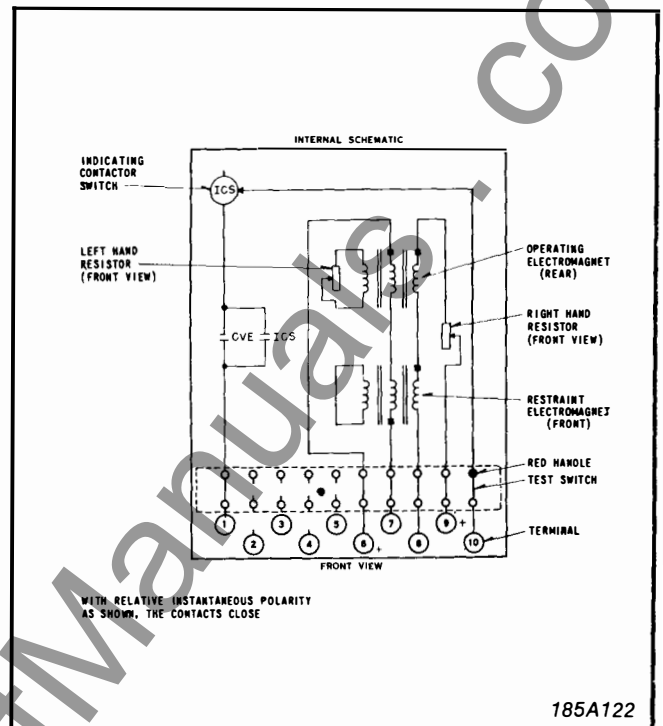


Fig. 4 Internal Schematic of CVE, with ICS Unit.

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.

Telephone Relay—CVE-1 Only

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

Operation With External Voltage Relays

The connections shown in Fig. 8 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 the 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.

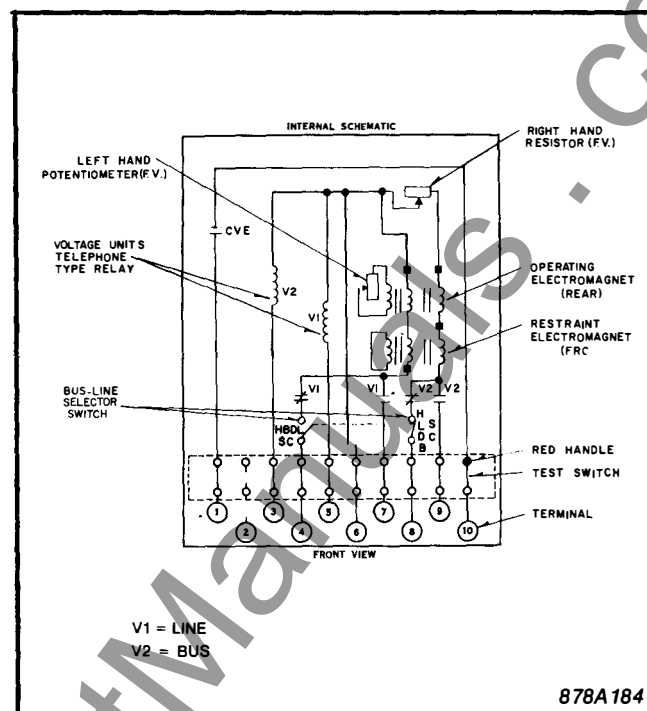
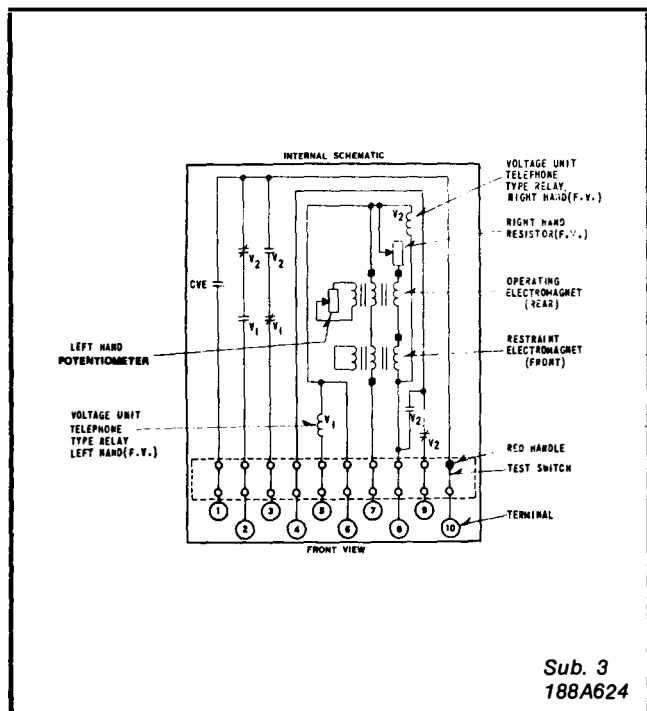
CVE-1 Operation

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 9 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.



★ Fig. 5. Internal Schematic of CVE-1 for use with RC Reclosing Relay. (See Fig. 21 for External Scheme), with commoned voltage coils, use with phase-to-phase connected vt's.

★ Fig. 6. Internal Schematic of CVE-1 with Internal Switch for HBDL or HLDB. (See Fig. 20 for External Scheme), with commoned voltage coils, use with phase-to-phase connected vt's.

CHARACTERISTICS

The type CVE and CVE-1 relays can be adjusted for operating circles from 20 to 60 degrees as shown in Fig. 10. 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 Fig. 11. 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 Fig. 12.

*Fig. 13 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.

Fig. 19 shows typical CVE reset times for 20°, 40°, and 60° circle settings.

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:

	Voltages in Phase	Voltages 180 Degrees Out of Phase
Volt-amperes	15.4	13.5
Power Factor	.422	.422
Watts	6.5	5.7

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.

Continuous Rating

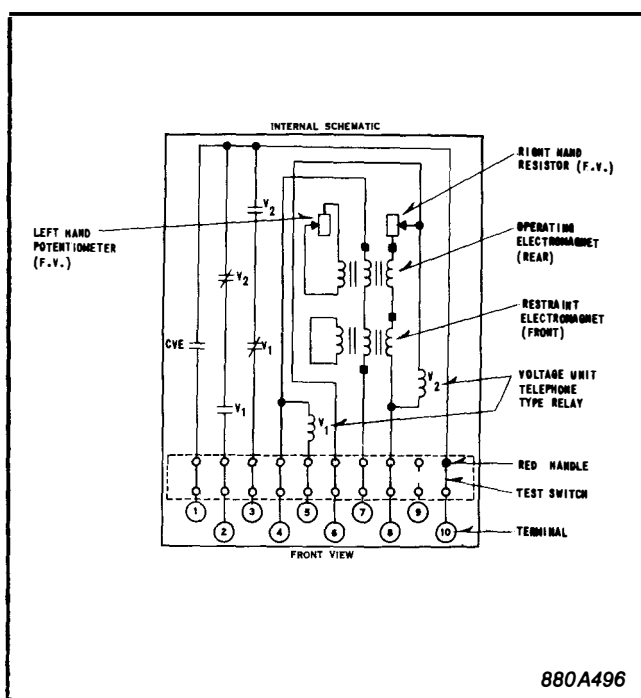
These relays will continuously stand 110% of rated voltage applied to the two circuits, either separately or simultaneously.

SETTINGS

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



★ Fig. 7. Internal Schematic of CVE-1 without commoned Potential Coils. (See Fig. 9 for External Scheme)

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 as low as ½ time dial should be satisfactory with the 20° circle. Note from Fig. 12 that the relay will operate in 1.4 seconds in the ½ 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 Fig. 11. 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 systems 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:

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

where T_B = breaker closing time in seconds

$$\text{Let } T_B = 0.5 \text{ seconds}$$

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

Indicating Contactor Switch (ICS)—When Used

No setting is required on the ICS unit.

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 Figure 22 for Outline and Drilling Plan. For detailed FT Case information refer to I.L. 41-076.

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.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order:

Indicating Contactor Switch (ICS)—When Used

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

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

Disc Unit.

1. **Contacts**—The index mark on the movement frame will coincide with the "O" 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 "O" 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 relay per the test diagram of Fig. 14. CVE-1 relays should be connected in a

TYPE CVE AND CVE-1 RELAYS

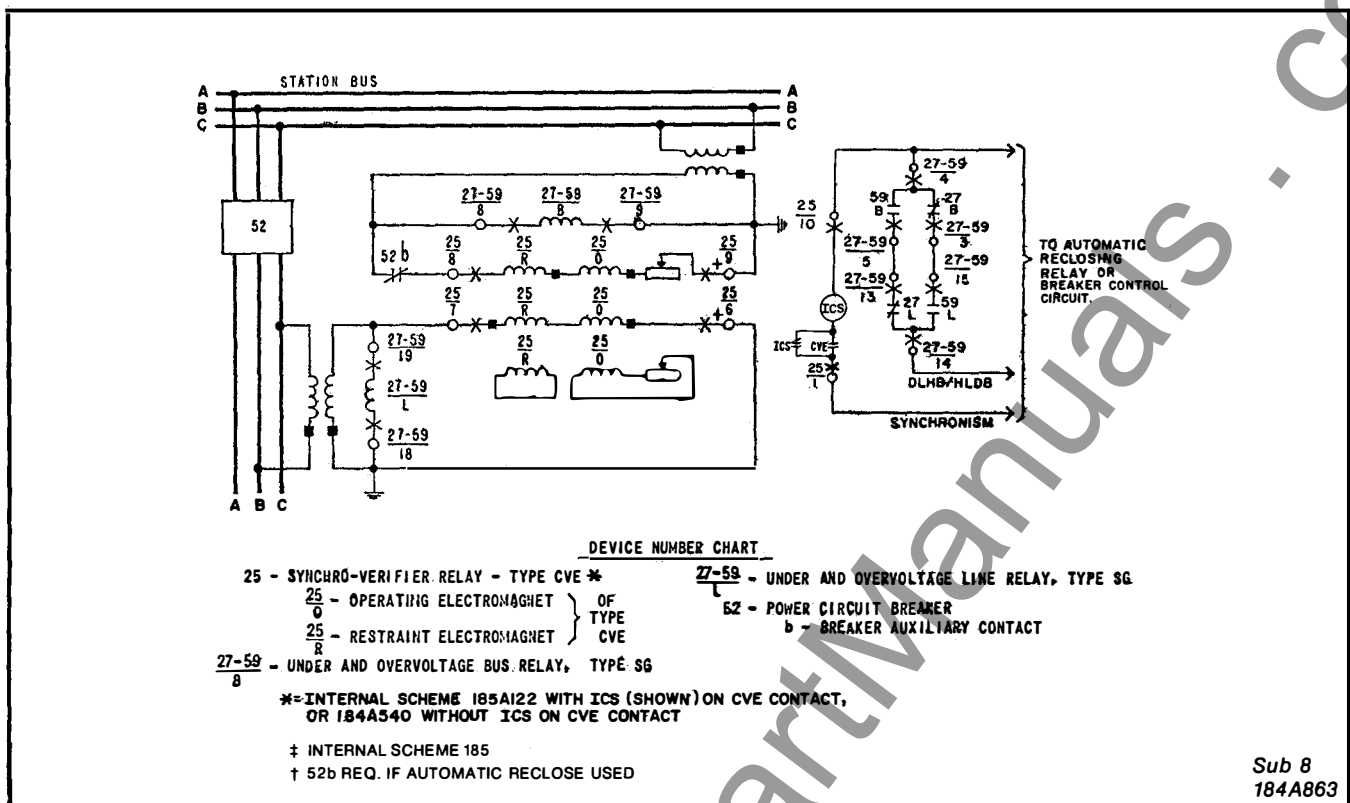


Fig. 8 External Schematic of the CVE with SG Relay for Dead-Line-Hot Bus and Hot Line-Dead Bus Reclosing.

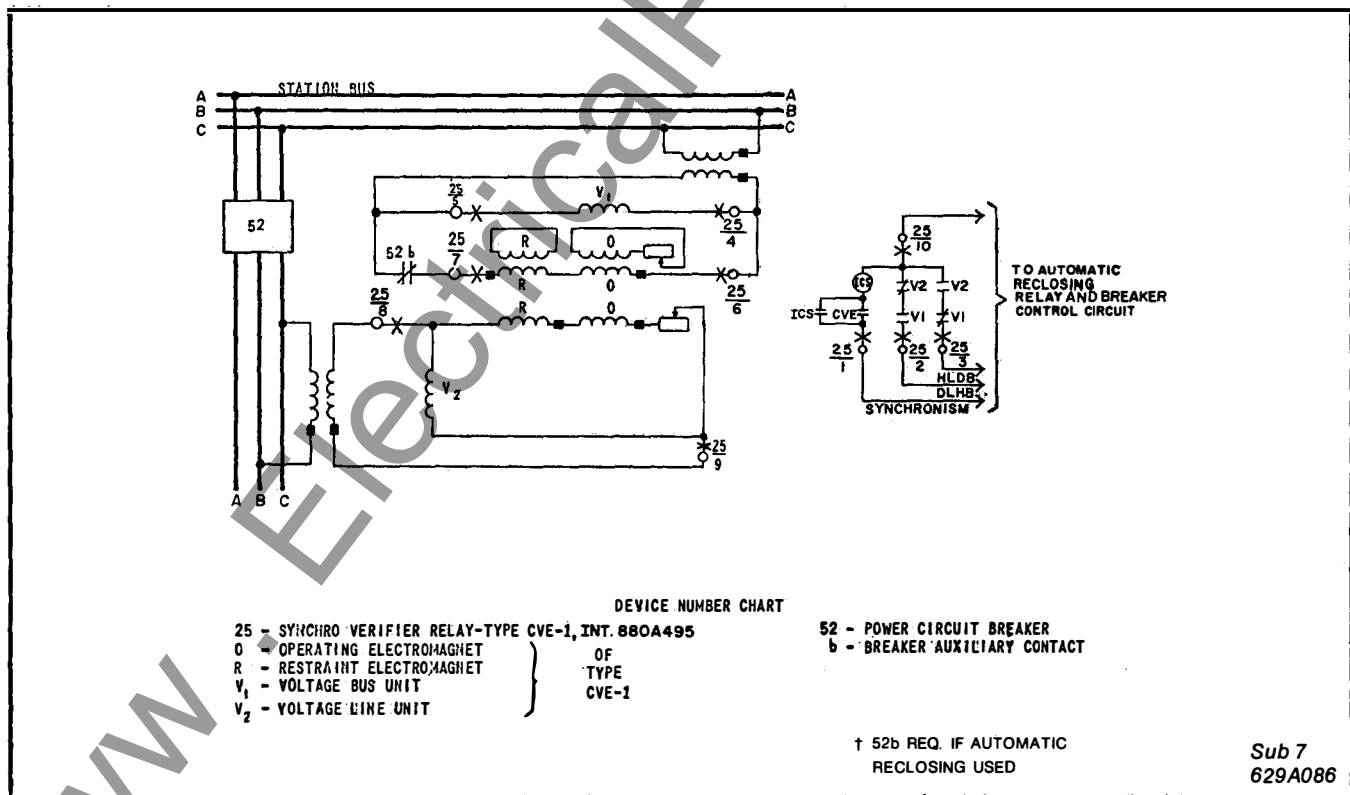


Fig. 9 External Schematic of CVE-1 for Dead-Line-Hot-Bus and Hot-Line-Dead-Bus Reclosing.

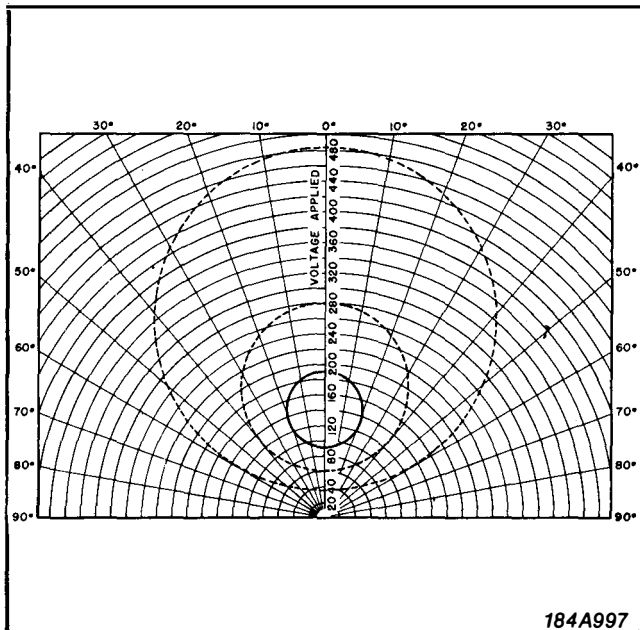


Fig. 10 Typical Voltage-Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.

similar manner to correspond with the wiring of the particular style CVE-1 using Figures 15 and 16. The contacts should just close under the following two 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 $94 \pm 4V$ 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.

Telephone Relays (CVE—1 only)

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

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 S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not

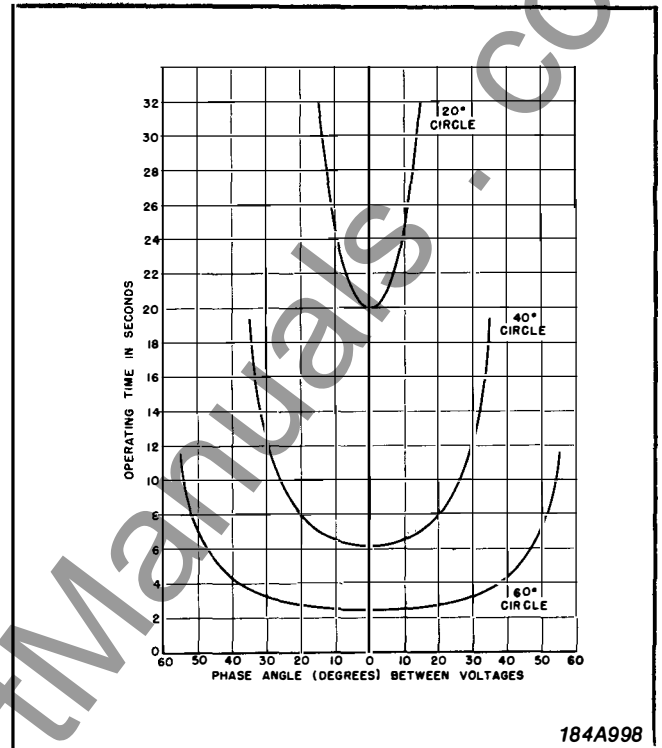


Fig. 11 Typical Time-Phase Angle Curves of CVE. Rated Voltage on Both Circuits No. #11 Dial Time Setting.

recommended, because of the danger of embedding small particles in the face of the soft silver contact and thus impairing the contact.

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*).

1. **Contact**—The index mark on the movement frame coincides with the "O" 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 "O" 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**—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.

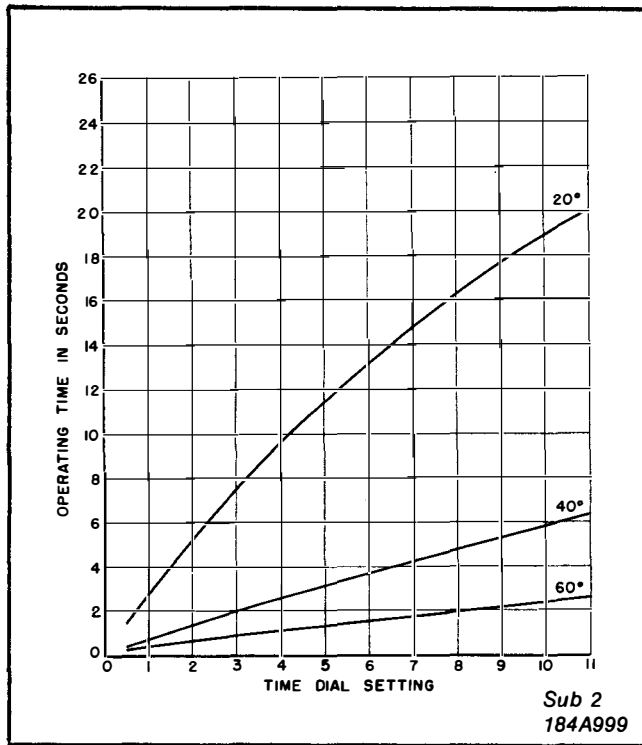


Fig. 12 Operating Time Variations with Changes in Time-Dial Settings. Rated In-Phase Voltage on Both Circuits, 20°, 40° and 60° Circle Setting.

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 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 Fig. 14 for CVE, or Figs. 15 or 16 for CVE-1, and apply rated voltage at zero 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

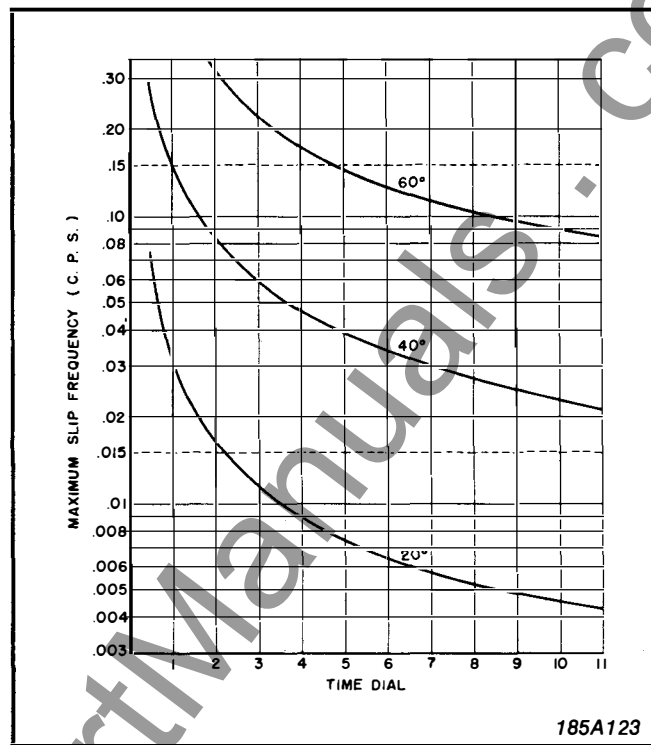
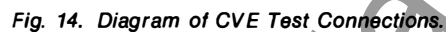


Fig. 13 Approximate Maximum Slip Frequency for which Operation Occurs—Rated Voltage on Both Sides.

equal to rated voltage. Note the angle at which the contacts 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 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 ± 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 $94 \pm 4V$ in phase with V_1 . If necessary, readjust spring slightly to obtain this condition. The relay is now calibrated for a 20 degree circle.

6. 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 ± 0.6 seconds with V_1 and V_2 equal to rated voltage at zero phase angle.



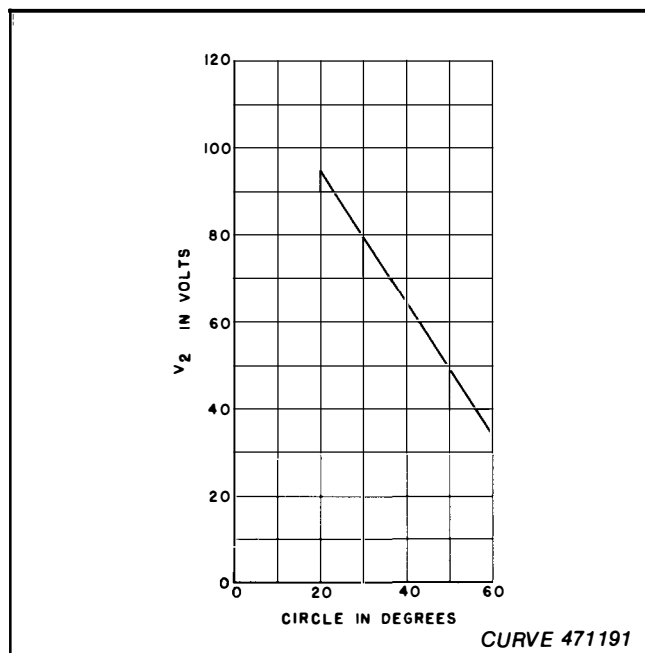


Fig. 17. V_2 Voltage for Different Operating Circle. V_2 equal to rated voltage at zero phase angle.

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 Fig. 11.

ELECTRICAL CHECKPOINTS

With V_1 in Fig. 14, 15 or 16 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

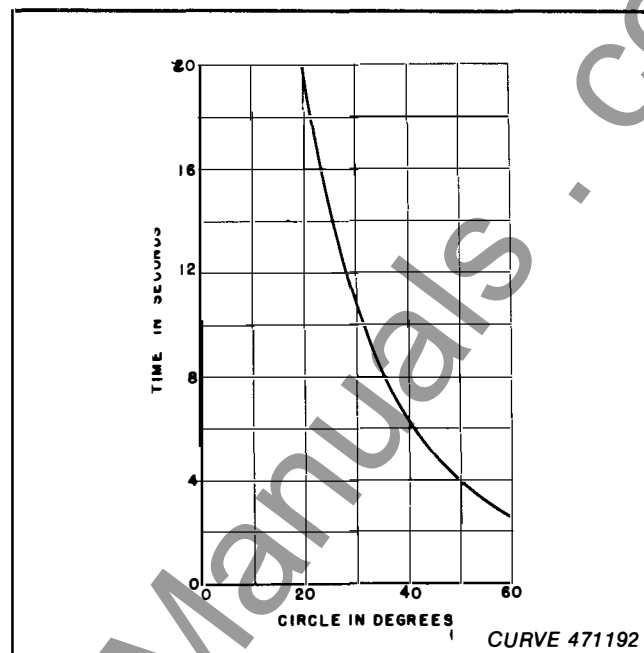


Fig. 18. Operating Times from the No. 11 Time Dial Position for the Type CVE Relay set for Different Operating Circles. V_1 and V_2 equal to rated voltage at zero phase angle.

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 d.c. 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

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.

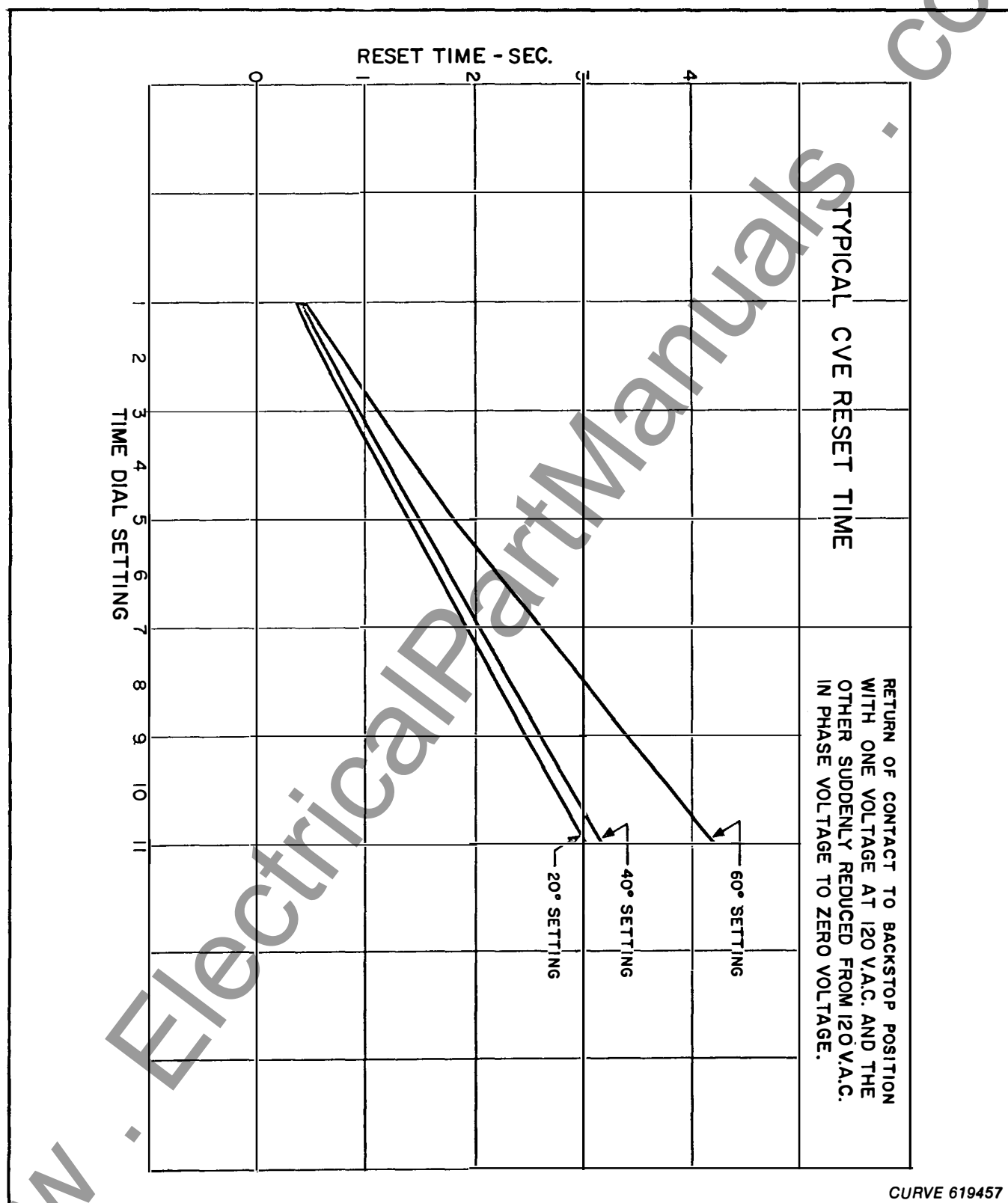


Fig. 19. Typical CVE Reset Times. Return of Contact to Backstop Position with One Voltage at Rated Voltage and the Other Suddenly Reduced from Rated in Phase Voltage to Zero Voltage.

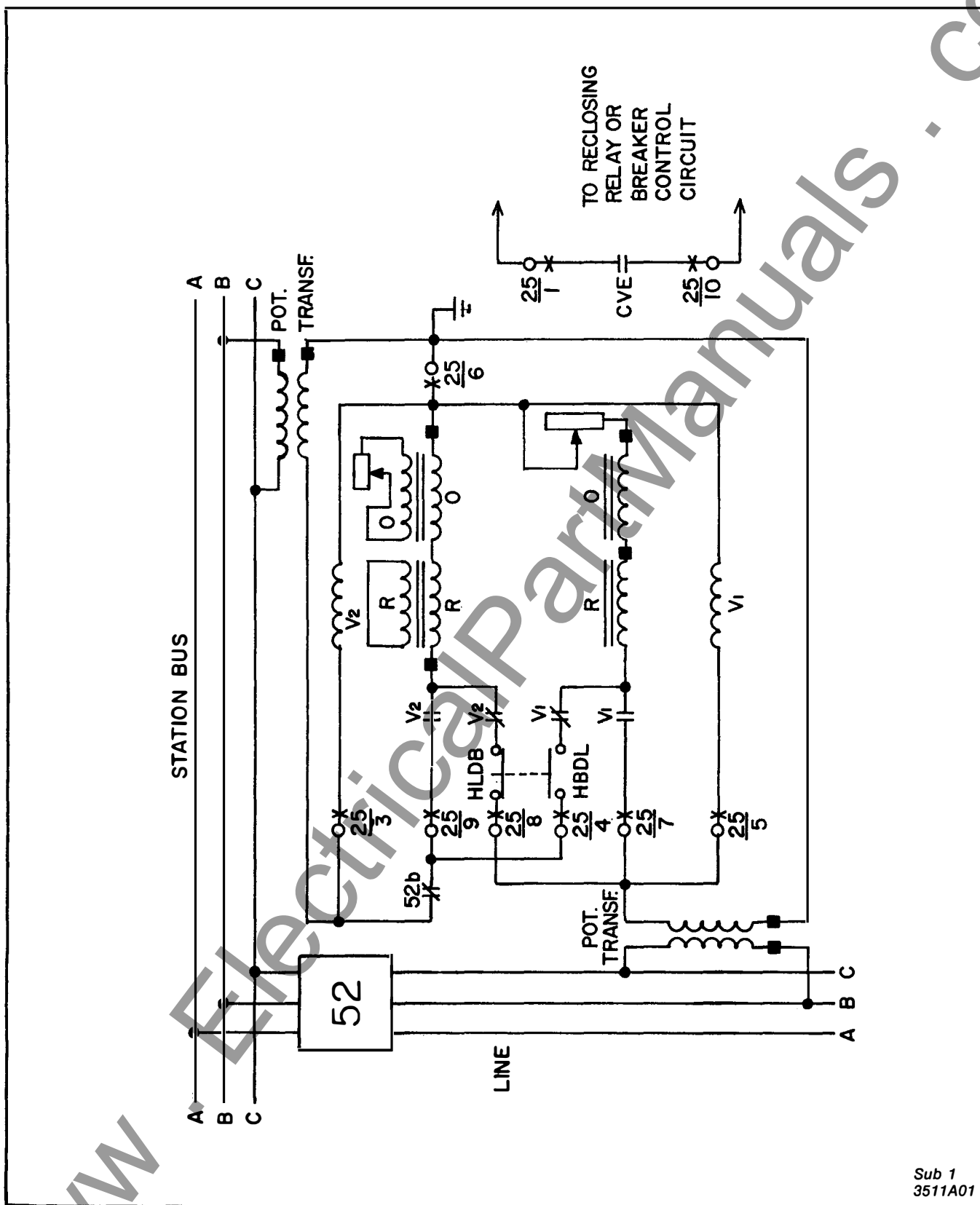


Fig. 20. External Schematic for CVE-1 with HLDB/HBDL Selector Switch, Internal Scheme 878A184.

Sub 1
3511A01

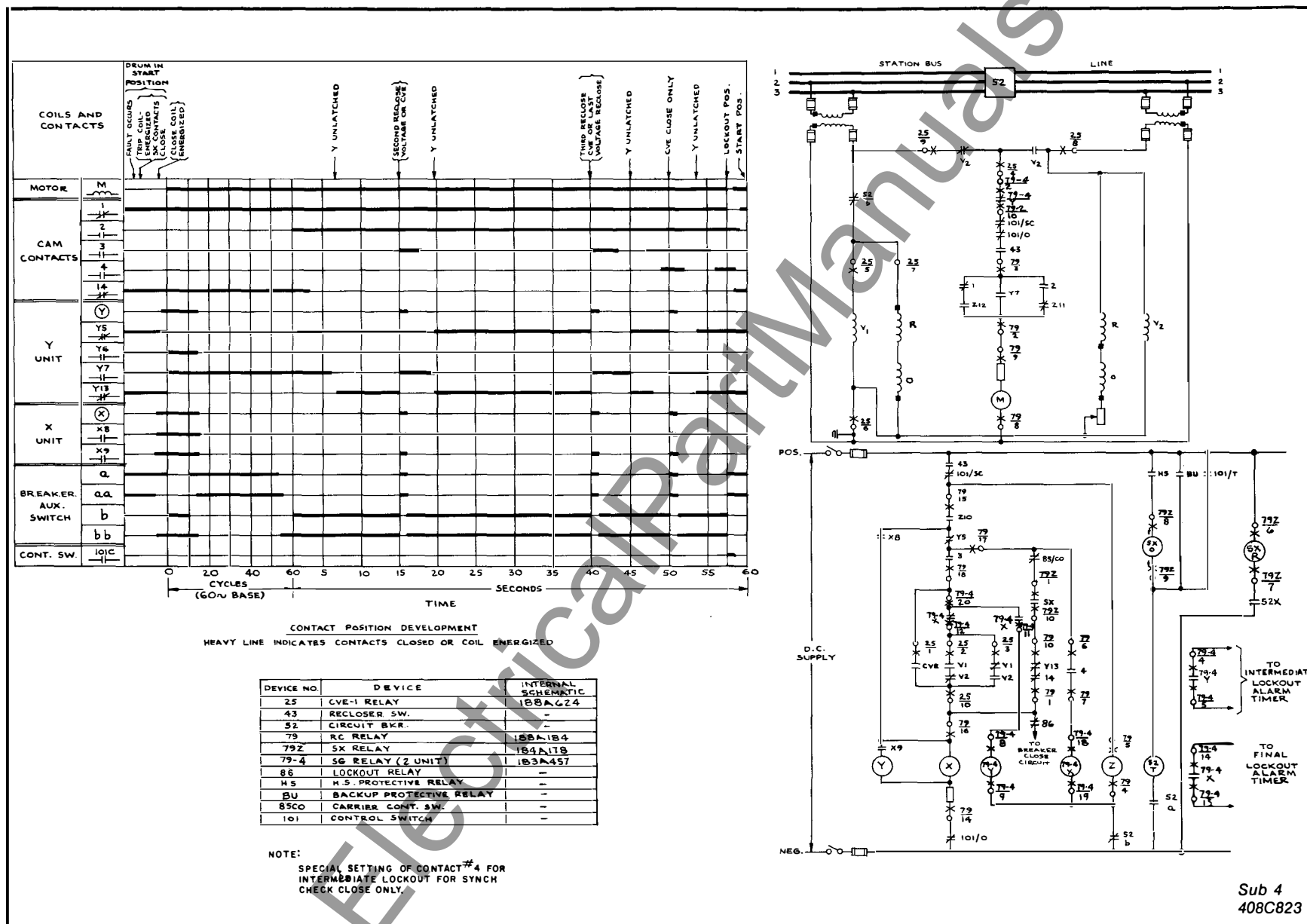


Fig. 21 External Schematic for CVE-1, Int. Scheme 188A624, with RC Reclosing Relay. Refer to RC I.L. 41-661 for additional data.

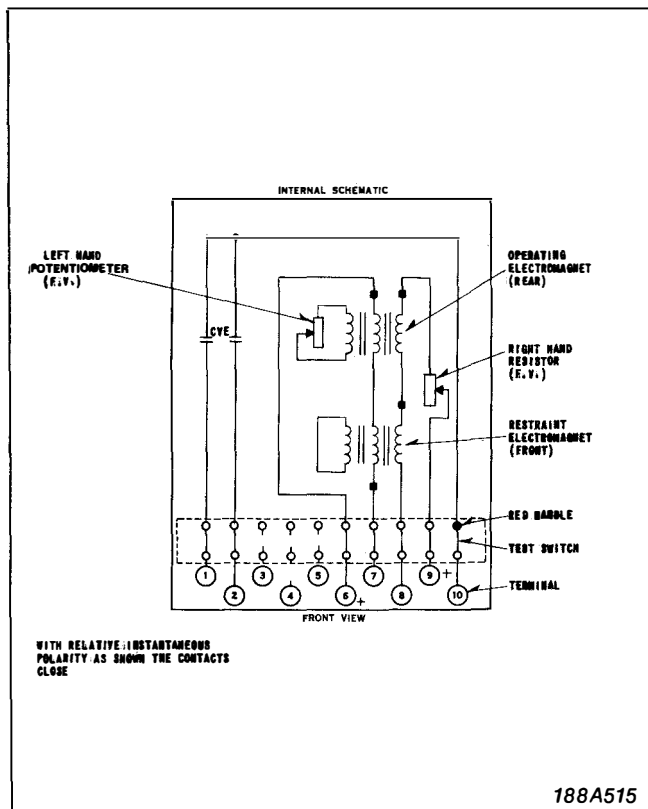


Fig. 22. Internal Schematic of CVE Synchro-Verifier, DPST Contacts.

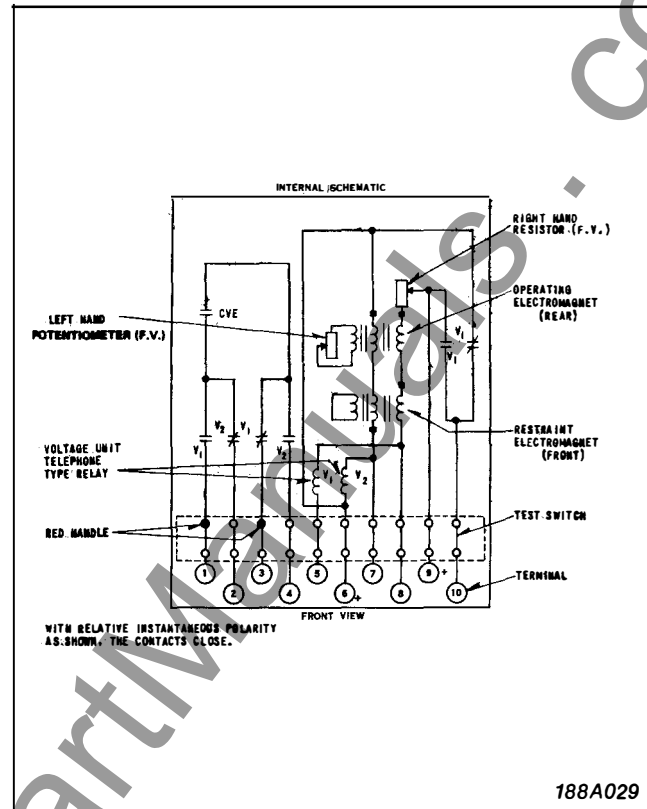


Fig. 23. Internal Schematic of CVE-1 with CVE Contacts Supervised by voltage contacts.

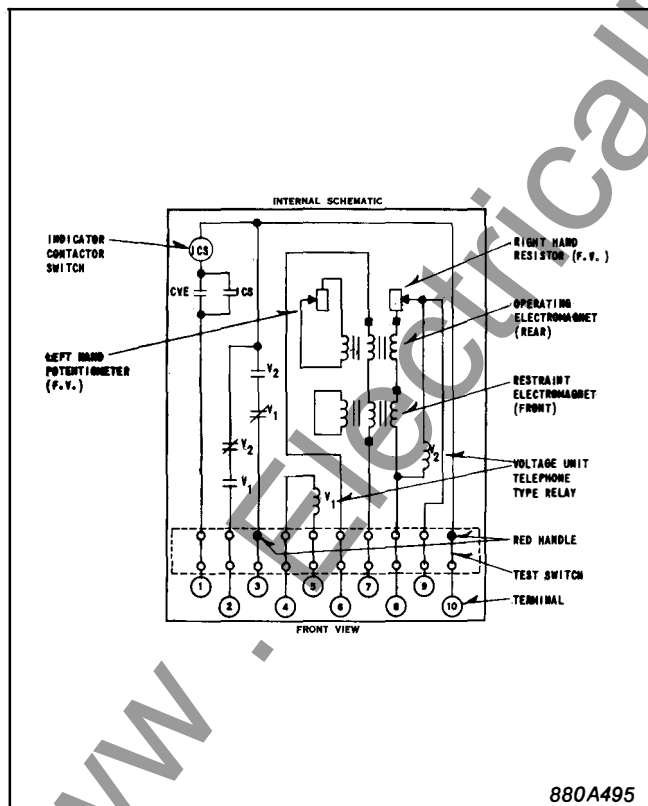


Fig. 24. Internal Schematic of CVE-1 without commoned potential coils, with ICS.

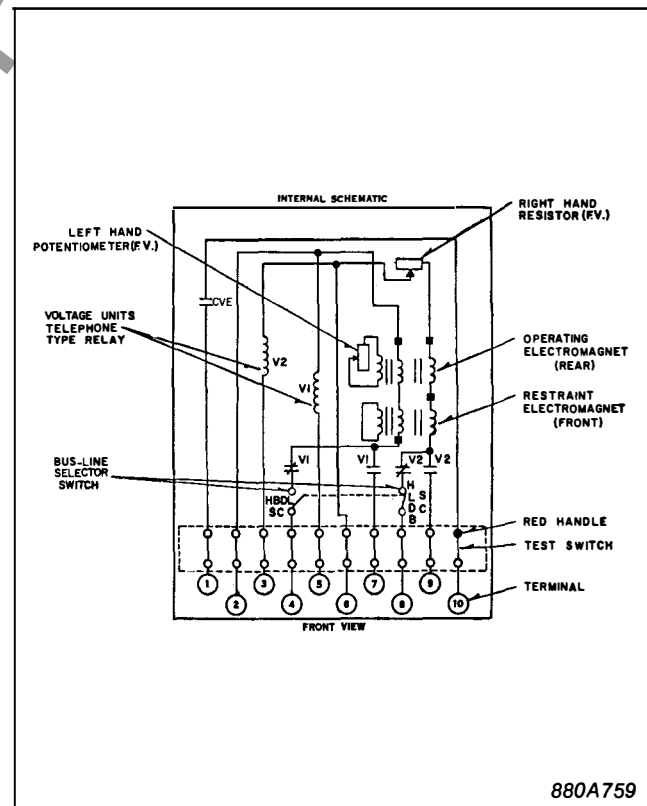


Fig. 25. Internal Schematic of CVE-1 with DPDT Switch, without commoned potential coils.

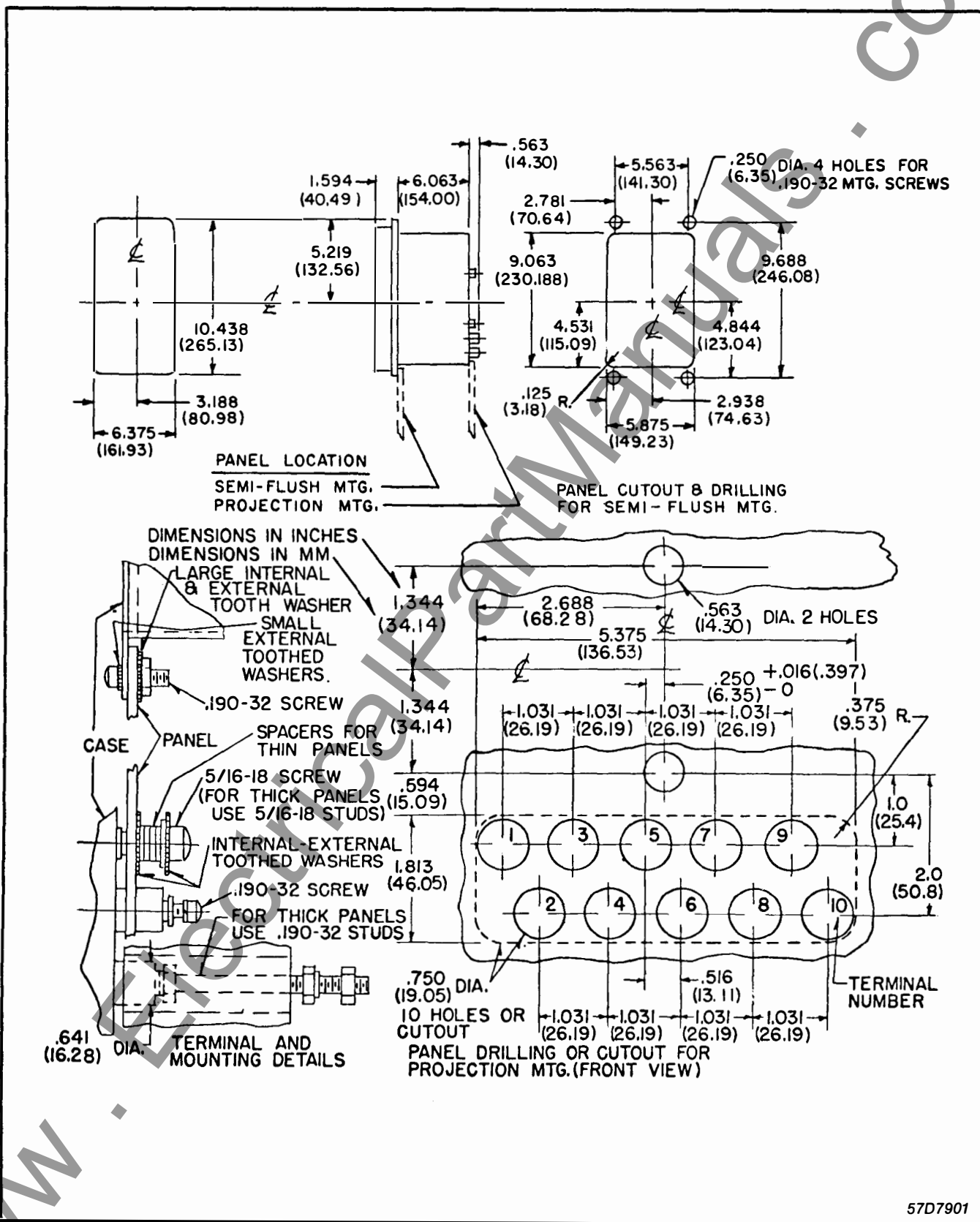


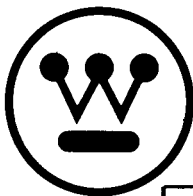
Fig. 26. Outlined and Drilling Plan for the CVE and CVE-1 in FT21 case.



WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION

CORAL SPRINGS, FL.

Printed in U.S.A.



INSTALLATION • OPERATION • MAINTENANCE I N S T R U C T I O N S

TYPE CVE AND CVE-1 SYNCHRO-VERIFIER 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 clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

This instruction leaflet applies to the following types of relays:

- CVE Synchro-Verifier Relay
- CVE-1 Synchro-Verifier Relay with
line and bus voltage
sensing relays

The synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The contacts will close when these voltages are within set limits.

The synchro-verifier is not an automatic synchronizer and should not be used as such. Automatic Synchronizers are available which permit closing ahead of synchronism at an angle of phase-advance proportional to the beat frequencies and determined by the speed of operation of the circuit breaker so that the two systems are connected right on synchronism.

A common application of the synchro-verifier 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 the automatic reclosing equipment to reclose the breaker.

Some provision, such as a reclosing relay, must be used to control closing through the CVE(-1) contacts to avoid the possibility of pumping when closing into a fault.

CONSTRUCTION & OPERATION

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 Figs. 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 as per Figure 5.

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.

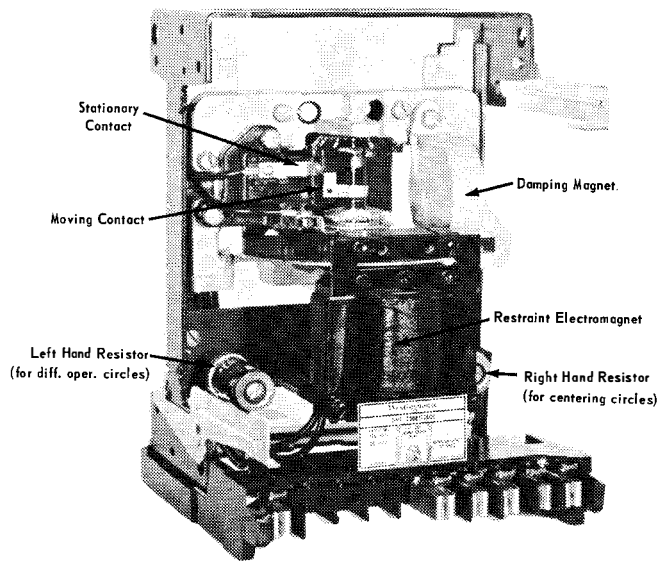
When the relay is energized with two voltages, a flux is produced that is proportional to the sum of the applied voltages. This flux divides and returns through the outer legs of the electromagnet. The lag coil on the left leg causes the flux in that leg to lag the main pole flux. The out-of-phase fluxes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

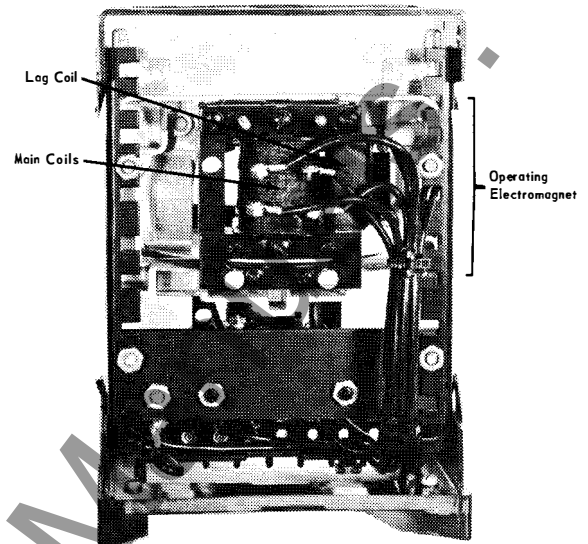
Restraining Element

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.

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 his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

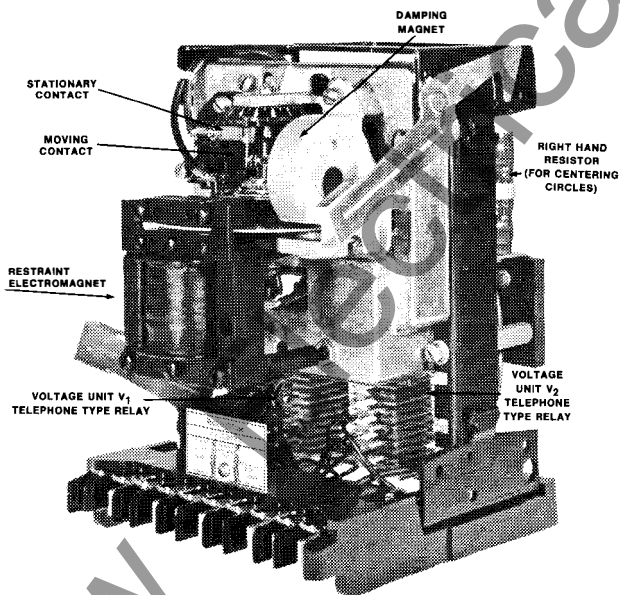


Front View

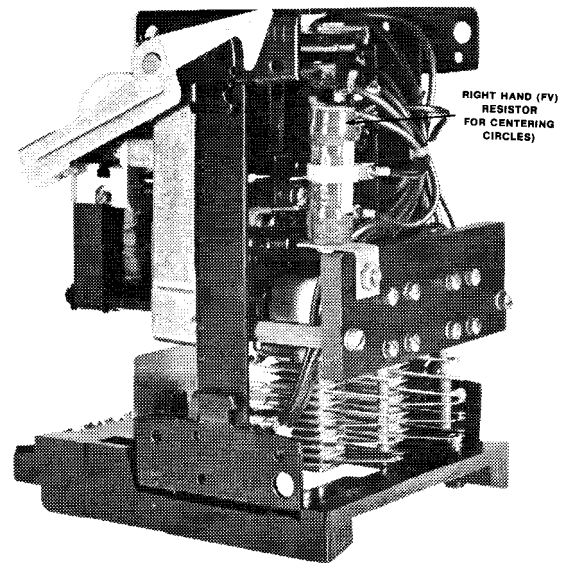


Rear View

Fig. 1. CVE Relay, Without Case



Front View



Rear View

Fig. 2. CVE-1 Relay, Without Case

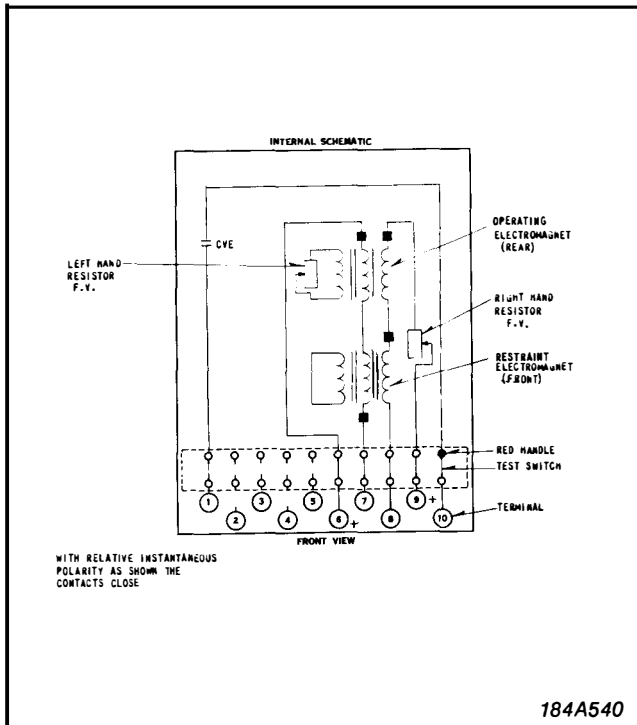


Fig. 3 Internal Schematic of CVE, without ICS Unit.

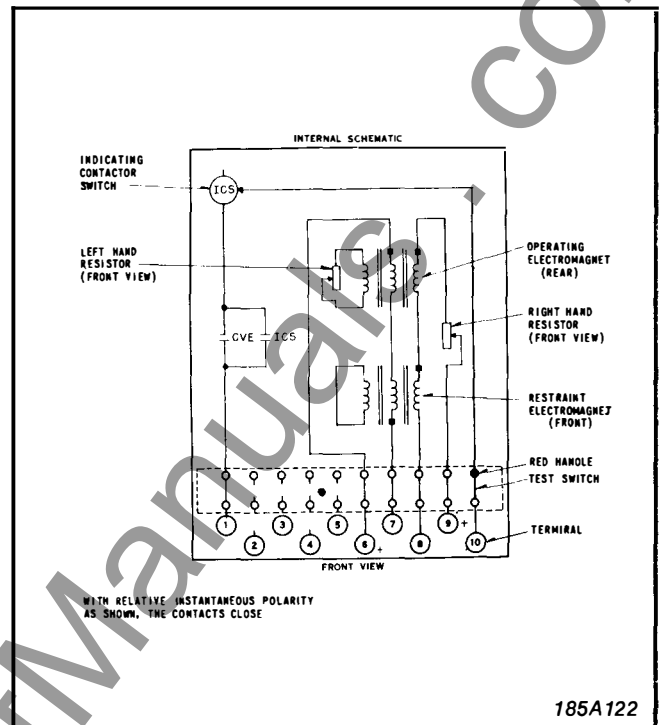


Fig. 4 Internal Schematic of CVE, with ICS Unit.

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.

Telephone Relay—CVE-1 Only

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

Operation With External Voltage Relays

The connections shown in Fig. 8 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 the 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.

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 9 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.

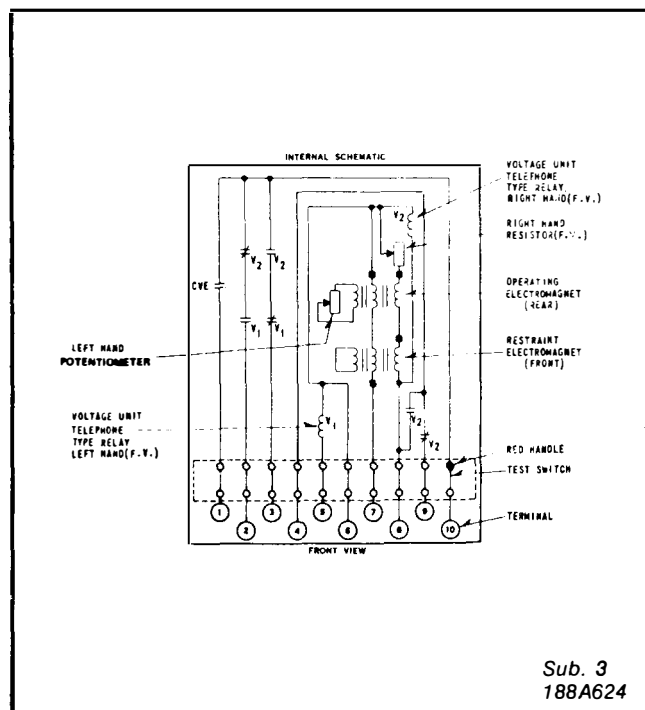


Fig. 5. Internal Schematic of CVE-1 for use with RC Reclosing Relay (See Fig. 21 for External Scheme). With commoned voltage coils, use with phase-to-phase connected vt's.

CHARACTERISTICS

The type CVE and CVE-1 relays can be adjusted for operating circles from 20 to 60 degrees as shown in Fig. 10. 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 Fig. 11. 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 Fig. 12.

Fig. 13 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.

Fig. 19 shows typical CVE reset times for 20°, 40°, and 60° circle settings.

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:

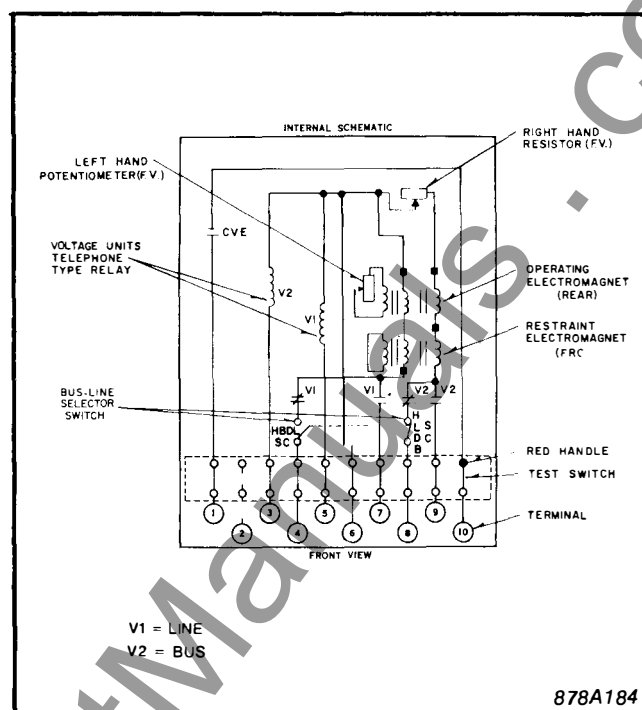


Fig. 6. Internal Schematic of CVE-1 with Internal Switch for HBDL or HLDB. (See Fig. 20 for External Scheme). With commoned voltage coils, use with phase-to-phase connected vt's.

	in Phase	Degrees Out of Phase
Volt-amperes	15.4	13.5
Power Factor	.422	.422
Watts	6.5	5.7

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.

Continuous Rating

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

SETTINGS

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

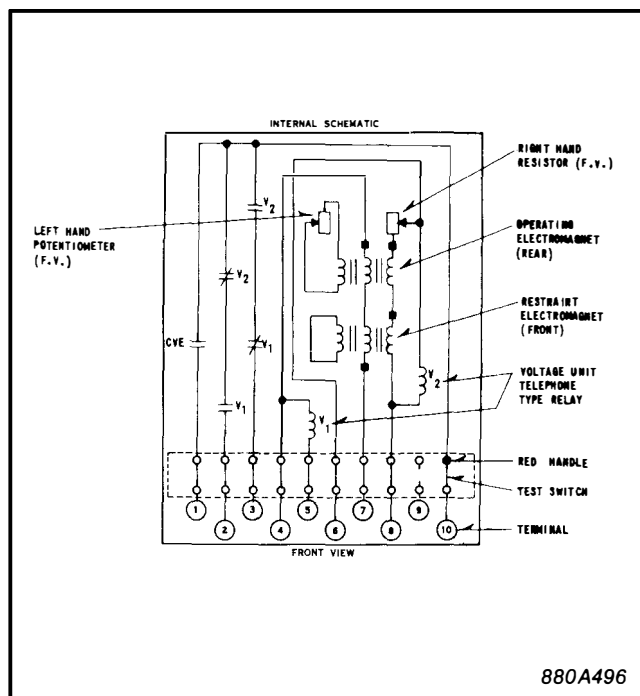


Fig. 7. Internal Schematic of CVE-1 without commoned Potential Coils. (See Fig. 9 for External Scheme)

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 as low as ½ time dial should be satisfactory with the 20° circle. Note from Fig. 12 that the relay will operate in 1.4 seconds in the ½ 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 Fig. 11. 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 systems 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:

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

where T_B = breaker closing time in seconds

$$\text{Let } T_B = 0.5 \text{ seconds}$$

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

Indicating Contactor Switch (ICS)—When Used

No setting is required on the ICS unit.

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 Figure 22 for Outline and Drilling Plan. For detailed FT Case information refer to I.L. 41-076.

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.

Acceptance Check

The following check is recommended to insure that the relay is in proper working order:

Indicating Contactor Switch (ICS)—When Used

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

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

Disc Unit.

1. *Contacts*—The index mark on the movement frame will coincide with the "O" 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 "O" 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 relay per the test diagram of Fig. 14. CVE-I relays should be connected in a

TYPE CVE AND CVE-1 RELAYS

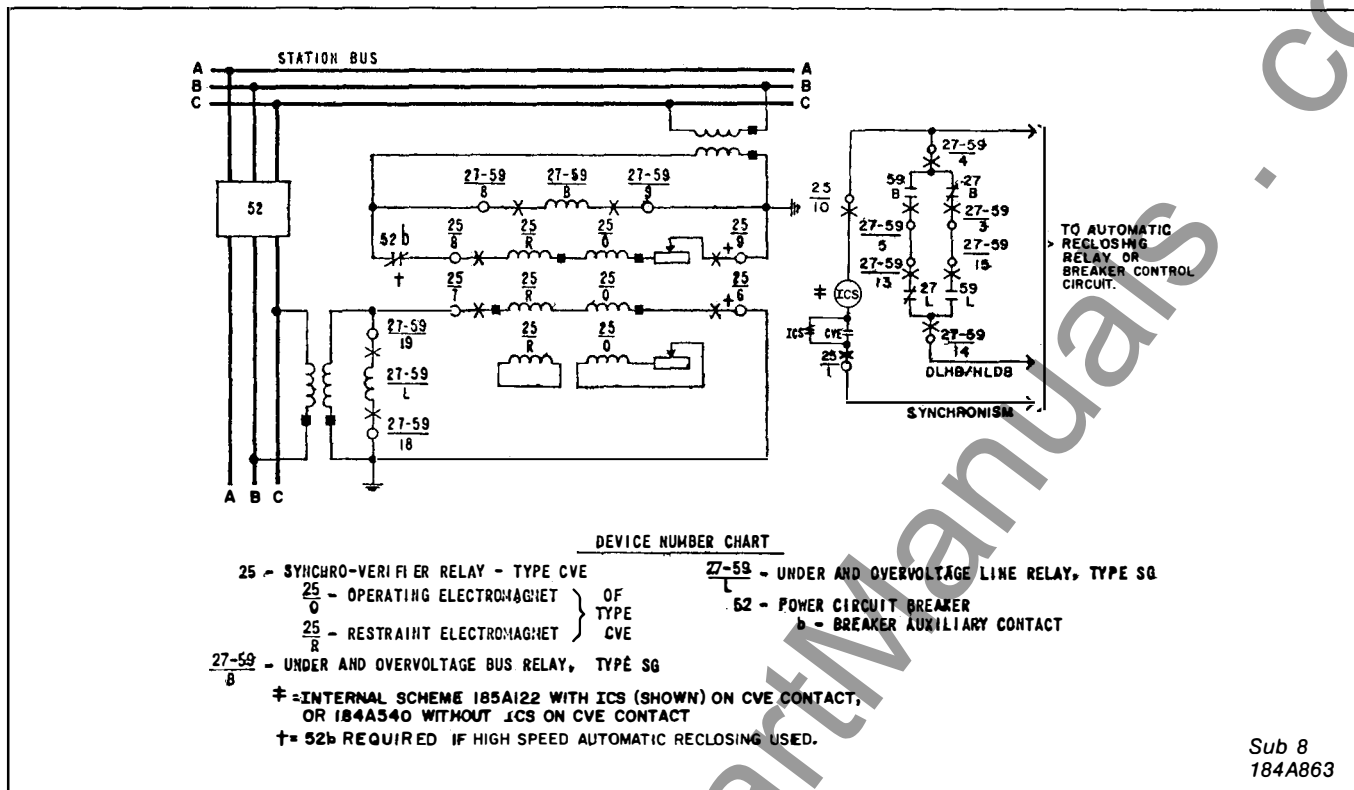


Fig. 8 External Schematic of the CVE with SG Relay for Dead-Line-Hot Bus and Hot Line-Dead Bus Reclosing.

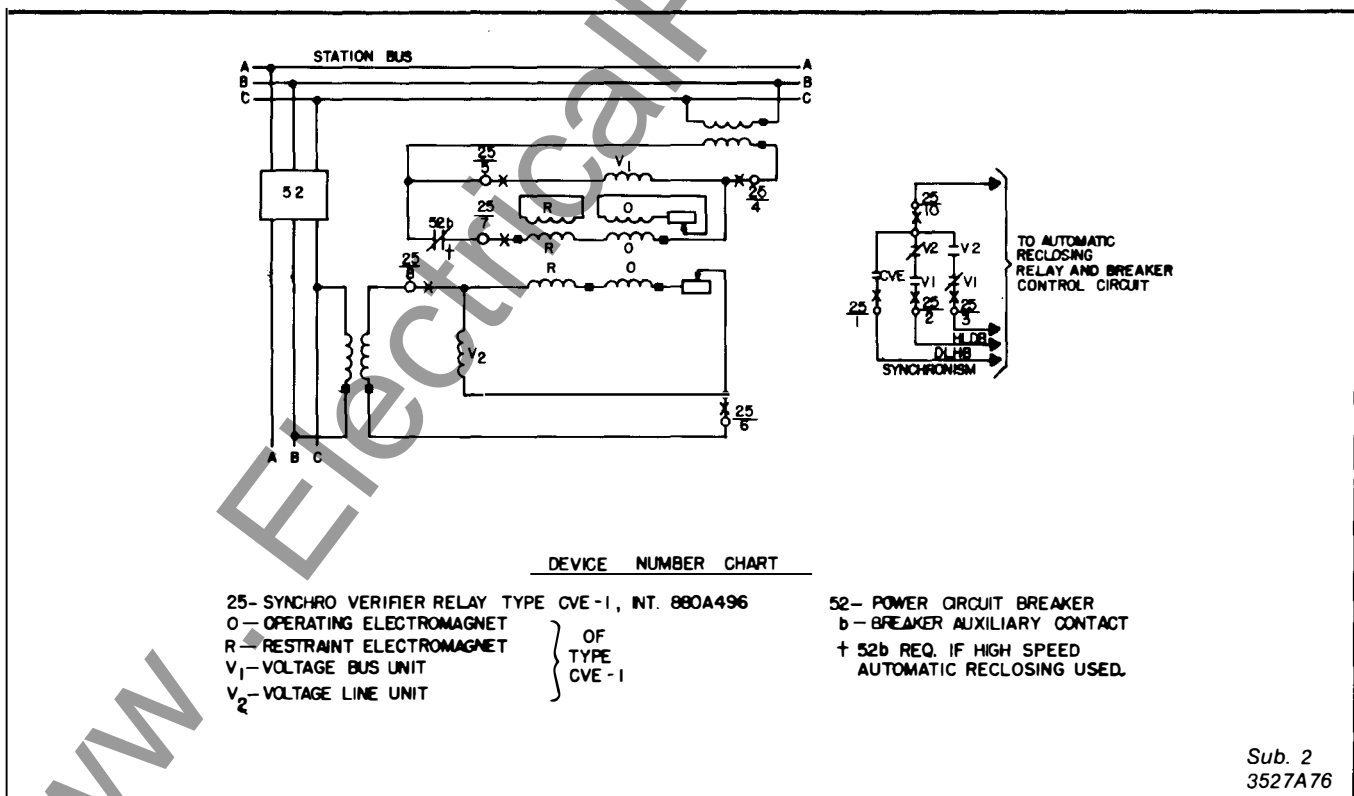


Fig. 9 External Schematic of CVE-1 for Dead-Line-Hot-Bus and Hot-Line-Dead-Bus Reclosing.

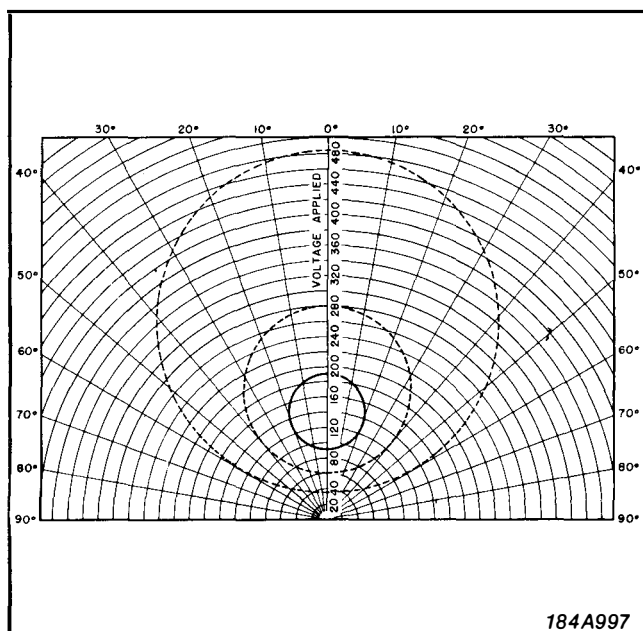


Fig. 10 Typical Voltage-Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.

similar manner to correspond with the wiring of the particular style CVE-1 using Figures 15 and 16. The contacts should just close under the following two 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 $94 \pm 4V$ 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.

Telephone Relays (CVE—1 only)

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

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 S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not

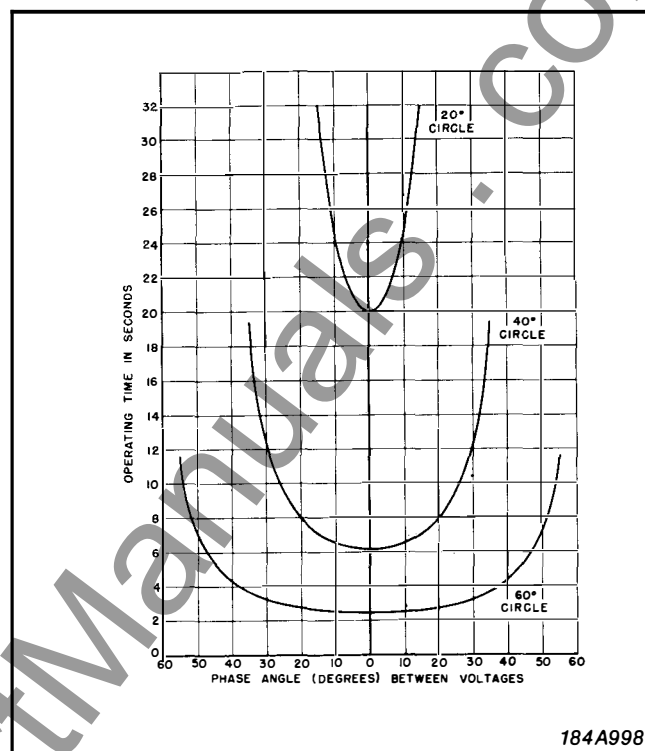


Fig. 11 Typical Time-Phase Angle Curves of CVE. Rated Voltage on Both Circuits No. #11 Dial Time Setting.

recommended, because of the danger of embedding small particles in the face of the soft silver contact and thus impairing the contact.

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*).

1. *Contact*—The index mark on the movement frame coincides with the "O" 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 "O" 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*—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.

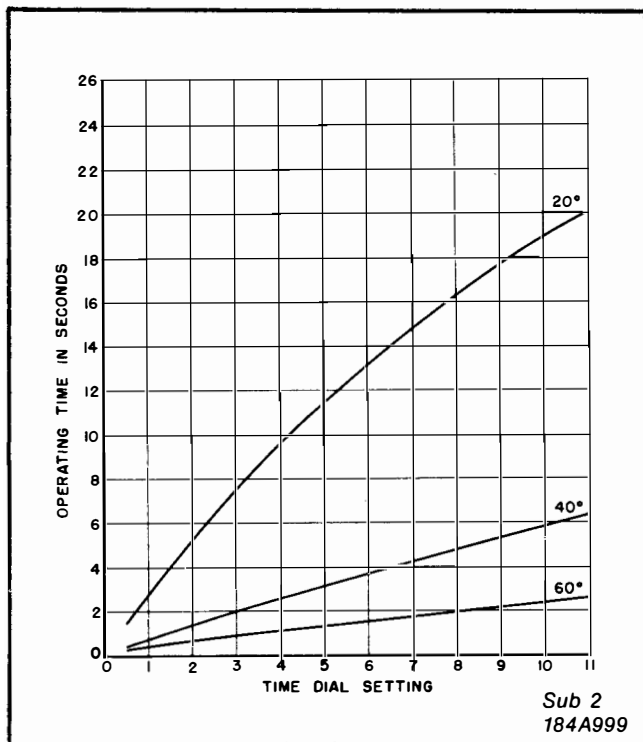


Fig. 12 Operating Time Variations with Changes in Time-Dial Settings. Rated In-Phase Voltage on Both Circuits, 20°, 40° and 60° Circle Setting.

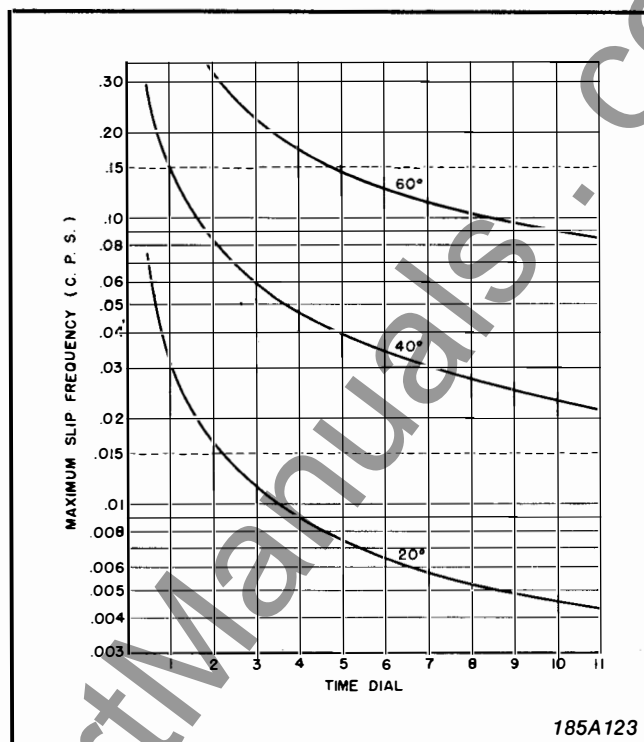


Fig. 13 Approximate Maximum Slip Frequency for which Operation Occurs—Rated Voltage on Both Sides.

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 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 Fig. 14 for CVE, or Figs. 15 or 16 for CVE-1, and apply rated voltage at zero 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 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 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 ± 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 $94 \pm 4V$ in phase with V_1 . If necessary, readjust spring slightly to obtain this condition. The relay is now calibrated for a 20 degree circle.

6. *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 ± 0.6 seconds with V_1 and V_2 equal to rated voltage at zero phase angle.

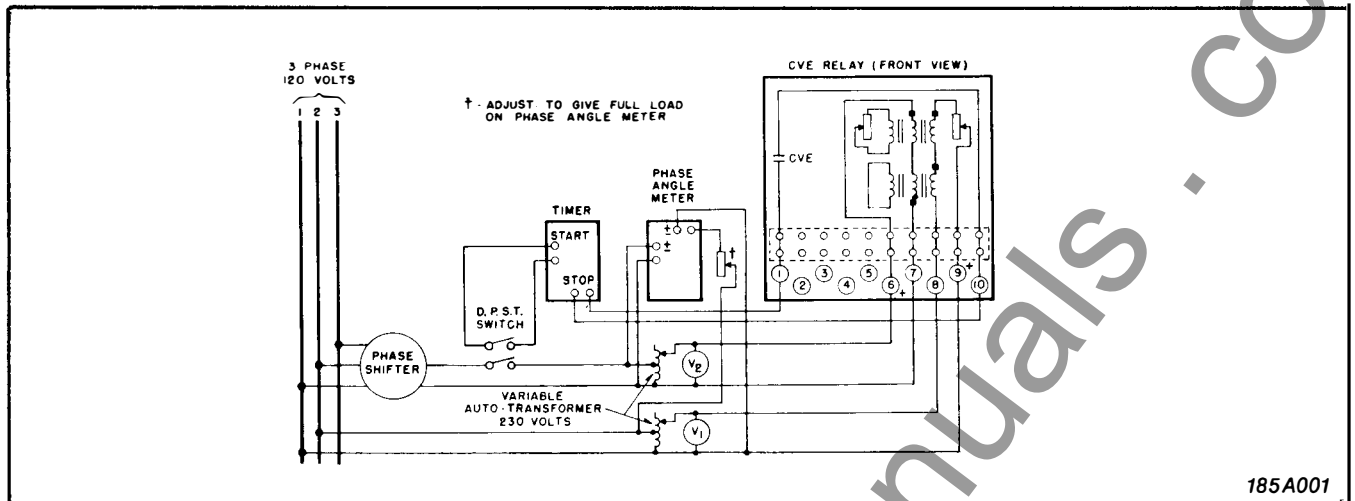
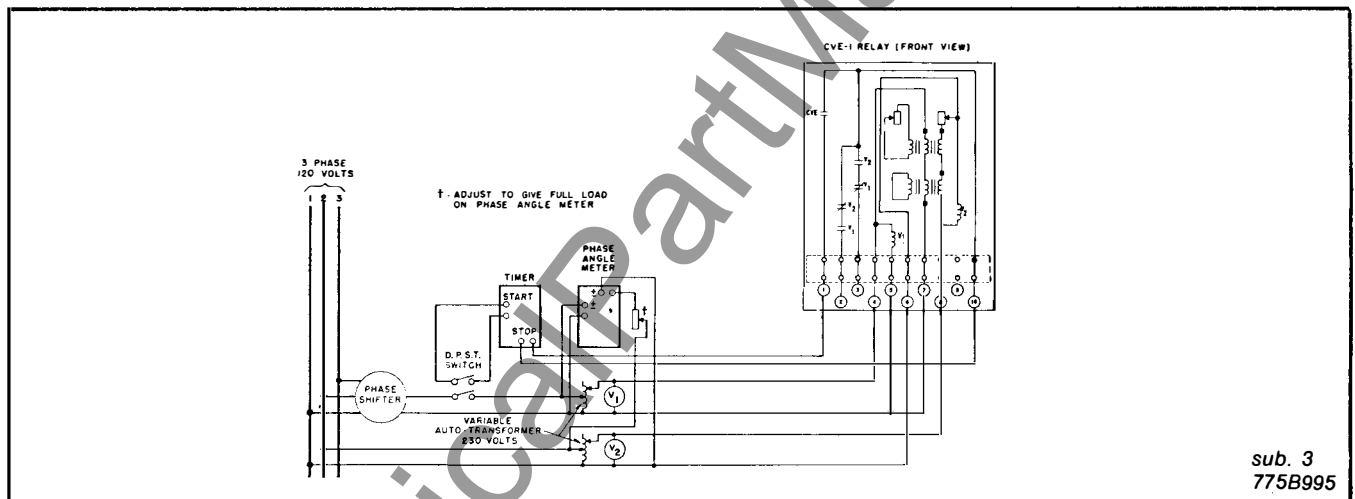


Fig. 14. Diagram of CVE Test Connections.



⊕ Fig. 15. Diagram of CVE-1 Test Connections without Commoned Potential Coils.

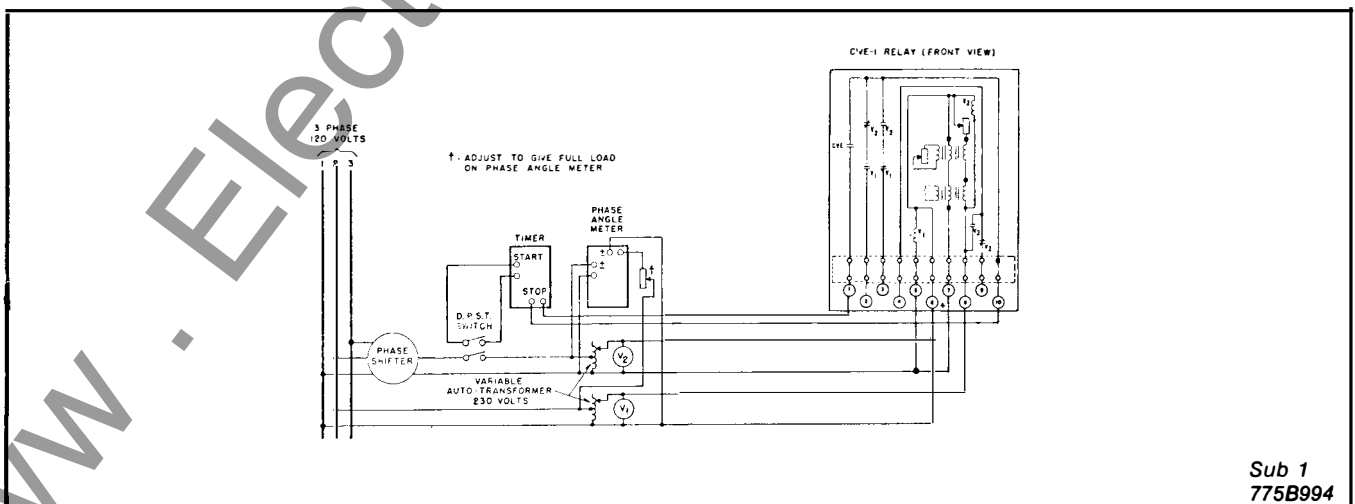


Fig. 16. Diagram of CVE-1 Test Connections with Commoned Potential Coils.

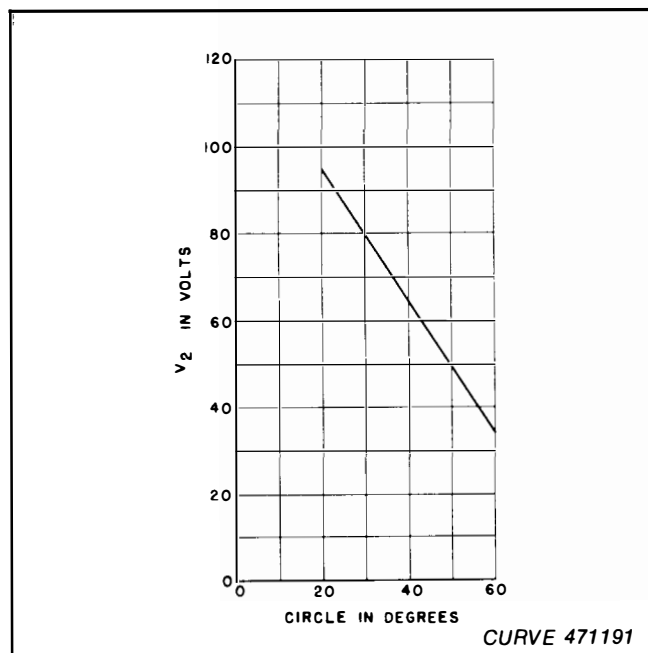


Fig. 17. V_1 Voltage for Different Operating Circle. V_2 equal to rated voltage at zero phase angle.

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 Fig. 11.

ELECTRICAL CHECKPOINTS

With V_1 in Fig. 14, 15 or 16 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

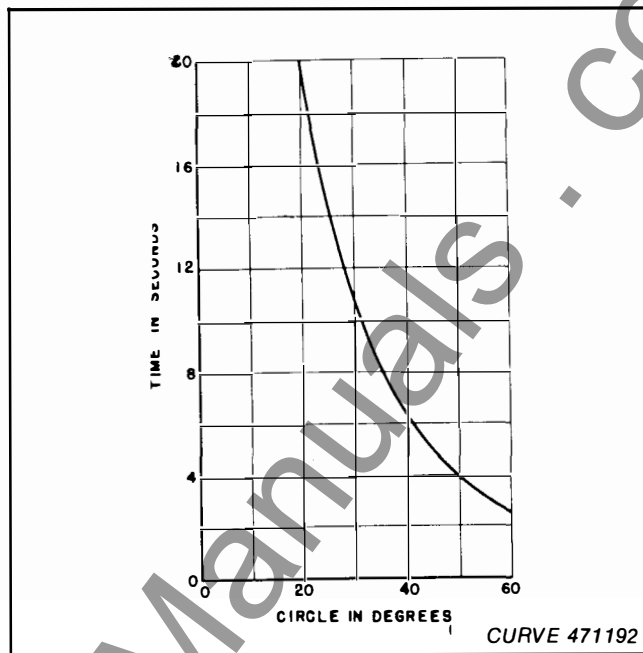


Fig. 18. Operating Times from the No. 11 Time Dial Position for the Type CVE Relay set for Different Operating Circles. V_1 and V_2 equal to rated voltage at zero phase angle.

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 d.c. 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

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.

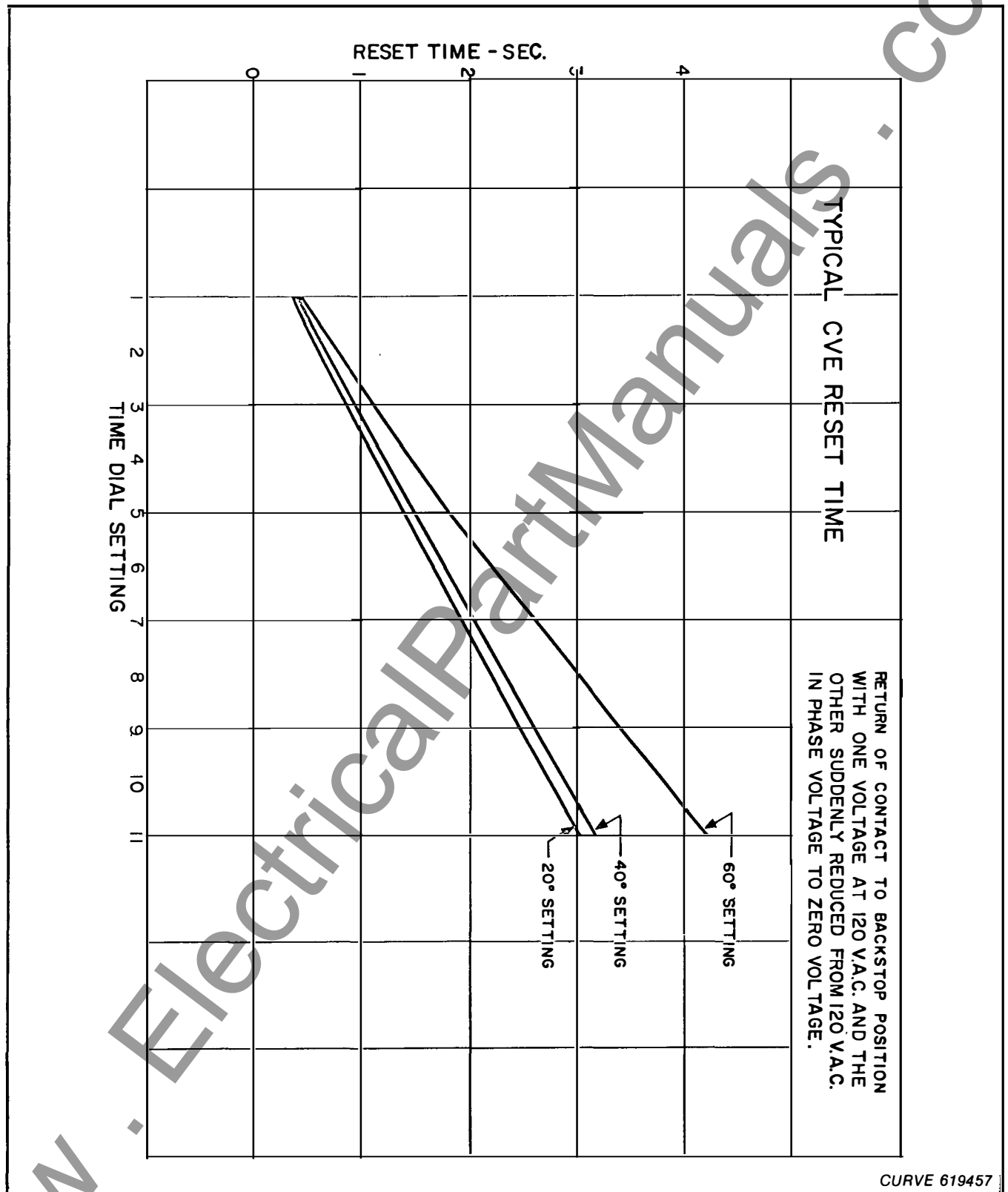
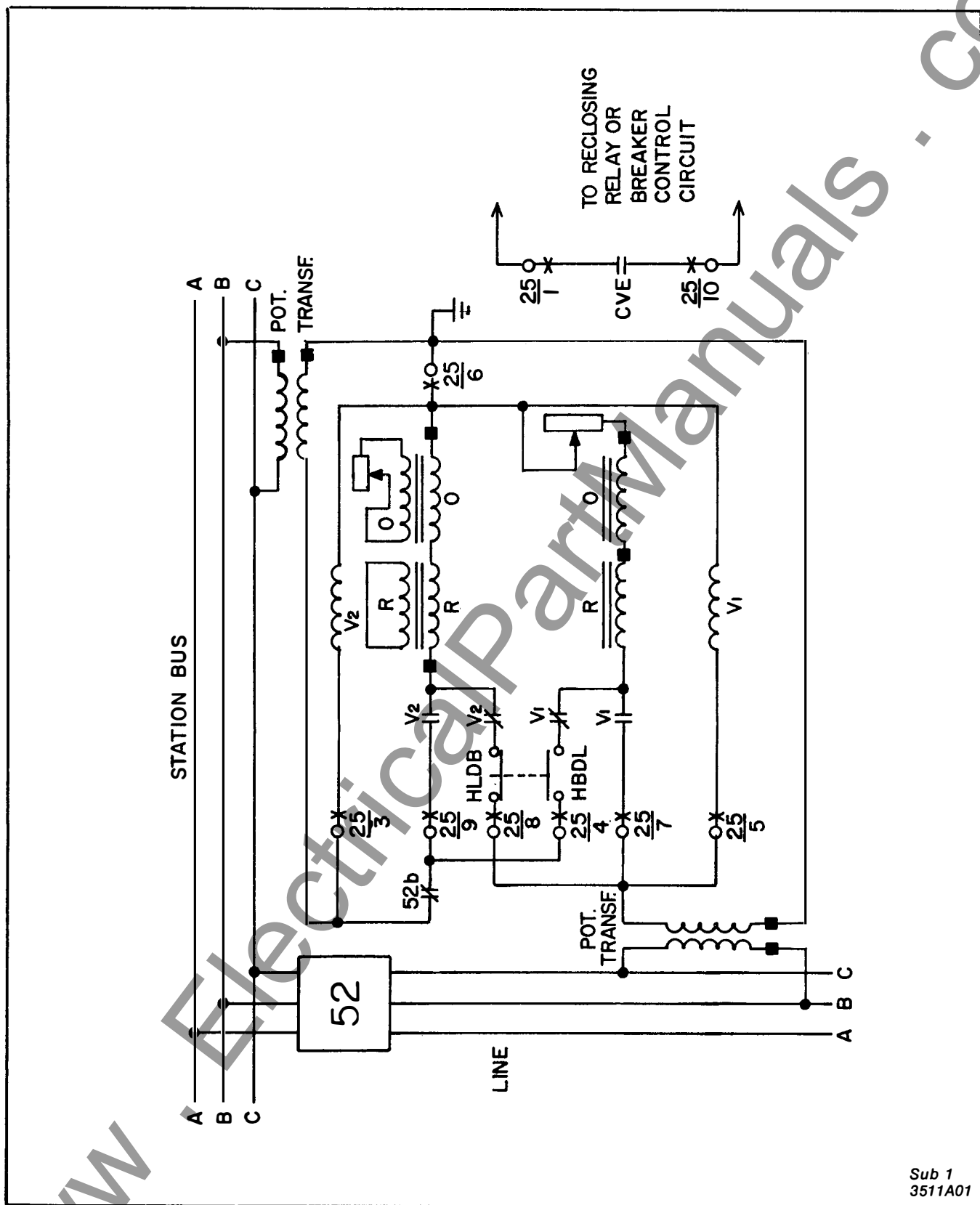


Fig. 19. Typical CVE Reset Times. Return of Contact to Backstop Position with One Voltage at Rated Voltage and the Other Suddenly Reduced from Rated in Phase Voltage to Zero Voltage.



Sub 1
3511A01

Fig. 20. External Schematic for CVE-1 with HLDB/HBDL Selector Switch, Internal Scheme 878A184.

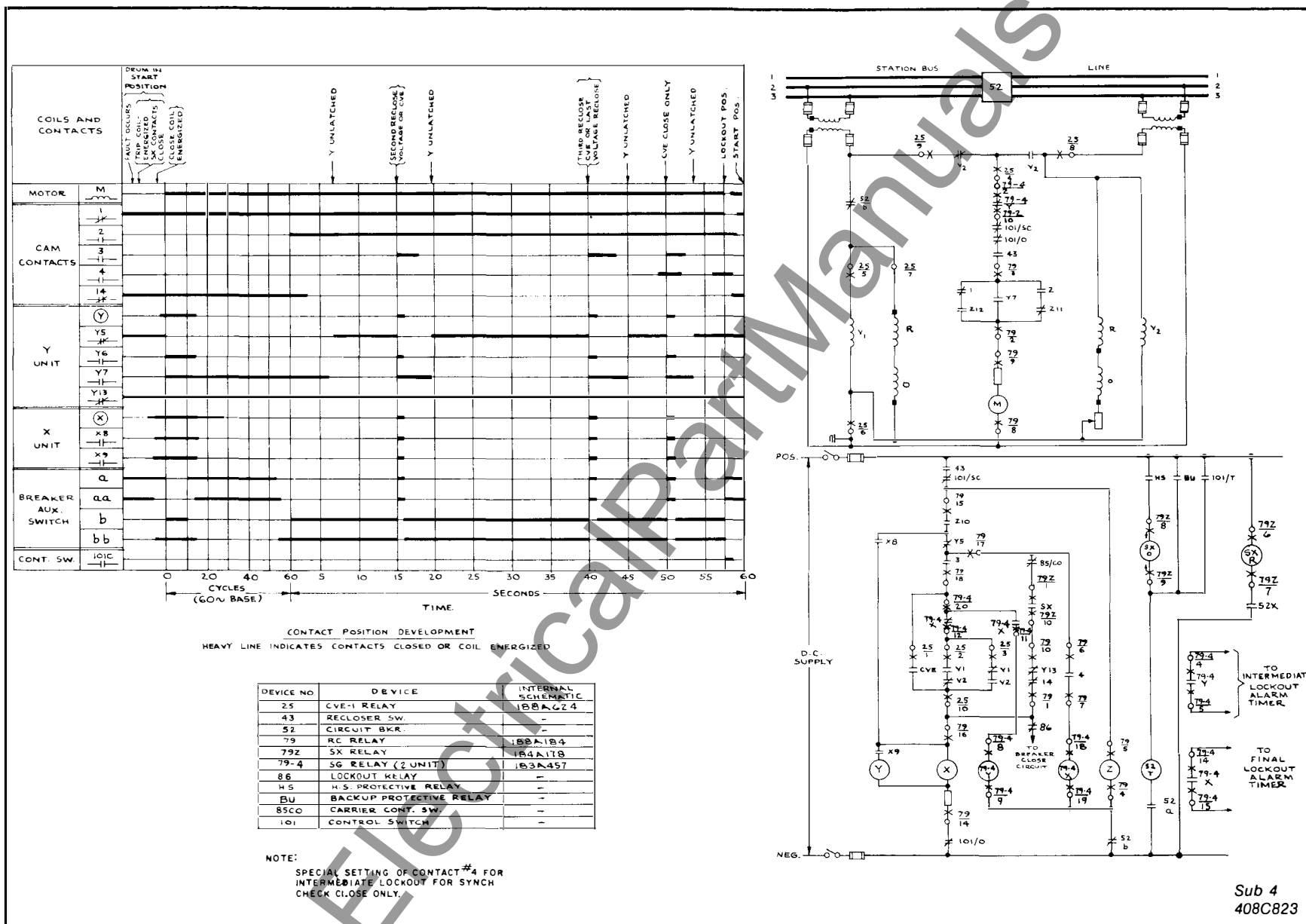


Fig. 21 External Schematic for CVE-1, Int. Scheme 188A624, with RC Reclosing Relay. Refer to RC I.L. 41-661 for additional data.

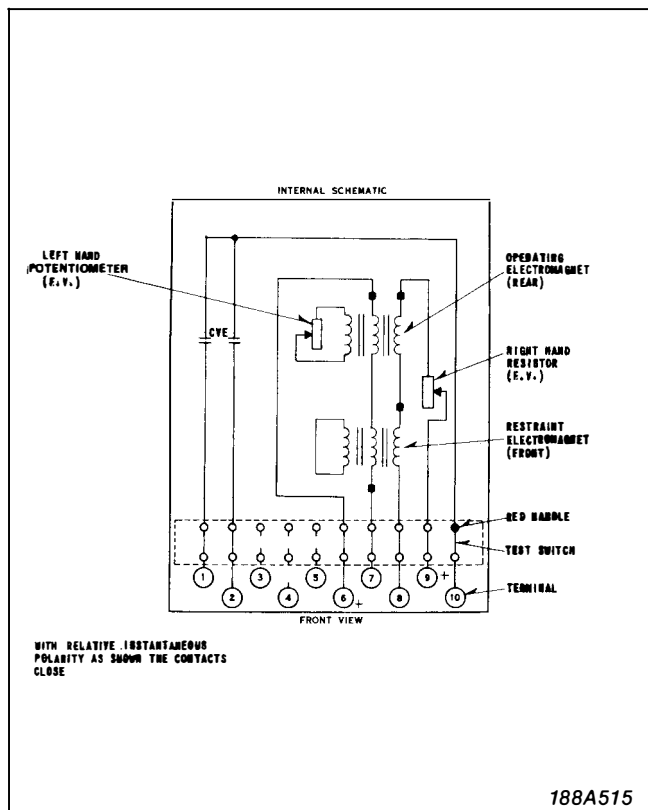


Fig. 22. Internal Schematic of CVE Synchro-Verifier, DPST. Contacts.

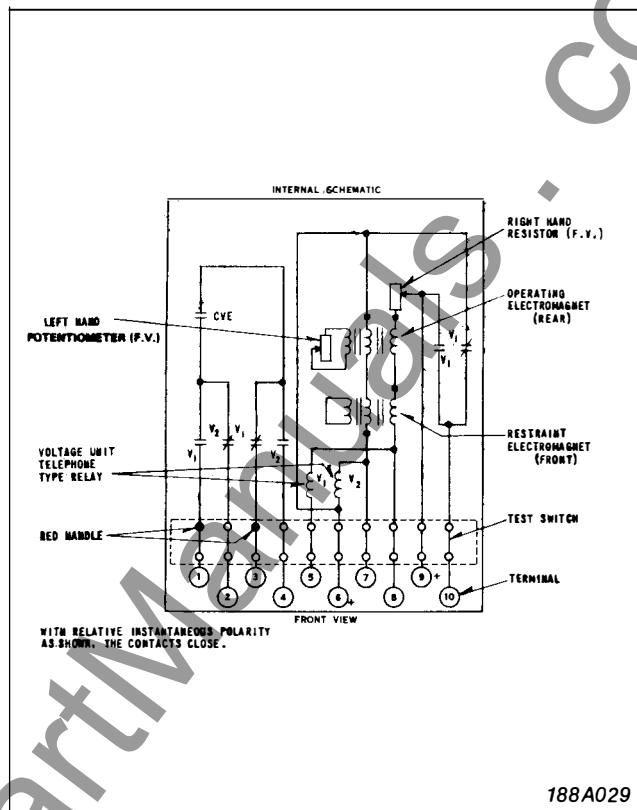


Fig. 23. Internal Schematic of CVE-1 with CVE Contacts Supervised by voltage contacts.

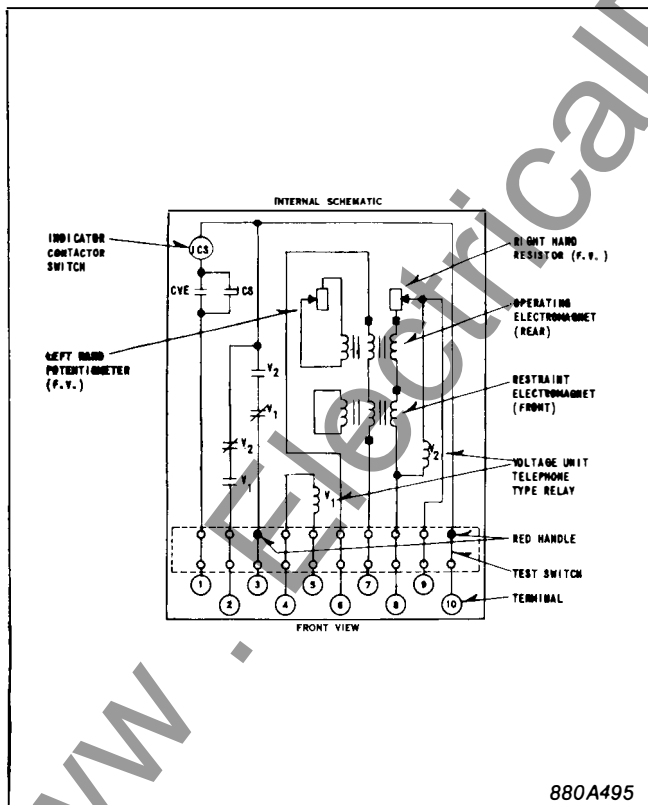


Fig. 24. Internal Schematic of CVE-1 without commoned potential coils, with ICS.

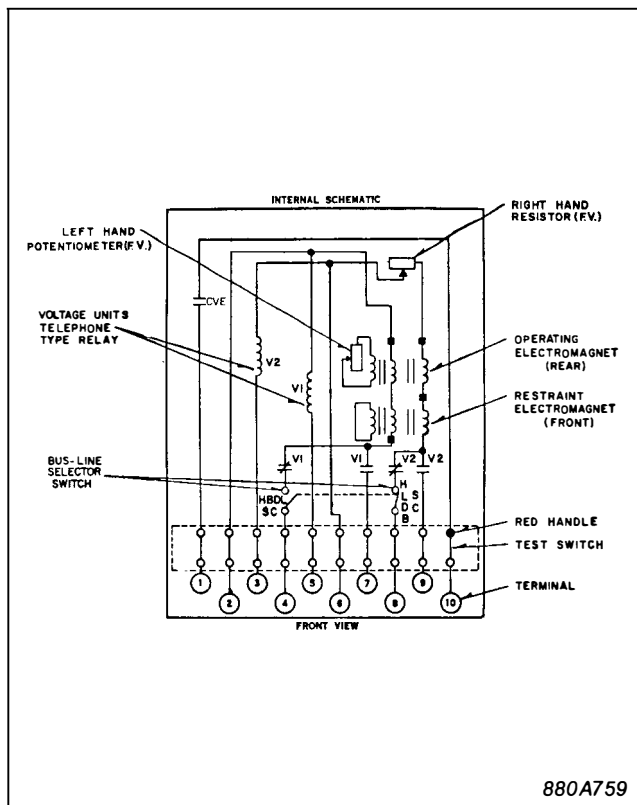
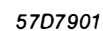
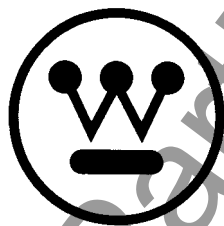


Fig. 25. Internal Schematic of CVE-1 with DPDT Switch, without commoned potential coils.



15



WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION

CORAL SPRINGS, FL.

Printed in U.S.A.



INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE CVE AND CVE-1 SYNCHRO-VERIFIER 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 clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

This instruction leaflet applies to the following types of relays:

CVE Synchro-Verifier Relay
CVE-1 Synchro-Verifier Relay with line and bus voltage sensing relays

The synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The contacts will close when these voltages are within set limits.

The synchro-verifier is not an automatic synchronizer and should not be used as such. Automatic Synchronizers are available which permit closing ahead of synchronism at an angle of phase-advance proportional to the beat frequencies and determined by the speed of operation of the circuit breaker so that the two systems are connected right on synchronism.

A common application of the synchro-verifier 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 the automatic reclosing equipment to reclose the breaker.

Some provision, such as a reclosing relay, must be used to control closing through the CVE(-1) contacts to avoid the possibility of pumping when closing into a fault.

CONSTRUCTION AND OPERATION

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 Figs. 1, 3 and 4.

The CVE-1 Relay, Fig. 2, consists of two telephone type a-c voltage sensing relays in addition to the components of the CVE relay. The principal parts of the relay are connected as per Fig. 5.

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 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 causes a contact closing torque.

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 his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

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.

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.

Indicating Contactor Switch Unit (ICS) – When Used

The d-c 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.

TELEPHONE RELAY – CVE-1 ONLY

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

OPERATION WITH EXTERNAL VOLTAGE RELAYS

The connections shown in Fig. 8 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 the 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.

CVE-1 OPERATION

In the CVE-1, the internal V₁ and V₂ perform the functions of external 59B and 27L relays respectively.

The connections shown in Fig. 9 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 V₁ make contact and V₂ break contact.
2. Close the breaker when the line is alive and the bus is dead, through the V₂ make contact and V₁ 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.

CHARACTERISTICS

The type CVE and CVE-1 relays can be adjusted for operating circles from 20 to 60 degrees as shown in Fig. 10. As shipped from the factory the relay is calibrated for the 20 degree circle.

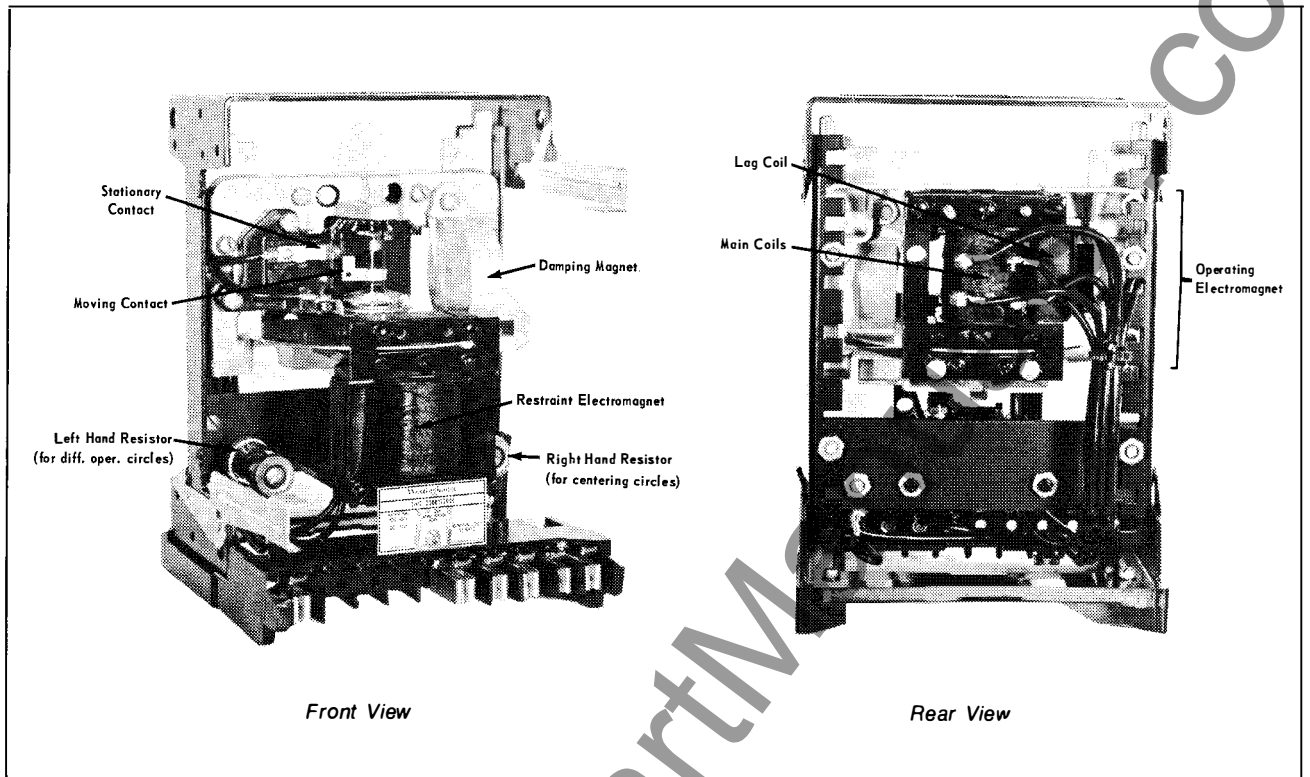


Fig. 1. CVE Relay, Without Case.

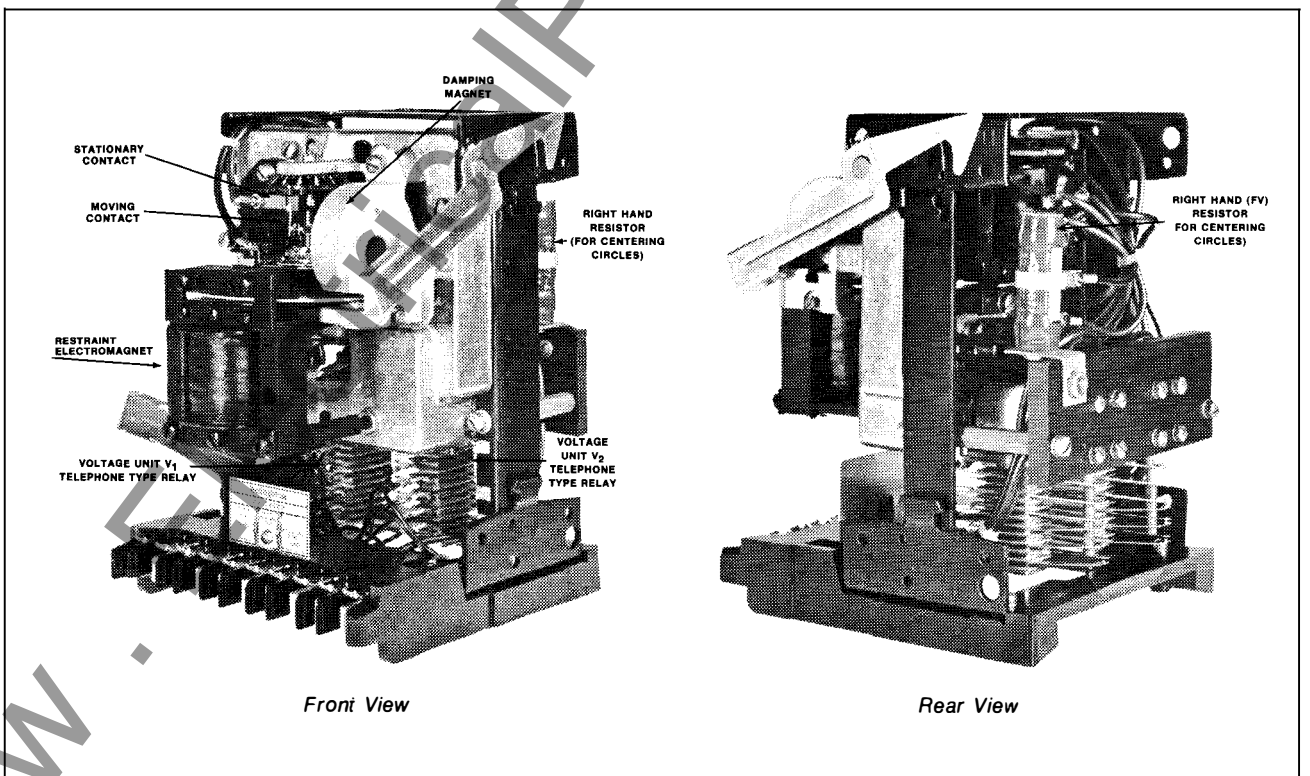


Fig. 2. CVE-1 Relay, Without Case.

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 Fig. 11. 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 Fig. 12.

Fig. 13 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.

Fig. 19 shows typical CVE reset times for 20°, 40°, and 60° circle settings.

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:

	60 Hertz	50 Hertz
Volt-Amperes	15.4	23.3
Power Factor422	.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
Voltage-Amperes	10.8	13.8
Power Factor422	.309
Watts	4.6	4.2

For the CVE-1 relay, additional burden of each telephone relay at 120 volts, 60 Hz, is as follows: 10.62 volt-amperes, Power Factor 0.64.

For 120 volts, 50 Hz, is as follows: 13.29 volt-amperes, Power Factor .47.

CONTINUOUS RATING

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

SETTINGS

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 as low as 1/2 time dial should be satisfactory with the 20° circle. Note from Fig. 12 that the relay will operate in 1.4 seconds in the 1/2 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 Fig. 11. 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 systems 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:

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

where T_B = breaker closing time in seconds

Let $T_B = 0.5$ seconds

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

INDICATING CONTACTOR SWITCH (ICS) – WHEN USED

No setting is required on the ICS unit.

INSTALLATION

The relays should be mounted on switchboard panels or their equivalent in a location free from

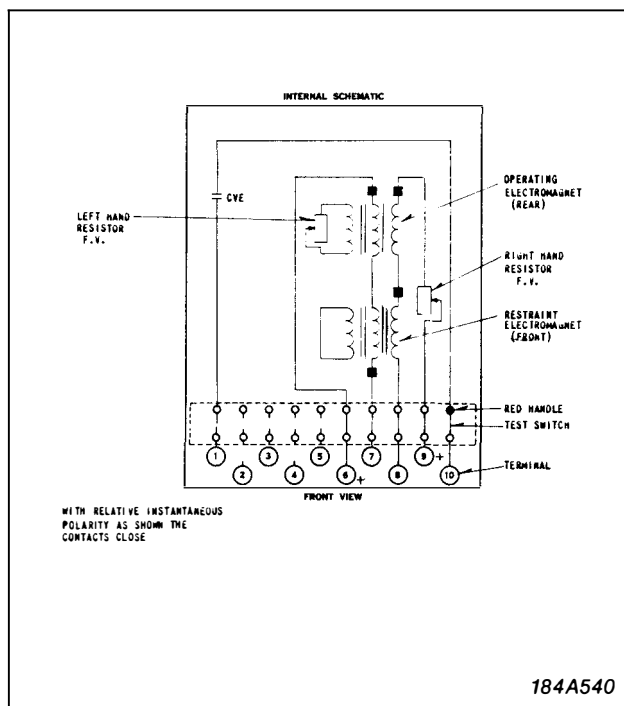


Fig. 3. Internal Schematic of CVE, without ICS Unit,

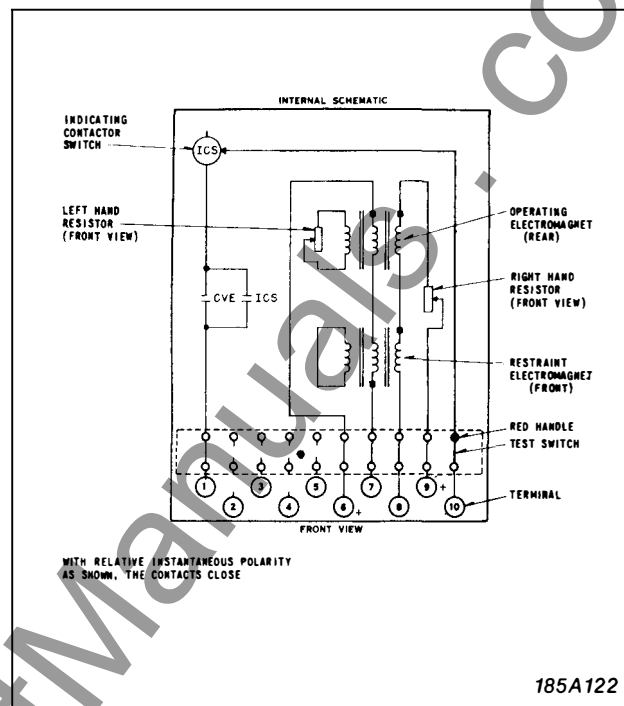


Fig. 4. Internal Schematic of CVE, with ICS Unit.

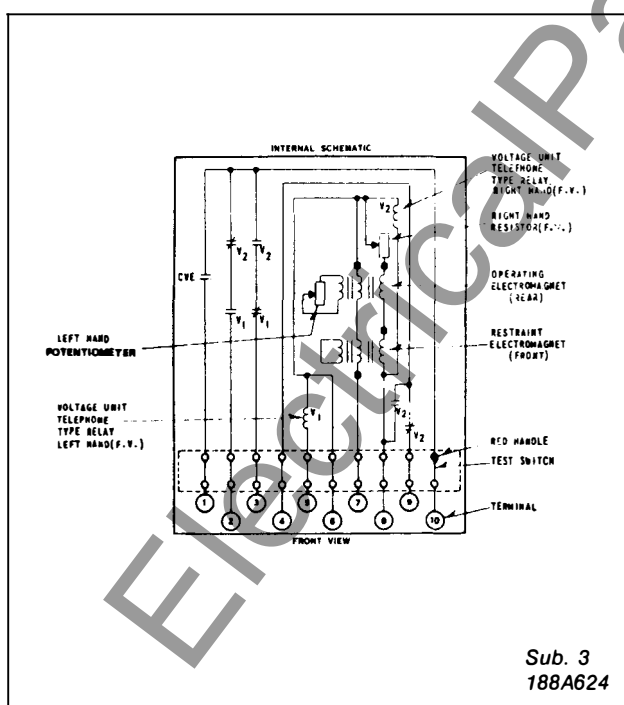


Fig. 5. Internal Schematic of CVE-1 for use with RC Reclosing Relay (See Fig. 21 for External Scheme). With commoned voltage coils, use with phase-to-phase connected vt's.

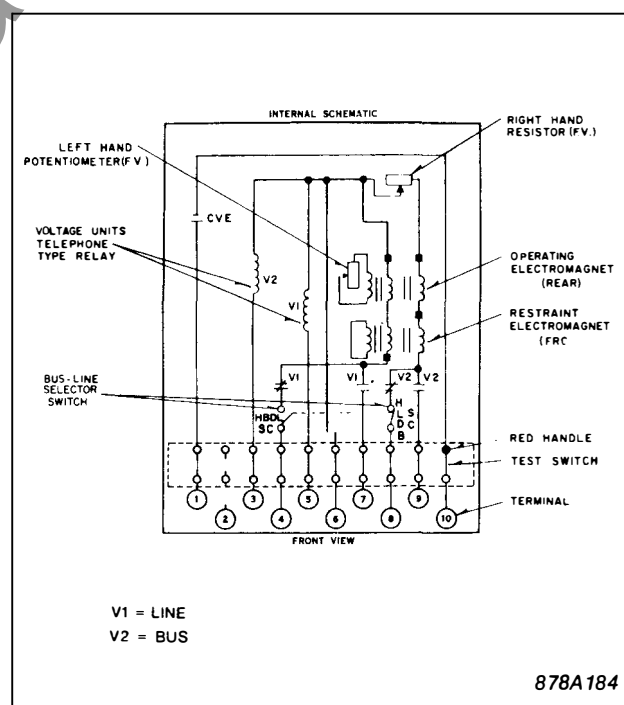


Fig. 6. Internal Schematic of CVE-1 with Internal Switch for HBDL or HLDB. (See Fig. 20 for External Scheme). With commoned voltage coils, use with phase-to-phase connected vt's.

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 Fig. 22 for Outline and Drilling Plan. For detailed FT Case information refer to I.L. 41-076.

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.

ACCEPTANCE CHECK

The following check is recommended to insure that the relay is in proper working order:

INDICATING CONTACTOR SWITCH (ICS) – WHEN USED

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

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

DISC UNIT

1. Contacts

The index mark on the movement frame will coincide with the "O" 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 "O" 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 relay per the test diagram of Fig. 14. CVE-1 relays should be connected in a similar manner to correspond with the wiring of the particular style CVE-1 using Figs. 15 and 16. The contacts should just close under the following two 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 $94 \pm 4V$ 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.

TELEPHONE RELAYS (CVE-1 ONLY)

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

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 S#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.

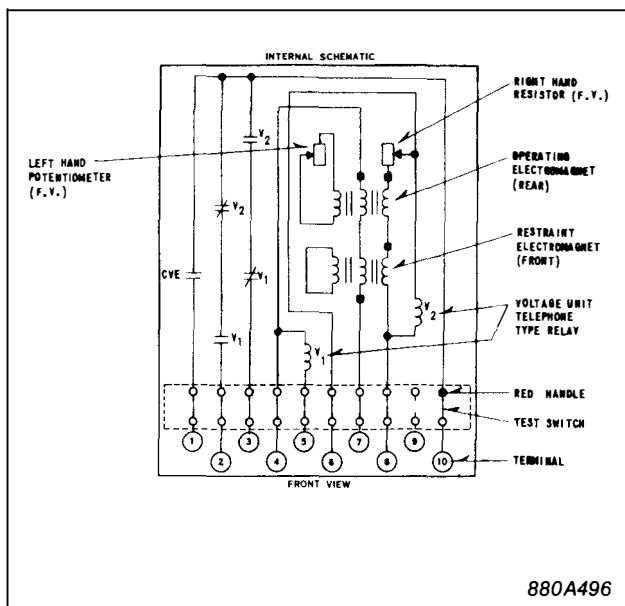


Fig. 7. Internal Schematic of CVE-1 without Commoned Potential Coils. (See Fig. 9 for External Scheme).

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*).

1. Contacts

The index mark on the movement frame coincides with the "O" 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 "O" 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

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.

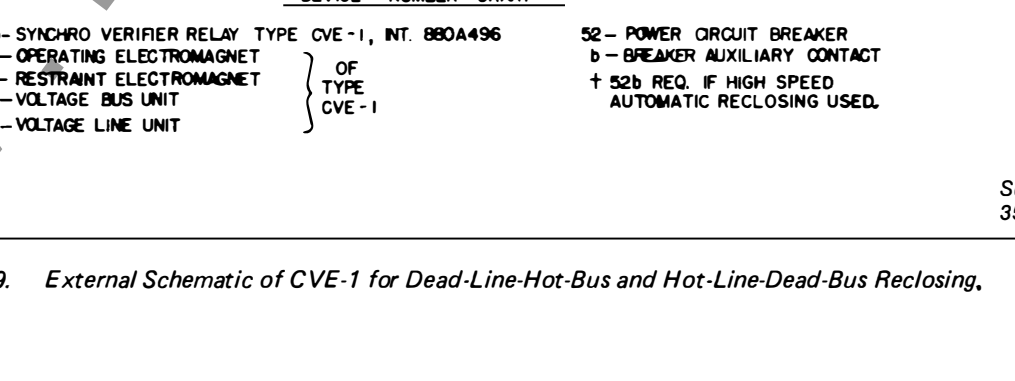
The spring convolutions may touch during this operation and the outer convolutions may hit other surfaces of the relay. This interference should be disregarded because its effect on the final calibration will be negligible. The reason for unwinding the spring is that the amount of tension on the reset 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 Fig. 14 for CVE, or Figs. 15 or 16 for CVE-1, and apply rated voltage at zero 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 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.



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

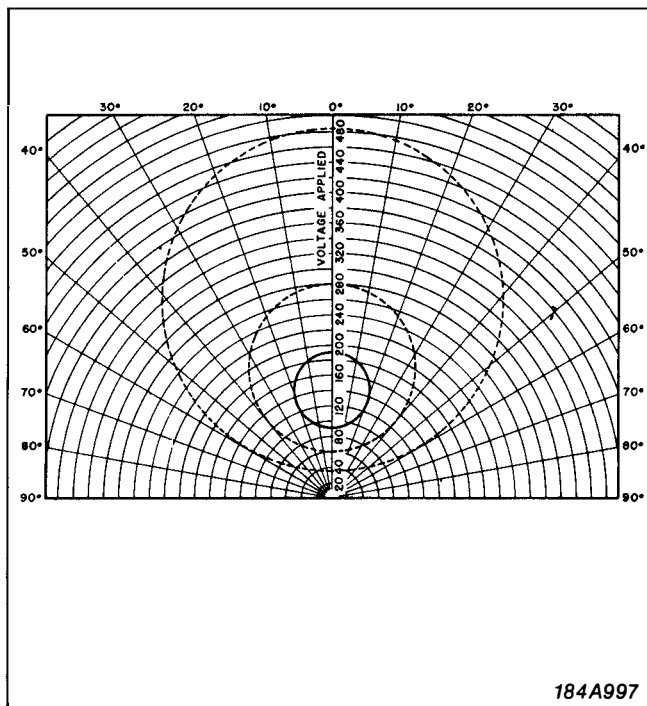


Fig. 10. Typical Voltage-Angle Characteristic of CVE for Various Closing Angle Settings. Rated Voltage on One Circuit.

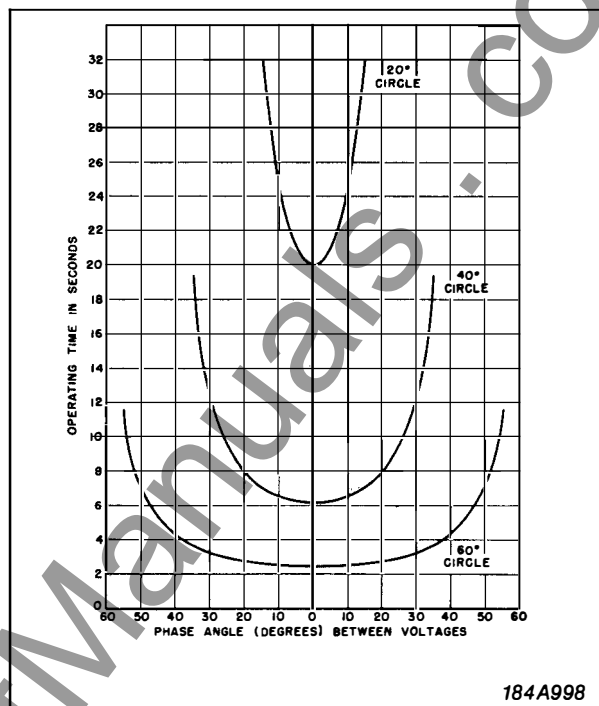


Fig. 11. Typical Time-Phase Angle Curves of CVE. Rated Voltage on Both Circuits No. 11 Dial Time Setting.

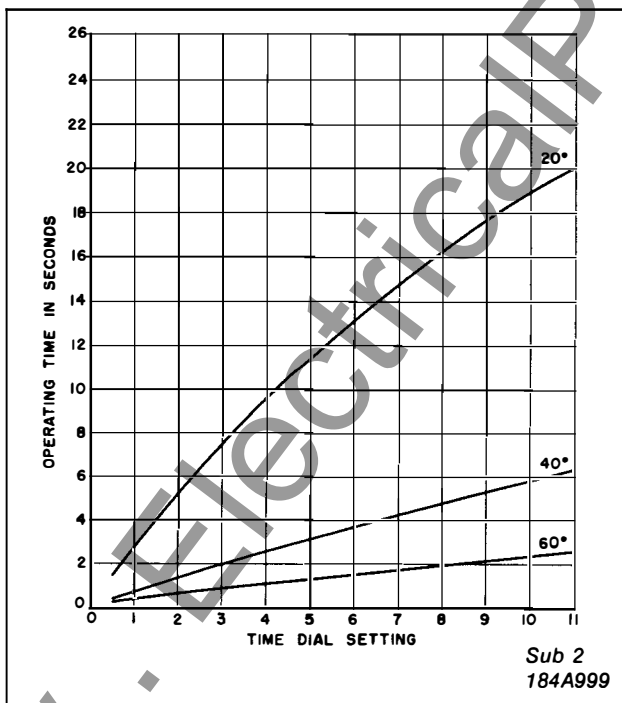


Fig. 12. Operating Time Variations with Changes in Time-Dial Settings. Rated In-Phase Voltage on Both Circuits, 20°, 40° and 60° Circle Setting.

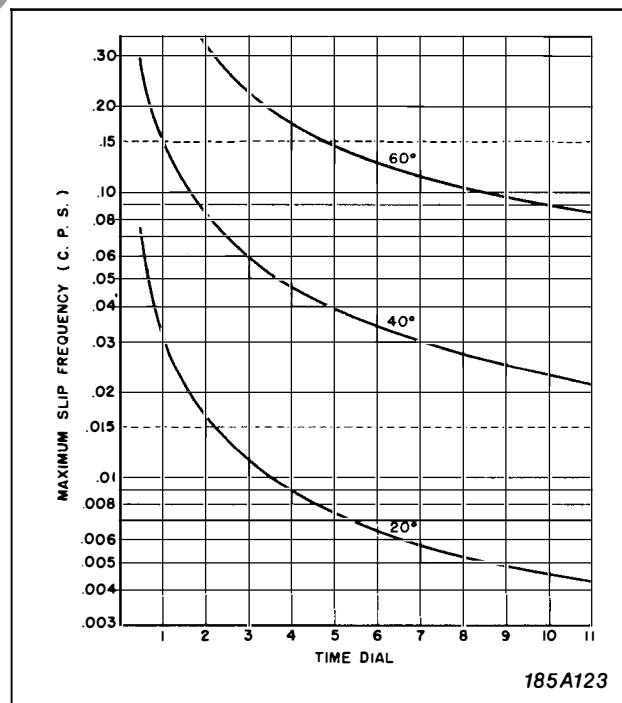


Fig. 13. Approximate Maximum Slip Frequency for which Operation Occurs – Rated Voltage on Both Sides.

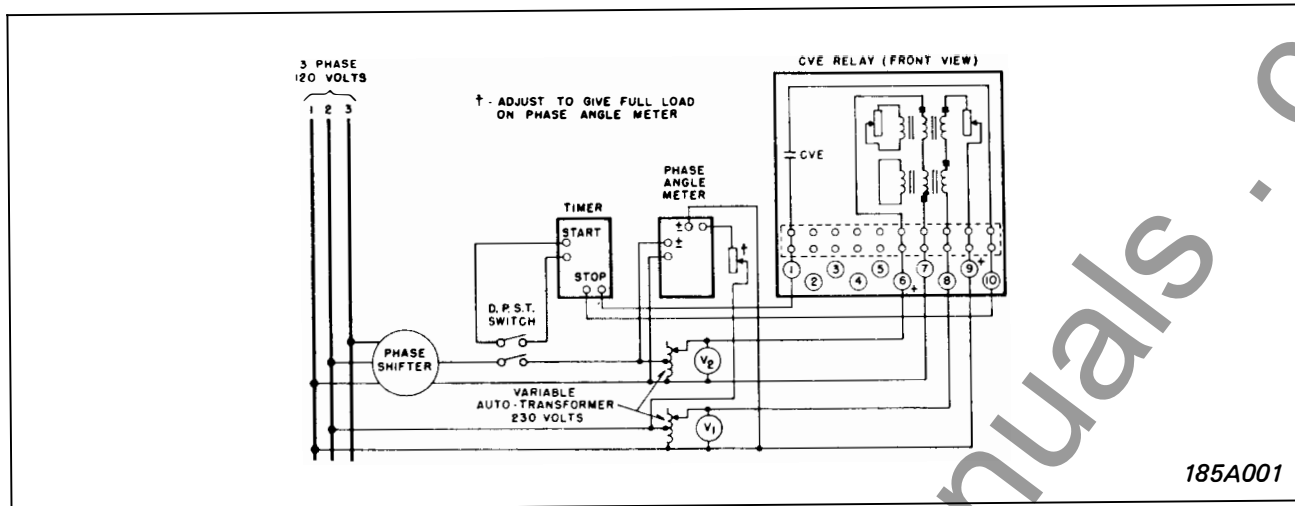


Fig. 14. Diagram of CVE Test Connections.

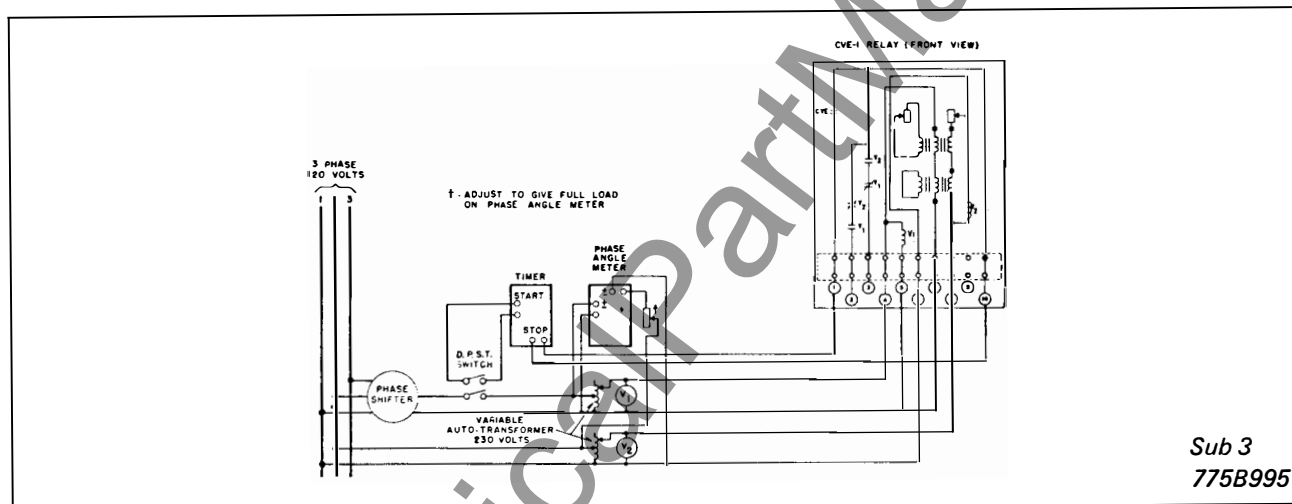


Fig. 15. Diagram of CVE-1 Test Connections without Commoned Potential Coils.

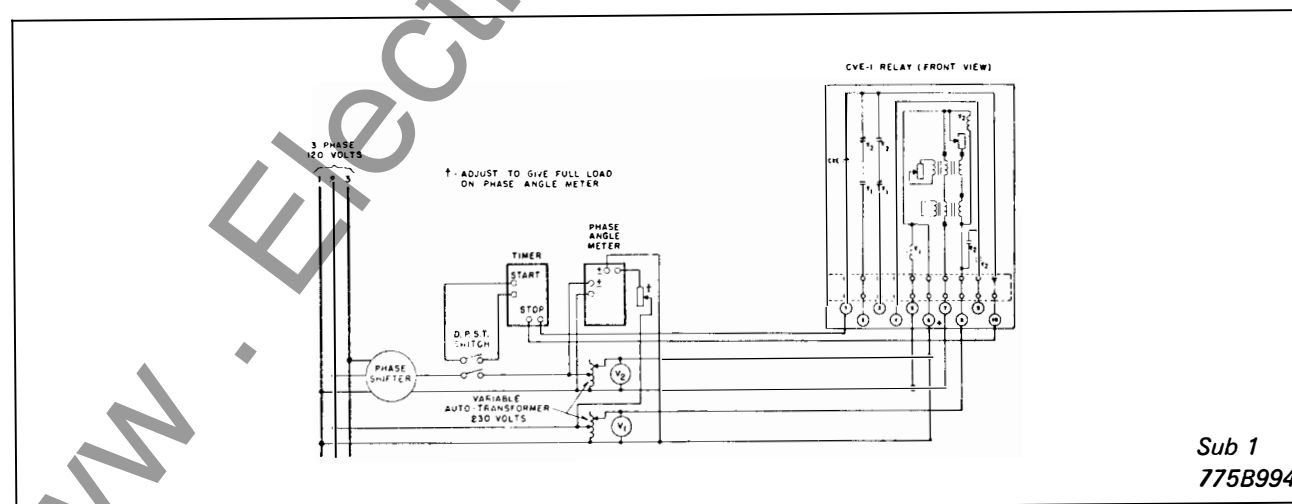


Fig. 16. Diagram of CVE-1 Test Connections with Commoned Potential Coils.

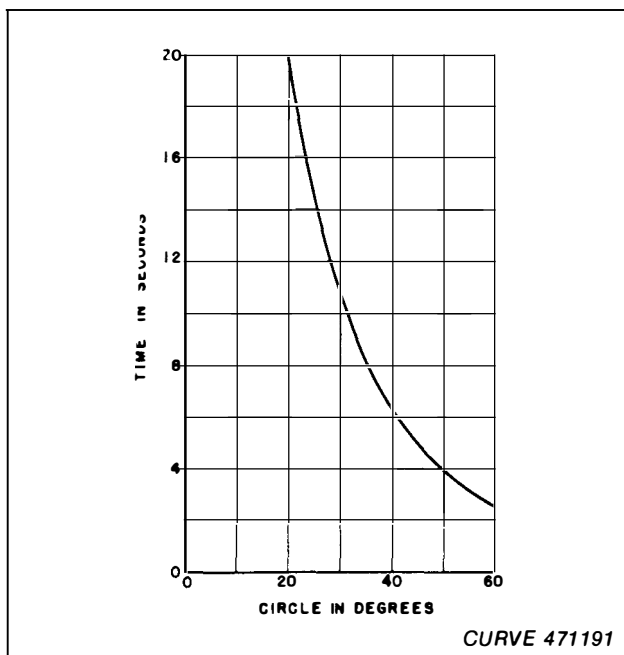


Fig. 17. V_1 Voltage for Different Operating Circle. V_2 Equal to Rated Voltage at Zero Phase Angle.

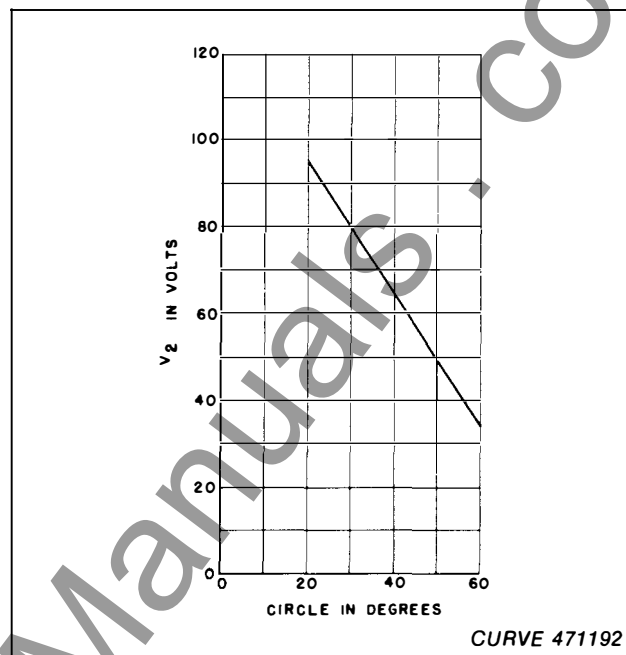


Fig. 18. Operating Times from the No. 11 Time Dial Position for the Type CVE Relay set for Different Operating Circles. V_1 and V_2 Equal to Rated Voltage at Zero Phase Angle.

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 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 ± 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 $94 \pm 4V$ in phase with V_1 . If necessary, readjust spring slightly to obtain this condition. The relay is now calibrated for a 20 degree circle.

6. Time Curve

Install the permanent magnet on the relay. Adjust the permanent magnet keeper until the op-

erating 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 Fig. 11.

ELECTRICAL CHECKPOINTS

With V_1 in Figs. 14, 15 or 16 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.

	<u>60 Hz</u>	<u>50 Hz</u>
Operating Electromagnet		
Upper terminals	59 volts	61 volts
Lower terminals	57 volts	59 volts
Lag coil circuit	22 volts	24 volts
Restraint Electromagnet		
Upper terminals	58 volts	61 volts
Lower terminals	54 volts	58 volts

With 120 volts applied to V_2 circuit only.

	<u>60 Hz</u>	<u>50 Hz</u>
Operating Electromagnet		
Upper terminals	57 volts	58.5 volts
Lower terminals	59 volts	61 volts
Lag coil circuit	22 volts	24 volts
Restraint Electromagnet		
Upper terminals	54 volts	57 volts
Lower terminals	58 volts	61 volts

Approximate d-c 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

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.

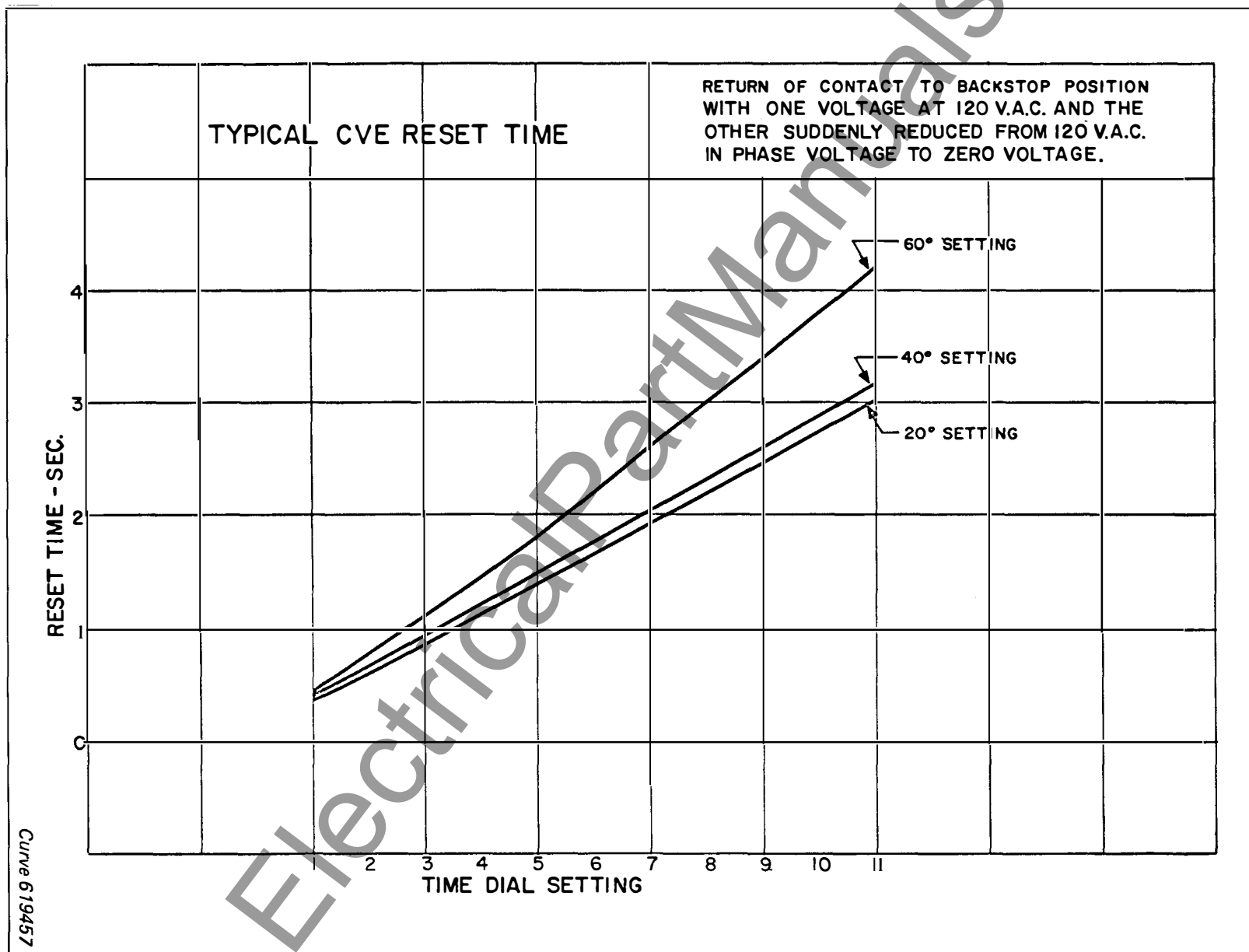


Fig. 19. Typical CVE Reset Times. Return of Contact to Backstop Position with One Voltage at Rated Voltage and the Other Suddenly Reduced from Rated in Phase Voltage to Zero Voltage.

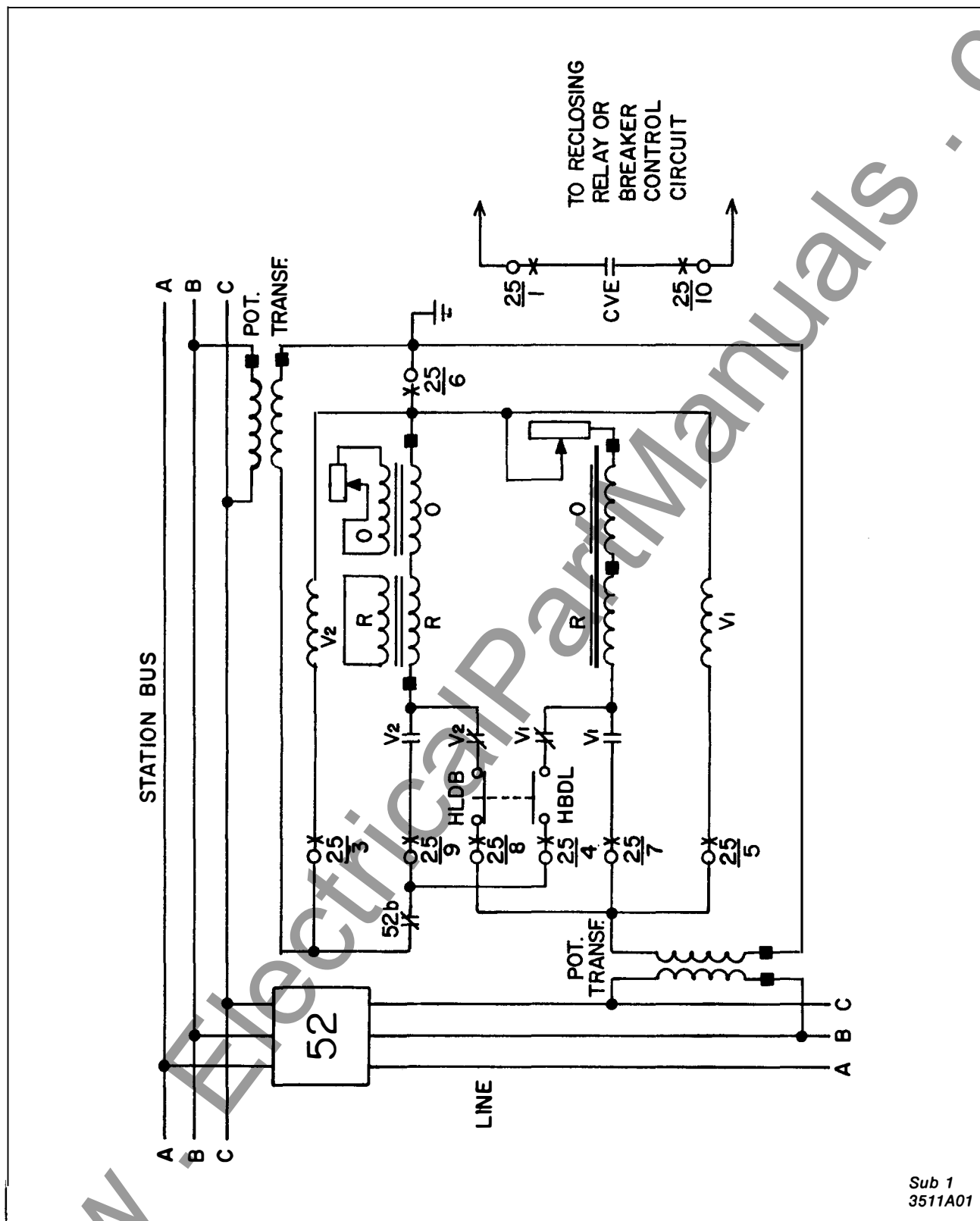


Fig. 20. External Schematic for CVE-1 with HLDB/HBDL Selector Switch, Internal Scheme 878A184.

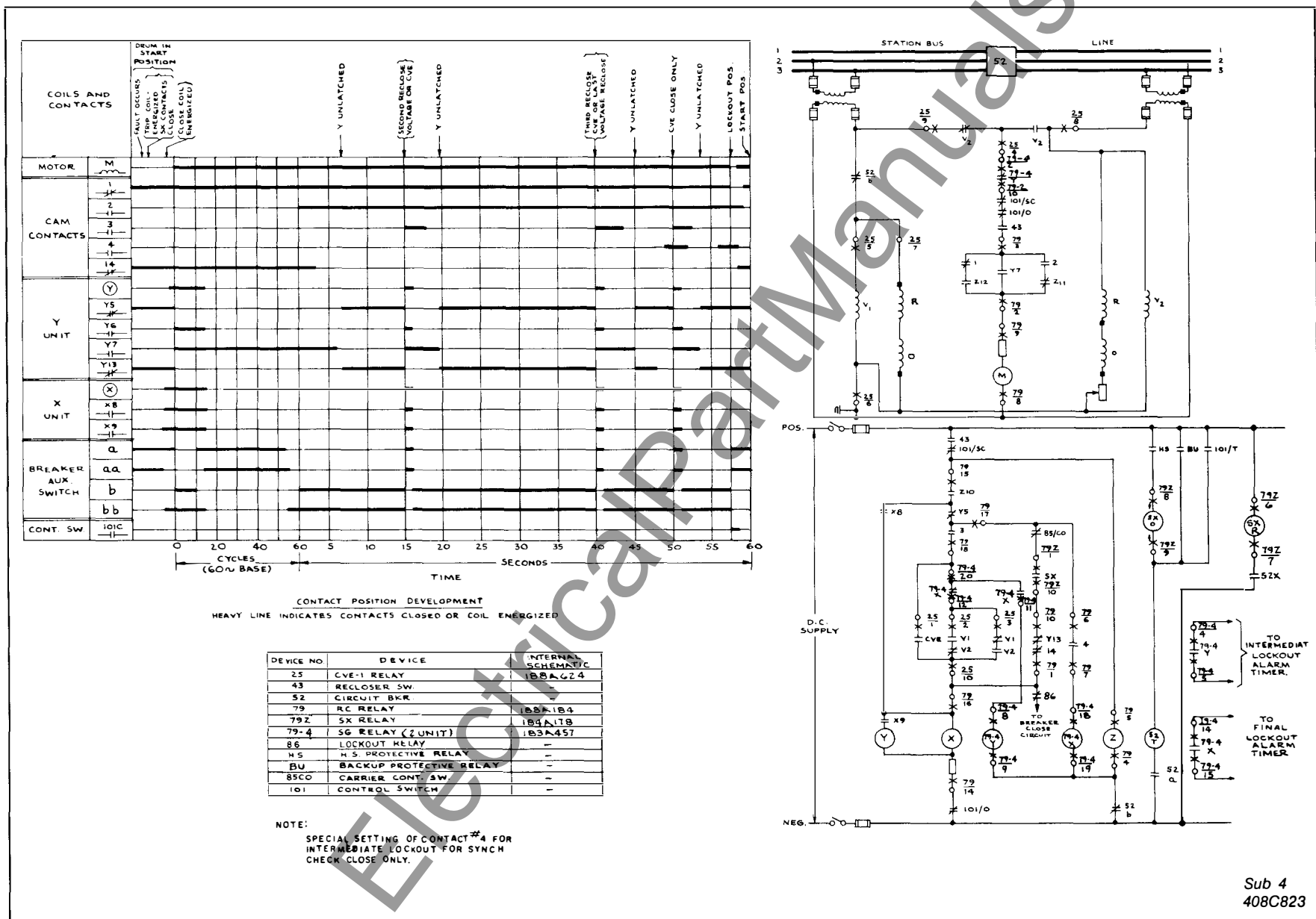


Fig. 21. External Schematic for CVE-1, Int. Scheme 188A624, with RC Reclosing Relay. Refer to RC I.L. 41-661 for additional data.

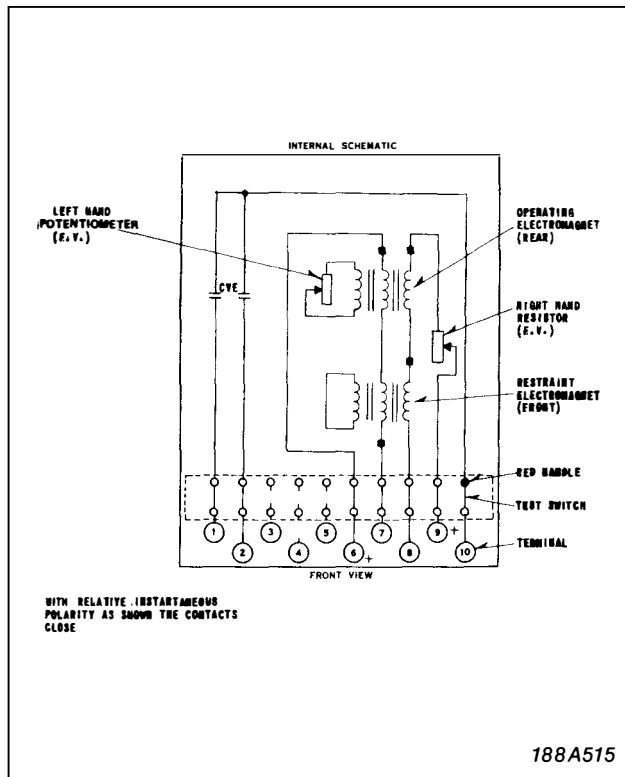


Fig. 22. Internal Schematic of CVE Synchro-Verifier, DPST Contacts.

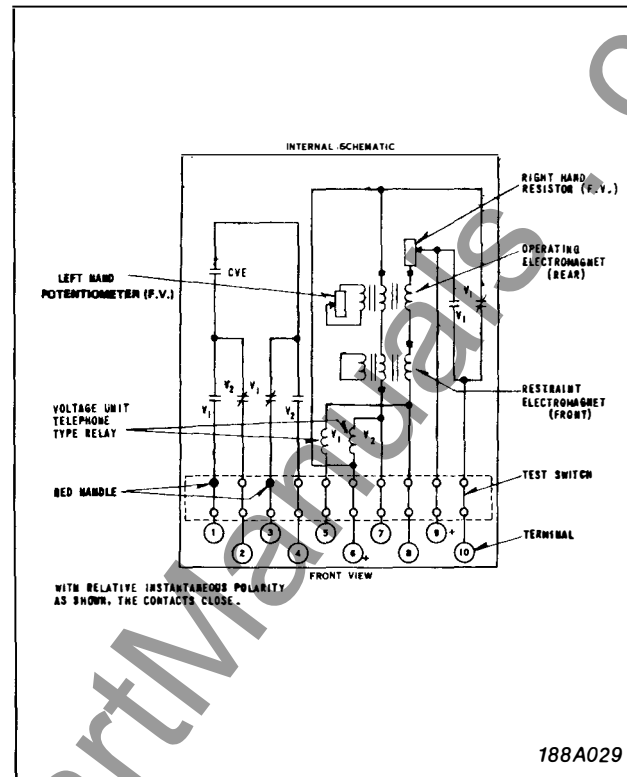


Fig. 23. Internal Schematic of CVE-1 with CVE Contacts Supervised by Voltage Contacts.

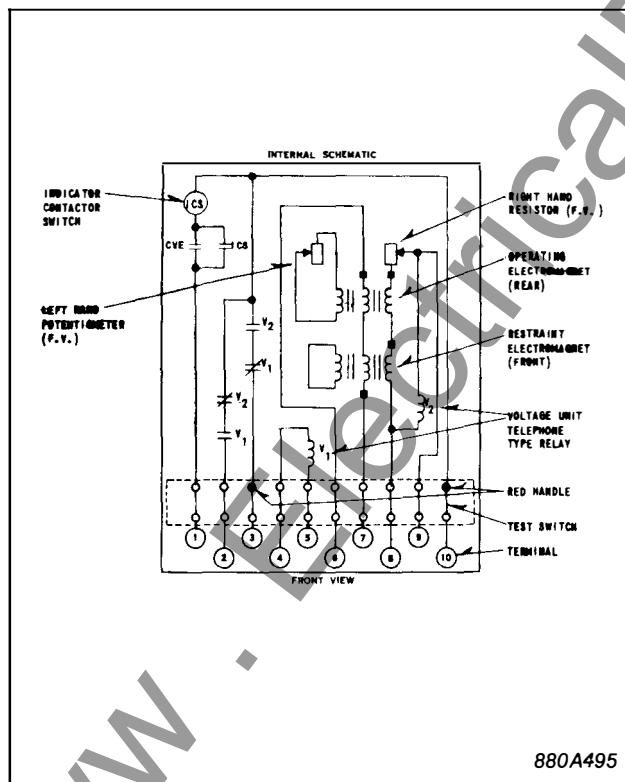


Fig. 24. Internal Schematic of CVE-1 without Commoned Potential Coils, with ICS.

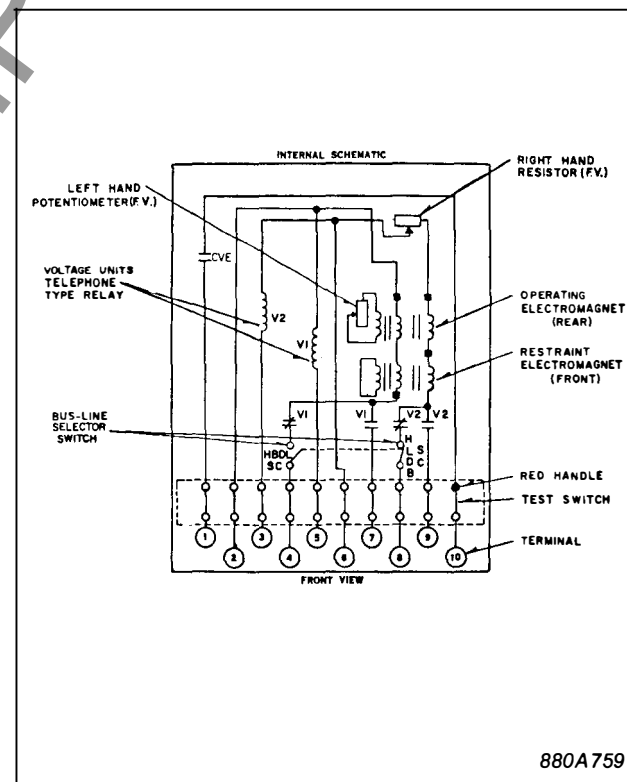


Fig. 25. Internal Schematic of CVE-1 with DPDT Switch, without Commoned Potential Coils.

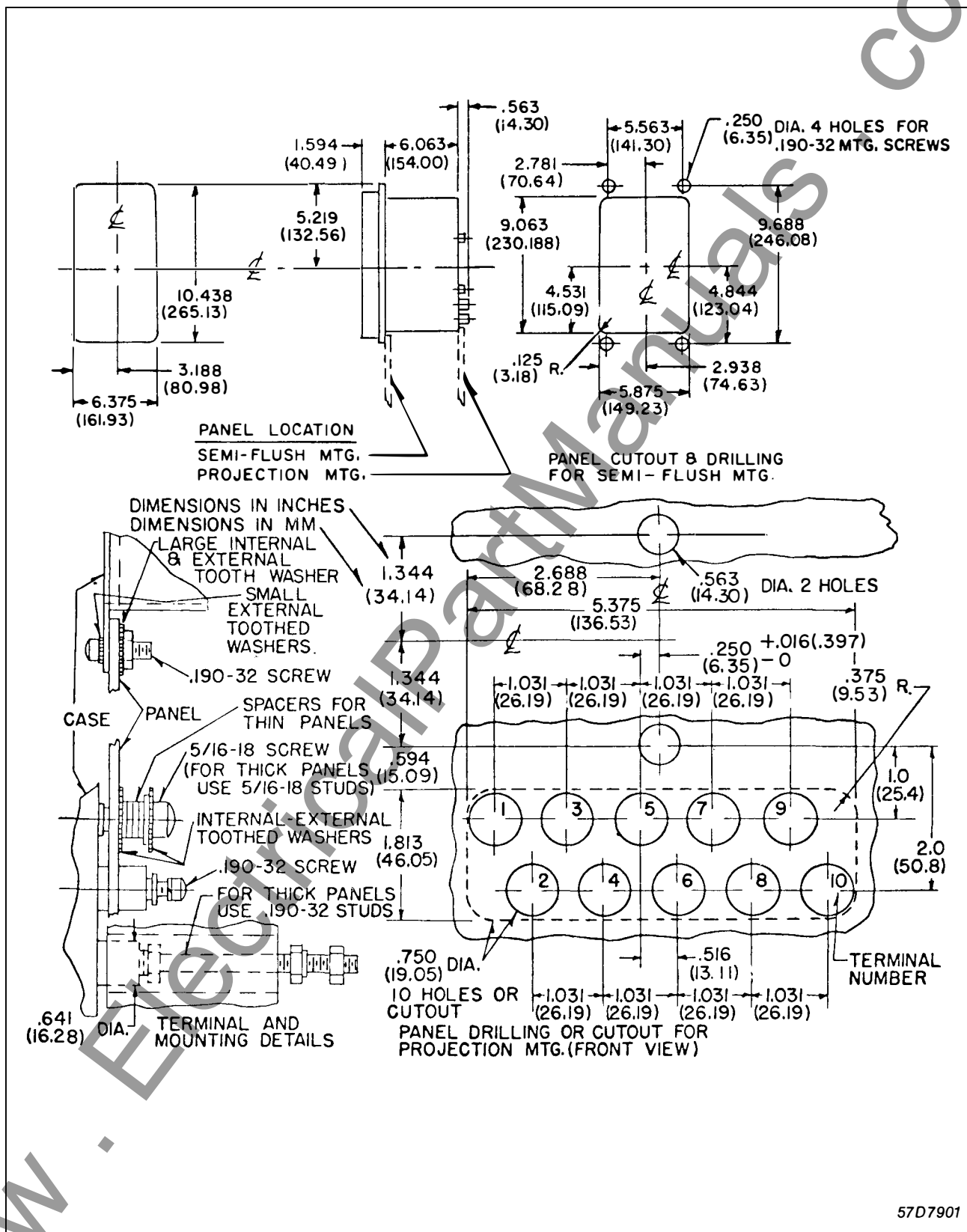
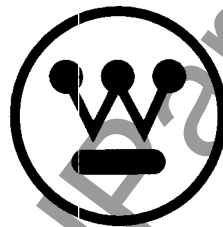


Fig. 26. Outline and Drilling Plan for the CVE and CVE-1 in FT21 Case.

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