INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE HZM DISTANCE RELAY
(WITH ANGULAR DISPLACEMENT 60° to 120°)

12/16/48

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

The type HZM relay is a three element high speed relay of the modified zoned distance type operating instantaneously or with a time delay depending upon the location of the fault. The relay is used for phase fault protection on transmission systems and is designed to be used independently or in the high speed carrier relaying system.

The type HZM relay measures the impedance of the line to which it is connected by measuring the ratio of the current and voltage supplied to it. The impedance characteristics may be adjusted and modified so that tripping at the faulted line angle is favored to permit tripping on fault impedances when it is desirable to do so while preventing tripping out on synchronous surges of such magnitude that the system will recover, even though the apparent impedance during such surges is considerably below that of the fault impedance. In the same manner tripping under heavy load conditions may be prevented, especially on the longer transmission lines, when the load impedance and the fault impedance are of the same magnitude. The type HZM relay accomplishes this by combining a distance response characteristic with a directional discrimination which can be regulated and adjusted both in magnitude and angle. The directional discrimination is adjusted to produce a high sensitivity at the fault impedance phase angle but a minimum sensitivity at the load impedance phase angle and at the synchronous surge impedance phase angles from which the system can recover. Therefore this relay with its adjustable characteristics can be set to fit the particular conditions of the line to be protected.

CONSTRUCTION

The type HZM relay contains three impedance elements, a synchronous timer, a directional element, four auxiliary contactor switches and three operation indicators, one for each impedance zone. In addition there is an external box with a phase shifter and mixing transformer for each impedance element.

Impedance Element

Construction details of these three elements are identical and are shown in Fig. 1. A balanced beam is restrained from operating by two voltage coils on the back end, and is pulled downward on the front contact end by a current coil. The fluxes of these two potential coils are shifted out of phase so that practically a constant balance can be obtained regardless of the phase angle between the current and voltage fluxes. A tap screw on the front of the element permits changing the number of turns on the current coil for coarse adjustments and a core screw on the bottom of the element changes the current coil electromagnet air gap for the fine adjustment. These two adjustments provide stepless impedance circle radius settings over the ten ohms to one ohm impedance range.

The silver moving contact is of the low-bounce type while a beam shock absorber is mounted on each of the impedance element beams to reduce the vibration of the moving element and to act as a counterweight.

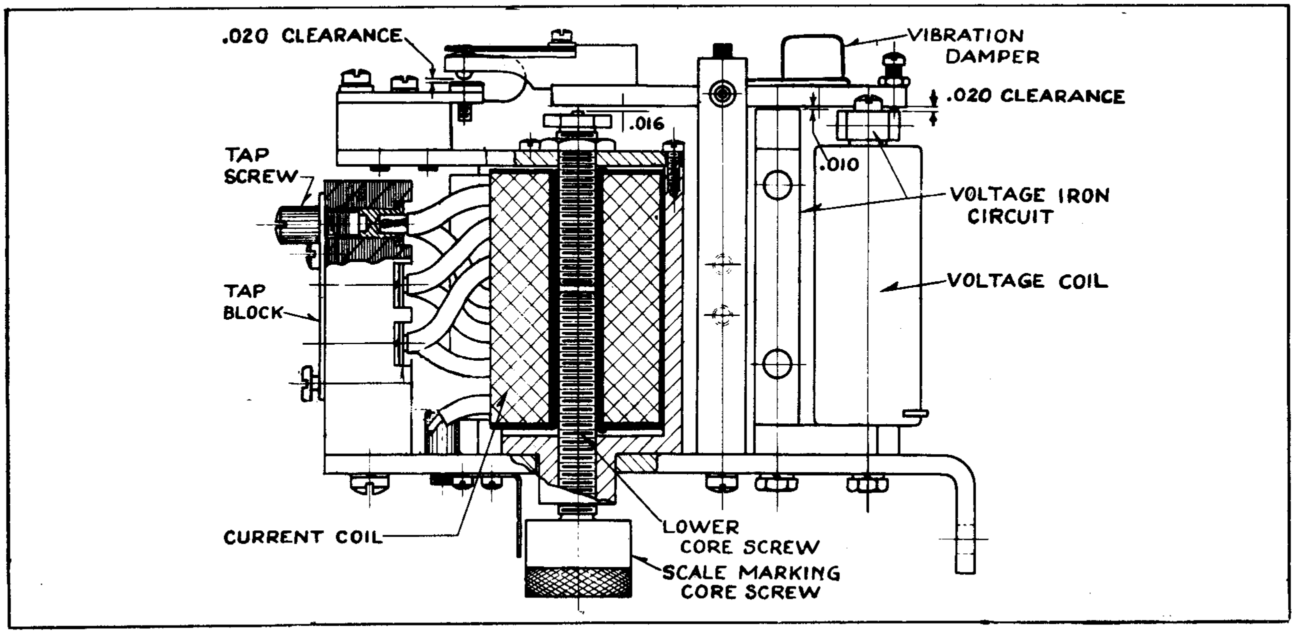

Fig. 1—Sectional View of the Impedance Elements.

Synchronous Timer

The timer is a small synchronous motor which operates from the current circuit thru a saturating transformer, and drives a moving contact arm thru a gear train. The contact on the moving arm is a cylindrical silver sleeve, loosely fitted on the moving arm. In making contact, this sleeve rolls across two vertically projecting stationary butt contacts to bridge the gap between them. Two sets of stationary contacts are mounted on a Micarta insulating block which is adjustable around a semi-circular calibrated guide. The maximum time setting of the timer is three seconds.

The synchronous motor has a floating rotor which is in mesh with the gear train only when energized. The rotor falls out instantly when the motor is deenergized, allowing a spring to reset the moving arm.

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 angles to each other with the one-turn voltage loop in the air gaps of the current coil flux path. The interaction of tne current and voltage fluxes produces torque and rotates the loop in one of two directions, depending on the direction of power flow.

From the movable aluminum loop extends a Micarta arm which carries a small low-bounce contact. The stationary contact screw fastens into a rigid projecting arm. Contact follow is secured by permitting the loop to travel for a short distance after the contacts close, thus deflecting the leaf spring. This is done by an adjustable stop screw. Another stop screw limits the travel of the loop in the opening direction. These stop screws act directly on the loop. This directional element has nearly true wattmeter characteristics.

Auxiliary Contactor Switches

These are small solenoid-type d-c switches. A cylindrical plunger with a silver disc mounted on its lower end moves in the core of the solenoid. As the plunger travels upwards, the disc bridges three silver stationary contacts.

Operation Indicator

The operation indicator is a small solenoid coil connected in the trip circuit. When the coil is energized, a spring-restrained armature releases the white target which falls by gravity to indicate completion of the trip circuit. The indicator is reset from outside of the case by a push rod in the cover or cover stud.

Auxiliary Box

The type HZM auxiliary box contains three identical phase shifting and transformer units connected so as to modify the characteristics of three relay impedance elements. All the units function independently so that the characteristics of each impedance element may be modified independently of the other impedance elements.

The addition of an external modifying auxiliary box makes it possible to displace the impedance circle characteristic of the impedance element as plotted on "R" and "X" coordinates, from a circle with the center at the origin to a circle with the center displaced from the origin. The center of the impedance circle may be angularly displaced over the range in current lag angle shown on the phase angle adjustment (Ø) and the center may be displaced in magnitude by the combined settings of the primary tap on the current transformer (Z_R) and the vernier potentiometer setting (A) (Fig. 5).

If it is desired to modify only the third impedance elements, one auxiliary box is required. If the third and second impedance elements in the three phases are to be modified, two auxiliary boxes will be required. If all impedance elements are to be modified in the three phase relays, three auxiliary boxes will be required.

OPERATION

The type HZM distance relay is designed to provide a modified operating characteristic that gives improved protection to long transmission lines. The relay consists of two units, the conventional impedance relay and an auxiliary box.

The impedance relay measures the impedance of the line to which it is connected by measuring the ratio of the current and voltage supplied to it. The relay is connected to receive a current and voltage proportional to those existing on the high-tension line. With a fault in zone 1, Fig. 6a, a given amount of current, I, will flow from the relay location to the fault. With zero voltage existing at the fault, the voltage at the relay must be equal to the drop in the line due to the current, I, or equal to IZ where Z is the impedance to neutral of the line from the relay to the point of fault. The ratio of the two values is $IZ/I=Z$. Thus, the ratio is constant for any value of current as the voltage on the relay is equal to the current times the line impedance. Therefore, if the first impedance element of the type HZM relay is adjusted by the core screw and taps on the current coil for a value of current such that the pull of the current coil is just equal to the potential restraint for a fault at the end of zone 1 in Fig. 6a, the beam will be balanced for a fault at that point for any value of current. Now, if the fault occurs to the right of this balance point, the beam will not trip as the voltage pull is the greater due to a larger amount of impedance and correspondingly larger potential restraint than the beam is balanced for. The second impedance element is adjusted to balance for a fault at the end of zone 2, and, therefore operates for faults anywhere up to this point. Likewise, the third impedance element is adjusted to balance for a fault at the end of zone 3 and operates for faults in all three zones.

The type HZM relay is a modified impedance relay that is identical to the conventional balanced beam impedance relay except that the restraint is produced by the potential and the current instead of by potential alone. The mixing of the current and potential energy to produce restraint torque is done external to the relay and the resultant energy fed into potential coils of the beam impedance element.

The trip circuit for each of the three zones differs depending upon whether the third impedance element is connected so that its characteristics are similar to those of the first and second impedance elements or its

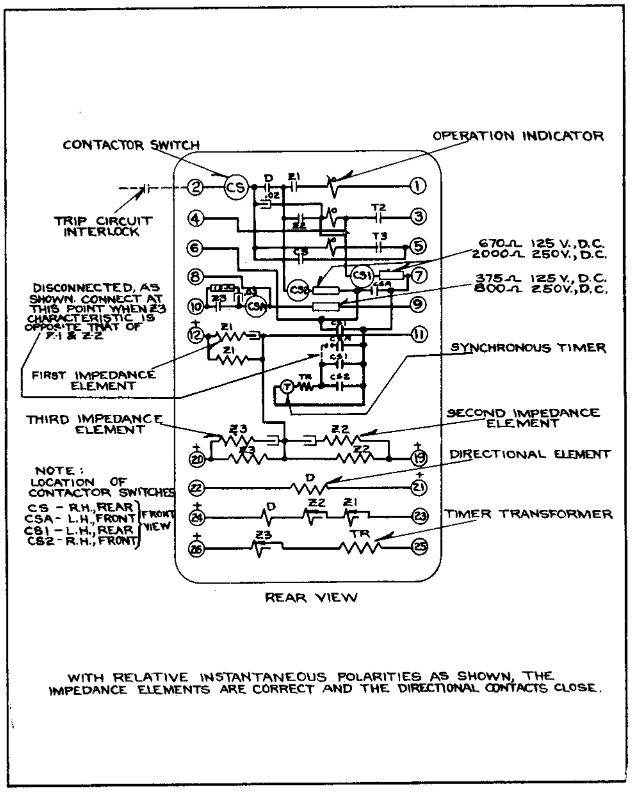

Fig. 2—Internal Schematic of the Type HZM Relay in the Standard Case.

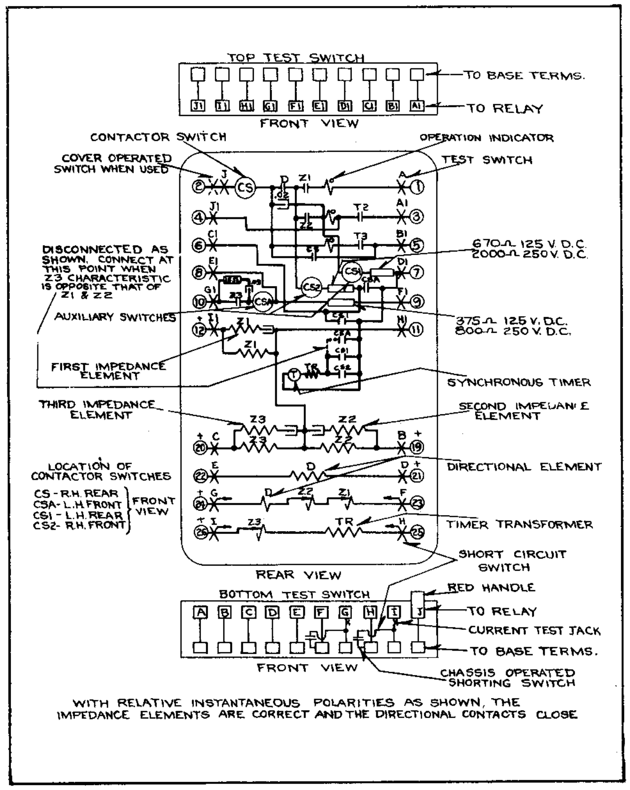

Fig. 3—Internal Schematic of the Type HZM Relay in the Type FT Case.

characteristics is directionally reversed, which is done usually in carrier current applications.

With the normal third impedance element, trip circuits for the three zones consists of the following contacts: First zone - directional, and first impedance element contacts; Second zone - directional, second impedance, and first set of timer contacts; Third zone - directional element and second set of timer contacts.

With the reversed third impedance element, trip circuits consist of the following contacts: First zone - directional, and first impedance element contacts; Second zone - directional, second impedance, and first set of timer contacts; Third zone - second set of timer contacts.

The coil of contactor switch CS is in series with all of the tripping circuits and with the trip coil of the breaker. If the type HZM relays are used without carrier the contactor switch contact seal around the relay contacts when the trip circuit coil is energized thereby relieving them of the duty of carrying the tripping current (Fig. 8). These contacts remain closed until the trip circuit is opened by the auxiliary switch on the breaker. If the relays are used with carrier, the contactor switch CS in the type HZM relay is supplemented and the contactor switch in the carrier auxiliary relay performs this function. An auxiliary switch on the circuit breaker must be provided so that when the circuit breaker is tripped, the tripping circuit will be opened by the switch.

CHARACTERISTICS

The modified characteristic is shown in Fig. 5. A pure impedance element characteristic plotted on the "R" and "X" coordinates would be a circle with the center at the origin. The type HZM relay is so designed that it is possible to displace the center of any impedance circle from the axis over an angle from 60° to 120° current lag.

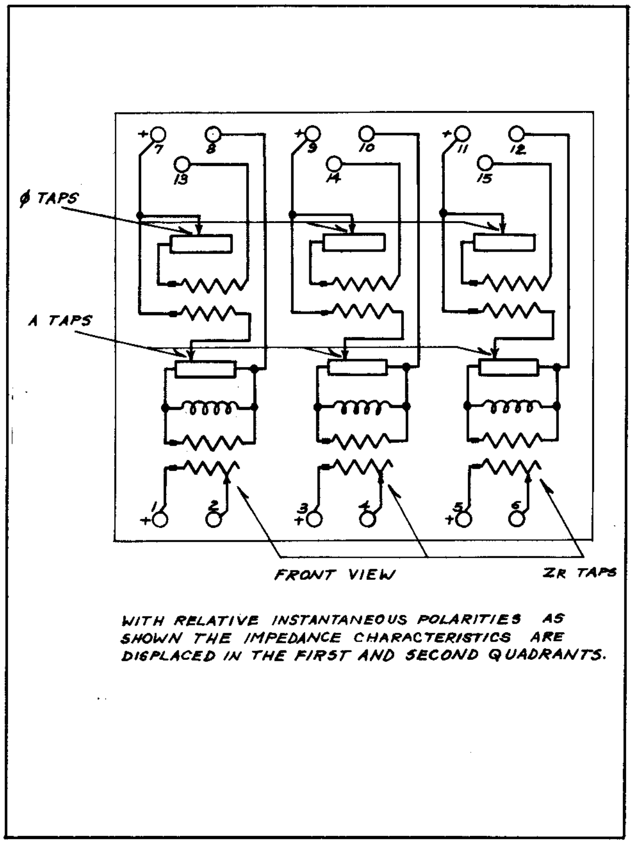

Fig. 4—Internal Schematic of the Three Element Auxiliary Unit for the Type HZM Relay.

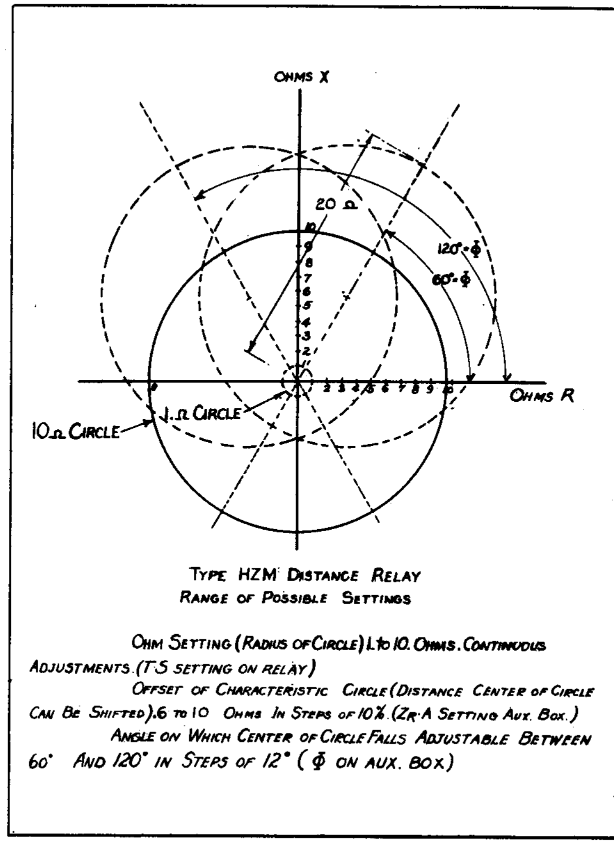

Fig. 5—Operating Characteristics and Ranges of the Type HZM Relay.

There are three variables that can be controlled to fit the transmission line protection requirements making the modified impedance relay very flexible in its applications.

1. The radius of the impedance circle on the "R" and "X" coordinates is entirely determined by the tap (T) and core screw (S) settings of the impedance element.
2. The magnitude of displacement of the center of the impedance circle from the origin is determined by the auxiliary box current transformer primary tap (Z_R) for the coarse adjustment multiplied by the vernier potentiometer adjustment (A) for the fine adjustment.
3. The angle of displacement of the impedance circle can be varied from 60° to 120° current lag by the auxiliary box phase angle adjustment (ϕ).

Each of the three preceding adjustments can be made separately and independently of one another so that a large combination of settings are possible with three independent variables.

The type HZM relay is available in one impedance range 1.00 to 10.0 ohms impedance circle radius (TS) with .66 to 10 ohm impedance circle center displacement (Z_RA) over a phase angle from 60° to 120° current lag (ϕ). All three impedance elements are identical and hence have the same range of adjustment. The tap and scale marking on the relay elements are as follows: All impedances are in terms of secondary ohms.

<u>Impedance Elements (1.0 to 10.0 Ohms)</u>

1. Radius of Impedance Circle

TAPS (T)					
6.2	9.4	13.5	20.8	29.8	45.

Core Screw Markings (S)				
1.4	1.6	1.8	2.0	2.2

Auxiliary Box

2. Displacement of impedance circle.

Coarse Ohm Taps (Z_R)						
0	.66	1.00	1.67	2.67	4.17	6.67

Fine Ohm Taps (A)
Continuous Adjustment From 1.00 to 1.50

3. Phase Angle Displacement (Ø)
Continuous Adjustment from 60° to 120° current lag

The time delay on the synchronous timer for the second and third impedance elements is adjustable in calibrated steps of 20 cycles from 0 to 180 cycles (60 cycle basis).

SETTINGS

The type HZM relay requires a setting for each of the three impedance elements and on the synchronous timer for Second and Third Zone time.

Z = the line-to-neutral ohmic impedance of the protected line from the relay to the desired balance point in terms of primary ohms.

For the First Element — 70 to 80% of the protected section.

For the Second Element — Approx. 50% into the adjacent section.

For the Third Element — Approx. 25% into the third line section.

When the balance impedance has been determined, the phase angle and magnitude of the minimum load ohms and the phase angle and magnitude of the minimum synchronizing surge ohms from which the system can recover should be determined or estimated to complete the analysis.

It will expedite the application by plotting the transmission line characteristics on "R" and "X" coordinates. An operating circle should then be drawn of a diameter and location to fulfill the following conditions.

1. The circle must pass through the point of the vector Z and must completely enclose the vector Z.

2. The circle must not enclose the point of the vector of minimum load ohms or of minimum synchronizing surge ohms from which the system can recover.

3. The circle should enclose the origin or intersection of the "R" and "X" axis by an appreciable value so as to be certain that under all possible conditions of operation the relay will trip for faults very close to the relay. This is particularly true of the first, or instantaneous distance element. It is recommended that the radius of the circle minus the displacement of the center of the circle from the intersection of the "R" and "X" axis be equal to at least 20% of the sum of the radius of the circle and the displacement of the center of the circle.

4. The angular displacement of the center of the circle must be within 60° to 120° current lagging phase angle.

After the operating circle for relay action has been obtained, it is necessary to adjust the relay characteristics to match this circle.

The radius of the circle in ohms should be measured and the impedance element set in accordance using the formula:

$$TS = \frac{10 Z_O R_C}{R_V}$$

where

T = The impedance element current tap value.

S = The impedance element current core screw value. The values appear as a series of dots on the drum of the lower core screw adjusting knob.

Z_o = Radius of circle, as determined in the preceding paragraphs, in ohms primary.

R_c = The current transformer ratio.

R_v = The potential transformer ratio.

The tap, T, is obtained by dividing the TS product by S to give an available tap number. When changing taps with the relay energized, the extra tap screw should be screwed in the desired tap before removing 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 just comes under the end of the pointer. This will occur in less than 3/4 of a turn. Then turn to correct setting. Sufficiently accurate setting can be made by interpolating between the marked points when necessary.

From the operating circle, previously constructed, measure the displacement of the center of the circle from the intersection of the "R" and "X" axis in magnitude and angle.

The auxiliary box should be set in accordance with the formula:

$$Z_R A = \frac{Z_D \; R_c}{R_v}$$

(ϕ) = angular displacement of center of operating circle.

where

Z_R = Auxiliary box tap value.

A = Auxiliary box setting.

Z_D = Displacement of the center of the operating circle in ohms primary.

R_c = The current transformer ratio.

R_v = The potential transformer ratio

When changing the Z_R tap with the relay energized, the current terminals of the auxiliary box should be shorted before unscrewing the tap screw to prevent open circuiting the transformers.

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 and the auxiliary box, 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 or in the auxiliary box setting from that calculated may be required so that the relay will just trip for the simulated fault at the balance point.

As an example of the formula setting, set the first impedance element to protect a 78°, 110 KV, 60 cycle line, 143 miles long. The line to neutral impedance is .79 ohms per mile. The current transformer ratio is 600/5, and the potential transformer ratio is 1000/1. The first element is to protect 80% of the line section or for a balance point .80 x 143 x .79 = 90 ohms. The phase angle and the magnitude of the minimum synchronizing surge ohms from which the system can recover should be determined.

Plot the transmission line characteristics on "R" and "X" coordinates as shown in Fig. 7. An operating circle should then be drawn of a diameter and location to fulfill the conditions previously stated.

The radius of the circle in ohms should be measured and the impedance element set in accordance using the formula:

$$TS = \frac{10 Z_o \; R_c}{R_v}$$

$$TS = \frac{10 \times 58.5 \times 600/5}{1000/1} = 70.0$$

T will be set on 45. (Relay Tap Setting)
S will be set on 1.56 (Relay Core Setting)

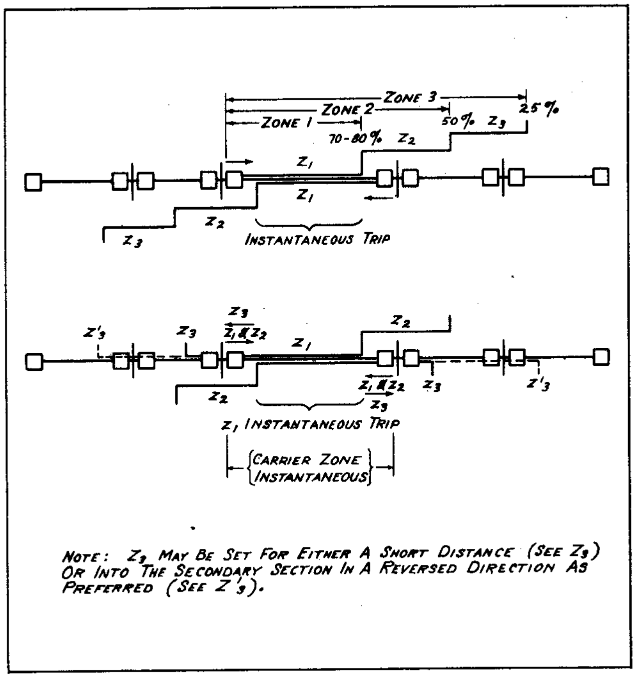

Fig. 6—Typical Settings of the Type HZM Relay in Terms of Line Length.

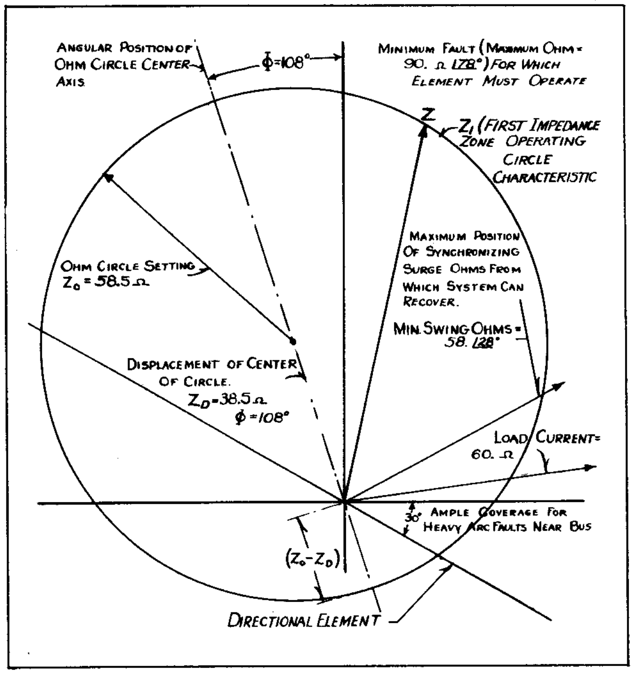

Fig. 7—Transmission Line and Relay Characteristics Plotted on R and X Coordinates in Primary Ohms.

The lag angle of the center of the circle should be measured and the phase angle adjustment on the auxiliary box (Ø) should be set to this angle. From Fig. 7 the angle is found to be 108°, therefore, Ø is set at 108°.

The distance, expressed in ohms impedance, between the center of the modified impedance circle and the intersection of the "R" and "X" axis is a separate adjustment that is made on the auxiliary box. This distance, expressed in ohms impedance, should be measured from Fig. 7 and the auxiliary box set in accordance using the formula:

$$Z_R A = \frac{Z_D\ R_c}{R_v}$$

$$Z_R A = \frac{38.5\ 600/5}{1000/1} = 4.6$$

Z_R should be set on 4.17 ohms.

A should be set on 1.1.

The setting for the second and third impedance element is obtained in the same manner as the preceding example for the first impedance element.

When the type HZM relay is used with carrier, the third zone element must be set to operate in a reverse direction, whenever the modified distance characteristic is used. This is done to assure positive carrier blocking when external faults are encountered on the adjacent line section. The dotted connection between CS-1 contact and secondary of timer current transformer (Figs. 2 and 3) indicates the internal connection changes necessary when Z-3 is used with a reversed characteristic. When this connection is made, it is also necessary to reverse the polarity of the current leads to external box terminals 5 and 6. The timer is started by either the second or third element and is directionally controlled. Dual control of the timer is required when the third zone is used with a modified characteristic.

The time delay on the synchronous timer is set to coordinate with the relays backed up by the second and third impedance elements. The setting is made by loosening the screws which clamp the contact assembly and move the complete assembly to the desired position as indicated by the scale.

On lines where taps or parallel feeders supply fault power to the adjacent sections the apparent impedance to the relay backing up the adjacent section is greater than the actual impedance. The reason for this is that the relay does not measure the additional fault current supplied by the other feeders, but at the same time, this current does increase the voltage drop from the fault to the relay. This increases the apparent impedance to the adjacent section by the ratio of the total current to the relay current. The effect on the relay impedance elements is to back up the balance point of the second and third impedance elements. In order to extend the range of back-up protection under these conditions, the second elements can be set for a balance point further than the 150% normally recommended, provided it is made to time select with the adjacent section relay second element. Similarly, the third element can be set further than normal if it is made to select with the second and third elements of the adjacent relay which it overlaps.

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 to 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. This exposes the relay elements and all the test switches for inspection and testing. The next step is to open the test switches. Always open the elongated red handle switches first before opening 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 for test as well as on its back or sides for easy inspection and maintenance.

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 short circuiting test switch prevents open circuiting that circuit when the short circuiting 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 thru 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 thru the relay are disconnected from the external circuit by opening the associated test switches. Opening the short circuiting test switch short-circuits that circuit and disconnects one side of the relay element but leaves the other side of the element connected to the external circuit thru the current test jack jaws. This circuit can be isolated by insertint 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 short circuiting test switch pair must be open when using the current test plug or insulating material in this manner to short-circuit the external circuit.

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 thru 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 thru 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 short circuiting 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 of the calibration.

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.

CONNECTIONS

Impedance Elements

The impedance to the balance point is measured from the point where the potential transformers are connected to the protected line. For protecting transmission lines, the relays should receive potential from potential transformers connected directly to the line at the point from which the impedance is to be measured.

In some applications a power transformer bank forms part of the transmission line, and potential transformers are available only on the bus side of the bank. In this case the relays may be set thru the bank to protect the line, only if the bank impedance is not too large as compared with the line impedance. If the bank impedance is too large in comparison with the line impedance, the 70 or 80% setting of the first element may cover only a very small percentage of the transmission line or in some cases not cover any of the line section. For the same reason the second and third elements will offer considerably less back-up protection over the adjacent lines. In order to use the potential transformers on the bus side of the bank under this condition, type KX compensators are used and the impedance measured from the line side of the bank to the balance points. The type KX compensators operate from the current transformers and provide voltage compensation equivalent to the drop in the power bank.

The above discussion assumes that power is fed thru the bank to faults on the line. Where a power transformer connects to a high tension transmission line and does not supply power to a line fault, low-tension potential transformers may be used without compensation. Then, the impedance to the balance point is measured from the point where the power bank connects to the protected line.

The conventional star connection of current transformers is not satisfactory where accurate distance relay protection is desired. With this connection the balance points of the impedance elements shift about 15% depending upon whether a phase-to-phase, a three phase or a double ground fault is involved. That is, if the balance point where adjusted at 80% for a three phase fault, then for a double ground fault the shift may be more or less than plus or minus 15% of the 80% setting, depending upon the ratio of the zero sequence impedance to the negative sequence impedance of the system from the source of power to the fault. This error can be entirely eliminated by making use of the vector difference between the line current, (i.e. delta currents) for actuating the relay.

The most common method is to connect the main current transformers in star and use a set of auxiliary 5/5 ratio transformers to supply delta currents to impedance and directional elements, as shown in Figure 8.

The delta voltages used on the impedance elements of the relays should be in phase with the delta current, at unity power factor.

Directional Element

The directional element coils should be connected to receive current that leads the voltage by 60°, when the line power factor is 100%. The advantage of connecting the directional element in this manner is that for anything except a three-phase fault the voltage applied to the relay required to trip will be equal to, or in excess of, the normal line-to-neutral voltage.

Trip Circuit

The contactor switch operates on a minimum of 1.0 ampere, but the trip circuit should draw at least 4 or 5 amperes in order to reduce the time of the operation of the switch to a minimum and provide more positive operation. If the type HZM relay is used to trip an auxiliary multi-contact relay, provision should be made for loading down the trip circuit with a resistor in parallel with the operating coils of the auxiliary relay. Also, since the total trip circuit resistance in the

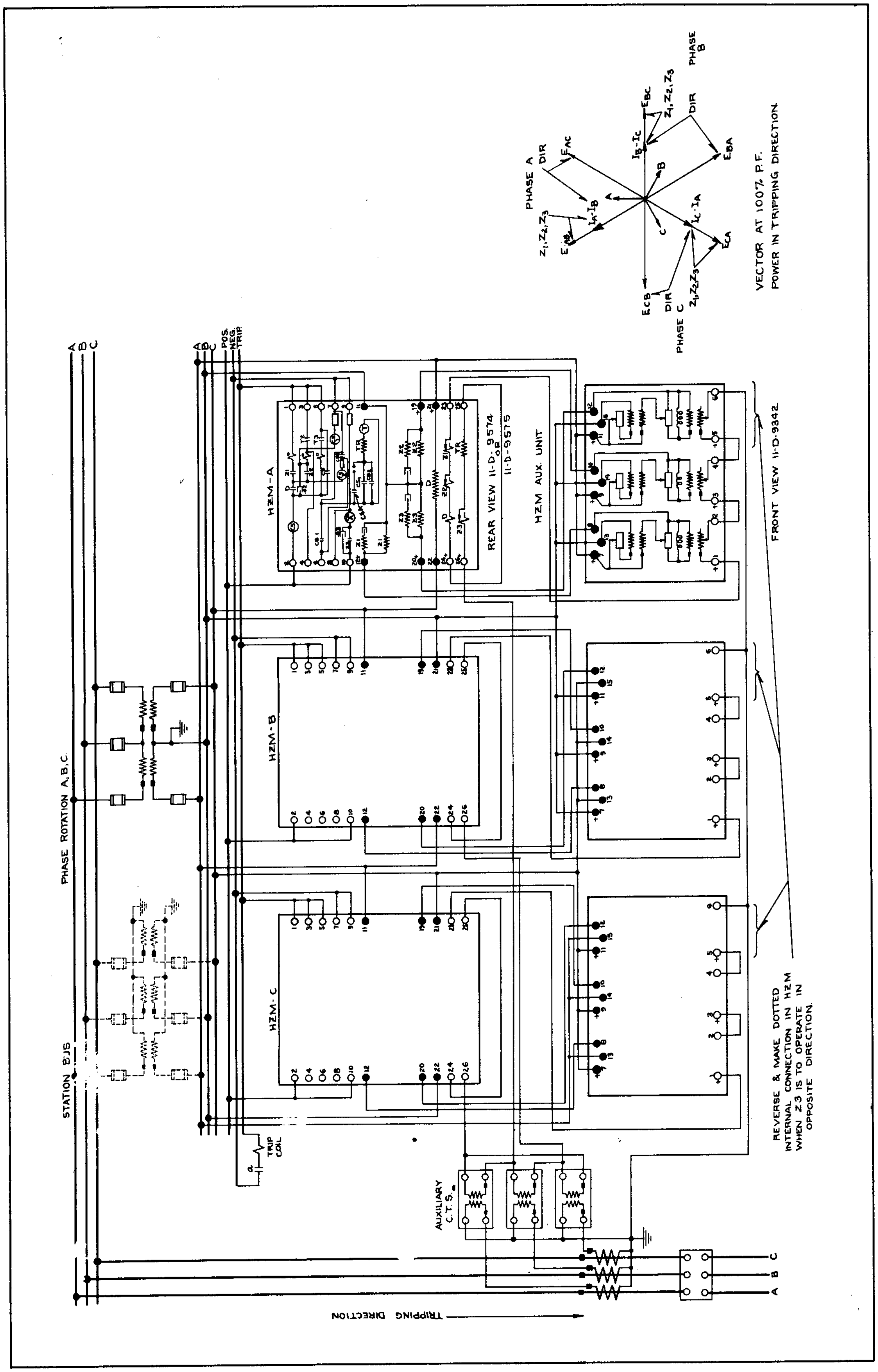

Fig. 8—External Connections for Phase Protection of a Transmission Line Using the Type HZM Relay.

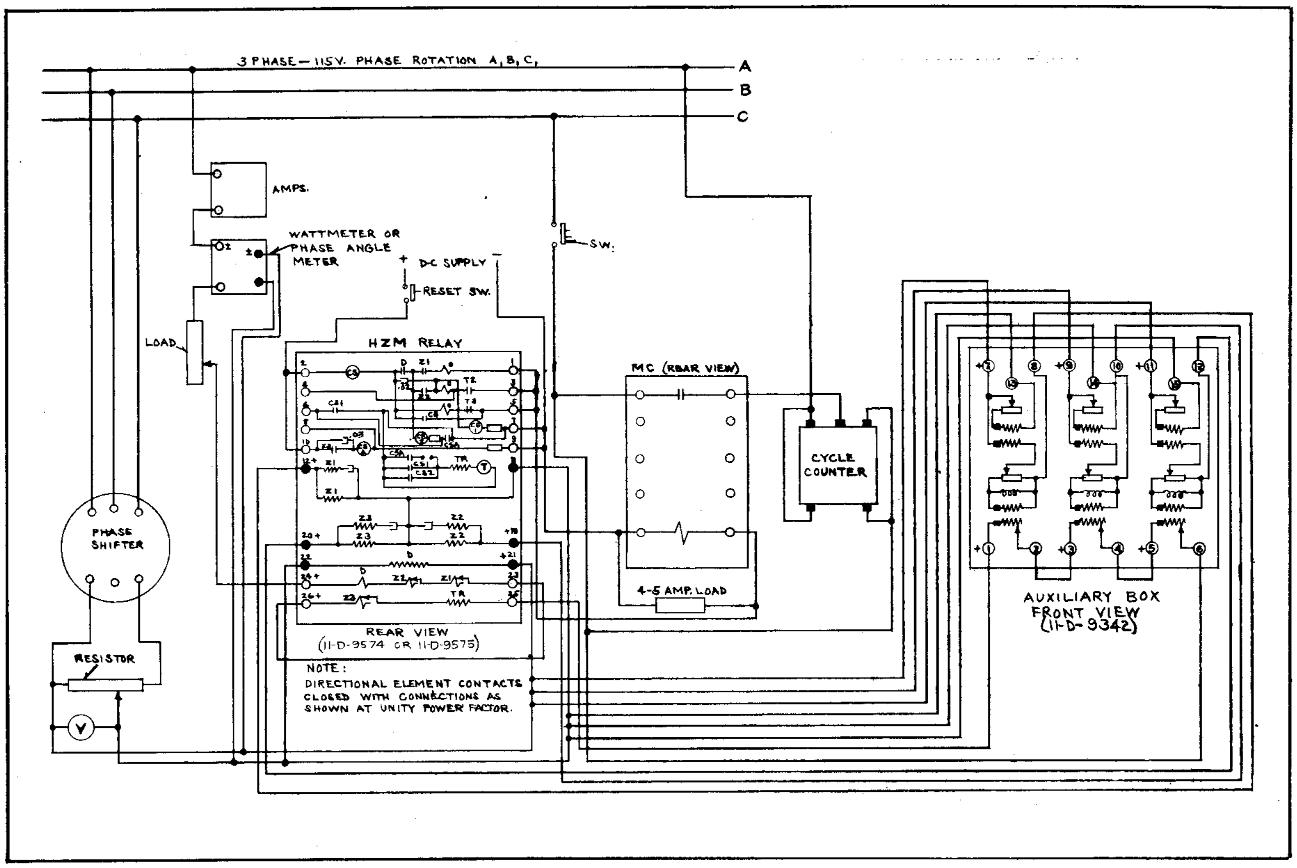

Fig. 9—Diagram of Test Connections for the Type HZM Relay.

relay is approximately 1.0 ohm, care must be taken to see that the breaker trip coil will receive enough current when low voltage control is used.

The main contact on the impedance elements and directional element will safely close 30 amperes at 250 volts d-c., and the switch contacts will safely carry this current long enough to trip a breaker.

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 regular 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.

Impedance Elements

Refer to Figure 1. Adjust the stop screw on the rear of the beam to give a clearance of .020 inch between the beam and the voltage iron circuit. With the beam in the reset position, i.e., with the stop screw against the stop, adjust the vertical gap for .010 inch between the adjustable iron and the beam. Care should be taken in this adjustment to keep the gap the same in 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 first and second impedance element beams should be balanced as follows. Connect the relay with polarities as shown in the test diagram, Figure 9. Set auxiliary box tap Z_R

on zero and A and Ø on any setting. With any tap and scale setting, check the impedance measured by the relay with 60 volts potential restraint. Apply 10 volts restraint and adjust the balance weight on the beam until the beam just trips with 1/6 of the current required to trip with 60 volts restraint. The current should be suddenly applied.

The third impedance element should be balanced so that with no restraint on the rear of the beam, the beam will reset so that in the deenergized condition, the third impedance element contact will not close. Do not introduce excessive resetting torque but only enough to reset element.

The stationary contact should be adjusted for an .020 inch gap when the beam is in the reset position. When the beam is in the operated position there should be a .015 inch deflection of the moving contact. The spring that carries the moving contact should lie flat on the Micarta arm with no initial tension on the contact. The flexible pigtail should be at least 3/32 inch from the end of the stationary contact.

Directional Element

Check the free movement of the directional element loop. The loop should assume approximately a vertical position with contacts open when the element is completely deenergized.

The movement of the loop is limited in the contact opening direction by a stop screw which strikes the lower part of the loop. This screw is located on the left-hand side of the element to the rear of the current coil. This back stop screw should be screwed forward until it just touches the loop when it is in its natural deenergized position. The contacts should have a separation of .020 inch. The front stop screw should be adjusted so that it touches the loop at the same time the contacts close. Then back off this screw 1/2 of a turn to give the contacts the right amount of follow.

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.

Apply 5 amperes suddenly at 2.5 volts to the directional element and make sure that a good contact is made. It may be necessary to adjust the stationary contact slightly in order to obtain a good steady contact. Reverse polarity to open contacts and apply 110 volts, 5 amperes and make sure that the contacts will not bounce closed when the voltage is suddenly interrupted.

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 elements.

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.

Contactor Switch (Seal-in Switch) CS

Adjust the stationary core of the switch for clearance between the stationary core and the moving core of 1/64 inch when the switch is picked up. This can be done by disconnecting the switch, turning it up-side-down and screwing up the core screw until the contact just separates. Then 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 inch by means of the two small nuts on either side of the Micarta disc. The switch should pick up at 1.0 amperes d-c. Test for sticking after 30 amperes d-c are passed thru the coil.

Contactor Switch CSA

The adjustments are the same as for the seal-in contactor switch "CS" except that the contact separation should be 1/32 inch. For 125 volt d-c relays apply 60 volts d-c to Nos. 9 and 10 terminals. Similarly for 250 volt d-c relays apply 120 volts d-c. to Nos. 9 and 10 terminals. See that the switch picks up and closes its contacts positively when the contact of the third impedance element is made. The switch coil is intermittently rated, and therefore care should be exercised so as not to overheat the coil.

Contactor Switches CS-1 and CS-2

The adjustments are the same as for the seal-in contactor switch CS except that the contact separation should be 1/32 inch. For 125 volts d-c relays apply 60 volts d-c positive to Nos. 2 and 10 terminals and negative to Nos. 7 and 9 terminals. Similarly for 250 volt d-c relays use a test voltage of 120 volts d-c. See that switch CS-1 picks up and closes its contact positively when the directional and Z-2 impedance element contacts are made. See that CS-1 picks up and closes its contacts when the directional element and Z-3 impedance element contacts are made. These switch coils are intermittently rated, and therefore care should be exercised so as not to overheat the coils.

Operation Indicator

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

Synchronous Timer

When testing the synchronous timer, complete the transformer circuit by a jumper around the contacts on the contactor switch CS-1 or CS-2 rather than operating the switch on d-c. Test the motor with 3.5 amperes thru the current circuit of the relay. This is the minimum current at which it will run in synchronism.

Timing Tests

Accurate time tests on the instantaneous and directional elements can only be taken with the aid of an oscillograph or high speed timer. The cycle counter is used only to time the synchronous timer and in timing the high speed elements near their balance point where the time may be several cycles.

The d-c trip circuit should be loaded with a resistor to draw approximately 5 amperes and an auxiliary relay should be used to operate the cycle counter if time tests are to be taken. There is a slight vibration of the beam and contacts to the pulsating pull on the current side of the instantaneous element. This vibration will prevent positive stopping of a cycle counter unless an auxiliary type MG relay is used. The loading resistor will cause the contactor switch to seal-in and simulates the actual service condition when a circuit breaker is to be tripped.

Calibration of Impedance Elements

The auxiliary box has been calibrated at the factory and this calibration should not be disturbed.

If the auxiliary box circle displacement setting is set on zero, that is $Z_R = 0$, then the HZM relay will have a characteristic similar to the type HZ relay and may be calibrated in the same manner as follows. The current required to operate the impedance elements against any given voltage is obtained from the equation:

$$TSI = 10E$$

where TSI is the operating force which is equal to T, the current tap setting times S, the setting of the calibrated core screw, times I, the current applied to the relay and 10E is the restraining force which is equal to E, the voltage applied to the relay multiplied by the constant ten. Thus, if the setting is $T = 20.8$, $S = 1.8$ and the voltage is 60 volts, then the current required at 60° lagging is

$$I = \frac{10E}{TS} = \frac{10 \times 60}{20.8 \times 1.8} = 16 \text{ amperes}$$

When calibrating the impedance elements it is best to do so at a phase angle equal to the phase angle between current and voltage on the transmission line to be protected by the relay.

CAUTION Make certain that the stops on the rear and front of each beam are absolutely clean otherwise the impedance at which the beam trips may be affected, particularly at 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.

Also, when checking the impedance elements at low voltage, observe the tripping of the beam instead of an indication in the trip circuit. This will prevent an error in the contact adjustment which might otherwise affect the beam calibration.

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 60 cycle burden of the various circuits of this relay are as follows:

Potential Circuits

Circuit	Volts	VA	PF Angle
All impedance elements including external auxiliary box.			
Box set at 60° = Ø	115	5.1	65°
Box set at 120° = Ø	115	18.5	48°
Directional Elements.	115	3.7	20° lag

Current Circuits

All impedance elements including external auxiliary box, timer, and directional element

Taps	Amps.	VA	PF Angle
Z_R=1.0, A=1.0,T=6.2,S=1.8	8.66	39.0	31° lag
Z_R=6.67,A=110,T=45, S=1.8	8.66	142.5	35° lag

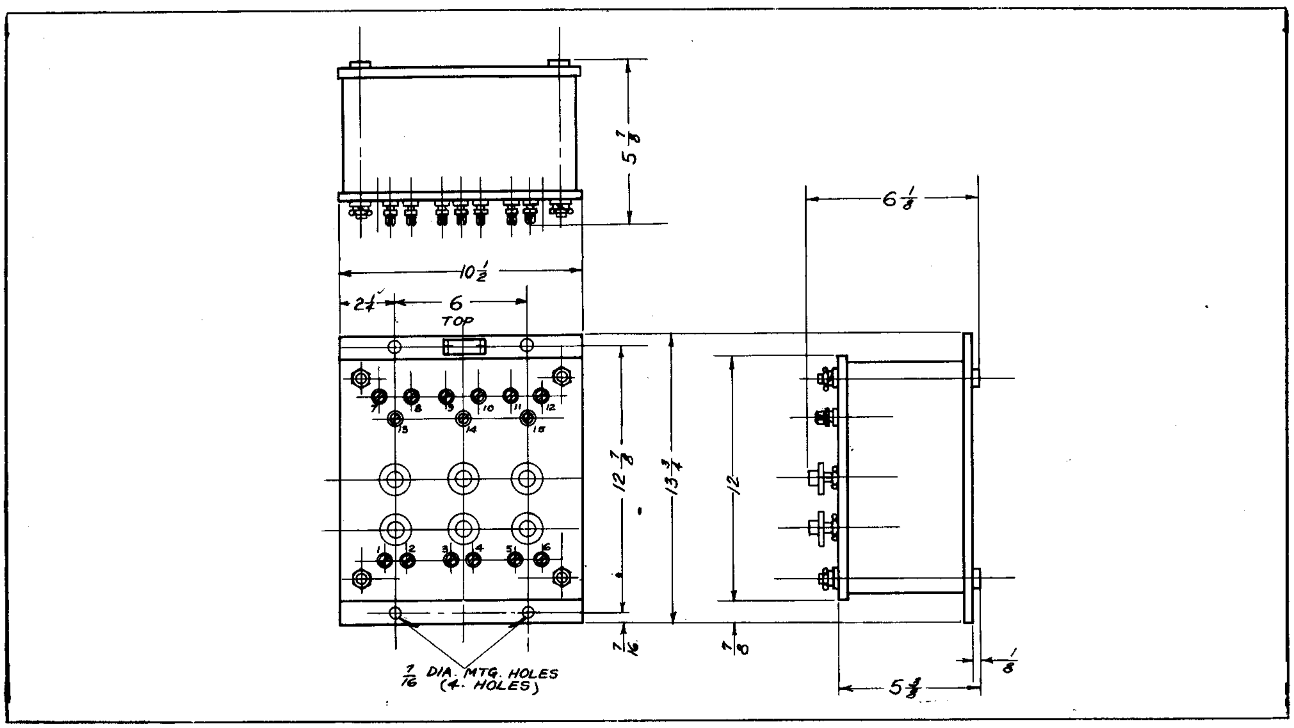

Fig. 10—Outline and Drilling Plan for the Three Element Auxiliary Unit. For Reference Only.

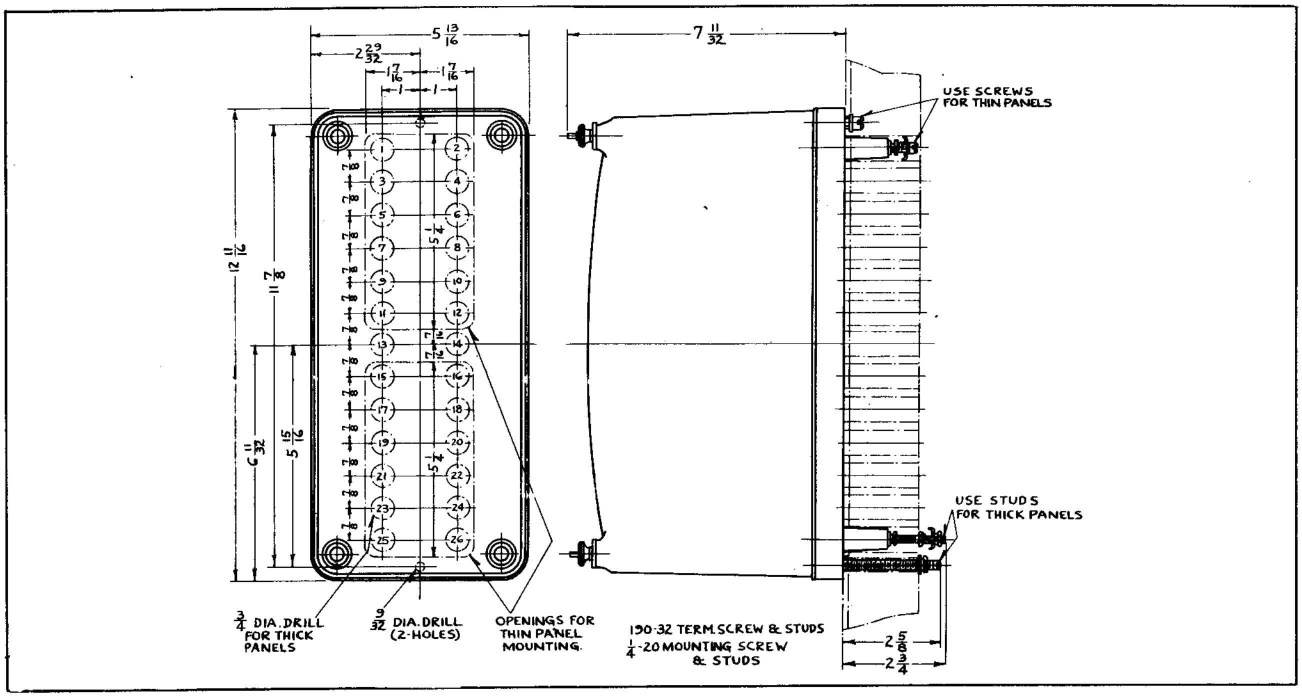

Fig. 11—Outline and Drilling Plan for the Standard Projection Case. See the Internal Schematics for the Terminals Supplied. For Reference Only.

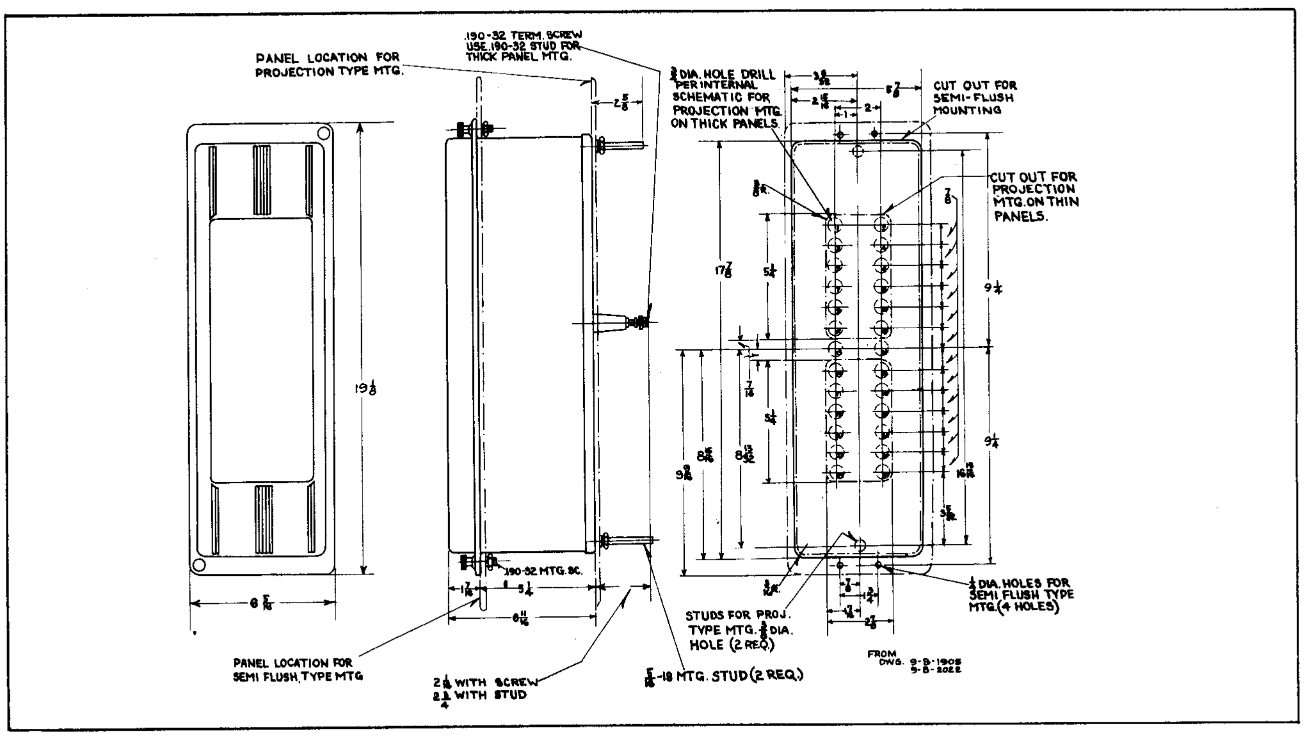

Fig. 12—Outline and Drilling Plan for the M20 Projection or Semi-Flush Type FT Case. See the Internal Schematics for the Terminals Supplied. For Reference Only.

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