INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE HLF LOSS OF FIELD 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 close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The HLF relay is a single-phase relay connected to the a-c side of a synchronous machine and contains three elements connected so that the operation of two elements sounds an alarm warning the operator of a low excitation condition, and the additional operation of the third element sets up the trip circuit. The relay can be applied without modification to all types of synchronous machines.

CONSTRUCTION

The relay consists of an impedance element, offset transformer, directional element, under voltage element, telephone relay, contactor switch, and an operation indicator. The relay is available in both the type FT and the standard case.

IMPEDANCE ELEMENT

A sectional view of the impedance element beam is 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 ar 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 make it possible to set the element to the desired impedance circle radius.

The moving contact is a thin-walled silver shell practically filled with tungsten powder. When this contact strikes the rigid stationary contact, the movement of the tungsten powder creates sufficient friction to absorb practically all of the energy of impact and thus the tendency of the contact to bounce is reduced to a minimum. The moving contact is loosely mounted on the element beam and held in place by a leaf spring. The construction is such that the beam continues to move slightly after the contacts close deflecting the spring. This provides the required contact follow. This spring should have zero tension on the contact when the beam is in the reset position. Current is conducted into the moving contact by means of a flexible metal ribbon.

A thin-walled cylinder filled with tungsten powder is mounted near the rear end of the beam. This acts as a counterweight and tends to damp out vibrations in the beam in the manner described above for the element contacts.

OFFSET TRANSFORMER

The offset transformer is an air gap transformer with a tapped primary winding to obtain the desired voltage at a given current. A portion of the secondary winding is shunted by a resistor to give the desired relay characteristic of 60° displacement.

SUPERSEDES I. L. 41-411
*Denotes changed from superseded issue.

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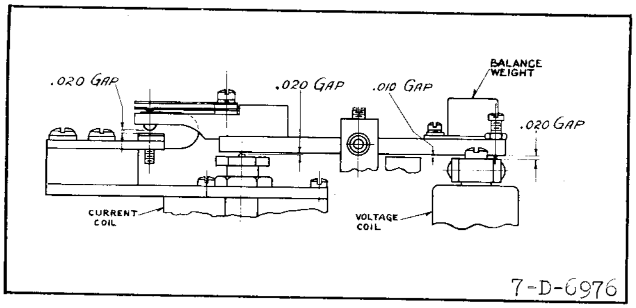

Fig. 1—Sectional View of the Impedance Element Beam.

DIRECTIONAL ELEMENT

The directional element is made up of five basic parts: the die-cast aluminum frame, the electromagnet, the molded cover assembly, the moving element assembly, and the bridge and upper bearing pin assembly. The lower bearing pin and the magnetic core with its adjustment lever are mounted on the frame. The electromagnet has two series-connected voltage coils mounted diametrically opposite one another, two series - connected current coils mounted diametrically opposite one another and two magnetic plugs accessible through the cover. The moving element consists of a spring and contact arm assembly and a double aluminum loop mounted on a shaft which has end jewels for the top and bottom bearings. This shaft rides between the bottom steel bearing pin mounted in the frame and a similar pin in the bridge that mounts on the two longer studs of the electromagnet. The stops for the moving element are mounted on the cover and are easily accessible for the adjustment of the contact travel. The spring adjuster seats on the molded cover and is attached to the contact through a spiral spring. The moving contact is made of two thin-walled silver shells practically filled with tungsten powder and mounted back to back on a thin leaf spring. The stationary silver contacts are mounted on the molded cover. The electrical connection is made from the stationary contact to the moving contact, through the spiral spring and spring adjuster to the spring adjuster clamp.

UNDERVOLTAGE ELEMENT

This element operates on the solenoid principle. A U-shaped iron frame, mounted on the micarta base, supports the coil and serves as the external magnetic path for the coil. The coil surrounds a core and flux shunt. The upper end of the core is threaded and projects through the upper side of the frame, to which it is fastened by a nut. A tube threaded on the outside at its lower end is assembled in the core, with its threaded end extending below the core. The lower bearing for the plunger shaft is inserted in the lower end of this threaded tube, and is held in place by a set screw. This bearing consists of a graphite bushing in a brass holder. The bearing for the upper end of the plunger shaft is a graphite bushing which is pressed in the upper end of the core. This bearing is visible when the plunger is in the energized position. The plunger itself does not touch the walls of the tube in which it moves.

A flux shunt which surrounds the core is screwed on the tube, its lower end projecting below the relay frame. The position of this shunt determines the drop-out setting of the relay. The lower end of the shunt is beveled and knurled so that it can be grasped by the fingers and turned to change the setting. A calibrated scale plate is mounted adjacent to the shunt. A groove just above the knurl in the lower end of the shunt serves as an index mark, and the relay drop-out setting is indicated by the calibration scale marking which is adjacent to the groove.

The construction of the plunger, core and flux shunt causes the plunger to float in its energized position, without being held against a stop, even when energized much above the pick-up value. Consequently, there is negligible noise and the contacts are free from chatter, even on heavy overloads.

The core, shunt and plunger construction also provides the high ratio of drop-out to pick-up. This ratio is above 90% for any setting.

The shunt is held in any desired position by means of a locking mechanism in which a spring

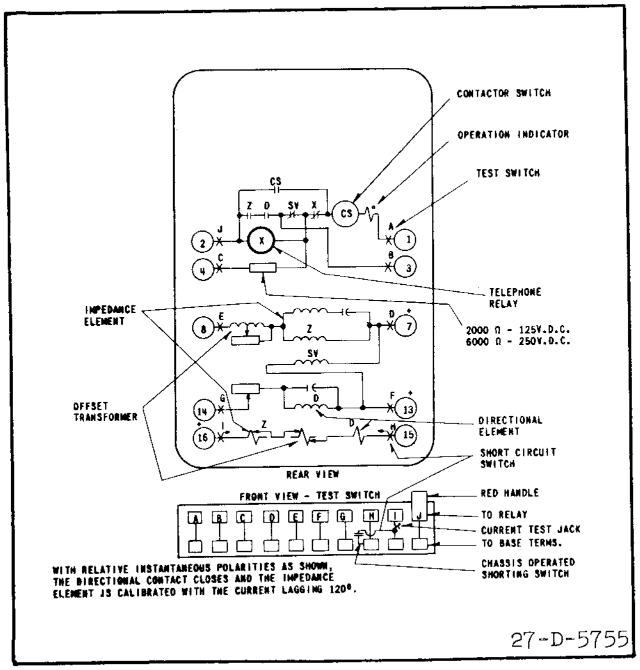

Fig. 2—Internal Schematic of the Type HLF Relay in the FT Case. Omit Test Switches for the Relay in the Standard Case.

lever presses against the shunt. The pressure is removed by pushing the free end of the lever to the left. Only a small amount of movement is necessary to remove the pressure entirely. The limit of the lever movement is readily apparent on inspection of the assembly, and this should not be exceeded since the lever may be bent. The shunt is made a fairly snug fit in the frame and on the coil core tube, but when the pressure is released, it can be readily turned by the fingers alone. By applying greater force, it will be possible to turn the shunt without moving the lever fully to the left, but the pressure of the spring lever will prevent any creeping of the shunt or undesired change of setting.

* The stationary contacts are assembled on slotted brackets. These are held in position on the base by fillister-head screws which are threaded into the terminal insert. The moving contacts are connected to the base terminals by flexible leads. All contacts are pure silver.

TELEPHONE RELAY

The telephone relay (X) has a slow drop-out characteristic. When energized, the solenoid core attracts an iron right-angle armature bracket which in turn opens the break contacts. In actual service, the relay is normally energized holding the break contacts open. (Note: the make contacts are not used.) Drop-out delay adjustment is obtained by varying the air-gap between the armature and the core.

AUXILIARY CONTACTOR SWITCH

This is a small solenoid-type d-c switch. 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 can be reset from outside of the case.

OPERATION

The relay is connected and applied to the system as shown in Figs. 3 and 4. The directional element closes its contacts for var flow into the machine. Its zero torque line has been set at -13° from the R-axis. Its primary function is to prevent operation of the relay during external faults. The impedance element closes its contacts when, as a result of reduction in excitation, the impedance of the machine as viewed from its terminals is less than a predetermined value. The operation of both the impedance and directional elements sounds an alarm, and the additional operation of the undervoltage element trips the machine. As shown in Fig. 3, the contacts of all three elements are connected in series across a telephone type relay designated X,

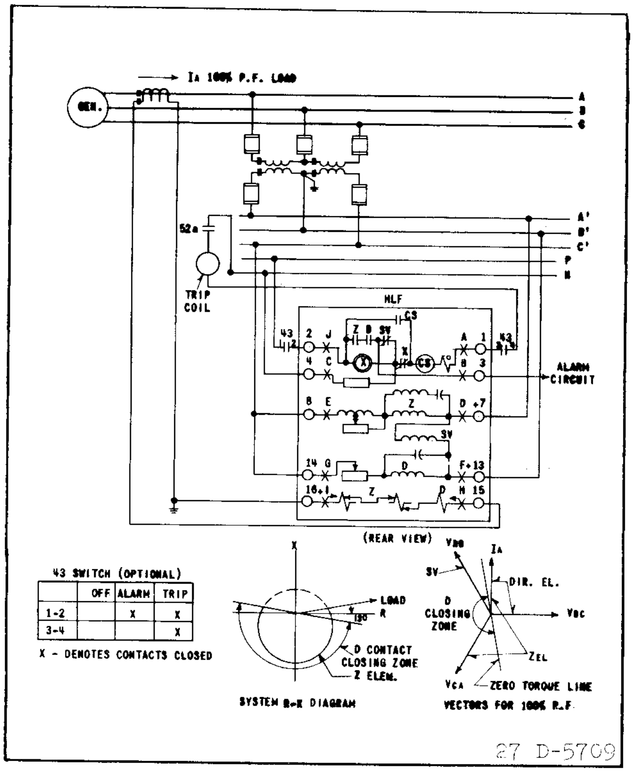

Fig. 3—External Connections for the Type HLF Relay.

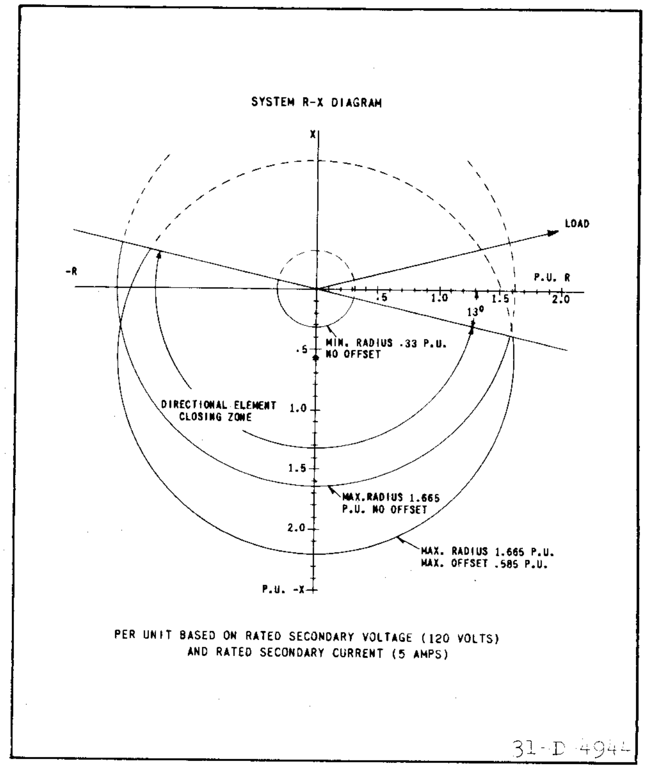

Fig. 4—Type HLF Relay-System R-X Diagram in per Unit Values.

which provides approximately 15 cycles time delay on drop-out before energizing the trip coil. This time delay is to ensure positive contact coordination under all possible operating conditions. During normal conditions, all contacts are open.

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 HLF 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 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 element and directional element will safely close 30 amperes at 250 volt d-c., and the switch contacts will safely carry this current long enough to trip a breaker.

CHARACTERISTICS

The type HLF relay is available in one range.

IMPEDANCE CIRCUIT

The relay R-X diagram, plotted in relay ohms, is shown in Fig. 5.

(a) 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.

(b) The magnitude of displacement of the center of the impedance circle from the origin is determined by the offset transformer taps selected (Z_R + A).

(c) The phase angle of displacement has been set at 60° current lag. This places the displacement angle for the system on the "-X" axis since star current lags delta voltage by

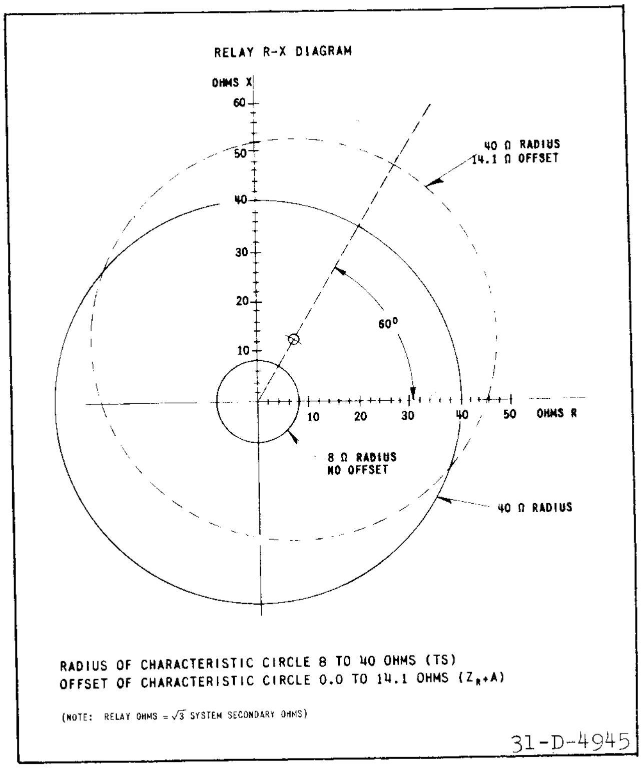

Fig. 5—Type HLF Relay—Relay R-X Diagram in Relay Ohms.

30° at 100% power factor. The impedance circle radius (TS) can be varied from 8 to 40 ohms. Impedance circle displacement (Z_R + A) can be varied from 0 to 14.1 ohms. The tap and scale markings on the relay are as follows: (All impedances are in terms of relay ohms)

Impedance Element - Radius of Impedance Circle (8 to 40 ohms)

Taps (T)

45	65	95	150

Core Screw Markings (S)

.17	.19	.21	.23	.25	.27

Offset Transformer
Impedance Circle Displacement (0 to 14.1 ohms)

Coarse Ohm Taps (Z_R)

0.0	2.8	5.5	8.2	11.1

Fine Ohm Taps (A)

0.0	.75	1.5	2.25	3.0

DIRECTIONAL ELEMENT

The HLF relay is designed for potential polarization with an internal phase shifter so that maximum torque occurs when the operating current leads the polarizing voltage by approximately 13°. The minimum pickup has been set by the spring tension to be approximately 1 volt and 5 amperes at maximum torque.

UNDERVOLTAGE ELEMENT

Voltage Drop-Out Values On Calibrated Scale Plate						
50	60	70	80	90	100	110

Since each of the three elements operates from a different system voltage, the relay will not trip on accidental loss of potential under normal operating conditions.

SETTINGS

IMPEDANCE CIRCUIT

For most applications the impedance circuit should be set to approximate the machine capability curve in the leading power factor zone, particularly from the directional element zero torque line to 50 percent leading power factor. This criterion for setting the relay assumes that the steady state stability limit is inside the capability curve when plotted on a per unit impedance basis, and that most of the relay operation will result from operation at leading power factor or loss of excitation when operating near the rated zone. Capability curves can usually be obtained from the manufacturer. If the capability curve for the particular machine is not available, a capability curve from Fig. 6 could be used for a good approximation.

To obtain the relay setting, the capability curve in the leading power factor zone is plotted as a per unit impedance. (The per unit impedance is equal to the reciprocal of

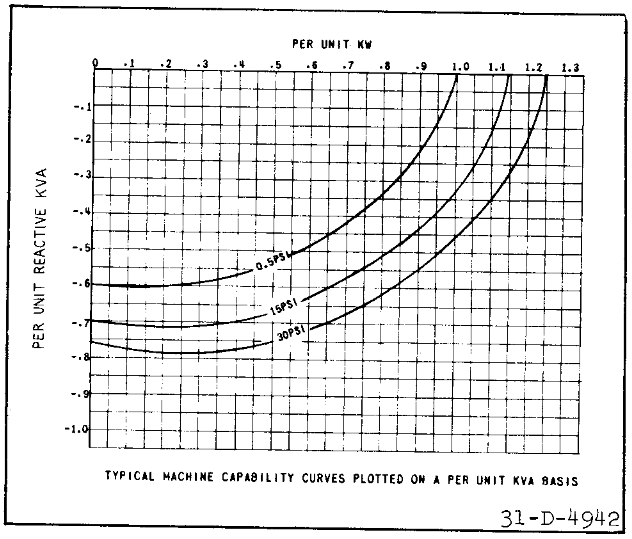

Fig. 6—Typical Machine Capability Curves Plotted on a per Unit KVA Basis.

the per unit KVA.) Fig. 7 is Fig. 6 plotted on a per unit impedance basis. An offset impedance and radius impedance are then selected such that the locus of the balance points of the impedance element is about ten percent inside the capability curve plotted as per unit impedance. Recommended settings, if the capability curves plotted on Fig.7 are applicable, are also plotted on Fig. 7. These settings will give adequate protection for the majority of applications. On a per unit basis, they are:

Operated at	Offset (Z_D per unit)	Radius (Z_O per unit)
0.5 psig	.40	.96
15 psig	.40	.81
30 psig	.40	.72

where:

Z_D per unit = per unit displacement of the origin of the impedance circle on the "-X" axis.

Z_O per unit = per unit radius of the impedance circle.

Relay ohms by convention are those measured by applying single-phase voltage and current to the relay. Since star current and delta voltage are applied in actual service, a factor, $\sqrt{3}$ will enter into the base formula.

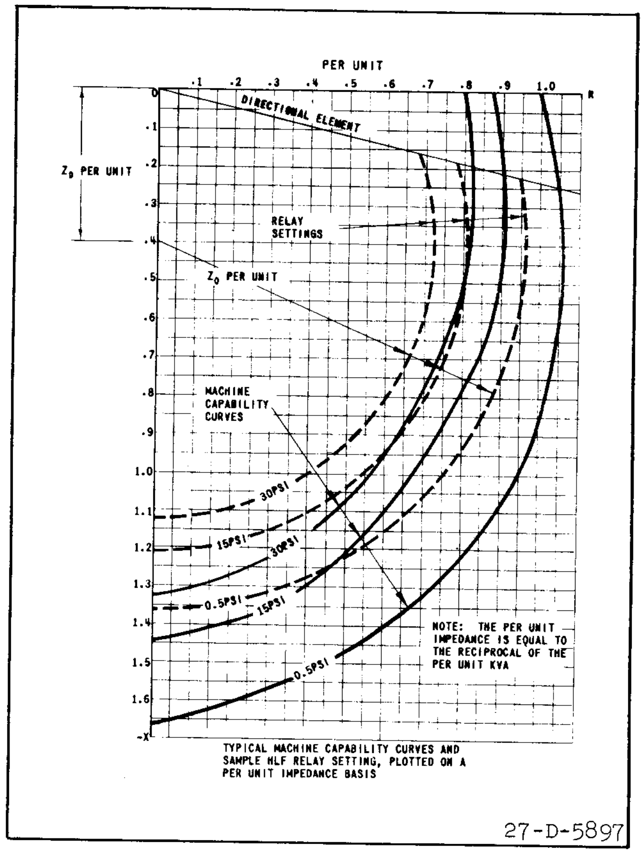

Fig. 7—Typical Machine Capability Curves and Sample HLF Relay Settings, on a per Unit Impedance Basis.

(1) $$Z_{base} = \frac{\sqrt{3}\ 1000(kv)^2 R_c}{(kva) R_v} \text{ ohms}$$

where:

Z_{base} = one per unit primary ohms as seen from the relay.

kv = rated voltage of the machine.

kva = rated kva of the machine.

R_c = the current transformer ratio.

R_v = the potential transformer ratio.

The actual settings are then:

(2) $Z_R + A = (Z_D \text{ per unit})\ (Z \text{ base})$

(3) $TS = (Z_O \text{ per unit})\ (Z \text{ base})$

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_R = offset tap value (coarse).
A = offset tap value (fine).

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 impedance circuit the voltage and current conditions which will be impressed on it at the desired balance point. A slight change in the scale value or in the offset setting from that calculated may be required.

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 transformer.

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 as to 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 approximately one turn. Then turn to correct setting. Sufficiently accurate setting can be made by interpolating between the marked points when necessary.

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

Sample Calculation

(Typical Generator from Westinghouse Transmission and Distribution Reference Book)

3-phase, 60 cycles, 3600 rpm, 13.2 kv, rated at 0.85 pf.
Capability for 0.5 psig Hydrogen Pressure = 47,058 kva.
$R_c = 500/1 \quad R_v = 110/1$
If the recommended setting from curve 7 is used,

Z_D per unit = .40 Z_O per unit = .96

(1) $$Z_{base} = \frac{\sqrt{3}\ 1000 (kv)^2 R_c}{(kva) R_v}$$

$$= \frac{\sqrt{3}\ 1000 \times 13.2^2 \times 500}{47{,}058 \times 110} = 29.2 \text{ ohms}$$

(2) $Z_R + A = (Z_D \text{ per unit})\ (Z \text{ base}) = (.40)\ (29.2) = 11.7$ ohms

(3) $TS = (Z_O \text{ per unit})\ (Z \text{ base}) = (.96)\ (29.2) = 28.1$ ohms

Therefore, the relay is set thus:

Z_R	A	T	S
11.1	.75	150	.19

(Note: An electrical check of this particular setting is outlined in this instruction leaflet, under the heading, ELECTRICAL CHECK POINTS.)

UNDERVOLTAGE ELEMENT

The undervoltage element is usually set to a value corresponding to the minimum safe system voltage for stability. This voltage depends upon system constants and is usually a value between 70 and 80 percent. A higher value could be used if it is desired to trip the machine immediately upon loss of field.

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 the wrench.

The recommended connections of the relay are shown in Fig. 3.

ELECTRICAL CHECK POINTS

To check the operation of the relay, the following instruction should be followed.

IMPEDANCE CIRCUIT

1. Connect the relay as shown in Fig. 8, with the switch in position 1 and the trip circuit deenergized.

2. Set T = 150, S = .19, and Z_R + A = 11.85. Turn the phase shifter to 60° (current lags voltage)

3. With the terminal voltage at 100 volts, increase the current until the contacts just close. This current should be within ± 5% of:

$$I = \frac{E}{TS + Z_R + A} = \frac{100}{150 \times .19 + 11.85} = 2.48$$

DIRECTIONAL ELEMENT CIRCUIT

1. Connect the relay as shown in Fig. 8, with the switch in position 1 and the trip circuit deenergized.

2. With a terminal voltage of 120 volts and 5 amperes applied, turn the phase shifter to 13° (current leads voltage). The contacts should be closed.

3. Vary the phase shifter to obtain the two angles where the moving contact just makes with the right hand contact. These two angles (where torque reverses) should be where the current leads the voltage by 283° ± 2° and 103° ± 4°

UNDERVOLTAGE CIRCUIT

1. Connect the relay as shown in figure 8, with switch in position 2 and the trip circuit deenergized.

2. Set the voltage drop out value on the calibrated scale plate to be 90.

3. Decrease the voltage until the plunger drops just enough to close the contacts. This value should be 90 volts ± 3%.

TRIP CIRCUIT

1. Connect the relay as shown in Fig. 8, with the switch in position 2.

2. Short terminals 2 and 3 together.

3. Set the voltage drop out value on the calibrated scale plate to be 90.

4. Decrease the voltage until the undervoltage contacts close. This should energize the trip circuit. (Note: Do not keep the trip circuit energized for a prolonged period as the contactor switch coil is intermittently rated.)

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 contacts.

IMPEDANCE ELEMENTS

The voltage circuit on the impedance elements is designed to have a comparatively flat phase angle curve. This is accomplished by energizing the two coils with currents that are essentially equal and 90° out of phase. The gaps as shown in Fig. 1 are nominal dimensions which yield equal restraints from the two coils. The actual gaps on any particular relay may vary a few thousandths from these values.

If the voltage circuits have been disassembled, the gaps referred to in Fig. 1 provide a nominal starting point for calibration. This is accomplished as follows:

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 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.

Make certain that the stops on the rear and front of the 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.

Further adjustment in the gaps may be necessary to obtain a flat phase angle curve.

The impedance element beam should be balanced as follows: Connect the relay with polarities as shown in the test diagram, Fig. 8. Set the offset taps Z_R and A on zero. With any tap and scale setting, check the impedance measured by the relay with 100 volts potential restraint. Apply 10 volts restraint and adjust the balance weight on the beam until the beam just trips with 1/10 of the current required to trip with 100 volts restraint. The current should be suddenly applied.

The stationary contact should be adjusted for a .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

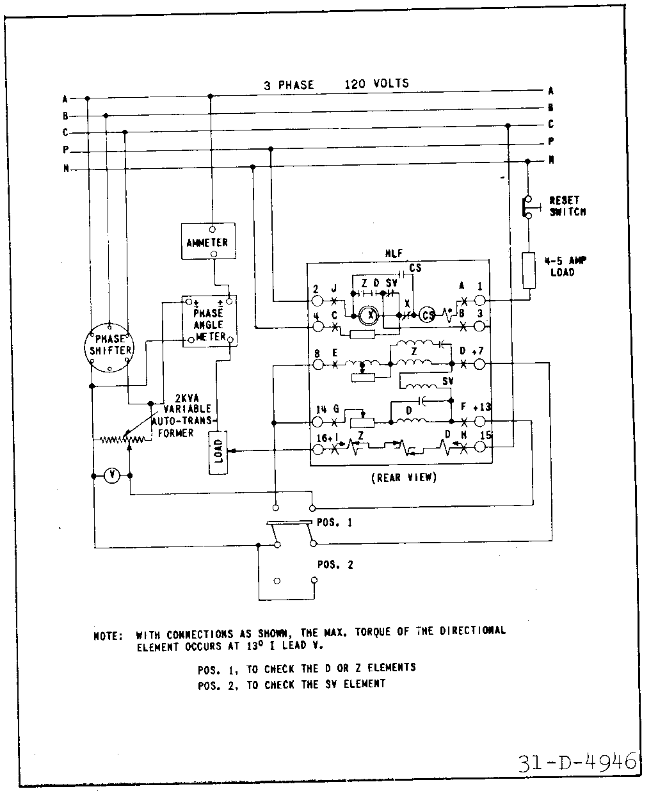

Fig. 8—Diagram of Test Connections for the Type HLF Relay.

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.

The current required at 60° lagging, to operate the impedance element at any given voltage, is obtained from the formula:

$$Z_R + A + TS = \frac{E}{I}$$

where E and I are the voltage and current respectively applied to the relay. Thus if the setting is T = 150, S = .1[illegible], Z_R = 11.1, A=.75, and E is 100 volts, then the current required at 60° lagging is:

$$I = \frac{[illegible]}{11.1 + .75 + 150 \times .19} = [illegible] \text{ amperes}$$

DIRECTIONAL ELEMENT

The upper bearing screw should be screwed down until there is only three to four thousandths of an inch clearance between it and the shaft, and then securely locked in position with the lock nut. This adjustment can be made best by carefully screwing down the top bearing screw until the double loop fails to turn freely and then backing up 1/8 of a turn. Great care must be taken in making this adjustment to prevent damage to the bearing.

The front contact spring should be positioned in the center of the .020 inch slot of the aluminum guard by means of the small adjusting screw located on the nut plate that holds the spring on the moving element. The travel of the moving contact is limited by the stationary contacts mounted on the molded cover. The contact gap should be adjusted as follows: With the moving contact centered between the studs, close the contact gaps by advancing the two front stationary contacts. Then back off the right-hand stationary contact .035 inch, and the left-hand stationary contact .010 inch. Then lock both contacts in place. The complete moving element is limited in travel by two stop screws, located on the molded cover. These should be adjusted so that the moving contact just barely misses the stationary contacts when energized in the opening and closing directions with 120 volts and 5.0 amperes at 193° and 13° current leading respectively. The right-hand stationary contact should be turned 1/6th of a turn counterclockwise to obtain .005 inch contact follow. The spring should be adjusted so that the contacts close with 1.0 volt and 5 amperes at maximum torque, 13° current leading.

There are two separate magnetic adjustments: Adjustable magnetic plugs, in the magnetic circuit, which are accessible from the top; and a small lever arm extending to the front on the bottom of the center of the electromagnet controlling a magnetic bias in the center of the electromagnet. With the terminals of the potential circuit (13, 14) short-circuited: (1) adjust the lever so that the right-hand contact will just remain open with 40 amperes suddenly applied; (2) adjust the plugs so that the right-hand contact will just remain open with 80 amperes suddenly applied; (3) check to see that the right-hand contact will just remain open with 55 amperes suddenly applied.

Recheck spring tension. Final settings should be made with current coils at room temperature.

UNDERVOLTAGE ELEMENT

Adjust the position of the lower (left-hand) stationary contact so that it just touches the moving contact when the latter is 1/32" above the de-energized position. Adjust the upper (right-hand) stationary contact so that it just touches the moving contact when the latter is 5/32" above the de-energized position.

CONTACTOR SWITCH (SEAL-IN SWITCH)

Adjust the stationary core of the switch for clearance between the stationary core and the moving core of .025 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 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 ampere d-c. Test for sticking after 30 amperes d-c is passed through the coil. The resistance is approximately 0.8 ohm.

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.

TELEPHONE RELAY

Energize the telephone relay with 120 volts d-c. The telephone relay should operate positively. With an air gap of .003" - .004" the contacts should not close for approximately 15 cycles after the relay is de-energized.

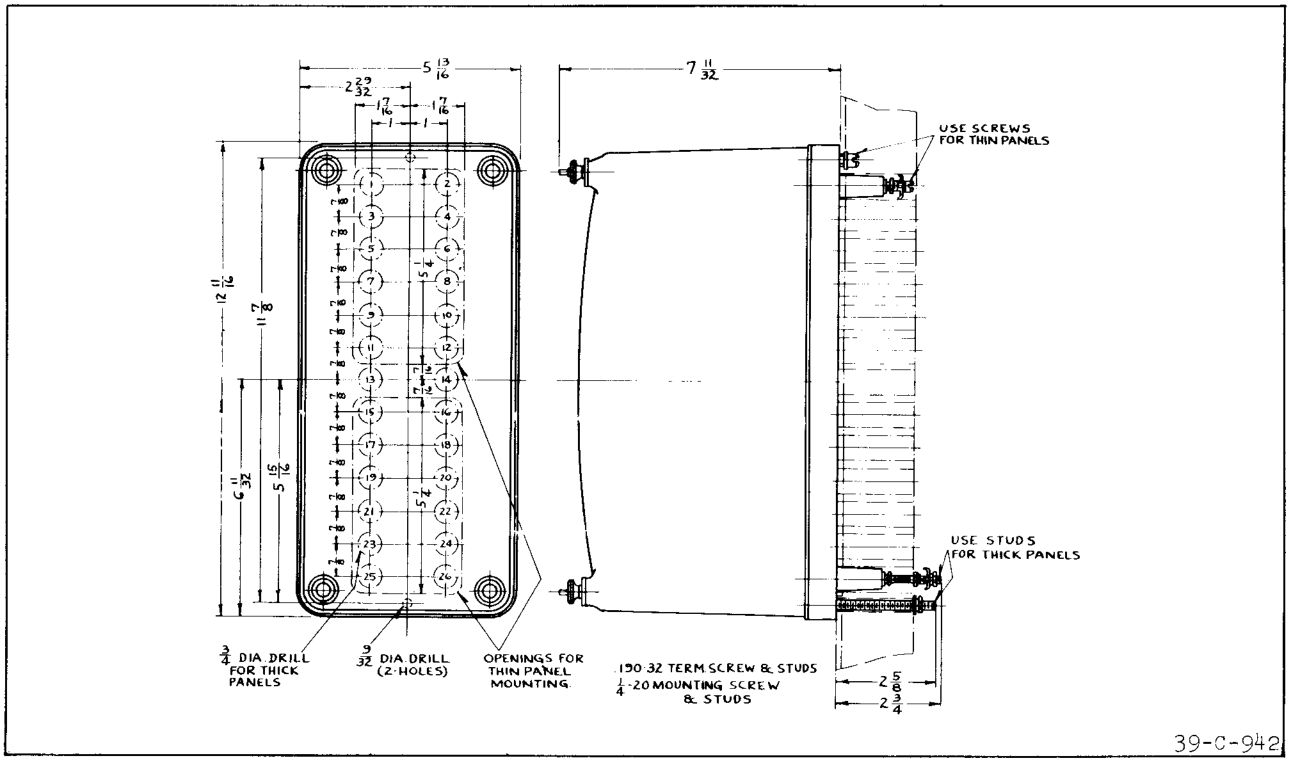

Fig. 9—Outline and Drilling Plan for the Standard Projection Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

RENEWAL PARTS

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

ENERGY REQUIREMENTS

Typical burden data of the various circuits are as follows:

POTENTIAL CIRCUITS AT 120 VOLTS, 60 CYCLES

Circuit	VA	pf Angle
Impedance	2.3	28° lag
Directional	7.2	23° lead
Undervoltage	12.0	59° lag

CURRENT CIRCUIT AT 5 AMPERES, 60 CYCLES

Circuit	VA	pf Angle
Maximum	23.75	52.5° lag
(T = 150, S = 2.7, Z_R + A = 14.1)		
Minimum	5.60	35° lag
(T = 45, S = 1.7, Z_R + A = 0.0)		

DIRECT CURRENT CIRCUIT

* Telephone Relay and 2000 ohm resistor	125 volts	3.9 watts
Telephone Relay and 6000 ohm resistor	250 volts	7.8 watts

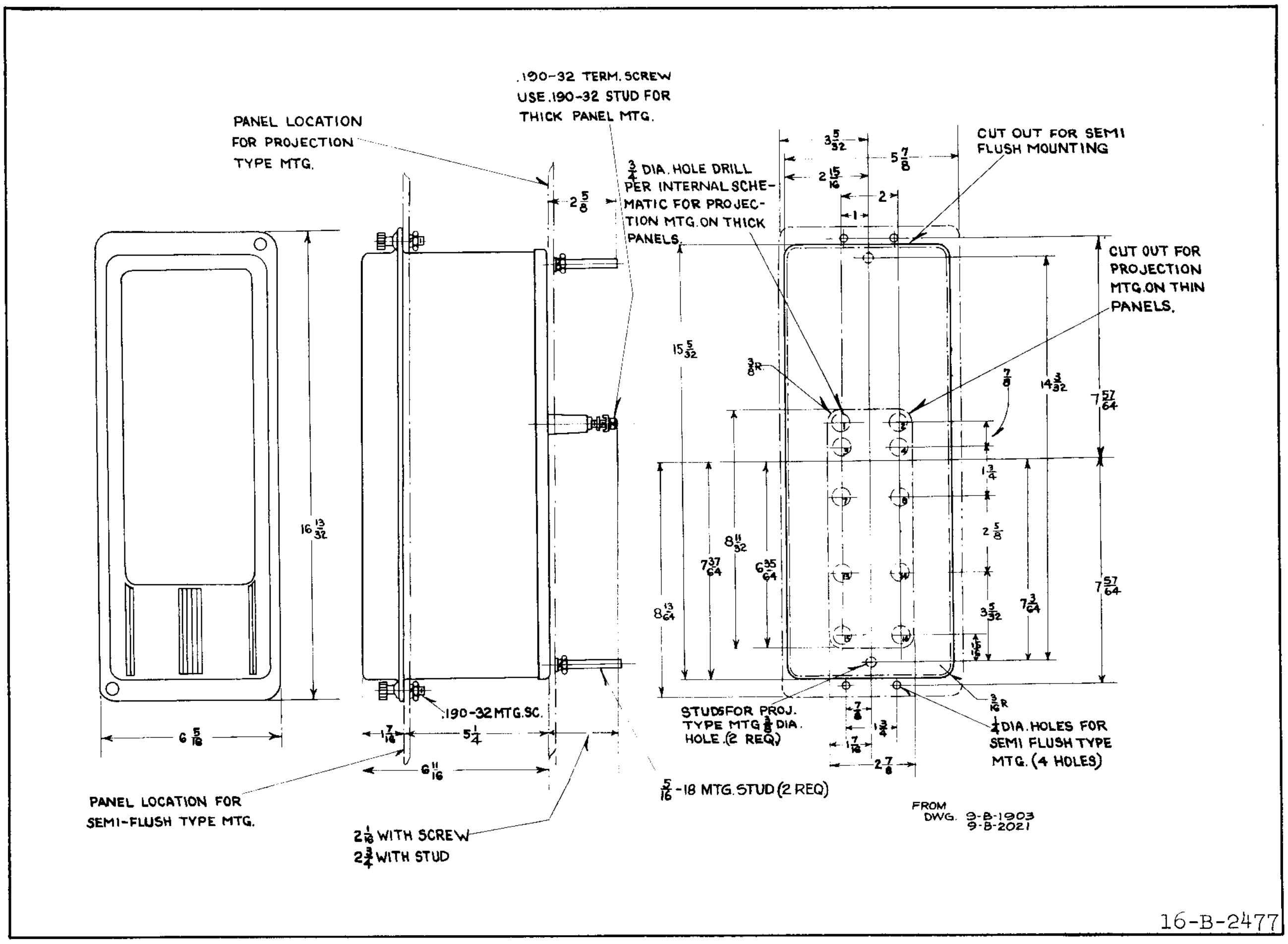

Fig. 10—Outline and Drilling Plan for the M-10 Projection or Semi-Flush Type FT Case. See the Internal Schematic for the Terminals Supplied, For Reference Only.