INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE HRZ DIRECTIONAL IMPEDANCE RELAY WITH ADJUSTABLE INVERSE OVERCURRENT ELEMENT

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 setting and electrical connections.

APPLICATION

The Type HRZ relay is a combination of the instantaneous impedance and directional elements of the Type HZ relay and the overcurrent element of the Type CO relay. This relay is used for high speed clearing of phase faults on transmission systems. It gives instantaneous protection over 80 to 90% of the protected section, and time delay overcurrent protection over the remaining 20 to 10% of the protected section, and the adjacent section.

CONSTRUCTION AND OPERATION

The Type HRZ relay contains an instantaneous impedance (HZ) element, and overcurrent (CO) element, a directional element, auxiliary contactor switches and operation indicators all mounted in a single case. The construction and operation of each of these elements is as follows.

Instantaneous Impedance (HZ) Element

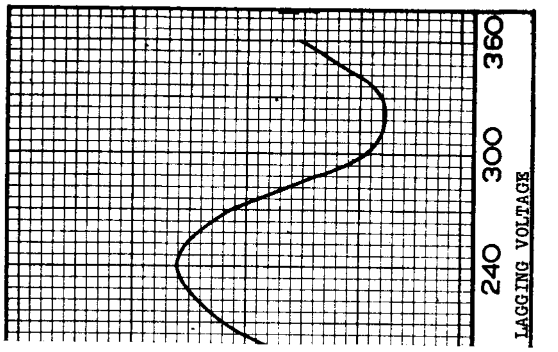
This element is similar to the first impedance element of the Type HZ relay. It consists of a balanced beam pivoted at the center (Figure 3) and pulled downward by a current coil on the forward end to close the relay contacts. This pull is opposed by two voltage coils acting on the other end of the beam. The fluxes set up by these two potential coils are shifted out of phase with respect to each other so that a balance between current and voltage fluxes can be held within desirable limits for all phase angles.

A tap screw on the front of the element permits changing the number of turns on the current coil, and a core screw on the bottom of the element changes an air gap in the magnetic path. These two adjustments make it possible to set the impedance element so that it will operate instantaneously, for all faults occurring within 80 to 90% of the protected line section. For a fault at the balance point of the element (determined by setting) the pull of the voltage coil, which measures the IZ drop from the fault to the relay, will just equal the pull of the current coil, which receives the fault current, I. If the fault occurs inside the balance point, the IZ voltage pull will be less than the I current pull and the beam will trip closing its contacts. Conversely, if the fault occurs outside the relay balance point, the IZ voltage pull will be greater than the I current pull and the beam will not trip.

A rectangular silver contact is flexibly fastened on the forward end of the beam. As the beam trips, the contact bridges two silver stationary hemispherical contacts mounted on the free end of a short leaf spring. A small set screw determines the position of the leaf spring and provides means for adjusting the contact gap and follow.

Overcurrent Element

This is an induction-disc type element operating on overcurrent. The induction disc is a spiral shaped aluminum type mounted on a vertical shaft. The shaft is supported on the lower end by a pin and end stone type bearing



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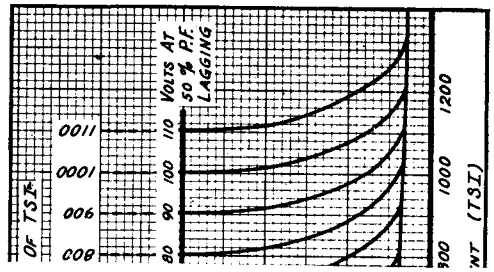

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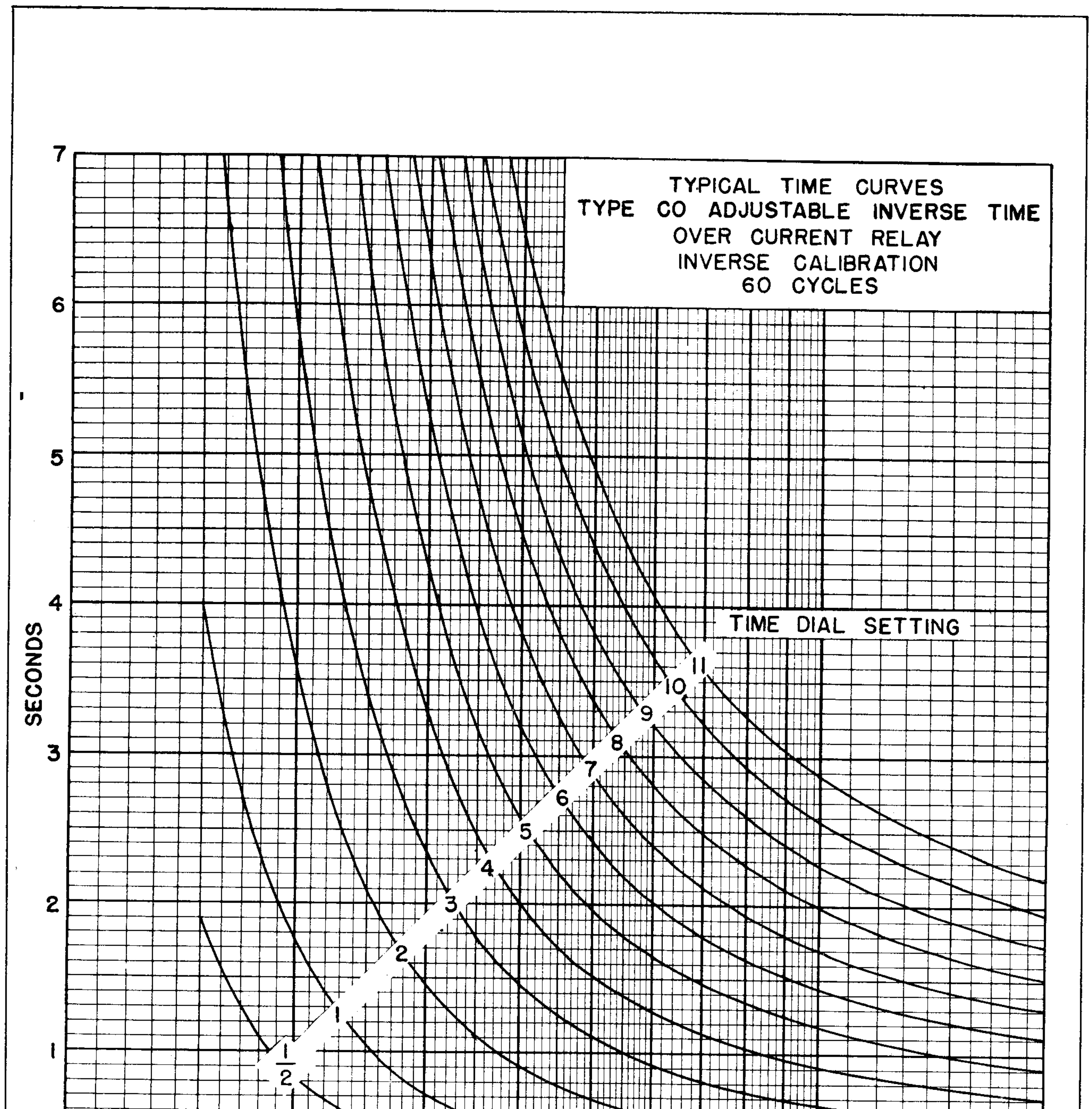
TYPE HRZ RELAY



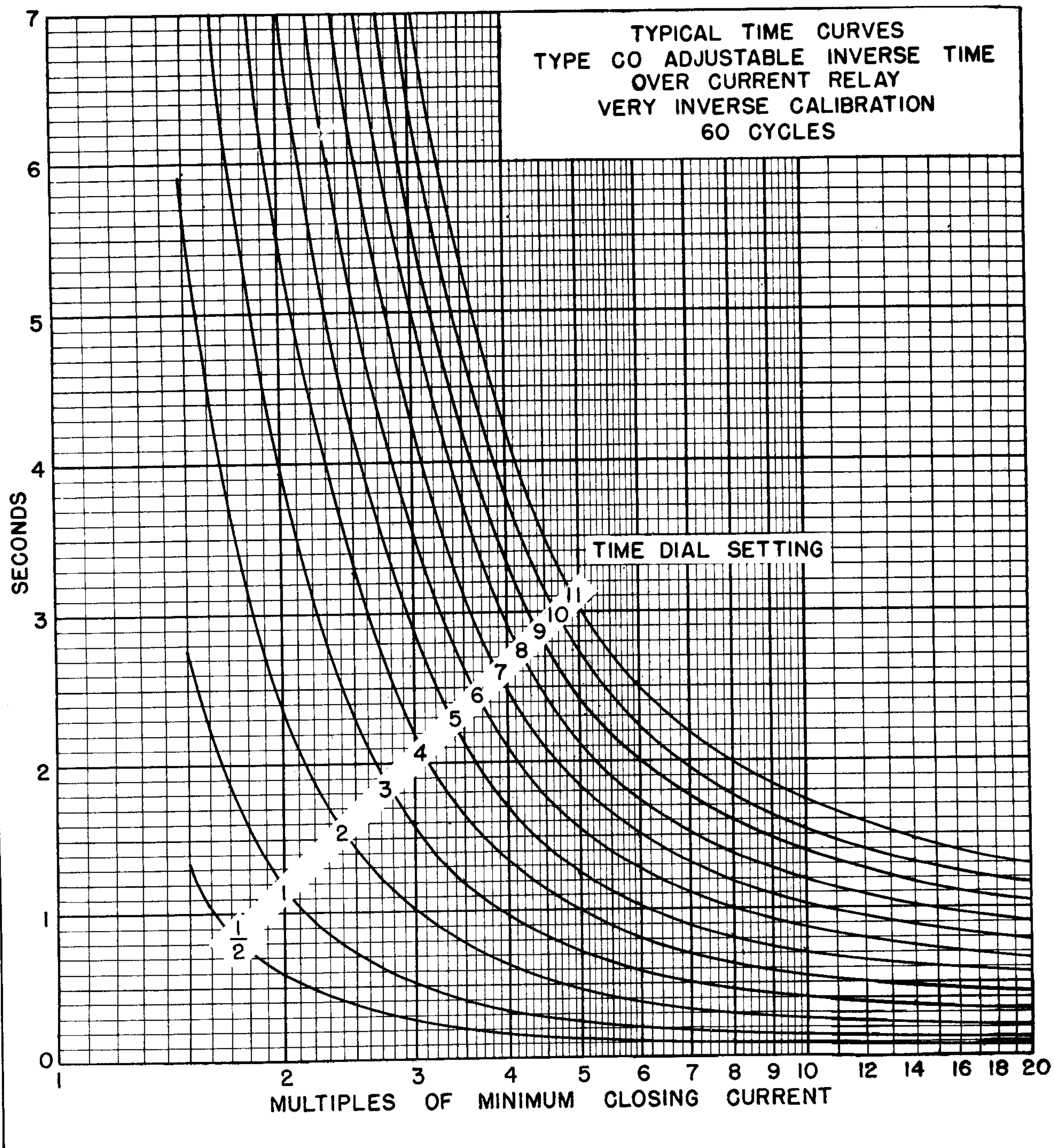


Fig. 11—Typical 60 Cycle Time Curves for the Very Inverse Calibration.

The star-delta auxiliary current transformer is the same as used with the type HZ relay and is described in I. L. 41-535.

RELAYS IN TYPE FT. CASE

The type FT cases are dust-proof enclosures combining relay elements and knife-blade test switches in the same case. This combination provides a compact flexible assembly easy tc maintain, inspect, test and adjust. There are three main units of the type FT case: the case, cover and chassis. The case is an all welded steel housing containing the hinge half of the knife-blade test switches and the terminals for external connections. The cover is a drawn steel frame with a clear window which fits over the front of the case with the switches closed. The chassis is a frame that supports the relay elements and the contact jaw half of the test switches. This slides in and out of the case. The electrical connections between the base and chassis are completed through the closed knife-blades.

Removing Chassis

To remove the chassis, first remove the cover by unscrewing the captive nuts at the corners. There are two cover nuts on the S size case and four on the L and M size cases. This exposes the relay elements and all the test switches for inspection and testing. The next step is to open the red handle test switches first before any of the black handle switches or the cam action latches. This opens the trip circuit to prevent accidental trip out. Then open all the remaining switches. The order of opening the remaining switches is not important. In opening the test switches they should be moved all the way back against the stops. With all the switches fully opened, grasp the two cam action latch arms and pull outward. This releases the chassis from the case. Using the latch arms as handles, pull the chassis out of the case. The chassis can be set on a test bench in a normal upright position as well as on its top, back or sides for easy inspection, maintenance and test.

After removing the chassis a duplicate chassis may be inserted in the case or the blade portion of the switches can be closed and the cover put in place without the chassis. The chassis operated shorting switch located behind the current test switch prevents open circuiting the current transformers when the current type test switches are closed.

When the chassis is to be put back in the case, the above procedure is to be followed in the reversed order. The elongated red handle switch should not be closed until after the chassis has been latched in place and all of the black handle switches closed.

Electrical Circuits

Each terminal in the base connects through a test switch to the relay elements in the chassis as shown on the internal schematic diagrams. The relay terminal is identified by numbers marked on both the inside and outside of the base. The test switch positions are identified by letters marked on the top and bottom surface of the moulded blocks. These letters can be seen when the chassis is removed from the case.

The potential and control circuits through the relay are disconnected from the external circuit by opening the associated test switches. Opening the current test switch short-circuits the current transformer secondary and disconnects one side of the relay coil but leaves the other side of the coil connected to the external circuit through the current test jack jaws. This circuit can be isolated by inserting the current test plug (without external connections), by inserting the ten circuit test plug, or by inserting a piece of insulating material approximately 1/32" thick into the current test jack jaws. Both switches of the current test switch pair must be open when using the current test plug or insulating material in this manner to short-circuit the current transformer secondary.

A cover operated switch can be supplied with its contacts wired in series with the trip circuit. This switch opens the trip circuit when the cover is removed. This switch can be added to the existing type FT cases at any time.

Testing

The relays can be tested in service, in the case but with the external circuits isolated or out of the case as follows:

Testing In Service

The ammeter test plug can be inserted in the current test jaws after opening the knife-blade switch to check the current through the relay. This plug consists of two conducting strips separated by an insulating strip. The ammeter is connected to these strips by terminal screws and the leads are carried out through holes in the back of the insulated handle.

Voltages between the potential circuits can be measured conveniently by clamping #2 clip leads on the projecting clip lead lug on the contact jaw.

Testing in Case

With all blades in the full open position, the ten circuit test plug can be inserted in the contact jaws. This connects the relay elements to a set of binding posts and completely isolates the relay circuits from the external connections by means of an insulating barrier on the plug. The external test circuits are connected to these binding posts. The plug is inserted in the bottom test jaws with the binding posts up and in the top test switch jaws with the binding posts down.

The external test circuits may be made to the relay elements by #2 test clip leads instead of the test plug. When connecting an external test circuit to the current elements using clip leads, care should be taken to see that the current test jack jaws are open so that the relay is completely isolated from the external circuits. Suggested means for isolating this circuit are outlined above under "Electrical Circuits".

Testing Out of Case

With the chassis removed from the case, relay elements may be tested by using the ten circuit test plug or by #2 test clip leads as described above. The factory calibration is made with the chassis in the case and removing the chassis from the case will change the calibration values by a small percentage. It is recommended that the relay be checked in position as a final check on calibration.

SETTINGS

The type HRZ relay requires two separate settings: one for the instantaneous HZ element and the other for the CO element. Each will be considered below:

The following nomenclature is used for the discussion of the HZ settings:

Z = the line-to-neutral ohmic impedance. The impedance for 80 to 90% of the protected line section.
R_c = the current transformer ratio.
R_v = the potential transformer ratio.
T = the instantaneous HZ element current tap.
S = the instantaneous HZ element current core screw.

Instantaneous (HZ) Element Settings

This element is set to give instantaneous protection over approximately 90% of the protected line section. Since the impedance of the voltage coil is the same at all times, the balance point of the element is adjusted by changing the pull on the current coil. This is done by taps (T) on the current coil winding and by the core screw (S) which varies the magnetic air gap for the current flux.

The most satisfactory method of arriving at the tap settings is by the use of the following equations:

Instantaneous Element Receiving Delta Current:

$$TS = \frac{10\ Z\ R_c}{R_v} \qquad (1)$$

Instantaneous Element Receiving Star Current:

$$TS = \frac{17.3\ Z\ R_c}{R_v} \qquad (2)$$

The nomenclature is as defined above. The tap, T, is obtained by dividing the TS product by S to give an available tap number. When changing taps, the extra tap screw should be screwed in the desired tap before moving the existing tap screw to prevent open circuiting the current transformers.

The numbers on the core screw appear in ascending order as the core screw is screwed into the core. In some cases, a question of doubt may arise whether the scale setting is correct, or is out by one full turn of the core screw. In such a case, the point may be verified by turning the core screw all the way in. Then back out the core screw until the highest scale marking and then continuing to back it off until the desired value appears exactly under the end of the pointer. Sufficiently accurate setting can be made by interpolating between the marked points when necessary.

The above formulas are based on the relay being used on a 60° line and are correct for lines of that angle. For lines other than 60° a slight error is introduced which may be as much as 8% and 6% on 40° and 80° lines respectively. However, the formula relay setting can be corrected for lines other than 60° by using the curve of Figure 5.

The formula settings are sufficiently accurate for most installations, where it is desired to set the balance point more accurately the tap and scale values may be checked by applying to the relay the voltage, current and phase angle conditions which will be impressed on it for a fault at the desired balance point. A slight change in the scale value from that calculated may be required so that the relay will just trip for the simulated fault at the balance point.

As an example, the instantaneous element is to be set for 90% of the line section AB which is 6 ohms long. The current transformer ratio is 200/5 star-connected with the star-delta auxiliary current transformer supplying delta current to the instantaneous element coils. The potential transformer ratio is 1000/1. Using equation (1)

$$TS = \frac{10 \times .90 \times 6 \times 40}{1000} = 2.16$$

Set tap 2 on the 0.2 to 2.0 ohm relay and core screw = 1.08. NOTE: The relay should not be required to operate when the drop from the relay to the fault for minimum fault is less than 5 relay volts.

Settings for the CO Element

There are two settings-namely the current value at which the relay closes its contacts and the time required to close them.

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 the proper selective action can be obtained throughout the system.

Current Setting

The connector screw on the terminal plate above the time dial 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 4.0 - 5.0 - 6.0 - 7.0 - 8 - 10 - 12 amperes, or as marked on the terminal plate.

Time Dial Setting

The time dial limits the motion of the disc and thus varies the time of operation. The latter decreases with lower time dial settings as shown in the typical time curves.

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

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not require readjustment after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, of if it is desired to change the operating characteristic, such as

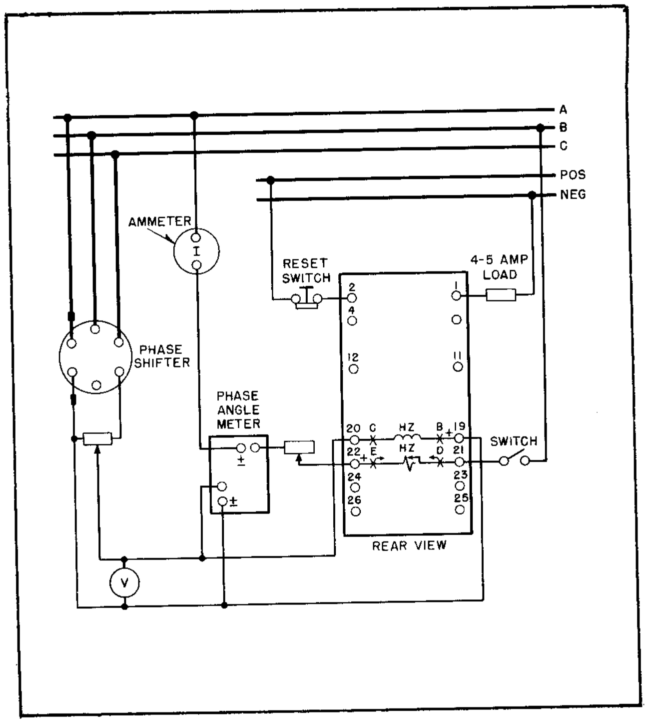


Fig. 12—Diagram Of Test Connections For The Instantaneous (HZ) Element Of The Type HRZ Relay In The Type FT Case. Omit Test Switches For The Relay In Standard Case.

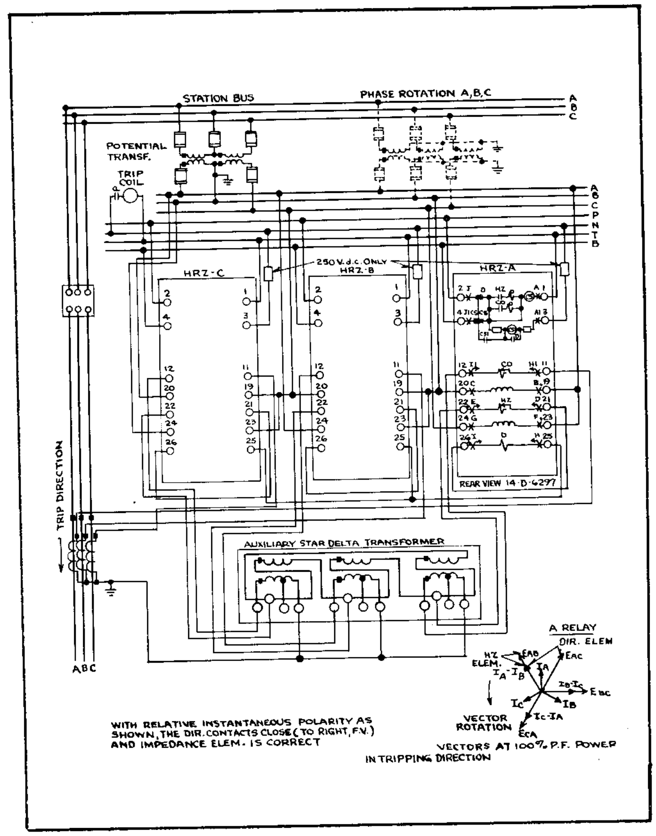


Fig. 13—External Connections For The Type HRZ Relay In The Type FT Case. Omit Test Switch For The Relay In Standard Case.

from inverse to very inverse, 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.

Instantaneous Impedance (HZ) Element

Refer to Figure 3. For the 60 cycle relays adjust the stop screw on the rear of the beam to give a clearance of .025 inch between the rear of the beam and the voltage iron circuit. This may be checked with a feeler gauge. With the beam in the reset position, i.e., back against the stop, adjust the gap between the adjustable iron and the beam to .009 inch. Care should be taken in this adjustment to keep the gap the same on both sides. Also, with the beam in the same position, adjust the gap between the front end of the beam and the stop in the upper core screw to .020 inch.

The beam should be balanced as follows. Connect the relay as shown in the test diagram, Figure 11. With any tap and scale setting, check the impedance measured by the relay with 35 volts potential restraint. Apply 5 volts restraint and adjust the balance weight on the beam until the beam just trips with 1/7 of the current required to trip with 35 volts restraint. Make certain that the stop on the voltage side is absolutely clean, otherwise the impedance at which the beam trips may be affected, particularly at the low voltages. The stop can be easily cleaned by drawing a piece of clean white paper between the beam and the stop while the beam is firmly pressed down.

The stationary contacts should be adjusted to give .015 inch clearance between them and the silver bridge on the beam when the beam is in the reset position. The bridge should be made to touch both contacts simultaneously, and deflect the contact springs at least .010 inch before the beam strikes the bronze stop on the core screw.

It is difficult to accurately adjust the contacts by eye. A good method consists in first adjusting one of the contacts to the correct gap and then applying just sufficient current to trip the beam against a restraint of about 5 volts. While the beam is in this position, that is, lightly pressing on the one contact, the other contact should be slowly adjusted upward by means of the set screw until it just touches the silver bridge without lifting it off the other contact. The trip circuit should be energized so that the lighting of a lamp or the tripping of an auxiliary relay will show when both contacts are made.

A further caution in regard to the contact adjustment is that too much follow or deflection of the stationary contacts will slightly delay the resetting of the high-speed element and thus the directional element contacts may get closed before the impedance contacts are open and result in unnecessary tripping.

Directional Element

Check the free movement of the directional element loop with the relay in a vertical position to see that it is free from friction and properly centered. The loop should assume a vertical position with the contacts open when the element is completely de-energized.

With the loop in the vertical position adjust the front and back stationary contacts for .020 inch separation from the vertical moving contact. Adjust the contact back stop screws to just touch the stationary contacts, then back off 1/4 of a turn to give correct contact follow. Adjust the two-stop screws which limit the movement of the loop (these screws are located to the rear of the current coil) so that the loop strikes these stops at the same instant the stationary contacts strike their back stop.

Too much follow on the directional contacts should be avoided in order to allow the directional element to reset fast enough by gravity to properly coordinate with the high speed impedance element.

Energize the loop with normal potential long enough to bring it up to temperature (about 10 or 15 minutes) and adjust the bearing screws so there is about .010 inch end play. See that the loop does not bind or strike against the iron or coil when pressed against either end jewel.

The minimum pick-up of the element is 10 amperes at 2.0 volts (unity power factor). Apply these values to the element and see that contacts make good contact in the correct direction. Reverse the direction of current to see that the contacts make good contact in the opposite direction.

When the directional element is energized on voltage alone, there may be a small torque which may hold contacts either open or closed. This torque is small and shows up only at high voltages with the entire absence of current. At voltages high enough to make this torque discernible, it will be found that only a fraction of an ampere in the current coils will produce wattmeter torque to insure positive action. This is mentioned because the slight torque shown on voltage alone has no significance in actual service and has no practical effect on the directional element operation.

Check the coordination of the directional and impedance contacts as follows. Set the impedance element on the maximum tap and scale setting. Connect the relay with the correct polarity so that the right-hand (front view) directional contacts close and apply rated d-c volts to the directional control circuit. Apply 115 volts a-c to the impedance and directional element potential coils and pass 5 amperes at unity power factor through the current circuit. Check trip circuit to see that it is not completed with the voltage on the impedance and directional elements is suddenly applied or interrupted. Do not interrupt the current circuit. Make several such tests. The trip circuit should draw about 5 amperes d-c for this test so that the contactor switch will pick up and seal in if the elements fail to coordinate. Otherwise, a failure to coordinate is not necessarily indicated by the flicker of a lamp, since the blocking resistor will prevent the pick-up of a trip coil plunger until the auxiliary

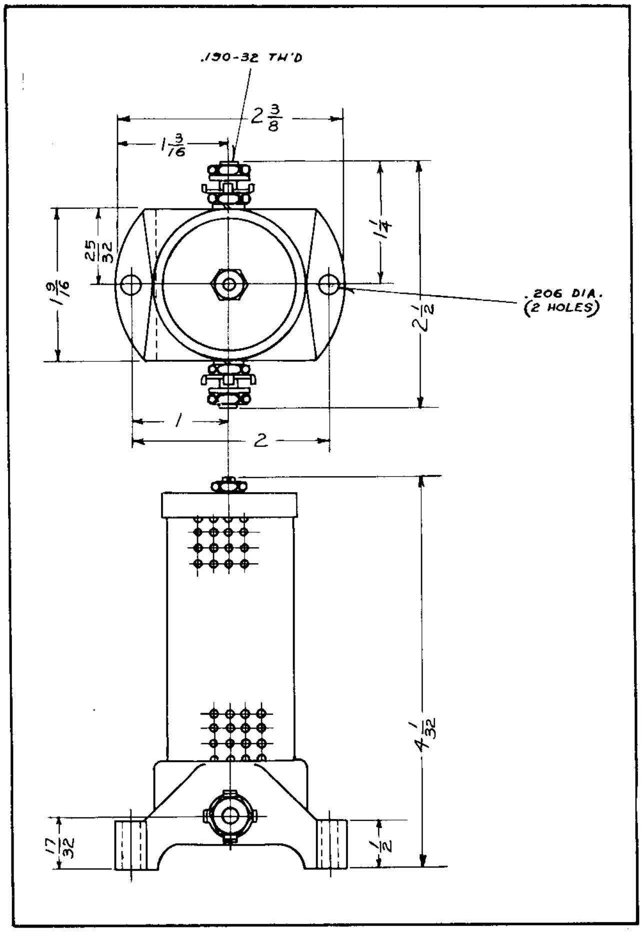


Fig. 14—Outline And Drilling Plan For The External Control Circuit Resistor For The 250 Volt d-c Relays. For Reference Only.

contactor falls out. This coordination test has been described for the most severe conditions. Consequently, an occasional failure to coordinate may be tolerated, since, in service, the directional element will be resetting under the positive action of reverse power flow rather than under the influence of gravity alone, as described in this test. If proper coordination is not obtained, it may be necessary to reduce the follow on the directional or impedance element contacts, as the case may be.

CO ELEMENT

For relays that are used with circuit breakers that are not instantaneously reclosed, adjust the stationary contact by means of its adjusting screw such that the contact spring is just free of the front spring stop. By means of the time dial, move the moving contacts until they deflect the stationary contacts approximately 1/64 inch. Set the index pointer such that it points to the "0" mark on the time dial. Adjust the stationary contact by means of its adjusting screw until the moving and stationary contacts just touch. This adjustment is to set "0" on the time dial and provide follow for the contacts.

For relays that are used with circuit breakers that are instantaneously reclosed, adjust the stationary contact for quick opening. This is done by screwing in the contact adjusting screw until the stationary contact rests solidly against the contact back stop. By means of the time dial, move the moving contacts until they just touch the stationary contact. Set the index pointer such that it points to the "0" mark on the time dial.

The adjustment of the spring tension and the tap value adjuster are most conveniently made with the damping magnet removed. The reason for this is both adjustments require the balance of two torques which can best be recognized with no damping magnet to retard the motion of the disc.

With the time dial still set on "0", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show. This is an initial rough adjustment. From this preliminary setting, and using minimum tap setting, adjust the spring tension so that the electrical torque balances the spring torque at a fixed value of current at #10-1/2 and #1/2 time dial settings. The best way to do this is to first measure the actual current required to balance the spring torque at the #1/2 and #10-1/2 time dial settings. If less current is required to balance the spring torque at the #10-1/2 position than at the #1/2 position, it is an indication that the spring needs to be wound up more, and vice-versa. All spring convolutions must be free. This setting of the spring will not necessarily be at tap value of current. By winding up or unwinding the spring as required, the current required to move the disc at the extreme limits of its travel (and consequently through the entire range of travel) may be made constant within very close tolerances.

After having balanced the spring torque and the electrical torque as above to match at a substantially constant value of current, then adjust this constant current value up or down as required to match the tap value current by means of the tap value adjuster located on the right hand leg, front view, of the electromagnet. Moving the slider toward the top decreases minimum trip current and moving the slider toward the bottom increases minimum trip current. The slider must be clamped tight when checking this adjustment.

Time Curve Calibration

After checking the adjustments as outlined above replace the permanent magnet and adjust it to calibrate the relay at 2 times tap value current. This adjustment is made by means of the damping magnet keeper screw. Adjust the keeper screw position such that the relay will operate in the time as defined by the curve of Fig. 9 for inverse or very inverse depending upon the calibration desired. For example, if the inverse calibration is desired, the damping magnet may be adjusted for 27 seconds from the #11 time dial setting. If the very inverse calibration is desired, the adjustment may be made for 18.3 seconds from the #11 time dial setting. Time values somewhat greater than those shown for the inverse calibration and somewhat less than those shown for the very inverse calibration may be obtained if particular problems require them.

The time of operation at 20 times tap value current is adjusted by means of the two adjustable magnetic plugs. Adjust the plug position such that the relay will operate in the time as defined by the current vs time curves of figure 10 or 11 for inverse or very inverse calibration depending upon the characteristic desired for which the 2 times tap value adjustment of time was made. For example, if the inverse calibration is desired, the relay may be calibrated for 2.18 seconds from the #11 time dial position at 20 times minimum trip current by screwing the right hand plug all the way in and adjusting the left hand plug for 2.18 seconds. If the very inverse calibration is desired, screw the left hand plug all the way in and adjust the right hand plug for 1.28 seconds from the #11 time dial position at 20 times minimum trip current.

Curve shapes that are different from the inverse or very inverse may be obtained by adjustable magnetic plugs. An example of this adjustment has been referred to under "Characteristics", and wherein one range of possibilities is shown by Fig. 8.

Contactor Switch (Seal-in-Switch)

Turn the relay up side down. Screw up the core screw until the contact ring starts rotating. Now back off the core until the contact ring stops rotating. Back off the core screw one more turn and lock in place. Adjust the two nuts at the bottom of the switch so that there is 3/32 inch clearance between the moving contact ring and the stationary contacts in the open position. The guide rod may be used as a scale as it has 52 threads per inch, therefore, 5 turns of the nuts will equal approximately 3/32 inch.

The switch should pick up at 2 amperes d-c. Test for sticking after 30 amperes have been passed through the coil.

(Directional Control Circuit)

The adjustments are the same as for the seal-in contactor switch except that the contact separation should be 3/64 inch. The switch should pick-up at not more than 80 volts d-c. Apply 140 volts d-c to the circuit and see that the contacts drop out when the coil is shorted by the left-hand directional contacts. For the 250 volt d-c relays the pick-up should be 165 volts and the contacts should drop-out when the directional element contacts short-circuit the coil with 250 to 280 volts applied to the circuit. Energize the directional element with 50 volts and 10 amperes in phase suddenly applied. The contactor switch must operate the first time the directional contacts close without fluttering or bouncing of the contacts.

Operation Indicator

Adjust the indicator to operate at 1.0 ampere d-c gradually applied. Test for sticking after 30 amperes d-c is passed through the coil.

Instantaneous Trip Attachment (When Supplied)

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. This 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 ratio of adjustments 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. It should be adjusted for about 2/3 of the minimum pickup.

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

The burdens of the various circuits of the 60 cycle relay are as follows:

Ampere Range	Tap	Continuous Rating (Amperes)	One Second Rating* (Amperes)	Power Factor Angle∅	Volt Amperes△ At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current
0.5/2.5-	0.5	2	56	72	2.38	21	132	350
	0.6	2.2	56	71	2.38	21	134	365
	0.8	2.5	56	69	2.40	21.1	142	400
	1.0	2.8	56	67	2.42	21.2	150	440
	1.5	3.4	56	62	2.51	22	170	530
	2.0	4.0	56	57	2.65	23.5	200	675
	2.5	4.4	56	53	2.74	24.8	228	800
2/6-	2	8	230	70	2.38	21	136	360
	2.5	8.8	230	66	2.40	21.1	142	395
	3	9.7	230	64	2.42	21.2	149	430
	3.5	10.4	230	62	2.48	22	157	470
	4	11.2	230	60	2.53	22.7	164	500
	5	12.5	230	58	2.64	24	180	580
	6	13.7	230	56	2.75	25.2	198	660
4/12-	4	16	460	68	2.38	21.3	146	420
	5	18.8	460	63	2.46	21.8	158	480
	6	19.3	460	60	2.54	22.6	172	550
	7	20.8	460	57	2.62	23.6	190	620
	8	22.5	460	54	2.73	24.8	207	700
	10	25	460	48	3.00	27.8	248	850
	12	28	460	45	3.46	31.4	292	1020

*Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

∅Degrees current lags voltage at tap value current.

△Voltages taken with Rectox Type Voltmeter.

DIRECTIONAL ELEMENT SERIES COIL

Rating	V.A. at 5 Amperes	Power Factor	One Second Rating (Amperes)
5	3.5	45° lag	140

DIRECTIONAL ELEMENT POTENTIAL POLARIZING COIL, ALONE

Rating	V.A. at 115 Volts	Power Factor
115V	9	28° lag

IMPEDANCE ELEMENT CURRENT COILS

Tap	V.A. at 5 Amperes	Power Factor
45	2.0	30° lag
13.5	0.55	30° lag

IMPEDANCE ELEMENT POTENTIAL COILS

V.A. at 115 Volts	Power Factor
1.8	20° lag

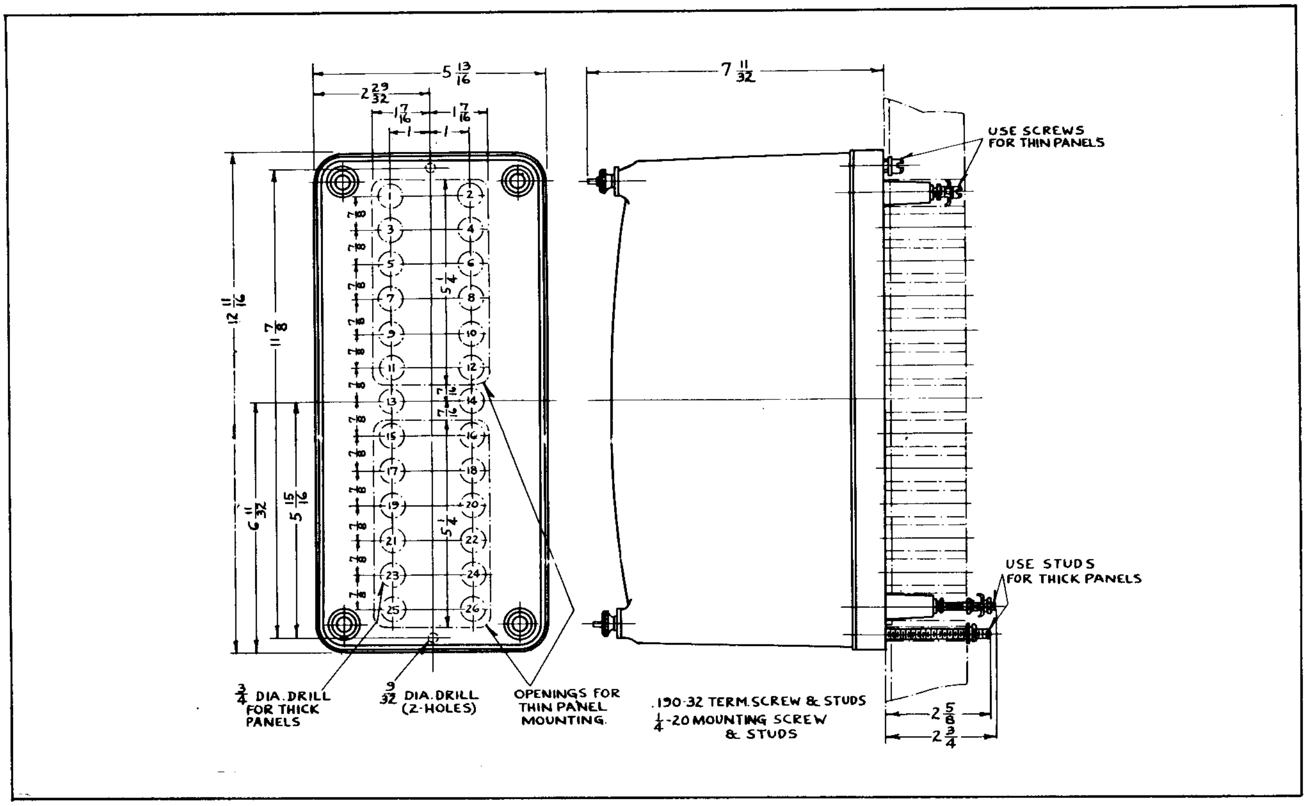


Fig. 15—Outline And Drilling Plan For The Standard Projection Type Case. See The Internal Schematics For Terminals Supplied. For Reference Only.

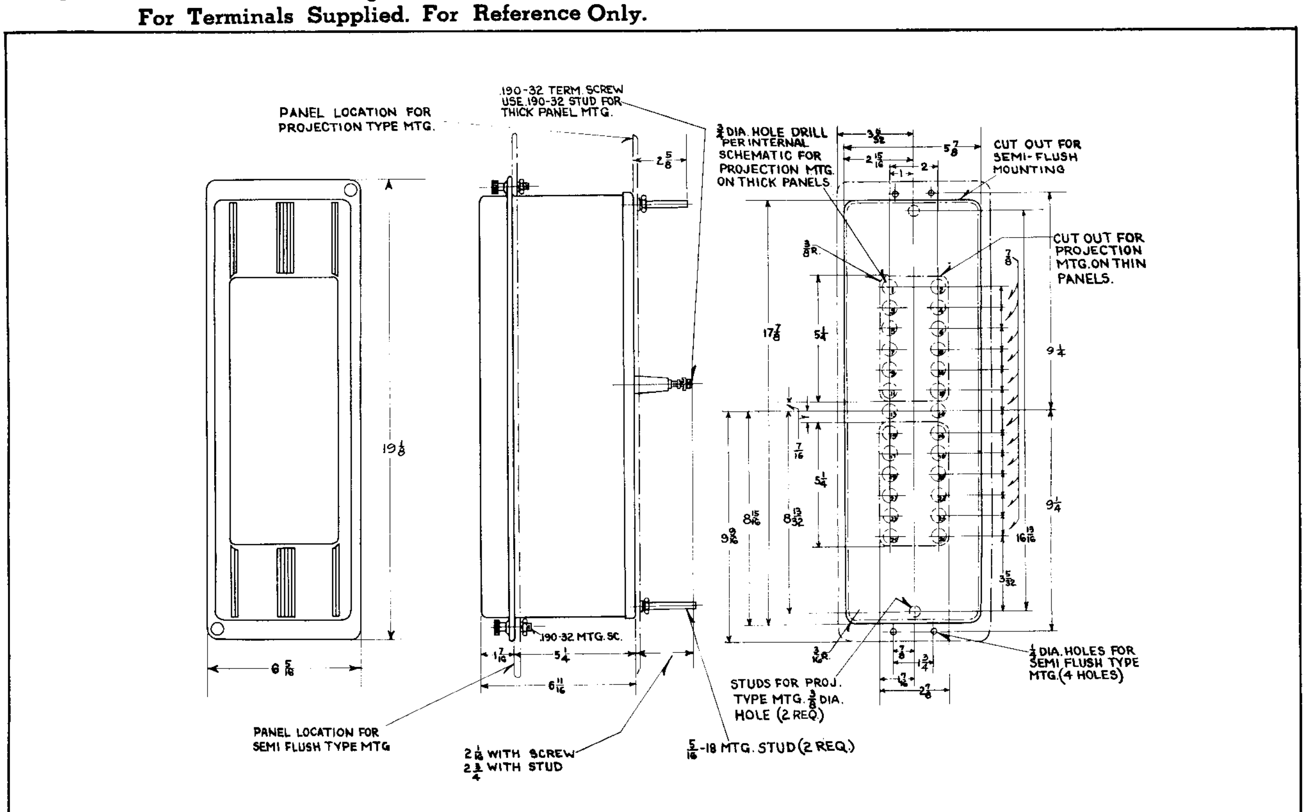


Fig. 16—Outline And Drilling Plan For The M20 Semi- Flush Or Projection Type FT Flexitest Case. See Internal Schematic For Terminals Supplied. For Reference Only.

WESTINGHOUSE ELECTRIC CORPORATION

METER DIVISION

NEWARK, N.J.

Printed in U. S. A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE HRZ DIRECTIONAL IMPEDANCE RELAY WITH ADJUSTABLE INVERSE OVERCURRENT ELEMENT

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 setting and electrical connections.

APPLICATION

The type HRZ relay is a combination of the instantaneous impedance element of the type HZ relay, the single loop directional element, and the overcurrent element of the type CO relay. This relay is used for high speed clearing of phase faults on transmission systems. It gives instantaneous protection over 80 to 90% of the protected section, and time delay overcurrent protection over the remaining 20 to 10% of the protected section, and the adjacent section.

CONSTRUCTION AND OPERATION

The Type HRZ relay contains an instantaneous impedance (HZ) element, an overcurrent (CO) element, a directional element, auxiliary contactor switches and operation indicators all mounted in a single case. The construction and operation of each of these elements is as follows.

Instantaneous Impedance (HZ) Element

This element is similar to the first impedance element of the Type HZ relay. It consists of a balanced beam pivoted at the center (Figure 3) and pulled downward by a current coil on the forward end to close the relay contacts. This pull is opposed by two voltage coils acting on the other end of the beam. The fluxes set up by these two potential coils are shifted out of phase with respect to each other so that a balance between current and voltage fluxes can be held within desirable limits for all phase angles.

A tap screw on the front of the element permits changing the number of turns on the current coil, and a core screw on the bottom of the element changes an air gap in the magnetic path. These two adjustments make it possible to set the impedance element so that it will operate instantaneously, for all faults occuring within 80 to 90% of the protected line section. For a fault at the balance point of the element (determined by setting) the pull of the voltage coil, which measures the IZ drop from the fault to the relay, will just equal the pull of the current coil, which receives the fault current, I. If the fault occurs inside the balance point, the IZ voltage pull will be less than the I current pull and the beam will trip closing its contacts. Conversely, if the fault occurs outside the relay balance point, the IZ voltage pull will be greater than the I current pull and the beam will not trip.

A rectangular silver contact is flexibly fastened on the forward end of the beam. As the beam trips, the contact bridges two silver stationary hemispherical contacts mounted on the free end of a short leaf spring. A small set screw determines the position of the leaf spring and provides means for adjusting the contact gap and follow.

Overcurrent Element

This is an induction-disc type element operating on overcurrent. The induction disc is a spiral shaped aluminum type mounted on a vertical shaft. The shaft is supported on the lower end by a pin and end stone type bearing

SUPERSEDES I. L. 41-421.1
*Denotes change from superseded issue.

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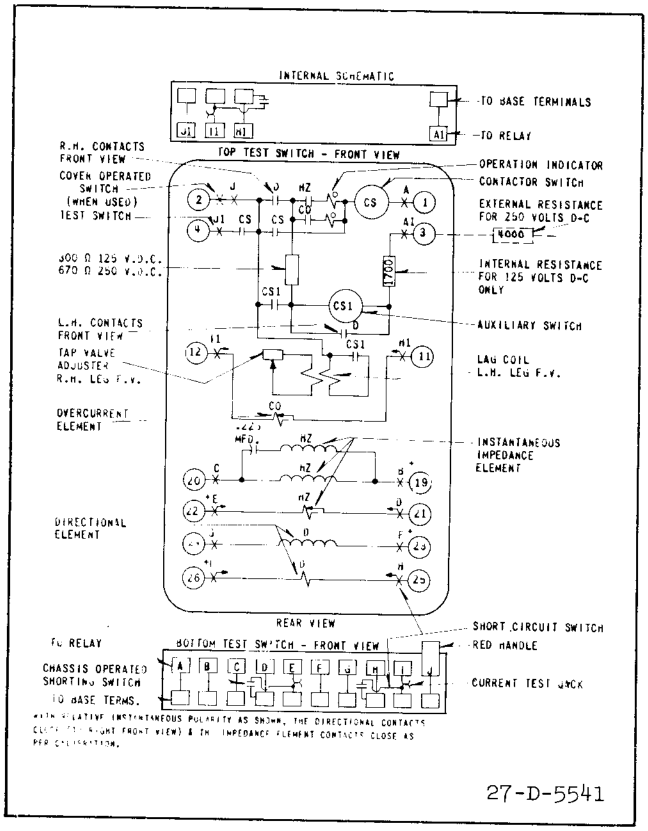


Fig. 1—Internal Schematic For The Inverse Or Very Inverse Type HRZ Relay In FT Case. Omit Test Switches For The Relay In Standard Case.

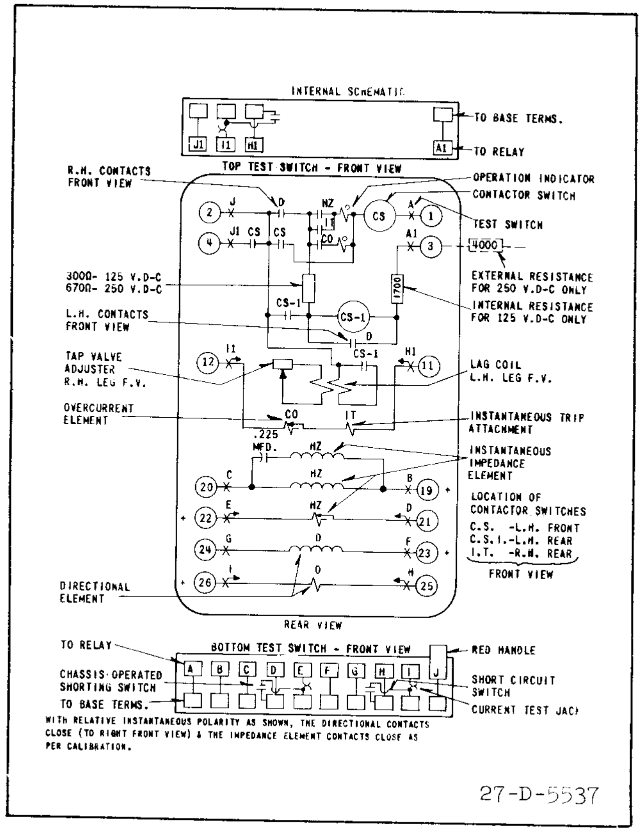


*Fig. 2—Internal Schematic For The Inverse Or Very Inverse Type HRZ Relay With Instantaneous Trip Attachment In FT Case. Omit Test Switches For The Relay In Standard Case.

and on the upper end by a pin and olive bearing.

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. The electrical connection is made from the moving contact through 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 Micarta block and mounted on the element frame. A small set screw permits the adjustment of contact follow.

Directional Element

A small voltage transformer causes a large current to flow in a single-turn movable aluminum secondary, which current is substantially in phase with the voltage. The current coils are mounted on a magnetic frame and the current and voltage elements are assembled at right angle to each other with the one-turn voltage loop in the air gaps of the current coil flux path. The interaction of the current and voltage fluxes produces torque and rotates the loop in one of two directions, depending on the direction of power flow.

An Isolantite arm extends from the moving loop and supports a rectangular silver contact which bridges two stationary contacts located on either side of the loop. The stationary contacts are silver hemi-spheres mounted on the lower end of vertically hanging spring leaves. The contact separation is adjustable by a small screw near the upper end of the rigid stationary contact supporting arm. One of these supporting arms hangs parallel to each of the four stationary contacts. The set

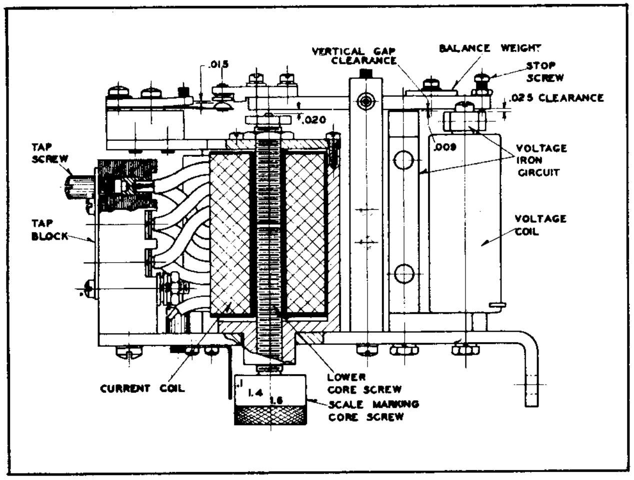


Fig. 3—Sectional View Of The Instantaneous (HZ) Element.

screw on the lower end of this arm provides the contact follow adjustment. Two additional screws on the movement frame beneath the current coil iron limit the movement of the one-turn loop.

Auxiliary Contactor Switch

This element is a small solenoid-type switch. A small cylindrical plunger with a silver disc supported on its lower end rides up and down on a vertical guide rod in the center of the solenoid coil. The guide rod is fastened to the stationary core which in turn screws into the element frame. When the coil is energized, the silver disc moves upward bridging three cone shaped stationary contacts. The operation of this D-C auxiliary switch is controlled by the directional element which in turn directionally controls CO overcurrent element. When fault current flows in the tripping direction, the auxiliary contactor switch operates to close and seal in the lag coil of the CO element. If the direction of the fault current reverses, a contact on the directional element shorts the auxiliary contactor switch coil, causing it to drop out. This opens the directional control circuit of the CO element.

Contactor Switch and Operation Indicator

The coil of the contactor switch is connected in the trip circuit. When the relay contacts close, the coil is energized and its contacts short around the relay contacts, relieving them of the duty of carrying the breaker tripping current. These contacts remain closed until the trip circuit is opened by a breaker auxiliary switch. The third contact of the contactor switch is connected to a separate relay terminal to operate an alarm circuit.

Two operation indicators show white targets with the letters HZ and CO. The HZ target operates when the trip circuit is completed through the instantaneous impedance element, and the CO target operates when the trip circuit is completed through the overcurrent element.

Instantaneous Trip (When Supplied)

The instantaneous trip attachment is a small solenoid type element. A cylindrical plunger rides up and down on a vertical guide rod in the center of the solenoid coil. The guide rod is fastened to the stationary core, which in turn screws into the element frame. A silver disc is fastened to the moving plunger through a helical spring. When the coil is energized, the plunger moves upward carrying the silver disc which bridges three conical-shaped stationary contacts. In this position, the helical spring is compressed and the plunger is free to move while the contact remains stationary. Thus, a-c vibrations of the plunger are prevented from causing contact bouncing. A Micarta disc screws on the bottom of the guide rod and its locked in position by a small nut. Its position determines the pick-up current of the element.

CHARACTERISTICS

The relay is available in two impedance ranges. These are the 0.2 to 2.0 ohm relay for short lines and the 0.6 to 6.0 ohm relay for long lines. The following are the tap markings:

Instantaneous (HZ) element 0.2 to 2.0 ohm range:

Tap = 2, 3, 4, 6, 9, 13

Core Screw = .8, .9, 1.0, 1.1, 1.2, 1.4, 1.6

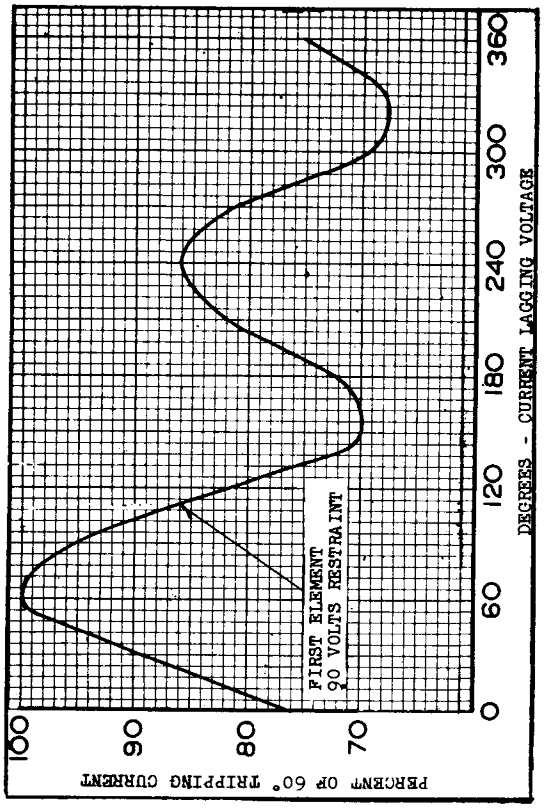


Fig. 5—Typical Phase Angle Curve Of The Instantaneous (HZ) Element.

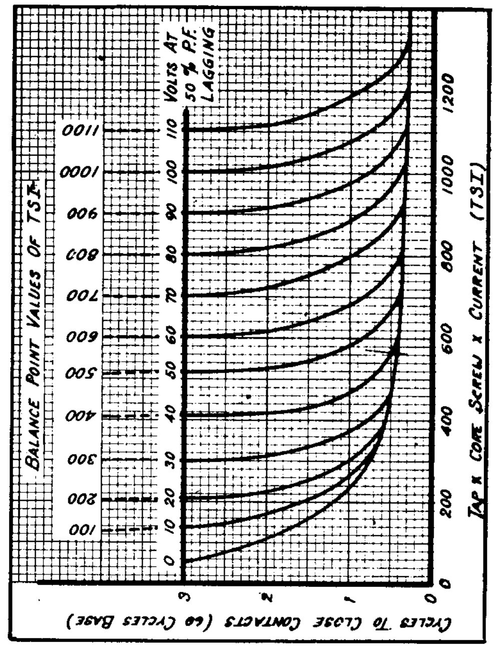


Fig. 7—Typical Time Of Operation Curves For The Instantaneous (HZ) Element.

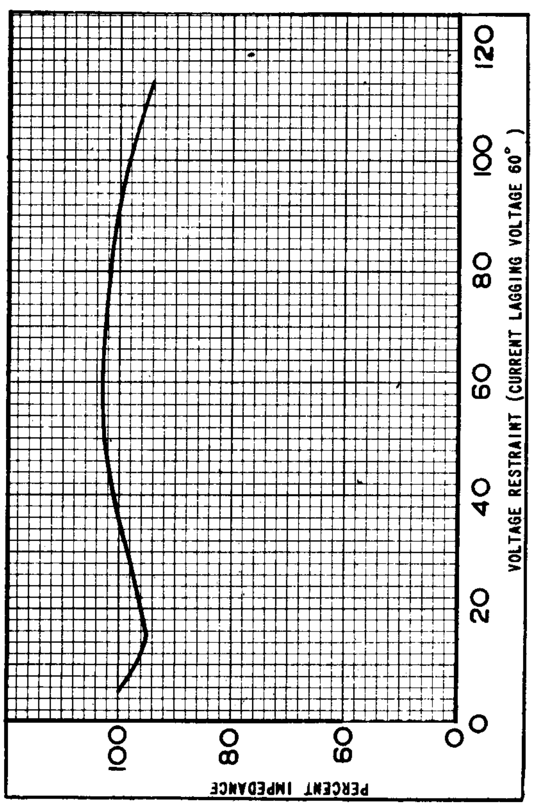


Fig. 4—Typical Impedance Curve For The Instantaneous (HZ) Element.

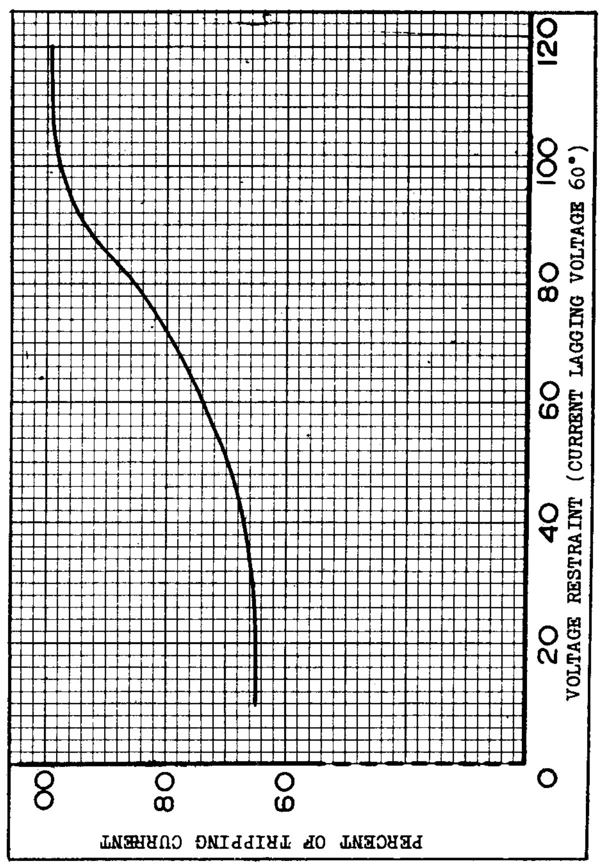


Fig. 6—Typical Reset Curve For The Instantaneous (HZ) Element.

TYPE HRZ RELAY

Instantaneous (HZ) element 0.6 to 6.0 ohm range:

Tap = 6.2, 9.4, 13.5, 20.8, 29.8, 45

Core Screw = .8, .9, 1.0, 1.1, 1.2, 1.3, 1.4

CO Overcurrent element

The type CO adjustable inverse time circuit closing relay is available in the following current ranges:

0.5	0.6	0.8	1.0	1.5	2.0	2.5
2	2.5	3	3.5	4	5	6
4	5	6	7	8	10	12

The tap value is the minimum current required to just close the relay contacts. The moving contacts will leave the time dial stop, regardless of the time dial setting, and move to touch the stationary contacts at tap value current.

The time vs current characteristics for the style calibration of inverse or very inverse are shown in Fig. 10 and Fig. 11 respectively. The term "style calibration" is used as there is no difference between the inverse and very inverse relays except in their calibration. Relays carrying a style number which indicates the inverse calibration may be changed to the very inverse calibration or vice versa through two simple adjustments. This is outlined in detail under Adjustments.

In addition to the one relay covering the inverse or the very inverse curves, the relay may be re-calibrated for a characteristic other than either of these. An example of the spread of adjustments to provide different curve shapes is shown by Fig. 8 wherein all curves are passed through 27 seconds at 2 times minimum trip current. The curves may be passed through a common point other than 27 seconds by adjustment of the damping magnet keeper screw. The range of adjustability indicated at 20 times minimum trip current is obtained by means of the magnetic plugs. The upper limit curve is obtained with the right hand plug "all in" and the left hand plug "all out" (approximately 20 turns of the screw). The lower limit is obtained with the left hand plug "all in" and the right hand plug "all out". Various adjustments of the plugs partially withdrawn from the magnetic circuit may be used as desired to obtain a curve within the band shown, including the standard or "pattern" curve to which the relay is calibrated at the factory. Thus, one or the other of the plugs will be partially withdrawn in the factory calibration to one or the other of the inverse or very inverse standard curves. Similarly, the factory set position of the damping magnet keeper screw will depend upon the "style calibration".

The burdens and thermal ratings are listed under Energy Requirements. The instantaneous trip attachment has a 1 to 4 ratio. Typical ranges are 10-40 or 20-80, but other ranges are also available.

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 terminals 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 recommended connections of relay are shown in Fig. 14. The 60° connection is used on the directional element, that is at unity power factor the current through the directional element coil should lead the polarizing voltage by 60° as shown in the vector diagram.

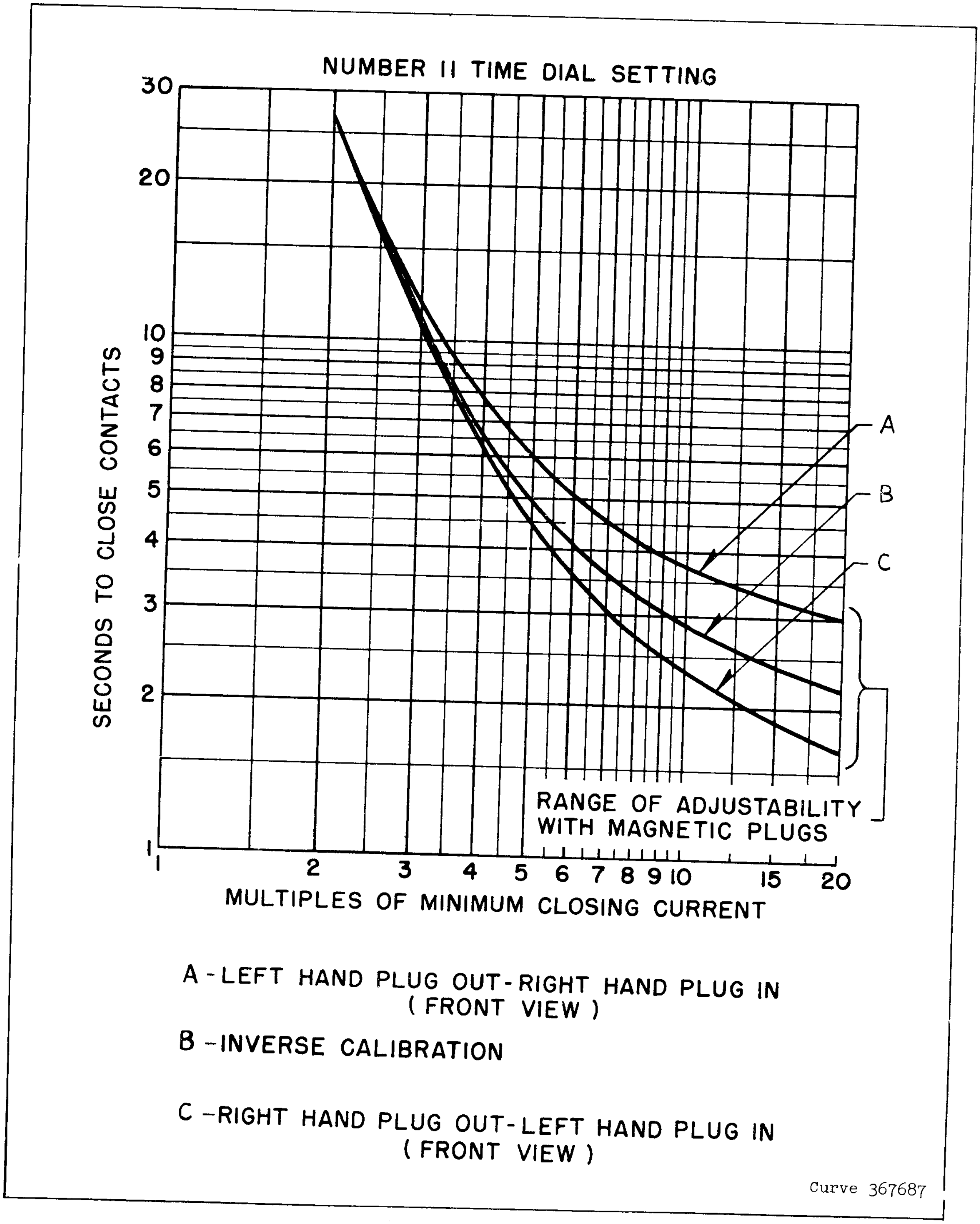


Fig. 8—Example Of The Range Of Adjustability Of The Time Curves By Means Of The Adjustable Plugs.

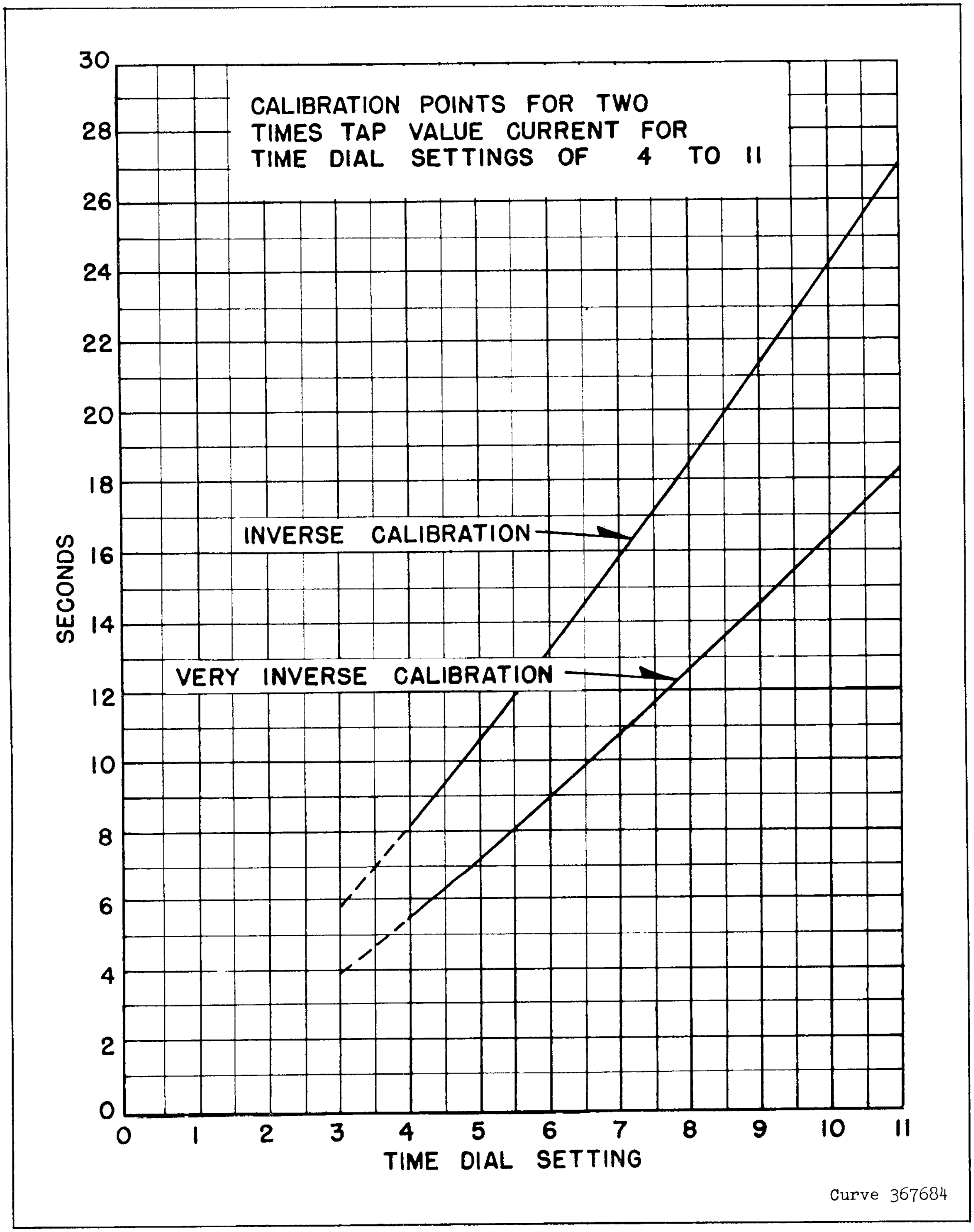


Fig. 9—The VS Time Dial Setting For Inverse And Very Inverse Calibration At 2 Times Minimum Trip.

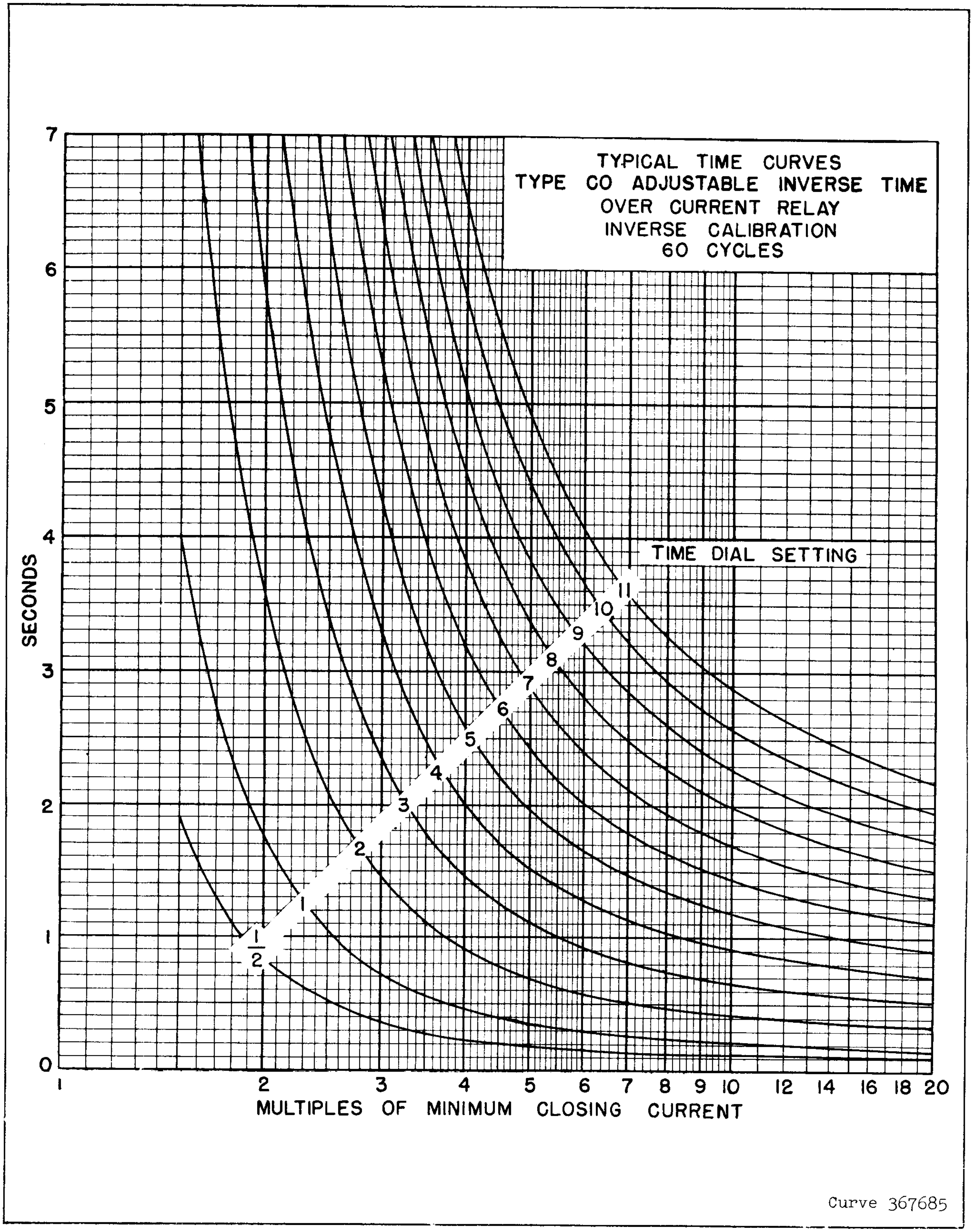


Fig. 10—Typical 60 Cycle Time Curves for the Inverse Calibration.

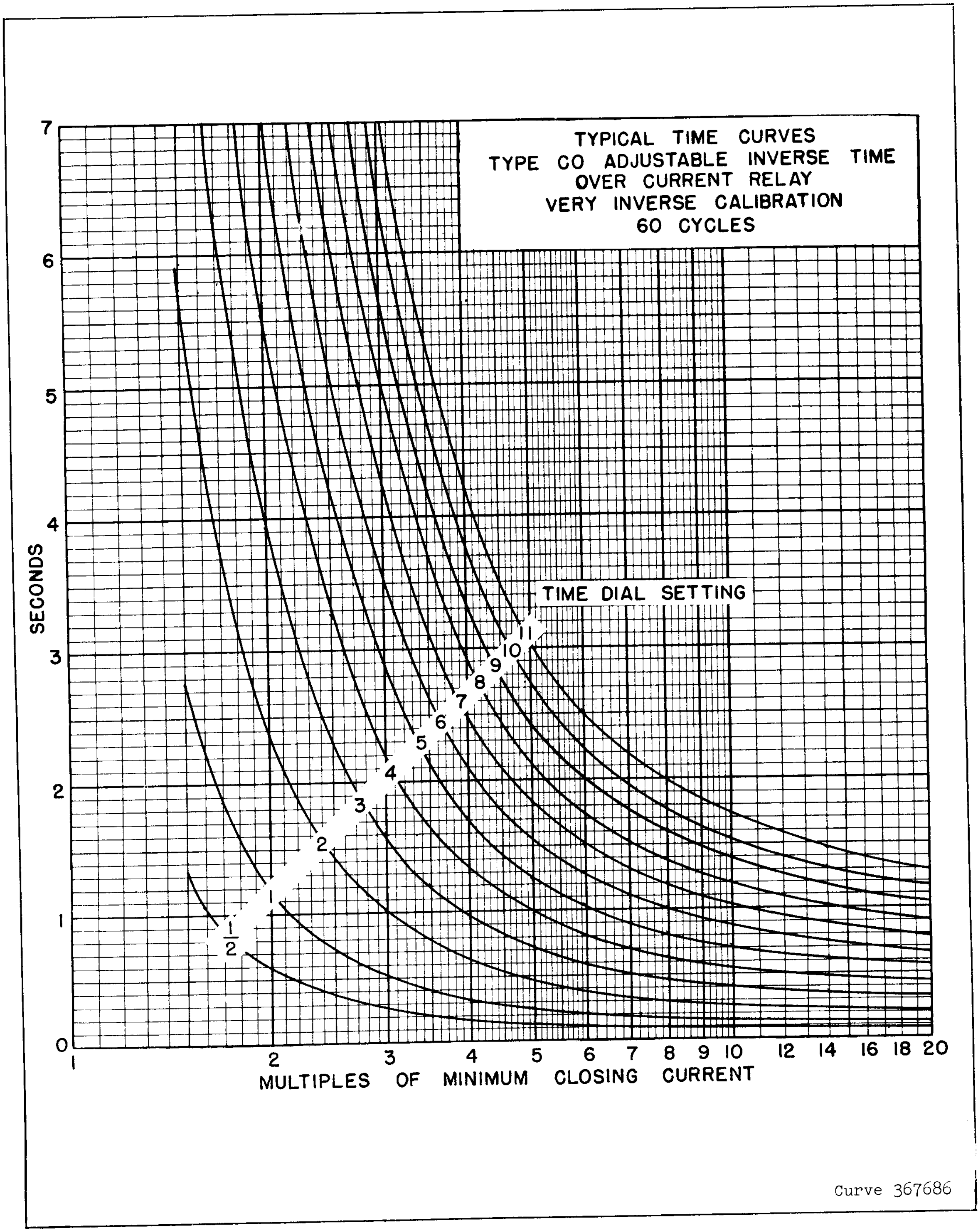
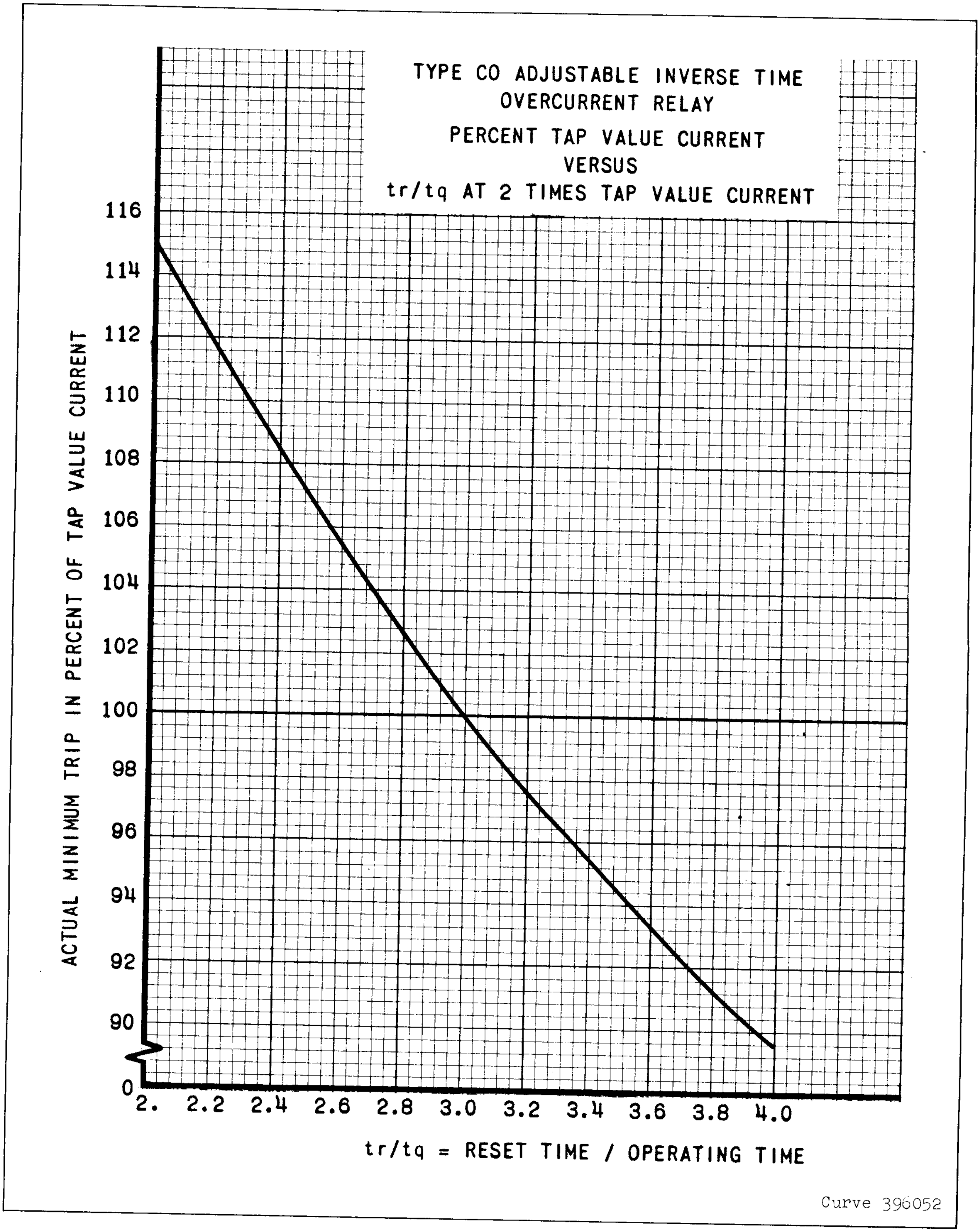


Fig. 11—Typical 60 Cycle Time Curves for the Very Inverse Calibration.



* Fig. 12—Curve for Determining Actual Minimum Trip Current in Percent of Tap Value Current.

The star-delta auxiliary current transformer is the same as used with the type HZ relay and is described in I. L. 41-535.

SETTINGS

The type HRZ relay requires two separate settings: one for the instantaneous HZ element and the other for the CO element. Each will be considered below:

The following nomenclature is used for the discussion of the HZ settings:

Z = the line-to-neutral ohmic impedance. The impedance for 80 to 90% of the protected line section.
R_c = the current transformer ratio.
R_v = the potential transformer ratio.
T = the instantaneous HZ element current tap.
S = the instantaneous HZ element current core screw.

Instantaneous (HZ) Element Settings

This element is set to give instantaneous protection over approximately 90% of the protected line section. Since the impedance of the voltage coil is the same at all times, the balance point of the element is adjusted by changing the pull on the current coil. This is done by taps (T) on the current coil winding and by the core screw (S) which varies the magnetic air gap for the current flux.

The most satisfactory method of arriving at the tap settings is by the use of the following equations:

Instantaneous Element Receiving Delta Current:

$$TS = \frac{10\ Z\ R_c}{R_v} \qquad (1)$$

Instantaneous Element Receiving Star Current:

$$TS = \frac{17.3\ Z\ R_c}{R_v} \qquad (2)$$

The nomenclature is as defined above. The tap, T, is obtained by dividing the TS product by S to give an available tap number. When changing taps, the extra tap screw should be screwed in the desired tap before moving the existing tap screw to prevent open circuiting the current transformers.

The numbers on the core screw appear in ascending order as the core screw is screwed into the core. In some cases, a question of doubt may arise whether the scale setting is correct, or is out by one full turn of the core screw. In such a case, the point may be verified by turning the core screw all the way in. Then back out the core screw until the highest scale marking and then continuing to back it off until the desired value appears exactly under the end of the pointer. Sufficiently accurate setting can be made by interpolating between the marked points when necessary.

The above formulas are based on the relay being used on a 60° line and are correct for lines of that angle. For lines other than 60° a slight error is introduced which may be as much as 8% and 6% on 40° and 80° lines respectively. However, the formula relay setting can be corrected for lines other than 60° by using the curve of Figure 5.

The formula settings are sufficiently accurate for most installations, where it is desired to set the balance point more accurately the tap and scale values may be checked by applying to the relay the voltage, current and phase angle conditions which will be impressed on it for a fault at the desired balance point. A slight change in the scale value from that calculated may be required so that the relay will just trip for the simulated fault at the balance point.

As an example, the instantaneous element is to be set for 90% of the line section AB which is 6 ohms long. The current transformer ratio is 200/5 star-connected with the star-delta auxiliary current transformer supplying delta current to the instantaneous element coils. The potential transformer ratio is 1000/1. Using equation (1)

$$TS = \frac{10 \times .90 \times 6 \times 40}{1000} = 2.16$$

Set tap 2 on the 0.2 to 2.0 ohm relay and core screw = 1.08. NOTE: The relay should not be required to operate when the drop from the relay to the fault for minimum fault is less than 5 relay volts.

Settings for the CO Element

There are two settings-namely the current value at which the relay closes its contacts and the time required to close them.

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 the proper selective action can be obtained throughout the system.

Current Setting

The connector screw on the terminal plate above the time dial 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 4.0 - 5.0 - 6.0 - 7.0 - 8 - 10 - 12 amperes, or as marked on the terminal plate.

Time Dial Setting

The time dial limits the motion of the disc and thus varies the time of operation. The latter decreases with lower time dial settings as shown in the typical time curves.

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

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not require readjustment after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, or if it is desired to change the operating characteristic, such as from inverse to very inverse, 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.

Instantaneous Impedance (HZ) Element

Refer to Figure 3. For the 60 cycle relays adjust the stop screw on the rear of the beam to give a clearance of .025 inch between the rear of the beam and the voltage iron circuit. This may be checked with a feeler gauge. With the beam in the reset position, i.e., back against the stop, adjust the gap between the adjustable iron and the beam to .009 inch. Care should be taken in this adjustment to keep the gap the same on both sides. Also, with the beam in the same position, adjust the gap between the front end of the beam and the stop in the upper core screw to .020 inch.

The beam should be balanced as follows. Connect the relay as shown in the test diagram, Figure 13. With any tap and scale setting, check the impedance measured by the relay with 35 volts potential restraint. Apply 5 volts restraint and adjust the balance weight on the beam until the beam just trips with 1/7 of the current required to trip with 35 volts restraint. Make certain that the stop on the voltage side is absolutely clean, otherwise the impedance at which the beam trips may be affected, particularly at the low voltages. The stop can be easily cleaned by drawing a piece of clean white paper between the beam and the stop while the beam is firmly pressed down.

The stationary contacts should be adjusted to give .015 inch clearance between them and the silver bridge on the beam when the beam is in the reset position. The bridge should be made to touch both contacts simultaneously, and deflect the contact springs at least .010 inch before the beam strikes the bronze stop on the core screw.

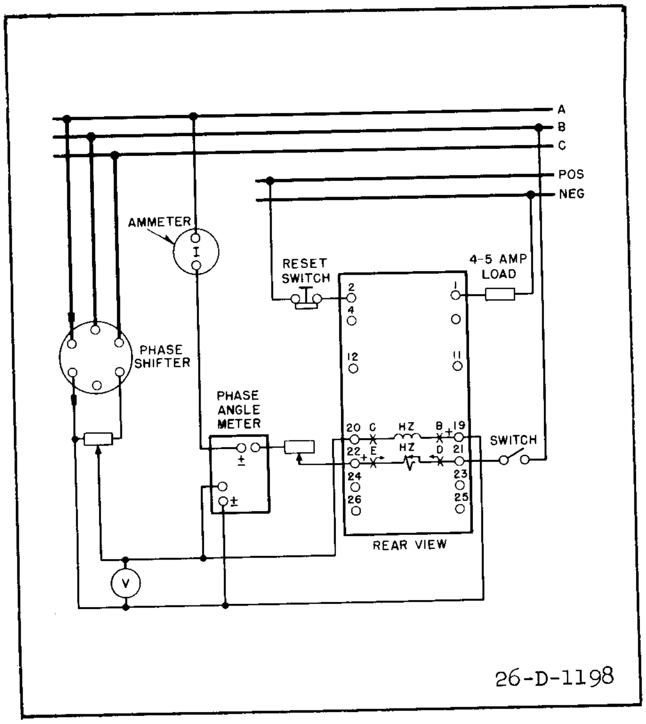


Fig. 13—Diagram Of Test Connections For The Instantaneous (HZ) Element Of The Type HRZ Relay In The Type FT Case. Omit Test Switches For The Relay In Standard Case.

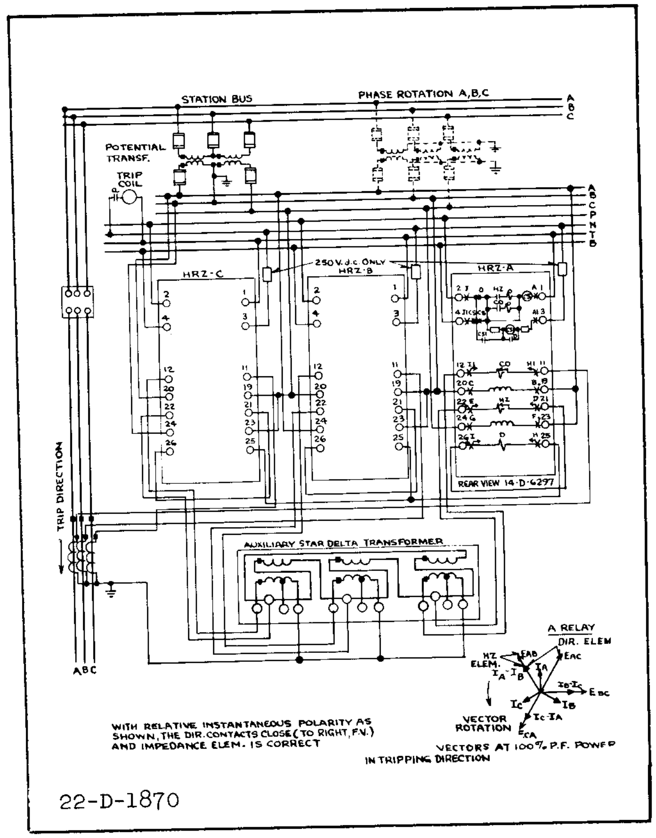


Fig. 14 —External Connections For The Type HRZ Relay In The Type FT Case. Omit Test Switch For The Relay In Standard Case.

It is difficult to accurately adjust the contacts by eye. A good method consists in first adjusting one of the contacts to the correct gap and then applying just sufficient current to trip the beam against a restraint of about 5 volts. While the beam is in this position, that is, lightly pressing on the one contact, the other contact should be slowly adjusted upward by means of the set screw until it just touches the silver bridge without lifting it off the other contact. The trip circuit should be energized so that the lighting of a lamp or the tripping of an auxiliary relay will show when both contacts are made.

A further caution in regard to the contact adjustment is that too much follow or deflection of the stationary contacts will slightly delay the resetting of the high-speed element and thus the directional element contacts may get closed before the impedance contacts are open and result in unnecessary tripping.

Directional Element

Check the free movement of the directional element loop with the relay in a vertical position to see that it is free from friction and properly centered. The loop should assume a vertical position with the contacts open when the element is completely de-energized.

With the loop in the vertical position adjust the front and back stationary contacts for .020 inch separation from the vertical moving contact. Adjust the contact back stop screws to just touch the stationary contacts, then back off 1/4 of a turn to give correct contact follow. Adjust the two-stop screws which limit the movement of the loop (these screws are located to the rear of the current coil) so that the loop strikes these stops at the same instant the stationary contacts strike their back stop.

Too much follow on the directional contacts should be avoided in order to allow the directional element to reset fast enough by gravity to properly coordinate with the high speed impedance element.

Energize the loop with normal potential long enough to bring it up to temperature (about 10 or 15 minutes) and adjust the bearing screws so there is about .010 inch end play. See that the loop does not bind or strike against the iron or coil when pressed against either end jewel.

The minimum pick-up of the element is 10 amperes at 2.0 volts (unity power factor). Apply these values to the element and see that contacts make good contact in the correct direction. Reverse the direction of current to see that the contacts make good contact in the opposite direction.

When the directional element is energized on voltage alone, there may be a small torque which may hold contacts either open or closed. This torque is small and shows up only at high voltages with the entire absence of current. At voltages high enough to make this torque discernible, it will be found that only a fraction of an ampere in the current coils will produce wattmeter torque to insure positive action. This is mentioned because the slight torque shown on voltage alone has no significance in actual service and has no practical effect on the directional element operation.

Check the coordination of the directional and impedance contacts as follows. Set the impedance element on the maximum tap and scale setting. Connect the relay with the correct polarity so that the right-hand (front view) directional contacts close and apply rated d-c volts to the directional control circuit. Apply 115 volts a-c to the impedance and directional element potential coils and pass 5 amperes at unity power factor through the current circuit. Check trip circuit to see that it is not completed with the voltage on the impedance and directional elements is suddenly applied or interrupted. Do not interrupt the current circuit. Make several such tests. The trip circuit should draw about 5 amperes d-c for this test so that the contactor switch will pick up and seal in if the elements fail to coordinate. Otherwise, a failure to coordinate is not necessarily indicated by the flicker of a lamp, since the blocking resistor will prevent the pick-up of a trip coil plunger until the auxiliary contactor falls out. This coordination test has been described for the most severe conditions. Consequently, an occasional failure to coordinate may be tolerated, since, in service, the directional element will be resetting under the positive action of reverse power flow rather than under the influence of gravity alone, as described in this test. If proper coordination is not obtained, it may be necessary to reduce the follow on the directional or impedance element contacts, as the case may be.

CO Element

For relays that are used with circuit breakers that are not instantaneously reclosed, adjust the stationary contact by means of its adjusting screw such that the contact spring is just free of the front spring stop. By means of the time dial, move the moving contacts until they deflect the stationary contacts approximately 1/64 inch. Set the index pointer such that it points to the "0" mark on the time dial. Adjust the stationary contact by means of its adjusting screw until the moving and stationary contacts just touch. This adjustment is to set "0" on the time dial and provide follow for the contacts.

For relays that are used with circuit breakers that are instantaneously reclosed, adjust the stationary contact for quick opening. This is done by screwing in the contact adjusting screw until the stationary contact rests solidly against the contact back stop. By means of the time dial, move the moving contacts until they just touch the stationary contact. Set the index pointer such that it points to the "0" mark on the time dial.

The adjustment of the spring tension and the tap value adjuster are most conveniently made with the damping magnet removed. The reason for this is both adjustments require the balance of two torques which can best be recognized with no damping magnet to retard the motion of the disc.

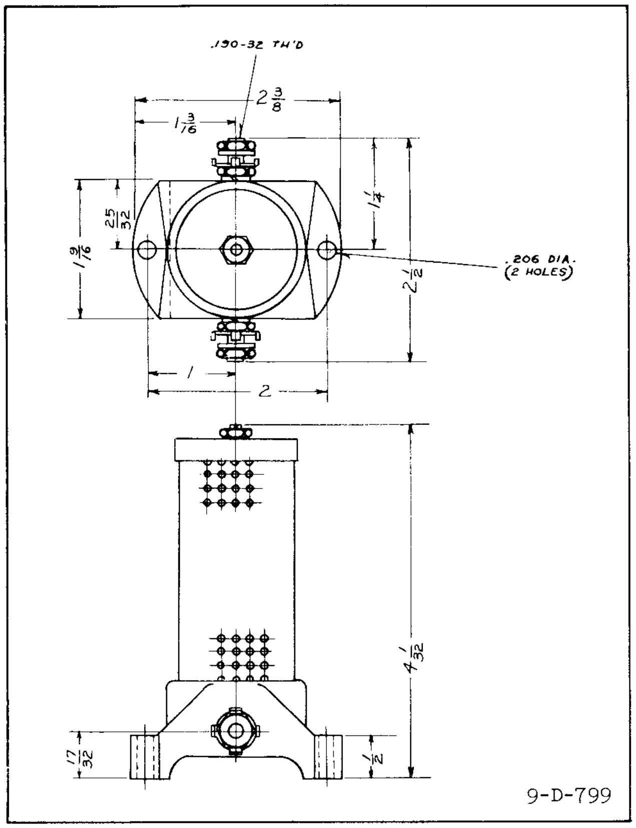


Fig. 15 —Outline And Drilling Plan For The External Control Circuit Resistor For The 250 Volt d-c Relays. For Reference Only.

With the time dial still set on "0", wind up the spiral spring by means of the spring adjuster until approximately 6-3/4 convolutions show. This is an initial rough adjustment. From this preliminary setting, and using minimum tap setting, adjust the spring tension so that the electrical torque balances the spring torque at a fixed value of current at #10-1/2 and #1/2 time dial settings. The best way to do this is to first measure the actual current required to balance the spring torque at the #1/2 and #10-1/2 time dial settings. If less current is required to balance the spring torque at the #10-1/2 position than at the #1/2 position, it is an indication that the spring needs to be wound up more, and vice-versa. All spring convolutions must be free. This setting of the spring will not necessarily be at tap value of current. By winding up or unwinding the spring as required, the current required to move the disc at the extreme limits of its travel (and consequently through the entire range of travel) may be made constant within very close tolerances.

After having balanced the spring torque and the electrical torque as above to match at a substantially constant value of current, then adjust this constant current value up or down as required to match the tap value current by means of the tap value adjuster located on the right hand leg, front view, of the electromagnet. Moving the slider toward the top decreases minimum trip current and moving the slider toward the bottom increases minimum trip current. The slider must be clamped tight when checking this adjustment.

Time Curve Calibration

After checking the adjustments as outlined above replace the permanent magnet and adjust it to calibrate the relay at 2 times tap value current. This adjustment is made by means of the damping magnet keeper screw. Adjust the keeper screw position such that the relay will operate in the time as defined by the curve of Fig. 9 for inverse or very inverse depending upon the calibration desired. For example, if the inverse calibration is desired, the damping magnet may be adjusted for 27 seconds from the #11 time dial setting. If the very inverse calibration is desired, the adjustment may be made for 18.3 seconds from the #11 time dial setting. Time values somewhat greater than those shown for the inverse calibration and somewhat less than those shown for the very inverse calibration may be obtained if particular problems require them.

The time of operation at 20 times tap value current is adjusted by means of the two adjustable magnetic plugs. Adjust the plug position such that the relay will operate in the time as defined by the current vs time curves of Fig. 10 or 11 for inverse or very inverse calibration depending upon the characteristic desired for which the 2 times tap value adjustment of time was made. For example, if the inverse calibration is desired, the relay may be calibrated for 2.18 seconds from the #11 time dial position at 20 times minimum trip current by screwing the right hand plug all the way in and adjusting the left hand plug for 2.18 seconds. If the very inverse calibration is desired, screw the left hand plug all the way in and adjust the right hand plug for 1.28 seconds from the #11 time dial position at 20 times minimum trip current.

Curve shapes that are different from the inverse or very inverse may be obtained by adjustable magnetic plugs. An example of this adjustment has been referred to under "Characteristics", and wherein one range of possibilities is shown by Fig. 8.

* Minimum Trip Current

The minimum trip current for a calibrated relay may be checked to an accuracy of ±5% by the use of the following formula:

$$I = \frac{I_2}{\sqrt{1 + t_r/t_2}}$$

where:

- I = Actual minimum trip current.
- I_2 = Current at a multiple of 2 times the minimum tap setting.
- t_2 = Operating time at the #11 time dial setting with I_2 applied.
- t_r = Reset time of the relay to the #11 time dial position.

To aid in determining the minimum trip current Fig. 12 has been provided in which a plot has been made of the minimum trip current in percent of tap value current versus values of t_r/t_q.

Example: I_2 = 8 amperes
t_2 = 27 seconds
t_r = 81 seconds
$t_r/t_q \approx 3$
I = 100% TAP VALUE CURRENT, Fig. 12.

Contactor Switch (Seal-in-Switch)

Turn the relay up side down. Screw up the core screw until the contact ring starts rotating. Now back off the core until the contact ring stops rotating. Back off the core screw one more turn and lock in place. Adjust the two nuts at the bottom of the switch so that there is 3/32 inch clearance between the moving contact ring and the stationary contacts in the open position. The guide rod may be used as a scale as it has 52 threads per inch, therefore, 5 turns of the nuts will equal approximately 3/32 inch.

The switch should pick up at 2 amperes d-c. Test for sticking after 30 amperes have been passed through the coil.

(Directional Control Circuit)

The adjustments are the same as for the seal-in contactor switch except that the contact separation should be 3/64 inch. The switch should pick-up at not more than 80 volts d-c. Apply 140 volts d-c to the circuit and see that the contacts drop out when the coil is shorted by the left-hand directional contacts. For the 250 volt d-c relays the pick-up should be 165 volts and the contacts should drop-out when the directional element contacts short-circuit the coil with 250 to 280 volts applied to the circuit. Energize the directional element with 50 volts and 10 amperes in phase suddenly applied. The contactor switch must operate the first time the directional contacts close without fluttering or bouncing of the contacts.

Operation Indicator

Adjust the indicator to operate at 1.0 ampere d-c gradually applied. Test for sticking after 30 amperes d-c is passed through the coil.

Instantaneous Trip Attachment (When Supplied)

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. This disc should be lowered or raised to the proper position by loosening the locknut which locks

TYPE HRZ RELAY

the Micarta disc and rotating the Micarta disc. The nominal ratio of adjustments 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. It should be adjusted for about 2/3 of the minimum pickup.

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

The burdens of the various circuits of the 60 cycle relay are as follows:

Ampere Range	Tap	Continuous Rating (Amperes)	One Second Rating* (Amperes)	Power Factor AngleØ	Volt Amperes△ At Tap Value Current	At 3 Times Tap Value Current	At 10 Times Tap Value Current	At 20 Times Tap Value Current
0.5/2.5-	0.5	2	56	72	2.38	21	132	350
	0.6	2.2	56	71	2.38	21	134	365
	0.8	2.5	56	69	2.40	21.1	142	400
	1.0	2.8	56	67	2.42	21.2	150	440
	1.5	3.4	56	62	2.51	22	170	530
	2.0	4.0	56	57	2.65	23.5	200	675
	2.5	4.4	56	53	2.74	24.8	228	800
2/6-	2	8	230	70	2.38	21	136	360
	2.5	8.8	230	66	2.40	21.1	142	395
	3	9.7	230	64	2.42	21.2	149	430
	3.5	10.4	230	62	2.48	22	157	470
	4	11.2	230	60	2.53	22.7	164	500
	5	12.5	230	58	2.64	24	180	580
	6	13.7	230	56	2.75	25.2	198	660
4/12-	4	16	460	68	2.38	21.3	146	420
	5	18.8	460	63	2.46	21.8	158	480
	6	19.3	460	60	2.54	22.6	172	550
	7	20.8	460	57	2.62	23.6	190	620
	8	22.5	460	54	2.73	24.8	207	700
	10	25	460	48	3.00	27.8	248	850
	12	28	460	45	3.46	31.4	292	1020

*Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

ØDegrees current lags voltage at tap value current.

△Voltages taken with Rectox Type Voltmeter.

DIRECTIONAL ELEMENT SERIES COIL

Rating	V.A. at 5 Amperes	Power Factor	One Second Rating (Amperes)
5	3.5	45° lag	140

DIRECTIONAL ELEMENT POTENTIAL POLARIZING COIL, ALONE

Rating	V.A. at 115 Volts	Power Factor
115V	9	28° lag

IMPEDANCE ELEMENT CURRENT COILS

Tap	V.A. at 5 Amperes	Power Factor
45	2.0	30° lag
13.5	0.55	30° lag

IMPEDANCE ELEMENT POTENTIAL COILS

V.A. at 115 Volts	Power Factor
1.8	20° lag

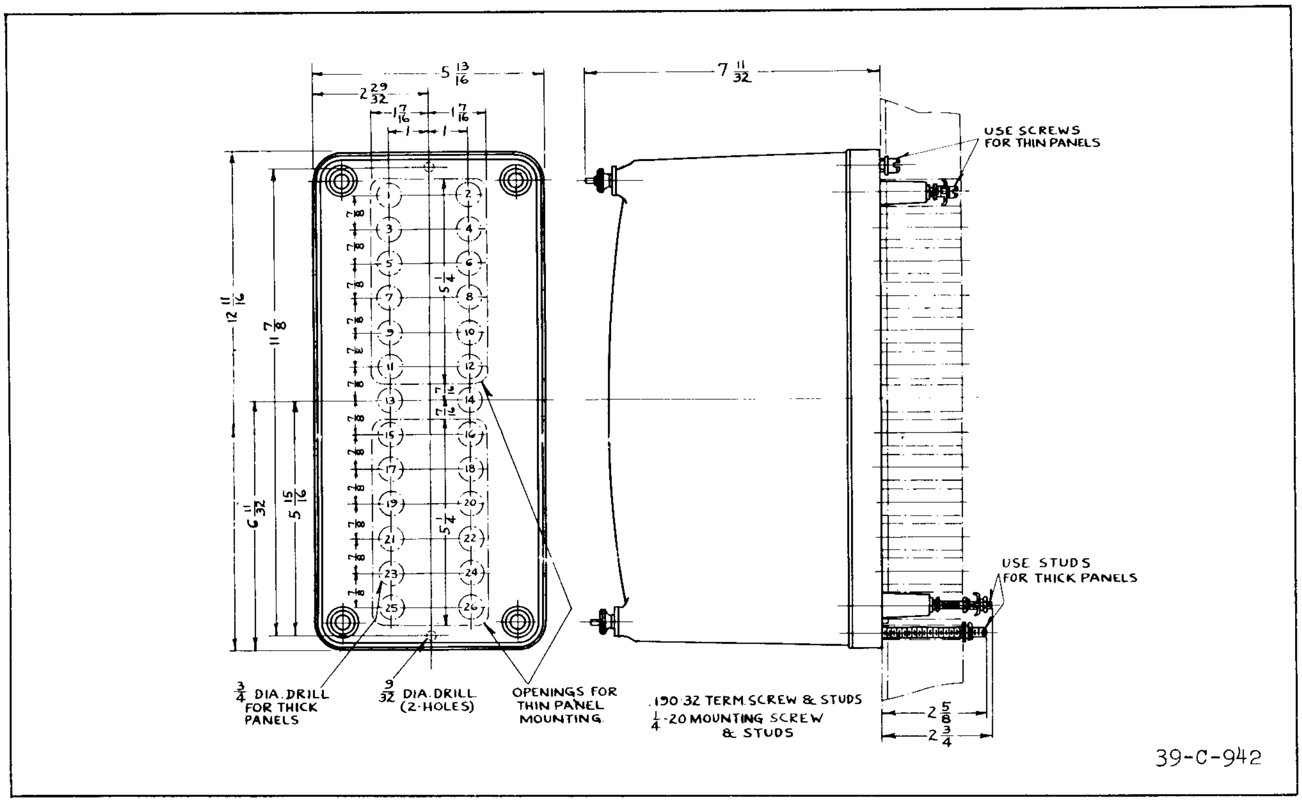


Fig. 16 —Outline And Drilling Plan For The Standard Projection Type Case. See The Internal Schematics For Terminals Supplied. For Reference Only.

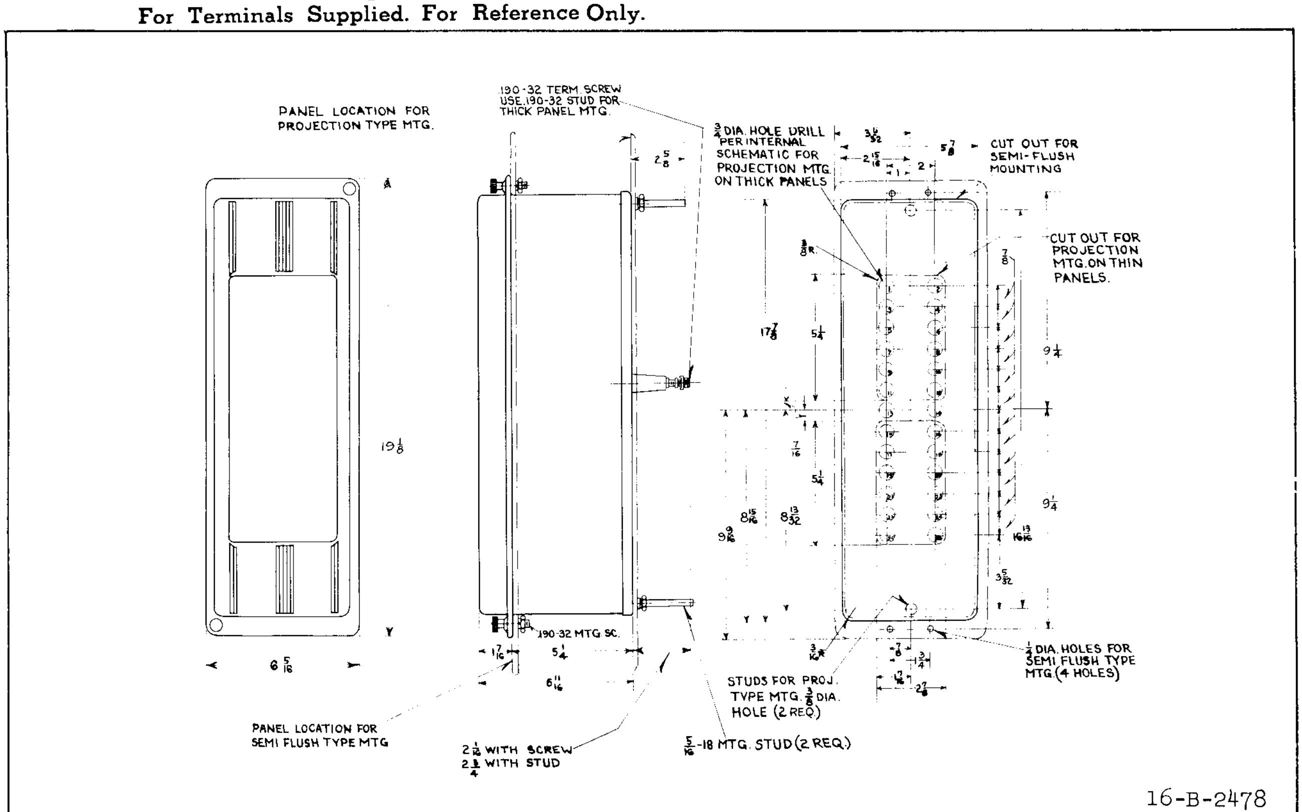


Fig. 17 —Outline And Drilling Plan For The M20 Semi- Flush Or Projection Type FT Flexitest Case. See Internal Schematic For Terminals Supplied. For Reference Only.

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

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