ABB Power T&D Company Inc.
Relay Division
Coral Springs, FL 33065

Instruction Leaflet
I.L. 41-331.2F

50 and 60 Hertz

Type CA Percentage Differential Relay for Generator Protection

Effective February 1988
Supersedes I.L. 41-331.2E dated February 1985

* Denotes change since previous issue

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 is designed for the differential protection of rotating ac machinery such as generators and motors.

CONSTRUCTION

The type CA relay consists of a percentage differential unit and an indicating contactor switch. The principal component parts of the relay and their locations are shown in Figs. 1 to 3.

PERCENTAGE DIFFERENTIAL UNIT

This unit is an induction disc unit with an electromagnet that has poles above and below the disc as shown in Fig. 2. Two restraint coils are placed on the lower left-hand pole (front view) and are connected in series. Their junction point is connected to the operating coil 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 winding in the same direction a contact opening torque is produced.

INDICATING CONTACTOR SWITCH UNIT (ICS)

The d-c indicating contactor switch is a small clapper type device. A magnetic armature, to which leaf-spring mounted contacts are attached, is attracted to the magnetic core upon energization of the switch. When the switch closes, the moving contacts bridge two stationary contacts, completing the trip circuit. Also during the operation two fingers on the armature deflect a spring located on the front of the switch which allows the operation indicator target to drop. The target is reset from the outside of the case by a push rod located at the bottom of the cover.

The front spring, in addition to holding the target, provides restraint for the armature and thus controls the pick-up value of the switch.

OPERATION

With the relay connected as in the schematic diagram Fig. 4A, a through fault causes currents to flow through two restraint 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 over-

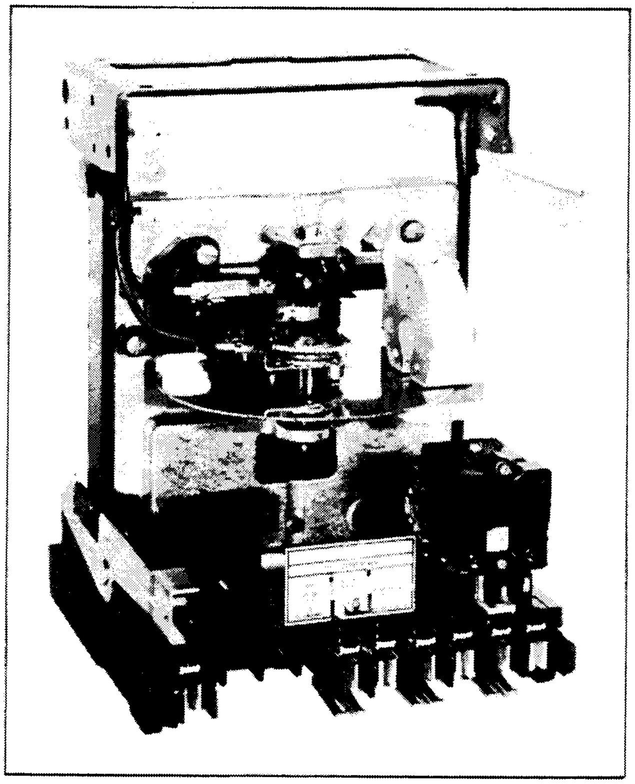


Fig. 1. Type CA Generator Relay (Front View)

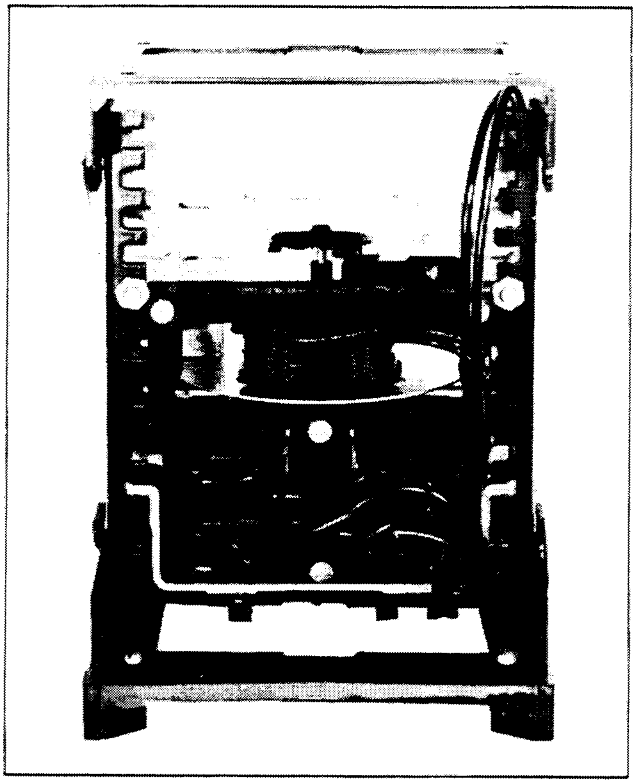


Fig. 2. Type CA Generator Relay (Rear View)

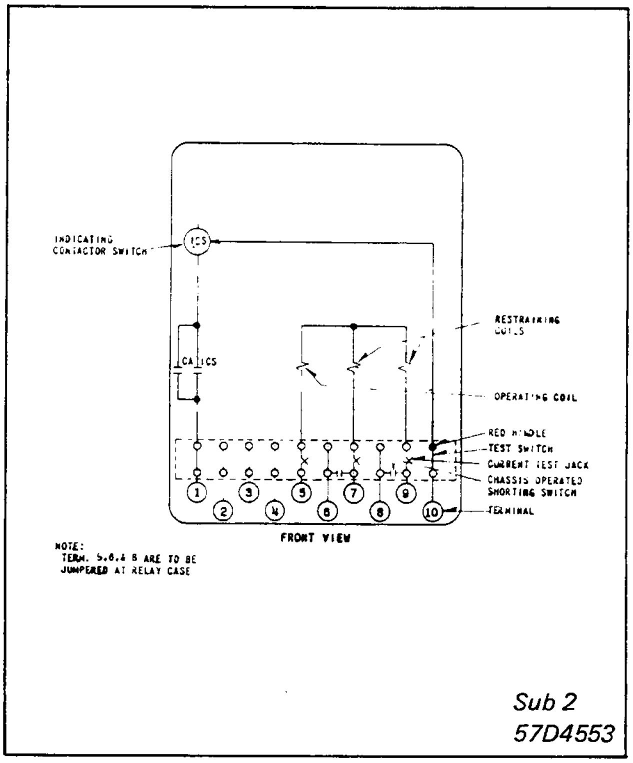


Fig. 3. Internal Schematic of the 10% or 25% Type CA Generator Relay in Type FT21 Case

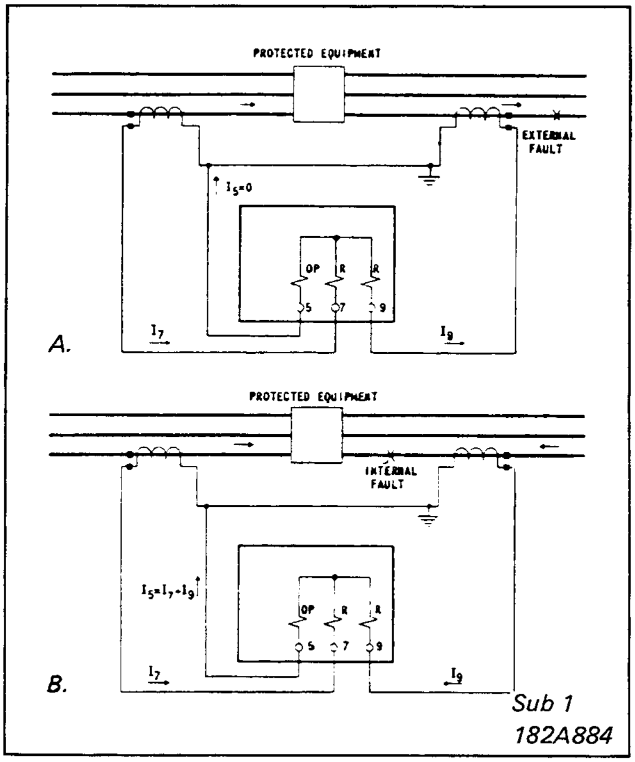


Fig. 4. Schematic Diagrams of the Percentage Differential Relays (A) shows the Fault Current Distribution for an External Fault; (B) the Distribution for an Internal Fault

come the restraining torque and close the relay contacts is a function of restraining current.

In the case of 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. 4B. 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.

CHARACTERISTICS

The type CA generator relay is available in two designs: One for 10% sensitivity and the other for 25% sensitivity.

The operating curves for the 10% and 25% type CA generator relays are shown in Figs. 5 and 6, respectively. For the 10% relay, 10% of the smaller restraint current must flow in the operating coil to cause tripping when the restraining currents are in phase. Similarly, 25% of the smaller restraint current is required to cause the 25% relay to close contacts.

Figs. 7 and 8 shows the operating curves for both relays with the restraint currents 180° out of phase. These curves also apply where current flows in only one restraint coil and the operating coil.

TRIP CIRCUIT

The main contacts will safely close 30 amperes at 250 volt d-c and the seal-in contacts of the indicating contactor switch will safely carry this current long enough to trip a circuit breaker.

The indicating contactor switch has two taps that provide a pick-up setting of 0.2 or 2 amperes. To change taps requires connecting the lead located in front of the tap block to the desired setting by means of a screw connection.

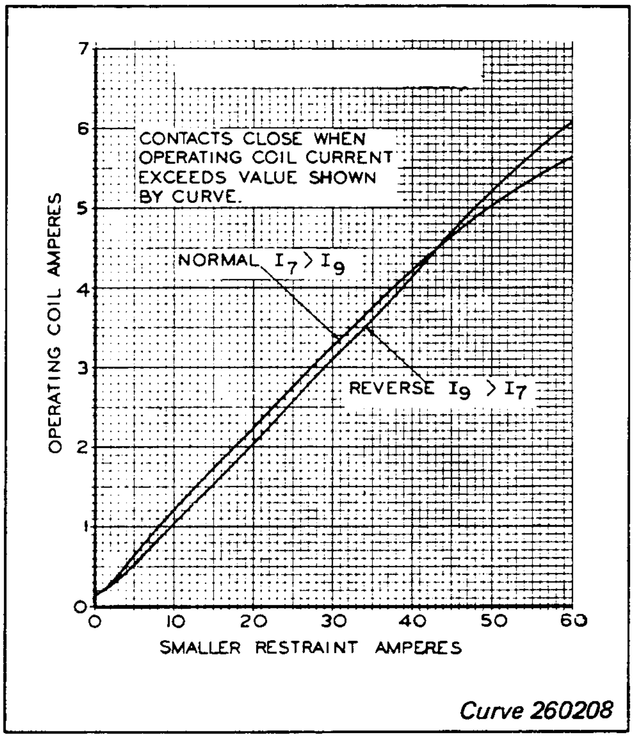


Fig. 5. Typical Operating Curves for the 10% Sensitivity Type CA Generator Relay

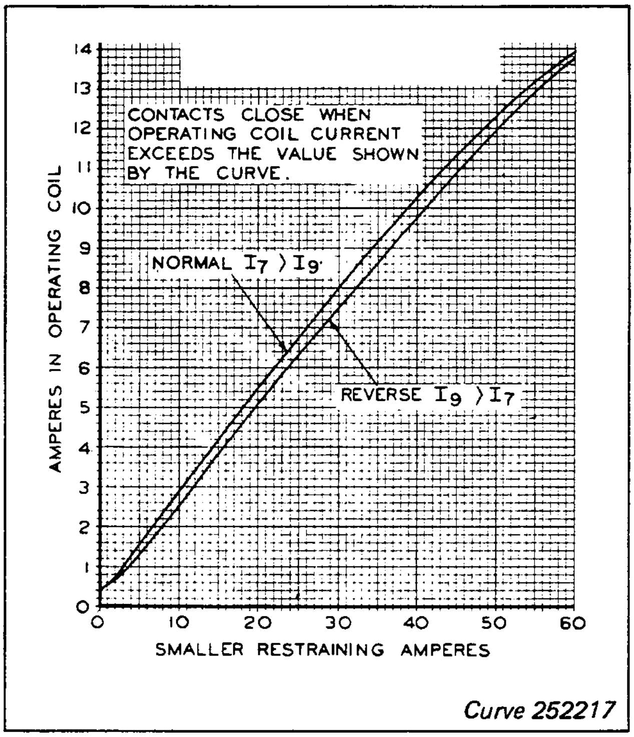


Fig. 6. Typical Operating Curves for the 25% Sensitivity Type CA Generator Relay

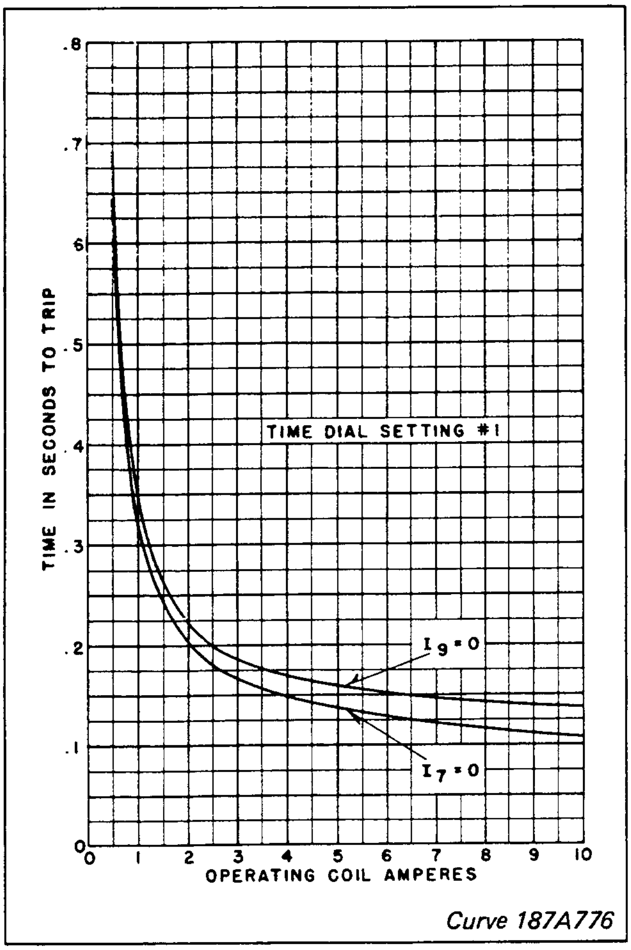


Fig. 7. Typical Time Curves for the 10% Sensitivity Type CA Generator Relay

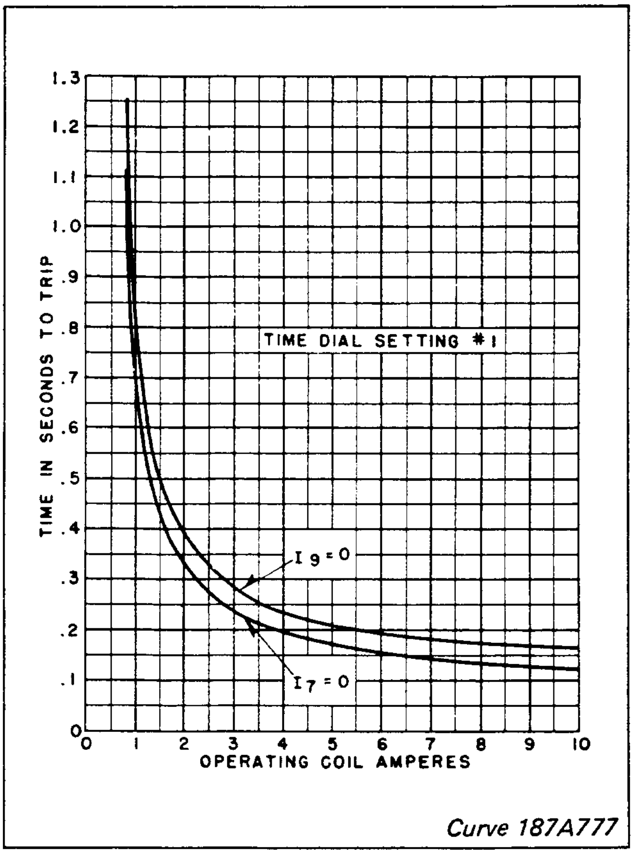


Fig. 8. Typical Time Curves for the 25% Sensitivity Type CA Generator Relay

TRIP CIRCUIT CONSTANT

Indicating contactor Switch (ICS):

0.2 Ampere Tap 6.5 Ohms D-C Resistance
2.0 Ampere Tap 0.15 Ohms D-C Resistance

ENERGY REQUIREMENTS

The 60 cycle burdens of the 10% and 25% sensitivity type CA relay are best given in curve form, as illustrated by Figs. 9, 10, and 11.

The burden data of the 50 Hz relay can be approximately estimated by using the following equations:

$$\Theta_2 = \text{arc Tan } \left(\frac{5}{6} \text{Tan } \Theta_1\right)$$

$$V_2 \cdot I_2 = V_1 \cdot I_1 \sqrt{\text{Cos}^2 \Theta_1 + \frac{25}{36} \text{Sin}^2 \Theta_1}$$

Where the $V_1 \cdot I_1$ & Θ_1 and $V_2 \cdot I_2$ & Θ_2 are the VA and angles for the 60 and 50 Hz relays respectively.

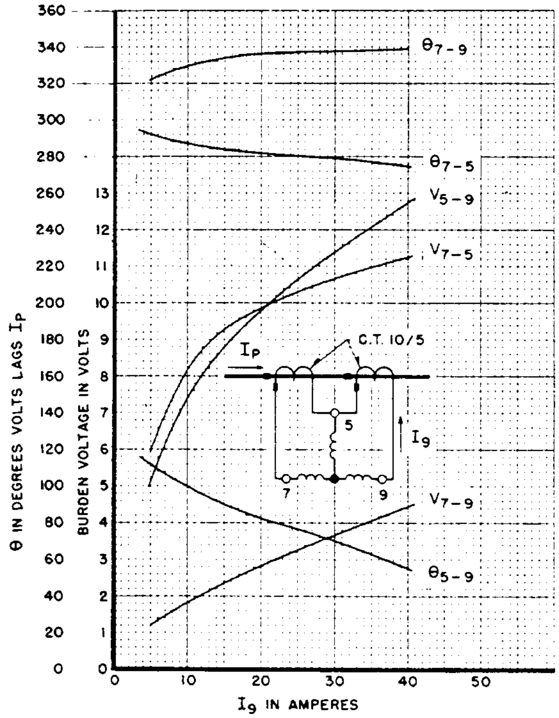
In Fig. 11, it gives the 60 Hz VA burdens only. The 50 Hz equivalent curves can be obtained by using the 60 Hz curve times a factor of 0.88.

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.

SETTINGS

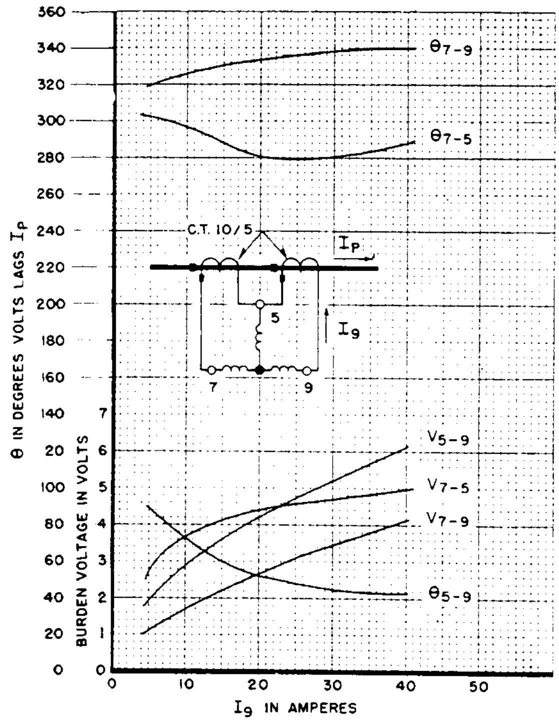
One setting is required for the percentage differential unit; that is, the setting of the time dial. This setting should be on the number 1 position.

Each type relay is designed for a specific sensitivity. Once the correct relay is chosen for a given



Curve 282554

Fig. 9. Typical 60 Cycles Burden Curves for the 10% Sensitivity Type CA Generator Relay



Curve 282555

Fig. 10. Typical 60 Cycle Burden Curves for the 25% Sensitivity Type CA Generator Relay

application, no adjustment is necessary. The spring tension controlling minimum operating current may be altered slightly, if desired.

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. Use the 25% relay, if ac saturation causes more than 1% ratio error in either set of CT's, for the maximum external fault.

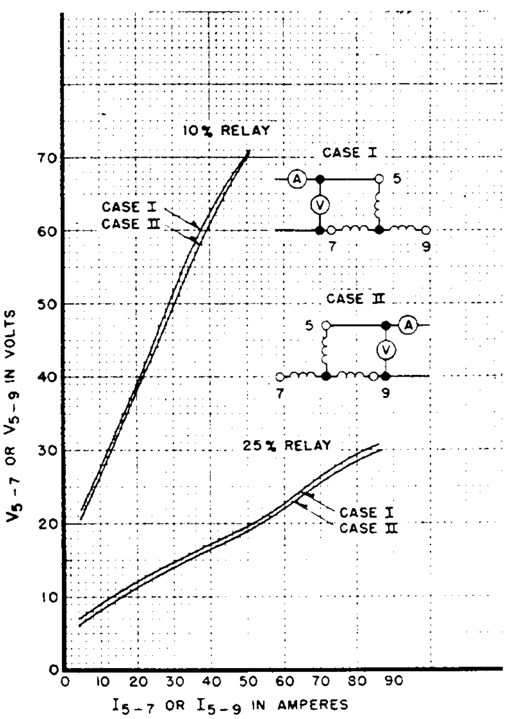
INDICATING CONTACTOR SWITCH (ICS)

The only setting required on the ICS unit is the selection of the 0.2 ampere tap setting or 2.0 ampere tap setting. This selection is made by connecting the lead located in front of the tap block to the desired setting by means of the connecting screw. When the relay energizes a 125 or 250 volt d-c type WL relay switch, or equivalent, use the 0.2 ampere tap.

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 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.



Curve 282553

Fig. 11. Typical 60 Cycle Saturation Curves for the Type CA Generator Relay

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.

ACCEPTANCE TESTS

The following check is recommended to insure that the relay is in proper working order.

1. Contact

The index mark on the movement frame will coincide with the "O" mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020 inch. The placement of the one time dial position in line with the index mark will give operating times as shown on the respective time-current curves. For double trip relays, the follow on the stationary contacts should be approximately 1/32 inch.

2. Minimum Trip Current

With current applied to terminals 9 and 5 of the relay, the contacts should close within the following limits:

10% Sensitivity Relay ..... 0.17 to 0.19 Amps
25% Sensitivity Relay ..... 0.42 to 0.47 Amps

3. Differential Characteristics

Connect the relay per test circuit of Fig. 12. (Normal connection). With 20 amperes applied to terminal 9 (meter A), the relay should operate between following limits:

10% Sensitivity Relay ..... 2.14 to 2.36 Amps
25% Sensitivity Relay ..... 5.2 to 5.8 Amps

The above points should be taken with the relay cool. Care should be taken not to overheat the relay.

Reverse connections to terminals 7 and 9 and apply 20 amperes to terminal 7 (meter A). The relay should operate between the following limits:

10% Sensitivity Relay ..... 1.9 to 2.15 Amps
25% Sensitivity Relay ..... 4.8 to 5.4 Amps

4. Time Curve

With the time dial on the number 1 position apply 10 amperes to terminals 9 and 5. The relay should operate within the following times:

10% Sensitivity Relay ..... 0.098 to 0.112
25% Sensitivity Relay ..... 0.115 to 0.128

5. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should not be greater than the particular ICS tap setting being used. The indicator target should drop freely.

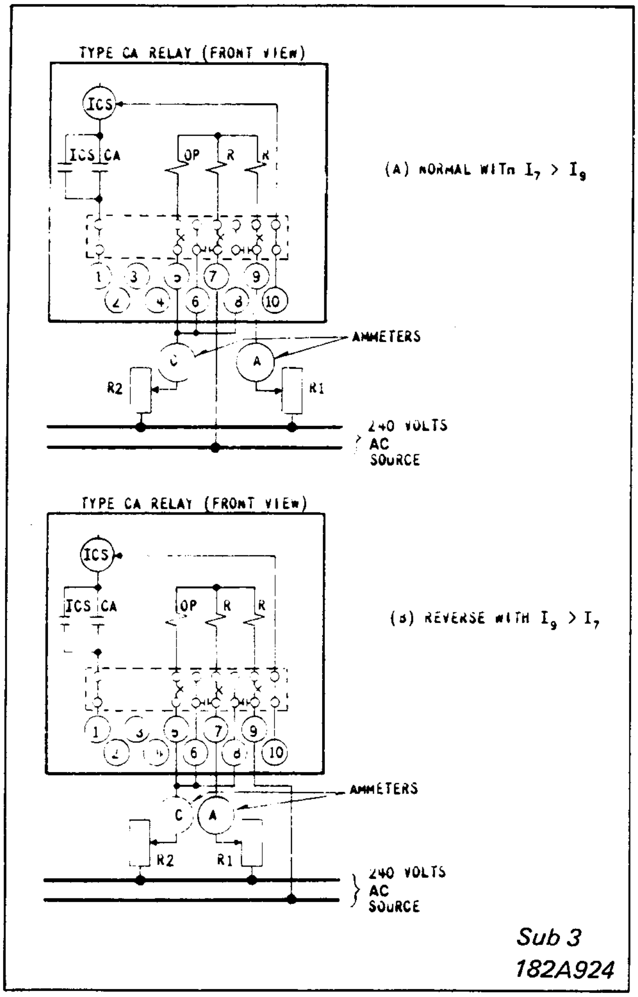


Fig. 12. Diagrams of Test Connections for the Type CA Generator Relay in the Type FT-21 Case

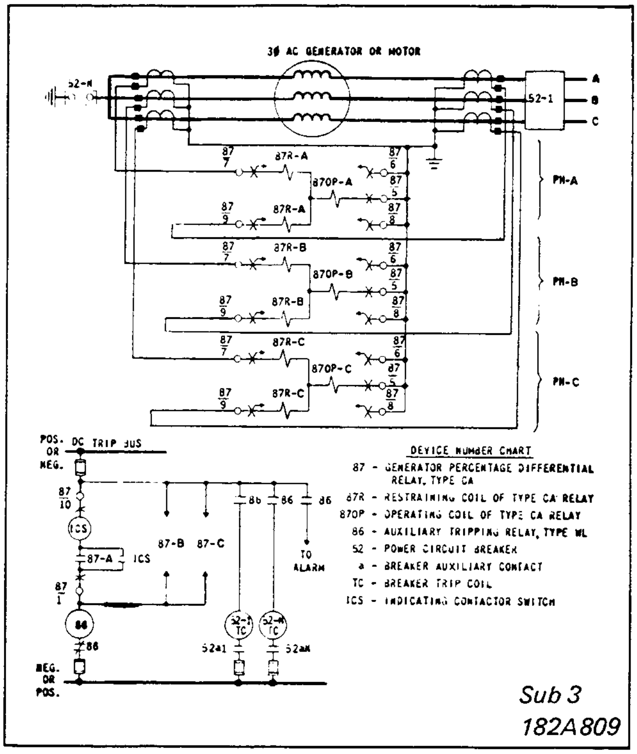


Fig. 13. External Schematic Diagram of the Type CA Generator Relay in the Type FT-21 Case for Phase and Ground Protection of the AC Generators and Motors

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

ROUTINE MAINTENANCE

All relays should be checked at least once every year or at such other time intervals as may be dictated by experience to be suitable to the particular application.

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.

CALIBRATION

Use the following procedure for calibrating the relay if the relay has been taken apart for repairs or the adjustments disturbed. This procedure should not be used until it is apparent that the relay is not in proper working order (See "Acceptance Check").

1. Contact

The index mark on the movement frame will coincide with the "O" Mark on the time dial when the stationary contact has moved through approximately one-half of its normal deflection. Therefore, with the stationary contact resting against the backstop, the index mark is offset to the right of the "O" mark by approximately .020". The placement of the one time dial position in line with the index mark will give operating times as shown on the respective time-current curve. For double trip relays, the follow on the stationary contacts should be approximately 1/32".

2. Minimum Trip Current

The adjustment of the spring tension in setting the minimum trip current value of the relay is most conveniently made with the damping magnet removed.

Apply current to terminals 9 and 5 of the relay and adjust the control spring tension so that the moving contact just closes between the following limits.

10% Sensitivity Relay . . . . . 0.175 to 0.185 Amps
25% Sensitivity Relay . . . . . 0.44 to 0.46 Amps

3. Percentage Slope Characteristic

Points on the percentage slope curve can be checked by use of the test circuit of Fig. 12. The operating current required to operate the relay should be within ± 7% of the curve value. Care should be taken not to overheat the relay during these tests.

4. Time Curve

Place the permanent magnet on the relay and set the time dial at the number 1 position. Adjust the permanent magnet keeper until the contacts close in the following times with 10 amperes applied to terminals 9 and 5.

10% Sensitivity Relay . . . . . 0.100 to 0.110 Sec.
25% Sensitivity Relay . . . . . 0.118 to 0.125 Sec.

5. Indicating Contactor Switch (ICS)

Close the main relay contacts and pass sufficient d-c current through the trip circuit to close the contacts of the ICS. This value of current should be not greater than the particular ICS tap setting being used. The operation indicator target should drop freely.

The contact gap should be approximately .047" between the bridging moving contact and the adjustable stationary contacts. The bridging moving contact should touch both stationary contacts simultaneously.

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.

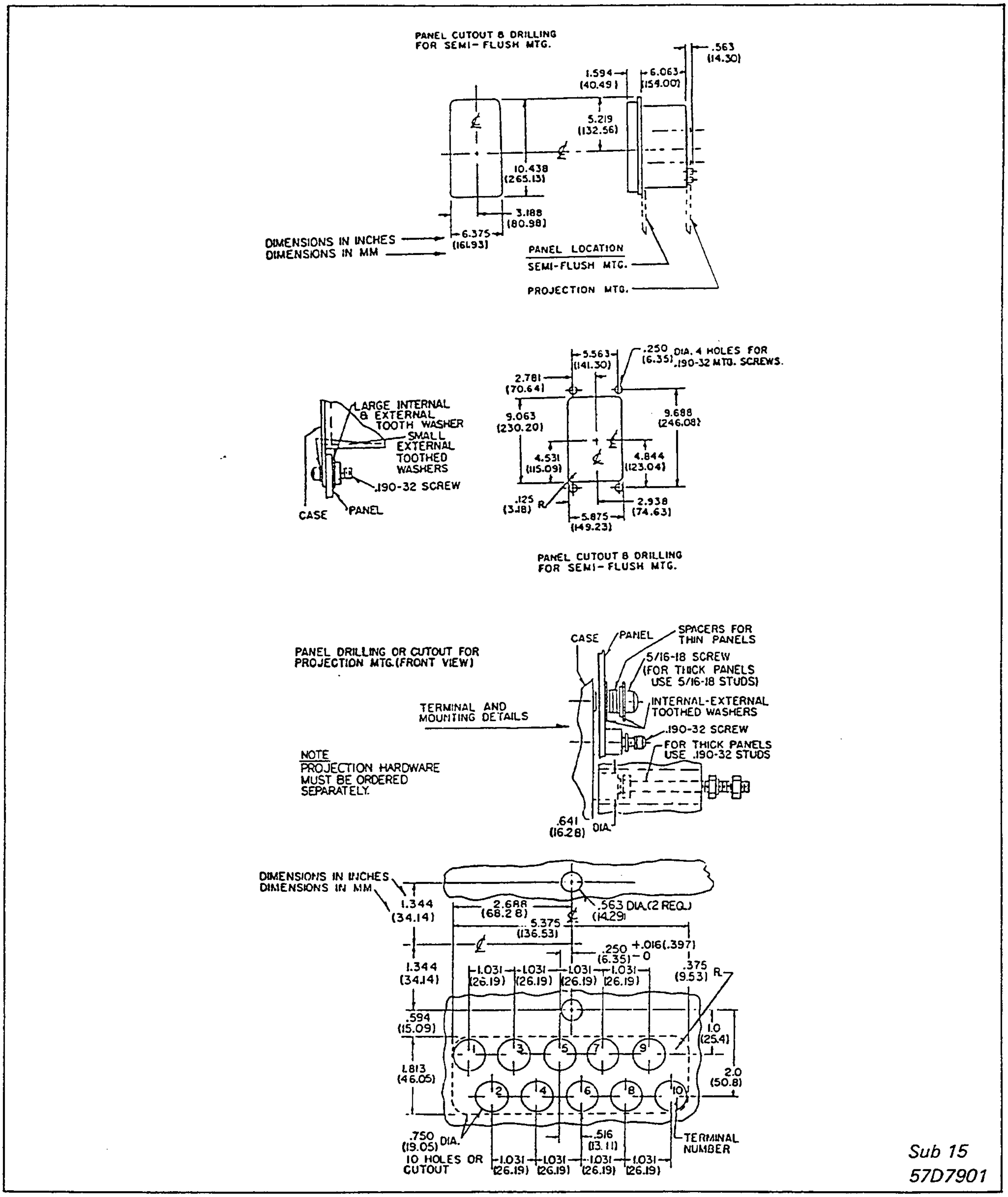


Fig. 14. *Outline and Drilling for the Type CA Generator Relay in the Type FT-21 Case*