INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE CA PERCENTAGE DIFFERENTIAL RELAY
FOR TRANSFORMER PROTECTION

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 CA percentage differential relay for transformer protection is designed for the differential protection of power transformers.

CONSTRUCTION AND OPERATION

The type CA relay consists of a percentage differential element, an operation indicator, and a contactor switch. The construction and operation of these elements are as follows:

Percentage Differential Element

This element has an electromagnet with several windings as shown in Figures 2 & 3. Two restraining windings are placed on the lower left-hand pole (front view). The operating coil winding is wound on the lower right-hand pole. A transformer winding is supplied on both the left and right-hand poles and these are connected in parallel to supply current to the upper pole windings. The upper pole current generates a flux which is in quadrature with the lower pole resultant flux, and the two fluxes react to produce a torque on the disc. If the operating winding is energized, the torque produced is in the contact closing direction; if current flows through the two restraining windings in the same direction, a contact opening torque is produced.

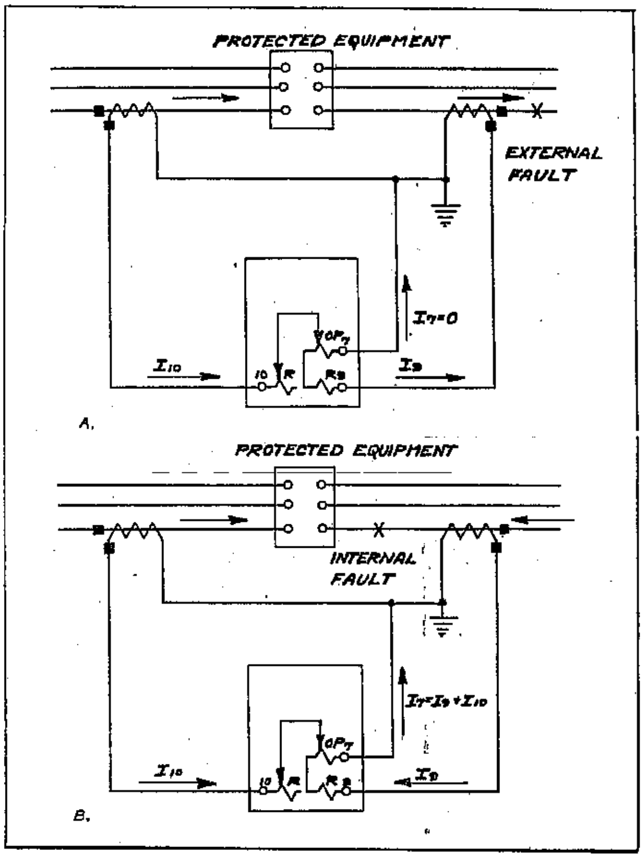

Fig. 1—Schematic Diagrams of the Percentage Differential Relay (A) Shows the Fault Current Distribution for an External Fault; (B) The Distribution for an Internal Fault.

With the relay connected as in the schematic diagram, Fig. 1A, a through fault causes currents to flow through the two restraining windings in the same direction. If the current transformers operate properly, these restraining currents are equal, or effectively equal if appropriate auto balance taps are used to compensate for a mismatch in current transformer ratios, and no effective current flows in the operating coil winding, and hence only contact opening torque is produced. If the currents in the two restraining windings are effectively unequal, the effective dif-

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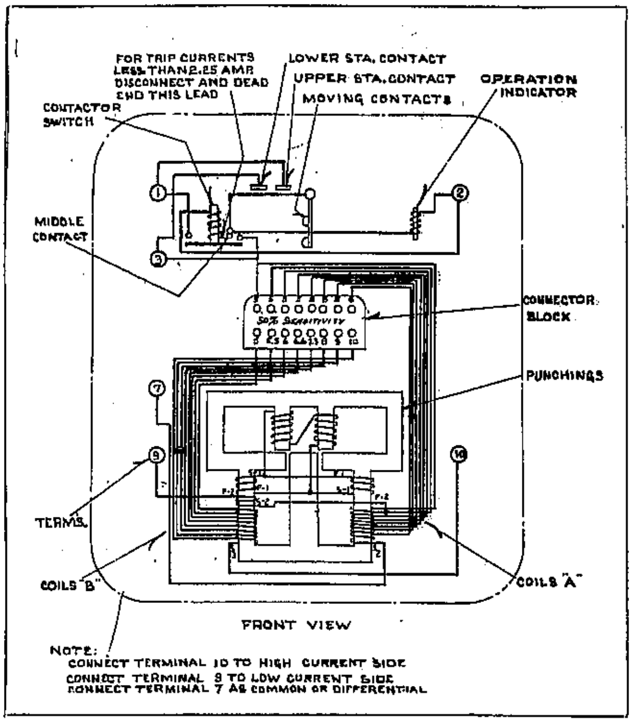

Fig. 2—Internal Schematic of the Type CA Transformer Relay in the Standard Case.

ference must flow in the operating coil. The operating coil current required to overcome the restraining torque and close the relay contacts is a function of the restraining current. The operating curves for the relay are shown in Fig. 4 and 5.

In the case of a heavy internal fault, when an external source feeds current into the fault, the restraining currents are in opposite directions, and restraining torque tends to cancel out as illustrated in Fig. 1B. When the currents fed from the two sides are equal or effectively equal because of the taps used, the restraint is totally cancelled. When effectively unequal currents flow in from the two sides, the restraint is equivalent to the difference in the two effective currents, divided by two, but since the more sensitive operating coil is energized by the sum of the two currents, the restraint in this case is inconsequential, and a large amount of contact closing torque is produced.

Fig. 7 shows the operating curves for the relay with the restraining currents 180° out-of phase. These curves also apply where current flows in only one restraining winding and the operating coil.

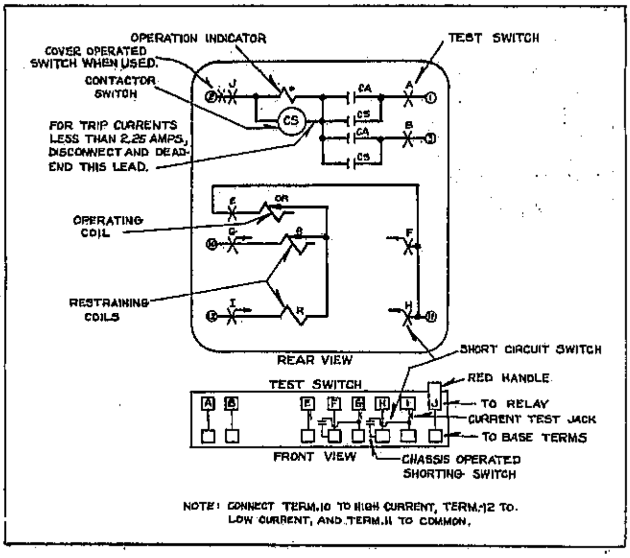

Fig. 3—Internal Schematic of the Type CA Transformer Relay in the Type FT Case.

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

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 studs.

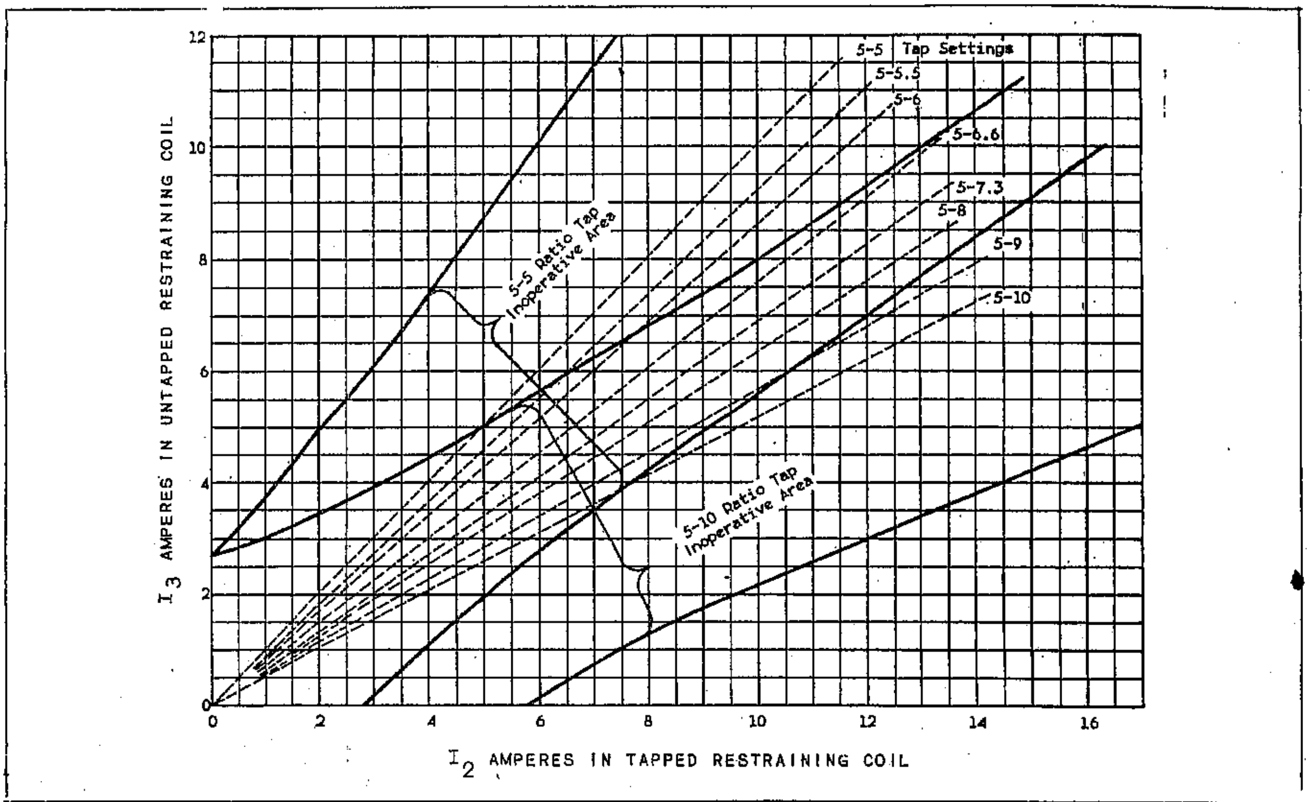

Fig. 4—Typical Operating Curves for Low Values of Current.

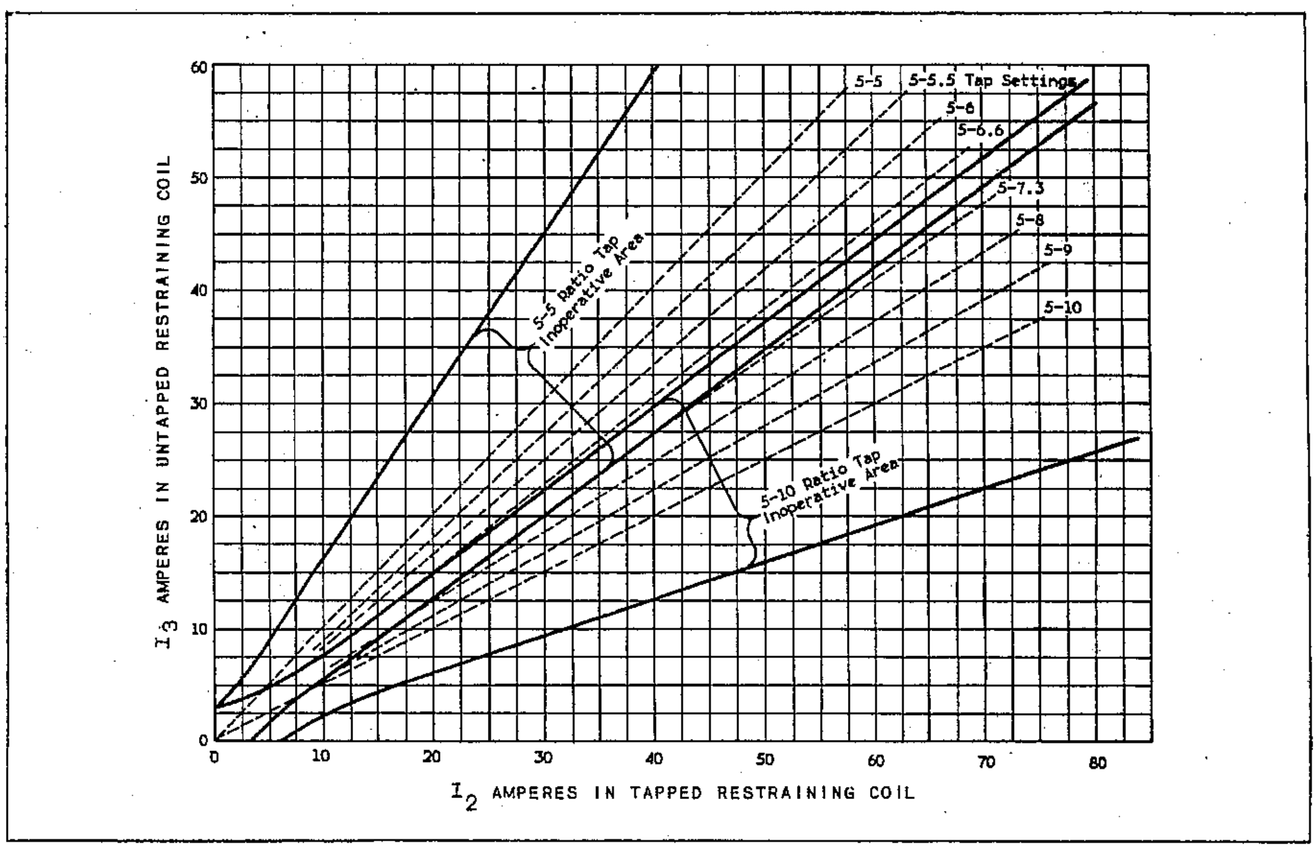

Fig. 5—Typical Operating Curves for High Values of Current.

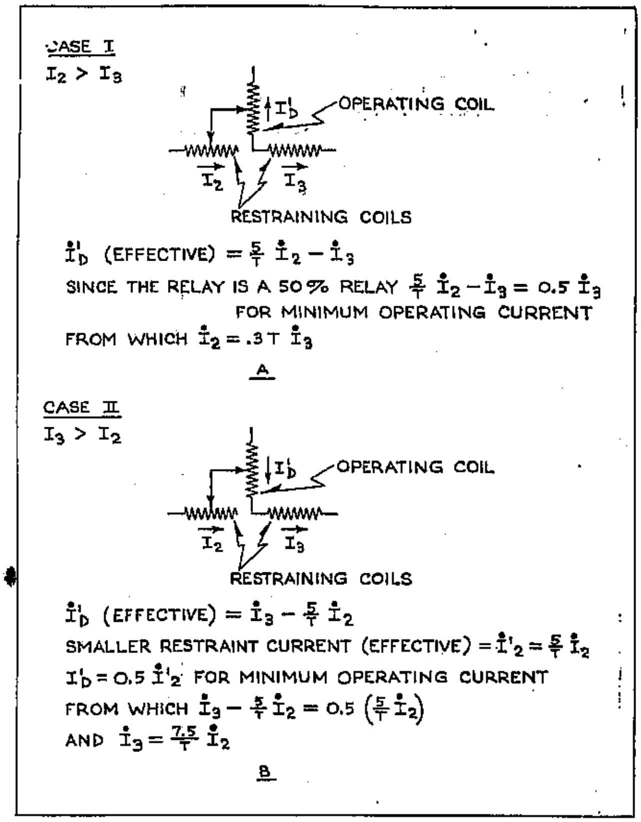

Fig. 6—Fundamental Relationships in the Type CA Electromagnet.

CHARACTERISTICS

The operating characteristics of the relay for normal through load current and through fault current are shown in Figures 4 and 5. When the currents flowing into and out of the relay are plotted on these curves, if the point falls outside of the inoperative area, the relay will close its contacts.

In Figures 4 and 5, the two curves going with the 5-5 tap are tied together with a heavy vertical and horizontal line to indicate that these two curves go together. Similarly, the two curves for the 5-10 tap are also tied together with a heavy line. The center lines between pairs of curves are shown for all taps. The paired curves, bounding the inoperative areas, are not shown for taps 5-5.5 through 5-9. These curves may be determined approximately by means of the following formulas:

For the upper curve: $I_3 = \frac{7.5I_2}{T}$ (1)

For the lower curve: $I_2 = .3TI_3$ (2)

In these formulas, T is the larger number of the tap pair. For example, if the relay is used on the 5-7.3 tap, then T = 7.3.

As an example of the degree of accuracy of the formula consider the point $I_2 = 43.5$, and $I_3 = 30$, read from the lower curve for the 5-5 tap, Figure 5. Applying the formula, equation (2), the calculated value of I_2 is found to be 45 amperes, which is fairly close to the curve value, $I_2 = 43.5$.

The derivations of equations (1) and (2) are given in Figure 6, which has been included to illustrate the meaning of these equations.

Typical time-of-operation curves are shown in Figure 8.

RELAYS IN TYPE FT CASE

The type FT cases are dust-proof enclosures combining relay elements and knife-blade test switches in the same case. This combination provides a compact flexible assembly easy to maintain, inspect, test and adjust. There are three main units of the type FT case: the case, cover and chassis. The case is an all welded steel housing containing the hinge half of the knife-blade test switches and the terminals for external connections. The cover is a drawn steel frame with a clear window which fits over the front of the case with the switches closed. The chassis is a frame that supports the relay elements and the contact jaw half of the test switches. This slides in and out of the case. The electrical connections between the base and chassis are completed through the closed knife blades.

Removing Chassis

To remove the chassis, first remove the cover by unscrewing the captive nuts at the corners. There are two cover nuts on the S size case and four on the L and M size cases. This exposes the relay element and all the test switches for inspection and testing. The next step is to open the test switches. Always open the elongated red handle switches first before any of the black handle switches or the cam action latches. This opens the trip circuit to prevent accidental trip out. Then open all the remaining switches. The order of opening the remaining switches is not important. In opening the test switches, they should be moved all the way back against the stops. With all the switches fully opened, grasp the two cam-action latch arms and pull outward. This releases the chassis from the case. The chassis can be set on a test bench in a normal upright position as well as on its top, back or sides for easy inspection, maintenance and test.

After removing the chassis, a duplicate chassis may be inserted in the case or the blade portion of the switches can be closed and the cover put in place without the chassis. The chassis operated shorting switch located behind the current test switch prevents open circuiting the current transformers when the current type test switches are closed.

When the chassis is to be put back in the case, the above procedure is to be followed in the reversed order. The elongated red handle switch should not be closed until after the chassis has been latched in place and all of the black handle switches closed.

Electrical Circuits

Each terminal in the base connects thru a test switch to the relay elements in the chassis as shown on the internal schematic diagrams. The relay terminal is identified by numbers marked both on the inside and outside of the base. The test switch positions are identified by letters marked on the top and bottom surface of the moulded blocks. These letters can be seen when the chassis is removed from the case.

The potential and control circuits thru the relay are disconnected from the external circuit by opening the associated test switches. Opening the current test switch short-circuits the current transformer secondary and disconnects one side of the coil but leaves the other side of the coil connected to the external circuit thru the current test jack jaws. This circuit can be isolated by inserting the ten circuit test plug, or by inserting a piece of insulating material approximately 1/32" thick into the current test jack jaws. Both switches of the current test switch pair must be open when using the current test plug or insulating material in this manner to short circuit the current transformer secondary.

A cover operated switch can be supplied with its contacts wired in series with the trip circuit. This switch opens the trip circuit when the cover is removed. This switch can be added to the existing type FT case at any time.

Testing

The relays can be tested in service, in the case but with the external circuits isolated, or out of the case as follows:

Testing in Service

The ammeter test plug can be inserted in the current test jaws after opening knife-blade switch to check the current thru the relay. This plug consists of two conducting strips separated by an insulating strip. The ammeter is connected to these strips by terminal screws and the leads are carried out thru holes in the back of the insulated handle.

Voltages between the potential circuits can be measured conveniently by clamping #2 clip leads on the projecting clip lead lug on the contact jaw.

Testing in Case

With all blades in the full open position, the ten circuit test plug can be inserted in the contact jaws. This connects the relay element to a set of binding posts and completely isolates the relay circuits from the external connections by means of an insulating barrier on the plug. The external test circuits are connected to these binding posts. The plug is inserted in the bottom test jaws with the binding posts up and in the top test

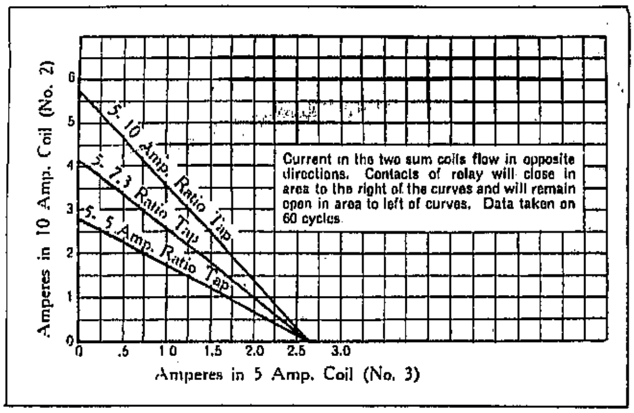

Fig. 7—Typical Sensitivity Characteristics of the Type CA Transformer Relay.

switch jaws with binding posts down.

The external test circuits may be made to the relay elements by #2 test clip leads instead of the test plug. When connecting an external test circuit to the current elements using clip leads, care should be taken to see that the current test jack jaws are open so that the relay is completely isolated from the external circuits. Suggested means for isolating this circuit are outlined above under "Electrical Circuits".

Testing Out of Case

With the chassis removed from the base, relay elements may be tested by using the ten-circuit test plug or by #2 test clip leads as described above. The factory calibration is made with the chassis in the case and removing the chassis from the case will change the calibration values of some relays by a small percentage. It is recommended that the relay be checked in position as a final check on calibration.

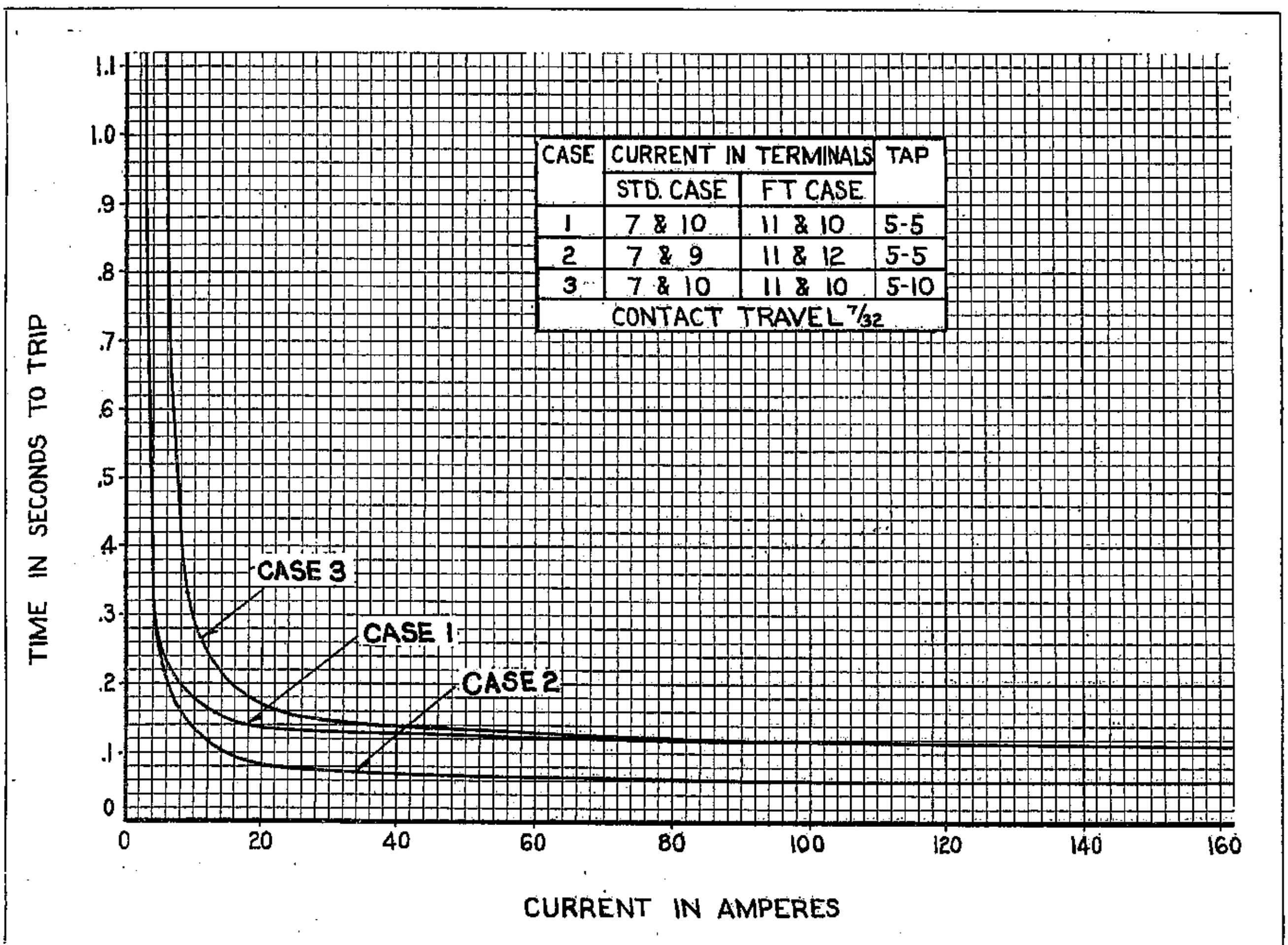

Fig. 8—Typical 60 Cycle Time-of-Operation Curves for the Type CA Transformer Relay.

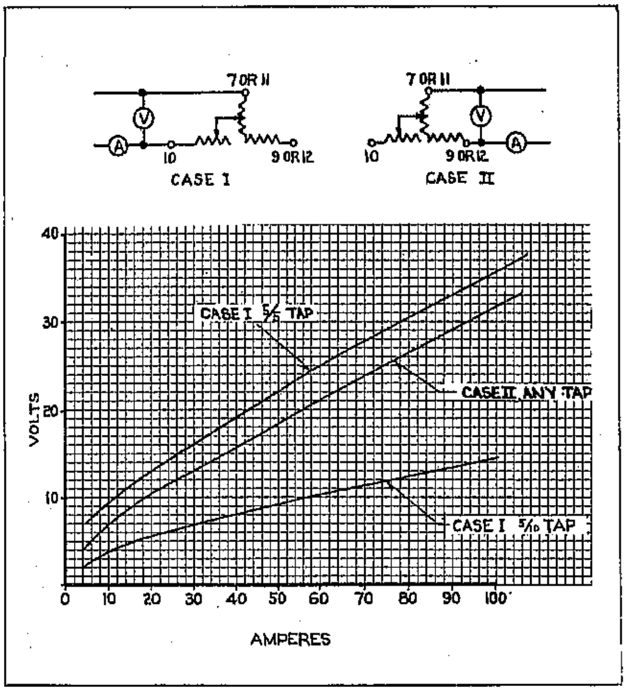

Fig. 9—Typical 60 Cycle Saturation Curves for the Type CA Transformer Relay.

An internal schematic diagram is available for each individual relay showing the schematic internal wiring.

INSTALLATION

The relay should be mounted on switchboard panels or their equivalent in a location free from dirt, moisture, excessive vibration and heat. Mount the relay vertically by means of the two mounting studs for the standard cases and the type FT projection case or by means of the four mounting holes on the flange for the semi-flush type FT case. Either of the studs or the mounting screws may be utilized for grounding the relay. The electrical connections may be made direct to the terminals by means of screws for steel panel mounting or to terminal studs furnished with the relay for ebony asbestos or slate panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the studs and then turning the proper nut with a wrench.

The relay is shipped with the operation indicator and the contactor switch coils in parallel. This circuit has a resistance of approximately 0.25 ohm and is suitable for all trip currents above 2.25 amperes d-c. If the trip current is less than 2.25 amperes, there is no need for the contactor switch and it should be disconnected. To disconnect the coil in the standard case relays, remove the short lead to the coil on the front stationary contact of the switch. This lead should be fastened (dead ended) under the small filister head screw located in the Micarta base of the contactor switch. To disconnect the coil and the type FT case relays, remove the coil lead at the spring adjuster and dead end it under the screw near the top of the moulded bracket. The operation indicator will operate for trip currents above 0.2 ampere d-c. The resistance of this coil is approximately 2.8 ohms.

With the contactor switch coil in service,

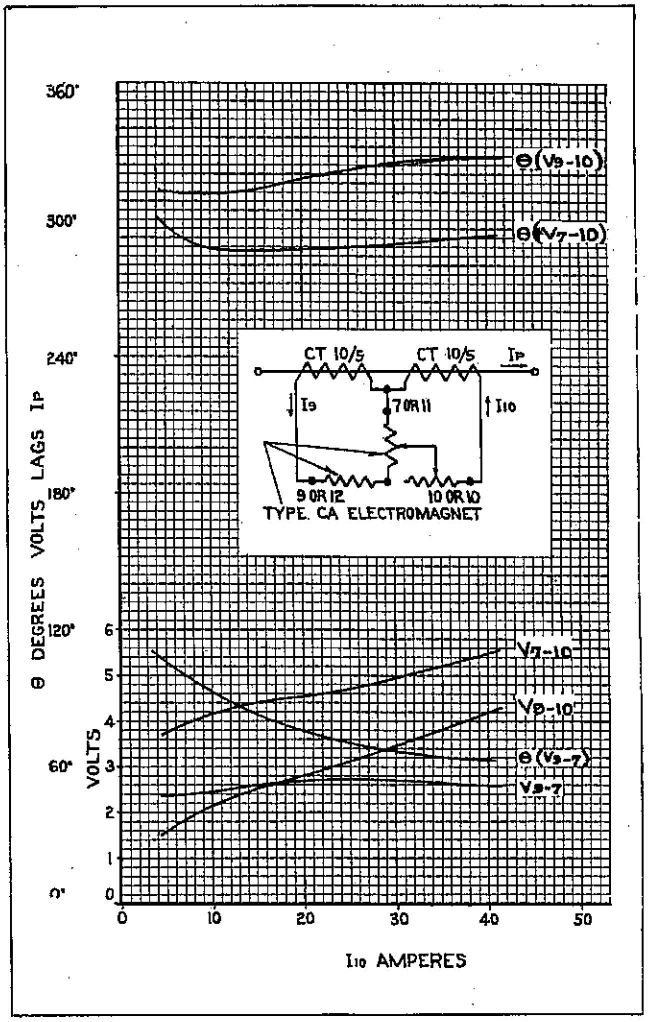

Fig. 10—Typical 60 Cycle Burden Curves for the Type CA Transformer Relay on the 5-5 Tap.

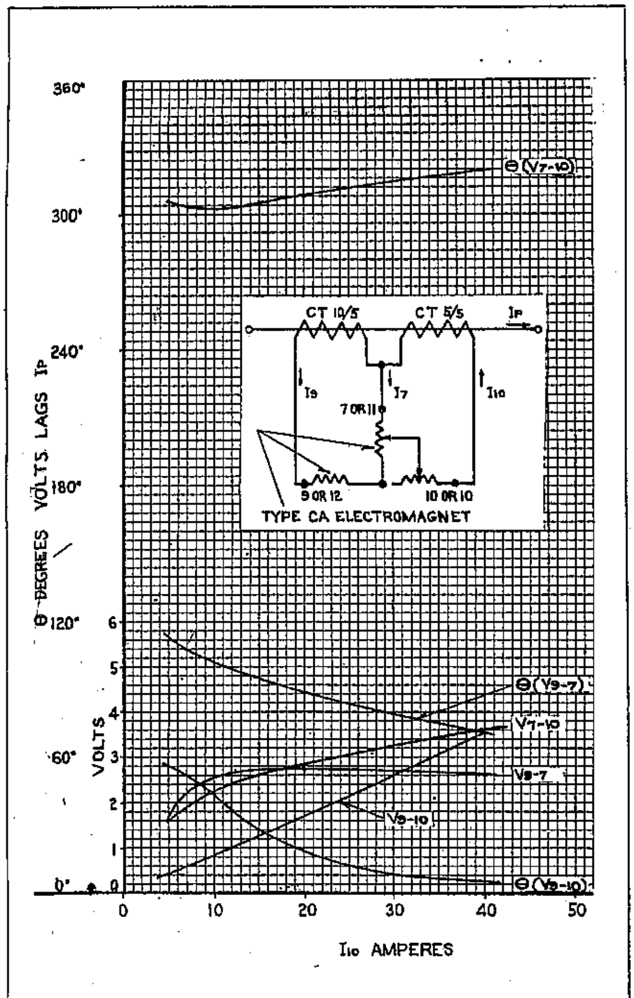

Fig. 11—Typical 60 Cycle Burden Curves for the Type CA Transformer Relay on the 5-10 Tap.

the trip circuit will carry 30 amperes long enough to trip the circuit breaker.

SETTINGS

The transformer relay is detailed in Figure 2. To change the tap setting of the transformer relay under load conditions, remove the extra tap screw and screw it firmly into the desired tap in one of the tap rows. Remove the other screw in the same row and screw it into the hole directly above or below the screw first inserted at the desired tap value. Then remove the screw still remaining in one of the previously used tap holes and replace it in the extra hole provided for the spare screws. When the relay is correctly set, one screw must be in the lower row of holes at the correct tap value and the other must be in the hole directly above.

To determine the correct tap setting, calculate the currents delivered to the relay at full load on the transformer bank, taking into consideration not only the current transformer ratios, but also any delta connections which may be used. These currents will be in a certain ratio and the taps on the relay should be chosen to match that ratio as closely as possible. For example, assume that the currents are 7.8 and 4.6 amperes, with the relay properly connected so that the higher current, 7.8 amperes, flows in the tapped restraining winding. The ratio, 4.6/7.8 is equal to 5/8.47. The nearest tap ratio on the relay is 5/8, and this pair of taps should be used.

ADJUSTMENTS AND MAINTENANCE

The proper adjustments to insure correct operation of this relay have been made at the factory and should not be disturbed after receipt by the customer. If the adjustments have been changed, the relay taken apart for repairs, or if it is desired to check the adjustments at regular maintenance periods, the instructions below should be followed.

All contacts should be periodically cleaned with a fine file. S#1002110 file is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact.

<u>Percentage Differential Element</u>

To check the polarity of the restraining coils, adjust the spiral spring for zero tension by turning the spring adjuster. Then with the relay connected as shown in Fig. 12 or 13 pass 10 amperes through the two restraining coils with the lead to the operating coil disconnected. This should produce a torque in the contact opening direction. Similarly, 5 amperes flowing in one restraining coil and the operating coil should produce a positive contact closing torque.

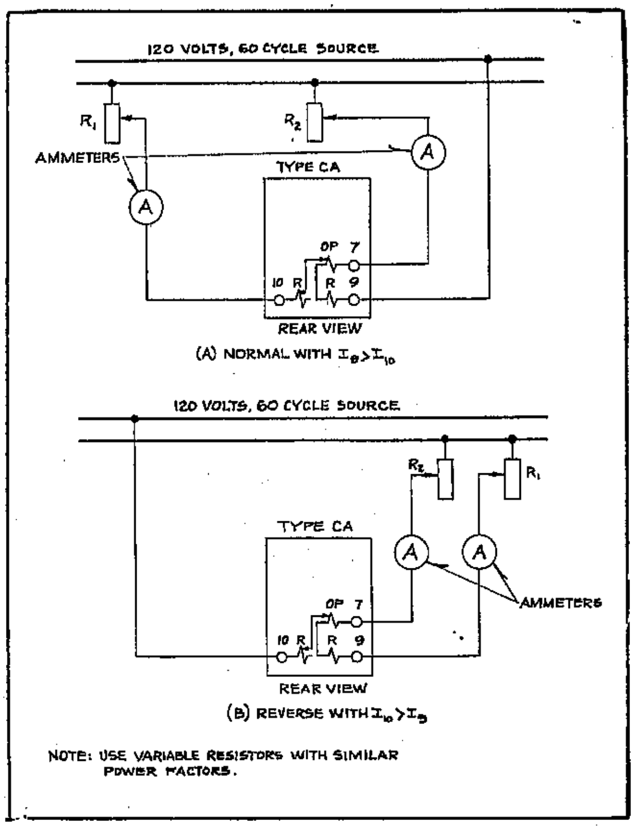

Fig. 12—Diagrams of Test Connections for the Type CA Transformer Relay in the Standard Case.

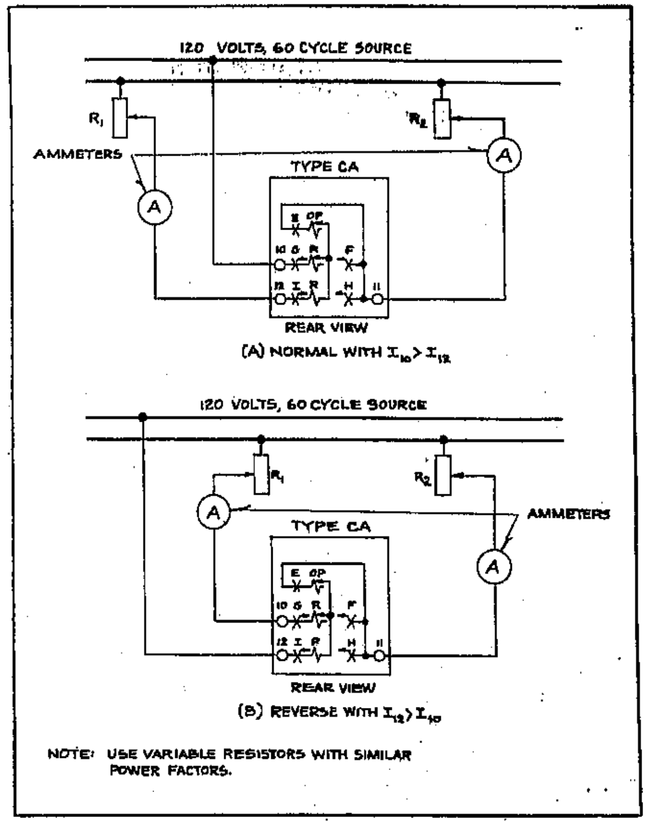

Fig. 13—Diagram of Test Connections for the Type CA Transformer Relay in the Type FT Case.

Adjust the position of the contact stop, and the position of the stationary contacts, so that the moving contact travel is 7/32 inch, and the stationary contacts make at exactly the same time. Adjust the relay for minimum trip by passing current through one restraining coil and the operating coil in series as shown in Fig. 12 or 13 with the lead to the other restraining coil disconnected. Tighten the spiral spring by means of the spring adjuster until the relay contacts just close at 2.75 amperes flowing through the untapped restraining coil and the operating coil with the relay set on the 5-5 tap.

In checking the percentage sensitivity, set the rheostat R_1 of Fig. 12 or 13 for 20 amps. restraining current, and then vary the operating current by adjusting the rheostat, R_2, until the relay just trips. This procedure may be followed for both the normal and reverse connections, and the results compared with Fig. 5 which represents typical curves. The rheostats used in the operating and restraining circuits should be of low inductance and have the same power factor, so that the currents will be substantially in phase. Since the temperature of the windings affect the relay characteristic, the final reading for any curve points taken at high currents should be taken with the relay cool. If these precautions are taken, a good check of the operating curves will be obtained. However, it should be remembered that individual relays will vary somewhat from the typical curves shown in Figs. 4 and 5.

Contactor Switch

Adjust the stationary core of the switch for a clearance between the stationary core and the moving core when the switch is picked up. This can be most conveniently done by turning the relay upside down. 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 point where the play in the moving contact assembly is taken up, and where the moving core just separates from the stationary core screws. Back off the stationary core screw one turn beyond this point 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 two small nuts on either side of the Micarta disc. The switch should pick up at 2 amperes d-c. Test for sticking after 30 amperes d-c. have been passed thru the coil. The coil resistance is approximately 0.25 ohm.

Operating Indicator

Adjust the indicator to operate at 0.2 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 2.8 ohms.

RENEWAL PARTS

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

ENERGY REQUIREMENTS

The 60 cycle burdens of the type CA relay are best given in curve form, as illustrated and given by the curves, Figs. 9, 10, and 11.

The restraining windings of the relay have a continuous rating of 10 amperes. The operating coil has a continuous rating of 5 amperes. However, it is best not to allow more than 5 amperes in the untapped restraining winding in order to keep from overloading a portion of the operating winding. For example, currents of 10 and 6.85 amperes would be in the proper ratio of the 5-7.3 taps, but when these taps are used, 6.85 amperes would flow in a portion of the 5 ampere operating coil.

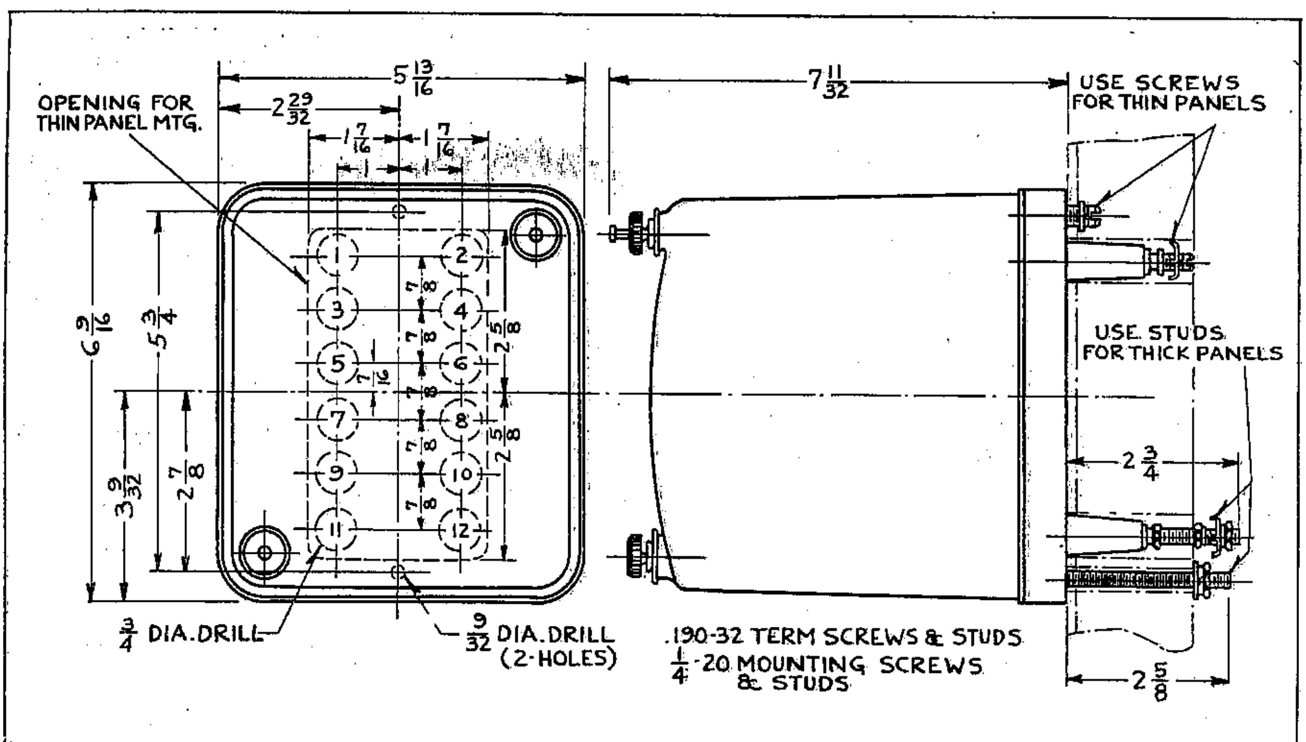

Fig. 14—Outline and Drilling Plan for the Standard Projection Type Case. See the Internal Diagrams for the Terminals Supplied. For Reference Only.

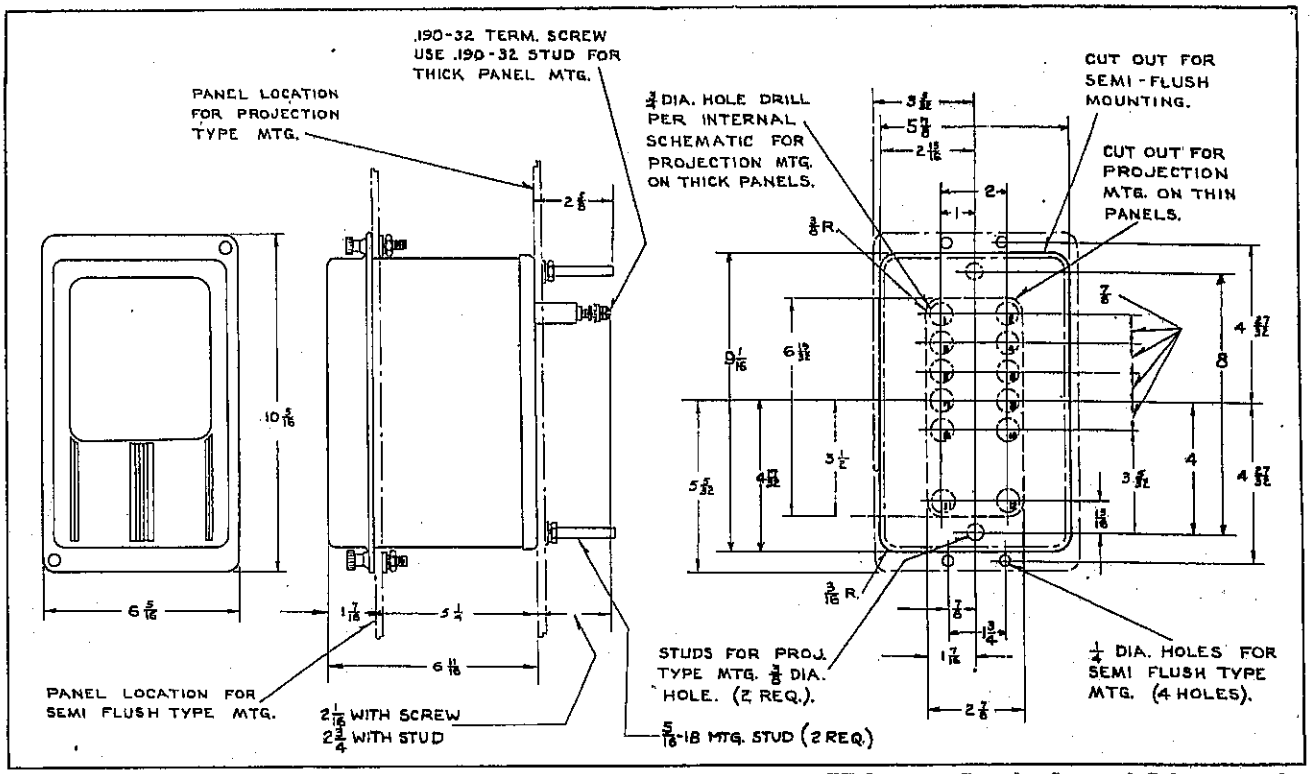

Fig. 15—Outline and Drilling Plan for the S10 Projection or Semi-Flush Type FT Case. See the Internal Schematics for the Terminals Supplied. For Reference Only.

WESTINGHOUSE ELECTRIC CORPORATION

METER DIVISION • NEWARK, N.J.

Printed in U.S.A.