INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE CI SYNCHRO-VERIFIER WITH EXTERNAL RESISTOR

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 it to check the settings and electrical connections.

APPLICATION

The type CI synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The contacts will close when these voltages are equal, within set limits, in phase, and of the same frequency. If the two systems have been split apart, so that a beat frequency exists across the open circuit breaker used to tie the two systems together, the synchro-verifier will not close its contacts unless this beat frequency is approximately 1/45 cycle or less.

The type CI 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 CI Synchro-Verifier consists of two induction disc elements. The rotating elements consist of two copper discs fastened on a steel shaft. The shaft is supported on the lower end by a steel ball riding between concave sapphire jewel surfaces, and on the upper end by a stainless steel pin.

The moving discs are rotated by two electromagnets designated A and B. Element A operates on the back half of the upper disc, and element B on the back half of the lower disc. The disc is damped by a permanent magnet mounted in front of the upper element.

The phasing coils of each element are wound on the upper poles, and the potential coils on the lower pole.

The moving contact is mounted on a countershaft which is geared to the shaft of the main rotating element. A hardened and polished steel pin in the lower end of the countershaft runs on a jewel bearing. The upper bearing is of the pin type. The countershaft is covered with a moulded insulation hub around which the moving contact arm is clamped. Normally the moving contact is held against the stationary contact by the spiral spring, except in adjustment #2 when this spring is reversed.

The inner end of this spring is fastened to the moving contact arm and the outer end is fastened to a spring adjuster. The spring adjuster allows the initial tension on the spring to be changed without changing the strength of the spring. To change the spring

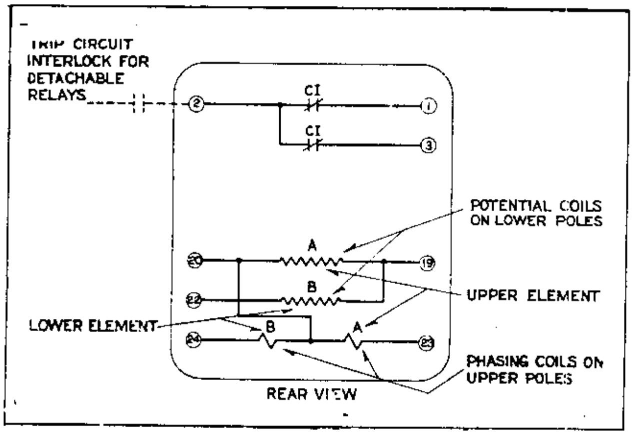


Fig. 1—Internal Schematic of the Double Contact Type CI Synchro-Verifier in the Standard Case. The Single Contact Synchro-Verifier Has Terminal 3 and Associated Circuits Omitted.

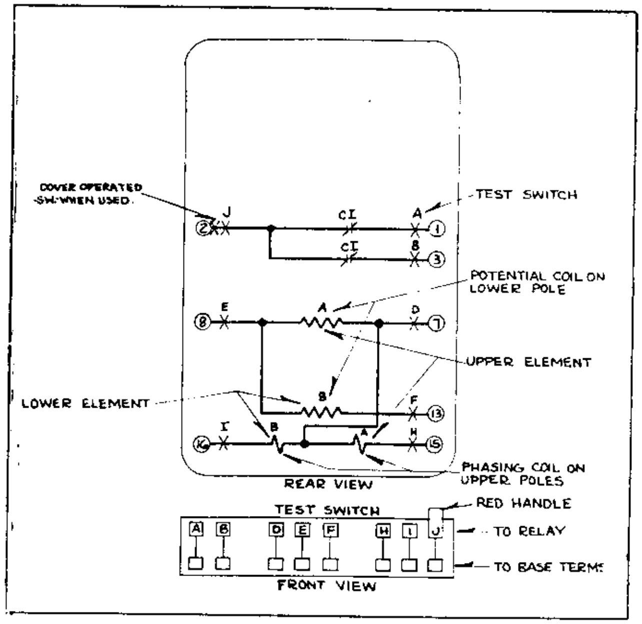


Fig. 2—Internal Schematic of the Double Contact Type CI Synchro-Verifier in the Type FT Case. The Single Contact Synchro-Verifier Has Terminal 3 and Associated Circuits Omitted.

tension it is necessary to loosen one screw, rotate the adjuster until the desired tension is obtained, and then tighten the screw again. The moving contact, countershaft, bearings and bearing bracket, and the spiral spring and spring adjuster can be removed as a unit by removing three screws and disconnecting the lead to the moving contact.

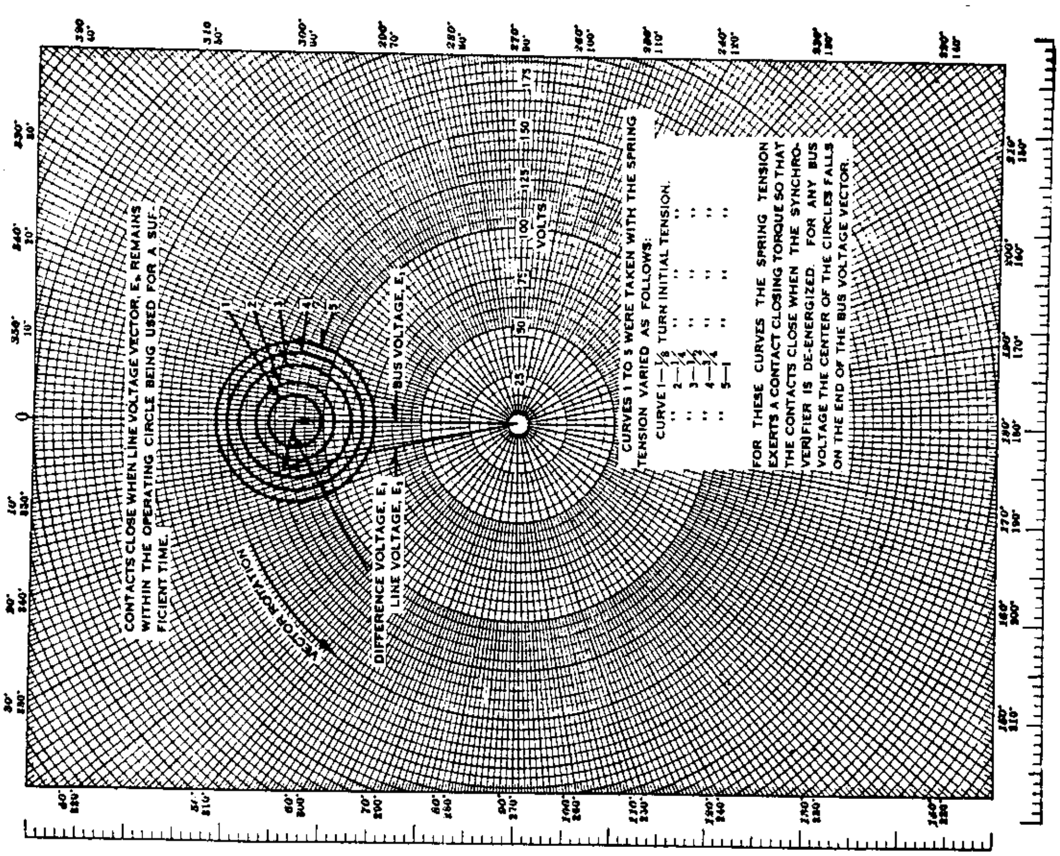
The stationary contact is mounted on a flat spring with a stop screw for adjusting the contact pressure. The travel of the moving contact is limited by a small stop riveted on the disc. The maximum contact opening is approximately 1/8".

OPERATION AND CHARACTERISTICS

The type CI synchro-verifier closes its contacts when the bus voltage E_1, and the line E_2, within set limits, are equal, in phase and of the same frequency. The potential coil of element A is energized by the voltage E_1, the potential coil of element B is energized by the voltage E_2, and the phasing coils of both elements are energized by the difference between these two voltages. With the spiral spring wound up in the direction to close the contacts (adjustment #1) the contacts will close when E_1 and E_2 are equal, in phase, and of the same frequency. Under this condition the difference between these two voltages is zero and no electrical torque will be produced because neither element will produce any torque unless its potential coil and phasing coil are both energized. Consequently when there is no difference voltage impressed across the phasing coil circuit, the contacts will be closed by the action of the spiral spring alone.

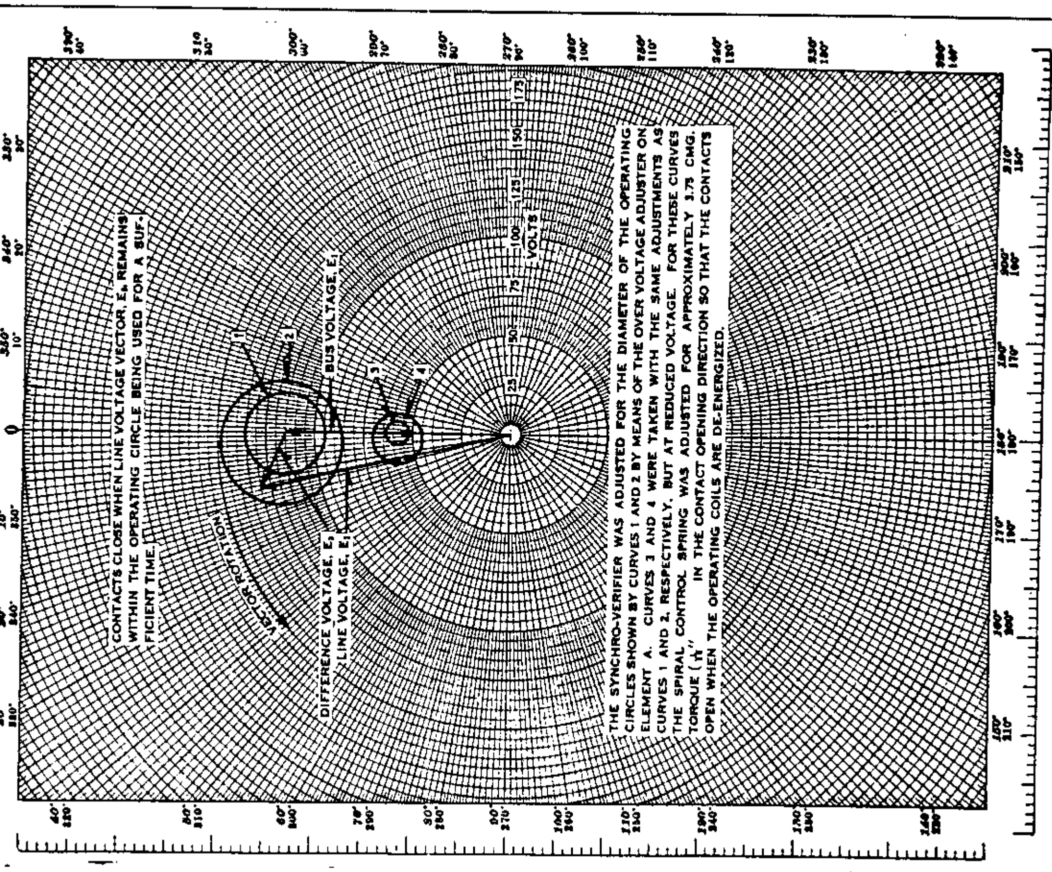
The two electro-magnets, A and B, produce opposing torques on the two discs and these torques increase as the voltage difference between the two voltages E_1 and E_2 increases. The net electrical torque acting on the discs is always in the contact opening direction and increases as the voltage difference increases, so that when the voltage difference exceeds a predetermined amount the net electrical torque becomes greater than the torque exerted by the spiral spring so that the contacts will be opened.

Typical operating curves for the type CI Synchro-Verifier are shown in Figures 3 and 4. The normal adjustment of the synchro-verifier (adjustment #1) is shown in Figure 3 for five values of spring tension. A spring tension of one whole turn is about the maximum which can be used without distorting the spring, while 1/8 turn is the minimum to give reliable operation.



Adjustment No. 1 - Elements Balanced
Both Voltages Zero - Contacts Closed
One Voltage Zero - Contacts Open
Both Voltages Within Circle - Contacts Closed

Fig. 3—Typical Operating Characteristic of the Type CI Synchro-Verifier with Adjustment No. 1.



Adjustment No. 2 - Elements Unbalanced By Voltage Bias
Both Voltages Zero - Contacts Opened
One Voltage Zero - Contacts Opened
Both Voltages Within Circle - Contacts Closed.

Fig. 4—Typical Operating Characteristic of the Type CI Synchro-Verifier with Adjustment No. 2.

The curves of Figure 3 were taken with a constant bus voltage E_1 and represent the locus of the line voltage E_2 which will just produce a balance condition in the synchro-verifier. The contacts will not move in either direction if the line voltage E_2 terminates on any point of the circle for which the spring has been adjusted. If the line voltage E_2 terminates within the circle and remains there for a sufficient length of time the contacts will close.

If E_2 is equal, in phase, and of the same frequency as E_1 so that the two vectors E_1 and E_2 coincide, the synchro-verifier will close its contacts with 1 turn spring tension (curve 5) from the full open position in approximately 5 seconds. Under the same conditions but with less spring tension (curves 1 to 4) the contacts will close at a slower rate.

If E_2 is equal in magnitude to E_1 but of a different frequency the vector E_2 will move thru the operating circle. With a uniform rate of speed so that approximately 5 seconds are required for E_2 to move from 20° lagging to 20° leading with respect E_1, the synchro-verifier contacts will not close if operating circle 5 is being used. This is because the net contact closing torque (spring tension minus electrical torque) is zero when E_2 is approximately 20° out of phase with E_1 and is at its maximum when E_2 is in phase with E_1. Since 5 seconds are required for the contacts to close when E_2 is equal to E_1 and is exactly in phase with it, (zero electrical opening torque) a longer time will be required for the contacts to close if E_2 is of different frequency than E_1. The time of 5 seconds required for E_2 to move through the operating circle 5 at a uniform rate of speed corresponds to a beat frequency of approximately 1/45 cycle so that a beat frequency of less than 1/45 cycle is required before the contacts will close if operating circle 5 is being used and correspondingly lower beat frequencies are required if operating circles with small diameter than 5 are being used.

The vector diagram on the curve illustrates the condition where the bus voltage E_1 is used as the reference voltage and is equal to 115 volts, the line voltage E_2 is 123 volts and leads the bus voltage by 12° and the difference voltage E_3 is equal to 26 volts and leads the bus voltage by 78°. If the system conditions are such that these voltages will remain fixed approximately at these values the contacts will close if either of the operating circles 3, 4 or 5 are used and will not close if either circles 1 or 2 are used.

The radius of the operating circle will remain constant for variations in the reference voltage E_1 as long as the over-voltage adjusters have been adjusted properly for these characteristics.

For applications where the contacts should remain open when the synchro-verifier is de-energized adjustment No. 2 should be used. The spiral spring is given a slight amount of tension in the contact opening direction, and the radius of the operating circle obtained by means of the over-voltage adjustment on element A. This is described in more detail under Adjustments. Typical operating curves for this adjustment are shown in Figure 4. It will be noted that the center of the operating circles do not coincide with the end of the reference voltage E_1 and that the radius of the operating circle decreases as the reference voltage E_1 is decreased. Both of these effects are inherent in the design of the synchro-verifier when this type of adjustment is used.

Synchro-Verifier In Type FT Case

The type FT cases are dust-proof enclosures combining the synchro-verifier elements and knife-blade test switches in the same case. This combination provides a compact flexible assembly easy to maintain, inspect, test and adjust. There are three main units of the type FT case: the case, cover and chassis. The case is an all welded steel housing containing the hinge half of the knife-blade test switches and the terminals for external connections. The cover is a drawn steel frame with a clear window which fits over the front of the case with the switches closed. The chassis is a frame that houses the synchro-verifier elements and supports the contact jaw

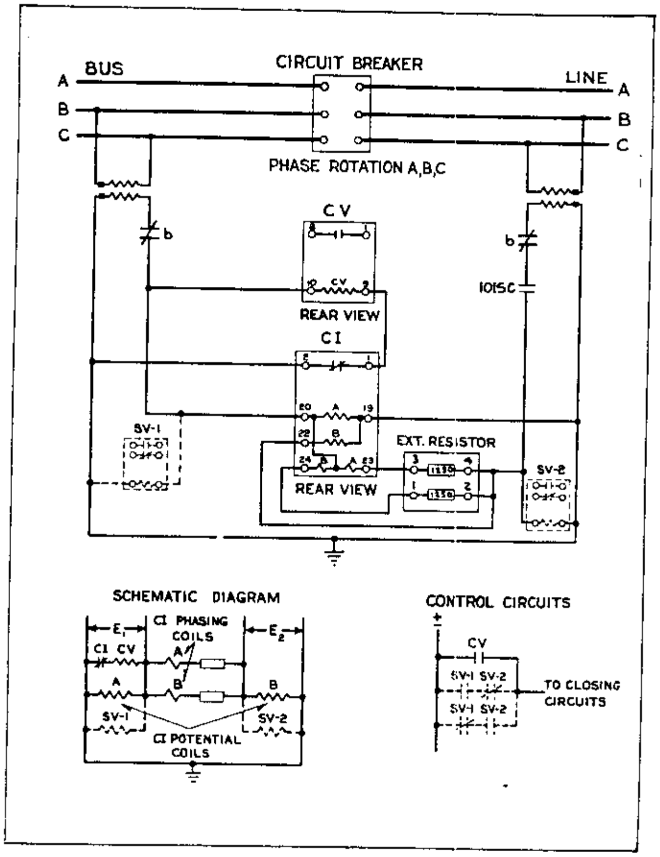


Fig. 5—External Connections of the Type CI Synchro-Verifier in the Standard Case.

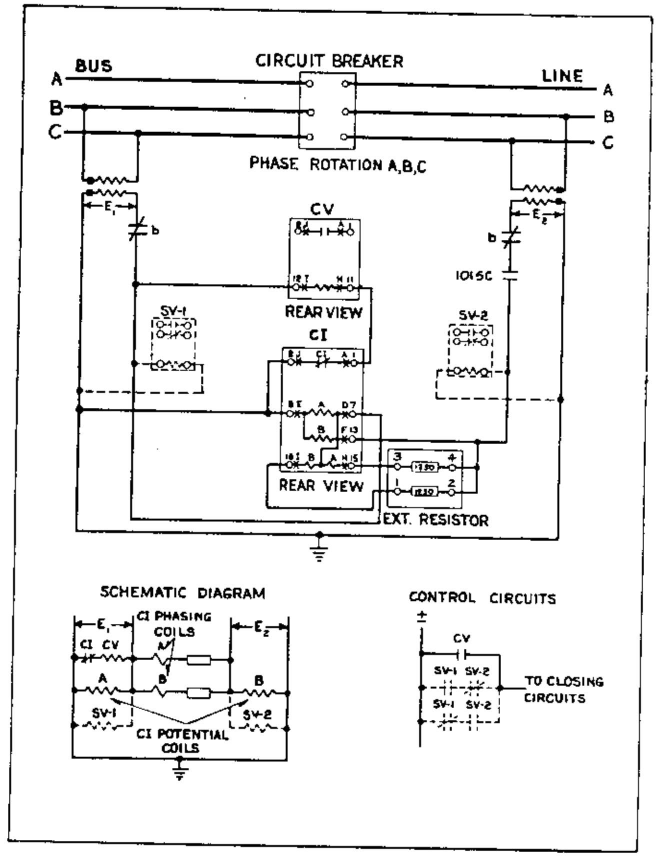


Fig. 6—External Connections of the Type CI Synchro-Verifier in the Type FT Case.

half of the test switches. This slides in and out of the case. The electrical connections between the base and chassis are completed through the closed knife-blades.

Removing Chassis

To remove the chassis, first remove the cover by unscrewing the captive nuts at the four corners. This exposes the elements and all the test switches for inspection and testing. The next step is to open the test switches. Always open the elongated red handle switches _first_ before any of the black handle switches or the cam action latches. This opens the contact circuit to prevent accidental operation. Then open all the remaining switches. The order of opening the remaining switches is not important. In opening the test switches they should be moved all the way back against the stops. With all the switches fully opened, grasp the two cam action latch arms and pull outward. This releases the chassis from the case. Using the latch arms as handles, pull the chassis out of the case. The chassis can be set on a test bench in a normal upright position as well as on its top, back or sides for easy inspection, maintenance and test.

After removing the chassis a duplicate chassis may be inserted in the case or the blade portion of the switches can be closed and the cover put in place without the chassis.

When the chassis is to be put back in the case, the above procedure is to be followed in the reversed order. The elongated red handle switch should not be closed until after the chassis has been latched in place and all of the black handle switches closed.

Electrical Circuits

Each terminal in the base connects thru a test switch to the synchro-verifier elements in the chassis as shown on the internal

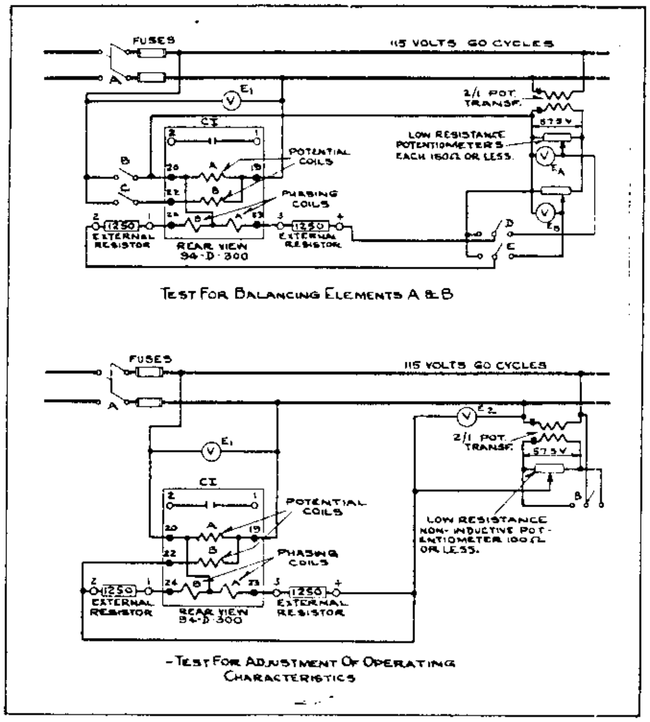


Fig. 7—Diagram of Test Connections for the Type CI Synchro-Verifier in the Standard Case.

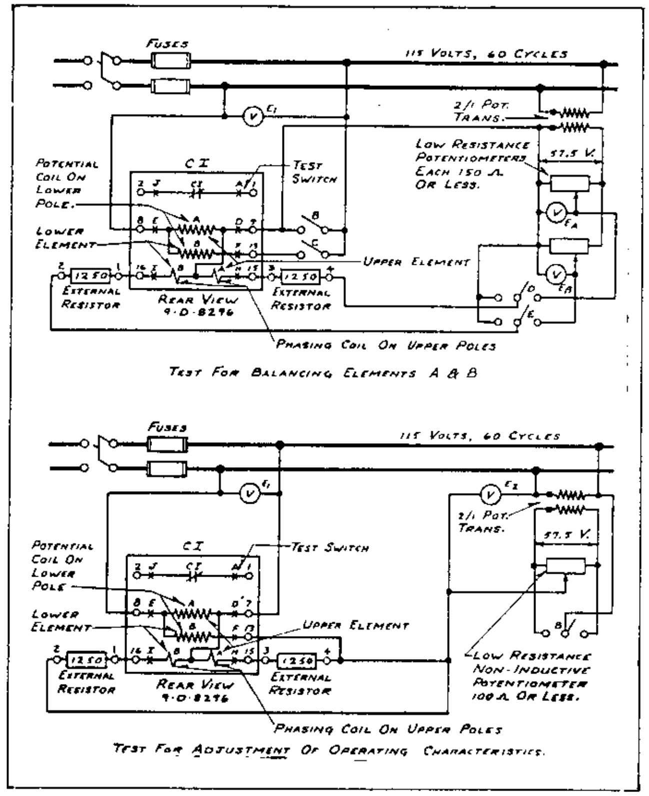


Fig. 8—Diagram of Test Connections for the Type CI Synchro-Verifier in the Type FT Case.

schematic diagrams. The synchro-verifier terminal is identified by numbers marked on both the inside and outside of the base. The test switch positions are identified by letters marked on the top surface of the moulded block. These letters can be seen when the chassis is removed from the case.

The potential and control circuits thru the synchro-verifier are disconnected from the external circuit by opening the associated test switches.

A cover operated switch can be supplied with its contacts wired in series with the contact circuit. This switch opens this circuit when the cover is removed. This switch can be added to the existing type FT case at any time.

Testing

The synchro-verifier can be tested in service in the case but with the external circuits isolated, or out of the case as follows:

Testing In Service

Voltages between the potential circuits can be measured conveniently by clamping #2 clip leads on the projecting clip lead lug on the contact jaw.

Testing In Case

With all blades in the full open position, the ten circuit test plug can be inserted in the contact jaws. This connects the synchro-verifier elements to a set of binding posts and completely isolates the synchro-verifier circuits from the external connections by means of an insulating barrier on the plug. The external test circuits are connected to these binding posts. The plug is inserted in the bottom test jaws with the binding posts up.

The external test circuits may be made to the synchro-verifier elements by #2 test clip leads instead of the test plug.

Testing Out Of Case

With the chassis removed from the base, synchro-verifier elements may be tested by using the ten circuit test plug or by #2 test clip leads as described above. The factory calibration is made with the chassis in the case and removing the chassis from the case will change the calibration values by a small percentage. It is recommended that the synchro-verifier be checked in position as a final check on the calibration.

INSTALLATION

The synchro-verifier should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the synchro-verifier vertically by means of the two mounting studs for the standard cases and the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. Either of the studs or the mounting screws may be utilized for grounding the synchro-verifier. The electrical connections may be made direct to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for ebony-asbestos or slate panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

Connections

The external connections of the type CI Synchro-Verifier are shown in Figures 5 and 6. The synchro-verifier is connected around the circuit breaker and is connected to the line and bus voltage whenever the breaker opens by b switches. When the line is energized from the remote breaker, voltage will be applied to the synchro-verifier. If this voltage as well as the bus voltage is approximately normal and the system has not pulled apart, the type CI Synchro-Verifier will close its contacts to energize the Type CV Timing Relay, which in turn will close the breaker thru suitable reclosing relays.

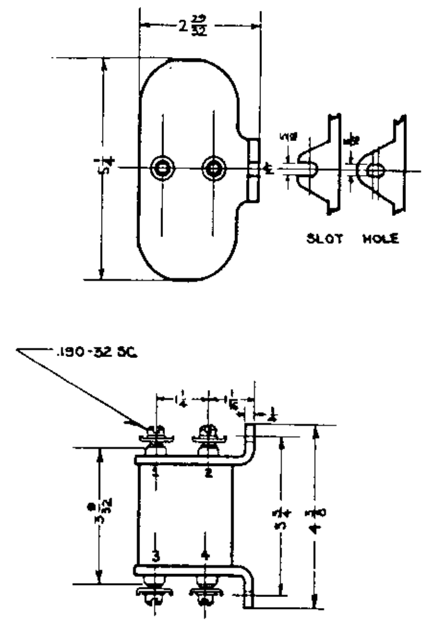


Fig. 9—Outline and Drilling Plan for the External Resistor. For Reference Only.

The synchro-verifier with adjustment No. 1 has its contacts closed when de-energized. The type CV relay is used to prevent the synchro-verifier from initiating the closing circuit when it is first energized and before it has had time to open its contacts.

Another function of the type CV relay is to provide additional time delay when the synchro-verifier is operating at a frequency difference. If the frequencies of the two systems are erratic, and the synchro-verifier is adjusted to close at a wide phase displacement angle, for example 20 degrees, it is possible that without the type CV relay the breaker closing relay may be energized 20 degrees late and at an instantaneous frequency considerably higher than 1/45 cycle. Thus when the breaker contacts finally close, the phase displacement may be too large. With the type CV relay, the highest frequency difference at which the breaker could be closed would be considerably lower than 1/45 cycle, and the probability of obtaining breaker closure off synchronism would be minimized. For this reason it is recommended that the type CV relay be used with the type CI Synchro-Verifier as shown, with either adjustment No. 1 or 2, if the transmission system is such that the two sides of the breaker can be connected to two independent systems. Summing up, the Type CV relay should be applied except when the synchro-verifier is adjusted for operating characteristics as per adjustment No. 2, and at the same time the system layout is such that a frequency difference cannot be expected between the two sides of the breaker.

The connections shown in Figures 5 and 6 using the type SV voltage relays will provide the following operation:

1. Close the breaker when the bus is alive and the line is dead.
2. Close the breaker when the line is alive and the bus is dead.
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.

Referring to the diagram, it will be seen that the type CI Synchro-Verifier functions only under the third condition while the type SV relays, with under and over voltage contacts, function under the other two conditions.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of the synchro-verifier have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed, the synchro-verifier taken apart for repairs, or if it is desired to check the adjustments at regular maintenance periods, the instructions below should be followed.

All contacts should be periodically cleaned with a fine file. S#1002110 file 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 and thus impairing the contact.

A slip contact on the breaker control switch should be used to open the line potential transformer secondary leads in order to prevent energizing the dead line thru the potential transformers of the synchro-verifier.

The upper bearing screw should be screwed down until there is only two or three thousandths inch clearance between it and the shaft and then securely locked in position with the lock nut. This adjustment can be made best by carefully screwing down the top bearing screw until the disc fails to turn freely and then backing up a fraction of a turn. Great care must be taken in making this adjustment to prevent damage to the bearings.

Balancing Elements A or B

Level the synchro-verifier before making any test. Remove the gear and contact assembly and connect the elements as shown in the upper half of Figures 7 and 8. Close switches A and B, and close switch D to the left hand side. This places 115 volts on the potential coil of element A and short-circuits the phasing coil circuit of element A. Adjust the over-voltage adjustment on element A so that the stop on the disc balances at a point mid-way of its travel. The over-voltage adjuster is the sliding lag plate which is mounted on the movement frame and extends into the air-gap between the lower potential pole and the disc. It may be moved to the right or left by means of the adjusting screw provided for this purpose. The two locking screws which hold the over-voltage adjuster in place should not be loosened when this adjustment is made. Moving the over-voltage adjuster to the right of the center line of the potential poles as the synchro-verifier is viewed from the front causes it to lag a part of the potential coil flux so that a contact opening torque is produced, while moving it to the left of the center line of the potential pole causes a contact closing torque to be developed. This test is made to balance out all torque which may be caused by voltage on the potential coil only.

Open switch B, close switch C and close switch E to the left-hand side. This places 115 volts, 60 cycles on the potential coil of element B and short-circuits the phasing coil circuit of element B. The over-voltage adjuster of element B should be adjusted in a similar manner to that of element A so that the disc will balance at a point mid-way of its travel.

Leaving switch A and switch C closed, close switch B and close switch D and E to the right-hand side. This places 115 volts, 60 cycles on each potential coil and places the voltage Ea and Eb on the phasing coil circuits. Set the voltage Ea to 15 volts by means of the potentiometers and then adjust Eb by means of its potentiometer until the disc just balances with its stop mid-way in its travel. If the two electro-magnets do not produce an equal amount of torque under the same conditions then the voltage Eb will differ from the voltage Ed by an amount depending upon the unbalance between the two electro-magnets. When this balance has been obtained the electro-magnet which shows the lowest voltage reading for Ea or Eb has the strongest torque. The two electro-magnets should balance within 1/2 volt at 15 volts, that is, when Ea is set for 15 volts, Eb should read between the limits of 14.5 and 15.5 volts. If the two electro-magnets do not balance within these limits they should be re-adjusted with respect to each other by raising or lowering the upper pole assemblies by means of the adjustment provided for this purpose. Raising or lowering the upper pole assembly will disturb the over-voltage adjustment which has been made previously, and consequently each time the upper pole assembly is raised or lowered it will be necessary to reset the over-voltage adjuster so that no torque is produced. That is, the disc must balance in the mid-way position when the voltage coil alone is energized and the phasing coil circuit is short-circuited. Since this adjustment must be made by the "cut and try" method and may have to be repeated several times the first adjustments may be made more roughly than the final adjustment. The two electro-magnets may be considered balanced with respect to each other when at the end of the test they will perform as follows:

1. The disc will remain in a position mid-way of its travel when element A is energized with 115 volts, 60 cycles on the potential coil and the phasing coil circuit is short-circuited.

2. The disc will remain at a point mid-way of its travel when element B potential coil is energized at 115 volts, 60 cycles and element B phasing coil circuit is short-circuited.

3. With both potential coils energized at 115 volts, 60 cycles and with 15 volts impressed across the phasing circuit of element A the torque of elements A and B should be balanced so that the disc will remain at a point mid-way of its travel when the voltage impressed across the phasing coil circuit of element B falls at some value between the limits of 14.5 and 15.5 volts.

Replace the gear and contact mechanism on the synchro-verifier after making sure that all adjustments which were made in the previous test will remain unchanged or, in other words, see that all screws which lock the adjustments in place are tight

Operating Circle Radius

Adjust the position of the stationary contact so that the contacts make when the stop on the disc is between 1" and 1-1/4" from the movement frame on the right-hand side. When the stop on the disc is at the extreme right end of its travel the stationary contact should not be deflected to such an extent that it rests against its own back stop. If this adjustment is not readily obtained the gear and contact assembly may be loosened

ENERGY REQUIREMENTS

The burden of the relay at 115 volts, 60 cycles is as follows:

	Z Ohms	R Ohms a-c	X Ohms	Watts	Volt Amperes	P.F.
Potential Coil	385	57	380	5.14	34.4	81.4° Lag
Phasing Coil & Resistor	1660	1536	628	7.4	8.0	22° Lag

The potential coil will operate satisfactorily on any voltage between 100 and 135 volts.

from the movement frame and the mesh between the pinion and gear changed by one tooth.

See that the synchro-verifier is free from friction and then adjust the spring adjuster so that it exerts no torque tending to move the contacts one way or the other just at the point where the contacts make. Reference marks should then be placed on the spring adjuster and its supporting piece in pencil to indicate the position of the spring adjuster which gives zero initial tension on the spiral spring.

Connect the synchro-verifier as shown in the bottom half of Figures 7 and 8. Close switch A. This places 115 volts, 60 cycles, (E_1) on the potential coil circuit of element A. Close switch B to the left-hand side. This places a variable voltage E_2 on the potential coil of element B and the difference between E_2 and E_1 is the voltage impressed on the two phasing coil circuits. Adjust the potentiometer until E_2 reads 145 volts, which is 30 volts greater than E_1. Then adjust the spiral spring adjuster in the direction to wind up the spiral control spring so that it tends to close the contacts. The tension on the spring should be increased until the contacts will close from the extreme open position when E_2 is 145 volts and will not close from the extreme open position when E_2 is 147 volts. A two volt limit is thus allowed on the voltage difference adjustment. Approximately one-half turn initial tension on the spring should be sufficient to make this adjustment, although this will vary some with different synchro-verifiers. Securely lock the spring adjuster in position by means of the locking screw provided and then change switch B to the right-hand position. Then adjust the potentiometer so that E_2 reads approximately 85 volts, which is 30 volts less than E_1. The contacts should close from the extreme open position when the voltage difference between E_2 and E_1 is not more than 32 volts nor less than 28 volts.

An adjustment for 30 volts difference between E_1 and E_2 has been specified. If a different value for this voltage difference adjustment is desired, it may be made in the same way with the same limiting value of plus or minus 2 volts on the check test made with E_2 less E_1.

As a further check on the correct operation of the relay, E_2 should be made equal to E_1 and under this condition the relay should develop a positive contact closing torque, and with E_2 radically more than 30 volts different from E_1 the relay should develop a strong contact opening torque.

When the adjustments have been made as outlined above, the contacts of the synchro-verifier will close when the operating coils are totally de-energized.

As previously stated, the contacts may be made to remain open when the operating circuits are de-energized (adjustment #2) by giving the spiral control spring a slight amount of tension in the contact opening direction and obtaining the desired radius of operating curve by means of the over-voltage adjustment on element A. Operating circles as shown in Figure 4 are obtained in this manner and the two elements are balanced at the desired voltage difference by means of the over-voltage adjuster on element A instead of by means of adjusting the tension on the spiral control spring as previously outlined. The negative spring tension used should be just sufficient to insure that the contacts will always open when the operating coils are de-energized.

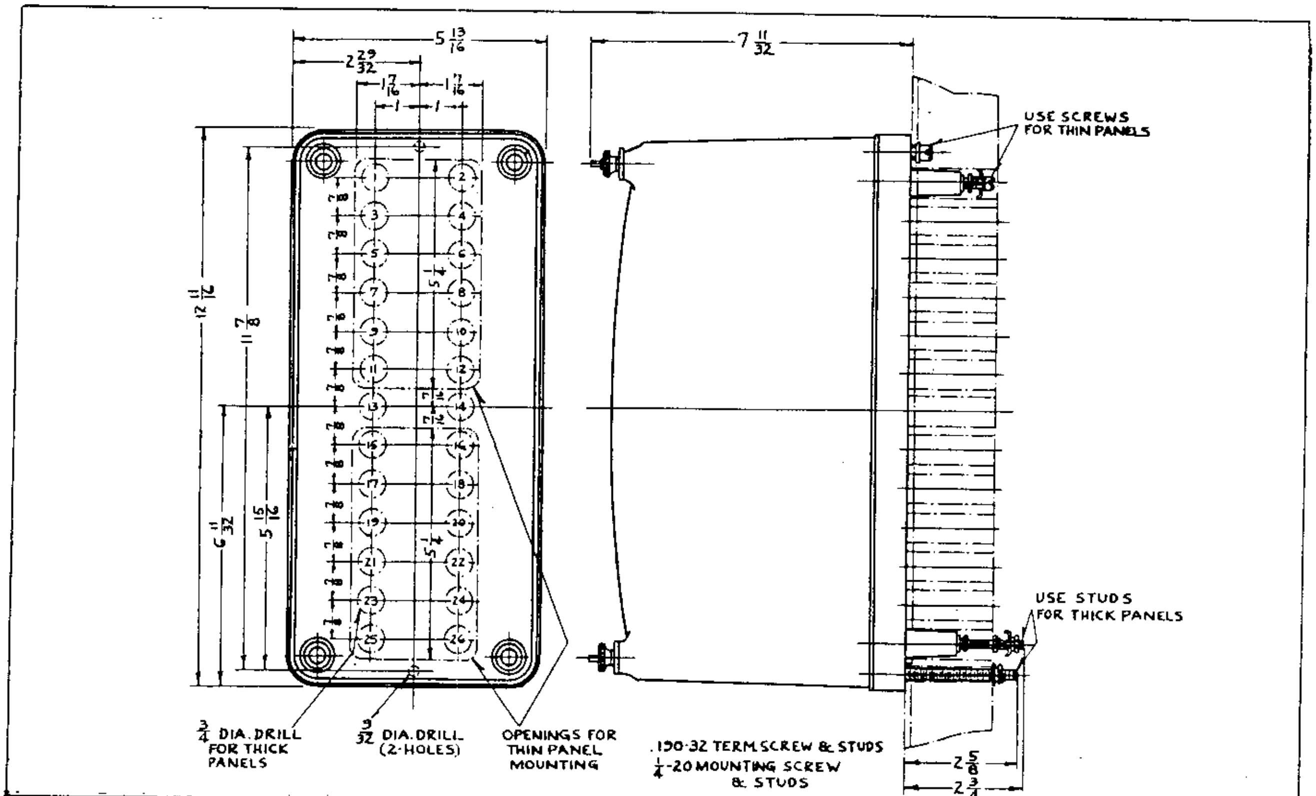


Fig. 10—Outline and Drilling Plan for the Standard Projection Type Case. See the Internal Schematics for the Terminals Supplied. For Reference Only.

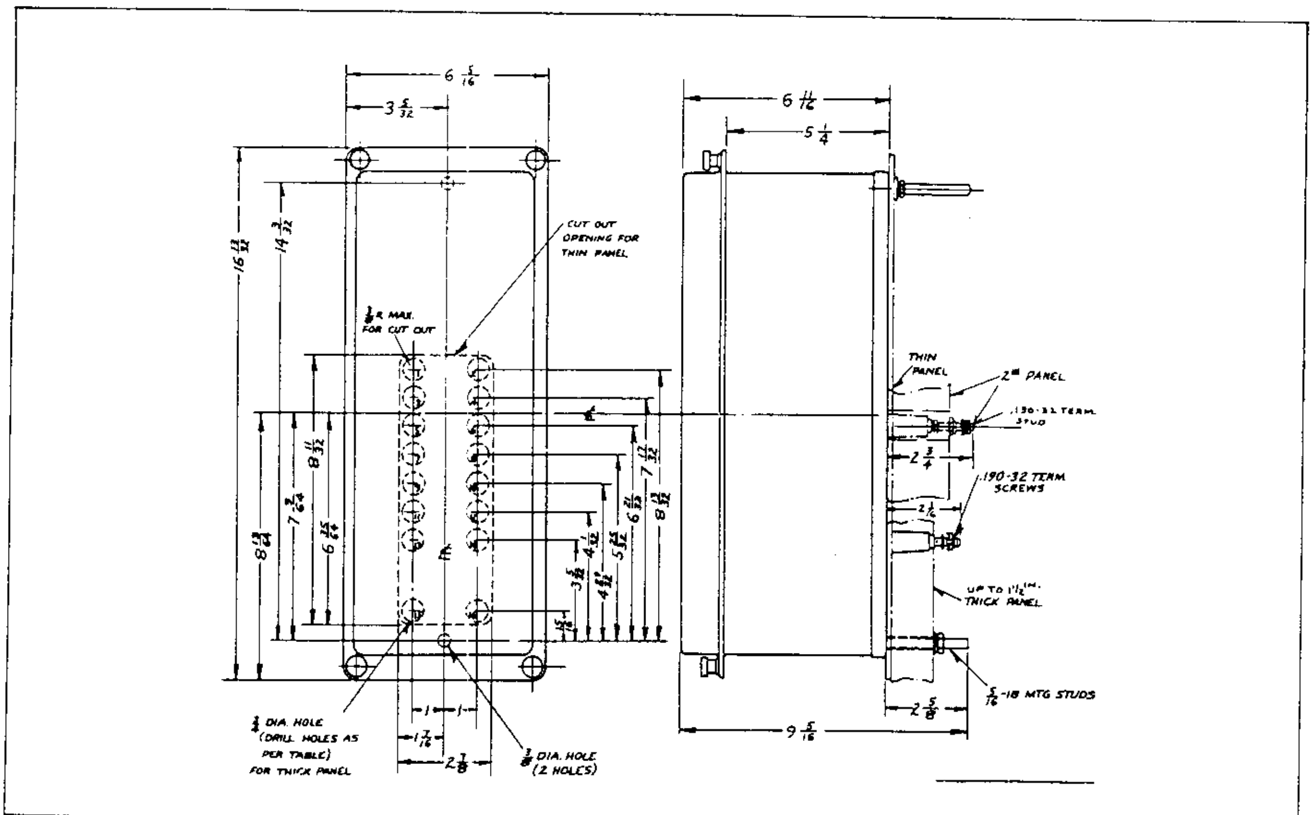


Fig. 11—Outline and Drilling Plan for the M10 Projection or Semi-Flush Type FT Flexitest Case. See the Internal Schematics for the Terminals Supplied. For Reference Only.