INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE HD CURRENT BALANCE RELAY

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 HD differential relay is a high-speed inductor-loop relay for differential protection of parallel lines on both line and ground faults. It has double throw contacts, making possible the balanced current protection of one end of a pair of parallel lines with the use of only four relays, three phase relays and one ground relay.

This relay may be used at the transmission end of any number of parallel lines of equal impedance, and at the receiving end of any number of parallel lines in a system having a source of power at both ends, or at the receiving end of three or more parallel feeders in a radial system. It cannot be used at the receiving end of a single pair of radial parallel feeders, since currents in the relay in this case would always be equal, and the relay would not operate.

CONSTRUCTION AND OPERATION

The relay is of the inductor-loop type in which the loop is pivoted at each end, and forms the secondary of a small transformer. The primary of the transformer consists of two symmetrically tapped windings, T_1 and T_2, which are so connected that with currents in the lines flowing in the same direction, the current which flows in the loop is proportional to the difference of the two line currents. (Figure 1).

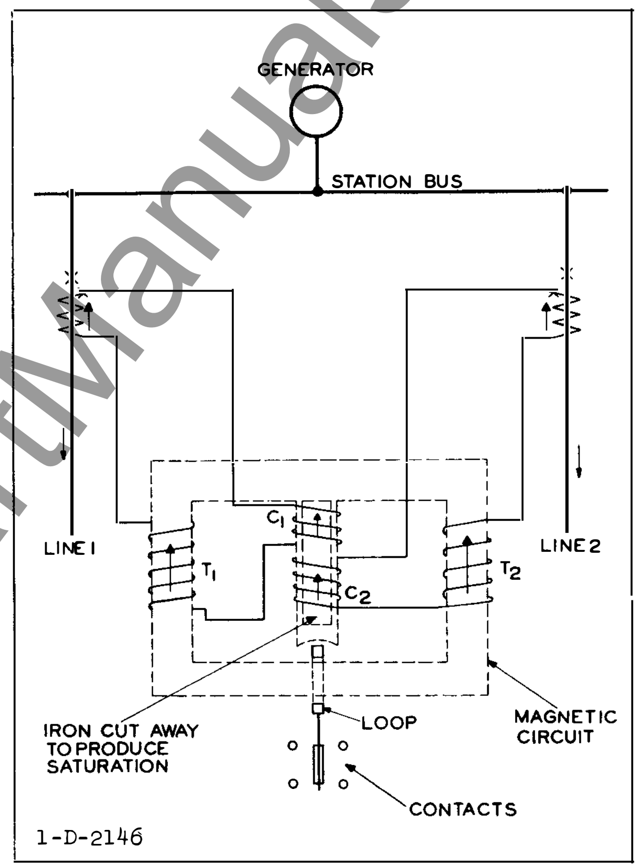

Fig. 1—Single Line Schematic Diagram of the Operating Element.

The loop is located in a magnetic field produced by two current coils, C_1 and C_2. These are so connected that their fluxes are adding when the currents in the lines are flowing in the same direction. The field thus produced is proportional to the sum of the two line currents.

From the above, it is obvious that, with currents in the lines in opposite directions, the transformer primary windings will be adding, and the windings producing the field will be bucking. Therefore, with equal currents in the lines, either in the same or in

SUPERSEDES I.L. 41-407C

✱Denotes change from superseded Issue

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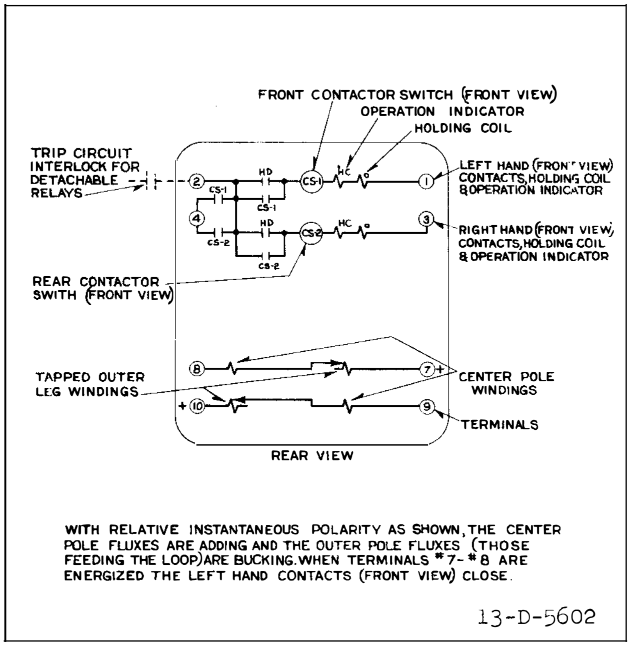

Fig. 2—Internal Schematic of the Type HD Relay in the Standard Case.

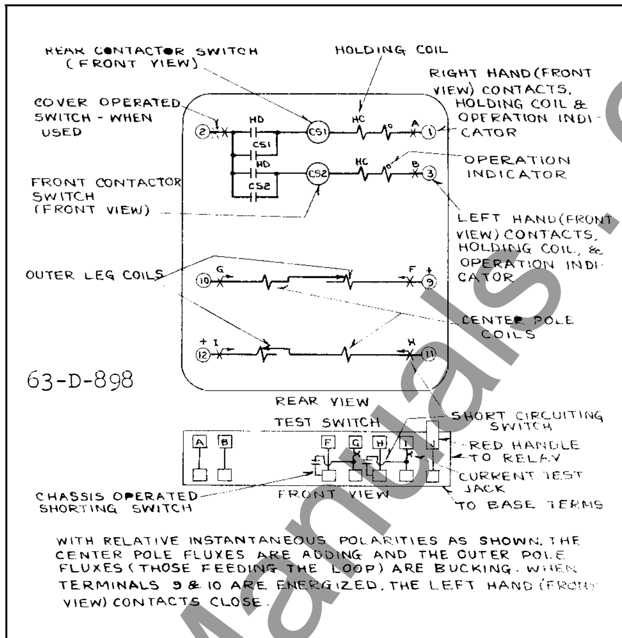

Fig. 3—Internal Schematic of the Type HD Relay in the Type FT Case.

opposite directions, no torque is produced, since in one case there is no current in the loop, and in the other case there is no flux in the gap. If, however, the currents are unequal, either in the same or opposite directions, a torque is produced to trip the breaker on the line having the higher current.

The moving contact assembly is fastened solidly to the loop by means of a small bar of Micarta. The stationary contacts are located so that a travel of approximately 1/16" either way of the moving contact will close the trip circuit by bridging the two stationary contacts, and trip the breaker on the line in fault.

Also mounted on the loop is a small piece of soft iron, which forms the armature of two holding coils. These coils are energized when the main contacts close, thus holding the contacts positively closed, and preventing vibration of the contacts under conditions of excessively high torque, such as is the case where there is a large difference in the currents in the lines during a fault. Reference to the schematics, Figs. 2 or 3, show that the holding coils remain energized as long as the main contactor switch is picked up, since these coils are in series with the trip circuit. In some cases the inductance of the trip coil of the breaker is so high that it prevents the trip coil current from building up sufficiently fast to insure the proper operation of the holding coil and contactor switch of the relay during the excessively high torque conditions. In such cases, the use of two resistors is recommended, as shown by R in Figs. 10 or 11. The 2 amperes of non-inductive current drawn by these resistors acts instantly to energize the holding coil and contactor switch coil, thus insuring a positive closure and seal in of the trip circuit. A wire wound porcelain tube type resistor is satisfactory for this purpose. The 6" or 6-1/2" tube is suggested. Two operation indicators and two contactor switches are provided. The left-hand operation indicator is wired in the left-hand contact circuit and, similarly, the right-hand operation indicator is wired in the right-hand contact circuit.

The resistance of the relay trip circuit is approximately 1.0 ohm. The main contacts of the relay will safely close 30 amperes at 125 volts d-c and the contactor switch contacts will safely carry this current until the auxiliary switch on the breaker opens the trip circuit.

The relay balances the current in one parallel line against that in the other, and will trip only when the current difference reaches a pre-determined value. This, tripping value is determined by the tap on the relay, and the value of secondary current in the lightly loaded line. Reference to Figs. 5 or 7 shows the tripping characteristics of the relay for conditions where the currents are flowing in the same direction in the lines. Figs. 6 or 8 show the tripping characteristics for the conditions where one current is flowing into the bus and the other current is flowing away from the bus (Currents in opposite directions).

CHARACTERISTICS AND SETTINGS

The operating characteristics are shown in Figures 5, 6, 7 and 8 for the line relay and ground relay respectively.

The tap values of the relays are as follows:

Line Relay	1.5	2	3	4
Ground Relay	.5	.8	1.3	2

These tap values represent the differential current necessary to trip the relay with 60 and 30 amperes secondary representing the relay in the good line in the case of the line relay and ground relay, respectively. For example, if a ground fault occurs near the remote end of two parallel lines, and 30 amperes flows in the good line, and 30.5 amperes flows in the faulted line, the ground relay will just close its contacts if used on the .5 tap, these currents being in the same direction.

It will be noted from the curves, Figures 5 to 8, that the relay will trip on a smaller difference current than the tap value when the currents are in opposite directions. This is particularly true for the ground relay. This increased sensitivity of the relay is a desirable characteristic, since currents cannot flow in opposite directions, unless there is a fault within the section being protected.

The most important factors in choosing the proper settings for the relay are:

1. Normal load current.
2. Short Circuit Current (secondary amperes).
3. Accuracy of current transformers.

1). Normal load current is important since it determines the value of current in one line when the other is out of service. Thus, if the load current is anything up to 3 secondary amperes, the relay may safely be used on the 1.5 tap, since more than 6 amperes (double load current) is required to operate the relay with only one line in service. Load currents higher than this will necessitate the use of a higher tap.

2). The magnitude of the secondary short-circuit current is important, since it determines the location on the characteristic curve at which the relay will operate. Since the relay becomes more sensitive at higher secondary currents, a current transformer ratio should be chosen which will give as high a current in the relay during fault conditions as possible, keeping in mind the requirements outlined under (1).

3). The satisfactory functioning of the relay during faults outside the section depends upon the accuracy of the current transformers.

During heavy through faults a difference in current transformer output equal to the trip value of the relay would give a false operation. The selection of the proper tap on the relay, therefore, is influenced by the accuracy of the current transformers, and a tap sufficiently high must be chosen, which will prevent false tripping on heavy through faults.

* 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 cleaned periodically. 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.

Loosen the spring holders and adjust both sides for zero initial spring tension. Then pass 60 amperes for the line relay (30 amperes for the ground relay) through the two coils in series in the same direction. (Current in terminal 7, out 8, in 10, out 9. The loop should not get warm for this test). The loop has a centering torque for this condition, and will center itself accordingly. Check the center adjusting lever to agree with this position. It is easier to check this position by using a very slight amount of initial tension on both springs but it must be possible to remove all spring tension, or difficulty will be experienced later. When the center adjusting lever has been adjusted as above, see that both spring arms strike the pin on the loop and the center adjusting lever at the same time, when the relay is de-energized. If they do not, this may be corrected by bending the vertical part of the center adjuster, as required. Summarizing the above, the pin on the loop must be in contact with both spring arms, and both spring arms must be in contact with the center adjuster, when the relay is de-energized.

Preliminary mechanical adjustments of the contacts and holding coil core screws are made as follows: Adjust the stationary contacts so that there is a gap of 3/64" between the moving contact and the rear stationary contact on each side. Adjust the front contact so that the moving contact strikes both front and rear contacts at the same time. Adjust the holding coil core screws so that the stationary contacts are deflected .010" before the armature on the loop strikes the holding coil core. With the loop in this position, the back stop screws should clear the stationary contacts by approximately .005".

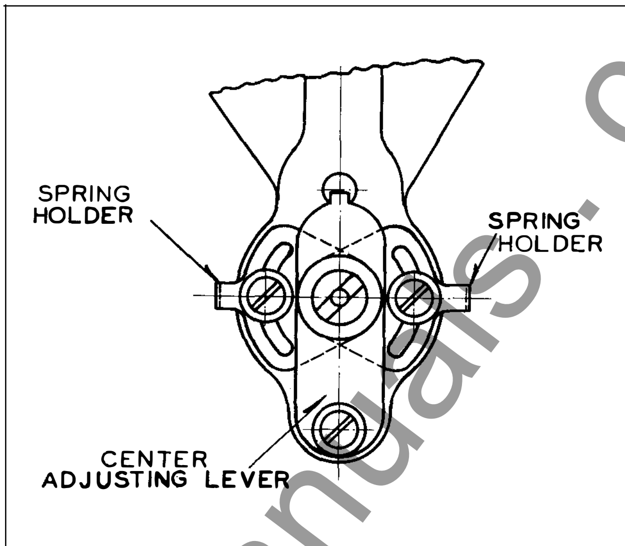

Fig. 4—Detail of the Spring Holders and Center Adjusting Lever.

CALIBRATION

NOTE: All current readings should be taken with suddenly applied currents. This duplicates service conditions, hence the readings should be taken this way. Readings taken with gradually increased currents will give different results. When checking the relay with heavy currents in the opposite direction, the loop heats very quickly, hence final readings should be taken only after the loop has been thoroughly cooled. An air hose will facilitate cooling both the loop and the coils when testing at high currents.

Line Relay

Connect as per Figure 9, and adjust the load to give A_1 = 60 amperes, and A_2 = 1.5 amperes. Adjust the spring tension so that the relay just trips to the left when the currents are suddenly applied, both tap screws being in the 1.5 taps. With A_1 = zero amperes, the current, A_2, to trip in one side only should be between 7 and 9 amperes. Then, reverse the connections to terminals 7 and 9 and adjust the spring for correct closing of the right-hand contacts at A_1 = 60 amperes, and A_2 = 1.5 amperes.

To check for correct operation with currents in opposite direction, connect as per Figure 9, except reverse the connections to terminals 9

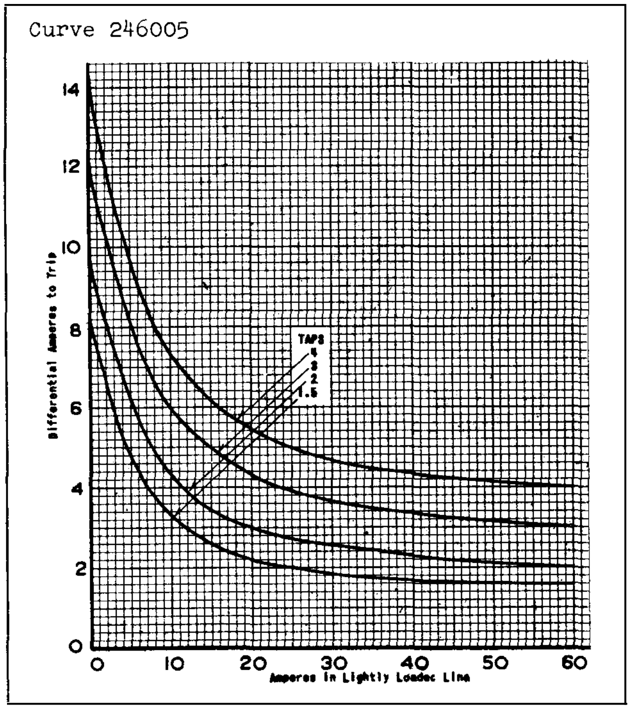

Fig. 5—Typical Operating Characteristics of the Line Relay, Currents in Line in Same Direction.

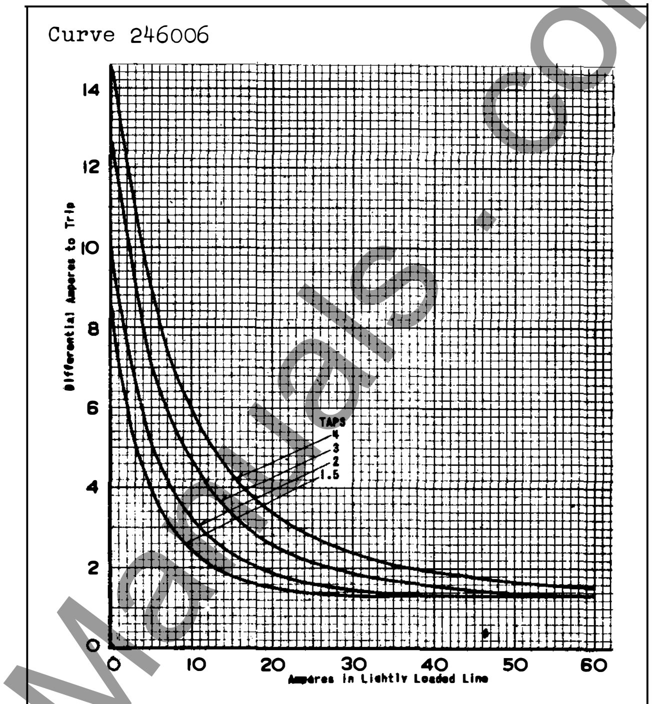

Fig. 6—Typical Operating Characteristics of the Line Relay, Currents in Lines in Opposite Direction.

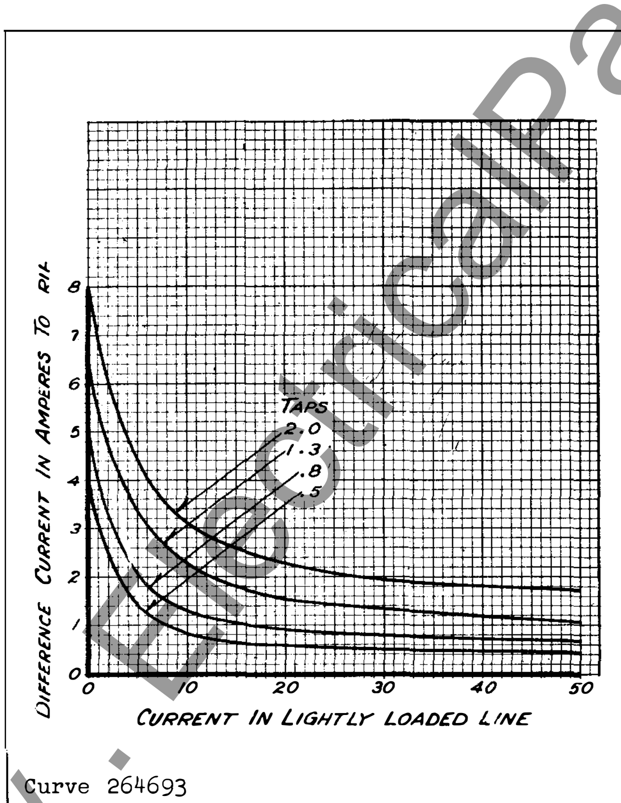

Fig. 7—Typical Operating Characteristics of the Ground Relay, Currents in Lines in Same Direction.

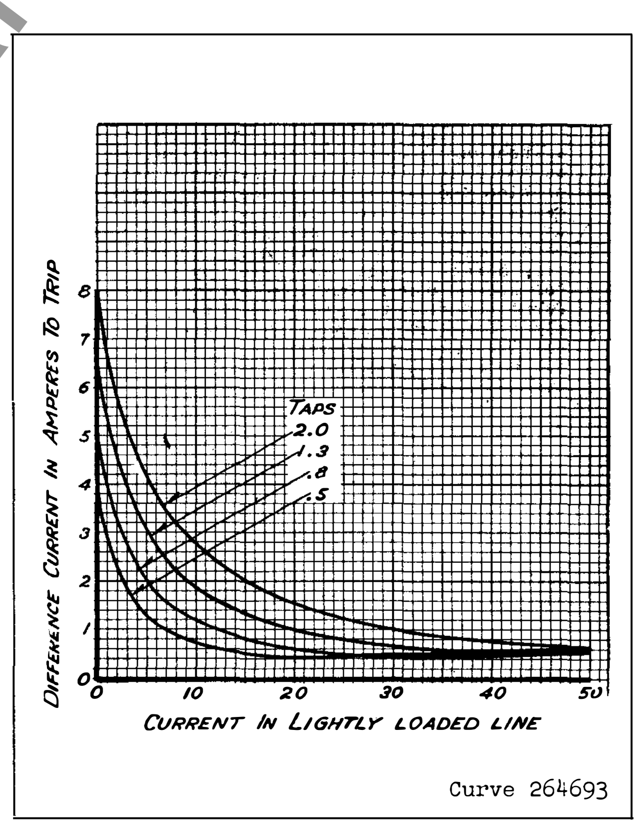

Fig. 8—Typical Operating Characteristics of the Ground Relay, Currents in Lines in Opposite Direction.

and 10. This checks tripping of the left-hand contacts. Beginning with this set-up, reverse the connections to terminals 7 and 10 to check the right-hand contacts. Check tripping values for both left-hand and right-hand contacts before making any adjustments. The difference current to trip should be between 1.0 and 1.5 amperes (tap 1.5) and the difference between the values for the left-hand and right-hand contacts is kept to within .25 amperes in the factory adjustment. If the tripping values are not within these limits, they may be corrected by turning out the holding magnet core screw slightly on the side requiring too much current to trip, or, if necessary, doing both. (This method is effective because the holding coil cores affect the distribution of the stray field from the loop, and not because of their own coils, since they are not energized with d-c until after the contacts close.) After each such adjustment of the holding coil cores, they should be locked in place by means of the lock nuts provided. Any such readjustment of the cores, as described, makes it necessary, of course, to trim up the adjustment of the stationary contacts, since the limit of travel of the loop is affected. Also, the tripping current should be checked again with the currents in the same direction, after the above is complete, for possible minor readjustment of the spring tension. In this recheck the factory limits are 1.35 to 1.65 amperes on the 1.5 taps with A_1 = 60 amperes. If necessary to change the spring tension, the values to trip with currents in opposite direction should be checked again.

If the coils and iron are ever replaced, make sure that the laminations are uniformly stacked, and that there are the same number of short and long laminations.

Ground Relay

This is calibrated and checked the same way as the line relay, except that the values are (Tap .5).

Currents in same direction:

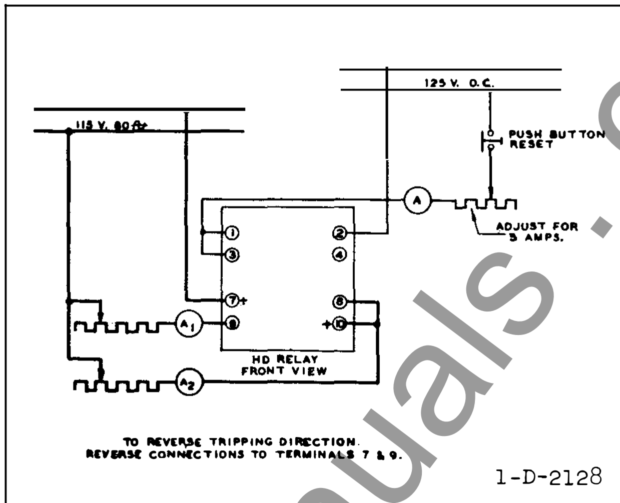

Fig. 9—Diagram of Test Connections. Currents in Same Direction.

A_1 = 30 amperes
A_2 = .45 to .55

Current in one side only:

A_2 = 2.5 to 3.5 amperes

Currents in opposite direction:

A_1 = 30 amperes
*A_2 = .050 ampere or more.

*Values for left-hand and right-hand side within ± 10% of their average value.

It is to be noted that the ground relay is much more sensitive in percent of the tap value when the currents are in opposite direction than the line relay is. However, as has been mentioned previously, this is an advantage instead of a disadvantage.

RENEWAL PARTS

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

ENERGY REQUIREMENTS

The burdens of the line and ground relays at 5 amperes 60 cycles with one line only energized:

Tap		Burden Volt-Amps.		Power Factor Angle	
Line	Ground	Line	Ground	Line	Ground
1.5	.5	2.05	5.6	32°	50°
2.	.8	1.8	5.15	33°	52°
3.	1.3	1.6	4.9	34°	53°
4.	2.	1.5	4.8	36°	54°

Burdens with both lines energized and currents in the same directions in the lines:

1.5	.5	2.4	8.35	49°	64.0°
2.	.8	2.3	8.20	50°	64.5°
3.	1.3	2.2	8.10	52°	64.0°
4.	2.	2.1	8.0	53°	64.5°

Burdens with both lines energized and currents in the opposite directions in the lines:

1.5	.5	1.93	4.0	11.0°	11.0°
2.	.8	1.5	3.3	8.5°	8.5°
3.	1.3	1.2	3.0	7.5°	7.5°
4.	2.	1.1	2.9	6.0°	7.5°

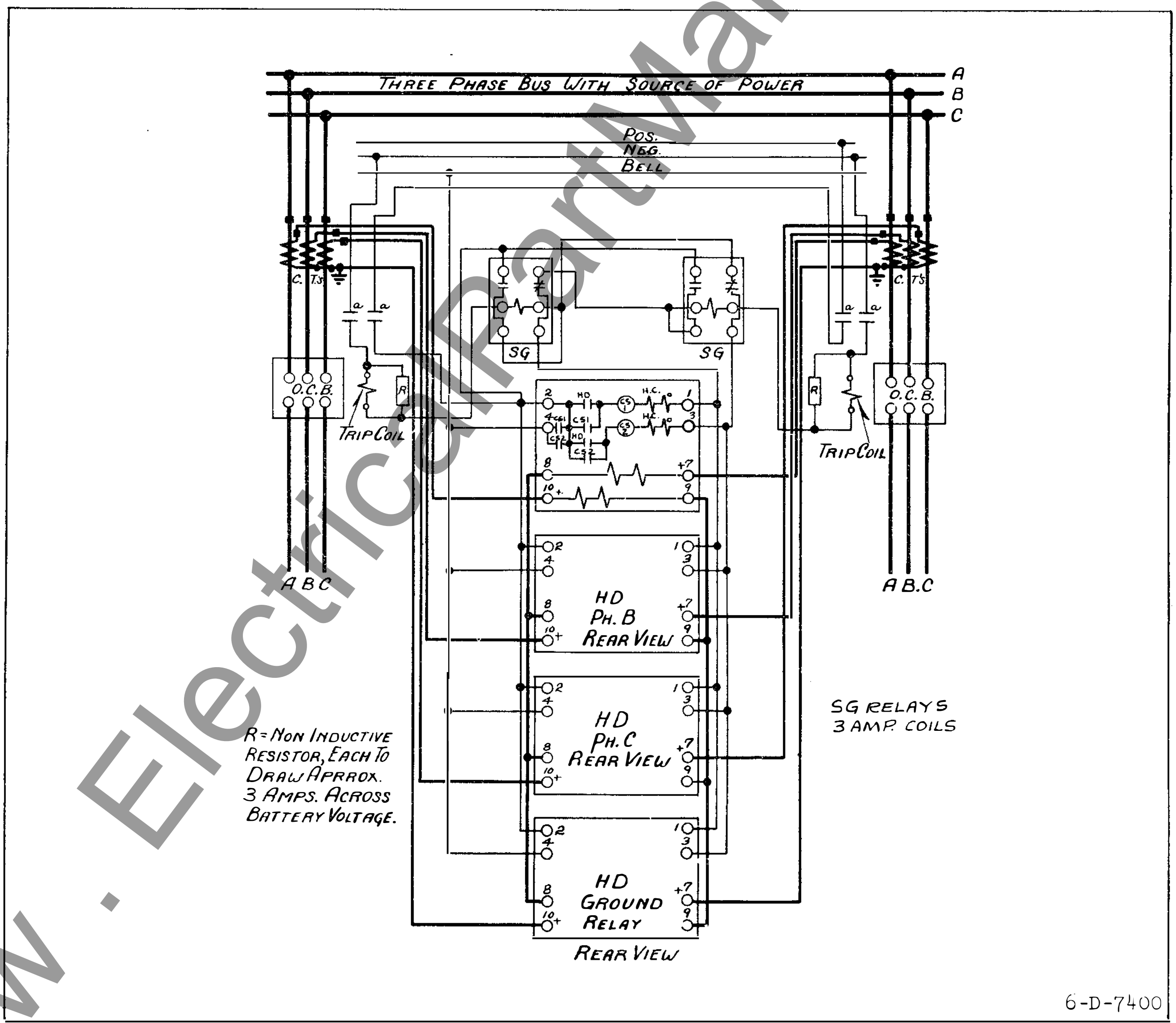

Fig. 10—External Connections of the Type HD Relay in the Standard Case For Phase and Ground Protection During Parallel Line Operation, Utilizing SG Relays (With Current Windings) For Interlock Between Circuits.

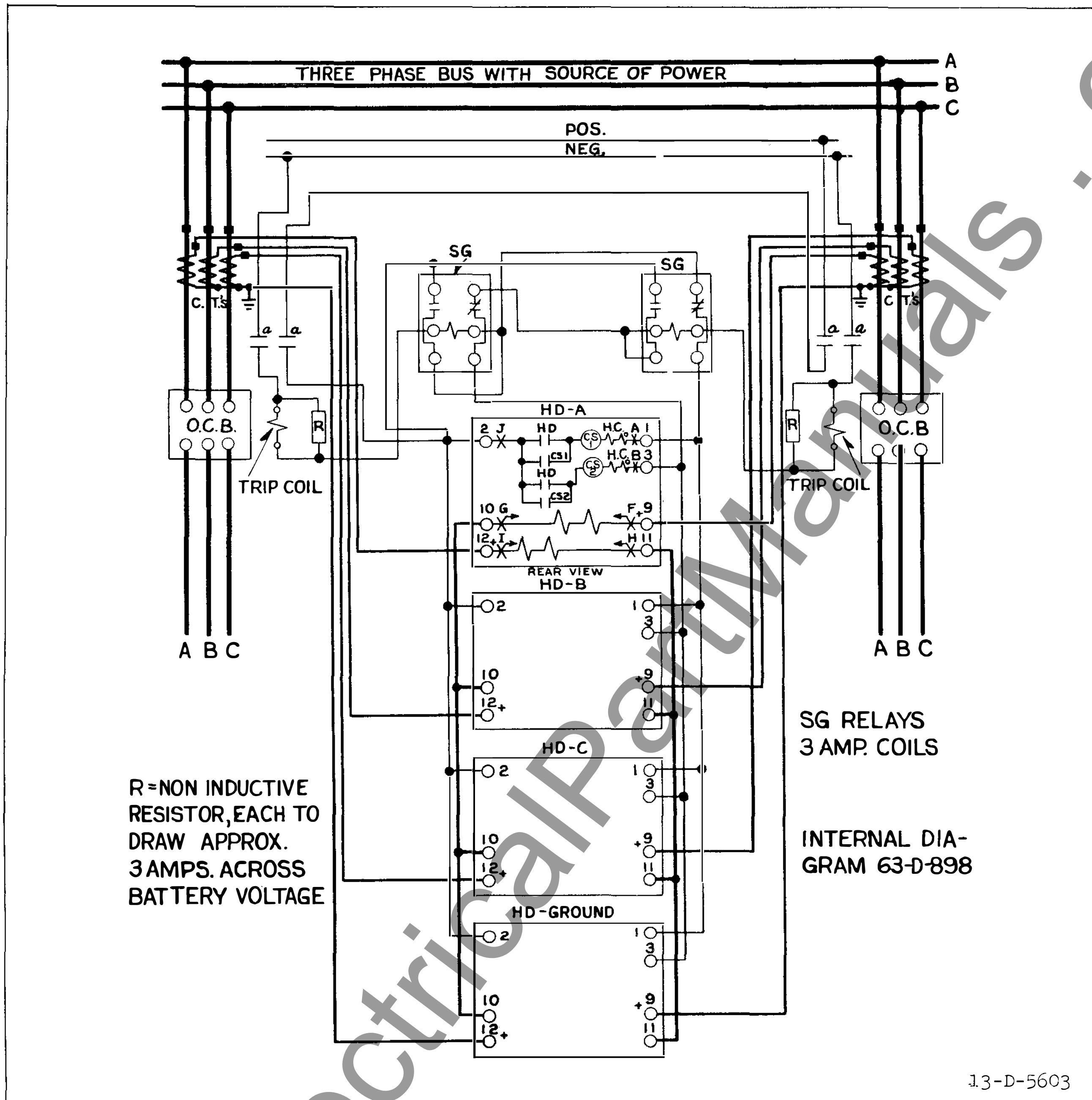

Fig. 11—External Connections of the Type HD Relay in the Type FT Case For Phase And Ground Protection During Parallel Line Operation, Utilizing SG Relays (With Current Windings) For Interlock Between Circuits.

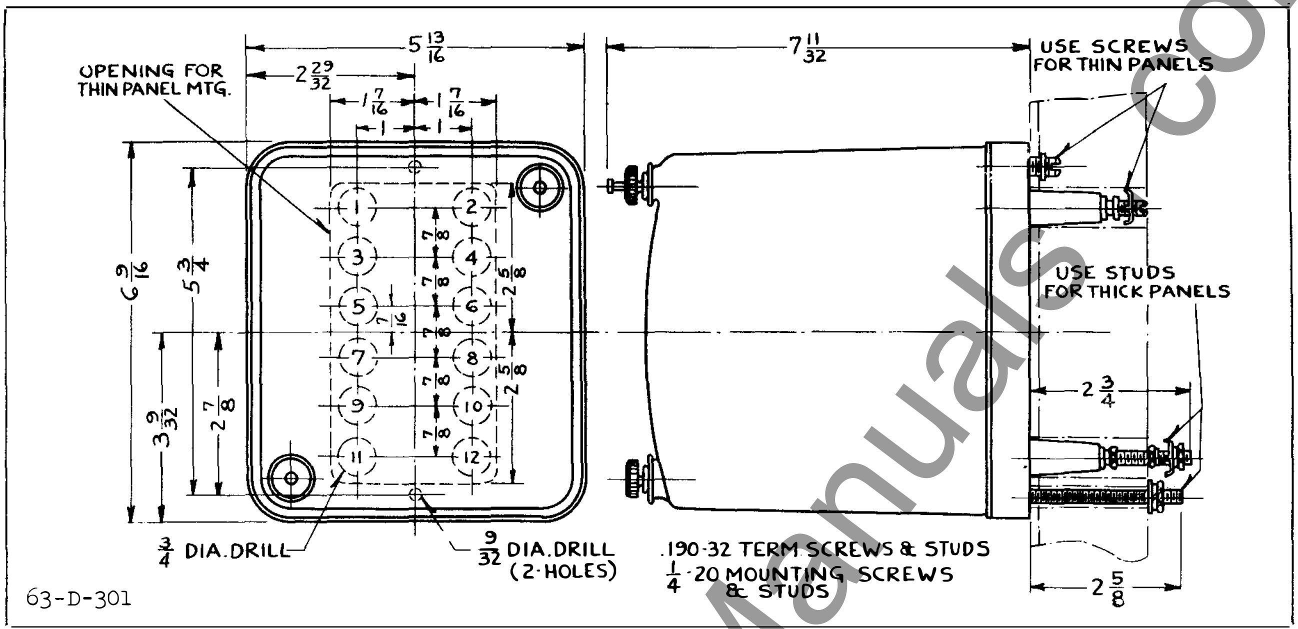

Fig. 12—Outline and Drilling Plan for the Standard Projection Type Case. See the Internal Schematics for Terminals Supplied. For Reference Only.

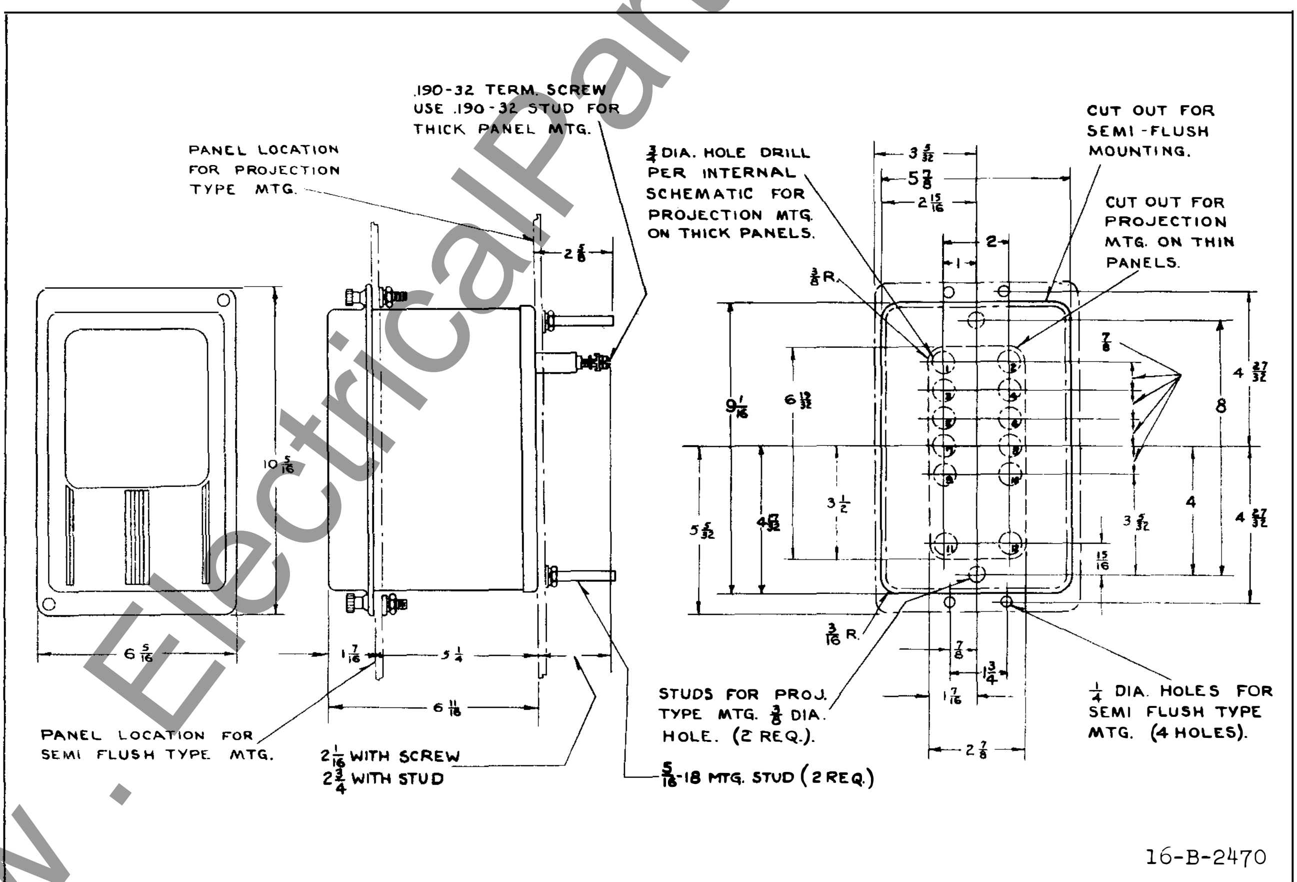

Fig. 13—Outline and Drilling Plan for the S10 Semi-flush or Projection Type FT Flexitest Case. See The Internal Schematics for the Terminals Supplied. For Reference Only.

WESTINGHOUSE ELECTRIC CORPORATION

METER DIVISION • **NEWARK, N.J.**

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CONSTRUCTION AND OPERATION

The relay is of the inductor-loop type in which the loop is pivoted at each end, and forms the secondary of a small transformer. The primary of the transformer consists of two symmetrically tapped windings, T_1 and T_2, which are so connected that with currents in the lines flowing in the same direction, the current which flows in the loop is proportional to the difference of the two line currents. (Figure 1).

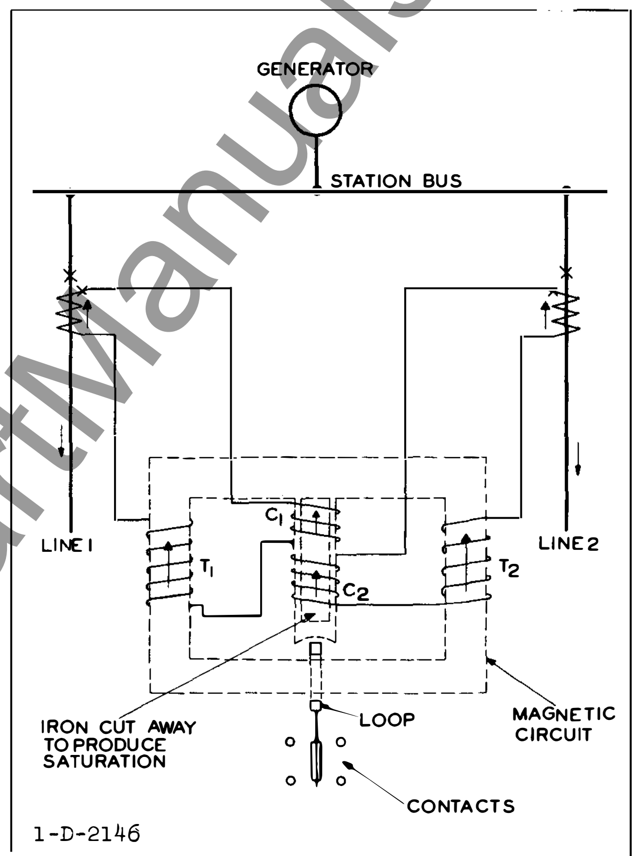

Fig. 1—Single Line Schematic Diagram of the Operating Element.

The loop is located in a magnetic field produced by two current coils, C_1 and C_2. These are so connected that their fluxes are adding when the currents in the lines are flowing in the same direction. The field thus produced is proportional to the sum of the two line currents.

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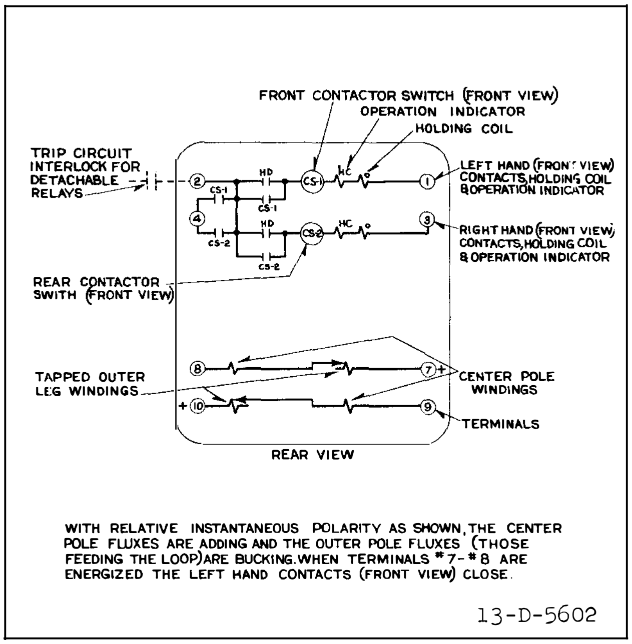

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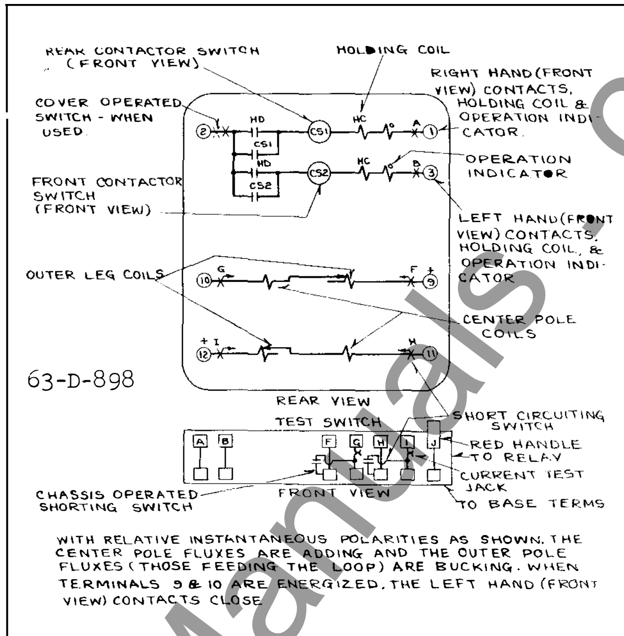

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The resistance of the relay trip circuit is approximately 1.0 ohm. The main contacts of the relay will safely close 30 amperes at 125 volts d-c and the contactor switch contacts will safely carry this current until the auxiliary switch on the breaker opens the trip circuit.

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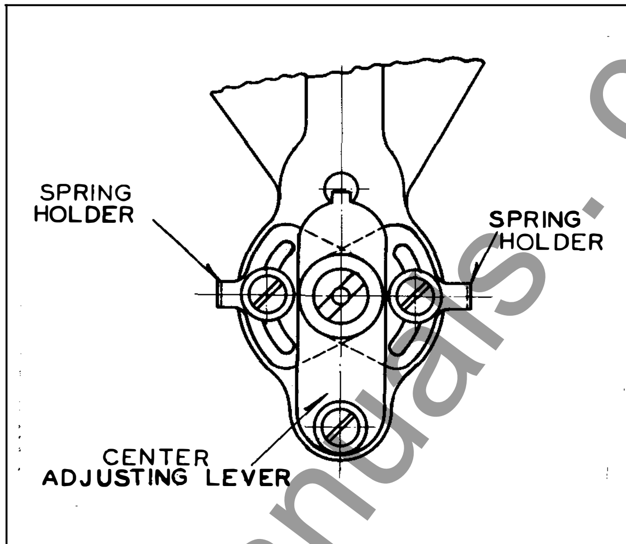

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NOTE: All current readings should be taken with suddenly applied currents. This duplicates service conditions, hence the readings should be taken this way. Readings taken with gradually increased currents will give different results. When checking the relay with heavy currents in the opposite direction, the loop heats very quickly, hence final readings should be taken only after the loop has been thoroughly cooled. An air hose will facilitate cooling both the loop and the coils when testing at high currents.

Line Relay

Connect as per Figure 9, and adjust the load to give A_1 = 60 amperes, and A_2 = 1.5 amperes. Adjust the spring tension so that the relay just trips to the left when the currents are suddenly applied, both tap screws being in the 1.5 taps. With A_1 = zero amperes, the current, A_2, to trip in one side only should be between 7 and 9 amperes. Then, reverse the connections to terminals 7 and 9 and adjust the spring for correct closing of the right-hand contacts at A_1 = 60 amperes, and A_2 = 1.5 amperes.

To check for correct operation with currents in opposite direction, connect as per Figure 9, except reverse the connections to terminals 9

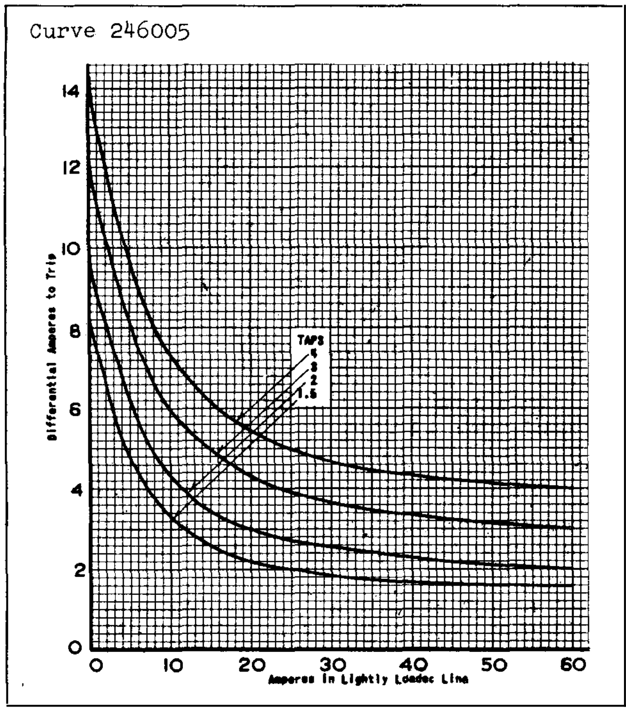

Fig. 5—Typical Operating Characteristics of the Line Relay, Currents in Line in Same Direction.

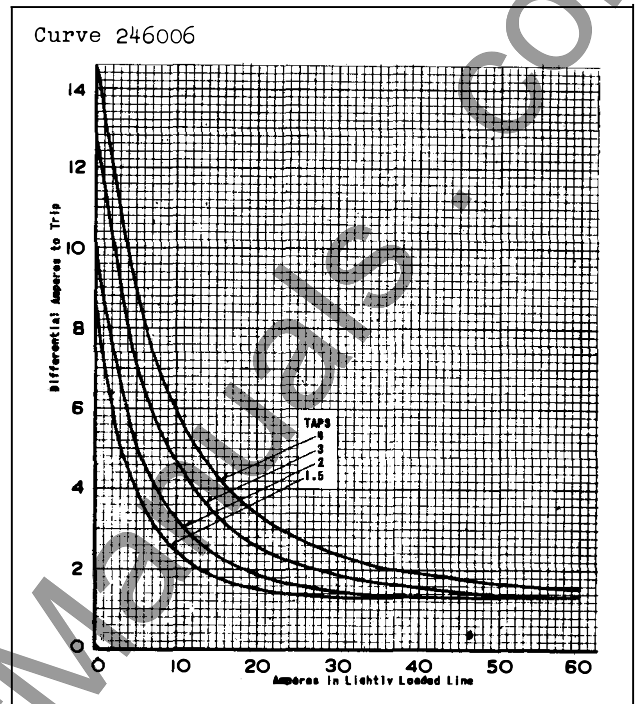

Fig. 6—Typical Operating Characteristics of the Line Relay, Currents in Lines in Opposite Direction.

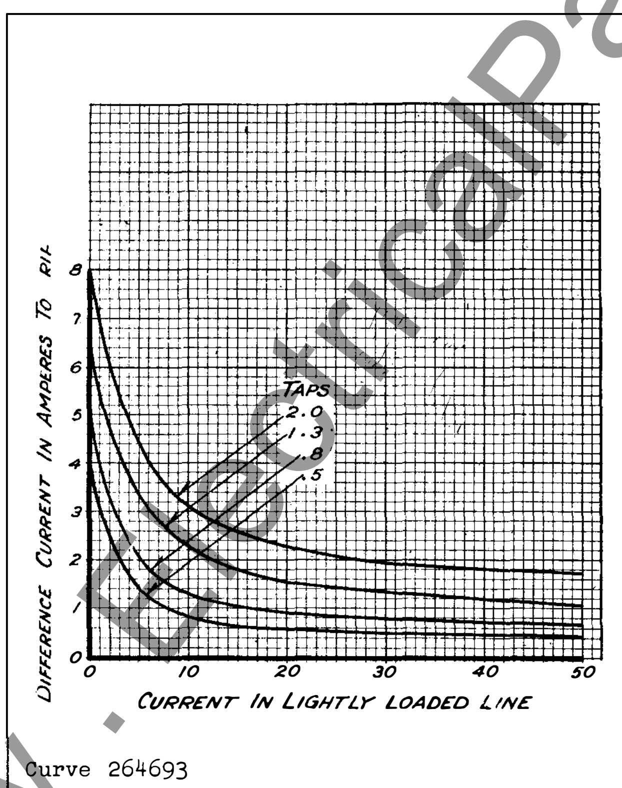

Fig. 7—Typical Operating Characteristics of the Ground Relay, Currents in Lines in Same Direction.

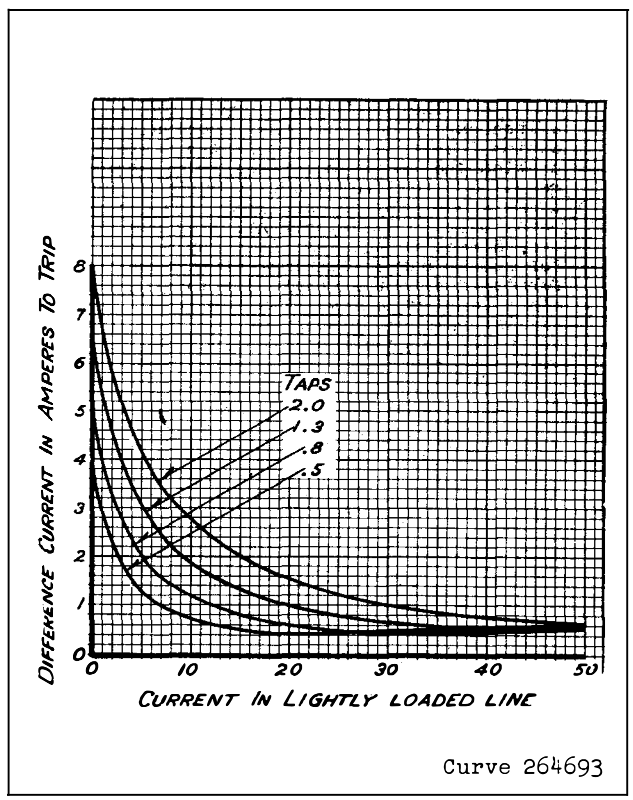

Fig. 8—Typical Operating Characteristics of the Ground Relay, Currents in Lines in Opposite Direction.

and 10. This checks tripping of the left-hand contacts. Beginning with this set-up, reverse the connections to terminals 7 and 10 to check the right-hand contacts. Check tripping values for both left-hand and right-hand contacts before making any adjustments. The difference current to trip should be between 1.0 and 1.5 amperes (tap 1.5) and the difference between the values for the left-hand and right-hand contacts is kept to within .25 amperes in the factory adjustment. If the tripping values are not within these limits, they may be corrected by turning out the holding magnet core screw slightly on the side requiring too much current to trip, or, if necessary, doing both. (This method is effective because the holding coil cores affect the distribution of the stray field from the loop, and not because of their own coils, since they are not energized with d-c until after the contacts close.) After each such adjustment of the holding coil cores, they should be locked in place by means of the lock nuts provided. Any such readjustment of the cores, as described, makes it necessary, of course, to trim up the adjustment of the stationary contacts, since the limit of travel of the loop is affected. Also, the tripping current should be checked again with the currents in the same direction, after the above is complete, for possible minor readjustment of the spring tension. In this recheck the factory limits are 1.35 to 1.65 amperes on the 1.5 taps with A_1 = 60 amperes. If necessary to change the spring tension, the values to trip with currents in opposite direction should be checked again.

If the coils and iron are ever replaced, make sure that the laminations are uniformly stacked, and that there are the same number of short and long laminations.

Ground Relay

This is calibrated and checked the same way as the line relay, except that the values are (Tap .5).

Currents in same direction:

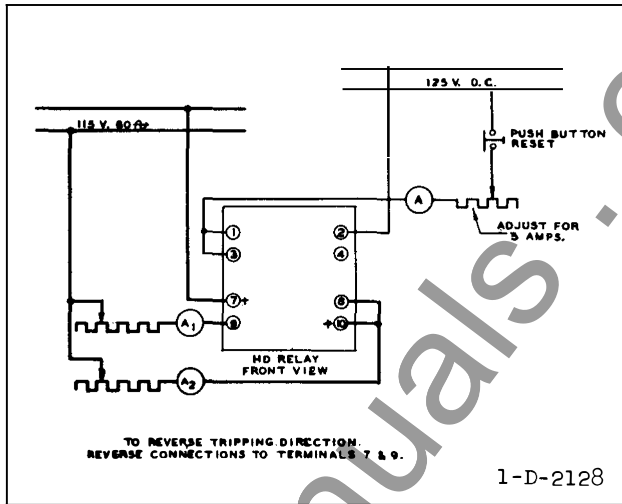

Fig. 9—Diagram of Test Connections. Currents in Same Direction.

A_1 = 30 amperes
A_2 = .45 to .55

Current in one side only:

A_2 = 2.5 to 3.5 amperes

Currents in opposite direction:

A_1 = 30 amperes
*A_2 = .050 ampere or more.

*Values for left-hand and right-hand side within ± 10% of their average value.

It is to be noted that the ground relay is much more sensitive in percent of the tap value when the currents are in opposite direction than the line relay is. However, as has been mentioned previously, this is an advantage instead of a disadvantage.

RENEWAL PARTS

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

ENERGY REQUIREMENTS

The burdens of the line and ground relays at 5 amperes 60 cycles with one line only energized:

Tap		Burden Volt-Amps.		Power Factor Angle	
Line	Ground	Line	Ground	Line	Ground
1.5	.5	2.05	5.6	32°	50°
2.	.8	1.8	5.15	33°	52°
3.	1.3	1.6	4.9	34°	53°
4.	2.	1.5	4.8	36°	54°

Burdens with both lines energized and currents in the same directions in the lines:

1.5	.5	2.4	8.35	49°	64.0°
2.	.8	2.3	8.20	50°	64.5°
3.	1.3	2.2	8.10	52°	64.0°
4.	2.	2.1	8.0	53°	64.5°

Burdens with both lines energized and currents in the opposite directions in the lines:

1.5	.5	1.93	4.0	11.0°	11.0°
2.	.8	1.5	3.3	8.5°	8.5°
3.	1.3	1.2	3.0	7.5°	7.5°
4.	2.	1.1	2.9	6.0°	7.5°

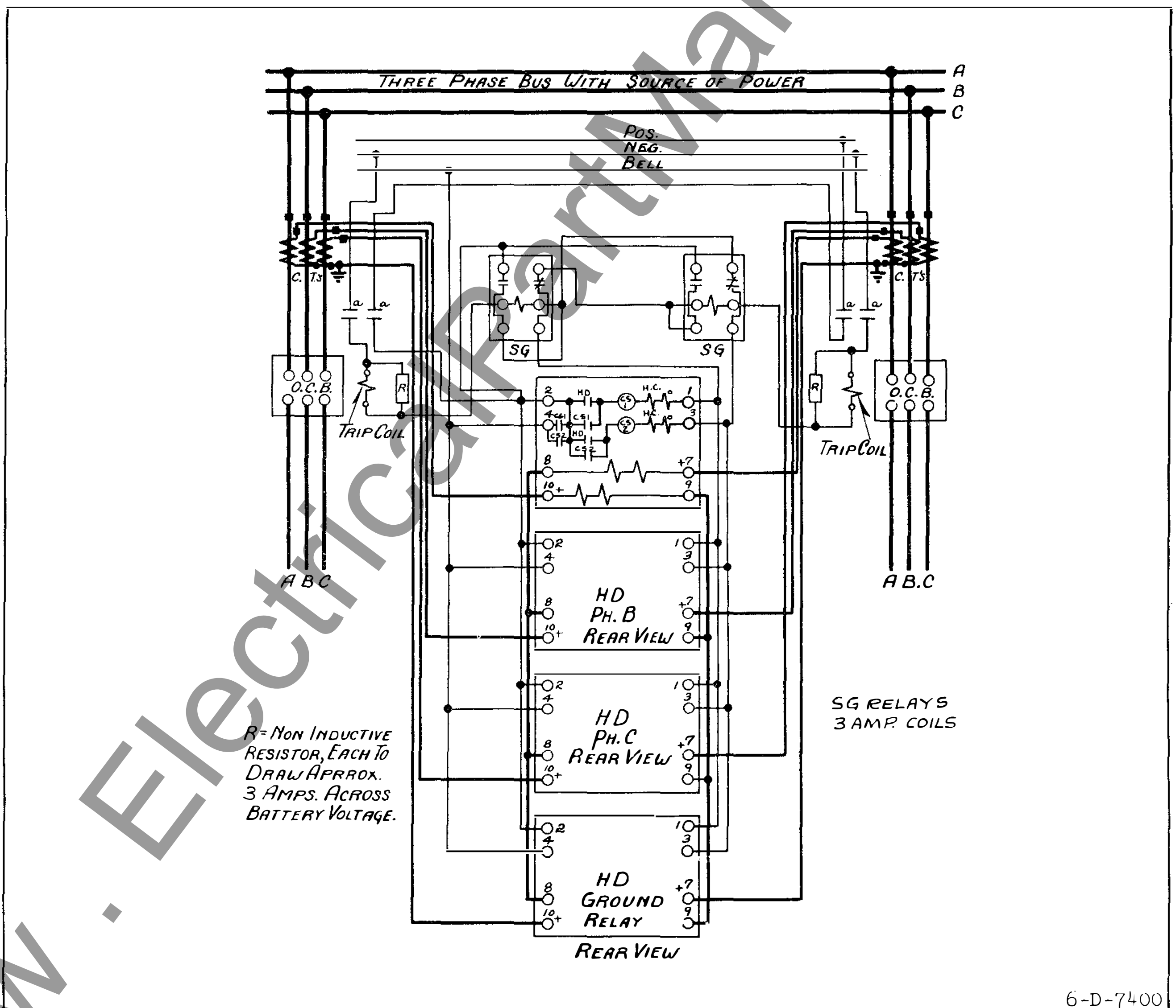

Fig. 10—External Connections of the Type HD Relay in the Standard Case For Phase and Ground Protection During Parallel Line Operation, Utilizing SG Relays (With Current Windings) For Interlock Between Circuits.

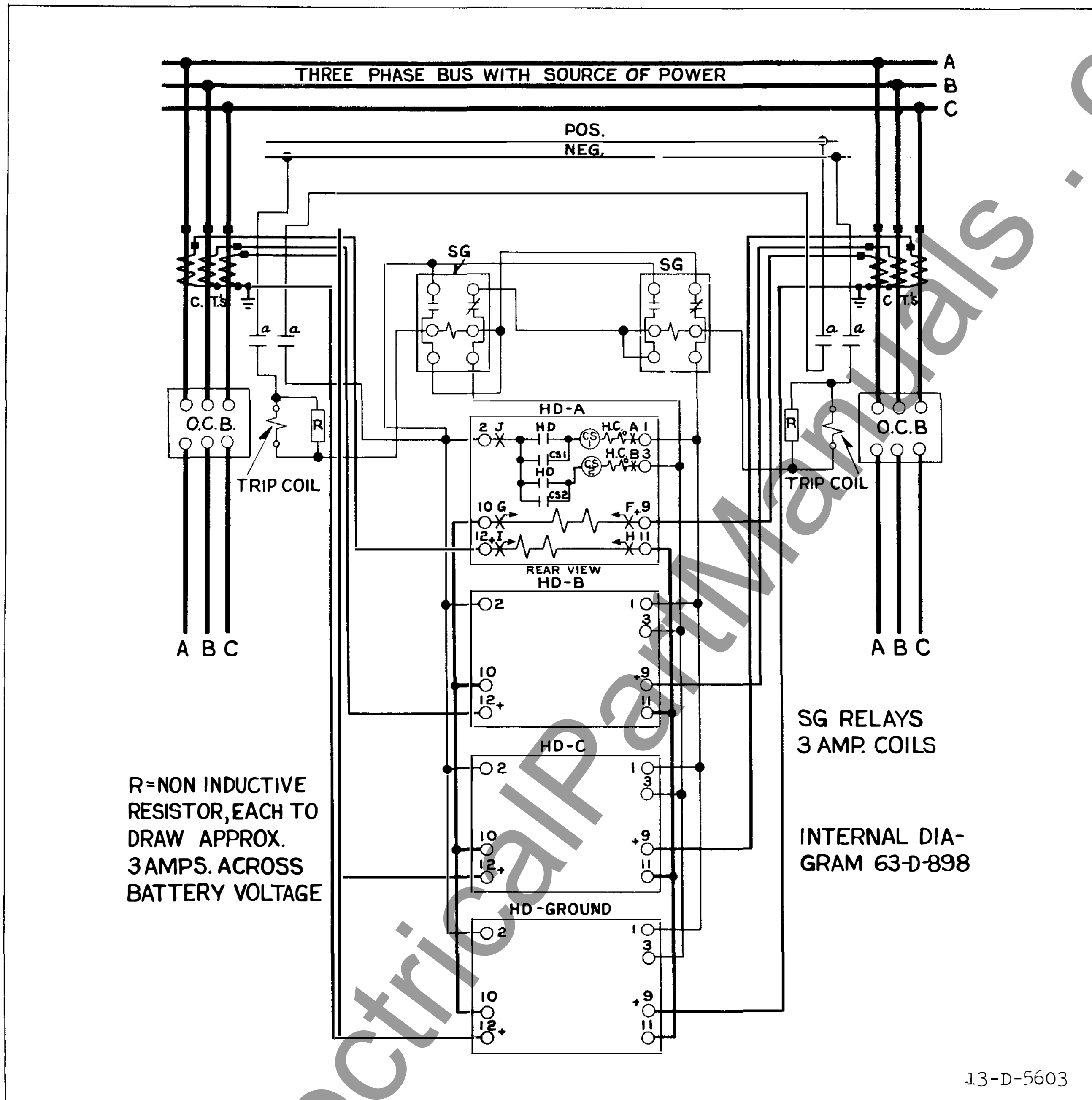

Fig. 11—External Connections of the Type HD Relay in the Type FT Case For Phase And Ground Protection During Parallel Line Operation, Utilizing SG Relays (With Current Windings) For Interlock Between Circuits.

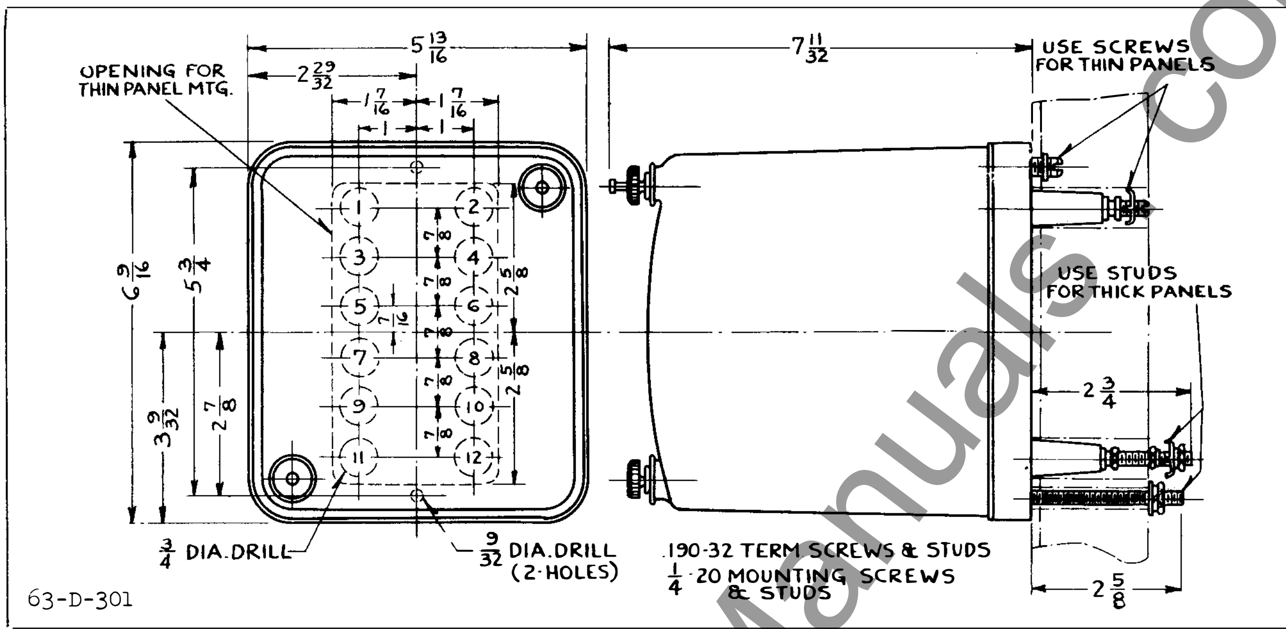

Fig. 12—Outline and Drilling Plan for the Standard Projection Type Case. See the Internal Schematics for Terminals Supplied. For Reference Only.

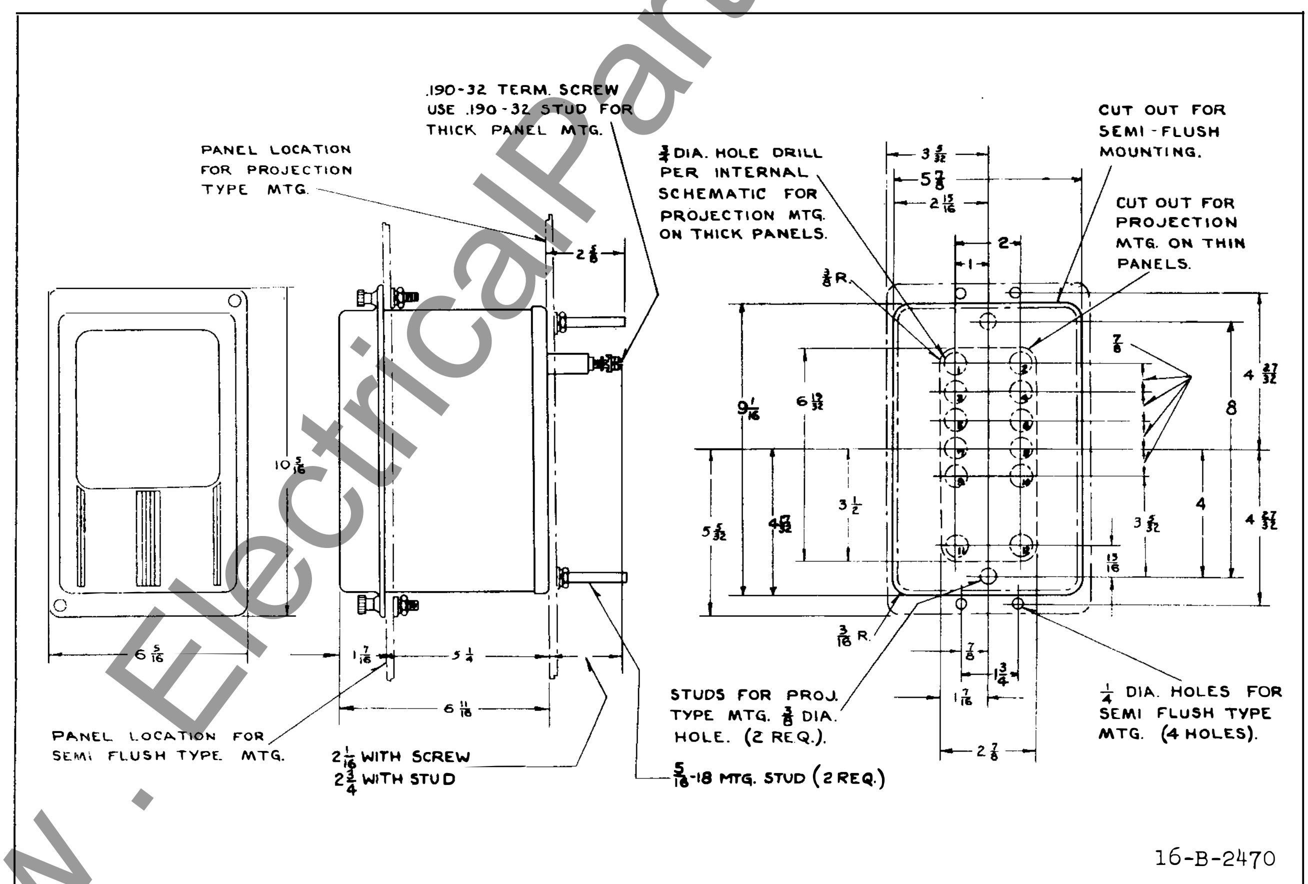

Fig. 13—Outline and Drilling Plan for the S10 Semi-flush or Projection Type FT Flexitest Case. See The Internal Schematics for the Terminals Supplied. For Reference Only.

WESTINGHOUSE ELECTRIC CORPORATION

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