INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE HR-1 DIRECTIONAL OVERCURRENT RELAY

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 can close properly. Operate the relay to check the settings and electrical connections.

APPLICATION

The type HR-1 relay is a high speed directional overcurrent induction disc type relay for high speed directional phase and ground fault protection.

The type HR-1 relay is suitable for the following single-line protection applications:

1 - Those cases where there is no question of selection with succeeding sections, as on loop systems having power supply at but one point on the loop. On these systems, the type HR-1 relay is applicable on the distant ends of sections adjacent to the source.

2 - Those cases where the fault-current magnitude is a fair measure of distance irrespective of source capacity, as on the lines whose impedance is high compared to the system impedance back of the line. For these applications, the HR-1 relay overcurrent-element pickup must be just above the maximum fault current for a fault at the next bus with maximum connected capacity. Faults closer to the relay give currents above the pickup point of the overcurrent element and cause high speed operation. If the system impedance does not increase appreciably in changing from maximum to minimum capacity, a large portion of the line will be provided with high speed relay operation. Protection for the remainder of the line section as well as backup protection for the next line section must be obtained with additional relays having suitable timing characteristics.

CONSTRUCTION AND OPERATION

Overcurrent Element

The type HR-1 relay overcurrent element consists of eight coils placed symmetrically about the shaft of an aluminum disc. Four of the coils are located above the disc and four are located below the disc. The lower magnetic assembly is rotated such that the pole faces below the disc are staggered with respect to those above the disc. The upper and lower pole coils are energized by means of a transformer, with a tapped primary for the various current taps, and are connected in the secondary circuit in such a manner that the upper pole current is approximately 90 degrees out of phase with the lower pole current. The actual connections of the coils are such that adjacent upper pole faces are of opposite polarity, and adjacent lower pole faces are also of opposite polarity. The two fundamental requirements for a rotating field are present namely, two air gap fluxes which are displaced with respect to each other, both in time phase and in space. The element, therefore, operates on the induction motor principle.

The overcurrent element construction is such that the relay can easily be dismantled. Both upper and lower bearing plates are mounted on the movement frame with two shoulder screws which allow for easy removal and replacement with proper alignment of the disc. When dismantling, removal of the two lower bearing plate screws allows the lower pole assembly to be removed. Then unscrewing the upper bearing screw and removing the contact arm from the shaft allows the shaft and disc to be removed

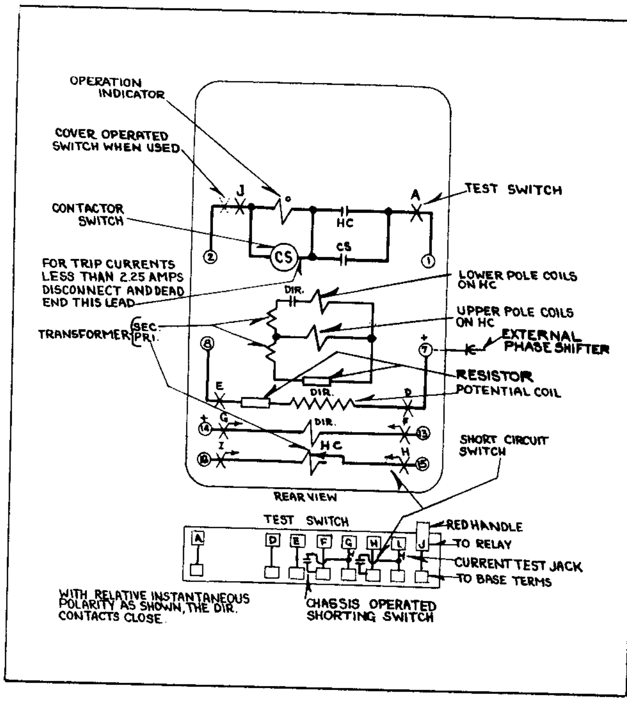

Fig. 1—Internal Schematic of the Type HR-1 Overcurrent Ground Relay in Type FT Case.

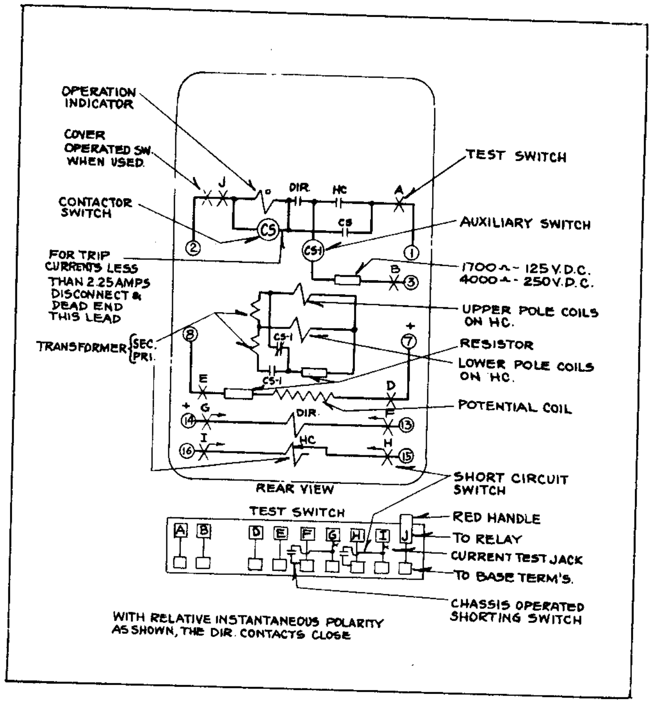

Fig. 2—Internal Schematic of the Type HR-1 Directional Overcurrent Phase Relay in Type FT Case.

from the bottom. The upper pole assembly can be removed as a unit after the disc has been removed by unscrewing the two mounting screws which mount it on the movement frame.

Directional Element

The directional element is very similar to the overcurrent element, with the exceptions of the torque producing quantities. The four upper poles are energized with current and the four lower poles with voltage.

Contactor Switch

The d-c contactor switch in the relay is a small solenoid type switch. A cylindrical plunger with a silver disc mounted on its lower end moves in the core of the solenoid. As the plunger travels upward, the disc bridges three silver stationary contacts. The coil is in series with the main contacts of the relay and with trip coil of the breaker. When the relay contacts close, the coil becomes energized and closes the switch contacts. This shunts the main relay contacts, thereby relieving them of the duty of carrying tripping current. These contacts remain closed until the trip circuit is opened by the auxiliary switch on the breaker.

Operation Indicator

The operation indicator is a small solenoid 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 Contactor Switch (For Phase Relays Only)

The auxiliary contactor switch is a small solenoid type switch with make-break contacts. The action of the switch is controlled by the directional element contacts. With the directional contacts open the switch is de-energized. The normally closed contacts of the switch are connected such as to cause the overcurrent element to have reverse torque when they are closed. With the directional contacts closed the auxiliary switch is energized, closing its make contacts. These contacts are connected in such a manner as to cause a contact closing torque in the overcurrent element.

CHARACTERISTICS

The type HR-1 relay is available in the following current ranges.

0.5	0.6	0.8	1.0	1.3	1.6	2.0
1.5	2.0	2.5	3.0	4.0	5.0	6.0
4	5	6	7	9	12	16
10	12	15	20	24	30	40
20	24	30	40	48	60	80

The tap value is the minimum current required to just close the overcurrent element contacts.

Phase Relays

Relays intended for phase protection have directional elements that have their maximum torque, when the current leads the voltage approximately 45°.

Ground Relays

Relays intended for ground protection have directional elements that have their maximum torque when the current leads the voltage approximately 45°, and are used with a phase shifter to provide maximum torque when the current lags the voltage approximately 80°. The use of the phase shifter requires reversing the connections of the potential as shown in Fig. 6.

Trip Circuit

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

The relay is shipped with the operation indicator and the contactor switch connected in parallel. This circuit is suitable for all trip currents above 2.25 amperes d.c. If the trip current is less than 2.25 amperes, there

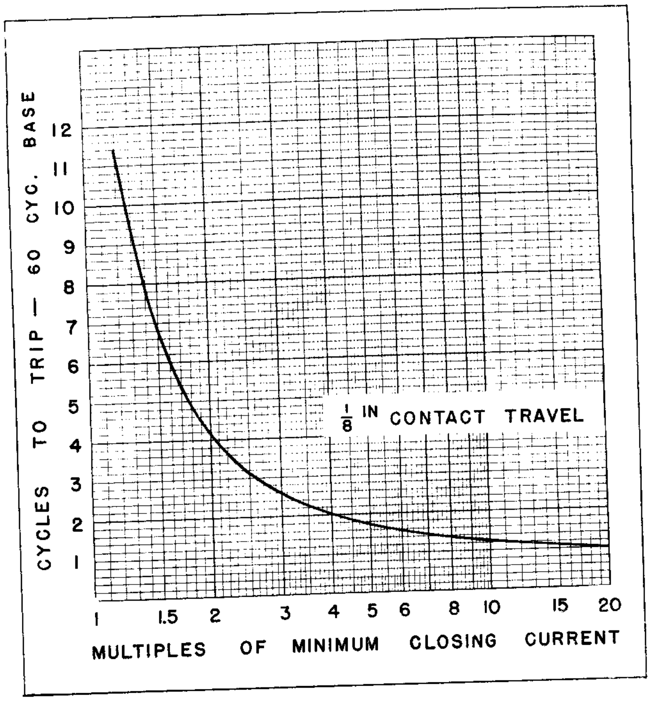

Fig. 3—Typical of Time of Operation Curve of the Type HC Relay (Overcurrent Element of the Type HR-1).

is no need for the contactor switch and it should be disconnected. To disconnect the coil, remove the short lead to the coil on the front stationary contact of the contactor switch. This lead should be fastened (dead ended) under the small filisterhead screw located in the Micarta base of the contactor switch.

Contact Circuit Constants

Universal Trip Circuit

Resistance of 0.2 ampere Target ....2.8 ohms
Resistance of 2.0 ampere Contactor Switch.....................0.25 ohm
Resistance of Target and Switch in Parallel.......................0.23 ohm

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

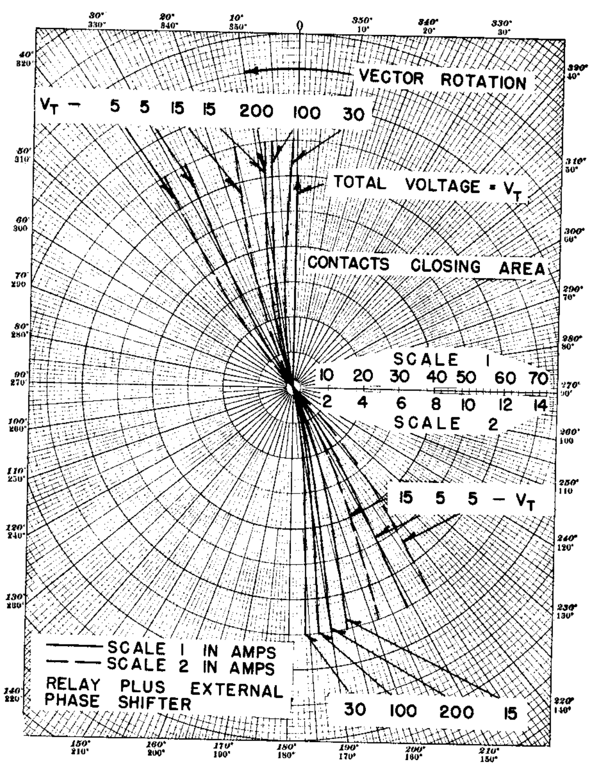

Fig. 4—Typical Phase Angle Characteristics of the Type HR-1 Ground Relay.

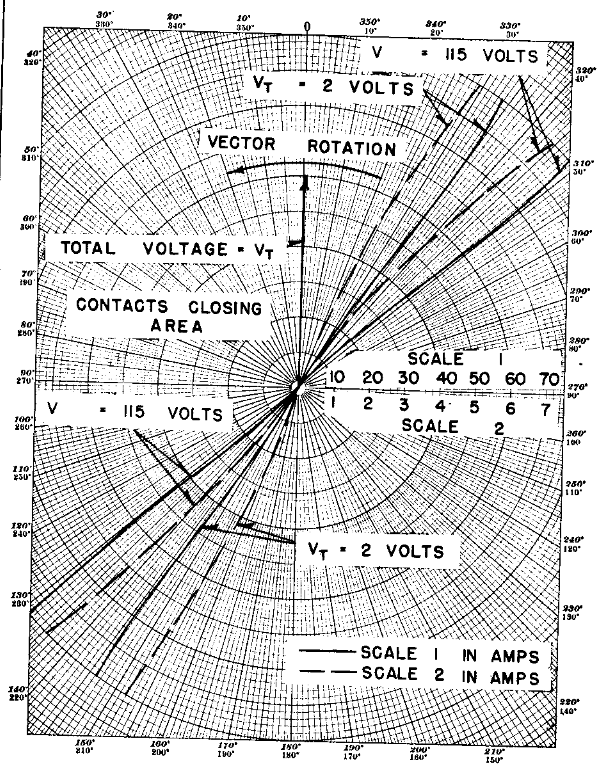

Fig. 5—Typical Phase Angle Characteristics of the Type HR-1 Phase Relay.

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 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 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.

TYPE HR-1 RELAY

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 surfaces 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 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.

Voltage 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 relay is completely isolated from the external circuits. Suggested means for isolating this circuit are outline above, under "Electrical Circuits".

Testing Out of Case

With the chassis removed from the base, 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 of some relays by a small percentage. It is recommended that the relay be checked in position as a final check on calibration.

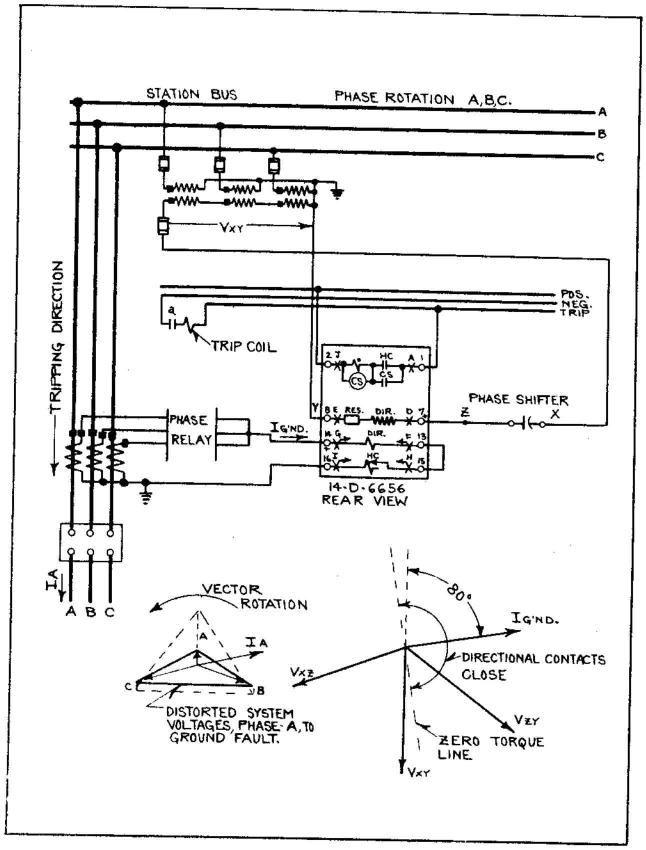

Fig. 6—External Connections for the Type HR-1 Relay Used for Ground Fault Protection.

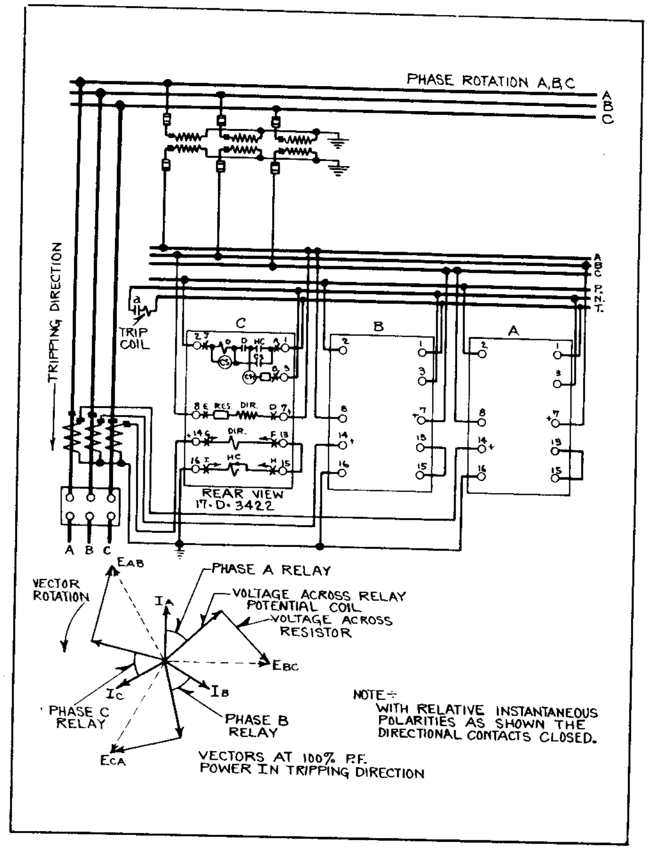

Fig. 7—External Connections for the Type HR-1 Relay Used for Phase Fault Protection.

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 case 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.

The type HR-1 phase relay uses the so-called 90° connection shown in Fig. 7. The 90° connection utilized the line-to-line voltage that lags 90° behind the unity power factor position of the line-to-neutral current. Therefore an element that has maximum torque at 45° current leading voltage will, when connected for the 90° connection, have maximum torque when the line current lags the unity power factor position 45°.

SETTINGS

The only setting to be made when using the type HR-1 relay, is the current setting, which is made by means of the connector screw, located on the terminal plate. By placing the connector screw in the various holes, the relay will just close contacts at the corresponding current, 4-5-6-7-9-12-16 or as marked on the terminal plate.

The tripping value of the relay on any tap may be altered approximately 15 percent above or 15 percent below tap value, by changing the initial tension of the spiral spring. This can be accomplished by turning the spring adjuster by means of a screw driver inserted in one of the notches of the plate to which the outside convolution of the spring is fastened.

CAUTION Be sure that the connector screw is turned up tight so as to make a good contact, for the operating current passes thru it. Since the overload element is 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 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.

The stationary contact is adjusted by means of the two adjusting screws located near the rear of the contact assembly. These screws are equipped with a self-locking spring. The screw nearest the front is the adjuster used to position the contact, and the adjacent screw is the adjuster used to position the back-up spring. The spacing between the contact spring and back-up spring should be adjusted to 1/64 inch, and the contact spring should be approximately 1/64 inch from the front stop-bar.

The moving contact travel may be adjusted by means of the left hand (front view) disc stop screw located on the movement frame. The contact travel is adjusted at the factory for 1/8 inch for the overcurrent element and 3/32 inch for the directional element. The contact follow may be adjusted by means of the right hand (front view) disc stop, located on the movement frame. A follow of 1/32 inch for the overcurrent element and 0.01 inch for the directional element is made at the factory.

The lower pole assembly of the overcurrent element should be adjusted by means of the adjusting screws located on the lower pole assembly plate, such that the lower pole pieces will be displaced symmetrically about the air gaps between the upper pole pieces. This displacement may be judged by eye, as 100 percent accuracy in this adjustment is not required.

The lower pole assembly of the directional element of the ground relay should be adjusted by means of the adjusting screws located on the lower pole assembly plate. The adjustment should be such that with 5 amps in the current circuit a volt meter connected across the relay potential circuit should read approximately zero. The volt meter may read a little off zero, as the lower pole assembly is first set for zero induced volts and then rotated slightly in order to obtain the 0.5 volt 3 amp sensitivity.

The lower pole assembly of the directional element of the phase relay should be adjusted by means of the adjusting screws located on the lower pole assembly plate.

With the spring adjusted so the disc is free to move in either direction, adjust for zero torque with current above as follows: Short the potential circuit at the relay terminals. Loosen the screws that hold the lower pole assembly to the lower bearing plate. (With 50 amperes in the current circuit) Rotate the lower pole assembly with respect to the upper pole assembly until there is no torque tending to open or close the contacts. Lighten all screws and lock in position. Check to see that the disc does not creep after adjustments have been locked. Care should be taken not to over-heat the relay.

Adjust the spiral spring such that the contacts will close with 0.5 volts and 3 amperes.

Minimum trip of the overcurrent element is set by means of the spiral spring adjuster by setting the tension so the contacts will just close with tap value of current.

Contactor Switch

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

Operation Indicator

Adjust the indicator to operate at 0.2 amps. d.c. gradually applied. Test for sticking after 5 amperes d.c. is passed.

Auxiliary Contactor Switch (For Phase Relays Only)

Adjust the contact gap of the auxiliary contactor switch for 0.015 inch. The contact screw has 100 threads per inch.

With the moving contact in the make position adjust the gap between plunger and top of the core to be 3/4 turn of the core. With the moving contact in the normally closed position adjust the spacing between the molded piece on the plunger and the contact spring to be 1-1/2 turns of the stop nuts located on the guide rod.

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 Directional Element

The burden of the current circuit at 5 amps is 9.6 V.A. at 42° lag.

The burden of the potential circuit, for ground relays, at 120 volts is 22.4 V.A. at 24° lead.

The burden of the potential circuit, for phase relays, at 120 volts is 20.5 V.A. at 34° lag.

Thermal rating of the current circuit is 8 amperes continuously, and 230 amps for one second.

Continuous rating of the potential circuit is 115 volts + 10% = 127 volts for both phase and ground relays.

TYPE HR-1 RELAY

Overcurrent Element

Range	Tap	VA at Tap Value Current		VA at 5 Amps.		Continuous Rating Amps.	One Sec. Rating Amps.
		VA	θ°Lag	VA	θ°Lag		
0.5-2	0.5	2.38	17.7	155	40.5	2	56
	0.6	2.42	16.9	123	37.3	2	56
	0.8	2.57	15.6	82	31.8	2	56
	1.0	2.69	14.4	58	27.2	2	56
	1.3	2.86	13.2	38.5	21.2	2	56
	1.6	3.04	12.3	28.5	17.6	2	56
	2.0	3.25	10.9	19.8	14.6	2	56
1.5-6	1.5	2.43	17.7	27.6	22.3	5	140
	2.0	2.60	16.9	16.75	17.4	5	140
	2.5	2.70	15.5	11.50	15.6	5	140
	3.0	2.85	14.7	8.35	14.7	5	140
	4.0	3.16	13.4	5.00	13.4	5	140
	5.0	3.30	12.5	3.30	12.5	5.5	140
	6.0	3.60	11.4	2.40	11.4	6	140
4-16	4	2.32	18.0	3.7	18.4	16	460
	5	2.47	17.2	2.47	17.2	16	460
	6	2.56	16.8	1.77	16.1	16	460
	7	2.61	15.8	1.30	15.7	16	460
	9	2.67	14.5	0.79	14.6	16	460
	12	3.00	13.8	0.50	13.8	16	460
	16	3.55	14.6	0.36	15.4	16	460
10-40	10	3.64	12.0	0.875	11.8	16	460
	12	4.37	11.2	0.640	11.0	16	460
	15	4.55	10.1	0.495	10.1	16	460
	20	5.64	9.1	0.335	9.0	16	460
	24	6.20	8.5	0.256	8.2	16	460
	30	6.93	8.2	0.175	7.0	16	460
	40	7.60	7.9	0.115	5.1	16	460
20-80	20	10.2	7.2	0.59	7.2	16	460
	24	11.8	6.9	0.50	6.6	16	460
	30	14.4	6.5	0.367	5.2	16	460
	40	19.2	5.9	0.283	4.8	16	460
	48	21.8	5.5	0.222	4.6	16	460
	60	25.3	5.1	0.163	4.2	16	460
	80	30.0	4.7	0.105	3.5	16	460

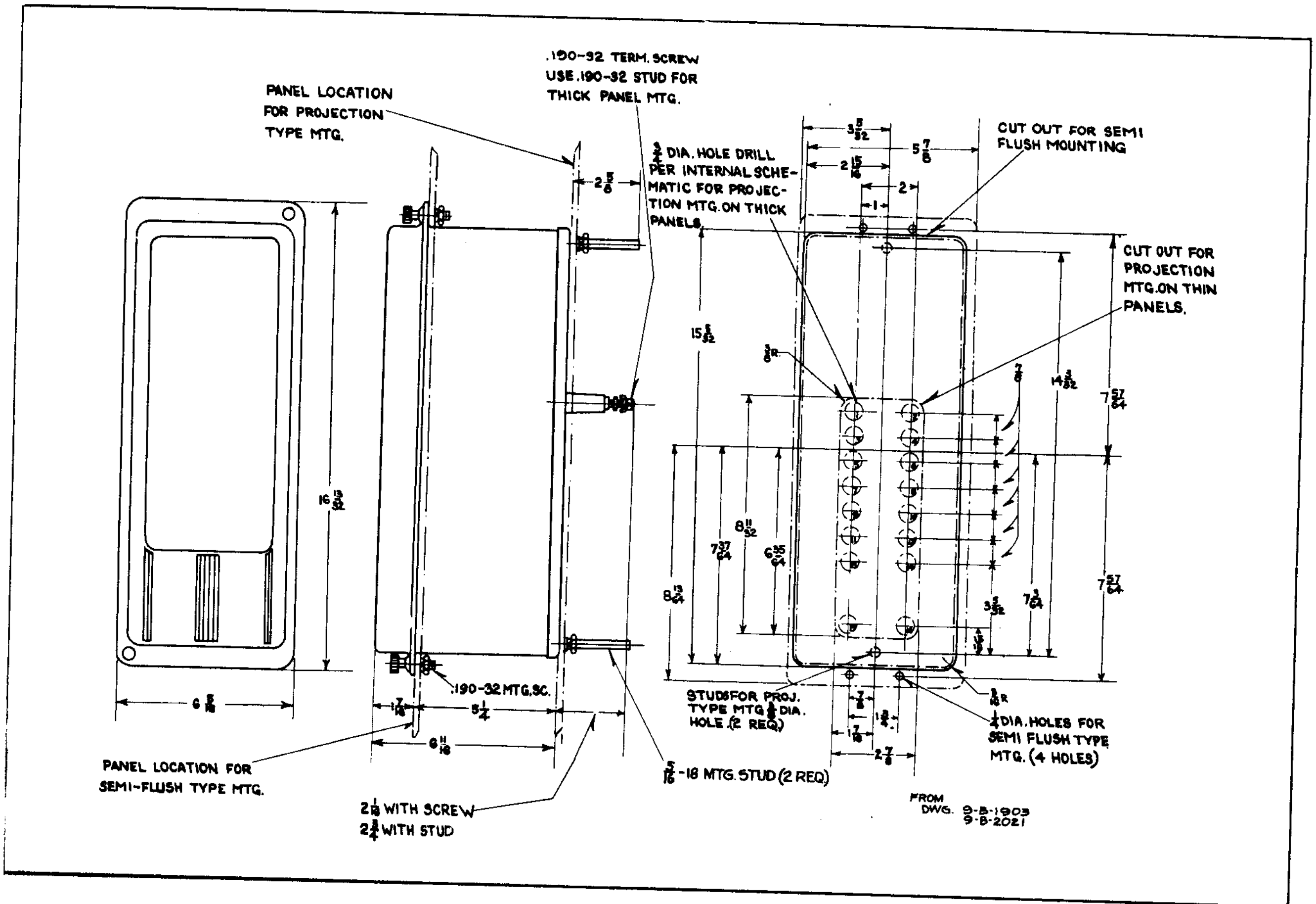

Fig. 8—Outline and Drilling Plan for the M-10 Semi-flush or Projection type FT Case. See Internal Schematics for Terminals Supplied. For Reference Only.

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