Westinghouse

Type CN-33, CN-J and SR-2 Network Relays

Instruction Book

This edition of I. B. 5794 is limited. It is printed with the purpose of supplying instructions for Type CN-33, CN-J and SR-2 Relays now being built, and is not intended for extensive circulation nor for overstocking of Classified Files.

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Index

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Types CN-33, CN-J and SR-2 Network Relays

General Application

1. The type CN-33, CN-J, and SR-2 relays have been designed to control the operation of the type CM-22 network protector which is used for the control and protection of low voltage alternating-current network systems. A low voltage a-c. network system is an interconnected grid or mesh of low voltage mains, from which the customers' services are taken, supplied through a number of network transformer banks over two or more high voltage feeders. Type CM 22 network protectors are connected in the secondary leads of each network transformer bank to provide means for disconnecting any high voltage or primary feeder and its associated network transformers from the secondary grid or network.

2. The characteristics of the type CN-33 network master relay are such that it will operate to close the network protector when the voltage on the transformer side of the protector is approximately equal to or greater than and substantially in phase with the voltage on the network side of the protector, and to trip the protector when the flow of power through the protector is reversed, that is, the flow is from the network to the transformer bank. For some systems the above characteristics are satisfactory and only the type CN-33 relay is necessary to control the network protector. On most systems, however, it is necessary to use the type CN-J relay in conjunction with the type CN-33 to prevent the network protector from closing under voltage conditions which would produce a reversal of power when the protector closed thus causing it to immediately reopen. Such repeated closing and opening of the network protector without any changes in load and voltage conditions on the system other than those produced by the operation of the protector is referred to as pumping. All type CM-22 network protectors are normally supplied with both the type CN-33 and type CN-J relays. The CN-J phasing relay can be omitted, however, if the protectors are to be installed on a system where it is definitely known that voltage conditions cannot exist which might cause pumping.

3. Even though pump-proof network protectors controlled by type CN 33 network master relays and type CN-J network phasing relays are used a large number of unnecessary protector operations may occur at certain locations on any network system, usually at times of light load on the system. These unnecessary operations may be due to the starting and stopping of regenerating elevators or to differences in primary feeder voltages coupled with large fluctuating loads on the system, such as large motors which may be started at frequent intervals. While in most cases the type CN-33 is set to trip its associated network protector on an in-phase reversal equal to about 0.3% of the ampere rating of the protector, it is possible to increase the reverse current setting of the standard CN-33 relay to a value equal to 10% of the protector rating. An in-phase reverse current setting of 10% of the protector rating in amperes or less will eliminate a large number of unnecessary protector operations. There will be some cases, however, where a higher reverse current setting is necessary to prevent a protector from opening on these frequent reversals of power which may occur at times of light load. To take care of these cases a type SR-2 voltage restraining relay should be added to the type CM-22 protector. The use of this relay permits the CN-33 relay to be set to trip its associated protector on a minimum in-phase reversal of approximately 20 or 40% of the protector rating in amperes under normal system conditions. When a fault occurs which appreciably affects the voltage at the protector, however, the reverse current setting of the CN-33 relay automatically becomes sensitive so as to insure its positive operation. The high reverse current setting is automatically restored when system conditions again become normal. All type CM-22 protectors are provided with the necessary wiring and mounting facilities for the type SR-2 relay so that the relay can be easily installed on the protector should the need for it develop.

4. When controlled by one or more of the above mentioned relays the type CM-22 network protector should function satisfactorily under all conditions which may be encountered in service. A detailed description of the construction, operation, and adjustment of each of the above three relays is given in the following pages.

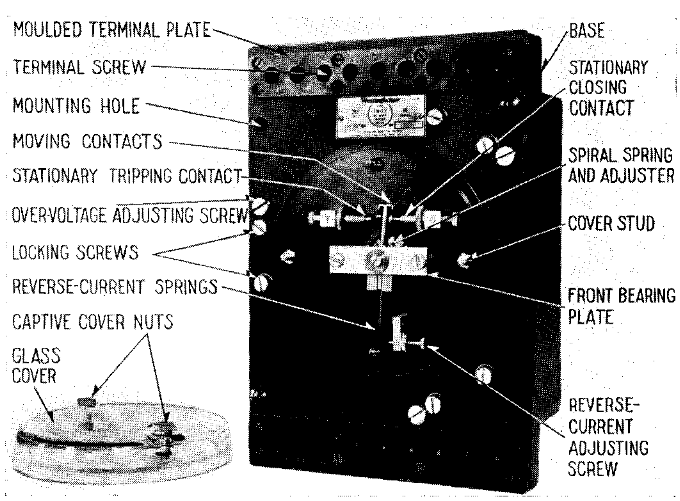


FIG. 1—TYPE CN-33 NETWORK MASTER RELAY. FRONT VIEW WITH GLASS COVER REMOVED.

Type CN-33 Network Master Relay

Construction

5. The type CN-33 network master relay shown in Figs. 1 and 2 is a three-phase relay which operates on the induction principle. Its moving element is a comparatively large and sturdy drum drawn from pure sheet aluminum. This drum is carried on a horizontal tool steel shaft which rotates through approximately a 15 degree angle on sturdy tool steel knife-edge bearings. Since this type of bearing can be placed at the exact center of the shaft, friction is reduced to a minimum. The construction is similar to that used in sensitive platform balances. Heavy phosphor bronze retaining rings have been added to encircle the ends of the drum shaft so as to prevent its being thrown off the knife-edges during heavy torque conditions. The stationary bearings have their knife-edges extending upward to avoid the danger of having dirt accumulate between the bearing surfaces. End thrust is taken care of by means of flat polished steel surfaces in the stationary bearing assemblies. The ends of the drum shaft are conical, and one end or the other makes point contact with its associate flat steel surface depending upon the direction of the thrust. The moving element is carried on a flat steel mounting plate. The drum is located behind this plate and its shaft extends through a hole in a moulded insulation plate located on the steel mounting plate. One of the drum shaft bearings is mounted on the back of the steel plate and one is mounted on the front of it.

6. The relay has single-pole, double-throw contacts all of which are made of pure silver. The moving contact arm is clamped around an insulation hub pressed on that portion of the drum shaft which extends through to the front of the relay mounting plate. This arm carries two spring mounted silver contacts which are electrically one, and three flat steel springs of different lengths which extend down from the shaft 180° from the contacts. These springs are used to adjust the amount of reverse current necessary to close the tripping contacts of the relay. Counter weights are also carried on the moving contact arm so that the moving element is substantially balanced in all positions.

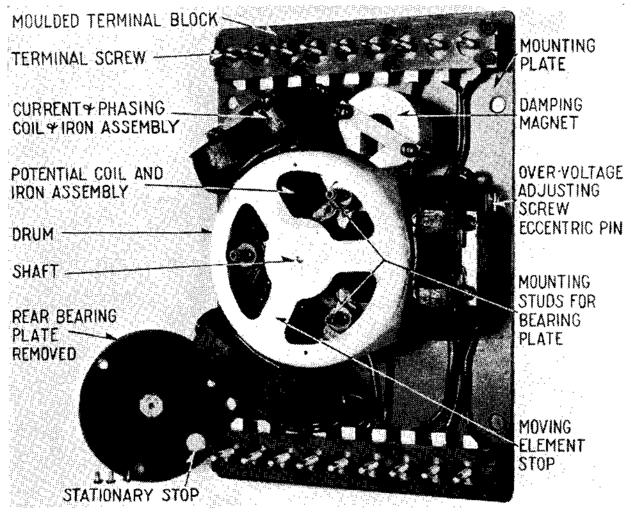


Fig. 2—Type CN-33 Network Master Relay. Rear View of Relay Removed from Base and with Rear Bearing Plate Removed.

7. The stationary contacts consist of two hemispherical silver buttons welded on the ends of two brass thumb screws. These two contact screws, screw into two brass blocks and are locked securely in place by means of two thumb nuts. The block which carries the stationary closing contact is mounted to the right of the moving contact on the insulation plate through which the drum shaft passes and is stamped with the letter "C". The block which carries the stationary tripping contact is mounted in the same insulation plate to the left of the moving contact and is stamped with the letter "T".

8. On the lower part of the insulation plate to the right of the three flat steel reverse-current springs is mounted another brass block with three tapped holes in it. This block carries a small thumb screw which acts as a stop to deflect the reverse-current springs. When mounted in the lower hole the screw will deflect one of the springs, in the middle hole two, and in the upper hole all three of the springs. This reverse-current screw is used to vary the amount of reverse current necessary to close the tripping contacts of the relay by varying the amount of deflection and the number of reverse-current springs deflected before the tripping contacts make. When the reverse-current adjustment is made the screw is securely locked in place by means of a thumb nut.

9. When the relay is completely de-energized the moving contact is held firmly against the closing stationary contact by means of a spiral spring around the moving element shaft. The inner end of this spring is fastened to the moving contact arm and the outer end is fastened to a spring adjuster which is carried on the front of the circular moulded insulation plate. This spring adjuster is of the friction type which has been used on many Westinghouse induction relays for years. Twelve radial slots in the movable spring support of the adjuster provide an easy means of changing the spring tension with a screw driver.

10. The use of a large diameter drum, a small permanent magnet for damping the movement of the drum, and a solid stop on the moving element which limits the movement of the drum to a relatively small angle, have made it possible to eliminate all gears from the relay without getting into difficulty from bouncing of the relay contacts. The elimination of gears simplifies the construction of the relay and removes a source of friction difficulties. The small permanent magnet is carried on the back of the mounting plate where it is protected by the relay base from dust, dirt and other foreign particles even when the glass cover of the relay is removed. The moving element stop is a heavy pin pressed into one of the spokes

of the drum. It operates in a large clearance hole in the rear bearing plate and limits the movement of the drum in both directions by striking the opposite sides of this hole.

11. The three electromagnets which are carried on the back of the flat steel mounting plate are mounted radially and equally spaced about the drum. Each electromagnet consists of a conventional potential coil and iron assembly mounted inside the drum and a current and phasing coil and iron assembly mounted on the same radial centerline outside the drum. The potential coil is a machine wound coil with a nominal rating of 120 volts but it will operate satisfactorily on any voltage between 100 and 135 volts. A current coil of a few turns of heavy wire is wound directly on each of the two poles of the outer iron assembly over the necessary insulation. The phasing coils which are made up of a large number of turns of small wire are machine wound. One phasing coil is placed on each of the two outer poles over the current coils and securely held in place. The two sections of each electromagnet are thoroughly impregnated with insulating varnish and baked. Lagging is used on the potential coil and iron assembly. Similar lag loops are mounted on the outer or current and phasing coil and iron assembly. These outer lag loops also serve to lag the potential coil flux and effectively limit magnetic unbalances that have made the use of two piece electromagnets difficult in the past.

12. Each current and phasing coil and iron assembly is pivoted at one end to produce a potential bias by unbalancing the air gap between the two sections of each electromagnet and thus obtain the necessary overvoltage adjustment. The outer coil and iron assembly is held securely in place on the back of the steel mounting plate by two screws whose heads are on the front of the plate. There is also an adjusting screw associated with each outer coil and iron assembly whose head is on the front of the mounting plate. This adjusting screw carries an eccentric pin which engages two pins in the outer coil and iron assembly at the end opposite its pivot point. With this construction it is possible to move the entire current and phasing coil and iron assembly through a small angle about its pivot by slightly loosening the two mounting or locking screws and then turning the adjusting screw. When the desired overvoltage adjustment is made the outer coil and iron assembly is securely held in the correct position by tightening the two locking screws. Since the locking and adjusting screws are not located under the glass cover of the relay this adjustment can be made from the front of the relay without removing the glass cover.

13. All parts of the relay located behind the steel mounting plate are completely enclosed in a cast iron base to which the mounting plate is fastened by two large screws. A shallow glass cover is mounted over the circular moulded insulation plate carried on the steel mounting plate. This cover is held in place by two captive thumb nuts and serves to protect the relay contacts, reverse-current adjusting springs, and front bearing of the moving element shaft from dust and dirt.

14. Moulded insulation terminal blocks are mounted on the two ends of the mounting plate. Silver tipped screws pass through threaded holes in small brass plates which are soldered on the ends of the relay coil and contact leads and slipped into slots in the moulded blocks. These screws extend on through the terminal blocks and holes in the relay base where their silver tips engage with stationary terminals which are mounted on the protector. These stationary terminals are silver plated copper jaws backed up by steel springs assembled in moulded insulation blocks. The relay terminal screws serve as plug or jack type connections between the relay and protector wiring, but are not used to mount the relay. The relay is mounted on two studs and held securely in place by two wing nuts which when tightened force the terminal screws firmly into engagement with their associated jaws. These jaw assemblies are free to move somewhat in their moulded insulation blocks so as to be self aligning. The heads of all terminal screws are accessible from the front of the relay, and when they are screwed down in their normal position the heads are completely surrounded on all sides by the moulded terminal blocks through which the screws pass. This prevents accidental contact with or shorting to ground or between screws. By partially

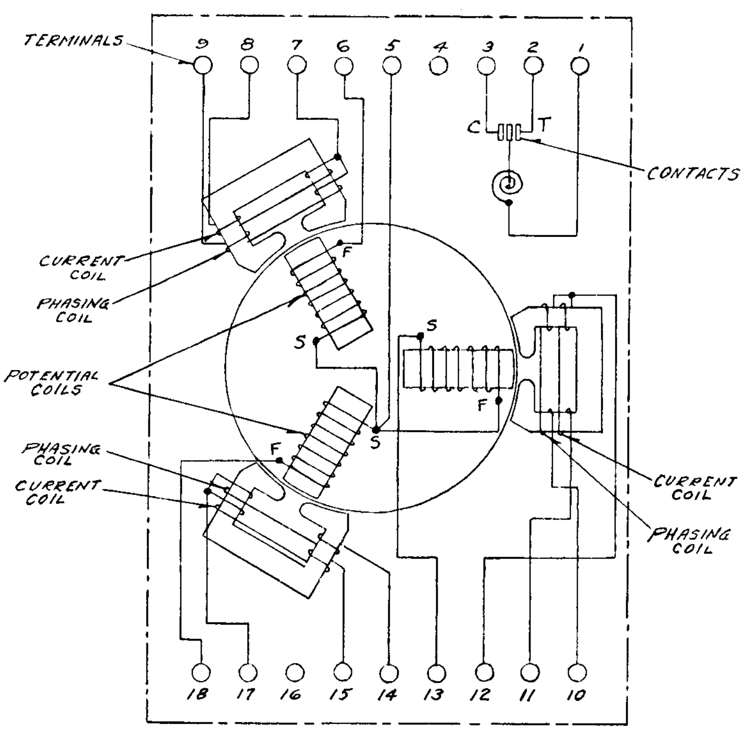


Fig. 3—Wiring Diagram of Internal Connections of the Type CN-33 Network Master Relay.

removing the proper terminal screw or screws any circuit or circuits between the relay and the protector can be opened. Before the head of a screw becomes flush with the surface of the terminal block the circuit is opened. The screw remains connected to its associated relay circuit, however, even after it is backed out until its head extends above the surface of the moulded block, so that a test clip can be connected to it in the groove around the screw head provided for that purpose. This type of terminal construction allows the terminal screws to be used as test switches and greatly facilitates testing and adjusting the relay when mounted on the protector. The relay can readily be mounted on or removed from the protector without disturbing any leads and without any possibility of connecting it improperly merely by tightening or removing the two wing nuts from its mounting studs. After the relay has been taken off the protector it can be completely removed from its base for inspection or maintenance without disturbing any parts or wiring details by removing the two screws which hold the steel mounting plate on the front of the base. The various coils and internal connections of the relay are shown in Fig. 3.

Operation

15. The operation of the type CN-33 relay can best be described by referring to Fig. 4. The figure shows a schematic diagram of the internal and external connections of the type CN-33 relay and the type CN-J relay when used on a three-phase network with a grounded neutral. The control circuits have been omitted to make the picture as clear as possible. When all primary feeders associated with the low voltage network are open, the type CN-33 relay will be completely deenergized and its closing contacts will be held in the closed position by the spiral spring. Likewise, the contacts of the type CN-J relay will be held closed. If the operator at the station closes the breaker on the feeder to which the transformer bank shown in the figure is connected, the protector will close and connect the transformer to the network since the closing contacts of both relays are closed.

16. It will be noted that when closing on a dead network the phasing and potential circuits of the relays are in series with normal line-to-neutral voltage applied across them. However, the impedance of the phasing circuits is so much higher than the impedance of the potential circuits that the voltages across the latter are extremely low. Since the phasing coils can produce torque only when the potential coils are energized, the resulting torque will be very small because the potential coil voltages are low and the angle between these voltages and the phasing coil voltages is almost equal to the zero torque angle. What little electrical torque there is will tend to close the closing contacts of the relays. Any phase-to-neutral load connected to the dead network will be in parallel with the potential coils of the relays and will further decrease the voltage across these coils and the electrical torque produced in the relays. The closing contacts of both the CN-33 and CN-J relays will, therefore, make due to the action of their spiral springs, and the protector will close on a dead network regardless of the magnitude of the load connected to the network.

17. Again referring to Fig. 4, let us start with the condition we had originally, that is, all feeders associated with

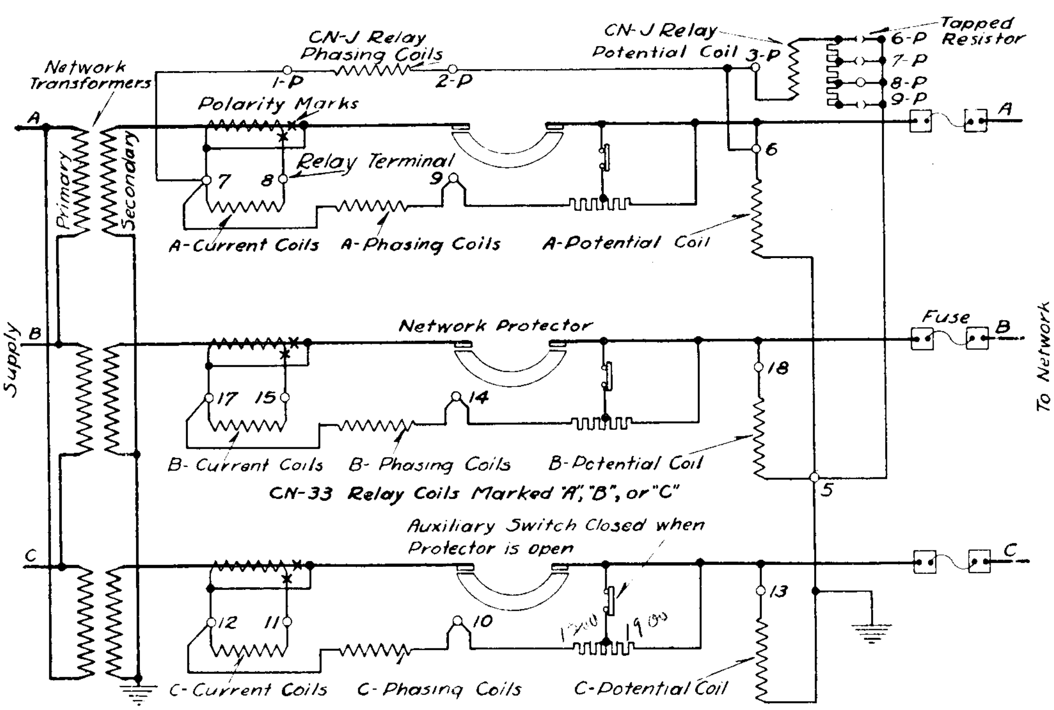


Fig. 4—Schematic Diagram of Internal and External Connections of Type CN-33 and CN-J Network Relays Used on a Three-Phase Network with a Grounded Neutral —Control Circuits Omitted.

the network are open. Now suppose that some network feeder, other than the one to which the transformer bank of Fig. 4 is connected, is energized by closing its breaker at the station. The network protectors on that feeder will close and connect it to the network as has been explained. This energizes the low voltage network and both the potential and phasing circuits of the type CN-33 relay shown in Fig. 4 become energized at once. The phasing circuits have line-to-neutral voltage impressed across them, but since the voltage on the network side of the protector is the higher, a very strong opening torque is produced and the moving contact of the relay moves quickly from the closing to the tripping position. The phasing circuits, being connected across the contacts of the protector, are energized when the protector is open by a voltage which is the vector difference between the transformer secondary voltage and the network voltage. The closing of the station breaker on the feeder to which the transformer bank of Fig. 4 is connected at a time when the secondary voltage of the transformers is appreciably less than the network voltage, will greatly reduce the voltage on the phasing circuits and consequently the tripping torque of the CN-33 relay. If when the feeder breaker is closed the transformer secondary voltages and the network voltages are equal and in phase the voltage across the phasing circuits will be zero, and the phasing coils in conjunction with the potential coils will produce no torque in either the closing or tripping direction. The closing contacts of the relay will not make under this condition, however, because each potential coil when energized alone produces a torque in the tripping direction slightly greater than the closing torque produced by the spiral spring. This torque or bias in the tripping direction, developed when only the potential coils are energized, is obtained by moving the outer coil and iron assemblies of the relay slightly so as to unbalance the air gaps, and is used for the overvoltage adjustment. With zero volts across the phasing circuits the moving contact of the relay will remain over toward the stationary tripping contact and may deflect the reverse current adjusting spring some but not enough to make the trip circuit. If when the feeder breaker at the station is closed the transformer secondary voltage is appreciably higher than the network voltage, the phasing coils in conjunction with the potential coils will produce a torque which will cause the moving contact of the CN 33 relay to make with the stationary closing contact and close the network protector, thus connecting transformer bank to the network.

18. The instant the protector closes, current starts to flow from the transformer into the network. This causes current to flow in the current coils of the relay, which are connected to the secondaries of saturating current transformer, and produce a torque in the closing direction. The network protector will remain closed even if conditions change so that there is no current flowing through it. As the current decreases to zero, the moving contact will move away from the stationary closing contact and take up a position somewhere between it and the stationary tripping contact and may deflect the reverse-current adjusting spring a certain amount. When the feeder is disconnected from the station bus by tripping its circuit breaker, the transformers will be magnetized from the network. This flow of exciting current from the network to the transformer bank will cause enough current to flow in the current coils of the type CN-33 relay to produce a tripping torque sufficient to deflect the reverse-current adjusting spring until the moving contact completes the relay trip circuit. In this way the feeder is disconnected from the network when the station breaker is opened. The action of the relay is just the same if a fault develops in the transformer or feeder, except the tripping torque will be much greater and the time of operation shorter.

19. The design of the phasing circuits must be such that the relay will make its closing contacts with one volt or less impressed across them. However, when the network is energized and the feeder breaker at the station is open, there will be full line-to-neutral voltage across the phasing circuits. There is the possibility of the transformer voltage being reversed due to an error in making connections and this would place twice normal line-to-neutral voltage across the phasing circuits when the feeder breaker is closed. In order to protect the phasing coils over this wide range of voltages and to assist in securing the desired phase-angle characteristics, a tapped resistor is placed in series with each pair of phasing coils. These phasing resistors are mounted on the protector external to the relay in order to decrease the amount of heat liberated in the relay case so as to keep the temperature of the relay coil within proper limits. The total value of each resistor is 3100 ohms with the tap taken off at 1200 ohms from one end and 1900 ohms from the other. When the protector is open the 1900 ohm sections of the resistors are shorted by auxiliary switches on the protector leaving 1200 ohms in series with each pair of phasing coils. The full 3100 ohms is inserted in each phasing circuit by the opening of the auxiliary switches when the protector closes. This extra resistance is inserted to assist in getting the desired phase angle characteristics in the relay and to reduce the heating in the phasing coils when the protector is closed.

20. The current transformers used to energize the current coils of the CN-33 relay are small through-type saturating transformers and are designed so that they start to saturate at about 350% of the current rating of the network protector. The saturation of the current transformers results in higher relay torque and faster relay operation on most lagging power factor faults. It also serves to reduce the heating and mechanical stresses in the relay under the conditions of heavy short-circuits on either the network or primary feeder. The ratio of the current transformers for all protector ratings is such that the full load secondary current is 5 amperes. The secondaries of these transformers may be safely opened under load.

21. Figs. 5, 6, 7 and 8 show the operating characteristics of the type CN-33 network master relay. Curve No. 1 of Fig. 5 shows the closing characteristics of the relay. Lines drawn to it from the origin at various angles with the network voltage represent in both magnitude and phase position the transformer voltages which will produce a torque in the relay just sufficient to cause its closing contacts to make. The closing contacts will also make and connect the transformer to the network if the transformer voltage terminates above the closing curve. Any transformer

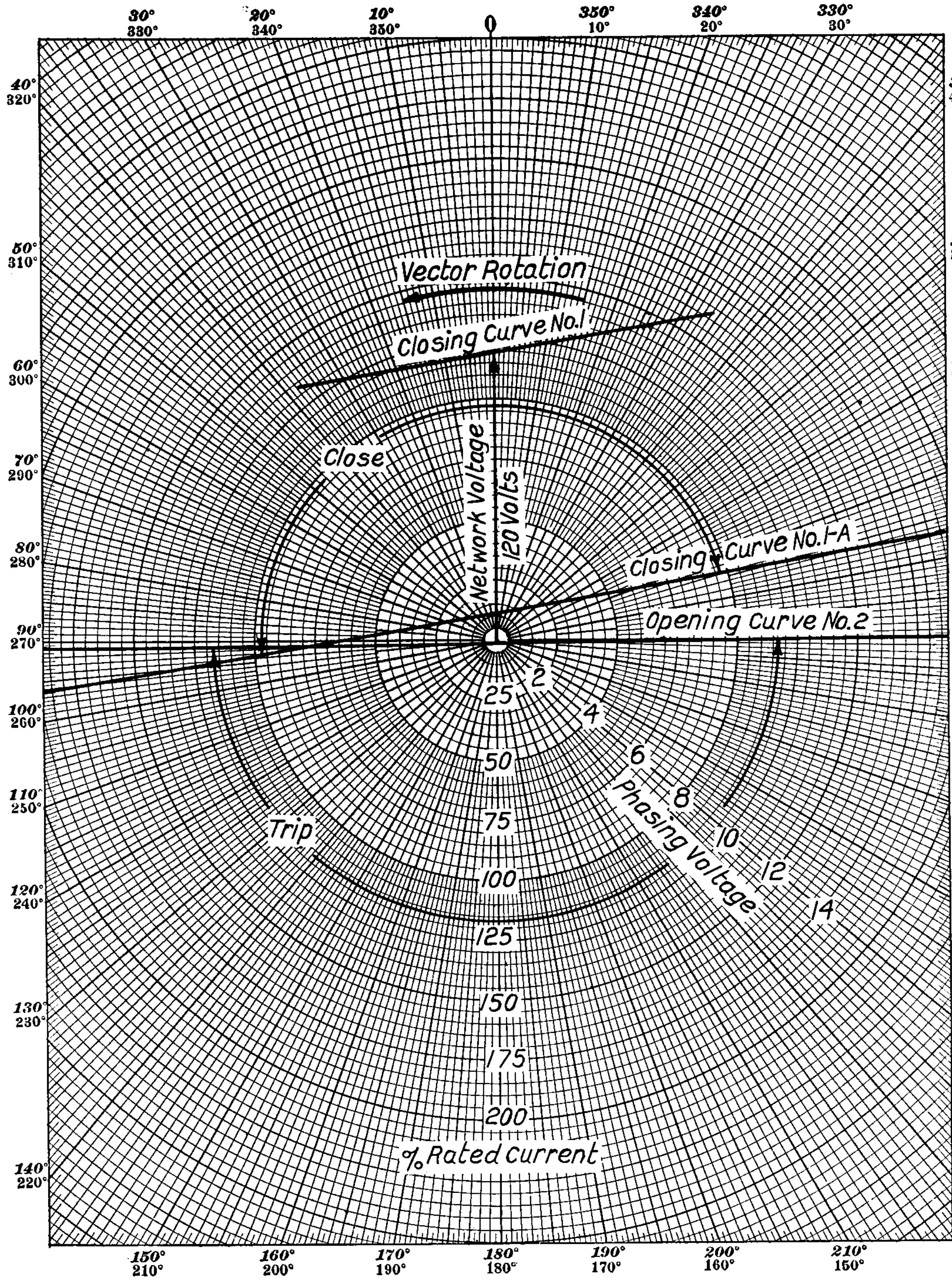


Fig. 5—Closing and Tripping Characteristics of the Type CN-33 Network Master Relay. Balanced Three-Phase Conditions Assumed.

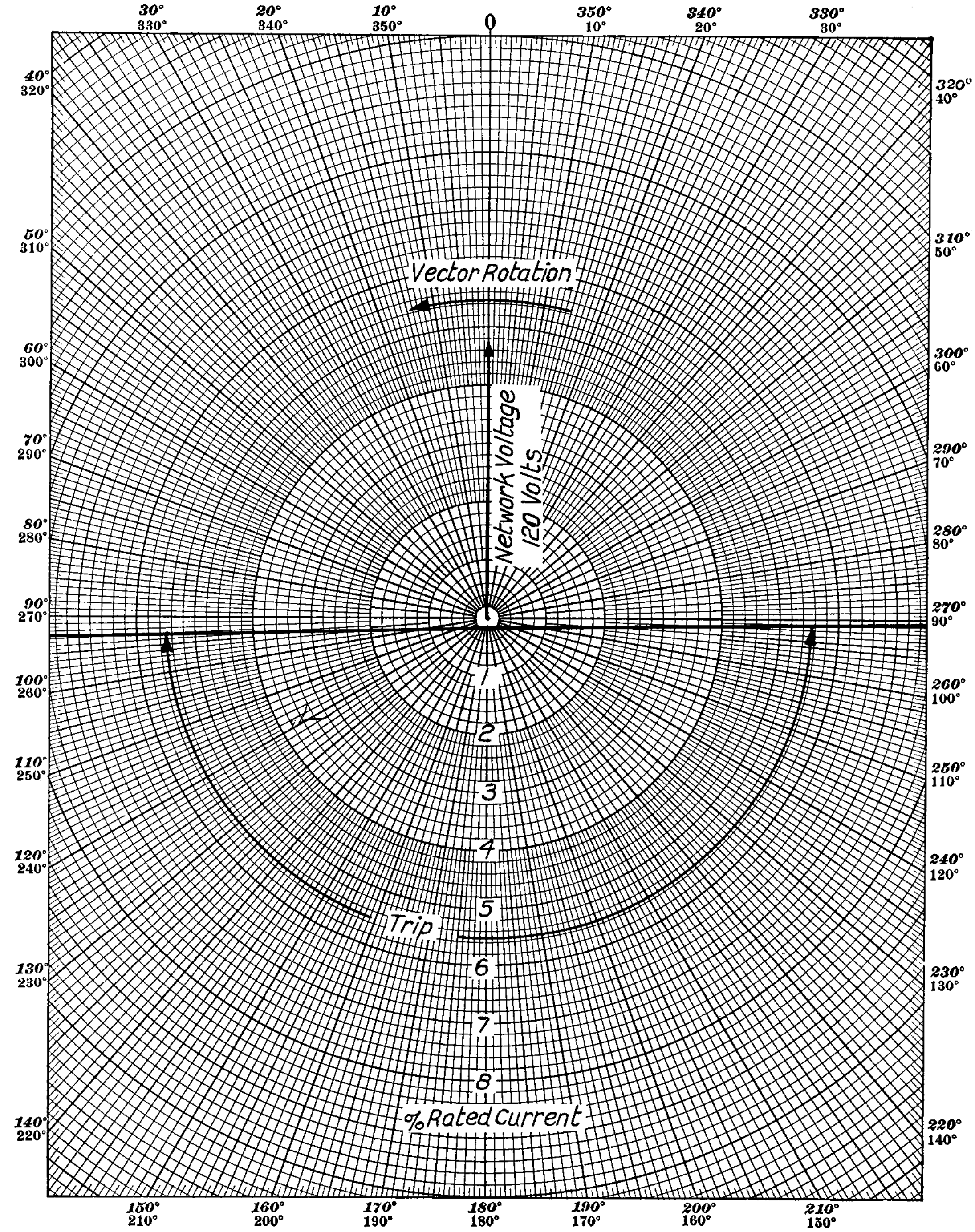


FIG. 6—TRIPPING CHARACTERISTICS OF THE TYPE CN-33 NETWORK MASTER RELAY. BALANCED THREE-PHASE CONDITIONS ASSUMED.

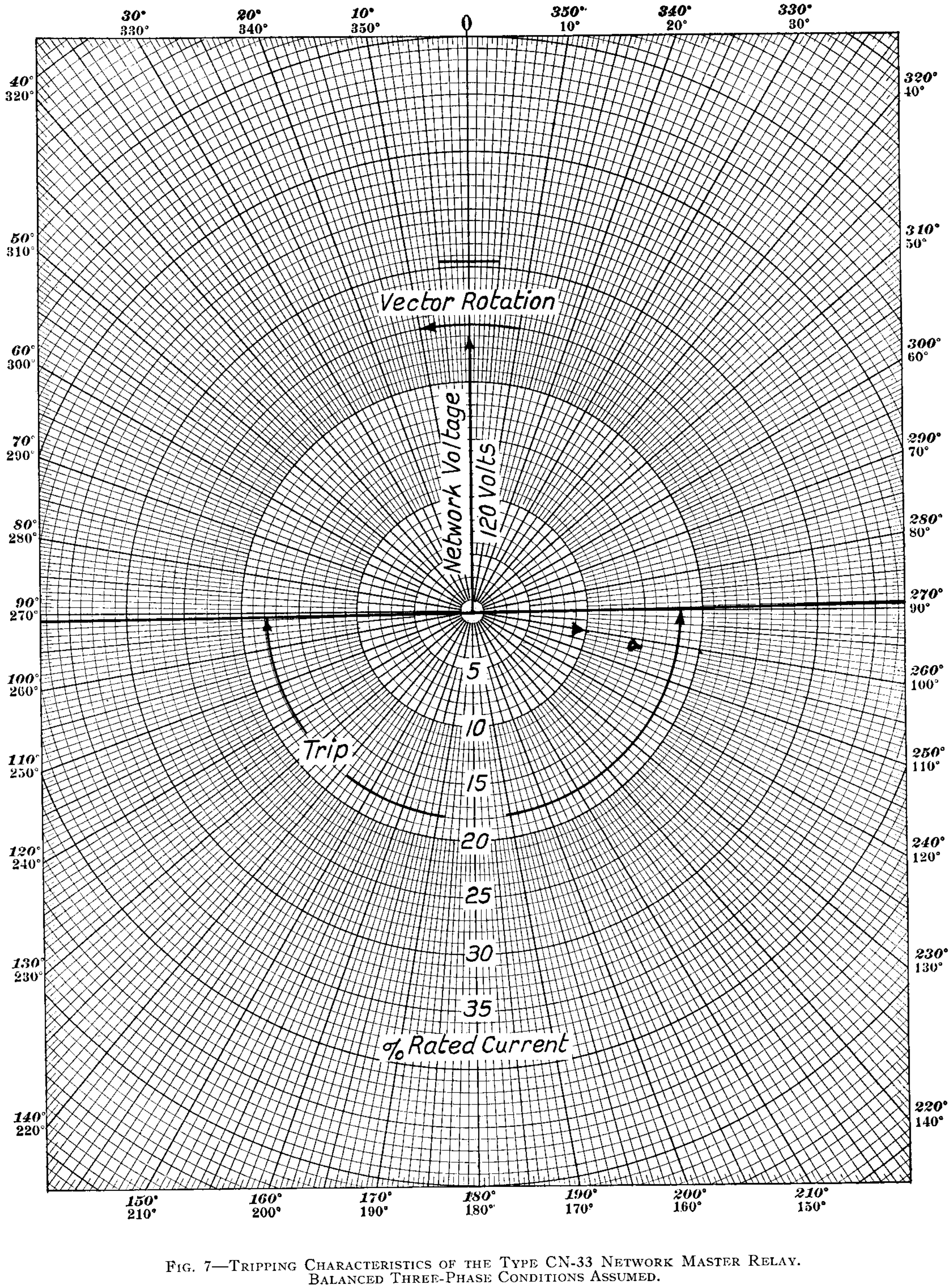


Fig. 7—Tripping Characteristics of the Type CN-33 Network Master Relay. Balanced Three-Phase Conditions Assumed.

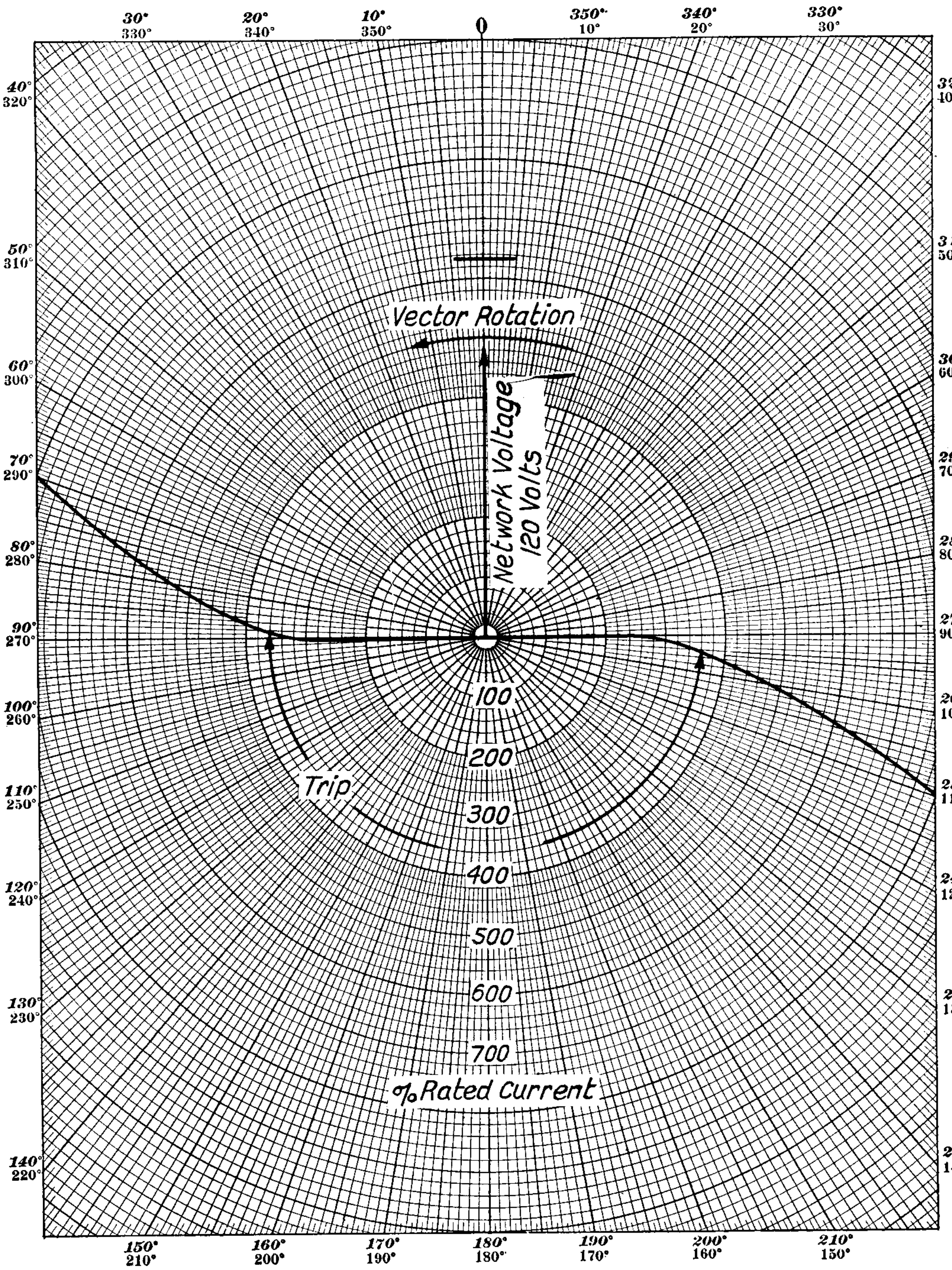


Fig. 8—Tripping Characteristics of the Type CN-33 Network Master Relay. Balanced Three-Phase Conditions Assumed.

voltage which does not terminate on or above the closing curve will produce a relay torque in the tripping direction which prevents the closing contacts from making and the network protector will remain open. The curve No. 1-A in the same figure shows a small section of the closing curve plotted to a much larger scale so as to show the characteristics of the relay for the values of phasing voltage at which it normally operates. Lines drawn from the origin to this curve represent in magnitude and phase position the phasing voltage, that is, the voltage across the open contacts of the network protector necessary to produce a torque in the relay just sufficient to make its closing contacts. The upper end or line potential end of the network voltage vector is at the origin in this case. The network voltage vector cannot be shown in its true relation to this curve because of the large scale to which the curve is plotted. It will be noted by referring to Curve No. 1-A of Fig. 5 that the relay will just close its closing contacts with approximately 0.8 volt across the phasing circuit in phase with the network voltage. When the phasing voltage leads the network voltage by 75°, it requires about 2.0 volts to close the closing contacts. This voltage at 75° leading, however, means only a very small angle between network and transformer voltages. This can readily be appreciated when it is pointed out that 10 volts across the phasing circuit leading the network voltage by 90° will throw the network and transformer voltages less than 5° out of phase.

22. The opening characteristics of the type CN-33 relay are shown by Curve No. 2 of Fig. 5. Lines drawn from the origin to curve No. 2 represent in magnitude and phase position the line currents which will produce a torque in the relay just sufficient to cause its tripping contacts to make. The tripping contacts will also make and disconnect the transformer from the network if the line current terminates below the opening curve. If, however, the line current does not cross the opening curve but terminates above it, the relay will close its closing contacts and maintain them closed as long as the line current amounts to one or two per cent of the protector rating. The curves shown in Figs. 6 and 7 represent a small section of the opening curve just discussed plotted to much larger scales in order to show the operation of the relay on small current values, such as the magnetizing currents of network transformers. The magnetizing current of a 300 Kv-a. transformer bank will be about 12 amperes per phase minimum at 120 volts and will lag the network voltage reversed between 60 and 76 degrees. A network protector rated at 1200 amperes would be used with such a bank, and it will be seen by referring to the opening curve of Fig. 6 that the relay will operate satisfactorily to trip the network protector when exciting current only is flowing.

23. On systems where the voltage of the primary feeders is fairly high, such as 11,000 volts or above, the charging current of the feeder and high tension cables must be considered. When the station breaker is open this charging current will flow through the network transformer bank. In such cases, therefore, the current on which the relay must operate is not the magnetizing current of the transformer bank alone, but the vector sum of the magnetizing current and that part of the feeder charging current flowing through its associated protector. When the charging current predominates over the magnetizing current, the current on which the relay must operate is a leading reversal rather than a lagging reversal. By referring to the opening curves discussed, it will be seen that the relay will operate equally as well on leading reversals as on lagging reversals, providing the leading reverse current does not exceed approximately 250% of the rating of the protector, even if the current is almost 90° out of phase with the network voltage reversed.

24. Fig. 8 shows the tripping characteristics of the type CN-33 relay on current values up to 800% of the protector rating, such as are encountered under short circuit conditions. The bend in the curve is caused by the saturation of the current transformers used with the relay. This bend in the opening curve at the higher values of current improves the action of the relay under certain short-circuit conditions. It will be noted that this curve is taken with normal voltage, that is, 120 volts on the potential coils of the relay, however, curves taken with small values of voltage on the relay potential coils are essentially the same shape.

Adjustments and Tests

25. There are only two adjustments to make on the type CN-33 relay, namely, the overvoltage closing adjustment and the reverse-current tripping adjustment. The overvoltage closing adjustment is made by varying the shape of the air gap in which the drum operates. This is done by rotating each outer coil and iron assembly individually about one of its mounting bolts. The nickel plated locking screws which extend through to the front of the steel mounting plate must first be loosened, then the associated eccentric adjusting screw marked "A" is turned to obtain the desired adjustment on each element. The setting thus obtained should be checked after tightening the locking screws, as the adjustment may change slightly if it is made with the locking screws too loose. Varying the symmetry of the air gap of each electromagnet in this manner unbalances the magnetic field of its potential coil. This unbalance produces a torque or voltage bias when the potential coil only is energized which tends to rotate the drum in the direction of the smaller air gap. This torque is used to oppose the closing torque produced by the phasing coils in conjunction with the potential coil. Thus a simple means is provided for adjusting the relay to close on various values of phasing voltage. The range of overvoltage settings per element thus obtained may be varied from 0 to 7 volts 75° leading the network voltage or 0 to 3 volts in phase with the network voltage without affecting the satisfactory closing of the relay on a dead network. When making the overvoltage adjustment, the current coils of the relay should be connected across the secondaries of network current transformers. The rating of the transformers used will not affect the adjustment. The overvoltage adjustment should be made on one element at a time with the other two elements completely de-energized, and each element should be given substantially the same setting.

26. It should be noted when the overvoltage adjustment is made in this manner on one element at a time that when it is checked using all three elements energized simultaneously, a higher phasing voltage will be found necessary to close the relay closing contacts. This is because the torque exerted by the spiral spring is taken into account three times when adjusting each element separately and only once when checking all three elements simultaneously. To eliminate this cumulative effect of spring action, it is recommended that each element be adjusted to operate at the required voltage using approximately one-third of the normal spring tension. Then energize all three elements simultaneously with the required value of voltage and increase the spiral spring tension until the closing contacts of the relay just make. Closing adjustments can be most easily made in this manner. If, after the overvoltage adjustment is made as described, voltage is applied to all three potential coils, the phasing voltage required on one element alone to close the closing contacts of the relay will be approximately three times that required when all phasing and potential coils are energized simultaneously.

27. The reverse-current tripping adjustment is made by varying the position of the reverse-current stop or adjusting screw. To set for small values of reverse current the adjusting screw should be placed in the lower tapped hole of its supporting block, for medium values it should be located in the middle hole, and for the higher values up to 10% of the protector rating it should be placed in the upper hole. Moving the reverse-current adjusting screw to the left increases the amount of reverse current necessary to close the tripping contacts of the relay and moving it to the right decreases this amount. When this adjustment is made, the reverse-current adjusting screw should be locked securely in place by means of the thumb nut provided for this purpose. The reverse-current tripping adjustment should be made with current flowing through the primaries of all three current transformers in series supplying the current coils of the relay, with all three potential coils energized, and with all three phasing coil circuits short-circuited through the 3100 ohms of their respective phasing resistors.

28. It should be noted that when the network protector is closed and carrying no load, a certain amount of deflection of the reverse current adjusting spring may be caused by the potential bias used to obtain the overvoltage setting. Thus it is possible with an incorrect setting of the reverse-current adjusting screw for the relay to close its tripping contacts and open the protector when there is no load current flowing. When the relay has been properly adjusted as described and the potential coils of all elements are energized, a current of approximately three times the three-element reverse-current setting is required through any one current transformer to close the tripping contacts. If the current and potential coils of only one element are energized, a current of about eight and one-third times the reverse-current setting is required to close the tripping contacts of the relay. This value will vary depending upon the overvoltage setting used. If the overvoltage setting is greater than 2 volts 75° leading the network voltage this value will be less, and if the overvoltage setting is less than 2 volts 75° leading this value will be more than about eight and one-third. These data regarding the tripping action of the relay with one element only energized are given not as representing a practical condition, for in practice all three elements are subjected simultaneously to magnetizing currents and potential coil voltages, but to avoid confusion when it is desired to check the action of any one element alone. For a given reverse-current setting the current necessary to close the tripping contacts of the relay will vary practically in direct proportion to the rating of the network current transformers being used.

29. It should be remembered that the overvoltage adjustment is independent of the reverse-current adjustment, but the reverse-current adjustment is by no means independent of the overvoltage adjustment. Therefore, the overvoltage adjustment should always be made first. With the relay set to operate on a given value of current and voltage, increasing the overvoltage adjustment will materially decrease the amount of reverse current required to close the tripping contacts of the relay. Changing the initial tension on the spiral spring will affect both adjustments. The spring is adjusted at the factory as described later and this adjustment should not be changed except when changing the overvoltage adjustment.

30. Fig. 9 shows the test diagram which should be used for checking the ranges of adjustment and for adjusting the type CN-33 relay in the laboratory. The air core reactor, Style No. 491701, shown on the diagram is designed so that the voltage drop across it leads the current flowing through it, and in this case the potential coil voltage, by 75°. The amount of voltage drop across the reactor, which is the voltage impressed across the phasing circuit, is determined by the ammeter shown in the circuit and can be adjusted by means of the variable resistance load. The above reactor, which is used at the factory in making overvoltage adjustments, has an impedance of approximately 8 ohms. A similar reactor having a lower impedance and requiring a current of about 0.7 ampere per volt is available, and its use will somewhat reduce the range of currents to be controlled and metered. Care must be exercised in mounting the reactor to avoid changing its impedance. It should be mounted with non-magnetic materials away from iron or steel. If it is desired to check or change the setting of the relay when one of these reactors is not available, a non-inductive resistor of 1 to 3 ohms resistance may be substituted for the air core reactor and the setting made at the equivalent values of in-phase voltage. The equivalent in-phase voltage setting for any 75° leading setting is approximately equal to the 75° leading setting divided by 2.35, as can be determined by referring to closing curve No. 1-A of Fig. 5 since the entire curve is raised or lowered parallel to the position shown by changing the overvoltage setting of the relay. The use of the reactor is somewhat preferable since it approximates the usual operating conditions, and since ammeter errors and inaccuracies in reading the meter will introduce a smaller voltage error than in the equivalent in-phase adjustment. The resistance of the leads from the current transformers to the current terminals of the relay is important. Each lead should be about 55 inches of 0.081 inch copper wire. The current transformers used are 600/5 ampere ratio, such as are supplied on

600 ampere, type CM-44, light duty, network protectors. The resistors used for adjusting the current through the current transformers and reactor should be non-inductive. This resistance load bank and the necessary ammeters are shown in detail in Fig. 10.

31. The following is a brief description of the proper method of testing the type CN-33 relay. Connect the relay exactly as shown in Fig. 9. First, see that the relay is mounted straight in a vertical plane and that the moving element is free from friction. Then check the position of the moving contacts on the drum shaft. These contacts should move equi-distant from a vertical line through the center of the shaft when the drum is rotated till it strikes its stop in both directions. Adjust the two stationary contact screws until they deflect the moving contact springs just short of their supporting bracket when the drum is rotated to its two extreme positions and securely lock the contact screws in this position by means of their associated thumb nuts. Rotate the spiral spring adjuster until the contacts come to rest in a position midway between the two stationary contacts. Then turn the spring adjuster in a clockwise direction two divisions from this zero torque position. This is approximately one-third of the final spring tension which will positively close the relay closing contacts when the relay is completely deenergized. The inner end of the spiral spring support should not touch the spring adjuster when the shaft is pressed against its rear thrust bearing. The end play of the shaft should be adjusted to approximately 0.005 inch. This completes the necessary mechanical inspection.

32. Next check the overvoltage closing range and make the overvoltage setting of each element one at a time. This is done for element "A" by closing switches "M", "A-A$_1$", "P" to the side marked 2, and "Y" to the side marked "OV". Slightly loosen the two nickel plated locking screws of element "A" and turn its associated adjusting screw marked "A" to the position to give the maximum air gap under the right hand pole of the outer coil and iron assembly. Then adjust the current through the reactor until the relay just closes its closing contacts as indicated by the lamp "C". By the ammeter reading the value of voltage across the phasing circuit can be determined. Open switch "Y" and turn the adjusting screw marked "A" to the position to give the minimum air gap under the right hand pole of the outer coil and iron assembly. The relay closing contacts should now close with zero voltage across the phasing circuit. The range of over voltage adjustment obtained on the above test should be at least 0 to 7 volts, or if a non-inductive resistor is used in place of the air core reactor at least 0 to 3 volts. Next close

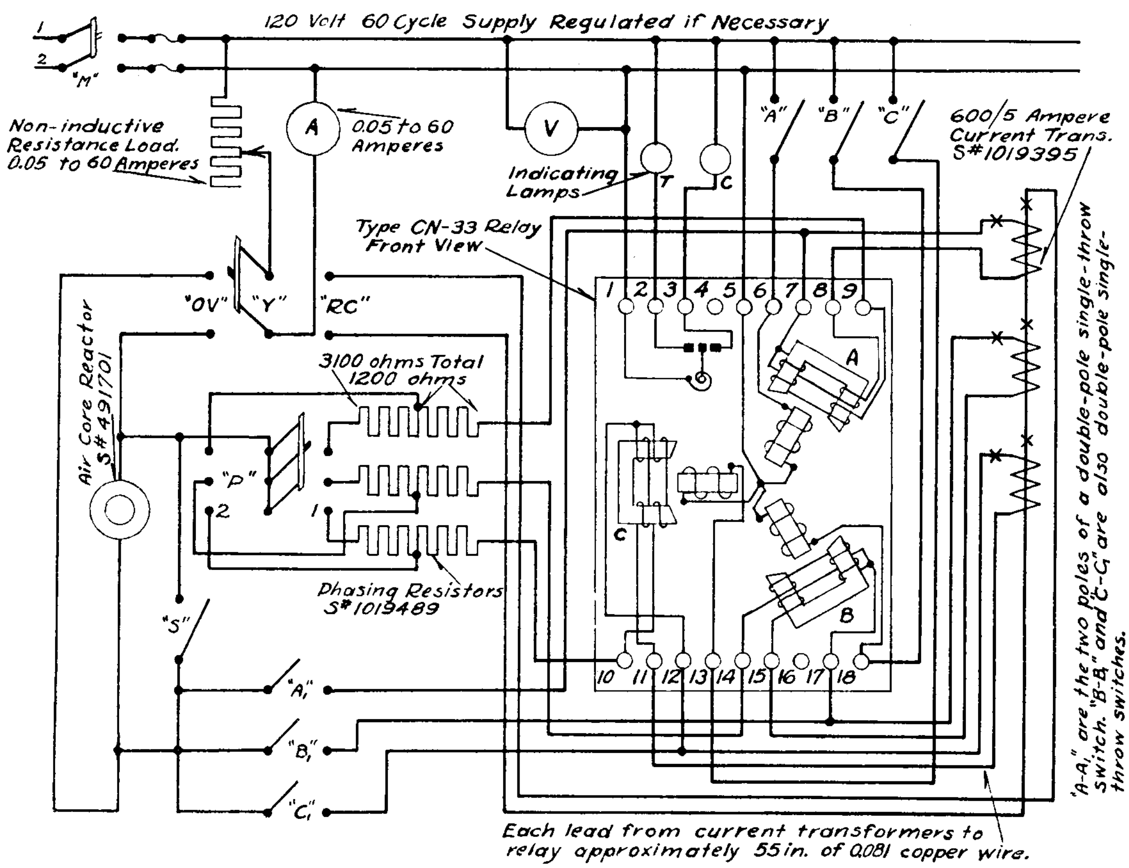


Fig. 9—Test Connections for Single-Phase Test and Adjustment of the Type CN-33 Network Master Relay.

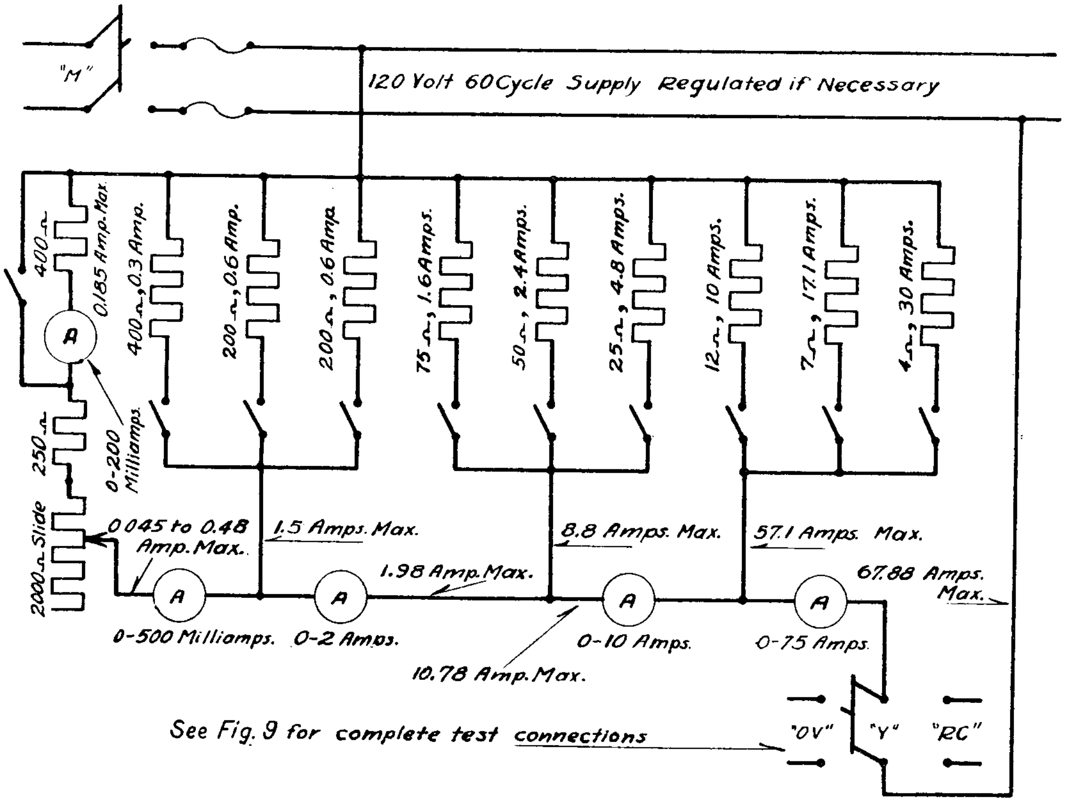


FIG. 10—DETAILS OF LOAD BANK AND AMMETERS FOR USE IN SINGLE-PHASE TEST OF THE TYPE CN-33 NETWORK MASTER RELAY.

switch "Y" to the side marked "OV" and turn the adjusting screw marked "A" to the position where the relay will just close its closing contacts with from 1.9 to 2.1 volt 75° leading the potential coil voltage applied across the phasing circuit. Lock the outer coil and iron assembly securely in place by tightening the two nickel plated locking screws. Then check the overvoltage setting to see that the closing contacts of the relay make within the above setting limits. If a resistor is used to make the overvoltage setting the closing contacts should close on 0.8 to 0.9 volt in phase with the potential coil voltage. Elements "B" and "C" should have their overvoltage closing range checked and their overvoltage setting made in a similar manner. Switch "B-B_1" is used in place of switch "A-A_1" when making the adjustment of element "B", and similarly switch "C-C_1" is used with switches "P", "Y", and "M" when adjusting element "C". After adjusting all three elements independently to those on 1.9 to 2.1 volts 75° leading, with switches "M", "P" and "Y" closed as described above, close switches "A-A_1", "B-B_1" and "C-C_1" and make the final overvoltage closing setting with all three elements energized simultaneously. With from 1.9 to 2.1 volts 75° leading the potential coil voltage applied across each phasing circuit, or if a resistor is used in place of the air core reactor with from 0.8 to 0.9 volt in phase with the potential coil voltage applied across each phasing circuit, increase the tension on the spiral spring by rotating the spring adjuster in the clockwise direction until the relay closing contacts just make. This will mean increasing the spring tension about four divisions, giving a final tension of about six divisions.

33. With the relay set for approximately 2 volts 75° leading when all three elements are energized simultaneously, next check the polarity of each current circuit independently. To check the polarity of the element "A" current circuit close switches "M", "S", "A-A_1", "P" to the side marked 1 and "Y" to the side marked "R.C." Pass approximately 25 amperes through the primaries of the current transformers and see that the moving contact of the relay moves positively toward the stationary tripping contact. Repeat this polarity check in a similar manner for elements "B" and "C" using switch "B-B_1" in place of switch "A-A_1" when checking element "B" and switch "C-C_1" when checking element "C". With switches "M", "S", and "P" closed as described above open switch "Y" and close switches "A-A_1", "B-B_1" and "C-C_1" and check the reverse current tripping range of the relay. Set the reverse current stop or adjusting screw in each of its three tapped holes to deflect the reverse-current spring or springs so that they will just fail to throw the moving contact to the closing position when it is suddenly released from its maximum tripping position. With the reverse-current adjusting screw in each of these three positions close switch "Y" to the side marked "RC" and pass enough current through the primaries of the current transformers to just make the tripping contacts of the relay as indicated by lamp "T". Currents of more than 4, 24 and 60 amperes should be required to just close the tripping contacts of the relay with the reverse current adjusting screw in its lower, middle, and upper tapped holes, respectively. The sensitive reverse current trip setting should be made with the adjusting screw in its lower hole. Pass 1.2 amperes through the primaries of the current transformers and adjust the stop screw so that the tripping contacts just close. With the relay set to close its tripping contacts when 1.2 amperes at 180° to the potential coil voltage is flowing through the primaries of the 600 ampere current transformers, securely lock the reverse current adjusting screw in position by means of the thumb nut provided for this purpose. Then check the setting by interrupting the circuit through the primaries of the current transformers, closing the circuit again with all resistance in and gradually increasing the current through the circuit until the tripping contacts make. When the relay closing adjustment is set for very small values of voltage, it should be noted that the drum will not move far enough for the reverse-current spring to engage its stop screw until the current circuit is energized to produce a tripping torque.

RECOMMENDED SETTINGS

34. The values for the overvoltage and reverse-current adjustments given in the preceding paragraphs are recommended as being the most suitable for general application. The relays are adjusted for these values, as described under Tests and Adjustments, at the factory. In some cases, however, it will be necessary or advisable to modify these adjustments to meet particular conditions, and the relay is provided with adjustments so that this may be readily done by the customer. For example, the magnetizing energy taken by a particular design of transformer may permit the use of a higher reverse current setting than recommended above. In this connection it should be remembered that the relay should always be given the highest reverse current setting which will allow positive relay operation on reverse energy flow when its associated primary feeder breaker is opened. This will eliminate a number of unnecessary network protector operations and reduce wear and protector maintenance. There may be certain locations on network systems where, particularly at times of light load, too frequent operation of the network protectors will occur due to large fluctuating shunt loads on the network, elevator regeneration, etc., if the relays are given the usual sensitive reverse current setting. Increasing the reverse current setting of the relays at these locations to a value equal to 10% of their associated protector rating or even less will often eliminate the unnecessary protector operations.

35. Care must be exercised in using high reverse current settings. The relay settings used should be only just high enough to prevent too frequent operation of the network protectors. If only a few protectors associated with each primary feeder are given a high reverse current setting, when the station breaker on a primary feeder is opened those protectors whose relays have sensitive settings will trip; then all of the charging current of the feeder and the magnetizing current of the transformers connected to the feeder will flow from the network through the few protectors whose relays have high settings, thus causing them to open and completely disconnect the feeder from the system. Obviously, if the relays on too many protectors are given high reverse current settings, there will not be enough current through each of the protectors to cause them to trip and the feeder will not be disconnected from the network.

INSTALLATION

36. The network relays are shipped separate from the network protector. This decreases the possibility of damage to the relays during shipment. Carefully unpack and closely examine the relays to see that none of the parts have been bent or broken in transit. Inspect the relays to see that they are free from friction.

37. The network protector and relays have each been thoroughly tested and inspected at the factory. It is advisable, however, to check the operation of the two separately or as a unit before they are placed in service in order to be sure that none of the parts have been damaged in shipment. The closing and tripping adjustments of the relays should be checked as described under "Tests and Adjustments" and care should be exercised to see that all locking, reverse-current, and contact screws are securely tightened or locked in place by their associated thumb nuts. If the protector and relays are to be tested as a unit see the Network Protector Instruction Book. The relays should be transported from the test department and mounted on their associated network protector after the protector has been completely installed and is ready to be placed in service. When transporting the relays, if they are likely to be subjected to considerable jolts and vibrations, it is advisable that they be placed upside-down to protect the knife-edge bearings. After the relays have been mounted on the protector and their wing nuts securely tightened see that all terminal screws are tight. Before leaving the network protector in automatic operation check its functioning by manually closing the relay closing and tripping contacts. Use an insulated screw driver for this final test as the relay contacts are hot. Be sure to replace the covers on the relays before leaving the installation.

MAINTENANCE

38. The construction of the type CN-33 network master relay has been made as simple and sturdy as possible. All parts have been made readily accessible to facilitate inspection and repairs. After the relay is properly installed and adjusted, it will require little attention. Whenever it is found necessary to inspect the protector, the relay should also be checked to see that it is free from friction and that its contacts are properly adjusted and not badly burned.

39. A periodic inspection of all network protectors should be maintained to see whether any units have failed to close when the feeder to which they are connected was energized. Such a failure can be detected either by finding the protector open or by comparing records of its operation counter readings. Failure of the protector to close may be due to any of the following causes:

1—Improper voltage conditions, that is, the network voltage is higher than the transformer voltage, or the transformer voltage is lagging the network voltage so that the phasing relay prevents the protector from closing. Failure to close because of such voltage conditions does not constitute a faulty operation.

2—Failure of the network breaker or its operating mechanism.

3—Failure of the network phasing relay.

4—Failure of the network master relay.

40. Failure of the type CN-33 relay to close under proper voltage conditions may be due to friction, to dirty or improperly adjusted contacts, to an open phasing circuit, or to too high an overvoltage closing adjustment. Friction in the relay may be caused by leads rubbing on the drum, by foreign material collecting on the damping magnet, by the inner support of the spiral spring rubbing on the spring adjuster, or by an accumulation of dirt on the knife-edge bearings. Should it become necessary to clean the bearings, it is advisable to oil them with less than a drop of light mineral oil. Westinghouse oil number 6000 is recommended. The silver contacts should be cleaned with a very fine file or burnishing tool. The use of sand or emery paper should be avoided as particles may become imbedded in the silver and prevent the closing of the relay control circuits under minimum torque conditions. The possibility of the phasing circuits being opened is mentioned, not because they are fragile or likely to cause trouble, but because the phasing coils are wound with smaller wire than the other coils in the relay, and because the phasing resistors may burn out or be accidentally broken. The overvoltage closing adjustment should always be checked after the locking screws have been securely tightened as the outer coil and iron assemblies may shift slightly and change this adjustment when their locking screws are being tightened. When a protector has failed to close, the relays should be inspected to see that they are free from friction and that their contacts are in good condition. The overvoltage closing adjustments should then be checked as described under "Adjustments and Tests". If these are found to be correct it will be necessary to look elsewhere for the cause of the failure. Should the breaker and operating mechanism also be found to be all right, the failure to close was undoubtedly due to the voltage conditions which existed on the system at the point where the protector is installed.

41. Failure of a network protector to open, assuming it has been properly applied, can be due only to the failure of the breaker, operating mechanism, or master relay to function. Should a protector fail to open when its associated feeder breaker is opened, the fact can be detected at once by a voltage indication on the feeder at the station. The type CN-33 relay may fail to close its tripping circuit due to friction, to dirty or improperly adjusted contacts, to too high a reverse current setting, or to a change in its tripping characteristics. The reverse-current trip setting may change if the reverse current stop screw is not securely locked in place by its thumb nut. If the outer coil and iron assemblies are not securely fastened by their locking screws they may be shifted inward by magnetic forces and slightly increase the reverse-current setting. The tripping curve of the relay would be rotated several degrees counterclockwise if the protector auxiliary switches failed to open the shunt circuits across a portion of the phasing resistors. Such a failure is, of course, almost impossible on a correctly wired protector.

42. The preceding is not given as a list of troubles which anyone may expect to encounter with the type CN-33 relay, but is given merely as a guide to help in locating the causes of any improper operations of the network protectors which may occur.

The Type CN-J Network Phasing Relay

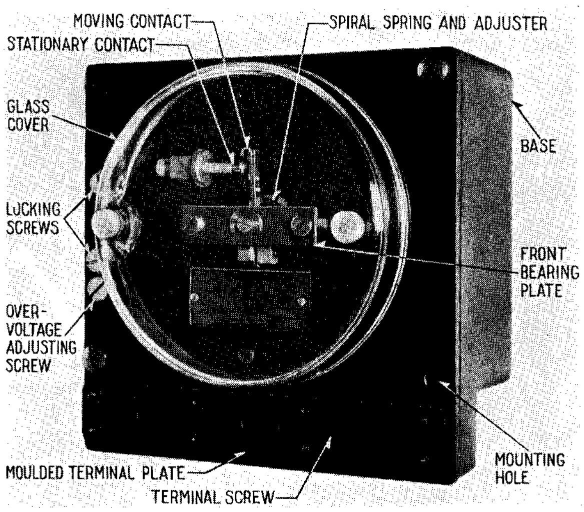


FIG. 11—TYPE CN-J NETWORK PHASING RELAY. FRONT VIEW WITH COVER ON.

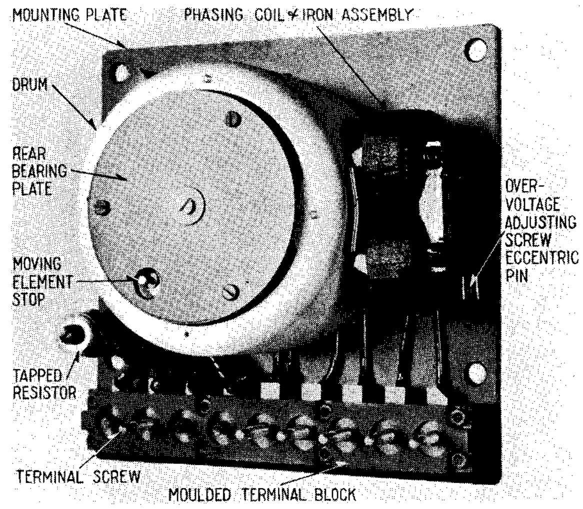


FIG. 12—TYPE CN-J NETWORK PHASING RELAY. REAR VIEW OF RELAY REMOVED FROM BASE

CONSTRUCTION

43. The type CN-J network phasing relay shown in Figs. 11 and 12 is a single-phase relay which operates on the induction principle. It is very similar to the type CN-33 relay. The same principles of construction are used throughout, and many of its parts, such as the moving element, bearings, spring adjuster, damping magnet, terminals, and glass cover are the same as those used in the type CN-33 relay. The single electromagnet of the type CN-J relay uses the same iron circuits and potential coil as does the master relay. The method of mounting and shifting the outer coil and iron assembly to obtain the overvoltage adjustment is also the same as that used in the type CN-33 relay. The phasing relay is mounted on the network protector in the same manner as is the master relay.

44. The following points of construction embodied in the type CN-J relay are not covered in the instructions for the type CN-33 relay. The type CN-J relay is equipped with single-pole, single-throw contacts of pure silver instead of double-throw contacts. The relay has no current coils and the entire winding space on the outer iron assembly is thus available for the phasing coils so that no external phasing resistor is necessary. A tapped resistor is located in the relay and connected in series with the potential coil. The purpose of this resistor is to change the slope of the closing curve of the relay. Each tap on the resistor is brought to a separate terminal of the relay as can be seen by referring to Fig. 13. There is only one terminal screw for the four terminals to which the resistor taps are connected. The desired closing curve is selected and the terminal screw is located in the terminal associated with the tap which gives that curve. Short dummy screws are screwed into the other three terminals to keep dust and dirt from entering the relay base. There is only one set of terminals, located at the lower end of the relay, instead of two sets as in the type CN-33 relay.

OPERATION

45. By referring to Fig. 4 it can be seen that the potential coil and phasing coils of the type CN-J network phasing relay are connected to phase "A" of the network protector in the same manner as the potential and phasing coils of element "A" of the type CN-33 relay. The operation of the two relays is exactly the same in principle. The type CN-J relay has different closing characteristics from the type CN-33 relay. These characteristics are obtained by means of specially designed phasing coils and the tapped resistor connected in series with the potential coil.

46. Fig. 14 shows the normal operating characteristics of the type CN-J relay. The relay may be adjusted to have closing characteristics similar to any one of the four curves shown, namely, No. 6, No. 7, No. 8, or No. 9. The network voltage, which is the voltage from ground to line "A" on the network side of the protector, is shown with the line potential end of the vector at the origin. This voltage vector could not be shown in its entirety because of the large scale used. Lines drawn from the origin to one of the curves represent in both magnitude and phase position the phasing voltages which will produce a torque in the relay just sufficient to cause its contacts to close. Any phasing voltage which does not terminate on or to the left of the curve in the zone marked "close" will produce a relay torque to maintain the relay contacts open. It will be noted that the relay will keep its contacts closed when the phasing voltage is reduced to zero if a closing adjustment is used similar to that used when these curves were taken. The curves may be shifted parallel to themselves either to the right or left by means of the overvoltage adjuster and spring, however, if this is found to be desirable. The relay is connected in the factory to have a characteristic similar to that shown as Curve No. 8 and given a similar adjustment. Any of the closing characteristics shown by Curves No. 6, No. 7, No. 8, and No. 9 can be obtained by placing the terminal screw in any one of the terminals 6, 7, 8 or 9 shown in Fig. 13. For example, if the terminal screw is placed in terminal 8 the relay will have closing characteristics as shown by Curve No. 8 of Fig. 14.

47. The operation of the type CN-J relay in conjunction with the type CN-33 relay can best be explained by referring to Fig. 15 which illustrates the closing characteristics of both the CN-J and CN-33 relays. Curve 1-A illustrates the closing curve of the type CN-33 relay, which is discussed in the instructions relating to the type CN-33 relay, and Cuve No. 8 illustrates the closing curve of the type CN-J relay. The area which lies in the "closing" zone common to both of these two curves is shaded. Thus a phasing voltage, such as E_1 which terminates in this shaded area will cause the type CN-J relay to make its contacts and the type CN-33 relay to make its closing contacts and thus cause the network protector to close. The current which will flow through the protector when it closes will lag the phasing voltage across the open protector by an angle approximately equal to the impedance angle of the system, and for a particular system this current may be as shown by the vector I_1. By noting the position of I_1 with respect to the network voltage and referring to curve No. 2 of Fig. 5, it will be seen that such a current will keep the type CN-33 relay closing contacts closed and thus the operation of the network protector will be stable. A phasing voltage, such as E_2, however, if the protector were manually closed, would cause a current I_2 to flow through the protector; and by referring again to Curve No. 2 of Fig. 5 it will be seen that this current would cause the type CN-33 relay to make its tripping contacts. The phasing voltage E_2, lying on the closing side of the Curve No. 1-A, causes the type CN-33 relay to make its closing contacts. Thus if the type CN-33 relay alone controlled the network protector, the protector would pump under this condition. The type CN-J relay will not close its contacts, however, when acted upon by a phasing voltage, such as E_2; and since the contacts of the two relays are connected in series and must be closed at the same time in order to allow the network protector to close, it will be seen that the type CN-J relay prevents pumping due to phasing voltages which appreciably lag the network voltage. It may be similarly shown that the closing characteristics of the type CN-33 relay prevent pumping from occurring when the phasing voltage leads the network voltage by more than 90°. It should be noted that the closing curve of the type CN-33 relay is such as to prevent the protector from closing under crossed-phase conditions, while the type CN-J relay used alone would allow the protector to close under certain crossed-phase conditions.

48. Under certain conditions a fairly large and very low power factor load may be carried by adjacent network protectors and cause the phasing voltage E_3 to exist across the protector under consideration. It will be seen, since this phasing voltage E_3 falls on the opening side of Curve No. 8, that under this condition the phasing relay would prevent the protector from closing. In the event it is desirable to have the protector close so that its associated transformer can assist in carrying the load, Curve No. 7 may be used for the type CN-J relay so as to allow the protector to close if such a change in characteristics will not cause pumping. It is to take care of such more or less special cases that the tapped resistor is provided in the phasing relay to change its closing characteristics.

ADJUSTMENTS AND TESTS

49. There is only one adjustment to make on the type CN-J relay, namely, the overvoltage closing adjustment. It is made by varying the shape of the air gap in which the drum operates. This is done just as in the type CN-33 relay by rotating the outer coil and iron assembly about one of its mounting bolts. The nickel plated locking screws which extend through to the front of the steel mounting plate must first be

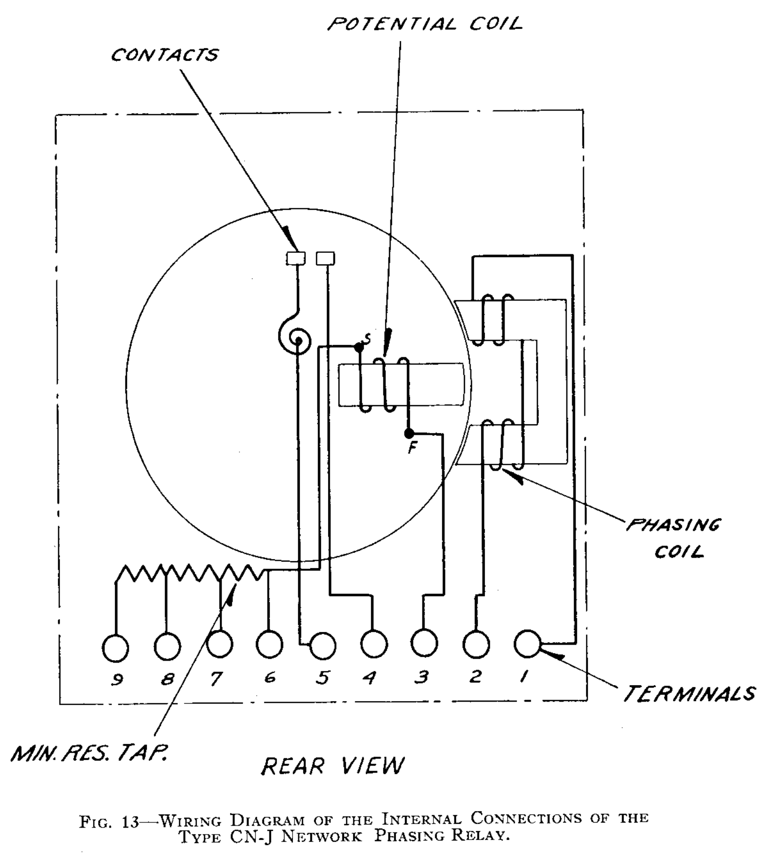


Fig. 13—Wiring Diagram of the Internal Connections of the Type CN-J Network Phasing Relay.

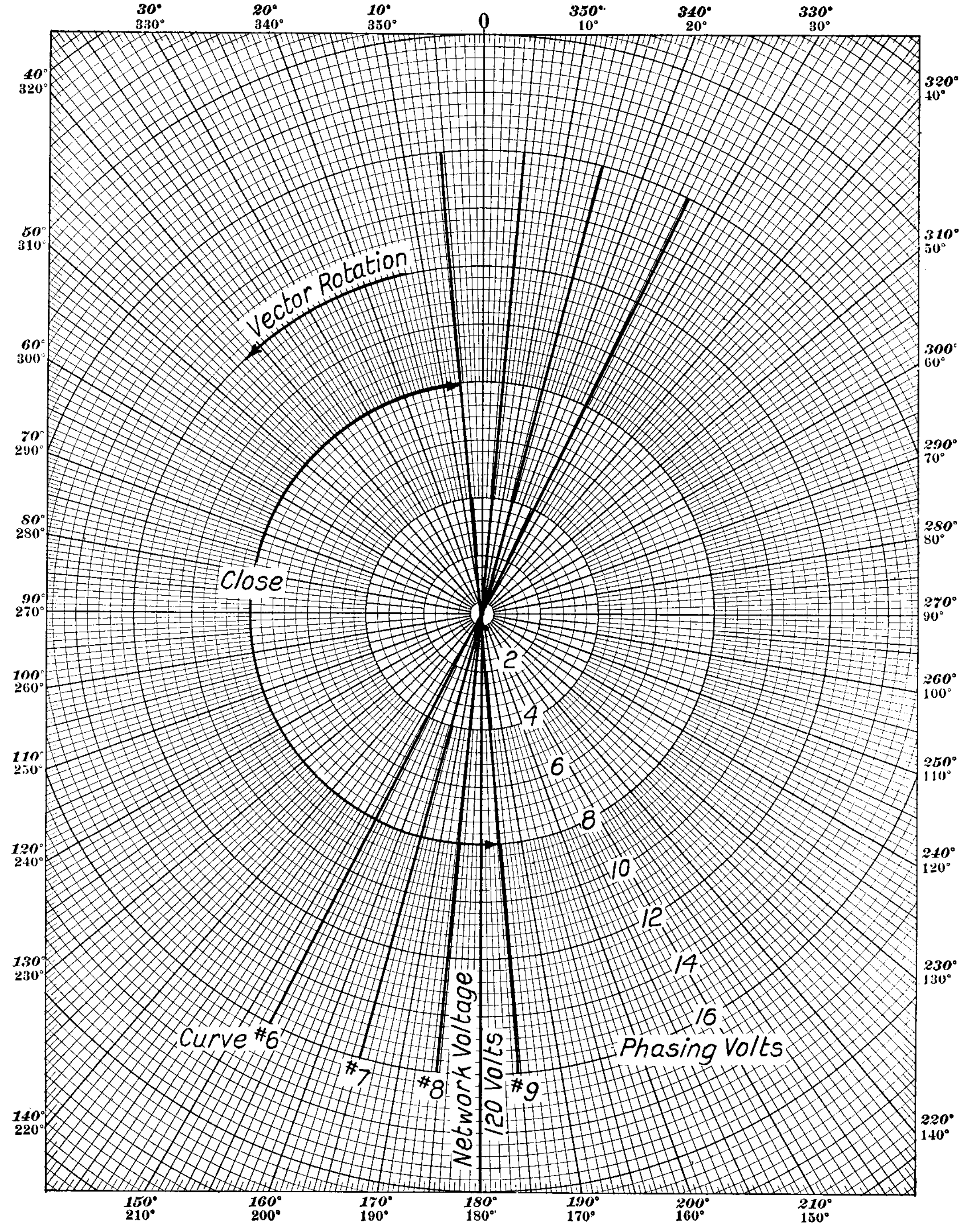


Fig. 14—Closing Characteristics of the Type CN-J Network Phasing Relay.

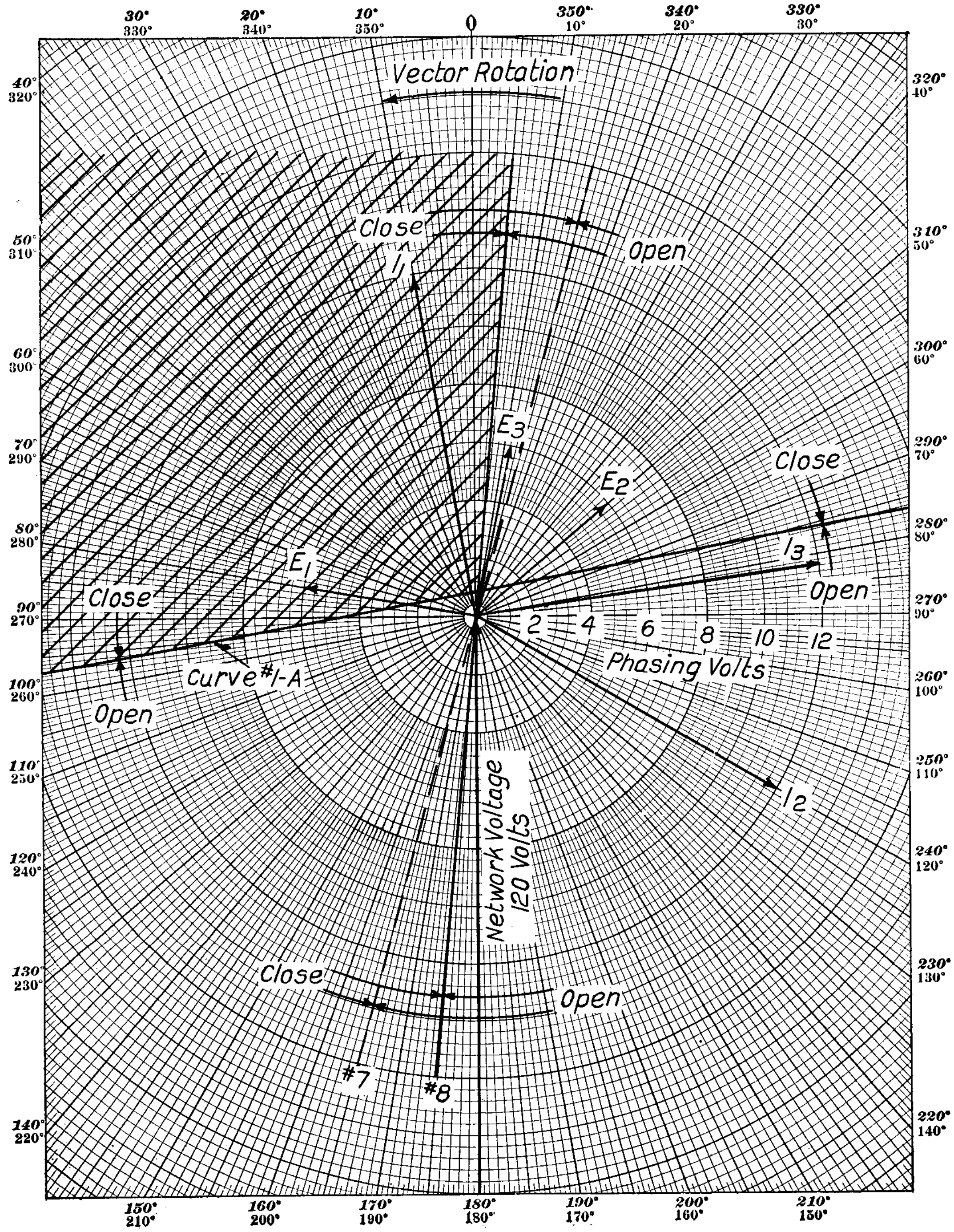


FIG. 15—COMBINED CLOSING CHARACTERISTICS OF THE TYPE CN-33 AND CN-J NETWORK RELAYS.

loosened, then the eccentric adjusting screw marked "A" is turned to obtain the desired adjustment. The setting thus obtained should be checked after tightening the locking screws, as the adjustment may change slightly if it is made with the locking screws too loose. Varying the symmetry of the air gap of the electro-magnet in this manner unbalances the magnetic field of its potential coil. This unbalance produces a torque or voltage bias when the potential coil only is energized which tends to rotate the drum in the direction of the smaller air gap. This torque is used to oppose the closing torque produced by the phasing coils in conjunction with the potential coil.

50. Fig. 16 shows the test diagram to be used for checking the range of adjustment and for adjusting the type CN-J relay in the laboratory. The air core reactor shown in the diagram is similar to the 75° air core reactor used in testing the type CN-33 relay, and has an impedance of approximately 8 ohms. The amount of voltage drop across the reactor, which is the voltage impressed across the phasing coils, is determined by the ammeter shown in the circuit and can be adjusted by means of the variable resistance load. Care must be exercised in mounting the reactor to avoid changing its impedance. It should be mounted with non-magnetic materials away from iron or steel.

51. The following is a brief description of the proper method of testing the type CN-J relay. Connect the relay exactly as shown in Fig. 16. First, see that the relay is mounted straight in a vertical plane and that the moving element is free from friction. Then check the position of the moving contact on the drum shaft. The contact should move through equal angles on each side of a vertical line through the center of the shaft when the drum is rotated till it strikes its stop in both directions. Adjust the stationary contact screw until it deflects the moving contact spring just short of its supporting bracket when the drum is rotated counterclockwise to its extreme position, and securely lock the contact screw in this position by means of its associated thumb nut. See that the inner spiral spring support cannot touch the spring adjuster. The end play of the drum shaft should be adjusted to approximately 0.005 inch. Rotate the spiral spring adjuster until the moving contact arm comes to rest with contacts just open.

52. Now place the terminal screw associated with the tapped resistor in terminal No. 6 and check the overvoltage closing range of adjustment. Turn the spiral spring adjuster in the counter-clockwise direction one division from its neutral or zero torque position. Slightly loosen the two nickel plated locking screws and turn the adjusting screw marked "A" to the position to give the minimum air gap under the lower or left hand pole of the outer coil and iron assembly. Close switches "R" and "M". The relay should have a positive electrical closing torque under this condition. Now with all switches open slightly loosen the two locking screws and turn the adjusting screw "A" to the position to give maximum air gap under the lower or left hand pole of the outer coil and iron assembly. Close switches "L" and "M" and the relay contacts should positively open. Then close switch "B" and increase the current through the air core reactor until the relay contacts just close. A phasing voltage of 1.0 volts or more should be

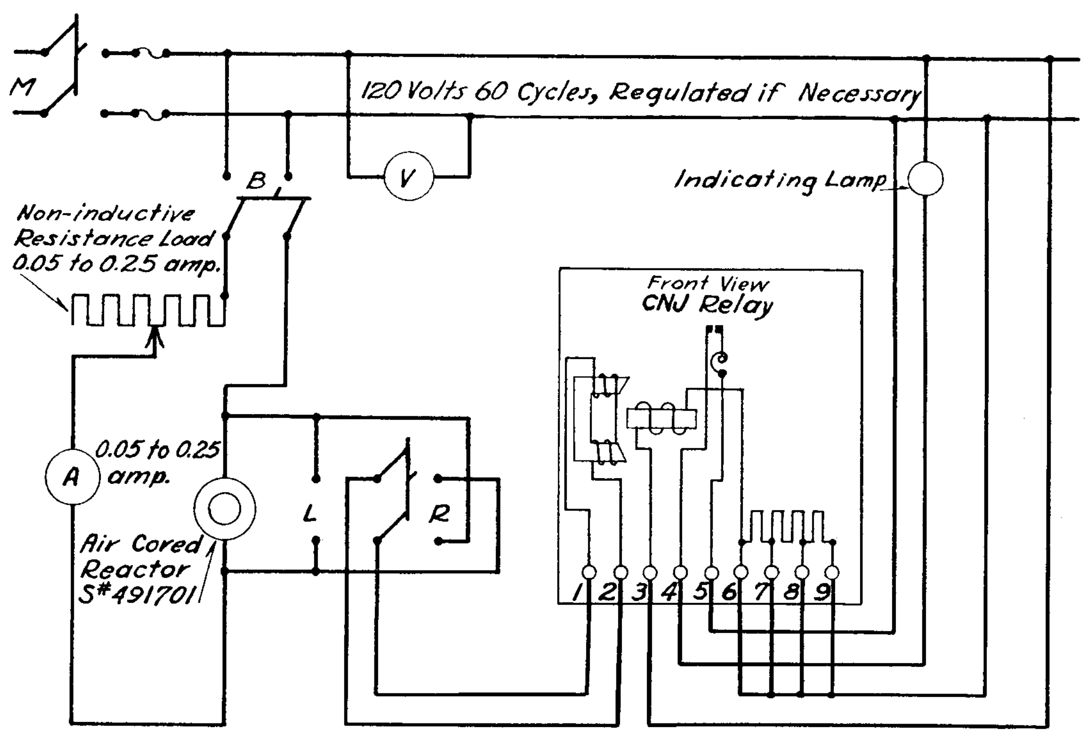


FIG. 16—TEST CONNECTIONS FOR SINGLE-PHASE TEST AND ADJUSTMENT OF THE TYPE CN-J NETWORK PHASING RELAY.

required to close the contacts. The above check should give a range of over-voltage closing adjustment of from zero to 1.0 volts 75° leading the potential coil voltage.

53. Move the terminal screw located in terminal No. 6 to the proper terminal to give the desired phase angle characteristics—terminal No. 8 is recommended for the usual application—and make the overvoltage setting of the type CN-J relay in the following manner. Starting with all switches open move the spring adjuster four more divisions in the counter-clockwise direction which gives a total tension of five divisions. Then close switches "R" and "M" and adjust the air gap by means of the adjusting screw "A" so that the relay contacts close slowly. Close switch "B" and gradually increase the current through the air core reactor until the relay contacts just open. The phasing voltage 75° leading the potential coil voltage reversed necessary to open the contacts should be 0.25 volt or less. Lock the outer coil and iron assembly securely in place by tightening the two nickel plated locking screws and check the overvoltage setting. This method of adjustment gives a value of phasing voltage necessary to close the type CN-J relay contacts practically equal to zero, and still insures that the contacts will remain closed when the network protector is closed and carrying load. This will prove to be the best adjustment for most network systems. However, if it is found necessary to give the relay an adjustment which will require a positive value of phasing voltage leading the network voltage to close its contacts, this can readily be done by changing the air gap or by changing both the air gap and the spiral spring tension. If the spiral spring is used to secure the desired setting its tension should not be reduced below one division as this much tension is necessary to insure closing of the relay contacts on a dead network.

INSTALLATION

54. The type CN-J relay is shipped separate from the network protector. This decreases the possibility of damage during shipment. Carefully unpack and closely examine the relay to see that none of its parts have been bent or broken in transit. Inspect the relay to see that it is free from friction. It is advisable to check the closing adjustment of the relay as described under "Tests and Adjustments", and be sure that the locking, contact, and terminal screws are securely tightened or locked in place.

55. The relay should be mounted on the protector after the protector has been completely installed and is ready to be placed in service. When transporting both the type CN-J and the type CN-33 relays from the test department to the point of installation the moving element of each relay should be locked with a rubber band placed around the counterweight and across the front bearing plate to the stationary contact screw at the left of the moving contact. If the relays are likely to be subjected to considerable jolts and vibrations when being transported, it is advisable to place them upside-down to protect the knife-edge bearings. After the relay has been mounted on the protector and its wing nuts securely tightened remove the rubber band used to lock the moving element, see that the moving element rotates freely and replace the glass cover on the relay.

MAINTENANCE

56. The construction of the type CN-J network phasing relay has been made as simple and sturdy as possible. All parts have been made readily accessible to facilitate inspection and repairs. After the relay is properly installed and adjusted, it will require little attention. Whenever it is found necessary to inspect the protector, the relay should also be checked to see that it is free from friction and that its contacts are properly adjusted and not badly burned.

57. As explained in the instructions covering the type CM-33 relay a periodic inspection of all network protectors should be maintained to see whether any units have failed to close when the feeder to which they are connected is energized. The failure of a type CN-J network phasing relay to close under proper voltage conditions may be due to friction, to very dirty or improperly adjusted contacts, or to an improper overvoltage closing adjustment. Friction in the relay may be caused by leads rubbing on the drum. by foreign material collecting on the damping magnet, by the inner support of the spiral spring rubbing on the spring adjuster, by an accumulation of dirt on the knife-edge bearings, or by a light sticky deposit on the drum stop and the points which it makes contact with the rear bearing plate. It is very unlikely that dirty or improperly adjusted contacts will ever cause the relay to fail to complete its contact circuit unless the adjustment is such that the contacts actually fail to touch. The overvoltage closing adjustment should always be checked after the locking screws have been securely tightened as the outer coil and iron assembly may shift slightly and change this adjustment when its locking screws are being tightened.

58. The preceding is not given as a list of troubles which anyone may expect to encounter with the type CN-J relay, but is given merely as a guide to help in locating the causes of any improper operations of the network protectors which may occur.

Type SR-2 Voltage Restraining Relay

Westinghouse Types CN-33, CN-J and SR-2 Network Relays

pick-up voltage can be varied in this manner over a range of about 75% to 96% of normal voltage when used on 120/208 volt network system. When the pick-up voltage is changed the drop-out voltage will also change. The latter in all cases will be approximately 94% of the former.

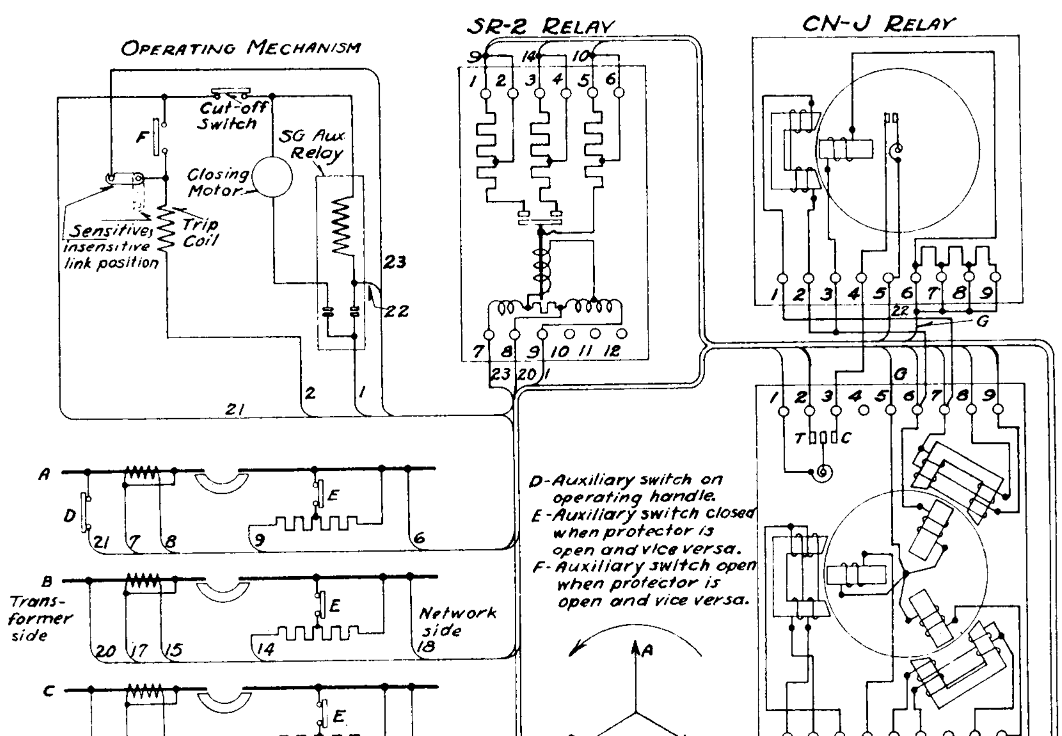
64. When a fault occurs on any phase or phases which appreciably affects the system voltage at the protector the positive sequence voltage at that point will be reduced. A reduction of about 10% in the positive sequence voltage will cause the type SR-2 relay to open its contacts and deenergize the phasing coils of the type CN-33 relay, thus reducing the restraining torque to zero and restoring the master relay to its sensitive condition as shown by the opening curves of Figs. 5, 6, 7 and 8. This puts the network protector under the control of a sensitive directional relay which will operate quickly and positively to trip if the fault is so located as to cause a reversal of power through the protector.

65. In order that the type SR-2 relay may be able to function to render its associated network protector insensitive under normal system conditions the link shown in Fig. 20 must be in the insensitive position so that the protector auxiliary switch can complete the connection between terminal No. 7 of the type SR-2 relay and phase "A" of the protector. With the link in the sensitive position the positive sequence filter of the type SR-2 relay cannot be operatively energized and the protector remains permanently sensitive. When using the type SR-2 relay it is essential that the protector be connected to the system with the phase rotation as shown in Fig. 20. Phase "A" in this figure is the left hand pole when facing the protector.

ADJUSTMENTS AND TESTS

66. The only adjustment necessary on the type SR-2 relay is that of the minimum voltage at which its contacts close. This is made by adding weights to the movable plunger. The recommended setting is 95% of normal network voltage, and can best be made by energizing the relay with balanced three-phase voltages as indicated in Fig. 22. Switches "M" and "Y" should be closed for this test. With the relay adjusted to close its contacts on 95% of normal 120/208 volts it should just open its contacts when the balanced voltages are reduced to about 90% of normal. The stationary contacts of the relay should be adjusted so that they make simultaneously with the moving contact as indicated by the two lamps. The stationary contacts must also be placed to limit the total travel of the plunger to approximately ⅛ inch and to give an initial contact gap of 1/16 inch. The leads to the moving contact must be sufficiently long and flexible to avoid interference with the movement of the plunger.

67. A proper balance of the positive sequence voltage filter parts can be checked by energizing the relay with a balanced negative sequence voltage.



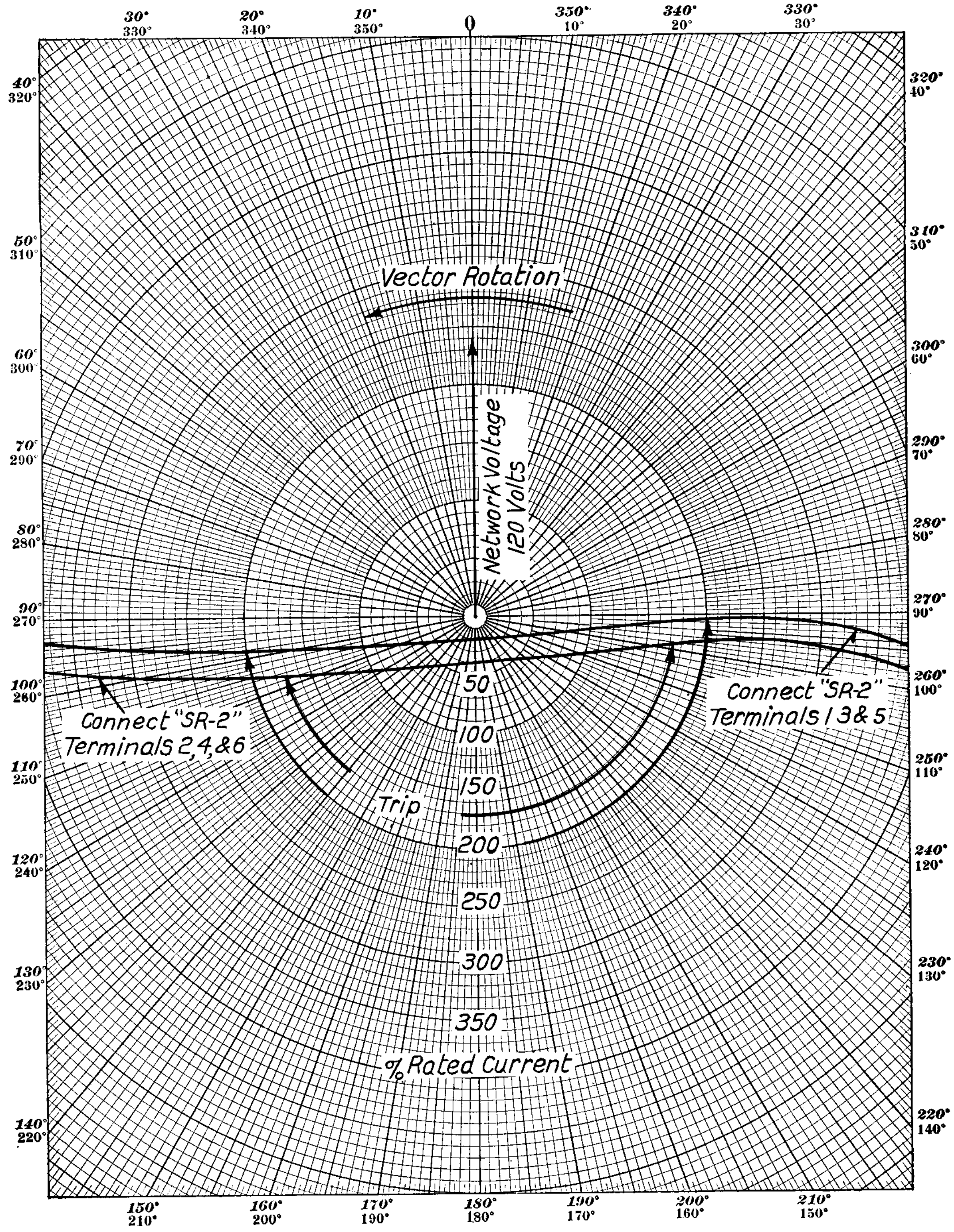


Fig. 21—Opening Characteristics of the Type CN-33 Network Master Relay when the Type SR-2 Voltage Restraining Relay is in the Normally Energized Position.

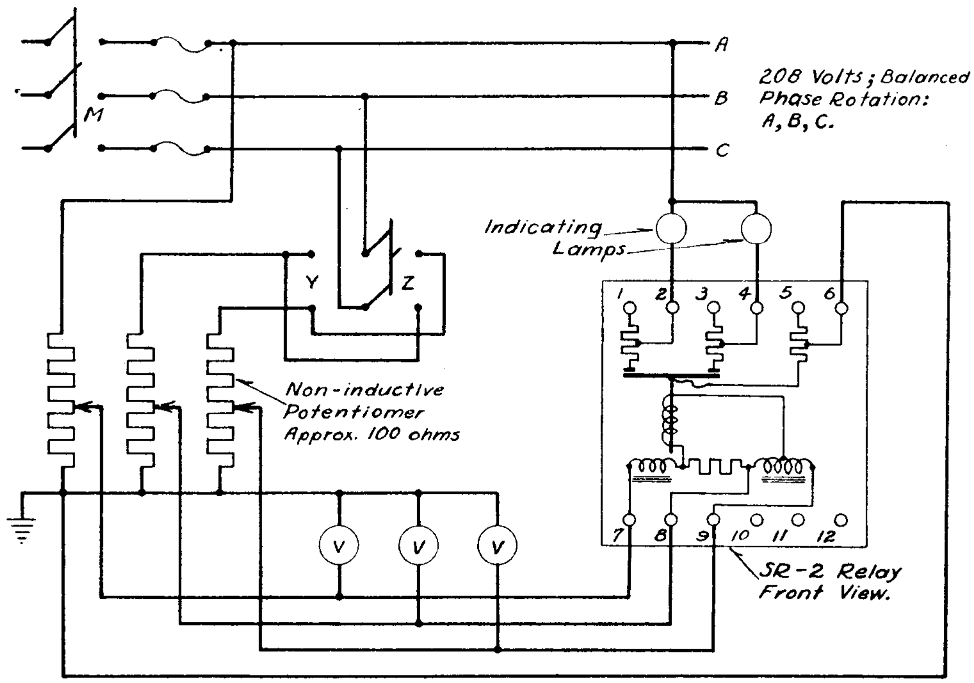


FIG. 22—TEST CONNECTIONS FOR THREE-PHASE TEST AND ADJUSTMENT OF THE TYPE SR-2 VOLTAGE RESTRAINING RELAY.

This can be done by closing switches "M" and "Z" and adjusting all voltages as read on the voltmeters "V" to 120 volts. Then measure the voltage from the autotransformer tap to the connection between the filter resistor and reactor, that is, the voltage across the coil of the plunger relay, with a high resistance voltmeter. This voltage should not exceed 5 volts. If this value of voltage is appreciably exceeded, the balance of the three-phase voltages should be checked. Should the filter output still be too high with balanced three-phase voltages this is an indication that the autotransformer, reactor, resistor, or some of their connections is defective.

INSTALLATION

68. The type SR-2 relay is shipped separate from the network protector. This decreases the possibility of damage during shipment. Carefully unpack and closely examine the relay to see that none of its parts have been bent or broken in transit. Inspect the relay to see that the plunger moves freely and that the leads to the moving element are smooth and arranged to avoid interference with the motion of the contacts. See that the contacts are properly adjusted. It is also advisable to check the minimum pick-up and drop-out voltage setting of the relay as described under "Tests and Adjustments". Be sure that the three upper terminal screws are in the correct terminals, that is, Nos. 1, 3 and 5 or Nos. 2, 4 and 6 depending upon the desired reverse current setting. All terminal screws and cover screws should be securely tightened. The relay should be mounted on the protector and securely fastened in place by means of its two wing nuts after the protector has been completely installed and is ready to be placed in service.

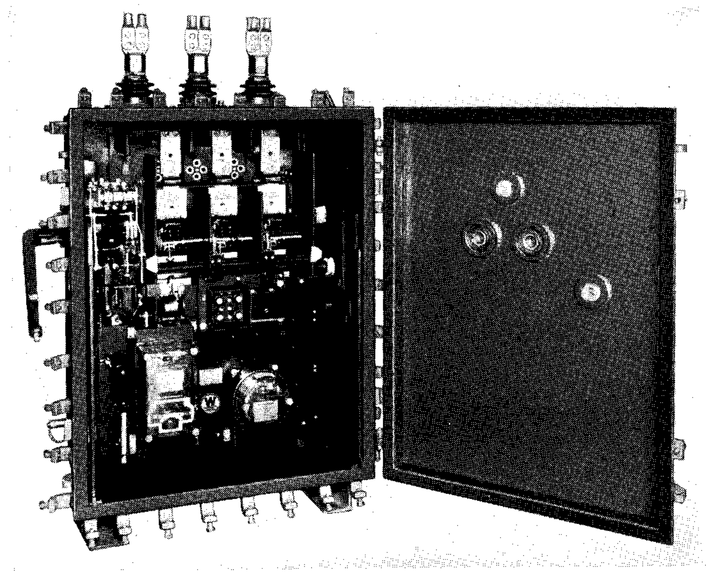
MAINTENANCE

69. The plunger and contacts of the type SR-2 voltage restraining relay are practically the only parts that will require attention. During each periodic inspection of the network protector the relay contacts should be examined to see that they are clean and properly adjusted to close at the same time. Movement of the plunger should be checked to see that it is free from obstructions. The leads to the moving contacts must be flexible and long enough to avoid interference with the movement of the plunger.

Westinghouse

Type CM-2 Network Protectors

Instruction Book



1600-Ampere CM-2 Network Protector for Mounting on Inerteen Network Transformers. Transformer Terminals Come in the Top-Back of the Unit and Are Carried Down Between Breaker Panel and Housing to the Bottom of the Protector. Network Leads Come Out the Top Through Special Low Porcelain Bushings Having Special Cast Copper Terminals for Connecting Four Cables Per Phase

Westinghouse Electric & Manufacturing Company

East Pittsburgh Works

East Pittsburgh, Pa.

I. B. 5414-E

Filing No. 35-500

uniformly around the periphery of the tank, by applying only light pressure to each bolt at first, and then gradually increasing each clamp pressure by progressing around the housing. It is preferable to clamp the "C" clamp which is at the center of each edge, first; and then proceed to the corners of the housing progressively. The final pressure should be sufficient to render the case water tight, but not so great as to injure or damage any of the parts.

23. The operating handle may now be locked for automatic operation. In case operating conditions are such that automatic operation is not desired, the circuit-breaker may be locked open, or locked closed, as is desired. On all models the protector may be locked open by means of the operating handle. The protector may be locked open or closed electrically by opening the two-pole knife switch on the relay panel, thus rendering the control circuit inoperative. It is only in rare cases that the protector should be locked closed. This may be done mechanically by means of the lock pin on the circuit-breaker. When locked by means of this pin, the mechanism and trip details should be rendered inoperative by opening the two-pole knife switch. On non-trip-free, 1600 ampere, transformer mounted protectors the operating handle opens the trip circuit whenever the protector is locked in closed position.

24. The seal of the housing may be tested by removing the small pipe plug on the lower end plate of the housing and connecting a pressure gauge and an air pump and placing approximately six pounds air pressure in the housing. Tests for leaks are made by applying soap water to all of the sealed joints, and noting where bubbles form.

25. Open type network protectors should be applied only in reasonably dry and clean places. The supporting means should be substantial masonry, or steel framework. In all cases the protector should be spaced away from the mounting wall or framework in such a manner that the bolt heads on the rear of the panel will clear this mounting medium by not less than two inches. The mounting bolts should be of ⅝ inch diameter steel. The spacers used should be of insulating material and one should be placed on each of the four mounting bolts. Wood is a satisfactory material for these spacers, porcelain being more satisfactory. In any case the four points formed by these spacers should lie in one plane, so that the protector panel is not sprung out of shape when it is bolted tight.

26. The cable connections for the open and porcelain bushing type protectors should be made as follows:

A. The end of the cable should be prepared for the terminal and this terminal thoroughly sweated to the end of the cable.

B. The cable insulation above the cable terminal should be properly taped and covered with insulating varnish to protect the cable insulation.

C. The cable terminal is then placed in the circuit-breaker and clamped in place.

27. The open type network protector is then placed in service according to the procedure outlined in paragraphs 20, 21 and 23.

PART II—MOTOR MECHANISM

Description

28. The operating mechanism of the type "CM-2" network protector, which is of the centrifugal type, is composed of a motor, a pair of revolving fly-balls, a system of toggles and levers and a shunt trip device. The mechanism is connected to the circuit-breaker by means of a steel link of adjustable length. See Fig. 6.

29. The motor of the mechanism is of the commutator type, for single-phase operation. The motor is constructed for operation with the shaft in a vertical position. An extension of the upper end of the shaft provides a guide for the fly-balls of the mechanism. The ball bearings have been filled with lubricant at the factory and ordinarily should require no attention.

30. The fly-balls operate the mechanism by pulling downward, through a ball thrust bearing on a set of links which are connected to the toggle mechanism which is located above. To bring the fly-balls back to the initial starting point, when the protector has been tripped, a spring is provided in the rear of the mechanism which serves to retrieve the fly-balls against the force of gravity. All exposed surfaces of the fly-ball mechanism are finished with rust-proof metallic plating. See Fig. 5.

31. The main mechanism toggle is located at the top of the mechanism frame, where it is readily accessible for inspection. The toggle is of the double construction, permitting of trip-free action. This is for the purpose of permitting the circuit-breaker to open on feeder shorts, in case such shorts occur immediately after the protector has latched, and the fly-balls and motor are still revolving, or in case of manual closing against a short-circuit by means of the hand operating handle. During a normal closing operation, the toggle is prevented from tripping free by the trigger of the shunt trip. The mechanism main toggle latches the circuit-breaker into closed position by passing over center against a stop.

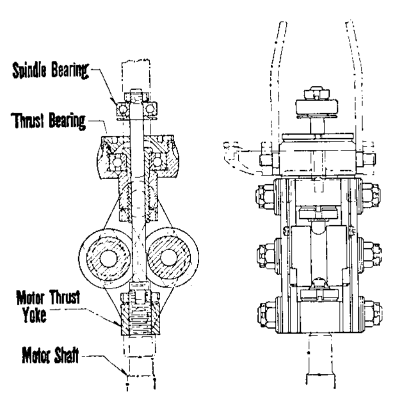


Fig. 5—Fly-Ball Assembly

32. The shunt trip functions by moving its armature, when energized, and this trips out the main latch and opens the protector by breaking the mechanism toggle. The mechanism automatically relatches for the next closing operation when the breaker opens and the fly-balls retrieve to their starting position. The light latch load and ball-bearing latch-roller combine to make the tripping possible even at very low voltages. The shunt trip coil is taken out of the circuit by means of the rotary switch at the top of the mechanism, which opens with the circuit-breaker.

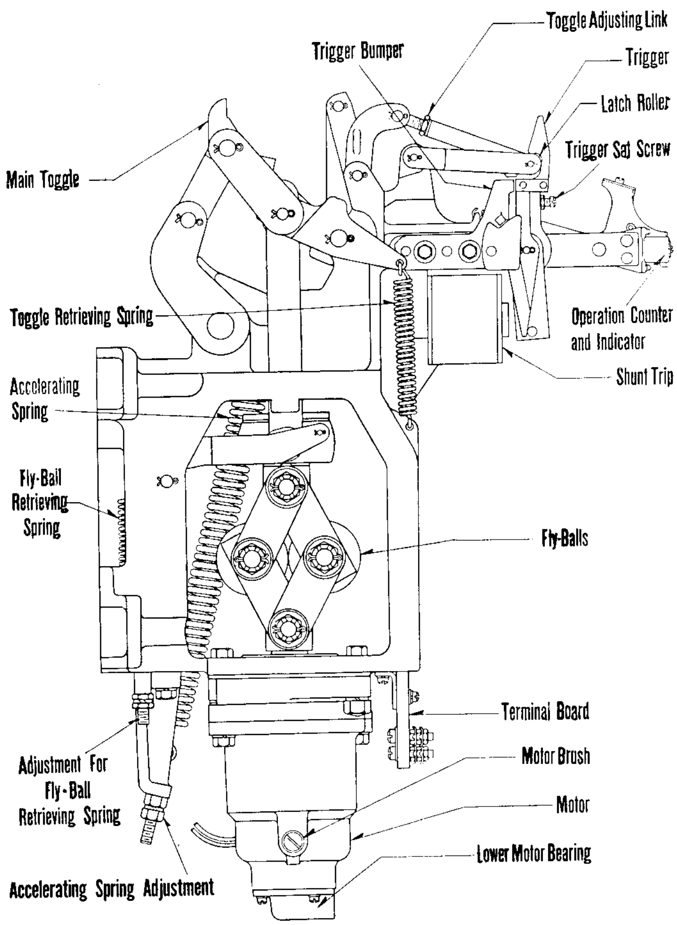


FIG. 6—MECHANISM (IN POSITION TO RECLOSE PROTECTOR)

33. The motor circuit is controlled by a control relay (See Fig. 7), which in turn is controlled by the types "CNA" and "CN-3" relays, and also by an auxiliary switch operated from the toggle linkage. The closing of the "closing" contacts of the relays energizes the coil of the control relay, which then closes its contacts. The closing of these contacts serves to close the circuit of the motor, and also to short out the contacts of the "CN-3" and "CNA" relays. The motor then closes the protector, and as the mechanism toggle passes over center in latching, an auxiliary switch is opened, thus opening the control relay.

34. On separate mounted protectors, the right hand, two-pole, auxiliary switch is connected to the circuit-breaker and closes with it. See Fig. 8. One pole of this switch is connected in the shunt trip coil circuit. The second pole of this auxiliary switch is used to control the green indicating light, when indicating lights are supplied, otherwise it is left vacant, and may be used for any signal service, if the customer desires to so use it. The red light operates from the switch for the shunt trip. On the transformer mounted protectors the auxiliary or rotary switch is assembled and mounted differently, but the principle of operation is the same. In this case the red light is in a circuit separate from the shunt trip.

35. In the case of all subway protectors, an operation counter is mounted on the front and is visible through a glass window in the housing cover. The mechanical position indicator is similarly mounted and is visible through the same window. When red and green indicating lamps are supplied as optional equipment they are mounted in the space otherwise occupied by the mechanical indicator.

36. To aid in quickly opening the circuit-breaker the mechanism is supplied with an accelerating spring having adjustable tension. See Fig. 6.

Maintenance and Adjustments

37. The motor brushes have long life and should require renewal or attention only after extended periods of service. Inspection is recommended annually.

38. During tests, care should be taken that the motor is not unduly overheated from continued operation. However, the motor will withstand continued operation under conditions of rapid "pumping" for considerable periods of time, even though the motor was intended primarily for intermittent service. The minimum closing voltage is 70% or less of line-to-line voltage.

39. The spring at the back of the mechanism, which counter-balances the fly-ball weights, should have its tension so adjusted that the fly-balls are definitely retrieved by it when the motor ceases revolving, and the protector has been tripped. For this purpose, the lower end of this spring is connected to a threaded eye-bolt. It is necessary that the fly-balls be retrieved in order that the latch may be brought into position for the next closing operation. When this spring is being adjusted, the fly-balls should be inspected to be sure that it is not friction or some other obstruction which is preventing the balls from being retrieved, in case they do not retrieve.

40. The fly-balls require no attention except to be certain that they are at all times free from friction or obstruction. In case moisture has gotten into the fly-ball mechanism, the same should be disassembled, thoroughly dried, lubricated slightly with graphite grease and reassembled.

41. The toggle retrieving spring, at the left hand side and front of the mechanism, should be sufficiently strong

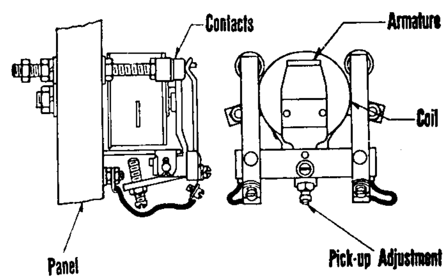


FIG. 7—CONTROL RELAY

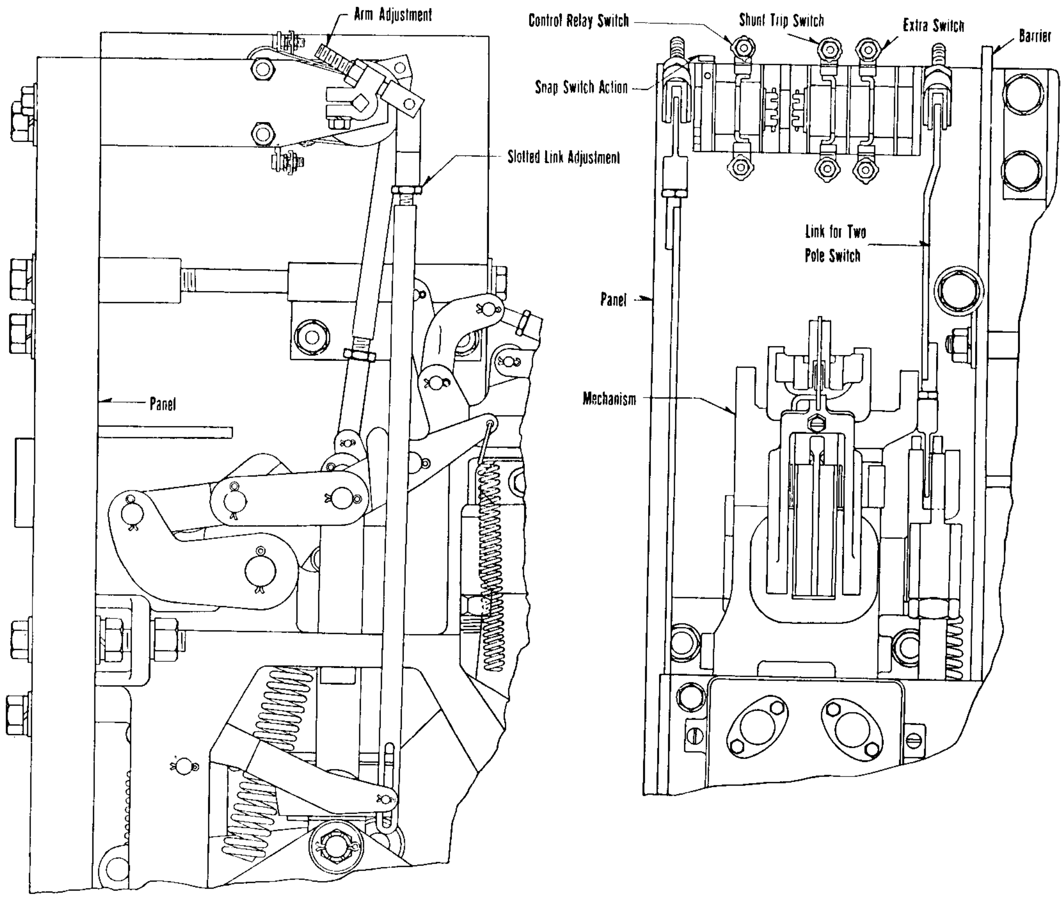


FIG. 8—AUXILIARY SWITCHES OF SEPARATE MOUNTED PROTECTOR

to hold the pin in the upper end of the slot in the toggle links during the retrieve from a trip-free operation. This is necessary for the proper operation of the auxiliary switch in the coil circuit of the control relay. Friction may prevent this spring from performing its proper function.

42. The adjustable link connecting the latch roller to the toggle should be so adjusted as to bring the pin in its lower end co-axial with the pin which passes through the mechanism frame. The adjustment of this link affects the latch load, and hence affects the minimum voltage at which the shunt trip will trip the protector. The standard network protectors are guaranteed to trip at a minimum voltage which will not exceed 15 volts, when the normal adjustments are used.

43. The armature of the shunt trip should have from $\frac{5}{32}$ inch minimum to $\frac{3}{16}$ inch maximum air gap. This gap is adjusted by changing the height of the rubber bumper against which the spring holds the armature. See Fig. 6. The trigger bumper should be so adjusted that the back of the trigger is about $\frac{3}{32}$ of an inch for new designs, or $\frac{1}{64}$ of an inch for some older designs, from the surface of the latch roller. When the armature bumper and the trigger bumper are adjusted as outlined above, the armature should move the trigger assembly in electrical operation (at minimum trip voltage) just far enough to trip the protector. This adjustment is approximately secured as follows: first, the trigger set screw is backed out to such a point that the armature will not trip the protector; second, the armature is held manually in the closed position and the trigger set screw moved forward until the protector trips, in which position it is locked by means of the lock nut. The springs for the armature and trigger should be just strong enough to hold their respective parts definitely in position. On applications where shock or vibration is encountered, the mechanism may be made shock proof by decreasing the $\frac{3}{32}$ inch dimension given in the first part of this paragraph. This will also increase the minimum trip voltage somewhat.

44. The auxiliary switch in the circuit of the control relay coil, during the retrieve from a trip-free operation, should not close its contacts until after the mechanism has retrieved and latched. When the auxiliary switch does make contact, it should make full contact, due to the snap switch action. These requirements are fulfilled by having the requirements of paragraph 41 fulfilled, by having the snap switch action of the auxiliary switch functioning properly, and lastly, by having the correct adjustment on the length of the link connecting it to the mechanism. To secure the proper adjustment of this auxiliary switch proceed as follows:

A. When the roller of the snap switch section first enters the cam notch the contact opening on either side of the rotor should be approximately $\frac{1}{32}$ inch. This contact opening can be changed by changing the position of the roller on the spring finger. The contact deflection should not be more than approximately $\frac{1}{32}$ inch, and is adjusted by bending the stops of these fingers.

B. To check the adjustment of the link at the left hand side of the mechanism and auxiliary switch, first set the fly-balls revolving at a high rate of speed (with the protector closed) by manually holding the control relay (Fig. 7) in the closed position. While the fly-balls are thus revolving, push the link upward as far as possible, in which position the cam roller should be just definitely out of the cam notch.

45. The link connecting the mechanism to the circuit-breaker should have its length so adjusted that the stops on the circuit-breaker operating lever have $\frac{1}{32}$ inch gap between them when the mechanism is latched. When a mechanism is first installed, it should be manually latched and inspected for this point before the protector is operated electrically. To do this, the circuit-breaker may be closed by means of the hand lever provided.

46. The operating arm of the operation counter may be adjusted as follows: The clamping screw in the arm of the counter should be loosened until the arm may be moved on its shaft, but still has sufficient friction to operate the counter. With the clamp screw so set, place the arm in approximately the correct position. Operate the protector several times to see if it counts correctly. If it has counted correctly, the arm is set properly and the clamp screw may be tightened in place. If it has failed to count, shift the arm on the shaft a slight amount in the proper direction and repeat.

47. The accelerating spring, which assists in rapidly opening the circuit-breaker is supplied with an adjustment. If this spring is adjusted too short, and hence too weak, the tendency is for the protector to fail to trip when the trip coil is energized, and may result in burned out trip coils. If the spring as adjusted is too long, and hence too strong, there is a tendency to raise the minimum voltage at which the motor will close the protector. To check for weak accelerating spring or for toggle friction proceed as follows: Close the protector in the regular manner and after the fly-balls have ceased rotating seize the latch roller (See Fig. 6) in the fingers and hold it in closed position, then manually move trigger to tripped position, next allow the trigger to rise very slowly under restraint of the fingers. During this slow rise of the latch roller the mechanism should at all points exert a definite tripping force on the latch roller until the actual tripping point is reached.

48. To keep the mechanism in the best operating condition, it is recommended that the protector be operated at least once in every two weeks.

Lubrication

49. All ball bearings have been lubricated at the factory and should require no further attention unless they may accidentally become filled with dirt or water. Pin bearings on the mechanism require very little, if any, lubrication.

Improper Operation

50. Failure of the mechanism to close the protector may be due to:

A. An open-circuit in the motor, or blown motor fuses.

B. A short-circuit or open-circuit in the control circuit of the motor.

C. Worn-out motor brushes.

D. Mechanical obstruction preventing the motor from rotating.

E. Mechanical obstruction in the fly-ball or toggle mechanism.

F. Incorrect adjustment of the link to the circuit-breaker.

G. An open circuit to the coil of the control relay.

51. Failure of the mechanism to latch may be due to:

A. Insufficient air gap on the armature of the shunt trip.

B. Incorrect adjustment of the trigger bumper.

C. Incorrect adjustment of the link connecting the latch roller to the toggle mechanism.

D. Lack of proper snap-switch action in the auxiliary switch.

E. Improper length adjustment of the auxiliary switch link.

F. Friction in the fly-ball mechanism which prevents the mechanism from pulling the toggle into latched position.

G. Friction in the fly-balls which prevents their being retrieved.

H. Improper adjustment of the fly-ball retrieving spring.

I. Friction in hand operating device. See paragraph 41.

52. Failure of the protector to trip may be due to:

A. An open-circuited shunt trip coil.

B. Too large an air gap on the armature of the shunt trip.

C. Friction or mechanical obstruction which prevents the tripping of the toggle.

D. Improper operation of the auxiliary switch in the shunt trip circuit.

E. An open control circuit through the "CN-3" relay.

F. Weak accelerating spring. See paragraph 47.

Removing a Mechanism

53. To remove a mechanism proceed as follows:

A. If the circuit-breaker is closed and it is desired to keep it closed, the lock-pin should be inserted in the circuit-breaker.

B. Open the two-pole knife switch and remove the two cartridge fuses on the relay panel, thus removing voltage from all of the mechanism wiring except the two indicating lamps when they are mounted on the mechanism.

C. Remove links to circuit-breaker and to auxiliary switches.

D. Disconnect the hand operating mechanism.

E. Disconnect the wires running to the terminal board from the panel and insulate these for safety.

F. Remove the four nuts which secure the mechanism to the panel and remove the same.

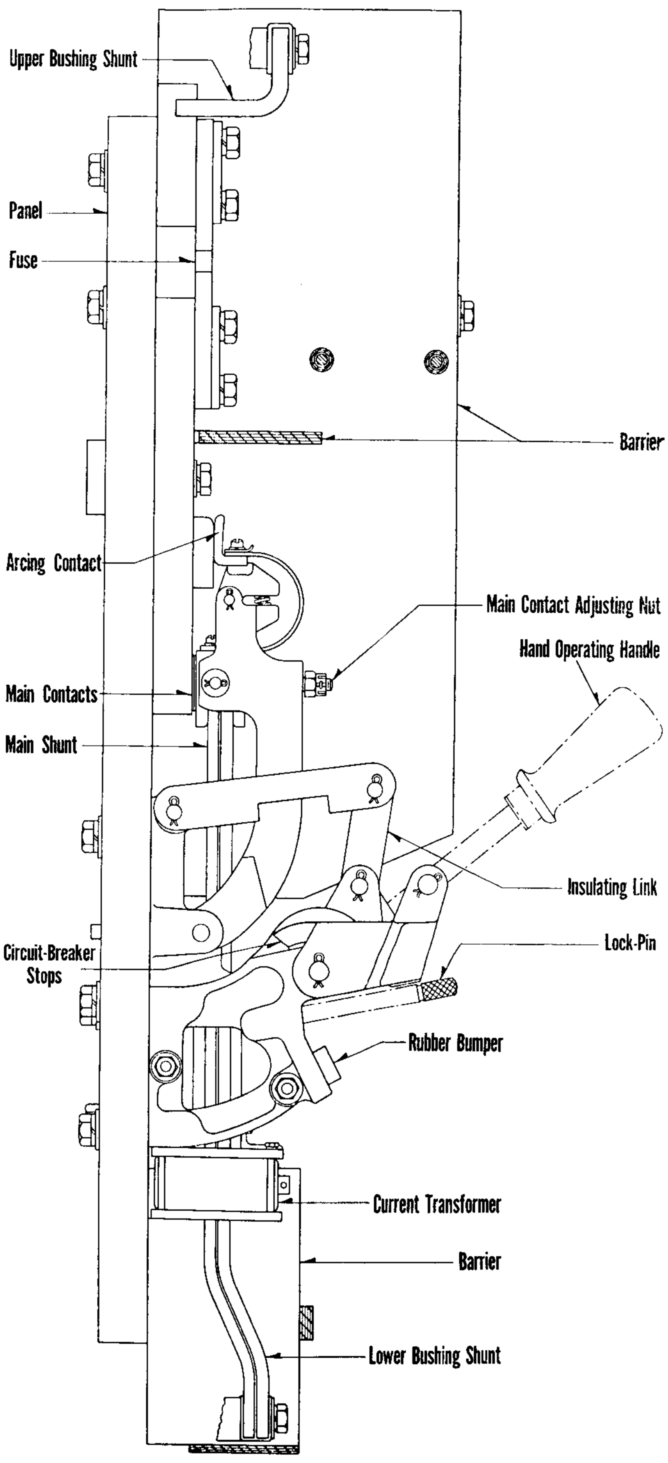


Fig. 9—1200 Ampere Circuit-Breaker—For Porcelain Bushing Housing—Side View

Installing a Mechanism

54. To install a mechanism, carry out the reverse procedure of paragraph 53. Before operating the protector with a newly installed mechanism, it should be adjusted as outlined in paragraphs 37 to 49 inclusive. Special attention should be given to the adjustment of the links to the auxiliary switch and to the circuit-breaker.

Removing or Installing a Motor

55. When removing or installing a motor on a protector, the mechanism wiring should first be made dead as outlined in paragraph 53, section B. The procedure to remove a motor is then as follows:

A. Disconnect the wiring at the mechanism terminal board.

B. Remove the two bolts through the fly-balls by removing one nut from each bolt.

C. Remove the fly-balls from the mechanism.

D. Remove the two bolts which pass through the motor flange and mechanism frame and remove the motor with the four links to the fly-balls attached.

To replace the motor, the reverse procedure is followed. If a new motor is being installed, the four fly-ball links and other parts must be removed from the shaft of the old motor and added to the new before it is placed in the mechanism.

Removing a Trip Coil

56. Before removing a trip coil the protector should either be opened and allowed to remain open, or else locked closed by means of the lock-pin on the circuit-breaker. Voltage should then be removed from the coil and mechanism. This is done by opening the two-pole knife switch, removing the two cartridge fuses in the motor circuit, and disconnecting the indicating lamps at the terminal board, when indicating lamps are so connected. The coil wiring may then be disconnected, after which the magnet armature and latching links must be removed. The coil may then be removed by removing the one retaining screw on the right hand side.

PART III—CIRCUIT-BREAKERS

Circuit-Breaker Description

57. The circuit-breaker consists of a three-pole circuit-breaker, an asbestos composition mounting panel, a relay panel for mounting relays and auxiliary control apparatus, and the necessary control wiring.

58. The circuit-breaker proper, which is mounted on the asbestos composition panel, consists of three-pole units, each with a toggle linkage, the three being actuated by a common rocker arm through three insulating links. See Figs. 9 to 13. Each pole unit in turn consists of terminals, a copper disconnecting link (or a fuse), a current transformer, a flexible shunt, main contacts and arcing contacts. A removable barrier assembly isolates the pole units from one another, especially in the region of the arcing details. The auxiliary switches used for control purposes are located in the upper left hand corner of the panel directly above the operating mechanism. See Fig. 8.

59. The cables are connected to the circuit-breaker by means of sleeves which are sweated to the cable ends and then clamped against the circuit-breaker proper. The contact surfaces are tinned or nickel plated to give good conductivity. The clamps are easily removed when it is desired to disconnect a cable. When porcelain bushings are used in subway housings the circuit-breaker is connected to the bushing by means of a flexible shunt. The cable is then connected to the outer end of the porcelain bushing stud.

60. Adjacent to the network terminal of the circuit-breaker there is located a disconnecting link which may be either a copper link or a fuse. When fuses are used, they are normally rated at two times the rating of the protector. In addition to acting as disconnecting links, the fuses serve to clear the circuit in case of apparatus failure at the time of a primary short.

61. The current transformers on the pole units work in conjunction with the type "CN-3" relay to open the protector on reverse power. Each rating of protector has a transformer which is suited only to that rating of protector, thereby making the relays interchangeable between the various ratings of protectors.

62. The circuit-breaker is of the single contact type, the entire current being carried through a flexible shunt of special design. The main contacts are of silver plate to reduce contact drop. These contacts are held together under considerable pressure by means of coil springs. The arcing tips are of copper and are non-breakable.

63. All wiring is connected on the front of the panel where it is readily accessible. The operating mechanism and relay panel are wired separately, and either may be removed from the main panel by simply disconnecting the convenient means provided, without the necessity of

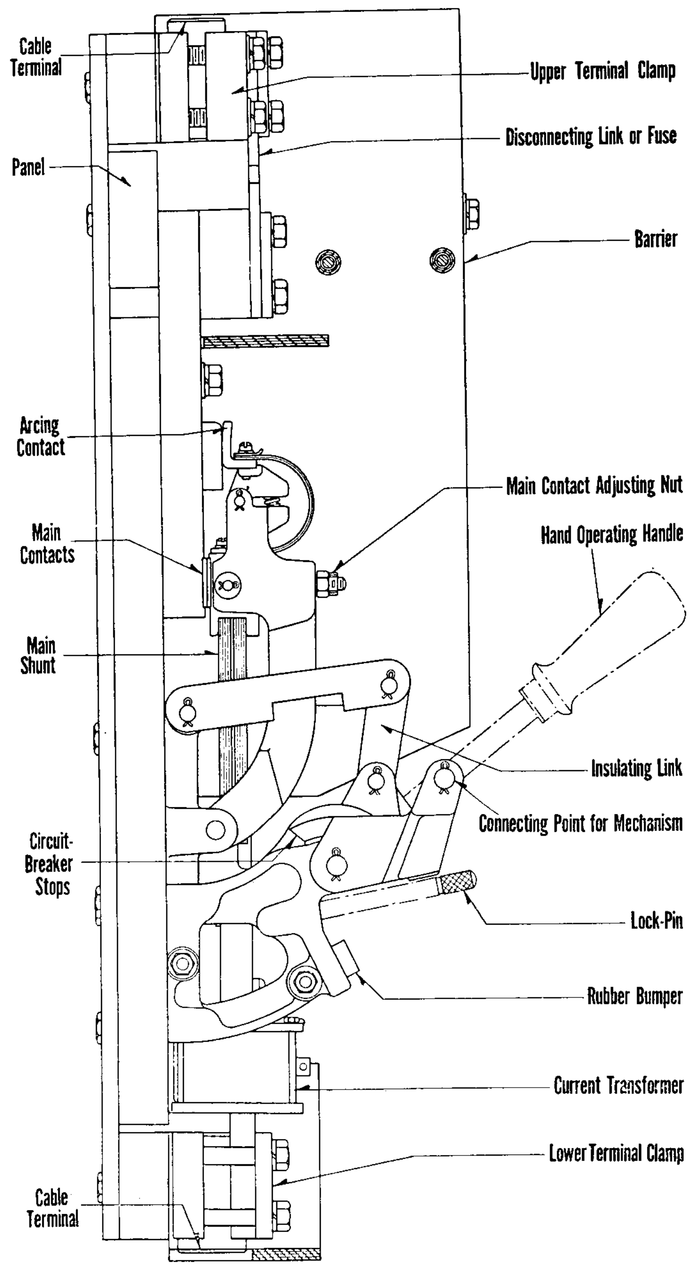


Fig. 10—1200 Ampere Circuit-Breaker—For Separate Mounted Wiping Nipple Housing—Side View

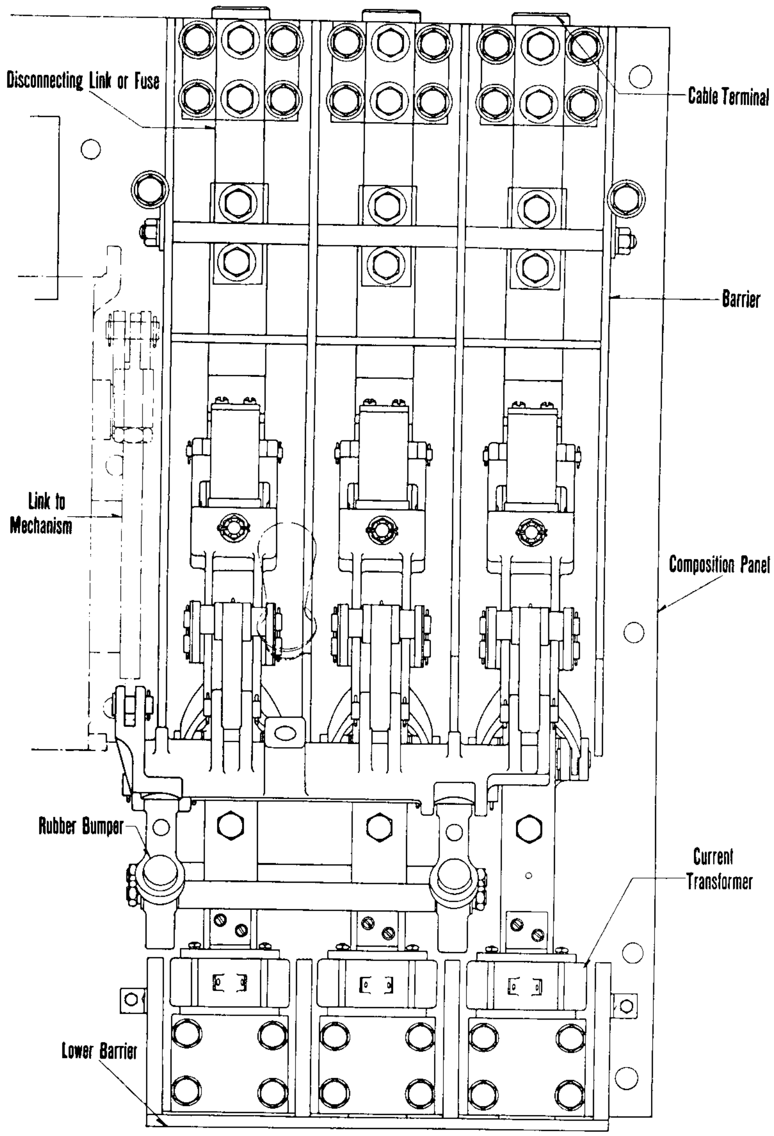


FIG. 11—1200 AMPERE CIRCUIT-BREAKER—FOR SEPARATE MOUNTED WIPING NIPPLE HOUSING—FRONT VIEW

disturbing permanent wiring. A grounding stud is provided for purposes of grounding the wiring either to the housing or to some other point.

64. The fuses or links at one end of the pole units and the terminal connections at the other serve as devices for disconnecting the protector from live lines. To disconnect the protector from the network side, it is only necessary to remove the connecting link or fuse. On the transformer side of the protector, the four bolts clamping the terminal are removed. After removing the four mounting bolts, the whole protector may be wheeled forward on its rails, thus completing the isolation and making the protector accessible. On those protectors not provided with rails it is possible to insert insulation after the terminal bolts have been removed.

Relay Panel Description

65. The steel relay panel is mounted in front of the circuit-breaker and is hinged so that it may be swung away from the circuit-breaker, thus making the latter more accessible. See Fig. 14. On this panel there are mounted the network relays with their phasing lamps or resistors and also the fuses and control relay used in conjunction with the mechanism. The wiring on this panel is rigidly fastened to the steel panel and runs to a set of terminal blocks adjacent to the hinged edge of the panel. From this terminal block to the main circuit-breaker, the connections are made by means of flexible cable. The wiring on the relay panel is accessible from the rear when the panel is swung clear of the circuit-breaker.

66. The relays are mounted on a set of terminal blocks in such a manner that the screws which form the electrical connections also form the mounting support for the relays. The wiring is permanently connected to the rear of the terminal blocks. The relays may therefore be removed from the protector without disturbing any wiring connections, and they may be replaced on the protector without the necessity of checking any wiring connections.

67. The control relay and fuses which are mounted on the relay panel are for the purpose of controlling and protecting the motor of the operating mechanism. The control relay is actuated by the contacts of the master and phasing relays. (See paragraphs 33 and 81).

68. The four lamps which are located in the upper left hand corner of the relay panel are the phasing lamps which are located in the phasing circuits of the relays. In later designs these have been replaced by resistors. The phasing lamps or phasing resistors serve to protect the relay circuits against injury when subjected to full line voltages.

Operation of Control Apparatus

69. The operation and theory of the master and phasing relays are completely covered by a separate instruction book.

70. A closing cycle consists of the following sequence of operation (See Figs. 15 to 18):

A. The master relay closing contacts and the phasing relay contacts close, thereby completing the circuit to the coil of the control relay.

B. The control relay picks up its armature, thereby closing its contacts.

C. The right hand pole of the control relay closes the circuit of the motor in the operating mechanism, and the left hand pole of the control relay serves to short out the contacts of the master and phasing relays, thereby preventing the control relay from opening in case of a momentary opening of the contacts in the master and phasing relays.

D. The motor starts and closes the protector.

E. As the motor mechanism passes into the latched position, a set of auxiliary switches are operated, one of these auxiliary switches opening the circuit of the control relay operating coil, and the second auxiliary switch closing the circuit of the shunt trip coil. The closing of the shunt trip circuit is in preparation for the tripping of the circuit-breaker at some future time.

F. The opening of the control relay opens the circuit of the motor, thereby removing it from the line.

71. A tripping cycle consists of the following sequence of operations:

A. The master relay closes its tripping contacts (due to the system conditions prevailing), thereby closing the circuit through the shunt trip coil. (The tripping cycle is independent of the position of the contacts in the phasing relay).

B. The opening of the circuit-breaker and mechanism returns the auxiliary switches to their original position, thereby opening the circuit of the shunt trip coil and closing the circuit of the coil of the control relay, preparatory to the next closing operation.

Maintenance and Adjustment

72. For satisfactory operation of the circuit-breaker, the silver contacts of the circuit-breaker must have full contact and be under full pressure. To be sure of these conditions, it is necessary that the circuit-breaker be closed to the proper point, which condition exists when the stops on the circuit-breaker operating lever are open approximately $\frac{1}{32}$ inch with the operating mechanism in the latched position. This is adjusted by adjusting the length of the operating link to the mechanism. In addition to this, it is necessary that the adjusting nut for the main contact spring be so set as to be under no load when the circuit-breaker is latched closed (in which position the contact spring should be compressed $\frac{1}{32}$ inch beyond the initial compression which this spring has). Also, the lower circuit-breaker terminal should be clamped by tightening the four clamp bolts uniformly, so that the lower portion of the pole unit is clamped in a position parallel to the panel and does not tend to hold the silver contacts out of parallel (separate mounted protectors only).

73. The shunts to the main contacts should require little attention, except that care should be taken to see that they are not damaged mechanically in any way. The design of these shunts is such that they have long life and hence replacements should be required only in very rare instances.

74. It is important that the silver contacts at all times be in good condition; a little attention, well directed, will keep them in good condition. The contacts should be protected from dirt

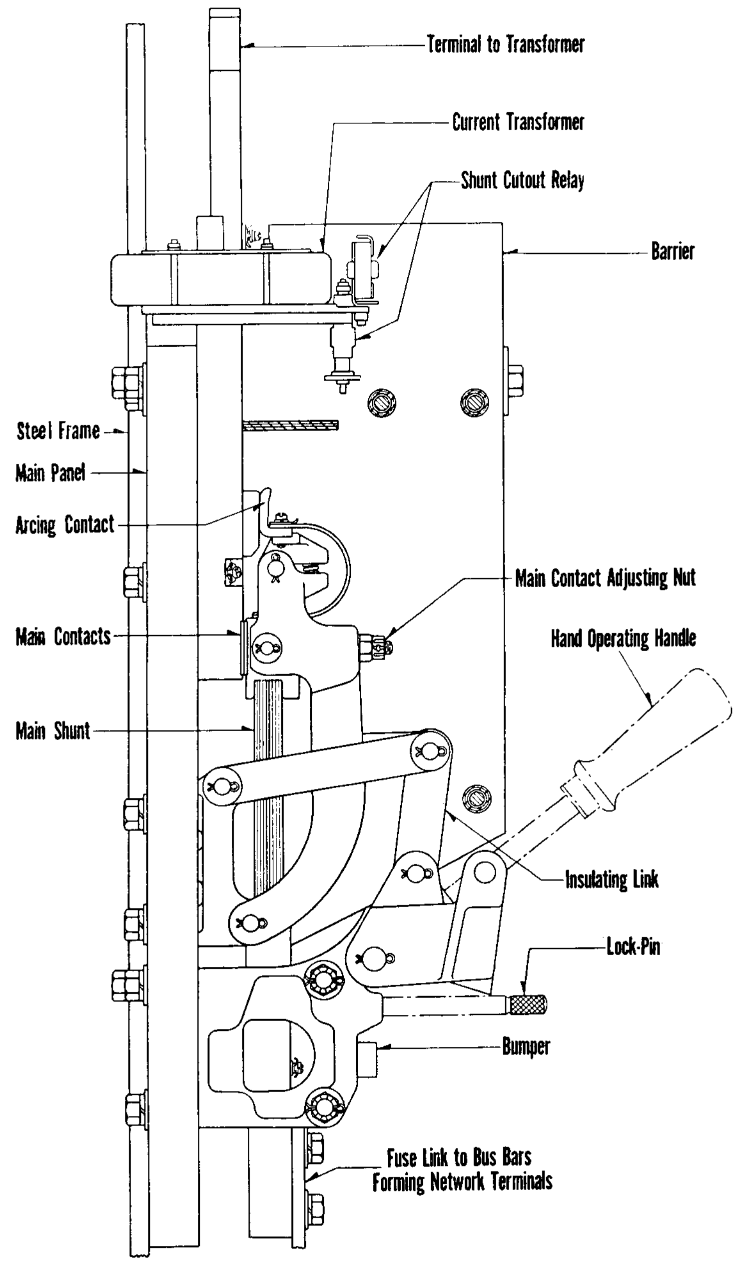


FIG. 12—1600 AMPERE CIRCUIT-BREAKER—FOR TRANSFORMER MOUNTED HOUSING—SIDE VIEW

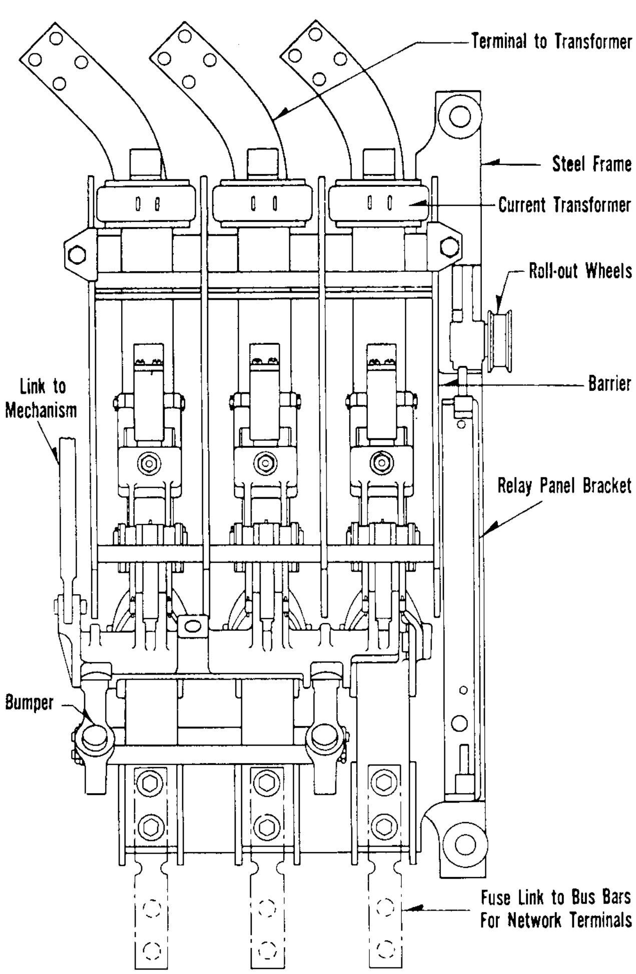


FIG. 13—1200 AMPERE CIRCUIT-BREAKER FOR TRANSFORMER MOUNTED HOUSING—FRONT VIEW

and mechanical injury. In case the silver contacts become injured, they must be made perfectly smooth before being placed in operation. Small injuries may be repaired by a skilled workman using a very fine file or crocus cloth, but extreme care must be exercised to see that the surfaces are left perfectly flat. After the protector has ruptured a severe short, it is recommended that the silver contact surfaces be inspected and repaired as found necessary. Dirty contact must be cleaned so that mechanical injury does not result. To test the silver contacts for character of contacts, the moving silver contact should be given a light coating of bearing blue (or artists' Prussian Blue paste) and the breaker then closed against a thin sheet of tissue paper. An impression of not less than 75% of the surface should result.

75. The spring which bears on the main contact should be compressed approximately $\frac{1}{32}$ inch in addition to its initial compression. This is adjusted by means of the main contact adjusting nut, which produces the initial compression in that spring.

76. The circuit-breaker arcing contacts are of copper and are non-breakable. These contacts must have a substantial initial spring tension, must have low resistance contact to the main circuit-breaker parts, and should be in such condition that their contact is of low resistance. After opening a short-circuit, or after a period of normal operation, the arcing contacts should be dressed with a file so as to produce satisfactory contact surfaces. If the arcing contacts are in extremely bad condition, they should be replaced. When the breaker is opening, the arcing contacts must remain in contact until the main contacts of the circuit-breaker are approximately ⅛ inch open and when closing, they must make contact at the same point. This clearance distance is affected by the condition of the arcing contacts and also by the adjustment of the main contact adjusting nut which produces the initial spring tension of the spring behind the silver contacts.

77. The disconnecting means at the network end of the pole unit may be either a copper link or a fuse. Whenever either of these are replaced on the protector, care should be taken that the surfaces are in such condition that good electrical contacts are made. The surfaces must be smooth and clean and must be securely clamped. Lock washers and washers must be in place.

78. In case a fuse has blown, the deposits from the blown fuse should be removed and the circuit-breaker parts cleaned as found necessary.

79. Each cable terminal is clamped to the circuit-breaker by means of four bolts and a clamping plate. To insure good contact, the contact surfaces must at all times be in good condition and be securely clamped. When clamping the cable terminals of separate mounted units in place, care should be taken to tighten all four bolts uniformly, so as to leave the clamping plates parallel to the protector panel, thereby relieving the circuit-breaker parts of any possible strains that might otherwise exist. When the lower terminal clamps are tightened, care should also be taken to see that the pin through the moving contact of the circuit-breaker is free in the moving arm (so that there is no binding) during the closing or opening of the circuit-breaker.

80. The main barriers of the circuit-breaker, which segregate the poles in the vicinity of the fuses and arcing tips, are built in one unit and may be removed by removing two retaining bolts. An energized protector should not be opened or closed while the barriers are removed. After heavy rupture, either by the circuit-breaker or by fuses, the barriers should be thoroughly cleaned of all residue. Fixed barriers are located at other points for the purpose of protection to workmen while working on or around the protector, or for protecting vulnerable parts of the protector at times of heavy rupture. These barriers must also be cleaned as required after heavy rupture.

81. The control relay which is mounted on the relay panel should be so adjusted that the armature will be picked up at from 167 to 177 volts. This is adjusted by means of the set-screw in the lower end, or tail, of the control relay armature. The stationary contact studs of the control relay should be so adjusted that the magnet has approximately $\frac{3}{32}$ to $\frac{1}{8}$ inch air gap at the armature when the contact fingers first make contact. This is accomplished by adjusting these studs in or out through the panel. It is preferable to have the left hand pole close slightly ahead of the right hand pole.

82. The two cartridge fuses which are mounted at the top of the relay panel are in the motor circuit for the purpose of protecting the motor windings in case the motor should become blocked while energized. Only authorized fuses should be used in these circuits.

83. The current transformers on the pole units operate in conjunction with the master relay to trip the protector on reverse magnetizing energy. It is therefore essential that the polarity of the transformers be correct. The transformer must be so connected that the drop across its terminals is in the same polarity direction as the resistance drop across the copper bar upon which it is mounted. The current transformers are always mounted with the white paint mark upward. The terminal adjacent to this white mark is then the one which is connected to the copper of the transformer side of the circuit-breaker, when the transformer side is the lower end of the protector. When the network side is the lower end of the protector it is the unmarked current transformer terminal which is connected to the circuit-breaker copper, the transformer side. See Figs. 15, 16, 17.

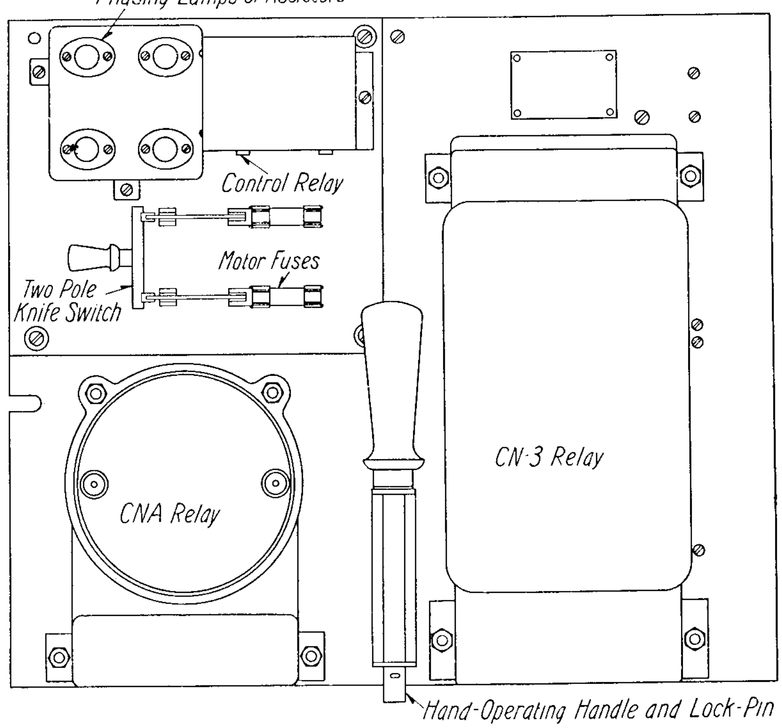


Fig. 14—Relay Panel Assembly for Separate Mounted Protectors (Others Similar)

The Shunt Cutout Relay

84. The shunt cutout relay is a device used on the type "CM-2" network protectors when it is desired to increase the reverse-current setting of the type "CN-3" master relay, which is used in conjunction with the network protector. The "CN-3" relay functions to trip the network protector under conditions of reverse-current, or "feed-back" through the network transformer associated with that particular network protector.

85. The shunt cutout relay consists essentially of two main parts—the shunt cutout and the shunt reactor. The shunt cutout consists of a magnetic circuit surrounding a protector pole, a pair of contacts in series with the reactor, a moving armature to open these contacts, and a compression spring to adjust the "pick-up" and "drop-out" values of the cutout. It is adjusted to "pick-up" and open the shunt reactor circuit when the protector load reaches 150% or more of normal full load, and to "drop-out" and close the shunt reactor circuit when the protector load again drops to 125% or less. The shunt reactor is an iron core reactor that has two coils, each consisting of two turns of No. 9 copper wire. The shunt reactor is connected in parallel with the network protector current transformer and the current coil of the "CN-3" master relay. The shunt cutout relay is mounted with the network protector current transformer, and the combination is located in the same position on the network protector as the current transformer.

86. The sole purpose of the shunt cutout relay is to increase the reverse current setting of the "CN-3" relay so that the protector will not trip on high momentary reverse currents, due to regenerative braking of elevator motors, etc. The shunt reactor coils which are connected in parallel with the current coils of the "CN-3" relay have a resistance of approximately .001 ohms and also a low impedance. Thus, with the shunt reactor coils in the "CN-3" relay current coil circuit, the major portion of the current will flow through the shunt reactor coils and, therefore, a high momentary reverse current will not cause the "CN-3" relay disc to move to the trip position. However, the "CN-3" relay will still function on high values of reverse current which are imposed for an appreciable length of time. The presence of the shunt reactor in this parallel relation gives to the "CN-3" relay a so-called "insensitive" setting—(not operable on small reverse current values), the normal relay being called "sensitive" (being operable on small reverse current values.)

87. In the case of feeder faults, causing reverse power to flow through the protector, it is desirable to trip the protector as quickly as possible. This

Index—(Continued)

(Numbers Refer to Paragraphs and Pages)