INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES HR AND HRC
DIRECTIONAL OVERCURRENT RELAYS

CAUTION Before putting protective relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The types HR and HRC relays are directional instantaneous overcurrent relays for high-speed directional phase and ground protection. They consist of a high speed induction loop type directional unit and instantaneous type SC overcurrent unit.

The type HRC relay is similar to the type HR relay except that the directional unit is polarized by current from the grounded power bank neutral instead of by residual voltage.

These relays are applicable only where there is enough difference in fault current magnitude for faults at the near and far ends of a section to permit the relays to cover a large portion of the line for maximum and minimum system conditions. In any case, relays of this type must be used only to supplement slow speed relays, since it is impossible with these relays to provide high-speed protection for faults at the far end of the transmission line and still maintain selectivity.

HR and HRC relays are 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 types HR and HRC relays are 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 and HRC relay overcurrent-unit pickup must be just above the maximum instantaneous assymetrical fault current for a fault at the next bus with maximum connected capacity. Faults closer to the relay give currents above the pickup of the overcurrent unit and cause instantaneous 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

The HR and HRC relay overcurrent unit consists of a U-shaped iron frame, mounted on the sub base, the coil is supported on this frame which also provides the external magnetic path for the flux. The coil surrounds a magnetic core and flux shunt. The position of this shunt determines the pick-up setting of the relay.

The lower end of the shunt is beveled and knurled so that it can be grasped by the fingers and rotated to change the setting of the unit. A calibrated scale plate is mounted adjacent to the shunt and serves to indicate, in relation to a grooved index mark on the adjustable shunt, the calibrated pick up setting of the unit.

The shunt is held in any desired position by means of a locking mechanism in which a spring lever presses against the shunt. By pressing the lever to the left the pressure against the shunt is removed allowing the shunt to be easily turned by hand.

The directional unit is of the inductor loop type. The rectangular loop of aluminum to which the moving contacts are fastened forms a short circuited secondary of a small transformer. The primary consists of the voltage coil. The loop is in the field

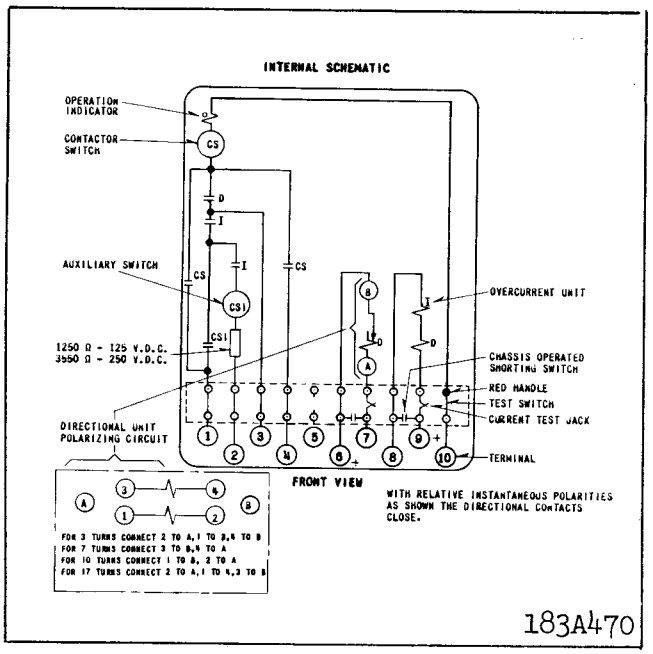


Fig. 1 Internal Schematic of the Type HRC Relay in the Type FT21 Case.

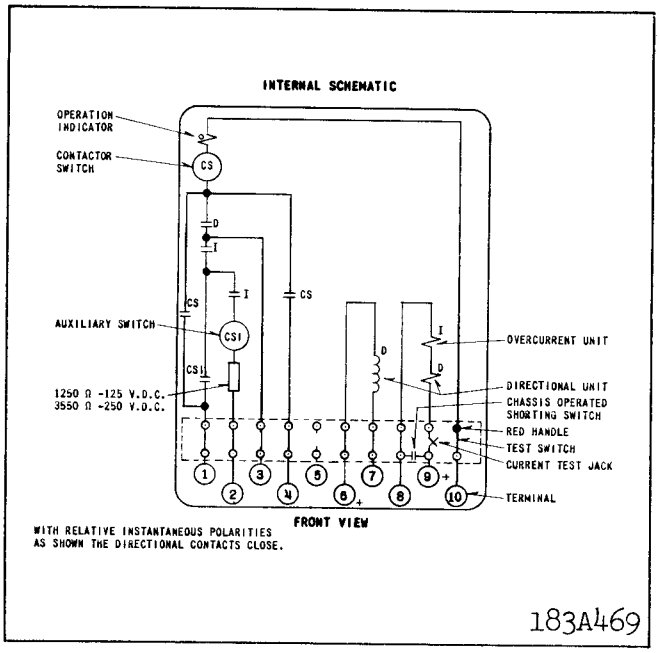


Fig. 2 Internal Schematic of the Type HR Relay in the Type FT21 Case.

produced by the current coils. Torque is caused by the interaction of the current flowing in the loop and the current flux threading the loop.

HRC Relay

The HRC relay is similar to the HR except the voltage coil in the directional unit is replaced by a current coil, thus polarizing the directional unit on current alone. One current coil utilizes the neutral current of the power transformer while the other uses the residual current of the line.

An auxiliary d.c. contactor switch is provided in both the type HR and HRC relays to insure proper coordination between the high speed directional and overcurrent units. The switch coil is energized by the closing of both the directional and overcurrent unit contacts while the auxiliary switch contacts are in series with the directional and overcurrent unit contacts in the relay trip circuit. A momentary closing of both overcurrent and directional unit contacts, such as might occur on a sudden power reversal therefore, will not complete the trip circuit.

Both relays are provided with an operation indicator and a 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 the 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.

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. The indicator is adjusted to trip at 1.0 amperes d.c. and the contactor switch to pick up at 1.0 ampere. For positive operation, at least four amperes should flow in the trip circuit. The relay trip circuit resistance is approximately 1.0 ohm.

* The main relay contacts will safely close 30 amperes at 250 volts d.c. and the contactor switch contacts will carry this current until the trip circuit is interrupted by the auxiliary switch on the breaker.

CHARACTERISTICS

The overcurrent unit will operate in less than 1 cycle. The operating or pick-up point is adjusted by

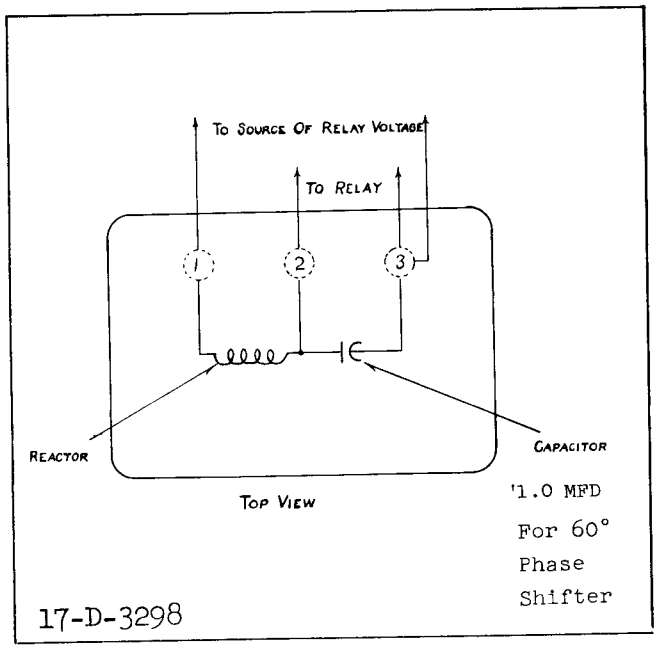


Fig. 3 Internal Schematic of the External Phase Shifter used with the type HR Relay for Ground Protection.

varying the magnetic shunt described under construction.

The relay is available with overcurrent unit ratings as shown under energy requirements.

The overcurrent unit contacts are so arranged that the CS1 switch will drop out after the fault conditions are cleared. This eliminates the need for a separate "a" switch when a trip coil indicating lamp is used.

The sensitivity of the directional unit in the type HR relay is 5 amperes, 2.5 volts in phase. When used for ground protection with the 60^{o} phase shifter, the sensitivity is 5 amperes, 2.5 volts at 60^{o} lagging current. This is the maximum torque angle.

The polarizing winding of directional unit in the HRC relay is wound in two sections brought out to taps marked 1, 2, 3 and 4. By various arrangement of the links between these taps and terminals A and B connecting to the base terminals, the relay can be used at its best operating point over a wide variation in polarizing current. The characteristics of the relay are shown in Table I.

TABLE I

Polarizing Turns	[1]Minimum Pick-up Amps.	Maximum Polarizing Amps.	Connections of Links
3	3.0	75.0	2 to A, 1 to 3, 4 to B
7	2.0	32.0	3 to B, 4 to A
10	1.5	25.0	1 to B, 2 to A
17	1.2	15.0	2 to A, 1 to 4, 3 to B

[1]The approximate minimum pick-up current of the directional unit with the polarizing and current winding in series.

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 four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information refer to I.L. 41-076.

External connections of three HR relays for phase protection are shown in Fig. 4. When an HR relay is used for ground protection as shown in Fig. 5, an external phase shifter is required for the directional unit potential circuit. The internal schematic and outline of the phase shifter are shown in Fig. 3 and 7 respectively. The HRC relay is used for ground protection when the bank neutral current is available for polarizing the directional unit. Fig. 6 shows the external connections for this application.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and

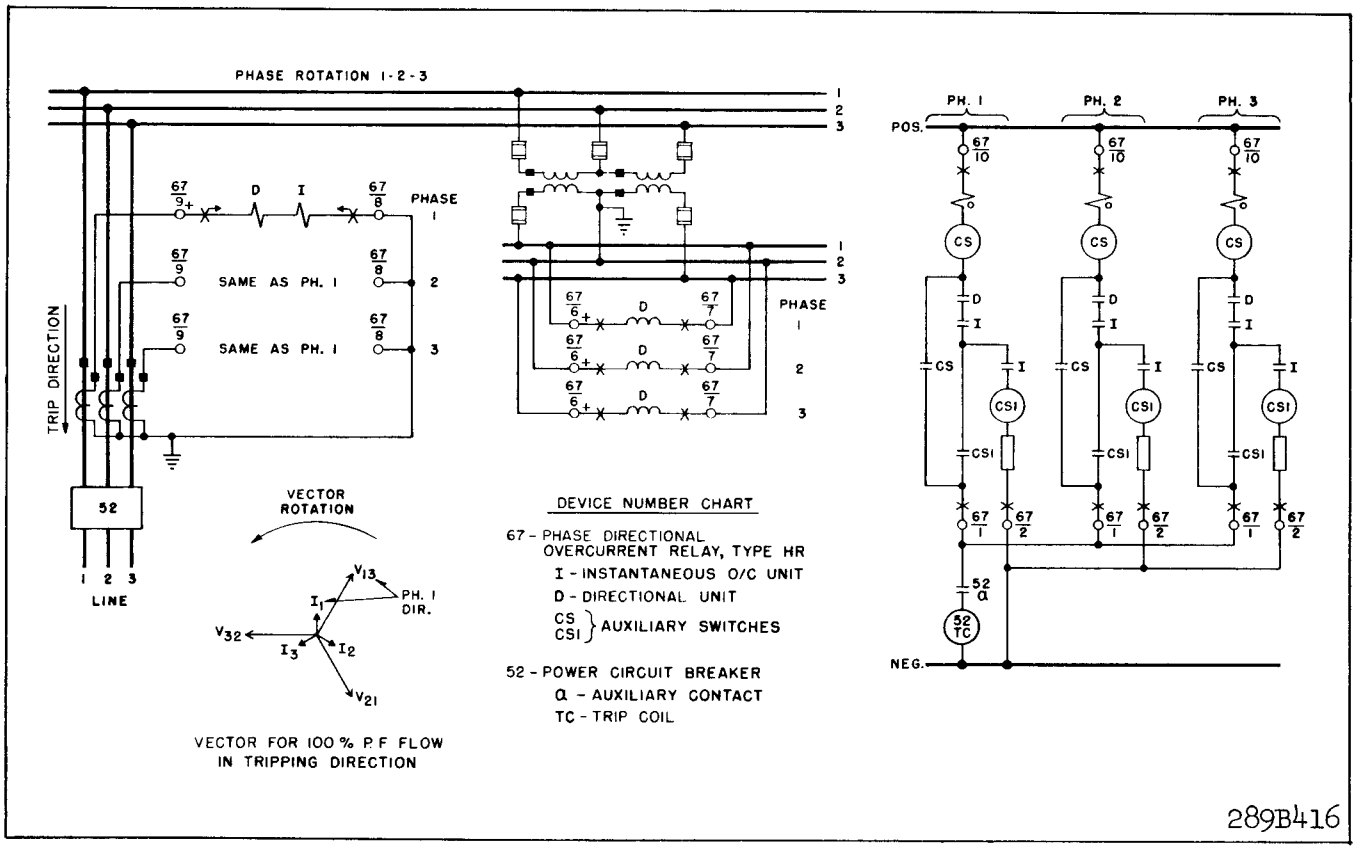


Fig. 4 External Schematic of the Type HR Relays for Phase Protection.

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. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

Overcurrent Unit

The pick-up current adjustment is made by turning the shunt adjuster. To do this, release the pressure on the locking spring by pressing the lever to the left. Rotate the shunt by grasping the lower knurled end with the fingers and turning. When the desired pick-up value is reached release the locking lever. This auto- * matically maintains the shunt-in position. The contact separation in the de-energized position should be 1/8".

Directional Unit

Check the free movement of the directional unit loop. The loop should assume approximately a vertical position with contacts open when the unit is completely de-energized.

The movement of the loop is limited to the contact opening direction by a stop screw which strikes the lower part of the loop. The screw is located on the left-hand side of the unit to the rear of the cur- * rent coil. The left-hand stop screw should be screwed forward until it just touches the loop when it is in its natural de-energized position.

The contacts should have a separation of .020". * The right-hand 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 right amount of follow.

Apply 5 amperes, 2.5 volts in phase to the directional unit 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.

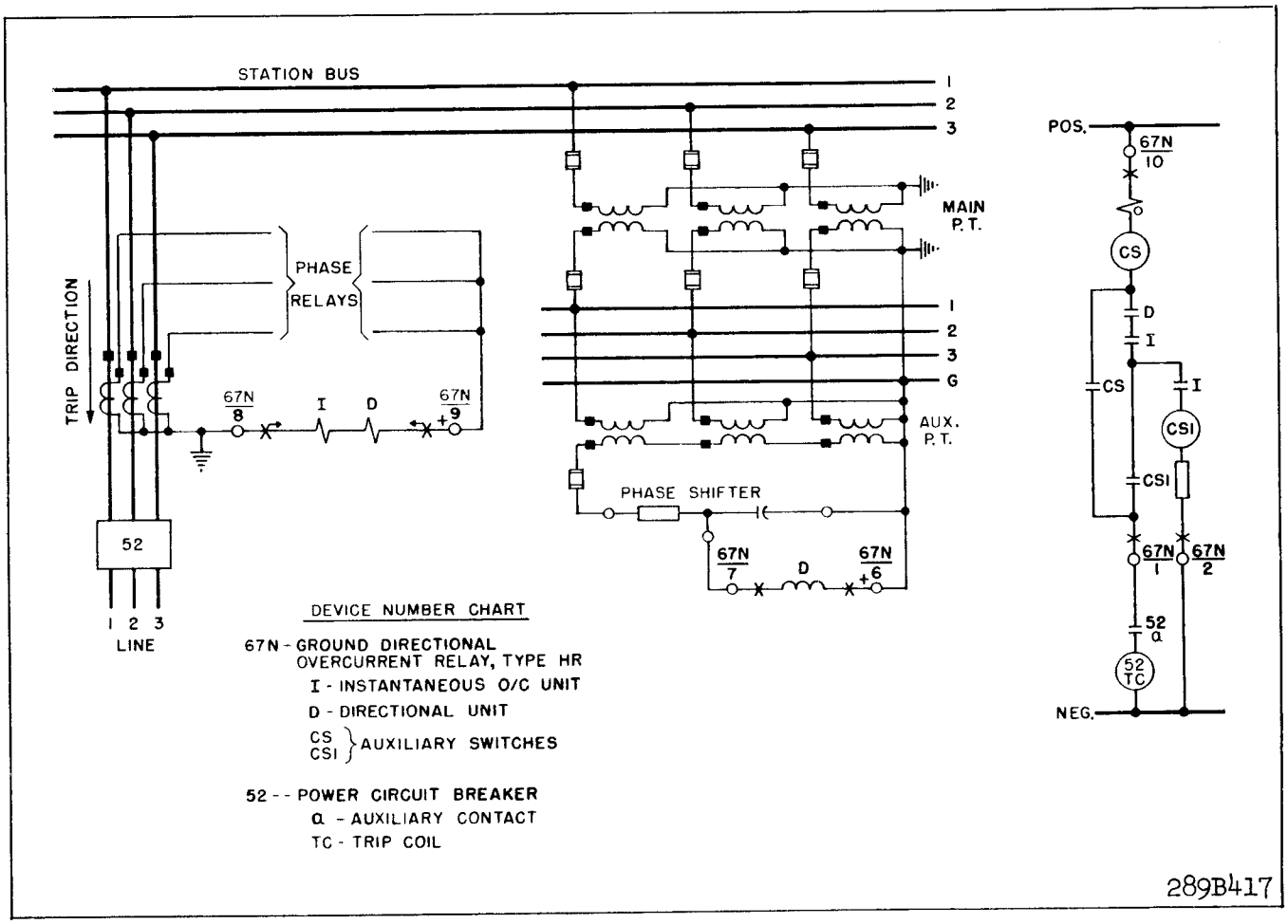


Fig. 5 External Schematic of the Type HR Relay for Ground Protection.

When the directional unit 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 and 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 sufficient true 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 unit operation.

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 1 ampere d.c. Test for sticking after 30 amperes d.c. have been passed * through the coil. Coil resistance is approximately 0.84 ohms.

Auxiliary Contactor Switch

Adjust the stationary core of the switch for a clearance of 1/64 when the switch is picked up, following the same procedure as in the adjustment of the contactor switch. Adjust the contact clearance

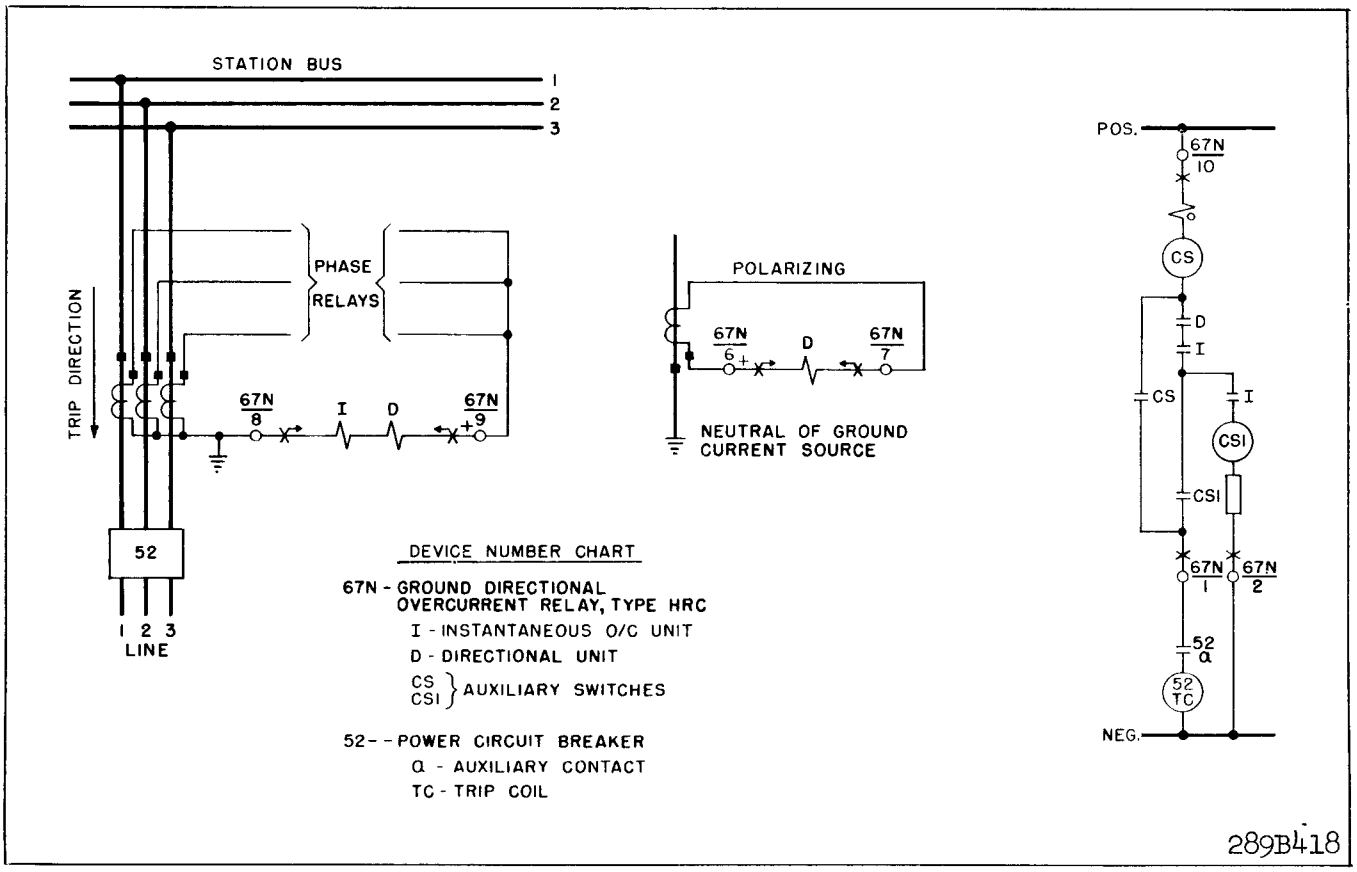


Fig. 6 External Schematic of the Type HRC Relay for Ground Protection.

for 1/8". The switch should pick-up positively at * 75 volts d.c. Coil resistance is approximately 1160 ohms.

Operation Indicator

Adjust the indicator to operate at 1.0 ampere d.c. gradually applied by loosening the two screws on the under side of the assembly, and moving the bracket forward or backward. If the two helical springs which reset the armature are replaced by new springs, they should be weakened slightly by stretching to obtain the 1 ampere calibration. The coil resistance is approximately 0.16 ohm.

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.

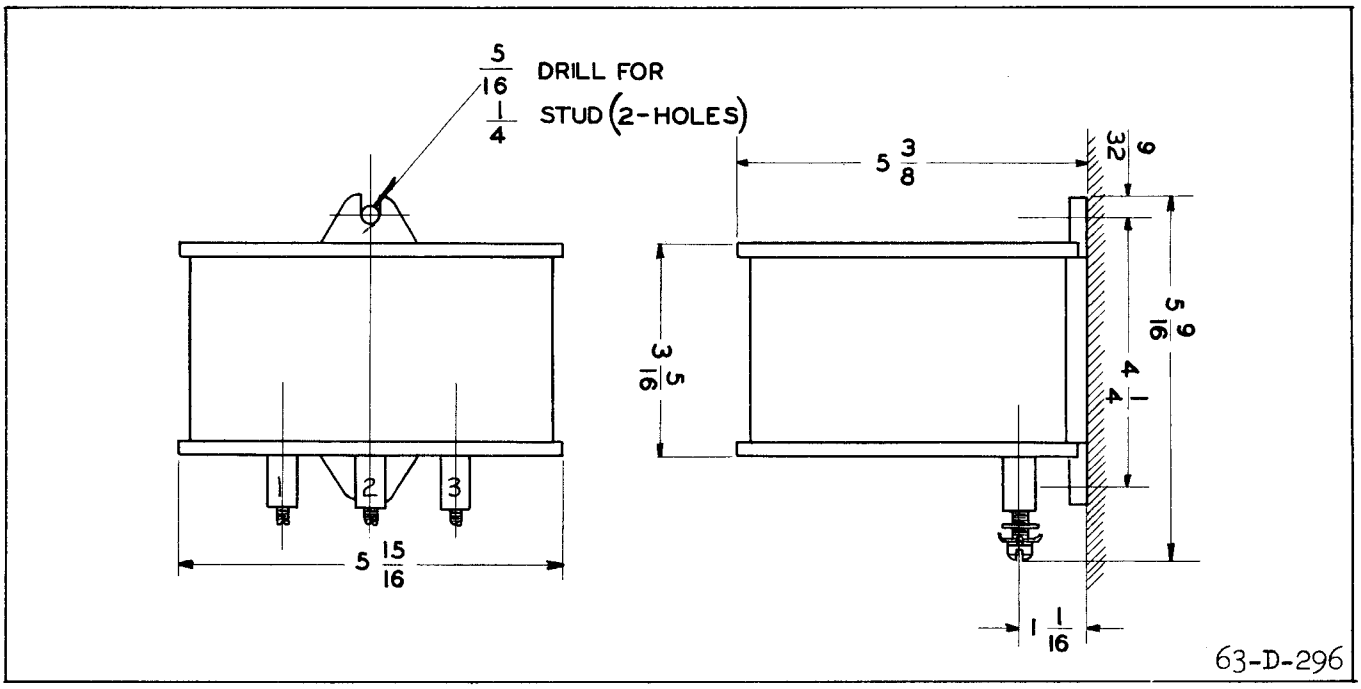


Fig. 7 Outline and Drilling Plan of the External Phase Shifter for the HR Relay for Ground Protection.

ENERGY REQUIREMENTS

The 60 cycle burdens of the overcurrent unit at 5 amperes are as follows:

Range	Max. Continuous Rating	Watts 5 Amps 60 Cycles	VA 5 Amps 60 Cycles	Dropout Ratio
.5 - 2.0	1.5	99	225	90 - 98%
1 - 4.0	3.0	28	65	90 - 98%
2 - 8.0	6.0	6.9	19	90 - 98%
4 - 16.0	12.0	1.5	5	90 - 98%
10 - 40.0	25.0	2.4	7	90 - 98%

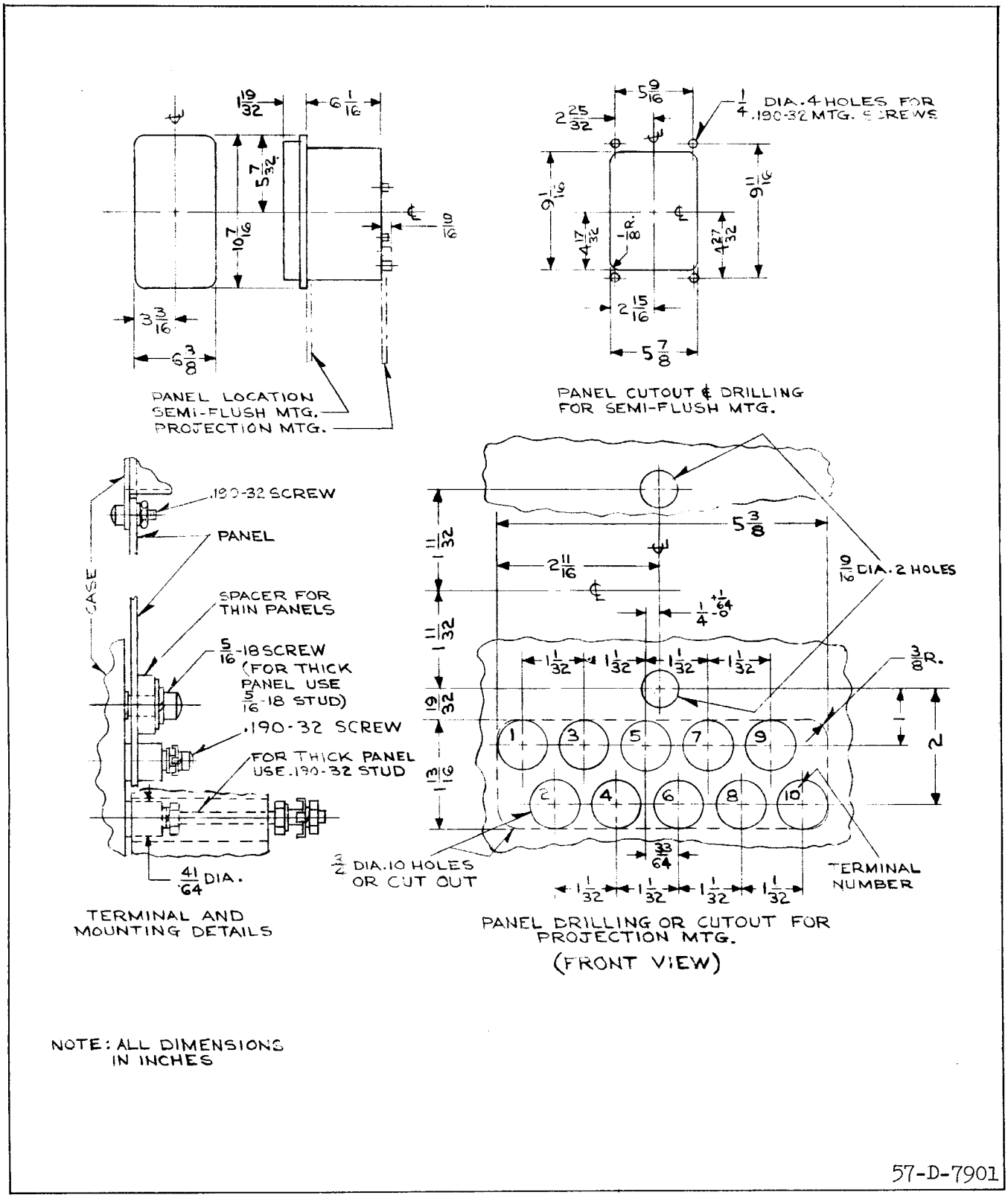
The 60 cycle burden of the directional unit polarizing winding of the type HRC relay at 5 amperes is as follows:

3 turns	1.22 VA	2° Lag
7 turns	0.78 VA	10.3° Lag
10 turns	1.18 VA	10.2° Lag
17 turns	2.75 VA	16° Lag

The 60 cycle burden of directional unit current windings at 5 amperes is 3.5 VA at 45°. The current winding of the directional unit is connected in series with the overcurrent winding on terminals 8 and 9 in both the HR and HRC. The maximum continuous rating of this is 5a.

The 60 cycle burden of the directional unit polarizing circuit of the type HR relay is as follows:

	Volts	Watts 5 Amps - 60 Cycles	VA 5 Amps - 60 Cycles	Power Factor Angle
with phase shifter	115	5.40	6.0	26° Lead
without phase shifter	115	4.04	4.3	20° Lag



* *Fig. 8 Outline and Drilling Plan for the HR and HRC Relays in the FT21 Case.*

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPES HR AND HRC
DIRECTIONAL OVERCURRENT RELAYS

CAUTION Before putting protective relays into service, remove all blocking which may have been inserted for the purpose of securing the parts during shipment, make sure that all moving parts operate freely, inspect the contacts to see that they are clean and close properly, and operate the relay to check the settings and electrical connections.

APPLICATION

The types HR and HRC relays are directional instantaneous overcurrent relays for high-speed directional phase and ground protection. They consist of a high speed induction loop type directional unit and instantaneous type SC overcurrent unit.

The type HRC relay is similar to the type HR relay except that the directional unit is polarized by current from the grounded power bank neutral instead of by residual voltage.

These relays are applicable only where there is enough difference in fault current magnitude for faults at the near and far ends of a section to permit the relays to cover a large portion of the line for maximum and minimum system conditions. In any case, relays of this type must be used only to supplement slow speed relays, since it is impossible with these relays to provide high-speed protection for faults at the far end of the transmission line and still maintain selectivity.

HR and HRC relays are 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 types HR and HRC relays are 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 and HRC relay overcurrent-unit pickup must be just above the maximum instantaneous assymetrical fault current for a fault at the next bus with maximum connected capacity. Faults closer to the relay give currents above the pickup of the overcurrent unit and cause instantaneous 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

The HR and HRC relay overcurrent unit consists of a U-shaped iron frame, mounted on the sub base, the coil is supported on this frame which also provides the external magnetic path for the flux. The coil surrounds a magnetic core and flux shunt. The position of this shunt determines the pick-up setting of the relay.

The lower end of the shunt is beveled and knurled so that it can be grasped by the fingers and rotated to change the setting of the unit. A calibrated scale plate is mounted adjacent to the shunt and serves to indicate, in relation to a grooved index mark on the adjustable shunt, the calibrated pick up setting of the unit.

The shunt is held in any desired position by means of a locking mechanism in which a spring lever presses against the shunt. By pressing the lever to the left the pressure against the shunt is removed allowing the shunt to be easily turned by hand.

The directional unit is of the inductor loop type. The rectangular loop of aluminum to which the moving contacts are fastened forms a short circuited secondary of a small transformer. The primary consists of the voltage coil. The loop is in the field

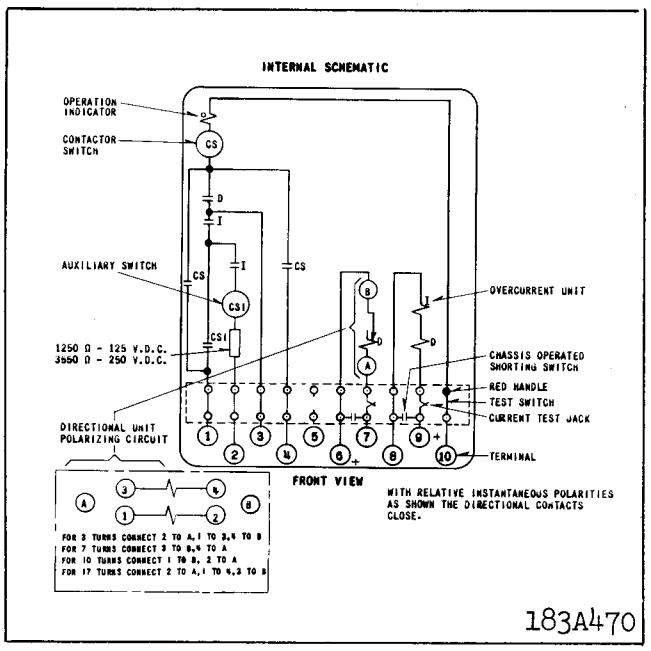


Fig. 1 Internal Schematic of the Type HRC Relay in the Type FT21 Case.

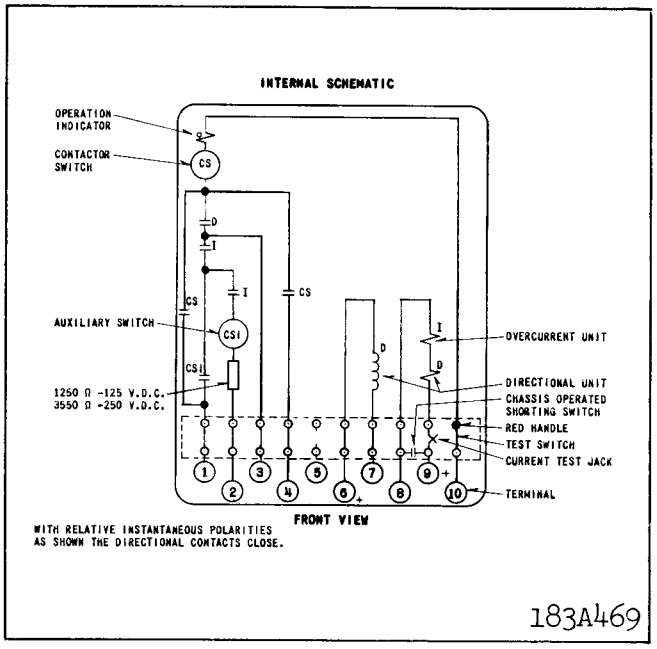


Fig. 2 Internal Schematic of the Type HR Relay in the Type FT21 Case.

produced by the current coils. Torque is caused by the interaction of the current flowing in the loop and the current flux threading the loop.

HRC Relay

The HRC relay is similar to the HR except the voltage coil in the directional unit is replaced by a current coil, thus polarizing the directional unit on current alone. One current coil utilizes the neutral current of the power transformer while the other uses the residual current of the line.

An auxiliary d.c. contactor switch is provided in both the type HR and HRC relays to insure proper coordination between the high speed directional and overcurrent units. The switch coil is energized by the closing of both the directional and overcurrent unit contacts while the auxiliary switch contacts are in series with the directional and overcurrent unit contacts in the relay trip circuit. A momentary closing of both overcurrent and directional unit contacts, such as might occur on a sudden power reversal therefore, will not complete the trip circuit.

Both relays are provided with an operation indicator and a 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 the 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.

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. The indicator is adjusted to trip at 1.0 amperes d.c. and the contactor switch to pick up at 1.0 ampere. For positive operation, at least four amperes should flow in the trip circuit. The relay trip circuit resistance is approximately 1.0 ohm.

The main relay contacts will safely close 30 amperes at 125 volts d.c. and the contactor switch contacts will carry this current until the trip circuit is interrupted by the auxiliary switch on the breaker.

CHARACTERISTICS

The overcurrent unit will operate in less than 1 cycle. The operating or pick-up point is adjusted by

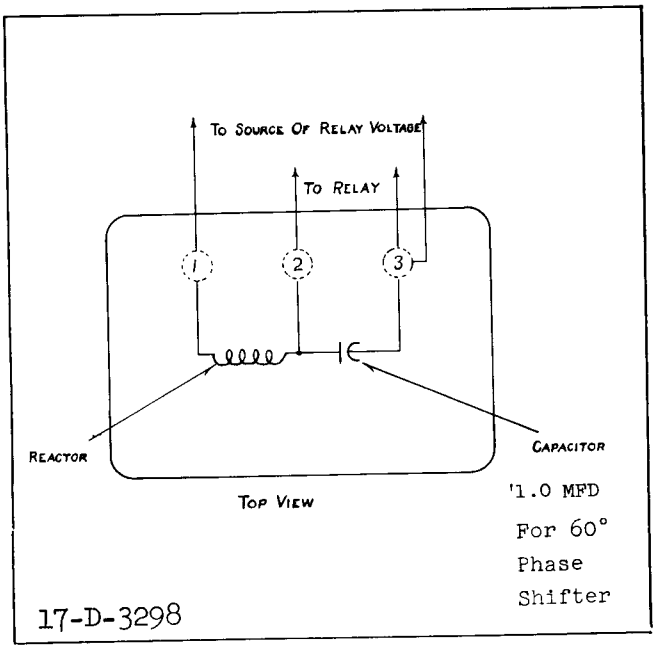


Fig. 3 Internal Schematic of the External Phase Shifter used with the type HR Relay for Ground Protection.

varying the magnetic shunt described under construction.

The relay is available with overcurrent unit ratings as shown under energy requirements.

The overcurrent unit contacts are so arranged that the CS1 switch will drop out after the fault conditions are cleared. This eliminates the need for a separate "a" switch when a trip coil indicating lamp is used.

The sensitivity of the directional unit in the type HR relay is 5 amperes, 2.5 volts in phase. When used for ground protection with the 60° phase shifter, the sensitivity is 5 amperes, 2.5 volts at 60° lagging current. This is the maximum torque angle.

The polarizing winding of directional unit in the HRC relay is wound in two sections brought out to taps marked 1, 2, 3 and 4. By various arrangement of the links between these taps and terminals A and B connecting to the base terminals, the relay can be used at its best operating point over a wide variation in polarizing current. The characteristics of the relay are shown in Table I.

TABLE I

Polarizing Turns	[1]Minimum Pick-up Amps.	Maximum Polarizing Amps.	Connections of Links
3	3.0	75.0	2 to A, 1 to 3, 4 to B
7	2.0	32.0	3 to B, 4 to A
10	1.5	25.0	1 to B, 2 to A
17	1.2	15.0	2 to A, 1 to 4, 3 to B

[1]The approximate minimum pick-up current of the directional unit with the polarizing and current winding in series.

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 four mounting holes on the flange for semi-flush mounting or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel panel mounting or to the terminal studs furnished with the relay for thick panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information refer to I.L. 41-076.

External connections of three HR relays for phase protection are shown in Fig. 4. When an HR relay is used for ground protection as shown in Fig. 5, an external phase shifter is required for the directional unit potential circuit. The internal schematic and outline of the phase shifter are shown in Fig. 3 and 7 respectively. The HRC relay is used for ground protection when the bank neutral current is available for polarizing the directional unit. Fig. 6 shows the external connections for this application.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and

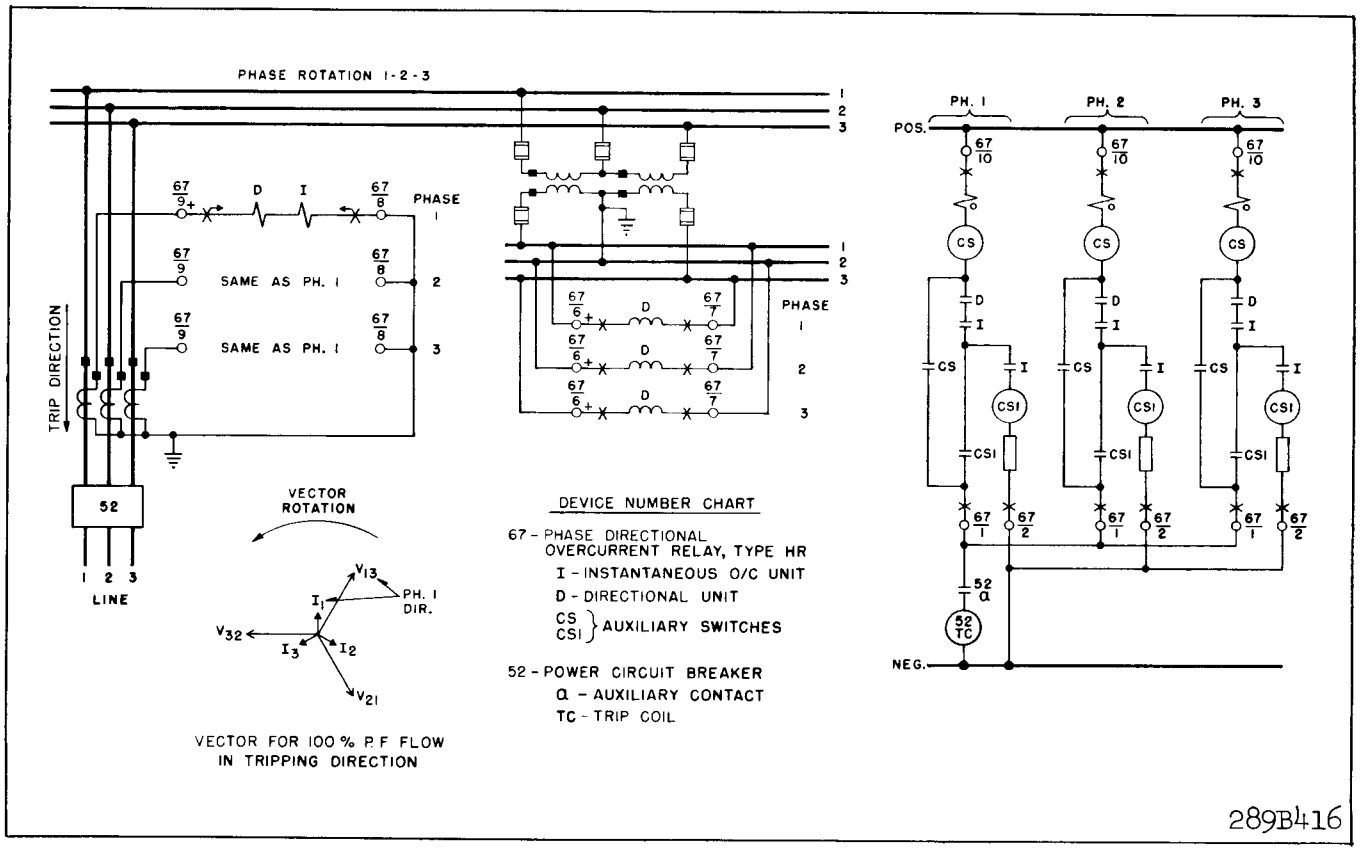


Fig. 4 External Schematic of the Type HR Relays for Phase Protection.

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. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

Overcurrent Unit

The pick-up current adjustment is made by turning the shunt adjuster. To do this, release the pressure on the locking spring by pressing the lever to the left. Rotate the shunt by grasping the lower knurled end with the fingers and turning. When the desired pick-up valve is reached release the locking lever. This automatically maintains the shunt in position.

Directional Unit

Check the free movement of the directional unit loop. The loop should assume approximately a vertical position with contacts open when the unit is completely de-energized.

The movement of the loop is limited in the contact opening direction by a stop screw which strikes the lower part of the loop. The screw is located on the left-hand side of the unit to the rear of the current coil. The back stop screw should be screwed forward until it just touches the loop when it is in its natural de-energized position.

The contacts should have a separation of .020". 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 right amount of follow.

Apply 5 amperes, 2.5 volts in phase to the directional unit 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.

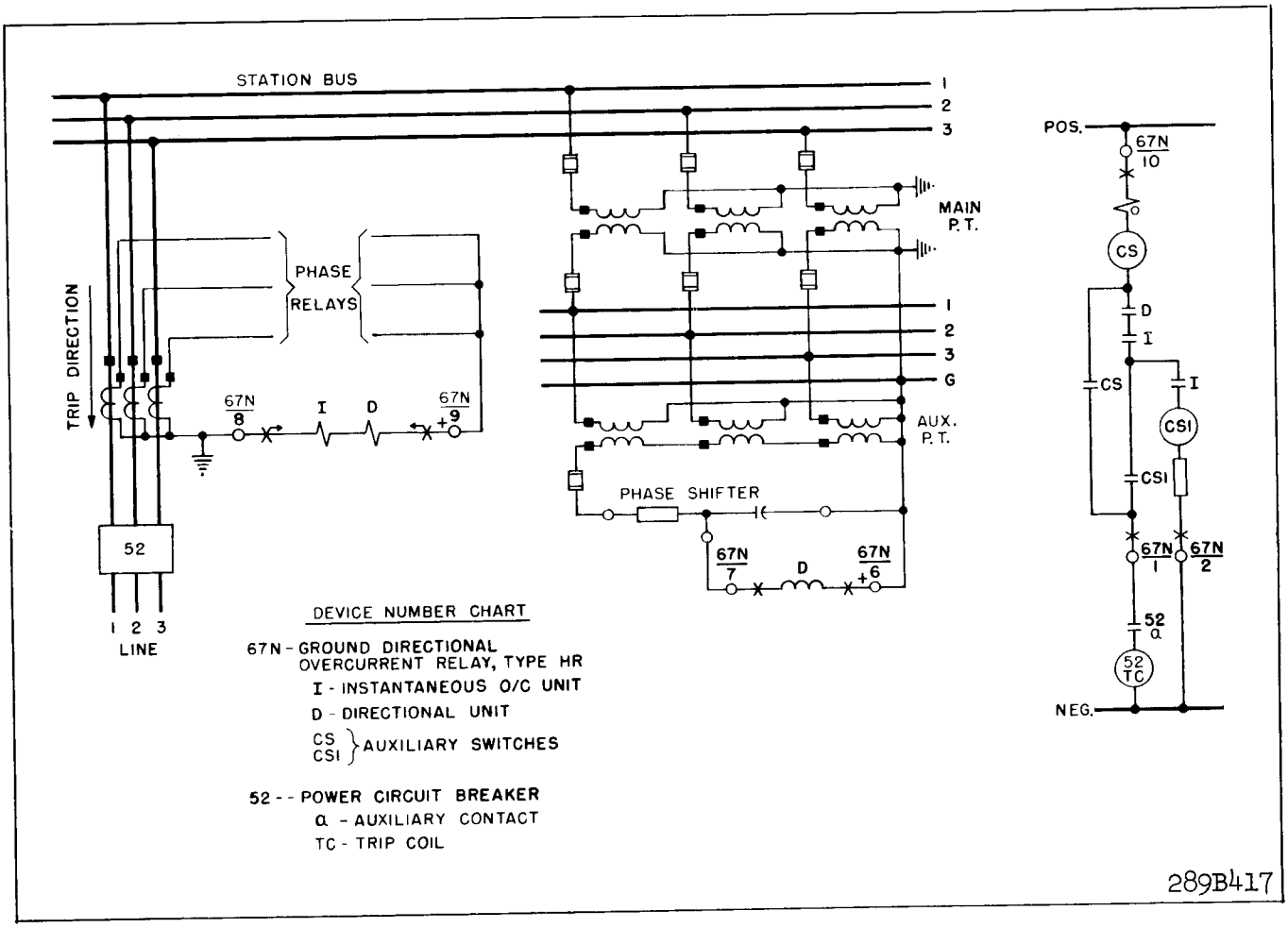


Fig. 5 External Schematic of the Type HR Relay for Ground Protection.

When the directional unit 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 and 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 sufficient true 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 unit operation.

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 1 ampere d.c. Test for sticking after 30 amperes d.c. have been passed through the coil.

Auxiliary Contactor Switch

Adjust the stationary core of the switch for a clearance of 1/64 when the switch is picked up, following the same procedure as in the adjustment of the contactor switch. Adjust the contact clearance for 1/8". The switch should pick-up positively at

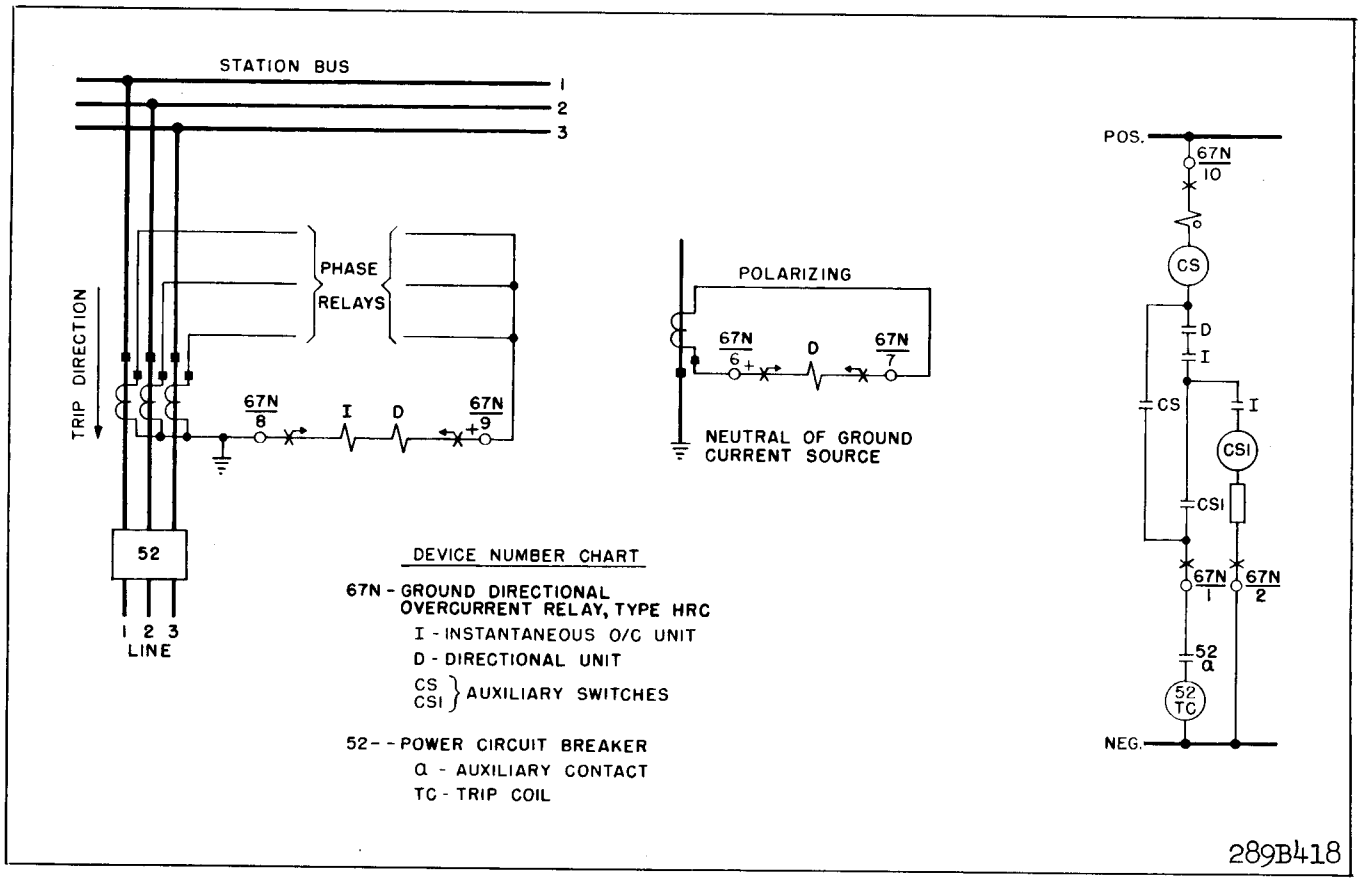


Fig. 6 External Schematic of the Type HRC Relay for Ground Protection.

75 volts d.c.

Operation Indicator

Adjust the indicator to operate at 1.0 ampere d.c. gradually applied by loosening the two screws on the under side of the assembly, and moving the bracket forward or backward. If the two helical springs which reset the armature are replaced by new springs, they should be weakened slightly by stretching to obtain the 1 ampere calibration. The coil resistance is approximately 0.16 ohm.

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.

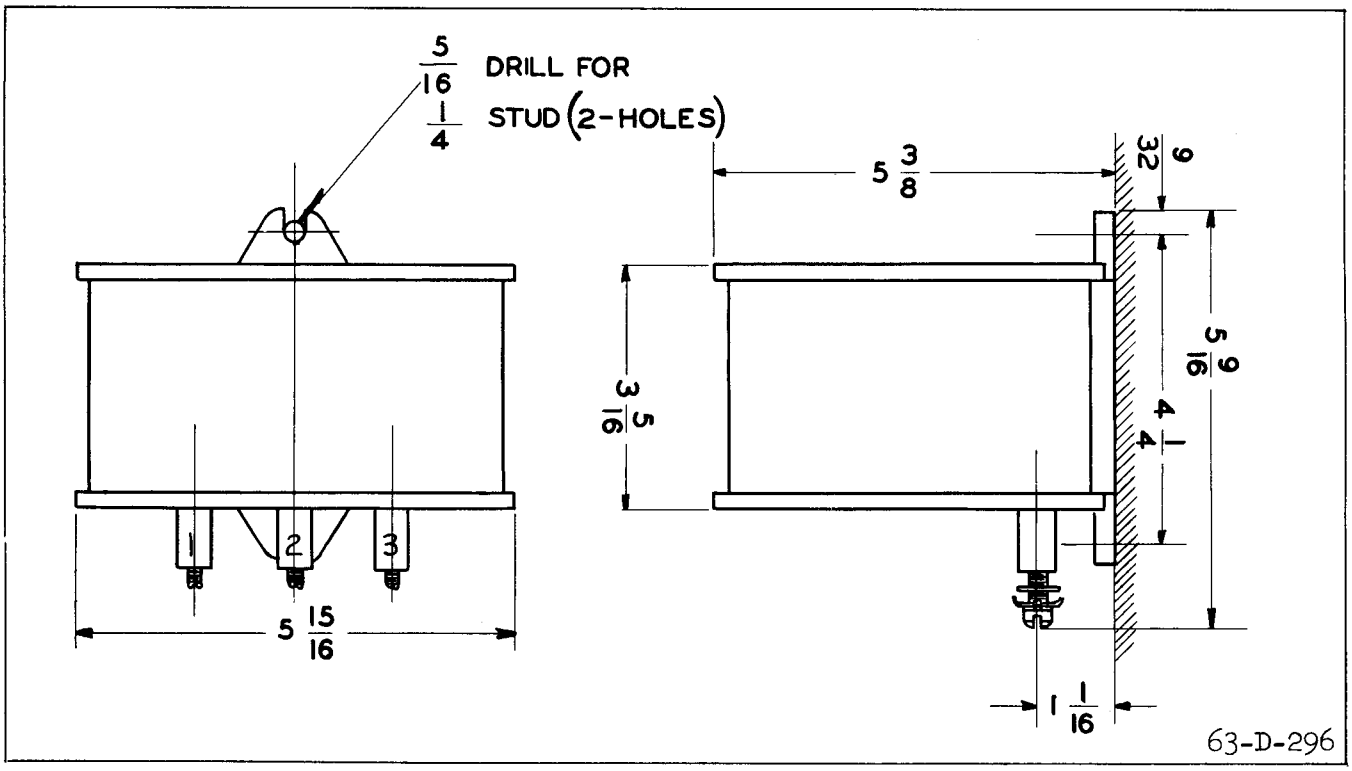


Fig. 7 Outline and Drilling Plan of the External Phase Shifter for the HR Relay for Ground Protection.

ENERGY REQUIREMENTS

The 60 cycle burdens of the overcurrent and directional unit current coils in series at 5 amperes are as follows:

Range	Max. Continuous Rating	Watts 5 Amps 60 Cycles	VA 5 Amps 60 Cycles	Dropout Ratio
.5 - 2.0	1.5	99	225	90 - 98%
1 - 4.0	3.0	28	65	90 - 98%
2 - 8.0	6.0	6.9	19	90 - 98%
4 - 16.0	12.0	1.5	5	90 - 98%
10 - 40.0	25.0	2.4	7	90 - 98%

The 60 cycle burden of the directional unit polarizing winding of the type HRC relay at 5 amperes is as follows:

3 turns	1.22 VA	2° Lag
7 turns	0.78 VA	10.3° Lag
10 turns	1.18 VA	10.2° Lag
17 turns	2.75 VA	16° Lag

The current winding of the directional unit is connected in series with the overcurrent winding on terminals 8 and 9 in both the HR and HRG. The maximum continuous rating of this is 5a.

The 60 cycle burden of the directional unit polarizing winding and phase shifter at 115 volts of the type HR relay is as follows:

Volts	Watts 5 Amps - 60 Cycles	VA 5 Amps - 60 Cycles
115	5.40	6.0

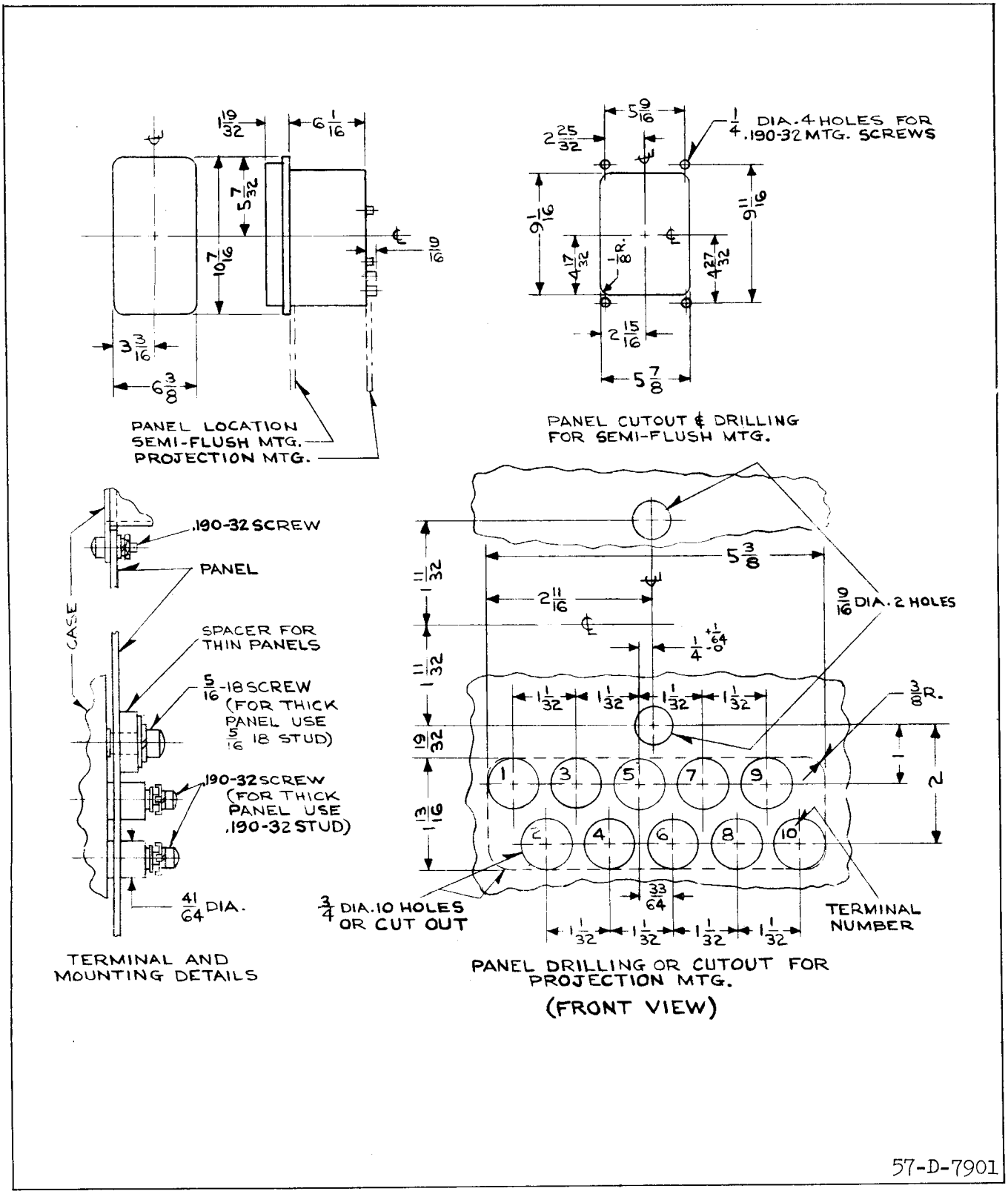


Fig. 8 Outline and Drilling Plan for the HR and HRC Relays in the FT21 Case.