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

SUPERSEDES I. L. 41-285P
*Denotes change from superseded issue.

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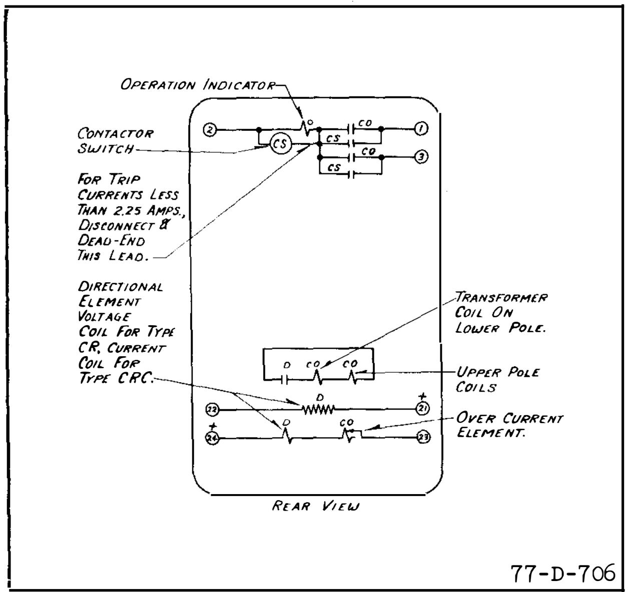

Fig. 1—Internal Schematic Of The Double Trip, Directional Control, Inverse Time (Low Energy 2 Sec., 25, 50 & 60 Cycles, 4 Sec., 25 Cycles) and Very Inverse Time, Circuit Closing Relays In The Standard Case. The Single Trip Relays Have Terminal 3 And-Associated Circuits Omitted.

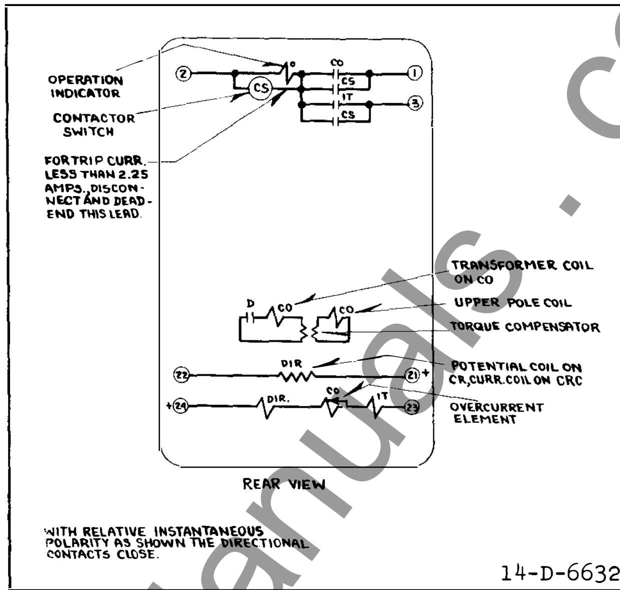

Fig. 2—Internal Schematic Of The Single Trip, Directional Control, Definite Minimum Time (2 and 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (Low Energy 4 Sec., 50 & 60 Cycles), Circuit Closing Relays With Instantaneous Trip In The Standard Case.

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.

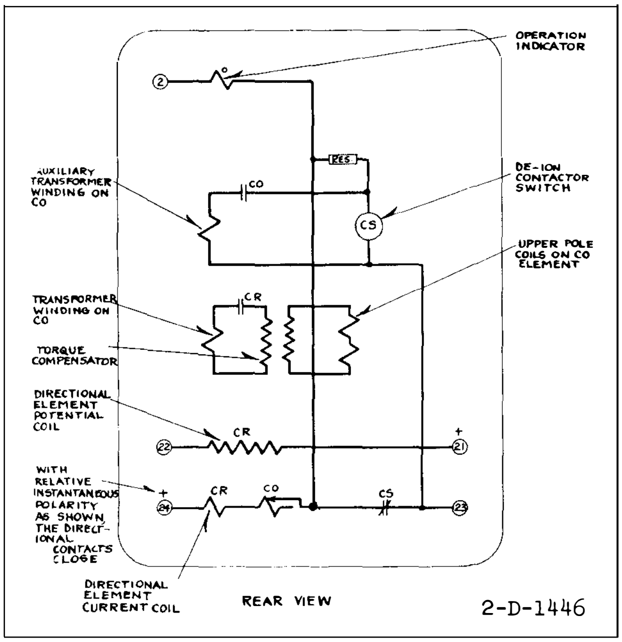

Fig. 3—Internal Wiring Diagram Of The Single Trip, Standard Energy, Circuit Opening Relay.

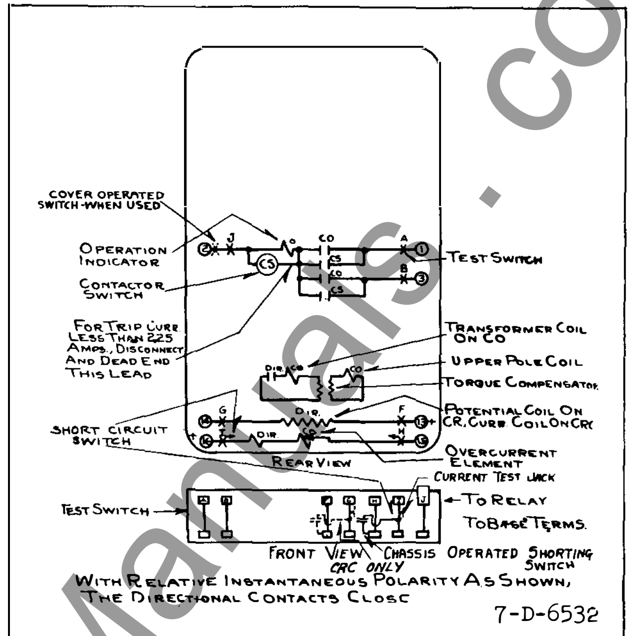

Fig. 4—Internal Schematic Of The Double Trip, Directional Control, Definite Minimum Time (Standard Energy 2 and 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (4 Sec., 50 & 60 Cycles) Circuit Closing Relay In The Type FT Case. The Single Trip Relays Have Terminal 3 And Associated Circuits Omitted.

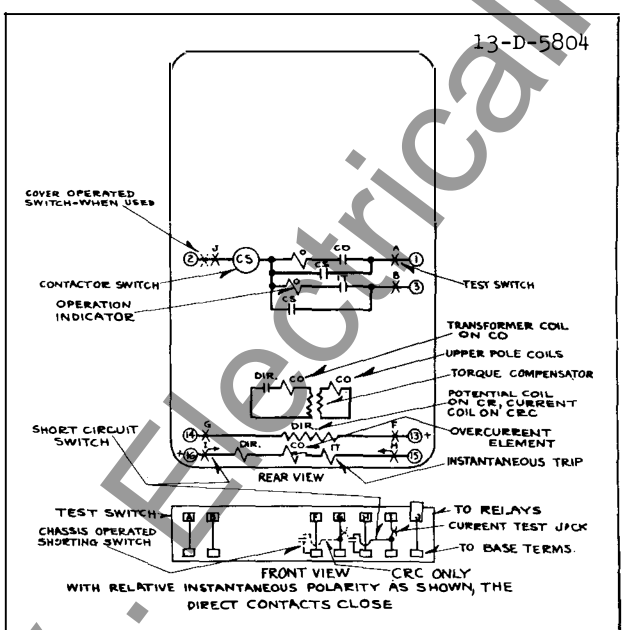

Fig. 5—Internal Schematic Of The Single Trip With Instantaneous Trip, Directional Control, Definite Minimum Time (Standard Energy 2 & 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (4 Sec., 50 & 60Cycles) Circuit Closing Relay In The Type FT Case.

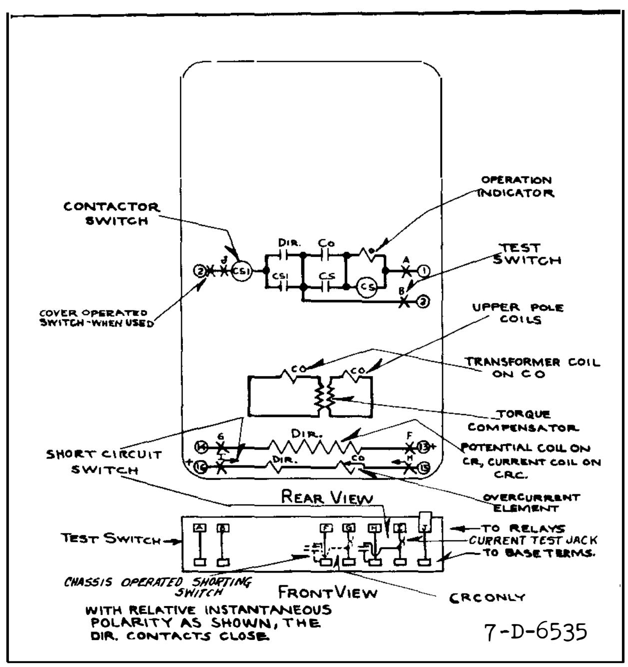

Fig. 6—Internal Schematic Of The Single Trip, Non-Directional Control With Terminal Between Directional And Overcurrent Contacts, Definite Minimum Time (Standard Energy 2 & 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (4 Sec., 50 & 60 Cycles) Circuit Closing Relay In the Type FT Case.

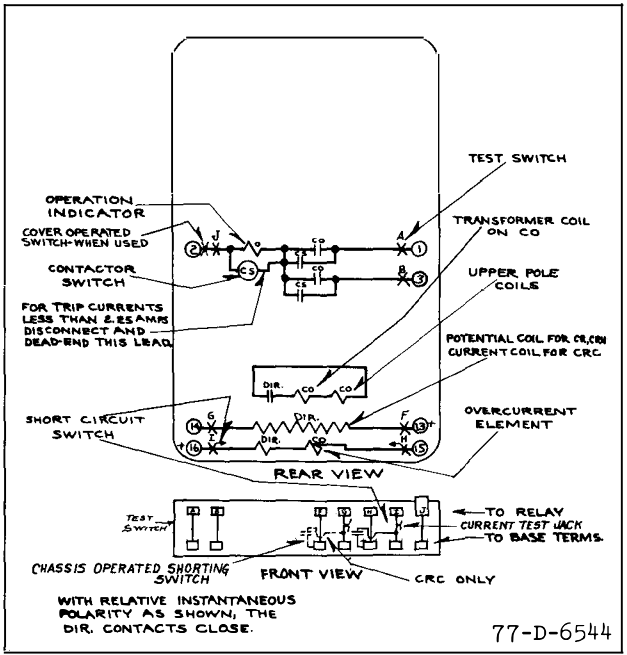

Fig. 7—Internal Schematic Of The Double Trip, Directional Control, Inverse Time (Low Energy 2 Sec., 25, 50 & 60 Cycles, 4 Sec., 25 Cycles) or Very Inverse Time, Circuit Closing Relay In The Type FT Case. The Single Trip Relays Have Terminal 3 And Associated Circuits Omitted.

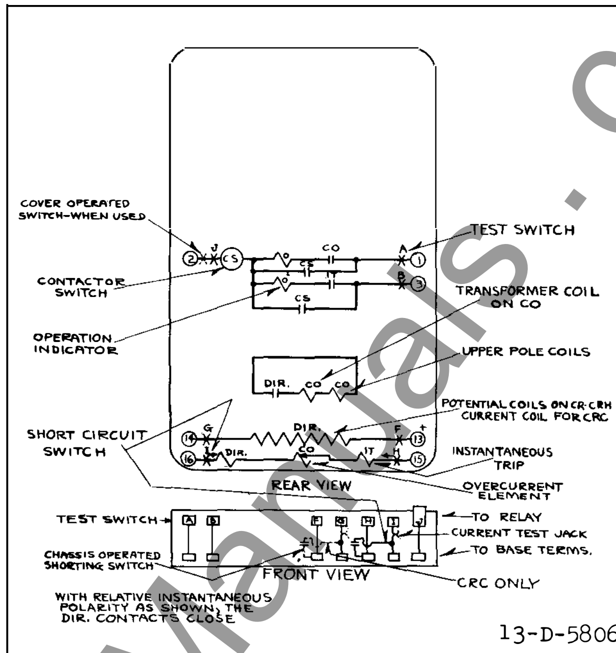

Fig. 8—Internal Schematic Of The Single Trip With Instantaneous Trip, Directional Control, Inverse Time (Low Energy, 2 Sec., 25, 50 & 60 Cycles 4 Sec., 25 Cycles) or Very Inverse Time, Circuit Closing Relay In The Type FT Case.

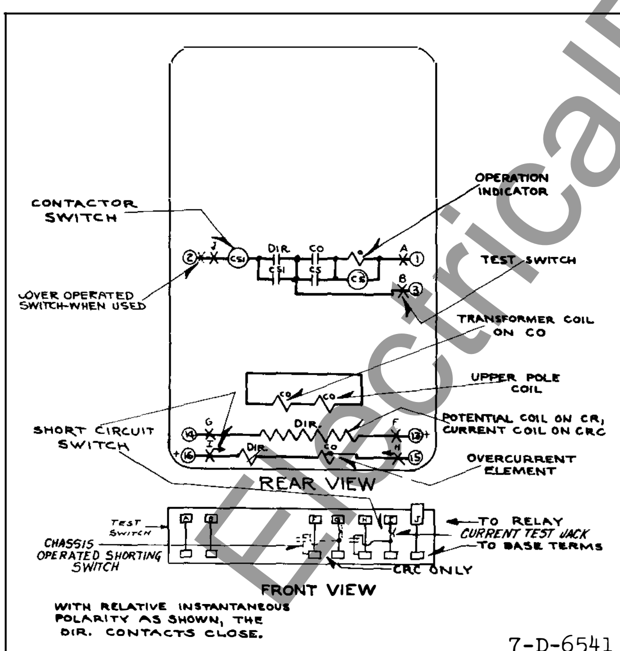

Fig. 9—Internal Schematic Of The Single Trip, Non-Directional Control With Terminal Between Directional And Overcurrent Contacts, Inverse Time (Low Energy 2 Sec., 25, 50 & 60 Cycles, 4 Sec., 25 Cycles) or Very Inverse Time, Circuit Closing Relay In The Type FT Case.

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.

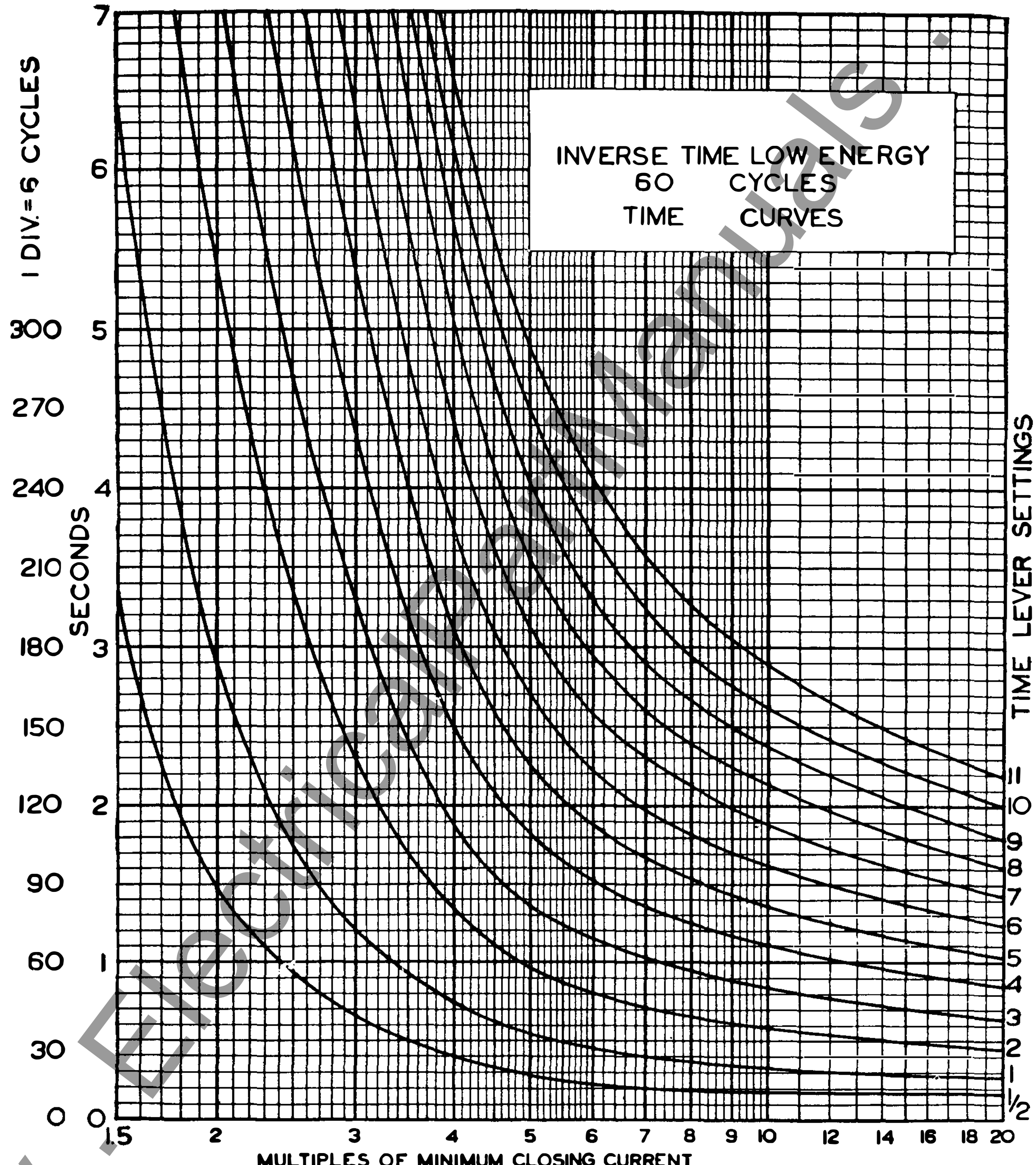

Fig. 10—Typical Inverse Time Curves Of The Overcurrent Element Of The Low Energy 60 Cycle Relays.

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 shooks 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

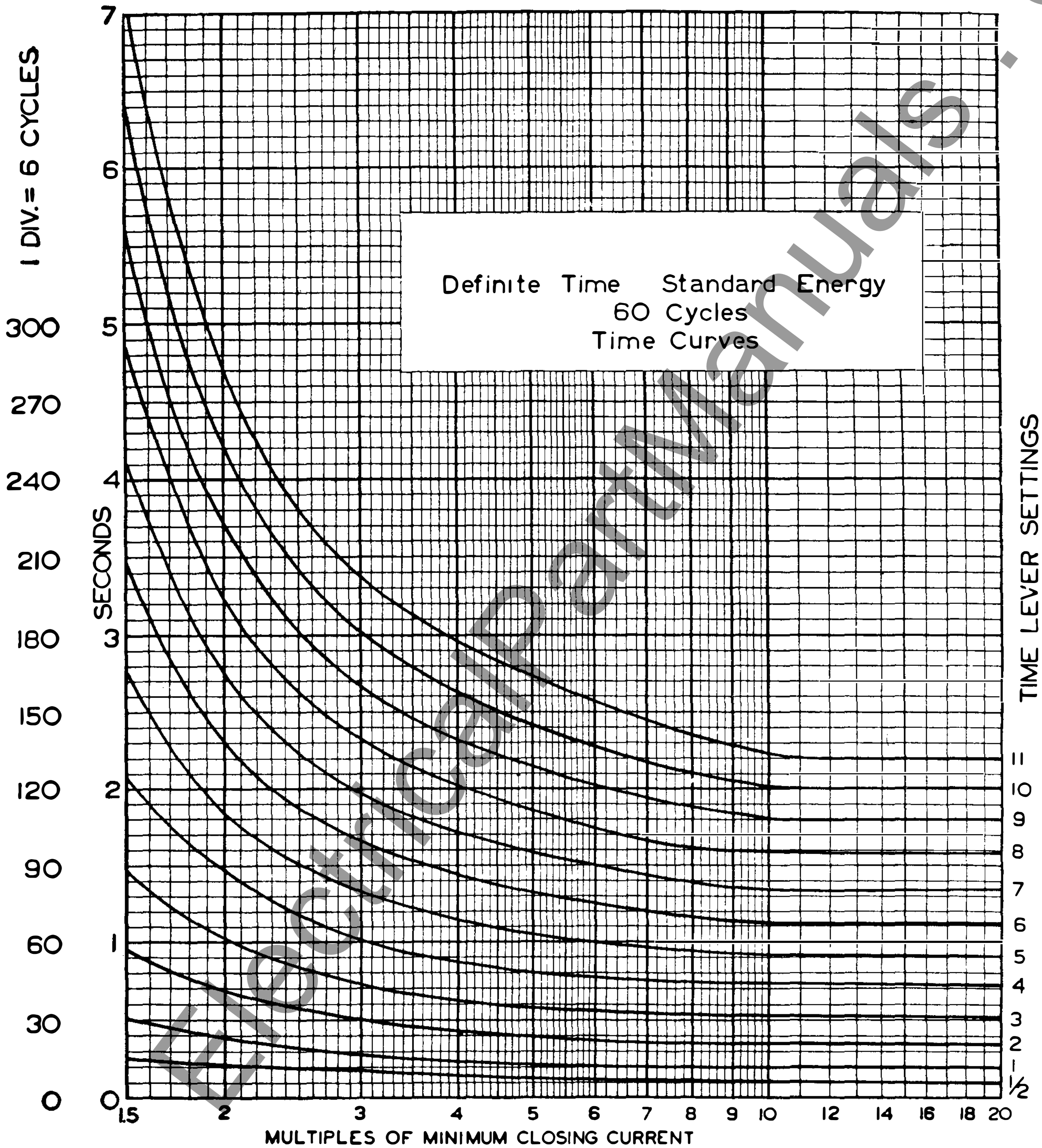

Fig. 11—Typical Inverse Definite Minimum Time Curves Of The Overcurrent Element Of The Standard Energy 60 Cycle Relays.

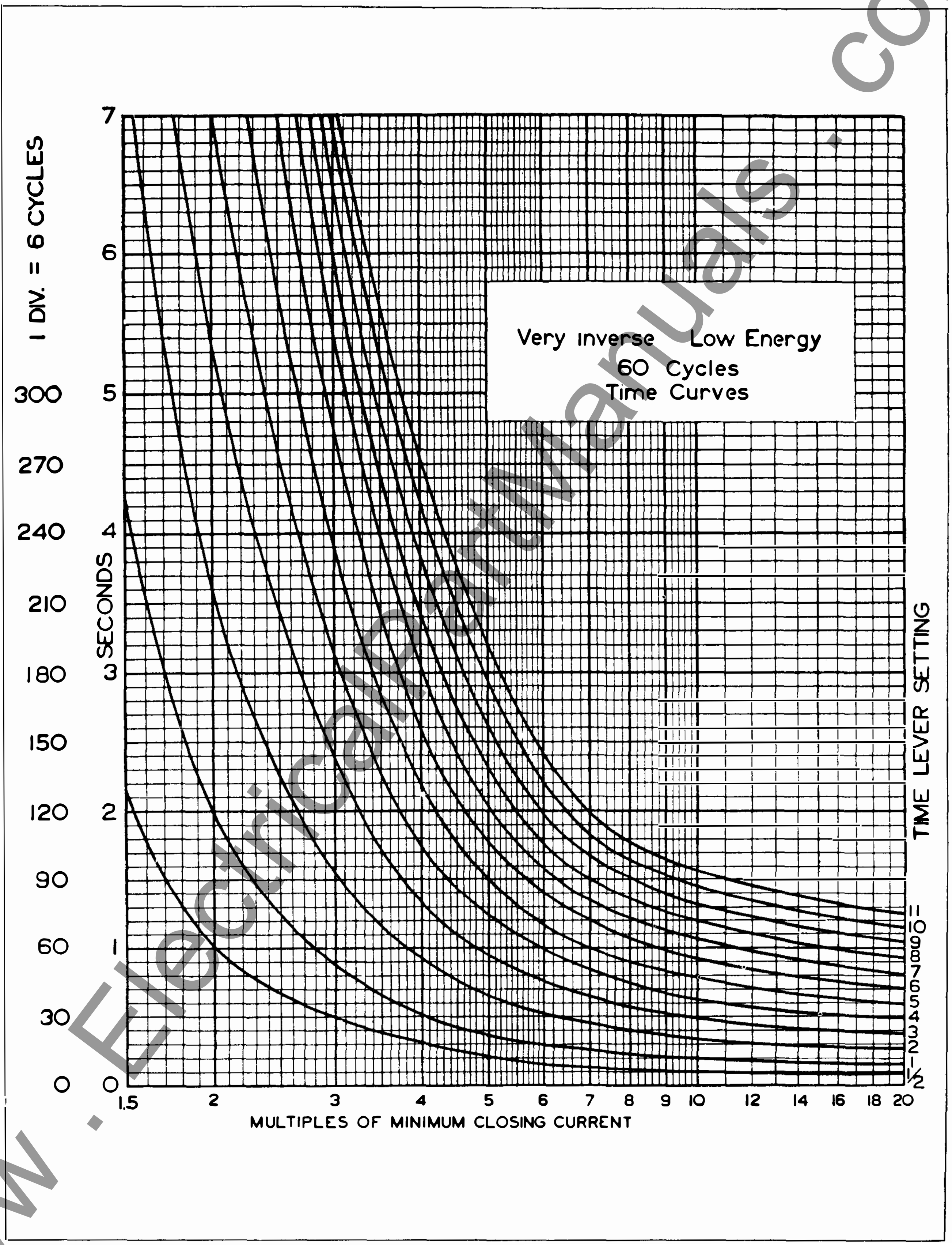

Fig. 12—Typical Very Inverse Time Curves Of The Overcurrent Element Of The Low Energy 60 Cycle Relays.

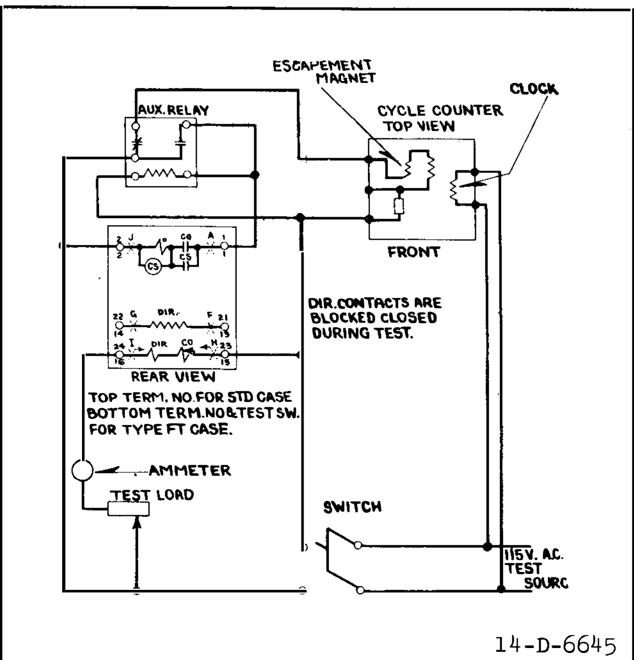

Fig. 13—Diagram Of Test Connections For The Circuit Closing Relays.

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. A contact burnisher S#182A836H01 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

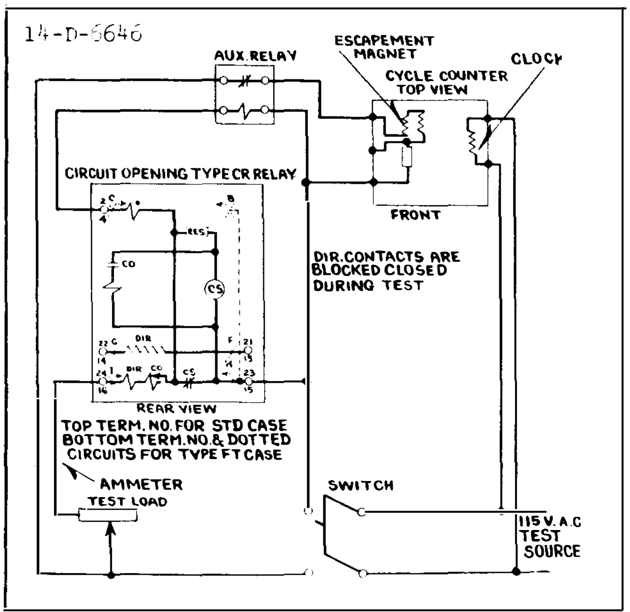

Fig. 14—Diagram Of Test Connections For The Circuit Opening Relays.

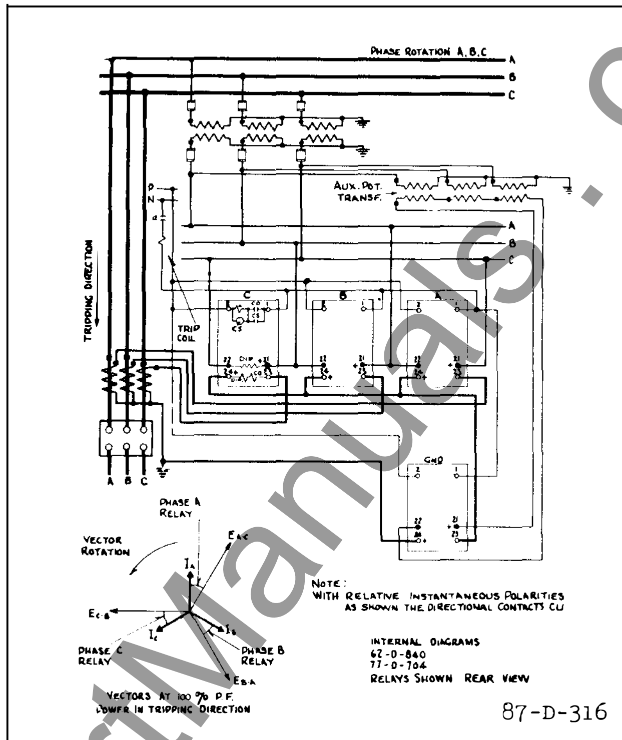

Fig. 15—External Connections Of The Circuit Closing Type CR Relay In The Standard Case For Phase And Ground Protection Using The 30° Connection On The Phase Directional Element.

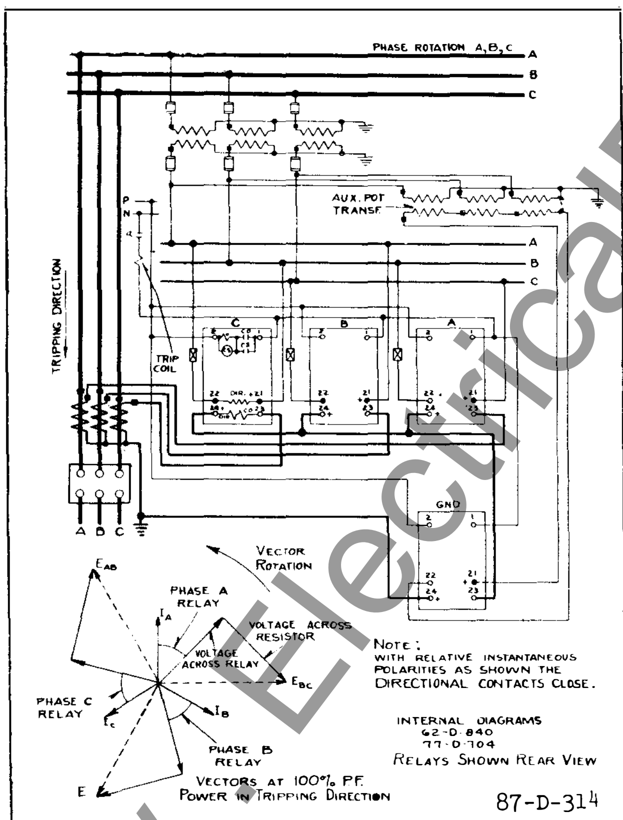

Fig. 16—External Connections Of The Circuit Closing Type CR Relay In The Standard Case For Phase And Ground Protection Using The 90° Connection (Maximum Torque 45° or 60° Lagging Current. 45° is shown above) On The Phase Directional Element.

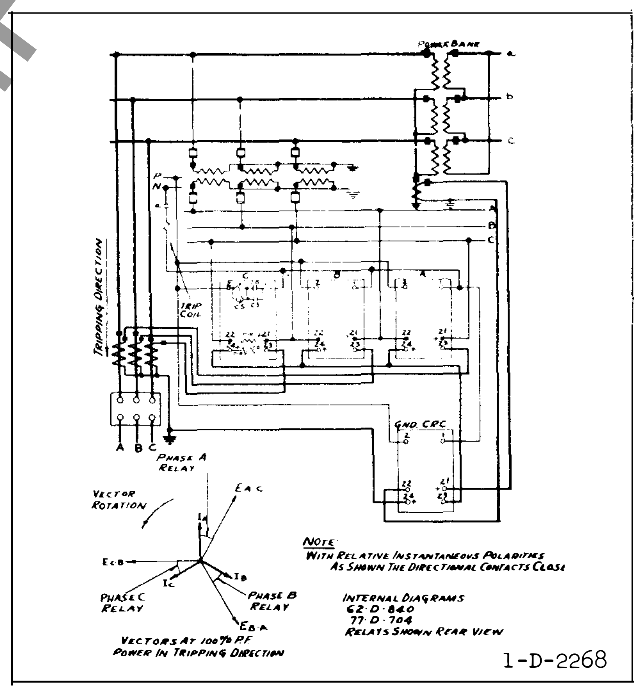

Fig. 17—External Connections Of The Circuit Closing Type CR Relay In The Standard Case For Phase Protection Using The 30° Connection Of The Directional Element And The Type CRC Relay In The Standard Case For Ground Protection.

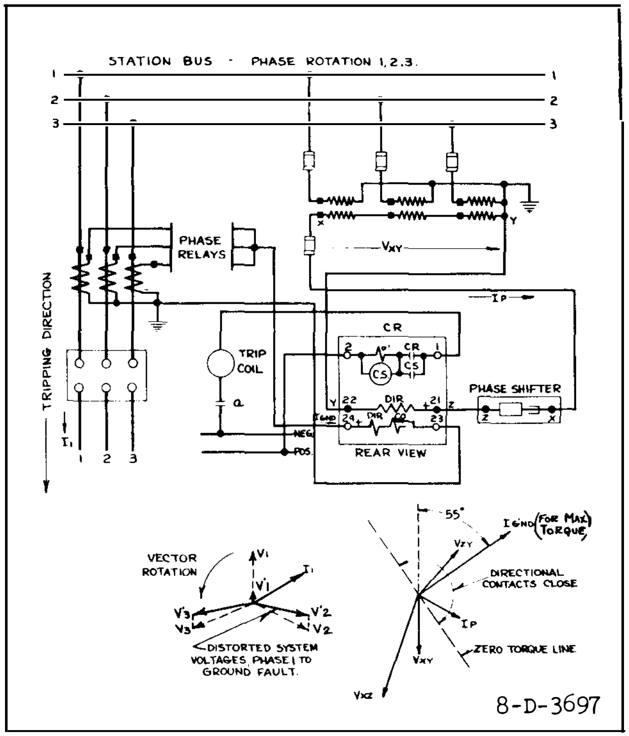

Fig. 18—External Connections Of The Type CR Ground Relay In The Standard Case For Ground Fault Protection Using An External Phase Shifter.

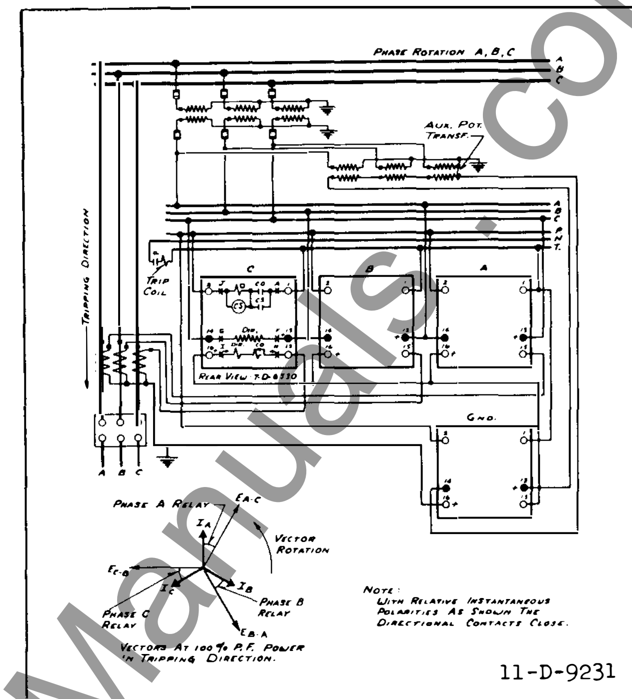

Fig. 19—External Connections Of The Circuit Closing Type CR Relay In The Type FT Case For Phase And Ground Protection Using The 30° Connection On The Phase Directional Element.

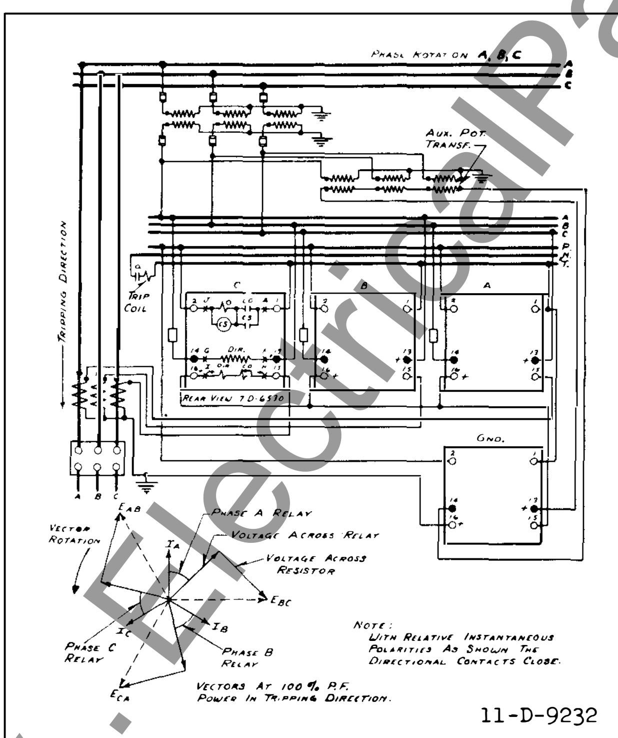

Fig. 20—External Connections Of The Circuit Closing Type CR Relay In The Type FT Case For Phase And Ground Protection Using The 90° Connection (Maximum Torque 45° or 60° Lagging Current 45° is shown above) On The Phase Directional Element.

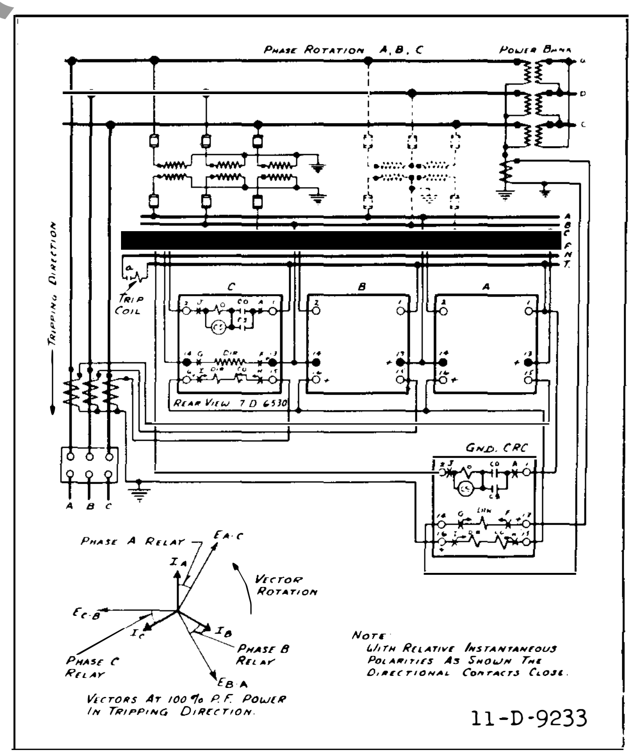

Fig. 21—External Connections Of The Circuit Closing Type CR Relay In The Type FT Case For Phase Protection Using The 30° Connection On The Directional Element And The Type CRC Relay In The Type FT Case For Ground Protection.

several cycles. This time is so small that it is usually ignored and the relays are tested by blocking the directional contacts in the closed position.

The position of the torque compensator on the overload element is adjustable but this is primarily a factory adjustment and the location of the torque compensator should not be changed in the field. If the relay has a metal cover, this cover must be in place when making tests.

Directional Element

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

The contact opening on the directionally-controlled relay should be 1/32" in order to reduce the time of operation of the directional element to a minimum. No harm will result if the directional contacts rebound to close momentarily after a fault is cleared, because the overcurrent contacts will be in the open position. The contact opening on relays which are not directionally controlled should be 3/32".

The tension of the spiral spring on the directional element should be just sufficient to return the disc to the stop and thus hold the contacts in the open position.

In many applications there is no objection to having the contacts closed when the relay is de-energized. This can be changed by shifting the spring adjuster but the tension on the spring should never be enough to prevent the contacts from taking their proper position, either open or closed, during time of short circuit when the forces acting on the disc are small.

There is an adjustable magnetic vane on each side of the upper pair of poles, which is intended to balance the current circuit. The * normal adjustment is to short circuit the voltage coils and apply heavy current to the current coils. The balancing vanes are then adjusted till there is no pronounced torque in either direction. This same adjustment may be used to positively close the contacts on current alone. This may be desired on some installations in order to insure that the relay will always trip the breaker even though the potential may be zero.

When operating at the maximum torque angle, the directional element of the Type CR Phase Relay and 2 to 6 and 4 to 15 amp. ground relay should pick-up on 1 volt and 4 amperes, and for the 0.5 to 2.5 amp. Type CR Ground Relays on 1 volt, 2.7 amperes. The directional element of the CRC Ground Relay will pick-up at 0.5 ampere each winding.

Contactor Switch

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core of 1/64" when the switch is picked up. This can be done by turning the relay up-side-down or by disconnecting the switch and turning it up-side-down. Then screw up the core screw until the moving core starts rotating. Now, back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/32" by means of the two small nuts on either side of the Micarta disc. The switch should pick-up at 2 amperes d-c. Test for sticking after 30 amperes d-c. have been passed through the coil.

Operation Indicator
(Circuit-Closing Relays)

Adjust the indicator to operate at 0.2

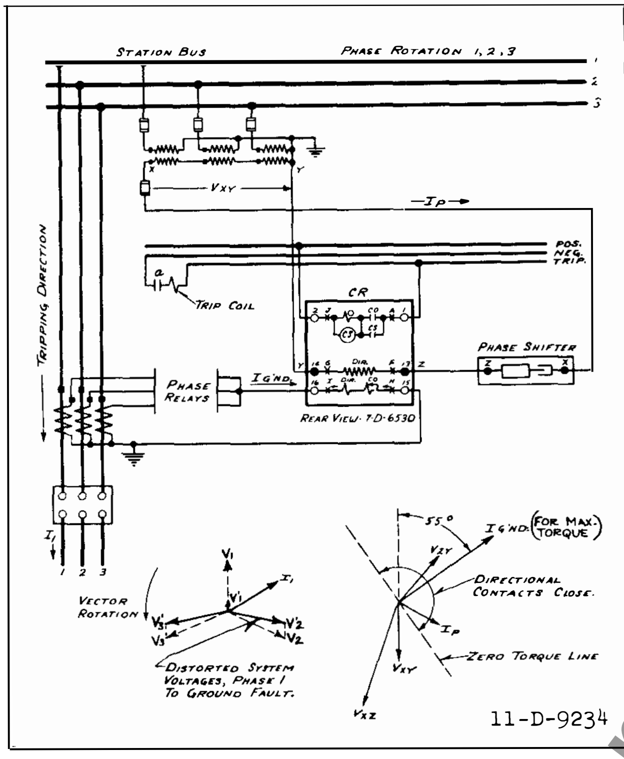

Fig. 22—External Connections Of The Type CR Relay In The Type FT Case For Ground Fault Protection Using An External Phase Shifter.

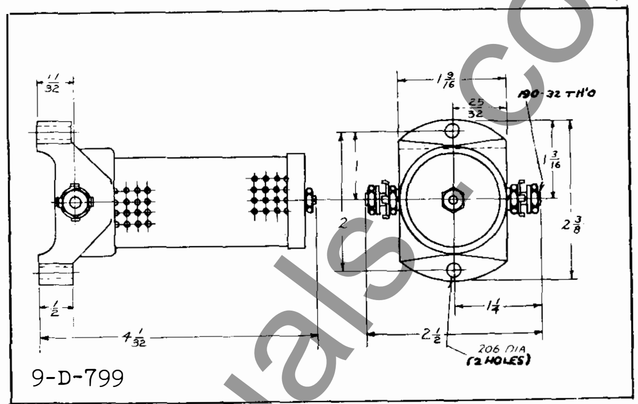

Fig. 23—Outline And Drilling Plan Of The External Resistor For The 90° Connection. For Reference Only.

ampere d-c. gradually applied. Test for sticking after 5 amperes d-c. is passed.

Overcurrent Element
(Circuit Opening Relays)

Adjust the relay with the instructions given under "Overcurrent Element (Circuit Closing Relays)" except that for the standard energy circuit opening relay the following cautions should be observed:

CAUTION When a signal lamp or other voltage operated device is to be connected in series with the relay contacts, disconnect the internal leads of the element from the stationary and moving contacts respectfully and dead end them. Then the lamp or other device can be connected to the stationary and moving contacts.

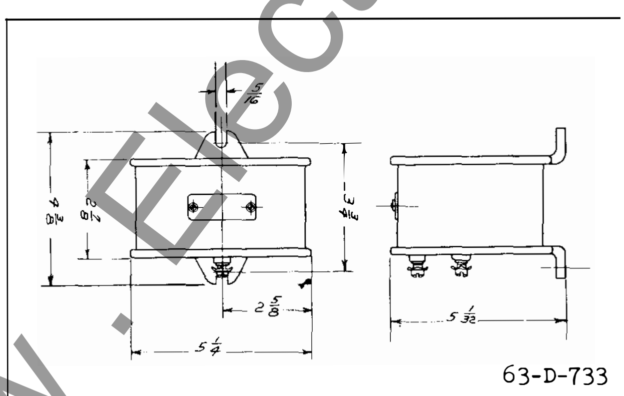

Fig. 24—Outline And Drilling Plan Of The Phase Shifter For The Ground Relay When Supplied. For Reference Only.

De-Ion Contactor Switch
(Circuit Opening Relays)

Adjust the core stop on the top as high as possible without allowing the insulating bushing at the bottom of the plunger to touch the Micarta angle. The contact will be separated from the Micarta angle by 1/32" to 1/16". Adjust the contact gap spacing to slightly less than 1/16 of an inch. Bend down the contact springs so that a firm contact is made but not so strong that the minimum pick-up value cannot be obtained. The spring tension should be about 15 grams.

Hold the relay contacts closed and with an auxiliary relay coil connected across the proper terminals to simulate the circuit breaker trip coil, note that the contactor switch picks up on less than 4 amperes on the 4 ampere overcurrent tap setting.

In the case of the standard energy circuit opening relay the contactor switch should pick-up and seal itself open at 75% of minimum trip current.

Operation Indicator
(Circuit Opening Relays)

Adjust the indicator to operate at 2 amperes a-c.

ATTACHMENTS TO THE RELAY
Instantaneous Trip

This element is a small solenoid switch the coil of which is in series with the overcurrent coil. It functions to energize the breaker trip coil instantaneously, independently of power direction when the fault current is exceptionally heavy. The three stationary contacts are in parallel with the main trip contacts and make possible double instantaneous trip on double-trip relays. The position of the Micarta disc at the bottom of the element with reference to the calibrated guide indicates the minimum overcurrent required to operate the element. The disc should be lowered or raised to the proper position by loosening the locknut which locks the Micarta disc and rotating the Micarta disc. The nominal range of adjustment is 1 to 4, for example, 10 to 40 amperes and it has an accuracy within the limits of approximately 10%.

The drop-out value is varied by raising or lowering the core screw at the top of the switch, and after the final adjustment is made, the core screw should be securely locked in place with the lock nut. The drop-out should be adjusted for about 2/3 of the minimum pick-up. Adjusting the drop-out will slightly affect the value of pick-up.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

ENERGY REQUIREMENTS

BURDENS FOR SATURATION CALCULATIONS

Readings taken with Rectox Type Voltmeter, 60 cycles.

Range	V.A. Burden at Minimum Pick Up on Min. Tap	V.A. Burden at 3 times Pick Up on Min. Tap	V.A. Burden at 10 Times Pick Up on Min. Tap	V.A. Burden at 20 Times Pick Up on Min. Tap
Definite Minimum (Standard Energy)				
2-6	18	105	520	1500
4-15	18	115	616	1647
Inverse (Low Energy)				
0.5 - 2.5	2.0	20.5	141	366
2 - 6	2.4	23.0	168	469
4 -15	3.6	32.8	248	746
Very Inverse (Low Energy)				
0.5 - 2.5	1.3	10.7	96	244
2 - 6	1.6	14.9	135	377
4 -15	2.8	25.3	218	6668

These values are the combined burden of the overcurrent and directional element coils in series.

ENERGY REQUIREMENTS

STANDARD ENERGY, DEFINITE TIME RELAY[1]

Burdens at 5 Amperes on the 5 Ampere Tap[2]

Frequency Cycles	Watts	Volt-Amperes	P.F.
25	10.6	18	54° Lag
50	9.5	19	60° Lag
60	9.5	19	60° Lag

Burdens at 5 Amperes, 60 Cycles for Various Tap[2] Settings

Tap	Watts	Reactive Volt-Amperes	Volt-Amperes	P.F.
2	55.0	95.4	110	60° Lag
2.5	35.0	60.5	70	"
3	24.5	42.5	49	"
3.5	18.5	32.0	37	"
4	14.0	24.2	28	"
5	9.5	16.5	19	"
6	7.0	12.1	14	"
8	4.25	7.36	8.5	"
10	3.25	5.64	6.5	"
12	2.5	4.33	5.0	"
15	2.0	3.46	4.0	"

LOW ENERGY, INVERSE TIME RELAY[1]

Burdens at 5 Amperes on the 5 Ampere Tap[2]

Frequency Cycles	Watts	Volt-Amperes	P.F.
25	1.96	4.0	61° Lag
50	1.60	4.0	66.4° Lag
60	1.60	4.0	66.4° Lag

Burdens at 5 Amperes, 60 Cycles for Various Tap[2] Settings

Tap	Watts	Reactive Volt-Amperes	Volt-Amperes	P.F.
0.5	50.8	116.	127.	66.4° Lag
0.6	35.6	81.5	89.	"
0.8	32.0	73.4	80.	"
1.0	20.8	47.6	52.	"
1.5	9.6	22.0	24.	"
2.0	5.8	13.2	14.5	"
2.5	4.0	9.2	10.	"
3.0	3.04	6.95	7.6	"
3.5	2.44	5.6	6.1	"

Tap	Watts	Reactive Volt-Amperes	Volt-Amperes	P.F.
4.	2.04	4.66	5.1	"
5.	1.6	3.66	4.0	"
6.	1.32	3.0	3.3	"
8.	1.12	2.56	2.8	"
10.	1.0	2.28	2.5	"
12.	0.94	2.16	2.35	"
15.	0.88	2.0	2.2	"

LOW ENERGY, VERY INVERSE RELAY[1]

Burdens at 5 Amperes on the 5 Ampere Tap[2]

Frequency Cycles	Watts	Volt-Amperes	P.F.
25	1.62	3.3	61° Lag
50	1.32	3.3	66.4° Lag
60	1.32	3.3	66.4° Lag

Burdens at 5 Amperes of Current Tap[2]

Tap	Watts	Reactive Volt-Amperes	Volt-Amperes	P.F.
0.5	50.8	116.	127.	66.4° Lag
0.6	35.6	81.5	89.	"
0.8	19.7	45.2	49.4	"
1.0	12.9	29.6	32.3	"
1.5	6.4	14.6	15.9	"
2.0	3.9	9.0	9.8	"
2.5	2.8	6.4	7.0	"
3.0	2.2	5.0	5.5	"
3.5	1.8	4.1	4.5	"
4.	1.6	3.67	4.0	"
5.	1.32	3.0	3.3	"
6.	1.16	2.66	2.9	"
8.	0.96	2.2	2.4	"
10.	0.92	2.1	2.3	"
12.	0.88	2.02	2.2	"
15.	0.85	1.96	2.14	"

POLARIZING COILS

The potential polarizing coil burden of the directional element at 115 volts for the type CR line relay are as follows:

* For 90° Connection[3]

Freq Cycles	Resistor	Watts	VA	Lagging P.F.	Approx. Max. Torque Angle
25	Yes	8.95	11.3	37.6	45°
50	Yes	11.2	14.0	37	45°
60	Yes	11.5	15.3	41.4	45°
60	Yes	11.0	19.0	54.8	60°

✱ For 30° Connection

Freq Cycles	Resistor	Watts	VA	Lagging P.F.	Approx. Max. Torque Angle
25	No	4.2	18.0	76.5	30°
50	No	3.45	23.0	81.4	30°
60	No	3.45	23.0	81.4	30°

The potential polarizing coil burdens of the directional element at 115 volts for the type CR Ground Relays are as follows:

Frequency Cycles	With Phase Shifter	Watts	Volt-Amps.	P.F.
60	No	5.6	27	78°Lag
60	Yes	12.6	22.6	56°Lead

The current polarizing burdens of the directional element of type CRC relay at rated 5 amperes are as follows:

Frequency Cycles	Watts	Volt-Amperes	P.F.
25	4.5	5.0	26° Lag
50	6.5	8.0	36° Lag
60	7.0	9.0	39° Lag

1. These values are the combined burden of the overcurrent and directional element coils in series.

2. The impedance of the overcurrent element coils varies approximately inversely as the square of the tap markings while the directional element coil impedance is constant. The burden of the directional element coil which is in series with the overcurrent element is 2 volt-amperes at 5 amperes, 60° lag.

✱ 3. The angle which the current lags the 100% p.f. position.

Continuous Ratings

The continuous ratings in amperes of the Type CR and CRC Relays are as follows:

Tap	Definite Min. Time		Inverse Time		Very Inverse Time	
	Continuous	One Second	Continuous	One Second	Continuous	One Second
.5			2	70	2	100
.6			2	70	2	100
.8			2	70	2	100
1.0			3	70	3	100
1.5			3	70	3	100
2.0			4	70	4	100
2.5			5	70	5	100
2	4	140	8	250†	8	250†
2.5	5	140	8	250†	8	250†
3	5	140	8	250†	8	250†
3.5	6	140	8	250†	8	250†
4	7	140	9†	250†	9†	250†
5	8	140	9†	250†	9†	250†
6	10†	140	10†	250†	10†	250†
4	8	250†	16†	250†	16†	250†
5	8	250†	16†	250†	16†	250†
6	9†	250†	16†	250†	16†	250†
8	10†	250†	17†	250†	17†	250†
10	12†	250†	18†	250†	18†	250†
12	13†	250†	19†	250†	19†	250†
15	15†	250†	20†	250†	20†	250†

† The directional element current coil of Type CR relay has a continuous rating of 8 amperes and a one second rating of 185 amperes. The upper winding of the Type CRC has a continuous rating of 6 amperes and a one second rating of 140 amperes while the lower coil has a continuous rating of 8 amperes and a one second rating of 185 amperes. The polarizing coil of the CR relay has a continuous rating of 127 volts.

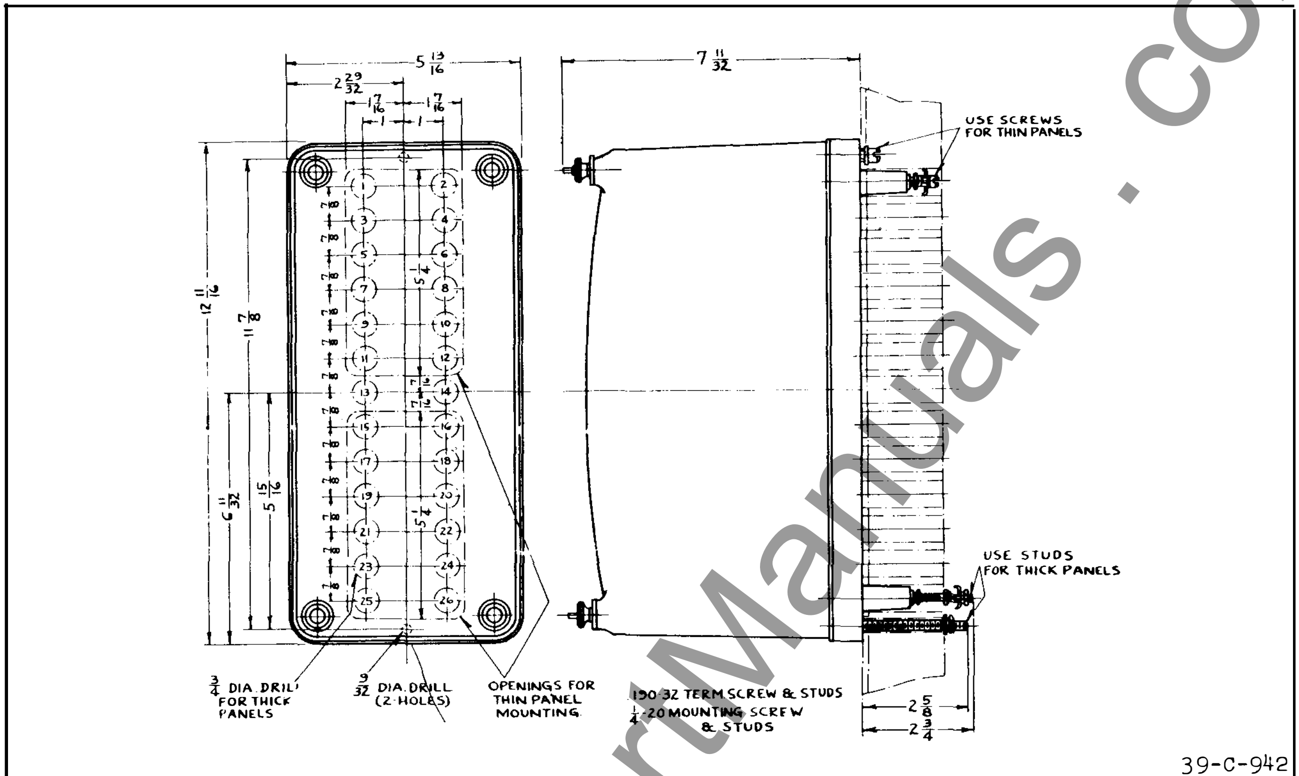

Fig. 25—Outline and Drilling Plan for Relays in the Standard Projection Type Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

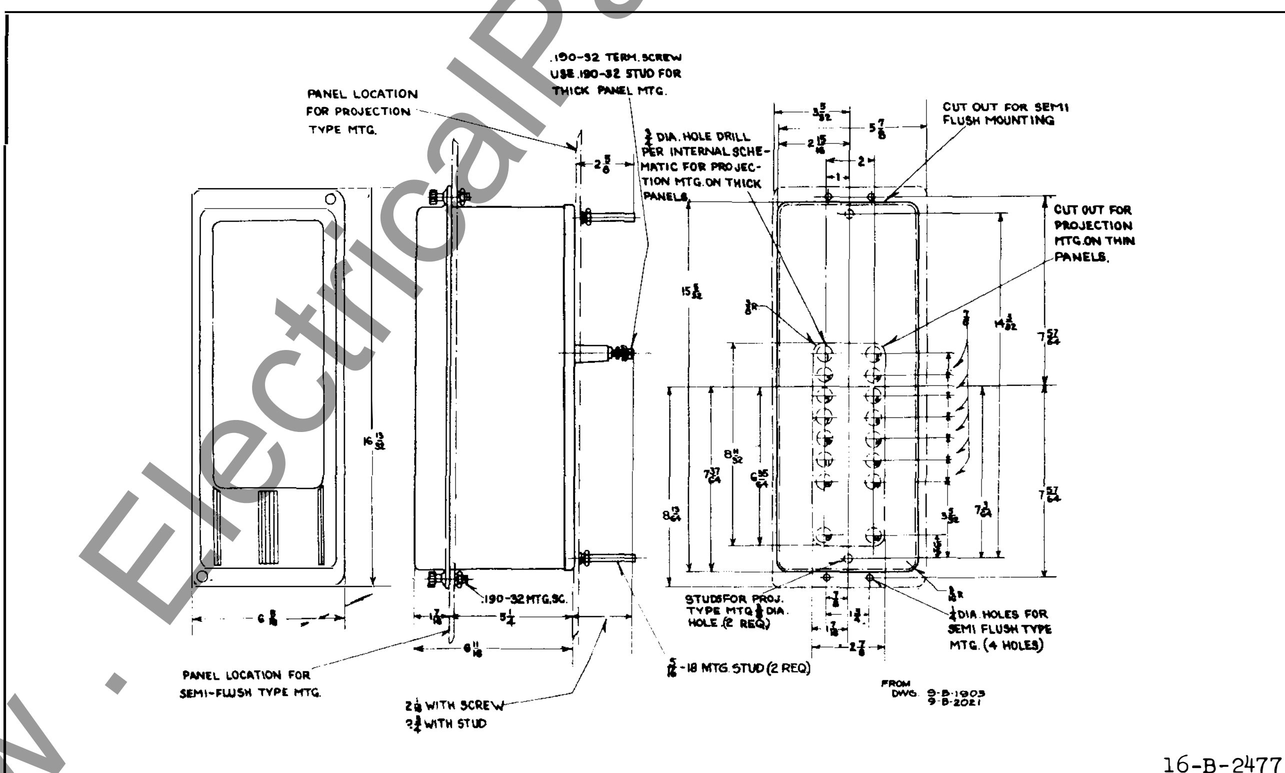

Fig. 26— Outline and Drilling Plan for the M-10 Projection or Semi-Flush Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

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INSTALLATION • OPERATION • MAINTENANCE
INSTRUCTIONS

WESTINGHOUSE OUT-OF-STEP NOTCHING RELAYS

CAUTION Before putting 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

This equipment consists of an out-of-step relay and a notching relay--the combination being designed to prevent damage to synchronous machines that fall out of step. It has been developed for use particularly on frequency changers.

CONSTRUCTION AND OPERATION

Out-of-Step Relay

The out-of-step relay is similar to a type CR relay. The over-current element operates faster than the normal type CO element and is similar to that used in the type COH relay. Since this element is likely to be set at below full load rating of the machine, it has adjustable tap settings of from 2 to 6 amperes or 4 to 15 amperes.

The directional element has contacts in both directions. The moving contacts oscillate between the two fixed contacts upon the occurrence of the heavy power surges which accompany out-of-step conditions.

Notching Relay

The notching relay consists of a series of seven type SG relays mounted in a single case and so connected that they will notch up one at a time on each alternate impulse but will not operate on repeated impulses in the same direction. The impulses are sent to this relay from the out-of-step relay. One notch is registered for each pole slipped by the machine being protected. After 3-1/2 pairs of poles have slipped, the seventh SG relay is closed, which will trip the circuit breaker and also indicate an alarm, if desired. It is possible to modify the wiring of the notching relay to eliminate as many steps in the notching chain as may be desired.

A few impulses may also be received from the out-of-step relay due to short circuits or severe hunting. In order to reset the relay after such an occurrence so that it will be ready to start counting from zero at the next disturbance, a time is arranged to reset all the SG relays after a predetermined elapsed time. This timer is a small synchronous motor relay which can be adjusted to close its contacts at any desired time between zero and 10 seconds. It is started when the #2 SG relay is picked up. This connection is made to the second relay to prevent needless operation of the timer, when only the #1 SG relay is picked up, as would be the case if the flow of power in the machine is reversed from its normal direction for any reason. When the power returns to its normal direction, it will notch up the #2 relay which will start the timer and thus reset the chain to zero Similarly, if the machine should be out of step for a short time and then pull back in, the time will restore the relays to full open position.

It is possible, also, to set the timing relay so that unless the pulsations due to the out-of-step conditions exceed a certain rate of speed, the notching relay will be reset before the seventh pole slips. The relay will thus not operate on slow pulsations but only these occuring above the predetermined rate.

Operation indicators are connected in the circuit of three of the SG relays to indicate how far the chain may have been notched up before it was reset. This is to assist in the study of system disturbances.

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 T 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.

The diagram shows the connections for star-connected out-of-step relays applied to a three-phase system. The star voltage may be obtained by the use of the two external reactors which, with the potential coil of the relay, form a star box. It may also be obtained by connecting a resistor in series with the relays potential coil. This leads the relays voltage by 30° so that the relay is at maximum torque when the line power factor is unity. The latter scheme is the one usually provided. For the protection of a single phase machine, the connections are the same except that the reactors are omitted and the potential coil should be connected across the line.

ADJUSTMENTS AND MAINTENANCE

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, the relay taken apart for repairs, or if it is desired to check the adjustments at regualr maintenance periods, the instructions below should be followed.

All contacts should be periodically cleaned with a fine file. S#1002110 file is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver. and thus impairing the contact.

The overcurrent element of the out-of-step relay should be set on the desired tap. The necessary value must be determined by a study of the conditions under which the machine will operate. If intermediate pick-up values are desired, the tension of the spring can be changed by means of the spring adjuster. This has slots in it of suitable size so that it can be turned by means of a screw-driver. The same adjustment can be used to increase the pick-up current for values above the last tap.

The directional contacts are adjusted at the factory and their position should not be changed. The spring on these contacts has sufficient tension to keep the circuit closed in the normal direction when the relay is de-energized. The total travel of the moving contact is made short so that the relay can keep in step with a very high rate of surge oscillation.

The only required adjustment on the notching relay is that of the timer. The time is proportional to the distance travelled by the contacts. The backstop which adjusts the contact travel is held solidly in position by the center screw which must be loosened with a screw-driver before making any adjustment. The full travel is 10 seconds. It should be borne in mind that this timing starts after the #2 SG relay is operated.

TEST AND MAINTENANCE

The correct performance of the notching relay can be determined by blocking the current element of the out-of-step relay in the

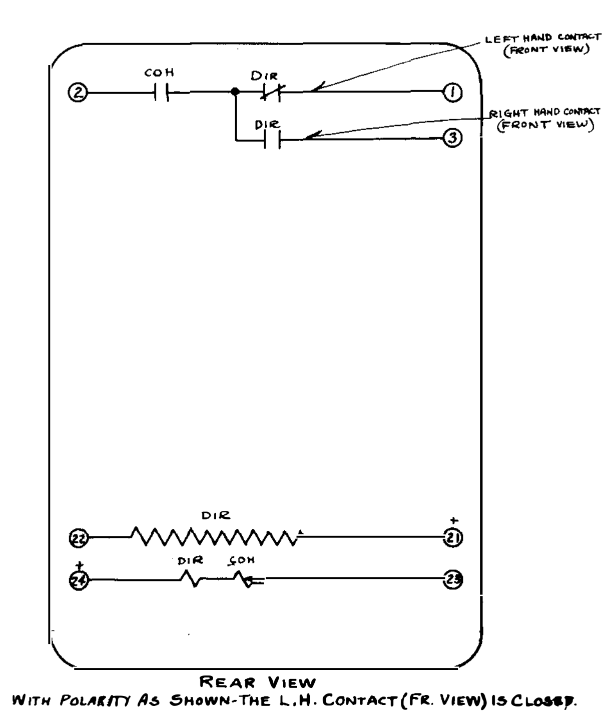

Fig. 1—Internal Schematic of the Out-of-Step Relay in the Standard Case.

closed position and vibrating the disc of the directional element with the finger. By this simple means everything can be checked except the out-of-step relay itself.

The out-of-step relay can be checked when the machine is put into operation by observing that the directional contacts are in the normal position when the machine is carrying power in the normal direction. The normal contact is the left-hand one when viewed from the front. An additional check on this will be to cause the machine to reverse its power flow and make certain that the directional element of the relay likewise reverses. The current element can be checked by observing it as the load on the machine is increased to the point where the current element is supposed to operate. If it is impractical to increase the load to that amount, the same effect may be obtained by producing a poor power factor, so that the current will increase. Laboratory test are easily made, and in the case of the out-of-step relay should closely follow those for the standard type CO and CR relays.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete name-plate data.

ENERGY REQUIREMENTS

The 60 cycle burdens of the out-of-step relay are as follows:

1. (Overcurrent coil plus directional element current coils).

a) 2-6 ampere range.

Tap	Volt-amps. at 5 amps.	Power Factor Angle-Degrees Lag
2	51	17.2
2.5	36.5	13.2
3	28	12.7
3.5	23.5	12.7
4	20	12.2
5	16.6	14.6
6	14.8	15.9

b) 4-15 ampere range

Tap	Volt-amps. at 5 amps.	Power Factor Angle-Degrees Lag
4	14.5	20.6
5	10.7	19.2
6	8.8	19.5
8	6.9	21.8
10	6.0	24.0
12	5.7	25.5
15	5.6	27.3

2. The potential coil burden of the directional element (70 volt rating) is 25.3 volt amperes at 80.4° lag.

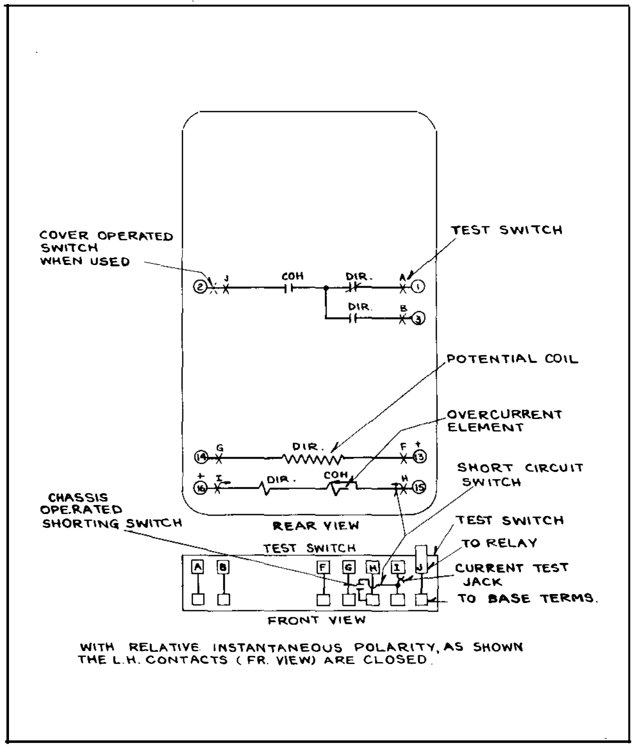

Fig. 2—Internal Schematic of the Out-of-Step Relay in the Type FT Case.

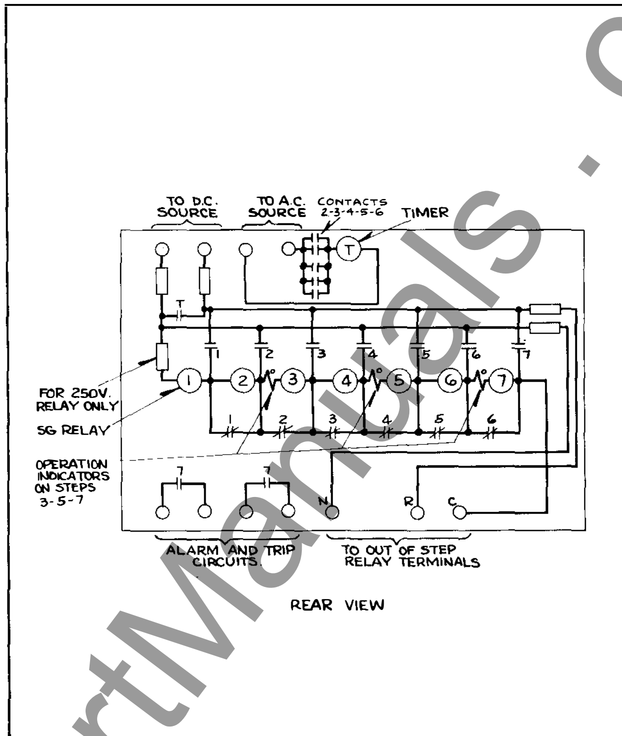

Fig. 3—Internal Schematic of the Notching Relay with Indicators on Steps 3, 5, 7.

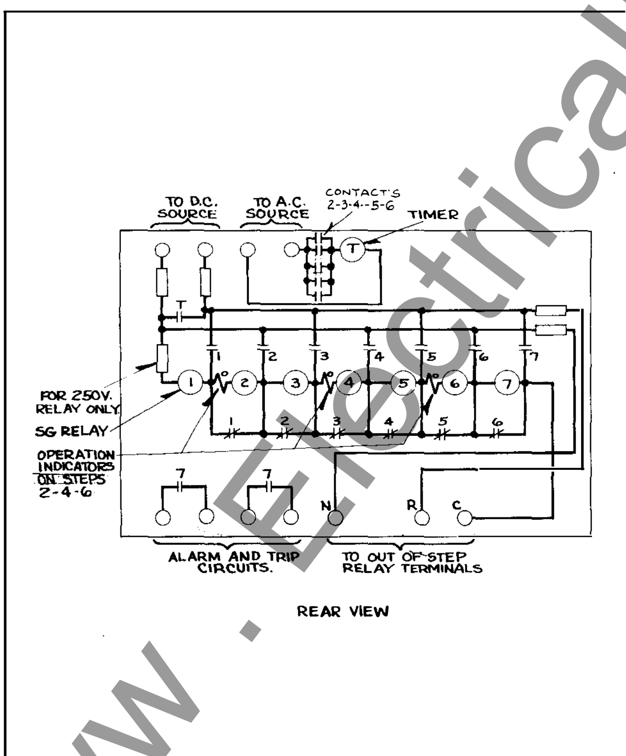

Fig. 4—Internal Schematic of the Notching Relay with Indicators on Steps 2, 4, 6.

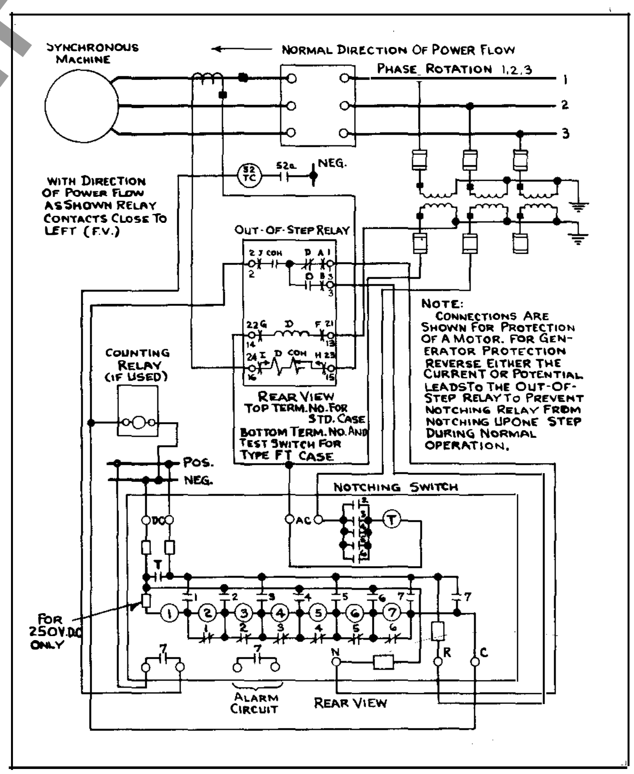

Fig. 5—External Connections of the Out-of-Step and Notching Relay Using Line-to-Line Voltage.

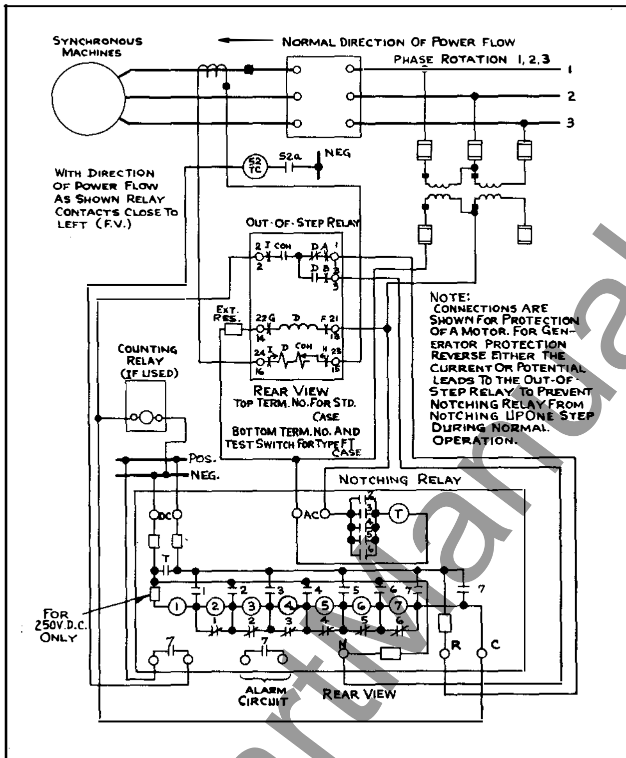

Fig. 6—External Connections of the Out-of-Step & Notching Relays Using Line-to-Line Voltage.

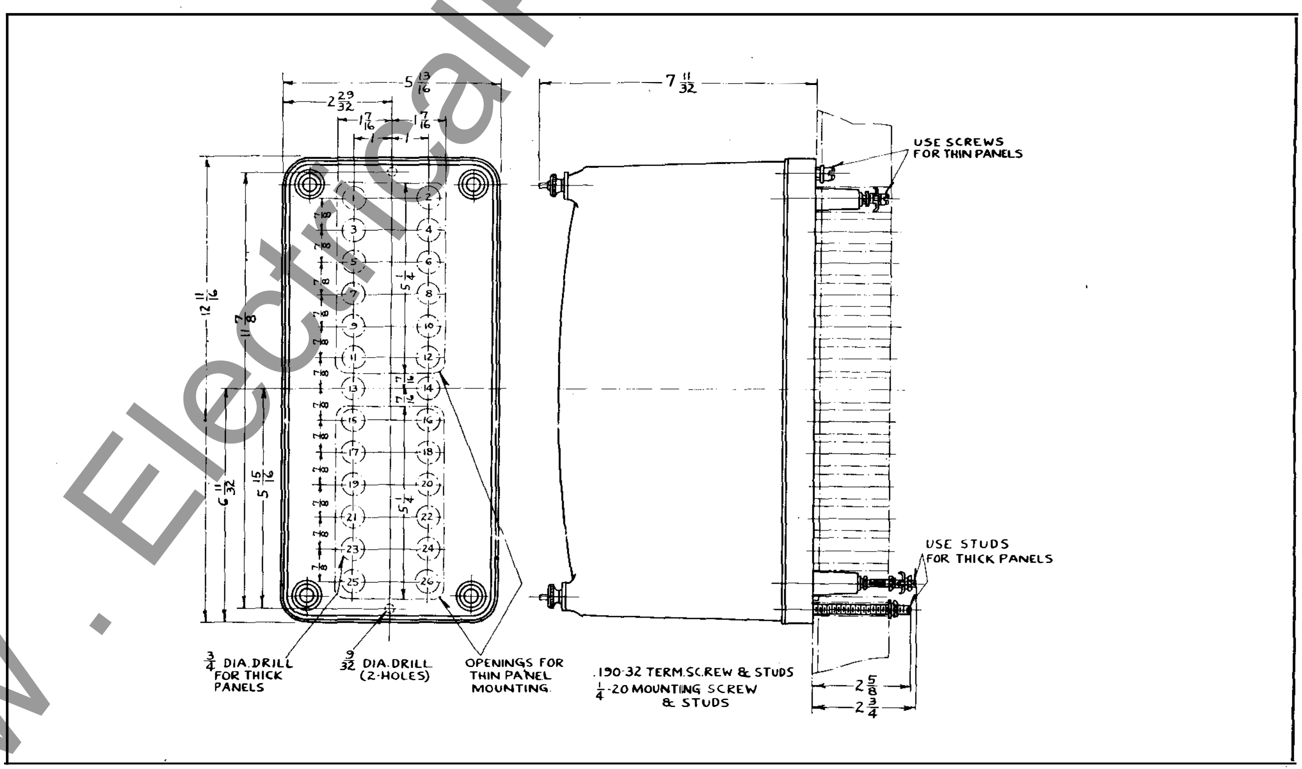

Fig. 7—Outline & Drilling Plan of the Out-of-Step Relay in the Standard Case.

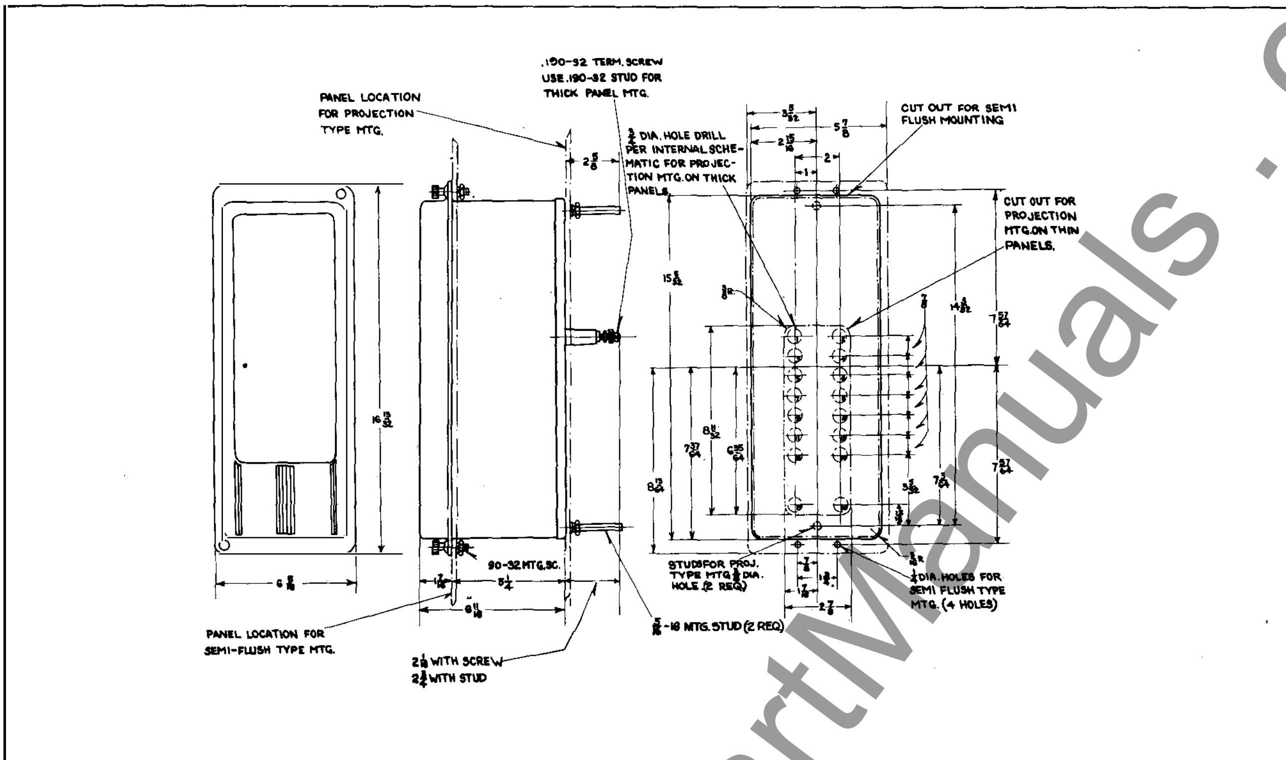

Fig. 8—Outline & Drilling Plan for the Out-of-Step Relay in the Projection or Semi-flush Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

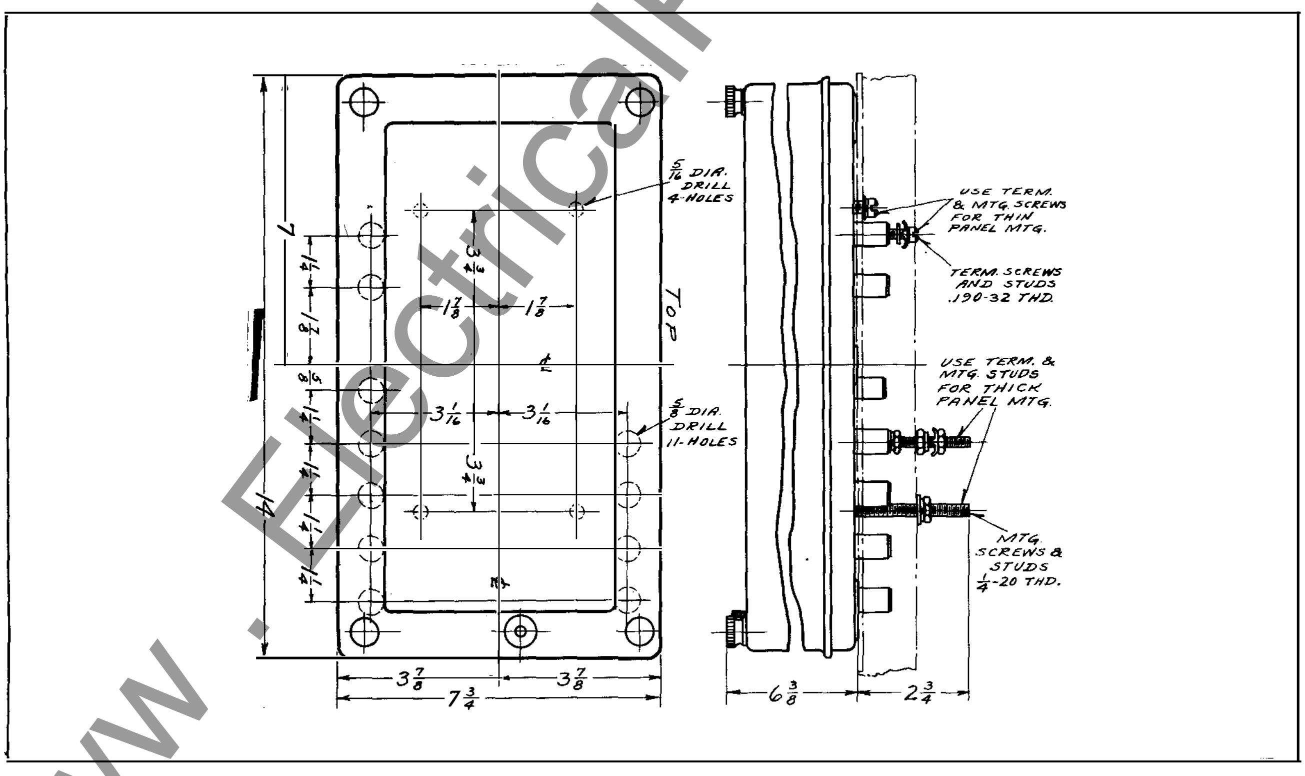

Fig. 9—Outline & Drilling Plan for the Notching Relay in the Projection Case. See the Internal Schematics for the Terminals Supplied. For Reference Only.

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VOLTAGE RESTRAINT AUXILIARY EQUIPMENT FOR USE WITH TYPE CR DIRECTIONAL OVERCURRENT RELAYS

APPLICATION

Voltage restraint auxiliary equipment is used with the type CR relay to restrain the directional element from closing its contacts on normal load flow in the tripping direction in order that the overcurrent element may have a setting less than full load.

The use of voltage restraint allows a wider choice of relay settings to fit the requirements of systems which have wide differences in minimum and maximum load conditions.

CONSTRUCTION AND OPERATION

The voltage restraint auxiliary equipment is mounted external to the relay, and consists of a transformer with a tapped secondary and a reactor and resistor connected in series with the transformer primary. There are two terminals for the voltage circuit and three for the current circuit. The use of this equipment with type CR relays not specifically designed for it necessitates the addition of a new terminal to the standard case relay and two terminals to the relay in the FT case, so that a connection may be made between the directional element and the overcurrent element current coils.

The directional element current coil is connected across the full secondary winding of the auxiliary transformer as shown in Figure 1 and Figure 2. The current, I_{ma}, which flows in this secondary circuit lags the primary voltage which produces it by approximately 60°, as a result of the phase shift in the reactor. The polarity of the connections between the relay and the voltage restraint auxiliary equipment, is such that the current, I_{ma}, makes an angle of approximately 180° with the relay polarizing voltage under normal conditions.

Line current, I_a, is connected to the secondary tap, where it divides into two components, $K_1 I_a$ and $(1-K_1) I_a$. The constant, K_1 is equal to K_2, where K_2 is a design constant. One of these components, $K_1 I_a$, tap flows through the directional element current coil and adds to I_{ma}, to give a resultant current, I_a^1. on the directional element current coil (see Figure 3). The total relay current, in the directional element current coil, is $I_a^1 = K_1 I_a + I_{ma}$, where $K_1 I_a = \frac{K2}{tap} I_a$, and I_{ma} is the restraining current produced by applying voltage E_{ba} to the voltage restraint auxiliary equipment. A vector diagram for these quantities for the phase A relay is shown in Figure 1 and Figure 2.

The actual tap makings of the auxiliary unit indicates the minimum line current in-phase with the polarizing voltage to just cause the directional contacts to close with the relays connected per Figure 1 or Figure 2 and line-to-line voltage of 120 volts.

The voltage restraint provided by this auxiliary equipment is greatly reduced when there is a phase-to-phase fault or a three-phase fault. In the event of a phase-to-phase fault, the restraining voltage will be considerably reduced on the relay which is supposed to operate. Using phase A relay as an example, its polarizing voltage is E_{ac} and its restraining voltage is E_{ba}. If there is a fault on phases AB, the voltage E_{ba} is reduced to a very small value so that the phase A relay will operate. In the event of a three phase fault, the restraining voltage is reduced on all three relays.

A solid fault at the relay will reduce the restraining voltage, on the relay involved, completely to zero. In general, the amount of

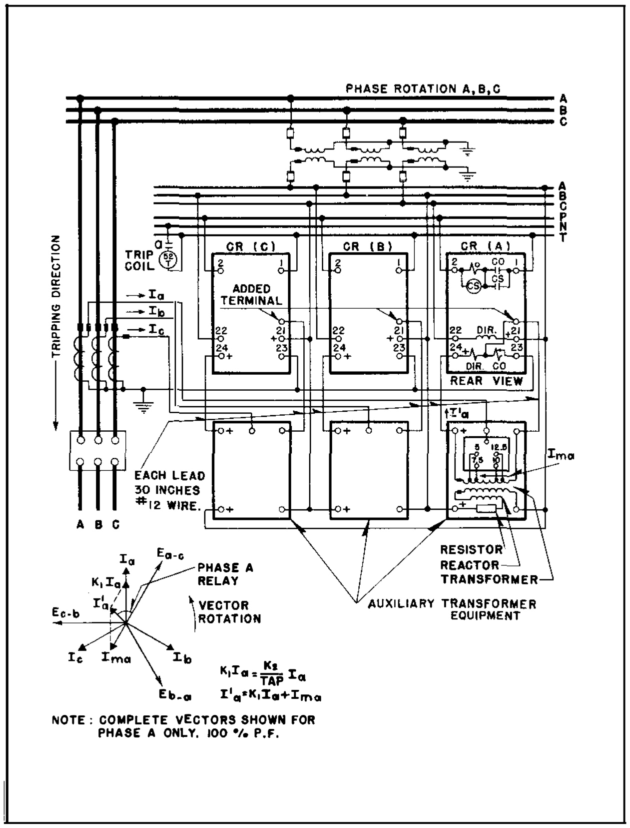

Fig. 1—External Connections of the Type CR Relay in the Standard Case with the Voltage Restraint Auxiliary Equipment for Phase Fault Protection.

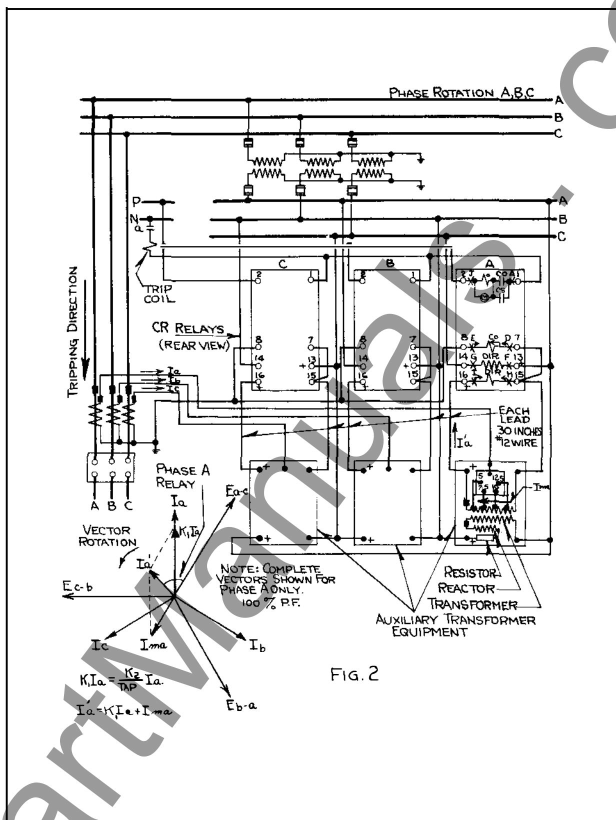

Fig. 2—External Connections of the Type CR Relay in the Type FT Case with the Voltage Restraint Auxiliary Equipment for Phase Fault Protection.

restraining voltage will be proportional to the distance of the fault from the relay and the arc drop at the fault.

Proper relay operation during a three-phase fault will depend upon the sensitivity of the relay. The minimum trip current, with 1 volt on the relay potential coil, may be figured from the following formula:

$$I_t \text{ (approximate)} = 0.38\ T\ I_x$$

Where T is the auxiliary transformer tap and I_x is the minimum trip current for the relay alone, at 1 volt.

For example, a relay with a minimum trip current of 4 amperes at 1 volt will have a sensitivity, on the 5 ampere restraint tap, of 0.38 x 5 x 4 = 7.6 amperes.

CHARACTERISTICS

Figure 4 shows typical phase angle curves for the CR relay for each tap value on voltage restraint auxiliary equipment.

Continuous ratings for the voltage restraint auxiliary equipment, including the directional element current coil, are as follows:

Tap	Amperes
5	10
7.5	10
10	10
12.5	12.5

ENERGY REQUIREMENTS

Burden of current circuit, including directional element and voltage restraining transformer, at 5 amperes, (not including overcurrent element).

The current circuit burden is very small. It ranges from a minimum of 0.1625 VA on the

12.5 ampere tap, with current in the contact closing direction, to a maximum of 2.1 VA on the 5 ampere tap, with current in the contact opening direction.

Burden of auxiliary equipment in the voltage circuit at 120 volts, 60 cycles.

	Watts	Volt-Amps.	Power Factor Angle
No line current	4.65	9.0	58.9° Lag
*Tap val. line cur.	4.38	8.15	57.5° Lag
*Tap val. line cur.	5.12	9.72	58.2° Lag

*With the line current flowing, there is a variation in the burden, depending upon the phase angle of the current. The two values shown are for minimum and maximum volt amperes. There is an overall variation of the power factor angle of the voltage circuit from 53.1° to 62.9°.

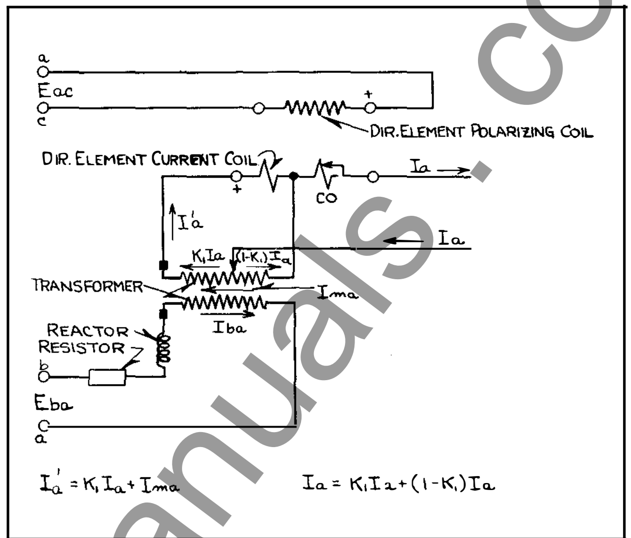

Fig. 3—Schematic Connections of the Voltage Restraint Scheme.

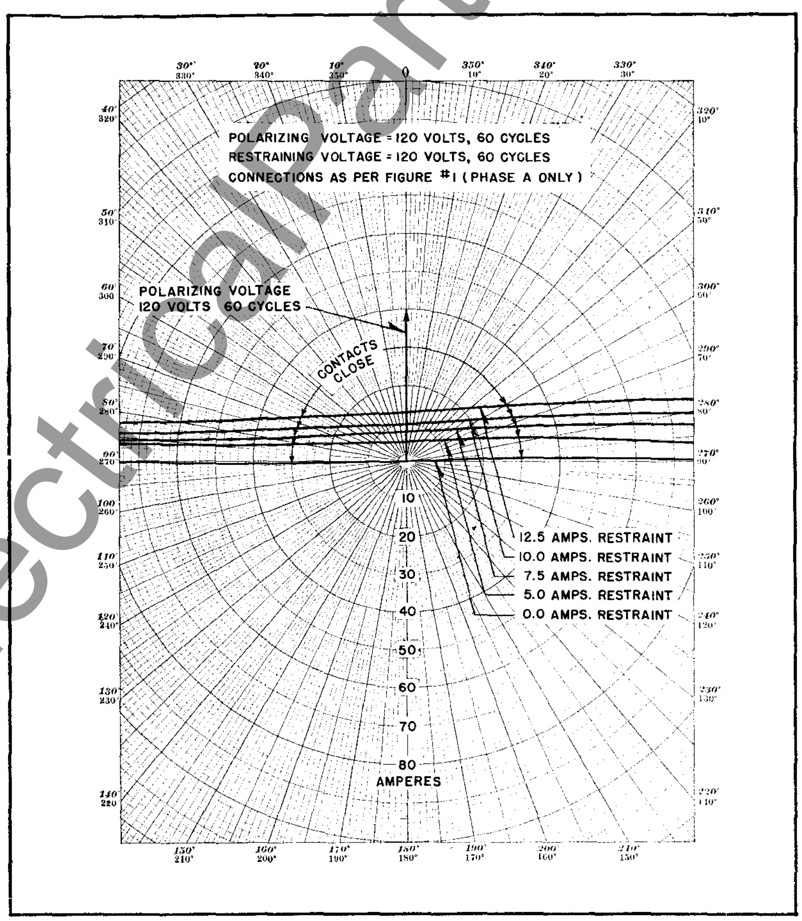

Fig. 4—Typical Phase Angle Curves of the Voltage Restraint Type CR Relay

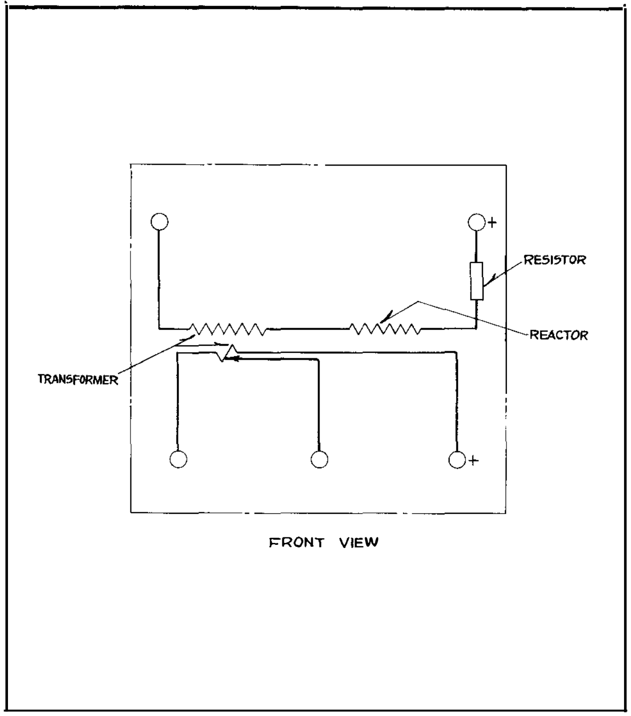

Fig. 5—Internal Schematic of the Auxiliary Unit for the Voltage Restraint Type CR Relay.

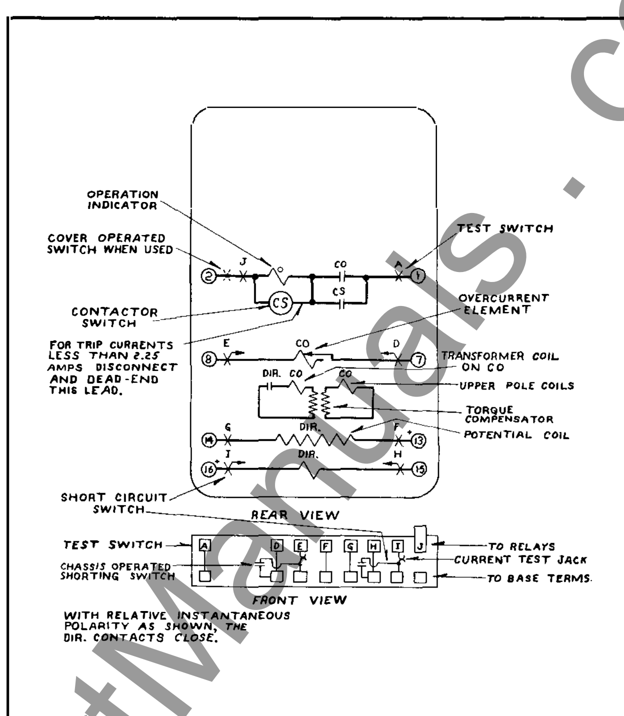

Fig. 6—Internal Schematic of the Definite Minimum Time Voltage Restraint Type CR Relay in the Type FT Case.

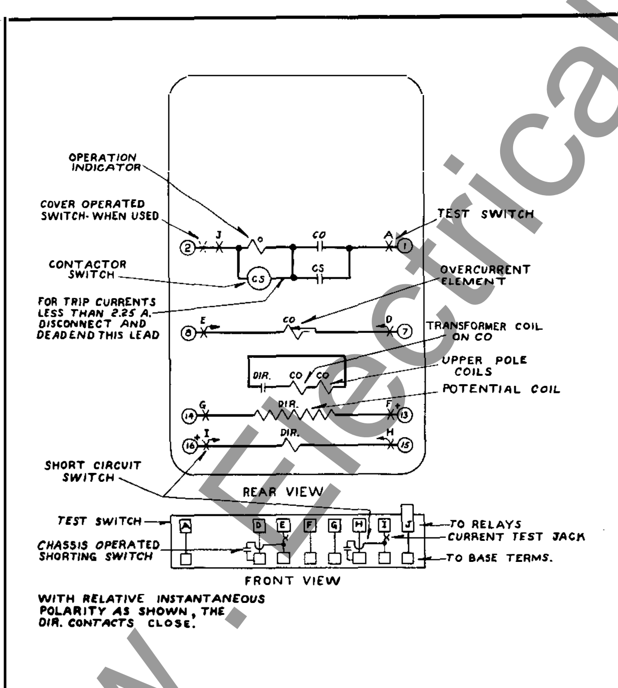

Fig. 7—Internal Schematic of the Inverse Time Voltage Restraint Type CR Relay in the Type FT Case.

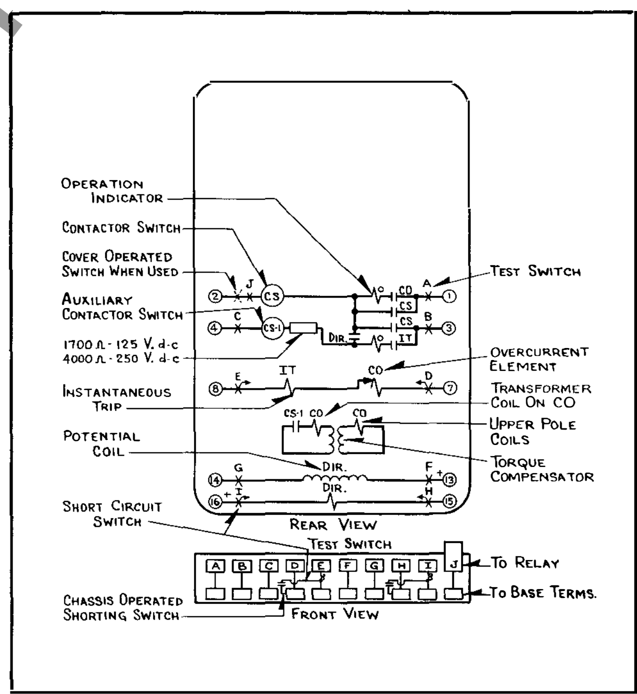

Fig. 8—Internal Schematic of the Definite Minimum Time Voltage Restraint Type CR Relay with Instantaneous Trip in Type FT Case.

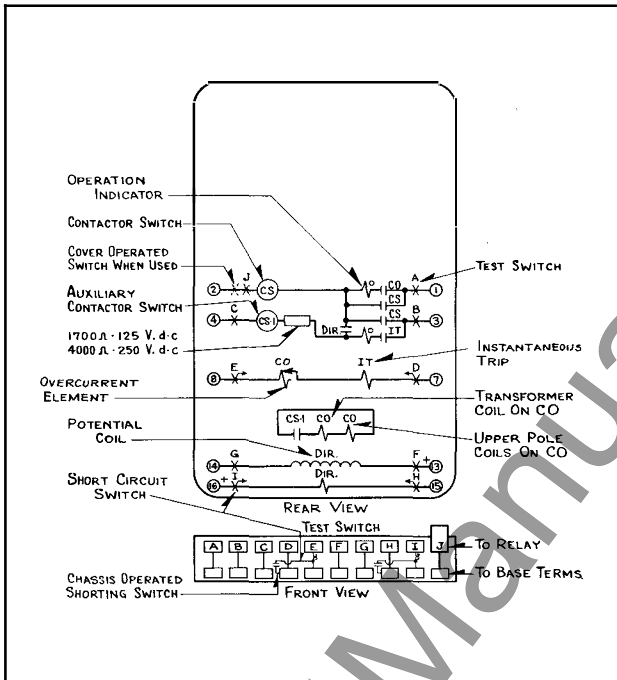

Fig. 9—Internal Schematic of the Inverse - Time Voltage Restraint Type CR Relay with Instantaneous Trip in Type FT Case.

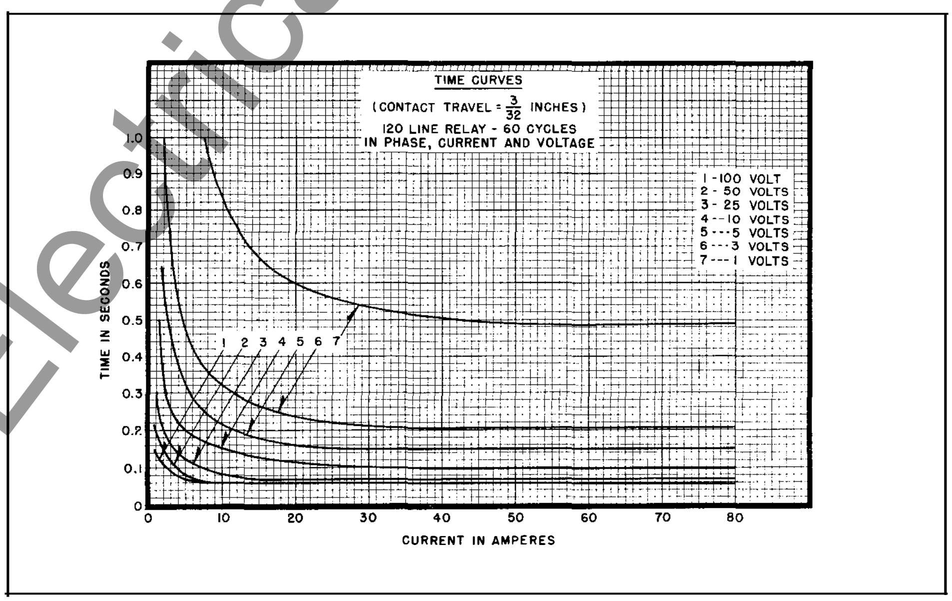

Fig. 10—Typical Time Curve for Directional Element Alone.

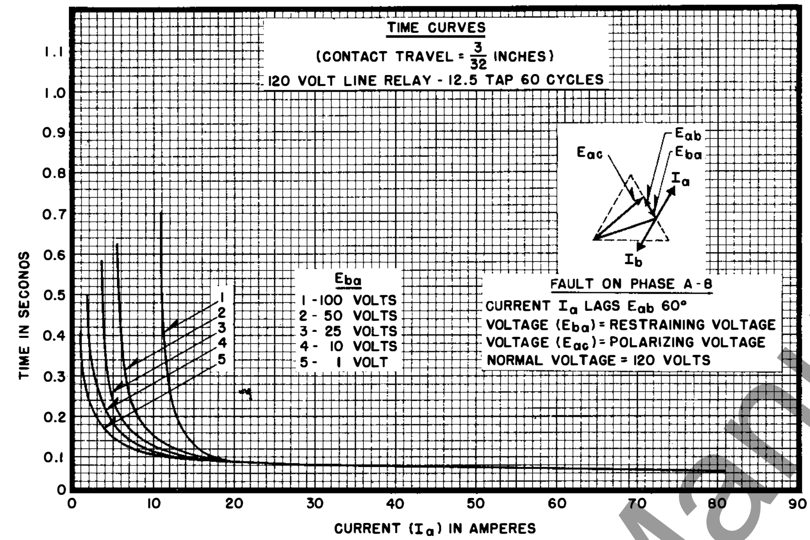

Fig. 11—Typical Time Curve for Directional Element, 12.5 Ampere Tap, Phase to Phase Fault.

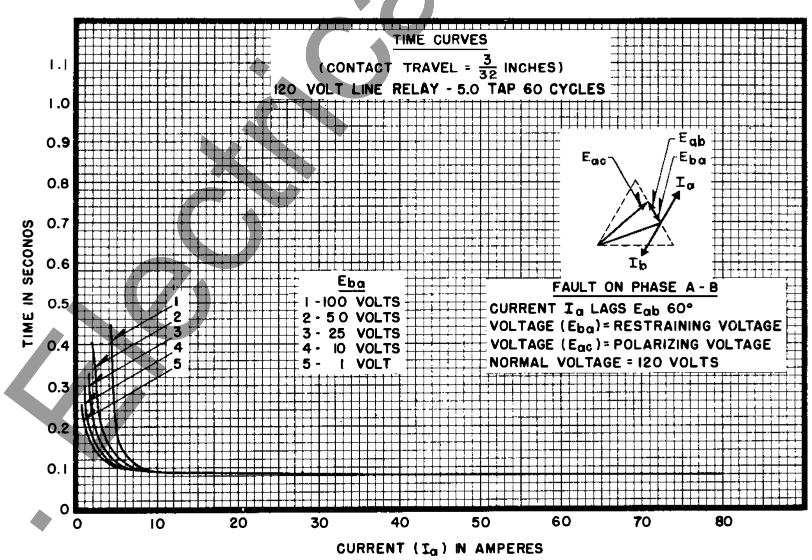

Fig. 12—Typical Time Curve for Directional Element, 5.0 Ampere Tap, Phase to Phase Fault.

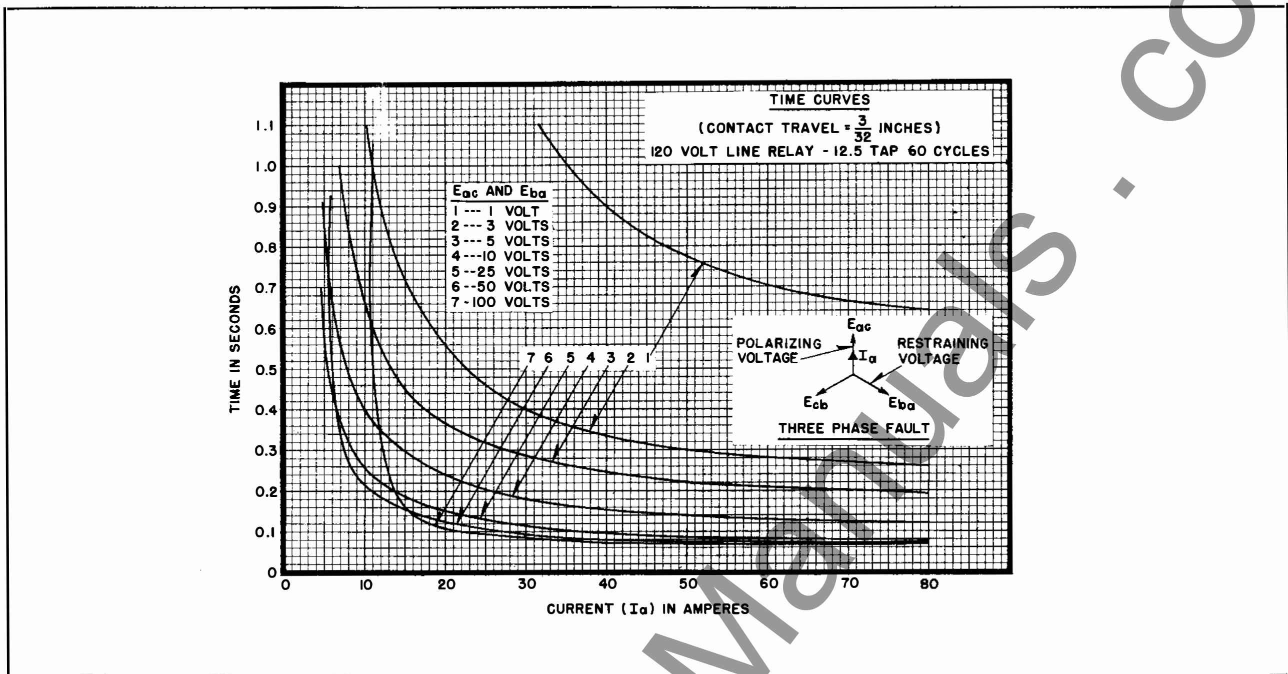

Fig. 13—Typical Time Curve for Directional Element, 12.5 Ampere Tap, Three Phase Fault.

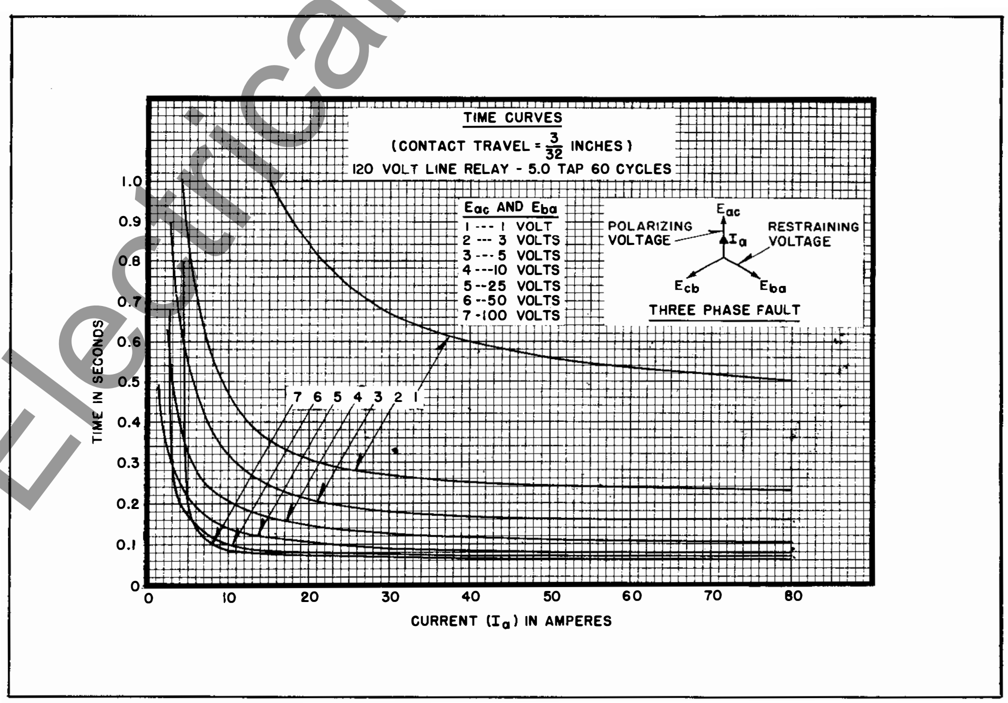

Fig. 14—Typical Time Curve for Directional Element, 5.0 Ampere Tap, Three Phase Fault.

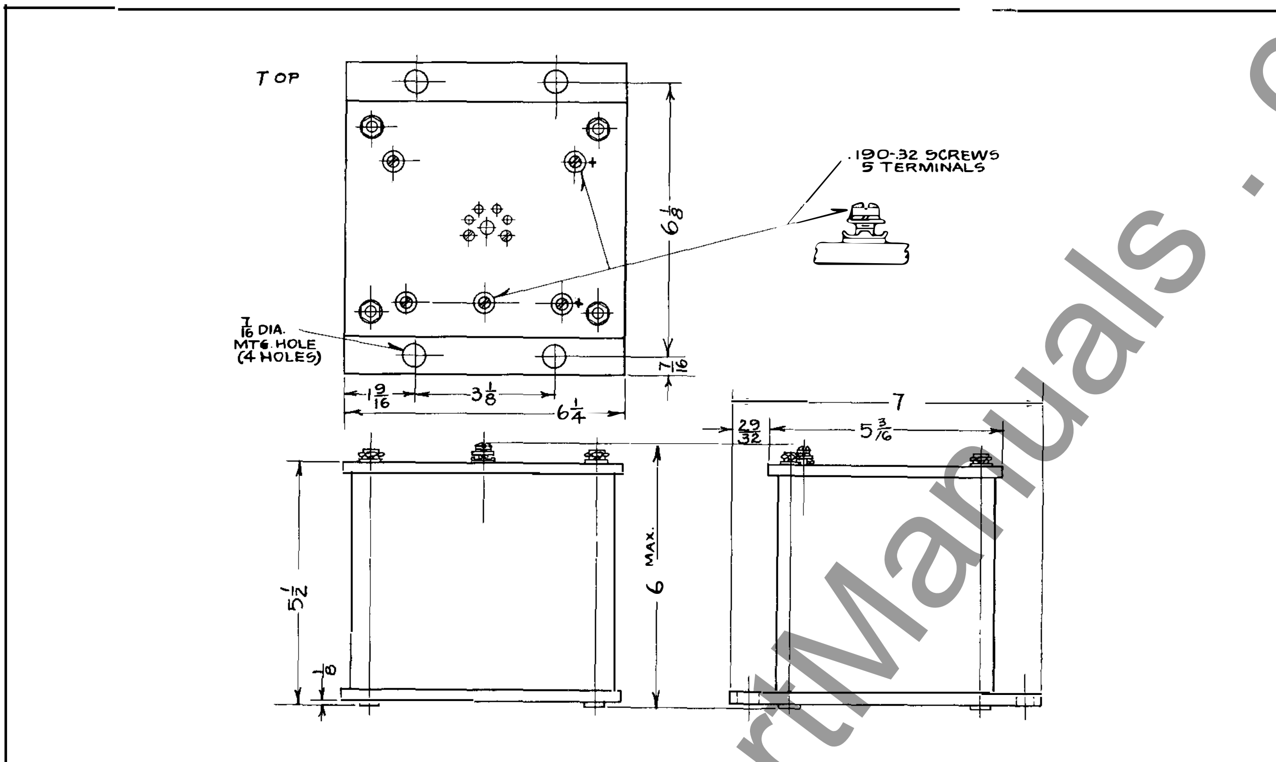

Fig. 15—Outline and Drilling Plan of the Auxiliary Transformer. For Reference Only.

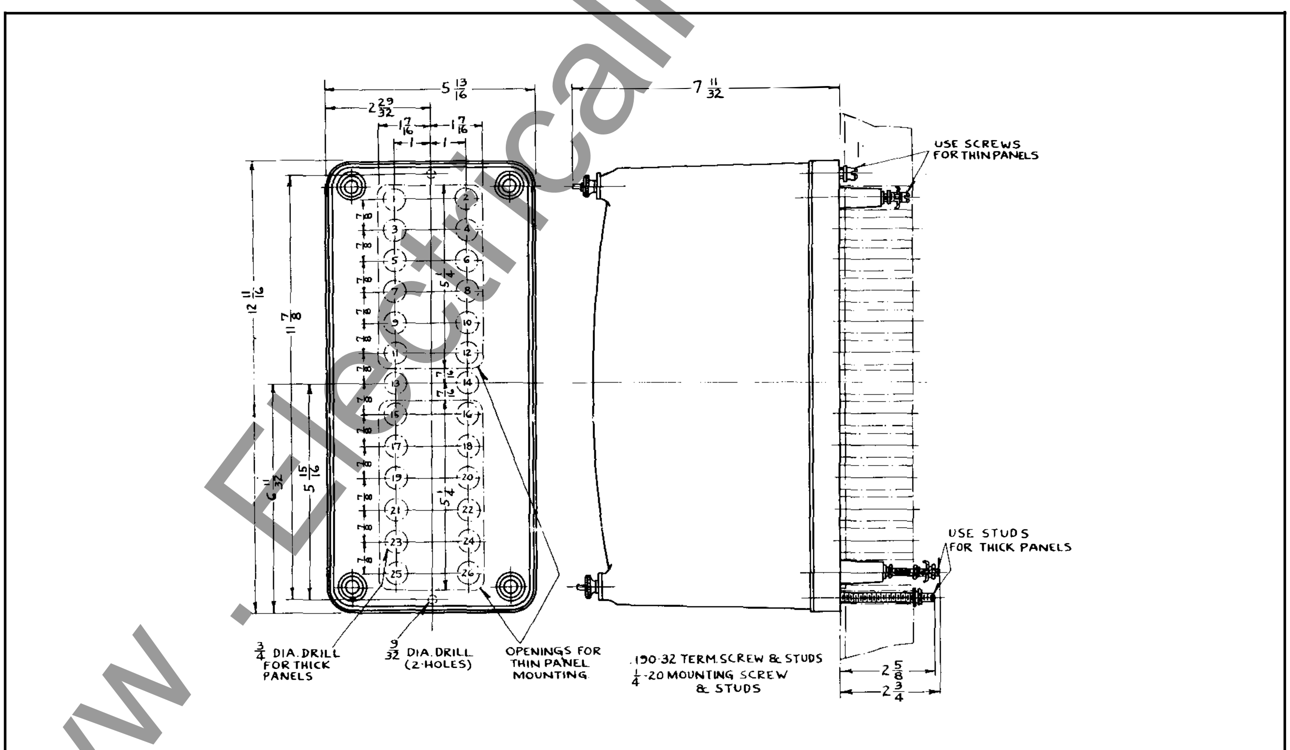

Fig. 16—Outline and Drilling Plan for the Standard Projection Type CR Relay Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

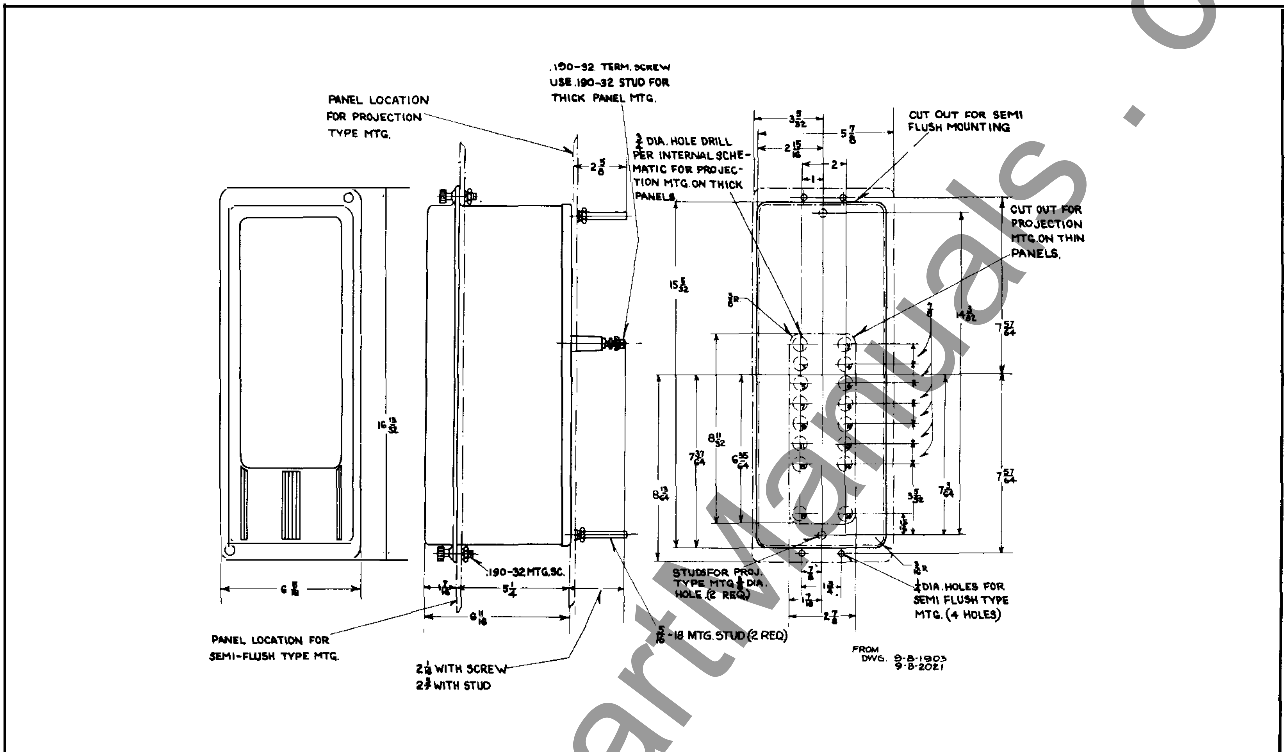

Fig. 17—Outline and Drilling Plan for the M10 Semi-Flush or Projection Type FT Flexitest CR Relay Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

WESTINGHOUSE ELECTRIC CORPORATION

METER DIVISION **NEWARK, N.J.**

Printed in U.S.A.

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

SUPERSEDES I. L. 41-285P
*Denotes change from superseded issue.

EFFECTIVE DECEMBER 1954

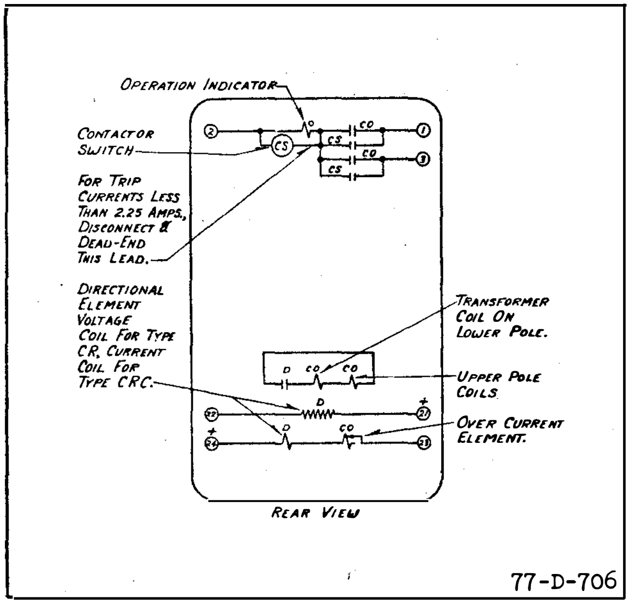

Fig. 1—Internal Schematic Of The Double Trip, Directional Control, Inverse Time (Low Energy 2 Sec., 25, 50 & 60 Cycles, 4 Sec., 25 Cycles) and Very Inverse Time, Circuit Closing Relays In The Standard Case. The Single Trip Relays Have Terminal 3 And Associated Circuits Omitted.

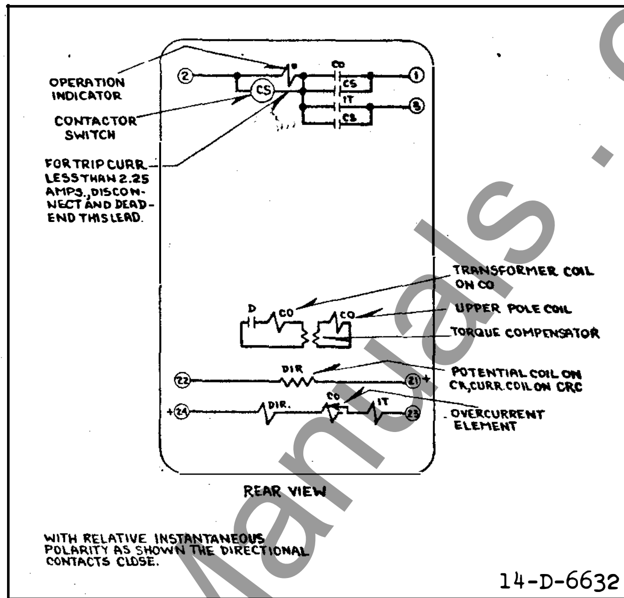

Fig. 2—Internal Schematic Of The Single Trip, Directional Control, Definite Minimum Time (2 and 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (Low Energy 4 Sec., 50 & 60 Cycles), Circuit Closing Relays With Instantaneous Trip In The Standard Case.

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.

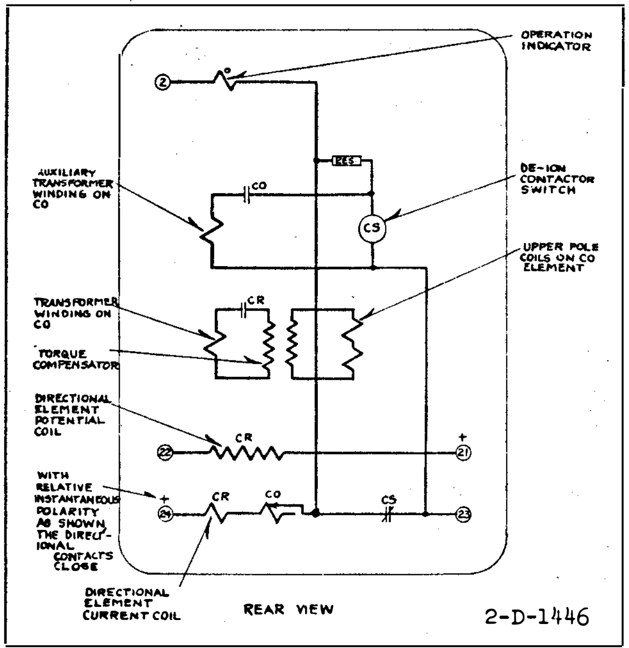

Fig. 3—Internal Wiring Diagram Of The Single Trip, Standard Energy, Circuit Opening Relay.

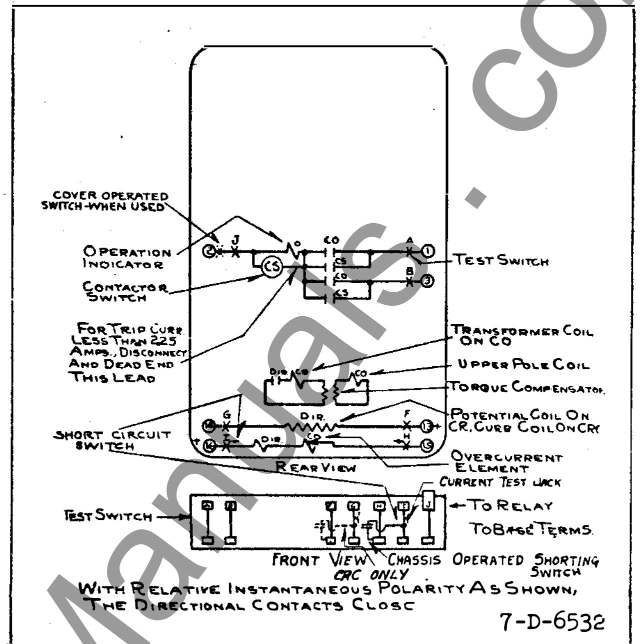

Fig. 4—Internal Schematic Of The Double Trip, Directional Control, Definite Minimum Time (Standard Energy 2 and 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (4 Sec., 50 & 60 Cycles) Circuit Closing Relay In The Type FT Case. The Single Trip Relays Have Terminal 3 And Associated Circuits Omitted.

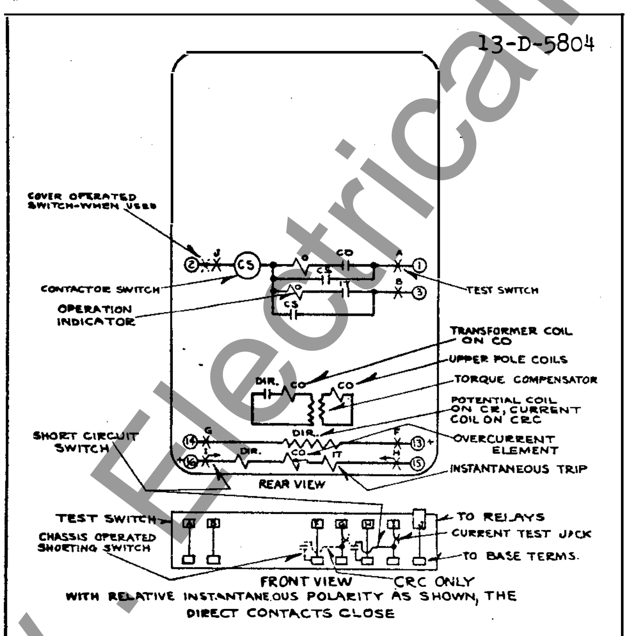

Fig. 5—Internal Schematic Of The Single Trip With Instantaneous Trip, Directional Control, Definite Minimum Time (Standard Energy 2 & 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (4 Sec., 50 & 60Cycles)Circuit Closing Relay In The Type FT Case.

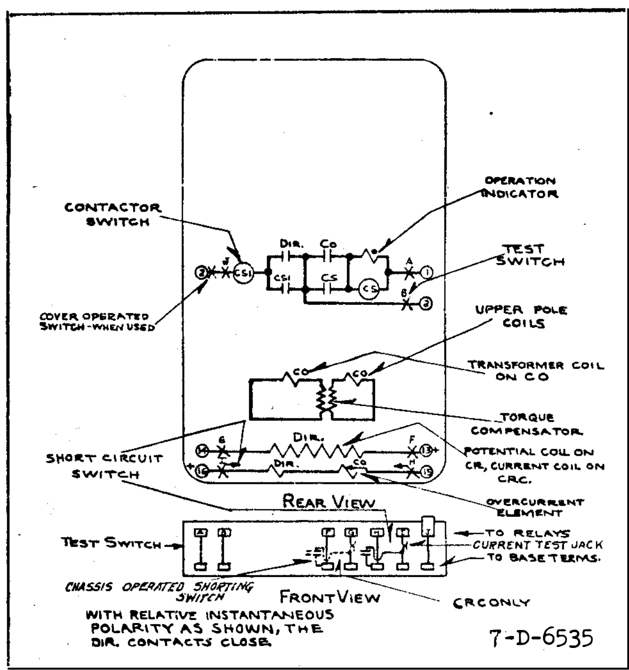

Fig. 6—Internal Schematic Of The Single Trip, Non-Directional Control With Terminal Between Directional And Overcurrent Contacts, Definite Minimum Time (Standard Energy 2 & 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (4 Sec., 50 & 60 Cycles) Circuit Closing Relay In the Type FT Case.

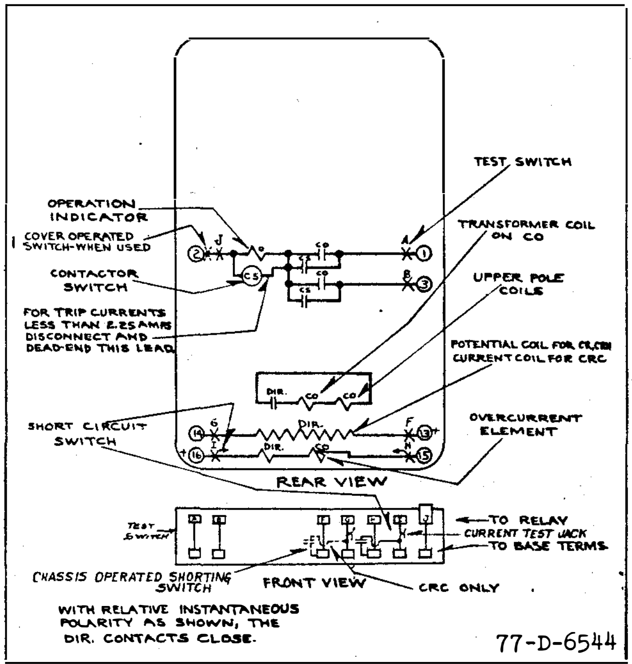

Fig. 7—Internal Schematic Of The Double Trip, Directional Control, Inverse Time (Low Energy 2 Sec., 25, 50 & 60 Cycles, 4 Sec., 25 Cycles) or Very Inverse Time, Circuit Closing Relay In The Type FT Case. The Single Trip Relays Have Terminal 3 And Associated Circuits Omitted.

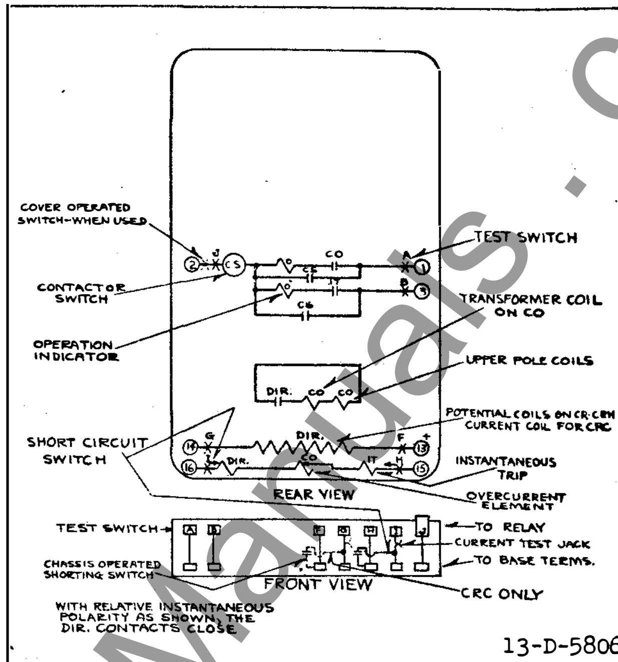

Fig. 8—Internal Schematic Of The Single Trip With Instantaneous Trip, Directional Control, Inverse Time (Low Energy, 2 Sec., 25, 50 & 60 Cycles 4 Sec., 25 Cycles) or Very Inverse Time, Circuit Closing Relay In The Type FT Case.

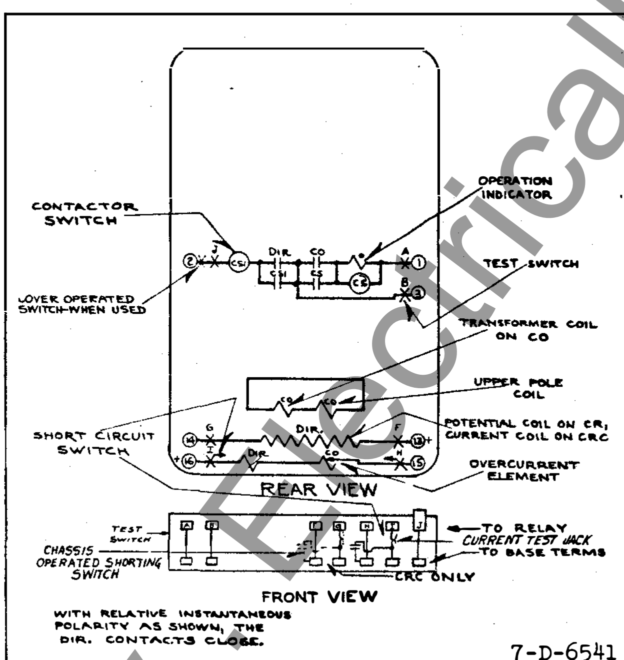

Fig. 9—Internal Schematic Of The Single Trip, Non-Directional Control With Terminal Between Directional And Overcurrent Contacts, Inverse Time (Low Energy 2 Sec., 25, 50 & 60 Cycles, 4 Sec., 25 Cycles) or Very Inverse Time, Circuit Closing Relay In The Type FT Case.

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.

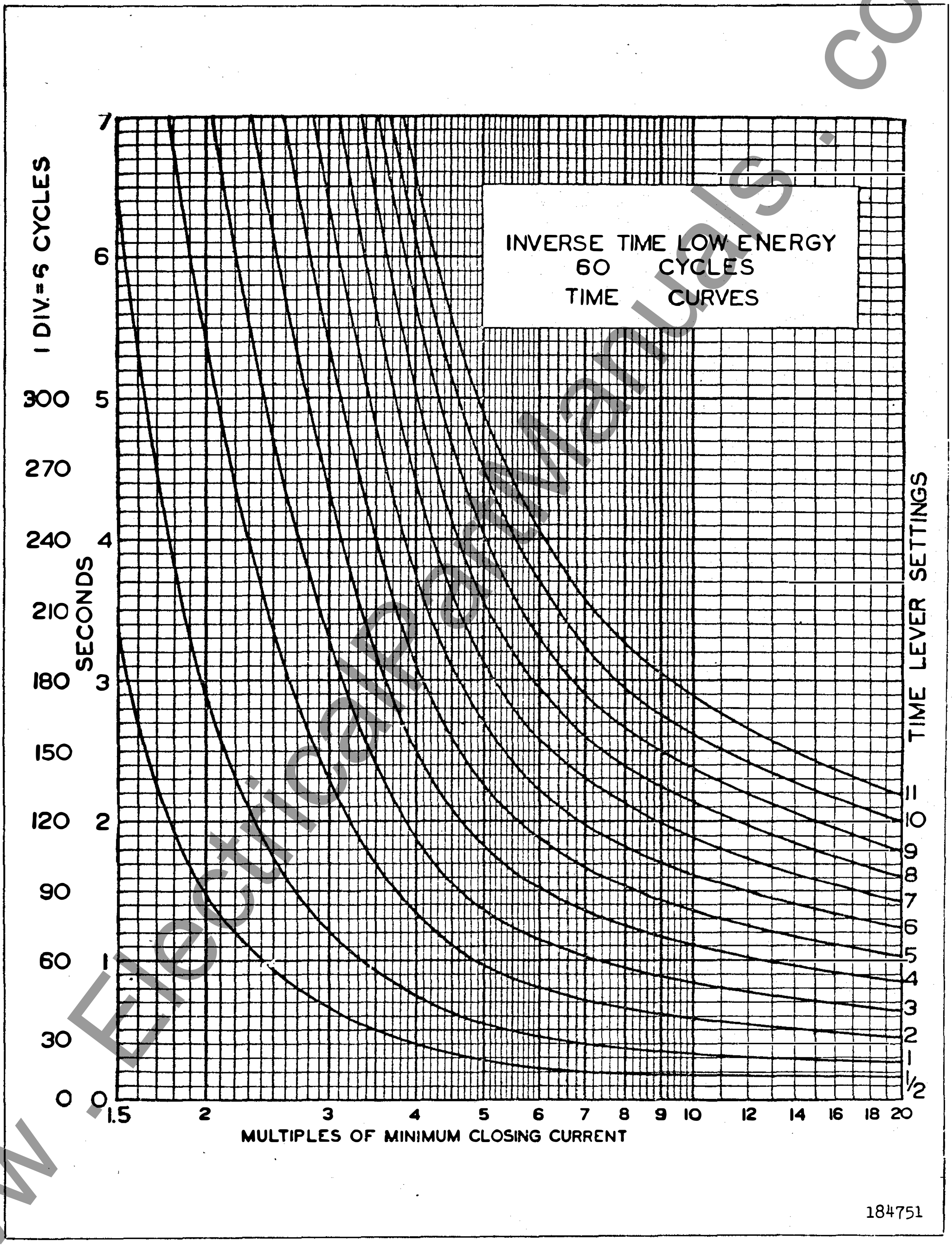

Fig. 10—Typical Inverse Time Curves Of The Overcurrent Element Of The Low Energy 60 Cycle Relays.

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

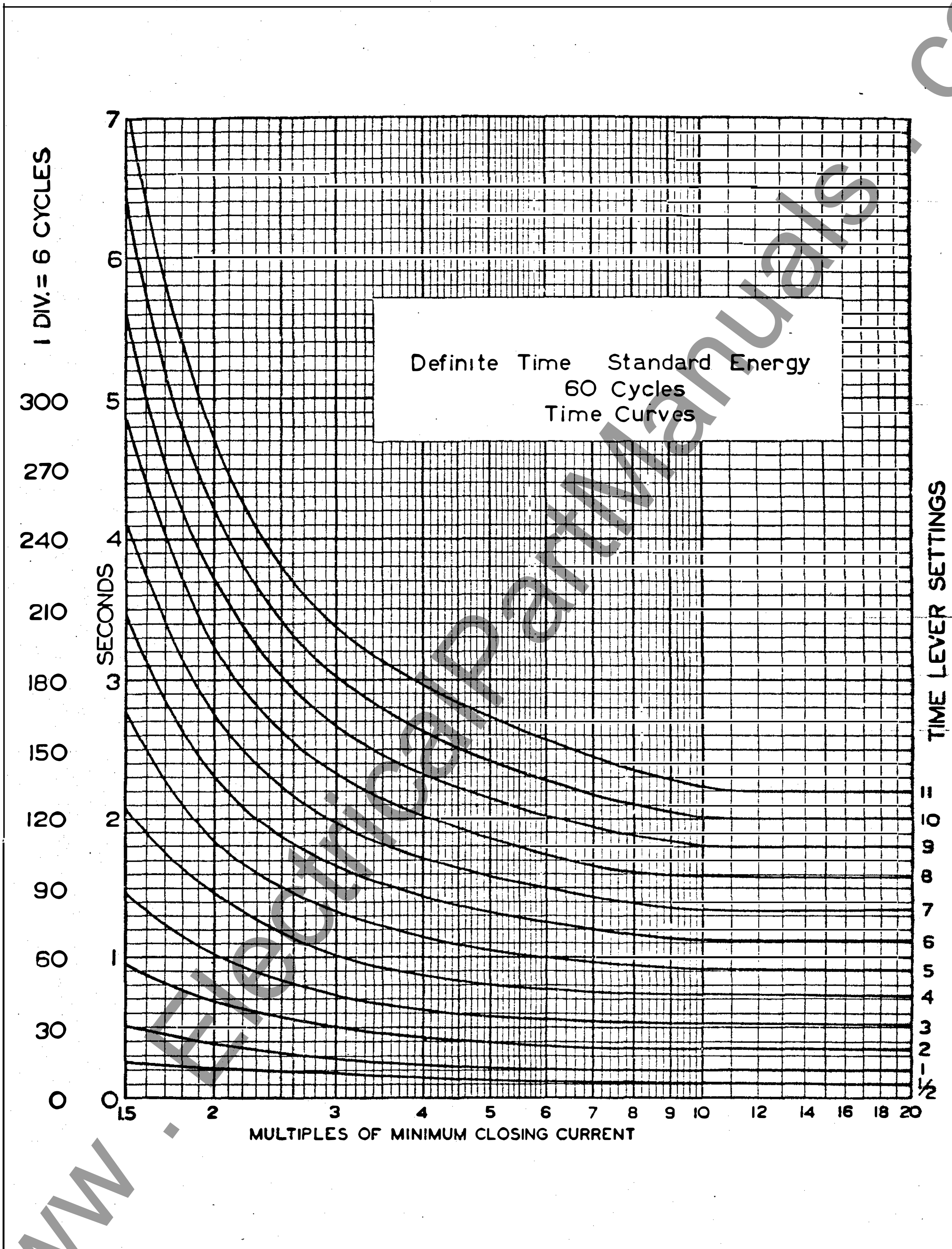

Fig. 11—Typical Inverse Definite Minimum Time Curves Of The Overcurrent Element Of The Standard Energy 60 Cycle Relays.

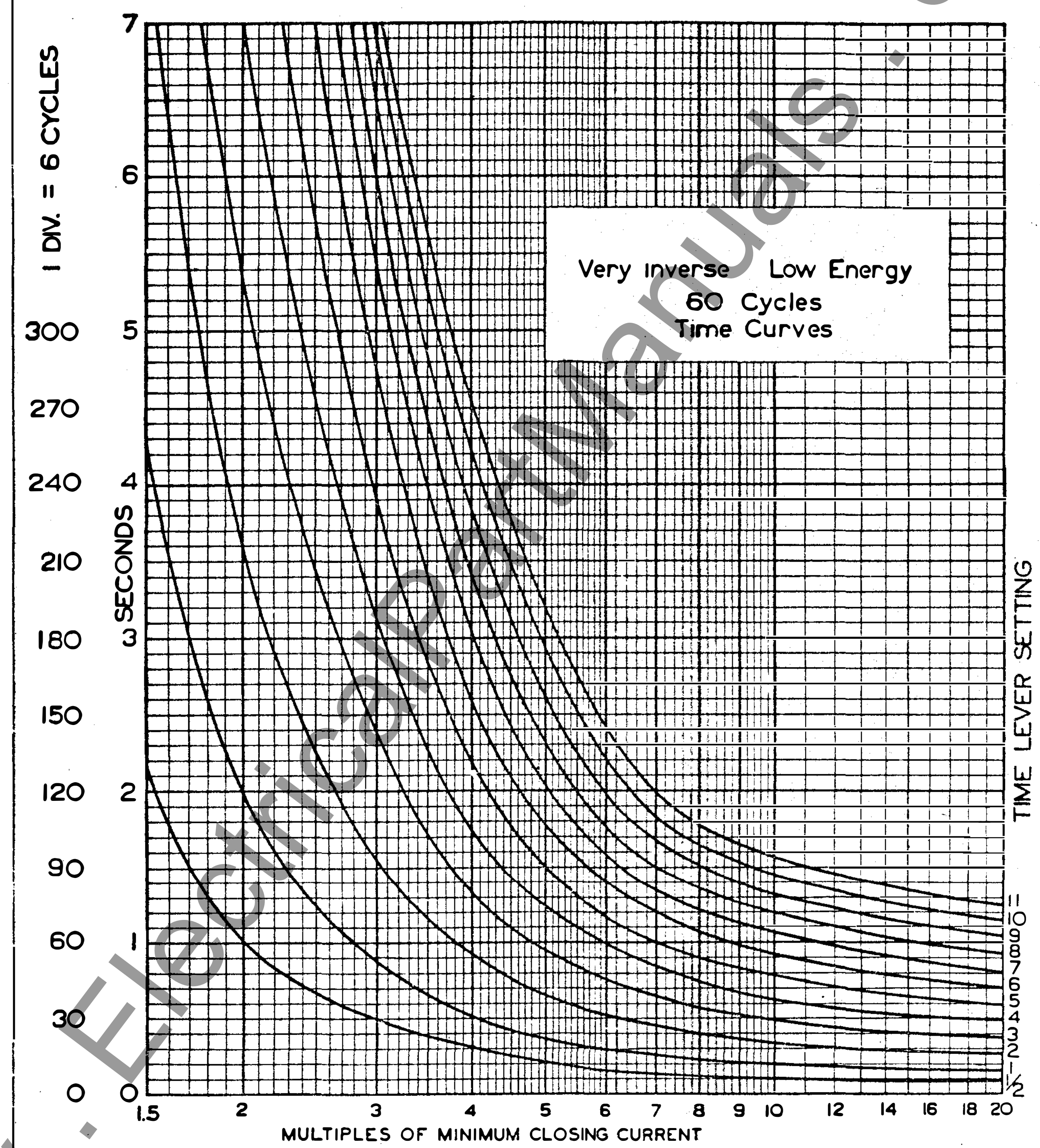

Fig. 12—Typical Very Inverse Time Curves Of The Overcurrent Element Of The Low Energy 60 Cycle Relays.

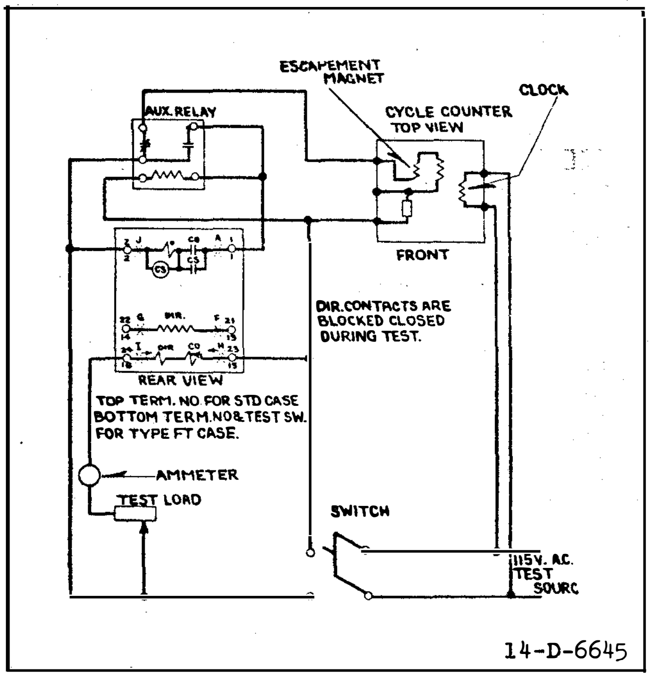

Fig. 13—Diagram Of Test Connections For The Circuit Closing Relays.

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 fillister-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

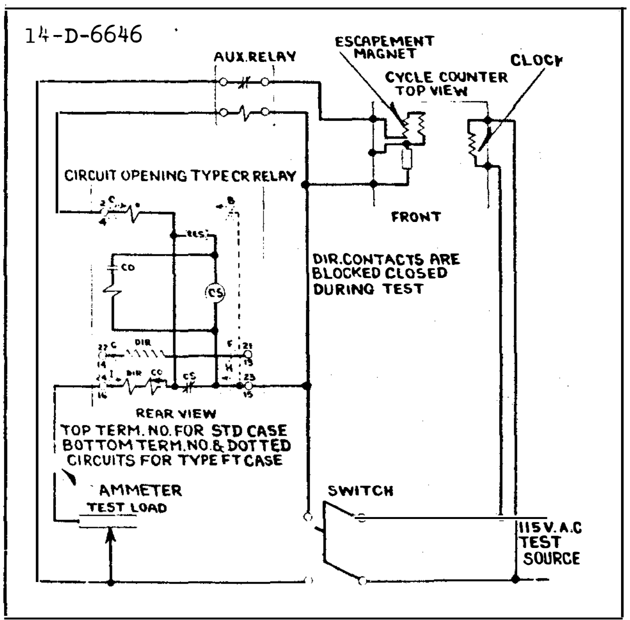

Fig. 14—Diagram Of Test Connections For The Circuit Opening Relays.

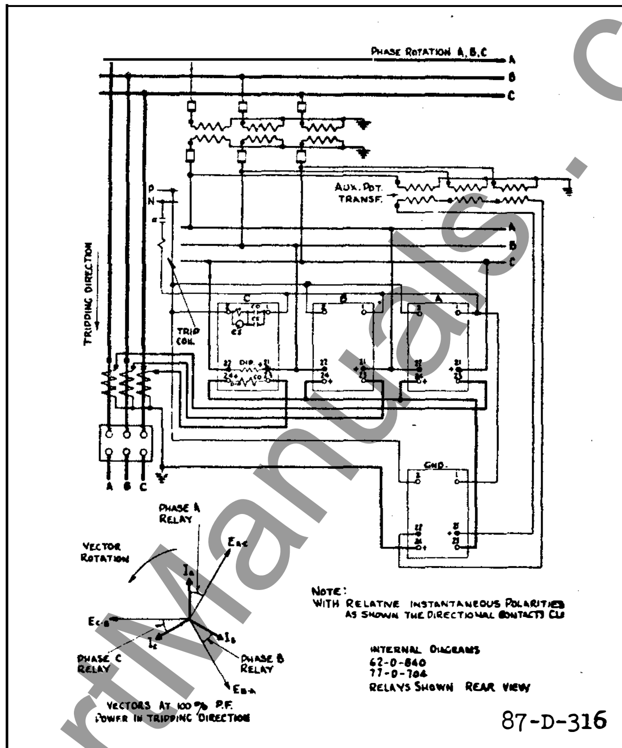

Fig. 15—External Connections Of The Circuit Closing Type CR Relay In The Standard Case For Phase And Ground Protection Using The 30° Connection On The Phase Directional Element.

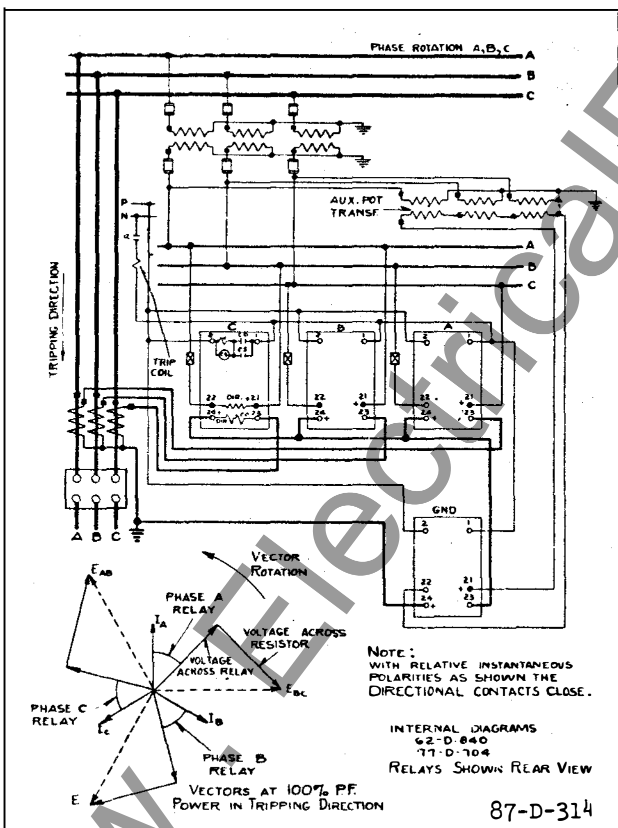

Fig. 16—External Connections Of The Circuit Closing Type CR Relay In The Standard Case For Phase And Ground Protection Using The 90° Connection (Maximum Torque 45° or 60° Lagging Current. 45° is shown above) On The Phase Directional Element.

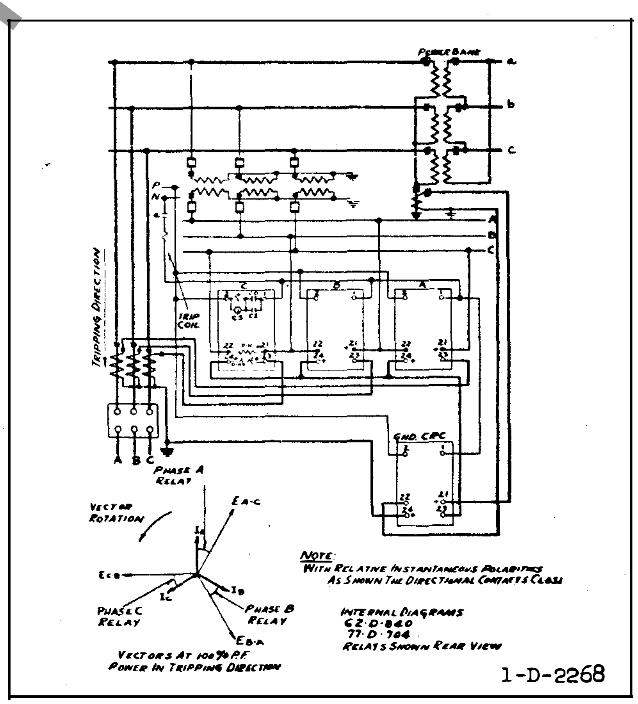

Fig. 17—External Connections Of The Circuit Closing Type CR Relay In The Standard Case For Phase Protection Using The 30° Connection Of The Directional Element And The Type CRC Relay In The Standard Case For Ground Protection.

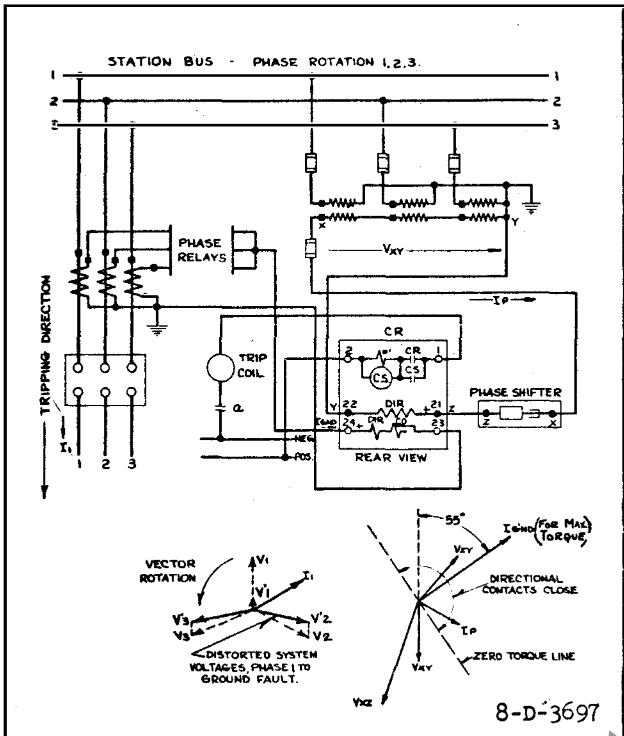

Fig. 18—External Connections Of The Type CR Ground Relay In The Standard Case For Ground Fault Protection Using An External Phase Shifter.

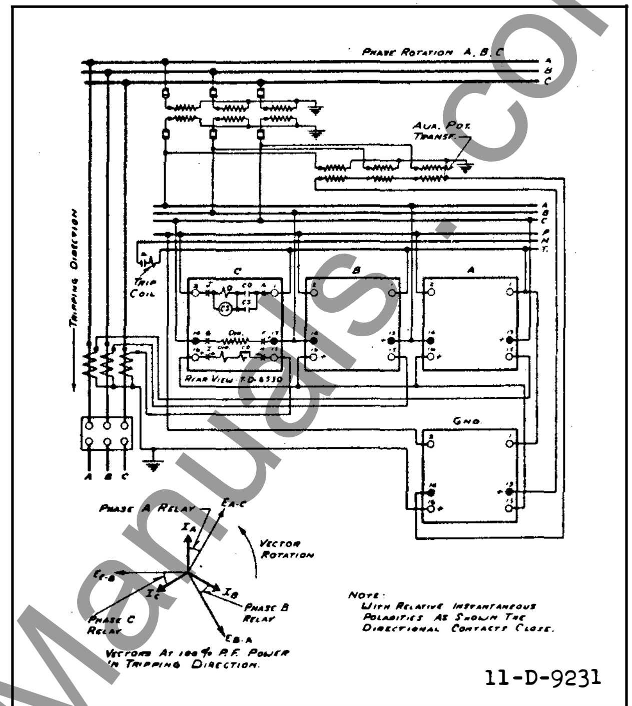

Fig. 19—External Connections Of The Circuit Closing Type CR Relay In The Type FT Case For Phase And Ground Protection Using The 30° Connection On The Phase Directional Element.

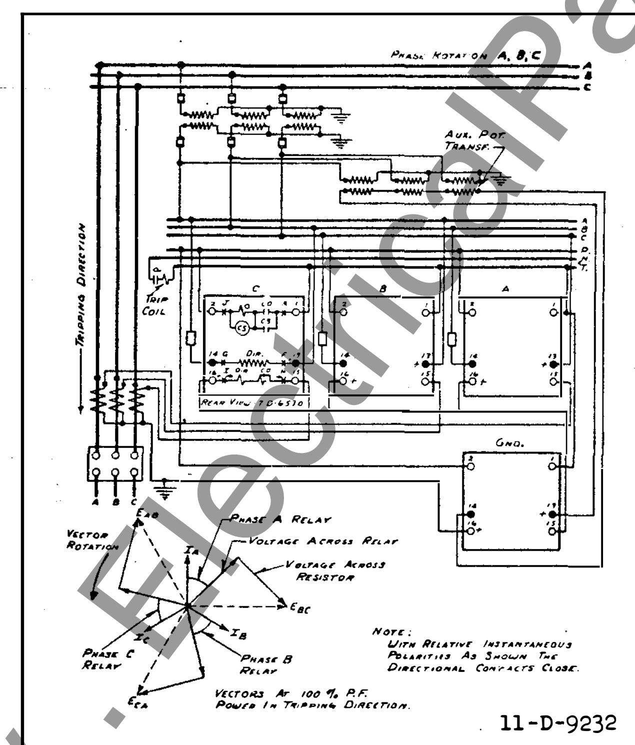

Fig. 20—External Connections Of The Circuit Closing Type CR Relay In The Type FT Case For Phase And Ground Protection Using The 90° Connection (Maximum Torque 45° or 60° Lagging Current 45° is shown above) On The Phase Directional Element.

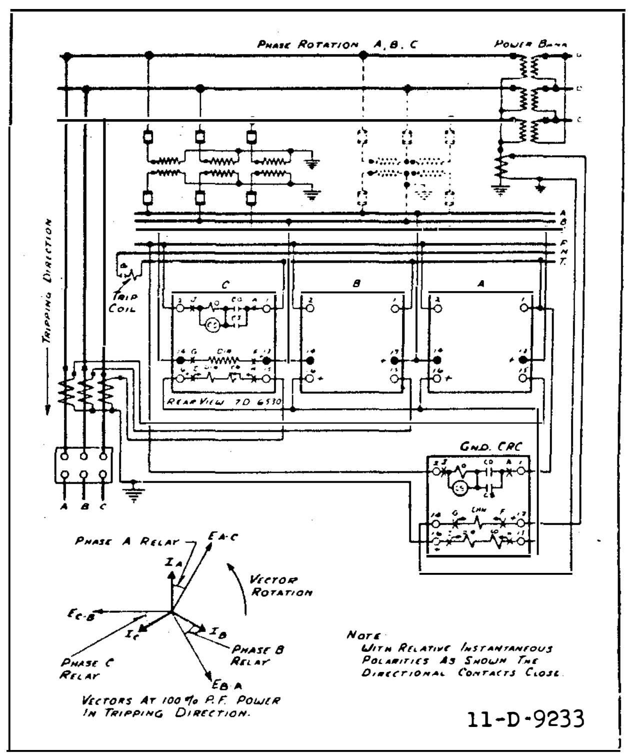

Fig. 21—External Connections Of The Circuit Closing Type CR Relay In The Type FT Case For Phase Protection Using The 30° Connection On The Directional Element And The Type CRC Relay In The Type FT Case For Ground Protection.

several cycles. This time is so small that it is usually ignored and the relays are tested by blocking the directional contacts in the closed position.

The position of the torque compensator on the overload element is adjustable but this is primarily a factory adjustment and the location of the torque compensator should not be changed in the field. If the relay has a metal cover, this cover must be in place when making tests.

Directional Element

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

The contact opening on the directionally-controlled relay should be 1/32" in order to reduce the time of operation of the directional element to a minimum. No harm will result if the directional contacts rebound to close momentarily after a fault is cleared, because the overcurrent contacts will be in the open position. The contact opening on relays which are not directionally controlled should be 3/32".

The tension of the spiral spring on the directional element should be just sufficient to return the disc to the stop and thus hold the contacts in the open position.

In many applications there is no objection to having the contacts closed when the relay is de-energized. This can be changed by shifting the spring adjuster but the tension on the spring should never be enough to prevent the contacts from taking their proper position, either open or closed, during time of short circuit when the forces acting on the disc are small.

There is an adjustable magnetic vane on each side of the upper pair of poles, which is intended to balance the current circuit. The normal adjustment is to remove all potential from the voltage coil and apply heavy current to the current coils. The balancing vanes are then adjusted till there is no pronounced torque in either direction. This same adjustment may be used to positively close the contacts on current alone. This may be desired on some installations in order to insure that the relay will always trip the breaker even though the potential may be zero.

When operating at the maximum torque angle, the directional element of the Type CR Phase Relay and 2 to 6 and 4 to 15 amp. ground relay should pick-up on 1 volt and 4 amperes, and for the 0.5 to 2.5 amp. Type CR Ground Relays on 1 volt, 2.7 amperes. The directional element of the CRC Ground Relay will pick-up at 0.5 ampere each winding.

Contactor Switch

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core of 1/64" when the switch is picked up. This can be done by turning the relay up-side-down or by disconnecting the switch and turning it up-side-down. Then screw up the core screw until the moving core starts rotating. Now, back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/32" by means of the two small nuts on either side of the Micarta disc. The switch should pick-up at 2 amperes d-c. Test for sticking after 30 amperes d-c. have been passed through the coil.

Operation Indicator
(Circuit-Closing Relays)

Adjust the indicator to operate at 0.2

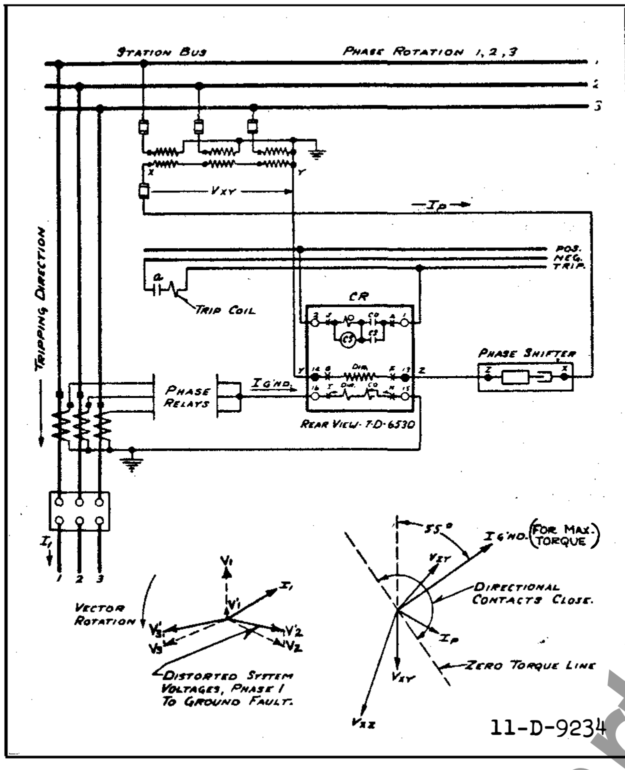

Fig. 22—External Connections Of The Type CR Relay In The Type FT Case For Ground Fault Protection Using An External Phase Shifter.

ampere d-c. gradually applied. Test for sticking after 5 amperes d-c. is passed.

Overcurrent Element
(Circuit Opening Relays)

Adjust the relay with the instructions given

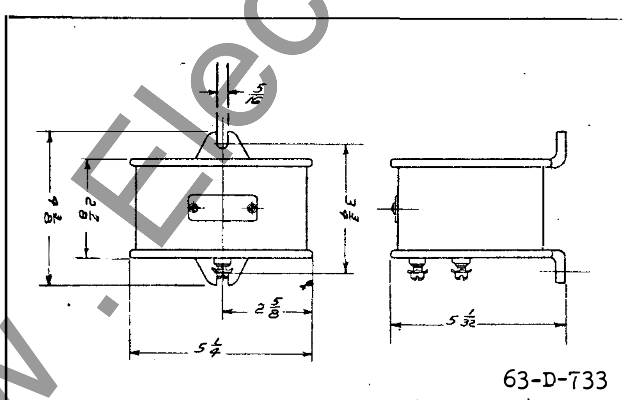

Fig. 24—Outline And Drilling Plan Of The Phase Shifter For The Ground Relay When Supplied. For Reference Only.

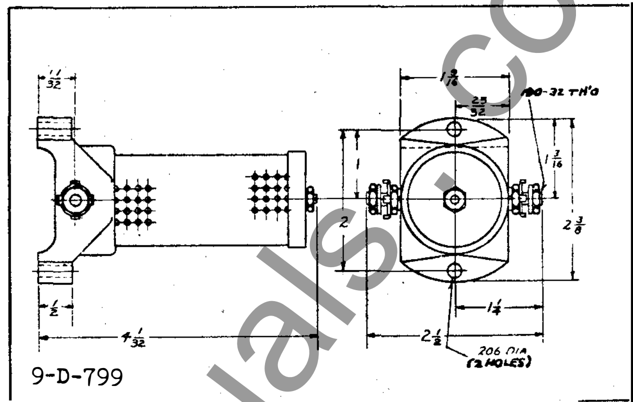

Fig. 23—Outline And Drilling Plan Of The External Resistor For The 90° Connection. For Reference Only.

under "Overcurrent Element (Circuit Closing Relays)" except that for the standard energy circuit opening relay the following cautions should be observed:

CAUTION When a signal lamp or other voltage operated device is to be connected in series with the relay contacts, disconnect the internal leads of the element from the stationary and moving contacts respectfully and dead end them. Then the lamp or other device can be connected to the stationary and moving contacts.

De-Ion Contactor Switch
(Circuit Opening Relays)

Adjust the core stop on the top as high as possible without allowing the insulating bushing at the bottom of the plunger to touch the Micarta angle. The contact will be separated from the Micarta angle by 1/32" to 1/16". Adjust the contact gap spacing to slightly less than 1/16 of an inch. Bend down the contact springs so that a firm contact is made but not so strong that the minimum pick-up value cannot be obtained. The spring tension should be about 15 grams.

Hold the relay contacts closed and with an auxiliary relay coil connected across the proper terminals to simulate the circuit breaker trip coil, note that the contactor switch picks up on less than 4 amperes on the 4 ampere overcurrent tap setting.

In the case of the standard energy circuit opening relay the contactor switch should pick-up and seal itself open at 75% of minimum trip current.

Operation Indicator
(Circuit Opening Relays)

Adjust the indicator to operate at 2 amperes a-c.

ATTACHMENTS TO THE RELAY
Instantaneous Trip

This element is a small solenoid switch the coil of which is in series with the overcurrent coil. It functions to energize the breaker trip coil instantaneously, independently of power direction when the fault current is exceptionally heavy. The three stationary contacts are in parallel with the main trip contacts and make possible double instantaneous trip on double-trip relays. The position of the Micarta disc at the bottom of the element with reference to the calibrated guide indicates the minimum overcurrent required to operate the element. The disc should be lowered or raised to the proper position by loosening the locknut which locks the Micarta disc and rotating the Micarta disc. The nominal range of adjustment is 1 to 4, for example, 10 to 40 amperes and it has an accuracy within the limits of approximately 10%.

The drop-out value is varied by raising or lowering the core screw at the top of the switch, and after the final adjustment is made, the core screw should be securely locked in place with the lock nut. The drop-out should be adjusted for about 2/3 of the minimum pick-up. Adjusting the drop-out will slightly affect the value of pick-up.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

ENERGY REQUIREMENTS

BURDENS FOR SATURATION CALCULATIONS

Readings taken with Rectox Type Voltmeter, 60 cycles.

Range	V.A. Burden at Minimum Pick Up on Min. Tap	V.A. Burden at 3 times Pick Up on Min. Tap	V.A. Burden at 10 Times Pick Up on Min. Tap	V.A. Burden at 20 Times Pick Up on Min. Tap
Definite Minimum (Standard Energy)				
2-6	18	105	520	1500
4-15	18	115	616	1647
Inverse (Low Energy)				
0.5 - 2.5	2.0	20.5	141	366
2 - 6	2.4	23.0	168	469
4 -15	3.6	32.8	248	746
Very Inverse (Low Energy)				
0.5 - 2.5	1.3	10.7	96	244
2 - 6	1.6	14.9	135	377
4 -15	2.8	25.3	218	6668

These values are the combined burden of the overcurrent and directional element coils in series.

ENERGY REQUIREMENTS

STANDARD ENERGY, DEFINITE TIME RELAY[1]

Burdens at 5 Amperes on the 5 Ampere Tap[2]

Frequency, Cycles	Watts	Volt-Amperes	P.F.
25	10.6	18	54° Lag
50	9.5	19	60° Lag
60	9.5	19	60° Lag

Burdens at 5 Amperes, 60 Cycles for Various Tap[2] Settings

Tap	Watts	Reactive Volt-Amperes	Volt-Amperes	P.F.
2	55.0	95.4	110	60° Lag
2.5	35.0	60.5	70	"
3	24.5	42.5	49	"
3.5	18.5	32.0	37	"
4	14.0	24.2	28	"
5	9.5	16.5	19	"
6	7.0	12.1	14	"
8	4.25	7.36	8.5	"
10	3.25	5.64	6.5	"
12	2.5	4.33	5.0	"
15	2.0	3.46	4.0	"

LOW ENERGY, INVERSE TIME RELAY[1]

Burdens at 5 Amperes on the 5 Ampere Tap[2]

Frequency Cycles	Watts	Volt-Amperes	P.F.
25	1.96	4.0	61° Lag
50	1.60	4.0	66.4° Lag
60	1.60	4.0	66.4° Lag

Burdens at 5 Amperes, 60 Cycles for Various Tap[2] Settings

Tap	Watts	Reactive Volt-Amperes	Volt-Amperes	P.F.
0.5	50.8	116.	127.	66.4° Lag
0.6	35.6	81.5	89.	"
0.8	32.0	73.4	80.	"
1.0	20.8	47.6	52.	"
1.5	9.6	22.0	24.	"
2.0	5.8	13.2	14.5	"
2.5	4.0	9.2	10.	"
3.0	3.04	6.95	7.6	"
3.5	2.44	5.6	6.1	"
4.	2.04	4.66	5.1	"
5.	1.6	3.66	4.0	"
6.	1.32	3.0	3.3	"
8.	1.12	2.56	2.8	"
10.	1.0	2.28	2.5	"
12.	0.94	2.16	2.35	"
15.	0.88	2.0	2.2	"

LOW ENERGY, VERY INVERSE RELAY[1]

Burdens at 5 Amperes on the 5 Ampere Tap[2]

Frequency Cycles	Watts	Volt-Amperes	P.F.
25	1.62	3.3	61° Lag
50	1.32	3.3	66.4° Lag
60	1.32	3.3	66.4° Lag

Burdens at 5 Amperes of Current Tap[2]

Tap	Watts	Reactive Volt-Amperes	Volt-Amperes	P.F.
0.5	50.8	116.	127.	66.4° Lag
0.6	35.6	81.5	89.	"
0.8	19.7	45.2	49.4	"
1.0	12.9	29.6	32.3	"
1.5	6.4	14.6	15.9	"
2.0	3.9	9.0	9.8	"
2.5	2.8	6.4	7.0	"
3.0	2.2	5.0	5.5	"
3.5	1.8	4.1	4.5	"
4.	1.6	3.67	4.0	"
5.	1.32	3.0	3.3	"
6.	1.16	2.66	2.9	"
8.	0.96	2.2	2.4	"
10.	0.92	2.1	2.3	"
12.	0.88	2.02	2.2	"
15.	0.85	1.96	2.14	"

POLARIZING COILS

The potential polarizing coil burden of the directional element at 115 volts for the type CR line relay are as follows:

* For 90° Connection

Freq Cycles	Resistor	Watts	VA	Lagging P.F.	Approx. Max. Torque Angle[3]
25	Yes	8.95	11.3	37.6	45°
50	Yes	11.2	14.0	37	45°
60	Yes	11.5	15.3	41.4	45°
60	Yes	11.0	19.0	54.8	60°

✱ For 30° Connection

Freq Cycles	Resistor	Watts	VA	Lagging P.F.	Approx. Max. Torque Angle[3]
25	No	4.2	18.0	76.5	30°
50	No	3.45	23.0	81.4	30°
60	No	3.45	23.0	81.4	30°

The potential polarizing coil burdens of the directional element at 115 volts for the type CR Ground Relays are as follows:

Frequency Cycles	With Phase Shifter	Watts	Volt-Amps.	P.F.
60	No	5.6	27	78°Lag
60	Yes	12.6	22.6	56°Lag

The current polarizing burdens of the directional element of type CRC relay at rated 5 amperes are as follows:

Frequency Cycles	Watts	Volt-Amperes	P.F.
25	4.5	5.0	26° Lag
50	6.5	8.0	36° Lag
60	7.0	9.0	39° Lag

1. These values are the combined burden of the overcurrent and directional element coils in series.

2. The impedance of the overcurrent element coils varies approximately inversely as the square of the tap markings while the directional element coil impedance is constant. The burden of the directional element coil which is in series with the overcurrent element is 2 volt-amperes at 5 amperes, 60° lag.

✱3. The angle which the current lags the 100% p.f. position.

Continuous Ratings

The continuous ratings in amperes of the Type CR and CRC Relays are as follows:

	Definite Min. Time		Inverse Time		Very Inverse Time	
Tap	Continuous	One Second	Continuous	One Second	Continuous	One Second
.5			2	70	2	100
.6			2	70	2	100
.8			2	70	2	100
1.0			3	70	3	100
1.5			3	70	3	100
2.0			4	70	4	100
2.5			5	70	5	100
2	4	140	8	250†	8	250†
2.5	5	140	8	250†	8	250†
3	5	140	8	250†	8	250†
3.5	6	140	8	250†	8	250†
4	7	140	9†	250†	9†	250†
5	8	140	9†	250†	9†	250†
6	10†	140	10†	250†	10†	250†
4	8	250†	16†	250†	16†	250†
5	8	250†	16†	250†	16†	250†
6	9†	250†	16†	250†	16†	250†
8	10†	250†	17†	250†	17†	250†
10	12†	250†	18†	250†	18†	250†
12	13†	250†	19†	250†	19†	250†
15	15†	250†	20†	250†	20†	250†

†The directional element current coil of Type CR relay has a continuous rating of 8 amperes and a one second rating of 185 amperes. The upper winding of the Type CRC has a continuous rating of 6 amperes and a one second rating of 140 amperes while the lower coil has a continuous rating of 8 amperes and a one second rating of 185 amperes. The polarizing coil of the CR relay has a continuous rating of 127 volts.

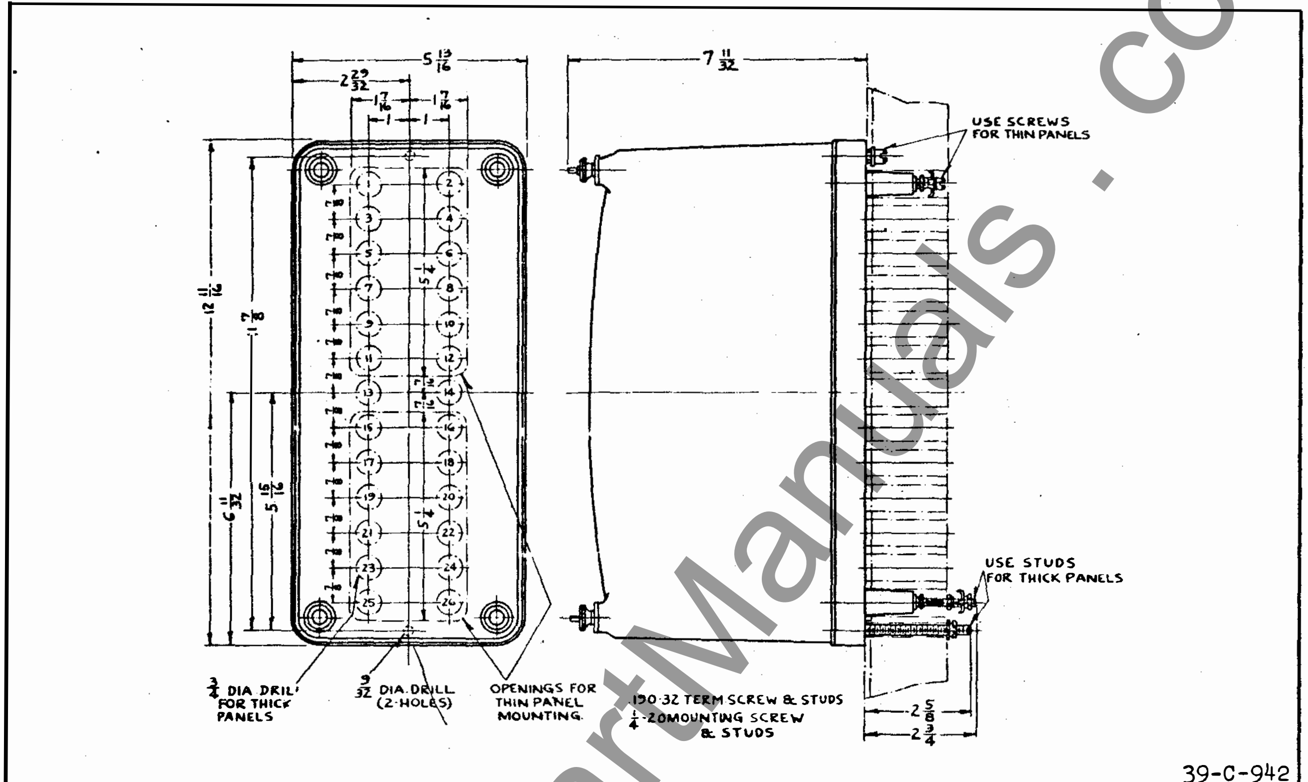

Fig. 25—Outline and Drilling Plan for Relays in the Standard Projection Type Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

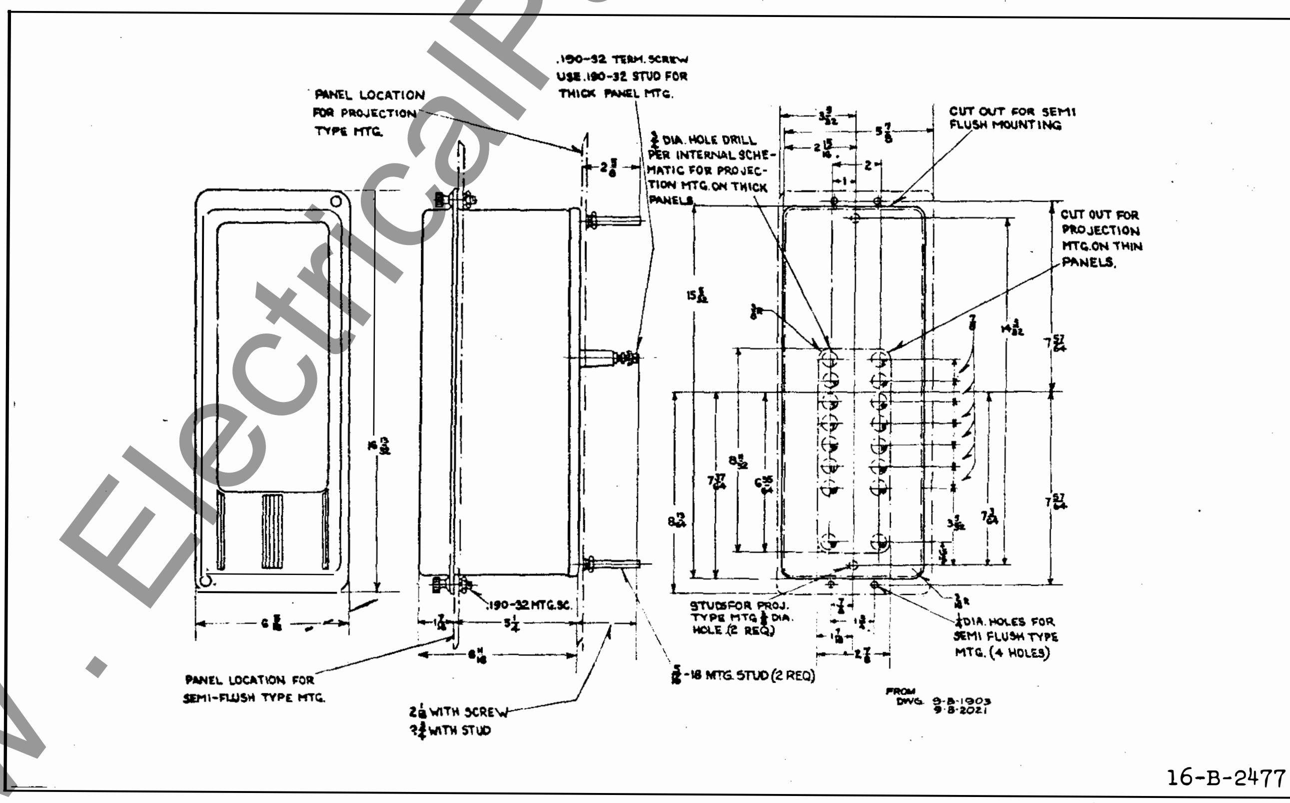

Fig. 26— Outline and Drilling Plan for the M-10 Projection or Semi-Flush Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

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

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*Denotes change from superseded issue.

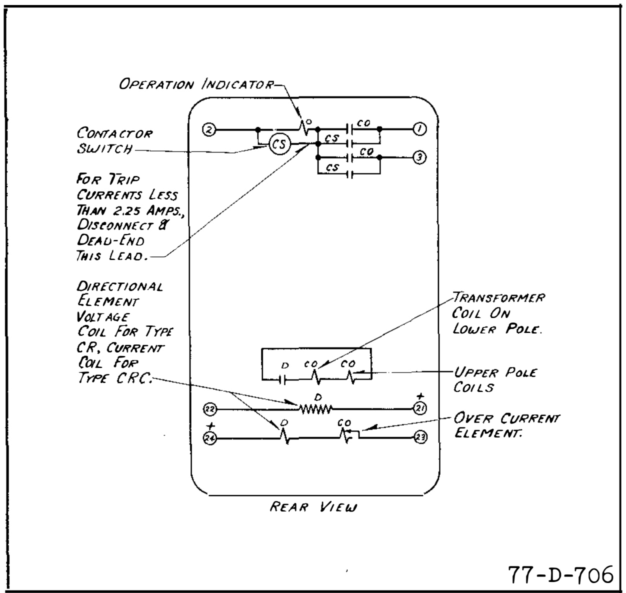

Fig. 1—Internal Schematic Of The Double Trip, Directional Control, Inverse Time (Low Energy 2 Sec., 25, 50 & 60 Cycles, 4 Sec., 25 Cycles) and Very Inverse Time, Circuit Closing Relays In The Standard Case. The Single Trip Relays Have Terminal 3 And Associated Circuits Omitted.

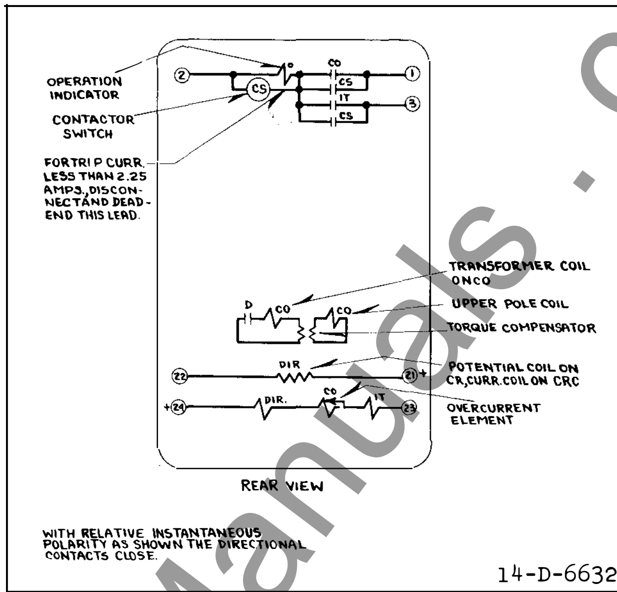

Fig. 2—Internal Schematic Of The Single Trip, Directional Control, Definite Minimum Time (2 and 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (Low Energy 4 Sec., 50 & 60 Cycles), Circuit Closing Relays With Instantaneous Trip In The Standard Case.

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.

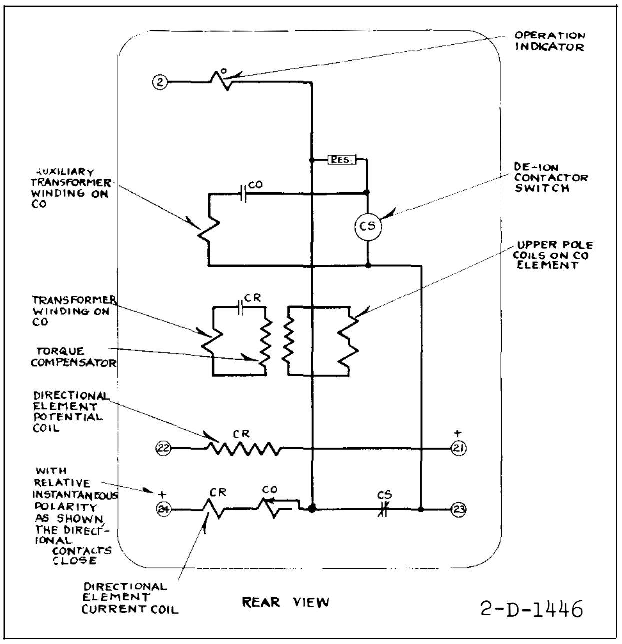

Fig. 3—Internal Wiring Diagram Of The Single Trip, Standard Energy, Circuit Opening Relay.

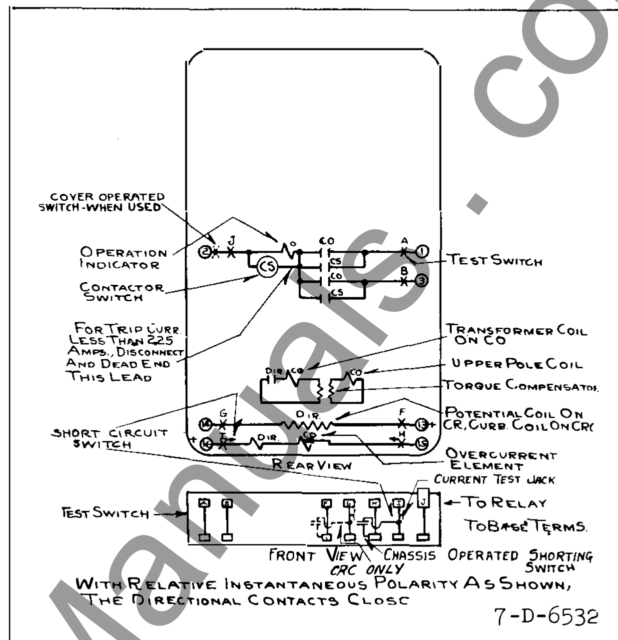

Fig. 4—Internal Schematic Of The Double Trip, Directional Control, Definite Minimum Time (Standard Energy 2 and 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (4 Sec., 50 & 60 Cycles) Circuit Closing Relay In The Type FT Case. The Single Trip Relays Have Terminal 3 And Associated Circuits Omitted.

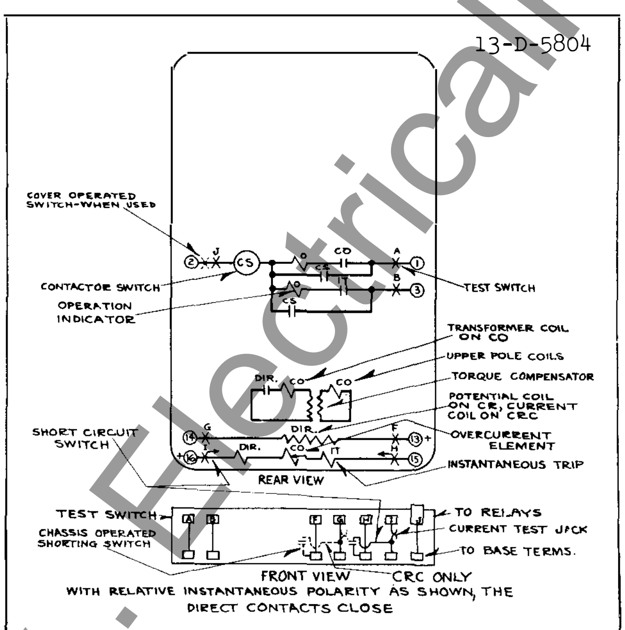

Fig. 5—Internal Schematic Of The Single Trip With Instantaneous Trip, Directional Control, Definite Minimum Time (Standard Energy 2 & 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (4 Sec., 50 & 60Cycles)Circuit Closing Relay In The Type FT Case.

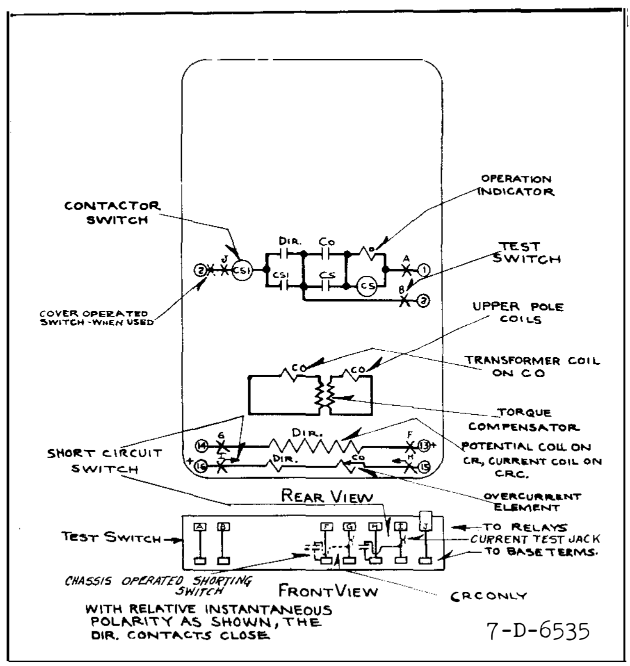

Fig. 6—Internal Schematic Of The Single Trip, Non-Directional Control With Terminal Between Directional And Overcurrent Contacts, Definite Minimum Time (Standard Energy 2 & 4 Sec., 25, 50 & 60 Cycles) or Inverse Time (4 Sec., 50 & 60 Cycles) Circuit Closing Relay In the Type FT Case.

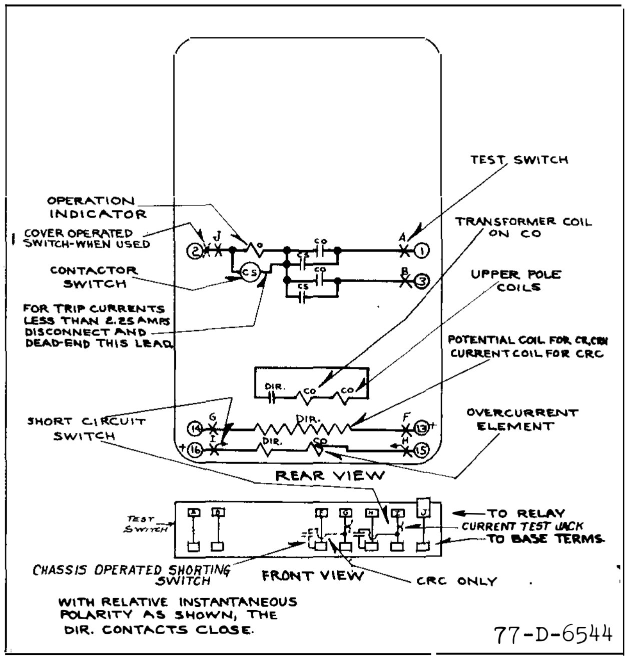

Fig. 7—Internal Schematic Of The Double Trip, Directional Control, Inverse Time (Low Energy 2 Sec., 25, 50 & 60 Cycles, 4 Sec., 25 Cycles) or Very Inverse Time, Circuit Closing Relay In The Type FT Case. The Single Trip Relays Have Terminal 3 And Associated Circuits Omitted.

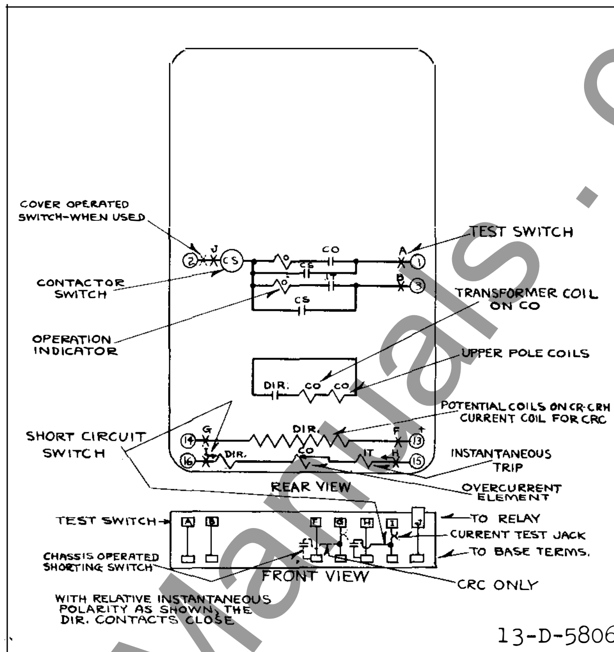

Fig. 8—Internal Schematic Of The Single Trip With Instantaneous Trip, Directional Control, Inverse Time (Low Energy, 2 Sec., 25, 50 & 60 Cycles 4 Sec., 25 Cycles) or Very Inverse Time, Circuit Closing Relay In The Type FT Case.

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.

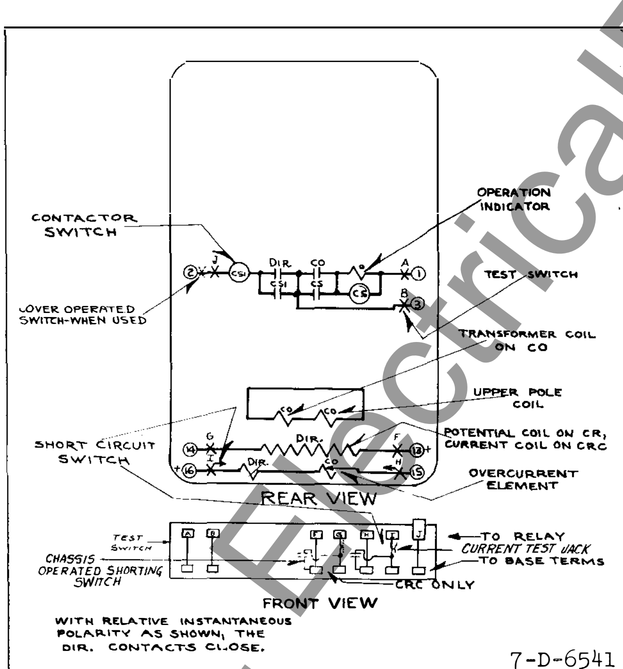

Fig. 9—Internal Schematic Of The Single Trip, Non-Directional Control With Terminal Between Directional And Overcurrent Contacts, Inverse Time (Low Energy 2 Sec., 25, 50 & 60 Cycles, 4 Sec., 25 Cycles) or Very Inverse Time, Circuit Closing Relay In The Type FT Case.

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.

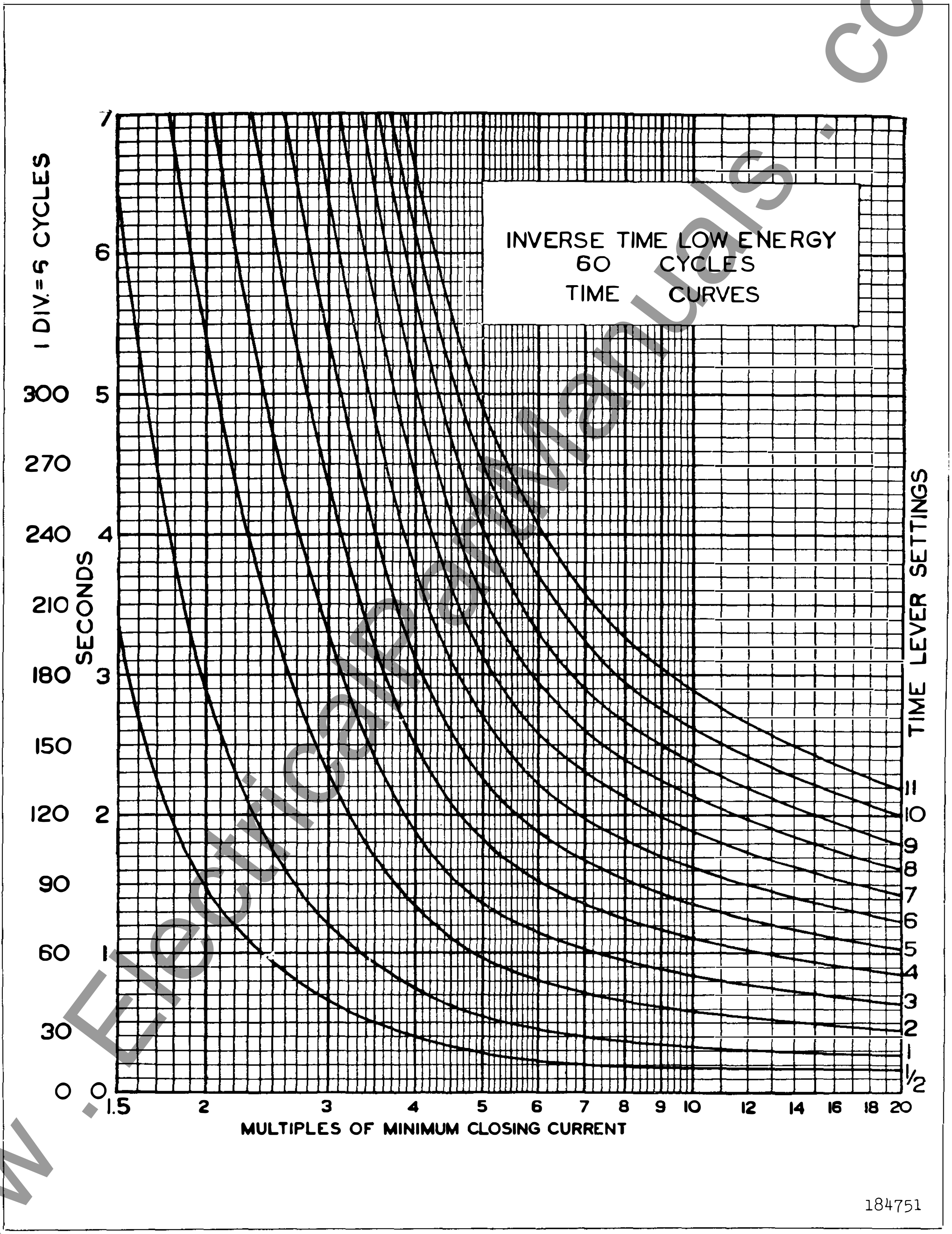

Fig. 10—Typical Inverse Time Curves Of The Overcurrent Element Of The Low Energy 60 Cycle Relays.

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

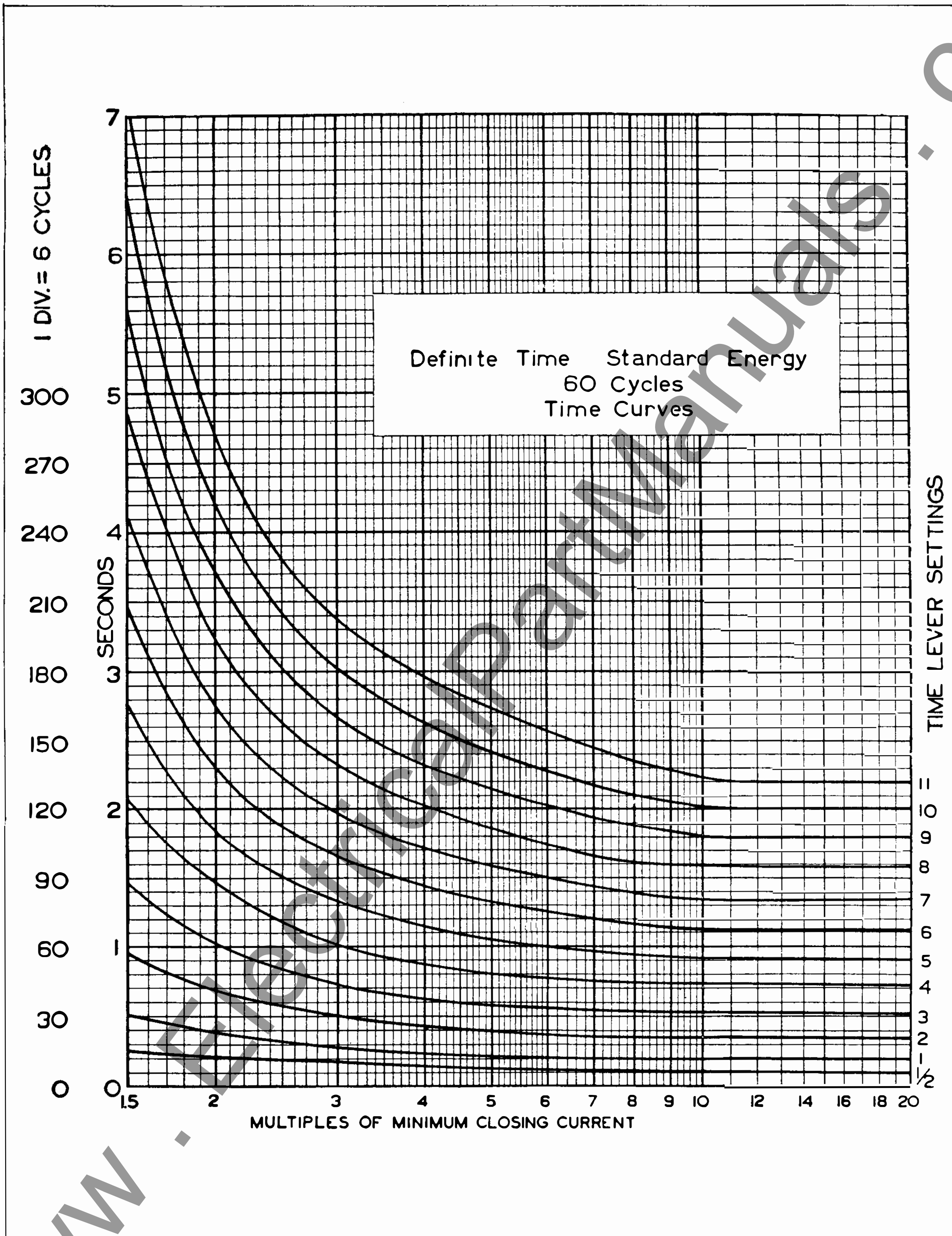

Fig. 11—Typical Inverse Definite Minimum Time Curves Of The Overcurrent Element Of The Standard Energy 60 Cycle Relays.

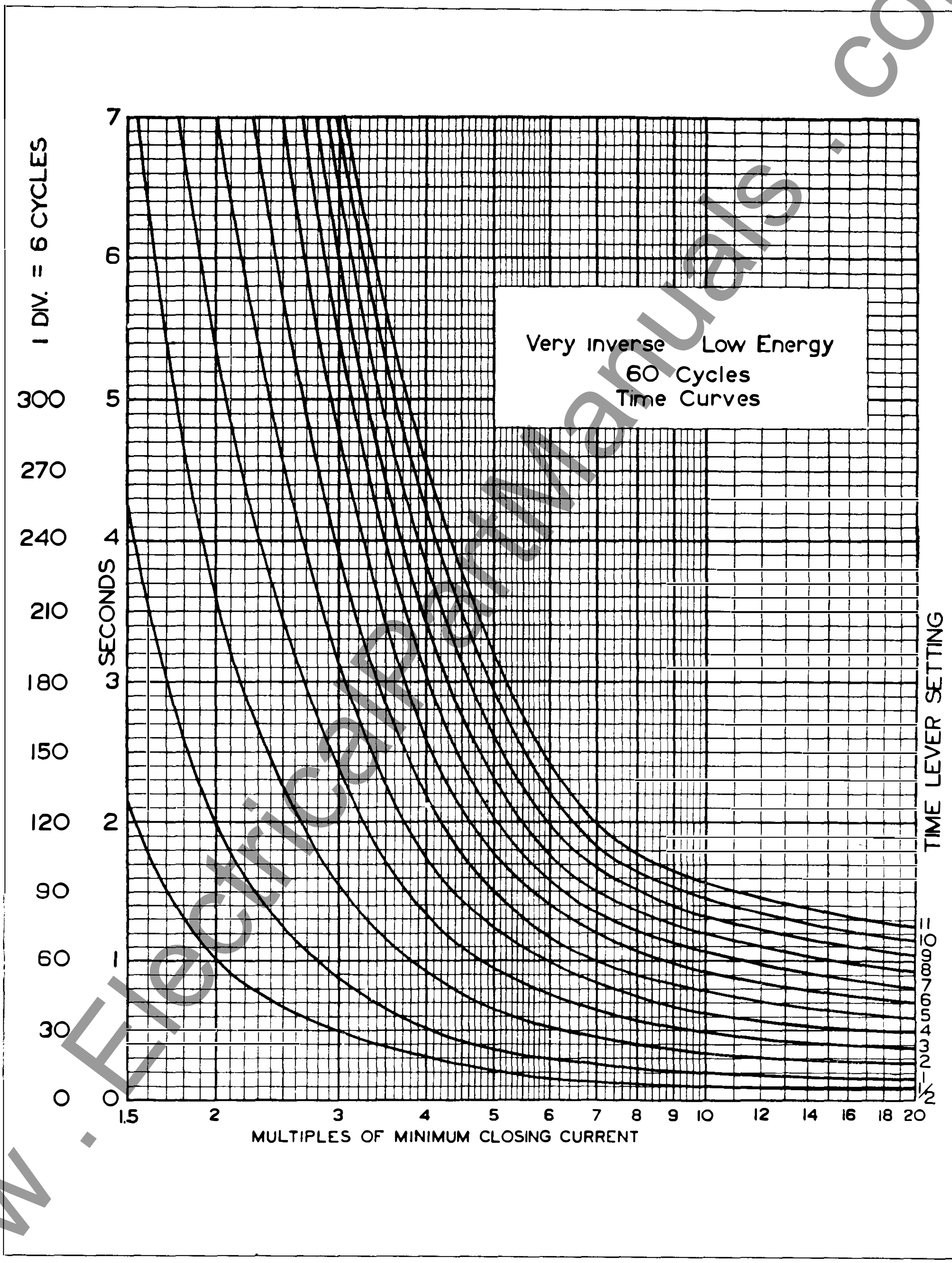

Fig. 12—Typical Very Inverse Time Curves Of The Overcurrent Element Of The Low Energy 60 Cycle Relays.

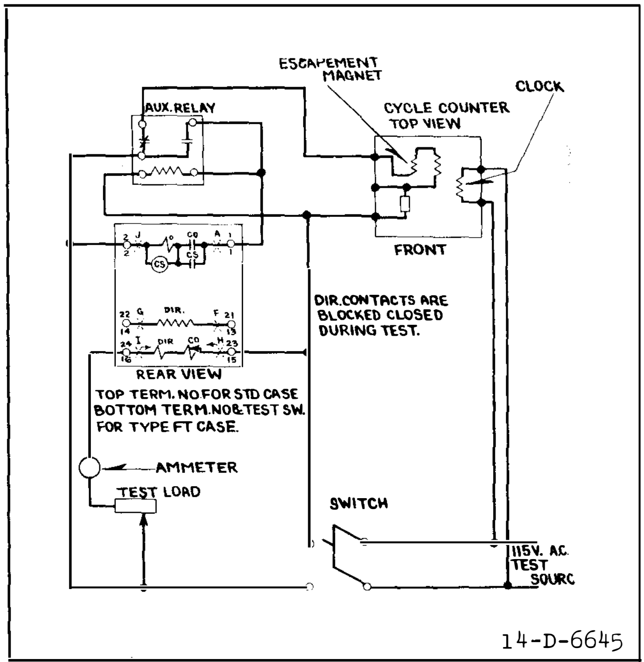

Fig. 13—Diagram Of Test Connections For The Circuit Closing Relays.

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

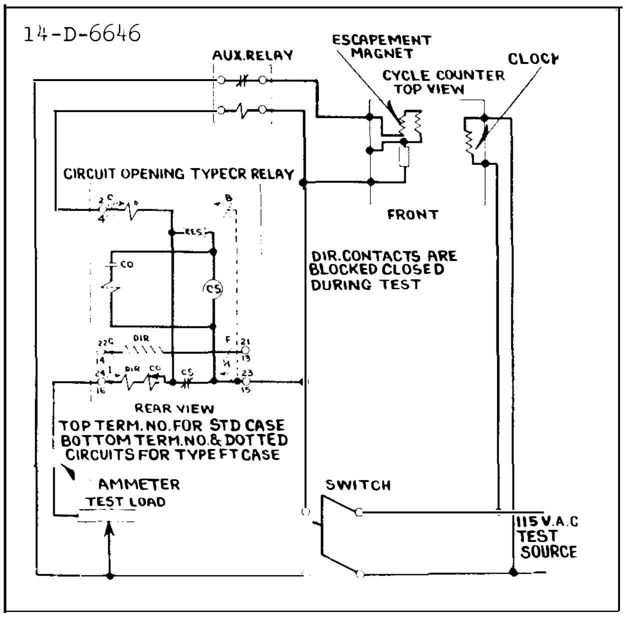

Fig. 14—Diagram Of Test Connections For The Circuit Opening Relays.

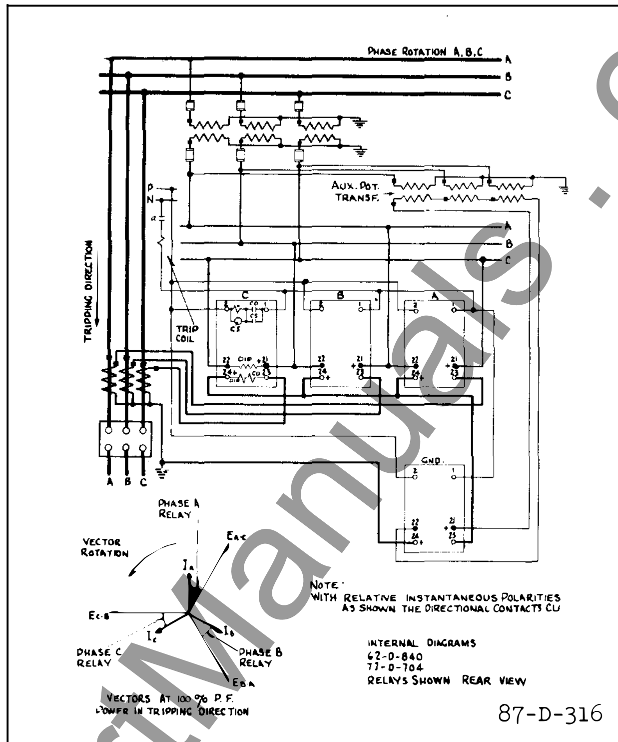

Fig. 15—External Connections Of The Circuit Closing Type CR Relay In The Standard Case For Phase And Ground Protection Using The 30° Connection On The Phase Directional Element.

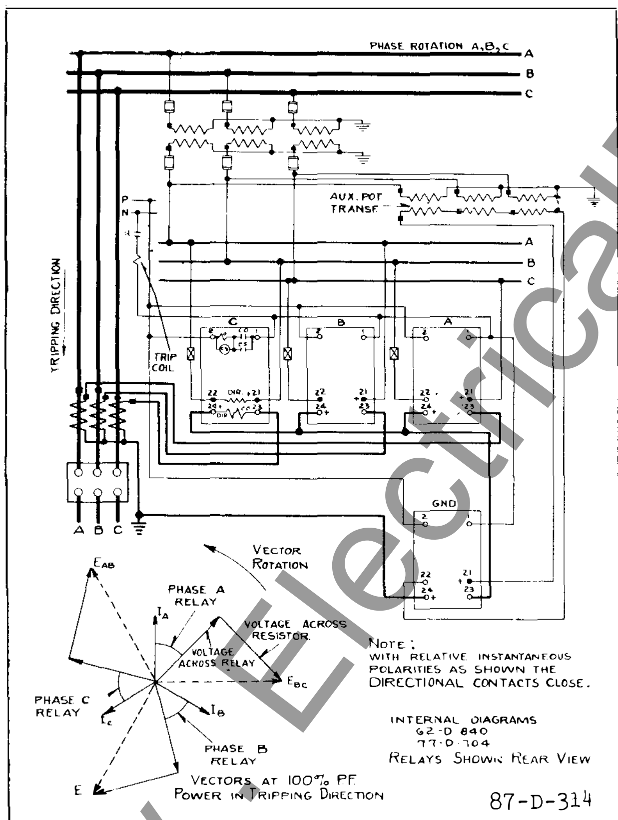

Fig. 16—External Connections Of The Circuit Closing Type CR Relay In The Standard Case For Phase And Ground Protection Using The 90° Connection (Maximum Torque 45° or 60° Lagging Current. 45° is shown above) On The Phase Directional Element.

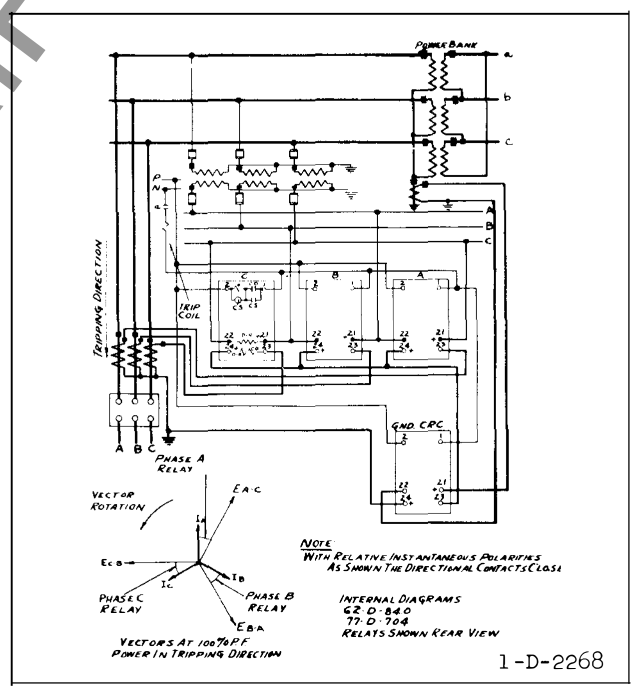

Fig. 17—External Connections Of The Circuit Closing Type CR Relay In The Standard Case For Phase Protection Using The 30° Connection Of The Directional Element And The Type CRC Relay In The Standard Case For Ground Protection.

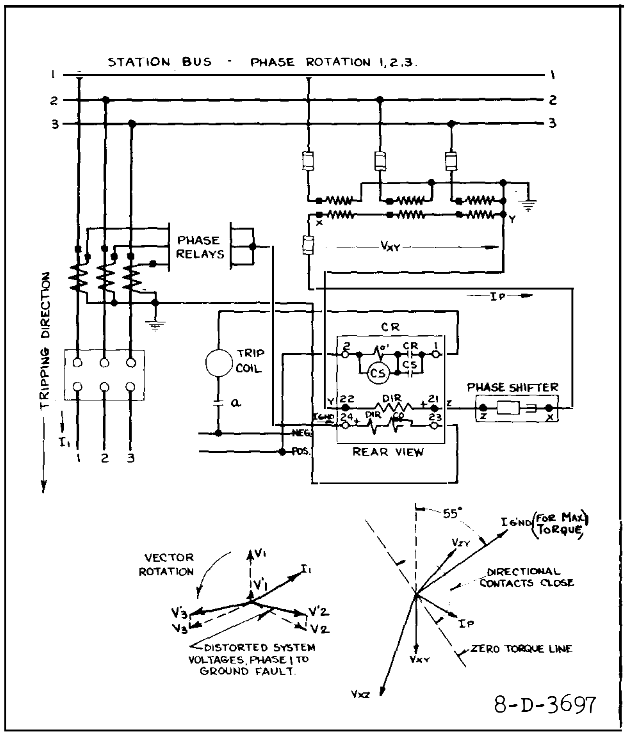

Fig. 18—External Connections Of The Type CR Ground Relay In The Standard Case For Ground Fault Protection Using An External Phase Shifter.

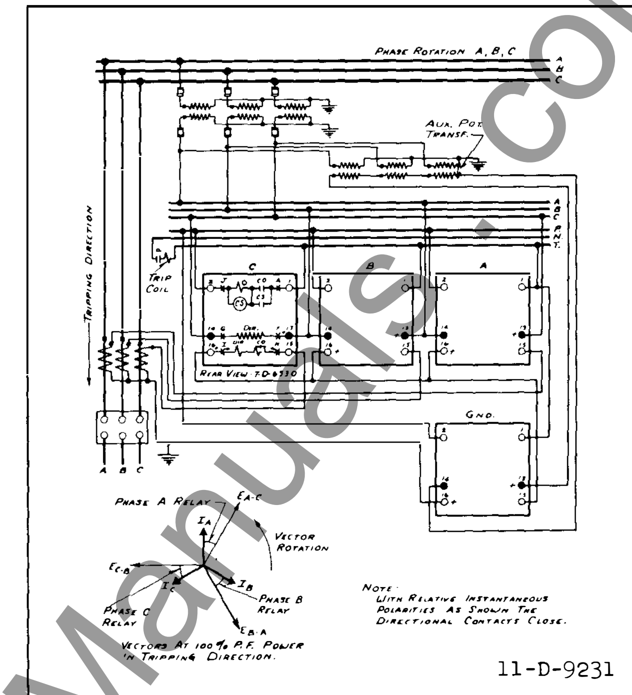

Fig. 19—External Connections Of The Circuit Closing Type CR Relay In The Type FT Case For Phase And Ground Protection Using The 30° Connection On The Phase Directional Element.

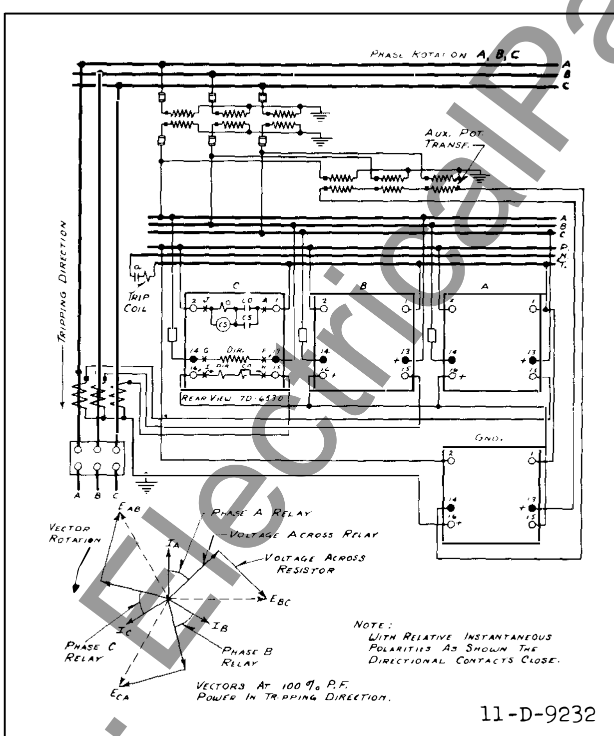

Fig. 20—External Connections Of The Circuit Closing Type CR Relay In The Type FT Case For Phase And Ground Protection Using The 90° Connection (Maximum Torque 45° or 60° Lagging Current. 45° is shown above) On The Phase Directional Element.

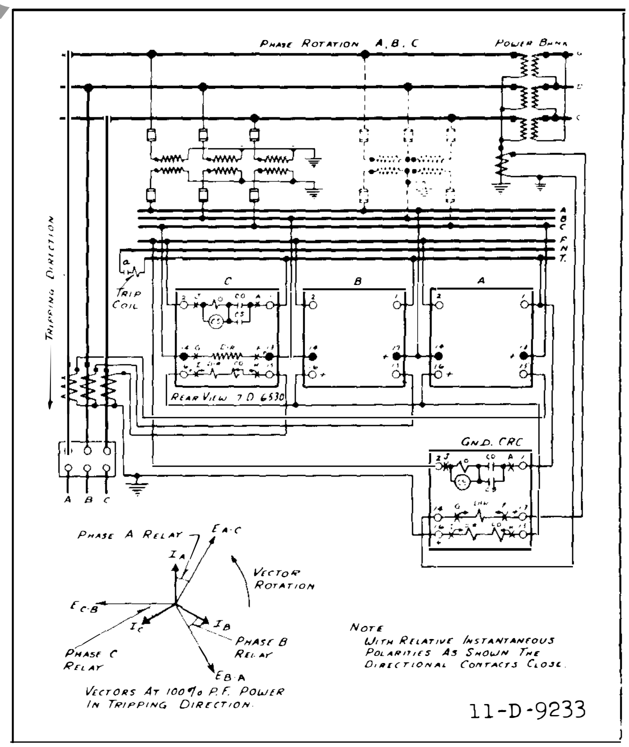

Fig. 21—External Connections Of The Circuit Closing Type CR Relay In The Type FT Case For Phase Protection Using The 30° Connection On The Directional Element And The Type CRC Relay In The Type FT Case For Ground Protection.

several cycles. This time is so small that it is usually ignored and the relays are tested by blocking the directional contacts in the closed position.

The position of the torque compensator on the overload element is adjustable but this is primarily a factory adjustment and the location of the torque compensator should not be changed in the field. If the relay has a metal cover, this cover must be in place when making tests.

Directional Element

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

The contact opening on the directionally-controlled relay should be 1/32" in order to reduce the time of operation of the directional element to a minimum. No harm will result if the directional contacts rebound to close momentarily after a fault is cleared, because the overcurrent contacts will be in the open position. The contact opening on relays which are not directionally controlled should be 3/32".

The tension of the spiral spring on the directional element should be just sufficient to return the disc to the stop and thus hold the contacts in the open position.

In many applications there is no objection to having the contacts closed when the relay is de-energized. This can be changed by shifting the spring adjuster but the tension on the spring should never be enough to prevent the contacts from taking their proper position, either open or closed, during time of short circuit when the forces acting on the disc are small.

There is an adjustable magnetic vane on each side of the upper pair of poles, which is intended to balance the current circuit. The normal adjustment is to remove all potential from the voltage coil and apply heavy current to the current coils. The balancing vanes are then adjusted till there is no pronounced torque in either direction. This same adjustment may be used to positively close the contacts on current alone. This may be desired on some installations in order to insure that the relay will always trip the breaker even though the potential may be zero.

When operating at the maximum torque angle, the directional element of the Type CR Phase Relay and 2 to 6 and 4 to 15 amp. ground relay should pick-up on 1 volt and 4 amperes, and for the 0.5 to 2.5 amp. Type CR Ground Relays on 1 volt, 2.7 amperes. The directional element of the CRC Ground Relay will pick-up at 0.5 ampere each winding.

Contactor Switch

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core of 1/64" when the switch is picked up. This can be done by turning the relay up-side-down or by disconnecting the switch and turning it up-side-down. Then screw up the core screw until the moving core starts rotating. Now, back off the core screw until the moving core stops rotating. This indicates the points where the play in the assembly is taken up, and where the moving core just separates from the stationary core screw. Back off the core screw approximately one turn and lock in place. This prevents the moving core from striking and sticking to the stationary core because of residual magnetism. Adjust the contact clearance for 3/32" by means of the two small nuts on either side of the Micarta disc. The switch should pick-up at 2 amperes d-c. Test for sticking after 30 amperes d-c. have been passed through the coil.

Operation Indicator

(Circuit-Closing Relays)

Adjust the indicator to operate at 0.2

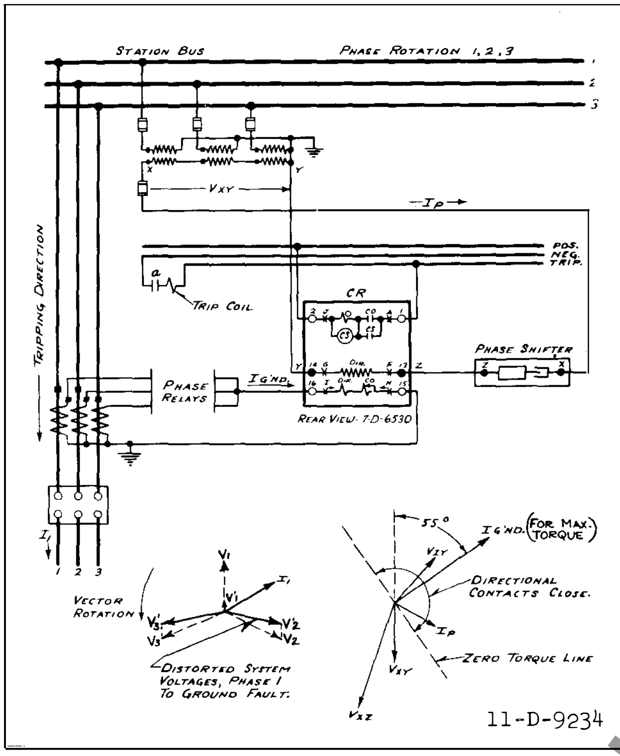

Fig. 22—External Connections Of The Type CR Relay In The Type FT Case For Ground Fault Protection Using An External Phase Shifter.

ampere d-c. gradually applied. Test for sticking after 5 amperes d-c. is passed.

Overcurrent Element
(Circuit Opening Relays)

Adjust the relay with the instructions given

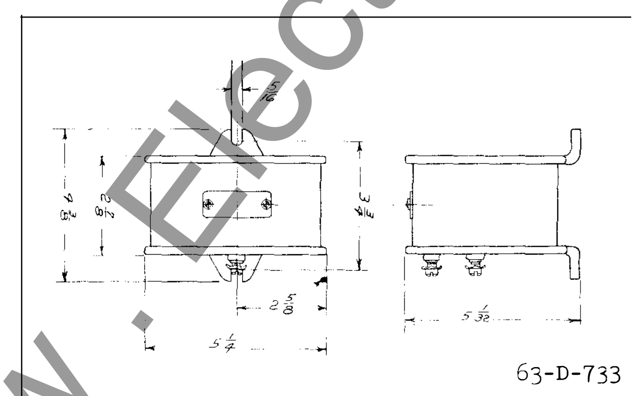

Fig. 24—Outline And Drilling Plan Of The Phase Shifter For The Ground Relay When Supplied. For Reference Only.

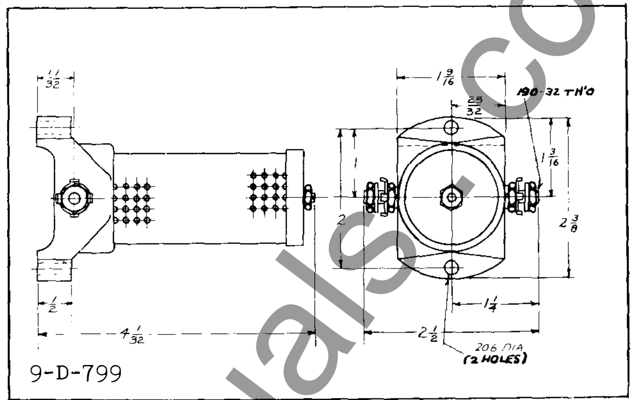

Fig. 23—Outline And Drilling Plan Of The External Resistor For The 90° Connection. For Reference Only.

under "Overcurrent Element (Circuit Closing Relays)" except that for the standard energy circuit opening relay the following cautions should be observed:

CAUTION When a signal lamp or other voltage operated device is to be connected in series with the relay contacts, disconnect the internal leads of the element from the stationary and moving contacts respectfully and dead end them. Then the lamp or other device can be connected to the stationary and moving contacts.

De-Ion Contactor Switch
(Circuit Opening Relays)

Adjust the core stop on the top as high as possible without allowing the insulating bushing at the bottom of the plunger to touch the Micarta angle. The contact will be separated from the Micarta angle by 1/32" to 1/16". Adjust the contact gap spacing to slightly less than 1/16 of an inch. Bend down the contact springs so that a firm contact is made but not so strong that the minimum pick-up value cannot be obtained. The spring tension should be about 15 grams.

Hold the relay contacts closed and with an auxiliary relay coil connected across the proper terminals to simulate the circuit breaker trip coil, note that the contactor switch picks up on less than 4 amperes on the 4 ampere overcurrent tap setting.

In the case of the standard energy circuit opening relay the contactor switch should pick-up and seal itself open at 75% of minimum trip current.

Operation Indicator
(Circuit Opening Relays)

Adjust the indicator to operate at 2 amperes a-c.

ATTACHMENTS TO THE RELAY
Instantaneous Trip

This element is a small solenoid switch the coil of which is in series with the overcurrent coil. It functions to energize the breaker trip coil instantaneously, independently of power direction when the fault current is exceptionally heavy. The three stationary contacts are in parallel with the main trip contacts and make possible double instantaneous trip on double-trip relays. The position of the Micarta disc at the bottom of the element with reference to the calibrated guide indicates the minimum overcurrent required to operate the element. The disc should be lowered or raised to the proper position by loosening the locknut which locks the Micarta disc and rotating the Micarta disc. The nominal range of adjustment is 1 to 4, for example, 10 to 40 amperes and it has an accuracy within the limits of approximately 10%.

The drop-out value is varied by raising or lowering the core screw at the top of the switch, and after the final adjustment is made, the core screw should be securely locked in place with the lock nut. The drop-out should be adjusted for about 2/3 of the minimum pick-up. Adjusting the drop-out will slightly affect the value of pick-up.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to the customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

ENERGY REQUIREMENTS

BURDENS FOR SATURATION CALCULATIONS

Readings taken with Rectox Type Voltmeter, 60 cycles.

Range	V.A. Burden at Minimum Pick Up on Min. Tap	V.A. Burden at 3 times Pick Up on Min. Tap	V.A. Burden at 10 Times Pick Up on Min. Tap	V.A. Burden at 20 Times Pick Up on Min. Tap
Definite Minimum (Standard Energy)				
2-6	18	105	520	1500
4-15	18	115	616	1647
Inverse (Low Energy)				
0.5 - 2.5	2.0	20.5	141	366
2 - 6	2.4	23.0	168	469
4 -15	3.6	32.8	248	746
Very Inverse (Low Energy)				
0.5 - 2.5	1.3	10.7	96	244
2 - 6	1.6	14.9	135	377
4 -15	2.8	25.3	218	6668

These values are the combined burden of the overcurrent and directional element coils in series.

ENERGY REQUIREMENTS

STANDARD ENERGY, DEFINITE TIME RELAY[1]

Burdens at 5 Amperes on the 5 Ampere Tap[2]

Frequency Cycles	Watts	Volt-Amperes	P.F.
25	10.6	18	54° Lag
50	9.5	19	60° Lag
60	9.5	19	60° Lag

Burdens at 5 Amperes, 60 Cycles for Various Tap[2] Settings

Tap	Watts	Reactive Volt-Amperes	Volt-Amperes	P.F.
2	55.0	95.4	110	60° Lag
2.5	35.0	60.5	70	"
3	24.5	42.5	49	"
3.5	18.5	32.0	37	"
4	14.0	24.2	28	"
5	9.5	16.5	19	"
6	7.0	12.1	14	"
8	4.25	7.36	8.5	"
10	3.25	5.64	6.5	"
12	2.5	4.33	5.0	"
15	2.0	3.46	4.0	"

LOW ENERGY, INVERSE TIME RELAY[1]

Burdens at 5 Amperes on the 5 Ampere Tap[2]

Frequency Cycles	Watts	Volt-Amperes	P.F.
25	1.96	4.0	61° Lag
50	1.60	4.0	66.4° Lag
60	1.60	4.0	66.4° Lag

Burdens at 5 Amperes, 60 Cycles for Various Tap[2] Settings

Tap	Watts	Reactive Volt-Amperes	Volt-Amperes	P.F.
0.5	50.8	116.	127.	66.4° Lag
0.6	35.6	81.5	89.	"
0.8	32.0	73.4	80.	"
1.0	20.8	47.6	52.	"
1.5	9.6	22.0	24.	"
2.0	5.8	13.2	14.5	"
2.5	4.0	9.2	10.	"
3.0	3.04	6.95	7.6	"
3.5	2.44	5.6	6.1	"
4.	2.04	4.66	5.1	"
5.	1.6	3.66	4.0	"
6.	1.32	3.0	3.3	"
8.	1.12	2.56	2.8	"
10.	1.0	2.28	2.5	"
12.	0.94	2.16	2.35	"
15.	0.88	2.0	2.2	"

LOW ENERGY, VERY INVERSE RELAY[1]

Burdens at 5 Amperes on the 5 Ampere Tap[2]

Frequency Cycles	Watts	Volt-Amperes	P.F.
25	1.62	3.3	61° Lag
50	1.32	3.3	66.4° Lag
60	1.32	3.3	66.4° Lag

Burdens at 5 Amperes of Current Tap[2]

Tap	Watts	Reactive Volt-Amperes	Volt-Amperes	P.F.
0.5	50.8	116.	127.	66.4° Lag
0.6	35.6	81.5	89.	"
0.8	19.7	45.2	49.4	"
1.0	12.9	29.6	32.3	"
1.5	6.4	14.6	15.9	"
2.0	3.9	9.0	9.8	"
2.5	2.8	6.4	7.0	"
3.0	2.2	5.0	5.5	"
3.5	1.8	4.1	4.5	"
4.	1.6	3.67	4.0	"
5.	1.32	3.0	3.3	"
6.	1.16	2.66	2.9	"
8.	0.96	2.2	2.4	"
10.	0.92	2.1	2.3	"
12.	0.88	2.02	2.2	"
15.	0.85	1.96	2.14	"

POLARIZING COILS

The potential polarizing coil burden of the directional element at 115 volts for the type CR line relay are as follows:

* For 90° Connection

Freq Cycles	Resistor	Watts	VA	Lagging P.F.	Approx. Max. Torque Angle[3]
25	Yes	8.95	11.3	37.6	45°
50	Yes	11.2	14.0	37	45°
60	Yes	11.5	15.3	41.4	45°
60	Yes	11.0	19.0	54.8	60°

✱ For 30° Connection

Freq Cycles	Resistor	Watts	VA	Lagging P.F.	Approx. Max.[3] Torque Angle
25	No	4.2	18.0	76.5	30°
50	No	3.45	23.0	81.4	30°
60	No	3.45	23.0	81.4	30°

The potential polarizing coil burdens of the directional element at 115 volts for the type CR Ground Relays are as follows:

Frequency Cycles	With Phase Shifter	Watts	Volt-Amps.	P.F.
60	No	5.6	27	78°Lag
60	Yes	12.6	22.6	56°Lag

The current polarizing burdens of the directional element of type CRC relay at rated 5 amperes are as follows:

Frequency Cycles	Watts	Volt-Amperes	P.F.
25	4.5	5.0	26° Lag
50	6.5	8.0	36° Lag
60	7.0	9.0	39° Lag

1. These values are the combined burden of the overcurrent and directional element coils in series.

2. The impedance of the overcurrent element coils varies approximately inversely as the square of the tap markings while the directional element coil impedance is constant. The burden of the directional element coil which is in series with the overcurrent element is 2 volt-amperes at 5 amperes, 60° lag.

✱3. The angle which the current lags the 100% p.f. position.

Continuous Ratings

The continuous ratings in amperes of the Type CR and CRC Relays are as follows:

Tap	Definite Min. Time		Inverse Time		Very Inverse Time	
	Continuous	One Second	Continuous	One Second	Continuous	One Second
.5			2	70	2	100
.6			2	70	2	100
.8			2	70	2	100
1.0			3	70	3	100
1.5			3	70	3	100
2.0			4	70	4	100
2.5			5	70	5	100
2	4	140	8	250 †	8	250 †
2.5	5	140	8	250 †	8	250 †
3	5	140	8	250 †	8	250 †
3.5	6	140	8	250 †	8	250 †
4	7	140	9 †	250 †	9 †	250 †
5	8	140	9 †	250 †	9 †	250 †
6	10 †	140	10 †	250 †	10 †	250 †
4	8	250 †	16 †	250 †	16 †	250 †
5	8	250 †	16 †	250 †	16 †	250 †
6	9 †	250 †	16 †	250 †	16 †	250 †
8	10 †	250 †	17 †	250 †	17 †	250 †
10	12 †	250 †	18 †	250 †	18 †	250 †
12	13 †	250 †	19 †	250 †	19 †	250 †
15	15 †	250 †	20 †	250 †	20 †	250 †

†The directional element current coil of Type CR relay has a continuous rating of 8 amperes and a one second rating of 185 amperes. The upper winding of the Type CRC has a continuous rating of 6 amperes and a one second rating of 140 amperes while the lower coil has a continuous rating of 8 amperes and a one second rating of 185 amperes. The polarizing coil of the CR relay has a continuous rating of 127 volts.

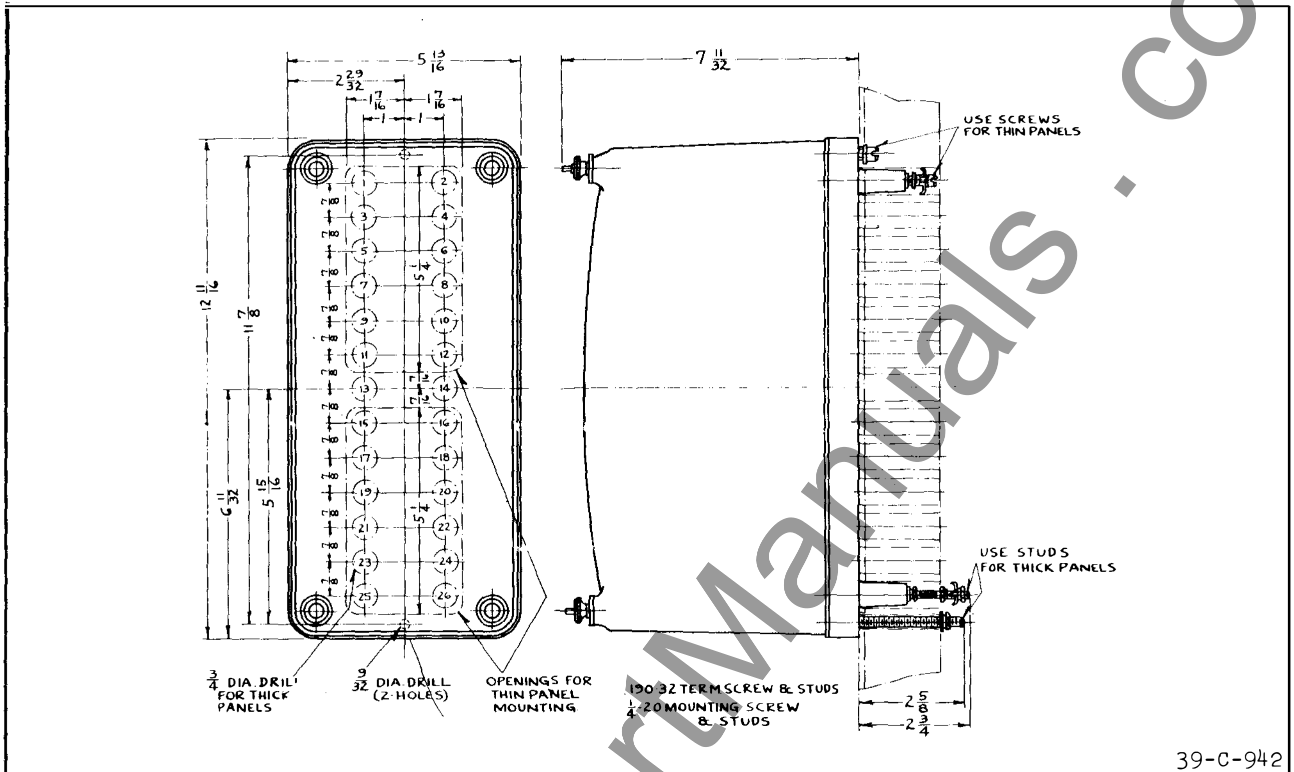

Fig. 25—Outline and Drilling Plan for Relays in the Standard Projection Type Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

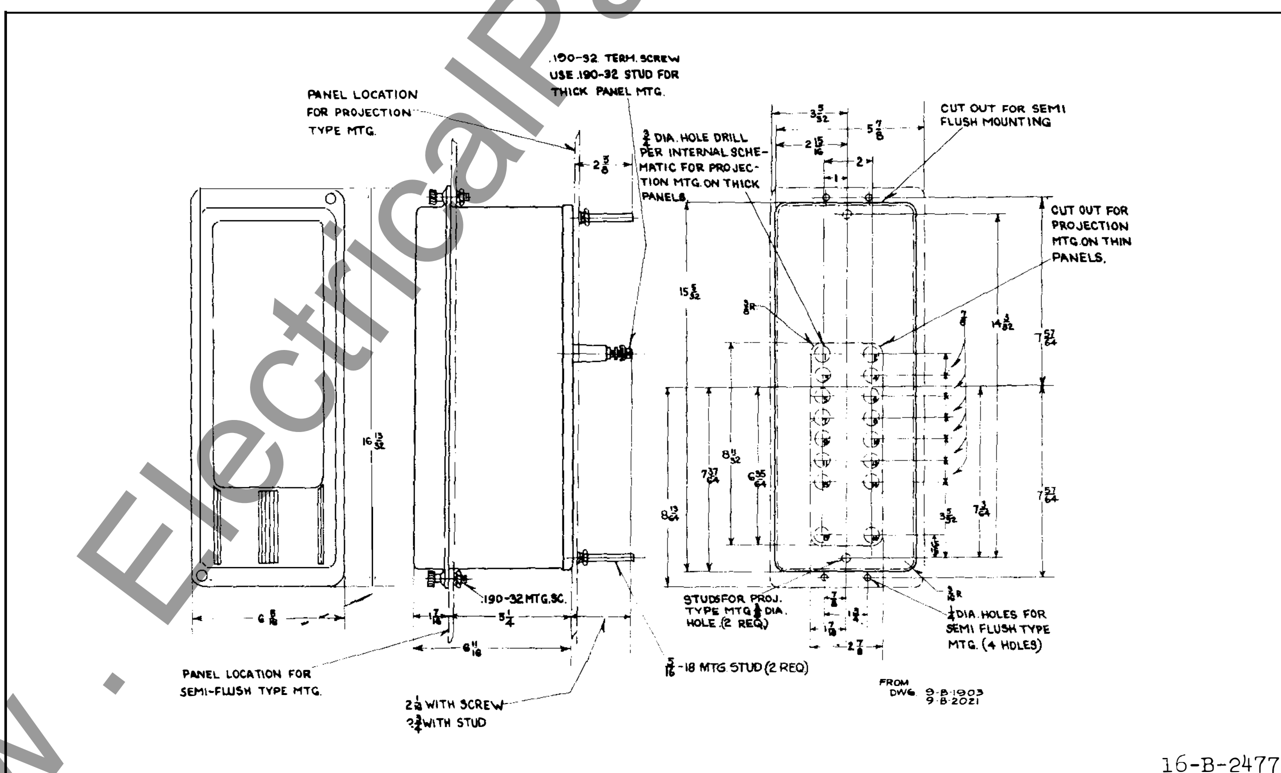

Fig. 26— Outline and Drilling Plan for the M-10 Projection or Semi-Flush Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

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METER DIVISION • **NEWARK, N.J.**

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voltage restraint auxiliary equipment
for use with type CR directional
overcurrent relays

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