INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE CA PERCENTAGE DIFFERENTIAL RELAY

FOR GENERATOR PROTECTION (NO TAPS)

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 10% and 25% percentage differential relays are designed for the differential protection of rotating a-c machinery such as generators, motors and frequency changers.

CONSTRUCTION AND OPERATION

The type CA relay consists of a percentage differential element, and 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), and are connected in series. Their junction point is connected to the operating coil winding which 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, this torque is in the contact closing direction; if current flows through the two restraining windings in the same direction, a contact opening torque is produced.

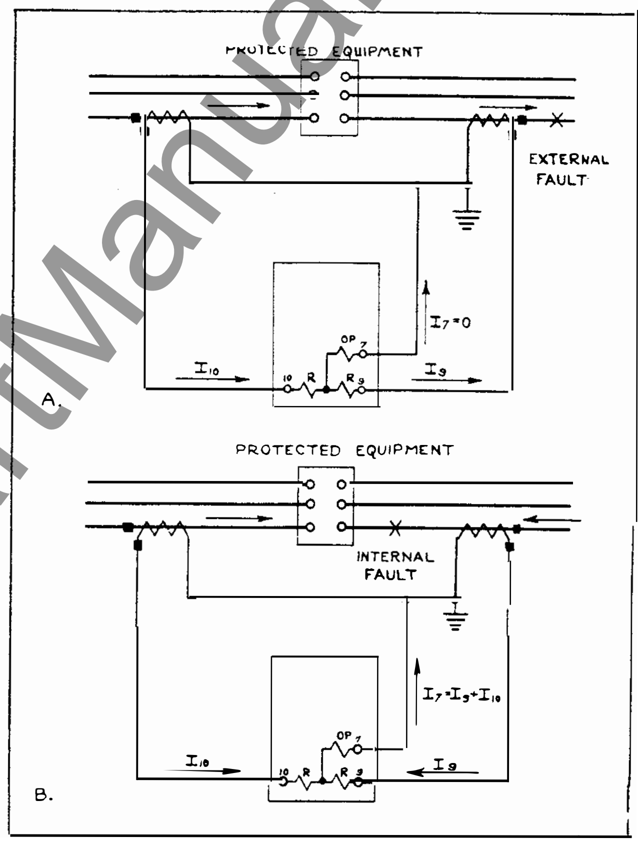

Fig. 1—Schematic Diagrams of the Percentage Differential Relay. (A) Shows the Fault Current Distribution for an External Fault; (B) The Distribution for an Internal Fault.

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 and no current flows in the operating coil winding, and hence only contact opening torque is produced. If the currents in the two restraining windings are unequal, the difference must flow in the operating coil. The operating coil current required to overcome the restraining torque

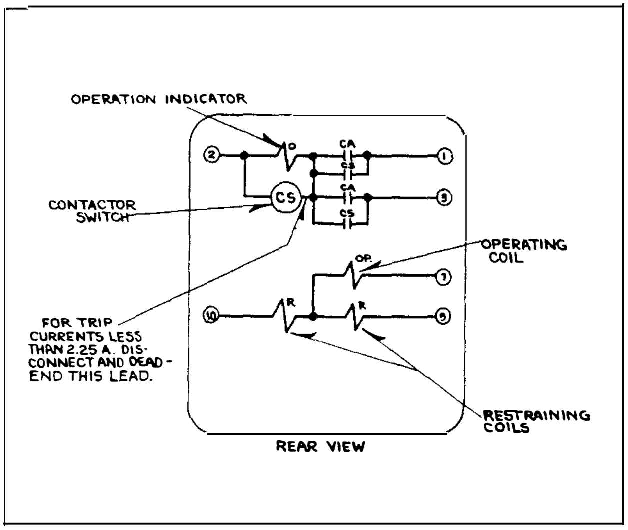

Fig. 2—Internal Connections of the 10% or 25% Type CA Generator Relay in the Standard Case.

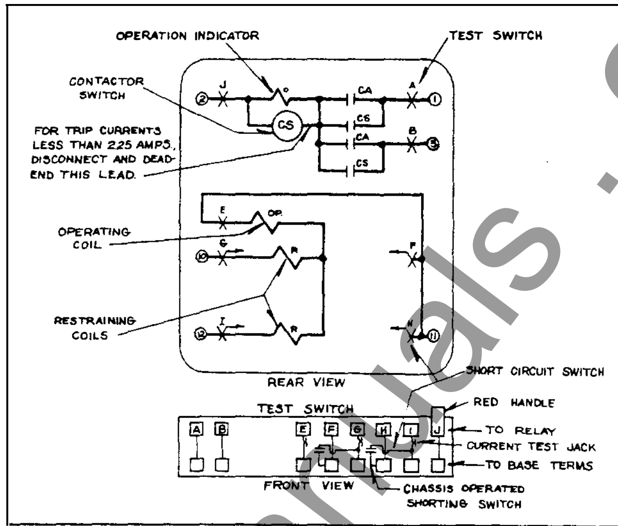

Fig. 3—Internal Schematic of the 10% or 25% Type CA Generator Relay in the Type FT Case.

and close the relay contacts is a function of restraining current. The operating curves for the 10% and 25% type CA generator relays are shown in Fig. 4 and Fig. 5, respectively. Note that for the 10% relay, 10% of the smaller restraining current must flow in the operating coil to cause tripping when the restraining currents are in phase. Similarly, 25% of the smaller restraining current is required to cause the 25% relay to close contacts. The relays are thus relatively insensitive to error currents flowing thru the operating coil as a result of high current thru faults, when current transformers are liable to unbalanced operation because of saturation effects. However, they are quite sensitive to light internal faults, for then only a relatively small operating coil current is required to produce tripping. Whatever the magnitude of fault current, a fixed percentage of the restraining current is required for tripping, rather than a fixed magnitude of difference current as would be the case in a differential protection scheme using over-current relays.

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, the restraint is totally cancelled. When unequal currents flow in from the two sides, the restraint is equivalent to the difference in the two 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 closing torque is produced. Under these circumstances the relay is very sensitive. Figs. 6 and 7 show the operating curves for both relays with the restraining currents 180° out-of-phase. These curves also apply where current flows in only one restraining winding and the operating coil.

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.

CHARACTERISTICS

The type CA generator relay is available in two designs: One for 10% sensitivity, and the other for 25% sensitivity. There are no taps, which means that the sensitivity of a given relay can not be adjusted. These two designs are adequate to meet the large majority of application problems encountered. The advantage of a relay with no taps is that the windings may be designed for a specific sensitivity with greater reliability at high current.

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 elements and all the test switches for inspection and testing. The next step is to open the test switches. Always open the elongated red handle switches first before any of the black handle switches or the cam action latches. This opens the trip circuit to prevent accidental trip out. Then open all the remaining switches. The order of opening the remaining switches is not important. In opening the test switches, they should be moved all the way back against the stops. With all the switches fully opened grasp the two cam action latch arms and pull outward. This releases the chassis from the case. Using the latch arms as handles, pull the chassis out of the case. The chassis can be set on a test bench in a normal upright position as well as on its top, back or sides for easy inspection, maintenance and test.

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

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 on both 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 cir-

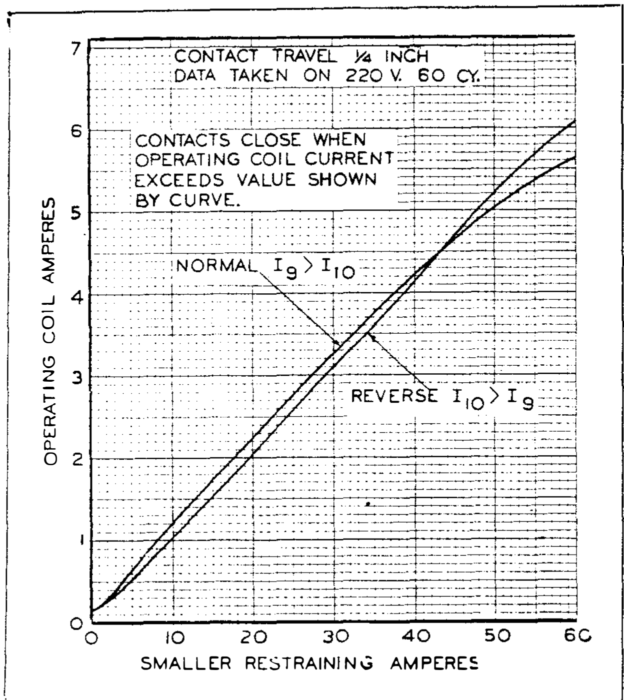

Fig. 4—Typical Operating Curves for the 10% Sensitivity Type CA Generator Relay.

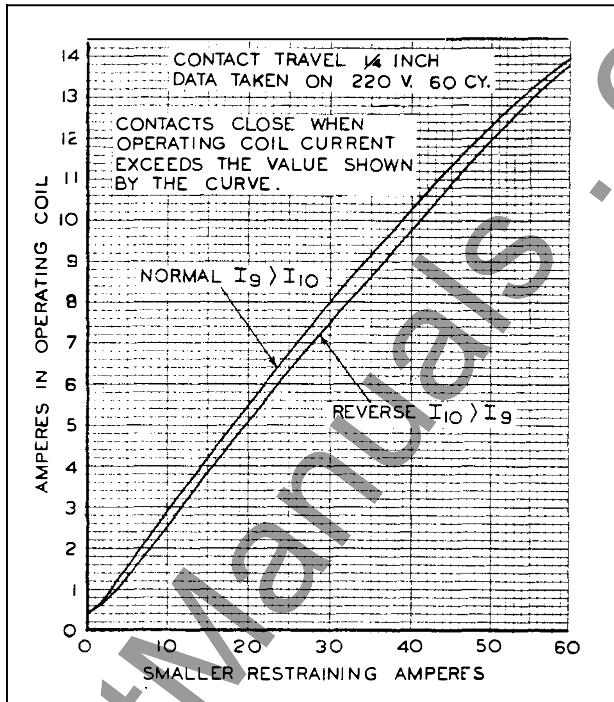

Fig. 5—Typical Operating Curves for the 25% Sensitivity Type CA Generator Relay.

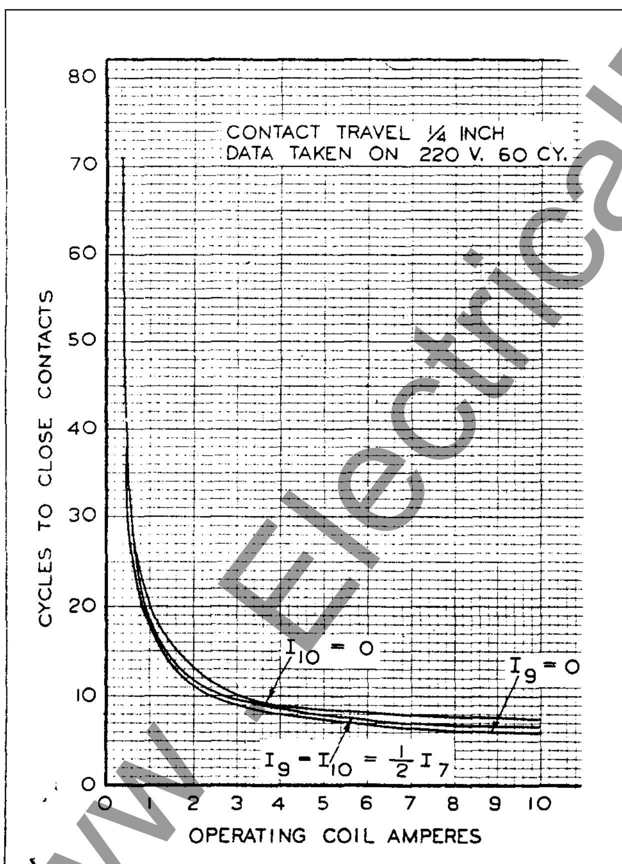

Fig. 6—Typical Time Curves for the 10% Sensitivity Type CA Generator Relay.

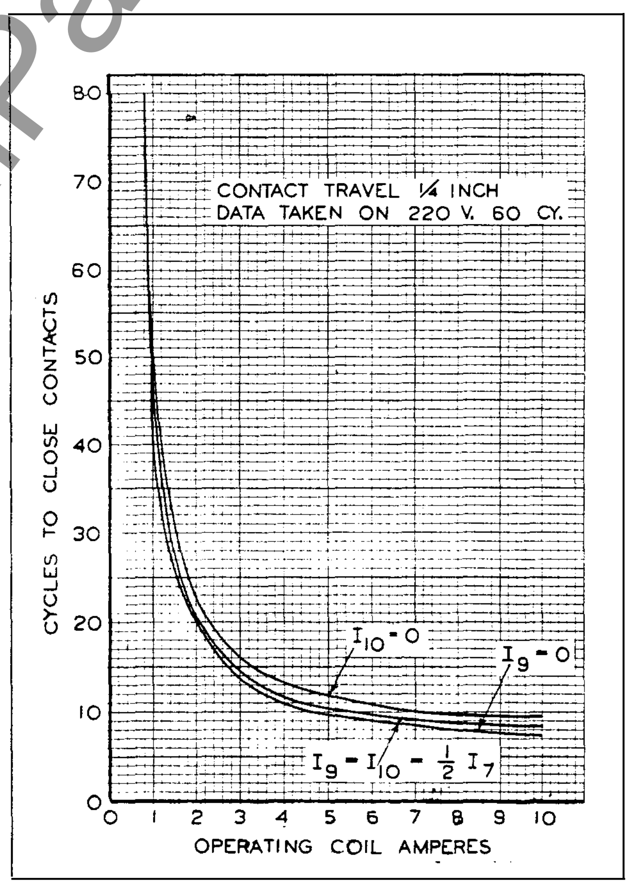

Fig. 7—Typical Time Curves for the 25% Sensitivity Type CA Generator Relay.

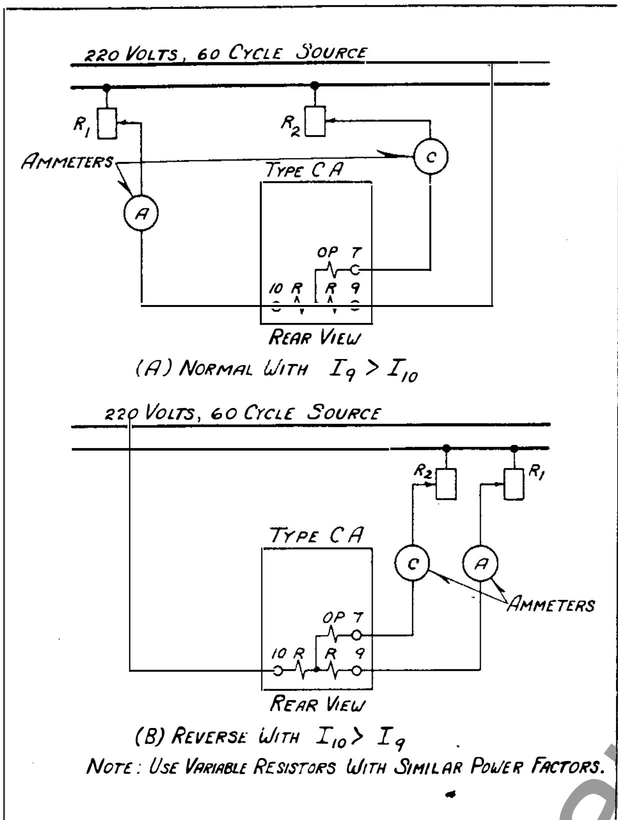

Fig. 8—Diagram of Test Connections for the Type CA Generator Relay in the Standard Case.

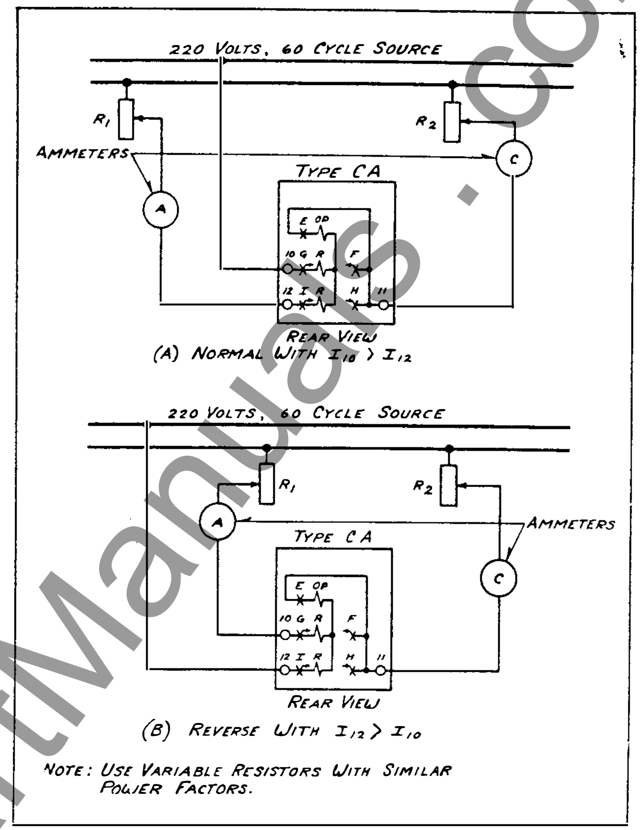

Fig. 9—Diagram of Test Connections for the Type CA Generator Relay in the Type FT Case.

cuit by opening the associated test switches. Opening the current test switch short-circuits the current transformer secondary and disconnects one side of the relay coil but leaves the other side of the coil connected to the external circuit thru the current test jack jaws. This circuit can be isolated by inserting the current test plug (without external connections), by inserting the ten circuit test plug, or by inserting a piece of insulating material approximately 1/32" thick into the current test jack jaws. Both switches of the current test switch pair must be open when using the current test plug or insulating material in this manner to short-circuit the current transformer secondary.

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

Testing

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

Testing In Service

The ammeter test plug can be inserted in the current test jaws after opening 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 elements to a set of binding posts and completely isolates the relay circuits from the external connections by means of an insulating barrier on the plug. The external test circuits are connected to these binding posts. The plug is inserted in the bottom test jaws with the binding posts up and in the top test switch jaws with 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.

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.

Typical external wiring diagrams are shown in Figs. 10 and 11. The outline and drilling plans for the relays are shown in Figs. 12 to 14.

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

SETTINGS

Each type relay is designed for a specific sensitivity and hence once the correct relay is chosen for a given application, no adjustment is necessary. If necessary, the spring tension controlling minimum operating current may be altered slightly.

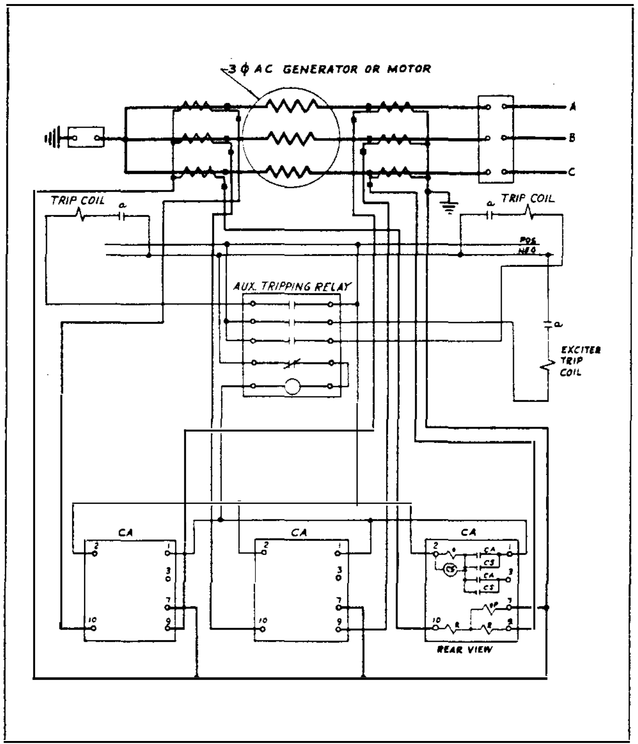

Fig. 10—External Connections of the Type CA Generator Relay in the Standard Case for Phase and Ground Protection of AC Generators and Motors.

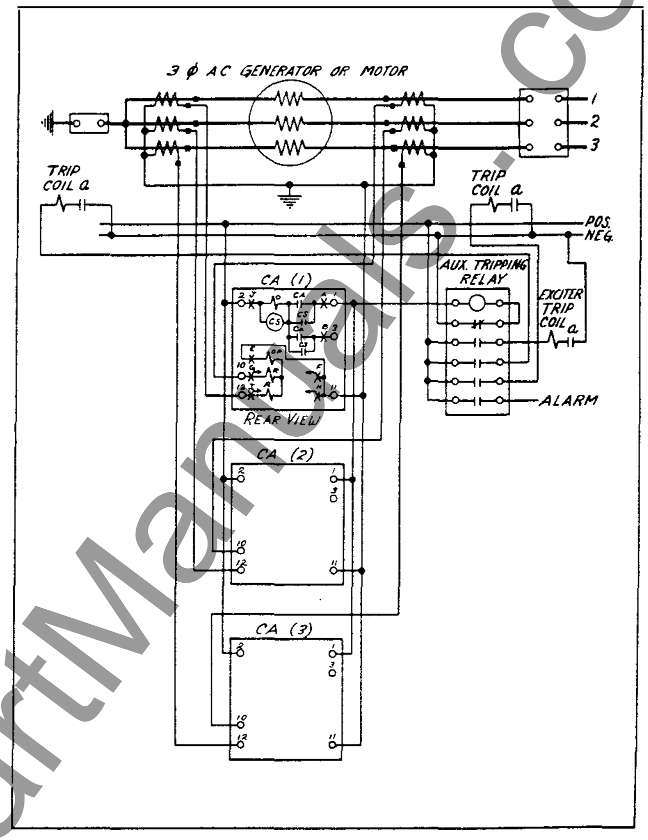

Fig. 11—External Connections of the Type CA Generator Relay in the Type FT Case for Phase and Ground Protection of AC Generators and Motors.

In general, for generator protection, a study of the current transformer characteristic curves under short circuit conditions should indicate whether the high sensitivity (10%) or the low sensitivity (25%) relay should be used. For special applications the nearest Westinghouse District Office should be consulted.

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.

Percentage Differential Element

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.8 or 9, 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, 1.0 ampere flowing in one restraining coil and the the operating coil should produce a positive contact closing torque.

Adjust the position of the contact stop, and the position of the stationary contacts, so that the moving contact travel is 1/4 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. 8A or 9A with the lead to the other restraining coil disconnected. Tighten the spiral spring by means of the spring adjuster until, for the 10% relay, 0.18 ampere just causes the relay contacts to close. For the 25% relay, 0.45 ampere is required to just make the relay contacts close at minimum trip.

In checking the percentage sensitivity, set the rheostat R_1 of Fig. 8 or 9, for 20 amperes restraining current, and then vary the operating current by adjusting the rheostat, R_2, until the relay just trips. This procedure should be followed for both the normal and reverse connections, and the results compared with Fig. 4 or 5, which represent 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 affects 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 on 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. For example, the Operating Coil Current to trip at 20 amperes smaller restraining current may be expected to vary between the limits of 1.7 to 2.3 amperes, for the 10% Sensitivity relay.

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 up-side-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 screw. 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 the two small nuts on either side of the Micarta disc. The switch should pick up at 2 amperes d-c. Test for sticking after 30 amperes d-c. have been passed thru the coil. The coil resistance is approximately 0.25 ohm.

Operation 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 0.2 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 the 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 10% and 25% sensitivity type CA relay at 5 amperes are as follows:

(A) 5.0 amperes in each restraining coil.

Across Terminals 9 and 7 in Standard Case. (Terminals 10 and 11 in Type FT Case.)

Relay	Watts	Volt-Amperes	P.F. Angle
10%	12.2	28.4	64.5° lag
25%	6.2	14.2	64° lag

Across Terminals 7 and 10 in Standard Case. (Terminals 11 and 12 in Type FT case.)

Relay	Watts	Volt-Amperes	P.F. Angle
10%	-9.6	24.6	113° lead
25%	-3.6	10.5	110° lead

(B) Minimum tripping conditions, smaller restraint current equals 5.0 amperes.

Across Terminals 9 and 7 in Standard Case. (Terminals 10 and 11 in Type FT Cases.)

Relay	Condition	Watts	V.A.	P.F. Angle	
10%	I9 > I10	17.2	50.3	70°	lag
10%	I10 > I9	-10.2	16.2	129°	lead
25%	I9 > I10	8.9	27.3	71°	lag
25%	I10 > I9	- 4.16	6.6	129°	lead

Across Terminals 7 and 10 in Standard Case. (Terminals 11 and 12 in Type FT Case.)

Relay	Condition	Watts	V.A.	P.F. Angle	
10%	I9 > I10	-16.6	46.4	111°	lead
10%	I10 > I9	12.1	17.7	47°	lag
25%	I9 > I10	- 7.2	22.1	105°	lead
25%	I10 > I9	6.65	8.7	40°	lag

With current flowing through the relay from terminals 9 to 10 in the Standard Case or terminals 10 to 12 in the Type FT Case, the burden voltage is the voltage drop from terminals 9 to 7 (or 10 to 11) for one current transformer and the drop from terminals 7 to 10 (or 11 to 12) for the other current transformer. The P.F. angle given in the tables shows the relationships between these currents with respect to the voltages.

The restraining windings of either relay have a continuous rating of 10 amperes. The operating winding of the 10% relay has a continuous rating of 2.5 amperes and 1 second rating of 70 amperes. The operating winding of the 25% relay has a continuous rating of 5 amperes and a 1 second rating of 140 amperes.

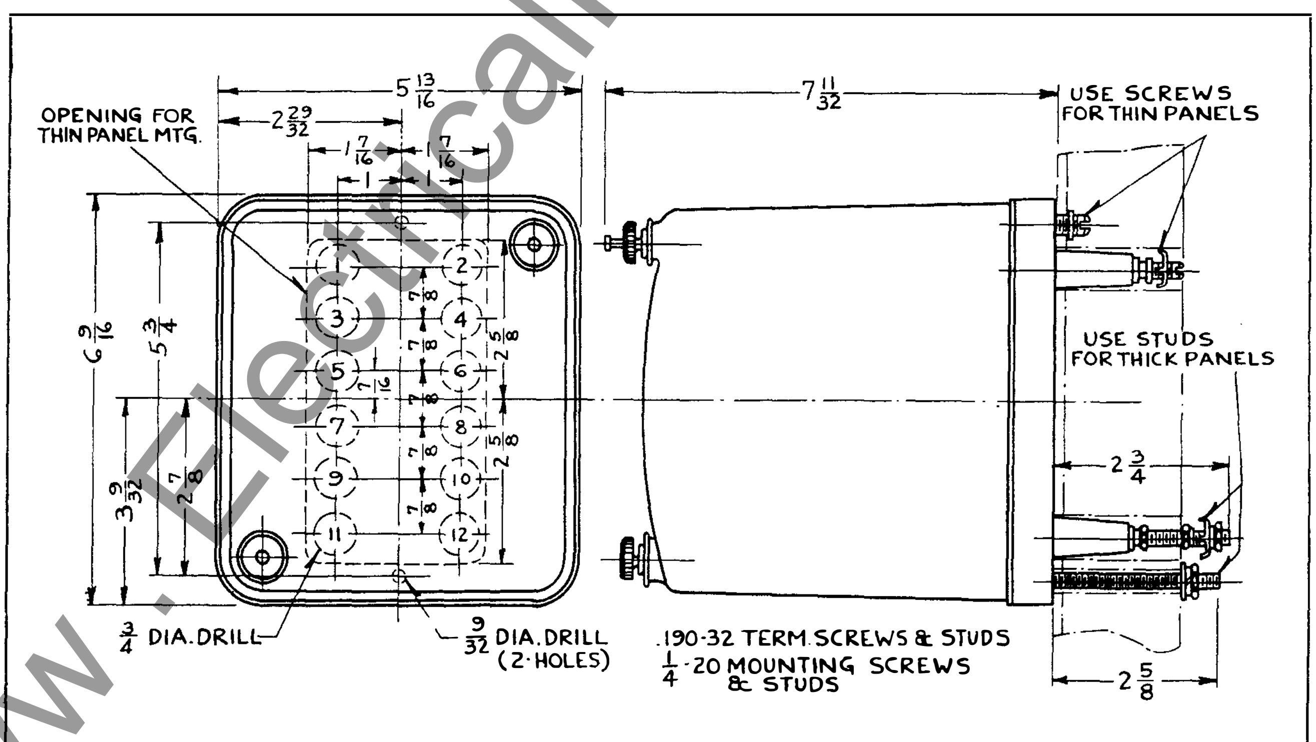

Fig. 12—Outline and Drilling Plan for the Standard Projection Type Case. See the Internal Diagrams for the Terminals Supplied. For Reference Only.

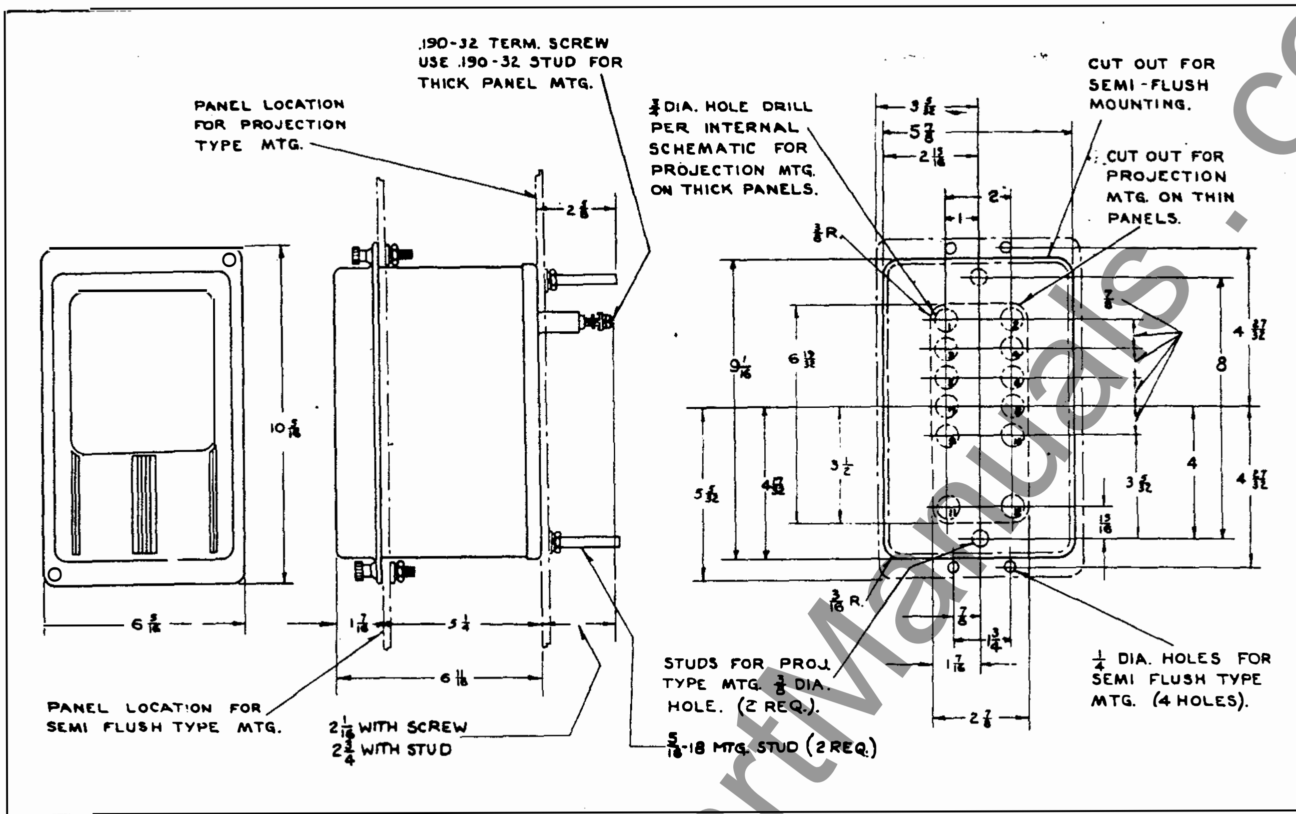

Fig. 13—Outline and Drilling Plan for the S10 Semi-flush or Projection Type FT Case. See the Internal Schematic for the Terminals Supplied. For Reference Only.

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