Westinghouse

Types CN-3, CNA and SR Network Relays

Instruction Book

This edition of I. B. 5806 is limited. It is printed with the purpose of supplying instructions for Types CN-3, CNA and SR 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-3, CNA and SR Network Relays

Type CN-3 Network Master Relay

CAUTION

Before cutting protective relays into service, remove all blocking which may have been inserted for the purpose of securing parts during shipment; make sure that all moving parts are frictionless and check the settings and electrical connections.

Application

1. The type CN-3 network master relay is designed to control the operation of the automatic alternating-current network breaker, which is used for the control and protection of low voltage aternating-current networks. A low voltage network is a solidly interconnected grid or mesh of low voltage mains fed through a number of distribution transformer banks by two or more high tension feeders. The network protectors are connected in the secondary leads of each bank of distribution transformers so as to disconnect a faulty high tension feeder from the network.

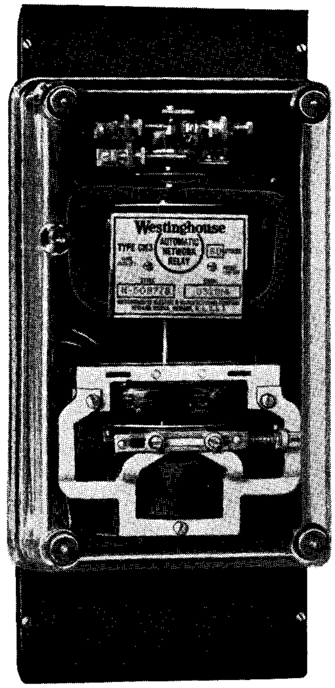


Fig. 1—Type CN-3 Network Master Relay

2. The characteristics of the type CN-3 relay are such that it will operate to connect the distribution transformer bank to the low voltage network when the transformers are capable of supplying load, and to disconnect the transformer bank from the network when the flow of energy is reversed, that is, the flow is from the network to the transformers.

Description

3. The type CN-3 network master relay shown in Figs. 1 and 2 is a three-phase relay which operates on the induction principle. The rotating element consists of two solid copper discs pressed on a hollow steel shaft. There is an inverted cup-shaped jewel on the lower end of the shaft which rests on a hardened and polished steel ball. The steel ball is carried in another cup-shaped jewel mounted in the lower

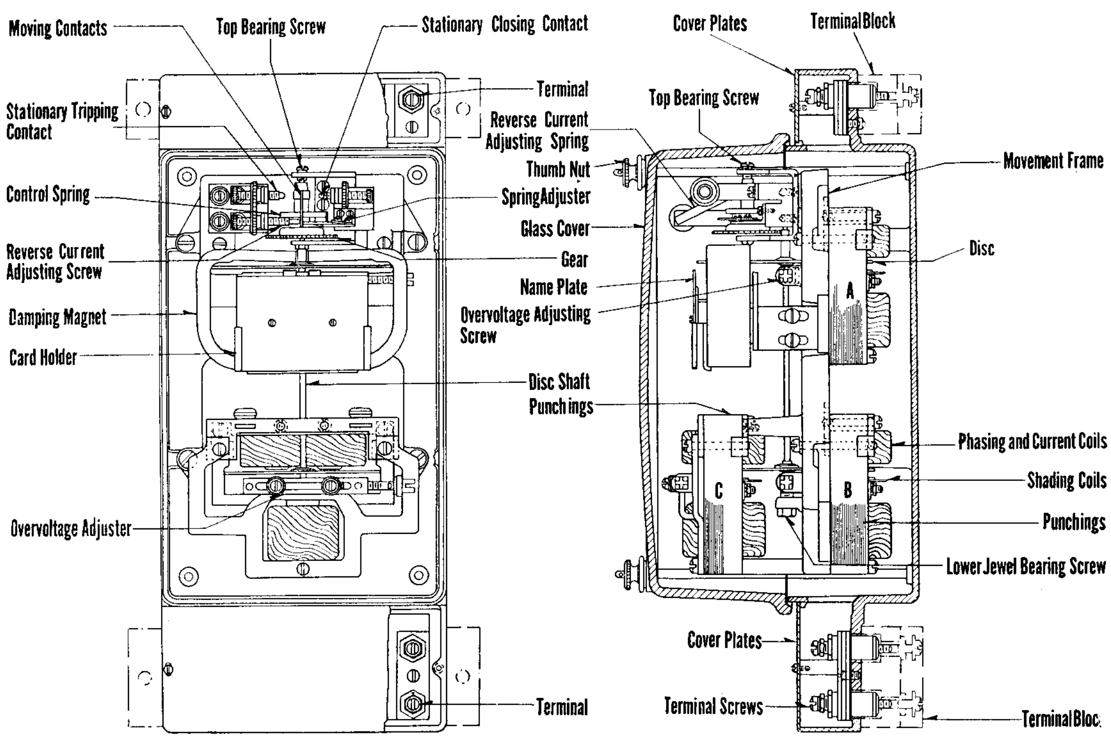


Fig. 2—Type CN-3 Network Master Relay

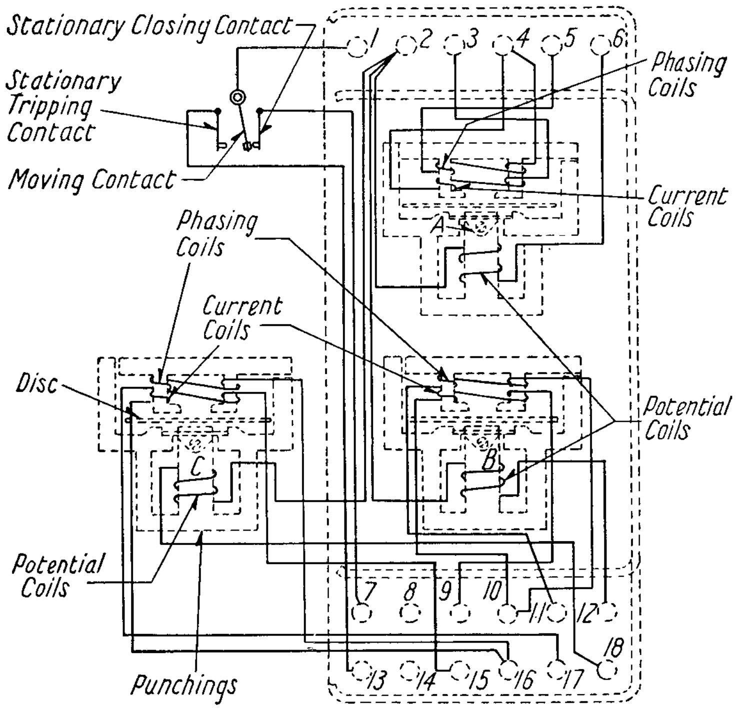


FIG. 3—WIRING DIAGRAM OF INTERNAL CONNECTIONS OF TYPE CN-3 NETWORK MASTER RELAY—3-PHASE, 3-ELEMENT

bearing screw. The clearance between the upper jewel support and the bearing screw which carries the lower jewel is very small so as to prevent the shaft from tilting and thus eliminate the possibility of the discs binding in the air gaps under very heavy torque conditions. Since there are only a few thousandths of an inch clearance between the jewel support on the shaft and the bearing screw, the possibility of dirt or other foreign matter getting on the jewels is greatly reduced. The upper jewel and its support can be readily removed from the shaft for replacement if necessary. The upper bearing which is of the pin type is constructed so as to reduce tilting of the shaft and end play to a minimum. The upper bearing screw is screwed down until there is a clearance of approximately 0.002 inch between it and the upper end of the shaft. It is then locked securely in place. This bearing design results in a very rugged construction with a minimum of wear or friction. The rotating element is made as light as possible, and yet gives the necessary strength and operating characteristics, so as to reduce the duty on its bearings.

4. The relay has single-pole, double-throw contacts all of which are made of pure silver. The moving contacts are mounted on a counter shaft which is geared to the shaft of the main rotating element. A hardened and polished steel pin in the lower end of the counter shaft runs on a jewel bearing. The upper bearing is of the pin type. The gear on the counter shaft and the pinion on the main shaft have special depth teeth, in order to prevent their ever coming out of mesh and also to reduce the friction to a minimum. The counter shaft is covered with a moulded insulation hub around which the moving contact arm is clamped. This arm carries two spring-mounted silver contacts which are electrically one and a flat steel spring which is used to adjust the amount of reverse current necessary to close the "tripping" contacts of the relay. The moving contact assembly is balanced by means of counter weights so as to reduce the friction in the counter shaft bearings. On the end of the moving contact arm, where they are easily visible, are stamped the letters "C" and "T". The letter "C" is stamped on the right and indicates that the right hand contacts are the "closing" contacts of the relay. The letter "T" is stamped on the left and indicates that the left hand contacts are the "tripping" contacts of the relay.

5. When the relay is completely de-energized, the moving contact is held firmly against the "closing" stationary contact by means of a spiral spring. The inner end of this spring is fastened to the moving contact arm and the outer end is fastened to a spring adjuster. This spring adjuster allows the initial tension on the spring to be changed without changing the strength of the spring. To change the spring tension, it is only necessary to loosen one screw, rotate the adjuster until the desired tension is obtained, and then tighten the screw again. The moving contact, counter shaft, bearings and bearing bracket, spiral spring and spring adjuster, reverse current adjusting spring, and the stationary "closing" contact can be removed from the relay as a unit by removing two screws and disconnecting the leads to the moving and stationary contacts. These two leads are securely fastened, one to the spring adjuster and the other to the stationary "closing" contact bracket, by means of screws and washers. Therefore, it is not necessary to open any soldered connections when removing the moving contact assembly from the relay.

6. The stationary contacts consist of two hemispherical pure silver buttons riveted into the ends of two brass thumb screws. These two contact screws screw into two "L" shaped brackets and are locked securely in place by means of two thumb nuts. The stationary "closing" contact and bracket are mounted to the right of the moving contact on the same Micarta block on which the spring adjuster is mounted. The stationary "tripping" contact and bracket are mounted to the left of the moving contact on a Micarta block which is in turn mounted on the movement frame of the relay. Just below the "tripping" contact on the same block, is mounted another "L" shaped bracket. This bracket carries a thumb screw which is similar to the stationary contact screws, except that it does not have a silver contact on the end of it. This is the reverse-current adjusting screw which acts as a stop against the reverse-current adjusting spring. After being adjusted, the screw is securely locked in place by means of a thumb nut. The "tripping" contact connection is similar to the connection to the "closing" contact described above, and the whole assembly may be easily removed when desired.

7. In order to secure the proper operation of the relay under sudden changes of voltage and current, a certain amount of damping of the movement of the disc is necessary. The damping is secured by means of a permanent magnet mounted in front of the upper element so as to act on the front half of the upper disc. The air gap of the magnet in which the disc rotates is about twice as wide as that of damping magnets used on most types of relays. This greatly reduces the possibility of friction due to dirt or other foreign matter getting into the air gap and rubbing on the disc.

8. The three electro-magnets are designated as elements "A", "B" and "C". Element "A" operates on the back half of the upper disc, element "B" operates on the back half of the lower disc, and element "C" operates on the front half of the lower disc. The laminated iron circuit of each electro-magnet is made in two sections. This construction is necessary in order to assemble the form-wound coils on the two upper poles. The two sections are built up and wound separately. The potential coil which is a machine wound coil is assembled on the lower or main pole punchings. It is a normal 120-volt coil but will operate satisfactorily on any voltage between 100 and 135 volts. The current coils of the relay consist of a few turns of heavy wire wound directly on the upper poles of each electro-magnet 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 upper poles over the current coils and securely cemented in place. The two sections of each electromagnet are impregnated with insulating varnish, thoroughly baked and assembled as a unit on the movement frame.

9. The complete relay is mounted in a rectangular cast-iron case with a glass cover. This allows it to be readily inspected at all times without removing the cover. A terminal chamber is cast on each end of the base. The leads are brought from the coils and contacts into the terminal chambers, through holes cast into the ends of the base for this purpose and fastened to the terminals. These terminals which are of special construction are used both as terminals and as mounting screws. A screw passes completely through a clearance hole in each terminal and screws into a brass bushing which is pressed into one of the two Micarta mounting blocks used with each relay. This clearance hole is tapped for a short distance at the entering end to prevent the screw from coming out and being lost when removed from the mounting block bushing. These screws not only hold the relay firmly in place but also form electrical connections between the terminals and the bushings. Connections from the breaker are made to the bushings in the mounting blocks which are securely fastened to either the main or relay panel of the breaker. This terminal construction insures a good pressure contact at all times. It also allows the relay to be mounted on or removed from the panel merely by inserting or removing the terminal screws. Therefore it is unnecessary to disturb any of the internal connections of the relay or any of the wiring on the breaker when mounting or removing a relay. This saves considerable work and eliminates the possibility of connecting the relay wrong when replacing it on the breaker unit. By removing the proper terminal screw or screws from the bushings in the mounting blocks, any circuit or circuits from the relay to the breaker can be opened. This will be found to be a great aid in testing the relay when mounted on the breaker unit. Fig. 3 shows the coils and internal connections of the relay.

Operation

10. The operation of the type CN-3 relay can best be described by referring to Fig. 4. This figure shows a schematic diagram of the internal and external connections of the type CN-3 relay and the type CNA relay when used on a three-phase network with a grounded neutral. The control circuit has been omitted in order to make the picture as simple and clear as possible. When all feeders connected to the low voltage network are open, the type CN-3 relay will be completely de-energized and its "closing" contacts will be held in the closed position by the spiral spring. Similarly, the contacts of the type CNA relay will be held closed. If the operator at the substation 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.

11. It will be noted that if no load is connected to the network the phasing circuits will be energized in series with the potential circuits. However, the impedance of the phasing circuit is so much higher than the impedance of the potential circuit that the voltage across the potential circuit is very low. Since the phasing coils can produce torque only when the potential coils are energized, the resulting torque will be small; but the angle between the voltages is such that the torque tends to open the closing contacts of the CNA relay, and of the CN-3 relay if used with shunt

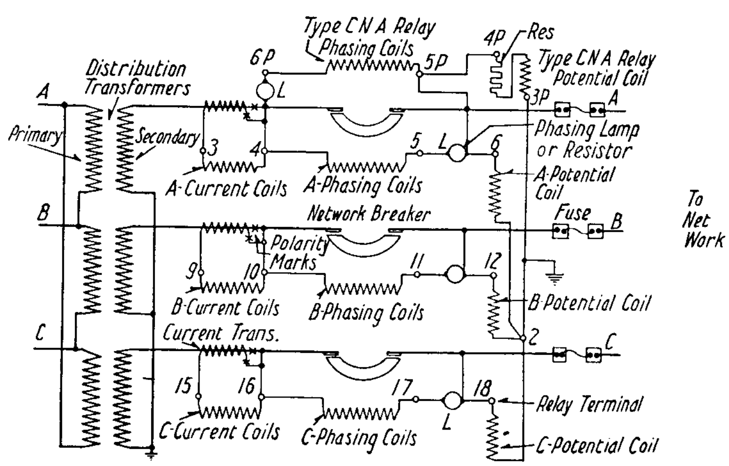


Fig. 4—Schematic Diagram of Internal and External Connections of Types CN-3 and CNA Network Relays Used on Three Phase Networks with Grounded Neutral—Control Circuits Omitted

reactors. Because the relay contacts are initially closed the contactor seals in as soon as the feeder is energized, and the closing operation is not interrupted even if the relay contacts swing open. Also, for most applications the parallel impedance of the permanently connected network load (such as other relay potential coils, watthour meter potential coils, etc.) reduces and shifts the potential coil voltage so that the relay has closing torque throughout the closing period. In rare applications it may be desirable to connect a load to the network permanently in order to insure having closing torque under all conditions for which the protector should close. This load can consist of a 500 ohm resistor (or any convenient smaller value) connected from each phase to neutral, or resistors of equivalent value connected between phases. An example of such an application is a "spot" network fed by only two or three protectors on separate feeders.

12. Again referring to Fig. 4, let us start with the condition we had originally, that is, all feeders connected to the network are open. Now suppose that some feeder other than the one to which the transformer bank is connected is energized by means of the feeder breaker at the substation. The network protectors on that feeder will close and connect it to the network as has just been explained. Both the potential and phasing circuits of the type CN-3 relay shown in Fig. 4 become energized at once. The phasing circuits have full potential impressed across them, but since the potential on the network side of the breaker 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 breaker, are energized when the breaker is open by a voltage which is the vector difference between the transformer secondary voltage and the network voltage. The closing of the substation breaker on the feeder to which the transformer bank is connected with the feeder regulator in the buck position so that the secondary voltage of the distribution transformers is less than the network voltage, will greatly reduce the voltage on the phasing circuits and consequently the tripping torque of the relay. As the voltage is raised on the feeder, the torque in the tripping direction is gradually reduced until a point is reached where the phasing coils produce no torque in either direction. The "closing" contacts of the relay will not make under this condition because a part of each potential coil flux is lagged by an adjustable shading coil in such a way as to produce a torque in the tripping direction slightly greater than the torque in the closing direction produced by the spiral spring when only the potential coils of the relay are energized. Under this condition, the moving contact will remain over toward the "tripping" contact and deflect the reverse current adjusting spring some but not enough to make the trip circuit. If the voltage on the feeder is raised still further, the phasing coils will produce a torque which will cause the moving contact to make with the stationary "closing" contact and cause the circuit-breaker to connect the transformer to the network.

13. The instant the breaker 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 transformers, and produces a torque in the closing direction. The network protector will remain closed even if the voltage 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 "closing" contact and take up a position somewhere between it and the "tripping" contact and will deflect the reverse-current adjusting spring a certain amount. When the feeder is de-energized at the substation end, by opening the feeder breaker, the transformers will be magnetized from the network. This flow of exciting current from the network to the transformers will cause enough current to flow in the current coils of the relay to produce a tripping torque sufficient to deflect the reverse current adjusting spring a still greater amount until the moving contact completes the trip circuit of the relay. 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 transformers or feeder, except the tripping torque will be much greater and the time of operation shorter.

14. The design of the phasing circuits must be such that the relay will close its "closing" contacts with two volts or slightly less impressed across them. However, when the network is energized and the feeder breaker at the substation is open, there will be full line to ground potential across the phasing circuits. There is a possibility of the transformer voltage being reversed due to an error in making connections and this would place twice normal voltage across the phasing circuits. In order to protect the phasing coils from these high voltages, a resistor is placed in series with each pair of phasing coils.

15. The 900-ohm phasing resistors are mounted external to the relay in order to decrease the amount of heat liberated in the relay case and thus keep the temperature of the coils within proper limits.

16. The current transformers used to energize the current coils of the relay are small through-type saturating transformers and are designed so that they start to saturate at approximately twice the current rating of the protector. In this way the heating and vibration within the relay is greatly reduced under the condition of heavy short-circuits on either network or feeder. The ratio of the current transformers for all protector ratings is such that the full load secondary current is 8.33 amperes. The secondary of these transformers may be safely opened under load.

17. Figs. 5 to 10 show the operating characteristics of the type CN-3 network master relay. Referring to Figs. 5 and 8, the curve number 1 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 balanced torque condition in the relay and result in the relay holding open both its "closing" and "tripping" contacts. Any transformer voltage whose magnitude and phase relation are such that it crosses the closing curve will cause the relay to close its "closing" contacts and thus connect the transformer to the network. Conversely, any transformer voltage which does not touch the closing curve will cause the relay to move toward the tripping position and thus the network breaker will remain open. The curve number 1-A in the same figures shows a

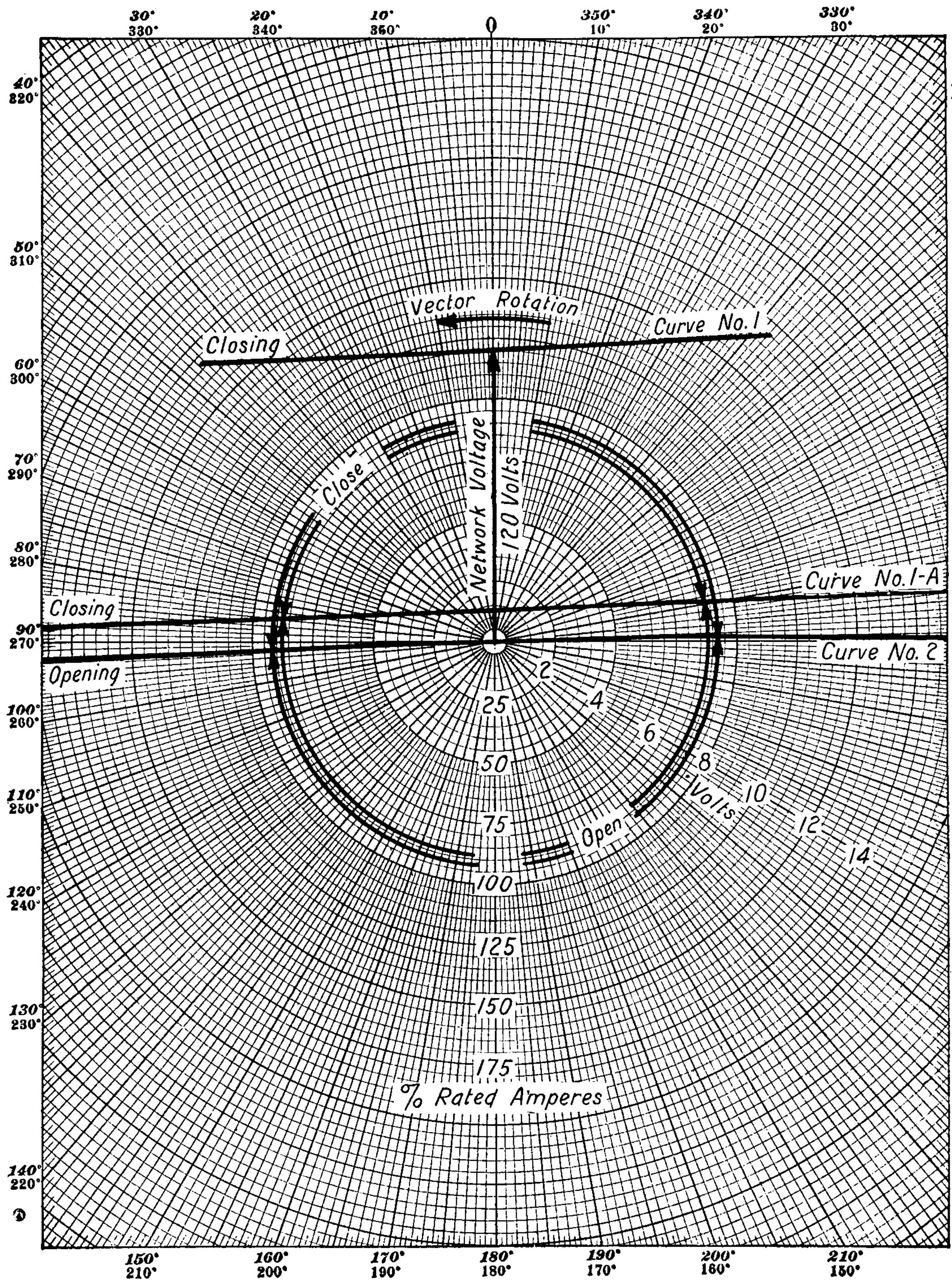


Fig. 5—Operating Characteristics of the Type CN-3 Network Master Relay Using Phasing Resistors, Balanced Three-Phase Conditions Assumed

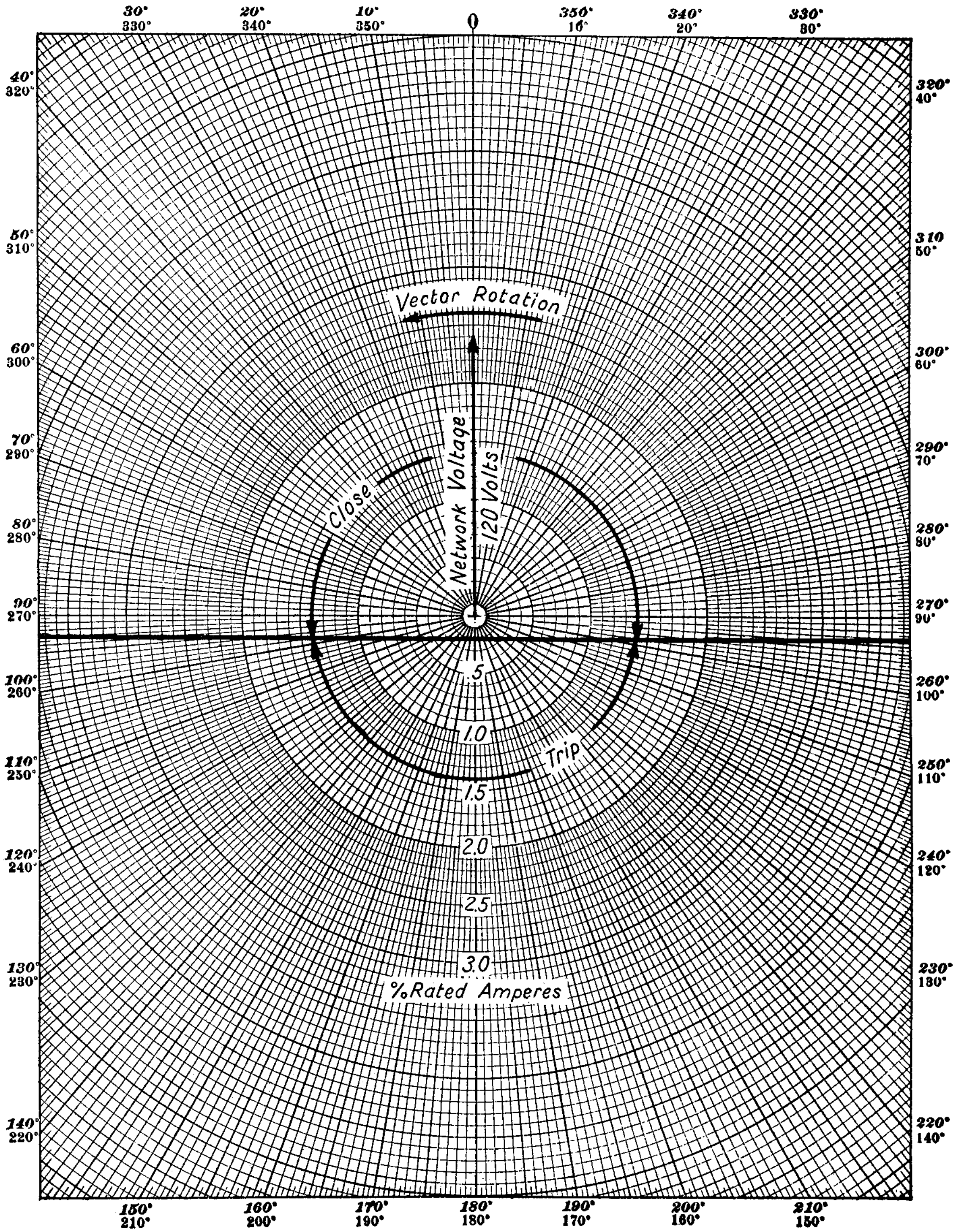


FIG. 6—OPERATING CHARACTERISTICS OF THE TYPE CN-3 NETWORK MASTER RELAY USING PHASING RESISTORS. BALANCED THREE-PHASE CONDITIONS ASSUMED

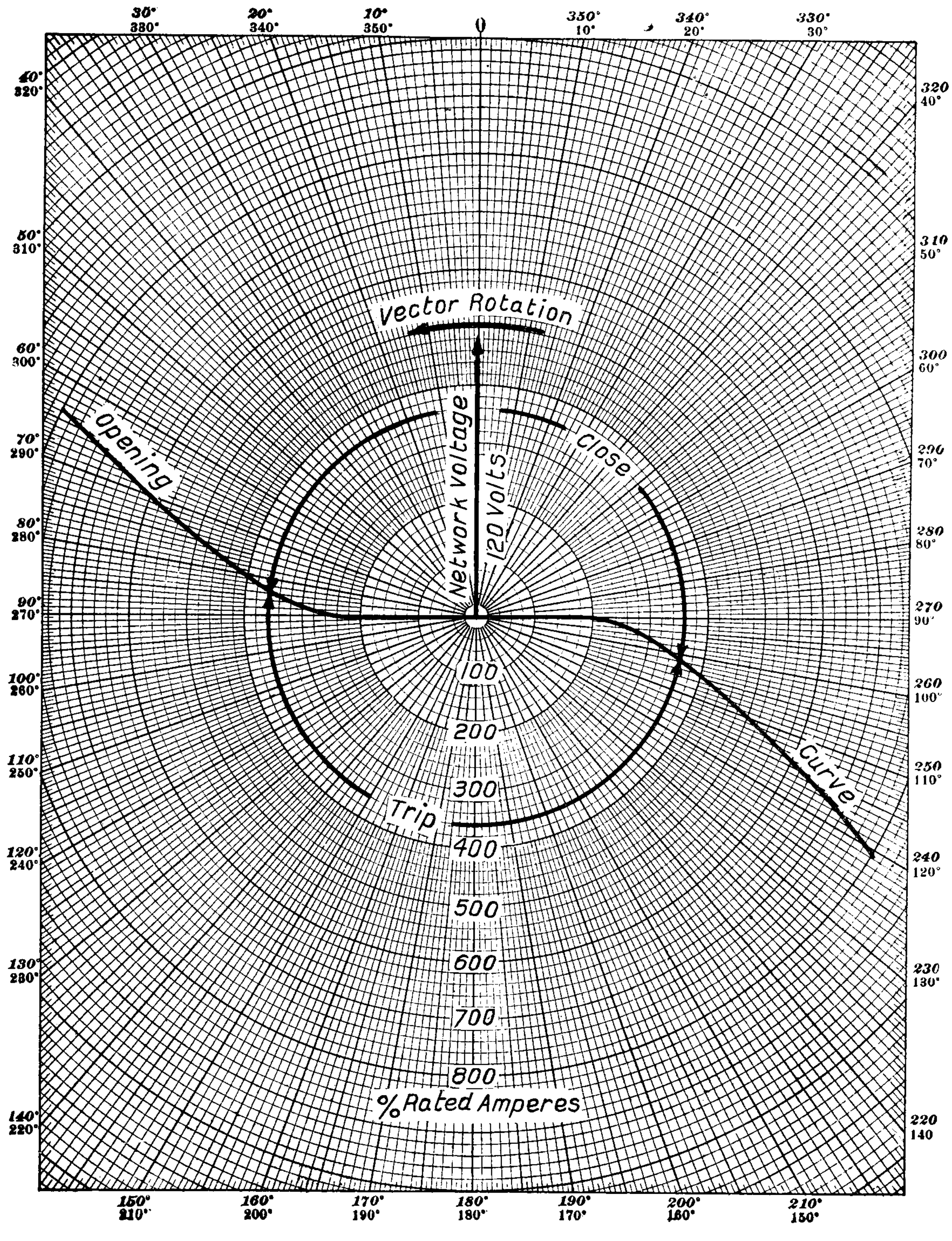


FIG. 7– OPERATING CHARACTERISTICS OF THE TYPE CN-3 NETWORK MASTER RELAY USING PHASING RESISTORS. BALANCED THREE-PHASE CONDITIONS ASSUMED

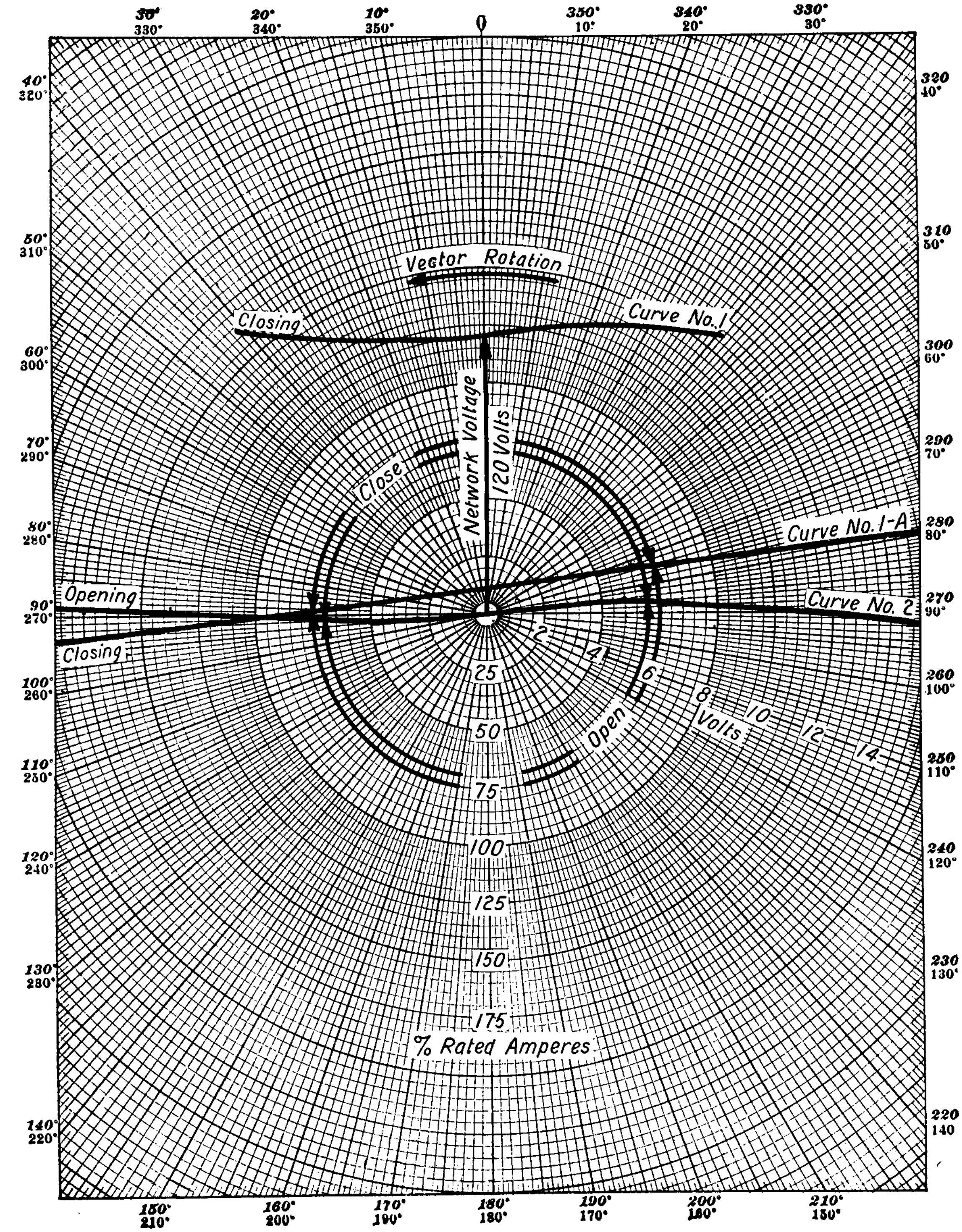


FIG. 8—OPERATING CHARACTERISTICS OF THE TYPE CN-3 NETWORK MASTER RELAY USING PHASING LAMPS, BALANCED THREE-PHASE CONDITIONS ASSUMED

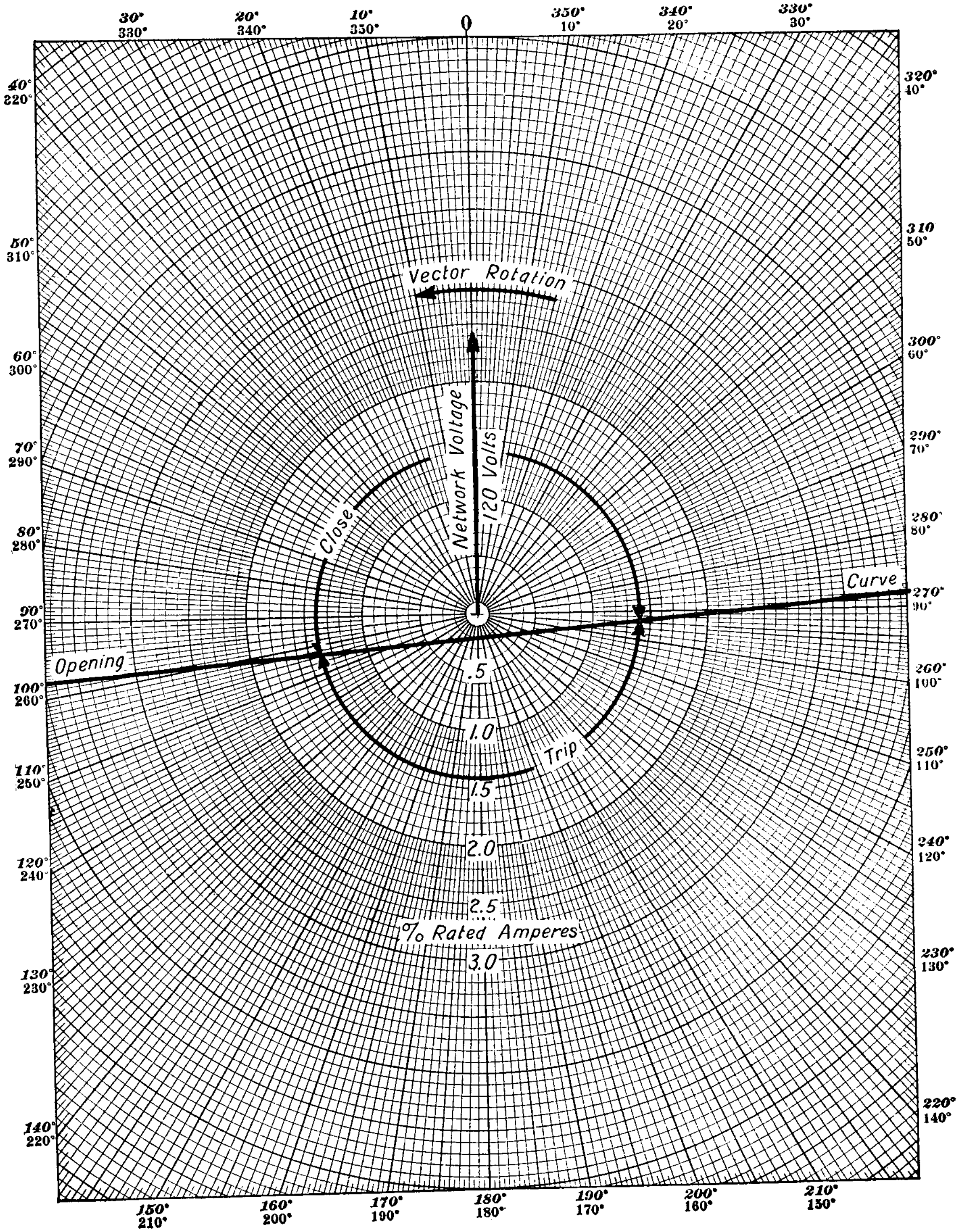


Fig. 9—Operating Characteristics of the Type CN-3 Network Master Relay Using Phasing Lamps, Balanced Three-Phase Conditions Assumed

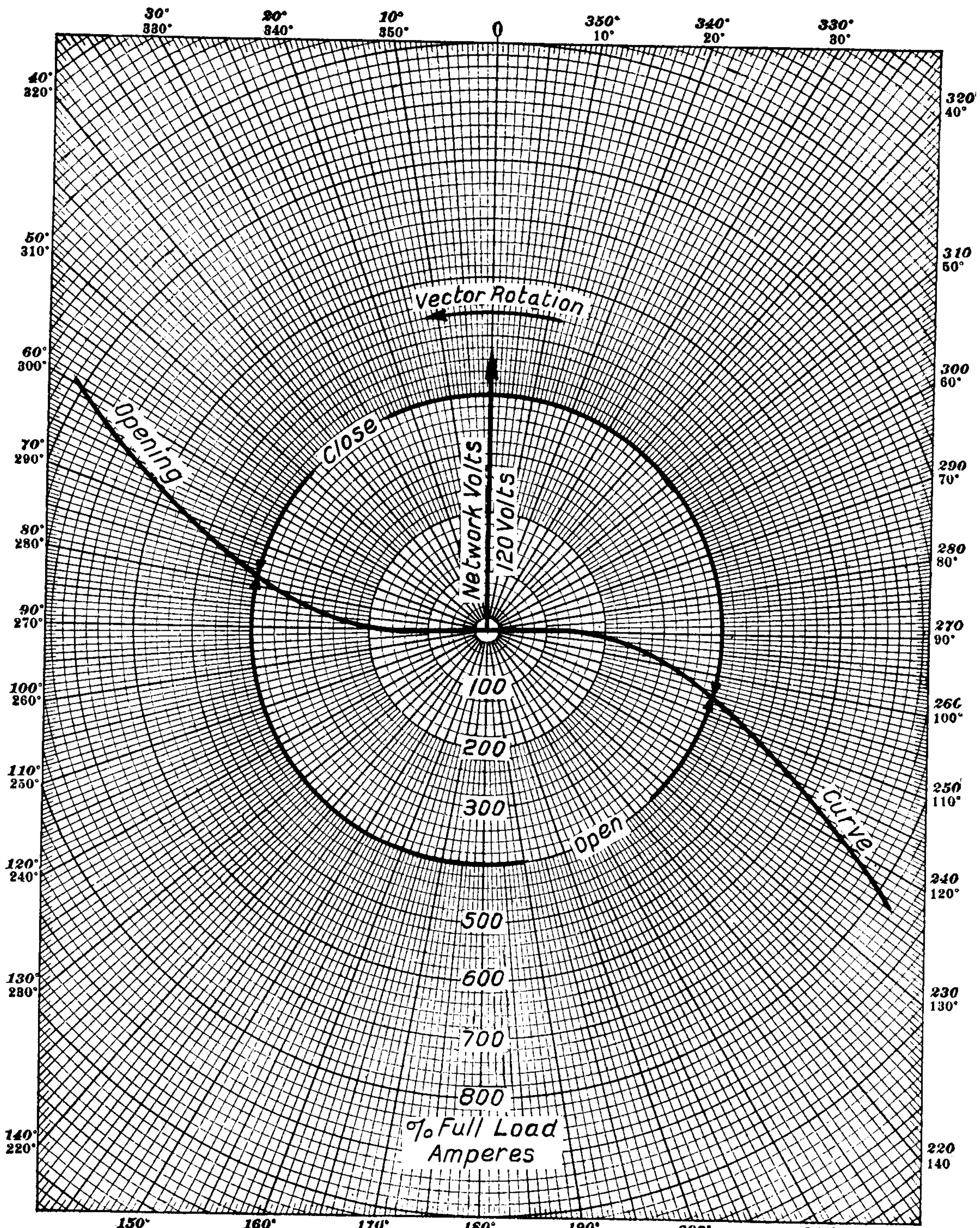


FIG. 10—OPERATING CHARACTERISTICS OF THE TYPE CN-3 NETWORK MASTER RELAY USING PHASING LAMPS. BALANCED THREE-PHASE CONDITIONS ASSUMED

small section of the closing curve plotted to a much larger scale so as to show the characteristics of the relay at 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, or voltage across the open contacts of the network breaker, necessary to produce a balanced condition in the relay. The upper end, or line potential end, of the network voltage vector is at the origin in this case. The network voltage vector could not 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 1-A of Fig. 5 that the relay will just close its "closing" contacts with approximately 1.1 volt across the phasing circuit in phase with the network voltage. When the phasing voltage leads the network voltage by 75°, it requires about 3.5 volts to close the "closing" contacts. However, this voltage at 75° leading means only a very small angle between network and transformer voltages, as can readily be seen when it is pointed out that 10 volts 90° leading the network voltage on the phasing circuit will throw these two voltages less than 5° out of phase.

18. The opening characteristics of the type CN-3 relay are shown by curve number 2 in Figs. 5 and 8. Lines drawn from the origin to curve number 2 represent in magnitude and phase position the line currents which will just produce a balanced torque condition in the relay. If the line current is increased slightly so that it just crosses the curve into the zone marked "trip", the relay will close its "tripping" contacts and disconnect the transformers from the network. If, however, the line current does not touch the opening curve but lies in the zone marked "close", 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 full load. The curves shown in Figs. 6 and 9 represent a small section of the opening curve just discussed drawn to a much larger scale in order to show the operation of the relay on small current values such as the magnetizing current of a transformer. The magnetizing current of a 300 kv-a. 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 may be seen by referring to the curve of Fig. 6 that the relay will operate satisfactorily to trip the network breaker when exciting current only is flowing.

19. On systems where the voltage of the 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 substation breaker is open this charging current will flow through the transformer. In such cases, therefore, the current on which the relay must operate is not the magnetizing current of the transformer alone, but the vector sum of the magnetizing current and that part of the charging current flowing through its breaker. 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 two opening curves discussed, it may be seen that the relay will operate equally as well on leading reversals as on lagging reversals, provided this leading reversed current does not exceed approximately twice the full load rating of the breaker even if it is almost 90° out of phase with the network voltage reversed.

20. Figs. 7 and 10 show the tripping characteristics of the relay on current values up to about eight times full load, such as are encountered under short circuit conditions. The bend in the curve is caused by the saturation of the current transformer used with the relay. This bend in the curve somewhat improves the action of the relay under certain short-circuit conditions.

21. Figs. 8 to 10 show the operating characteristics of the CN-3 relay using phasing lamps. Comparison of Fig. 8 with Fig. 5, Fig. 9 with Fig. 6 and Fig. 10 with Fig. 7, will show the differences in the characteristics of the two styles of relays. It will be observed that curve number 2 of Fig. 5 is much straighter than curve number 2 of Fig. 8. The phasing coils are short-circuited under the condition for which curve number 2 was taken, and energization of the current coils will induce current in the phasing coils. Variation in the impedance of the phasing circuit will change the lagging effect of the phasing coils upon the current coil flux, and will alter the tripping characteristics of the relay. As the current through the network protector increases the current through the phasing lamps also increases, and likewise their resistance. This accounts for the distortion of curve number 2 in Fig. 8. As a result of this distortion, the CN-3 relay using phasing lamps will not operate on as highly lagging magnetizing currents or as highly leading charging currents as will the relay using phasing resistors. Present-day application conditions vary so widely, even on the same system, that the use of the CN-3 relay with phasing resistors is now preferable. The curves of Figs. 5-10 were taken with current transformers of the ratio used for a 1200-ampere network protector. The relay characteristics when used with current transformers of other ratios are very closely identical, but there may be a variation of two or three degrees in the opening curves for currents above several hundred per cent of the protector rating.

Adjustments and Tests

22. There are only two adjustments to make on the type CN-3 relay, namely the overvoltage closing adjustment and the reverse-current tripping adjustment. The overvoltage closing adjustment is made by means of adjustable shading coils which are located over the potential poles in the air gaps of the electro-magnets just below the discs. The positions of the coils, and consequently the amount of voltage across the phasing circuits of the relay necessary to close the contacts, are adjusted by turning screws located on the right side of the movement frame. For the "A" and "B" elements, moving these coils to the left increases the voltage necessary to close the "closing" contacts, and moving them to the right decreases the voltage. If the coil is moved far enough to the right, the relay will close its "closing" contacts with zero voltage across the phasing circuit. It should be noted that the adjustment on the "C" element for overvoltage closing is made in just the reverse manner to that on "A" and "B" elements. These adjustments are made

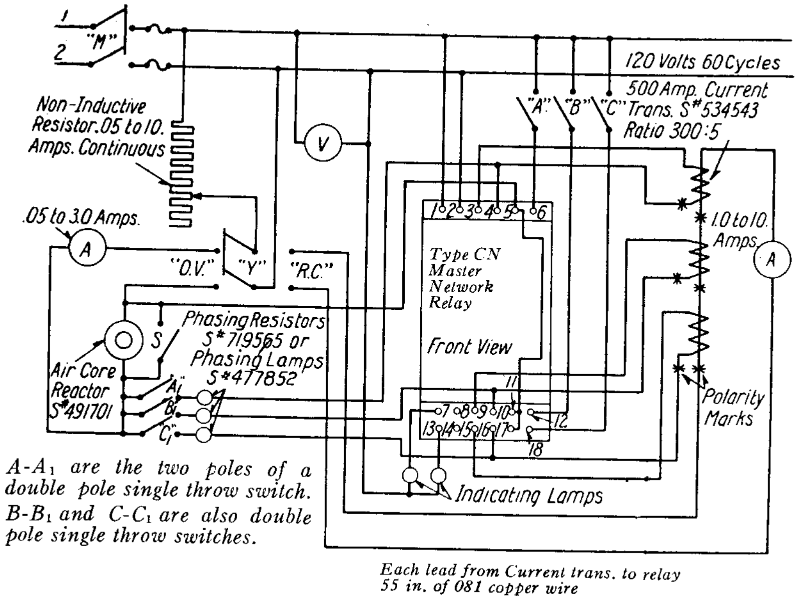


FIG. 11—TEST CONNECTIONS FOR SINGLE PHASE TEST AND ADJUSTMENT OF TYPE CN-3 NETWORK MASTER RELAY

without touching the two screws which are used to mount the adjustable shading coil. These two screws carry flat washers and lock washers which hold the shading coil securely in place for any adjustment. When making the overvoltage adjustment, the current coils of the relay should be connected across the secondaries of the network current transformers. The rating of the transformers used will not affect the adjustment. The overvoltage adjustment should be made on one element at a time and with the other two elements completely de-energized. This adjustment should be made with the tip of the stationary "closing" contact extending approximately ¼ inch from the "L" shaped bracket which supports it.

23. It should be noted that when the overvoltage adjustment is made in this manner on one element at a time that when it is checked using all three elements energized simultaneously, a slightly higher phasing voltage will be found necessary to close the "closing" contacts. For example, when each element is adjusted individually to close the relay "closing" contacts on 2.0 volts at 75° leading, the value required when using all three elements together will be between 2.3 and 2.5 volts on the relay using phasing lamps and between 3.2 and 3.5 volts on the relay using phasing resistors. This is because the torque exerted by the spiral spring is taken into account three times when adjusting each element separately and only once when checking all three together. Also if, after the overvoltage adjustment is made on all three elements, voltage is applied to all three potential coils, the phasing voltage required on one element alone to close the "closing" contacts will be approximately three times the setting of the individual element.

24. The reverse-current tripping adjustment is made by varying the position of the stationary "tripping" contact. When making this adjustment, the position of the reverse-current stop screw should first be checked. The reverse-current stop screw is the screw located just below the stationary "tripping" contact which acts as a stop for the flat spring carried by the moving contact support. It should be so placed that the reverse-current adjusting spring just touches it without any deflection when there is approximately ⅛ inch separation between the moving contact and the stationary "closing" contact. Moving the stationary "tripping" contact to the left increases the amount of reverse-current necessary to close the "tripping" contacts and moving it to the right decreases this amount. When this adjustment is made, the stationary "tripping" contact 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 network 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 their respective phasing lamps or resistors. It should be noted that under the condition where the breaker is closed and no load is flowing through it, a certain amount of deflection of the reverse-current adjusting spring is caused by the action of the overvoltage adjusters working in conjunction with the potential coils. Thus it is possible, with an incorrect setting of the stationary "tripping" contact, for the relay to close its "tripping" contacts and thus trip the breaker when there is no load current flowing. When the relay has been properly adjusted as described above and the potential coils of all three elements are energized, a current of approximately three times the setting is required on any one element to close the "tripping" contacts. When the current and potential coils of only one element are energized, a current of approximately twelve times the reverse-current setting (depending upon the overvoltage adjustments used) is required to close the "tripping" contacts of the relay using phasing lamps. For the relay using phasing resistors this value is about eight times the reverse current setting. These data regarding the tripping action of the relay for one element alone are given not as representing a practical condition, for in practice all three elements are subjected to magnetizing currents and potential coil voltage at once, but to avoid confusion when it is desirable to check the action of any one element. For a given setting, the reverse current adjustment of the relay will vary practically in direct proportion to the rating of the network current transformers being used with the relay.

25. 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 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 so as to rotate the disc through a distance equivalent to ⅛ inch free contact travel in approximately 25 seconds when the relay is de-energized, and this adjustment should not ordinarily be changed. However, it may be desirable in some cases to decrease this time somewhat in order to minimize the effect of friction but in such cases the overvoltage and reverse-current settings should be checked after the change in the spring adjustment.

26. Fig. 11 shows a wiring diagram which should be used for checking the ranges of adjustment and for adjusting the network relay in the laboratory. The air core reactor, Style Number 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 resistor. The above reactor is used at the factory in making these adjustments and has an impedance of approximately 8 ohms. A similar reactor having a lower impedance and requiring a current of about 0.7 ampere per volt can be had. 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 approximately 1 ohm resistance may be substituted for it and the setting made at equivalent values of in-phase voltage. The use of the reactor is somewhat preferable since it approximates usual operating conditions and since meter errors will introduce a smaller voltage error in the equivalent in-phase adjustment. The resistance of the leads from the current transformers to the current terminals is important. Each lead should be 55 inches of 0.081 inch copper wire. The current transformers used are standard 500-ampere current transformers such as are supplied on a 500-ampere network breaker. The resistor used for adjusting the current through the current transformers, as well as the current through the reactor, should be non-inductive.

27. The following is a brief description of the proper method of testing the relay. Connect the relay exactly as shown in Fig. 11. With the contacts adjusted as previously described, see that the time required for the relay to close its "closing" contacts through ⅛ inch free travel is 25 seconds plus or minus 2 seconds when the relay is de-energized. If the time of closing is not correct, it can be corrected by changing the initial tension of the spiral spring. It is important that the relay be approximately level when checking this time of closing and when testing. The reverse-current stop screw should not deflect the reverse-current adjusting spring at the beginning of the travel of the contact when checking the time of closing with the relay de-energized. Check the overvoltage closing range of one element at a time. This is done for element "A" by closing switches "M", $A-A_1$" and "Y" to the side marked "O.V." and placing the adjustable shading coil at the extreme left end of its travel. Then adjust the current through the reactor until the relay just closes its "closing" contacts. By the ammeter reading, the value of voltage across the phasing circuit can be determined. Open switch "Y" and move the shading coil to the right until the relay "closing" contacts close on zero volts across the phasing circuit. The range of overvoltage adjustment on all the relay elements should be approximately 0 to 12 volts. However, in the usual testing or calibration of the relay this check of the overvoltage range may be omitted. Next set the adjustable shading coil so that the relay will close its "closing" contacts from the point where the reverse-current adjusting spring just touches the reverse-current stop screw on 2 volts 75° leading and will not close its "closing" contacts from this point when the voltage is reduced to 1.5 volts at 75° leading. With the "closing" contacts closed and the potential coil energized, the relay should open its "closing" contacts when the phasing voltage is reduced to zero volts. Switch "$B-B_1$" is used in place of switch "$A-A_1$" when making the adjustment on the element "B" and similarly switch "$C-C_1$" is used with switches "Y" and "M" when adjusting the element "C". As previously mentioned, it should be noted that the adjustment of the shading coil on element "C" is made in just the reverse manner to that for elements "A" and "B" due to the fact that it is acting on the front half of the disc.

28. The voltage values mentioned above apply to both the CN-3 relay with phasing resistors and the relay with phasing lamps. If the relays are to be adjusted to close on an in-phase voltage equivalent to 2.0 volts at 75° leading, however, the voltage values for the two relays will be different on account of the difference in the slopes of their respective closing curves. The relay with phasing resistors should be adjusted to just close its "closing" contacts on 0.6 volt in phase, and it should not close its contacts on 0.45 volt in phase. The relay with phasing lamps should be adjusted to close its "closing" contacts on 0.85 volt in phase and it should not close its contacts on 0.65 volt in phase.

29. With the relay thus set for two volts closing, check the range of reverse-current tripping. Close switches "M", "$A-A_1$", "$B-B_1$", "$C-C_1$", "S", and "Y" to the side marked "R. C." Move the stationary "tripping" contact as far to the left as possible without having the point of contact come too close to the edge of the moving contact and adjust the current through the current transformers until the "tripping" contacts just make. This gives the maximum value of reverse-current for which the relay can be adjusted. The minimum is of course, zero amperes. The range obtained on this test should be approximately 0 to 10 amperes, when using 500-ampere network current transformers. Next set the relay to close its "tripping" contacts when 1.0 ampere at 180° to the potential coil voltage is flowing through the current transformers. When the relay has been so adjusted to close its "tripping" contacts on 1.0 ampere flowing through the 500-ampere current transformers, the stationary "tripping" contact should be securely locked in position by means of the thumb nut provided for this purpose.

Recommended Settings

30. The values for the overvoltage and the reverse-current adjustment given in the two preceding paragraphs are recommended as being the most suitable for general applications. The relays are adjusted for these values in the factory. In some cases, however, it may be necessary to modify these adjustments somewhat to meet particular conditions, and the relay is provided with adjustments so that this may be readily done by the customer. For example, the magnetizing energy taken by a particular type of transformer may be so low that the network relay will not trip the protector when given the settings recommended above. In such a case, the reverse-current setting of the relay should be reduced so that positive operation will be secured. In this connection, it should be remembered that the relay should always be given as high a reverse-current setting as possible, which will still allow positive operation of the relay when tripping on reverse energy flow.

Installation

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

32. The network protector and relays have each been completely tested at the factory. It is advisable, however, to check the operation of the complete unit before placing it in service in order to make sure that none of the parts have been broken or damaged in shipment. See the Network Protector Instruction Book for diagrams and instructions for testing the relays and protector as a unit. Before leaving the network protector set for automatic operation, see that all terminal screws are in place and tight, then replace the terminal chamber covers and see that the glass cover is on the relay.

Maintenance

33. The mechanical construction of the type CN-3 network master relay has been made as simple and rugged as possible. An attempt has been made to make all parts readily accessible. The relay has been, as far as possible, made up of small unit assemblies. All of this tends to decrease the maintenance to a minimum and to facilitate repairs. After the relays are properly installed and adjusted, they will require little attention. When it is found necessary to inspect a breaker, the relays should also be inspected to see that they are free from friction and that the contacts are properly adjusted and not badly burned.

34. A periodic inspection of all units 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 switch open or by comparing records of the reading of the operation counter. Failure to close may be due to any one of the three following causes:

(1) Improper voltage conditions, i.e., the network voltage is higher than the transformer voltage, or the phase relations are such that the phasing relay keeps the unit from closing. Failure to close because of this does not constitute a faulty operation.

(2) Failure of the breaker or its operating mechanism.

(3) Failure of the network master relay.

35. The failure of a type CN-3 relay to close under proper voltage conditions may be due to friction, to dirty or improperly adjusted contacts, to an open circuit in the phasing circuit of the relay, or to an improper overvoltage closing adjustment. Friction in the relay may be due to dirty or broken lower bearings; to bent pins in the upper bearings; to foreign material in the air gaps of the damping magnets or the electro-magnets; to leads rubbing against the back of the discs; to the adjustable shading coils being bent so that they rub against the discs; to the counter shaft being out of line with the disc shaft, so that the gears do not mesh properly, or to the spring adjuster being bent down enough to rub on the molded hub of the counter shaft. The phasing circuits may open due to the breaking or the burning out of the phasing resistors, but no trouble need be expected due to the potential coil becoming open-circuited although such a thing is possible. When a breaker is found to have failed to close, the relay should be inspected to see that it is free from friction and that the contacts are in good condition. The overvoltage closing and reverse-current tripping adjustments should then be checked as described under "Adjustments and Tests". If these are found to be correct it will be necessary to look elsewhere for the cause of the failure. Should the breaker and operating mechanism also be found to be all right, the failure to close was undoubtedly due to the voltage conditions, which existed on the system at the point where the unit is installed.

36. Failure of a network breaker to open (assuming that the units have been properly applied) can be due only to a failure of the relays or the breaker to open. Should a breaker fail to open when the feeder breaker is opened, the fact can be detected at once by a voltage indication on the feeder at the station. The type CN-3 relay may fail to close its "trip" circuit due to friction, to dirty or improperly adjusted contacts, or to open-circuits in the operating coils. It should be remembered that an open circuit in any one potential coil or current coil does not necessarily prevent the relay from tripping the network breaker when it should, due to the fact that there are two other elements to give tripping torque to the relay.

37. The preceding is not given as a list of troubles which anyone may expect to encounter with the type CN-3 relay, but is given merely as a guide to help in locating the causes of any improper operations of the protectors which may occur.

Type CNA Network Phasing Relay

Application

38. The type CNA network phasing relay is designed to control the closing operation of the alternating-current automatic network protector in conjunction with the type CN-3 network master relay. The characteristics of the relay are such that it will operate to close its contacts and assist the type CN-3 relay in closing the network protector when voltage conditions across the open protector are such that when the breaker closes power will flow into the network. The closing characteristics of the type CNA relay and the type CN-3 relay are inter-dependent, that is, it takes the characteristics of the two working together to insure that the protector will always close when the feeder is energized, if voltage conditions are such that the transformers are capable of supplying power to the network and that the protector will not close when conditions are such as to cause pumping.

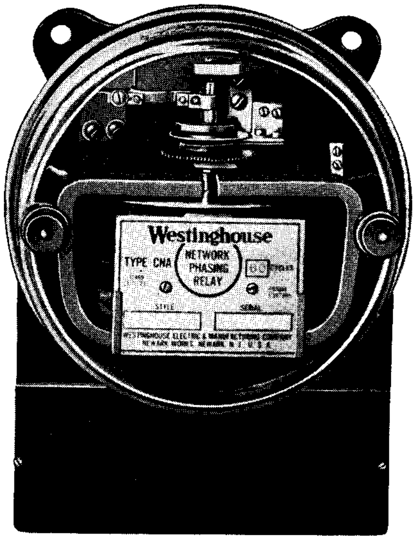
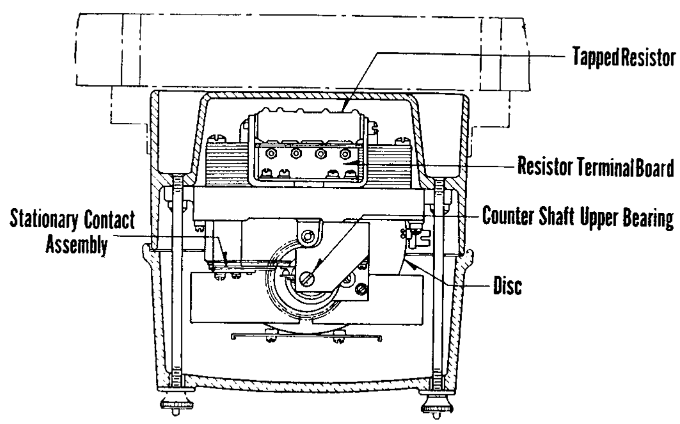


Fig. 12—Type CNA Network Phasing Relay

Description

39. The type CNA relay shown in Figs. 12 and 13 operates on the induction principle. It is very similar in many respects to the type CN-3 relay and the same principles of construction are used throughout. The type CNA relay is essentially the same as one element of the type CN-3 relay but with different operating coils and characteristics. The following points of construction embodied in the type CNA relay are not covered in the instructions for the type CN-3 relay.

40. The relay is equipped with single-pole, single-throw contacts of pure silver. The moving contact is mounted on a rigid contact arm which is fastened to the molded hub on the counter shaft. The stationary contact is mounted on a flat spring and is provided with a set-screw for adjusting the contact pressure. The travel of the moving contact is limited by a small bronze stop riveted on the disc. The maximum contact opening is approximately ⅛ inch. This is sufficient to prevent the contacts accidentally closing even when the relay is subjected to extremely



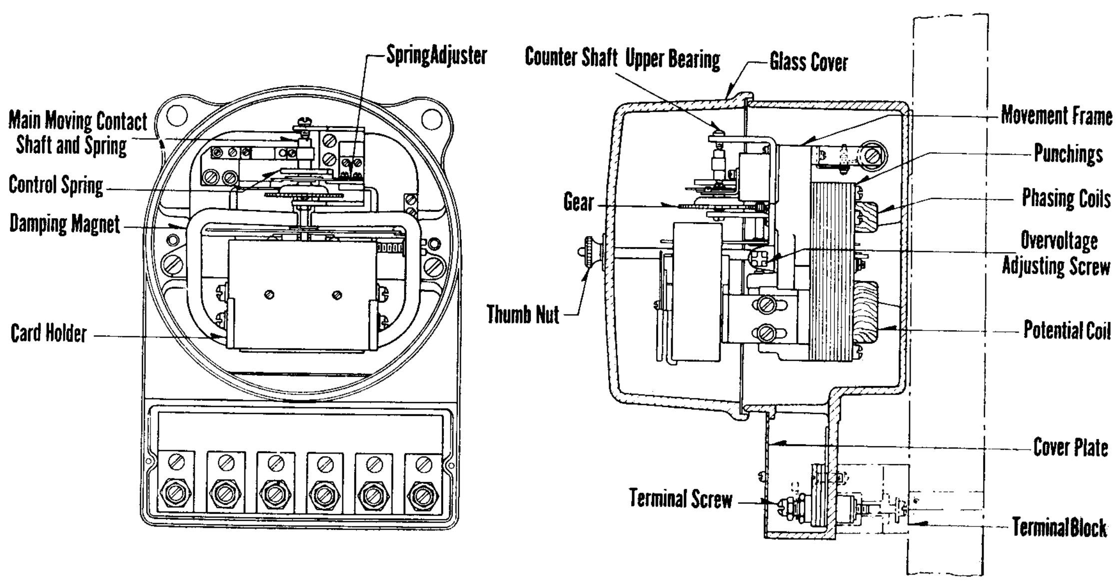


Fig. 13—Type CNA Network Phasing Relay

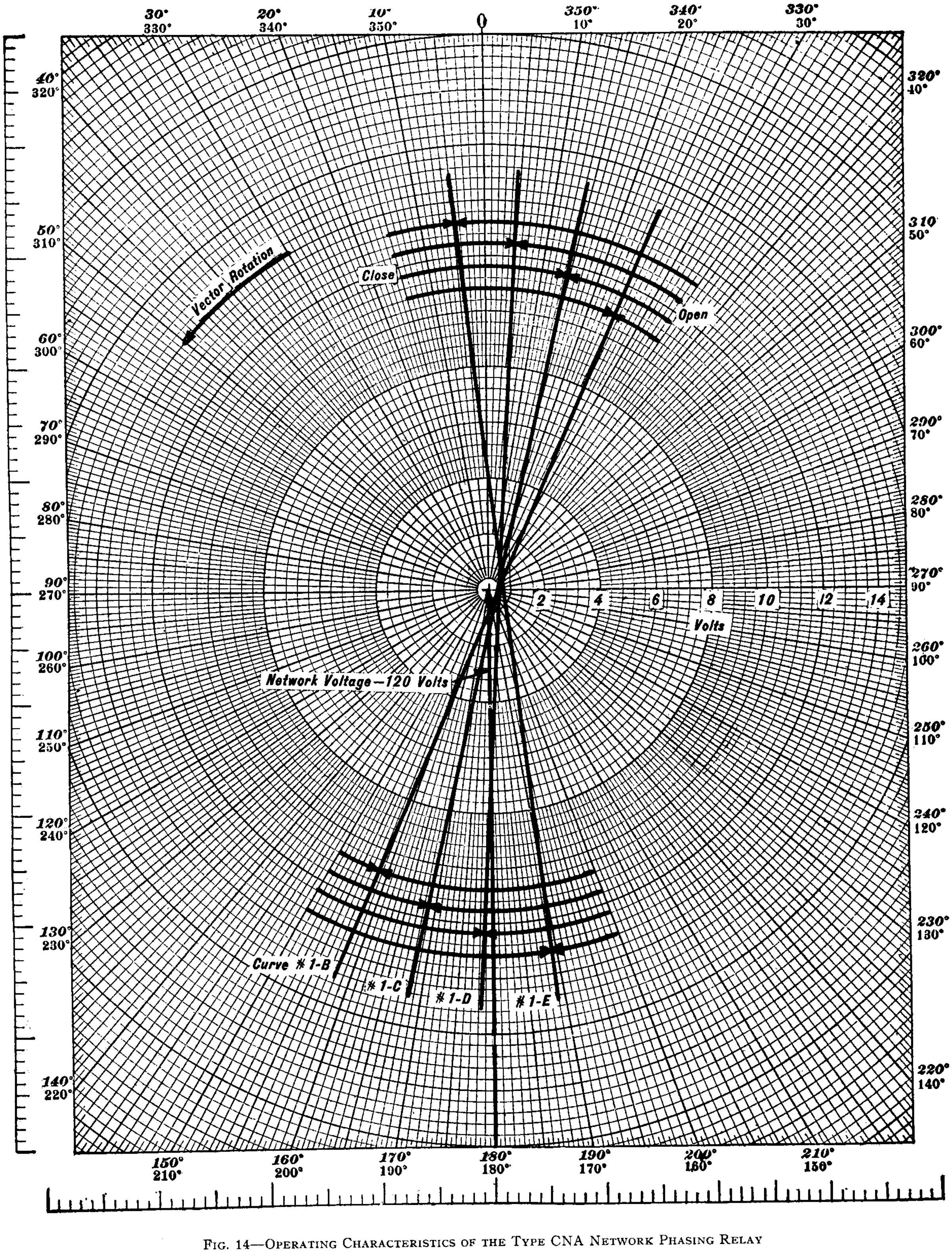


Fig. 14—Operating Characteristics of the Type CNA Network Phasing Relay

heavy jars or vibrations. A tapped resistor is mounted in the back of the relay case above the electromagnet. The connections are made to screws which are supplied with extra nuts so that when changing connections to the resistor, the connection may be made under a nut and washer or it may be soldered if this is considered more desirable. See Fig. 17.

Operation

41. Referring to Fig. 4, it may be seen that the potential coil and phasing coils for the type CNA network phasing relay are connected to phase "A" of the circuit-breaker in exactly the same manner as the potential and phasing coils of element "A" of the type CN-3 relay. The operation of the two relays is exactly the same in principle. The type CNA relay has different closing characteristics from the type CN-3 relay; these are obtained by means of specially designed phasing coils and by means of the tapped resistor connected in series with the potential coil.

42. Fig. 14 shows the normal operating characteristics of the type CNA relay. The relay may be adjusted so as to have characteristics similar to any one of the four curves shown, namely, 1-B, 1-C, 1-D, or 1-E. The network voltage, which is the voltage from line "A" to ground, 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 voltage which will produce a balanced torque condition in the relay. Phasing voltages which do not cross the curve being used but lie in the zone marked "close" will cause the phasing relay to close its contacts and phasing voltages which cross the curve being used into the zone marked "open" will cause the phasing relay to keep its contacts open. It should be noted that the relay will keep its contacts closed when the phasing voltage is reduced to zero when an adjustment for phasing voltage is used similar to that used when these curves were taken. However, the curve may be shifted parallel to itself by means of the overvoltage adjuster, if the network system design is such that this is desirable. The relay is connected in the factory to have a characteristic similar to that shown as curve 1-D, and with a similar adjustment. The curves 1-E, 1-D, 1-C and 1-B are obtained in order by moving the connection to the terminal board in the upper part of the relay from right to left.

43. The operation of the type CNA relay in conjunction with the type CN-3 relay can best be explained by referring to Fig. 15 which illustrates the closing characteristics of both the CNA relay and the CN-3 relay with phasing resistors. Curve 1-A illustrates the closing curve of the type CN-3 relay, which is discussed in the instructions relating to the type CN-3 relay, and curve 1-D illustrates the closing curve for the type CNA relay. The area which lies in the "closing" zone common to both of these two curves is shaded. Thus a network phasing voltage such as E_1 which extends into this shaded area will cause the type CNA relay to make its contacts and the type CN-3 relay to make its "closing" contacts and thus cause the network breaker to close. The current which will flow through the breaker when it closes will lag the phasing voltage across the open breaker by an angle approximately equal to the impedance angle of the system, and for a particular system may be such as shown as I_1. Noting the position of I_1, with respect to the network voltage and referring to curve 2 on Figs. 5 and 8, it may be seen that such a current will keep the type CN-3 relay "closing" contacts closed and thus the operation of the protector will be stable. However, a phasing voltage such as E_2 if the breaker were manually closed, would cause a current such as I_2 to flow through the breaker, and by referring again to curve 2 on Figs. 5 and 8 it may be seen that this current would cause the type CN-3 relay to make its "tripping" contacts. The phasing voltage E_2, lying on the closing side of the curve 1-A, causes the type CN-3 relay to make its "closing" contacts, and thus if the type CN-3 relay alone controlled the network breaker, it would pump under this condition. However, the type CNA relay will not close its contacts when acted upon by a phasing voltage such as E_2, and since the contacts of the two relays in series must be closed at the same time in order to allow the network breaker to close, it may be seen that the type CNA 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-3 relay also prevent pumping from occurring when the phasing voltage leads the network voltage by more than approximately 90°. It should be further noted that the closing curve of the type CN-3 relay is such as to prevent the breaker from closing under crossed-phase conditions while the type CNA relay used alone would allow the breaker to close under certain crossed-phase conditions.

44. 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 may be seen that since this phasing voltage E_3 falls on the opening side of curve 1-D that the phasing relay would prevent the protector from closing. In the event that it is desirable to have the protector close under such conditions, the curve 1-C may be used for the type CNA relay which would allow the protector to close if such a change in characteristics will not cause pumping. It is to provide for such more or less special cases that the tapped resistor is provided in the relay.

Adjustments and Tests

45. There is only one adjustment to make on the type CNA relay, namely, the overvoltage closing adjustment. It is made by means of the adjustable shading coil exactly similar to the one used on the type CN-3 relay. Moving this coil to the right, increases the voltage necessary to close the relay contacts, and moving it to the left decreases the voltage. If the coil is moved far enough to the left, the relay will close its contacts with zero voltage across the phasing circuit. As with the type CN-3 relay, it is only necessary to turn the screw located on the right hand side of the movement frame to make the adjustment, and when the adjustment is made, the shading coil remains securely in place without the necessity of tightening any locking screws.

46. No special test set-up is required for making the usual adjustment of the CNA relay, since the relay is ordinarily

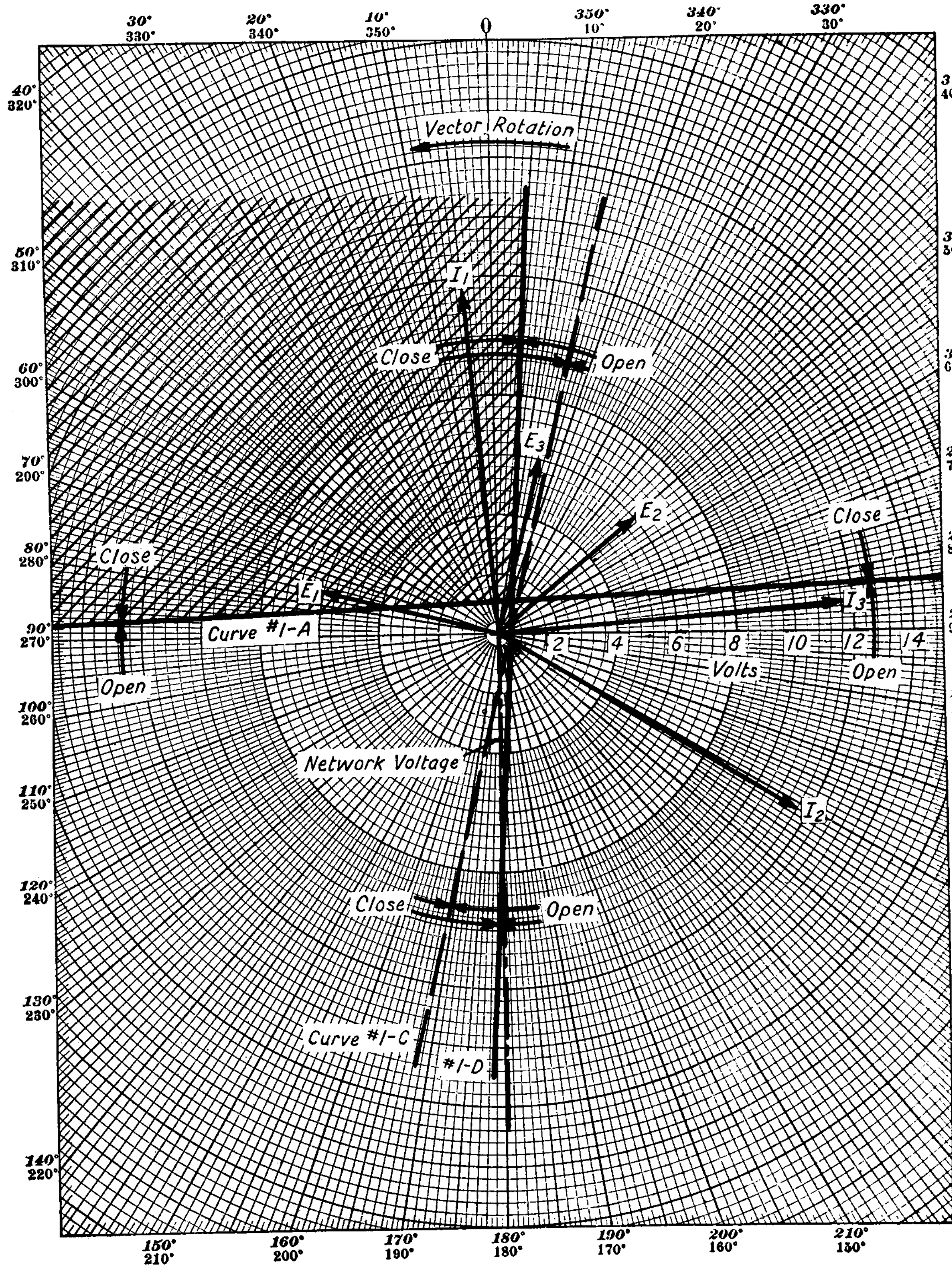


Fig. 15—Combined Closing Characteristics of the Types CN-3 and CNA Network Relays Used with Phasing Resistors

adjusted to just close with zero volts on the phasing circuit. If for any reason it should be desired to check the overvoltage closing range, however, or if it should be necessary to give the relay an adjustment which will require a positive value of phasing voltage to close its contacts, the connections shown in Fig. 16 should be used. The special reactor shown in the diagram is similar to the 75° air core reactor used in testing the type CN-3 relay. The following is a brief description of the proper method of testing the relay. By means of the adjustable set screw provided on the stationary contact move the stationary contact back until the moving contact does not touch it when the stop on the disc strikes the stop on the right hand side of the movement frame. See that the time required for the relay disc to travel approximately 190° from the stop on the left hand side of the movement frame to the stop on the right hand side of the movement frame is 15 seconds plus or minus 1.0 second when the relay is de-energized. If this time is not correct, it can be corrected by changing the initial tension on the spiral spring. It is important that the relay be approximately level while checking this time of closing and when testing. The stationary contact should then be brought forward by means of the adjustable set screw, so that, when the spring tension is correct as noted previously, the contacts will close in approximately 10 seconds from the extreme open position when the relay is de-energized. After connecting the relay as shown in Fig. 16 check the overvoltage closing range. This is done by closing switches "A" and "B", and placing the adjustable shading coil at the extreme right end of its travel. Then adjust the current through the reactor until the relay contacts just close. By the ammeter reading, the value of voltage across the phasing circuit can be determined. Open switch "B" and close switch "C" and move the shading coil to the left until the relay contacts close on zero volts across the phasing circuit. The range of overvoltage adjustment should be approximately 0 to 2 volts at 75° leading the network voltage. Next, set the relay to close on zero phasing volts as follows. With switches "A" and "C" closed, adjust the shading coil so that the contacts will close from the extreme open position. Then remove the phasing lamp or resistor, thus open-circuiting the phasing coil circuit, and see that the relay contacts just open. This test should be repeated several times to see that the relay will always close its contacts from the extreme open position when the potential coil is energized at normal voltage and the phasing coils are short-circuited through their phasing lamp or resistor, and that the contacts will always open when the phasing coils are open-circuited. This method of adjustment gives a value of phasing voltage necessary to close the contacts practically equal to zero and still insures that the contacts will remain closed when the network breaker is closed and carrying load. The air-core reactor, resistor and ammeter are of course unnecessary if the CNA relay is given this adjustment. This will prove to be the best adjustment for most network systems. However, if it is found necessary to give the relay an adjustment which will require a positive value of phasing voltage leading the network voltage to close its contacts, such an adjustment can be readily made.

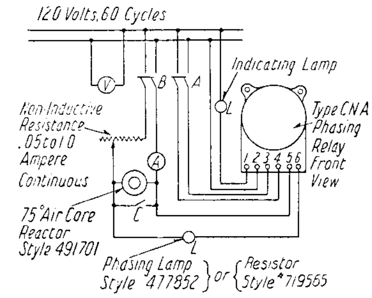


Fig. 16—Diagram of Test Connections for Single Phase Test and Adjustment of Type CNA Network Phasing Relay

Installation

47. The type CNA relay is shipped separate from the breaker unit. This decreases the possibility of damage during shipment. Carefully unpack and closely examine the relay to see that none of the parts have been bent or broken during shipment. Inspect the relay to see that it is free from friction. It has been previously recommended to check the operation of the complete unit and the type CNA relay should be used along with the type CN-3 relay in making this test.

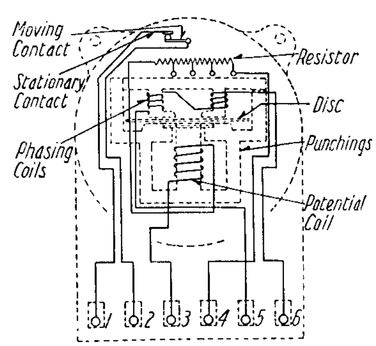


Fig. 17—Wiring Diagram of Internal Connections of Type CNA Network Phasing Relay

48. The discs of both the type CNA and the type CN-3 relays should be blocked with paper while transporting the network protector to the manhole in order to lessen the effect of jars on the bearings. However, it is advisable to remove the relays after testing is complete, as this will facilitate handling of the breakers and eliminate the possibility of the relays being accidentally damaged.

Maintenance

49. The mechanical construction of the type CNA relay has been made as simple and rugged as possible. An attempt has been made to make all parts readily accessible. The relay has been, as far as possible, made up of small unit assemblies. All of this tends to decrease the maintenance to a minimum and to facilitate repairs. After the relays are properly installed and adjusted, they will require little attention. When it is found necessary to inspect a breaker, the relay should be inspected to see that it is free from friction and that the contacts are properly adjusted and not badly burned.

50. As discussed under that part of these instructions dealing with the type CN-3 relay, a periodic inspection of all protectors should be maintained to see whether any protectors have failed to close when the feeder to which they are connected was energized. The failure of a type CNA network phasing relay to close under proper voltage conditions may be due to friction, to very dirty or improperly adjusted contacts, to an open-circuit in the phasing-circuit of the relay, or to an improper overvoltage closing adjustment. Friction in the relay may be due to dirty or broken lower bearings, to bent pins in the upper bearings, to foreign material in the air gap of the damping magnet of the electro-magnet, to leads rubbing against the back of the disc, to the adjustable shading coil being bent so that it rubs against the disc, to the counter shaft being out of line with the disc shaft so that the gears do not mesh properly, or to the spring adjuster being bent down enough to rub on the molded hub of the counter shaft. It is very unlikely that dirty or improperly adjusted contacts will ever cause a relay to fail to close the contact circuit unless the adjustment is such that the contacts actually fail to make. The phasing circuit may open up due to the burning out or breaking of the phasing lamp or resistor.

51. The preceding is not given as a list of the troubles which anyone may expect to encounter with the type CNA relays, but is given merely as a guide to help in locating the cause of any improper operations of the protectors which may occur.

Type SR Voltage Restraining Relay

Application and Operation

52. Provisions for adding a type SR relay is included in some of the type CM-2 and CM-22 network protectors. Its function is to provide an adjustment by means of which the sensitivity of the protector to reverse power can be decreased below, or restored to, that of the type CN-3 master relay, as desired.

53. Under certain operating conditions it is advisable to permit a considerable amount of reverse power for short periods of time in order to avoid an excessive number of unnecessary operations of the circuit-breaker. Examples of such conditions occur where networks are fed from a number of separate stations whose voltages are at times appreciably different in magnitude or phase position. Networks supplying power to a large amount of apparatus employing the regenerative braking principle may be subject to a similar condition. Frequent unnecessary operations must eventually lead to unnecessarily high maintenance expense, and since they are of no advantage to the distribution system the insensitive setting can be used to eliminate them while still maintaining adequate protection.

54. If there is no probability that any such condition will apply to a given network before the next inspection of the protector the type CN-3 relay may well be left in control without having its sensitivity modified by the type SR. Changing the positions of connecting links on an insulating base at the front of the protector changes from sensitive to insensitive setting or vice versa.

55. The type SR relay operates on the voltage restraint principle but differs from other voltage restraining schemes in that it provides for eliminating all restraint under fault conditions, thus rendering the protector sensitive and insuring positive operation when a primary fault occurs. A simple voltage relay, a positive phase sequence voltage filter, and three tapped resistors are mounted within the case.

56. Assuming that the links are in position for insensitive operation, the CN-3 and CNA relays function in the usual manner to "make" their closing contacts. These two sets of contacts in series when closed energize the auxiliary relay and complete the energizing of the positive phase sequence voltage filter in the SR voltage restraining relay. The SR relay picks up and closes its contacts. This connects the phasing coils of the CN-3 relay together through the three resistors in the SR relay. Appreciably more current now passes through the phasing coils at such an angle that these coils, acting in conjunction with the potential coils produce a strong torque to keep the CN-3 relay contacts closed. When the auxiliary relay closes, one set of its contacts energizes the closing motor of the protector and its other set shunts the contacts of the CNA relay. This seals the auxiliary relay in the energized position through the CN-3 relay contacts. These contacts, of course, remain closed after the protector closes, due to the restraining torque produced by the phasing and potential coils. The CNA relay contacts may or may not remain closed and it is therefore necessary to shunt them by the auxiliary relay contacts.

57. With the protector closed the phasing coils act as restraining coils and, in conjunction with the potential coils produce a torque which must be overcome by the action of the current and potential coils. The amount of reverse current at normal voltage necessary to overcome the restraining torque and trip the circuit-breaker can be adjusted by changing taps on the resistors in the SR relay and thus regulating the amount of current through the phasing coils.

58. When a fault that appreciably affects the system voltage at the protector occurs on any phase or phases the positive phase sequence voltage at that point is reduced. If this reduction amounts to about 10% it will cause the SR relay to open its contacts, thus de-energizing the phasing coils, reducing the restraining torque to zero, and restoring the CN-3 relay to its sensitive condition. The network protector will then be under the control of the sensitive directional master 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.

59. The most important advantage of this method of obtaining high reverse current settings when compared with other voltage restraining schemes is that with this scheme, the restraining torque is reduced to zero on any type of fault which causes an appreciable drop in voltage on any phase or phases, thus giving maximum reliability of operation. With other voltage restraining schemes the restraining torque under most fault conditions is by no means zero.

60. Failure of the SR relay contacts to make would leave the protector operating with the sensitive setting. In view of the high normal pressure of the contacts and the voltage of the circuit which they control the possibility of failure to make contact is negligible. "Freezing" or failure of the contacts to open would maintain the insensitive setting. This also is an improbable condition but not disastrous, since the reverse current required to trip decreases as the voltage decreases.

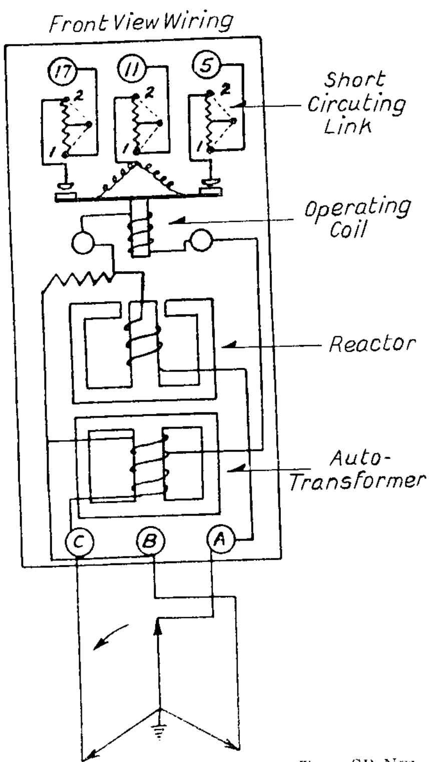


Fig. 18—Wiring Diagram for Type SR Network De-Sensitizing Relay

61. The closing characteristics of the protector are the same whether the sensitive or the insensitive setting is used.

The operating coil of the "SR" relay is energized with a voltage proportional to the positive phase sequence voltage applied to terminals A, B, and C. It serves to control the restraining circuit (through terminals 5, 11 and 17) of the Network Master Relay. See Fig. 18.

Characteristic of Master Relay with "SR" restraint approximates a watt curve with settings indicated below:

Link Position	Approx. Restraint at 100% P.F.
Open	18%
1	24%
2	40%

Tests and Inspection

I—MECHANICAL INSPECTION

(A). Make sure that the plunger is free from friction. Its maximum travel should be ⅛″.

(B). See that both contacts are securely fastened to make both circuits at the same time and have an initial gap of $\frac{1}{16}$″.

(C). Flexible leads must be free from friction.

II—THREE PHASE TEST

Voltages 1, 2, and 3 must be equal and variable.

(A). Set weights on plunger so that contacts just close when the line to neutral voltage is 94 to 96% of normal.

(B). Check drop-out; it should be 94% at minimum pick-up voltage.

(C). Check filter balance by interchanging leads B and C. The voltage measured across the relay coil shall be less than 3% of the line-to-neutral voltage, when all voltages are balanced and 120° apart.

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-3 NETWORK MASTER RELAY

For Illustration of Parts See Fig. 2

Relays in use up to and including			1	5
Description of Part	**Style No.**	**No. Req.**	**Recommended for Stock**	
Relay Complete	... ...	1	0	0
Disc and Shaft with Jewel and Support	561 638	1	0	0
*Jewel and Support	703 942	1	0	0
*Steel Ball for Jewel Bearing (Disc Shaft)	25 463	1	0	0
Lower Jewel Bearing Screw (Disc Shaft)	289 762	1	0	0
*Upper Bearing Screw (Disc Shaft)	561 611	1	0	0
Gear and Shaft	561 651	1	0	0
Lower Bearing Screw (Gear Shaft)	237 672	1	0	0
Upper Bearing Screw (Gear Shaft)	628 937	1	0	0
Moving Contact with Stationary Closing Contact	561 652	1	0	0
Moving Contact	561 649	2	2	4
Stationary Closing Contact	561 653	1	1	2
Control Spring	306 037	1	0	1
Spring Adjuster	496 270	1	0	0
Reverse Current Adjusting Spring—Inner	563 343	1	0	1
Reverse Current Adjusting Spring—Outer	563 351	1	0	1
Stationary Tripping Contact	561 654	1	1	0
Stationary Contact Screw	561 653	1	0	2
Reverse Current Adjusting Screw	563 342	1	0	0
Coils and Iron (50 cycles)	561 645	3	0	1
Coils and Iron (60 cycles)	561 646	3	0	1
Damping Magnet	561 621	1	0	0
Glass Cover	376 021	1	0	1
Cover Thumb Nut	289 840	4	0	4
Terminal without Screws—Upper	561 867	6	0	0
Terminal without Screws—Lower	561 868	6	0	0
Terminal Screw	562 817	18	0	3

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

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 CNA NETWORK PHASING RELAY

For Illustration of Parts See Fig. 13

Relays in use up to and including			1	5
Description of Part	**Style No.**	**No. Req.**	**Recommended for Stock**	
Relay Complete	... ...	1	0	0
Disc and Shaft with Jewel and Support	561 633	1	0	0
*Jewel and Support	703 943	1	0	0
*Steel Ball for Jewel Bearing (Disc Shaft)	25 463	1	0	0
*Lower Jewel Bearing Screw (Disc Shaft)	289 762	1	0	0
*Upper Bearing Screw (Disc Shaft)	561 611	1	0	0
Gear and Shaft	561 622	1	0	0
Lower Bearing Screw (Gear Shaft)	237 672	1	0	0
Upper Bearing Screw (Gear Shaft)	703 938	1	0	0
Main Moving Contact	238 452	1	1	2
Control Spring	306 037	1	0	1
Spring Adjuster	496 270	1	0	0
Stationary Contact	561 625	1	1	2
Coils and Iron (50 cycles)	561 631	1	0	0
Coils and Iron (60 cycles)	561 632	1	0	0
Damping Magnet	561 621	1	0	0
Tapped Resistor for Relay S#539919	838 393	1	0	1
Tapped Resistor for Relay S#561655	838 389	1	0	1
Tapped Resistor for Relay S#561656	838 391	1	0	1
Tapped Resistor for Relay S#627279	838 394	1	0	1
Glass Cover	152 389	1	0	1
Cover Thumb Nut	289 840	2	0	2
Terminal without Screws	561 867	6	0	0
Terminal Screw	562 817	6	0	2

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

TYPE SR VOLTAGE RESTRAINING RELAY

Not Illustrated

Relay Complete	818 821	1	0	0
Relay Mechanism	... ...	1	0	0
Moving Contact Complete	819 792	1	1	2
Coil (208 volts, 60 cycles)	703 435	1	1	1
Stationary Contact Complete	819 793	2	2	4
Filter Resistor (1150 ohms)	407 279	1	0	1
Restraining Resistor (3100/100 ohms)	819 701	1	0	1
Reactor	724 024	1	0	0
Transformer	724 025	1	0	0
Set of Beads for Lead Insulation	179 153	1	0	0
Connector (to Resistors)	427 755	3	0	0
Terminal Block without Screws	561 867	6	0	0
Terminal Screw	562 817	6	0	2
Base	821 809	1	0	0
Glass Cover	704 876	1	0	1
Cover Thumb Screw	722 706	1	0	1

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 Shop Order Number, and the type of Relay as shown on the nameplate. For example: One Control Spring, Style No. 306037, for Type CN-3 Network Master Relay, Style No. ....

To avoid delays and mis understandings, 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**.