INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES CR AND CRC DIRECTIONAL OVERCURRENT RELAYS

CAUTION Before putting protective relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

These induction-type directional overcurrent relays are used to disconnect transmission and feeder circuits when the current thru them in a given direction exceeds a predetermined value. The type CR relay is potential polarized and is used for both phase and ground fault protection. The type CRC relay is current polarized and used for ground fault protection.

Two forms of the relay are manufactured: a low energy and a standard energy. This refers to the burden that is placed on the current transformers and not to the current rating.

The low-energy type relay is used in preference to the standard-energy relay where the requirements necessitate (1) a lower burden on the current transformer, or (2) a more inverse curve for selectivity, or (3) a lower current range as for example, ground protection of transmission systems. The very-inverse relay is similar to the low-energy relay and is used where a still more inverse curve is desired.

Relays with circuit closing contacts are used most commonly with the station battery to energize the trip coil thru the relay contacts. Occasionally, where there is no reliable source of potential available for tripping, the breaker may be tripped by current from the current transformer, by the use of circuit opening relays.

CONSTRUCTION AND OPERATION

CIRCUIT-CLOSING RELAYS

The circuit-closing relay consists of an overcurrent element, a directional element, an operation indicator, a contactor switch, and in some cases, an instantaneous trip attachment.

Overcurrent Element

This element is an induction-disc type element operating an overcurrent. The induction disc is a thin four-inch diameter aluminum disc mounted on a vertical shaft. The shaft is supported on the lower end by a steel ball bearing riding between concave, sapphire jewel surfaces, and on the upper end by a stainless steel pin.

The moving contact is a small silver hemisphere fastened on the end of an arm. The other end of this arm is clamped to an insulated section of the disc-shaft in the non-geared type relays, or to an auxiliary shaft geared to the disc shaft in the geared type relays. The electrical connection is made from the moving contact thru the arm and spiral spring. One end of the spring is fastened to the arm, and the other to a slotted spring adjuster disc which in turn fastens to the element frame.

The stationary contact assembly consists of a silver contact attached to the free end of a leaf spring. This spring is fastened to a

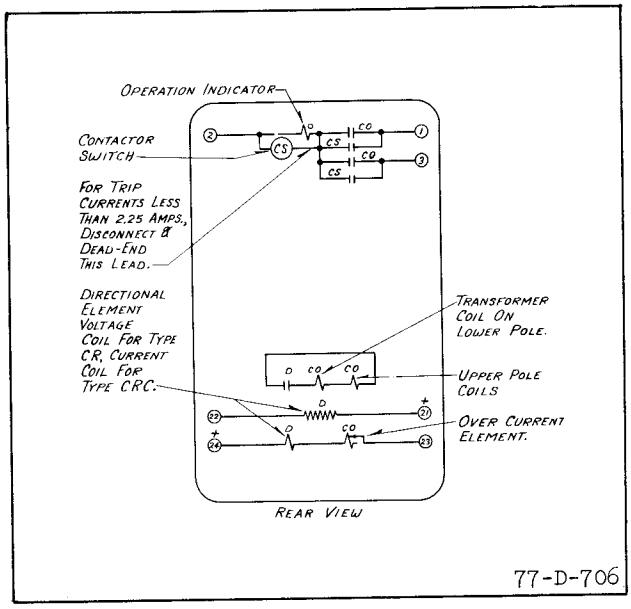

Fig. 1—Internal Schematic Of The Double Trip, Directional Control, Inverse Time (Low Energy 2 Sec., 25, 50 & 60 Cycles, 4 Sec., 25 Cycles) and Very Inverse Time, Circuit Closing Relays In The Standard Case. The Single Trip Relays Have Terminal 3 And Associated Circuits Omitted.

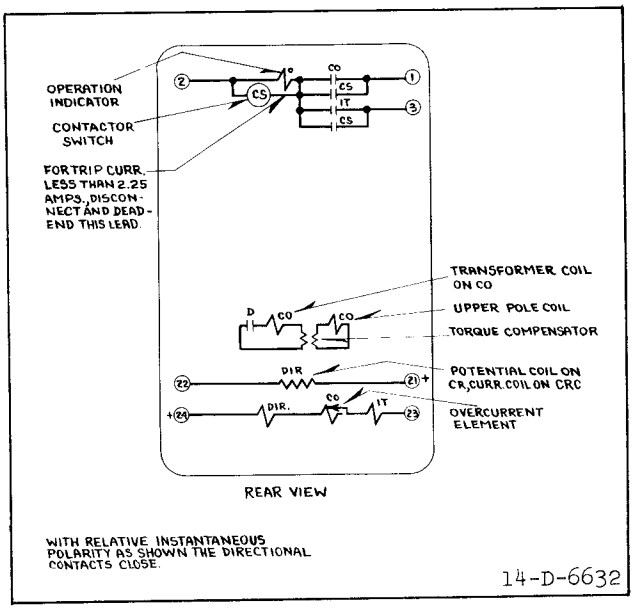

Fig. 2—Internal Schematic Of The Single Trip, Directional Control, Definite Minimum Time (2 and 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (Low Energy 4 Sec., 50 & 60 Cycles), Circuit Closing Relays With Instantaneous Trip In The Standard Case.

Micarta block and mounted on the element frame. A small set screw permits the adjustment of contact follow. When double trip is required, another leaf spring is mounted on the Micarta block and a double contact is mounted on the rigid arm. Then the stationary contact set screws permit adjustment so that both circuits will be made simultaneously.

The moving disc is rotated by an electromagnet in the rear and damped by a permanent magnet in the front. The operating torque is obtained by the circuit arrangement shown in figure 1. The main pole coil of the relay acts as a transformer and induces a voltage in a secondary coil. Current from this secondary coil flows through the upper pole coils and thus produces torque in the disc by the reaction between the fluxes of the upper and lower poles. The inverse and very inverse relays operate on this principle. The definite-time, standard-energy relay obtains its flat characteristic curve because of a small saturating transformer that is interposed between the secondary coil and the upper pole coils. This is called the torque compensator and it slows down the disc movement at high currents to such an extent that no gearing is required. (See Fig. 2).

Directional Element

This element is similar to the over-current element except the quantities used to rotate the disc and the contact assembly. The two upper poles of the electromagnet are energized by overcurrent, and the lower pole by polarizing voltage on the type CR relay and by polarizing current on the type CRC relay. The fluxes produces by these two electrical quantities cause rotation of the disc in a direction depending on the phase angle between the current and voltage. As fault power reverses, the current in the relay reverses while the polarizing current or voltage remains fixed, thus a directional torque is obtained.

The rotation of the disc is limited in the opening direction to a few degrees by a projecting stop on the disc which strikes the element frame, and in the closing direction by the rigid moving arm striking the stationary contact arm.

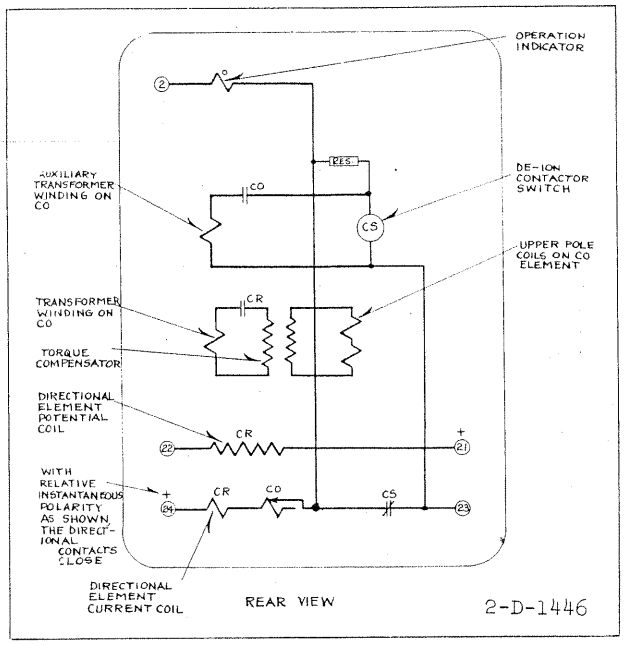

Fig. 3—Internal Wiring Diagram Of The Single Trip, Standard Energy, Circuit Opening Relay.

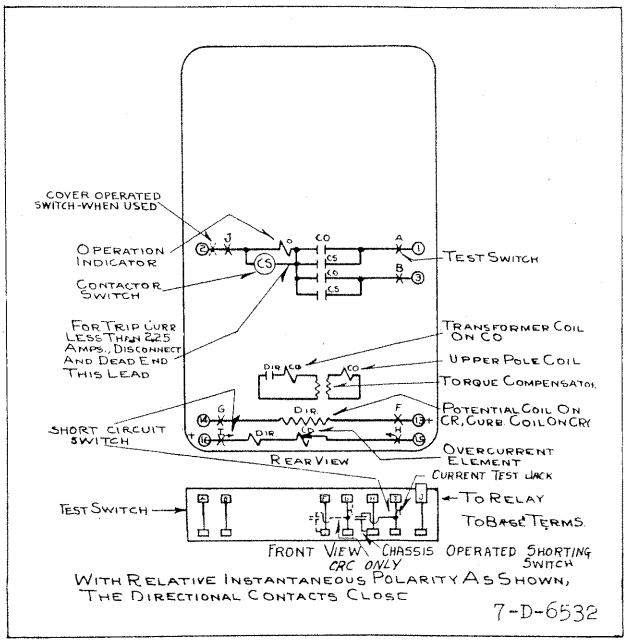

Fig. 4—Internal Schematic Of The Double Trip, Directional Control, Definite Minimum Time (Standard Energy 2 and 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (4 Sec., 50 & 60 Cycles) Circuit Closing Relay In The Type FT Case. The Single Trip Relays Have Terminal 3 And Associated Circuits Omitted.

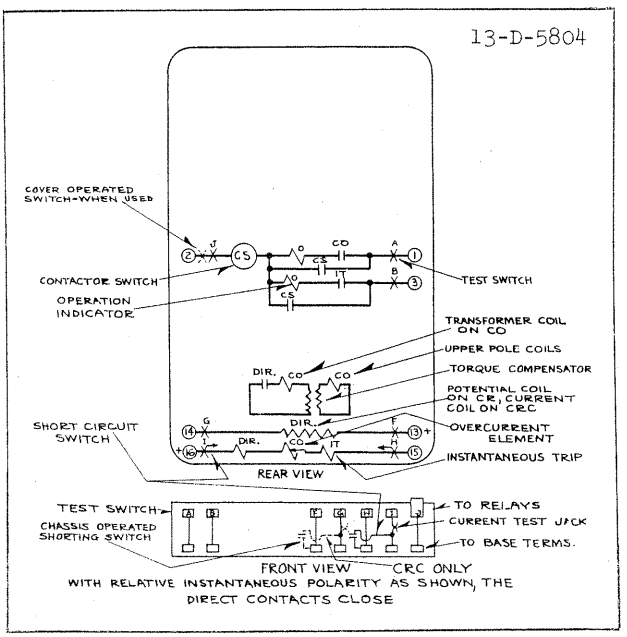

Fig. 5—Internal Schematic Of The Single Trip With Instantaneous Trip, Directional Control, Definite Minimum Time (Standard Energy 2 & 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (4 Sec., 50 & 60 Cycles) Circuit Closing Relay In The Type FT Case.

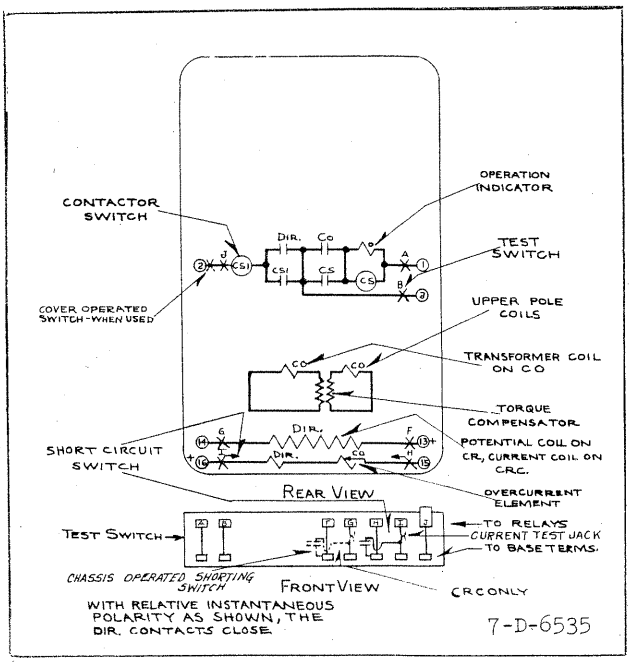

Fig. 6—Internal Schematic Of The Single Trip, Non-Directional Control With Terminal Between Directional And Overcurrent Contacts, Definite Minimum Time (Standard Energy 2 & 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (4 Sec., 50 & 60 Cycles) Circuit Closing Relay In the Type FT Case.

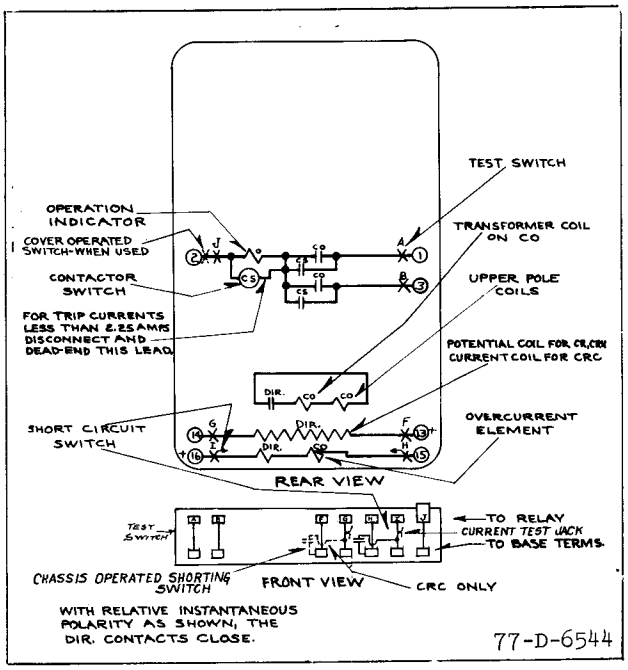

Fig. 7—Internal Schematic Of The Double Trip, Directional Control, Inverse Time (Low Energy 2 Sec., 25, 50 & 60 Cycles, 4 Sec., 25 Cycles) or Very Inverse Time, Circuit Closing Relay In The Type FT Case. The Single Trip Relays Have Terminal 3 And Associated Circuits Omitted.

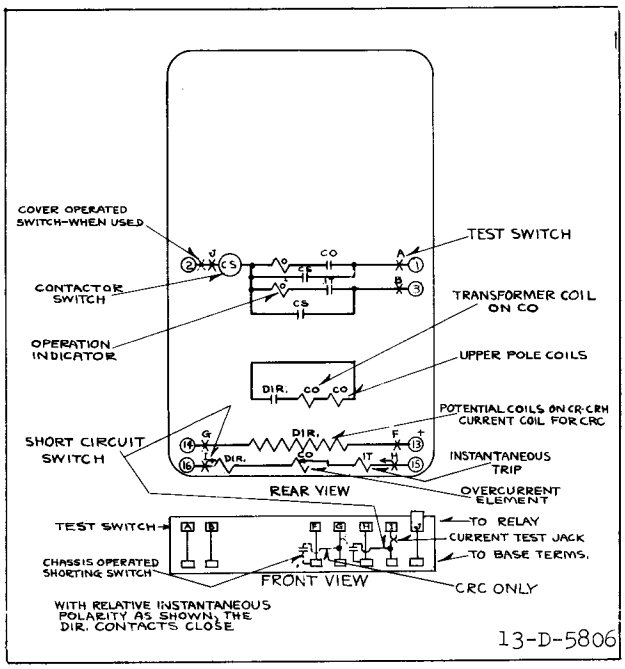

Fig. 8—Internal Schematic Of The Single Trip With Instantaneous Trip, Directional Control, Inverse Time (Low Energy, 2 Sec., 25, 50 & 60 Cycles 4 Sec., 25 Cycles) or Very Inverse Time, Circuit Closing Relay In The Type FT Case.

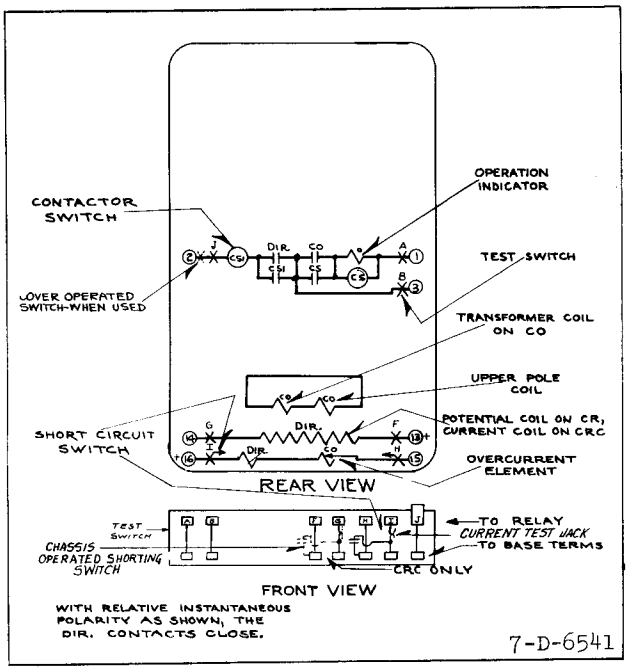

Fig. 9—Internal Schematic Of The Single Trip, Non-Directional Control With Terminal Between Directional And Overcurrent Contacts, Inverse Time (Low Energy 2 Sec., 25, 50 & 60 Cycles, 4 Sec., 25 Cycles) or Very Inverse Time, Circuit Closing Relay In The Type FT Case.

The moving contact assembly consists of a rigid counterweighted arm fastened to an insulated section of the disc shaft. A leaf spring fastens to the shaft end of the arm with a silver contact attached to the free end of the leaf spring. When the moving contact strikes the stationary contact, the spring deflects to provide the required contact follow. The spiral spring assembly is the same as described above for the overcurrent element.

The stationary contact consists of a right-angle bracket fastened to the element frame thru a Micarta insulating block. A contact screw projects thru the outer end of the bracket and provides adjustable contact separation.

To prevent the relay from operating for faults in the non-tripping direction, the directional element contact are connected in the upper pole circuit of the overcurrent element. This means that the overcurrent element cannot operate unless the power flow is a predetermined direction. This is known as directional control of the overcurrent element.

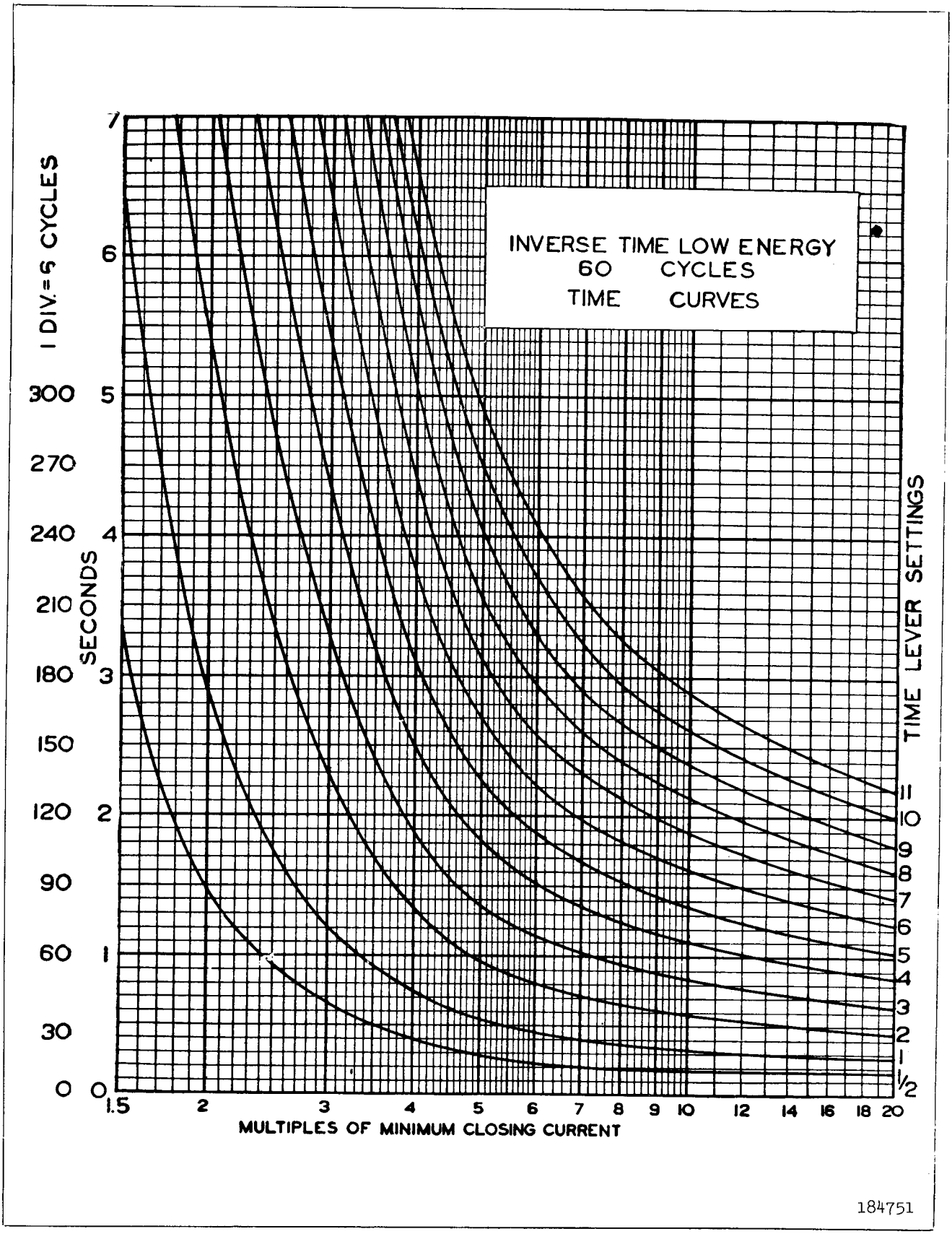

Fig. 10—Typical Inverse Time Curves Of The Overcurrent Element Of The Low Energy 60 Cycle Relays.

The older method, now known as non-directional control, was to connect the overcurrent contacts in series and directly in the tripping circuits.

Contactor Switch and Operation Indicator

The contactor switch is a small solenoid type d-c. switch, the coil of which is connected in the trip circuit. A cylindrical plunger with a silver disc mounted on its lower end moves in the core of the solenoid. As the plunger travels upward the disc bridges three silver stationary contacts. In the single-trip relay, two of these contacts seal around the main relay contact. In the double-trip relays, all three contacts are used to seal in both trip circuits.

The operation indicator coil is connected in the trip circuit to show a white target when the trip circuit is completed.

CIRCUIT-OPENING RELAYS

The circuit-opening type CR relay consists of an overcurrent element, a directional element, a de-ion contactor switch, an operation indicator and an instantaneous trip attachment where required. The connections are shown in Fig. 3.

Overcurrent and Directional Element

These elements are similar to the elements described above under circuit-closing type relay. Directional control is used.

De-ion Contactor Switch

This switch is a small a-c solenoid switch whose coil is energized from a few turns on the lower pole of the overcurrent element in the standard-energy type relays, and from a small transformer connected in the main current circuit in the low-energy type relays. Its construction is similar to the d-c type switch except that the plunger operates a spring leaf arm with a silver contact surface on one end and rigidly fixed to the frame on the other end.

The overcurrent element contacts are in the contactor switch coil circuit and when they close, the solenoid plunger moves upward to open the de-ion contacts which normally short circuit the trip coil. These contacts are able to break the heavy current due to a short circuit and permit this current to energize the breaker trip coil.

The transformer coil on the lower pole of the overcurrent element and the contactor switch circuits in the standard-energy type relays are connected to the main circuits as shown in Fig. 3. When the overcurrent contact closes, the contactor switch operates, and the voltage across the trip coil is impressed on the transformer and contactor switch coils. This voltage acts to seal-in the contactor switch, and to feed energy through the transformer coil to the main overcurrent winding which produces contact closing torque. This arrangement provides a definite minimum pick-up value largely independent of the value of trip coil impedance.

Operation Indicator

The operation indicator is in series with the breaker trip coil, and has a minimum pick-up of 2 amperes a-c.

CHARACTERISTICS

The characteristic curves of the Type CR and CRC relays are shown in Figs. 10, 11 and 12. The standard-energy definite-time relay is made in either of the following current ranges:

2 - 2.5 - 3 - 3.5 - 4 - 5 - 6 or
4 - 5 - 6 - 8 - 10 - 12 - 15

The low-energy type relay is made in the above two tap ranges and also in the following range frequently used for ground protection:

.5 - .6 - .8 - 1.0 - 1.5 - 2 - 2.5

The circuit-opening relay is made only in the 4 to 15 ampere range. A lower range is not desirable because the burden of a low-range trip coil is too heavy on the current

transformer. One trip coil is required for each relay.

Phase Relays

Relays intended for phase protection have directional elements that are true wattmeters; that is, they have their maximum torque when the current and voltage are in phase.

Ground Relays

Ground relays operate on low current values and consequently, the low-energy type relays are used. The directional element of these relays (designated as type CR ground relays) is not a true wattmeter, but is compensated so that its maximum torque occurs when the current lags 15 degrees behind the voltage.

When specially ordered, S#1161078 Phase Shifter can be used with the type CR Ground Relay to provide maximum torque at 45 to 65 degrees current lagging residual voltage. The use of the phase shifter requires reversing either the current or the potential connections but not both. Actually, the current connections are shown reversed in Figs. 18 and 22.

INSTALLATION

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

Because the circuit-opening relay contacts short circuit the trip coil, it is important that the relay be mounted where it will not be subject to shocks which may jar the contacts open and thereby allow current to flow through the trip coil. Trouble of this kind can be avoided by preventing jars to the switchboard and also by setting the trip coil high enough so that it will not operate on normal load current. This is an extra safe-guard so that there is no danger from even an excessive shock unless the current is also heavy.

Phase Relay 30° Connection

The directional element should be connected using a delta voltage across the polarizing winding that lags 30 degrees behind the respective star-current at unity power factor. These connections are shown in Figs. 15, 17, 19 or 21. These connections produce a maximum torque in the relay when the current lags 30° behind its 100% pf position.

Phase Relay - 90° Connection

* Another connection is the so-called 90° connection shown in Figs. 16 and 20. The relay uses the current in one wire and the potential across the other two wires of the circuit. When this is done, a resistor should be put in series with the potential coil of the relay.

One combination of resistor and potential coil produces a maximum torque in the relay when the current lags 45° behind its 100% P.F. position. These external resistors can be ordered by style number as follows:

25 cycle, 115 volts, 760 ohms, S#721435
50 cycle, 115 volts, 670 ohms, S#721436
60 cycle, 115 volts, 565 ohms, S#721437

Another combination of resistor and potential coil produces a maximum torque in the relay when the current lags 60° behind its 100% pf position. This external resistor can be ordered by style number as follows.

60 cycle, 115 volts, 315 ohms, S#1723744

Ground Relays

The directional element should be connected

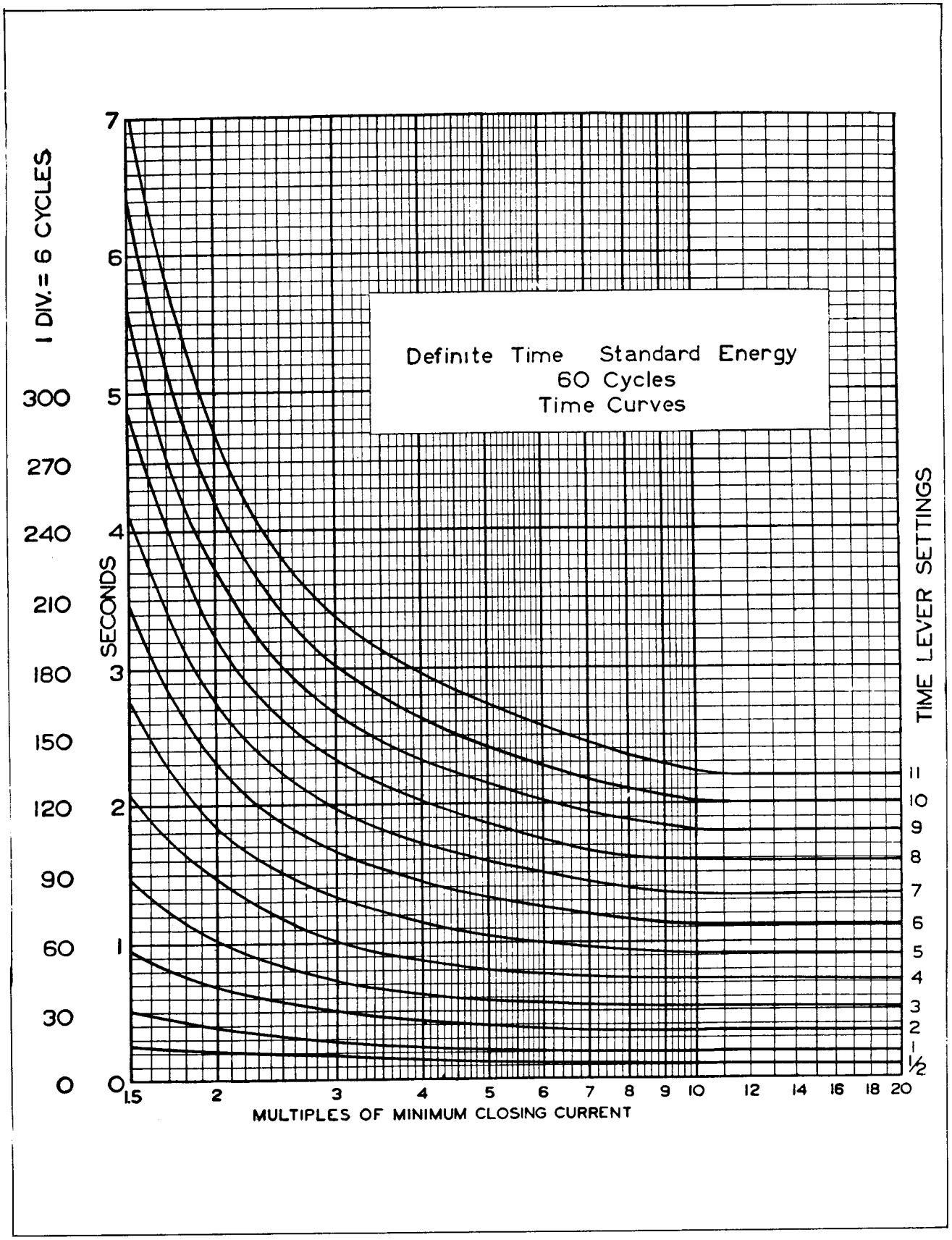

Fig. 11—Typical Inverse Definite Minimum Time Curves Of The Overcurrent Element Of The Standard Energy 60 Cycle Relays.

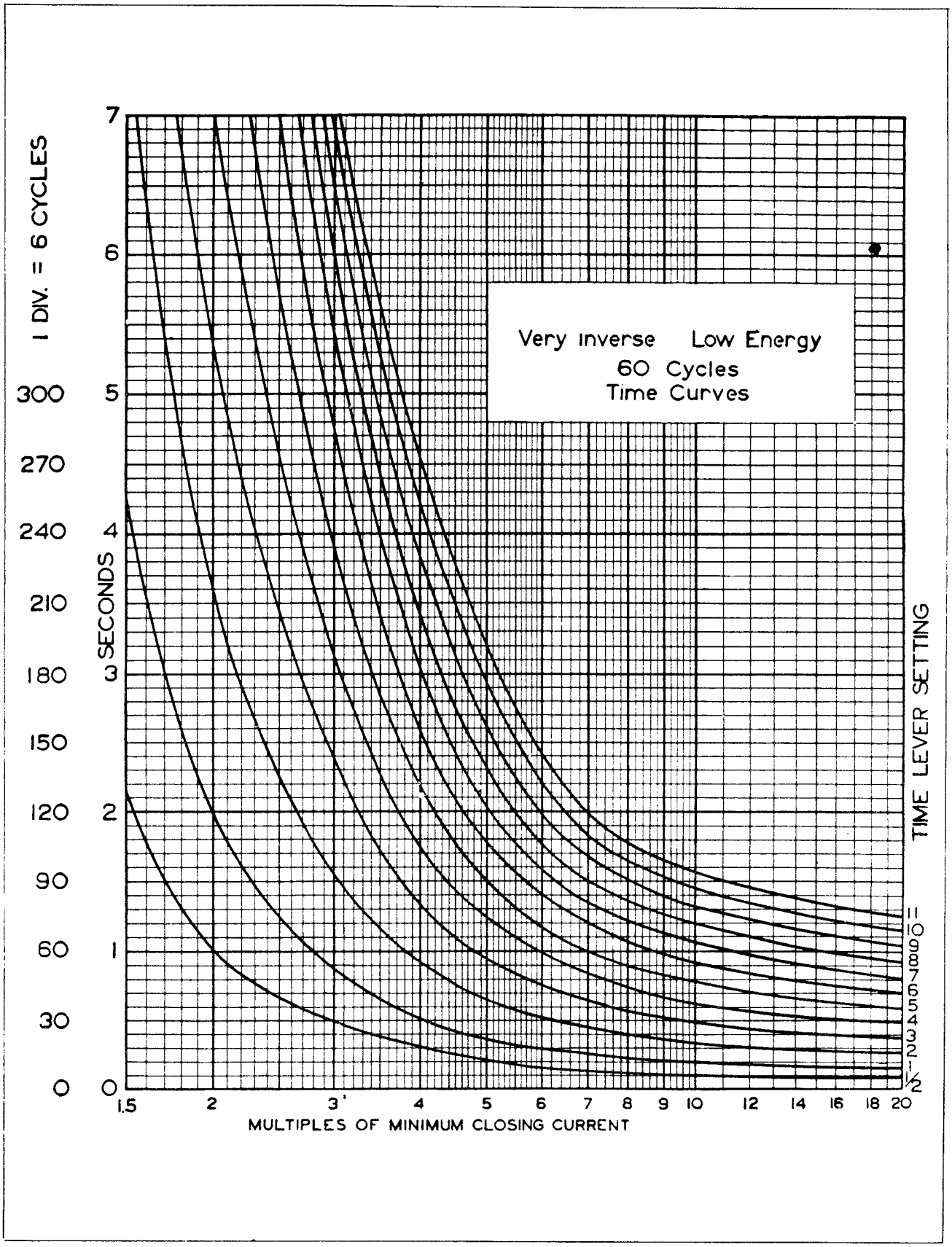

Fig. 12—Typical Very Inverse Time Curves Of The Overcurrent Element Of The Low Energy 60 Cycle Relays.

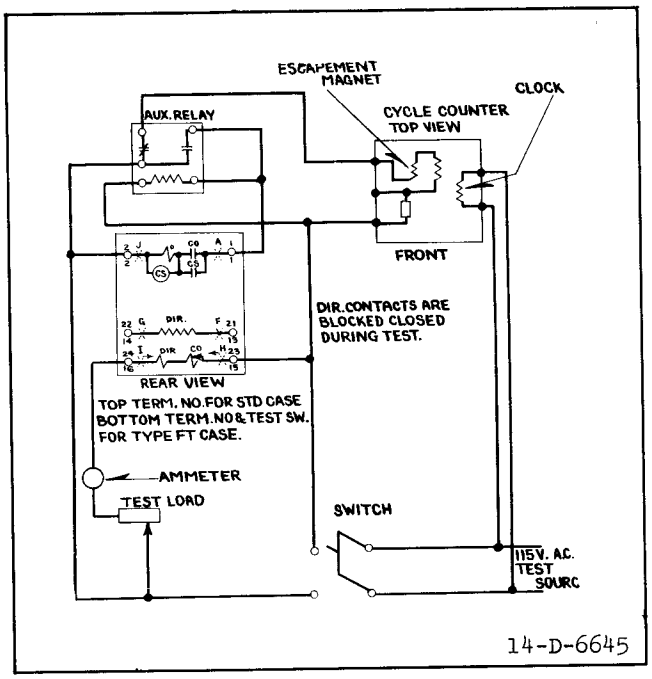

Fig. 13—Diagram Of Test Connections For The Circuit Closing Relays.

to operate on residual current and voltage for the type CR relay, and on residual currents for the type CRC relay, as shown in Figs. 15 to 22.

When using the circuit-opening relays for phase protection, ground protection may be secured by using a low-energy circuit-closing relay operating on a-c. Voltage trip coil energized from a single-phase potential transformer.

Trip Circuit

The main contacts will safely close 30 amperes at 250v. d-c, and the switch contacts will safely carry this current long enough to trip a breaker.

The relay is shipped with the operation indicator and the contactor switch connected in parallel. This circuit has a resistance of approximately 0.25 ohm and is suitable for all trip currents above 2.25 amperes d-c. If the trip current is less than 2.25 amperes, there is no need for the contactor switch and it should be disconnected. To disconnect the coil, remove the short lead to the coil on the front stationary contact of the contactor switch. This lead should be fastened (dead ended) under the small filister-head screw located in the Micarta base of the contactor switch. The operation indicator will operate for trip currents above 0.2 ampere d-c. The resistance of its coil is approximately 2.8 ohms.

An auxiliary switch on the circuit breaker should be used so that when the circuit breaker is tripped, the tripping circuit will be opened by this switch.

The circuit-closing relay may also be used to trip a circuit breaker equipped with a Westinghouse "Direct-trip attachment" on the trip coils. This is a device that trips a circuit breaker by energy received from a current transformer.

Relay With Quick Opening Contacts

When the relays are used with circuit breakers that are instantaneously reclosed, it is necessary to arrange the relay contacts to be quick opening. This is done by screwing in the small set screw on the stationary contact assembly until the contact rivet rests solidly on the Micarta support. When this is done, the position of the contact stop on the time lever should be shifted so that the moving and stationary contacts barely touch when the time lever is set on zero.

SETTINGS

There are two settings-namely the current value at which the relay closes its contacts and the time required to close them. When the relay is to be used to protect equipment against overload, the setting must be determined by the nature of the load, the magnitude of the peaks and the frequency of their occurrence.

For sectionalizing transmission systems the current and time setting must be determined by calculation, due consideration being given to the time required for circuit breakers to open so that proper selective action can be obtained throughout the system.

Current Setting

The connector screw on the terminal plate above the time scale makes connections to various turns on the operating coil. By placing this screw in the various holes, the relay will just close contacts at the corresponding current, 4-5-6-8-10-12 or 15 amperes, or as marked on the terminal plate.

The tripping value of the relay on any tap may be altered by changing the initial tension of the spiral spring. This can be accomplished by turning the spring adjuster by means of a screw driver inserted in one of the notches of the plate to which the outside convolution of the spring is fastened. An adjustment of tripping current approximately 15 per cent above or below any tap value, can be secured without materially affecting the operating characteristics of the relay. By choosing the proper tap, a continuous adjustment of tripping current from 3.4 amperes to 17.5 amperes may be secured. The characteristic time curve will be affected less for any large adjustment if the next higher tap is selected and the initial tension of the spiral spring is decreased to secure the desired tripping value. For example, the relay should be set on the 8 ampere tap with less initial tension in order to secure a 7 ampere tripping value.

CAUTION Be sure that the connector screw is turned up tight so as to make a good contact, for the operating current passes through it. Since the overload element is connected directly in the current transformer circuit, the latter should be short-circuited before changing the connector screw. This can be done conveniently by inserting the extra connector screw, located on the right-hand mounting boss, in the new tap and removing the old screw from its original setting.

Time Lever Setting

The index or time lever limits the motion of the disc and thus varies the time of operation. The latter decreases with lower lever settings as shown in the typical time curves Figs. 10 to 12.

The relay has been calibrated from the #10 time lever setting. The #11 time setting may be used to secure a time delay approximately 10 per cent longer; that is, to secure a setting of 2.2 seconds for a 2 second relay.

ADJUSTMENTS AND MAINTENANCE

All relays should be inspected periodically and the time of operation should be checked at least once every six months. For this purpose, a cycle counter should be employed because of its convenience and accuracy. Phantom loads should not be used in testing induction-type relays because of the resulting distorted current wave form which produces an error in timing.

All contacts should be periodically cleaned with a fine file. S#1022110 file is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed or the relay taken apart for repairs, the following instructions should be followed in reassembling and setting it.

Overcurrent Element

Shift the position of the contact stop on the time lever and adjust the contacts so that they barely touch when the time lever is set on zero. Adjust the tension of the spiral spring so that the relay will close its contacts at its rated current, as shown by the position of the screw on the terminal block. Shift the position of the damping magnets so that the time characteristics of the relay, as shown on the typical time curve. Test connections for the overcurrent element are shown in Fig. 13 or 14.

The directional control overcurrent element cannot start until the watt element has closed its contacts which introduces a delay of

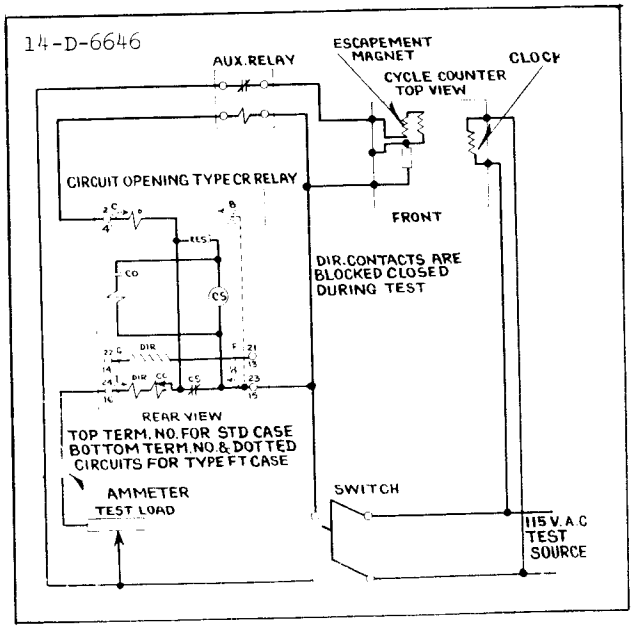

Fig. 14—Diagram Of Test Connections For The Circuit Opening Relays.

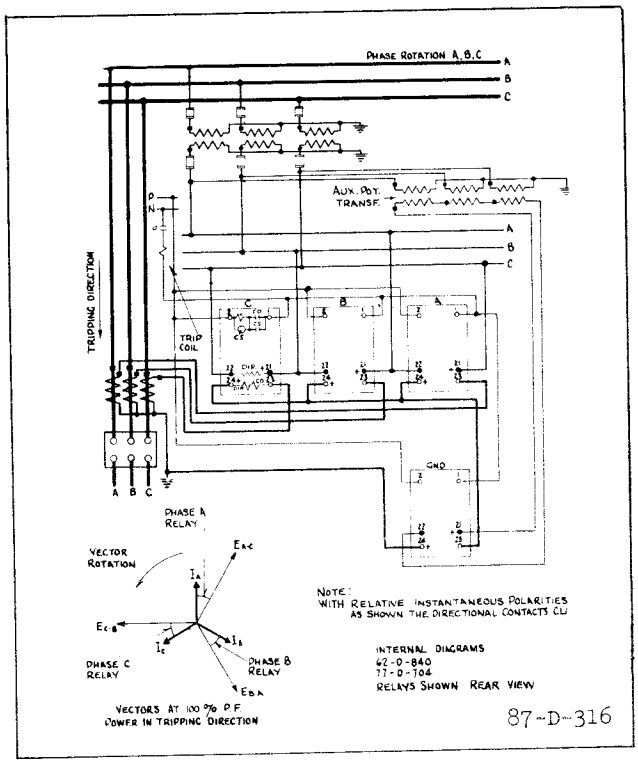

Fig. 15—External Connections Of The Circuit Closing Type CR Relay In The Standard Case For Phase And Ground Protection Using The 30° Connection On The Phase Directional Element.

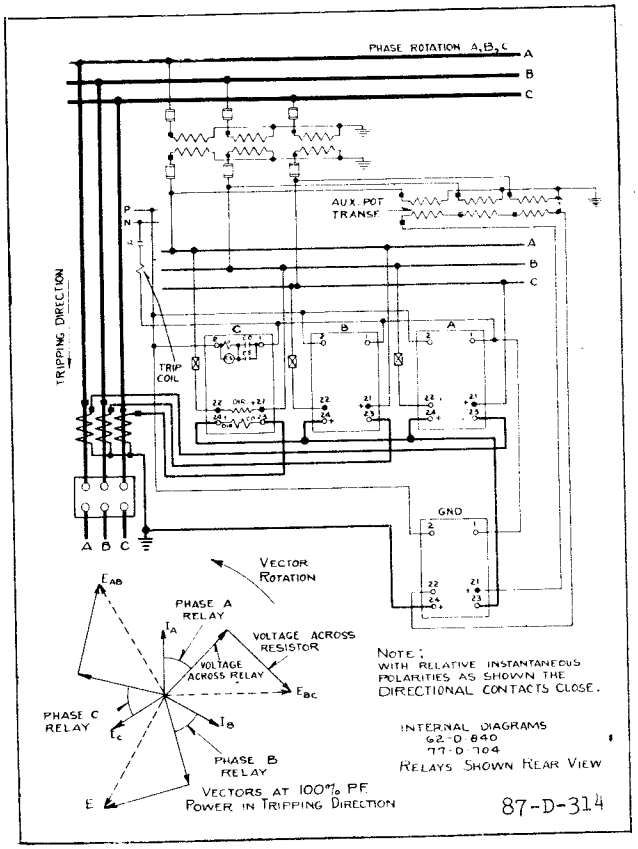

Fig. 16—External Connections Of The Circuit Closing Type CR Relay In The Standard Case For Phase And Ground Protection Using The 90° Connection (Maximum Torque 45° or 60° Lagging Current. 45° is shown above) On The Phase Directional Element.

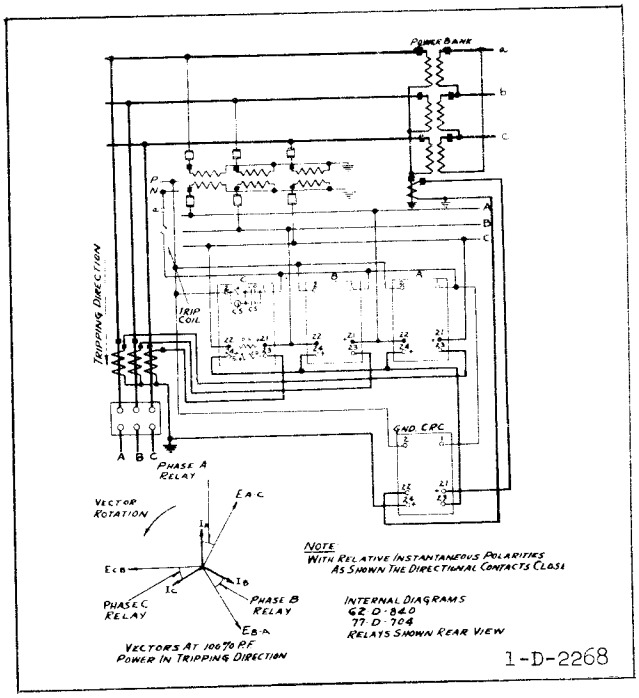

Fig. 17—External Connections Of The Circuit Closing Type CR Relay In The Standard Case For Phase Protection Using The 30° Connection Of The Directional Element And The Type CRC Relay In The Standard Case For Ground Protection.

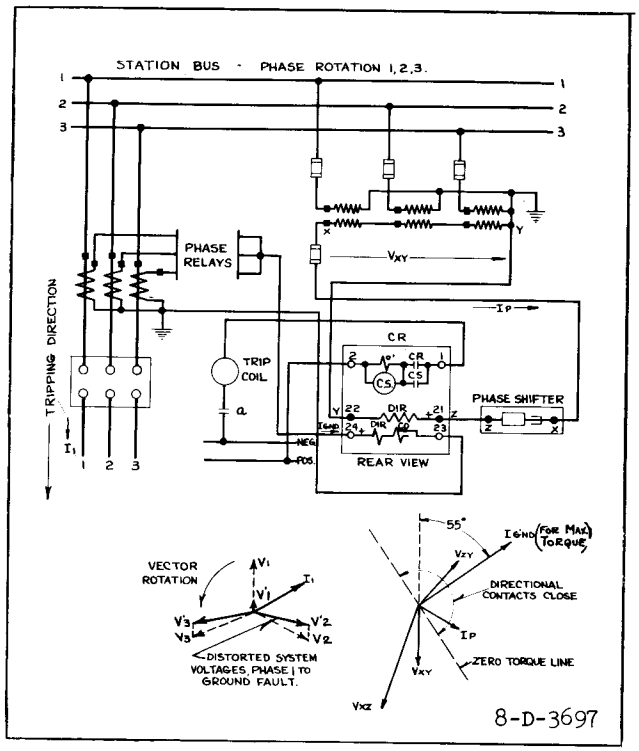

Fig. 18—External Connections Of The Type CR Ground Relay In The Standard Case For Ground Fault Protection Using An External Phase Shifter.

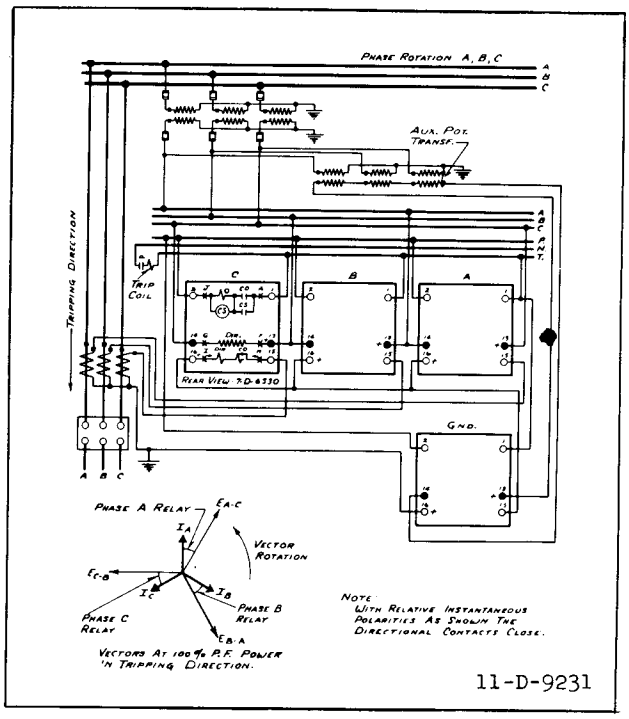

Fig. 19—External Connections Of The Circuit Closing Type CR Relay In The Type FT Case For Phase And Ground Protection Using The 30° Connection On The Phase Directional Element.

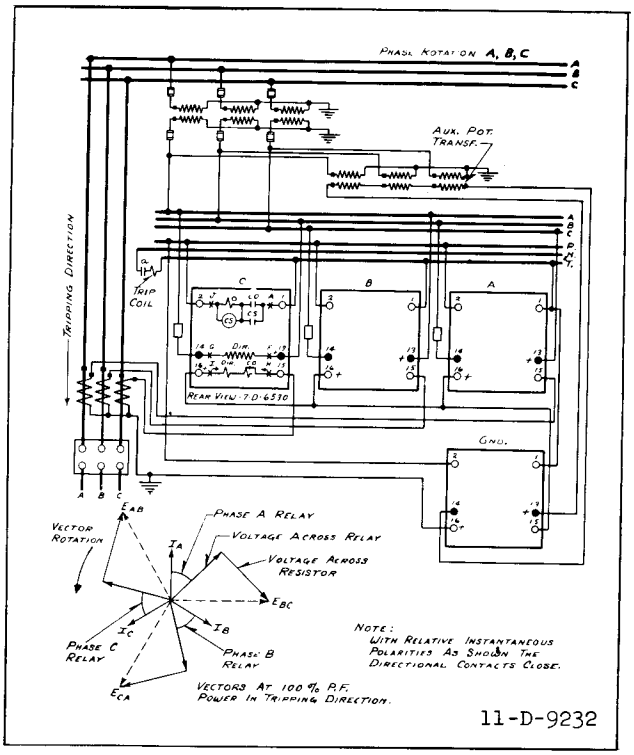

Fig. 20—External Connections Of The Circuit Closing Type CR Relay In The Type FT Case For Phase And Ground Protection Using The 90° Connec

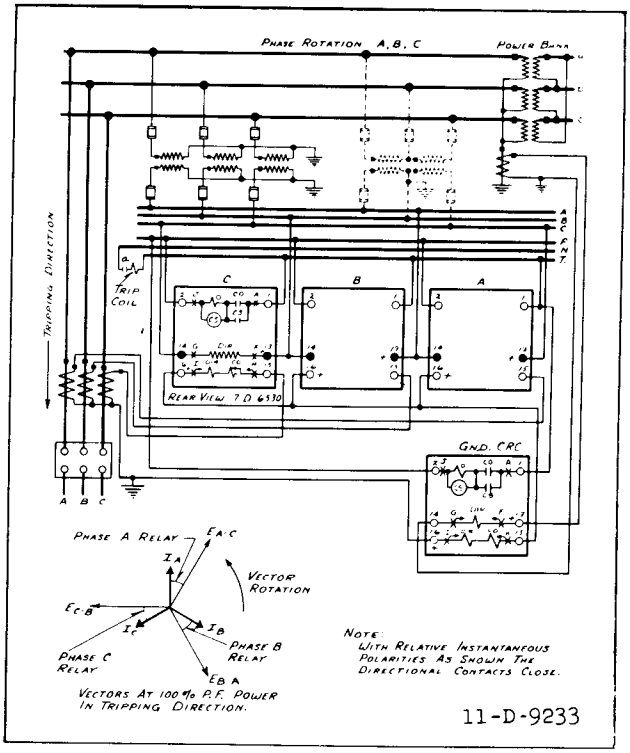

Fig. 21—External Connections Of The Circuit Closing Type CR Relay In The Type FT Case For Phase Protection

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