Westinghouse

Types 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 Types 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 types CN-33, CN-J, and SR-2 relays have been designed to control the operation of the types CM-22 and CM-44 network protectors which are 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. Network protectors are connected in the secondary leads of all network transformer banks 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 and CM-44 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 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 and CM-44 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 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.

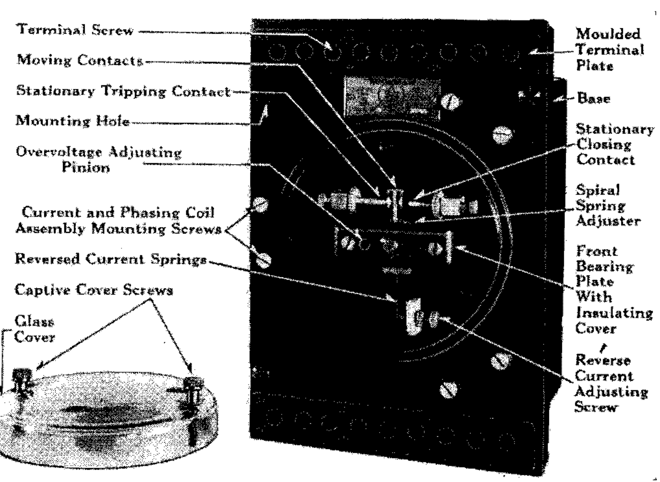


Fig. 1—Type CN-33 Network Master Relay. Front View with Glass Cover Removed.

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 insulating 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.

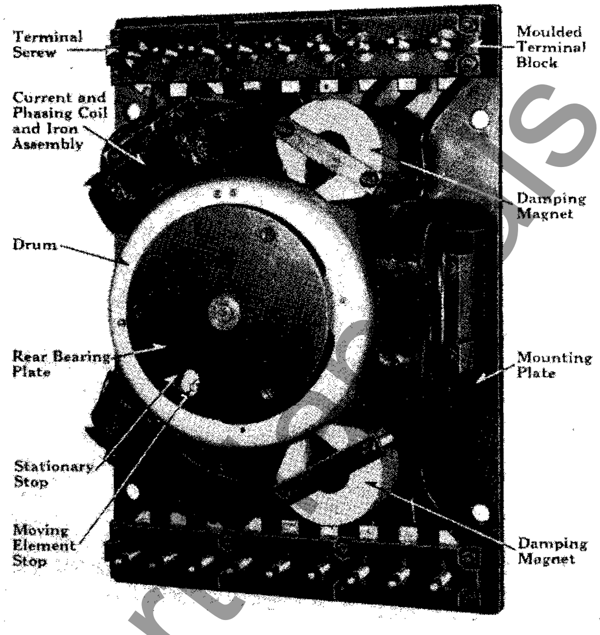


Fig. 2—Type CN-33 Network Master Relay. Rear View of Relay Removed from Base.

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 on 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. Gear teeth on the adjuster engage a pinion, the insulated shaft of which extends through a hole in the front bearing plate. The spring tension is easily adjusted by rotating the pinion with a screwdriver without danger of grounding the spring assembly. This adjustment is located under the glass cover to prevent unauthorized changing of adjustments.

10. The use of a large diameter drum, two small permanent magnets 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 magnets are carried on the back of the mounting plate where they are 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 125 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 securely fastened to the back of the mounting plate by two screws. The relay is so assembled at the factory that the air gaps between the two sections of each electromagnet are symmetrically unbalanced to provide the normal range of overvoltage adjustment. The overvoltage adjustment within this range is made by the geared spring adjuster under the glass cover. If it is ever necessary, the range of overvoltage adjustment can be changed by loosening the two mounting screws of each outer coil and iron assembly and shifting the assembly through a small angle with a wrench (Style No. 1095881). When the desired range is obtained, the mounting screws should be securely tightened.

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 screws and serves to protect the relay contacts, reverse-current and overvoltage adjustments, 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 thumb 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

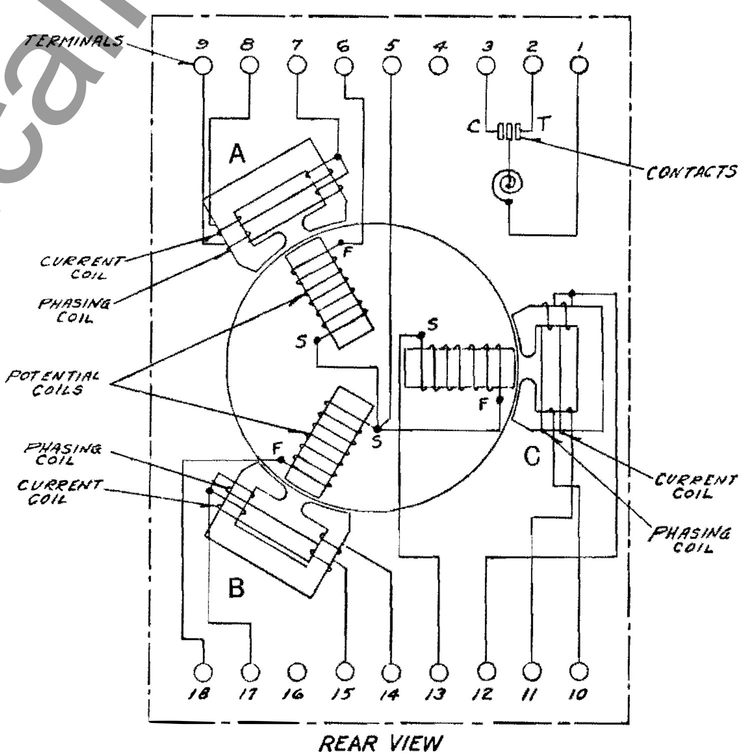


Fig. 3—Wiring Diagram of Internal Connections of the Type CN-33 Network Master Relay.

ground or between screws. By partially 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 thumb 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 CN-33 relay and open the contacts of the CN-J relay. 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. For this reason the indicator lamp in the protector is connected in parallel with the phasing relay potential coil so that the CN-J relay as well as the CN-33 tends to close its closing contacts under all dead network conditions. Therefore, 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 the network are open. Now suppose that some network feeder, other than

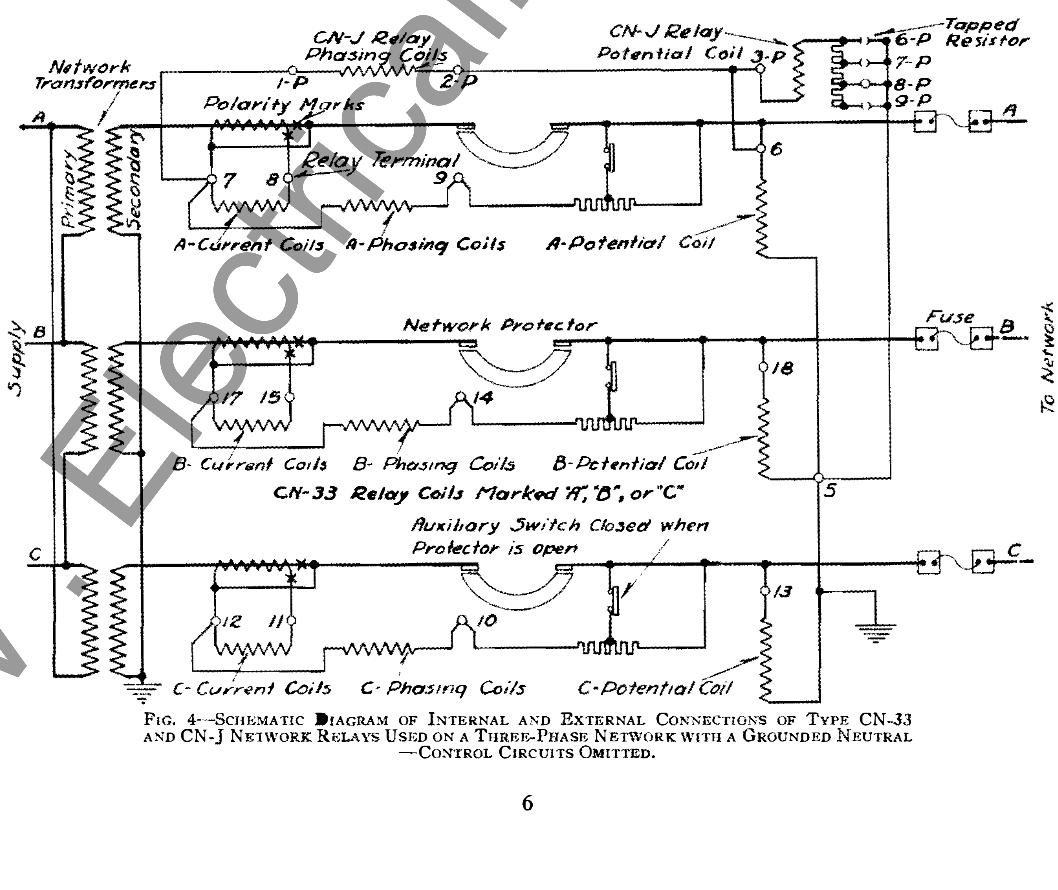


FIG. 4—SCHEMATIC DIAGRAM OF INTERNAL AND EXTERNAL CONNECTIONS OF TYPE CN-33 AND CN-J NETWORK RELAYS USED ON A THREE-PHASE NETWORK WITH A GROUNDED NEUTRAL —CONTROL CIRCUITS OMITTED.

the 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 to fix the range of 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, if the CN-J contacts are closed.

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, if the relay has a sensitive setting. 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

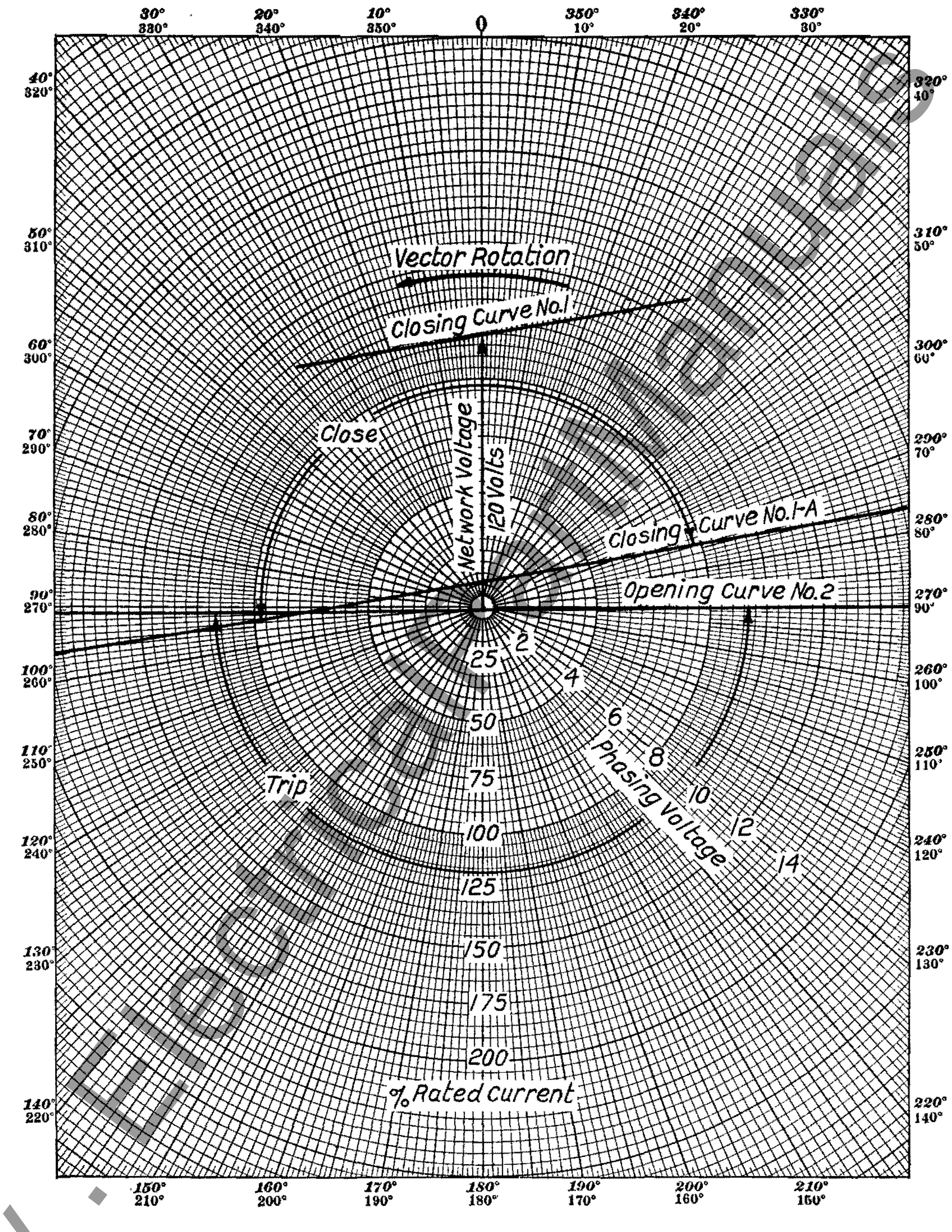


Fig. 5—Closing and Tripping Characteristics of the Type CN-33 Network Master Relay. Balanced Three-Phase Conditions Assumed.

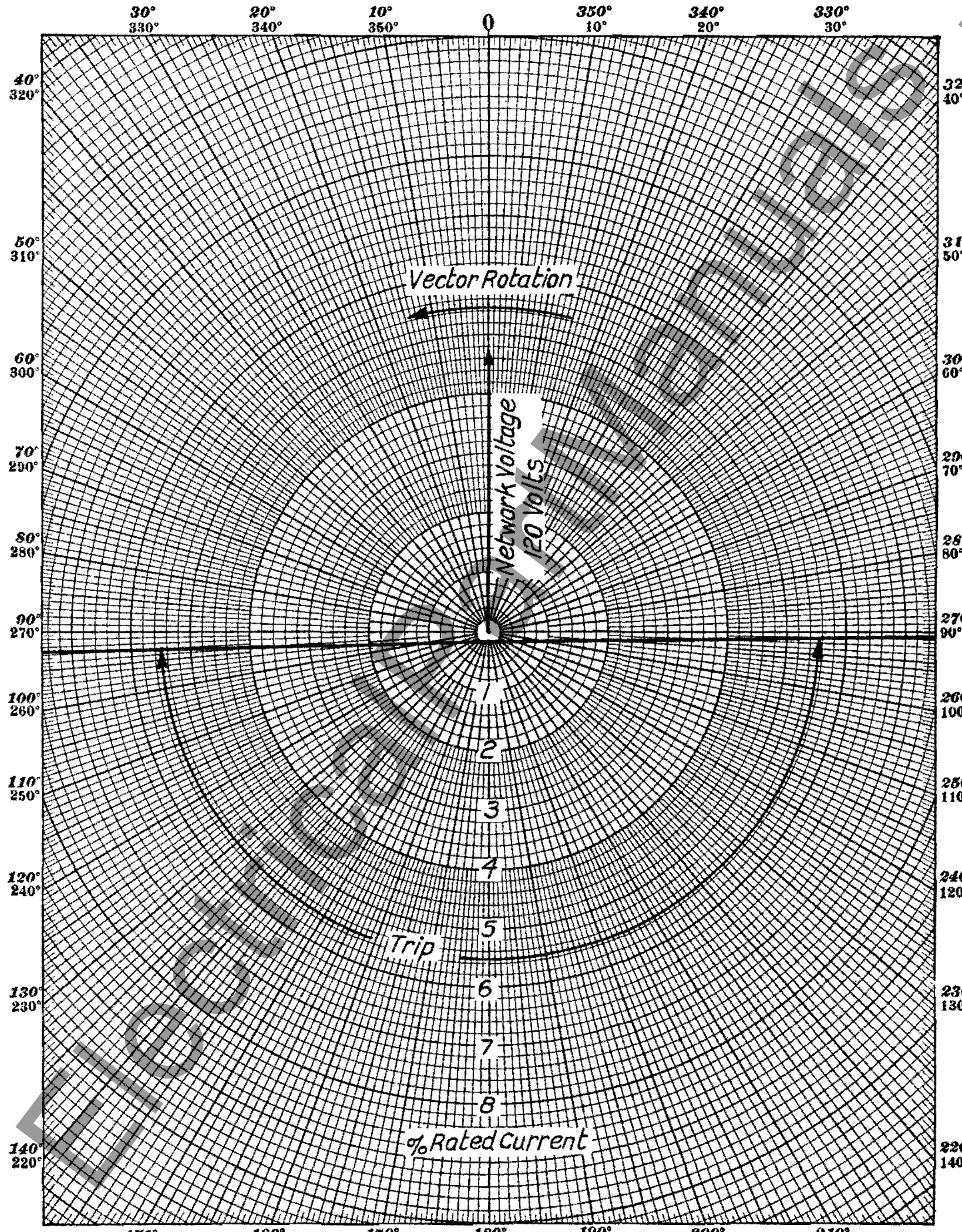


FIG. 6—TRIPPING CHARACTERISTICS OF THE TYPE CN-33 NETWORK MASTER RELAY. BALANCED THREE-PHASE CONDITIONS ASSUMED.

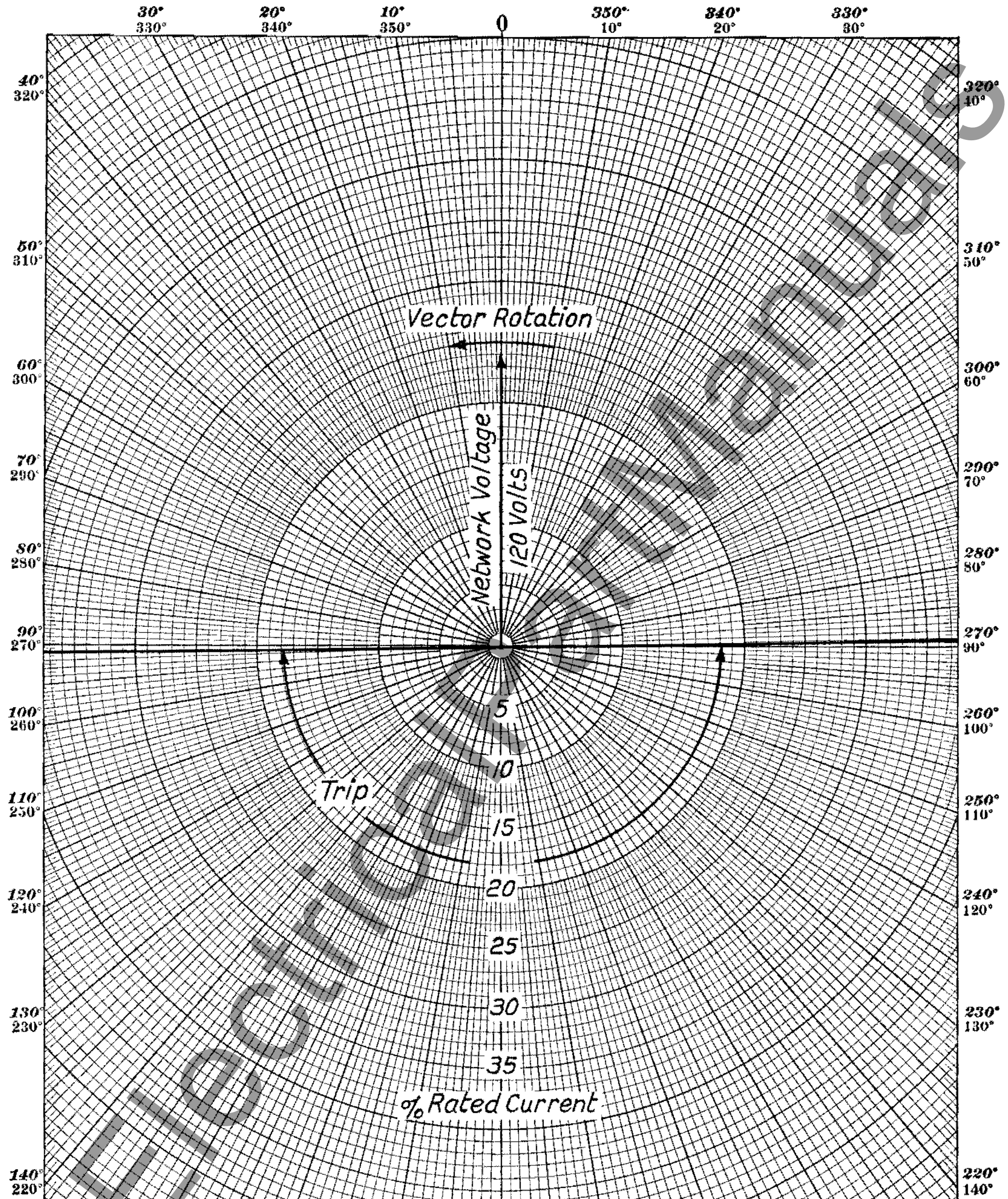


Fig. 7—Tripping Characteristics of the Type CN-33 Network Master Relay. Balanced Three-Phase Conditions Assumed.

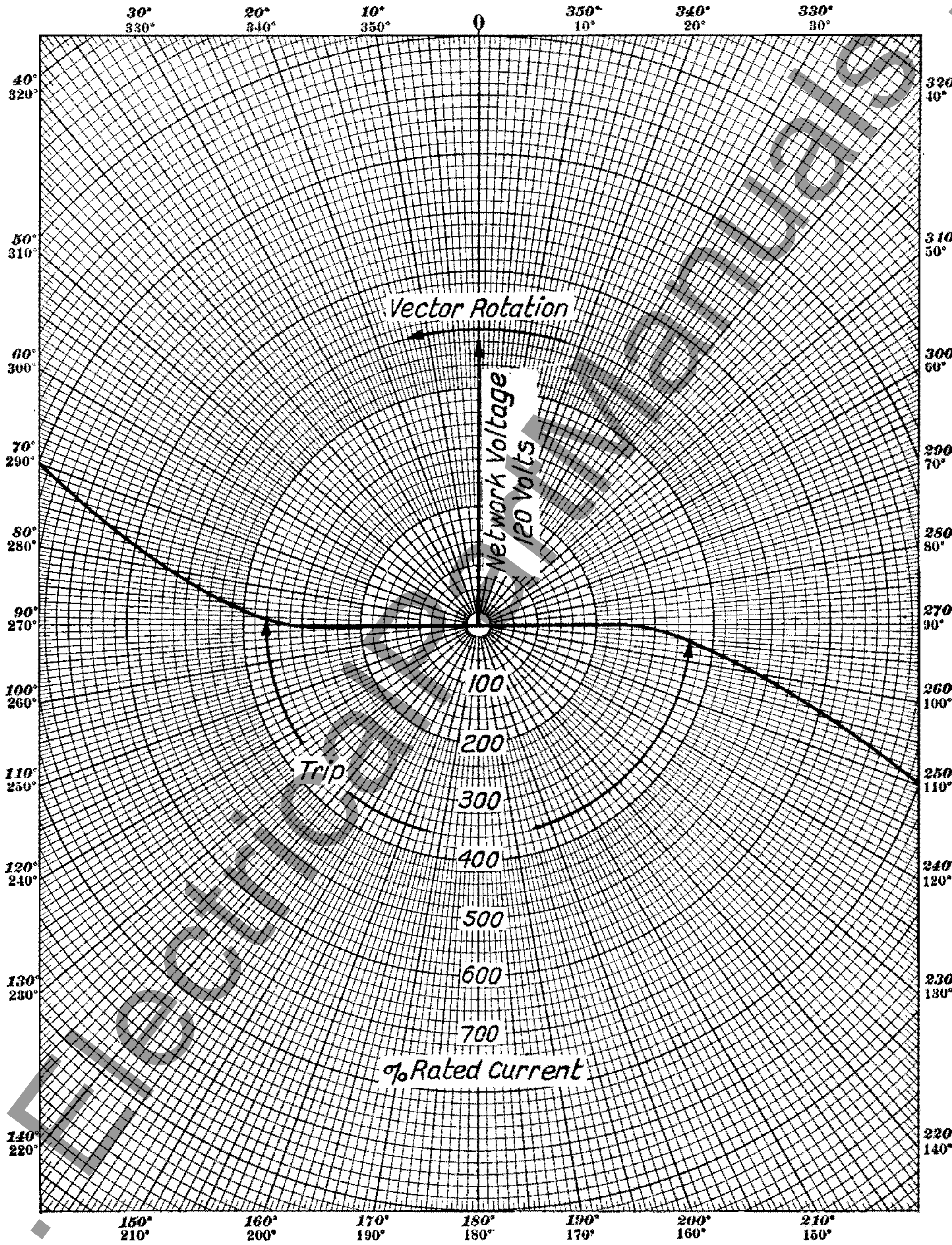


FIG. 8—TRIPPING CHARACTERISTICS OF THE TYPE CN-33 NETWORK MASTER RELAY. BALANCED THREE-PHASE CONDITIONS ASSUMED.

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, 125 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 CN-33 relay, namely, the overvoltage closing adjustment and the reverse-current tripping adjustment.

26. The normal range of overvoltage adjustment as set at the factory is 0.5 to 2.0 volts in phase with the network voltage or approximately 1.2 to 4.7 volts, 75° leading the network voltage. This range has been found to be sufficient for most network applications. If it is ever necessary the range may be changed by loosening the mounting screws and shifting the outer coil and iron assemblies individually. Smooth overvoltage closing adjustment within this range is made by changing the spiral spring tension by means of the geared adjuster, the shaft of which extends through the front bearing support. The adjuster has a screwdriver slot in a cupped recess and is insulated from the control circuits to prevent grounds when making adjustments. The overvoltage adjustment within the range should be made with all elements energized as in normal operation. When making overvoltage adjustments of any kind the current coils of all energized elements should be connected across the secondaries of network current transformers. The rating of the transformers used will not affect the adjustment.

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 in phase 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 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 times. 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 (Style No. 1059225) having a lower impedance of approximately 0.9 ohm 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 to deflect the contact springs until the back of the contact almost touches the main supporting arm when the drum is rotated to its two extreme positions. Securely lock the contact screws in position by means of their associated thumb nuts. The end play of the shaft should be adjusted to approximately 0.005 inch. This completes the necessary mechanical inspection.

32. Next, close switches "M", "A-A_1", "B-B_1", "C-C_1", "P" to the side marked 2, and "Y" to the side marked "●V" and adjust the spiral spring to obtain the required three-phase closing adjustment. Any adjustment from 1.2 to 4.7 volts leading the network voltage 75 degrees should be obtainable. The equivalent adjustment for voltages in phase with the network voltage will be approximately the 75 degree leading value divided by 2.35. This may be checked by substituting a 1 to 3 ohm non-inductive resistor for the air cored reactor in the test circuit. Only in very rare cases should it be necessary to change the overvoltage closing range by loosening the mounting screws and shifting the outer coil and iron assemblies.

33. With the overvoltage closing adjustment completed, 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. Experience indicates than an over-voltage closing adjustment of approximately 0.8 volt in phase (2 volts 75 degrees leading) and an in phase reverse current tripping setting of 0.2 per cent of the protector rating are correct for a majority of protector installations. The factory adjustments normally are made at these values. 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

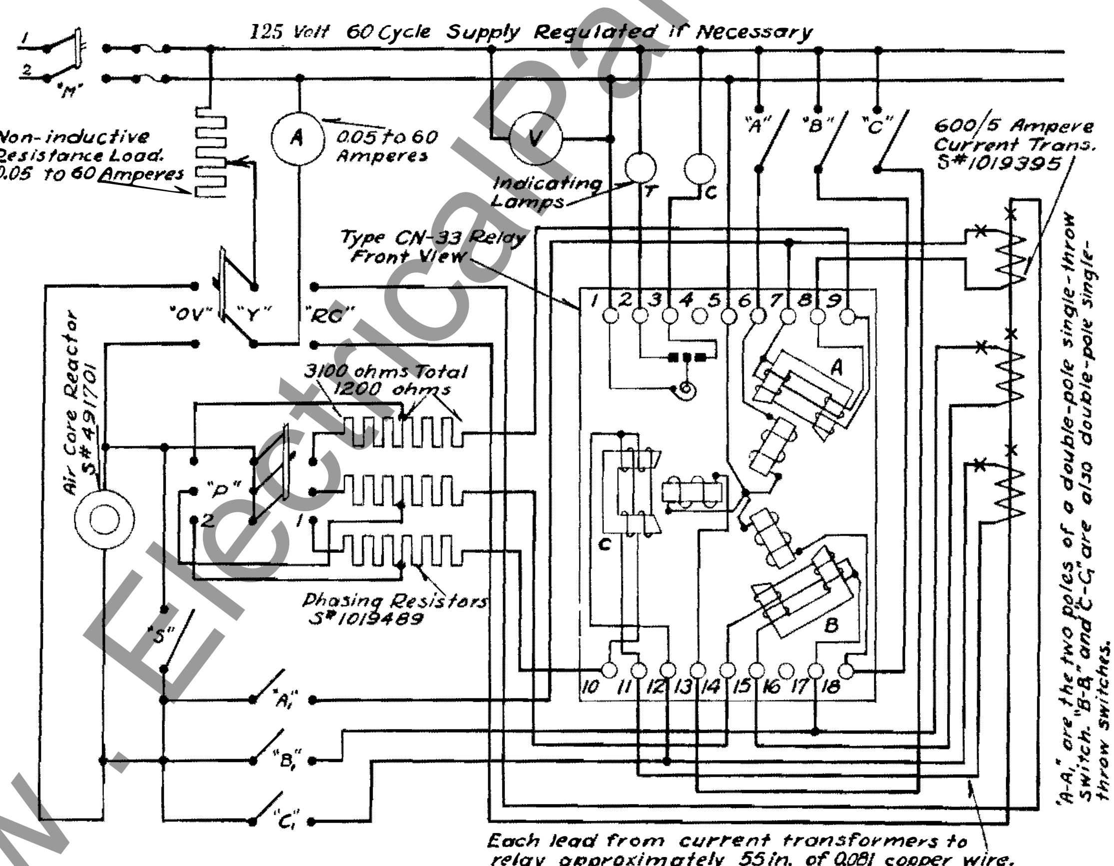


FIG. 9—TEST CONNECTIONS FOR SINGLE-PHASE TEST AND ADJUSTMENT OF THE TYPE CN-33 NETWORK MASTER RELAY.

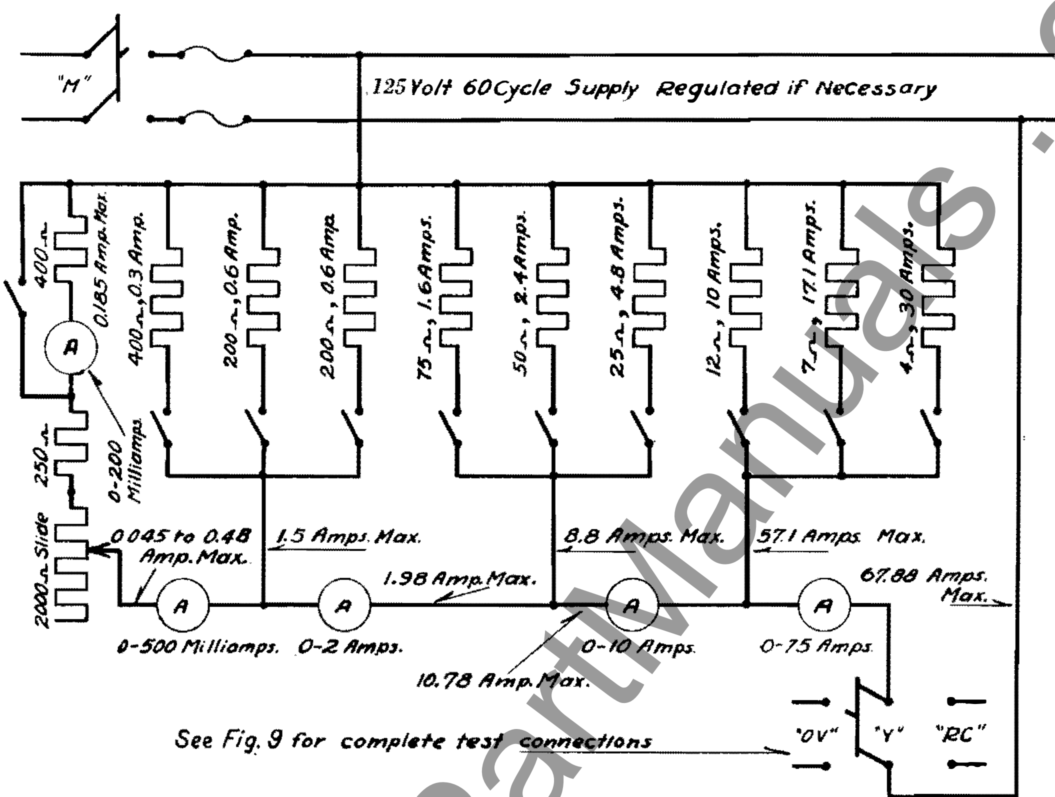


Fig. 10—Details of Load Bank and Ammeters for Use in Single-Phase Test of the Type CN-33 Network Master Relay.

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 an in phase 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 thumb 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 6258-3 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. 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 and the phasing relay is properly adjusted 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 counter-clockwise 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

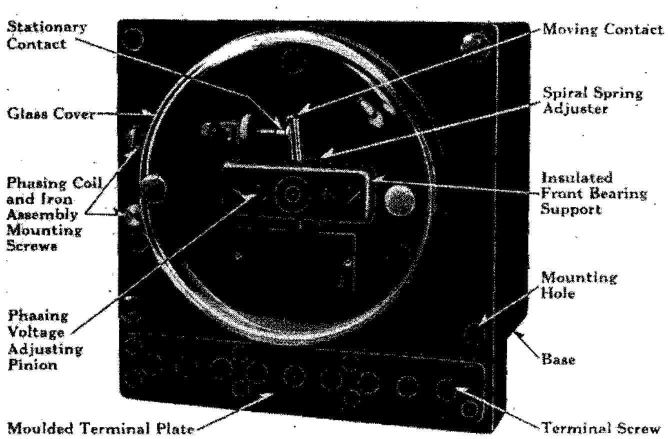


FIG. 11—TYPE CN-J NETWORK PHASING RELAY. FRONT VIEW WITH COVER ON.

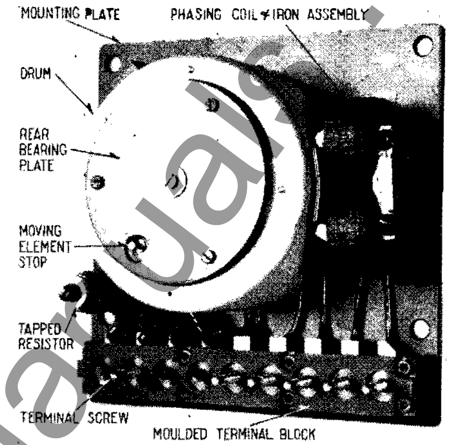


FIG. 12—TYPE CN-J NETWORK PHASING RELAY. REAR VIEW OF RELAY REMOVED FROM BASE

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 range of 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 spring adjuster, 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. This adjustment is made by means of the geared spring adjuster by rotating the adjuster pinion with a screwdriver as in the CN-33 relay. The range of overvoltage closing adjustment is set at the factory at 0 to 1.5 volts leading the network voltage 75 degrees with the resistor terminal screw in terminal No. 6. This range is sufficient for practically all

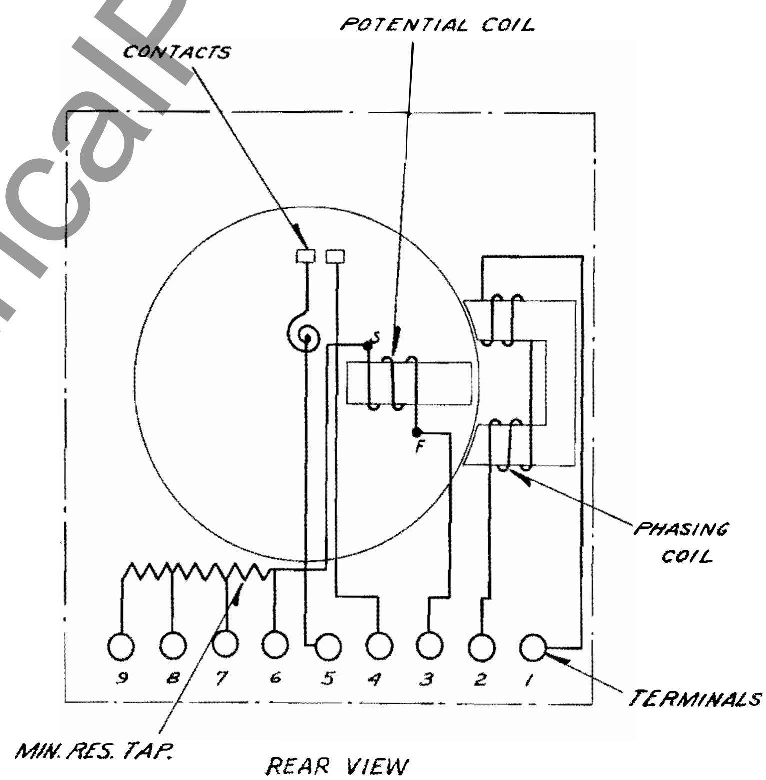


Fig. 13—Wiring Diagram of the Internal Connections of the Type CN-J Network Phasing Relay.

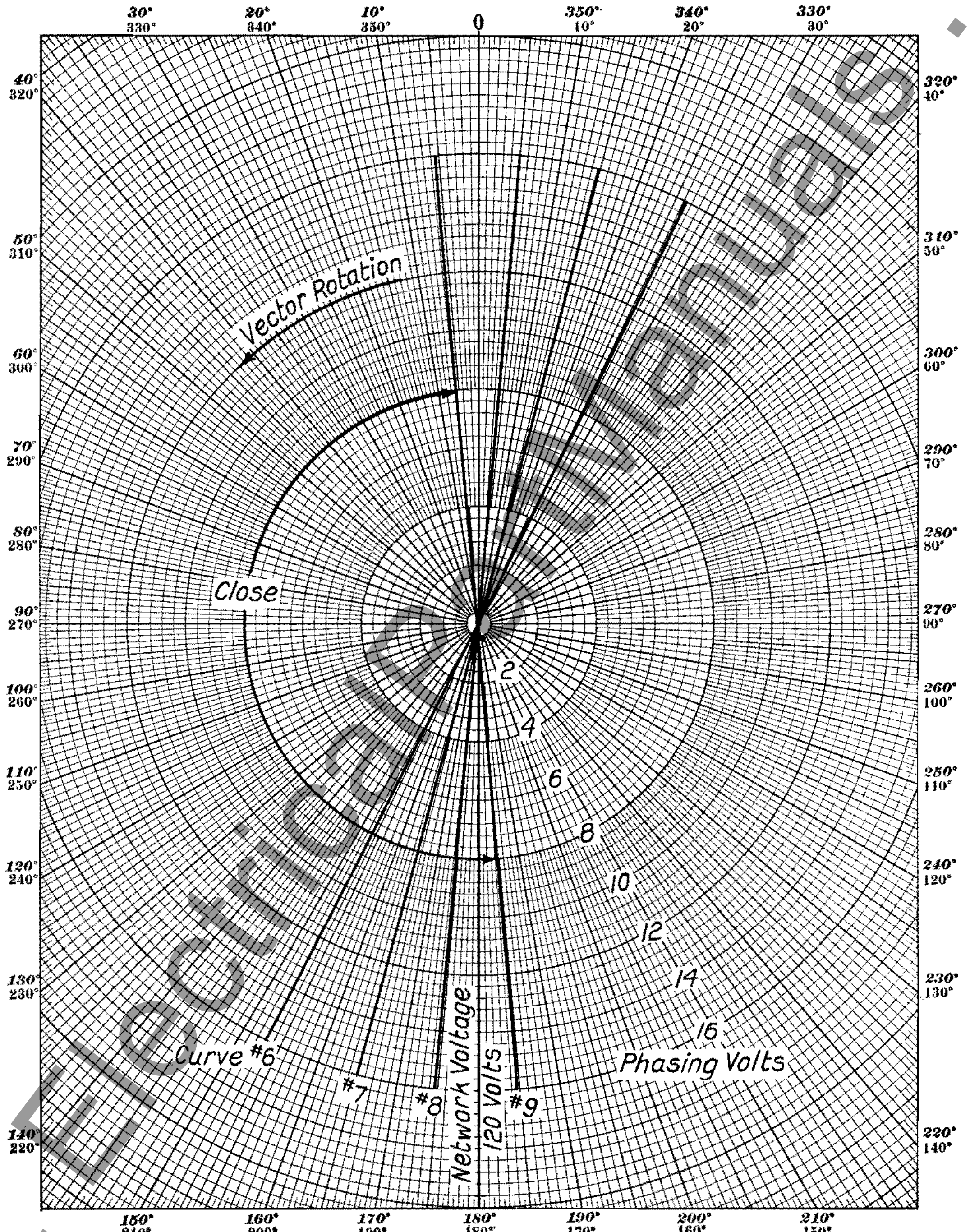


FIG. 14—CLOSING CHARACTERISTICS OF THE TYPE CN-J NETWORK PHASING RELAY.

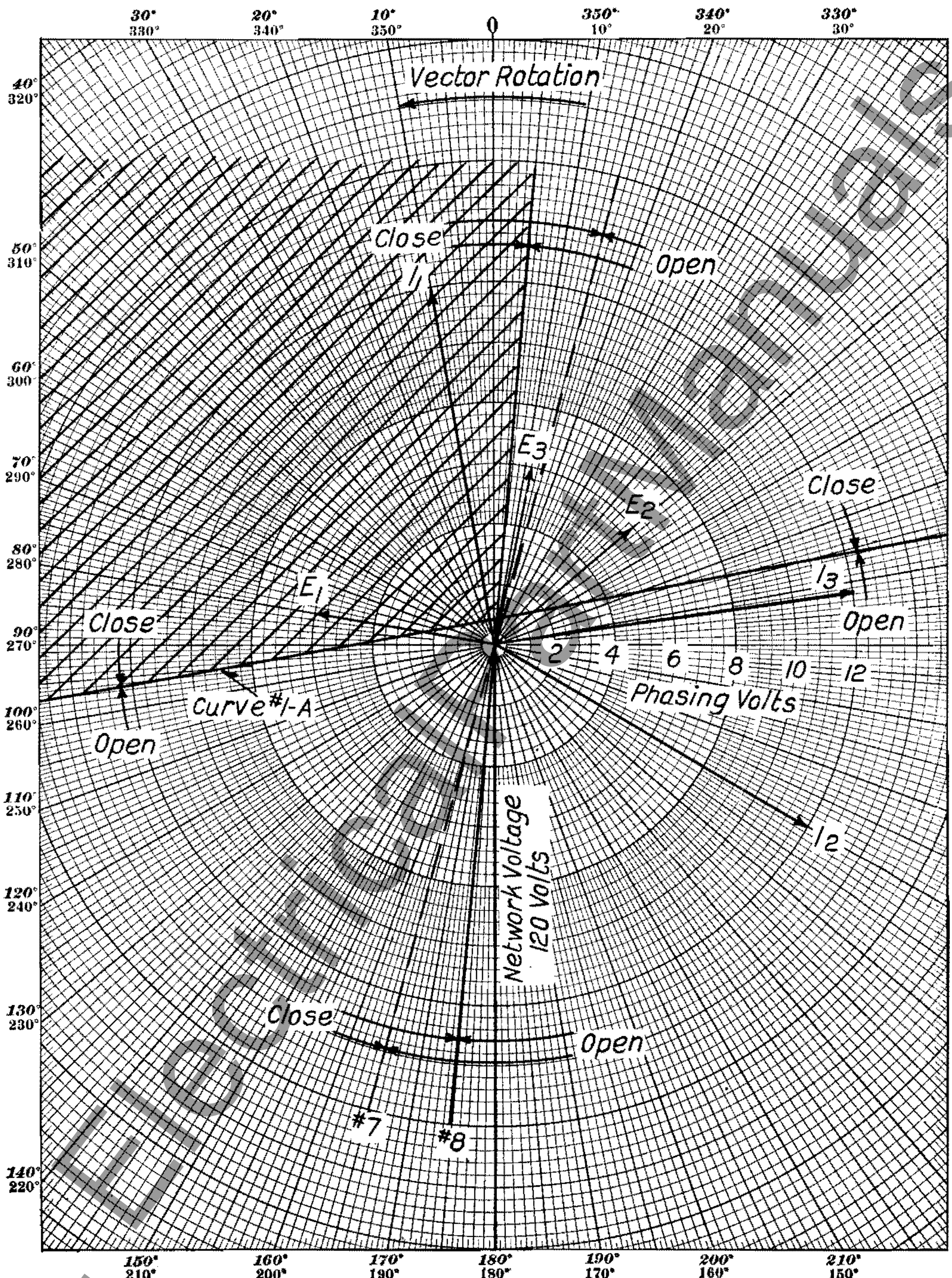


FIG. 15—COMBINED CLOSING CHARACTERISTICS OF THE TYPE CN-33 AND CN-J NETWORK RELAYS.

applications; if it is necessary to use settings outside of this range the range can be changed by shifting the outer coil and iron assembly.

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 to deflect the contact springs until the back of the contact almost touches the main supporting arm when the drum is rotated counterclockwise to its extreme position. 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. The range of overvoltage adjustment of the CN-J relay can be checked in the following manner: with the relay completely deenergized increase the closing tension, beyond the point where the contacts just close, by ¼ turn of the screwdriver adjuster. Then close switches B, L and M and increase the current through the reactor until the contacts just close. The corresponding phasing voltage (drop in the reactor) is the maximum limit of the overvoltage adjustment range. Open switch L and it should be possible to increase the spring tension until the relay contacts will again just close. This corresponds to zero phasing voltage.

53. To make the desired phasing voltage setting move the terminal screw located in terminal No. 6 to the 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. Close switches B, L and M and adjust the current through the reactor to give the desired phasing potential. Then adjust the spring tension so that the contacts just close. It is recommended that the phasing relay be adjusted to close at approximately zero volts. If the phasing voltage setting is nearly zero the adjustment should be checked by closing switches B, R and M and determining the voltage 75 degrees leading the network voltage reversed that causes the relay contacts to just open. This voltage should not exceed 0.15 volts. This recommended adjustment gives a value of

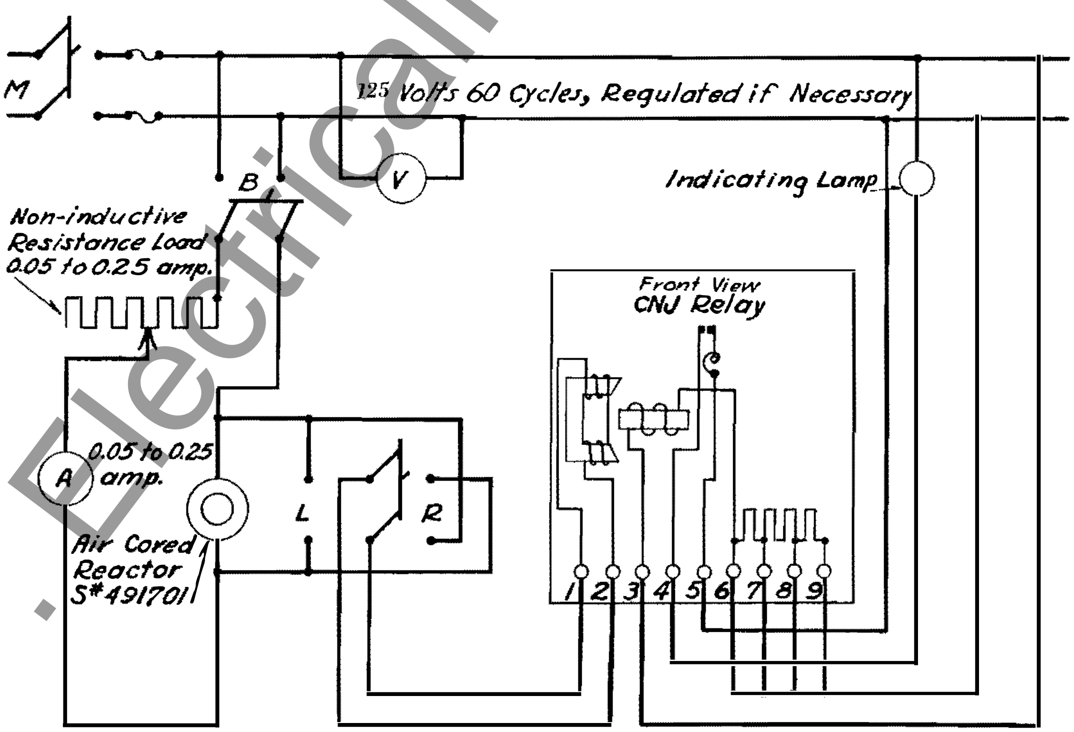


Fig. 16—Test Connections for Single-Phase Test and Adjustment of the Type CN-J Network Phasing Relay.

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 desirable to give the relay an adjustment which will require a negative value of phasing voltage leading the network voltage to close its contacts, it will be necessary to change the range of overvoltage by shifting the outer coil and iron assembly and then make the exact setting with the spiral spring adjuster. In no case should the spring tension be less than one-quarter turn of the adjuster pinion 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 thumb 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 CN-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 where 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.

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

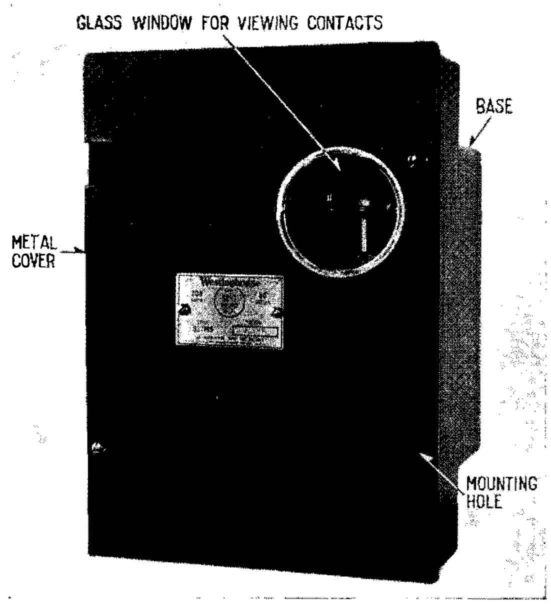


Fig. 17—Type SR-2 Voltage Restraining Relay, Front View with Cover On.

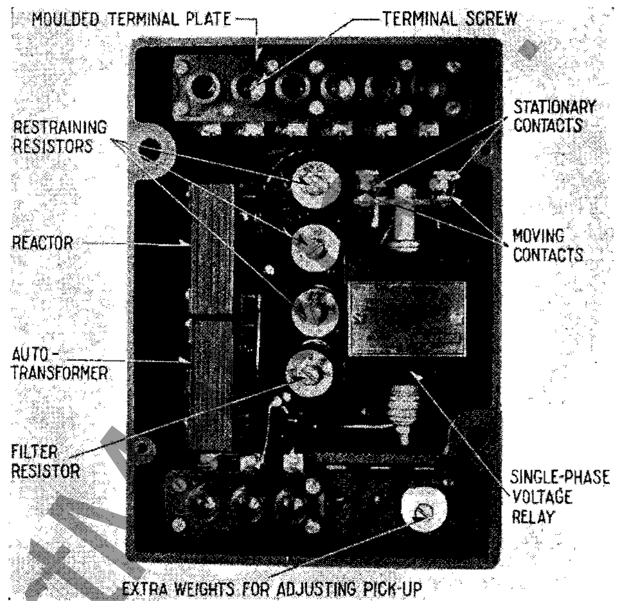


Fig. 18—Type SR-2 Voltage Restraining Relay Front View with Cover Removed.

CONSTRUCTION

59. The type SR-2 voltage restraining relay shown in Figs. 17 and 18 is a three phase voltage device used to make the type CN-33 relay insensitive to small power reversals under normal system conditions and sensitive under short-circuit conditions. The type SR-2 relay consists of a single plunger type voltage relay, a positive sequence voltage filter, and three tapped resistors all mounted in one case. The plunger type relay is a high drop-out over-voltage relay which closes two sets of silver contacts when it picks up. The two moving contacts are connected together so that they are electrically one. Weights are added on the bottom of the movable plunger to vary the minimum voltage at which the contacts close. A number of extra weights are located in the relay case to be used in adjusting the pick-up voltage should it be desired to change the standard setting of the relay. The positive sequence voltage filter consists of an autotransformer tapped at approximately its mid-point, a resistor, and a reactor. The resistor and reactor in series have a combined impedance angle of 60°. The voltage drop across the resistor is equal in magnitude to the voltage which appears across half the autotransformer. When the filter is properly connected to a positive sequence voltage source, the voltage across half the autotransformer and the drop across the resistor add together at 60°. The resultant voltage is proportional to the positive sequence voltage applied to the terminals of the filter. When only negative sequence voltage is applied to the filter the drop across the resistor is 180° from the autotransformer voltage so that the two cancel and give zero voltage across the coil of the voltage relay. The three tapped or restraining resistors are connected between the contacts of the voltage relay and the relay terminals as shown in Fig. 19. This figure also shows how the positive sequence voltage filter and the relay coil are connected inside the relay case.

60. The case and terminal construction of the SR-2 relay is similar to that used in the type CN-33 and type CN-J relays. The cover consists of a flat steel plate with a circular glass window in it through which the relay contacts are visible. The relay is mounted on two studs and held securely in place by two thumb nuts which when tightened force the terminal screws firmly into engagement with their associated terminal jaws on the protector.

OPERATION

61. The way in which the type SR-2 voltage restraining relay operates to render the type CN-33 relay and its associated network protector insensitive to small power reversals under normal system conditions and sensitive under short-circuit conditions can best be described in connection with Fig. 20. When the network protector is open the simultaneous closing of the type CN-J relay contacts and the closing contacts of the type CN-33 relay energizes the operating coil of the closing contactor or type SG relay. One set of the SG relay contacts shunts the contacts of the CN-J and CN-33 relays, thus sealing the SG relay in the energized position, and the other set of contacts completes the circuit of the closing motor. When the protector closes, its cut-off switch deenergizes the operating coil of the SG relay which drops out, thus deenergizing the closing motor and removing the shunt around the closing contacts of the CN-J and CN-33 relays. Two of the terminals of the positive sequence voltage filter in the SR-2 relay, namely, terminals No. 8 and No. 9 are permanently connected to phases "B" and "C" respectively of the network protector. The closing of the protector connects the third terminal, namely, terminal No. 7 of the filter through an auxiliary switch on the protector to phase "A". This places normal voltage on the positive sequence voltage filter and causes the voltage relay of the type SR-2 to pick up and close its contacts. The closing of these contacts connects the phasing coils of the type CN-33 relay in star through the tapped resistors of the type SR-2 relay, so that the phasing coils acting in conjunction with the CN-33 relay potential coils produce a restraining torque which holds the closing contacts of the type CN-33 relay firmly closed. In order to overcome this restraining torque additional current must be passed through the current coils of the CN-33 relay in the reverse direction before its tripping contacts can close. The amount of reverse current necessary to overcome the restraining torque and trip the network protector can be adjusted by changing taps on the resistors in the type SR-2 relay, which varies the amount of current through the phasing coils of the type CN-33 relay.

62. Only three terminal screws are supplied in the upper terminal block of the type SR-2 relay. The other three terminals are provided with short dummy screws to keep dust and dirt from entering the relay base. With these terminal screws located in terminals No. 1, No. 3, and No. 5 all of each tapped resistor in the SR-2 relay is connected in series with a phasing circuit of the CN-33 relay. Under this condition an in-phase reversal of approximately 20% of the protector rating is required to close the tripping contacts of the type CN-33 relay. By placing the three terminal screws in terminals No. 2, No. 4 and No. 6 only a portion of each tapped resistor in the SR-2 relay is connected in series with a phasing circuit of the CN-33 relay, and an in-phase reverse current setting of approximately 40% of the protector rating is obtained. The opening curve of the type CN-33 when the type SR-2 relay is in the normally energized position, so that the CN-33 relay phasing coils are functioning as restraining coils, is shown in Fig. 21. The SR-2 relay provides these in-phase reverse current setting of 20% or 40% when the type CN-33 relay has the usual sensitive reverse current setting of 0.2 to 0.3% of its protector rating. If the in-phase reverse current setting of the type CN-33 relay is increased by means of its reverse current adjusting screw to 10% the 20% and 40% settings obtained with the type SR-2 relay will increase to approximately 30% and 50% respectively. Thus by taking advantage of the adjustments and settings provided on the type CN-33 and type SR-2 relays and in-phase reverse current setting between approximately 0 to 10%, 20 to 30%, or 40 to 50% of the protector rating can be secured.

63. Having selected the reverse current setting desired and placed the terminal screws in the proper terminals no other setting or adjustment of the type SR-2 relay will ordinarily be required in service. The relay is adjusted at the factory to pick up on about 95% and drop out on 90% of normal positive sequence voltage. The pick-up voltage can be changed, however, if necessary by changing the number of weights attached to the movable plunger. The

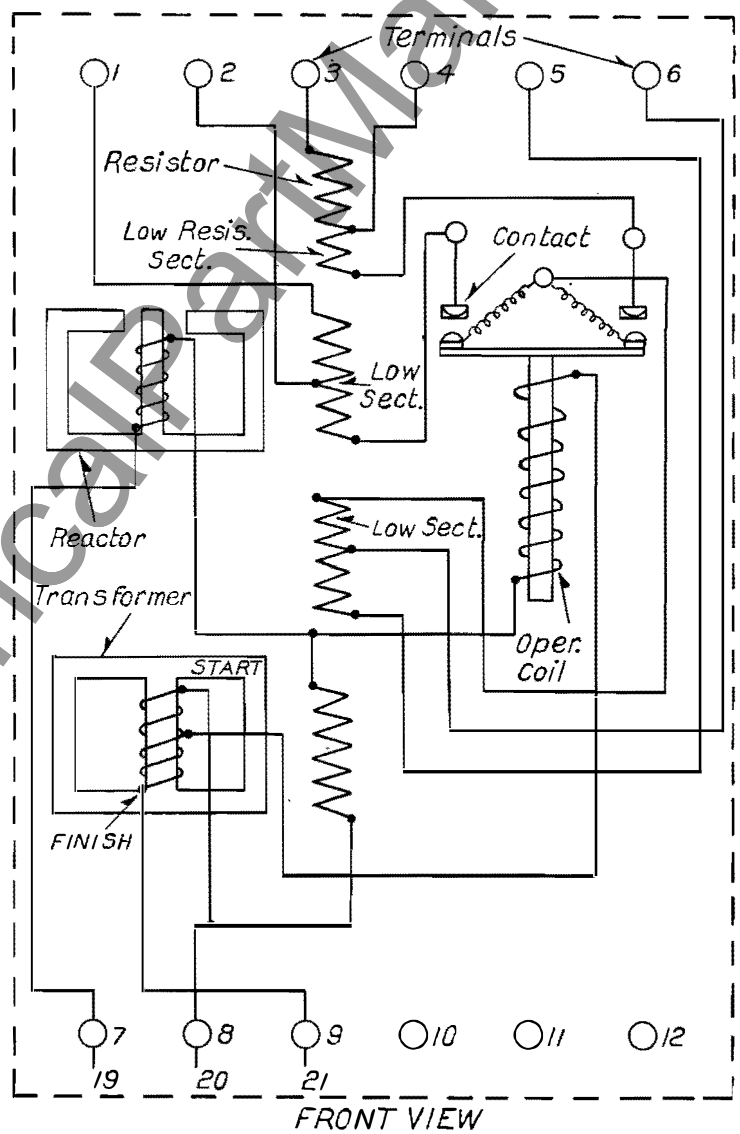


Fig. 19—Wiring Diagram of the Internal Connections of the Type SR-2 Voltage Restraining Relay.

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. The SR-2 relay is connected in the protector control circuits as shown in Fig. 20. As long as the relay terminals are fully screwed into their proper places, the SR-2 relay renders the protector insensitive to reversed currents according to the location of the terminal screws in the upper terminal block. The protector can be restored to continuously sensitive operation by simply removing the SR-2 relay from the protector, or by removing two of the three screws 7, 8 and 9. 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 1/8 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.

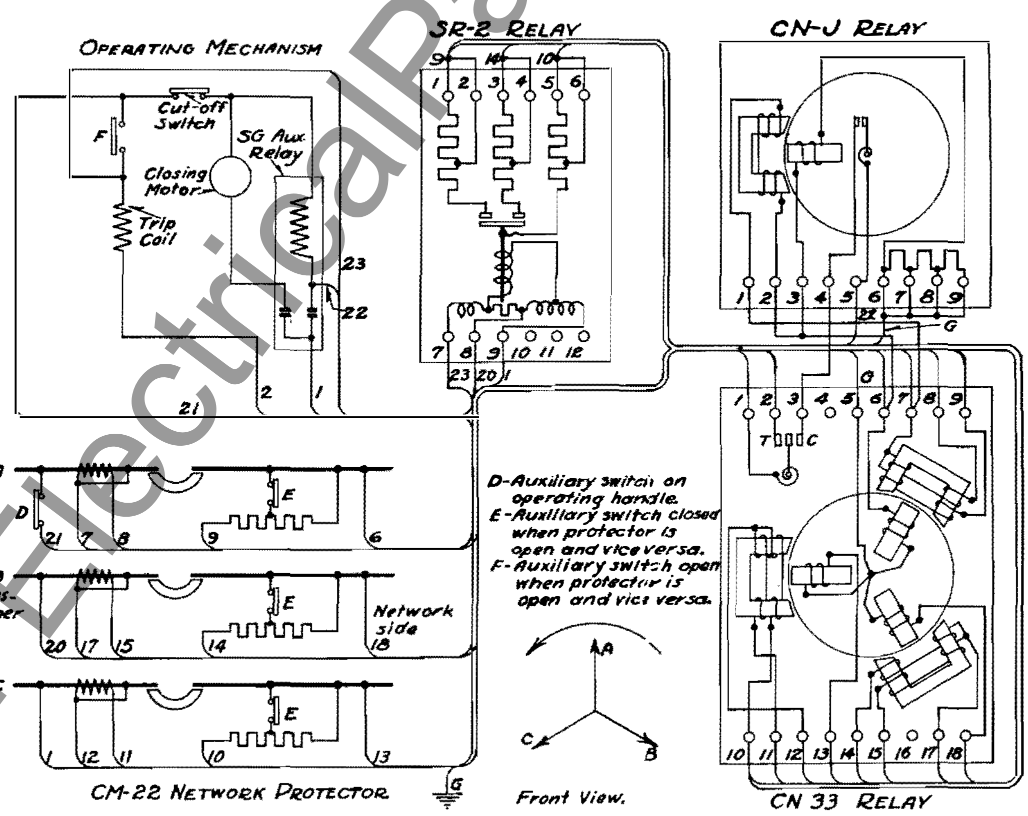


Fig. 20—Schematic Wiring Diagram of a Network Protector Controlled by Type CN-33, Type CN-J, and Type SR-2 Network Relays.

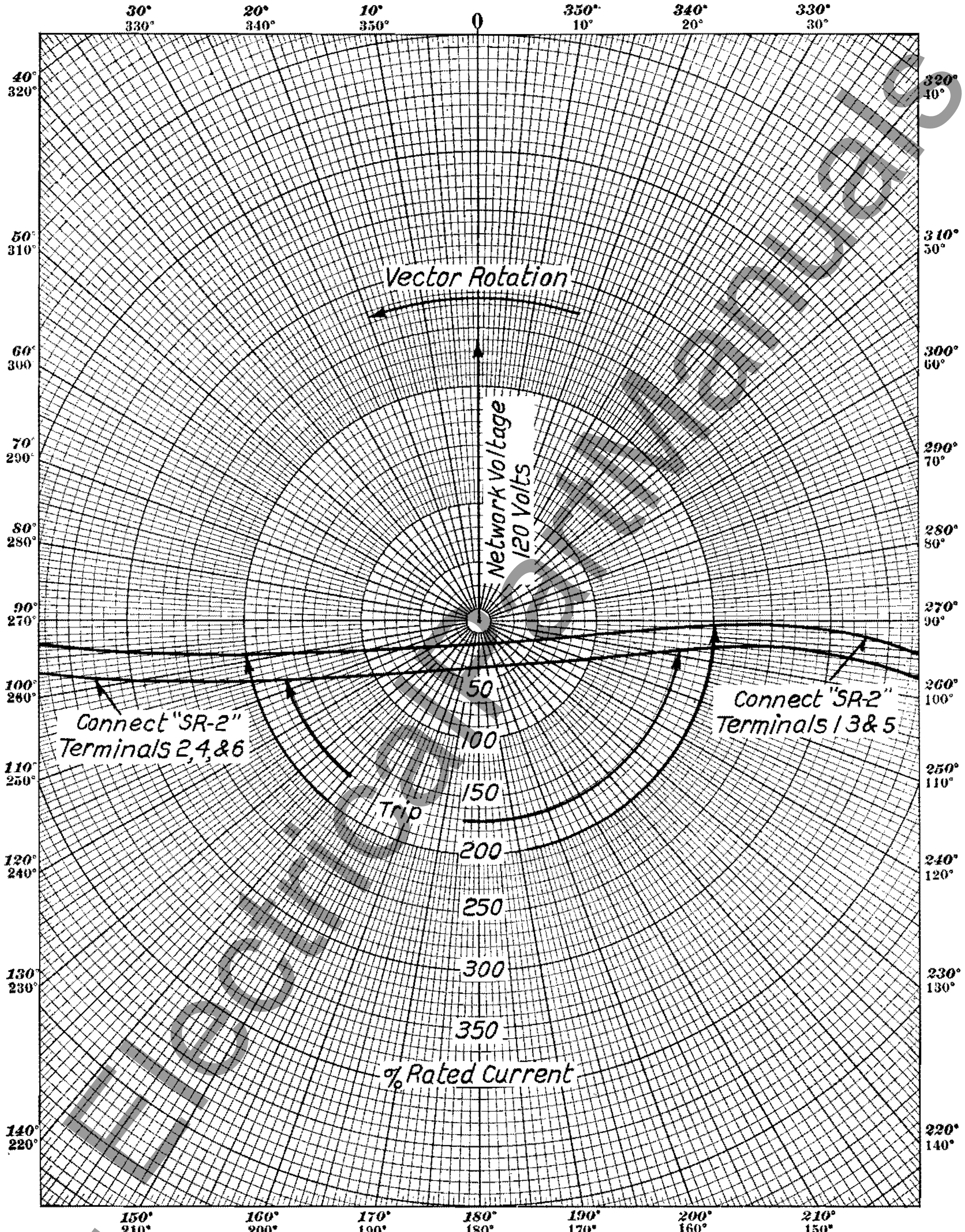


Fig. 21—Opening Characteristics of the Type CN-33 Network Master Relay when the Type SR-2 Voltage Restraining Relay is in the Normally Energized Position.

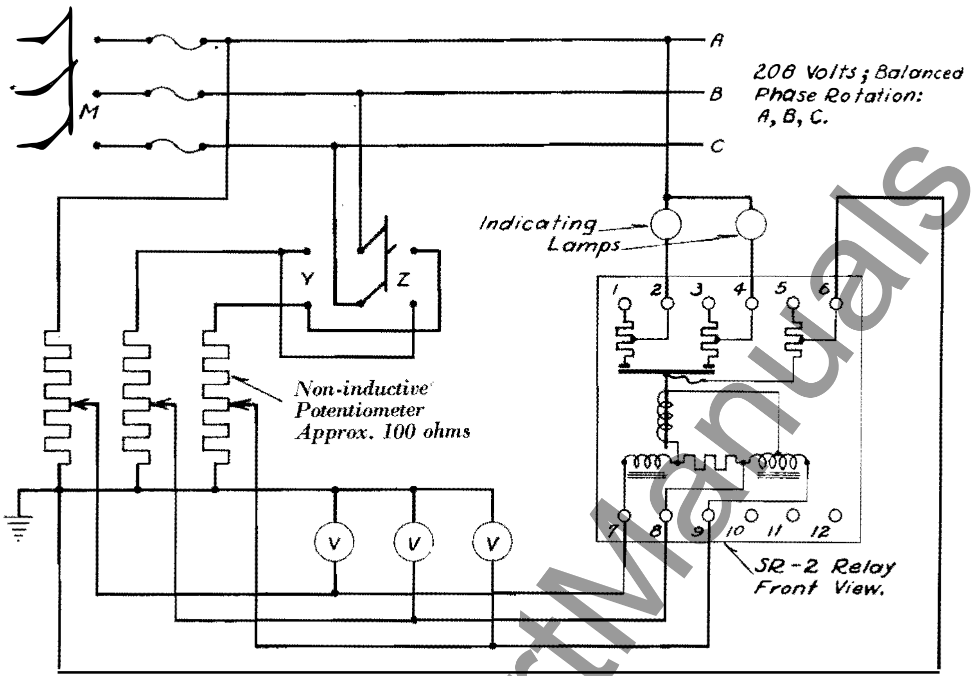


FIG. 22—TEST CONNECTIONS FOR THREE-PHASE TEST AND ADJUSTMENT OF THE TYPE SR-2 VOLTAGE RESTRAINING RELAY.

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 thumb 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.

70 RENEWAL PARTS DATA
NETWORK RELAYS

The following is a list of the Renewal Parts and the quantities of each that we recommend should be stocked by the user of this apparatus to minimize interrupted operation caused by breakdowns. The parts recommended are those most subject to wear in normal operation or those subject to damage or breakage due to possible abnormal conditions. This list of Renewal Parts is given only as a guide. When continuous operation is a primary consideration additional insurance against shut-downs is desirable. Under such conditions more Renewal Parts should be carried, the amount depending upon the severity of the service and the time required to secure replacement.

Recommended Stock of Renewal Parts
Type CN-33 Network Master Relay
FOR ILLUSTRATION OF PARTS SEE FIGS. 1 AND 2

Fig. No.	Name of Part	Style No. of Part		No. Req.	Recommended For Stock	
	Relays in use up to and including				1	5
1	Relay Complete	Plain Style	Sub A and B Style	1	0	0
1	Terminal Screw	1 009 350	1 009 350	18	0	0
1	Moving Contacts	1 009 341	1 009 341	1	0	0
1	Moving Contact and Support	5 61649	5 61 649	2	2	4
1	Reverse Current Spring (1 51/64" Long)	939 386	939 386	1	0	1
1	Reverse Current Spring (1 19/32" Long)	939 387	939 387	1	0	1
1	Reverse Current Spring (1 3/8" Long)	939 388	939 388	1	0	1
*	Spiral Spring	1 095 879	1 095 879	1	0	1
1	Stationary Tripping Contact	1 009 340	1 009 340	1	1	2
1	Stationary Tripping Contact Thumb Nut	559 072	559 072	1	0	0
1	Overvoltage Adjusting Pinion	— — —	1 096 308	1	0	0
*	Overvoltage Adjusting Screw	1 009 332	— — —	3	0	0
1	Glass Cover	1 000 829	1 000 829	1	0	0
1	Cover Screw	1 009 317	1 095 855	2	0	0
1	Moulded Terminal Plate	1 001 773	1 001 773	2	0	0
1	Base	939 385	939 385	1	0	0
1	Stationary Closing Contact	1 009 340	1 009 340	1	1	2
1	Stationary Closing Contact Thumb Nut	559 072	559 072	1	0	0
1	Spiral Spring Adjuster	1 009 335	1 096 300	1	0	0
1	Front Bearing Plate	1 009 342	1 009 342	1	0	0
1	Front Bearing Plate Insulating Cover	— — —	1 095 855	1	0	0
1	Reverse Current Adjusting Screw	1 009 344	1 095 856	1	0	0
2	Current and Phasing Coils and Iron (60 Cycles)	937 711	1 096 760	3	0	0
2	Current and Phasing Coils and Iron (50 Cycles)	1 094 869	1 096 761	3	0	0
2	Drum with Moving Element Stop	1 009 349	1 009 349	1	0	0
2	Rear Bearing Plate with Stationary Stop	1 009 346	1 009 346	1	0	0
*	Potential Coil and Iron (60 Cycles)	937 712	937 712	3	0	0
*	Potential Coil and Iron (50 Cycles)	938 657	938 657	3	0	0
2	Moulded Terminal Block	1 001 774	1 001 774	2	0	0
2	Damping Magnet	1 009 353	1 009 353	∅	0	0

* Not illustrated. — — — Not used.
∅ Required 1 for plain and Sub A and 2 for Sub B Style.
Parts indented are included in the part under which they are indented.

Type CN-J Network Phasing Relay
FOR ILLUSTRATION OF PARTS SEE FIGS. 11 AND 12

11	Relay Complete	Plain Style	Sub A Style	1	0	0
11	Moving Contact	1 009 359	1 009 359	1	0	0
11	Moving Contact and Support	561 649	561 649	1	1	2
11	Stationary Contact	1 009 340	1 009 340	1	1	2
11	Stationary Contact Thumb Nut	559 072	559 072	1	0	0
11	Glass Cover	1 009 829	1 009 829	1	0	0
11	Phasing Voltage Adjusting Pinion	— — —	1 096 308	1	0	0
*	Phasing Voltage Adjusting Screw	1 009 332	— — —	1	0	0
11	Moulded Terminal Plate	1 001 773	1 001 773	1	0	0
11	Spiral Spring Adjuster	1 009 335	1 096 300	1	0	0
11	Front Bearing Support	1 009 342	1 009 342	1	0	0
11	Front Bearing Support Insulating Plate	— — —	1 095 855	1	0	0
11	Base	939 384	939 384	1	0	0
11	Terminal Screw	1 009 350	1 009 350	6	0	0
12	Mounting Plate	1 009 357	1 009 357	1	0	0
12	Drum with Moving Element Stop	1 009 349	1 009 349	1	0	0
*	Potential Coil and Iron (60 Cycles)	1 008 327	1 008 327	1	0	0
*	Potential Coil and Iron (50 Cycles)	938 658	938 658	1	0	0
12	Rear Bearing Plate	1 009 346	1 009 346	1	0	0
12	Tapped Resistor (60 Cycle Relays)	1 002 290	1 002 290	1	0	1
12	Tapped Resistor (50 Cycle Relays)	1 003 922	1 003 922	1	0	1
12	Phasing Coil and Iron	9.37 710	1 096 759	1	0	0
12	Moulded Terminal Block	1 001 774	1 001 774	1	0	0

* Not illustrated. — — — Not used.
Parts indented are included in the part under which they are indented.

Type SR-2 Voltage Restraining Relay
FOR ILLUSTRATION OF PARTS SEE FIGS. 17 AND 18

Fig. No.	Name of Part	Style No. of Part	No. Req.	Recommended For Stock	
	Relays in use up to and including			1	5
17	Relay Complete	937 185	1	0	0
18	Single Phase Voltage Relay	....	1	0	0
18	Moving Contact	819 792	1	1	2
*	Shunt	724 041	1	0	0
*	Coil	703 435	1	0	1
18	Stationary Contact	819 793	2	2	4
17	Metal Cover with Glass Window	939 391	1	0	0
17	Glass Window	376 740	1	0	0
17	Base	939 390	1	0	0
18	Moulded Terminal Plate (Top)	939 392	1	0	0
18	Moulded Terminal Plate (Bottom)	939 393	1	0	0
18	Restraining Resistor	723 989	3	0	1
18	Reactor	724 024	1	0	0
18	Autotransformer	724 025	1	0	0
18	Filter Resistor (1150 Ohms)	407 279	1	0	1
18	Terminal Screw	1 009 350	6	0	0
18	Extra Weights for Adjusting Pick-Up	780 812	3	0	0

* Not illustrated.
Parts indented are included in the part under which they are indented.

ORDERING INSTRUCTIONS

When ordering Renewal Parts, always specify the name of the part wanted as shown on the illustrations in this Instruction Book, giving Style Number, and the type of Relay as shown on the nameplate. For Example: **One Moving Contact, Style No. 819792, for Type SR-2 Network Relay, Style No. 937185.**

To avoid delays and misunderstandings, note carefully the following points:

1. Send all correspondence and orders to the nearest Sales Office of the Company.
2. State whether shipment is to be made by freight, express or parcel post. In the absence of instructions, goods will be shipped at our discretion. Parcel post shipments will be insured only on request. All shipments are at purchaser's risk.
3. Small orders should be combined so as to amount to a value of at least **$1.00** net. Where the total of the sale is less than this, the material will be invoiced at **$1.00.**

Westinghouse

Types CN-33, CN-J and BN Network Relays

Instruction Book

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

Westinghouse Electric Corporation
East Pittsburgh, Pa.

I. B. 5794-C
Filing No. 35-000

Index

Westinghouse

Types CN-33, CN-J and BN Network Relays

General Application

1. The types CN-33, CN-J, and BN relays have been designed to control the operation of the types CM-22 and CM-44 network protectors which are 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. Network protectors are connected in the secondary leads of all network transformer banks 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 and CM-44 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 0.2% 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 BN timing relay should be added to the protector. This relay can be set to delay sensitive tripping operations of the CN-33 relay (that is, all tripping operations below full-load current) from one to five minutes and yet permit instantaneous tripping of the associated protector when reverse currents exceed full-load magnitude. These features provide a ready means for eliminating excessive numbers of protector operations without sacrificing the sensitive tripping characteristics of the master relay. However, the timing feature may be entirely eliminated to permit reverse currents of less than full-load magnitude to flow continuously through the protector if desired. All types CM-22 and CM-44 protectors are provided with the necessary wiring and mounting facilities for the type BN 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 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.

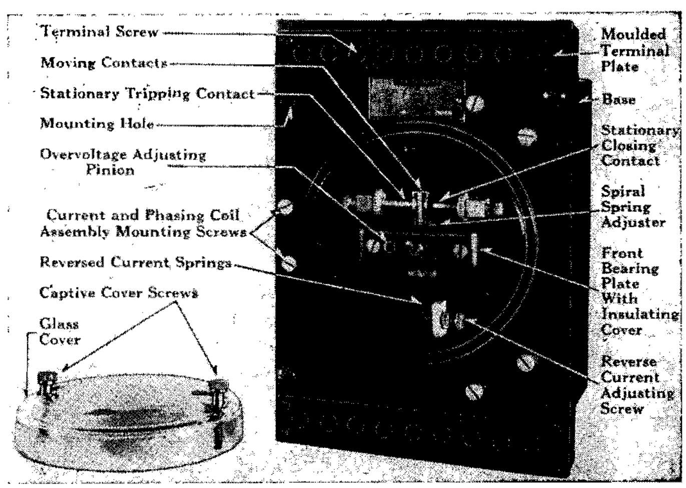


FIG 1—TYPE CN-33 NETWORK MASTER RELAY. FRONT VIEW WITH GLASS COVER REMOVED.

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 large and sturdy. This drum is carried on a horizontal tool steel shaft which rotates through 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 encircle the ends of the drum shaft to prevent its being thrown off the knife-edges during heavy torque conditions. The knife-edges extend 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.

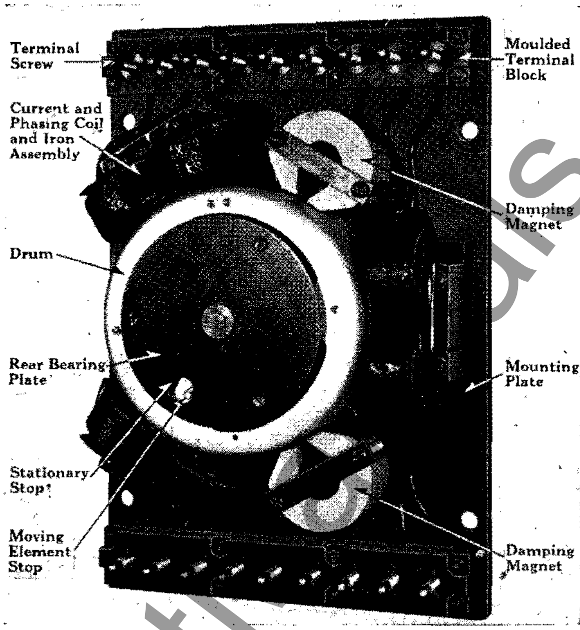


FIG. 2—TYPE CN-33 NETWORK MASTER RELAY. REAR VIEW OF RELAY REMOVED FROM BASE.

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 insulating 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.

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 on 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. Gear teeth on the adjuster engage a pinion, the insulated shaft of which extends through a hole in the front bearing plate. The spring tension is easily adjusted by rotating the pinion with a screwdriver without danger of grounding the spring assembly. This adjustment is located under the glass cover to prevent unauthorized changing of adjustments.

10. The use of a large diameter drum, two small permanent magnets for damping the movement of the drum, and a

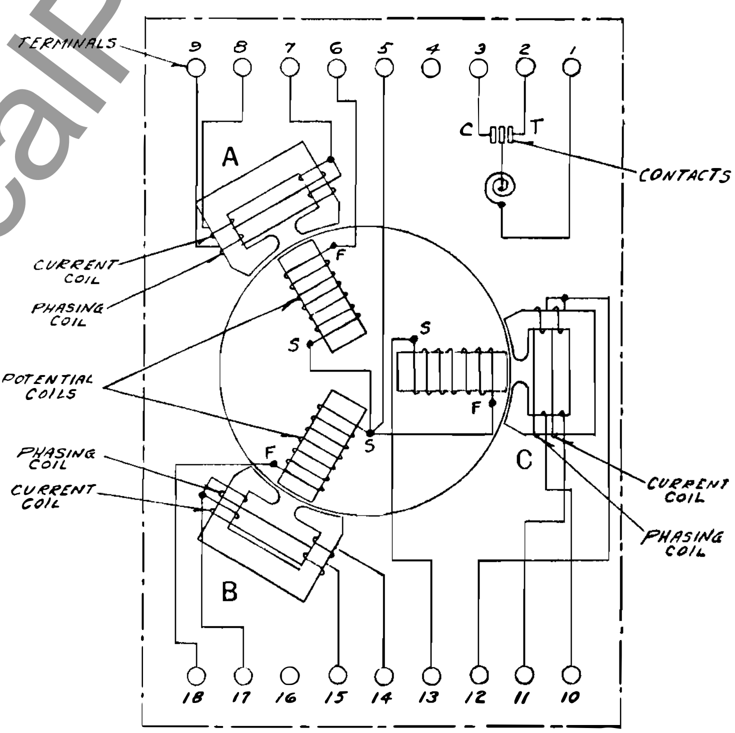
solid stop on the moving element which limits the movement of the drum to a relatively small angle have made it possible to eliminate all gears from the relay without getting into difficulty from bouncing of the relay contacts. The elimination of gears simplifies the construction of the relay and removes a source of friction difficulties. The small permanent magnets are carried on the back of the mounting plate where they are 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 125 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 relatively small wire are machine wound. Onephasing 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 securely fastened to the back of the mounting plate by two screws. The relay is so assembled at the factory that the air gaps between the two sections of each electromagnet are symmetrically unbalanced to provide the normal range of overvoltage adjustment. The overvoltage adjustment within this range is made by the geared spring adjuster under the glass cover. If it is ever necessary, the range of overvoltage adjustment can be changed by loosening the two mounting screws of each outer coil and iron assembly and shifting the assembly through a small angle with a wrench (Style No. 1095881). When the desired range is obtained, the mounting screws should be securely tightened.

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 screws and serves to protect the relay contacts, reverse-current and overvoltage adjustments, 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 tapped holes in small brass plates which are silver 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 thumb 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



REAR VIEW

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

ground or between screws. By partially 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 below a shoulder under 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 be mounted on or removed from the protector readily without disturbing any leads and without any possibility of connecting it incorrectly, merely by tightening or removing the two thumb 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 CN-33 relay and open the contacts of the CN-J relay. 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. For this reason the indicator lamp in the protector is connected in parallel with the phasing relay potential coil so that the CN-J relay as well as the CN-33 will close its closing contacts under all dead network conditions. Therefore, 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 the network are open. Now suppose that some network feeder, other than

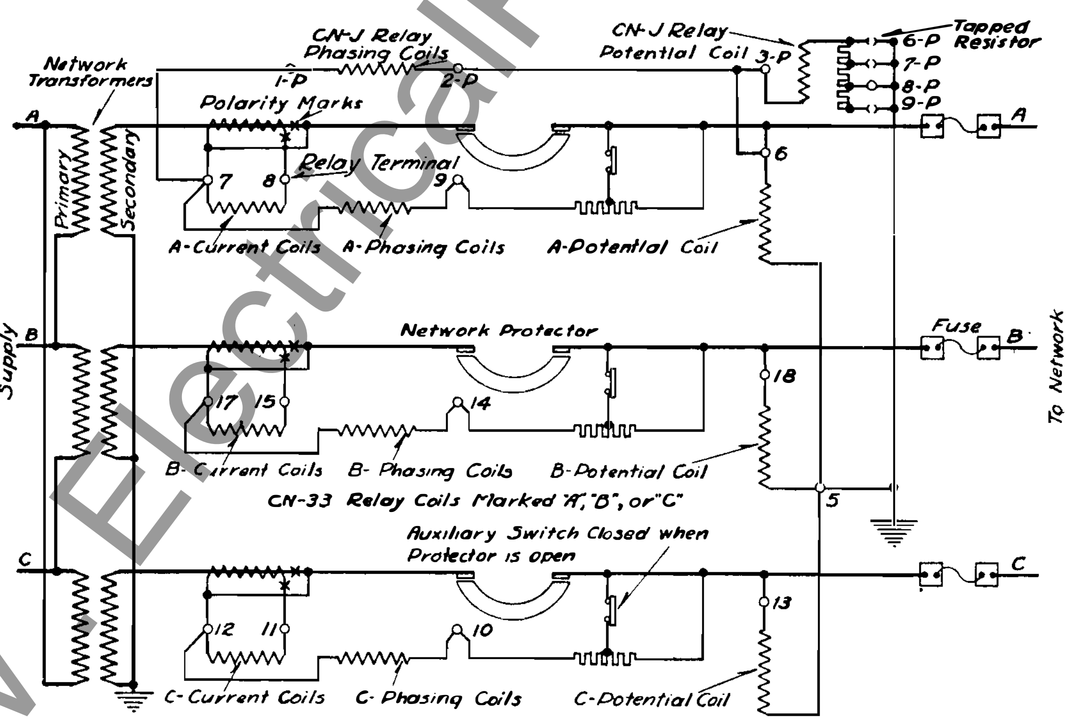


Fig 4—Schematic Diagram of Internal and External Connections of Type CN-33 and CN-J Network Relays Used on a Three-Phase Network with a Grounded Neutral—Control Circuits Omitted.

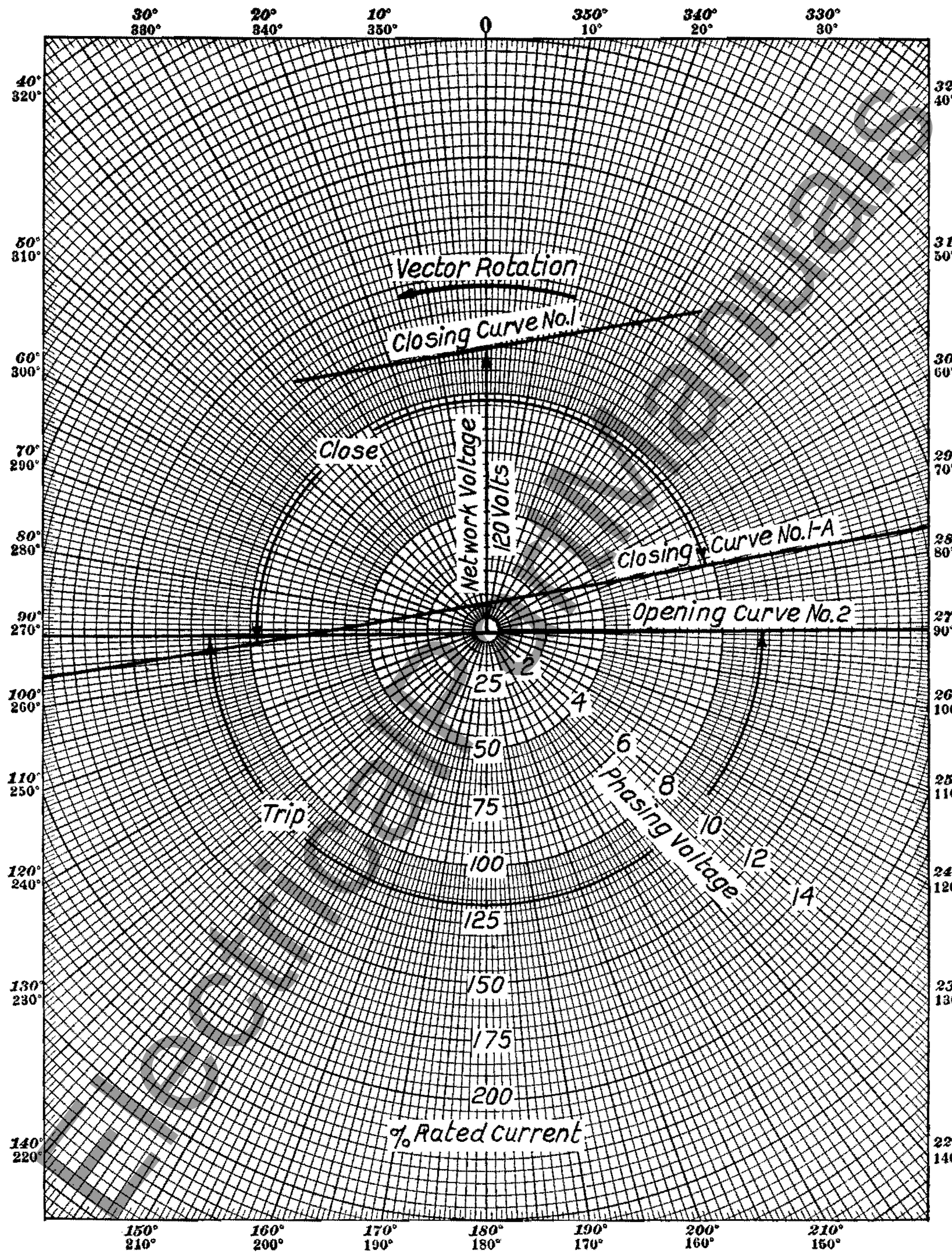
the one to which the transformer bank of Fig. 4 is connected, is energized by closing its breaker at the station. The network protectors on that feeder will close and connect it to the network as has been explained. This energizes the low voltage network and both the potential and phasing circuits of 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 to fix the range of 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 cause 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, if the CN-J contacts are closed.

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, if the relay has a sensitive setting. 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



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

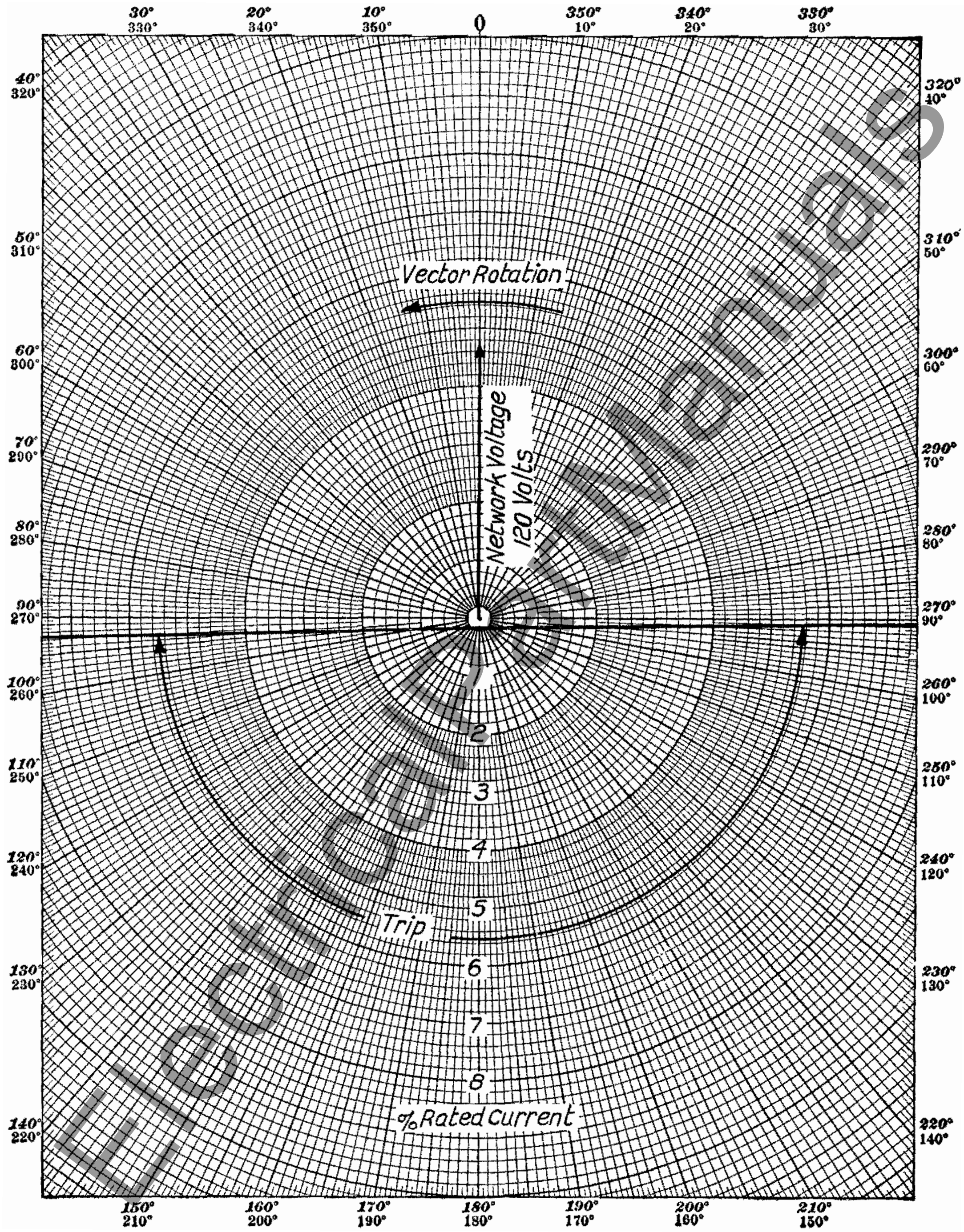


Fig. 6—Tripping Characteristics of the Type CN-33 Network Relay. Balanced Three-Phase Conditions Assumed.

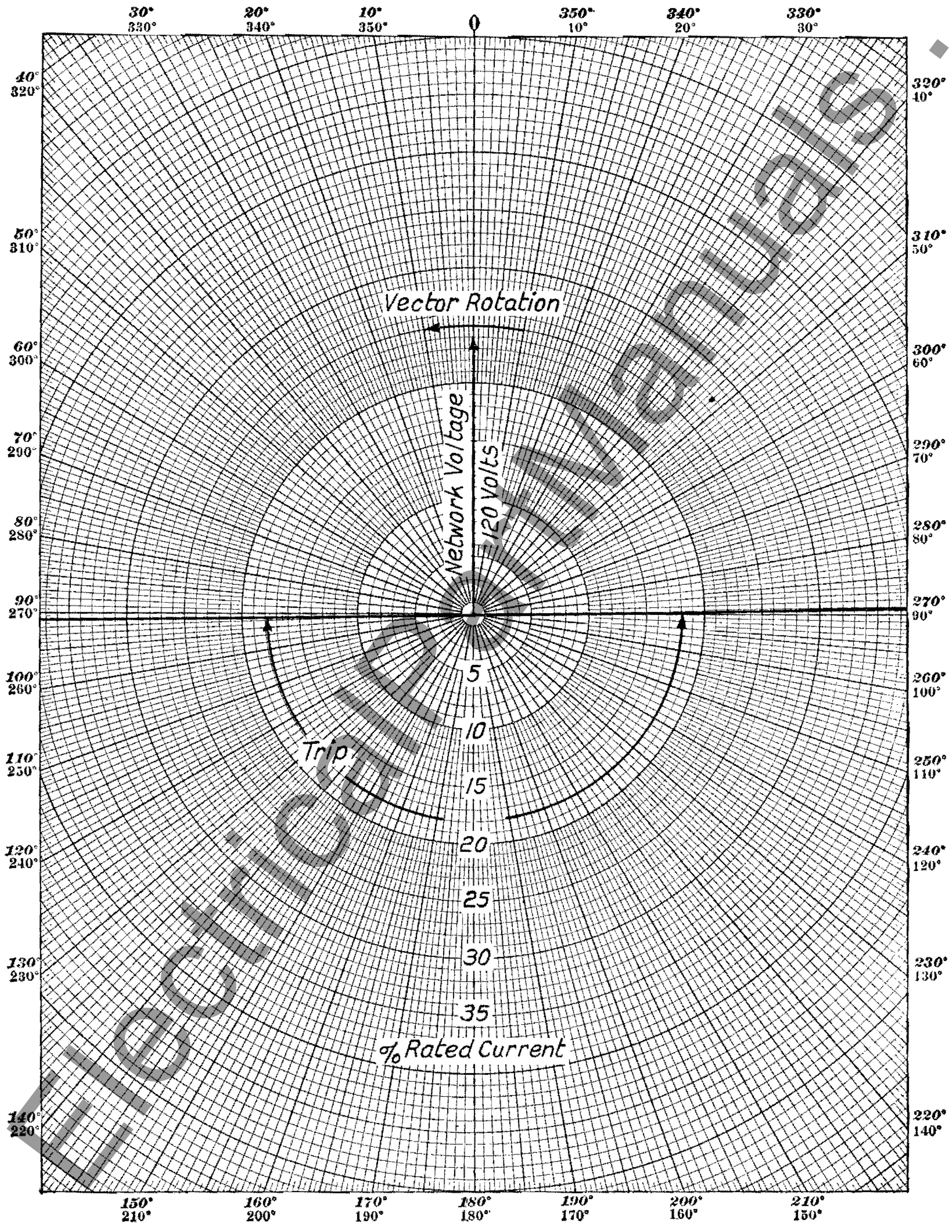


FIG 7—TRIPPING CHARACTERISTICS OF THE TYPE CN-33 NETWORK MASTER RELAY
BALANCED THREE-PHASE CONDITIONS ASSUMED.

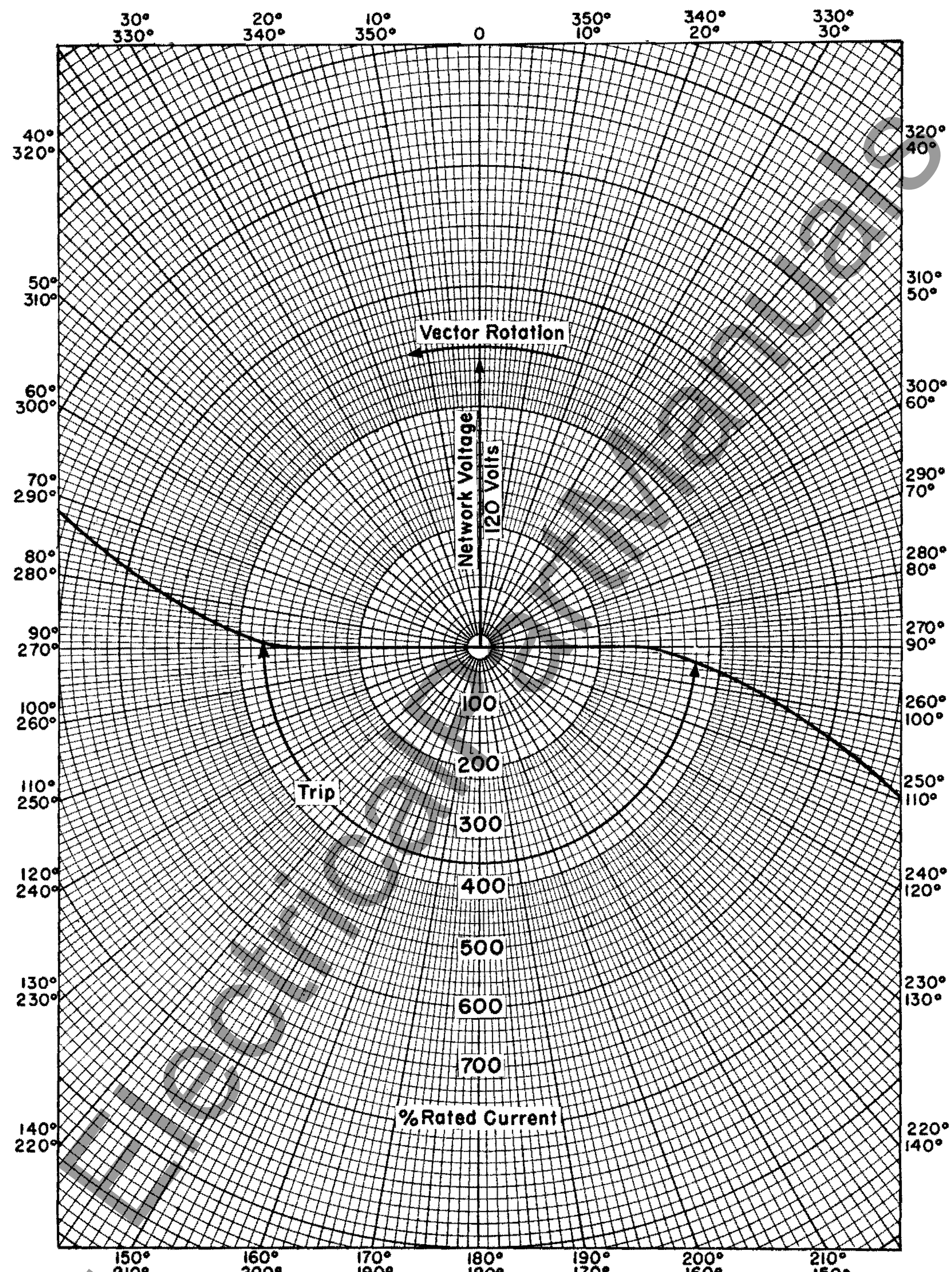


FIG. 8—TRIPPING CHARACTERISTICS OF THE TYPE CN-33 NETWORK MASTER RELAY.
BALANCED THREE-PHASE CONDITIONS ASSUMED.

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 CN-33 relay, namely, the overvoltage closing adjustment and the reverse-current tripping adjustment.

26. The normal range of overvoltage adjustment as set at the factory is 0.5 to 2.0 volts in phase with the network voltage or approximately 1.2 to 4.7 volts, 75° leading the network voltage. This range has been found to be sufficient for most network applications. If it is ever required the range may be changed by loosening the mounting screws and shifting the outer coil and iron assemblies individually. Smooth overvoltage closing adjustment within this range is made by changing the spiral spring tension by means of the geared adjuster, the shaft of which extends through the front bearing support. The adjuster has a screwdriver slot in a cupped recess and is insulated from the control circuits to prevent grounds when making adjustments. The overvoltage adjustment within the range should be made with all elements energized as in normal operation. When making overvoltage adjustments of any kind the current coils of all energized elements should be connected across the secondaries of network current transformers. The rating of the transformers used will not affect the adjustment.

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 in phase 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 in parallel, 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 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 times. 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 (Style No. 1059225) having a lower impedance of approximately 0.9 ohm 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 to deflect the contact springs until the back of the contact almost touches the main supporting arm when the drum is rotated to its two extreme positions. Securely lock the contact screws in position by means of their associated thumb nuts. The end play of the shaft should be adjusted to approximately 0.005 inch. This completes the necessary mechanical inspection.

32. Next, close switches "M", "A-A_1", "B-B_1", "C-C_1", "P" to the side marked 2, and "Y" to the side marked "OV" and adjust the spiral spring to obtain the required three-phase closing adjustment. Any adjustment from 1.2 to 4.7 volts leading the network voltage 75 degrees should be obtainable. The equivalent adjustment for voltages in phase with the network voltage will be approximately the 75 degree leading value divided by 2.35. This may be checked by substituting a 1 to 3 ohm non-inductive resistor for the air cored reactor in the test circuit. Only in very rare cases should it be necessary to change the overvoltage closing range by loosening the mounting screws and shifting the outer coil and iron assemblies.

33. With the overvoltage closing adjustment completed, 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. Experience indicates than an overvoltage closing adjustment of approximately 0.8 volt in phase (2 volts 75 degrees leading) and an in phase reverse current tripping setting of 0.2 per cent of the protector rating are correct for a majority of protector installations. The factory adjustments normally are made at these values. 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. For example, the magnetizing energy taken by a particular design

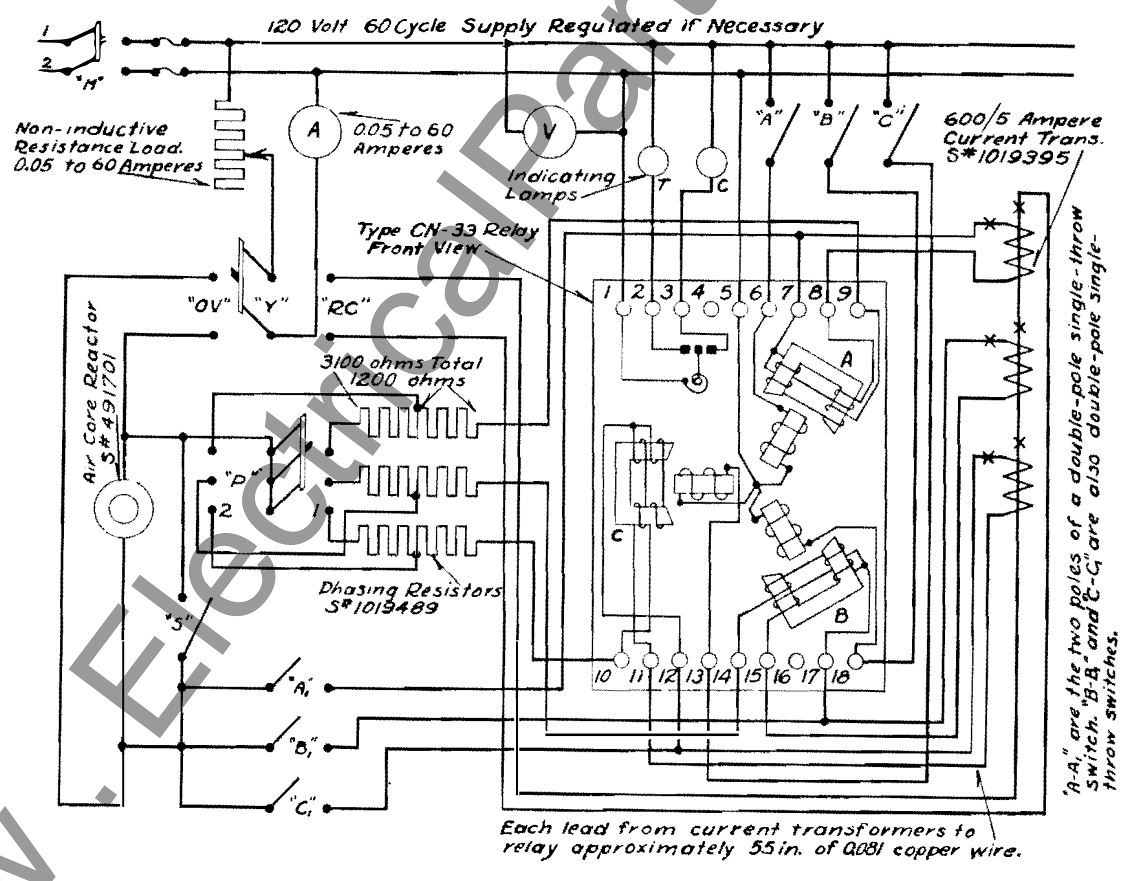


Fig. 9—Test Connections for Single-Phase Test and Adjustment of the Type CN-33 Network Master Relay.

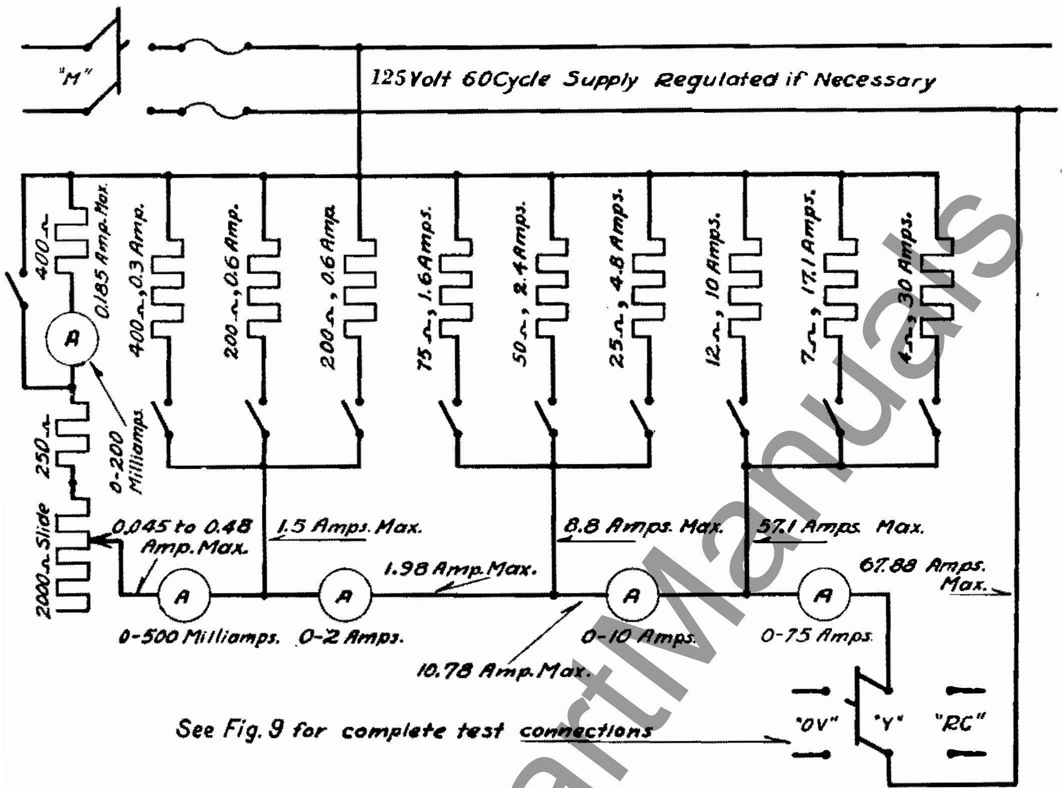


Fig. 10—Details of Load Bank and Ammeters for Use in Single-Phase Test of the Type CN-33 Network Master Relay.

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 an in phase 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 and 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 thumb 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 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 6258-3 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. 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 and the phasing relay is properly adjusted 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 counter-clockwise 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

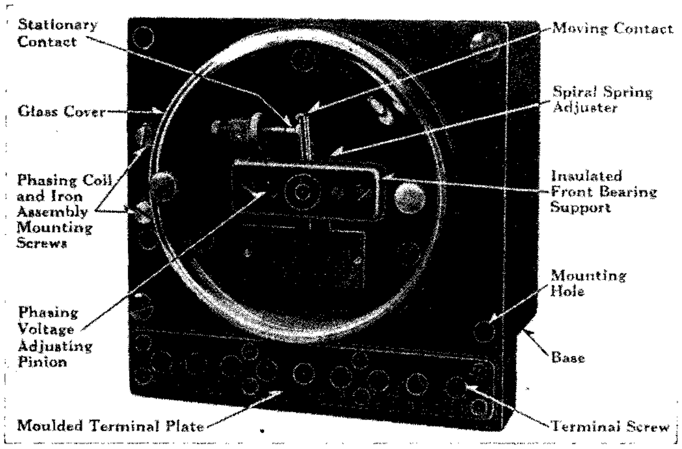


FIG. 11—TYPE CN-J NETWORK PHASING RELAY. FRONT VIEW WITH COVER ON.

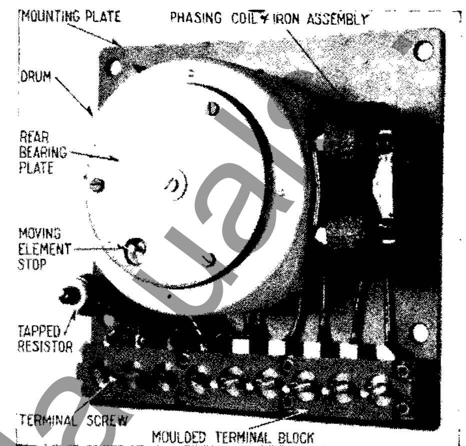


FIG. 12—TYPE CN-J NETWORK PHASING RELAY. REAR VIEW OF RELAY REMOVED FROM BASE

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 range of 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 spring adjuster, 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_3; 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. This adjustment is made by means of the geared spring adjuster by rotating the adjuster pinion with a screwdriver as in the CN-33 relay. The range of overvoltage closing adjustment is set at the factory at 0 to 1.5 volts leading the network voltage 75 degrees with the resistor terminal screw in terminal No. 6. This range is sufficient for practically all

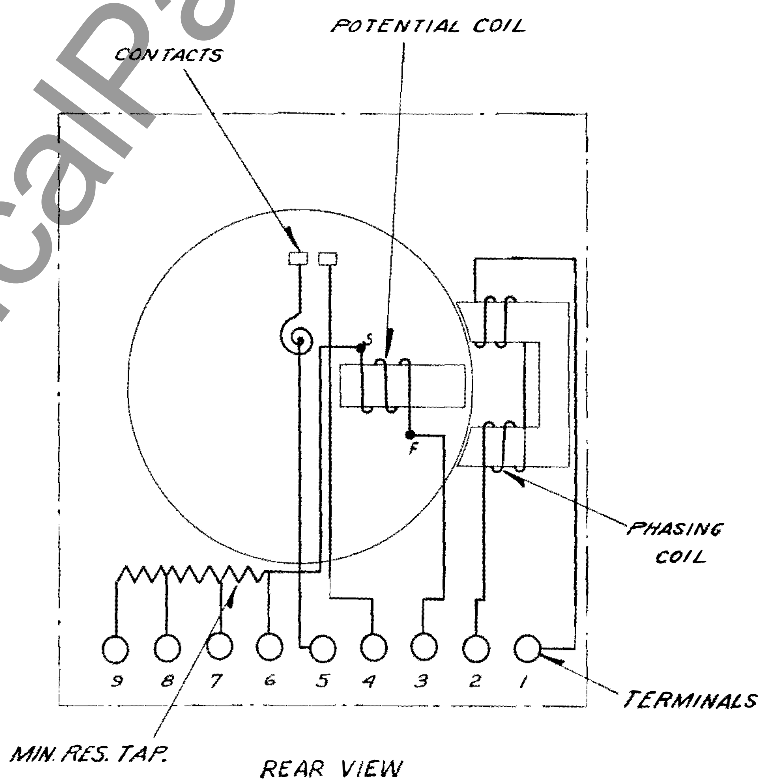


Fig. 13—Wiring Diagram of the Internal Connections of the Type CN-J Network Phasing Relay.

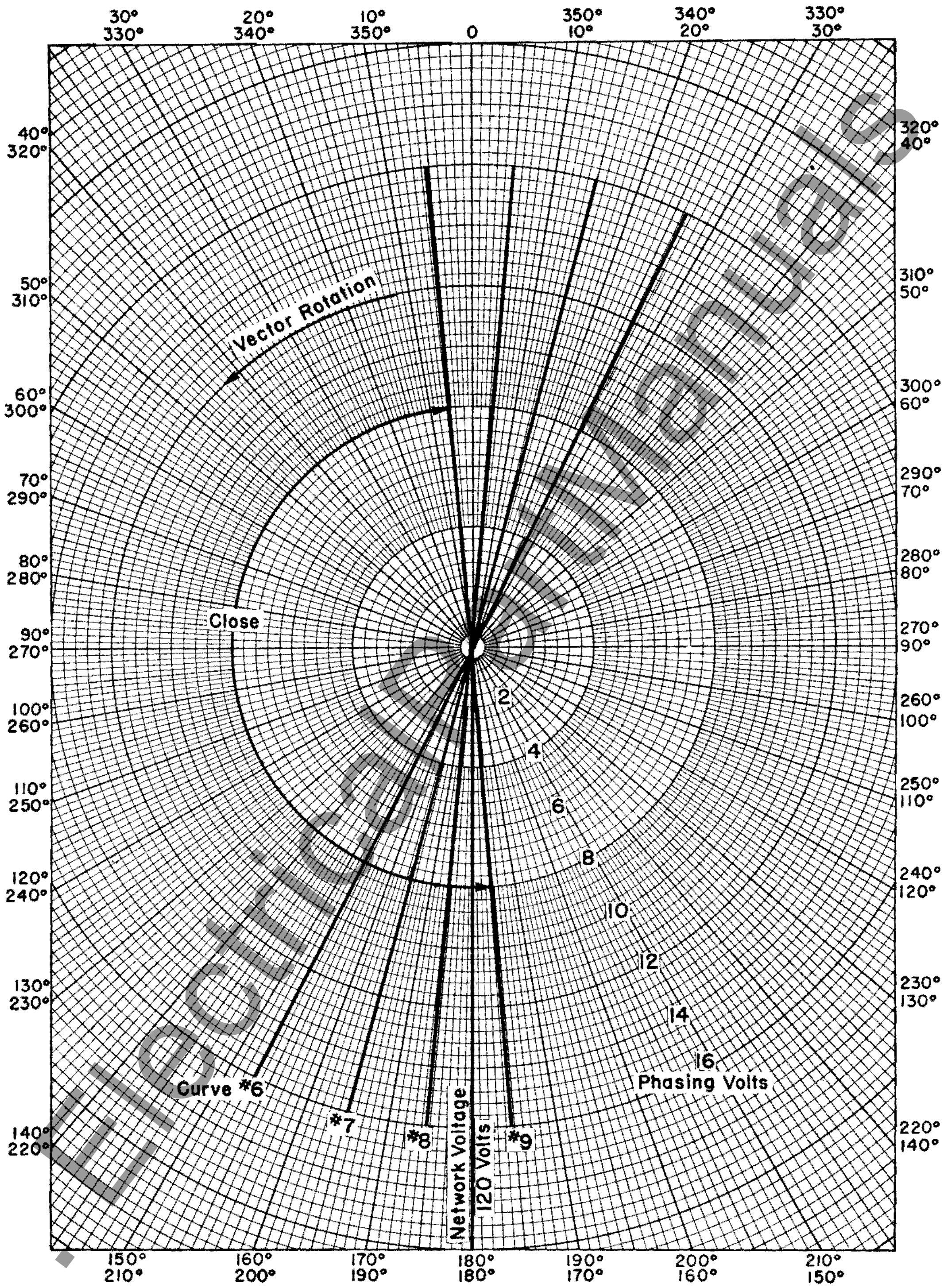


Fig. 14—Closing Characteristics of the Type CN-J Network Phasing Relay.

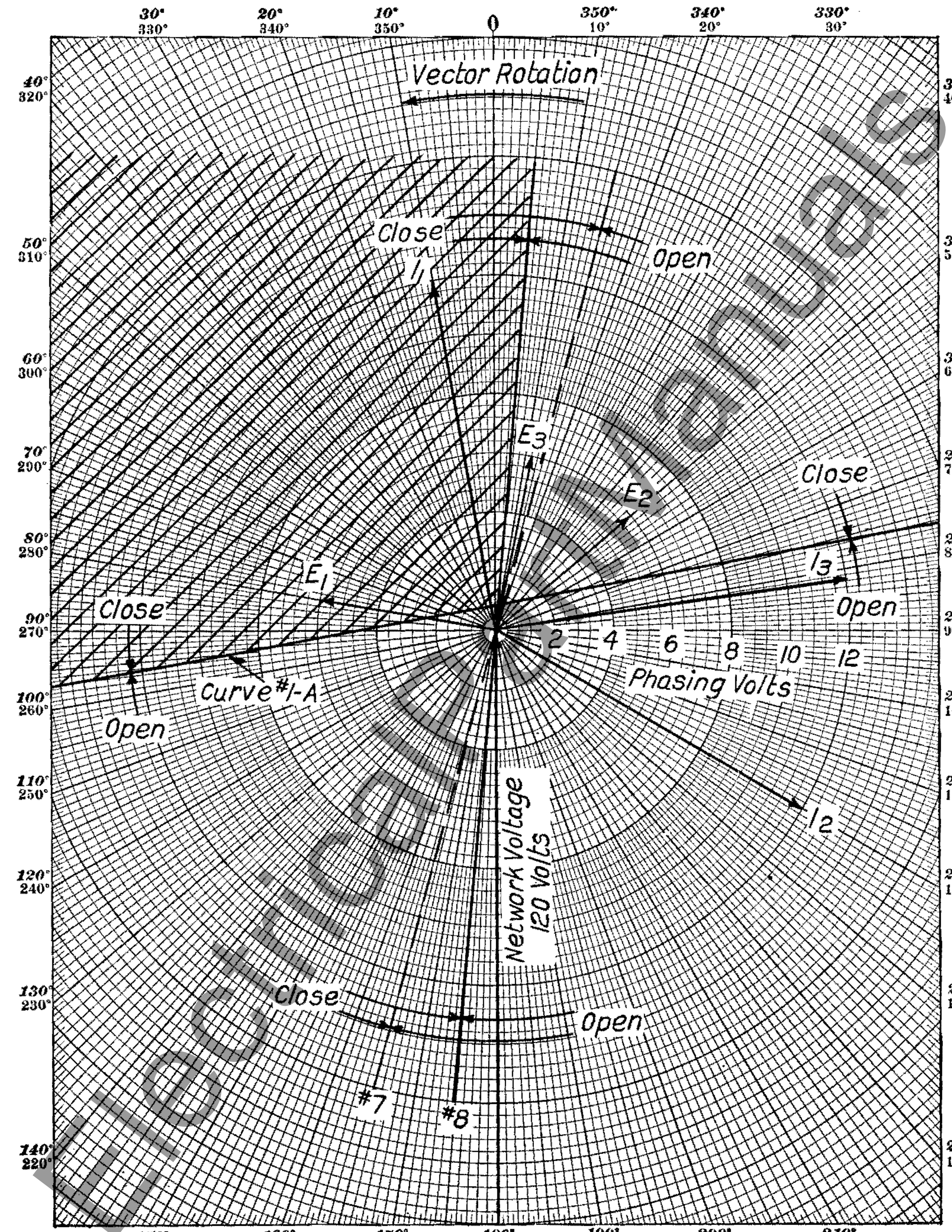


FIG. 15--COMBINED CLOSING CHARACTERISTICS OF THE TYPE CN-33 AND CN-J NETWORK RELAYS.

applications; if it is necessary to use settings outside of this range the range can be changed by shifting the outer coil and iron assembly.

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 duplicates 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 to deflect the contact springs until the back of the contact almost touches the main supporting arm when the drum is rotated counterclockwise to its extreme position. 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. The range of overvoltage adjustment of the CN-J relay can be checked in the following manner: with the relay completely deenergized increase the closing tension, beyond the point where the contacts just close, by ¼ turn of the screwdriver adjuster. Then close switches B, L and M and increase the current through the reactor until the contacts just close. The corresponding phasing voltage (drop in the reactor) is the maximum limit of the overvoltage adjustment range. Open switch B and it should be possible to increase the spring tension until the relay contacts will again just close. This corresponds to zero phasing voltage.

53. To make the desired phasing voltage setting move the terminal screw located in terminal No. 6 to the 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. Close switches B, L and M and adjust the current through the reactor to give the desired phasing potential. Then adjust the spring tension so that the contacts just close. It is recommended that the phasing relay be adjusted to close at approximately zero volts. If the phasing voltage setting is nearly zero the adjustment should be checked by closing switches B, R and M and determining the voltage 75 degrees leading the network voltage reversed that causes the relay contacts to just open. This voltage should not exceed 0.35 volts. This recommended adjustment gives a value of

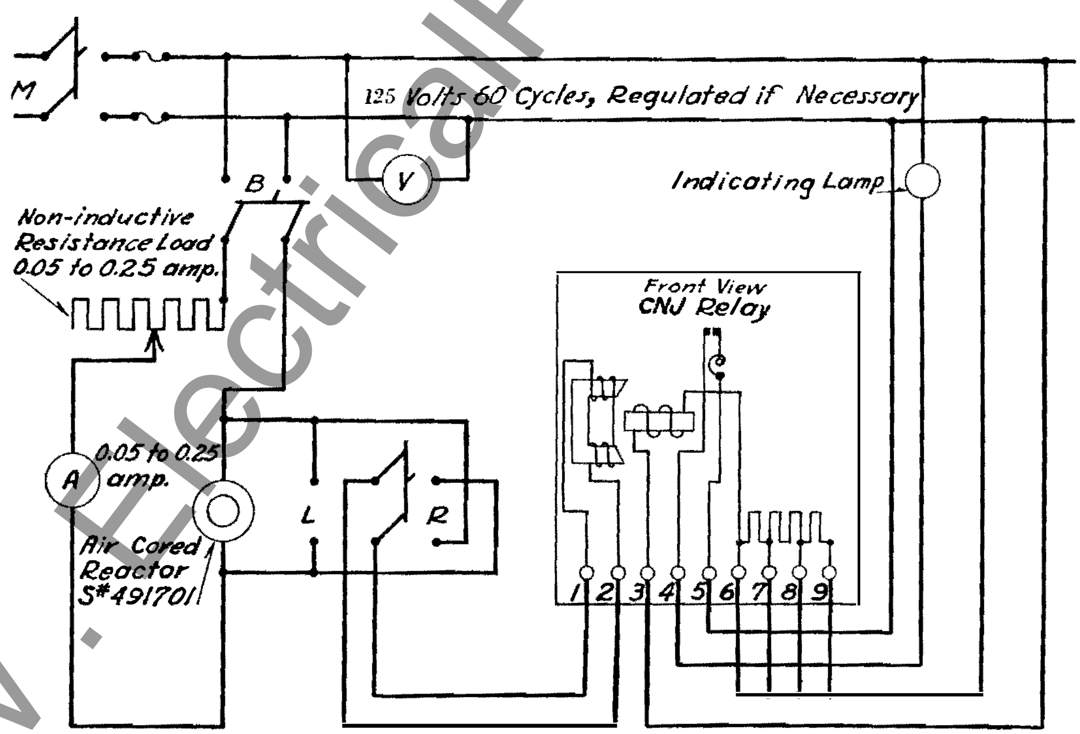


Fig. 16—Test Connections for Single-Phase Test and Adjustment of the Type CN-J Network Phasing Relay.

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 desirable to give the relay an adjustment which will require a negative value of phasing voltage leading the network voltage to close its contacts, it will be necessary to change the range of overvoltage by shifting the outer coil and iron assembly and then make the exact setting with the spiral spring adjuster. In no case should the spring tension be less than one-quarter turn of the adjuster pinion 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 thumb 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 CN-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 correct voltage conditions may be due to friction, to very dirty or incorrectly adjusted contacts, or to an incorrect overvoltage closing adjustment. Friction in the relay may be caused 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 where it makes contact with the rear bearing plate. It is very unlikely that dirty or incorrectly 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.

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 faulty operations of the network protectors which may occur.

Type BN Network De-Sensitizing Relay

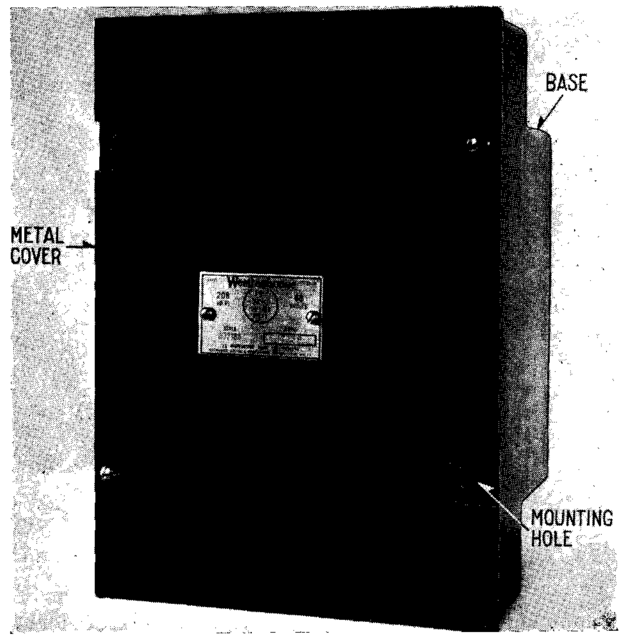


FIG. 17—TYPE BN NETWORK DE-SENSITIZING RELAY FRONT VIEW WITH COVER ON

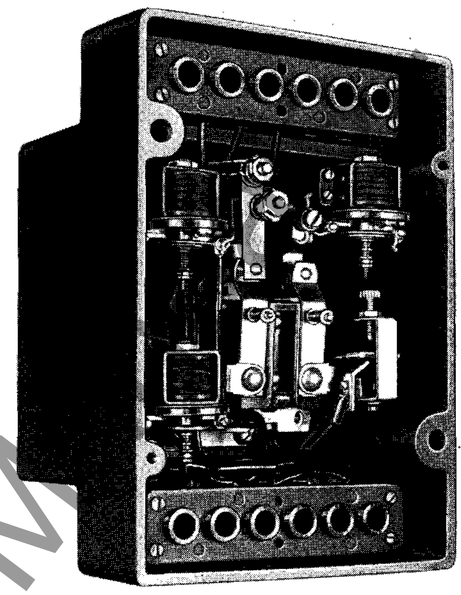


FIG. 18—TYPE BN NETWORK DE-SENSITIZING RELAY FRONT VIEW WITH COVER REMOVED

CONSTRUCTION

59. The type BN relay shown in Figs. 17 and 18 includes three instantaneous overcurrent contactor elements and a bimetallic timer. It can be adjusted to delay sensitive tripping of a network protector for from one to five minutes after the master relay contacts are closed, yet permit instantaneous operation under short circuit conditions. The relay contacts are to be connected in series with the type CN-33 master relay trip contacts, as shown in Fig. 19.

60. The overcurrent elements are small solenoid-operated contactors that can be adjusted to pick up at from 100 to 250% of full load current. They drop out when the current is reduced to approximately 70% of pick-up current and it is recommended that they be set so that their drop-out is above normal full load current. Their pure silver bridging-type contacts are connected in parallel to short circuit the timer contacts and instantly provide a trip circuit whenever the pick-up current of one or more relays is exceeded. A specially shaped magnetic circuit, a spring-mounted silver disc-type moving contact and three stationary contacts insure a positive chatter-proof contact operation in this relay.

61. The bimetallic timer employs both heating and cooling cycles to avoid the effects of cumulative heating that result from successive short period energizations. This is accomplished by using an auxiliary relay with the thermal element. The thermal element consists of two heavy bimetallic springs, one mounted directly above the other. The lower spring supports two adjustable stationary contacts. These provide a restricted space in which the free end of the upper, heated spring moves. The upper spring is heated by passing relatively high current directly through it, from a small transformer in the relay base. The required thermal characteristics are obtained by splitting the spring at its stationary end and restricting the area of its cross section. Normally, the moving contact on the heated spring presses heavily against the lower stationary "cold" contacts. When heated, the moving contact is moved upwards to touch the "hot" stationary contact. This energizes the auxiliary relay which de-energizes the heater and allows it to cool and complete the timing cycle. Since both heated and stationary contacts are mounted on similar bimetallic springs, the relative position of their free ends, and the length of the operating cycle is unchanged by variations in ambient temperature. The periods of time required to operate the thermal element, including both heating and cooling cycles, can be varied by changing the travel of the moving contact between adjustable "hot" and "cold" stationary contacts.

62. The auxiliary relay is a standard type "SG" element having a 208 volt, 60 cycle coil. Its armature carries one single-pole, front contact and one single-pole, double-throw contact. These are arranged to interrupt the heater and seal in the auxiliary relay after the thermal element has made its hot contact. The trip circuit is completed through the timer "cold" contact and one of the front contacts of the auxiliary relay. All contacts of the auxiliary relay are fixed in position so need no adjustment.

63. These elements are mounted in a single, plug-in case similar to those used by the type CN-33 and CN-J relays. It is mounted on two studs, held in place by two thumb nuts which tighten to force the terminal screws firmly into engagement with their associated terminal jaws on the protector.

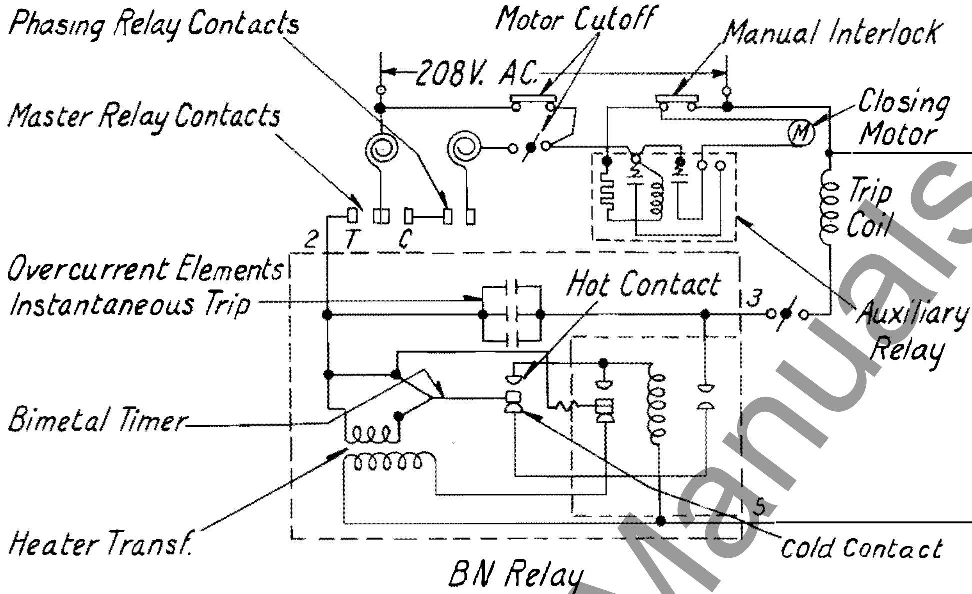


FIG. 19—SCHEMATIC DIAGRAM OF NETWORK PROTECTOR CONTROL CIRCUIT INCLUDING MASTER PHASING AND AUXILIARY TIMING RELAYS

OPERATION

64. As described under "Construction" and illustrated in the schematic diagram, Fig. 19, the thermal element trip contacts are connected in series with the master relay trip contacts. Consequently, the type BN relay functions only when initiated by closing of the master relay trip contacts. Furthermore, it will be noted in Fig. 19 that the timer contacts are shunted by the instantaneous over current element contacts. Hence, all of the effective timer operations are limited to the condition encountered when power reversals are below the setting of the overcurrent elements.

65. To visualize the relay operation first assume that a continuous reversal of transformer magnetizing watts has caused the master type CN-33 relay trip contacts to close. As the reversal is continuous and of small current magnitude, the complete timing cycle of the BN relay will be obtained. When the master relay trip contacts close, the BN relay heater is energized through the back contacts of the auxiliary relay. If the timer is set for a two-minute delay, it will be noted that about one minute will be required for the heated bimetallic spring to carry the moving contact from the "cold" contact to the upper or "hot" contact position. When the upper contact is made, it completes a circuit through the auxiliary relay coil to other side of line. The auxiliary relay then interrupts the heater circuit and seals itself closed as its single pole, double-throw contact makes in the closed position. The single-pole, single-throw contact sets up the protector trip circuit in series with the master relay trip contacts and the cold contacts of the thermal element. This circuit is completed and the circuit breaker is tripped when the timer contact returns to its cold position.

66. Now assume that the protector is again closed and a momentary power reversal is encountered, as may be caused by the sudden stopping of a regenerative elevator in some nearby building. The reversal in this case may be as much as 25 or 30% of full load current. Again the master relay trip contacts will close and start the BN timer operation. In this case the reversal will last only a few seconds and the timer will not move. If the reversal had been caused by the starting of a very large motor, or a series of motors nearby, it may have caused a reversal that lasted slightly more than a minute. Under such a circumstance, the timer will have operated to close its "hot" contact and picked up the auxiliary relay. The master relay contacts would then open before the cooling cycle was completed and the protector would remain closed. A second low-energy short-time power reversal immediately following this operation would fail to trip the protector as the heating cycle would have to be repeated by the BN element in order to pick up the auxiliary relay and set up the trip circuit.

67. During any of the above operations, current of fault magnitude would have picked up one or more of the overcurrent elements and instantly tripped the protector. In this manner needless protector operations are avoided and both insensitive and instantaneous tripping characteristics are maintained. It should also be noted that for special installations continuous reverse currents below the setting of the overcurrent elements can be permitted by interrupting the timing element of the BN relay. This can be done by removing the line connection to the timer by unscrewing terminal #5, Fig. 20, marked 12.

ADJUSTMENTS AND TESTS

68. Two adjustments are available in the type BN relay. These are the time delay and instantaneous overcurrent element settings. The relays are shipped from the factory with approximately a three-minute time setting, and an instantaneous overcurrent setting of 150% of the ampere rating of the protector. These adjustments will be found satisfactory for practically all applications; however, various settings can be made as described in the following paragraphs.

69. To check the timer operation energize the relay terminals #2 and 5 with 208 volts, 60 cycle frequency. Closing of the trip contacts can be indicated with a 120 volt lamp in series with the power source and relay terminals 2 and 3. Timing can be checked with the second hand of an ordinary watch. It will be noted that the total timing operation includes a heating period, which is interrupted by operation of the auxiliary relay, and a cooling period. Normally, the heating period will be found to be less than half of the full timing cycle.

70. The specific adjustments are to be made as follows:

a. Move the lower stationary "cold" contacts to a position where it will not limit the moving contact travel.

b. Measure the distance between the two bimetallic springs.

c. Adjust the "cold" contact so as to increase the spacing between springs $\frac{3}{64}''$. It will be noted that a positive contact pressure with good follow is obtained.

d. Set the "hot" contact about $\frac{1}{32}''$ above the moving contact to obtain a minimum operating time of about one minute. Increasing this contact gap will increase time delay and provide the only timing adjustment.

71. The auxiliary relay is permanently adjusted to pick up when energized with approximately 176 volts or more.

72. The overcurrent elements can be adjusted to operate from approximately five to twelve amperes (100% to 250% of the protector rating). A setting of one hundred and fifty percent of the protector rating (7.5 amperes secondary current) is recommended. The only adjustment ordinarily required is the minimum pick-up setting which should be checked with 60 cycle current, gradually increased in magnitude. Variations in pick-up are adjusted by raising or lowering the position of the solenoid mounted contact. This is done by loosening the

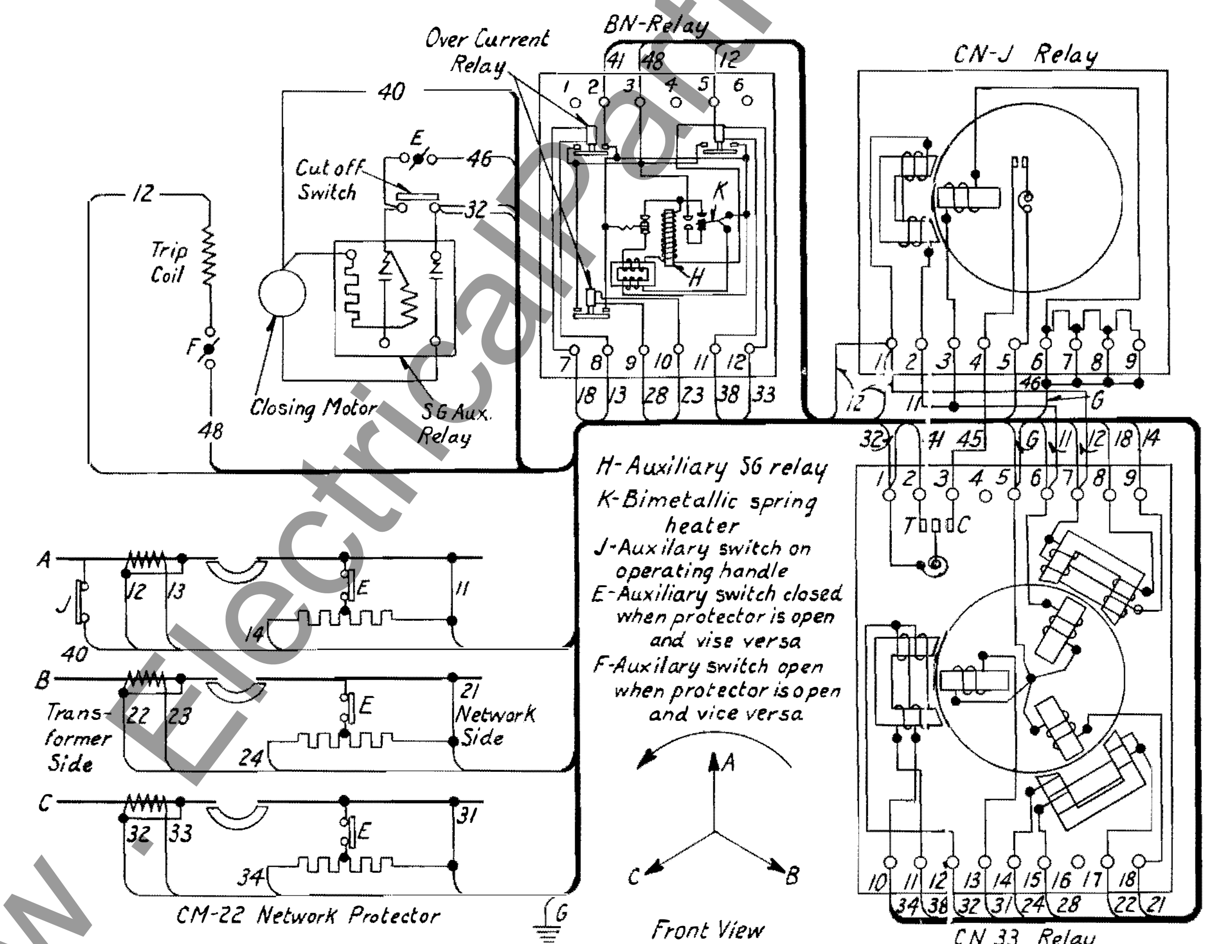


Fig. 20—Schematic Wiring Diagram of a Network Protector Controlled by Type CN-33, CN-J and BN Network Relays

small lock nut on the shaft below the moving contact and then raising or lowering the moving contact assembly. The lock nut should again be tightened to avoid changes in calibration.

73. If the overcurrent element should be dismantled for any reason, it should be reassembled in the following manner, before final overcurrent adjustments described in the preceding paragraph are made.

(a) Hold the moving contact solidly against the stationary contacts.

(b) Screw the core center down until it just touches the plunger inside the core.

(c) Energize the coil with the minimum pick-up current; 7.5 amperes, 150% of protector rating is recommended. Then raise the upper core screw so as to obtain a maximum deflection of the spiral spring below the contact. This can be observed by looking just above the silver disc contact and noting the separation between the contact and the shoulder on the moving core.

(d) Fasten the locking nut at the top of the element when the maximum spring deflection is obtained.

(e) Adjust the position of the plunger on its shaft by use of the two locking nuts to obtain minimum pick-up at the required value.

(f) With a correct adjustment, as outlined above, the relay contacts will open when the current is decreased to 60 or 75% of the minimum pick-up value.

(g) Contact operation can be checked by connecting a low wattage-indicating lamp in the trip circuit. Excessive vibration of the armature indicates that too great a spiral spring deflection is used. The upper core screw should be moved down slightly to prevent this.

(h) The minimum pickup of the overcurrent element must never be set below 140% of the maximum sustained load. This is required to avoid wear as the element is not designed for continuous operation.

74. All of the silver contacts should be cleaned with a small fine file or burnishing tool about once a year; the frequency of cleaning being determined by local conditions. To do this the relay element can be partially removed from its base in the following manner:

(1) Remove the relay from the protector.

(2) Loosen four captive screws which mount each terminal block in its respective terminal chamber.

(3) Loosen three captive extension nuts which fasten the main relay panel in the base and fasten them on the outer end of their respective posts.

(4) Draw the relay element and terminal blocks forward in the base to a point where all parts become easily accessible.

INSTALLATION

75. The type BN relay is shipped separate from the network protector. This decreases the possibility of damage in shipment. Carefully unpack and examine the relay to see that none of its parts have been bent or broken in transit. Inspect the auxiliary and overcurrent relays to see that their armatures move freely. See that all contacts are clean and properly adjusted. It is also advisable to check the minimum pick-up and drop-out of all elements as described under "Tests and Adjustments".

MAINTENANCE

76. The moving armatures of all elements and contacts are the only parts that will require attention. During each periodic inspection of the protector the relay contacts should be examined to see that they are clean and properly adjusted.

RENEWAL PARTS DATA

NETWORK RELAYS

The following is a list of the Renewal Parts and the quantities of each that we recommend should be stocked by the user of this apparatus to minimize interrupted operation caused by breakdowns. The parts recommended are those most subject to wear in normal operation or those subject to damage or breakage due to possible abnormal conditions. This list of Renewal Parts is given only as a guide. When continuous operation is a primary consideration additional insurance against shut-downs is desirable. Under such conditions more Renewal Parts should be carried, the amount depending upon the severity of the service and the time required to secure replacement.

Recommended Stock of Renewal Parts

Type CN-33 Network Master Relay

FOR ILLUSTRATION OF PARTS SEE FIGS. 1 AND 2

Fig. No.	Name of Part	Style No. of Part		No. Req.	Recommended For Stock	
	Relays in use up to and including				1	5
1	Relay Complete	Plain Style	Sub A and B Style	1	0	0
1	Terminal Screw	1 009 350	1 009 350	18	0	0
1	Moving Contacts	1 009 341	1 009 341	1	0	0
1	Moving Contact and Support	561 649	561 649	2	2	4
1	Reverse Current Spring ($1\frac{51}{64}$" Long)	939 386	939 386	1	0	1
1	Rever e Current Spring ($1\frac{19}{32}$" Long)	939 387	939 387	1	0	1
1	Reverse Current Spring ($1\frac{5}{8}$" Long)	939 388	939 388	1	0	1
*	Spiral Spring	1 095 879	1 095 879	1	0	1
1	Stationary Tripping Contact	1 009 340	1 009 340	1	1	2
1	Stationary Tripping Contact Thumb Nut	559 072	559 072	1	0	0
1	Overvoltage Adjusting Pinion	— — —	1 096 308	1	0	0
*	Overvoltage Adjusting Screw	1 009 332	— — —	3	0	0
1	Glass Cover	1 000 829	1 000 829	1	0	0
1	Cover Screw	1 009 317	1 095 855	2	0	0
1	Moulded Terminal Plate	1 001 773	1 001 773	2	0	0
1	Base	939 385	939 385	1	0	0
1	Stationary Closing Contact	1 009 340	1 009 340	1	1	2
1	Stationary Closing Contact Thumb Nut	559 072	559 072	1	0	0
1	Spiral Spring Adjuster	1 009 335	1 096 300	1	0	0
1	Front Bearing Plate	1 009 342	1 009 342	1	0	0
1	Front Bearing Plate Insulating Cover	— — —	1 095 855	1	0	0
1	Reverse Current Adjusting Screw	1 009 344	1 095 856	1	0	0
2	Current and Phasing Coils and Iron (60 Cycles)	937 711	1 096 760	3	0	0
2	Current and Phasing Coils and Iron (50 Cycles)	1 094 869	1 096 761	3	0	0
2	Drum with Moving Element Stop	1 009 349	1 009 349	1	0	0
2	Rear Bearing Plate with Stationary Stop	1 009 346	1 009 346	1	0	0
*	Potential Coil and Iron (60 Cycles)	937 712	937 712	3	0	0
*	Potential Coil and Iron (50 Cycles)	938 657	938 657	3	0	0
2	Moulded Terminal Block	1 001 774	1 001 774	2	0	0
2	Damping Magnet	1 009 353	1 009 353	Ø	0	0

* Not illustrated. — — — Not used. Ø Required 1 for plain and Sub A and 2 for Sub B Style.
Parts indented are included in the par under which they are indented.

Type CN-J Network Phasing Relay

FOR ILLUSTRATION OF PARTS SEE FIGS. 11 AND 12

Fig. No.	Name of Part	Plain Style	Sub A Style	No. Req.	1	5
11	Relay Complete	Plain Style	Sub A Style	1	0	0
11	Moving Contact	1 009 359	1 009 359	1	0	0
11	Moving Contact and Support	561 649	561 649	1	1	2
11	Stationary Contact	1 009 340	1 009 340	1	1	2
11	Stationary Con act Thumb Nut	559 072	559 072	1	0	0
11	Glass Cover	1 009 829	1 009 829	1	0	0
11	Phasing Voltage Adjusting Pinion	— — —	1 096 308	1	0	0
*	Phasing Voltage Adjusting Screw	1 009 332	— — —	1	0	0
11	Moulded Terminal Plate	1 001 773	1 001 773	1	0	0
11	Spiral Spring Adjuster	1 009 335	1 096 300	1	0	0
11	Front Bearing Support	1 009 342	1 009 342	1	0	0
11	Front Bearing Support Insulating Plate	— — —	1 095 855	1	0	0
11	Base	939 384	939 384	1	0	0
11	Terminal Screw	1 009 350	1 009 350	6	0	0
12	Mounting Plate	1 009 357	1 009 357	1	0	0
12	Drum with Moving Element Stop	1 009 349	1 009 349	1	0	0
*	Potential Coil and Iron (60 Cycles)	1 008 327	1 008 327	1	0	0
*	Potential Coil and Iron (50 Cycles)	938 658	938 658	1	0	0
12	Rear Bearing Plate	1 009 346	1 009 346	1	0	0
12	Tapped Resistor (60 Cycle Relays)	1 002 290	1 002 290	1	0	1
12	Tapped Resistor (50 Cycle Relays)	1 003 922	1 003 922	1	0	1
12	Phasing Coil and Iron	937 710	1 096 759	1	0	0
12	Moulded Terminal Block	1 001 774	1 001 774	1	0	0

* Not illustrated. — — — Not used. Parts indented are included in the part under which they are indented.

Type BN Relay—Style No. 1 153 653

	Name of Part	Style No.	No. Req.	1	5
	Overcurrent Element	1 204 739	3	0	0
	Coil	1 096 787	3	0	0
	Stationary Contact Assembly	1 204 738	3	0	0
	Moving Contact Assembly	877 092	3	0	1
	Core Screw	1 204 737	3	0	1
	Core Screw Nut	877 557	3	0	1
	Auxiliary Relay	1 204 736	1	0	0
	Coil	1 008 520	1	0	0
	Stationary Contact	1 002 172	1	0	1
	Stationary Contact	1 008 711	2	0	1
	Moving Contact—Right Hand	1 008 710	2	0	1
	Moving Contact—Left Hand	1 008 709	2	0	1
	Transformer	1 269 065	1	0	0
	Timing Unit	1 204 732	1	0	0
	Stationary Contact Screw	1 155 629	1	0	1
	Stationary Contact (Lower)	1 204 734	1	0	1
	Moulded Contact Support	1 097 313	1	0	0
	Moving Contact and Heater	1 204 733	1	0	0
	Stationary Contact Support (Bi-me al)	1 204 735	1	0	0
	Terminal Screws	1 009 350	9	0	6

Parts indented are included in the part under which they are indented.

ORDERING INSTRUCTIONS

When ordering Renewal Parts, always specify the name of the part wanted as shown on the illustrations in this Instruction Book. giving Style Number, and the type of Relay as shown on the nameplate. For Example: **One Moving Contact, Style No. 819792, for Type SR-2 Network Relay, Style No. 937185.**

To avoid delays and misunderstandings, note carefully the following points:

1. Send all correspondence and orders to the nearest Sales Office.
2. State whether shipment is to be made by freight, express or parcel post. In the absence of instructions, goods will be shipped at our discretion. Parcel post shipments will be insured only on request. All shipments are at purchaser's risk.
3. Small orders should be combined so as to amount to a value of at least **$1.00** net. Where the total of the sale is less than this. the material will be invoiced at **$1.00.**